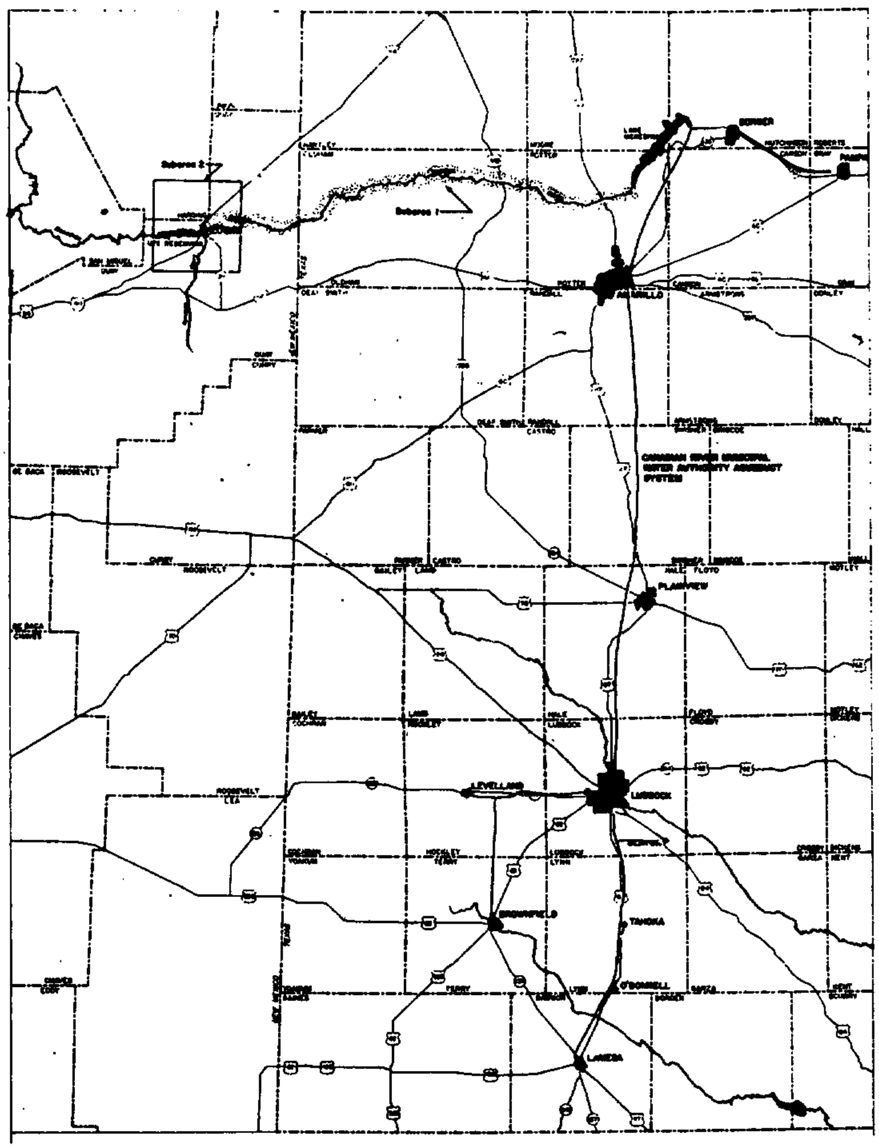
CANADIAN RIVER MUNICIPAL WATER AUTHORITY
REGIONAL WATER SUPPLY PLANNING GRANT
TWDB CONTRACT NO. 92-483-314



Parkhill, Smith & Cooper, Inc.

in association with

LEE WILSON & ASSOCIATES
ENVIRONMENTAL PLANNING • RESOURCE MANAGEMENT

OVERVIEW OF
CONJUNCTIVE MANAGEMENT ALTERNATIVES

FOR THE
CANADIAN RIVER
MUNICIPAL WATER AUTHORITY

Parkhill, Smith and Cooper, Inc.
and
Lee Wilson and Associates, Inc.

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EXECUTIVE SUMMARY

The development of a conjunctive management program, by which ground water would be used to supplement surface water supplies from Lake Meredith, appears to be the only viable means by which the Canadian River Municipal Water Authority (CRMWA) can meet the projected water demands of its member cities. Such a project would have substantial water-quality benefits as well and could enable CRMWA member cities to meet secondary drinking water standards for chloride, sulfate and total dissolved solids. To accomplish both the objectives of improved water supply and improved water quality, a ground water project would need to provide at least 30,000 acre-feet per year (AFY) on average, at least 45,000 AFY during droughts, and potentially 65,000 AFY under extreme conditions.

Ground water resources in the Ogallala aquifer of the High Plains of Texas were assessed based on readily available information in order to identify locations where CRMWA might develop a large, good quality water supply without undue expense, impact on existing water uses, or other problems. Generally, the best locations are northeast of a line which extends from the New Mexico State Line in southern Hartley County, southeast to Donley County.

Two areas of special interest have large blocks of water rights owned by Southwestern Public Service Company (SPS): one in and near southwestern Roberts County is by far the largest reserve of essentially unused water in the region; and the second, south of Fritch in Potter and Carson Counties, adjoins the existing CRMWA aqueduct. Data on both areas were obtained from SPS and from the Panhandle Groundwater Conservation District No. 3.

A hypothetical water supply project was evaluated for the Roberts County area, as this location contains a large enough resource to meet the full CRMWA need. Conditions favorable to a project include: a single ownership of water rights; large saturated thickness; generally good aquifer properties (permeability, specific yield); depths to water which are not excessive; good natural water quality; the absence of known pollution problems; and a location

outside a water district (hence no specific permitting requirements at this time).

The hypothetical project involves a 54-inch pipeline from Roberts County which would join the existing CRMWA aqueduct just above existing pumping station No. 3. The project design is for 45,000 AFY, because there is minimal cost savings for a smaller size project; expansion to 65,000 AFY could be accomplished at relatively little additional cost. The capital cost of the project would be $62 million. The CRMWA annual budget would increase from $8.1 million at present to somewhere in the range of $16.7 to $19.6 million, depending on the quantity of ground water pumped in a given year.

The net effect of conjunctive management would be to: 1) increase the firm yield of the CRMWA system to 121,000 AFY; 2) produce a water which would be expected to meet State of Texas standards for chloride, sulfate and dissolved solids under most conditions; 3) increase the unit cost of CRMWA water from about 35 cents per thousand gallons to a cost which would be in the range 50 to 64 cents per thousand gallons, depending on the exact mix of surface and ground water.

To date, no major problems have been identified with respect to CRMWA developing a conjunctive management program, in which ground water would supplement the existing surface water supply. However, while this analysis is favorable to CRMWA's development of a ground water project, it is important to note that access to the SPS water supply in Roberts County has yet to be negotiated, the public reaction to the project is yet to be gaged, and more detailed studies may be required before the project can be designed and optimized. We recommend that CRMWA proceed to the next step in project implementation, which is negotiation with the water-rights owner.

1. INTRODUCTION

1.1 Background and Objectives

Lake Meredith is the major reservoir in the High Plains of Texas. Located on the Canadian River, north-northeast of Amarillo, Lake Meredith is used to supply water to 11 Texas cities via a pumping and distribution system which is operated by the Canadian River Municipal Water Authority (CRMWA). Studies described in a separate report indicate that the firm yield of Lake Meredith is substantially less than the future water demands of the 11 cities, and that the quality of water produced from Lake Meredith is likely to continue to be of marginal quality due to excess salinity.

This study has been authorized by CRMWA in order to help determine the feasibility and costs of a conjunctive management program, by which ground water resources in the High Plains of Texas would be developed in order to increase the firm yield and improve the quality of the CRMWA water supply. A fundamental assumption in the study is that the conjunctive management program would be fully integrated into the CRMWA system, so that all member cities would participate on the same basis as they do now. Alternative concepts, under which only some cities would benefit from (and pay for) ground water have not been considered.

A separate report indicates that Lake Meredith has a firm yield of roughly 76,000 acre-feet per year (AFY). The design conditions for the CRMWA project were 103,000 AFY firm yield and 126,000 AFY peak yield, though the capacity of the aqueduct no longer allows the latter value. Existing demands among CRMWA member cities were about 103,000 AF in 1991, but 35,500 AF was met from ground water pumped directly by the cities, including 22,260 AF for Amarillo alone. Based on experience of the City of Amarillo, effective conjunctive management for water quality purposes requires at least 28% ground water in order to blend with surface water and meet salinity standards for drinking water. Much larger proportions of ground water would be needed for blending if Lake Meredith becomes substantially more saline than it is today, and even larger amounts would be required if salinity standards are based on EPA-specified levels instead of (as at present) State of Texas levels.

Reflecting these considerations, this analysis considers three different levels of ground water production to supplement surface water.

- At least 30,000 AFY would be needed to bring CRMWA firm yield up to original design levels <u>and</u> reduce the salinity of delivered water to existing State of Texas standards, if Lake Meredith salinity is at present levels.
- At least 45,000 AFY would be needed to bring CRMWA firm yield up to near original aqueduct capacity <u>and</u> reduce the salinity of delivered water to existing State of Texas standards, if Lake Meredith salinity is at levels projected to occur (on average) during a severe drought.
- Perhaps 65,000 AFY would be needed to meet salinity standards under a worst-case scenario of: a) Lake Meredith salinity at the end of a severe drought; and/or b) imposition of EPA salinity standards.

1.2 Approach of Study

This evaluation of conjunctive management alternatives contains three components:

- an assessment of ground-water resources in the High Plains area (see Section 2 of this report);
- an evaluation of a hypothetical project which would develop ground water in the vicinity of Lake Meredith, including preliminary cost estimates for various project alternatives (Section 3); and
- a summary of important consequences of a recommended conjunctive management program (Section 4).

Major findings are presented in the Executive Summary.

This study has been funded in substantial part by a grant from the Texas Water Development Board. Engineering components of the study, including conceptual design and cost analysis, have been performed by Parkhill, Smith and Cooper, Inc., Lubbock, under the supervision of John Kelley, Registered Professional Engineer. Hydrogeologic and other components of the study have been performed by Lee Wilson and Associates, Santa Fe, under the supervision of Dr. Lee Wilson, Certified Professional Hydrogeologist.

2. RESOURCE ASSESSMENT

2.1 Assessment Criteria

The first step in this study was to identify and evaluate ground water resources which may be conjunctively managed by CRMWA. The evaluation criteria which we applied are as follows.

- The preferred location for the ground water supply is near the upstream end of the CRMWA aqueduct, so that use of the supply can be fully integrated with the use of surface water. Supplies relatively close to this location (i.e. close to Sanford Dam) are preferred to more distant sources, because transportation costs (pipeline length, pumping energy) will be less. However, the supply should not be located so that pumping effects would reduce runoff to or storage in Lake Meredith. [The alternative of locating a supply to benefit only the southern part of the CRMWA service area is not considered in this study, as it would not provide full conjunctive management. Moreover, based on Figure 2-1, discussed subsequently, long-term ground water resources in the southern part of the High Plains are limited.]

- Several aquifer properties are important to a high production, long-lived, reasonably priced supply of ground water. Saturated thickness should be at least a few hundred feet, and specific yield should be 10% or more, if the aquifer is to be able to provide at least 1.5 million AF (30,000 AFY over 50 years) from an economically-sized well field. A depth to water of a few tens to no more than a few hundreds of feet is preferred, as shallow depths reduce pumping costs. Areas of relatively high recharge rates would be desirable.

- Consideration should be given to whether or not the resource being evaluated is already in demand. High demands can be indicated by large rates of existing pumping, a relatively rapid decline in water levels and/or a location within an underground water district. Typically it is difficult for new users to obtain water in areas of high demand; and if access is obtained, the costs can be high and/or the long-term supply can be limited.

- Water quality is an important criteria to CRMWA. If ground water is to mitigate the high salinity of surface water, it needs to have a low content of dissolved solids (a few hundred mg/l at most), with chloride and sulfate less than 20 mg/l. Other parameters must be well within Safe Drinking Water Act standards and, based on problems experienced by some cities, low concentrations of fluoride are desirable. Of course, supplies need to be free of existing pollution problems, and preference should be given to resources which can be protected effectively against future contamination. In general, areas where existing and projected pumping rates are high are areas of relatively intensive land use, where risks of pollution could be higher than elsewhere.

- Other factors can be considered on a case-by-case basis. For example, if development of a particular resource could pose environmental problems, that resource would have a relatively low priority. The market availability of the water - through purchase and lease - and any possible problems in siting pipeline rights-of-way also bear on the suitability and costs of the resources.

2.2 Regional Aquifers

The authoritative reference on ground water in the High Plains of Texas is a four-volume study published by the Texas Department of Water Resources (Knowles, Nordstrom and Klemt, 1984). That report confirms that the Ogallala Formation is the major water-bearing unit on the High Plains. The Ogallala is a geologically young assemblage of sedimentary materials - sand, silt, clay and gravel - deposited by streams which eroded the southern Rocky Mountains to the northwest. The Ogallala lies at or near the land surface throughout the High Plains. It fills in an ancient erosion surface which is marked by southeast trending river valleys.

Older, deeper geologic units are not a major consideration in the development of High Plains ground water, except to the extent that such units may be in direct hydraulic connection with the Ogallala. The term "High Plains aquifer" is used to refer to the combined saturated sediments of the Ogallala and any connected older formations.

Knowles et al. (1984, p. 22) summarize important hydrogeologic properties of the Ogallala. Saturated thicknesses range up to several hundred feet, with sand being more dominant than clay on average. The greatest thicknesses are found in the southeastern trending buried valleys (see subsequent discussion of Figure 2-1). Locally thick clay accumulations scattered throughout the area suggest the possibility of several Ogallala-age lake basins. Gravels are relatively rare, except along suspected ancient channels where thicknesses may reach 100 feet. However, a basal gravel is commonly found at the aquifer bottom. The aquifer is unconfined, with specific yields that are often in the 15 to 20% range, and sometimes higher.

2.3 Areas Where Supplies are Most Abundant

Information presented in Knowles et al. (1984) was compared to the criteria discussed in Section 2.1. The judgment was made to use saturated thickness as a primary criteria for initial indication of areas where CRMWA could look for a ground-water supply. The 1984 report includes relatively detailed saturated thickness maps for the Ogallala for each county in the High Plains, along with computer-generated predictions of future saturated thickness amounts. The predictions reflect aquifer properties, recharge, existing amounts of storage and expected pumping rates.

Figure 2-1 is the computer forecast of saturated thickness for the year 2030 for the entire High Plains area. Over much of the area, saturated thickness is predicted to be less than 60 feet. Knowles et al. (1984, p. 89) discuss how this forecast, if accurate, could lead to deficient supplies to municipal and industrial wells throughout the region.

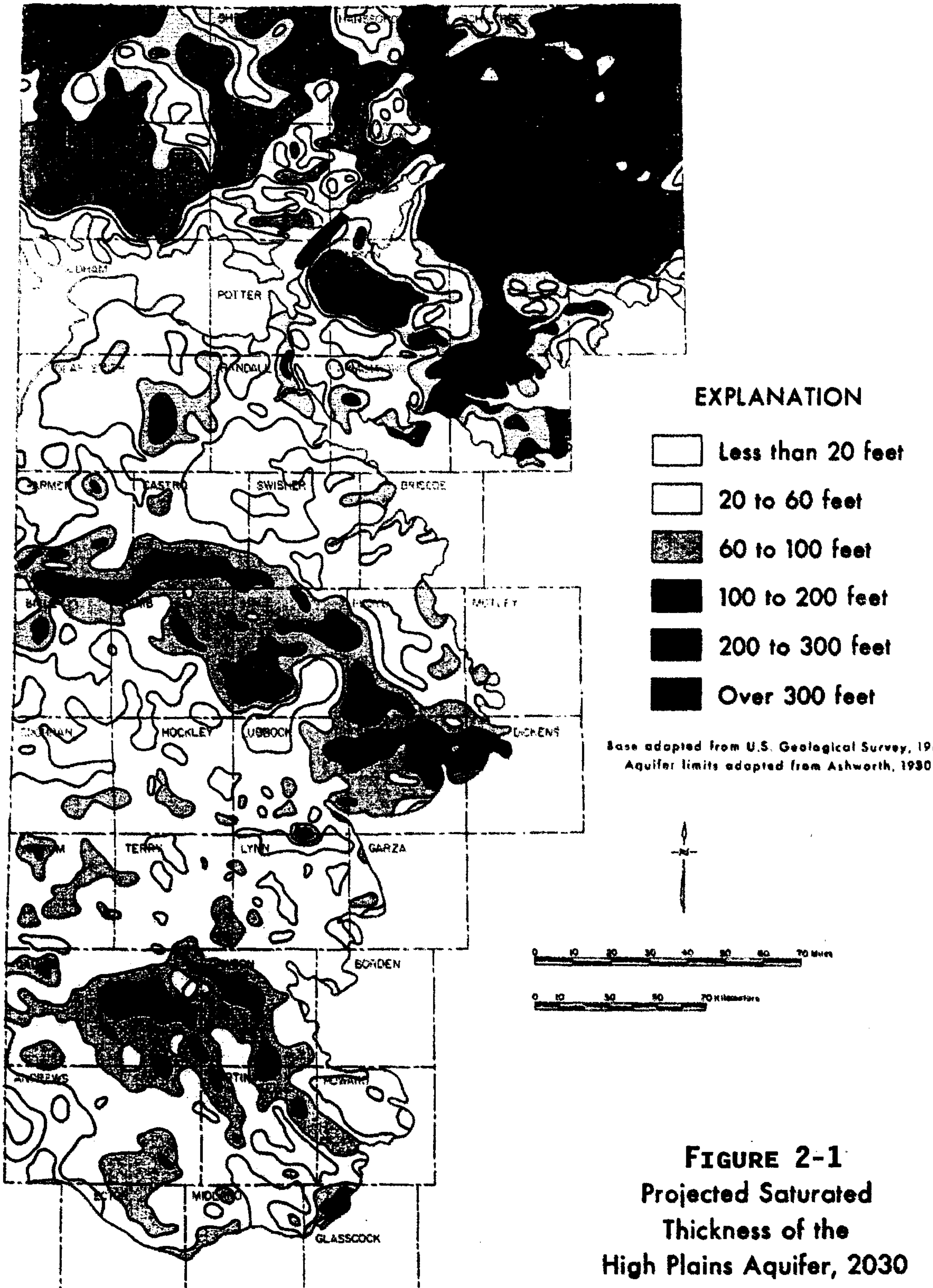


FIGURE 2-1
Projected Saturated Thickness of the High Plains Aquifer, 2030

By far the bulk of the stored ground water in 2030 will lie northeast of a line which extends from the New Mexico State Line in southern Hartley County, southeast to Donley County. In most of that area, saturated thickness will still exceed 100 feet in 2030. The greatest reserves are shown in a southeast-trending zone (along an ancient buried valley) which, in Roberts and Hemphill Counties, contains the only large areas of saturated thickness over 300 feet which will remain in the High Plains.

The areas of maximum water supply availability are indicated by the following tabulation, which lists counties where 2030 Ogallala storage is predicted to exceed 15 million acre-feet (Knowles et al., 1984, Table 19).

Roberts County	28.15 million AF
Hartley County*	22.69 million AF
Dallam County*	20.26 million AF
Lipscomb County	18.62 million AF
Hemphill County	16.98 million AF

* = county is relatively larger than others in this list

The sizeable reserve in Roberts County is further indicated by the fact that in 2030, the prediction is for a total of almost 50 acre-feet of water in storage per acre. Note that all these estimates of storage are for total supply; water recoverable to well fields is a somewhat lesser amount.

Southeast-trending zones of greater saturated thickness (also along an ancient buried valley) are shown in the southern High Plains near Plainview and Lamesa. However, "thicker" for these areas means 60 to 200 feet, indicating relatively limited total reserves by 2030.

On Figure 2-1, six areas in the northern High Plains have been marked because they have substantial saturated thickness in 2030 and thus could be considered as potentially important alternatives for CRMWA to consider if a ground-water supply is developed. The six areas are as follows:

1. northwest of Lake Meredith in Moore County, near Dumas;

2. north of Lake Meredith in Hutchinson County, near Stinnett;
3. in the vicinity of the community of Panhandle, Carson County, southeast of Lake Meredith, including easternmost Potter County;
4. in Roberts and Ochiltree Counties, north of Pampa;
5. in the vicinity of Miami, in Roberts and Hemphill Counties; and
6. near Jericho, along the Gray-Donley county line.

These are not all the areas of potential interest. For example, it is known that the City of Amarillo has obtained water rights in Hartley County, west of area 1. Resources in that area could be considered by CRMWA, if the closer-in supplies do not prove feasible for reasons other than economics.

2.4 Application of Other Criteria

The areas of greatest ground water potential shown in Figure 2-1 were assessed according to the other criteria discussed in Section 2.1. The assessment involved relatively simple checks to identify major advantages or disadvantages of each area. Some of these checks utilized information in Knowles et al. (1984) or other references; others involved personal communications with employees of CRMWA member cities, who were familiar with ground water supplies in their area.

The discussion which follows identifies only those evaluations which appear to have a potentially major bearing on decisions to be made by CRMWA. Except as noted, all areas currently contain ground water with a chloride content of less than 50 mg/l; and include significant portions which are within an underground water district and where water use is relatively high. All areas have generally favorable properties of specific yield and permeability.

Area 1. The most significant aspect of this area is its relative distance from the CRMWA aqueduct system. An area of elevated chlorides occurs near this area. Currently, depths to water average over 200 feet.

Area 2. This appears to be the smallest of the six resources which are shown on Figure 2-1; indeed, it was included in the list only because it is the closest to Sanford Dam. At least one large block of potentially marketable water is in single ownership in this area. Because of proximity to the Canadian River, recharge rates are higher than average.

Area 3. The area near the town of Panhandle is well-located with respect to the CRMWA water system. Some portions of the area which are not irrigated nor heavily pumped are adjacent to the CRMWA aqueduct; these include a large acreage within a single ownership. A zone of high-chloride water occurs northeast of Panhandle. Depth to water in this area tends to be high, averaging nearly 300 feet in Carson County in 1980. Recharge rates are the highest in the region, exceeding 0.15 inches per year (which, for an aquifer with specific yield of 15% or so, means an accretion of one inch of storage each year).

Area 4. This is by far the largest of the six resources which are shown in Figure 2-1 and, because the overlying land is hilly, there is minimal potential irrigation demand.

Much of the prime aquifer area is within a single ownership and/or is outside the current boundaries of any underground water district. Recharge rates are high, in excess of 0.15 inches per year. However, depth to water is locally greater than in most of the High Plains, with substantial areas where the 1980 water table is greater than 300 feet. High-chloride water is found near the southernmost edge of the area.

Area 5. Most features are similar to area 4. However, as reported to LWA by the City of Pampa, a significant portion of this resource has experienced a salt-water pollution problem. This area also is relatively distant from the CRMWA aqueduct system.

Area 6. This area is relatively distant from the CRMWA aqueduct system. While rates of water use are moderate, zones of high chloride are found in the general area.

Areas 3 and 4 have the most favorable characteristics under the specified criteria. Area 4 is by far the largest resource, is little used, and is not excessively distant from the CRMWA aqueduct. It represents a primary resource which CRMWA might consider utilizing for a large scale, baseload water supply. The western part of area 3 contains a little used resource which, while smaller than that in area 4, is along the CRMWA aqueduct and has the same ownership as the large parcel in Area 4. It has the potential to be developed as a supplemental source for use in the short term, or during periods of peak demand and/or shortage.

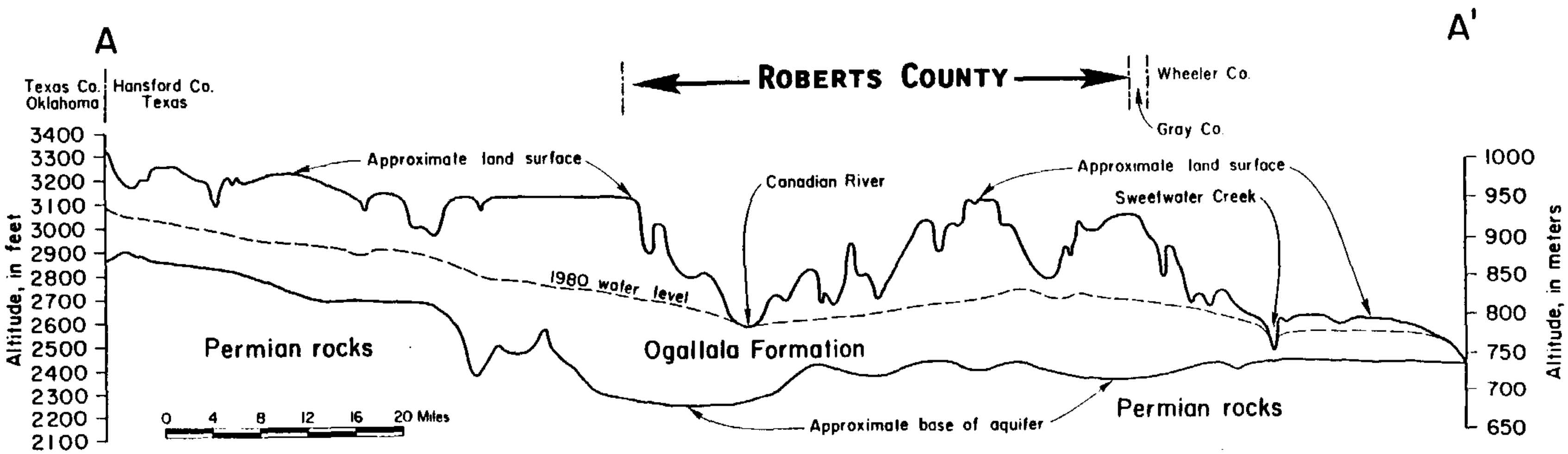
Areas 3 and 4 were deemed suitable for studies which provide a preliminary assessment of feasibility of hypothetical ground-water development projects.

2.5 Hypothetical Project Area In Roberts County

The location denoted by a rectangle on Figure 2-1 is located primarily in Roberts County, with the westernmost portion being in Hutchinson County. One reason for selecting this particular location is that the entire acreage is within the exterior boundaries of a large area in which all water rights are owned by Southwestern Public Service Company (SPS). Within that area, it is both the closest to Lake Meredith and among the best sites in terms of having a large saturated thickness.

Figure 2-2 is a cross-section passing near this location, after Figures 21 and 22 of Knowles et al. (1984). The hilly nature of the land surface in this part of Roberts County, the erosional contact of the Ogallala with the underlying Permian rocks and the relatively large saturated thickness of the Ogallala are all apparent.

Figure 2-3 is a closer-view map of the location. The specific area shown for a hypothetical project is about 48 square miles, centered about 15 miles north of Pampa. It consists of Sections 104-108, 123-127, 130-134, 149-153, 156-160, 175-179, 182-186, 201-205, 209-212 and 227-230 of the I. & G. N. R. R. Survey, Block 2.



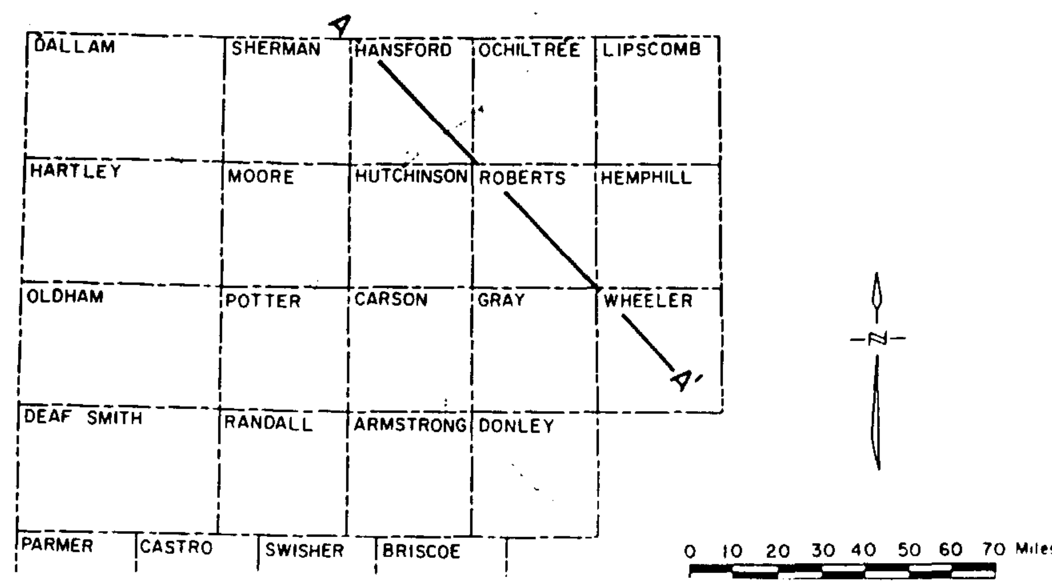


FIGURE 2-2
GEOLOGIC CROSS SECTION THROUGH ROBERTS COUNTY

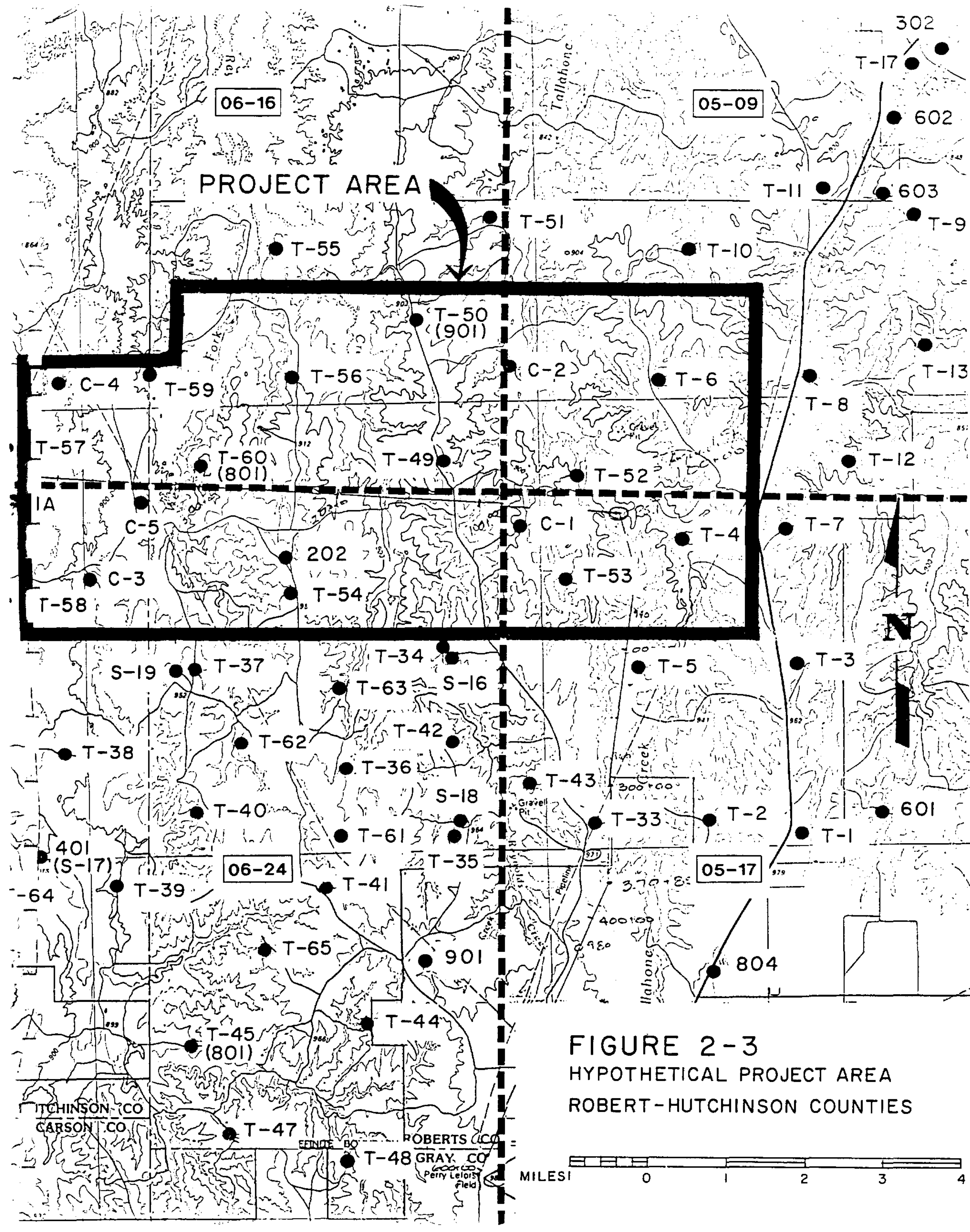


FIGURE 2-3
HYPOTHETICAL PROJECT AREA
ROBERT-HUTCHINSON COUNTIES

Information on study area. CRMWA has indicated to SPS its desire to analyze a hypothetical project for the area shown in Figure 2-3. In response, SPS was extremely cooperative in providing access to an extensive data base in its files. Information obtained from SPS included the following:

- An undated report by W.G. McDonald on the results of the drilling of the first 48 test wells by SPS.
- A 1977 report by A. Wayne Wyatt and Associates evaluating the SPS water rights based on the results of all 70 test wells drilled; the accompanying maps are based on USGS 7 minute topographic maps and show the elevation of the water table in 1977, the elevation of the base of the Ogallala Formation and the saturated thickness of the Ogallala in 1977.
- Maps not part of the above report; one map shows the areas where SPS owns the water rights in Carson-Gray-Hutchinson-Roberts counties and Carson-Potter counties; the second map shows the location (in sections and survey blocks) of the test wells, oil and gas wells and wells where water samples were collected.
- A list of the test wells, their locations in sections and survey blocks and the surface landowner.
- A list of test wells T-49 through T-60 and Campbell 1 through 5; the date drilled, the drill site elevation, the elevation of the "red beds" that mark the base of the Ogallala, the elevation of the water table, the gross saturated thickness and the well location are provided. A map accompanies the list.
- Water-level measurements in 4 wells in 1976 and 5 wells in 1977 and 1978.
- Graphs of water-level measurements in 4 wells from 1976 through 1991, 1 well from 1977 through 1991 and 3 wells from 1987 through 1991.
- Driller's logs of test holes T-1 through T-65.

- Electrical logs for 6 test holes - T-6, T-18, T-45, T-49, T-50 and T-60. (Additional logs are available in SPS files.)

- Data for aquifer tests conducted on 4 wells - T-18, T-45, T-50 and T-60; well records filed with the Texas Water Development Board for the wells accompany the test data.

- Water-quality data for 11 windmill wells sampled in 1973, for 34 wells sampled in 1975 and 5 wells sampled in 1976.

Knowles et al. (1984) includes detailed county-level data. Volume 2 of the Knowles report covers the northern third of the Texas High Plains. For each county, a table of well records, a map showing the locations of the control wells, a map of the elevation of the base of the High Plains Aquifer, a map of winter 1979-1980 water levels in the High Plains Aquifer and a map of the 1980 saturated thickness in the High Plains Aquifer are provided. SPS data are prominent among the records relied upon by the state for its interpretations in Roberts and other counties. However, it should be noted that seven SPS test wells within the hypothetical project area, and four nearby, apparently are neither listed in the "Records of Wells" nor plotted on any of the maps in Volume 2 of Knowles et al. (1984).

The Texas Water Development Board (TWDB) generously provided retrievals from its databases of water level measurements and water quality analyses for the area near the hypothetical project. These data provide an update of the earlier reports.

The Panhandle Groundwater Conservation District No. 3 provided water-level measurements, copies of well records filed with the Texas Water Development Board and analyses of 10 water samples collected between 1987 and 1992. The water-level measurements are duplicates of the TWDB retrievals. The well records are for "plotted" wells, that is, wells whose locations are given by the driller, but have not been field-checked. Locations for most of the wells sampled for water quality analyses were not available.

Saturated thickness. Figure 2-4 is a copy of that portion of the SPS saturated thickness map which covers the area shown in Figure 2-3. Hypothetical well locations shown on the map are discussed subsequently. Based on the Wyatt and Associates interpretation provided by SPS, 1977 Ogallala saturated thickness in the hypothetical project area varied from 245 to 615 feet. The average value was on the order of 390 feet. It should be noted that the Wyatt and Associates interpretations are based solely on the SPS test wells; data then available in the files of the TWDB were too limited to provide much assistance.

Volume 2 of Knowles et al. (1984) includes maps of the saturated thickness of the High Plains Aquifer in Roberts and Hutchinson counties in the winter of 1979-1980. These maps relied in significant part upon the SPS data base, but also made use of TWDB file data and new data gathered for the report. For many of the SPS test wells, the state report indicates a shallower depth of the base of the High Plains Aquifer and, consequently, a smaller value of saturated thickness. To give just one (relatively extreme) example, elevation of the base of the Ogallala in well T-49 was picked by Wyatt and Associates at 2200 feet; Knowles et al. (1984) indicate an elevation of 2446 feet for the base of the High Plains Aquifer in the same well.

Conversations with two of the TWDB report authors, Tommy Knowles and Phil Nordstrom, provide several possible explanations for the differences. There are collapse features in the Permian strata underlying the Ogallala in Roberts County which result in thicker Ogallala sections in local areas. Because the state-prepared maps were used to create input files for a regional-scale computer model, such local features were deliberately ignored. In addition, in wells in which the lower part of the Ogallala section did not contain the sands characteristic of a good aquifer, TWDB sometimes would pick the base of the High Plains Aquifer above the base of the Ogallala. The "Records of Wells" tables were not intended to be all-inclusive; if the desired level of information was available for the area of a model cell, some wells in that area would not be included. The maps indicate that "not all data points are presented which were used in contouring." Despite these factors, the same area shown in Figure 2-4

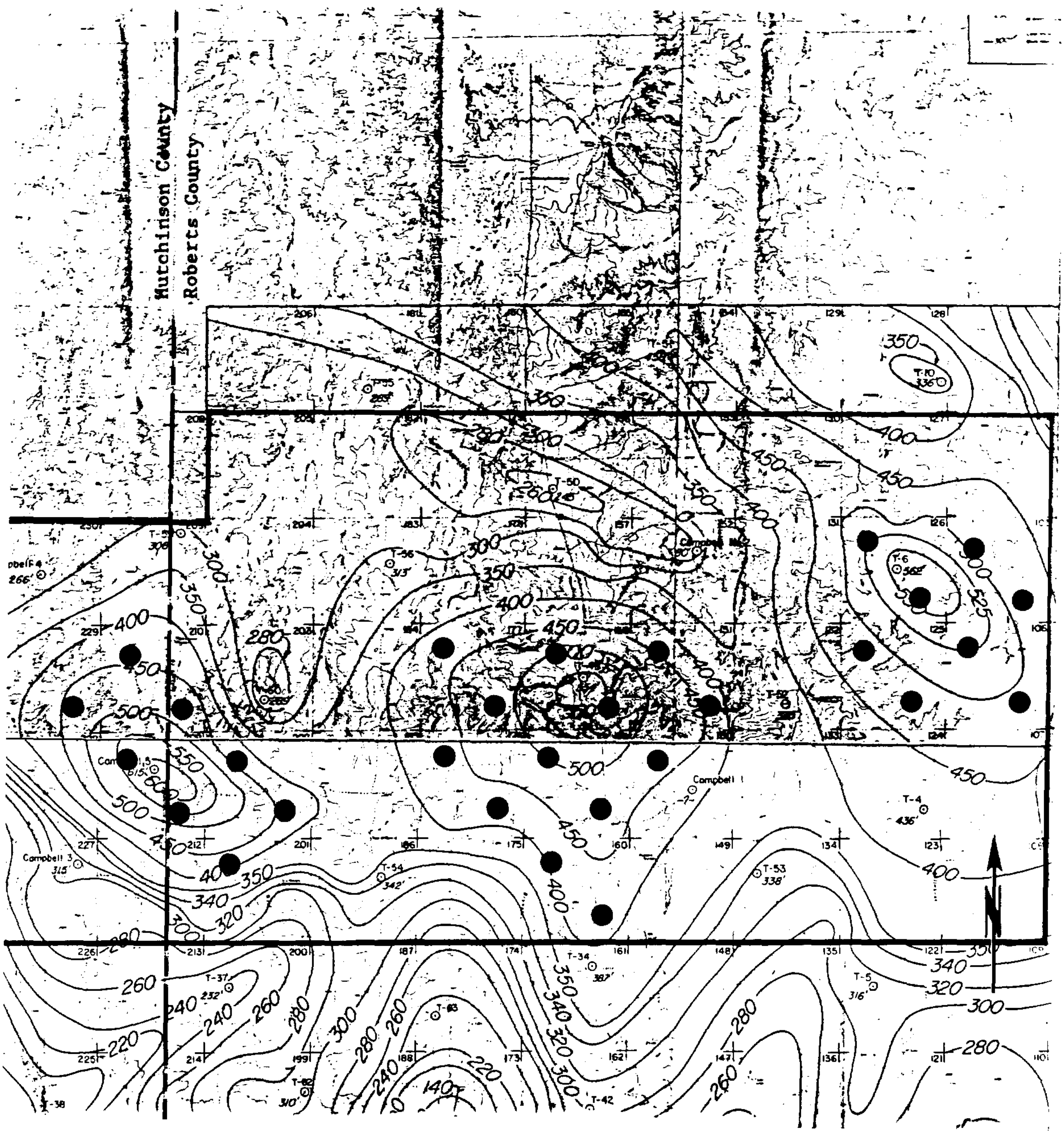


FIGURE 2-4

SATURATED THICKNESS OF THE OGALLALA IN THE PROJECT AREA, 1977, AS MAPPED BY WYATT AND ASSOCIATES

0 1 Mile

is mapped by the state as having substantial saturated thickness - typically 220 to 440 feet.

For this report, the saturated thickness as contoured by Wyatt and Associates has been used. However, it would be appropriate to examine the differences with the TWDB in detail if the project progresses from the conceptual to the design stage.

The computer model projections for the High Plains Aquifer (Figure 2-1) show over 300 feet of saturated thickness remaining beneath the project area in 2030, and little net change from current conditions. There are indications that the actual pumping in Roberts County has been less than projected in the model. Net withdrawals for the model area approximating all of Roberts County were projected to be 9590 acre-feet (AF) in 1990 (Knowles et al., Table 20). The detailed irrigation survey for Roberts County made by the Soil Conservation Service and the Texas Water Development Board estimated a withdrawal of 4243 AF in 1989 for agricultural use (Tuck, 1992); agriculture is by far the major use of Roberts County water.

As noted above, the SPS data suggest a greater saturated thickness than recognized by the state. Combined with the possibility that future pumping will be less than utilized in the state's computer model, the future saturated thickness shown in Figure 2-1 may be conservative.

Water in storage. Figure 2-4 was used to estimate that in 1977, roughly 1.3 million acre-feet of recoverable water underlay the hypothetical project area, assuming a specific yield of 14% for the entire saturated thickness and 80% recovery of the in-place volume of water. Water-level monitoring data, to be discussed subsequently, show no significant decline in the project area since 1977, indicating that this estimate of water in storage should be representative of the current condition.

Figure 36 of Knowles et al. (1984) shows the areal distribution of specific yield in the High Plains Aquifer, based on analyses of cores from 41 TWDB test holes and surface electrical resistivity surveys. Specific yield in the project area is shown to be generally more than 12 but less than 16 per cent. The average specific yield of the High Plains Aquifer in TWDB test hole 05-09-602 core was 14%; this test hole is about 3 miles northeast of the project area.

Water table; depth to water. The winter 1979-1980 water-level map in Volume 2 of Knowles et al. (1984) shows the 2800 foot contour running east to west through the middle of the hypothetical project area. The map is generally consistent with the more local map obtained from SPS. The water table slopes northeast to north at a maximum gradient of about 15 feet per mile. The SPS map, however, includes two closed depressions in the water table, roughly centered on Campbell wells #2 and #4 ("C-2" and "C-4" on Figure 2-3). These wells apparently were not included in the TWDB analysis.

The land surface within the project area has been deeply dissected by Reynolds Creek, which flows north, and Tallahone Creek and its tributaries, which flow north or northwest. The average gradient along Reynolds Creek in the project area is about 24 ft/mile; other stream gradients appear at least as steep. Thus, depth to water will tend to be greatest in the uplands in the southern part of the project area and smallest in the drainage in the northern parts of the project area.

TWDB maintains a network of monitoring wells in the High Plains Aquifer. Data were provided to Lee Wilson and Associates (LWA) by TWDB for those wells in the vicinity of the project area. Those data show little change in water levels since winter 1979-1980 in the general area of the project.

Of the six TWDB monitoring wells nearest the hypothetical project area, only 05-17-804 has experienced a significant decline in water level. Well 05-17-804 is to the south of the project area, on the mesa where large-scale irrigated agriculture is possible. The monitoring data from these six wells are summarized below.

Well	Depth to water/Date	Depth to water/Date	Decline, ft./yr.
05-09-603	181.3 / 2-15-80	185.6 / 11-08-91	0.37
05-17-804	396.7 / 2-19-80	415.4 / 11-09-91	1.59
06-16-801(T-60)	212.2 / 1-02-80	214 / 11-08-91	0.15
06-16-901(T-50)	218.8 / 1-02-80	221.5 / 11-08-91	0.23
06-24-202	295.9 / 2-19-80	302.2 / 11-08-91	0.54
06-24-401	6.3 / 11-17-79	6.4 / 1-02-91	0.01

Figure 2-5 shows the record of water-level measurements in well 06-16-901, one of three monitoring wells which falls within the project area.

Well yield and specific capacity. Ogallala wells, in general, are good producers; Knowles, et al. (1984) describe the Ogallala over the Texas High Plains as yielding "moderate to large amounts of water to wells", with "yields of some wells in excess of 1000 gal/min."

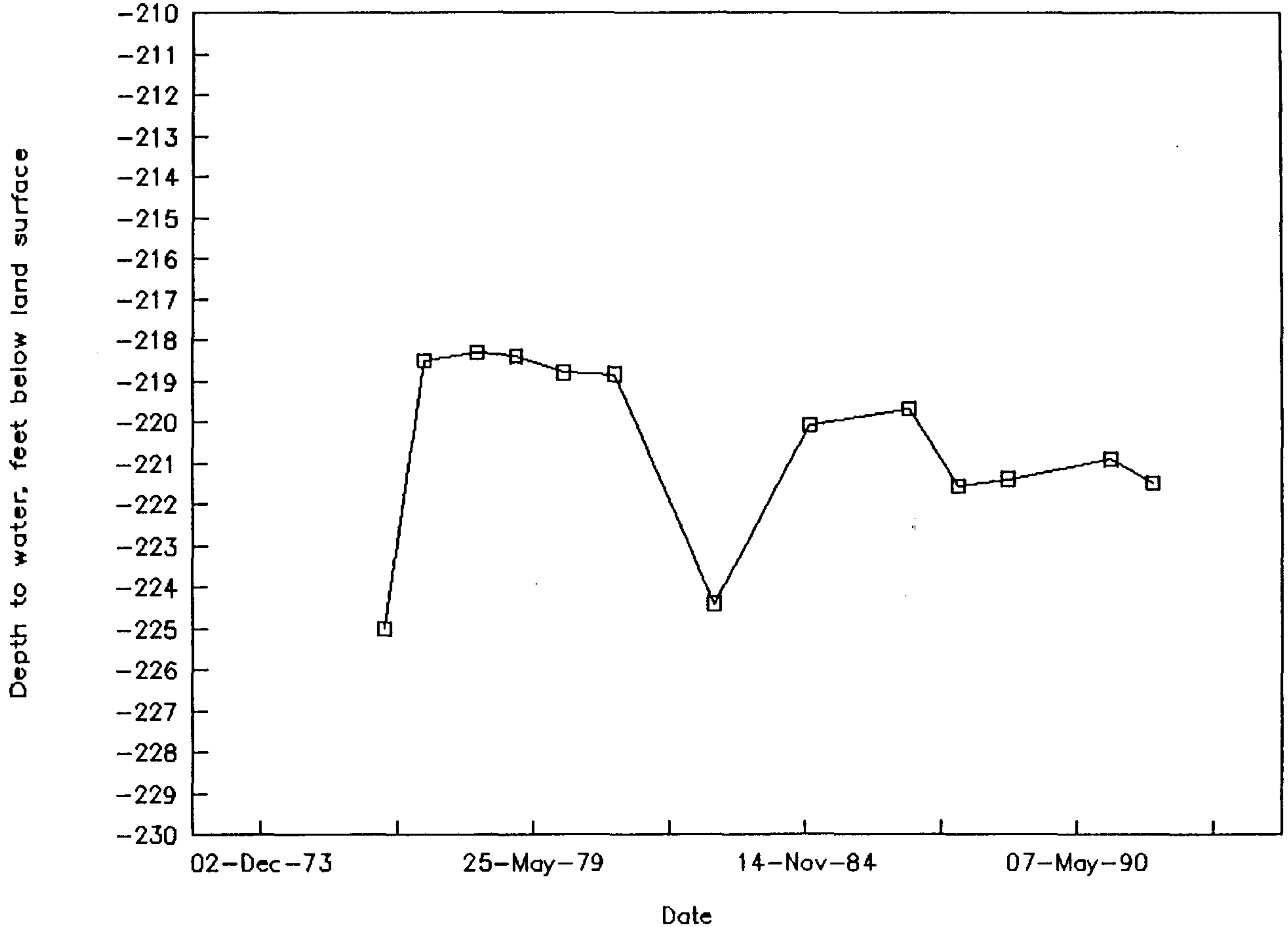
Four well tests are reported in Volume 2 of Knowles et al. (1984) for the vicinity of the hypothetical project area; SPS provided detailed information for three of these well tests, and for one additional well test (06-24-801, T-45) not reported in Knowles et al. (1984). TWDB well records provided by Panhandle Groundwater Conservation District No. 3 generally were for small-diameter wells; however, tests for three additional large-diameter wells in the project vicinity were identified.

The data from the tests of these wells are summarized below.

Well	Production rate, gpm	Specific capacity, gpm/ft. drawdown	Yield, gpm, per 100 ft. sat. thk.	Specific capacity per 100 ft. sat. thk.
05-10-4A (T-18)	2050	34	403	6.6
06-16-801 (T-60)	1200	15	446	5.7
06-16-901 (T-50)	1550	17	632	7.0
06-24-1A	680	16	178	3.5
06-24-801 (T-45)	1500	19	704	8.8
06-24-9	1000	17	448	7.5
06-24-9A	1000	50	248	12.4
06-24-9B	1000	50	244	12.2

Figure 2-5

Water levels in well 06-16-901



Only wells 06-16-801 (T-60) and 06-16-901 (T-50) are within the project area. Well 06-24-1A is just west of the project area; 05-10-4A (T-18) is about 4 miles northeast of the project area, outside the area of Figure 2-3; well 06-24-801 (T-45) is about 6 miles south of the project area; and wells 06-24-9, 9A, 9B are about 6 miles south of the project area. Wells 06-24-9, 9A and 9B are located in the NW , SE and SW , respectively, of Section 169, I. G.& N. R. R. Survey, Block 2; because no better locations are available, wells 06-24-9, 9A and 9B have not been spotted on Figure 2-3. Section 169 is about 2 miles east of 06-24-801.

The only well which produced less than 1000 gpm was 06-24-1A; no casing diameter or perforated interval for this well were reported in Knowles et al. (1984), so it cannot be determined if the lower productivity is due to aquifer or well properties. Given the relatively small fraction that most of the test drawdowns are of the drawdowns that could be sustained during maximum production, a yield of 1200 gpm per well for planning purposes seems conservative.

The detailed test information provided by SPS for the four wells was reviewed by LWA. The tests were step-drawdown tests, which can be used to gain some idea of the efficiency of a well completion. Only one well, 06-24-801 (T-45), provided test data of adequate quality to permit even this type of analysis. Analysis by the technique detailed in Driscoll (1986, pp. 555-559) indicated that at a production rate of 1500 gpm, 71% of the head loss in the aquifer and well could be attributed to laminar flow, 29% to turbulent flow. Since the turbulent flow losses can be presumed to be primarily in the well and a significant portion of the laminar losses are likely to be the result of formation damage during drilling and completion, the efficiency of the well is not very good. This result confirms that well completions should use well screen and gravel packs, rather than the slotted pipe used in this well, for efficient production at high rates.

A core from the TWDB stratigraphic test well, 05-09-602 (about 3 miles northeast of the project area), had an average permeability of 72 gpd/ft^2 in the High Plains Aquifer. Saturated thickness in the High Plains Aquifer in the well was 348 feet, giving a transmissivity of 25,056 gpd/ft. A rough calculation made by LWA, using the value of "B" derived from the analysis of the well 06-24-801 (T-45) test described above and the Thiem equation with an assumed effective radius of 500 feet, indicates a somewhat higher transmissivity at the well T-45 location.

Water quality data. SPS provided analyses of 47 water samples collected between 1973 and 1976. The samples generally were not collected from the SPS test holes, but rather from local wells. They are identified only by sample numbers; the locations of 36 of the sampled wells are spotted on an accompanying map. Ten of the located samples are within the project area.

The samples were analyzed for only a small number of parameters, but the quality in the project area appears quite good. The water is moderately hard, with total hardness ranging from 154 to 196 ppm. The highest nitrate value was 22.7 ppm (as nitrate) in sample S-37, collected at well T-60. The next highest nitrate value was 12 ppm. Sulfate ranged from 5.5 to 17 ppm, with an average value of 13 ppm and a median value of 14.3 ppm. Chloride ranged from 10 to 22 ppm, with an average value of 15.5 ppm and a median value of 16 ppm.

Somewhat poorer-quality water is indicated in some of the samples collected to the south of the project area and in two samples collected to the northeast of the project area, as summarized below.

Sample	Location	Sulfate ppm	Chloride ppm
S-12	Sec 5, H&GN, Blk B	34	346
S-16	Sec 161, I&GN, Blk 2	34.5	56
S-17	Sec 224, I&GN, Blk 2	45	74
S-18	Sec 163, I&GN, Blk 2	27	72
S-19	Sec 200, I&GN, Blk 2	17.5	28
T-18	Sec 5, EL&RR	25	85

There are samples of better-quality water interspersed with these samples, so it is not clear whether they represent ambient ground water quality or localized pollution. S-16 and S-18 are within one-half mile of the south boundary of the project area.

Figures 38 and 39 of Knowles et al. (1984) provide generalized water quality maps for the High Plains Aquifer. Figure 38 shows water in the hypothetical project area to be below 400 mg/l TDS. Figure 39 shows water in the project area to contain less than 50 mg/l chloride. However, both figures show a large area of poorer-quality water trending northeast across eastern Carson, northern Gray and southern Roberts counties, and passing within a few miles of the southeast corner of the project area.

The maps indicate that samples were collected from 5 wells in the project area and its immediate vicinity, but no reports of the analyses are included in Volume 2. Note that data from wells showing "abnormally high constituent levels" were excluded (as representing contamination) in the Knowles et al. (1984) mapping.

The Texas Water Development Board has occasionally collected water samples from Ogallala wells since the publication of Knowles et al. (1984). The most recent data available for Roberts County are for samples collected in September of 1991 from 15 wells; the samples were analyzed by a Texas Department of Health laboratory. Selected data for the four wells closest to the hypothetical project area are summarized below. Figure 2-3 shows the locations of three of these wells. Well 05-18-101 is to the east of the project area off the map.

Well	Total dissolved solids, mg/l	Chloride mg/l	Sulfate mg/l	Nitrate (as N), mg/l	Fluoride mg/l
05-09-302	198	5	8	0.42	0.7
05-17-601	267	12	19	1.40	0.9
05-18-101	325	8	10	1.09	0.8
06-24-901	263	9	11	1.80	0.8

Analyses for other general chemical parameters, metals and radioactivity also were made. No exceedances of current Safe Drinking Water Act primary or secondary standards are noted. However, no analyses for organic chemicals were made, and the detection limits of the cadmium and lead analyses are above the current standards.

The available data suggest that good quality water will be produced from the project area, at least initially. But sampling is required from a well within the project area for the full suite of Safe Drinking Water Act parameters. And a careful analysis of the possible movement of the poorer-quality water nearby into project wells under long term, high rate pumping must be made.

2.6 Hypothetical Project Area in Carson County

SPS also controls some water-rights acreage in northwestern Carson County, extending into Potter County. While the total quantity of water controlled by SPS is much less than in Roberts County, the location is very near the main CRMWA aqueduct, and many other attributes of the resource are potentially favorable to development. Therefore, this area also was considered for a hypothetical project. It should be noted that the entire Carson-Potter acreage is within the boundaries of Panhandle Ground Water Conservation District No. 3, so that there may be additional institutional constraints compared to the Roberts County acreage.

Figure 2-6 is a closer-view map of the location. The specific area shown for a hypothetical project is the entire acreage controlled by SPS, about 15 square miles, centered about 15 miles south of Fritch. It consists of Sections 1, 2, 3, parts of 4 and 5, 6, 10, 11, 12, 15 and part of 18 of the S. K. & K. Survey, Block 1; part of Section 49 and Section 50 of the B. S. & F. Survey, Block 1; Sections 1 and 2 of the B. & B. Survey; Section 1 of the B. S. & F. Survey; and Section 9 and parts of Sections 10 and 11 of the A. B. & M. Survey, Block T. An area not controlled by SPS lies west of the central part of the SPS property; the area appears to have water conditions comparable to the SPS acreage and could be a good addition to a hypothetical project.

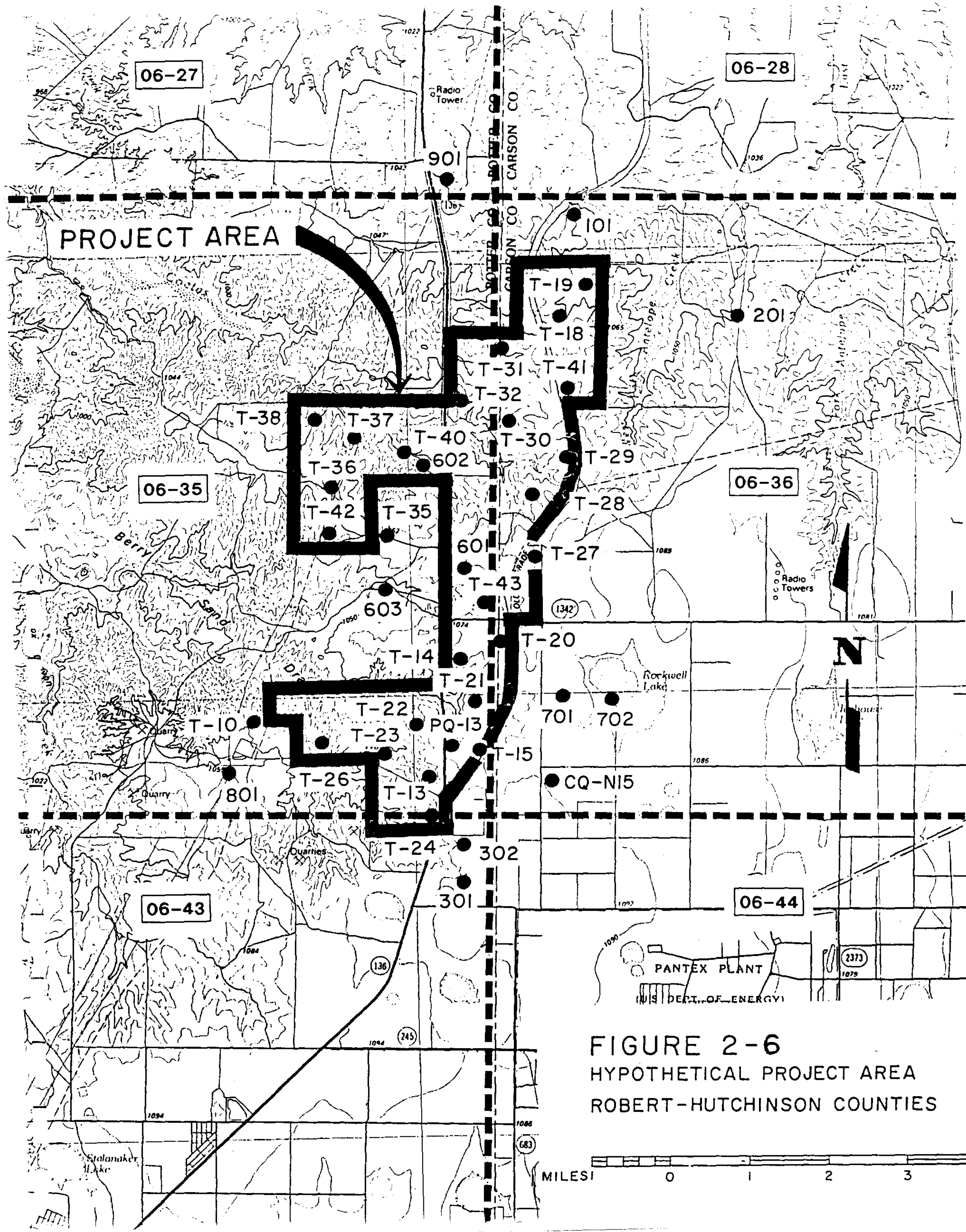


FIGURE 2-6
HYPOTHETICAL PROJECT AREA
ROBERT-HUTCHINSON COUNTIES

Information on this area provided by SPS is much less extensive than for Roberts County, and consists of maps showing the elevation of the water table in 1977, the elevation of the base of the Ogallala Formation and the saturated thickness of the Ogallala in 1977; the well record and a pump test on one well; analyses of four water quality samples; and graphs of water levels in 4 monitoring wells in the Carson-Potter water rights area. Of course, some additional data are available from Knowles et al. (1984). Note that the Panhandle Ground Water Conservation District No. 3 prepared the parts of the detailed maps in Volume 2 of Knowles et al. (1984) that were within the District boundaries. The SPS maps show 36 test wells drilled by SPS in the project area and immediately to the south. Only 10 SPS wells are listed in Volume 2 of Knowles et al. (1984).

Specific yield; saturated thickness; water in storage. Figure 36 of Knowles et al. (1984) shows the areal distribution of specific yield in the High Plains Aquifer, based on analyses of cores from TWDB test holes and surface electrical resistivity surveys. Specific yield in the project area is shown to be generally more than 16 but less than 20 per cent. The average specific yield of the High Plains Aquifer in TWDB test hole 06-35-601 core was 18%; this test hole is in the central part of the project area.

The map of 1977 Ogallala saturated thickness in the project area provided by SPS shows a range from 162 feet in well T-24 to 383 feet in well T-37. Figure 2-7 is a reproduction of the SPS map. The Knowles et al. (1984) map of winter 1979-80 saturated thickness of the High Plains Aquifer shows a range of from about 120 to 380 feet in the project area. A comparison by LWA of the base of the Ogallala as picked by SPS and by Panhandle Ground Water Conservation District No. 3 generally showed very small differences.

Figure 2-7 was used to estimate that in 1977, roughly 440,000 acre-feet of recoverable water underlay the hypothetical project area, assuming a specific yield of 18% for the entire saturated thickness and 80% recovery of the in-place volume of water. Water-level monitoring data, to be discussed subsequently, show relatively small declines within the project area itself since 1977, though there

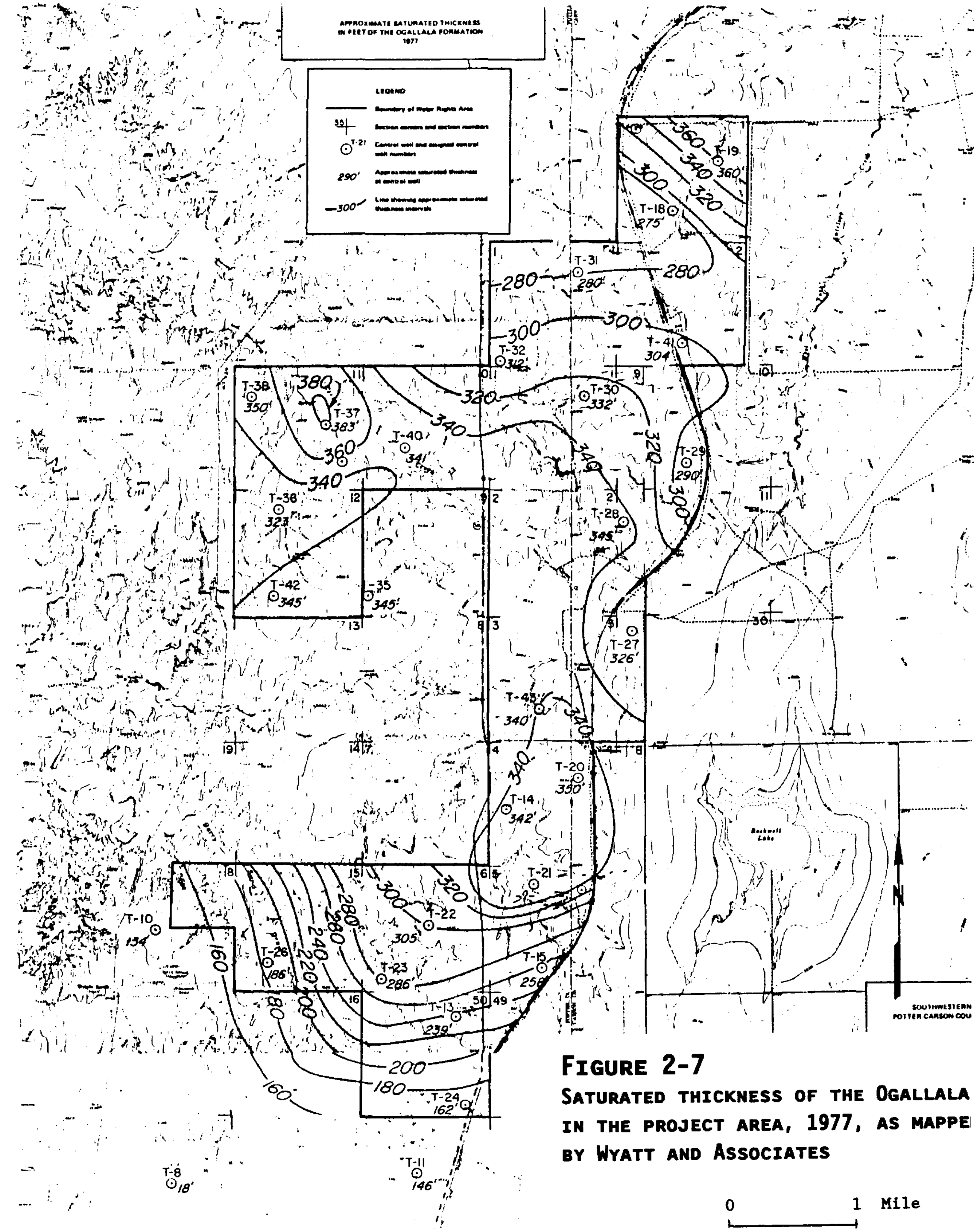


FIGURE 2-7

SATURATED THICKNESS OF THE OGALLALA IN THE PROJECT AREA, 1977, AS MAPPE BY WYATT AND ASSOCIATES

are somewhat larger declines in some wells nearby. Therefore this estimate of the volume of water in storage still should be approximately correct.

Water levels. The graphs SPS furnished of water levels in four wells in the project area provide only a limited period of record, ending in 1991. Graphs for 3 of the wells include 4 years of data; water level declines were about 3 feet over this time period in two wells, and about 7 feet in the third. There are 14 years of record for Stinnett #1; water levels have declined about 12 feet in this time period.

The TWDB also furnished water-level monitoring data for the vicinity of the project. Much larger declines in water levels during the period 1979 to 1992 are apparent in the Carson-Potter project vicinity, compared to the Roberts project vicinity. Data from the ten wells closest to the project are summarized below.

Well	Depth to water/Date	Depth to water/Date	Change, ft./yr.
06-27-901	240.5 / 3-13-81	244.9 / 12-14-91	-0.41
06-35-602	302.0 / 3-13-81	318.4 / 2-11-92	-1.50
06-35-603	192.5 / 12-04-80	272.0 / 12-04-91	-7.23
06-35-801	94.7 / 12-04-80	141.3 / 1-09-92	-3.85
06-36-101	287.8 / 3-31-81	308.7 / 1-09-92	-1.93
06-36-201	335.8 / 12-07-79	347.3 / 1-09-92	-0.95
06-36-701	472.0 / 1979	484.0 / 1989	-1.2
06-36-702	465.0 / 1979	424.0 / 8-11-89	+4.1
06-43-301	445.9 / 1-05-80	483.3 / 2-11-92	-3.09
06-43-302	445.5 / 1-05-80	491.5 / 1-09-92	-3.84

The average change in these ten wells is a decline of about 2 feet/year.

These data suggest that water levels within the project area and its immediate vicinity are declining at a somewhat faster rate than those in the hypothetical project area in Roberts County. This is due to the closer proximity of the Carson-Potter project area to high-capacity irrigation and public supply wells. As Figure 2-1 shows, however, 200 to 300 feet of saturated thickness are projected to remain in some of the Carson-Potter project area in the year 2030.

Well yields; aquifer permeability. Data from a step-drawdown test on well T-26, cased with 16-inch casing, were furnished by SPS. The test was of insufficient quality to permit any analysis. The well yielded as much as 1320 gpm, though the drawdown at this flow rate was not reported. Flow rates with reliable recorded drawdowns varied from 600 to 1010 gpm, with specific capacities ranging from 17 to 20 gpm per foot of drawdown. The longest pumping period was 16 hours at a rate of 800 gpm; the specific capacity at this rate was 17 gpm/ft. The saturated Ogallala section in this well is recorded as 186 feet on the map provided by SPS, so the well yield per 100 feet of saturated thickness and specific capacity per 100 feet of saturated thickness are comparable to the Roberts County area.

Panhandle Ground Water Conservation District No. 3 provided flow test information for 7 wells in Carson County. Flow rates ranged from 335 to 735 gpm. Pump diameters were 8-inches in the three wells for which this information was available, so it is likely that larger-diameter wells could be pumped at higher rates.

There are no records of well tests in Carson County or Potter County in Knowles et al. (1984). Core from the TWDB stratigraphic test well, 06-35-601, had an average permeability of 165 gpd/ft^2. Multiplied by the 345 foot saturated thickness, the transmissivity of the Ogallala at the well location is about 57,000 gpd/ft. Since this is a much higher permeability than was averaged in core from the TWDB stratigraphic test well near the Roberts-Hutchinson project area, it seems reasonable to assume that well yields in the Carson-Potter project area will be 800 to 1200 gpm.

Water quality. SPS furnished analyses of samples collected from three windmills within the project area and T-26 in 1976. Nitrates ranged from 4 to 12 ppm (as NO_3); total hardness ranged from 132 to 184 ppm; sulfate ranged from 7 to 19 ppm; and chloride ranged from 4 to 20 ppm.

Panhandle Ground Water Conservation District No. 3 provided analyses of samples collected from 2 wells in Potter County and 6 wells in Carson County over the time period 1987-1992. Some of the parameters were measured in the field, so that the accuracy with which they were determined may not be as high as laboratory tests. Two of the wells are in or quite near the project area; data from these two wells are summarized below.

Well	CQ-N15	PQ-13
Location	Sec. 15, A.B.& M., Blk. T	Sec. 5, S. K. & K., Blk. 1
Date	8/10/92	9/04/90 - 7/22/92
No. of Samples	2	3
Iron, mg/l	0.00	0.00 -0.15
Ammonia, mg/l	0.25 -0.54	0.10 -0.23
Sulfate, mg/l	16 - 30	10 - 24
Chloride, mg/l	12 - 19	10 - 23
Nitrate, as NO_3, mg/l	1.6 - 1.8	1.2 - 4.4
Fluoride, mg/l	1.2	1.2 - 1.3
Hardness, mg/l	65-204	196-233
TDS, mg/l	240-246	211-240

Figures 38 and 39 of Knowles et al. (1984) show water quality in the project area to be good, with TDS less than 400 mg/l and chloride less than 50 mg/l. However, there appear to be only two sampling locations in the immediate vicinity of the project. Unlike the Roberts County project area, no poorer-quality water is mapped nearby.

TWDB provided analyses of samples collected in 1990 and 1991 from 8 wells in the general vicinity of the project in Potter and Carson Counties. The samples were analyzed for general chemical parameters, metals and radionuclides. No exceedances of current Safe Drinking Water Act primary or secondary standards are noted. However, no analyses for organic chemicals were made, and the detection limits for the cadmium and lead analyses are above the current standards.

With one exception, the new analyses do not change the picture presented in Figures 38 and 39 of Knowles et al. (1984). The exception is well 06-43-704, at least 5 miles southwest of the project area, which had 7.7 mg/l nitrate (as N), 85 mg/l chloride and 87 mg/l sulfate. The high nitrate value is suggestive of pollution, so the higher chloride and sulfate values may not be representative of ambient ground water quality at this location.

The well closest to the project area sampled was 06-36-201, about 1 mile east. Chloride was 9 mg/l, fluoride 0.5 mg/l, nitrate 1.06 mg/l (as N), sulfate 15 mg/l and total dissolved solids 250 mg/l. This is consistent with other data, indicating that water quality in the project area and its immediate vicinity is very good.

2.7 Comparison of Two Hypothetical Project Areas

Both the Roberts County and the Carson County hypothetical project areas are similar in that water-rights are owned by SPS. Hydrologically, the Roberts County area has a resource which is substantially larger, both in terms of area (hundreds of square miles versus perhaps 15 square miles) and saturated thickness (nearly 400 feet versus perhaps 200-250 feet). Water level declines appear to be potentially significant in the Carson County area, but not in the Roberts County area. Water quality appears comparable at the two sites.

Our preliminary judgment, which would require detailed modeling to confirm, is that the Carson County resource would not produce at least 30,000 AFY (26.8 MGD) for a 50-year period from wells located only within the SPS property; or if such production did occur, there would be large drawdown effects on adjoining lands within the Panhandle Groundwater Conservation District No. 3. This judgment is supported by the fact that when SPS offered to sell water from the Carson County area to the City of Amarillo in 1981, only 10 MGD were to be provided. If the Carson County resource were to be utilized by CRMWA, it would be considered as a short-term or supplemental supply only, even if expanded by purchase of water rights from nearby areas.

On this basis, we have selected the Roberts County site as the hypothetical project site for purposes of a more detailed analysis.

3. COSTS OF ROBERTS COUNTY GROUND-WATER DEVELOPMENT

3.1 Description of Hypothetical Project

For purposes of a reconnaissance feasibility study, a hypothetical project would be to develop wells within the area shown on Figure 2-4, and to produce 30,000 to 45,000 AFY for 50 years. Normal operations would be as a baseload facility, i.e. the production rate would be reasonably constant for steady blending with Lake Meredith surface water. The evaluations also consider possible expansion to 65,000 AFY.

Based on the available data, it appears likely that individual wells drilled to a maximum depth of about 800 feet would yield at least 1200 gpm; at a load factor of 65%, this would be about 1250 acre-feet per year per well and thus a supply of 30,000 AFY would require a total of 24 wells. With a higher load factor and/or yield, drought-period production rates would be higher; probably at least 29 wells would be needed to produce 45,000 AFY. 65,000 AFY might require 50 wells or so.

On Figure 2-4, three well fields containing a total of 29 wells are shown: a western field of 8 wells; a central field with 13 wells; and an eastern field of 8 wells. All wells are in areas where SPS data (but not necessarily TWDB data) report a saturated thickness of at least 400 feet; well spacing with respect to other large-capacity wells is at least one-half mile. One reason for using a half-mile spacing is to provide two wells per section, which is a representative rule-of-thumb for large capacity wells tapping the Ogallala Formation. A higher density of wells probably would be practical and certainly would reduce costs. Costs also would be reduced if the numerous wells already drilled by SPS prove to be efficient, in good condition, and otherwise appropriate for municipal supply purposes.

The analyses which follow are based on hypothetical development of 24 wells in the western and central fields for a project involving 30,000 AFY, and all 29 wells for a project involving 45,000 AFY. The 65,000 AFY was not analyzed directly, as it represents an extreme condition rather than current conditions; rather various alternatives were evaluated to determine whether an expansion to 65,000 AFY would be possible if needed. Three routes are considered for bringing water from the hypothetical Roberts County area to the existing CRMWA aqueduct as indicated on Figure 3-1.

- Route 1 goes south to Pampa, then westward parallel to the existing CRMWA Borger-Pampa aqueduct until it joins the main aqueduct system. Route 1 is nearly 47 miles long.

- Route 2 goes directly overland to the main aqueduct and is about 34 miles long. Because of uncertainties over this route, cost estimates include a greater contingency allowance than estimates for Route 1.

- Route 3 goes southwest from the well field through an existing pump station along the east aqueduct between Borger and Pampa. From there, the aqueduct continues until it joins the main aqueduct at forebay 3. Route 3 is approximately 39 miles long and also includes a small 14-inch pipeline to serve the City of Borger.

All routes would require three booster stations. Under routes 1 and 2, it would be possible to serve all CRMWA cities with blended surface and ground water pumped from existing pump Station No. 2. Route 3 would serve Borger by an additional pipeline and Pampa through the existing east aqueduct. Route 1 would offer the option that Borger and Pampa would obtain ground water directly from the ground water pipeline while Route 3 would offer that option to Borger only.

Preliminary investigations indicated that either a 48-inch or 54-inch pipeline would effectively transport water in the range of 30,000 to 45,000 AFY (26.8 to 40.1 MGD). A line smaller than 48-inches would not be adequate to deliver 45,000 AFY and would provide virtually no cost savings (compared to 48-inches) for a 30,000 AFY delivery; therefore only 48-inch and 54-inch lines were considered. The 48-inch line would not allow expansion of deliveries to

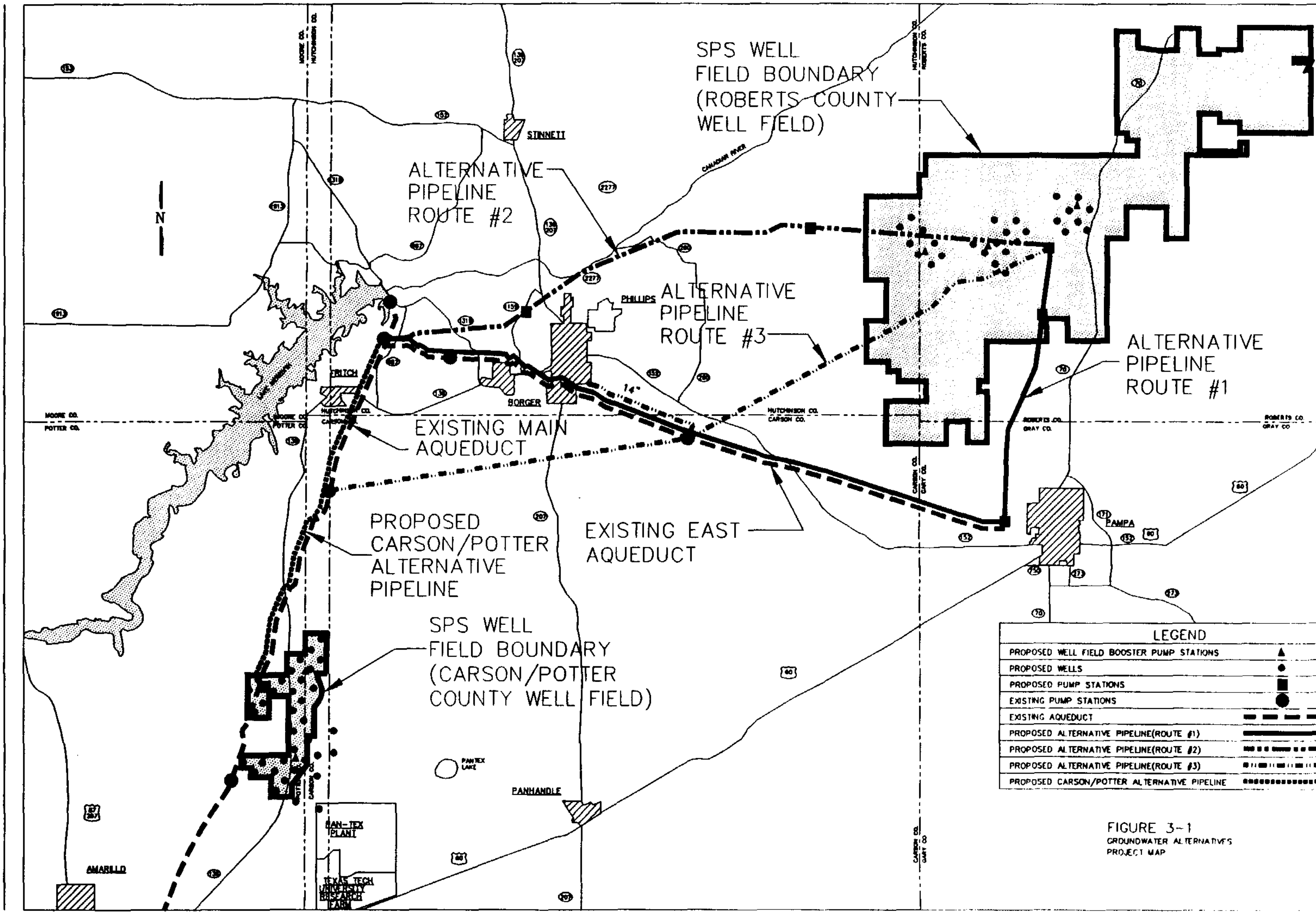


FIGURE 3-1
GROUNDWATER ALTERNATIVES
PROJECT MAP

65,000 AFY if needed to meet EPA drinking water standards, but the 54-inch line would allow such expansion.

Pumping lifts are estimated to range from 150 to 250 feet at the time of well field start-up. Based on a simple Theis analysis which ignores recharge, an average pumping rate of 30,000 AFY, and representative aquifer parameters (transmissivity = 25,000 sq-ft/day; storage coefficient = 14%), drawdown averaged over a 50-year period would be another 50 feet. For estimating purposes, an average net pumping lift of 250 feet is assumed in this report.

3.2 Capital and Operating Costs

Detailed cost estimates are provided for various combinations of routes, line sizes and project deliveries, as follows:

Alternative	Route	Line size	Delivery	Cost estimate
A	1	48-inch	30,000 AFY	Table 3-1
B	1	48-inch	45,000 AFY	Table 3-2
C	1	54-inch	30,000 AFY	Table 3-3
D	1	54-inch	45,000 AFY	Table 3-4
E	2	48-inch	30,000 AFY	Table 3-5
F	2	48-inch	45,000 AFY	Table 3-6
G	2	54-inch	30,000 AFY	Table 3-7
H	2	54-inch	45,000 AFY	Table 3-8
I	3	54-inch	30,000 AFY	Table 3-9
J	3	54-inch	45,000 AFY	Table 3-10

These cost tables can be found in the Appendix A.

In each table, there is a relatively detailed estimate of capital costs which includes wells, wellfield piping, the main pipeline, booster stations, and ancillary facilities. Capital costs range from roughly $51 million (alternative E) to $62 million (alternatives D and J). Costs are greater for alternatives which use the longest route 1, the larger pipe, and the larger number of wells (larger delivery amount). However, for a given route, the largest project requires only a bit more than 15% extra investment compared to the smallest project.

Each table also provides an estimate of operation and maintenance costs (mostly for pumping energy). Initial costs range from about $1.6 million/year (alternative G) to $3.4 million/year (alternative J); these costs would increase over time with inflation. Costs depend mostly on the delivery amount (30,000 or 45,000 AFY). Energy and O&M costs are greater for alternatives which use the longest route 1, but are actually less (for a given amount of water) in the 54-inch line compared to the 48-inch line because of reduced energy loss resulting from pipe friction.

The tables do not include a cost for purchase of water rights, which must be considered. However, the cost of water is assumed to be the same for all alternatives. Estimating a water rights price is difficult, given that negotiations with the owner have not begun. Several cities in the region have purchased and/or have been offered water rights at a cost of $125 to $150/acre. If this cost were applied to the hypothetical project area, the cost to CRMWA might be $4 to 5 million, or roughly $12.50 per acre-foot, which would be reasonable.

The large size of the Roberts County resource, and institutional considerations (single owner, outside a District) might justify a slightly higher price, if water quality proves to be as good as suggested by the limited available data. In addition, consideration needs to be given to possible institutional or transaction costs not captured elsewhere in the analysis, such as those for a possible wellhead protection program and/or monitoring program. In the analyses given here, a value of $25 per acre-foot is used to cover the $12.50 payment to SPS (plus possibly a small premium) and other potential costs which relate to the water resource itself.

Table 3-11 summarizes costs for the ten alternatives, including capital cost and initial annual cost.

Other than costs, some additional items must be considered when determining the optimum pipeline. They include future growth and tightening regulations. Therefore, the following assumptions have been made:

- There is only a small extra capital cost (for additional wells) between the 30,000 AFY and 45,000 AFY project sizes. Subsequent discussions assume a project sized to provide 45,000 AFY, but with actual deliveries in the range 30,000 to 45,000 AFY as needed to meet demands and blending requirements. As delivery rates increase, unit costs of water will decrease significantly.

- The higher capital costs of a 54-inch line are offset by reduced energy costs. Given that there is no cost penalty, it clearly is advantageous for CRMWA to construct the 54-inch line, because that would allow eventual project expansion (to 65,000 AFY if necessary), simply by adding more wells and pumping facilities. Subsequent discussions assume construction of a 54-inch line.

Considering the previously stated assumptions (45,000 AFY production capacity and 54-inch pipeline), an optimum route to serve the needs of the member cities must be determined based on costs to the consumer and accessibility of construction and operation. The following discussion will address these points.

Routes 1 and 2 enter the aqueduct at the same location; therefore, providing the same level of service to consumers. However, due to reduced length and pumping requirements, route 2 is less expensive both to construct and operate than route 1. Route 2 costs include a conservative amount for contingencies due to the location of its route. However, even with these contingencies, route 2 is considerably less expensive than route 1, and therefore, subsequent discussions will include an analysis of only routes 2 and 3.

Route 3 enters the main aqueduct at pumping station number 3 while route 2 enters the aqueduct at pumping station 2. Although route 3 has a higher capital cost and a higher pumping cost than route 2, a savings is incurred by entering the main aqueduct at pumping station number 3. This savings is due to reduced pumping energy along the main aqueduct by not pumping additional groundwater through pumping station number 2. Additionally, the same contingencies have been assumed for both routes 2 and 3. However, route 3 does not pass through any large oil fields or over rugged terrain as does route 2, and therefore, the actual cost of the construction of route 3 may be reduced even more over initial estimates if fewer problems than anticipated occur during construction. The actual path taken by route 2 could cause more problems than initially perceived due to its passing through oil production and refining facilities north of Borger. With all these considerations, the cost savings to the consumers of route 2 over route 3 under optimum conditions would be only 2 cents per thousand gallons.

Reflecting the above comments, alternative J is the focus of subsequent discussions. Alternative J would use the 54-inch pipeline along route 3 and would deliver 45,000 AFY to the aqueduct system, with capabilities of conveying 65,000 AFY providing that additional wells and pumping facilities are provided. The projected maximum capacity of the 54-inch pipeline would be approximately 81,000 AFY or 72 mgd.

4. IMPACT OF CONJUNCTIVE MANAGEMENT

4.1 Summary of Recommended Alternative

The recommended alternative (alternative J) provides a project sized to deliver 45,000 AFY, using a 54-inch pipeline which follows the direct route from Roberts County to the CRMWA aqueduct (Route 3) at forebay 3. An important conclusion of the cost analysis presented in Section 3.2 is that there is very little cost savings if CRMWA chooses instead to build a smaller project (e.g. 48-inch pipeline; enough wells only to produce 30,000 AFY). Moreover, the larger project offers the Authority additional operational flexibility and, most important, the option for expansion if needed.

Although the recommended alternative would be sized at 45,000 AFY, actual deliveries would vary depending on operational conditions. Pumping rates would increase in proportion to Lake Meredith salinity, in order to provide adequate blending supplies. Pumping rates probably would decrease in winter, because there are months when (even when current ground water use is considered) the combined demand of member cities is less than aqueduct capacity. Development of detailed operational scenarios is beyond the scope of this report, but based on current salinity conditions, a range of 30,000 to 45,000 AFY is plausible, at least in the long-term.

4.2 Firm Yield and Reliability of CRMWA Water Supply

Conjunctive management of Lake Meredith with a ground water alternative such as the Roberts County hypothetical project would substantially increase the firm yield of the CRMWA water supply, and consequently would increase the reliability of that supply. With a 45,000 AFY project (a size based on water quality considerations), and based on a separate study which indicates the firm yield of Lake Meredith is about 76,000 AFY, firm yield for the conjunctively managed supply would be 121,000 AFY, a value which probably exceeds the existing aqueduct capacity. Were aqueduct capacity to be restored to 126,000 AFY, a firm yield of 126,000 AFY could be accomplished by minor expansion of the ground-water project.

Our study of Lake Meredith's firm yield indicates that CRMWA could release water from Lake Meredith to the Canadian River in order to reduce the salt content of the lake water, but that would reduce the firm yield of the reservoir. An advantage of a 45,000 AFY ground water project is that this type of reservoir operation would not jeopardize the water supply available to the CRMWA member cities.

Many cities would need to retain existing well fields to provide capacity to meet peak summer demands, since irrespective of firm yield, the CRMWA aqueduct has inadequate capacity to meet 100% of demands in peak periods. The cities could consider purchase of CRMWA water in winter during times when there is surplus aqueduct capacity and injection of that water in the area of their existing well fields. The good quality water could then be withdrawn as needed in summer. Experience elsewhere in Texas indicates such a program of aquifer storage is cost-effective.

4.3 Quality of CRMWA Water Supply

The effect of conjunctively blending 30,000 to 45,000 AFY ground water with the existing CRMWA surface supply would be to substantially dilute salinity in water delivered by CRMWA. The exact dilution benefits would depend on the amount of ground water used, the quality of the ground water, and the salinity in Lake Meredith (which tends to get much higher in drought periods).

Amarillo already blends ground and surface water using a ground water which is believed to be very similar in quality to the ground water in Roberts County. A blend of 30,000 AFY of ground water and 76,000 AFY of surface water would be proportionally almost identical to the blending ratio currently used by Amarillo, and thus it would represent the type of blending to be expected in the near-term (and over the long-term, on average). A simple calculation illustrates the impact of blending. The calculation is based on actual Amarillo blending data for September 13, 1992 (except that in the real-world Amarillo condition the blend was 68% surface water, 32% ground water).

Specifically, the calculation assumes 71.7% surface water with sulfate of 268 mg/l, chloride of 388 mg/l and total dissolved solids or TDS of 1238 mg/l; which is blended with 28.3% ground water with sulfate of 14 mg/l, chloride of 8 mg/l and TDS of 280 mg/l. The quality impacts of blending are as follows:

Constituent	Without Blending	With Blending	Standard
sulfate	268	196 mg/l	300 mg/l
chloride	388	280 mg/l	300 mg/l
TDS	1238	963 mg/l	1000 mg/l

The hardness of the blended water probably would not be a simple mixture of the hardness of the surface and ground water supplies, but would be impacted by some chemical reactions during blending. Based on experience of the City of Amarillo, the blended water probably would be slightly softer than the current CRMWA water supply, but hardness probably would exceed 200 mg/l (as $CaCO_3$).

Without blending, Lake Meredith water does not meet State of Texas safe drinking water secondary (aesthetic) standards for chloride or TDS. The blended water does meet the State standards. The benefits of blending include: an improved taste of water; reduced corrosion and other salt impacts; and better prospects of having a State approved water supply.

There are three major factors impacting the quality of the blended water supply:

- The water supply may have slightly more chloride than assumed in our calculation.
- During droughts, Lake Meredith will definitely have more salt than assumed in the calculation.
- The possibility exists that standards might be lowered, e.g. chloride could be set at 250 mg/l (which is the EPA standard).

Blending calculations show that, for all cases, standards could be met by an appropriate blending ratio of ground to surface water. In fact, the project size of 45,000 AFY was developed based on the amount of ground water needed for blending if standards are to be met on average during the critical drought when Lake Meredith salinity would be highest. Expansion to 65,000 AFY would be undertaken if needed to meet standards during the extremes of a drought, or if standards are tightened; in such circumstances it is possible that the firm yield might drop below 121,000 AFY. Detailed operational studies can be conducted to indicate the quality of blended water under a variety of scenarios, once current data on ground-water quality in the Roberts County area are obtained.

No water quality problems have been identified which would be expected to result from a conjunctive management program. For example, Ogallala ground water would be expected to meet all parameters regulated by the Safe Drinking Water Act, such as nitrate or fluoride, though this needs to be confirmed through actual testing of the Roberts County supply.

Also, because blending would take place within the CRMWA aqueduct system, the blended mix would require treatment (coagulation/filtration) prior to delivery to customers, just as the existing surface water supply requires treatment. Water-quality parameters potentially important to treatment include ions such as calcium and bicarbonate, along with water hardness; these parameters are not substantially different between surface and ground water. The provisional judgment is that there should be no significant problems accomplishing treatment of the blended supply. This judgment can be verified through properly designed treatability tests which are beyond the scope of the current study.

Treatment costs would increase for cities which increase their use of CRMWA water. However, in general, capital investments have already been made in the necessary treatment facilities; indeed, by loading treatment plants at higher levels, the unit capital costs of water treatment actually would decrease (i.e. more of the original capital investment would pay off). The primary additional expenses would be for chemicals and energy. Based on a representative example

(City of Lubbock), these chemical and energy costs are in the range of 3 cents per thousand gallons.

4.4 Costs of CRMWA Water Supply

To provide CRMWA with a practical understanding of the costs of conjunctive management, several scenarios have been evaluated. In each case, the evaluations are based on present-day costs for debt service, energy and operations and maintenance (O&M); thus the results are directly comparable to the current CRMWA budget and to average costs incurred by member cities. The analysis does not consider the effects of inflation, which would cause real costs (for energy and O&M) to increase over time; nor does it consider that debt obligations would cease around 2014, at which time water costs could drop substantially.

Based on the fiscal year 1992-93 budget, with a 71,200 AFY delivery, CRMWA anticipates budget costs of $1.9 million for general operations and maintenance, (including the reservoir and aqueduct), $2.9 million for pumping costs through the aqueduct, and $3.4 million debt service, for a total of about $8.1 million. Restated in terms of cents per thousand gallons, these costs are as follows:

general O&M reservoir/aqueduct	8 cents
pumping energy	12 cents
debt service	15 cents
TOTAL	35 cents

The average cost of water to member cities will depend on how CRMWA conjunctively manages its surface and ground water supplies. Three different cost estimates are provided below, as follows.

Budget 1. Delivery of 106,000 AFY using 30,000 AFY of ground water and 76,000 AFY of surface water. This size is selected in order to make use of the basic production capacities of both resources. It slightly exceeds the total existing demand of member cities, but is a realistic delivery target for early in the next decade.

general O&M reservoir/aqueduct	$ 1.9 million
energy/O&M ground water	$ 2.2 million
pumping energy	$ 3.6 million
institutional costs, ground water	$ 0.8 million
debt service, reservoir/aqueduct	$ 3.4 million
debt service, ground water	$ 5.8 million
TOTAL	$17.7 million

The net cost of CRMWA water would be about 51 cents per thousand gallons.

Budget 2. Delivery of 121,000 AFY using 45,000 AFY of ground water and 76,000 AFY of surface water. This size is selected in order to make maximum use of the ground water resource. Demand for this amount of water is several decades away.

general O&M reservoir/aqueduct	$ 1.9 million
energy/O&M ground water	$ 3.4 million
pumping energy	$ 3.9 million
institutional costs, ground water	$ 1.1 million
debt service, reservoir/aqueduct	$ 3.4 million
debt service, ground water	$ 5.9 million
TOTAL	$19.6 million

The net cost of CRMWA water would be about 50 cents per thousand.

Budget 3. Delivery of 80,000 AFY using 30,000 AFY of ground water and 50,000 AFY of surface water. This size is selected in order to meet the minimum probable demand at the time the ground water project is completed.

general O&M reservoir/aqueduct	$ 1.9 million
energy/O&M ground water	$ 2.2 million
pumping energy	$ 2.6 million
institutional costs, ground water	$ 0.8 million
debt service, reservoir/aqueduct	$ 3.4 million
debt service, ground water	$ 5.8 million
TOTAL	$16.7 million

This would bring costs to 64 cents per thousand gallons.

To summarize, near-term costs for conjunctive management could cause the cost of CRMWA's delivered water to increase from 35 cents to as much as 64 cents per thousand gallons, an increase of 83%. However, in our judgment, it seems likely that demand for CRMWA water would increase once the quality of the supply is improved. If so, cost would drop toward 51 cents per thousand gallons, which represents about a 50% increase over the present cost. Costs in the range of 51 to 64 cents per thousand gallons for reliable delivery of good quality raw water are quite reasonable when compared with current water supply costs faced by most cities in the southwestern United States.

4.5 Other Considerations

Preliminary evaluations have identified no unacceptable environmental or other impacts of a proposed conjunctive management system development of the type analyzed here. In particular, the ground water which is assessed in the hypothetical project is already committed to municipal/industrial use; and would not substantially conflict with existing uses of High Plains ground water for irrigation.

The water quality benefits of a ground water project are substantial, especially given that without such a project, many community water supplies will not meet all drinking water standards. Failure to meet standards could adversely impact the economic development potential of these communities. Indeed, the fact that something like a Roberts County project is essential to the economic well-being of the CRMWA service area could be a major rationale upon which CRMWA obtains access to the water from SPS, since SPS energy sales are highly dependent on the well being of the same area.

Water quality improvements to Lake Meredith may be obtained by other means, such as through control of brines in the area of Logan, New Mexico, or even through desalting at Lake Meredith. A conjunctive management project does not negate the need for a salinity control project near Logan; salinity control could be cost-effective when compared to expansion of ground water production to (say) 65,000 AFY; or to reduce the salinity of Lake Meredith water to levels substantially below standards. However, the converse also is true: brine control would not negate the need for conjunctive management, since only a ground water alternative of the type discussed here can substantially increase firm yield.

Although this analysis is highly favorable to a CRMWA conjunctive management project, some cautions need to be expressed.

There is no assurance that water can be obtained from SPS or other vendors, or that pipeline rights-of-way can be readily obtained.

While the hypothetical project is outside the bounds of any current water district, and no well or diversions permit would be required at this time, the possibility exists that future regulatory requirements (and or opposition by area landowners) could affect implementation; also, the reaction of potentially affected members of the public (landowners near the project; ratepayers in CRMWA cities) has yet to be gaged.

This analysis has been based on limited data from the hypothetical project area, especially with respect to aquifer properties, expected well yields, drawdowns during the project lifetime, and water quality. If CRMWA decides to proceed with a specific project, it would be advisable to include at least some field testing and aquifer modeling during project design. Likewise, confirmation that the blended water is treatable should be accomplished before there is a final commitment to the project.

4.6 Carson-Potter County as an Interim Alternative

Perhaps the most significant concern over a hypothetical project in Roberts County is the near-term cost. As indicated in Section 4.4, if CRMWA delivers only 80,000 AFY, of which 30,000 is ground water, the estimated cost is 64 cents per thousand gallons--an 85% increase over current raw water costs. The Carson-Potter County hypothetical project could provide a lower cost alternative in the short-term, until such time as CRMWA deliveries are large enough to make full use of both Lake Meredith and a Roberts County ground-water supply. The interim project was evaluated on a very simple basis to provide a first estimate of costs. Key assumptions are as follows:

- 30 wells, half-mile spacing, 650 feet average depth, 375 feet average lift;

- peak production 34.2 MGD and average production at 64% load factor of 22 MGD (nearly 25,000 AFY), which (for a total delivery of 85,000 AFY) gives a blend of 71% surface water and 29% ground water;

- well field adjoins aqueduct, and water is placed into it with a new pump station; a pump station and 3 MGD pipeline are used to convey water northward to the Borger-Pampa aqueduct;

- for a 20-year project, the unit cost of water would average 60 cents per thousand gallons delivered to the aqueducts, and the net cost of the CRMWA water supply would be 50 cents per thousand gallons.

For comparison, the 1981 SPS offer to the City of Amarillo, which apparently is still open, was 31 cents per thousand gallons, for 10 MGD.

Several significant problems could be associated with this alternative. Most critical is that it would not provide enough ground water for blending if Lake Meredith water quality significantly worsens or CRMWA demand significantly increases. This risk could be reduced by expanding the field by about one-third, to go onto adjoining property which is not controlled by SPS. Without such expansion, the risk also exists that the project lifetime might not be the full 20-year amortization period, especially given the regional trend of a 2 feet/year water-level decline.

Operationally, the project would be more complicated than Roberts County, as it would connect into the aqueduct at a point which is not at a booster station. Institutional complications would arise from site location within a water district, and adjacent to areas of irrigation and municipal (City of Amarillo) pumping.

4.7 Additional Peak Water Supply for Amarillo

As mentioned previously in the report, the City of Amarillo currently blends ground water with surface water at its water treatment plant for quality purposes. The City also uses ground water to meet demands during peak water use periods which is not blended at the water treatment plant, but is injected directly into the distribution system. The City's current capacity at the water treatment plant is inadequate to treat all the water needed during peak periods. This problem, in addition to restrictions being placed on the City's current ground water supplies, led to an investigation of supplying the City of Amarillo with an additional 15 million gallons per day (MGD) of ground water from the Roberts County project over their current allocation.

The aqueduct recommended earlier (Alternative J) has the capacity to carry an additional 15 MGD (16,800 AFY) even during severe conditions when a supply of 65,000 AFY is required by the member cities. However, to supply the City of Amarillo with an additional 15 MGD (16,800 AFY) of ground water to meet peak demands, additional wells, pumps and collection means would have to be installed. The capital expense for these upgrades to the well collection system and the 54-inch line (pressure rating of pipe, etc.) are approximately $3.2 million. Increased operation and maintenance costs are also incurred due to the additional supply. These costs are shown in Table 4.1. The total expense to the City of Amarillo to provide an additional 15 MGD (16,800 AFY) within the 54-inch pipeline is approximately 36 cents per thousand gallons.

To serve the City of Amarillo, three alternative pipeline routes paralleling the existing aqueduct were investigated to convey the additional 15 MGD (16,800 AFY) from pumping station number 3 to Amarillo. The three alternatives run from pumping station 3 to the City's northeast booster pump station, the City's 24th Street pump station or to the City's Masterson pump station. Capital costs for the three 36-inch pipelines to the northeast booster pump station, the 24th

Street pump station and the Masterson pump station are $12.0 million, $14.7 million and $10.7 million, respectively. Total capital expenditures to the City of Amarillo are $15.3 million, $18.0 million and $13.9 million for the three alternatives including the $3.2 million for additional costs within the 54-inch line. As shown in tables 4-2 through 4-4, the total unit cost of the additional 15 MGD (16,800 AFY) ranges from 65 to 76 cents per thousand gallons, which represents the City of Amarillo's unit cost for the additional 15 MGD.

It should be noted that the prices given reflect only delivery of the ground water to the three proposed locations. Subsequent costs incurred in delivering the ground water from each of these locations into the City's distribution system must also be considered.

4.8 Summary

If member cities seek an increased firm yield and improved quality of water from CRMWA, and unless cost considerations are unacceptable, we recommend that the Authority pursue a conjunctive management program as described in this report. The recommended alternative is described in Section 4.1 and is sized at 45,000 AFY in order to provide CRMWA with the amount of water it may need to meet future demands and water-quality requirements.

The main problem identified with the alternative is cost: the charge for raw water delivered to CRMWA cities would increase from 35 cents per thousand gallons per day to an amount in the range 50 to 64 cents per thousand gallons. Costs will be toward the lower end if the ground water project is operated at a high load factor, and if CRMWA deliveries are 100,000 AFY or more. An interim project using the Carson-Potter County area would be appropriate for consideration only if CRMWA does not foresee an increase in demand in the near-term and if the Roberts County costs are judged prohibitive.

Initially, negotiations would be with SPS and would involve the Roberts County area (and the Carson County area if that is chosen as an interim project). CRMWA should be prepared to negotiate with other owners of Roberts County water rights (or rights in other areas identified in Chapter 2) if SPS proves an unwilling seller.

In addition to economic and engineering factors, the negotiations should seek to have SPS develop (or allow CRMWA to develop) additional data to confirm the quantity and quality of the Roberts County supply. Prior to concluding negotiations, CRMWA may wish to authorize some relatively specialized studies, such as modeling of well field impacts, operational optimization, and pilot-scale treatment of blended water; but such studies seem premature until negotiations begin and make progress.

Reference

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APPENDIX A

TABLE 3–1

CANADIAN RIVER MUNICIPAL WATER AUTHORITY WELL WATER SUPPLY PIPELINE ROUTE #1 – 48 INCH (30,000 AC–FT/YR)

Item No. Description	Unit	Quantity	Unit Price	Extension
1.48 inch Pipeline (Class 106)	LF	226,550	$68.80	$15,586,640.00
2.48 inch Pipeline (Class 150)	LF	16,430	$74.90	$1,230,610.00
3.48 inch Pipeline (Class 200)	LF	3,520	$85.00	$299,200.00
4.Pipe Installation	LF	246,500	$37.00	$9,120,500.00
5.Pumps (Pump Sta. #1)	EA	6	$133,500.00	$801,000.00
6.Pump Station #1	SF	4,780	$50.00	$239,000.00
7.Pumps (Pump Sta. #2)	EA	6	$112,000.00	$672,000.00
8.Pump Station #2	SF	4,560	$50.00	$228,000.00
9.Pumps (Pump Sta. #3)	EA	6	$98,500.00	$591,000.00
10.Pump Station #3	SF	4,380	$50.00	$219,000.00
11.Air/Vacuum Release Manholes	EA	40	$4,000.00	$160,000.00
12.Construction Right of Way	AC	167	$750.00	$125,250.00
13.FM Road Crossings	EA	4	$4,000.00	$16,000.00
14.State Hwy Crossing	EA	1	$85,000.00	$85,000.00
15.Railroad Crossings	EA	3	$70,000.00	$210,000.00
16.Tie in to Existing Line	EA	1	$25,000.00	$25,000.00
17.Trench Safety	LF	246,500	$1.50	$369,750.00
18.24' wide, Sealcoat street to P.S. #1	SY	24,000	$15.00	$360,000.00
19.24' wide, Sealcoat street to P.S. #2	SY	9,300	$15.00	$139,500.00
20.Street Improvements to Pump Sta #2	SY	53,000	$8.00	$424,000.00
21.200' Dia.x 25' Water Storage Tanks	EA	2	$2,100,000.00	$4,200,000.00
22.Chlorination Building	LS	1	$150,000.00	$150,000.00
23.Chlorination Equipment	LS	1	$75,000.00	$75,000.00
24.Well Collection System				
Well Placement	EA	24	$96,185.00	$2,308,440.00
Pumps for Wells	EA	24	$24,900.00	$597,600.00
Electrical Service to Pumps	LS	1	$200,000.00	$200,000.00
Control System	LS	1	$185,000.00	$185,000.00
12 inch Pipeline	LF	56,400	$17.20	$970,080.00
18 inch Pipeline	LF	25,900	$20.90	$541,310.00
24 inch Pipeline	LF	3,500	$27.30	$95,550.00
30 inch Pipeline	LF	3,400	$34.50	$117,300.00
36 inch Pipeline	LF	15,000	$41.50	$622,500.00
54 inch Pipeline	LF	15,500	$79.00	$1,224,500.00
Collection System Installation	LF	119,700	$30.00	$3,591,000.00
Ground Storage at B.S.#1	LS	1	$40,000.00	$40,000.00
Pumps (Booster Sta. #1)	EA	4	$100,000.00	$400,000.00
Booster Station #1	SF	3,400	$50.00	$170,000.00
Ground Storage at B.S. #2	LS	1	$125,000.00	$125,000.00
Pumps (Booster Sta. #2)	EA	6	$110,000.00	$660,000.00
Booster Station #2	SF	4,500	$50.00	$225,000.00
Ground Storage at B.S. #3	LS	1	$25,000.00	$25,000.00
Pumps (Booster Sta. #3)	EA	4	$45,000.00	$180,000.00
Booster Station #3	SF	2,500	$50.00	$125,000.00
SUB–TOTAL				**$47,730,000.00**
CONSTRUCTION CONTINGENCY (7.5%)				**$3,580,000.00**
ENGINEERING, SURVEYING, GEOTECHNICAL (7.5%)				**$3,580,000.00**
TOTAL				**$54,890,000.00**

OPINION OF PROBABLE COST

CANADIAN RIVER MUNICIPAL WATER AUTHORITY WELL WATER SUPPLY PIPELINE
ROUTE #1 – 48 INCH (30,000 AC–FT/YR)

Parkhill, Smith & Cooper, Inc.
4010 Avenue R
Lubbock, Texas 79412

	Average Flow (MGD)	Average Flow (gpm)	Head (ft)	Efficiency (%)	Required Power (Hp)	Required Power (kW)	Required Power (kW–hr/yr)	Yearly Expense ($)
Pump Station #1	26.8	18,585	199	70	1,334	995	8,715,467	$392,196
Pump Station #2	26.8	18,585	140	70	939	700	6,131,484	$275,917
Pump Station #3	26.8	18,585	72	70	483	360	3,153,335	$141,900
Booster Station #1	9.0	6,240	140	70	315	235	2,058,674	$92,640
Booster Station #2	22.3	15,487	140	70	782	583	5,109,405	$229,923
Booster Station #3	4.5	3,100	85	70	95	71	620,949	$27,943
Well Pumping	26.8	18,585	250	70	1,676	1,250	10,949,079	$492,709
Subtotal								$1,653,228
Chlorine Cost								$40,000
Maintenance Cost								$350,000
Total								$2,043,228

Electricity cost 4.5 cents per kW–hr
Pump Efficiency: 70 %

TABLE 3–2

CANADIAN RIVER MUNICIPAL WATER AUTHORITY WELL WATER SUPPLY PIPELINE
ROUTE #1 – 48 INCH (45,000 AC–FT/YR)

Item No. Description	Unit	Quantity	Unit Price	Extension
1.48 inch Pipeline (Class 106)	LF	226,550	$68.80	$15,586,640.00
2.48 inch Pipeline (Class 150)	LF	16,430	$74.90	$1,230,610.00
3.48 inch Pipeline (Class 200)	LF	3,520	$85.00	$299,200.00
4.Pipe Installation	LF	246,500	$37.00	$9,120,500.00
5.Pumps (Pump Sta. #1)	EA	6	$133,500.00	$801,000.00
6.Pump Station #1	SF	4,780	$50.00	$239,000.00
7.Pumps (Pump Sta. #2)	EA	6	$112,000.00	$672,000.00
8.Pump Station #2	SF	4,560	$50.00	$228,000.00
9.Pumps (Pump Sta. #3)	EA	6	$98,500.00	$591,000.00
10.Pump Station #3	SF	4,380	$50.00	$219,000.00
11.Air/Vacuum Release Manholes	EA	40	$4,000.00	$160,000.00
12.Construction Right of Way	AC	167	$750.00	$125,250.00
13.FM Road Crossings	EA	4	$4,000.00	$16,000.00
14.State Hwy Crossing	EA	1	$85,000.00	$85,000.00
15.Railroad Crossings	EA	3	$70,000.00	$210,000.00
16.Tie in to Existing Line	EA	1	$25,000.00	$25,000.00
17.Trench Safety	LF	246,500	$1.50	$369,750.00
18.24' wide, Sealcoat street to P.S. #1	SY	24,000	$15.00	$360,000.00
19.24' wide, Sealcoat street to P.S. #2	SY	9,300	$15.00	$139,500.00
20.Street Improvements to Pump Sta #2	SY	53,000	$8.00	$424,000.00
21.200' Dia.x 25' Water Storage Tanks	EA	2	$2,100,000.00	$4,200,000.00
22.Chlorination Building	LS	1	$150,000.00	$150,000.00
23.Chlorination Equipment	LS	1	$75,000.00	$75,000.00
24.Well Collection System				
Well Placement	EA	29	$96,185.00	$2,789,370.00
Pumps for Wells	EA	29	$24,900.00	$722,100.00
Electrical Service to Pumps	LS	1	$200,000.00	$200,000.00
Control System	LS	1	$185,000.00	$185,000.00
12 inch Pipeline	LF	64,900	$17.20	$1,116,280.00
18 inch Pipeline	LF	26,400	$20.90	$551,760.00
24 inch Pipeline	LF	3,500	$27.30	$95,550.00
30 inch Pipeline	LF	5,400	$34.50	$186,300.00
36 inch Pipeline	LF	28,000	$41.50	$1,162,000.00
54 inch Pipeline	LF	15,500	$79.00	$1,224,500.00
Collection System Installation	LF	143,700	$30.00	$4,311,000.00
Ground Storage at B.S.#1	LS	1	$40,000.00	$40,000.00
Pumps (Booster Sta. #1)	EA	4	$100,000.00	$400,000.00
Booster Station #1	SF	3,400	$50.00	$170,000.00
Ground Storage at B.S. #2	LS	1	$125,000.00	$125,000.00
Pumps (Booster Sta. #2)	EA	6	$110,000.00	$660,000.00
Booster Station #2	SF	4,500	$50.00	$225,000.00
Ground Storage at B.S. #3	LS	1	$40,000.00	$40,000.00
Pumps (Booster Sta. #3)	EA	4	$90,000.00	$360,000.00
Booster Station #3	SF	3,200	$50.00	$160,000.00
SUB–TOTAL				**$50,050,000.00**
CONSTRUCTION CONTINGENCY (7.5%)				**$3,754,000.00**
ENGINEERING, SURVEYING, GEOTECHNICAL (7.5%)				**$3,754,000.00**
TOTAL				**$57,558,000.00**

OPINION OF PROBABLE COST

CANADIAN RIVER MUNICIPAL WATER AUTHORITY WELL WATER SUPPLY PIPELINE
ROUTE #1 – 48 INCH (45,000 AC–FT/YR)

Parkhill, Smith & Cooper, Inc.
4010 Avenue R
Lubbock, Texas 79412

	Average Flow (MGD)	Average Flow (gpm)	Head (ft)	Efficiency (%)	Required Power (Hp)	Required Power (kW)	Required Power (kW–hr/yr)	Yearly Expense ($)
Pump Station #1	40.1	27,877	213	70	2,142	1,597	13,992,672	$629,670
Pump Station #2	40.1	27,877	182	70	1,830	1,365	11,956,180	$538,028
Pump Station #3	40.1	27,877	131	70	1,317	982	8,605,822	$387,262
Booster Station #1	11.1	7,680	145	70	402	300	2,624,244	$118,091
Booster Station #2	29.0	20,160	145	70	1,055	786	6,888,641	$309,989
Booster Station #3	11.1	7,680	100	70	277	207	1,809,824	$81,442
Well Pumping	40.1	27,877	250	70	2,514	1,875	16,423,324	$739,050
Subtotal								$2,803,532
Chlorine Cost								$62,000
Maintenance Cost								$350,000
Total								$3,215,532

Electricity cost 4.5 cents per kW–hr
Pump Efficiency: 70 %

TABLE 3-3

CANADIAN RIVER MUNICIPAL WATER AUTHORITY WELL WATER SUPPLY PIPELINE
ROUTE #1 - 54 INCH (30,000 AC-FT/YR)

Item No.	Description	Unit	Quantity	Unit Price	Extension
1.	54 inch Pipeline (Class 106)	LF	207,250	$79.00	$16,372,750.00
2.	54 inch Pipeline (Class 150)	LF	30,750	$88.00	$2,706,000.00
3.	54 inch Pipeline (Class 200)	LF	8,500	$99.00	$841,500.00
4.	Pipe Installation	LF	246,500	$40.00	$9,860,000.00
5.	Pumps (Pump Sta. #1)	EA	6	$175,000.00	$1,050,000.00
6.	Pump Station #1	SF	4,780	$50.00	$239,000.00
7.	Pumps (Pump Sta. #2)	EA	6	$126,000.00	$756,000.00
8.	Pump Station #2	SF	4,780	$50.00	$239,000.00
9.	Pumps (Pump Sta. #3)	EA	6	$88,000.00	$528,000.00
10.	Pump Station #3	SF	3,910	$50.00	$195,500.00
11.	Air/Vacuum Release Manholes	EA	40	$4,500.00	$180,000.00
12.	Construction Right of Way	AC	167	$750.00	$125,250.00
13.	FM Road Crossings	EA	4	$4,000.00	$16,000.00
14.	State Hwy Crossing	EA	1	$85,000.00	$85,000.00
15.	Railroad Crossings	EA	3	$70,000.00	$210,000.00
16.	Tie in to Existing Line	EA	1	$25,000.00	$25,000.00
17.	Trench Safety	LF	246,500	$1.50	$369,750.00
18.	24' wide, Sealcoat street to P.S. #1	SY	24,000	$15.00	$360,000.00
19.	24' wide, Sealcoat street to P.S. #2	SY	9,300	$15.00	$139,500.00
20.	Street Improvements to Pump Sta #2	SY	53,000	$8.00	$424,000.00
21.	200' Dia.x 25' Water Storage Tanks	EA	2	$2,100,000.00	$4,200,000.00
22.	Chlorination Building	LS	1	$150,000.00	$150,000.00
23.	Chlorination Equipment	LS	1	$75,000.00	$75,000.00
24.	Well Collection System				
	Well Placement	EA	24	$96,185.00	$2,308,440.00
	Pumps for Wells	EA	24	$24,900.00	$597,600.00
	Electrical Service to Pumps	LS	1	$200,000.00	$200,000.00
	Control System	LS	1	$185,000.00	$185,000.00
	12 inch Pipeline	LF	56,400	$17.20	$970,080.00
	18 inch Pipeline	LF	25,900	$20.90	$541,310.00
	24 inch Pipeline	LF	3,500	$27.30	$95,550.00
	30 inch Pipeline	LF	3,400	$34.50	$117,300.00
	36 inch Pipeline	LF	15,000	$41.50	$622,500.00
	54 inch Pipeline	LF	15,500	$79.00	$1,224,500.00
	Collection System Installation	LF	119,700	$30.00	$3,591,000.00
	Ground Storage at B.S. #1	LS	1	$40,000.00	$40,000.00
	Pumps (Booster Sta. #1)	EA	4	$100,000.00	$400,000.00
	Booster Station #1	SF	3,400	$50.00	$170,000.00
	Ground Storage at B.S. #2	LS	1	$125,000.00	$125,000.00
	Pumps (Booster Sta. #2)	EA	6	$110,000.00	$660,000.00
	Booster Station #2	SF	4,500	$50.00	$225,000.00
	Ground Storage at B.S. #3	LS	1	$25,000.00	$25,000.00
	Pumps (Booster Sta. #3)	EA	4	$45,000.00	$180,000.00
	Booster Station #3	SF	2,500	$50.00	$125,000.00
SUB-TOTAL					**$51,551,000.00**
CONSTRUCTION CONTINGENCY (7.5%)					**$3,866,000.00**
ENGINEERING, SURVEYING, GEOTECHNICAL (7.5%)					**$3,866,000.00**
TOTAL					**$59,283,000.00**

OPINION OF PROBABLE COST

CANADIAN RIVER MUNICIPAL WATER AUTHORITY WELL WATER SUPPLY PIPELINE
ROUTE #1 – 54 INCH (30,000 AC-FT/YR)

Parkhill, Smith & Cooper, Inc.
4010 Avenue R
Lubbock, Texas 79412

	Average Flow (MGD)	Average Flow (gpm)	Head (ft)	Efficiency (%)	Required Power (Hp)	Required Power (kW)	Required Power (kW-hr/yr)	Yearly Expense ($)
Pump Station #1	26.8	18,585	193	70	1,294	965	8,452,689	$380,371
Pump Station #2	26.8	18,585	123	70	825	615	5,386,947	$242,413
Pump Station #3	26.8	18,585	66	70	443	330	2,890,557	$130,075
Booster Station #1	9.0	6,240	140	70	315	235	2,058,674	$92,640
Booster Station #2	22.3	15,487	140	70	782	583	5,109,405	$229,923
Booster Station #3	4.5	3,100	85	70	95	71	620,949	$27,943
Well Pumps	26.8	18,585	250	70	1,676	1,250	10,949,079	$492,709
Subtotal								$1,596,074
Chlorine Cost								$40,000
Maintenance Cost								$350,000
Total								$1,986,074

Electricity cost 4.5 cents per kW-hr
Pump Efficiency: 70 %

TABLE 3-4

CANADIAN RIVER MUNICIPAL WATER AUTHORITY WELL WATER SUPPLY PIPELINE ROUTE #1 – 54 INCH (45,000 AC-FT/YR)

Item No.	Description	Unit	Quantity	Unit Price	Extension
1.	54 inch Pipeline (Class 106)	LF	207,250	$79.00	$16,372,750.00
2.	54 inch Pipeline (Class 150)	LF	30,750	$88.00	$2,706,000.00
3.	54 inch Pipeline (Class 200)	LF	8,500	$99.00	$841,500.00
4.	Pipe Installation	LF	246,500	$40.00	$9,860,000.00
5.	Pumps (Pump Sta. #1)	EA	6	$175,000.00	$1,050,000.00
6.	Pump Station #1	SF	4,780	$50.00	$239,000.00
7.	Pumps (Pump Sta. #2)	EA	6	$126,000.00	$756,000.00
8.	Pump Station #2	SF	4,780	$50.00	$239,000.00
9.	Pumps (Pump Sta. #3)	EA	6	$88,000.00	$528,000.00
10.	Pump Station #3	SF	3,910	$50.00	$195,500.00
11.	Air/Vacuum Release Manholes	EA	40	$4,500.00	$180,000.00
12.	Construction Right of Way	AC	167	$750.00	$125,250.00
13.	FM Road Crossings	EA	4	$4,000.00	$16,000.00
14.	State Hwy Crossing	EA	1	$85,000.00	$85,000.00
15.	Railroad Crossings	EA	3	$70,000.00	$210,000.00
16.	Tie in to Existing Line	EA	1	$25,000.00	$25,000.00
17.	Trench Safety	LF	246,500	$1.50	$369,750.00
18.	24' wide, Sealcoat street to P.S. #1	SY	24,000	$15.00	$360,000.00
19.	24' wide, Sealcoat street to P.S. #2	SY	9,300	$15.00	$139,500.00
20.	Street Improvements to Pump Sta #2	SY	53,000	$8.00	$424,000.00
21.	200' Dia.x 25' Water Storage Tanks	EA	2	$2,100,000.00	$4,200,000.00
22.	Chlorination Building	LS	1	$150,000.00	$150,000.00
23.	Chlorination Equipment	LS	1	$75,000.00	$75,000.00
24.	Well Collection System				
	Well Placement	EA	29	$96,185.00	$2,789,370.00
	Pumps for Wells	EA	29	$24,900.00	$722,100.00
	Electrical Service to Pumps	LS	1	$200,000.00	$200,000.00
	Control System	LS	1	$185,000.00	$185,000.00
	12 inch Pipeline	LF	64,900	$17.20	$1,116,280.00
	18 inch Pipeline	LF	26,400	$20.90	$551,760.00
	24 inch Pipeline	LF	3,500	$27.30	$95,550.00
	30 inch Pipeline	LF	5,400	$34.50	$186,300.00
	36 inch Pipeline	LF	28,000	$41.50	$1,162,000.00
	54 inch Pipeline	LF	15,500	$79.00	$1,224,500.00
	Collection System Installation	LF	143,700	$30.00	$4,311,000.00
	Ground Storage at B.S. #1	LS	1	$40,000.00	$40,000.00
	Pumps (Booster Sta. #1)	EA	4	$100,000.00	$400,000.00
	Booster Station #1	SF	3,400	$50.00	$170,000.00
	Ground Storage at B.S. #2	LS	1	$125,000.00	$125,000.00
	Pumps (Booster Sta. #2)	EA	6	$110,000.00	$660,000.00
	Booster Station #2	SF	4,500	$50.00	$225,000.00
	Ground Storage at B.S. #3	LS	1	$40,000.00	$40,000.00
	Pumps (Booster Sta. #3)	EA	4	$90,000.00	$360,000.00
	Booster Station #3	SF	3,200	$50.00	$160,000.00
SUB-TOTAL					**$53,871,000.00**
CONSTRUCTION CONTINGENCY (7.5%)					**$4,040,000.00**
ENGINEERING, SURVEYING, GEOTECHNICAL (7.5%)					**$4,040,000.00**
TOTAL					**$61,951,000.00**

OPINION OF PROBABLE COST

CANADIAN RIVER MUNICIPAL WATER AUTHORITY WELL WATER SUPPLY PIPELINE
ROUTE #1 – 54 INCH (45,000 AC–FT/YR)

Parkhill, Smith & Cooper, Inc.
4010 Avenue R
Lubbock, Texas 79412

	Average Flow (MGD)	Average Flow (gpm)	Head (ft)	Efficiency (%)	Required Power (Hp)	Required Power (kW)	Required Power (kW–hr/yr)	Yearly Expense ($)
Pump Station #1	40.1	27,877	201	70	2,021	1,507	13,204,353	$594,196
Pump Station #2	40.1	27,877	182	70	1,830	1,365	11,956,180	$538,028
Pump Station #3	40.1	27,877	75	70	754	562	4,926,997	$221,715
Booster Station #1	11.1	7,680	145	70	402	300	2,624,244	$118,091
Booster Station #2	29.0	20,160	145	70	1,055	786	6,888,641	$309,989
Booster Station #3	11.1	7,680	100	70	277	207	1,809,824	$81,442
Well Pumps	40.1	27,877	250	70	2,514	1,875	16,423,324	$739,050
Subtotal								$2,602,510
Chlorine Cost								$62,000
Maintenance Cost								$350,000
Total								$3,014,510

Electricity cost 4.5 cents per kW–hr
Pump Efficiency: 70 %

TABLE 3–5

CANADIAN RIVER MUNICIPAL WATER AUTHORITY WELL WATER SUPPLY PIPELINE
ROUTE #2 – 48 INCH (30,000 AC–FT/YR)

Item No.	Description	Unit	Quantity	Unit Price	Extension
1.	48 inch Pipeline (Class 106)	LF	124,600	$68.80	$8,572,480.00
2.	48 inch Pipeline (Class 150)	LF	45,900	$74.90	$3,437,910.00
3.	48 inch Pipeline (Class 200)	LF	8,000	$85.00	$680,000.00
4.	Pipe Installation	LF	178,500	$37.00	$6,604,500.00
5.	Pumps (Pump Sta. #1)	EA	8	$87,000.00	$696,000.00
6.	Pump Station #1	SF	6,370	$50.00	$318,500.00
7.	Pumps (Pump Sta. #2)	EA	8	$90,000.00	$720,000.00
8.	Pump Station #2	SF	6,370	$50.00	$318,500.00
9.	Pumps (Pump Sta. #3)	EA	6	$110,000.00	$660,000.00
10.	Pump Station #3	SF	4,780	$50.00	$239,000.00
11.	Air/Vacuum Release Manholes	EA	46	$4,000.00	$184,000.00
12.	Construction Right of Way	AC	410	$750.00	$307,500.00
13.	FM Road Crossings	EA	7	$4,000.00	$28,000.00
14.	State Hwy Crossing	EA	4	$85,000.00	$340,000.00
15.	Tie in to Existing Line	EA	1	$25,000.00	$25,000.00
16.	Trench Safety	LF	178,500	$1.50	$267,750.00
17.	24' wide, Sealcoat street to P.S. #1	SY	24,000	$15.00	$360,000.00
18.	24' wide, Sealcoat street to P.S. #2	SY	800	$15.00	$12,000.00
19.	Street Improvements to Pump Sta #2	SY	20,200	$8.00	$161,600.00
20.	24' wide, Sealcoat street to P.S. #3	SY	1,600	$15.00	$24,000.00
21.	200' Dia.x 25' Water Storage Tanks	EA	2	$2,100,000.00	$4,200,000.00
22.	Chlorination Building	LS	1	$150,000.00	$150,000.00
23.	Chlorination Equipment	LS	1	$75,000.00	$75,000.00
24.	Well Collection System				
	Well Placement	EA	24	$96,185.00	$2,308,440.00
	Pumps for Wells	EA	24	$24,900.00	$597,600.00
	Electrical Service to Pumps	LS	1	$200,000.00	$200,000.00
	Control System	LS	1	$185,000.00	$185,000.00
	12 inch Pipeline	LF	56,400	$17.20	$970,080.00
	18 inch Pipeline	LF	25,900	$20.90	$541,310.00
	24 inch Pipeline	LF	3,500	$27.30	$95,550.00
	30 inch Pipeline	LF	3,400	$34.50	$117,300.00
	36 inch Pipeline	LF	15,000	$41.50	$622,500.00
	54 inch Pipeline	LF	15,500	$79.00	$1,224,500.00
	Collection System Installation	LF	119,700	$30.00	$3,591,000.00
	Ground Storage at B.S. #1	LS	1	$40,000.00	$40,000.00
	Pumps (Booster Sta. #1)	EA	4	$100,000.00	$400,000.00
	Booster Station #1	SF	3,400	$50.00	$170,000.00
	Ground Storage at B.S. #2	LS	1	$125,000.00	$125,000.00
	Pumps (Booster Sta. #2)	EA	6	$110,000.00	$660,000.00
	Booster Station #2	SF	4,500	$50.00	$225,000.00
	Ground Storage at B.S. #3	LS	1	$25,000.00	$25,000.00
	Pumps (Booster Sta. #3)	EA	4	$45,000.00	$180,000.00
	Booster Station #3	SF	2,500	$50.00	$125,000.00
SUB–TOTAL					**$40,785,000.00**
CONSTRUCTION CONTINGENCY (15%)					**$6,118,000.00**
ENGINEERING, SURVEYING, GEOTECHNICAL (10%)					**$4,079,000.00**
TOTAL					**$50,982,000.00**

OPINION OF PROBABLE COST

CANADIAN RIVER MUNICIPAL WATER AUTHORITY WELL WATER SUPPLY PIPELINE
ROUTE #2 – 48 INCH (30,000 AC–FT/YR)

Parkhill, Smith & Cooper, Inc.
4010 Avenue R
Lubbock, Texas 79412

	Average Flow (MGD)	Average Flow (gpm)	Head (ft)	Efficiency (%)	Required Power (Hp)	Required Power (kW)	Required Power (kW–hr/yr)	Yearly Expense ($)
Pump Station #1	26.8	18,585	52	70	349	260	2,277,408	$102,483
Pump Station #2	26.8	18,585	53	70	355	265	2,321,205	$104,454
Pump Station #3	26.8	18,585	149	70	999	745	6,525,651	$293,654
Booster Station #1	9.0	6,240	140	70	315	235	2,058,674	$92,640
Booster Station #2	22.3	15,487	140	70	782	583	5,109,405	$229,923
Booster Station #3	4.5	3,100	85	70	95	71	620,949	$27,943
Well Pumping	26.8	18,585	250	70	1,676	1,250	10,949,079	$492,709
Subtotal								$1,343,807
Chlorine Cost								$40,000
Maintenance Cost								$350,000
Total								$1,733,807

Electricity cost 4.5 cents per kW–hr
Pump Efficiency: 70 %

TABLE 3-6

CANADIAN RIVER MUNICIPAL WATER AUTHORITY WELL WATER SUPPLY PIPELINE
ROUTE #2 - 48 INCH (45,000 AC-FT/YR)

Item No.	Description	Unit	Quantity	Unit Price	Extension
1.	48 inch Pipeline (Class 106)	LF	124,600	$68.80	$8,572,480.00
2.	48 inch Pipeline (Class 150)	LF	45,900	$74.90	$3,437,910.00
3.	48 inch Pipeline (Class 200)	LF	8,000	$85.00	$680,000.00
4.	Pipe Installation	LF	178,500	$37.00	$6,604,500.00
5.	Pumps (Pump Sta. #1)	EA	8	$87,000.00	$696,000.00
6.	Pump Station #1	SF	6,370	$50.00	$318,500.00
7.	Pumps (Pump Sta. #2)	EA	8	$90,000.00	$720,000.00
8.	Pump Station #2	SF	6,370	$50.00	$318,500.00
9.	Pumps (Pump Sta. #3)	EA	6	$110,000.00	$660,000.00
10.	Pump Station #3	SF	4,780	$50.00	$239,000.00
11.	Air/Vacuum Release Manholes	EA	46	$4,000.00	$184,000.00
12.	Construction Right of Way	AC	410	$750.00	$307,500.00
13.	FM Road Crossings	EA	7	$4,000.00	$28,000.00
14.	State Hwy Crossing	EA	4	$85,000.00	$340,000.00
15.	Tie in to Existing Line	EA	1	$25,000.00	$25,000.00
16.	Trench Safety	LF	178,500	$1.50	$267,750.00
17.	24' wide, Sealcoat street to P.S. #1	SY	24,000	$15.00	$360,000.00
18.	24' wide, Sealcoat street to P.S. #2	SY	800	$15.00	$12,000.00
19.	Street Improvements to Pump Sta #2	SY	20,200	$8.00	$161,600.00
20.	24' wide, Sealcoat street to P.S. #3	SY	1,600	$15.00	$24,000.00
21.	200' Dia.x 25' Water Storage Tanks	EA	2	$2,100,000.00	$4,200,000.00
22.	Chlorination Building	LS	1	$150,000.00	$150,000.00
23.	Chlorination Equipment	LS	1	$75,000.00	$75,000.00
24.	Well Collection System				
	Well Placement	EA	29	$96,185.00	$2,789,370.00
	Pumps for Wells	EA	29	$24,900.00	$722,100.00
	Electrical Service to Pumps	LS	1	$200,000.00	$200,000.00
	Control System	LS	1	$185,000.00	$185,000.00
	12 inch Pipeline	LF	64,900	$17.20	$1,116,280.00
	18 inch Pipeline	LF	26,400	$20.90	$551,760.00
	24 inch Pipeline	LF	3,500	$27.30	$95,550.00
	30 inch Pipeline	LF	5,400	$34.50	$186,300.00
	36 inch Pipeline	LF	28,000	$41.50	$1,162,000.00
	54 inch Pipeline	LF	15,500	$79.00	$1,224,500.00
	Collection System Installation	LF	143,700	$30.00	$4,311,000.00
	Ground Storage at B.S. #1	LS	1	$40,000.00	$40,000.00
	Pumps (Booster Sta. #1)	EA	4	$100,000.00	$400,000.00
	Booster Station #1	SF	3,400	$50.00	$170,000.00
	Ground Storage at B.S. #2	LS	1	$125,000.00	$125,000.00
	Pumps (Booster Sta. #2)	EA	6	$110,000.00	$660,000.00
	Booster Station #2	SF	4,500	$50.00	$225,000.00
	Ground Storage at B.S. #3	LS	1	$40,000.00	$40,000.00
	Pumps (Booster Sta. #3)	EA	4	$90,000.00	$360,000.00
	Booster Station #3	SF	3,200	$50.00	$160,000.00
SUB-TOTAL					**$43,106,000.00**
CONSTRUCTION CONTINGENCY (15%)					**$6,466,000.00**
ENGINEERING, SURVEYING, GEOTECHNICAL (10%)					**$4,311,000.00**
TOTAL					**$53,883,000.00**

OPINION OF PROBABLE COST

CANADIAN RIVER MUNICIPAL WATER AUTHORITY WELL WATER SUPPLY PIPELINE
ROUTE #2 – 48 INCH (45,000 AC-FT/YR)

Parkhill, Smith & Cooper, Inc.
4010 Avenue R
Lubbock, Texas 79412

	Average Flow (MGD)	Average Flow (gpm)	Head (ft)	Efficiency (%)	Required Power (Hp)	Required Power (kW)	Required Power (kW-hr/yr)	Yearly Expense ($)
Pump Station #1	40.1	27,877	98	70	986	735	6,437,943	$289,707
Pump Station #2	40.1	27,877	112	70	1,126	840	7,357,649	$331,094
Pump Station #3	40.1	27,877	175	70	1,760	1,312	11,496,327	$517,335
Booster Station #1	11.1	7,680	145	70	402	300	2,624,244	$118,091
Booster Station #2	29.0	20,160	145	70	1,055	786	6,888,641	$309,989
Booster Station #3	11.1	7,680	100	70	277	207	1,809,824	$81,442
Well Pumping	40.1	27,877	250	70	2,514	1,875	16,423,324	$739,050
Subtotal								$2,386,708
Chlorine Cost								$62,000
Maintenance Cost								$350,000
Total								$2,798,708

Electricity cost 4.5 cents per kW-hr
Pump Efficiency: 70 %

TABLE 3-7

CANADIAN RIVER MUNICIPAL WATER AUTHORITY WELL WATER SUPPLY PIPELINE ROUTE #2 - 54 INCH (30,000 AC-FT/YR)

Item No.	Description	Unit	Quantity	Unit Price	Extension
1.	54 inch Pipeline (Class 106)	LF	129,800	$79.00	$10,254,200.00
2.	54 inch Pipeline (Class 150)	LF	48,700	$88.00	$4,285,600.00
3.	Pipe Installation	LF	178,500	$40.00	$7,140,000.00
4.	Pumps (Pump Sta. #1)	EA	8	$87,000.00	$696,000.00
5.	Pump Station #1	SF	5,210	$50.00	$260,500.00
6.	Pumps (Pump Sta. #2)	EA	8	$90,000.00	$720,000.00
7.	Pump Station #2	SF	6,370	$50.00	$318,500.00
8.	Pumps (Pump Sta. #3)	EA	6	$120,000.00	$720,000.00
9.	Pump Station #3	SF	4,780	$50.00	$239,000.00
10.	Air/Vacuum Release Manholes	EA	46	$4,500.00	$207,000.00
11.	Construction Right of Way	AC	410	$750.00	$307,500.00
12.	FM Road Crossings	EA	7	$4,000.00	$28,000.00
13.	State Hwy Crossing	EA	4	$85,000.00	$340,000.00
14.	Tie in to Existing Line	EA	1	$25,000.00	$25,000.00
15.	Trench Safety	LF	178,500	$1.50	$267,750.00
16.	24' wide, Sealcoat street to P.S. #1	SY	24,000	$15.00	$360,000.00
17.	24' wide, Sealcoat street to P.S. #2	SY	800	$15.00	$12,000.00
18.	Street Improvements to Pump Sta #2	SY	20,200	$8.00	$161,600.00
19.	24' wide, Sealcoat street to P.S. #3	SY	1,600	$15.00	$24,000.00
20.	200' Dia.x 25' Water Storage Tanks	EA	2	$2,100,000.00	$4,200,000.00
21.	Chlorination Building	LS	1	$150,000.00	$150,000.00
22.	Chlorination Equipment	LS	1	$75,000.00	$75,000.00
23.	Well Collection System				
	Well Placement	EA	24	$96,185.00	$2,308,440.00
	Pumps for Wells	EA	24	$24,900.00	$597,600.00
	Electrical Service for Pumps	LS	1	$200,000.00	$200,000.00
	Control System	LS	1	$185,000.00	$185,000.00
	12 inch Pipeline	LF	56,400	$17.20	$970,080.00
	18 inch Pipeline	LF	25,900	$20.90	$541,310.00
	24 inch Pipeline	LF	3,500	$27.30	$95,550.00
	30 inch Pipeline	LF	3,400	$34.50	$117,300.00
	36 inch Pipeline	LF	15,000	$41.50	$622,500.00
	54 inch Pipeline	LF	15,500	$79.00	$1,224,500.00
	Collection System Installation	LF	119,700	$30.00	$3,591,000.00
	Ground Storage B.S. #1	LS	1	$40,000.00	$40,000.00
	Pumps (Booster Sta. #1)	EA	4	$100,000.00	$400,000.00
	Booster Station #1	SF	3,400	$50.00	$170,000.00
	Ground Storage B.S. #2	LS	1	$125,000.00	$125,000.00
	Pumps (Booster Sta. #2)	EA	6	$110,000.00	$660,000.00
	Booster Station #2	SF	4,500	$50.00	$225,000.00
	Ground Storage at B.S. #3	LS	1	$25,000.00	$25,000.00
	Pumps (Booster Sta. #3)	EA	4	$45,000.00	$180,000.00
	Booster Station #3	SF	2,500	$50.00	$125,000.00
SUB-TOTAL					**$43,195,000.00**
CONSTRUCTION CONTINGENCY (15%)					**$6,479,000.00**
ENGINEERING, SURVEYING, GEOTECHNICAL (10%)					**$4,320,000.00**
TOTAL					**$53,994,000.00**

OPINION OF PROBABLE COST

CANADIAN RIVER MUNICIPAL WATER AUTHORITY WELL WATER SUPPLY PIPELINE
ROUTE #2 – 54 INCH (30,000 AC-FT/YR)

Parkhill, Smith & Cooper, Inc.
4010 Avenue R
Lubbock, Texas 79412

	Average Flow (MGD)	Average Flow (gpm)	Head (ft)	Efficiency (%)	Required Power (Hp)	Required Power (kW)	Required Power (kW-hr/yr)	Yearly Expense ($)
Pump Station #1	26.8	18,585	33	70	221	165	1,445,278	$65,038
Pump Station #2	26.8	18,585	30	70	201	150	1,313,890	$59,125
Pump Station #3	26.8	18,585	139	70	932	695	6,087,688	$273,946
Booster Station #1	9.0	6,240	140	70	315	235	2,058,674	$92,640
Booster Station #2	22.3	15,487	140	70	782	583	5,109,405	$229,923
Booster Station #3	4.5	3,100	85	70	95	71	620,949	$27,943
Well Pumping	26.8	18,585	250	70	1,676	1,250	10,949,079	$492,709
Subtotal								$1,241,323
Chlorine Cost								$40,000
Maintenance Cost								$350,000
Total								$1,631,323

Electricity cost 4.5 cents per kW-hr
Pump Efficiency: 70 %

TABLE 3-8

CANADIAN RIVER MUNICIPAL WATER AUTHORITY WELL WATER SUPPLY PIPELINE ROUTE #2 – 54 INCH (45,000 AC-FT/YR)

Item No. Description	Unit	Quantity	Unit Price	Extension
1.54 inch Pipeline (Class 106)	LF	129,800	$79.00	$10,254,200.00
2.54 inch Pipeline (Class 150)	LF	48,700	$88.00	$4,285,600.00
3.Pipe Installation	LF	178,500	$40.00	$7,140,000.00
4.Pumps (Pump Sta. #1)	EA	8	$87,000.00	$696,000.00
5.Pump Station #1	SF	5,210	$50.00	$260,500.00
6.Pumps (Pump Sta. #2)	EA	8	$90,000.00	$720,000.00
7.Pump Station #2	SF	6,370	$50.00	$318,500.00
8.Pumps (Pump Sta. #3)	EA	6	$120,000.00	$720,000.00
9.Pump Station #3	SF	4,780	$50.00	$239,000.00
10.Air/Vacuum Release Manholes	EA	46	$4,500.00	$207,000.00
11.Construction Right of Way	AC	410	$750.00	$307,500.00
12.FM Road Crossings	EA	7	$4,000.00	$28,000.00
13.State Hwy Crossing	EA	4	$85,000.00	$340,000.00
14.Tie in to Existing Line	EA	1	$25,000.00	$25,000.00
15.Trench Safety	LF	178,500	$1.50	$267,750.00
16.24' wide, Sealcoat street to P.S. #1	SY	24,000	$15.00	$360,000.00
17.24' wide, Sealcoat street to P.S. #2	SY	800	$15.00	$12,000.00
18.Street Improvements to Pump Sta #2	SY	20,200	$8.00	$161,600.00
19.24' wide, Sealcoat street to P.S. #3	SY	1,600	$15.00	$24,000.00
20.200' Dia.x 25' Water Storage Tanks	EA	2	$2,100,000.00	$4,200,000.00
21.Chlorination Building	LS	1	$150,000.00	$150,000.00
22.Chlorination Equipment	LS	1	$75,000.00	$75,000.00
23.Well Collection System				
Well Placement	EA	29	$96,185.00	$2,789,370.00
Pumps for Wells	EA	29	$24,900.00	$722,100.00
Electrical Service to Pumps	LS	1	$200,000.00	$200,000.00
Control System	LS	1	$185,000.00	$185,000.00
12 inch Pipeline	LF	64,900	$17.20	$1,116,280.00
18 inch Pipeline	LF	26,400	$20.90	$551,760.00
24 inch Pipeline	LF	3,500	$27.30	$95,550.00
30 inch Pipeline	LF	5,400	$34.50	$186,300.00
36 inch Pipeline	LF	28,000	$41.50	$1,162,000.00
54 inch Pipeline	LF	15,500	$79.00	$1,224,500.00
Collection System Installation	LF	143,700	$30.00	$4,311,000.00
Ground Storage B.S. #1	LS	1	$40,000.00	$40,000.00
Pumps (Booster Sta. #1)	EA	4	$100,000.00	$400,000.00
Booster Station #1	SF	3,400	$50.00	$170,000.00
Ground Storage B.S. #2	LS	1	$125,000.00	$125,000.00
Pumps (Booster Sta. #2)	EA	6	$110,000.00	$660,000.00
Booster Station #2	SF	4,500	$50.00	$225,000.00
Ground Storage at B.S. #3	LS	1	$40,000.00	$40,000.00
Pumps (Booster Sta. #3)	EA	4	$90,000.00	$360,000.00
Booster Station #3	SF	3,200	$50.00	$160,000.00
SUB-TOTAL				**$45,516,000.00**
CONSTRUCTION CONTINGENCY (15%)				**$6,827,000.00**
ENGINEERING, SURVEYING, GEOTECHNICAL (10%)				**$4,552,000.00**
TOTAL				**$56,895,000.00**

OPINION OF PROBABLE COST

CANADIAN RIVER MUNICIPAL WATER AUTHORITY WELL WATER SUPPLY PIPELINE
ROUTE #2 – 54 INCH (45,000 AC–FT/YR)

Parkhill, Smith & Cooper, Inc.
4010 Avenue R
Lubbock, Texas 79412

	Average Flow (MGD)	Average Flow (gpm)	Head (ft)	Efficiency (%)	Required Power (Hp)	Required Power (kW)	Required Power (kW–hr/yr)	Yearly Expense ($)
Pump Station #1	40.1	27,877	59	70	593	442	3,875,905	$174,416
Pump Station #2	40.1	27,877	63	70	634	472	4,138,678	$186,240
Pump Station #3	40.1	27,877	153	70	1,539	1,147	10,051,074	$452,298
Booster Station #1	11.1	7,680	145	70	402	300	2,624,244	$118,091
Booster Station #2	29.0	20,160	145	70	1,055	786	6,888,641	$309,989
Booster Station #3	11.1	7,680	100	70	277	207	1,809,824	$81,442
Well Pumping	40.1	27,877	250	70	2,514	1,875	16,423,324	$739,050
Subtotal								$2,061,526
Chlorine Cost								$62,000
Maintenance Cost								$350,000
Total								$2,473,526

Electricity cost 4.5 cents per kW–hr
Pump Efficiency: 70 %

TABLE 3-9

CANADIAN RIVER MUNICIPAL WATER AUTHORITY WELL WATER SUPPLY PIPELINE
ROUTE #3 – 54 INCH (30,000 AC-FT/YR)

Item No. Description	Unit	Quantity	Unit Price	Extension
1.54 inch Pipeline (Class 106)	LF	93,667	$79.00	$7,399,690.00
2.54 inch Pipeline (Class 150)	LF	50,579	$88.00	$4,450,950.00
3.54 inch Pipeline (Class 200)	LF	48,994	$99.00	$4,850,410.00
4.54 inch Pipeline (Class 250)	LF	12,760	$110.00	$1,403,600.00
5.14 inch Pipeline (Class 106)	LF	34,836	$18.50	$644,470.00
6.54 inch Pipe Installation	LF	206,000	$40.00	$8,240,000.00
7.14 inch Pipe Installation	LF	34,836	$12.00	$418,030.00
8.Pump Station #1	SF	8,050	$50.00	$402,500.00
High Head Pumps	EA	4	$85,000.00	$340,000.00
Low Head Pumps	EA	3	$40,000.00	$120,000.00
9.Pump Station #2 (Existing)	SF	7,175	$50.00	$358,750.00
Pumps to Aqueduct	EA	3	$106,000.00	$318,000.00
Pumps to Borger	EA	3	$7,000.00	$21,000.00
10.Air/Vacuum Release Manholes	EA	48	$4,500.00	$216,000.00
11.Construction Right of Way	AC	473	$750.00	$354,750.00
12.FM Road Crossings	EA	1	$4,000.00	$4,000.00
13.State/US Hwy Crossing	EA	2	$85,000.00	$170,000.00
14.Tie in to Existing Line	EA	1	$25,000.00	$25,000.00
15.24' wide, Sealcoat street to P.S. #1	LF	9,000	$40.00	$360,000.00
16.Trench Safety	LF	206,000	$1.50	$309,000.00
17.200' Dia.x 25' Water Storage Tanks	EA	2	$2,100,000.00	$4,200,000.00
18.Chlorination Building	LS	1	$150,000.00	$150,000.00
19.Chlorination Equipment	LS	1	$75,000.00	$75,000.00
20.Well Collection System				
Well Placement	EA	24	$96,185.00	$2,308,440.00
Pumps for Wells	EA	24	$24,900.00	$597,600.00
Electrical Service to Pumps	LS	1	$200,000.00	$200,000.00
Control System	LS	1	$185,000.00	$185,000.00
12 inch Pipeline	LF	56,400	$17.20	$970,080.00
18 inch Pipeline	LF	25,900	$20.90	$541,310.00
24 inch Pipeline	LF	3,500	$27.30	$95,550.00
30 inch Pipeline	LF	3,400	$34.50	$117,300.00
36 inch Pipeline	LF	15,000	$41.50	$622,500.00
54 inch Pipeline	LF	15,500	$79.00	$1,224,500.00
Collection System Installation	LF	119,700	$30.00	$3,591,000.00
Ground Storage B.S. #1	LS	1	$40,000.00	$40,000.00
Pumps (Booster Sta. #1)	EA	4	$100,000.00	$400,000.00
Booster Station #1	SF	3,400	$50.00	$170,000.00
Ground Storage B.S. #2	LS	1	$125,000.00	$125,000.00
Pumps (Booster Sta. #2)	EA	6	$110,000.00	$660,000.00
Booster Station #2	SF	4,500	$50.00	$225,000.00
Ground Storage at B.S. #3	LS	1	$25,000.00	$25,000.00
Pumps (Booster Sta. #3)	EA	4	$45,000.00	$180,000.00
Booster Station #3	SF	2,500	$50.00	$125,000.00
SUB-TOTAL				**$47,234,000.00**
CONSTRUCTION CONTINGENCY (15%)				**$7,085,000.00**
ENGINEERING, SURVEYING, GEOTECHNICAL (10%)				**$4,723,000.00**
TOTAL				**$59,042,000.00**

OPINION OF PROBABLE COST

CANADIAN RIVER MUNICIPAL WATER AUTHORITY WELL WATER SUPPLY PIPELINE
ROUTE #3 – 54 INCH (30,000 AC-FT/YR)

Parkhill, Smith & Cooper, Inc.
4010 Avenue R
Lubbock, Texas 79412

	Average Flow (MGD)	Average Flow (gpm)	Head (ft)	Efficiency (%)	Required Power (Hp)	Required Power (kW)	Required Power (kW-hr/yr)	Yearly Expense ($)
Pump Station #1	26.8	18,587	212	70	1,422	1,060	9,285,963	$417,868
Pump Station #2	26.8	18,587	302	70	2,025	1,510	13,228,117	$595,265
Booster Station #1	9.0	6,240	140	70	315	235	2,058,674	$92,640
Booster Station #2	22.3	15,487	140	70	782	583	5,109,405	$229,923
Booster Station #3	4.5	3,100	85	70	95	71	620,949	$27,943
Well Pumping	26.8	18,587	250	70	1,676	1,250	10,950,428	$492,769
Subtotal								$1,856,409
Chlorine Cost								$40,000
Maintenance Cost								$350,000
Total								$2,246,409

Electricity cost 4.5 cents per kW-hr
Pump Efficiency: 70 %

TABLE 3-10

CANADIAN RIVER MUNICIPAL WATER AUTHORITY WELL WATER SUPPLY PIPELINE ROUTE #3 – 54 INCH (45,000 AC-FT/YR)

Item No.	Description	Unit	Quantity	Unit Price	Extension
1.	54 inch Pipeline (Class 106)	LF	93,667	$79.00	$7,399,690.00
2.	54 inch Pipeline (Class 150)	LF	50,579	$88.00	$4,450,950.00
3.	54 inch Pipeline (Class 200)	LF	48,994	$99.00	$4,850,410.00
4.	54 inch Pipeline (Class 250)	LF	12,760	$110.00	$1,403,600.00
5.	14 inch Pipeline (Class 106)	LF	34,836	$18.50	$644,470.00
6.	54 inch Pipe Installation	LF	206,000	$40.00	$8,240,000.00
7.	14 inch Pipe Installation	LF	34,836	$12.00	$418,030.00
8.	Pump Station #1	SF	8,050	$50.00	$402,500.00
	High Head Pumps	EA	4	$85,000.00	$340,000.00
	Low Head Pumps	EA	3	$40,000.00	$120,000.00
9.	Pump Station #2 (Existing)	SF	7,175	$50.00	$358,750.00
	Pumps to Aqueduct	EA	3	$106,000.00	$318,000.00
	Pumps to Borger	EA	3	$7,000.00	$21,000.00
10.	Air/Vacuum Release Manholes	EA	48	$4,500.00	$216,000.00
11.	Construction Right of Way	AC	473	$750.00	$354,750.00
12.	FM Road Crossings	EA	1	$4,000.00	$4,000.00
13.	State/US Hwy Crossing	EA	2	$85,000.00	$170,000.00
14.	Tie in to Existing Line	EA	1	$25,000.00	$25,000.00
15.	24' wide, Sealcoat street to P.S. #1	LF	9,000	$40.00	$360,000.00
16.	Trench Safety	LF	206,000	$1.50	$309,000.00
17.	200' Dia.x 25' Water Storage Tanks	EA	2	$2,100,000.00	$4,200,000.00
18.	Chlorination Building	LS	1	$150,000.00	$150,000.00
19.	Chlorination Equipment	LS	1	$75,000.00	$75,000.00
20.	Well Collection System				
	Well Placement	EA	29	$96,185.00	$2,789,370.00
	Pumps for Wells	EA	29	$24,900.00	$722,100.00
	Electrical Service to Pumps	LS	1	$200,000.00	$200,000.00
	Control System	LS	1	$185,000.00	$185,000.00
	12 inch Pipeline	LF	64,900	$17.20	$1,116,280.00
	18 inch Pipeline	LF	26,400	$20.90	$551,760.00
	24 inch Pipeline	LF	3,500	$27.30	$95,550.00
	30 inch Pipeline	LF	5,400	$34.50	$186,300.00
	36 inch Pipeline	LF	28,000	$41.50	$1,162,000.00
	54 inch Pipeline	LF	15,500	$79.00	$1,224,500.00
	Collection System Installation	LF	143,700	$30.00	$4,311,000.00
	Ground Storage B.S. #1	LS	1	$40,000.00	$40,000.00
	Pumps (Booster Sta. #1)	EA	4	$100,000.00	$400,000.00
	Booster Station #1	SF	3,400	$50.00	$170,000.00
	Ground Storage B.S. #2	LS	1	$125,000.00	$125,000.00
	Pumps (Booster Sta. #2)	EA	6	$110,000.00	$660,000.00
	Booster Station #2	SF	4,500	$50.00	$225,000.00
	Ground Storage at B.S. #3	LS	1	$40,000.00	$40,000.00
	Pumps (Booster Sta. #3)	EA	4	$90,000.00	$360,000.00
	Booster Station #3	SF	3,200	$50.00	$160,000.00
SUB-TOTAL					**$49,555,000.00**
CONSTRUCTION CONTINGENCY (15%)					**$7,433,000.00**
ENGINEERING, SURVEYING, GEOTECHNICAL (10%)					**$4,956,000.00**
TOTAL					**$61,944,000.00**

OPINION OF PROBABLE COST

CANADIAN RIVER MUNICIPAL WATER AUTHORITY WELL WATER SUPPLY PIPELINE
ROUTE #3 – 54 INCH (45,000 AC–FT/YR)

Parkhill, Smith & Cooper, Inc.
4010 Avenue R
Lubbock, Texas 79412

	Average Flow (MGD)	Average Flow (gpm)	Head (ft)	Efficiency (%)	Required Power (Hp)	Required Power (kW)	Required Power (kW–hr/yr)	Yearly Expense ($)
Pump Station #1	40.1	27,881	258	70	2,595	1,935	16,951,263	$762,807
Pump Station #2	40.1	27,881	341	70	3,430	2,558	22,404,576	$1,008,206
Booster Station #1	11.1	7,680	145	70	402	300	2,624,244	$118,091
Booster Station #2	29.0	20,160	145	70	1,055	786	6,888,641	$309,989
Booster Station #3	11.1	7,680	100	70	277	207	1,809,824	$81,442
Well Pumping	40.1	27,881	250	70	2,515	1,875	16,425,642	$739,154
Subtotal								$3,019,689
Chlorine Cost								$62,000
Maintenance Cost								$350,000
Total								$3,431,689

Electricity cost 4.5 cents per kW–hr
Pump Efficiency: 70 %

TABLE 3–11

Summary of Cost Estimates for the Ten Alternatives

Alternative	Total Debt	Energy, O&M
Route 1		
A (48–inch, 30,000 AFY)	$54,890,000	$2,040,000
B (48–inch, 45,000 AFY)	$57,560,000	$3,220,000
C (54–inch, 30,000 AFY)	$59,280,000	$1,990,000
D (54–inch, 45,000 AFY)	$61,950,000	$3,010,000
Route 2		
E (48–inch, 30,000 AFY)	$50,980,000	$1,730,000
F (48–inch, 45,000 AFY)	$53,880,000	$2,800,000
G (54–inch, 30,000 AFY)	$53,990,000	$1,630,000
H (54–inch, 45,000 AFY)	$56,900,000	$2,470,000
Route 3		
I (54–inch, 30,000 AFY)	$59,040,000	$2,250,000
J (54–inch, 45,000 AFY)	$61,940,000	$3,430,000

TABLE 4–1

COSTS ASSOCIATED WITH ADDITIONAL 15 MGD 54 INCH PIPELINE WELL COLLECTION SYSTEM to FOREBAY 3	
Capital costs	$2,570,000
Construction Contingency (15%)	$385,500
Engineering, Surveying, Geotechnical (10%)	$257,000
TOTAL CAPITAL OUTLAY	**$3,212,500**
Annual Debt Service (20 years @ 7%)	$300,000
Energy/O&M Costs	$1,270,000
Institutional Costs, ground water	$420,000
TOTAL ANNUAL COSTS	**$1,990,000**
TOTAL COST PER 1,000 GALLONS	**$0.363**

TABLE 4–2

36 INCH PIPELINE (15 MGD) FOREBAY 3 to NORTHEAST PUMP STATION	
Capital costs	$9,630,000
Construction Contingency (15%)	$1,444,500
Engineering, Surveying, Geotechnical (10%)	$963,000
TOTAL CAPITAL OUTLAY	**$12,037,500**
Annual Debt Service (20 years @ 7%)	$1,136,000
Annual O&M Costs	$652,000
TOTAL ANNUAL COSTS	**$1,788,000**
36 inch – Cost per 1,000 gallons	**$0.327**
Cost per 1000 gallons for Add'l 15 MGD through 54–in *	$0.363
TOTAL COST PER 1,000 GALLONS	**$0.690**

* See Table 4–1

TABLE 4-3

36 INCH PIPELINE (15 MGD) FOREBAY 3 to 24th STREET PUMP STATION	
Capital costs	$11,791,000
Construction Contingency (15%)	$1,768,650
Engineering, Surveying, Geotechnical (10%)	$1,179,100
TOTAL CAPITAL OUTLAY	**$14,738,750**
Annual Debt Service (20 years @ 7%)	$1,391,000
Annual O&M Costs	$803,000
TOTAL ANNUAL COSTS	**$2,194,000**
36 inch – Cost per 1,000 gallons	$0.401
Cost per 1000 gallons for Add'l 15 MGD through 54-in *	$0.363
TOTAL COST PER 1,000 GALLONS	**$0.764**

TABLE 4-4

36 INCH PIPELINE (15 MGD) FOREBAY 3 to MASTERSON PUMP STATION	
Capital costs	$8,577,000
Construction Contingency (15%)	$1,286,550
Engineering, Surveying, Geotechnical (10%)	$857,700
TOTAL CAPITAL OUTLAY	**$10,721,250**
Annual Debt Service (20 years @ 7%)	$1,012,000
Annual O&M Costs	$559,000
TOTAL ANNUAL COSTS	**$1,571,000**
36 inch – Cost per 1,000 gallons	$0.287
Cost per 1000 gallons for Add'l 15 MGD through 54-in *	$0.363
TOTAL COST PER 1,000 GALLONS	**$0.650**

* See Table 4-1

APPENDIX B

APPENDIX B
HISTORIC AND PROJECTED WATER USE STUDY

General

The Canadian River Municipal Water Authority (CRMWA) currently supplies water from Lake Meredith to the municipalities of Amarillo, Borger, Brownfield, Lamesa, Levelland, Lubbock, O'Donnell, Pampa, Plainview, Slaton and Tahoka. Each of these municipalities, with the exception of Slaton, supplements their supply of CRMWA water with various quantities of local well water. Undesirably high salinity in the CRMWA water along with growing demands for water delivery has prompted the study of supplementing Lake Meredith water with well water through the CRMWA system. The following is a description of both historic and projected water quality and quantity for the CRMWA member cities.

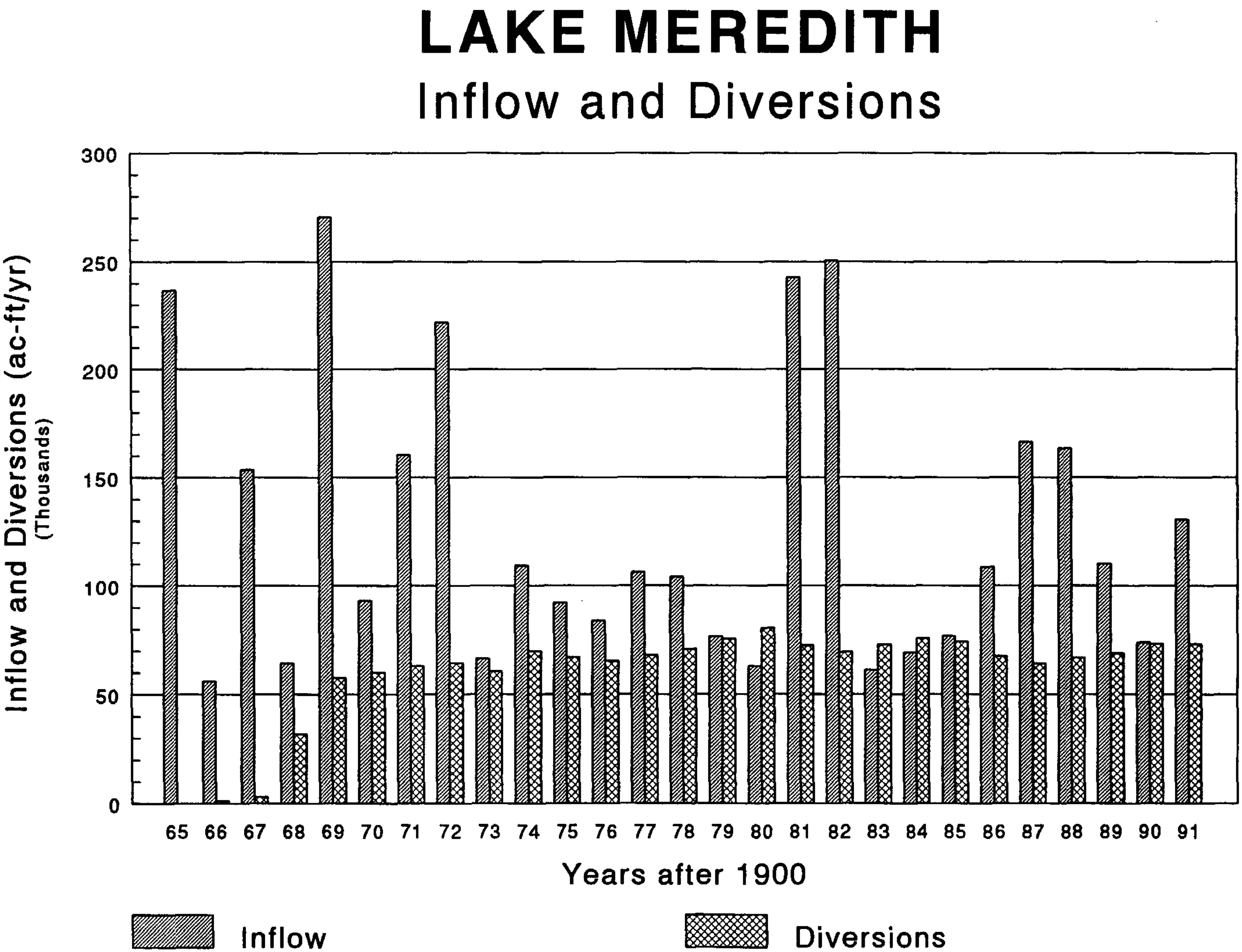
Lake Meredith Reservoir

Lake Meredith Reservoir was completed in 1965 under the direction of the Canadian River Water Authority. The reservoir has a maximum storage capacity of approximately 550,000 acre feet with a average inflow of approximately 126,000 acre feet per year. Figure B-1 is a graphical representation of annual reservoir inflow and diversions from 1965 to 1991.

The theoretical yield of the lake has been determined in a separate study to be 76,000 acre feet per year, which is significantly lower than what was originally calculated. Over the past ten years the reservoir has supplied an average of 66,800 acre feet per year for delivery to CRMWA member municipalities. During this time, the annual municipal usage of reservoir water has fluctuated from a minimum of 60,000 acre feet to a maximum of 74,000 acre feet.

CRMWA Delivery Capacity

The CRMWA system delivers reservoir water mostly by gravity flow through a pipeline with a design capacity of 126,000 acre feet per year or 3.42 billion gallons per month (BG/Mo). The actual capacity of the system has been reduced



LAKE MEREDITH
Inflow and Diversions
Inflow and Diversions (ac-ft/yr)
(Thousands)
300
250
200
150
100
50
0
65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91
Years after 1900
Inflow
Diversions

FIGURE B-1

due to scaling and aging. Records show that the system is currently delivering approximately 106,000 acre-feet per year (2.89 BG/Mo) during capacity flow conditions, a reduction in capacity to 84.5 percent of the original condition.

Population and Water Demand

Based on Texas Water Development Board (TWDB) population projections, a total population growth in the user municipalities of 38.7 percent is projected during the 50 year period from 1990 to 2040, with the larger cities (Amarillo and Lubbock) showing the greatest increase in population during this time period. The City of Brownfield has indicated that their population should stabilize or increase over the time period (contrary to TWDB projections) due to the addition of prison facilities in the City. Water demand is expected to grow in proportion to population. Some municipalities have indicated that they could expect a slightly higher increase in water demand over the population growth due to potential industrial development. Table B-1 shows the projections of population as proposed by TWDB along projected annual water usage for each of the municipalities disregarding any large industrial development. A graphical illustration of the total projected water usage for all municipalities is shown in Figure B-2. Also indicated on Figure B-2 is the current system capacity and the recent average CRMWA water supply.

Most of the municipalities, with the exception of Amarillo and to some extent Borger and Plainview, supplement CRMWA water with local ground water to meet quantity demands in excess of that supplied by CRMWA. Amarillo currently blends high quality groundwater with CRMWA water to meet current state regulations, such as chloride and total dissolved solids, on a year round basis. Figure B-3 shows graphically the historical total use of CRMWA water and local ground water for each year from 1965 to 1991. Table B-2 shows the average yearly consumption of ground water, CRMWA water, and total consumption for each municipality based on the last ten years of usage. Also shown in this table is the corresponding percentage use of ground water and CRMWA water. As can be seen, the municipalities have typically supplied approximately 35 percent of their total water use from city owned well water and approximately 65 percent has been supplied by CRMWA.

TABLE B-1

Canadian River Municipal Water Authority
Projected Water Use

City	Current Population 1990	Projected Population 2000	2010	2020	2030	2040	Projected Water Use (Million Gallons per Year) 2000	2010	2020	2030	2040
Amarillo	157,615	168,580	184,465	198,921	213,742	226,787	15,043	16,461	17,750	19,073	20,237
Borger	15,675	15,780	15,826	15,686	15,510	15,335	1,591	1,596	1,582	1,564	1,547
Brownfield	9,560	9,236	8,982	8,737	8,499	8,269	479	466	454	441	429
Lamesa	10,809	11,102	11,701	11,621	11,564	11,476	628	662	657	654	649
Levelland	13,986	15,255	16,204	17,238	18,362	19,570	837	889	946	1,008	1,074
Lubbock	186,206	206,744	227,680	245,765	262,962	281,325	13,703	15,091	16,290	17,429	18,646
O'Donnell	1,102	1,067	1,040	1,019	1,027	1,039	45	43	43	43	43
Pampa	19,959	19,327	19,301	18,976	18,665	18,504	1,369	1,367	1,344	1,322	1,311
Plainview	21,700	22,334	22,770	23,105	23,552	24,068	1,623	1,655	1,679	1,712	1,749
Slaton	6,078	6,273	6,303	7,164	8,246	8,999	293	295	335	386	421
Tahoka	2,868	2,783	2,703	2,628	2,580	2,570	145	141	137	135	134
TOTAL	**445,558**	**478,481**	**516,975**	**550,860**	**584,709**	**617,942**	**35,757**	**38,666**	**41,217**	**43,766**	**46,240**

SOURCE: Texas Water Development Board
NOTE: All average water consumption data is based on 10-year average of CRMWA furnished data.

TABLE B–2

Canadian River Municipal Water Authority
Water Consumption Rates

City	County	Average Annual Water Consumption (gallons)			Water Distribution		Per Capita Water Consumption (gallons)	
		Wells	CRMWA	Total	Wells	CRMWA	Per Year	Per Day
Amarillo	Potter	7,253.616	6,810.961	14,064.576	51.6%	48.4%	89,233.74	244.48
Borger	Hutchinson	656.087	924.734	1,580.821	41.5%	58.5%	100,849.82	276.30
Brownfield	Terry	38.119	458.114	496.232	7.7%	92.3%	51,907.11	142.21
Lamesa	Dawson	68.187	543.124	611.310	11.2%	88.8%	56,555.65	154.95
Levelland	Hockley	153.847	613.596	767.433	20.0%	80.0%	54,871.51	150.33
Lubbock	Lubbock	1,909.665	10,432.244	12,341.910	15.5%	84.5%	66,280.95	181.59
O'Donnell	Lynn	1.028	44.991	46.019	2.2%	97.8%	41,759.53	114.41
Pampa	Gray	602.445	811.316	1,413.761	42.6%	57.4%	70,833.26	194.06
Plainview	Hale	840.141	737.138	1,577.318	53.3%	46.7%	72,687.47	199.14
Slaton	Lubbock	0.000	284.157	284.157	0.0%	100.0%	46,751.73	128.09
Tahoka	Lynn	40.994	108.562	149.556	27.4%	72.6%	52,146.44	142.87
AVERAGE/TOTAL		**11,564**	**21,769**	**33,333**	**34.7%**	**65.3%**	**63,988.84**	**175.31**

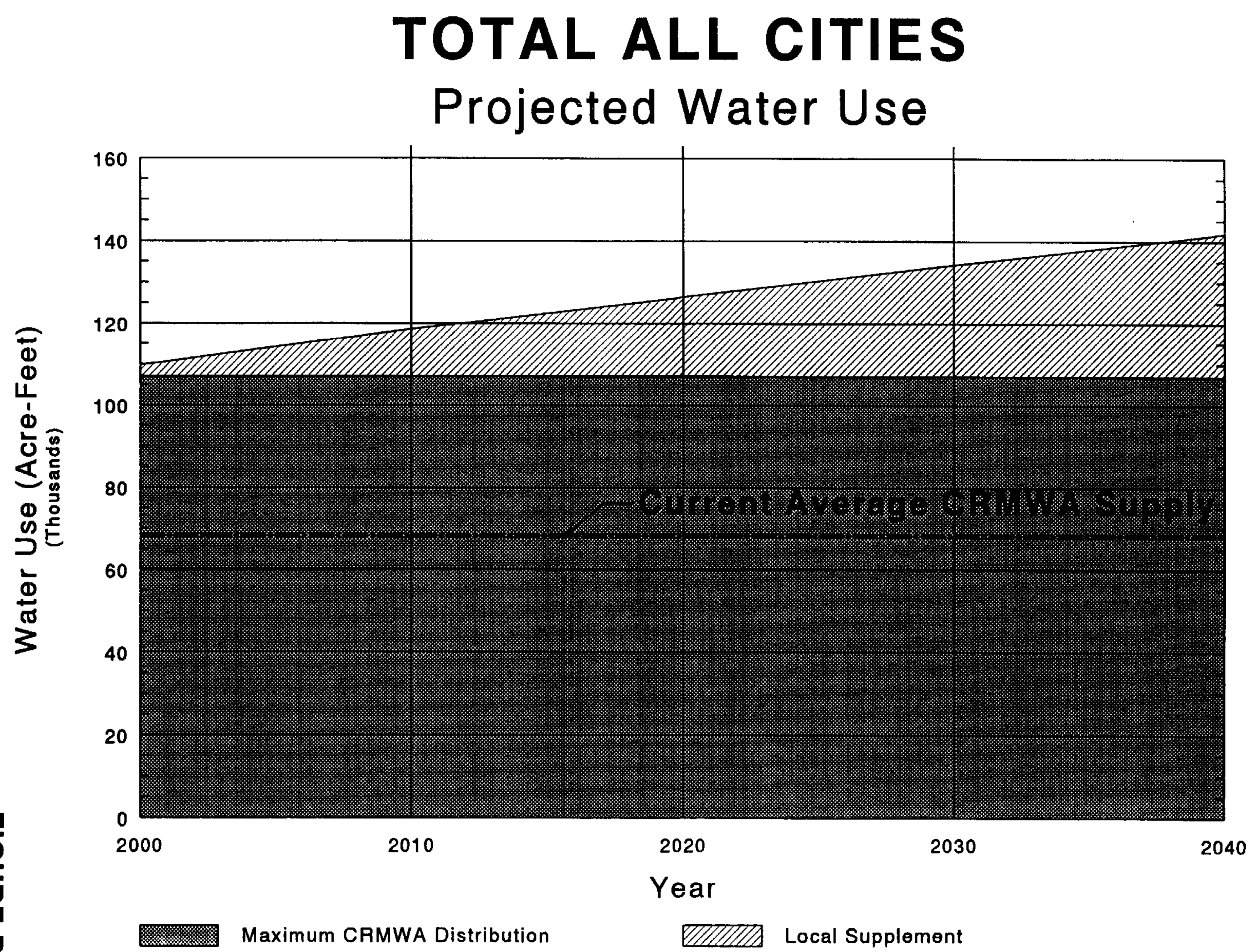

TOTAL ALL CITIES
Projected Water Use
Water Use (Acre-Feet)
(Thousands)
160
140
120
100
80
60
40
20
0
2000
2010
2020
2030
2040
Year
Current Average CRMWA Supply
Maximum CRMWA Distribution
Local Supplement

FIGURE B-2

TOTAL ALL CITIES

Water Usage (1965-1991)

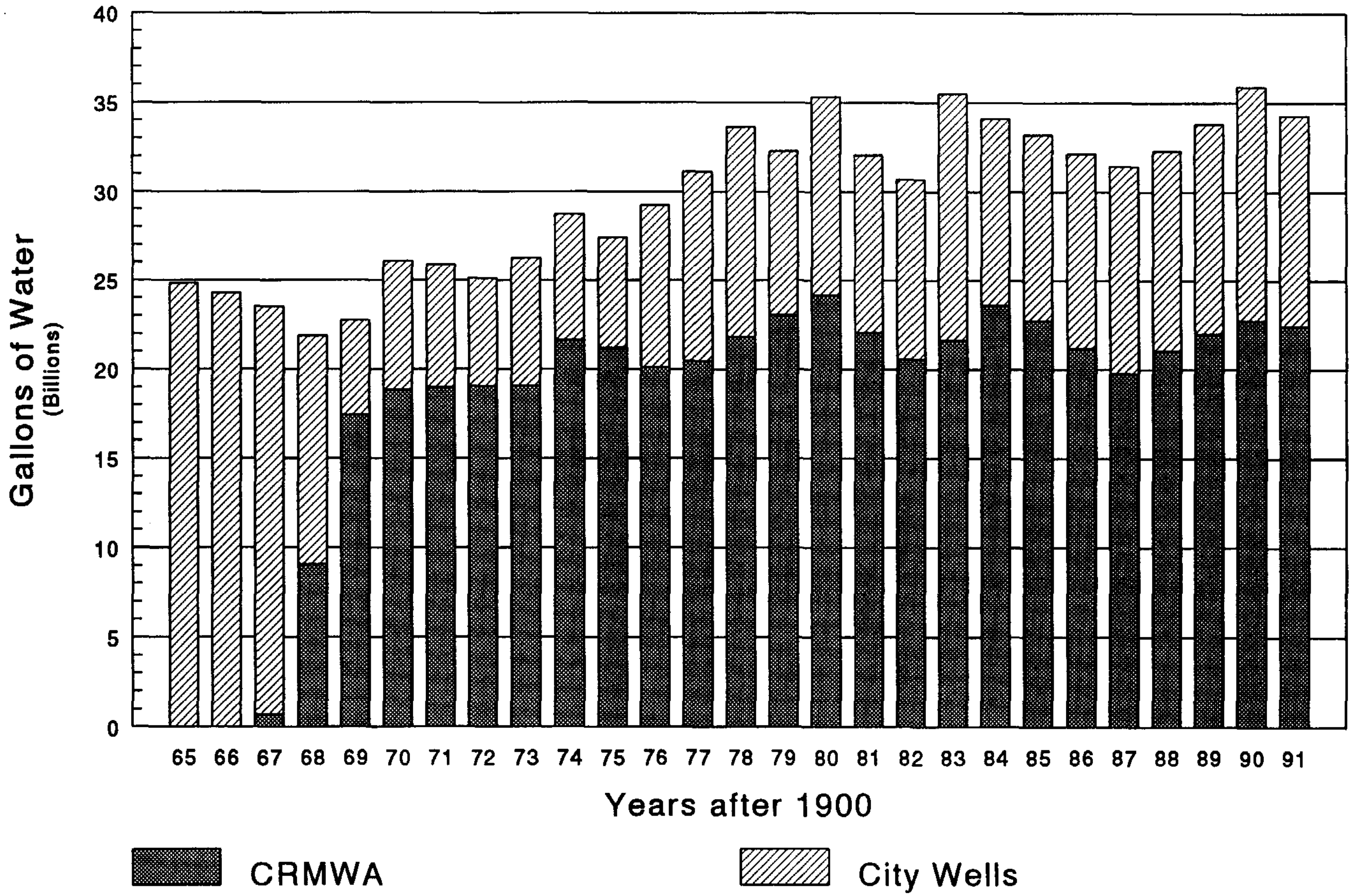


FIGURE B-3

Indications are from most of the municipalities that current groundwater reserves have adequate capacity for the near future at current water demand needs. However, most of the member Cities would like to preserve those sources, if possible.

The last column of Table B-2 reports the per capita yearly water consumption of each community. The per capita consumption of all municipalities is shown as 74,812.02 gallons per capita per year (205 gallons per capita per day) which is approximately 25 percent higher than the average statewide per capita consumption. The higher consumption is attributed to the arid climate which exists in these communities requiring more water for landscape irrigation. Another reason for the high per capita consumptions is the fact that the cities of Amarillo, Borger and Plainview, which have an even higher per capita consumption, currently supply industrial users with a significant amount of water both from CRMWA and from city wells. If the large industrial users in these member cities are disregarded, the average per capita consumption falls to 57,326.30 gallons per capita per year (157 gallons per capita per day) which is more in line with the statewide average.

The total annual usage of CRMWA water has historically fallen below the allotted quantity each year. This is due mostly to reduced demand during winter months. Figure B-4 shows a comparison of total annual usage and allocations for each year from 1968 to 1991.

In addition to annual fluctuation of water usage, there is a historically consistent pattern of seasonal usage. As would be expected, peak usage occurs in the hotter growing months of June, July and August. Figure B-5 shows the average monthly usage of both CRMWA and city supplied well water for all CRMWA municipalities during the decade ending in 1990. Also shown on this graph is the ten year peak of total water usage for each month and the year the peak occurred. A line representing the current maximum capacity of the CRMWA pipeline is shown to illustrate that all usage exceeding that amount must be supplied by alternate sources. It should be noted that water use by the southern cities (Lubbock, Slaton, Tahoka, Levelland, Brownfield, Lamesa and O'Donnell) is even more demanding on the system than this graph illustrates. During the months of high

USAGE vs ALLOCATION

Total All Cities (1965-1991)

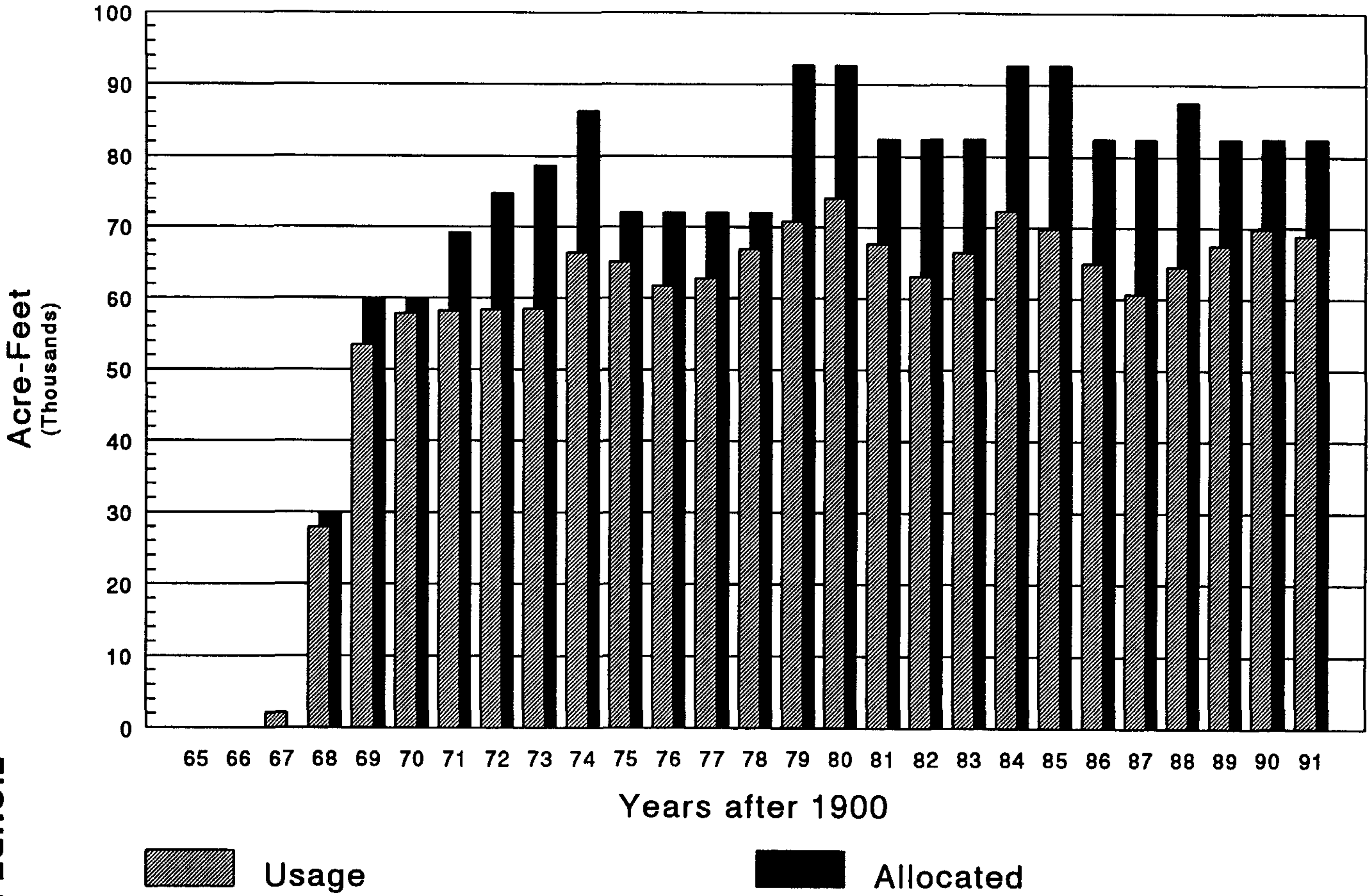


FIGURE B-4

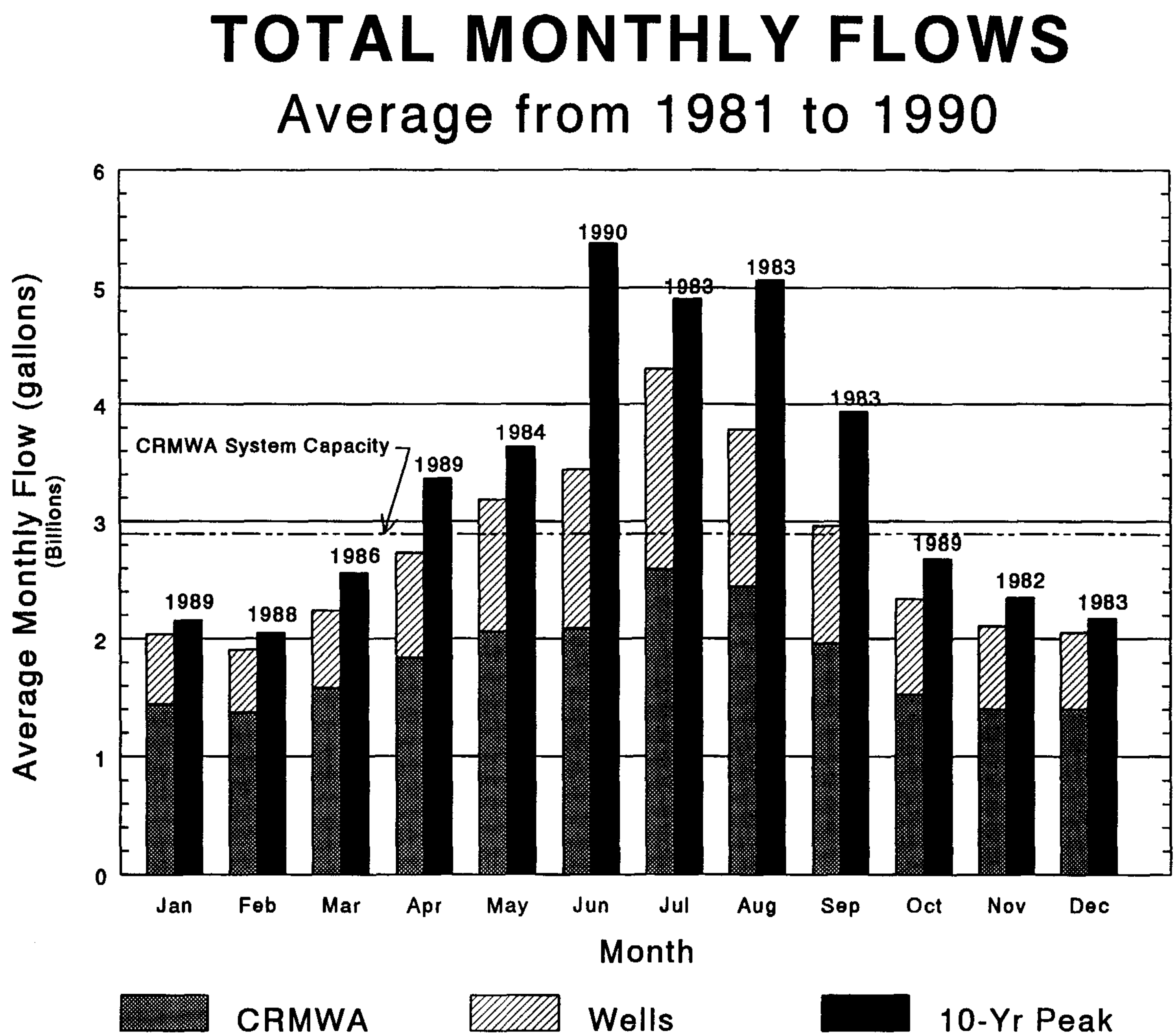

TOTAL MONTHLY FLOWS
Average from 1981 to 1990
Average Monthly Flow (gallons)
(Billions)
0
1
2
3
4
5
6
CRMWA System Capacity
1989
1988
1986
1989
1984
1990
1983
1983
1983
1989
1982
1983
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
CRMWA
Wells
10-Yr Peak

FIGURE B-5

water demand the pipeline from Amarillo south to Lubbock is at its maximum capacity. The fact that Amarillo and Borger blend water for quality rather than quantity purposes tends to skew the data. Water demand south of Amarillo is already meeting the system capacity during the warmer months.

Historical and projected water quantity data for each of the member cities are included at the end of this report. Three figures for each city are included to illustrate historic and projected water use as well as to indicate the particular cities seasonal variations in water use.

Water Treatment Plant Capabilities

The CRMWA member cities are served by five (5) separate water treatment plants. The cities of Amarillo, Borger, Pampa and Plainview treat water at their own water treatment plant facilities. The Lubbock Water Treatment Plant serves the cities of Lubbock, Levelland, Brownfield, Slaton, Tahoka, O'Donnell and Lamesa.

The Amarillo Water Treatment Plant has a current capacity of 25 million gallons per day (MGD) with expansion planned to 40 MGD. Borger currently has a treatment capacity of 5 MGD with a possible increase of an additional 3 MGD in the future. The Plainview Water Treatment Plant has a capacity of 4 MGD. The Pampa Water Treatment Plant has a current capacity of 4 MGD. The City plans to upgrade the water treatment plant capacity within the next ten years. Treatment capacity at the Lubbock Water Treatment Plant is currently being upgraded to 75 MGD. This additional capacity should provide adequate water treatment capacity for the southern CRMWA cities.

With the above mentioned upgrades, the member cities of CRMWA should have adequate water treatment capacity and facilities to provide sufficient and safe drinking water into the near future.

Lake Meredith Water Quality

The salinity of Lake Meredith has been on an upward trend since its establishment. Substantial reductions were recorded in 1981 and 1982, but in the following years the chloride concentrations have continued an upward trend.

Current Environmental Protection Agency (EPA) secondary regulations state that approved municipal drinking water have a maximum concentration of chlorides of 250 mg/l with state regulations set at 300 mg\l. The chloride concentrations in the reservoir water have rarely fallen below the state limit. Total dissolved solids (TDS) concentrations in the lake are also currently exceeding state standards with sulfate levels approaching the current state regulation. The state standards for TDS and sulfates are 1000 and 300 mg/l respectively. The lake is currently producing water with a TDS concentration of approximately 1240 mg/l and a sulfate concentration of 270 mg/l.

Funding has been appropriated to study and reduce chloride concentrations in the Canadian River. A Salinity Control Project is underway to reduce chloride loadings to the Canadian River upstream of Lake Meredith. The project could possibly to reduce chloride concentrations at Lake Meredith Reservoir by 25 percent when the controls are put into service.

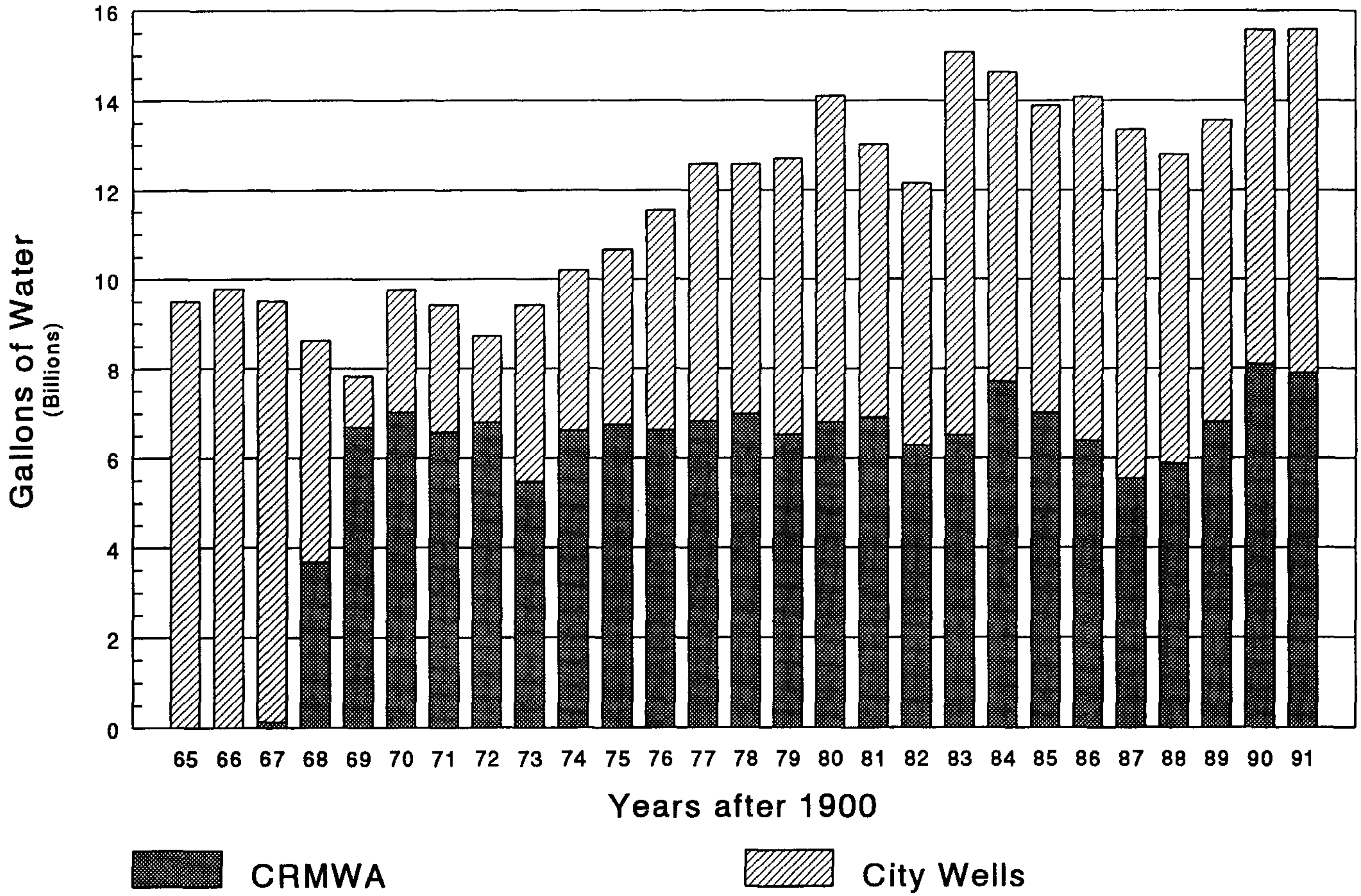
As mentioned earlier, two of the CRMWA member municipalities, Amarillo and Borger, currently blend local well water with delivered CRMWA water before the water enters the distribution system. Amarillo blends well water strictly to reduce chloride concentrations to about 300 mg/l by dilution. Borger blends well water with CRMWA water for general distribution, but also supplies some industries with 100 percent well water. Plainview also blends some well water with lake water, but most well water is injected directly into the distribution system to meet peak demands rather than to improve water quality.

Other municipalities that use well water in addition to CRMWA water do not blend the two sources prior to distribution, but simply inject well water at isolated points within the distribution system when peak demands require additional water. The cities which are served by the Lubbock Water Treatment

Plant (Lubbock, Slaton, Tahoka, Levelland, Brownfield, Lamesa and O'Donnell) cannot blend well and lake water simply because water is provided to these cities in a treated form, and cannot currently be blended upstream of the Lubbock Water Treatment Plant. Additionally, most groundwater sources which are available to the southern cities (south of Lubbock) are of poor quality and would not provide a substantial increase in quality if blended with CRMWA water. Generally, groundwater used by the northern cities (Amarillo, Borger and Pampa) is of an acceptable quality for blending purposes.

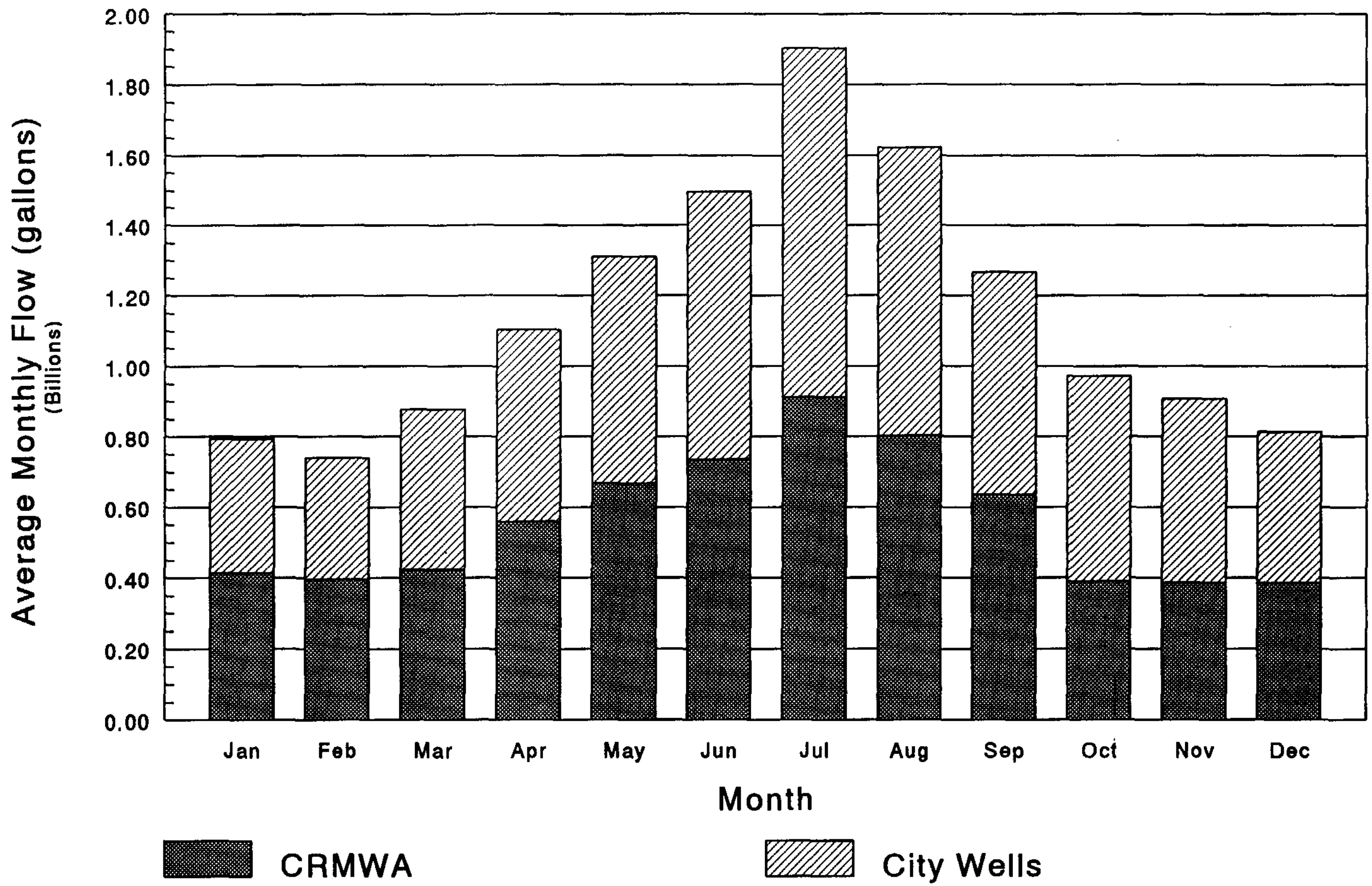
CITY OF AMARILLO

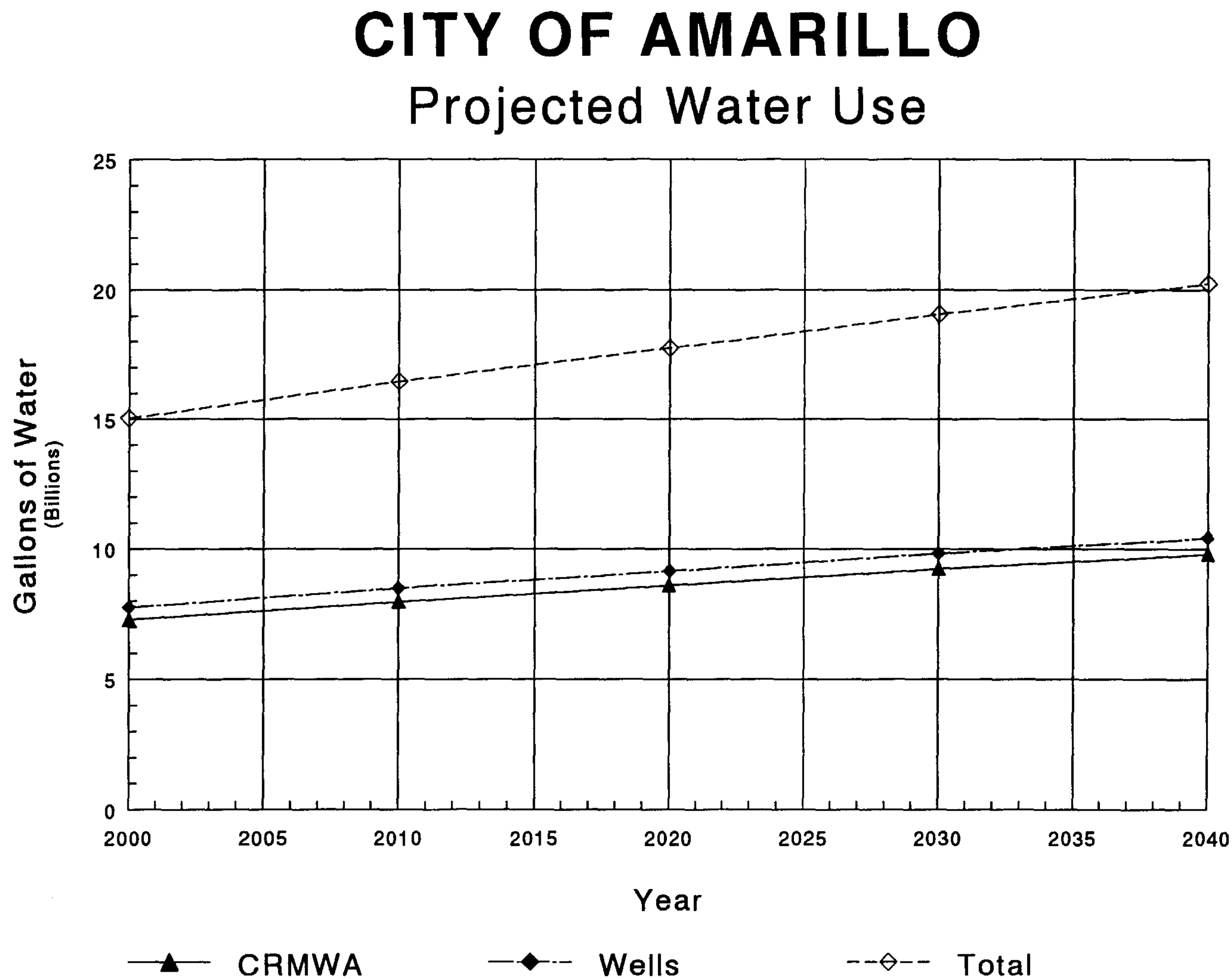
Water Usage (1965-1991)

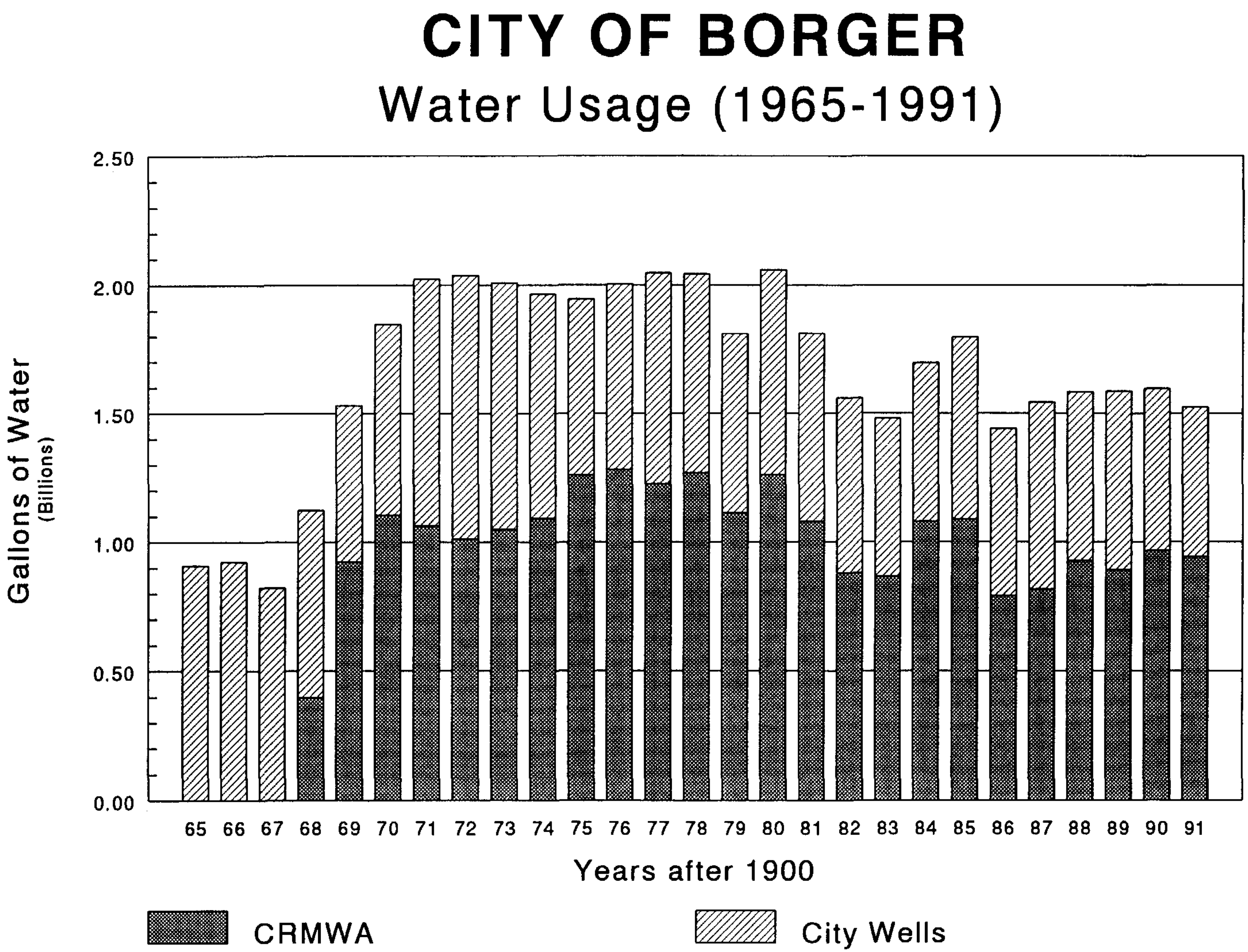


AMARILLO - MONTHLY FLOWS

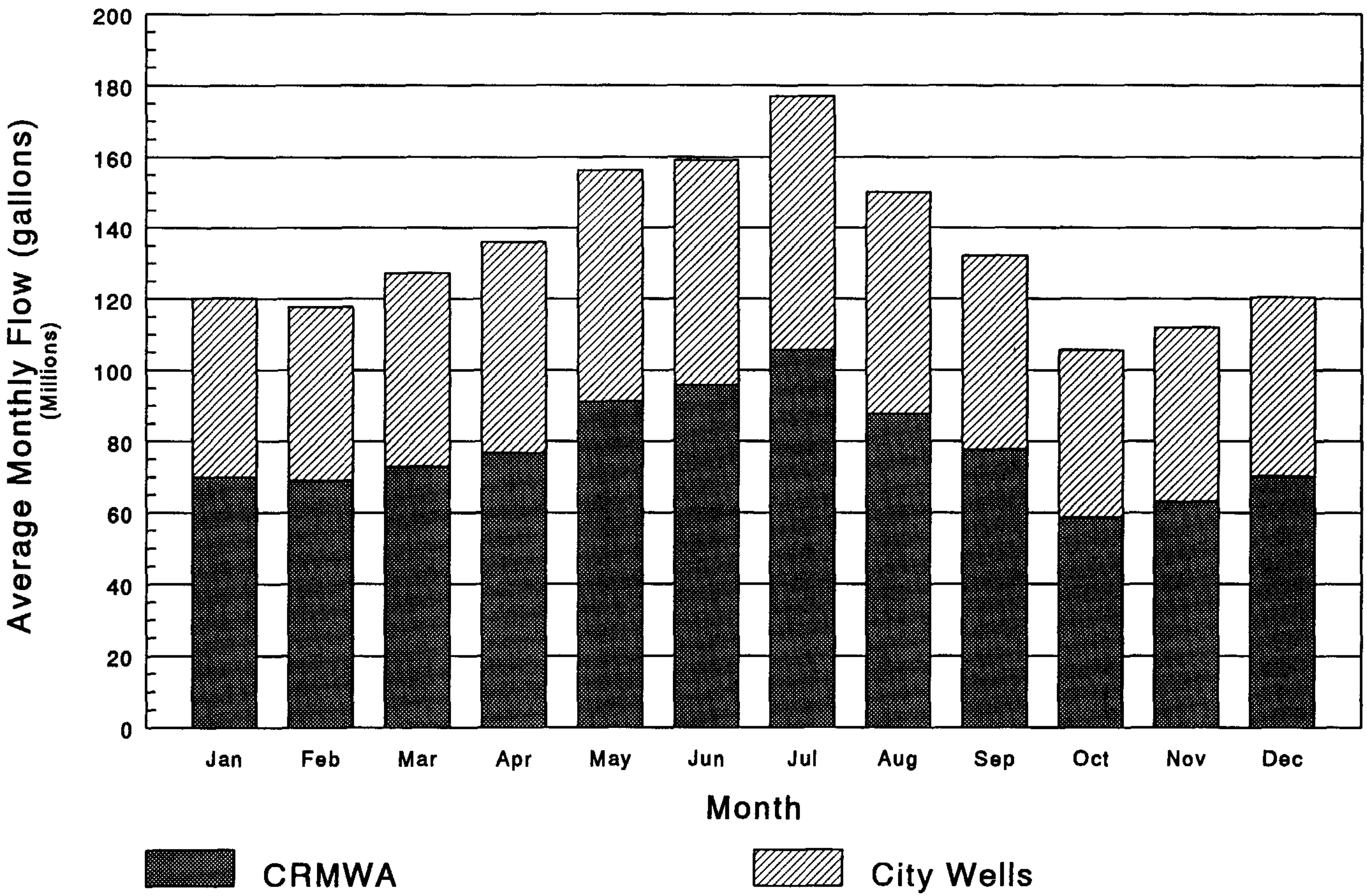
Average from 1981 to 1990

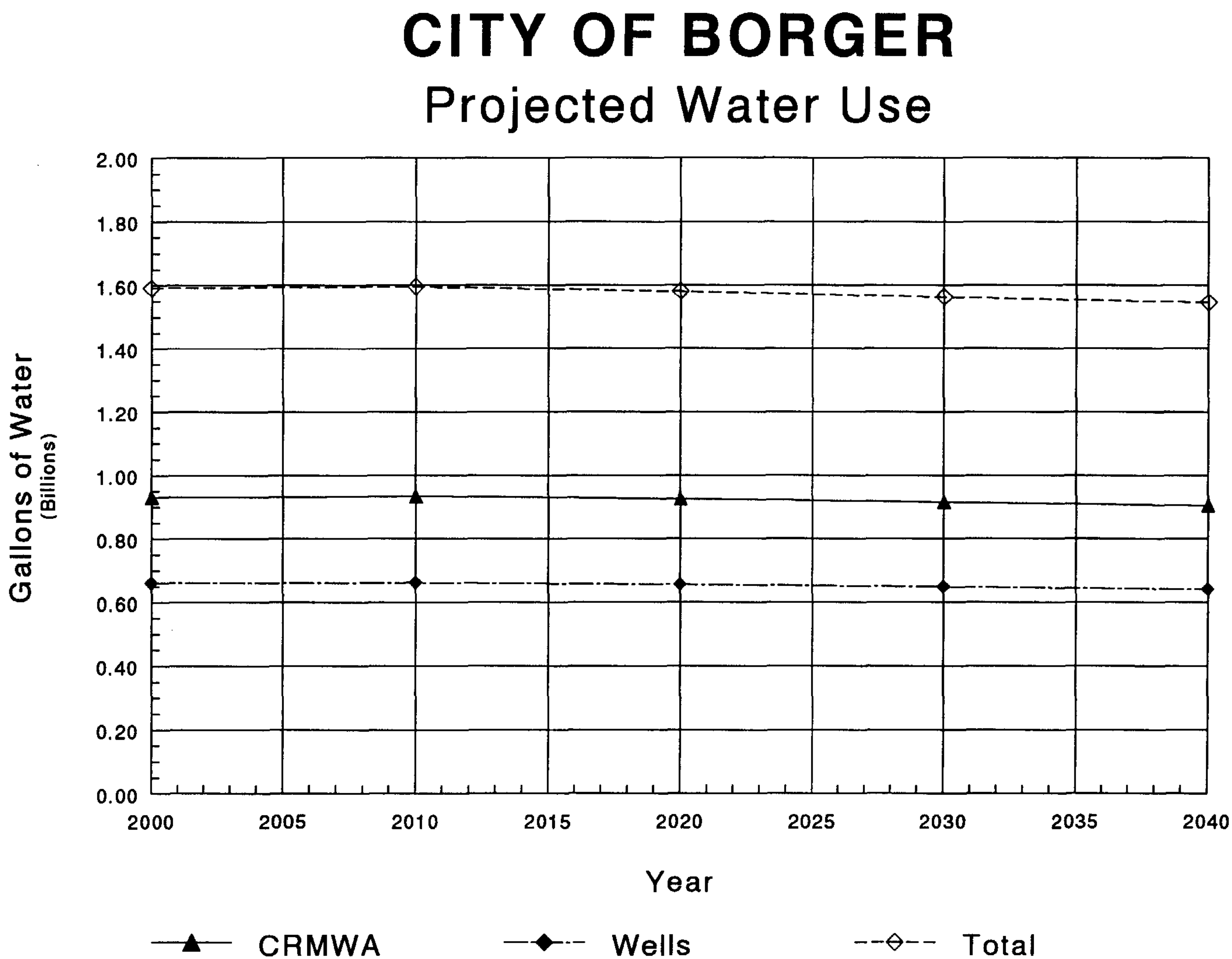



CITY OF AMARILLO
Projected Water Use
Gallons of Water
(Billions)
0
5
10
15
20
25
2000
2005
2010
2015
2020
2025
2030
2035
2040
Year
CRMWA
Wells
Total


CITY OF BORGER
Water Usage (1965-1991)
Gallons of Water
(Billions)
2.50
2.00
1.50
1.00
0.50
0.00
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
Years after 1900
CRMWA
City Wells

BORGER - MONTHLY FLOWS
Average from 1981 to 1990

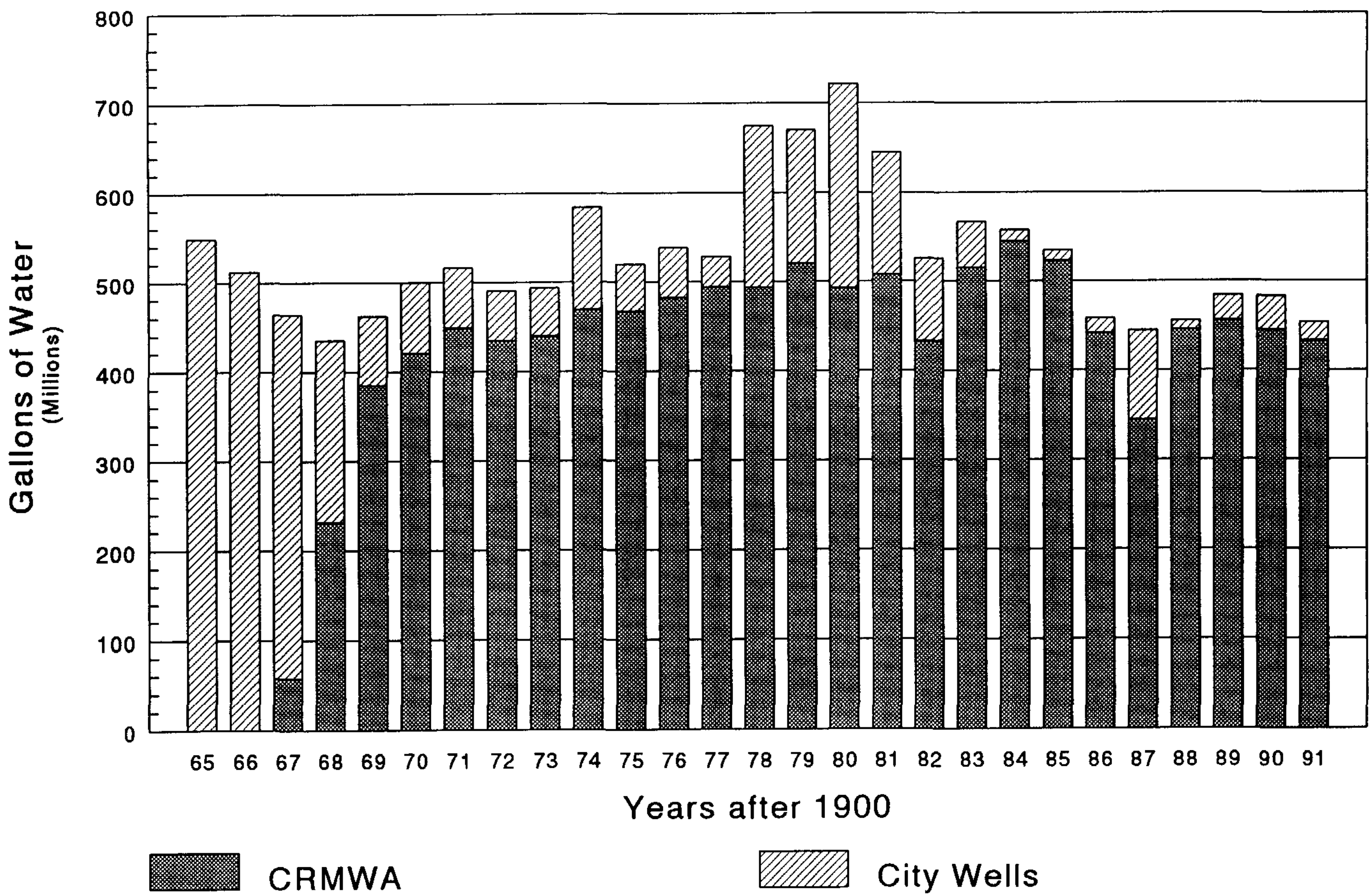




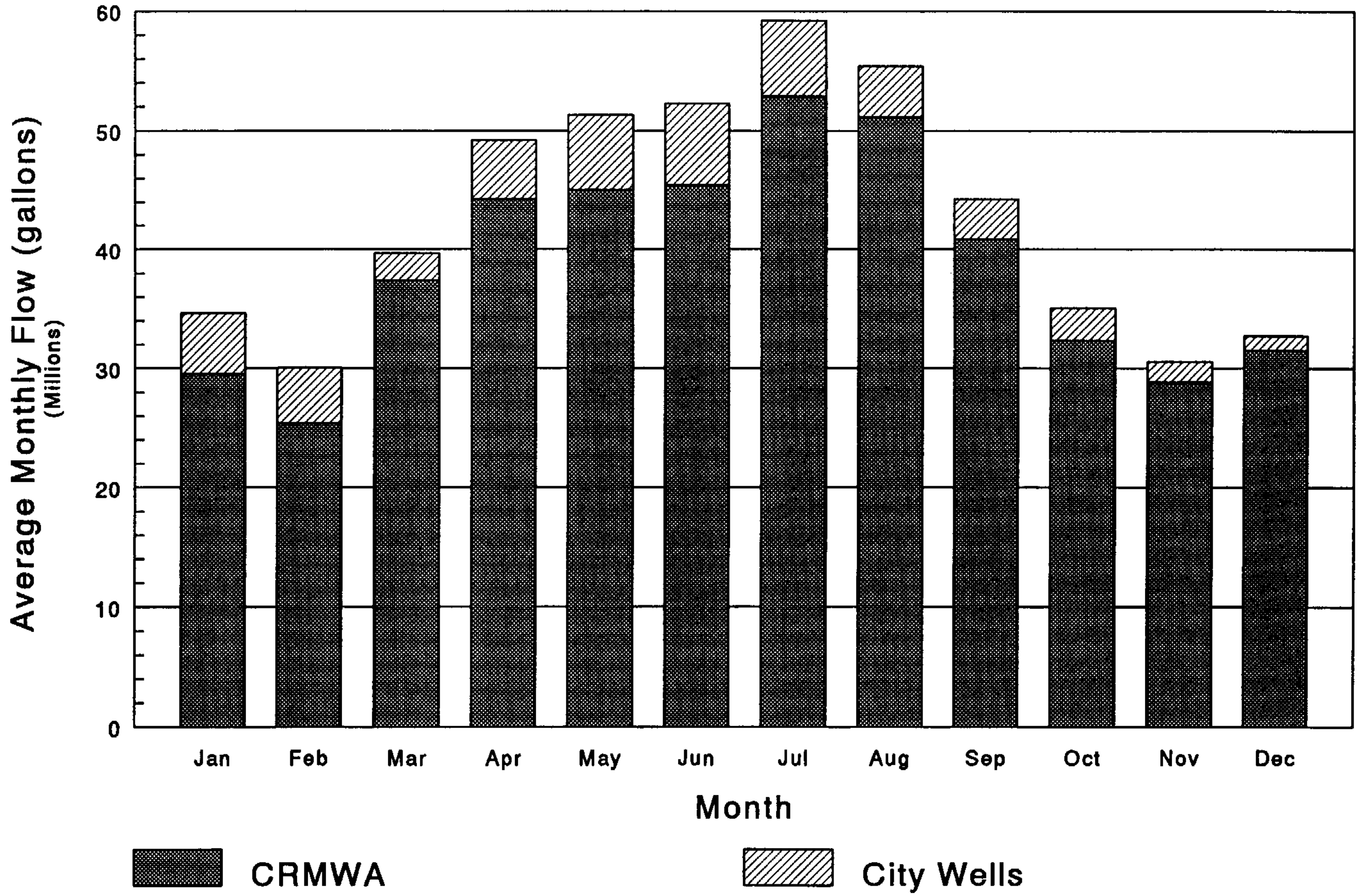
CITY OF BORGER
Projected Water Use
Gallons of Water
(Billions)
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
2000
2005
2010
2015
2020
2025
2030
2035
2040
Year
CRMWA
Wells
Total

CITY OF BROWNFIELD

Water Usage (1965-1991)

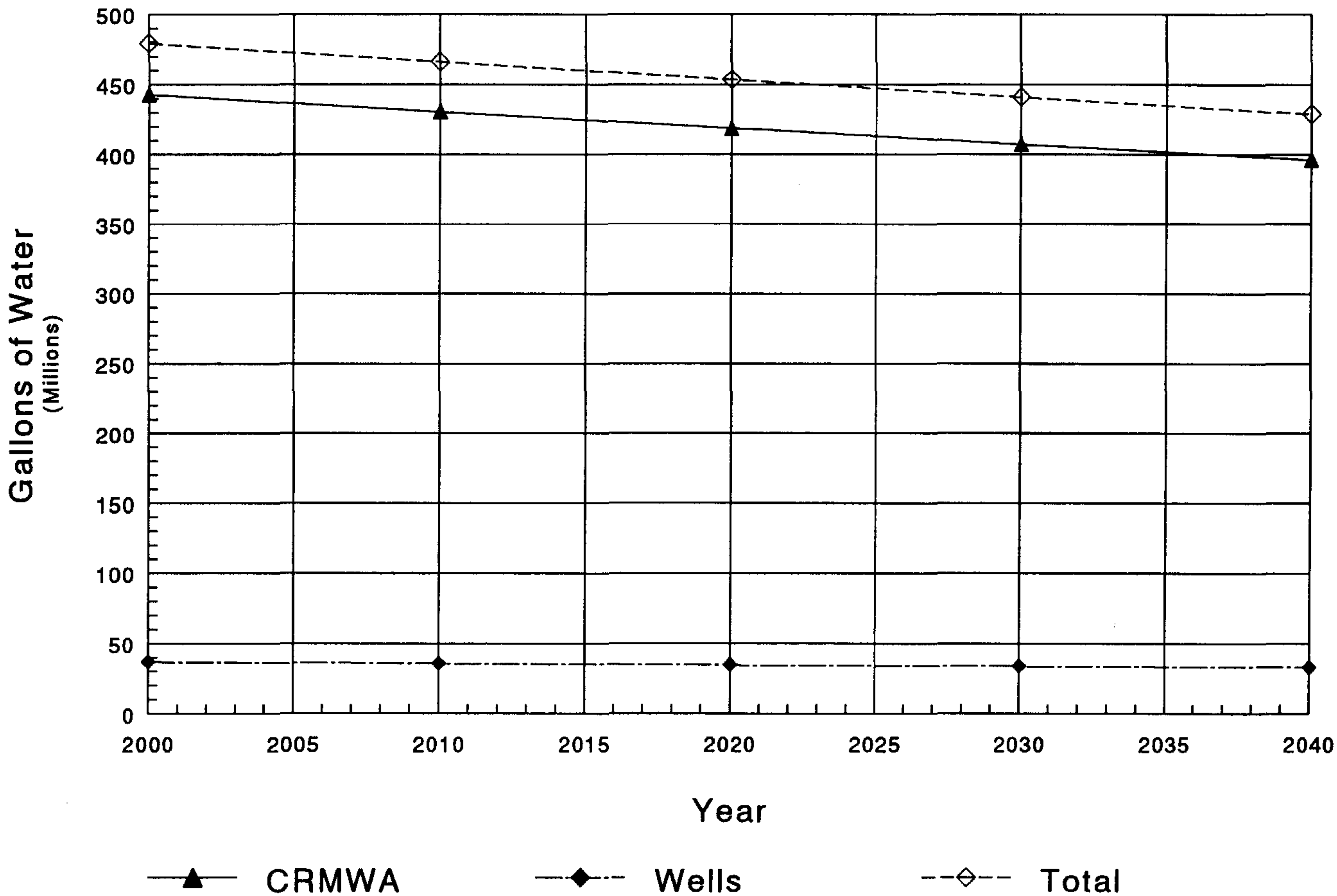


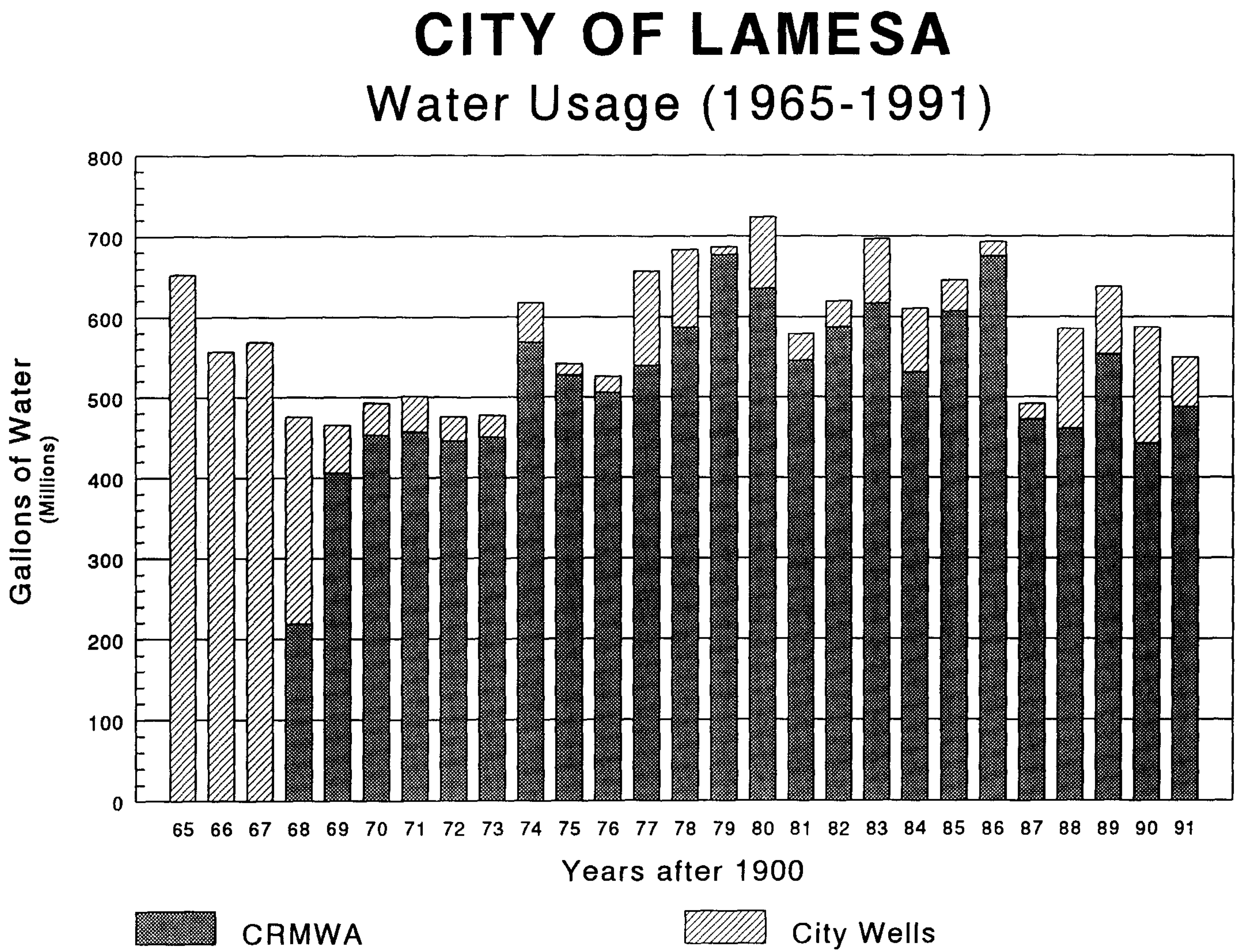
BROWNFIELD - MONTHLY FLOWS
Average from 1981 to 1990

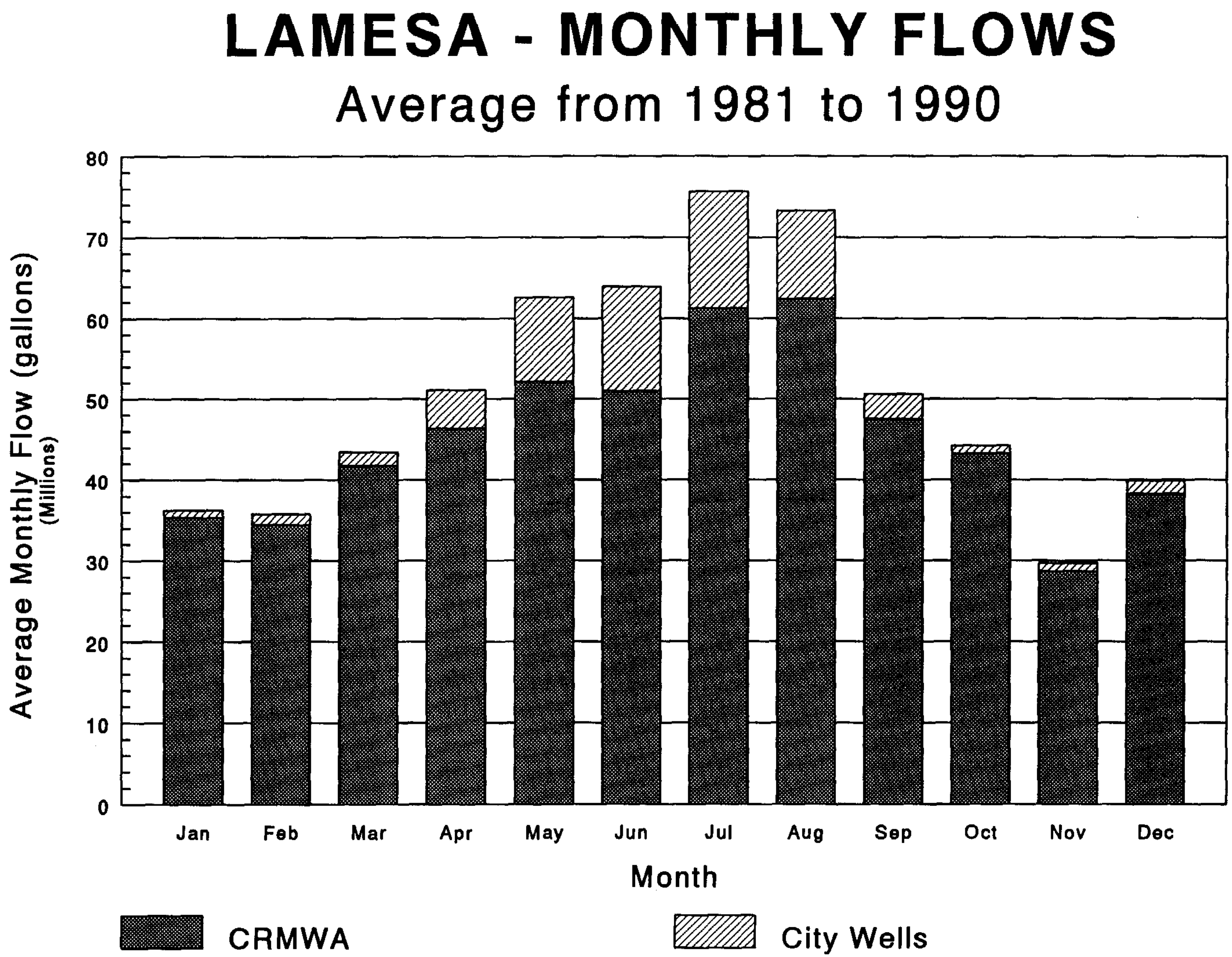


CITY OF BROWNFIELD

Projected Water Use

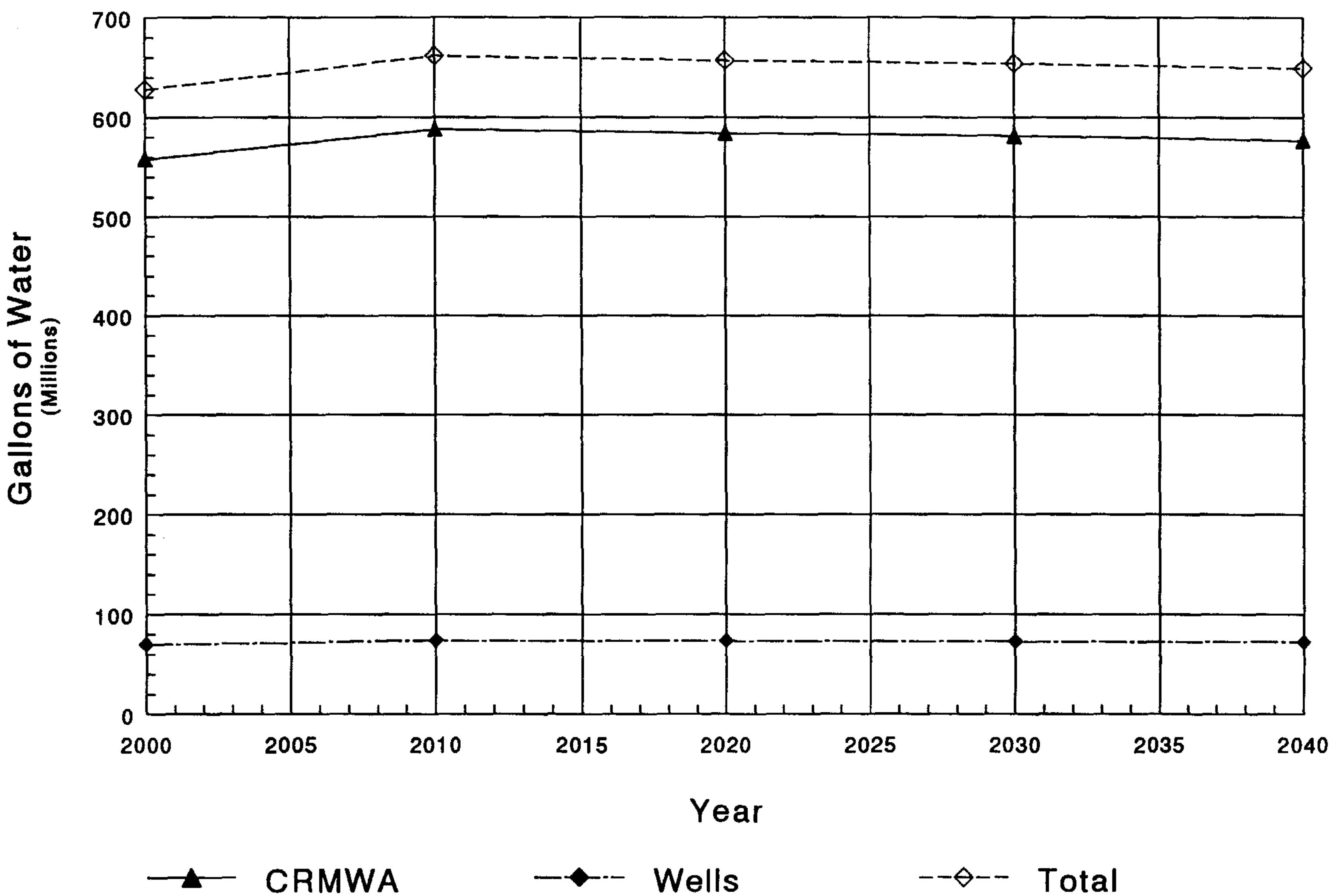


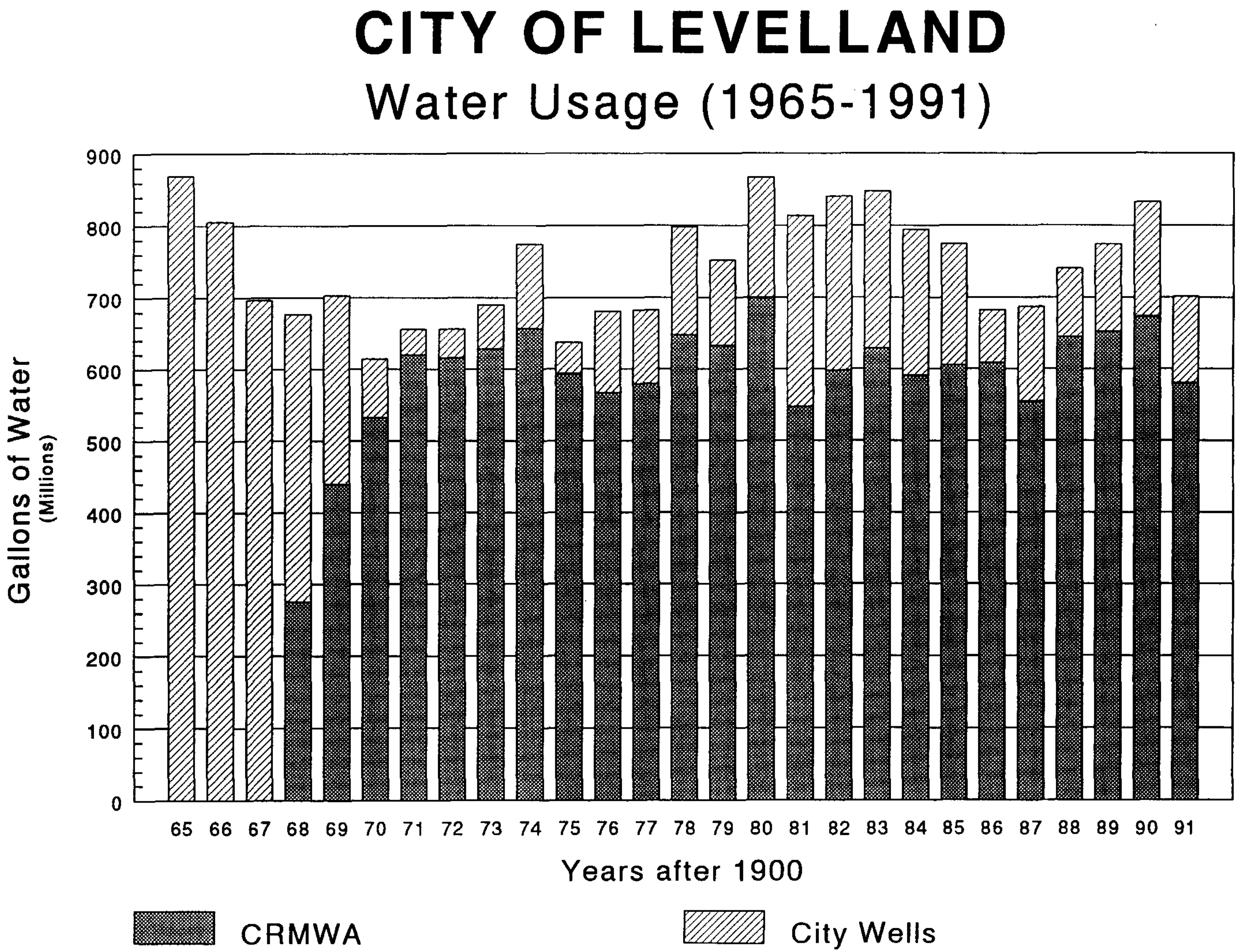

CITY OF LAMESA
Water Usage (1965-1991)
Gallons of Water
(Millions)
800
700
600
500
400
300
200
100
0
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
Years after 1900
CRMWA
City Wells


LAMESA - MONTHLY FLOWS
Average from 1981 to 1990
Average Monthly Flow (gallons)
(Millions)
80
70
60
50
40
30
20
10
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
CRMWA
City Wells

CITY OF LAMESA

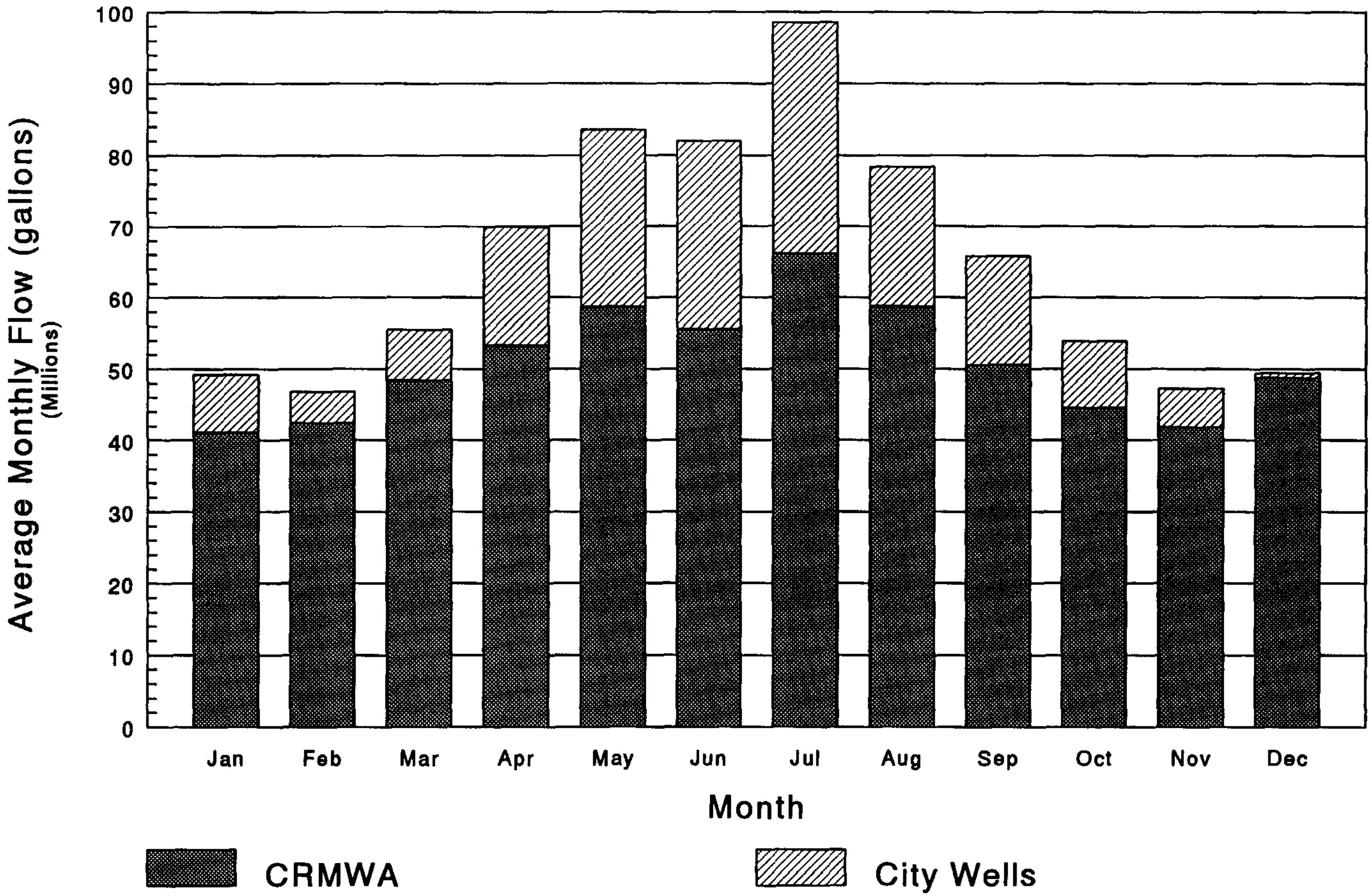
Projected Water Use




CITY OF LEVELLAND
Water Usage (1965-1991)
Gallons of Water
(Millions)
900
800
700
600
500
400
300
200
100
0
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
Years after 1900
CRMWA
City Wells

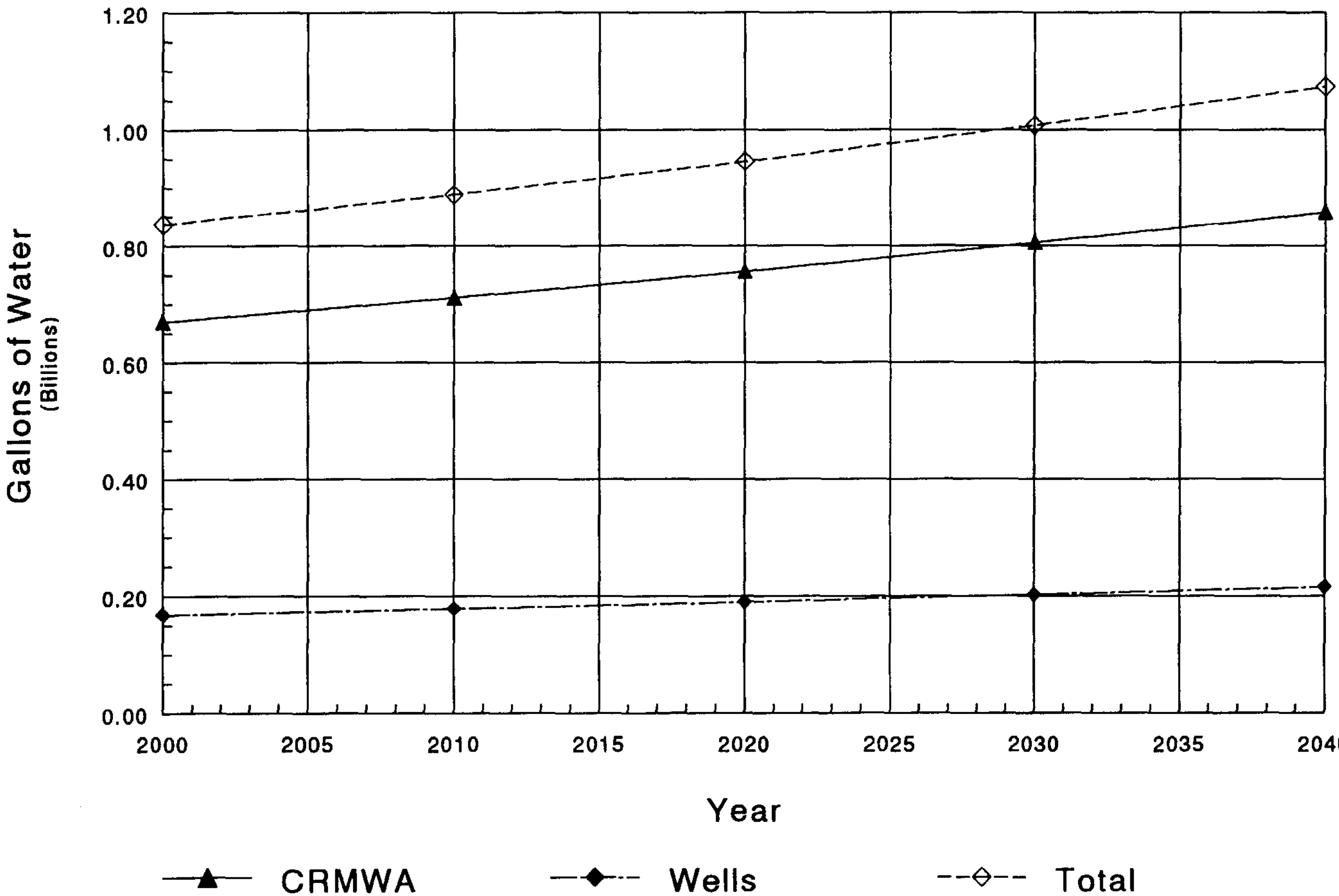
LEVELLAND - MONTHLY FLOWS

Average from 1981 to 1990



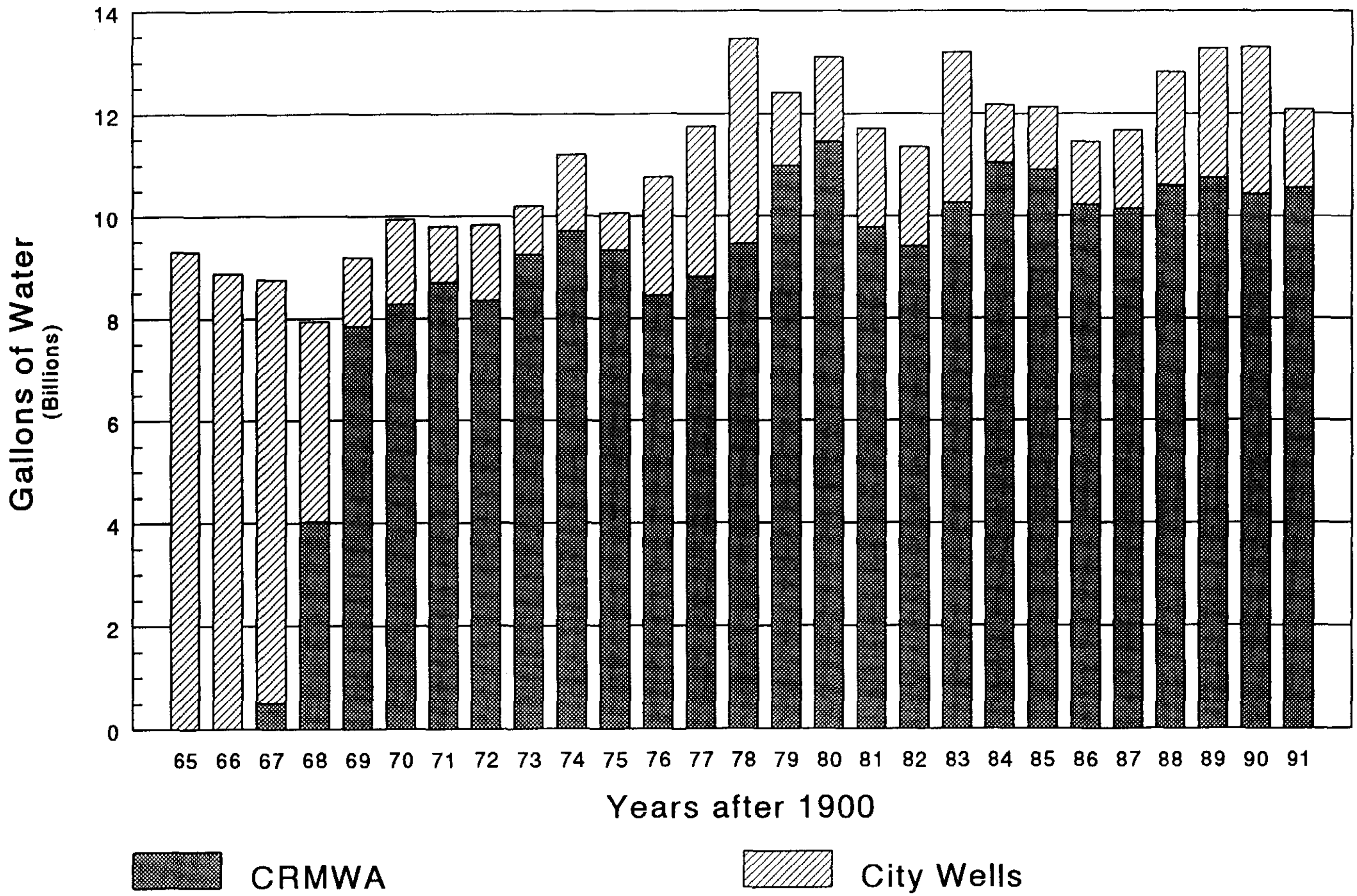
CITY OF LEVELLAND

Projected Water Use



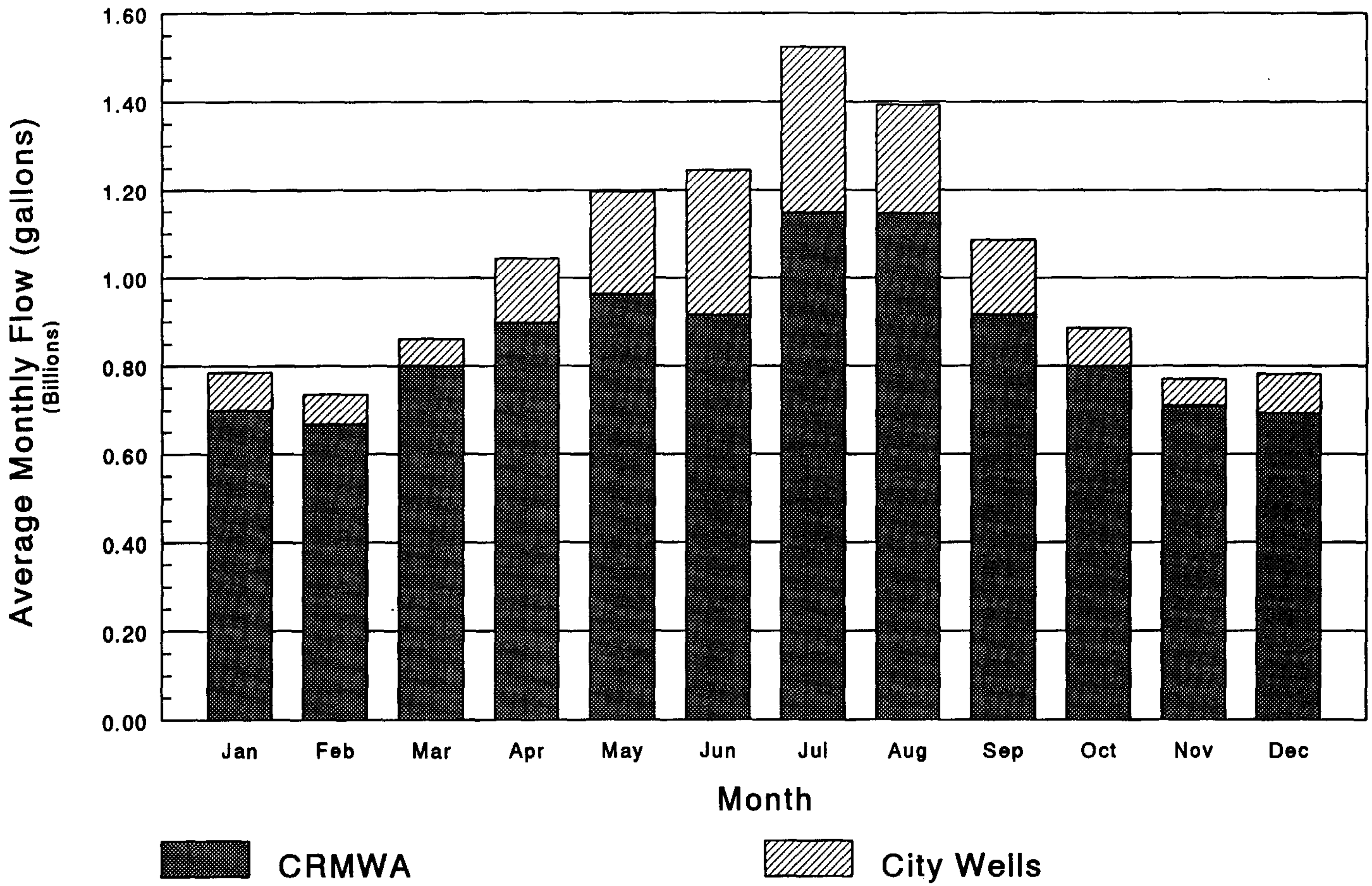
CITY OF LUBBOCK

Water Usage (1965-1991)

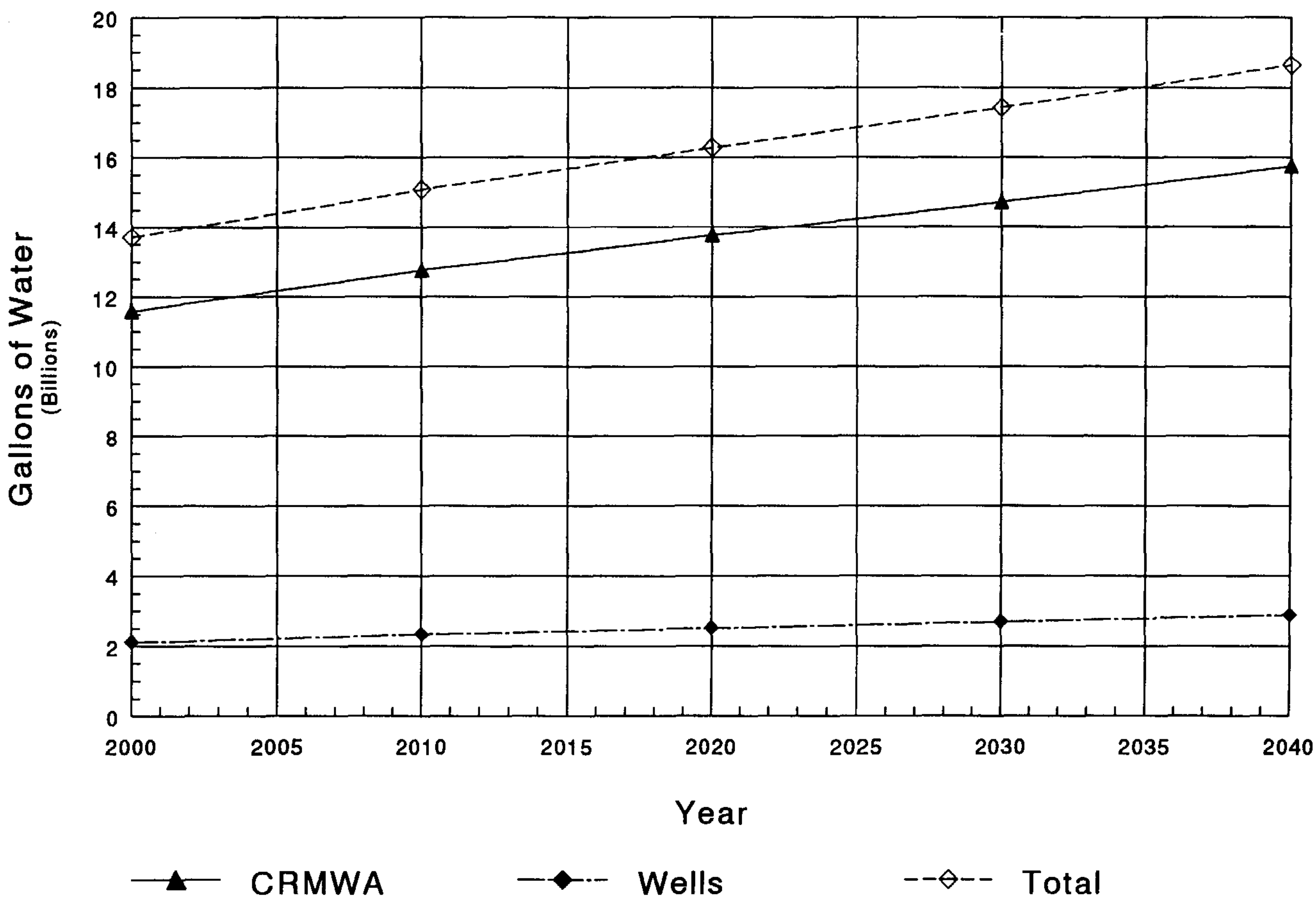


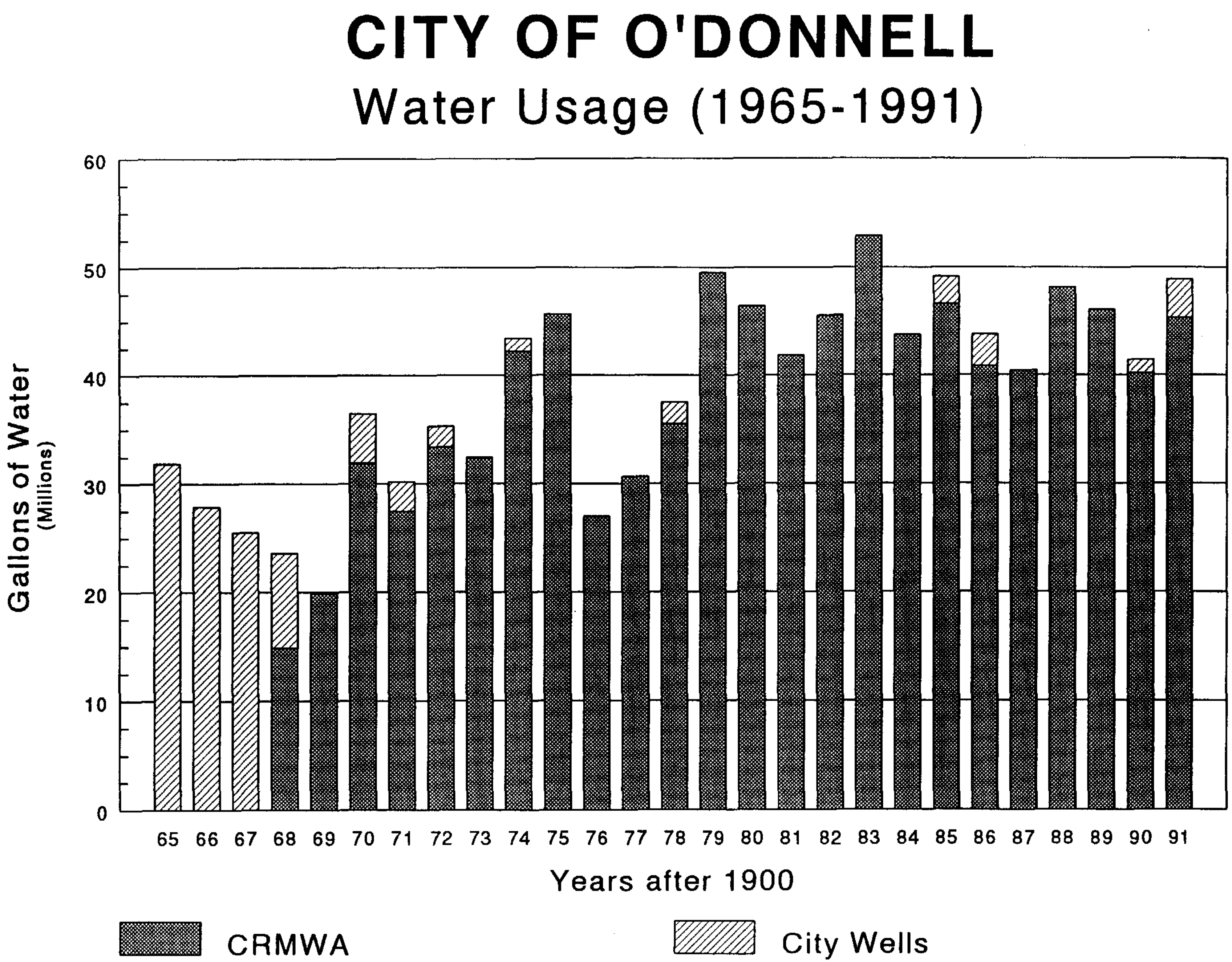
LUBBOCK - MONTHLY FLOWS

Average from 1981 to 1990



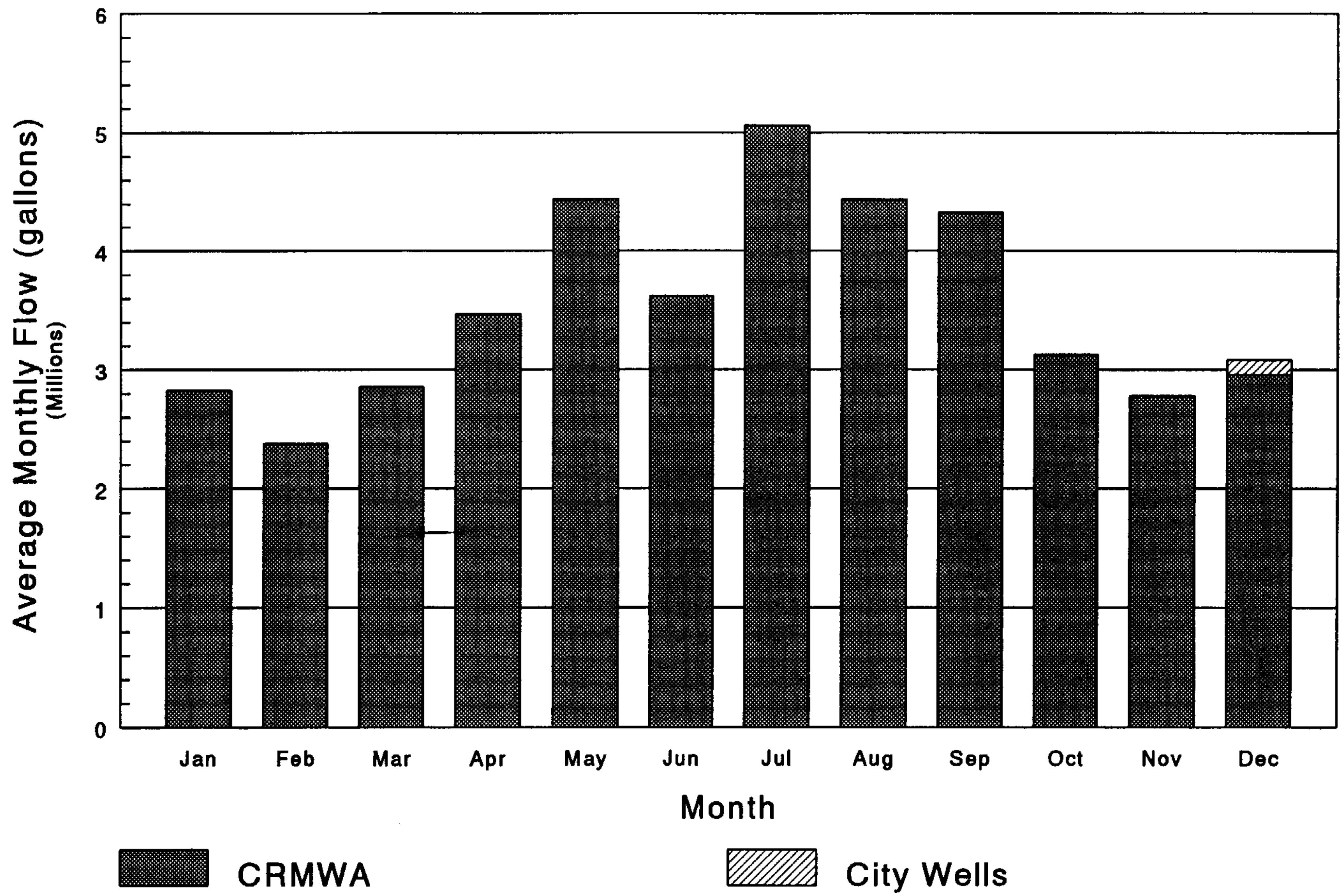
CITY OF LUBBOCK
Projected Water Use




CITY OF O'DONNELL
Water Usage (1965-1991)
Gallons of Water
(Millions)
60
50
40
30
20
10
0
65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91
Years after 1900
CRMWA
City Wells

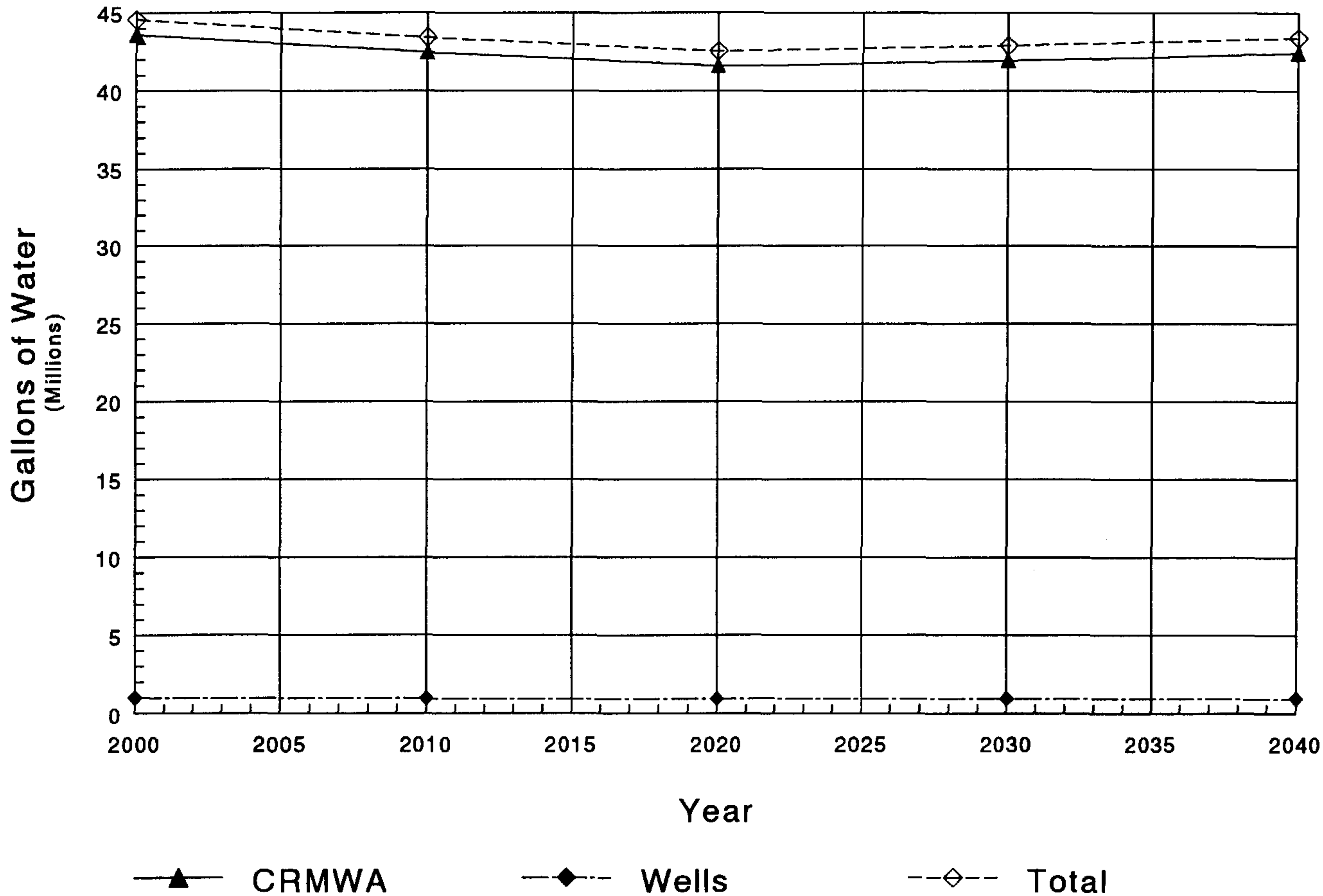
O'DONNELL - MONTHLY FLOWS

Average from 1981 to 1990



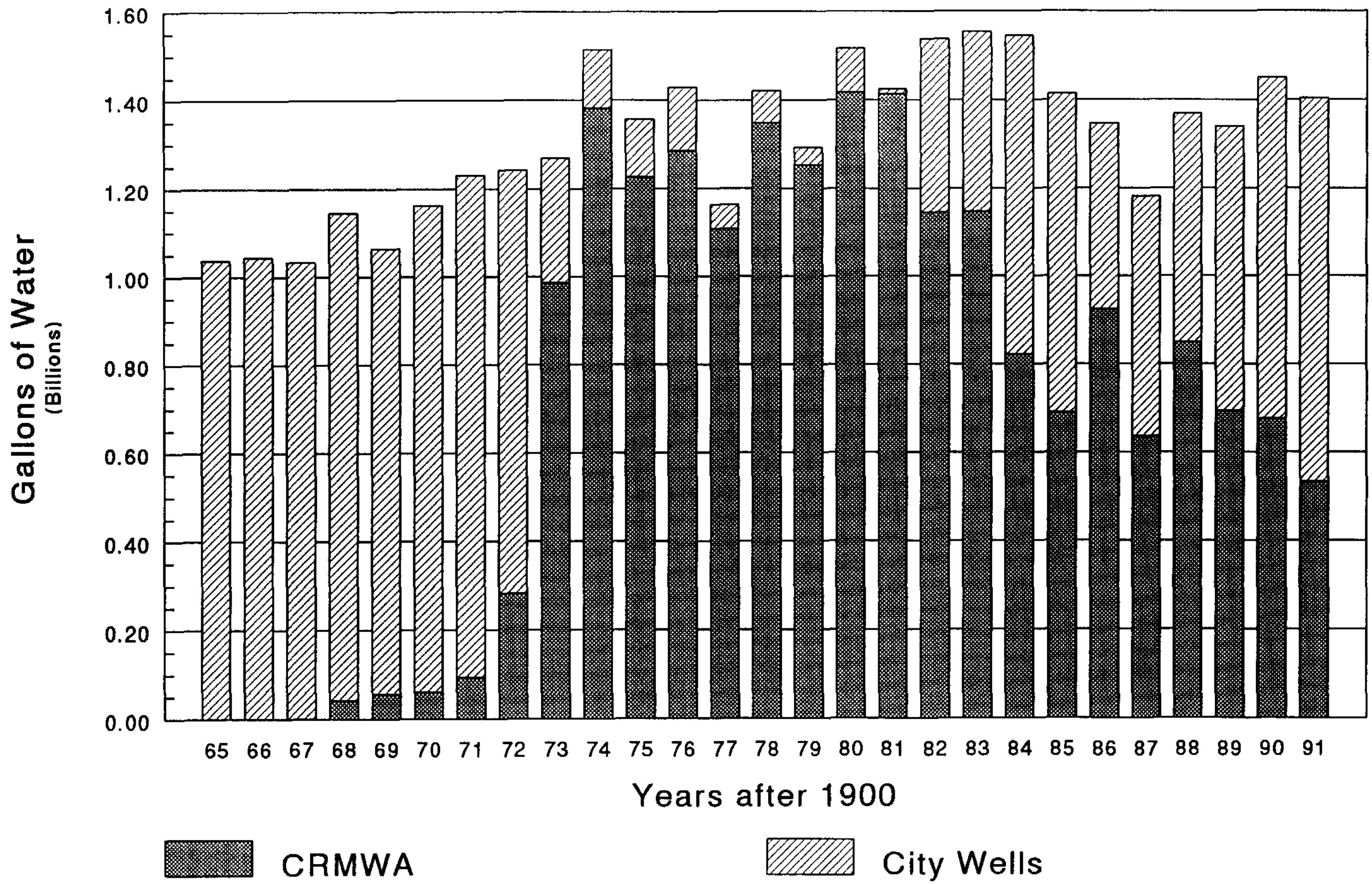
CITY OF O'DONNELL

Projected Water Use



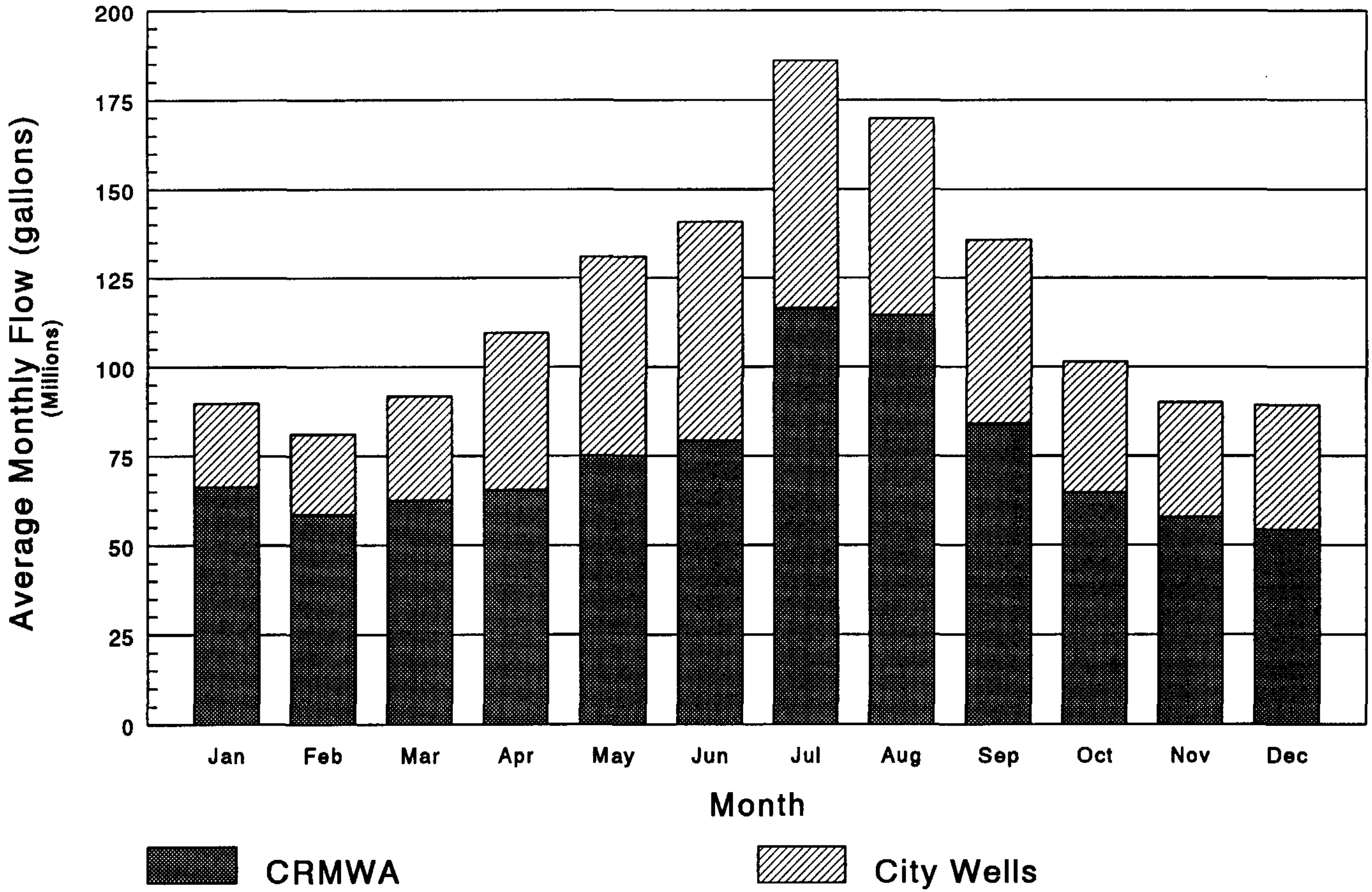
CITY OF PAMPA

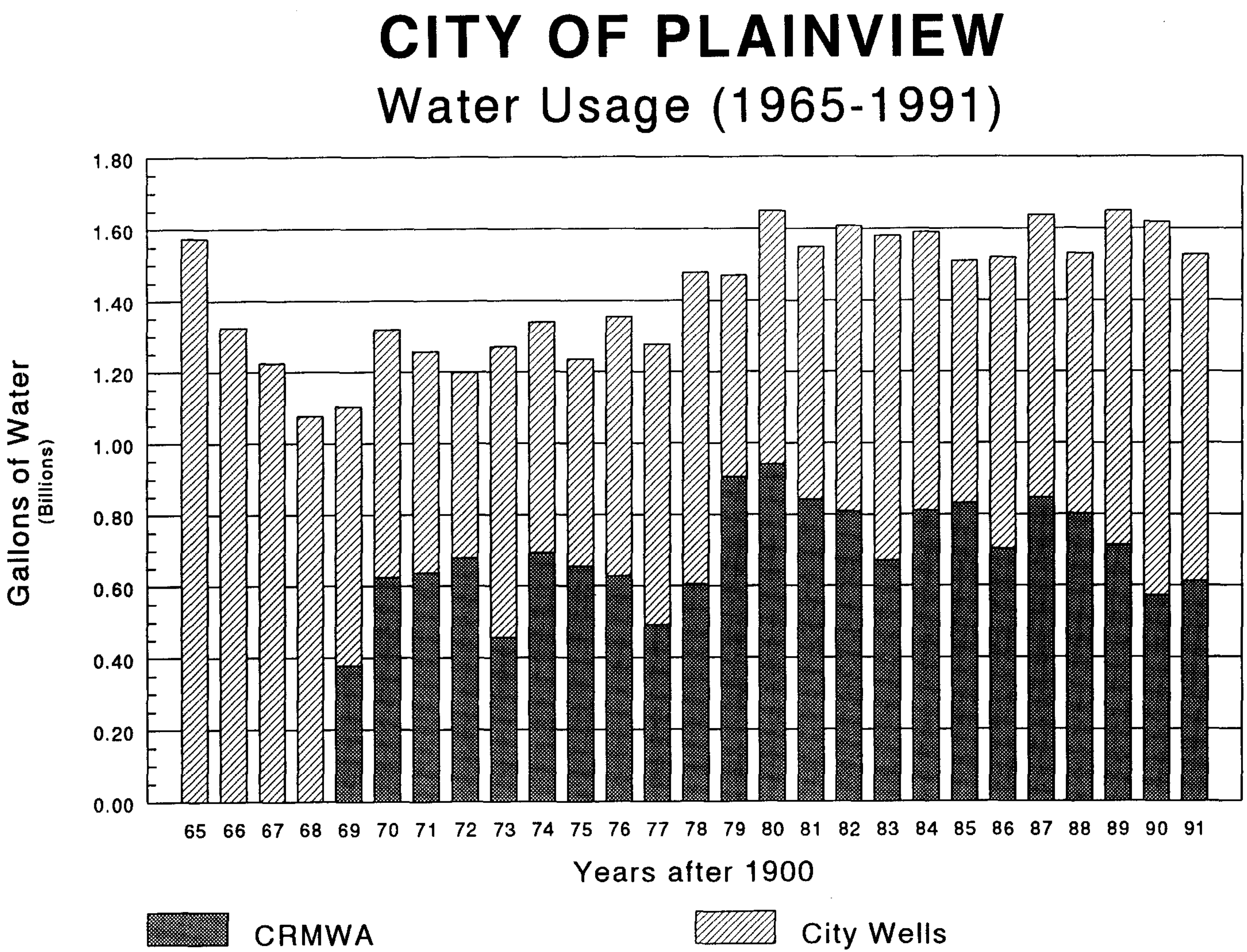
Water Usage (1965-1991)



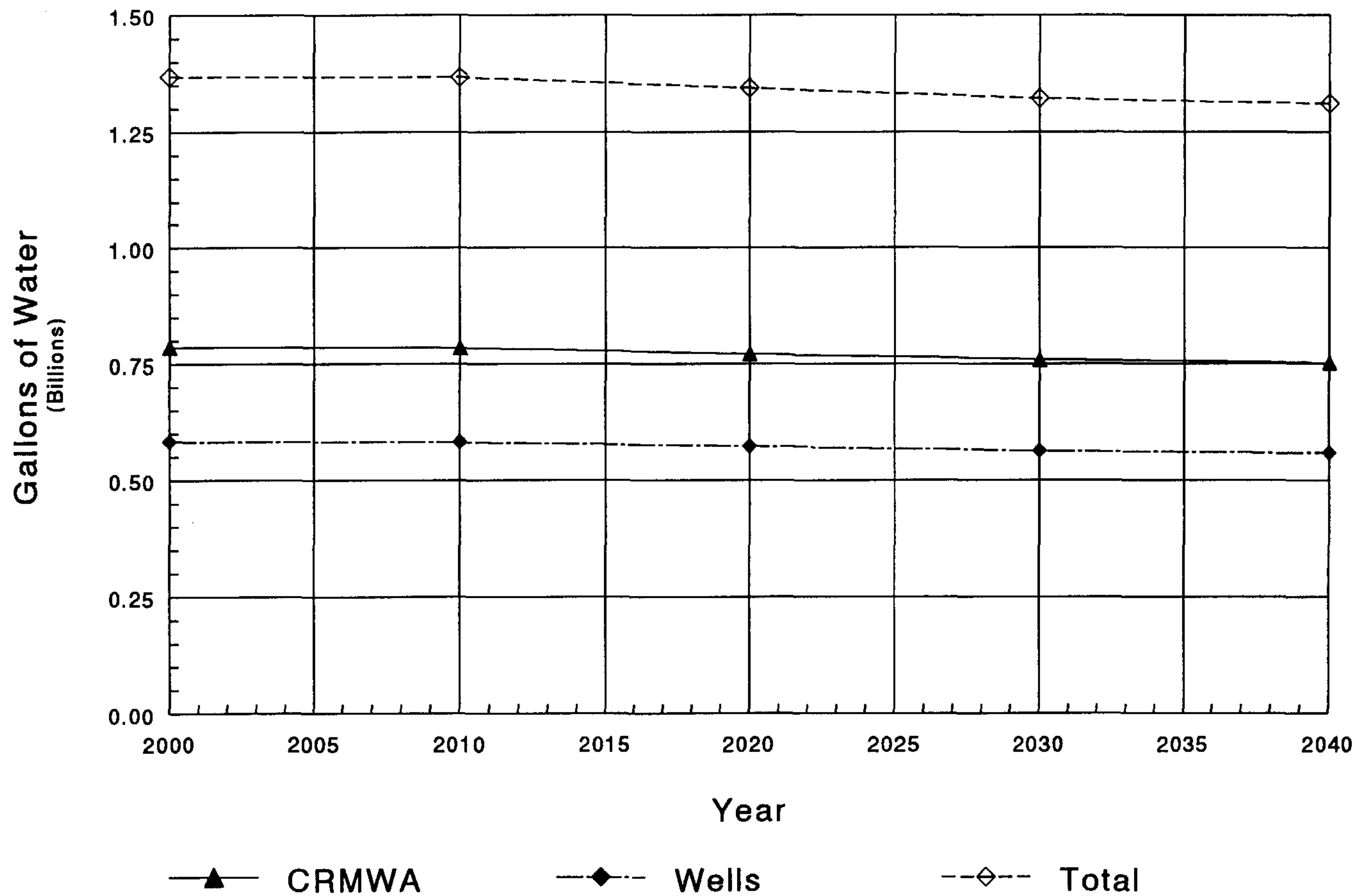
PAMPA - MONTHLY FLOWS

Average from 1981 to 1990



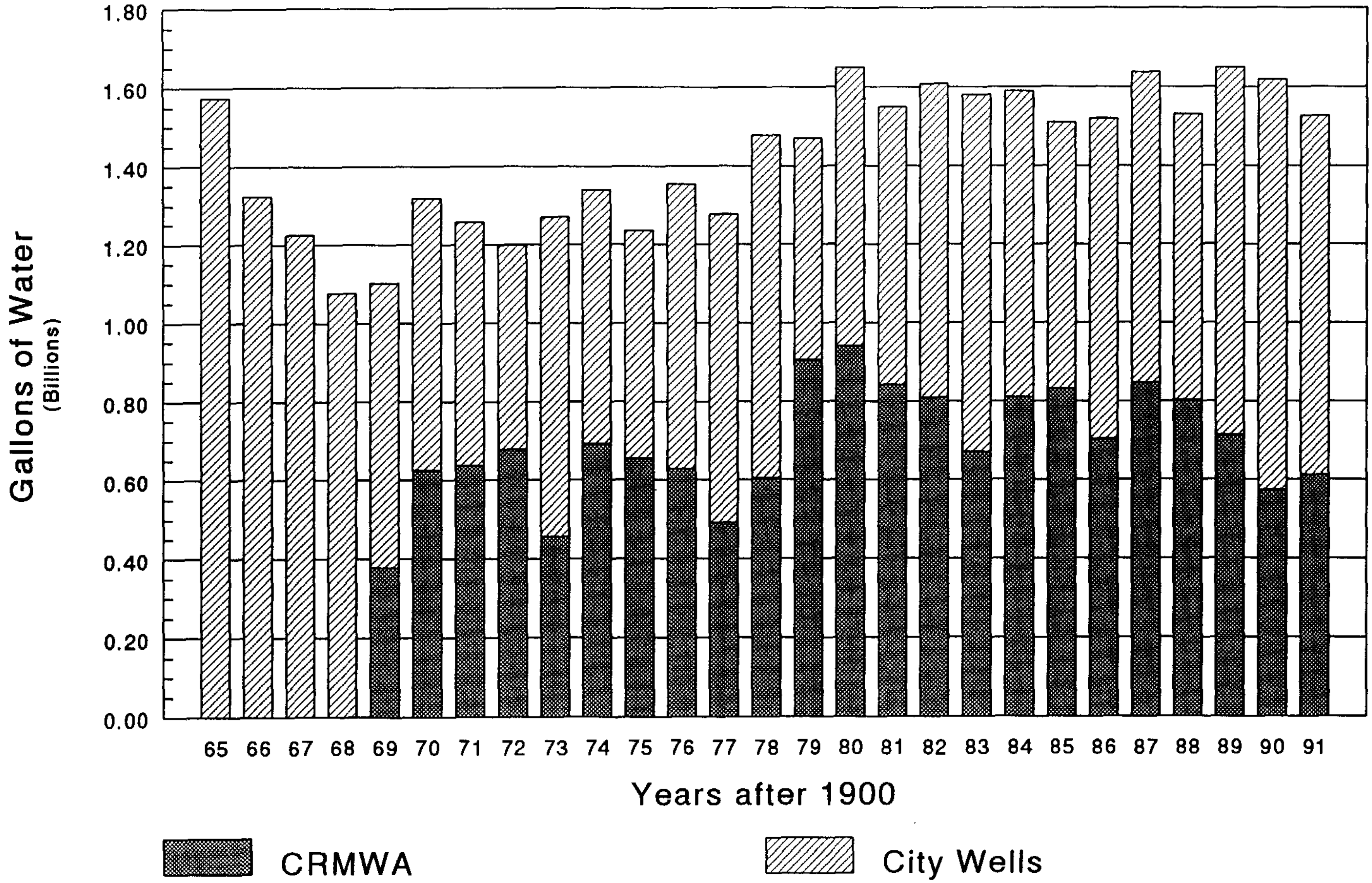

CITY OF PLAINVIEW
Water Usage (1965-1991)
Gallons of Water
(Billions)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
Years after 1900
CRMWA
City Wells

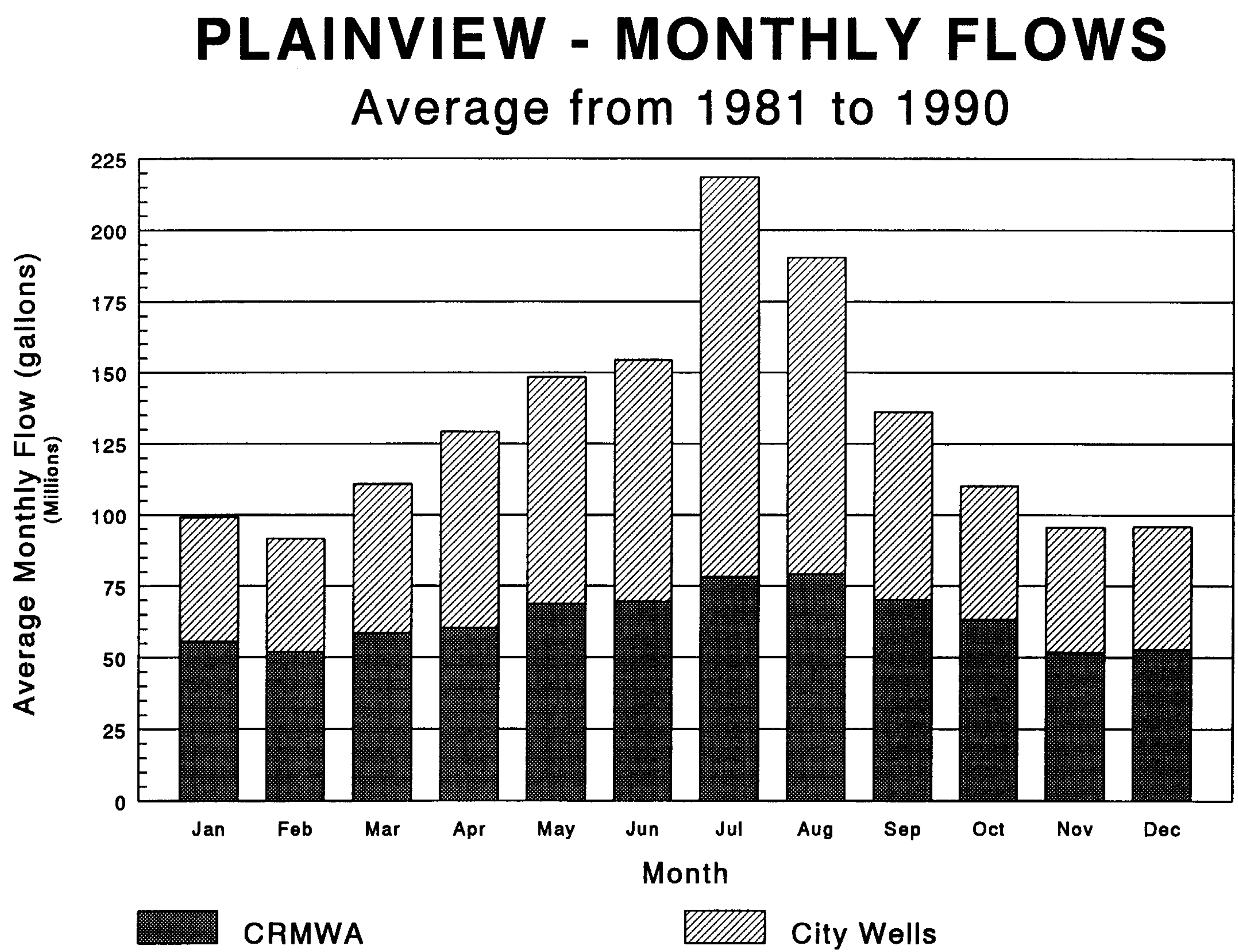
CITY OF PAMPA
Projected Water Use

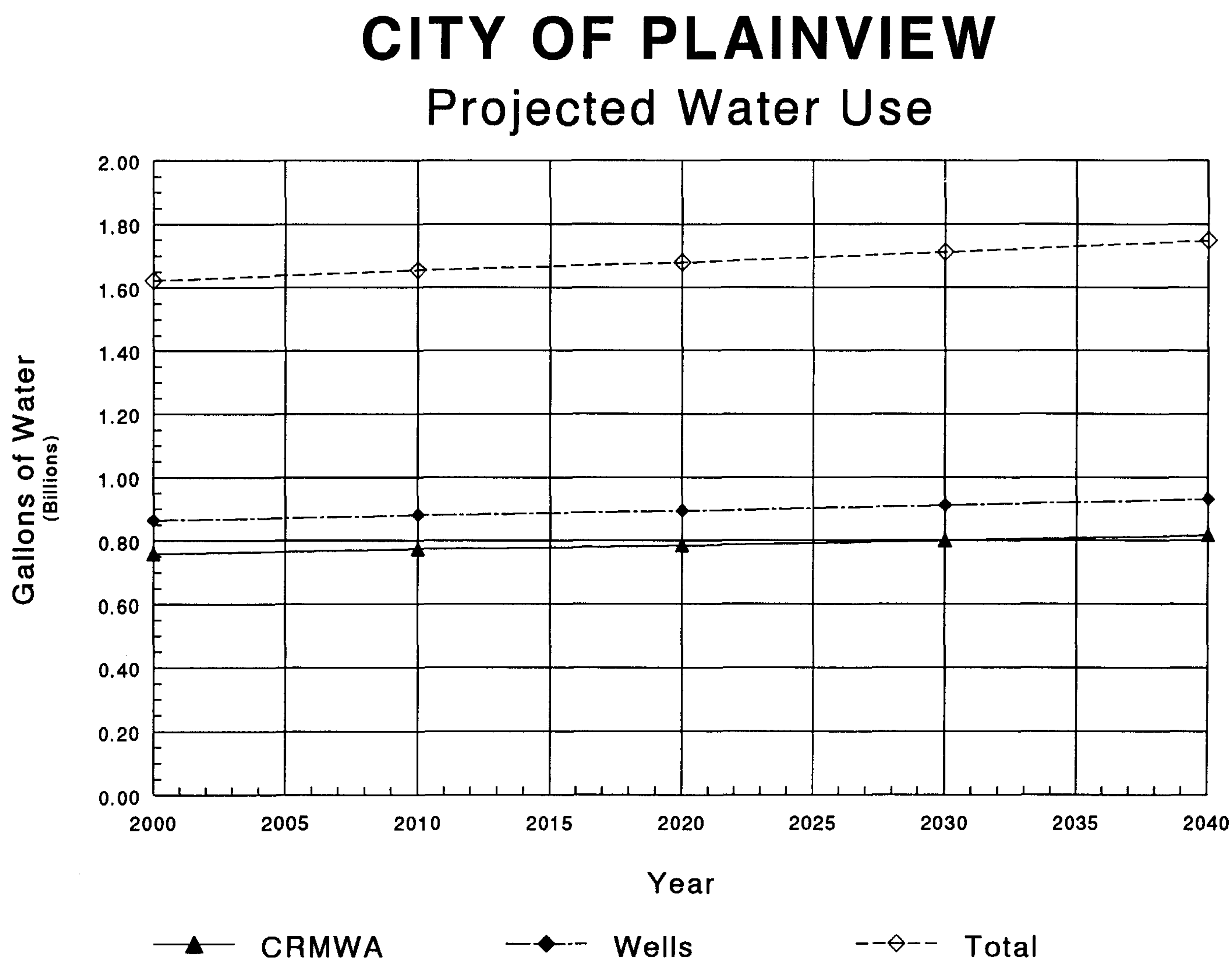


CITY OF PLAINVIEW

Water Usage (1965-1991)



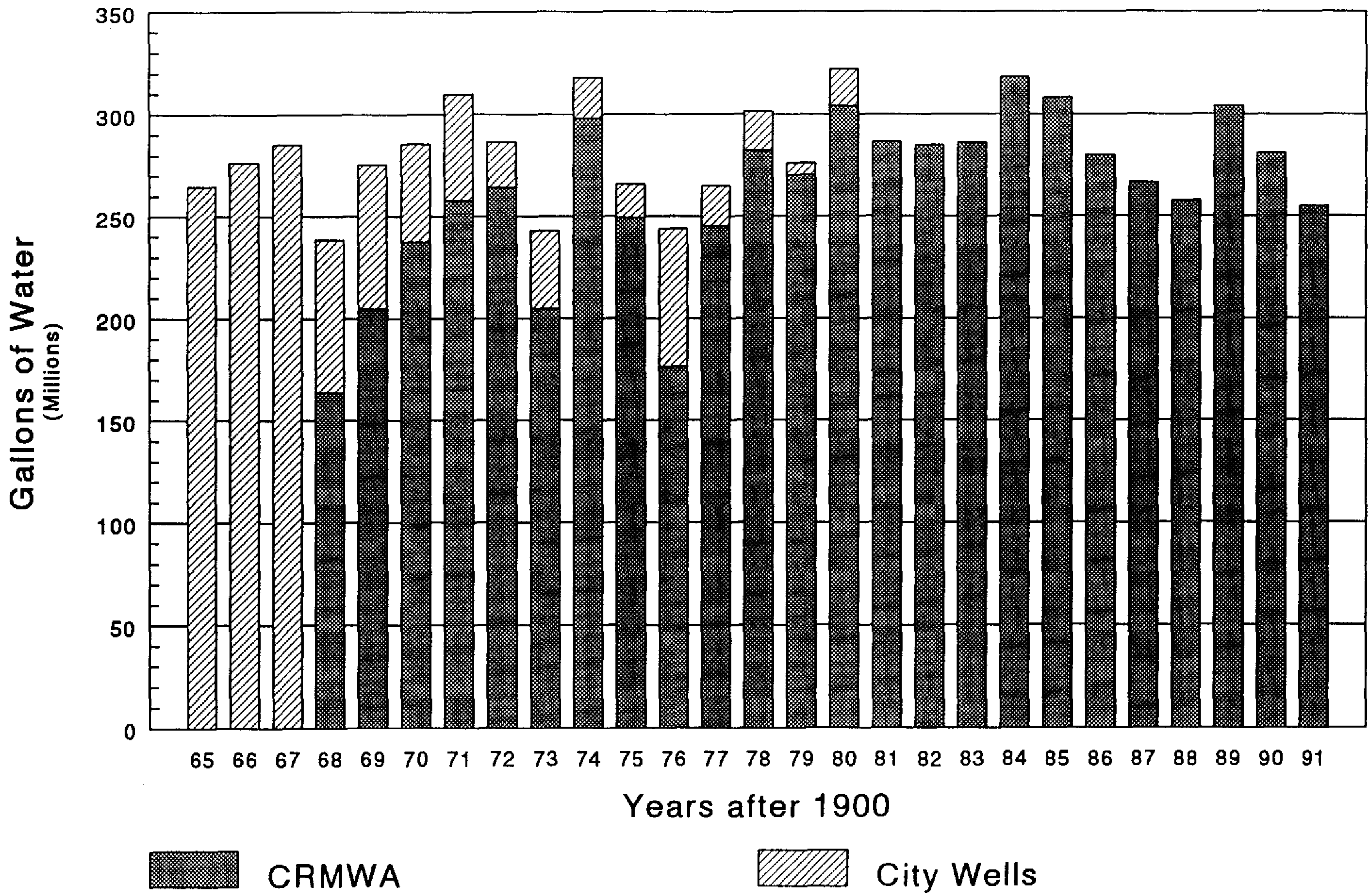

PLAINVIEW - MONTHLY FLOWS
Average from 1981 to 1990
Average Monthly Flow (gallons)
(Millions)
0
25
50
75
100
125
150
175
200
225
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
CRMWA
City Wells

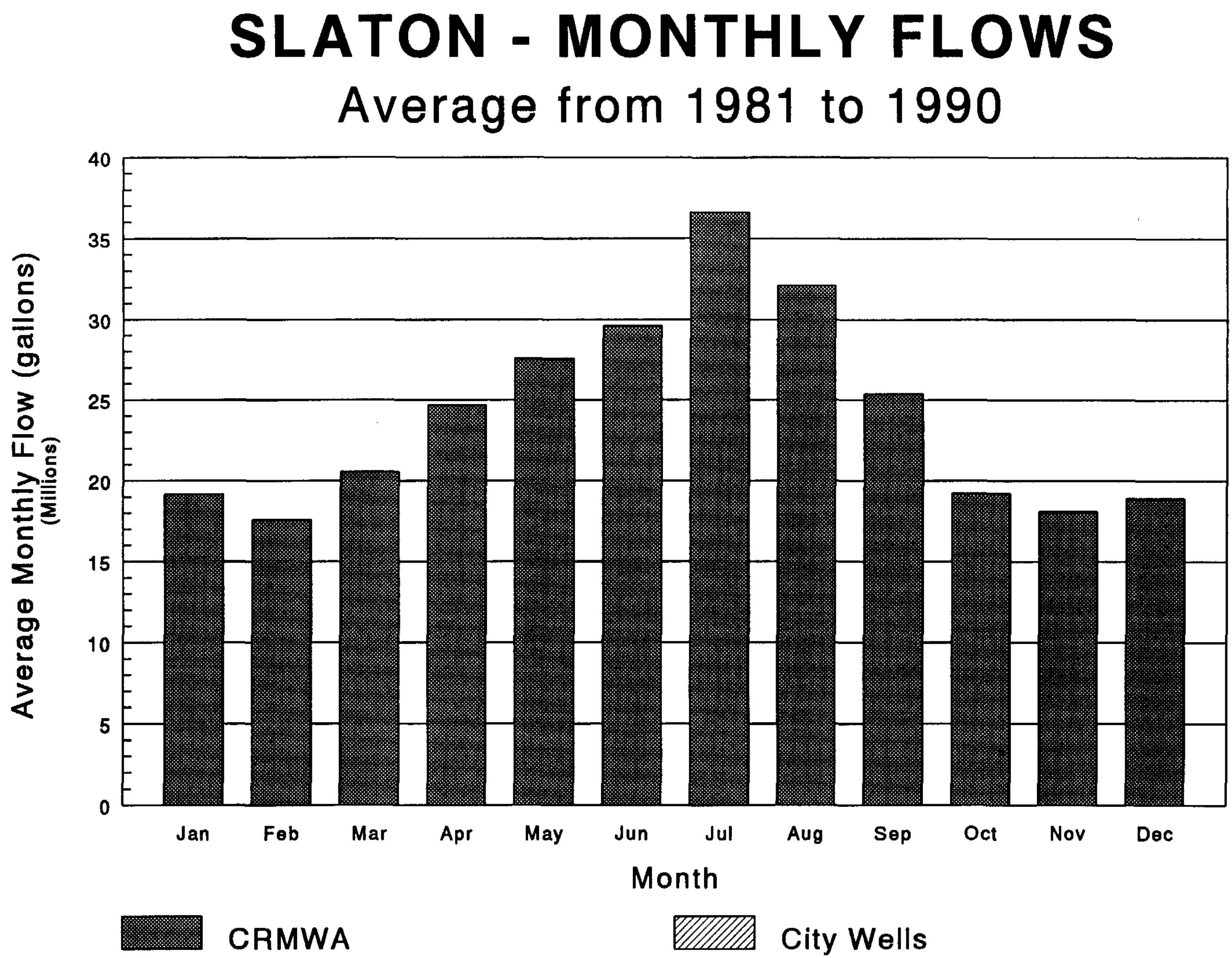


CITY OF PLAINVIEW
Projected Water Use
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Gallons of Water
(Billions)
2000
2005
2010
2015
2020
2025
2030
2035
2040
Year
CRMWA
Wells
Total

CITY OF SLATON

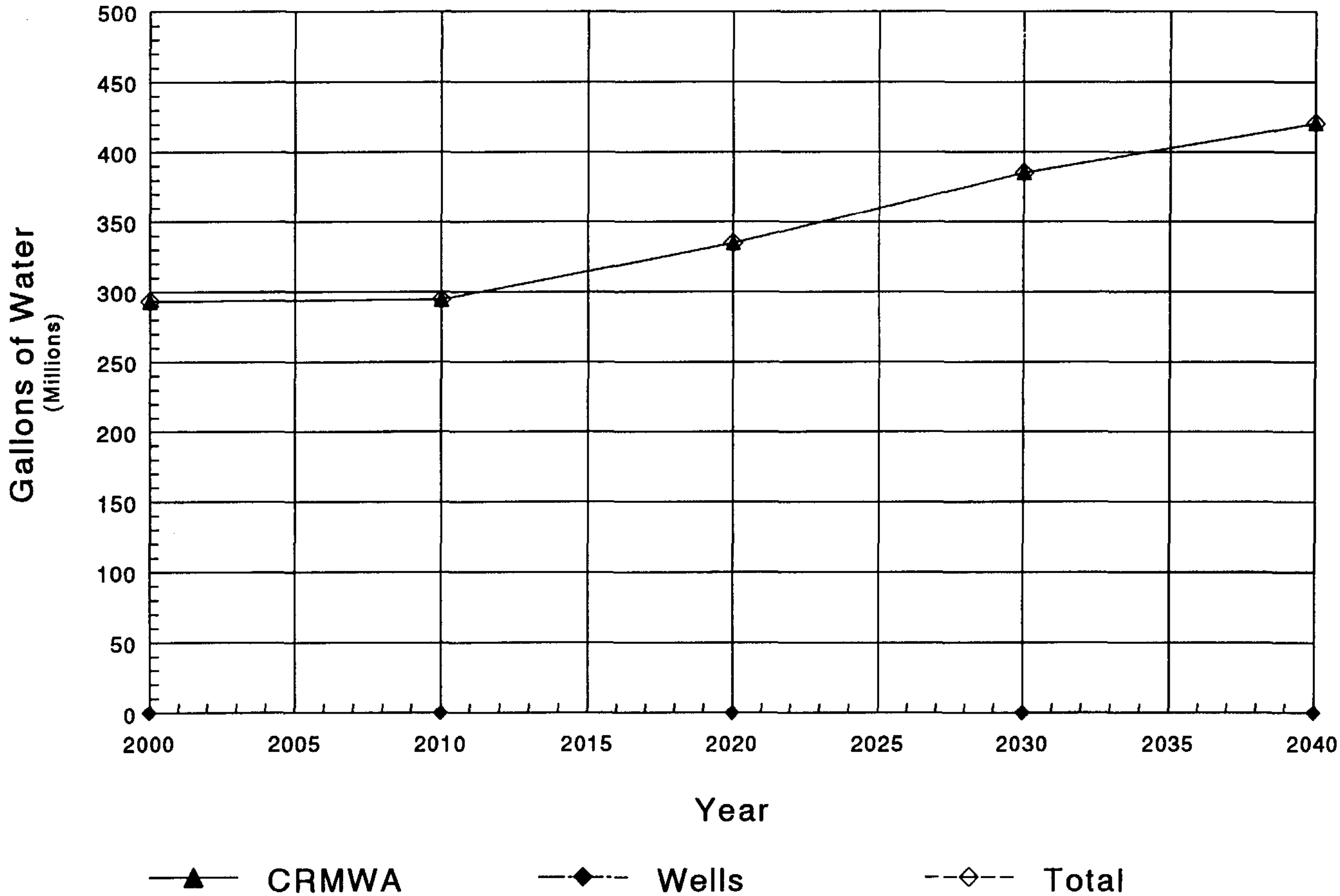
Water Usage (1965-1991)

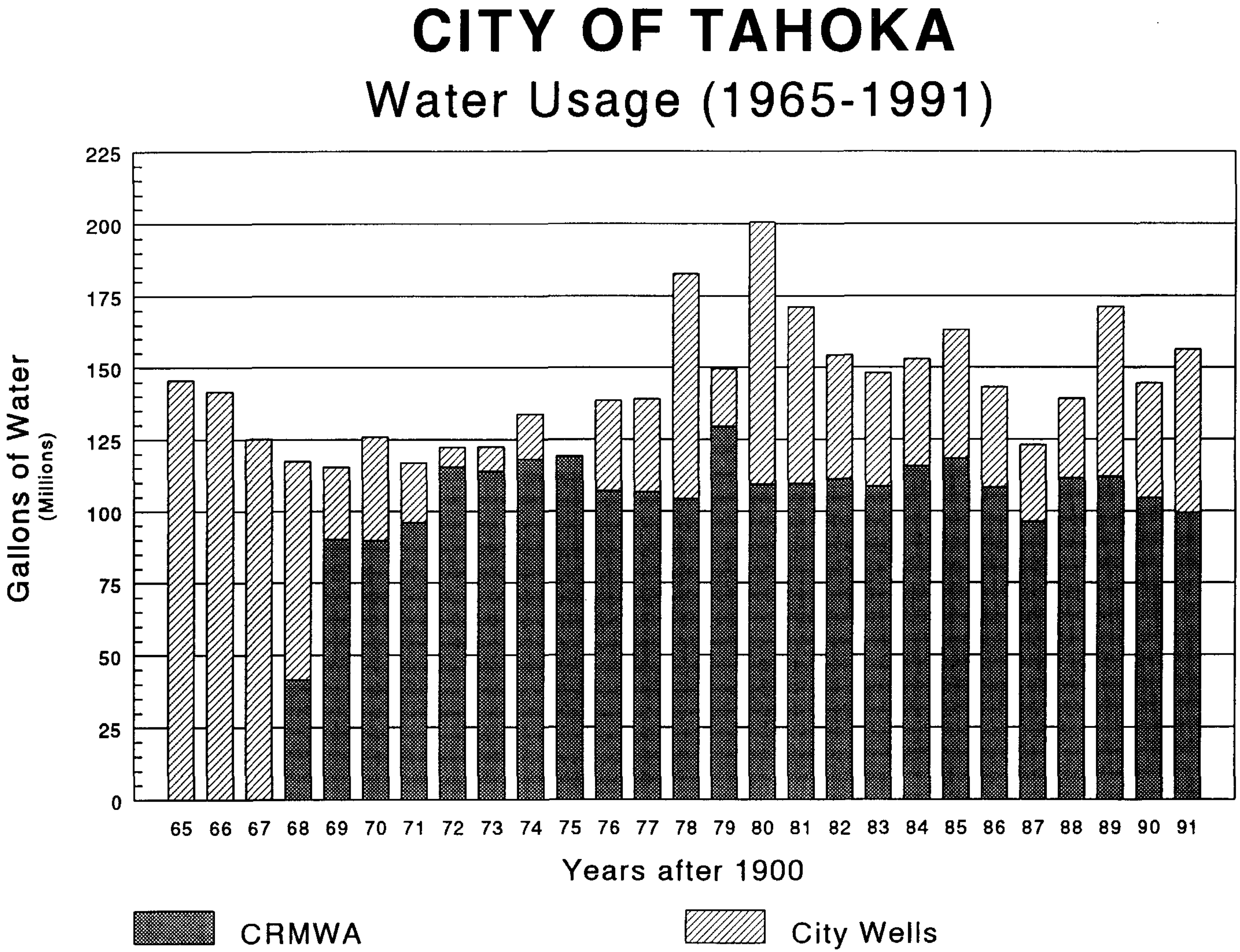



SLATON - MONTHLY FLOWS
Average from 1981 to 1990
Average Monthly Flow (gallons)
(Millions)
0
5
10
15
20
25
30
35
40
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
CRMWA
City Wells

CITY OF SLATON

Projected Water Use

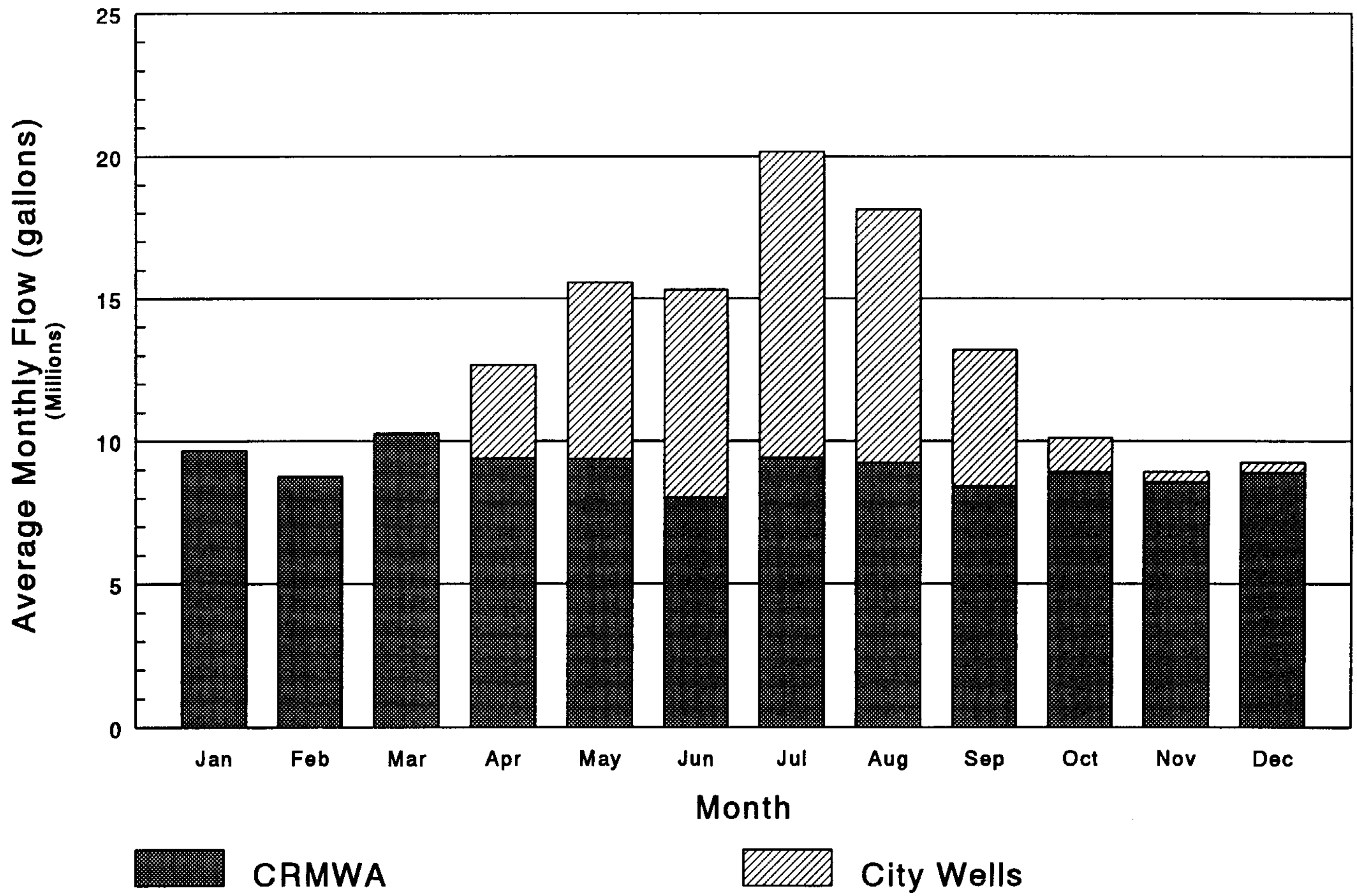




CITY OF TAHOKA
Water Usage (1965-1991)
Gallons of Water
(Millions)
225
200
175
150
125
100
75
50
25
0
65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91
Years after 1900
CRMWA
City Wells

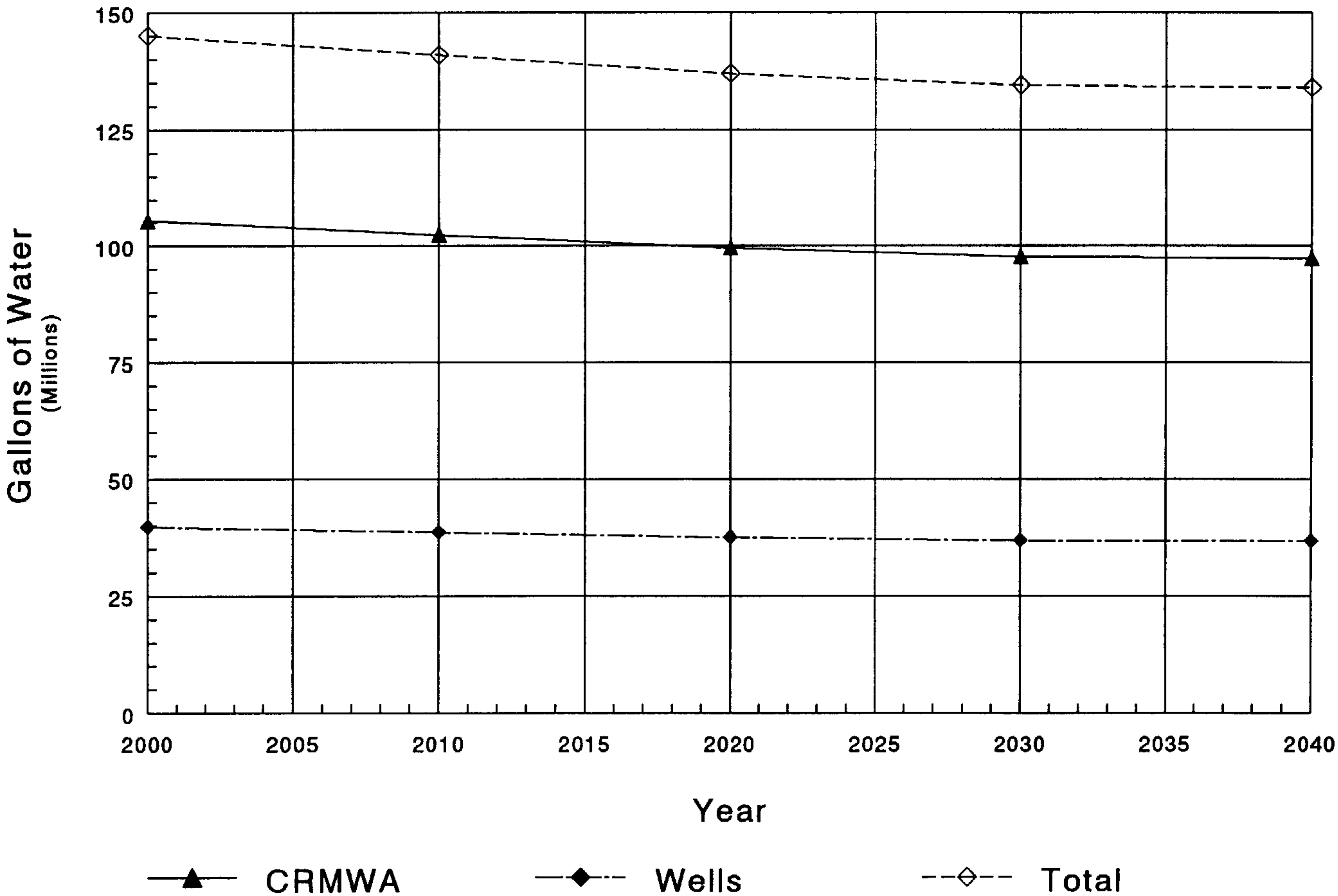
TAHOKA - MONTHLY FLOWS

Average from 1981 to 1990



CITY OF TAHOKA

Projected Water Use



APPENDIX C

APPENDIX C

SUMMARY OF WATER CONSERVATION AND DROUGHT CONTINGENCY PLANS OF THE MEMBER CITIES

Water conservation is encouraged of users by all of the member cities of the Canadian River Municipal Water Authority (CRMWA). One of the member cities (Lubbock) has adopted a formal water conservation and drought contingency plan with several other cities in the process of developing such plans. The following paragraphs summarize the efforts of the member cities to develop such plans.

Amarillo

The City of Amarillo has not officially adopted a Water Conservation and Drought Contingency Plan; however, a draft plan was prepared in 1990. The following activities are currently being performed to encourage water conservation and drought contingency planning:

Substitution:

1. The City provides Southwestern Public Service Company (SPS) nearly four billion gallons of reclaimed effluent annually from the River Road WWTP for industrial purposes.
2. Treated effluent from the Hollywood Road WWTP is used to irrigate area farm land and the City's Comanche Trail Golf Course. Also, digested sludge is used on area farmland.

System Facilities:

1. A metering system is maintained in which all meters are inspected routinely and replaced periodically based on size of meters. (Min. 10-year change-out).
2. No unmetered water is allowed to exist in the City's distribution system. Portable meters are required for all construction and other temporary services.
3. Maximum meter sizing for various type facilities (residential, etc.) is practiced by City Officials.

4. Pressure-reducing valves are provided and maintained in certain areas of the City.

Pricing:

1. The City's water and wastewater rates were increased 12 percent on December 1, 1992.
2. The City finances a majority of its capital improvements with revenue from the sale of water and wastewater services.

Mandatory Public Action:

1. City building and plumbing codes were updated last year to require water-saving plumbing fixtures in all new or remodeled facilities.

Voluntary Public Action:

1. Bill stuffers with information on ways to conserve water are distributed throughout the year.

Borger

At this time, the City of Borger has not received any grants from the TWDB and does not have an official water conservation or drought contingency plan. However, the following activities are currently being performed to encourage such programs:

Substitution:

1. The City blends well water with treated lake water at a ratio of 30% to 70% well to lake, dependent on the quality of the lake water.
2. The City recycles within the water system, such as for filter backwash.

System Facilities:

1. The City promptly repairs leaks within the water system as they are detected.

2. The City maintains accurate and adequate metering of all water flows within the system (to obtain data necessary for design of conservation programs).
3. The City inspects water meters and replaces those that are found to be leaking.

Pricing:

1. The City maintains universal metering coupled with rates that contain a commodity charge, so that the cost of water is in some way proportional to the use of water.
2. The City sets prices to secure revenues equal to, but no less than the total existing water costs.
3. The City sets wastewater prices to encourage recycling.
4. The City utilizes cash financing for capital improvements.

Voluntary Public Actions:

1. The City provides occasional bill stuffers with information on water conservation.

Brownfield

The City of Brownfield has not formally adopted a water conservation or drought contingency plan. Water conservation measures taken by the City include regular maintenance of leaking water lines and meters as well as the irrigation of farmland with all of the City's treated effluent.

Lamesa

The City of Lamesa does not have an official water conservation or drought contingency plan. The City has not had a need to ration either CRMWA or well field supplies. Water conservation issues have only been considered by the City upon request of local restaurants. However, the following activities are currently being performed to encourage water conservation and drought contingency planning:

Substitution:

1. The City utilizes reclaimed wastewater for turn irrigation (especially golf courses, parks and cemeteries).

System Facilities:

1. The City maintains accurate and adequate metering of all water flows within the system (to obtain data necessary for design of conservation programs).
2. The City inspects meters and replaces those that are found to be leaking.
3. The City strives for pressure reduction and stabilization.

Pricing:

1. The City maintains universal metering coupled with rates that contain a commodity charge, so that the cost of water is in some way proportional to the use of water.
2. The City sets prices to secure revenues equal to, but no less than the total existing water costs.
3. The City does not offer discounts or wholesale rates.
4. The City utilizes some cash financing for capital improvements.
5. The City generally finances through revenue rather than general obligation bonds.

Levelland

The City of Levelland does not have an official water conservation or drought contingency plan. The City has never had a problem with supply and has never had to consider rationing. Discouraging consumption has been accomplished primarily by maintaining high water rates.

The City's water department stays quite active by fixing leaks in lines and meters as soon as they are detected. In recent years, the City has applied for Texas Community Development Project (TCDP) funds to steadily replace old lines in the distribution system.

In July of 1991, the City of Lubbock formally adopted a water conservation and drought contingency plan approved by the TWDB. The primary goal of the water conservation plan was to reduce the per capita water usage by 9.5 gallons per day. This would be a five percent reduction from the current usage. Nine principal water conservation methods are to be implemented as described below:

Education: The City will send mail outs to all water users on an annual basis including information provided by the TWDB, the American Water Works Association (AWWA) and other appropriate organizations. In addition, the City will institute a school education program to be conducted by either the utility or the teachers.

Plumbing Codes: The City will comply with Title 5, Health and Safety Code, Subtitle E.-Water Use Regulation, Chapter 421-Water Saving Performance Standards, effective September 1, 1991. The water standards in this code meet or exceed the standards contained in the TWDB Guidelines for Municipal Water Conservation and Drought Contingency Planning and Program Development.

Retrofit Program: Information will be made available to the public concerning the advantages of purchasing water saving devices in plumbing and lawn watering equipment.

Universal Metering: All water users are metered except for designated fire protection systems. A successful metering program coupled with computerized billing will enable the City to more easily detect leaks in the distribution system.

Water Conserving Landscaping: Both water customers and local landscape contractors will be encouraged to utilize minimal water consumptive plants and grasses, to promote drip irrigation systems, and to use ornamental fountains that recycle water. Local nurseries will be encouraged to offer low water consumptive plants and grasses as well as efficient water devices.

Leak Detection and Repair: A quarterly accounting of water delivery efficiencies will be made by the City's water utility. Comparison of computerized billing and water distribution data will more easily detect leaks to be repaired.

Recycle and Reuse: The City currently utilizes water from both wastewater treatment plants for beneficial use on agricultural land. In addition, a 412 million gallon effluent storage reservoir has been built at the City's Land-Application Site for the storage of treated effluent during periods when use is not required. A reuse rate of 50% of raw water has already been achieved through land application.

Water Sewer Rate Structures: The City is evaluating the implementation of a non-declining rate structure, with each 1,000 gallons costing no less per unit than the prior unit.

Implementation/Enforcement: The Director of Water Utilities for the City will act as administrator of the Water Conservation Program. The Director will oversee the execution and implementation of all aspects of the program as well as keep adequate records for program verification.

The City of Lubbock also adopted a drought contingency plan for use during times of mild, moderate and severe conditions. The plan primarily focuses on voluntary and mandatory limitations on lawn watering, car washing and water wasting. The public will be informed through television, radio and newspaper of an impending drought condition and will be given instructions applicable to the drought condition.

A copy of the City of Lubbock's Water Conservation and Drought Contingency Plan on file with the Texas Water Development Board.

O'Donnell

The City of O'Donnell does not have an official water conservation or drought contingency plan. Lines and meters are repaired as leaks are detected. The City has never had problems with water shortages as is reflected in the City's arrangement with the City of Lamesa to purchase some of O'Donnell's CRMWA water rights.

Pampa

The City of Pampa does not have an official water conservation or drought contingency plan. However, the following activities are currently being performed to encourage water conservation and drought contingency planning:

Substitution:

1. The City is in the process of developing a plan for reuse of treated effluent for irrigation of the Municipal Golf Course.
2. The City is beginning reclamation of two abandoned water wells that do not meet TWC standards for potable water. The water will be used for irrigation of a portion of the park system.

System Facilities:

1. An ongoing leak detection program in is place.
2. Park sprinkler systems, from potable water, are automatically operated. The City has instituted ground condition monitoring to prevent over watering.

Mandatory Public Actions:

Federal and State Law requires all new appliances manufactured, to be of "Water Saver" design. The City is following these guidelines in Building Code Enforcement.

Plainview

The City of Plainview is working on a water conservation and drought contingency plan. The draft copy of this plan is currently being reviewed by the

TWDB. Activities described in the plan include the limitation of residential sprinkler meters to less than one inch. Also, the watering of parks and public schools would be curtailed in the event of a drought. As with other cities, Plainview repairs and replaces lines and meters as leaks are detected.

Slaton

The City of Slaton does not have an official water conservation or drought contingency plan. However, the following activities are currently being performed to encourage water conservation and drought contingency planning:

Water:

1. The City refrains from use of its underground water wells while sufficient water is available from CRMWA.
2. The City does not sell its excess CRMWA water allocation to other cities. (Slaton seldom exceeds 70% of its surface water allocation).
3. Water meters are monitored during the monthly reading process for signs of leakage or defect, and are promptly replaced.
4. A regular replacement program has been in place for the past eight years to replace older meters even though they appear to be in good operating order.
5. The city has a four person line crew dedicated to replacement and upgrade of older water lines.
6. The City charges established rates for water and does not permit discounted sales for volume users.
7. Water storage tanks, pumping stations and mains are visually inspected on a regular basis to prevent waste.
8. Fire hydrants are closely monitored by fire and police personnel for waste prevention and mischief.
9. Water pressure is maintained in the 34 psi range for conservation purposes.
10. Revenue bonds have been utilized for improvements whenever possible, as opposed to general obligation bond projects.
11. City council persons voice strong support for user fee based utility systems rather than tax supported operations.

12. Though not presently under ordinance, building and plumbing officials encourage water conservation through use of insulation, flow restrictive appliances, syphon action toilets, aerators, and other water saving devices.
13. The citywide recycling program includes emphasis on conservation as well as recycling techniques.
14. City water and wastewater personnel are available to inspect and advise customers on water saving devices and ways to reduce use and cost.
15. City officials are prepared to reduce water use during times of drought by odd/even day watering programs, control of lawn watering during hot periods of the day, or other measures depending on the severity of the situation.

Wastewater:

1. Wastewater is processed and used to water the city's nine hole golf course.
2. Wastewater is used for high transpiration grass crop irrigation (Alfalfa, red top cane, etc.).

Tahoka

The City of Tahoka does not have an official water conservation or drought contingency plan; however, the City has a plumbing code which is not very stringent. Lines and meters are repaired as leaks are detected. The City relies primarily on CRMWA supplies; however, raw well water is blended into the distribution system during the summer peak demands. The City also uses all of the treated effluent from its wastewater treatment plant to irrigate private farmland.

WATER RATES

One method of encouraging water conservation is by the implementation of water rates in proportion to the amount of water used. Table C-1 describes the current user rates for potable water for the member cities.

SUMMARY

Each member city of the Canadian River Municipal Water Authority is making efforts in the area of water conservation/drought contingency. Several of the member cities are in the process of adopting water conservation/drought contingency plans of one form or another. In addition, the City of Lubbock has previously adopted a plan for water conservation/drought contingency and is currently implementing the plan. Amarillo has a draft water conservation plan and the City of Plainview is in the process of developing such a plan. The larger member cities of the Authority which control the major portion of the allocated water are actively pursuing the conservation issue.

In lieu of an Authority wide water conservation plan, it is suggested that measures being taken by the member cities continue to be practiced. An Authority wide water conservation/drought contingency plan might limit some of the member cities while imposing unattainable goals on others. The individualized plans should serve the needs of each specific city and should not exceed the capabilities of those cities to enforce such measures. However, water conservation should continue to be encouraged by the Authority.

TABLE C-1

Canadian River Municipal River Authority
Water Rates of Member Cities

City	User Type	Base Rate (1" Meter)	Base Gallons Included	$/1,000 gal Additional	Effective Date
Amarillo	Inside CL	$7.11	2,000	$1.02	04/24/92
	Outside CL	$10.70	2,000	$1.55	04/24/92
Borger	Residential	$8.20	2,000	$2.15	04/12/88
	Commercial	$8.20	2,000	$2.15	04/12/88
	Raw Water	None	None	$0.60	09/01/90
Brownfield	Standard	$6.50	1,000	$1.60	04/01/92
	Schools	None	None	$1.60	04/01/92
	Senior Citizen	$6.25	1,000	$1.35	04/01/92
Lamesa	Inside CL	$10.75	3,000	$1.75	04/01/92
	Outside CL	$21.50	3,000	$3.50	04/01/92
Levelland	All Users	$5.00	1,000	$1.60	
Lubbock	Single Family	$9.31	0	$1.34	10/01/92
	Multiple Family	$15.61	0	$1.13	10/01/92
	Commercial	$15.61	0	$1.23	10/01/92
	Schools	$15.61	0	$1.23	10/01/92
	Sprinkler	$15.61	0	$1.68	10/01/92
	Reese A.F.B.	$15.61	0	$1.13	10/01/92
O'Donnell	All Users	$10.00	2,000	$1.30	
	Poka-Lambro	$300.00	250,000	$0.00	
Pampa	Inside CL	$11.66	3,000	$1.46	10/01/90
	Outside CL	$17.49	3,000	$2.19	10/01/90
Plainview	All Users	$8.25	0	$0.90	
Slaton	All Users	$12.00	3,000	$2.05	
Tahoka	All Users	$8.00	3,000	$1.50	

APPENDIX D

APPENDIX D

SUMMARY OF PUBLIC MEETINGS FOR THE CANADIAN RIVER MUNICIPAL WATER AUTHORITY REGIONAL WATER SUPPLY PLANNING GRANT AUGUST 30 AND 31, 1993

Two public meetings were held to discuss the report entitled "Canadian River Municipal Water Authority; Regional Water Supply Planning Grant". The first meeting was held the Amarillo City Library in Amarillo, Texas on August 30, 1993 for interested parties from the northern member cities of Canadian River Municipal Water Authority (CRMWA). The second meeting, which was held for interested parties from the central and southern cities, was held at Lubbock Mahon Library in Lubbock, Texas on August 31, 1993. The purpose of these meetings was to obtain input from and discuss with concerned consumers the feasibility of supplementing Lake Meredith water with available ground water for the dual purpose of improving the quality of the water and increasing the quantity of water delivered to the consumers.

At the beginning of each meeting a brief overview presentation of the engineering study was given to inform the attendees of the results of the study. Following the overview presentation comments and questions were accepted from the audience. The following paragraphs describe the comments and/or questions from each of the two meetings.

Amarillo Public Meeting - August 30, 1993

The meeting held in Amarillo on August 30, 1993 was attended by approximately 12 people. The attendees consisted of consultants, CRMWA administrators, CRMWA board members, underground water district administrators, City of Amarillo personnel, media and general public. The consensus of the attendees was support for the project.

Several questions were raised regarding the project and how it would be implemented following the presentation of the report. A summary of the questions is as follows:

Q. What portion of the water rights is the seller considering selling/leasing?

A. Approximately the western 1/2 of the water rights has been discussed with the owner.

Q. Is there some potential for developing a similar project using the City's own ground water reserves?

A. No. Several of the member Cities have little or no ground water reserves and those that do would prefer to preserve those reserves to meet future needs.

Q. What are the trihalomethane concerns with a groundwater project of this nature?

A. Trihalomethane concerns will have to be addressed during the actual design of the project.

Q. What degree of support have the member Cities given this project?

A. Ten of the Eleven member Cities have passed resolutions in support of the project.

Lubbock Public Meeting - August 31, 1993

Attendance at the Lubbock public meeting held on August 31, 1993 was approximately 25 people. Once again the attendees consisted of consultants, CRMWA administrators, CRMWA board members, underground water district administrators, City personnel from Lubbock, Brownfield and Levelland, television media and general public. Once again, the overall consensus of the attendees was support for the project.

A summary of the questions/comments raised is as follows:

Q. Why does the water in the northern portions of the Ogallala aquifer have lower total dissolved solids (TDS) than other portions of the Ogallala?

A. As a general rule, the northern portion of the Ogallala aquifer has much better overall water quality than do the southern areas. The water investigated for this particular project appears to be of excellent quality with regard to TDS, chlorides and sulfates.

Q. Is it feasible to recharge groundwater with additional water during the winter for use during summer peak demands?

A. This type of operation has been used by at least one of the member Cities in the past and has been done successfully in other areas.

Q. Will sufficient sampling of quantity and quality of the groundwater take place before the actual design of the project begins?

A. The next step of the project, along with negotiating with the water rights owner, is to begin extensive sampling of the quantity and quality of the groundwater.

Q. Are there other potential users of these groundwater reserves for municipal drinking water (i.e. western Oklahoma)?

A. We are unaware of any other interested parties at this juncture.

Q. Are there concerns on obtaining right-of-way throughout the length of the new pipelines?

A. A very conservative price was estimated for the purchase of right-of-way along the pipelines in the feasibility study. Also, large portions of the projected right-of-way are owned by single property owners, which should aid in negotiations.

Q. What is the proposed schedule?

A. Negotiations with the water rights owner have begun and testing of the groundwater has begun. Due to City of Amarillo constraints, a decision as to whether to proceed with the project or not must be made within 5 months.

Summary

As mentioned previously, support for the project was almost unanimous with only minor concerns raised during the public meetings. The meetings were well attended by both affected government entities and the general public. Interest was high from all parties because of regulatory enforcement issues and because of public perception of the overall drinking water quantity and quality.

CANADIAN RIVER MUNICIPAL WATER AUTHORITY
REGIONAL WATER SUPPLY PLANNING GRANT

Public Meeting's
Attendance List

Amarillo, Texas
August 30, 1993

Lubbock, Texas
August 31, 1993

NAME	ADDRESS	PHONE
Larry West	2707 Salem Amarillo, Texas	358-0643
Tom Edmonds	210 Broadmoor Borger, Texas 79007	273-9935
George Sell	2615 S. Hughes Amarillo, Texas	376-8938
Rodney Chapin	4010 Avenue R Lubbock, Texas 79412	747-0161
C.E. Williams	Box 637 Whitedeer, Texas	883-2501
James Cope	Rt. 1, Box 353 Claude, Texas	944-5438
Sonny Bohavan	Globe-News	376-4488
Ron Freeman	City of Amarillo	378-3035
John Kelley	4010 Avenue R Lubbock, Texas 79412	792-6463
Curtis E. Johnson	1700 N. Congress Austin, Texas	(512) 463-8060
Dan Hawkins	P.O. Box 2000 Lubbock, Texas	767-2595
Tony Phillips	201 W. Broadway Brownfield, Texas	637-4547
Bruce Blalack	P.O. Box 2000 Lubbock, Texas	767-2613
Rick Osburn	P.O. Box 1010 Levelland, Texas	894-0113
Tony Calsllan	Shallowater	

Teresa Calsllan	Shallowater	
Clyde and Irene Myres	Lubbock	763-6183
Max M. Winn	4911 49th Street Lubbock, Texas	795-2584
Xen Oden	2302 Slide Road #25 Lubbock, Texas	799-7697
Don McReynolds	1721 28th Street Lubbock, Texas	765-7084
Roy LeMaster	4531 77th Street Lubbock, Texas	797-1169
Norman Wright	P.O. Box 580 Plainview, Texas	
Glenn Bickel	207 Tucca Terrace Plainview	
Kent Satterwhite	P.O. Box 99 Sanford, Texas	865-3325

PUBLIC MEETING NOTICE
CANADIAN RIVER MUNICIPAL WATER AUTHORITY
REGIONAL WATER SUPPLY PLANNING PROJECT

A series of public meetings will be held on August 30 and 31, 1993 for the purpose of discussing the results of a preliminary engineering study prepared for the Canadian River Municipal Water Authority (CRMWA). The CRMWA is comprised of eleven West Texas cities which obtain all or part of their water supply from Lake Meredith located in the Texas Panhandle.

The study was funded in part by the Texas Water Development Board and addressed the feasibility of supplementing Lake Meredith water with available ground water for the dual purposes of improving the quality of the water and increasing the quantity of water delivered to the member cities.

The study included historic and projected water use requirements, water quality trends in Lake Meredith, recent efforts of each of the cities in regard to water conservation efforts, and alternative ground water supply projects and their associated costs.

The meetings will be held at the following dates and locations:

Monday, August 30th
Amarillo City Library
413 East 4th Street
Second Floor, Room A
7:00 p.m.

Tuesday, August 31st
Lubbock Mahon Library
1306 9th Street
Community Room
7:00 p.m.

A copy of the report is available for review at each of the meeting locations.

PSC

July 30, 1993

Mr. Ron Freeman
Director of Utilities
City of Amarillo
P. O. Box 1971
Amarillo, Texas 79186-0001

Re: Canadian River Municipality Water Authority
Regional Water Supply Planning Project

Dear Mr. Freeman:

Enclosed for your review is a copy of the report entitled "Overview of Conjunctive Management Alternatives" dated August 1993. This document is the final version of the report distributed for review in January 1993 to each member city and to the Texas Water Development Board.

The results of this study will be presented and discussed at public meetings to be held on August 30th in Amarillo and on August 31st in Lubbock. You are encouraged to make this document available for review by interested parties and to advertise the public meetings as appropriate for your community. Enclosed is a sample meeting notice for your use.

The meetings will begin at 7:00 p.m. and will be held at the following locations:

Monday, August 30th
Amarillo City Library
413 East 4th Street
Second Floor, Room A

Tuesday, August 31st
Lubbock Mahon Library
1306 9th Street
Community Room

If you need additional information, please call me.

Sincerely,

PARKHILL, SMITH & COOPER, INC.

By________________________________
John S. Kelley, P.E.

Enclosure

cc: Mr. John Williams, General Manager, CRMWA
Mr. Lee Wilson, Lee Wilson & Associates, Inc.
Mr. Curtis Johnson, Texas Water Development Board
Mr. Don Manning, Texas Water Commission
Mr. Larry Smith, Texas Water Commission

Parkhill, Smith & Cooper, Inc.
Engineers • Architects • Planners
4010 Avenue R, Lubbock, Texas 79412 (806) 747-0161
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Lubbock El Paso Midland

Mr. Ron Freeman
Director of Utilities
City of Amarillo
P. O. Box 1971
Amarillo, Texas 79186-0001

Mr. Alyn Rogers
City Manager
City of Borger
P. O. Box 5250
Borger, Texas 79008-5250

Mr. Dick Fletcher
City Manager
City of Brownfield
201 W. Broadway
Brownfield, Texas 79316

Mr. Paul Feazelle
City Manager
City of Lamesa
310 South Main
Lamesa, Texas 79331

Mr. Greg Ingham
City Manager
City of Levelland
P. O. Box 1010
Levelland, Texas 79336-1010

Mr. Dan Hawkins
Director of Water Utilities
City of Lubbock
P. O. Box 2000
Lubbock, Texas 79457

The Honorable David Smith
Mayor
City of O'Donnell
P. O. Box 236
O'Donnell, Texas 79351

Mr. Nathan Hopson
Director of Public Works
City of Pampa
P. O. Box 2499
Pampa, Texas 79065-2499

Mr. Bill Hogge
Director of Public Works
City of Plainview
901 Broadway
Plainview, Texas 79072

Mr. Jim Estes
City Manager
City of Slaton
9th & Garza Street
Slaton, Texas 79364

Mr. Barry Pittman
City Manager
City of Tahoka
P. O. Box 300
Tahoka, Texas 79373

August 2, 1993

1 ~

Re: Canadian River Municipal Water Authority
Regional Water Supply Planning Project

Dear 2 ~:

Enclosed for your review is a copy of the report entitled "Overview of Conjunctive Management Alternatives" dated August 1993. This document is the final version of the report distributed for review in January 1993 to each member city and to the Texas Water Development Board. Certain modifications and revisions have since been incorporated into the report.

The results of this study will be presented and discussed at public meetings to be held on August 30th in Amarillo and on August 31st in Lubbock. Copies of the document have been made available to each member city (City Manager or Director of Utilities) for review by interested parties prior to the public meetings. Enclosed is a sample meeting notice for your information.

The meetings will begin at 7:00 p.m. and will be held at the following locations:

Monday, August 30th
Amarillo City Library
413 East 4th Street
Second Floor, Room A

Tuesday, August 31st
Lubbock Mahon Library
1306 9th Street
Community Room

Copies of the documents are also available for review at each of the library locations.

If you need additional information, please call me.

Sincerely,

PARKHILL, SMITH & COOPER, INC.

By______________________________
John S. Kelley, P.E.

Enclosure

cc: Mr. John Williams, General Manager, CRMWA

Mr. E. R. Moore
President
CRMWA
P.O. Box 185
O'Donnell, TX 79351

Mr. Hal Miner
Director
CRMWA
P.O. Box 1856
Amarillo, TX 79105

Mr. Stansell Clement
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Vice President
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Mr. Tom Edmonds
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210 Broadmoor
Borger, TX 79007

Mr. Ray Renner
Director
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Lamesa, TX 79331

Mr. Leroy Montoya
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Mr. Glenn Bickel
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Mr. L. J. Richardson
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301 W. Main
Brownfield, TX 79316

Mr. O. W. Marcom
Director
CRMWA
101 San Jacinto
Levelland, TX 79336

Mr. Jerry Carlson
Director
CRMWA
2364 Chestnut
Pampa, TX 79065

Mr. Steve Tucker
Director
CRMWA
P.O. Box 160
Slaton, TX 79364

Agriculture

Local crop climatic data

PET (in inches)

	Halfway	Lubbock	Lamesa
Aug. 24	0.360	0.314	0.413
25	0.384	0.316	0.365
26	0.382	0.354	0.406
cum.	1.126	0.984	1.184

Heat Units (DD-60)

	Halfway	Lubbock	Lamesa
Aug. 24	17.0	20.1	21.8
25	15.8	17.3	17.4
26	16.2	17.9	20.4
cum.	49.0	55.3	59.6

Heat Units (DD-60)

	Halfway	Lubbock	Lamesa
5-1/8-26	1664.3	1929.7	2051.8
avg.	1692.6	1850.6	2017.0

*PET - Potential Evapotranspiration (inches)
N/A = not available
Source: Texas A&M, High Plains Underground Water Conservation District

A-J Graphic

In 1682, 100 Quakers, led by William Penn, sailed for America.

Light cotton market

By DUANE HOWELL
A-J Farm Editor

Cotton futures traded erratically on both sides of an important chart point Friday and settled modestly lower for the second day in a row.

The market closed off 15 to 49 points in generally light activity estimated at 3,750 contracts.

Trading in options totaled about 200 puts and 700 calls, with spreads

Analysis

and far out-of-the-money strikes accounting for most of the volume.

December flitted over a wide 105-point range and settled just above the median at 57.65 cents.

It spent most of the morning on the topside of the technically important 57.50-cent area and traded against that point on the downside during most of the afternoon.

A late rally in soybeans and Chicago grains may have given cotton a psychological lift.

For the week, October gained 117 points, December advanced 157 points and March rose 143 points.

Uncertainty over supply-side fundamentals in various part world neutralized the bear time being and opened the more emphasis on technic erations, said Mike Steven specialist with Swiss Finar vices Inc. at Mandeville, La

"There are enough cr lems in the world to make

PUBLIC MEETING NOTICE
CANADIAN RIVER MUNICIPAL AUTHORITY
REGIONAL WATER SUPPLY PLANNING PROJECT

A series of public meetings will be held on August 30 and 31, 1993 for the purpose of discussing the results of a preliminary engineering study prepared for the Canadian River Municipal Water authority (CRMWA). The CRMWA is comprise of eleven West Texas cities which obtain all or part of their water supply from Lake Meredith located in the Texas Panhandle.

The study was funded in part by the Texas Water Development Board and addressed the feasibility of supplementing Lake Meredith water with available ground water for the dual purpose of improving the quality of the water and increasing the quantity of water delivered to the member cities.

The study included historic and projected water use requirements, water quality trends in Lake Meredith, recent efforts of each of the cities in regard to water conservation efforts, and alternative ground water supply projects and their associate costs.

The meetings will be held at the following dates and locations:

Monday, August 30th	Tuesday, August 31st
Amarillo City Library	Lubbock Mahon Library
413 East 4th Street	1306 9th Street
Second Floor, Room A	Community Room
7:00 p.m.	7:00 p.m.

A copy of the report is available for review at each of the meeting locations.