Water Supply Study

prepared for

THE CITY OF WICHITA

WATER & SEWER DEPT.

1993

92-195-4

Burns & McDonnell

MID-KANSAS ENGINEERING CONSULTANTS PA

100% EMPLOYEE-OWNED
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June 30, 1993

City of Wichita Water and Sewer
Department
City Hall - Eighth Floor
455 North Main Street
Wichita, KS 67202-1677

WICHITA
Water Supply Study
Project 92-195-4

Ladies and Gentlemen:

Presented herewith is our report titled "Water Supply Study," in accordance with our contract for professional engineering services dated June 30, 1992.

This study includes the evaluation of 27 water supply alternatives for the purpose of providing additional raw water to meet the City of Wichita's projected water demands through the year 2050. Three water supply plans are developed from these alternatives, including the Milford Reservoir Water Supply Plan, the Integrated Local Water Supply Plan with 250 MGD Little Arkansas Diversion and the Integrated Local Water Supply Plan with 150 MGD Little Arkansas Diversion. The water supply plans are evaluated in terms of cost, water availability, political and legal constraints, water quality and other factors with the objectives of ranking the alternatives and selecting the preferred water supply plan.

The assistance provided by the staff of the Wichita Water and Sewer Department during the course of this study is greatly appreciated. The project team remains ready to discuss the details of this report at your convenience.

Sincerely,

Joel A. Cerwick

Joel A. Cerwick, P.E.
Vice President

Frank L. Shorney

Frank L. Shorney, P.E.
Project Manager

L. Jeffrey Klein

L. Jeffrey Klein, P.E.
Project Engineer

JAC/FLS/LJK/sr377

4800 East 63rd Street, Kansas City, Missouri 64130
Phone (816) 333-4375 Fax (816) 333-3690

CITY OF WICHITA
WATER SUPPLY STUDY
PROJECT 92-195-4

INDEX AND CERTIFICATION PAGE

REPORT INDEX

PART NO.	PART TITLE	NUMBER OF PAGES
ES	Executive Summary	21
IN	Introduction	1
I	Water Service Area and Demands	25
II	Inventory of Conventional Water Supplies	24
III	Inventory of Nonconventional Water Supplies	17
IV	Regional Water Balance	3
V	Evaluation Criteria	11
VI	Development of Alternatives	47
VII	Evaluation of Alternatives	45

CERTIFICATION(S)

FRANK LAVERN SHORNEY
LICENSED
6011
KANSAS
PROFESSIONAL ENGINEER

6/30/93

Executive Summary

EXECUTIVE SUMMARY

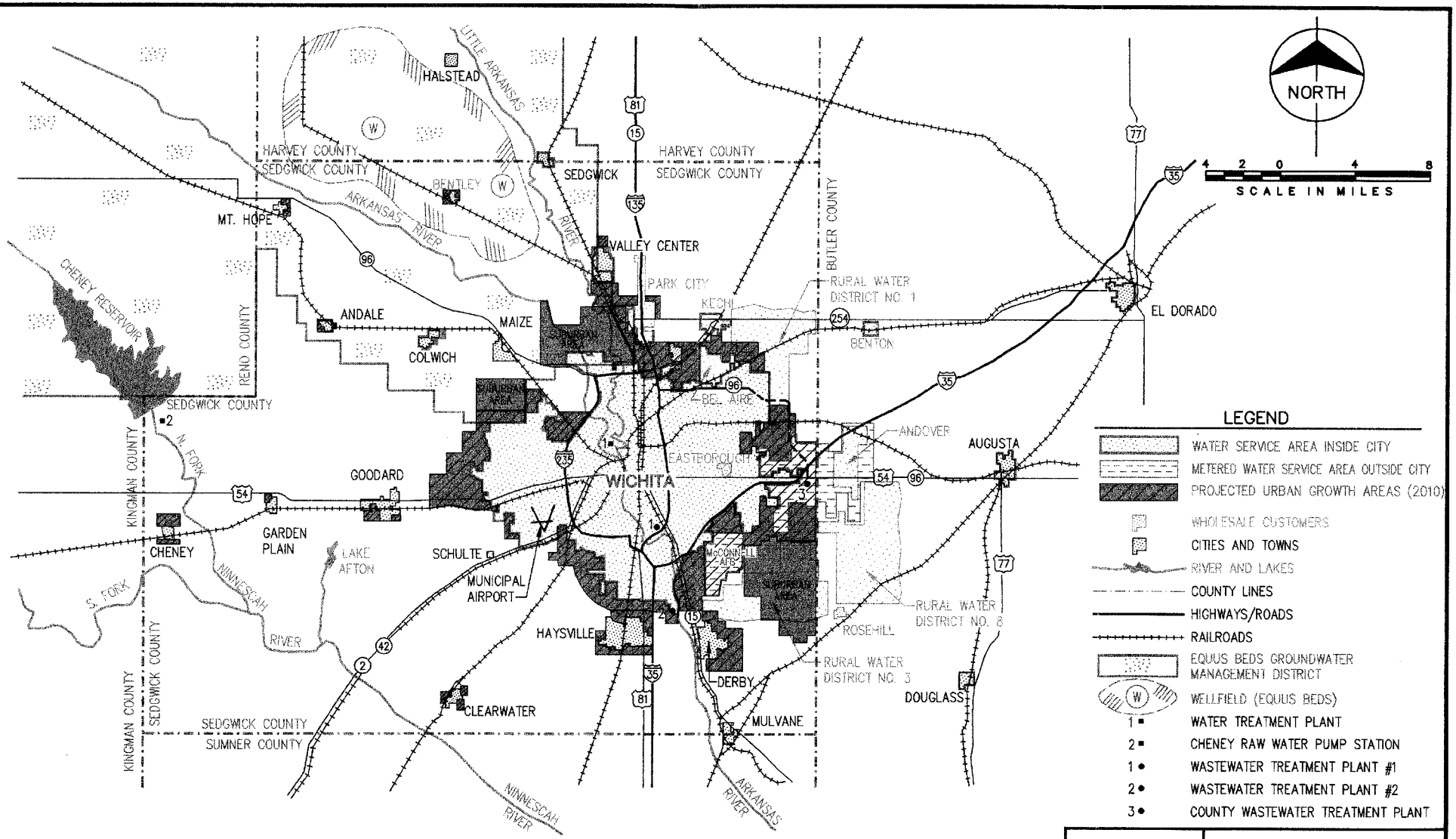
PURPOSE

This executive summary provides information from a water supply study of the City of Wichita's water service area for a planning period extending to year 2050. The study was initiated by a professional engineering services contract with Burns & McDonnell and Mid-Kansas Engineering Consultants on June 30, 1992.

WATER SERVICE

The City of Wichita provides potable water to over 114,000 water customers inside its 140 square-mile corporate area and to 11 wholesale customers and several residential/commercial customers outside the city limits as shown in Figure ES-1. Untreated well water is also provided to one wholesale customer, the City of Bentley, which is located outside the city limits in the City's Equus Beds Well Field.

The water service population is approximately 335,000 of which about 31,000 people are served outside the city limits. In the future, the City's water service area is expected to expand to serve smaller outlying water systems. This is because of the higher cost and greater operational complexity of meeting regulations of the Safe Drinking Water Act and encouragement of regionalization of water service by state and federal agencies.



NOTE:
PROJECTED GROWTH AREAS FROM INFORMATION PROVIDED BY THE WICHITA-SEDGWICK COUNTY METROPOLITAN AREA PLANNING DEPARTMENT

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Figure ES – 1

CURRENT WATER SYSTEM SERVICE AREA

Historical and projected population and water demands for the water service area are as follows:

Item	Historical Year 1991	Projected Year 2050
Average Day (AvDy) Demand[1]	62 MGD[3]	125 MGD[4]
Maximum Day (MxDy) Demand[2]	125 MGD	249 MGD
Population Served Inside City	304,000	445,000
Population Served Outside City	31,000	123,000
Total Population Served	335,000	568,000[5]
AvDy Demand Outside City	1.4 MGD	18.6 MGD

Notes:
[1]AvDy: Total amount of raw water used in a calendar year divided by number of days.
[2]MxDy: Highest raw water demand on a given day in a calendar year; usually occurs in July or August.
[3]MGD denotes million gallons of water per day.
[4]Includes a low-range water conservation plan which reduces average day demand by 18.5 MGD in year 2050.
[5]Service to 99% of projected population in Sedgwick County in the year 2050.

Population projections for the study are developed through the use of data from the U.S. Census Bureau, the U.S. Department of Commerce - Bureau of Economic Analysis and the Wichita-Sedgwick County Metropolitan Area Planning Department. Water demand projections are developed from water department customer data and include the impacts of the City's water conservation program. This program now includes a review and modification of the water rate structure on an annual basis to help achieve and maintain water conservation goals; maintaining watering restrictions (twice per week by address); public education programs; leak detection surveys; meter testing, repair and replacement programs; and, cooperative efforts with industries to encourage conservation of cooling, process, and irrigation water.

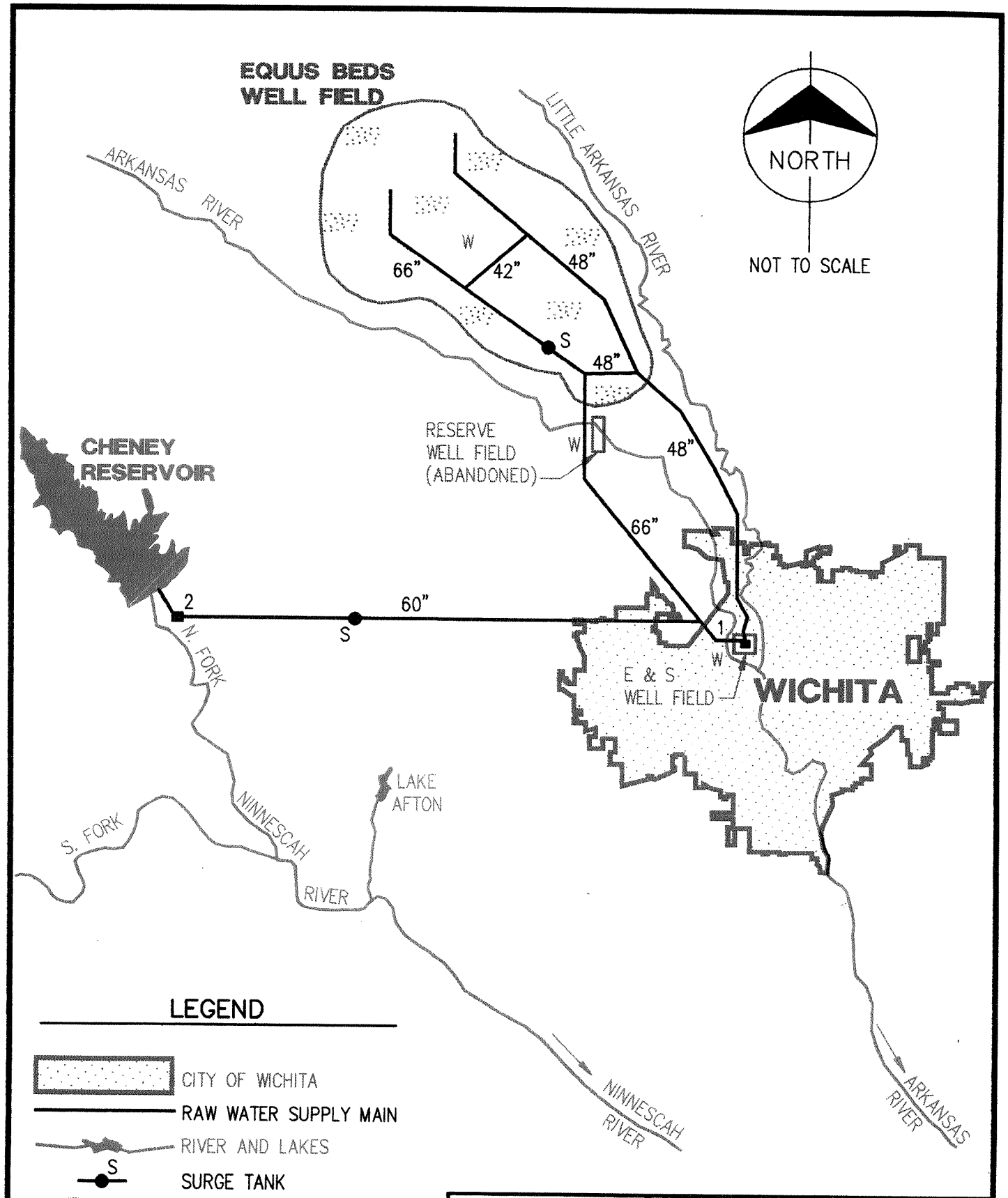
WATER SUPPLY SYSTEM

The City of Wichita has three principal raw water supply sources as shown in Figure ES-2, including Cheney Reservoir which is located 20 miles west of the City and the Equus Beds Aquifer which is located 16 miles northwest of the City. Raw water is pumped from these two sources through pipelines to the City's Central Water Treatment Plant which is located in Sim Memorial Park at the confluence of the Little Arkansas River and the Arkansas River. The City also uses a third water source consisting of 16 local wells located near the water plant which are referred to as the Emergency and Sim (E&S) Wells.

The Central Water Treatment Plant has a treatment capacity of 130 MGD and is currently undergoing construction to expand treatment capacity to 160 MGD. This expansion will utilize much of the remaining available space at the plant site. Engineering studies by others propose a new water plant site in the vicinity of a corridor along 21st Street north and west of I-235.

The Equus Beds Well Field was originally constructed in 1940 and now includes 55 vertical wells which lie within the boundaries of the Equus Beds Groundwater Management District No. 2. The District was formed in 1975 to manage the aquifer, to limit groundwater withdrawals to annual recharge from precipitation, and to protect the water quality in the aquifer.

Cheney Reservoir was placed in service in 1965 with a conservation pool for water supply of 151,780 acre-feet and 100 years of sediment storage. To address questions concerning the sediment load and its effect on the life of the lake, the U.S. Bureau of Reclamation is currently quantifying the sediment volume in the reservoir. Additionally, the City has obtained a 50 percent grant from the



LEGEND

- CITY OF WICHITA
- RAW WATER SUPPLY MAIN
- RIVER AND LAKES
- S — SURGE TANK
- W — WELL FIELD
- 1 — WATER TREATMENT PLANT
- 2 — CHENEY RESERVOIR PUMP STATION

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Figure ES – 2

RAW WATER SUPPLY SYSTEM SCHEMATIC

Kansas Department of Health and Environment (KDHE) to develop a watershed management plan. The City is also working with Reno County Soil Conservation Service and Sedgwick County Conservation District to develop this plan. Pending the Bureau's findings, the City may consider watershed management techniques, such as the construction of upstream siltation ponds, paying farmers to plant grass strips along stream banks and educating farmers in minimum pesticide and fertilizer application methods, to protect the reservoir's water storage volume and water quality.

The raw water delivery capacities and the existing and pending water rights for the City's current water supply sources with existing facilities are as follows:

Item	Existing Delivery Capacity (MGD)[1]		Existing & Pending Water Rights	
	AvDy	MxDy	AvDy	MxDy
Equus Beds Well Field	36	55	36	78
Cheney Reservoir	27	60	47	103
Local E&S Wells	15	15	16	33
Total	78	130	99	214

Notes:
[1]As limited by pumping capacity, water rights or firm yield.

A comparison of projected water demands with existing raw water delivery capacity indicates that water supply shortfalls during extended dry weather periods could occur in year 2004 for the average day demand and in year 1996 for the maximum day demand. The City currently has applications to the state for additional water rights in Cheney Reservoir and the Equus Beds Well Field. Additional water needs to meet average day demands are typically used to size new water sources and additional water needs to meet maximum day demands are typically used to size raw water delivery facilities and water treatment plants.

NEAR-TERM WATER SUPPLY SOURCE IMPROVEMENTS

Near-term water supply source improvements are proposed to increase the pumping capacity of the City's water supply system, thereby delaying projected water supply deficits and providing more time to implement a major water supply plan. Anticipated near-term improvements include:

Near-Term Project	Improvement Description	Year Complete
1	Rehabilitate 16 E&S Wells for an Estimated Cost of $0.6 Million.	1994
2	Rehabilitate 25 Equus Beds Wells for an Estimated Cost of $2.2 Million, Increase Pumping Capacity of Cheney Pump Station and Increase Height of Surge Tank by 75 Feet for an Estimated Cost of $3.4 Million, and Install a Raw Water Control Valve Structure and Bypass at the Central Water Plant for an Estimated Cost of $3.7 Million.	1995

Note:
[1]Estimated costs include construction, engineering and other special services costs.

These improvements will increase the average day pumping capacity to 90 MGD which will delay the average day supply shortfall to year 2015 and will increase the maximum day pumping capacity to 165 MGD which will delay the maximum day supply shortfall to year 2008. Additional improvements to make full use of all of the City's existing and pending water rights are included in later phases of water supply plans which are described hereafter.

ADDITIONAL LONG-TERM WATER NEEDS

With provision of the near-term improvements, the projected additional water needs for the City for the year 2050 are as follows:

- **Average day deficit of 35 MGD.**
- **Maximum day deficit of 54 MGD.**

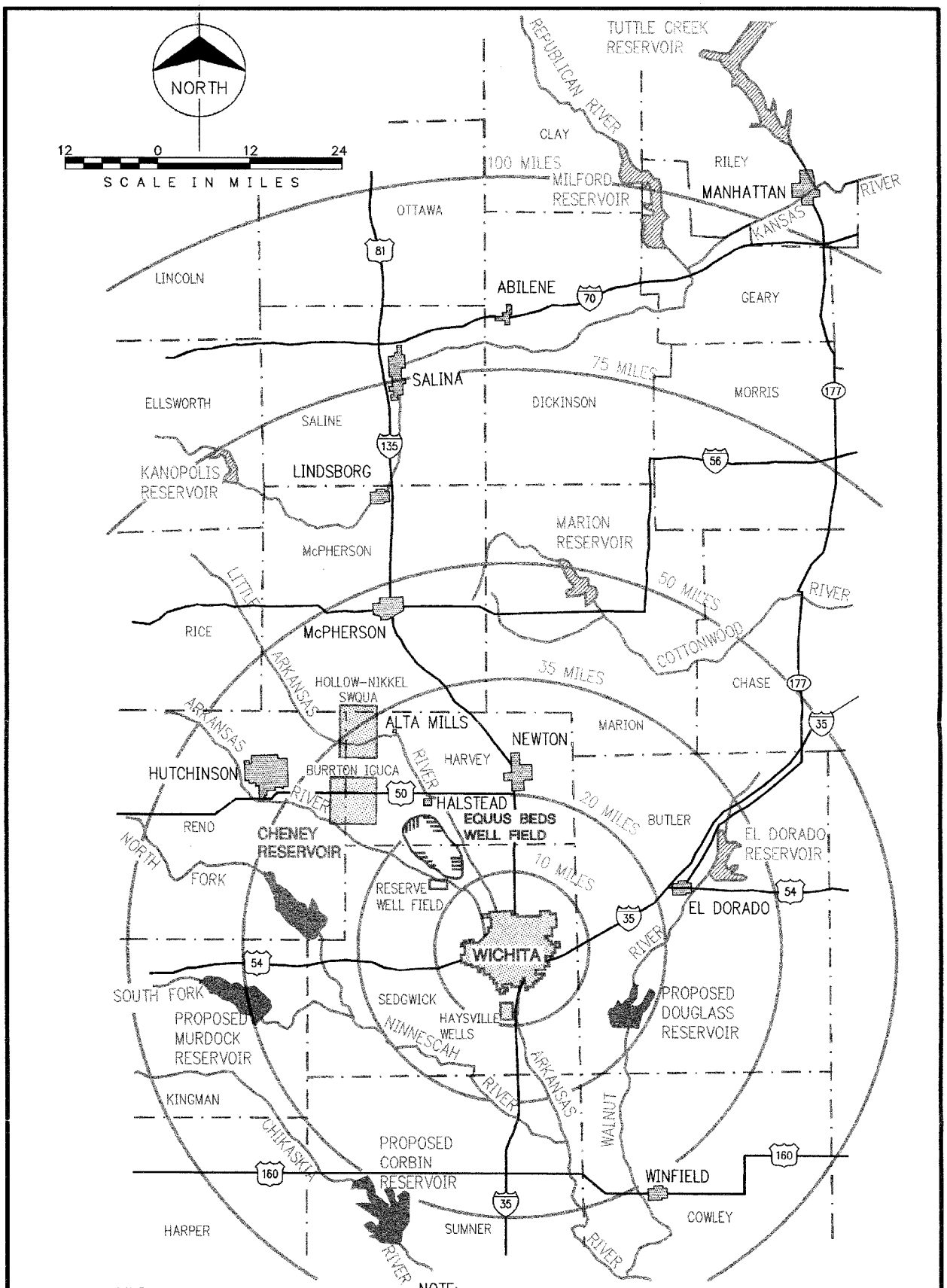
Implementation of water supply plans to furnish these projected water needs may require up to 10 years in advance of the projected year of water deficit for completion of planning, permitting, design, construction, start-up and operational activities. As a result, certain concept development studies related to each plan should begin in the near future.

WATER SUPPLY ALTERNATIVES

Twenty-seven water supply alternatives were evaluated in the water supply study to meet the City's additional long-term water needs. Major source alternatives are shown in Figure ES-3 and are listed hereafter.

induced flow

- Groundwater from bank storage along the Little Arkansas River.
- Excess surface water flow in the Little Arkansas River.
- Operations modifications to use flood and surcharge pool storage in Cheney Reservoir.
- Existing and new surface water reservoirs (Milford, Kanopolis, Tuttle Creek, Corbin, Douglass and Murdock).
- Treated wastewater reuse for irrigation of parks and golf courses.
- Reverse osmosis treatment or blending of high-chloride water sources such as the Arkansas River and river alluvium, the Haysville Well Field, the Hollow-Nikkel Special Water Quality Use Area (SWQUA) and the Burrton



LEGEND

- EXISTING RESERVOIR
- EXISTING RESERVOIR/CITY OF WICHITA SUPPLY SOURCE
- EXISTING CITY OF WICHITA WELL FIELD
- PROPOSED RESERVOIR
- POTENTIAL GROUNDWATER SOURCE

NOTE:
WATER CONSERVATION, E&S WELLFIELD, GILBERT-MOSLEY REMEDIATED GROUNDWATER, AND WASTEWATER REUSE ARE NOT SHOWN.

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Figure ES – 3

CITY OF WICHITA WATER SUPPLY SOURCE LOCATION MAP

Intensive Groundwater Use Control Area (IGUCA) in Equus Beds Groundwater Management District No. 2.

- Remediated groundwater from the Gilbert-Mosley Well Field.
- Groundwater from redeveloped Reserve Well Field.
- No Action (with no additional, low range and high range water conservation).

The most feasible alternatives from this list were used to develop two basic water supply plans capable of meeting the projected water needs of the City's water service area through the year 2050. These alternatives were selected after screening and elimination of water sources based on available flow, unit cost information and related policy/political, legal, environmental, and water quality issues. For example, the construction of new reservoirs was eliminated on the basis of high unit costs and significant environmental impacts. Similarly, reverse osmosis treatment of high-salt water sources was eliminated on the basis of high costs associated with process operation and reject water disposal.

The "no action" alternative differed from the other alternatives since it considered the ramifications to system operation under the condition of no new water sources for a self-imposed limited growth scenario. With this alternative, the City would construct only the necessary facilities to convey their pending maximum day water rights of 214 MGD and would supply average day demands up to the average day water rights of 99 MGD. The potential service area population for this alternative and the year the available supply would be exceeded under conditions of no additional water conservation, low range water conservation and high range water conservation vary as follows:

Water Conservation Option	Based on AvDy Water Rights[2] Maximum Service Area Population	Projected Year Supply Exceeded	Based on MxDy Water Rights[3] Maximum Service Area Population	Projected Year Supply Exceeded
No Additional[1]	470,000	2018	410,000	2017
Low Range	495,000	2023	470,000	2033
High Range	540,000	2040	550,000	2049

Notes:
[1]Maintains on-going conservation efforts by the City.
[2]Based on average day water rights of 99 MGD.
[3]Based on maximum day water rights of 214 MGD and year 2050 projected per capita water use.

Based on this information, the "no action" alternative will not meet projected year 2050 water demands under any water conservation option (no additional, low range or high range). Adherence to a "no action" plan throughout the planning period would limit growth and risk loss of future development, tax revenues and jobs and would involve changes in current philosophy and policy by the City's governing body. Since this alternative does not meet the basic study evaluation criteria of furnishing water demands through the year 2050 planning period, it was dropped from further consideration.

WATER SUPPLY PLANS

Two basic water supply plans (one plan has two options) are developed for evaluation and cost comparison in the water supply study. These plans are designated the Milford Reservoir Water Supply Plan, the Integrated Local Water Supply Plan with 250 MGD Little Arkansas Division Option, and the Integrated Local Water Supply Plan with 150 MGD Little Arkansas Diversion Option. Each plan will meet the City of Wichita's projected water needs through year 2050.

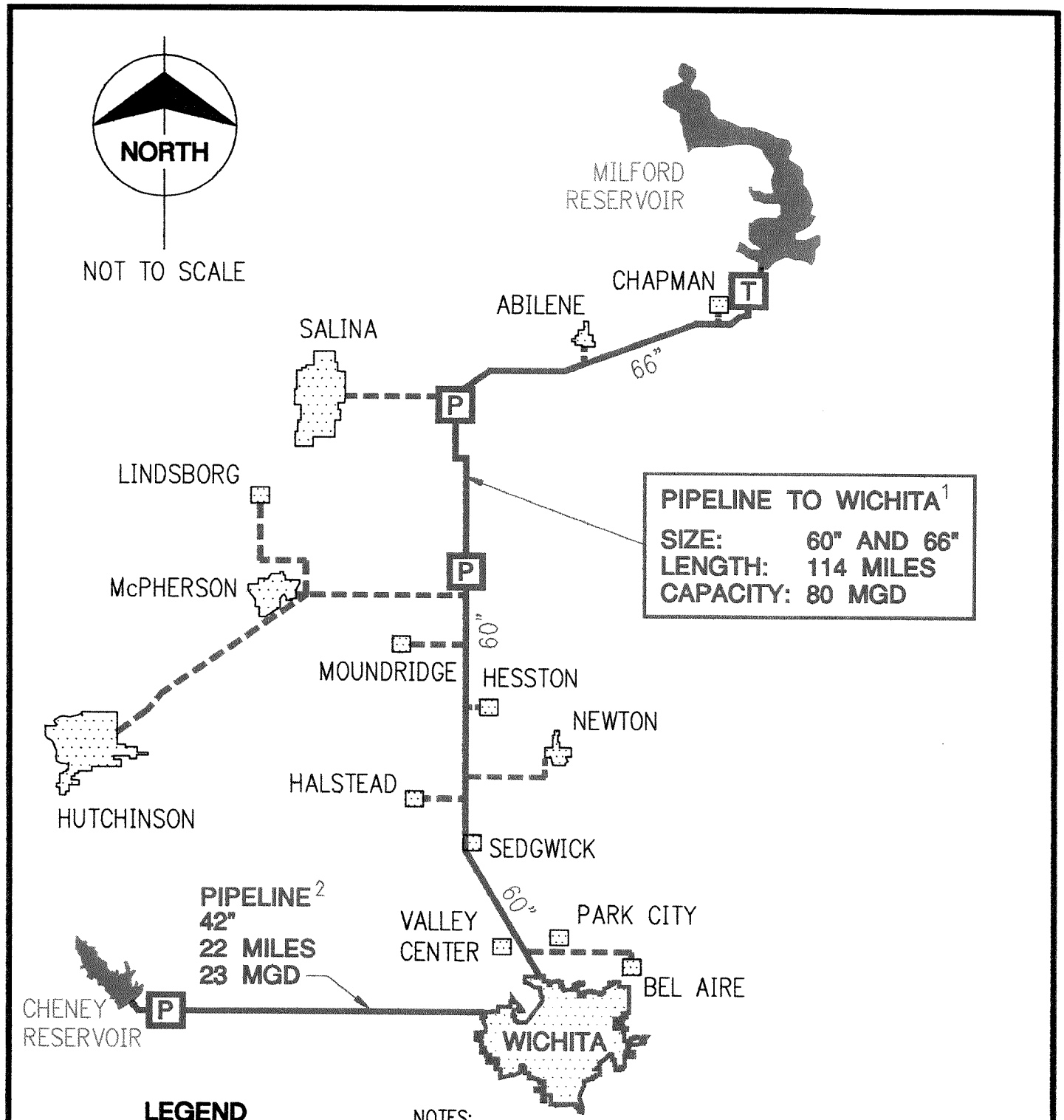
MILFORD RESERVOIR WATER SUPPLY PLAN

The Milford Reservoir Water Supply Plan includes the use of water from Milford Reservoir as shown in Figure ES-4, the continued use of existing water sources, including Cheney Reservoir, the Equus Beds Well Field and the E&S Well Field, and the continued practice of water conservation by the City. The basic concept of the Milford Reservoir Supply Plan was presented in an engineering study completed by others in 1991 for the City of Wichita and 14 other cities (designated in the study as Public Wholesale Water District No. 10).

The District 10 plan included the conveyance of treated water from Milford Reservoir to Wichita through 114 miles of 60-inch and 66-inch diameter pipeline while serving various entities in central Kansas along the pipeline route. The pipeline was sized to carry a maximum of 80 MGD of which about 60 MGD would be supplied to Wichita on a continuous basis.

Three basic phases of construction of new facilities are proposed in the implementation of the Milford Reservoir Water Supply Plan (which incorporates the District 10 plan) to meet projected water demands. These phases are anticipated as follows:

- Phase 1 - Additional Water Conservation Measures (1995-1999):
  - Make building plumbing code changes to incorporate low flush toilets (1.6 gallons per flush) and low flow shower heads and faucets (2.5 gpm) to be in effect by 1995.
  - Initiate a full scale plumbing fitting retrofit program for housing units built before the new water conservation plumbing code goes into effect (the study assumes January 1, 1995).



LEGEND

- CITY OR TOWN
- T — WATER PLANT
- P — PUMP STATION
- PROPOSED PIPELINE
- PROPOSED PIPELINES SERVING CITIES & TOWNS OTHER THAN WICHITA

NOTES:

1. PLAN ALSO INCLUDES A WATER CONSERVATION PROGRAM AND MINOR IMPROVEMENTS IN THE EQUUS BEDS WELL FIELD.
2. SECOND PIPELINE FROM CHENEY RESERVOIR TO PROVIDE MAXIMUM DAY WATER RIGHT.

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Figure ES – 4

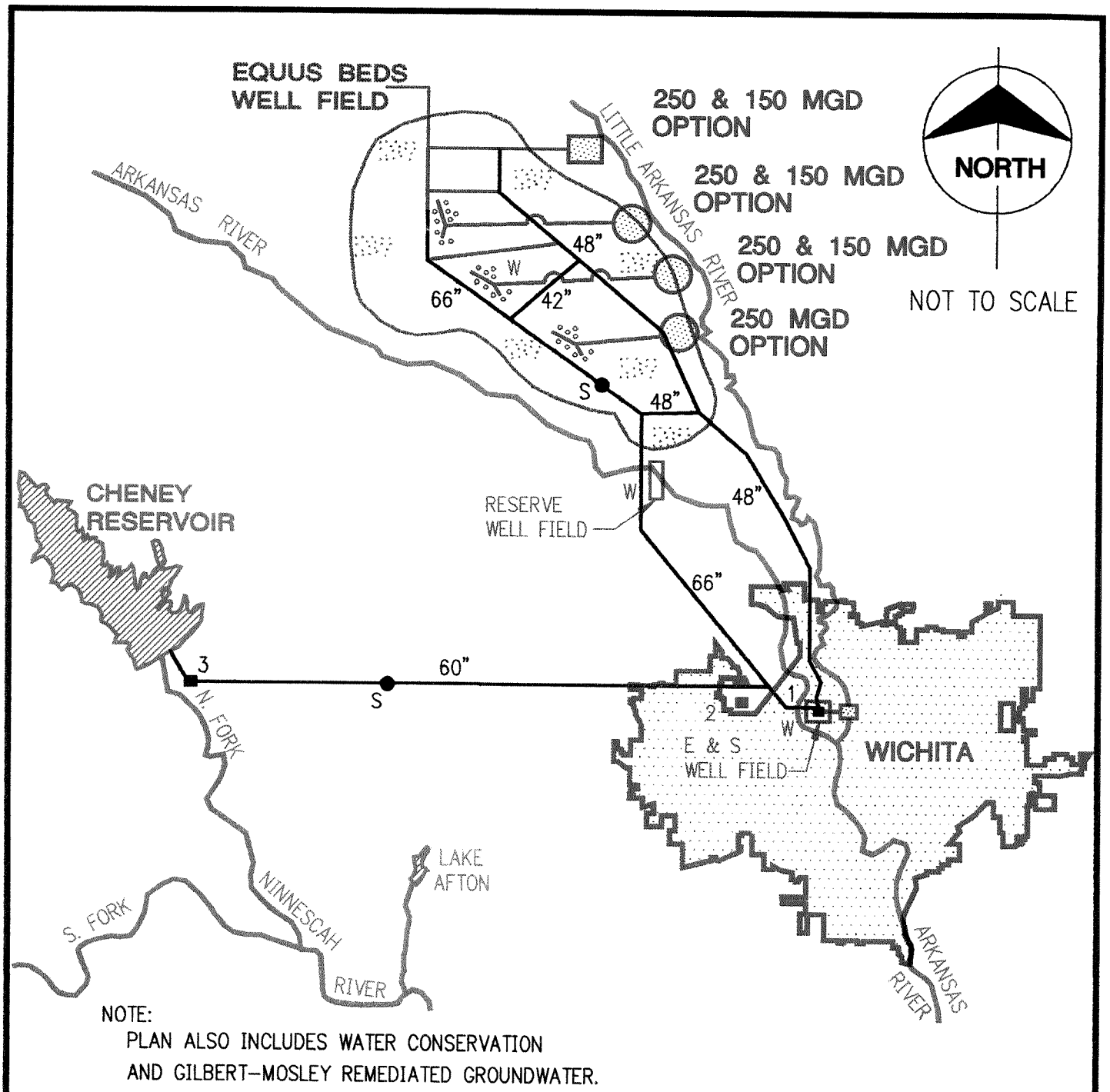
MILFORD RESERVOIR WATER SUPPLY PLAN SCHEMATIC

- Phase 2 - Milford Reservoir Supply (complete year 2005).
  - 80 MGD raw water intake.
  - 60-inch diameter pipeline from intake to water plant with 80 MGD capacity.
  - 80 MGD water treatment plant.
  - About 114 miles of 66-inch and 60-inch diameter transmission pipeline with 80 MGD capacity.
  - About 87 miles of 6-inch through 30-inch feeder pipelines to customers other than Wichita.
  - Three booster pump stations along main transmission pipeline, each with 80 MGD pumping capacity.
  - One booster pump station for Hutchinson.
  - Customer metering, pressure reducing stations, and appurtenances.
  - District Operations Headquarters.
- Phase 3 - Cheney Reservoir Pipeline and Equus Beds Well Field Improvements (complete year 2038).
  - About 22 miles of 42-inch diameter pipeline from Cheney Reservoir to Wichita's water plant(s).
  - One 23 MGD booster pump station at Cheney Reservoir.
  - 5 new 1,500 gpm wells (for firm capacity).
  - Pipeline improvements including 3 miles of 66-inch diameter pipeline and a booster pump station.
  - 30 MGD water plant at a new plant site.

INTEGRATED LOCAL WATER SUPPLY PLAN

The Integrated Local Water Supply Plan incorporates the use of water from local sources, including the capture of excess surface water and bank storage water from the Little Arkansas River with recharge and storage of water in the Equus Beds Aquifer as shown in Figure ES-5. The plan also includes water source operating modifications to increase raw water use from flood, surcharge and conservation pools in Cheney Reservoir while conserving groundwater in the Equus Beds Well Field area. Water conservation is an integral part of the plan and is identical to that for the Milford Plan.

Two options were developed for the Integrated Local Water Supply Plan which offer different levels of operating flexibility at significantly different capital costs. The 250 MGD Diversion Option includes higher capacity pumping and water transmission facilities, provides the capability of meeting projected year 2050 maximum day demands from stored water in the Equus Beds during a drought condition, and has a higher capital cost. The 150 MGD Diversion Option includes slightly less operating flexibility based on meeting the projected year 2050 maximum day demands from a combination of both stored water in the Equus Beds and Cheney Reservoir during a drought condition, and has a lower capital cost. The features of each option are as follows:



NOTE:
PLAN ALSO INCLUDES WATER CONSERVATION
AND GILBERT–MOSLEY REMEDIATED GROUNDWATER.

LEGEND

- RAW WATER SUPPLY MAIN
- RIVER AND LAKES
- S — SURGE TANK
- W — WELL FIELD
- 1 ■ CENTRAL WATER TREATMENT PLANT
- 2 ■ NEW WATER TREATMENT PLANT
- 3 ■ CHENEY RESERVOIR PUMP STATION
- PROPOSED PIPELINE
- SURFACE WATER INTAKE
- BANK STORAGE RECOVERY PUMP SITE & INJECTION WELLS

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Figure ES – 5

INTEGRATED LOCAL WATER SUPPLY PLAN SCHEMATIC

Parameter	250 MGD Diversion Option	150 MGD Diversion Option
Equus Beds Fill Time[1]	9 years	10.4 years
Little Arkansas River Diversion Capacity[2]	250 MGD	150 MGD
Equus Beds Well Field Pumping & Piping Capacity	220 MGD	170 MGD
Cheney Reservoir Operation[3,4]		
Average Level	1,418.0 ft	1,417.7 ft
Minimum Level	1,398.6 ft	1,394.3 ft
Equus Beds Operation[3,5]		
Average Drawdown	1.3 ft	1.6 ft
Maximum Drawdown	7.9 ft	7.9 ft

Notes:
[1]Average fill time based on drawdown at current levels, year 2010 demands over 69 years of record, 100 cfs minimum flow in Little Arkansas and fill to target groundwater levels of the 1950s.
[2]Includes both excess surface water and bank storage water.
[3]Sources half-full at beginning of simulation, year 2050 demands over 69 years of record.
[4]Top of conservation pool is 1,420 ft USGS and bottom of conservation pool is 1,392.9 ft USGS.
[5]Drawdown from target groundwater levels in the 1950s.

Completion of construction phases for the Integrated Local Water Supply Plan with the 250 MGD Diversion Option or 150 MGD Diversion Option are scheduled to meet projected water demands as follows:

- Phase 1 - Gilbert-Mosley Well Field (1994 to 1995):
  - Convey remediated Gilbert-Mosley groundwater to the Central Water Plant at a continuous rate of 3 MGD.

- Phase 2 - Additional Water Conservation Measures (1995-1999):
  - (Same as for Milford Plan)

- Phase 3 - Reserve Well Field (1997 to 2004):
  - Redevelop abandoned Bentley Reserve Well Field to supply groundwater during peak water use periods. Add six wells with a capacity of 10.8 MGD.

- Phase 4 - Little Arkansas River Intake Adjacent to Central Water Plant (1997 to 2004):
  - Construct a 160 MGD surface water intake on the Little Arkansas River, 0.5 miles of 96-inch diameter pipeline and a 160 MGD presedimentation basin at the water plant. Water will be conveyed to the plant on an "as-available" basis.

- Phase 5 - Little Arkansas River Diversion to Equus Beds (2004):

  <u>250 MGD Diversion Option</u>:
  - Construct 160 MGD surface water intake and pipeline to the Equus Beds Well Field and 40 surface spreading basins. Water will be spread on basins at well sites to recharge the aquifer.
  - Construct six bank storage horizontal collector wells with a total capacity of 90 MGD, pipelines to Equus Beds Well Field and injection wells to recharge the aquifer.
  - Equus Beds Well Field piping improvements include a 66-inch diameter pipeline from the Central Water Plant to Well No. 1.

150 MGD Diversion Option:

- Construct 90 MGD surface water intake and pipeline to the Equus Beds Well Field and 23 surface spreading basins. Water will be spread on basins at well sites to recharge the aquifer.
- Construct four bank storage horizontal collector wells with a total capacity of 60 MGD, pipelines to the Equus Beds Well Field and injection wells to recharge the aquifer.
- Equus Beds Well Field piping improvements include 8.5 miles of 66-inch diameter and 5.5 miles of 48-inch diameter pipelines.

- Phase 6 - Water Treatment Plant (2006):
  - Construct initial facilities for 30 MGD capacity at a new water plant with an ultimate planned capacity of 90 MGD.

- Phase 7 - Equus Beds Well Field Improvements (2009):

  250 MGD Diversion Option:
  - Expand Equus Beds Well Field conveyance capacity from about 55 MGD to about 150 MGD, firm capacity. Add 40 wells, a 120 MGD booster pump station on the east 66-inch diameter pipeline.

  150 MGD Diversion Option:
  - Expand Equus Beds conveyance capacity from about 55 MGD to about 130 MGD, firm capacity. Add 30 wells, a 120 MGD booster pump station on the 66-inch diameter pipeline and 4.5 miles of 72-inch diameter pipeline.

- Phase 8 - Additional Improvements (2020):
  - Expand new water plant by 20 MGD to total 50 MGD capacity.

250 MGD Diversion Option:

- Expand Equus Beds Well Field conveyance capacity from 150 MGD to 170 MGD, firm capacity. Add 10 wells.

- Phase 9 - Additional Improvements (2030):

  - Expand new water plant by 20 MGD to total 70 MGD capacity.

  250 MGD Diversion Option:

  - Expand Equus Beds Well Field conveyance capacity from 170 MGD to 190 MGD, firm capacity. Add 10 wells, the second 120 MGD booster pump station.

  150 MGD Diversion Option:

  - Expand Equus Beds Well Field conveyance capacity from 130 MGD to 150 MGD, firm capacity. Add 10 wells.

- Phase 10 - Additional Improvements (2040):

  - Expand new water plant by 20 MGD to total 90 MGD capacity.

  250 MGD Diversion Option:

  - Expand Equus Beds Well Field conveyance capacity from 190 MGD to 210 MGD, firm capacity. Add 10 wells.

  150 MGD Diversion Option:

  - Expand Equus Beds Well Field conveyance capacity from 150 MGD to 170 MGD, firm capacity. Add 10 wells, a booster pump station on the 48-inch diameter pipeline and 7 miles of 66-inch diameter pipeline.

COMPARISON OF PLANS

A comparison of costs for the three water supply plans in March, 1993 dollars are as follows:

Plan	Project Cost ($ million)	Present Value ($ million)	Unit Cost ($/1000 gal.)
Milford Reservoir Water Supply Plan	322	447	1.90
Integrated Local Water Supply Plan with 250 MGD Little Arkansas Diversion Option	291	360	1.35
Integrated Local Water Supply Plan with 150 MGD Little Arkansas Diversion Option	237	316	1.29

Project costs include construction costs for water supply and treatment components and include contingency allowances of 20 percent. Costs of land and right-of-way, engineering services and purchase of reservoir storage are included as part of the project cost estimates. The water treatment project cost included in each plan is approximately $106 million.

Present value cost estimates permit comparison of project costs and operation and maintenance costs for all phases of each water supply plan in terms of March, 1993 dollars. The present value computations cover a period from 1994 to year 2050 with an annual inflation rate of 4 percent and are discounted to 1993 at an annual rate of 7 percent.

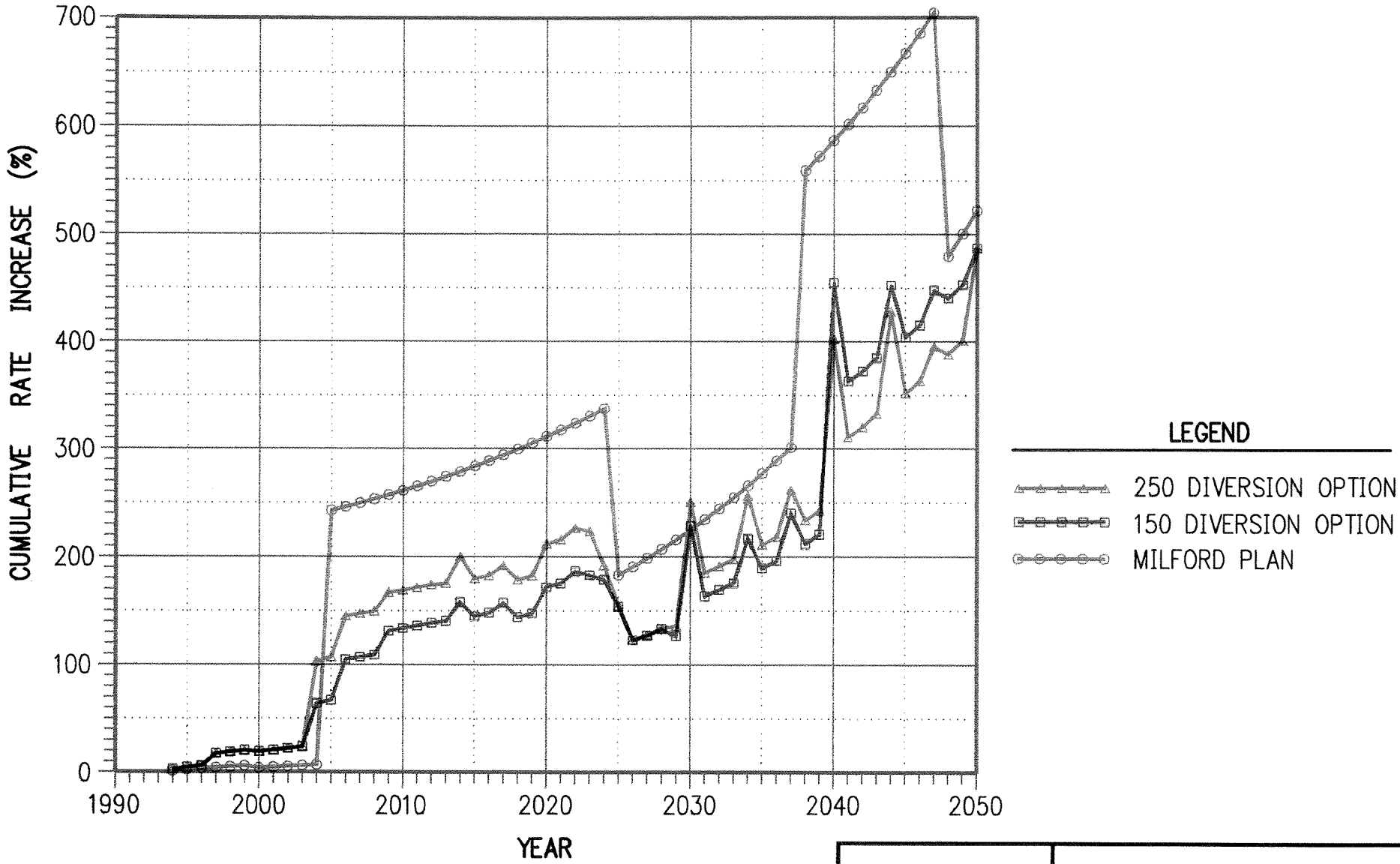
Unit costs of water for each plan are determined by dividing the total cost (debt service and operation and maintenance) of each plan over the study period by the

total amount of water used over the study period. Total cost is expressed in terms of inflated dollars.

Cost estimates indicate that the Integrated Local Water Supply Plan with 150 MGD Little Arkansas Diversion Option has the lowest total project cost at $237 million, the lowest 1993 present value cost of $316 million, and the lowest unit cost of $1.29 per 1000 gallons over the study period. The Integrated Local Water Supply Plan with 250 MGD Diversion Option is the second lowest cost plan and the Milford Reservoir Water Supply Plan is the most expensive plan.

The impact of each water supply plan on water rates is shown in Figure ES-6. The projected water rates represent minimum increases to maintain debt service coverage to fund the capital improvements and contingency funds in each plan phase. The Milford Reservoir Supply Plan requires the greatest increase (700%) in water rates over the planning period from 1995 through 2050. The two diversion options of the Integrated Local Water Supply Plan require a lower water rate increase (490%) and are similar because of similar operation and maintenance cost over the planning period. In the early years of operation, the 150 MGD diversion option has the least impact on rates of all alternatives because it has the lowest capital cost.

Other factors or parameters besides costs may be used to evaluate the suitability of preference of a water supply plan. Such items may include comparisons of water supply capability and availability, water quality and political and legal considerations.



Burns & McDonnell

Figure ES - 6

CUMULATIVE RATE INCREASES FOR WATER SUPPLY PLANS

The Milford Reservoir Water Supply Plan provides additional water supply from Milford Reservoir to the City on a firm-yield basis. This plan requires state approval through the Water Transfer Act and raises political/legal issues regarding the transfer of water from the northeast region of the state to the south-central part of the state. The Water Transfer Act, as recently amended by the State legislature, requires State approval for the diversion and transportation of water in a quantity of 2000 acre-feet (652 million gallons) or more per year for beneficial use at a point of use outside a 35-mile radius from the point of diversion of such water. Also, since the completion of the District 10 report in 1991, the Kansas Water Office is reevaluating the quantity of water which is available from Milford for use in an engineering study to be completed in December, 1993. This study may influence the amount of water available to District 10 and the City of Wichita.

The Integrated Local Water Supply Plans use existing local water supplies and excess water from the Little Arkansas River, above base stream flow, on an "as-available" basis to meet the City's water demands and to recharge the Equus Beds Aquifer. Concurrently, water in the flood and surcharge pools of Cheney Reservoir will be conveyed to the City for treatment on a priority "as-available" basis to meet system demands. Use of these "as-available" waters will allow the Equus Beds to be recharged for later use during drought conditions and eliminates the need for additional water supply sources from outside the region during the study period. This plan will not automatically require state approval through the Water Transfer Act and should be less controversial than the Milford Plan.

Implementation of the Local Integrated Water Supply Plan will require an integrated or conjunctive use permit from the Kansas Division of Water Resources

to allow the City to use its local supplies on an "as-available" basis. Preliminary discussions with the state indicate that the acquisition of such a permit is possible, although further discussions with the state are necessary. Such a permit would limit the annual average and maximum water withdrawals from various sources on a combined or total source basis instead of an individual source basis, and thus, allow the City to optimize the use of its local water resources. Obtaining a conjunctive use permit from the state is necessary to make the Integrated Local Water Supply Plan feasible.

The water quality of each plan is considered comparable and is suitable for treatment to potable water quality. Both plans offer additional water sources with increased surface water characteristics which will likely increase the complexity and cost of treatment to some extent. The Integrated Local Plans will also use groundwater from the E&S Well Field, the redeveloped Reserve Well Field and the Gilbert-Mosely Remediated Well Field which will require blending of water on an occasional basis to maintain desired chloride levels below the City's goal of 200 mg/l.

The Integrated Local Water Supply Plan (either option) will recharge the Equus Beds within an approximate 10-year period and preserve the aquifer for use by both the City and local farmland irrigators. Groundwater drawdown in the area now approaches 40 feet in some areas and chloride plumes from the Arkansas River to the south and from abandoned oil wells to the northwest are now migrating into the City's well field. Recharging the aquifer will prevent water quality degradation and provide a large volume of stored groundwater for future use during drought conditions. The Milford Reservoir Water Supply Plan does not offer significant benefits to preserving the aquifer.

RANKING OF WATER SUPPLY PLANS

Based on the evaluations performed, the three water supply plans are ranked in terms of preference as follows:

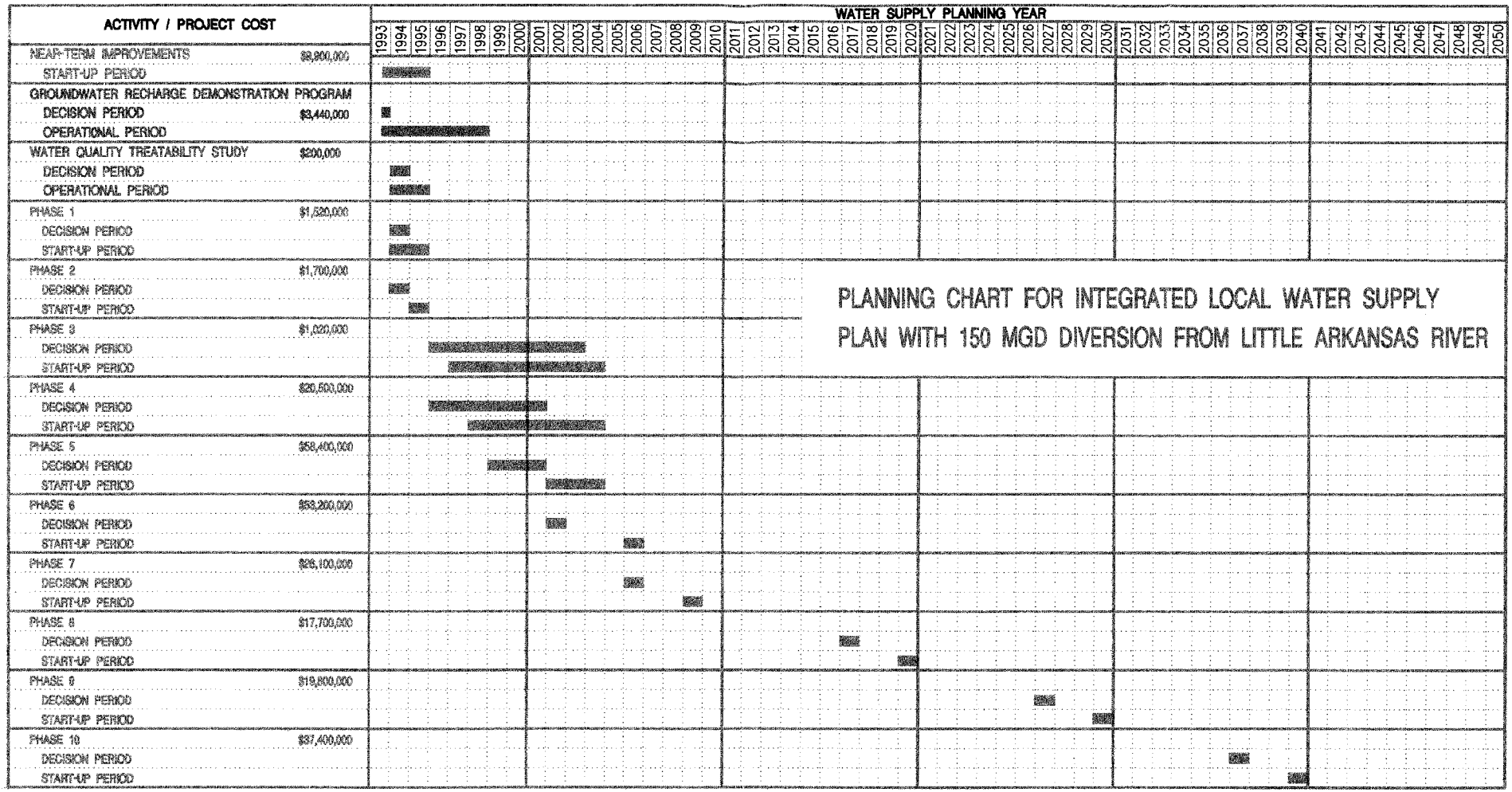
Rank	Plan
Preferred	Integrated Local Water Supply Plan with 150 MGD Little Arkansas Diversion Option
Second	Integrated Local Water Supply Plan with 250 MGD Little Arkansas Diversion Option
Third	Milford Reservoir Water Supply Plan

Plans are ranked based primarily on cost estimates with consideration of political/legal ramifications associated with water transfer from one region of the state to another.

Although the Integrated Local Water Supply Plan with 150 MGD Diversion Option offers slightly less operating flexibility and causes slightly greater impacts to water levels in Cheney Reservoir and the Equus Beds Well Field than the 250 MGD Diversion Option, it is preferred because of cost savings. Both options are capable of meeting projected water demands through year 2050.

PREFERRED AND RECOMMENDED PLAN

The preferred water supply plan, on the basis of the engineering studies performed, is the Integrated Local Water Supply Plan with 150 MGD Little Arkansas Diversion Option. This plan is recommended as the first choice option for implementation by the City of Wichita. A planning chart for various plan phases from year 1993 through year 2050 is shown on Figure ES-7.



NOTES:

1. DECISION PERIODS INDICATE SCHEDULED TIME FRAMES FOR AUTHORIZATION OF IMPROVEMENT PHASES BY THE CITY COUNCIL . START-UP PERIODS INDICATE TIME FRAMES DURING WHICH IMPROVEMENT PHASES SHOULD BECOME OPERATIONAL.
2. NEAR-TERM IMPROVEMENTS HAVE BEEN AUTHORIZED BY THE CITY COUNCIL AND INCLUDE REHABILITATION OF 18 E&S WELLS AND 25 EQUUS BEDS WELLS AND INCREASING PUMPING CAPACITY AT CHENEY PUMP STATION.
3. PHASE 1 INCLUDES DEVELOPMENT OF THE 3 MGD GILBERT-MOSLEY WELL FIELD.
4. PHASE 2 INCLUDES IMPLEMENTATION OF A FULL SCALE PLUMBING RETROFIT PROGRAM.
5. PHASE 3 INCLUDES DEVELOPMENT OF 11 MGD RESERVE WELL FIELD.
6. PHASE 4 INCLUDES DEVELOPMENT OF 160 MGD LITTLE ARKANSAS RIVER DIVERSION TO THE CENTRAL WATER TREATMENT PLANT.
7. PHASE 5 INCLUDES DEVELOPMENT OF 150 MGD LITTLE ARKANSAS RIVER DIVERSION TO THE EQUUS BEDS AQUIFER FOR RECHARGE.
8. PHASE 6 INCLUDES CONSTRUCTION OF 30 MGD IN WATER TREATMENT PLANT CAPACITY AT A NEW PLANT SITE.
9. PHASE 7 INCLUDES A 50 MGD EXPANSION TO 150 MGD TOTAL CAPACITY IN THE EQUUS BEDS WELL FIELD.
10. PHASE 8 INCLUDES A 20 MGD EXPANSION TO 50 MGD AT THE NEW WATER PLANT.
11. PHASE 9 INCLUDES A 20 MGD EXPANSION TO 70 MGD AT NEW WATER PLANT AND A 20 MGD EXPANSION TO 150 MGD TOTAL CAPACITY IN EQUUS BEDS WELL FIELD.
12. PHASE 10 INCLUDES A 20 MGD EXPANSION TO 90 MGD AT NEW WATER PLANT AND A 20 MGD EXPANSION TO 170 MGD TOTAL CAPACITY IN EQUUS BEDS WELL FIELD.
13. PROJECT COSTS ARE IN 1993 DOLLARS.

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Figure ES – 7

CITY OF WICHITA
WATER SUPPLY PLANNING CHART
YEAR 1993 TO YEAR 2050

Additional engineering studies, including a groundwater recharge demonstration project, are recommended in the future. These studies should be started in fiscal year 1993 in order to take advantage of a $1 million (or more) grant which may be available from the U.S. Bureau of Reclamation. The findings of this study are needed to obtain state approval of the integrated or conjunctive use permit and to develop design criteria for the groundwater recharge system.

Another engineering study which should be completed by the City in the near future is a surface water treatability study. This study is required to determine the impacts to water treatment as a result of using greater quantities of surface water in lieu of Equus Beds groundwater. This study should define any needed operational changes and treatment process modifications which may be required at the Central Water Plant and the new water treatment plant.

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Table of Contents

TABLE OF CONTENTS

	Page No.
EXECUTIVE SUMMARY	ES-1
INTRODUCTION	IN-1
1. Purpose	IN-1
2. Scope	IN-1
PART 1 - WATER SERVICE AREA AND DEMANDS	
A. General	I-1
B. Service Area	I-1
C. Historical and Projected Population	I-4
1. Historical Population	I-4
2. Projected Population	I-5
D. Historical and Projected Water Demands	I-7
1. Historical Water Use	I-7
2. Projected Water Use	I-9
E. Water Demand with Conservation	I-16
1. Conservation Activities	I-17
2. Conservation Quantity Evaluation	I-19
3. Water Use Projections with Conservation	I-23
PART II - INVENTORY OF CONVENTIONAL CURRENT WATER SUPPLIES	
A. General	II-1
B. Existing Water System	II-1
1. History	II-1
2. Raw Water System	II-3
3. Treatment	II-13
4. Distribution	II-14
C. Potential Water Sources	II-15
1. Reservoirs	II-16
2. Groundwater	II-17
3. Little Arkansas and Arkansas River	II-19
4. Cheney Reservoir	II-21
5. No Action Alternative	II-23
PART III - INVENTORY OF NONCONVENTIONAL WATER SUPPLIES	
A. General	III-1
B. Factors Influencing Use	III-1
C. Utilization of Cheney Overflow	III-3
D. Aquifer Recharge, Storage and Recovery	III-5
1. Potential Water Sources	III-5
2. Recharge Operation	III-8
3. State of Kansas Requirements	III-9
4. Infiltration Methods	III-10
E. Treated Wastewater Reuse	III-11
1. Wastewater Effluent Quality	III-12
2. State of Kansas Guidelines	III-13
3. Potential Users and Quantities	III-13

TABLE OF CONTENTS
(Continued)

	Page No.
F. Gilbert-Mosley Groundwater Remediation	III-17
G. Cessna Groundwater Remediation	III-17
PART IV - REGIONAL WATER BALANCE	
A. General	IV-1
B. Projected Water Demand	IV-1
C. Existing Water Supplies	IV-1
D. Net Water Needs	IV-2
E. Summary of Potential Water Supplies	IV-2
PART V - EVALUATION CRITERIA	
A. General	V-1
B. Water Supply Capability	V-1
1. Firm Yield	V-2
2. Safe Peaking Ability or Firm Capacity	V-2
3. Ability to Meet Demands	V-3
4. Water Rights	V-3
5. Integrated Use	V-3
6. Peak Nonpotable Use Criteria	V-4
C. Water Quality	V-4
D. Legal Issues	V-5
E. Policy and Political Issues	V-6
F. Future Availability	V-6
G. Planning Horizon	V-6
H. Environmental Issues	V-7
I. Cost Estimates and Economic Comparisons	V-7
1. Project Costs	V-8
2. Operation, Maintenance, Replacement and Energy Costs	V-10
3. Present Value Analysis	V-10
PART VI - DEVELOPMENT OF ALTERNATIVES	
A. General	VI-1
B. Alternative Development Procedures	VI-1
1. Evaluation Criteria	VI-1
2. Conceptual Design and Operating Protocol	VI-2
3. Water Quality Goals	VI-5
4. Cost Estimates	VI-7
C. Water Supply Alternatives	VI-8
1. Conventional	VI-8
2. Nonconventional	VI-25
3. Selection of Viable Alternatives	VI-44
PART VII - EVALUATION OF ALTERNATIVES	
A. General	VII-1
B. Related Plan Elements	VII-3
1. Basic Components	VII-3
2. Near-Term Improvements	VII-4
3. Purchase of Groundwater Rights	VII-5

TABLE OF CONTENTS
(Continued)

	Page No.
C. Water Supply Plan 1 - Milford Reservoir Supply	VII-6
1. Water Delivery	VII-6
2. Water Quality	VII-11
3. Environmental Considerations	VII-11
4. Economic Evaluations	VII-13
D. Water Supply Plan 2 - Integrated Local Supply	VII-16
1. Water Delivery	VII-17
2. Computer Simulation Model	VII-29
3. Water Quality	VII-36
4. Environmental Considerations	VII-38
5. Economic Evaluations	VII-39
E. Water Supply Plan Comparison	VII-42
F. Recommendations	VII-43

Appendices (Enclosed in a Separate Bound Volume)

Appendix A - References
Appendix B - Service Area Customer and Usage Projection Model
Appendix C - Linear Regression Projections
Appendix D - Wholesale Customer and Usage Projections
Appendix E - Water Quality Data
Appendix F - Water Treatment Plant
Appendix G - Reservoir Data
Appendix H - State of Kansas Guidelines for Reuse of Treated Domestic Wastewater
Appendix I - Industrial Surveys
Appendix J - Golf Course Surveys
Appendix K - Bank Storage
Appendix L - Flow Duration Curves
Appendix M - Cheney Reservoir Operations Study
Appendix N - Computer Simulation Model
Appendix O - Economic Impact of Plan
Appendix P - Miscellaneous

LIST OF TABLES

Table No.		Following Page No.
I-1	Water Service Area Population	I-1
I-2	Historical Population Data	I-4
I-3	Customer Records by Year and Number of Meters	I-5
I-4	Historical and Projected Population	I-6
I-5	Customer Projection Summary	I-7
I-6	Historical Average Day Metered Water Use	I-7
I-7	Average Day Water Use Projections	I-9
I-8	Historical Maximum Day/Average Day Factors	I-9
I-9	Historical and Projected Residential Water Use	I-9
I-10	Historical and Projected Commercial Water Use	I-9
I-11	Historical and Projected Industrial Water Use	I-11
I-12	Historical and Projected Lawn Service Water Use	I-11
I-13	Historical and Projected Institutional Water Use	I-13
I-14	Historical and Projected Wholesale Water Use	I-13
I-15	Water Use Projection without Conservation	I-15
I-16	Water Use Projections with Low Range Conservation (Recommended)	I-23
I-17	Water Use Projections with High Range Conservation	I-23
II-1	Water System History	II-1
II-2	Cheney Reservoir Physical and Hydrologic Data	II-4
II-3	Select Water Quality for Cheney Reservoir	II-6
II-4	Water Quality Data for Cheney Reservoir for 1990	II-6
II-5	Cheney Reservoir Pump Station Data	II-6
II-6	Water Rights and Screen Data for Equus Beds Well Field	II-7
II-7	Equus Beds Well Field Hydrologic Data and Yield Information	II-7
II-8	Select Water Quality Data for Equus Beds Well Field	II-8
II-9	Composite Water Quality Data for Equus Beds Well Field	II-8
II-10	Water Rights and Well Data for Local Well Field	II-10
II-11	Select Water Quality Data for Local Well Field for 1992	II-10
II-12	Water Supply Source Summary	II-11
II-13	Water Supply Net Needs Summary	II-12
II-14	Select Finished Water Quality Data for Central Water Treatment Plant for 1991	II-14
II-15	Distribution System Storage Tanks and Pump Stations	II-15
II-16	Reservoir Background Data	II-16
II-17	Water Quality Data for Reserve Well Field	II-18
II-18	Select Water Quality Data for the Little Arkansas River	II-20
II-19	Select Water Quality Data for the Arkansas River	II-21
III-1	Aquifer Recharge, Subsurface Storage and Recovery Requirements	III-9
III-2	Categories of Municipal Wastewater Reuse and Potential Constraints	III-11
III-3	Wastewater Treatment Plant No. 2 Effluent Water Quality	III-12
III-4	State of Kansas Guidelines for Reuse of Treated Domestic Wastewater Summary	III-13

LIST OF TABLES
(Continued)

Table No.		Following Page No.
III-5	Irrigation Potential at City Parks and Golf Courses which Use City Water	III-13
III-6	Water Use by Large Industries	III-14
III-7	Industrial Water Use Survey	III-15
IV-1	Recommended Water Demand Projections for Water Supply Study	IV-1
IV-2	Water Supply Net Needs Summary	IV-2
IV-3	Net Water Needs	IV-2
IV-4	Potential Water Supply Summary	IV-2
V-1	Drinking Water Standards	V-4
VI-1	Unit Project Costs	VI-7
VI-2	Kanopolis Reservoir Water Transmission System Project Cost Estimate	VI-9
VI-3	Milford Reservoir Water Transmission System Project Cost Estimate	VI-10
VI-4	Proposed Corbin Reservoir Water Transmission System Project Cost Estimate	VI-11
VI-5	Proposed Douglass Reservoir Water Transmission System Project Cost Estimate	VI-12
VI-6	Proposed Murdock Reservoir Water Transmission System Project Cost Estimate	VI-13
VI-7	Hollow Nickel and Burrton IGUCA Well Fields Raw Water Transmission System Project Cost Estimate	VI-15
VI-8	Haysville Irrigation Supply Alternative Water Transmission System Project Cost Estimate	VI-16
VI-9	Redevelopment of Bentley Reserve Well Field Water Transmission System Project Cost Estimate	VI-17
VI-10	Big Arkansas River Supply Alternative Water Transmission System Project Cost Estimate	VI-19
VI-11	Little Arkansas River Supply Alternative Water Transmission System Project Cost Estimate	VI-21
VI-12	Cheney Reservoir Operations/Management Modifications Summary	VI-22
VI-13	Reverse Osmosis Treatment Project Cost Estimate	VI-24
VI-14	Equus Beds Well Field Improvements Water Transmission System Project Cost Estimate	VI-25
VI-15	Cheney Reservoir Overflow to Water Treatment Plants Water Transmission System Project Cost Estimate	VI-26
VI-16	Cheney Reservoir Overflow to Equus Beds Alternative Water Transmission System Project Cost Estimate	VI-28
VI-17	Little Arkansas River Supply to Equus Beds Alternative Water Transmission System Project Cost Estimate	VI-31
VI-18	Treated Wastewater Reuse Local Irrigation Alternative Project Cost Estimate	VI-34
VI-19	Treated Wastewater Reuse Subsurface Storage Alternative Project Cost Estimate	VI-35

LIST OF TABLES
(Continued)

Table No.		Following Page No.
VI-20	Treated Wastewater Reuse to Equus Beds Irrigators Alternative Project Cost Estimate	VI-36
VI-21	Bank Storage of Little Arkansas River High Stream Flow Alternative Project Cost Estimate	VI-39
VI-22	Rain Harvesting Supply Alternative Project Cost Estimate	VI-40
VI-23	Gilbert-Mosley Remediated Groundwater Raw Water Transmission System Project Cost Estimate	VI-40
VI-24	Water Supply Alternative Ranking Summary	VI-44
VII-1	Milford Reservoir Water Quality Data	VII-11
VII-2	Milford Reservoir Water Supply Plan Project Cost Estimate	VII-13
VII-3	Milford Reservoir Water Supply Plan Present Value Estimate	VII-14
VII-4	Model Reservoir Levels - Cheney Reservoir	VII-31
VII-5	Model Reservoir Levels - Equus Beds Well Field	VII-31
VII-6	Allocation Order of Supply Sources	VII-32
VII-7	Summary of Equus Beds Fill Analysis	VII-34
VII-8	Summary of Simulated Operating Results	VII-35
VII-9	Integrated Local Water Supply Plan - 250 MGD Diversion Option - Project Cost Estimate	VII-39
VII-10	Integrated Local Water Supply Plan - 150 MGD Diversion Option - Project Cost Estimate	VII-39
VII-11	Integrated Local Water Supply Plan - 250 MGD Diversion Option - Present Value Estimate	VII-40
VII-12	Integrated Local Water Supply Plan - 150 MGD Diversion Option - Present Value Estimate	VII-40
VII-13	Water Supply Plan Cost Comparison	VII-42
VII-14	Water Supply Plan Comparison	VII-43

LIST OF FIGURES

Figure No.		Following Page No.
ES-1	Current Water System Service Area	ES-1
ES-2	Raw Water Supply System Schematic	ES-3
ES-3	City of Wichita Water Supply Source Location Map	ES-6
ES-4	Milford Reservoir Water Supply Plan Schematic	ES-9
ES-5	Integrated Local Water Supply Plan 150 & 250 MGD Diversion Options Schematic	ES-11
ES-6	Cumulative Rate Increases for Water Supply Plans	ES-17
ES-7	City of Wichita, Water Supply Planning Chart, Year 1993 to Year 2050	ES-20
I-1	Current Water System Service Area	I-1
I-2	Population Projections	I-6
I-3	Residential Customers Projection	I-7
I-4	Commercial and Lawn Service Customer Projections	I-7
I-5	Industrial and Institutional Customer Projections	I-7
I-6	Residential Water Usage Projection	I-9
I-7	Commercial Water Usage Projection	I-11
I-8	Industrial Water Usage Projection	I-11
I-9	Lawn Service Water Usage Projection	I-12
I-10	Institutional Water Usage Projection	I-13
I-11	Wholesale Water Usage Projection	I-14
I-12	Projected Water Use Without Conservation	I-15
I-13	Projected Water Use With Conservation	I-23
II-1	Raw Water Supply System Schematic	II-3
II-2	Cheney Reservoir Raw Water Pump Station and Vicinity Map	II-6
II-3	Equus Beds Raw Water Supply System	II-7
II-4	Typical Well Design	II-7
II-5	Equus Beds Groundwater Management District No. 2 Boundaries	II-9
II-6	Local (E&S) Well Field	II-10
II-7	Water Demand/Supply Graph	II-12
II-8	Existing Water Distribution System Major Components	II-14
II-9	City of Wichita Water Supply Source Location Map	II-15
III-1	Cheney Reservoir Overflow Utilization Alternative Schematic	III-4
III-2	Aquifer Recharge, Storage and Recovery Alternative Schematic	III-5
III-3	Hydrogeologic Profile for the Bank Storage Groundwater Recovery Concept	III-7
III-4	Treated Wastewater Reuse Alternatives Schematic	III-11
III-5	Parks, Golf Courses and Large Industries - City of Wichita	III-13
IV-1	Raw Water Supply System Schematic	IV-1
IV-2	Projected Net Water Needs	IV-2
IV-3	Potential Water Supply Summary	IV-2

LIST OF FIGURES
(Continued)

Figure No.		Following Page No.
VI-1	Raw Water Supply System Schematic	VI-2
VI-2	Kanopolis Reservoir Water Supply Schematic	VI-8
VI-3	Milford Reservoir Water Supply Schematic	VI-9
VI-4	Proposed Corbin Reservoir Water Supply Schematic	VI-10
VI-5	Proposed Douglass Reservoir Water Supply Schematic	VI-11
VI-6	Proposed Murdock Reservoir Water Supply Schematic	VI-12
VI-7	SWQUA & IGUCA Groundwater Supply Schematic	VI-14
VI-8	Haysville Groundwater Supply Schematic	VI-15
VI-9	Redeveloped Bentley Reserve Well Field Water Supply Schematic	VI-16
VI-10	Arkansas River Water Supply to Water Plant Schematic	VI-17
VI-11	Little Arkansas River Water Supply to Water Plant Schematic	VI-19
VI-12	Reverse Osmosis Treatment Schematic	VI-24
VI-13	Equus Beds Well Field Improvement Schematic	VI-25
VI-14	Cheney Reservoir Overflow to Water Plants Supply Schematic	VI-26
VI-15	Cheney Reservoir Overflow Subsurface Storage and Recovery Schematic	VI-27
VI-16	Little Arkansas River Subsurface Storage and Recovery Schematic	VI-29
VI-17	Reclaimed Water to Golf Courses and Parks-Water Supply Schematic	VI-32
VI-18	Reclaimed Water Surface Spreading and Recovery in Equus Beds-Water Supply Schematic	VI-34
VI-19	Reclaimed Water to Equus Beds Irrigators-Water Supply Schematic	VI-36
VI-20	Little Arkansas River Bank Storage Alternative-Water Supply Schematic (Vertical Wells)	VI-37
VI-21	Little Arkansas River Bank Storage Alternative-Water Supply Schematic (Horizontal Wells)	VI-37
VI-22	Rain Harvesting-Water Supply Schematic	VI-39
VII-1	Milford Reservoir Water Supply Plan Schematic	VII-6
VII-2	Milford Reservoir Water Supply Plan, Cumulative Rate Increases	VII-16
VII-3	Integrated Local Water Supply Plan 150 MGD & 250 MGD Diversion Options Schematic	VII-17
VII-4	Integrated Local Water Supply Plan Schematic	VII-17
VII-5	Surface Water Intake	VII-25
VII-6	Integrated Local Water Supply Plan Computer Model Schematic	VII-30
VII-7	Demand Distribution	VII-32
VII-8	Annual Equus Beds Fill Duration	VII-34
VII-9	Average Day Demand by Source	VII-35
VII-10	Simulated Water Levels 250 MGD Diversion Option 2050 Demands	VII-35
VII-11	Simulated Water Levels 150 MGD Diversion Option 2050 Demands	VII-35

LIST OF FIGURES
(Continued)

Figure No.		Following Page No.
VII-12	Integrated Local Water Supply Plan, Cumulative Rate Increases	VII-42

* * * * *

Introduction

INTRODUCTION

PURPOSE

The purpose of this report is to conduct an engineering study of water source alternatives for the City of Wichita, Kansas with the general objective of developing a plan capable of meeting projected water demands through the year 2050.

SCOPE

This report includes the following:

- Analyses of historical population and water demand data and projections of population and water demands from year 1993 to year 2050.

- A description of existing water system facilities and compilations of existing water rights, firm yields and existing pumping capacities.

- Engineering investigations of conventional and nonconventional water supply alternatives, including existing and proposed reservoirs, groundwater, excess stream flows, river bank storage, wastewater reuse, and water conservation.

- Development of net or additional source water needs through the study period.

- Comparison of alternatives based on project cost and present value estimates, water supply capacity, water quality, legal issues, policy and political issues, future availability, and environmental issues.

- Development and comparison of water supply plans to meet projected water demands through year 2050.

- Recommendation of a first-choice water supply plan.

* * * * *

Part I - Water Service Area and Demands

PART I

WATER SERVICE AREA AND DEMANDS

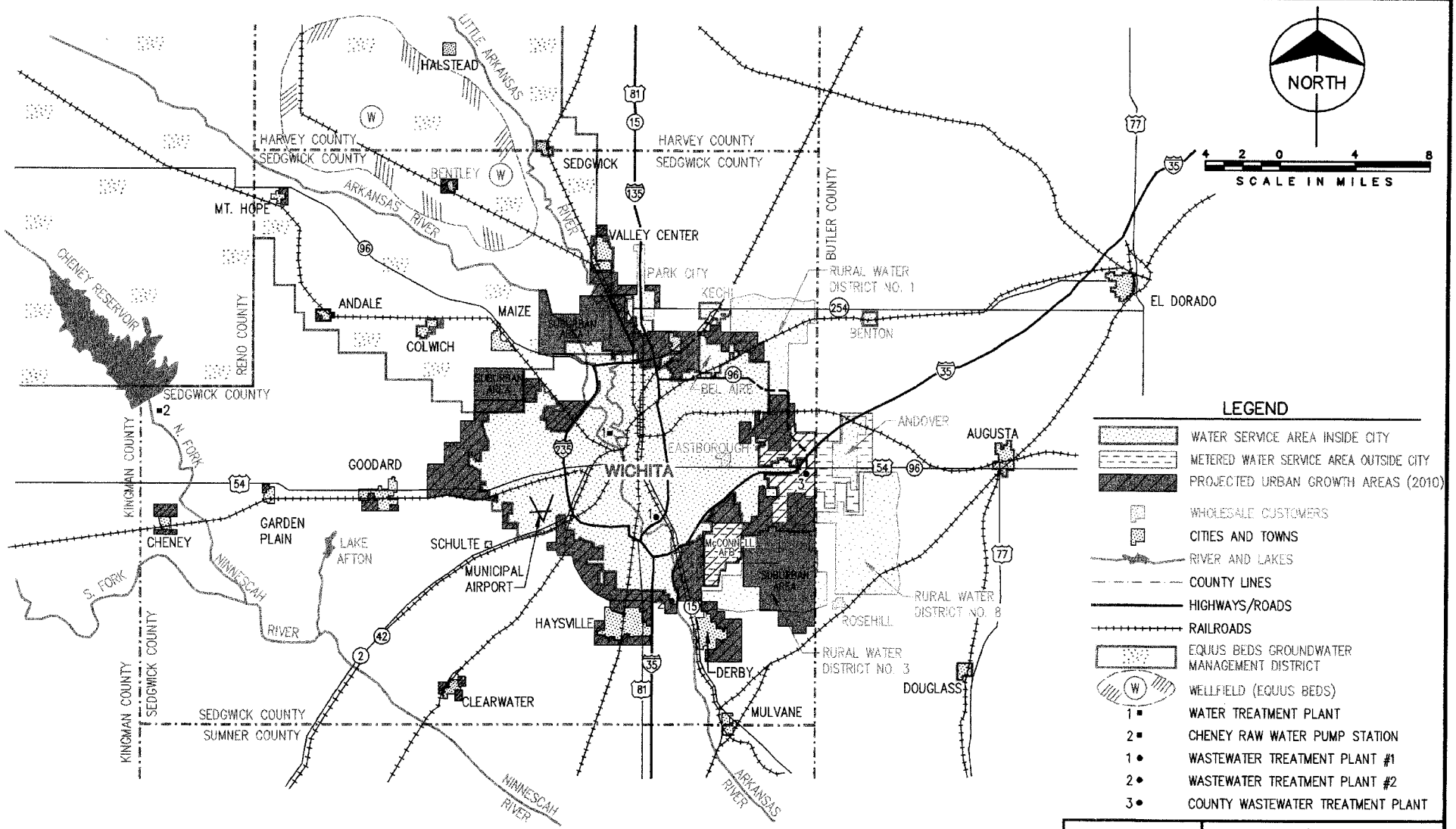
A. GENERAL

This section of the report describes the City of Wichita's water service area, presents historical water use data, and projects population and water demands with a year 2050 planning horizon. Water conservation methods for potential water use savings in the water service area are also presented.

B. SERVICE AREA

The City of Wichita provides potable water to over 114,000 water customers inside its 140 square-mile corporate area and to 11 wholesale customers and several residential/commercial customers outside the city limits as shown in Figure I-1. Untreated well water is also provided to one wholesale customer, the City of Bentley, which is located outside the city limits in the City's "Equus Beds" well field.

The water service population is approximately 335,000 as shown in Table I-1. About 305,000 people are served inside the city limits and about 30,000 people are served outside the city limits. In the future, the Wichita service area is expected to expand to serve smaller outlying water systems because of the cost and operational complexity of meeting regulations of the Safe Drinking Water Act and encouragement of regionalization of water service by state and federal agencies.



NOTE:
PROJECTED GROWTH AREAS FROM INFORMATION PROVIDED BY THE WICHITA-SEDGWICK COUNTY METROPOLITAN AREA PLANNING DEPARTMENT

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Figure I – 1

CURRENT WATER SYSTEM SERVICE AREA

Table I – 1

WATER SERVICE AREA POPULATION

Entity	Population
Wichita (1) (3)	304,011
Andover (1) (3)	4,047
Eastborough (1) (3)	896
Park City (1) (4)	5,050
Kechi (1)	517
Bel Aire (1)	3,695
Benton (1)	669
Rose Hill (1)	2,338
Bentley (1)	360
Rural Water District 1 (2)	508
Rural Water District 3 (2) (5)	1,651
Rural Water District 8 (2)	1,016
Oaklawn/Sunview (6)	3,420
McConnell AFB (6)	3,000
Other Customers Outside City Limits (6) (7)	4,500
Total Estimated Service Area Population	335,678

Notes:

(1) City population based on 1990 U.S. Census Bureau data.
(2) Population data for rural water districts estimated from contract data.
(3) Individually metered customers.
other entities shown are wholesale customers with master meters.
(4) Has other water supply sources in addition to water supply from City of Wichita.
(5) The disconnection of Rural Water District No. 3 from Wichita's water system is anticipated by 1995.
(6) Not classified as a wholesale customer.
(7) Population data for Other Customers Outside City Limits based on information from City.

Inside the City, water is provided to customers through individual meters, except for 700 to 800 housing units in southeast Wichita known as the "Planeview" area. Meters are currently being added to customer service lines on these housing units. Customers outside the city limits are either individually metered by the City or metered via wholesale master meters.

In 1991, the average day water demand in the service area was 62.2 million gallons per day (MGD) and the maximum day water demand was 125.7 MGD. During the year, water use included 44 percent by residential customers, 27 percent by commercial customers, 16 percent by industrial customers, 2 percent by wholesale customers and 11 percent by all other customer classifications, including unaccounted-for water. Restrictions on lawn watering have been in place since June 1990.

The water service area is provided with treated water from the Central Water Treatment Plant which is located in the City at the confluence of the Little Arkansas River and the Arkansas River. The water plant has a treatment capacity of 130 MGD and is currently being expanded to 160 MGD. Raw water is supplied to the water plant for treatment from Cheney Reservoir, which is located approximately 20 miles west of the City, and from well fields in the Equus Beds, which are located approximately 16 miles northwest of the City.

Wastewater from the service area is treated in two wastewater treatment plants which are located in the southern section of the City near the Arkansas River. Wastewater Treatment Plant No. 1 provides 30.6 MGD of primary treatment and discharges to Wastewater Treatment Plant No. 2. Plant

No. 2 has 10 MGD of primary treatment capacity and 54.4 MGD of secondary treatment capacity.

Additionally, Sedgwick County operates a 10 MGD wastewater treatment plant in the Four Mile Creek area as shown in Figure I-1. This plant was placed into operation in 1990 and a majority of the plant's capacity is currently unused.

Major transportation arteries which serve the area include Interstate 35, U.S. Highway 81, U.S. Highway 54, and the Atchison Topeka and Santa Fe and the Union and Pacific Railroads. Over the next 10 years, $460 million is scheduled for improvements to State and U.S. highways and interstates in the City and Sedgwick County to relieve congestion and reduce commuting times. Railways continue to be important to local industries by providing an efficient means to move raw materials and manufactured products. Future industrial growth is planned and zoned with consideration of the existing rail system.

Land use in the service area includes a mixture of agriculture, residential, commercial, industrial, parks/recreational and other uses. Agricultural land represents 15 percent of the City's area and 80 percent of the county's area while residential land represents 28 percent of the City's area and 8 percent of the County's area. The City is currently growing to the west and northeast with residential and commercial development. This trend, along with "fill-in" growth within the City, is anticipated to continue through the year 2010 and beyond.

The service area has a stable industrial base, including several large aviation companies (Boeing, Cessna, Lear, and Beech Aircraft), manufacturing, food processors, bottlers, and refineries. McConnell Air Force Base is also served by the city water system. These facilities typically employ large numbers of people and use large quantities of water.

In 1992, the City completed a comprehensive master plan for community development. The study evaluated water, sewer, stormwater, solid waste systems, fire protection, transportation, law enforcement, schools and libraries, medical services, parks, housing and neighborhoods, land use planning, community appearance and historic preservation through the year 2010. Additionally, two engineering studies are to be completed in 1992 and 1993, including a 20 year sewer system master plan (completed in May 1992) and the water distribution system master plan (expected to be completed in 1993). These studies will project growth and associated needs and plan facilities necessary to maintain and improve the quality of life and to encourage future economic development in the Wichita area.

C. HISTORICAL AND PROJECTED POPULATION

1. HISTORICAL POPULATION

Historical population data for the City of Wichita, Sedgwick County and the Wichita metropolitan statistical area are shown in Table I-2. Population data for the City of Wichita includes the area defined by the city limits; population data for Sedgwick County includes the area defined by the county line; and, population data for the statistical

Table I – 2

HISTORICAL POPULATION DATA
CITY OF WICHITA, KANSAS, SEDGWICK COUNTY AND METROPOLITAN STATISTICAL AREA

Year	Population Within City (1)	Population Within County (1)	OBERS Population Within Statistical Area (2)
1900	24,671	–	–
1910	52,450	–	–
1920	72,217	92,234	–
1930	111,110	136,330	–
1940	114,966	143,311	–
1950	168,279	222,290	–
1960	254,698	343,231	–
1969	–	–	389,400
1970	276,554	350,694	–
1973	–	–	378,700
1978	–	–	400,700
1980	279,272	366,531	–
1983	–	–	428,800
1990	304,011	403,662	–

Notes:
(1) U.S. Census Bureau
(2) U.S. Department of Commerce – Bureau of Economic Analysis, 1985 Regional Projections.

metropolitan area includes the City of Wichita in addition to the remaining areas in Sedgwick County and the adjoining Butler County.

The City of Wichita's water service area is slightly larger than the city limits and smaller than the county and metropolitan statistical area. The City also supplies water to 11 wholesale customers. The cities of Andover and Eastborough are retail customers outside the City limits with customer meters which are serviced and read by the City of Wichita. All other wholesale customers are served through master meters.

Historical customer data from 1970 to 1991 for the water service area is shown in Table I-3. The number of customers has grown from approximately 81,000 in 1970 to 114,000 in 1991 for an average growth rate of 1.6 percent per year.

2. PROJECTED POPULATION

Population projections for the water service area are developed through the use of U.S. Census Bureau data, water department customer data, U.S. Department of Commerce - Bureau of Economic Analysis (OBERS) data, Wichita-Sedgwick County Metropolitan Area Planning Department (MAPD) studies and engineering studies by others. Projections include consideration for the availability of land, water, and sewer systems, current and future transportation plans, zoning, area topography, and socioeconomic factors.

Table I – 3

CUSTOMER RECORDS BY YEAR AND NUMBER OF METERS (1)

Year	Residential	Commercial	Industrial	Lawn Service	Fire Protection	Golf Course	Institutional	Wholesale	Total Customers
1970	71,011	9,323	168	–	243	–	662	–	81,407
1971	71,448	9,284	167	–	261	–	641	–	81,813
1972	71,939	9,243	164	–	296	–	953	–	82,595
1973	73,115	9,234	158	–	330	–	679	1	83,517
1974	74,182	9,398	162	–	360	–	690	2	84,794
1975	75,513	9,542	159	–	386	–	706	2	86,308
1976	77,171	9,645	155	221	399	–	701	2	88,294
1977	78,368	9,727	155	303	424	–	692	3	89,672
1978	79,785	9,795	151	419	460	–	719	3	91,332
1979	82,203	9,888	147	327	479	–	711	3	93,758
1980	84,610	10,032	149	386	506	–	739	3	96,425
1981	86,571	10,113	146	479	520	–	748	3	98,580
1982	87,623	10,148	144	487	536	–	750	5	99,693
1983	89,039	10,364	140	489	562	–	754	5	101,353
1984	91,082	10,328	137	510	578	–	764	5	103,404
1985	92,105	10,485	134	522	692	–	768	5	104,711
1986	93,414	10,532	134	544	637	–	779	8	106,048
1987	95,469	10,534	135	587	655	–	781	10	108,171
1988	97,003	10,474	133	653	678	–	796	9	109,746
1989	98,220	10,392	167	1075	692	3	831	10	111,390
1990	99,439	10,309	201	1496	706	5	866	10	113,032
1991	100,580	10,279	197	2008	715	5	877	10	114,672

Note:

(1) Historical data from Wichita Water and Sewer System Annual Reports, 1970 – 1991.

Comparisons of population data from several information sources are shown in Table I-4 and Figure I-2. Historical population for the City of Wichita is used to develop lower and upper limits of the population projection range. The lower limit was determined from a linear regression of city population from 1960 to 1990 and resulted in a year 2050 population of 391,000. The upper limit was determined from a linear regression of city population from 1950 to 1990 and resulted in a year 2050 population of 493,000. According to the 1990 Census, the City of Wichita had a 1990 population of approximately 304,000 with 2.43 people per housing unit.

Based on evaluation of upper and lower growth scenarios with the OBERS projection to the year 2035, the MAPD 1992 Comprehensive Study, and population projections by others, city population is anticipated to increase by 3,000 people (1,235 residential connections) per year to the year 2015 and then increase by 2,000 people (825 residential connections) per year from 2016 to 2050. This results in a year 2010 City population of 363,000 (119,075 residential connections) and a year 2050 city population of 448,000 (154,125 residential customers). These additional connections or housing units include single family, duplex and multi-family type. Multi-family units are currently included in the commercial class; however, for the purposes of this study, all additional housing units from 1992 to 2050 are included in the residential class.

In addition to the City's residential population, the projected service area also includes existing and anticipated wholesale customers and

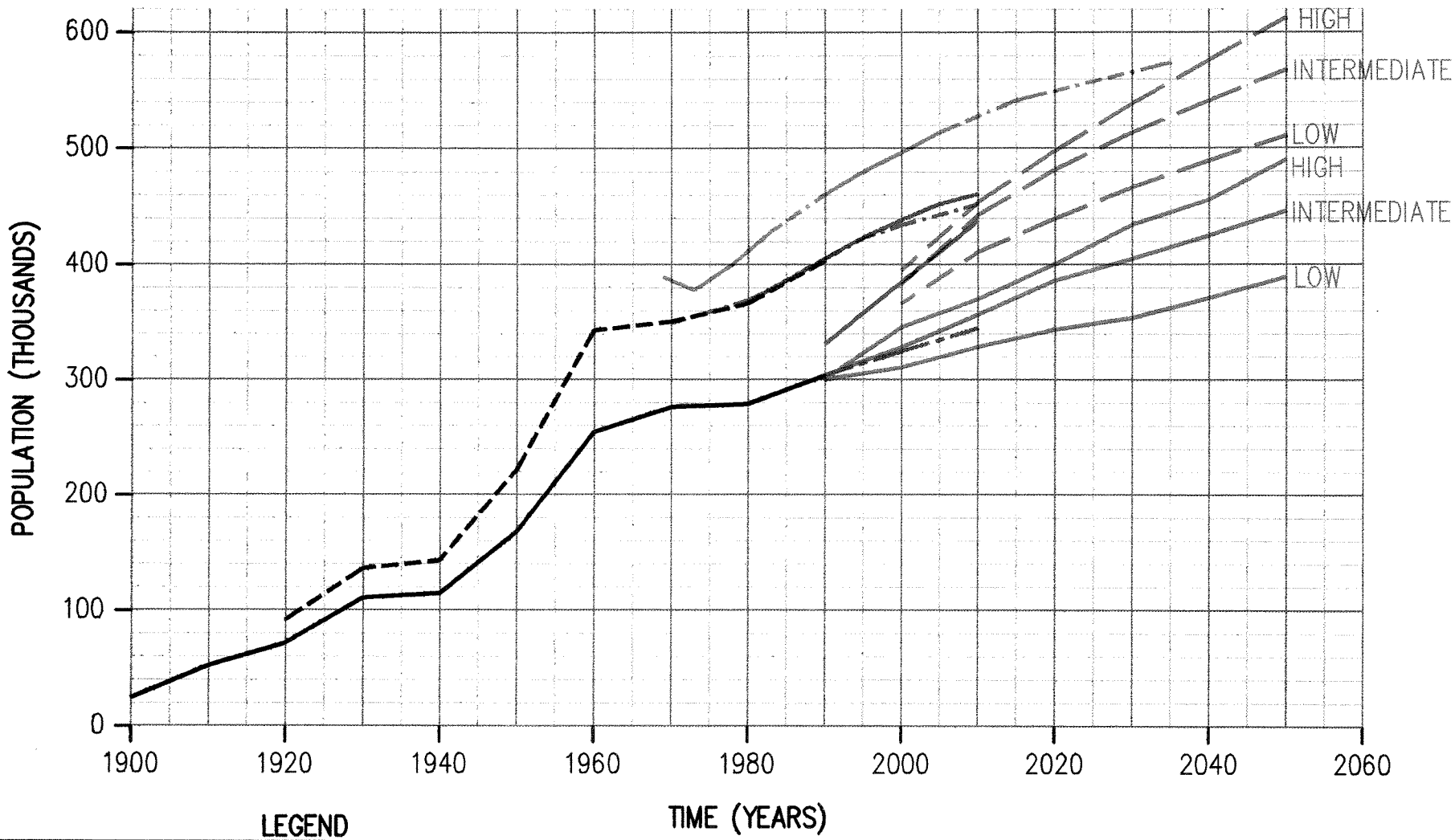
Table I – 4

HISTORICAL AND PROJECTED POPULATION (7)
DATA FOR WICHITA, KANSAS AND SURROUNDING AREA

Year	U.S. Census (1)		MAPD (2)		County: NPA Data Services (3)	OBERS (4)	CDM Water Master Plan (5)	BURNS & McDONNELL							
								City of Wichita			Existing Wholesale Customers (6)	Anticipated Wholesale Customers	Service Area Population		
	City	County	City	County				High	Low	Intermediate			High	Low	Intermediate
1900	24,671	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1910	52,450	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1920	72,217	92,234	–	–	–	–	–	–	–	–	–	–	–	–	–
1930	111,110	136,330	–	–	–	–	–	–	–	–	–	–	–	–	–
1940	114,966	143,311	–	–	–	–	–	–	–	–	–	–	–	–	–
1950	168,279	222,290	–	–	–	–	–	–	–	–	–	–	–	–	–
1960	254,698	343,231	–	–	–	–	–	–	–	–	–	–	–	–	–
1969	–	–	–	–	–	389,400	–	–	–	–	–	–	–	–	–
1970	276,554	350,694	–	–	349,000	–	–	–	–	–	–	–	–	–	–
1973	–	–	–	–	–	378,700	–	–	–	–	–	–	–	–	–
1978	–	–	–	–	–	400,700	–	–	–	–	–	–	–	–	–
1980	279,272	366,531	279,855	367,670	369,000	–	–	–	–	–	–	–	–	–	–
1983	–	–	–	–	–	428,800	–	–	–	–	–	–	–	–	–
1985	–	–	–	–	386,000	–	–	–	–	–	–	–	–	–	–
1990	304,011	403,662	304,011	405,570	405,000	460,800	331,000	304,000	304,000	304,000	31,487	–	335,487	335,487	335,487
1991	–	–	–	–	409,000	–	–	–	–	–	–	–	–	–	–
1995	–	–	–	423,610	423,000	480,000	358,000	–	–	–	–	–	–	–	–
2000	–	–	324,586	438,580	434,000	496,400	385,000	345,000	316,000	333,000	35,417	18,801	399,218	370,218	387,218
2005	–	–	–	452,520	–	513,900	411,000	–	–	–	–	–	–	–	–
2010	–	–	345,162	460,940	452,000	–	438,000	374,000	331,000	363,000	40,521	43,537	458,058	415,058	447,058
2015	–	–	–	–	–	541,600	–	–	–	–	–	–	–	–	–
2020	–	–	–	–	–	–	–	404,000	346,000	388,000	45,504	52,255	501,759	443,759	485,759
2030	–	–	–	–	–	–	–	433,000	361,000	408,000	49,374	60,230	542,604	470,604	517,604
2035	–	–	–	–	–	574,200	–	–	–	–	–	–	–	–	–
2040	–	–	–	–	–	–	–	463,000	376,000	428,000	52,444	64,840	580,284	493,284	545,284
2050	–	–	–	–	–	–	–	493,000	391,000	448,000	55,634	68,150	616,784	514,784	571,784

Notes:

(1) Historical U.S. Census Bureau Data for the City of Wichita and Sedgwick County.
(2) Wichita – Sedgwick Co. Metropolitan Area Planning Department, The Wichita – Sedgwick County Comprehensive Plan, 1992.
(3) Key Indicators of County Growth, 1970 – 2010, NPA Data Services, 1991 edition.
(4) U.S. Dept. of Commerce – Bureau of Economic Analysis, 1985 Regional Projections for the Statistical Metropolitan Area.
(5) Water System Master Plan by CDM, 1992, Draft, Service Area Projections.
(6) Includes wholesale customers, McConnell AFB, Benefit Districts and individually metered customers outside the City limits.
(7) Sewer Master Plan by Black & Veatch projects 342,846 people in the Year 2000 and 364,347 people in the Year 2010. The Sewer Service Area is smaller than the water service area.



LEGEND

- U.S. CENSUS DATA – CITY ONLY
- U.S CENSUS DATA – SEDGWICK COUNTY
- OBERS PROJECTION (1985) – SMA
- MAPD PROJECTION (1992)
- COUNTY NPA DATA SERVICES PROJECTION (1991)
- CDM WATER MASTER PLAN (1992) DRAFT – SERVICE AREA
- B&McD PROJECTION OF CITY POPULATION
- B&McD PROJECTION OF SERVICE AREA POPULATION

Burns & McDonnell

Figure I – 2

POPULATION PROJECTIONS

individually metered customers outside the city limits. Table I-4 shows the projected growth for the wholesale and individually-metered customers outside the city limits (existing wholesale category) increasing from approximately 31,000 people in 1990 to 56,000 people in 2050.

Anticipated wholesale customers include additional towns/areas in Sedgwick County not currently served by the City's water system. Connection of these customers to the system would add about 68,000 people to the year 2050 projected service area.

A service area customer and water usage projection computer model was developed in Lotus 3.1 to help forecast the number of customers, usage and water conservation savings by customer class to the year 2050. Historical data is included in the model from 1986 to 1991 which shows recent trends in customer growth, gallons per meter day usage, and average day and maximum day usage. Customer data from 1970 to 1991 was evaluated in this analysis and customer projections by the model are shown in Table I-5 and Figures I-3 to I-5.

D. HISTORICAL AND PROJECTED WATER DEMANDS

1. HISTORICAL WATER USE

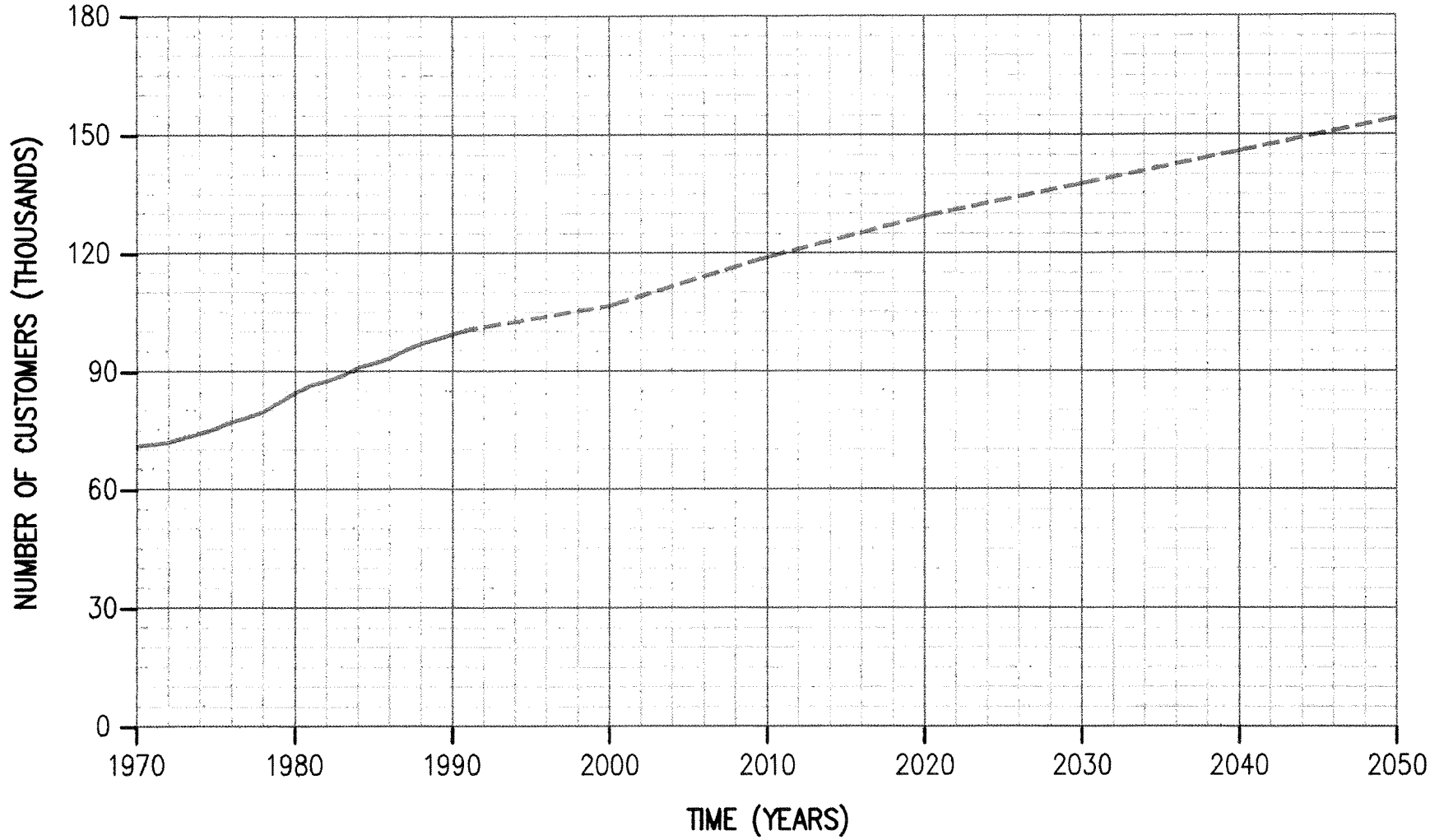
Historical average daily water use by customer class and unaccounted-for water for the water service area from 1970 through 1991 are shown in Table I-6. Data prior to 1986, especially unaccounted-for water, is questionable because of suspected errors in the data collection/entry

Table I – 5

CUSTOMER PROJECTION SUMMARY

Year	Residential	Commercial	Industrial	Lawn Service	Fire Protection	Golf Course	Institutional	Water Utility	Wholesale	Total Customers
1990 (1)	99,439	10,309	201	1,496	706	5	866	1	10	113,033
2000	106,725	10,751	205	3,498	782	5	877	1	13	122,857
2010	119,075	11,301	211	3,998	864	6	941	1	16	136,413
2020	129,375	11,879	217	4,423	954	7	1,007	1	19	147,882
2030	137,625	12,486	224	4,773	1,054	8	1,072	1	22	157,265
2040	145,875	13,125	231	5,123	1,164	9	1,130	1	22	166,680
2050	154,125	13,796	238	5,473	1,286	10	1,202	1	22	176,153

Note:
(1) Historical data from Wichita Water and Sewer System Annual Report, 1990.



LEGEND

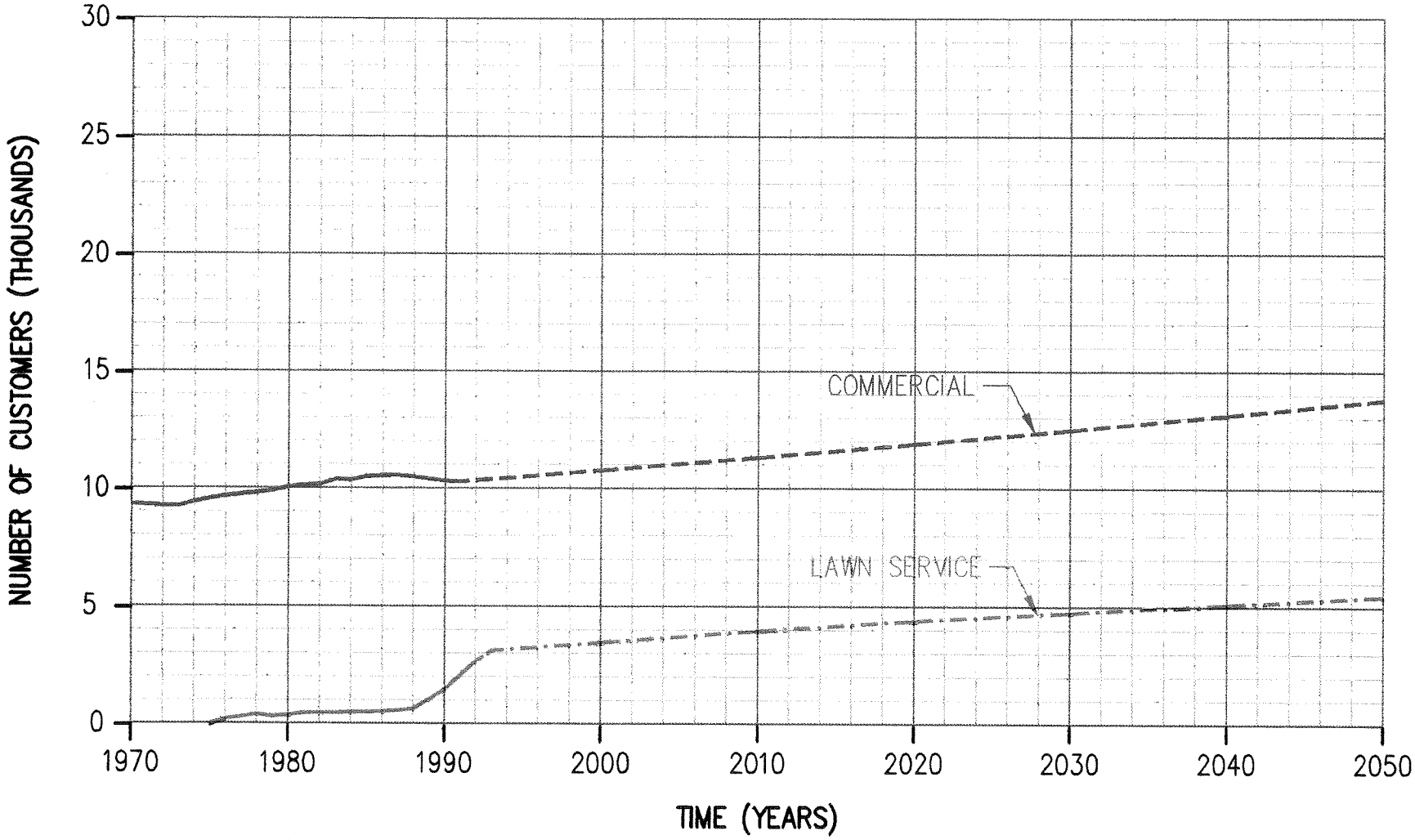
WICHITA DATA HISTORICAL

B&McD PROJECTION

Burns & McDonnell

Figure I – 3

RESIDENTIAL CUSTOMERS PROJECTION



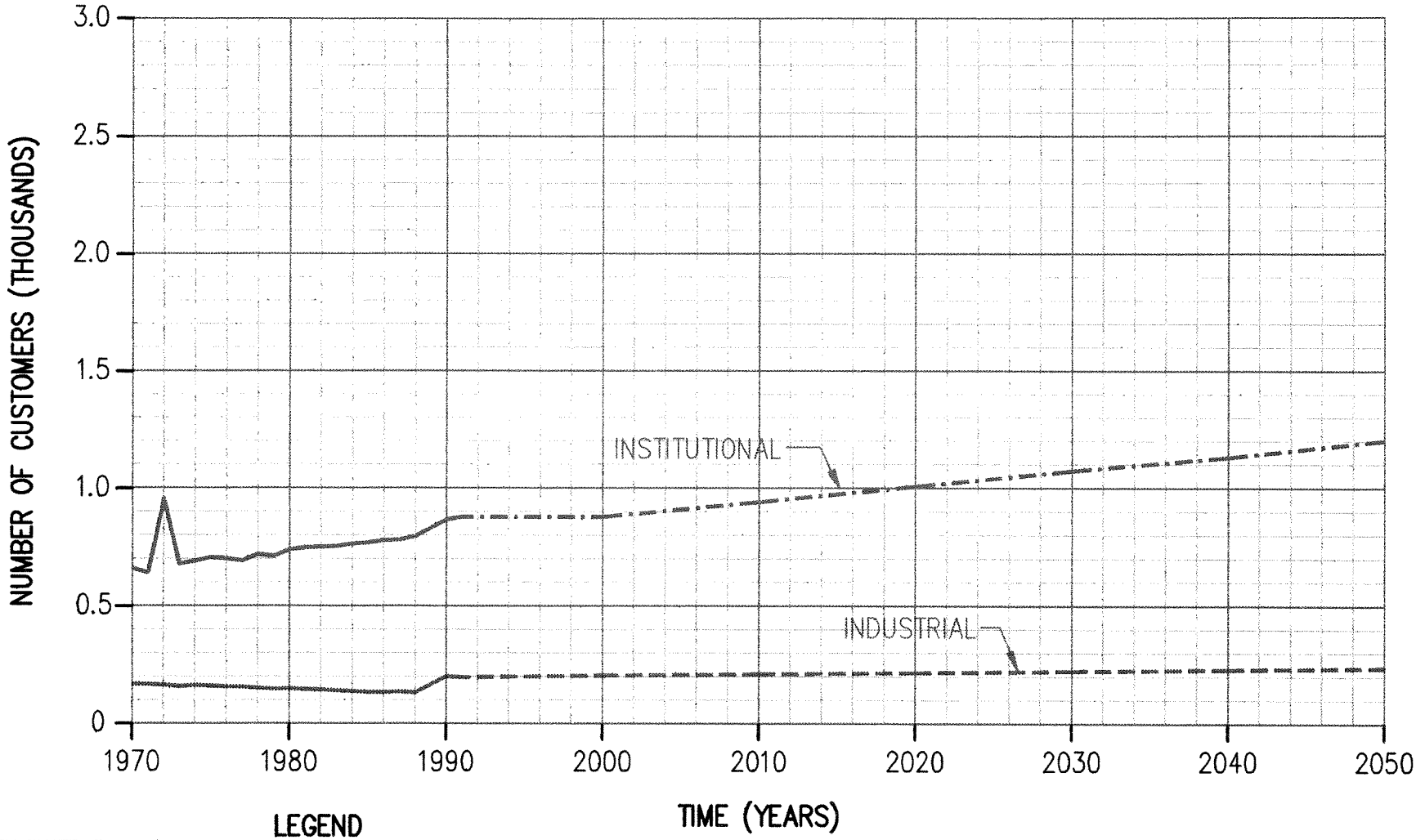
LEGEND

- WICHITA DATA HISTORICAL COMMERCIAL
- WICHITA DATA HISTORICAL LAWN SEVICE
- B&McD PROJECTION COMMERCIAL
- B&McD PROJECTION LAWN SERVICE

Burns & McDonnell

Figure I – 4

COMMERCIAL AND LAWN SERVICE CUSTOMER PROJECTIONS



LEGEND

- WICHITA DATA HISTORICAL INDUSTRIAL
- WICHITA DATA HISTORICAL INSTITUTIONAL
- B&McD PROJECTION INDUSTRIAL
- B&McD PROJECTION INSTITUTIONAL

Burns & McDonnell

Figure I – 5

INDUSTRIAL AND INSTITUTIONAL CUSTOMER PROJECTIONS

Table I – 6

HISTORICAL AVERAGE DAY METERED WATER USE (1)
(MGD)

Year	Residential	Commercial	Industrial	Lawn Service (2)	Fire Protection	Golf Course (3)	Institutional	Water Utility	Wholesale (4)	Total Metered Water	Total Pumpage	Unaccounted–For Water (%) (5)
1970	15.6	8.4	9.5	–	<0.05	–	2.2	<0.05	–	35.7	37.7	5.3
1971	14.6	8.8	9.2	–	<0.05	–	2.6	<0.05	–	35.2	37.2	5.3
1972	16.0	8.9	9.7	–	<0.05	–	2.2	<0.05	–	36.8	38.2	3.5
1973	16.1	9.8	10.1	–	<0.05	–	2.9	<0.05	<0.05	38.9	39.3	1.0
1974	16.0	10.8	9.6	–	<0.05	–	2.9	<0.05	<0.05	39.3	39.5	0.0
1975	15.4	12.4	8.3	–	<0.05	–	2.8	<0.05	0.20	39.1	39.1	0.0
1976	17.4	10.9	8.0	0.5	<0.05	–	2.5	<0.05	0.10	39.4	39.9	1.1
1977	16.4	11.9	9.2	0.4	<0.05	–	2.3	<0.05	0.20	40.4	40.6	0.1
1978	18.5	13.0	9.5	0.7	<0.05	–	3.4	<0.05	0.20	45.3	45.3	0.0
1979	18.9	13.9	10.8	1.1	<0.05	–	2.4	<0.05	0.20	47.3	47.9	1.3
1980	22.8	15.8	9.5	1.6	<0.05	–	3.2	<0.05	0.30	53.2	53.2	0.0
1981	22.0	16.3	6.4	1.1	<0.05	–	2.7	0.20	0.20	48.9	49.1	0.0
1982	20.5	16.4	6.6	1.2	<0.05	–	3.3	0.20	0.30	48.5	48.6	0.0
1983	23.3	15.4	6.2	2.0	<0.05	–	3.3	0.20	0.40	50.8	51.0	0.4
1984	23.8	15.5	7.5	1.6	<0.05	–	2.5	0.10	0.50	51.5	51.7	0.4
1985	22.5	14.7	7.1	1.5	<0.05	–	2.3	0.10	0.50	48.7	48.8	0.1
1986	21.9	14.1	7.4	1.7	<0.05	–	2.1	0.20	0.60	48.0	48.1	0.2
1987	22.7	15.2	7.4	1.5	<0.05	–	1.9	0.10	0.70	49.5	53.2	7.6
1988	25.0	13.7	8.7	2.2	<0.05	–	2.2	<0.05	0.80	52.7	57.6	9.3
1989	25.0	14.7	8.7	1.8	<0.05	0.1	2.2	<0.05	2.30	54.9	58.4	6.5
1990	26.3	15.4	8.7	2.7	<0.05	0.2	2.2	<0.05	1.20	56.8	64.2	13.0
1991	27.2	16.7	10.1	2.8	<0.05	0.2	1.8	<0.05	1.40	60.2	62.2	3.3

Note:
(1) From Wichita Water and Sewer System Annual Reports, 1970 – 1991.
(2) Classification started in 1976.
(3) Classification started in 1989.
(4) Classification started in 1973.
(5) Unaccounted–For water below 7 to 10 % appears questionable based on industry norms.

system. Customer classes include residential, commercial, industrial, lawn service, fire protection, golf course, institutional, water utility and wholesale.

The percentage of water use by customer classification and unaccounted-for water in 1991 was as follows:

Classification	Percentage
Residential	44
Commercial	27
Industrial	16
Lawn Service	5
Fire Protection	<1
Golf Course	<1
Institutional	3
Water Utility	<1
Wholesale	2
Unaccounted-for Water	0
Total =	100%

Unaccounted-for water includes treated water which is lost in the system because of pipe leakage, inaccurate meters and unaccounted-for uses. Records show unaccounted-for water ranging 0 percent to 13 percent since 1970. Figures below 7 percent are considered to not be easily attainable and are believed to be caused by inconsistencies associated with reading meters every two months and other data collection/entry errors. City staff believes that a realistic range for unaccounted-for

water is 11 to 13 percent. As of July 1992, meters are being read monthly.

2. PROJECTED WATER USE

Projected average day water demands for each customer class are shown in Table I-7. The computer model for service area customer and water usage projection was used to calculate the projected average day usage (refer to computer output tables in Appendix B). Input data on customer projections and water usage per meter was used in the projection analysis.

The maximum day demand projection band was determined by applying demand factors of 2.14, 2.0, and 1.8 to the average day demand projections from year 1992 through year 2050. Data from 1960 to 1991 was used to determine these maximum day to average day factors which average 1.8 over the 22-year period and reached a maximum of 2.14 in 1983 as shown in Table I-8. The maximum day factor of 2.0 represents the design value used in the September 1992 draft of the Water System Master Plan and appears to be a reasonable maximum goal for the City. The maximum day water demand was intentionally controlled by the City in 1990 and 1991 through watering restrictions and limiting the pumping of water to conserve water in storage at the water plant.

a. Residential Water Use Projection

Historical and projected water demands for residential customers are shown in Table I-9 and Figure I-6. Projected usage is determined by applying the projected number of residential customers from

Table I – 7

AVERAGE DAY WATER USE PROJECTIONS
(MGD)

Year	Residential	Commercial	Industrial	Lawn Service	Fire Protection	Golf Course	Institutional	Water Utility	Wholesale	Subtotal	Unaccounted–For Water	Average Day Usage
1990 (1)	26.3	15.4	8.7	2.7	0.0	0.2	2.2	0.0	1.2	56.7	7.5	64.2
2000	30.0	18.0	10.5	4.2	0.1	0.2	2.4	0.2	8.5	74.1	8.9	83.0
2010	35.1	21.1	10.9	4.8	0.1	0.3	2.6	0.2	12.8	87.8	10.5	98.3
2020	40.0	24.0	11.2	5.3	0.1	0.3	2.8	0.2	15.6	99.5	11.9	111.4
2030	44.5	26.7	11.5	5.8	0.1	0.3	3.0	0.2	16.0	108.1	13.0	121.1
2040	49.2	29.5	11.9	6.2	0.1	0.4	3.2	0.2	17.1	117.8	14.1	131.9
2050	54.1	32.5	12.3	6.6	0.1	0.4	3.4	0.2	18.1	127.7	15.3	143.0

Note:
(1) From Wichita Water and Sewer System Annual Report, 1990.

Table I – 8

HISTORICAL MAXIMUM DAY/AVERAGE DAY FACTORS (1)

Year	Annual Average Day (MGD)	Maximum Day (MGD)	Maximum Day/ Average Day Factor
1960	24.9	40.1	1.61
1961	24.8	42.5	1.71
1962	27.0	46.6	1.73
1963	29.3	48.8	1.67
1964	30.4	57.9	1.90
1965	30.6	52.1	1.70
1966	34.5	67.5	1.96
1967	33.9	53.6	1.58
1968	35.9	61.9	1.72
1969	35.2	57.1	1.62
1970	37.7	69.9	1.85
1971	36.4	63.3	1.74
1972	38.1	63.1	1.66
1973	39.3	70.8	1.80
1974	38.2	74.5	1.95
1975	38.8	69.7	1.80
1976	39.9	70.9	1.78
1977	40.1	70.0	1.74
1978	45.2	84.3	1.87
1979	48.0	79.5	1.66
1980	53.8	104.1	1.94
1981	49.1	76.3	1.55
1982	48.6	92.0	1.89
1983	49.3	105.5	2.14
1984	51.7	96.7	1.87
1985	48.5	91.6	1.89
1986	48.2	96.4	2.00
1987	53.4	104.0	1.95
1988	57.9	112.3	1.94
1989	58.4	90.9	1.55
1990 (2)	64.2	109.5	1.71
1991 (2)	62.2	125.7	2.02
		Average	1.80
		Minimum	1.55
		Maximum	2.14

Notes:

(1) Data for 1960 – 1985 collected from 1985 C & O report. Data for 1986 – 1991 collected from Wichita Water and Sewer Annual Reports, 1986 – 1991.

(2) The maximum day demands in 1990 and 1991 were artificially controlled.

Table I – 9

HISTORICAL AND PROJECTED
RESIDENTIAL WATER USE

Year	Residential Customers	Residential Population (1)	Average Annual gal/cap/day	Average Annual Daily Demand (MGD) (2)
1970	71,011	217,290	72.0	15.6
1980	84,610	221,680	103.0	22.8
1990	99,439	241,635	109.0	26.3
2000	106,725	259,342	116.5	30.0
2010	119,075	289,352	122.2	35.1
2020	129,375	314,381	128.4	40.0
2030	137,625	334,429	134.1	44.5
2040	145,875	354,476	140.3	49.2
2050	154,125	374,524	146.0	54.1

Notes:

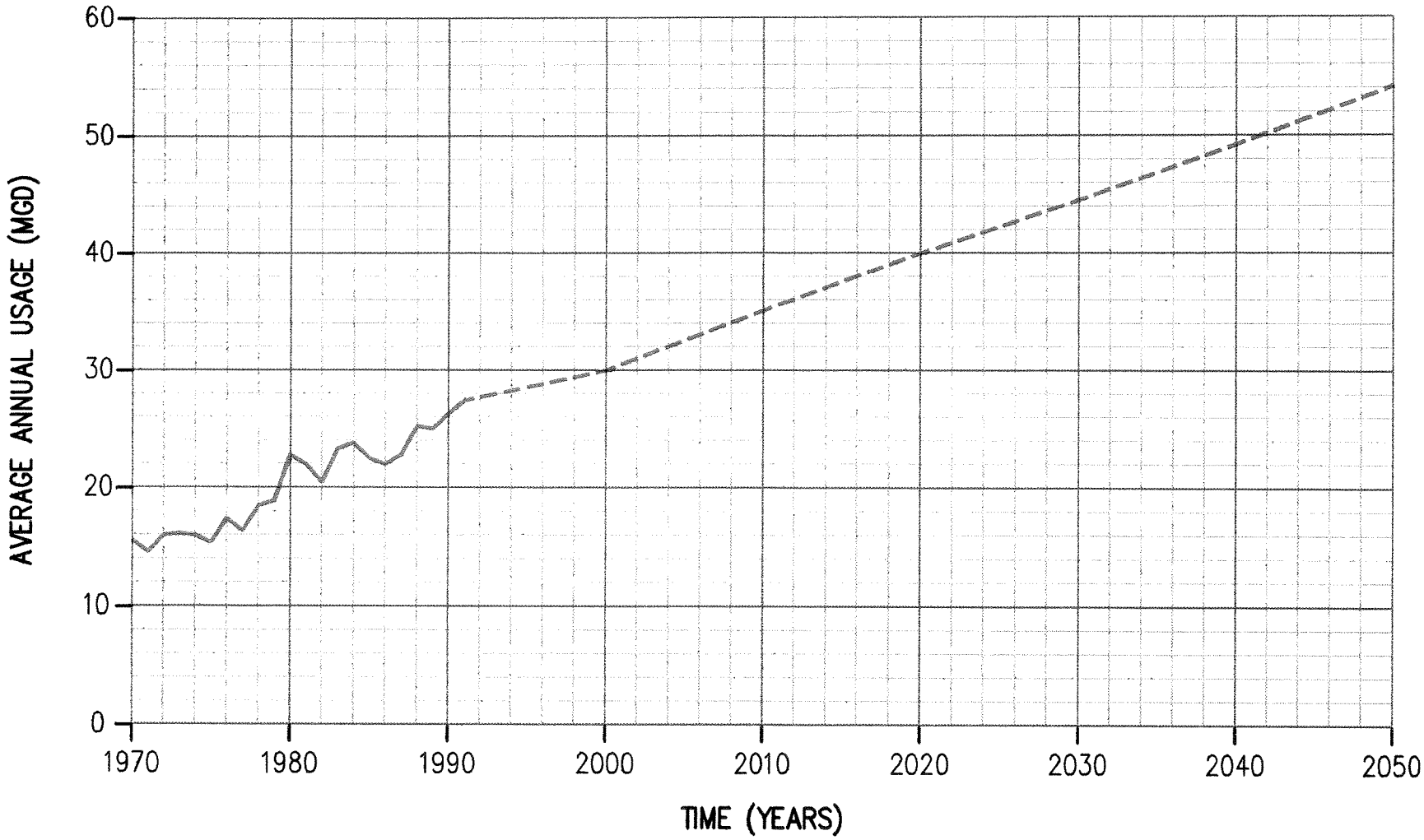
(1) Residential population from 1970 through 1990 represents single family and duplex housing units, no multi–family. Approximately 63,000 people lived in multi–family housing units in 1990 which are included in the commercial water user classification. Population for City of Wichita only.

(2) Average Annual Daily Demand includes a negative adjustment for residential lawn sprinkler customers.

Table I – 10

HISTORICAL AND PROJECTED
COMMERCIAL WATER USE

Year	Commercial Customers	Average Annual gal/meter/day	Average Annual Daily Demand (MGD)
1970	9,323	901	8.4
1980	10,032	1,575	15.8
1990	10,309	1,491	15.4
2000	10,751	1,673	18.0
2010	11,301	1,865	21.1
2020	11,879	2,019	24.0
2030	12,486	2,136	26.7
2040	13,125	2,248	29.5
2050	13,796	2,353	32.5



LEGEND

WICHITA DATA HISTORICAL

B&McD PROJECTION

Burns & McDonnell

Figure I – 6

RESIDENTIAL WATER USAGE PROJECTION

Table I-5 to projected gallons per day per meter (gpd/meter) water demands. Customer growth is based on 1,235 new customers per year from 1992 to 2015 and 825 new customers per year from 2016 to 2050. This projection reflects the shape of the OBERS population growth curve and averages 1,000 new housing units per year over the study period. By comparison, MAPDs 1992 Comprehensive Plan uses an average of approximately 1,000 new housing units per year through the year 2010.

Historical per capita water use is determined from historical population data and annual residential water consumption records from Table I-6. Per capita usage has grown steadily since 1970 at an average rate of 1.7 percent per year to 109 gallons per capita per day (gpcd) or 265 gpd/meter in 1990. Based on a linear regression from 1980 to 1991, usage of 146 gpcd or 355 gpd/meter is projected in the year 2050. The 1980's appears to be the most reasonable time period to evaluate long-term residential water use as it represents the time period when many people had acquired water-using devices such as dishwashers, clothes washers, garbage grinders, and other devices.

Another projection evaluated in this study is uncontrolled residential use. Uncontrolled use assumes no limitations on available supply, no restrictions or conservation, and an economical unit cost of water. Based on a linear regression from 1970 to 1991, average uncontrolled use of 174 gpcd would result in the year 2050.

This figure compares with 146 gpcd for year 2050 which is used to represent controlled use conditions in the future.

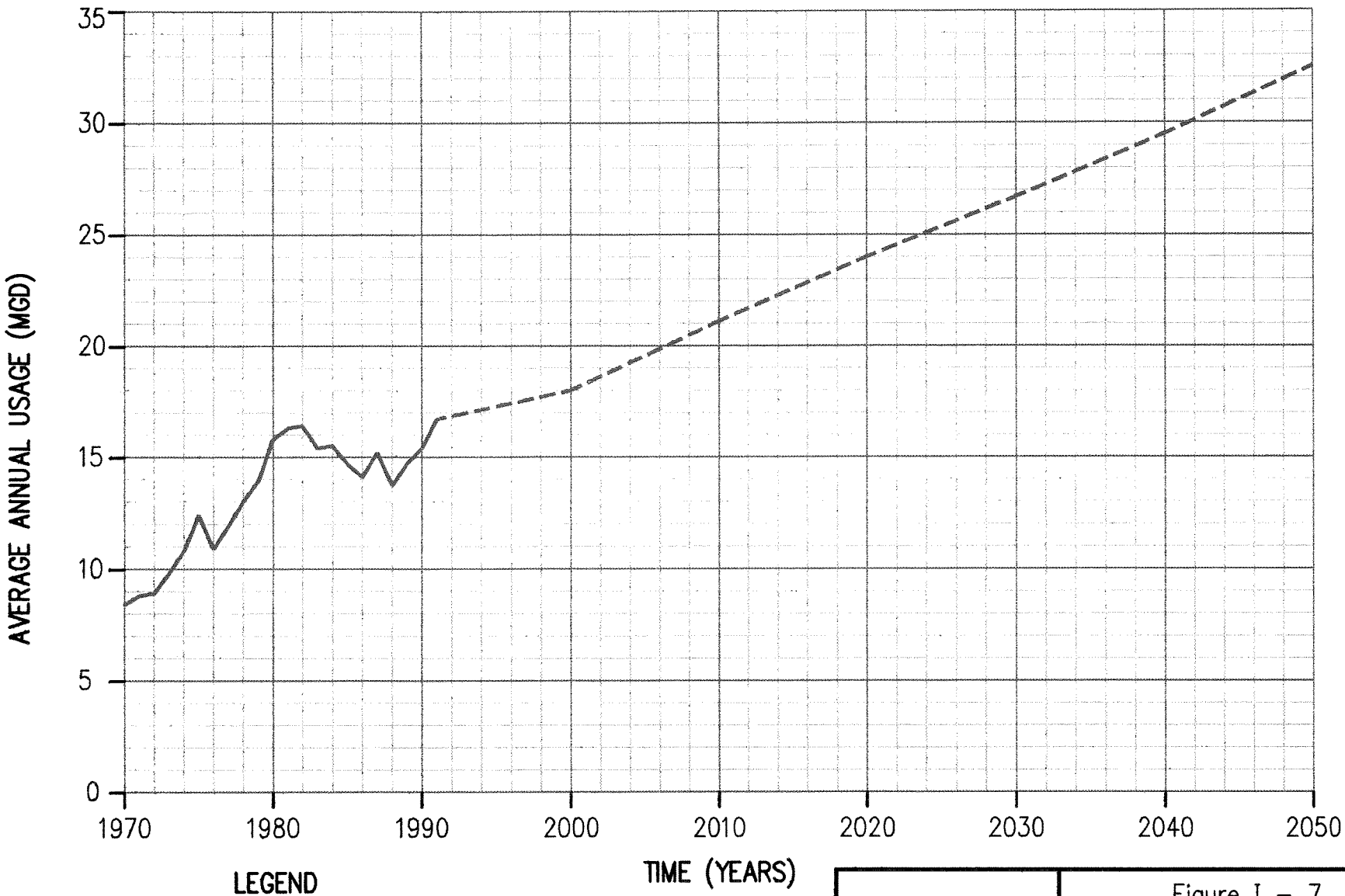
b. Commercial Water Use Projection

Historical and projected water usage for commercial customers are shown in Table I-10 and Figure I-7. The projected demand is based on historical commercial customer growth and water usage from 1970 to 1991. Customer growth occurred at a rate of 0.5 percent per year and is anticipated to continue to grow at that rate through the study period.

Review of the commercial to residential usage factors from 1970 to 1991 shows commercial usage to be approximately 60 percent of the residential usage. This factor of 60 percent is projected through the year 2050 and yields an anticipated average day commercial use of 33.9 MGD.

c. Industrial Water Use Projection

Historical and projected water usage for industry are shown in Table I-11 and Figure I-8. The number of industrial customers had steadily decreased from 1970 (168 customers) to 1988 (133 customers); however, large customer increases occurred in 1989 and 1990, allowing this water user classification to achieve a current level of approximately 200 customers. Customer growth is anticipated to continue increasing at a rate of approximately 0.3 percent per year. This rate of growth is equivalent to the average growth rate in water usage from 1970 through 1991.



LEGEND

WICHITA DATA HISTORICAL

B&McD PROJECTION

Burns & McDonnell

Figure I – 7

COMMERCIAL WATER USAGE PROJECTION

Table I – 11

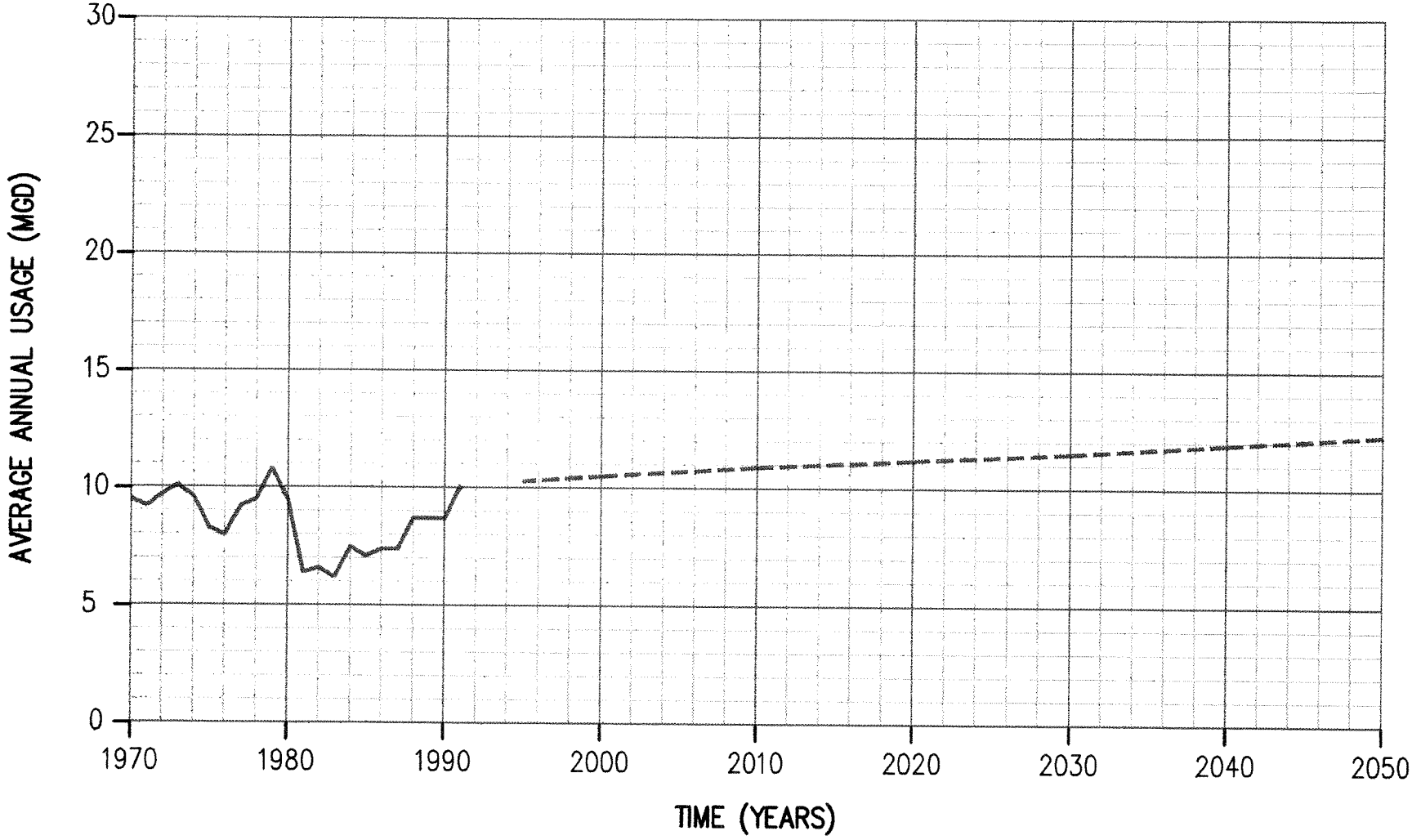
HISTORICAL AND PROJECTED
INDUSTRIAL WATER USE

Year	Industrial Customers	Average Annual gal/meter/day	Average Annual Daily Demand (MGD)
1970	168	56,550	9.5
1980	149	63,760	9.5
1990	201	43,290	8.7
2000	205	51,500	10.5
2010	211	51,500	10.9
2020	217	51,500	11.2
2030	224	51,500	11.5
2040	231	51,500	11.9
2050	238	51,500	12.3

Table I – 12

HISTORICAL AND PROJECTED
LAWN SERVICE WATER USE

Year	Lawn Service Customers	Average Annual gal/meter/day	Average Annual Daily Demand (MGD)
1976	221	2,230	0.5
1980	386	4,137	1.6
1990	1,496	1,805	2.7
2000	3,498	1,205	4.2
2010	3,998	1,205	4.8
2020	4,423	1,205	5.3
2030	4,773	1,205	5.8
2040	5,123	1,205	6.2
2050	5,473	1,205	6.6



LEGEND

WICHITA DATA HISTORICAL

B&McD PROJECTION

Burns & McDonnell

Figure I – 8

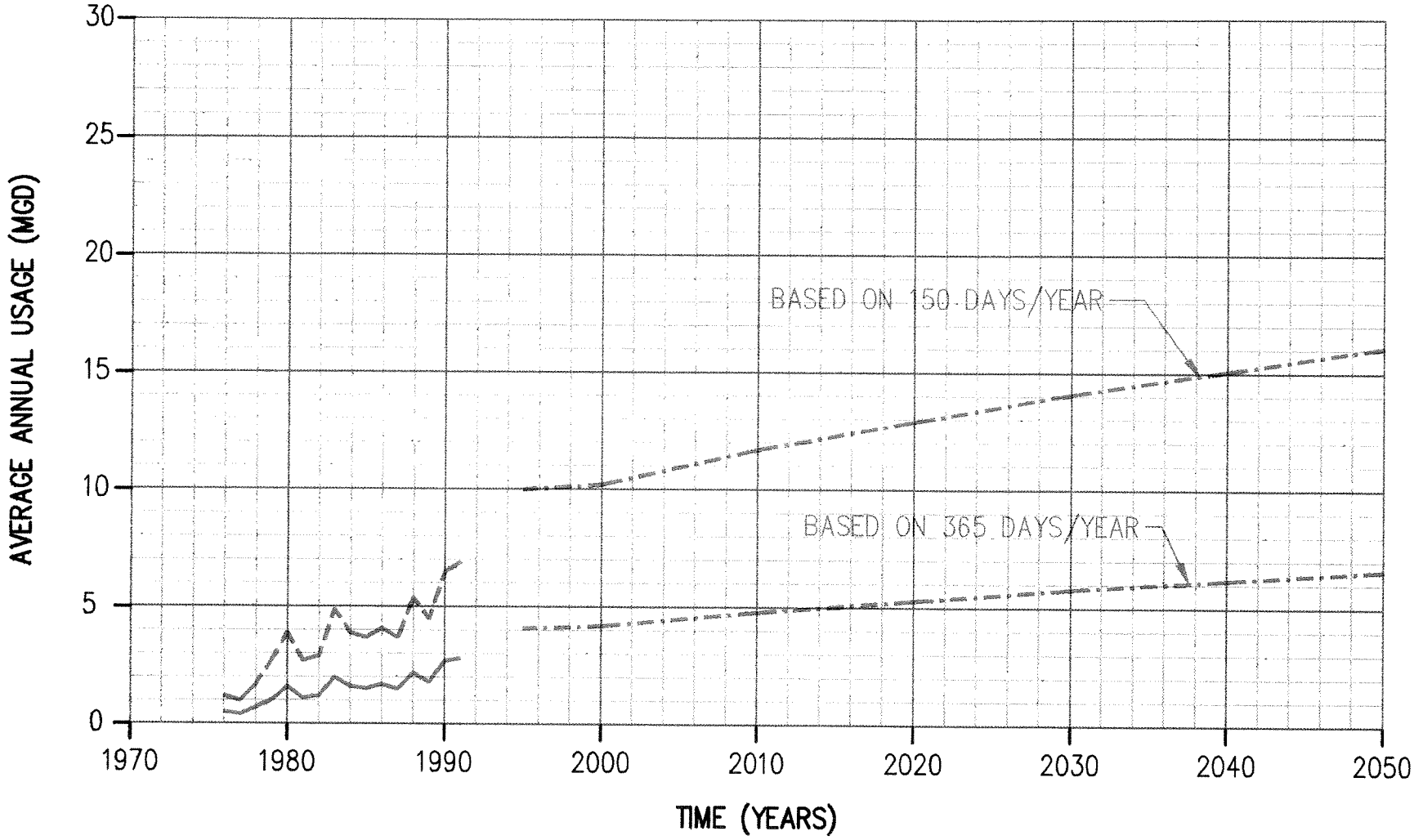
INDUSTRIAL WATER USAGE PROJECTION

Reference to Figure I-8 shows the average industrial usage following a similar pattern to the number of customers, i.e., steadily decreasing to 7.4 MGD in 1987 then increasing slightly to 8.7 MGD in 1990 and 10.1 MGD in 1991. A modest increase in the number of customers and associated usage, approximately 0.3 percent per year, is anticipated through the study period.

d. Lawn Service Water Use Projections

Historical and projected water usage for lawn service customers are shown in Table I-12 and Figure I-9. The lawn service classification includes residential and commercial connections to the distribution pipe network with sprinkler systems. Customer growth is anticipated to continue at a high rate in 1993 and 1994 until the effects of the conservation water rates are noticed. Growth is then decreased to 50 customers per year until 2015 and to 35 customers per year from 2016 to 2050.

Reference to Figure I-9 shows a rapid increase in water usage since the creation of this water user classification in 1976. Over the 16-year historical period, the number of customers has increased by a factor of 9 and usage by a factor of 5.5. As the number of customers increase, the average gpd/meter continues to decrease. The gpd/meter value is anticipated to decrease to a level of 1,205 by the year 2000 and to maintain that level through the study period. Applying the projected number of customers with estimated gpd/meter results in an average annual day water use of 6.6 MGD in



LEGEND

- WICHITA DATA HISTORICAL (BASED ON 365 DAYS/YEAR)
- WICHITA DATA HISTORICAL (BASED ON 150 DAYS/YEAR)
- B&McD PROJECTION

Burns & McDonnell

Figure I – 9

LAWN SERVICE WATER USAGE PROJECTION

year 2050. Based on 150 watering days per year, lawn service customers would use 16.1 MGD on an "average" summer day of demand.

e. Fire Protection Water Use Projections

Fire protection usage is a function of the amount of water used to extinguish fires for fire protection customers. From 1970 to 1991, no significant water usage was recorded. This trend of no significant usage is anticipated to continue through the study period. The projected usage for this customer classification is shown in Table I-7.

f. Golf Course Water Use Projections

The golf course user classification was added in 1989 when three customers were connected. Five customers are now connected to the system with a projected increase of one new customer every ten years. Each customer, on the basis of 365 days per year, is anticipated to use an average of 41,000 gpd/meter, which is the maximum rate found in this short period of historical record. This results in a year 2050 annual average use of 0.4 MGD. Based on 150 watering days per year, golf courses are projected to use 1.0 MGD based on an "average" summer day of demand.

g. Institutional Water Use Projections

Historical and projected water uses for institutional customers are shown in Table I-13 and Figure I-10. Institutional customers include city and county facilities, universities and schools. The number of customers for the classification grew at a rate of

Table I – 13

HISTORICAL AND PROJECTED
INSTITUTIONAL WATER USE

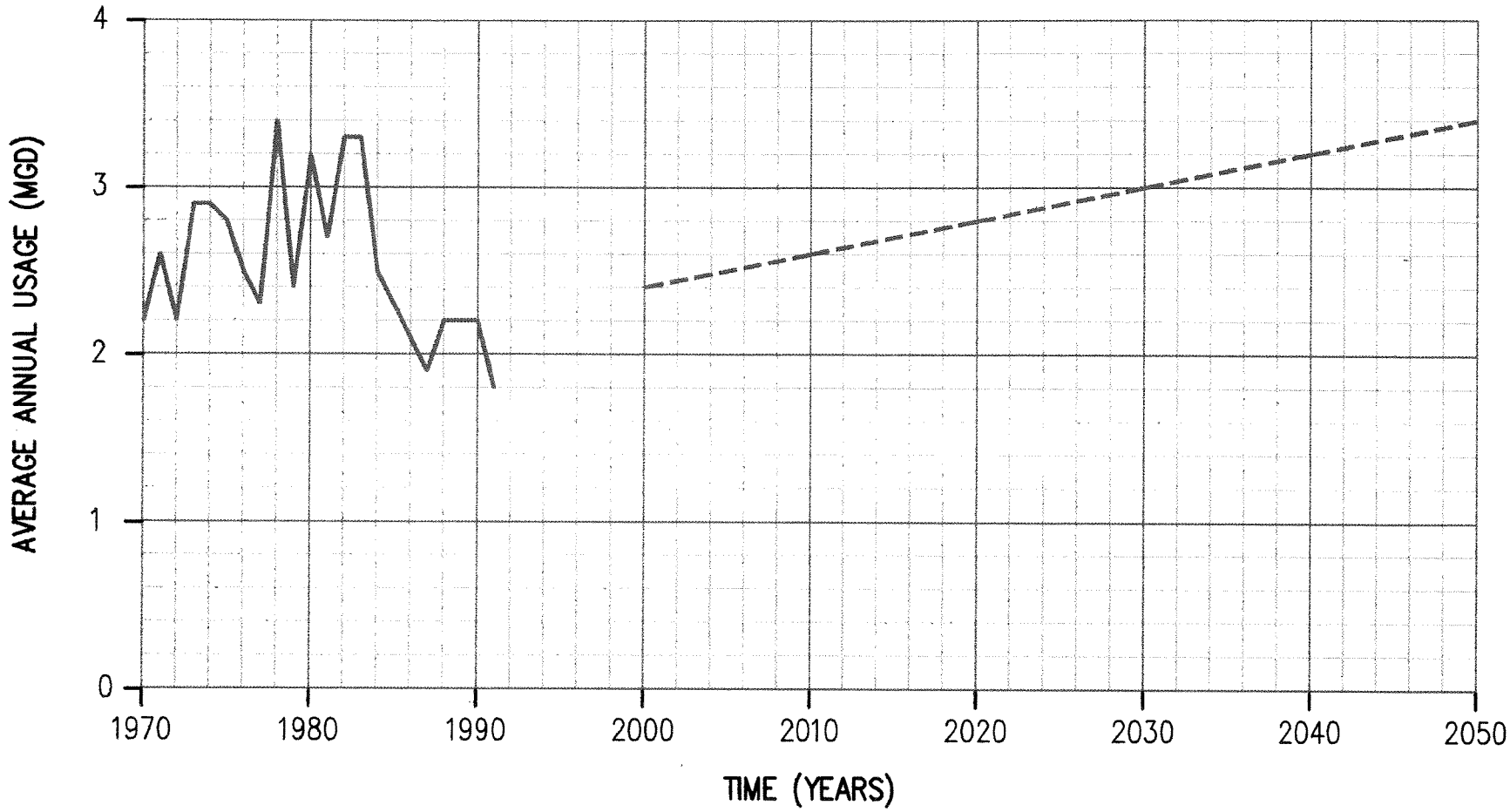
Year	Institutional Customers	Average Annual gal/meter/day	Average Annual Daily Demand (MGD)
1970	662	3,320	2.2
1980	739	4,330	3.2
1990	866	2,585	2.2
2000	877	2,724	2.4
2010	941	2,752	2.6
2020	1,007	2,779	2.8
2030	1,072	2,807	3.0
2040	1,130	2,836	3.2
2050	1,202	2,864	3.4

Table I – 14

HISTORICAL AND PROJECTED
WHOLESALE WATER USE

Year	Existing Wholesale Customers	Anticipated Wholesale Customers	Existing Wholesale Average Annual Daily Demand (MGD) (1)	Anticipated Wholesale Average Annual Daily Demand (MGD)	Total Wholesale Average Annual Daily Demand (MGD)
1970	1	–	0.03	–	0.03
1980	3	–	0.30	–	0.30
1990	10	–	1.20	–	1.20
2000	11	4	5.70	2.8	8.50
2010	11	6	6.30	6.5	12.80
2020	11	9	7.80	7.8	15.60
2030	11	11	7.00	9.0	16.00
2040	11	11	7.40	9.7	17.10
2050	11	11	7.90	10.2	18.10

Note:
(1) Excludes McConnell AFB, not classified as a wholesale customer.



LEGEND

WICHITA DATA HISTORICAL

B&McD PROJECTION

Burns & McDonnell

Figure I – 10

INSTITUTIONAL WATER USAGE PROJECTION

0.9 percent per year from 1970 to 1991. A linear regression of customer data from 1970 to 1991 projects 1,202 customers in 2050.

Reference to Figure I-10 shows erratic changes in usage from 1970 to 1991, ranging from 1.9 MGD to 3.8 MGD. For the purpose of this study, water demand is anticipated to grow at a slow, steady rate from 2.4 MGD in 1990 to 3.4 MGD in 2050.

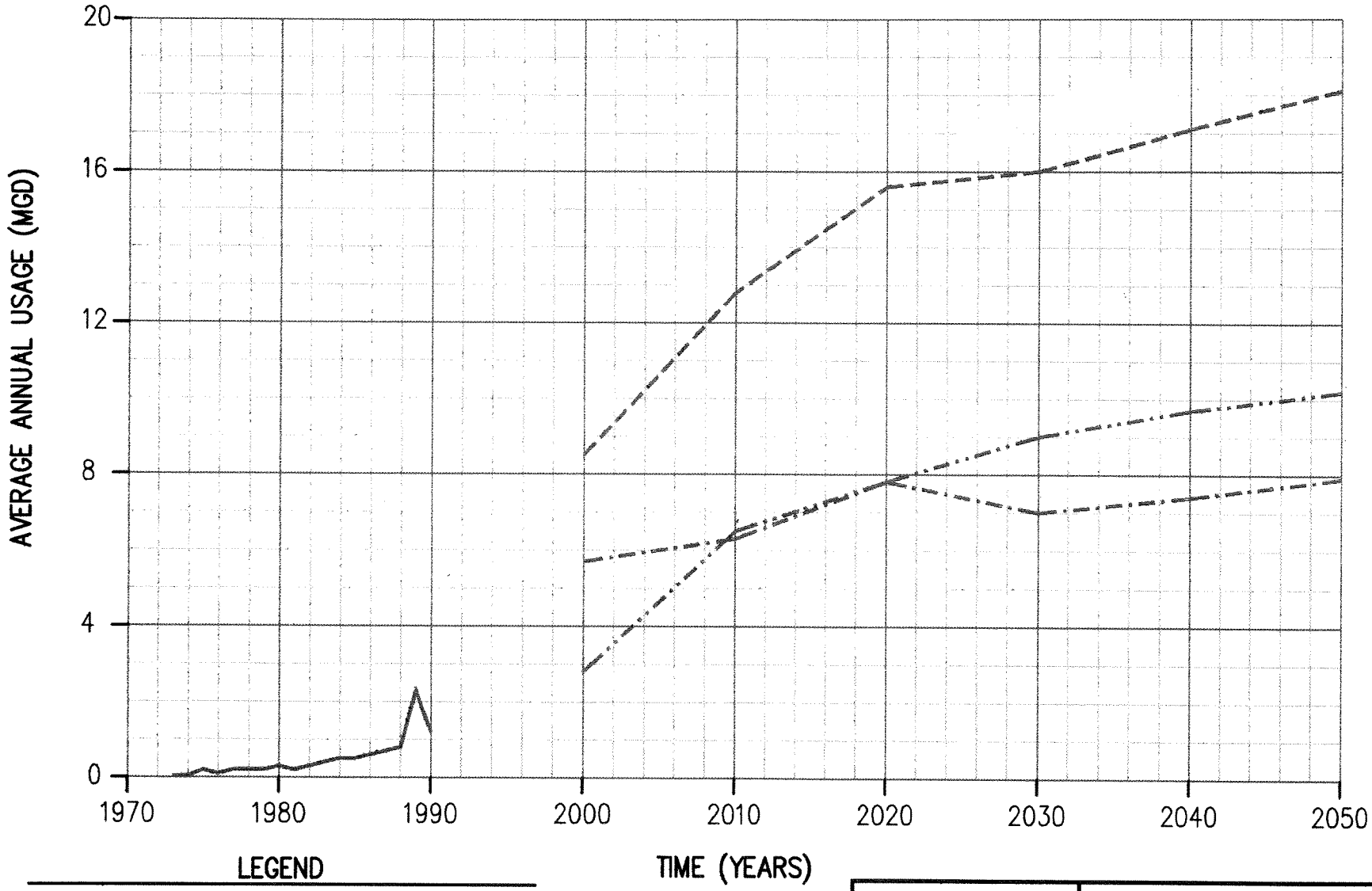
h. Water Utility Water Use Projections

The water department utilizes water for various construction and maintenance activities, including flow testing of the distribution system, pipeline construction and fire hydrant flushing. Historically, a maximum average annual flow of 0.2 MGD has been recorded and is used as the projected water utility usage from 1992 through 2050.

i. Wholesale Water Use Projections

Historical and projected water demands by wholesale customers are shown in Table I-14 and Figure I-11. The City serves 11 wholesale customers, including eight towns and Rural Water Districts (RWD) Nos. 1, 3 and 8. RWD No. 3 is expected to disconnect from the City's system by 1995.

Reference to Figure I-11 shows a slow, steady increase in water use from 0.03 MGD in 1973 to 1.4 MGD in 1991. During this time period, wholesale customers only used about half of their contracted water supply amount.



LEGEND

- WICHITA DATA HISTORICAL
- B&McD PROJECTION TOTAL CUSTOMERS
- B&McD PROJECTION EXISTING CUSTOMERS
- B&McD PROJECTION ANTICIPATED CUSTOMERS

Burns & McDonnell

Figure I – 11

WHOLESALE WATER USAGE PROJECTION

Two types of wholesale customers and associated water use are evaluated in this study; existing and anticipated. The existing wholesale customers and their associated use is expected to grow from 28,000 people in the year 1990 to 51,000 people in year 2050 with an average day demand of 8.0 MGD.

Anticipated wholesale customers include additional towns/areas in Sedgwick County not currently served by the City. Connection of these customers to the city water system would make the City a regional water purveyor. Under this scenario, the City would provide raw and potable water to approximately 85 percent of the county by year 2030. The anticipated wholesale customers are projected to serve approximately 70,000 people with a 10 MGD average day water demand by the year 2050.

Several existing contracts between the City and wholesale customers include excessive and unused supply capacities. Future wholesale contracts may be rewritten to allocate water supply to the wholesale customers which more closely represent anticipated water use. This will allow the City to better utilize its resources and prevent overbuilding of facilities.

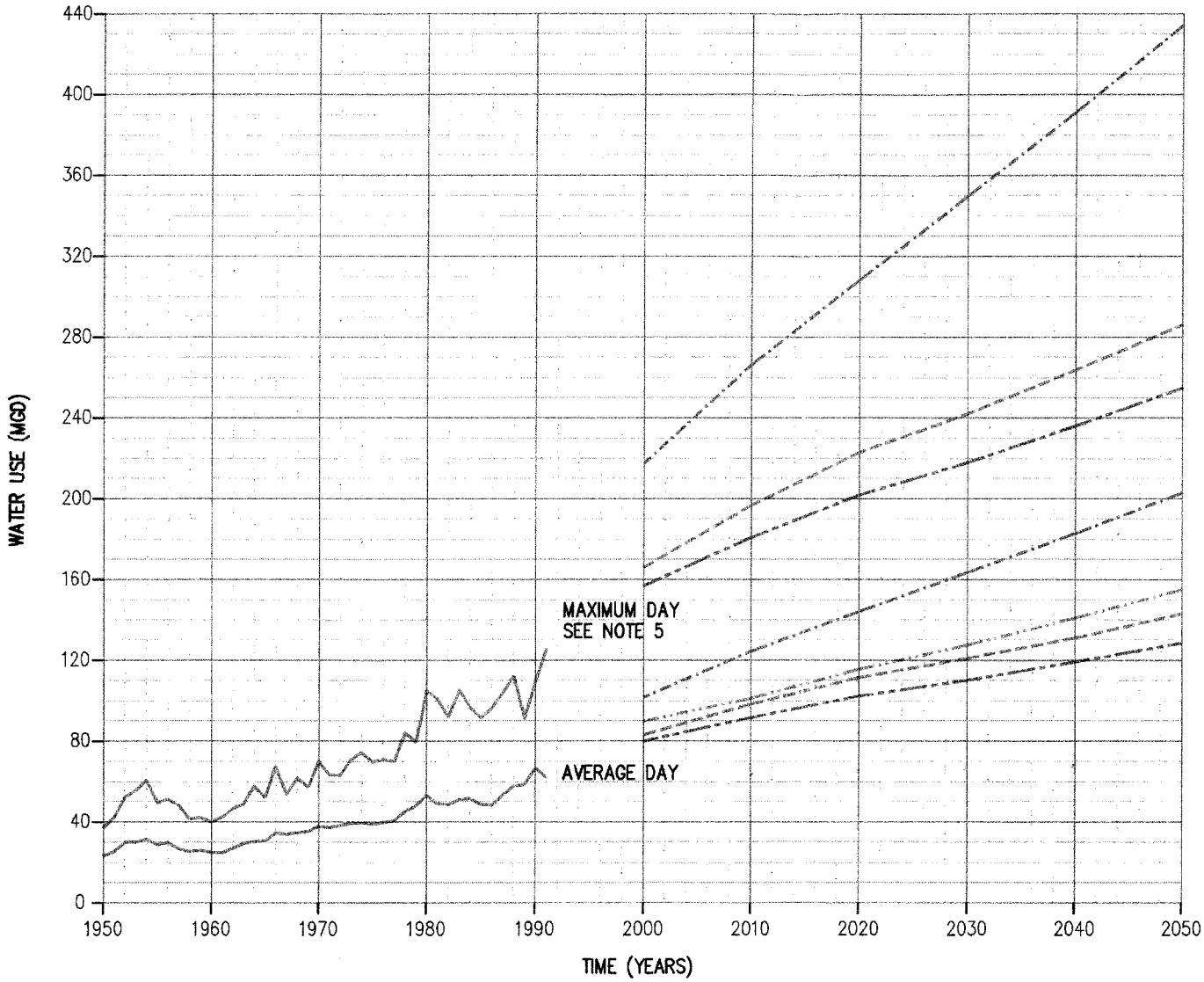
j. Total Water Demand (Without Effects of Water Conservation)

Total historical and projected average day and maximum water demands (without conservation) for the water service area are shown in Table I-15 and Figure I-12. Projected demands include water for residential, commercial, industrial, lawn service, fire protection,

Table I – 15

WATER USAGE PROJECTION
WITHOUT CONSERVATION

Year	Average Day			Maximum Day (2.14 factor)			Maximum Day (2.00 factor)			Maximum Day (1.80 factor)		
	Low (MGD)	High (MGD)	Intermediate (MGD)	Low (MGD)	High (MGD)	Intermediate (MGD)	Low (MGD)	High (MGD)	Intermediate (MGD)	Low (MGD)	High (MGD)	Intermediate (MGD)
1990	64.2	64.2	64.2	125.7	125.7	125.7	125.7	125.7	125.7	125.7	125.7	125.7
2000	79.9	89.9	83.0	171.0	192.4	177.6	159.8	179.8	166.0	143.8	161.8	149.4
2010	91.6	101.2	98.3	196.0	216.6	210.4	183.2	202.4	196.6	164.9	182.2	176.9
2020	102.2	115.5	111.4	218.7	247.2	238.4	204.4	231.0	222.8	184.0	207.9	200.5
2030	110.1	127.5	121.1	235.6	272.9	259.2	220.2	255.0	242.2	198.2	229.5	218.0
2040	119.2	141.0	131.9	255.1	301.7	282.3	238.4	282.0	263.8	214.6	253.8	237.4
2050	128.5	155.1	143.0	275.0	331.9	306.0	257.0	310.2	286.0	231.3	279.2	257.4



LEGEND

- WICHITA HISTORICAL DATA
- B&McD HIGH PROJECTION
- B&McD LOW PROJECTION
- B&McD INTERMEDIATE PROJECTION
- UNCONTROLLED PROJECTION

NOTES:

1. B&McD HIGH PROJECTION IS BASED ON HIGH POPULATION PROJECTION
2. B&McD LOW PROJECTION IS BASED ON LOW POPULATION PROJECTION
3. B&McD INTERMEDIATE PROJECTION IS BASED ON INTERMEDIATE POPULATION PROJECTION
4. UNCONTROLLED PROJECTION IS BASED ON HIGH POPULATION PROJECTION AND AN UNCONTROLLED GPCD USAGE RATE
5. MAXIMUM DAY DEMAND IS BASED ON A MAXIMUM DAY AVERAGE DAY FACTOR OF 2.0, EXCEPT FOR UNCONTROLLED WHICH HAS A FACTOR OF 2.14

Burns & McDonnell

Figure I – 12

PROJECTED WATER USE WITHOUT CONSERVATION

golf courses, institutional, water utility and wholesale customer classifications and unaccounted-for water. Unaccounted-for water is assumed to be 12 percent.

Historical information shown in Figure I-12 is from Wichita Water and Sewer System Annual Reports. The high, intermediate and low water use projections are based on the high, intermediate, and low population projections shown in Figure I-2. The uncontrolled water demand is based on the high population projection with residential per capita water increasing from 108 in 1990 to 174 in 2050.

The total water demand projection shown in Figure I-12 does not include the full impact of additional water conservation measures which have been implemented by the City within the last two years. The City has limited lawn watering to two days per week per customer since 1990 and has had an active meter repair/replacement program for many years. The City currently has a public education program on water conservation and will place a water conservation rate into effect in January 1993. The possible impacts of these and other water conservation measures are discussed hereafter.

E. WATER DEMAND WITH CONSERVATION

History has shown that the amount of water used by consumers can be influenced by water conservation programs. Water conservation is possible through the continuous use of various management and technological activities; public awareness and education programs; and enforcement efforts. A thorough water conservation program should encourage the most

effective use of water resources and the most efficient use of water by water consumers.

1. CONSERVATION ACTIVITIES

Management activities associated with conservation of water resources may include operating surface water and groundwater supplies to minimize water losses or yield reductions. Groundwater supplies should be managed to reduce aquifer declines and deterioration due to overpumping.

Other management and technological activities may include emphasis on water conservation in water system operation and maintenance activities. For example, the Wichita Water Department has in place a leak detection program to reduce water distribution system losses and a meter testing and repair program to increase the accuracy of water quantity monitoring. All meters are tested, repaired or replaced on an eight-year cycle. Additionally, water treatment facilities are operated to minimize water losses through recycle of filter backwash water and recycle of supernatant from treatment basin sludge blowdown. The City also has performed a plumbing fitting retrofit pilot program, has plans to xeriscape City facilities, has instituted new water conservation rates (inverted block) effective January 1, 1993, and is planning new plumbing code requirements, including low flush toilets and conservation showerheads and faucets. The City's water rates prior to January 1, 1993 were declining block rates which decreased the unit cost of water as water use increased.

Other programs under consideration may include methods to encourage the recycle and/or treatment and reuse of various industrial and municipal

wastewaters in nonpotable reclaimed water systems. Such reclaimed water could be used in cooling, irrigation, or washdown systems where potable quality is not required. The use of zero liquid discharge water management systems in industrial complexes to supplement available water supplies is another method available to conserve water and to reduce or eliminate liquid waste streams.

Public awareness and education programs are frequently used to promote water conservation to water consumers. Wichita has several public awareness and education programs in progress, including radio and television commercials.

Conservation at the consumer level essentially consists of encouraging more efficient use of water. For domestic consumers, this may be achieved by using flow-restricting faucets and showerheads, reducing toilet tank capacity, or restricting lawn watering or car washing activities. For commercial and industrial consumers, water conservation may be achieved by optimizing product or process water and cooling water, reducing landscape watering, recycling or treating and reusing waste streams and installing more efficient sanitary waste handling facilities.

Regulation and enforcement efforts are also needed for an effective water conservation program. Revisions to local building and plumbing codes to require installation of water conserving devices as a requirement for a building permit are helpful in reducing water use. In critical water shortage situations, prohibition of outdoor water uses

for lawn watering and washing cars and reduction of sanitary water for domestic needs may be required. Enforcement of regulations or restrictions by fines or termination of water service is necessary to assure compliance by all water users.

Some water conservation will occur without specific programs because of federal regulations concerning water pollution control. These programs which may require industrial wastewater pretreatment before discharge to the municipal sewer system will promote industrial water recycle, treatment and reuse because of economic conditions which influence the relative cost of water.

2. CONSERVATION QUANTITY EVALUATIONS

Two levels of conservation are evaluated in this study, a low and high range. The low range conservatively estimates potential savings from conservation activities and more closely reflects case studies by other cities. The high range estimates potential savings from conservation activities based on theoretical values. The degree of water conservation achieved will be influenced largely by the amount of emphasis the City places on water conservation, including enforcement activities.

Research and case studies have shown the following water conservation factors to be representative and feasible for water systems similar to the Wichita area:

- General Residential:
  - Savings due to public education (up to 9 percent) and conservation water rates (6 percent plus) is estimated at 10 percent for the low range and 15 percent for the high range.

- Indoor plumbing fixture retrofit for pre-1995 housing units:
  - Case studies (1981-1991) show savings of 5.7 to 9.6 gallons per capita day (gpcd). More recent studies show savings of 8.4 to 9.6 gpcd.
  - This study estimates a savings of 8 gpcd or 20 gpd/meter for each housing unit (2.43 people per household) for the low range (based on a 70 percent penetration).
  - Based on review of winter usage for Wichita (86 gpcd) and potential indoor usage with retrofitted conservation devices (60 gpcd), a reasonable savings of 12 gpcd or 28 gpd/meter for each housing unit is estimated for the high range (based on a 90 percent penetration).
  - References include HUD, Bureau of Reclamation, Metropolitan Water District of Southern California, and the Lower Colorado River Authority.

- Indoor plumbing fixtures for housing units built in 1995 and beyond:
  - Plumbing fixtures include 1.6 gallons per flush toilet and 2.5 gpm showerheads and faucets.
  - Case studies show low flush toilets save 12 to 24 gpcd over 5 to 6 gallons per flush toilets and 8 to 12 gpcd over 3.5 gallon per flush toilets.
  - This study estimates a savings of 13 gpcd or 31 gpd/meter for each post-1995 housing unit for the low range - toilet (19 gpd/meter), plus showerhead (10 gpd/meter) plus faucet (2 gpd/meter).
  - This study estimates a savings of 26 gpcd or 63 gpd/meter for post-1995 housing units for the high range (water-conserving home uses 60 gpcd while an average home had indoor usage of 86 gpcd in Wichita in 1990 for a difference of 26 gpcd).
  - References include HUD, Bureau of Reclamation, Metropolitan Water District of Southern California, and the Lower Colorado River Authority.

- Outdoor Watering:
  - This study estimates a savings of 5 percent of residential lawn watering (20,400 gallons per year per house) and lawn service use (260,000 gallons per year per meter) for the low range and 12 percent for the high range. This is a conservative estimate based on public education, conservation water rates and current watering restrictions.

Public education conserves up to 9 percent and increasing water rates conserves approximately 6 percent.

- Reference AWWA.

- Industrial Recycle:
  - This study estimates savings of 10 percent for the low range and 30 percent for the high range. Large industrial users have shown savings of 40 percent or more in various technical articles.
  - References include AWARE Inc., Whitely, Burdett and Associates, and the Denver Water Department.

- Commercial:
  - The commercial user class includes multi-family housing units, whose conservation savings are part of housing unit savings. Multi-family usage was calculated to be approximately 10 percent of total commercial usage. Therefore, savings for the commercial class are based on 90 percent of the total commercial usage.
  - This study estimates savings of 10 percent for the low range and 25 percent for the high range of commercial water use and commercial lawn watering (760,000 gallons per year per meter). The literature review shows potential commercial savings of 20 to 39 percent.
  - Reference the Bureau of Reclamation.

- Wholesale:
  - Wholesale customers are expected to reduce potable water use by 10 percent for the low range and 15 percent for the high range due to public education and conservation water rates.

The following ongoing and planned future conservation activities must be included in the City's conservation program to meet and possibly exceed the savings estimated in this study:

- Review and modify rate structure on an annual basis to help achieve and maintain conservation goals.
- Maintain current watering restrictions (twice per week by address).
- Make building plumbing code changes to incorporate low flush toilets (1.6 gallons per flush) and low flow shower heads and faucets (2.5 gpm) to be in effect by 1995.
- Continue public education programs.
- Continue leak detection surveys.
- Continue meter repair and replacement programs.
- Continue cooperative efforts with industries.
- Initiate a full scale plumbing fitting retrofit program for housing units built before the new code goes into effect (this study assumes January 1, 1995).

3. WATER USE PROJECTIONS WITH CONSERVATION

Projected annual water savings due to water conservation and associated average and maximum day demands are shown in Tables I-16 and I-17 and Figure I-13. These savings assume implementation of conservation

Table I – 16

WATER USE PROJECTIONS WITH LOW RANGE CONSERVATION (RECOMMENDED) (MGD)

Year	Average Day Usage	Maximum Day Usage (1)	Number of Occupied Housing Units	Resident General	Resident Indoors Pre – 1995	Resident Indoors Post – 1995	Resident Watering	Industrial Recycle	Commercial	Wholesale	Subtotal Avg Day Savings	Adjusted Avg Day Usage	Adjusted Max Day Usage
2000	83.0	166.0	135,547	3.8	2.6	0.2	1.0	1.1	1.9	0.9	11.5	71.5	143.0
2010	98.3	196.6	147,897	4.4	2.6	0.6	1.1	1.1	2.2	1.3	13.3	85.0	170.0
2020	111.4	222.8	158,197	4.9	2.6	0.9	1.2	1.1	2.5	1.6	14.8	96.6	193.2
2030	121.1	242.2	166,447	5.4	2.6	1.2	1.2	1.2	2.8	1.6	16.0	105.1	210.2
2040	131.9	263.8	174,697	6.0	2.6	1.4	1.3	1.2	3.0	1.7	17.2	114.7	229.4
2050	143.0	286.0	182,947	6.5	2.6	1.7	1.4	1.2	3.3	1.8	18.5	124.5	249.0

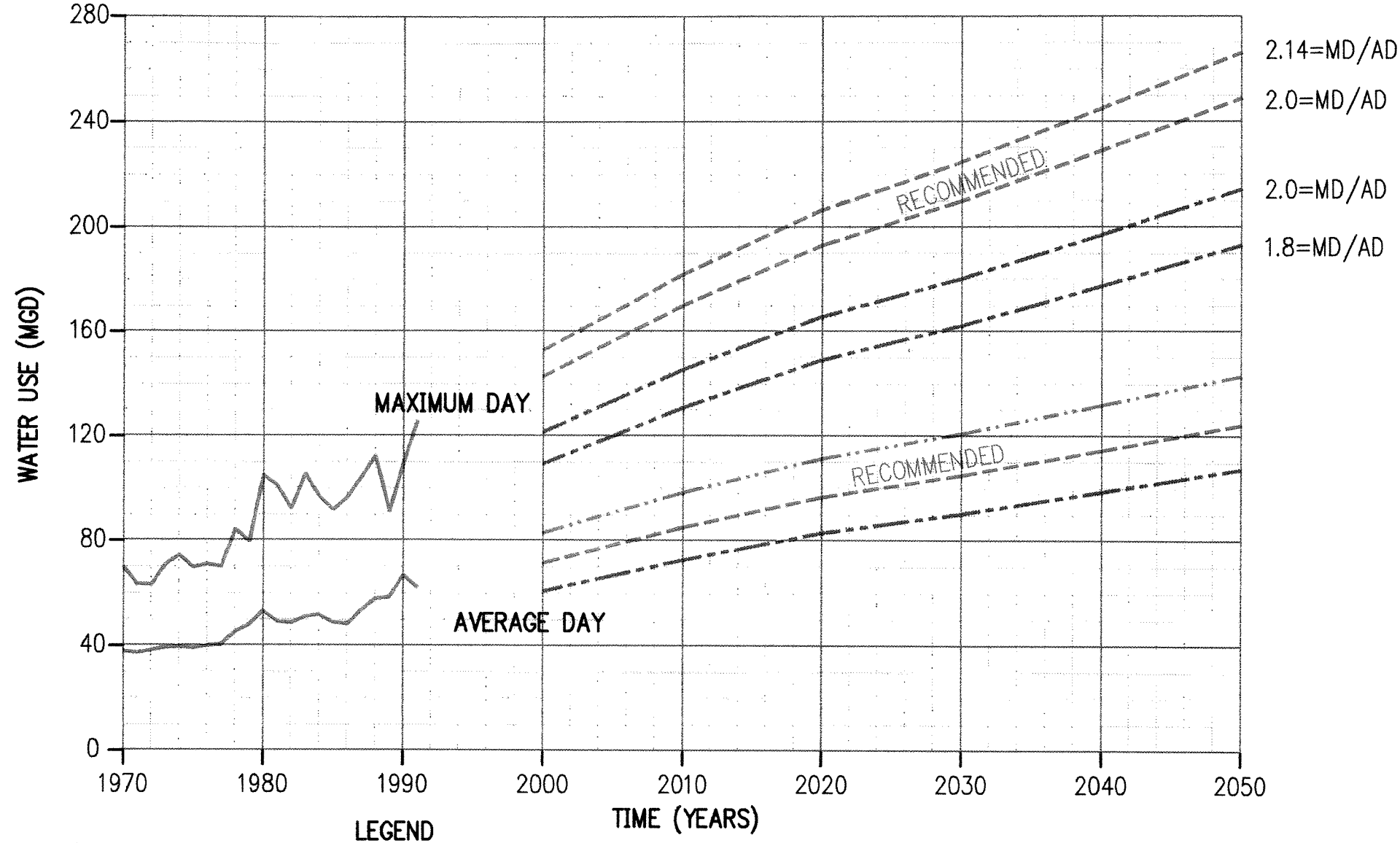
Note:
(1) Maximum Day/Average Day Factor = 2.0

Table I – 17

WATER USE PROJECTIONS WITH HIGH RANGE CONSERVATION (MGD)

Year	Average Day Usage	Maximum Day Usage (1)	Number of Occupied Housing Units	Resident General	Resident Indoors Pre – 1995	Resident Indoors Post – 1995	Resident Watering	Industrial Recycle	Commercial	Wholesale	Subtotal Avg Day Savings	Adjusted Avg Day Usage	Adjusted Max Day Usage
2000	83.0	166.0	135,547	5.8	3.6	0.5	2.4	3.2	4.7	1.3	21.5	61.5	123.0
2010	98.3	196.6	147,897	6.6	3.6	1.2	2.6	3.3	5.5	1.9	24.7	73.6	147.2
2020	111.4	222.8	158,197	7.4	3.6	1.9	2.8	3.4	6.2	2.3	27.6	83.8	167.6
2030	121.1	242.2	166,447	8.1	3.6	2.4	3.0	3.5	6.9	2.4	29.9	91.2	182.4
2040	131.9	263.8	174,697	8.9	3.6	2.9	3.1	3.6	7.6	2.6	32.3	99.6	199.2
2050	143.0	286.0	182,947	9.7	3.6	3.5	3.3	3.7	8.3	2.7	34.8	108.2	216.4

Note:
(1) Maximum Day/Average Day Factor = 2.0



LEGEND

WICHITA DATA HISTORICAL

B&McD PROJECTION WITHOUT CONSERVATION

B&McD PROJECTION WITH HIGH RANGE CONSERVATION

B&McD PROJECTION WITH LOW RANGE CONSERVATION

MD/AD = MAXIMUM DAY/AVERAGE DAY FACTOR

Burns & McDonnell

Figure I – 13

PROJECTED WATER USE WITH CONSERVATION

measures are gradually undertaken over several years and are fully realized by the year 2000.

Average day water use is estimated at 125 MGD in year 2050 with low range conservation measures and 108 MGD with high range conservation measures. Maximum day usage, with a 2.0 maximum day factor, is estimated at 249 MGD in year 2050 with low range conservation measures and 217 MGD with high range conservation measures. Low range conservation is anticipated to reduce demand by approximately 13 percent while high range conservation is anticipated to reduce demand by approximately 25 percent.

Literature on water conservation indicates that 15 percent conservation is an obtainable goal for most cities and could be a reasonable goal for the City of Wichita. Based on a conservation goal of 15 percent, the average day usage in year 2050 would be 122 MGD and the maximum day usage would be 243 MGD.

For the purpose of this study, the water use projection with low range conservation is recommended to provide a degree of high-side conservation to the water demand projections. Future tasks in this study will evaluate alternatives to supply an average day demand of 125 MGD and a maximum day demand of 249 MGD in the year 2050.

* * * * *

Part II - Inventory of Conventional Water Supplies

PART II

INVENTORY OF CONVENTIONAL CURRENT WATER SUPPLIES

A. GENERAL

This section of the report describes the City of Wichita's projected additional and associated existing and undeveloped raw water supply capacity. Projected additional water needs for the water system through the year 2050 are also discussed.

B. EXISTING WATER SYSTEM

1. HISTORY

The history of the Wichita water system spans a 122-year period with the water distribution system coming under ownership by the City in 1957. Major historical events are listed below in Table II-1.

Table II-1

WATER SYSTEM HISTORY

Date	Event
July 21, 1870	Wichita incorporated as a Village in the State of Kansas.
September 18, 1882	City adopts an ordinance franchising a private system of waterworks within the City limits to give the City a supply for domestic usage and fire protection.
1883	Waterworks system, consisting of two wells, a pumping station, a standpipe and 9 miles of wooden mains, is completed.

Table II-1 (continued)

WATER SYSTEM HISTORY

Date	Event
1886	Wichita Water Company sold its assets to the American Waterworks Company, which built a new water plant at its present location, replaced wooden mains, drilled wells along the Arkansas River and extended the distribution system.
1886 to 1917	City makes many attempts to purchase the water system. The water system is greatly expanded due to growth in the Wichita area.
1917	New 20-year franchise provided that if the City developed a softer water supply, the company would distribute the water.
1917 to 1930	City unsuccessfully attempts to get a better water supply both in quality and quantity.
1938	City obtains a Federal Public Works Administration grant of $1,091,250 to drill wells in the Equus Beds and to construct a 48-inch diameter pipeline to Wichita.
1939	City completes drilling the first 25 wells and awards a contract for a pipeline and a treatment plant near the confluence of the Arkansas and Little Arkansas Rivers.
September 1940	Water from the Equus Beds is transported through the new 48-inch diameter raw water main and treated by the new treatment facility.
1949	Nine E&S wells are constructed near the water plant. Completed 10 more wells in Equus Beds.
1953	Eight E&S wells are constructed near the water plant.
1956	66-inch diameter water transmission main from the Equus Beds adds reliability and capacity to the supply; six reserve wells are constructed along the Arkansas River for additional water supply during a drought period.
1956	City initiates steps to develop a new source on the Ninnescah River.

Table II-1 (continued)

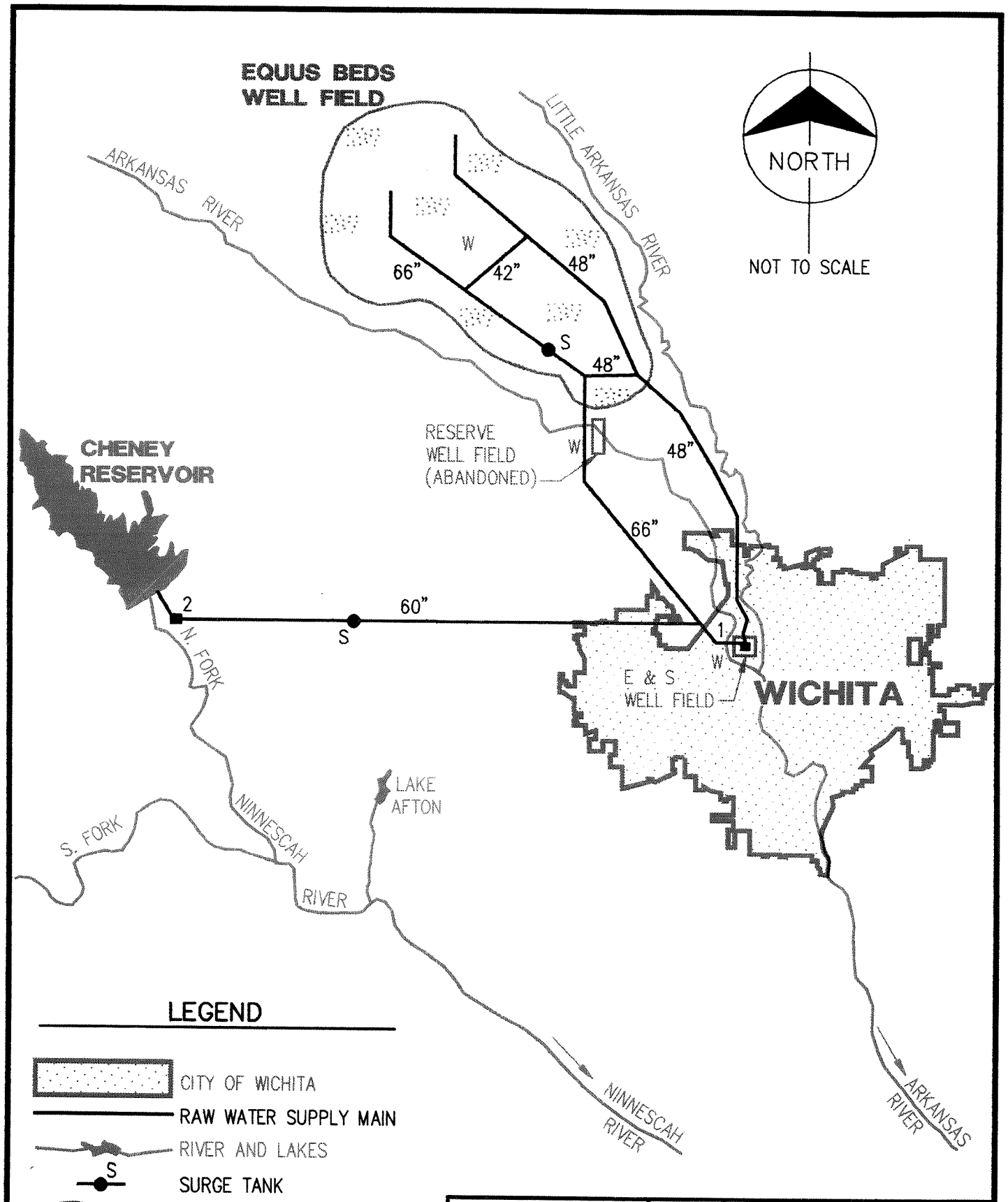
WATER SYSTEM HISTORY

Date	Event
1957	City purchases the Water Company and its distribution system.
1958	City completes 20 new wells in the Equus Beds.
1962	Construction of Cheney Dam begins.
1964	Cheney pipeline is completed.
1965	Cheney Dam is completed.
1974	Hess pumping station is completed.
1975 to 1992	Additional treatment capacity and raw water transmission improvements are constructed. Distribution mains and storage facilities are constructed.

Note:
[1]Source of historical information is "The Ayes Have It" Wichita Water Department, 1982.

2. RAW WATER SUPPLY

The City of Wichita has two principal water supply sources, Cheney Reservoir and the Equus Beds Aquifer, as shown in Figure II-1. Raw water is pumped from these two sources through pipelines to the City's water treatment plant located on the north bank of the Arkansas River in Sim Park. The City also uses a third water source consisting of 16 local wells near the water plant which are referred to as the Emergency and Sim or E&S wells. At one time, the City also used several wells northwest of the City along the Arkansas River which were referred to as the Bentley Reserve wells. These wells were high in chlorides and have been abandoned.



LEGEND

- CITY OF WICHITA
- RAW WATER SUPPLY MAIN
- RIVER AND LAKES
- S — SURGE TANK
- W — WELL FIELD
- 1 — WATER TREATMENT PLANT
- 2 — CHENEY RESERVOIR PUMP STATION

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Figure II–1

RAW WATER SUPPLY SYSTEM SCHEMATIC

a. Cheney Reservoir

The City of Wichita participated in the sponsorship and construction of Cheney Reservoir with the U.S. Bureau of Reclamation in the 1960s to increase its raw water supply capacity. This reservoir is the City's only source of surface water. Physical and hydrologic data for the reservoir are listed in Table II-2.

Cheney Reservoir is located 20 miles west of Wichita and has a reported firm yield of 38.2 million gallons per day (MGD). The City currently owns the water rights (File No. 5033) to an average day of 27.4 MGD with a maximum permitted withdrawal of 60 MGD. The City applied for the remaining water rights (File No. 40126) in September, 1992, which will increase the average day permitted withdrawal to 47 MGD and maximum day permitted withdrawal to about 103 MGD.

Cheney Reservoir was originally designed to provide a firm yield of 47 MGD for the City of Wichita. However, several severe drought periods in the 1950s caused the Bureau of Reclamation to recalculate the firm yield of the Cheney at 38.2 MGD. Operation studies by the Bureau showed that a daily withdrawal of 47 MGD from Cheney would result in two depletions of the conservation pool over a 60-year period.

Sedimentation of silt and organic matter from agricultural runoff has been a concern at Cheney Reservoir for the last several years. The sediment displaces water, reducing the storage capacity of the

Table II – 2

CHENEY RESERVOIR PHYSICAL AND HYDROLOGIC DATA

Item	Top of Pool Elevation (feet, USGS)	Surface Area (acres)	Storage Capacity (acre–feet)	Summation of Storage Capacity (acre–feet)
Dead Pool	1,378.9	–	980	980
Fish & Wildlife Pool	1,392.9	1,740	14,310	15,290
Conservation Pool	1,421.6	9,400	151,780	167,070
Flood Pool	1,429.0	12,417	80,860	247,930
Surcharge Pool	1,447.8	18,110	318,350	566,280

Notes:

(1) Spillway is morning–glory type with diameter of 22.25 ft at El. 1429 ft. Conduit is 9.5 ft diameter with capacity of 3,000 cubic feet per second (cfs) at El. 1447.8 ft.

(2) Outlet works is an 11 ft diameter conduit with a capacity of 4,580 cfs with water surface at El. 1447.8 ft.

(3) Intake structure connects to Wichita pump station with a 72" diameter pipeline and a capacity of 93 cfs.

(4) Dead pool was designed to store the 100 year sediment load.

(5) Information from Bureau of Reclamation data.

1392.90 – 1421.60 COW
1421.60 – 1429.0 Corp. of Engineers
1429.0 – BOR

reservoir, and carries agricultural chemicals that adversely affect the quality of the stored water. The design of the reservoir included a 100 year sediment pool; however, sedimentation of the reservoir should be minimized to protect reservoir storage capacity and water quality.

Watershed management techniques to control upstream erosion include terracing and creating a buffer of grassland around the lake. Construction of a series of siltation dams along streams tributary to Cheney may be an economically feasible technique for reducing the amount of sediment entering the reservoir. Sediment in the reservoir can be removed by dredging.

The sedimentation problem at Cheney Reservoir is being addressed by a Bureau of Reclamation study as authorized by the City of Wichita. The Bureau study is scheduled for completion in 1993. Additionally, the City has obtained a 50 percent grant from the Kansas Department of Health and Environment (KDHE) to develop a watershed management plan. The City is also working with Reno County Soil Conservation Service (SCS) and Sedgwick County Conservation District to develop this plan.

Operating data for Cheney Reservoir indicates that the average water surface level has varied by approximately 3 feet since the reservoir filled in 1968, except for 1972 when the level averaged 1,413 feet, USGS, or 8.6 feet below the conservation pool. The City operates the reservoir to maintain the water surface level at the top of the

conservation pool, elevation (El.) 1421.6 feet, and to maximize storage for water supply. Since 1968, an average of 94 MGD of water has flowed through the reservoir's spillway in excess of the City's water supply needs, which averaged 17.4 MGD.

Select water quality data for Cheney Reservoir is summarized in Tables II-3 and II-4 (refer to Appendix E for additional water quality data). Table II-3 presents key water quality data for 1972 through 1976 and 1987 through 1991. Table II-4 details a more complete range of water quality parameters for 1990. Review of this data shows the reservoir to be a proven reliable source of quality water. Chloride levels appear to temporarily increase during extended periods of high usage or drought conditions, but are still below the recommended secondary standard of 250 mg/l.

The existing raw water supply system at Cheney Reservoir includes four bottom suction horizontal split case pumps as shown in Figure II-2. Detailed information on the pumps and electrical and control systems are listed in Table II-5. The pump station has a current firm capacity of 60 MGD and is expandable to 80 MGD. The raw water transmission system includes a 20-mile, 60-inch diameter prestressed concrete pipeline between the pump station and the Central Water Treatment Plant, one surge tank, and flow control valves at the plant.

Table II–3

SELECT WATER QUALITY DATA FOR CHENEY RESERVOIR
FROM 1972 TO 1976 AND 1987 TO 1991

Year	Calcium (mg/L)			Total Hardness (mg/L as CaCO3)			Nitrates as N (mg/L)			Chlorides (mg/L)			Total Dissolved Solids (mg/L)			Precipitation In./Yr.
	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.	
1972				209	184	222	1.200	0.750	1.550	240	205	265	632	554	696	23.3
1973				185	158	214	2.039	1.000	2.750	180	145	260	540	362	684	42.0
1974				187	162	242	2.833	2.100	4.900	129	98	205	510	244	976	28.5
1975				174	118	194	2.125	1.000	3.900	126	53	150	496	360	594	29.6
1976	54			187			1.500			160			502			23.6
1987	53	46	78	170	154	182	0.560	0.400	0.720	102	90	110	419	350	478	38.6
1988	61	53	86	191	178	202	0.450	0.060	0.890	113	90	140	472	418	526	17.1
1989	61	49	82	194	170	224	0.141	0.002	0.419	144	135	160	472	284	546	34.7
1990	55	48	60	176	55	200	0.119	0.020	0.274	156	145	167	509	444	588	19.7
1991	55	51	64	192	182	213	0.142	0.000	0.264	162	158	190	560	518	648	26.7

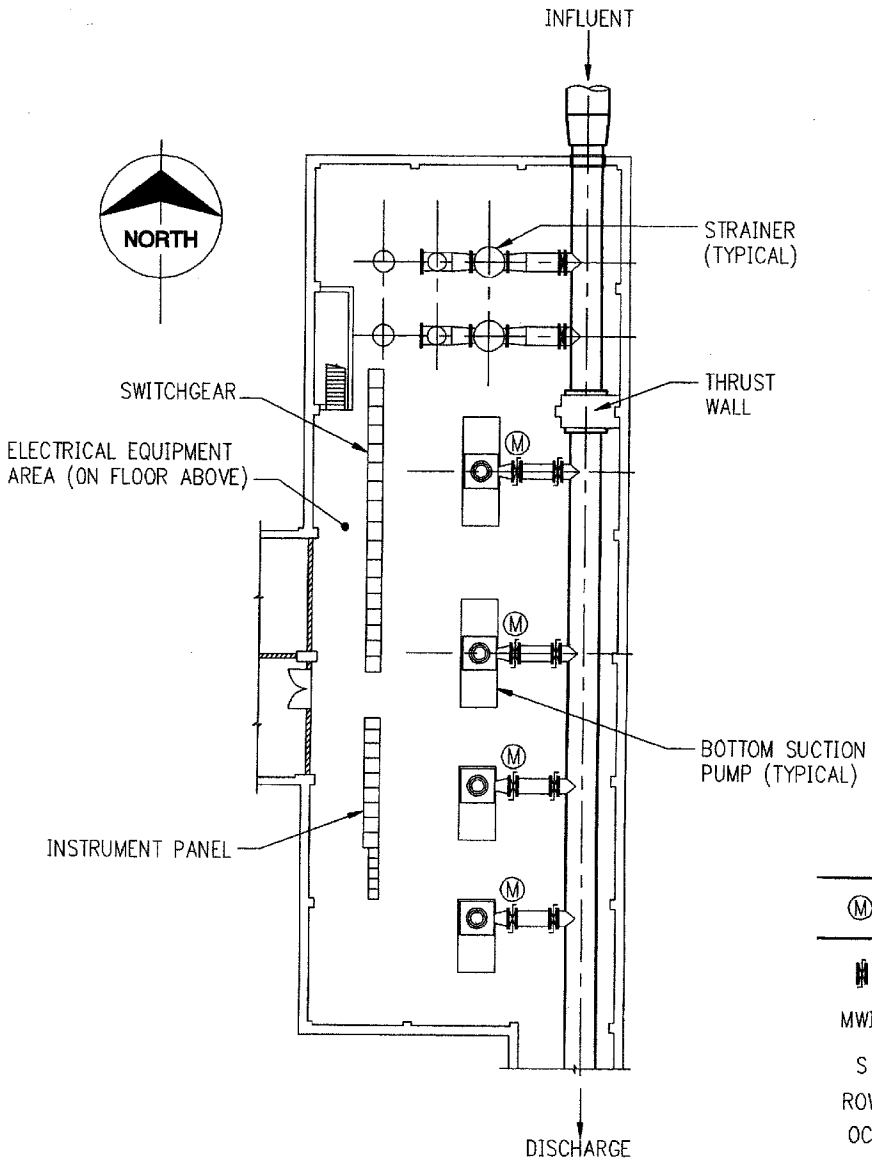
Notes:
(1) Based on City of Wichita records
(2) Data between 1977 and 1986 was questionable or not available at the intake.

Table II–4

WATER QUALITY DATA
FOR CHENEY RESERVOIR FOR 1990

Parameter	Units	Average	Maximum	Minimum
Ammonia	mg/L as N	0.07	0.13	0.009
Total Solids	mg/L	509	588	444
Silica	mg/L	1.72	3.7	0.59
Calcium	mg/L	55.1	60	48
Fluoride	mg/L	0.404	0.447	0
Magnesium	mg/L	14.85	16.34	0
Sulfate	mg/L	39	48	32
Iron	mg/L	0.41	0.67	0
Sodium	mg/L	111.45	123.12	0
Chloride	mg/L	156	167	145
Nitrate	mg/L as N	0.119	0.274	0
Phosphorus	mg/L	0.101	0.148	0.05
Total Hardness	mg/L as CaCO3	176	200	55
Total Alkalinity	mg/L as CaCO3	167	222	167
Carbonate	mg/L as CaCO3	0	0	0
Bicarbonate	mg/L as CaCO3	186	222	172
Excess Alkalinity	mg/L as CaCO3	0	0	0
pH		7.8	8.3	7.6
Conductivity	umhos/cm	898	982	825
Turbidity	NTU	9	22.5	2.2
Arsenic	ug/L	3.29	5.09	1.9
Barium	ug/L	239.83	333.84	185.47
Cadmium	ug/L	0.36	0.62	0.03
Chromium	ug/L	1.93	3.27	0.58
Copper	ug/L	60.81	100.46	23.65
Lead	ug/L	4.97	13.94	1.73
Manganese	ug/L	24.69	71.4	7.84
Mercury	ug/L	0.22	0.84	0
Nickel	ug/L	17.1	21.52	13.95
Selenium	ug/L	0.72	2.19	0
Silver	ug/L	0.36	1.01	0.05
Zinc	ug/L	9.81	15.7	3.42

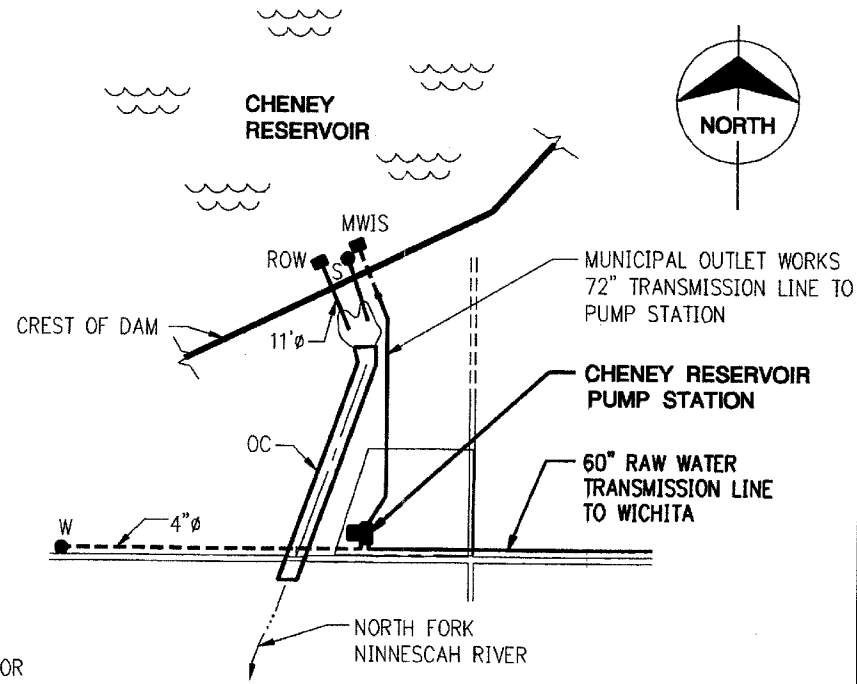
Notes:
(1) Based on City of Wichita records.



MULTI-LEVEL PLAN OF PUMP STATION
NOT TO SCALE

LEGEND

Ⓜ	MOTOR OPERATOR
———	PIPING
	BUTTERFLY VALVE
MWIS	MUNICIPAL WATER INTAKE STRUCTURE
S	SPILLWAY
ROW	RIVER OUTLET WORKS
OC	OUTLET CHANNEL
W	WELL



SCHEMATIC VICINITY MAP
NOT TO SCALE

Burns & McDonnell

Figure II – 2

CHENEY RESERVOIR RAW WATER PUMP STATION AND VICINITY MAP

Table II – 5

CHENEY RESERVOIR PUMP STATION DATA

Pump					Motor				
No.	Manufacturer	Capacity (gpm)	Head (feet)	Year Installed	Manufacturer	Rated Horsepower	Speed (rpm)	Year Installed	Drive
1	Fairbanks Morse & Co. (1)	12500 16100	116 167	1965 1965	Fairbanks Morse & Co.	450 800	600 720	1965 1965	Variable Constant
2	Fairbanks Morse & Co. (1)	12800 15250	116 167	1965 1965	Fairbanks Morse & Co.	450 800	600 720	1965 1965	Constant Constant
3	Fairbanks Morse & Co.	15250	167	1965	Fairbanks Morse & Co.	800	720	1965	Constant
4	Fairbanks Morse & Co.	14850	167	1965	Fairbanks Morse & Co.	800	720	1965	Variable

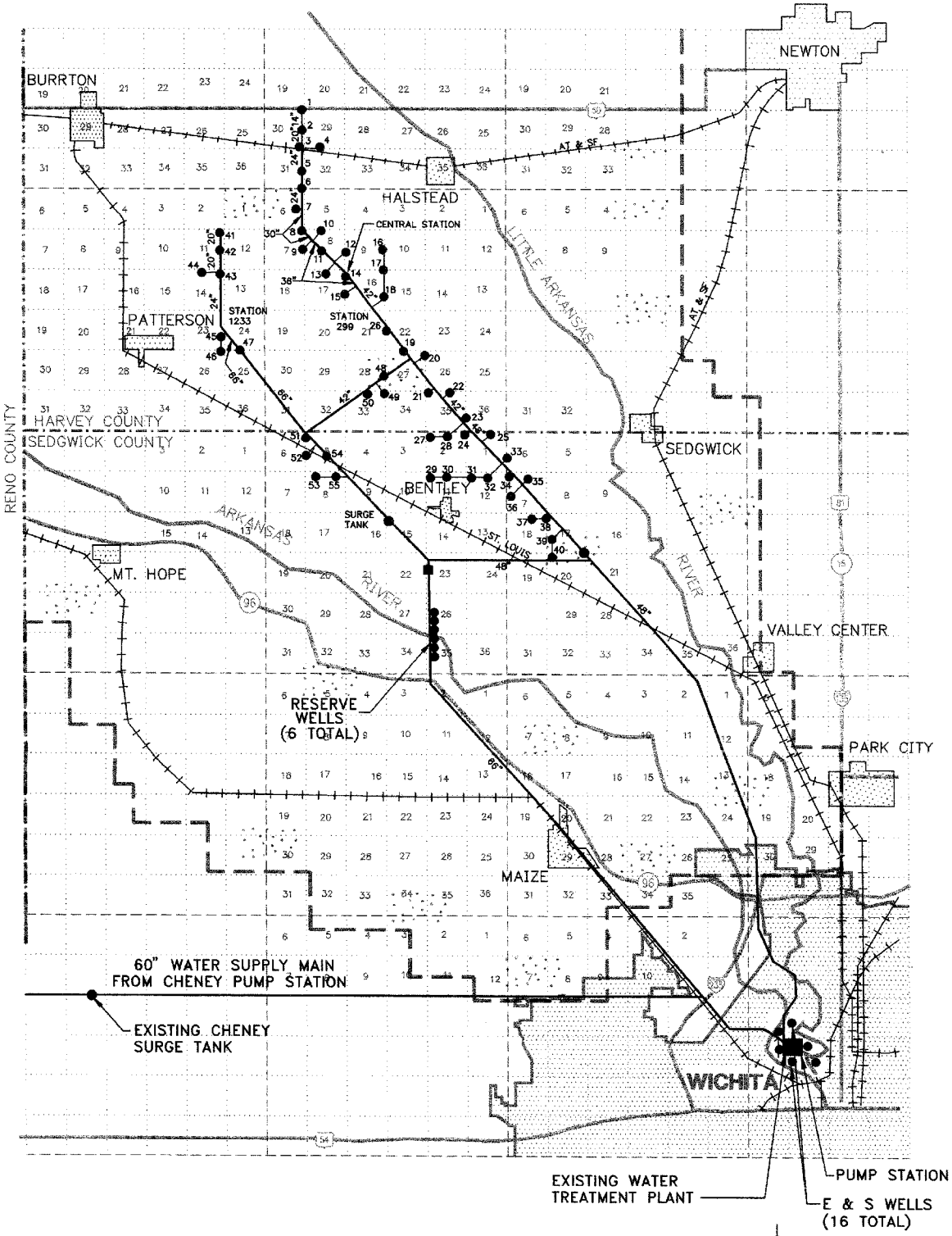
Note:
(1) Two motors on a single pump.

b. Equus Beds Well Field

The current Equus Beds Well Field consists of 55 wells and over 69 miles of pipeline as shown in Figure II-3. The Equus Beds Well Field is in an area bounded by U.S. Highway 50 on the north, the Arkansas River on the west and south and the Little Arkansas River on the east. Groundwater is conveyed from the Equus Beds through two major transmission lines to the City's water treatment plant. A 48-inch pipeline of cast iron construction with leaded joints was installed circa 1939 and has experienced numerous breaks in recent years. A 66-inch pipeline of reinforced concrete construction was installed in the mid-1950s. Forty-two and 48-inch cross-tie lines between the 48-inch and the 66-inch pipelines allow flexibility, reliability, and efficiency in the operation of various wells by permitting the transfer of groundwater in either or both pipelines. These facilities are capable of delivering about 55 MGD to the water plant with the current hydraulic configuration.

Water rights and well screen data for the wells were shown in Table II-6 and a typical well cross section is shown in Figure II-4. The City began pumping groundwater from 25 wells in the Equus Beds in 1939. Additional water rights were purchased in the mid-1950s, allowing the City to add 30 more wells to reach the current total of 55 wells. Current water rights allow the City to use groundwater at an average rate of 35.7 MGD and a maximum rate of 78.1 MGD.

Hydrogeologic data and yield information for the wells are shown in Table II-7. Screen capacity, specific capacity, and available



LEGEND

TRANSMISSION LINE

19 EXISTING SUPPLY WELL & NUMBER

EQUUS BEDS GROUNDWATER MANAGEMENT DISTRICT BOUNDRY

TOWNSHIP BOUNDRY

Burns & McDonnell

Figure II – 3

EQUUS BEDS RAW WATER SUPPLY SYSTEM

J:\WICHITA\921954\WATER1B.DWG 06-11-1993 14:47 BES

Table II – 6

WATER RIGHTS AND SCREEN DATA FOR THE EQUUS BEDS WELL FIELD

WELL		WELL TOP USGS EL. (FT)	STATE PERMITTED WITHDRAWAL					YEAR RE-DRILLED	WELL SCREEN(S)						
			FILE NUMBER	DATE FILED	MAXIMUM RATE (GPM)	ANNUAL AMOUNT (MGY)	ANNUAL AMOUNT (AC-FT)		SETTING (DEPTH IN FEET) #1	#2	#3	#4	#5	TOTAL LENGTH (FEET)	MATERIAL
NO.	LOCATION														
1	NW NW NW SEC. 29-23-2W	1431	HV0006	9/15/53	1125	277.6	851.8	1991	109-169 (60')	201-231 (30')	–	–	–	90'	S. STEEL
2	NW NW SW SEC. 29-23-2W	1429	HV0006	9/15/53	1353	292.5	897.5	1960	182-202 (20')	211-231 (20')	–	–	–	40'	S. STEEL
3	SE SE SE SEC. 30-23-2W	1431	HV0006	9/15/53	362	258.5	793.2	1988	124-142 (18')	147-157 (10')	162-172 (10)	202-213 (11')	218-234 (16')	65'	S.STEEL
4	SE SE SW SEC. 29-23-2W	1426	HV0006	9/15/53	345	354.6	1088	1977	130-140 (10')	150-170 (20')	187-202 (15')	207-217 (10')	–	55'	S.STEEL
5	NW NW SW SEC. 32-23-2W	1433	HV0006	9/15/53	876	272.7	836.8	1965	181-196 (25')	206-231 (25')	–	–	–	50'	S.STEEL
6	SW SW SW SEC. 32-23-2W	1431	HV0006	9/15/53	1063	252.1	773.6	1959	136-141 (5')	178-198 (20')	232-249 (17')	–	–	42'	S. STEEL
7	SE SE NE SEC. 6-24-2W	1428	HV0006	9/15/53	690	186.3	571.6	1991	122-132 (10')	136-151 (15')	197-212 (15')	226-251 (25')	–	65'	S.STEEL
8	NW NW NW SEC. 8-24-2W	1421	HV0006	9/15/53	1082	300.8	923	1959	149-174 (25')	195-220 (25')	–	–	–	50'	S.STEEL
9	SW SW NW SEC. 8-24-2W	1417	HV0006	9/15/53	1293	385.6	1183	1969	99-109 (10')	142-157 (15')	161-176 (15')	191.201 (10')	–	50'	S.STEEL
10	NE NE NW SEC. 8-24-2W	1421	HV0006	9/15/53	1053	360.9	1107	1957	145-160 (15')	198-203 (5')	217-237 (20')	–	–	40'	S. STEEL
11	NW NW SE SEC. 8-24-2W	1419	HV0006	9/15/53	1040	293.1	899.4	1974	120-140 (20')	180-200 (20)	210-230 (20')	–	–	60'	S.STEEL
12	NW NW SE SEC. 9-24-2W	1416	HV0006	9/15/53	803	357.8	1098	1979	120-130 (10')	150-172 (22')	182-196 (14')	206-226 (20')	–	66'	S.STEEL
13	NW NW NE SEC. 17-24-2W	1416	HV0006	9/15/53	1081	376.3	1155	1940	86-106 (20')	151-161 (10')	181-191 (10')	211-221 (10')	–	50'	IRON
14	NW NW NW SEC. 16-24-2W	1416	HV0006	9/15/53	935	318.8	978.2	1960	125-150 (25')	160-180 (20')	194-204 (10')	–	–	55'	S. STEEL
15	NW NW SW SEC. 16-24-2W	1415	HV0006	9/15/53	2122	460.9	1414	1985	145-169 (24')	179-189 (10')	209-245 (36)	–	–	70'	S. STEEL

Table II – 6 (continued)

WATER RIGHTS AND SCREEN DATA FOR
THE EQUUS BEDS WELL FIELD

WELL		WELL TOP USGS EL. (FT)	STATE PERMITTED WITHDRAWAL					YEAR RE-DRILLED	WELL SCREEN(S)						
						ANNUAL AMOUNT			SETTING (DEPTH IN FEET)					TOTAL LENGTH	
NO.	LOCATION		FILE NUMBER	DATE FILED	MAXIMUM RATE (GPM)	(MGY)	(AC-FT)		#1	#2	#3	#4	#5	(FEET)	MATERIAL
16	SE SE NE SEC. 9-24-2W	1410	HV0006	9/15/53	1270	355.7	1091	1968	116-126 (10')	132-152 (20')	171-191 (20')	–	–	50'	S. STEEL
17	SE SE SE SEC. 9-24-2W	1408	HV0006	9/15/53	1096	251.9	772.9	1973	125-165 (40')	180-190 (10')	–	–	–	50'	S. STEEL
18	NE NE SE SEC. 16-24-2W FLO-KING 90 GAL'S	1404	HV0006	9/15/53	1136	296.2	908.9	1968	67-77 (10')	90-110 (20')	138-158 (20')	–	–	50'	S. STEEL
19	SE SE SW SEC. 22-24-2W	1401	HV0006	9/15/53	1352	188.8	579.3	1965	61-86 (25')	–	–	–	–	25'	S.STEEL
20	NE NE NE SEC. 27-24-2W	1396	HV0006	9/15/53	956	199	610.6	1940	90-125 (35')	130-135 (5')	140-145 (5')	–	–	45'	IRON
21	SW SW SW SEC. 26-24-2W	1392	HV0006	9/15/53	456	297	911.3	1992	43-78 (35')	–	–	–	–	35'	S.STEEL
22	SW SW SE SEC. 26-24-2W	1392	HV0006	9/15/53	910	231.8	711.3	1960	148-188 (40')	–	–	–	–	40'	S.STEEL
23	SE SE NE SEC. 35-24-2W	1389	HV0006	9/15/53	935	336.6	1033	1973	135-165 (30')	170-190 (20')	–	–	–	50'	S.STEEL
24	SE SE SE SEC. 35-24-2W	1390	HV0006	9/15/53	712	125.8	386	1992	66-96 (30')	–	–	–	–	30'	IRON
25	SW SW SE SEC. 36-24-2W	1384	HV0006	9/15/53	1028	413.8	1270	1969	109-134 (25')	144-149 (5')	162-182 (20')	–	–	50'	S. STEEL
26	SW SW NW SEC. 22-24-2W	1402	000388	7/23/48	344	272.3	835.5	1977	70-90 (20')	159-166 (7')	171-180 (9')	185-199 (14')	–	50'	S.STEEL
27	NW NW NW SEC. 2-25-2W	1391	000388	7/23/48	834	241.2	740.1	1983	78-98 (20')	156-171 (15')	201-216 (15')	–	–	50'	S.STEEL
28	NE NE NW SEC. 2-25-2W	1393	000388	7/23/48	553	439.8	1350	1980	88-100 (12')	134-150 (16')	192-218 (26')	–	–	54"	S.STEEL
29	NW NW NW SEC. 11-25-2W	1393	000388	7/23/48	786	341.8	1049	1986	95-105 (10')	160-195 (35')	210-220 (10')	–	–	55'	S.STEEL
30	NE NE NW SEC. 11-25-2W	1389	000388	7/23/48	1016	243.7	747.8	1948	68-83 (15')	103-113 (10')	198-223 (25')	–	–	50'	BRONZE

Table II – 6 (continued)

WATER RIGHTS AND SCREEN DATA FOR
THE EQUUS BEDS WELL FIELD

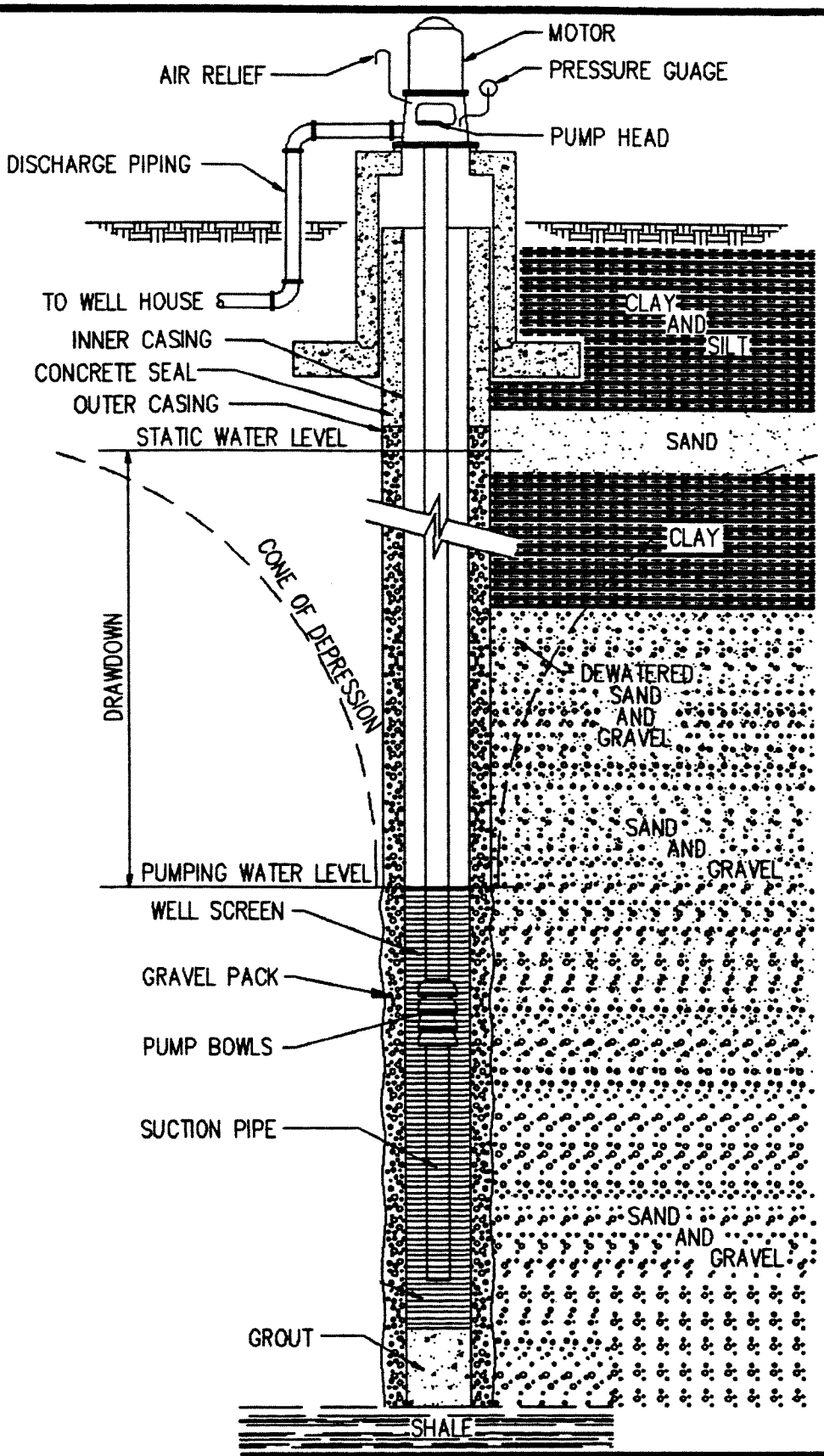
WELL		WELL TOP USGS EL. (FT)	STATE PERMITTED WITHDRAWAL					YEAR RE-DRILLED	WELL SCREEN(S)						
			FILE NUMBER	DATE FILED	MAXIMUM RATE (GPM)	ANNUAL AMOUNT (MGY)	ANNUAL AMOUNT (AC-FT)		SETTING (DEPTH IN FEET) #1	#2	#3	#4	#5	TOTAL LENGTH (FEET)	MATERIAL
NO.	LOCATION														
31	NW NW NW SEC. 12-25-2W	1388	000388	7/23/48	1177	561.3	1722	1981	75-85 (10')	103-119 (16')	160-179 (19')	183-199 (16')	–	61'	S. STEEL
32	NE NE NW SEC. 12-25-2W	1385	000388	7/23/48	978	287.3	881.6	1985	103-118 (15')	146-186 (40')	–	–	–	55'	S.STEEL
33	NE NE SE SEC. 1-25-2W	1383	000388	7/23/48	637	120.9	371	1948	68-79 (11')	113-123 (10')	133-138 (5')	143-168 (25')	–	51'	BRONZE
34	SW SW SW SEC. 6-25-1W	1384	000388	7/23/48	826	168.9	518.3	1949	58-68 (10')	108-123 (15')	133-148 (15')	–	–	40'	BRONZE
35	NE NE NW SEC. 7-25-1W	1383	000388	7/23/48	1199	418.2	1288	1981	65.6-75.6 (10')	85.6-98.6 (13')	108.6-13 (27')	–	–	50'	S.STEEL
36	SW SW NW SEC. 7-25-1W	1383	001006	10/2/52	20871	8146	24996	1959	108-118 (10')	125-140 (15')	169-184 (15')	–	–	40'	S.STEEL
37	NW NW NE SEC. 18-25-1W	1375	001006	10/2/52				1959	114-124 (10')	139-159 (20)	165-170 (5')	–	–	35'	S. STEEL
38	NE NE NE SEC. 18-25-1W	1375	001006	10/2/52				1959	93-128 (35')	–	–	–	–	35'	S. STEEL
39	NW NW SW SEC. 17-25-1W	1372	001006	10/2/52				1991	85-110 (25')	135-155 (20')	–	–	–	45'	S.STEEL
40	SW SW SW SEC. 17-25-1W	1371	001006	10/2/52				1959	92-127 (35')	–	–	–	–	35'	S. STEEL
41	NE NE NE SEC. 11-24-3W FLO-KING 120 GAL'S	1426	001006	10/2/52				1958	196-236 (40)	–	–	–	–	40'	S. STEEL
42	SE SE NE SEC. 11-24-3W	1429	001006	10/2/52				1958	214-259 (45')	–	–	–	–	45'	S.STEEL
43	SE SE SE SEC. 11-24-3W	1426	001006	10/2/52				1993							
44	SW SW SE SEC. 11-24-3W	1425	001006	10/2/52				1991	84-109 (25')	130-140 (10')	–	–	–	35'	S. STEEL
45	NE NE SE SEC. 23-24-3W	1423	001006	10/2/52				1983	88-98 (10')	115-125 (10')	145-175 (30')	–	–	50'	S. STEEL

Table II – 6 (continued)

WATER RIGHTS AND SCREEN DATA FOR THE EQUUS BEDS WELL FIELD

WELL		WELL TOP USGS EL. (FT)	STATE PERMITTED WITHDRAWAL					YEAR RE-DRILLED	WELL SCREEN(S)						
						ANNUAL AMOUNT			SETTING (DEPTH IN FEET)					TOTAL LENGTH (FEET)	MATERIAL
NO.	LOCATION		FILE NUMBER	DATE FILED	MAXIMUM RATE (GPM)	(MGY)	(AC-FT)		#1	#2	#3	#4	#5		
46	SE SE SE SEC 23-24-3W	1424	001006	10/2/52				1958	45-55 (10')	104-109 (5')	–	–	–	15'	S. STEEL
47	SW SW SE SEC. 24-24-3W	1420	001006	10/2/52				1958	106-146 (40)	–	–	–	–	40'	S. STEEL
48	NE NE SE SEC. 28-24-2W	1404	001006	10/2/52				1959	136-146 (10')	181-186 (5')	206-216 (10')	226-256 (30')	–	55'	S. STEEL
49	SE SE SE SEC. 28-24-2W	1404	001006	10/2/52				1958	123-128 (5')	158-178 (20')	198-203 (5')	220-230 (10')	239-249 (10')	50'	S. STEEL
50	SW SW SE SEC. 28-24-2W	1407	001006	10/2/52				1958	128-133 (5')	145-150 (5')	180-200 (20')	230-250 (20')	–	50'	S. STEEL
51	NW NW NW SEC. 5-25-2W	1407	001006	10/2/52				1958	88-108 (20')	155-165 (10')	175-185 (10')	–	–	40'	S. STEEL
52	SW SW NW SEC. 5-25-2W	1406	001006	10/2/52				1959	30-40 (10')	–	–	–	–	10'	S. STEEL
53	SE SW SW SEC. 5-25-2W	1403	001006	10/2/52				1959	36-46 (10')	55-70 (15')	82-92 (10')	–	–	35	S. STEEL
54	NW NW SE SEC. 5-25-2W	1403	001006	10/2/52				1959	38-48 (10')	70-80 (10')	–	–	–	20'	S. STEEL
55	SE SW SE SEC. 5-25-2W	1404	001006	10/2/52				1959	36-46 (10')	–	–	–	–	10'	S. STEEL
	TOTAL				54295	18687	57344								

Notes:
(1) Well Numbers 36 through 55 were permitted together and have the cumulative water right shown in Well No. 36
(2) The annual permitted withdrawal from the Equus Beds is 39,934 acre-feet per the Kansas Division of Water Resources.



Burns & McDonnell

Figure II – 4

TYPICAL WELL CROSS SECTION WITH PUMP

J:\WICHITA\921954\FIG2WELL.DWG 05-12-1995 12:19 JRO

Table II – 7

EQUUS BEDS WELL FIELD
HYDROGEOLOGIC DATA AND YIELD INFORMATION

Well No.	Date	Screen Length (feet)	Screen Slot Size	Screen Type	Static Water Level (feet)	Well Test Drawdown (feet)	Well Test Pumping Rate (gpm) (1)	Specific Capacity (gpm/ft DD)	Screen Capacity (gpm) (2)	Top of Screen Elevation (feet)	Available Drawdown (feet)	Potential Well Discharge Rate (gpm)	Long-term Well Yield (gpm) (3)
1	1939 1991	REPLACED 90	0.060	WW	63.3	57.6	1,400	24.3	2,623	109	45.7	1,111	778
2	1939 1960	REPLACED 40	0.105 +	SHUTTER	47.1	81.1	1,800	22.2	687	182	134.9	2,994	687
3	1939 1979 1992	REPLACED 65	0.080	WW	60.7	25.9	726	28.0	2,378	119	58.3	1,634	1,144
4	1939 1977 1992	55	0.060 +	WW	59.8	25.7	984	38.3	1,603	130	70.2	2,688	1,603
5	1939 1965	REPLACED 50	0.100	WW	51.3	30.1	839	27.9	2,100	181	129.7	3,615	2,100
6	1939 1949 1959	REPLACED 42	0.105 +	SHUTTER	45.5	38.8	1,130	29.1	721	136	90.5	2,636	721
7	1939 1949 1991	REPLACED 65	0.060	WW	57.2	32.5	1,400	43.1	1,894	122	64.8	2,791	1,894
8	1939 1959 1992	REPLACED 50	0.105 +	SHUTTER	53.0	38.3	923	24.1	859	149	96.0	2,314	859
9	1939 1969 1992	REPLACED 50	0.105 +	SHUTTER	56.4	13.9	1,011	72.6	859	88	31.7	2,297	859
10	1939 1957 1992	REPLACED 40	0.105	SHUTTER	61.7	48.2	968	20.1	687	145	83.4	1,676	687
11	1939 1974 1992	REPLACED 60	0.060 +	WW	54.5	33.5	927	27.6	1,748	120	65.5	1,810	1,267
12	1939 1979 1992	REPLACED 66	0.080	WW	55.8	18.0	1,004	55.9	2,414	120	64.2	3,587	2,414
13	1939 1940	50	0.105 +	SHUTTER	NA	NA	NA	NA	859	86			859
14	1939 1960 1992	REPLACED 55	0.105 +	SHUTTER	53.8	22.2	767	34.5	945	125	71.2	2,460	945
15	1939 1959 1984	REPLACED 70	0.060 +	WW	36.0	19.2	1,770	92.1	2,040	145	109.0	10,043	2,040
16	1939 1968 1992	REPLACED 50	0.105 +	SHUTTER	50.7	22.8	1,019	44.8	859	116	65.3	2,926	859
17	1939 1973 1992	REPLACED 50	0.060 +	WW	47.6	26.0	988	38.0	1,457	125	77.4	2,943	1,457

Table II – 7 (continued)

EQUUS BEDS WELL FIELD
HYDROGEOLOGIC DATA AND YIELD INFORMATION

Well No.	Date	Screen Length (feet)	Screen Slot Size	Screen Type	Static Water Level (feet)	Well Test Drawdown (feet)	Well Test Pumping Rate (gpm) (1)	Specific Capacity (gpm/ft DD)	Screen Capacity (gpm) (2)	Top of Screen Elevation (feet)	Available Drawdown (feet)	Potential Well Discharge Rate (gpm)	Long-term Well Yield (gpm) (3)
18	1939	REPLACED											
	1968	50	0.100	WW					2,100	67	23.0	894	626
	1992				44.0	25.3	984	38.8					
19	1939	REPLACED											
	1965	25	0.100	WW	29.0	56.1	955	17.0	1,050	61	32.0	546	382
20	1940	45	0.105 +	SHUTTER	NA	NA	NA	NA	773	90			773
21	1939	REPLACED				20.9	1,870	89.5					
	1961	35	0.130	SHUTTER					743	43	8.0	716	501
	1984				35.0								
22	1939	REPLACED											
	1960	40	0.105 +	SHUTTER					687	148	106.3	1,427	687
	1992				41.7	59.0	792	13.4					
23	1939	REPLACED											
	1973	50	0.060 +	WW					1,457	135	96.7	2,149	1,457
	1992				38.3	43.9	976	22.2					
24	1939	REPLACED			11.2								
	1959		0.105 +	SHUTTER									
	1992	30				NA	NA	NA	515	66	54.8	NA	515
25	1939	REPLACED											
	1969	50	0.105 +	SHUTTER	NA	NA	NA	NA	859	109	NA	NA	858.7
26	1949	REPLACED											
	1977 *	30	0.060 +	WW					874	70	27.5	481	337
	1992				42.5	19.4	339	17.5					
27	1949	REPLACED											
	1983	50	0.080	WW					1,829	78	38.1	1,632	1,143
	1992				39.9	20.1	862	42.8					
28	1949	REPLACED											
	1980 *	42	0.080	WW					1,536	88	45.2	933	653
	1992				42.8	40.8	844	20.7					
29	1949				13.3	52.2	2,000	38.3					
	1986	55	0.060 +	WW					1,603	95	81.7	3,131	1,603
30	1948 *	35							1,020	68	31.8	1,074	752
	1992		0.060 +	WW	36.2	27.6	932	33.8					
31	1949	REPLACED											
	1981	61	0.080	WW	27.8	45.6	1,500	32.9	2,231	75	47.2	1,553	1,087
32	1949												
	1985	55	0.060 +	WW					1,603	103	61.1	1,445	1,012
	1992				41.9	38.3	906	23.7					
33	1948	51	0.105 +	SHUTTER	13.8	47.1	1,070	22.7	876	68	54.3	1,233	863
34	1949	40	0.105 +	SHUTTER	14.6	40.0	1,485	37.1	687	58	43.4	1,611	687
35	1949	REPLACED											
	1981	50	0.080	WW	30.6	56.3	1,250	22.2	1,829	65.6	35.0	778	545
36	1948												
	1959	40	0.105 +	SHUTTER					687	108	66.5	1,895	687
	1992				41.5	36.5	1,041	28.5					
37	1948												
	1959	35	0.105 +	SHUTTER					601	114	82.1	2,037	601
	1992				32.0	38.9	966	24.8					

Table II – 7 (continued)

EQUUS BEDS WELL FIELD
HYDROGEOLOGIC DATA AND YIELD INFORMATION

Well No.	Date	Screen Length (feet)	Screen Slot Size	Screen Type	Static Water Level (feet)	Well Test Drawdown (feet)	Well Test Pumping Rate (gpm) (1)	Specific Capacity (gpm/ft DD)	Screen Capacity (gpm) (2)	Top of Screen Elevation (feet)	Available Drawdown (feet)	Potential Well Discharge Rate (gpm)	Long-term Well Yield (gpm) (3)
38	1948												
	1959	35	0.105 +	SHUTTER					601	93	60.8	1,210	601
	1992				32.2	50.6	1,007	19.9					
39	1948												
	1991	45	0.070	WW	25.1	25.9	1,400	54.0	1,479	85	59.9	3,237	1,479
40	1948												
	1959	35	0.105 +	SHUTTER					601	92	61.0	1,729	601
	1992				31.0	32.9	932	28.3					
41	1948												
	1958	40	0.105 +	SHUTTER	26.2	70.2	1,090	15.5	687	196	169.8	2,638	687
42	1948												
	1958	45	0.105 +	SHUTTER					773	214	152.1	2,943	773
	1992				61.9	18.2	352	19.4					
43	1948	REPLACED											
	1958	43							1,253	85	52.5	858	601
	1974		0.060 +	WW									
	1992				32.5	38.8	635	16.3					
44	1991	35	0.060	WW	23.7	56.7	1,400	24.7	1,020	84	60.3	1,491	1,020
45	1979												
	1983 *	40	0.080	WW	18.5	45.6	1,100	24.1	1,463	88	69.5	1,677	1,174
46	1948												
	1958	15	0.105 +	SHUTTER	13.5	26.8	1,022	38.2	258	45	31.5	1,204	258
47	1948												
	1958	40	0.105 +	SHUTTER					687	106	70.0	1,565	687
	1992				36.0	38.2	853	22.4					
48	1948												
	1959	55	0.105 +	SHUTTER	28.7	41.4	1,515	36.6	945	136	107.3	3,925	945
49	1948												
	1958	50	0.105 +	SHUTTER	27.7	23.9	1,515	63.4	859	123	95.3	6,045	859
50	1948												
	1958	50	0.105 +	SHUTTER					859	128	81.3	1,876	859
	1992				46.7	41.4	956	23.1					
51	1948												
	1958 *	20	0.105 +	SHUTTER					343	88	52.1	1,116	343
	1992				35.9	24.3	521	21.4					
52	1948												
	1959	10	0.105 +	SHUTTER	NA	NA	NA	NA	172	30	NA	NA	172
53	1948												
	1959	35	0.105 +	SHUTTER	NA	NA	NA	NA	601	36	NA	NA	601
54	1948												
	1959	20	0.105 +	SHUTTER	NA	NA	NA	NA	343	38	NA	NA	343
55	1948												
	1959	10	0.105 +	SHUTTER	NA	NA	NA	NA	172	36	NA	NA	172
					TOTALS		50,726		61,406			102,573	49,113

Notes:
* Screen length decreased due to pumpage in the upper screen.
+ Screen types and sizes are assumed.
(1) Well test pumping rate to determine drawdown and specific capacity.
(2) Assumes 50 percent blockage.
(3) Equal to the lesser of Screen Capacity or 70 percent of Potential Well Discharge Rate.

drawdown were evaluated and the long-term yield of the existing 55 wells was determined to be 49,000 gpm or 71 MGD. The cleaning and upgrading of 30 wells was recently completed and the City recently contracted for the cleaning and upgrading of the remaining 25 wells, which should increase the long-term yield to 78 MGD (assuming full availability of the well field). The resulting firm yield (10 percent of facilities out of service) of the existing well field is 70 MGD, assuming 10 percent of the wells are out of service for mechanical failures and maintenance. Future improvements are required to increase the well field firm yield to 78 MGD, the current maximum day water right.

Select water quality data by well for the Equus Beds Well Field is shown in Table II-8 and composite water quality data for 1990 is listed in Table II-9 (refer to Appendix E for additional water quality data). Water quality is generally very good and varies slightly from well to well throughout the aquifer. For example, Wells Nos. 1 through 6, 8, 10, 16, 17 and 38 have the lowest chloride levels and Well Nos. 1, 34 through 38, 53 and 55 have the highest nitrate levels. All concentrations are below the secondary chloride standard of 250 mg/l and the nitrate maximum contaminant level of 10 mg/l. Chlorides in the area are believed to originate from oil field activities while nitrates originate from agricultural runoff, the use of fertilizer and livestock waste. City staff reports that no significant concentration of synthetic organics, pesticides or atrazine have been detected in the water. Water from

Table II – 8

SELECT WATER QUALITY DATA FOR EQUUS BEDS WELL FIELD
BY WELL FOR FALL 1990 AND SPRING 1991

Well No.	Calcium (mg/L)		Total Hardness (mg/L as CaCO3)		Chlorides (mg/L)		Nitrates as N (mg/L)		Total Dissolved Solids (mg/L)	
	1990	1991	1990	1991	1990	1991	1990	1991	1990	1991
1	38	–	120	–	20	–	2.7	–	260	–
2	40	39	132	120	15	15	0.1	0.0	266	232
3	38	38	122	120	18	15	0.2	0.3	214	222
4	39	39	130	122	18	15	0.3	0.2	226	246
5	42	41	144	128	15	15	0.0	0.0	254	258
6	38	39	118	115	22	18	0.0	0.0	226	214
7	–	–	–	–	–	–	–	–	–	–
8	54	53	181	163	20	20	0.0	–	326	316
9	74	97	230	294	38	45	0.0	–	430	544
10	41	40	137	126	20	19	0.0	0.0	278	246
11	68	73	213	212	35	30	0.1	0.0	416	396
12	61	73	200	224	30	36	0.0	0.0	432	428
13	92	103	322	312	45	66	0.0	–	540	632
14	106	120	352	356	75	73	0.0	–	768	690
15	81	125	290	380	58	40	0.0	–	666	758
16	39	39	137	136	20	13	0.1	–	340	276
17	76	75	236	227	25	25	0.0	–	504	464
18	–	59	–	164	–	28	–	–	–	368
19	68	92	278	282	45	42	0.0	0.0	586	550
20	89	89	292	284	35	29	0.0	0.0	620	564
21	–	–	–	–	–	–	–	–	–	–
22	63	56	192	174	40	41	0.0	0.0	444	458
23	61	60	198	190	55	48	0.0	–	506	466
24	–	–	–	–	–	–	–	–	–	–
25	65	65	206	198	35	38	0.4	0.4	434	460
26	70	76	240	230	32	25	0.2	0.2	482	502
27	54	79	220	240	42	40	0.3	0.2	623	435
28	79	79	256	230	60	58	0.0	–	560	478
29	76	76	242	240	65	60	1.7	2.0	532	480
30	89	95	280	284	45	39	3.0	3.0	542	486
31	93	104	306	318	45	31	0.4	0.6	546	558
32	66	90	250	277	62	57	0.0	0.0	600	522
33	69	68	230	215	38	35	0.0	–	396	434
34	97	98	307	299	30	30	4.5	4.0	486	494
35	84	87	260	259	275	25	6.1	5.6	438	420
36	73	71	235	223	50	45	3.0	1.1	414	462
37	70	73	240	238	50	45	3.1	3.0	414	404
38	82	113	258	280	25	21	9.6	7.2	418	536
39	–	–	–	–	–	–	–	–	–	–
40	83	90	262	280	58	56	0.1	0.2	470	486
41	53	53	168	165	25	24	0.0	0.0	324	308
42	59	64	198	196	45	46	0.0	–	414	392
43	139	145	445	459	98	120	0.0	–	880	1006
44	–	–	–	–	–	–	–	–	–	–
45	101	111	332	330	115	110	1.0	1.0	664	661
46	114	137	413	401	98	93	2.4	1.9	740	796
47	91	96	299	304	98	93	0.0	–	632	662
48	66	73	233	235	62	58	0.0	–	448	534
49	68	70	228	217	45	45	0.0	–	412	454
50	70	72	226	229	55	50	0.0	0.0	446	464
51	80	81	274	265	95	93	0.0	0.0	512	692
52	78	88	278	270	55	56	0.4	0.5	430	548
53	79	97	294	286	80	82	5.5	5.2	488	581
54	78	79	234	250	45	43	1.0	0.8	436	439
55	83	89	264	278	55	65	7.2	8.2	440	498

Table II – 9

COMPOSITE WATER QUALITY DATA
FOR EQUUS BEDS WELL FIELD FOR 1990

Parameter	Units	Average	Maximum	Minimum
Calcium	mg/l	65.00	79.00	25.00
Total Hardness	mg/l	201.00	250.00	68.00
Chlorides	mg/l	55.00	95.00	43.00
Conductivity	mhos/cm	0.69	0.75	0.64
Turbidity	NTU	2.17	8.20	0.60
pH		7.10	7.30	6.80
Alkalinity – P	mg/l	0.00	0.00	0.00
Alkalinity – T	mg/l	230.00	283.00	188.00
Nitrates as N	mg/l	1.52	2.78	0.63
Phosphates as P	mg/l	0.19	0.58	0.03
Sulfates	mg/l	72.00	80.00	60.00
Silicates	mg/l	21.00	25.00	15.00
Fluoride	mg/l	0.41	0.46	0.37
Ammonia as N	mg/l	0.11	0.26	0.01
Total Solids	mg/l	435.00	488.00	396.00
Iron	mg/l	1.35	5.82	0.08
Magnessium	mg/l	13.30	14.82	12.17
Sodium	mg/l	60.86	78.00	54.40

Notes:

(1) Based on City of Wichita records. Composite of wells for a given day. Data can vary based on which wells were operating.

the aquifer now serves not only Wichita, but also Halstead, Newton, Bentley, and other communities.

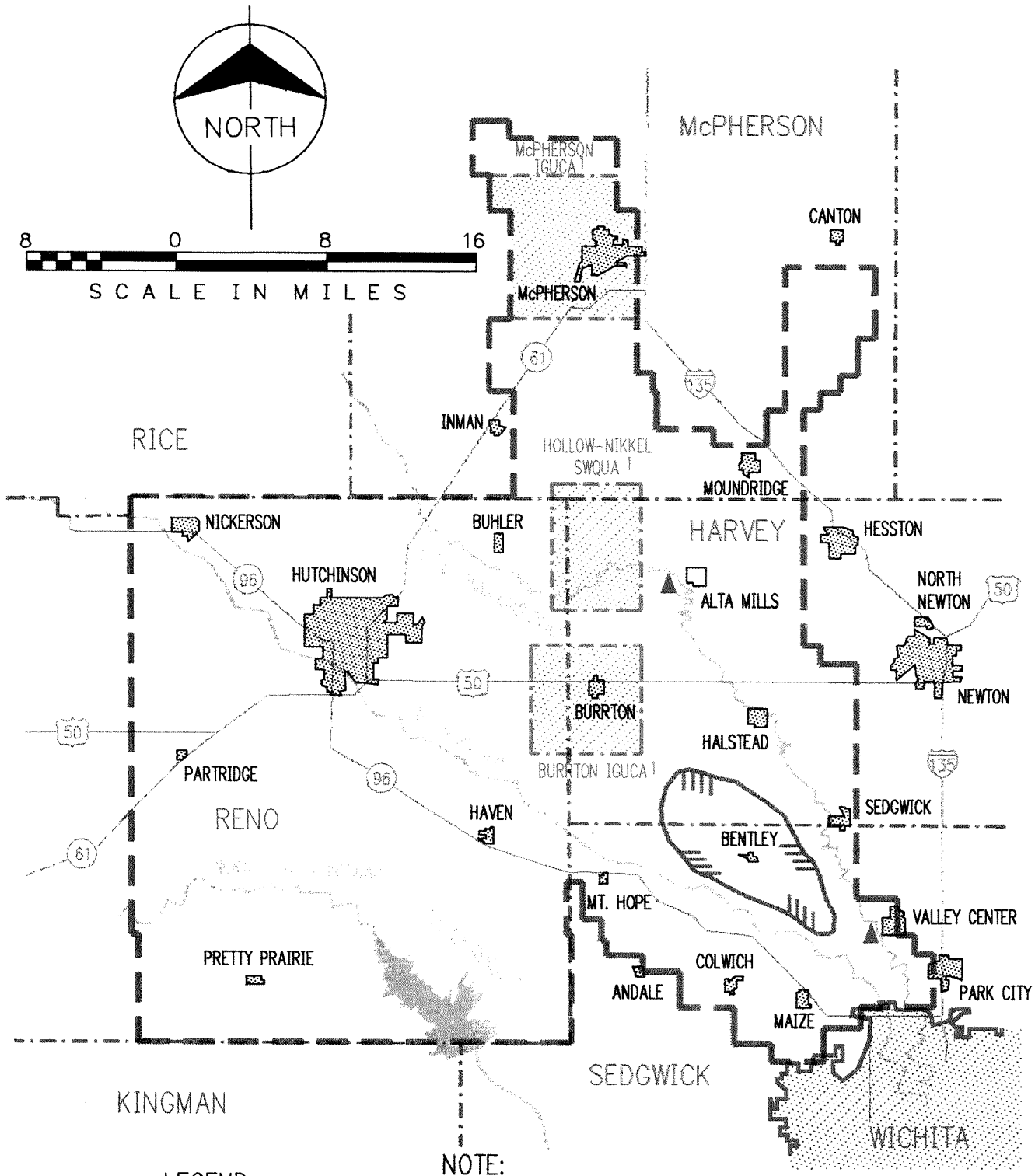
The City's Equus Beds Well Field lies within the boundaries of the Equus Beds Groundwater Management District No. 2 as shown in Figure II-5. The District was formed in 1975 and manages the Equus Beds Aquifer on two basic principals: 1) limit withdrawals to annual groundwater recharge, and 2) maintain and protect the water quality in the aquifer.

The Equus Beds Aquifer underlies portions of four counties; Sedgwick, Harvey, McPherson and Reno. The aquifer is about 900,000 acres in size with an average withdrawal of 157,340 acre-feet (141 MGD). Water from the aquifer is used as follows:

- Industrial - 15 percent
- Irrigation - 44 percent
- Municipal - 41 percent

In 1988, 183,230 acre-feet (164 MGD) was withdrawn from the Equus Beds. Sedgwick County averaged a withdrawal of 48,055 acre-feet (43 MGD) or 26 percent of the usage from the Equus Beds. User categories and their associated usage are listed below:

User Category	Usage Acre-Feet	Usage (MGD)	Percentage (%)
Industrial	2,949	2.6	6
Irrigation	26,292	23.5	55
Municipal	18,729	16.7	39
Other	85	0.1	0
Subtotal	48,055	42.9	100



NOTE:

1 DENOTES SPECIAL WATER QUALITY USE AREA. AREAS CONTAIN GROUND WATER WITH HIGH CHLORIDE LEVELS.

LEGEND

- DISTRICT BOUNDARY
- EQUUS BEDS WELL FIELD
- SPECIAL MANAGEMENT AREA BOUNDARY
- COUNTY LINE
- USGS GAGE

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Figure II – 5

EQUUS BEDS GROUNDWATER MANAGEMENT DISTRICT NO. 2 BOUNDRIES

In an effort to increase water supply capacity, the City began purchasing water rights from agricultural land owners who irrigate crops in the Equus Beds area in 1990. To date, the City has acquired 2,000 acre-feet, which results in 1.6 MGD of water supply after the state reduces the available water volume, at an average cost of $400 per acre-foot ($500,000 per MGD). These water rights are located adjacent to the existing well field. The City hopes to purchase 10,000 acre-feet of water rights and to develop these rights in the near future.

c. Local (E&S) Wells

The Local (E&S) Well Field includes 16 wells constructed in 1949 and 1953. These wells are located adjacent to the water plant between the Little Arkansas and the Arkansas Rivers as shown in Figure II-6. Water rights and well data for these wells are shown in Table II-10. Water rights for these wells allow an average day withdrawal rate of 16.1 MGD and a maximum day withdrawal rate of 32.8 MGD. Based on the current piping configuration, a maximum of 15 MGD can be supplied by these wells.

Select water quality data for the Local (E&S) Wells is shown in Table II-11. Raw water from these wells is typically hard, about 300 mg/l as $CaCO_3$, and is relatively high in chlorides, 125 to 250 mg/l. Such water is blended with other source waters of higher quality and softened at the water plant to meet finished water quality levels desired by the City.

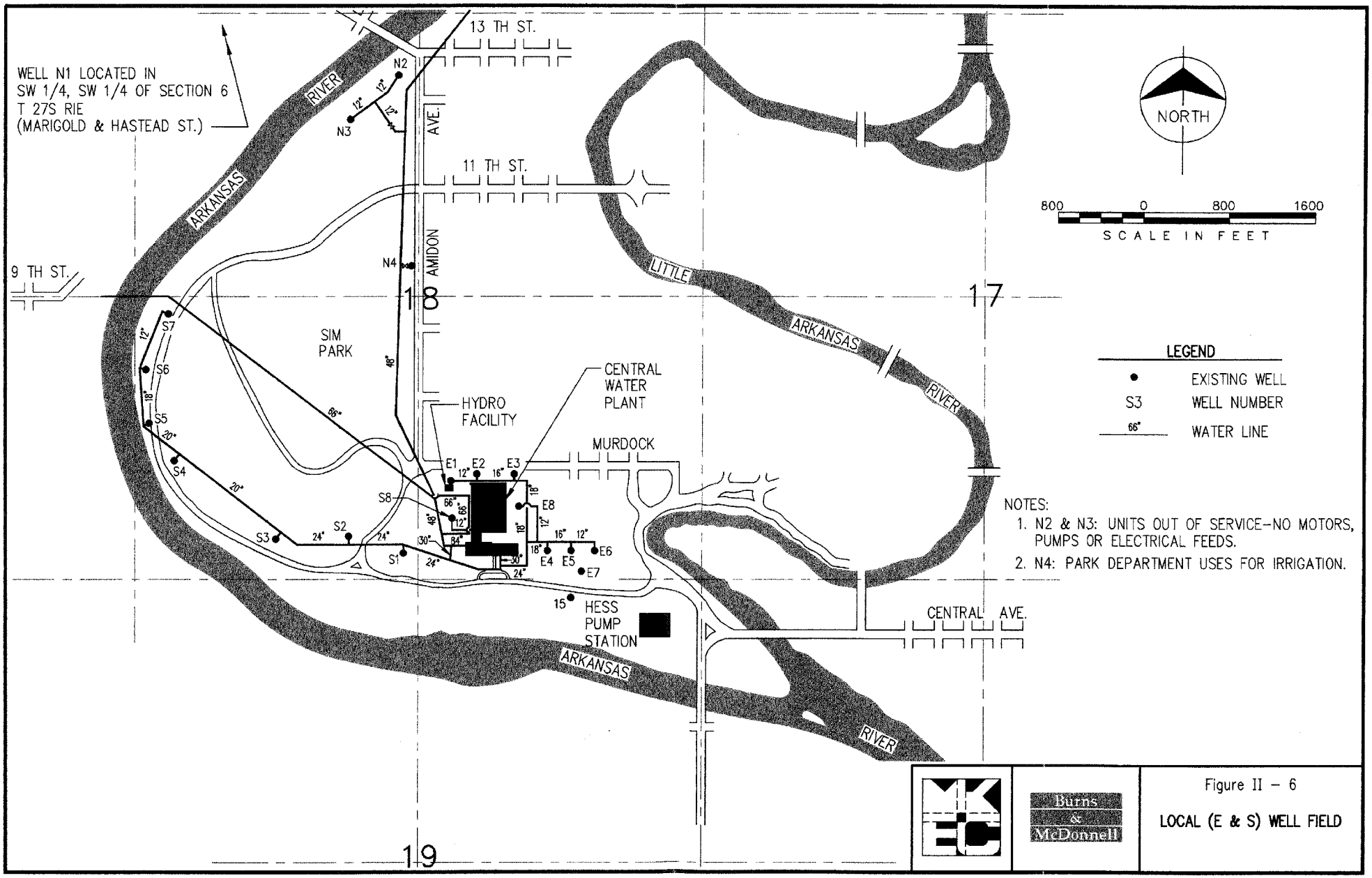


Figure II – 6

LOCAL (E & S) WELL FIELD

Table II – 10

WATER RIGHTS AND WELL DATA FOR LOCAL (E and S) WELL FIELD

WELL		WELL TOP USGS EL. (FT)	STATE PERMITTED WITHDRAWAL					YEAR DRILLED	WELL SCREEN		
NO.	LOCATION		FILE NUMBER	DATE FILED	MAXIMUM RATE (GPM)	ANNUAL AMOUNT (MGY)	ANNUAL AMOUNT (AC-FT)		SETTING (DEPTH IN FEET)	TOTAL LENGTH (FEET)	MATERIAL
E-1	1500N, 2500W, SEC. 18, T27, R1E	–	000540	05/23/49	1088	571.9	1754.8	1948	19.5–34.5	15	–
E-2	1500N, 2200W, SEC. 18, T27, R1E	–	000540	05/23/49	1269	667.0	2046.6	1948	19.5–34.3	15	–
E-3	1500N, 1900W, SEC. 18, T27, R1E	–	000540	05/23/49	897	471.5	1446.8	1948	17.3–32.3	15	–
E-4	0850N, 1650W, SEC. 18, T27, R1E	–	000540	05/23/49	1388	729.5	2238.4	1948	18.3–33.3	15	–
E-5	0850N, 1350W, SEC. 18, T27, R1E	–	000540	05/23/49	883	464.1	1424.1	1948	19.4–34.4	15	–
E-6	0850N, 1050W, SEC. 18, T27, R1E	–	000540	05/23/49	788	414.2	1270.9	1948	18.5–33.5	15	–
E-7	0575N, 1300W, SEC. 18, T27, R1E	–	000540	05/23/49	993	521.9	1601.4	1948	18.5–33.5	15	–
E-8	1250N, 1800W, SEC. 18, T27, R1E	–	000540	05/23/49	1574	827.3	2538.5	–	–	–	–
S-1	0700N, 3000W, SEC. 18, T27, R1E	–	SG0001	09/15/53	1532	91.7	281.4	1953	42.0–52.0	10	–
S-2	0950N, 3450W, SEC. 18, T27, R1E	–	SG0001	09/15/53	1920	84.2	258.4	1953	47.9–57.9	10	–
S-3	0850N, 4000W, SEC. 18, T27, R1E	–	SG0001	09/15/53	1965	91.1	279.5	1953	44.6–54.6	10	–
S-4	0950N, 4400W, SEC. 18, T27, R1E	–	SG0001	09/15/53	1259	79.8	244.9	1953	45.2–55.2	10	–
S-5	1300N, 4900W, SEC. 18, T27, R1E	–	SG0001	09/15/53	1621	51.2	157.1	1953	64.8–74.8	10	–
S-6	1750N, 5000W, SEC. 18, T27, R1E	–	SG0001	09/15/53	1593	67.5	207.1	1953	43.2–53.2	10	–
S-7	2300N, 5100W, SEC. 18, T27, R1E	–	SG0001	09/15/53	1611	32.0	98.2	1953	43.3–53.3	10	–
S-8	1250N, 2450W, SEC. 18, T27, R1E	–	000540	05/23/49	1312	689.6	2116.0	–	–	–	–
N-4	3900N, 2600W, SEC. 18, T27, R1E	–	SG0001	09/15/53	1100	37.5	115.1	–	–	–	–
	TOTAL				22793	5892	18079				

Table II – 11

SELECT WATER QUALITY DATA FOR LOCAL (E & S) WELL FIELD FOR 1992

Well No.	Date	Calcium (mg/l)	Total Hardness as CaCO3 (mg/l)	Chlorides (mg/l)	Conductivity (micromhos/cm)	Turbidity (NTU)	pH	Alkalinity P	Alkalinity T	Nitrates as N (mg/l)	Phosphates as P (mg/l)	Sulfates (mg/l)	Silicates (mg/l)	Fluorides (mg/l)	Total Suspended Solids (mg/l)	Iron (mg/l)	Manganese (mg/l)	Sodium (mg/l)
S1	9/16/92	152	356	164	1380	0.4	7.0	0	330	4.04	0.07	1.3	12	0.38	904			
S2	9/16/92	141	350	278	1770	0.3	7.2	0	310	5.91	0.04	165	18	0.42	1122			
S3	9/16/92	105	278	242	1560	0.3	7.2	0	338	2.46	0.04	140	11	0.46	988			
S4	9/16/92	92	138	205	1420	14.6	7.0	0	334	0.38	0.18	90	13	0.43	896			
S5	9/16/92	89	274	250	1480	3.4	7.3	0	272	0.59	0.09	95	14	0.47	916			
S6	9/16/92	90	260	240	1380	0.5	7.4	0	248	0.29	0.07	105	12	0.42	868			
S7	9/16/92	86	224	280	1510	0.4	7.2	0	239	0.11	0.08	100	11	0.50	898			
S8	9/17/92	85	245	137	1060	0.2	7.0	0	304	1.63	0.04	45	20	0.39	638			
E1	9/17/92	122	338	137	1060	0.3	7.1	0	300	0.95	0.04	50	18	0.38	646			
E2	9/17/92	126	345	138	1100	0.3	7.1	0	316	0.80	0.04	55	17	0.40	632			
E3	9/17/92	116	330	130	1080	0.3	7.2	0	308	0.30	0.04	60	16	0.44	660			
E4	9/17/92	122	324	156	1220	0.3	7.0	0	340	0.37	0.04	80	19	0.35	748			
E5	9/17/92	110	327	145	1150	0.4	7.1	0	330	0.70	0.04	70	18	0.35	710			
E6	9/17/92	97	314	130	1070	0.3	7.1	0	322	0.38	0.04	50	19	0.41	648			
E7	9/17/92	104	308	125	1090	0.3	7.1	0	329	2.19	0.05	60	16	0.39	682			
(1)	8/24/90	32	280	270	152	1.5	7.6					112	15	0.44	866	0.19	21.7	182.1
(2)	6/20/90	59.2	226	145	959	0.5			252	0.57	0.05	62	2102	0.33	566	0.05	24.2	106.0

Notes:

(1) Composite of South Wells Nos. 1,3,5,7.

(2) Composite of East Wells Nos. 1,3,5.

d. Total Supply Capacity

The City's existing and pending water rights, existing pumping capacity and future pumping capacity (with future capital improvements) is shown in Table II-12. The City's existing water rights total an average of 79.2 MGD and a maximum of 170.9 MGD from the Equus Beds, Cheney Reservoir and the Local (E&S) Wells. The City has applied for the water rights for the undeveloped portion of Cheney Reservoir which will increase their total water rights to an average day of 98.8 MGD and a maximum day of 213.8 MGD.

The existing raw water supply system can currently pump a maximum of approximately 130 MGD. Future system improvements are required to supply the maximum day water right on a firm capacity basis with 10 percent of the facilities out of service. These improvements will likely include the installation of additional wells, piping, and a pump station in the Equus Beds and Local Well Fields and the installation of larger pumps in Cheney Pump Station. These improvements should be designed to allow the City to fully utilize their maximum day water rights.

e. Net Water Needs

Estimated net water needs are based on the total water use projections (shown in Table I-13 in Part I), less the drought yields of available supplies. In Part I, average day demands of 125 MGD and maximum day demands of 249 MGD by the year 2050 were projected, including adjustments for water conservation.

Table II – 12

WATER SUPPLY SOURCE SUMMARY

Source	Water Rights		Existing Pumping Capacity		Potential Pumping Capacity (5)	
	Average Day (MGD)	Maximum Day (MGD)	Average Day (MGD)	Maximum Day (MGD)	Average Day (MGD)	Maximum Day (MGD)
Equus Beds (55 wells)	35.7	78.1	35.7	55.0	35.7	78.1 (3)
Cheney Reservoir (1)	27.4	60.0	27.4	60.0	27.4	60.0
Local (E&S) Wells	16.1	32.8	15.0	15.0	16.1	32.8 (3)
Existing Source Subtotal	79.2	170.9	78.1	130.0	79.2	170.9
Cheney Reservoir Pending (1)(4)	19.6	42.9	0.0	0.0	19.6	42.9
Total (1)	98.8	213.8	78.1	130.0	98.8	213.8
Total (2)	90.0	194.4			90.0	194.4

Notes:

(1) Withdrawal rates are based on existing and anticipated water right permits which allow 47 MGD to be withdrawn from Cheney Reservoir. According to a Bureau of Reclamation report, the withdrawal of 47 MGD could result in two depletions of the conservation pool in a 60 year period. with a chance of yield interruption greater than 2 %.

(2) Based on a firm yield of 38.2 MGD from Cheney Reservoir with a 2% chance of interruption, per the Bureau of Reclamation.

(3) Firm capacity based on 90% of future maximum day capacity to account for units out of service and normal maintenance.

(4) The City applied for the pending water rights for the total conservation pool storage capacity in Cheney Reservior in September 1992.

(5) Future pumping capacity is based on future improvements to allow City to use 100% of their 1992 existing and pending water rights. The City is legally restricted to pump quantities up to their permitted water rights.

Projected net water needs for the Wichita service area with water conservation are listed in Table II-13 and shown in Figure II-7. Based on water rights and firm yields, the year 2050 average day net need is 35 MGD and the year 2050 maximum day net need is 54 MGD. Based on existing pumping capacity, the year 2050 maximum day net need is 119 MGD. Future capital improvements will allow the City to pump their full water right yielding a year 2050 maximum day net need of 35 MGD.

The following near-term water improvements are planned to increase the pumping capacity of the City's water supply systems:

- Rehabilitate 16 E&S wells, complete in or by 1994.
- Rehabilitate 25 Equus Beds Wells, increase pumping capacity of Cheney Pump Station and increase the height of the existing surge tank by 75 feet, and install a raw water control valve structure and bypass at the Central Water Plant, complete in or by 1995.

These improvements are required to increase use of the City's existing water rights and raw water supply facilities. Additional improvements are required to make full use of the City's water rights. Construction of these improvements would delay the construction of new water supply facilities by 5 to 15 years.

Table II – 13

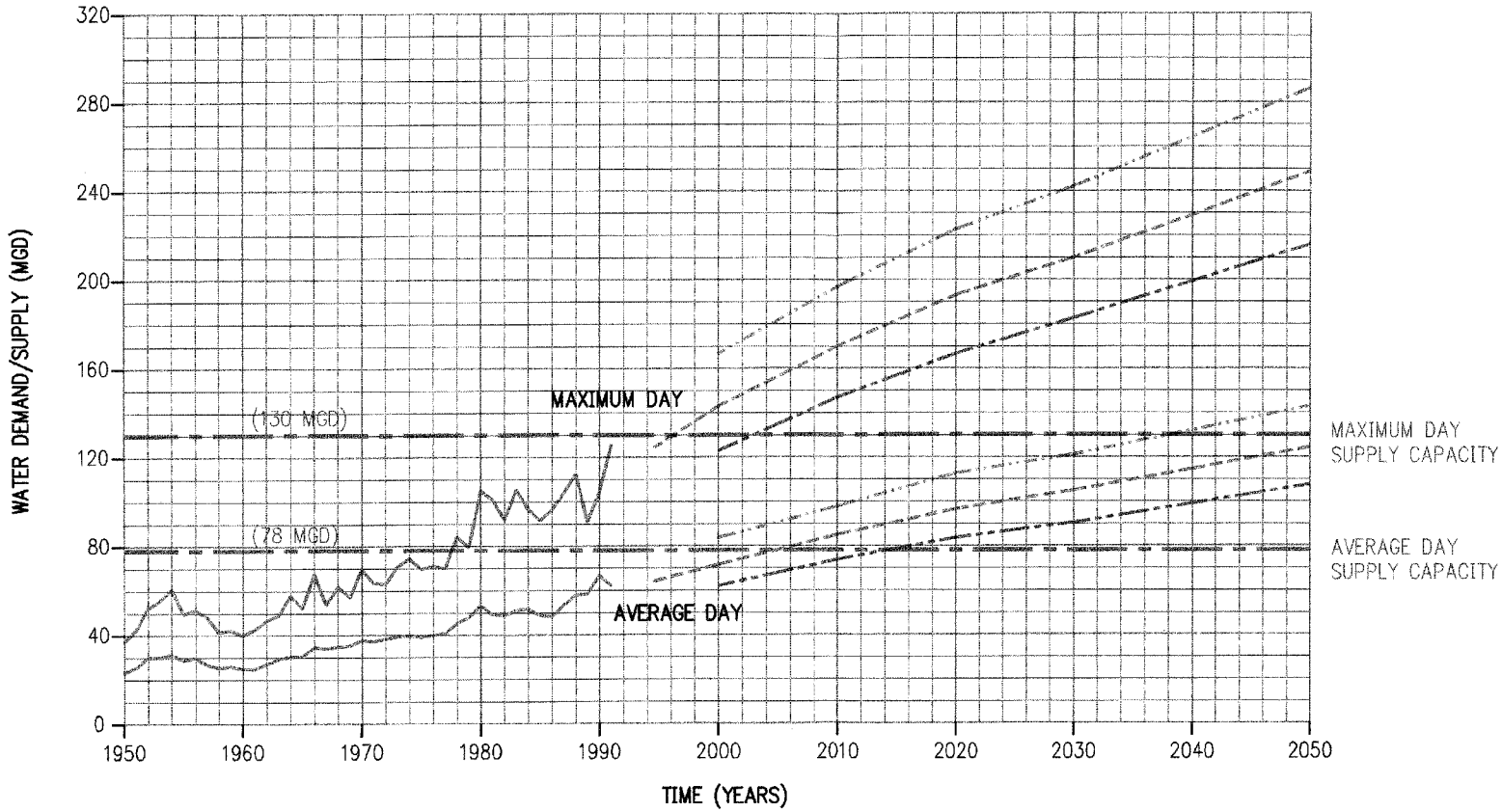
WATER SUPPLY NET NEEDS SUMMARY

	Water Rights		Existing Pumping Capacity		Potential Pumping Capacity	
	Average Day (MGD)	Maximum Day (MGD)	Average Day (MGD)	Maximum Day (MGD)	Average Day (MGD)	Maximum Day (MGD)
Projected Year 2050 Usage with Low Range Conservation	125	249	125	249	125	249
– Existing Supply Sources (1)	– 79	– 171	– 78	– 130	– 79	– 171
Net Need Subtotal	46	78	47	119	46	78
– Undeveloped Available Sources (2)	– 11	– 24	– 0	– 0	– 11	– 24
Required Net Need	35	54	47	119	35	54

Notes:

(1) Existing Supply Sources include Cheney Reservoir, Equus Beds Wells, and Local (E&S) Wells.

(2) Undeveloped Available Sources include additional supplies from Cheney Reservoir up to a firm yield of 38.2 MGD. Based on water rights for Cheney Reservoir 47 MGD, the average day required net need is 26 MGD and the maximum day required net need is 35 MGD.



LEGEND

- WICHITA HISTORICAL DATA (AVERAGE DAY DEMAND AND MAXIMUM DAY DEMAND)
- B&McD HIGH PROJECTION WITH HIGH POPULATION GROWTH AND NO CONSERVATION
- B&McD LOW PROJECTION WITH LOW POPULATION GROWTH AND HIGH RANGE CONSERVATION
- B&McD INTERMEDIATE PROJECTION WITH INTERMEDIATE POPULATION GROWTH AND LOW RANGE CONSERVATION (RECOMMENDED)
- EXISTING SUPPLY CAPACITY (AVERAGE DAY OR MAXIMUM DAY)

NOTE: MAXIMUM DAY USE PROJECTION IS BASED ON A 2.0 MAXIMUM DAY/AVERAGE DAY FACTOR

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Figure II – 7

WATER DEMAND/SUPPLY GRAPH

Review of Tables II-12 and II-13 and projected water demands shown in Figure II-7 result in water supply deficits occurring as follows:

		Year Water Deficit Occurs
1. Existing Pumping Capacity:		
Average Day	78.1 MGD	2005
Maximum Day	130.0 MGD	1996
2. Water Rights:[1]		
Average Day	98.8 MGD	2023
Maximum Day	213.8 MGD	2033
3. Potential Pumping Capacity:[2]		
Average Day	90.0 MGD	2015
Maximum Day	194.4 MGD	2021

Notes:
[1]Based on full utilization of existing and pending water rights.
[2]Based on firm capacity of Cheney Reservoir of 38.2 MGD.

3. TREATMENT

The City's water treatment plant is located on the north bank of the Arkansas River, southeast of Sim Memorial Park, as shown in Figure II-6. The plant, referred to as the Central Water Treatment Plant, is currently undergoing construction to expand treatment capacity from 130 MGD to 160 MGD.

The water treatment plant uses conventional surface water treatment processes, including aeration, chemical addition and rapid mixing, flocculation, sedimentation, filtration, and disinfection. Settled water is recarbonated prior to filtration by adding carbon dioxide gas. Lime softening is accomplished as a single stage process for removal of carbonate hardness. Lime sludge and filter backwash are conveyed to a

wash water holding tank with supernatant and concentrated solids conveyed to a thickening basin. Thickened sludge is pumped to an off-site lagoon. The lagooned sludge is periodically land applied.

Finished water quality data for 1991 for water produced by the plant are presented in Table II-14. Finished water must comply with USEPA's Safe Drinking Water Act Amendments. Raw water from the Equus Beds and Cheney Reservoir is normally blended (about 60 percent groundwater and 40 percent surface water) to a hardness of approximately 220 mg/l (as $CaCO_3$) ahead of the plant and is softened at the plant to a hardness of approximately 105 mg/l (as $CaCO_3$) before being delivered to consumers. To date, no significant concentrations of organic contaminants, pesticides or herbicides have been detected in the water by plant staff.

Raw water from Cheney Reservoir and the Equus Beds Well Field is used to generate electricity at a hydroelectric facility located at the influent of the water treatment plant. The facility includes two generators capable of producing 468 kilowatts of power. Generated power is used to run the water treatment plant and the Hess pumping station. At times of high water usage, above approximately 100 MGD, the hydroelectric facility piping becomes a hydraulic restriction to the plant and is bypassed.

4. DISTRIBUTION

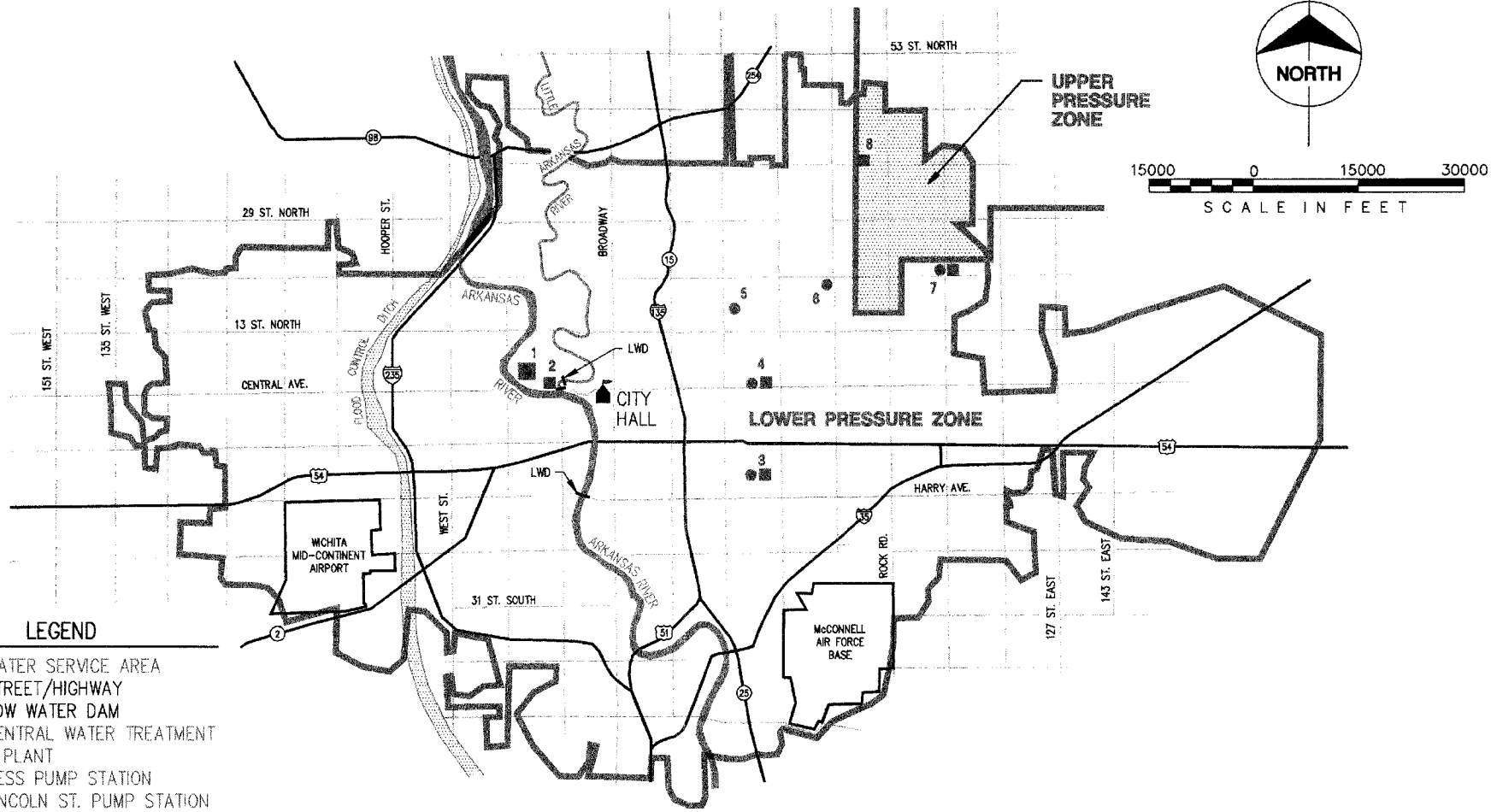
Major storage tanks and pump stations which serve to meet water demands in the distribution system are shown in Figure II-8. A tabulation of

Table II – 14

SELECTED FINISHED WATER QUALITY DATA FOR
CENTRAL WATER TREATMENT PLANT FOR 1991

Parameter	Units	Average	Maximum	Minimum
Dissolved Oxygen	mg/L	8.95	10.1	7.71
Residual Chlorine	mg/L	1.77	1.83	1.69
Ammonia	mg/L as N	0.363	0.67	0.194
Total Solids	mg/L	391	420	334
Silica	mg/L	11.4	14	9
Calcium	mg/L	21.3	35	16
Fluoride	mg/L	0.371	0.443	0.337
Magnesium	mg/L	13.78	17.97	12.32
Sulfate	mg/L	70	76	55
Iron	mg/L	0.01	0.02	0
Sodium	mg/L	87.5	97.6	81.3
Chloride	mg/L	105	128	90
Nitrate	mg/L as N	0.713	0.96	0.511
Phosphorous	mg/L	0.105	0.171	0.048
Total Hardness	mg/L as CaCO3	104	145	98
Total Alkalinity	mg/L as CaCO3	84	131	66
Carbonate	mg/L as CaCO3	0	0	0
Bicarbonate	mg/L as CaCO3	84	131	66
Excess Alkalinity	mg/L as CaCO3	0	0	0
pH		8.4	8.43	8.33
Temperature	°C	16.8	23	12
Conductivity	umhos/cm	658	711	617
Turbidity	NTU	0.36	1.3	0.1
Total Dissolved Solids	mg/L	366	400	340
Surfactants	mg/L	0.025	0.12	0
THMs	mg/L	0.032	0.044	0
Arsenic	ug/L	3.32	4.72	0.11
Barium	ug/L	47.85	77.31	30.34
Cadmium	ug/L	0.33	0.74	0.02
Chromium	ug/L	0.66	2.03	0.16
Copper	ug/L	4.65	8.56	2.04
Lead	ug/L	1.92	9	0
Manganese	ug/L	2.25	5.14	0
Mercury	ug/L	0.18	1	0
Nickel	ug/L	11.77	21.95	5.25
Selenium	ug/L	2.54	4.11	1.49
Silver	ug/L	0.37	1.1	0.08
Zinc	ug/L	1.99	6.84	0.13

Notes:
(1) Based on City of Wichita records.
(2) THM = Trihalomethane



LEGEND

	WATER SERVICE AREA
	STREET/HIGHWAY
LWD	LOW WATER DAM
1	CENTRAL WATER TREATMENT PLANT
2	HESS PUMP STATION
3	LINCOLN ST. PUMP STATION AND STORAGE TANK
4	MURDOCK ST. PUMP STATION AND STORAGE TANK
5	ROOSEVELT ELEVATED TANK
6	WOODLAWN ELEVATED TANK
7	21 ST. & WEBB ST. PUMP STATION AND RESERVOIR
8	37 ST. BOOSTER STATION

NOTE: WATER SERVICE AREA MODELED IN 1992 WATER SYSTEM MASTER PLAN.

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Figure II – 8

EXISTING WATER DISTRIBUTION SYSTEM MAJOR COMPONENTS

these facilities with storage and pumping capacities is shown in Table II-15.

The primary delivery of treated water to the distribution system is accomplished by the Hess Pump Station located adjacent to the Central Water Treatment Plant. The Hess Pump Station contains eight pumps (six constant speed and two variable speed) and has a total pumping capacity of 200 MGD and a firm pumping capacity of 165 MGD. The station receives treated water from clearwell storage totaling 26.5 MG.

The water distribution system is divided into service zones which are referred to as the low pressure zone and the high pressure zone. The low service pressure zone comprises the majority of the system and is serviced by the Hess Pump Station, as well as the Lincoln Pump Station, Murdock Pump Station, and Webb Pump Station. The upper pressure zone serves the northeast part of the City and is supplied by pumps located at the Webb Road Pump Station and the 37th Street Pump Station, which boost water from the lower zone.

C. POTENTIAL WATER SOURCES

Existing and potential conventional water supplies in the area around Wichita and the central Kansas region north of the City are shown in Figure II-9. These sources include the following:

- Existing Reservoirs
  - El Dorado
  - Kanapolis
  - Marion
  - Milford
  - Tuttle Creek

Table II – 15

DISTRIBUTION SYSTEM
STORAGE TANKS AND PUMP STATIONS

Pump Station	No. of Pumps	Total Capacity (MGD)	Firm Capacity (MGD)	Head (feet)	Drive
Lower Pressure Zone					
Hess	8	200.0	165.0	264	6 – Constant Speed 2 – Variable Speed
Webb Road	3	15.0	10.0	115	Constant Speed
Murdock (1)	3	15.0	10.0	125	Constant Speed
Lincoln (1)	2	9.0	4.5	149	Constant Speed
Total	16	239	189.5		
Upper Pressure Zone					
Webb Road	2	5.0	2.0	95,190	Constant Speed
37th Street	2	5.3	2.7	120	1 – Variable Speed 2 – Constant Speed
Total	4	10.3	4.7		

Storage Tank	Type	Total Storage (MGD)	Useful Storage (MGD)	Overflow (ft., USGS Datum)
Central Treatment Plant				
Clearwells (2)	Ground	2.1	1.6	1301.1
Reservoirs (2)	Ground	28.1	24.9	1301.1
Webb Road	Ground	10.0	9.5	1392.1
Murdock	Ground	2.0	1.8	1424.0
Lincoln	Ground	2.0	1.8	1372.0
Roosevelt	Elevated	2.0	2.0	1517.0
Woodlawn	Elevated	2.0	2.0	1487.0
Andover	Elevated	0.1	0.1	1487.0

Notes:
(1) Pump station recommended for dismantling in September 1992 Master Plan.
(2) Based on data in the September 1992 Draft of the Master Plan.

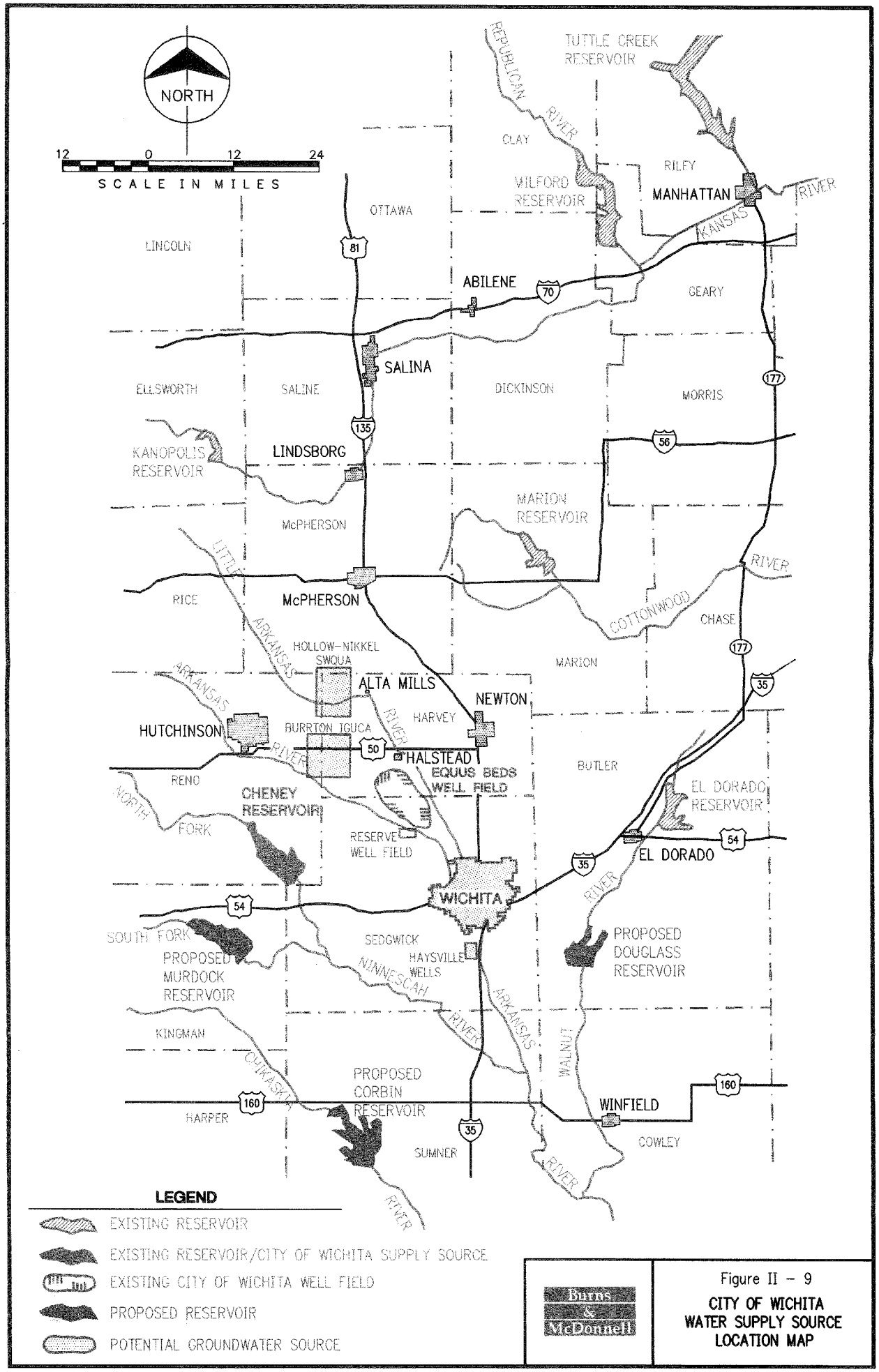


Figure II - 9

CITY OF WICHITA WATER SUPPLY SOURCE LOCATION MAP

- Proposed Reservoirs
  - Corbin
  - Douglass
  - Murdock
- Groundwater
  - Equus Beds
  - Abandoned Reserve Well Field
  - Other sites
- Arkansas and Little Arkansas Rivers
- No Action
- Cheney Reservoir Operations/Management Modifications

1. RESERVOIRS

General background data on five existing and three proposed reservoirs which have historically been considered by others for water supply to Wichita, is shown in Table II-16 (refer to Appendix G for more information). Milford and Tuttle Creek Reservoirs are the only existing reservoirs capable of contributing any water of adequate quantity to meet year 2050 net water needs and quality to Wichita. These reservoirs are located approximately 100 miles north of the City. The three proposed reservoirs, Corbin, Douglass and Murdock, are considerably closer to Wichita than Milford, about 50 miles, but present very difficult challenges of being permitted in a general environmental atmosphere of "no new reservoir construction." The remaining three existing reservoirs, El Dorado, Kanapolis and Marion have disadvantages of little or no available yield and, in the case of Kanapolis, environmental and relocation concerns associated with raising the dam.

Murdock Reservoir is the largest of the proposed reservoirs with an estimated yield of 65 MGD. According to the U.S. Geological Survey

Table II – 16

RESERVOIR BACKGROUND DATA

Name	Status	Location	Dependable Future Yield (MGD)	Water Quality	Environmental Consideratons	Comments
El Dorado	existing	28± miles east of Wichita WTP	12±	adequate	minimal	All storage capacity owned by City of El Dorado
Kanapolis	existing	70± miles northwest of Wichita WTP	27± 44±(if dam is raised 25')	high chlorides during droughts, about 400 mg/l	significant	Relocations involved
Marion	existing	46± miles north of Wichita WTP	3	adequate	not significant	Minimal yield Compared to distance from Wichita
Milford	existing	96± miles north of Wichita WTP	85±	adequate periodic taste and odor	not significant	65 mgd uncommitted
Tuttle Creek	existing	110± miles north of Wichita WTP	163± total 73± available	acceptable	not significant	Not as favorable as Milford because of additional distance
Corbin	proposed	46± miles south of Wichita WTP	47±	acceptable	significant	Extensive relocations, 25,000 acres of land required, alter aquatic environment of river
Douglass	proposed	14± east of of Wichita WTP	14±	acceptable	significant	Reservoir would alter the aquatic environment of the Walnut River
Murdock	proposed	45± miles west of Wichita WTP	65±	unacceptable high chlorides, 280 mg/L ± Potential to reduce chlorides to < 100 mg/L (2)	significant	Extensive relocations, 13,000 acres of land required, estimated construction cost of $142 million

Notes:

(1) Data taken from the Public Wholesale Water Supply District No. 10 Conceptual Study of Alternative Water supply Sources by Mid–Kansas Water Consultants, December 2, 1991.

(2) Determined from discussions between USGS and Burns and McDonnell.

(USGS) in Lawrence, chloride concentrations in the South Fork Ninnescah River, which feeds the proposed reservoir are approximately 280 mg/l. This high concentration of chlorides is probably caused by contamination from a single location along the river where chloride concentrations are approximately 30,000 to 40,000 mg/l. According to USGS, relief wells could possibly be used to remediate the contaminated area and reduce chloride concentrations in the base flow of the river to less than 100 mg/l. Costs of the construction and operation of a relief system and brine disposal have not been addressed by the USGS.

2. GROUNDWATER

Potential groundwater locations which may provide additional groundwater supplies are shown in Figure II-9. All areas are believed to have groundwater which is high in chlorides.

- Abandoned Reserve Well Field near the Arkansas River in northwestern Sedgwick County.
- Equus Beds Special Water Quality Use Area near Burrton.
- Arkansas River aquifer near Haysville.

a. Reserve Wells

At one time, the City used a well field known as the Bentley Reserve Well Field located approximately 22 miles northwest of the water plant along the Arkansas River as shown in Figure II-9. Six wells of 1,500 gpm capacity each were constructed in the well field in 1956. The City used these wells for water supply during a drought period, but abandoned the wells at a later date, apparently because of poor water quality.

Raw water quality from these wells was found to be very hard (350 to 500 mg/l as $CaCO_3$) and high in chlorides (350 to 850 mg/l) as shown in Table II-17. New wells developed in this abandoned well field might be capable of increasing water supply if high chloride groundwater is blended with the low chloride groundwater from the Equus Beds Well Field.

b. Burrton, Kansas

The Equus Beds Aquifer has two potential supply locations near Burrton approximately 35 miles northwest of the City's water plant. The Equus Beds Special Water Quality Use Area (SWQUA) overlies the Hollow-Nikkel Oil Pool in an area north of Burrton. The Burrton Intensive Groundwater Use Control Area (IGUCA) overlies the Burrton oil pool in an area lying south of Burrton. Preliminary estimates indicate that these areas may be capable of yielding 9 MGD at the SWQUA and 10 MGD at the IGUCA. The aquifer in these areas was polluted by disposal of brine from oil wells. Pollution has stopped, but residual brine remains in the aquifer with chloride concentrations typically exceeding 8,000 mg/l.

Due to the chloride contamination, groundwater from these areas is not used and water rights can likely be obtained. Combinations of blending water from higher quality sources, aquifer recharge, or desalting treatment might be considered to provide additional groundwater supply with acceptable chloride levels. Additionally, long-term pumping may clean up the aquifer, since contamination has ceased, providing a future source of good quality water.

Table II – 17

WATER QUALITY DATA FOR
RESERVE WELL FIELD

Well No.	Date	Calcium (mg/l)	Total Hardness (mg/L as CaCO3)	Total Alkalinity (mg/L as CaCO3)	Chlorides (mg/l)	Sulfates (mg/l)	Magnesium (mg/l)	Total Solids
1	5/26/56	123	396	198	559	171	22	1,302
	5/28/56	160	526	207	635	315	31	1,764
2	5/31/56	127	408	185	373	141	22	1,116
	6/1/56	139	497	177	639	247	38	1,788
3	5/12/56	318	456	200	754	323	33	1,932
	5/18/56	267	361	197	612	165	23	1,426
4	6/7/56	256	372	201	686	205	28	1,624
	6/8/56	307	439	198	840	328	32	2,206
5	5/19/56	132	425	174	495	202	23	1,354
	5/22/56	146	483	188	610	304	29	1,766
6	6/15/56	147	488	206	593	273	29	1,500
	6/18/56	118	385	183	523	162	23	1,192

Note:
(1) Based on City of Wichita records.

c. Haysville, Kansas

The aquifer in the alluvial deposits of the Arkansas River near Haysville, approximately 8 miles south of the City's water plant, is another potential groundwater supply. Available groundwater yield from the area is estimated at 2.85 MGD for the 20-square-mile area and is high in chlorides, 150 to 450 mg/l, making it unsuitable for irrigation. One possible option which may be considered includes the use of treated wastewater plant effluent from the City's nearby plant which could be traded to area irrigators for their groundwater rights, which are all allocated, or used to remediate or recharge the area with higher quality water. In turn, groundwater from this area could be pumped to the water treatment plant in Sim Park and blended with raw water from other sources to obtain acceptable chloride levels prior to treatment.

3. LITTLE ARKANSAS AND ARKANSAS RIVERS

The Little Arkansas River and the Arkansas River which flow through the City of Wichita may offer some potential to provide additional water supplies. An intake and pump station could possibly be constructed along either river to pump raw water to the treatment plant during periods of high streamflow. Greater use of these sources could decrease the use of the Equus Beds and Cheney Reservoir.

Flow in the Little Arkansas River ranges from less than 8 cfs to over 21,000 cfs. The river has a minimum desired streamflow of 20 cfs at the Valley Center gage, just north of Wichita.

Monthly raw water quality data taken in 1992 for Little Arkansas River is shown in Table II-18. The water is generally of adequate quality for water supply. Chloride levels in the river historically range from 5 mg/l to approximately 350 mg/l with low chloride concentrations occurring at high flow rates and the high chloride concentrations occurring at low flow rates.

Review of the flow duration curve for the Little Arkansas River at Valley Center, a USGS gaging station, shows the following available flows and the percentage of time they are equaled or exceeded.

Flow (cfs)	Flow (MGD)	Percentage of Time Flows are Equaled or Exceeded
7	5	99
18	12	95
20	13	90
30	19	80
35	23	70
45	29	60
57	37	50
75	48	40
100	65	30
150	97	20
428	276	10
1,600	1,032	5
5,250	3,387	1

Additional flow will be available at the mouth of the Little Arkansas River due to its larger drainage basin. This available flow, however, will not normally be available during extended dry weather periods.

The Little Arkansas River could be used on an "as-available" basis providing the water quality is adequate. An intake and pump station

Table II – 18

SELECT WATER QUALITY DATA FOR
THE LITTLE ARKANSAS RIVER AT THE
WATER TREATMENT PLANT IN 1992

Parameters	Units	January	February	March	April	May	June	July	August	September
Calcium	mg/L	70	100	65	101	100	22	32	95	114
Total Hardness as CaCO3	mg/L	216	316	212	328	280	72	82	286	347
Chlorides	mg/L	110	175	99	201	102	20	21	189	270
Specific Conductivity	ohms	739	1090	743	1140	990	207	219	1038	1350
Turbidity	NTU	35.6	13.5	33.8	26.5	43.6	180.8	188.4	37.9	43
pH		7.8	8.2	7.7	8.6	8.0	6.8	7.1	8.1	8.2
Alkalinity – P	mg/L	0	0	0	32	0	0	0	0	0
Alkalinity – T	mg/L	180	260	182	252	230	64	68	204	229
Nitrates as N	mg/L	1.84	1.29	1.69	0.473	0.421	1	0.48	0.021	0.277
Phophates as P	mg/L	0.66	0.73	0.75	0.41	0.773	1.04	1.09	0.53	0.483
Sulfates	mg/L	70	90	60	80	60	20	20	30	76
Silica	mg/L	20	10	20	12	18	25	19	21	13
BOD	mg/L	6	5	4	12	5	4	4	6	8
Total Solids	mg/L	542	1468	510	848	656	552	772	736	934
Total Suspended Solids	mg/L	43	33	59	69	81	291	312	97	98
Ammonia as N	mg/L	1.05	0.14	0.32	0.11	0.312	0.256	0.148	0.176	0.074
Dissolved Oxygen	mg/L	10.26	10.83	8.64	13.52	5.52	5.17	5.5	9.33	6.42
Temperature	°C	6	5.5	9.5	16.5	23	25	26.5	20.5	24.5

Notes:
(1) Based on City of Wichita records.

could be constructed just upstream of the low level dam adjacent to the City's water treatment plant. Excess river flow could be utilized as the primary water supply for the City, allowing more opportunity for Cheney Reservoir to fill and the Equus Beds Aquifer to recharge.

Flow in the Arkansas River ranges from less than 100 cfs to over 8,500 cfs. The river has no minimum desired streamflow at this time, but a minimum standard may be developed in the near future.

Monthly raw water quality data taken in 1992 for the Arkansas River is shown in Table II-19. Water is generally high in chlorides, with concentrations historically ranging from 12 mg/l at very high flow rates to over 700 mg/l at low flow rates. Approximately 200 MGD should be available 50 percent of the time from the river. This available flow, however, will not normally be available during extended dry weather periods and chlorides may be too high for use as a water supply. Reverse osmosis treatment could be used to reduce chloride levels and other salts with the product water used to help meet peak demands.

4. CHENEY RESERVOIR

Cheney Reservoir currently serves as the City's only surface water source and may have potential to provide additional water supply. Two possible options could be investigated to increase water supply, including reallocation of the flood storage pool and modification of reservoir operations and management practices.

Table II – 19

SELECT WATER QUALITY DATA FOR
THE ARKANSAS RIVER AT THE
WATER TREATMENT PLANT IN 1992

Parameter	Units	January	February	March	April	May	June	July	August	September
Calcium	mg/L	101	97	97	100	100	34	61	66	86
Total Hardness as CaCO3	mg/L	338	342	318	336	338	109	171	204	297
Chlorides	mg/L	540	554	550	598	536	124	200	209	389
Specific Conductivity	ohms	2213	2350	2318	2540	2518	660	987	1104	1892
Turbidity	NTU	2.9	1.6	7.5	3	3.1	82.2	167.2	72.3	13.6
pH		8.0	8.3	8.0	8.2	8.0	7.3	7.7	8.0	8.4
Alkalinity – P	mg/L	0	0	0	0	0	0	0	0	13.6
Alkalinity – T	mg/L	228	178	206	210	208	100	132	176	220
Nitrates as N	mg/L	1.54	1.39	1.45	0.619	0.125	0.44	0.8	0.778	0.787
Phophates as P	mg/L	0.23	0.46	0.28	0.19	0.24	0.64	0.93	0.62	0.363
Sulfates	mg/L	150	155	140	140	145	30	40	50	130
Silica	mg/L	5	0.42	9	3	8	23	15	23	9
BOD	mg/L	N/D	1	N/D	1	N/D	3	N/D	N/D	6
Total Solids	mg/L	1360	786	1374	1590	1440	600	868	784	1148
Total Suspended Solids	mg/L	14	5	25	18	8	76	876	124	39
Ammonia as N	mg/L	0.225	0.21	0.21	0.182	0.217	0.201	0.145	0.271	0.058
Dissolved Oxygen	mg/L	11.73	13.21	10.63	10.36	8.23	6.4	7.09	8.23	9.53
Temperature	°C	3	5.5	9	8.5	21.5	25	26.5	19.5	22

Note:
(1) Based on City of Wichita records.

a. Storage Reallocation

The option to reallocate flood storage in the reservoir for water supply would entail an extended implementation process with cooperation by the Corps of Engineers, Bureau of Reclamation and other federal and state agencies. The reallocation could increase the conservation pool up to approximately 80,000 acre-feet which would increase reservoir firm yield approximately 9 MGD.

Various activities associated with this option include:

- Construction of an additional spillway, either morning-glory type or emergency bypass earth type.
- Relocation of existing marinas, docks and park areas.
- Extensive hydrologic studies.
- Downstream flood benefit studies.
- Economic feasibility analysis.
- Dam safety study.
- Environmental studies.
- Approval by the Corps of Engineers, Bureau of Reclamation, Division of Water Resources, and Wildlife and Parks.
- Congressional authorization.

b. Operations/Management Modifications

The proposed operation/management modification would involve greater use of the reservoir for water supply which would result in a lowering of the operating level by approximately 2 to 8 feet. This will allow the City to trap a larger portion of flood water, which would normally flow through the spillway, and to maximize the use of

flood water for water supply. This operation would reduce the use of the Equus Beds and allow groundwater levels to recover. The Equus Beds would be used more heavily for water supply during drought periods when the Cheney Reservoir level was low.

One major drawback to this operation is the adverse effects on recreation at Cheney Reservoir. The lake level would fluctuate extensively and impact recreational uses. This condition would also occur during a drought condition even without implementation of the operations/management option. One strong point for this option is the fact that the City owns all of the conservation pool and no recreation pool storage is included in the reservoir.

5. NO ACTION ALTERNATIVE

The "no action" alternative evaluates the water demand, water supply and usage reduction alternatives for a self-imposed limited growth scenario. Additionally, it evaluates the impact of not acquiring any additional water supplies. For the purpose of comparison, population and water demand projections for year 2050 for a water system growth plan as delineated in Part I with conservation and the "no action" alternative with continuing service to the City's existing wholesale customers without conservation is as follows:

	System Growth Plan (with Conservation)	No Action Alternative (without Conservation)
Population	568,000	500,000
Average Day Demand	124 MGD	132 MGD
Maximum Day Demand	249 MGD	263 MGD
Net Water Need - Avg. Day[1]	25 MGD	33 MGD
Net Water Need - Max. Day[2]	35 MGD	49 MGD

Notes:
[1]Based on existing and pending average day water rights of 99 MGD (Table II-12).
[2]Based on existing and pending maximum day water rights of 214 MGD (Table II-12).

Other variations of the "no action" alternative include a low-range conservation option and a high-range conservation option as presented in Part I. Comparative data for the variations in year 2050 for continuing service to the City and the City's existing wholesale customers include the following:

	No Action (with Low-Range Conservation)	No Action (with High-Range Conservation)
Population	500,000	500,000
Average Day Demand	114 MGD	97 MGD
Maximum Day Demand	228 MGD	194 MGD
Net Water Need - Avg. Day[1]	15 MGD	-0-
Net Water Need - Max. Day[2]	14 MGD	-0-

Notes:
[1]Based on existing and pending average day water rights of 99 MGD (Table II-12).
[2]Based on existing and pending maximum day water rights of 214 MGD (Table II-12).

The "no action" alternative includes no new water sources for the self-imposed limited growth scenario and requires the City to construct facilities to convey their pending maximum day water right of 214 MGD. The potential service area population for this alternative and the year

the available supply would be exceeded under conditions of no additional water conservation, low range water conservation and high range water conservation vary as follows:

	Based on AvDy Water Rights[2]		Based on MxDy Water Rights[3]	
Water Conservation Option	Maximum Service Area Population	Projected Year Supply Exceeded	Maximum Service Area Population	Projected Year Supply Exceeded
No Additional[1]	470,000	2018	410,000	2017
Low Range	495,000	2023	470,000	2033
High Range	540,000	2040	550,000	2049

Notes:
[1]Maintains on-going conservation efforts by the City.
[2]Based on average day water rights of 99 MGD.
[3]Based on maximum day water rights of 214 MGD and year 2050 projected per capita water use.

Based on this information, the "no action" alternative will not meet projected water demands through the year 2050 planning period under any water conservation option (no additional, low range and high range).

* * * * *

Part III - Inventory of Non-Conventional Water Supplies

PART III

INVENTORY OF NONCONVENTIONAL WATER SUPPLIES

A. GENERAL

This section of the report describes nonconventional water supply alternatives which may provide a portion of the City's projected year 2050 average day water demand of 125 MGD and maximum day water demand of 249 MGD as presented in Part I. Water supply alternatives discussed include the following:

- Utilization of Cheney Reservoir Overflow
- Aquifer Recharge, Storage and Recovery
- Treated Wastewater Reuse
- Gilbert-Mosley Remediated Groundwater.

B. FACTORS INFLUENCING USE

The conventional groundwater and surface water supplies used by the City, as described in Part II, are most likely the highest quality and most economical water sources available in the region. As additional sources are developed, their capital and operating costs will probably be higher because of their greater distance from the water treatment plant and/or their lower raw water quality.

Consideration of nonconventional water supplies allows further examination of local water resources through water management techniques to increase available water supply capacity while meeting water quality goals. This process will likely include the concept of integrated use of multiple water

sources and require the acquisition of additional water rights or modifications in water use permitting from the state.

To be acceptable, raw water which is used for municipal water supply must be capable of being treated to meet the regulations of Safe Drinking Water Act Amendments as promulgated by the United States Environmental Protection Agency (refer to Table V-1). Of particular concern with the use of treated wastewater is the safeguarding of public health in applications involving reclaimed water systems for irrigation or industrial cooling or recycle to water supply sources serving the municipal water system. Further concern is the treatment of water containing high chlorides, typical of the Arkansas River drainage, because of the high cost of treatment with reverse osmosis membranes and disposal of high-salt wastewater. The City's desired maximum chloride level in finished water is 200 mg/l, well below the EPA secondary standard of 250 mg/l.

Historically, the limitation of the City's water supplies has been the capability to meet peak summer demands which are approximately twice the average annual supply rate. Control or reduction of peak summer demands would help to reduce or delay the need for larger water supply, treatment and distribution facilities and would reduce the size and cost of facilities. Maximum summer demands for treated water may be reduced through the water conservation program discussed in Part I and by use of other close-in, available nonconventional supplies, as discussed herein. Working with large users to encourage conservation or restriction of usage during critical demand periods (less irrigation during peak periods and/or delay of high water use to off-peak periods) is another method that might be used.

Water conservation techniques to reduce the summer peaks were evaluated in detail in Part I. The major techniques evaluated included the following:

- Watering restrictions - instituted in June 1990.
- Public education - existing program.
- Inverted block water rates (cost increases as water use increases beyond normal use) - new rate effective January 1, 1993.
- New conservation plumbing codes - planning for implementation by 1994.
- Enforcement (fines for not following restrictions).
- Plumbing retrofit (replace old plumbing fixtures with conservation fixtures).

Two levels of conservation were evaluated in Part I, low range and high range. Low range conservation measures were based on savings experienced during applicable case studies and resulted in an estimated savings of about 13 percent. High range conservation measures were based on theoretical values and resulted in an estimated savings of about 25 percent. The low range conservation, which saves an estimated 18.5 MGD of the year 2050 average day demand, is recommended and is included in the year 2050 projected average day demand of 125 MGD being used in this study for planning purposes.

C. UTILIZATION OF CHENEY OVERFLOW

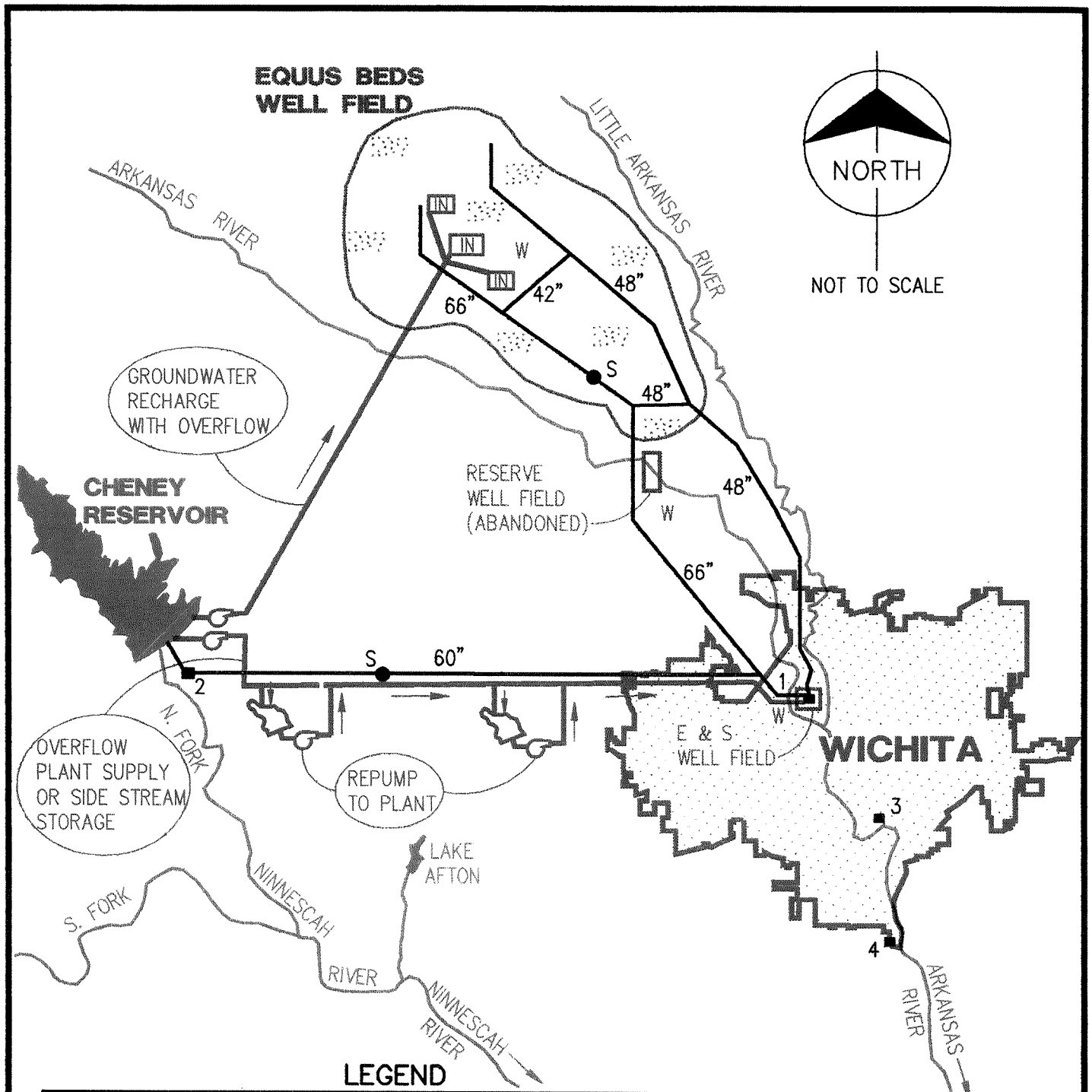
Overflows from Cheney Reservoir represent flood waters which are lost to the City of Wichita as a potential water supply. Utilization of these overflows could possibly be accomplished with the objective of reducing groundwater use from the Equus Beds Well Field. This would allow recharge of the

aquifer with recovery of the groundwater table and storage of water in the aquifer for later use during an extended drought period.

Options for utilization of overflow from Cheney Reservoir are shown in Figure III-1 and include (1) pumping direct to the water plant, (2) pumping to sidestream storage with repumping from storage to the water plant during drought conditions, and (3) pumping to the Equus Beds for aquifer recharge and storage with repumping from the aquifer to the water plant during drought conditions.

Storage of overflow water in sidestream storage reservoirs would allow such water to be held and used during drought periods. Creeks flowing into the North Fork Ninnescah River downstream from the Cheney Dam are potential sidestream storage sites. Typical problems with sidestream storage lakes include poor water quality, large variations in water surface levels, insects, and aesthetics. Monitoring, maintenance and security are other important aspects of this operation. An operations study of Cheney Reservoir is required to determine the validity of this alternative.

Pumping excess flow from the reservoir directly to the water plant would allow reduced groundwater pumping from the Equus Beds; thus, saving the aquifer for future use during dry weather conditions. Excess flows would include all water above the conservation pool elevation in the reservoir and high flows in the North Fork Ninnescah River just downstream of the dam. This alternative would require the construction of an additional pipeline to the water plant and an expansion of Cheney Pump Station.



Burns & McDonnell

Figure III-1

CHENEY RESERVOIR OVERFLOW UTILIZATION ALTERNATIVES SCHEMATIC

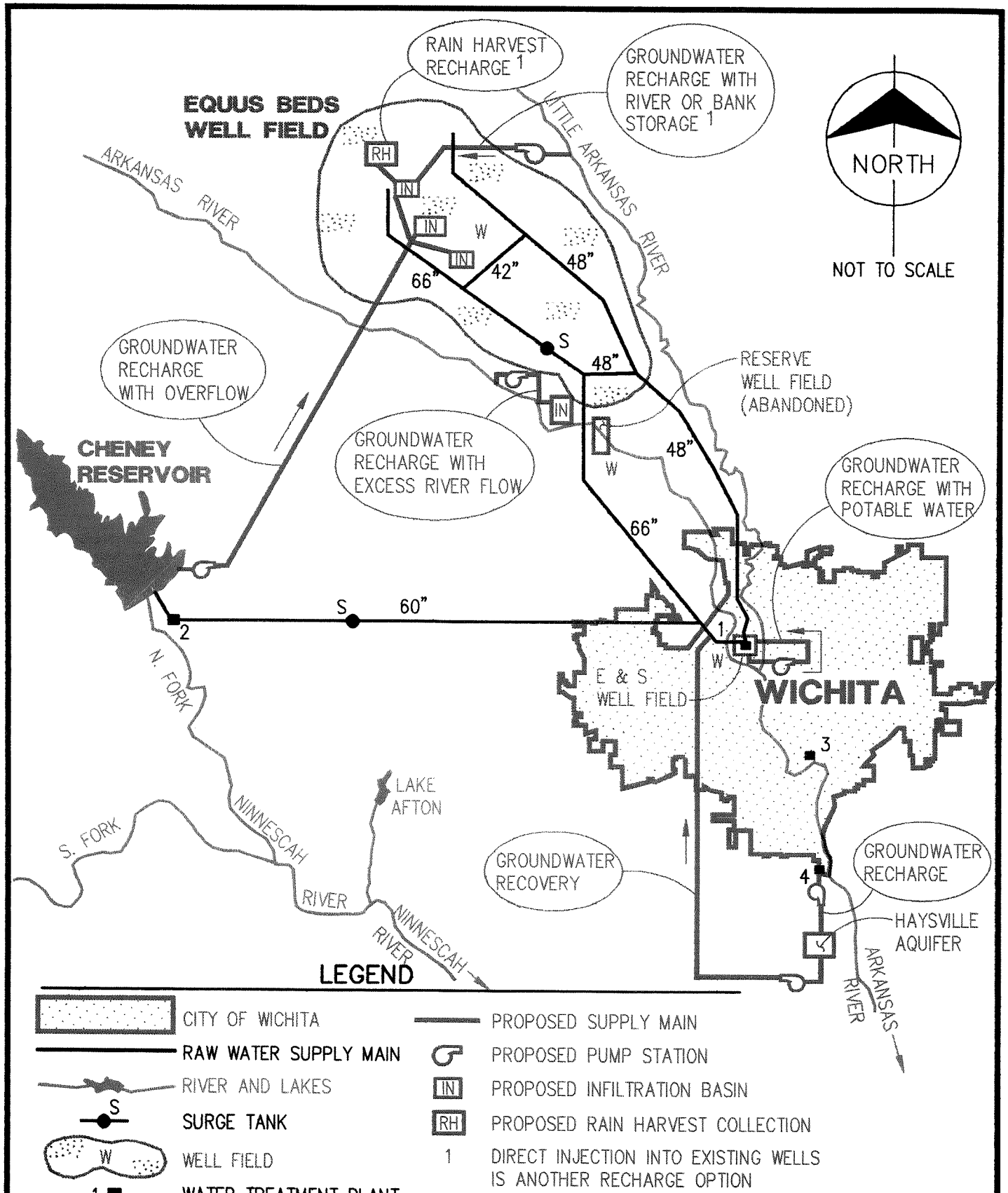
D. AQUIFER RECHARGE, STORAGE AND RECOVERY

Aquifer recharge, storage and recovery is another method of temporarily diverting and storing excess storm water or treated wastewaters until needed to meet water demands during dry weather conditions as shown in Figure III-2. The Equus Beds Well Field, Local (E&S) Well Field, Reserve Well Field or other local aquifers could potentially be used for recharge, storage and recovery. On-site pilot testing is needed to establish design criteria for use in determining the feasibility of such artificial recharge projects.

1. POTENTIAL WATER SOURCES

Several potential sources of recharge water may be available to the City as follows:

Potential Source	Available Quantity
• Cheney Reservoir Overflow	Average spillage is estimated in excess of 55 MGD based on computer simulations in Part VII; however, spillage can occur at rates up to 3000 cfs or 1290 MGD, which are too large to economically capture.
• Surface water from the Little Arkansas River (during high flows)	Variable; flow varies from 0 to over 2000 cfs. Source can be used on an as-available basis.
• Arkansas River (during high flows)	Variable; minimum flows of about 2000 cfs are required before water quality is acceptable for conventional treatment.
• Treated Wastewater (reclaimed water)	40 MGD+
• Potable Water	Variable



Burns & McDonnell

Figure III-2

AQUIFER RECHARGE, STORAGE AND RECOVERY ALTERNATIVES SCHEMATIC

• Bank storage from the Little Arkansas River (during high flows)	Variable; approximately 30 to greater than 250 MGD on an as-available basis.
• Rain Harvesting	Variable

a. Excess Surface Water Recharge

Three of the potential recharge source waters include excess surface water flow from Cheney Reservoir, the Arkansas River, and the Little Arkansas River. Supply alternatives for these sources include pumping flood waters to aquifer storage with retrieval of water at a later date during dry weather periods.

b. Treated Wastewater Recharge

This option involves the use of treated wastewater from Wastewater Treatment Plant No. 2 for recharge of the Equus Beds Aquifer and the Haysville Aquifer. The Haysville Aquifer is located along the Arkansas River south of Wichita. This option is discussed in more detail in this report section under the heading "Wastewater Reuse."

c. Potable Water Recharge

This option involves the production of excess potable water at the water treatment plant during periods of wet weather, the storage of potable water in the aquifer adjacent to the plant, and the recovery of potable water from the aquifer during drought periods. Excess potable water would be injected into the aquifer by pumping into injection wells and would be removed from the aquifer by pumping out of existing pumping wells. Water quality would be closely monitored

to assure compliance with drinking water standards prior to use in the distribution system.

d. Little Arkansas River Bank Storage Recharge

The hydrogeologic profile of the bank storage concept for groundwater recovery from the Little Arkansas River is shown in Figure III-3. This option involves the collection of groundwater in bank storage during periods of excess flow in the Little Arkansas River and the transfer of this water by pipeline to the Equus Beds Well Field where it would be used to recharge the aquifer. Wells would be used to collect the bank storage groundwater and injection wells and/or infiltration basins could be used in the aquifer recharge process. The recharged groundwater would be stored in the Equus Beds Aquifer and pumped from the well field to the water plant via the existing well field pipeline system for use during dry weather periods. The volume of available bank storage along the Little Arkansas River from Alta Mills to Valley Center is preliminarily estimated at 12,000 million gallons per year (MGY) to 50,000 MGY.

Bank storage is the temporary increase in groundwater levels in the alluvial river bank during periods of high (or excess) river flows (refer to Figure III-3). As surface water flows increase and the river level rises, surface water infiltrates into the river bank where it is temporarily stored, causing groundwater levels to increase. As river flows decrease, groundwater in bank storage slowly flows back into the river. Groundwater in bank storage

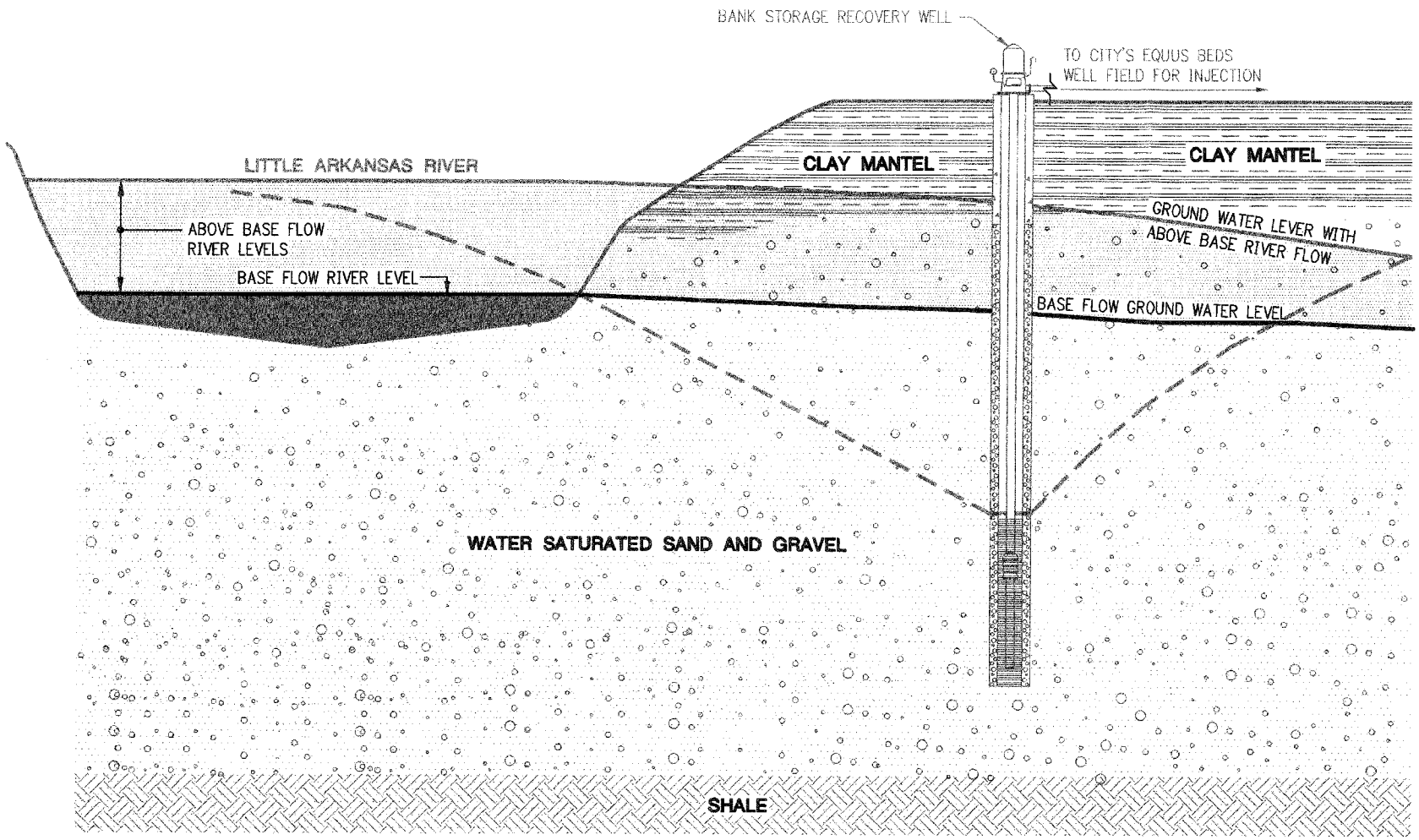


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Figure III-3
HYDROGEOLOGIC PROFILE
FOR BANK STORAGE
GROUNDWATER
RECOVERY CONCEPT

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resulting from flows above base flow may be used by the City to recharge the Equus Beds Aquifer. Baseflow is the minimum flow in the river to meet minimum desired streamflow and some surface water rights and is currently established as 25 cfs at Valley Center by Groundwater Management District No. 2.

e. Rain Harvesting Recharge

This option involves the collection of rainfall on a plastic membrane in the Equus Beds area and the direct injection of collected water into the aquifer by wells to prevent water quality degradation by soil contact. Such water would be stored in the aquifer until needed during a dry weather period.

2. RECHARGE OPERATION

A typical recharge operation includes the following steps:

- Wetting Cycle (time varies with source availability and recharge system configuration):
  - Divert water from supply source to storage aquifer. The recharge water may require treatment (such as sedimentation or grass overland flow to remove solids) to meet recharge water quality standards.
  - A piping network transports the diverted water to either infiltration galleries, surface spreading basins, or injection wells, for storage in the aquifer.

- Recharge Cycle (time varies with infiltration rates):
  - The diverted water recharges the aquifer.

- Drying Cycle (time varies with soil type and weather conditions):
  - Recharge area is allowed to dry (infiltration galleries and surface spreading basins).
  - Injection wells are pumped or cleaned periodically.

- Recovery:

  The diverted water is subsequently recovered by City wells located downstream of the recharge area and is transported by pipeline to the water plant for treatment. Because of variation in water demands and system operation and the unconfined nature of an aquifer, the City will not likely be able to recover 100 percent of all recharged water from storage.

3. STATE OF KANSAS REQUIREMENTS

Requirements by the state of Kansas for aquifer recharge, subsurface storage, and recovery vary with the quality of the diverted water source as shown in Table III-1. Alternatives which divert surface water flows will require the City to apply for additional water rights to pump water from the river, maintain minimum desired stream flows, obtain additional water rights to pump stored water from the aquifer, construct additional wells as needed, and possibly treat the diverted water. Other alternatives (such as bank storage or rain harvesting) will require the City to obtain additional water rights to pump stored water from the aquifer, to construct additional wells as needed, and possibly treat the diverted water.

Table III – 1

AQUIFER RECHARGE, SUBSURFACE STORAGE, AND RECOVERY
KANSAS STATE BOARD OF AGRICULTURE, DIVISION OF WATER RESOURCES and
KANSAS DEPARTMENT OF HEALTH AND ENVIRONMENT REQUIREMENTS

Potential Source	Water Transfer Act	Minimum Desired Streamflow (MDS)	Additional Water Rights for Well Field	New Facilities (1)	Diverted Water Quality Requirements
Cheney Reservoir Overflow	Not Applicable	Ranges from 5 to 50 cfs downstream of Cheney Reservoir	Required	Additional Facilities may be required	To be Determined by KDHE
Little Arkansas River (During High Flows)	Not Applicable	25 cfs at Valley Center Gage	Required	Additional Facilities may be required	To be Determined by KDHE
Arkansas River (During high flows)	Not Applicable	No MDS at this time	Required	Additional Facilities may be required	To be Determined by KDHE
Gray Water	Not Applicable	Not Applicable	Required	Additional Facilities may be required	To be Determined by KDHE
Potable Water	Not Applicable	Not Applicable	Required	Additional Facilities may be required	To be Determined by KDHE
Bank Storage	Not Applicable	Not Applicable	Required	Additional Facilities may be required	To be Determined by KDHE
Rain Harvesting	Not Applicable	Not Applicable	Required	Additional Facilities may be required	To be Determined by KDHE

Notes:
(1) Additional facilities may be required to pump diverted water from storage to the water plant.
(2) City must prove hydraulic validity of the recovery system. City must recover the same water they diverted into storage.

Recharge water quality requirements are handled on a case by case basis by the Kansas Department of Health and Environment (KDHE). Surface water sources applied to surface spreading basins or infiltration galleries will probably require sedimentation treatment. Other sources, groundwater, reclaimed water, and potable water applied to surface spreading basins or infiltration galleries may not require any treatment. Water sources with high chloride concentrations may require blending with low chloride water or membrane filtration treatment. Water sources injected into the aquifer must meet more stringent water quality criteria due to the lack of soil-aquifer treatment.

4. INFILTRATION METHODS

Variables such as soil type, permeability, transmissivity and storativity will be used to determine the ability of the soils in the Equus Beds and Local Well Fields to recharge. Preliminary information indicates these soils may be suitable for the construction of infiltration galleries, surface spreading basins, or injection wells.

Surface spreading is the simplest, oldest and most widely applied means of artificial recharge. It requires a large land area but maintenance is typically simple and soil-aquifer treatment is provided. Additionally, recharge areas can be placed in the vicinity of the most severe depletions of groundwater. Typical problems with this method include the following:

- Creation of standing water for mosquitos and other insects.
- Clogging of recharge area by biofouling or sediment buildup.

Infiltration galleries or trenches also offer the advantages of soil-aquifer treatment and recharging areas where the groundwater depletion is most severe. Infiltration galleries have similar problems as surface spreading with respect to nuisance insects in standing water and clogging of the recharge area.

Injection wells may be used when water quality is relatively free of suspended solids. Such wells are also used where surface spreading is impractical due to land requirements or where a freshwater barrier is needed. Typical problems with this method include recharge area clogging and a potential for high maintenance. A higher quality recharge water is generally required due to the lack of soil-aquifer treatment.

E. TREATED WASTEWATER REUSE

Categories of treated wastewater reuse with potential uses and constraints are shown on Table III-2. Treated wastewater (or reclaimed water) reuse is suited for applications not requiring potable water quality, such as, irrigation, industrial cooling and process water, groundwater recharge, groundwater remediation and other uses. Alternative methods to reuse treated wastewater are shown in Figure III-4. Reuse can directly reduce potable water use and, in turn, reduce the need for additional raw water supply and treatment facilities. The potential for use of reclaimed water will typically be the greatest during summer months when irrigation is required and the highest demands are experienced by the water system.

Table III – 2

CATEGORIES OF MUNICIPAL WASTEWATER REUSE AND POTENTIAL CONSTRAINTS

Reuse Category	Potential Uses	Potential Constraints
Agricultural Irrigation	crop irrigation commercial nurseries	Effect of water quality, particularly salts, on soils and crops Public health concerns related to pathogens (bacteria, viruses and parasites) Surface and ground water pollution if not properly managed Marketability of crops and public acceptance
Landscape Irrigation	park school yard freeway median golf course cemetery greenbelt residential	Public health concerns related to pathogens (bacteria, viruses, and parasites) Surface and groundwater pollution if not properly managed Public acceptance
Industrial Reuse	cooling boiler feed process water (non–potable) heavy construction	Reclaimed wastewater constituents related to scaling, corrosion, biological growth, and fouling Public health concerns, particularly aerosol transmission of organics, and pathogens in cooling and boiler feed
Groundwater Recharge	groundwater replenishment salt water intrusion subsidence control	Organic chemicals in reclaimed wastewater and their toxicological effects Total dissolved solids, metals, and pathogens in reclaimed wastewater
Recreational/ Environmental Uses	lakes and ponds marsh enhancement streamflow augmentation fisheries snowmaking	Health concerns of bacteria and viruses Eutrophication due to nitrogen and phosphorous
Nonpotable Urban Uses	fire protection air conditioning toilet flushing	Public heatlh concerns about pathogens transmitted by aerosols Effects of water quality on scaling, corrosion, biological growth, and fouling
Potable Reuse	blending in water supply pipe to pipe water supply	Organic chemicals in reclaimed wastewater and their toxicological effects Esthetics and public acceptance Public health concerns on pathogen transmission including viruses

Note:
(1) Arranged in descending order of volume of use.

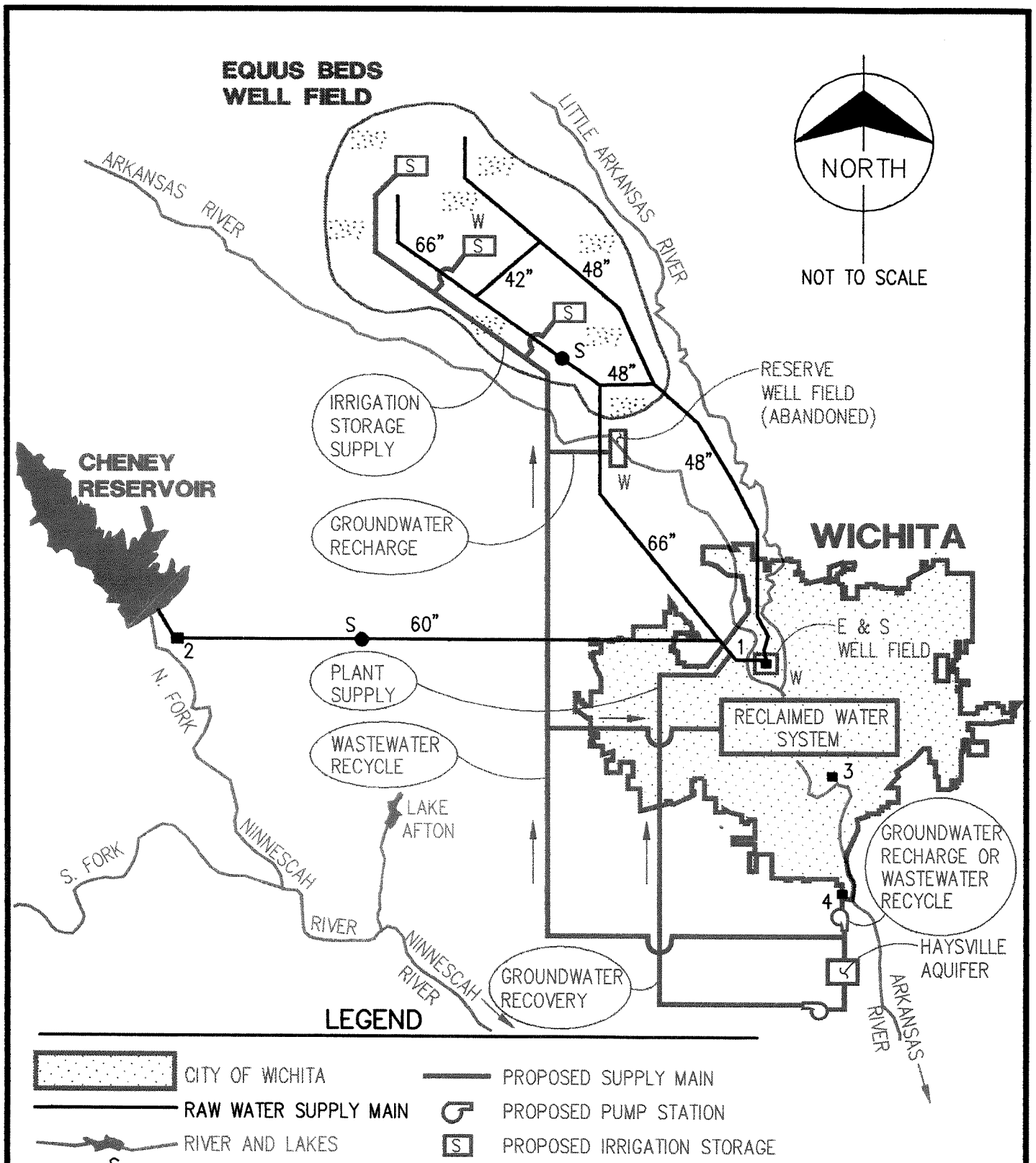

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Figure III - 4

TREATED WASTEWATER REUSE ALTERNATIVES SCHEMATIC

1. WASTEWATER EFFLUENT QUALITY

Wastewater Treatment Plant No. 2 in the southernmost city limits provides primary treatment to about 25 percent of the City's sanitary sewage and secondary treatment to all of the City's wastewater. Plant No. 2 utilizes screening, grit removal, primary clarification, trickling filters, intermediate clarification, aeration, final clarification, chlorination, sulfur dioxide dechlorination, static flow reaeration and sludge processing treatment processes. These processes result in an excellent quality effluent which meets all state standards for discharge into the Arkansas River; however, the KDHE may require the City to construct denitrification facilities in the near future to reduce the nitrate load being discharged to the river.

Effluent water quality data for Plant No. 2 for 1990 and 1991 are listed in Table III-3 (refer to Appendix E for monthly effluent quality data for 1991 and 1992, and influent quality data). The average chloride concentrations of the plant effluent is about 200 mg/l.

The concentration of fecal coliforms is the primary water quality parameter used by KDHE to determine the potential for wastewater reuse. From May 1 to October 31, when use of irrigation water is high, Plant No. 2 typically discharges an effluent ranging from 33 to 64 fecal colonies per 100 ml. This level is slightly higher than the State's permitted limit of 20 colonies per 100 ml for unrestricted access, but is well below the state's permitted limit of 200 colonies per 100 ml for restricted access. Boosting chlorine concentrations may reduce the fecal coliforms below 20 colonies per 100 ml.

Table III – 3

WASTEWATER TREATMENT PLANT No. 2
EFFLUENT WATER QUALITY

Parameter	Units	1990	1991		
		Average	Average	Maximum	Minimum
Flow	MGD	39.70	42.80	46.36	38.30
Fecal Coliforms	MPN/100 ml	–	5,144	27,758	33
Chlorides	mg/l	191	214	472	155
pH	standard	–	6.7	6.9	6.5
TSS	mg/l	7.0	8.8	19.0	2.2
BOD	mg/l	14.0	6.8	–	–
COD	mg/l	51	36	65	26
DO	mg/l	–	8.6	11.0	7.6
Nitrite	mg/l	0.273	0.182	1.399	0.011
Nitrate	mg/l	15.150	21.282	24.704	19.400
Ammonia	mg/l	3.980	0.647	2.005	0.130
Phosphates	mg/l	6.50	4.99	6.08	3.39
Surfactants	mg/l	0.45	0.33	0.54	0.18
Phenols	mg/l	0.00	0.00	–	–
Pesticides	ug/l	ND	ND	ND	ND
Metals:					
Cadmium	mg/l	0.06	0.00	0.10	0.00
Copper	mg/l	0.02	0.01	0.02	0.00
Chromium	mg/l	0.11	0.01	0.03	0.00
Chromium 6	mg/l	–	0.08	0.31	0.00
Lead	mg/l	0.01	0.02	0.05	0.00
Mercury	ug/l	0.18	0.07	0.29	0.00
Nickel	mg/l	0.02	0.05	0.44	0.00
Zinc	mg/l	0.04	0.03	0.07	0.01
Arsenic	ug/l	2.919	2.504	6.470	0.000
Cyanide	mg/l	0.069	0.045	0.107	0.012
Silver	mg/l	–	0.0	0.1	0.0

Note:
(1) – = data not available
(2) ND = not detected
(3) MPN = Most Probable Number

2. STATE OF KANSAS REUSE GUIDELINES

KDHE developed guidelines for the use of reclaimed water (treated wastewater) about 10 years ago as shown in Table III-4. These guidelines set maximum basic limits on two key parameters associated with reuse, fecal coliforms and chorine residual, for restricted public access and nonrestricted public access cases.

Restricted public access during irrigation requires an average monthly fecal coliform level below 200 colonies per 100 ml with a monthly maximum not exceeding 400 colonies per 100 ml. These levels can be met with the existing processes at Plant No. 2; however, it may be difficult to maintain enforced restricted access to irrigation areas such as parks and golf courses.

The case for nonrestricted public access during irrigation requires an average monthly fecal coliform level below 20 colonies per 100 ml with a monthly maximum not exceeding 40 colonies per 100 ml. These levels are below those being produced with the existing processes at Plant No. 2. The addition of filters at Plant No. 2 would probably be required to meet these levels.

3. POTENTIAL USERS AND QUANTITIES

City parks and golf courses which may be potential users of treated wastewater are listed in Table III-5 with estimated quantities of irrigation water. The location of these potential users and the existing wastewater treatment plants are shown in Figure III-5. The City currently has over 40 parks and golf courses as well as several

Table III – 4

STATE OF KANSAS
GUIDELINES FOR REUSE OF TREATED DOMESTIC WASTEWATER SUMMARY

Management Practice	Acceptable Situations	Testing Requirements and Limits			
		Disinfection Technique	Residual (mg/l)	Maximum Fecal Coliforms (colonies/100 ml)	
				Monthly Average	Monthly Maximum
Restricted public access during irrigation	Golf Courses Ball Fields Parks Cemetaries Recreational Areas Highway Medians Other "green" Areas	Chlorination	0.1(free) 1.0(combined)	200	400
		Ultraviolet	NA	200	400
Non–restricted public access during irrigation	Golf Courses Ball Fields Parks Cemetaries Recreational Areas Highway Medians Other "green" Areas	Chlorination	0.1(free) 1.0(combined)	20	40
		Ultraviolet	NA	20	40

Note:
(1) Additional guidelines include permits, signs, monitoring, and no cross connections.

Table III – 5

IRRIGATION POTENTIAL AT CITY PARKS AND GOLF COURSES WHICH USE CITY WATER

Sample Golf Courses & Parks	Is your water use monitored?	Is there a conservation program?	Do you need a particular quality of water?	Do you have another source of water?	Are you making changes to reuse or conserve water?	Usage Average Day in Gallons	Usage Maximum Day in Gallons	Acreage	Turf Type	Application Rate
Clapp Park Golf Course	Yes	Employee education and equipment modifi-cation.	Fecal coliform max. 200/ml.	No	Rain shut-offs, change grass types, enhance cultural practices, &	145,000	870,000	70	Bent, Rye, Blue and Bermuda	1/4" to 1/2" per day
Country Place Greens (Home Owners Assoc.)						40,000	240,000			
K-96 Expressway	Landscaping	not yet installed, est. water	requirement 15,500,000 for	93, 94, 95; 10,400,000	gal. annually beg. in 1996.	35,000	210,000			
Lakepoint (Home Owners Assoc.)						90,000	540,000			
McAdam Park	Yes	Partly (3 acres) converted to auto. night watering	Fecal coliform max. 200/ml.	No		10,000	60,000	8	Fescue	1/4" to 1/2" per day
McConnell AFB Golf Course	No	Do not water rough	Fecal coliform max. 200/ml.	Ponds	Will cut back time by 20% this year.	60,000	360,000	30	Bent, Rye & Blue	Dont' know
McDonald Golf Course	Yes	Employee education and equipment modifi-cation.	Fecal coliform max. 200/ml.	No	Rain shut-offs, change grass types, enhance cultural practices, & night watering only.	140,000	840,000	72		
Plainview Park	Yes	Converted to automatic night watering	Fecal coliform max. 200/ml.			15,000	90,000	4	Fescue, Blue & Rye	1/4" to 1/2" per day
Tallgrass East (Home Owner's Association)						20,000	120,000			
Tallgrass Golf Course	Yes	Monitoring, employee educ., recycling, good maintnance, night watering, & minimize runoff.	Must be suitable for turf, can use gray water, fecal coliform maximum 200/ml.	Ponds		145,000	870,000	70	Bent, Blue and Rye	
Terradyne Golf Course	Yes	Monitoring, employee educ., recycling, reuse cooling tower water, equip. modification.	Prefer low sodium, non toxic; can use gray water, fecal coliform max. 200/ml.	Holding ponds, 4 wells, & rural water district	Would like to use gray water from 4 Mile Creek Treatment Plant	65,000	390,000			
Wichita Country Club Golf Course						60,000	360,000			
WSU Golf Course	Yes	Burmuda Fairways	Can use gray water, fecal coliform max. 200/ml.	No		65,000	390,000	50	Bermuda, Rye Fescue & Bent	1/4" to 1/2" per day
Willowbend Golf Course	Yes	Monitoring, employee ed., recycling, reuse cool. tower & runoff, equip. mod., wetting agents, less pesticides & fertil., adj. mowing.	Can use gray water, fecal coliform max. 200/ml.	Ponds	Are planning to construct more ponds.	155,000	930,000	75	Bent, Rye, Blue, Zoysia & Fescue	

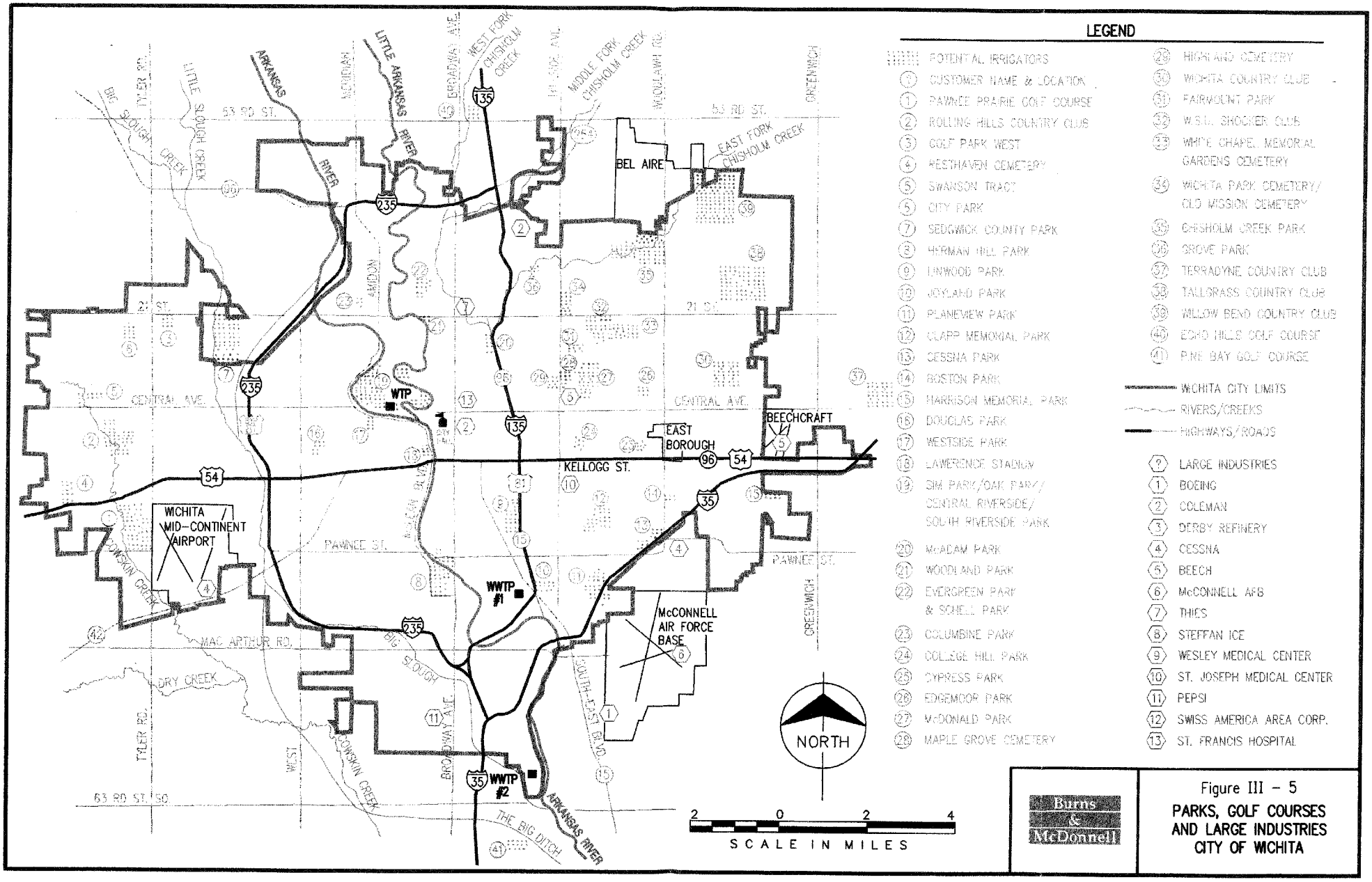

Figure III - 5
PARKS, GOLF COURSES AND LARGE INDUSTRIES CITY OF WICHITA

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industries which might be able to use reclaimed water instead of potable water for many applications.

In 1991, over 200 industrial water customers used 10.1 MGD of potable water on an average day demand basis or 16 percent of the total system average day water demand of 62.2 MGD. The average water use per customer was 50,500 gallons/day. Thirteen of the larger industrial water users are shown in Figure III-5 which have an average day water use totaling 7.7 MGD as shown in Table III-6. The primary uses of water from the City's water system by industry are process water, cooling water, potable water and irrigation water.

By comparison, in 1991 over 10,300 commercial customers used 16.7 MGD on an average day demand basis or 27 percent of the total system average day water demand. The average use per customer was 1,620 gallons/day. The primary uses of water from the City's water system by commercial establishments are potable water, irrigation water and cooling water.

Several local industries and commercial establishments could be potential users of the reclaimed water through reclaimed water systems for irrigation, cooling waters and other nonpotable water uses. However, to date, few industries have expressed an interest in using reclaimed water. This may stem from the fact that industries are already conserving potable water in order to reduce operating costs associated with potable water supply and industrial waste pretreatment. Additionally, costs for converting piping and modifying processes to accommodate reclaimed water use and the possibility for inadvertent

Table III – 6

WATER USE BY LARGE INDUSTRIES

Industry Name	1991 Average Use (MGD)	Industry Type
Boeing	2.571	Aircraft Manufacturing
Coleman	1.164	Manufacturer
Cessna	0.928	Aircraft Manufacturing
Derby/Coastal (1)	0.790	Refinery
Thies	0.647	Packing Company
McConnell AFB	0.367	Air Force Base
St. Joseph	0.222	Medical Center
Pepsi	0.219	Soft Drink Bottling
Wesley	0.205	Medical Center
Steffen Dairy	0.165	Dairy Products
Swiss America Avia Corp	0.161	Lear Jet
Beech	0.152	Aircraft Manufacturing
St. Francis Hospital	0.149	Medical Center
Total:	7.74	

Note:
(1) The Derby/Coastal Refinery will be closed in 1993 and the demand of the remaining facilities will be about 0.144 MGD.

cross connections may be preventing some industries from pursuing this option.

The results of an industrial survey to gather data on the potential for water conservation and use of reclaimed water for nonpotable water applications is shown in Table III-7. One progressive industry, Coleman Industries, is considering the installation of a cooling tower which will use less water and save about 1 MGD in potable water. Other significant water savings or applications of reclaimed water use do not appear to be feasible at this point in time.

Equus Beds irrigators, which used 26,292 acre-feet (23.5 MGD) of water in Sedgwick County in 1988, are another potential user of reclaimed water. Reclaimed water could be traded to the irrigators in return for their groundwater rights. Reclaimed water could be provided from Wastewater Treatment Plant No. 2, which discharges an average of approximately 40 MGD. Additionally, a new peripheral package wastewater treatment plant of 2 to 5 MGD± capacity in the upper Chisholm Creek drainage basin might be constructed with the plant effluent used for irrigation water by new developments in the north part of the City.

Chloride concentrations in wastewater effluent, which average about 200 mg/l, must be considered when irrigating crops and cropland with reclaimed water. Waters with chloride levels between 140 and 350 mg/l may have slight to moderate restrictions on their use. The major crops grown in the Equus Beds, wheat, alfalfa and soybeans, are moderately sensitive to chlorides. The Equus Beds Groundwater Management District

Table III – 7

INDUSTRIAL WATER USE SURVEY

Sample Industry	Is your water use monitored?	Is there a conservation program?	Do you need a particular quality of water?	Do you have another source of water?	Are you making changes to reuse or conserve water?
Beech	Yes	No formal program.	Yes	Lake and wells	–
Boeing	Yes	Yes, water use monitoring, employee ed., recycling, reuse of cooling tower water, and equipment modification.	No	Unused Well	Yes, Task Team working on ways to conserve.
J.I. Case	Yes	Yes, reuse of process water and reuse of cooling tower water.	No	No	Yes, changes are being considered.
Cessna	–	–	–	–	–
Coastal Derby	–	–	–	–	–
Coca Cola	–	–	–	–	–
Coleman	Yes	Employee education, cooling tower water reuse, and monitoring	For new chillers. No gray water.	No	Making a concerted effort.
Lear Jet	–	–	–	–	–
Pepsi Cola	–	–	–	–	–

Note:
(1) Cessna, Coastal, Coca Cola, Lear Jet, and Pepsi opted not to participate in the survey.

No. 2 Management Plan dated July 1, 1990 sets a maximum chloride concentration of 500 mg/l for irrigation. Preliminary discussions with the state indicate that the chloride concentrations in the range of 200 mg/l should not be a problem for irrigation.

Another use for reclaimed wastewater is direct recycling. This process involves pumping some quantity of reclaimed water back to the head of the water treatment plant for blending and treatment with raw water from Cheney Reservoir and the Equus Beds. Direct recycling is often perceived as aesthetically displeasing and unacceptable by the public and is normally considered undesirable by public health officials. However, indirect recycle of reclaimed water through recharge of aquifers or discharge to reservoirs is gaining acceptance in many parts of the country because of the limited quantity of unused fresh water sources.

Dual water systems for potable water and reclaimed wastewater effluent is another method which can be used. Such systems require strict adherence to plumbing codes, construction specifications and backflow prevention to eliminate the possibility of contamination of the potable water system. A reclaimed water system is typically used to supply irrigation or cooling water needs. These systems are becoming increasingly popular in southern Florida and the Southwestern United States where water supplies are limited. Many cities in these regions have adopted ordinances requiring dual water systems for new subdivisions when reclaimed water is made available for use.

F. GILBERT MOSLEY GROUNDWATER REMEDIATION

The Gilbert-Mosley area in downtown Wichita is a 6 square-mile site where the groundwater was contaminated with TCE. The area is being studied with remediation methods to be designed and constructed in the near future. The groundwater, once remediated, could serve as a reclaimed water supply for irrigation or cooling water needs. Water quality is expected to be similar to the Local (E&S) Well Field and a continuous supply of 3 MGD is expected.

G. CESSNA GROUNDWATER REMEDIATION

The Cessna groundwater remediation area is a 0.5-square-mile site adjacent to the southeast corner of the Mid-Continent Airport where the groundwater was contaminated by TCE. The groundwater is being remediated via 5 wells, along Hoover Road between MacArthur Road and 31st Street South, and a VOC stripper tower at a rate of about 1000 gpm. Remediation is expected to be completed in the next 5 to 10 years.

Because the remediated water is discharged to a ditch, consideration was given to pumping the remediated water to the Pawnee Prairie Golf Course and Rolling Hills Country Club for irrigation. However, these golf courses are about 5 miles from the remediation site, and this distance may limit the economic feasibility of such a project particularly since the wells are to be abandoned in the next 5 to 10 years.

* * * * *

Part IV - Regional Water Balance

PART IV

REGIONAL WATER BALANCE

A. GENERAL

This section of the report describes the regional water balance for the City of Wichita's anticipated water service area. The total water supply available within the study area is compared to projected water demands and the net water needs are determined throughout the study period from year 2000 to year 2050. Information used in this section includes water demand projections from Part I, conventional water supply capacity from Part II, and nonconventional water supply potential from Part III.

B. PROJECTED WATER DEMAND

Projected water demands for the water supply study are shown in Table IV-1 and include year 2050 projections of 125 MGD for the average day demand and 249 MGD for the maximum day demand. The recommended projection is based on expansion of the service area, an intermediate rate of growth, a maximum day to average day factor of 2.0 and a low range water conservation program as described in Part I.

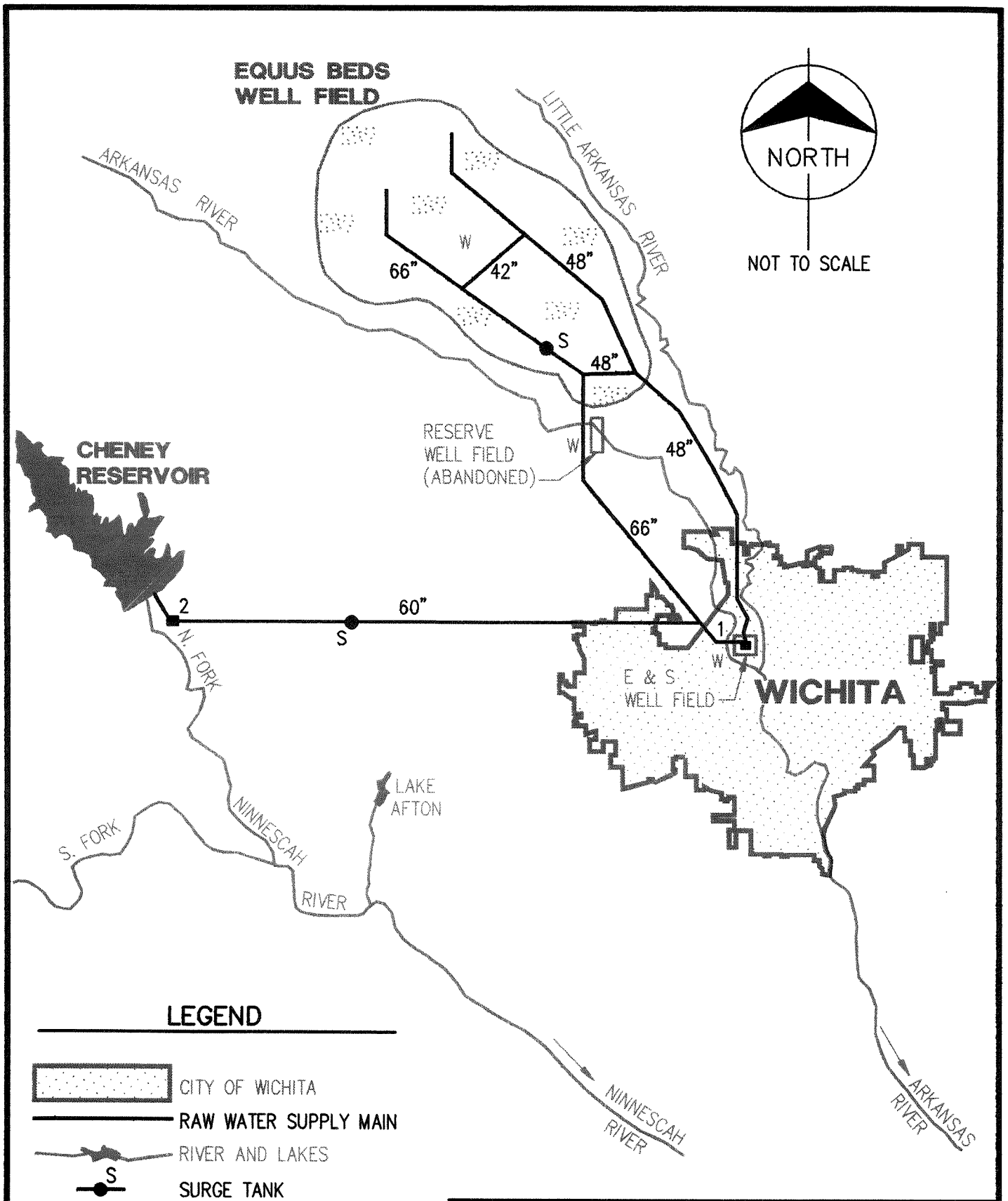
C. EXISTING WATER SUPPLIES

The City currently uses water from Cheney Reservoir, the Equus Beds Well Field and the Local (E&S) Well Field as shown in Figure IV-1. Existing and pending water rights for these supplies, based on a firm yield of 38.2 MGD for Cheney Reservoir, total 90 MGD for an average day (79 MGD from existing sources and 11 MGD from undeveloped available sources) and 195 MGD for a

Table IV – 1

RECOMMENDED WATER DEMAND PROJECTIONS
FOR WATER SUPPLY STUDY

Year	Demand Projections Without Conservation		Projected Low Range Conservation Savings	Recommend Demands With Conservation	
	Average Day Demand	Maximum Day Demand		Average Day Demand	Maximum Day Demand
2000	83.0	166.0	11.4	71.6	143.2
2010	98.3	196.6	13.2	85.1	170.2
2020	111.4	222.8	14.8	96.6	193.2
2030	121.0	242.0	15.9	105.1	210.2
2040	131.9	263.8	17.2	114.7	229.4
2050	143.0	286.0	18.5	124.5	249.0



LEGEND

- CITY OF WICHITA
- RAW WATER SUPPLY MAIN
- RIVER AND LAKES
- S — SURGE TANK
- W — WELL FIELD
- 1 ■ WATER TREATMENT PLANT
- 2 ■ CHENEY RESERVOIR PUMP STATION

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Figure IV – 1

RAW WATER SUPPLY SYSTEM SCHEMATIC

maximum day (171 MGD from existing sources and 24 MGD from undeveloped available sources) as shown in Table IV-2.

Currently, the City is unable to supply 100 percent of their existing and pending water rights to the water treatment plant due to hydraulic restrictions in their system. Future pumping capacity assumes the construction of additional piping, wells, and pump stations necessary to supply the existing and pending water rights on a firm capacity basis.

D. NET WATER NEEDS

Net water needs are the total water demand projections less the firm yields of potential water source alternatives as listed in Table IV-3 and shown in Figure IV-2. Based on 100 percent utilization of existing and pending water rights and a firm yield of Cheney Reservoir of 38.2 MGD, the year 2050 net needs are approximately 35 MGD for the average day and 54 MGD for the maximum day. With 100 percent utilization of water rights, review of Figure IV-2 shows an average day usage deficit occurring about year 2023 and a maximum day usage deficit occurring about year 2033. By contrast, based on firm yield an average day usage deficit would occur about year 2015 and the maximum day usage deficit would occur about year 2021.

E. SUMMARY OF POTENTIAL WATER SUPPLIES

Nineteen conventional and six nonconventional water sources which are being evaluated as potential additional water supplies to the City are shown in Figure IV-3 and Table IV-4. Detailed descriptions of each supply are presented in Tasks II and III. Two alternatives, the El Dorado and Marion Reservoirs, appear to have insufficient available yield and are not

Table IV – 2

WATER SUPPLY NET NEEDS SUMMARY

	Water Rights		Existing Pumping Capacity		Potential Pumping Capacity	
	Average Day (MGD)	Maximum Day (MGD)	Average Day (MGD)	Maximum Day (MGD)	Average Day (MGD)	Maximum Day (MGD)
Projected Year 2050 Usage with Low Range Conservation	125	249	125	249	125	249
– Existing Supply Sources (1)	– 79	– 171	– 78	– 130	– 79	– 171
Net Need Subtotal	46	78	47	119	46	78
– Undeveloped Available Sources (2)	– 11	– 24	– 0	– 0	– 11	– 24
Required Net Need	35	54	47	119	35	54

Notes:

(1) Existing Supply Sources include Cheney Reservoir, Equus Beds Wells, and Local (E&S) Wells.

(2) Undeveloped Available Sources include additional supplies from Cheney Reservoir up to a firm yield of 38.2 MGD. Based on water rights for Cheney Reservoir 47 MGD, the average day required net need is 26 MGD and the maximum day required net need is 35 MGD.

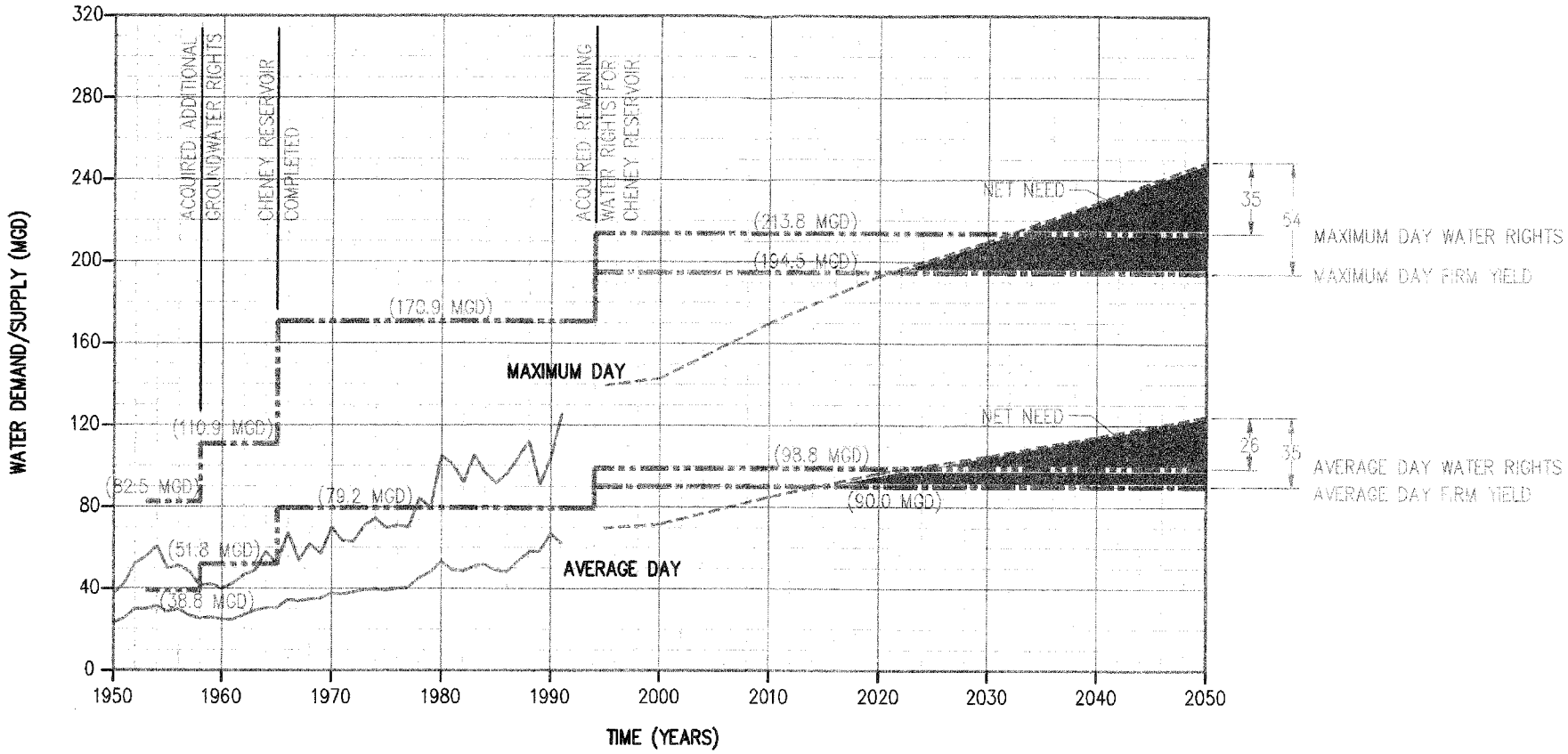
Table IV – 3

NET WATER NEEDS

Year	Average Day Demand (MGD)	Average Day Supply (MGD)	Average Day Net Need (MGD)
2000	72	90	–18
2010	85	90	–5
2020	97	90	7
2030	105	90	15
2040	115	90	25
2050	124	90	34

Year	Maximum Day Demand (MGD)	Maximum Day Supply (MGD)	Maximum Day Net Need (MGD)
2000	143	195	–52
2010	170	195	–25
2020	193	195	–2
2030	210	195	15
2040	229	195	34
2050	249	195	54

Notes:
(1) Based on projections developed in Part I.
(2) Based on existing and pending water rights adjusted for a firm yield of 38.2 MGD for Cheney Reservoir.
(3) Minus sign indicates surplus.



LEGEND

- WICHITA HISTORICAL DATA (AVERAGE DAY DEMAND AND MAXIMUM DAY DEMAND)
- B&McD INTERMEDIATE PROJECTION WITH INTERMEDIATE POPULATION GROWTH AND LOW RANGE CONSERVATION (RECOMMENDED)
- SUPPLY CAPACITY BASED ON EXISTING AND PENDING WATER RIGHTS (AVERAGE DAY OR MAXIMUM DAY)
- SUPPLY CAPACITY BASED ON FIRM YIELD (AVERAGE DAY OR MAXIMUM DAY)

NOTES:
1. MAXIMUM DAY USE PROJECTION IS BASED ON A 2.0 MAXIMUM DAY/AVERAGE DAY FACTOR
2. THE STATE OF KANSAS STARTED REQUIRING WATER RIGHTS IN 1953
3. NEAR TERM IMPROVEMENTS AND ADDITIONAL IMPROVEMENTS TO CHENEY RESERVOIR AND EQUUS BEDS WELL FIELD ARE REQUIRED TO PUMP FULL WATER RIGHTS

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Figure IV – 2

PROJECTED NET WATER NEEDS

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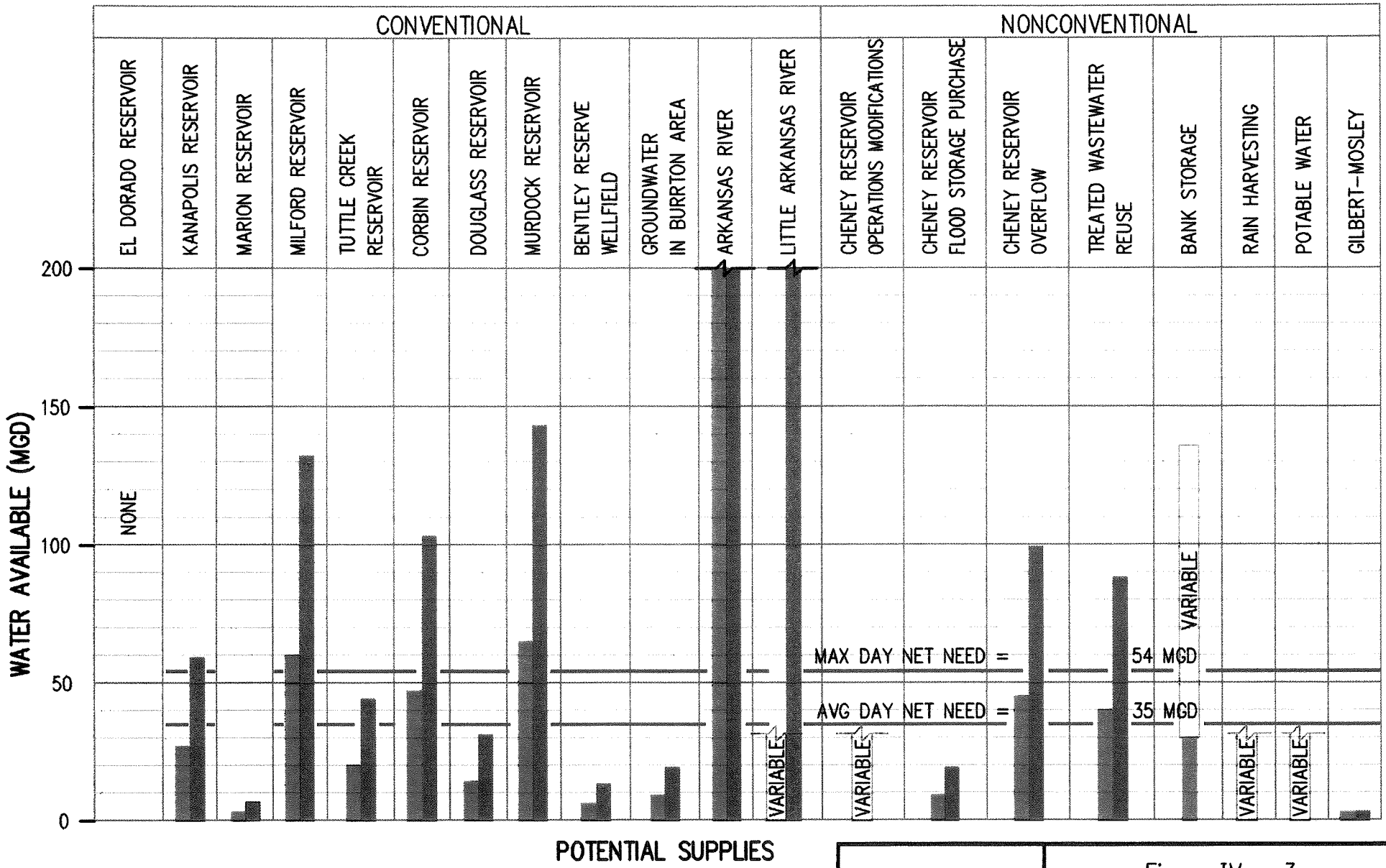

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Figure IV – 3

POTENTIAL WATER SUPPLY SUMMARY

Table IV – 4

POTENTIAL WATER SUPPLY SUMMARY

Alternative Type	Supply Source	Firm Yield	Comments
Conventional	El Dorado Reservoir	12 MGD ± Firm Yield	Existing. No water rights available
Conventional	Kanapolis Reservoir	27 MGD ± Firm Yield	Existing. 27 MGD water rights available; Raise Dam 25 feet to increase yield to 44 MGD
Conventional	Marion Reservoir	3 MGD ± Firm Yield	Existing. 3 MGD water rights available
Conventional	Milford Reservoir	85 MGD ± Firm Yield	Existing. 60 MGD water rights available
Conventional	Tuttle Creek Rservoir	163 MGD ± Firm Yield	Existing. 20 MGD water rights available
Conventional	Corbin Reservoir	47 MGD ± Firm Yield	Proposed Reservoir
Conventional	Douglass Reservoir	14 MGD ± Firm Yield	Proposed Reservoir
Conventional	Murdock Reservoir	65 MGD ± Firm Yield	Proposed Reservoir
Conventional	Equus Beds Groundwater (Option No. 1)	Variable	City must purchase existing water rights. City is awaiting state approval to contract for 2,000 acre–feet of water rights.
Conventional	Equus Beds Groundwater (Option No. 2)	9 MGD	Equus Beds Special Water Quality Use Area north of Burrton. Chloride concentrations of about 8,000 mg/L. Blend with other sources. Potential long–term supply source.
Conventional	Equus Beds Groundwater (Option No. 3)	10 MGD	Burrton Intensive Groundwater Use Control Area south of Burrton. Chloride concentrations of about 8,000 mg/L. Blend with other sources. Potential long–term supply source.
Conventional	Haysville Groundwater	Variable	Alluvial desposits of Arkansas River near Haysville. Chloride concentrations of up to 450 mg/L. Blend with other sources. Potential long–term supply source. City must purchase water rights.
Conventional	Abandoned Reserve Wellfield	13 MGD	Original capacity. Poor water quality, high chloride levels.
Conventional	Arkansas River Intake and Pump Station	–	Low firm yield, < 26 MGD, with associated very poor quality (high chloride levels)
Conventional	Little Arkansas River Intake and Pump Station	0 MGD Firm Yield	2 % availablity of water is 13 MGD ± which is equal to minimum desired streamflow at Valley Center. Potential source on an as available basis.

Table IV – 4 (continued)

POTENTIAL WATER SUPPLY SUMMARY

Alternative Type	Supply Source	Firm Yield	Comments
Conventional	Little Arkansas River Intake and Pump Station (Continued)	184 MGD ± Annual Mean (1922–1991)	Availability is variable. Could pump during rain events based on a preset Valley Center streamflow, from a proposed intake and pump station upstream of the low flow dam and adjacent to the water plant.
Conventional	Cheney Reservoir Operations/ Management Modifications	0 MGD Firm Yield	Requires lowering conservation pool elevation on reservoir. May increase yield in wet years and decrease yield in dry drought years. Requires an operations study to determine additional quantities.
Conventional	Purchase flood stroage in Cheney Reservoir	Up to 8.8 MGD ±	Requires installation of an additional spillway, potential relocation of state park facilities, and other items to purchase flood storage for conservation storage.
Nonconventional	Cheney Reservoir Overflow	0 MGD Firm Yield Average 45 MGD ±	Availablitiy is variable. Overflow may not be available when demands are high. Demand decreases during a rainfall event. Additionally, overflow may be too large to capture. Potential uses for this water include direct pipeline to water plant, side storage reservoir, and subsurface storage and recovery.
Nonconventional	Treated Wastewater Reuse	Average 40 MGD ±	Available at Wastewater Plant No. 2. Potential uses for effluent are irrigation, industrial uses, direct reuse and subsurface storage and recovery.
Nonconventional	Bank Storage of Little Arkansas River excess streamflows	0 MGD Firm Yield average 12,000 – 50,000 MG/Year	Use water for subsurface storage and recovery operation
Nonconventional	Rain Harvesting	0 MGD firm yield	Large land purchases required. Collect 0.33 MG per acre per foot of rainfall
Nonconventional	Subsurface Storage and Recovery of Potable Water	Up to about 18,250 MG/Year	Treat excess flow, when available, and recharge aquifer for retrieval at a later date.
Nonconventional	Gilbert–Mosley Remediated Groundwater	3 MGD	Continuous supply
Conventional	No Action	–	Reduces year 2050 maximum day demand 23 MGD by limiting growth (no new wholesale customers)

considered to be viable options for future water supply to the City. El Dorado Reservoir has no available water and Marion Reservoir has a very low yield, about 3 MGD, and is over 40 miles away from the City's water plant.

The following alternatives are believed to be capable of meeting all or a part of the City's net water need and, therefore, should be carried forward in the study to undergo an alternatives screening evaluation in Part VI.

- Kanopolis Reservoir (existing)
- Milford Reservoir (existing)
- Tuttle Creek Reservoir (existing)
- Corbin Reservoir (proposed)
- Douglass Reservoir (proposed)
- Murdock Reservoir (proposed)
- Equus Beds Groundwater (3 options)
  - Haysville Groundwater
  - Reserve Wellfield
  - Burrton Area Groundwater
- Arkansas River Intake and Pump Station
- Little Arkansas River Intake and Pump Station
- Cheney Reservoir Operations/Management Modifications
- Cheney Reservoir Purchase of Flood Pool Storage
- Cheney Reservoir Overflow
- Treated Wastewater Reuse
- Bank Storage
- Rain Harvesting
- Potable Water Subsurface Storage
- Gilbert-Mosley Remediated Groundwater
- No Action

* * * * *

Part V - Evaluation Criteria

PART V

EVALUATION CRITERIA

A. GENERAL

This section of the report describes evaluation criteria that will be applied to each water supply alternative to guide the decision-making process involved in screening out undesirable alternatives and selecting viable alternatives for the City of Wichita. This criteria will be used in the development of alternatives in Part VI and in the evaluation of alternatives in Part VII. Major evaluation criteria will include the following:

- Water Supply Capability
- Water Quality
- Legal Issues
- Policy and Political Issues
- Future Availability
- Planning Horizons
- Environmental Issues
- Cost Estimates and Economic Comparisons

B. WATER SUPPLY CAPABILITY

Each potential water source alternative must have the capability to supply all or a part of the projected year 2050 net needs for the average day demand and the maximum day demand. Water supply capability may be indicated by the following terms:

- Firm Yield
- Safe Peaking Ability
- Ability to Meet Demands
- Water Rights
- Conjunctive Use
- Peak Nonpotable Use Criteria

The interpretation of several terms may vary slightly depending on whether a surface water, groundwater or reclaimed water source is involved.

1. FIRM YIELD

The firm yield of a surface water reservoir is sometimes considered to be the yield of the reservoir during the most severe drought of record as determined by a reservoir inflow/outflow operational study. Another approach is to consider the firm yield as one with a two percent chance of interruption as caused by a drought condition with a one-in-50-year recurrence cycle.

By contrast, the firm yield of a groundwater well is normally considered to be the pumping rate which will not cause incrustation or solidification damage to the aquifer formation (assuming adequate recharge from rainfall or rivers is available). Such yield is normally established by well screen entrance velocities and aquifer characteristics including water chemistry, rate of drawdown, and static groundwater level.

2. SAFE PEAKING ABILITY OR FIRM CAPACITY

"Safe" peaking ability may be determined by time of use or frequency of use or other conditions. For mechanical components, such as pumps or wells, "safe" peaking ability (or firm capacity) is figured as the available flow with the largest unit considered to be out of service. For systems with a large number of wells, such as the City's 55 wells in the Equus Beds, a larger number of mechanical units is often considered to be out of service at any given time for maintenance or emergency

repair. In this case, 10 percent of the units are considered to be out of service for planning purposes when considering "safe" peaking ability or firm yield.

3. ABILITY TO MEET DEMANDS

The ability of a water supply to meet total water demands (either collectively with other sources or as a separate project) will likely impact costs to a significant degree. Maximum use of existing water supply/treatment infrastructure is an important consideration in the development of alternatives for cost savings. Additionally, the ability of a supply(s) to be developed in stages (which allows costs to be delayed until demands increase) is another important consideration.

4. WATER RIGHTS

The Kansas Water Office permits annual average day and maximum day withdrawal rates or water rights for water supplies. These rates are typically based on firm yield; therefore, the permitted annual average day withdrawal rate allowed by the State is typically the firm yield. Review of the City's water rights shows the maximum day withdrawal rate is about 2.2 times the average day water right for Cheney Reservoir and the Equus Beds Well Field. This maximum to average day use factor will be considered in the evaluation of potential surface and groundwater supply alternatives.

5. INTEGRATED USE

Based on discussions with the State of Kansas, a integrated use permit could possibly be issued to the City, allowing the use of preset

quantities of water from groundwater and surface water sources. Such a permit would allow the City to manage the operations of their water supplies to maximize use of excess runoff from surface water sources with accompanying groundwater recovery and storage until needed during drought conditions.

6. PEAK NONPOTABLE USE CRITERIA

Use of treated wastewater effluent, storm water storage or remediated groundwater in a reclaimed water system could be used to reduce summer peak demands for potable water. Such a system(s) could be used to supply irrigation water to City parks, golf courses, or farm land and to supply nonpotable process water, cooling water, and irrigation water to large industries.

C. WATER QUALITY

The quality of raw water from a water supply alternative and the quality of treated or finished water desired by the City are important variables because the type and cost of water treatment can vary significantly with each alternative. All finished (or drinking) water quality must meet existing and pending regulations of the Safe Drinking Water Act Amendments as shown in Table V-1. Parameters such as chlorides, nitrates, atrazine, pesticides, etc. will be important since these constituents require special treatment processes for removal which will impact costs. Use of high-chloride groundwater, for example, may require raw water blending or reverse osmosis treatment and product blending to obtain acceptable chloride levels of under 250 mg/L.

Table V – 1

DRINKING WATER STANDARDS (1)

Contaminant	MCLG	MCL	Best Available Treatment Technology (BAT) and Comments (2)
Fluoride (3)	4	4	
Volatile Organics (VOCs)			Final Rule July 1987
Trichloroethylene	zero	0.005	BAT for all VOC's is PTS
Carbon Tetrachloride	zero	0.005	BAT for all VOC's except Vinyl Chloride is GAC
1,1,1–Trichloroethane	0.2	0.2	
1,2–Dichloroethane	zero	0.005	
Vinyl Chloride	zero	0.002	
Benzene	zero	0.005	
p–Dichlorobenzene	0.075	0.075	
1,1– Dichloroethylene	0.007	0.007	
Coliform & Surface Water Treatment			Final Rule June 1989, BAT is CSF, D
Total Coliform	zero	n/a	Coliform is based on presence/absence testing.
Turbidity	n/a	n/a	95 % of samples must be < 0.5 NTU
Giardia lamblia	zero	TT (4)	
Viruses	zero	TT	
Standard plate count	n/a	TT	
Legionella	n/a	TT	
Phase II			Final Rule January 1991, Phase II BAT include:
Tetrachloroethylene	zero	0.005	GAC, CSF, IE, RO, PTA, CC,ED
Chlorobenzene	0.1	0.1	
trans–1,2–Dichloroethylene	0.1	0.1	
cis–1,2–Dichloroethylene	0.07	0.07	
o–Dichlorobenzene	0.6	0.6	
Barium	2	2	
Cadmium	0.005	0.005	
Chromium (total)	0.1	0.1	
Mercury (inorganic)	0.002	0.002	
Nitrate	10	10	
Selenium	0.05	0.05	
Asbestos (fiber > 10um/L)	7 MFL	7 MFL	
Lindane	0.000	0.0002	
Methoxychlor	0.04	0.04	
Toxaphene	zero	0.005	
2,4–D	0.07	0.07	
2,4,5–TP	0.05	0.05	
Aldicarb	0.001	0.003	
Chlordane	zero	0.002	
Carbofuran	0.04	0.04	
Alachlor	zero	0.002	
Epichlorohydrin	zero	TT	

Table V – 1 (continued)

DRINKING WATER STANDARDS (1)

Contaminant	MCLG	MCL	Best Available Treatment Technology (BAT) and Comments (2)
Toluene	1	1	
PCBs	zero	0.0005	
Atrazine	0.003	0.003	
Acrylamide	zero	TT	
Dibromochloropropane (DBCP)	zero	0.0002	
1,2–Dichloropropane	zero	0.005	
Pentachlorophenol	zero	0.001	
Ethylene dibromide (EDB)		0.00005	
Xylenes (total)	10	10	
Removed from Initial Phase II List			
Silver			
Aluminum			
Molybdenum			
Vanadium			
Sodium			
Zinc			
Dibromomethane			
Added Phase II Contaminants			BAT are the same as for other Phase II Contaminants
Ethylbenzene	0.7	0.7	
Styrene	0.1	0.1	
Heptachlor	zero	0.0004	
Heptachlor epoxide	zero	0.0002	
Nitrite	1	1	
Aldicarb sulfoxide	0.001	0.004	
Aldicarb sulfone	0.001	0.002	
Lead and Copper (5)			Final Rule June 1991, BAT include pH, alkalinity, and calcium adjustment or the addition of corrosion inhibitors
Lead	zero	TT	
Copper	1.3	TT	
Phase V			BAT include GAC, CSF, LS, RO, PTA, IE, AA, Cl
Dichloromethane	zero	0.005	
1,2,4–Trichlorobenzene	0.07	0.07	
Hexachlorobenzene	zero	0.001	
Antimony	zero	0.006	
Nickel	0.1	0.1	
Thallium	0.001	0.002	
Beryllium	0.004	0.004	
Cyanide	0.2	0.2	
Endrin	0.002	0.002	
Dalapon	0.2	0.2	
Diquat	0.02	0.02	
Endothall	0.1	0.1	
Glyphosate	0.7	0.7	
Adipates (diethylphenyladipate)	0.5	0.5	

Table V – 1 (continued)

DRINKING WATER STANDARDS (1)

Contaminant	MCLG	MCL	Best Available Treatment Technology (BAT) and Comments (2)
2,3,7,8–TCDD (Dioxin)	zero	3E–08	
1,1,2–Trichloroethane	0.003	0.005	
Oxamyl	0.2	0.2	
Simazine	0.004	0.004	
PAHs (benzo(a)pyrene)	zero	0.0002	
Phthalates	zero	0.006	
Picloram	0.5	0.5	
Dinoseb	0.007	0.007	
Hexachlorocyclopentadiene	0.05	0.05	
Radionuclides (Proposed)			Proposed July 1991, Final expected April 1993
Radium 226	zero	20 pCi/L	IE, RO, LS
Radium 228	zero	20 pCi/L	IE, RO, LS
Beta particle and photon radioactivity	zero	4 mrem/yr	IE, RO
Uranium	zero	0.02	IE, RO, LS, CSF
Gross alpha particle activity	zero	15 pCi/L	
Radon	zero	300 pCi/L	AS
Sulfate (Proposed)	400/500	400/500	Interim secondary standard is 250 mg/L
Arsenic (Interim)	0.05	0.05	
Total Trihalomethanes (Interim) (6)	0.1		
Hardness			City of Wichita maintains hardness <110 mg/L,
Chloride			LS; Secondary interim standard = 250 mg/L. Wichita standard = 200 mg/L, IE, RO, ED
TDS			Intermin secondary standard = 500 mg/L, RO, ED
Iron			Interim secondary standard = 0.3 mg/L, CSF, LS

Notes:

(1) Source: USEPA. MCLG = Maximum Contaminant Level Goal, MCL = Maximum Contaminant Level

(2) PTS = Packed Tower Stripping, GAC = Granular Activated Carbon, CSF = Coagulation/ Sedimentation/Filtration, IE = Ion Exchange, RO = Reverse Osmosis, PTA = Packed Tower Aeration, CC = Corrosion Control, ED = Electrodialysis, LS = Lime Softening, AA = Activated Alumina, Cl = Chlorination, AS = Air Stripping.

(3) Indicates original contaminants with interimstandards which will be revised.

(4) Treatment technique requirement.

(5) Lead and Copper Rule is based on action levels of 0.015 mg/L lead and 1.3 mg/L copper at the consumer's tap.

(6) Part of the Disinfectant–Disinfection By–Products Rule currently going through the Negotiated Regulation process. Proposed rule is expected June 1993.

Water supply alternatives involving aquifer recharge may need treatment of recharge water to meet requirements by the Kansas Department of Health and Environment (KDHE). KDHE typically looks at each recharge application on a case-by-case basis with the general guideline that the recharge water should not degrade water quality in the aquifer. At this time, KDHE has no minimum water quality standards for aquifer recharge and subsurface storage.

D. LEGAL ISSUES

The recently amended Kansas Water Transfer Act applies to any water supply alternative which transfers more than 2,000 acre-feet of water a distance of more than 35 miles. The purpose of this law is "to determine whether the benefits to the State for approving the transfer outweighs the benefits to the State for not approving the transfer." As such, consideration of this law will be important in the evaluation of almost all water supply alternatives for the City.

Over the last year, the state has been evaluating the criteria for the Water Transfer Act. The state recently increased the distance from 10 miles to 35 miles and the volume from 1,000 acre-feet to 2,000 acre-feet. Transfer applications are evaluated by a "transfer panel", consisting of the Chief Engineer and two other state agency directors. As the act is currently written, many of the alternatives evaluated in this report would be required to obtain the necessary approval before water could be transferred. An effective water conservation program is also required in order to obtain approval of a water transfer.

E. POLICY AND POLITICAL ISSUES

Policy issues which need to be considered include the City's purchase of water rights from groundwater irrigators and use of City's right of condemnation. Political issues associated with each water supply alternative will be considered since any significant opposition could cause long-term delays, substantial cost increases, litigation and the eventual cancelling of a project. For example, a concern with the proposed Milford Project is that the water needs of Northeast Kansas could be pitted against those of South-Central Kansas.

F. FUTURE AVAILABILITY

Future availability of a water supply may be related to the ability of the City to execute the plan given a number of regulatory, social, economic and political constraints. For example, in today's regulatory climate with wetlands issues and emphasis on environmental concerns, entering into a planning phase with the goal of constructing a new reservoir would likely be a very difficult, time-consuming process with no assurance of success. Other factors, also need to be considered, such as continuing development and the need for water by other communities which could eliminate remaining available water supplies over the next 10 to 50 year period.

G. PLANNING HORIZON

Each water supply alternative, individually or as part of a larger water supply plan, will be scheduled for implementation in phases or stages to meet the City's net water needs from year 2000 through year 2050.

H. ENVIRONMENTAL ISSUES

Environmental issues associated with each alternative will be evaluated to determine if a possible environmental "deficiency" or "fatal flaw" might exist. Typical fatal flaws deal with the presence of federal endangered species or wetlands or other significant environmental impacts.

Various environmental areas of concern might involve the following:

- Relocations (Dwellings, Churches, and Cemeteries)
- Land or Right-of-Way Required for Project
- Timber Removal
- Inundation of Rivers and Streams
- Wetlands
- Cultural Resources
- Biological Resources
  - Federal Endangered Species
  - Federal Threatened Species
  - State Endangered Species
  - State Rare Species
- State Forests and Natural Areas

I. COST ESTIMATES AND ECONOMIC COMPARISONS

Cost estimates for construction and operation, maintenance, replacement and energy (OMR&E), present value analysis and other cost allowances will be used to compare each viable water supply alternative to determine the most economically feasible and best alternative.

Cost estimates for water supply alternatives developed in previous studies by others will be reviewed and updated for use in this report. Cost estimates for new water supply alternatives developed as a result of this study will require the conceptual design of facilities for the purpose of

determining preliminary sizes and quantities of materials and components. Unit cost data and component cost information from historical projects are used in the estimates. Determination of OMR&E costs require preliminary consideration of how each plan will function in relation to existing water system facilities. All costs are developed for an Engineering News Record (ENR) construction cost index of 5037 for the Kansas City regional area for March 1993.

1. PROJECT COSTS

Project costs for each alternative include construction costs, contingencies, land or right-of-way costs, environmental mitigation costs, water storage purchase costs (from existing reservoirs) and other costs. Project costs are often used for the general comparison of alternatives in present-day dollars without consideration of the time value of money.

a. Construction Cost Estimates

Construction cost estimates are the primary components of project costs from which many related costs are determined. Estimates of construction costs are based on the application of unit or component costs, as derived from historical projects, to the number and size of components and quantities of materials associated with each water supply plan.

Contingencies of 20 percent for construction are included as part of the project cost estimates. Contingencies are cost allowances for

items or conditions which are not known or anticipated for the project at this point in time.

b. Land and Right-of-Way Costs

Land and right-of-way costs associated with each water supply alternative are estimated from historical information. A contingency allowance is included in the costs to account for some escalation of prices created by the need for land and right-of-way by various projects.

Right-of-way costs for the pipeline alternatives are based on the acquisition of a permanent 50-foot-wide easement with a temporary 50-foot-wide construction easement (for a total of 100 feet, including severance costs). Permanent easements are used for the right-of-access along the pipeline route for future repairs and operation and maintenance activities. Temporary construction easements are used during construction and revert back to the landowner after pipeline construction is complete.

c. Environmental Mitigation Costs

Cost estimates for various types of environmental mitigation will be included in each water supply alternative. Typical cost allowances may include fish and wildlife mitigation, wetlands mitigation, and archaeological resource mitigation.

d. Water Storage Purchase Costs

The purchase of a portion of the water storage in existing reservoirs will be included in the cost estimates.

e. Other Costs

Other costs associated with each project include the fees and expenses associated with the technical, professional and special services required to execute the delivery of each plan. Such costs include environmental, technical, geotechnical and hydrogeologic studies; land and right-of-way appraisals and negotiations, design and resident engineering fees, construction materials testing, legal fees, project insurance, land surveying and legal descriptions, project design surveying, operation and maintenance (O&M) manuals, additional management O&M personnel, and personnel training.

2. OPERATION, MAINTENANCE, REPLACEMENT AND ENERGY COSTS

Operation, maintenance, replacement and energy (OMR&E) costs are used along with capital costs in the economic comparison of alternatives. Such costs, which are usually budgeted for on an annual basis, are on-going project costs related to facility operation which extend over the life of each project.

3. PRESENT VALUE ANALYSIS

Present value analyses will be performed on each water supply plan to permit an economic comparison of project costs and OMR&E costs of all the various phases of each alternative in 1993 dollars. Present value computations cover a study period from years 1993 through 2050 for all

project alternatives with inflation of costs figured at an annual rate of 4 percent and the discount rate for bringing costs back to 1993 figured at a discount rate of 7 percent. The cost of debt service is figured at an annual interest rate of 7 percent.

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Part VI - Development of Alternatives

PART VI

DEVELOPMENT OF ALTERNATIVES

A. GENERAL

This section of the report presents schematic design concepts of 27 alternatives capable of meeting or contributing to the City of Wichita's year 2050 average day net water need of 34 MGD and maximum day net water need of 54 MGD. Schematics of each alternative are used to prepare project cost estimates and water unit costs for use in the comparison of alternatives. Information used in this report section includes water supply alternatives introduced in Parts II, III and IV and evaluation criteria detailed in Part V.

B. ALTERNATIVE DEVELOPMENT PROCEDURES

Water supply alternatives are developed into schematic designs with consideration of the following:

- Adherence to Evaluation Criteria.
- Development of Concept Designs and Operating Protocol.
- Meeting Water Quality Goals.
- Preparation of Project Cost Estimates.

These procedures are discussed hereafter.

1. EVALUATION CRITERIA

Evaluation criteria for water supply capability, legal issues, policy and political issues, future availability, planning horizon and

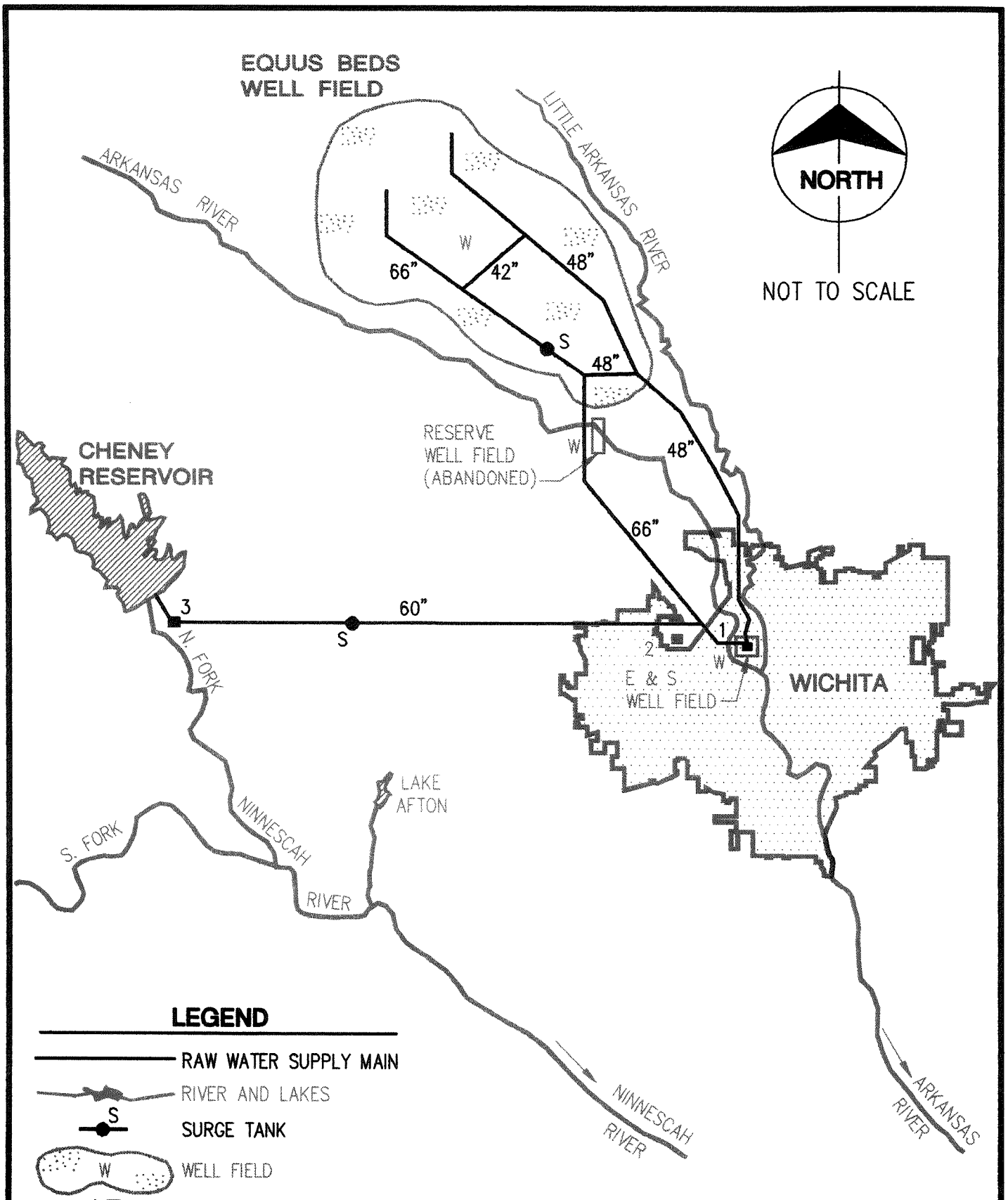
environmental issues are detailed in Part V. The existence of major deficiencies or fatal flaws with respect to these issues for each alternative will be investigated in this task. The occurrence of a fatal flaw would eliminate an alternative from further study. The most promising or viable alternatives will be carried forward in the study and evaluated in more detail in Part VII titled "Evaluation of Alternatives."

2. CONCEPTUAL DESIGN AND OPERATING PROTOCOL

Each of the 27 alternatives is designed conceptually to operate in conjunction with existing water system components as shown in Figure VI-1. The combined facilities must be capable of furnishing the year 2050 projected average day demand of 125 MGD and the maximum day demand of 249 MGD to the City of Wichita's water service area as determined in Part I of the report.

a. Existing Water Supply Capacity and Net Needs

Utilization of the capacity of existing raw water pumping, transmission and treatment facilities is considered in the development of each alternative to reduce construction costs. Hydraulic capacities for the existing raw water pumping, transmission and treatment facilities are listed below:



LEGEND

- RAW WATER SUPPLY MAIN
- RIVER AND LAKES
- S — SURGE TANK
- W — WELL FIELD
- 1 ■ CENTRAL WATER TREATMENT PLANT
- 2 ■ NEW WATER TREATMENT PLANT
- 3 ■ CHENEY RESERVOIR PUMP STATION

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Figure VI – 1

RAW WATER SUPPLY SYSTEM SCHEMATIC

Facility	Existing Capacity
Cheney Raw Water Pump Station	60 MGD (capacity can be increased to 80 MGD)
Cheney Raw Water Transmission Piping	80 MGD
Equus Beds Well Field/Transmission Piping	55 MGD (expandable to 80 MGD)
E&S (Local) Well Field/Transmission Piping	15 MGD (being upgraded to 30 MGD)
Central Water Treatment Plant	160 MGD

Projected net water needs (projected demand minus supply capacity) are presented in Part II of the report. Full utilization of the City's water rights leaves a required net need of 26 MGD for the average day and 35 MGD for the maximum day. Approximately 40 MGD of supply capacity in upgraded facilities are required to fully utilize the City's existing maximum day water rights of 171 MGD including well and transmission pipeline improvements in the Equus Beds and Local Well Fields. Based on firm yield of existing supply sources, the controlling factor, the net need is 35 MGD for the average day demand and 54 MGD for the maximum day demand. Facilities must be sized to meet these projected needs.

b. Raw Water Pumping and Transmission

The Cheney Reservoir raw water transmission system is limited to a supply capacity of 80 MGD due to the pressure class limitation of the pipeline. Water supply alternatives which convey flows in excess of 80 MGD from the reservoir to the water treatment plant(s) will require a new water transmission pipeline which must be designed for maximum day capacities.

The Equus Beds raw water transmission system is currently limited to about 55 MGD due to production limitations of several wells and the pressure class limitation or rating of the pipelines. Operating pressures in excess of rated pressure can cause damage to the pipelines. Rehabilitation work on the wells, which is currently under contract, should increase the pumping capacity to 80 MGD. Hydraulic restrictions will still limit conveyance capacity to 55 MGD. Water supply alternatives which convey flows in excess of 80 MGD from the well field to the water treatment plant(s) require extensive transmission system improvements which must be designed for maximum day capacities.

c. Water Treatment

The existing water treatment plant (referred to as the Central Plant) is currently being expanded to 160 MGD which will utilize most of the remaining available space at the plant site. Additional treatment capacity, totaling 90 MGD, must be constructed to meet the projected year 2050 maximum day demand of 249 MGD. Because future growth in water demands is expected to be the greatest in the western part of the City and associated outlying areas, the delivery of additional water from a new source(s) is directed to the existing plant and to a future water treatment plant located in the western part of the City. Engineering studies by others indicate the new water plant site will be located in the vicinity of a corridor along 21st Street North and west of I-235.

d. Raw Water Delivery Points

Alternatives are evaluated for delivery of water to both the Central Water Plant and the proposed water treatment plant at a new site on the west side of Wichita. The location of the new plant was selected in engineering studies by others.

3. WATER QUALITY GOALS

Water quality is an important consideration of each water supply alternative in determining if the raw water can be treated to drinking water quality with existing conventional water treatment processes. Drinking water which is supplied to the City's water service area must comply with the federally-mandated 1974 Safe Drinking Water Act (SDWA) and the Amendments to the act. Development of regulations stemming from the act is accomplished by the United States Environmental Protection Agency (USEPA) and enforcement of the regulations is carried out by the State of Kansas through its Department of Health and Environment (KDHE), which presently has primacy with respect to enforcement of the regulations.

Drinking water standards which must be met through source selection and water treatment are presented in Part V of the report in Table V-1. For this study of alternative supply sources, all standards are expected to be met with the use of conventional (clarification and/or softening, filtration and disinfection) and advanced treatment processes (such as use of granular activated carbon for synthetic organic containments). Water quality parameters which are expected to have the greatest impact

on costs and operations include high chloride levels and disinfection by-products.

High chloride concentrations are a major consideration in the evaluation of alternatives since chlorides cannot be removed in conventional water treatment processes. The City has a maximum desired chloride limit of 200 mg/l for finished (or treated) water and the KDHE regulated limit is 250 mg/l.

Water supply alternatives with chlorides in excess of 200 mg/l must either be blended with lower chloride water or treated via reverse osmosis membranes. Chlorides are evaluated on an individual basis for source alternatives which are conveyed to the water plant for treatment or which are used to recharge an aquifer. Alternatives involving aquifer recharge must not degrade the water quality of the aquifer.

Among several disinfection by-products which may be of concern, the formation of trihalomethanes (THMs) in excess of pending standards should be considered. The City currently blends about 60 percent Equus Beds groundwater and 40 percent Cheney Reservoir surface water in the production of potable water at the Central Water Plant. The groundwater helps to maintain low THM levels in the finished water because groundwater typically contains less organic materials than surface water and the reaction of chlorine to form THMs is less pronounced. Many of the alternatives evaluated would increase the use of surface water to 100 percent most of the time. This will probably increase THM levels; but, an increase above the current KDHE regulated limit of 100 ug/l

cannot be predicted at this time. The THM regulated limit is expected to be decrease to 80 ug/l in 1995 with the final limit subject to on-going regulatory negotiations between water utilities and U.S. EPA. Additional studies may be required to confirm compliance or to determine corrective measures.

4. COST ESTIMATES

Project cost estimates and costs per unit of available flow estimates are required for the purpose of comparing each water supply alternative to determine the most economically viable alternative(s). The cost estimating techniques and project cost categories used herein are detailed in Part V. The unit project costs used in this evaluation are listed in Table VI-1. Estimates of cost per unit of available flow are based on the total project cost divided by the total available flow over a 55-year period from year 1996 through 2050. This time frame is used for most alternatives and allows the alternatives to be evaluated on an equal basis. Some alternatives, like Milford, could not be completed in time to be in service in year 1996 and are based on 50 years of operation.

"Other Costs" include engineering, administration, inspection, geotechnical, survey, environmental and legal work associated with the project. These costs are estimated at 15 percent of the construction cost including the contingency and may actually vary with the size and scope of the project. The contingency of 20 percent on construction costs accounts for unknown and unaccounted-for construction items which are not typically detailed at this stage of project development.

Table VI – 1

UNIT PROJECT COSTS

Item	Cost ($)
Intake and Pump Station:	
20 MGD	1,300,000
60 MGD	2,500,000
160 MGD	5,200,000
250 MGD	7,000,000
Booster Pump Station:	
3 MGD	240,000
30 MGD	1,300,000
70 MGD	3,000,000
125 MGD	5,000,000
175 MGD	6,000,000
Well:	
Well, Pump & 75 Hp Motor	90,000
Well House	15,000
Well House Piping	8,000
Powerlines	22,000 /mile
Electrical/Controls	15,000
Pipe (1):	
In alluvium:	
24–inch	75 /LF
30–inch	90 /LF
36–inch	110 /LF
48–inch	145 /LF
66–inch	210 /LF
96–inch	370 /LF
120–inch	480 /LF
In streets:	
16–inch	65 /LF
24–inch	100 /LF
30–inch	120 /LF
36–inch	140 /LF
48–inch	175 /LF
66–inch	290 /LF
96–inch	470 /LF
120–inch	590 /LF
Miscellaneous:	
Infiltration Gallery (5 acre site) with piping/vault	150,000
Land	2,000 /acre
Right–of–way	0.85 /lf
Contingency	20 %
Other Costs	15 %

Note:
(1) Prices shown are for 150 psi pressure class pipe;
Add 8% to pipe costs for 250 psi pressure class pipe.

C. WATER SUPPLY ALTERNATIVES

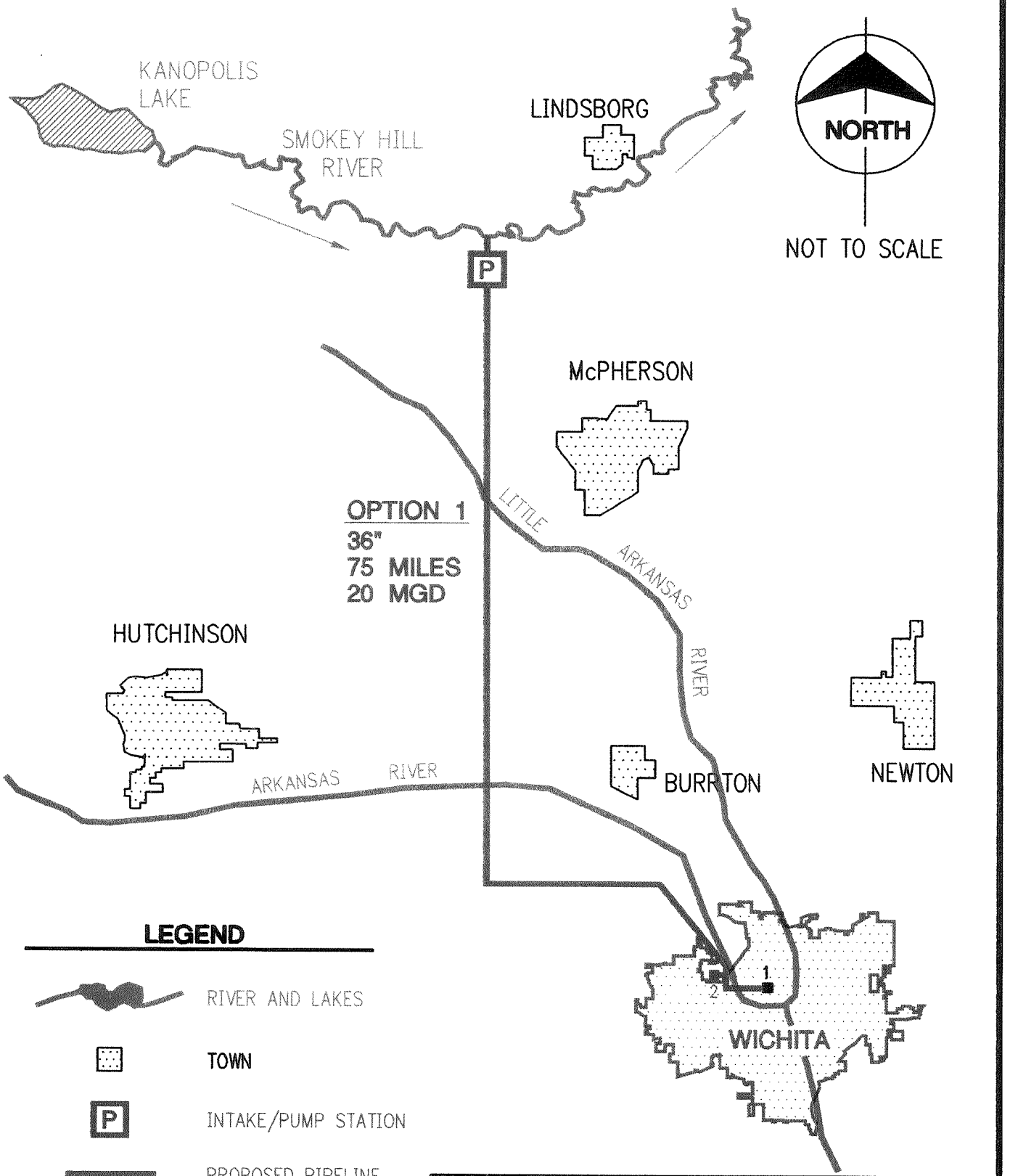
Potential water sources, consisting of conventional and nonconventional alternatives, throughout the regional area in and around Wichita are evaluated hereafter. Conventional alternatives include existing and proposed reservoirs, groundwater and surface water flow. Nonconventional alternatives include use of reservoir overflows, excess stream flow, treated wastewater reuse, groundwater bank storage, rain harvesting and water conservation.

1. CONVENTIONAL

a. Kanopolis Reservoir

A schematic of the water supply alternative which involves the conveyance of raw water from the Kanopolis Reservoir is shown in Figure VI-2. This alternative includes the construction of an intake and pump station on the Smokey Hill River upstream of Lindsborg and raw water transmission piping to the water plants.

The City of Salina and the Post Rock Water District have expressed interest in purchasing storage from the reservoir; however, no rights have been allocated and no storage capacity has been purchased. The state of Kansas is considering the purchase of the Kanopolis Reservoir storage from the Corps of Engineers and marketing the water. This will substantially reduce the cost of reservoir storage since the state purchases reservoir storage at original construction costs which are in 1948 dollars for Kanopolis Reservoir. A possibility exists that the City of Wichita might be



LEGEND

- RIVER AND LAKES
- TOWN
- P — INTAKE/PUMP STATION
- PROPOSED PIPELINE
- 1 — CENTRAL WATER TREATMENT PLANT
- 2 — NEW WATER TREATMENT PLANT

Burns & McDonnell

Figure VI – 2

KANOPOLIS RESERVOIR WATER SUPPLY SCHEMATIC

J:\WICHITA\92\1954\FIG6-15.DWG 06-17-1995 14:19 BES

able to purchase the full storage capacity from the Corps of Engineers.

The project cost estimate is based on the City of Wichita purchasing a portion of storage capacity with associated water rights for 10 MGD, about one-third of the reservoir's 27-MGD firm yield. The concept design includes a transmission system with a 20-MGD intake and pump station on the Smokey Hill River and 75 miles of 36-inch diameter pipeline to the water plants.

The estimated project cost for the new raw water transmission system is $69 million (plus storage) as shown in Table VI-2. The unit cost for the alternative is $344/MG.

b. Milford Reservoir

A schematic of the water supply alternative which involves the conveyance of treated water from Milford Reservoir is shown in Figure VI-3. This alternative includes construction of an intake, treatment plant and pump station at the reservoir, two booster pump stations and approximately 114 miles of transmission piping to Wichita. Detailed information for this alternative is listed in the "Public Wholesale Water Supply District No. 10 Conceptual Study" completed December 1991.

This alternative could serve the 15 sponsor cities, all of whom would be members of the Public Wholesale Water District No. 10. The sponsor cities include the following:

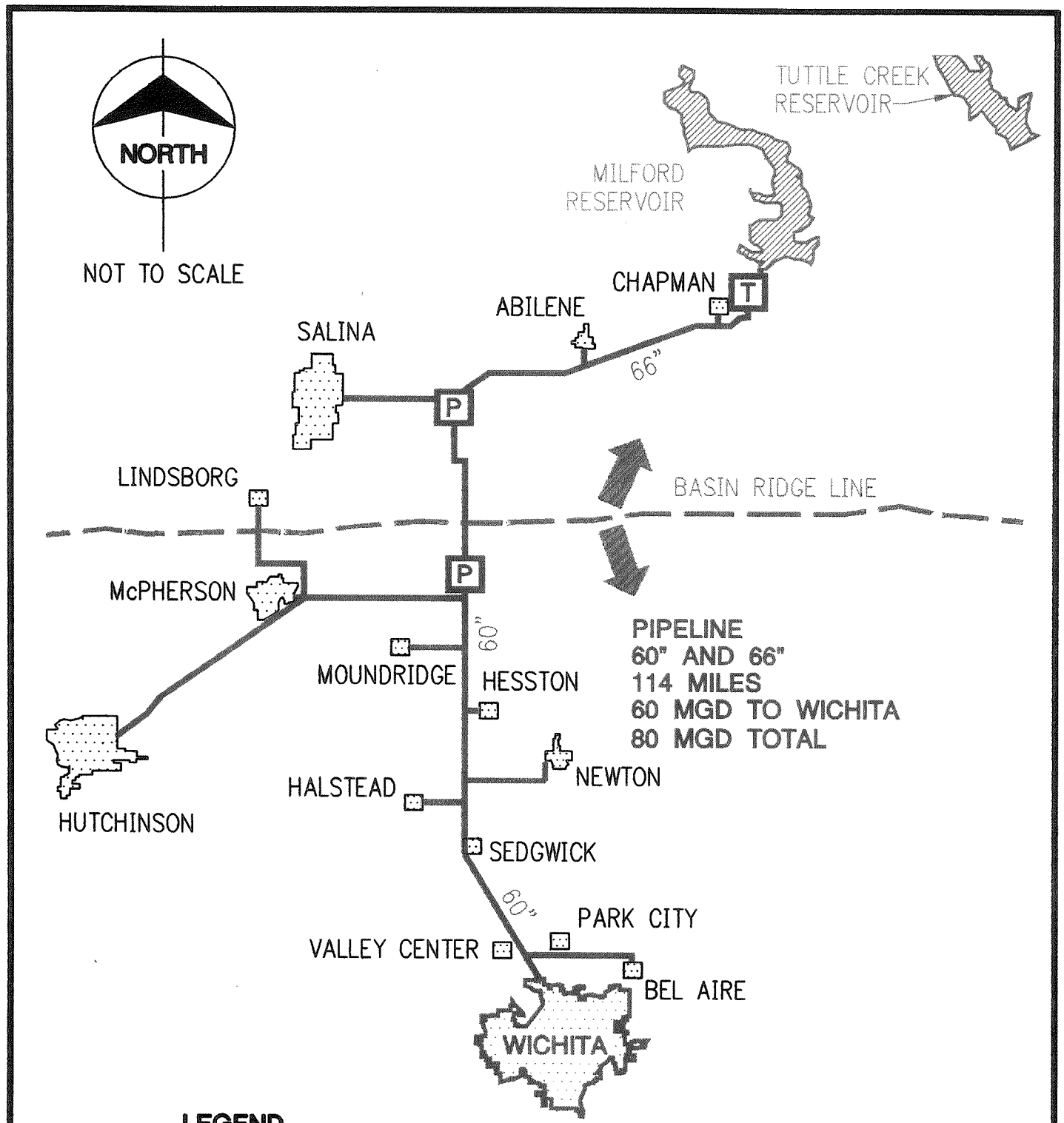
- Abilene
- McPherson

Table VI – 2

KANOPOLIS RESERVOIR
RAW WATER TRANSMISSION SYSTEM
PROJECT COST ESTIMATE

Item	Cost ($)
Intake and Pump Station (1)	$ 1,300,000
Reservoir Storage Capacity	NA
Booster Pump Station (1)	1,000,000
Pipeline (2)	47,700,000
Subtotal	$ 50,000,000
Contingency @ 20%	10,000,000
Subtotal	$ 60,000,000
Other Costs @ 15%	9,000,000
Total Project Cost	**$ 69,000,000**
Available Flow (3)	**200,800 MG**
Unit Cost (4)	**$ 344 /MG**

Notes:
(1) Capacity of 10 MGD average and 20 MGD maximum. Transmission facilities sized for maximum day capacity.
(2) 75 miles of 36–inch pipeline.
(3) Available flow equals average capacity times 365 days times 55 years.
(4) Unit cost is Total Project Cost divided by Available Flow.
(5) Costs of enlarging and improving the reservoir are not included in this cost estimate.



LEGEND

- RIVER AND LAKES
- TOWN
- T — WATER PLANT
- P — PUMP STATION
- PROPOSED PIPELINE

NOTE:
MILFORD RESERVOIR IS IN THE MISSOURI RIVER BASIN AND WICHITA IS IN THE ARKANSAS RIVER BASIN.

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Figure VI – 3

MILFORD RESERVOIR WATER SUPPLY SCHEMATIC

J:\WICHITA\92195A\FIG6-10.DWG 06-24-1995 10:29 MMD

- Bel Aire
- Chapman
- Halstead
- Hesston
- Hutchinson
- Lindsborg
- Moundridge
- Newton
- Park City
- Salina
- Sedgwick
- Valley Center
- Wichita

The concept design of this alternative is based on Milford Reservoir supplying a continuous maximum of 80 MGD to the Wholesale District members, with 60 MGD to Wichita. Flow from the reservoir would be treated (treatment plant costs are not included in this part of the study) and pumped via approximately 114 miles of 66-inch and 60-inch diameter pipelines to the cities. The Kansas Water Office is currently evaluating available supply capacity from the reservoir.

The estimated project cost for Wichita's portion of the transmission system is $155 million as shown in Table VI-3 with a unit cost of $141/MG based on costs by others. For the purpose of this study the project cost estimate is $176 million as shown in Table VI-3, Note 6, with a unit cost of $161/MG.

c. <u>Proposed Corbin Reservoir</u>

A schematic of the water supply alterative which involves the conveyance of water from Corbin Reservoir is shown in Figure VI-4. This alternative includes the construction of a new reservoir,

Table VI – 3

MILFORD RESERVOIR
WATER TRANSMISSION SYSTEM
PROJECT COST ESTIMATE

Item	Cost ($)
Intake/Low Service Pump Station	$ 6,100,000
Raw Waterline	1,000,000
Pipelines & Appurtenances (1)	103,800,000
Subtotal	$ 110,900,000
Contingency @ 20%	22,200,000
Subtotal	$ 133,100,000
Other Costs @15%	20,000,000
Land	1,600,000
Total Project Cost	**$ 154,700,000**
Available Flow (3)	**1,095,000 MG**
Unit Cost (4)	**$ 141 /MG**

Notes:

(1) Maximum day capacity of 60 MGD to Wichita and 80 MGD total (Alternative A) Public Water District 10 Report dated December 1991.
(2) Kansas Water Office will not sell storage capacity, but will sell water for at an estimated rate of $1.96/acre–foot for 50 years.
(3) Available Flow is average capacity of 60 MGD times 365 days times 50 years.
(4) Unit cost is Total Project Cost divided by Available Flow.
(5) Cost of the treatment facility, shown as $81,500,000 in the District 10 Report, is not included in this cost estimate.
(6) These costs were developed by the Mid–Kansas Water Consultants in 1991 and are escalated to 1993 dollars. For study purposes, the cost is estimated at $176,000,000.

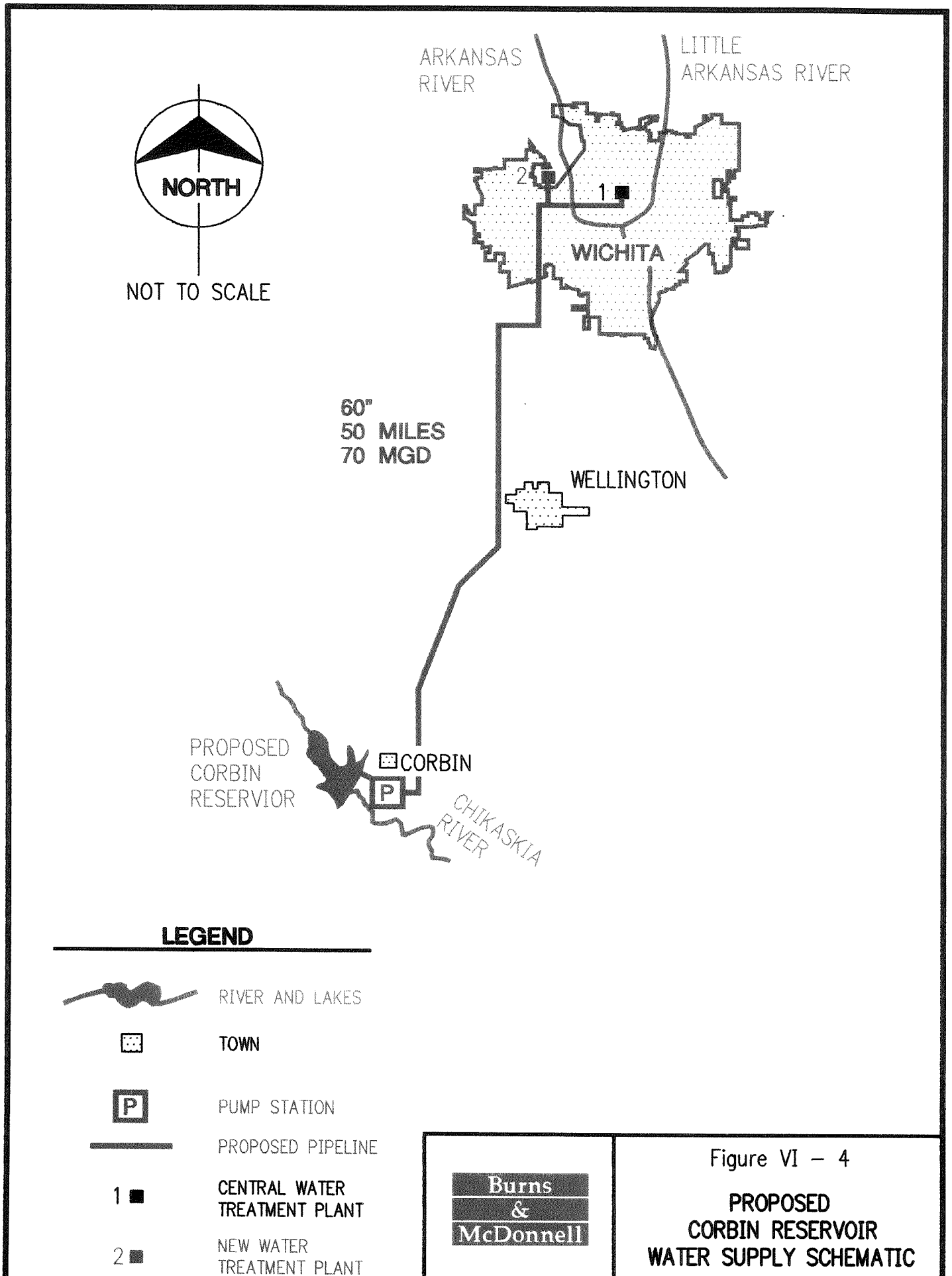


Figure VI – 4

PROPOSED CORBIN RESERVOIR WATER SUPPLY SCHEMATIC

J:\WICHITA\92193\FIG6-12.DWG 06-11-1999 14:10 BES

intake and pump station and 50 miles of transmission piping to the water plants.

The proposed reservoir would be located on the Chikaskia River about 5 miles northeast of Caldwell in Sumner County. The dam would be a 31,700-foot-long, rolled earthfill structure 91 feet above the streambed. The multipurpose reservoir, if built to maximum size, would have a total firm yield of 53 MGD, and an available yield of 47 MGD. The City of Wichita only requires 35 MGD of the available 47 MGD to meet the year 2050 average day demand.

The concept design for this alternative is based on Corbin Reservoir supplying an average of 35 MGD and a maximum of 70 MGD to the City. The transmission system includes a 70-MGD pump station and 50 miles of 60-inch diameter pipeline to the water plants.

The estimated project cost for the new water transmission system is $470 million as shown in Table VI-4. The unit cost for the alternative is $669/MG.

d. Proposed Douglass Reservoir

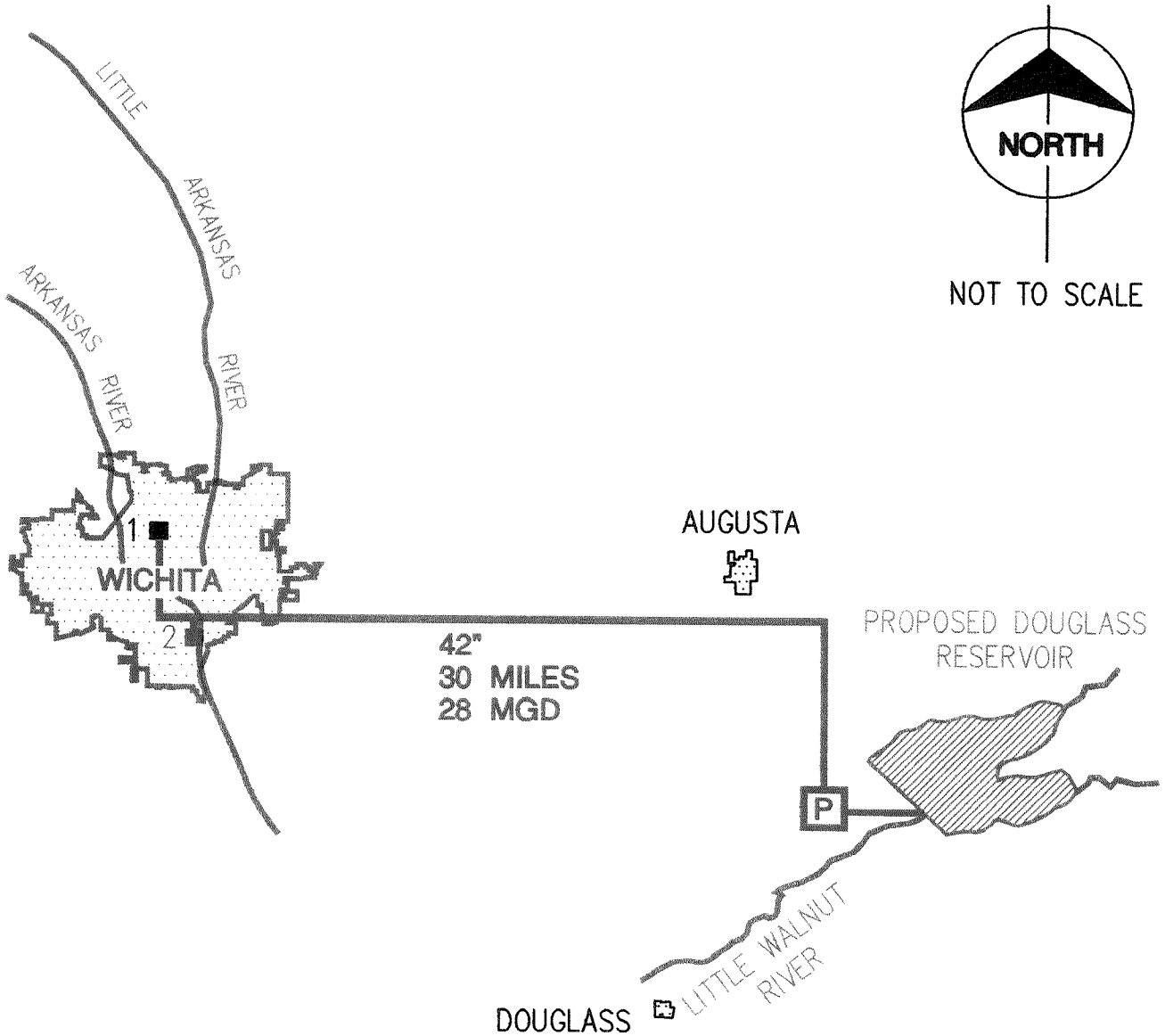
A schematic of the water supply alternative which involves the conveyance of water from Douglass Reservoir is shown in Figure VI-5. This alternative includes the construction of a new reservoir, intake and pump station and 30 miles of transmission piping to the water plants.

Table VI – 4

PROPOSED CORBIN RESERVOIR
WATER TRANSMISSION SYSTEM
PROJECT COST ESTIMATE

Item	Cost ($)
Reservoir (1)	$ 280,000,000
Pump Station (2)	3,000,000
Pipeline (3)	57,300,000
Subtotal	$ 340,300,000
Contingency @ 20%	68,100,000
Subtotal	$ 408,400,000
Other Costs @15%	61,300,000
Total Project Cost	**$ 469,700,000**
Available Flow (4)	**702,600 MG**
Unit Cost (5)	**$ 669 /MG**

Notes:
(1) Firm yield up to 53 MGD. Size for firm yield of 35 MGD.
(2) Capacity of 70 MGD, maximum day.
(3) 50 miles of 60–inch diameter pipeline.
(4) Available Flow is average capacity times 365 days times 55 years.
(5) Unit Cost is Total Project Cost divided by Available Flow.
(6) Cost of the water treatment plant is not included in this cost estimate.



LEGEND

- RIVER AND LAKES
- TOWN
- PUMP STATION
- PROPOSED PIPELINE
- 1 CENTRAL WATER TREATMENT PLANT
- 2 NEW WATER TREATMENT PLANT

Burns & McDonnell

Figure VI – 5

PROPOSED DOUGLASS RESERVOIR WATER SUPPLY SCHEMATIC

The proposed reservoir would be located 15 miles southeast of Wichita on the Little Walnut River in Butler County. The dam would be a 11,600-foot-long, rolled earthfill structure 89 feet above the streambed. The multipurpose reservoir would have a total firm yield of 14.2 MGD.

The concept design for this alternative is based on Douglass Reservoir supplying an average of 14.2 MGD and a maximum of 28.4 MGD to the City. The transmission system includes a 30-MGD pump station and 30 miles of 42-inch diameter pipeline to the water plants.

The estimated project cost for the new water transmission system is $202 million as shown in Table VI-5. The unit cost for the alternative is $707/MG.

e. Proposed Murdock Reservoir

A schematic of the water supply alternative which involves the conveyance of water from Murdock Reservoir is shown in Figure VI-6. This alternative includes the construction of a new reservoir, intake and pump station and 44 miles of raw water transmission piping to the water plants.

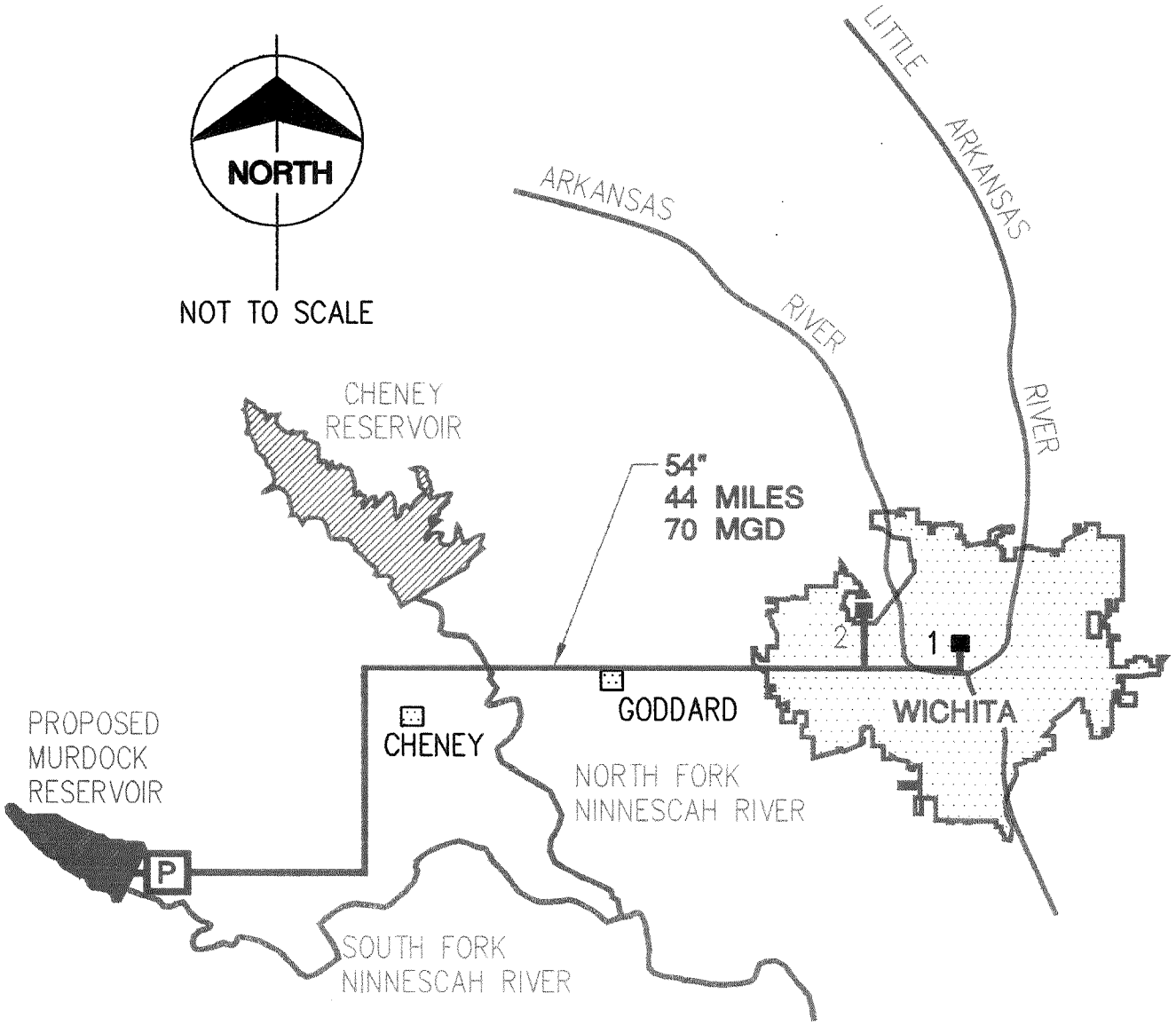
The proposed reservoir would be located on the South Fork of the Ninnescah River near Kingsman in Kingman County. The dam would be a 15,000-foot-long, rolled earthfill structure 83 feet above the streambed. The reservoir, if built to maximum size, would yield

Table VI – 5

PROPOSED DOUGLASS RESERVOIR
WATER TRANSMISSION SYSTEM
PROJECT COST ESTIMATE

Item	Cost ($)
Reservoir (1)	$ 123,200,000
Pump Station (2)	1,600,000
Pipeline (3)	21,400,000
Subtotal	$ 146,200,000
Contingency @ 20%	29,200,000
Subtotal	175,400,000
Other Costs @ 15%	26,300,000
Total Project Cost	**$ 201,700,000**
Available Flow (4)	**285,100 MG**
Unit Cost (5)	**$ 707 /MG**

Notes:
(1) Firm yield up to 14.2 MGD.
(2) Capacity of 28 MGD.
(3) 30 miles of 42–inch diameter pipeline.
(4) Available Flow is average capacity times 365 days times 55 years.
(5) Unit Cost is Total Project Cost divided by Available Flow.
(6) Cost of the water treatment plant is not included in this cost estimate.. The cost of constructing the reservoir was estimated to be $117,800,000. This figure is adjusted per ENR inlfation factor (4.7%).



LEGEND

- RIVER AND LAKES
- TOWN
- P — PUMP STATION
- PROPOSED PIPELINE
- 1 ■ CENTRAL WATER TREATMENT PLANT
- 2 ■ NEW WATER TREATMENT PLANT

Burns & McDonnell

Figure VI – 6

PROPOSED MURDOCK RESERVOIR WATER SUPPLY SCHEMATIC

J:\WICHITA\921954\FIG6-11.DWG 04-29-1993 10:54 BES

65 MGD. The City only requires 35 MGD of the available 65 MGD to meet their year 2050 average day demand.

The concept design for this alternative is based on Murdock Reservoir supplying an average of 35 MGD and maximum of 70 MGD to the City. Flow from the reservoir would be pumped via approximately 44 miles of 54-inch diameter pipeline to the water plants.

The estimated project cost for the new water transmission system is $231 million as shown in Table VI-6. The unit cost for the alternative is $329/MG.

f. Equus Beds Groundwater

(1) Purchase Equus Beds Water Rights: The City of Wichita initiated a program to purchase water rights adjacent to the Equus Beds Well Field in 1990. This program has produced contracts for 2,200 acre-feet of water to date at a cost of $400 per acre-foot to the City. Based on the limited history of this program, a rate of additional water right purchases cannot be estimated at this time.

The area of concern for water rights purchases is 150 square miles in size and is adjacent to the exiting Equus Beds Well Field. The annual recharge rate for calculating water rights is assumed by the State to be 6 inches per year. Therefore, this area has a calculated water right of 48,000 acre-feet.

Table VI – 6

PROPOSED MURDOCK RESERVOIR
WATER TRANSMISSION SYSTEM
PROJECT COST ESTIMATE

Item	Cost ($)
Reservoir (1)	$ 122,000,000
Pump Station (2)	3,000,000
Pipeline (3)	42,400,000
Subtotal	$ 167,400,000
Contingency @ 20%	33,500,000
Subtotal	200,900,000
Other Costs @ 15%	30,100,000
Total Project Cost	**$ 231,000,000**
Available Flow (4)	**702,600 MG**
Unit Cost (5)	**$ 329 /MG**

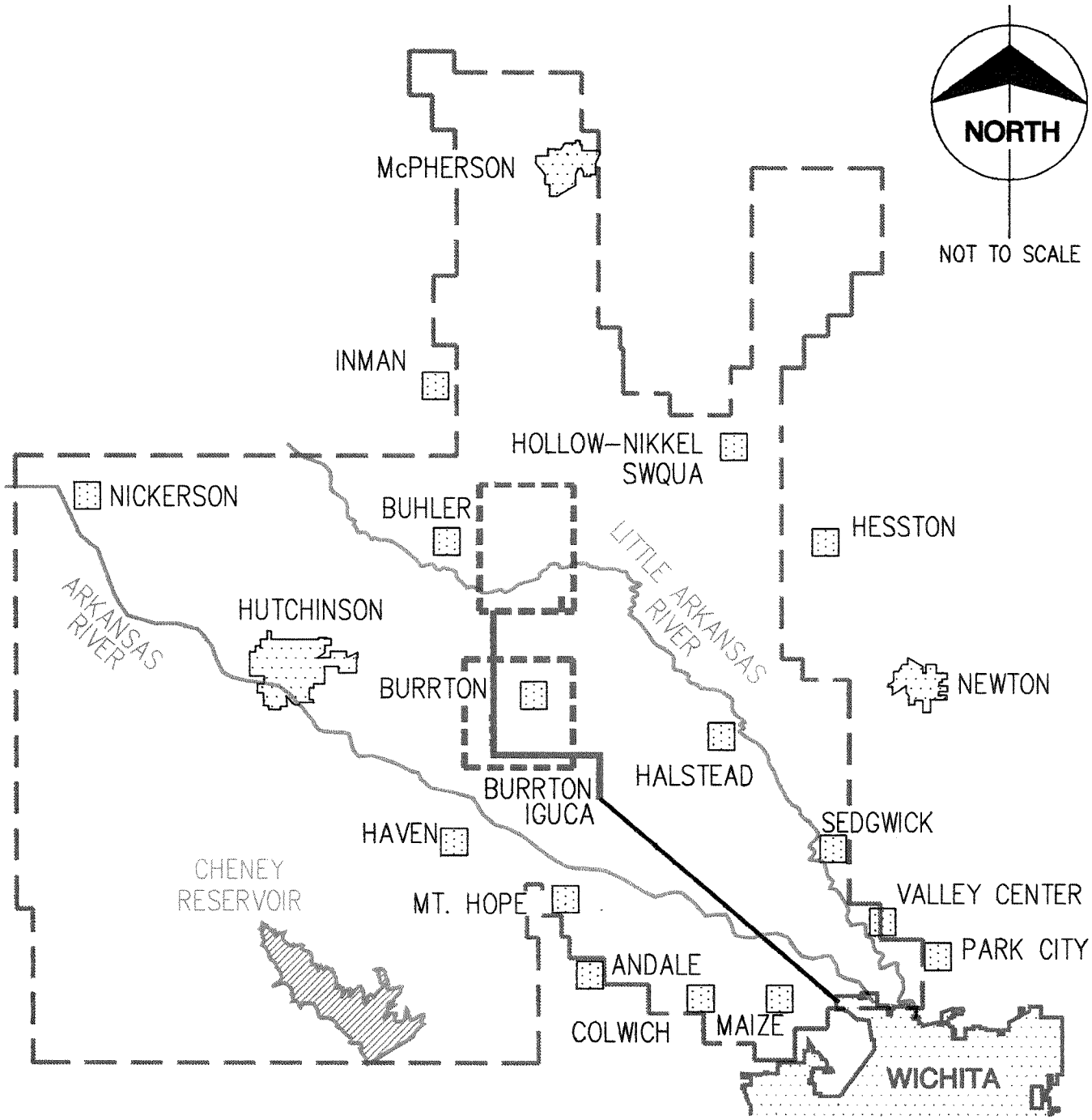
Notes:
(1) Firm yield up to 65 MGD. Size for firm yield of 35 MGD.
(2) Capacity of 70 MGD, maximum day.
(3) 44 miles of 54–inch diameter pipeline.
(4) Available Flow is average capacity times 365 days times 55 years.
(5) Unit Cost is Total Project Cost divided by Available Flow.
(6) Cost of the water treatment plant is not included in this cost estimate.

The area's water rights are currently overallocated. The City owns 40,000 acre-feet in this area and additional water rights are owned by local irrigators. Remaining water rights of up to 8,000 acre-feet or 7.2 MGD may be available; however, purchases above the safe yield of the aquifer of 48,000 acre-feet may not provide any additional groundwater.

Continuation of this program should be evaluated after completion of this report. Acquisition of water rights by condemnation is not a part of current City policy.

(2) Hollow Nikkel SWQUA and Burrton IGUCA Areas: A schematic of a water supply option which involves the use of water from the Hollow-Nikkel Special Water Quality Use Area (SWQUA) and the Burrton Intensive Groundwater Use Control Area (IGUCA) is shown on Figure VI-7. These areas were created by the Division of Water Resources to control high salinity levels in the groundwater. Saltwater problems in both areas were caused by oil field activities and an upward movement of saltwater from the underlying Permian Bedrock known as the Wellington Formation. The chloride concentration in the Hollow-Nikkel area is about 300 mg/l while the chloride concentration in the Burrton area is about 2,000 mg/l in the deep wells.

The concept design for this option is based on the supply of 9.8 MGD of high chloride water to the water plants. The water would be pumped when the high chloride water can be blended at the



LEGEND

- RIVER AND LAKES
- TOWN
- AREA OF INTEREST
- PROPOSED PIPELINE
- EXISTING PIPLINE
- AREA OF INTEREST LIMITS

HOLLOW–NIKKEL SWQUA SUPPLY	BURRTON IGUCA SUPPLY
24"	24"
17 MILES	9 MILES
2 MGD	6 MGD

Burns & McDonnell

Figure VI – 7

SWQUA & IGUCA GROUNDWATER SUPPLY SCHEMATIC

water plants with other supplies without exceeding the City's desired finished water chloride concentration of 200 mg/l. Actual quantities used may vary due to blending requirements which would not allow 100 percent use of the high chloride water. The transmission system includes seven wells and 25 miles of 24-inch diameter pipeline.

The estimated project cost for the SWQUA and IGUCA transmission system is $26 million as shown in Table VI-7. The unit cost for the option is $130/MG based on 100 percent pumpage. Continuous pumping of the groundwater is expected to substantially reduce chloride levels in the aquifer over time and provide a long-term moderate quality water supply for Wichita.

g. Haysville Groundwater

A schematic of the water supply alternative which involves the sale of reclaimed water from Wichita's Wastewater Plant No. 2 to Haysville irrigators in exchange for their water rights is shown in Figure VI-8. The area under investigation is 20 square miles in size, bounded by Seneca on the west, Oliver on the east, MacArthur on the north, and 79th Street on the south. The groundwater in the area contains moderately high levels of chlorides, approximately 250 mg/l.

The Division of Water Resources has established a 3 inch per year recharge rate for the area. This recharge rate limits the availability of water from this source to 2.85 MGD.

Table VI – 7

HOLLOW NIKKEL SWQUA AND BURRTON IGUCA WELL FIELDS
RAW WATER TRANSMISSION SYSTEM
PROJECT COST ESTIMATE

Item	Cost ($)
Wells (1)	$ 2,000,000
Pipeline (2)	9,900,000
Water Rights	6,600,000
Subtotal	$ 18,500,000
Contingency @ 20%	3,700,000
Subtotal	$ 22,200,000
Other Costs @ 15%	3,300,000
Total Project Cost	**$ 25,500,000**
Available Flow (3)	**196,700 MG**
Unit Cost (4)	**$ 130 /MG**

Notes:
(1) Seven wells for a total capacity of 9.8 MGD.
(2) 25 miles of 24–inch pipeline.
(3) Available flow equals capacity times 365 days times 55 years.
(4) Unit Cost is Total Project Cost divided by Available Flow.

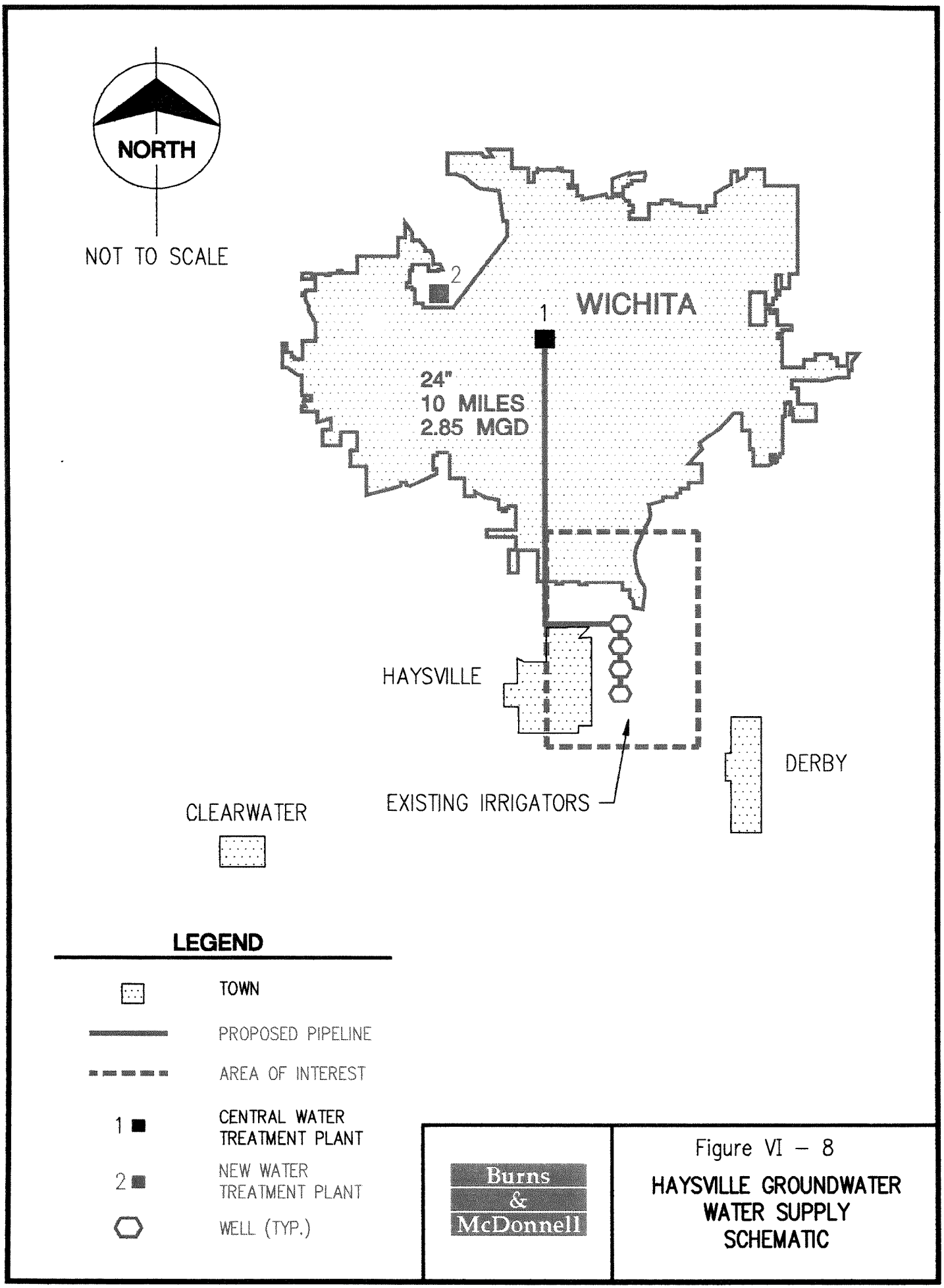


Figure VI – 8

HAYSVILLE GROUNDWATER WATER SUPPLY SCHEMATIC

The estimated project cost for the new water transmission system is $22 million as shown in Table VI-8. The unit cost for the alternative is $386/MG. For this alternative, some revenue could be generated from the sale of reclaimed water.

h. Abandoned Reserve Well Field

A schematic of the water supply alternative which involves the construction of new wells in the abandoned Bentley Reserve Well Field is shown in Figure VI-9. The abandoned well field consisted of six wells located along the Arkansas River north of K-96 adjacent to the City's 66-inch diameter raw water transmission main.

Water quality analyses from 1956 shows chloride concentrations ranging from 350 to 850 mg/l with an average of 610 mg/l. The City's maximum desired finished water chloride level is 200 mg/l. Water from the abandoned well field must be blended at the water plants with water from other sources. The actual flow that can be used from the well field is dependent upon the chloride concentration and flow rate of water from other source(s) as listed below:

Chloride Concentration In Water from Other Source(s) (mg/l)	Minimum Flow from Other Source(s) (MGD)
50	30
100	44
150	88
175	177
200	0

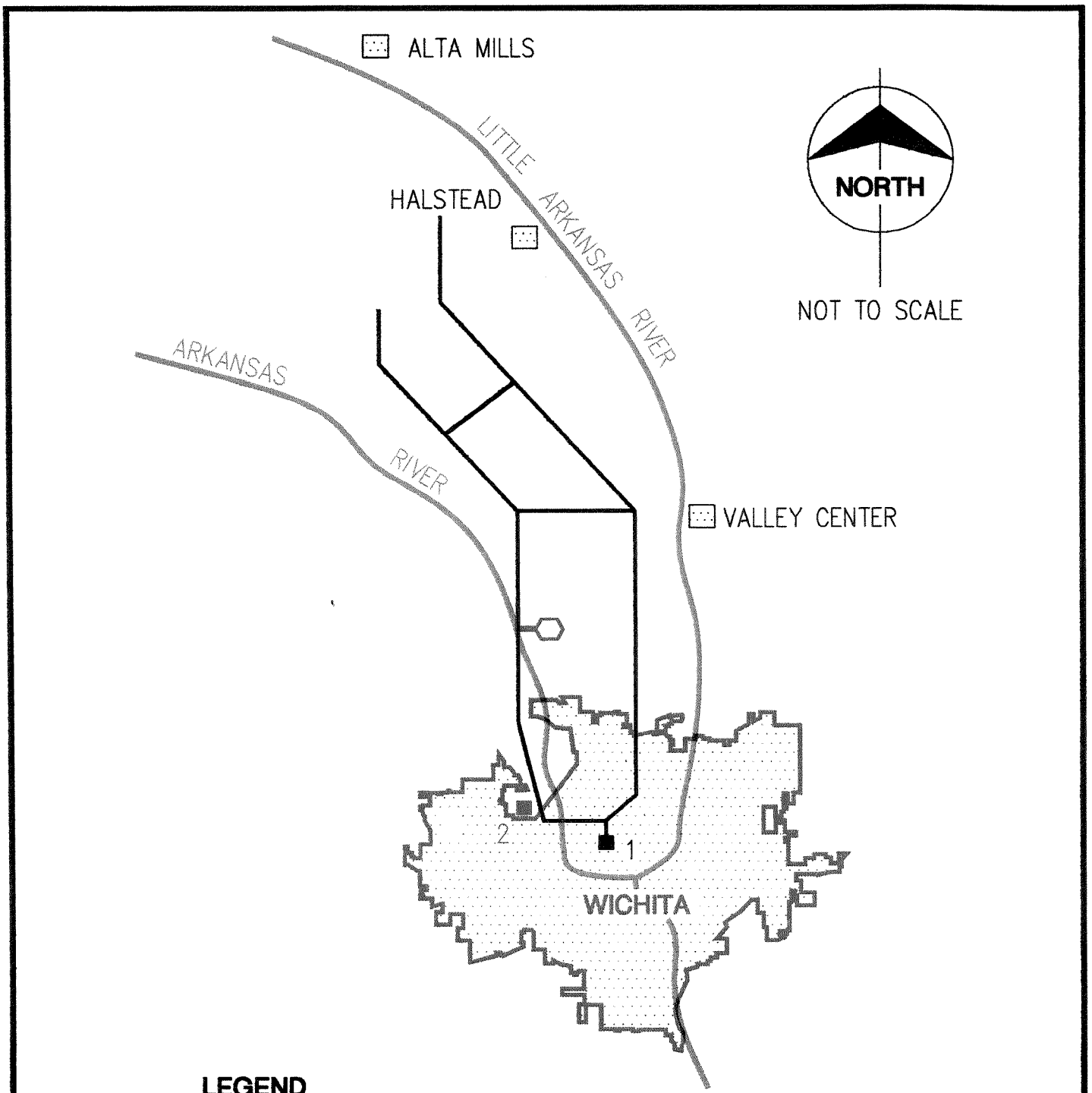
Table VI – 8

HAYSVILLE IRRIGATION SUPPLY ALTERNATIVE
RAW WATER TRANSMISSION SYSTEM
PROJECT COST ESTIMATE

Item	Cost ($)
Pump Station & Storage Tank (1)	$ 1,200,000
Wells (2)	600,000
Pipeline (3)	14,200,000
Subtotal	$ 16,000,000
Contingency @ 20%	3,200,000
Subtotal	$ 19,200,000
Other Costs @ 15%	2,900,000
Total Project Cost	**$ 22,100,000**
Available Flow (4)	**57,200 MG**
Unit Cost (5)	**$ 386 /MG**

Notes:

(1) 2.85 MGD pump station and 0.5 MG elevated storage tank.
(2) Four wells pumping a maximum available water right of 2.85 MGD.
(3) 18 miles of 6–inch to 20–inch reclaimed water pipelines and ten miles of 24–inch and 2 miles of 16–inch pipelines for water retrieval.
(4) Available flow is based on 55 years of supply at an average rate of 2.85 MGD.
(5) Unit Cost is Total Project Cost divided by Available Flow.



LEGEND

- RIVER
- TOWN
- 1 CENTRAL WATER TREATMENT PLANT
- 2 NEW WATER TREATMENT PLANT
- PROPOSED WELL (TYP. OF 6)
- EXISTING EQUUS BED WELL FIELD PIPELINES

Burns & McDonnell

Figure VI – 9

REDEVELOPED BENTLEY RESERVE WELL FIELD WATER SUPPLY SCHEMATIC

The above values are based on a supply of 10.8 MGD from the abandoned well field with an associated average chloride concentration of 610 mg/l.

The concept design of this alternative is based on the supply of 10.8 MGD from the redeveloped well field to meet peak demands and conserve other water sources for dry periods. The transmission system includes six 1,500 gpm, 200 feet deep wells and associated piping. The use of the existing piping which connects to the 66-inch diameter raw water transmission main may be feasible.

The estimated project cost for the redeveloped Bentley Reserve Well Field is $1 million as shown in Table VI-9. The unit cost for this alternative is $37/MG based on 46 days per year of pumping. Since this alternative is so economical, construction of additional wells should be considered based on chloride levels in other (selected) water sources.

i. Arkansas River Supply to Water Plant

A schematic of the water supply alternative which involves the conveyance of raw water from the Arkansas River to the water plants is shown in Figure VI-10. The alternative includes construction of an intake and pump station adjacent to the Central Water Plant with raw water transmission pipelines to the Central and New Water Plants.

Table VI – 9

REDEVELOPMENT OF BENTLEY RESERVE WELL FIELD
RAW WATER TRANSMISSION SYSTEM
PROJECT COST ESTIMATE

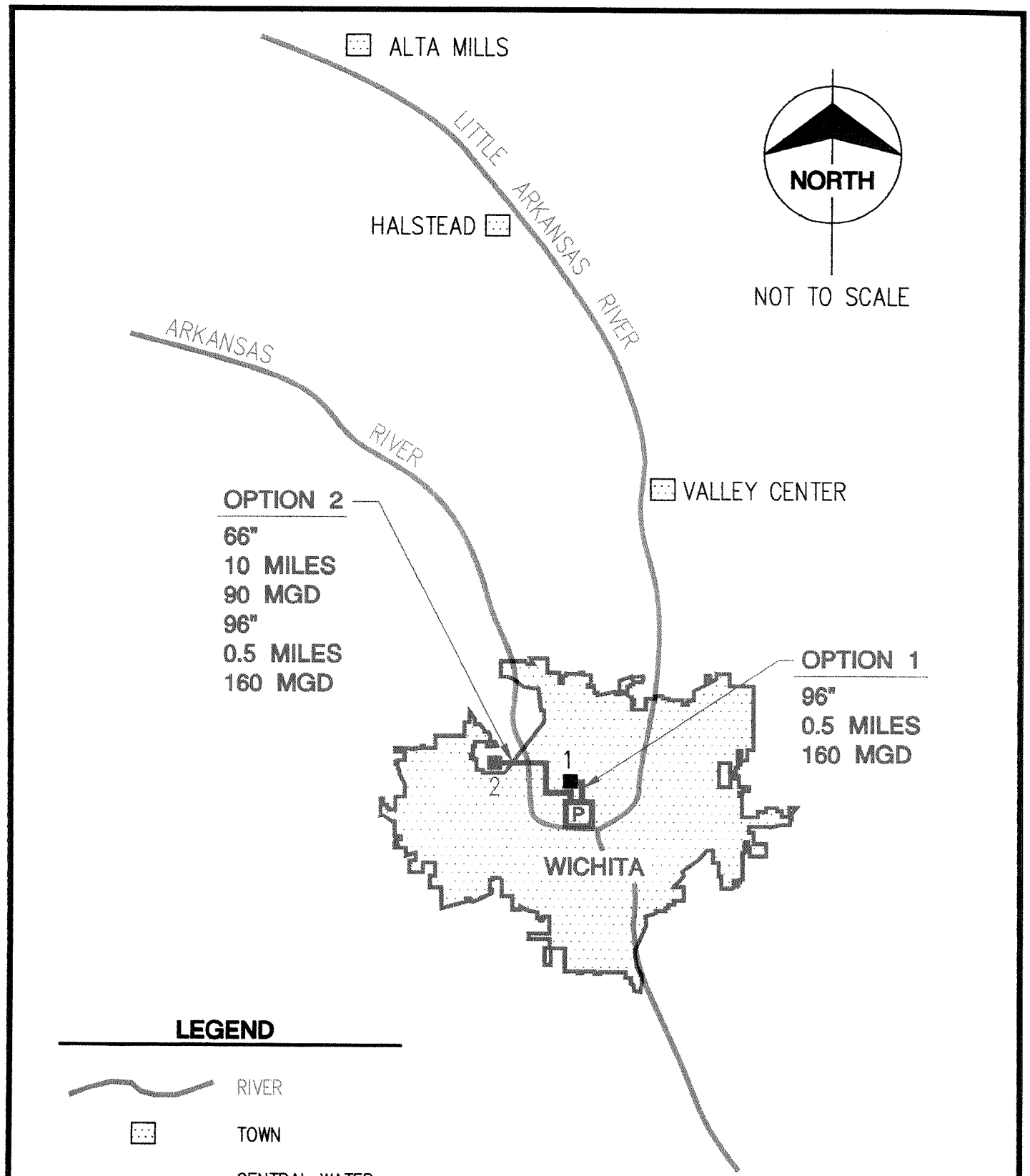
Item	Cost ($)
Wells (1)	$ 740,000
Subtotal	$ 740,000
Contingency @ 20%	150,000
Subtotal	$ 890,000
Other Costs @ 15%	130,000
Total Project Cost	**$ 1,020,000**
Available Flow (2)	**27,300 MG**
Unit Cost (3)	**$ 37 /MG**

Notes:

(1) Six 1,500 gpm wells, 200 feet deep, complete with well house, piping and electrical/controls with a firm capacity of 10.8 MGD.

(2) Available flow equals firm capacity times 46 days times 55 years. Additional use of the wells will decrease the unit cost. Constant use (216,800 MG) would decrease unit cost to $4.70/MG.

(3) Unit Cost is Total Project Cost divided by Available Flow.



LEGEND

- RIVER
- TOWN
- 1 ■ CENTRAL WATER TREATMENT PLANT
- 2 ■ NEW WATER TREATMENT PLANT
- P INTAKE/PUMP STATION
- PROPOSED PIPELINE

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Figure VI – 10

ARKANSAS RIVER WATER SUPPLY TO WATER PLANT SCHEMATIC

The Arkansas River has a mean annual discharge of 1,015 cfs or 656 MGD based on a 57-year period of record. The associated chloride concentrations average about 400 mg/l with a low of 10 mg/l and a high in excess of 800 mg/l. The lower chloride concentrations occur at high flow rates.

Review of the Arkansas River flow duration curves (refer to Appendix L) shows the following:

- Two percent firm yield is approximately 50 cfs or 32 MGD. This does not account for future minimum desired streamflow (MDS) requirements. Associated average chloride concentrations would be approximately 600 mg/l.

- The year 2050 maximum day demand of 249 MGD (386 cfs) would be available approximately 55 percent of the time; however, associated chloride concentrations would range from about 350 mg/l to over 800 mg/l.

- Minimum flow to assure chloride concentrations less than 200 mg/l is 3,000 cfs. Flows of 3,000 cfs or more occur about 8 percent of the time.

The river's average chloride concentration of 400 mg/l is double the City's maximum desired finished water chloride concentration of 200 mg/l. Membrane filtration treatment could be used at the treatment plant to reduce the chlorides to the desired level;

however, this treatment process is very expensive and would make the alternative economically nonviable.

The concept design of this alternative is based on the Arkansas River supplying an average of 8 percent of the City's water needs from year 1996 through 2050, about 8 MGD, without additional water treatment. The estimated project cost for Options 1 and 2 for the new raw water transmission system are $21 million and $51 million, respectively, as shown in Table VI-10. Option 1 includes a 160 MGD intake, pump station and presedimentation basin, and 0.5 miles of 96-inch diameter pipeline (160 MGD) to the Central Water Plant. Option 2 includes a 250 MGD intake, pump station, and presedimentation basin, 0.5 miles of 96-inch diameter pipeline (160 MGD) to the Central Water Plant and 10 miles of 66-inch diameter pipeline (90 MGD) to the New Water Plant. The unit cost for the alternative is $132/MG for Option 1 and $207/MG for Option 2.

j. Little Arkansas River Supply to Water Plant

A schematic of the water supply alternative which involves the conveyance of raw water from the Little Arkansas River to the water plant is shown in Figure VI-11. This alternative includes construction of an intake and pump station adjacent to the Central Water Plant with raw water transmission piping to the Central Water Plant.

Table VI – 10

BIG ARKANSAS RIVER SUPPLY ALTERNATIVE
RAW WATER TRANSMISSION SYSTEM
PROJECT COST ESTIMATE

Item	Option 1 Cost ($)	Option 2 Cost ($)
Intake and Pump Station (1)	$ 5,200,000	$ 7,000,000
Presedimentation Basin (2)	8,400,000	13,000,000
Pipeline (2)	1,200,000	16,600,000
Subtotal	$ 14,800,000	$ 36,600,000
Contingency @ 20%	3,000,000	7,300,000
Subtotal	$ 17,800,000	$ 43,900,000
Other Costs @ 15%	2,700,000	6,600,000
Total Project Cost	**$ 20,500,000**	**$ 50,500,000**
Available Flow (3)	**155,800 MG**	**243,400 MG**
Unit Cost (4)	**$ 132 /MG**	**$ 207 /MG**

Notes:
(1) Capacity of 160 MGD for Option 1 and 250 MGD for Option 2.
(2) 0.5 miles of 96–inch pipeline for Option 1 and 0.5 miles of 96–inch and 10 miles of 66–inch pipelines for Option 2.
(3) Flow is available is about 8% of the time from year 1996 through 2050.
(4) Unit Cost is Total Project Cost divided by Available Flow.

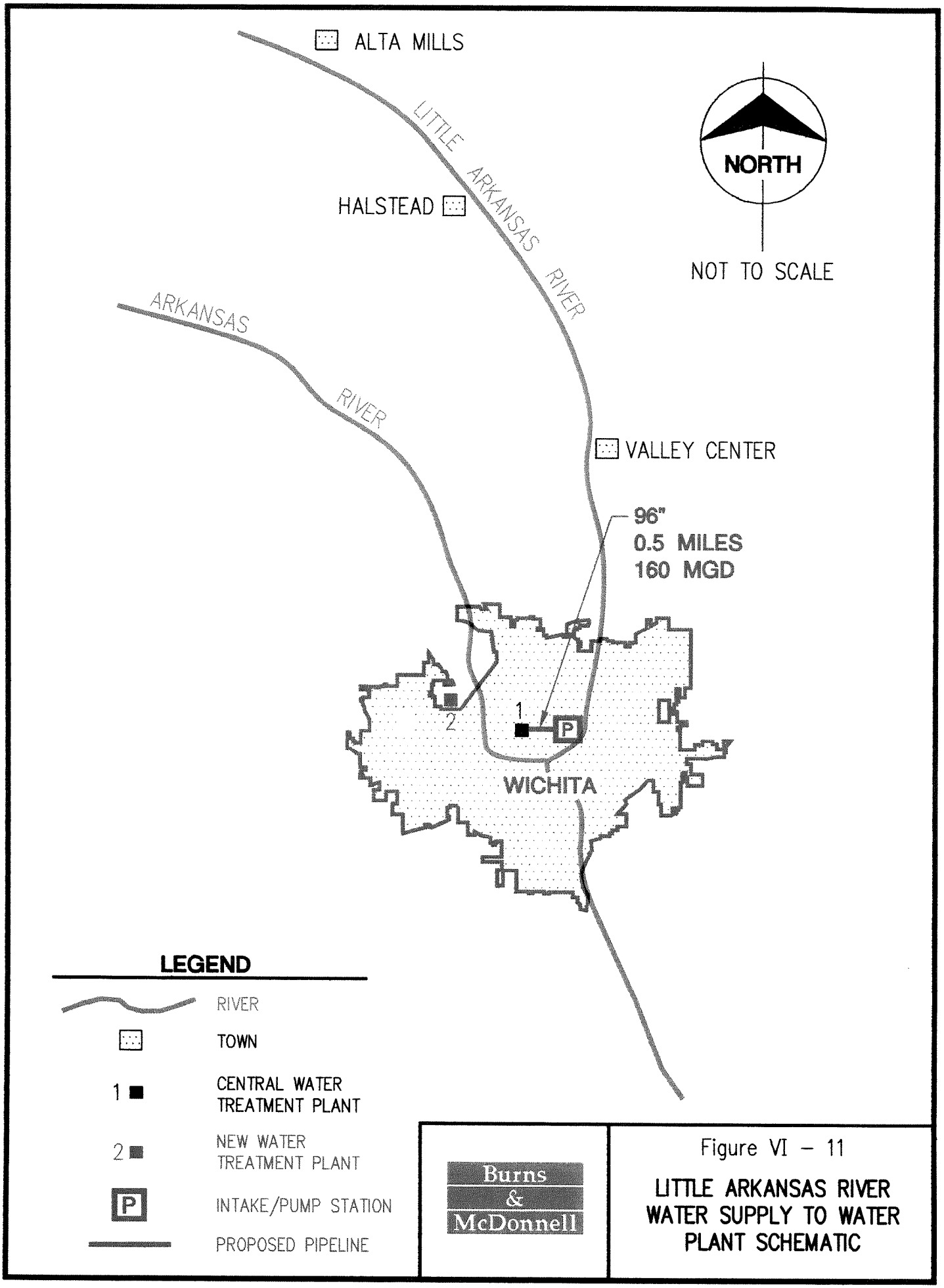


Figure VI – 11

LITTLE ARKANSAS RIVER WATER SUPPLY TO WATER PLANT SCHEMATIC

The Little Arkansas River has a mean annual discharge of 285 cfs or 184 MGD at Valley Center based on a 70-year period of record. The associated chloride concentrations average about 120 mg/l with a low of 5 mg/l and a high in excess of 400 mg/l. The river has a minimum desired streamflow of 20 cfs at Valley Center and 11 cfs at Alta Mills. Additionally, about 19 surface water rights exist between Alta Mills and Valley Center.

Review of Little Arkansas flow duration curves (refer to Appendix L) shows the following:

- Two percent firm yield is approximately 20 cfs or 13 MGD. This flow is less than the MDS at Valley Center; however, the MDS is 0 below Valley Center.

- The year 2050 maximum day demand of 249 MGD (386 cfs) would be available approximately 11 percent of the time.

- The Central Water Plant's capacity of 160 MGD (248 cfs) would be available approximately 26 percent of the time at the mouth of the Little Arkansas River. Lower flows are available a greater percentage of the time.

The concept design of this alternative is based on the Little Arkansas River supplying an average of 44 MGD of the City's water needs from year 1996 through 2050. This flow is about 45 percent of the City's average day demand of 97 MGD from year 1996 to 2050.

Flow will be pumped from the river to a new presedimentation basin at the nearby Central Water Plant on an "as-available" basis. The transmission system includes a 160-MGD intake and pump station and 0.5 miles of 96-inch diameter pipeline to the Central Water Plant and a 160 MGD presedimentation basin.

A series of horizontal collector wells along the Little Arkansas River near the water plant were considered as an alternative intake concept. The concept design includes eleven 15 MGD horizontal collector wells on 1 mile spacings linked together with 11.5 miles of 36-inch to 96-inch diameter pipeline at a project cost of $35 million. The collector well alternative is substantially more expensive than the surface water intake alternative and may encounter higher salt levels in groundwater. As a result, the collector well alternative is not proposed for use at this time.

The estimated project cost for the Little Arkansas River supply is $21 million as shown in Table VI-11. The unit cost for the alternative is $23/MG.

k. <u>Cheney Reservoir Operations/Management Modifications</u>

The Cheney Reservoir Operations/Management Modifications alternative involves the withdrawal of Cheney Reservoir water at an average rate greater than its average day water right of 47 MGD. Use of the reservoirs' water in this manner allows water in the Equus Beds to be stored for use when the water level in the reservoir is low and increases the total amount of water withdrawn from the reservoir;

Table VI – 11

LITTLE ARKANSAS RIVER SUPPLY ALTERNATIVE
RAW WATER TRANSMISSION SYSTEM
PROJECT COST ESTIMATE

Item	Cost ($)
Intake and Pump Station (1)	$ 5,200,000
Presedimentation Basin (1)	8,400,000
Pipeline (2)	1,200,000
Subtotal	$ 14,800,000
Contingency @ 20%	3,000,000
Subtotal	$ 17,800,000
Other Costs @ 15%	2,700,000
Total Project Cost	**$ 20,500,000**
Available Flow (3)	**880,000 MG**
Unit Cost (4)	**$ 23 /MG**

Notes:
(1) Capacity of 160 MGD.
(2) 0.5 miles of 96–inch pipeline.
(3) Available flow is about 33% of average day demand from year 1996 through 2050.
(4) Unit Cost is Total Project Cost divided by Available Flow.

however, the probability of a water shortage, i.e., no water available in the reservoir, increases.

A preliminary operations study was performed with Burns & McDonnell's RESNET computer program to model the operations/ management modifications. The program models reservoir withdrawals, level and storage as "inputted" operating conditions. Model inputs include flow and net evaporation data at the reservoir for a historical period of record from 1951 to 1990.

A series of average annual withdrawal rates from the reservoir were modeled including 47, 60, 80, 100 and 125 MGD. Withdrawal rates of 47, 60, 80, 100 and 125 MGD resulted in respective 0.4, 2.5, 11, 21 and 35 percent shortage probabilities as shown in Table VI-12. Additionally, the reservoir experienced extensive level variations (refer to Appendix M).

Withdrawals of 60 MGD resulted in 4 months with partial shortages and 8 months with complete shortages and yielded an average of 58.8 MGD over the 40-year period compared to 2 months with partial shortages for 47 MGD withdrawals. Increasing the reservoir withdrawal from 47 MGD to 60 MGD appears to be a viable alternative with minimal additional impacts on reservoir level. An integrated water use permit is required from the state to allow the City to operate the reservoir in this way. Additionally, a detailed yield analysis of Cheney Reservoir should be performed to confirm the firm yield.

Table VI – 12

CHENEY RESERVOIR OPERATIONS/MANAGEMENT MODIFICATIONS SUMMARY

Set Yield (MGD)	Available Flow to Wichita (1)		Shortages		Flood Releases		No. of Months with Shortages			Shortage Probability (%)
	(Ac–Ft)	(MGD)	(Ac–Ft)	(MGD)	(Ac–Ft)	(MGD)	Partial	Complete	Total	
47	2,103,000	46.9	2,500	0.1	737,000	16.5	2	0	2	0.4
60	2,634,000	58.8	55,000	1.2	611,000	13.5	4	8	12	2.5
80	3,308,000	73.8	278,000	6.2	475,000	10.6	38	15	53	11.0
100	3,866,000	86.2	617,000	13.8	310,000	6.9	87	16	103	21.0
125	4,333,000	96.7	1,270,000	28.3	215,000	4.8	150	20	170	35.0

Note:
(1) Based on a 40 year period of record from 1951 to 1990.

l. Purchase Flood Storage in Cheney Reservoir

The yield of Cheney Reservoir could be increased through the purchase of a portion of the flood storage pool. A preliminary operations study indicated that the purchase of 1 foot of flood pool increased the estimated firm yield by 3 MGD, 2 feet by 5 MGD and 3 feet by 6 MGD.

Increasing the reservoir's conservation pool was discussed with the Bureau of Reclamation and the Corps of Engineers. Their major concerns include environmental impacts, loss of flood benefits, dam safety and relocation of existing (recreational) facilities. Additionally, any proposal to decrease flood storage capacity requires congressional reauthorization. This alternative could be viable; however, highly detailed hydrologic, environmental, cultural and economic studies are required.

m. Membrane Filtration of High Chloride Groundwater

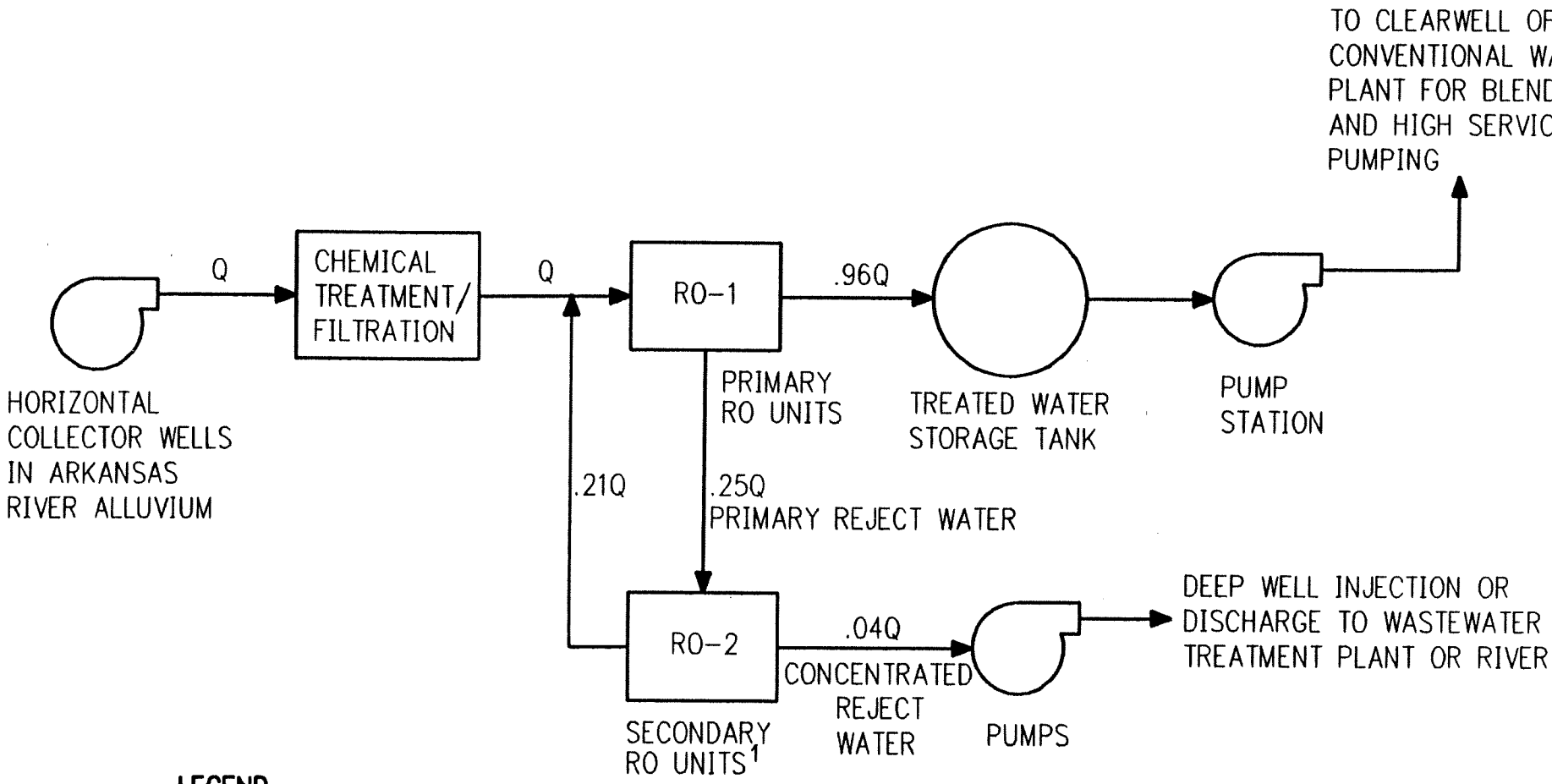
Water with high chloride concentrations can be treated via membrane filtration to reduce chlorides, hardness and other parameters to desired and potable levels. The Arkansas River can supply a firm yield of 32 MGD of surface water with chlorides ranging from 10 mg/L to over 800 mg/L. Alternatively, horizontal collector wells could be constructed along the Arkansas River and should allow withdrawals in excess of 60 MGD from the groundwater. Chloride levels in the groundwater are estimated to range from less than 100 mg/L to over 2000 mg/L.

The membrane filtration process creates a reject stream of concentrated brine that is about 25 percent of the total flow. Disposal of brine can be very difficult. Disposal alternatives include the following:

- Concentrate via a second treatment unit.
- Inject into the Arbuckle Formation, about 2000 feet deep.
- Convey to wastewater plant (if allowed by KDHE).
- Convey back to river (if allowed by KDHE).

A preliminary schematic for a 60 MGD membrane filtration plant is shown in Figure VI-12. The plant includes four 15 MGD horizontal collector wells adjacent to the Arkansas River, transmission piping, 60 MGD chemical treatment/filtration, 60 MGD of primary membrane filtration units, 15 MGD of secondary membrane filtration units, clearwells, high service pump station and five 0.5 MGD, 2000 feet deep injection wells.

The project cost for the 60 MGD plant is estimated at $191 million (based on March, 1993 dollars) as shown in Table VI-13. Operations, maintenance and energy costs are estimated at $48 million per year and the estimated unit cost is $158/MG. For comparison, a 10 MGD plant has a project cost estimate of $34 million and an operations, maintenance and energy cost estimate of $11 million per year with an estimated unit cost of $168/MG. This alternative does not appear to be economically viable at this time because of high operating costs, but should again be considered in the future under a new set of pricing conditions.



LEGEND

RO REVERSE OSMOSIS

Q FLOW

NOTE:

[1] FOR TREATMENT OF PRIMARY REJECT WATER TO REDUCE REJECT FLOW.

Burns & McDonnell

Figure VI – 12

REVERSE OSMOSIS TREATMENT SCHEMATIC

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Table VI – 13

REVERSE OSMOSIS TREATMENT PLANT
PROJECT COST ESTIMATE

Item	Option 1 Cost ($)	Option 2 Cost ($)
Horizontal Collector Wells	$ 12,800,000	$ 2,500,000
Transmission Piping	2,700,000	200,000
Treatment Plant	121,300,000	21,500,000
Brine Disposal Injection Wells	1,300,000	300,000
Subtotal	$ 138,100,000	$ 24,500,000
Contingency @ 20%	27,600,000	4,900,000
Subtotal	$ 165,700,000	$ 29,400,000
Other Costs @15%	24,900,000	4,400,000
Total Project Cost	**$ 190,600,000**	**$ 33,800,000**
Available Flow (4)	**1,205,000 MG**	**201,000 MG**
Unit Cost (5)	**$ 158 /MG**	**$ 168 /MG**

Notes:
(1) Option 1 is a 60 MGD water treatment plant and Option 2 is a 10 MGD water treatment plant.

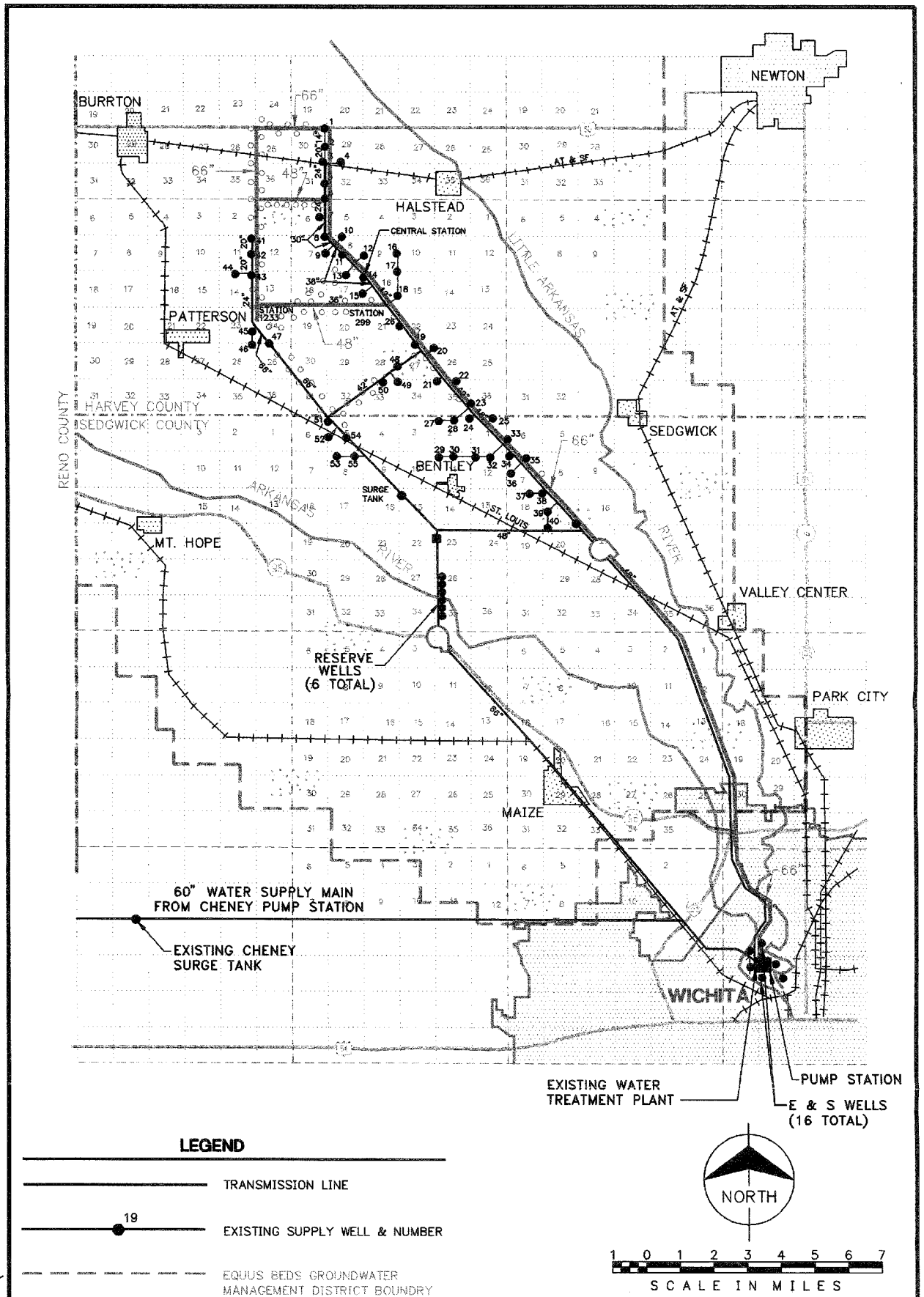
2. NONCONVENTIONAL

Thirteen nonconventional water supply alternatives are evaluated hereafter. These alternatives include the use of excess flow from Cheney Reservoir and the Little Arkansas River, treated wastewater reuse, rain harvesting and conservation.

Nonconventional alternatives involving subsurface storage and recovery of water in the Equus Beds require well field improvements for recovery and delivery of the stored water to the water plants as shown in Figure VI-13. The well field improvements include the addition of 70, 1,500 gpm wells, 38 miles of 66-inch diameter pipeline, 8 miles of 48-inch diameter pipeline and two 120 MGD booster pump stations with an estimated project cost of $99 million. Construction of these improvements can be phased and will increase the well field's firm pumping capacity to 220 MGD and allow the City of supply its year 2050 maximum day demand of 249 MGD through the use of the Equus Beds (220 MGD) and E&S (30 MGD) Well Fields.

The estimated project cost for these improvements is $99 million as shown in Table VI-14. These costs are included in the following alternatives:

- Little Arkansas River - Subsurface Storage and Recovery.
- Cheney Reservoir Overflow - Subsurface Storage and Recovery.
- Treated Wastewater Reuse - Subsurface Storage and Recovery.
- Bank Storage of Little Arkansas River Excess Stream Flows - Subsurface Storage and Recovery.



LEGEND

- TRANSMISSION LINE
- 19 — EXISTING SUPPLY WELL & NUMBER
- EQUUS BEDS GROUNDWATER MANAGEMENT DISTRICT BOUNDRY
- TOWNSHIP BOUNDRY
- PROPOSED PIPELINE
- PROPOSED BOOSTER PUMP STATION

Burns & McDonnell

Figure VI – 13

EQUUS BEDS WELL FIELD IMPROVEMENT SCHEMATIC

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Table VI – 14

EQUUS BEDS WELL FIELD IMPROVEMENTS
RAW WATER TRANSMISSION SYSTEM
PROJECT COST ESTIMATE

Item	Cost ($)
Wells (1)	$ 10,500,000
Transmission Piping (2)	49,700,000
Control Valve Vault (3)	1,800,000
Booster Pump Station (4)	10,000,000
Subtotal	$ 72,000,000
Contingency @ 20%	14,400,000
Subtotal	$ 86,400,000
Other Costs @ 15%	13,000,000
Total Project Cost	**$ 99,400,000**

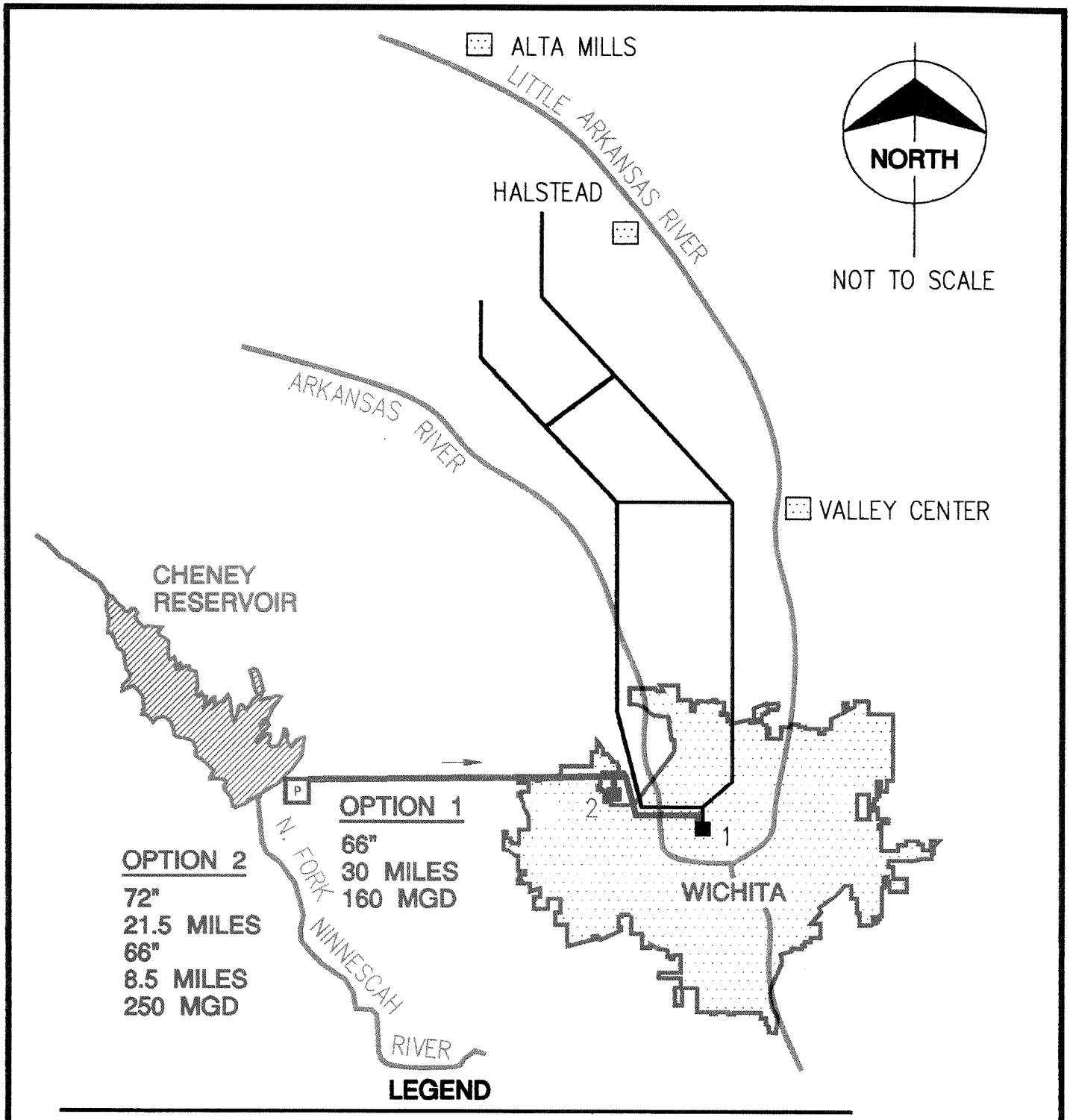
Notes:
(1) 75 wells with 1,500 gpm capacity, 200 feet deep.
(2) 38 miles of 66–inch pipeline and 8 miles of 48–inch pipeline.
(3) 18 control valve vaults on Equus Beds transmission piping.
(4) Two booster pump stations with 120 MGD capacity.

a. Cheney Reservoir Overflow

(1) Pipeline to Water Plants: A schematic of the water supply option which involves the conveyance of Cheney Reservoir overflow to the water plants is shown in Figure VI-14. The option includes construction of an intake and pump station adjacent to the outlet works discharge with a new water transmission pipeline to the water plants.

Cheney Reservoir overflow averaged approximately 94 MGD from 1965 to 1992. Review of flow duration curves for the reservoir show an average of 10 MGD (11,200 acre-feet) available with a pumping capacity of 160 MGD and 12.5 MGD (14,040 acre-feet) available with a pumping capacity of 250 MGD. These values are based on an operation history which maintained the reservoir at or near the top of the conservation pool. The withdrawal of water from Cheney Reservoir at its firm yield or full water right will cause a general lowering in reservoir operating water level and reduce the volume and frequency of overflows.

The concept design of this option is based on the City utilizing flow from Cheney as available. The estimated project costs for Options 1 and 2 are respectively $53 million and $60 million as shown in Table VI-15. Option 1 includes a 160 MGD intake and 30 miles of 66-inch diameter pipeline (160 MGD) to the water plants. Option 2 includes a 250 MGD intake and 21.5 miles of 72-inch diameter and 8.5 miles of 66-inch diameter pipelines to



LEGEND

RIVER	
TOWN	
1 ■	CENTRAL WATER TREATMENT PLANT
2 ■	NEW WATER TREATMENT PLANT
PROPOSED PIPELINE	
EXISTING EQUUS BED WELL FIELD PIPELINES	
P	INTAKE/PUMP STATION

Burns & McDonnell

Figure VI – 14

CHENEY RESERVOIR OVERFLOW TO WATER PLANTS SUPPLY SCHEMATIC

Table VI – 15

CHENEY RESERVOIR OVERFLOW TO WATER TREATMENT PLANTS
RAW WATER TRANSMISSION SYSTEM
PROJECT COST ESTIMATE

Item	Option 1 Cost ($)	Option 2 Cost ($)
Intake and Pump Station (1)	$ 5,200,000	$ 7,000,000
Pipeline (2)	33,300,000	36,700,000
Subtotal	$ 38,500,000	$ 43,700,000
Contingency @ 20%	7,700,000	8,700,000
Subtotal	$ 46,200,000	$ 52,400,000
Other Costs @ 15%	6,900,000	7,900,000
Total Project Cost	**$ 53,100,000**	**$ 60,300,000**
Available Flow (3)	**554,400 MG**	**695,000 MG**
Unit Cost (4)	**$ 96 /MG**	**$ 87 /MG**

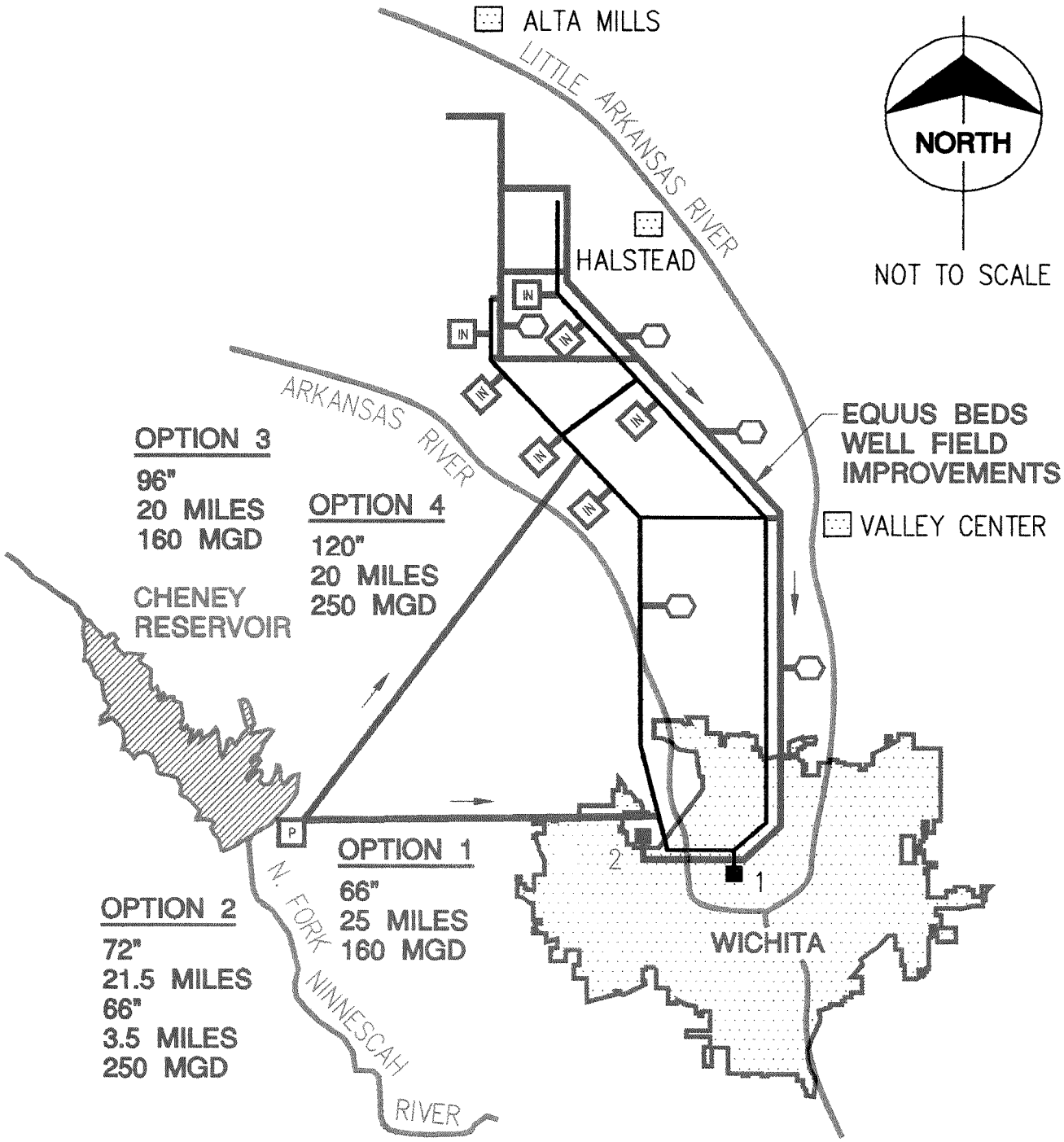
Notes:
(1) Capacity of 160 MGD for Option 1 and 250 MGD for Option 2.
(2) 30 miles of 66–inch pipeline for Option 1 and 21.5 miles of 72–inch and 8.5 miles of 66–inch pipelines for Option 2.
(3) Available flow is based on 55 years of supply at an average of 11,200 MGY for Option 1 and 14,040 MGY for Option 2 minus 10% for general losses and evaporation. Values are high since they are based on actual reservoir operation from 1965 to 1992. If water was withdrawn at the full firm yield, the availability of overflow would decrease.
(4) Unit Cost is Total Project Cost divided by Available Flow.

the water plants. The unit cost for the alternative is $96/MG for Option 1 and $87/MG for Option 2. This alternative could readily be connected to the Equus Beds transmission piping with the excess overflow used to recharge the Equus Beds.

(2) Side Stream Storage Reservoir: This water supply option involves the conveyance of excess flow from Cheney Reservoir to a side stream storage reservoir off the Ninnescah River. Review of USGS quadrangle sheets covering the Ninnescah River basin downstream of Cheney Reservoir showed two potential sites; Clearwater Creek and Spring Creek. The Clearwater Creek drainage area includes Lake Afton and Garden Plain. The Spring Creek drainage area is located between Garden Plain and Cheney.

These drainage areas are very flat, causing the reservoir to be very shallow with a large surface area and a resulting small storage volume. A large reservoir surface area increases reservoir evaporation, land requirements and environmental impacts. Additionally, highway and railroad relocations may also be required. Based on these conditions, suitable side stream storage reservoir sites do not appear to be available.

(3) Subsurface Storage and Recovery: A schematic of the water supply option which involves the supply of Cheney Reservoir overflow to the Equus Beds Aquifer for subsurface storage and recovery is shown in Figure VI-15. This option includes



LEGEND

- RIVER
- TOWN
- 1 ■ CENTRAL WATER TREATMENT PLANT
- 2 ■ NEW WATER TREATMENT PLANT
- PROPOSED PIPELINE
- EXISTING EQUUS BED WELL FIELD PIPELINES
- P INTAKE/PUMP STATION
- IN PROPOSED INFILTRATION BASIN
- PROPOSED WELL (TYP.)

Burns & McDonnell

Figure VI – 15

CHENEY RESERVOIR OVERFLOW SUBSURFACE STORAGE & RECOVERY SCHEMATIC

construction of an intake and pump station and pipeline from Cheney Reservoir to recharge sites in the Equus Beds.

Chloride concentrations in the overflow water average about 150 to 200 mg/l or double the chlorides in the shallow groundwater near the Equus Beds wells. Chlorides are typically less than 100 mg/l in the shallow groundwater. Subsurface storage and recovery with overflow water may be determined by KDHE to degrade the quality of the groundwater. This would be a fatal flaw for this option. One way to bypass this problem might be to purchase recharge sites closer to the Arkansas River where the chloride levels in the shallow aquifer approach or exceed 200 mg/l. Additionally, mixing Little Arkansas River excess flow with Cheney Reservoir overflow may be possible. This could reduce the average chloride concentration of the recharge water to the Equus Beds Aquifer.

The concept design of this option is based on Cheney overflow supplying an average of 28 MGD to 35 MGD to the Equus Beds for subsurface storage and recovery from year 1996 through 2050. Flow would be pumped to the Equus Beds Well Field on an "as-available" basis.

The estimated project costs for Options 1, 2, 3, and 4 for the new raw water transmission system are respectively $54 million, $65 million, $69 million, and $93 million without Equus Beds Well Field Improvements, as shown in Table VI-16. Option 1

Table VI – 16

CHENEY RESERVOIR OVERFLOW TO EQUUS BEDS ALTERNATIVE
RAW WATER TRANSMISSION SYSTEM
PROJECT COST ESTIMATE

Item	Option 1 Cost ($)	Option 2 Cost ($)
Intake and Pump Station (1)	$ 5,200,000	$ 7,000,000
Pipeline (2)	27,700,000	31,100,000
Surface Spreading Basins (3)	6,000,000	9,300,000
Equus Beds Well Field Improvements (4)	72,000,000	72,000,000
Subtotal	$ 110,900,000	$ 119,400,000
Contingency @ 20%	22,200,000	23,900,000
Subtotal	$ 133,100,000	$ 143,300,000
Other Costs @ 15%	20,000,000	21,500,000
Total Project Cost	**$ 153,100,000**	**$ 164,800,000**
Project Cost (5)	**$ 53,700,000**	**$ 65,400,000**
Available Flow (6)	**554,400 MG**	**695,000 MG**
Unit Cost (7)	**$ 276 /MG**	**$ 237 /MG**
Unit Cost (8)	**$ 97 /MG**	**$ 94 /MG**

Notes:
(1) Capacity of 160 MGD for Options 1 and 3 and 250 MGD for Options 2 and 4.
(2) 25 miles of 66–inch pipeline for Option 1 and 21.5 miles of 72–inch and 3.5 miles of 66–inch pipelines for Option 2.
(3) 40 four acre surface spreading basins for Options 1 and 3 and 62 basins for Options 2 and 4.
(4) Includes 70 1,500 gpm wells, 38 miles of 66–inch pipeline, 8 miles of 48–inch pipeline and two booster pump stations.
(5) Project cost without Equus Beds Well Field Improvements.
(6) Available flow is based on 55 years of supply at an average of 11,200 MGY for Options 1 and 3 and 14,040 MGY for Options 2 and 4 minus 10 % for general losses and evaporation. Values are high since they are based on actual reservoir operation from 1965 to 1992. If water was was withdrawn at the full firm yield, the avilability of overflow would decrease.
(7) Unit Cost is Total Project Cost divided by Available Flow.
(8) Unit cost without Equus Beds Well Field Improvements.

Table VI – 16 (Continued)

CHENEY RESERVOIR OVERFLOW TO EQUUS BEDS ALTERNATIVE
RAW WATER TRANSMISSION SYSTEM
PROJECT COST ESTIMATE

Item	Option 3 Cost ($)	Option 4 Cost ($)
Intake and Pump Station (1)	$ 5,200,000	$ 7,000,000
Pipeline (2)	39,100,000	50,700,000
Surface Spreading Basins (3)	6,000,000	9,300,000
Equus Beds Well Field Improvements (4)	72,000,000	72,000,000
Subtotal	$ 122,300,000	$ 139,000,000
Contingency @ 20%	24,500,000	27,800,000
Subtotal	$ 146,800,000	$ 166,800,000
Other Costs @ 15%	22,000,000	25,000,000
Total Project Cost	**$ 168,800,000**	**$ 191,800,000**
Project Cost (5)	**$ 69,400,000**	**$ 92,500,000**
Available Flow (6)	**554,400 MG**	**695,000 MG**
Unit Cost (7)	**$ 304 /MG**	**$ 276 /MG**
Unit Cost (8)	**$ 125 /MG**	**$ 133 /MG**

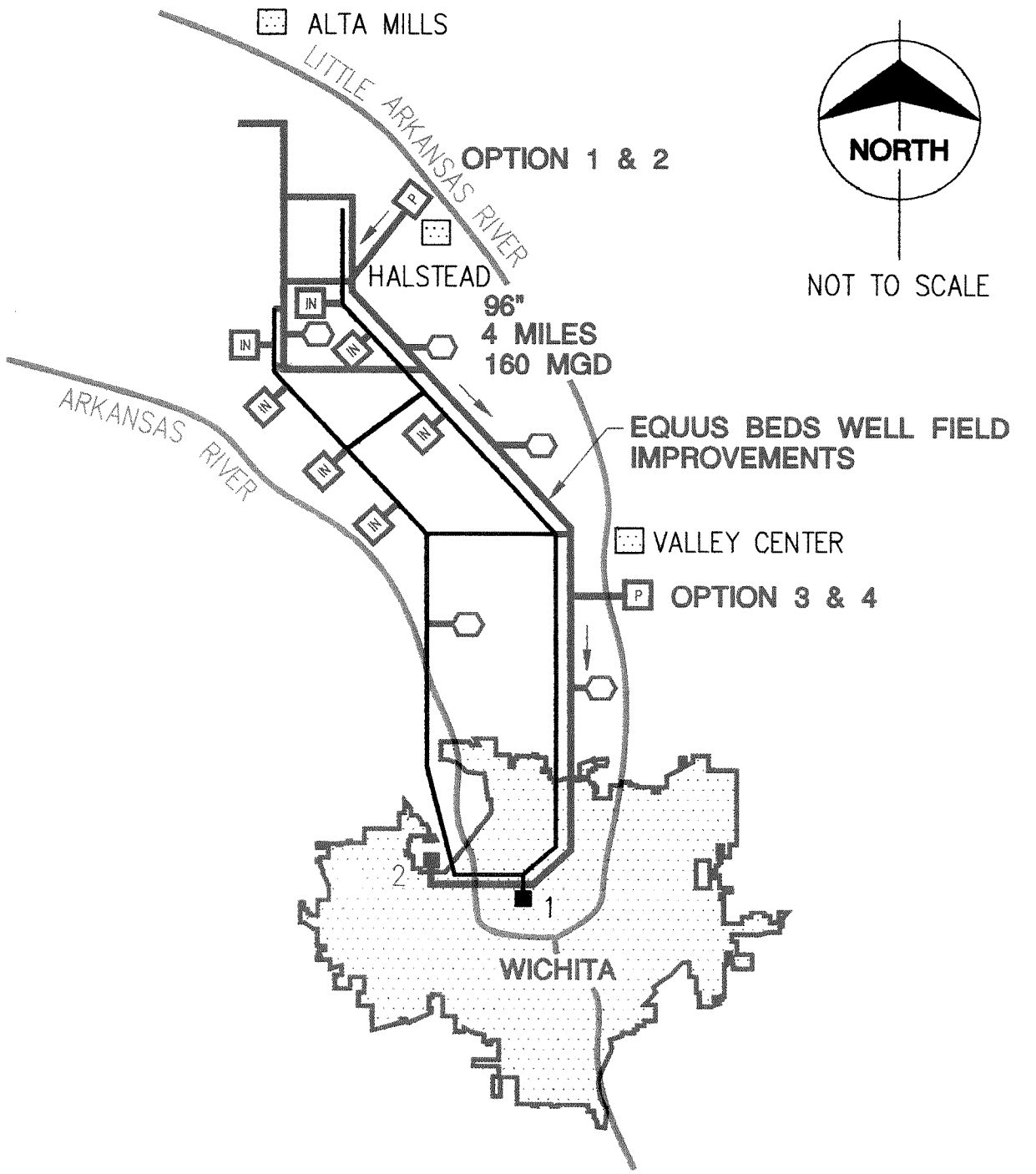
Notes:
(1) Capacity of 160 MGD for Options 1 and 3 and 250 MGD for Options 2 and 4.
(2) 20 miles of 96–inch pipeline for Option 3 and 20 miles of 120–inch pipeline for Option 4.
(3) 40 four acre surface spreading basins for Options 1 and 3 and 62 basins for Options 2 and 4.
(4) Includes 70 1,500 gpm wells, 38 miles of 66–inch pipeline, 8 miles of 48–inch pipeline and two booster pump stations.
(5) Project cost without Equus Beds Well Field Improvements.
(6) Available flow is based on 55 years of supply at an average of 11,200 MGY for Options 1 and 3 and 14,040 MGY for Options 2 and 4 minus 10 % for general losses and evaporation. Values are high since they are based on actual reservoir operation from 1965 to 1992. If water was was withdrawn at the full firm yield, the avilability of overflow would decrease.
(7) Unit Cost is Total Project Cost divided by Available Flow.
(8) Unit cost without Equus Beds Well Field Improvements.

includes a 160 MGD intake and pump station, 25 miles of 66-inch diameter pipeline (160 MGD) to the well field and 40 surface spreading basins. Option 2 includes s 250 MGD intake and pump station, 21.5 miles of 72-inch diameter and 3.5 miles of 66-inch diameter pipelines (250 MGD) to the well field and 62 surface spreading basins. Option 3 includes a 160 MGD intake and pump station, 20 miles of 96-inch diameter pipeline (160 MGD) to the well field and 40 surface spreading basins. Option 4 includes a 250 MGD intake and pump station, 20 miles of 120-inch diameter pipeline (250 MGD) to the well field 62 surface spreading basins. Options 1 and 2 could allow water to be conveyed to the Central Water Plant with the addition of 3.5 miles of pipeline. Unit costs for the alternative are $97/MG for Option 1, $94/MG for Option 2, $125/MG for Option 3, and $133/MG for Option 4.

b. Little Arkansas River Supply for Subsurface Storage and Recovery

A schematic of the water supply alternative which involves the conveyance of raw water from the Little Arkansas River to the Equus Beds is shown in Figure VI-16. This alternative includes the intake and pump station near Halstead with raw water transmission piping to the Equus Beds Well Field for subsurface storage and recovery.

The Little Arkansas River has a mean annual discharge of 285 cfs or 184 MGD at Valley Center based on a 70-year period of record and 192.5 cfs or 124 MGD at Alta Mills based on a 19-year period of record. The associated chloride concentrations average about 120 mg/l with a low of 5 mg/l and a high in excess of 400 mg/l. The



LEGEND

- RIVER
- TOWN
- 1 CENTRAL WATER TREATMENT PLANT
- 2 NEW WATER TREATMENT PLANT
- PROPOSED PIPELINE
- EXISTING EQUUS BED WELL FIELD PIPELINES
- P INTAKE/PUMP STATION
- IN PROPOSED INFILTRATION BASIN
- PROPOSED WELL (TYP.)

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Figure VI – 16

LITTLE ARKANSAS RIVER SUBSURFACE STORAGE & RECOVERY SCHEMATIC

river has a minimum desired streamflow of 20 cfs at Valley Center and 11 cfs at Alta Mills. Additionally, about 19 surface water rights exist between Alta Mills and Valley Center.

Review of Little Arkansas flow duration curves (refer to Appendix L) shows the following:

- Two percent firm yield is approximately 7 cfs or 4.5 MGD at Alta Mills and 20 cfs or 13 MGD at Valley Center. This flow is less than the MDS at Valley Center; however, the MDS is 0 below Valley Center.

- The year 2050 maximum day demand of 249 MGD (386 cfs) would be available approximately 10 percent of the time.

- The Central Water Plant's capacity of 160 MGD (248 cfs) would be available approximately 13 percent of the time at Halstead. Lower flows are available a greater percentage of the time.

The concept design of this alternative is based on the Little Arkansas River supplying an average of up to 39 MGD from Halstead or up to 52 MGD from Valley Center to the Equus Beds for storage. Flow will be pumped to the Equus Beds Well Field on an "as-available" basis.

The estimated project costs for Options 1, 2, 3, and 4 for the new raw water transmission system are respectively $26 million, $36 million, $49 million and $66 million without Equus Beds Well Field improvements, as shown in Table VI-17. Option 1 includes a 160 MGD intake and pump station near Halstead, 4 miles of 96-inch diameter pipeline (160 MGD) to the well field and 40 surface spreading basins. Option 2 includes a 250 MGD intake and pump station near Halstead, 4 miles of 120-inch diameter pipeline (250 MGD) to the well field and 62 surface spreading basins. Option 3 includes a 160 MGD intake near Valley Center, 12.5 miles of 96-inch diameter pipeline (160 MGD) to the well field and 40 surface spreading basins. Option 4 includes a 250 MGD intake near Valley Center, 12.5 miles of 120-inch diameter pipeline (250 MGD) to the well field and 62 surface spreading basins. Unit costs for the alternative are $46/MG for Option 1, $51/MG for Option 2, $65/MG for Option 3 and $71/MG for Option 4.

c. Treated Wastewater Reuse

Three options for treated wastewater reuse (or use of reclaimed water) are investigated, including use as irrigation water for golf courses and parks, use as subsurface aquifer storage and recovery, and use as irrigation water to the Equus Beds irrigators. Each alternative includes the construction of a storage tank and pump station at the City's Wastewater Plant No. 2 and transmission piping to the potential users. Treated wastewater could also be used to remediate areas with contaminated groundwater (such as previously described for the Haysville well field).

Table VI – 17

LITTLE ARKANSAS RIVER SUPPLY TO EQUUS BEDS ALTERNATIVE
RAW WATER TRANSMISSION SYSTEM
PROJECT COST ESTIMATE

Item	Option 1 Cost ($)	Option 2 Cost ($)
Intake and Pump Station (1)	$ 5,200,000	$ 7,000,000
Pipeline (2)	7,800,000	10,100,000
Surface Spreading Basins (3)	6,000,000	9,300,000
Equus Beds Well Field Improvements (4)	72,000,000	72,000,000
Subtotal	$ 91,000,000	$ 98,400,000
Contingency @ 20%	18,200,000	19,700,000
Subtotal	$ 109,200,000	$ 118,100,000
Other Costs @ 15%	16,400,000	17,700,000
Total Project Cost	**$ 125,600,000**	**$ 135,800,000**
Project Cost (5)	**$ 26,200,000**	**$ 36,400,000**
Available Flow (6)	**574,200 MG**	**712,800 MG**
Unit Cost (7)	**$ 219 /MG**	**$ 191 /MG**
Unit Cost (8)	**$ 46 /MG**	**$ 51 /MG**

Notes:
(1) Capacity of 160 MGD for Option 1 and 250 MGD for Option 2.
(2) 4 miles of 96–inch pipeline for Option 1 and 4 miles of 120–inch pipeline for Option 2.
(3) 40 four acre surface spreading basins for Option 1 and 62 basins for Option 2.
(4) Includes 70 1,500 gpm wells, 38 miles of 66–inch pipeline, 8 miles of 48–inch pipeline and two booster pump stations.
(5) Project cost without Equus Beds Well Field Improvements.
(6) Available flow is based on 55 years of supply at an average of 11,600 MGY for Option 1 and 14,400 MGY for Option 2 minus 10 % for general losses and evaporation.
(7) Unit Cost is Total Project Cost divided by Available Flow.
(8) Unit cost without Equus Beds Well Field Improvements.
(9) Options 1 and 2 are based on an intake near Halsted and Options 3 and 4 are based on an intake near Valley Center.

Table VI – 17 (Continued)

LITTLE ARKANSAS RIVER SUPPLY TO EQUUS BEDS ALTERNATIVE
RAW WATER TRANSMISSION SYSTEM
PROJECT COST ESTIMATE

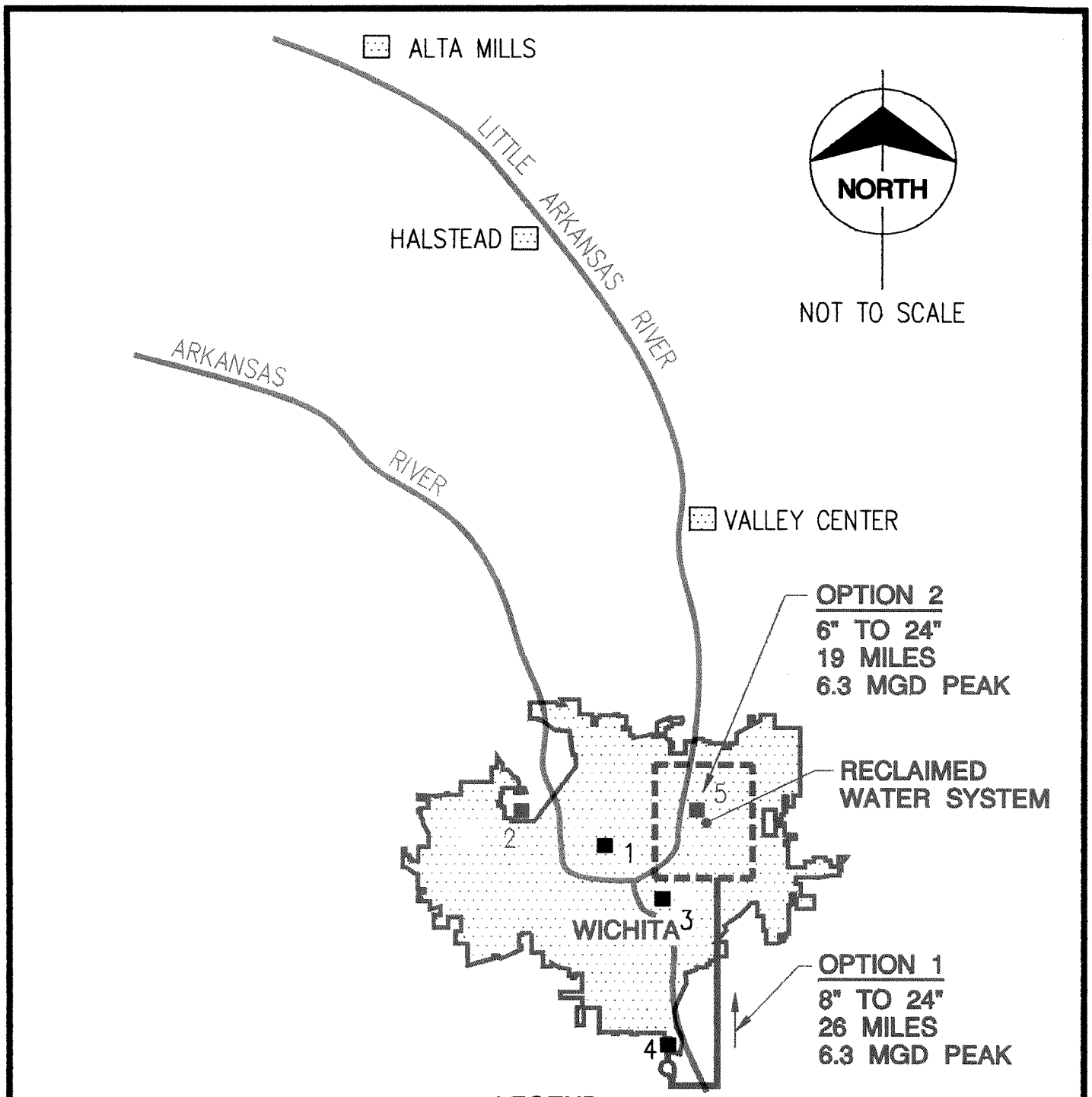
Item	Option 3 Cost ($)	Option 4 Cost ($)
Intake and Pump Station (1)	$ 5,200,000	$ 7,000,000
Pipeline (2)	24,400,000	31,700,000
Surface Spreading Basins (3)	6,000,000	9,300,000
Equus Beds Well Field Improvements (4)	72,000,000	72,000,000
Subtotal	$ 107,600,000	$ 120,000,000
Contingency @ 20%	21,500,000	24,000,000
Subtotal	$ 129,100,000	$ 144,000,000
Other Costs @ 15%	19,400,000	21,600,000
Total Project Cost	**$ 148,500,000**	**$ 165,600,000**
Project Cost (5)	**$ 49,100,000**	**$ 66,200,000**
Available Flow (6)	**757,400 MG**	**930,600 MG**
Unit Cost (7)	**$ 196 /MG**	**$ 178 /MG**
Unit Cost (8)	**$ 65 /MG**	**$ 71 /MG**

Notes:
(1) Capacity of 160 MGD for Option 1 and 250 MGD for Option 2.
(2) 12.5 miles of 96–inch pipeline for Option 3 and 12.5 miles of 120–inch pipeline for Option 4.
(3) 40 four acre surface spreading basins for Option 1 and 62 basins for Option 2.
(4) Includes 70 1,500 gpm wells, 38 miles of 66–inch pipeline, 8 miles of 48–inch pipeline and two booster pump stations.
(5) Project cost without Equus Beds Well Field Improvements.
(6) Available flow is based on 55 years of supply at an average of 15,300 MGY for Option 3 and 18,800 MGY for Option 4 minus 10 % for general losses and evaporation.
(7) Unit Cost is Total Project Cost divided by Available Flow.
(8) Unit cost without Equus Beds Well Field Improvements.
(9) Options 1 and 2 are based on an intake near Halsted and Options 3 and 4 are based on an intake near Valley Center.

The concentration of fecal coliforms is the primary water quality parameter used by KDHE to determine the suitability of wastewater reuse in various applications. From May 1 to October 31, when use of irrigation water is high, Plant No. 2 typically discharges an effluent ranging from 33 to 64 fecal colonies per 100 ml. This level is slightly higher than the State's unrestricted access reuse permitted limit of 20 colonies per 100 ml, but is well below the state's restricted access reuse permitted limit of 200 colonies per 100 ml. Based on discussions with potential users, reuse water can be applied when site access is restricted, therefore, additional treatment facilities are not required at the wastewater plant to meet the restricted access average fecal coliform level of 200 colonies per 100 ml.

(1) Irrigation for Golf Courses and Parks: A schematic of the water supply options which involves the supply of up to a maximum of 6.3 MGD of reclaimed water to golf courses and parks is shown in Figure VI-17. Option 1 includes construction of a pump station, storage tank, and pipelines from Wastewater Plant No. 2 to potential reclaimed water customers. Option 2 includes a 6 MGD capacity wastewater treatment plant with sequencing batch reactors, a pump station, storage tank and pipelines to potential reclaimed water customers.

An average of 1.1 MGD is expected to be used by the potential customers from May through October. From November through April



LEGEND

RIVER	5 ■	NEW SATELLITE WASTEWATER TREATMENT PLANT	
TOWN		PROPOSED PIPELINE	PROPOSED PUMP STATION
1 ■ CENTRAL WATER TREATMENT PLANT		AREA OF INTEREST	
2 ■ NEW WATER TREATMENT PLANT			
3 ■ WASTEWATER PLANT NO. 1			
4 ■ WASTEWATER PLANT NO. 2			

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Figure VI – 17
RECLAIMED WATER TO GOLF COURSES & PARKS WATER SUPPLY SCHEMATIC

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the plant does not meet the fecal coliform limitations set by KDHE so the reclaimed water cannot be reused.

Potential customers for the reclaimed water are located on the east side of the City and include the following:

- Clapp Park Golf Course
- Country Place Greens Home Owners Association
- K-96 Expressway Landscaping
- Lakepoint Home Owners Association
- McConnell AFB Golf Course
- McDonald Golf Course
- Planeview Park
- Tallgrass East Home Owners Association
- Tallgrass Golf Course
- Terradyne Golf Course
- Wichita Country Club Golf Course
- Wichita State Golf Course
- Willowbend Golf Course

The concept design for Option 1 is based on Wastewater Plant No. 2 supplying an average of 1.1 MGD and a maximum of 6.3 MGD for reuse from year 1996 through 2050. Use of the reclaimed water reduces the City's maximum day peak by about 6.3 MGD. The reclaimed water will be pumped from the pipeline just upstream of the dechlorination facility via a 6.3 MGD pump station through 26 miles of 8-inch through 24-inch diameter pipeline to the reclaimed water customers.

The concept design for Option 2 is based on a new satellite wastewater plant supplying an average of 1.1 MGD and a maximum of 6.3 MGD for reuse from year 1996 through 2050. The reclaimed water reduces the City's maximum day by about 6.3 MGD. The satellite wastewater plant includes sequencing batch reactors. The reclaimed water is chlorinated and pumped via 19 miles of 6-inch through 24-inch diameter pipelines to the reclaimed water customer.

The estimated project cost for the reclaimed water transmission system is $18 million for Option 1 and $15 million for Option 2 as shown in Table VI-18. Unit costs, are $1,627/MG for Option 1 and $1,336/MG for Option 2.

This option could be structured to generate revenue from the sale of reclaimed water. Additionally, the use of reclaimed water reduces the peak summer demand and directly impacts the need for additional supply capacity.

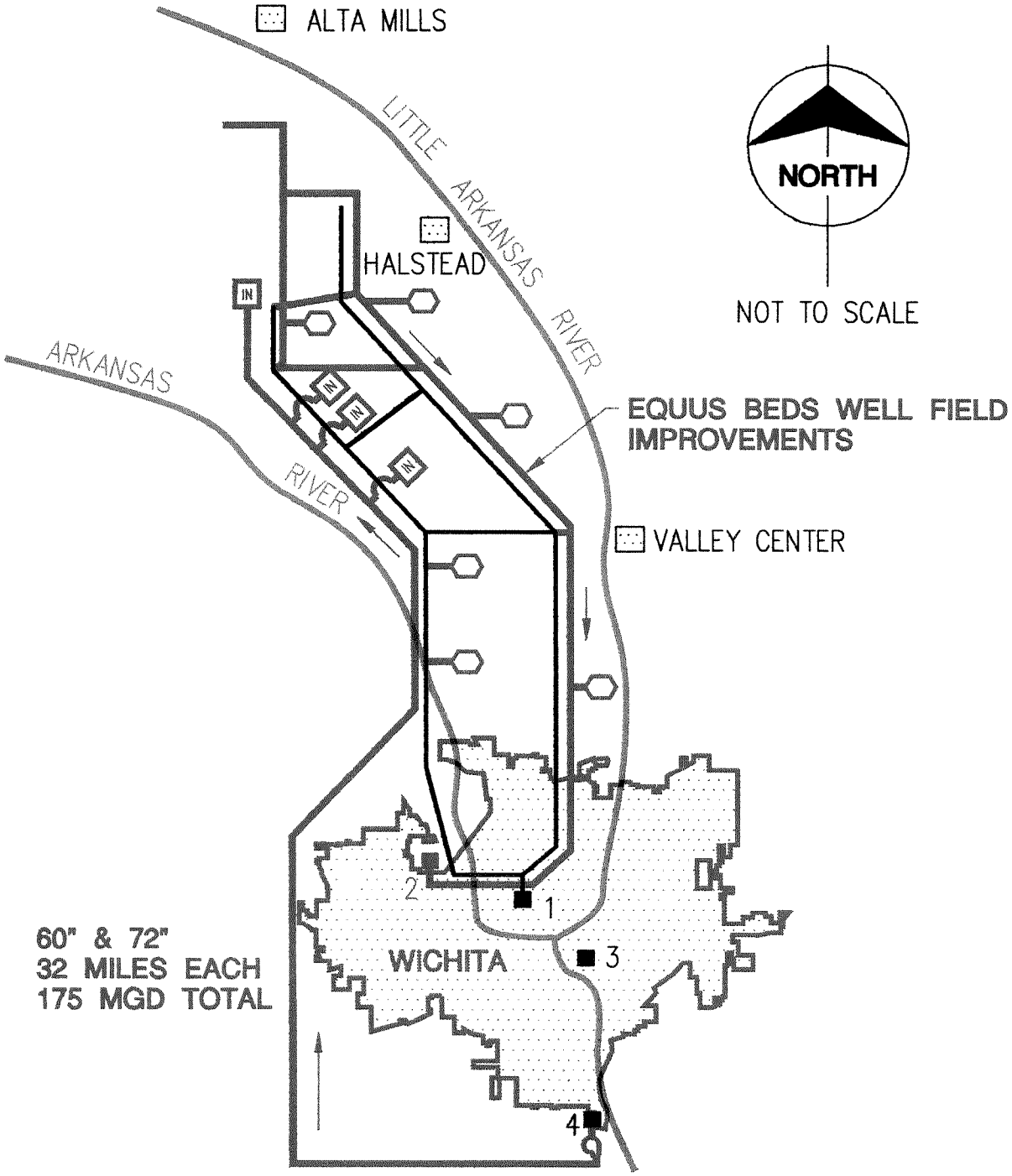
(2) Subsurface Storage and Recovery in Equus Beds: A schematic of the water supply option which involves the supply of reclaimed water from Wastewater Plant No. 2 to the Equus Beds Aquifer for subsurface storage and recovery is shown in Figure VI-18. This option includes construction of pump stations and pipelines from Wastewater Plant No. 2 to recharge sites in the Equus Beds.

Table VI – 18

TREATED WASTEWATER REUSE
LOCAL IRRIGATION ALTERNATIVE
PROJECT COST ESTIMATE

Item	Option 1 Cost ($)	Option 2 Cost ($)
Pump Station and Storage Tank (1)	$ 1,000,000	$ 800,000
Wastewater Treatment Plant (2)	–	6,000,000
Pipeline (3)	12,000,000	3,900,000
Subtotal	$ 13,000,000	$ 10,700,000
Contingency @ 20%	2,600,000	2,100,000
Subtotal	$ 15,600,000	$ 12,800,000
Other Costs @15%	2,300,000	1,900,000
Total Project Cost	**$ 17,900,000**	**$ 14,700,000**
Available Flow (4)	**11,000 MG**	**11,000 MG**
Unit Cost (5)	**$ 1,627 /MG**	**$ 1,336 /MG**

Notes:
(1) Average available of 1.1 MGD and a maximum capacity of 6.3 MGD. 0.5 MG ground storage tank for Option 1 and 0.5 MG elevated storage tank for Option 2.
(2) 6 MGD sequencing batch reactor wastewater treatment plant.
(3) 26 miles of 8–inch to 24–inch pipelines for Option 1 and 19 miles of 6–inch to 24–inch pipelines for Option 2.
(4) Available flow is based on 55 years of supply at an average rate of 1.1 MGD for 182 days per year.
(5) Unit Cost is Total Project Cost divided by Available Flow.



LEGEND

	RIVER		PROPOSED PUMP STATION		PROPOSED WELL (TYP.)
	TOWN		PROPOSED PIPELINE		
1 ■	CENTRAL WATER TREATMENT PLANT	IN	PROPOSED INFILTRATION BASIN		
2 ■	NEW WATER TREATMENT PLANT				
3 ■	WASTEWATER PLANT NO. 1				
4 ■	WASTEWATER PLANT NO. 2				
	EXISTING EQUUS BED WELL FIELD PIPELINES				

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Figure VI – 18
RECLAIMED WATER SURFACE SPREADING AND RECOVERY IN EQUUS BEDS WATER SUPPLY SCHEMATIC

Chloride concentrations in the reclaimed water average about 200 mg/l or double the chlorides in the shallow groundwater near the Equus Beds wells. Chlorides are typically less than 100 mg/l in the shallow groundwater. Subsurface storage and recovery with reclaimed water may be determined by KDHE to degrade the quality of the groundwater which would represent a fatal flaw for this option. One way to bypass this problem might be to purchase recharge sites closer to the Arkansas River where the chloride levels in the shallow aquifer approach or exceed 200 mg/l.

The concept design of this option is based on Wastewater Plant No. 2 supplying an average of 68 MGD to the Equus Beds for storage and recovery from year 1996 through 2050. The transmission system includes one 5 MG storage tank at Plant No. 2, two 175 MGD pump stations, 32 miles of 60-inch and 72-inch diameter parallel pipelines to the Equus Beds, and 35 surface spreading basins.

The estimated project cost for the reclaimed water transmission system is $130 million without Equus Beds Well Field improvements as shown in Table VI-19. The unit cost for this option is $96/MG.

(3) <u>Use of Reclaimed Water by Equus Beds Irrigators</u>: A schematic of the water supply option which involves the supply of reclaimed water from Wastewater Plant No. 2 to the Equus Beds irrigators

Table VI – 19

TREATED WASTEWATER REUSE
SUBSURFACE STORAGE ALTERNATIVE
PROJECT COST ESTIMATE

Item	Cost ($)
Storage Tank & Piping (1)	$ 400,000
Pump Station (2)	12,000,000
Pipeline (3)	76,900,000
Surface Spreading Basins (4)	5,200,000
Equus Beds Well Field Improvements (5)	72,000,000
Subtotal	$ 166,500,000
Contingency @ 20%	33,300,000
Subtotal	$ 199,800,000
Other Costs @ 15%	30,000,000
Total Project Cost	**$ 229,800,000**
Project Cost (6)	**$ 130,400,000**
Available Flow (7)	**1,361,300 MG**
Unit Cost (8)	**$ 169 /MG**
Unit Cost (9)	**$ 96 /MG**

Notes:
(1) 0.5 MG ground storage tank.
(2) Two 175 MGD capacity pump stations.
(3) 32 miles of 72–inch and 32 miles of 60–inch transmission pipelines 3.3 miles of 16–inch distribution pipelines.
(4) 35 surface spreading basins and control valve piping.
(5) Includes 75 1,500 gpm wells, 38 miles of 66–inch pipeline, 8 miles of 48–inch pipeline and two booster pump stations.
(6) Project cost without Equus Beds Well Field improvements.
(7) Available flow is based on 55 years supply at an average of 24,750 MGY.
(8) Unit Cost is Total Project Cost divided by Available Flow.
(9) Unit cost without Equus Beds Well Field Improvements.

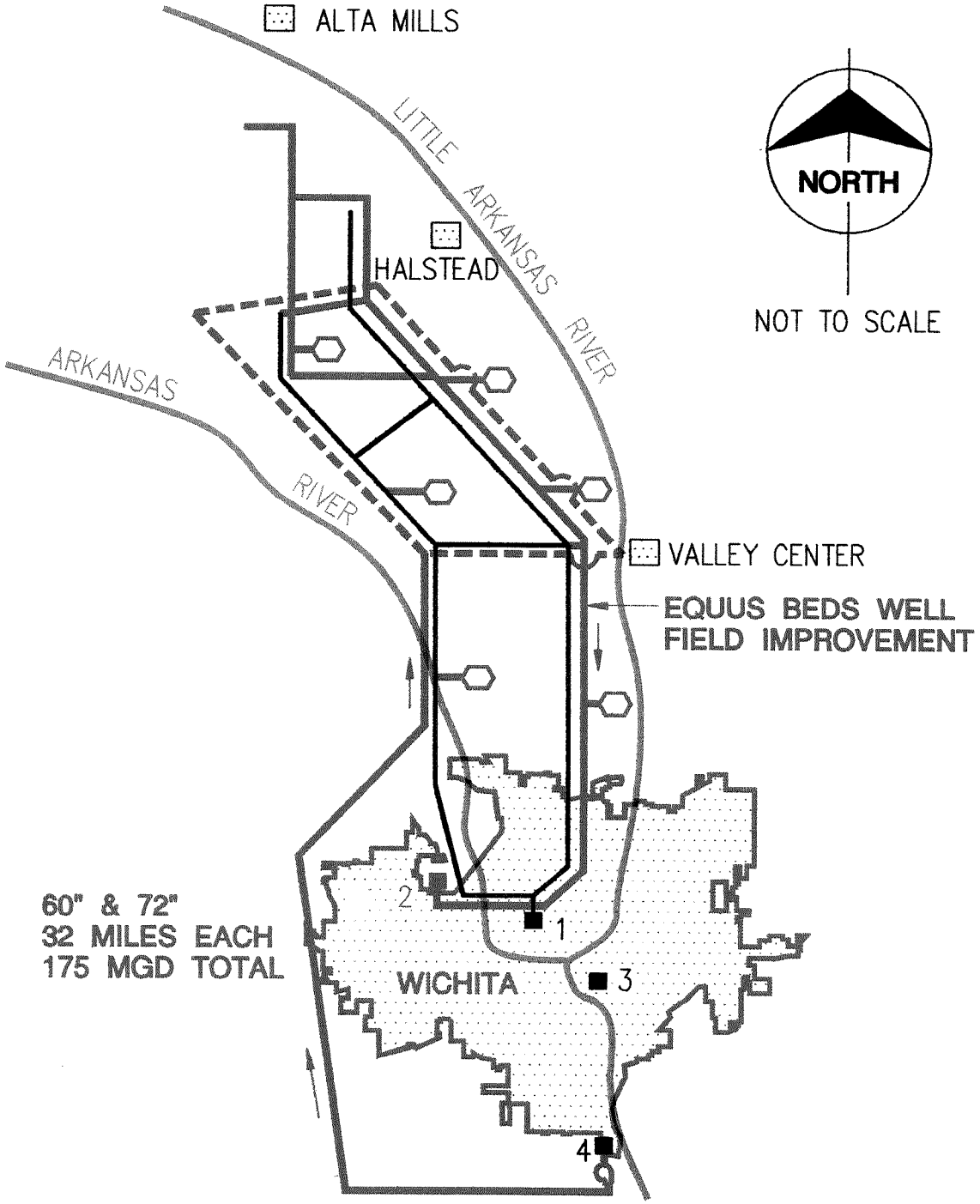
in exchange for their water rights is shown in Figure VI-19. This option includes construction of pump stations and pipelines from Wastewater Plant No. 2 to Equus Beds irrigation sites.

Evaluation of water quality criteria for irrigation indicates that the reclaimed water is low in sodium, but has a marginally high salinity hazard which may be borderline for irrigation. The water could be used, but a soil management program should be implemented by the irrigators to assure that salinity does not build up in the groundwater and soil. Such a build-up would be a fatal flaw.

The concept design of this option is based on Wastewater Plant No. 2 supplying an average of about 68 MGD from the Equus Beds for irrigation from year 1996 through 2050. The transmission system includes one 0.5 MG storage tank at Plant No. 2, two 175 MGD pump stations, 32 miles of 72-inch and 60-inch diameter pipelines to the Equus Beds and 20 miles of 12-inch diameter distribution pipelines.

The estimated project cost for the reclaimed water transmission system to Equus Beds irrigators is $129 million as shown in Table VI-20. The unit cost for this option is $95/MG.

This option might be structured to generate revenue from the sale of reclaimed water to the irrigators. Collected revenues could be used to partially finance the construction of this



LEGEND

	RIVER		PROPOSED PUMP STATION		PROPOSED WELL (TYP.)
	TOWN		PROPOSED PIPELINE		AREA OF INTEREST
1	CENTRAL WATER TREATMENT PLANT		EXISTING EQUUS BED WELL FIELD PIPELINES		
2	NEW WATER TREATMENT PLANT				
3	WASTEWATER PLANT NO. 1				
4	WASTEWATER PLANT NO. 2				

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Figure VI – 19
RECLAIMED WATER TO EQUUS BEDS IRRIGATORS WATER SUPPLY SCHEMATIC

J:\WICHITA\92954\FIG6-6.DWG 05-10-1993 15:05 BES

Table VI – 20

TREATED WASTEWATER REUSE
TO EQUUS BEDS IRRIGATORS ALTERNATIVE
PROJECT COST ESTIMATE

Item	Cost ($)
Storage Tank & Piping (1)	$ 400,000
Pump Station (2)	12,000,000
Pipeline (3)	81,100,000
Subtotal	$ 93,500,000
Contingency @ 20%	18,700,000
Subtotal	$ 112,200,000
Other Costs @ 15%	16,800,000
Total Project Cost	**$ 129,000,000**
Available Flow (4)	**1,361,300 MG**
Unit Cost (5)	**$ 95 /MG**

Notes:
(1) 0.5 MG ground storage tank.
(2) Two 175 MGD capacity pump stations.
(3) 32 miles of 72–inch and 32 miles of 60–inch transmission pipelines and 20 miles of 12–inch distribution pipelines.
(4) Available flow is based on 55 years supply at an average of 24,750 MGY.
(5) Unit Cost is Total Project Cost divided by Available Flow.

option. As part of this option, irrigators would give the City with their water rights in order to participate in this program.

d. Bank Storage of Little Arkansas River High Stream Flows

A schematic of the water supply alternative which involves the use of stored water along the Little Arkansas River banks is shown in Figure VI-20 for Option 1 and Figure VI-21 for Option 2. This alternative includes construction of a series of recovery units, which consist of 10 wells each over 1 river mile, transmission piping connecting to the Equus Beds Well Field transmission piping and 20 injection wells for Option 1 and two horizontal collector wells (on 1 mile spacing), transmission piping connecting to the Equus Beds Well Field transmission piping and 40 injection wells for Option 2.

Bank storage has a 2 percent firm yield of 20 cfs which is less than the MDS at Valley Center, therefore, no flow is available on a firm or reliable basis. The bank storage recovery system would be operated on an "as-available" basis, when base flow in the Little Arkansas River is exceeded. The excess flow would be pumped to the well field, recharging the aquifer and storing the water for use during dry weather periods. Each Option 1 recovery unit has a 14.4 MGD pumping capacity and is expected to yield the following average quantities of water based on estimated river flow at Halstead:

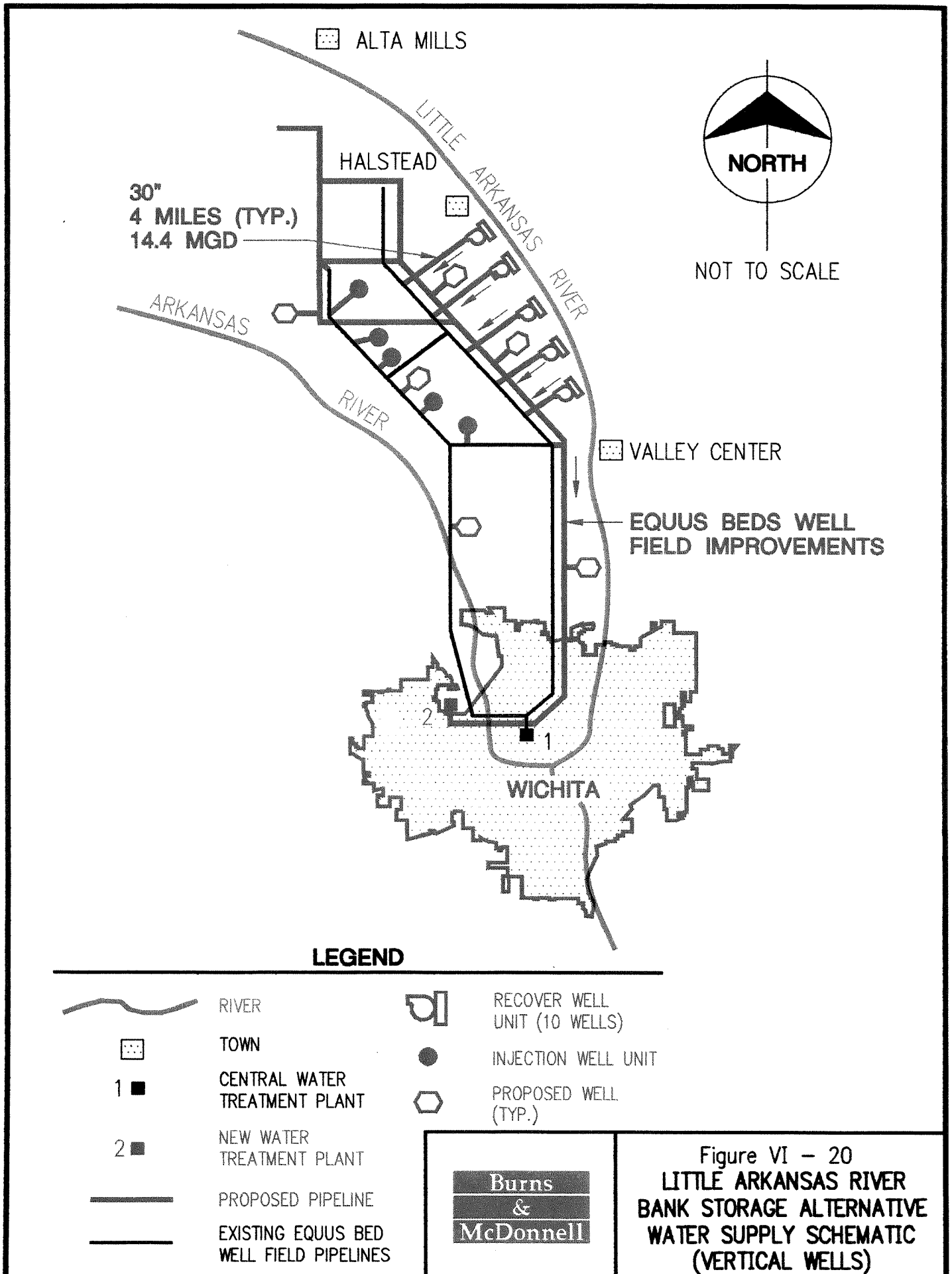

Figure VI – 20
LITTLE ARKANSAS RIVER BANK STORAGE ALTERNATIVE WATER SUPPLY SCHEMATIC (VERTICAL WELLS)

J:\WICHITA\921954\FIG6-4.DWG 04-29-1993 15:16 JRO

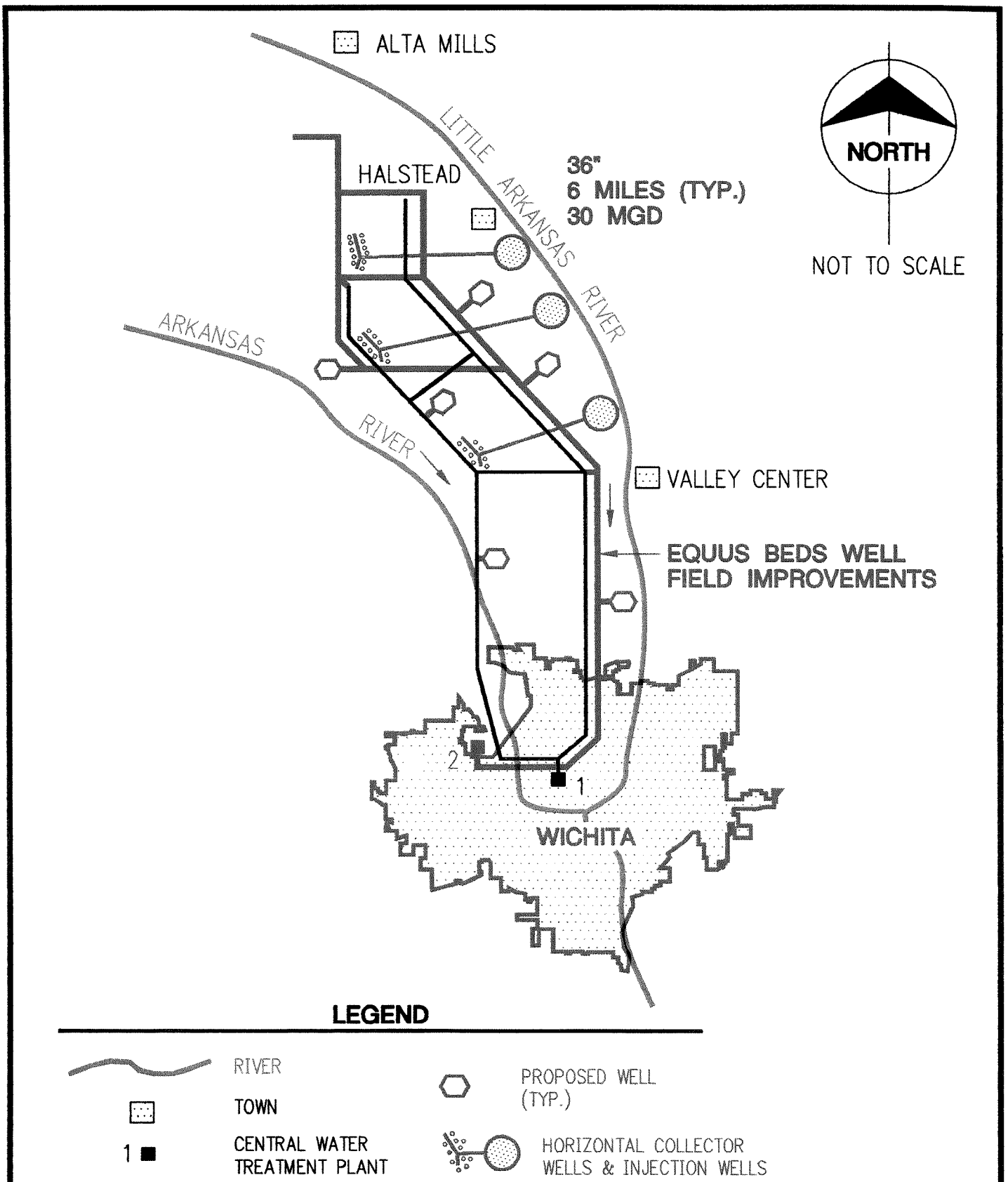

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Figure VI – 21

LITTLE ARKANSAS RIVER BANK STORAGE ALTERNATIVE WATER SUPPLY SCHEMATIC (HORIZONTAL WELLS)

Number of Recovery Units	Pumping Capacity (MGD)	Average Annual Available Flow (MGY)
1	14	2,500
4	50	6,000
7	100	8,900
11	150	11,600
14	200	13,300
17	250	14,400

Each Option 2 recovery unit consists of two 15-MGD horizontal collector wells with a pumping capacity of 30 MGD.

Review of the average annual available flow data shows a decreasing quantity of water available from the Little Arkansas River as recovery units are added and pumping capacities increase. This is due to a limited supply of water in the Little Arkansas River.

The concept design for Option 1 of this alternative is presented for a range of recovery unit pumping capacities from 14 MGD to 250 MGD. A typical single unit system includes 10 recovery wells on 500-foot spacings, associated piping and valves, 4 miles of 30-inch diameter pipeline to the Equus Beds, and 20 injection wells in the well field.

The concept design for Option 2 of this alternative is presented for a range of recovery unit pumping capacities from 30 MGD to 240 MGD. A typical single unit system includes two horizontal collector wells (on 1 mile spacing), associated piping and valves, 6 miles of 36-inch diameter pipeline to the Equus Beds, and 40 injection wells in the well field.

The estimated project costs for typical recovery units are $6.2 million for Option 1 and $11.5 million for Option 2 as shown in Table VI-21. The unit costs for the alternative ranges from $45/MG for a 1-unit system to $133/MG for a 17-unit system for Option 1 and ranges from $41/MG for a 1 unit system to $116/MG for a 8 unit system for Option 2.

e. Rain Harvesting

A schematic of the water supply alternative which involves the harvesting or collection of rainfall for injection into the Equus Beds Aquifer is shown in Figure VI-22. This alternative includes the construction of impermeable membrane lined basins to collect rainfall and prevent water quality degradation by soil contact and a well for injection into the aquifer. A typical system includes a PVC geomembrane fabric lined basin covered with 12 inches of nonangular rock and a 6-inch injection well with an air surging equipment connection for well cleaning. Collected waters would be stored in the aquifer until needed during a dry period and collected via the City's wells in the Equus Beds.

The Wichita area has historically experienced an average rainfall of about 30 inches per year. A typical rain harvesting site provides an effective recharge area of 3.25 acres yielding 2.65 MG per year of direct recharge per site. These sites could be constructed at the City's Equus Beds wells, most of which are 5 acres in size. Approximately 50 of the City's wells are situated in 5-acre sites

Table VI – 21

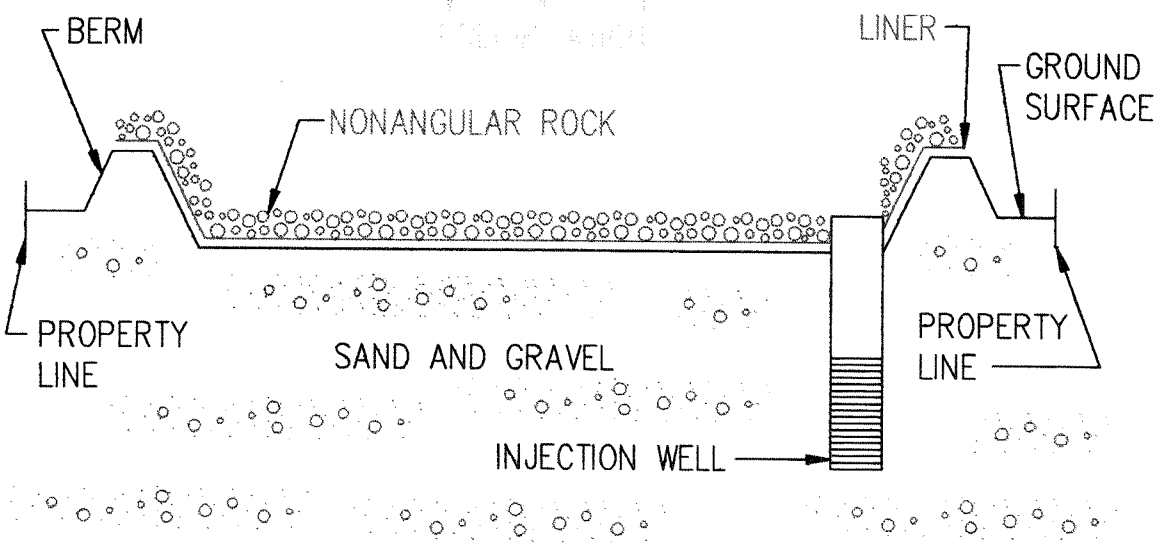
BANK STORAGE OF LITTLE ARKANSAS RIVER
HIGH STREAM FLOW ALTERNATIVE
PROJECT COST ESTIMATE

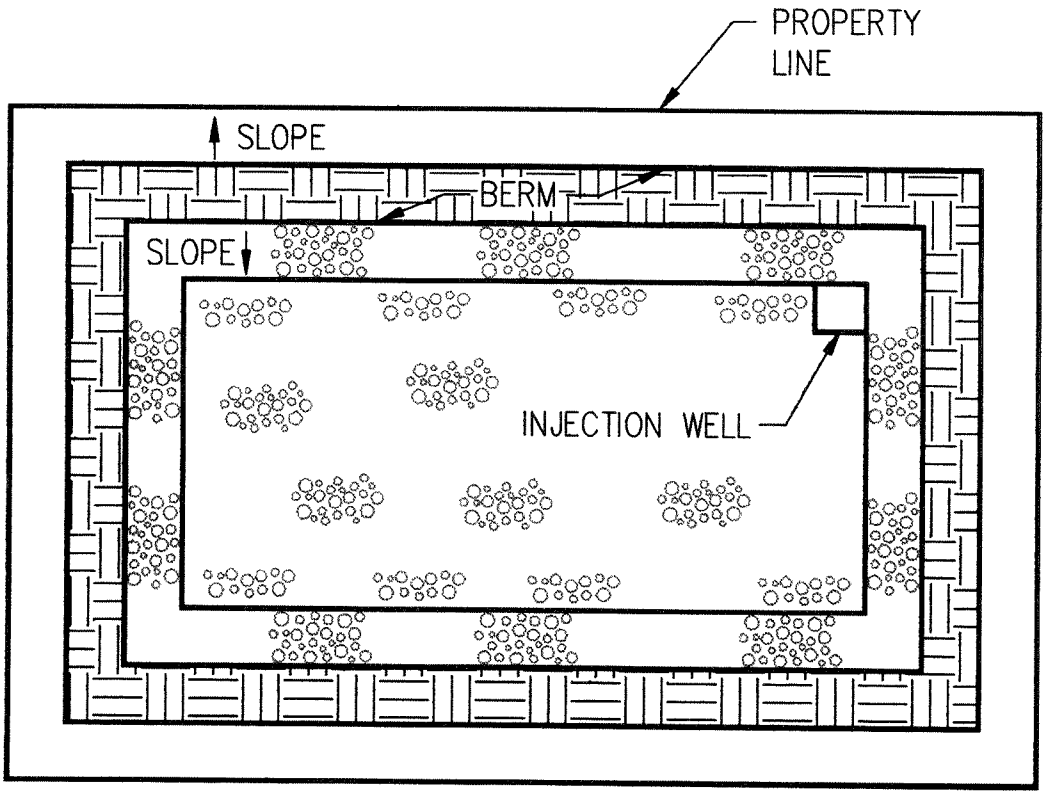
Item	Option 1 Cost ($)	Option 2 Cost ($)
Bank Storage Recovery Wells (1)	$ 1,260,000	$ 2,600,000
Header Piping and Valves	740,000	600,000
Transmission Piping (2)	1,900,000	3,900,000
Injection Wells (3)	400,000	800,000
Injection Well Piping and Valves	200,000	400,000
Subtotal	$ 4,500,000	$ 8,300,000
Contingency @ 20%	900,000	1,700,000
Subtotal	$ 5,400,000	$ 10,000,000
Other Costs @15%	800,000	1,500,000
Total Project Cost	**$ 6,200,000**	**$ 11,500,000**
Available Flow (4)	**137,500 MG**	**280,000 MG**
Unit Cost (5)	**$ 45 /MG**	**$ 41 /MG**

Notes:
(1) 10 recovery wells with 1,000 gpm capacity, 200 feet deep for Option 1 and two 15 MGD horizontal collector wells for Option 2.
(2) 4 miles of 30–inch pipeline for Option 1 and 6 miles of 36–inch pipeline for Option 2.
(3) 20 6–inch injection wells, 100 feet deep for Option 1 and 40 for Option 2.
(4) Available flow is based on 55 years of supply at an average of 3,300 MGY for Option 1 and 5,090 MGY for Option 2.
(5) Unit Cost is Total Project Cost divided by Available Flow.
(6) for Option 1:

No. of Units	Proj. Cost	Avail. Flow	Unit Cost
4	$24,800,000	330,000 MG	$75/MG
7	$43,400,000	489,500 MG	$89/MG
11	$68,200,000	638,000 MG	$107/MG
14	$86,800,000	731,500 MG	$119/MG
17	$105,400,000	792,000 MG	$133/MG
17 (7)	$177,400,000	792,000 MG	$224/MG

(7) Includes cost of Equus Beds Well Field improvements consisting of 70 1,500 gpm wells, 38 miles of 66–inch pipeline and 8 miles of 48–inch pipeline and 2 booster pump stations.





NOT TO SCALE

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Figure VI – 22

RAIN HARVESTING WATER SUPPLY SCHEMATIC

increasing the potential average annual recharge to 130 MG per year or 0.4 MGD.

The estimated project cost for a typical rain harvesting collection system is $0.6 million as shown in Table VI-22. The unit cost for the alternative is $4,117/MG.

f. Gilbert-Mosley Remediated Groundwater

This water supply alternative involves the conveyance of 3 MGD of remediated groundwater from the Gilbert-Mosley site to the Central Water Plant for treatment to potable quality. The groundwater at the Gilbert-Mosley site is contaminated with TCE and is being treated on-site with a VOC stripper tower. The remediated water quality should be similar to the E&S Well Field quality.

The concept design for this alternative includes a 3 MGD pump station and 2.5 miles of 16-inch diameter pipe to the Water Plant. The estimated project cost for the conveyance system is $1.5 million as shown in Table VI-23. The unit cost is $25/MG. Additionally, a construction cost share may be available since this would provide for disposal of the groundwater.

g. Subsurface Storage and Recovery of Potable Water

This water supply alternative involves the production of excess potable water at the Central Plant during periods of wet weather, the storage of the potable water in the aquifer adjacent to the plant, and the recovery of the potable water from the aquifer during

Table VI – 22

RAIN HARVESTING SUPPLY ALTERNATIVE
PROJECT COST ESTIMATE

Item	Cost ($)
Rain Harvesting Basin (1)	$ 410,000
Injection Well (2)	25,000
Subtotal	$ 435,000
Contingency @ 20%	87,000
Subtotal	$ 522,000
Other Costs @ 15%	78,000
Total Project Cost	**$ 600,000**
Available Flow (3)	**146 MG**
Unit Cost (4)	**$ 4,117 /MG**

Notes:
(1) Basin has an effective 3.25 acre surface area on a 5 acre site.
(2) 6–inch injection well with air surging equipment connections.
(3) Average yield of 2.65 MGD per year per 5 acre site from year 1996 through 2050 based on an average rainfall of 30 inches per year.
(4) Unit Cost is Total Project Cost divided by Available Flow.
(5) Excludes the cost of Equus Beds Wellfield improvements, $116 million, consisting of 75 1,500 gpm wells, 38 miles of 66–inch pipeline and 8 miles of 48–inch pipeline and two booster pump stations.

Table VI – 23

GILBERT–MOSLEY REMEDIATED GROUNDWATER
RAW WATER TRANSMISSION SYSTEM
PROJECT COST ESTIMATE

Item	Cost ($)
Pump Station (1)	$ 240,000
Pipeline (2)	860,000
Subtotal	$ 1,100,000
Contingency @ 20%	200,000
Subtotal	$ 1,300,000
Other Costs @ 15%	200,000
Total Project Cost	**$ 1,500,000**
Available Flow (3)	**60,200 MG**
Unit Cost (4)	**$ 25 /MG**

Notes:
(1) Pumping capacity of 3.0 MGD, continuous.
(2) 2.5 miles of 16–inch pipeline.
(3) Available flow equals capacity times 365 days times 55 years.
(4) Unit Cost is Total Project Cost divided by Available Flow.
(5) A cost share for this project may be possible.

dry periods. Water quality would be closely monitored to assure compliance with drinking water standards prior to use in the distribution system.

The aquifer adjacent to the Central Water Plant has a surface area of about 80 acres including the water plant, Botanica, Sim Park and Sim Golf Course. This area could store about 640 acre-feet of water or 0.6 MGD for one year based on 40-feet of saturated thickness. The limited storage capacity of aquifer, the potential for contamination from golf course chemicals, the high public use of the area and the potential to create marshy-wetland type conditions from rising aquifer water level to or near ground surface level makes this alternative nonviable or fatally flawed.

h. Low Range Water Conservation

The low range water conservation alternative involves the following management techniques as detailed in Part 1:

- Review and modify rate structure on an annual basis to help achieve and maintain conservation goals.

- Maintain current watering restrictions (twice per week by address).

- Make building plumbing code changes to incorporate low flush toilets (1.6 gallons per flush) and low flow shower heads and faucets (2.5 gpm) to be in effect by 1995.

- Continue public education programs.

- Continue leak detection surveys.

- Continue meter repair and replacement programs.

- Continue cooperative efforts with industries.

- Initiate a full scale plumbing fitting retrofit program for housing units built before the new code goes into effect (this study assumes January 1, 1995).

Savings from these techniques are included in the projection of future raw water needs.

The programs which require capital expenditure to implement include leak detection surveys, meter testing, repair and replacement, public education, and plumbing retrofit. These expenditures are estimated at $23 million, and would save about 297,500 MG through the study period. This results in a unit cost of $77/MG of water. Additionally, cost savings in water treatment, wastewater treatment and water supply development would be experienced, as well as delaying the construction of additional facilities. These savings will also decrease annual expenditures.

i. No Action

The "no action" alternative reduces the net water need through self-imposed growth limitations. The City would continue water service to their existing retail and wholesale customers, but would not serve any additional wholesale customers. This could reduce the year 2050 maximum day demand by about 23 MGD to 263 MGD without additional water conservation. Low range water conservation and use of the City's total maximum day water right of 214 MGD would reduce the year 2050 maximum day net need to 14 MGD.

The potential service area population for this alternative based on the available supply of 99 MGD for the average day and 214 MGD for the maximum day are respectively projected to be 470,000 and 410,000 people with no additional water conservation measures, 495,000 and 470,000 people with low range conservation measures and 540,000 and 550,000 people with high range conservation measures. Based on this information, the "no action" alternative will not meet projected year 2050 water demands under any water conservation option. Any decision to limit growth and risk loss of future development, tax revenues, and jobs, would involve changes in current philosophy and policy by the City's governing body. Since this alternative does not meet the basic study evaluation criteria of furnishing water demands through the year 2050 planning period, it is dropped from further consideration.

3. SELECTION OF VIABLE ALTERNATIVES

The 27 water supply alternatives evaluated to meet or contribute to the City of Wichita's year 2050 net water need are summarized and ranked in Table VI-24. A ranking of 1 denotes the preferred alternative. Each alternative is evaluated on the basis of cost and on the basis of political/policy, legal, environmental and water quality issues. Potential water supplies with unit costs greater than the Milford Reservoir Alternative are generally considered nonviable from a cost basis.

Based on the data summarized in Table VI-24, several alternatives are selected for additional study in Part VII. These alternatives are considered viable for further engineering studies in Part VII as follows:

Alternative	Rank
Low Range Water Conservation (included in every alternative)	1 (preferred)
Little Arkansas River Supply to Central Water Treatment Plant	2
Little Arkansas River Subsurface Storage via Surface Spreading Basins/Bank Storage	3
Gilbert-Mosley Remediated Groundwater	4
Cheney Reservoir Operations Modifications	5
Abandoned Reserve Well Field	6
Cheney Overflow to Water Plants	7
Equus Beds Water Rights Purchase	8
Milford Reservoir	9

Table VI – 24

WATER SUPPLY ALTERNATIVE
RANKING SUMMARY

Alternative	Construction Cost ($million)	Available Flow	Unit Cost ($/MG)	Issues: Policy/ Political	Issues: Legal	Issues: Environmental	Issues: Water Quality	Advantages	Disadvantages	Rank
Kanapolis Resevoir	69	10 MGD firm yield 200,800 MG (1)	344	Water Transfer Act	Must obtain additional water rights	–	Periodic high chlorides Questionalbe	– Firm supply	– Water quality concerns – Difficult to obtain all of the water rights	NS
Milford Resrvoir	155	60 MGD firm yield 1,095,000 MG (1)	141	Water Transfer Act Potential conflict with northeast Kansas	Must obtain additional water rights	–	Moderately hard Adequate	– Single source – Firm supply – Regional supply	– Political problems – Availability under investigation by State	9
Corbin Resrvoir	470	35 MGD firm yield 702,600 MG (1) Max yield of 53 MGD	669	–	Must obtain additional water rights	Significant impact assoc with new reservoir construction	Expected to be adequate	– Firm supply – Recreation	– Significant environmental impact	NS
Douglass Reservoir	202	14.2 MGD firm yield 285,100 MG (1)	707	–	Must obtain additional water rights	Significant impact assoc with new reservoir construction	Expected to be poor	– Firm supply – Recreation – Flood control	– Significant environmental impact – Poor water quality	NS
Murdock Reservoir	231	35 MGD firm yield 702,600 MG (1) Max yield of 65 MGD	329	–	Must obtain additional water rights	Significant impact assoc with new reservoir construction	High chlorides Questionalbe	– Firm supply – Recreation	– Significant environmental impact – Questionable water quality	NS
Equus Beds: Purchase Water Rights	$400/Ac–Ft	As Available	NA	–	Must obtain additional water rights	–	Generally good	– Low cost – Close to wellfield – Good water quality	– Availability concerns	8
Equus Beds: Burrton SWQUA & IGUCA	26	9.8 MGD firm yield 196,700 MG (1). 100% use	130	–	Must obtain additional water rights	Remediate area over time	Very high chlorides	– Long–term supply for City – Potential aquifer remediation	– Availability concerns – Poor water quality	NS
Haysville Groundwater	22	2.85 MGD firm yield 57,200 MG (1). 100% use	386	–	Must obtain additional water rights	Remediate area over time	Very high chlorides,	– Long–term supply for City – Potential aquifer remediation	– Availability concerns – Poor water quality	NS
Reserve Well Field	1.0	10.8 MGD firm yield 216,800 MG (1) 100% use	4.70	–	Must obtain additional water rights	–	Poor High chlorides & hardness Affects of long–term pumping unknown	– Low cost – Firm supply – Supplement Peak demands	– Poor water quality – High chlorides – Additional treatment cost	6
	1.0	10.8 MGD firm yield 27,300 MG (1) Peak use	37							

Table VI – 24 (Continued)

WATER SUPPLY ALTERNATIVE
RANKING SUMMARY

Alternative	Construction Cost ($million)	Available Flow	Unit Cost ($/MG)	Issues: Policy/ Political	Issues: Legal	Issues: Environmental	Issues: Water Quality	Advantages	Disadvantages	Rank
Gilbert–Mosley Remediated Groundwater	1.5	Continuous supply of 3 MGD	25	–	–	Conserves water, not conveyed to WWTP	Adequate	– Low cost – Conserves resources – Firm supply	–	4
Arkansas River Supply to WTP	21	0 Firm Yield 155,800 MG (1) as available (avg 8 MGD)	132	Integrated water use permit required	Must obtain additional water rights	–	High flows required for acceptable WQ	– Close to WTP – Low cost	– Poor water quality – Low available flows	NS
Little Arkansas River Supply to WTP	21	0 Firm Yield 880,000 MG (1) as available (avg 44 MGD)	23	Integrated water use permit required	Must obtain additional water rights	–	Good	– Close to WTP – Low construction cost – High available flows	– Poor water quality – No firm yield	2
Cheney Reservoir: Operations Modifications	0	Withdrawal up to about 60 MGD	0	Integrated water use permit required	Must obtain additional water rights	Potential impact on reservoir due to water level variations	Aqdequate	– Increased water availability	– Recreation impacts – Public relations impacts – Increased probability shortage	5
Cheney Reservoir: Purchase Flood Storage	–	Estimated 3 MGD yield for 1 foot, 2 MGD for 2 feet, & 1 MGD for 3 feet	–	Integrated water use permit required	Must obtain additional water rights	Potential impact on reservoir due to water level variations	Aqdequate	– Increased firm yield	– Recreation impacts – Public relations impacts – Extensive relocations	*
Membrane Filtration Plant	191 34	60 MGD Capacity 10 MGD Capacity	158 168	–	–	Brine disposal	Poor Potable WQ after treatment	– Source of the future	– Very high operating cost – Brine disposal – 2% yield of 32 MGD	NS
Cheney Overflow: Pipeline to WTP	53 60	554,400 MG (1) as available (avg 28 MGD) 695,000 MG (1) as available (avg 35 MGD)	96 87	Integrated water use permit required	Must obtain additional water rights	–	Aqdequate	– Uses excess flow – Conserves resources – Allows Equus Beds to recharge	– No firm yield	7
Cheney Overflow: Side Storage Reservoir	NA	NA	NA	Integrated water use permit required	Must obtain additional water rights	Significant impact assoc with new reservoir construction	Expected to be poor	– Uses excess flow – Conserves resources – Allows Equus Beds to recharge	– No sites – Aesthetic problems – Operational problems – Multiple pumping req'd	NS
Cheney Overflow: Subsurface Storage	65 165**	695,000 MG (1) as available (avg 34 MGD)	94 237**	Account for stored water Integrated water use permit required	Must obtain additional water rights	Potential for Equus Beds groundwater quality degradation	High chlorides, about 200 mg/l	– Uses excess flow – Conserves resources – Recharges Equus Beds	– High chlorides – No firm yield – State may not approve	10

Table VI – 24 (Continued)

WATER SUPPLY ALTERNATIVE
RANKING SUMMARY

Alternative	Construction Cost ($million)	Available Flow	Unit Cost ($/MG)	Issues: Policy/ Political	Issues: Legal	Issues: Environmental	Issues: Water Quality	Advantages	Disadvantages	Rank
Little Arkansas River: Subsurface Storage	26 126**	0 Firm Yield 574,200 MG (1) as available (avg 29 MGD)	46 219**	Account for stored water Integrated water use permit required	Must obtain additional water rights	–	Adequate	– Conserves resources – Low cost	– No firm yield	3A
Treated Waste–water Reuse: Local Irrigation	15	Avg firm yield of 1.1 MGD for 55 year study period 11,000 MG (1)	1336	–	–	Potential impacts	Adequate	– Reduces summer peak – Generates revenue – Conserves resources	– No public access during irrigation cycle	11
Treated Waste–water Reuse: Subsurface Storage	130 230**	Avg firm yield of 68 MGD for 55 year study period	96 169**	Account for stored water Integrated water use permit required	Must obtain additional water rights	Potential to degrade aquifer water quality	High chlorides, 200 mg/l	– Firm supply – Conserves resources – Recharges Equus Beds	– High construction cost – Water quality concerns	NS
Treated Waste–water Reuse: Sell to Irrigators	129	Avg firm yield of 68 MGD for 55 year study period	95		Water rights must be transferred	Water is borderline quality for irrigation	Marginal, farmers should initiate a management program for soil	– Generates revenue – Obtains water rights – Conserves resources	– High construction cost – Water quality concerns	NS
Little Arkansas River: Bank Storage	6.2 to 175 11.5 to 164	0 Firm Yield Variable with units installed, range from 7 to 39 MGD	45 to 221 41 to 207	Account for stored water Integrated water use permit required	Must obtain additional water rights	Effects must be evaluated	Good	– Phased construction – Use injection wells – Water available for an extended time period	– No firm yield – Potential impacts on other users	3B*
Rain Harvesting	.6/unit	Firm yield of .007 MGD/ unit	4117	Account for stored water Integrated water use permit required	Must obtain additional water rights	–	Good	– Good water quality	– Low available volume – Very high unit cost	NS
Excess Potable Water: Subsurface Storage	–	–	–	Account for stored water Integrated water use permit required	Must obtain additional water rights	–	Must be monitored Treat to potable standards	– Conserves resources	– Insufficient land avail–able for storage – Water quality concerns	NS
Low Range Water Conservation	23	279,500 MG (1) with an avg savings of 15 MGD	77	–	–	–	–	– Other cost savings to be realized – Reduces max day – Conserves resources	–	1
No Action	0	Reduces year 2050 max day demand 23 MGD	0	–	–	–	–	– Reduces demand, max day net need is 14	– Reduces service area – Reduces tax base	NS

Notes:
(1) Over a 55 year period from 1996 to 2050. (2) 'NS' = not selected * Requires highly detailed study to confirm viability. ** Includes Equus Beds Well Improvements.

Alternative	Rank
Cheney Reservoir Subsurface Storage	10
Treated Wastewater Reuse - Local Irrigation	11

The Milford Reservoir Alternative is the only supply source capable of meeting the City's full year 2050 net water needs on a firm yield basis. All other alternatives must be used in combination with other alternatives to meet the year 2050 water needs.

Alternatives which require more detailed study to determine their viability are listed below:

- Little Arkansas River Subsurface Storage via Bank Storage/Injection: Appears viable, high project and unit costs for high yields, and low unit costs for low yields.

- Cheney Reservoir - Purchase Flood Storage: Anticipated low project and unit costs, potential conflicts with marinas and recreational users, and potential environmental impacts.

These alternatives should also be evaluated further.

Alternatives which were not selected are as follows and are marked with a "NS" in Table VI-24.

- Kanopolis Reservoir - High unit cost. Low possibility of receiving water rights for the full firm yield.

- Proposed Corbin, Douglass and Murdock Reservoirs: High project and unit costs, significant environmental impacts, and questionable water quality.

- Groundwater Remediation in Equus Beds areas north and south of Burrton and in Haysville: High project and unit costs, low flows, no guarantees on clean-up potential, and low yields.

- Arkansas River Supply: High chloride concentrations requiring blending with high-quality water or reverse osmosis treatment.

- Membrane Filtration: Very high operating costs and problems with disposal of brine reject water.

- Cheney Reservoir Overflow - Side Storage Reservoir: High project and unit costs, significant environmental impact, and aesthetic and operational problems.

- Treated Wastewater Reuse - Subsurface Storage: High project and unit costs.

- Treated Wastewater Reuse - Sell to Irrigators: High project and unit costs, questionable water quality for irrigation.

- Rain Harvesting: Very low yield and high unit costs.

- Excess Potable Water Subsurface Storage: Insufficient land available for storage.

- No Action: Would require a "no-growth" philosophy by City government which is inconsistent with current City policies and actions.

* * * * *

Part VII - Evaluation of Alternatives

PART VII

EVALUATION OF ALTERNATIVES

A. GENERAL

This section of the report evaluates three water supply plans, designated the Milford Reservoir Water Supply Plan, the Integrated Local Water Supply Plan with 250 MGD Little Arkansas Diversion Option and the Integrated Local Water Supply Plan with 150 MGD Little Arkansas Diversion Option. Each plan will meet the City of Wichita's projected water needs through the year 2050.

These water supply plans were developed using the viable water supply alternatives from Part VI of the report. The viable alternatives were selected after preliminary screening and elimination of options based on available flow, unit cost information and related policy/political, legal, environmental, and water quality issues. The viable water supply alternatives were identified as follows:

- Low Range Water Conservation.
- Little Arkansas River Intake at Water Plant.
- Little Arkansas River Surface Water Intake/Bank Storage to Equus Beds.
- Gilbert-Mosley Remediated Groundwater.
- Cheney Reservoir Operations Modifications.
- Reserve Well Field.
- Cheney Reservoir Overflow Pipeline to Water Plant.
- Purchase Equus Beds Water Rights.

- Milford Reservoir.
- Cheney Reservoir Overflow with Aquifer Recharge.
- Local Treated Wastewater Reuse.

The Milford Water Supply Plan, as developed from the alternatives, includes water conservation, use of Milford Reservoir, a second pipeline from Cheney Reservoir to the water plant, and various improvements in the Equus Beds Well Field. With continued use of the Equus Beds Well Field and Cheney Reservoir, this water supply plan is the only alternative capable of supplying enough water to meet the projected year 2050 maximum day water demand on a firm yield basis. This plan requires state approval through the Water Transfer Act and raises political/legal issues regarding the transfer of water from the northeast region of the state to the south-central region of the state.

The Integrated Local Water Supply Plan includes water conservation and the use of the Little Arkansas River (via intake at the water plant), the Gilbert-Mosley Remediated Well Field, the Little Arkansas River (via diversion to the Equus Beds) and the Reserve Well Field. With continued use of the Equus Beds Well Field and Cheney Reservoir, the water supply plan requires the integrated and coordinated use of local water supplies with capture, storage and use of excess water to meet the projected year 2050 maximum day water demand. This plan will require an integrated or conjunctive water use permit from the Kansas Division of Water Resources to allow the City to use its local supplies on an "as available" basis.

Two options were developed for the Integrated Local Water Supply Plan which offer different levels of operating flexibility and system redundancy at significantly different capital costs. The 250 MGD Diversion Option includes higher capacity pumping and water transmission facilities, provides the capability of meeting projected year 2050 maximum day demands from stored water in the Equus Beds during a drought condition, and has a higher capital cost. The 150 MGD Diversion Option includes less operating flexibility based on meeting the projected year 2050 maximum day demands from a combination of both stored water in the Equus Beds and Cheney Reservoir during a drought condition, and has a lower capital cost. The 150 MGD Diversion Option impacts water level drawdown in Cheney Reservoir to a slightly greater extent than the 250 MGD Diversion Option.

B. RELATED PLAN ELEMENTS

1. BASIC COMPONENTS

In order to complete evaluations on a comparable basis, each water supply plan includes raw water source pumping, transmission and water treatment facilities. Preliminary designs are completed on basic plan components to size facilities so that estimates of construction costs and operation and maintenance costs can be made for economic comparisons. High service pumping of treated water to the distribution system and near-term improvements are common to all plans and are not included in the economic evaluations. Water conservation is an integral part of all water supply plans throughout the planning period and is included in the cost estimates.

2. NEAR-TERM IMPROVEMENTS

Additional improvements are required to make full use of the City's water rights. Completion of near-term improvements are needed to avoid delivery shortfalls of projected maximum day demands by 1996 and projected average day demands by 2004. For the purposes of planning and preparing economic cost studies, the scheduling of all water supply plans are based on the implementation of the following near-term water supply improvements by the City:

- Rehabilitate 16 E&S wells for estimated cost of $0.6 million, complete in or by 1994.
- Rehabilitate 25 Equus Beds Wells for estimated cost of $2,200,000, increase pumping capacity of Cheney Pump Station and increase the height of the existing surge tank by 75 feet for estimated cost of $3,400,000, and install a raw water control valve structure and bypass at the Central Water Plant for estimated cost of $3.7 million, complete in or by 1995.

Note:
[1]Estimated cost includes construction, engineering and other special service costs.

These improvements are required to increase pumping capacity to make additional use of the City's existing water rights (55 MGD Equus Beds, 80 MGD Cheney Reservoir and 30 MGD E&S wells) to meet near-term water demands and extend the maximum day supply shortfall to the year 2008. The City's total Equus Beds water rights of 78 MGD cannot be used without construction of additional wells (for firm capacity), minor

pipeline improvements and a booster pump station which are included in later phases of the water supply plan.

3. PURCHASE OF GROUNDWATER RIGHTS

If the Milford Reservoir Water Supply Plan is implemented, the City should continue to purchase groundwater rights in the Equus Beds Well Field area as these rights become available. If an Integrated Local Water Supply Plan is implemented, the purchase of additional water rights in the Equus Beds Well Field area will probably not be beneficial to the City. This is because maximum day water demands could be pumped from the Equus Beds without additional water rights if the state grants an integrated or conjunctive water use permit.

The program to purchase additional water rights was instituted in 1990 and has produced contracts for 2,200 acre-feet of water rights to date. Based on this limited history, the rate of acquisition of additional water rights through purchases on an "as-available" basis is unknown at this time.

When purchasing water rights, the City should consider the fact that the Equus Beds are over-allocated and have a limited safe yield of 48,000 acre-feet based on natural recharge by rainfall. The City currently owns 40,000 acre-feet of water rights in the Equus Beds. Purchases beyond the safe yield may not provide any additional rights, but could provide a means of conserving the Equus Beds by reducing the number of people or entities who pump groundwater from the aquifer.

C. MILFORD RESERVOIR WATER SUPPLY PLAN

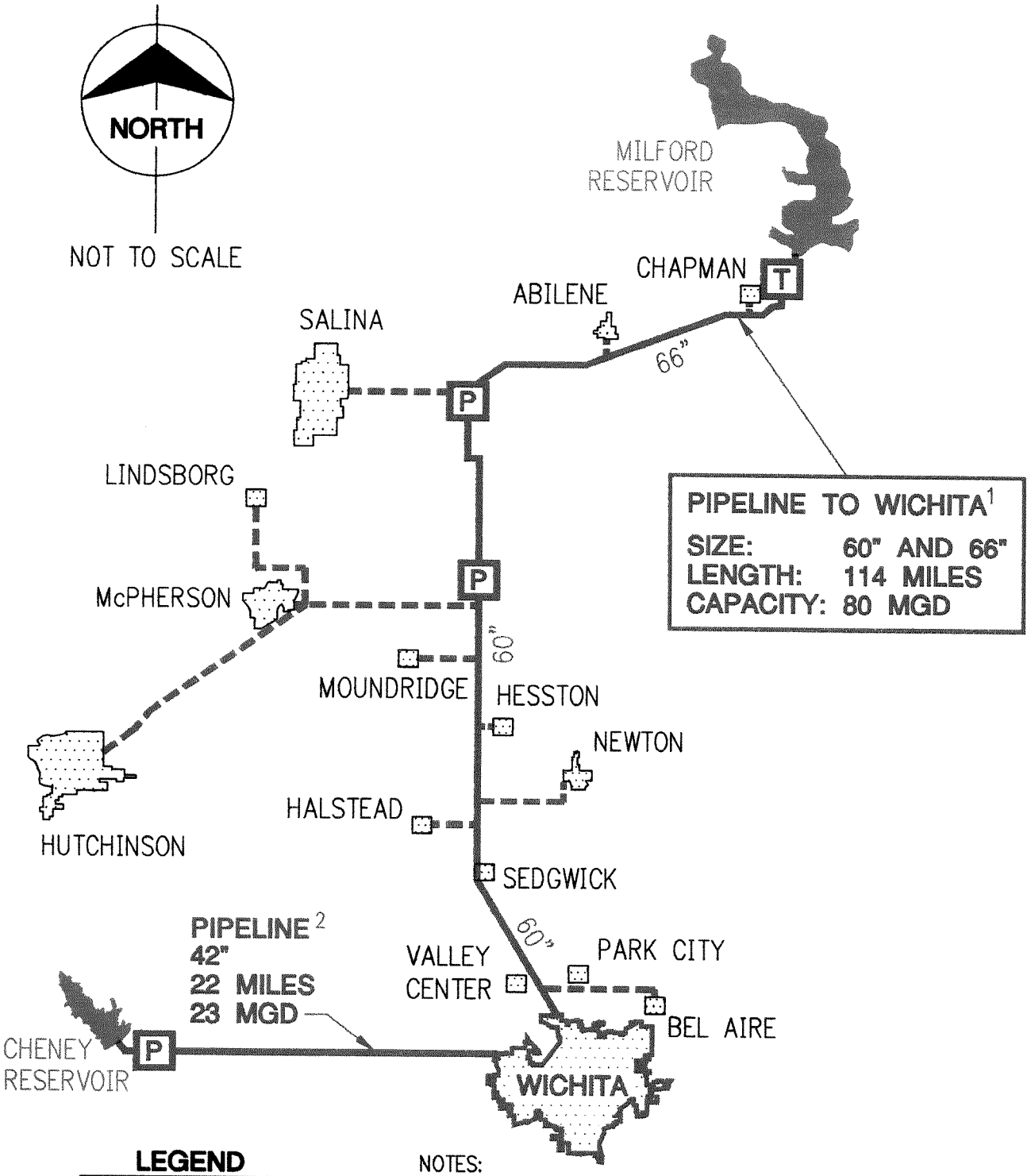
1. WATER DELIVERY

a. Concept and Operational Plan

A schematic of the Milford Reservoir Water Supply Plan, which includes the use of Milford Reservoir, is shown in Figure VII-1. The Milford Reservoir Supply Plan was developed by Mid-Kansas Water Consultants, a consortium of several engineering companies (not to be confused with Mid-Kansas Engineering Consultants in Wichita). Their efforts resulted in the "Conceptual Study of Alternative Water Supply Sources" completed in December 1991. The proposed project was envisioned to serve the following cities which were designated as Public Wholesale Water District No. 10:

- Abilene
- Bel Aire
- Chapman
- Halstead
- Hesston
- Hutchinson
- Lindsborg
- McPherson
- Moundridge
- Newton
- Park City
- Salina
- Sedgwick
- Valley Center
- Wichita

The plan involves the conveyance of treated water from Milford Reservoir through 114 miles of 60-inch and 66-inch diameter transmission piping to the City of Wichita while serving 14 other cities along the pipeline corridor. The pipeline was sized can



LEGEND

- CITY OR TOWN
- T — WATER PLANT
- P — PUMP STATION
- PROPOSED PIPELINE
- PROPOSED PIPELINE SERVING CITIES & TOWNS OTHER THAN WICHITA

NOTES:

1. PLAN ALSO INCLUDES A WATER CONSERVATION PROGRAM AND MINOR IMPROVEMENTS IN THE EQUUS BEDS WELL FIELD.
2. SECOND PIPELINE FROM CHENEY RESERVOIR TO PROVIDE MAXIMUM DAY WATER RIGHT.

Burns & McDonnell

Figure VII – 1

MILFORD RESERVOIR WATER SUPPLY PLAN SCHEMATIC

carry a maximum of 80 MGD of which about 60 MGD would be supplied to Wichita on a continuous basis.

For the purpose of this study, raw water from Milford Reservoir is assumed to be available to the City of Wichita as presented in the District 10 report. However, recent contacts with the Kansas Water Office indicate that the availability of water in Milford Reservoir will be reevaluated with the results of this study available by December 1993. This evaluation could influence the amount of water available to District 10 and the City of Wichita.

Water conservation is included as an integral part of the Milford Reservoir Water Supply Plan. A water conservation program has been implemented by the City and should be expanded over the next six years to incorporate additional conservation measures necessary to realize projected water savings (refer to subsequent subsection titled "Plan Components").

Additional pumping capacity, beyond existing capacities with near-term improvements and the Milford Reservoir supply, is required to meet the year 2050 maximum day demand. Cheney Reservoir pumping capacity is limited to 80 MGD while the maximum day water right is about 103 MGD. Construction of a 22-mile, 42-inch diameter pipeline from Cheney Reservoir to the water plant is required to deliver the extra 23 MGD. Additionally, the pumping capacity of the Equus Beds Well Field is currently limited to about 55 MGD due to hydraulic restrictions. The maximum day water right is 78 MGD and piping

improvements and additional wells are required to convey this amount on a firm capacity basis.

b. Plan Implementation

Maximum day water demands for the City of Wichita are projected to exceed the maximum day supply capacity of the existing system (165 MGD from Cheney Reservoir, Equus Beds and E&S Well Fields) in year 2008. As a result, an additional water supply must be operational prior to year 2008. Another consideration is the timing of additional water needs of the 14 other members of Public Water District No. 10 which may need additional water supplies in the near future.

Potential delays and time considerations associated with completion of the project include legal difficulties due to water transfer across regional boundaries, resolving water rights issues, obtaining state approval via the Water Transfer Act, and studies of water availability being conducted by the Kansas Water Office. Other time elements are required for permitting and land acquisition, design, construction, and coordination with the 15 entities in Public Water District 10. With these considerations, the completion of the Milford Reservoir Supply Plan is scheduled for year 2005, slightly in advance of the projected water deficit in year 2008.

Three basic phases of construction of new facilities are proposed in the implementation of the Milford Reservoir Water Supply Plan to

meet projected water demands. These phases are anticipated as follows:

- Phase 1 - Water Conservation (1995-1999):
  - Full scale plumbing retrofit program.
  - Existing and planned water conservation measures as detailed in a subsequent subsection titled "Plan Components."
- Phase 2 - Milford Reservoir Supply (complete year 2005).
  - 80 MGD raw water intake.
  - 60-inch diameter pipeline from intake to water plant with 80 MGD capacity.
  - 80 MGD water treatment plant.
  - About 114 miles of 66-inch and 60-inch diameter transmission pipeline with 80 MGD capacity.
  - About 87 miles of 6-inch through 30-inch feeder pipelines to customers other than Wichita.
  - Three booster pump stations along main transmission pipeline, each with 80 MGD pumping capacity.
  - One booster pump station for Hutchinson.
  - Customer metering, pressure reducing stations, and appurtenances.
  - District Operations Headquarters.

- Phase 3 - Cheney Reservoir Pipeline and Equus Beds Well Field Improvements (complete year 2038).
  - About 22 miles of 42-inch diameter pipeline from Cheney Reservoir to Wichita's water plant(s).
  - One 23 MGD booster pump station at Cheney Reservoir.
  - 5 new 1,500 gpm wells (for firm capacity).
  - Pipeline improvements including 3 miles of 66-inch diameter pipeline and a booster pump station.
  - 30 MGD water plant at a new plant site.

c. Plan Components

The basic components of Milford Reservoir supply plan as previously described in the subsection titled "Plan Implementation" were developed by others in the District 10 report. Associated costs for these components are presented subsequently in the subsection titled "Economic Evaluations."

Low range water conservation activities are included as part of the plan as follows:

- Review and modify rate structure on an annual basis to help achieve and maintain water conservation goals.
- Maintain current watering restrictions (twice per week by address).
- Make building plumbing code changes to incorporate low flush toilets (1.6 gallons per flush) and low flow shower heads and faucets (2.5 gpm) to be in effect by 1995.
- Continue public education programs.

- Continue leak detection surveys.
- Continue meter testing, repair and replacement programs.
- Continue cooperative efforts with industries to encourage conservation of cooling, process, and irrigation water.
- Initiate a full scale plumbing fitting retrofit program for housing units built before the new water conservation plumbing code goes into effect (this study assumes January 1, 1995).

Note that most of these activities are continuations of existing City programs. The importance of water conservation cannot be over-emphasized since such activities directly influence water demands which, in turn, reduce the size of future facilities and delay the need for additional water supplies.

2. WATER QUALITY

Water quality data for Milford Reservoir is shown in Table VII-1. According to the District 10 report, the water quality of Milford Reservoir is moderately hard, but capable of being treated with conventional treatment processes to acceptable quality. In the District 10 report some quality issues were reported to need additional evaluation.

3. ENVIRONMENTAL CONSIDERATIONS

According to the District 10 report, the development of the Milford Reservoir water conveyance system will involve the following environmental considerations:

Table VII–1

MILFORD RESERVOIR
WATER QUALITY DATA (1)

Parameter	Units	Corps of Engineer's Data (2)			KDHE Data (3)		
		High	Low	Mean	High	Low	Mean
Temperature	˚C	27.1	2.1	14.0	25.0	2.5	13.4
Conductivity	umho	729	330	531	770	610	727
Turbidity	TU	180.0	5.0	31.7	12.0	1.0	5.1
Total Dissolved Solids	mg/l				495	357	445
Total Alkalinity, CaC03	mg/l	241	92	188			
HCO3 Alkalinity, CaCO3	mg/l	170	120	138			
Bicarbonate, HCO3	mg/l				230	180	211
Carbonate, CO3	mg/l				0	0	0
Tot. Hardness, CaCO3	mg/l	545	130	199	270	200	242
Carb. Hardness, CaCO3	mg/l	207	126	144			
Non–Carb. Hardness, CaCO3	mg/l				79	50	68
pH	su	8.70	6.80	8.07			
Calcium, CaCO3	mg/l	0.200	0.005	0.147			
Calcium, dissolved	mg/l				74.0	56.0	67.3
Magnesium	mg/l				21.0	13.0	17.8
Sodium	mg/l				61.0	44.0	54.8
Chloride	mg/l	51.0	7.0	33.0	57.0	42.0	52.5
Sulfate	mg/l	129.0	29.0	69.0	130.0	92.0	117.3
Iron	mg/l	1.876	0.060	0.555	0.060	0.040	0.050
Manganese	mg/l	0.901	0.000	0.100	0.000	0.000	0.000
Potassium	mg/l				11.000	9.500	10.200
Phosphorus	mg/l	0.450	0.000	0.105	0.110	0.060	0.080
Nitrate	mg/l				0.32	0.07	0.21
NO2 & No3 – N	mg/l	1.10	0.12	0.69			
NO3 – N	mg/l	1.800	0.000	0.231			
SiO2	mg/l				5.40	1.60	2.90
Fluoride	mg/l				0.50	0.30	0.40
Boron	mg/l				0.17	0.08	0.12
Sodium Absorption Ratio	–				1.60	1.40	1.50

(1) Source: Appendix A, Engineering Report, Central Kansas Wholesale Water Supply District, Feasibility Study – Phase I for District Steering Committee; Mid–Kansas Water Consultants; July 1983.

(2) Sampling points above and below Milford Dam. From data supplied by the Corps of Engineers. Analysis from March 1969 to August 1981.

(3) Sampling points below Miilford Dam. From data supplied by the Kansas Department of Health and Environment, Study 06857100. Chemical analysis from July 1974 to September 1975.

(4) From 1991 – "Conceptual Study of Alternative Water Supply Sources" by Mid–Kansas Water Consultants.

- Construction of intake structure and water plant at the reservoir will have some short-term environmental effects.
- Construction of pump stations and pipelines will require right-of-way acquisition and entail some short-term environmental impacts. These effects may be mitigated through replanting trees and grasses on disturbed earth.
- Withdrawal of water from the reservoir will not cause significant water level variations except during severe drought conditions (per comments from the Kansas Water Office).

Other environmental considerations that are typical for an intake and pipeline project are listed below:

- Land use features such as dwellings, cemeteries and churches may affect the pipeline alignment.
- Cultural resource surveys (historic and archaeologic) are generally required and may affect the alignment.
- Endangered and threatened species surveys are generally required and may affect the alignment.
- Highway, road, stream and river crossings typically have minor and temporary impacts.
- Recreational resources at the lake may be affected by water level variations.
- Mitigation or reconstruction of wetlands, especially stream crossings, may be necessary.
- Control of storm water runoff from construction activities which disturb soil cover will be required.

4. ECONOMIC EVALUATIONS

a. Cost Estimates

Project cost estimates for the Milford Reservoir Water Supply Plan, which involves water conservation, the Milford Reservoir supply, a second Cheney Reservoir pipeline and Equus Beds Well Field Improvements, are presented in Table VII-2. Cost estimates by others for the Milford Reservoir pipeline and water treatment plant were estimated at $186 million (in 1991 dollars).

Based on unit costs developed in this study and recent contacts with heavy construction contractors, the cost of the Milford Reservoir pipeline and water treatment plant are currently estimated at $247 million (in 1993 dollars). The major differences in estimates of cost between this study and the District 10 study are as follows:

- Inflation of construction costs from 1991 to 1993 are based on Engineering News Record figures at 6.3 percent.

- Slightly higher unit cost for pipeline construction at $200 per linear foot for 60- and 66-inch diameter pipes in this study versus about $188 per linear foot (1993 dollars) for the District 10 report.

- Contingency of 20 percent versus 10 percent used in the District 10 report.

Table VII – 2

MILFORD RESERVOIR WATER SUPPLY PLAN
PROJECT COST ESTIMATE

Item	Cost ($)
1. MILFORD RESERVOIR SUPPLY:	
Intake/Low Service Pump Station	$ 6,100,000
Raw Waterline	1,000,000
Water Treatment Plant	51,300,000
Pipelines & Appurtenances (1)	119,400,000
Subtotal	$ 177,800,000
Contingency @ 20%	35,600,000
Subtotal	$ 213,400,000
Other Costs @ 15%	32,000,000
Land	1,600,000
Milford Project Cost	**$ 247,000,000**
2. WATER CONSERVATION:	
Water Conservation Kits (2)	$ 1,700,000
Water Conservation Project Cost	**$ 1,700,000**
3. CHENEY RESERVOIR SUPPLY:	
Pipeline (3)	15,100,000
Pump Station (4)	1,200,000
Subtotal	$ 16,300,000
Contingency @ 20%	3,300,000
Subtotal	$ 19,600,000
Other Costs @ 15%	2,900,000
Cheney Supply Project Cost	**$ 22,500,000**

Table VII – 2 (Continued)

MILFORD RESERVOIR WATER SUPPLY PLAN
PROJECT COST ESTIMATE

Item	Cost ($)
4. EQUUS BEDS WELL FIELD IMPROVEMENTS:	
Pipelines (5)	$ 3,300,000
Pump Station (6)	5,000,000
Wells (7)	800,000
Subtotal	$ 9,100,000
Contingency @ 20%	1,800,000
Subtotal	$ 10,900,000
Other Costs @ 15%	1,600,000
Equus Beds Project Cost	**$ 12,500,000**
5. WATER TREATMENT PLANT:	
30 MGD Water Treatment Plant	$ 28,000,000
Subtotal	$ 28,000,000
Contingency @ 20%	5,600,000
Subtotal	$ 33,600,000
Other Costs @ 15%	5,000,000
Water Plant Project Cost	**$ 38,600,000**
Total Project Cost	**$ 322,300,000**

Notes:

(1) Maximum day capacity of 60 MGD to Wichita and 80 MGD total (Alternative A) Public Water District 10 Report dated December 1991.
(2) All other conservation costs are annual operating costs and are included in the present value estimate.
(3) 22 miles of 42–inch diameter pipeline.
(4) 25 MGD pump station.
(5) 3 miles of 66–inch diameter pipeline.
(6) 120 MGD booster pump station.
(7) 5 new 1,500 gpm wells.

- Rock excavation estimated at $13 million compared to $2 million in the District 10 report.

The Milford Reservoir Water Supply Plan has a total estimated project cost of $322 million. This cost includes the Milford Reservoir pipeline and water treatment plant, plus water conservation, Equus Beds Well Field improvements, and a second pipeline from Cheney Reservoir.

b. Present Value Analysis

Estimates of the present value for the Milford Reservoir Water Supply Plan are shown in Table VII-3. Present value analyses permit the comparison of the present day value of the total cost of each alternative in 1993 dollars. Such analyses take into consideration project costs, and operation, maintenance, replacement and energy costs associated with each plan and account for the time-value of money. The cost of high service pumping of treated water to the City's water distribution system is not included in the analysis. All costs are escalated into the future at an annual rate of 4 percent and discounted to 1993 at an annual rate of 7 percent.

The plan components are scheduled for implementation as follows:

- Current water conservation measures should continue and additional measures should be scheduled, as noted in the subsection titled "Plan Components," to meet projected water savings. The plumbing retrofit program should be upgraded to

Table VII – 3

MILFORD RESERVOIR WATER SUPPLY PLAN
PRESENT VALUE ESTIMATE

Year	Avg Day Demand (MGD)	Milford Reservoir Supply						Water Conserv	Other Supplies	Total	Total Present Value	Summation Present Value
		Debt Service	Water Plant OMR&E	Pipeline OMR&E	Admin. & Support	Raw Water Storage	Subtotal					
1993	65.1							200,000	274,000	474,000	470,000	470,000
1994	66.9							427,000	386,000	813,000	760,000	1,230,000
1995	63.0							952,000	175,000	1,127,000	980,000	2,210,000
1996	64.7							1,056,000	284,000	1,340,000	1,090,000	3,300,000
1997	66.4							1,098,000	403,000	1,501,000	1,150,000	4,450,000
1998	68.1							1,142,000	530,000	1,672,000	1,190,000	5,640,000
1999	69.8							1,186,000	667,000	1,853,000	1,230,000	6,870,000
2000	71.6							614,000	821,000	1,435,000	890,000	7,760,000
2001	72.9							639,000	950,000	1,589,000	920,000	8,680,000
2002	74.3							665,000	1,095,000	1,760,000	960,000	9,640,000
2003	75.6							692,000	1,242,000	1,934,000	980,000	10,620,000
2004	76.9							720,000	1,399,000	2,119,000	1,010,000	11,630,000
2005	78.3	37,328,000	9,426,000	3,552,000	927,000	3,066,000	54,299,000	749,000	1,576,000	56,624,000	25,140,000	36,770,000
2006	79.6	37,328,000	9,803,000	3,694,000	964,000	3,066,000	54,855,000	779,000	1,755,000	57,389,000	23,810,000	60,580,000
2007	81.0	37,328,000	10,195,000	3,842,000	1,002,000	3,066,000	55,433,000	810,000	1,956,000	58,199,000	22,570,000	83,150,000
2008	82.4	37,328,000	10,602,000	3,996,000	1,042,000	3,066,000	56,034,000	842,000	2,170,000	59,046,000	21,400,000	104,550,000
2009	83.7	37,328,000	11,027,000	4,156,000	1,084,000	3,066,000	56,661,000	876,000	2,387,000	59,924,000	20,300,000	124,850,000
2010	85.1	37,328,000	11,468,000	4,322,000	1,127,000	3,066,000	57,311,000	910,000	2,630,000	60,851,000	19,260,000	144,110,000
2011	86.4	37,328,000	11,926,000	4,495,000	1,172,000	3,066,000	57,987,000	946,000	2,876,000	61,809,000	18,290,000	162,400,000
2012	87.6	37,328,000	12,403,000	4,675,000	1,219,000	3,066,000	58,691,000	984,000	3,127,000	62,802,000	17,370,000	179,770,000
2013	88.9	37,328,000	12,899,000	4,862,000	1,268,000	3,066,000	59,423,000	1,024,000	3,406,000	63,853,000	16,500,000	196,270,000
2014	90.1	37,328,000	13,415,000	5,056,000	1,319,000	3,066,000	60,184,000	1,065,000	3,689,000	64,938,000	15,680,000	211,950,000
2015	91.4	37,328,000	13,952,000	5,258,000	1,372,000	3,066,000	60,976,000	1,108,000	4,002,000	66,086,000	14,920,000	226,870,000
2016	92.4	37,328,000	14,510,000	5,469,000	1,426,000	3,066,000	61,799,000	1,152,000	4,295,000	67,246,000	14,190,000	241,060,000
2017	93.5	37,328,000	15,091,000	5,687,000	1,484,000	3,066,000	62,656,000	1,198,000	4,618,000	68,472,000	13,500,000	254,560,000
2018	94.5	37,328,000	15,694,000	5,915,000	1,543,000	3,066,000	63,546,000	1,246,000	4,947,000	69,739,000	12,850,000	267,410,000
2019	95.6	37,328,000	16,322,000	6,152,000	1,605,000	3,066,000	64,473,000	1,295,000	5,308,000	71,076,000	12,240,000	279,650,000
2020	96.7	37,328,000	16,975,000	6,398,000	1,669,000	3,066,000	65,436,000	1,347,000	5,691,000	72,474,000	11,660,000	291,310,000
2021	97.5	37,328,000	17,654,000	6,654,000	1,736,000	3,066,000	66,438,000	1,401,000	6,048,000	73,887,000	11,110,000	302,420,000
2022	98.3	37,328,000	18,360,000	6,920,000	1,805,000	3,066,000	67,479,000	1,457,000	6,424,000	75,360,000	10,590,000	313,010,000
2023	99.2	37,328,000	19,094,000	7,196,000	1,877,000	3,066,000	68,561,000	1,516,000	6,838,000	76,915,000	10,100,000	323,110,000
2024	100.0	37,328,000	19,858,000	7,484,000	1,952,000	3,066,000	69,688,000	1,576,000	7,257,000	78,521,000	9,640,000	332,750,000
2025	100.9		20,652,000	7,784,000	2,030,000	3,066,000	33,532,000	1,639,000	7,717,000	42,888,000	4,920,000	337,670,000

Table VII – 3 (Continued)

MILFORD RESERVOIR WATER SUPPLY PLAN
PRESENT VALUE ESTIMATE

Year	Avg Day Demand (MGD)	Milford Reservoir Supply						Water Conserv	Other Supplies	Total	Total Present Value	Summation Present Value
		Debt Service	Water Plant OMR&E	Pipeline OMR&E	Admin. & Support	Raw Water Storage	Subtotal					
2026	101.7		21,479,000	8,095,000	2,112,000	3,066,000	34,752,000	1,704,000	8,182,000	44,638,000	4,790,000	342,460,000
2027	102.5		22,338,000	8,419,000	2,196,000	3,066,000	36,019,000	1,772,000	8,673,000	46,464,000	4,660,000	347,120,000
2028	103.4		23,231,000	8,756,000	2,284,000	3,066,000	37,337,000	1,843,000	9,211,000	48,391,000	4,530,000	351,650,000
2029	104.3		24,160,000	9,106,000	2,375,000	3,066,000	38,707,000	1,918,000	9,778,000	50,403,000	4,410,000	356,060,000
2030	105.1		25,127,000	9,470,000	2,470,000	3,066,000	40,133,000	1,995,000	10,353,000	52,481,000	4,290,000	360,350,000
2031	106.1		26,132,000	9,849,000	2,569,000	3,066,000	41,616,000	2,075,000	11,006,000	54,697,000	4,180,000	364,530,000
2032	107.0		27,177,000	10,243,000	2,672,000	3,066,000	43,158,000	2,157,000	11,669,000	56,984,000	4,070,000	368,600,000
2033	108.0		28,264,000	10,652,000	2,779,000	3,066,000	44,761,000	2,244,000	12,394,000	59,399,000	3,970,000	372,570,000
2034	108.9		29,395,000	11,079,000	2,890,000	3,066,000	46,430,000	2,334,000	13,132,000	61,896,000	3,860,000	376,430,000
2035	109.9		30,571,000	11,522,000	3,005,000	3,066,000	48,164,000	2,428,000	13,936,000	64,528,000	3,760,000	380,190,000
2036	110.8		31,794,000	11,983,000	3,126,000	3,066,000	49,969,000	2,524,000	14,755,000	67,248,000	3,670,000	383,860,000
2037	111.8		33,065,000	12,462,000	3,251,000	3,066,000	51,844,000	2,625,000	15,647,000	70,116,000	3,570,000	387,430,000
2038	112.7	56,592,000	34,388,000	12,960,000	3,381,000	3,066,000	110,387,000	2,730,000	16,556,000	129,673,000	6,170,000	393,600,000
2039	113.7	56,592,000	35,763,000	13,479,000	3,516,000	3,066,000	112,416,000	2,839,000	17,545,000	132,800,000	5,910,000	399,510,000
2040	114.7	56,592,000	37,194,000	14,018,000	3,657,000	3,066,000	114,527,000	2,953,000	18,587,000	136,067,000	5,660,000	405,170,000
2041	115.7	56,592,000	38,682,000	14,579,000	3,803,000	3,066,000	116,722,000	3,071,000	19,683,000	139,476,000	5,420,000	410,590,000
2042	116.6	56,592,000	40,229,000	15,162,000	3,955,000	3,066,000	119,004,000	3,194,000	20,802,000	143,000,000	5,190,000	415,780,000
2043	117.6	56,592,000	41,838,000	15,768,000	4,113,000	3,066,000	121,377,000	3,322,000	22,016,000	146,715,000	4,980,000	420,760,000
2044	118.6	56,592,000	43,512,000	16,399,000	4,278,000	3,066,000	123,847,000	3,455,000	23,294,000	150,596,000	4,780,000	425,540,000
2045	119.6	56,592,000	45,252,000	17,055,000	4,449,000	3,066,000	126,414,000	3,593,000	24,639,000	154,646,000	4,590,000	430,130,000
2046	120.6	56,592,000	47,062,000	17,737,000	4,627,000	3,066,000	129,084,000	3,736,000	26,055,000	158,875,000	4,400,000	434,530,000
2047	121.6	56,592,000	48,945,000	18,447,000	4,812,000	3,066,000	131,862,000	3,886,000	27,544,000	163,292,000	4,230,000	438,760,000
2048	122.6		50,902,000	19,185,000	5,004,000	3,066,000	78,157,000	4,041,000	29,111,000	111,309,000	2,690,000	441,450,000
2049	123.6		52,939,000	19,952,000	5,204,000	3,066,000	81,161,000	4,203,000	30,759,000	116,123,000	2,630,000	444,080,000
2050	124.6		55,056,000	20,750,000	5,413,000	3,066,000	84,285,000	4,371,000	32,492,000	121,148,000	2,560,000	446,640,000
Total		1,312,480,000	1,195,821,000	450,694,000	117,564,000	141,036,000	3,217,595,000	104,324,000	544,762,000	3,866,681,000	446,640,000	

Notes:
(1) Milford Reservoir Supply based on costs by other consultants, except for debt service which is based on project costs listed in Table VII – 2. Water plant construction costs are included. Milford supplies 60 MGD continuously to Wichita.

a full scale program by 1995. The program should be conducted over a five-year period with completion in 1999.

- Pipeline from Milford Reservoir in service in year 2005.

- 42-inch diameter pipeline from Cheney Reservoir, Equus Beds Well Field Improvements, and 30 MGD Water Treatment Plant at new plant site, in service in year 2038.

Project cost, as shown in Table VII-2 and used in the analysis, includes escalated cost estimates of various plan components. The abbreviation "OMR&E" stands for operation, maintenance, replacement and energy costs. All "OMR&E," "Administrative and Support," and "Raw Water Storage" costs for the Milford Reservoir Supply are escalated from costs provided in the District 10 report. The "Other Supplies" figures account for the actual cost of raw water conveyance and treatment from existing sources and improvements to existing sources for water demands in excess of the 60 MGD which is supplied by Milford Reservoir. Operating costs for "Other Supplies" are based on Wichita's 1993 water operations budget for raw water conveyance and treatment of $3.5 million and the 1993 projected average day demand of 65.1 MGD and results in a unit cost of $147/MGD in 1993 dollars. The Milford Reservoir Water Supply Plan has a total present value of $447 million in 1993 dollars. The plan has a unit water cost of $1.90 per 1000 gallons based on the plan's total cost in inflated dollars divided by the total water used over the study period.

c. Economic Impacts

The Milford Reservoir Water Supply Plan increases the water rates to a maximum cumulative rate increase of 705 percent in year 2046 and 522 percent in the year 2050 (the end of the study period) as shown in Figure VII-2. Rate increases between years 2005 and 2024 are due to retirement of debt service for the Milford Reservoir supply pipeline and rate increases between 2038 and 2047 are due to retirement of debt service for Equus Beds Weld Field improvements, a second pipeline from Cheney Reservoir and a 30 MGD water plant. The projected rates represent minimum increases to fund the plan's capital improvements and to maintain debt service coverage and contingency funds.

D. INTEGRATED LOCAL WATER SUPPLY PLAN

The two options of Integrated Local Water Supply Plan include the integrated use of the same basic local water supplies, but offer different levels of operating flexibility at significantly different capital costs. The options differ as follows:

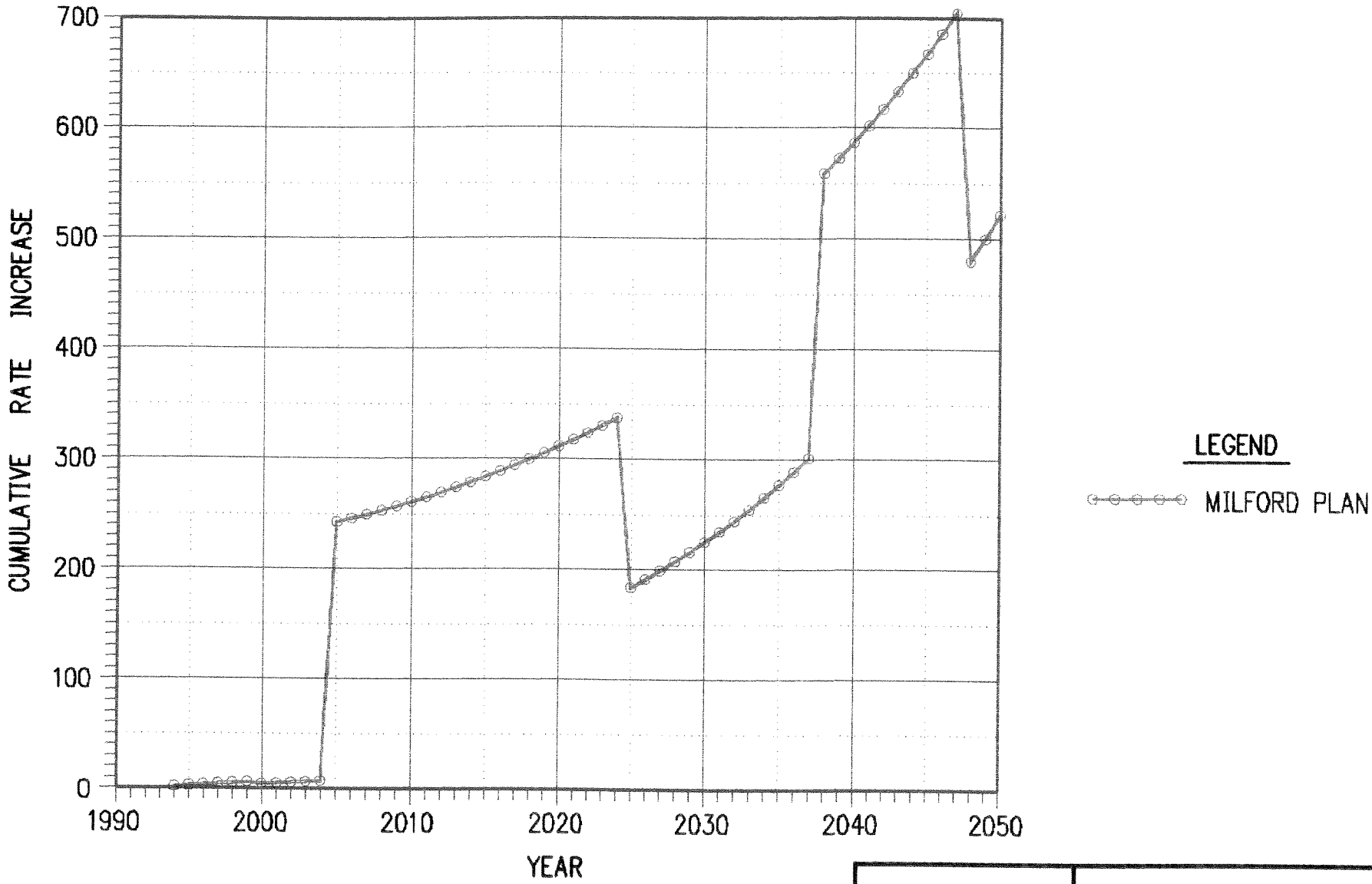


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Figure VII – 2

MILFORD RESERVOIR WATER SUPPLY PLAN
CUMULATIVE RATE INCREASES

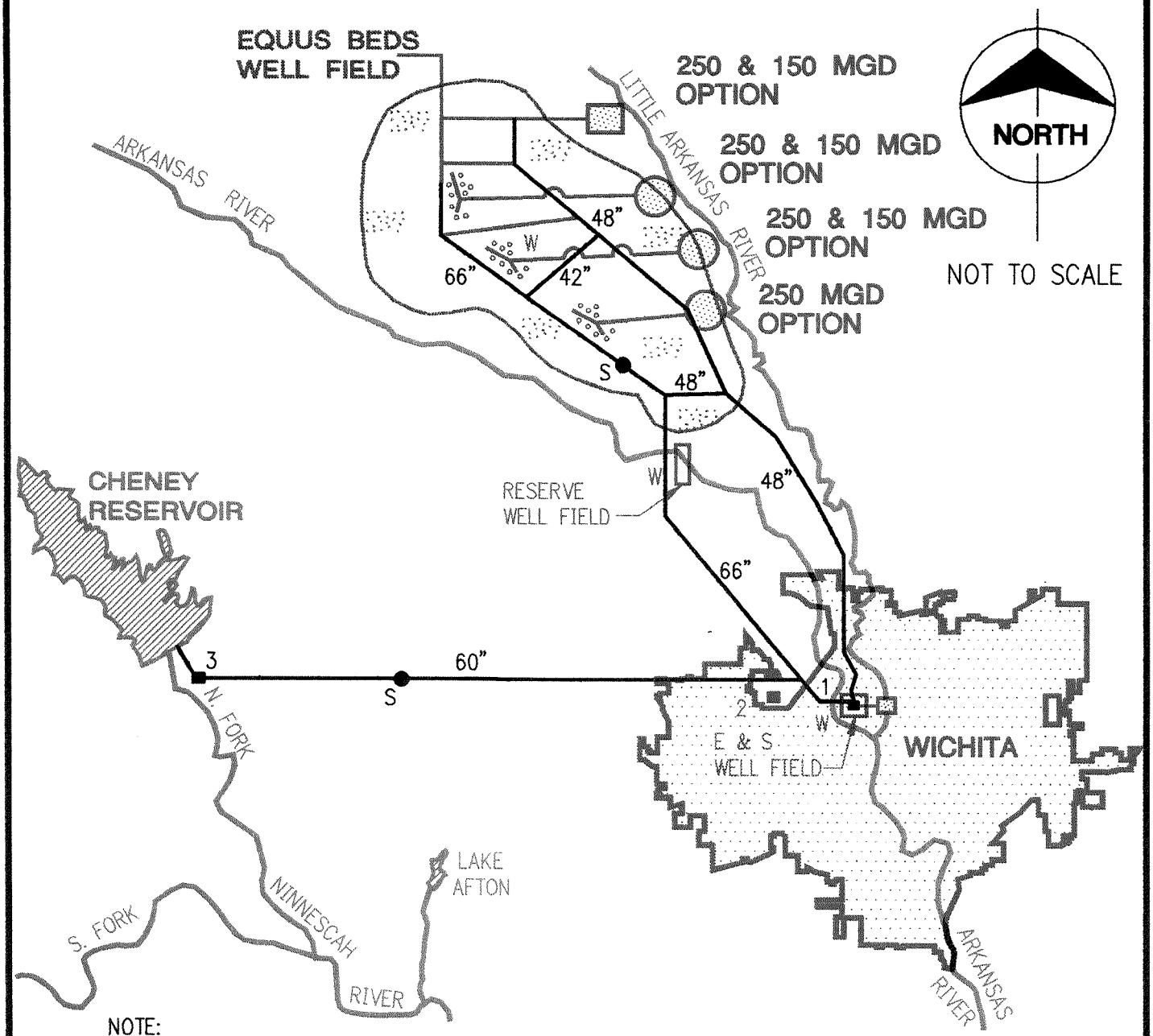
Item	250 MGD Diversion Option	150 MGD Diversion Option
Little Arkansas River Diversion Capacity	250 MGD	150 MGD
Equus Beds Well Field Pumping Capacity	220 to 240 MGD	170 MGD With Reserve Well Field
Equus Beds Well Field Pipeline Improvements	More Expensive	Less Expensive
Plan Operations to Supply Year 2050 Maximum Day Demand During Drought Conditions	Cheney Reservoir Not Used	Cheney Reservoir Operating at Average Day Water Right of 47 MGD
Impact on Cheney Reservoir Level	Minimal (Refer to Figure VII-10)	Slightly Greater than the 250 MGD Diversion Option (Refer to Figure VII-11)

1. WATER DELIVERY

a. Concept and Operational Plan

A schematic of the options for the Integrated Local Water Supply Plan is shown in Figure VII-3. A more detailed layout of pipeline improvements is shown in Figure VII-4. This plan involves the use of the following water sources:

- Little Arkansas River intake adjacent to the Central Water Plant.
- Little Arkansas River surface water diversion and pumping of groundwater from bank storage to recharge the Equus Beds Aquifer.



NOTE:
PLAN ALSO INCLUDES WATER CONSERVATION
AND GILBERT–MOSLEY REMEDIATED GROUNDWATER.

LEGEND

- RAW WATER SUPPLY MAIN
- RIVER AND LAKES
- S — SURGE TANK
- W — WELL FIELD
- 1 ■ CENTRAL WATER TREATMENT PLANT
- 2 ■ NEW WATER TREATMENT PLANT
- 3 ■ CHENEY RESERVOIR PUMP STATION
- PROPOSED PIPELINE
- SURFACE WATER INTAKE
- BANK STORAGE RECOVERY PUMP SITE & INJECTION WELLS

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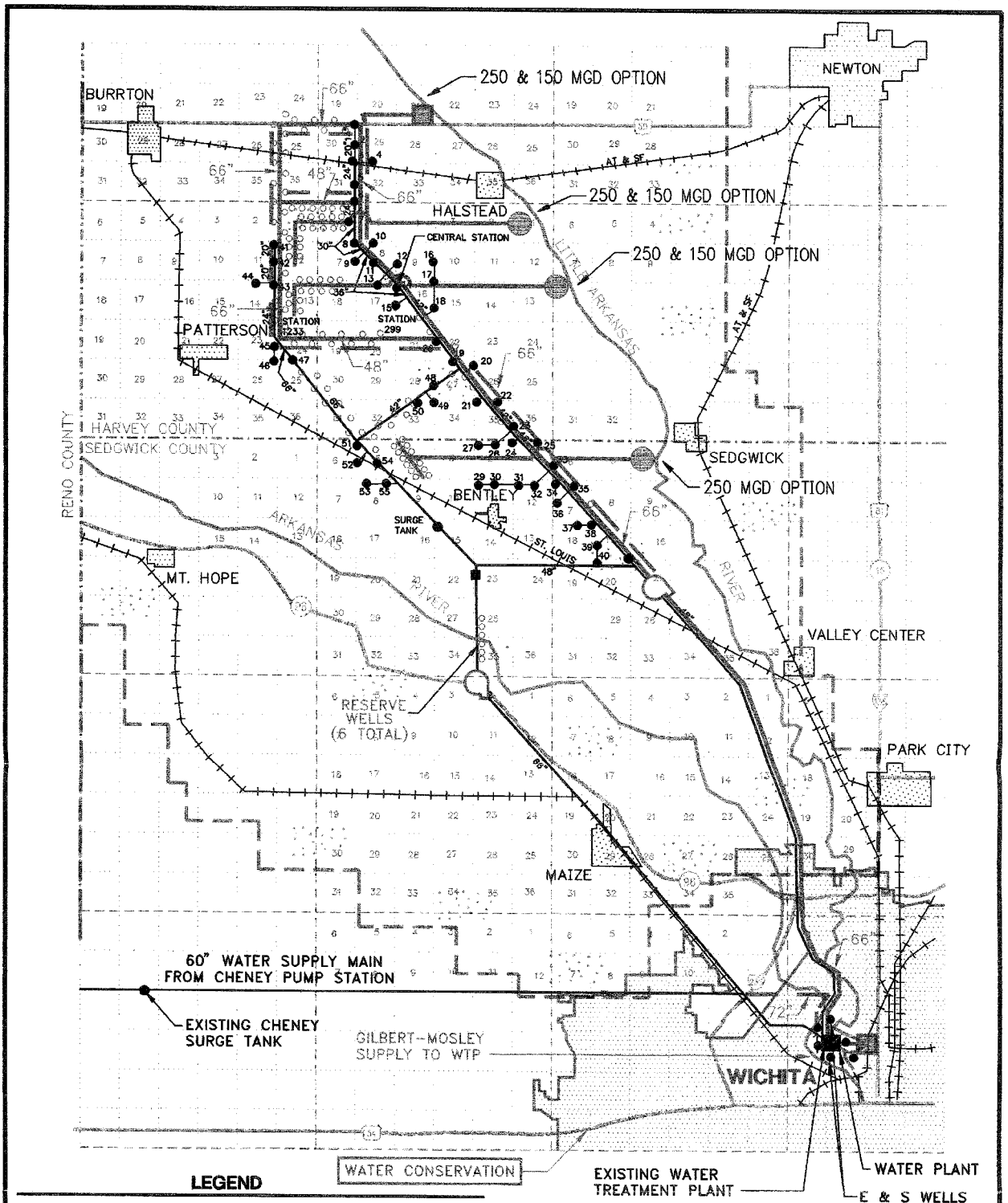
Figure VII – 3

INTEGRATED LOCAL WATER SUPPLY PLAN SCHEMATIC



LEGEND

- TRANSMISSION LINE
- 19 EXISTING SUPPLY WELL & NUMBER
- EQUUS BEDS GROUNDWATER MANAGEMENT DISTRICT BOUNDRY
- TOWNSHIP BOUNDRY
- PROPOSED PIPELINE (250 MGD OPTION)
- PROPOSED PIPELINE (150 MGD OPTION)
- PROPOSED BOOSTER PUMP STATION
- PROPOSED WELL
- BANK STORAGE RECOVERY PUMP SITE & INJECTION WELLS
- SURFACE WATER INTAKE

NOTE:

DEVELOP 40 SURFACE WATER RECHARGE BASINS AT EXISTING AND PROPOSED WELL SITES FOR OPTION A AND 23 FOR OPTION B.

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Figure VII – 4

INTEGRATED LOCAL WATER SUPPLY PLAN SCHEMATIC

J:\WICHITA\921954\FIGVII-2.DWG 06-11-1993 14:08 BES

- Redevelopment of the Reserve Well Field.
- Use of remediated groundwater from the Gilbert-Mosley Well Field.
- Continued use of Cheney Reservoir (up to its maximum capacity of 80 MGD).
- Continued use of E&S Well Field (up to its maximum capacity of 32.8 MGD).
- Expansion of Equus Beds Well Field pumping capacity (to supply the maximum day demand in conjunction with the E&S and Gilbert-Mosley Well Fields).
- Water Conservation.

This plan optimizes use of existing supplies and uses excess water from the Little Arkansas River, above base stream flow, on an "as-available" basis to meet the City's water demands and to recharge the Equus Beds Aquifer. Additionally, water in the Cheney Reservoir flood and surcharge pool will be conveyed to the water plant for treatment on an "as-available" basis to meet system water demands. Use of these "as-available" waters allows the Equus Beds to be recharged for later use during drought conditions and minimizes the need for additional water supply sources from outside the region.

The potential exists to recharge the Equus Beds Aquifer with Cheney Reservoir overflow. This requires construction of a new valve vault at the confluence of the 60- and 66-inch pipelines. The occasional use of Cheney overflow should not significantly alter the average chloride concentrations of the "recharged" groundwater.

The state of Kansas issues water rights for individual surface water sources and groundwater wells or well fields. These water rights limit the annual and maximum withdrawals from the permitted sources. Since the Integrated Local Water Supply Plan optimizes the use of available local water resources on an integrated-use basis, water rights for individual sources will be exceeded during certain operating conditions which will require approval from the state.

Based on discussions with the state, the City may be able to obtain an integrated or conjunctive water use permit for the raw water sources. This permit would limit the annual average and maximum withdrawal from the sources on a total, not individual basis, and allow the City to maximize the use of their water resources. Obtaining this conjunctive permit from the state is necessary to make the plan feasible.

The Integrated Local Water Supply Plan also requires the City to use Cheney Reservoir, the largest firm supply source, at its firm yield. Based on operations studies performed in Part VI, the 2 percent firm yield of Cheney Reservoir is estimated to be closer to the water right of 47 MGD instead of the Bureau's revised yield of 38.2 MGD. Utilizing the reservoir's firm yield could cause substantial water level variations, especially during an extended drought period, and will impact recreation. A 2 percent firm yield will theoretically reduce the reservoir level to the bottom of the conservation pool an average of one time every 50 years.

Water conservation is another element in the Integrated Local Water Supply Plan. A water conservation program has been implemented by the City and should be expanded over the next six years to incorporate additional conservation measures (refer to previous subsection titled "Plan Components") necessary to realize projected water savings as indicated in Part I of this report.

b. Plan Implementation

Basic phases of construction of new facilities are proposed in the implementation of the Integrated Local Water Supply Plan to meet projected water demands. Maximum day demands are expected to exceed maximum day pumping capacity of about 180 MGD (55 MGD Equus Beds, 80 MGD Cheney Reservoir, 30 MGD E&S wells, 10 MGD Reserve wells and 3 MGD Gilbert-Mosley wells) in the year 2014. Average day demands are projected to exceed average day supply capacity of about 90 MGD in the year 2015. As a result, additional water sources must be operational and the Equus Beds must be recharged prior to year 2014. This would permit the Equus Beds to be used to supply water to meet demands during drought periods when Cheney Reservoir's conservation pool storage is low or depleted.

Completion of construction phases for the Integrated Local Water Supply Plan with the 250 MGD Diversion Option and the 150 MGD Diversion Option are scheduled as follows:

- Phase 1 - Gilbert-Mosley Well Field (1994 to 1995):

- Convey remediated Gilbert-Mosley groundwater to the Central Water Plant at a continuous rate of 3 MGD.

- Phase 2 - Water Conservation (1995-1999):
  - Full scale plumbing retrofit program.
  - Existing and planned water conservation measures as detailed in a subsequent subsection titled "Plan Components."

- Phase 3 - Reserve Well Field (1997 to 2004):
  - Redevelop abandoned Bentley Reserve Well Field to supply groundwater during peak water use periods. Add six wells with a capacity of 10.8 MGD.

- Phase 4 - Little Arkansas River Intake Adjacent to Central Water Plant (1997 to 2004):
  - Construct a 160 MGD surface water intake on the Little Arkansas River, 0.5 miles of 96-inch diameter pipeline and a 160 MGD presedimentation basin at the water plant. Water will be conveyed to the plant on an "as-available" basis.

- Phase 5 - Little Arkansas River Diversions to Equus Beds (2004):

  250 MGD Diversion Option:
  - Construct 160 MGD surface water intake and pipeline to the Equus Beds Well Field and 40 surface spreading basins.

Water will be spread on basins at well sites to recharge the aquifer.

- Construct six bank storage horizontal collector wells (3 units with 2 wells per unit) with a total capacity of 90 MGD, pipelines to Equus Beds Well Field and injection wells to recharge the aquifer.
- Equus Beds Well Field piping improvements include a 66-inch diameter pipeline from the Central Water Plant to Well No. 1.

150 MGD Diversion Option:

- Construct 90 MGD surface water intake and pipeline to the Equus Beds Well Field and 23 surface spreading basins. Water will be spread on basins at well sites to recharge the aquifer.
- Construct four bank storage horizontal collector wells (2 units with 2 wells per unit) with a total capacity of 60 MGD, pipelines to the Equus Beds Well Field and injection wells to recharge the aquifer.
- Equus Beds Well Field piping improvements includes 8.5 miles of 66-inch diameter and 5.5 mile of 48-inch diameter pipelines.

• Phase 6 - Water Treatment Plant (2006):

- Construct initial facilities for 30 MGD capacity at a new water plant with an ultimate planned capacity of 90 MGD.

- Phase 7 - Equus Beds Well Field Improvements (2009):

  250 MGD Diversion Option:

  - Expand Equus Beds Well Field conveyance capacity from about 55 MGD to about 150 MGD, firm capacity. Add 40 wells, a 120 MGD booster pump station on the east 66-inch diameter pipeline.

  150 MGD Diversion Option:

  - Expand Equus Beds conveyance capacity from about 55 MGD to about 130 MGD, firm capacity. Add 30 wells, a 120 MGD booster pump station on the 66-inch diameter pipeline and 4.5 miles of 72-inch diameter pipeline.

- Phase 8 - Additional Improvements (2020):

  - Expand new water plant by 20 MGD to total 50 MGD capacity.

  250 MGD Diversion Option:

  - Expand Equus Beds Well Field conveyance capacity from 150 MGD to 170 MGD, firm capacity. Add 10 wells.

- Phase 9 - Additional Improvements (2030):

  - Expand new water plant by 20 MGD to total 70 MGD capacity.

  250 MGD Diversion Option:

  - Expand Equus Beds Well Field conveyance capacity from 170 MGD to 190 MGD, firm capacity. Add 10 wells, the second 120 MGD booster pump station.

150 MGD Diversion Option:

- Expand Equus Beds Well Field conveyance capacity from 130 MGD to 150 MGD, firm capacity. Add 10 wells.

- Phase 10 - Additional Improvements (2040):

  - Expand new water plant by 20 MGD to total 90 MGD capacity.

  250 MGD Diversion Option:

  - Expand Equus Beds Well Field conveyance capacity from 190 MGD to 210 MGD, firm capacity. Add 10 wells.

  150 MGD Diversion Option:

  - Expand Equus Beds Well Field conveyance capacity from 150 MGD to 170 MGD, firm capacity. Add 10 wells, a 120 MGD booster pump station and 7 miles of 66-inch diameter pipeline.

c. Plan Components

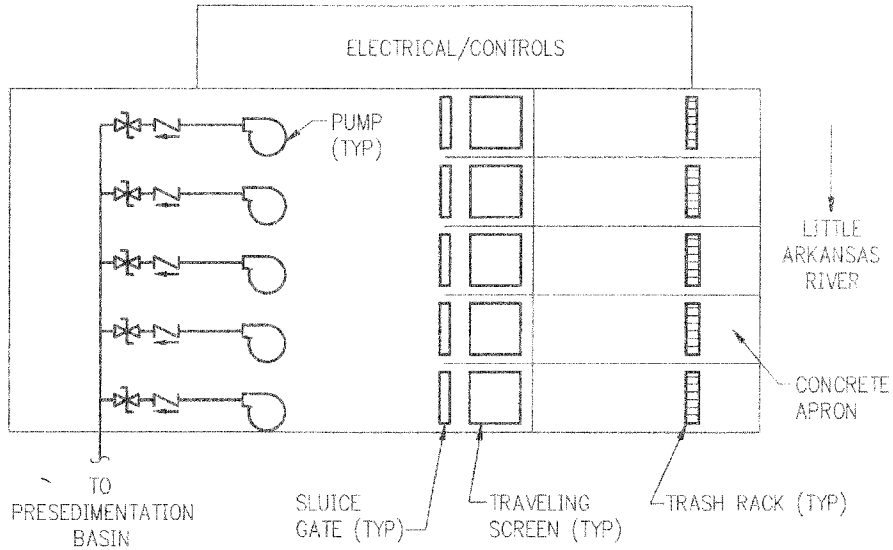
(1) Little Arkansas River Intake adjacent to the Central Water Plant: This plan component includes the construction of a 160 MGD intake and pump station upstream of the low flow dam on the Little Arkansas River near the Central Water Plant. A 96-inch diameter pipeline, about 1/2 mile long, will connect the intake to a new 160 MGD presedimentation basin at the water plant. Water will be pumped from the river on an "as-available" basis.

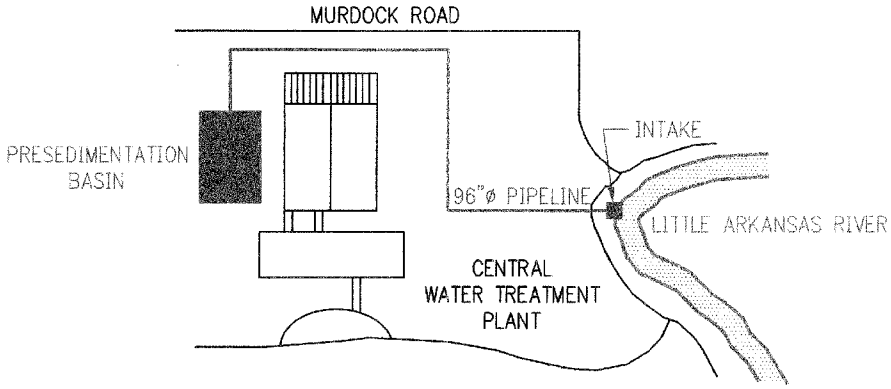
The intake is shown schematically in Figure VII-5. The preliminary concept for the facility includes trash racks and traveling screens and five 40 MGD vertical turbine pumps with a variable frequency drive connected to one or two pumps. A presedimentation basin with parallel plate equipment could be located west of the existing clarifiers at the water plant on an approximate 140 feet x 210 feet area.

(2) Equus Beds Aquifer Recharge System: The recharge system diverts excess flow from the Little Arkansas River between Alta Mills and Valley Center to the Equus Beds Aquifer for infiltration. The system includes the following components as shown in Figure VII-4:

250 MGD Diversion Option:

- An intake and pump station will divert up to 160 MGD of excess surface water to spreading basins for recharge. Water is conveyed through four miles of 96-inch diameter pipeline to the Equus Beds piping system. Forty 4-acre surface spreading basins will be constructed at existing and future well sites (which are on 5-acres) for infiltration. Basins will be filled when excess flow is available, water will infiltrate through the basins, and the basins will be allowed to dry to prevent plugging. Basins will also be scarified to loosen topsoil between recharge cycles.





VICINITY MAP

LEGEND

- BUTTERFLY VALVE
- CHECK VALVE
- PROPOSED PIPELINE

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Figure VII-5

TYPICAL RIVER INTAKE SCHEMATIC

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- Three sets of two horizontal collector wells with a capacity of 15 MGD each (for a total of 90 MGD) will be constructed along the bank of the Little Arkansas River to recover the water in bank storage as available. Water from each set of two collector wells will be conveyed through 6 miles of 36-inch diameter pipeline and 3,000 feet of 30-inch diameter pipeline to 40 injection wells for recharge. The capability for surface spreading of bank storage recovery water will also be available.

- An Equus Beds Aquifer recharge water recovery network including the addition of up to 70 wells over the study period, 38 miles of 66-inch diameter, and 8 miles of 48-inch diameter pipelines are required to supply the maximum day demand (with the E&S Wells) during drought periods to the water plant(s). This system would operate when the water level in Cheney Reservoir drops to a predetermined low level (refer to subsequent subsection titled "Computer Simulation Model").

150 MGD Diversion Option:

- An intake and pump station will divert up to 90 MGD of excess surface water to spreading basins for recharge. Water is conveyed through four miles of 72-inch diameter pipeline to the Equus Beds piping system. Twenty-three 4-acre surface spreading basins will be constructed at existing and future well sites (which are on 5 acres) for

infiltration. Basins will be filled when excess flow is available, water will infiltrate through the basin, and the basins will be allowed to dry to prevent plugging. Basins will also be scarified to loosen topsoil between recharge cycles.

- Two sets of two horizontal collector wells with a capacity of 15 MGD each (for a total of 60 MGD) will be constructed along the Little Arkansas River bank to recover the water in bank storage as available. Water from each set of two collector wells will be conveyed through 6 miles of 36-inch diameter pipeline and 3,000 feet of 30-inch diameter pipeline to 40 injection wells for recharge. The capability for surface spreading of bank storage recovery water will also be available.

- An Equus Beds Aquifer recharge water recovery network, including the addition of up to 50 wells over the study period and 15.5 miles of 66-inch diameter 5.5 miles of 48-inch diameter and 4.5 miles of 72-inch diameter pipelines, are required to supply the maximum day demand (with Cheney Reservoir, Reserve wells and E&S wells).

(3) Reserve Well Field: Redevelopment of the abandoned Bentley Reserve Well Field can supply up to 10.8 MGD of high chloride water to meet peak demands. The wells will be constructed adjacent to the Arkansas River and the City's existing 66-inch

diameter raw water transmission main. The high chloride water must be blended with water from other sources to a level less than 200 mg/l.

(4) Gilbert-Mosley Well Field: Development of the Gilbert-Mosley groundwater remediation site as a raw water supply includes a 3 MGD booster pump station and 2.5 miles of 16-inch diameter pipeline to convey the remediated groundwater to the Central Water Plant. The contaminant, TCE, will be removed on-site by a stripper tower and the resulting remediated groundwater will be supplied on a continuous basis to the water treatment plant for treatment to potable quality.

(5) Existing Supply Sources:

- Continued use of Cheney Reservoir up to its maximum pipeline capacity of 80 MGD.
- Continued use of E&S Well Field up to its maximum capacity of 32.8 MGD.
- Continued use of the Equus Beds Well Fields; however, water will be used on an "as-needed" basis in an effort to maximize recharge water storage in the aquifer and to maximum storage in Cheney Reservoir.

(6) Water Conservation:

- Review and modify rate structure on an annual basis to help achieve and maintain conservation goals.

- Maintain current watering restrictions (twice per week by address).
- Make building plumbing code changes to incorporate low flush toilets (1.6 gallons per flush) and low flow shower heads and faucets (2.5 gpm) to be in effect by 1995.
- Continue public education programs.
- Continue leak detection surveys.
- Continue meter repair and replacement programs.
- Continue cooperative efforts with industries to encourage conservation of cooling, process and irrigation water.
- Initiate a full scale plumbing fitting retrofit program for housing units built before the new code goes into effect (this study assumes January 1, 1995).

2. COMPUTER SIMULATION MODEL

The Integrated Local Water Supply Plan includes the integrated use of several local water supply sources having limited yields, and the capture of excess flows in the Little Arkansas River on an "as-available" basis to recharge the Equus Beds and to meet projected system demands. The ability of these water supply sources to perform these operations requires verification by a computer simulation model.

For this project, an integrated raw water supply system model was developed using Burns & McDonnell's Reservoir Network (RESNET) computer program. The program solves water supply simulation models using network optimization techniques.

a. Model Development

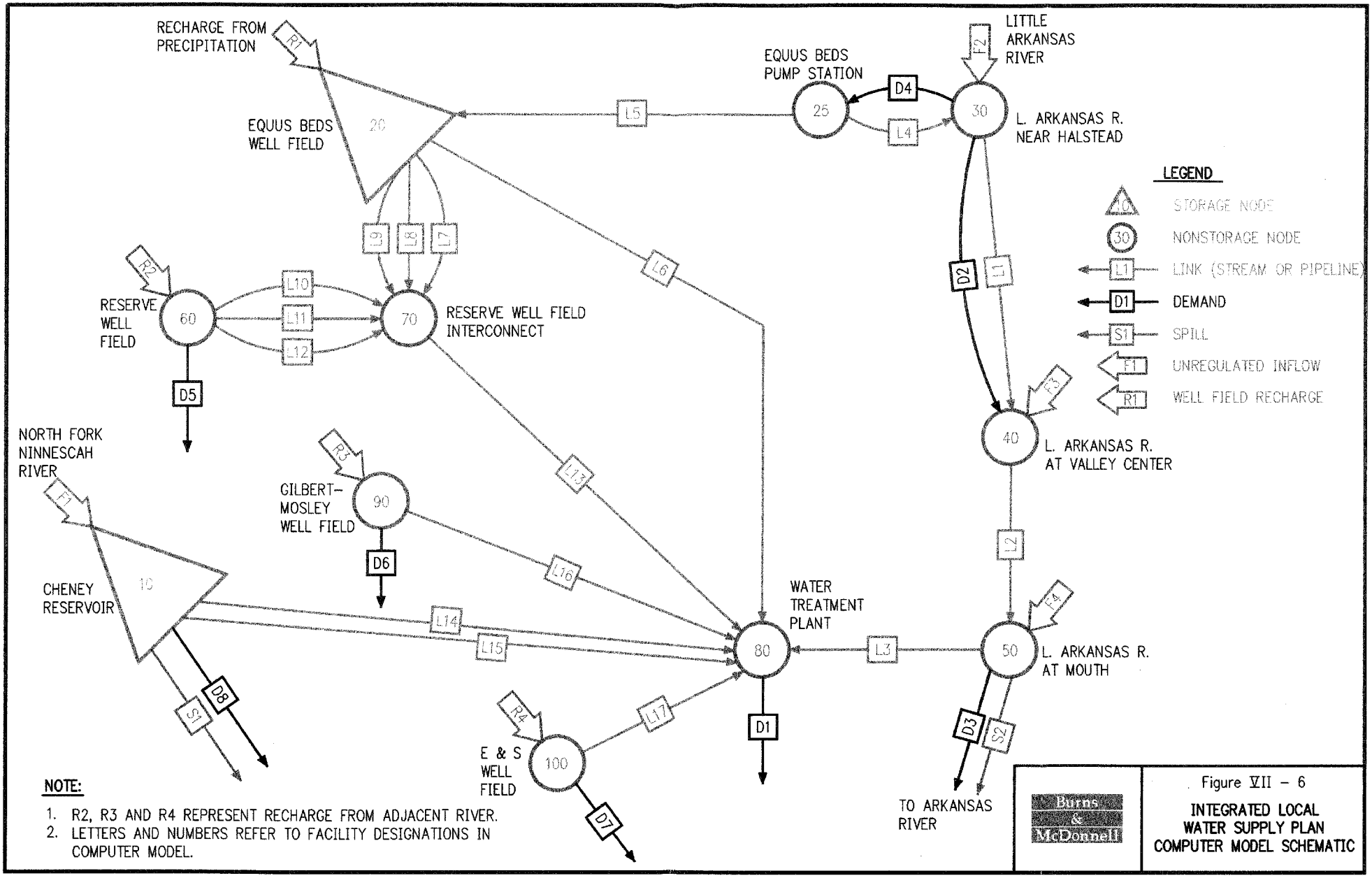
The integrated raw water supply system model includes the following components as shown schematically in Figure VII-6:

- Cheney Reservoir.
- Equus Beds Well Field.
- Little Arkansas River.
- E&S Well Field.
- Reserve Well Field.
- Gilbert-Mosley Remediated Groundwater.
- Water Treatment Plant.

Informational inputs to the model also include surface water flows, daily water demands, and operating procedures.

System components are modeled to imitate anticipated daily system operations as closely as possible within the confines of the program. The modeling criteria and assumptions are as follows:

- Cheney Reservoir:
  - Maximum supply capacity of 80 MGD. Assumed available when Cheney Reservoir water level is 1,420 feet or greater.
  - Firm yield assumed to be 47 MGD. Below water level of 1,420 feet, 47 MGD is the maximum supply available.
  - The model maximizes use of Cheney Reservoir spillage (water above the conservation pool that would normally flow through the spillway).



NOTE:

1. R2, R3 AND R4 REPRESENT RECHARGE FROM ADJACENT RIVER.
2. LETTERS AND NUMBERS REFER TO FACILITY DESIGNATIONS IN COMPUTER MODEL.

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Figure VII – 6

INTEGRATED LOCAL WATER SUPPLY PLAN COMPUTER MODEL SCHEMATIC

J:\WICHITA\921954\FIGVII-5.DWG 06-11-1993 13:11 MMD

- Cheney Reservoir operating criteria are listed in Table VII-4 and show how water is used in conjunction with the Equus Beds in order to minimize significant water level variations in both sources.

- Equus Beds Well Field:
  - Receives water from natural recharge, precipitation, at a conservatively assumed rate of 4 inches per year or 23,500 acre feet per year or 21 MGD.
  - Receives water from Little Arkansas River Diversion, located near Halstead, on an "as-available" basis. Diversion/ recharge water losses are assumed to be 10 percent.
  - Capable of delivering groundwater to the water plant at the following rates: year 2010 - 150 MGD, year 2020 - 170 MGD, year 2030 - 190 MGD, year 2040 - 210 MGD.
  - Equus Beds operating criteria are listed in Table VII-5 and show how water is used in conjunction with the Equus Beds in order to minimize significant water level variations in both sources.

- Little Arkansas River:
  - Supplies excess flow from river to Equus Beds for recharge and from river to water plant for treatment. Excess flow is stream flow above base flow, which is anticipated to be about 25 to 50 cfs at Halstead. The model was evaluated for more conservative river base flows of 100 cfs and 30 cfs. The 100 cfs is based on minimum desired streamflow (MDS) and

Table VII - 4

MODEL RESERVOIR LEVELS
CHENEY RESERVOIR

Level No.	Pool Elevation (feet)	Storage Contents (acre-feet)	Storage Priority	Remarks
1	1,379	1,140	999	Top of inactive pool
2	1,393	15,476	900	Top of Fish and Wildlife pool and the lower limit of storage available for water supply withdrawals
3	1,397	24,817	750	Intermediate reservoir levels where Cheney Reservoir and Equus Beds should experience balanced withdrawals. That is, the levels in both should generally be within the same reservoir level.
4	1,401	37,170	725	
5	1,405	53,265	700	
6	1,409	73,356	675	
7	1,413	97,645	650	
8	1,417	125,843	350	Water in levels 8 and above at Cheney will be used prior to the corresponding levels in the Equus Beds
9	1,420	152,222	300	Minimum pool level were withdrawals up to 80 MGD are allowed. Below this level, the maximum water supply withdrawal rate is assumed to be 47 MGD.
10	1,422	170,575	100	Top of conservation pool
11	1,429	247,931	1	Top of flood storage pool

Table VII - 5

MODEL RESERVOIR LEVELS
EQUUS BEDS WELL FIELD

Level No.	Drawdown (feet)	Storage Contents (1) (acre-feet)	Storage Priority	Remarks
1	40.0	0	999	Current water level and lower limit of available storage
2	4.0	285,459	775	Intermediate reservoir levels where Cheney Reservoir and Equus Beds should experience balanced withdrawals. That is, the levels in both should generally be within the same reservoir level.
3	3.5	298,879	750	
4	3.0	312,683	725	
5	2.5	326,871	700	
6	2.0	341,442	675	
7	1.5	356,398	650	
8	1.0	371,737	625	Water in levels 8 and above in the Equus Beds will be used after the corresponding levels in Cheney Reservoir
9	0.5	387,460	600	
10	0.0	403,565	575	
11	0.0	403,566	1	Maximum well field storage level

Notes:
(1) Assumes 25 percent porosity.

minor water quality concerns. The 30 cfs is based on MDS concerns.

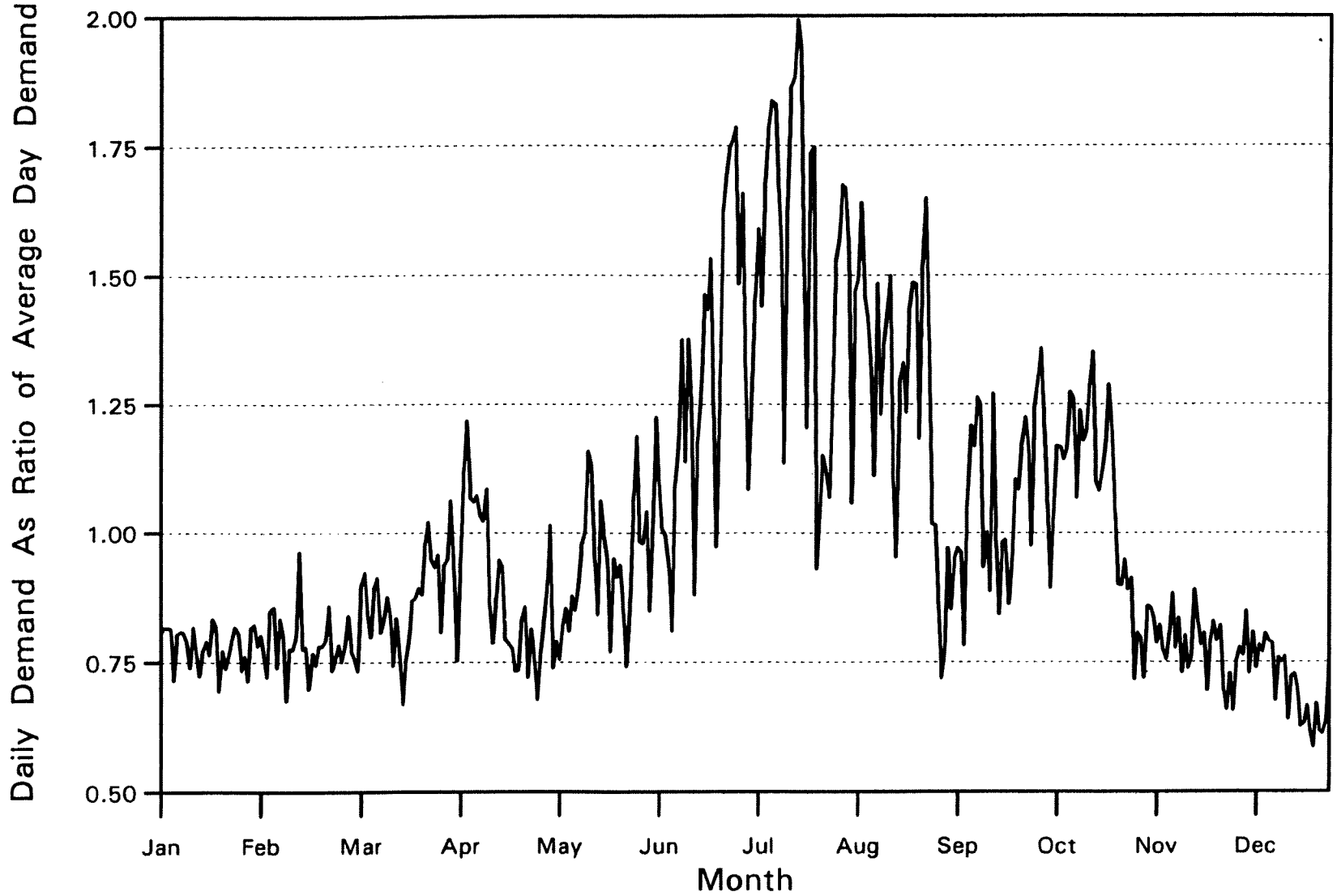
- E&S Well Field:
  - Maximum pumping capacity of 33 MGD.

- Reserve Well Field:
  - Maximum pumping capacity of 10.8 MGD.
  - Due to high chloride concentrations, water is mixed with Equus Beds Well Field water at a 3 to 1 ratio, 3 parts Equus Beds water and 1 part Reserve water.

- Gilbert-Mosley Remediation Groundwater:
  - Continuous supply of 3 MGD.

- Water Treatment Plant:
  - Collection point for all raw water.
  - Daily demand based on percentage of average day from 1991 City pumping records and average day demand for the test year as shown in Figure VII-7.

- Priority of Water Use:
  - The allocation order of the supply sources is shown in Table VII-6. Review of this table shows that usage from Cheney Reservoir and the Equus Beds Well Field are balanced to minimize water level variations in both sources.



Note: Derived from actual raw pumpage data for 1991.

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Figure VII – 7

DEMAND DISTRIBUTION

Table VII - 6

ALLOCATION ORDER OF SUPPLY SOURCES

Allocation Order	Source	Maximum Supply Rate (MGD)	Remarks
1	Gilbert-Mosley Remediation Site Well Field	3	Assumed to always be available
2	Little Arkansas River at Water Treatment Plant	160	Availability depends on river flow. Minimum desirable stream flow requirement and any demand for withdrawals near Halstead to recharge Equus Beds Well Field must be satisfied first.
3	Cheney Reservoir	80	If pool level is at or above 1,420 feet
		47	If pool level in the range 1,417-1,420 ft.
		0	If pool level below 1,417 feet
4	E & S Well Field	33	Assumed to always be available
5	Reserve/ Equus Beds Well Fields	43.2	Mix of one part Reserve Well Field water (up to 10.8 MGD) and three parts Equus Beds water (up to 32.4 MGD)
6	Equus Beds Well Field	143-249 (1)	If Cheney Reservoir is above elevation 1,417 feet, use only as source of last resort unless Equus Beds are full. If Cheney Reservoir is below 1,417 feet, use in combination with Cheney Reservoir to balance drawdowns in both sources (4 feet in Cheney to every 0.5 feet in Equus Beds).
7	Cheney Reservoir	47	If Cheney Reservoir level is below 1,417 feet, use in combination with Equus Beds to balance drawdowns as described above

Notes:

(1) Improvements in the Equus Beds Well Field are expected to increase maximum supply rate from 143 MGD in 2000 to 249 MGD by 2050.

Surface water inflows at Cheney Reservoir were developed from USGS gage data on the North Fork of the Ninnescah River from October 1950 through September 1991 and the Valley Center gage on the Little Arkansas River for July 1922 through September 1950. Inflow data for the Little Arkansas River intakes at Halstead and the mouth of the river adjacent to the Central Water Plant are based on USGS data from the Alta Mills gage for 1973 to 1991 and Valley Center gage for July 1922 through September 1991.

b. Equus Beds Fill Analysis

Average Equus Bed Aquifer replenishment times were determined using the model. Three special model runs were made using an arbitrarily large void volume for the Equus Beds of 10 million acre-feet. This value is approximately 25 times the actual void volume of 131,000 MG.

For each of the special cases, the Equus Beds Aquifer was assumed to be initially empty with water surface elevations at current-day levels. Since the void volume used for these model runs is so large, it is effectively impossible to ever fill this volume during the 69-year simulation period. Therefore, these model runs show the maximum amount of recharge that could be expected each year while meeting the year 2010 projected water demand. The year 2010 projected water demand represents the average day demand during the anticipated initial recharge period from 2005 to 2014.

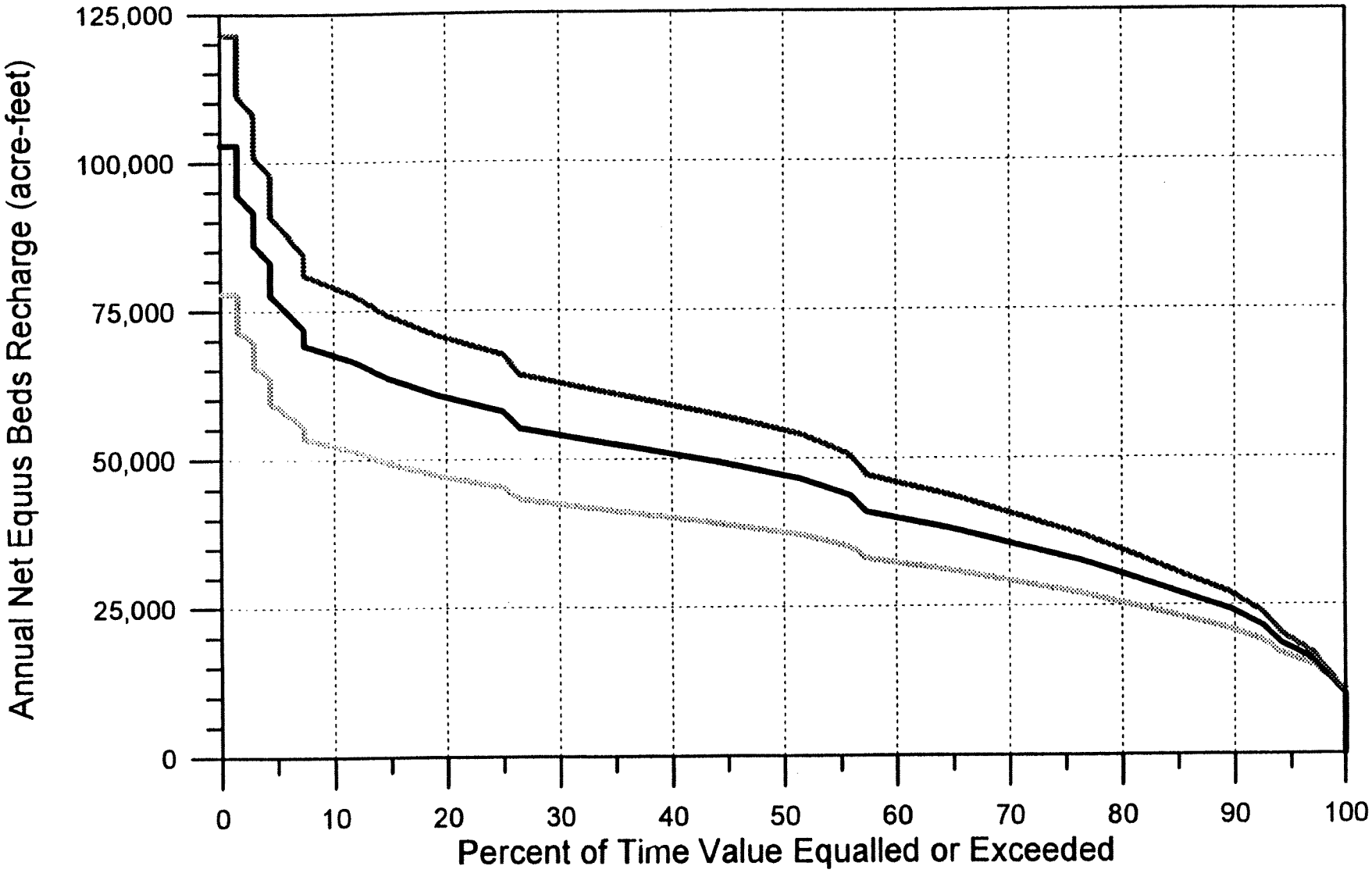
Three different test cases were run utilizing 150 MGD, 250 MGD, and 340 MGD combined maximum diversion capacities from the Little Arkansas River surface water intake located near Halstead and the bank storage recovery wells. The results are shown in Figure VII-8 and are summarized in Table VII-7. Review of the table shows the 150 MGD, 250 MGD, and 340 MGD diversions filling the Equus Beds void, respectively, in an average of 10.4, 9.0, and 8.0 years, based on a base flow of 100 cfs. A base flow of 30 cfs will reduce the filling time about 1 year.

c. Actual Operating Conditions

To demonstrate the operation of the integrated water supply system under different demand levels, five different model runs were made as follows:

- Year 2010 - 85.6 MGD average day
- Year 2020 - 96.7 MGD average day
- Year 2030 - 105.7 MGD average day
- Year 2040 - 115.3 MGD average day
- Year 2050 - 124.6 MGD average day

For each of these runs, Cheney Reservoir was assumed to be only half full (on a volumetric basis) at the start of the simulation period. Similarly, the Equus Beds were also assumed to be half full for all model runs except with the 2010 demand levels in which the Equus Beds were assumed to be initially empty. Base flow in the Little Arkansas River was assumed to be 100 cfs and the diversion capacity was figured at 250 MGD.



Maximum Diversion Rate

- 150 MGD
- 250 MGD
- 340 MGD

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Figure VII – 8

ANNUAL
EQUUS BEDS
FILL DURATIONS

Table VII - 7

SUMMARY OF
EQUUS BEDS FILL ANALYSIS

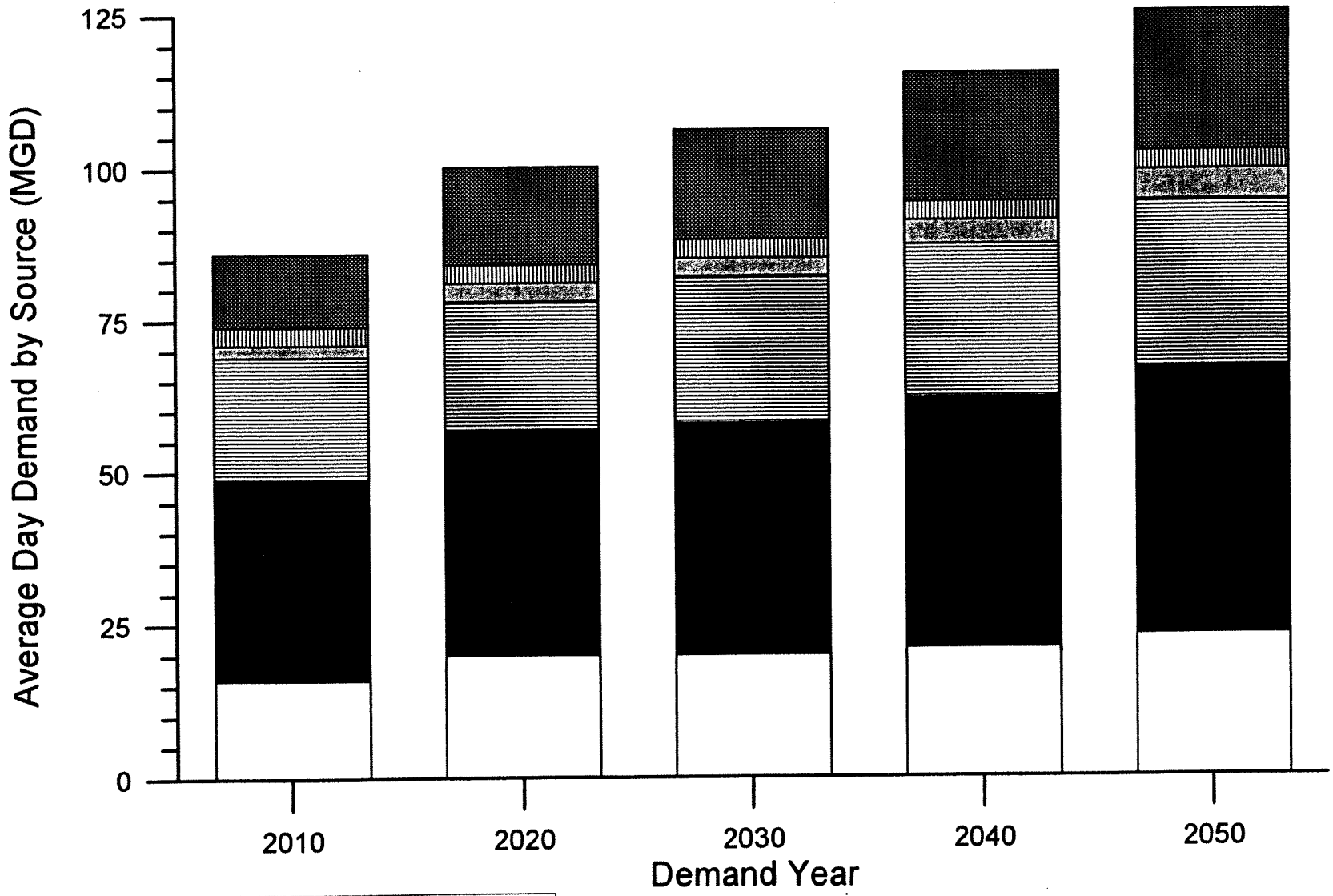
Net Recharge Statistic		Net Equus Beds Recharge for Given Maximum Diversion Rate near Halstead (1)		
		150 MGD	250 MGD	340 MGD
Total (2)		2,413,400	2,869,377	3,198,456
Annual	Average (3)	34,477	40,991	45,692
	Minimum	10,761	10,112	10,112
	Maximum	77,895	102,949	121,472
	Median (4)	38,835	44,809	50,607
Equus Beds Fill Time at Median Annual Rate (5)		10.4	9.0	8.0

Notes:
(1) All values in acre-feet unless noted overwise. Maximum diversion rate includes combined capacity of Little Arkansas River surface water intake and bank storage recovery wells.
(2) Total net recharge over simulation period, July 1922 - September 1991
(3) Annual average includes partial years 1922 and 1991.
(4) Median annual values obtained from net recharge duration curves shown in Figure VII-7.
(5) Years to fill Equus Beds void volume of 403,566 acre-feet.

The results of the model runs for the 250 MGD Diversion Option are shown in Figure VII-9 and in Table VII-8, which show the individual supply source contributions to the total raw water demand with time. Review of the table shows the water demands were met and the Equus Beds were refilled with minimum impacts on water surface levels in Cheney Reservoir.

Simulated water levels in Cheney Reservoir and the Equus Beds for the year 2050 demand levels are shown in Figure VII-10 for the 250 MGD Diversion Option. Since these were the highest demand levels investigated in this study, the water level declines shown on this figure are the most severe of those for the five model runs. Review of this figure shows there are two major drought periods during the period of record which occur in the mid-1930s and the mid-1950s. In both cases, even with the year 2050 demands, the water levels in Cheney Reservoir and the Equus Beds maintained reasonable storage volumes considering the severity of the droughts, and recovered fairly quickly after these droughts.

Simulated water levels in Cheney Reservoir and the Equus Beds for year 2050 demand levels are shown in Figure VII-11 for the 150 MGD Diversion Option. Review of the figure shows water level variations during the two drought periods which occur over the period of record. The water level in Cheney Reservoir almost reaches the bottom of the conservation pool and the level variations are more extensive than the 250 MGD Diversion Option; however, water levels



L Arkansas River
Cheney Reservoir
Equus Beds WF
Reserve WF
Gilbert-Mosley
E & S WF

Burns & McDonnell

Figure VII - 9

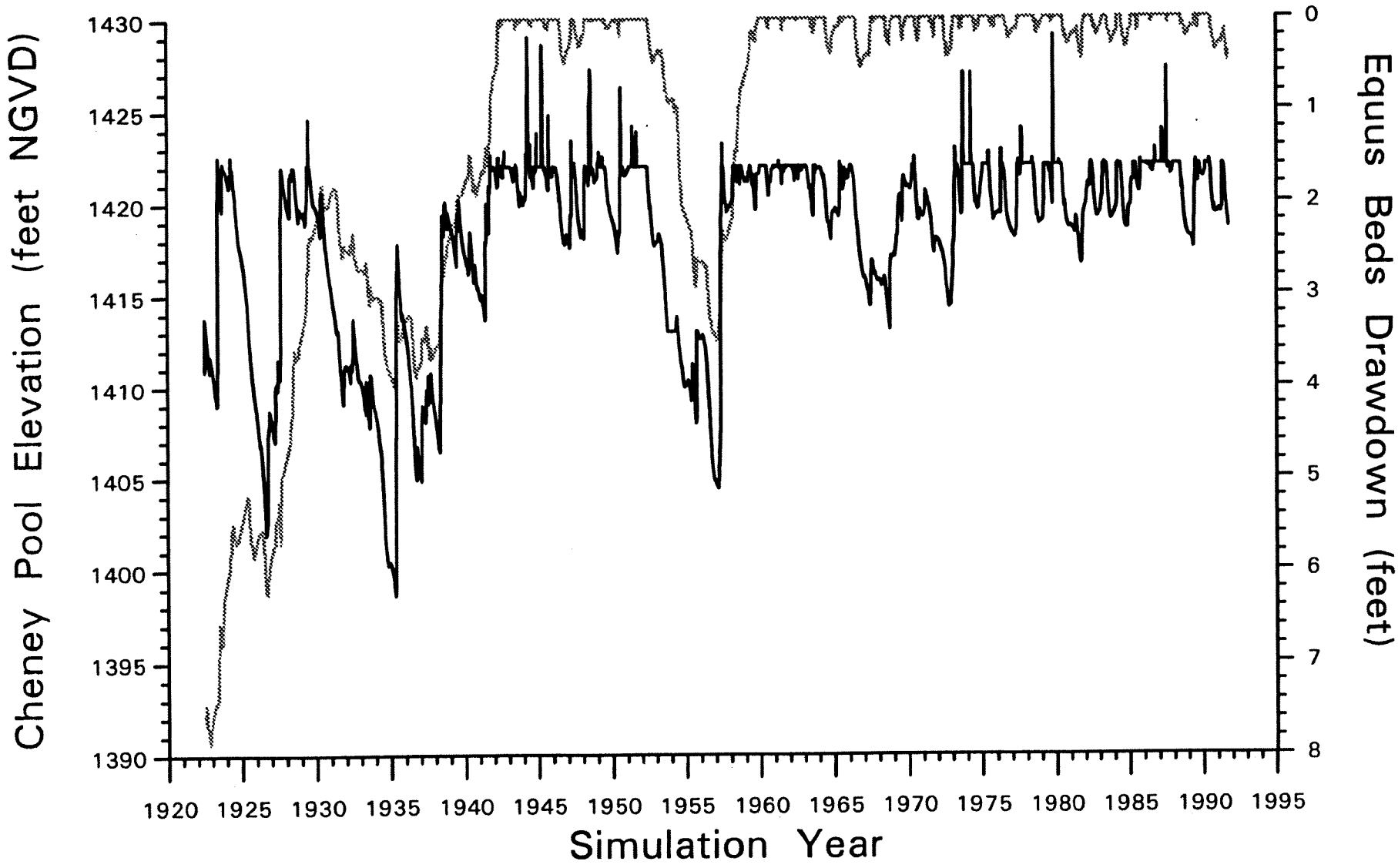
AVERAGE DAY DEMAND BY SOURCE

Table VII - 8

SUMMARY OF
SIMULATED OPERATING RESULTS

Year	Statistic		Contribution of Source to Meet Given Demand						Total Demand
			Little Arkansas Intake	Cheney Reservoir	Well Fields				
					Equus Beds	Reserve	Gilbert-Mosley	E & S	
2010	Total (1)		397	838	507	46	74	306	2,168
	Daily (2)	Average	16	33	20	2	3	12	86
		Minimum	0	0	4	0	3	0	50
		Maximum	160	80	124	11	3	33	171
2020	Total (1)		450	912	575	56	74	382	2,449
	Daily (2)	Average	18	36	23	2	3	15	97
		Minimum	0	0	4	0	3	0	57
		Maximum	160	80	146	11	3	33	193
2030	Total (1)		493	968	606	72	74	463	2,677
	Daily (2)	Average	20	38	24	3	3	18	106
		Minimum	0	0	4	0	3	0	62
		Maximum	160	80	164	11	3	33	211
2040	Total (1)		535	1,037	640	94	74	537	2,918
	Daily (2)	Average	21	41	25	4	3	21	115
		Minimum	0	0	4	0	3	0	68
		Maximum	160	80	183	11	3	33	230
2050	Total (1)		573	1,116	685	121	74	587	3,156
	Daily (2)	Average	23	44	27	5	3	23	125
		Minimum	0	0	4	0	3	0	73
		Maximum	160	80	202	11	3	33	248

Notes:
(1) Billions of gallons for the simulation period July 1922 - September 1991.
(2) Daily statistics are in million gallons per day.



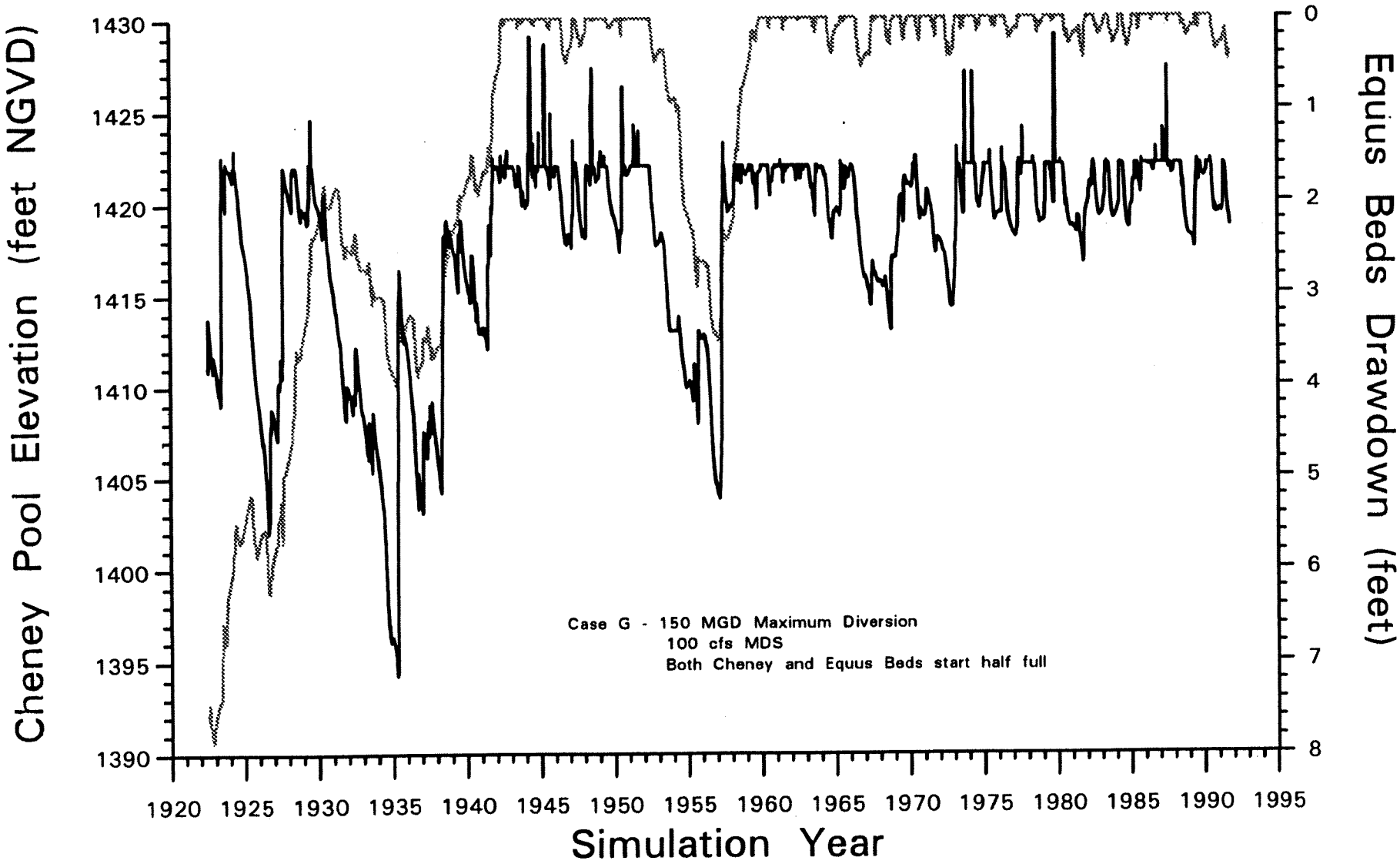
Cheney Pool Elevation

Equus Beds Drawdown

Burns & McDonnell

Figure VII – 10

SIMULATED
WATER LEVELS
250 MGD DIVERSION OPTION
2050 DEMANDS



Cheney Pool Elevation

Equus Beds Drawdown

Burns & McDonnell

Figure VII – 11

SIMULATED
WATER LEVELS
150 MGD DIVERSION OPTION
2050 DEMANDS

are maintained in Cheney Reservoir and the Equus Beds and both refill fairly quickly after the droughts.

Detailed tables and figures showing annual operating results for the five test runs and water level figures for the other four test runs are included in Appendix N.

3. WATER QUALITY

Raw and finished water quality are key issues in the Integrated Local Water Supply Plan. The plan must provide a raw water that can be treated by conventional processes to produce an economic, quality finished water that meets all SDWA regulations. Water quality is shown for the Cheney Reservoir, Equus Beds, E&S Wells, water plant, reserve wells and the Little Arkansas River in respective Tables II-4, II-8 and 9, II-11, II-14, II-17 and II-18 in Part II of the report.

Water quality in the Equus Beds Well Field is generally good. Total hardness averages about 170 mg/l as $CaCO_3$ and chlorides average about 55 mg/l. Some potential may exist to combine untreated, chlorinated Equus Beds water with treated water from surface water and other lower quality groundwater sources in the water plant's clearwell. The surface water and lower quality groundwater would require excess softening to maintain the City's desired hardness levels.

Protection of the Equus Beds Aquifer water quality is a major concern. The Bureau of Reclamation's Arkansas River Management study involved computer modeling of chloride plumes from the Burrton area (northwest of

the City's well field) and from the Arkansas River (south of the City's well field) to determine their impact on the Equus Beds Aquifer through the year 2050. If the Equus Beds are not recharged and current operating practices by the City and irrigators continue, chloride levels could range from 120 to 300 mg/l by the year 2050. Chlorides above 250 mg/l may require nonconventional water treatment like reverse osmosis to reduce the chlorides to the current regulated level. Recharging the Equus Beds and filling the void in the well field area will cause the chlorides to stabilize below projected levels in the year 2050.

Water quality in the E&S Wells includes total hardness of about 250 mg/l as $CaCO_3$ and chlorides of about 200 mg/l. This groundwater should be suitable for treatment to potable quality using conventional water treatment processes.

Water quality in the Reserve Wells is poor based on 1956 data. Total hardness ranges from 350 to 500 mg/l as $CaCO_3$ and chlorides range from 350 to 800 mg/l. This water must be blended with water from other sources to reduce the chlorides in the finished water below the EPA limit of 250 mg/l and City's desired level of 200 mg/l. The Reserve Well Field water will be used to meet peak water demands.

Water quality of the Little Arkansas River at Valley Center varies with flow. Review of USGS water quality data from 1959 to 1975 shows occasions of high total hardness (>200 mg/l as $CaCO_3$) and chlorides (>150 mg/l) at flows less than 100 cfs. Average chloride concentrations

of excess flow are not expected to degrade aquifer water quality when used for aquifer recharge, but more water quality data is needed for a more thorough evaluation. Pesticides have been detected in the Little Arkansas River and the impact of pesticides on the recharge of the aquifer requires additional study.

Water quality at the mouth of Little Arkansas River adjacent to the Central Water Plant is variable, but adequate for treatment during periods of higher excess flow. Total hardness typically ranges from 60 to 370 mg/l as $CaCO_3$, chlorides range from 20 to 300 mg/l, total solids range from 1600 to 27 mg/l and turbidity ranges from 350 to less than 1 NTU for a flow range of 2000 to 4 cfs. Use of the water at river flows less than 30 cfs may have chlorides greater than 250 mg/l and a total hardness ranging from 250 to 350 mg/l as $CaCO_3$.

Water treatability studies are needed to determine the impacts of using greater quantities of surface waters (in lieu of Equus Beds groundwater) and other groundwater sources of lower water quality as required in the Integrated Local Water Supply Plan. Such studies should outline any needed operational changes and treatment process modifications for the Central Water Treatment Plant and the new water plant.

4. ENVIRONMENTAL CONSIDERATIONS

Environmental considerations that are typical for an intake and pipeline construction are listed below:

- Construction of intake structure and water plant will have some short-term environmental affects.

- Construction of wells, pump stations and pipelines will require right-of-way acquisition and entail some short-term environmental impacts. These affects may be mitigated through replanting trees and grasses on disturbed earth.
- Withdrawal of water from Cheney Reservoir can cause significant water level variations during drought conditions.
- Land use features such as dwellings, cemeteries and churches may affect the pipeline alignment.
- Cultural resource surveys (historic and archaeologic) are generally required and may affect the pipeline alignment.
- Endangered and threatened species surveys are generally required and may affect the pipeline alignment.
- Highway, road, stream and river crossings typically have minor and temporary impacts.
- Recreational resources at the lake may be affected by water level variations.
- Mitigation or reconstruction of wetlands, especially at stream crossings, may be necessary.
- Control of storm water runoff from construction activities which disturb soil cover will be required.

5. ECONOMIC EVALUATIONS

a. Project Cost Estimates

Project cost estimates for the Integrated Local Water Supply Plan are presented in Tables VII-9 and VII-10 for respective 250 MGD and 150 MGD Diversion Options. The Integrated Local Plan includes the

Table VII – 9

INTEGRATED LOCAL WATER SUPPLY PLAN
250 MGD DIVERSION OPTION
PROJECT COST ESTIMATE

Item	Cost ($)
1. GILBERT–MOSLEY WELL FIELD:	
Pump Station (1)	$ 240,000
Pipeline (2)	860,000
Subtotal	$ 1,100,000
Contingency @ 20%	220,000
Subtotal	$ 1,320,000
Other Costs @15%	200,000
Gilbert–Mosley Project Cost	**$ 1,520,000**
2. WATER CONSERVATION:	
Water Conservation Kits (3)	$ 1,700,000
Water Conservation Project Cost	**$ 1,700,000**
3. L. ARKANSAS RIVER INTAKE AT PLANT:	
Intake and Pump Station (4)	$ 5,200,000
Presedimentation Basin	8,400,000
Pipeline (5)	1,200,000
Subtotal	$ 14,800,000
Contingency @ 20%	3,000,000
Subtotal	$ 17,800,000
Other Costs @ 15%	2,700,000
L. Arkansas River Intake Project Cost	**$ 20,500,000**

Table VII – 9 (Continued)

INTEGRATED LOCAL WATER SUPPLY PLAN
250 MGD DIVERSION OPTION
PROJECT COST ESTIMATE

Item	Cost ($)
4. RESERVE WELL FIELD:	
Wells (6)	$ 740,000
Subtotal	$ 740,000
Contingency @ 20%	150,000
Subtotal	$ 890,000
Other Costs @ 15%	130,000
Reserve Well Field Project Cost	**$ 1,020,000**
5. BANK STORAGE:	
Horizontal Collector Wells (7)	$ 7,800,000
Pump Stations (8)	1,800,000
Transmission Piping (9)	11,700,000
Injection Wells (10)	2,400,000
Injection Well Piping and Valves	1,200,000
Subtotal	$ 24,900,000
Contingency @ 20%	5,000,000
Subtotal	$ 29,900,000
Other Costs @15%	4,500,000
Bank Storage Project Cost	**$ 34,400,000**

Table VII – 9 (Continued)

INTEGRATED LOCAL WATER SUPPLY PLAN
250 MGD DIVERSION OPTION
PROJECT COST ESTIMATE

Item	Cost ($)
6. L. ARKANSAS RIVER DIVERSION INTAKE:	
Intake and Pump Station (11)	$ 5,200,000
Pipeline (12)	7,800,000
Surface Spreading Basins (13)	6,000,000
Subtotal	$ 19,000,000
Contingency @ 20%	3,800,000
Subtotal	$ 22,800,000
Other Costs @ 15%	3,400,000
Intake Project Cost	**$ 26,200,000**
7. EQUUS BEDS IMPROVEMENTS:	
Wells (14)	$ 10,500,000
Transmission Piping (15)	49,700,000
Booster Pump Station (16)	10,000,000
Control Valve Vaults (17)	1,800,000
Subtotal	$ 72,000,000
Contingency @ 20%	14,400,000
Subtotal	$ 86,400,000
Other Costs @ 15%	13,000,000
Equus Beds Well Field Project Cost	**$ 99,400,000**

Table VII – 9 (Continued)

INTEGRATED LOCAL WATER SUPPLY PLAN
250 MGD DIVERSION OPTION
PROJECT COST ESTIMATE

Item	Cost ($)
8. WATER TREATMENT PLANT:	
Water Treatment Plant (18)	$ 77,000,000
Subtotal	$ 77,000,000
Contingency @ 20%	15,400,000
Subtotal	$ 92,400,000
Other Costs @15%	13,900,000
Water Plant Project Cost	**$ 106,300,000**
TOTAL PROJECT COST	**$ 291,000,000**

NOTES:
(1) 3 MGD pump station.
(2) 2.5 miles of 16–inch pipline.
(3) Purchase and distribution of 150,00 water conservation kits.
(4) Capacity of 160 MGD.
(5) 0.5 miles of 96–inch pipeline.
(6) Six 1,500 gpm wells, 200 feet deep, complete with well house, piping and electrical/controls with a firm capacity of 10.8 MGD.
(7) Three sets of two horizontal collector wells with 15 MGD capacity each per mile.
(8) Each collector well includes a pump station with 15 MGD capacity.
(9) Each set of collector wells includes 6 miles of 36–inch and 3,000 lf of 30–inch pipelines.
(10) Each set of collector wells includes 40 6–inch injection wells, 100 feet deep.
(11) Capacity of 160 MGD.
(12) 4 miles of 96–inch pipeline.
(13) 40 four acre surface spreading basins.
(14) 70 wells with 1,500 gpm capacity, 200 feet deep.
(15) 38 miles of 66–inch pipeline and 8 miles of 48–inch pipeline.
(16) Two booster pump stations with 120 MGD capacity each.
(17) 18 control valve vaults on Equus Beds transmission piping.
(18) Water treatment plant with an ultimate capacity of 90 MGD. Based on unit costs developed in the District No. 10 report by others and used for the Milford alternative.

Table VII – 10

INTEGRATED LOCAL WATER SUPPLY PLAN
150 MGD DIVERSION OPTION
PROJECT COST ESTIMATE

Item	Cost ($)
1. GILBERT–MOSLEY WELL FIELD:	
Pump Station (1)	$ 240,000
Pipeline (2)	860,000
Subtotal	$ 1,100,000
Contingency @ 20%	220,000
Subtotal	$ 1,320,000
Other Costs @15%	200,000
Gilbert–Mosley Project Cost	**$ 1,520,000**
2. WATER CONSERVATION:	
Water Conservation Kits (3)	$ 1,700,000
Water Conservation Project Cost	**$ 1,700,000**
3. L. ARKANSAS RIVER INTAKE AT PLANT:	
Intake and Pump Station (4)	$ 5,200,000
Presedimentation Basin	8,400,000
Pipeline (5)	1,200,000
Subtotal	$ 14,800,000
Contingency @ 20%	3,000,000
Subtotal	$ 17,800,000
Other Costs @ 15%	2,700,000
L. Arkansas River Intake Project Cost	**$ 20,500,000**

Table VII – 10 (Continued)

INTEGRATED LOCAL WATER SUPPLY PLAN
150 MGD DIVERSION OPTION
PROJECT COST ESTIMATE

Item	Cost ($)
4. RESERVE WELL FIELD:	
Wells (6)	$ 740,000
Subtotal	$ 740,000
Contingency @ 20%	150,000
Subtotal	$ 890,000
Other Costs @ 15%	130,000
Reserve Well Field Project Cost	**$ 1,020,000**
5. BANK STORAGE:	
Horizontal Collector Wells (7)	$ 5,200,000
Pump Stations (8)	1,200,000
Transmission Piping (9)	7,800,000
Injection Wells (10)	1,600,000
Injection Well Piping and Valves	800,000
Subtotal	$ 16,600,000
Contingency @ 20%	3,300,000
Subtotal	$ 19,900,000
Other Costs @15%	3,000,000
Bank Storage Project Cost	**$ 22,900,000**

Table VII – 10 (Continued)

INTEGRATED LOCAL WATER SUPPLY PLAN
150 MGD DIVERSION OPTION
PROJECT COST ESTIMATE

Item	Cost ($)
6. L. ARKANSAS RIVER DIVERSION INTAKE:	
Intake and Pump Station (11)	$ 3,500,000
Pipeline (12)	5,100,000
Surface Spreading Basins (13)	3,500,000
Subtotal	$ 12,100,000
Contingency @ 20%	2,400,000
Subtotal	$ 14,500,000
Other Costs @ 15%	2,200,000
Intake Project Cost	**$ 16,700,000**
7. EQUUS BEDS IMPROVEMENTS:	
Wells (14)	$ 7,500,000
Transmission Piping (15)	29,000,000
Booster Pump Station (16)	10,000,000
Control Valve Vaults (17)	1,800,000
Subtotal	$ 48,300,000
Contingency @ 20%	9,700,000
Subtotal	$ 58,000,000
Other Costs @ 15%	8,700,000
Equus Beds Well Field Project Cost	**$ 66,700,000**

Table VII – 10 (Continued)

INTEGRATED LOCAL WATER SUPPLY PLAN
150 MGD DIVERSION OPTION
PROJECT COST ESTIMATE

Item	Cost ($)
8. WATER TREATMENT PLANT:	
Water Treatment Plant (18)	$ 77,000,000
Subtotal	$ 77,000,000
Contingency @ 20%	15,400,000
Subtotal	$ 92,400,000
Other Costs @15%	13,900,000
Water Plant Project Cost	**$ 106,300,000**
TOTAL PROJECT COST	**$ 237,300,000**

NOTES:
(1) 3 MGD pump station.
(2) 2.5 miles of 16–inch pipline.
(3) Purchase and distribution of 150,00 water conservation kits.
(4) Capacity of 160 MGD.
(5) 0.5 miles of 96–inch pipeline.
(6) Six 1,500 gpm wells, 200 feet deep, complete with well house, piping and electrical/controls with a firm capacity of 10.8 MGD.
(7) Two sets of two horizontal collector wells with 15 MGD capacity each per mile.
(8) Each collector well includes a pump station with 15 MGD capacity.
(9) Each set of collector wells includes 6 miles of 36–inch and 3,000 lf of 30–inch pipelines.
(10) Each set of collector wells includes 40 6–inch injection wells, 100 feet deep.
(11) Capacity of 90 MGD.
(12) 4 miles of 72–inch pipeline.
(13) 23 four acre surface spreading basins.
(14) 50 wells with 1,500 gpm capacity, 200 feet deep.
(15) 15.5 miles of 66–inch, 5.5 miles of 48–inch and 4.5 miles of 72–inch pipelines.
(16) Two booster pump stations with 120 MGD capacity each.
(17) 18 control valve vaults on Equus Beds transmission piping.
(18) Water treatment plant with an ultimate capacity of 90 MGD. Based on unit costs developed in the District No. 10 report by others and used for the Milford alternative.

components previously discussed and has a total project cost of $291 million for the 250 MGD Diversion Option and $237 million for the 150 MGD Diversion Option.

b. Present Value Analysis

Estimates of the present value for the Integrated Local Water Supply Plan are shown in Table VII-11 for the 250 MGD Diversion Option and Table VII-12 for the 150 MGD Diversion Option. Present value analyses permit the comparison of the present day value of the total cost of each alternative in 1993 dollars. Such analyses take into consideration project costs, and operation, maintenance, replacement and energy costs associated with each plan and account for the time-value of money. High service pumping costs are not included in the analysis. All costs are escalated into the future at an annual rate of 4 percent and discounted to 1993 at an annual rate of 7 percent.

The plan components are scheduled for implementation as follows:

- Gilbert-Mosley Well Field in-service in 1994 or 1995.
- Water conservation plumbing retrofits installed between 1995 and 1999. Annual conservation measures, previously described, should continue.
- Reserve Well Field in-service between 1997 and 2004 (assumed 1997 for the present value analysis, most conservative approach).

Table VII – 11

INTEGRATED LOCAL WATER SUPPLY PLAN – 250 MGD DIVERSION OPTION
PRESENT VALUE ESTIMATE

Year	Avg Day Demand (MGD)	Water Source Development (1)					Water Conserv	Raw Water Pumpage/ Treatment (2)	Total	Total Present Value	Summation Present Value
		Debt Service	Additional O&M	Additional Replace.	Recharge Energy	Subtotal					
1993	65.1						200,000	3,500,000	3,700,000	3,700,000	3,700,000
1994	66.9	150,000				150,000	427,000	3,741,000	4,318,000	4,040,000	7,740,000
1995	63.0	150,000				150,000	952,000	3,664,000	4,766,000	4,160,000	11,900,000
1996	64.7	150,000				150,000	1,056,000	3,913,000	5,119,000	4,180,000	16,080,000
1997	66.4	2,527,000				2,527,000	1,098,000	4,176,000	7,801,000	5,950,000	22,030,000
1998	68.1	2,527,000				2,527,000	1,142,000	4,455,000	8,124,000	5,790,000	27,820,000
1999	69.8	2,527,000				2,527,000	1,186,000	4,748,000	8,461,000	5,640,000	33,460,000
2000	71.6	2,527,000				2,527,000	614,000	5,066,000	8,207,000	5,110,000	38,570,000
2001	72.9	2,527,000				2,527,000	639,000	5,364,000	8,530,000	4,960,000	43,530,000
2002	74.3	2,527,000				2,527,000	665,000	5,686,000	8,878,000	4,830,000	48,360,000
2003	75.6	2,527,000				2,527,000	692,000	6,017,000	9,236,000	4,700,000	53,060,000
2004	76.9	20,241,000	386,000			20,627,000	720,000	6,365,000	27,712,000	13,170,000	66,230,000
2005	78.3	20,241,000	402,000		380,000	21,023,000	749,000	6,740,000	28,512,000	12,660,000	78,890,000
2006	79.6	28,603,000	418,000		395,000	29,416,000	779,000	7,126,000	37,321,000	15,490,000	94,380,000
2007	81.0	28,603,000	435,000		411,000	29,449,000	810,000	7,541,000	37,800,000	14,660,000	109,040,000
2008	82.4	28,603,000	452,000		428,000	29,483,000	842,000	7,979,000	38,304,000	13,880,000	122,920,000
2009	83.7	32,068,000	470,000	19,000	445,000	33,002,000	876,000	8,429,000	42,307,000	14,330,000	137,250,000
2010	85.1	32,068,000	489,000		463,000	33,020,000	910,000	8,912,000	42,842,000	13,560,000	150,810,000
2011	86.4	32,068,000	508,000		481,000	33,057,000	946,000	9,410,000	43,413,000	12,840,000	163,650,000
2012	87.6	32,068,000	529,000		500,000	33,097,000	984,000	9,923,000	44,004,000	12,170,000	175,820,000
2013	88.9	32,068,000	550,000	131,000	68,000	32,817,000	1,024,000	10,473,000	44,314,000	11,450,000	187,270,000
2014	90.1	31,918,000	572,000	5,469,000	71,000	38,030,000	1,065,000	11,039,000	50,134,000	12,110,000	199,380,000
2015	91.4	31,918,000	595,000		74,000	32,587,000	1,108,000	11,646,000	45,341,000	10,230,000	209,610,000
2016	92.4	31,918,000	619,000		77,000	32,614,000	1,152,000	12,244,000	46,010,000	9,710,000	219,320,000
2017	93.5	29,541,000	643,000	3,819,000	80,000	34,083,000	1,198,000	12,886,000	48,167,000	9,500,000	228,820,000
2018	94.5	29,541,000	669,000		83,000	30,293,000	1,246,000	13,545,000	45,084,000	8,310,000	237,130,000
2019	95.6	29,541,000	696,000	55,000	86,000	30,378,000	1,295,000	14,250,000	45,923,000	7,910,000	245,040,000
2020	96.7	35,637,000	724,000		90,000	36,451,000	1,347,000	14,991,000	52,789,000	8,500,000	253,540,000
2021	97.5	35,637,000	753,000		93,000	36,483,000	1,401,000	15,719,000	53,603,000	8,060,000	261,600,000
2022	98.3	35,637,000	783,000	1,762,000	97,000	38,279,000	1,457,000	16,482,000	56,218,000	7,900,000	269,500,000
2023	99.2	35,637,000	814,000	23,000	101,000	36,575,000	1,516,000	17,299,000	55,390,000	7,280,000	276,780,000
2024	100.0	17,923,000	847,000	9,532,000	105,000	28,407,000	1,576,000	18,136,000	48,119,000	5,910,000	282,690,000
2025	100.9	17,923,000	881,000		109,000	18,913,000	1,639,000	19,031,000	39,583,000	4,540,000	287,230,000

Table VII – 11 (Continued)

INTEGRATED LOCAL WATER SUPPLY PLAN – 250 MGD DIVERSION OPTION
PRESENT VALUE ESTIMATE

Year	Avg Day Demand (MGD)	Water Source Development (1)					Water Conserv	Raw Water Pumpage/ Treatment (2)	Total	Total Present Value	Summation Present Value
		Debt Service	Additional O&M	Additional Replace.	Recharge Energy	Subtotal					
2026	101.7	9,561,000	916,000		120,000	10,597,000	1,704,000	19,949,000	32,250,000	3,460,000	290,690,000
2027	102.5	9,561,000	952,000		133,000	10,646,000	1,772,000	20,910,000	33,328,000	3,340,000	294,030,000
2028	103.4	9,561,000	990,000	237,000	146,000	10,934,000	1,843,000	21,937,000	34,714,000	3,250,000	297,280,000
2029	104.3	6,096,000	1,030,000	3,016,000	159,000	10,301,000	1,918,000	23,013,000	35,232,000	3,080,000	300,360,000
2030	105.1	17,900,000	1,071,000	16,432,000	174,000	35,577,000	1,995,000	24,118,000	61,690,000	5,050,000	305,410,000
2031	106.1	17,900,000	1,114,000		190,000	19,204,000	2,075,000	25,321,000	46,600,000	3,560,000	308,970,000
2032	107.0	17,900,000	1,159,000		206,000	19,265,000	2,157,000	26,557,000	47,979,000	3,430,000	312,400,000
2033	108.0	17,900,000	1,205,000		224,000	19,329,000	2,244,000	27,878,000	49,451,000	3,300,000	315,700,000
2034	108.9	17,900,000	1,253,000	11,983,000	243,000	31,379,000	2,334,000	29,234,000	62,947,000	3,930,000	319,630,000
2035	109.9	17,900,000	1,303,000		262,000	19,465,000	2,428,000	30,683,000	52,576,000	3,070,000	322,700,000
2036	110.8	17,900,000	1,356,000		283,000	19,539,000	2,524,000	32,172,000	54,235,000	2,960,000	325,660,000
2037	111.8	17,900,000	1,410,000	8,369,000	306,000	27,985,000	2,625,000	33,760,000	64,370,000	3,280,000	328,940,000
2038	112.7	17,900,000	1,466,000		329,000	19,695,000	2,730,000	35,393,000	57,818,000	2,750,000	331,690,000
2039	113.7	17,900,000	1,525,000	61,000	354,000	19,840,000	2,839,000	37,136,000	59,815,000	2,660,000	334,350,000
2040	114.7	29,614,000	1,586,000	23,376,000	381,000	54,957,000	2,953,000	38,961,000	96,871,000	4,030,000	338,380,000
2041	115.7	29,614,000	1,649,000		409,000	31,672,000	3,071,000	40,873,000	75,616,000	2,940,000	341,320,000
2042	116.6	29,614,000	1,715,000		438,000	31,767,000	3,194,000	42,838,000	77,799,000	2,830,000	344,150,000
2043	117.6	29,614,000	1,784,000	569,000	470,000	32,437,000	3,322,000	44,934,000	80,693,000	2,740,000	346,890,000
2044	118.6	29,614,000	1,855,000	20,103,000	503,000	52,075,000	3,455,000	47,128,000	102,658,000	3,260,000	350,150,000
2045	119.6	29,614,000	1,929,000		538,000	32,081,000	3,593,000	49,427,000	85,101,000	2,520,000	352,670,000
2046	120.6	29,614,000	2,007,000		560,000	32,181,000	3,736,000	51,834,000	87,751,000	2,430,000	355,100,000
2047	121.6	29,614,000	2,087,000	4,697,000	582,000	36,980,000	3,886,000	54,354,000	95,220,000	2,470,000	357,570,000
2048	122.6	29,614,000	2,170,000	61,000	605,000	32,450,000	4,041,000	56,993,000	93,484,000	2,260,000	359,830,000
2049	123.6	29,614,000	2,257,000		630,000	32,501,000	4,203,000	59,756,000	96,460,000	2,180,000	362,010,000
2050	124.6	0	2,347,000	46,292,000	655,000	49,294,000	4,371,000	62,649,000	116,314,000	2,460,000	364,470,000
Total		1,177,460,000	51,371,000	156,006,000	13,537,000	1,398,374,000	104,324,000	1,248,304,000	2,751,002,000	364,470,000	

Notes:
(1) Water sources include Little Arkansas River intake at water plant and diversion to Equus Beds, Gilbert–Mosley Wells, Reserve Wells, and Equus Beds Well Field Improvements.
(2) Includes OMR&E costs for existing and new supplies (raw water pumpage and treatment).

Table VII – 12

INTEGRATED LOCAL WATER SUPPLY PLAN – 150 MGD DIVERSION OPTION
PRESENT VALUE ESTIMATE

Year	Avg Day Demand (MGD)	Water Source Development (1)					Water Conserv	Raw Water Pumpage/ Treatment (2)	Total	Total Present Value	Summation Present Value
		Debt Service	Additional O&M	Additional Replace.	Recharge Energy	Subtotal					
1993	65.1						200,000	3,500,000	3,700,000	3,700,000	3,700,000
1994	66.9	150,000				150,000	427,000	3,741,000	4,318,000	4,040,000	7,740,000
1995	63.0	150,000				150,000	952,000	3,664,000	4,766,000	4,160,000	11,900,000
1996	64.7	150,000				150,000	1,056,000	3,913,000	5,119,000	4,180,000	16,080,000
1997	66.4	2,527,000				2,527,000	1,098,000	4,176,000	7,801,000	5,950,000	22,030,000
1998	68.1	2,527,000				2,527,000	1,142,000	4,455,000	8,124,000	5,790,000	27,820,000
1999	69.8	2,527,000				2,527,000	1,186,000	4,748,000	8,461,000	5,640,000	33,460,000
2000	71.6	2,527,000				2,527,000	614,000	5,066,000	8,207,000	5,110,000	38,570,000
2001	72.9	2,527,000				2,527,000	639,000	5,364,000	8,530,000	4,960,000	43,530,000
2002	74.3	2,527,000				2,527,000	665,000	5,686,000	8,878,000	4,830,000	48,360,000
2003	75.6	2,527,000				2,527,000	692,000	6,017,000	9,236,000	4,700,000	53,060,000
2004	76.9	11,014,000	386,000			11,400,000	720,000	6,365,000	18,485,000	8,780,000	61,840,000
2005	78.3	11,014,000	402,000		267,000	11,683,000	749,000	6,740,000	19,172,000	8,510,000	70,350,000
2006	79.6	19,376,000	418,000		278,000	20,072,000	779,000	7,126,000	27,977,000	11,610,000	81,960,000
2007	81.0	19,376,000	435,000		289,000	20,100,000	810,000	7,541,000	28,451,000	11,030,000	92,990,000
2008	82.4	19,376,000	452,000		301,000	20,129,000	842,000	7,979,000	28,950,000	10,490,000	103,480,000
2009	83.7	23,990,000	470,000	19,000	313,000	24,792,000	876,000	8,429,000	34,097,000	11,550,000	115,030,000
2010	85.1	23,990,000	489,000		325,000	24,804,000	910,000	8,912,000	34,626,000	10,960,000	125,990,000
2011	86.4	23,990,000	508,000		338,000	24,836,000	946,000	9,410,000	35,192,000	10,410,000	136,400,000
2012	87.6	23,990,000	529,000		352,000	24,871,000	984,000	9,923,000	35,778,000	9,890,000	146,290,000
2013	88.9	23,990,000	550,000	131,000	50,000	24,721,000	1,024,000	10,473,000	36,218,000	9,360,000	155,650,000
2014	90.1	23,840,000	572,000	3,646,000	52,000	28,110,000	1,065,000	11,039,000	40,214,000	9,710,000	165,360,000
2015	91.4	23,840,000	595,000		54,000	24,489,000	1,108,000	11,646,000	37,243,000	8,410,000	173,770,000
2016	92.4	23,840,000	619,000		56,000	24,515,000	1,152,000	12,244,000	37,911,000	8,000,000	181,770,000
2017	93.5	21,463,000	643,000	3,819,000	58,000	25,983,000	1,198,000	12,886,000	40,067,000	7,900,000	189,670,000
2018	94.5	21,463,000	669,000		61,000	22,193,000	1,246,000	13,545,000	36,984,000	6,810,000	196,480,000
2019	95.6	21,463,000	696,000	55,000	63,000	22,277,000	1,295,000	14,250,000	37,822,000	6,510,000	202,990,000
2020	96.7	26,280,000	724,000		66,000	27,070,000	1,347,000	14,991,000	43,408,000	6,990,000	209,980,000
2021	97.5	26,280,000	753,000		68,000	27,101,000	1,401,000	15,719,000	44,221,000	6,650,000	216,630,000
2022	98.3	26,280,000	783,000	1,762,000	71,000	28,896,000	1,457,000	16,482,000	46,835,000	6,580,000	223,210,000
2023	99.2	26,280,000	814,000	23,000	74,000	27,191,000	1,516,000	17,299,000	46,006,000	6,040,000	229,250,000
2024	100.0	17,793,000	847,000	6,632,000	77,000	25,349,000	1,576,000	18,136,000	45,061,000	5,530,000	234,780,000
2025	100.9	17,793,000	881,000		80,000	18,754,000	1,639,000	19,031,000	39,424,000	4,520,000	239,300,000

Table VII – 12 (Continued)

INTEGRATED LOCAL WATER SUPPLY PLAN – 150 MGD DIVERSION OPTION
PRESENT VALUE ESTIMATE

Year	Avg Day Demand (MGD)	Water Source Development (1)					Water Conserv	Raw Water Pumpage/ Treatment (2)	Total	Total Present Value	Summation Present Value
		Debt Service	Additional O&M	Additional Replace.	Recharge Energy	Subtotal					
2026	101.7	9,431,000	916,000		91,000	10,438,000	1,704,000	19,949,000	32,091,000	3,440,000	242,740,000
2027	102.5	9,431,000	952,000		104,000	10,487,000	1,772,000	20,910,000	33,169,000	3,320,000	246,060,000
2028	103.4	9,431,000	990,000	237,000	117,000	10,775,000	1,843,000	21,937,000	34,555,000	3,240,000	249,300,000
2029	104.3	4,817,000	1,030,000	2,077,000	131,000	8,055,000	1,918,000	23,013,000	32,986,000	2,890,000	252,190,000
2030	105.1	12,794,000	1,071,000	16,432,000	146,000	30,443,000	1,995,000	24,118,000	56,556,000	4,630,000	256,820,000
2031	106.1	12,794,000	1,114,000		162,000	14,070,000	2,075,000	25,321,000	41,466,000	3,170,000	259,990,000
2032	107.0	12,794,000	1,159,000		179,000	14,132,000	2,157,000	26,557,000	42,846,000	3,060,000	263,050,000
2033	108.0	12,794,000	1,205,000		197,000	14,196,000	2,244,000	27,878,000	44,318,000	2,960,000	266,010,000
2034	108.9	12,794,000	1,253,000	7,989,000	216,000	22,252,000	2,334,000	29,234,000	53,820,000	3,360,000	269,370,000
2035	109.9	12,794,000	1,303,000		237,000	14,334,000	2,428,000	30,683,000	47,445,000	2,770,000	272,140,000
2036	110.8	12,794,000	1,356,000		258,000	14,408,000	2,524,000	32,172,000	49,104,000	2,680,000	274,820,000
2037	111.8	12,794,000	1,410,000	8,369,000	281,000	22,854,000	2,625,000	33,760,000	59,239,000	3,020,000	277,840,000
2038	112.7	12,794,000	1,466,000		306,000	14,566,000	2,730,000	35,393,000	52,689,000	2,510,000	280,350,000
2039	113.7	12,794,000	1,525,000	61,000	332,000	14,712,000	2,839,000	37,136,000	54,687,000	2,430,000	282,780,000
2040	114.7	41,618,000	1,586,000	23,376,000	360,000	66,940,000	2,953,000	38,961,000	108,854,000	4,530,000	287,310,000
2041	115.7	41,618,000	1,649,000		389,000	43,656,000	3,071,000	40,873,000	87,600,000	3,400,000	290,710,000
2042	116.6	41,618,000	1,715,000		420,000	43,753,000	3,194,000	42,838,000	89,785,000	3,260,000	293,970,000
2043	117.6	41,618,000	1,784,000	569,000	453,000	44,424,000	3,322,000	44,934,000	92,680,000	3,150,000	297,120,000
2044	118.6	41,618,000	1,855,000	13,747,000	488,000	57,708,000	3,455,000	47,128,000	108,291,000	3,440,000	300,560,000
2045	119.6	41,618,000	1,929,000		525,000	44,072,000	3,593,000	49,427,000	97,092,000	2,880,000	303,440,000
2046	120.6	41,618,000	2,007,000		546,000	44,171,000	3,736,000	51,834,000	99,741,000	2,760,000	306,200,000
2047	121.6	41,618,000	2,087,000	4,697,000	568,000	48,970,000	3,886,000	54,354,000	107,210,000	2,780,000	308,980,000
2048	122.6	41,618,000	2,170,000	61,000	591,000	44,440,000	4,041,000	56,993,000	105,474,000	2,550,000	311,530,000
2049	123.6	41,618,000	2,257,000		614,000	44,489,000	4,203,000	59,756,000	108,448,000	2,450,000	313,980,000
2050	124.6	0	2,347,000	46,292,000	639,000	49,278,000	4,371,000	62,649,000	116,298,000	2,460,000	316,440,000
Total		1,072,090,000	51,371,000	139,994,000	11,643,000	1,275,098,000	104,324,000	1,248,304,000	2,627,726,000	316,440,000	

Notes:
(1) Water sources include Little Arkansas River intake at water plant and diversion to Equus Beds, Gilbert–Mosley Wells, Reserve Wells, and Equus Beds Well Field Improvements.
(2) Includes OMR&E costs for existing and new supplies (raw water pumpage and treatment).

- Little Arkansas River Intake and presedimentation basin at plant in-service between 1997 and 2004 (assumed 1997 for the present value analysis, most conservative approach).
- Little Arkansas River Diversion to Equus Beds in-service in 2004.
- Equus Beds Pumping and Piping Improvements in-service in 2004, 2009, 2020, 2030 and 2040 for the 250 MGD Diversion Option and 2004, 2009, 2030 and 2040 for the 150 MGD Diversion Option.
- New water plant in-service in 2006 and expansion in-service in 2020, 2030 and 2040.

Project cost, as shown in Tables VII-9 and VII-10 and used in the analysis, includes the escalated cost estimates for the plan components. "Water Source Development" accounts for "Additional O&M," operation and maintenance, for new raw water facilities, "Additional Replace," replacement, for new raw water facilities and "Recharge Energy" for conveyance of water from the Little Arkansas River to the Equus Beds for recharge. Raw water/pumpage/treatment accounts for the annual cost of raw water conveyance and treatment to meet daily water demands.

The Integrated Water Supply Plan has a total present value of $360 million for the 250 MGD Diversion Option and $316 million for the 150 MGD Diversion Option in 1993 dollars. Respective unit water costs of $1.35 per 1000 gallons and $1.29 per 1000 gallons are based

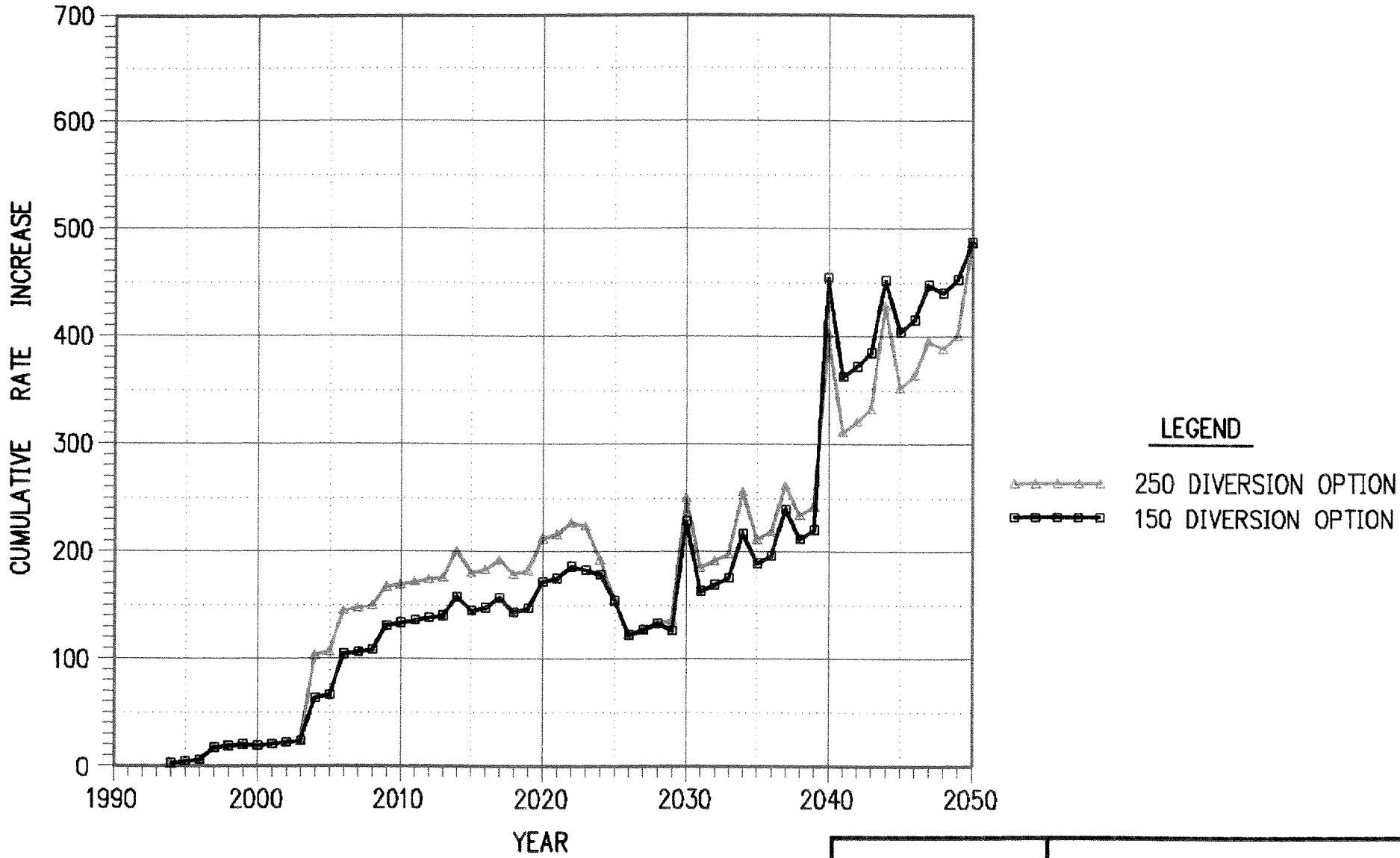
on each plan's total cost in inflated dollars divided by the total water used over the study period.

c. Economic Impacts

The Integrated Local Water Supply Plans increase the water rates to a maximum cumulative rate increase of 487 percent in the year 2050 as shown in Figure VII-12. The 250 MGD Diversion Option has a greater rate increase than the 150 MGD Diversion Option between years 2004 and 2023 due to the additional capital improvements and retirement of the associated debt service. Alternatively, the 150 MGD Diversion Option has a greater rate increase than the 250 MGD Diversion Option between years 2040 and 2049. This is due to the scheduling of the 150 MGD Diversion Option which delays construction of many facilities in the Equus Bed Well Field from year 2004 in the 250 MGD Diversion Option to year 2040. The projected rates represent minimum increases to fund the plan's capital improvements and to maintain debt service coverage and contingency funds.

E. WATER SUPPLY PLAN COMPARISON

The water supply plans are compared on a cost basis as shown in Table VII-13. All plans require the implementation of the previously discussed near-term improvements to conform to the project schedule and meet the City's water demands through the year 2050. The Integrated Local Water Supply Plan with 150 MGD Diversion Option is least expensive on the basis of project cost, present value cost, and unit cost followed by the Integrated Local Water Supply Plan with 250 MGD Diversion Option and the Milford Reservoir Water Supply Plan.



Burns & McDonnell

Figure VII – 12

INTEGRATED LOCAL WATER SUPPLY PLAN
CUMULATIVE RATE INCREASES

Table VII – 13

WATER SUPPLY PLAN COST COMPARISON

Item	Milford Reservoir Water Supply Plan	Integrated Local Water Supply Plan	
		250 MGD Option	150 MGD Option
Project Cost	$ 322,300,000	$ 291,000,000	$ 237,300,000
Present Value	$ 446,640,000	$ 359,970,000	$ 316,440,000
Unit Cost	$ 1.90/1000 gallons	$ 1.35/1000 gallons	$ 1.29/1000 gallons
Maximum Cumulative Rate Increase	705%	487%	487%
Staged Costs:			
1994		1,500,000	1,500,000
1997		21,500,000	21,500,000
1995–1999	1,700,000	1,700,000	1,700,000
2004		122,000,000	58,400,000
2005	247,000,000		
2006		53,200,000	53,200,000
2009		19,600,000	26,100,000
2020		22,400,000	17,700,000
2030		29,300,000	19,800,000
2038	73,600,000		
2040		19,800,000	37,400,000

Notes:
(1) Costs are in 1993 dollars.

The water supply plans are compared on a supply capability, water quality, legal, political, availability, environmental, cost and planning horizon basis as shown in Table VII-14. The Integrated Local Water Supply Plan with 150 MGD Diversion Option offers several advantages including protection of the Equus Beds water quality and low cost and involves a minimum initial investment that could be expanded in scope towards the 250 MGD Diversion Option over time. The Integrated Local Plan with 250 MGD Diversion Option also protects the Equus Beds and offers operational flexibility with high pumping capacity to the water plant and the Equus Beds. The Milford Plan is a firm supply, but does not offer protection of water quality in the Equus Beds Aquifer.

F. RECOMMENDATIONS

The preferred water supply plan, on the basis of engineering studies in this report, is the Integrated Local Water Supply Plan with 150 MGD Diversion Option. This plan is recommended as the first choice for implementation by the City of Wichita.

The Integrated Local Water Supply Plan (either option) requires the City to obtain an integrated or conjunctive water use permit from the Kansas Division of Water Resources. This permit would allow the City to convey water from sources on an "as available" basis without regard to individual water rights and optimize the use of their water resources (i.e., if water is flowing through Cheney Reservoir spillway all year long, the City could pump an average 80 MGD from the reservoir throughout the year which would exceed their pending average annual water right of 47 MGD). Various state

contacts and investigations to date indicate that the City of Wichita should be able to obtain the necessary permits to allow implementation of the plan.

The Integrated Local Water Supply Plan will help to preserve the Equus Beds Aquifer for use by future generations. Recharging the aquifer will protect the ground water from chloride plumes migrating towards the well field and provide a large volume of stored groundwater for future use, not only by the City of Wichita, but by local farm land irrigators.

Additional engineering studies are recommended to further define the feasibility and practicality of the Integrated Local Water Supply Plan. These studies include the following:

- Equus Beds Recharge Demonstration Study - This engineering study is necessary to demonstrate the concept of surface water and bank storage water recharge of the Equus Beds Aquifer for state approval and to develop design criteria for the groundwater recharge system. The study may be eligible for a $1 million grant from the U.S. Bureau of Reclamation and should be conducted over a five-year period from 1994 to 1998.

- Surface Water Treatability Study - This engineering study is required to determine the impacts of using greater quantities of surface water (in lieu of Equus Beds groundwater) and other groundwater sources of lower quality. Such studies should outline any needed operational charges and treatment process modifications for the Central Water Treatment Plant and the new water treatment plant.

- Cheney Reservoir Firm Yield Study - This engineering study is needed to determine whether the reservoir's firm yield is 38.2 MGD, 47 MGD or some other value. The last value determined by the U.S. Bureau of Reclamation was 38.2 MGD and preliminary reservoir operating studies performed for this report indicate that the firm yield may be 47 MGD or more. This report used the more conservative 38.2 MGD firm yield to determine additional water needs. The actual firm yield of the reservoir could affect the scheduling of improvement phases within each water supply plan and is required to optimize the operation of the raw water system.

These studies should be initiated immediately to insure adequate time for implementation of the initial phases of the Integrated Local Water Supply Plan to allow the Equus Beds to be recharged by the year 2014.

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Table VII – 14

WATER SUPPLY PLAN COMPARISON

PARAMETER	MILFORD RESERVOIR WATER SUPPLY PLAN			INTEGRATED LOCAL WATER SUPPLY PLAN – 250 MGD OPTION			INTEGRATED LOCAL WATER SUPPLY PLAN – 150 MGD OPTION		
	RANK	ADVANTAGES	DISADVANTAGES	RANK	ADVANTAGES	DISADVANTAGES	RANK	ADVANTAGES	DISADVANTAGES
Supply Capacity	1	– 60 MGD Firm Supply to Wichita, continuous	– Availability being studied by State – Constant Supply – Most Expensive Water in Wichita system	2	– Multiple Sources – Capacity beyond year 2050 available – High pumping capacity	– L. Arkansas River is not a reliable source, must use on a as–available basis	2	– Multiple Sources – Capacity beyond year 2050 available – Less pumping capacity than 250 MGD Option	– L. Arkansas River is not a reliable source, must use on a as–available basis
Water Quality	3	– Adequate Water Quality	– Equus Beds Aquifer not recharged WQ will be contaminated by chlorides	1	– Recharges Equus Beds protects WQ of aquifer	– Variable WQ to treatment plant – Treatment will be more challenging	2	– Recharges Equus Beds protects WQ of aquifer	– Variable WQ to treatment plant – Treatment will be more challenging
Legal/Political	3	– Serves 14 other water purveyors	– Extensive legal difficulties expected – Water Transfer Act involved – Pits Northeast Region against South–Central Region	2	– Minimal legal problems expected	– New type of permit required – Water Transfer Act potential, involvement not automatic	1	– Minimal legal problems expected – Lower pumping capacity than 250 MGD Option	– New type of permit required – Water Transfer Act potential, involvement not automatic
Availability	1	–Milford Reservoir provides a firm capacity	– Water availability being evaluated by State – Availability may be questionable	2	– Recharging Equus Beds will store up to about 131,000,000,000 gallons of water for use by City	– L. Arkansas River has no firm yield	2	– Recharging Equus Beds will store up to about 131,000,000,000 gallons of water for use by City	– L. Arkansas River has no firm yield
Environmental	3		– Equus Beds Aquifer WQ will be contaminated by chlorides	1	– Recharging Equus Beds protects WQ of aquifer – Greater capacity to recharge		1	– Recharging Equus Beds protects WQ of aquifer	
Cost/Economics	3		– Cannot build in phases – Highest project cost, present value and unit cost	2	– 2nd Lowest present value and project cost – Phased construction – Reduced economic impacts on customers compared to Milford – Flexible	– Significantly higher costs than 150 MGD Option	1	– Lowest present value and project cost – Phased construction – Significantly reduced economic impacts on customers – Flexible	– Slightly higher construction cost
Planning Horizon	3	– 60 MGD maximum day meets beyond year 2050 projected demand	– Capacity cannot be increased	1	– Can meet water needs beyond projected year 2050 demand – Potential to serve other customers – Costs for future upgrades included		1	– Can meet water needs beyond projected year 2050 demand – Potential to serve other customers – Can be upgraded with growth	