Docuware Cover Sheet DWR

Cabinet (circle one): ☑ DWR ☐ RRCA ☐ ARCA ☐ GMD

File Name State Programs (from index)

Sub File Name ASR (from index)

Sub-Sub File Name Wichita

Year (calendar) 2000

End Year

Privileged Yes - Circle if true

Comments/Keywords

Summary of Activities for calendar year 1999

After scanning:

File hard copy CE Desk / CE Cabinet / Laterals

Send to Archives ☐

Send to Field Office ☐

Recycle ☐

File only:

File hard copy CE Desk / CE Cabinet / Laterals

Equus Beds Groundwater Recharge Demonstration Project

Summary of Activities for Calendar Year 1999

prepared for

CITY OF WICHITA

April 2000
92-195-4-016

MKEC ENGINEERING CONSULTANTS, INC.

Burns & McDonnell
SINCE 1898

Burns & McDonnell
SINCE 1898

April 24, 2000

Mr. Gerald T. Blain, P.E.
Superintendent of Production and Pumpage
Wichita Water & Sewer Department
City Hall, Eighth Floor
455 North Main Street
Wichita, KS 66202-1677

WICHITA
Equus Beds Groundwater Recharge Demonstration Project
Summary of Activities for Calendar Year 1999
B&McD Project No. 92-195-4-016

Dear Mr. Blain:

Enclosed is an activities report on the Equus Beds Groundwater Demonstration Recharge Project for calendar year 1999. Primary accomplishments include operation of demonstration facilities with data collection, project tours, and presentation of demonstration progress and findings to project participants. As of the end of 1999, a total of 818 million gallons or 2,509 acre-feet of water was recharged to the Equus Beds Aquifer.

The project recently received recognition through the receipt of another award. The Wichita Chapter of the Kansas Society of Professional Engineers selected the project for the 2000 Outstanding Engineering Achievement Award.

Future monthly reports will keep you posted on the progress of the project.

Sincerely,

Frank L. Shorney, P.E.	David H. Stous, P.E., P.G.	L. Jeffrey Klein, P.E.
Project Manager	Project Hydrogeologist	Project Engineer

FLS\DHS\LJK\le273cm.doc
Enclosure

cc:	Mr. Chris Cherches	Mr. Walt Aucott	Mr. Rick Bair	Mr. Dennis Cantrell
	Mr. David Warren	Mr. Don Carlson	Mr. Joe Cramer	Mr. Mike Dealy
	Mr. Bob Dunlevy	Mr. Chuck Hunt	Mr Steve Hurst	Mr. Al LeDoux
	Mr. John Phillips	Mr. Fred Pinkney	Mr. David Pope	Mr. Tom Stiles
	Mr. Larry Tandeski	Mr. Dave Waldo	Mr. Doug Yoder	Mr. Andy Ziegler

9400 Ward Parkway
Kansas City, Missouri 64114-3319
Tel: 816 333-9400
Fax: 816 333-3690
www.burnsmcd.com

CITY OF WICHITA, KANSAS

EQUUS BEDS GROUNDWATER RECHARGE DEMONSTRATION PROJECT
SUMMARY OF ACTIVITIES FOR CALENDAR YEAR 1999

92-195-4-016

INDEX AND CERTIFICATION PAGE

REPORT INDEX

Recognition is given to the following additional people who assisted in completing this report:

Fred Pinkney, Ph.D. Environmental Specialist
David Vallejo, Water Supply Engineer
Cindy Maroney, P.E., R.G., Hydrogeologist

CERTIFICATION(S)

FRANK LaVERN SHORNEY
LICENSED
6011
KANSAS
PROFESSIONAL ENGINEER

4/24/2000

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES

APPENDICES

INTRODUCTION

INTRODUCTION

A. PURPOSE

This document summarizes activities performed during calendar year 1999 for the Equus Beds Groundwater Recharge Demonstration Project. These activities pertain to Project 2, as described in the final proposal to the U.S. Bureau of Reclamation, and include the following work phases:

- Project 2, Phase 1, started in early 1997, included design and construction observation of the recharge demonstration facilities.
- Project 2, Phase 2, started in May 1997 and continued through 1999, involves the operation of recharge demonstration facilities.

Project 1, completed in December 1996, included engineering, geotechnical, and water quality investigations to locate the demonstration test (diversion) well, surface water intake and recharge sites.

B. PROJECT DESCRIPTION

1. Background

In 1993, the City adopted the Integrated Local Water Supply (ILWS) Plan (Burns & McDonnell, 1993), which has a planning horizon to year 2050. Implementation of the ILWS Plan began in 1994. The ILWS Plan has been modified slightly over the years based on additional studies. A complete list of the associated engineering, environmental and related reports completed by Burns & McDonnell and the U.S. Geological Survey is included in the Appendix.

One component of the ILWS Plan is recharge of the Equus Beds Aquifer with above-base flow water from the Little Arkansas River. The Equus Beds Groundwater Recharge Demonstration Project is a phased small-scale research project being used to test the feasibility of a full-scale groundwater recharge and recovery project. Demonstration facilities are located north of the City of Wichita near the City's Equus Beds Well Field along the Little Arkansas River as shown in Figure IN-1. The demonstration project is envisioned to evolve into a

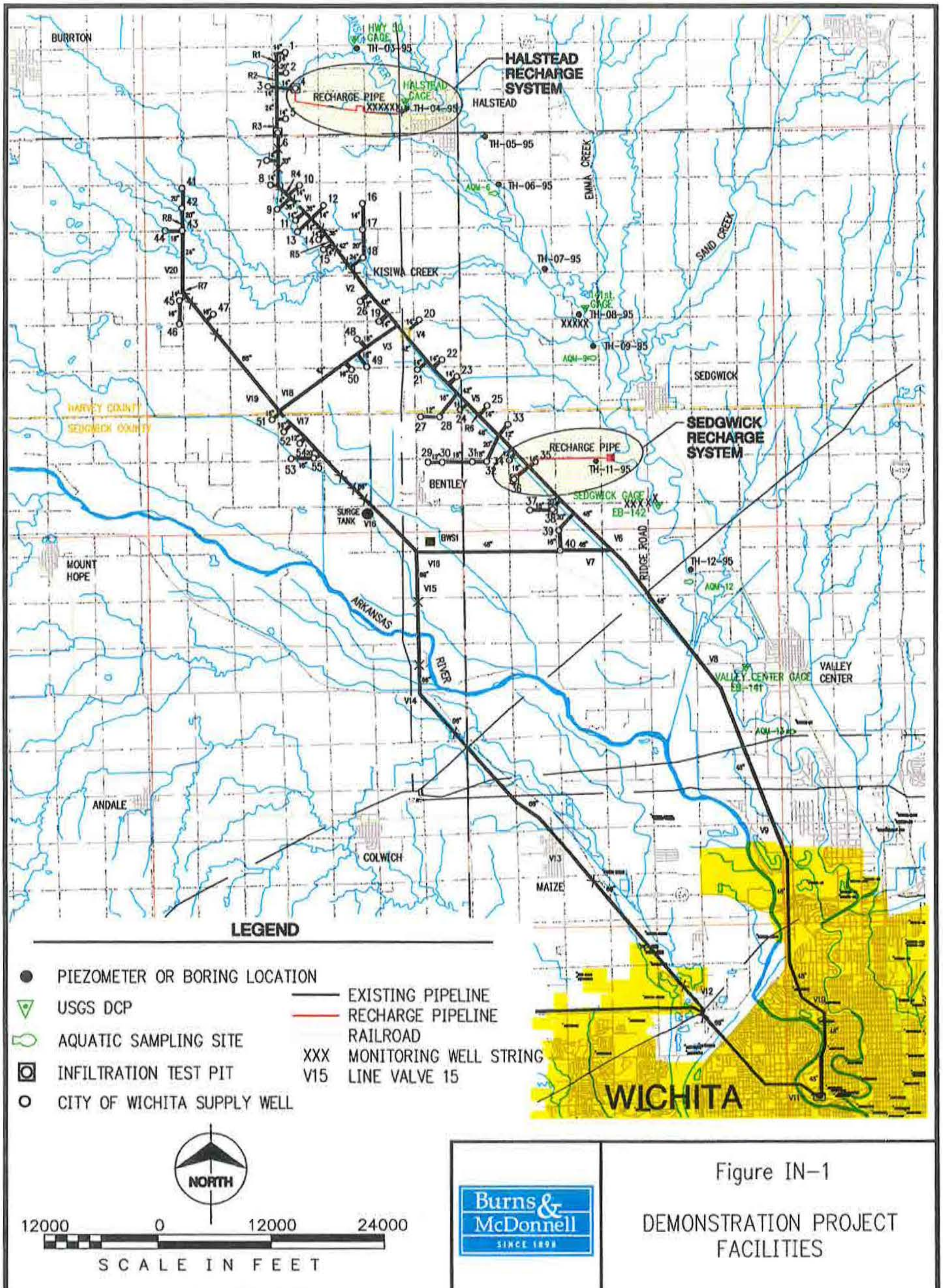


Figure IN-1

DEMONSTRATION PROJECT FACILITIES

full-scale project, which will be a key part of the City of Wichita's ILWS Plan that is being implemented over a multi-year period. The full-scale plan will provide additional water supply to the City and surrounding communities through year 2050.

The general operating concept of the groundwater recharge project involves the capture of "above-base" flow water in the Little Arkansas River and the transfer of captured water to the Equus Beds Aquifer for recharge and storage. Stored water will be recovered in the future to help meet City water demands in times of drought when the City's other water sources have limited yield. Above-base flow is defined as the volume of flow in the river, which is generated from rainfall runoff that is above the base river flow as established by the State or local regulatory agencies.

Major historical events leading to the implementation of the groundwater recharge component of the City's ILWS Plan are shown in Table IN-1. The groundwater recharge demonstration project began operation in mid-1997 and is scheduled to operate through 2000. The objectives of the demonstration program are to collect operational data to help establish design criteria and to obtain agency approvals for construction of full-scale groundwater recharge facilities.

Table IN-1

Major Historical Events Leading to Implementation of the Groundwater Recharge Component of the City's Integrated Local Water Supply Plan

Date	Event
June 30, 1992	City of Wichita initiates a Water Supply Study to determine water needs through year 2050.
July 23, 1993	Original submittal of Equus Beds Groundwater Recharge Demonstration Proposal sent to U.S. Bureau

Table IN-1 (Continued)

Major Historical Events Leading to Implementation of the Groundwater Recharge Component of the City's Integrated Local Water Supply Plan

Date	Event
	of Reclamation, Great Plains Region, Billings, Montana.
June 30, 1993	City's Water Supply Study completed with recommendations to implement the Integrated Local Water Supply Plan with Groundwater Recharge Component.
August 31, 1993	Wichita City Council approves Integrated Local Water Supply Plan with Groundwater Recharge Component.
May 6, 1994	Report titled *Equus Beds Groundwater Recharge Demonstration Project Feasibility Study (Phase 1, Part 1 - Preliminary Data Review and Concept Development)* submitted to City.
October 6, 1994	Kickoff meeting of the Equus Beds Groundwater Recharge Demonstration Project with Reclamation and project participants; notice of anticipated federal funding of 50% for the project and funding of $0.5 million for FY 1995; demonstration project noted to require NEPA compliance.
November 2, 1994	Notice from Reclamation that an Environmental Assessment of the Demonstration Project is needed by end of month in order to protect federal funding.

Table IN-1 (Continued)

Major Historical Events Leading to Implementation of the Groundwater Recharge Component of the City's Integrated Local Water Supply Plan

Date	Event
November 29, 1994	Submitted draft of *Environmental Assessment, Equus Beds Groundwater Recharge Demonstration Project* to Reclamation and project participants for review.
August, 1995	Received term permit for test well at Halstead from GMD2.
September, 1995	Distributed final Environmental Assessment and "Findings-Of-No-Significant Impact" (FONSI) for the Demonstration Project.
July 9, 1996	Presented findings of 30-day pump test to GMD2 Board. Board reaffirmed their support for the groundwater recharge project.
September 12, 1996	Conducted state and federal agency meeting in Topeka to update project participants on project status. Received general indication that the groundwater recharge demonstration project could proceed.
October, 1996	Initiated "fast-track" design of demonstration facilities with the objective of getting facilities under construction and in operation in preparation for FY 1997 runoff events and Reclamation's tour in April, 1997.

Table IN-1 (Continued)

Major Historical Events Leading

to Implementation of the Groundwater Recharge Component

of the City's Integrated Local Water Supply Plan

Date	Event
December 12, 1996	Report titled *Equus Beds Groundwater Recharge Project (Phase I, Part II - Engineering Study Involving Water Quality, Testing, Facility Siting, Test Well Construction and Aquifer Test)* submitted to City.
December 13, 1996	Opened bids on the Groundwater Recharge Demonstration Project.
December 17, 1996	Recommended award of demonstration facility construction contract to Utility Contractors, Inc. of Wichita, Kansas in the amount of $2,267,700.
May 23, 1997	Began recharge operations in basins and trench at the Halstead Test Facility.
June 13, 1997	Opened bids for the supervisory control and data acquisition (SCADA) contract for the demonstration project. Recommended award to Southwestern Electric of Wichita, Kansas.
August 26, 1997	Completed recharge well in the Halstead Recharge System and started recharge tests.
October 17, 1997	Started preliminary testing of the Sedgwick Recharge System.

Table IN-1 (Continued)

Major Historical Events Leading to Implementation of the Groundwater Recharge Component of the City's Integrated Local Water Supply Plan

Date	Event
December 3, 1997	Presented project results for fiscal year 1997 at state and federal update meeting in Topeka.
March, 1998	Supervisory Control and Data Acquisition (SCADA) System for the demonstration facility became operational.
May 5, 1998	Submitted first-draft of Operations and Testing Manual for the Equus Beds Recharge Demonstration Project for use and review comments.
May 27, 1998	Met with City, Reclamation, USGS, and the Kansas Corporation Commission to review demonstration project status, goals and schedule. Oil field chloride contamination plume migration towards the City's Equus Beds Well Field was discussed.
June 22, 1998	Met with GMD2 to initiate development of groundwater recharge regulations and recharge/recovery accounting system.
July 21, 1998	Met with Reclamation, USGS and EPA in Wichita to discuss operations, water quality, funding and to tour demonstration facilities.
August 21, 1998	Toured facilities with Kansas and Oklahoma members

Table IN-1 (Continued)

Major Historical Events Leading to Implementation of the Groundwater Recharge Component of the City's Integrated Local Water Supply Plan

Date	Event
	of the Arkansas River Compact.
September 1, 1998	Closed out the demonstration facility construction contract with Utility Contractors, Inc.
October 27, 1998	Presented demonstration findings to date to the Wichita City Council and Chamber of Commerce. Recharge of the Equus Beds Aquifer with "above-base" flow from the Little Arkansas River was noted as being a viable option for water supply.
November, 1998	Public access to web page for the Equus Beds Recharge Project was initiated via the USGS Kansas District Home Page.
November 27, 1998	Presented demonstration results to date at state and federal update meeting in Topeka.
February 13, 1999	Received honorary award for Equus Beds Recharge Project from Consulting Engineers' Council of Missouri at the 25th Annual Engineering Excellence Awards Reception/Banquet.
April 28, 1999	Met with the Bureau of Reclamation and Kansas Corporation Commission to help facilitate coordination of remediation activities for the Burrton high-chloride

Table IN-1 (Continued)

Major Historical Events Leading to Implementation of the Groundwater Recharge Component of the City's Integrated Local Water Supply Plan

Date	Event
	groundwater plume.
April 28, 1999	Met with the City and Kansas Division of Water Resources to review and discuss proposed groundwater recharge accounting system and regulations.
May, 1999	Delivered to the City the plans and specifications for passive recharge well option for the Halstead Recharge Site.
June, 1999	Closed out the SCADA contract with Southwestern Electric.
July, 1999	Reports titled *Local Well Field Concept Development Study* and *Raw Water Delivery with 48-Inch Pipeline Replacement* delivered to City.
July, 1999	Met with USGS to discuss groundwater storage volumes.
July, 1999	Met with Kansas Board of Agriculture, Division of Water Resources to discuss the Integrated Local Water Supply Plan and work being performed to refine storage volume estimates and to review examples of accounting systems for the recharge project.
August, 1999	Awarded construction of the passive recharge system at

Table IN-1 (Continued)

Major Historical Events Leading

to Implementation of the Groundwater Recharge Component

of the City's Integrated Local Water Supply Plan

Date	Event
	the Halstead Recharge Site to Clarke Well & Equipment Company of Great Bend Kansas.
August 31, 1999	City conducted a tour of the recharge facilities with the Little Arkansas River Basin Watershed Coalition.
September, 1999	SCADA system for the demonstration project was incorporated into the City's overall water monitoring system.
November, 1999	Completed construction of the passive recharge well system at the Halstead Recharge Site. Began testing of the passive recharge well system.
November 23, 1999	Made project status report to City Council on the Equus Beds Groundwater Recharge Demonstration Project and the Integrated Local Water Supply Plan.
December, 1999	Met with the USGS to discuss locations and screen levels of Index Wells to be used to monitor background water quality and water level and had follow-up meeting with the City and GMD2.

2. Demonstration Facilities

Two systems, referred to as the Halstead Recharge System and the Sedgwick Recharge System, are being investigated in the Demonstration Project to recharge the Equus Beds Aquifer. Each system has a water capture and a normal recharge capacity of 1,000 gpm.

The Halstead Recharge System, as shown in Figure IN-2, includes the capture of induced river water during periods of above-base flow from a diversion (or test) well near the Little Arkansas River at Halstead. The Sedgwick Recharge System, as shown in Figure IN-3, includes the capture of above-base flow surface water during periods of high river flow from a surface water intake in the Little Arkansas River near Sedgwick.

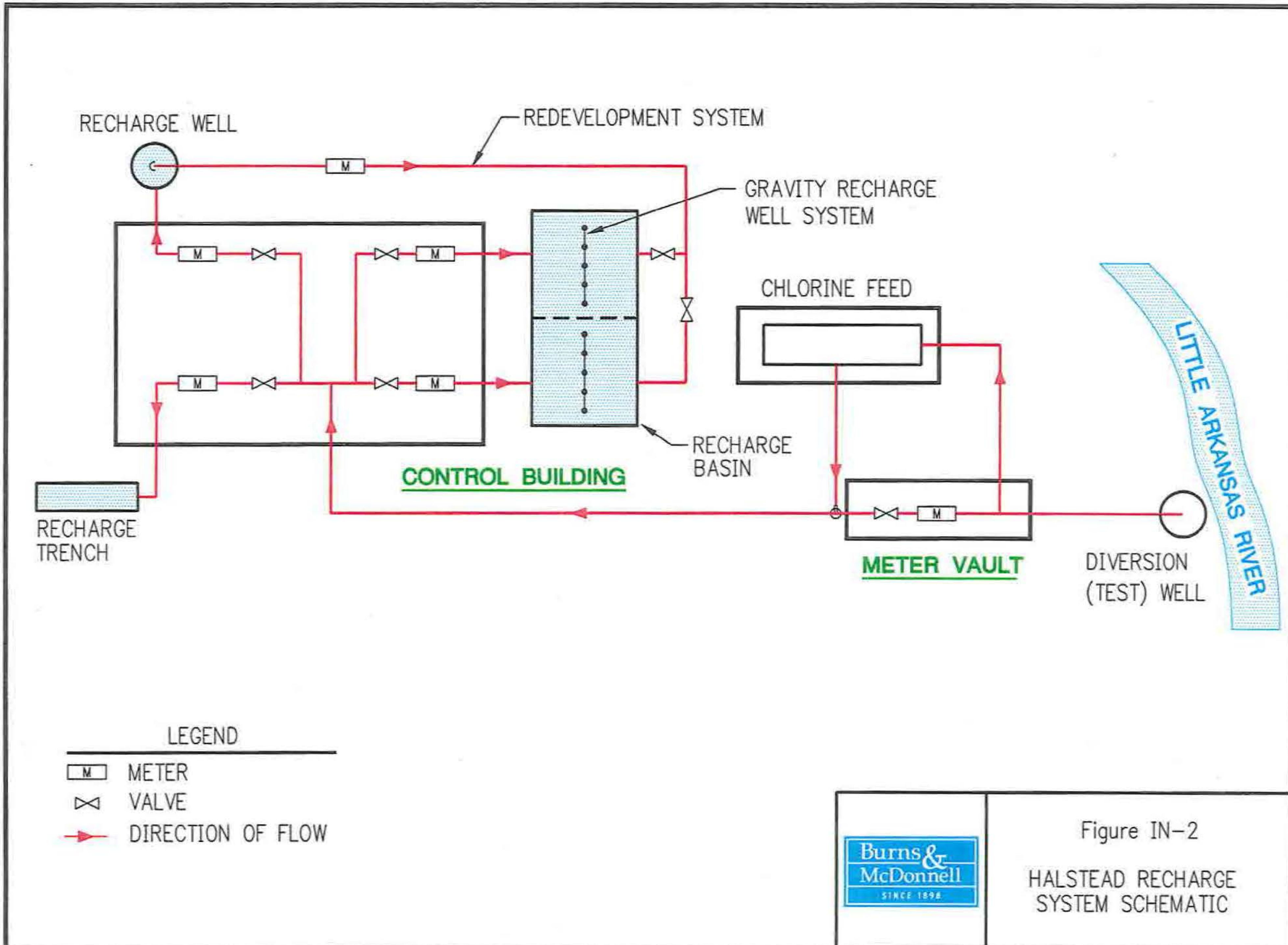
Term permits (water rights that expire within four years) have been obtained for each facility from the Kansas Department of Agriculture, Division of Water Resources for each facility. In 1999, these term permits were renewed for an additional four years. Above-base flow water may be withdrawn from the river near Sedgwick only when flow exceeds 40 cubic feet per second (cfs) and at Halstead only when flow exceeds 42 cfs from April 1 through September 30 and only when flow exceeds 20 cfs from October 1 through March 31. The higher minimum flow rates in the summer reflect the need to provide adequate water supplies to meet existing water rights from the river.

Chemical treatment systems will be used at each recharge system. Chlorine can be used as needed to control biological growths at the Halstead Recharge System. At the Sedgwick facility, polymer can be used to reduce turbidity in the river water as it passes through a parallel plate separator and powdered activated carbon (PAC) can be fed to remove atrazine and other herbicides. Chlorine can be used upstream of the parallel plate separator to oxidize minerals and downstream of the separator, when the PAC unit is off, to control biological growth. Polymer may also be used at an earthen pre-sedimentation basin located near the recharge basins. Tests to optimize surface water pretreatment were conducted during 1998 and 1999 and will continue in 2000.

3. Project Design, Construction and Operation

The design of water collection and recharge facilities for the Project was completed in late 1996 and a construction contract was awarded to Utility Contractors of Wichita in January 1997. Construction of the Project was

J:\WICHITA\921954.014\Procws\hwy50gsm.dwg 03-24-2000 16:32 AAO



Burns & McDonnell SINCE 1898

Figure IN-2

HALSTEAD RECHARGE SYSTEM SCHEMATIC

J:\WICHITA\921954.014\Procws\sedwgasm.dwg 03-24-2000 16:35 AAO

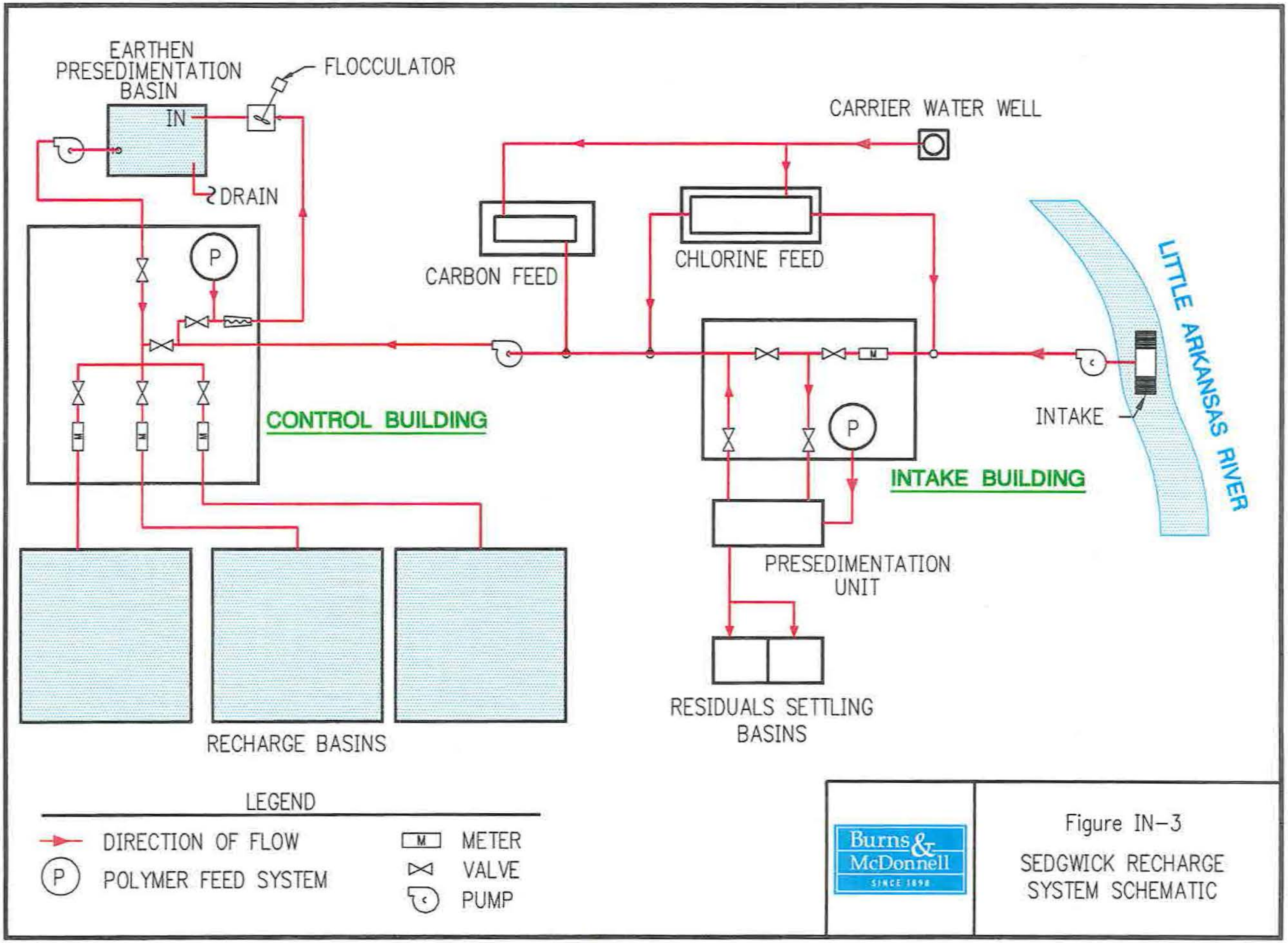


Figure IN-3

SEDGWICK RECHARGE SYSTEM SCHEMATIC

substantially complete in September 1997. The Supervisory Control And Data Acquisition (SCADA) System for the Project was included in a second contract awarded to Southwestern Electric in June 1997 and became operational in the first quarter of 1998.

Recharge operations at the Halstead and Sedgwick Recharge Systems were respectively initiated in May 1997 and October 1997. Recharge tests at both facilities continued through the end of 1999 when the Little Arkansas river stage was above the minimum levels as established by the State of Kansas. Additional testing will continue through the end of year 2000.

C. ENVIRONMENTAL CONSIDERATIONS

Various environmental activities were completed during 1999 and included field reviews of construction and soil boring sites, in-stream flow modeling data collection along the Little Arkansas River and aquatic monitoring reports. The final report *for Aquatic Monitoring Along the Little Arkansas River* was completed in 1999. Work continued for the preparation of NEPA document *Chapter 1-Purpose and Need* and *Chapter 2-Alternatives* of the Environmental Impact Statement (EIS). The draft copy of the NEPA document Chapters 1 and 2 was submitted in March. Data on existing human and natural environments in the four county project area were collected and analyzed for *Chapter 3-Affected Environments*. Also in 1999, the Instream Flow Incremental Methodology (IFIM) modeling for the Little Arkansas River and North Fork of the Ninnescah continued. Preliminary drafts of the *IFIM Report on the Little Arkansas River* and *IFIM Report for the North Fork of the Ninnescah* were completed.

D. PROJECT SCHEDULE

Operation of the demonstration project with data collection is envisioned to continue through 2000. Following evaluation of test results and approval by state and federal agencies, the City would like to begin construction of full-scale water capture, recharge, storage and recovery facilities in year 2002. Construction cannot start until the Environmental Impact Statement (EIS) for the ILWS Plan is completed, reviewed and approved. Approval of the EIS is expected in the first quarter of 2001.

E. PROJECT PARTICIPANTS

Project participants and contributors to basic activities listed herein include the City of Wichita, Equus Beds Groundwater Management District No. 2 (GMD2), the U.S. Bureau of Reclamation (Reclamation), the U.S. Geological Survey (USGS), MKEC Engineering Consultants (MKEC), and Burns & McDonnell. Agency participants with regulatory overview include the Kansas Department of Agriculture, Division of Water Resources; the Kansas Water Office; the Kansas Department of Health and Environment; the Kansas Department of Wildlife and Parks; U.S, Fish and Wildlife Service; and the Environmental Protection Agency.

* * * * *

PART I

BASIC ACCOMPLISHMENTS

PART I

BASIC ACCOMPLISHMENTS

A. PROJECT 2 – PHASE 1: DESIGN AND CONSTRUCTION

- Completed the supervisory control and data acquisition (SCADA) project.

B. PROJECT 2 – PHASE 2: OPERATION

- Continued recharge operations at the Halstead Test Facility when river stage was above 42 cfs (April 1 to August 31) or 20 cfs (September 1 to March 31) at the Highway 50 gage and coordinated USGS sampling activities.

- Initiated recharge operations at Sedgwick Recharge System after winter shutdown and continued system testing when river stage was above 40 cfs at the Sedgwick gage.

- Completed construction of the passive recharge well system in the Halstead recharge basin to investigate methods to increase recharge to the lower aquifer through perching clay layers that are found in many areas throughout the well field.

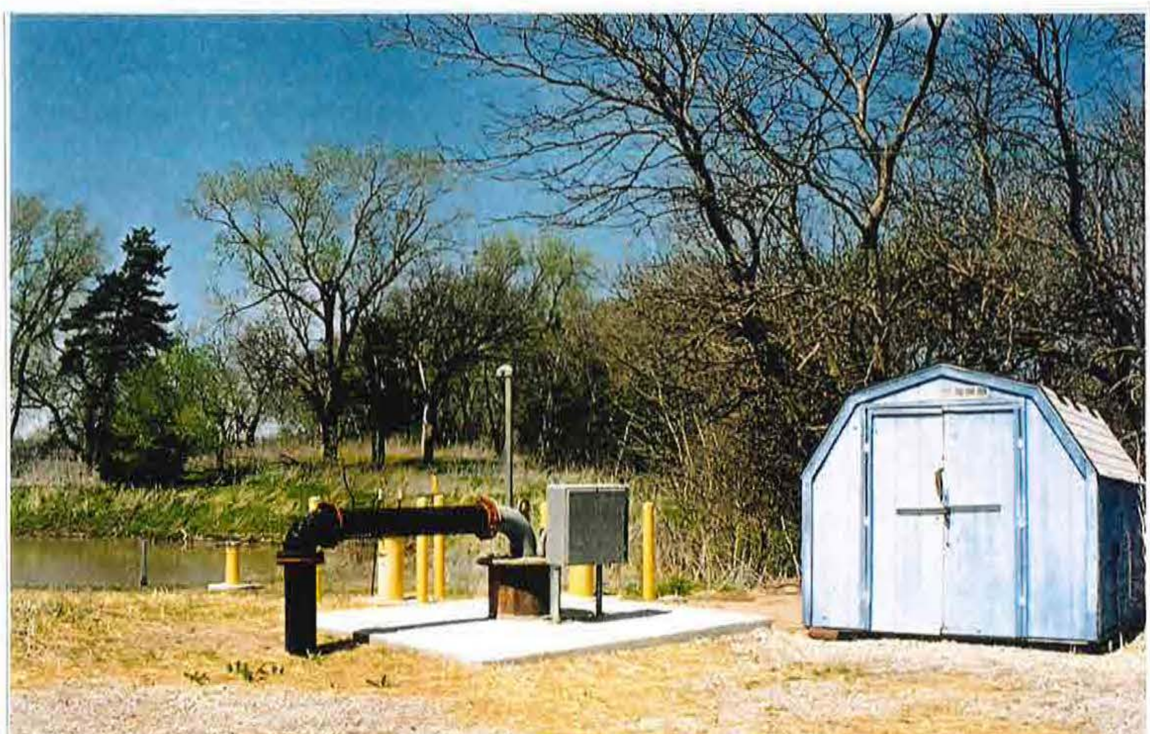
- Constructed simulated surface water recharge trenches at the Sedgwick Recharge Site and conducted limited testing in September 1999 before the Sedgwick Recharge System was shut down and winterized. Additional testing is planned in year 2000 to determine the viability of this recharge method.

- Conducted filter column tests and obtained cores of basin sands at the Sedgwick Intake Site and Sedgwick Recharge Site to determine "plugging potential" of recharge basin sands by water of varying turbidities and different treatment processes.

- Investigated surface water treatment technologies to determine cost-effective treatment for recharge water and water conveyed to the City's Central Water Treatment Plant.

- Continued operation provided insight to development of groundwater recharge regulations and accounting systems which occurred through several meetings with the Division of Water Resources, GMD2, City and Engineer.

Halstead Intake Site with Chlorine Feed Building, Valve Vault, Diversion Well, Shed, and Eleven Monitoring Wells - April 13, 1998



Halstead Diversion Well and Test Equipment Storage Shed
April, 13, 1998

- Continued on-going project coordination with cooperating state and federal agencies; USGS continued to collect water quality samples and to monitor instantaneous water levels in two sets of monitoring well strings and three surface water gages.

- Continued hydrogeologic and water quality evaluations of the Halstead and Sedgwick Recharge Sites.

- Held project status, assessment and strategy meetings with City staff, USGS, Reclamation, GMD2, state and federal agencies.

- Toured recharge demonstration facility sites with City, USGS, Reclamation, and other interested agencies and organizations.

- USGS continued to provide public access to the Equus Beds Recharge Project web page on the USGS Kansas District home page (http://www-ks.cr.usgs.gov/Kansas/equus/).

* * * * *

PART II

CHRONOLOGY OF EVENTS BY MONTH

PART II

CHRONOLOGY OF EVENTS BY MONTH

A. JANUARY

1. Project 2 – Phase 1: Facility Design and Construction

- Completed punch list work on the supervisory control and data acquisition (SCADA) system and notified SCADA subcontractor (Southwestern Electrical) about contract finalization.

- Installed SCADA "read-only" software on GMD2 computer for public access and information.

2. Project 2 – Phase 2: Facility Demonstration/Operation

- The USGS Gaging Station on the Little Arkansas River at Highway 50 near Halstead, Kansas (Station 07143672) was updated on January 5, 1999. The update recalibrates the gage after possible channel changes from the November 2, 1999 flood.

- The USGS Gaging Station on the Little Arkansas River at Fry Bridge near Sedgwick, Kansas (Station 07144100) was updated on January 24, 1999.

B. FEBRUARY

1. Project 2 – Phase 1: Facility Design and Construction

- Worked with SCADA subcontractor (Southwestern Electrical) to complete punch list work on the supervisory control and data acquisition (SCADA) system for contract finalization.

2. Project 2 – Phase 2: Facility Demonstration/Operation

- Prepared plans and specifications for the passive recharge well option for the Halstead Recharge Site for review by City, GMD2, and KDHE.

- Developed preliminary concept and drawings to modify the recharge trench to reduce iron oxidation.

- River flow for the entire month was above minimum requirements for operation at both sites. The Halstead Recharge System operated 278 hours. The Sedgwick Recharge System is shut down for the winter.

- Received honorary award for Equus Beds Recharge Project from the Consulting Engineers' Council of Missouri at the 25th Annual Engineering Excellence Awards Reception/Banquet on February 13 in St. Louis.

C. MARCH

1. Project 2 – Phase 1: Facility Design and Construction

- Subcontractor completed punch list work on the supervisory control and data acquisition (SCADA) system.

2. Project 2 – Phase 2: Facility Demonstration/Operation

- Conducted filter column tests at the Sedgwick Recharge Site using native soil from the pre-sedimentation basin to evaluate the effects of recharge water pretreatment on the distribution of particles trapped at the pre-sedimentation basin bottom. Preliminary tests showed that the use of polymer to treat raw water helps to prevent particles from going deep into the formation.

- Developed preliminary concept and drawings to modify the recharge trench to reduce iron oxidation.

- River flow for the entire month was above minimum requirements for operation at both sites. The Halstead Recharge System operated 727 hours. The total accumulated recharge volume at this site at the end of the month was 474,641,900 gallons. The Sedgwick Recharge System began operation on March 9, after the winter shut-down period and was operated 350 hours. The total accumulated recharge volume at this site at the end of the month was 73,374,700 gallons.

D. APRIL

1. Project 2 – Phase 2: Facility Demonstration/Operation

- Continued filter column tests and additional jar tests with an alternative polymer. A second filter column was constructed at the Sedgwick Recharge Site using native soil from the infiltration basins to test the differences between finished water from the Lamella and the pre-sedimentation basin and to study potential effects on recharge rates.

- Monitored testing of surface water samples by Microsep to determine future application for water treatment at the project site.

- Met with representatives of Reclamation and Kansas Corporation Commission on April 16 to help facilitate coordination of remediation activities for the Burrton high-chloride groundwater plume.

- Met with City to review cause of air surges in pump discharge a the Sedgwick Intake Site.

- Initiated coordination with the City to implement improvements to the Halstead Recharge Trench for iron oxidation control.

- Held tours of demonstration facilities with Kansas Water Authority in mid-April, University of Missouri at Kansas City Hydrogeology Class on April 17, and Julie Grauer and Mark Rude, Division of Water Resources, on April 23.

- River flow for the entire month was above minimum requirements for operation at both sites. The Halstead Recharge System operated 602 hours. The total accumulated recharge volume at this site at the end of the month was 502,687,400 gallons. The Sedgwick Recharge System operated 148 hours. The total accumulated recharge volume at this site at the end of the month was 82,616,300 gallons.

E. MAY

1. Project 2 – Phase 2: Facility Demonstration/Operation

- Met with GMD2 to discuss index wells, passive recharge at Halstead, the groundwater model, and the diversion well term permit.

- Submitted a technical memorandum to the City on a Microsep treatability study of water samples from the Little Arkansas River.

- Continued filter column tests and additional jar tests with an alternative polymer. Testing included examination of the use of filter fabric, the effect of PAC carry-over on recharge rates, and the effect of Lamella turbidity on recharge rates.

- Evaluated use of particle counting on the raw water, lamella effluent, pre-sedimentation basin effluent and the effluent from the filter columns (particle counting technology may be used to help determine plugging rates based on particle deposition).

- Evaluated lamella treatment unit and the variation of changing flow rates on effluent water quality. At lower flow rates, various weirs were plugged to determine the effect of changing loading rates with varying rapid mix/flocculation times.

- Completed tests on soil cores from recharge basins to determine turbidity profiles, soil clogging characteristics, and maintenance requirements for basin permeability.

- Completed the plans and specifications for the passive recharge well option for the Halstead Recharge Site. Delivered final copies for bidding to the City's Purchasing Department.

- Worked with City to install improvements to the Halstead Recharge Trench for iron oxidation control and began initial testing.

- River flow for the entire month was above minimum requirements for operation at both sites. The Halstead Recharge System operated 764 hours.

Recharge Trench and Well - Halstead Recharge Site
September 17, 1997

Recharge Basins - Halstead Recharge Site
September 17, 1997

The total accumulated recharge volume at this site at the end of the month was 536,016,900 gallons. The Sedgwick Recharge System operated 202 hours. The total accumulated recharge volume at this site at the end of the month was 94,616,300 gallons.

F. JUNE

1. Project 2 – Phase 1: Facility Design and Construction

- SCADA contract finalized.

2. Project 2 – Phase 2: Facility Demonstration/Operation

- Continued filter sand column tests and additional jar tests with an alternative polymer. Testing included longer time, lower head column tests.
- Finalized work with calibration and automation of the streaming current detector to adjust polymer dose according to raw water turbidity levels.
- Continued evaluation of use of particle counting on the raw water, lamella effluent, pre-sedimentation basin effluent and the effluent from the filter columns (particle counting technology may be used to help determine plugging rates based on particle deposition).
- River flow for the entire month was above minimum requirements for operation at both sites. The Halstead Recharge System operated 716 hours. The total accumulated recharge volume at this site at the end of the month was 568,807,200 gallons. The Sedgwick Recharge System operated 720 hours. The total accumulated recharge volume at this site at the end of the month was 98,943,100 gallons.

G. JULY

1. Project 2 – Phase 2: Facility Demonstration/Operation

- Finalized work with calibration and automation of the streaming current detector to adjust polymer dose according to raw water turbidity levels.
- Continued evaluation of use of particle counting on the raw water, lamella effluent, pre-sedimentation basin effluent and the effluent from the filter

columns (particle counting technology may be used to help determine plugging rates based on particle deposition).

- Continued working with City to test improvements to the Halstead Recharge Trench for iron oxidation control. Initial tests indicated some continued "iron fouling" with investigations to continue.

- Harvey County removed the bridge near the Halstead Diversion Site on County Highway 501. The USGS stage gaging station was damaged during the bridge demolition. The USGS repaired the gage in July.

- The low head dam located downstream of the Halstead Diversion Site was breached in July. This affected groundwater and gage level recordings in the area.

- River flow for the entire month was above minimum requirements for operation at both sites. The Halstead Recharge System operated 682 hours. The total accumulated recharge volume at this site at the end of the month was 599,068,700 gallons. The Sedgwick Recharge System operated 391 hours. The total accumulated recharge volume at this site at the end of the month was 114,095,200 gallons.

H. AUGUST

1. Project 2 – Phase 2: Facility Demonstration/Operation

- Continued evaluation of use of particle counting on the raw water, lamella effluent, pre-sedimentation basin effluent and the effluent from the filter columns (particle counting technology may be used to help determine plugging rates based on particle deposition).

- City's Purchasing Department awarded construction of the passive recharge system at the Halstead Recharge Basins to Clarke Well & Equipment Company of Great Bend, Kansas.

- Continued working with City to test improvements to the Halstead Recharge Trench for iron oxidation control.

- The Wichita Well Field crew scraped approximately 3 inches of dirty sand, PAC, and vegetation from the southwest basin at the Sedgwick Recharge Facility.

- The Wichita Well Field crew installed "simulated surface water trenches" in the southwest basin at the Sedgwick Recharge Facility and began initial testing. Testing started on August 25.

- The City conducted a tour of the recharge facilities with the Little Arkansas River Basin Watershed Coalition on August 31.

- Flow of the Little Arkansas River at Highway 50 was great enough for operation of the Halstead Site for 360 hours in August; however, the facility was not operated to allow the basins to dry in preparation for installation of the gravity recharge wells. Flow at Sedgwick was high enough for operation the entire month (744 hours). Because of storm damage to the well field electrical system and lightning damage to the SCADA system, the Sedgwick system was operated for 392 hours. The total accumulated recharge volume at this site at the end of the month was 122,360,800 gallons.

I. SEPTEMBER

1. Project 2 – Phase 2: Facility Demonstration/Operation

- Continued working with City to test improvements to the Halstead Recharge Trench for iron oxidation control.

- Continued working with City to test "simulated surface water trenches" in the southwest basin at the Sedgwick Recharge Facility. The purpose of these tests is to demonstrate operating parameters, maintenance requirements and feasibility for simulated trenches with geofabric tops. Initial test resulted in surficial plugging of the geofabrics by algae growth. Covering the "simulated surface water trenches" to keep water from being exposed to sunlight seemed to be effective in preventing algae growth, resulting in longer run times.

View Northeast - Sedgwick Recharge Site
April 13, 1998

View West - Sedgwick Recharge Site
April 13, 1998

- The SCADA system for the Demonstration Project was incorporated into the City's overall water monitoring system. This transition caused operational difficulties due to system unavailability or reduced speed.

- The Halstead facility was not operated in September to allow the basins to dry in preparation for installation of the passive recharge well system. Flow at Sedgwick was high enough for operation the entire month (720 hours). Run time for the Sedgwick system was not available because of the SCADA modifications. The total accumulated recharge volume at this site at the end of the month was 145,912,800 gallons.

J. OCTOBER

1. Project 2 – Phase 2: Facility Demonstration/Operation

- Obtained a waiver from the Kansas Department of Health and Environment (KDHE) on October 12 to install the 12 flush mount passive recharge wells at the Halstead Recharge Basins.

- Completed construction of the passive recharge wells at the Halstead Recharge Basins by Clarke Well & Equipment Company of Great Bend, Kansas. Clarke still has to install the laterals connecting the wells.

- The City well field crew cleaned the Halstead Basins after Clarke completed well installation.

- The City well field crew cleaned the northeast and southeast basin at the Sedgwick Recharge Site. The Sedgwick system was then shut down for the winter.

- The SCADA system for the Demonstration Project was incorporated into the City's overall water monitoring system. This transition caused operational difficulties due to system unavailability or reduced speed.

- The Halstead facility was not operated in October to allow construction of the passive recharge well system. Flow at Sedgwick was high enough for operation the entire month (744 hours). Run time for the Sedgwick system was not available because of the SCADA modifications. The total accumulated recharge volume at this site at the end of the month was 148,334,300 gallons.

K. NOVEMBER

1. Project 2 – Phase2: Facility Demonstration/Operation

- Held public information meeting on the Equus Beds Groundwater Recharge Project using Power Point presentation with information boards on November 22, 1999 at the school auditorium in Sedgwick. Updated project information was provided by representatives of GMD2, City and Engineer.

- Completed construction of the passive recharge wells and the laterals at the Halstead Recharge Basins by Clarke Well & Equipment Company of Great Bend. Worked with City during startup and initial testing of the passive recharge well system.

- City well field crew cleaned the Halstead Recharge Basins after Clarke completed well installation. Crews also cleaned the southeast and northeast basins at the Sedgwick Recharge Site.

- The SCADA system for the Demonstration Project was incorporated into the City's overall water monitoring system in September. This transition continued to cause operational difficulties due to system unavailability or reduced speed.

- Run time for the Halstead system was not available because of the SCADA modifications. The total accumulated recharge volume at this site at the end of the month was 613,525,800 gallons. The lower limit for operation of the Halstead Recharge System is now 20 cfs for the winter season. The Sedgwick system was shut down for the winter.

- Made project status report to the City Council on November 23 on the Equus Beds Groundwater Recharge Demonstration Project and the City's Integrated Local Water Supply Plan.

L. DECEMBER

1. Project 2 – Phase 2: Facility Demonstration/Operation

- Continued working with City during initial testing of the passive recharge well system. Recharge system was shut down before Christmas.
- The SCADA system for the Demonstration Project was incorporated into the City's overall water monitoring system in September. This transition continued to cause operational difficulties due to system unavailability or reduced speed.
- Run time for the Halstead system was not available because of the SCADA modifications. The total accumulated recharge volume at this site at the end of the month was 634,404,400 gallons. The lower limit for operation of the Halstead Recharge System is now 20 cfs for the winter season. The Sedgwick system was shut down for the winter.

* * * * *

PART III

RECHARGE TEST RESULTS

PART III

RECHARGE TEST RESULTS

A. OPERATION

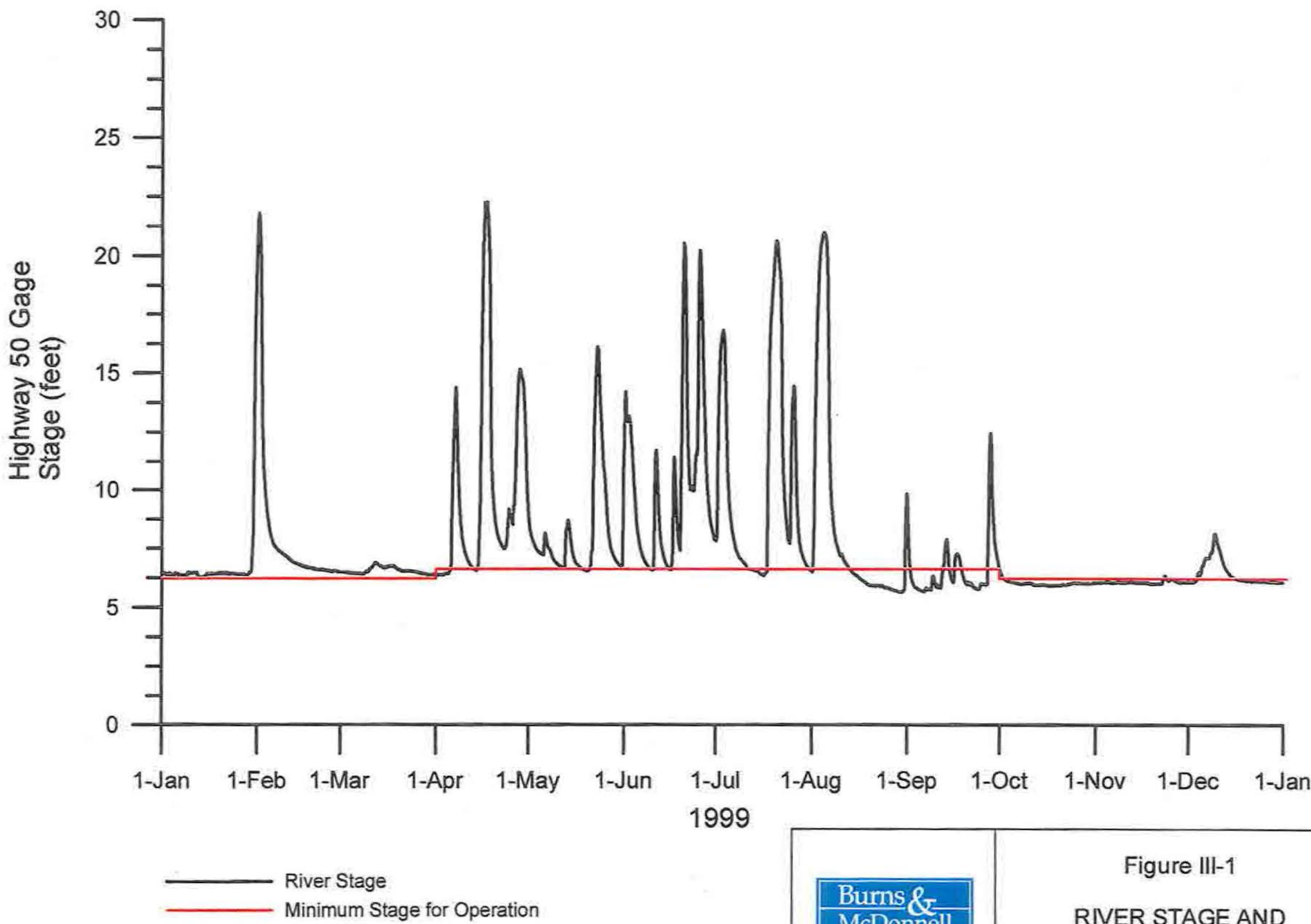
1. Halstead

Recharge operations at the Halstead Recharge System began on May 23, 1997 with the two basins and the recharge trench and on August 26, 1997 with the recharge well. Subsequently, operational tests of all three recharge components of the Halstead Recharge System were conducted through the remainder of 1997 and continued through the end of 1999.

The term permit from the Kansas Division of Water Resources for the diversion (test) well at the Halstead System establishes minimum flow in the Little Arkansas River for operation of 42 cfs or 20 cfs, depending on the season. Precipitation events maintained the flow in the river above the minimum limit for most of the time period from the beginning of the year until July 14, 1999, so recharge operations were nearly uninterrupted. During the months of July and August 1999, the recharge system was operated when the river flow was above 42 cfs at the Highway 50 gage.

The Halstead facility was not operated during the months of September and October to allow the basins to dry and construction of the gravity recharge well system. From November 1999 through the end of 1999, the system was operated as the river flow increased and the minimum stage for operation dropped to 20 cfs. A graph of Little Arkansas River stage at Highway 50 for 1999 in shown in Figure III-1. The graph also shows the minimum stage limit for operation.

The USGS Gaging Station on the Little Arkansas River at Highway 50 near Halstead, Kansas (Station 07143672) was updated on January 5, 1999. The update recalibrates the gage after possible channel changes from the November 2, 1998 flood. The new stages for the Halstead Recharge System flow limits became:



Burns & McDonnell SINCE 1898

Figure III-1

RIVER STAGE AND PERMIT LIMITS HIGHWAY 50 GAGE

J:\WICHITA\921954.016\DATA\H50STAGE.GRF

	Flow (cfs)	Gage Height (ft)
Winter Minimum (October – March)	20	6.07
Summer Minimum (April – September)	42	6.49

The low head dam located downstream of the Halstead Diversion Site was breached in July. The low head dam was reconstructed resulting in altered stage limits. The new stages for the Halstead Recharge System flow limits are:

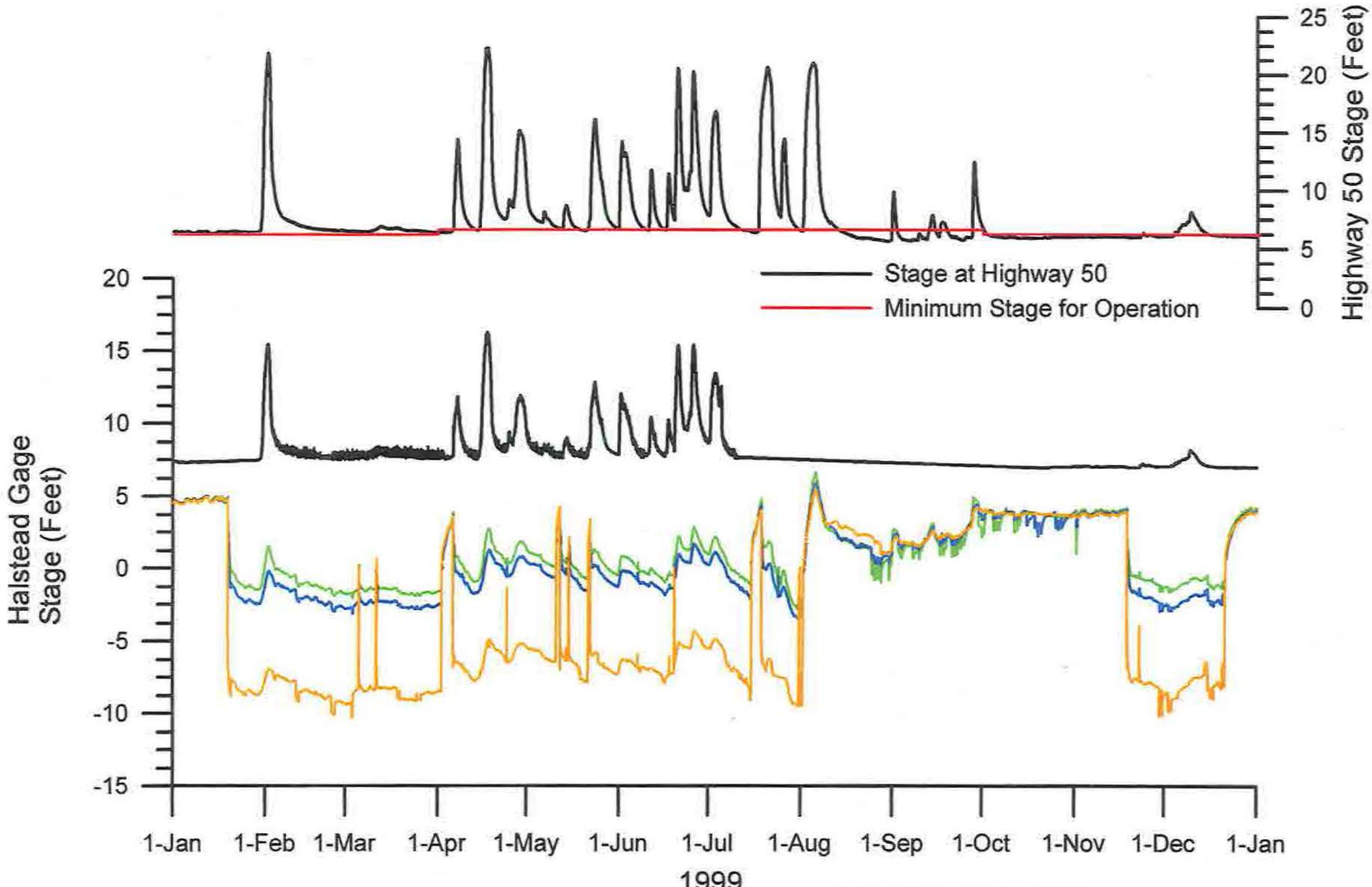
	Flow (cfs)	Gage Height (ft)
Winter Minimum (October – March)	20	6.06
Summer Minimum (April – September)	42	6.23

Current stage information can be obtained by use of a telephone connection to the gage and from the Kansas USGS "real-time" Internet web page (http://www-ks.cr.usgs.gov/kansas/ equus.). The Equus Recharge Project web page also provides historic and current water quality information. A hard copy of the Equus Beds Recharge Project web home page is provided in the Appendix.

Groundwater levels in selected monitoring wells and the river stage near the diversion (test) well near Halstead are shown in Figure III-2. The monitoring wells are part of the line of monitoring wells perpendicular to the river that were installed to evaluate river-aquifer interaction. River stage and groundwater level data is collected by the USGS data collection platform (DCP) at the site and transmitted by satellite to the main computer database in Lawrence, Kansas. Operation of the diversion (test) well is clearly shown by drawdowns in the monitoring well data. Additionally, the "hydrologic connection" between the river and aquifer is clearly shown by the response of groundwater levels to storm events.

2. Sedgwick

Operation of the Sedgwick Recharge System was initiated in October 1997. The system was operated on a limited basis during that year before being shutdown for the winter. In March 1998, recharge operations at the Sedgwick Recharge System were restarted and system testing was continued when the river stage was



Burns & McDonnell SINCE 1898

Figure III-2

RIVER STAGE AND GROUNDWATER LEVELS AT DIVERSION (TEST) WELL SITE NEAR HALSTEAD

J:\WICHITA\921954.016\report\figures\HAL_STAGE.GRF above 40 cfs at the Sedgwick gage. The system was shut down for the winter on October 15, 1998 and restarted on March 9, 1999.

The USGS Gaging Station on the Little Arkansas River at Fry Bridge near Sedgwick, Kansas (Station 07144100) was updated on January 24, 1999. The new stage for the Sedgwick Recharge System flow limit is:

Flow (cfs)	Gage Height (ft)
40	3.62

During 1999, the system was operated from March through August. Then a storm damaged the well field electrical system and part of the SCADA system were damaged by lightning. From September into November, the recharge system was operated until it was shut down for the winter. Figure III-3 shows a graph of Little Arkansas River stage at Sedgwick for 1999. The river stage remained above 40 cfs for the entire year.

3. Summary

A summary of system recharge operations in 1999 for both systems is shown in Table III-1. The SCADA System with associated instruments and controls provided automated operation of the recharge systems since March of 1998. The SCADA system for the Demonstration Project was incorporated into the City's overall water monitoring system in September, 1999. This transition caused operational difficulties due to system unavailability or reduced speed. During the transition, no data was available for analysis. Data became available beginning November 8, 1999. Detailed descriptions of these activities are discussed hereafter.

Cumulative recharge volumes through the end of 1999 at the respective Halstead and Sedgwick sites are shown in Figures III-4 and III-5. Both recharge facilities were operational from January through December 1999. The total recharge volume in 1999 was more than the volume recharged in 1998 (948 acre-feet) and double the volume recharged in 1997 (416 acre-feet).

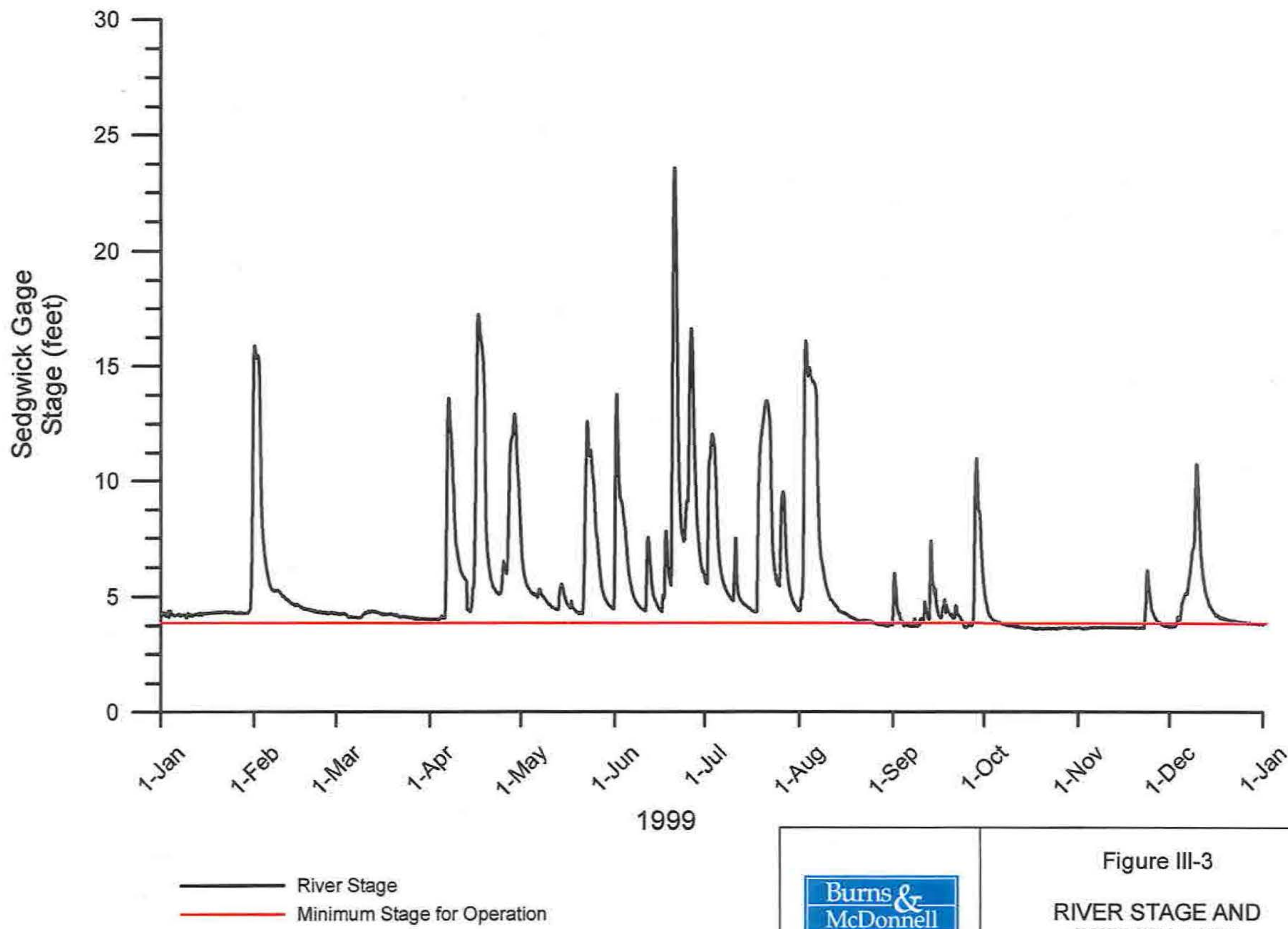


Figure III-3

RIVER STAGE AND
PERMIT LIMITS
SEDWICK INTAKE SITE

J:\WICHITA\921954.016\DATA\S_STAGE99.GRF

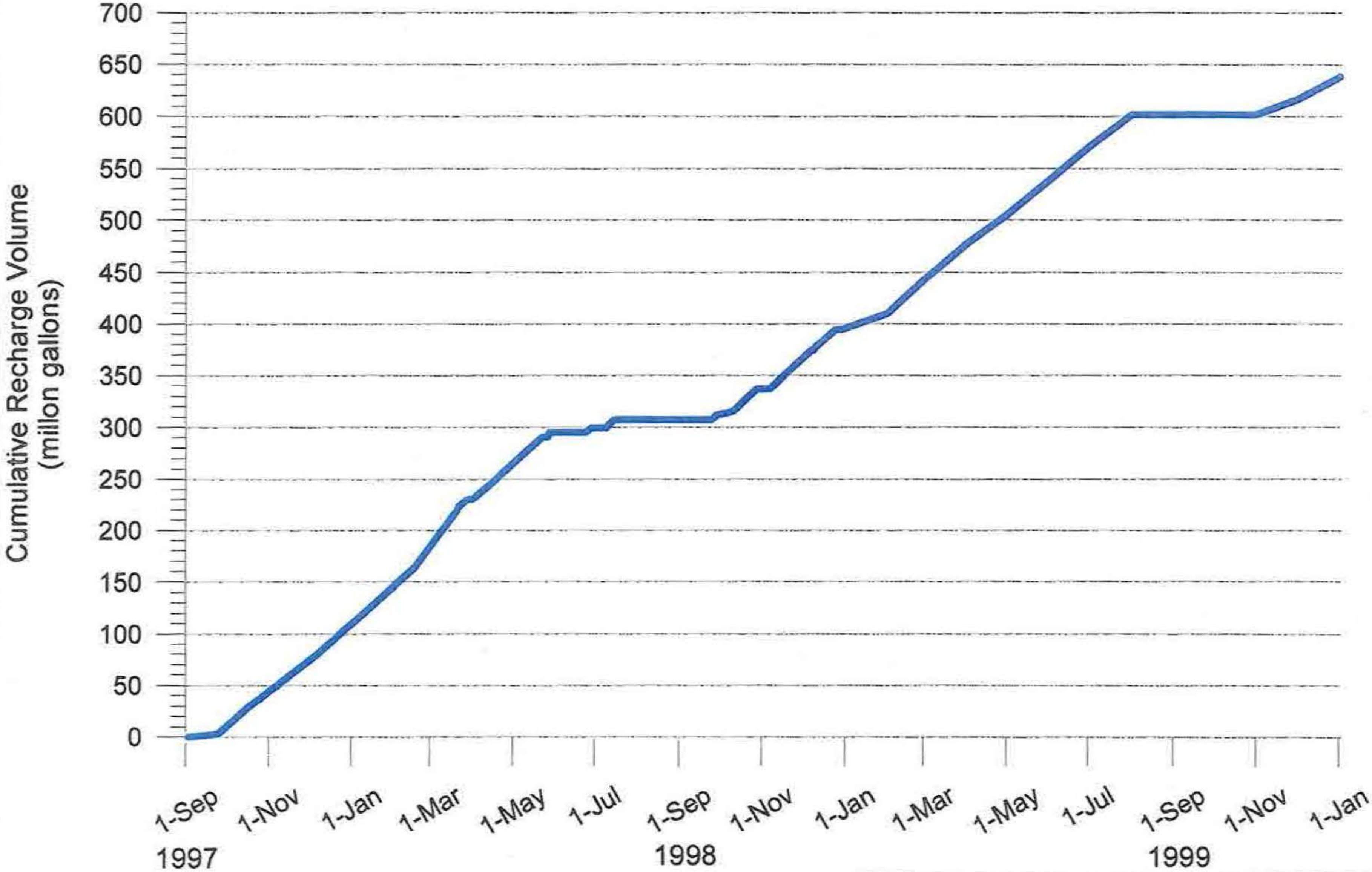
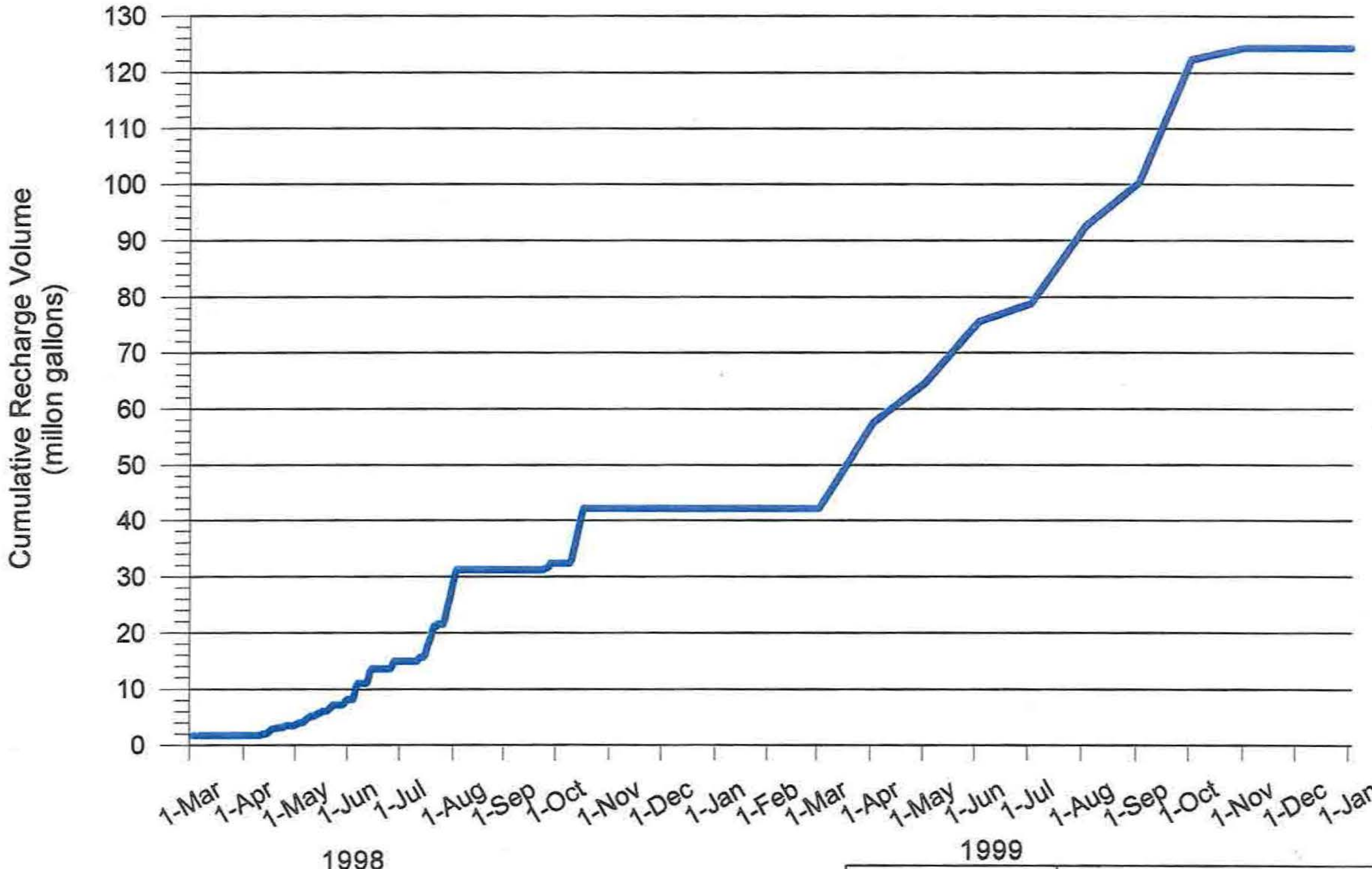


Figure III-4

HALSTEAD RECHARGE SITE
CUMULATIVE
RECHARGE VOLUME

j:\wichita\921954.016\report\figures\tvol.grf



Burns & McDonnell SINCE 1898

Figure III-5

SEDGWICK RECHARGE SITE CUMULATIVE RECHARGE VOLUME

4/21/00 i:\wichib\921954.016\report\figures\SVol.grf

Table III-1

Equus Beds Recharge Demonstration Project

Recharge Volume in 1999

Halstead Recharge System		
North Basin	3,388,300	
South Basin	15,304,100	
Recharge Trench	2,394,700	
Recharge Well	222,367,300	
Total	243,454,400	gallons
Sedgwick Recharge System		
Southeast Basin	23,444,700	
Northeast Basin	19,614,000	
West Basin	39,226,600	
Pre-sedimentation Basin	1,998,000	
Total	84,283,300	gallons
Total for 1999:	327,737,700 (or 1,005 acre-feet)	gallons

B. HALSTEAD RECHARGE SYSTEM

1. Recharge Basins

The two Halstead recharge basins were the first components of the demonstration program to be brought into operation. The north basin has a bottom area of 0.35 acre and the south basin has a bottom area of 0.20 acre. Each basin is about 12 feet deep with the bottom of the basin below the surficial clays.

A significant clay layer exists from a depth of about 30 to 60 feet below ground surface, preventing direct movement of the recharge water to the main aquifer and causing water to "perch" above the clay layer. Drill logs from installed piezometers and a monitoring well indicate that the intermediate clay layer in this area is laterally extensive. The potentiometric water level in the lower aquifer was below the top of the clay layer when recharge operations began.

Testing conducted during 1997 and 1998 showed that, although the bottoms and underlying sand layers of the basins are very permeable, recharge rates decreased considerably after the sand above the relatively shallow, intermediate clay layer became saturated. While recharge rates of about 15 to 20 ft/day were observed during the system startup, those rates stabilized at about 1 to 2 ft/day once the subsurface sand layer was filled and "groundwater mounding" occurred. The change from vertical flow to predominantly horizontal flow in the sand above the clay layer was the cause for the lower recharge rates.

Typically, a shallow water depth should be maintained in the basins when a perching layer is not present; however, when the piezometric levels rise above the bottom of the basin, infiltration rates can be increased by raising basin water levels to increase static head. Testing in 1998 showed that until the soil beneath the basins becomes totally saturated, infiltration rates can be temporarily higher.

Recharge rates with time and the associated water levels at both Halstead recharge basins are shown in Figure III-6. The figure also shows the response of shallow groundwater levels in selected monitoring wells. The rise in shallow groundwater levels is primarily due to recharge through the basins.

In November 1999, construction of the gravity recharge well system was completed. Five wells, constructed of two-inch PVC and screen, were installed in each basin to a total depth of about 200 feet. The five wells in each basin are connected with a four-inch horizontal lateral screen buried about three feet below the basin bottom. The top of the wells are sealed to prevent direct introduction of water and each well is vented. Figure III-7 shows the layout of the gravity well system within the Halstead Recharge Basins. Figure III-8 shows a typical cross-section through a gravity recharge well.

Operation of the Halstead Recharge System was resumed in November after completion of construction of the gravity recharge well system. Initial testing was conducted until the system was shut down in late December. Initial testing of the basins, after addition of the gravity recharge system, showed a 400 percent increase in recharge rates as shown in Figure III-9. Further improvement in recharge rates is expected as the system is operated and fine sediment that has washed into the laterals and formation is removed. Testing will continue through the spring and summer of 2000.

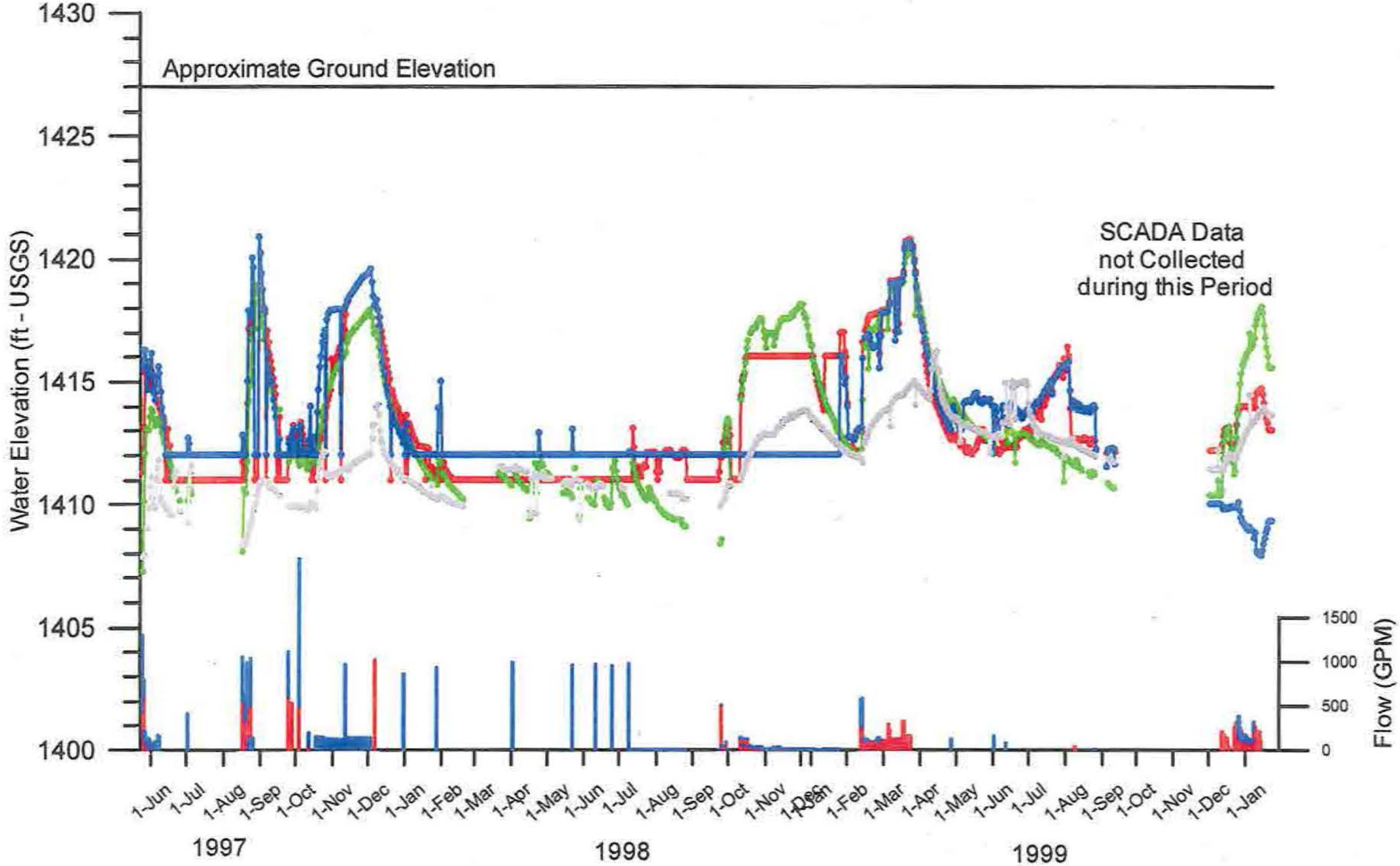
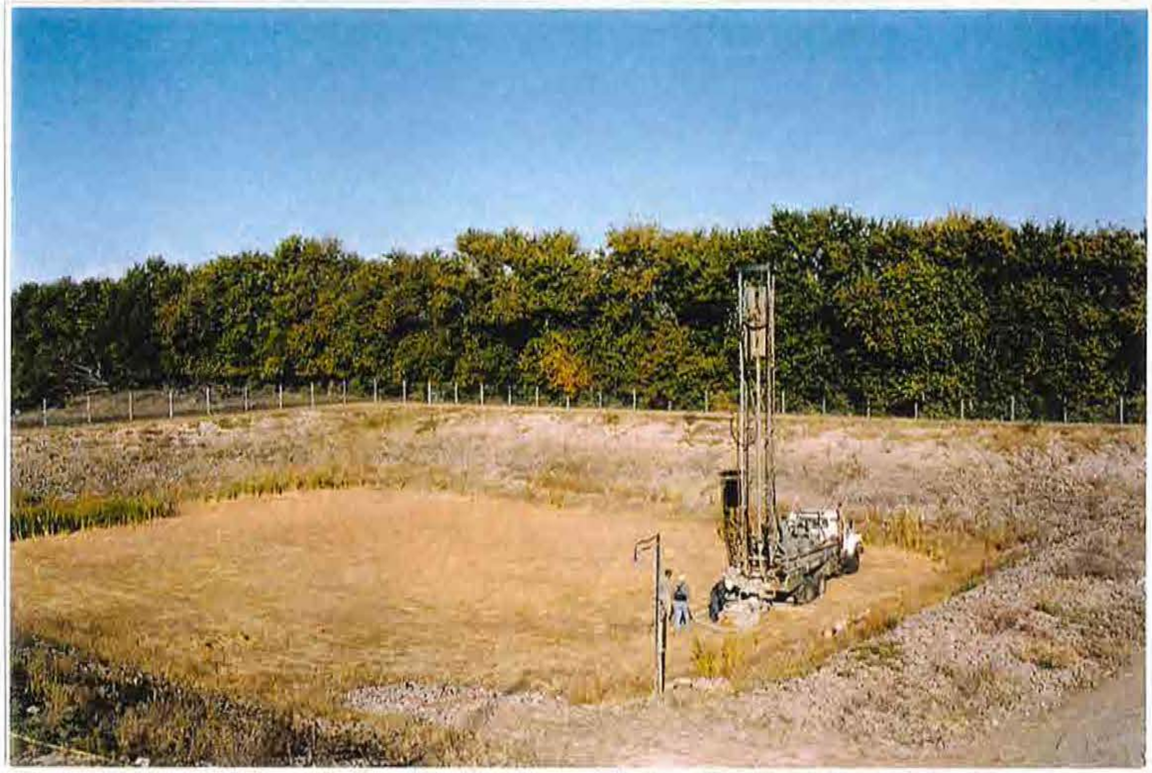


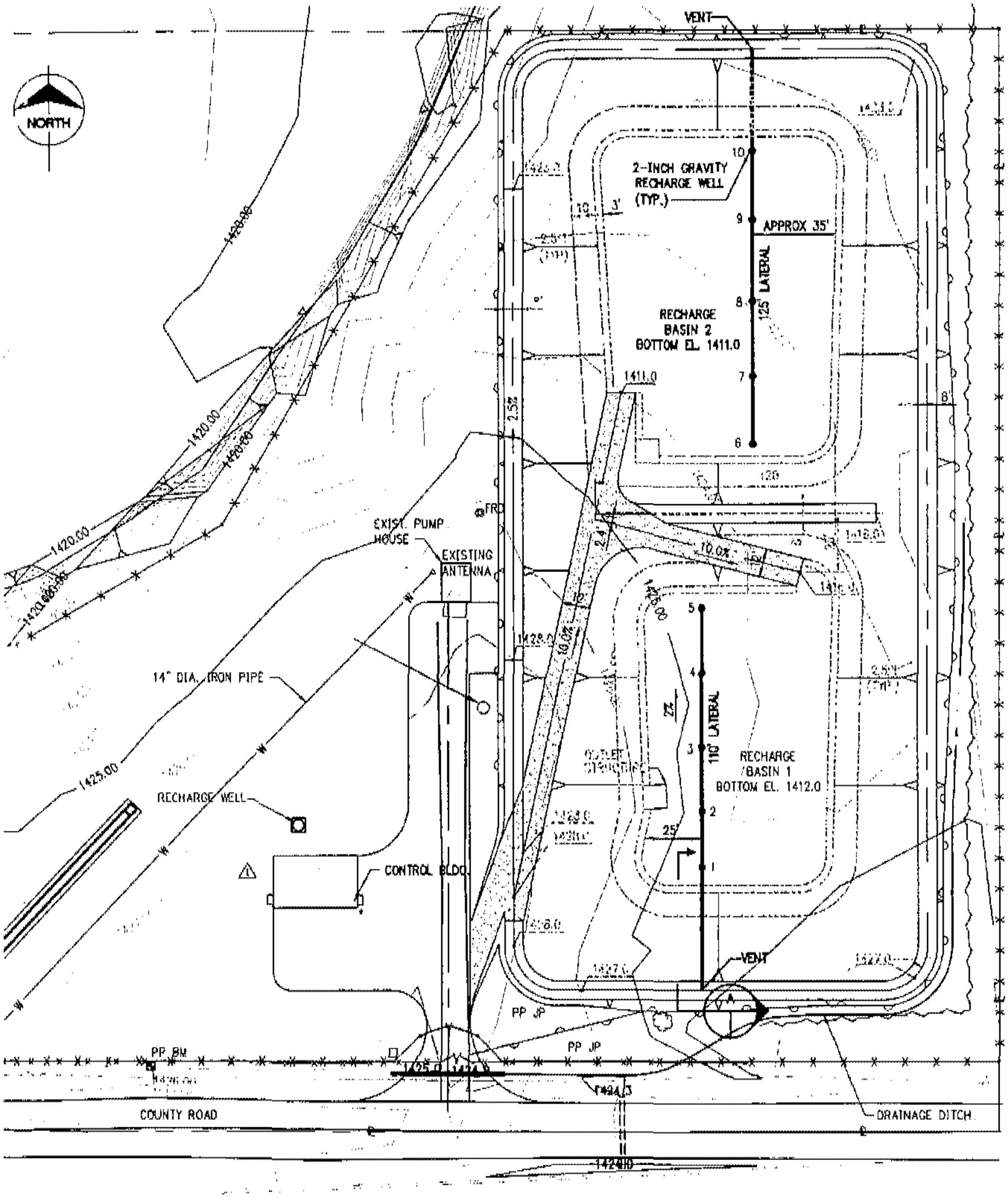
Figure III-6

HALSTEAD RECHARGE SITE
SHALLOW WELLS & BASIN
DEPTH WITH BASIN FLOW



Installation of Gravity Recharge Wells - Halstead Recharge Site
October 20, 1999

Recharge Basin with Gravity Recharge Wells - Halstead Recharge Site
November 17, 1999



HALSTEAD SITE

60 0 60 120

SCALE IN FEET

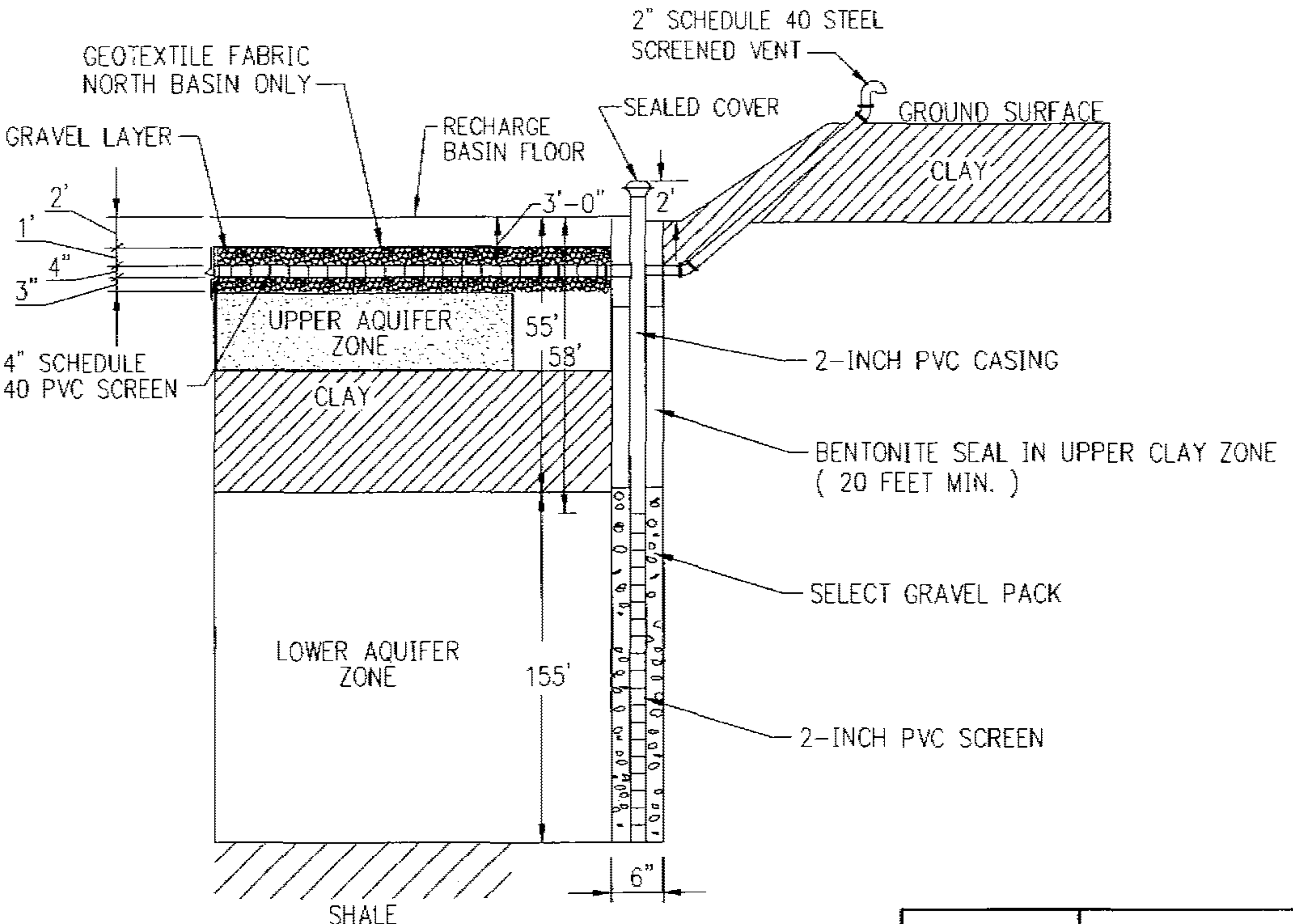
Burns & McDonnell SINCE 1898

Figure III-7

GRAVITY RECHARGE WELLS - LAYOUT

J:\WICHITA\921954.012\CONSW3.dwg 04-11-2000 11:21 jro

J:\WICHITA\921954.012\CONSW4.dwg 03-22-2000 14:05 jro



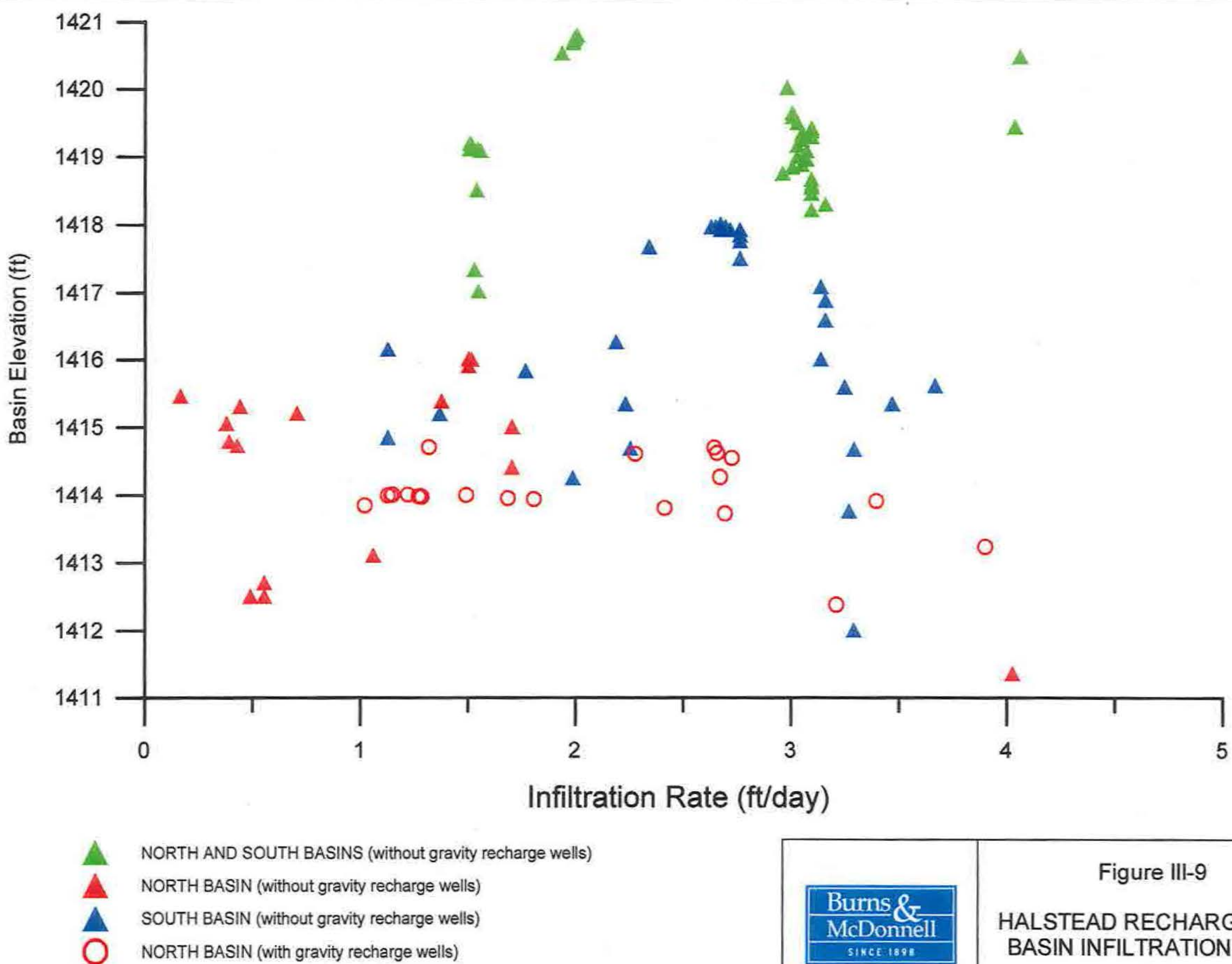
SECTION GRAVITY RECHARGE WELL

NOT TO SCALE

Burns & McDonnell SINCE 1898

Figure III-8

TYPICAL GRAVITY RECHARGE WELL CROSS SECTION



Burns & McDonnell SINCE 1898

Figure III-9

HALSTEAD RECHARGE SITE
BASIN INFILTRATION RATE

4/21/00 j:\wichita\921954.016\reports\figures\infilt.grf

2. Recharge Trench

The recharge trench was initially recommended as a test facility during a peer review of the recharge concepts. The trench was recommended because of the perched clay layer in the Halstead area. The recharge trench allows a thin vertical flow zone down to the clay layer. The thin flow is easily dispersed laterally. A "groundwater mound" is minimized using a linear recharge area (trench), whereas a non-linear area, such as a basin, will cause greater "groundwater mounding". As discussed above, when this groundwater mound rises above the bottom of the basins, vertical percolation ceases, resulting in reduced recharge rates.

The recharge trench has a history of minor operational problems caused by plugging of the upper filter fabric by iron precipitation caused by aeration of the water. Wichita well field personnel now periodically clean the filter fabric by wet shop vacuum as part of the normal operation and maintenance requirements for continuing recharge operations.

In 1998, the recharge trench inlet structure was modified to minimize water aeration. During June 1999, additional modifications were made to the recharge trench to control water agitation and to reduce iron oxidation. Modifications include the installation of distribution piping and use of floating covers. Tests showed that run time was increased slightly; however, the filter fabric continues to experience problems with iron fouling.

3. Recharge Well

The recharge well is screened below the extensive clay layer that exists from approximately 30 to 60 feet below ground surface. This allows recharge in the lower portion of the aquifer, which causes the groundwater system to respond as a confined aquifer. Monitoring wells constructed in the lower aquifer showed large changes of 10 to 15 feet in water levels, depending on pumping or recharge conditions.

Piezometric levels in the deep aquifer zone vary mainly in response to changes at the recharge well. However, pumping from City water supply wells and irrigation wells located over 1/2 mile away may also cause some fluctuations in

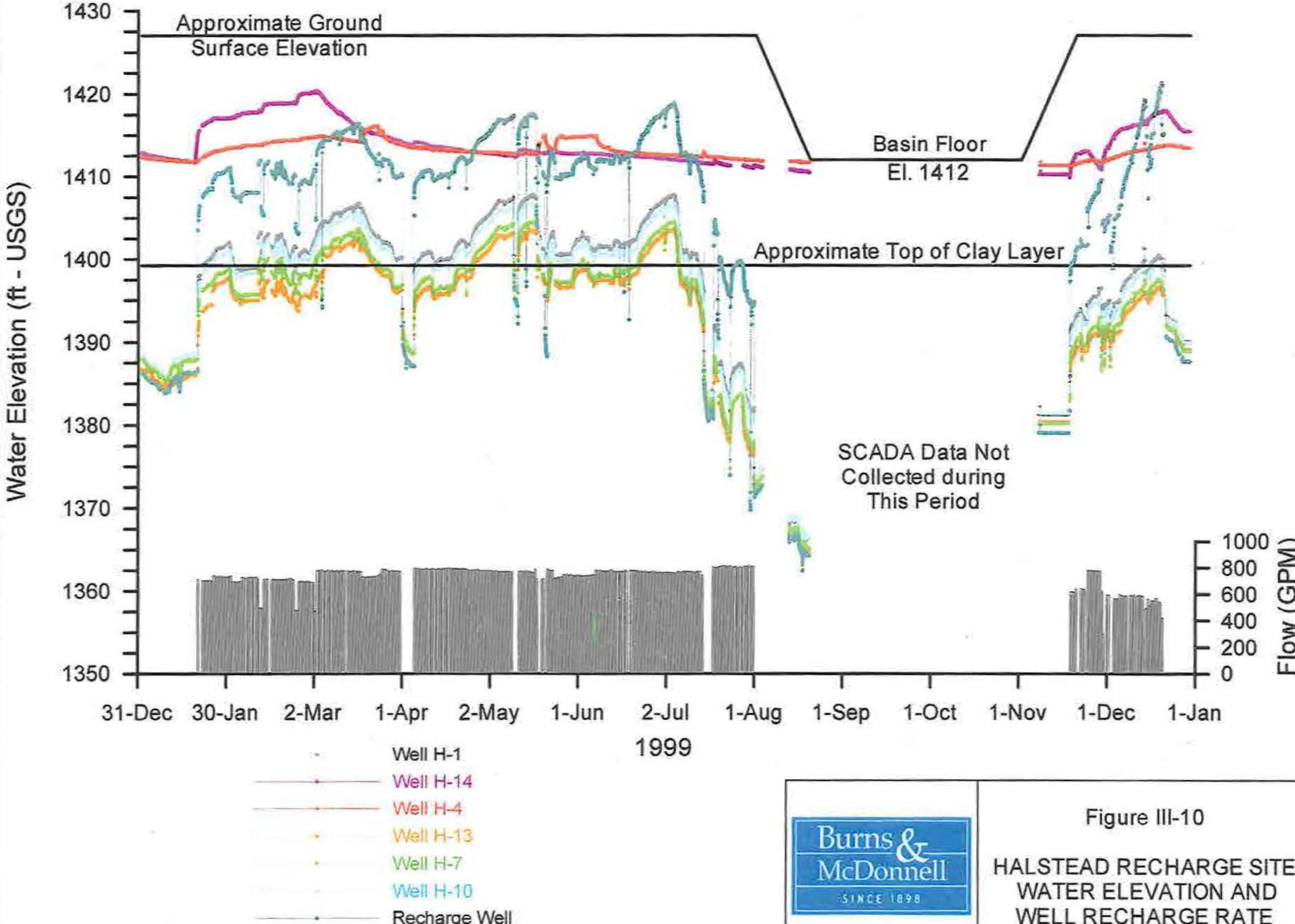
Distribution Piping
Halstead Recharge Site
May 1999

piezometric levels. The responses of groundwater levels in the recharge well and associated piezometric levels in selected monitoring wells are presented in Figure III-10. The system recharge rates and groundwater levels in the shallow portion of the aquifer above the intermediate clay layer are also shown in Figure III-10. Recharge rates were maintained at an approximate average rate of 750 gpm during system operation. The observed rise in shallow groundwater levels is due to recharge through the basins or trench.

Figure III-11 shows the difference between the water levels in the recharge well and Monitoring Well H-1 with time. During recharge events, the difference in water levels between the recharge well and Monitoring Well H-1 was in the range of 10 to 15 feet and did not show any noticeable increasing trend by the end of 1998. However, during November and December 1999, the difference in water levels shows a significant increase, which indicates plugging of the well screen and/or aquifer is occurring. A stable difference between the recharge well and monitoring well water levels is an indication of adequate well performance, while an increasing difference is a sign of possible well deterioration due to well or formation plugging.

The recharge well was periodically redeveloped to remove sediment that could potentially block the inside of the screen. Redevelopment is accomplished by surging the redevelopment pump 10 to 20 times and then pumping to waste into one of the recharge basins for approximately one hour.

Testing of the recharge well was initiated in August 1997 and continued through the end of 1999 when the flow in the Little Arkansas River was above the minimum limit. Figure III-12 provides the well recharge specific capacity (ratio of recharge flow to groundwater rise at the well relative to the static level) with time for the entire period of well operation. Recharge test results show that the well recharge specific capacity stabilized in the range of 25 gpm/ft-rise to 35 gpm/ft-rise during periods of continuous operation. A significant decrease in the well average recharge specific capacity was observed in November - December 1999, which denotes deteriorating well performance. This could be caused by need for redevelopment, changing conditions in the aquifer or changes in the City's SCADA System which occurred in September 1999. Specific



Burns & McDonnell SINCE 1898

Figure III-10

HALSTEAD RECHARGE SITE WATER ELEVATION AND WELL RECHARGE RATE

j:\wichita\921954.016\halstead\HrevGPMb.grf

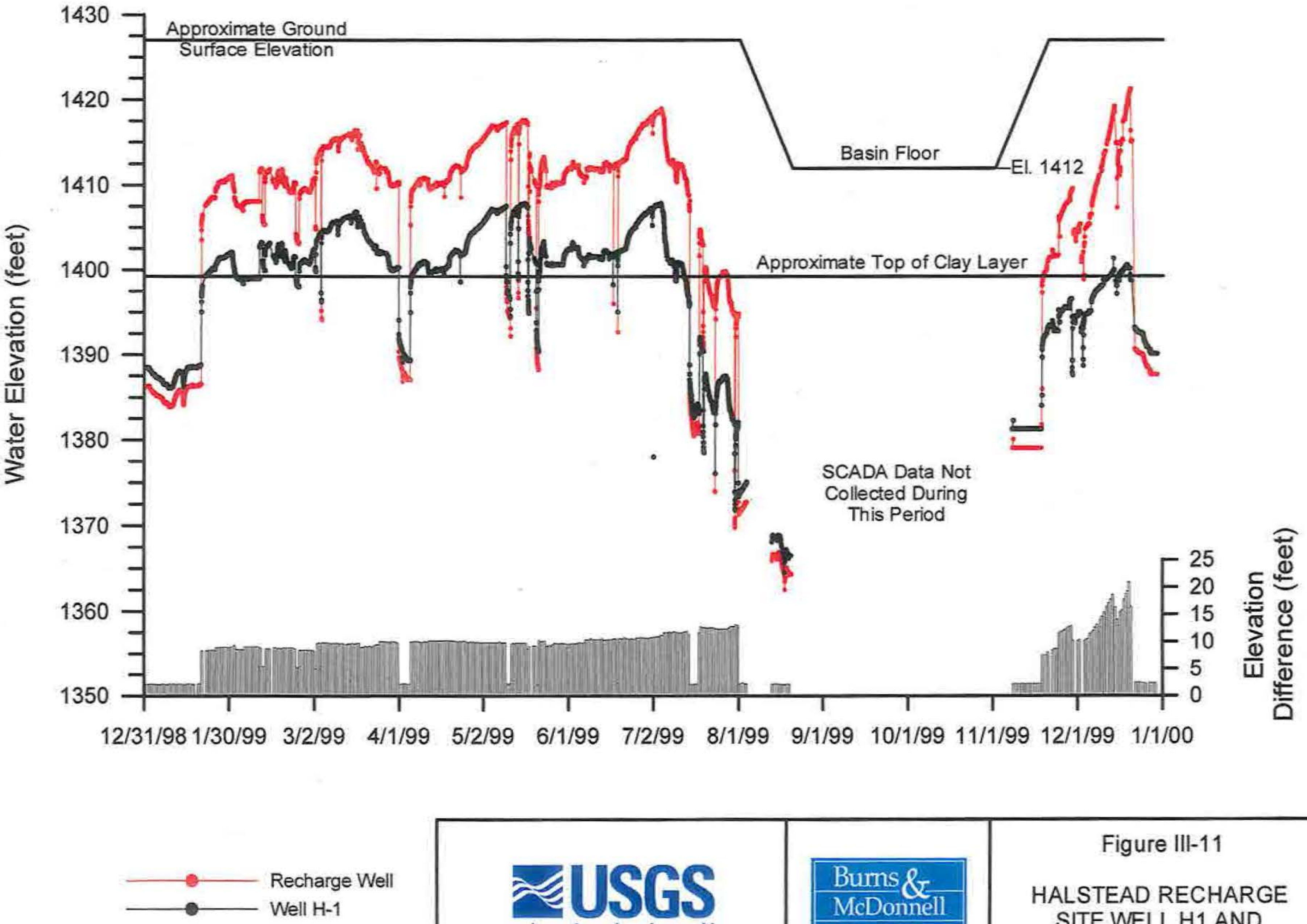
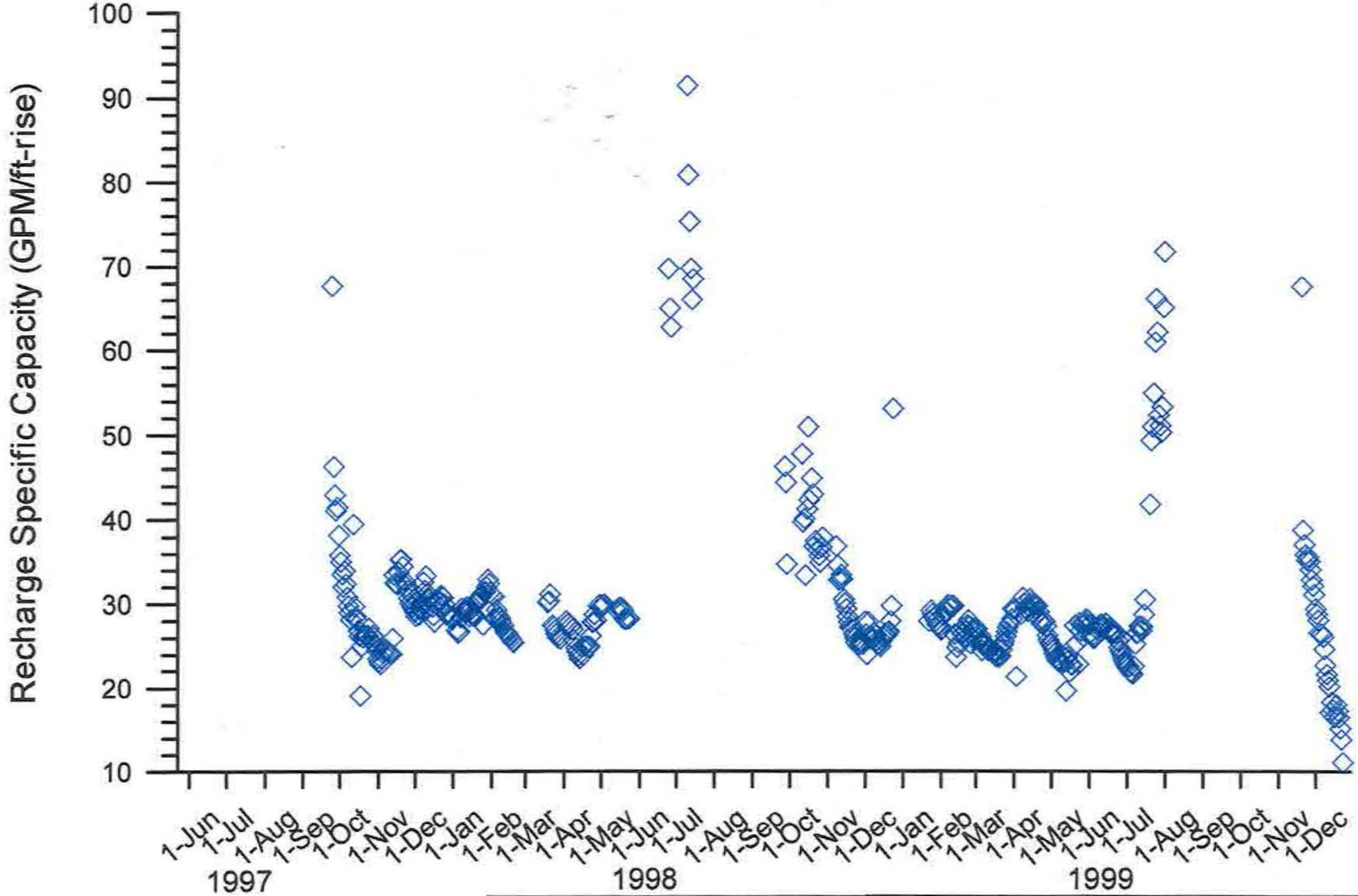


Figure III-11

HALSTEAD RECHARGE SITE WELL H1 AND RECHARGE WELL WATER ELEVATION COMPARISON

j:\wichita\921954.016\halstead\ElevH1RW.grf



◇ Specific Capacity

USGS science for a changing world

Burns & McDonnell SINCE 1898

Figure III-12

HALSTEAD RECHARGE SITE
RECHARGE
SPECIFIC CAPACITY

capacity data will continue to be monitored in the future to verify well performance.

C. SEDGWICK RECHARGE SYSTEM

1. Recharge Basins

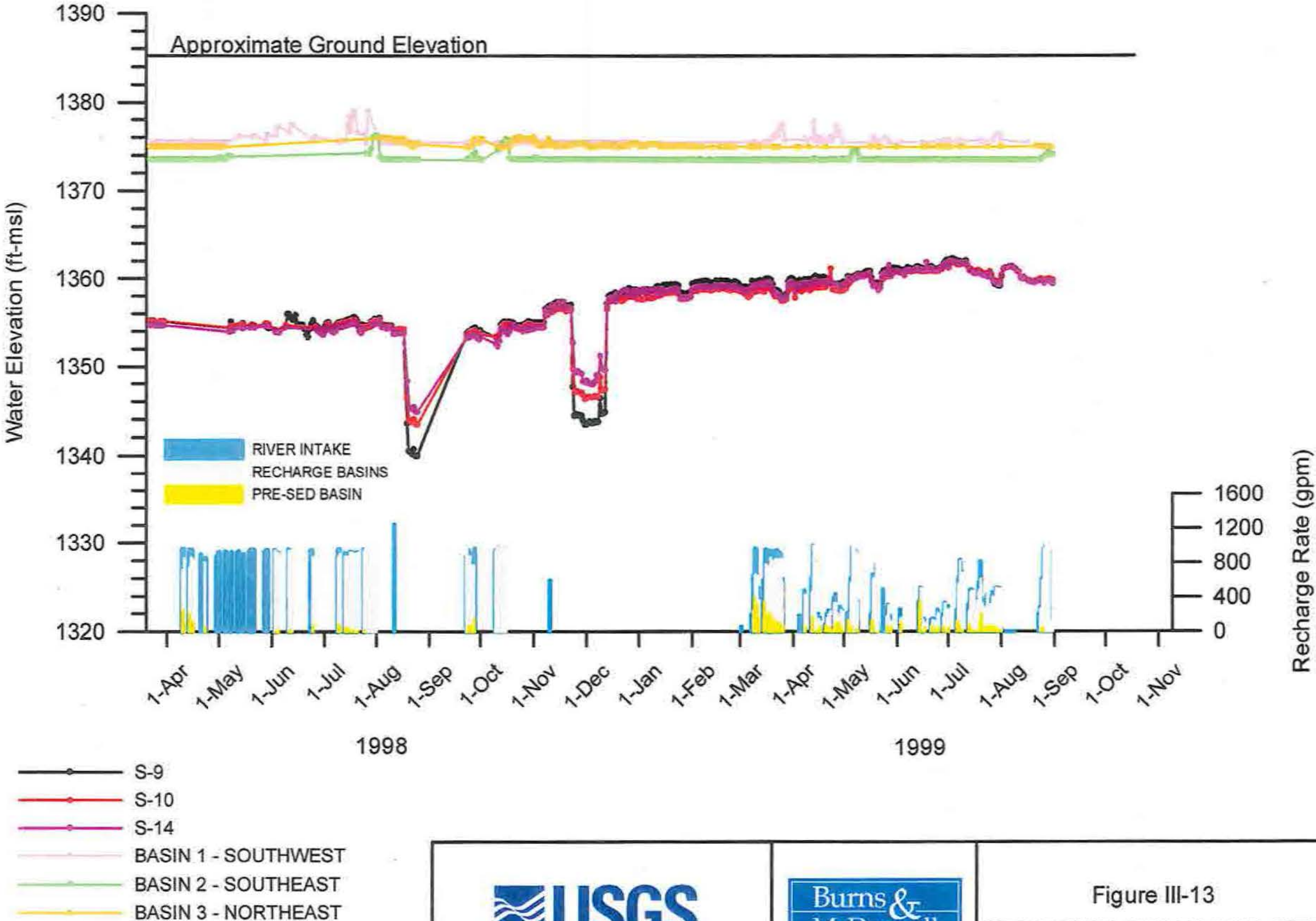
On March 9, 1999, recharge operations were restarted after the winter shut down, and system testing was conducted when the river stage was above 40 cfs at the Sedgwick gage. In contrast to the Halstead site, no extensive clay layers exist to impede vertical seepage of the recharge water. As a result, the formation of a significant "groundwater mound" has not been observed during testing.

Recharge rates observed at the Sedgwick Recharge Basins are higher than those obtained at the Halstead Basins. The recharge basins at Sedgwick infiltrate water at a rate of about 8 to 9 feet per day with low heads (shallow water levels). This rate could potentially be increased by raising the water level in the basins. The limiting factor at the Sedgwick Recharge Demonstration Site is the maximum supply of 1,000 gpm from the surface water intake. Recharge basins appear to be an excellent method of recharging the Equus Beds Aquifer in regions with no intermediate clay layers. Water elevations and recharge flow rates at the recharge basins with time, as well as the associated response of groundwater levels in selected monitoring wells are shown in Figure III-13.

2. Pretreatment of Recharge Water

The recharge water was treated with polymer at the pre-sedimentation unit at the intake site. When the pre-sedimentation unit was bypassed, polymer was added at the earthen pre-sedimentation basin at the recharge site. In 1998, alternative coagulants, specifically polymers, were evaluated, and one polymer was found to out perform the control polymer to a significant level (i.e., PRC 3070S). This polymer was recommended for future coagulation/flocculation tests at the demonstration facilities.

Extensive recharge occurred through the presedimentation basin before sediment from the surface water and powdered activated carbon began to plug the bottom. When this occurred, water levels rose high enough to be transferred to the



USGS
science for a changing world

Burns & McDonnell
SINCE 1898

Figure III-13
SEDGWICK RECHARGE SITE WATER ELEVATION AND BASIN RECHARGE RATE

i:\wichita\016\reports\figures\Fig15.grf 04/24/00

Treatment Facilities - Sedgwick Intake Site
November 4, 1997

Control Building Piping - Sedgwick Recharge Site
April 13, 1998

recharge basins. More than 17% of the Sedgwick recharge volume in year 1998 occurred through infiltration at the presedimentation basin.

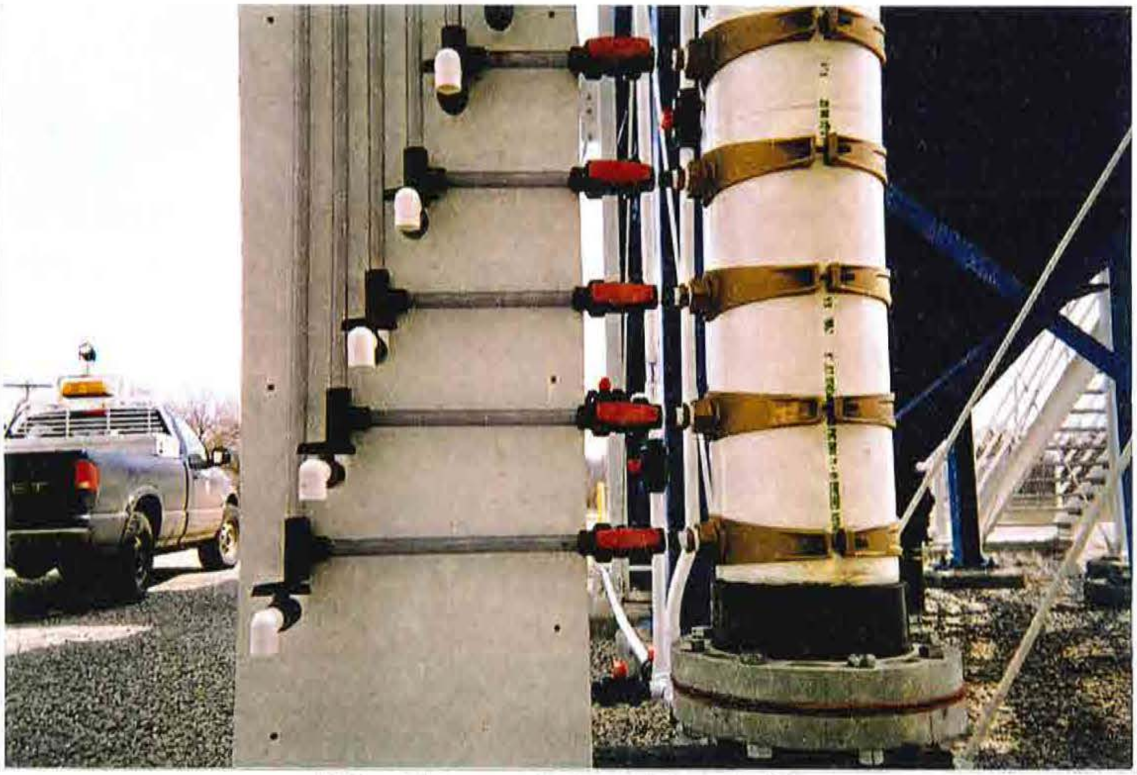
When surface water is used for recharge, a direct relationship occurs between the amount of surface water pretreatment required to provide the necessary recharge and the level of maintenance required to keep the recharge facilities operational. Although high levels of turbidity removal from the recharge water would potentially allow extended operation of the basins with relatively low maintenance, construction and operation of facilities to provide a higher level of treatment is typically more expensive. Direct recharge without treatment, on the other hand, would eliminate the expenses associated with the treatment facilities, but would require extremely high maintenance of the recharge basins or could potentially result in irreversible plugging of the recharge facilities (particle migration and accumulation deeper into the basin bottom).

The packaged pre-sedimentation unit installed as part of the demonstration facilities in the Sedgwick System is as parallel plate separator (Lamella) unit. The unit is located at the Sedgwick Intake Site to remove turbidity from the Little Arkansas River water prior to recharge. An earthen pre-sedimentation basin at the Sedgwick Recharge Site is used to settle out powdered activated carbon (PAC) which is fed into the flow of pre-settled water to reduce herbicides (mainly atrazine) as water is pumped to the recharge site.

In addition to the operation of the packaged water treatment unit at the Sedgwick Recharge System, several small-scale column infiltration tests were conducted to study how surface water pretreatment affects long-term recharge rates and the recharge basin maintenance requirements. Two testing columns were constructed and used at the Sedgwick Intake and Recharge Sites as a tool to conduct "compressed time testing." Data collected during these investigations were evaluated and used to develop recommendations on the level of surface water pretreatment required.

a. Filter Column Setup

Two sand infiltration columns were built at the Sedgwick System, one at the Sedgwick Intake Site next to the Lamella unit and the other at the



Filter Column - Sedgwick Intake Site
May 24, 1999

Filter Column Adjacent to Treatment Facilities - Sedgwick Intake Site
May 24, 1999

Sedgwick Recharge Site next to the pre-sedimentation facilities. These infiltration columns were used to test the Lamella effluent separately from the entire system and to compare data with tests of pre-sedimentation effluent turbidity.

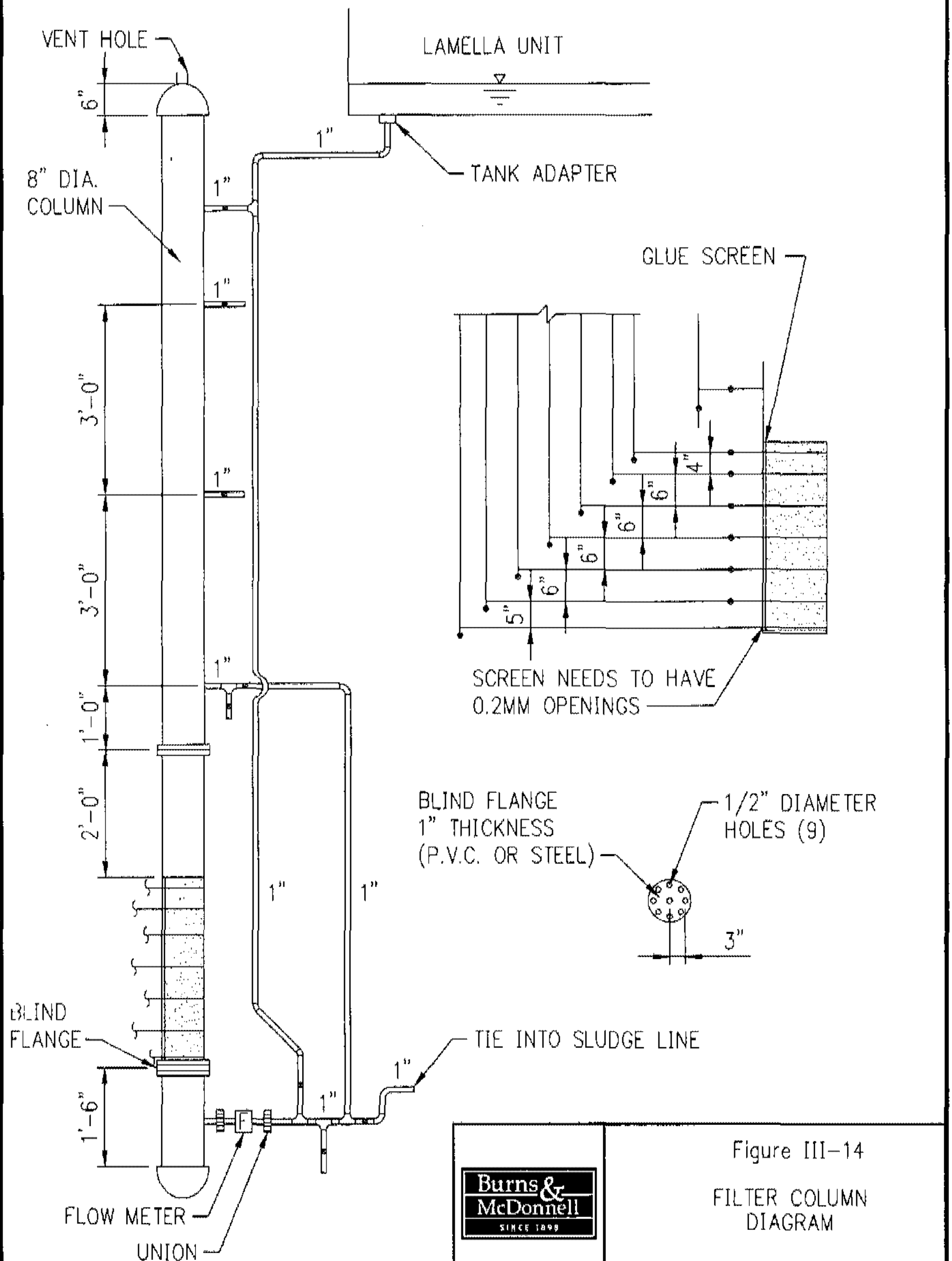
Each column was constructed of 8-inch diameter PVC pipe and was mounted vertically (24 feet in height). The columns contained 3 feet of earth-fill material (sand) from the Sedgwick recharge basins. A diagram of the filter column is shown in Figure III-14. One column was connected to the effluent box of the Lamella unit at the intake site. The second column was attached to the pump discharge after the pre-sedimentation basin at the recharge site. Both columns were provided with backwash capabilities.

Immediately above the earth-fill material in each column is a piezometer which measured the potentiometric level above the fill. Six additional piezometers were situated throughout the length of the earth-fill material to measure the potentiometric head loss at different depths and allow for evaluation of turbidity/particle removal throughout the bed. Beneath the earthen material, a small layer of gravel and a media retaining cap were installed to prevent loss of finer material. A detailed description of the infiltration columns setup is provided in a memorandum issued on May 13, 1999.

b. Filter Column Field Testing

The two sand filter columns were used to test the "plugging potential" of water with varying turbidities and different treatment processes on recharge basin sands. Tests were performed at high flow rates and low flow rates. In the high flow rate tests, the water column was maintained approximately 13 feet above the top of the earth-fill material (high head). Lower flow rate tests had approximately 3 feet of water above the top of the earth-fill material.

Field testing at the Sedgwick Intake Site infiltration column was started on March 25 and 26, 1999. During these initial tests, the column was



Burns & McDonnell SINCE 1898

Figure III-14

FILTER COLUMN
DIAGRAM

J:\WICHITA\921954.014\Procws\WFLTRCOL.dwg 04-11-2000 11:20 jro used to test the treated Lamella water and also the viability of recharge without any treatment at low raw-water turbidities. Additional field testing of the infiltration column at the Sedgwick Intake Site was conducted when raw water turbidity became elevated with high flow in the river. These tests began on May 24, 1999, were completed on May 28, 1999, and involved six additional infiltration test runs with treated water from the Lamella unit. The tests were conducted to investigate the following conditions:

- Effects of higher turbidity raw water compared to the initial runs conducted in March 1999,
- Impacts of reduced flow rate on system performance,
- Performance of a new polymer that appeared to provide better water clarity, and
- Effectiveness of a filter fabric on top the sand media.

Four infiltration runs with treated water from the pre-sedimentation basin were conducted at this site to study the effects of using a new polymer (PRC 3070 S) and a filter fabric on the top of the sand media.

Particle counting was conducted during some of the test runs to determine the nature of particulates in the raw water, treated water from the Lamella unit, treated water from the pre-sedimentation basin, and discharge from the column tests at the recharge site. Particle count analyses were used to determine the distribution of particle sizes in particular samples, influent, effluent and backwash. Particle countets have sensors available in different-size ranges which allow measurement of particle concentrations in these ranges.

c. Column Infiltration Test Observations

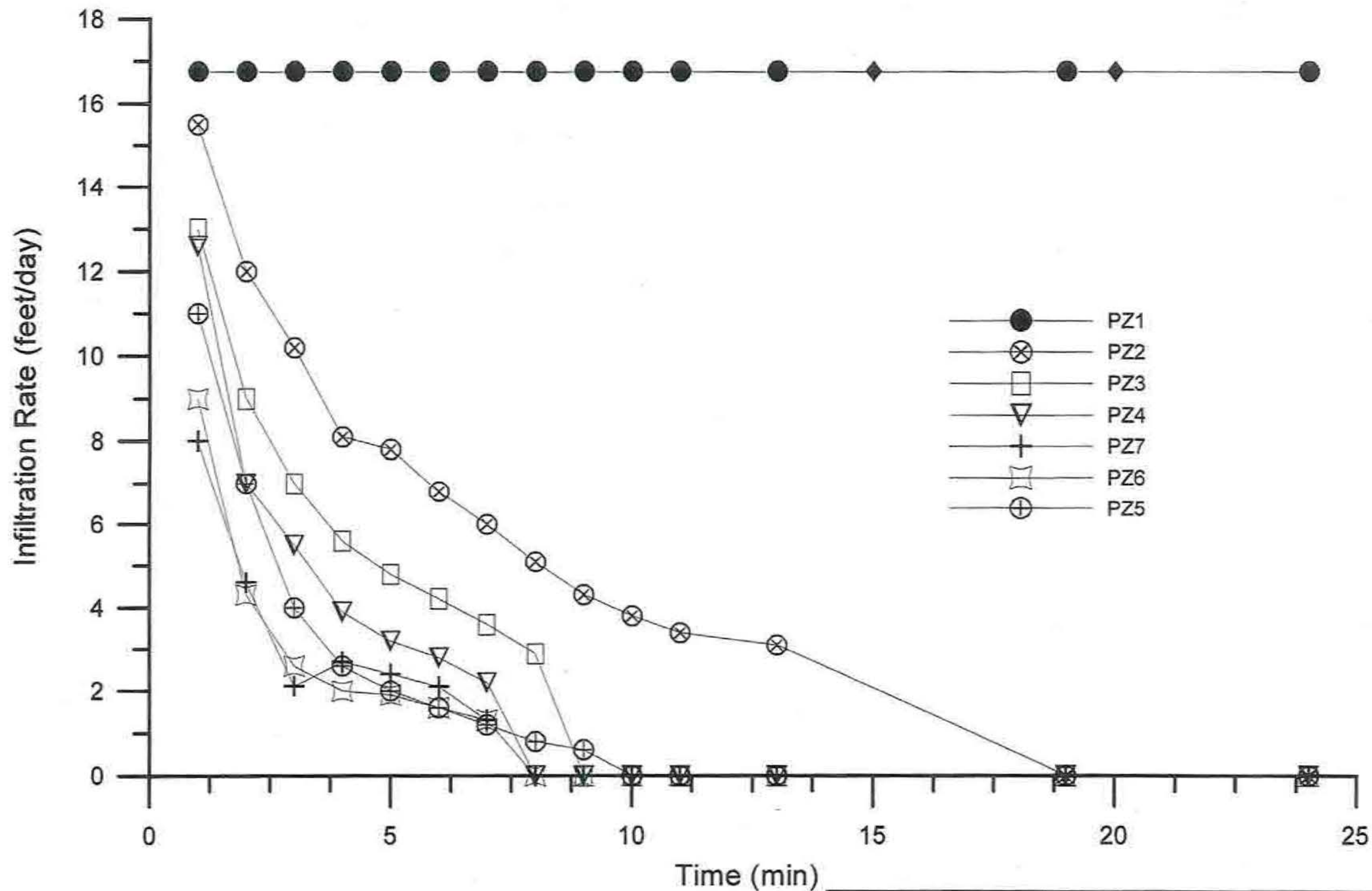
1.) Viability of Recharge Without Treatment

When raw water from the Little Arkansas River was processed through the intake site column, the piezometer readings slowly decreased after initial start-up, exhibiting a higher head over a longer period of time as shown in Figure III-15 (raw water test on 3/26/99). The volume of water passed through the column was high and the amount of particles drawn deep into the bed appeared to be significant. This indicates that particle removal takes place throughout the entire depth of the sand media when raw water is applied to the column. This is not a desirable effect because particles that are below the first 2 to 3 inches cannot be easily removed, causing increased maintenance cost for media cleaning.

When raw water was applied to the column, infiltration rates of the raw water stream were initially higher than those observed when treated water from the packaged pretreatment (Lamella) unit was used. Since particles in raw water penetrate deeper into the media than floc particles which pack on top of the media, the initial headloss through the column is relatively small which results in higher initial infiltration rates. However, the loss of infiltration capacity over time was observed to be greater for the raw water compared to the water treated with polymer as shown in Figure III-16 (initial four-test summary). Based on this data, all surface water should be treated before recharge.

2.) Low vs. High Turbidity Recharge Water

The turbidity of the water applied to the intake site column during the initial tests on March 25 and 26, 1999 was lower than the turbidity observed during the tests conducted in May 1999. Comparison of data for these tests revealed that high raw water turbidities produce treated waters which are easier to recharge (higher infiltration rates and larger total recharge volumes) than those produced by low raw water turbidities. Floc formation in low turbidity waters is slower and floc size is smaller, resulting in greater floc carry over. This results in recharge water with turbidity that causes earlier plugging of the test column.

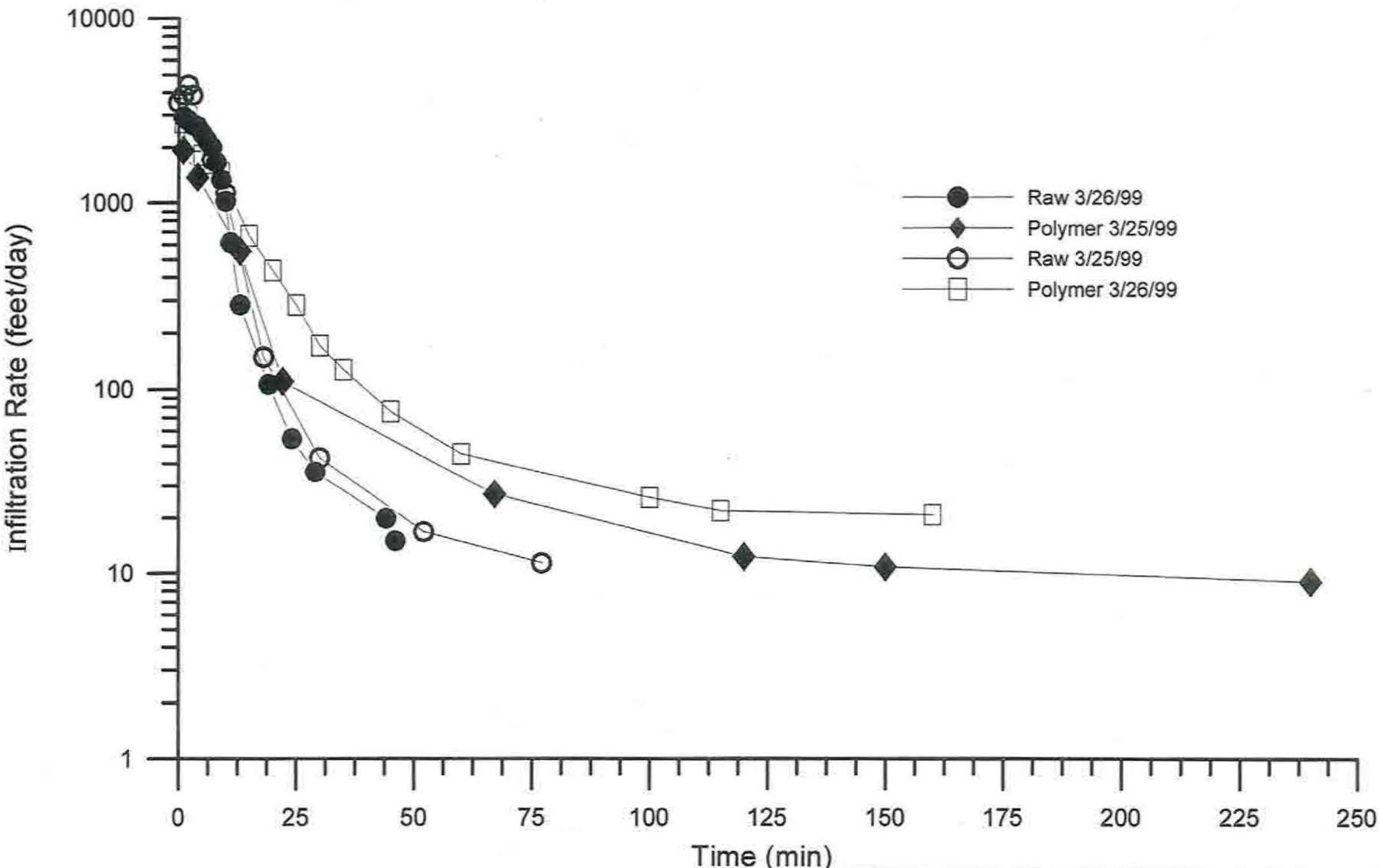


Burns & McDonnell SINCE 1898

Figure III-15

PIEZOMETER LEVELS
RAW WATER TEST - 3/26/99
SEDGWICK INTAKE SITE

J:\WICHITA\921954.016\REPORT\FIGURES\FIGIII_15.GRF 4/20/00



Burns & McDonnell SINCE 1898

Figure III-16

COLUMN TEST - LAMELLA
SEDGWICK INTAKE SITE

J:\WICHITA\921954.016\REPORT\FIGURES\FIGIII 16.GRF 4/21/00

3.) Effects of Reduced Flow Rate

Reducing the flow rate through the treatment system by about 50 percent, from 1,000 gpm to 530 gpm, resulted in a significant drop in treated water turbidity. The lower turhidity of the treated water resulted in a recharge volume increase of 1.5 times at the intake site and 5.5 times at the recharge site columns. Reduced PAC carryover at lower flow rates is believed to be the principal reason for higher recharge volumes.

The change in flow rate through the Lamella unit from 1,000 gpm to 530 gpm increased the rapid mix time from 30 seconds to 1 minute and the flocculation time from 2 minutes to 4 minutes. The plate overflow rate was reduced from 0.5 gpm/ft^2 to 0.25 gpm/ft^2. To evaluate which of these changes had the biggest impact, half of the Lamella unit weirs were plugged to increase the plate overflow rate back to 0.5 gpm/ft^2. The increase of overflow rate had no effect on the low Lamella effluent turbidity, which leads to the conclusion that rapid mix and flocculation times are the limiting factors for turbidity reduction in the Lamella treatment unit.

4.) Polymer Type

Two polymers were selected for testing in the pilot unit based on jar testing conducted in July, 1998. Superfloc C-587 was used at the water treatment plant and was also used for water treatment at the Sedgwick Recharge System. As an alternative, PRC 3070C, supplied by Polymer Research Corporation, was tested in the pilot treatment system.

The PRC 3070 S performed better than Superfloc C-587, yielding better recharge rates and total volume of water passing through the test columns. Analysis showed that particles generated from the addition of PRC 3070 S were large in size and produced less headloss inside the column.

5.) Effects of Filter Fabric

The use of a filter fabric at the intake site column reduced both the recharge rates and the total volume of water recharged through the column. The filter fabric was effective in reducing the solids which penetrated into the sand media and may be an option to be considered further for surface water recharge.

6.) Effects of Water Levels (Heads)

Column testing with high water levels (high head) has a tendency to "pack" solids on top of the sand media. Lower water levels above the media allow longer recharge times before plugging occurs. The solids do not pack as tightly in the lower head application and lower head loss occurs. This effect is described in water treatment literature and emphasizes the need to remove as much turbidity as possible to prolong recharge time between basin media cleaning events.

d. Basin Bottom Sampling

In addition to the column tests, sampling was conducted in the existing Sedgwick Recharge Basins to determine the depth at which particle removal occurred in the basins. The southwest basin was essentially plugged at the time of the sampling and the northeast basin had never been used. Both basins were sampled using a 1-inch diameter piece of schedule 80 PVC pipe. The pipe was driven into the basin bottom to collect a sample of the bottom material. The procedure was repeated in three-inch increments to a depth of 1 foot. Each 3-inch depth of sample was washed with 2 liters of low turbidity water to remove the fine particles. The rinseate was then analyzed by the particle counting instruments to determine the distribution of sediment from the recharge water with depth.

Analysis of the bottoms of Basins 1 and 2 showed particles of powdered activated carbon (PAC) carried over from the earthen pre-sedimentation basin. PAC particles are usually less than 50 microns in size and sand particles are 300 microns, or more, in size. The smaller size allows PAC to penetrate several inches into the sand bottom which eventually reduces the recharge rate. Because of this potential plugging concern, effective removal of PAC is important in extending the operation of the recharge basins between maintenance events. A detailed description of the testing procedures was provided in two memorandums issued on May 13, 1999 and July 7, 1999.

The turbidities detected in the water used to wash the samples from each basin are shown in Table III-2. In these tests, the southwest basin was operated while the northeast basin (control) had not yet been used for recharge.

Table III-2

Basin Bottom Core Sampling Results

Depth of Sample (inches)	Southwest Basin Turbidity (NTU)	Northeast Basin Turbidity (NTU)
0 to 3	>1000	325
3 to 6	377	804
6 to 9	244	660
9 to 12	357	618

The test results indicate particles were removed from the recharge water in the top two to three inches of the bottom sand. The layers sampled beneath the top three inches were actually cleaner in the basin that received recharge than in the basin that had never been used. This is believed to be a result of "washing" by recharging large volumes of water through these layers. Based on the observations made during the column tests, most of the plugging in this basin is believed attributable to deposition of PAC. After the tests, the basin was dewatered, dried and recharge water was reapplied with no substantial recharge improvements. If most of the plugging were due to polymer accumulation, the results would be different. Polymer consists of organic molecules that break down by microbial action and by dewatering or drying. Infiltration characteristics typically increase in a basin that is dried for a period of time.

3. Simulated Surface Water Recharge Trenches

Recharge trenches have shown to be an effective method of maintaining high recharge rates with diversion well water in areas where subsurface clay layers cause significant groundwater mounding. Use of recharge trenches, however, was not considered for treated surface water because of expected problems with plugging caused by water that contains some (carry-over) turbidity. For the same reason, treated surface water was not considered for application with recharge wells.

To evaluate the potential of using treated surface water in trenches, four test cells (or simulation surface water trenches) were installed in the southwest basin at the Sedgwick Recharge Site by the City's well field crew in August, 1999. The cells were set up using the 11.5 feet diameter steel tube assemblies that were used in the initial infiltration tests in 1995. The four cells were connected to the basin recharge inlet pipes by PVC piping. Each cell had a water meter and a valve to control flow. Different filter fabrics were installed in each of the three cells. No fabric was installed in the fourth cell which was used as a baseline or control cell.

Limited testing of the simulated surface water trenches occurred in September, 1999 before the Sedgwick Recharge System was shut down and winterized. Additional testing is planned in year 2000 to determine the viability of this recharge method.

D. WATER QUALITY

Over 3,700 water samples have been collected and analyzed as part of the demonstration project. Approximately 700 water samples were collected in 1999. Baseline (or background) water quality data was collected in 1995, 1996 and part of 1997. Once demonstration facilities became operational in mid-to late-1997, additional water quality data were obtained in part of 1997, 1998 and 1999 to determine possible impacts caused by system operation.

Graphs of chlorides, triazine (herbicide class that includes, among other compounds, atrazine and cianazine), and specific conductance in the Little Arkansas River from samples at the Highway 50 gage are respectively shown in Figures III-17, III-18 and III-19. The figures show the test results for the last several years in addition to the 1999 data. River flow is also presented to illustrate the concentration variation of these parameters with the volume of stream flow.

Similar graphs of chlorides, triazine, and specific conductance analyzed from samples obtained at the Sedgwick gage are respectively shown in Figures III-20, III-21 and III-22. As seen in Figures III-17, III-19, III-20 and III-22, increases in river flow are usually accompanied by decreases in both chlorides and specific conductance due to dilution. Similarly, dry weather periods are generally paralleled by higher concentrations of chlorides and specific conductance.

In contrast to the above observations, Figures III-18 and III-21 show that increases in river flow are usually accompanied by increases in triazine concentrations. This can be explained by the fact that that pesticide loads are expected to increase with increasing surface runoff from agricultural areas, particularly at the beginning of each runoff event.

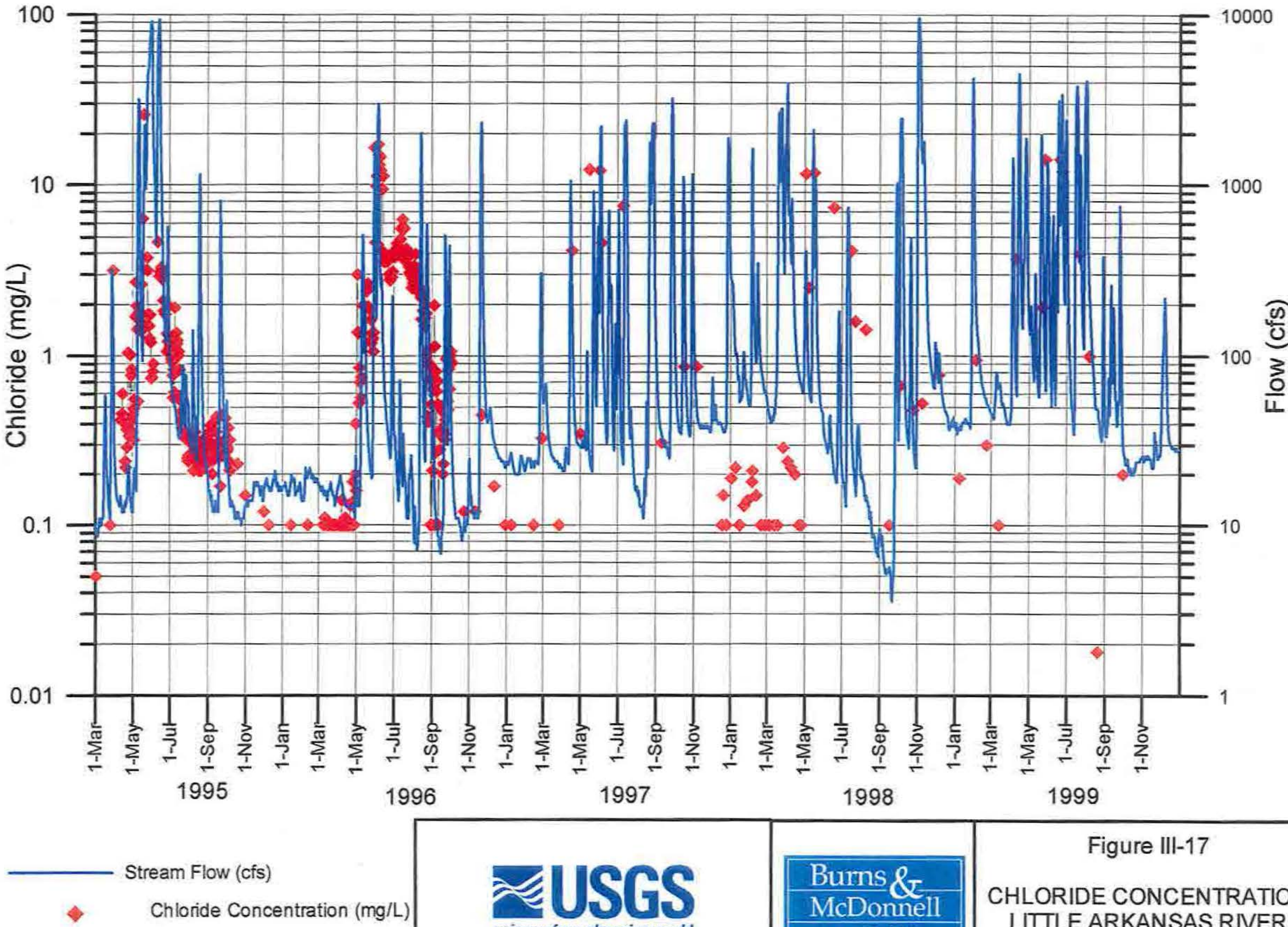
Atrazine and chloride, among other water quality parameters, were extensively monitored at the two sources of recharge water, the Halstead diversion well and the Sedgwick surface water treatment system. Atrazine concentrations for various types of water are shown in Figure III-23 for the Halstead Recharge System and in Figure III-24 for the Sedgwick Recharge System. Chloride concentrations for various types of water are shown in Figure III-25 for the Halstead Recharge System and in Figure III-26 for the Sedgwick Recharge System. These figures summarize the effect of demonstration recharge operations on water quality with respect to background water quality levels.

Baseline concentrations of atrazine in the surface water (at the Highway 50 gage near Halstead) during the study ranged from less than 0.10 to 46 μg/L[1] and chlorides ranged from 8 to 400 mg/L (Ziegler et al., 1999). Atrazine concentrations are typically higher at high river flows, depending on the timing of agricultural applications. Chlorides usually decreased with flow with higher chloride concentrations occurring at low stream flows.

[1] As determined by the ELISA detection method

Simulated Surface Water Trench - Sedgwick Recharge Site
October 20, 1999

Floor of Simulated Surface Water Recharge Trench
Sedgwick Recharge Site

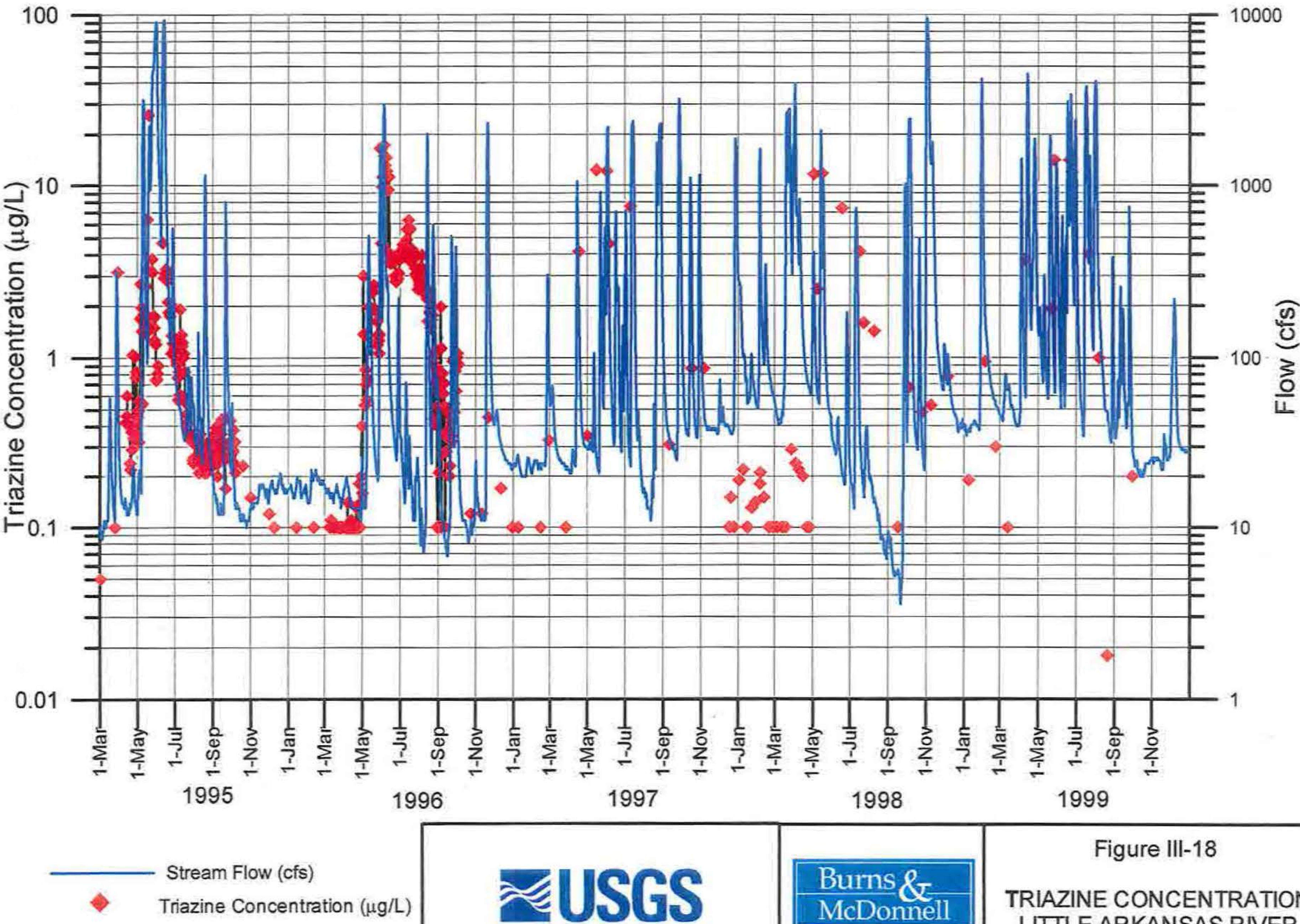


USGS science for a changing world

Burns & McDonnell SINCE 1898

Figure III-17

CHLORIDE CONCENTRATION
LITTLE ARKANSAS RIVER
AT HIGHWAY 50 NEAR
HALSTEAD, KANSAS



USGS science for a changing world

Burns & McDonnell SINCE 1898

Figure III-18

TRIAZINE CONCENTRATION
LITTLE ARKANSAS RIVER
AT HIGHWAY 50 NEAR
HALSTEAD, KANSAS

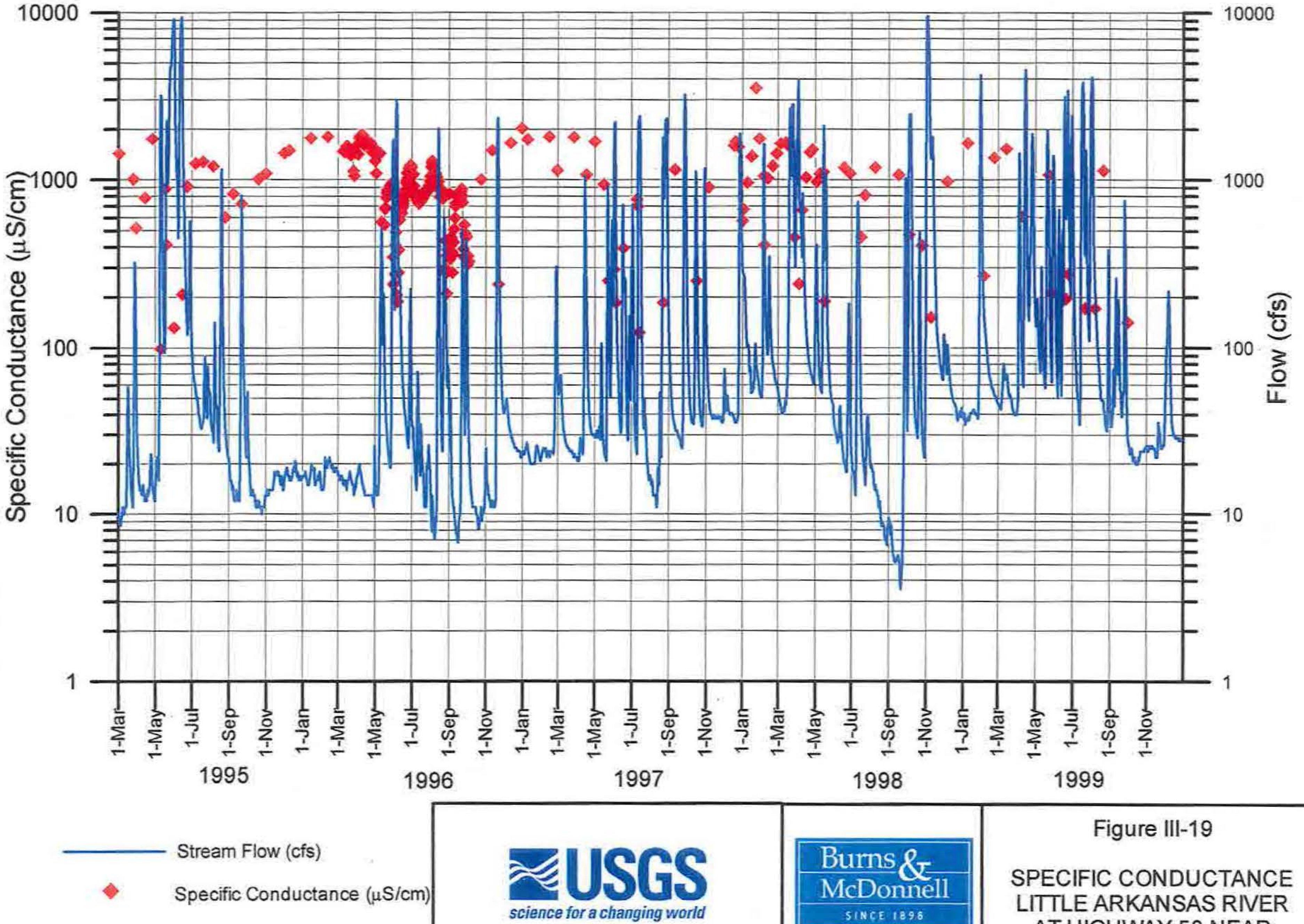


Figure III-19

SPECIFIC CONDUCTANCE
LITTLE ARKANSAS RIVER
AT HIGHWAY 50 NEAR
HALSTEAD, KANSAS

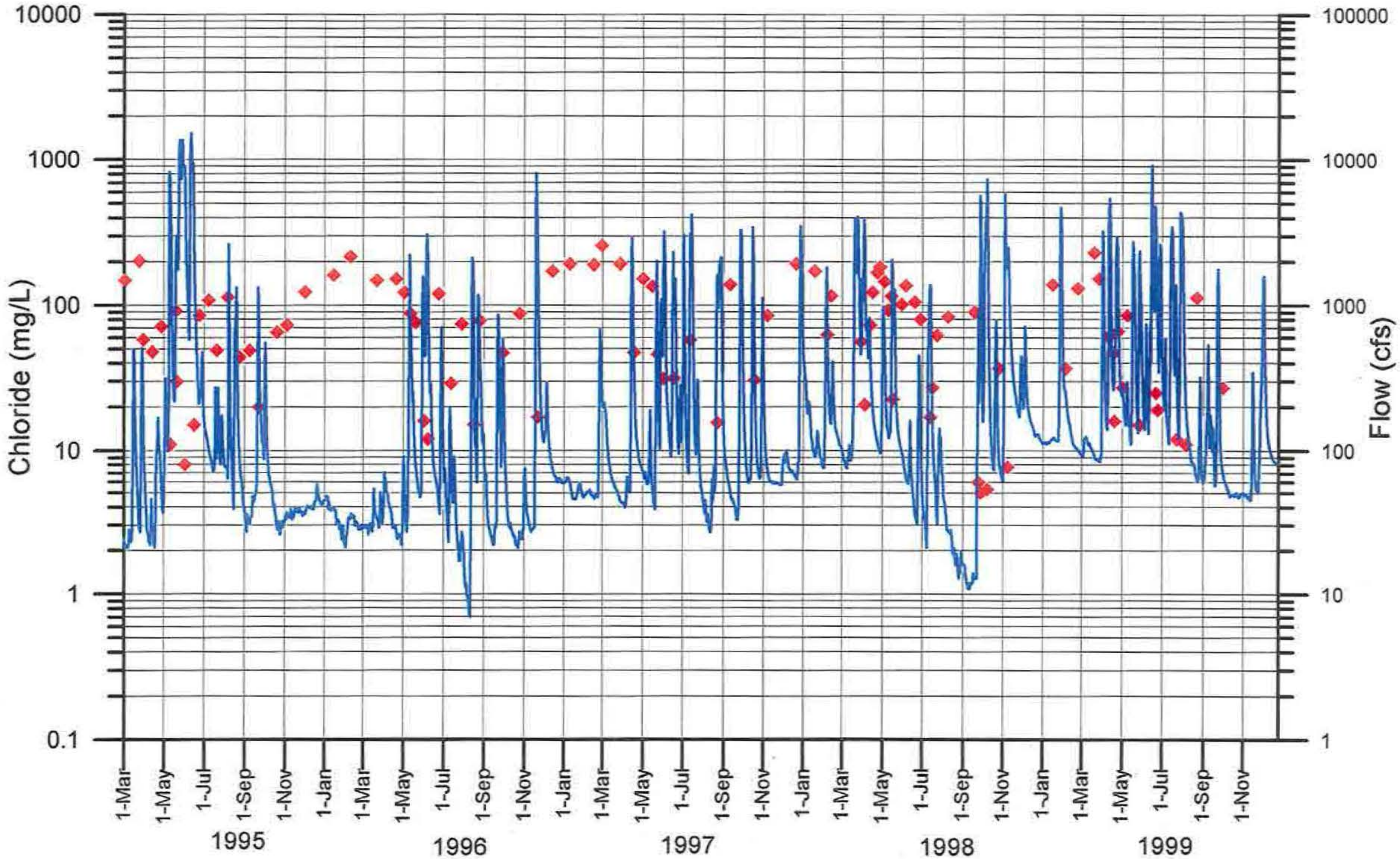


Figure III-20

CHLORIDES SCREEN
LITTLE ARKANSAS RIVER
NEAR SEDGWICK, KANSAS

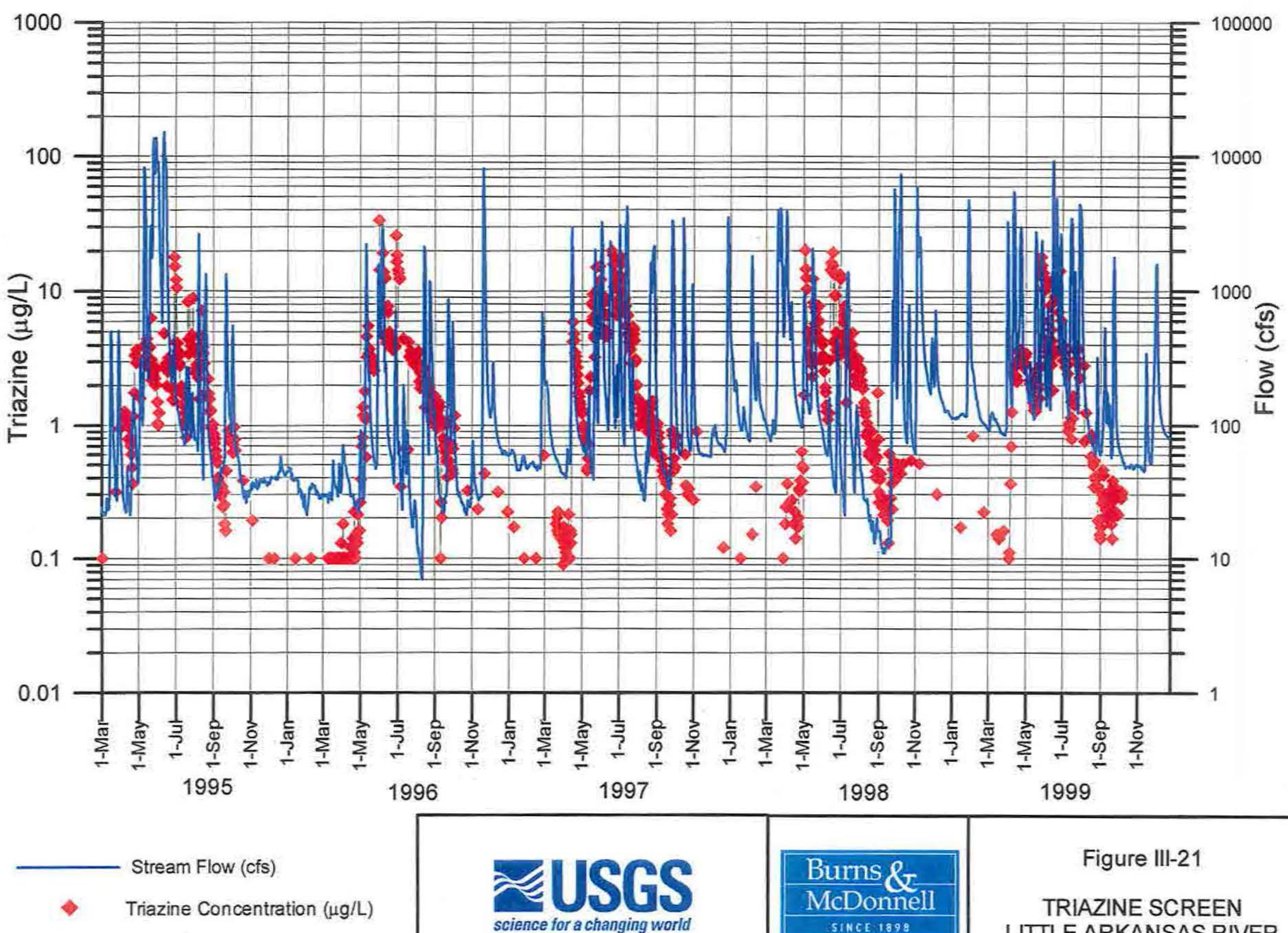


Figure III-21

TRIAZINE SCREEN
LITTLE ARKANSAS RIVER
NEAR SEDGWICK, KANSAS

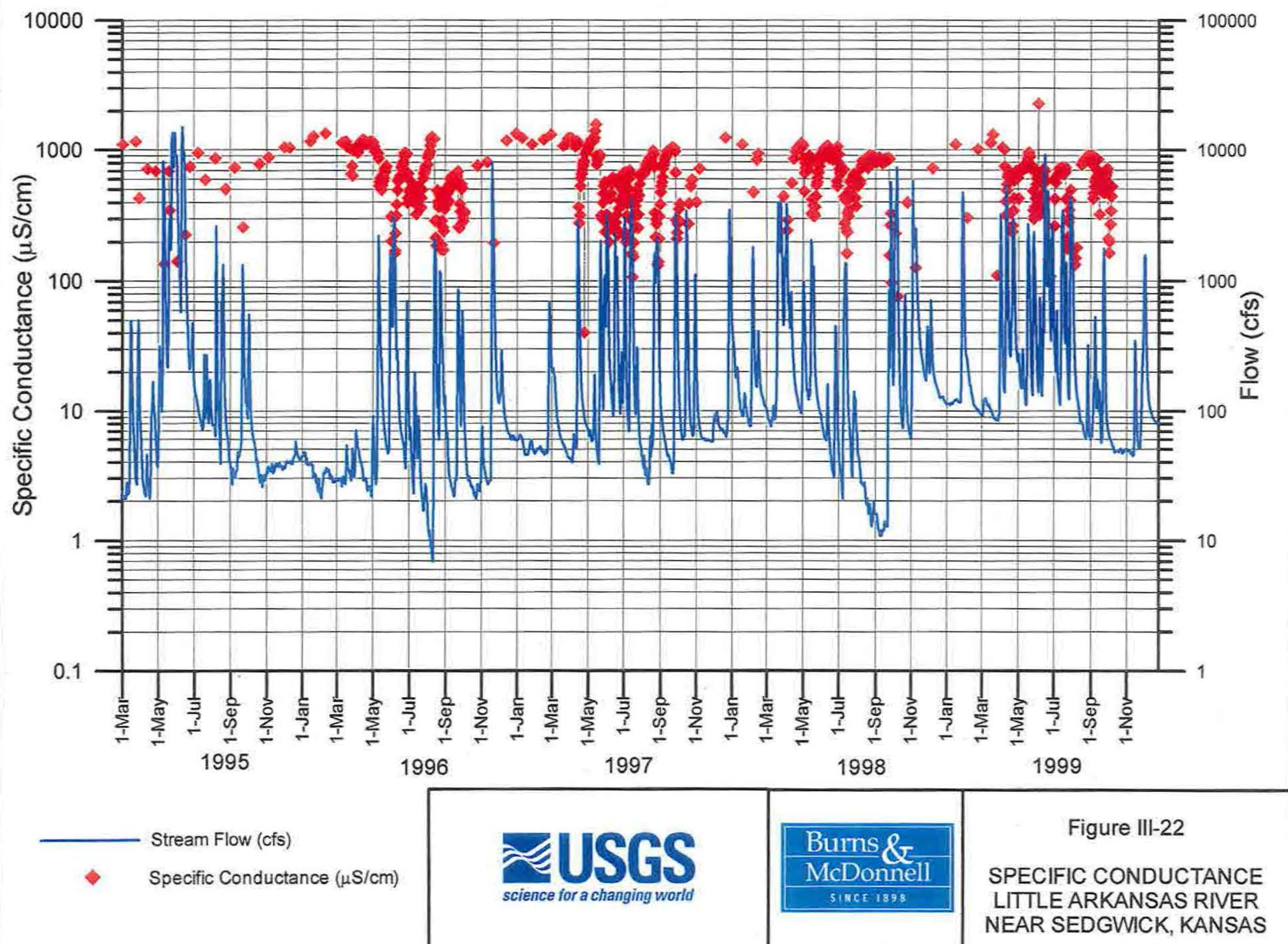
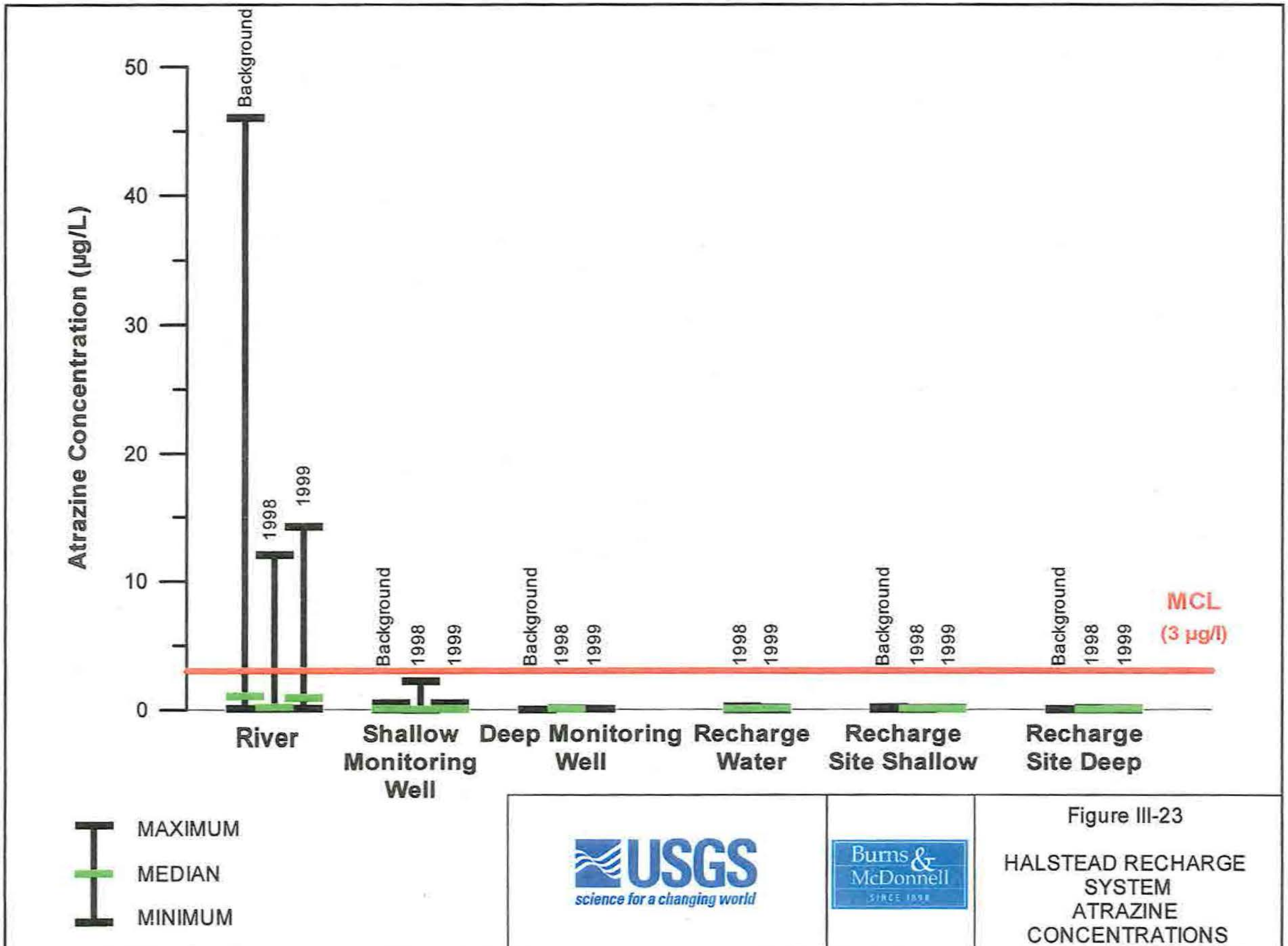


Figure III-22

SPECIFIC CONDUCTANCE
LITTLE ARKANSAS RIVER
NEAR SEDGWICK, KANSAS

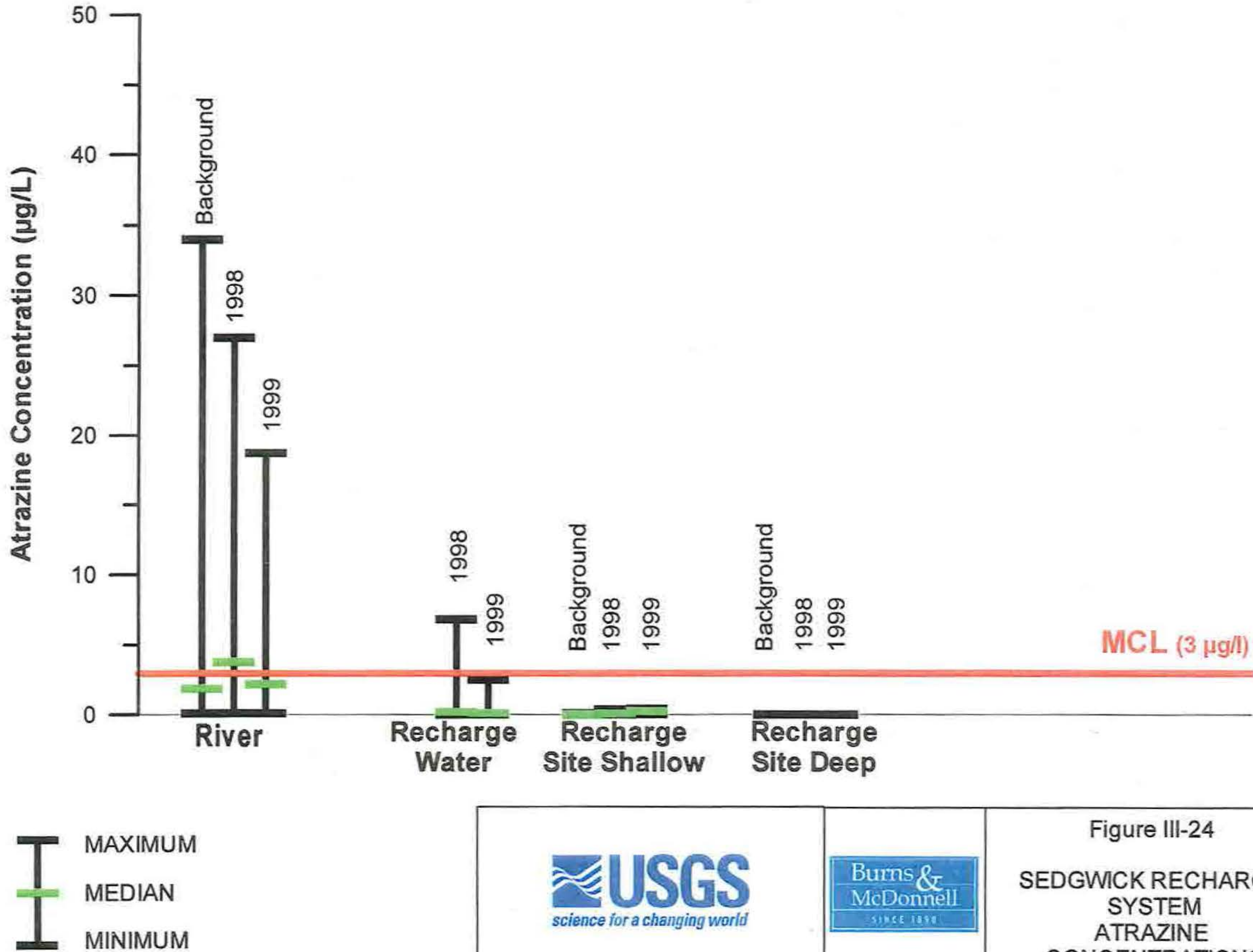


USGS science for a changing world | Burns & McDonnell SINCE 1898

Figure III-23

HALSTEAD RECHARGE SYSTEM ATRAZINE CONCENTRATIONS

J:\WICHITA\921954.016\REPORT\FIGURES\FIGIII-23.GRF 4/20/00



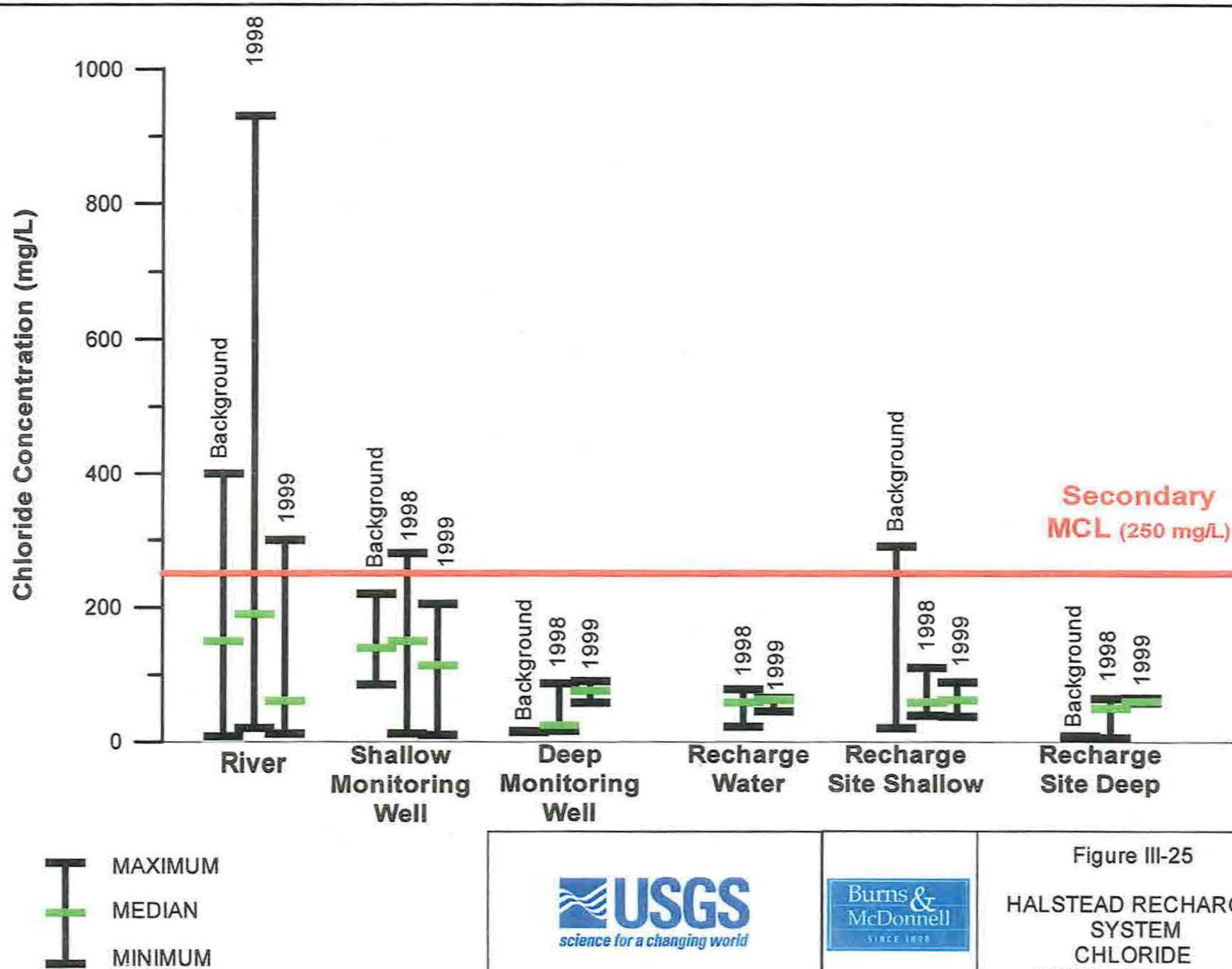
USGS science for a changing world

Burns & McDonnell SINCE 1898

Figure III-24

SEDGWICK RECHARGE SYSTEM ATRAZINE CONCENTRATIONS

J:\WICHITA\921954.016\REPORT\FIGURES\FIGIII-24 4/21/00



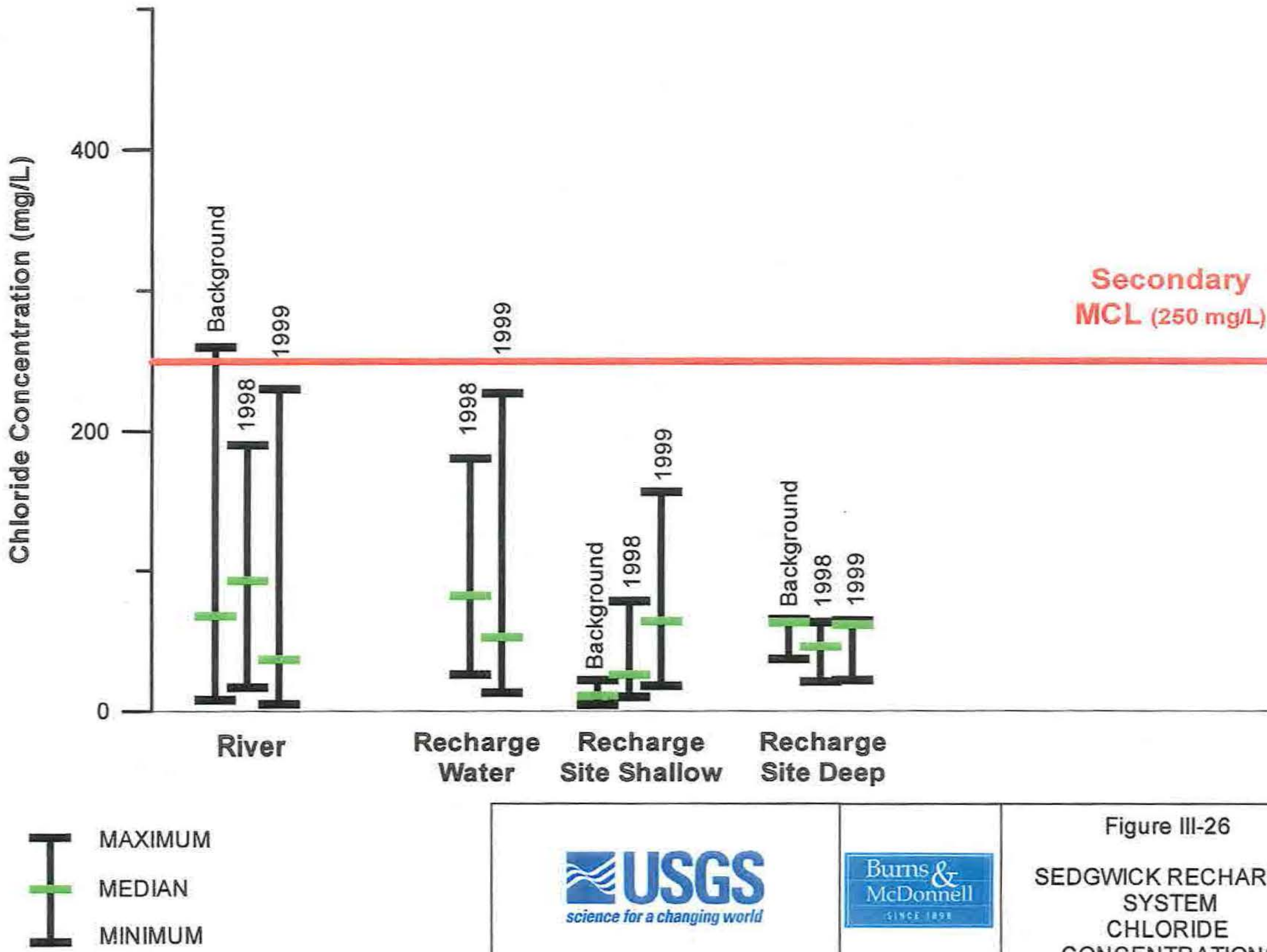
USGS science for a changing world

Burns & McDonnell SINCE 1898

Figure III-25

HALSTEAD RECHARGE SYSTEM CHLORIDE CONCENTRATIONS

J:\WICHITA\921954.016\REPORT\FIGURES\FIGIII-25.GRF 4/20/00



USGS science for a changing world

Burns & McDonnell

Figure III-26

SEDGWICK RECHARGE SYSTEM CHLORIDE CONCENTRATIONS

J:\WICHITA\921954.016\REPORT\FIGURES\FIGIII-26.GRF 4/20/00

Atrazine concentrations in the diversion well discharge ranged from less than 0.1 to 0.21 μg/L[1] (based on USGS data through July 1999) and were significantly less than the EPA's MCL of 3 μg/L. Chloride concentrations in the diversion well discharge ranged from 22 to 78 mg/L (based on USGS data through July 1999), which is similar to the average aquifer chloride concentration of about 55 mg/L (Burns & McDonnell, 1994).

Atrazine concentrations in the treated surface water at the Sedgwick Site ranged from less than 0.1 to 6.8 μg/L (based on USGS data through July 1999). Atrazine was detected above the MCL of 3 μg/L in only one occasion (6.8 μg/L) due to a temporary failure of the powered activated carbon feed system. All other detections were well below the MCL level. Chloride concentrations in the treated surface water at the Sedgwick Site ranged from 13 to 227 mg/L (based on USGS data through July 1999), which is below the EPA's Secondary Maximum Contaminant Level (SMCL) of 250 mg/L (Ziegler, et al 1999) for chloride.

Water quality results at both the Halstead and Sedgwick Recharge Sites indicate that although concentrations of chloride and atrazine have increased in some monitoring wells, concentrations remain within the range of baseline values in the Equus Beds Aquifer and are significantly less than drinking water limits. Although river atrazine concentrations at both recharge sites were near to or sometimes above the MCL of 3 μg/L, adsorption and/or degradation at the river bank (Halstead Site) or recharge water treatment and dilution in the aquifer (Sedgwick Site) resulted in groundwater concentrations much lower than the MCL.

Major ion and trace element chemistry of source water and receiving water was also analyzed as part of the water quality control program to determine the compatibility of waters for artificial recharge. Based on these evaluations, the source water and the receiving groundwater are believed to be generally compatible at both recharge sites.

* * * * *

PART IV

SURFACE WATER TREATMENT TECHNOLOGY EVALUATION

PART IV

SURFACE WATER TREATMENT TECHNOLOGY EVALUATION

A. TREATMENT ISSUES

The concept of using surface water from the Little Arkansas River as a source of recharge water for the Equus Beds ASR Project has been tested at the Sedgwick Site of the Equus Beds Groundwater Recharge Demonstration Project for the past two years. In general, the parallel plate treatment system (with polymer and PAC addition) used at the demonstration facilities is effective in achieving turbidity and contaminant (herbicides, mainly atrazine) reduction to levels suitable for aquifer recharge. Operational monitoring and testing of these recharge facilities, however, have raised concerns regarding cost and maintenance as follows:

- The surface water from the Little Arkansas River which will be used in the Equus Beds ASR system has highly variable turbidity with solids increasing with increasing stream flow. The solid particles in the water are charged over all flow ranges which slows settling and retards clarification. This high charge requires polymer addition to neutralize the electric charges to allow flocculation and sedimentation. Polymer dosages up to 30 mg/L are required to achieve turbidity reductions below 10 NTU in the pre-sedimentation basin effluent. Feeding polymer at a rate of 30 mg/L results in high polymer costs for the City, averaging about $0.09 per 1,000 gallons.

- Powder Activated Carbon (PAC) is currently fed to the demonstration system to remove herbicides (mainly atrazine) from the surface water prior to recharge. Analysis of the bottom of Basins 1 and 2 of the Sedgwick Site showed PAC carryover intermixed with the sand. This is not desirable because PAC (usually less than 50 microns in size) is smaller than sand particles (at more than 300 microns) and could penetrate several inches into the sand bottom. This could potentially result in the basins being plugged to greater depths than caused by sediment and biological activity alone, resulting in reduced recharge rates and increased maintenance cost.

- An on-going environmental movement is underway to ban, or severely restrict, the use of atrazine as a herbicide for agricultural purposes. Atrazine may be replaced by some other herbicide in the future. Because of this, the design of future surface water treatment facilities for the Equus Beds ASR Project should have flexibility to remove different types of herbicides.

B. TREATMENT TECHNOLOGIES CONSIDERED

Alternative treatment technologies for possible future application with the full-scale ASR Project may include:

1. Ballasted Flocculation

Ballasted flocculation is an option, which in theory, can be cost competitive on a construction and operational basis with traditional surface water sedimentation processes.

The process utilizes fine sand (about 100 μm) as a weighting agent and polymer as a binding agent to attach a metal hydroxide floc (usually alum) to the sand. The sand provides a large contact area and acts as a ballast which accelerates settling of the floc. The sand does not need to be of any select type and may be obtained from any local supplier.

Equipment for this process includes a pump to remove residuals. In the transfer, the impeller of the pump breaks the polymer bond between the metal hydroxide floc and the sand. Sludge is typically passed through a centrifuge and the sand is separated and recycled to the front of the process.

In a ballasted flocculation system, a coagulant (alum) is dosed at a rapid mix basin where it is dispersed into the raw water. Following rapid mix, water flows through a coagulation tank designed to promote floc formation. Anionic polymer is first dosed at the underflow of the centrifuge that separates the sand from the rest of the process residuals. The polymer-coated sand is added to an injection tank where it is bound to the flocs created upstream in the coagulation tank. Polymer is also dosed at the outlet of the injection tank to bind the sand-ballasted flocs together into bigger, denser flocs. Water flows through a maturation basin where flocs are aggregated by gentle agitation and, finally, solid/liquid separation occurs in a tube settler. The advantage of this technology is that the total detention time through the system is a fraction of the time needed by a conventional surface water sedimentation system resulting in smaller and less expensive facilities.

An option to sand-based ballasted flocculation is a system which uses recycled residuals as a weighting agent. Both systems have much higher upflow rates than conventional upflow treatment systems, resulting in smaller layout area and lower cost.

2. Immersed Microfiltration/Ultrafiltration Membranes

Membrane filtration is a viable process alternative for removal of turbidity and PAC from surface water prior to recharge. Water and wastewater treatment manufacturers (ZENON and US Filter) have developed systems that insert hollow-fiber membrane modules into a tank for utilization as a membrane filtration unit. These membrane modules operate under a suction condition which is different from conventional membrane units. Raw water is delivered directly into the membrane tank where it is filtered to separate the suspended solids.

Potential advantages of this technology include application of PAC directly to a tank for herbicide removal. This eliminates the need for polymer addition and removes nearly 100 percent of the solids. PAC removal is effective, thus eliminating the potential for "carry over" as experienced with the demonstration unit.

3. Advanced Oxidation Technologies

Advanced Oxidation Technologies (AOT) involve the use of an oxidant, such as hydrogen peroxide or ozone with or without a catalyst, to chemically oxidize organic contaminants into innocuous products, typically water and carbon dioxide. UV/Oxidation is a type of AOT that uses ultraviolet (UV) light in conjunction with standard oxidants, typically hydrogen peroxide, to achieve increased treatment performance as compared to peroxide alone. UV light is used to split the hydrogen peroxide molecule, producing highly oxidizing hydroxyl radicals (OH). Utilizing high concentrations of these radicals causes complete break down of organic contaminants to final products of water and carbon dioxide. A potential advantage of this technology is that contaminants are destroyed on site with no requirement for disposal of secondary by-products, such as spent activated carbon. One disadvantage is that the electrical requirements for removing atrazine in the full-scale Equus Beds ASR Plant would be very intensive and expensive.

Preliminary cost evaluations of this process reveal this technology alone would require a capital investment ranging from $4.2 million to $12.5 million for every 10 MGD treatment train. The operation and maintenance cost for a 10-MGD AOT system is estimated to cost between $0.55 and $1.35 per 1,000 gallons of water treated, which would result in an annual cost between $2 million and $5.0 million. This high cost is due to the fact that atrazine requires one of the highest levels of UV light exposure for breakdown compared to other organic compounds. Based on this preliminary cost information, AOT is eliminated from further consideration.

C. VIABLE TREATMENT TECHNOLOGIES

Viable treatment technologies for surface water from the Little Arkansas River are believed to include ballasted flocculation and membrane treatment in combination with parallel plate sedimentation similar to that used in the demonstration unit. The evaluated treatment technologies in combination with the technologies currently used at the demonstration project were assembled into six potential surface water treatment systems for evaluation purposes. All treatment systems consist of a surface water intake followed by parallel trains of water treatment units to remove turbidity and herbicides.

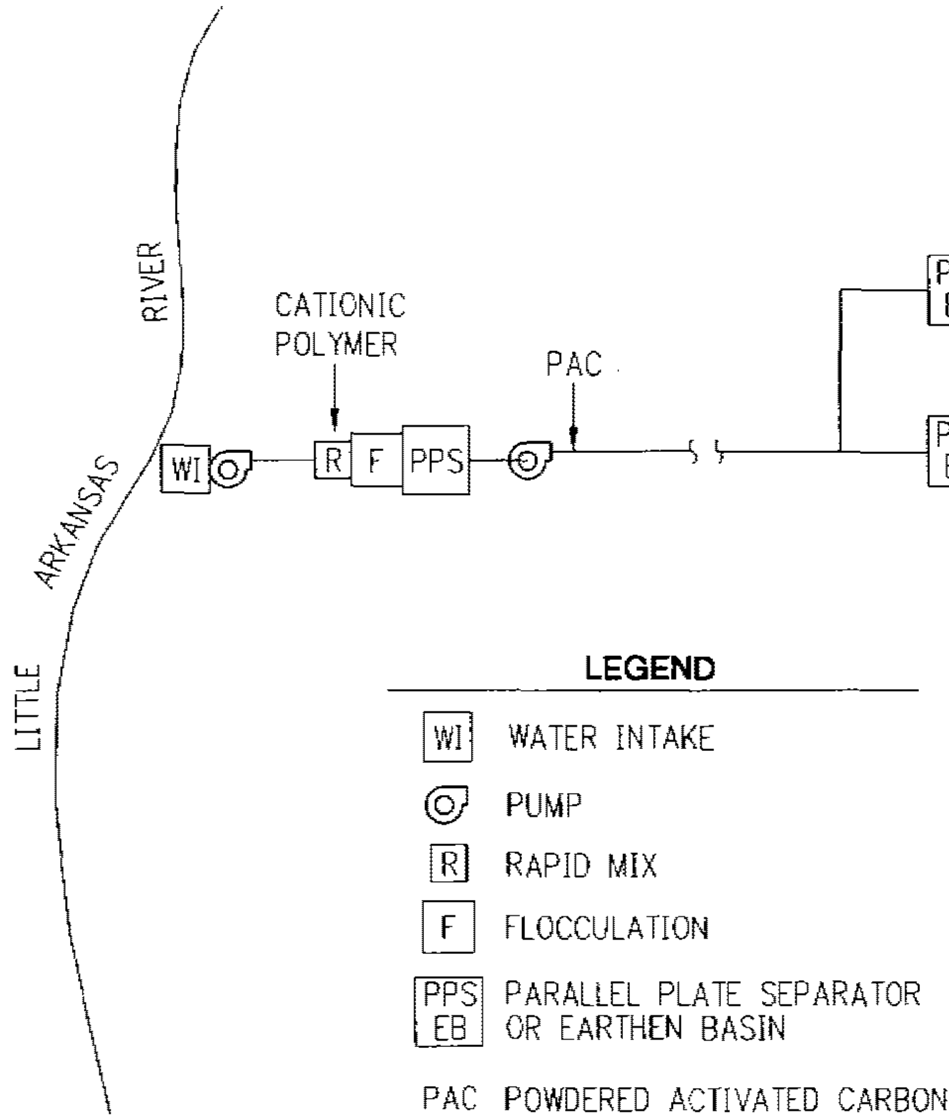
Water conveyed to the City's existing Central Water Treatment Plant has a higher turbidity goal (approximately 60 NTU or less) as compared to the recharge water (approximately 10 NTU or less) because the former will be subject to further treatment before reaching the distribution system. Due to these distinct goals, different criteria were used for designing these two water treatment systems. Thus, while several alternative technologies were studied for treating the recharge water in order to meet a low turbidity goal, a simpler treatment scheme using conventional coagulation, flocculation and parallel-plate sedimentation at an overflow rate of 0.5 g.p.m./ft^2 was used in all cases for the pretreatment of water conveyed directly to the City's existing Central Water Treatment Plant and nearby future water plant (WTPs). This latter configuration is expected to meet the turbidity reduction levels required by the City's WTPs (60 NTU or less), while reducing capital and operation and maintenance costs.

Since recharge water can come from a combination of both bank storage (induced infiltration) water and surface water from the Little Arkansas River, the capacity of the recharge water treatment system depends on the flow split between these two sources. Two alternatives capacities of 100 MGD and 150 MGD were identified with options to include or delete a 60 MGD direct diversion to the City's WTPs. Six flow split options were identified for diverting water from the Little Arkansas River. The split options for the 150 MGD alternative are 90 MGD surface water / 60 MGD bank storage water, 75 MGD surface water / 75 MGD bank storage water, and 50 MGD surface water / 100 MGD bank storage water. The split options for the 100 MGD alternative are 40 MGD surface water / 60 MGD bank storage water, 25 MGD surface water / 75 MGD bank storage water, and 100 MGD bank storage water. The capacities of the recharge water treatment systems can thus be 90 MGD, 75 MGD, 50 MGD, 40 MGD, 25 MGD, or 0 MGD, depending on the selected flow split option.

1. Surface Water Treatment System 1(SWTS 1)

System 1 consists of conventional coagulation/flocculation and sedimentation trains for removal of river turbidity followed by PAC addition and separation for herbicide removal as shown in Figure IV-1. On each train, cationic polymer is added to the raw water at a rapid mix basin. Water flows through a flocculation basin where destabilized particles are aggregated by gentle agitation. Solid/liquid separation occurs in a parallel-plate type separator at an overflow rate of 0.5 g.p.m./ft^2.

PAC is applied to the water immediately after clarification. Contact time between PAC and the water is provided in a pipeline sized specifically for that purpose. PAC particles are removed from both the water conveyed to the City's WTPs and the recharge water in either a parallel-plate type separator or an earthen basin. The former system would be designed at an overflow rate of 0.5 g.p.m./ft^2, while the latter system would provide an overflow rate of 0.25 g.p.m./ft^2.



Burns & McDonnell

Figure IV-1

SURFACE WATER TREATMENT SYSTEM 1

Each treatment system would involve a combination of treatment trains of different capacities to provide adequate flexibility. The treatment system for water conveyed to the City's WTPs (60 MGD) would have one 30 MGD train, plus three 10 MGD trains (2nd stage). The number of trains in the recharge water treatment system would vary depending on the system's total capacity as shown in Table IV-1.

2. Surface Water Treatment System 2 (SWTS 2)

System 2 consists of PAC addition for herbicide adsorption followed by conventional coagulation/flocculation and sedimentation for removal of river turbidity and PAC for both the City water and the recharge water treatment systems as shown in Figure IV-2. PAC is added to the water immediately downstream of the water intake. Contact time between PAC and the water is provided in a pipeline sized specifically for that purpose. Cationic polymer is added to the raw water at a rapid mix basin.

Water flows through a flocculation basin where destabilized particles (river sediments and PAC) are aggregated by gentle agitation and, finally, solid/liquid separation occurs in a Lamella separator. The City water system would be designed at an overflow rate of 0.5 g.p.m./ft^2, while the recharge water system would provide an overflow rate of 0.165 g.p.m./ft^2.

Each treatment system would involve a combination of treatment trains of different capacities to provide adequate flexibility. The treatment system for water conveyed to the City's WTPs (60 MGD) would have one 30 MGD train, plus three 10 MGD trains to provide adequate treatment flexibility. The number of trains in the recharge water treatment system would vary depending on the system's total capacity as shown in Table IV-1. SWTS 2 would require a higher dose of PAC than SWTS1 due to greater PAC demand by raw water solids.

3. Surface Water Treatment System 3 (SWTS 3)

System 3 consists of a conventional coagulation/flocculation/sedimentation system and a ballasted flocculation system for the removal of river turbidity from the City water and the recharge water, respectively, followed by PAC addition and separation for herbicide removal as shown in Figure IV-3. In the City water

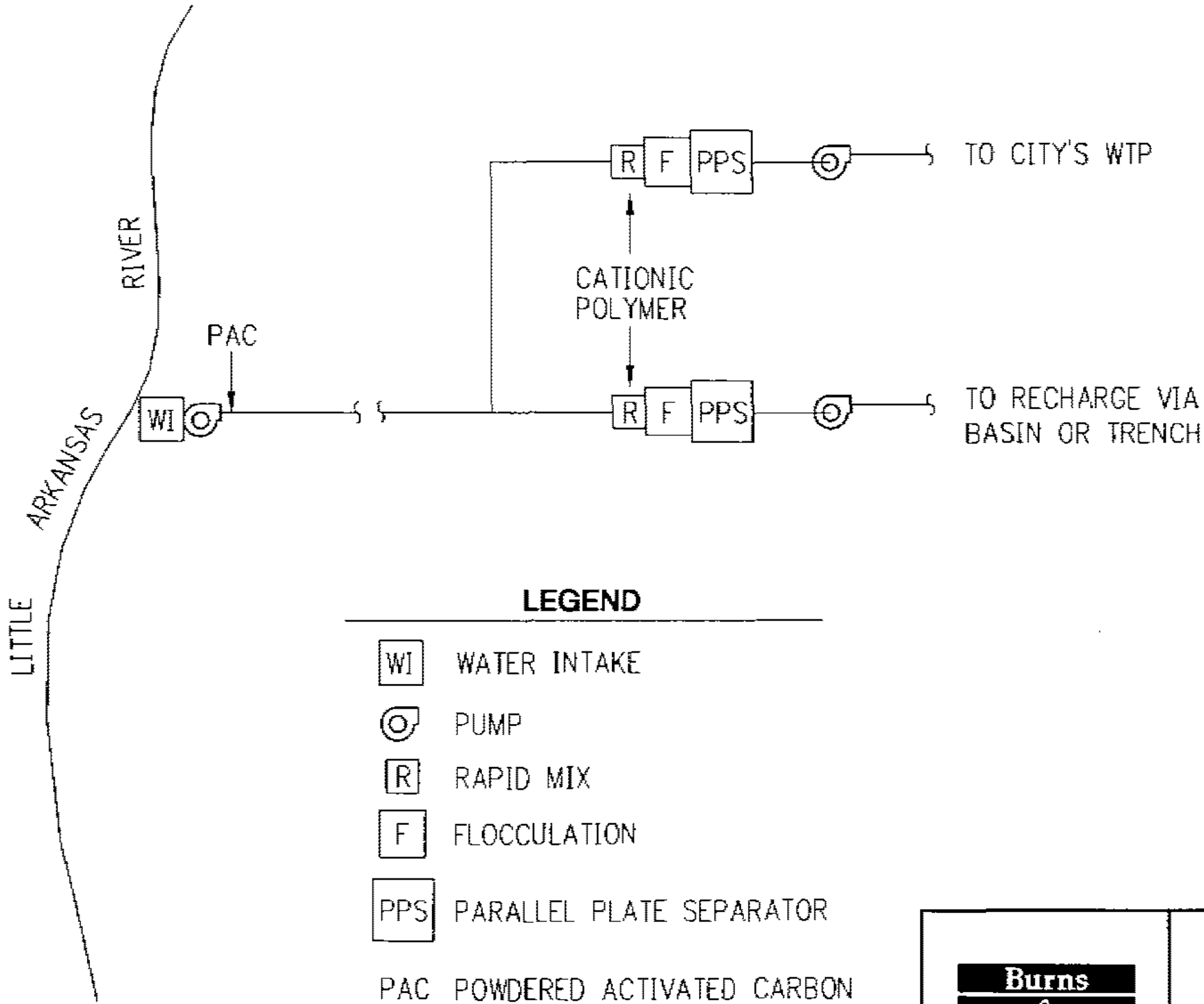
Table IV-1

Capacity of Recharge Water Trains

Water Treat. Option	Stage #	Alternative 1 (150 MGD Recharge System)			Alternative 2 (100 MGD Recharge System)		
		60/90 Option	75/75 Option	100/50 Option	60/40 Option	75/25 Option	100/0 Option
SWTS 1	1 (a)	Four 30-MGD + three 10-MGD	Four 30-MGD + two 10-MGD	Three 30-MGD + two 10-MGD	Three 30-MGD + one 10-MGD	Two 30-MGD + three 10-MGD	None
	2	Two 30-MGD + three 10-MGD	Two 30-MGD + two 10-MGD	One 30-MGD + two 10-MGD	One 30-MGD + one 10-MGD	Three 10-MGD	None
SWTS 2	1	Two 30-MGD + three 10-MGD	Two 30-MGD + two 10-MGD	One 30-MGD + two 10-MGD	One 30-MGD + one 10-MGD	Three 10-MGD	None
SWTS 3	1	Four 25 MGD	Three 25 MGD	Two 25 MGD	One 25 MGD + One 15 MGD	One 25 MGD	None
	2	Two 30-MGD + three 10-MGD	Two 30-MGD + two 10-MGD	One 30-MGD + two 10-MGD	One 30-MGD + one 10-MGD	Three 10-MGD	None
SWTS 4	1	Four 25 MGD	Three 25 MGD	Two 25 MGD	One 25 MGD + One 15 MGD	One 25 MGD	None
SWTS 5	1	Four 25 MGD	Three 25 MGD	Two 25 MGD	One 25 MGD + One 15 MGD	One 25 MGD	None
	2	Four 25 MGD	Three 25 MGD	Two 25 MGD	One 25 MGD + One 15 MGD	One 25 MGD	None
SWTS 6	1	Two 30-MGD + three 10-MGD	Two 30-MGD + two 10-MGD	One 30-MGD + two 10-MGD	One 30-MGD + one 10-MGD	Three 10-MGD	None

(a) The trains are common for both the recharge water and the City water systems.

J:\WICHITA\921954.012\SURWAT5.dwg 01-10-2000 14:07 jrc

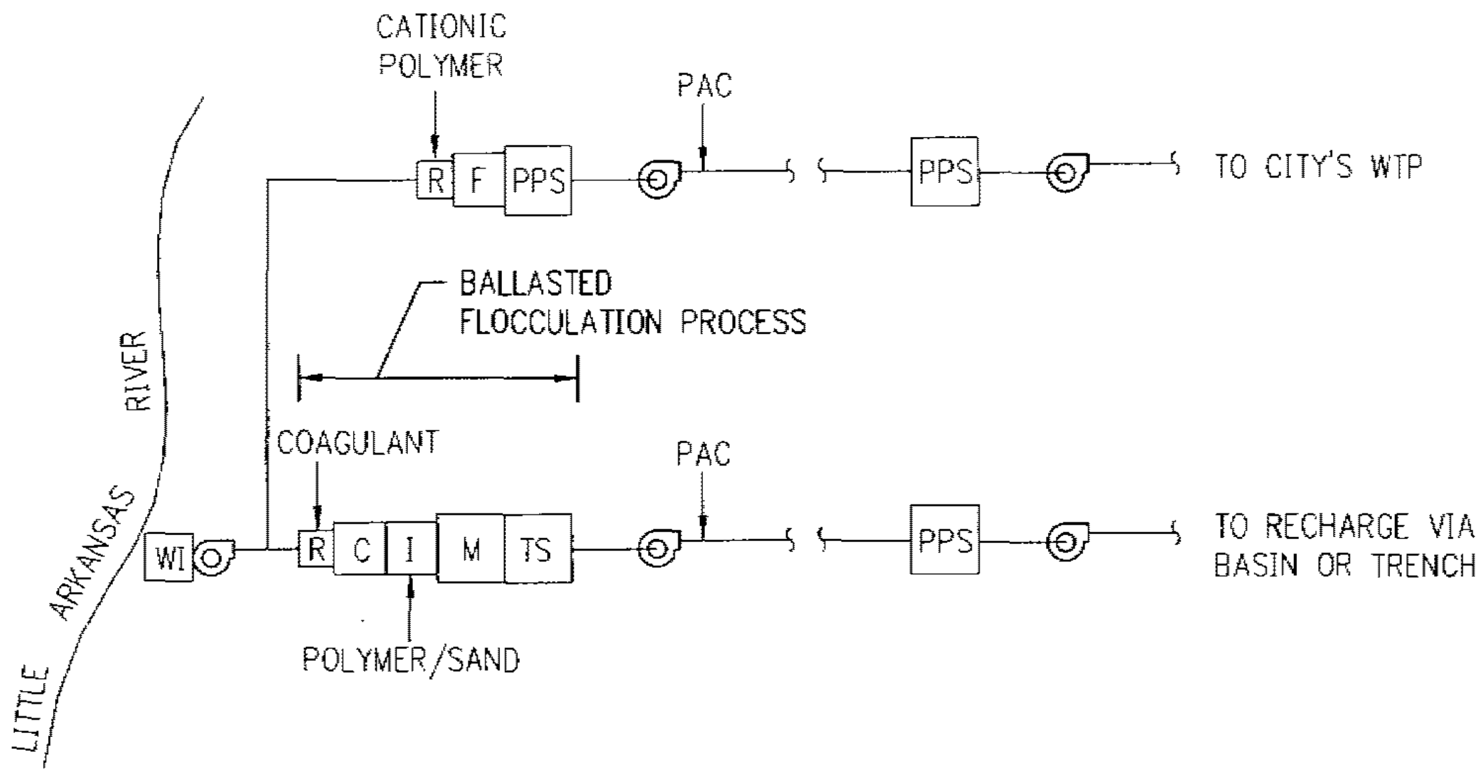


Burns & McDonnell

Figure IV-2

SURFACE WATER TREATMENT SYSTEM 2

J: \WICHITA\921954.012\SURWAT6.dwg 01-10-2000 14:18 JRO



LEGEND

WI	WATER INTAKE	F	FLOCCULATION
(pump symbol)	PUMP	M	MATURATION
R	RAPID MIX	TS	TUBE SETTLER
C	COAGULATION	PPS	PARALLEL PLATE SEPARATOR
I	INJECTION	PAC	POWDERED ACTIVATED CARBON

Burns & McDonnell

Figure IV-3

SURFACE WATER TREATMENT SYSTEM 3

system, cationic polymer is added to the raw water at a rapid mix basin. Water flows through a flocculation basin where destabilized particles are aggregated by gentle agitation. Solid/liquid separation occurs in a parallel-plate type separator at an overflow rate of 0.5 g.p.m./ft^2.

In the ballasted flocculation system (recharge water), solid/liquid separation occurs as water flows through rapid mix, coagulation, injection, maturation, and sedimentation (tube settler) tanks. PAC is applied to the water immediately after clarification. Contact time between PAC and the water is provided in a pipeline sized specifically for that purpose. PAC particles are removed from the water in a parallel-plate type separator at overflow rates of 0.5 g.p.m./ft^2 and 0.25 g.p.m./ft^2, respectively, for the City water and recharge water systems.

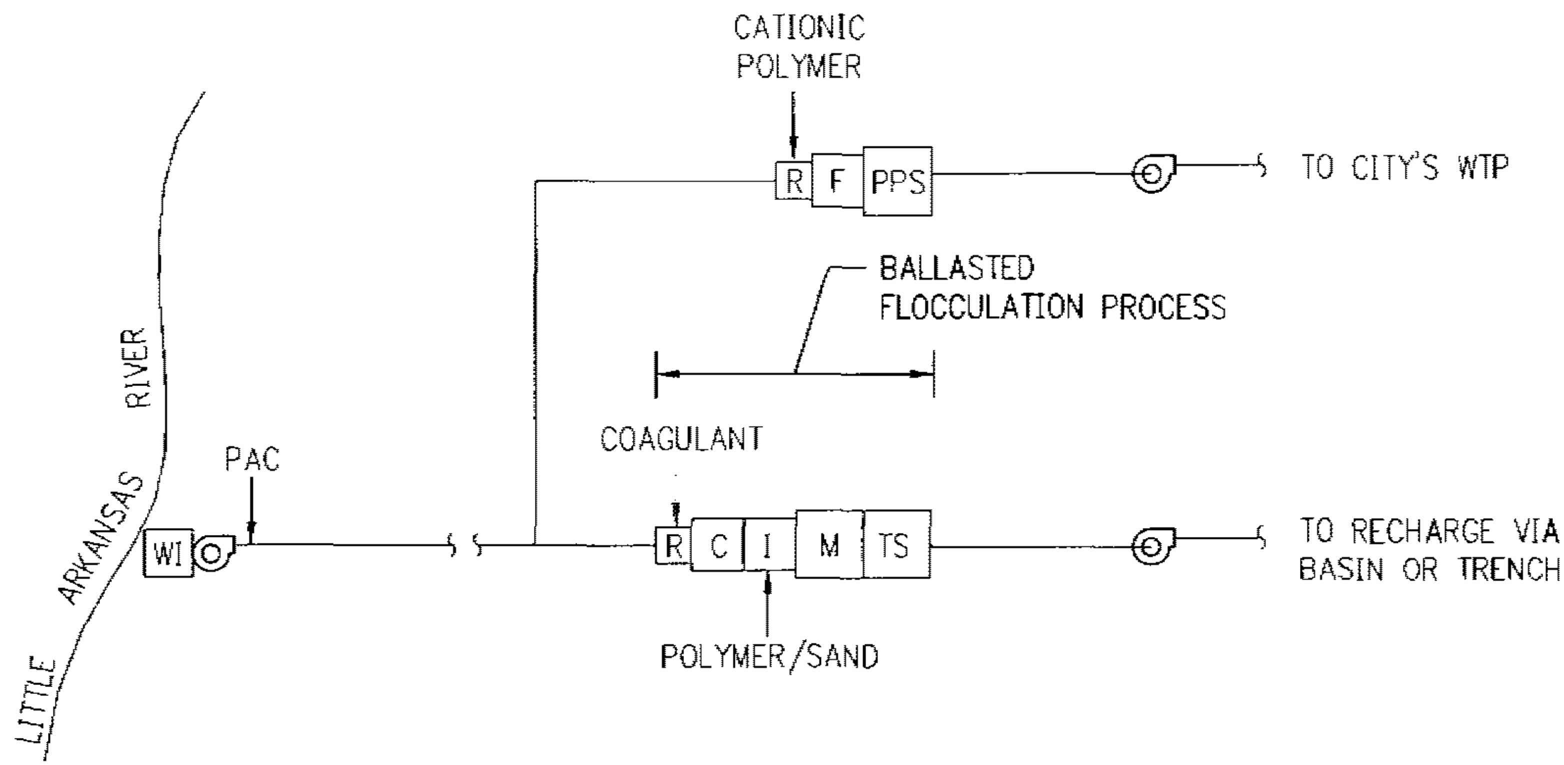
This treatment system would involve a combination of treatment trains of different capacities to provide adequate flexibility. The treatment system for water conveyed to the City's WTPs (60 MGD) would have one 30 MGD train, plus three 10 MGD trains. The number of trains in the recharge water treatment system would vary depending on the system's total capacity as shown in Table IV-1. The ballasted flocculation trains were sized at 25 MGD when possible because smaller trains are not economical as suggested by the vendor of this technology.

4. Surface Water Treatment System 4 (SWTS 4)

System 4 consists of PAC addition for herbicide adsorption followed by a conventional coagulation/flocculation/ sedimentation system and a ballasted flocculation system for removal of river turbidity and PAC from the City water and the recharge water, respectively, as shown in Figure IV-4. PAC is applied to the water immediately downstream of the water intake. Contact time between PAC and the water is provided in a pipeline sized specifically for that purpose.

In the City water system, cationic polymer is added to the raw water at a rapid mix basin. Water flows through a flocculation basin where destabilized particles are aggregated by gentle agitation. Solid/liquid separation occurs in a parallel-plate type separator at an overflow rate of 0.5 g.p.m./ft^2. In the ballasted flocculation system (recharge water), solid/liquid separation occurs as water

J:\WICHITA\921954.012\SURWAT7.dwg 01-10-2000 14:19 jro



LEGEND

- WI — WATER INTAKE
- PUMP
- R — RAPID MIX
- C — COAGULATION
- I — INJECTION
- F — FLOCCULATION
- M — MATURATION
- TS — TUBE SETTLER
- PPS — PARALLEL PLATE SEPARATOR
- PAC — POWDERED ACTIVATED CARBON

Burns & McDonnell

Figure IV-4

SURFACE WATER TREATMENT SYSTEM 4

flows through rapid mix, coagulation, injection, maturation, and sedimentation (tube settler) tanks.

This treatment system would involve a combination of treatment trains of different capacities to provide adequate flexibility. The treatment system for water conveyed to the City's WTPs (60 MGD) would have one 30 MGD train plus three 10 MGD trains. The number of trains in the recharge water treatment system would vary depending on the system's total capacity as shown in Table IV-1. The ballasted flocculation trains were sized at 25 MGD when possible because smaller trains are not economical as suggested by the vendor of this technology. SWTS 4 would require a higher dose of PAC than SWTS3 due to greater PAC demand by raw water solids.

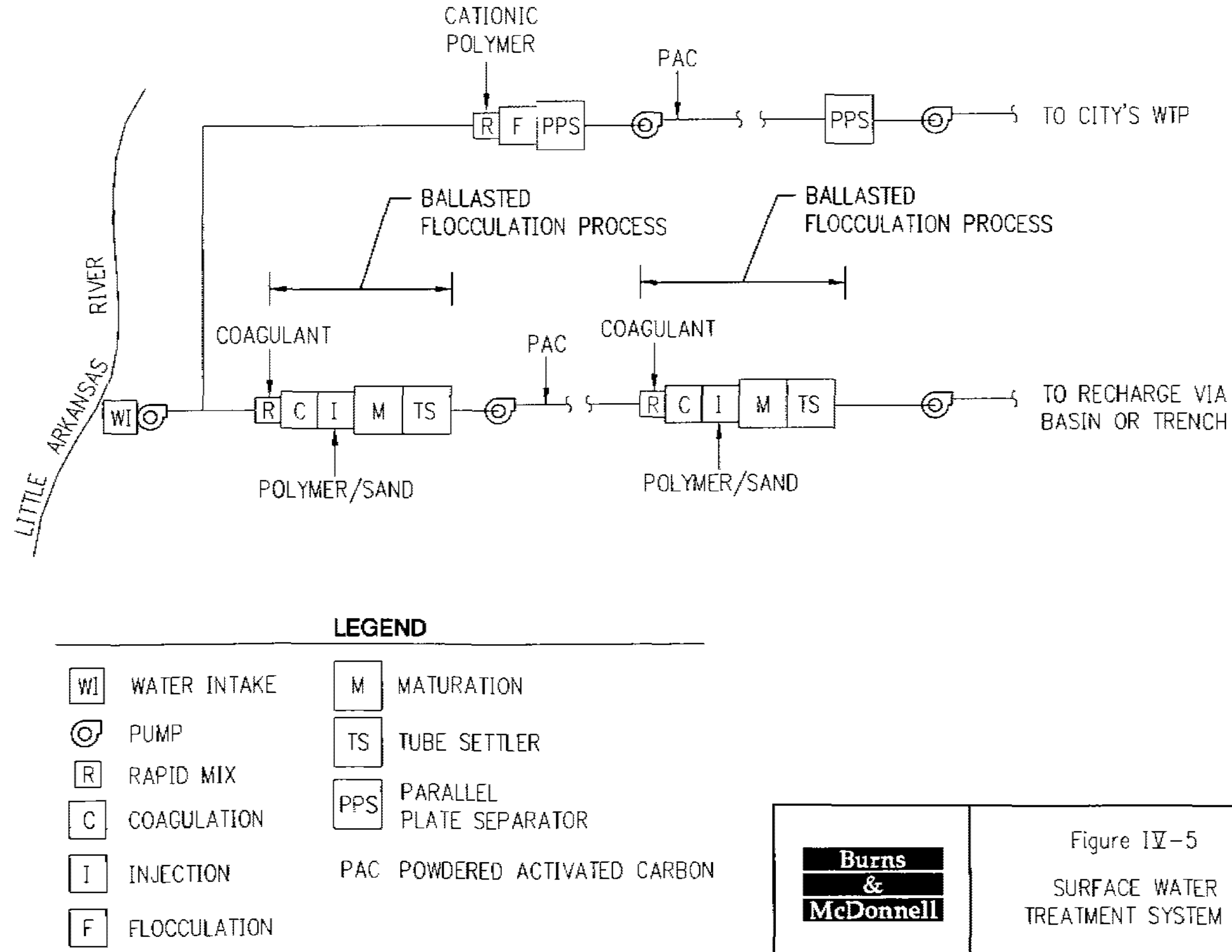
5. Surface Water Treatment System 5 (SWTS 5)

System 5 consists of a conventional coagulation/flocculation/sedimentation system followed by PAC addition and removal and a two-stage ballasted flocculation system, respectively, for the treatment of City water and recharge water as shown in Figure IV-5. In the City water system, cationic polymer is added to the raw water at a rapid mix basin. Water flows through a flocculation basin where destabilized particles are aggregated by gentle agitation. Solid/liquid separation occurs in a parallel-plate type separator at an overflow rate of 0.5 g.p.m./ft^2.

PAC is applied to the water immediately after the parallel-plate separator. Contact time between PAC and the water is provided in a pipeline sized specifically for that purpose. PAC particles are removed from the water in a second parallel-plate type separator at an overflow rate of 0.5 g.p.m./ft^2. In each ballasted flocculation stage of the recharge water treatment system, solid/liquid separation occurs as water flows through rapid mix, coagulation, injection, maturation, and sedimentation (tube settler) tanks.

This treatment system would involve a combination of treatment trains of different capacities to provide adequate flexibility. The treatment system for water conveyed to the City's WTPs (60 MGD) would have one 30 MGD train, plus three 10 MGD trains. The number of trains in the recharge water treatment

J:\WICHITA\921954.012\SURWAT8.dwg 01-10-2000 14:24 JRO



Burns & McDonnell

Figure IV-5

SURFACE WATER TREATMENT SYSTEM 5

system would vary depending on the system's total capacity as shown in Table IV-1. The ballasted flocculation trains were sized at 25 MGD when possible because smaller trains are not economical as suggested by the vendor of this technology.

6. Surface Water Treatment System 6 (SWTS 6)

System 6 consists of PAC addition for herbicide adsorption followed by a conventional coagulation/flocculation/ sedimentation system and a water immersed microfiltration/ultrafiltration membrane system, respectively, for removal of turbidity and PAC from the City water system and the recharge water system as shown in Figure IV-6. In the City water system, cationic polymer is added to the raw water at a rapid mix basin. Water then flows through a flocculation basin where destabilized particles are aggregated by gentle agitation. Solid/liquid separation occurs in a parallel-plate type separator at an overflow rate of 0.5 g.p.m./ft^2.

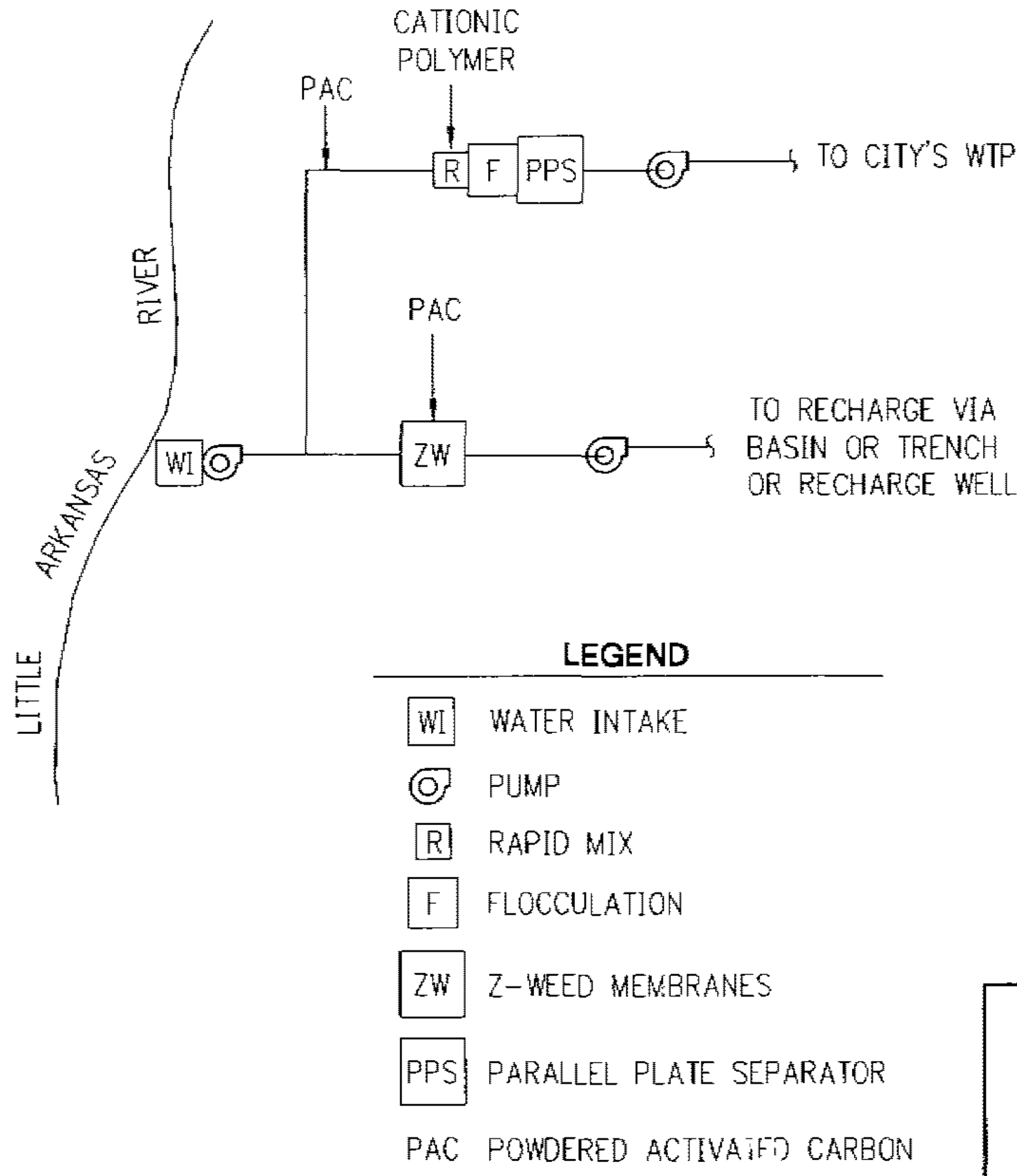
In the membrane system (recharge water), PAC can be added directly into the membrane basin where contact time is provided by the basin residence time. The PAC concentration in the basin would be maintained at a high level to obtain improved performance. The raw water passes through the membrane modules leaving PAC and river turbidity behind.

Each treatment system would involve a combination of treatment trains of different capacities to provide adequate flexibility. The treatment system for water conveyed to the City's WTPs (60 MGD) would have one 30 MGD train, plus three 10 MGD trains. The number of trains in the recharge water treatment system would vary depending on the system's total capacity as shown in Table IV-1.

D. COST EVALUATION

Surface Water Treatment Systems 1 through 6 were evaluated in detail to develop relative capital and operation and maintenance cost opinions for these alternatives. Project costs were used to compare the surface water treatment alternatives from an economical standpoint. Cost opinions for these systems were developed for total capacities of 150 MGD, 135 MGD, and 110 MGD, which correspond to the three flow

J:\WICHITA\921954.012\SURWAT3.dwg 01-10-2000 14:30 JRO



Burns & McDonnell

Figure IV-6

SURFACE WATER TREATMENT SYSTEM 6

split options identified for the diversion of water at 150 MGD (90 MGD surface water / 60 MGD bank storage water, 75 MGD surface water / 75 MGD bank storage water, and 50 MGD surface water / 100 MGD bank storage water) and for total capacities of 100 MGD, 85 MGD, and 60 MGD, which correspond to the three flow split options identified for the diversion of water at 100 MGD (40 MGD surface water / 60 MGD bank storage water, 25 MGD surface water / 75 MGD bank storage water, and 0 MGD surface water / 100 MGD bank storage water).

Costs for the six surface water treatment options are summarized in Tables IV-2 through IV-7. These cost opinions include capital costs and operation and maintenance costs. Capital costs include construction costs for the project components, contingencies and other costs. Contingencies of 15 percent for construction are included for unknown conditions or requirements not known at this level of project development. Other costs associated with each option (10 percent) include the fees and expenses associated with the technical, professional and special services required to execute the delivery of each surface water treatment alternative. Such costs may include environmental, technical and geotechnical studies; land and right-of-way appraisals and negotiations; design and resident engineering fees; construction materials testing; land surveying and legal descriptions and project design surveying.

Capital costs were discounted to an annual basis over a 20 year period at a rate of 6 percent in order to determine the contribution of capital costs to the total annual project cost and calculate a unit cost ($/1,000 gallons) for each alternative. Operation and maintenance costs include all the annual expenditures ($/year) needed to keep the system in operation, such as power costs for the operation of buildings, pumps and electric drives, cost of chemicals, equipment repair costs, and general building and site maintenance costs as well as contingencies. These costs were developed based on the assumption that the surface water treatment system will treat a total annual volume of surface water equal to that resulting from running at full-capacity for a period of 40 days per year. Electricity costs were assumed to be $0.07/Kw-hr. Contingencies of 15 percent are included to account for unknown operation and maintenance requirements not known at this conceptual level. Total annual costs include both the annualized capital costs and the operation and maintenance costs. Costs per 1,000 gallons of treated raw water were also developed based on a 40-day-per-year operation period at full capacity.

Table IV-2

Cost Analysis of Surface Water Treatment Alternatives
Summary of System Costs for 150 MGD Option

SYSTEM	CAPITAL COST ($)	ANNUALIZED CAPITAL COST (1) ($/year)	ANNUAL O&M COST ($/year)	TOTAL ANNUAL COST ($/year)	UNIT COST ($/1,000 gal)
SWTS 1	55,136,928	5,004,000	2,053,000	7,057,000	1.18
SWTS 2	47,959,057	4,353,000	2,332,000	6,685,000	1.11
SWTS 3	57,151,248	5,187,000	2,159,500	7,346,500	1.22
SWTS 4	42,865,000	3,890,000	2,337,500	6,227,500	1.04
SWTS 5	54,830,602	4,976,000	2,298,000	7,274,000	1.21
SWTS 6	77,930,840	7,073,000	4,500,000	11,573,000	1.93

(1) Annual debt service is calculated over a 20 year period at a 6.5 % interest rate

Table IV-3

Cost Analysis of Surface Water Treatment Alternatives
Summary of System Costs for 135 MGD Option

SYSTEM	CAPITAL COST ($)	ANNUALIZED CAPITAL COST (1) ($/year)	ANNUAL O&M COST ($/year)	TOTAL ANNUAL COST ($/year)	UNIT COST ($/1,000 gal)
SWTS 1	52,089,000	4,728,000	1,869,000	6,597,000	1.22
SWTS 2	45,744,000	4,152,000	2,088,000	6,240,000	1.16
SWTS 3	53,907,500	4,893,000	1,958,000	6,851,000	1.27
SWTS 4	40,751,000	3,699,000	2,076,000	5,775,000	1.07
SWTS 5	46,646,000	4,234,000	2,053,000	6,287,000	1.16
SWTS 6	72,518,000	6,582,000	4,053,000	10,635,000	1.97

(1) Annual debt service is calculated over a 20 year period at a 6.5 % interest rate

Table IV-4

Cost Analysis of Surface Water Treatment Alternatives
Summary of System Costs for 110 MGD Option

SYSTEM	CAPITAL COST ($)	ANNUALIZED CAPITAL COST (1) ($/year)	ANNUAL O&M COST ($/year)	TOTAL ANNUAL COST ($/year)	UNIT COST ($/1,000 gal)
SWTS 1	41,208,500	3,740,000	1,519,000	5,259,000	1.20
SWTS 2	35,741,500	3,244,000	1,708,000	4,952,000	1.13
SWTS 3	43,482,000	3,946,000	1,580,000	5,526,000	1.26
SWTS 4	32,899,500	2,986,000	1,723,000	4,709,000	1.07
SWTS 5	41,461,500	3,763,000	1,664,000	5,427,000	1.23
SWTS 6	55,729,500	5,058,000	2,964,000	8,022,000	1.82

(1) Annual debt service is calculated over a 20 year period at a 6.5% interest rate

Table IV-5

Cost Analysis of Surface Water Treatment Alternatives
Summary of System Costs for 100 MGD Option

SYSTEM	CAPITAL COST ($)	ANNUALIZED CAPITAL COST (1) ($/year)	ANNUAL O&M COST ($/year)	TOTAL ANNUAL COST ($/year)	UNIT COST ($/1,000 gal)
SWTS 1	38,559,500	3,500,000	1,398,000	4,898,000	1.22
SWTS 2	32,923,500	2,988,000	1,577,000	4,565,000	1.14
SWTS 3	41,119,000	3,732,000	1,471,000	5,203,000	1.30
SWTS 4	31,914,500	2,897,000	1,597,000	4,494,000	1.12
SWTS 5	40,124,500	3,642,000	1,556,000	5,198,000	1.30
SWTS 6	49,132,500	4,459,000	2,570,000	7,029,000	1.76

(1) Annual debt service is calculated over a 20 year period at a 6.5% interest rate

Table IV-6

Cost Analysis of Surface Water Treatment Alternatives
Summary of System Costs for 85 MGD Option

SYSTEM	CAPITAL COST ($)	ANNUALIZED CAPITAL COST (1) ($/year)	ANNUAL O&M COST ($/year)	TOTAL ANNUAL COST ($/year)	UNIT COST ($/1,000 gal)
SWTS 1	33,402,500	3,032,000	1,227,000	4,259,000	1.25
SWTS 2	28,580,500	2,594,000	1,379,000	3,973,000	1.17
SWTS 3	35,467,000	3,219,000	1,244,000	4,463,000	1.31
SWTS 4	26,456,500	2,401,000	1,369,000	3,770,000	1.11
SWTS 5	33,384,500	3,030,000	1,316,000	4,346,000	1.28
SWTS 6	40,057,500	3,636,000	2,125,000	5,761,000	1.69

(1) Annual debt service is calculated over a 20 year period at a 6.5% interest rate

Table IV-7

Cost Analysis of Surface Water Treatment Alternatives
Summary of System Costs for 60 MGD Option

SYSTEM	CAPITAL COST ($)	ANNUALIZED CAPITAL COST (1) ($/year)	ANNUAL O&M COST ($/year)	TOTAL ANNUAL COST ($/year)	UNIT COST ($/1,000 gal)
SWTS 1	22,530,500	2,045,000	883,000	2,928,000	1.22
SWTS 2	18,227,000	1,654,000	976,000	2,630,000	1.10

(1) Annual debt service is calculated over a 20 year period at a 6.5% interest rate

E. TREATMENT RECOMMENDATIONS

Based on the evaluation of the six raw water treatment alternatives previously identified, a single-stage parallel-plate (SWTS 2) or ballasted flocculation (recharge water)/parallel-plate (City water) system (SWTS 4) appears to be the most economical method from a capital and unit cost ($/1,000 gallons) basis. Ballasted flocculation systems may be more advantageous than parallel-plate systems in that they have the potential to produce better effluent water quality (1 NTU), but they may also require increased operation and maintenance.

Two stage parallel-plate or ballasted flocculation/parallel-plate systems (SWTS 1, SWTS 3, and SWTS 5) have higher capital costs due to the increased number of treatment basins and facilities required; however, these systems have less operation and maintenance costs as compared to the single-stage systems mainly due to their reduced PAC use. SWTS 6 has the highest capital and operation and maintenance costs of all treatment alternatives, which result in the highest unit cost ($/1,000 gallons) of all options; however, the effluent water quality from this alternative is the best of all six treatment options. Furthermore, based on the observed past trends, the cost of membrane technologies is expected to decrease in the future as materials and manufacturing technologies improve.

Based on the above considerations, further evaluation of the ballasted flocculation and membrane technologies through on-site pilot testing is recommended. This testing will allow collection of site-specific water quality and operation and maintenance data to support the technology selection process. SWTS 4, a one-stage ballasted flocculation (recharge water)/parallel-plate separation (City water) system, is selected as the surface water treatment alternative to be used for cost analysis purposes in the remainder of this report (Part VIII) because this system has the lowest unit cost ($/1,000 gallons).

* * * * *

PART V

CONCLUSIONS

PART V

CONCLUSIONS

A. GENERAL

Based on the findings of the Demonstration Project through the end of 1999, the concepts for aquifer recharge, storage and recovery are considered to be feasible and suitable for full-scale implementation. The main conclusions reached from the development, construction, and operation of the Demonstration Project and associated investigations and tests through the end of 1999 are discussed in this section.

B. GEOLOGY AND HYDROGEOLOGY

In general, the unconsolidated materials forming the Equus Beds Aquifer are coarse-grained with intermediate fine-grained (silt and clay) units scattered throughout the area. Although the fine-grained layers, where present, are anticipated to inhibit vertical percolation of recharge water from the upper sand and gravel units, this is expected to be a localized problem only due to the scattered nature of the silt and clay layers. Consequently, the full-scale groundwater recharge project is considered to be feasible based on location of facilities using detailed, site-specific geotechnical information.

C. RECHARGE TESTING

Based on the results observed at the Sedgwick Recharge Site, recharge basins are expected to work adequately in areas where no extensive clay layers exist to impede vertical seepage of the recharge water. At locations where fine-grained layers inhibit vertical percolation, the recharge basin concept will have to be modified to improve recharge rates, as shown by the Halstead Site recharge results. During periods of continuous recharge, recharge rates of more than 8 ft/day were observed at the Sedgwick Site, while rates of only up to 3 ft/day were obtained at the Halstead Site.

In November 1999, construction of the gravity recharge well system was completed. Operation of the Halstead Recharge System was resumed in November after completion of construction of the gravity recharge well system. Initial testing of the basins, after addition of the gravity recharge system, showed a 400 percent increase in recharge rates. Further improvement in recharge rates is expected as the system is operated and fine

Recharge Well
Halstead Recharge Site
July 21, 1998

sediment that has washed into the laterals and formation is removed. Testing will continue through the spring and summer of 2000.

Recharge trenches may be a more efficient alternative to the existing recharge basin concept at locations where intermediate clay layers impede vertical percolation. At such sites, recharge trenches would potentially minimize the formation of a "groundwater mound" by allowing a thin vertical flow zone down to the clay layer which can be easily dispersed laterally. Based on the observations at the Halstead Recharge Site, infiltration rates of more than 75 ft/day are expected with a recharge trench.

The recharge trench has a history of minor operational problems caused by plugging of the upper filter fabric by iron precipitation caused by aeration of the water. In 1998 and 1999, the recharge trench inlet structure was modified to minimize water aeration and reduce iron oxidation. Tests showed that run time was increased slightly; however, the filter fabric continues to experience problems with iron fouling.

As demonstrated at the Halstead Recharge Site, recharge wells are expected to be effective in recharging the deep aquifer zones. Recharge test results revealed that recharge specific capacities of 25 gpm/ft-rise to 35 gpm/ft-rise can be consistently achieved during periods of continuous well operation without any noticeable long-term decreases in well performance. The recharge water and aquifer water appear to be compatible with no apparent plugging or yield reduction of the aquifer. Redevelopment of the recharge well was originally thought to be required on a daily basis. For operational purposes, the recharge well is redeveloped on a monthly basis.

Basin bottom core sampling results indicate particles were removed from the recharge water in the top two to three inches of the bottom sand. Most of the plugging may be attributed to deposition of PAC. Dewatering and drying the recharge basin after plugging caused by PAC deposition does not improve recharge rates. Plugging due to polymer accumulation does respond to dewatering and drying and infiltration rates will improve.

Filter column testing showed that particle removal from raw surface water extends beyond 2 to 3 inches. Particles that are below 2 to 3 inches cannot be easily removed, causing increased maintenance cost for basin bottom cleaning. Surface water from the Little Arkansas River is suitable for recharge to the aquifer after pretreatment. High raw water turbidities produce treated waters which are easier to recharge as floc formation is faster and floc size is larger. Rapid mix and flocculation times are the limiting factors for turbidity reduction in the Lamella treatment unit.

Jar testing of polymers showed that PRC 3070 S performed better than Superfloc C-587, yielding better recharge rates and total volume of water passing through the test columns. Particles generated from the addition of PRC 3070 S were larger in size and produced less headloss inside the column.

D. WATER QUALITY

Recharge operations are not anticipated to have any detrimental impacts on the long-term aquifer water quality. The quality of the water recharged to the aquifer remain within the range of baseline values in the Equus Beds aquifer. Water quality results at both the Halstead and Sedgwick Recharge Sites are significantly less than drinking water limits. Both chloride and herbicide (atrazine) concentrations in the aquifer water resulting from recharge operations were substantially below regulatory maximum contaminant levels the entire period of demonstration system operation.

E. SURFACE WATER TREATMENT TECHNOLOGIES

A single-stage parallel plate or ballasted flocculation for recharge water appears to be the most economical method from a capital and unit cost basis. Ballasted flocculation systems may be more advantageous than parallel-plate systems in that they have the potential to produce better effluent water quality, but they may also require increased operation and maintenance. On-site pilot tests are recommended to develop design criteria for design of full-scale facilities and use in the competitive bidding process for future construction contracts.

F. REGULATIONS AND ACCOUNTING SYSTEMS

Groundwater modeling was used to demonstrate various accounting systems that could potentially be used for a full-scale groundwater recharge system. Work in 1998 helped demonstrate how recharge water would migrate from a recharge point towards an adjacent accounting unit. Additional work in early 1999 was conducted to compare different accounting systems for presentation to the Kansas Division of Water Resources. No further work on the accounting system will be productive until the State finishes drafting state-wide recharge regulations which is expected in the third quarter of 2000.

faster and floc size is larger. Rapid mix and flocculation times are the limiting factors for turbidity reduction in the Lamella treatment unit.

Jar testing of polymers showed that PRC 3070 S performed better than Superfloc C-587, yielding better recharge rates and total volume of water passing through the test columns. Particles generated from the addition of PRC 3070 S were larger in size and produced less headloss inside the column.

D. WATER QUALITY

Recharge operations are not anticipated to have any detrimental impacts on the long-term aquifer water quality. The quality of the water recharged to the aquifer remain within the range of baseline values in the Equus Beds aquifer. Water quality results at both the Halstead and Sedgwick Recharge Sites are significantly less than drinking water limits. Both chloride and herbicide (atrazine) concentrations in the aquifer water resulting from recharge operations were substantially below regulatory maximum contaminant levels the entire period of demonstration system operation.

E. SURFACE WATER TREATMENT TECHNOLOGIES

A single-stage parallel plate or ballasted flocculation for recharge water appears to be the most economical method from a capital and unit cost basis. Ballasted flocculation systems may be more advantageous than parallel-plate systems in that they have the potential to produce better effluent water quality, but they may also require increased operation and maintenance. On-site pilot tests are recommended to develop design criteria for design of full-scale facilities and use in the competitive bidding process for future construction contracts.

F. REGULATIONS AND ACCOUNTING SYSTEMS

Groundwater modeling was used to demonstrate various accounting systems that could potentially be used for a full-scale groundwater recharge system. Work in 1998 helped demonstrate how recharge water would migrate from a recharge point towards an adjacent accounting unit. Additional work in early 1999 was conducted to compare different accounting systems for presentation to the Kansas Division of Water Resources. No further work on the accounting system will be productive until the State finishes drafting state-wide recharge regulations which is expected in the third quarter of 2000.

The groundwater model is anticipated to be utilized with the final accounting system selected by State as part of the regulations. The model will track migration of recharge water through the well field and quantify the increase in aquifer discharge to the Little Arkansas River resulting from the recharge project. Such information will be the basis of requests to recover increased seepage losses from the recharge aquifer for downstream capture at the Local Well Field for use at the water treatment plant.

* * * * *

PART VI

FUTURE ACTIVITIES

PART VI

FUTURE ACTIVITIES

A. 2000 INITIATIVES

Facilities will continue to be evaluated to determine technical, operational, environmental, and economic impacts. Data on recharge rates, water quality and water levels will be collected, analyzed and used to determine design criteria, operating guidelines, and water accounting methods for full-scale facilities. Collection and recharge of induced river infiltration water and settled surface water will be observed for quality and quantity impacts to in-situ groundwater.

General activities for 2000 will include:

- Finalize the accounting system to keep track of water recharged to the aquifer, system losses, and the amount of water available to the City for future use. The accounting system must comply with requirements of groundwater recharge regulations which are expected to be finalized by the third quarter of year 2000.
- Operation of the Halstead and Sedgwick Recharge Facilities whenever above-base flow events occur in the Little Arkansas River.
- Operation of water treatment facilities for solids and atrazine removal and biological growth control in recharge water.
- Operation with SCADA system to optimize system monitoring and control.
- Continued environmental checks to ensure that environmental commitments made in the 1996 environmental assessment and the "finding of no significant impact" (FONSI) are maintained.

B. FACILITY TEST OBJECTIVES

1. Halstead Recharge Basins

Testing objectives for next year include:

- Monitor operation and cleaning requirements for passive wells which penetrate underlying clay layers and allow flow to lower aquifer areas.

- Monitor recharge well to determine if reason for specific capacity decline in November – December 1999 is due to concurrent change in the SCADA System, need for well redevelopment or changing conditions in the aquifer formation.

- Continue development of operation and maintenance experience to determine required drying or bottom reconditioning frequency for the recharge basins.

- Continue on-going studies on water level – recharge rate characteristics using the SCADA system alarms and controls.

B. Halstead Recharge Trench

Testing objectives for next year include:

- Continue investigative methods to control groundwater oxygenation to reduce iron precipitation which plugs the filter fabric and develop operation and maintenance experience associated with methods of reducing iron precipitation to determine required filter reconditioning frequency.

- Determine more precise water level – recharge rate characteristics using the SCADA system alarms and controls.

C. Halstead Recharge Well

Testing objectives for the next year include:

- Continue on-going operation and maintenance data evaluation to determine required redevelopment and treatment frequency for the recharge well.

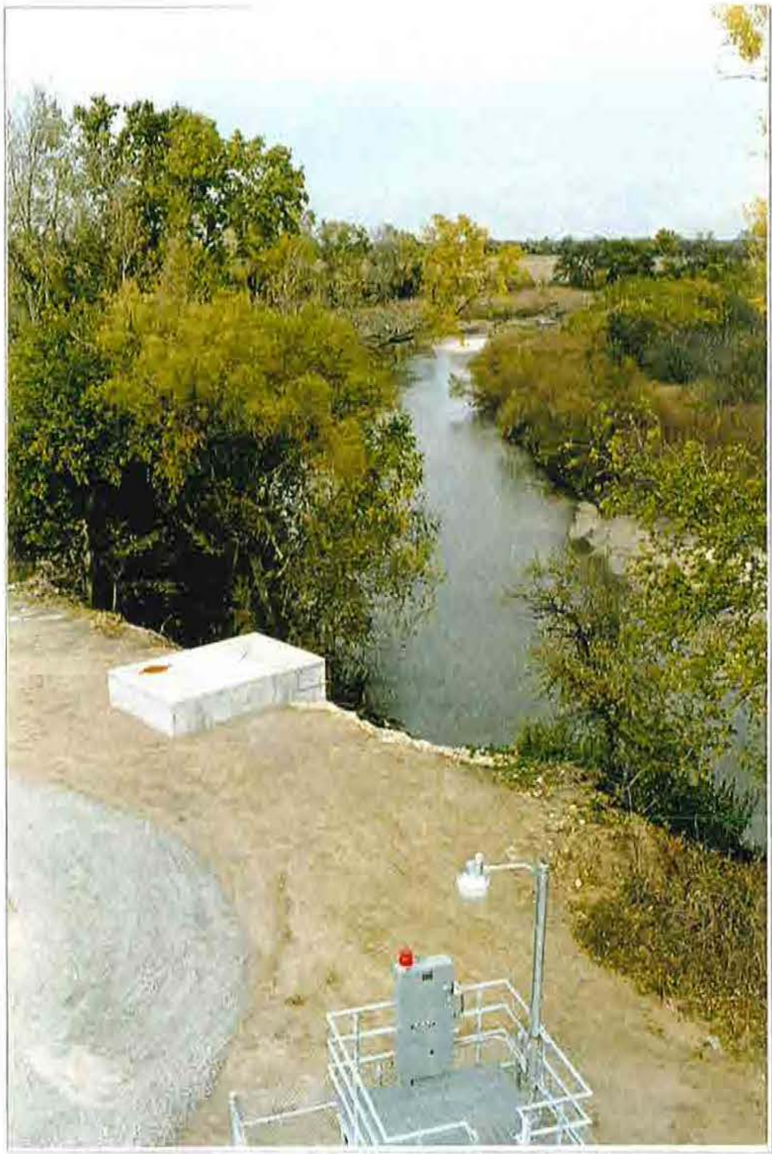
- Continue on-going studies on water level - recharge rate characteristics using the SCADA system alarms and controls.

- Continue to evaluate water level and water quality impacts.

D. Sedgwick Recharge System

Testing objectives for the next year include:

- Obtain operation and maintenance data of several pilot water treatment units and continue experiments with different polymers, combinations of



Intake Pump Vault and Electrical Gear
Sedgwick Intake Site
November 4, 1997

polymers, changes in flocculation time, different upflow rates, and varying sludge blowdown intervals to improve coagulation and flocculation of sediments.

- Continue on-going operation and maintenance data evaluation for the earthen pre-sedimentation basin and the recharge basin units using SCADA controls and monitoring.

- Continue on-going studies on water level – recharge rate characteristics using the SCADA system alarms and controls.

- Continue to evaluate water level and water quality impacts.

- Collect operating data on the quantity and handling characteristics of water treatment residuals.

* * * * *

APPENDIX

LIST OF ABBREVIATIONS

LIST OF ABBREVIATIONS

ASR	Aquifer Storage and Recovery
cfs	cubic feet per second
CPU	Central Processing Unit
DCP	Data Collection Platform
DWR	Division of Water Resources
EA	environmental assessment
ELISA	enzyme-linked immunosorbent assay (ELISA)
FONSI	Findings-Of-No-Significant Impact
GC	gas chromatography
GMD2	Groundwater Management District No. 2
HA	Health Advisory Limit
IFIM	Instream Flow Incremental Methodology
ILWS	Integrated Local Water Supply
KDHE	Kansas Department of Health and Environment
KDWP	Kansas Department of Wildlife and Parks
KWh	Kilowatt hour
MCL	Maximum Contaminant Limit
MGD	million gallons per day
MKEC	Mid-Kansas Engineering Consultants
MS	mass spectrometry
MSL	above mean sea level
ND	Non-detect
NEPA	National Environmental Policy Act
PAC	powdered activated carbon
PLC	Programmable Logic Controller
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
SCADA	Supervising Control and Data Acquisition
SDWA	Safe Drinking Water Act
SHPO	State Historic Preservation Office
SMCL	Suggested Maximum Contaminant Limit
U.S.EPA	United States Environmental Protection Agency
UPS	uninterruptible power system
USGS	United States Geological Survey
VOC	volatile organic compound

EQUUS BEDS RECHARGE PROJECT WEB PAGE

Equus Beds Recharge Demonstration Project

Description of *Equus* Beds Recharge Demonstration Project

NEW Highlights of Results to Date

Maps of *Equus* Beds Recharge Demonstration Data-Collection Sites

- Map of Little Arkansas Basin
- Map of Recharge sites

Publications

Water Quality

- Are Total Recoverable Analyses Necessary for Monitoring Water Quality in Recharge Studies?, Ziegler, A.C., Trombley, T.J., Blain, G.T., Klein, L.J., Pajor, T.A., and Strasser, V.A., 1997 *in* Water Quality Technology Conference, Denver, Colorado, Proceedings: American Water Works Association, compact disk.

- Atrazine in Source Water Intended for Artificial Ground-Water Recharge, South-Central Kansas, Christensen, V.G., and Ziegler, A.C., 1998, U.S. Geological Survey Fact Sheet FS-074-98, 4p.

- Baseline Data-Collection and Quality-Control Protocols and Procedures for the *Equus* Beds Ground-Water Recharge Demonstration Project Near Wichita, Kansas, 1995-96, Ziegler, A.C., and Combs, L.J., 1997, U.S. Geological Survey Open-File Report 97-235, 57 p.

- NEW Baseline Water Quality and Preliminary Effect of Artificial Recharge on Ground Water, South-Central Kansas, 1995-98, Ziegler, A.C., Christensen, V.G., and Ross, H.C., 1999, U.S. Geological Survey Water-Resources Investigations Report 99-4250, 74 p.

- NEW Characteristics of Atrazine in Source Water: A Case Study From Kansas, 1998, Christensen, V.G., and Ziegler, A.C. 1998, *in* Water Quality Technical Conference, San Diego, California, November 1-4, 1998, Proceedings: American Water Works Association, CD-ROM catalog 20400, 9 p.

- *Equus* Beds Ground-Water Recharge Demonstration Project, South-Central Kansas: Baseline Water Quality and Preliminary Effects of Artificial Recharge on Ground-Water Quality, Ziegler, A.C., Christensen, V.G., and Ross, H.C., 1998 *in* Proceedings: Midwest Groundwater Conference, October 12-14, 1998 [abstract and oral presentation].

- NEW: Use of Real-Time Water-Quality Monitoring and Multiple-Regression Analysis for Estimation of Selected Constituent Loads in Streamflow, South-Central Kansas, Christensen, V.G., Jian, Xiaodong, and Ziegler, A.C., 1999, *in* Proceedings of the Seventh Symposium on Chemistry and Fate of Modern Pesticides, September 14-16, 1999 [abstract and poster].

Ground Water

- Changes in Ground-Water Levels and Storage in the Wichita Well Field Area, South-Central Kansas, 1940-98, Aucott, W.R., and Myers, N.C., 1998, U.S. Geological Survey Water-Resources Investigations Report 98-4141, 29 p.

- Changes in Ground-Water Levels and Storage in the Wichita Well Field Area, South-Central Kansas, 1940-98, Aucott, W.R., and Myers, N.C., 1998, *in* Proceedings: Midwest Groundwater Conference, October 12-14, 1998 [abstract and poster].

- Increased Use of Cheney Reservoir for Wichita Area Water Supply Benefits *Equus* Beds Aquifer, Ross, H.C., Myers, N.C., and Aucott, W.R., 1997, U.S. Geological Survey Fact Sheet FS-156-97, 2p.

- Status of Ground-Water Levels and Storage in the Wichita Well Field Area, South-Central Kansas, 1997, Aucott, W.R., Myers, N.C., and Dague, B.J., 1998, U.S. Geological Survey Water-Resources Investigations Report 98-4095, 15 p.

- NEW: Wichita Recharge Project: Sustaining and Preserving the *Equus* Beds aquifer, Stous, D.H., Aucott, W.R., Blain, H.T., and Dealy, M.T., 1999, *in* Proceedings of the Geological Society of America, October 25-28, 1999 [abstract and oral presentation].

Streamflow and Ground-Water level data

Current Steamflow Conditions--via satellite (last seven days)

07143665 Little Arkansas River at Alta Mills, Kansas
07143672 Little Arkansas River at Highway 50 near Halstead, Kansas
07144100 Little Arkansas River near Sedgwick, Kansas
07144200 Little Arkansas River at Valley Center, Kansas

* The demonstration project permit allows water withdrawals from the Little Arkansas River near Halstead when streamflow at the Highway 50 gage is larger than 42 cubic feet per second from April 1 through September 30 and is larger than 20 cubic feet per second from October 1 through March 31 or from the Little Arkansas River near Sedgwick when streamflow at the Sedgwick gage is larger than 40 cubic feet per second.

Historical Streamflow Data (period of record)

07143665 Little Arkansas River at Alta Mills, Kansas
07143672 Little Arkansas River at Highway 50 near Halstead, Kansas
07144100 Little Arkansas River near Sedgwick, Kansas
07144200 Little Arkansas River at Valley Center, Kansas

Current River Stage and Ground-Water Level Data (last seven days)

07143665 Little Arkansas River at Alta Mills, Kansas
07143680 Little Arkansas River at Halstead, Kansas
07144100 Little Arkansas River near Sedgwick, Kansas
07144200 Little Arkansas River at Valley Center, Kansas

Historical River Stage and Ground-Water Level Data (since beginning of water year)

07143665 Little Arkansas River at Alta Mills, Kansas
07143680 Little Arkansas River at Halstead, Kansas
07144100 Little Arkansas River near Sedgwick, Kansas
07144200 Little Arkansas River at Valley Center, Kansas

Water-Quality Data

Current water temperature, specific conductance, pH, and dissolved oxygen data--updated daily (last seven days)

07143672 Little Arkansas River at Hwy 50 and diverted water at Halstead Recharge site near Halstead, Kansas
07144100 Little Arkansas River and diverted water near Sedgwick, Kansas

Historical water temperature, specific conductance, pH, dissolved oxygen data--updated daily (since beginning of water year)

07143672 Little Arkansas River at Hwy 50 and diverted water at Halstead Recharge site near Halstead, Kansas
07144100 Little Arkansas River and diverted water near Sedgwick, Kansas

For information on the more than 3,000 water quality samples collected since 1996 see Highlights or Preliminary Water Quality Effects Report.

For additional Information, please write or call:

Andy Ziegler
U.S. Geological Survey
4821 Quail Crest Place
Lawrence, KS 66049-3839
Telephone: (785) 842-9909

Fax: (785) 832-3500
Email: equus@maildkslwr.cr.usgs.gov

Top of Page || **Description of Project** || **Highlights of Results**

USGS Water Resources of Kansas Web Site							
Kansas Home Page	What's New	About Us	Kansas Water Data	Studies & Research	Publications	Education & Other Info	Search

National USGS Web Sites					
USGS	Water	Geology	Mapping	Biology	On-line Help

U.S. Department of the Interior, U.S. Geological Survey
Comments and suggestions: webmaster@maildkslwr.cr.usgs.gov
URL: http://ks.water.usgs.gov/Kansas/equus/
Last modified: March 6, 2000

CITY COUNCIL UPDATE

Raw Water System Update to Wichita City Council

November 23, 1999

Mid-Kansas Engineering Consultants, Inc

Burns & McDonnell

Raw Water System Project Update

Background

Integrated Local Water Supply Plan
Adopted in 1993

Raw Water System Project Update

Background

Integrated Local Water Supply Plan

- Greater use of Cheney Reservoir
- Equus Beds Aquifer Storage & Recovery
- Expand Local Well Field
- Bentley Reserve Well Field
- Conservation

Raw Water System Project Update

Background

Integrated Local Water Supply Plan Implementation

- Approximately 60% of City's supply is from Cheney Reservoir
- Completed Report on replacement of the 48-inch pipeline
- Completed Local Well Field Report

Local Well Field Expansion

Local Well Field Expansion

Local Well Field Expansion

- Report completed in 1999
- Based on extensive field testing and groundwater modeling.
- Considered high chloride water from the Arkansas River and plume from the landfill
- Diversion of good quality "Above-base-flow" water from Little Arkansas River
  - 27 MGD 50% of time
  - 37 MGD 40% of time

Local Well Field Expansion

Conceptual Design
- **Four horizontal collector wells**
- **Five vertical wells**
- **Collecting pipelines**

Recharge Demonstration Project Update

Equus Beds Aquifer Recharge Project

Project Update

Recharge Demonstration Project Update

Background

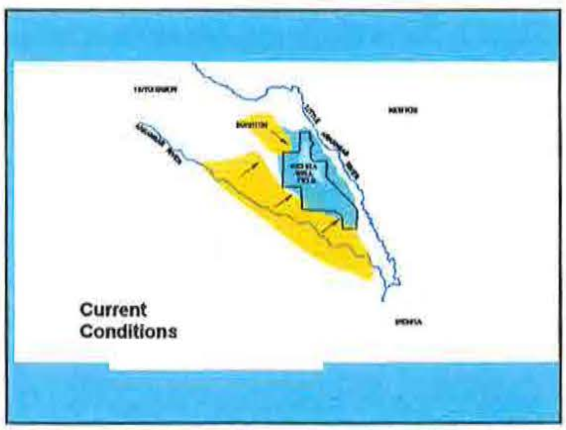
Equus Beds Aquifer Storage & Recovery

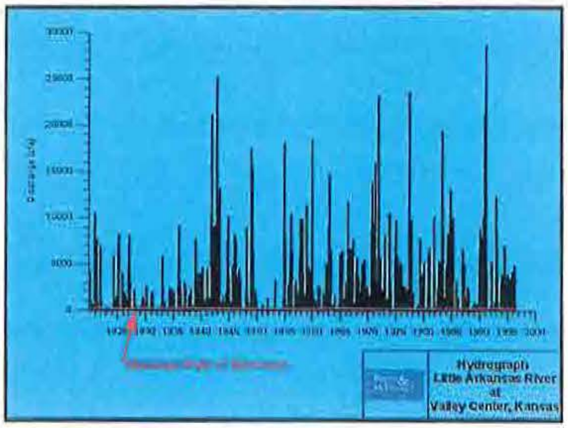
• 1994	Feasibility Study
• 1996	Engineering Study
• 1997	Demonstration Facility Construction
• 1997 - Present	Demonstration Facility Operation
• 1997 - Present	Environmental Studies

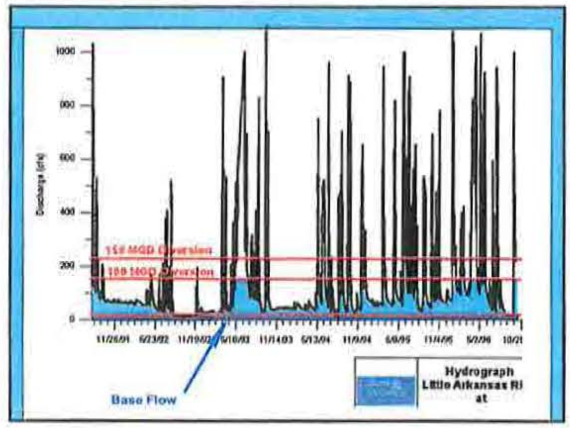
Recharge Demonstration Project Update

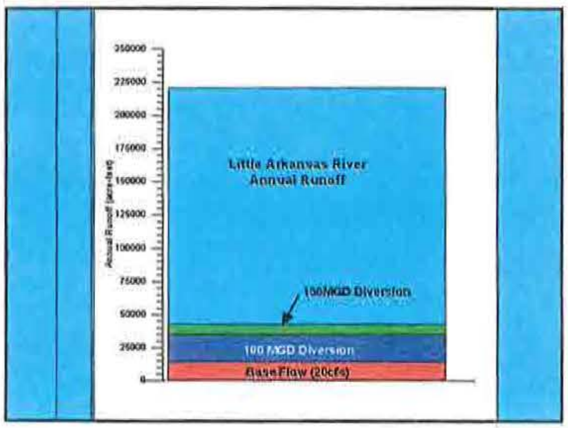
Background

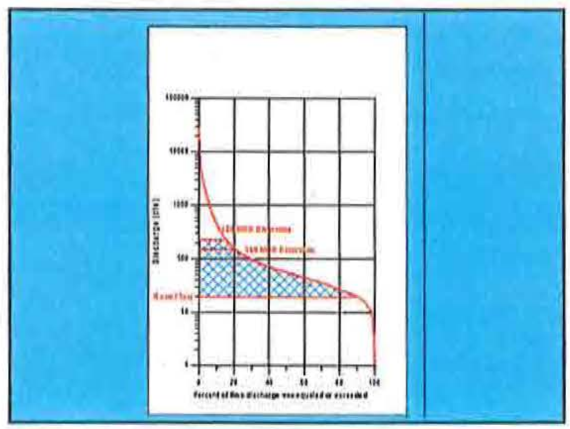
Equus Beds Aquifer Storage & Recovery
- Major component of the Integrated Local Water Supply Plan
- Store up to 70 billion gallons for use during times of drought
- Protect aquifer from natural and manmade saltwater intrusion



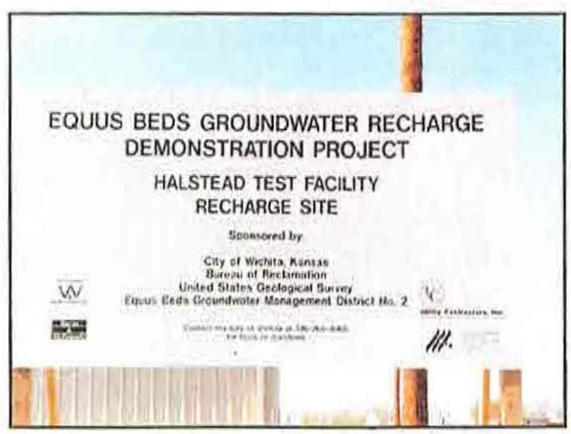

Hydrograph
Little Arkansas River
at
Valley Center, Kansas

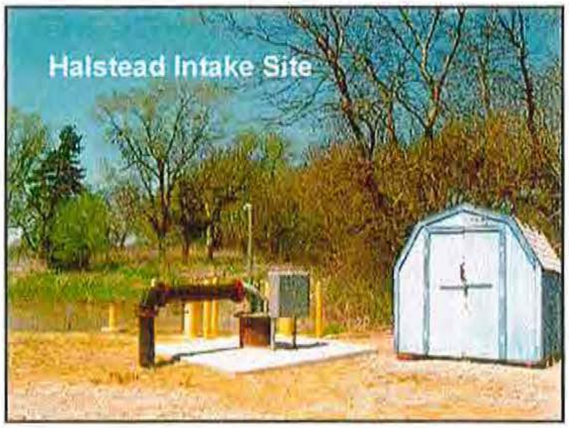

150 MGD Diversion
100 MGD Diversion
Base Flow
Hydrograph
Little Arkansas Ri
at


Little Arkansas River
Annual Runoff
150MGD Diversion
100 MGD Diversion
Base Flow (20cfs)

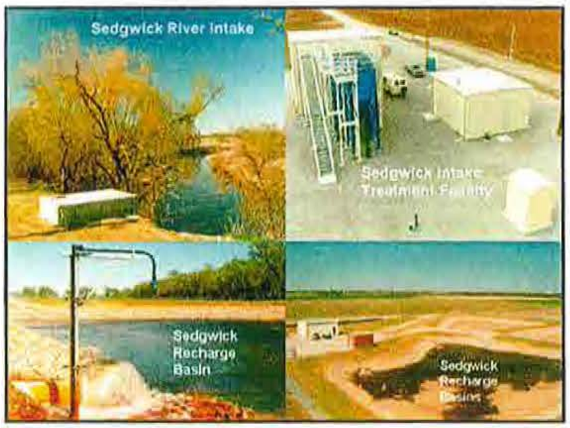


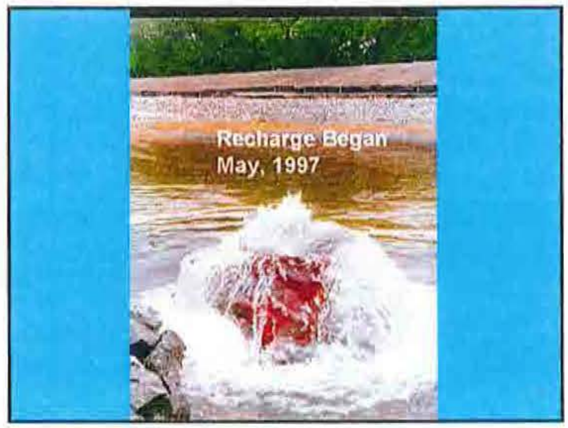

RIVERSIDE PARK

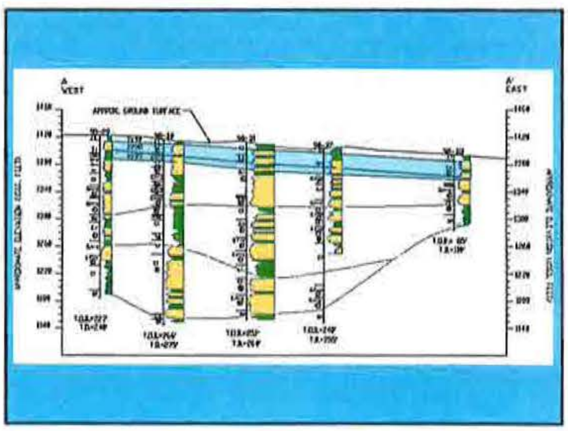

EQUUS BEDS GROUNDWATER RECHARGE
DEMONSTRATION PROJECT
HALSTEAD TEST FACILITY
RECHARGE SITE
Sponsored by
City of Wichita, Kansas
Bureau of Reclamation
United States Geological Survey
Equus Beds Groundwater Management District No. 2

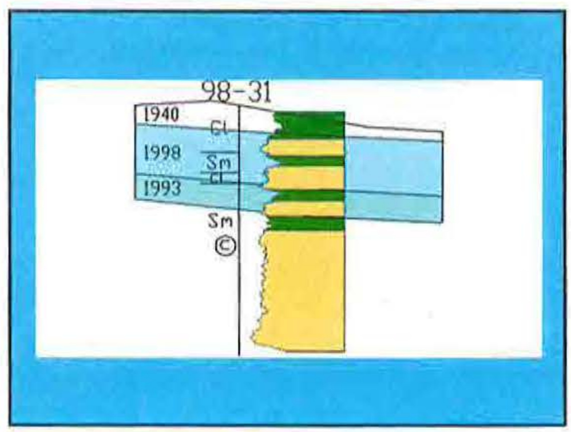

Halstead Intake Site

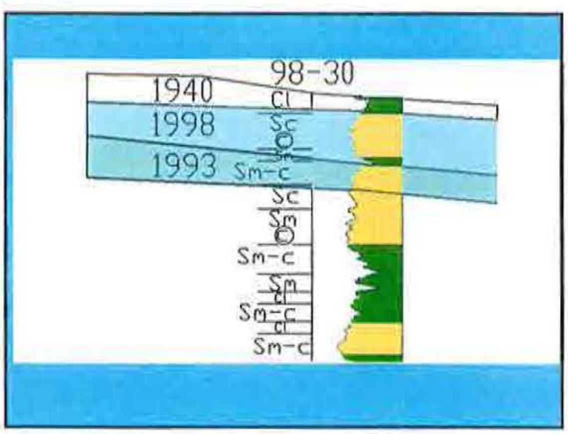

lstead Control Building
Recharge Well
Halstead Recharge Basins
Recharge Trench

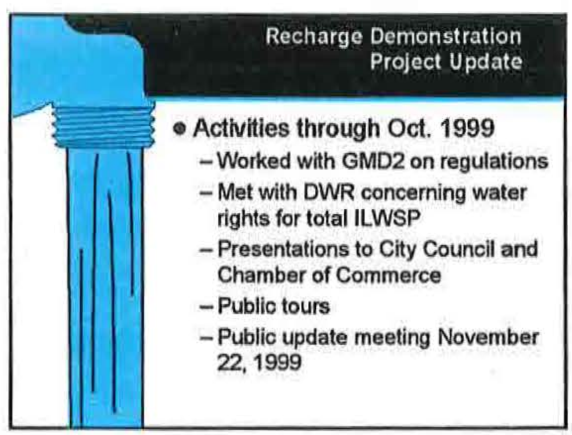

Sedgwick River Intake
Sedgwick Intake Treatment Facility
Sedgwick Recharge Basin
Sedgwick Recharge Basins


Recharge Began
May, 1997




98-31
1940
1998
1993
Cl
Sm
Sm


98-30
1940
1998
1993
Cl
Sc
Sm-c
Sc
Sm-c
Sm-c


Recharge Demonstration
Project Update
• Activities through Oct. 1999
– Worked with GMD2 on regulations
– Met with DWR concerning water rights for total ILWSP
– Presentations to City Council and Chamber of Commerce
– Public tours
– Public update meeting November 22, 1999

Recharge Demonstration Project Update

- Activities through Oct. 1998
  - Continued operation of both systems
  - Installed passive recharge wells to enhance infiltration rates
  - Installed and tested simulated surface water trenches
  - Conducted testing to refine the value of specific yield
  - Began conceptual design of full-scale recharge & recovery system

Recharge Demonstration Project Update

- Results (November 1, 1999)
  - 721 million gallons recharged
    (2,200 acre-feet)
    <u>**4,700 households for one year**</u>
  - Over 4,000 samples analyzed
    - Baseline
    - River
    - Recharge water
    - Shallow and deep groundwater

Recharge Demonstration Project Update

Recharge Demonstration Project Update

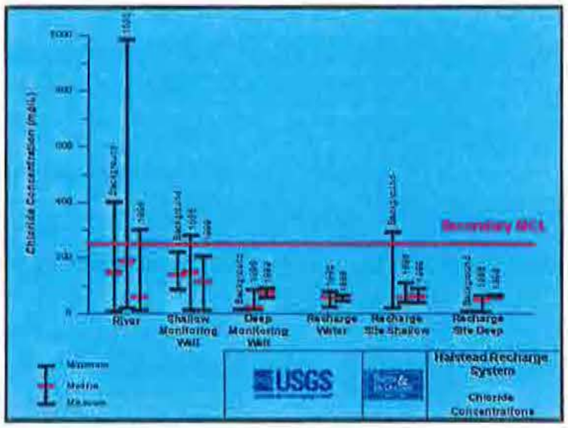
- Water Quality Summary
  - Constituents of Concern
    - Chloride and Atrazine
  - Surface Water
    - chloride frequently above drinking water limits
    - atrazine frequently exceeds 3 ug/L

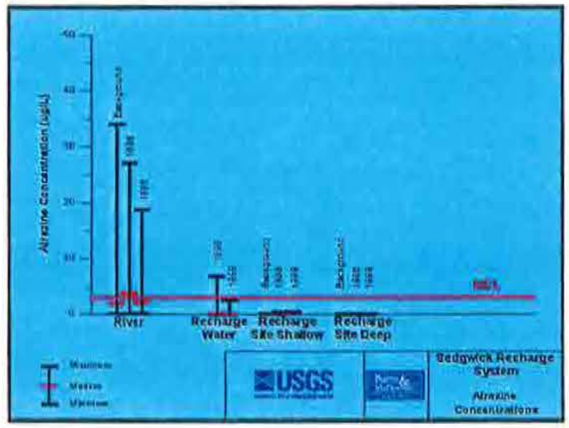
Recharge Demonstration Project Update

- Water Quality Summary (cont)
  - Halstead diversion site - deep groundwater
    - chloride increased from 15 to 80 mg/L
    - atrazine all <0.05 ug/L

Recharge Demonstration Project Update

- Water Quality Summary (cont)
  - Halstead Recharge Site
    - shallow - decreased to match recharge water
    - deep - increased to match recharge water
  - Sedgwick Recharge Site
    - shallow - chloride increased from 10 to 80 mg/L (1998) & 64 in 1999
    - atrazine ranged from <0.05 to 0.39 ug/L
    - deep - no impacts





Recharge Demonstration Project Update

Conclusion

The Recharge Project Works!

Recharge Demonstration Project Update

Equus Beds Groundwater Recharge Demonstration Project

Internet Web Page

http://www-ks.cr.usgs.gov

Water Resources Research and Studies in the Kansas District

Recharge Demonstration Project Update

- Activities for Year 2000
  - Surface Water Treatment Optimization Studies
    - Polymer dosage adjustments
    - Different polymers
    - Adjust upflow rate through Lamella
    - Impact on Lamella solids disposal
    - Alternative treatment pilots

Recharge Demonstration Project Update

- Work for Year 2000 (continued)
  - Halstead Recharge Site
    - test passive recharge well system
    - iron fouling in trench
  - Finalize Environmental Studies
  - Continue with other parts of the Integrated Local Water Supply Plan

Recharge Demonstration Project Update

- **Activities for Year 2000 (continued)**
  - Develop full-scale design criteria
  - Develop full-scale operating criteria
  - Work with State and GMD2 to develop regulations for the Recharge Project

Recharge Demonstration Project Update

- **Environmental Activities in 1999**
  - Aquatic Monitoring
    - Completed reports
    - Fisheries typical of Kansas streams
    - Adjust to changing conditions
  - Instream Flow Monitoring
    - Model runs & analysis underway
    - Report preparation initiated

Recharge Demonstration Project Update

- **Environmental Activities in 1999**
  - Continued preparation of Environmental Report
    - Project Need, Alternative Selection, and Existing Environment chapters drafted
    - Impact of Conceptual Design initiated
  - Continued environmental review of specific sites for field investigations
  - Maintained coordination with Agencies

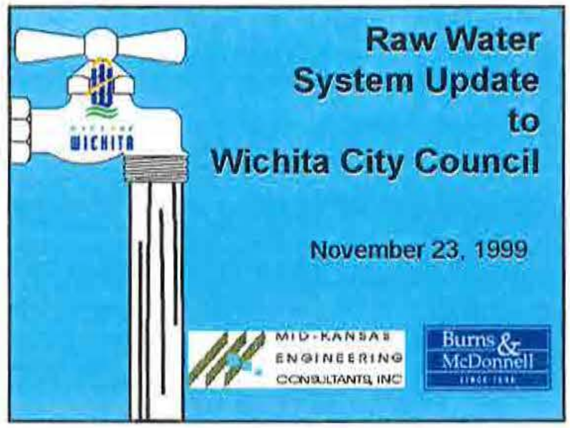
Recharge Demonstration Project Update

- **Environmental Activities For Year 2000**
  - Instream Flow Monitoring
    - Complete analysis and report
    - Coordinate results with agencies

Recharge Demonstration Project Update

- **Environmental Activities For Year 2000**
  - Environment Report
    - Evaluate Conceptual Design impacts
    - Coordinate analysis with agencies
    - Complete draft Report
    - Request public review and comment
    - Finalize Environmental Report
    - Apply for and obtain environmental permits


Raw Water System
Project Update
Future City Council Action
• Obtain land for replacement pipeline.
• Action to begin installation of Index Well System for recharge project.
• Action to begin design of "Prototype" 10 MGD recharge facility.
• Action to begin design and construction of first Local Well Field expansion unit.
• Water Supply CIP estimated expenditures - $86 million over next 6 years


WICHITA
Raw Water
System Update
to
Wichita City Council
November 23, 1999
MID-KANSAS
ENGINEERING
CONSULTANTS, INC
Burns & McDonnell

PREVIOUS REPORTS

PREVIOUS REPORTS

In 1992, the City of Wichita contracted with Burns & McDonnell, Kansas City, Missouri and Mid-Kansas Engineering Consultants, Wichita, Kansas to conduct a study of water source alternatives for the City's water service area with the general objective of developing a plan capable of meeting projected water demands through the year 2050. In 1993, the report titled *Water Supply Study* (Burns & McDonnell, 1993) was completed with recommendations to implement the Integrated Local Water Supply (ILWS) Plan with a groundwater recharge component.

The 1993 *Water Supply Study* recommended the implementation of a small-scale groundwater recharge demonstration project to confirm feasibility of recharge and to develop operating and design criteria and data for permitting a full-scale recharge system. In 1994, a recharge demonstration project was proposed to the USBR according to their investigative format and, to date, over $2 million has been received from USBR for project funding.

Two phases of demonstration activities have been implemented as follows:

- Phase I - Feasibility Determination and Design
  - Part I, Feasibility Study, an investigation of existing geologic, hydrogeologic, water quality, water rights and environmental data, was completed in 1994. This study entitled *Equus Beds Groundwater Recharge Demonstration Project Feasibility Study* (Phase I, Part I - Preliminary Data Review and Concept Development) (Burns & McDonnell, 1994), confirmed the likelihood of the demonstration project feasibility.
  - Part II, Engineering Study, included collection of field data with additional studies of geology, hydrogeology, water quality and environmental and cultural resources. Work included construction of one 1,000-gpm pumping well near the Little Arkansas River, 4 temporary infiltration test pits, 17 monitoring wells, 3 river stage gages, and 16 piezometers. This study, titled *Equus Beds Groundwater Recharge Demonstration Project* (Phase I, Part II - Engineering Study Involving Water Quality, Testing, Facility Siting, Test Well Construction and Aquifer Test) (Burns & McDonnell, 1996), was completed in 1996.

- Part III, substantially completed in 1997, included the design and construction of the demonstration project facilities. The plans and specifications, titled *Equus Beds Groundwater Recharge Demonstration Project* (Burns & McDonnell, 1996) were completed in 1996.

- Phase II includes the on-going operation of the demonstration facilities, which started in 1997 and is scheduled to run through the end of year 2000.

In order to fulfill the requirements of the National Environmental Policy Act (NEPA) of 1969, an environmental assessment (EA) was prepared to determine potential environmental impacts of the demonstration project. The final report, titled Environmental Assessment and "Findings-Of-No-Significant-Impact" (FONSI) for the Equus Beds Groundwater Recharge Demonstration Project (Burns and McDonnell, 1995), was submitted to the sponsoring agencies in 1995.

Other engineering reports completed for the City of Wichita that provide information for various components of the City's ILWS Plan include:

- *Local Well Field Feasibility Study Data Review and Initial Work Plan*, April 1996, Burns & McDonnell Engineering Company.

- Equus Beds Groundwater Recharge Demonstration Project, Summary of Activities for Calendar Year 1996, February 1997, Burns & McDonnell Engineering Company.

- *Customer and Water Demand Projection Reevaluation*, 1997, Burns & McDonnell Engineering Company.

- *Quality Assurance Plan for Water Quality Sampling and Analyses, Equus Beds Groundwater Recharge Demonstration Project*, 1997, Burns & McDonnell Engineering Company.

- *State and Federal Agency Update Meeting, Raw Water Supply Projects, City of Wichita, Kansas*, December 1997, Burns & McDonnell Engineering Company.

- *Cheney Reservoir Field Study*, March 1998, Burns & McDonnell Engineering Company.

- *Equus Beds Groundwater Recharge Demonstration Project, Summary of Activities for Calendar Year 1997*, March 1998, Burns & McDonnell Engineering Company.

- *Operation and Testing Manual for the Equus Beds Groundwater Recharge Demonstration Project*, May 1998, Burns & McDonnell Engineering Company.
- *Report On Pipeline Improvements At Key Locations Along City's 48-Inch Well Field Supply Main*, June 1998, Burns & McDonnell Engineering Company.
- *Equus Beds Groundwater Recharge Demonstration Project, Summary of Activities for Calendar Year 1998*, March 1999, Burns & McDonnell Engineering Company.
- *Local Well Field Concept Development Study*, July 1999, Burns & McDonnell Engineering Company.
- *Report On Raw Water Delivery With 48-Inch Pipeline Replacement*, July 1999, Burns & McDonnell Engineering Company.

Other environmental reports completed for the City of Wichita for the ILWS Plan include:

- *Environmental Assessment for the Equus Beds Groundwater Recharge Demonstration Project*, 1994, Burns & McDonnell Engineering Company.
- *Annual Aquatic Monitoring Report for Little Arkansas River, Equus Beds Groundwater Recharge Demonstration Project*, 1995, Burns & McDonnell Engineering Company.
- *Annual Aquatic Monitoring Report for Little Arkansas River, Equus Beds Groundwater Recharge Demonstration Project*, 1996, Burns & McDonnell Engineering Company.
- *Annual Aquatic Monitoring Report for Little Arkansas River, Equus Beds Groundwater Recharge Demonstration Project*, 1997, Burns & McDonnell Engineering Company.
- *Aquatic Monitoring Report for the Little Arkansas River, Equus Beds Groundwater Recharge Demonstration Project*, 1995-1997, Burns & McDonnell Engineering Company.
- *Local Well Field Expansion Test Well Project, Final Environmental Assessment*, 1997, Burns & McDonnell Engineering Company.

- *Annual Aquatic Monitoring Report for the North Fork of the Ninnescah, Equus Beds Groundwater Recharge Demonstration Project*, 1997, Burns & McDonnell Engineering Company.

- *Annual Aquatic Monitoring Report for the North Fork of the Ninnescah and the Ninnescah Rivers, Equus Beds Groundwater Recharge Demonstration Project*, , 1998, Burns & McDonnell Engineering Company.

- *Aquatic Monitoring Report for the North Fork of the Ninnescah and the Ninnescah Rivers, Equus Beds Groundwater Recharge Demonstration Project*, , 1998, Burns & McDonnell Engineering Company.

Related project reports completed by the U.S. Geological Survey include:

- *Atrazine in Source Water Intended for Artificial Groundwater Recharge, South-Central Kansas*, USGS Fact Sheet FS-074-98, May 1998, Ziegler, A.C., Christensen, V.G., U.S. Geological Survey, Lawrence, Kansas.

- *Changes in Groundwater Levels and Storage in the Wichita Well Field Area, South-Central Kansas*, 1940-98, Water Resources Investigations Report 98-4141, 1998, U.S. Geological Survey, Lawrence, Kansas.

- *Status of Groundwater Levels and Storage in the Wichita Well Field Area, South-Central Kansas*, 1997, Water Resources Investigations 98-4095, 1998, U.S. Geological Survey, Lawrence, Kansas.

- *Baseline Water Quality and Preliminary Effects of Artificial Recharge On Groundwater, South-Central Kansas*, 1995-98, Water Resources Investigations Report 99-4250, 1999, U.S. Geological Survey, Lawrence, Kansas.

PUBLIC/AGENCY INFORMATION PROGRAM

Since the inception of the ILWS Plan in 1993, the City has pursued an active program to inform the public and governmental agencies about the aquifer recharge, storage and recovery project. Presentations and informational materials have been provided to the City Council, Chamber of Commerce and Groundwater Management District No. 2. Public meetings have been held in the Cities of Wichita, Halstead and Sedgwick and agency meetings have been held in the City of Topeka with attendees from federal, state and local governmental entities. Tours of the demonstration facilities have been conducted and informational brochures on the demonstration project have been prepared and distributed to visitors. Monthly progress reports have been distributed to interested parties since 1995. Project update meetings are held at periodic intervals with project team members.

As a result of the project information program, many people and entities have contributed to the development of groundwater recharge concepts for the project. Project participants include the Water and Sewer Department of the City of Wichita, the Equus Beds Groundwater Management District No. 2 (GMD2), the U.S. Bureau of Reclamation (USBR), the U.S. Geological Survey (USGS), MKEC Engineering Consultants, and Burns & McDonnell. Agency participants with regulatory overview include the Kansas Department of Agriculture, Division of Water Resources (DWR); the Kansas Water Office; the Kansas Department of Health and Environment; the Kansas Department of Wildlife and Parks; U.S. Fish and Wildlife Service; and the U.S. Environmental Protection Agency, Region 7.

* * * * *