Selected exhibits of USGS Studies related to hearings on the city of Wichita's applications to operate an aquifer storage and recovery project in Harvey County, Kansas by the Chief Engineer, Division of Water Resources, Kansas Department of Agriculture,

Andrew C. Ziegler,

United States Geological Survey

Testimony presented December 21-22, 2004 in Hutchinson, Kansas at the request of the city of Wichita

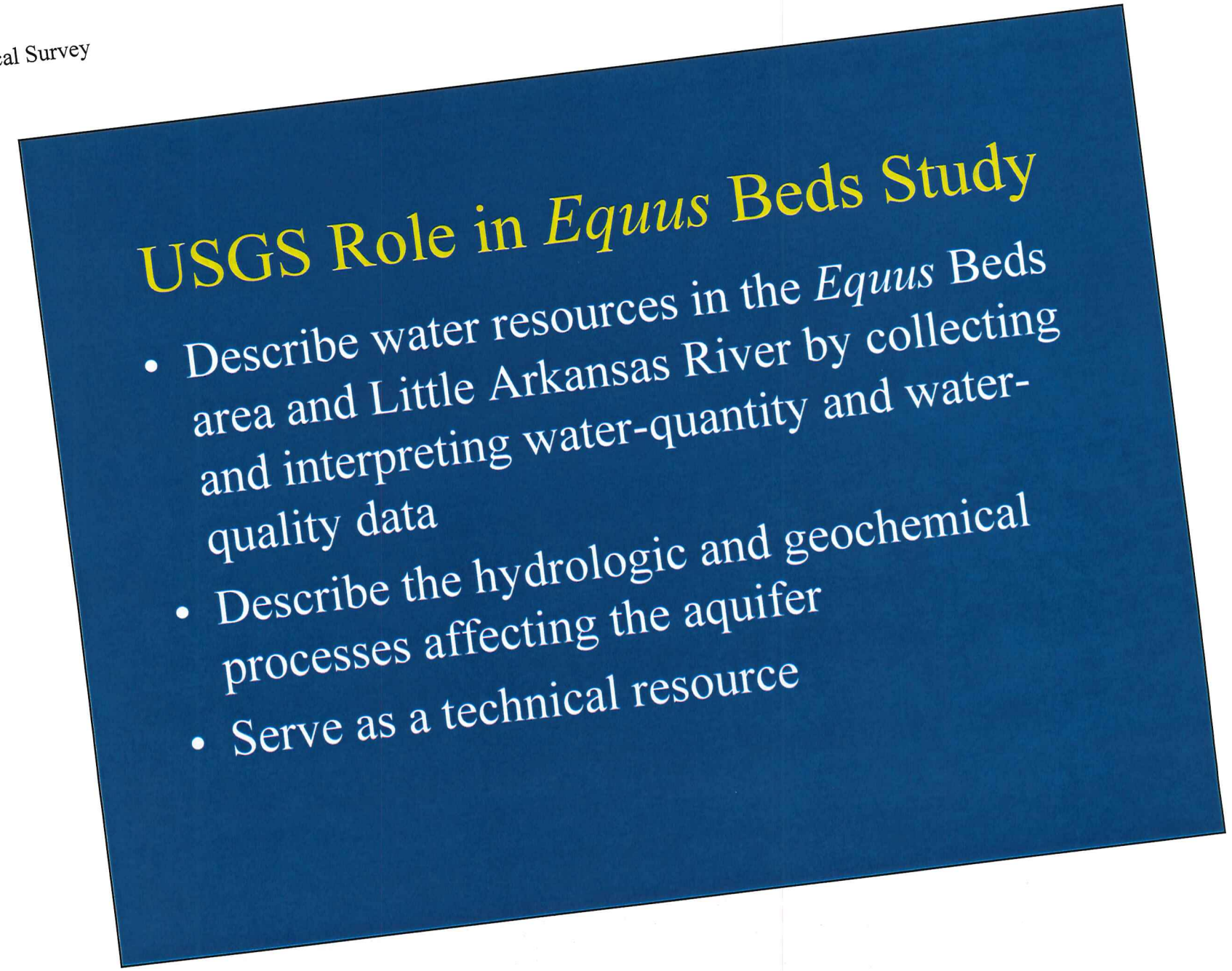
Permission to testify as a fact witness granted by USGS on December 15, 2004

Andrew C. Ziegler

- Supervisory Hydrologist, water-quality specialist and project chief for the *Equus* Beds recharge study
- Employed by USGS since 1985 in Missouri and in Kansas since 1992
- Studies of geochemistry of acidic mine drainage, agricultural chemicals in water, reservoir sediment studies, continuous water quality and the *Equus* study since 1995
- Undergraduate degree in Geology from University of Missouri-Kansas City in 1985
- Masters of Science degree in Urban Environmental Geology in 1989

USGS background

- The USGS, founded in 1879, is part of the Department of Interior, with a mission to serve the nation by providing reliable scientific information to: describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect our quality of life
- Part of USGS mission is to describe water resources of the Nation
- USGS enters in to cooperative agreements to collect data and perform studies with other federal, State and local agencies where USGS contributes expertise and funds in cooperation with funding and expertise from the cooperating agency
- *Equus* study is an example of one of these type of studies in cooperation with the city of Wichita
- Funding during the demonstration project from 1995-2000, was $3.8 Million with USGS contributing $1.4 Million
- Funding for USGS activities with continued ground-water level monitoring and index well network from 2000 – 2004 are $ 4.4 Million with USGS contributing $1.3 million


USGS Role in *Equus* Beds Study
• Describe water resources in the *Equus* Beds area and Little Arkansas River by collecting and interpreting water-quantity and water-quality data
• Describe the hydrologic and geochemical processes affecting the aquifer
• Serve as a technical resource

Citations of information

City of Wichita Exhibit H

Myers, N.C, Hargadine, G.D, and Gillespie, J.B., 1996, Hydrologic and Chemical Interaction of the Arkansas River and the *Equus* Beds Aquifer Between Hutchinson and Wichita, South-Central Kansas: U.S. Geological Survey Water Resources Investigations Report 95-4191, 100pp.

City of Wichita Exhibit E

Hansen, C.V., and Aucott, W.R., 2004, Status of ground-water levels and storage volume in the *Equus* Beds aquifer near Wichita, Kansas, January 200-January 2003: U.S. Geological Survey Water Resources Investigations Report 03-4298, 36pp.

City of Wichita Exhibit F

Ziegler, A.C., Christensen, V.G., and Ross, H.C., 1999, Baseline water-quality and preliminary effects of artificial recharge on ground water, south-central Kansas, 1995-98: U.S. Geological Survey Water-Resources Investigations Report 99-4250, 74 p.

City of Wichita Exhibit G

Ziegler, A.C., Ross, H.C., Trombley, T.J., and Christensen, V.G., 2001, Effects of artificial recharge on water quality in the *Equus* Beds aquifer, south-central, Kansas, 1995-2000: U.S. Geological Survey Fact Sheet 096-01, 4 p.

City of Wichita Exhibit S-W

Ziegler, A.C., written communication of summary of index well data from 2001 through 2004, and maps of average concentrations of arsenic, atrazine, chloride, nitrate, and sulfate.

Testimony related to the Chief Engineer's Questions

- Background ground-water information and chloride contamination movement
- Water-levels and storage changes in the *Equus* Beds area
- Water-quality/water-quantity during the demonstration project
- Water quality in the Index wells

U.S. Geological Survey

Well field and study area

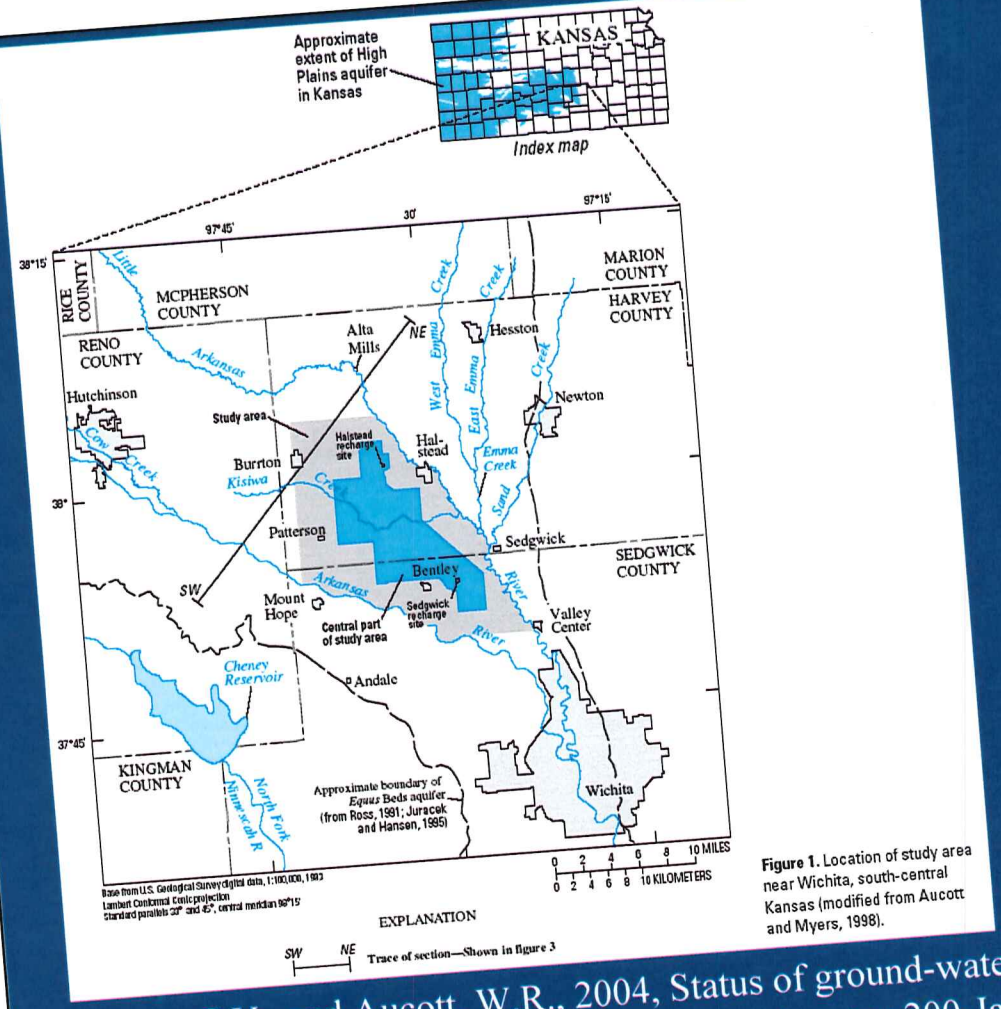


Figure 1. Location of study area near Wichita, south-central Kansas (modified from Aucott and Myers, 1998).

Hansen, C.V., and Aucott, W.R., 2004, Status of ground-water levels and storage volume in the *Equus* Beds aquifer near Wichita, Kansas, January 200-January 2003: U.S. Geological Survey Water Resources Investigations Report 03-4298, page 2.

City Exhibit H

Chloride Sources to the *Equus* Beds Aquifer

- Arkansas River--natural
- Wellington formation—natural
- Oil-field activities
- Brine from salt-mining activities
- Evaporation-pan brine activities
- Sewage treatment facilities

Myers, N.C, Hargadine, G.D, and Gillespie, J.B., 1996, Hydrologic and Chemical Interaction of the Arkansas River and the *Equus* Beds Aquifer Between Hutchinson and Wichita, South-Central Kansas: U.S. Geological Survey Water Resources Investigations Report 95-4191, p.18.

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Table 2. Summary of chloride-concentration data collected from Cow Creek and the Arkansas River, August 1988–July 1991

Sampling-site name and number (fig. 6)	Number of samples	Chloride concentration, in milligrams per liter			
		Mean	Median	Minimum	Maximum
Cow Creek near confluence with Arkansas River 375906097503900	22	533	495	380	740
Arkansas River at Hutchinson 375903097515700	27	621	640	340	1,100
Arkansas River near Hutchinson 07143330	40	634	640	190	1,100
Arkansas River near Mount Hope 375343097394000	29	610	620	380	1,000
Arkansas River 4 miles northeast of Colwich 375032097305500	30	619	635	240	1,100
Arkansas River near Maize 07143375	49	590	620	140	1,100
Arkansas River, all sites	**175**	**613**	**630**	**140**	**1,100**

Myers, N.C, Hargadine, G.D, and Gillespie, J.B., 1996, Hydrologic and Chemical Interaction of the Arkansas River and the *Equus* Beds Aquifer Between Hutchinson and Wichita, South-Central Kansas: U.S. Geological Survey Water Resources Investigations Report 95-4191, p.23.

City Exhibit H

U.S. Geological Survey

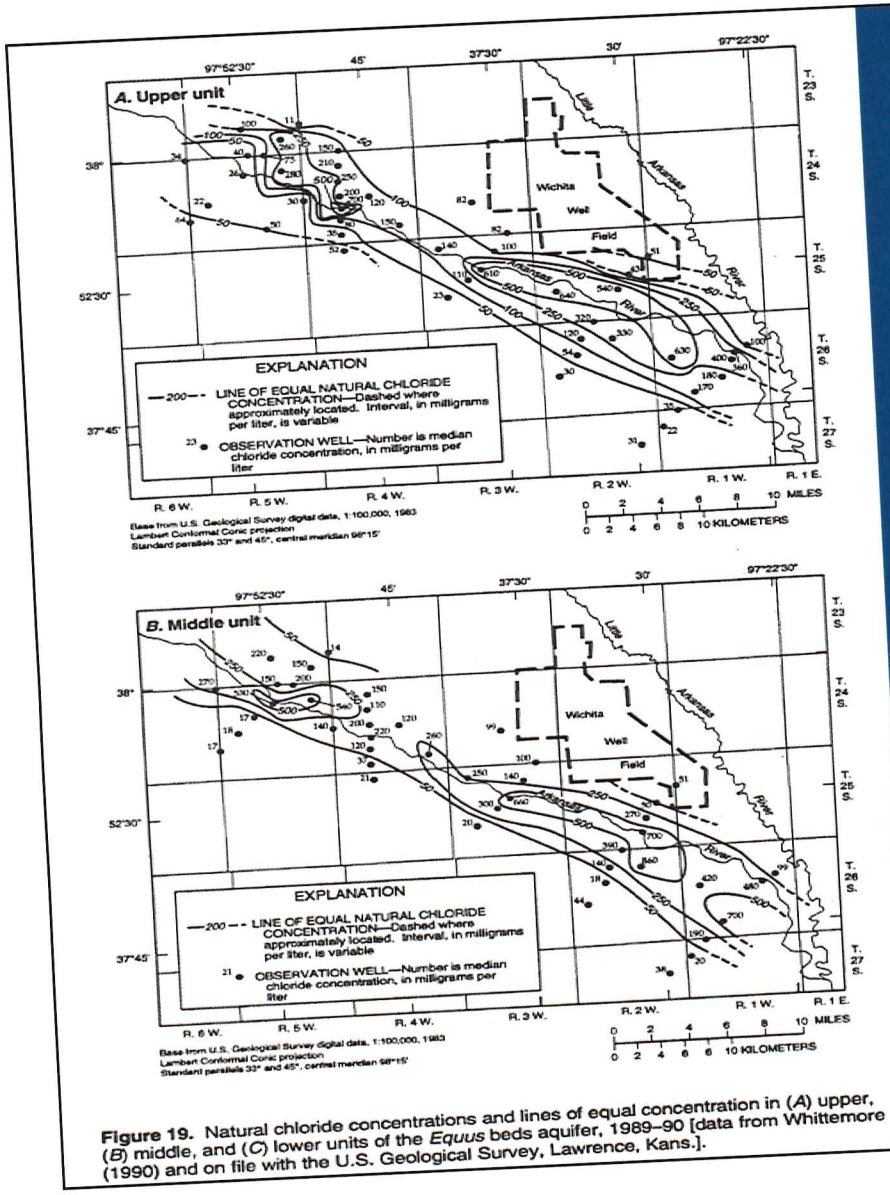

Figure 19. Natural chloride concentrations and lines of equal concentration in (*A*) upper, (*B*) middle, and (*C*) lower units of the *Equus* beds aquifer, 1989–90 [data from Whittemore (1990) and on file with the U.S. Geological Survey, Lawrence, Kans.].

Chloride in *Equus* Beds Aquifer in 1989-90

Myers, N.C, Hargadine, G.D, and Gillespie, J.B., 1996, Hydrologic and Chemical Interaction of the Arkansas River and the *Equus* Beds Aquifer Between Hutchinson and Wichita, South-Central Kansas: U.S. Geological Survey Water Resources Investigations Report 95-4191, p.25.

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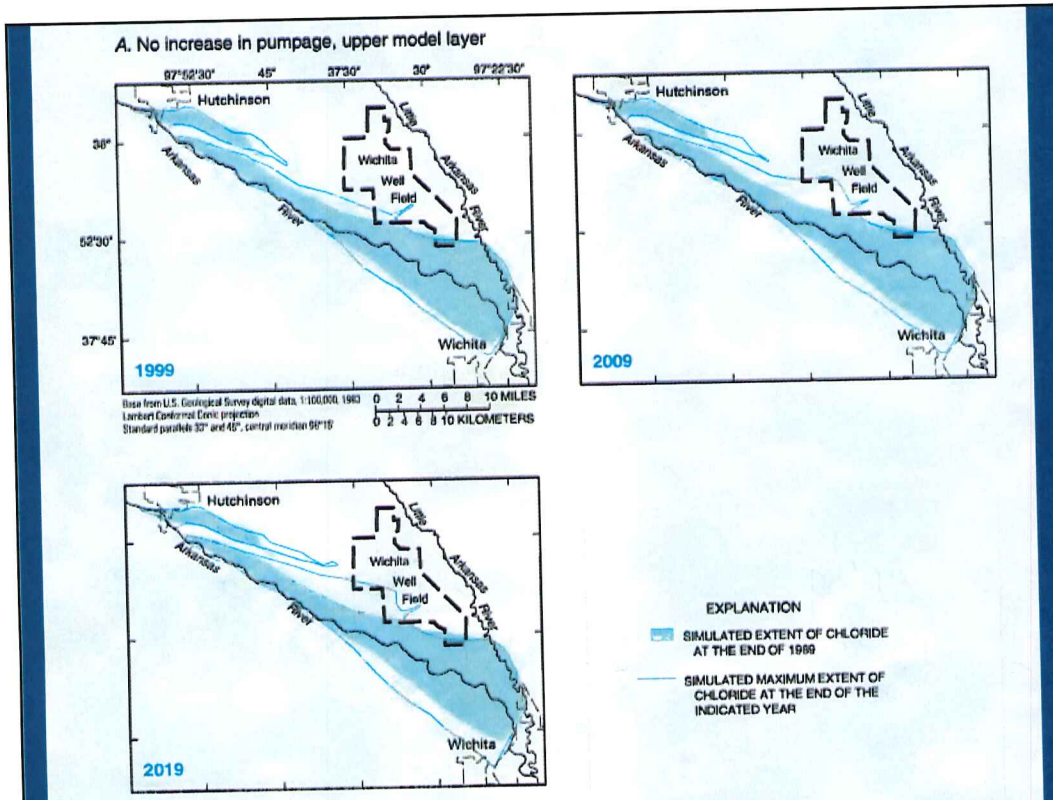


Figure 40. Simulated extent of chloride from Arkansas River at end of each stress period in upper, middle, and lower model layers assuming (*A*) no increase in pumpage since 1989, (*B*) a 1-percent per year increase in pumpage since 1989, (*C*) a 2-percent per year increase in pumpage since 1989, and (*D*) a 3-percent per year increase in pumpage since 1989.

70 **Hydrologic and Chemical Interaction of the Arkansas River and the *Equus* Beds Aquifer Between Hutchinson and Wichita, South-Central Kansas**

Simulated chloride migration

Blue line approximates the simulated 100 mg/L chloride concentration

Myers, N.C, Hargadine, G.D, and Gilliespie, J.B., 1996, Hydrologic and Chemical Interaction of the Arkansas River and the *Equus* Beds Aquifer Between Hutchinson and Wichita, South-Central Kansas: U.S. Geological Survey Water Resources Investigations Report 95-4191, p.23.

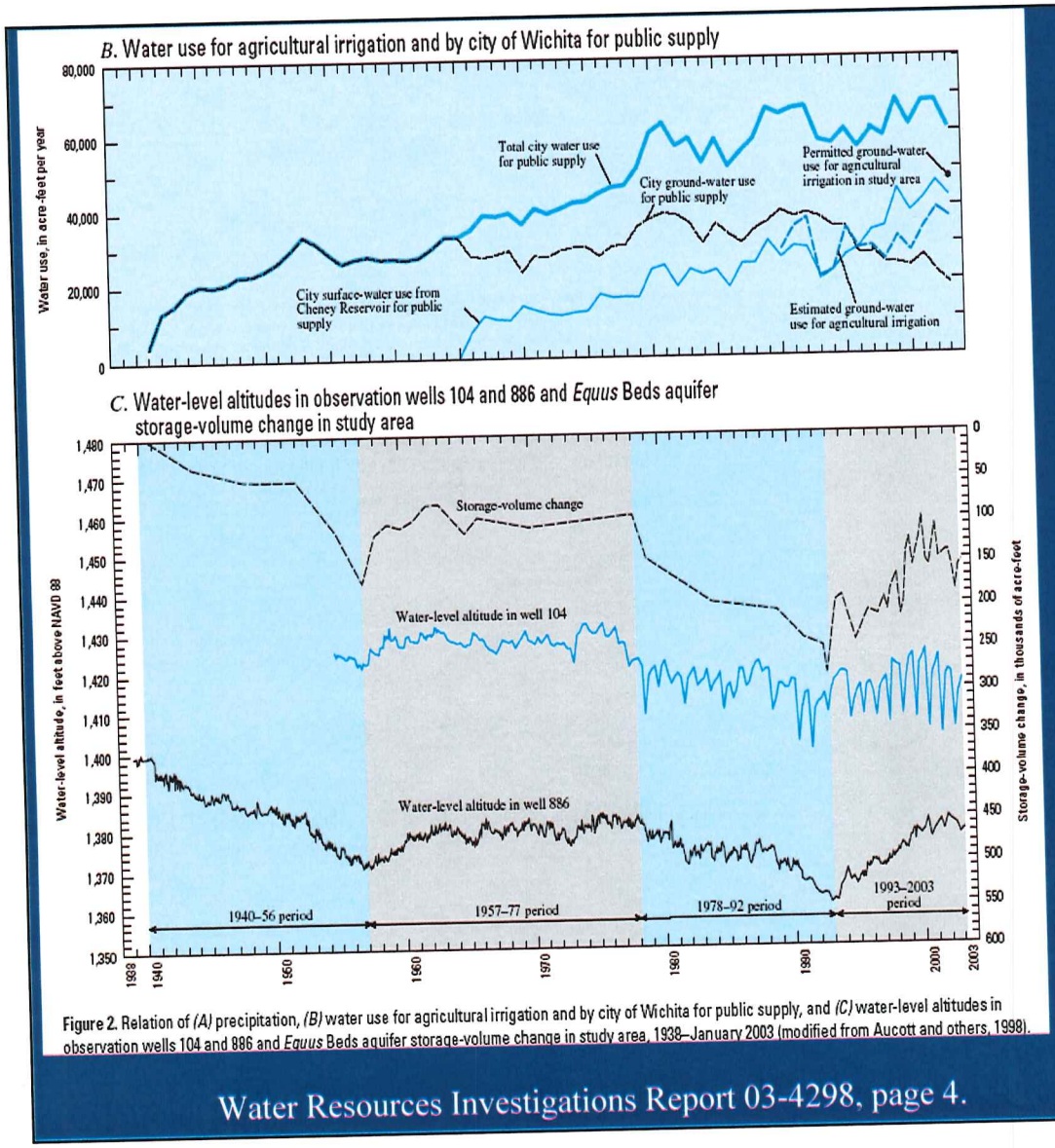


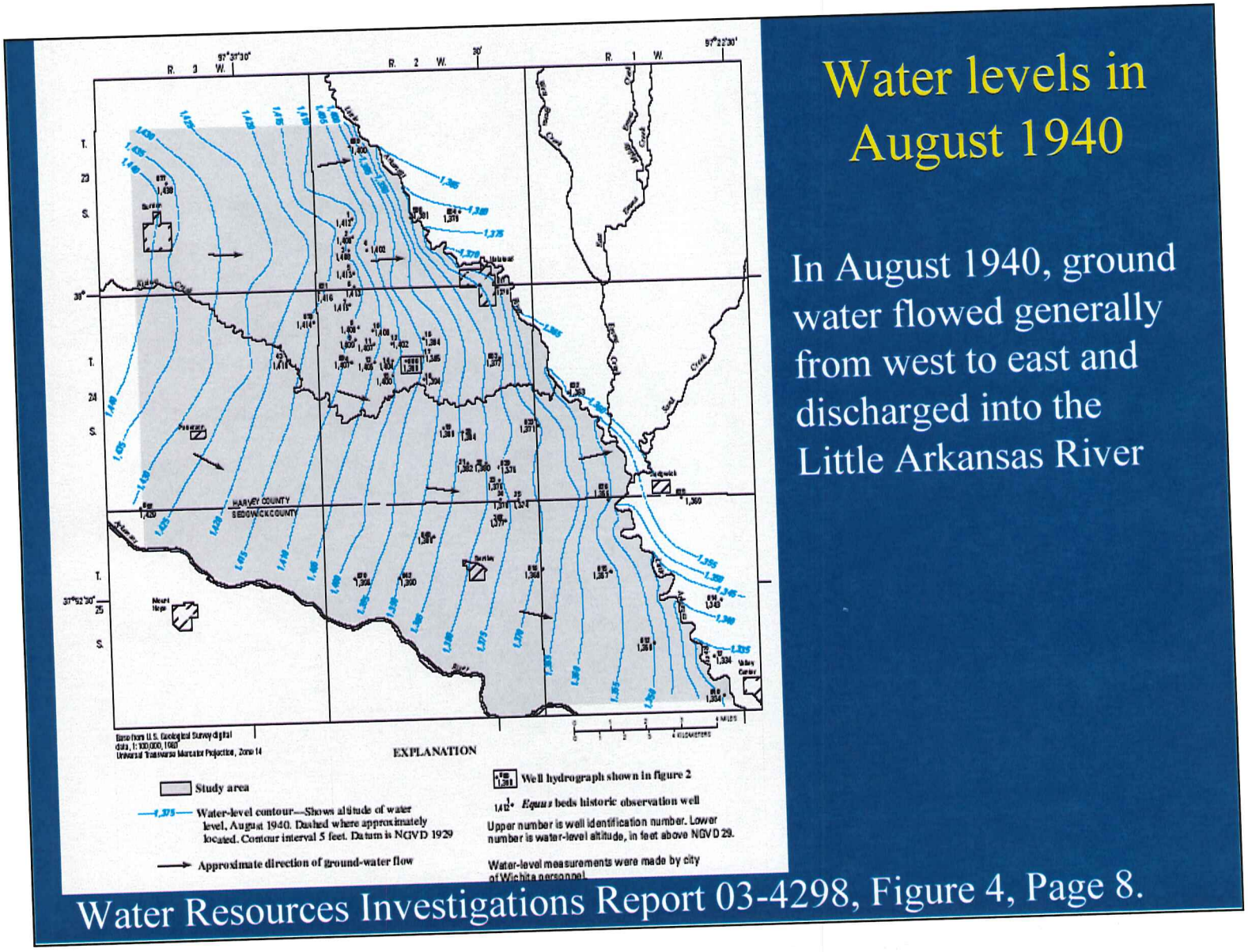
Figure 2. Relation of *(A)* precipitation, *(B)* water use for agricultural irrigation and by city of Wichita for public supply, and *(C)* water-level altitudes in observation wells 104 and 886 and *Equus* Beds aquifer storage-volume change in study area, 1938–January 2003 (modified from Aucott and others, 1998).

Water Resources Investigations Report 03-4298, page 4.

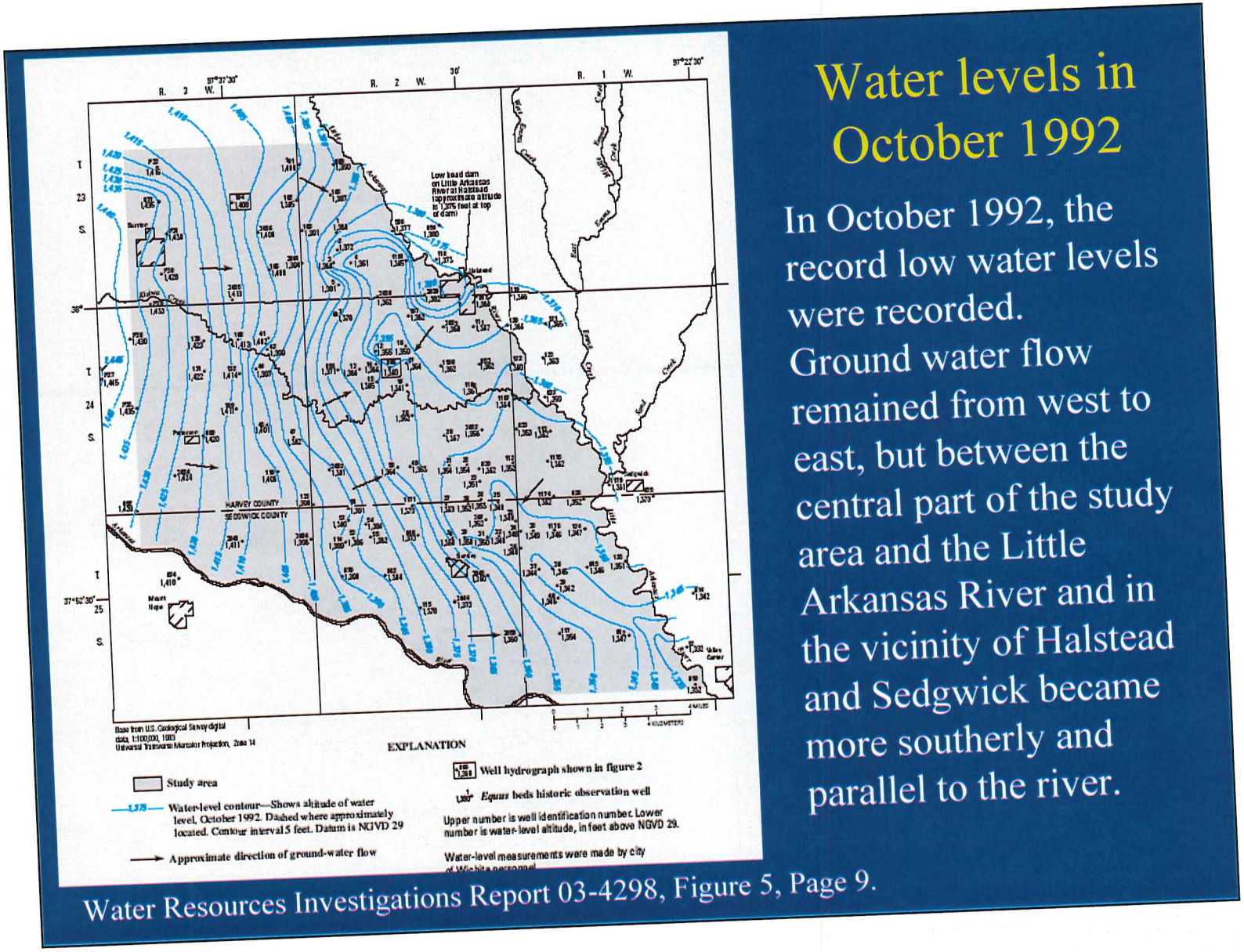
Historical water use and storage-volume change in the *Equus* Beds Aquifer, August 1940 – January 2003

- City withdrawals have decreased by 50 percent since 1997
- Agricultural withdrawals are less than the permitted amounts

City Exhibit E


Water levels in August 1940
In August 1940, ground water flowed generally from west to east and discharged into the Little Arkansas River
R. 3 W.
R. 2 W.
R. 1 W.
HARVEY COUNTY
SEDGWICK COUNTY
EXPLANATION
Study area
Water-level contour—Shows altitude of water level, August 1940. Dashed where approximately located. Contour interval 5 feet. Datum is NGVD 1929
Approximate direction of ground-water flow
Well hydrograph shown in figure 2
Equus beds historic observation well
Upper number is well identification number. Lower number is water-level altitude, in feet above NGVD 29.
Water-level measurements were made by city of Wichita personnel
Water Resources Investigations Report 03-4298, Figure 4, Page 8.

U.S. Geological Survey



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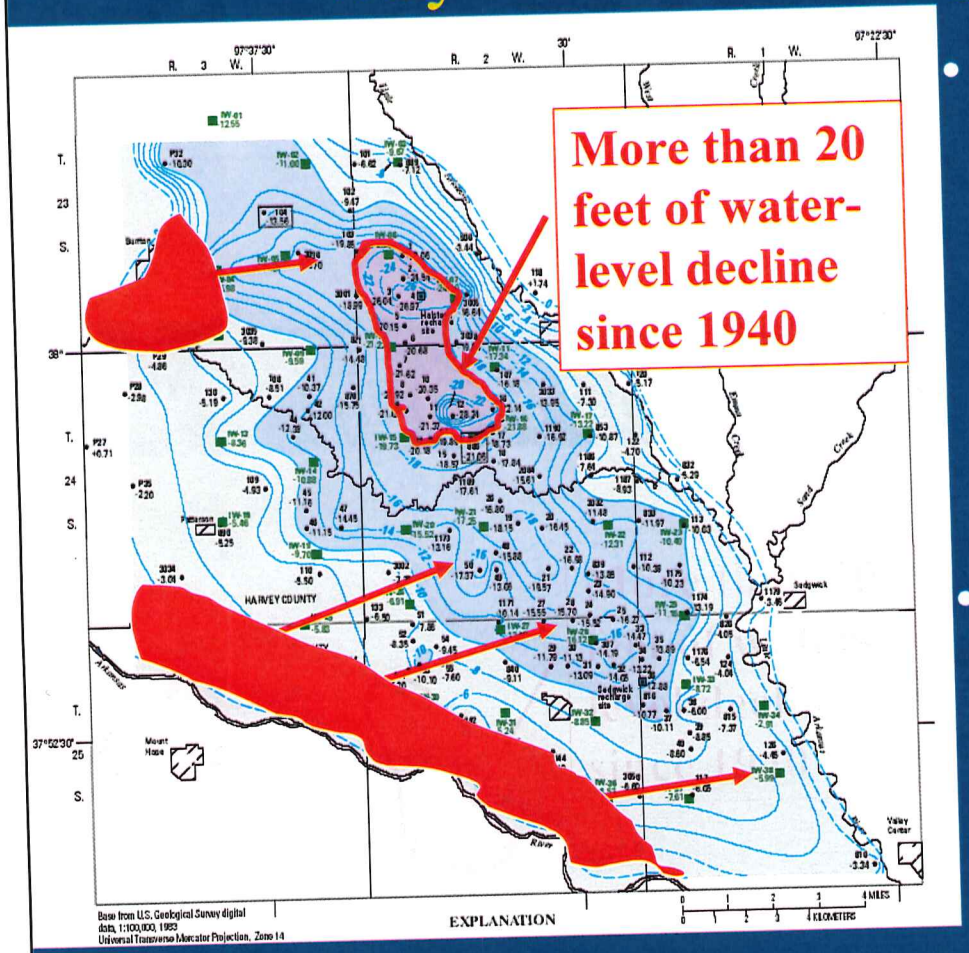
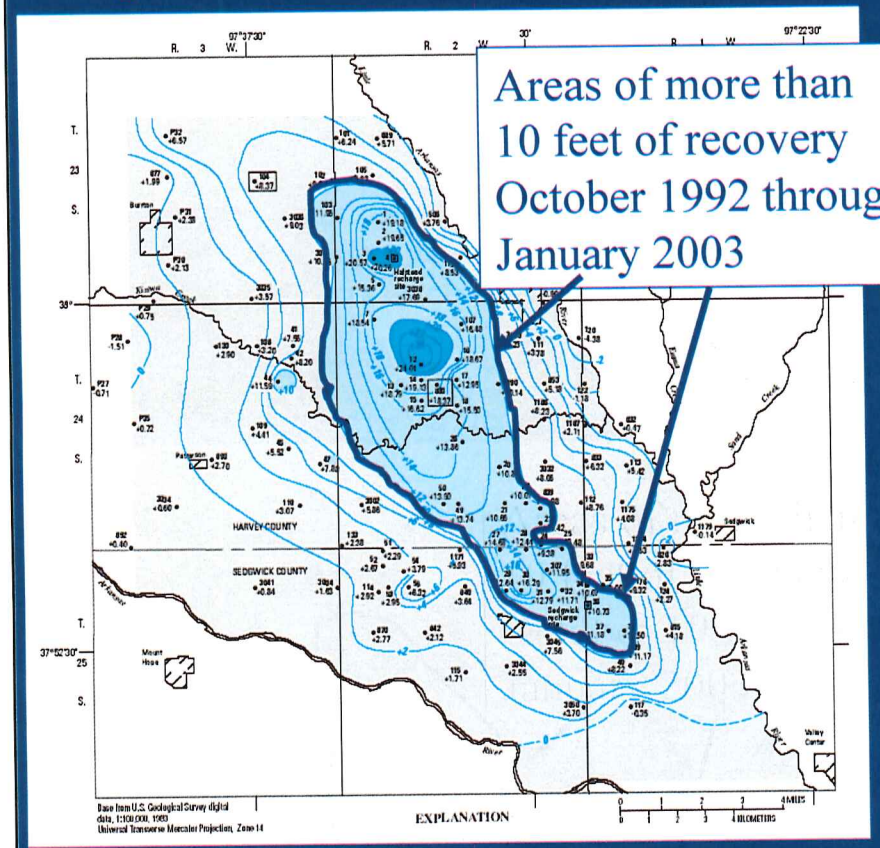
Why is salt water migrating?



- Since 1940, agricultural and municipal pumping created a depression encouraging migration of the chloride plumes toward the well field
- From 1940 -1992, aquifer storage decreased by 283,000 acre feet

Water Resources Investigations Report 03-4298, Figure 19, Page 23.

Greater use of water from Cheney has had a positive effect on *Equus* Beds water levels



As of 2003, aquifer storage volume has recovered 124,000 acre feet since the low in 1992 partly because of decreased pumping by Wichita and normal to wet precipitation decreasing agricultural pumping

- From 1940 – 2003, the aquifer storage volume decreased 159,000 acre feet

Water Resources Investigations Report 03-4298, Figure 22, Page 27.

Table 1. Storage-volume changes in *Equus* Beds aquifer near Wichita, south-central Kansas, August 1940–January 2003.

[Data on file with U.S. Geological Survey, Lawrence, Kansas]

Time period	Storage-volume change, in acre-feet		Proportion of change in study area that occurred in the central part of the study area (percent)
	Within study area	Within central part of study area	
August 1940–October 1992	[1]-283,000	[1]-159,000	56
August 1940–January 1993	[2]-255,000	[2]-154,000	60
August 1940–January 2000	[1]-126,000	[1]-70,600	56
August 1940–April 2000	-101,000	-74,500	74
August 1940–July 2000	-152,000	-76,700	50
August 1940–October 2000	-159,000	-87,000	55
August 1940–January 2001	-134,000	-78,900	59
August 1940–April 2001	-110,000	-72,500	66
August 1940–July 2001	-149,000	-74,900	50
August 1940–October 2001	-146,000	-76,700	52
August 1940–January 2002	-142,000	-77,100	54
August 1940–April 2002	-141,000	-74,900	53
August 1940–July 2002	-162,000	-78,600	49
August 1940–October 2002	-187,000	-90,100	48
August 1940–January 2003	-159,000	-83,400	52
October 1992–January 2000	+157,000	+88,400	56
October 1992–April 2000	+182,000	+84,500	46
October 1992–October 2002	+96,000	+68,000	72
October 1992–January 2003	+124,000	+75,600	61
January 2000–October 2002	-61,000	-19,500	32
January 2000–January 2003	-33,000	-12,800	39
April 2000–October 2002	-86,000	-15,600	18
April 2000–January 2003	-58,000	-8,900	15

[1]Storage-volume change previously reported by Hansen and Aucott (2001)

[2]Storage-volume change previously reported by Aucott and Myers (1998).

Storage changes in the aquifer

Water Resources Investigations Report 03-4298, page 32.

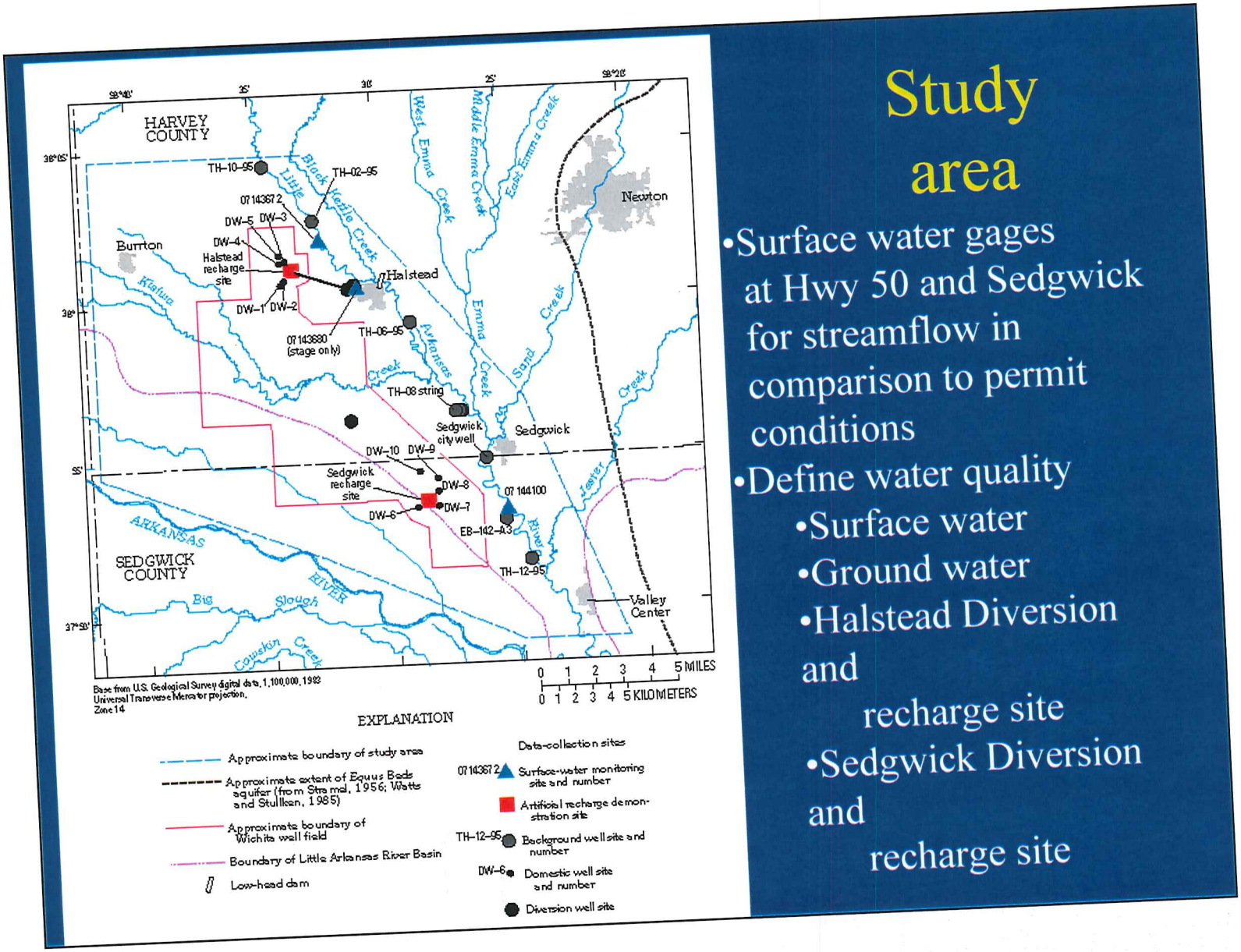
Equus Beds Water Quantity and Quality

- Demonstration project (1995-2000)
  - Surface-water quantity on the Little Arkansas River at Highway 50, at Sedgwick, and stage at Halstead.
  - Surface-water quality in the Little Arkansas River and ground-water quality in the vicinity of the two recharge areas
  - Defined chemicals of concern and effects of recharge
- Index well network (2001-present)
  - Define current water quantity and quality throughout the area
  - Monitor potential future changes from land use and artificial recharge
  - Continued continuous water-quality and quantity monitoring of streams.

Ziegler, A.C., Christensen, V.G., and Ross, H.C., 1999, Baseline water-quality and preliminary effects of artificial recharge on ground water, south-central Kansas, 1995-98: U.S. Geological Survey Water-Resources Investigations Report 99-4250, 74 p.

City Exhibit F

U.S. Geological Survey



Study area

- Surface water gages at Hwy 50 and Sedgwick for streamflow in comparison to permit conditions
- Define water quality
  - Surface water
  - Ground water
  - Halstead Diversion and recharge site
  - Sedgwick Diversion and recharge site

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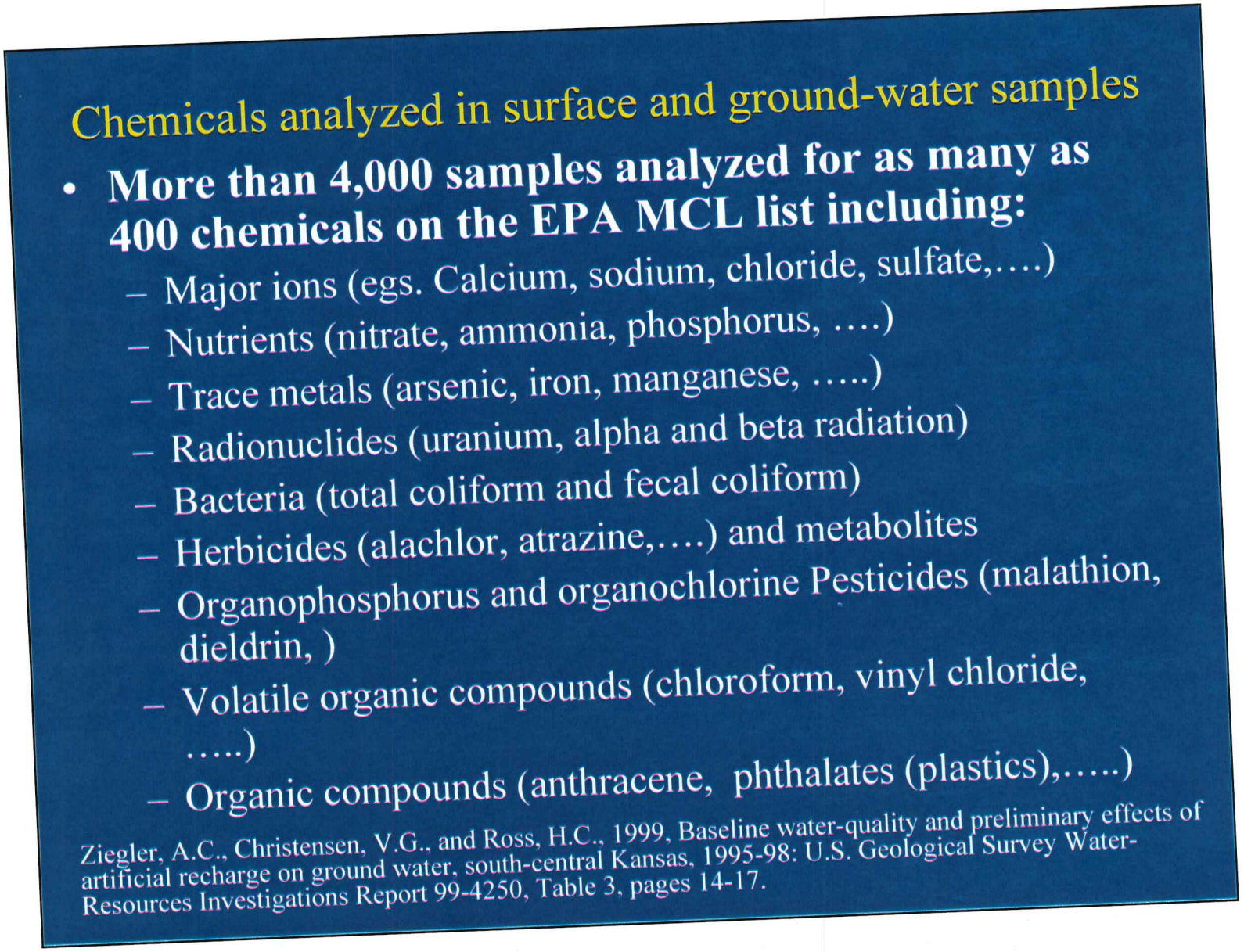
Streamflow, ground-water, and water –quality monitoring

- Little Arkansas River at Highway 50:
  - DWR term permit requirements of 42 cubic feet per second from April 1 through September 30 and 20 cubic feet per second from October 1 through March 31 each year
- Little Arkansas River at Halstead: Measured continuous ground-water levels during diversion well pumping. Demonstrates the river/aquifer connection
- Little Arkansas River near Sedgwick streamflow and ground-water levels:
  - DWR term permit requirements of 40 cubic feet per second at all times
- The Little Arkansas River at Sedgwick has exceeded permit flows for more than 100 days annually during 1995 through 2002
- Since 1998, continuous water-quality monitors at 2 stream sites measured specific conductance, water temperature, pH, dissolved oxygen, and turbidity to estimate hourly chloride and other constituents

Ziegler, A.C., Christensen, V.G., and Ross, H.C., 1999, Baseline water-quality and preliminary effects of artificial recharge on ground water, south-central Kansas, 1995-98: U.S. Geological Survey Water-Resources Investigations Report 99-4250, 74 p.

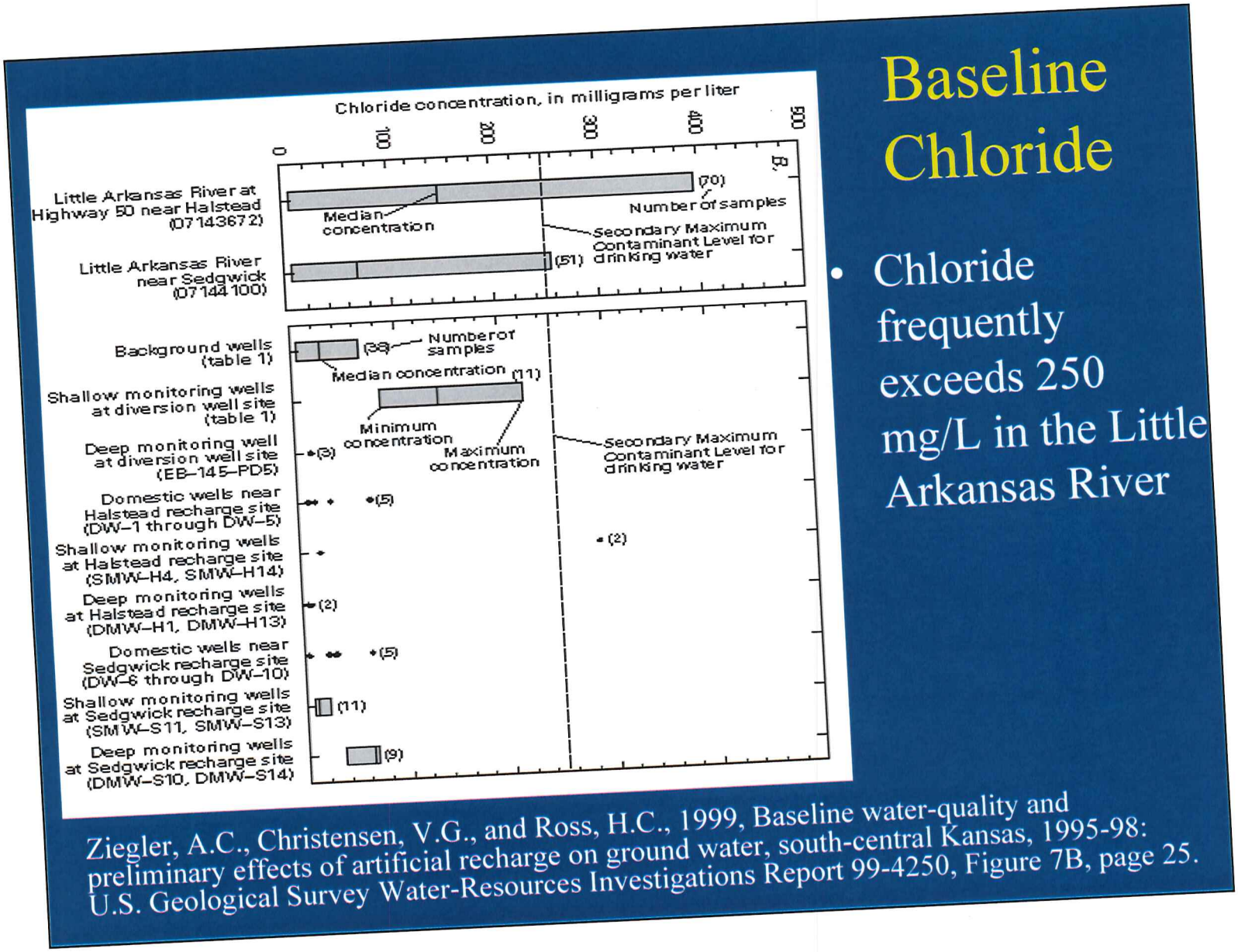

Chemicals analyzed in surface and ground-water samples
• More than 4,000 samples analyzed for as many as 400 chemicals on the EPA MCL list including:
– Major ions (egs. Calcium, sodium, chloride, sulfate,….)
– Nutrients (nitrate, ammonia, phosphorus, ….)
– Trace metals (arsenic, iron, manganese, …..)
– Radionuclides (uranium, alpha and beta radiation)
– Bacteria (total coliform and fecal coliform)
– Herbicides (alachlor, atrazine,….) and metabolites
– Organophosphorus and organochlorine Pesticides (malathion, dieldrin,)
– Volatile organic compounds (chloroform, vinyl chloride, …..)
– Organic compounds (anthracene, phthalates (plastics),…..)
Ziegler, A.C., Christensen, V.G., and Ross, H.C., 1999, Baseline water-quality and preliminary effects of artificial recharge on ground water, south-central Kansas, 1995-98: U.S. Geological Survey Water-Resources Investigations Report 99-4250, Table 3, pages 14-17.

Baseline water-quality conditions

- Constituents of concern-frequently (20 percent of the samples) exceed drinking water standards
  - Surface water
    - Sodium, chloride, total coliform bacteria, and atrazine.
  - Ground water
    - Nitrite plus nitrate, arsenic, iron, manganese

Ziegler, A.C., Christensen, V.G., and Ross, H.C., 1999, Baseline water-quality and preliminary effects of artificial recharge on ground water, south-central Kansas, 1995-98: U.S. Geological Survey Water-Resources Investigations Report 99-4250, 74 p.

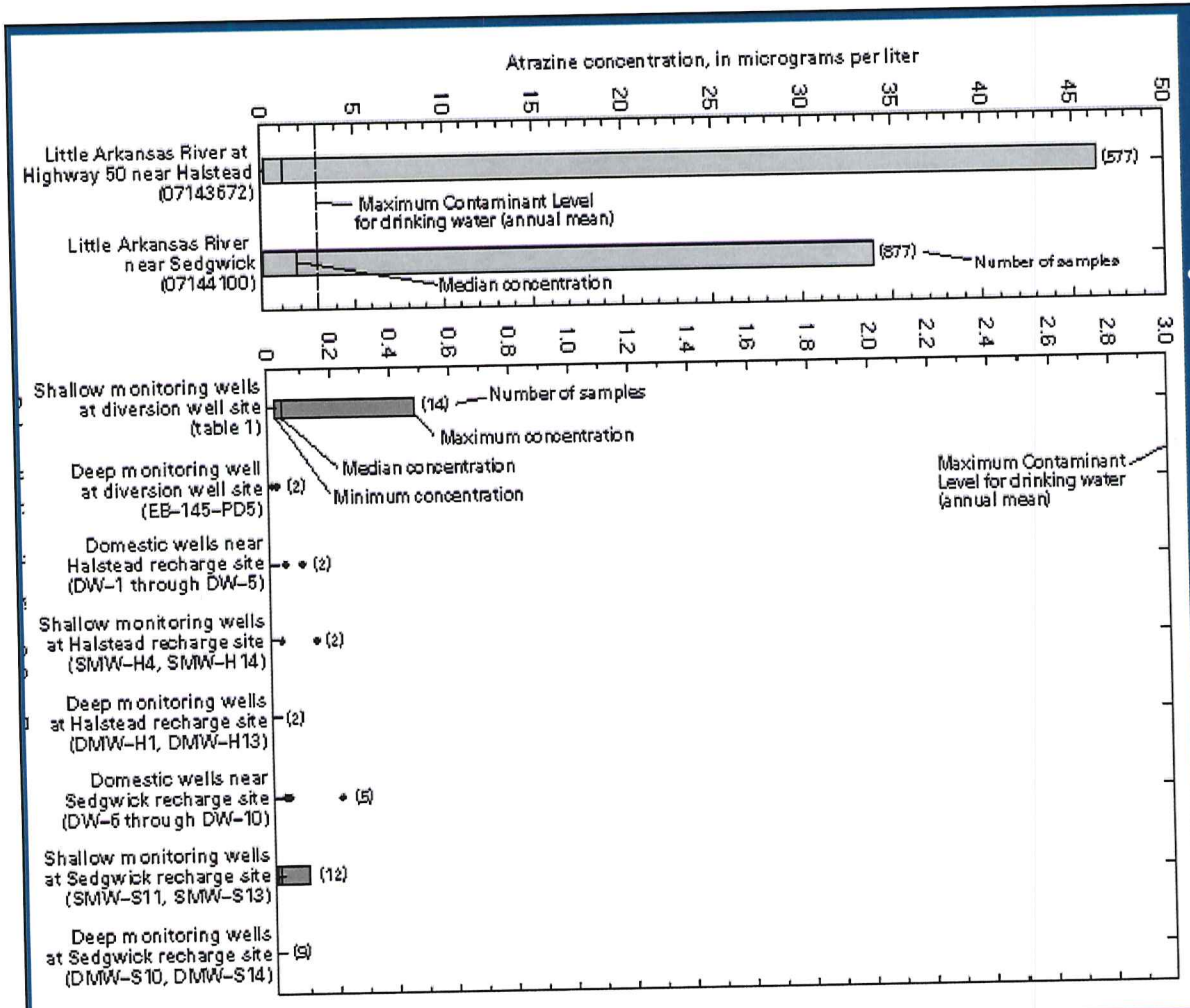
Sodium is not advisory only for heart patients.



Baseline Chloride

- Chloride frequently exceeds 250 mg/L in the Little Arkansas River

Ziegler, A.C., Christensen, V.G., and Ross, H.C., 1999, Baseline water-quality and preliminary effects of artificial recharge on ground water, south-central Kansas, 1995-98: U.S. Geological Survey Water-Resources Investigations Report 99-4250, Figure 7B, page 25.



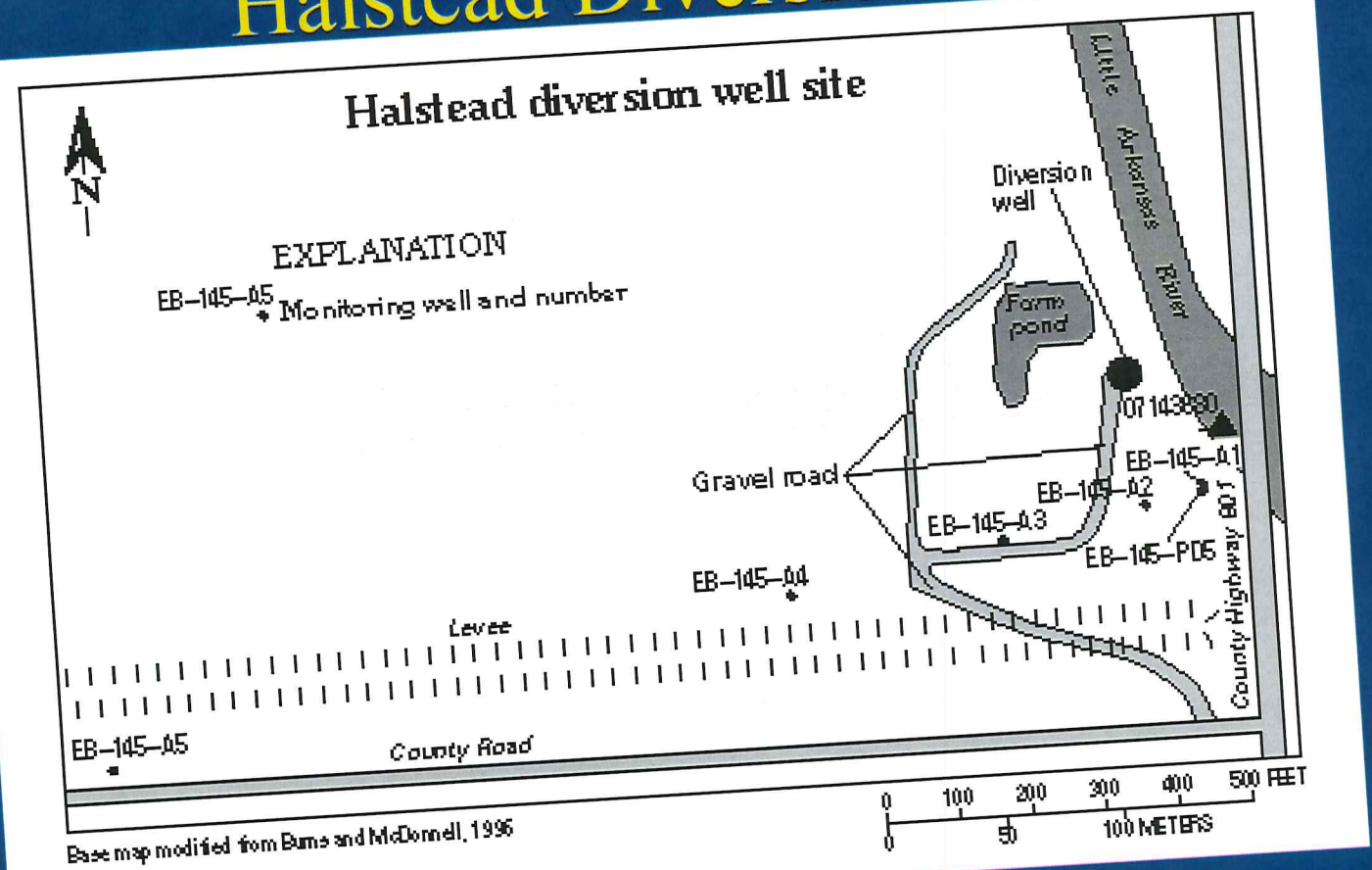
Baseline Atrazine

- Atrazine frequently exceeds 3 micrograms per liter in the Little Arkansas River
- Range from less than 0.1 to 46 micrograms per liter
- Detected in ground water samples before recharge

Ziegler, A.C., Christensen, V.G., and Ross, H.C., 1999, Baseline water-quality and preliminary effects of artificial recharge on ground water, south-central Kansas, 1995-98: U.S. Geological Survey Water-Resources Investigations Report 99-4250, Figure 10, page 48.

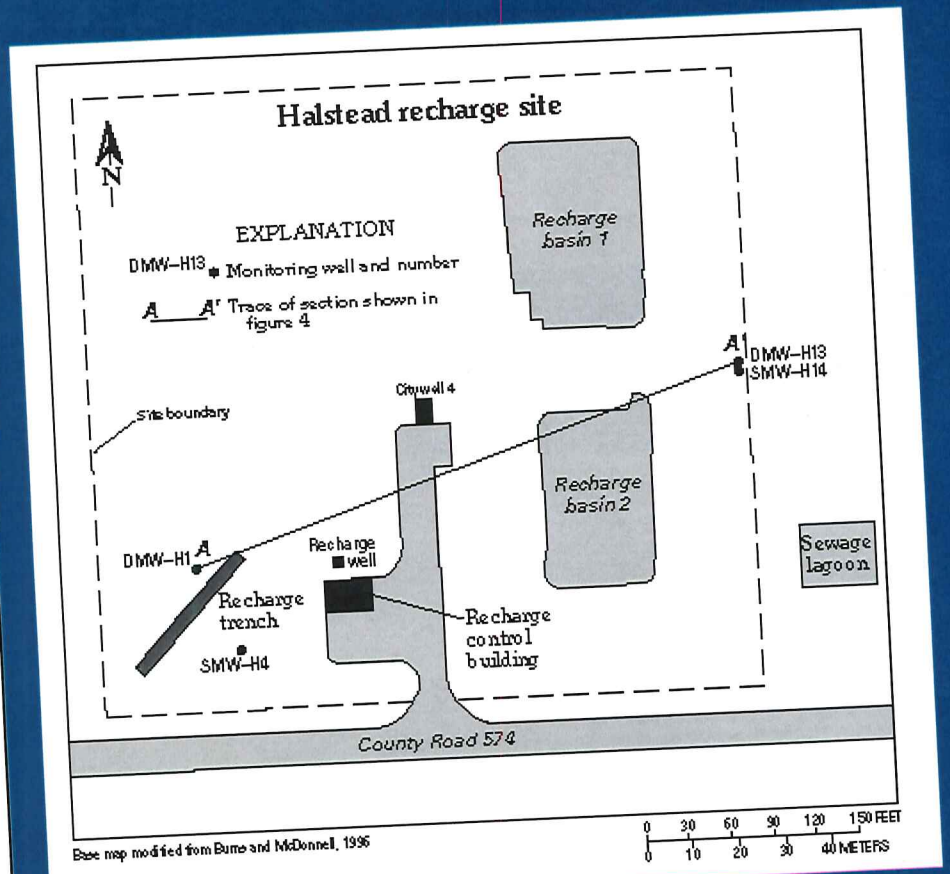
U.S. Geological Survey

Halstead Diversion Site



USGS Water-Resources Investigations Report 99-4250, Figure 3, page 7.

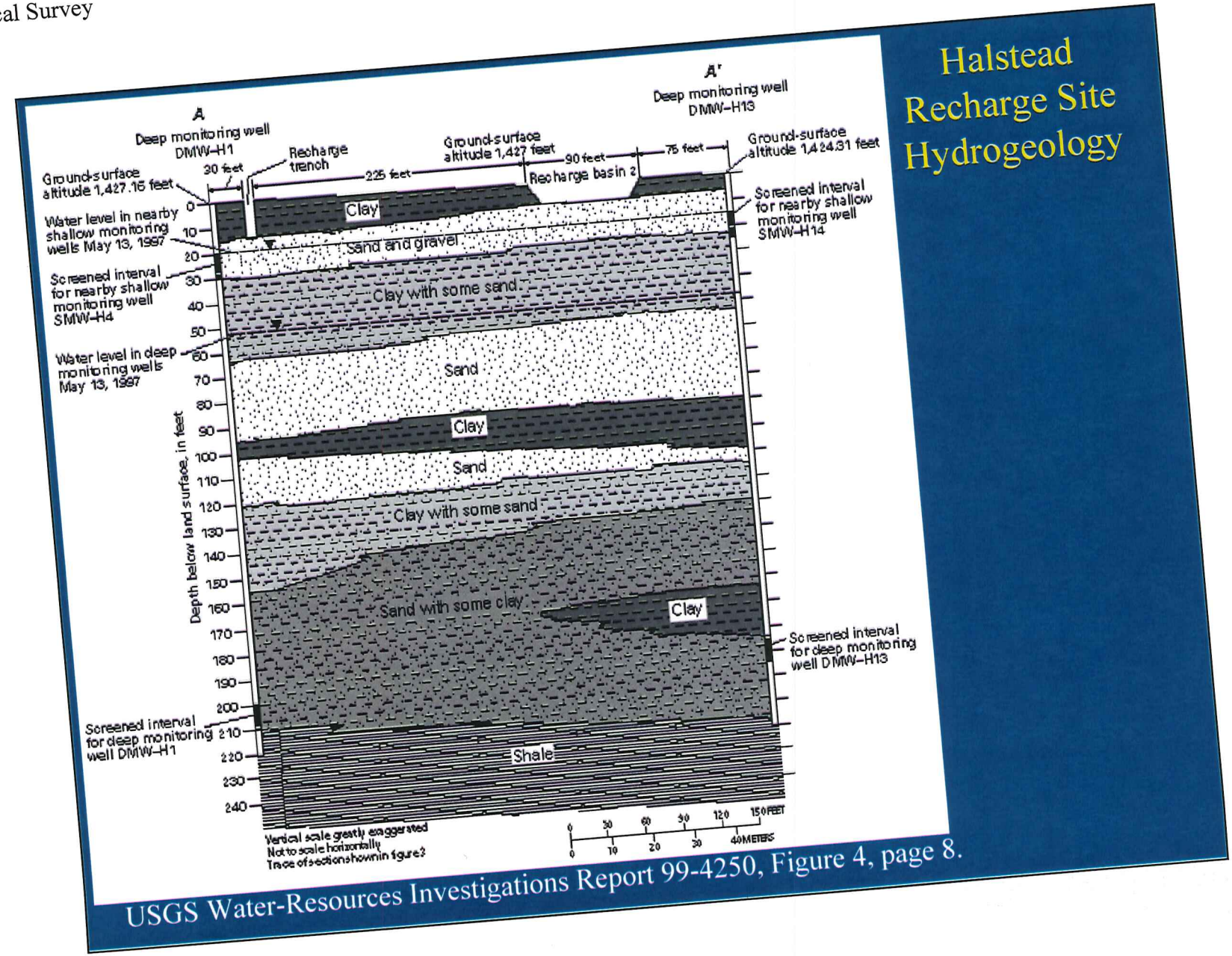
Halstead Recharge Site



USGS Water-Resources Investigations Report 99-4250, Figure 3, page 7.

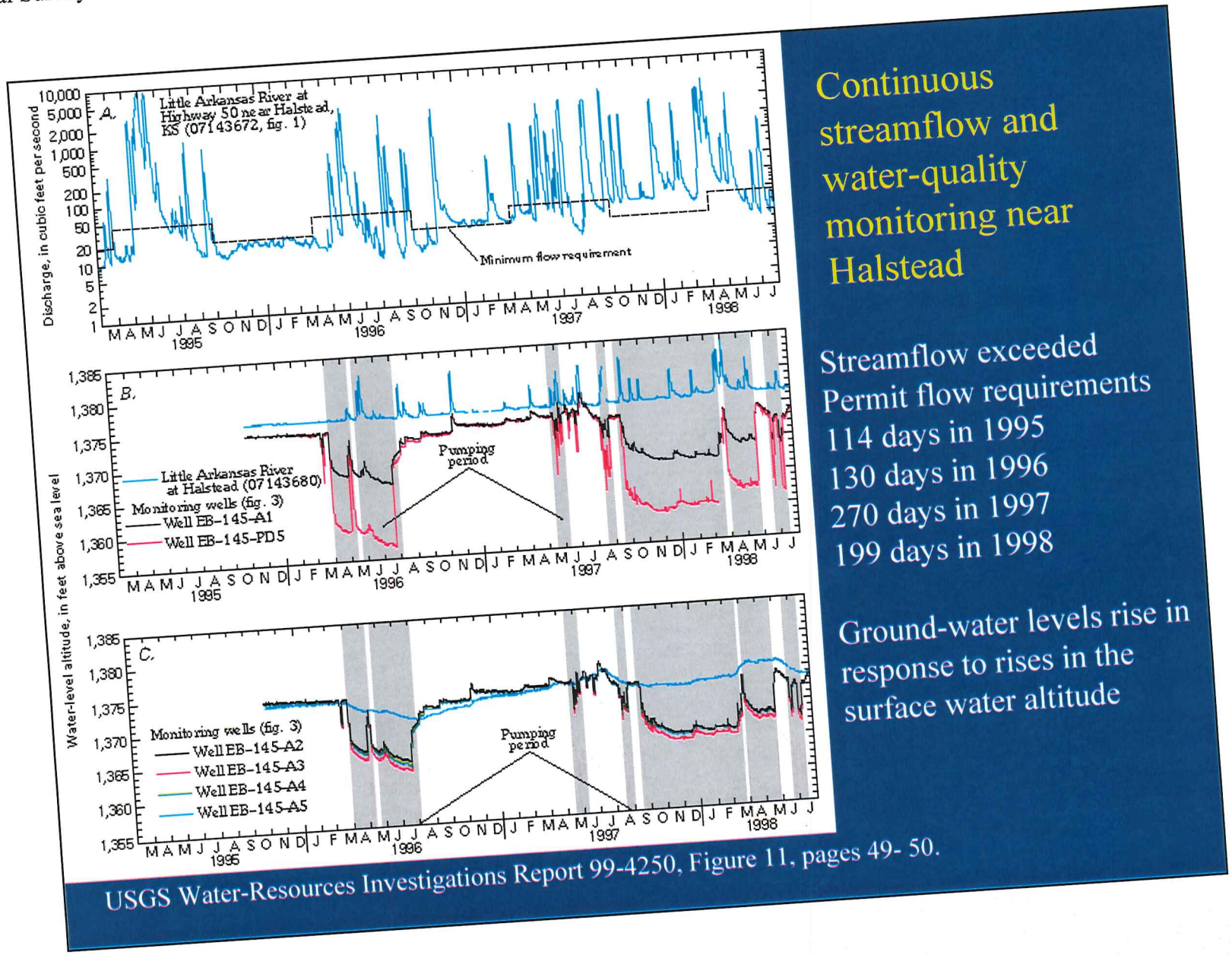
U.S. Geological Survey

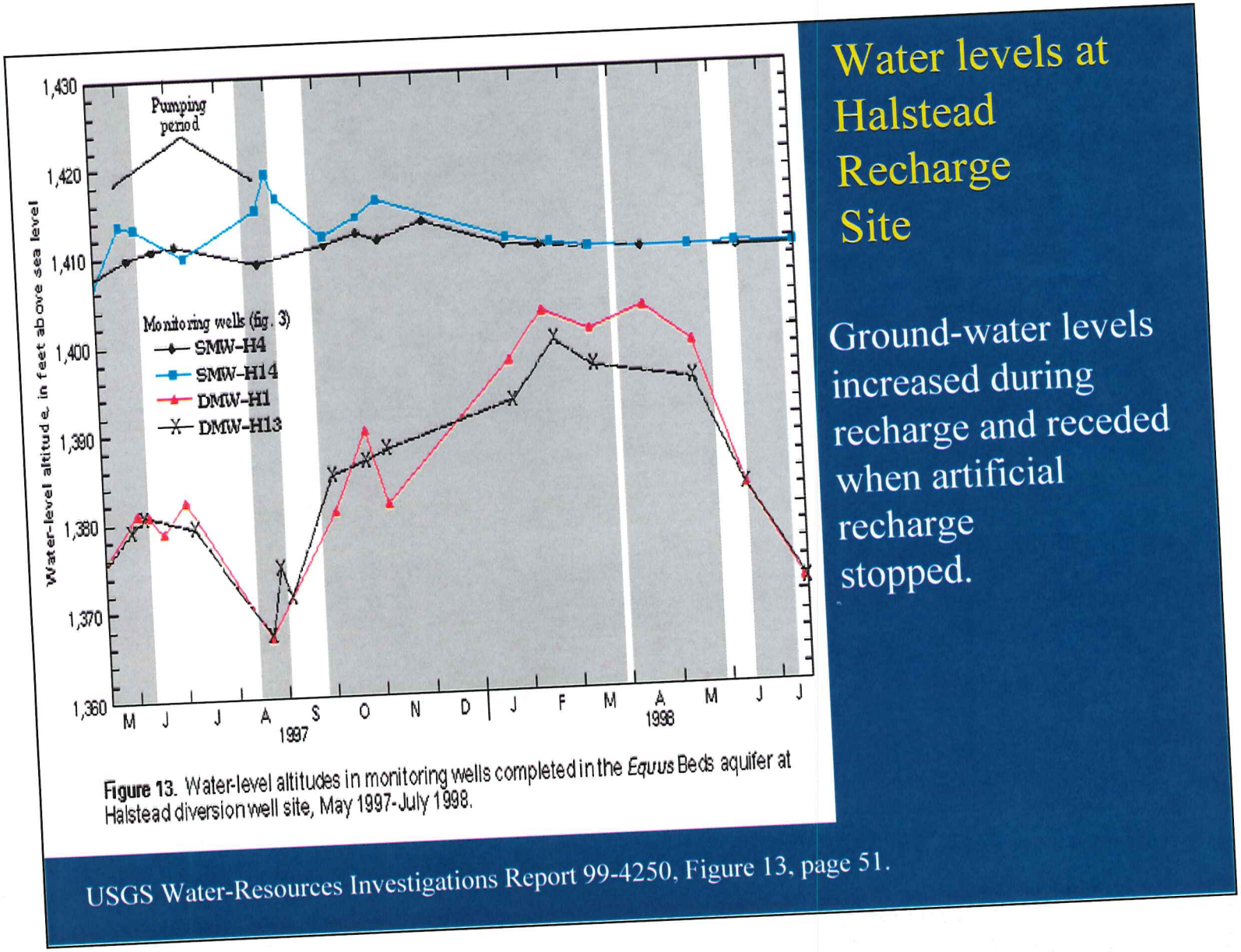
Halstead Recharge Site Hydrogeology

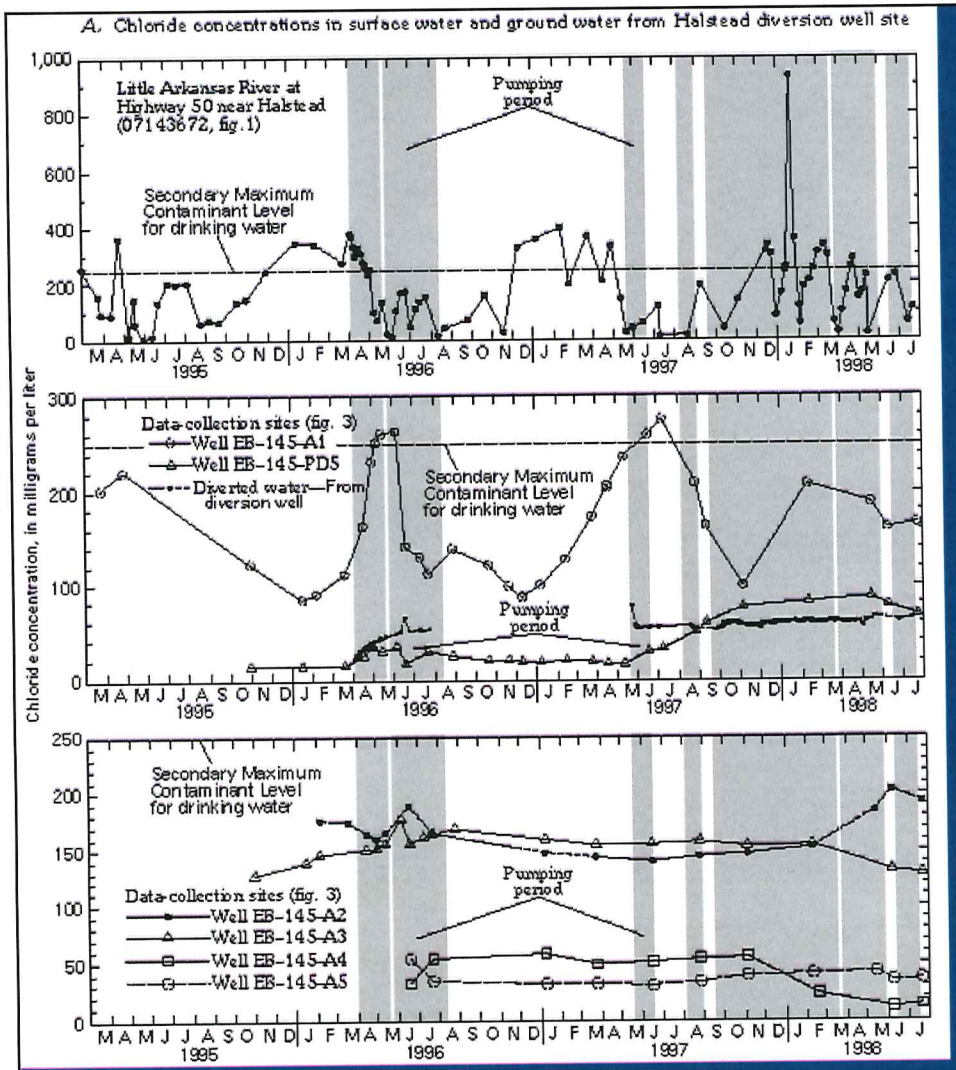


USGS Water-Resources Investigations Report 99-4250, Figure 4, page 8.

U.S. Geological Survey




Water levels at Halstead Recharge Site
Ground-water levels increased during recharge and receded when artificial recharge stopped.
Pumping period
Monitoring wells (fig. 3)
SMW-H4
SMW-H14
DMW-H1
DMW-H13
Water-level altitude, in feet above sea level
1,430
1,420
1,410
1,400
1,390
1,380
1,370
1,360
M J J A S O N D J F M A M J J
1997
1998
Figure 13. Water-level altitudes in monitoring wells completed in the Equus Beds aquifer at Halstead diversion well site, May 1997-July 1998.
USGS Water-Resources Investigations Report 99-4250, Figure 13, page 51.



USGS Water-Resources Investigations Report 99-4250, Figure19, page 58.

Chloride concentrations at Halstead Diversion site

- River ranges from 20 to 930 milligrams per liter
- Diversion well averages 60 milligrams per liter
- Deep well PD5 concentrations increased from 14 to 60 milligrams per liter because of surface water being induced into the ground water

U.S. Geological Survey

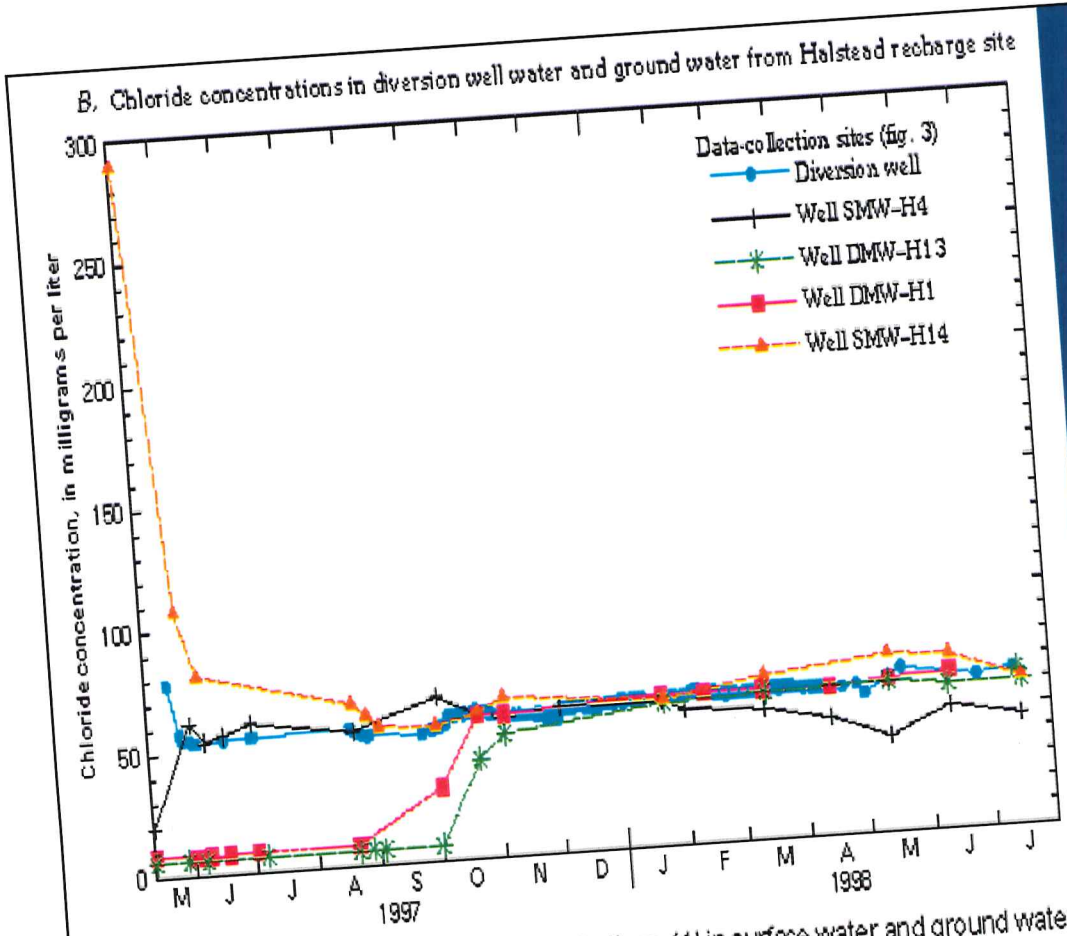
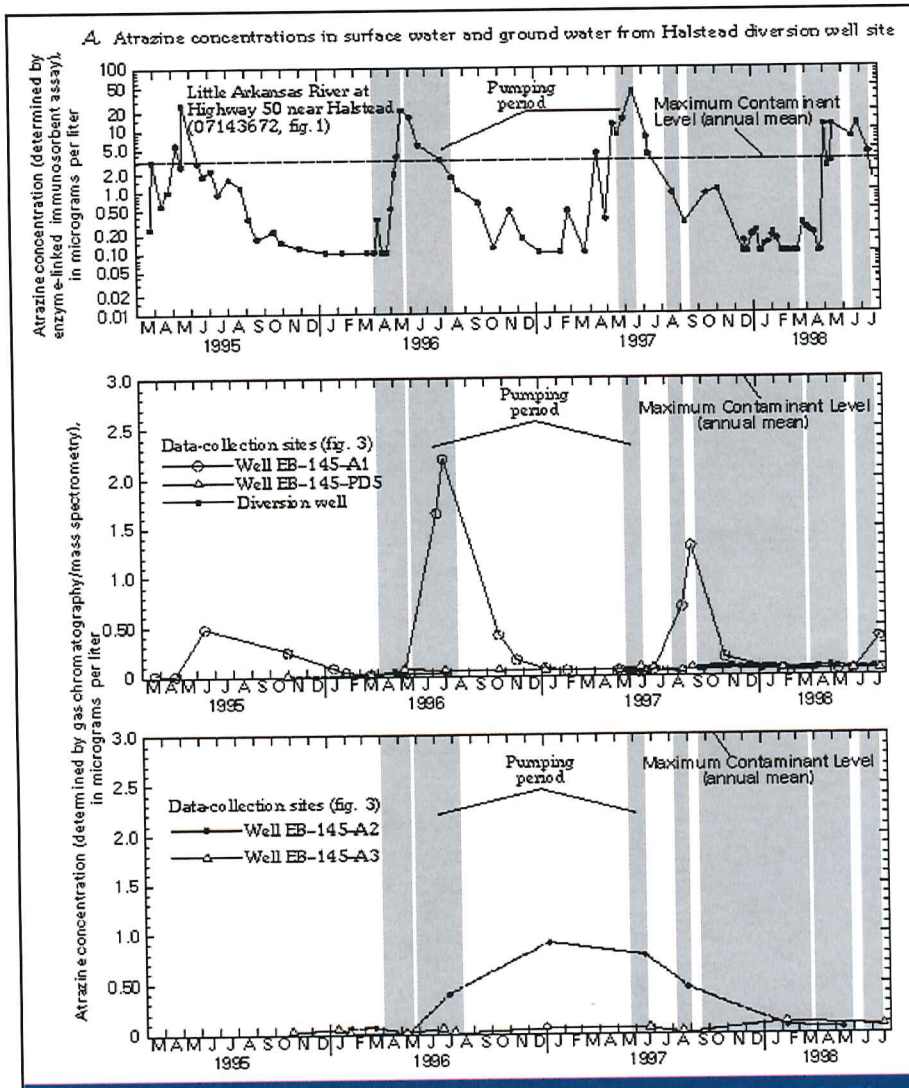


Figure 19b. Comparison of chloride concentrations (*A*) in surface water and ground water from Halstead diversion well site, March 1995-July 1998, and (*B*) in diversion well water and ground water from Halstead recharge site, May 1997-July 1998. Secondary Maximum Contaminant Level from U.S. Environmental Protection Agency (1999)--Continued.

USGS Water-Resources Investigations Report 99-4250, Figure 19, page 59.

Chloride at Halstead Recharge site

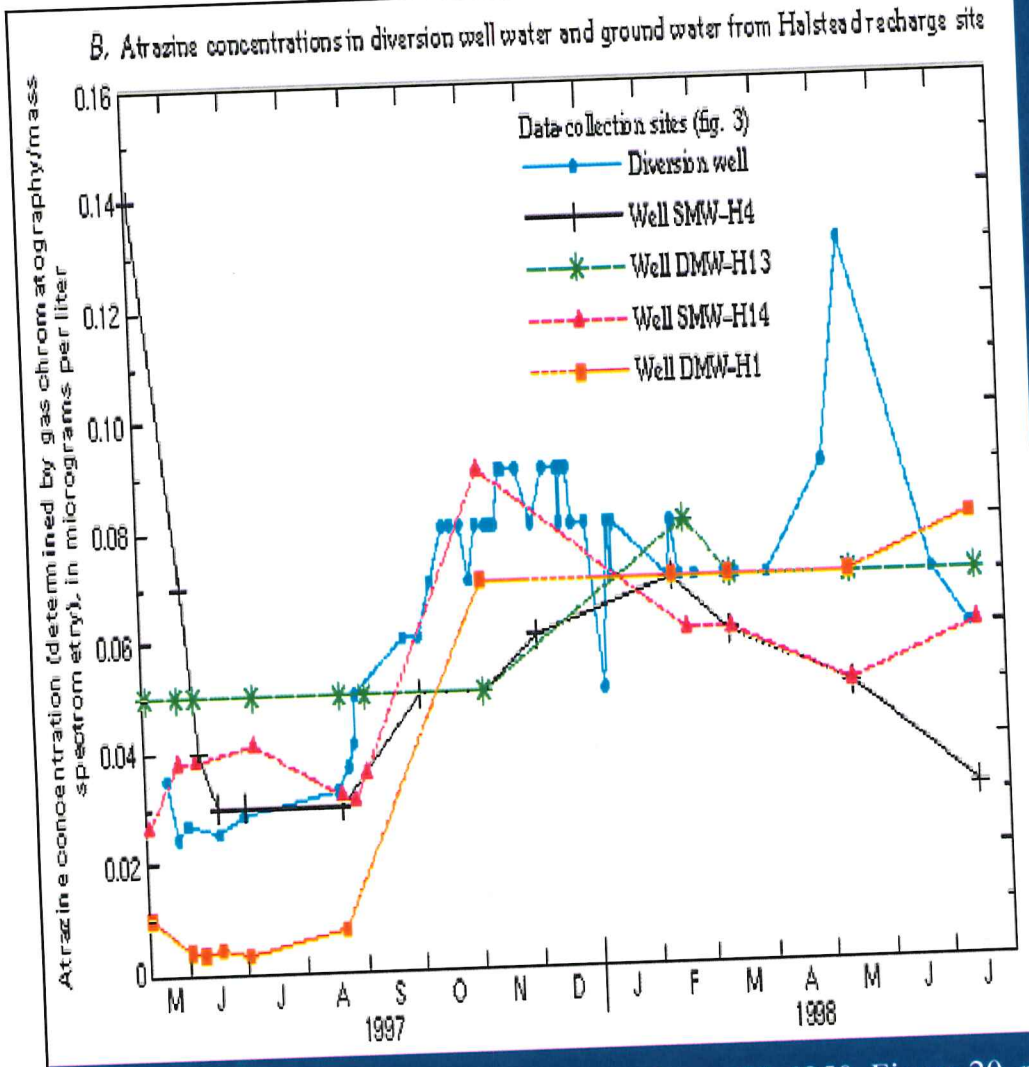
- Concentrations decreased from 290 to 64 milligrams per liter in shallow wells
- Concentrations increased from less than 10 to 60 milligrams per liter, similar to recharge water and within the range of baseline concentrations at the site



Atrazine at Halstead Diversion site

- River range from 0.1 to 46 micrograms per liter
- Diversion well concentration ranged from 0.006 to 0.09 micrograms per liter
- Deep well PD5 concentrations increased from<.001 to 0.08 micrograms per liter because of surface water being induced into the ground water

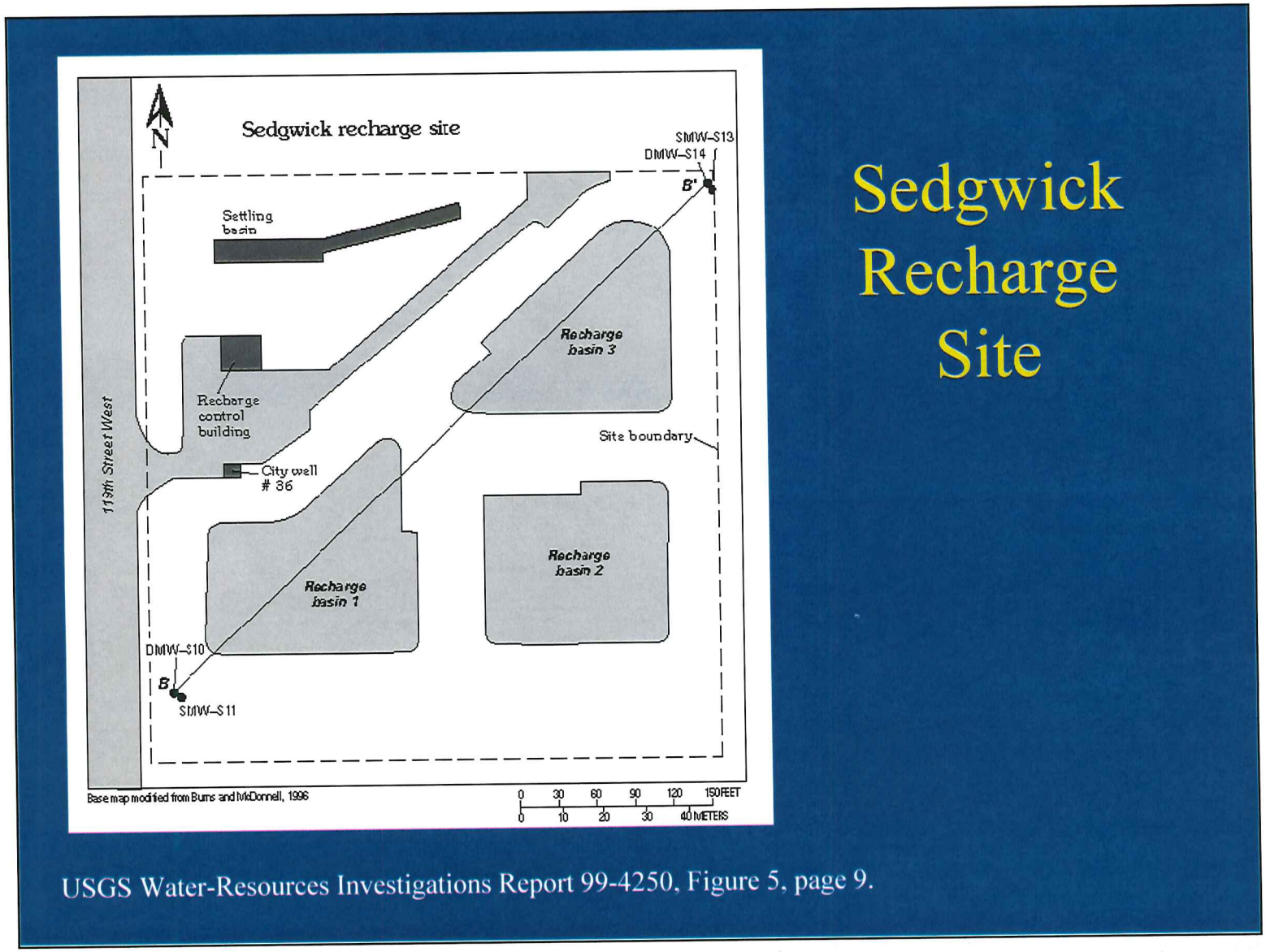
USGS Water-Resources Investigations Report 99-4250, Figure 20, page 60.



USGS Water-Resources Investigations Report 99-4250, Figure 20, page 61.

Atrazine at Halstead Recharge site

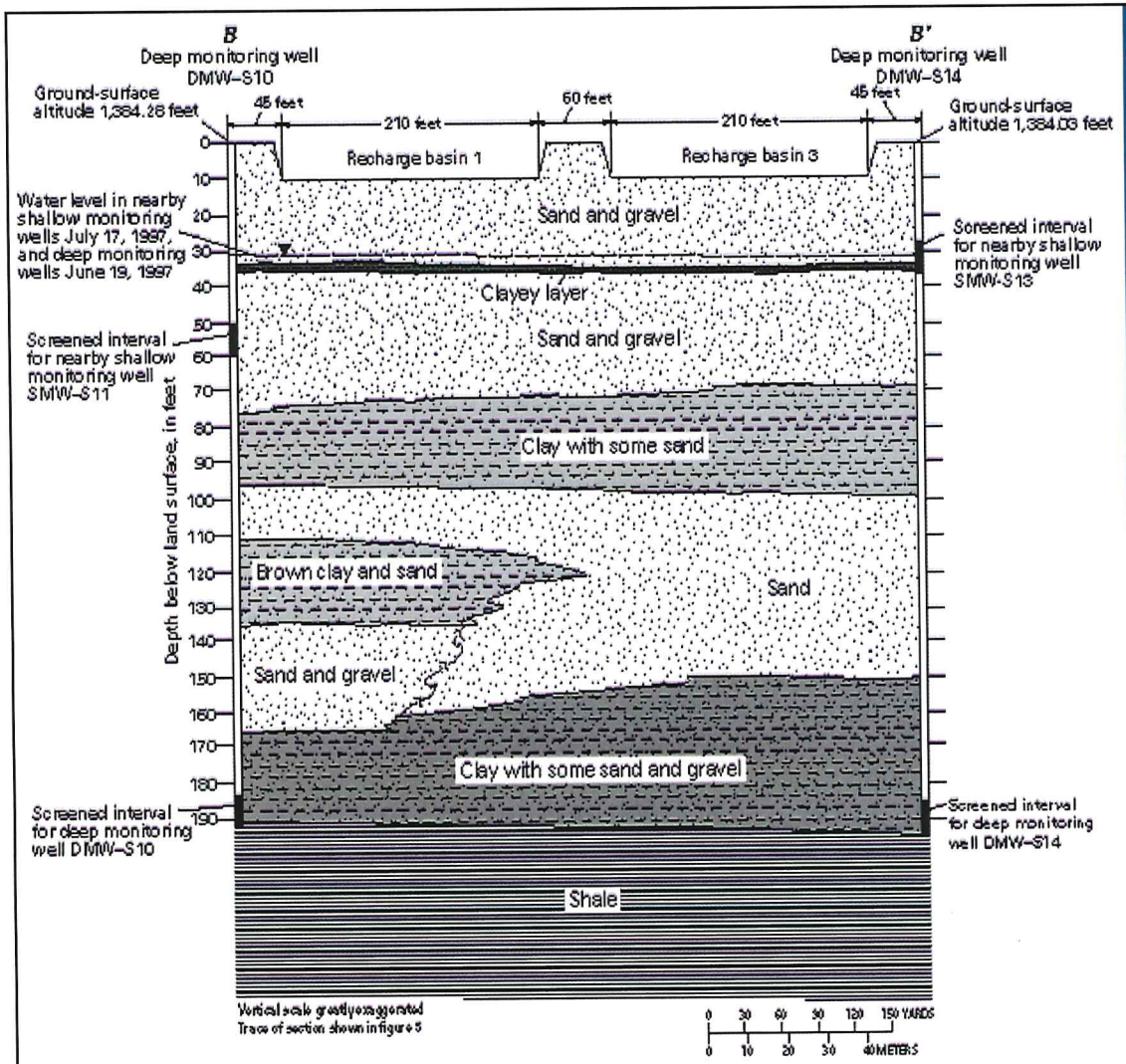
- Diversion well concentration ranged from 0.006 to 0.09 micrograms per liter
- Concentrations increased slightly in deep wells, but did not exceed the baseline maximum of 0.14 micrograms per liter



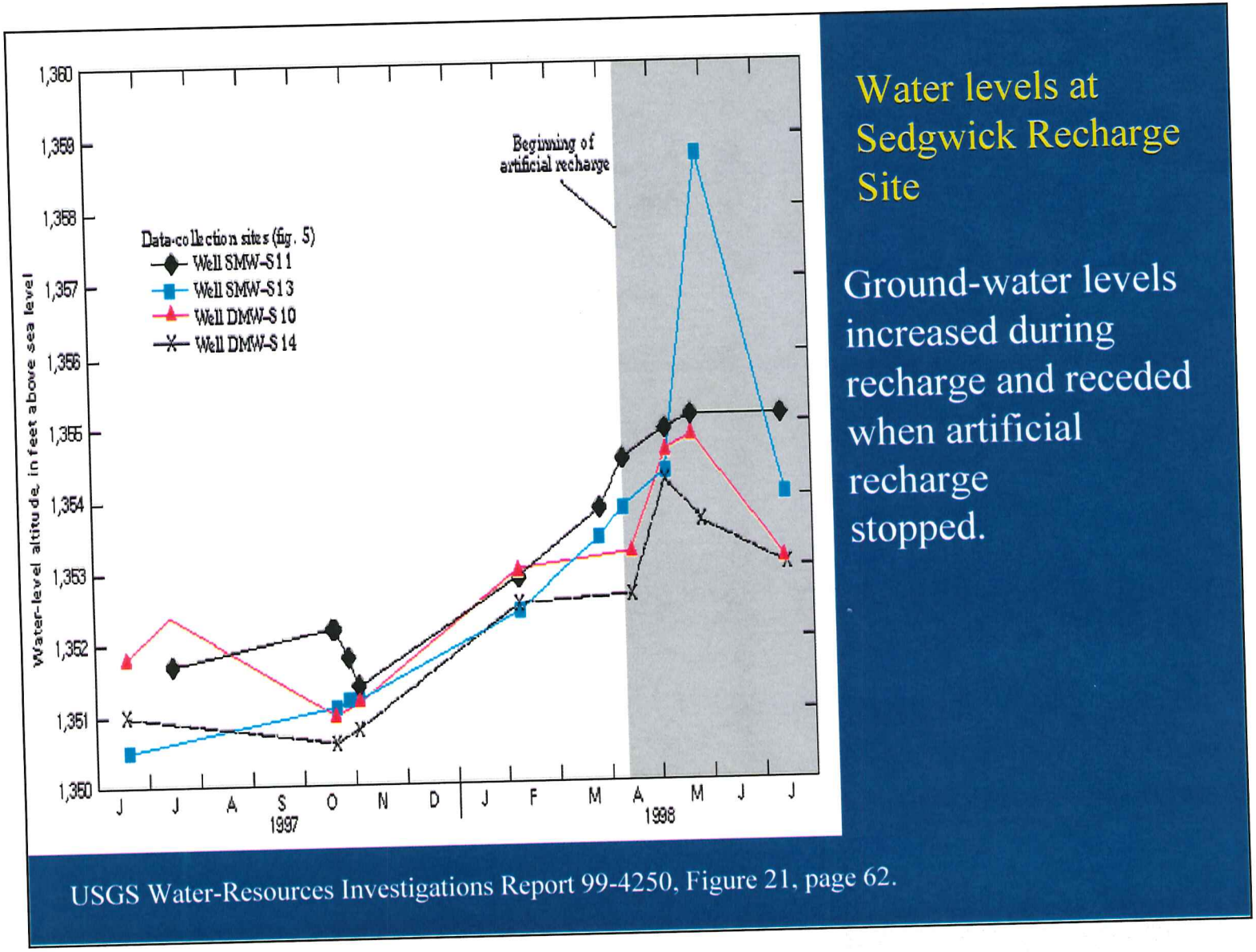
Sedgwick Recharge Site

USGS Water-Resources Investigations Report 99-4250, Figure 5, page 9.

Sedgwick Recharge Site Hydrogeology



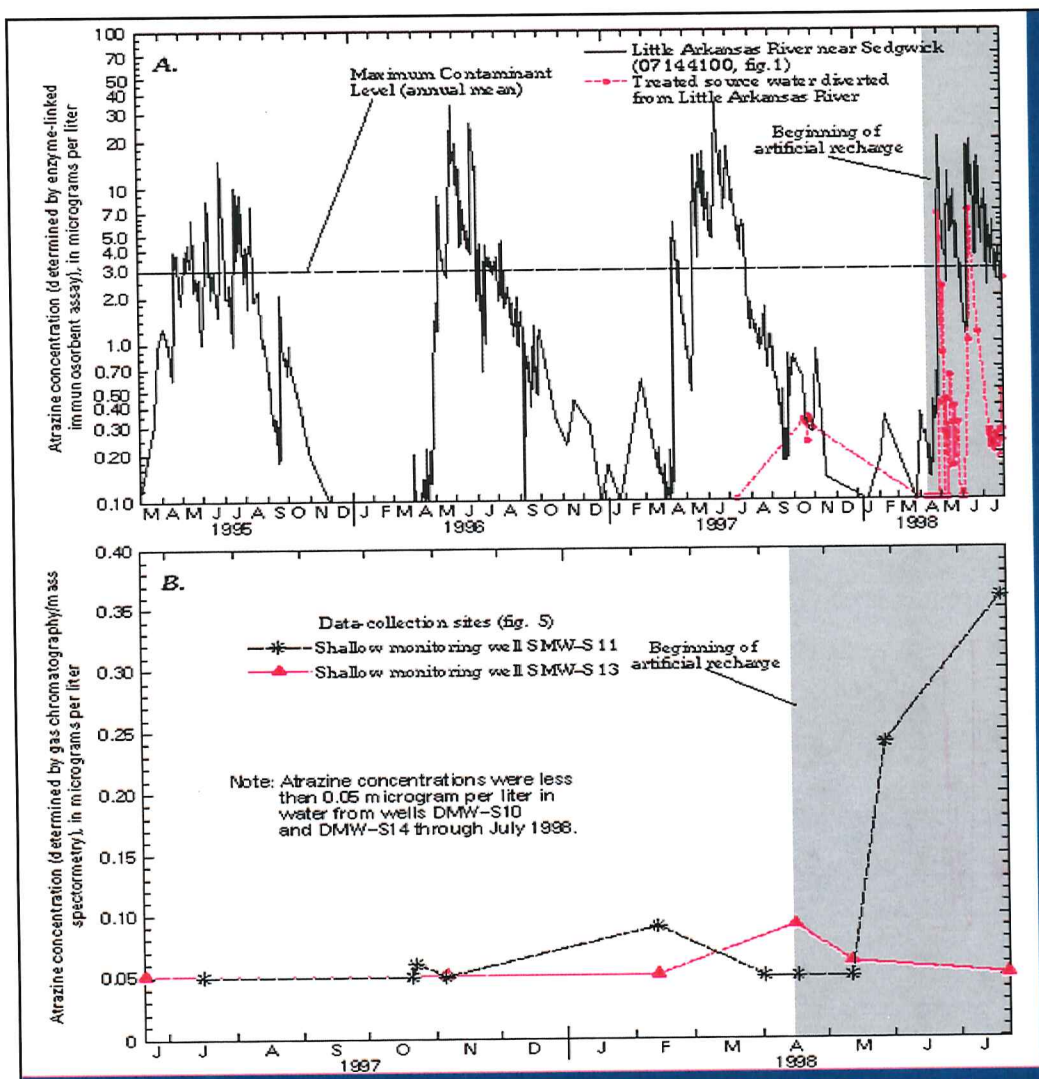
USGS Water-Resources Investigations Report 99-4250, Figure 4, page 8.



Water levels at Sedgwick Recharge Site

Ground-water levels increased during recharge and receded when artificial recharge stopped.

USGS Water-Resources Investigations Report 99-4250, Figure 21, page 62.



USGS Water-Resources Investigations Report 99-4250, Figure 28, page 68.

Atrazine at Sedgwick Recharge site

- Concentrations generally decreased to baseline concentrations by treatment

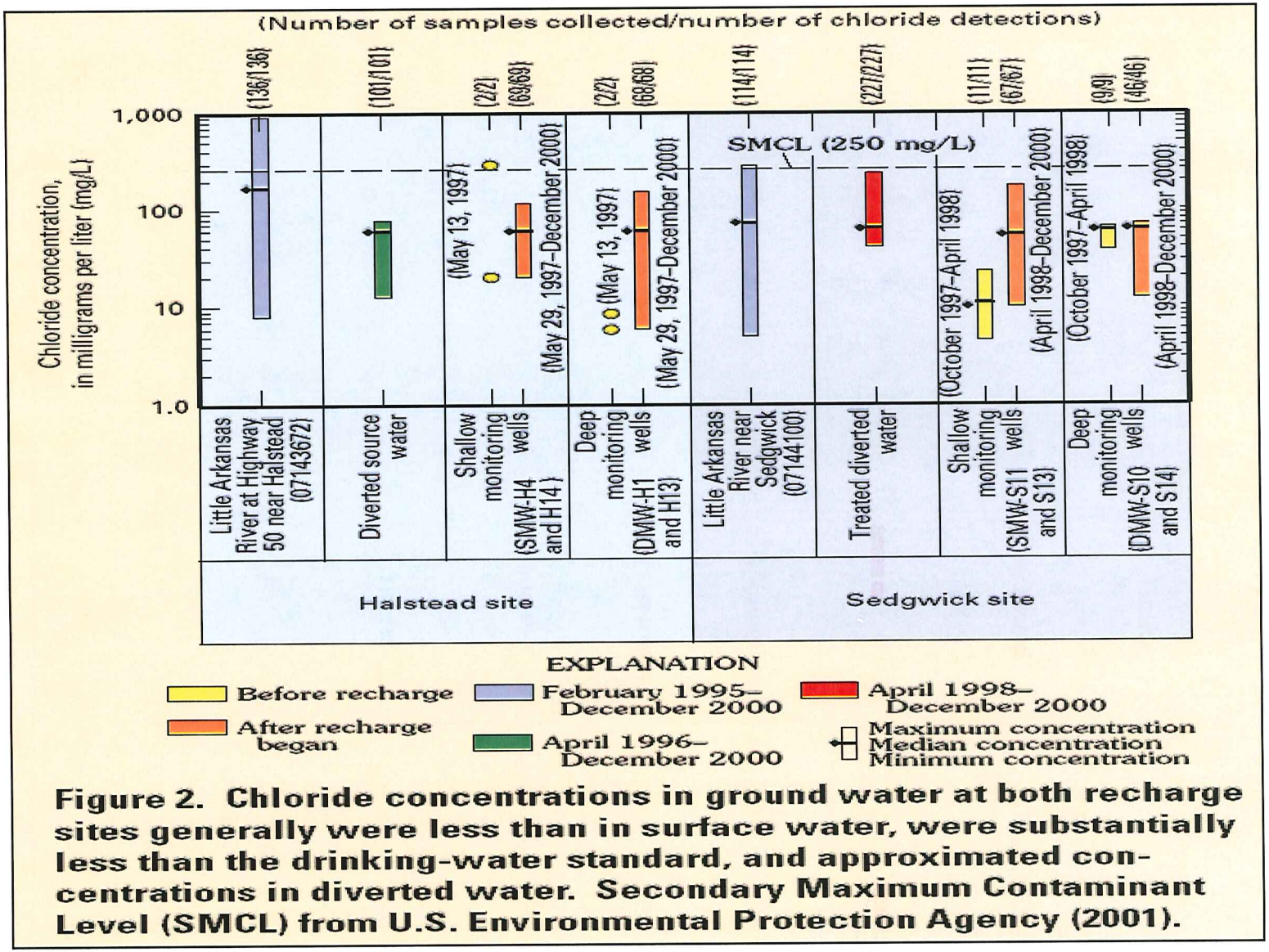


Figure 2. Chloride concentrations in ground water at both recharge sites generally were less than in surface water, were substantially less than the drinking-water standard, and approximated concentrations in diverted water. Secondary Maximum Contaminant Level (SMCL) from U.S. Environmental Protection Agency (2001).

City Exhibit 6

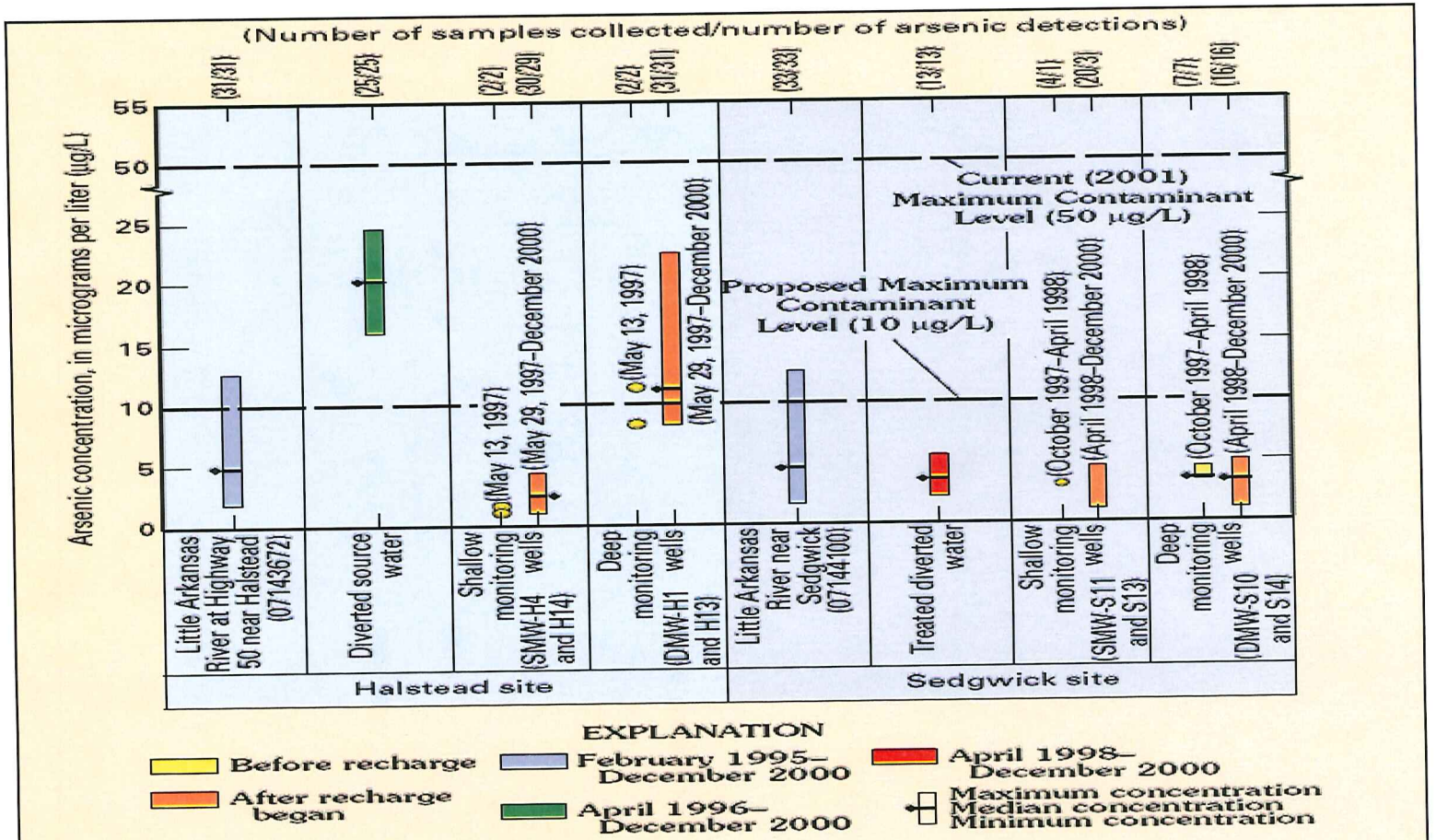


Figure 3. Arsenic concentrations were less than the current drinking-water standard in ground water at the Sedgwick recharge site. However, arsenic concentrations exceeded the proposed (2001) water-quality standard in diverted water and in most water from deep wells at the Halstead recharge site. Current and proposed Maximum Contaminant Levels from U.S. Environmental Protection Agency (2001).

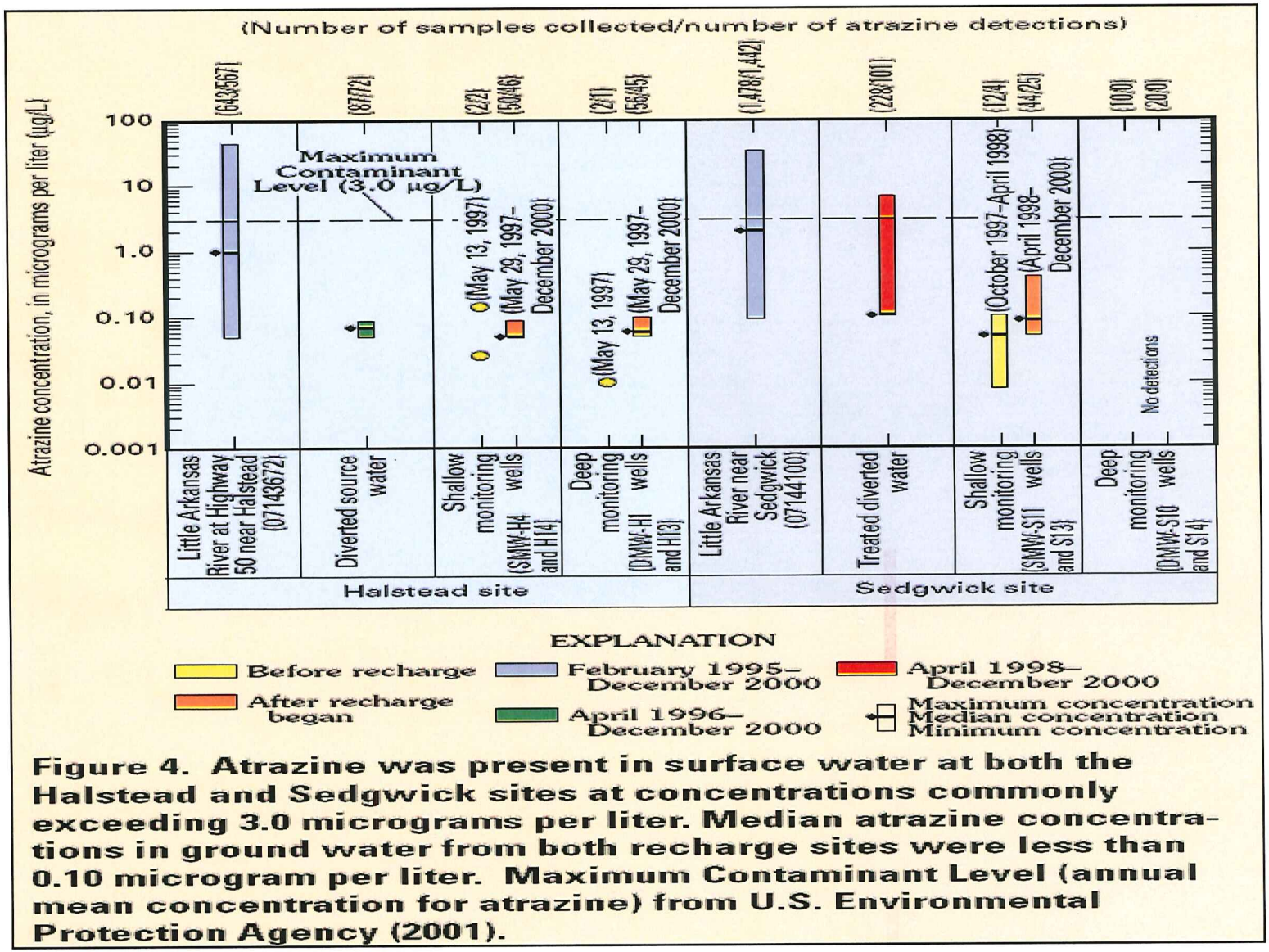
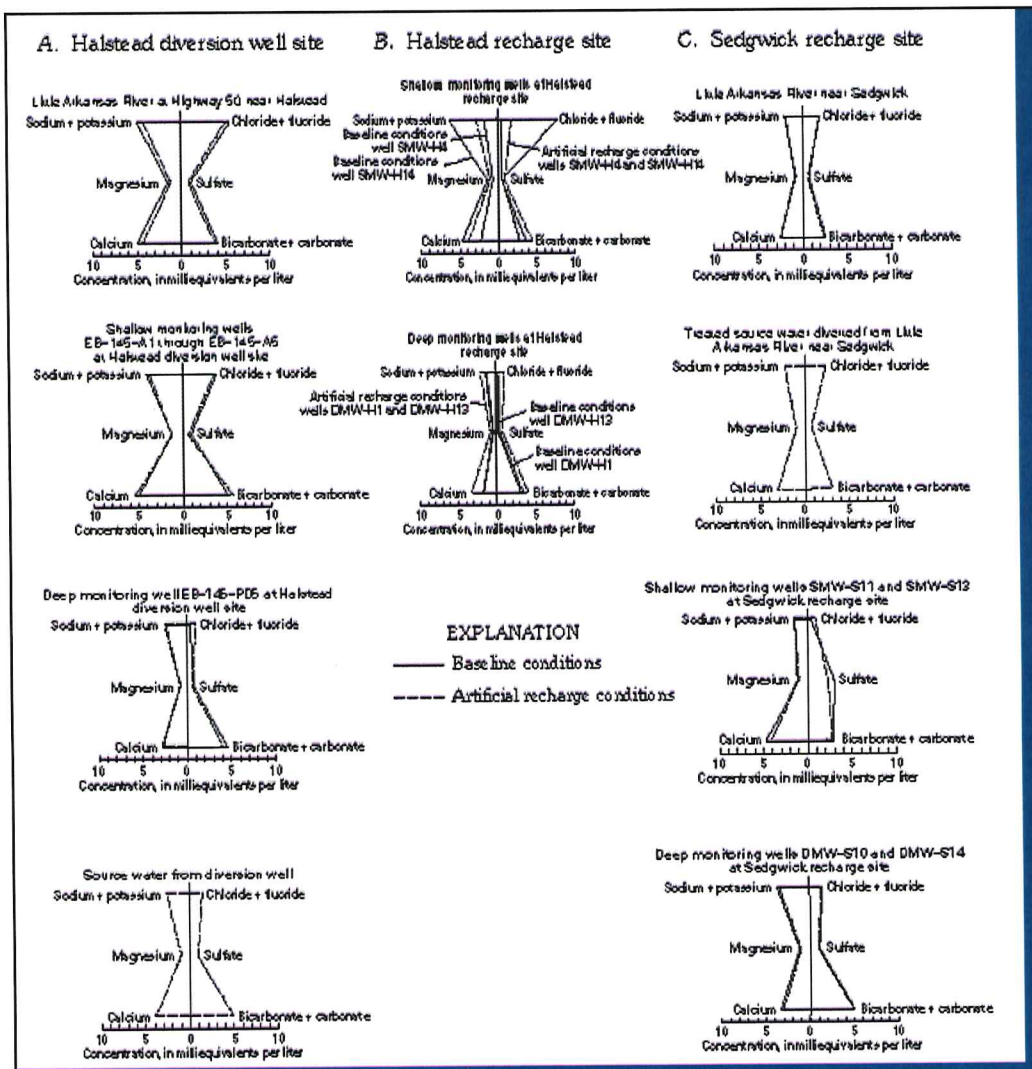


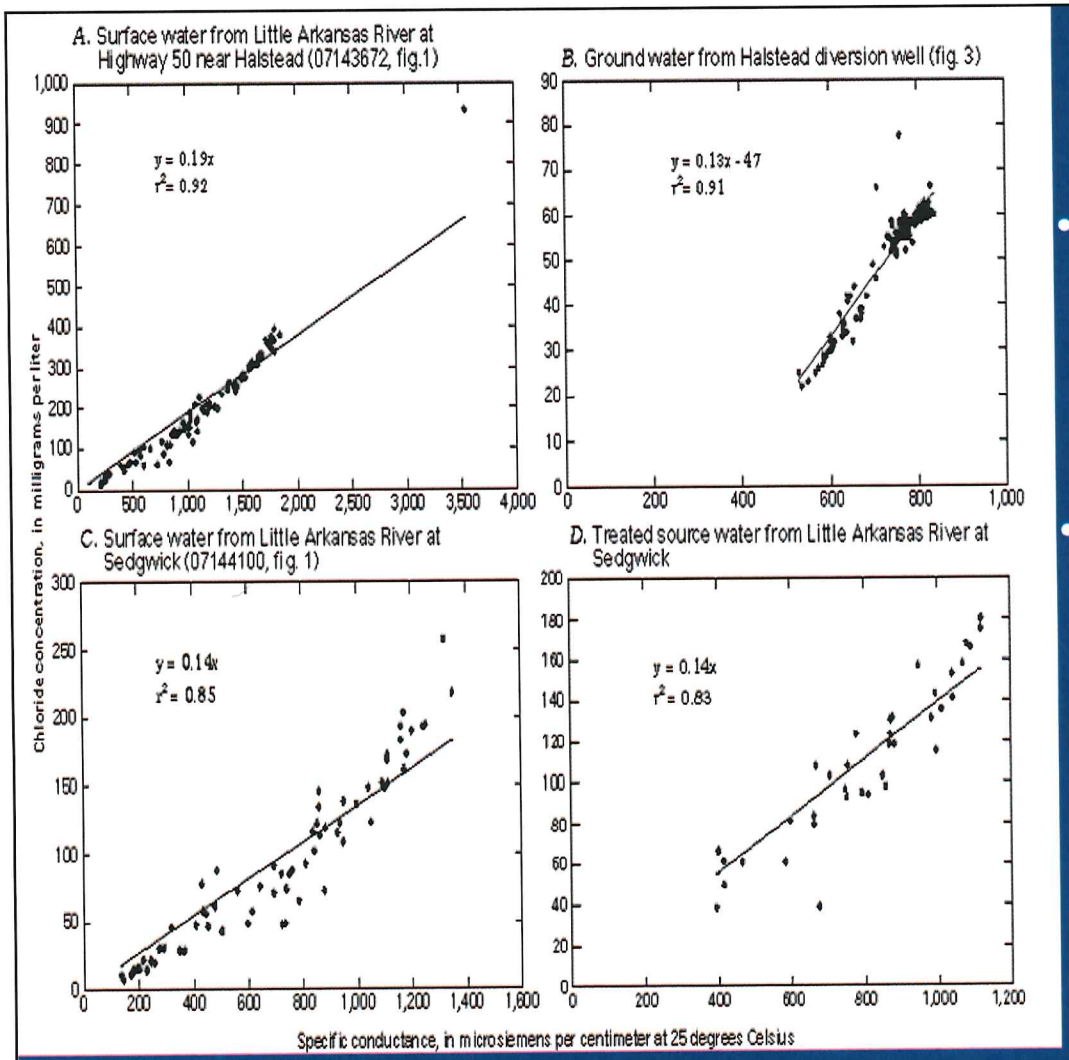
Figure 4. Atrazine was present in surface water at both the Halstead and Sedgwick sites at concentrations commonly exceeding 3.0 micrograms per liter. Median atrazine concentrations in ground water from both recharge sites were less than 0.10 microgram per liter. Maximum Contaminant Level (annual mean concentration for atrazine) from U.S. Environmental Protection Agency (2001).



Compatibility of water for recharge

- Recharge water is of similar chemistry to baseline ground water chemistry at recharge sites

USGS Water-Resources Investigations Report 99-4250, Figure 29, page 69.



USGS Water-Resources Investigations Report 99-4250, Figure 30, page 71.

Future Monitoring

- Use of real-time water quality monitoring for chloride using specific conductance
- Monthly sampling of source water and quarterly sampling of ground water probably are adequate to monitor changes in water quality

Summary of demonstration water quality

- More than 4,000 samples were collected and analyzed for more than 400 chemicals and bacteria in surface and ground water before and after recharge.
- Before recharge,
  - only fecal coliform, chloride, and atrazine frequently exceeded MCLs in surface water
  - Halstead recharge ground water and one well at the Halstead recharge site exceeded the 2001 MCL for arsenic of 10 micrograms per liter.
- Concentrations of these constituents after 6 years of recharge were similar to those before recharge.

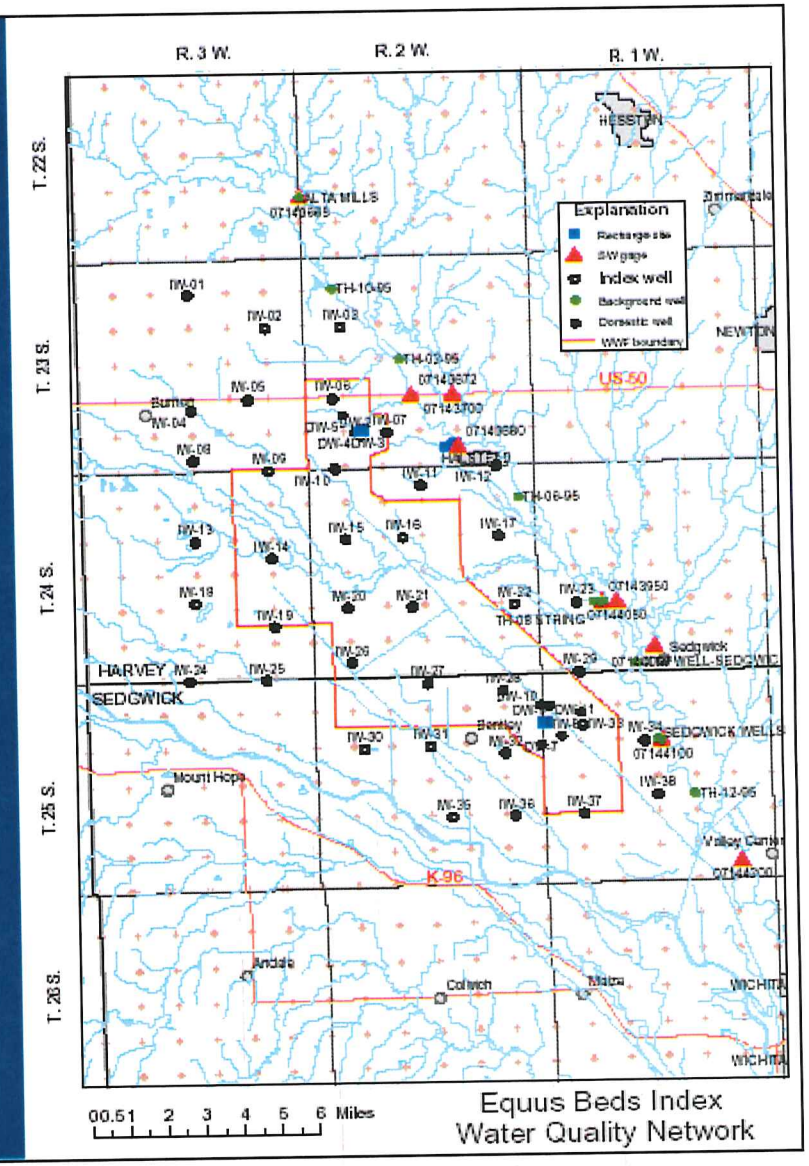
USGS

Index well network 2001-2004

- Objective is to define the general water quality and quantity in the *Equus* Beds and monitor changes
  - 38 locations (every 4 square miles)
  - Represents existing water quality (background)
  - Shallow and deep well at each location
    - Shallow (25 to 80 feet) mean depth = 46 feet
    - Deep (more than 80 feet) mean depth = 142 feet
  - Water levels measured quarterly by GMD2 and Wichita staff to determine changes in water levels and storage
  - 76 Wells sampled every 6 months since November 2001 for a total of 6 times through August 2004

USGS

Location of data-collection sites



USGS

Summary of index well data collected by the U.S. Geological Survey for selected water-quality constituents, *Equus* Beds area near Wichita, Kansas November 2001 through August 2004.

[Shallow wells are less than 80 feet deep. Deep wells are more than 81 feet deep. Water-quality criteria established by the U.S. Environmental Protection Agency (2004); mg/L, milligrams per liter; SWDR, Secondary Drinking Water Regulation; mg/L as N, milligrams per liter as Nitrogen; MCL, Maximum Contaminant Level; ug/L, micrograms per liter; <, less than]

		Shallow Index Wells				Deep Index Wells			
	U.S. Environmental Protection Agency (2004) Water-Quality Criteria	Average concentration	Number of samples	Percentage of detections	Percentage of wells exceeding water-quality criteria[1]	Average concentration	Number of samples	Percentage of detections	Percentage of wells exceeding water-quality criteria[1]
Chloride, dissolved (mg/L)	250 mg/L (SDWR)	76	231	100%	5%	111	232	97%	5%
Sulfate, dissolved (mg/L)	250 mg/L (SDWR)	155	231	100%	21%	108	233	99%	13%
Nitrite plus nitrate, dissolved (mg/L as N)	10 mg/L (MCL)	3.5	231	70%	13%	0.41	233	52%	0%
Arsenic, dissolved (ug/L)	10 ug/L (MCL)	3.8	231	48%	13%	7.5	233	84%	34%
Atrazine, dissolved (ug/L)	3 ug/L as an annual average (MCL)	<.05	58	9%[2]	0%	<.05	25	0%[2]	0%
Triazine herbicide screen, dissolved, (ug/L as atrazine)	3 ug/L as an annual average (MCL)	<.1	232	13%[2]	0%	<.1	233	2%[2]	0%

[1]Percentage of wells exceeding water-quality criteria were calculated by determining the average concentration of the six samples from each individual well. If the average concentration exceeded the water-quality criteria, the well was included in the percentage that exceeded water-quality criteria.

[2]The percentage of detections for atrazine and triazine herbicide screen were calculated if any sample from a well was detected at a concentration greater than or equal to 0.1 micrograms per liter.

The average concentration of chloride, sulfate, nitrite plus nitrate, or arsenic exceeds water-quality criteria in 42.1 percent of shallow wells and 39.5 percent of deep wells.

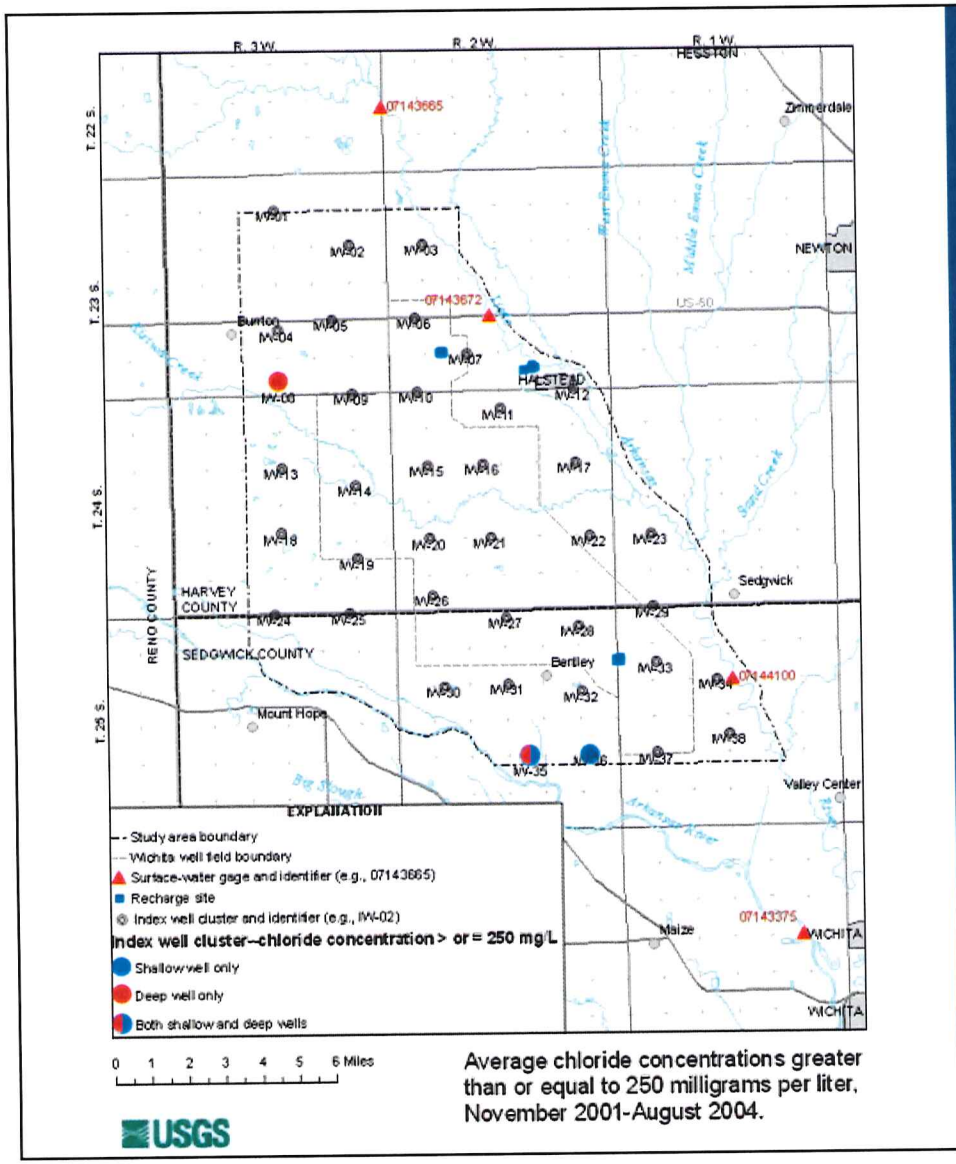
USGS

City Exhibits S-W

Organics in ground water detected

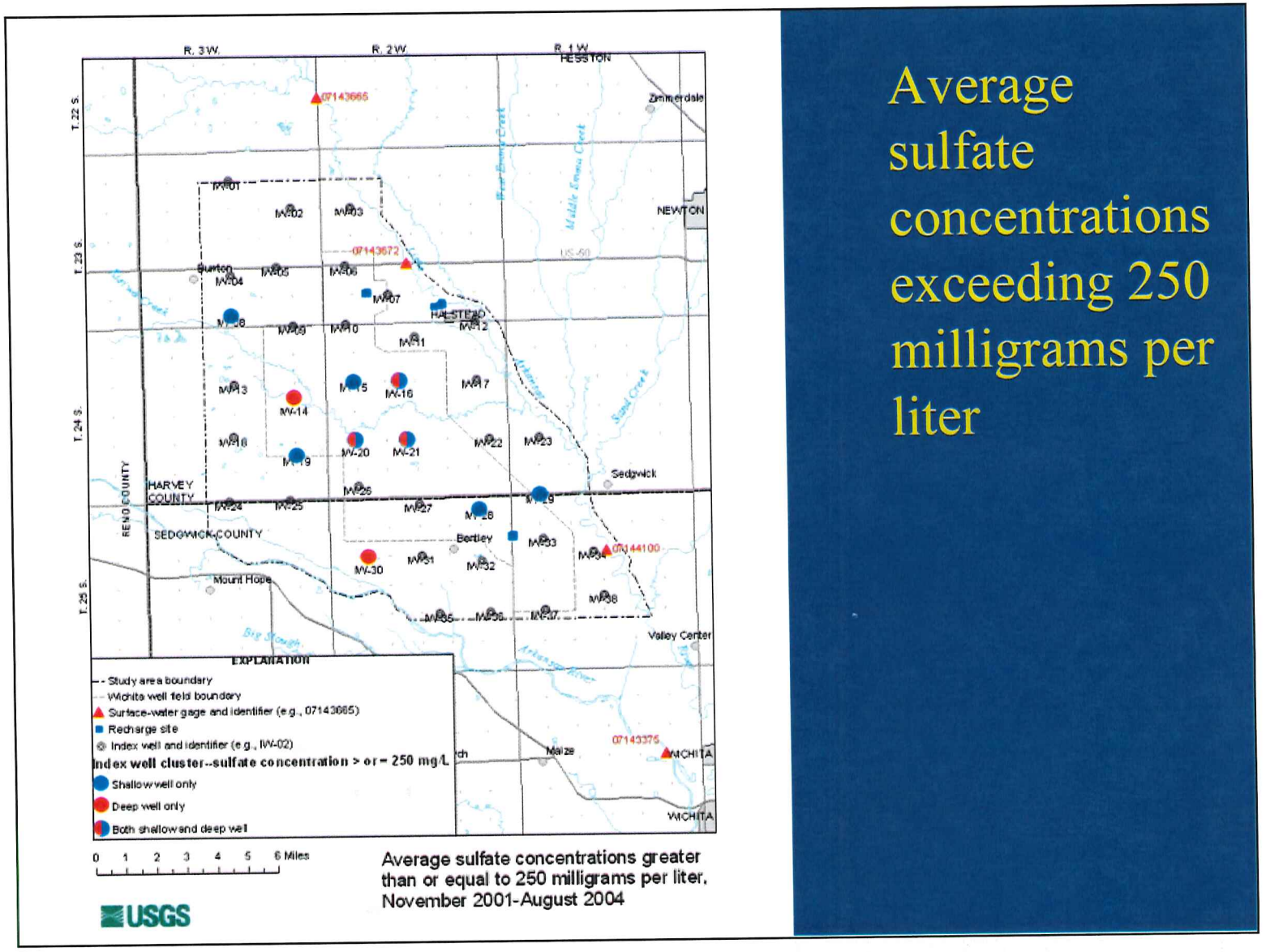
- Shallow wells
  - 1,2 Dichloroethane, MTBE, Trichloromethane (Chloroform), Bis(2-ethylhexyl) phthalate, Di-n-butyl phthalate, De-ethyl atrazine, Alachlor, Atrazine, Metolachlor, Molinate, Prometon, Tebuthiuron, Alachlor OXA, Metolachlor ESA, Metolachlor OXA, Clorotetracycline, Didalkylatrazine, Diuron, **AMPA (glyphosate degradation product)**
- Deep wells
  - 1,2-Dichloroethane, MTBE, Trichloromethane (Chloroform), 2,6-Diethylaniline, De-ethyl atrazine, Atrazine, Metolachlor, Acetochlor, Alachlor, Cyanazine acid, De-ethyl cyanazine acid, Diuron
- None exceed water-quality standards

USGS



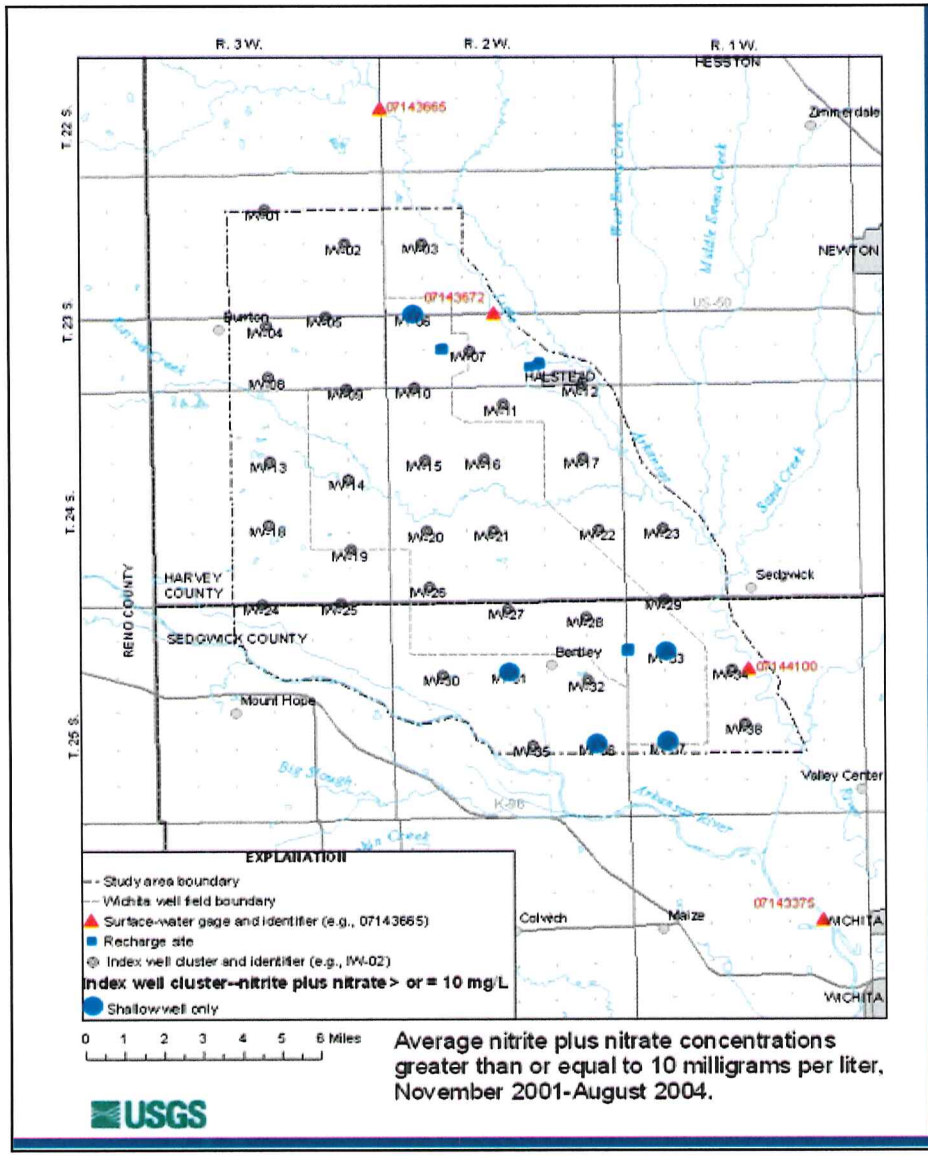
Average chloride concentrations greater than or equal to 250 milligrams per liter, November 2001-August 2004.

Average chloride concentrations exceeding 250 milligrams per liter



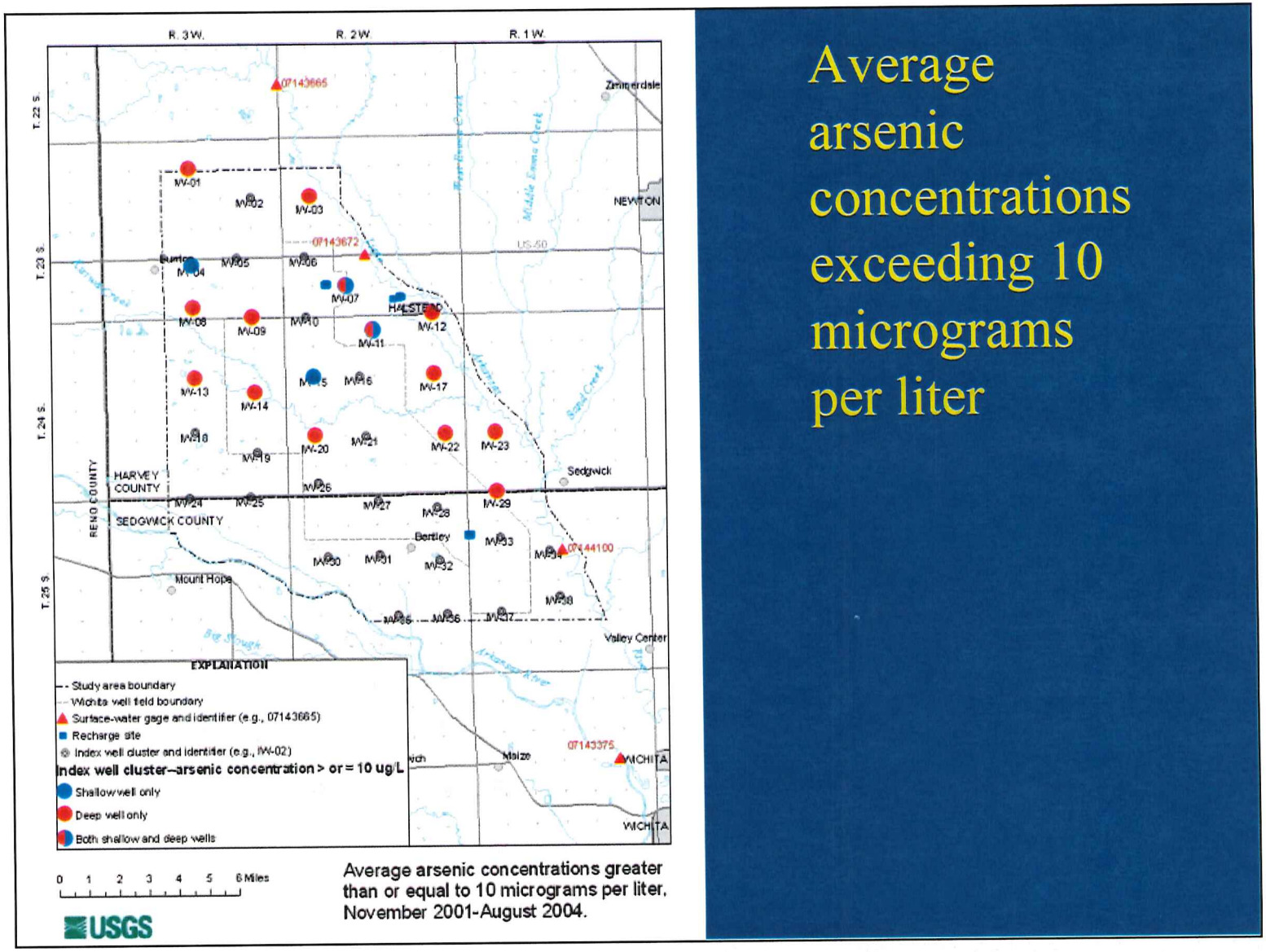
Average sulfate concentrations greater than or equal to 250 milligrams per liter, November 2001-August 2004

Average sulfate concentrations exceeding 250 milligrams per liter

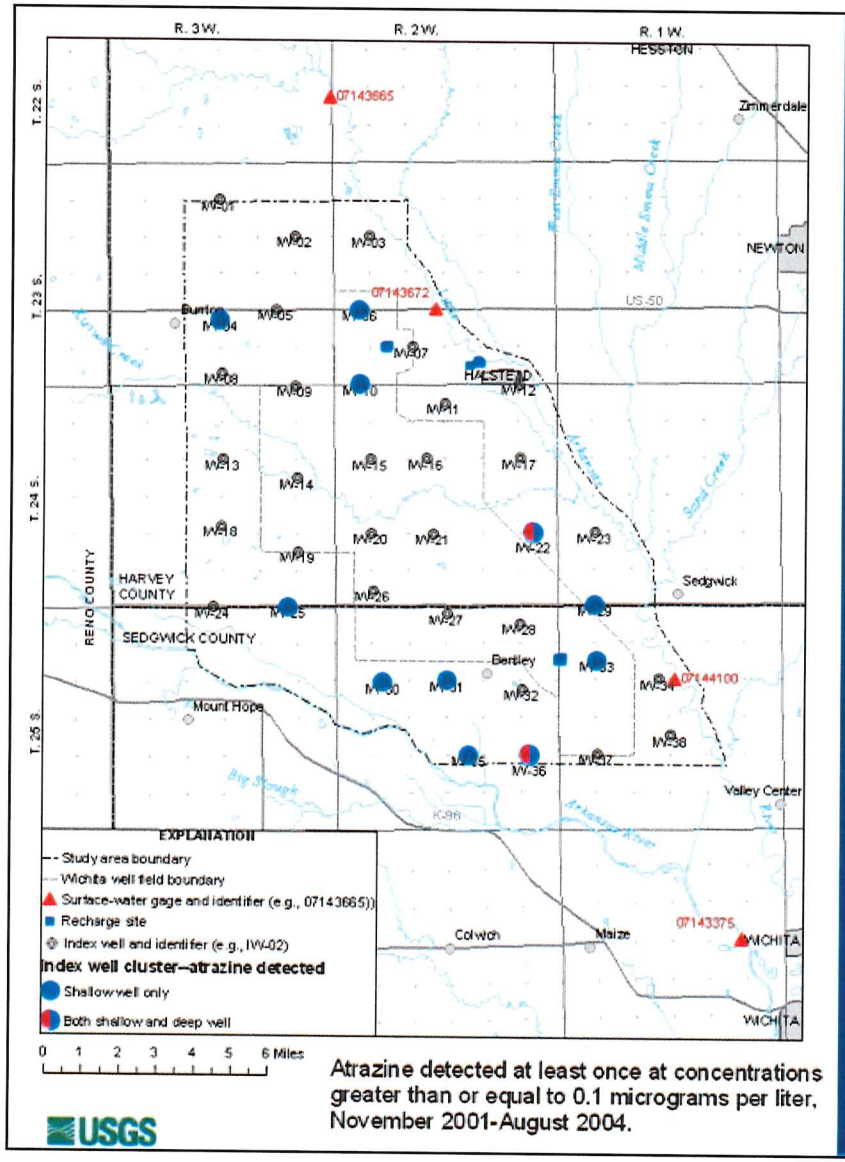


Average nitrite plus nitrate concentrations greater than or equal to 10 milligrams per liter, November 2001-August 2004.

Average nitrite plus nitrate concentrations exceeding 10 milligrams per liter



Average arsenic concentrations exceeding 10 micrograms per liter



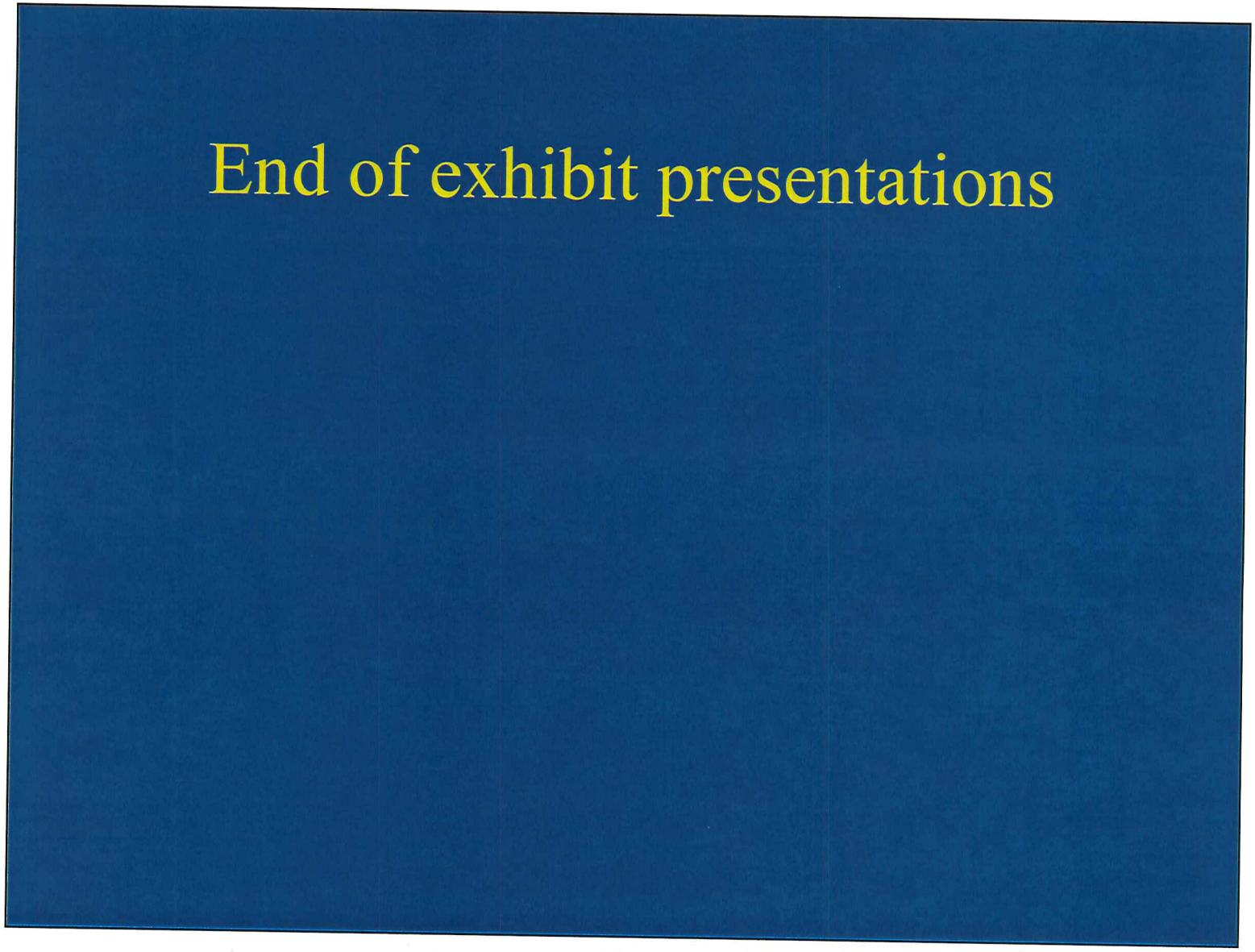
Atrazine detected at least once at concentrations greater than or equal to 0.1 micrograms per liter, November 2001-August 2004.

Atrazine concentrations detected at least once exceeding 0.10 microgram per liter

Summary of Background Shallow and Deep Index Well Water Quality 2001 - 2004

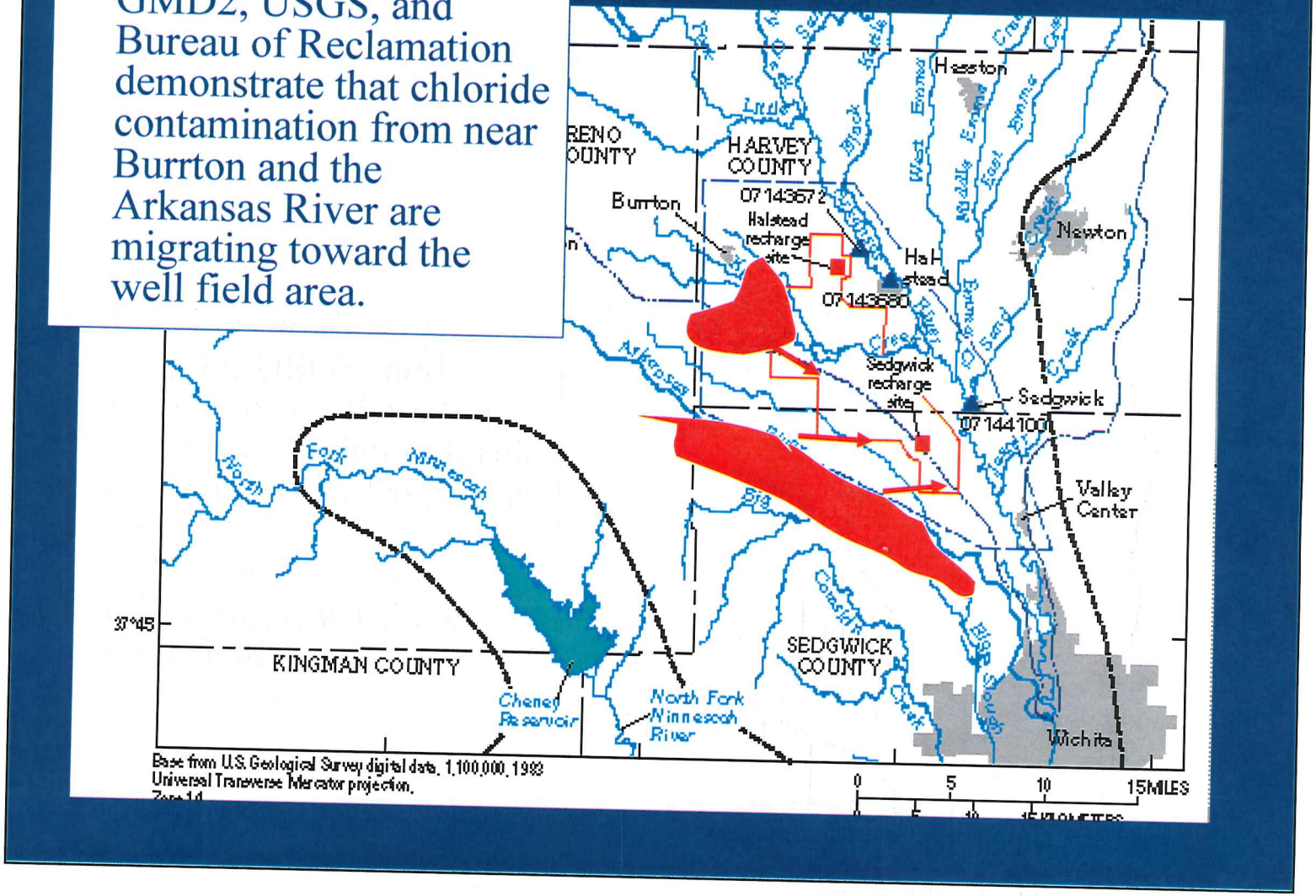
- Large chloride and sulfate values generally near Ark River and area near Burrton
- Nitrate, arsenic, and atrazine distributed throughout the area.
- Nitrate highest in shallow wells.
- Arsenic highest in deep wells.
- Atrazine detected in 28.9 percent of shallow wells and in 5.3 percent of deep wells. No samples exceed standards

USGS

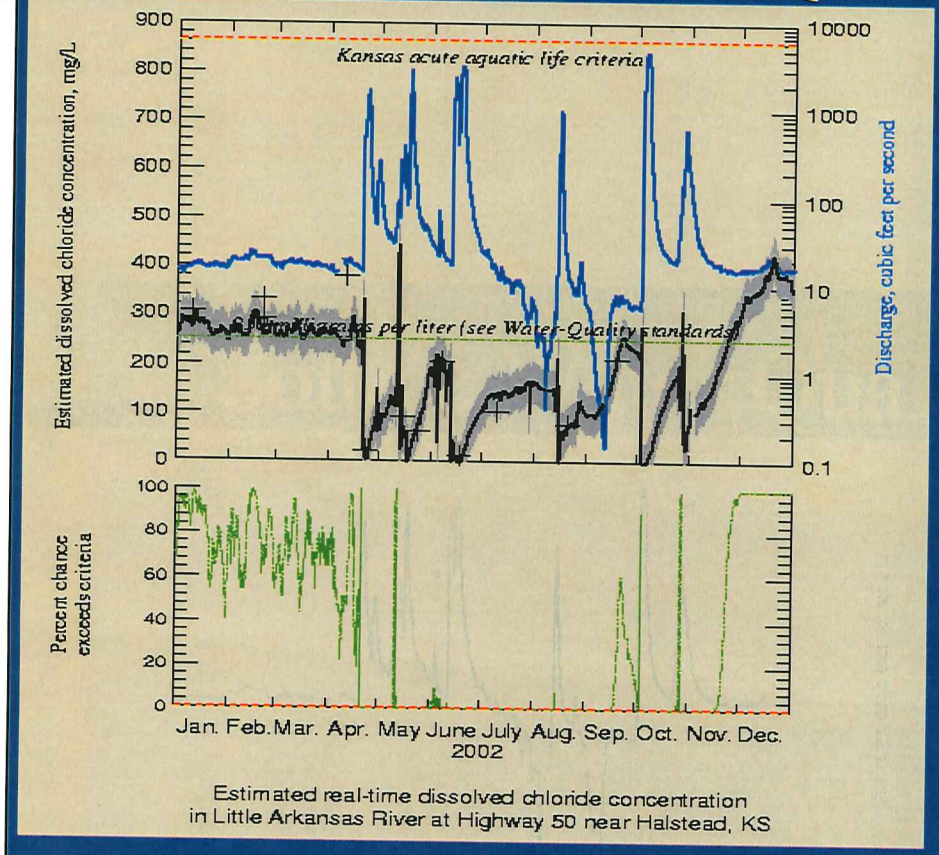

End of exhibit presentations

Ground-water and chloride

- Previous studies by GMD2, USGS, and Bureau of Reclamation demonstrate that chloride contamination from near Burrton and the Arkansas River are migrating toward the well field area.



Source Water Quality-RTQW



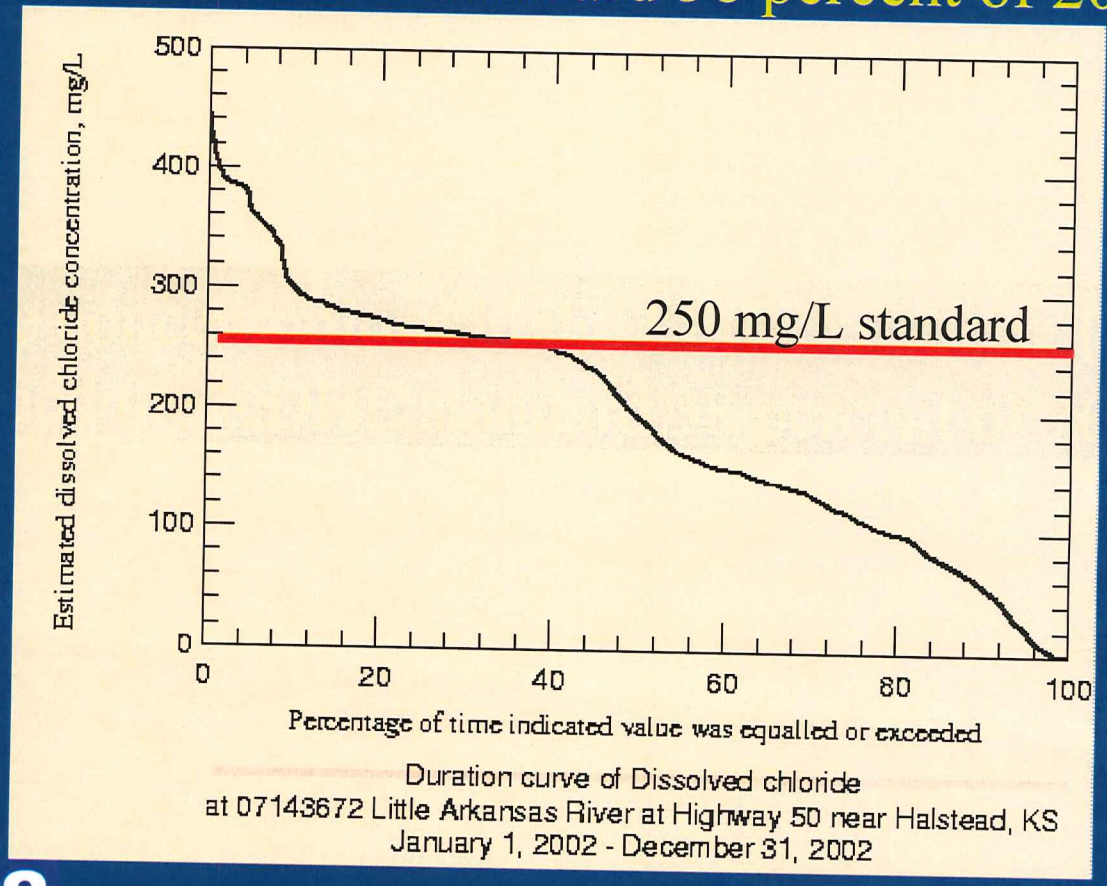
Estimated real-time dissolved chloride concentration in Little Arkansas River at Highway 50 near Halstead, KS

- New real-time water-quality approach using in-stream water quality monitors, collected samples, and statistical analysis developed to estimate concentrations in surface water before it is recharged.

USGS

http://ks.water.usgs.gov/Kansas/rtqw/

Chloride concentrations in the Little Arkansas River exceeded the KDHE standard 38 percent of 2002



USGS