Analysis of Selected Groundwater Quality Trends in the Panhandle Water Planning Area

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CONTENTS

Tables

Figures

EXECUTIVE SUMMARY

Areas of concern for dissolved chloride and nitrate in groundwater in the major and minor aquifers were identified to indicate whether there are water-quality issues to be addressed along with water-supply issues in the Panhandle Water Planning Area (PWPA). The areas of concern were defined on the basis of the following criteria. For Cl: (a) individual reported analyses with Cl>250 mg/L, or (b) clusters or groups where Cl>50 mg/L. For NO_3: (a) individual reported analyses with NO_3 >44 mg/L, or (b) clusters or groups where NO_3 >20 mg/L. The Cl area of concern covers ~13 percent of the aquifer areas of the PWPA, and the NO_3 area of concern covers ~2 percent. Not all of the area within each area of concern has solute concentrations that exceed maximum contaminant levels. Some wells have concentrations less than MCLs and many have concentrations less than the cut-off values used to define the clusters.

Eight public-water supplies lie within these delineated areas of concern. Elevated Cl concentrations for most of these wells are less than the secondary MCL for dissolved chloride. Some of the wells have NO_3 concentrations that exceed the MCL for dissolved NO_3. The well fields include those operated by:

- City of Perryton in Ochiltree County,
- Canadian River Municipal Water Authority (CRMWA) in Roberts County,
- City of Pampa in Gray County,
- City of Lefors in Gray County,
- Red River Authority in Donley County,

- City of McLean in Gray County,
- City of Wheeler in Wheeler County, and
- City of Dobson and Red River Authority–Dodson Water Authority in Collingsworth County.

There are several statistically significant long-term trends in water quality that show up and merit further study:

- Average NO_3 concentrations in the Seymour and Blaine aquifers in the PWPA appear to have decreased during the past few decades.
- Average Cl concentration in the Blaine aquifer may have increased between the 1970s and 1990s.
- NO_3 concentration might have increased in the Dockum aquifer in the past decade, but additional statistical analysis on a larger group of samples is needed to confirm this result.

As of 2003, 147 reported or confirmed cases of groundwater contamination in the PWPA, 2.1 percent of the statewide total, were being investigated, monitored, or remediated by governmental agencies. Fuel hydrocarbons (gasoline, diesel, and kerosene) are the most frequently cited constituents in the PWPA. Potter, Hutchinson, Randall, and Carson Counties have roughly 60 percent of the groundwater contamination cases, which probably reflects the greater population and industrial activity in those counties than in the rest of the PWPA.

INTRODUCTION

Purpose and Scope

The purpose of this report is to summarize water-quality information for the Ogallala, Rita Blanca, Seymour, Blaine, and Dockum aquifers in the Panhandle Water Planning Area (PWPA). Water-quality data used in this report include dissolved chloride (Cl), nitrate (NO_3), and total dissolved solids (TDS), which tend to represent regional characteristics of water quality in these aquifers. The report includes a brief summary of:

- Sources of data used.
- How the data were evaluated and processed.
- Analysis of water-quality variation during recent decades.
- Identification of areas of concern with regard to concentrations of chloride and nitrate concentrations.
- Delineation of public-water-supply well fields in the areas of concern.

Additional water-quality data cited in this report are from the summary of groundwater contamination cases being monitored and acted upon by the Texas Commission on Environmental Quality (TCEQ) and Railroad Commission of Texas (RRC) (Texas Commission on Environmental Quality, 2004). These contamination cases reflect local impacts on water quality.

Previous Studies

Hudak (2002) summarized the regional geographic distribution of NO_3 and Cl concentrations in the Ogallala aquifer, using 1996 and 2000 data for much of the PWPA planning area. Hudak's (2002) results show NO_3 concentrations exceed the 10 mg/L NO_3-N (~45 mg/L as NO_3) standard (U.S. Environmental Protection Agency, 2002) in only 5 of the 391 wells and Cl concentrations exceed its 300 mg/L secondary standard (Texas Administrative Code) also in 5 wells. Most Ogallala groundwaters in the PWPA have Cl concentration of less than 50 mg/L. Hudak (2002) showed more incidences of Cl concentration greater than 50 mg/L than did Knowles and others (1984). Hudak (2002) did not specifically evaluate whether statistically significant changes occur in ionic concentrations through time. Mehta and others (2000) discussed hydrogeologic controls on the location of zones of elevated concentration (Cl>50 mg/L) of dissolved Cl in part of the Ogallala aquifer between the Canadian River and Prairie Dog Town Fork of the Red River.

Dutton and Simpkins (1986) and Bradley and Kalaswad (2003) compiled data from a variety of sources and mapped regional trends in total dissolved solids in the Dockum Group. Dutton and Simpkins (1986) hypothesized several natural hydrogeologic controls on variations in water quality. Dutton and Simpkins (1986) and Dutton (1995) showed that groundwater in the Dockum aquifer beneath the High Plains is derived from downward leakage of water from the Ogallala aquifer.

Harden and Associates (1978) studied water quality in the Seymour aquifer in Haskell and Knox Counties, Texas. Although that study area is outside the PWPA, some information may be applicable to the Seymour aquifer in the PWPA. Harden and

Associates (1978) showed that elevated NO_3 is one of the most important water-quality issues in the Seymour aquifer. At the time of their study, 70 percent of 820 wells exceeded the recommended drinking water standard for NO_3 (as NO_3) of 45 mg/L. Sources of elevated NO_3 included cultivation of soils, which released stored soil NO_3, and domestic and animal sources, for example, septic tanks and barnyard wastes (Harden and Associates, 1978). Ewing and others (2004) likewise found more than half of the wells in the Seymour aquifer have at least one analysis with NO_3 (as N) of >10 mg/L.

Ewing and others (2004) reported that 12 percent of wells in the Blaine aquifer exceeded the 10 mg/L NO_3-N standard and that 26 percent of wells exceeded the 300 mg/L secondary standard for Cl. Sulfate also tends to have high concentrations in the Blaine aquifer (Ewing and others, 2004). The Blaine aquifer is at the hydrologic down-gradient end of some of the flow paths that go through the salt-dissolution zone that underlies the eastern rim of the High Plains and much of the Rolling Plains (Gustavson and Finley, 1985; Simpkins and Fogg, 1982; Johnson, 1981; Dutton and Orr, 1986; Richter and Kreitler, 1986; Dutton, 1987; Dutton, 1989). Variation in water quality in the Blaine aquifer reflects mixing of:

(a) Groundwater locally recharged in the outcropping and near-surface part of the Blaine aquifer, and

(b) Groundwater flowing from the salt-dissolution zone lying to the west.

DATA AND METHODS

Texas Water Development Board (TWDB) Internet-posted data on chemical composition of groundwater include more than 6,000 water-quality records for aquifers in the study area; almost half of the records are for samples collected between 1991 and 2000. About 94 percent of the 1990 samples, for example, are for the Ogallala aquifer. Additional data on groundwater samples include:

- Analyses of water samples from wells in the City of Amarillo well field in Carson County, provided by Mr. Dan Coffey;
- Data for wells and test holes in the Ogallala aquifer in and near the CRMWA well field on Campbell Ranch in Roberts Counties, provided by Mr. Rod Goodwin and Mr. John Williams; and
- Data for wells and test holes in the Ogallala aquifer in Hutchinson and Roberts Counties, provided by Mr. Bob Harden; and
- Analyses of water samples from wells in the Rita Blanca and Ogallala aquifers in the North Plains GCD, provided by Mr. Dale Hallmark.

The best data include concentrations of typical major constituents (including calcium, sodium, magnesium, potassium, chloride, sulfate, bicarbonate, and nitrate) that allow the overall charge balance to be checked. Data were not used if charge balance was less than 95 percent or if all major constituents were not reported.

Data analysis focused on Cl, NO_3, and TDS. Several approaches to data analysis were used.

(1) Data for each aquifer were sorted out and grouped by decade. Values for mean, variance, and standard deviation of concentration were calculated for each decade. Statistical values were calculated on log-transformed concentration units because concentration data tend to have a log-normal frequency distribution. Analysis of variance (ANOVA), a routine statistical test (for example, Miller and Freund,

1977), was used to determine whether there are differences between decadal average concentrations. These results are graphed in Figure 1 and Table 1.

(2) Histograms of concentrations of Cl, NO_3, and TDS for each aquifer were plotted for data from the 1990-2004 period. These histograms are presented in Figures 2 to 4.

(3) Concentrations of Cl, NO_3, and TDS for the Ogallala, Seymour, Rita Blanca, Dockum, and Blaine aquifers were posted and mapped using features in ArcView 3.3 and ArcGIS software. Areas of concern were marked for each aquifer and composited for the PWPA area. Criteria for defining areas of concern for Cl were:

(a) Individual reported analyses with Cl>250 mg/L, or

(b) Clusters or groups of wells where Cl>50 mg/L.

Criteria for defining areas of concern for NO_3 were

(a) Individual reported analyses with NO_3 >44 mg/L, or

(b) Clusters or groups of wells where NO_3 >20 mg/L.

The maps are given in Figures 5 to 19. Figure 20 is the composite map of areas of concern for Cl and NO_3. Appendix A provides a reference map showing the names of counties in the PWPA.

The TWDB data base reports NO_3 as NO_3, not as nitrogen (N). The maximum contaminant level (MCL) for NO_3 (as N) is 10 mg/L. The historical NO_3 data in the TWDB data base cannot be routinely converted back to NO_3-N unless collection techniques and lab procedures are known (http://www.twdb.state.tx.us/data/waterwell/groundwaterexplanation.htm#qualityassurance). For comparison, the approximate NO_3 equivalent to the MCL of 10 mg/L for NO_3-N is ~45 mg/L.

Data on incidents of reported or confirmed groundwater contamination in the PWPA were taken from Texas Commission on Environmental Quality (2004). This annual summary includes cases under the jurisdiction of the TCEQ, RRC, and other governmental agencies. Only sites under the jurisdiction of the TCEQ and RRC occur in the PWPA. Appendix B lists the cases from that report for the counties in the PWPA.

RESULTS

Analysis of Water-Quality Trends by Decade

Figure 1 shows trends in average concentrations of Cl, NO_3, and TDS calculated by decade for each aquifer. Both average and standard deviation of concentrations for the decadal data are shown; the former at the top and the latter at the base of each graph. Average Cl concentration in the Blaine aquifer for the 2000-to-2004 period was calculated from only two analyses, so the average Cl concentration may not be an accurate estimate of the typical most recent concentration in the Blaine aquifer. The line is dashed between concentrations plotted at 1995 and 2004 (Fig. 1a). Lines are also dashed for the Seymour aquifer between plotted values at 1945 and 1965 because there were no data for the intervening 1950s decade. Likewise, the line is dashed for the Rita Blanca aquifer between 1945 and 1975. All lines for standard deviation are dashed.

Most variations in these decadal estimates of water quality are statistically significant (Table 1). The ANOVA test takes sample size into account. For example, average dissolved Cl might appear to vary more in the Blaine aquifer than in the Ogallala aquifer (Fig. 1a), yet differences in decadal Cl averages are statistically significant in both aquifers (Table 1). The Ogallala aquifer has more than 10 times as much data as has the Blaine aquifer so smaller variations in the Ogallala aquifer can prove to be significant. The differences in decadal Cl and TDS are not statistically significant in the Dockum and Rita Blanca aquifers (Table 1). The Rita Blanca aquifer has a small sample size, small average values, and small standard deviation; differences in mean values between decades are small in comparison to within-decade variance. In contrast, average concentration and standard deviation are higher in the Dockum aquifer than in the Rita Blanca aquifer. Between-decades differences in mean concentrations in the Dockum aquifer, however, are small in comparison to within-decade variance.

Further tests whether there are statistically significant trends with time were not included in this study. For example, Figure 1 suggests that while there are significant differences in decadal average Cl and TDS in the Ogallala aquifer, there are no obvious long-term trends in those regional data. In comparison, it appears that there are several other trends:

- An increase in Cl in the Blaine aquifer between the 1970s and 1990s, discounting the average for the two samples collected since 2000 (Fig. 1a). That trend may be significant. Additional data from the Blaine aquifer collected since 2000 is needed to determine if the apparent increasing trend from the 1970s and 1990s has continued.

- Elevated NO_3 concentrations in the Seymour aquifer are well documented (Harden and Associates, 1976; Ewing and others, 2004). The decadal average data, however, suggest that NO_3 concentration in the Seymour aquifer in the PWPA has decreased since peak values in the 1970s (Fig. 1b).

- There also is a suggestion of a decrease in NO_3 concentration in the Blaine aquifer in the last decade (Fig. 1b). An increase in standard deviation of decadal NO_3, however, might be large enough that the apparent decrease might not be statistically significant.

- An increase in NO_3 concentration in the Dockum aquifer in the past decade is apparent, but its statistical significance remains to be tested.

Further statistical and hydrogeologic analysis to evaluate what might account for these apparent trends may be justified.

Statistical Distribution of Water Quality during the Past Decade

Dissolved Cl during the period from 1990 to 2004 has a similar statistical distribution in the Seymour, Ogallala, Dockum, and Rita Blanca aquifers (Fig. 2). The Ogallala and Rita Blanca aquifers are to a large extent interconnected, and are sometimes collectively called the High Plains aquifer (Gutentag and others, 1984). While the Dockum aquifer is typically less well connected to the Ogallala aquifer than the Rita Blanca is, groundwater in the Dockum aquifer mainly derives from the Ogallala aquifer beneath the High Plains (Dutton, 1995). So it makes sense that the Cl content is roughly similar in the Ogallala, Dockum, and Rita Blanca aquifers. The Cl content of the Seymour aquifer is similar to that of typical Ogallala aquifer groundwater, perhaps because, as in the Ogallala aquifer, there are few sources of Cl in the Seymour aquifer.

In contrast, the Blaine aquifer has a higher average Cl concentration and greater range in Cl than the other aquifers in the PWPA (Fig. 1a, 2d). This most likely reflects the fact that the Blaine aquifer is at the hydrologic down-gradient end of some of the flow paths that go through the salt-dissolution zone that underlies the eastern rim of the High Plains and much of the Rolling Plains (Gustavson and Finley, 1985; Simpkins and Fogg, 1982; Johnson, 1981; Dutton and Orr, 1986; Dutton, 1987; Richter and Kreitler, 1986; Dutton, 1989). Variation in water quality in the Blaine aquifer reflects the contribution and mixing of multiple sources of groundwater.

The Ogallala, Dockum, and Rita Blanca aquifers also have roughly similar distributions of dissolved NO_3 (Fig. 3). Local areas might be impacted by elevated NO_3. The City of Wheeler, for example, has relocated its municipal well field owing to issues associated with NO_3 contamination. Few samples from these aquifers during the period from 1990 to 2004 in the TWDB data base, however, show NO_3 concentrations of more than 44 mg/L.

Dissolved NO_3 during the period from 1990 to 2004 was greater in the Blaine and Seymour aquifers than in the Ogallala, Dockum, and Rita Blanca aquifers (Fig. 3). There are many groundwater samples in the Blaine and Seymour aquifers collected between 1990 and 2004 that exceed the ~45 mg/L equivalent drinking-water standard for NO_3. The apparent trends in decreasing NO_3 concentration in the Seymour and Blaine aquifers (Fig. 1b) suggest that water quality in those aquifers has been improving in recent decades.

Variation in TDS concentrations pretty much corresponds to that seen for dissolved Cl in these aquifers. The TDS distribution is similar in the Ogallala, Dockum, and Rita Blanca aquifers (Fig. 4). TDS tends to be highest in the Blaine aquifer, most likely related to the position of this aquifer near the salt-dissolution zone.

Groundwater Contamination

As of 2003 there were 147 reported or confirmed cases of groundwater contamination in the PWPA that were being investigated, monitored, or remediated by the TCEQ or RRC (Texas Commission on Environmental Quality, 2004). This is 2.1 percent of the 6,750 cases documented or under enforcement statewide during 2003. Table 2 tallies the number of cases by county and lists the described contaminants. Appendix B lists the data compiled from Texas Commission on Environmental Quality (2004) for the PWPA counties.

Fuel hydrocarbons (gasoline, diesel, and kerosene) are the most frequently cited constituents in the PWPA as well as statewide; approximately 60 percent of the cases are under the jurisdiction of TCEQ's Petroleum Storage Tank (PST) Division. Potter, Hutchinson, Randall, and Carson Counties have roughly 60 percent of the groundwater contamination cases, which probably reflects the greater population and industrial activity in those counties than in the rest of the PWPA.

Areas of Concern

Ogallala aquifer

Whereas Figure 1a shows *temporal* trends in average Cl in the Ogallala and other aquifers, and Figure 2b shows the *statistical* distribution of Cl during the period from 1990 to 2004, Figure 5 shows the *spatial* distribution of Cl in the Ogallala aquifer for the period from 1990 to 2004. Most of the Ogallala aquifer in the PWPA has Cl concentration < 50 mg/L (Figs. 2b, 5). Areas of concern for dissolved Cl are defined in this report on the basis of the previously given criteria (page 7). Two areas of concern for Cl along the Canadian River and Carson and Gray Counties match those areas marked by Mehta and others (2000) as having Cl greater than 50 mg/L. It is possible that some of the samples from along the Canadian River valley, however, are from wells that are partially completed in the Permian red beds that underlie the Ogallala aquifer.

There are a few other areas of concern for NO_3 in the Ogallala aquifer in the PWPA where NO_3 is >45 mg/L (Fig. 6). These include wells in Wheeler, Hansford, Hemphill, Gray, and Donley Counties. Areas of concern for Cl and NO_3 overlap in part of Donley County (Figs. 5 and 6).

There were no groundwater samples in the Ogallala aquifer in the PWPA in which TDS exceeded 3,000 mg/L (Fig. 7). Some samples exceeded 1,000 mg/L in TDS. The “salinity plume” in northern Gray County and northeastern Carson County, identified by Mehta and others (2000), contains almost 30 percent of these samples with TDS greater than 3,000 mg/L.

Dockum aquifer

There are many fewer samples of groundwater that have been analyzed for chemical composition from the Dockum aquifer than from the Ogallala aquifer. Areas of concern for Cl in the Dockum aquifer include two locations at the eastern side of Oldham County in the Canadian River Breaks and in southwestern Randall County (Fig. 8). Only one sample in the Dockum aquifer had a NO_3 concentration greater than ~45 mg/L and was in Potter County (Fig. 9). One sample from the Dockum aquifer with TDS > 3,000 mg/L was located in Randall County (Fig. 10). Most of the area with TDS > 3,000 mg/L lies to the south of the PWPA (Dutton and Simpkins, 1986; Bradley and Kalaswad, 2003).

Blaine aquifer

Since the Blaine aquifer is down-gradient of the salt-dissolution zone beneath the eastern rim of the High Plains, most of its water samples exceed 300 mg/L in dissolved Cl (Figs. 2d, 11). Several samples also have NO_3 >~45 mg/L (Figs. 2e, 12). The elevated NO_3 most likely has a more local source than the elevated Cl. Most of the water samples in the Blaine aquifer also exceed 3,000 mg/L in TDS (Fig. 13).

Rita Blanca aquifer

Only one of the water samples from the Rita Blanca aquifer exceeds 100 mg/L in Cl (Fig. 14) and none exceeds 20 mg/L in dissolved NO_3 (Fig. 15). The Rita Blanca aquifer is generally thought to be well interconnected to the Ogallala aquifer and to derive its water from the Ogallala aquifer (Gutentag and others, 1984). So it makes sense for the Cl content of groundwaters in the Rita Blanca and Ogallala aquifers to be similar (Figs. 5, 14). Overall distribution of TDS is similar in the Rita Blanca and Ogallala aquifers (compare Figures 4b and 4e, and Figures 7 and 16).

Seymour aquifer

Although groundwater has somewhat more variable concentrations of dissolved Cl in the Seymour aquifer than in the Ogallala aquifer (Figs. 2a and 2b), all of the Seymour water samples have Cl <150 mg/L (Fig. 17). Areas of concern for dissolved NO_3, however, remain extensive in the Seymour aquifer (Fig. 18). Sources of dissolved

NO_3 in the Seymour aquifer include domestic and animal waste, and leaching of accumulated soil- NO_3 (Harden and Associates, 1976). None of the water samples from the Seymour aquifer exceed 3,000 mg/L (Fig. 19).

SUGGESTIONS FOR FURTHER STUDY

Some of the observations made in this study have been previously made. For example, it is well known that the Seymour aquifer has had serious water-quality issues associated with NO_3 concentrations (Harden and Associates, 1976; Ewing and others, 2004). Another example is that there are zones in the Ogallala aquifer where Cl concentrations, while below secondary MCLs, are above 50 mg/L (Mehta and others, 2000). Most Ogallala aquifer waters in the PWPA have Cl of less than 50 mg/L.

New findings suggested by this study include:

- Cl concentration in the Blaine aquifer may have increased between the 1970s and 1990s (Fig. 1a).
- Average NO_3 concentration in the Seymour aquifer in the PWPA appears to have decreased since values peaked in the 1970s (Fig. 1b).
- While average NO_3 concentration has been more variable in the Blaine aquifer than in the Seymour aquifer, there also appears to have been a decrease in NO_3 concentration in the Blaine aquifer in the last decade (Fig. 1b).
- An increase in NO_3 concentration in the Dockum aquifer in the past decade is apparent, but its statistical significance remains to be tested.

Additional hydrogeologic research might be justified to evaluate these long-term trends. It would be good news if the apparent improvement in NO_3 concentration in the Seymour and Blaine aquifers could be verified. The cause for the apparent improvement in water quality should be documented. It could form a basis for predicting future NO_3 change in the PWPA and in other areas. Likewise, it could be important to identify whether the recent trending in increasing average NO_3 concentration in the Dockum aquifer is statistically and hydrogeologically meaningful.

DISCUSSION AND CONCLUSIONS

Areas of concern for dissolved Cl and NO_3 are composited in Figure 20 for the five aquifers included in this study of the PWPA. The area of concern for Cl covers as much as ~13 percent of the aquifer areas of the PWPA, whereas the area of concern for NO_3 covers ~2 percent. It should be noted that not all of the area included within the areas of concern for Cl and NO_3 have concentrations that exceed maximum contaminant levels. The areas includes apparent clusters of wells with Cl>50 mg/L or with NO_3 >20 mg/L, in addition to wells that exceed the MCL for either Cl or NO_3. Other wells with concentrations less than the MCLs and less than the cut-off values used to define the clusters may lie within the identified areas of concern. The purpose of identifying the areas of concern is to draw attention to these areas and to raise the question of whether there are water-quality issues to be addressed along with water-supply issues. Pinpointing the hydrogeologic controls, sources, or local causes of contamination may require collection and further analysis of additional water samples and consideration of local hydrogeologic conditions.

Ogallala aquifer

Areas of concern for Cl along the Canadian River and in Carson and Gray Counties (Figs. 5, 20) match those areas marked by Mehta and others (2000) as having Cl greater than 50 mg/L. Another large area extends from southeastern Hansford County to northwestern Lipscomb County. There are other smaller areas in parts of Randall, Potter, Moore, Hansford, and Donley Counties, where elevated Cl might reflect movement of water from the underlying Permian section, as suggested by Mehta and others (2000). Some of these areas are defined by one or just a few samples. Some of the samples may come from wells completed not only in the Ogallala aquifer but also partly in the Permian section. Samples from dual-completion wells could falsely indicate a Cl problem for the Ogallala aquifer.

Areas of concern are smaller for NO_3 than Cl in the Ogallala aquifer. Most of the areas fall near the eastern side of the High Plains (Figs. 6, 20). Some are defined by single samples. Individual samples might reflect local problems with well completion allowing vertical migration of contaminated water, and might not reflect widespread contamination of the aquifer.

The Cl areas of concern in the Ogallala aquifer include public-water-supply well fields (Fig. 21) operated by:

- City of Perryton in Ochiltree County (map area 1, Fig. 21),
- City of Pampa in Gray County (map area 2, Fig. 21),
- City of Lefors in Gray County (map area 3, Fig. 21), and
- Red River Authority in Donley County (map area 6, Fig. 21).

Elevated Cl concentrations in most of the reported samples are less than the secondary MCL for dissolved chloride (Table 3).

The NO_3 areas of concern in the Ogallala aquifer include public-water-supply well fields operated by:

- City of McLean in Gray County (map area 4, Fig. 21),
- City of Wheeler in Wheeler County (map area 5, Fig. 21), and
- Red River Authority in Donley County, which well field also lies in the Cl area of concern (map area 6, Fig. 21).

Some NO_3 concentrations in the reported samples exceed the MCL for dissolved NO_3 (Table 3).

Dockum aquifer

Areas of concern for Cl in the Dockum aquifer (Figs. 8, 20) may all occur beneath and alongside topographically low-lying areas, where there may be cross-formational flow of water from the Permian section into the Dockum aquifer. Most of the area with poor water quality in the Dockum aquifer lies south of the PWPA (Dutton and Simpkins, 1986).

Blaine aquifer

Chronic water quality problems in the Blaine aquifer, especially elevated concentrations of Cl (Figs. 11, 20) and sulfate, are typically related to the aquifer's position down-gradient of the salt-dissolution zone beneath the eastern rim of the High

Plains. Cl and TDS are expected to be greater beneath valleys in the confined part of the aquifer than in upland areas in the unconfined part.

Rita Blanca aquifer

No areas of concern were defined for Cl or NO_3 on the basis of criteria defined in this study.

Seymour aquifer

Elevated concentrations of NO_3 are common in the Seymour aquifer (Harden and Associates, 1976; Ewing and others, 2004). There is, however, some evidence that NO_3 concentration in the Seymour aquifer in the PWPA has decreased since values peaked in the 1970s (Fig. 1b). Additional work may be warranted to verify this conclusion. The NO_3 areas of concern in the Seymour aquifer in the PWPA include public-water-supply wells operated by the City of Dobson and Red River Authority–Dodson Water Authority in Collingsworth County (map area 7, Fig. 21). One of two reported samples (measured in 1993) has a NO_3 concentration that exceeds the MCL for dissolved NO_3 (Table 3).

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Table 1. Analysis of variance of water-quality trends. Statistical evaluation by analysis of variance (ANOVA). The ANOVA test calculates a value for F ($F_{calculated}$) from between-groups, within-groups, and total variance with *n* and *m* degrees or freedom (Df) determined from the sample size and number of groups. The value of $F_{statistic}$ is looked up in a standard F-statistic probability chart. If $F_{calculated}$ is greater than $F_{statistic}$, then the null hypothesis that there is no difference between groups is rejected and the apparent difference between concentration averages between the decadal groups is found to be statistically significant (*). Numbers in the table are for $F_{calculated}$, $F_{statistic}$ and the degrees of freedom.

Aquifer	Statistical information	Chloride	Nitrate	Total Dissolved Solids
Ogallala	$F_{calculated}$	4.658*	17.8437*	3.054*
	Df (*n*, *m*)	(7, 3141)	(7, 3091)	(7, 3141)
	$F_{statistic}$	2.012	2.012	2.012
Blaine	$F_{calculated}$	13.710*	8.483*	6.673*
	Df (*n*, *m*)	(7, 226)	(7, 166)	(7, 226)
	$F_{statistic}$	2.050	2.065	2.050
Dockum	$F_{calculated}$	1.250	4.462*	0.621
	Df (*n*, *m*)	(4, 141)	(4, 140)	(4, 141)
	$F_{statistic}$	2.436	2.436	2.436
Seymour	$F_{calculated}$	3.496*	4.012*	5.620*
	Df (*n*, *m*)	(5, 62)	(5, 54)	(5, 62)
	$F_{statistic}$	2.363	2.386	2.363
Rita Blanca	$F_{calculated}$	0.925	3.613*	1.375
	Df (*n*, *m*)	(5, 77)	(4, 76)	(5, 77)
	$F_{statistic}$	2.330	2.492	2.333

$F_{calculated}$ Ratio of between-groups variance to within-groups variance calculated from data.

Df (*n*, *m*) Degrees of freedom: *n* and *m* are degrees of freedom for between groups and within groups comparisons, respectively.

$F_{statistic}$ Determined from F-statistic probability chart.

* Not statistically significant. ($F_{calculated} < F_{statistic}$). All others $F_{calculated} > F_{statistic}$ at 0.05 confidence level and the stated degrees of freedom.

Table 2. Tally of groundwater contamination cases for 2003 by county in the PWPA. Compiled from Texas Commission on Environmental Quality (2004)

County	Total number of reported cases	Cases including gasoline, diesel, or kerosene	Percent of total cases including gasoline, diesel, or kerosene	Cited constituents
Armstrong	0	0	—	None
Carson	14	1	7	1-2 Dichloroethane, Benzene, Chromium, Drip gas or condensate, Explosives, Gasoline, High explosives, Metals, Organic solvents, SVOC, TCE, Trichloroethylene
Childress	13	8	—	Chlorinated solvents, Chloroform, Diesel, Gasoline, Unknown
Collingsworth	0	0	—	None
Dallam	5	2	40	Chlorinated solvents, Chloroform, Diesel, Gasoline, Unknown
Donley	0	0	—	None
Gray	8	3	38	Acetone, Benzene, BTEX, Chloride, Gasoline, MTBE
Hall	5	2	40	Blank, Gasoline, Unknown
Hansford	0	0	—	None
Hartley	0	0	—	None
Hemphill	7	7	100	Gasoline, Kerosene
Hutchinson	22	8	36	1,4-Dichlorobenzene, Arsenic, Benzene & free phase HC, Free phase HC & BTEX, Gasoline, Hydrocarbons, Hydrocarbons & SW, Inorganics, Kerosene, Metals, Organics, Sulfolane, TPH, VOCs, Waste oil
Lipscomb	0	0	—	None
Moore	10	4	40	Benzene, Bis(2-Ethylhexy)Phthlate, Diesel, Gasoline, LNAPL, Metals, Nitrates, VOCs
Ochiltree	2	0	0	Carbon tetrachloride, Nitrates
Oldham	0	0	—	None
Potter	36	28	78	Benzene, Chloride, Chromium, Diesel, Free phase HC , Gasoline, Hydrocarbons, Nitrate, Sulfate, TPH
Randall	17	12	71	Atrazine, Diesel, Gasoline, MW-12: VOCs (Methlyene chloride), Unknown
Roberts	3	3	100	Gasoline
Sherman	1	1	100	Gasoline
Wheeler	4	4	100	Gasoline
Total	147	83	56	

Table 3. List of public-water-supply well fields occurring in areas of concern for dissolved chloride and nitrate in groundwater. Map label number from Figure 21.

Map label	County	Constituent of concern	Public-water-supply-well field operators	Aquifer	Reported concentration (mg/L)	No. of samples in file	Sample years
1	Ochiltree	Chloride	City of Perryton	Ogallala	Cl: 57 to 130	3	1991 to 1996
2	Roberts	Chloride	Canadian River Municipal Water Authority	Ogallala	Cl: 16 to 348	53	1999 to 2004
3	Gray	Chloride	City of Pampa	Ogallala	Cl: 115 to 295	4	1991 to 2000
4	Gray	Chloride	City of Lefors	Ogallala	Cl: 95 to 583	2	1991 to 2000
5	Gray	Nitrate	City of McLean	Ogallala	NO_3: 14 to 65	2	2000
6	Wheeler	Nitrate	City of Wheeler	Ogallala	NO_3: 91	1	2000
7	Donley	Chloride and Nitrate	Red River Authority	Ogallala	Cl: 49 to 164 NO_3: 22 to 33	3 3	1991 to 2000 1991 to 2000
8	Collingsworth	Nitrate	City of Dodson and Red River Authority–Dodson Water Authority	Seymour	NO_3: 14 to 60	2	1991 to 2000

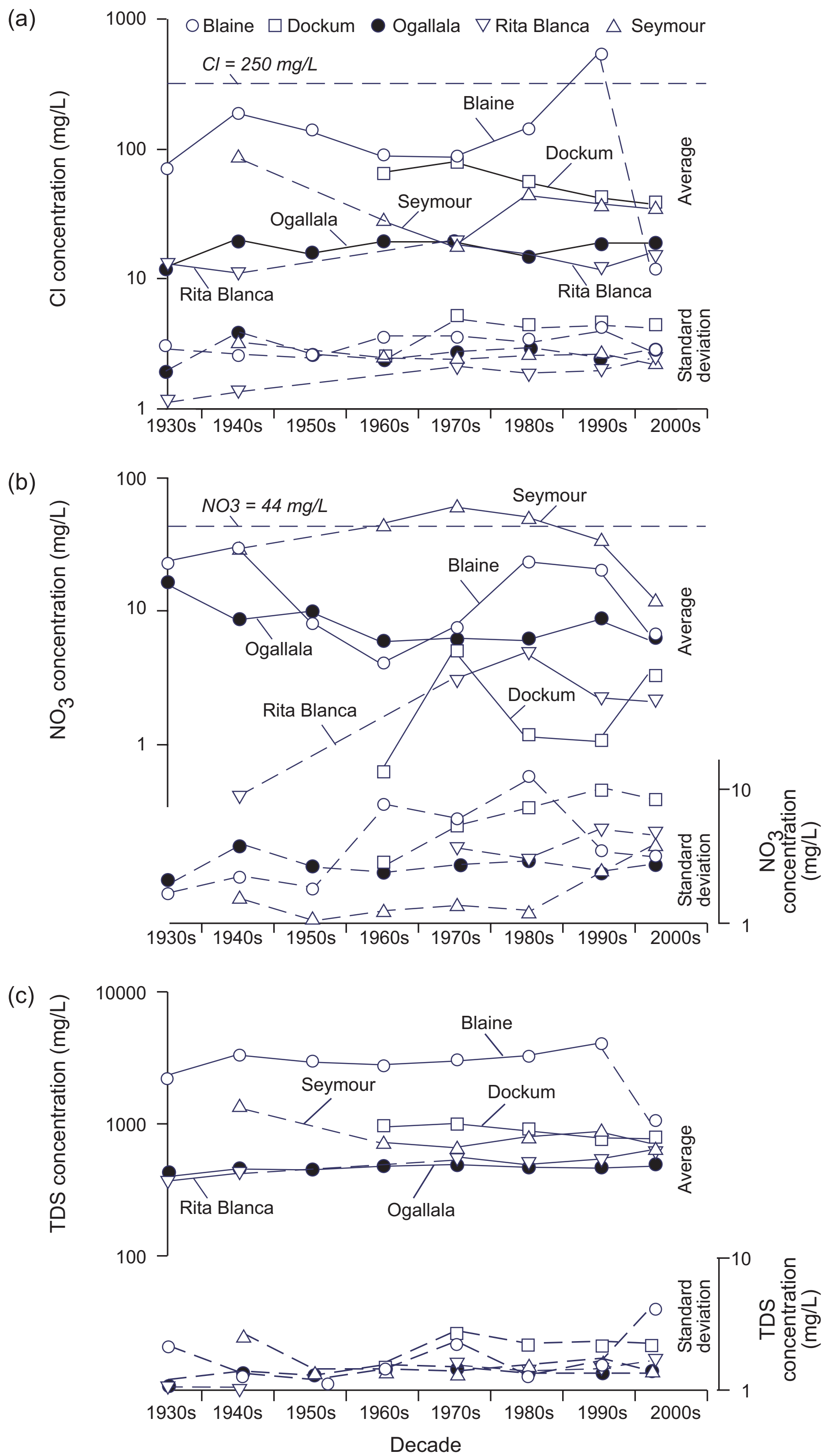


Figure 1. Variation in average and standard deviation of Cl (a), NO_3 (b), and TDS (c) in samples from aquifers in the PWPA.

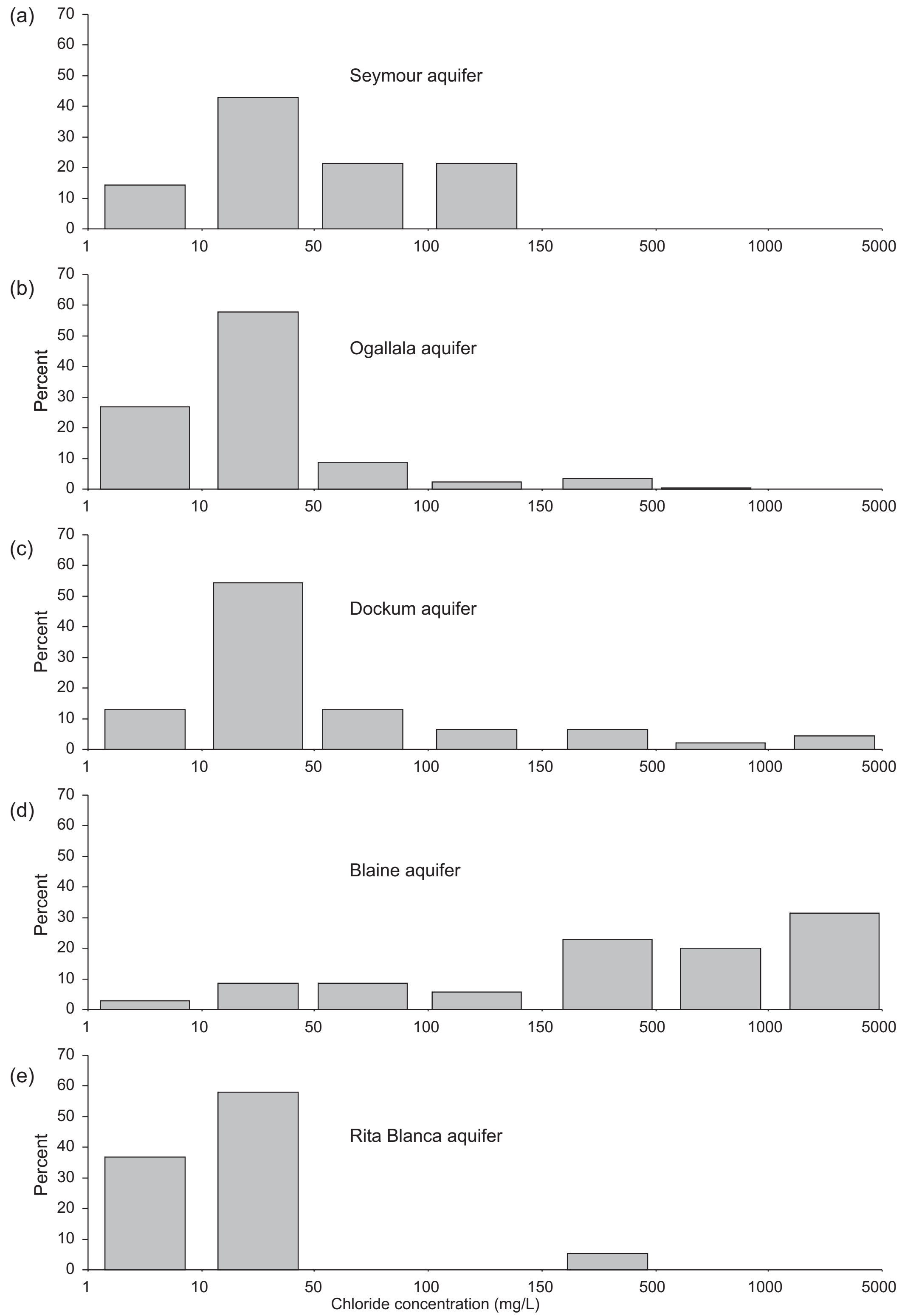


Figure 2. Statistical distribution of Cl in the Seymour (a), Ogallala (b), Dockum (c), Blaine (d), and Rita Blanca (e) aquifers in the PWPA. Data for the period 1990 to 2004.

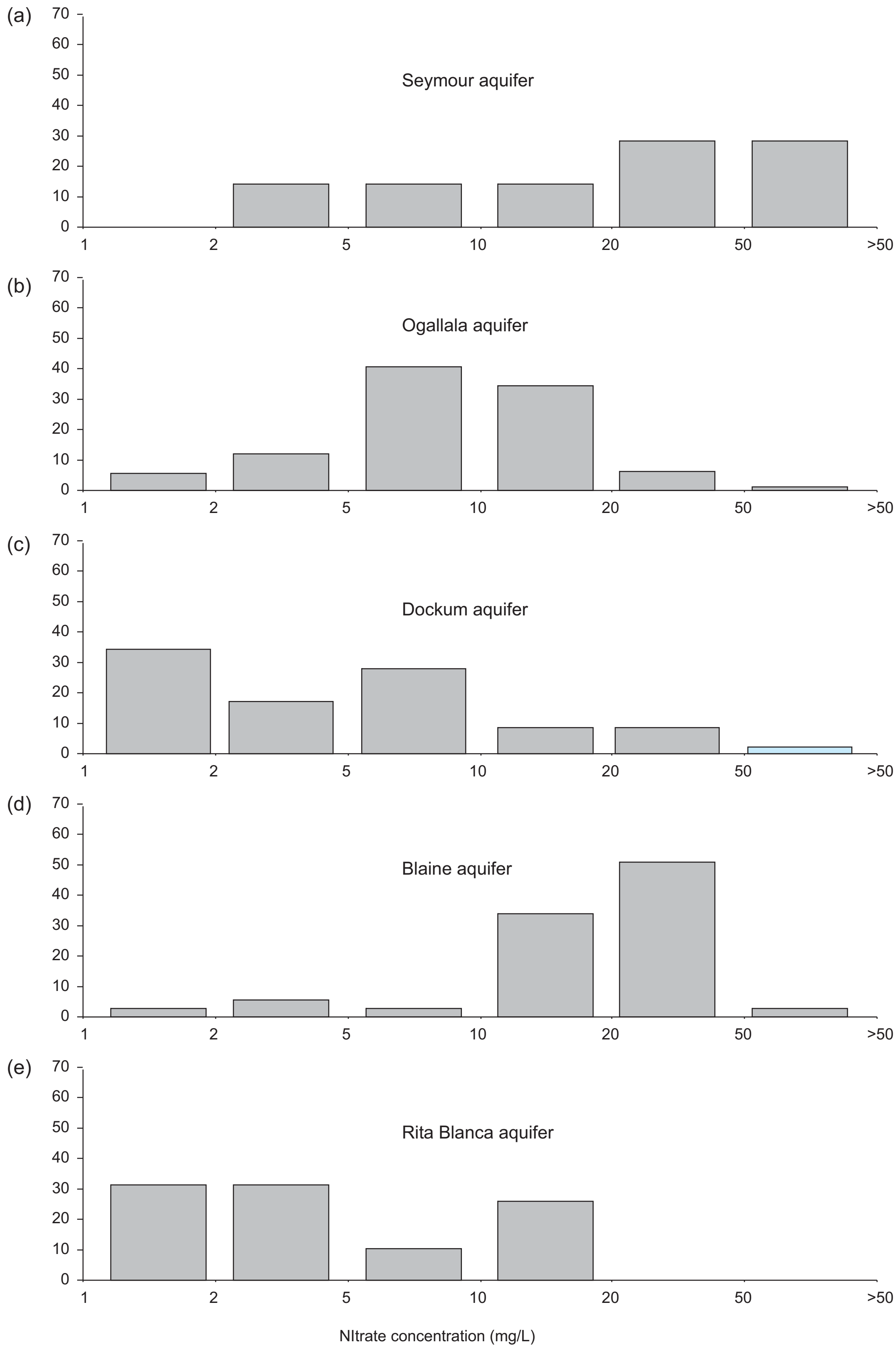


Figure 3. Statistical distribution of NO_3 in the Seymour (a), Ogallala (b), Dockum (c), Blaine (d), and Rita Blanca (e) aquifers in the PWPA. Data for the period 1990 to 2004.

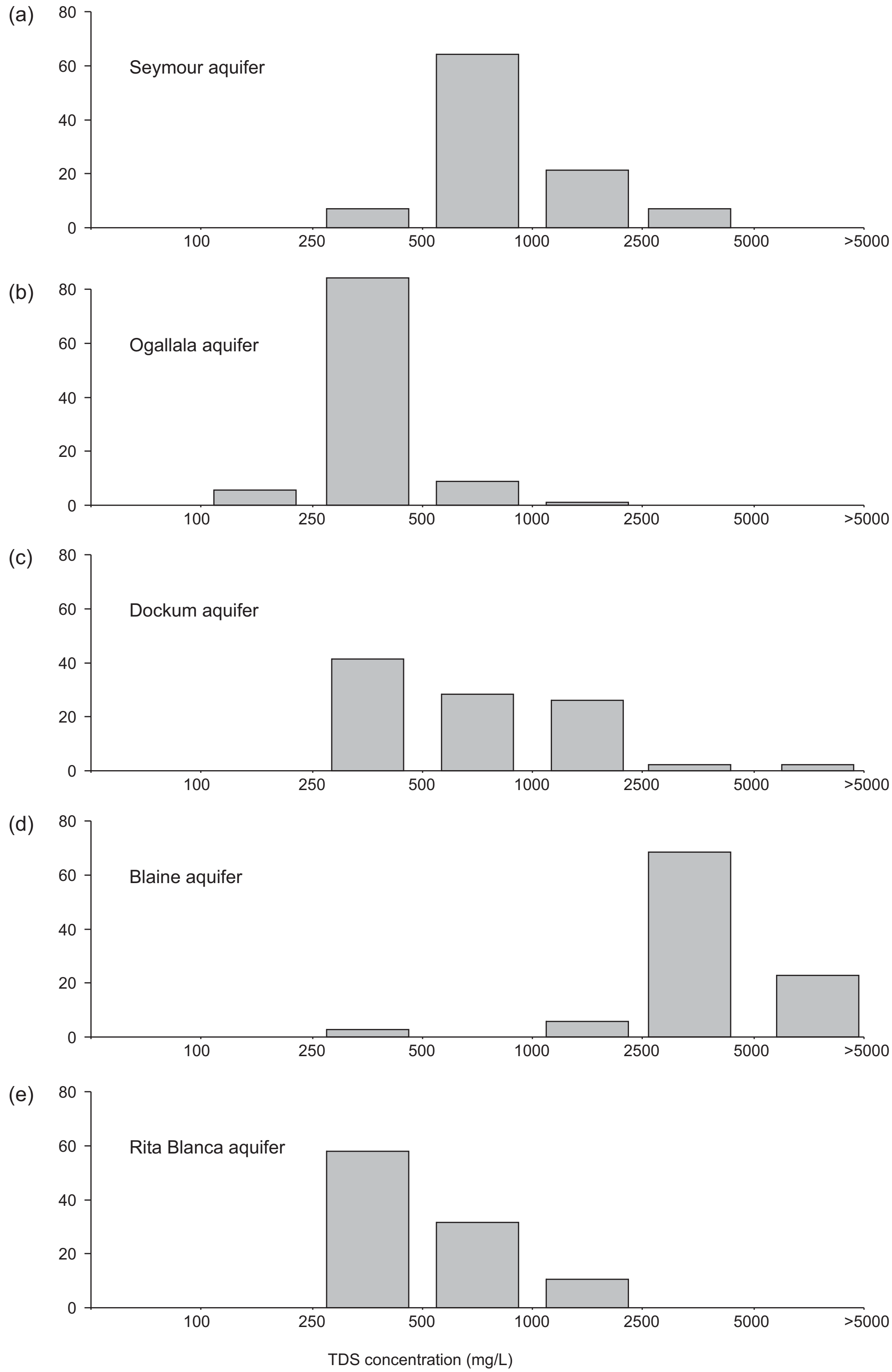


Figure 4. Statistical distribution of TDS in the Seymour (a), Ogallala (b), Dockum (c), Blaine (d), and Rita Blanca (e) aquifers in the PWPA. Data for the period 1990 to 2004.

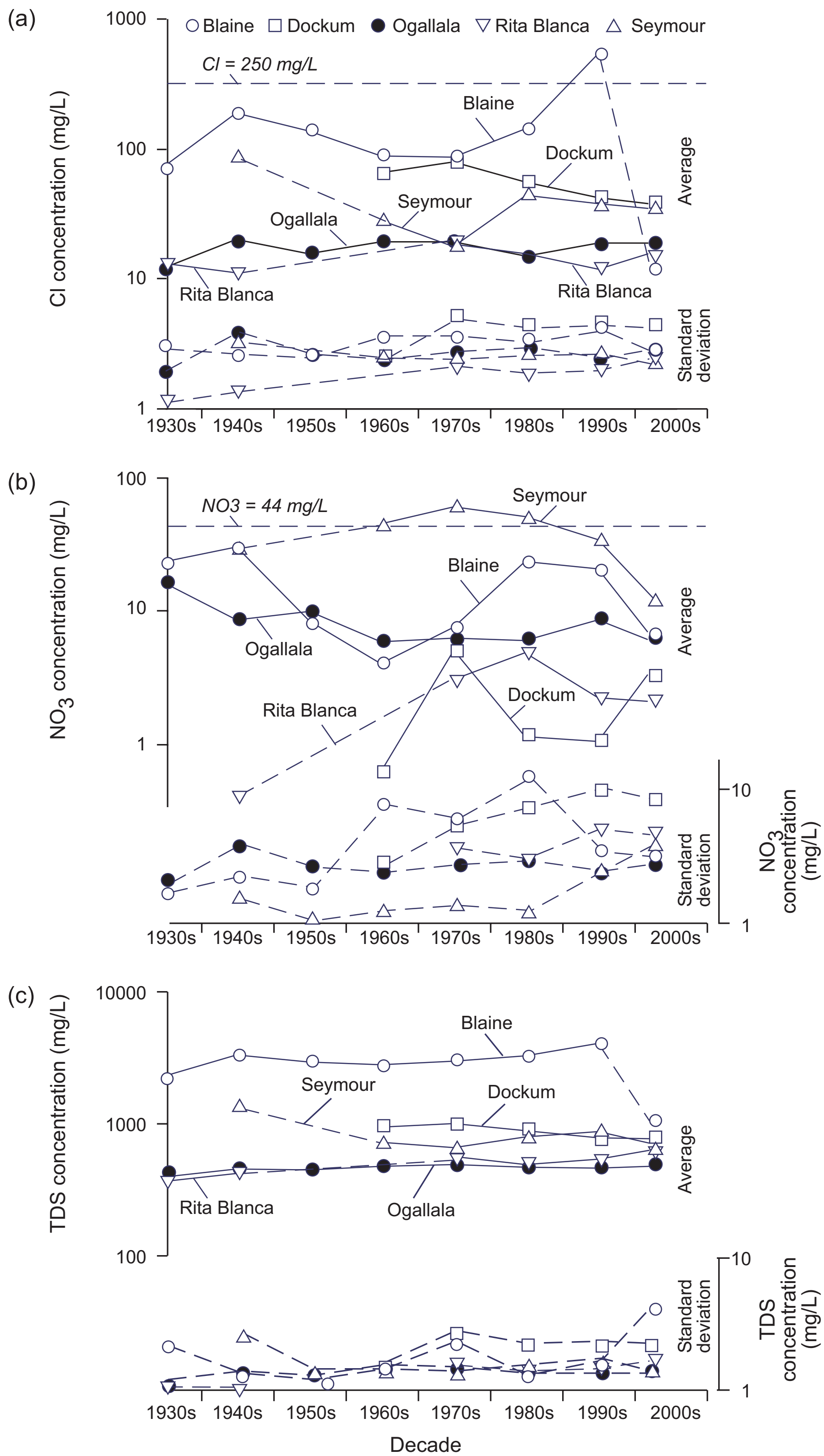


Figure 1. Variation in average and standard deviation of Cl (a), NO_3 (b), and TDS (c) in samples from aquifers in the PWPA.

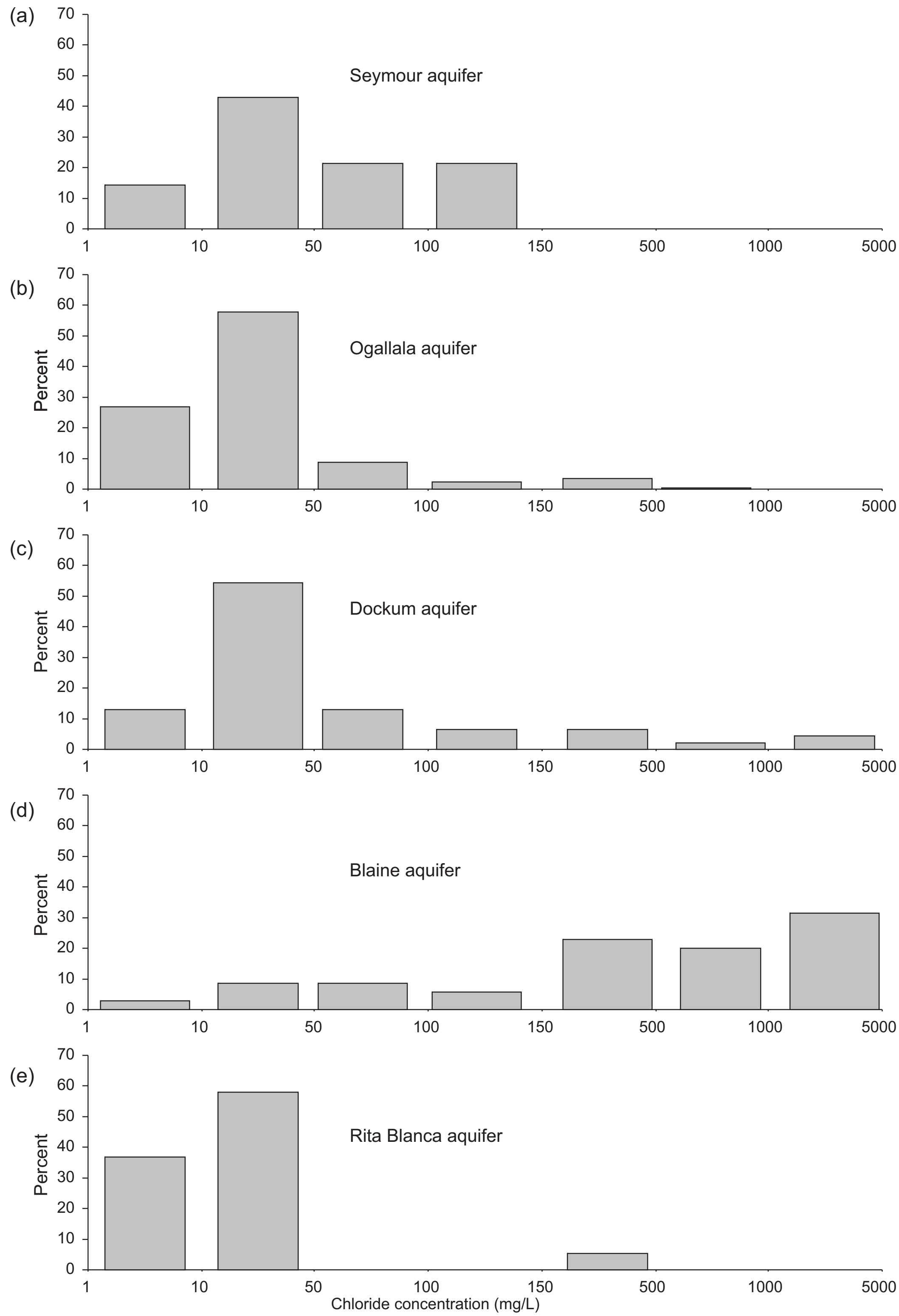


Figure 2. Statistical distribution of Cl in the Seymour (a), Ogallala (b), Dockum (c), Blaine (d), and Rita Blanca (e) aquifers in the PWPA. Data for the period 1990 to 2004.

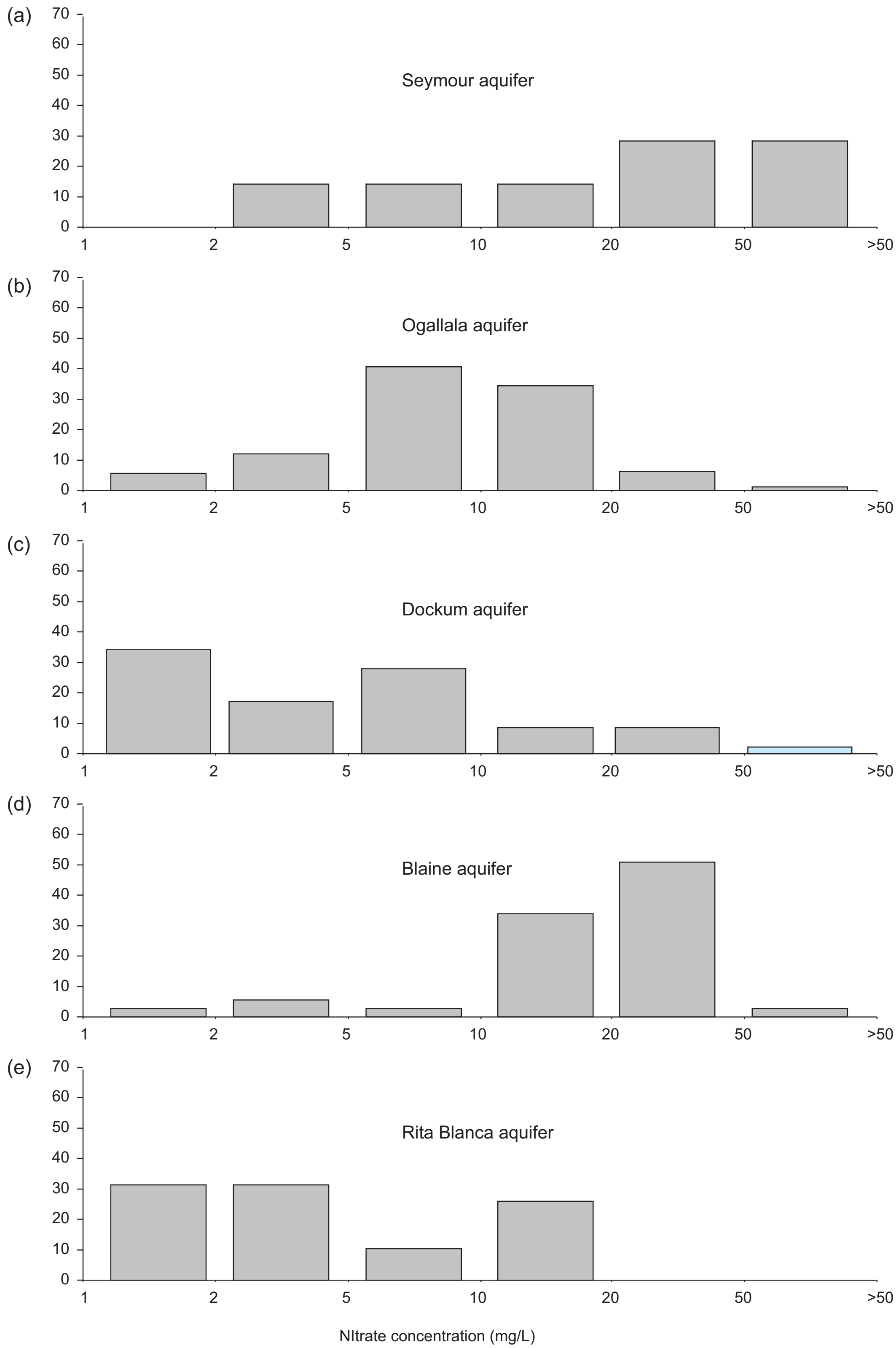


Figure 3. Statistical distribution of NO_3 in the Seymour (a), Ogallala (b), Dockum (c), Blaine (d), and Rita Blanca (e) aquifers in the PWPA. Data for the period 1990 to 2004.

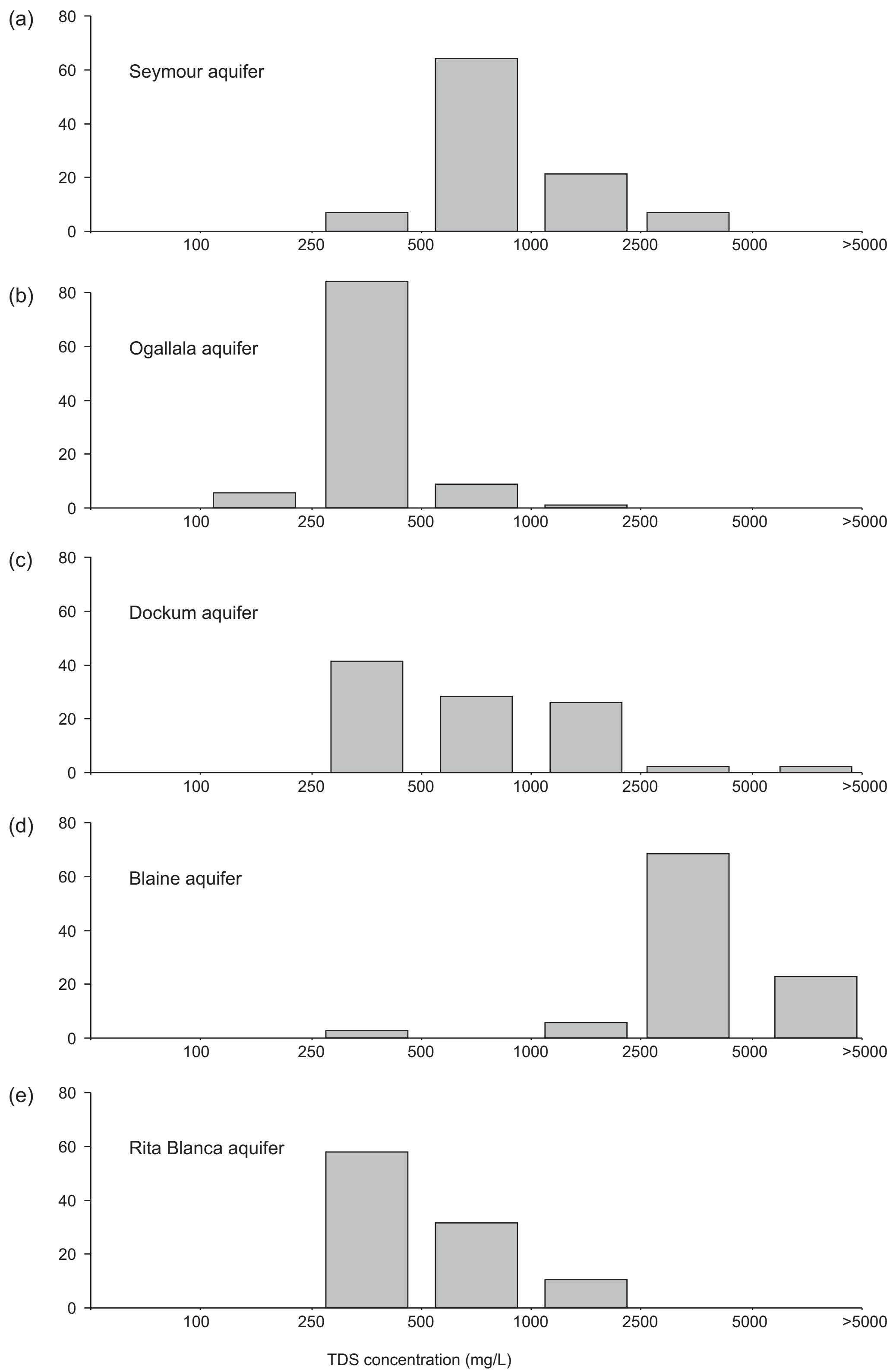


Figure 4. Statistical distribution of TDS in the Seymour (a), Ogallala (b), Dockum (c), Blaine (d), and Rita Blanca (e) aquifers in the PWPA. Data for the period 1990 to 2004.

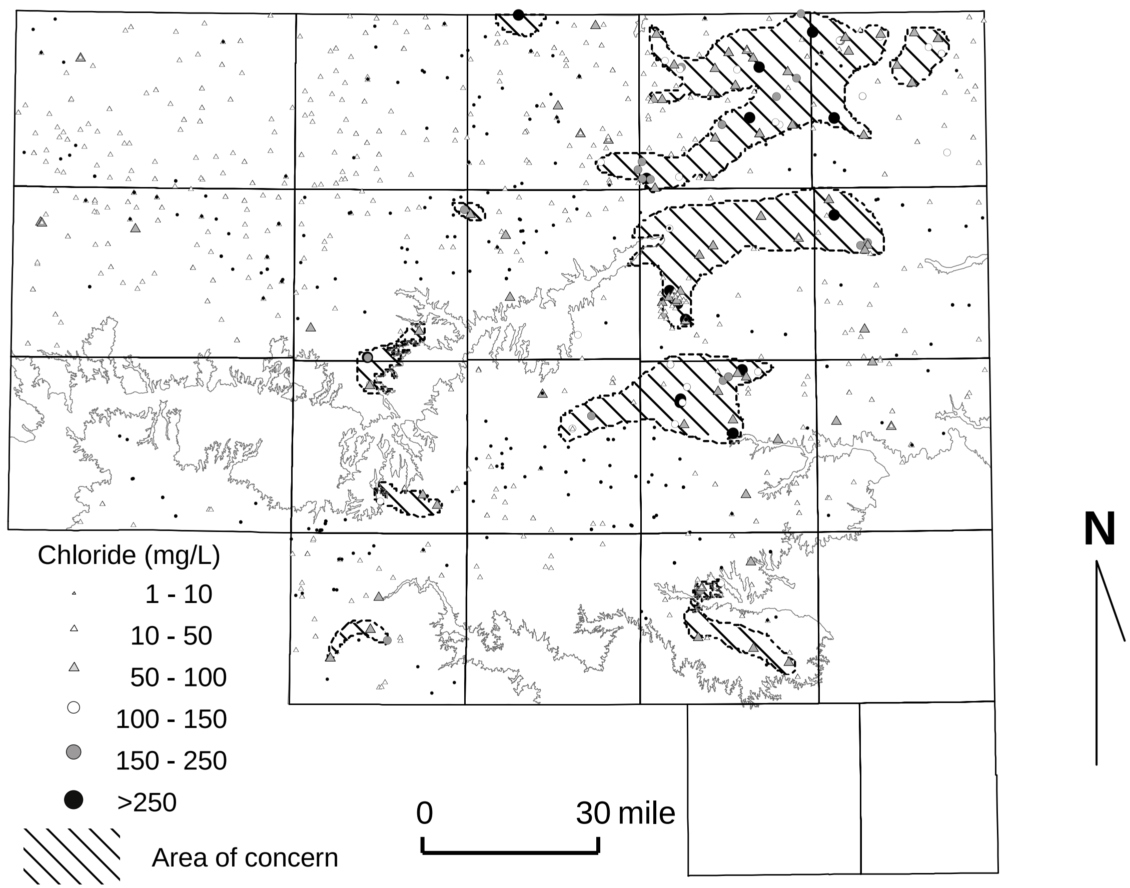


Figure 5. Map of spatial distribution of dissolved chloride in the Ogallala aquifer. Data from 1990-to-2004 period. Area of concern defined whether either (a) individual reported analyses with Cl>250 mg/L or (b) clusters or groups where Cl>50 mg/L.

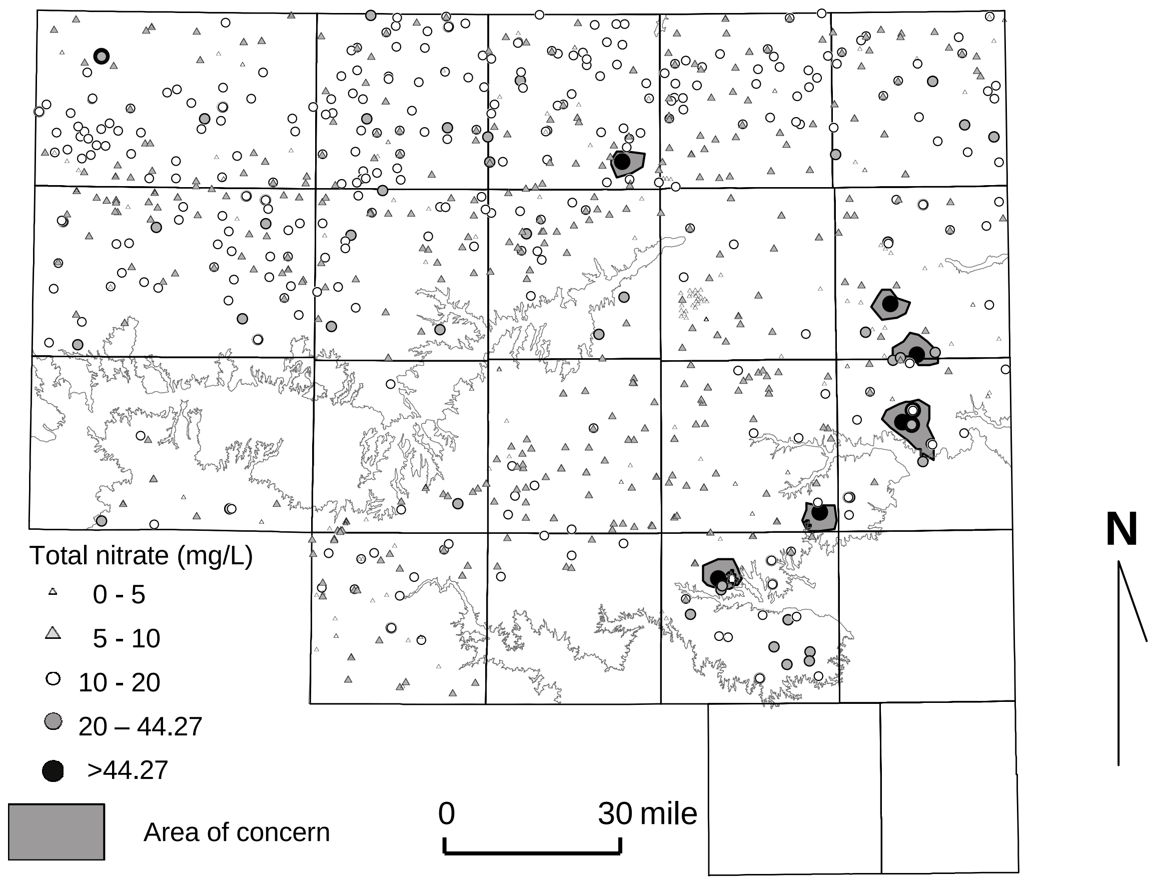


Figure 6. Map of spatial distribution of dissolved nitrate in the Ogallala aquifer. Data from 1990-to-2004 period. Area of concern defined whether either (a) individual reported analyses with nitrate >~45 mg/L or (b) clusters or groups where nitrate >20 mg/L.

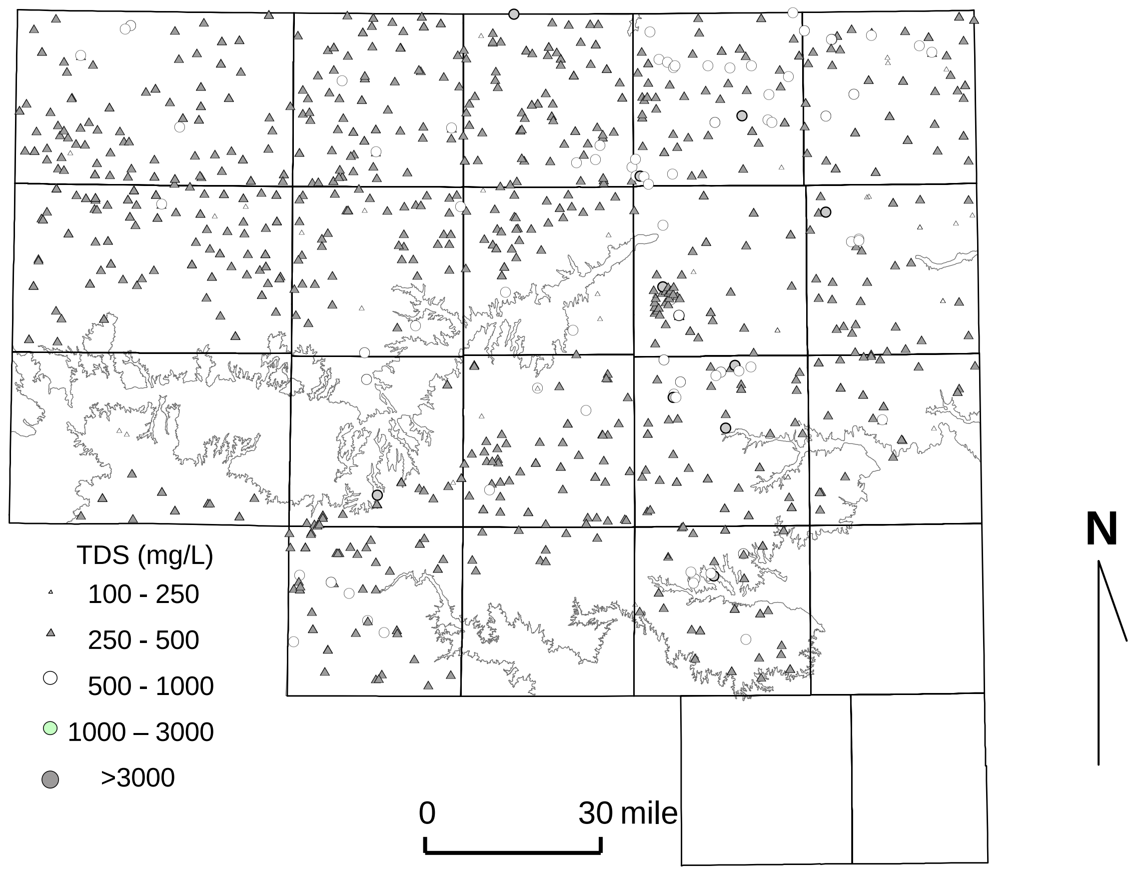


Figure 7. Map of spatial distribution of total dissolved solids (TDS) in the Ogallala aquifer. Data from 1990-to-2004 period.

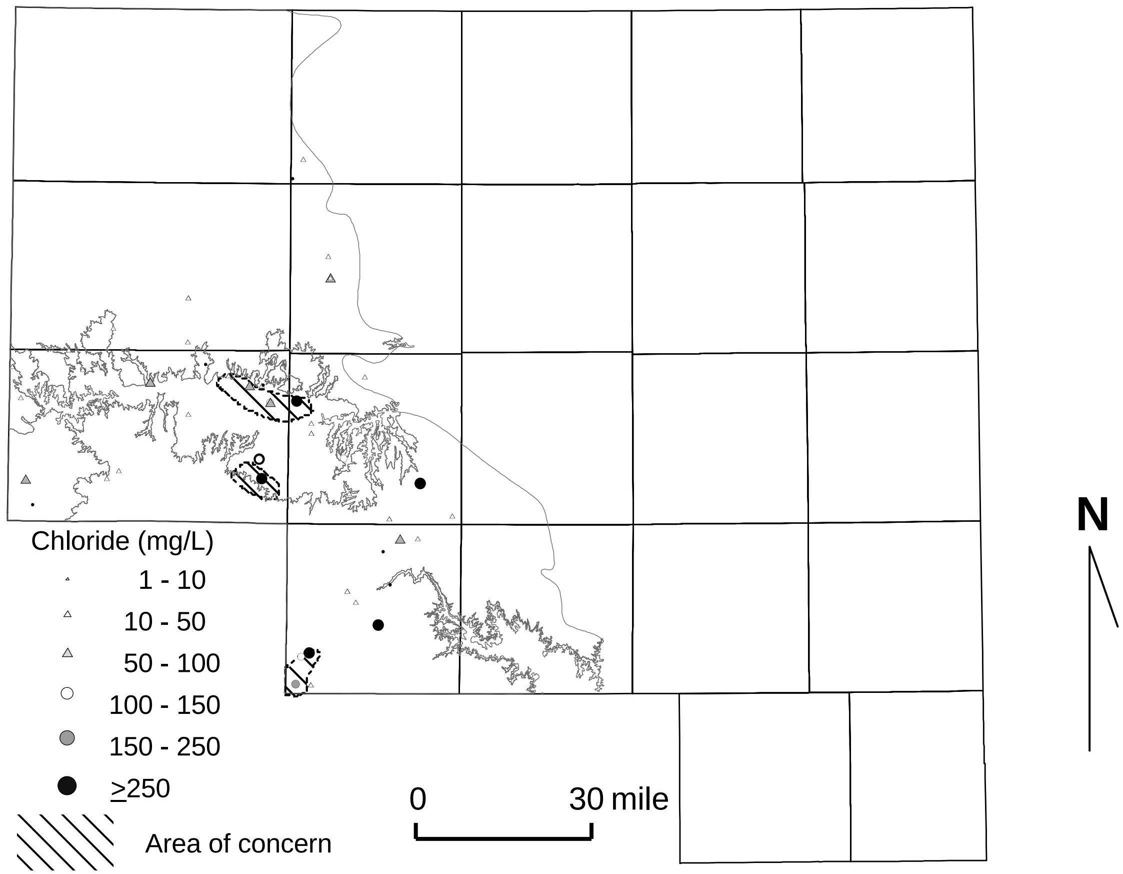


Figure 8. Map of spatial distribution of dissolved chloride in the Dockum aquifer. Data from 1990-to-2004 period. Area of concern defined whether either (a) individual reported analyses with Cl>250 mg/L or (b) clusters or groups where Cl>50 mg/L.

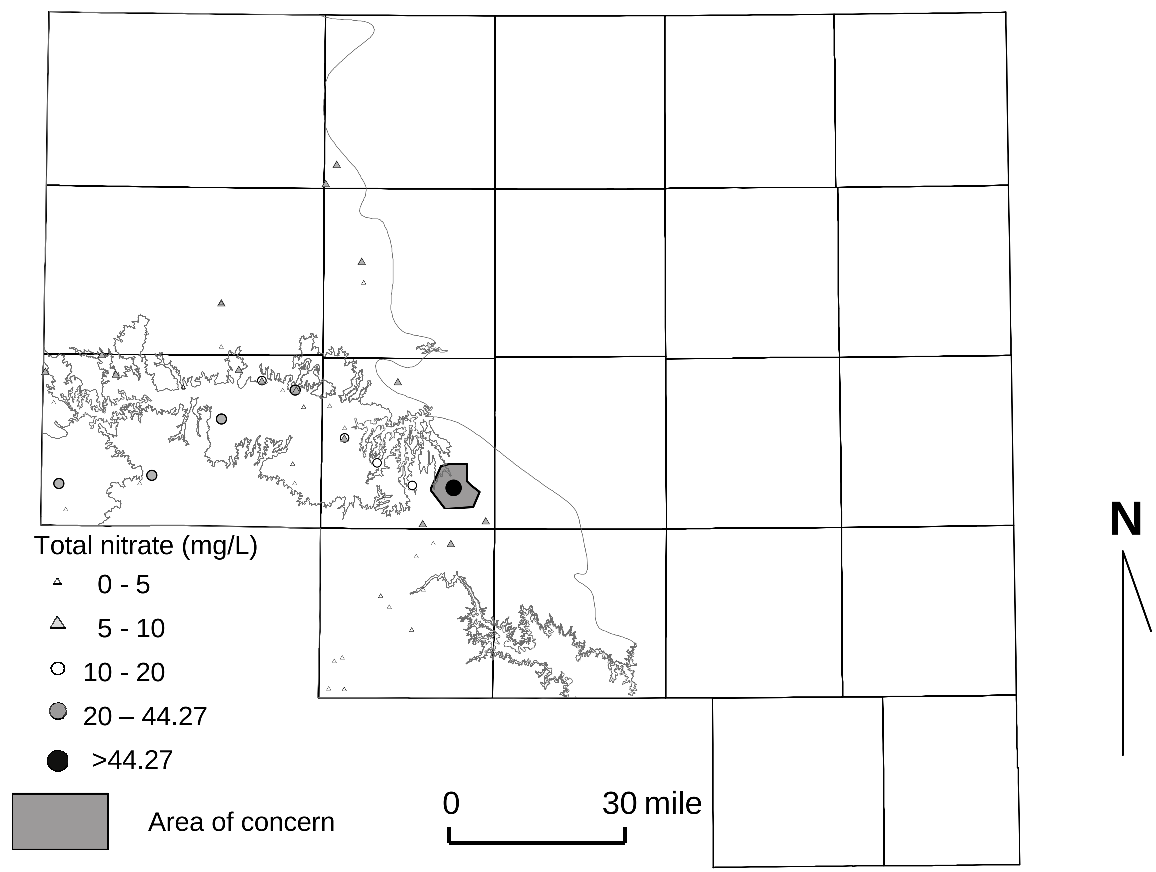


Figure 9. Map of spatial distribution of dissolved nitrate in the Dockum aquifer. Data from 1990-to-2004 period. Area of concern defined whether either (a) individual reported analyses with nitrate >~45 mg/L or (b) clusters or groups where nitrate >20 mg/L.

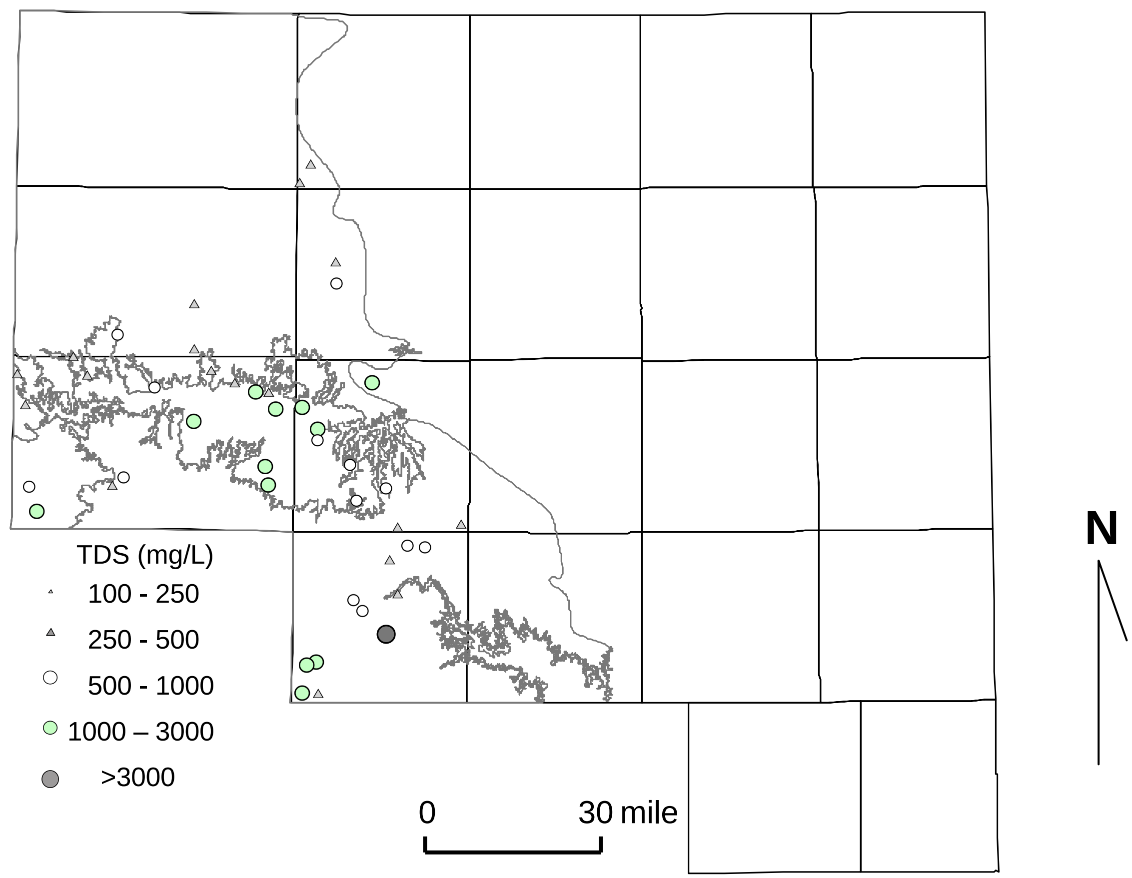


Figure 10. Map of spatial distribution of total dissolved solids (TDS) in the Dockum aquifer. Data from 1990-to-2004 period.

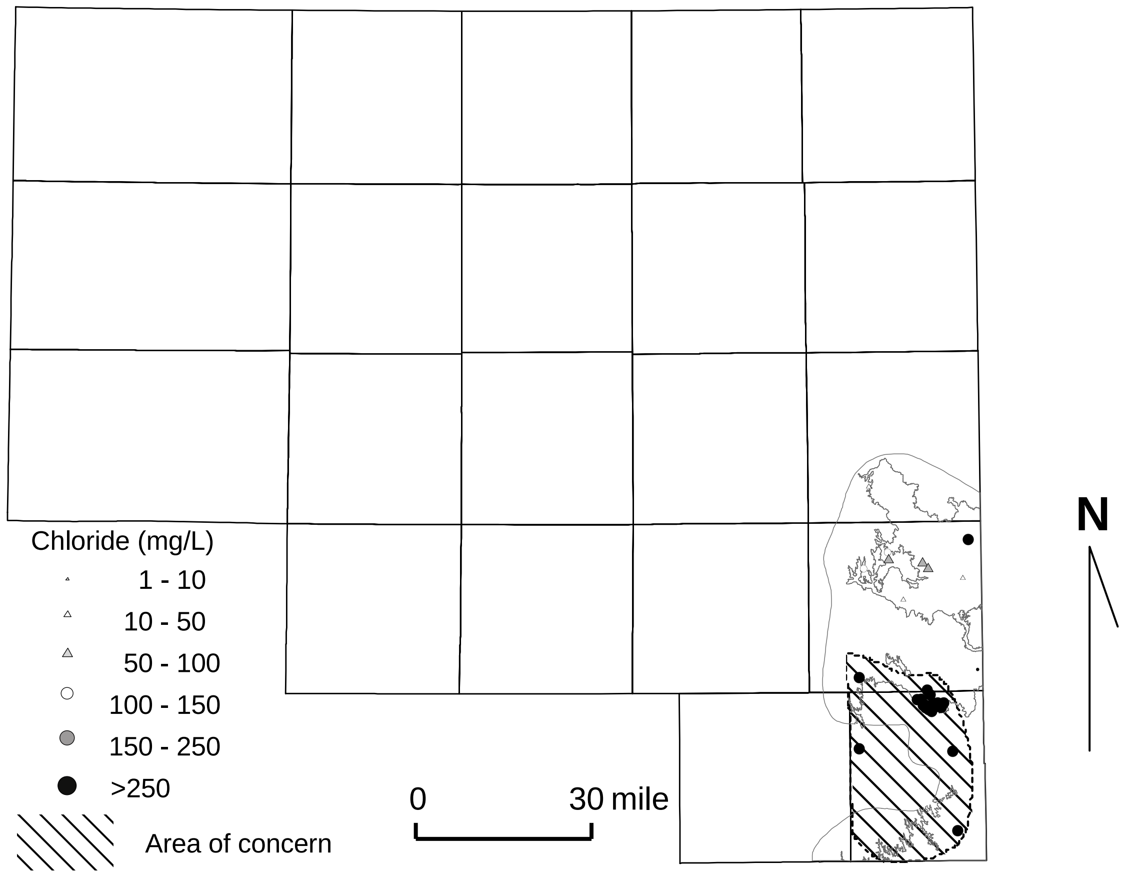


Figure 11. Map of spatial distribution of dissolved chloride in the Blaine aquifer. Data from 1990-to-2004 period. Area of concern defined whether either (a) individual reported analyses with Cl>250 mg/L or (b) clusters or groups where Cl>50 mg/L.

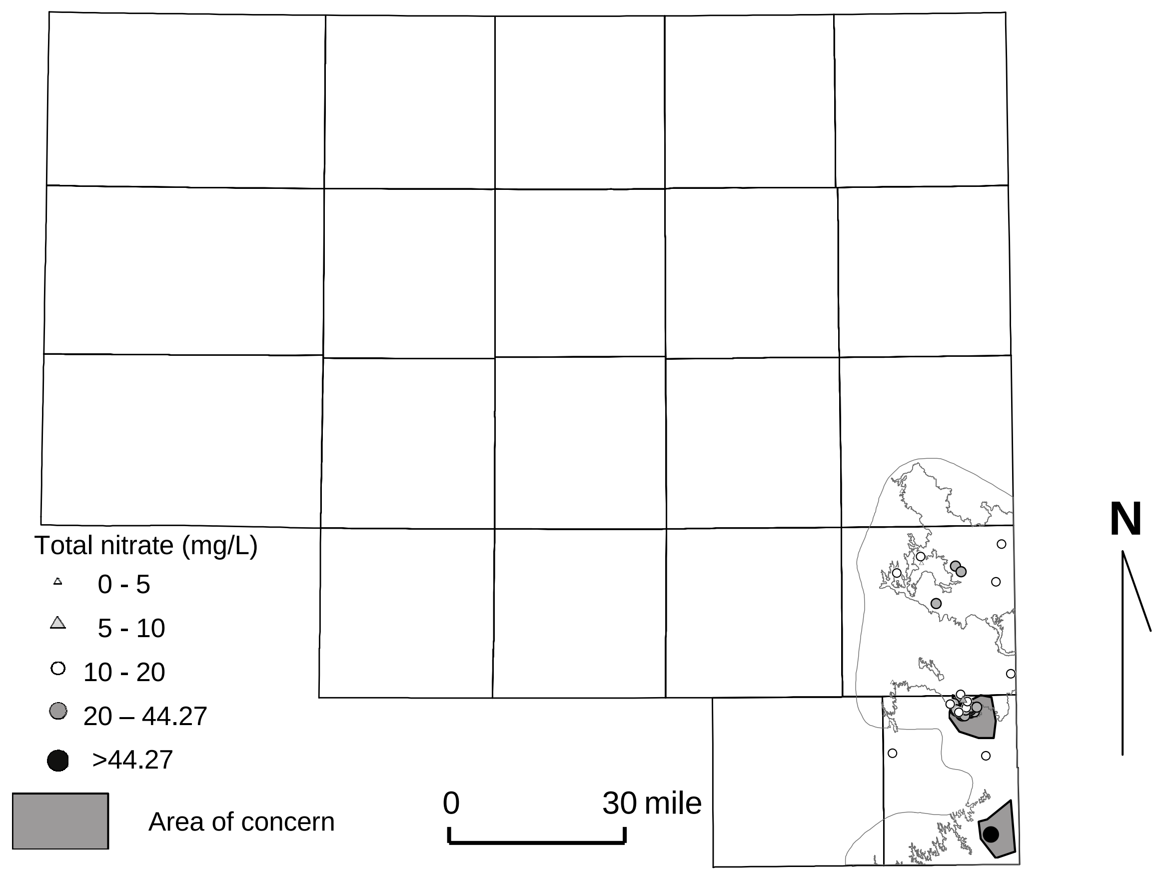


Figure 12. Map of spatial distribution of dissolved nitrate in the Blaine aquifer. Data from 1990-to-2004 period. Area of concern defined whether either (a) individual reported analyses with nitrate >~45 mg/L or (b) clusters or groups where nitrate >20 mg/L.

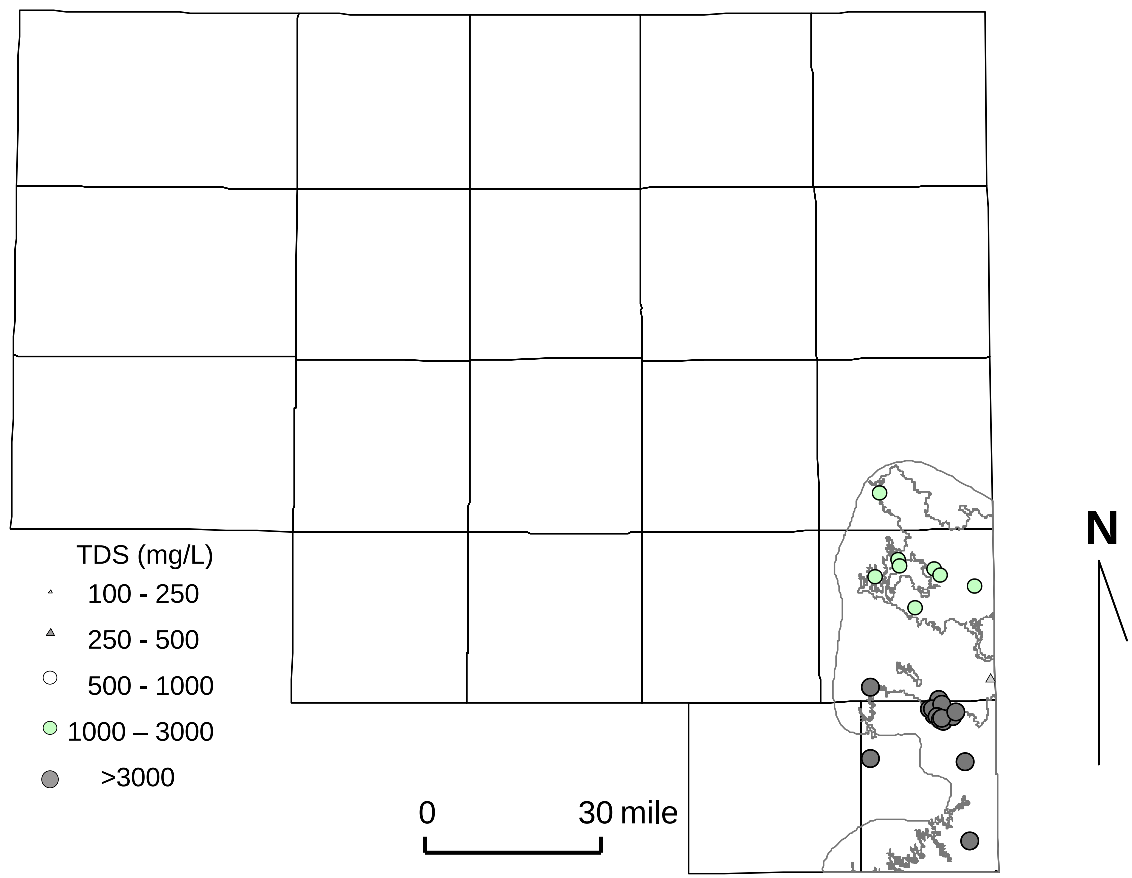


Figure 13. Map of spatial distribution of total dissolved solids (TDS) in the Blaine aquifer. Data from 1990-to-2004 period.

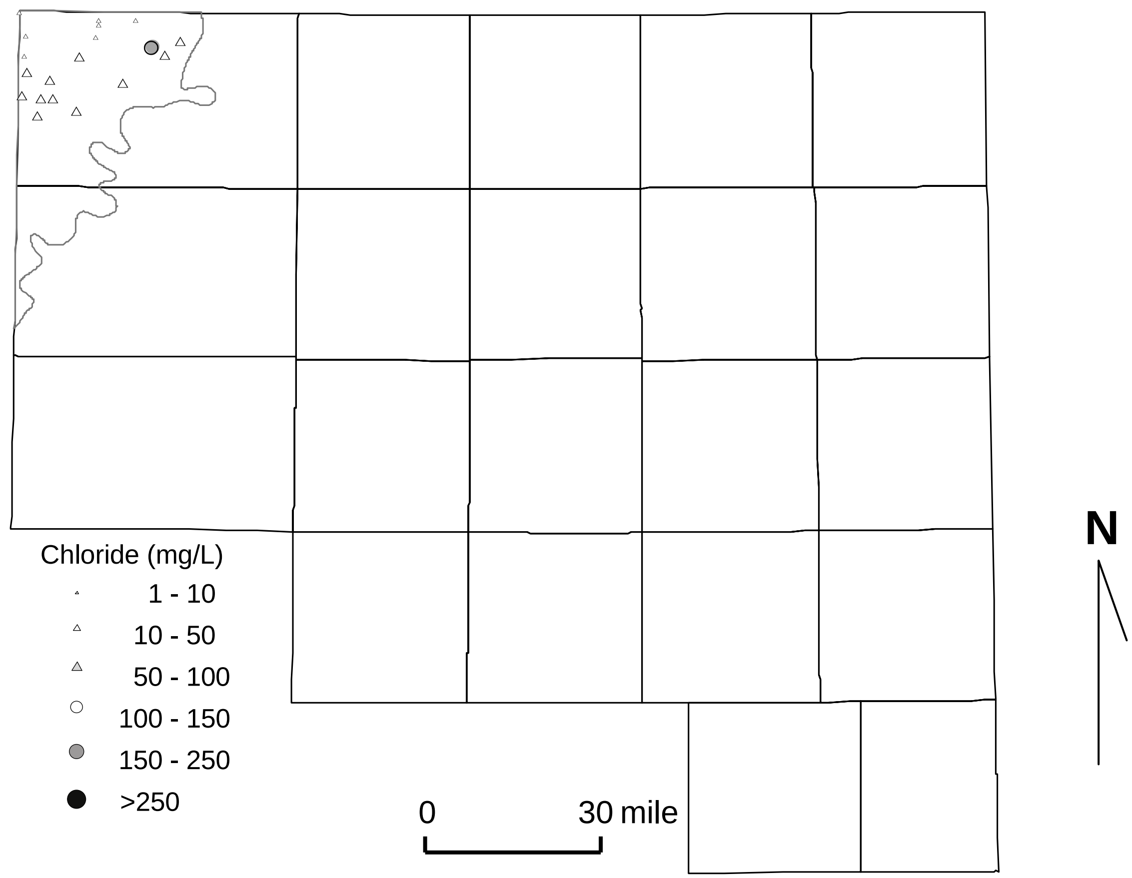


Figure 14. Map of spatial distribution of dissolved chloride in the Rita Blanca aquifer. Data from 1990-to-2004 period. Area of concern defined whether either (a) individual reported analyses with Cl>250 mg/L or (b) clusters or groups where Cl>50 mg/L.

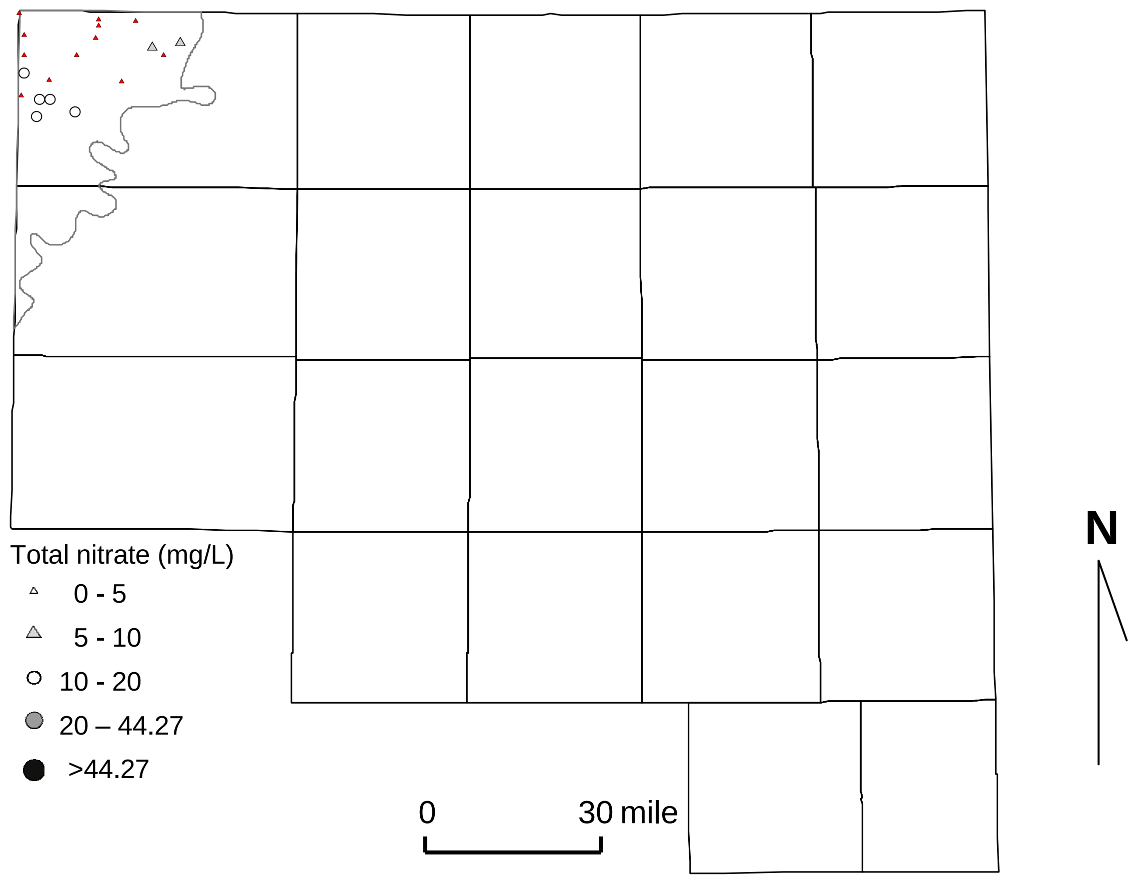


Figure 15. Map of spatial distribution of dissolved nitrate in the Rita Blanca aquifer. Data from 1990-to-2004 period. Area of concern defined whether either (a) individual reported analyses with nitrate >~45 mg/L or (b) clusters or groups where nitrate >20 mg/L.

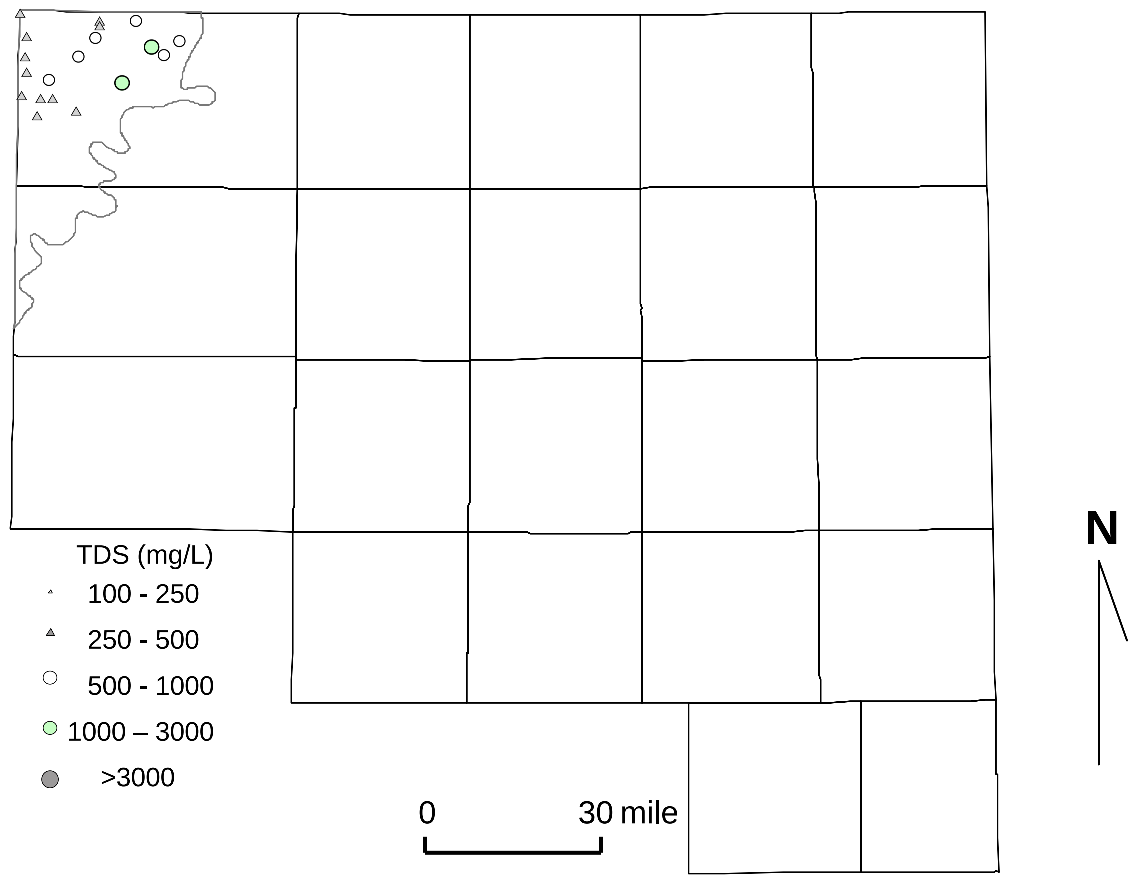


Figure 16. Map of spatial distribution of total dissolved solids (TDS) in the Rita Blanca aquifer. Data from 1990-to-2004 period.

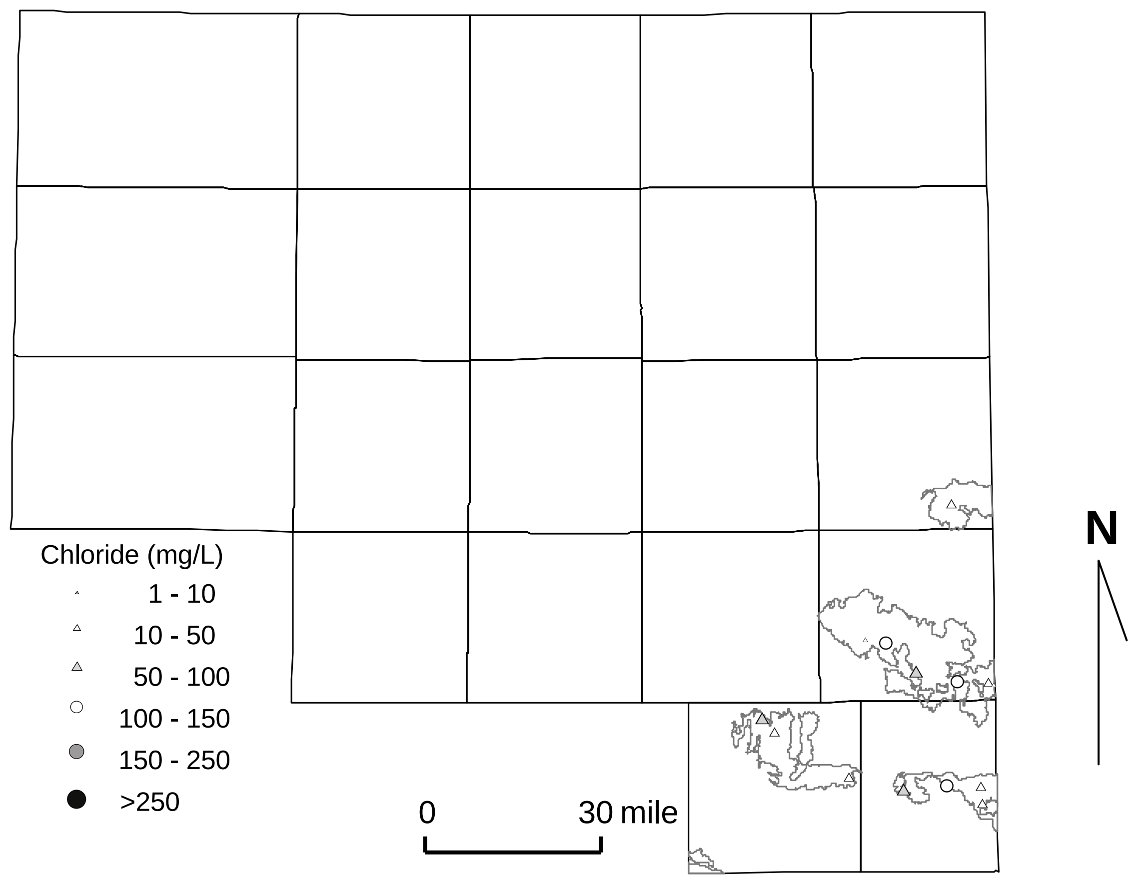


Figure 17. Map of spatial distribution of dissolved chloride in the Seymour aquifer. Data from 1990-to-2004 period. Area of concern defined whether either (a) individual reported analyses with Cl>250 mg/L or (b) clusters or groups where Cl>50 mg/L.

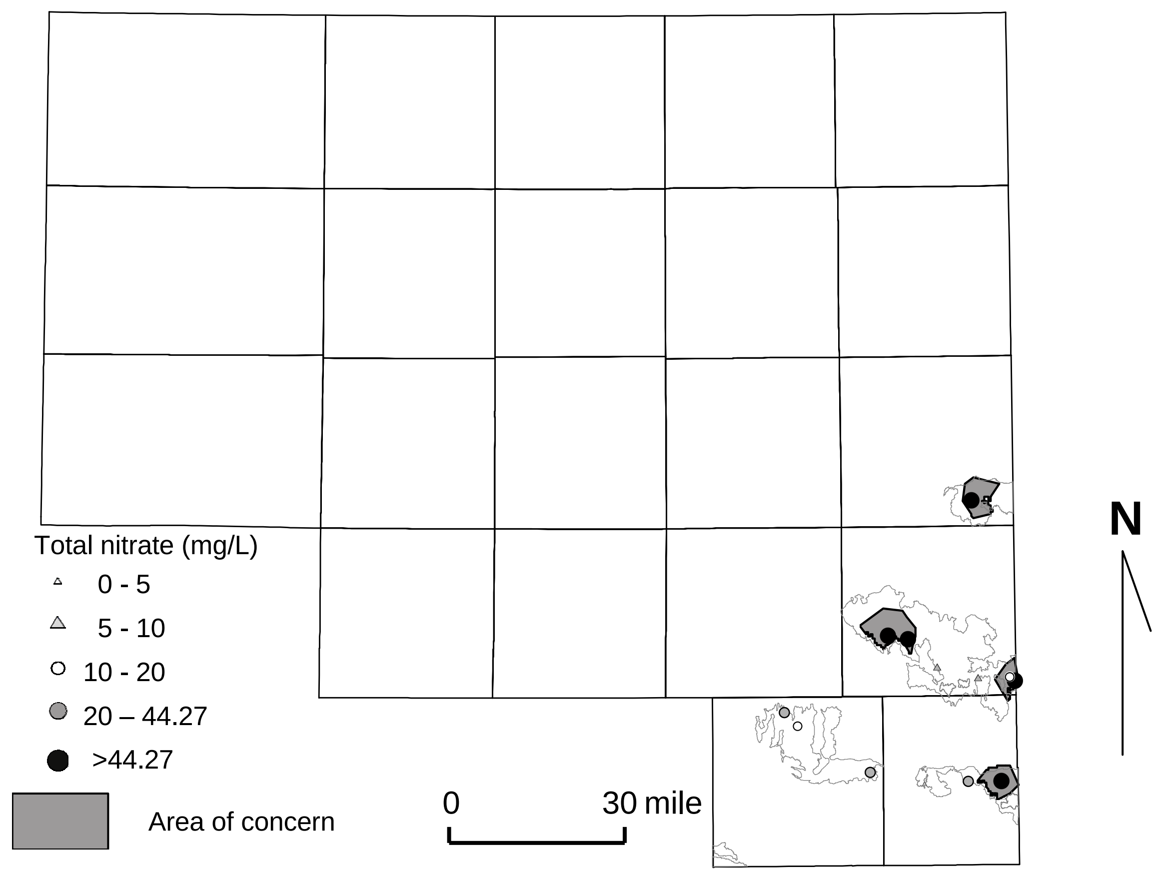


Figure 18. Map of spatial distribution of dissolved nitrate in the Seymour aquifer. Data from 1990-to-2004 period. Area of concern defined whether either (a) individual reported analyses with nitrate >~45 mg/L or (b) clusters or groups where nitrate >20 mg/L.

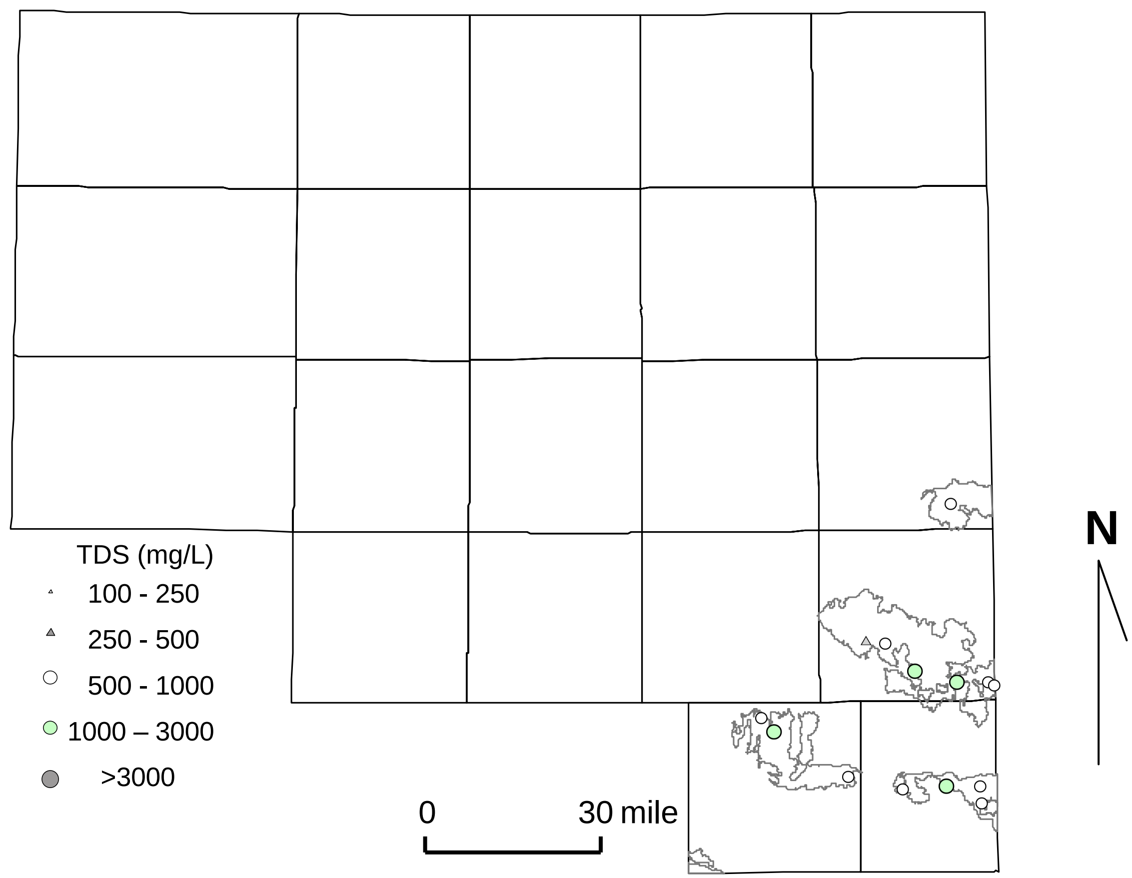


Figure 19. Map of spatial distribution of total dissolved solids (TDS) in the Seymour aquifer. Data from 1990-to-2004 period.

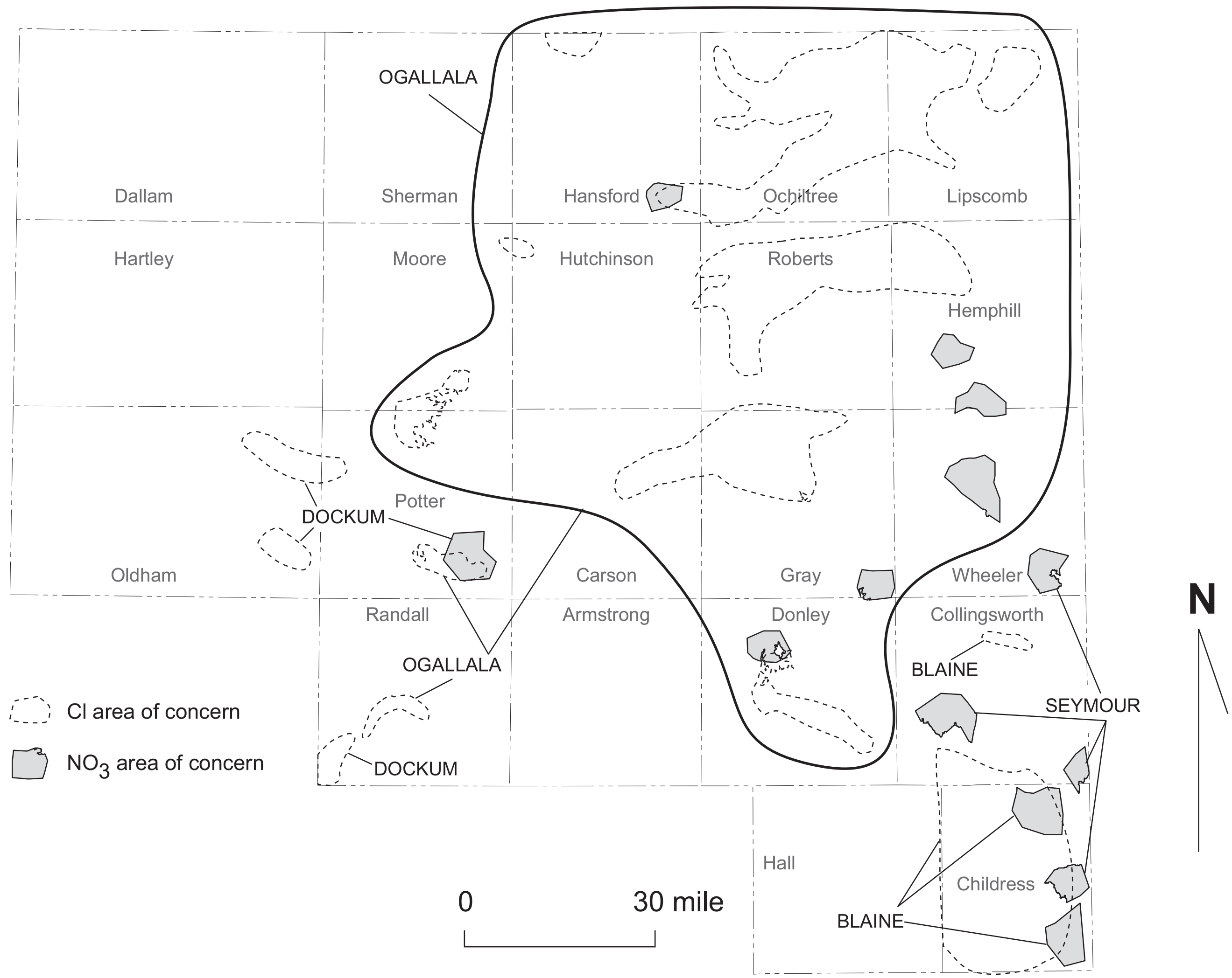


Figure 20. Composite of areas of concern identified on the basis of dissolved chloride (Cl) and nitrate (NO3) in the Ogallala, Dockum, Blaine, Rita Blanca, and Seynour aquifers. Area of concern for Cl defined whether either (a) individual reported analyses with Cl>250 mg/L or (b) clusters or groups where Cl>50 mg/L. Area of concern for NO3 defined whether either (a) individual reported analyses with NO3 >44.27 mg/L or (b) clusters or groups where NO3 >20 mg/L.

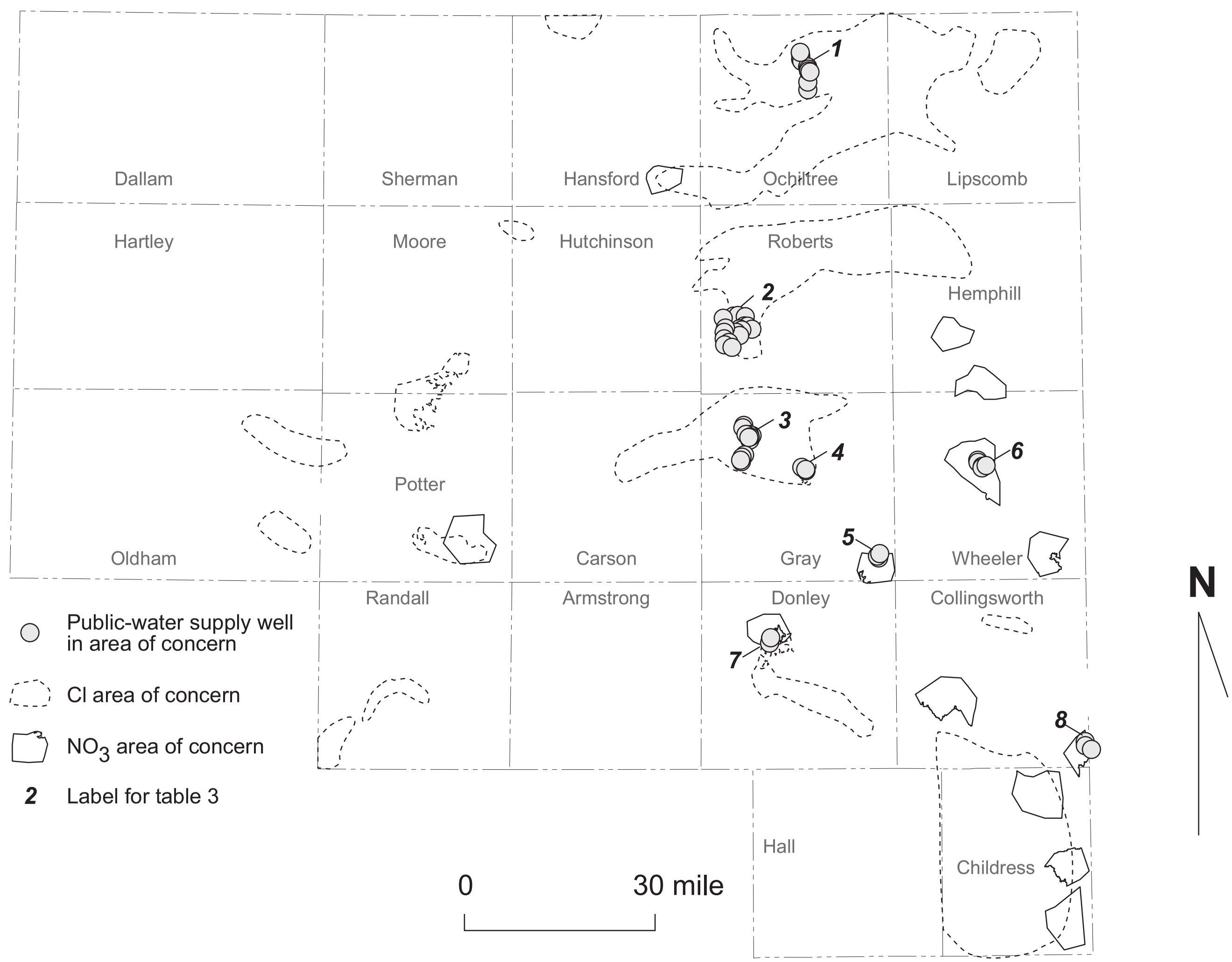
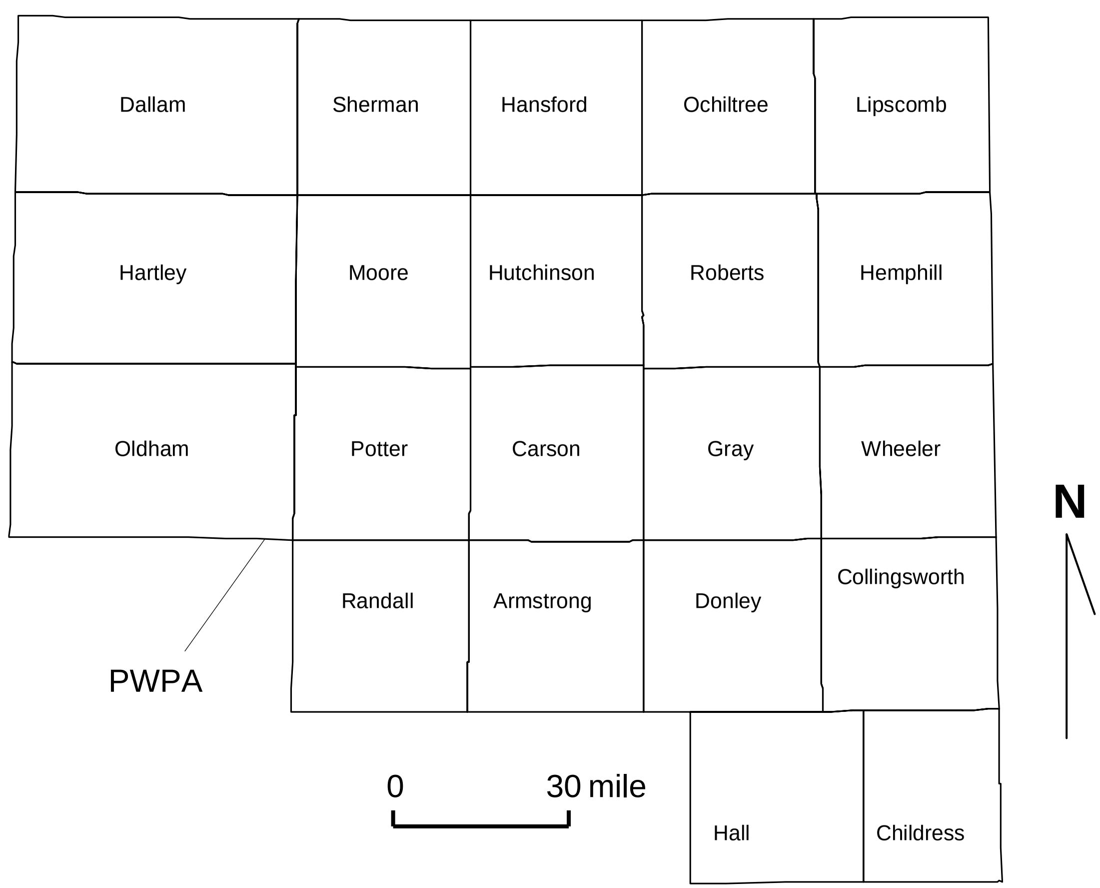


Figure 21. Location of public-water supply wells located in areas of concern identified on the basis of chloride (Cl) and nitrate (NO_3). Map labels identified in Table 3.



Appendix A. Map identifying names of counties in the Panhandle Water Planning Area.

Appendix B. Table of groundwater contamination cases in the Panhandle Water Planning Area. Compiled from Tables 1 and 2 of Texas Commission on Environmental Quality (2004).

County	Agency	Division	File name	File number	Location	Contamination description	Enforcement status	Activity status
Carson	TCEQ	RMD/CA	USDOE Pantex Plant	30459	Amarillo 79120	Benzene, TCE, High explosives, Chromium	5A, 3D, 2B, 2D, 1B	2,3,4
Carson	TCEQ	RMD/CA	USDOE Pantex Plant	30459	Amarillo 79120	Organic solvents, Metals, Explosives	3A	2, 3, 4
Carson	TCEQ	RMD/CA	Former Pantex Ordinance Plant	T1615	Amarillo	SVOC, Metals	1A, 5B	1, 2
Carson	TCEQ	RMD/CA	Pantex Plant (USDOE)	Filed by site name	Hwy 60	Trichloroethylene, 1-2 Dichloroethane, Chromium	5A, 3D, 2B, 2D, 1B	3
Carson	TCEQ	RMD/PST	Panhandle Butane & Oil Co Inc	96161	Panhandle	Gasoline	2	2A
Carson	RRC	Oil&Gas	Walt Poling vs Unknown (Frank Sheehan)	10-1378, 10	Fritch	Drip gas or condensate	1C	5
Childress	TCEQ	RMD/CA	TXDOT (Childress Maintenance Facility)	F0482	Childress	Chloroform	0A	2
Childress	TCEQ	RMD/PST	Garrison Inc	108723	Childress	Gasoline	2	4
Childress	TCEQ	RMD/PST	TXDOT	95703	Childress	Gasoline	2	2A
Childress	TCEQ	RMD/PST	Jimmy Bridges	113452	Childress	Gasoline, Diesel	2	4
Childress	TCEQ	RMD/PST	Joe Tarrant Oil Co	97222	Childress	Gasoline, Diesel	5B	4
Childress	TCEQ	RMD/PST	Veta Marlene Havins	113721	Childress	Gasoline, Diesel	2	4
Childress	TCEQ	RMD/PST	Anadarko Development Co	110920	Childress	Unknown	2	4
Childress	TCEQ	RMD/PST	Geo Bitexplorationj Inc	111752	Childress	Unknown	2	4
Childress	TCEQ	RMD/PST	RDJ Investments	111306	Childress	Unknown	2	2A
Childress	TCEQ	RMD/VC	Burlington Northern Railroad	417	Childress	Chlorinated solvents	blank	5
Dallam	TCEQ	RMD/PST	DB & E	107386	Dalhart	Gasoline, Diesel	2	2A
Dallam	TCEQ	RMD/PST	Dalhart Consumers	112159	Dalhart	Unknown	2	2A

Appendix B (continued). Table of groundwater contamination cases in the Panhandle Water Planning Area.

County	Agency	Division	File name	File number	Location	Contamination description	Enforcement status	Activity status
			Fuel Assoc					
Dallam	TCEQ	RMD/PST	Sam & Gerrie Putts Estate	115152	Dalhart	Unknown	1B	1A
Dallam	TCEQ	RMD/PST	State LeadPerforming	111835	Dalhart	Unknown	5B	2A
Gray	TCEQ	RMD/CA	Celenese Ltd	30072	Pampa	Benzene, Acetone, MTBE	2C	4
Gray	TCEQ	RMD/PST	Brock Crockett	97200	Alanree	Gasoline	5B	2A
Gray	TCEQ	RMD/PST	FFP Operating Partners	111657	Lefors	Gasoline	2	4
Gray	TCEQ	RMD/PST	Gray County	102652	Lefors	Gasoline	2	2A
Gray	RRC	Oil&Gas	Equilon Pipeline Co. (Lefors Station)	10-5240	Lefors	BTEX	0	5
Gray	RRC	Oil&Gas	Ruby Gage Complaint	10-1434	Pampa	Chloride	1C	1
Hall	TCEQ	RMD/PST	OR Saye Enterprises	94567	Memphis	Gasoline	5B	4
Hall	TCEQ	RMD/PST	TXDOT	106930	Memphis	Gasoline	2	2A
Hall	TCEQ	RMD/PST	Allsups Petroleum Inc	111588	Turkey	Unknown	2	6
Hall	TCEQ	RMD/PST	BCK Mcqueen Inc	115228	Memphis	Unknown	5B	1A
Hemphill	TCEQ	RMD/PST	Ward Oil Co	104495	Canadian	blank	5B	6
Hemphill	TCEQ	RMD/PST	Allsups Petroleum Inc	103262	Canadian	Gasoline	2	6
Hemphill	TCEQ	RMD/PST	Bob Ward	109701	Canadian	Gasoline	2	2A
Hemphill	TCEQ	RMD/PST	Brainard Cattle Co	103402	Canadian	Gasoline	2	2A
Hemphill	TCEQ	RMD/PST	Canadian Fuel Supply Inc	95834	Canadian	Gasoline	5B	2A
Hemphill	TCEQ	RMD/PST	Small Business Administration	96276	Canadian	Gasoline	2	4
Hemphill	TCEQ	RMD/PST	Nations Bank	111131	Canadian	Gasoline, Kerosene	2	6
Hutchinson	TCEQ	RMD/CA	Agrium US Inc	30770	Borger	Arsenic	3B	5
Hutchinson	TCEQ	RMD/CA	Chevron Phillips Chemical Company LP (Philtex-Ryton Plant)	30131	Borger	Hydrocarbons, Sulfolane, 1,4-Dichlorobenzene	1	2A
Hutchinson	TCEQ	RMD/CA	Phillips 66 Co	30111	Borger	Organics, Inorganics	3A	4, 5
Hutchinson	TCEQ	RMD/CA	Phillips Rubber Chemical Complex	30043	Borger	Organics, Metals	3A	2A

Appendix B (continued). Table of groundwater contamination cases in the Panhandle Water Planning Area.

County	Agency	Division	File name	File number	Location	Contamination description	Enforcement status	Activity status
Hutchinson	TCEQ	RMD/CA	Dowell Schlumberger Inc	33597	Borger	TPH, VOCs	3B	2A
Hutchinson	TCEQ	RMD/PST	Allsups Petroleum Inc	112323	Fritch	Gasoline	2	2A
Hutchinson	TCEQ	RMD/PST	Charles Edwards	105472	Borger	Gasoline	2	2A
Hutchinson	TCEQ	RMD/PST	Claude P Robinson	107946	Borger	Gasoline	2	2A
Hutchinson	TCEQ	RMD/PST	Lewis Sargent	101933	Stinnett	Gasoline	5B	6
Hutchinson	TCEQ	RMD/PST	National Park Service	113384	Sanford Marina	Gasoline	2	2A
Hutchinson	TCEQ	RMD/PST	Ray Wright	97451	Borger	Gasoline	5B	6
Hutchinson	TCEQ	RMD/PST	Southwest Coca Cola	98649	Borger	Gasoline	2	4
Hutchinson	TCEQ	RMD/PST	Phillips 66 Co	109760	Borger	Kerosene	2D	2A
Hutchinson	TCEQ	RMD/PST	Dowell Schlumberger Inc	107128	Borger	Waste oil	1B	1A
Hutchinson	RRC	Oil&Gas	Ranger Gathering Corp (Sanford Yard)	R-5 No. 10	Sanford	Benzene & free phase HC	0	4
Hutchinson	RRC	Oil&Gas	El Paso Corp	OPC 1891	Sanford	Free phase HC & BTEX	0	1
Hutchinson	RRC	Oil&Gas	Phillips Petroleum Co (Patton Creek)	OPC 1430	Borger	Hydrocarbons & SW	0	4
Moore	TCEQ	RMD/CA	Diamond Shamrock Refining Co (McKee)	30871	Sunray	Benzene, LNAPL	3B	3
Moore	TCEQ	RMD/PST	First State Bank of Dumas	96903	Cactus	Gasoline, Diesel	2	2A
Moore	TCEQ	RMD/PST	Jack Oldham Oil Co	113555	Dumas	Gasoline, Diesel	2	2A
Moore	TCEQ	RMD/SSDAT	Cactus Ordnance Works	Filed by site name	12 mi N of Dumas	Bis(2-Ethylhexy)Phthlate	blank	blank
Moore	TCEQ	RMD/VC	Cactus Plant	411	Cactus	Nitrates, Metals	blank	0
Moore	RRC	Oil&Gas	Colorado Interstate Gas (Bivins Sta)	10-0041	Masterson	VOCs	0	5
Ochiltree	TCEQ	RMD/SC	City of Perryton Well 2	Filed by site name	Perryton	Carbon tetrachloride, Nitrates	5A, 3D, 2B, 2D, 1A	5E
Potter	TCEQ	RMD/CA	Elements IS LTP Inc	61027	Amarillo	Chromium	1B	5
Potter	TCEQ	RMD/CA	Texaco Refining & Marketing Inc		Amarillo	Hydrocarbons	3A	2A
Potter	TCEQ	RMD/CA	Diamond Shamrock Refining Co	81663	Amarillo	TPH, Benzene	1A	2B
Potter	TCEQ	RMD/PST	Petro Shopping	115353	Amarillo	Diesel	2	2A

Appendix B (continued). Table of groundwater contamination cases in the Panhandle Water Planning Area.

County	Agency	Division	File name	File number	Location	Contamination description	Enforcement status	Activity status
			Centers					
Potter	TCEQ	RMD/PST	A to Z Tire	115465	Amarillo	Gasoline	1B	1A
Potter	TCEQ	RMD/PST	ATEX Gas Bankruptcy & 101824	98617	Amarillo	Gasoline	5B	6
Potter	TCEQ	RMD/PST	Burlington Northern Railroad	110485	Amarillo	Gasoline	2	2A
Potter	TCEQ	RMD/PST	Chevron Products Co	102786	Amarillo	Gasoline	2	6
Potter	TCEQ	RMD/PST	City of Amarillo	93607	Amarillo	Gasoline	2	2A
Potter	TCEQ	RMD/PST	Diamond Shamrock Ref & Mktg Co	93721	Amarillo	Gasoline	2	2A
Potter	TCEQ	RMD/PST	EZ Mart Stores	102977	Amarillo	Gasoline	2	2A
Potter	TCEQ	RMD/PST	EZ Mart Stores	109387	Amarillo	Gasoline	2	2A
Potter	TCEQ	RMD/PST	Glenda Scott	95341	Amarillo	Gasoline	2	4
Potter	TCEQ	RMD/PST	Great Western Dist	96928	Amarillo	Gasoline	2	2A
Potter	TCEQ	RMD/PST	J Lee Milligan Inc	108424	Amarillo	Gasoline	2	6
Potter	TCEQ	RMD/PST	Kerr McGee Refining Corp	94099	Amarillo	Gasoline	2	2A
Potter	TCEQ	RMD/PST	Macks Super Market	95344	Amarillo	Gasoline	2	2A
Potter	TCEQ	RMD/PST	Palo Duro Estate	95016	Amarillo	Gasoline	2	2A
Potter	TCEQ	RMD/PST	Scott & Co Realtor	108622	Amarillo	Gasoline	2	6
Potter	TCEQ	RMD/PST	Texaco Refining & Marketing Inc	93600	Amarillo	Gasoline	2	4
Potter	TCEQ	RMD/PST	Toot N Totum Food Stores	100194	Amarillo	Gasoline	2	2A
Potter	TCEQ	RMD/PST	Toot N Totum Food Stores	101928	Amarillo	Gasoline	2	2A
Potter	TCEQ	RMD/PST	Toot N Totum Food Stores	113008	Amarillo	Gasoline	2	2A
Potter	TCEQ	RMD/PST	Toot N Totum Food Stores	115056	Amarillo	Gasoline	2	2A
Potter	TCEQ	RMD/PST	Toot N Totum Food Stores	95734	Amarillo	Gasoline	2	2A
Potter	TCEQ	RMD/PST	Toot N Totum Food Stores	98301	Amarillo	Gasoline	2	4
Potter	TCEQ	RMD/PST	W A Innes	102202	Amarillo	Gasoline	2	4
Potter	TCEQ	RMD/PST	Northern OBrien	101931	Amarillo	Gasoline, Diesel	2	2A

Appendix B (continued). Table of groundwater contamination cases in the Panhandle Water Planning Area.

County	Agency	Division	File name	File number	Location	Contamination description	Enforcement status	Activity status
Potter	TCEQ	RMD/PST	Pro Am III Truck Stop	112575	Amarillo	Gasoline, Diesel	2	4
Potter	TCEQ	WQD/WQAS	Southwestern Public Service Co	WQ01990	NE of Amarillo	Nitrate, Chloride, Sulfate	2C, 3C	4, 5
Potter	RRC	Oil&Gas	Williams Energy Service Inc	OPC 1776	Pioneer Tank Battery #2	Free phase HC	0	4
Randall	TCEQ	RMD/CA	Valero Logistics	T1572	Palo Duro	Gasoline	1B	1, 2, 5
Randall	TCEQ	RMD/PST	High Plains UWCD No. 1 Sampling Program	1109806	Well 11-09-806 (sample 381-2-4)	Atrazine	1D, 1B	1B
Randall	TCEQ	RMD/PST	Air Speed Oil Co	102201	Lake Tanglewood	Gasoline	2	2A
Randall	TCEQ	RMD/PST	City of Canyon	103056	Canyon	Gasoline	2	4
Randall	TCEQ	RMD/PST	Consumers Fuel Association	106775	Canyon	Gasoline	2	4
Randall	TCEQ	RMD/PST	Donut Stop Inc	101388	Canyon	Gasoline	5B	2A
Randall	TCEQ	RMD/PST	Estate of Annie Weaver	95334	Canyon	Gasoline	5B	2A
Randall	TCEQ	RMD/PST	Exxon Mobil	93874	Canyon	Gasoline	2	2A
Randall	TCEQ	RMD/PST	Kjack Sisemor E Traveland	112841	Amarillo	Gasoline	2	2A
Randall	TCEQ	RMD/PST	Lagrone H Odell	95015	Canyon	Gasoline	5B	2A
Randall	TCEQ	RMD/PST	Weingarten Realty	93548	Amarillo	Gasoline	2	2A
Randall	TCEQ	RMD/PST	Sterling Gibson	113997	Amarillo	Gasoline, Diesel	2	2A
Randall	TCEQ	RMD/PST	BFI/Southwest	MSW01663B	N of Canyon	MW-12: VOCs (Methlyene chloride)	2B	4, 5
Randall	TCEQ	RMD/PST	SJKR Inc	115550	Canyon	Unknown	5B	2A
Randall	TCEQ	RMD/PST	Sun Country Inc	115551	Canyon	Unknown	1B	1A
Randall	TCEQ	RMD/PST	Western Marketing	115549	Canyon	Unknown	2	2A
Roberts	TCEQ	RMD/PST	Bailey Oil Products Co	96902	Miami	Gasoline	5B	2A
Roberts	TCEQ	RMD/PST	Environmental Impact	96931	Miami	Gasoline	5B	2A
Roberts	TCEQ	RMD/PST	FFP Operating Partners	106989	Miami	Gasoline	2	4
Sherman	TCEQ	RMD/PST	Olive Boston Estate	103192	Stratford	Gasoline	2	6
Wheeler	TCEQ	RMD/PST	C&H Supply Inc	96883	Shamrock	Gasoline	2	2A

Appendix B (continued). Table of groundwater contamination cases in the Panhandle Water Planning Area.

County	Agency	Division	File name	File number	Location	Contamination description	Enforcement status	Activity status
Wheeler	TCEQ	RMD/PST	Kelton ISD	113722	Wheeler	Gasoline	2	2A
Wheeler	TCEQ	RMD/PST	Royce Cantrell Corp	97320	Shamrock	Gasoline	2	2A
Wheeler	TCEQ	RMD/PST	TXDOT	97739	Wheeler	Gasoline	2	2A

TCEQ Agency Division

RMD/CA	TCEQ Remediation Division Corrective Action Section
RMD/PST	TCEQ Remediation Division Petroleum Storage Tank Section
RMD/SC	TCEQ Remediation Division Superfund Cleanup Section
RMD/SSDAT	TCEQ Remediation Division Superfund Site Discovery and Assessment Team
RMD/VC	TCEQ Remediation Division Voluntary Cleanup
WQD/WQAS	Water Quality Division Water Quality Assessment Section

Enforcement status

0	Voluntary action
0A	Voluntary compliance and notification
1	Staff discovery
2	Staff action
1A	Staff discovery/Inspection
1B	Staff discovery/Data review
1C	Staff discovery/Complaint
1D	Staff discovery/Referral
2B	Staff action/Plan approval
2C	Staff action/Notice of contamination
2D	Staff action/Referred
3A	Executive action/Permit
3B	Executive action/Order
3C	Executive action
3D	Executive action/Federal referral
5A	Federal Funds
5B	State Funds

Activity Status

0	No activity
1	Contamination confirmed
2	Investigation
3	Corrective action planning
4	Implementing action
5	Monitoring action
6	Action completed
1A	Contamination confirmed/Action
1B	Contamination confirmed/No action
2A	Investigation/No action
2B	Investigation/Action
5E	Monitoring action/Engineering