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Executive Summary

- Large capacity septic systems are defined as having a discharge volume greater than 2,000 gallons per day and function by removing solids in the septic tank and discharging clarified effluent to the leachfield.
- The effluent contains significant concentrations of nitrogen that readily oxidizes to nitrate in the soil and tends to persist in ground water, causing a health threat to drinking water resources. Additionally, shallow ground water settings may contain reducing environments in which nitrogen is found as total kjehdahl nitrogen (TKN) and where the reduction of manganese, iron and sulfur can result in decreased water quality.
- In New Mexico, large capacity septic systems are regulated as Class V underground injection control wells through ground water discharge permits issued by the Ground Water Quality Bureau (GWQB) of the New Mexico Environment Department. The discharge permits generally require monitoring of ground water, effluent or both.
- Currently there are 115 active, inactive and pending discharge permits for large capacity septic systems in the state of New Mexico. The largest percentage of discharge permits fall into the Multiple Dwelling category (31%) followed by Institution (22%) and School (19%).
- Previous studies have found that the strength of the effluent, the discharge volume, and the depth to ground water influence the potential for ground water contamination from large capacity septic systems.
- This study used the data available from monitoring reports submitted to the GWQB and facility information from the discharge permits to analyze the impacts of large capacity septic systems on ground water in New Mexico. Ground water monitoring data and site and facility factors were evaluated to identify and predict the occurrence of ground water contamination.
- The process of compiling the data revealed a large number of facilities that were required to submit monitoring reports but failed to do so which, along with obstacles presented by inconsistencies in the monitoring requirements, reduced the quantity of usable data available for this study.
- The average total nitrogen concentration of the effluent monitoring reports submitted was 76 mg/l, which is a higher strength waste as compared to national figures. This finding coupled with higher average TDS and Cl concentrations in the effluent suggest that New Mexico may have a more concentrated waste stream.
- Campground/RV Parks, Institutions and Schools were found to have higher average concentrations of total nitrogen in effluent than Commercial or Multiple Dwelling facilities. However small sample sizes and great variability prohibited identifying a specific average or range of waste strength for a particular facility type.
- Close to half (48%) of all the facilities examined, for which there was usable ground water data, had concentrations of nitrate that were equal to or exceeded the WQCC regulation standard of 10 mg/l in ground water. In addition, 63% had concentrations of total nitrogen in ground water that exceeded 10 mg/l.
- Waste strength, as measured by the concentration of total nitrogen, was found to potentially impact the concentration of total nitrogen measured in ground water but not to correspond to the concentration of nitrate in the ground water. Sites with shallow ground water (<=10ft) reported elevated levels of TKN in ground water rather than nitrate.

- Discharge volume appears to potentially impact the concentration of nitrate in ground water. A regression analysis of the 33 facilities for which there are usable ground water data indicated a trend towards a statistically significant direct relationship between discharge volume and the maximum nitrate concentration in ground water ($p < .1$).
- No trend was found between the depth to water and the maximum nitrate concentration in ground water ($p > .1$). High concentrations of TKN at shallow depths to ground water coupled with the effects of other factors appear to confound this relationship.
- Although no statistical differences were found between the average nitrate concentrations in ground water at different facility types, Schools and Campground/ RV Park facility types were found to have high percentages of sites with nitrate concentrations in ground water that exceed the standard (70% and 67% respectively).
- Almost half (49%) of currently permitted facilities which are required to submit monitoring reports were found to be out of compliance with respect to the monitoring requirements of their permits. This high number impairs the GWQB's assessment of whether or not these permits and septic systems are protective of ground water quality.
- The case studies illustrate that the installation of advanced treatment options such as a lagoon or package plant system can reduce the negative impact of large capacity septic systems on ground water. However, nitrate contamination can persist in ground water after the source of the contamination has been removed or reduced which in some situations may warrant more active ground water remediation activities.
- The results of this study reveal that all three of the characteristics examined in this study, depth to ground water, discharge volume and waste strength, were found to influence the impact of large capacity septic systems on ground water quality. Due to the fact that no one factor was shown to stand alone as a cause for nitrate contamination of ground water, the best prevention tool available appears to be regular monitoring of ground water quality.
- Recommendations based on the patterns suggested by the data include:
    - New permits for facilities with a discharge volume of greater than 10,000 gallons per day, or for facilities located where ground water is at depths less than 10 ft, or has elevated concentrations of total nitrogen in the effluent, should include a requirement to install an advanced treatment system.
    - At facilities where ground water monitoring results suggest a possible reducing environment, monitoring requirements should be expanded to include sampling for manganese, iron and sulfur.
    - Compliance, enforcement, and the standardization of the monitoring requirements of the discharge permits should be a priority for the GWQB. Compliance efforts should include the distribution of educational materials on permit requirements.

Introduction

In September 2000 the United States Environmental Protection Agency Region 6 awarded the Ground Water Quality Bureau of the New Mexico Environment Department funding to utilize existing data to assess the impacts of large capacity septic systems on ground water quality. This grant was awarded as part of an ongoing nationwide evaluation of Class V underground injection control wells with the intent of improving regulatory guidelines in order to ensure protection of ground water resources.

Objectives

The objectives of this study are to:

1. Describe and characterize the facilities currently permitted by the New Mexico Environment Department, Ground Water Quality Bureau for large capacity septic systems.
2. Determine how many sites in New Mexico have ground water contamination caused by large capacity septic systems. Large capacity septic systems are defined as those serving a discharge volume of greater than 2,000 gallons per day (gpd).
3. Evaluate several of the site and system factors that influence whether ground water is at risk from contamination by large capacity septic systems.
4. Make recommendations for regulatory measures to reduce the impacts of large capacity septic systems on ground water quality.

Overview of Large Capacity Septic Systems

Numerous studies, including a recent study conducted by the United States Environmental Protection Agency (USEPA), have identified septic systems as potential sources of contamination to ground water in the US (USEPA, 1999). Ground water contamination poses a major health concern in New Mexico because 90% of residents rely on ground water as their primary source for drinking water. Specifically, the EPA has recognized nitrate as "one of the most problematic contaminants in septic system effluent" (USEPA, 1999) due to its potential health effects, mobility, and tendency to persist in ground water. The EPA considers nitrate in ground water a threat to human health due to studies linking high nitrate concentrations in drinking water with methemoglobinemia, or blue baby syndrome, a potentially fatal condition for infants and fetuses. In addition, a recent study conducted in Iowa has implicated exposure to even relatively low levels of nitrate in drinking water [2.46 milligrams per liter (mg/l)] with other health concerns such as the increased incidence of ovarian, uterine, rectal and bladder cancer in women (Weyer et al. 2001). Because of the increased risk of blue baby syndrome associated with the ingestion of nitrate contaminated water, EPA has set a maximum contaminant level of 10 mg/l of nitrate for public drinking water supplies regulated by the United Stated Safe Drinking Water Act (42 USC Section 300f et seq.). Similarly, the New Mexico Water Quality Control Commission Regulations set a standard of 10 mg/l of nitrate for all ground water in New Mexico that has a total dissolved solids concentration of less than 10,000 mg/l (Section 20.6.2.3103 NMAC).

The septic system is currently one of the least expensive and widely used methods of treatment and disposal of domestic waste in non-sewered areas. Septic systems function by removing solids in the septic tank and then discharging clarified effluent to a subsurface leachfield. This effluent contains significant concentrations of nitrogen compounds that could potentially contaminate ground water and may also alter the subsurface in such a manner as to release naturally occurring contaminants into ground water. The nitrogen in effluent occurs mainly in the form of organic nitrogen and ammonia nitrogen (which are usually measured together as Total Kjeldahl Nitrogen (TKN)). Septic system effluent may also contain varying concentrations of nitrogen in the form of nitrate. The sum of the concentrations of the different nitrogen components, TKN and nitrate, is referred to as total nitrogen (total N) and is most commonly used to describe the amount of nitrogen in the effluent. The nitrogen in the effluent discharged from the leachfield readily oxidizes to nitrate in the soil and infiltrates to the ground water. While site conditions and underlying geology differ in their ability to attenuate the concentrations of nitrate, most studies show that very little denitrification (conversion of nitrate to nitrogen gas) occurs below the leachfield and that the majority of septic systems rely on dilution rather than nitrate degradation to prevent contamination of ground water. (USEPA, 1999)

In addition, in some shallow ground water settings the subsurface can be naturally reducing or become reducing due to the discharge of large volumes of septic tank effluent, which is an oxygen-demanding waste. Under these conditions, the depletion of oxygen results in the progressive reduction and release of manganese, iron, sulfur and carbon in ground water. Both the USEPA and the NM Water Quality Control Commission have set standards for manganese and iron in ground water. High concentrations of manganese can cause damage to the brain, liver, kidneys, and the developing fetus (ATSDR

2001). Increased concentrations of iron and sulfur can lead to unpleasant odors and discoloration making ground water unsuitable for human consumption.

Regulatory Framework for Large Capacity Septic Systems

Both federal and state regulations distinguish between large capacity septic systems and smaller systems (typically serving an individual residence or small group of residences). In New Mexico large capacity septic systems are defined as facilities with a design flow of greater than 2,000 gallons per day (gpd). These systems are designated as Class V underground injection control (UIC) wells for which the New Mexico Environment Department has been delegated primacy enforcement authority under the Water Quality Control Commission (WQCC) Regulations. The EPA's recent analysis of Class V wells found that "large capacity septic systems, as a result of their high effluent flow rates, pose a greater threat to ground water by nitrate contamination when compared to small individual systems" (USEPA, 1999).

In New Mexico, all Class V wells that receive regulated water contaminants are required to have ground water discharge permits obtained from the Ground Water Quality Bureau (GWQB) of the New Mexico Environment Department. Through its UIC permitting program, the GWQB has issued ground water discharge permits for large capacity septic systems since 1977 and has required effluent and ground water monitoring for the majority of these systems since 1993. The septic system is one of the many types of treatment and disposal methods approved for the disposal of domestic liquid waste in New Mexico. Domestic liquid waste is defined by the New Mexico WQCC Regulations as "human excreta and water-carried waste from typical residential plumbing fixtures and activities, including but not limited to waste from toilets, sinks, bath fixtures, clothes or dishwashing machines and floor drains" (20.6.2.7 NMAC). Other treatment methods include: evaporative lagoons, package wastewater treatment plants, constructed wetlands, and connection to publicly owned sewer systems and treatment plants. These treatment methods are permitted in combination with the following disposal methods: total evaporation ponds, land application to irrigated crops or landscaping, and leachfields.

The ground water discharge permits issued by the GWQB, under the authority of WQCC Regulation 20.6.2 3107, detail the type of monitoring (effluent, ground water, or both), the frequency of monitoring, the due dates for the monitoring reports and which constituents are required to be included in the chemical analyses. The most common constituents tested for are: nitrate (NO_3), total kjehdahl nitrogen (TKN), chloride (Cl) and total dissolved solids (TDS). Monitoring reports are typically required on an annual, semiannual or quarterly basis, and chemical analyses are required to be conducted using EPA approved methods.

Discharge permits that require the monitoring of ground water also specify the type of well that may be used to sample the ground water. While some facilities rely on samples taken from supply or irrigation wells, the majority of discharge permits require the discharger to install from one to three monitoring wells. The GWQB has issued specifications for monitoring well design and will inspect sites to approve the location of the wells (Appendix I). The monitoring wells are expected to sample the shallowest ground water at the site, and at least one well is required to be located down gradient from the leachfield of the septic system.

Characteristics of Currently Permitted Large Capacity Septic Systems

Currently there are 115 active, inactive and pending discharge permits for large capacity septic systems located throughout the state (Figure 1), of which 69% (79) require the discharger to monitor the quality of effluent, ground water, or both. Large capacity septic systems are employed at a variety of facilities categorized as the following types: School, Multiple Dwelling, Commercial, Campground/RV Park, and Institution. The largest percentage of discharge permits fall into the Multiple Dwelling category (31%) followed by Institution (22%) and School (19%) (Figure 2).

Large capacity septic systems are utilized at a wide range of sites for a variety of facilities. These facilities differ in both the quality of the effluent produced and in the hydrogeology of the site on which they are located. Some of these differences, such as subsurface geology and ground water flow, are more difficult to characterize. Others, such as the strength of the effluent, the discharge volume, and the depth to ground water at the site are relatively simple to measure and data for these factors are readily available to the GWQB. These factors are all believed to influence the potential for ground water contamination from large capacity septic systems.

The nature of domestic waste is commonly described by referring to its “strength” which is a measure of the concentration of potential contaminants it contains. The concentration of total nitrogen is one indicator of waste strength and is widely used as a variable in nitrogen loading equations to determine the potential for nitrogen contamination. Domestic waste includes both wastewater and wash water, which can dilute the strength of the effluent. Studies have proposed that different types of facilities are associated with varying strengths of effluent depending on the fraction of wastewater to wash water (Harman et al 1996, EPA 1999). Both schools (Harman et al 1996) and RV Parks (Janes 2000) have been identified as having the potential for a higher strength waste than other facilities due to the higher fraction of wastewater and lack of wash water. High strength (high concentrations of total nitrogen) waste is believed to increase a site's susceptibility to ground water contamination due to the introduction of more nitrogen to the subsurface, which can override the attenuation and dilution capacity of the soil and ground water (Hantzche and Finnemore 1992, Harman et al 1996).

The GWQB maintains records of the depth to ground water and design flow volume for each discharge permit issued. Discharge volume is believed to be an important factor in determining the potential for ground water contamination. Large volumes of water can overload a system and create an extensive plume of contamination in ground water. Discharge permits include a maximum allowable discharge volume based on the design capacity of the system. Although facilities often discharge smaller volumes, the allowable discharge volume included in the discharge permit is a maximum value useful for comparison under "worst case" conditions. There is an extensive range of discharge volumes (from 1,000-38,500 gpd) for currently permitted systems (Figure 3). Nearly half of these facilities (49%) have a permitted discharge volume of less than or equal to 5,000 gpd (Figure 4).

Many studies have found the depth to ground water beneath the site to be a factor in determining the susceptibility of ground water to contamination (Nolan 2001, McQuillan et al 1989). Sites with a shallow depth to water are believed to be more susceptible due to the proximity of water and the reduction of the retention time in the soils below the leachfield. In contrast, other studies have shown a direct relationship between nitrate concentrations and depth to the water table where the likelihood of nitrate contamination increased as the depth to water increased (Nolan 2001). The depth to ground water beneath currently permitted facilities in New Mexico ranges from 5 feet to 1,120 feet (Figure 5). These facilities are divided almost equally with 51% located at a depth of under 100ft to ground water and 49% located at a depth to ground water of over 100ft. Ground water beneath about a third of the facilities is between 100ft and 300ft (Figure 6).

While the currently permitted facilities are distributed fairly evenly with respect to the depth to ground water at each site, the proportion of these facilities that are required by their permits to monitor ground water is more skewed. Around 59% of currently permitted facilities with a depth to water of under 100ft are required to monitor ground water quality, while only around 21% of facilities with a depth to water of over 100ft are required to do so (Figure 7). This discrepancy in monitoring requirements for ground water is not as prominent in relation to discharge volume (Figure 8). The reason for the variation in monitoring requirements with respect to depth to water may be explained by the high cost of installing monitoring wells at depths greater than 100 feet. The result of this uneven distribution is a skewed dataset where there is significantly more data available for sites located where the water table is less than 100 feet below the surface.

New Mexico WQCC Regulations include provisions for the modification of wastewater systems at facilities where monitoring of ground water has indicated high levels of nitrate (Section 20.6.2.3109 NMAC). These modifications generally involve the installation of a new wastewater disposal system that either includes additional treatment of effluent or eliminates the discharge from a leachfield to ground water. Examination of the concentrations of nitrogen measured in the ground water before and after the installation of an improved wastewater treatment and disposal system can provide valuable information on possible methods to reduce the impacts of large capacity septic systems on ground water quality.

Previous studies have shown large capacity septic systems to be potential sources of ground water contamination (EPA 1999, Harman et al 1996, Hantzche and Finnemore 1992). This study examines the impacts of large capacity septic systems on ground water in New Mexico through analysis of ground water monitoring data and investigates potential site and facility factors that could predict incidents of ground water contamination. The results of this study are intended to assist the GWQB regulate and permit large capacity septic systems in a manner that is protective of ground water resources.

Study Area Description

Geography and Hydrology

While New Mexico's geography is varied from high mountains to plains, plateaus, and river valleys, the majority of the population density is centered in the river valleys and flood plains. New Mexico's hydrogeology and reliance on ground water for water supply can be described regionally. Eastern New Mexico relies primarily on the High Plains basin-fill aquifer (primarily Ogallala formation), while the northwestern region contains sandstone aquifers, the southeastern area relies on limestone aquifers, and the southwestern area relies on other sedimentary aquifers. The more heavily populated central and northern regions utilize ground water from valley fill aquifers along the Rio Grande, Rio Chama, and the San Juan and Pecos Rivers. Surface water from these rivers also supplies water locally, but surface water is scarce throughout the rest of the state.

Land surface elevations range from less than 3,000 ft in the southeast to over 13,000 ft in the northern mountains. The climate is arid to semiarid with the evaporation from open water surfaces exceeding precipitation in most areas.

Procedures

Data Collection

The Ground Water Quality Bureau database of all ground water discharge permits was queried to obtain information about facilities that use large capacity septic systems. This information included the depth to water, discharge volume, and monitoring requirements as reported in the discharge permit. A more detailed database was developed from this information that incorporated data from monitoring reports and the compliance status for all those facilities required to monitor ground water and/or effluent quality. The monitoring reports include the results of chemical analyses conducted on ground water and effluent samples by a variety of different laboratories located throughout the state. The frequency of monitoring requirements varies among permits and includes annual, semiannual and quarterly due dates for reports. In addition, the availability of monitoring data varies depending on the age of the facility, when monitoring requirements were instituted and compliance history of the owner. The data were compiled from the hard copies of the reports and entered by hand into the computer. All non-detect values were entered as zero in order to standardize the range of minimum detection limits used by the different laboratories.

Analysis of the current condition of large capacity septic systems in the state was conducted using only the active discharge permits. However, data from both the active and non-active discharge permits were used to study the relationship between facility characteristics and ground water contamination. The sample size for each component of the study therefore reflects these distinctions and is noted on each graph. Many facilities that are required to submit monitoring reports have not done so. These facilities are described in the compliance section.

Assumptions

In order to facilitate compiling the monitoring data the following assumptions were made.

1. The designation of the monitoring wells as up or down gradient from the leachfield was entered based on the most recent information available in the discharge permit file.
2. The data submitted were assumed to accurately depict ground water and effluent conditions.
3. The values for discharge volume and depth to water reported in the discharge permit for each facility were assumed to be correct.

Data Analysis

A preliminary examination of the database was conducted in order to identify the data that most accurately represents the quality of the ground water at each site. This involved removing the data submitted from sampling supply, irrigation, and up gradient wells. Where possible, water quality data from down gradient wells were compared to water quality data from up gradient wells in order to identify and remove sites where there was evidence of up gradient contamination of ground water. The remaining data set (n=52) of facilities that have submitted monitoring reports was used to study the relationship between facility characteristics and ground water contamination.

In this study ground water quality at different facilities was compared using two different measures of the occurrence of nitrate in ground water (n=33 facilities). In order to look at incidents of contamination, the monitoring data for nitrate were compared to the standard. The Ground water Quality Bureau defines nitrate contamination as concentrations that are equal to or exceed the New Mexico Water Quality Commission Regulation standard of 10 mg/l (Section 20.6.2.3103 NMAC). The percentage of sites with nitrate levels greater than or equal to the standard was calculated to use in comparison between facilities with different characteristics. A more detailed analysis of the ground water data at each of the sites is shown in Figure 9 using the maximum concentration of nitrate. A regression analysis was used to compare the maximum concentrations of nitrate to facility characteristics such as depth to ground water and discharge volume. The average maximum concentration of nitrate for each mean was used to compare between facility types. Statistical differences and relationships were analyzed using an Analysis of Variance (ANOVA) and regression analysis. P values of less than or equal to .05 were considered statistically significant while values of less than or equal to .10 were considered indicative of a trend toward statistical significance.

In addition to looking at ground water characteristics, this study also evaluated effluent monitoring data (i.e. samples collected from the septic tanks). The average concentration of total nitrogen of all the effluent samples submitted for each facility was utilized as a means of comparison between facilities (n=29). An ANOVA analysis and individual T-tests were used to determine statistically relevant differences. In addition, a regression analysis was used to examine the relationship between waste strength (average total N concentration) and concentrations of nitrate in ground water (maximum nitrate concentration) for those facilities that have submitted both ground water and effluent monitoring (n=10).

Two facilities, which originally had large capacity septic systems and were required to replace them with alternative systems that are more protective of ground water, were selected for more detailed case studies. These two facilities were chosen based on the following criteria:

1) they had reliable ground water monitoring data from down gradient wells before and after the installation of new systems; and 2) the septic systems had caused nitrate contamination of ground water before the installation of new systems. Differences in nitrate and total nitrogen concentrations in ground water were examined using a time series covering the time period during which monitoring reports were submitted.

The process of compiling the data revealed facilities that were required to send in regular monitoring reports but failed to do so. These facilities were considered out of compliance with respect to the monitoring requirements in their discharge permits. Out of compliance facilities were divided into two groups: those that have never submitted any monitoring reports and those that have not submitted any reports in over a year. Information about which facilities are out of compliance was included to illustrate the gaps that currently exist in the database and to provide a resource for developing regulatory tools to improve permit compliance. Only currently active facilities are included in the compliance analysis.

In addition to finding a substantial number of facilities with missing monitoring reports, other difficulties in compiling the data were encountered. Over the years inconsistencies in the monitoring requirements of the discharge permits have resulted in: varying numbers of monitoring wells at each site, improper siting of monitoring wells, uncertainties regarding the direction of ground water flow at each site, confusing and varying identification of the location of the monitoring wells, and a relatively small number of facilities which have submitted data for both effluent and ground water monitoring. These obstacles reduced the quantity of usable data available for this study.

Results

Characteristics of Septic System Effluent

The data submitted from effluent monitoring suggests that New Mexico has a high strength waste stream as compared to national figures. Based on the monitoring reports submitted by 28 currently active facilities, the average concentration of total nitrogen is 76 mg/l. This value is higher than the 60 mg/l total nitrogen concentration classified as strong wastewater by Metcalf and Eddy (1991) and cited by the EPA in their most recent study of large capacity septic systems (EPA 1999) (Figure 10). Likewise, the average Cl (144 mg/l) and TDS (1102 mg/l) for effluent in New Mexico effluent would also be classified as strong wastewater (greater than 75 mg/l and 700 mg/l respectively) according to Metcalf and Eddy (1991).

Although the high concentrations of TDS may simply be related to the quality of the water supply, the elevated concentrations of Cl and nitrogen species in effluent are most likely the result of water conservation strategies employed in response to water shortages common in New Mexico's desert environment. These strategies include installing water saving equipment such as low flow plumbing fixtures that reduce the volume of water in the effluent, resulting in a more concentrated waste. High strength effluent is of concern because it may exceed a site's capacity to attenuate the concentrations of contaminants. This relationship is illustrated in the direct relationship observed between the total nitrogen measured in effluent and that measured in ground water ($p< .1$) (Figure 11). For this reason, estimations of waste strength are an integral part of siting, permitting and evaluating the potential threat to ground water posed by large capacity septic systems. The effluent data suggest that in New Mexico a higher estimation of waste strength than the national average may be required for design calculations and permitting decisions to adequately prevent ground water contamination.

Analyses of the concentrations of chloride and total dissolved solids are also regularly required as part of effluent monitoring. The data from 11 active facilities where data on the average total nitrogen concentration and average chloride concentration are available illustrate a direct relationship ($p=. 05$) (Figure 12). This supports the practice of monitoring both effluent and ground water for Cl, because the more concentrated the effluent with respect to nitrogen the greater the potential for ground water contamination with Cl as well. In contrast, there is not a significant relationship between total nitrogen and total dissolved solids in the data from 15 active facilities ($p>.1$) (Figure 13). This is most likely due to high background concentrations of total dissolved solids in the supply water.

The concentration of total nitrogen in effluent varied widely [Standard Deviations (SD) averaged around 50] between sampling events for each facility (Figure 9). Factors that could influence this variability include: fluctuations in occupancy or use of the facilities, sampling techniques, the heterogeneity of the effluent stream, and variation in laboratory analysis. The average concentration of total nitrogen was used to summarize this variability and allow for comparison between different facilities (Figure 10). Campground/RV Parks, Institutions and Schools were found to have high average concentrations of total nitrogen in effluent (137 mg/l, 118 mg/l, and 77 mg/l respectively). The average concentration of total nitrogen was found to be significantly greater for these three types of facilities than for Commercial facilities or Multiple Dwelling facilities which had average concentrations of 25 mg/l average and 54 mg/l respectively ($p < .05$). However, no statistical difference was found between the concentration of total nitrogen at Campground/RV Parks, Institutions and Schools ($p > .1$).

In comparing waste strength to facility type, the sample size for each facility type was small ranging between 3 and 10 facilities for each type. Although the data illustrated that some facility types produced effluent with higher average concentrations of total nitrogen, the high variability between facilities makes it difficult to pinpoint significant differences that could be used to predict an average or range of waste strength for an individual facility based on its type.

Impacts to Ground Water Quality

The data available for this study suggest that large capacity septic systems can significantly and negatively impact the quality of ground water. Close to half (48%) of all the facilities examined (both active and non-active) for which there was usable ground water data had concentrations of nitrate that were equal to or exceeded the WQCC regulation standard of 10 mg/l in ground water. This trend is also apparent in currently active facilities where 42% of facilities submitting ground water monitoring results exceeded the standard for nitrate (Figure 14). In addition, 63% of all the facilities examined (both active and non-active) exceeded 10 mg/l of total nitrogen in ground water. Although there are no regulatory ground water standards for nitrogen species other than nitrate, high concentrations of total nitrogen in ground water are of concern since organic nitrogen can be converted to nitrate in ground water under favorable conditions. Additionally, high total nitrogen concentrations in ground water may indicate a reducing environment where manganese, iron and sulfur can be released, further diminishing the quality of the ground water.

While many different site and facility characteristics can potentially influence the impacts of large capacity septic systems on ground water, this study looked principally at the role of waste strength, discharge volume, and depth to ground water. In addition, the type of facility and the concentration of TDS and chloride were examined as potentially useful indicators for nitrate contamination of ground water.

The 10 (both active and non-active) facilities from which there was usable data for both ground water and effluent gave the most insight into the relationship between waste strength and the impacts of large capacity septic systems on ground water. While the data illustrate a trend towards a direct relationship between total nitrogen in the effluent and total nitrogen measured in ground water (Figure 11) ($p < .1$), the trend is not readily observed with nitrate concentrations in ground water ($p > .1$) (Figure 15). The small sample size makes identifying trends with certainty difficult. However, the potential significance of this data supports the importance of evaluating waste strength as a strategy to prevent ground water contamination.

The ground water data indicate that not all of the total nitrogen discharged to ground water is converted to nitrate as evidenced by the fact that some ground water samples contain elevated levels of TKN. In particular, sites with a shallow depth to ground water (<=10 ft) have high concentrations of TKN rather than nitrate (Figure 16). A high percentage of facilities (75%) overlying shallow ground water exceed 10 mg/l of total nitrogen in ground water; however, ground water quality at only half of these facilities exceeds 10 mg/l nitrate. These percentages suggest oxidation of TKN to nitrate is less likely to occur at sites with shallow ground water. The percentage of facilities with high total nitrogen in ground water decreases as the depth to water increases, and at sites with greater than 50 ft to ground water the majority of the total nitrogen concentration is in the form of nitrate. Although not all the total nitrogen appears to convert to nitrate in shallow ground water, the high levels of total nitrogen present at these sites represents a potential source of nitrate contamination. In particular, as ground water containing elevated concentrations of TKN moves down gradient, it may encounter an oxidizing environment that would result in the oxidization of the TKN to nitrate. Conversely, the TKN may intensify the reducing environment, resulting in the release of unacceptable levels of manganese, iron, and sulfur in ground water.

Discharge volume appears to potentially impact the concentration of nitrate in ground water. Using a regression analysis of the 33 (both active and non-active) facilities for which there are usable ground water data, there is a trend towards a statistically significant direct relationship between discharge volume and the maximum nitrate concentration ($p < .1$) (Figure

17). The small sample size may be a significant reason this relationship is statistically determined to be a trend towards a significant relationship. This trend is most evident in the high percentage (80%) of facilities with a discharge volume of over 10,000 gallons per day that have evidence of nitrate concentrations which are equal to or greater than 10 mg/l (Figure 18). The percentages of facilities with high total nitrogen follow the same pattern with respect to discharge volume as those with nitrate. (Figure 18) The data suggest that discharge volume is an important factor in contributing to the potential for ground water contamination from large capacity septic systems.

The relationship between the depth to ground water and the concentration of nitrate in ground water is not evident in the available data (33 active and non-active facilities). A regression analysis indicates no trend between depth to water and the maximum nitrate concentration ($p>.1$) (Figure 19). There appears to be a number of confounding factors that affect this relationship. One factor appears to be the high levels of TKN measured at the shallow depths to ground water. In addition, the small sample size and the effects of other variables such as discharge volume and differences in waste strength all mitigate the effects of the depth to ground water.

Comparison of the percent of facilities with samples that exceed ground water standards overlying different depths to ground water reveals different trends depending on whether nitrate or total nitrogen is being considered (Figure15). The percent of facilities that exceed the nitrate standard shows an increasing trend with depth to water up to 300 ft. The opposite trend is apparent when looking at the percent of facilities that exceed 10 mg/l of total nitrogen. This is probably due to the large concentrations of TKN found at sites with shallower depths to ground water. Three quarters of all the sites, which are located at less than or equal to 10ft to ground water, have ground water total nitrogen levels that exceed or are equal to 10 mg/l. Therefore, the potential for additional nitrate contamination of ground water at shallow depths may be considerable.

Harman et al (1996) suggested that the higher strength waste produced by schools could result in a greater impact to ground water. Similarly the effluent data compiled in this study found greater concentrations of total nitrogen at the School, Campground/RV Park, and Institution facility types. However, the ground water quality data available for this study was not found to be statistically different between different facility types for either the maximum nitrate or total nitrogen concentrations ($p>.1$) (Figure 20). It is important to note that the trends in effluent strength found between the different facility types can not be effectively compared to the trends seen in the ground water quality because very few of the facilities have submitted data from both effluent and ground water.

Nonetheless, Schools and Campground/ RV Park facility types were found to have high percentages of sites with nitrate concentrations in ground water that exceed the standard (70% and 67% respectively). In contrast, the Institution facility type had a lower percentage of sites with nitrate concentrations exceeding the ground water standards but a high percentage of sites with total nitrogen concentrations in ground water equal or greater than 10 mg/l (Figure 21). Further inspection of the Institution facilities with high concentrations of total nitrogen reveals that they are located where ground water is shallow. Therefore, the depth to ground water factor at these sites may confound any potential relationship between nitrate concentrations in ground water and facility type. The data suggest that it is possible that high levels of total nitrogen found in the effluent of Campground/RV Parks and Schools could be the cause of the high percentages of those facilities where ground water samples exceed the nitrate standard. Although, until there is more data from both the effluent and the ground water at the same facility this relationship remains uncertain. Other factors, such as depth to ground water and discharge volume, which this study has shown to also influence the concentration of nitrate in ground water, may confound any relationship between facility type and ground water quality.

Cl and TDS are the other constituents, beside nitrogen species, commonly tested for in ground water. These analyses are conducted in order to provide information on the source of the contamination and because there are ground water standards for Cl and TDS. There is a statistically significant direct relationship ($p < .01$) between the concentration of total nitrogen in ground water and the concentration of TDS (Figure 22). In contrast, the relationship between the maximum concentrations of chloride and total nitrogen in ground water includes the effect of background levels in the supply water. There is a significant ($p < .05$) direct relationship between chloride and total nitrogen in ground water when chloride is below the standard. ($Cl \le 250$mg/l) When the values over 250 mg/l are included the trend is less significant and is statistically determined to be a possible trend ($p = .1$) (Figure 23). This may be due to high chloride values in the supply water, which is demonstrated by at least one facility that exhibited high chloride concentrations in samples taken from an up gradient monitoring well.

Compliance

Almost half (49%) of currently permitted facilities which are required to regularly submit monitoring reports were found to be out of compliance with respect to the monitoring requirements of their permits. These 38 facilities include 21 that have never submitted a monitoring report and 17 that have not sent in a report for over a year. Over one out of every four (27%) facilities currently required to submit monitoring reports have never submitted any monitoring data. Thirty percent of the remaining facilities have not submitted a report in over a year. The large percent of facilities failing to submit monitoring reports greatly reduced the data available for analysis. The importance of consistent monitoring of ground water is illustrated by the finding that half of the facilities that are currently one year or more overdue in reporting, have also had samples which exceed the WQCC standard for nitrate. The problem of facilities not complying with the monitoring requirements of their permits significantly impacts the ability of the GWQB to assess whether or not these permits and the septic systems are protective of ground water quality.

Case Studies

The following two case studies, Kirtland Elementary School and Peñaso School, were conducted to help determine the efficacy of wastewater source control on ground water contamination due to nitrate. Each of the facilities is underlain by a fairly shallow alluvial aquifer and was originally serviced by large capacity septic system. As a result of ground water contamination, the schools were required to upgrade the septic systems with alternative treatment systems. The alternative treatment systems reduced the amount of nitrogen discharged to the leachfield and ground water. The monitoring data from before and after the installation of the treatment systems illustrate the resultant effects on ground water quality.

<u>Kirtland Elementary School</u>

Site Description

A description of the regional geology, obtained from the preliminary assessment report for the nearby Kirtland Landfill site, was submitted as part of the original discharge permit. Kirtland is located in San Juan County in the northwest region of New Mexico. The geology of this region is described as consisting of Tertiary fill overlaying Cretaceous sedimentary rocks. The aquifer is identified as alluvial valley fill underlain by sandstone and shale bedrock. Ground water is the main source of drinking water in the region and the area has been described as highly vulnerable to ground water contamination from surface leaching.

A more localized description of the site's hydrogeology was presented in a 1999 site investigation report prior to the installation of the new evaporative lagoon system. The investigation included one soil boring and the installation of three monitoring wells. The drill logs showed that the lithology consists of interbedded claystone, sand, and sandy clay with some occurrences of gravel and cobbles at depths below 45ft. Only two of the three monitoring wells encountered ground water at approximately 70 ft below the surface. The most recent survey of the monitoring wells reported ground water flow as southwest with a gradient of .0074 ft/ft (Site map-Appendix II).

Ground water quality and permitting history

The first ground water discharge permit (Dp-505) was issued to Kirtland Elementary School in 1987 with requirements to install and sample a down gradient monitoring well. The original permit was issued for a discharge volume of 9,000 gallons per day (gpd). For the first three years the concentrations of nitrate and TKN in the monitoring wells remained below WQCC standards. In 1991, the nitrate concentrations increased to 14 mg/l. A site inspection in the early 1990s reported improper sampling techniques, which could have been the source for the higher nitrate values. Over the next five years nitrate concentrations remained fairly consistent at less than 1 mg/l until January of 1996 when the nitrate concentration was reported to be 11 mg/l. Another site inspection identified faulty sampling procedures as a possible explanation for the unusually elevated nitrate concentrations measured in the well. Between 1987 and 1996 discharge modifications and renewals increased the allowable discharge volume to 16,000 gpd.

In 1996, the permit was modified again to increase the allowable discharge volume to 21,300 gpd (Figure 24). After the increase in discharge volume, the nitrate concentrations detected in the samples from the monitoring well increased to 40 mg/l and remained consistently over 40 mg/l for the next four years. In April of 1997 in response to the high nitrate levels, the GWQB required the replacement of the existing system. In the fall of 1999, a total evaporative lagoon system was installed at the site. Continued quarterly ground water monitoring was required in the discharge plan renewal issued in January of 2000. The three samples received since the discharge plan was renewed have shown a decreasing trend in the concentration of nitrate in the down gradient monitoring well (Figure 24). Although the levels are decreasing, they remain above the 10 mg/l standard at this time. A well up gradient from the old leachfield and down gradient from the new lagoon was installed at the time the lagoon system was constructed to check for possible contamination resulting from other sources of nitrogen located up gradient from the school. Nitrate levels in the up gradient well have been consistently low, at around 1.5 mg/l, indicating that the nitrate in the ground water results from the former large capacity septic system at the school.

Peñasco Schools

Site Description

Peñasco is located in Taos County in north central New Mexico. The regional hydrogeology of the Peñasco area consists of a valley fill aquifer underlain by the crystalline bedrock of the Sangre de Cristo Mountains. The geology and soil characteristics at the site were described in the discharge plan submitted in 1995. The information was taken from 8 test holes drilled to depths between 10 and 20 ft. The soils encountered were described as a surficial layer of very sandy clay to very clayey sand overlying cobbles with silt, sand, and clay. The sandy clay layer was described as firm to stiff and was found at depths ranging from 4 -12 ft. The clay layer was described as moist to very moist. The underlying cobble layer was described as dense and was encountered at depths ranging from 8 -17 ft.

The hydrology at the site has been described based on a 1994 survey conducted along with the installation of new monitoring wells. The report indicated a north westerly ground water flow direction based on the ground water elevation measured in 7 monitoring wells. The depth to ground water at the site is reported as 16 ft (Site map-Appendix III)

Ground water quality and permitting history

The first ground water discharge permit (Dp-731) was issued to Peñasco Schools in 1992 with requirements to replace an existing undersized leachfield and install four monitoring wells. Over the next three years, system failures and high nitrate concentrations in the down gradient monitoring wells (5 – 15 mg/l) resulted in the requirement of two additional down gradient wells. At the time, monitoring wells located up gradient from the leachfield were found to have low concentrations of nitrate (<1 mg/l). The high concentrations of nitrate in ground water were believed to be due to the large capacity septic system (Figure 25).

In 1995, the schools submitted a plan to consolidate the permitted septic tank leachfield along with other smaller septic tank leachfield systems into a combined wastewater collection and treatment system with a package treatment plant and new leachfield. The 1996 permit renewal, included the approval of the proposed modification, the installation of two new monitoring wells down gradient from the new leachfield, and required monitoring of both effluent and ground water. Most recently, in April of 2001 the permit was renewed with a reduction from 20,000 gallons per day (gpd) to 10,000 gpd discharge volume to reflect differences between the volume monitoring reports and the design volume (Figure 25).

After the transition to the package plant (during the fall of 1995), nitrate concentrations in both effluent and ground water samples were low for the summer (while the students were on vacation) but by the next sampling date in January of 1997 the levels were high, approximately 10 mg/l. One year after the installation of the package plant, nitrate levels in ground water were under 5 mg/l. From the fall of 1997 through the winter of 1998, high levels of total nitrogen measured in the effluent samples were attributed to a lack of maintenance of the package plant. The maintenance problems caused elevations in the total nitrogen and nitrate levels in ground water but the standards were not exceeded. Since 1997 the concentration of nitrate in ground water at the site has remained below 10 mg/l except for one sampling date in March of 2000 (14 mg/l) (Figure 25).

Case Studies Summary

The two facilities chosen as case studies each adopted different means of reducing the impact of a large capacity septic system on ground water. Kirtland Elementary School installed a total evaporative lagoon system, which eliminated the discharge of effluent to ground water. In contrast, Peñasco Schools installed a package treatment plant, which was designed to improve the quality of effluent being discharged through reduction of the concentration of nitrogen in the effluent. At both schools, replacement of the septic system has resulted in reduction of nitrate concentrations in ground water. Furthermore at both schools a time lag was observed in the reduction of nitrate concentrations to below WQCC standards. These case studies suggest that nitrate contamination can persist in ground water after the source of the contamination has been removed or reduced which in some situations may warrant more active ground water remediation activities. In addition, the case studies are two success stories illustrating that the installation of advanced treatment options such as a lagoon or package plant system can reduce the negative impact of large capacity septic systems on ground water.

Conclusions

The results of this study reveal that there is not a single factor that determines the impact of a large capacity septic system on the quality of ground water. All three of the characteristics examined in this study, depth to ground water, discharge volume and waste strength, were found to influence the impact of large capacity septic systems on ground water quality. The available data suggest that these factors combine to create conditions under which ground water is susceptible to contamination. Additionally, site characteristics not included in this study such as soils and geology almost certainly contribute to ground water susceptibility. Lack of data, and the resulting small sample size, prevented this study from making stronger statistical conclusions. The database of usable monitoring data was not only small but skewed. In particular, there was limited data available from sites with a depth to ground water greater than 100 ft, and none available for depths greater than 300 ft. Large capacity septic systems built in areas where it is very deep to ground water may not adversely impact ground water but for now the data is not sufficient to verify this hypothesis.

This study highlights the prevalence of nitrate contamination in ground water at sites with large capacity septic systems. The fact that nearly half of the sites (48%) with ground water monitoring data had nitrate levels that exceed the health based WQCC standard of 10 mg/l is a significant finding that merits further attention and study. Due to the fact that no one factor was shown to stand alone as a cause for nitrate contamination of ground water, the best prevention tool available appears to be regular monitoring of ground water quality. Finally, the two case studies presented illustrated how the replacement of septic systems with advanced treatment systems, which reduced the discharge of nitrogen to ground water, resulted in the reduction of nitrate levels in ground water. This finding highlights the importance of not only monitoring the septic system but also upgrading the system in response to measured contamination.

Recommendations

While the data did not implicate certain factors in causing ground water contamination, it did identify some patterns that deserve further attention.

- Discharge volumes of greater than 10,000 gallons per day to large capacity septic systems appear to increase the likelihood of the contamination of ground water. Therefore, new permits for facilities with greater than 10,000 (gpd) should include a requirement to install an advanced treatment system, whereas all existing facilities should be required to install monitoring wells.
- Large capacity septic systems located where ground water is at depths less than 10 ft below the surface appear to result in increased levels of total nitrogen in ground water. New permits for facilities where ground water is less than 10 ft below the surface should include a requirement to install an advanced treatment system. Due to the potential for the conversion over time of organic nitrogen to nitrate down gradient, the installation and monitoring of wells further down gradient should be required to determine the full impact of these systems on ground water. In addition, the monitoring program should be tailored to analyze for the presence of contaminants prevalent in a reducing environment, in particular manganese, iron and sulfur.
- The presence of TKN in ground water accompanied by a lack of nitrate may indicate a reducing environment regardless of the depth to ground water. Therefore, monitoring requirements should be re-evaluated and expanded to include manganese, iron and sulfur at sites where sampling of monitoring wells demonstrates high concentrations of total nitrogen.
- High concentrations of total nitrogen in septic system effluent appeared to result in higher concentrations of total nitrogen in ground water. This highlights the importance of monitoring the strength of the effluent. Elevated concentrations of total nitrogen in effluent could be used to indicate that installation of advanced treatment systems be required at these sites.
- New Mexico appears to have a more concentrated and therefore higher strength domestic waste than the national average. A higher estimation of waste strength should be used in design calculations and permitting decisions in order to adequately prevent ground water contamination.

- The installation of advanced treatment systems instead of large capacity septic systems, where feasible, could reduce the impact these facilities have on ground water quality.
- The time lag observed on the reduction of nitrate levels to below standards at both case study sites suggests that continued monitoring after implementation of source control measures is essential to adequately evaluate the extent of contamination. In addition, in some situations where ground water is contaminated by large capacity septic systems, which could result in immediate health concerns, a more aggressive approach to ground water remediation may be needed.
- The high percentage of facilities that are out of compliance with respect to the discharge permit monitoring requirements, suggest that increased attention to this problem is warranted. Compliance and enforcement of permits for large capacity septic systems should be a priority for the Ground Water Quality Bureau.
- Ground water monitoring is essential to identifying septic systems that are impacting ground water. In order to facilitate the monitoring, the GWQB should standardize the monitoring requirements in the permits for large capacity septic tank septic systems to include:
    1. Quarterly sampling of effluent and ground water for all facilities, including analyses for TKN, nitrate, Cl and TDS.
    2. Ground water sampling should include analyses for manganese, iron and sulfur in addition to TKN, nitrate, Cl and TDS at sites where ground water is less than 10 ft below the surface or where sampling of monitoring wells demonstrates high concentrations of total nitrogen.
    3. All samples should be sampled and analyzed according to the provisions outlined in 20.6.2.3107 NMAC.
    4. Three monitoring wells including an up gradient well surveyed to a common permanent benchmark, installed within a specified distance from the leachfield, and clearly labeled on a site map.
    5. Measurements of water levels in the monitoring wells to determine ground water gradient and flow direction should be conducted every time a sample is collected.
- After the implementation of a standardized monitoring and improved compliance effort, new monitoring data should be evaluated comprehensively and consistent with this study.

- The relative lack of ground water monitoring data from sites where the depth to ground water is greater than 100ft prohibited this study from drawing conclusions on the potential impacts of large capacity septic systems at sites that are deep to ground water. Facilities which pose high risks for contamination due to high waste strength and/or high discharge volume should be required to install monitoring wells even if they are located at sites where it is deep to ground water.
- The GWQB should develop an education pamphlet to be included with each approved permit that provides instructions for sample collection, preservation and analysis. The pamphlet should also emphasize the importance of timely reporting and the consequences if reports are delinquent.

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List of Figures

Figure 1: Map of All Currently Permitted (Active, Inactive, Pending) Large Capacity Septic Systems in New Mexico

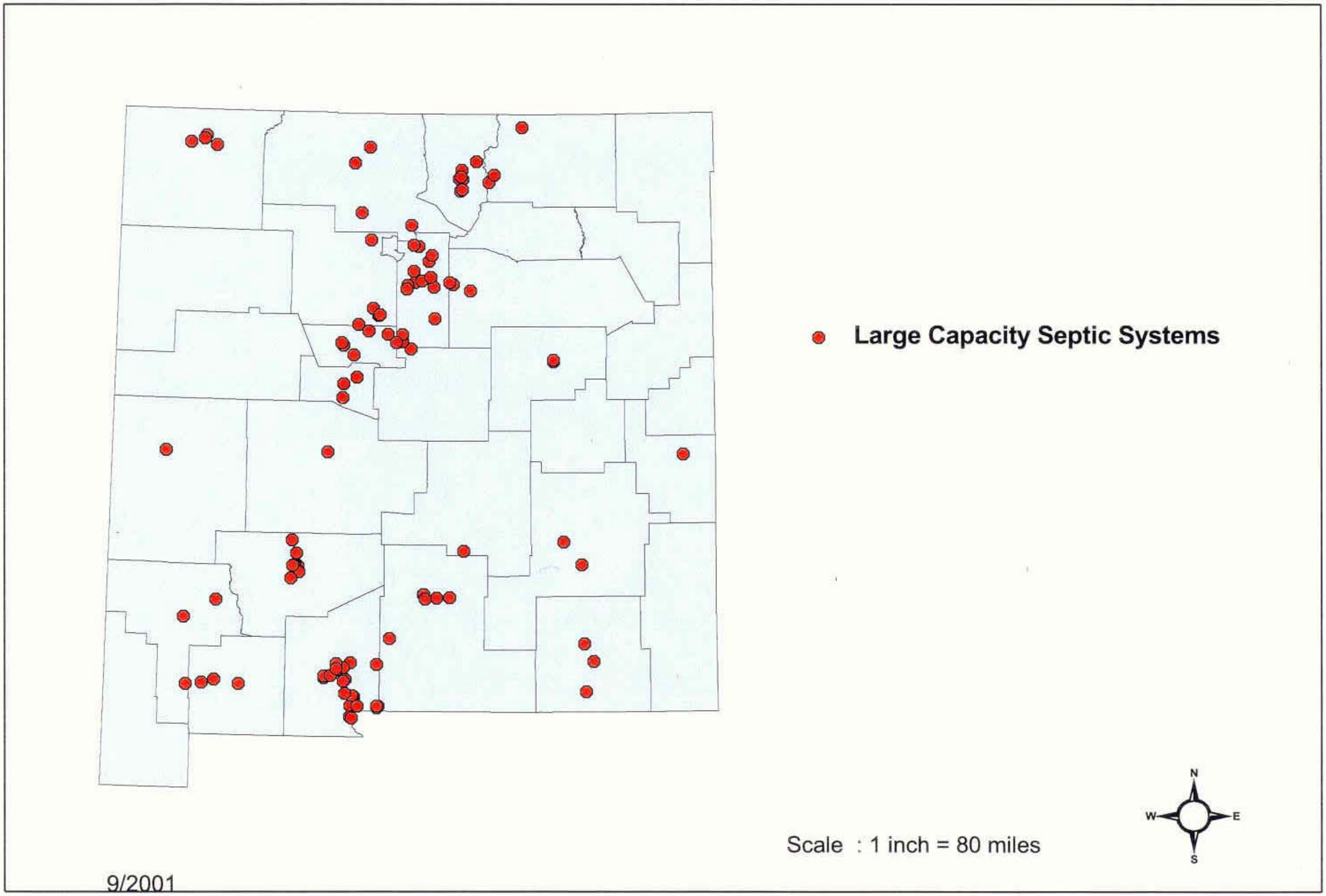
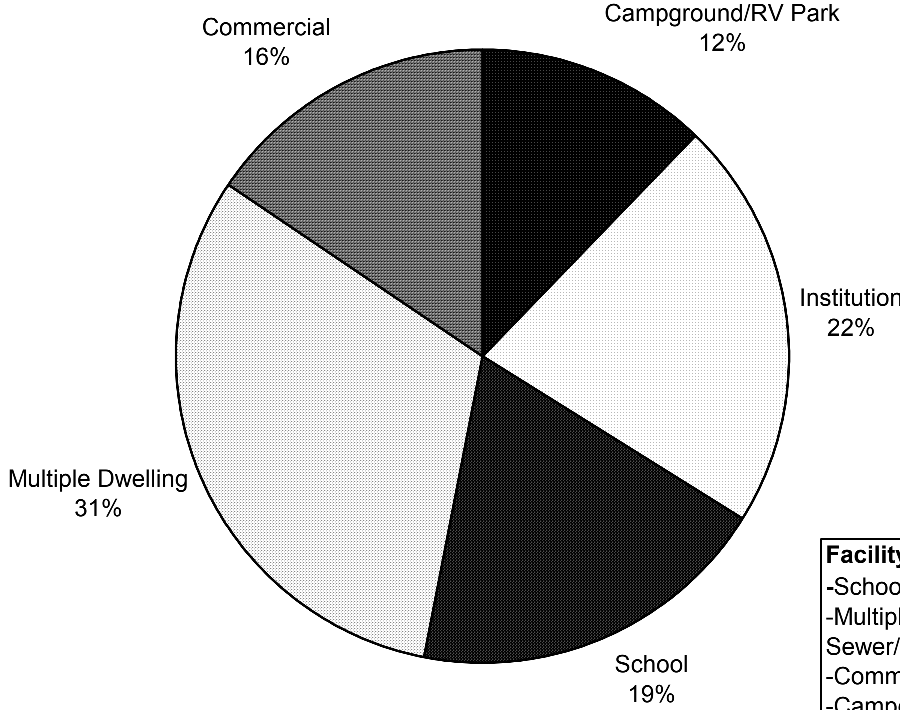


FIGURE 2: The Distribution of All Currently Permitted (Active, Inactive and Pending) Large Capacity Septic Systems According to Facility Type



Facility Types
-School
-Multiple Dwelling (Mobile Home Park, Subdivision, Sewer/Septic Association
-Commercial (Truck Stop, Restaurant, Hotel)
-Campground/ RV Park
-Institution (Church, Rest Stop, Recreation Center, Rehabilitation Facility)

n=115 facilities

Figure 3: Map of All Currently Permitted Large Capacity Septic Systems According to Daily Discharge Volume in Gallons Per Day (gpd)

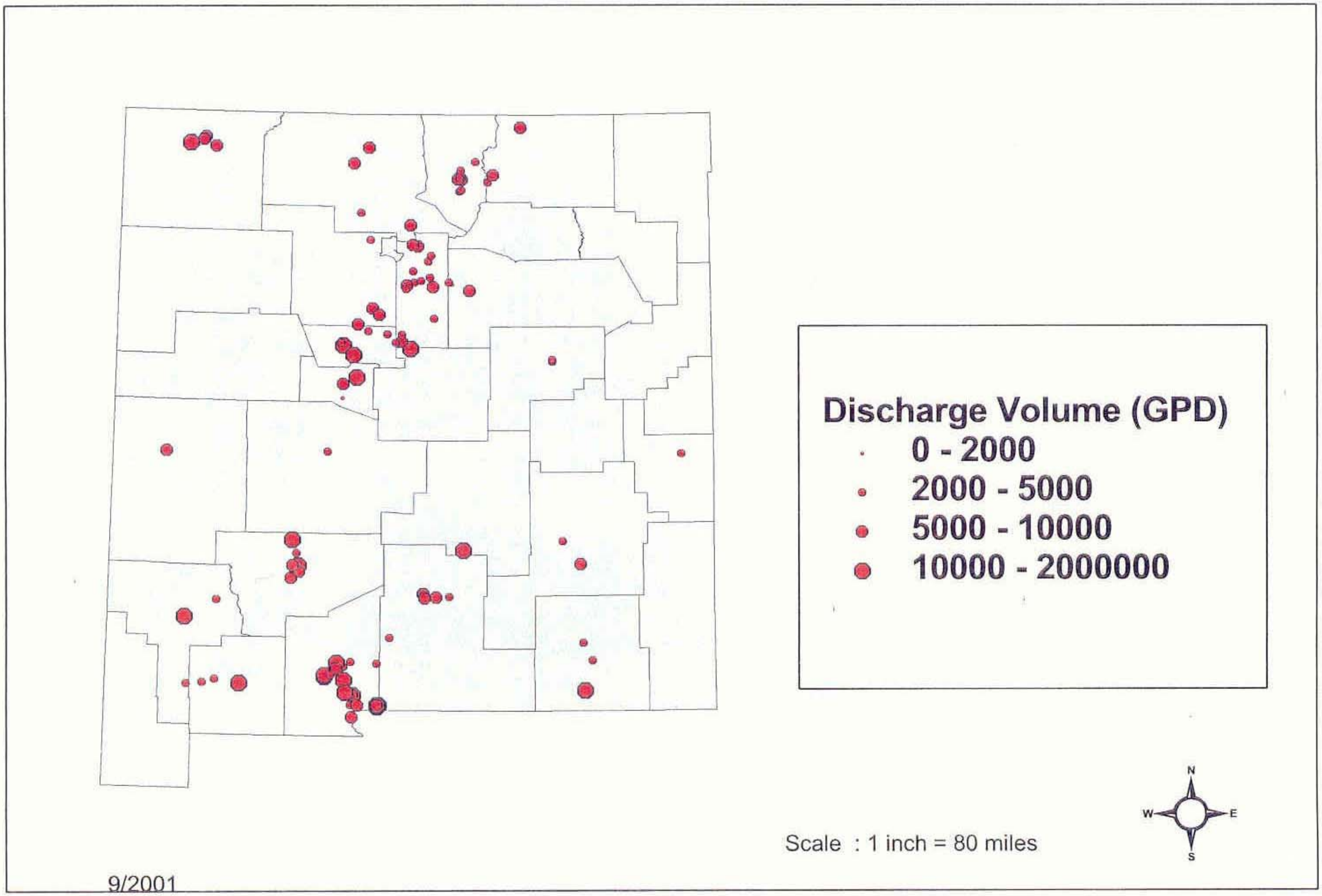


FIGURE 4: The Distribution of All Currently Permitted (Active, Inactive and Pending) Large Capacity Septic Systems According to Daily Discharge Volume in Gallons per Day (gpd)

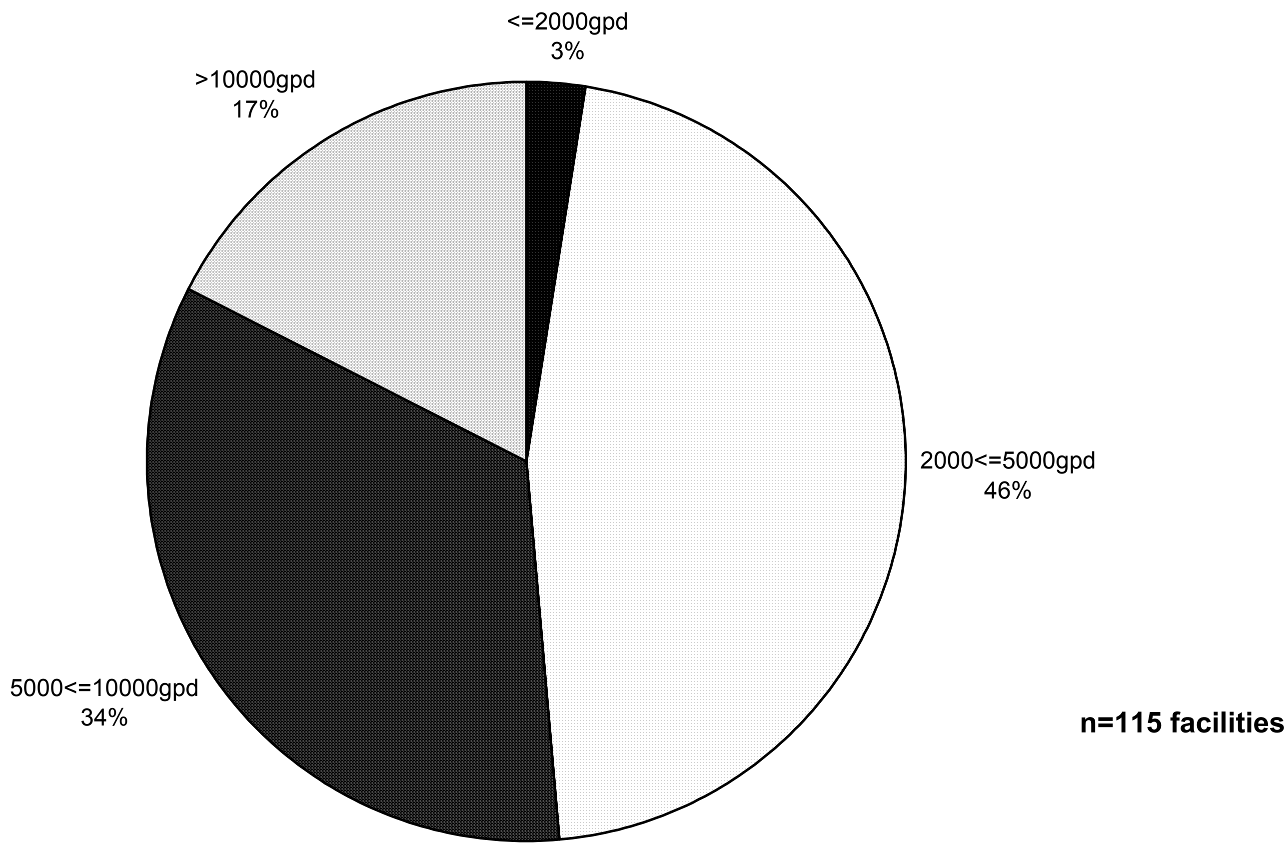


Figure 5: Map of All Currently Permitted Large Capacity Septic Systems According to Depth to Ground Water Beneath the Facility in Feet (ft)

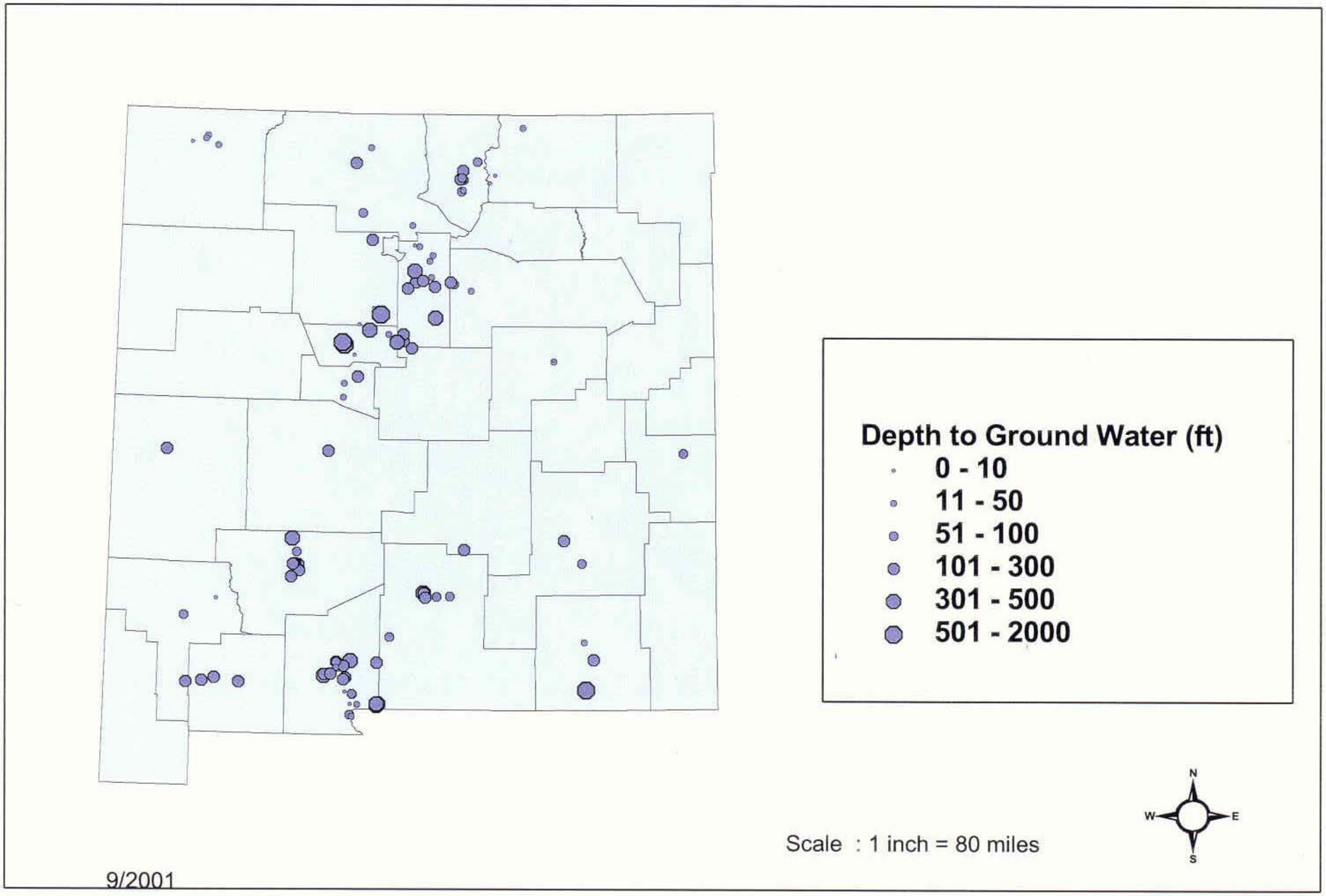
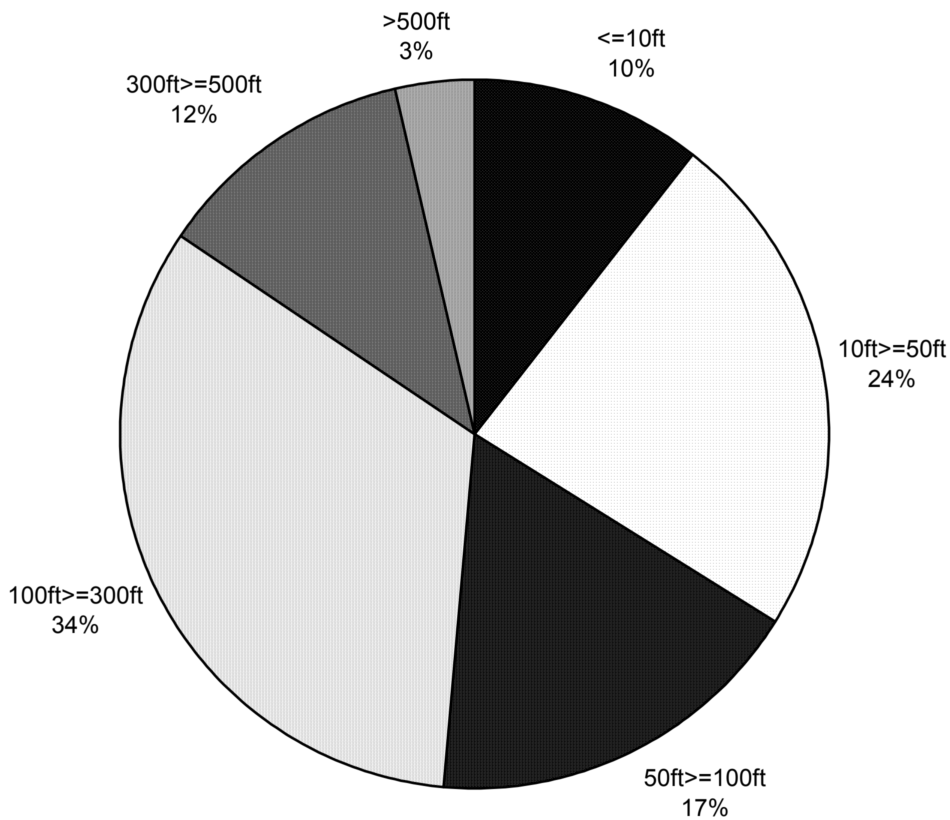


FIGURE 6: The Distribution of All Currently Permitted (Active, Inactive and Pending) Large Capacity Septic Systems According to Depth to Ground Water



n=115 facilities

FIGURE 7: Ground Water Monitoring Characteristics of Currently Permitted (Active, Pending and Inactive) Large Capacity Septic Systems at Different Depths to Ground Water

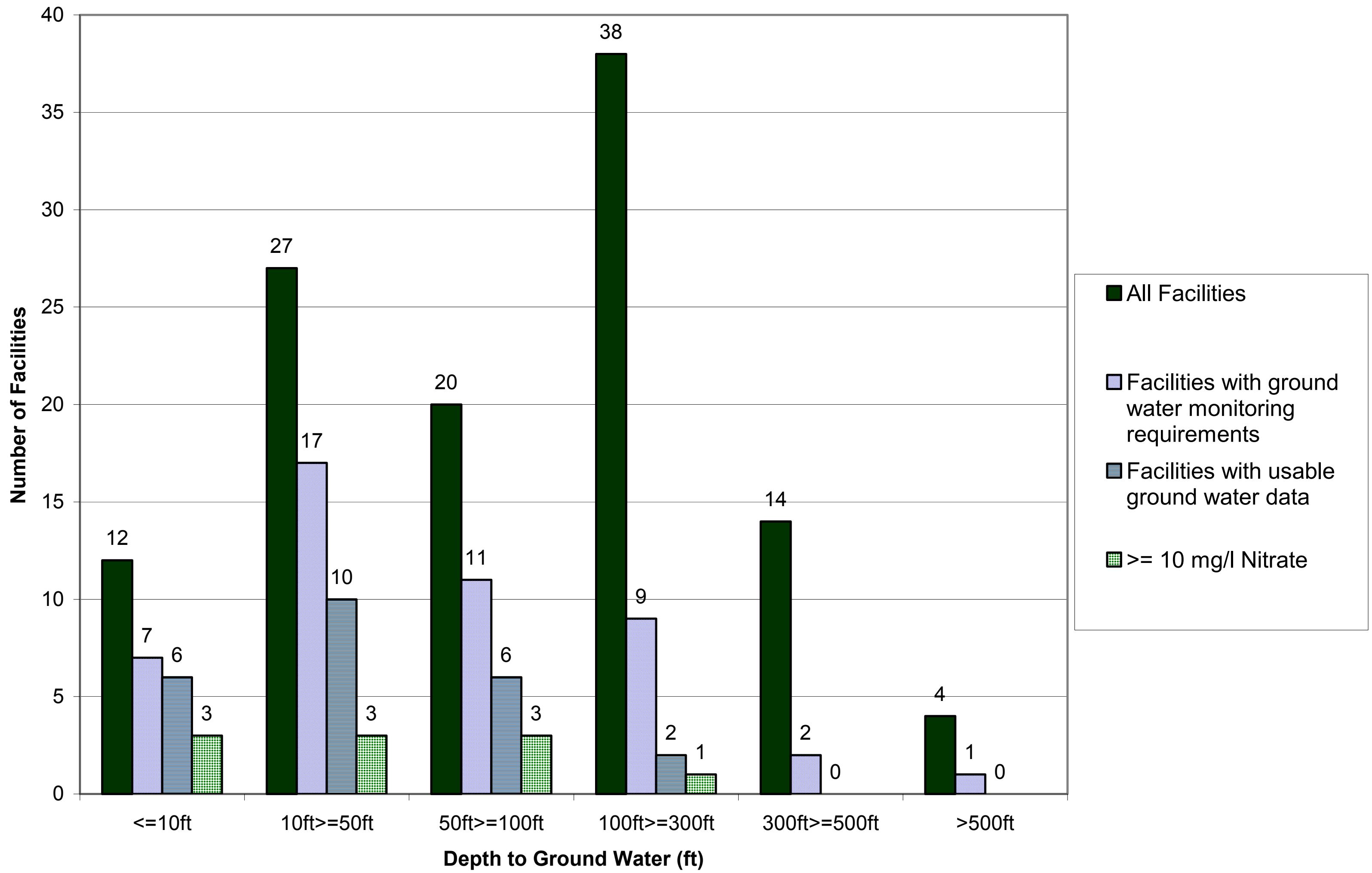


FIGURE 8: Ground Water Monitoring Characteristics of Currently Permitted (Active, Pending and Inactive) Large Capacity Septic Systems with Different Daily Discharge Volumes (gpd)

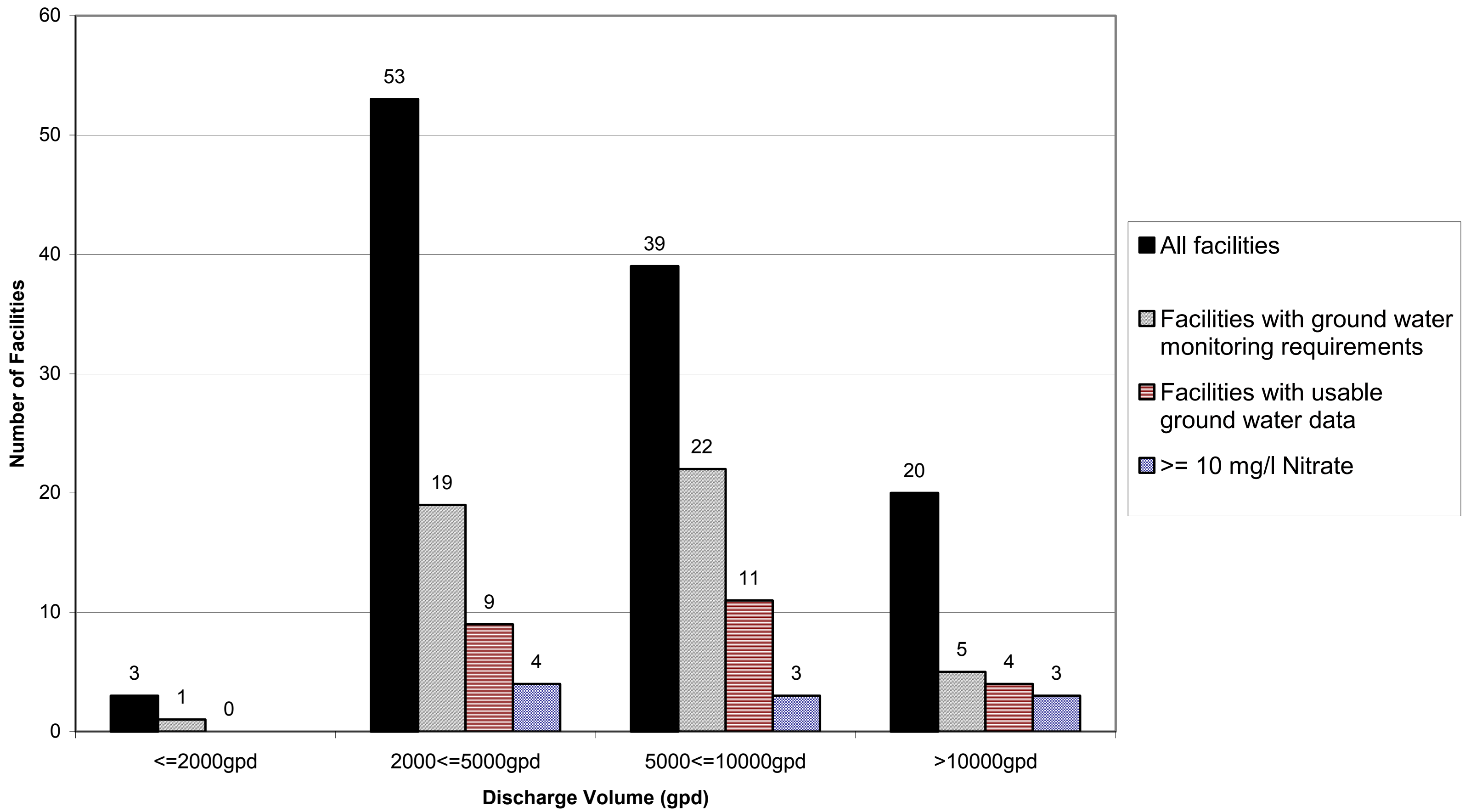


FIGURE 9: Data Table

						Ground Water			Effluent		
Dp #	Facility Name	Facility Type	Stat	Dtw	Gpd	Max NO3-N	Max Total N	n-samples	Avg Total N	SD	n-samples
9	GOLDEN WEST FUEL DEPOT	Commercial	A	50	4000	19	21.8	16			
65	TURQUOISE LODGE	Institution	C	6	10000	2	33	36			
66	KIRTLAND MOBILE HOME PARK	Multiple Dwelling	A	10	12250	12.8	11.4	46	37.3		1
81	PUEBLO DE LUNA TRAILER PARK	Multiple Dwelling	A	140	10750				24.44	3.02	2
91	CHAPARRAL ELEMENTARY SCHOOL	School	A	350	20925				66.39	10.15	2
110	AUSTING HAUS HOTEL	Commercial	A	80	4000				13.63	5.79	15
194	LOS PADILLAS COM. CTR.	Institution	T	10	2640	1.04	10.1	45			
203	TELLBROOK SUBDIVISION	Multiple Dwelling	A	150	4750				72		1
261	VERMEJO PARK RANCH	Commercial	A	27	8750				27.01	14.46	3
266	CENTRAL NM CORRECTIONAL FAC	Institution	T	11	6000	57.8	61.55	37	103.02	15.59	37
294	LA LUZ ELEMENTARY SCHOOL	School	A	315	8000				70.61	48.15	8
303	DESERT HILL TRAILER PARK	Multiple Dwelling	A	200	7200				44.5		1
328	ELEPHANT BUTTE STATE PARK	Campground/RV Park	A	200	20000	63	63.3	18			
334	CABALLO LAKE STATE PARK	Campground/RV Park	*	25	4000	57.14	70.5	54	31.28	18.95	9
358	INN AT ANGEL FIRE	Commercial	A	10	3000	5.2	10.8	7			
366	ANGEL NEST APTS.	Multiple Dwelling	A	15	6000	9.2	12.55	66	97.44	156	20
388	PNM SANTA FE SER. CEN.	Institution	A	200	1000				67.06	14.2	16
411	MONTICELLO R.V. PARK	Campground/RV Park	A	75	4650	0.45	2.6	21			
424	COMPOUND DE DON DIEGO	Multiple Dwelling	C	20	3600	3.83	6.9	6			
429	LOS COLONIAS MHP	Multiple Dwelling	A	60	7200	0.83	1.68	7			
	Nitrate >= 10 mg/l	n=52 total facilities with useable data (33 active and non-active facilities with groundwater data, 28 active facilities with effluent data, 10 active and non-active facilities with both groundwater and effluent data)									
	Total Nitrogen >= 10 mg/l										
			*	Replaced a large capacity septic system with an advanced treatment system							
				Standard Deviation of Average							

						Ground Water			Effluent		
Dp #	Facility Name	Facility Type	Stat	Dtw	Gpd	Max NO3-N	Max Total N	n-samples	Avg Total N	SD	n-samples
430	VISTA MIDDLE SCHOOL	School	A	97	4400	19	20	4	55.29	22.58	9
456	ANN PARISH ELEMENTARY SCHOOL	School	A	250	14500	0.72	1.073	15			
470	JUNIPER MOBILE HOME PARK	Multiple Dwelling	A	60	10000				38.83	13.45	4
479	PATRICIO TELLEZ TRAILER PARK	Multiple Dwelling	A	10	2200	40.38	38.8	29			
505	KIRTLAND ELEMENTARY SCHOOL	School	*	70	21300	62.6	62.37	31			
532	RANCHEROS DE SANTA FE	Campground/RV Park	A	250	6800				103		1
544	LA UNION ELEMENTARY SCHOOL	School	A	12	8292	0.65	3.1	23	85.73	16.87	2
589	TOMBAUGH ELEMENTARY SCHOOL	School	T	15	4400	35.2	35.2	50			
608	PUEBLO LARGO SUBDIVISION	Multiple Dwelling	A	225	6160				53.2		1
634	BEST VIEW RV PARK	Campground/RV Park	A	120	10450				120.75	27.69	4
687	PLACITAS ELEMENTARY SCHOOL	School	A	140	5000				67.83	13.22	3
711	ALGODONES ELEMENTARY SCHOOL	School	A	5	6215	7.4	8.61	31			
712	BERINO ELEMENTARY SCHOOL	School	A	50	9000	13.2	13.66	53			
730	TIERRA AMARILLA JAIL	Institution	A	32	7250	15.5	15.5	7	67.83		1
739	BIENVENIDOS RESORT	Multiple Dwelling	A	40	7530	5.3	7.5	17			
754	MILLER MOBILE MANOR	Multiple Dwelling	A	190	2250				63.4	26.18	8
774	SANGRE DE CRISTO CENTER	Institution	A	30	3000	1.79	3.4	11			
781	CHAPARRAL MIDDLE SCHOOL	School	A	350	25000				38.45	28.02	23
816	TESUQUE ELEMENTARY SCHOOL	School	C	32	2948	25.6	25.6	8			
822	BERNADINE GARCIA MHP	Multiple Dwelling	A	90	3750	25.2	25.65	9			
871	EL RANCHO TRAILER PARK	Multiple Dwelling	A	5	6000	1.2	3.561	14			
971	NATIONAL TRUCK STOP	Commercial	A	74	9000	74.9	91.8	72			
990	APS POLK MIDDLE SCHOOL	School	A	8	38500	31.2	31.5	67	57.56	35.45	16
1019	LA MERCED ELEMENTARY SCHOOL	School	C	110	3585	14.5	14.5	4			
1031	SOUTH MOUNTAIN ELEMENTARY	School	A	300	5000				178		1
1063	SANCHEZ MOBILE HOME PARK	Multiple Dwelling	A	100	7000	0.8	1.2	6	44.7	50.61	8

						Ground Water			Effluent		
Dp #	**Facility Name**	**Facility Type**	**Stat**	**Dtw**	**Gpd**	**Max NO3-N**	**Max Total N**	**n-samples**	**Avg Total N**	**SD**	**n-samples**
1106	HARRY'S ROADHOUSE	Commercial	A	50	3000	1.68	23.88	34			
1142	CAVCO INDUSTRIES INC	Commercial	A	50	6000	3.9	3.9	12			
1146	CROSSMAN RV PARK	Campground/RV Park	A	200	4000				292.42	247.55	3
1148	NM HIGHWAY DEPT SCENIC VIEW	Institution	A	310	5000				217.75	220.26	2
1201	ROCKY MOUNTAIN MHP	Multiple Dwelling	A	20	7000				64.03	64.03	3
1241	PETE'S RESTAURANT	Commercial	A	50	2922	1.8	2.2	2	33.05	13.08	2

FIGURE 10: Average Total Nitrogen in Effluent from Different Facility Types

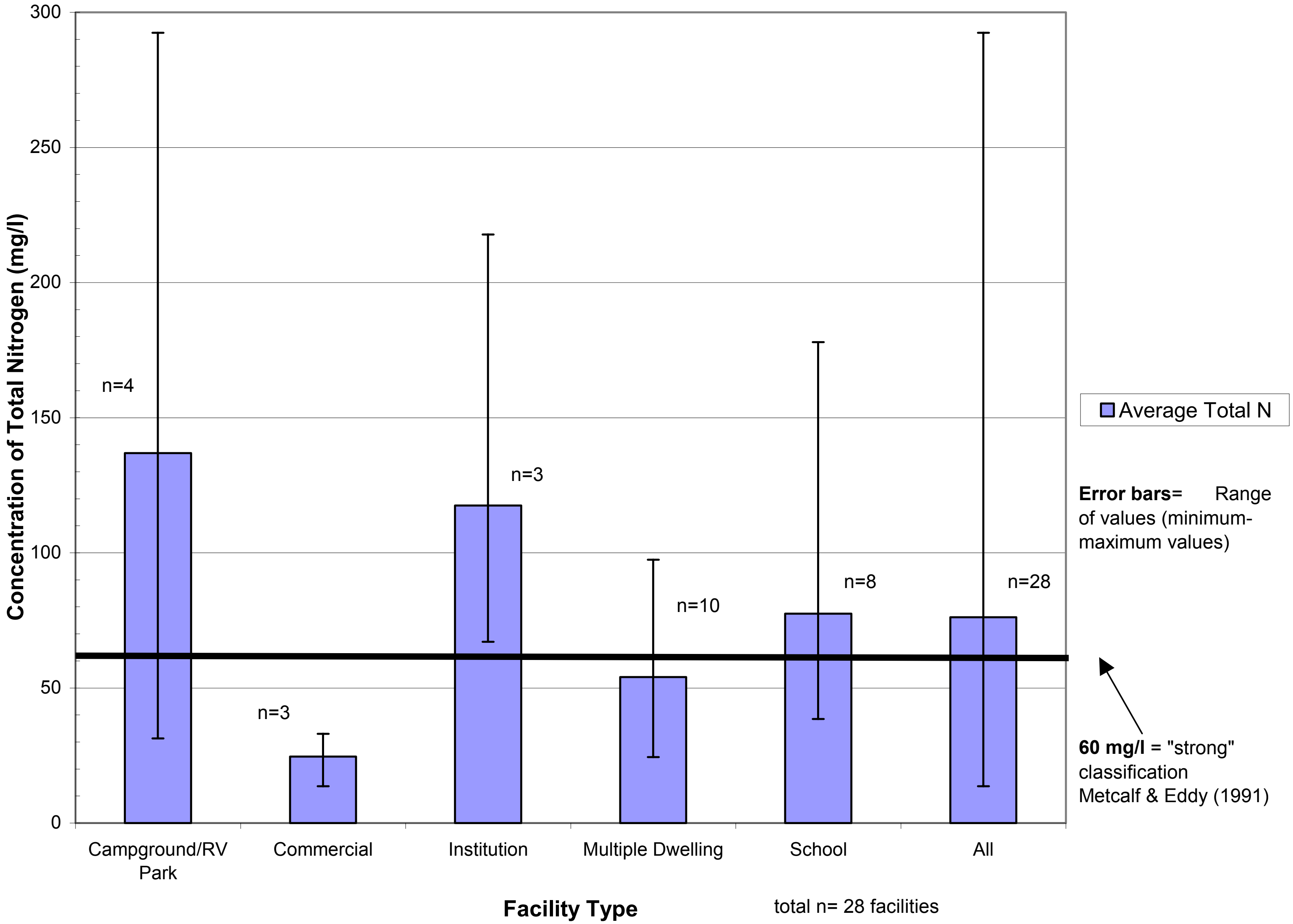


FIGURE 11: Average Total Nitrogen in Effluent Samples vs. Maximum Total Nitrogen in Ground Water Samples

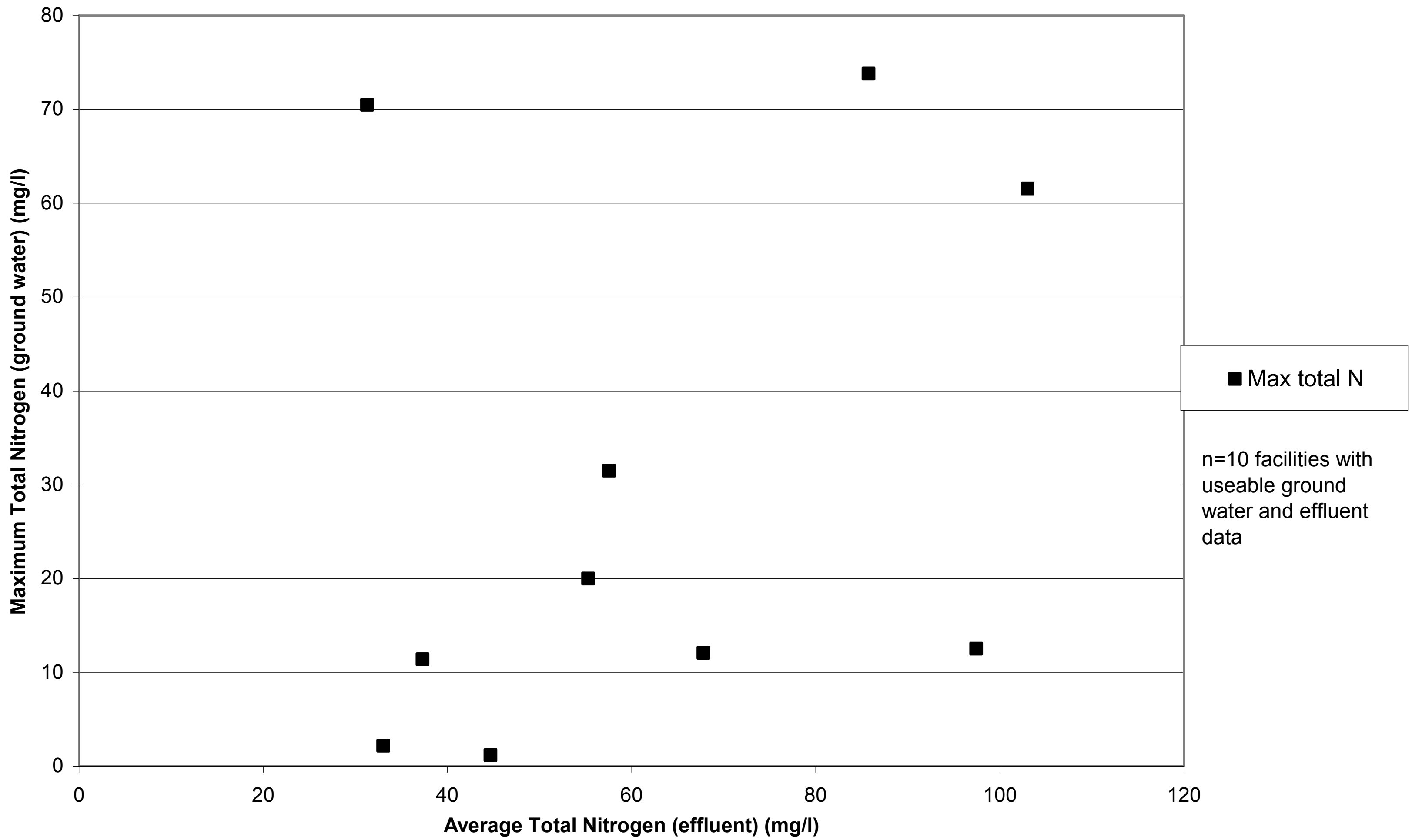


FIGURE 12: Average Total Nitrogen in Effluent vs. Average Chloride (Cl) in Effluent

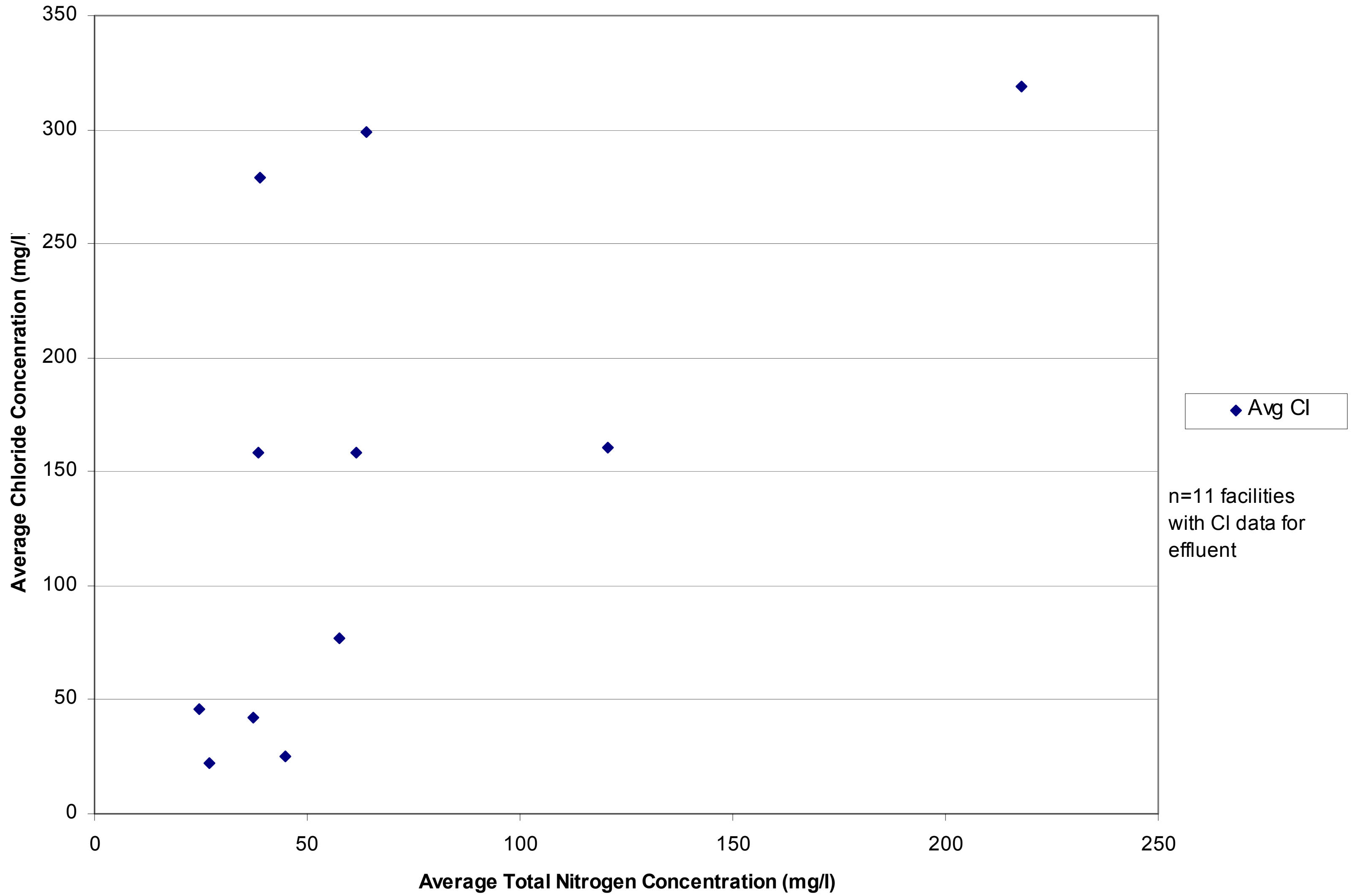


FIGURE 13: Average Total Nitrogen in Effluent vs. Average Total Dissolved Solids (TDS) in Effluent

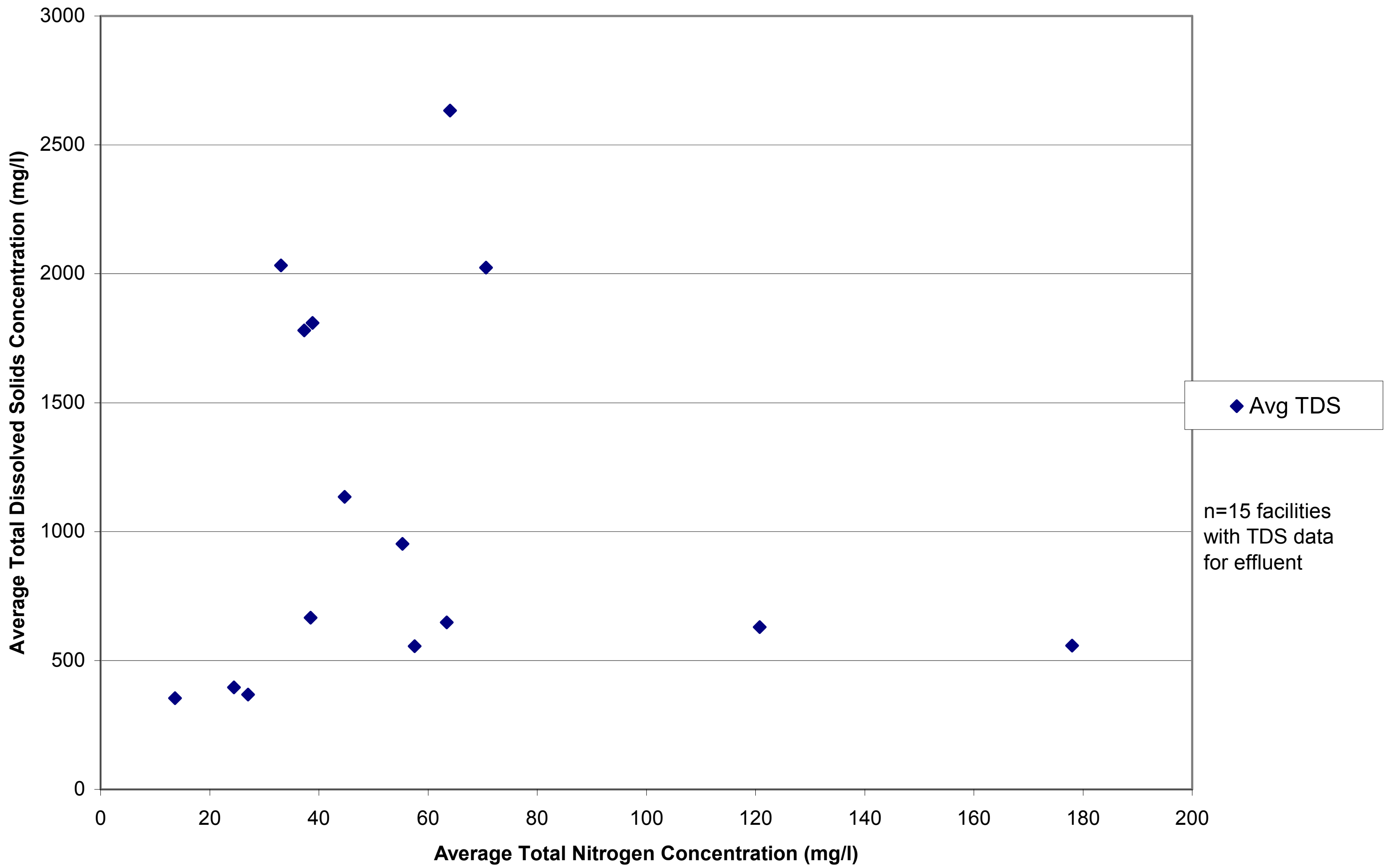
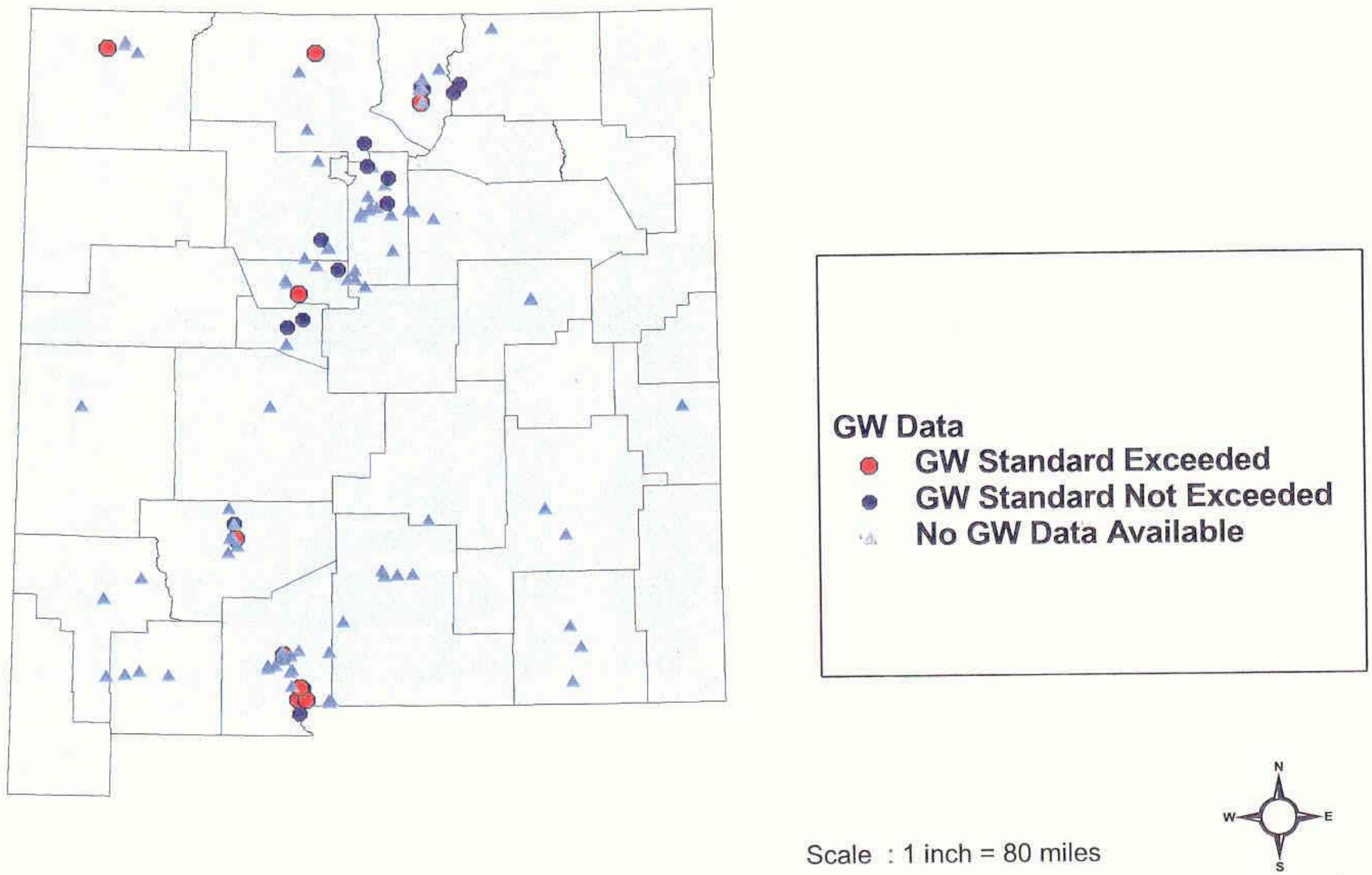


Figure 14: Map of All Currently Permitted Large Capacity Septic Systems According to Whether the Ground Water (GW) Standard for Nitrate (10mg/L) is Exceeded



9/2001

FIGURE 15: Average Total Nitrogen in Effluent Samples vs. Maximum Nitrate in Ground Water Samples

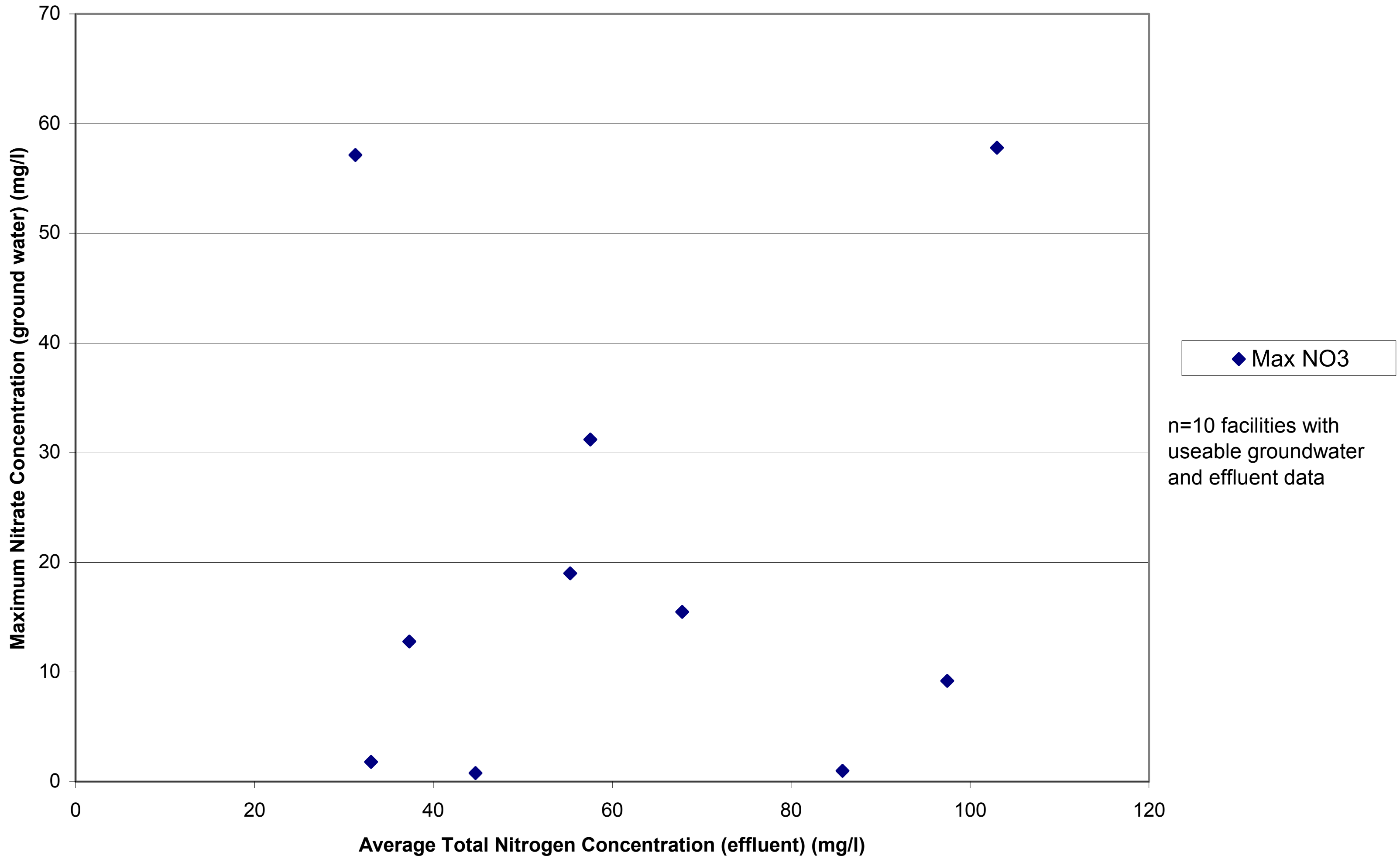
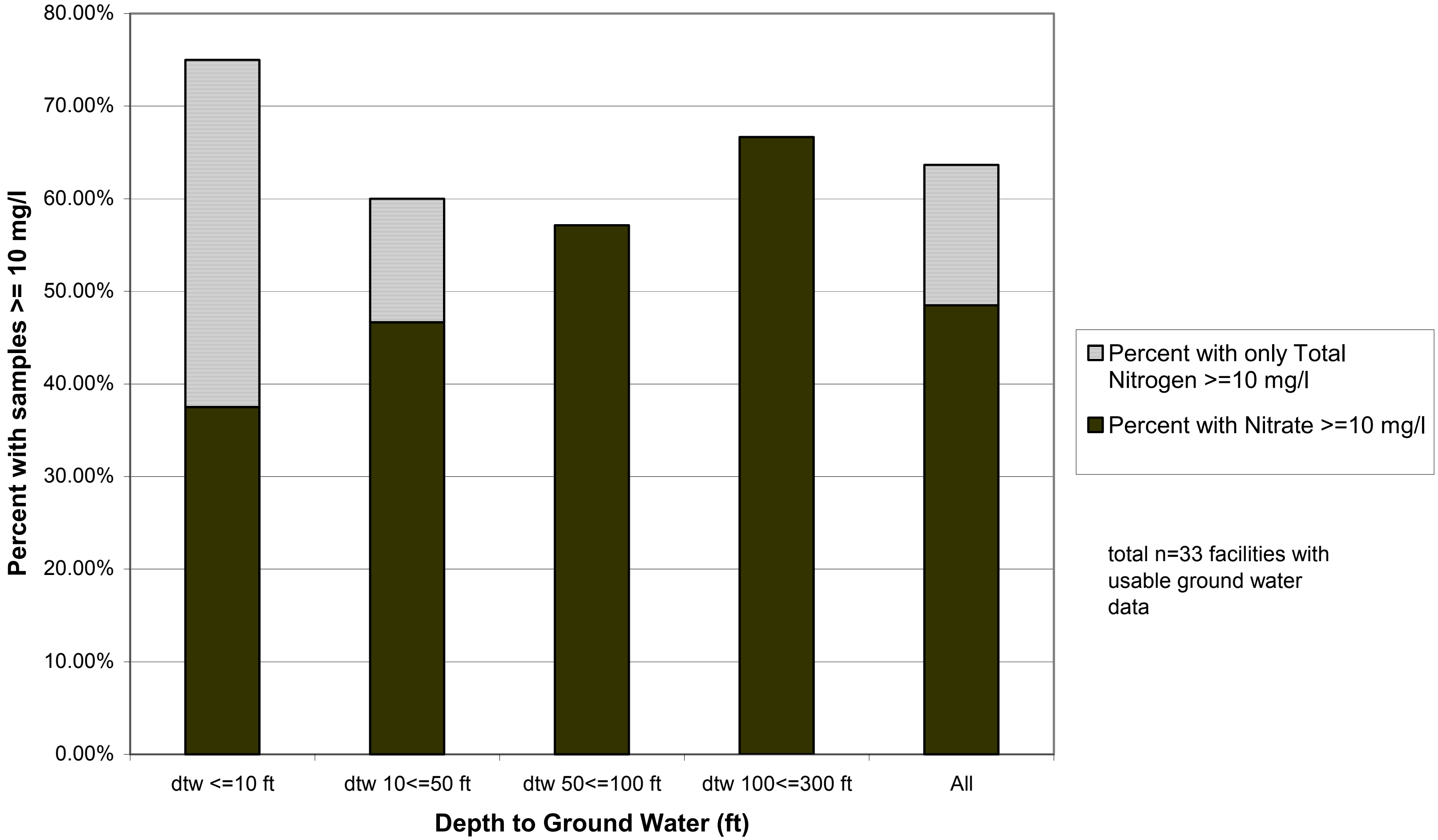


FIGURE 16: Percent of Facilities with Monitoring Data that Have Samples that Exceed Standards for Nitrate and Total Nitrogen According to Depth to Ground Water



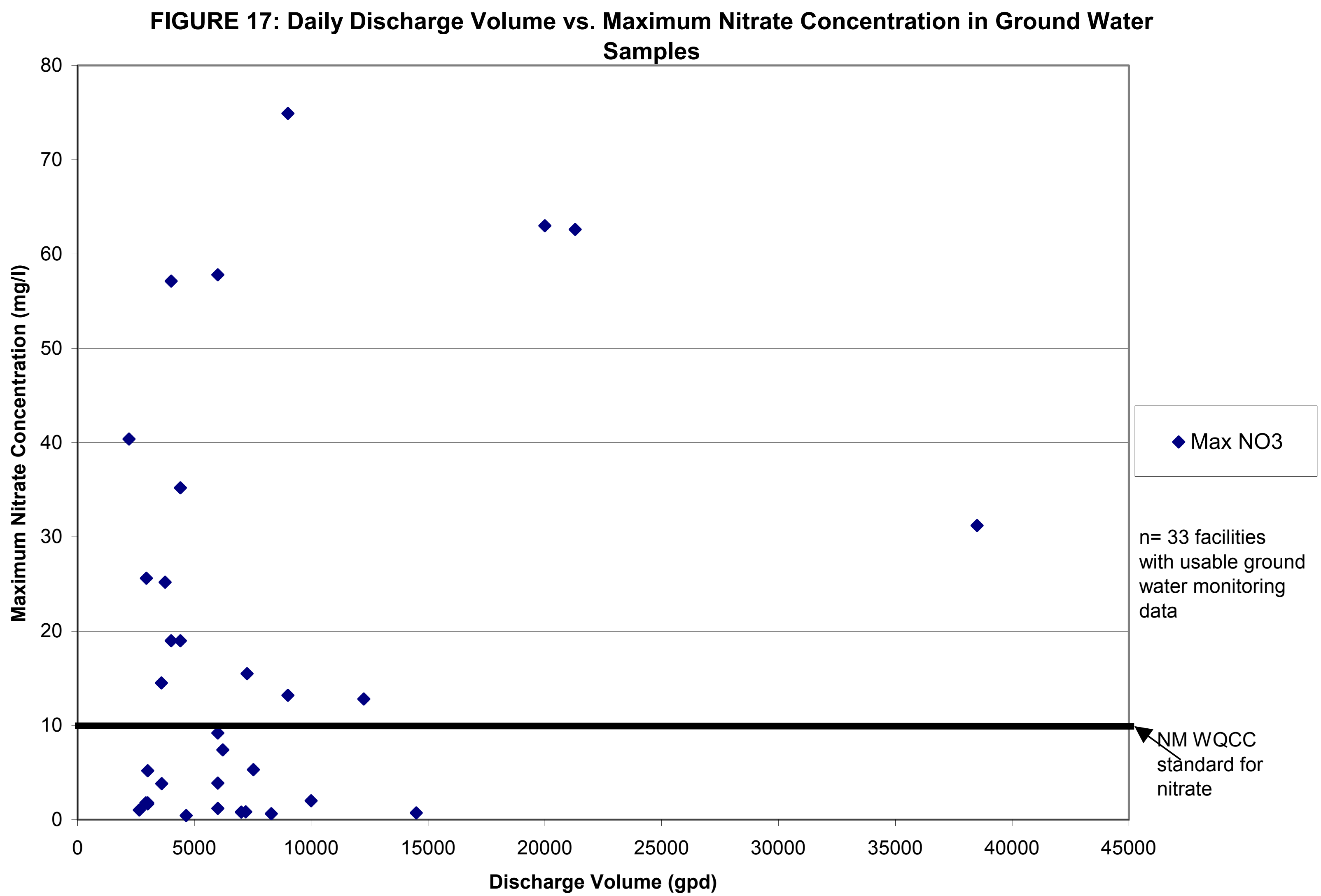


FIGURE 17: Daily Discharge Volume vs. Maximum Nitrate Concentration in Ground Water Samples
Maximum Nitrate Concentration (mg/l)
80
70
60
50
40
30
20
10
0
0
5000
10000
15000
20000
25000
30000
35000
40000
45000
Discharge Volume (gpd)
Max NO3
n= 33 facilities with usable ground water monitoring data
NM WQCC standard for nitrate

FIGURE 18: Percent of Facilities with Monitoring Data that Have Samples that Exceed Standards for Nitrate and Total Nitrogen According to Discharge Volume

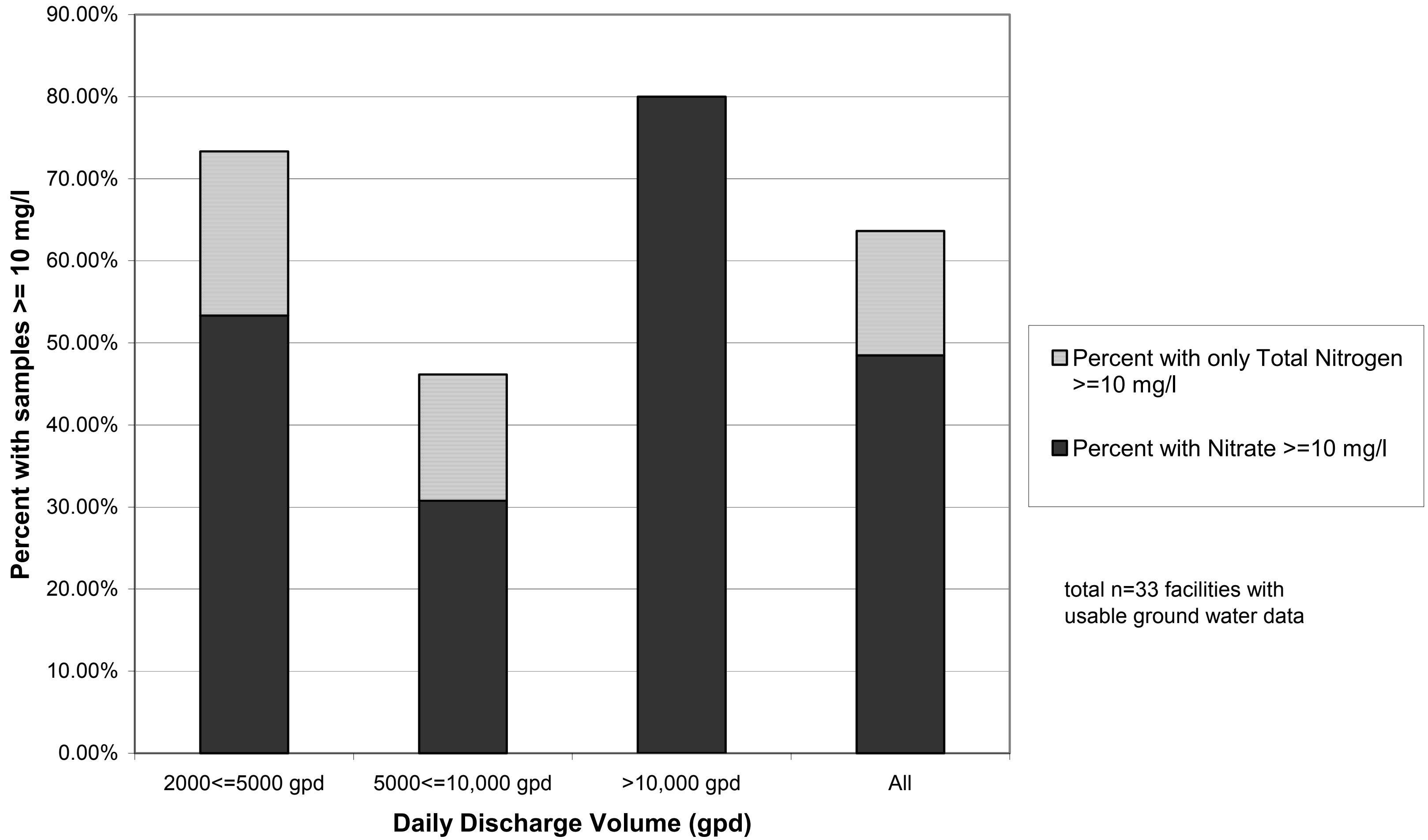


FIGURE 19: Depth to Ground Water vs. Maximum Nitrate Concentration in Ground Water Samples

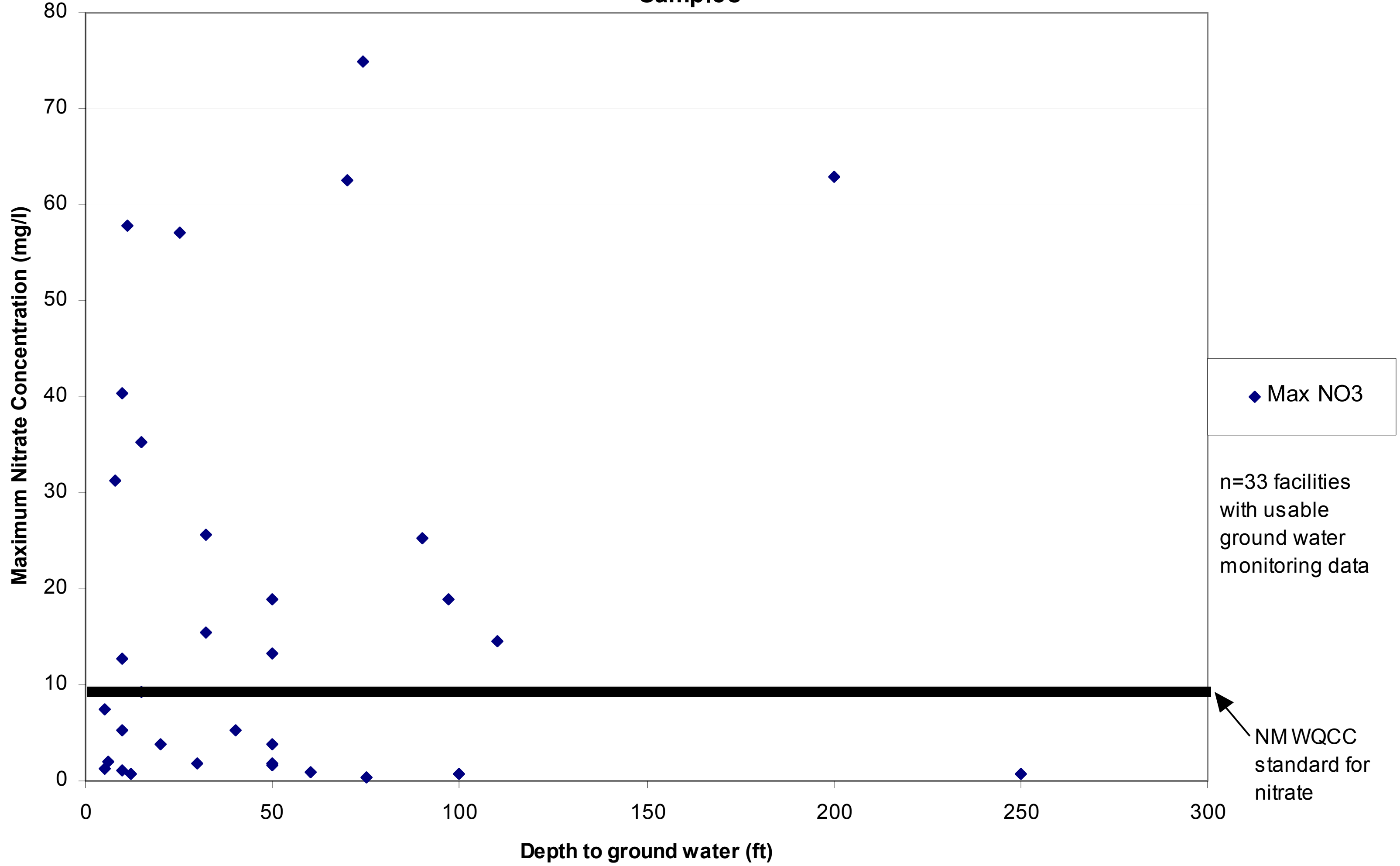


FIGURE 20: Average Nitrate and Total Nitrogen in Ground Water Samples from Different Facility Types

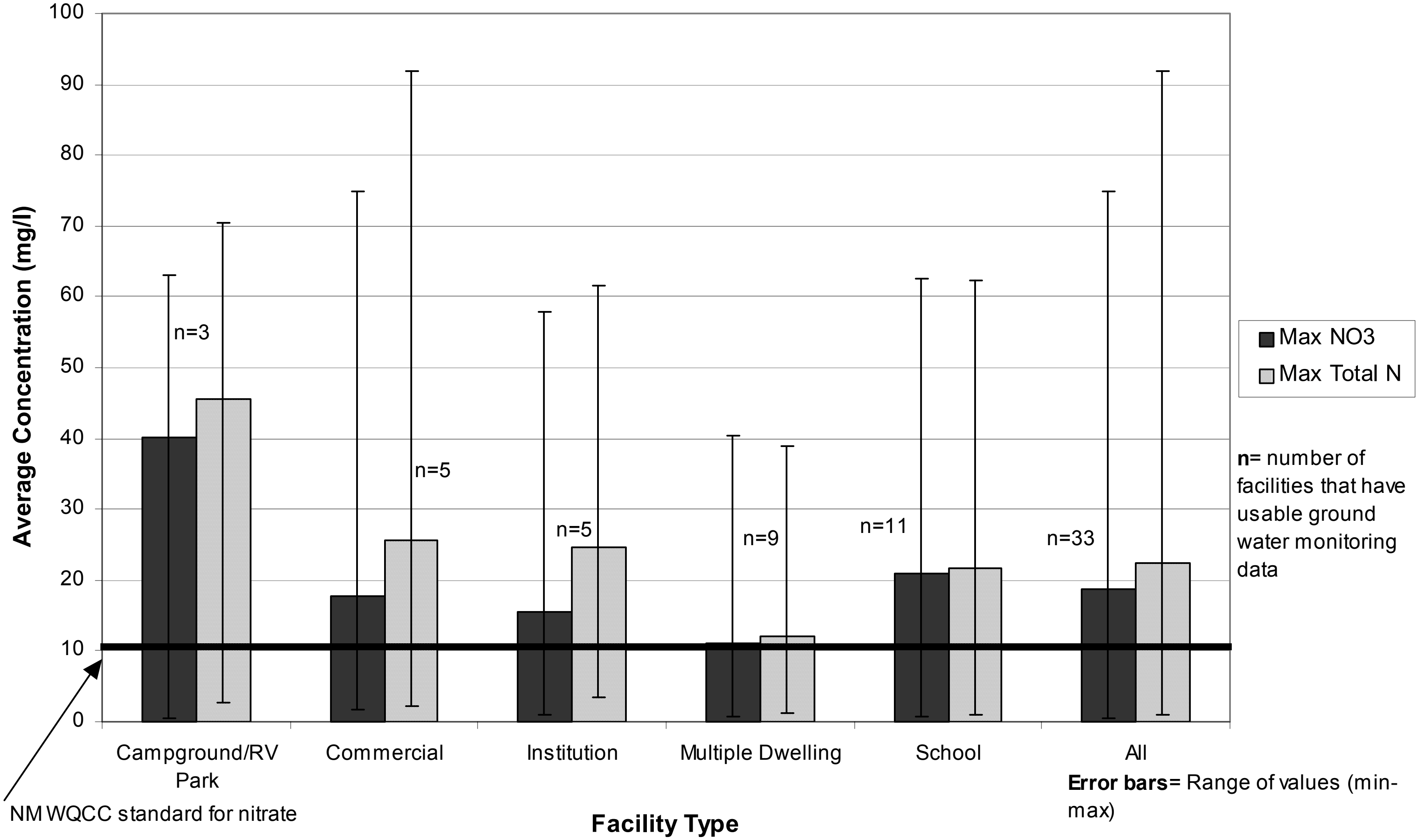


FIGURE 21: Percent of Facilities with Monitoring Data that Have Samples that Exceed Standards for Nitrate and Total Nitrogen According to Facility Type

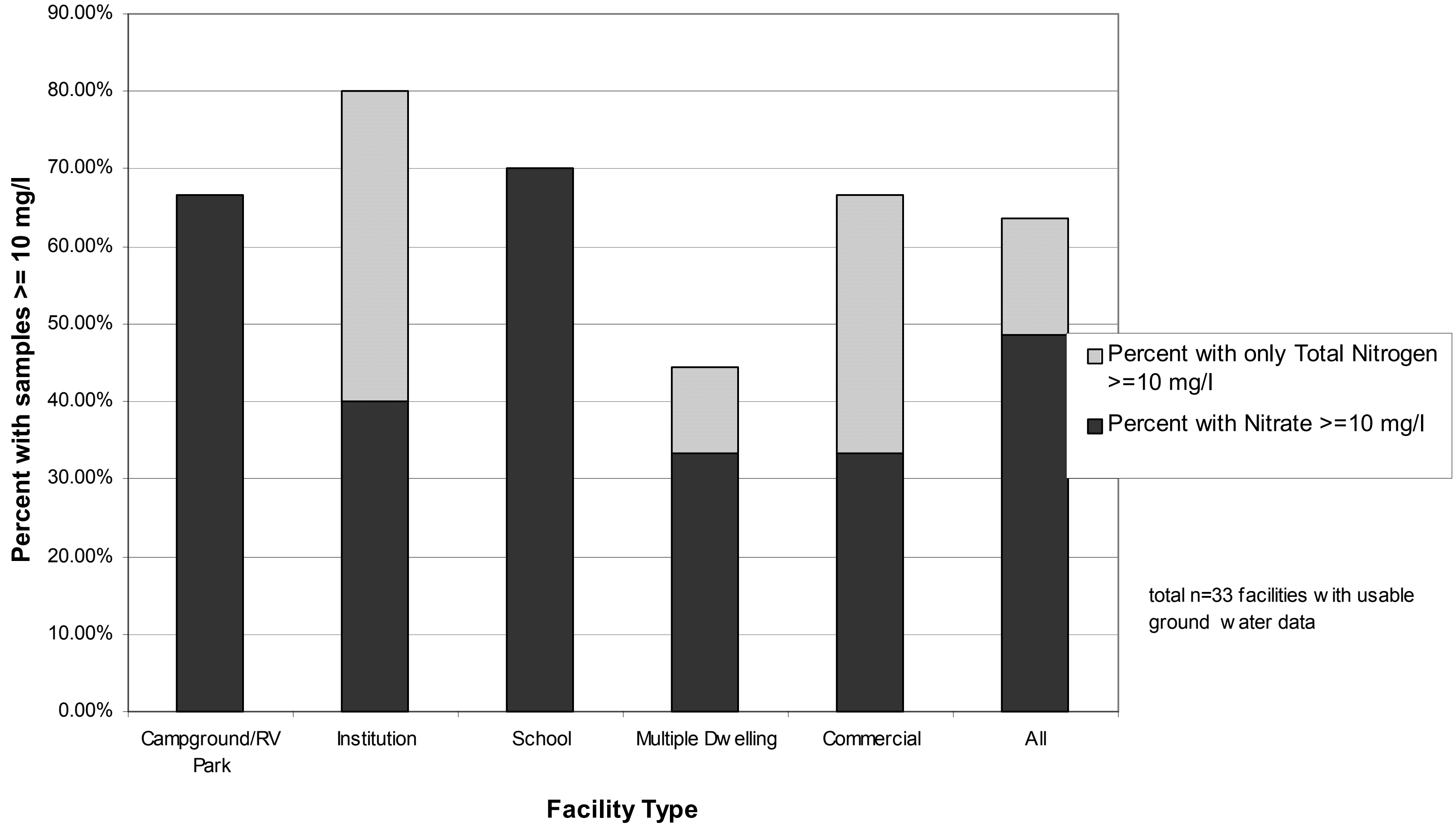


FIGURE 22: Maximum Concentration of Total Nitrogen in Ground Water vs. Maximum Concentration of Total Dissolved Solids (TDS) in Ground Water

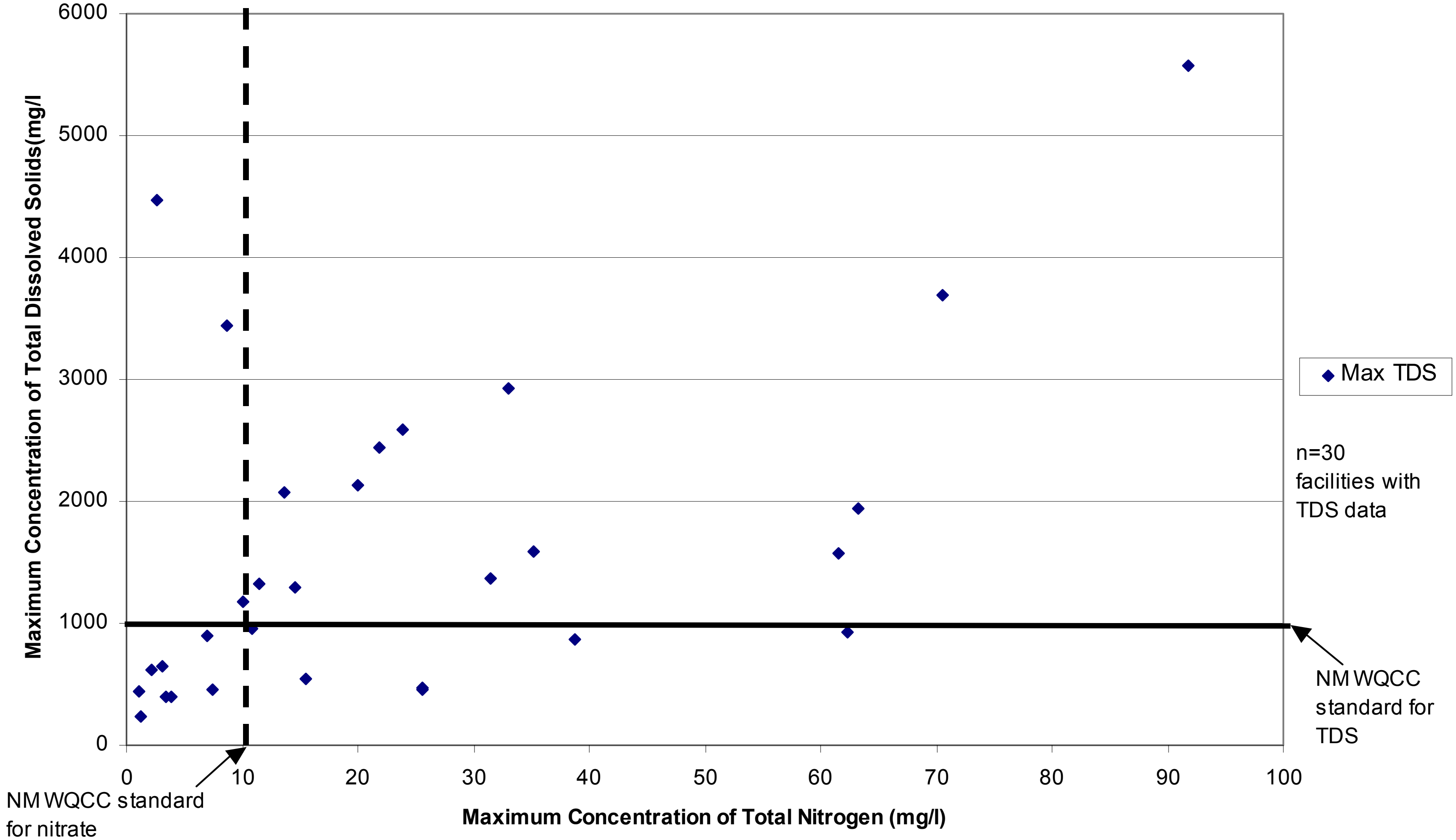
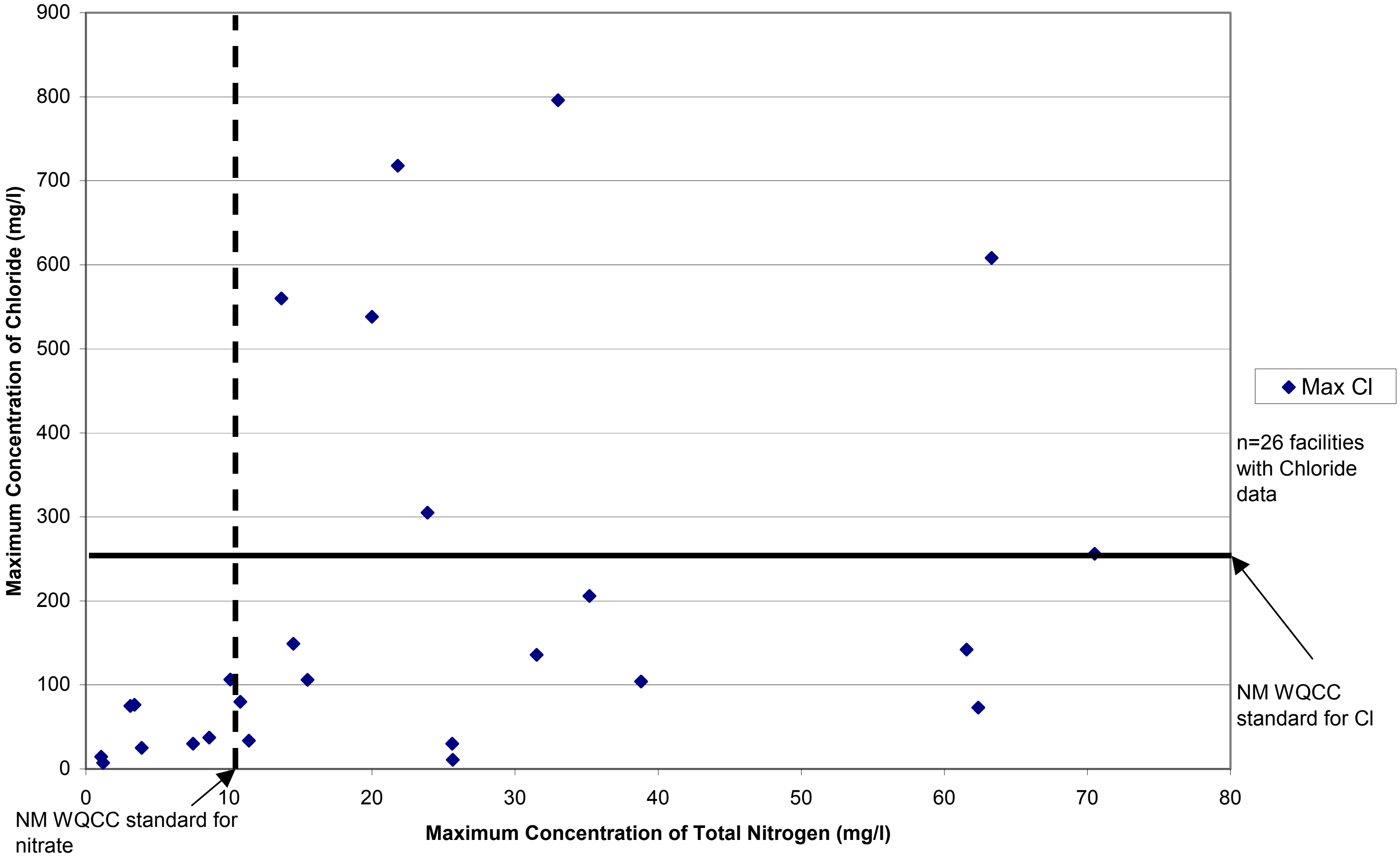


FIGURE 23: Maximum Concentration of Total Nitrogen in Ground Water vs. Maximum Concentration of Chloride (Cl) in Ground Water



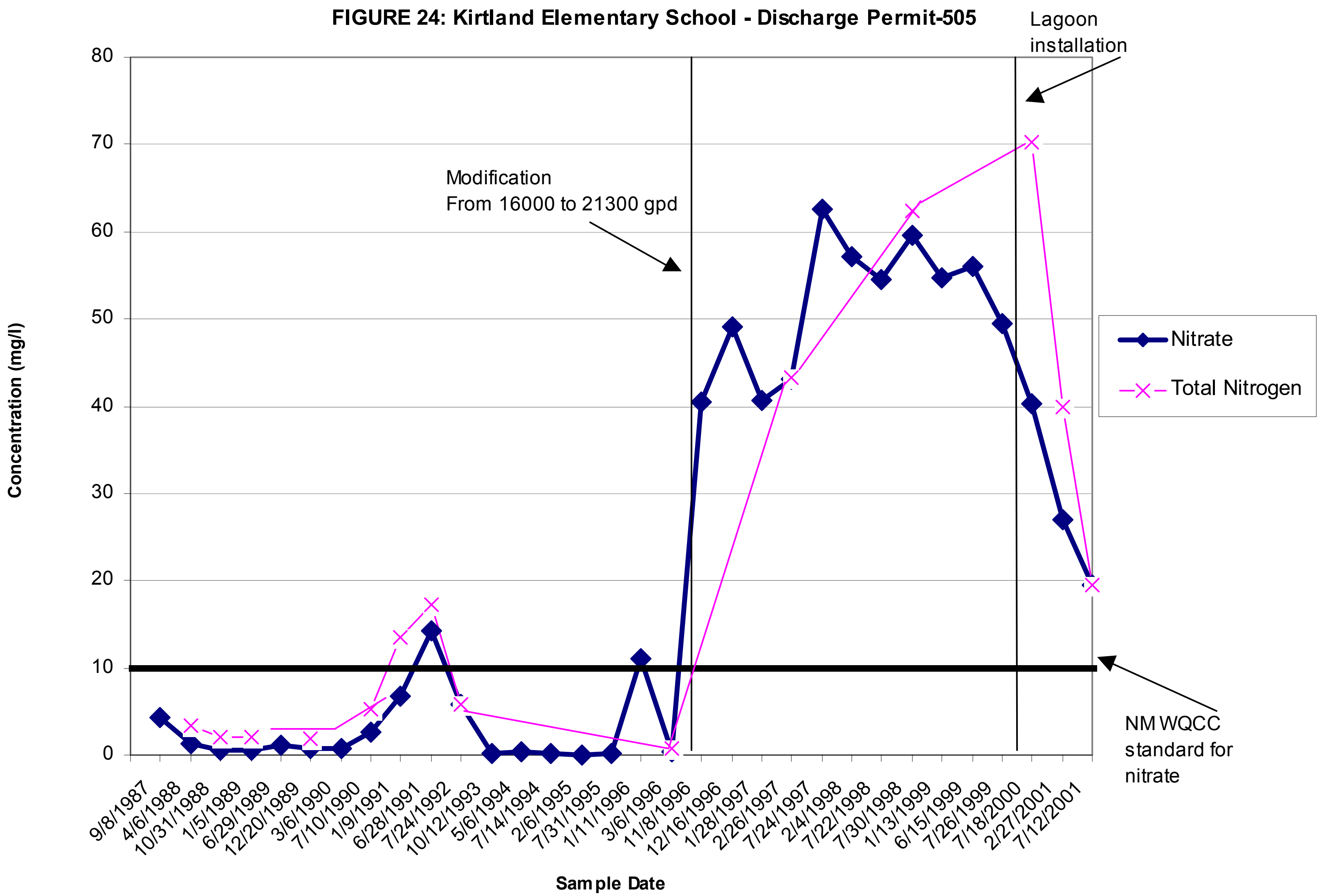
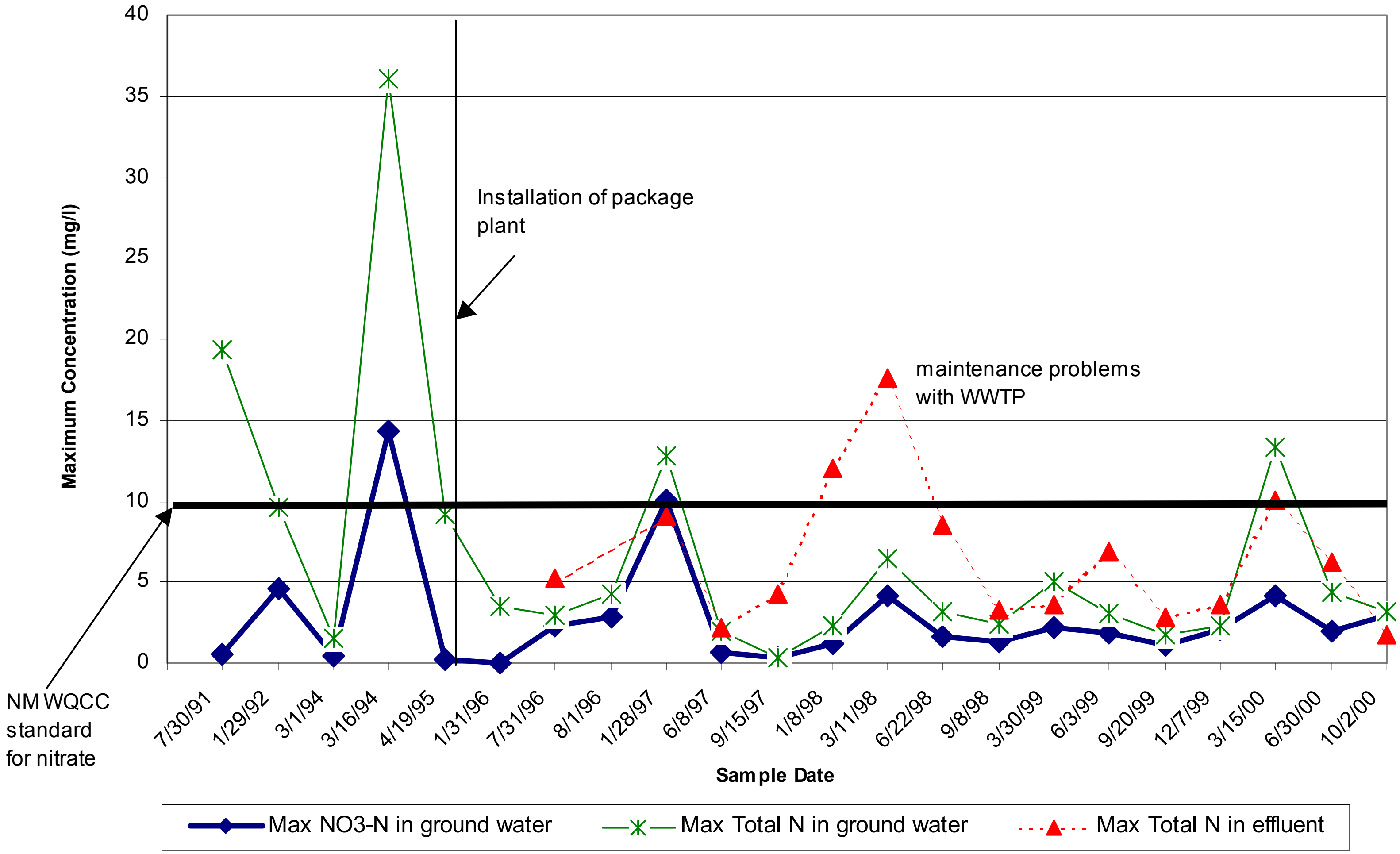


FIGURE 24: Kirtland Elementary School - Discharge Permit-505
Lagoon installation
Modification
From 16000 to 21300 gpd
Concentration (mg/l)
Sample Date
Nitrate
Total Nitrogen
NM WQCC standard for nitrate
0
10
20
30
40
50
60
70
80
9/8/1987
4/6/1988
10/31/1988
1/5/1989
6/29/1989
12/20/1989
3/6/1990
7/10/1990
1/9/1991
6/28/1991
7/24/1992
10/12/1993
5/6/1994
7/14/1994
2/6/1995
7/31/1995
1/11/1996
3/6/1996
11/8/1996
12/16/1996
1/28/1997
2/26/1997
7/24/1997
2/4/1998
7/22/1998
7/30/1998
1/13/1999
6/15/1999
7/26/1999
7/18/2000
2/27/2001
7/12/2001

FIGURE 25: Penasco Schools - Discharge Permit-731



Appendix I

NM ENVIRONMENT DEPARTMENT - GROUND WATER POLLUTION PREVENTION SECTION
MONITORING WELL CONSTRUCTION AND ABANDONMENT GUIDELINES

Purpose: These guidelines provide minimum construction and abandonment standards for drilled monitoring wells to be sampled for general chemistry analyses. There may be additional requirements if hydrocarbons or other chemicals are involved. Different guidelines may also apply for other types of well construction (eg., driven wells)

General Drilling Specifications:

1. No contaminants shall be present in the drilling fluids.
2. All drill bits, drill rods, and down-hole tools shall be thoroughly cleaned immediately prior to the start of drilling. The bore hole diameter shall be drilled a minimum of 4 inches larger than the casing diameter to allow for the emplacement of sand and sealant.
3. After completion, the well should be allowed to stabilize for 24 hours before development is initiated.
4. The well shall be developed so that formation water flows freely through the screen and is not turbid, and all sediment has been removed from the well.

Well Specifications: (Refer to figure on reverse side.)

1. Schedule 40 or heavier PVC pipe, not less than 2 inches ID, shall be used as casing. The casing shall extend from the top of the screen to at least one foot above ground surface. No glues shall be used at casing joints; threaded PVC is preferred. The top of the casing must be protected by a cap, and the exposed casing must be protected by a locking shroud. The shroud shall be large enough in diameter to allow easy access for removal of the plastic cap on the PVC casing.
2. A 20-foot section of machine slotted or other manufactured screen shall be installed. A slot size of 0.010-inch is generally adequate for most installations. (No hack-saw slotting.)
3. The top of the screen shall be 5 feet above the water table to allow for seasonal fluctuations. A variance should be sought for screening intervals in very shallow groundwater (< 10 feet).
4. The screen section shall have centralizers at the top and bottom.
5. The annular space from 2 feet below the bottom of the screen to 2 feet above the top of the screen shall be packed with clean, medium to coarse sand. The sand pack shall be properly sized to prevent fine particles in the formation from entering the well. For wells deeper than 30 feet, the sand shall be placed by a tremmie pipe. The well should be surged or bailed to settle the sand pack and additional sand added, if necessary, before the bentonite/cement is emplaced.
6. The annular space above the sand pack shall be grouted or sealed at least 2 feet above the sand pack. Pressure grouting with bentonite or cement using a tremmie pipe is preferred. An alternative is to form a bentonite seal by emplacing and hydrating bentonite pellets (0.25 or 0.5 inch in size). Adequate time should be allowed for the bentonite/cement to cure before placing materials on top of the seal. The annular space above the bentonite/cement seal can be filled with uncontaminated drill cuttings, clean sandy clay or fine grained soil to within 10 feet of the ground surface. The remaining 10 feet must be sealed with a bentonite-cement grout seal (2 to 8% bentonite by weight) and allowed to cure for at least 24 hours before installing a surface pad.
7. A 2-foot minimum radius, 4-inch minimum thickness concrete pad shall be poured around the shroud. The concrete and surrounding soil shall be sloped to direct rainfall and runoff away from the shroud.

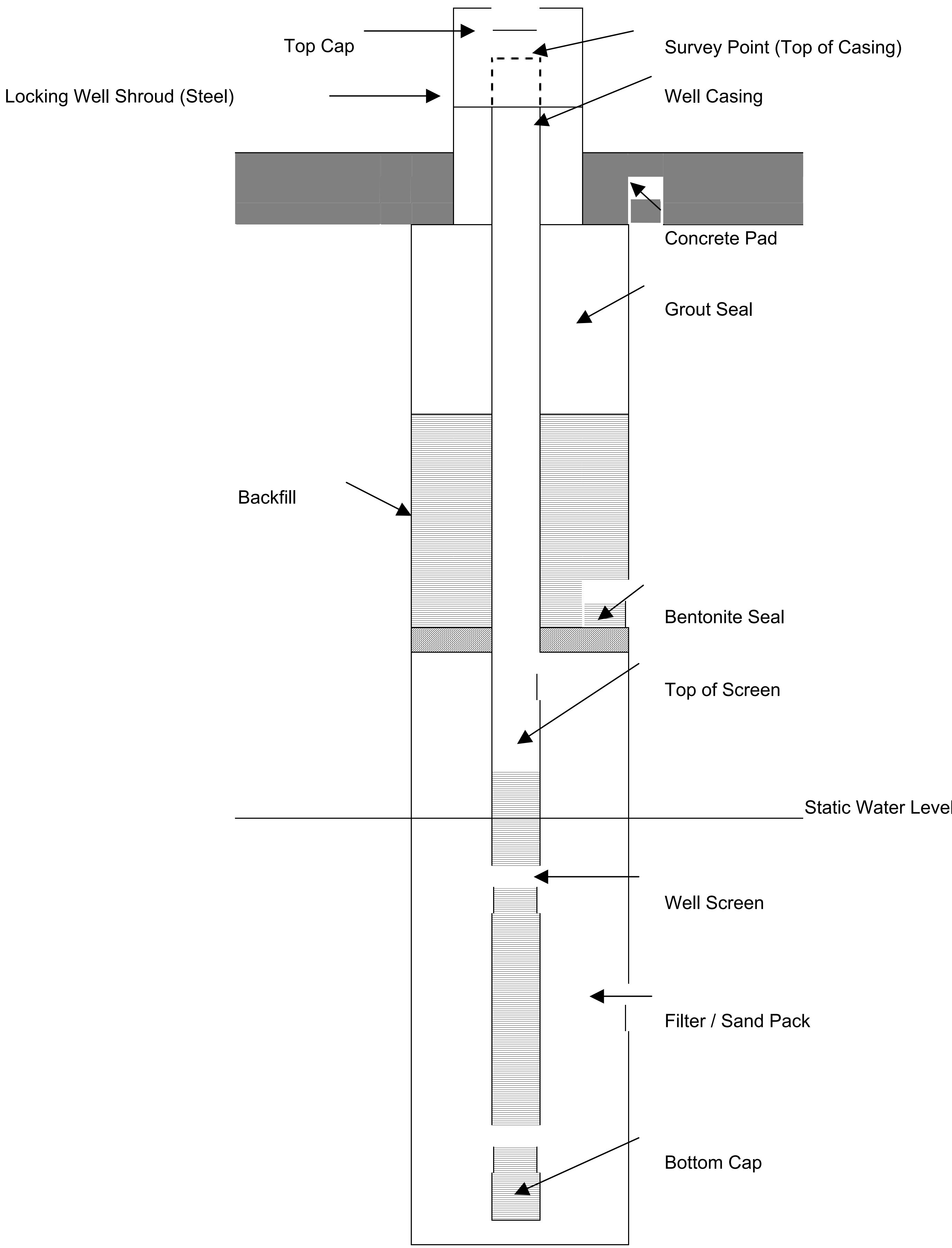
Abandonment:

1. Monitoring wells no longer in use shall be plugged in such a manner as to prevent migration of surface runoff or ground water along the length of the well casing. Where possible, this shall be accomplished by removing the well casing and pumping expanding cement from the bottom to the top of the well using a tremmie pipe. If the casing cannot be removed, the casing shall be ripped or perforated and pressure grouted along its entire length.
2. Filling with bentonite pellets from the bottom to the top is an acceptable alternative to pressure grouting.
3. After abandonment, written notification must be submitted to the GWPPS with date and method of abandonment.

Variances: Requests for variances from these guidelines shall be submitted in writing to the Program Manager, NMED Ground Water Pollution Prevention Section (GWPPS), 1190 St. Francis Drive, P.O. Box 26110, Santa Fe, NM 87502. Each request shall explain in detail the evidence supporting the request. The GWPPS approval also shall be in writing.

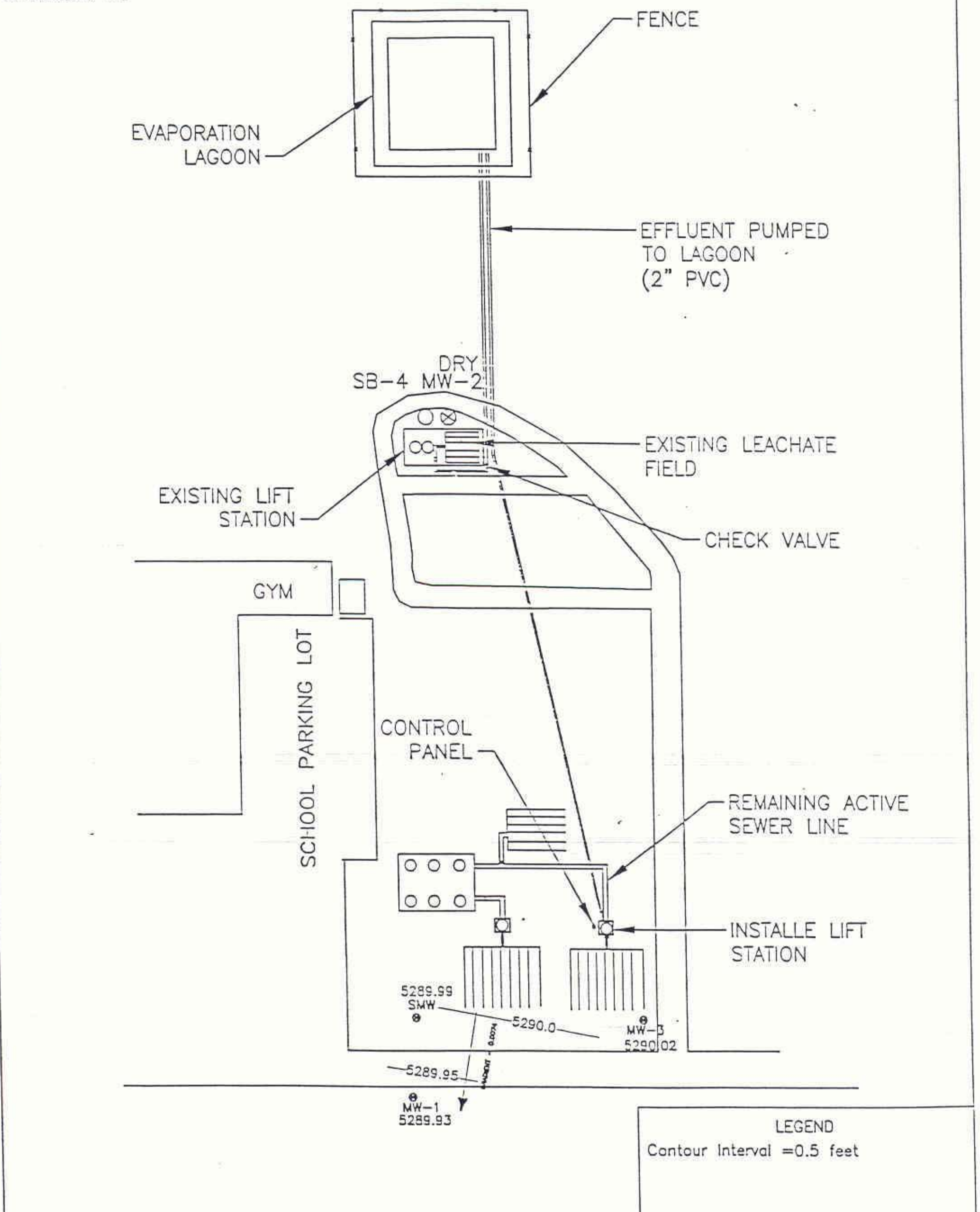
Signed: ______________________________ Date:

Maura Hanning, Program Manager, GWPPS



Generalized Monitoring Well Schematic (Not to Scale)

APPENDIX II



CENTRAL CONSOLIDATED SCHOOLS
KIRTLAND ELEMENTARY

ENVIROTECH INC.

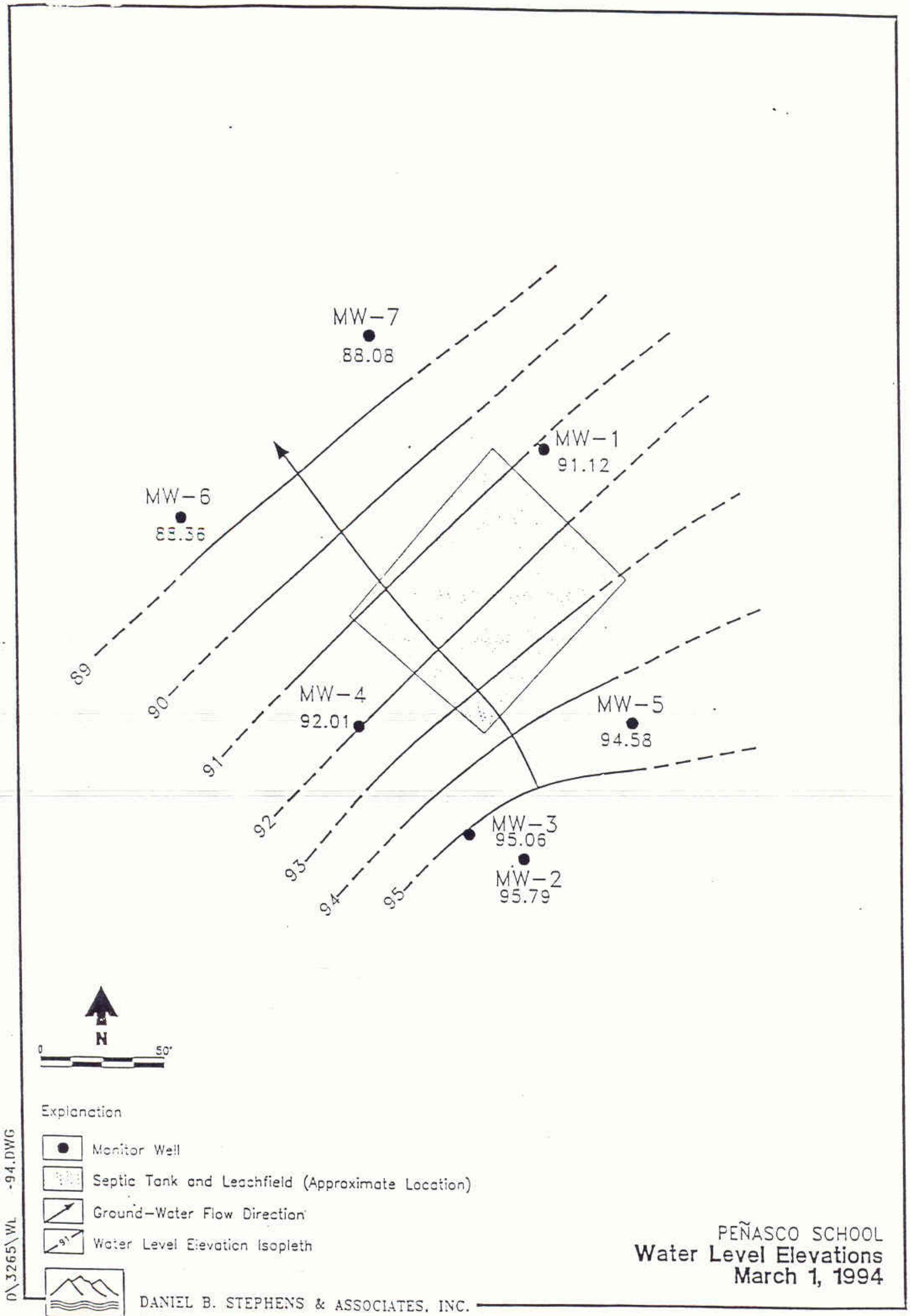
WATER ELEVATIONS

REVISIONS
BY TLC DATE 03/02/1
BY ___ DATE ______

PRJ #97042-014

ENVIRONMENTAL SCIENTISTS & ENGINEERS
5796 U.S. HIGHWAY 64
FARMINGTON, NEW MEXICO 87401
(505) 632-0615

DATE 07/24/01 DRAWN SB
SCALE 1"=150' APPROVED CJC
FIGURE 1



PEÑASCO SCHOOL
Water Level Elevations
March 1, 1994

DANIEL B. STEPHENS & ASSOCIATES, INC.
5-94
JN 3265

Figure 4