TOOELE
COUNTY

SEPTIC SYSTEM DENSITY STUDY

(HAL Project No.: 283.02.101)

May 2016

HANSEN
ALLEN
& LUCE INC
ENGINEERS

TOOELE COUNTY

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EXECUTIVE SUMMARY

This report summarizes the results of an evaluation of the impact of septic system discharges into groundwater within the Tooele Valley. The study area includes the unincorporated areas north and east of Tooele City and Grantsville. The purpose of the report is to recommend septic system densities that will protect groundwater for drinking water supplies.

A review of septic system density related studies demonstrates that throughout the United States, high septic system densities often result in degradation of groundwater quality. Existing regulations promulgated by the Utah Division of Drinking Water and Division of Water Quality provide a basis for Tooele County to implement septic system density limitations for the protection of groundwater.

Nitrate is used as an indicator of septic system groundwater pollution because it is persistent in the groundwater, is easy to monitor, and there is a reliable historical record from existing groundwater sources. Groundwater in Tooele Valley has been classified by the U.S. Geological Survey as Class I-A Pristine and Class II Drinking Water quality. Background nitrate concentrations in the mountain areas upgradient from human development in the Tooele Valley are less than 1 mg/L based on available information. Areas within Tooele Valley that are downgradient of development (including septic systems) have nitrate concentrations from 2 to 5 mg/L.

The study area was divided into 4 smaller subareas based upon hydrogeologic conditions and groundwater flow paths within the valley. These include the Lakepoint Subarea, East Erda Subarea, Erda / Lincoln Subarea, and West Erda Subarea. Hydrogeologic data for each subarea was used in a mass balance approach with risk analysis to determine septic system densities that would prevent nitrate concentrations from degrading to above 5 or 6 mg/L. The recommended septic system density is 6 acres per septic system in the Lakepoint Subarea and 5 acres per septic system in the other 3 subareas. Consideration should be made for existing subdivisions that currently exceed these densities (as dense as 1.2 acres per septic system).

CHAPTER 1 - INTRODUCTION

BACKGROUND

Tooele Valley is located between the Oquirrh Mountains and the Stansbury Mountains southwest of the Great Salt Lake. Urban development within the valley has been rapid over the past 20 years leading to the construction of large residential subdivisions. Many of these subdivisions have been located within the service areas of municipal sewer systems (Tooele City, Grantsville) or special service districts (Stansbury Park Improvement District, Lake Point Improvement District) to collect and treat wastewater. However, there have been an increasing number of subdivisions planned and developed in areas of the county that currently are not served by a sanitary sewer system. Consequently, the number of septic systems has increased significantly.

In 1998, the Utah Geological Survey (UGS) prepared a report presenting the potential impacts of septic systems on groundwater quality in the Tooele Valley (Wallace and Lowe, 1998). Wallace and Lowe concluded that a maximum of 3,000 septic systems could be supported by the Tooele Valley aquifer system with 1 mg/L degradation of nitrate concentration from the reported background nitrate concentration of 2.5 mg/L. This would maintain an overall nitrate concentration of 3.5 mg/L. The UGS study has been used as guidance for the approval of residential developments in unsewered areas. While it is useful for overall averaging of the dilution of septic system discharge in the groundwater, the calculations used in the Wallace and Lowe (1998) study "*do not account for localized, high-concentration nitrate plumes associated with individual or clustered septic-tank systems.*" It also does not factor in the issue of a mixing depth of nitrate but rather assumes "*uniform, instantaneous ground-water mixing for the entire aquifer below the site.*"

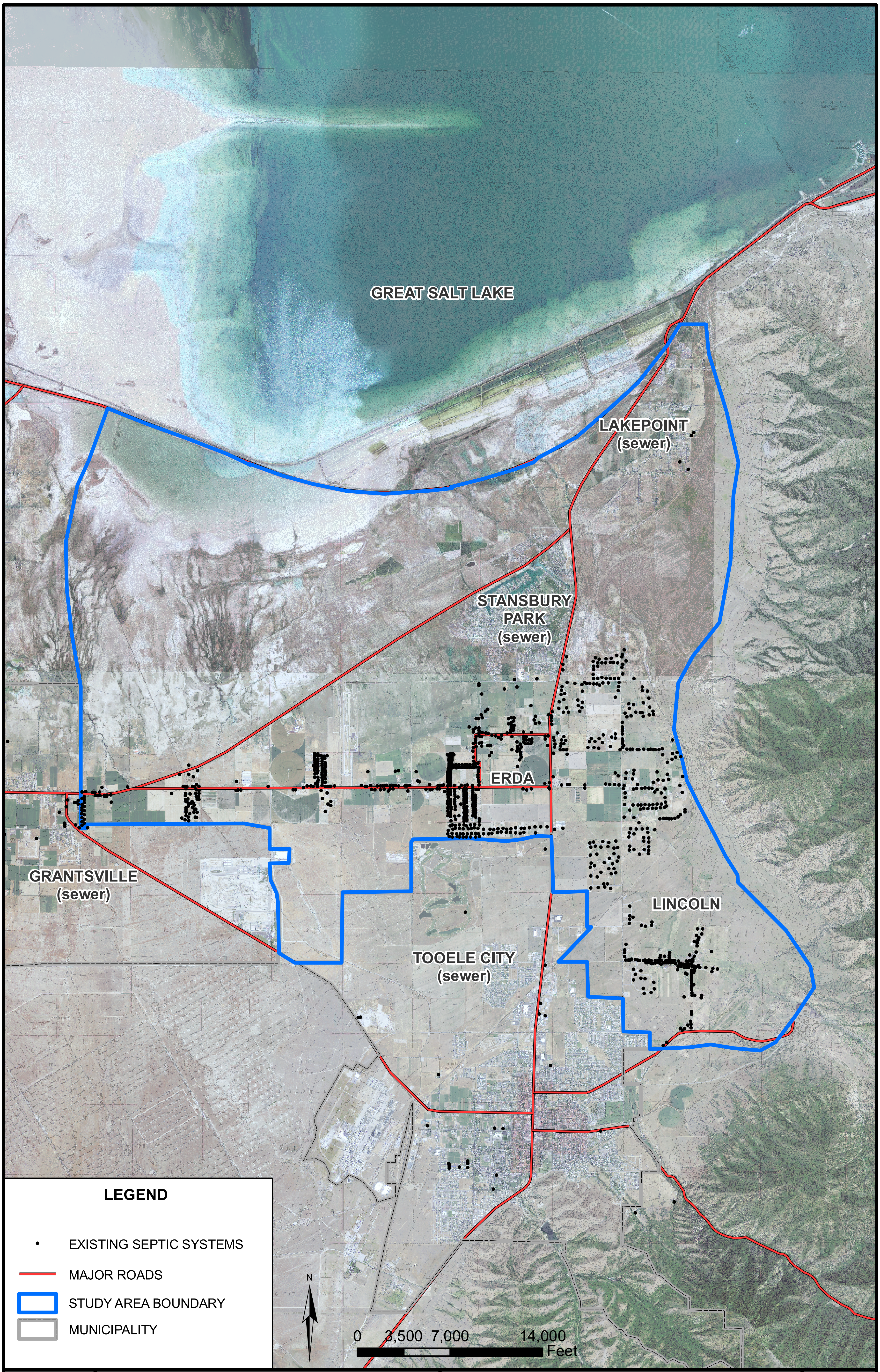
Tooele County is now in the process of preparing a sewer master plan for the unincorporated portions of the Tooele Valley. An important consideration for the scope and timing of the development of capital facilities for the master plan is the effect that recently constructed and planned future residential developments with septic systems may have upon groundwater quality. Consequently, Tooele County retained Hansen, Allen & Luce, Inc. (HAL) to perform a septic system density study to predict the effects of existing septic systems upon groundwater quality and to predict reasonable septic system densities.

STUDY AREA

The study area was identified by Tooele County as the unincorporated areas not served by a sanitary sewer system within the Tooele Valley. Figure 1-1 shows the study area, the areas served by a sanitary sewer system, and the locations of existing septic systems within the valley.

PURPOSE

The purpose of this study was to recommend septic system densities (number of acres per septic system) for Tooele Valley. Implementation of the recommended densities will help prevent excessive degradation of groundwater quality. This study relied on existing geologic, water resources, water quality, and land use data together with septic system density determination procedures developed by HAL.



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SEPTIC SYSTEM DENSITY STUDY

STUDY AREA AND
EXISTING SEPTIC SYSTEMS

FIGURE
1-1

CHAPTER 2 – SEPTIC SYSTEM RELATED POLLUTION

BACKGROUND

Septic tank/soil absorption systems were originally developed in France during the 1860's as a means for disposing of human wastes, and for preventing the spread of pathogens (Canter and Knox, 1985 and DeFeo, Wait & Associates, 1991). Septic systems typically consist of a buried tank (septic tank) and a soil absorption system (leach field). A typical septic system is shown in Figure 2-1. The septic tank is designed to remove scum, grease and settleable solids from wastewater by gravity separation. Bacteria then treat or reduce the organic portion of these materials anaerobically (without oxygen) in the septic tank. The partially treated wastewater is then evenly distributed by piping to the leach field for aerobic treatment (with oxygen) of the remaining pollutants in the underlying soils.

EFFECTIVENESS OF SEPTIC SYSTEMS

Septic systems, if designed, installed, and maintained correctly, can be an effective means of preventing the spread of pathogens and other harmful substances. They function well when considering the parameters within which they are intended to operate. However, septic systems are not perfect wastewater disposal systems. They do not remove 100% of the pollutants associated with residential wastewater. There are some remaining pollutants which are discharged to the environment. How then do regulators, planners and designers deal with these remaining pollutants to help ensure that public health and the environment are protected to acceptable levels? In part the answer lies in the old adage: “Dilution is the Solution to Pollution.” This means that there must be sufficient groundwater available to decrease, or dilute, the concentration of remaining pollutants to an acceptable level.

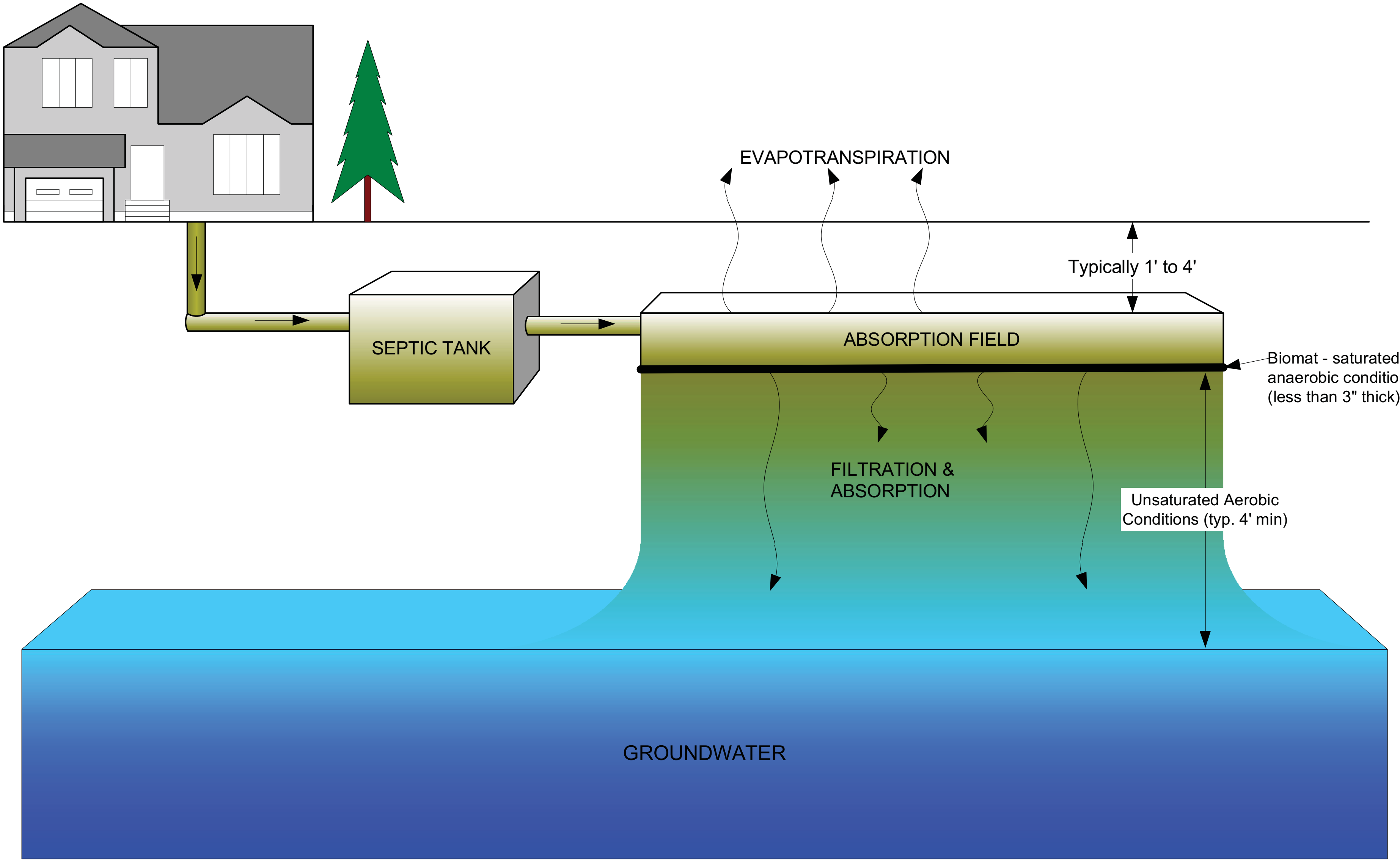
Therein lies the dilemma associated with septic systems. Septic systems are effective for waste disposal, but at what point do they become a problem? The answer to that question depends on the assimilative capacity of the underlying groundwater. The overall effectiveness of septic systems, including their impact on the environment, is dependent on the determination of appropriate septic system densities (number of septic systems per unit of land area). Appropriate densities help maintain adequate dilution potential in the underlying groundwater. The lower the development density, the higher the dilution potential will be.

KEY FACTORS

The U.S. Congress Office of Technology Assessment (OTA) stated that “*Major factors affecting the potential of septic systems to contaminate groundwater in general are the density of systems per unit area and hydrogeological conditions. Areas with a density of more than 40 systems per square mile (1 unit per 16 acres) are considered regions with potential for contamination.*” (OTA, 1984)

SEPTIC SYSTEM RELATED WATER QUALITY STUDIES

Septic system related water quality studies in other locations within the United States confirm that excessive densities of septic systems can result in water quality degradation. Table 2-1 summarizes several septic system water quality studies performed across the nation.



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TYPICAL SEPTIC SYSTEM

FIGURE
2-1

Table 2-1
Summary of Septic System Related Water Quality Studies

Reference	Location	Summary / Description
Woodward, et al. (1961)*	Coon Rapids, Minnesota	Correlated well contamination to septic system density. • Areas with 7.4 acres/septic system had 2% of wells contaminated with nitrate. • Areas with 1.5 acres/septic system had >29% of wells contaminated with nitrate.
Miller (1972, 1975)*	Delaware	Recommended increase of lot sizes from 0.5 to 2.0 acres for homes with septic systems due to: • 25% of shallow wells with nitrate concentrations twice the background levels (4.5 mg/L as nitrogen). • Nitrate concentrations up to 31 mg/L as nitrogen in areas with 0.25 to 0.5 acre lot sizes.
Walker, et al. (1973a, 1973b)*	Wisconsin	Estimated maximum septic density of 2 septic systems/acre to keep groundwater nitrate concentration below 10 mg/L as nitrogen.
Geraghty and Miller (1978)*	Long Island, New York	Correlated septic density to groundwater nitrate concentration from 865 samples at 54 wells. Samples exceeded 10 mg/L as nitrogen at rates of: • 50% in areas with septic densities >2.8 septic systems/acre and • <10% in areas with septic densities less than 1.25 septic systems/acre.
Konikow and Bredhoeft (1978)*	New Mexico	Evaluated septic density effects using a computer simulation concluding that it may take decades to reach steady state nitrate concentration from septic systems. Predicted 10-year nitrate concentrations of: • 60 mg/L as nitrogen with 0.25 acre lots • 35 mg/L as nitrogen with 1.2 acre lots
Ford, et al. (1980)*	Jefferson County, Colorado	Associated groundwater nitrate contamination to increasing septic density. Where densities exceeded 1 septic system/acre and wells were within 100 feet of septic systems, nitrate concentrations exceeded 20 mg/L as nitrogen.
Trela and Douglas (1978)*; Brown (1980)*; Tateman and Lee Associates, Inc. (1983)*	New Jersey; Texas; Delaware	Trela and Douglas (1978) developed model to determine septic density required to keep groundwater nitrate concentration below 10 mg/L as nitrogen in sandy soils in New Jersey. This model was adapted by Brown (1980) and Tateman and Lee Associates, Inc. (1983) for Texas and Delaware, respectively. Results by state were as follows: • 0.8 acres/septic system in New Jersey • 0.34 acres/septic system in Texas • 1 acre/septic system in Delaware
Holzer (1975)*; Peavy and Brawner (1979)*; Starr and Sawhney (1980)*	No specific area indicated	Recommend septic system densities less than 1 septic system/acre in well drained soils.
Olivieri, et al. (1981)*	No specific area indicated	Indicated that septic densities exceeding one septic system per 1.4 acres may threaten groundwater quality and public health.
California Regional Water Quality Control Board (2002)	Los Osos, California	Community information flyer documenting shallow groundwater quality degradation. Stated that previous studies (not referenced) on the aquifer revealed that elevated groundwater nitrate concentrations are mostly due to septic systems.
Verstraeten, et al. (2004)	Eastern Nebraska	Analyzed water samples from 26 shallow domestic wells in a shallow unconfined aquifer along the Platte River for tracers from septic system effluent. Found tracers derived from septic systems in several of the sampled wells. Wells completed less than 45 feet deep, or were within 100 feet of a septic system, or where the water table was less than 10 feet deep were more vulnerable to contamination from septic systems.

Reference	Location	Summary / Description
Bleifuss, et al. (1998)	Long Island, New York	Nitrate pollution above the drinking water standard led to closure of several public water supply wells. Nitrogen and Oxygen isotopes and other geochemical data were used to determine the source of the nitrate. Results of the investigation included: • Nitrate is primarily from nitrification of ammonium in the soil. • Influence from septic system wastes was evident in shallower wells • About 50% of nitrate may be derived from turf grass fertilization • "The closure of the shallower wells….clearly demonstrates that changes in residential land use practices are necessary to protect the quality of groundwater."
Thiros (2000)	Great Salt Lake Basins in Utah, Idaho, and Wyoming	USGS Water Resources Investigations Report 00-4043 evaluated nitrate concentrations in wells by land use. Resulting concentrations were as follows: • Agricultural areas = 1.41 mg/L as nitrogen • Urban/Residential = 1.20 mg/L as nitrogen • Rangeland = 0.76 mg/L as nitrogen
McQuillan (2006)	Middle Rio Grande Valley, New Mexico	Observed that "septic tanks were never intended for use in closely built-up areas." Indicated that the addition of BOD from high densities of septic systems can reduce dissolved oxygen in groundwater. While this does result in denitrification, it also results in anaerobic degradation byproducts such as iron, manganese, and sulfate. Presented the following: • Aerobic groundwater: nitrate >2.0 mg/L as nitrogen, iron and manganese rarely detected • Anaerobic groundwater (downgradient from aerobic groundwater): iron >0.3 mg/L, nitrate not detected.

* As referenced by Brown and Bicki (1987)

CHAPTER 3 – REGULATORY CONSIDERATIONS

The purpose of this chapter is to consider regulatory alternatives that may affect the determination of allowable or advisable septic system densities.

POLICY CONSIDERATIONS

Currently, the overall State of Utah water quality protection policy is “anti-degradation.” The following policy alternatives regarding further septic system usage are appropriate for consideration by Tooele County:

- Non-degradation = no decrease in groundwater quality
- Anti-degradation = degradation allowed to an acceptable limit
- Selective degradation = degradation allowed in selected areas to an acceptable limit

TOOELE COUNTY

Tooele County Health Department

In Utah, local health departments have the primary responsibility for assuring that proposed individual wastewater disposal systems, including septic tank leach field systems, will not have an adverse impact upon water quality. The Utah Department of Environmental Quality has adopted minimum standards for local health departments to use in assessing the adequacy of proposed individual wastewater disposal systems. The Utah Administrative Code gives local health departments the authority to determine the minimum lot size based upon a number of factors as discussed in this chapter.

Tooele County Commission

The Tooele County Commission determines minimum lot sizes for developments within the County that are installing sanitary sewer systems. When septic systems are proposed for developments, the County Commission seeks guidance from the Health Department to determine minimum lot sizes based on State of Utah requirements for septic systems.

STATE OF UTAH

Utah Drinking Water Board

The State of Utah and the Utah Drinking Water Board have developed a number of administrative rules, policies, and programs which relate to the protection, development, and use of water for drinking water purposes. Some of these relate to the use of septic systems.

The Utah Drinking Water Board and Utah Division of Drinking Water have primary responsibility for regulating all community water systems to ensure that public drinking water meets State primary and secondary standards. Source water drawn from groundwater supplies must meet primary and secondary standards. Primary standards specify a maximum contaminant level (MCL) for organic, inorganic, and microbiological contaminants, as well as for turbidity and radioactivity. Secondary standards address taste, odor, color, and other conditions associated with drinking water aesthetics. Inorganic contaminants are generally considered good indicators of potential pollution sources like septic systems. State of Utah standards for inorganic contaminants (R309-200) are presented in Table 3-1.

Table 3-1
Utah Primary and Secondary Inorganic Drinking Water Standards

Primary Inorganic Standards		Secondary Inorganic Standards	
Parameter	Maximum Contaminant Level	Parameter	Maximum Contaminant Level
Antimony	0.006 mg/L	Aluminum	0.05 – 0.2 mg/L
Arsenic	0.010 mg/L	Chloride	250 mg/L
Asbestos	7 million fibers/L (>10 µm)	Color	15 Color Units
Barium	2 mg/L	Copper	1 mg/L
Beryllium	0.004 mg/L	Corrosivity	Non-corrosive
Cadmium	0.005 mg/L	Fluoride	2.0 mg/L
Chromium	0.1 mg/L	Foaming Agents	0.5 mg/L
Cyanide	0.2 mg/L (as free cyanide)	Iron	0.3 mg/L
Fluoride	4.0 mg/L	Manganese	0.05 mg/L
Mercury	0.002 mg/L	Odor	3 threshold odor number
Nickel*	---	pH	6.5 – 8.5
Nitrate	10 mg/L (as nitrogen)	Silver	0.1 mg/L
Nitrite	1 mg/L (as nitrogen)	Sulfate	250 mg/L
Selenium	0.05 mg/L	TDS	500 mg/L
Sodium*	---	Zinc	5 mg/L
Sulfate	1,000 mg/L		
Thallium	0.002 mg/L		
Total Dissolved Solids (TDS)	2,000 mg/L		

* No MCL has been established for nickel and sodium.

The complete primary and secondary standards are presented in the Utah Administrative Code, Rules for Public Drinking Water Systems, R309-200.

In addition to drinking water standards, the Division of Drinking Water administers the Drinking Water Source Protection (DWSP) Rule (R309-600) to govern the protection of groundwater sources of drinking water from potential contamination. The rule requires that each public water supplier (PWS) submit a DWSP Plan for each of its groundwater sources. DWSP Plans include the following:

- DWSP Zone Delineation Report
- Prioritized Inventory of Potential Contamination Sources (PCSs)
- Assessment of Hazards at PCSs
- Management Programs to Control Existing and Future PCSs
- Implementation Schedule
- Resource Evaluation
- Record Keeping
- Contingency Plan
- Public Notification

Management programs are intended to determine whether hazards at each PCS are adequately controlled and to develop strategies to control hazards that are not adequately controlled. Implementation of the DWSP Rule does not directly limit septic system densities. However, Tooele County has enacted a DWSP ordinance (Chapter 25 of the Tooele County Land Use Ordinance) which limits the installation of septic systems within a 250-day travel time distance of a public drinking water source.

Utah Water Quality Board

The Utah Water Quality Board and Utah Division of Water Quality (Division) have responsibility to provide additional and cumulative remedies to prevent, abate, and control the pollution of the waters of the state under primacy of the federal Water Pollution Control Act as amended by the Water Quality Act of 1987. R317-2-1(a) of the Utah Administrative Code declares that it is public policy of the State of Utah to " *. . . conserve the waters of the state and to protect, maintain and improve the quality thereof for public water supplies, for the propagation of wildlife, fish and aquatic life, and for domestic, agricultural, industrial, recreational and other legitimate beneficial uses; to provide that no waste be discharged into any waters of the state without first being given the degree of treatment necessary to protect the legitimate beneficial uses of such waters; to provide for the prevention, abatement and control of new or existing water pollution; to place first in priority those control measures directed toward elimination of pollution which creates hazards to the public health . . .* "

Individual wastewater disposal systems. Individual wastewater disposal systems (IWDS), or septic systems, usually consist of a building sewer pipe, a septic tank, and an absorption system. IWDS are single dwelling unit underground disposal systems with a capacity of 5,000 gallons per day or less. These systems are not generally designed to serve multiple dwelling units except for condominiums and twin homes.

Utah Administrative Code, R317-4-4.1.C indicates that one of the following two methods shall be used for determining minimum lot size for a single-family dwelling when an individual wastewater disposal system is to be used:

1. Method 1.

   The local health department having jurisdiction may determine minimum lot size. Under this method, local health departments may elect to involve other affected governmental entities and the Division in making joint lot size determinations. The Division will develop technical information, training programs, and provide engineering and geohydrologic assistance in making lot size determinations that will be available to local health departments upon their request. Individuals or developers requesting lot size determinations under this method will be required to submit to the local health department, at their own expense, a report that accurately takes into account at least the following factors:
   a. soil type and depth;
   b. area drainage, lot drainage, and potential for flooding;
   c. protection of surface and ground waters;
   d. setbacks from property lines, water supplies, etc.;
   e. source of culinary water;
   f. topography, geology, hydrology and ground cover;
   g. availability of public sewers;
   h. activity or land use, present and anticipated;
   i. growth patterns;
   j. individual and accumulated gross effects on water quality;
   k. reserve areas for additional subsurface dispersal;
   l. anticipated wastewater volume;
   m. climatic conditions;
   n. installation plans for wastewater system; and
   o. area to be utilized by dwelling and other structures.

2. Method 2.

    a. Whenever local health departments do not establish minimum lot sizes for single-family dwellings that will be served by onsite wastewater systems, the requirements of Section R317-4-13 Tables 1.1 and 1.2 shall be met.
    b. For non-residential facilities, one-half of the buildable area of the lot must be available for the absorption system and replacement area.
        i. The area required for the absorption system and replacement area may be adjusted during the permitting process.

Whenever an individual wastewater disposal system is found by the regulatory authority to create or contribute to any dangerous or unsanitary condition which may involve a public health hazard, the regulatory authority may order the owner to take the necessary action to cause the condition to be corrected, eliminated or otherwise come into compliance. A public health hazard consists of sufficient types and amounts of biological, chemical, or physical agents relating to water or sewage which are likely to cause human illness, disorders or disability. These include, pathogenic viruses and bacteria, parasites, toxic chemicals and radioactive isotopes.

Groundwater Quality Protection Rules. The State of Utah's Water Pollution Control Committee (now the Utah Water Quality Board) in 1989 passed the Groundwater Quality Protection Regulations for the protection of Utah's groundwater resources. The Utah Administrative Code, Rules for Groundwater Quality Protection, R317-6 provides for six groundwater classes based upon water quality. Representative characteristics of each class are described below:

1. Class IA - Pristine Groundwater
   Class IA groundwater has the following characteristics:
    a. Total dissolved solids of less than 500 mg/l.
    b. No contaminant concentrations that exceed the groundwater quality standards found in Table 1 of R317-6-2.
2. Class IB - Irreplaceable Groundwater
   Class IB groundwater is a source of water for a community public drinking water system for which no reliable supply of comparable quality and quantity is available because of economic or institutional constraints.
3. Class IC - Ecologically Important Groundwater
   Class IC groundwater is a source of groundwater discharge important to the continued existence of wildlife habitat.
4. Class II - Drinking Water Quality Groundwater
   Class II groundwater has the following characteristics:
    a. Total dissolved solids greater than 500 mg/l and less than 3000 mg/l.
    b. No contaminant concentrations that exceed groundwater quality standards found in Table 1 of R317-6-2.
5. Class III - Limited Use Groundwater
   Class III groundwater has one or both of the following characteristics:
    a. Total dissolved solids greater than 3000 mg/l and less than 10,000 mg/l, or;
    b. One or more contaminants that exceed the groundwater quality standards found in Table 1 of R317-6-2.
6. Class IV - Saline Groundwater
   Class IV groundwater has total dissolved solids greater than 10,000 mg/l.

In 2001, the Utah Division of Water Quality published a map showing the groundwater classification for the principal valley-fill aquifer of the Tooele Valley. Based on this map, much of the study area has been classified as a Class II – Drinking Water Quality Groundwater. The perimeter of the valley fill aquifer is classified as a Class IA – Pristine Groundwater.

REGULATORY APPROACH

The recommended regulatory approach to controlling the density of septic systems in the study area includes the following:

1. Use of the State of Utah Individual Wastewater Disposal System Requirements, specifically as they relate to determining lot sizes by requiring the consideration of “Protection of Surface and Groundwaters” and “Individual and Accumulated Gross Effects on Water Quality”.
2. Use of the EPA and State of Utah Primary Drinking Water Standards as the absolute limit for degradation of potential drinking water sources.
3. Use of completed Drinking Water Source Protection Plans and associated source protection zones to determine areas where the use of septic systems may not be considered due to the restrictions of the plans and Tooele County’s Drinking Water Source Protection Ordinance.
4. Use of the State of Utah Groundwater Quality Protection Rule to provide guidelines for protecting existing and probable future beneficial uses of groundwater including potential drinking water sources.
5. Use of the local planning, zoning, and public health ordinances to implement recommended septic system densities.

CHAPTER 4 – CONTAMINANT INDICATOR SELECTION

POTENTIAL INDICATORS

Well understood pollutants from septic systems are usually selected as indicators of the effect of septic systems on the environment. Four of these include: pathogens, organic compounds, phosphorus and nitrogen. The majority of reported health problems in the U.S. associated with septic systems are caused by pathogens which have passed through septic systems to groundwater. Organic compounds such as cleaning solvents have been identified as possible groundwater contaminants related to septic systems. Phosphorus released from septic systems can lead to eutrophication problems in surface water impoundments. However, previous work by HAL and others has indicated that pathogens, organic contaminants and phosphorus all have significant limitations as indicators and that nitrate nitrogen is one of the more reliable indicators of potential pollution from septic systems. A study completed for the State of Massachusetts concluded that "*using nitrogen loading as a means of determining acceptable density limits may be the most effective means of protecting the quality of water in wells or surface water bodies over the long term*" (DeFeo, Wait & Associates, 1991).

NITROGEN RELATED HEALTH RISK

The United States Environmental Protection Agency (EPA) has determined that nitrate nitrogen poses an acute health concern at certain levels of exposure (EPA, 2004). Excessive levels of nitrate in drinking water may cause serious illness, and sometimes death, in infants under six months of age. EPA has set the maximum contaminant level (MCL) for nitrate in drinking water at 10 mg/L as nitrogen to prevent methemoglobinemia or "blue baby syndrome". Nitrate concentrations in public drinking water systems have been monitored on a regular basis for many years. Treatment for removal of nitrates from contaminated water sources, such as wells, is generally not cost effective for individual home owners, nor is it easily treated by public water suppliers that rely on large producing wells.

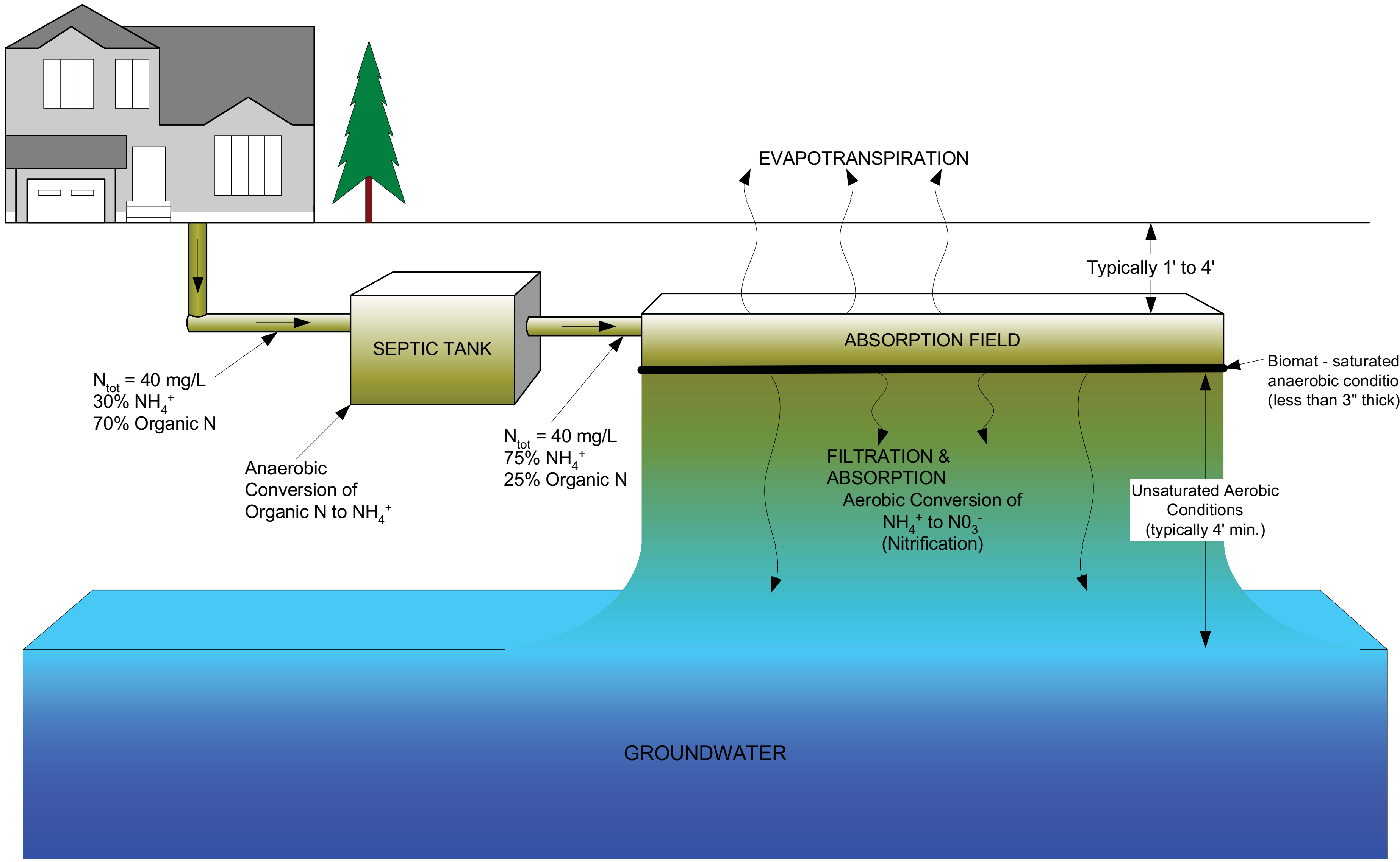
All nitrate concentrations in this report follow the State of Utah's method of measurement (mg/L as nitrogen). Therefore, only the nitrogen (N) component of nitrate (NO_3^-) is used to report the mass of contaminant per unit volume of water.

SOURCES OF NITROGEN

The most common sources of nitrate in groundwater include fertilizer, animal waste, and sewage wastes from humans. Other minor sources of nitrogen in groundwater may include nitrogen associated with precipitation and naturally occurring nitrogen in the aquifer.

SEPTIC SYSTEMS AND NITROGEN

Septic systems have generally been found to be relatively ineffective in removing nitrogen from the wastewater stream. Figure 4-1 shows schematically the effect of a typical septic system on the associated nitrogen compounds. Nitrogen entering the septic system is typically 70% organic nitrogen and 30% ammonia. The anaerobic environment in the septic tank transforms most of the organic nitrogen to ammonia nitrogen. The nitrogen leaving the septic tank is typically 25% organic nitrogen and 75% ammonia. A properly functioning absorption system has a biomat which forms at the soil interface directly below the absorption system. The biomat has a greatly reduced permeability and provides an unsaturated zone below the absorption



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FATE OF NITROGEN
COMPOUNDS IN A TYPICAL
SEPTIC SYSTEM

FIGURE
4-1

system. This unsaturated zone is critical for the removal of pathogens. The unsaturated zone typically is an aerobic environment in which the ammonia is oxidized to nitrate (nitrification). An adequate depth of unsaturated flow, necessary for bacteriological treatment and for phosphorus removal, also establishes conditions which allow for rapid nitrification which converts ammonia and organic nitrogen to nitrate (Canter and Knox, 1985).

TRANSPORT AND FATE OF NITROGEN

Figure 4-2 represents the fate of nitrogen compounds associated with septic systems. When nitrate reaches the underlying groundwater, it becomes very mobile because of its solubility and anionic form. Nitrate moves with groundwater with minimal transformation. Nitrates can be removed from groundwater through two mechanisms: (1) direct uptake by plants, and (2) denitrification. Direct plant nitrate uptake adjacent to an absorption field is negligible if the drain field is installed properly so that an adequate unsaturated soil depth is maintained.

Denitrification, or the bacteriological transformation of nitrate to nitrogen gas, requires a low oxygen or an oxygen free (anaerobic) environment. Conditions that may lead to a low oxygen environment include low permeability aquifer materials, oxygen demand associated with the septic system contaminant plume, and increasing depth below the groundwater potentiometric surface. Most aquifers that yield significant quantities of high quality drinking water to wells consist of high permeability sands and gravels that tend to result in a more oxygenated groundwater. As a result, denitrification in these aquifers is less likely to occur. However, if the density of septic systems is large enough that biological oxygen demand (BOD) from septic system discharges uses up the dissolved oxygen in the water, the aquifer could become anaerobic. McQuillan (2006) reports that this would lead to denitrification, but would also lead to elevated iron and manganese.

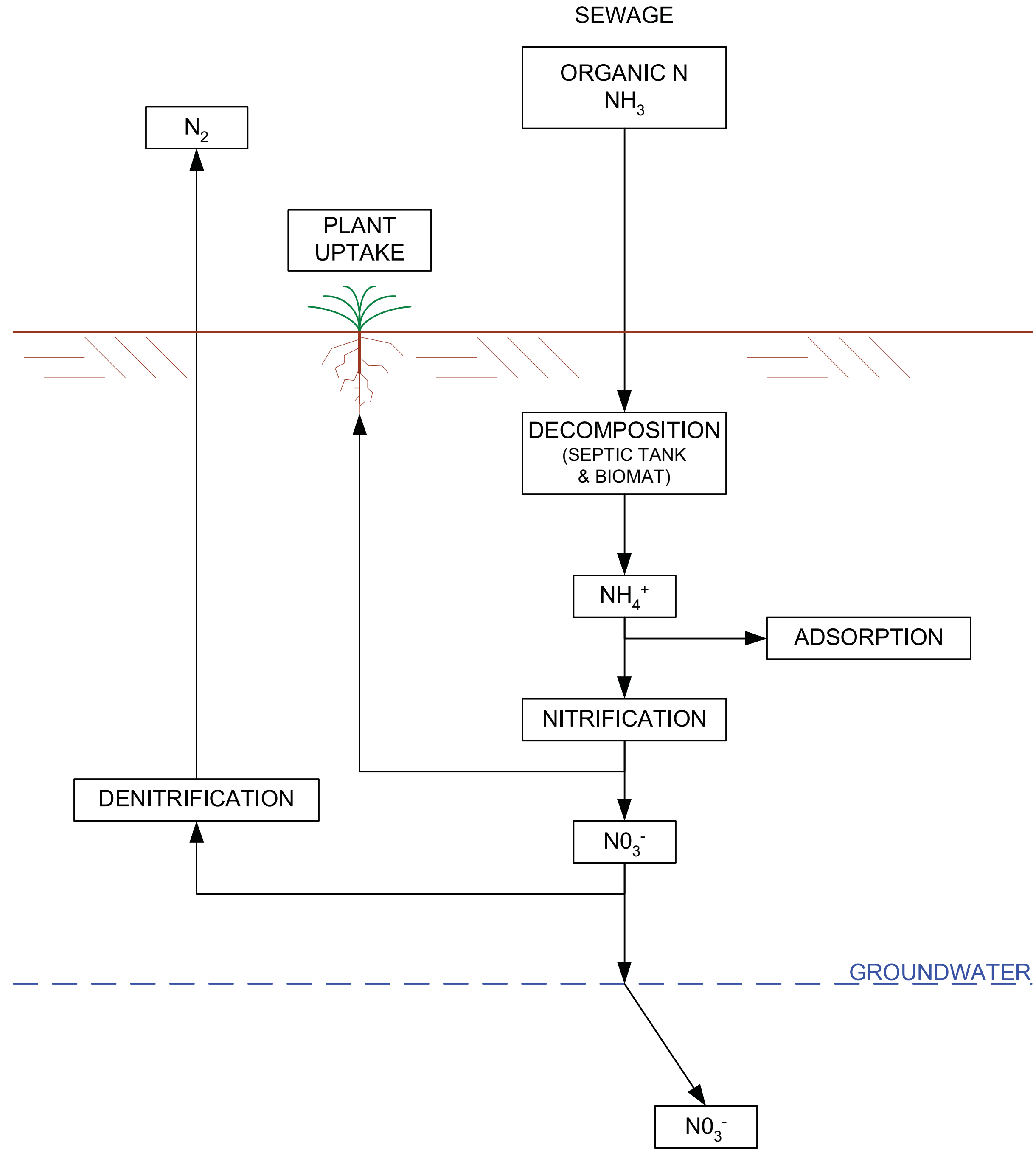
ADVANTAGES OF NITRATE AS AN INDICATOR

Nitrate offers the following advantages as an indicator:

- Excessive concentrations of nitrate in drinking water present a well documented health hazard.
- Nitrate is an effective indicator of human activity because the major sources of nitrate in groundwater are associated with wastewater disposal and application of fertilizer to land.
- Nitrate concentrations are relatively easy to measure.
- A reliable historical groundwater quality data base exists.
- Attenuation of nitrate in groundwater in productive aquifers is not very likely to occur except by dilution.

KEY

NH_4^+	AMMONIUM ION
N_2	NITROGEN GAS
NO_3^-	NITRATE
NH_3	AMMONIA



ADAPTED FROM CANTER & KNOX (1985)

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TOOELE COUNTY
SEPTIC SYSTEM DENSITY
STUDY

FORM AND FATE OF NITROGEN
COMPOUNDS ASSOCIATED
WITH SEPTIC SYSTEMS

FIGURE
4-2

CHAPTER 5 – EXISTING GROUNDWATER QUALITY

Existing groundwater quality provides a baseline condition for determination of allowable downstream degradation.

DATA SOURCES

Existing groundwater quality was obtained from the Utah Division of Drinking Water for public drinking water sources located throughout the Tooele Valley and the surrounding mountains. Groundwater quality data was also provided by Tooele County Health Department for private wells completed within the past 6 years within the valley. The location of public drinking water sources and private wells is shown on Figure 5-1. Nitrate concentration for each source is also shown on the figure.

OVERVIEW OF GROUNDWATER QUALITY

Based on a review of the available water quality data for wells and springs within the study area, most inorganic water quality parameters were within primary and secondary standards. There were a few exceptions which are summarized in Table 5-1. The only parameter that exceeded primary drinking water standards in any well was chromium, which was found in 3 sources at values of 0.0051-0.0061 mg/L (primary standard: 0.005 mg/L). Secondary standards for chloride, iron, sulfate, TDS, and zinc were exceeded in various public and private wells throughout the study area.

Table 5-1
Summary of Drinking Water Parameter Exceedance

Parameter	Standard	Location	Values
Chromium	0.005 mg/L (primary)	Grantsville – South Willow Well Tooele City – England Acres Well Lincoln – Springs	0.0060 mg/L 0.0061 mg/L 0.0051 mg/L
Chloride	250 mg/L (secondary)	Erda Acres – Sampling Station 2 private wells in Lakepoint	358-377 mg/L 330-550 mg/L
Iron	0.3 mg/L (secondary)	Stansbury Park – Well #4 Tooele City – England Acres Well Erda Acres – Sampling Station	1.57 mg/L 0.33 mg/L 1.11 mg/L
Sulfate	250 mg/L (secondary)	2 private wells in East Erda 1 private well in Lincoln	307-406 mg/L 250 mg/L
TDS	500 mg/L (secondary)	West Erda – Wells #1 & #2 Stansbury Park – Clegg Well Tooele City – Well #9A Erda Acres – Sampling Station 12 private wells in East Erda 2 private wells in East Erda 2 private wells in West Erda 5 private wells in Lincoln 2 private wells in Lakepoint 2 private wells north of Grantsville	651-658 mg/L 896 mg/L 600 mg/L 764 mg/L 500-700 mg/L 838-1,210 mg/L 606-888 mg/L 536-674 mg/L 838-1,180 mg/L 988-1,188 mg/L
Zinc	5 mg/L (secondary)	Stansbury Park – Well #4	9.27 mg/L

Overall, while there are some aesthetic groundwater quality concerns, the groundwater throughout the study area is of high enough quality to provide drinking water to both public drinking water systems and private land owners.

NITRATE

Background nitrate levels are a significant part of the evaluation of septic system impacts on groundwater. Source nitrate concentrations for public and private drinking water sources are shown on Figure 5-1. Nitrate concentrations within the study area range from as low as 0.2 mg/L in the mountains to as high as 4.8 mg/L in the Erda area. In general, water sources that are located upgradient from human development have nitrate concentrations at or below 1 mg/L. Therefore, the background nitrate concentration is assumed to be 1 mg/L for the overall aquifer system for this study. However, sources that are located in valley areas where development has occurred have concentrations ranging from 1 to almost 5 mg/L, with most of the values between about 2 to 3 mg/L.

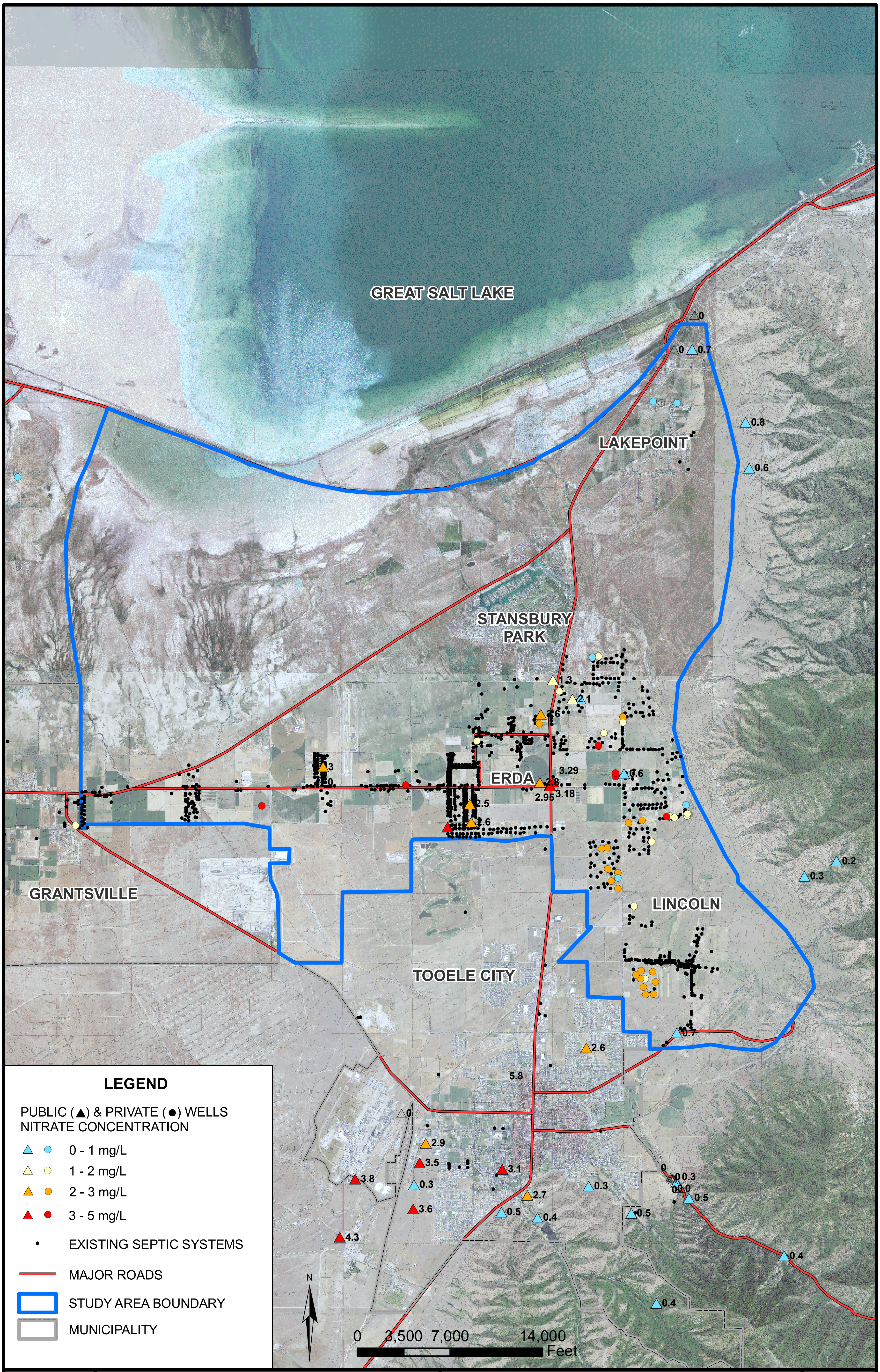
It can generally be assumed that public drinking water wells in the valley areas are completed into deeper portions of the aquifer than private wells. It follows that nitrate concentrations for public drinking water wells are assumed to be more representative of impacts upon the deeper groundwater aquifer and that nitrate concentrations in private wells are assumed to be more representative of impacts upon the shallower groundwater aquifer. Table 5-2 summarizes nitrate values by location within the study area and by source type.

Table 5-2
Summary of Nitrate Concentrations in Study Area

Location (# of Existing Septic Systems)	Source Type (# of wells)	Nitrate (mg/L as N)
Lakepoint (<25)	Public (1)	0.7
	Private (2)	0.6 – 0.8 (Ave: 0.7)
East Erda / Stansbury Park (255)	Public (5)	0.6 – 2.6 (Ave: 1.5)
	Private (19)	0.7 – 4.2 (Ave: 2.1)
Erda (382) [located downgradient from Lincoln]	Public (7)	2.5 – 4.8 (Ave: 3.2)
	Private (2)	1.9 – 4.6 (Ave: 3.3)
Lincoln (184)	Private (17)	0.4 – 2.8 (Ave: 2.2)
West Erda (170)	Public (1)	3.0
	Private (1)	3.3

One observation that can be made from Table 5-2 is that private wells (typically shallower) consistently have higher nitrate concentrations than public wells (typically deeper). This is consistent with surface discharge of nitrate sources (septic systems and agricultural activities). Another observation is that areas with larger numbers and a higher density of septic systems had higher nitrate concentrations.

It is interesting to note that the nitrate concentrations in wells located in the Lakepoint area (0.7 mg/L) are the same as the average nitrate concentration in the two Oquirrh Mountain Water Company Wells located east of this area in the foothills. There are very few, if any, septic systems directly upgradient from these wells. Although there are agricultural areas upgradient from these wells, there appears to be no increase in nitrate concentration. This may indicate that elevated nitrate levels in other areas are largely due to septic system discharge.



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EXISTING WELLS AND
NITRATE CONCENTRATIONS

FIGURE
5-1

In the East Erda / Stansbury Park area, nitrate levels are about 1 to 1.5 mg/L higher than the back ground nitrate levels found in the mountains to the southeast of the area. This increase is likely in large part due to existing septic systems located in the area. Some developments within this area have about 3.5 – 4.0 acres of land per septic system.

This is contrasted to the Erda and Lincoln areas which have developments that have only 1.5 – 1.6 acres per septic system. It is believed that these higher septic system densities are in large part responsible for nitrate levels that are 1.5 to 2.5 mg/L higher than the background nitrate concentration demonstrated by Tooele City's Kennecott B Well (0.7 mg/L).

Similarly, a development in the West Erda area has only 1.2 acres per septic system. Nitrate concentrations in wells in this area are over 2 mg/L more than established background levels. Most of Tooele City is directly upgradient from this area and it is believed that a portion of the elevated nitrate concentrations in this area may be attributed to fertilizer application to lawns and gardens within the City.

Previous Nitrate Study

In 2005, D.D. Susong published a study of elevated nitrate concentrations found in wells located in the East Erda between 1997 and 2000. Susong (2005) documented the presence of a nitrate plume exceeding 10 mg/L in the upper portions of the shallow aquifer in the East Erda area. It was noted that within an 8-month period, nitrate concentrations changed significantly indicating that plume was moving downstream. The source of the nitrate plume was not able to be identified. However, it was concluded that it was not likely from septic systems because high nitrate was detected above the highest septic systems.

Since 2000, it is believed that whatever the source of the nitrate was, the plume has moved downstream and is no longer a major factor in the groundwater system of the area. This is based upon the nitrate data evaluated in this study. It is possible that there may be residual effects of this plume in nitrate concentrations observed in the East Erda / Stansbury Park area.

CHAPTER 6 – HYDROGEOLOGY

BACKGROUND

Evaluation of the hydrogeology of the Tooele Valley aquifer is important for determination of appropriate septic system densities by characterizing the volume of water available for dilution of septic system discharges to the aquifer. It is also important for identification of smaller subareas for septic system density determination.

Several studies have been performed over the years for the Tooele Valley aquifer system. The latest major hydrogeological evaluation was prepared by Stolp and Brooks (2009) and published by the US Geological Survey (USGS). This study included calibration of a transient 3-dimensional groundwater model to over 3 decades of historical data. Groundwater flow and aquifer characteristics used in this septic system density study were based on Stolp and Brooks (2009).

SUBAREA DETERMINATION

Septic system density determination relies upon dilution potential of the groundwater system. Since septic discharges are just below the land surface, the top portions of the aquifer begin mixing with the discharge first. As groundwater moves downstream, the discharge from the septic system disperses vertically and mixes to increasing aquifer depths. The discharge from one septic system also mixes with the discharges from other septic systems located downstream. Because of the additive effect of septic system discharges on groundwater, subareas were selected generally following groundwater flow paths.

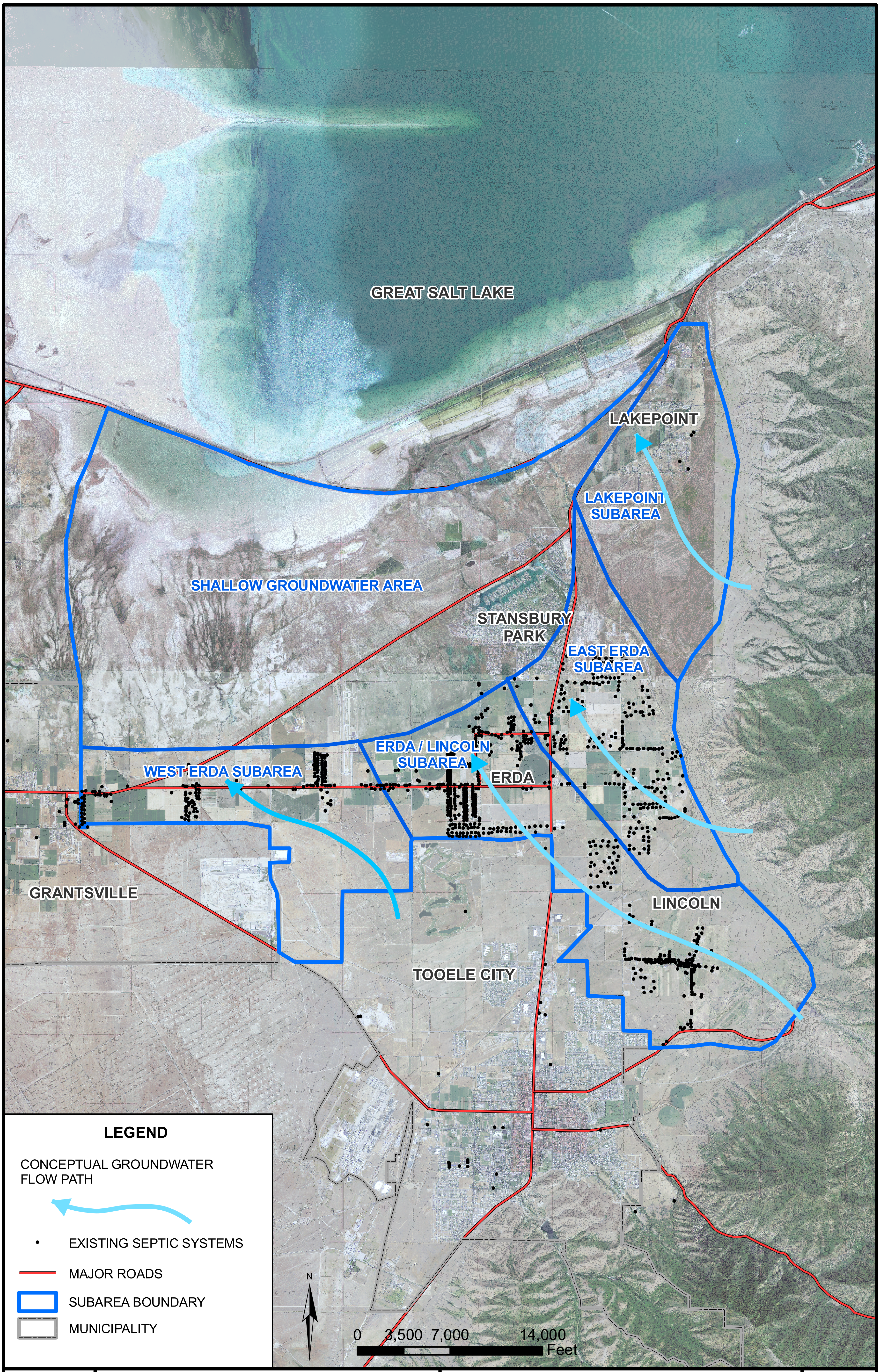
Groundwater contours developed from the 3-dimensional groundwater model prepared by Stolp and Brooks (2009) were used to select subarea boundaries. The intent was to separate areas based on septic system development potential and to account for the accumulative effect of multiple septic systems moving downstream through the aquifer. Using these criteria, four subareas were delineated as shown on Figure 6-1. Areas that are within existing municipal boundaries of Tooele City or Grantsville were excluded because development within those areas will be sewered. Areas lower in the valley to the north were also excluded from the subareas because high groundwater would prevent septic systems from being installed in these areas.

The subareas are named after the areas which they cover. Moving from east to west, the subareas are referred to as follows:

- Lakepoint
- East Erda
- Erda / Lincoln
- West Erda

GROUNDWATER CHARACTERISTICS

The groundwater flow volume available for dilution of septic system discharges within each subarea can be determined from the hydraulic conductivity of the aquifer, the hydraulic gradient of the aquifer, the width of the flow within the subarea, and the mixing depth. The hydraulic conductivity and gradient for each subarea was obtained from the calibrated 3-dimensional



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SUBAREA BOUNDARIES
AND GROUNDWATER FLOW

FIGURE
6-1

groundwater model (Stolp and Brooks, 2009). The width of the subarea was measured as the approximate distance perpendicular to the groundwater flow at the downstream end of the subarea.

Because of dispersion properties, the mixing depth available for dilution is dependent upon the distance groundwater has to flow while mixing with septic system discharges. In other words, a longer subarea has a greater potential mixing depth. Based on dispersion models presented by Fetter (1993), and due to limitations of vertical dispersion due to horizontal layering of unconsolidated deposits, it is assumed that there is approximately 50 feet of mixing depth for every mile of groundwater flow along the subarea.

Table 6-1 summarizes the groundwater characteristics for each subarea.

Table 6-1
Groundwater Characteristics by Subarea

Subarea	Hydraulic Conductivity	Hydraulic Gradient	Flow Width	Mixing Depth
Lakepoint	400 ft/day	0.0013 ft/ft	14,500 ft	80 ft
East Erda	80 ft/day	0.0018 ft/ft	11,500 ft	200 ft
Erda / Lincoln	80 ft/day	0.0016 ft/ft	12,900 ft	300 ft
West Erda	80 ft/day	0.0017 ft/ft	16,000 ft	160 ft

CHAPTER 7 – SEPTIC SYSTEM DENSITY ANALYSIS

GENERAL

The methodology used to develop a range of septic system densities for consideration incorporates a three-step process:

1. Subarea Selection – described in Chapter 6
2. Risk Analysis
3. Mass Balance Analysis

RISK ANALYSIS

The purpose of a risk analysis is to consider factors that may be associated with the study area that are not easily quantifiable and may be difficult to incorporate into a mass balance equation. For example, conditions may exist in one area that may make septic system use a higher risk to groundwater quality than another area.

Risk Analysis Criteria

The following criteria were used to analyze the risk in each subarea.

- **Dispersion Predictability**. This criterion has to do with the type of formation underlying the study area. Reductions in key contaminant concentrations, specifically nitrate, are due to dilution and especially dispersion potential. Due to the sinuous path that groundwater must travel through the spaces between individual soil particles, it is relatively easy to predict the ability of an unconsolidated granular material to disperse pollutants. However, because of the potential for discrete groundwater pathways through fractures in bedrock, it is not as easy to make the same prediction in a fractured bedrock formation.
- **Depth to Water Table**. Increased depth to the water table increases the potential for more adequate subsurface treatment and reduces the risk of contamination from septic systems.
- **Potential for Pollutants to Travel Vertically to Water Table**. The presence of confining layers reduces the potential for pollutants to travel vertically to the water table.
- **Potential to Influence Drinking Water Supplies**. If the aquifer has significant potential for use as a current or future drinking water supply, septic systems represent a greater risk than if the aquifer has little potential use for a drinking water supply.

Relative Ranking of Risk Criteria

Each criterion is evaluated in terms of low, medium, or high risk based on the local conditions of the area being evaluated. A numerical value was then assigned based on whether the area was low, medium, or high. The numerical values assigned to each criterion were weighted according to the relative importance of individual criterion in the study area. A display of the selected risk analysis criteria and their relative rankings and possible scores are included as Table 7-1.

Table 7-1
Risk Analysis Criteria

Criteria		Weight Factor	Ranking			Possible Score		
			Low Risk (1x)	Medium Risk (2x)	High Risk (3x)	Low Risk	Medium Risk	High Risk
1	Dispersion Predictability	5	High	Medium	Low	5	10	15
2	Depth to Water Table	5	>50 ft	15-50 ft	<15 ft	5	10	15
3	Potential for Pollutants to Travel Vertically to Water Table	8	Low	Medium	High	8	16	24
4	Potential to Influence Drinking Water Supplies	10	Low	Medium	High	10	20	30

Risk Scores

The total risk of the study area is determined by summing the risk scores for each criterion for the study area. Based on the numerical values and weights assigned to the criteria, the lowest possible total risk score is 28 and the highest possible risk score is 84. By dividing this range equally, the study area can be assigned to a risk category of high, medium high, medium low, or low based on its total risk score. If the study area risk score is 71 or higher, it is assigned a high risk. If the risk score is 57 to 70, it is assigned a medium high risk. If the risk score is 43 to 56, it is assigned a medium low risk. If the risk score is 42 or less, the study area is assigned a low risk. The risk scores are summarized by category in Table 7-2.

Table 7-2
Risk Score Summary

Risk Score Range	Risk Category	Allowable Down-Gradient Nitrate Concentration
71 or higher	High	3 mg/L (as N)
57 – 70	Medium High	4 mg/L (as N)
43 – 56	Medium Low	5 mg/L (as N)
42 or lower	Low	6 mg/L (as N)

Risk Based Allowable Down Gradient Nitrate Concentration

To incorporate the risk analysis into the mass balance analysis, and thus the septic system density determination, a correlation was developed between the risk scores and the recommended allowable degradation of groundwater quality. The ground water quality was allowed to degrade, or experience an increase in nitrate concentration, above background based on the risk. Background was assumed to be 1 mg/l based on historical water source data. If the study area total risk is high, the area is allowed a down gradient predicted concentration of 3 mg/L. If the study area total risk is medium high, medium low, or low, it is allowed a concentration of 4 mg/L, 5 mg/L, or 6 mg/L, respectively. *<u>This allowable downgradient nitrate concentration includes the effect of existing septic systems</u>*. The allowable down gradient concentration for the study area is used in the mass balance analysis to determine the final recommended septic system density. Table 7-2 summarizes the risk scores by risk category and their respective allowable down gradient nitrate concentrations. A summary of the total risk analysis, including the recommended allowable down gradient nitrate concentration, is shown in Table 7-3.

Table 7-3
Risk Analysis Summary

Area	Criteria / Score				Total Risk Score	Risk Category	Allowable Down Gradient Nitrate Concentration
	1	2	3	4			
Lakepoint	5	5	16	10	36	Low	6 mg/L (as N)
East Erda	5	5	16	30	56	Medium Low	5 mg/L (as N)
Erda / Lincoln	5	5	16	30	56	Medium Low	5 mg/L (as N)
West Erda	5	10	8	20	43	Medium Low	5 mg/L (as N)

MASS BALANCE ANALYSIS

Mass Balance Equation

The mass balance analysis provides a quantifiable approach to determining recommended septic system densities and to distinguishing the characteristics of the individual subareas within the overall study area. The mass balance analysis used in this study considers five flow and nitrate loading components as depicted in Figure 7-1. Those five components are:

1. The flow (Q_s) and nitrate loading (N_s) associated with the effluent from the septic system(s).
2. The flow (Q_i) and nitrate loading (N_i) associated with the watering and fertilizing of residential lawns and agricultural areas (both referred to generally as irrigation).
3. The flow (Q_p) and nitrate loading (N_p) associated with precipitation.
4. The flow (Q_b)and nitrate concentration (N_b) associated with background or ambient groundwater flow.
5. The total flow (Q_t) and nitrate concentration (N_t) resulting from combining the other four components.

The generalized equation used for analyzing the relationship of these factors is as follows:

$$Q_sN_s + Q_iN_i + Q_pN_p + Q_bN_b = Q_tN_t$$

The allowable number of septic systems can be calculated by fixing N_t (the desired or allowable nitrate concentration in down gradient groundwater as determined in the risk analysis) to a constant value and by solving the above equation for the flow and loading associated with septic systems (based on the number of septic systems). Using a representative transect of land in the study area, the septic system density for the area can be determined. The expanded equation, including conversion factors, is included in Appendix A.

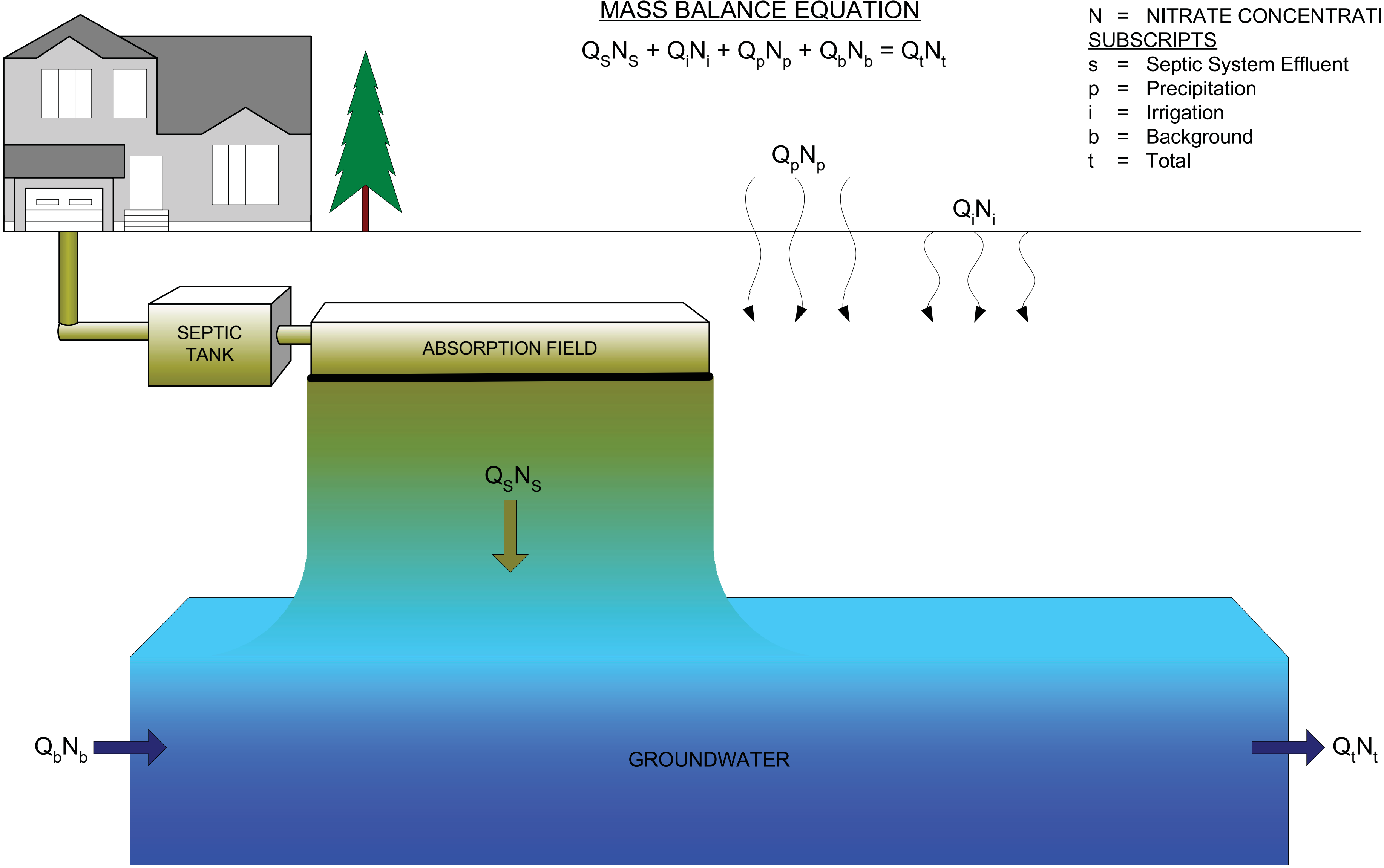
Criteria and Assumptions

A range of resultant densities are possible depending upon the specific assumptions included in the analysis. A discussion of selected criteria and assumptions follows.

MASS BALANCE EQUATION

$$Q_SN_S + Q_iN_i + Q_pN_p + Q_bN_b = Q_tN_t$$

VARIABLES
Q = FLOW
N = NITRATE CONCENTRATION
SUBSCRIPTS
s = Septic System Effluent
p = Precipitation
i = Irrigation
b = Background
t = Total



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SEPTIC SYSTEM DENSITY STUDY

MASS BALANCE
METHODOLOGY

FIGURE
7-1

Down-Gradient Nitrate Concentration. The down-gradient or allowable total nitrate concentration in the groundwater associated with individual subareas was determined using the risk analysis.

Mixing Depth. This factor refers to the vertical distance below the ground water table that is available for dilution. To estimate the maximum mixing depth, the dispersion potential for the selected contaminant nitrate was calculated using dispersion equations found in Fetter (1999), assuming no degradation, attenuation, or retardation. Because of dispersion properties, the mixing depth available for dilution is dependent upon the distance groundwater has to flow while mixing with septic system discharges. In other words, the longer the subarea is, the greater the potential mixing depth will be. Based on dispersion models presented by Fetter (1993), historic data from other studies (Schmidt, 1971), and due to limitations of vertical dispersion due to horizontal layering of unconsolidated deposits, it is assumed that there is approximately 50 feet of mixing depth for every mile of groundwater flow along the subarea.

Some researchers and regulatory entities feel that there should be no allowance for the ability of the groundwater to accept pollutants, particularly where the hydrogeology of the area is not well understood. This means that the nitrate concentration in the combined flows from septic system discharge, precipitation, and irrigation immediately prior to entering the groundwater should be at or below the required or desired down gradient concentration. If this approach or restriction were applied in most areas in Utah, the required density would be unreasonably high. We feel that a restrictive approach such as this (i.e. mixing zone depth of “0" feet) is unreasonable for this study area, primarily because there is a reasonable understanding of local hydrogeology.

Septic System Effluent Flow. Typical values for the amount of flow discharged by the average residence vary from approximately 200 to 400 gallons per system per day. The increasing awareness of water conservation will likely result in long term values that are nearer the lower end of this range or even lower.

In the Design Manual for On-Site Wastewater Treatment and Disposal Systems, the United States Environmental Protection Agency (EPA) recommends that 75 gallons/day/person (gpd/person) be used for septic system design. According to DeFeo, Wait & Associates (1991), this is roughly 50% greater than actual average daily flows of about 50 gpd/person. Cantor and Knox (1985) report a typical residential wastewater flow range of 40-45 gpd/person. Assuming a range of 4 to 6 people per home and a range of 50-75 gpd/person, the estimated range of septic system flows is from 200-450 gpd depending on whether average or septic system design flows are used. For this study, it is assumed that average flows are applicable with an average of 6 people per household. This results in an average septic system flow of 300 gpd.

Septic System Effluent Strength. Septic system effluent nitrate concentrations typically range from 30 to 80 mg/l NO_3-N depending on the strength of the wastewater. Cantor and Knox (1985) and DeFeo, Wait & Associates (1991) indicate that the average concentration of total nitrogen in septic tank effluent is between 38 and 42 mg/l as nitrogen. This nitrogen is 75% in the ammonium form and 25% in the organic form. As indicated in Chapter 4, most of the nitrogen is converted to nitrate through the nitrification process in the unsaturated zone below the septic drain field. DeFeo, Wait & Associates (1991) indicate that in most septic systems, the effectiveness of nitrogen removal is limited to about 5%. Therefore, the average concentration of nitrate as it enters groundwater is likely between 36 and 40 mg/l as nitrogen. A value of 40 mg/l was used in this study.

Total Groundwater Flow. The quantity of water flowing through each study area was estimated using Darcy’s Law as shown below:

$$Q = k*i*A$$

Where:

Q = groundwater flow (ft^3/day)
k = hydraulic conductivity (ft/day)
i = hydraulic gradient (ft/ft)
A = cross-sectional area (ft^2)

The hydraulic conductivity and hydraulic gradient values are estimated in Chapter 6 for each subarea. The cross-sectional area is computed from the mixing depth and the width of flow. Mixing depth is discussed above. The width of flow was estimated using the width of the subarea parallel to the groundwater contours at the downstream end of the subarea.

Precipitation and Irrigation. Effects of precipitation and irrigation contribute to the hydraulic gradient. As precipitation and irrigation increase the hydraulic gradient would tend to increase. Because the total groundwater flow was estimated based on the hydraulic gradient that included the effects of precipitation and irrigation, these components are already included in the total groundwater flow. It is assumed that the contribution of precipitation and irrigation will remain relatively constant into the foreseeable future.

Because precipitation and irrigation are already included in the groundwater flow, the irrigation (Q_iN_i) and precipitation (Q_pN_p) terms in the generalized mass balance equation shown above are already included in the background groundwater flow (Q_bN_b) term. Therefore, the effective mass balance equation used for this analysis is as follows:

$$Q_sN_s + Q_bN_b = Q_tN_t$$

Denitrification. Denitrification is the conversion of nitrate to nitrogen gas. As discussed in Chapter 4, it would be unlikely for such a conversion to occur in groundwater aquifers that typically produce high quality drinking water. A couple of wells in the study area had high concentrations of iron which can sometimes be an indication of anaerobic groundwater conditions. It is possible that there may be areas within the aquifer where denitrification may occur. However, because conditions favorable for denitrification also result in other water quality problems, it is assumed that there is no denitrification for the purposes of determining appropriate septic system densities.

Ambient Groundwater Nitrate Concentration. Ambient or background nitrate concentration was assumed to be 1.0 mg/l as nitrogen throughout the study area based upon a review of the data included in Chapter 5.

MASS BALANCE ANALYSIS RESULTS

The results of the mass balance analysis are included in Appendix B and presented according to risk category in Table 7-4. These results are also incorporated into the recommendations found in Chapter 8.

Table 7-4
Mass Balance Analysis Results

Subarea	**Septic System Density (acres/septic system)**			
	High Risk 3 mg/L (as N)	Medium High Risk 4 mg/L (as N)	Medium Low Risk 5 mg/L (as N)	Low Risk 6 mg/L (as N)
Lakepoint	16	11	8	**6***
East Erda	10	7	**5***	4
Erda / Lincoln	11	7	**5***	4
West Erda	10	7	**5***	4

* Recommended reasonable septic system density based on risk.

CHAPTER 8 – RECOMMENDATIONS

IMPLEMENTATION CONSIDERATIONS

The recommendation of septic system densities for the study area depends not only upon the risk and mass balance analyses, but also upon how local regulatory authorities want to manage the development review process. It is possible to establish procedures which could be used by developers to determine the site specific septic system density required for each development. This would involve the gathering of significant amounts of data, analyses similar to that included in this study, and review of the results by local officials. However, this approach would require significant resources of both the developer and local officials. In addition, it would require longer time periods for the review of proposed developments. For these reasons, it was felt that the adoption of reasonable average septic system densities for areas having similar physical conditions and risks would be the most appropriate for this study area.

RECOMMENDATIONS SUMMARY

Septic system density recommendations depend in part on future plans for wastewater disposal. If the wastewater disposal plan for a study area is to construct a sewer system, then housing density within sewered areas may be determined by factors not related to septic systems. However, where septic systems are the plan for future wastewater disposal, the housing density should be controlled to limit the effects of these septic systems on groundwater supplies.

Table 8-1 presents the recommended septic system density for each study area along with total number of allowable septic systems and the existing number of septic systems. Also included in this table are the peak septic system densities at existing subdivisions within the subarea.

Table 8-1
Septic System Density Recommendations

Subarea	Recommended Septic System Density (acres/residence)	Total Allowable # of Septic Systems	Current # of Septic Systems	Current Peak Septic System Density (acres/residence)
Lakepoint	**6**	760	<25	n/a
East Erda	**5**	930	260	3.5 – 4.1
Erda / Lincoln	**5**	1,500	570	1.5 – 1.6
West Erda	**5**	960	170	1.2

As can be seen in Table 8-1, none of the subareas have exceeded the total number of allowable septic systems based on this analysis. However, some existing subdivisions have greatly exceeded the allowable density. From an overall perspective, these higher densities can be diluted by areas where there are lower densities. But on a localized basis, these areas of higher density likely result in pockets of the aquifer that have higher than allowable nitrate concentrations. It is recommended that future subdivisions be limited to the recommended septic system density.

Since the Lakepoint subarea is mostly sewered, it is unlikely that septic system density will be a major concern. However, if new development is planned that proposes to use septic systems, it is recommended that the density of septic systems be limited to the recommended value to prevent localized pollution of the groundwater.

OTHER CONSIDERATIONS

The recommended densities shown in Table 8-1 are considered to be reasonable septic system densities based on the results of the risk analysis. However, due to the nature of the analysis, it is believed that Tooele County would be justified in choosing final septic system densities within one acre/residence above or below the densities shown in Table 8-1. Other considerations for selecting appropriate septic system densities for the study area include the following:

- **Nitrate is only an indicator**. Excessive concentrations for other current and future contaminants may have a similar or more detrimental effect on groundwater supply.

- **Other sources of nitrates**. Other sources of nitrates including animal waste, crop production, and natural geologic sources should be considered in the allowable degradation from septic systems.

- **Septic system design**. This study assumed the use of “conventional” septic systems. The use of alternative individual wastewater systems may allow greater densities.

- **Future groundwater development**. If the pattern of groundwater development within the study area changes, subsequent effects on the groundwater table and gradient will occur. If so, it may be prudent to re-evaluate recommended septic system densities considering the effects of large scale pumping.

- **Water supply alternatives**. The recommended septic system density depends in some degree on how water supply demands are met. This is due to the risks associated with private wells as opposed to public water supply wells. Private wells are typically much shallower than public water supply wells. Also, there are no monitoring requirements for private wells to detect increases in contaminant concentrations. Therefore, the risk of septic system contamination is generally greater for private wells. Currently, there are both private wells and public water systems serving the water demands in the study area. The recommended septic system densities include the higher risks associated with the use of private wells. If water supply demands were principally met in the future by public water systems instead of private wells, a reduction of the land area required for each septic system could be considered.

Several existing developments on septic systems within the County have exceeded the recommended septic system densities within individual subdivisions. It is expected that the County will continue to grow, which could result in degradation of the groundwater quality. Because of this, it is recommended that the County develop a plan for the collection and treatment of wastewater in currently unincorporated areas. It is also recommended that the County consider formation of a special service district to fund, construct, operate, and maintain the wastewater collection and treatment system.

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APPENDIX A

Mass Balance Equation

HANSEN ALLEN & LUCE inc
ENGINEERS

TOOELE COUNTY HEALTH DEPARTMENT
SEPTIC SYSTEM DENSITY STUDY
MASS BALANCE EQUATION

$$A_{mls} = \frac{q_s A\left(C_F - C_S\right)\cdot\left(ft^3/7.4805\,gal\right)}{Q_B\left(C_B - C_F\right) + \left[PF_P A\left(C_P - C_F\right) + IF_I AF_{AI}\left(C_I - C_F\right)\right]\cdot\left(\frac{9.9452\ ft^3/day}{acre\cdot in/year}\right)}$$

Variable	Units	Description
A_{mls} =	acres	Minimum lot size for septic systems
A =	acres	Area of transect
Q_B =	ft3/day	Groundwater flow within mixing depth (calculated)
k =	ft/day	average hydraulic conductivity
i =	ft/ft	hydraulic gradient of the aquifer
w =	ft	width of transect
d =	ft	mixing depth of the aquifer
q_s =	gal/day	Flow from each individual septic system
P =	in/year	Annual precipitation over study area (already included in flow)
F_P =		Fraction of precipitation entering groundwater (" " ")
I =	in/year	Total applied irrigation depth (already included in flow)
F_I =		Fraction of irrigation entering groundwater (" " ")
F_{AI} =		Fraction of study area irrigated (" " ")
C_B =	mg/l	Background concentration of NO_3 (as N) in groundwater
C_S =	mg/l	NO_3 (as N) concentration in septic system effluent
C_P =	mg/l	NO_3 (as N) concentration in precipitation
C_I =	mg/l	NO_3 (as N) concentration in irrigation
C_F =	mg/l	Final downstream concentration of NO_3 (as N) in groundwater

APPENDIX B

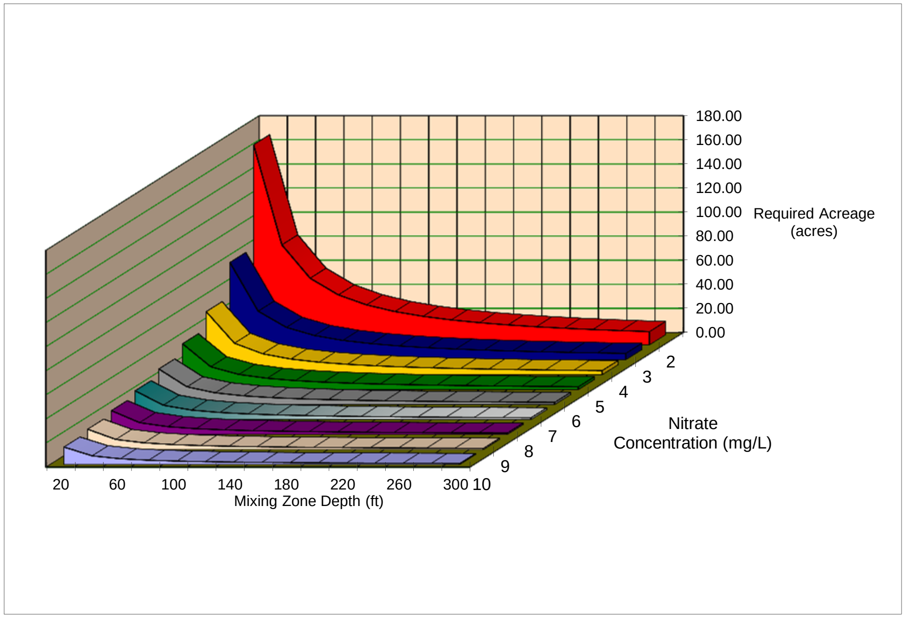
Mass Balance Analysis Results

HANSEN
ALLEN
& LUCE INC
ENGINEERS

TOOELE COUNTY HEALTH DEPARTMENT
SEPTIC SYSTEM DENSITY STUDY - LAKE POINT AREA
MASS BALANCE ANALYSIS

$$A_{mls} = \frac{q_s A\left(C_F - C_S\right)\cdot\left(ft^3/7.4805\,gal\right)}{Q_B\left(C_B - C_F\right) + \left[PF_P A\left(C_P - C_F\right) + IF_I AF_{AI}\left(C_I - C_F\right)\right]\cdot\left(\dfrac{9.9452\ ft^3/day}{acre\cdot in/year}\right)}$$

A_{mls} =	(calculated)	acres	Minimum lot size for septic systems
A =	4555	acres	Area of transect
Q_B =	(k*i*w*d)	ft3/day	Groundwater flow within mixing depth (calculated)
k =	80	ft/day	average hydraulic conductivity
i =	0.0018	ft/ft	hydraulic gradient of the aquifer
w =	14500	ft	width of transect
d =	(see below)	ft	mixing depth of the aquifer
q_s =	300	gal/day	Flow from each individual septic system
P =	0	in/year	Annual precipitation over study area (already included in flow)
F_P =	0		Fraction of precipitation entering groundwater (" " ")
I =	0	in/year	Total applied irrigation depth (already included in flow)
F_I =	0		Fraction of irrigation entering groundwater (" " ")
F_{AI} =	0		Fraction of study area irrigated (" " ")
C_B =	1	mg/l	Background concentration of NO_3 (as N) in groundwater
C_S =	40	mg/l	NO_3 (as N) concentration in septic system effluent
C_P =	0	mg/l	NO_3 (as N) concentration in precipitation
C_I =	0	mg/l	NO_3 (as N) concentration in irrigation
C_F =	(see below)	mg/l	Final downstream concentration of NO_3 (as N) in groundwater



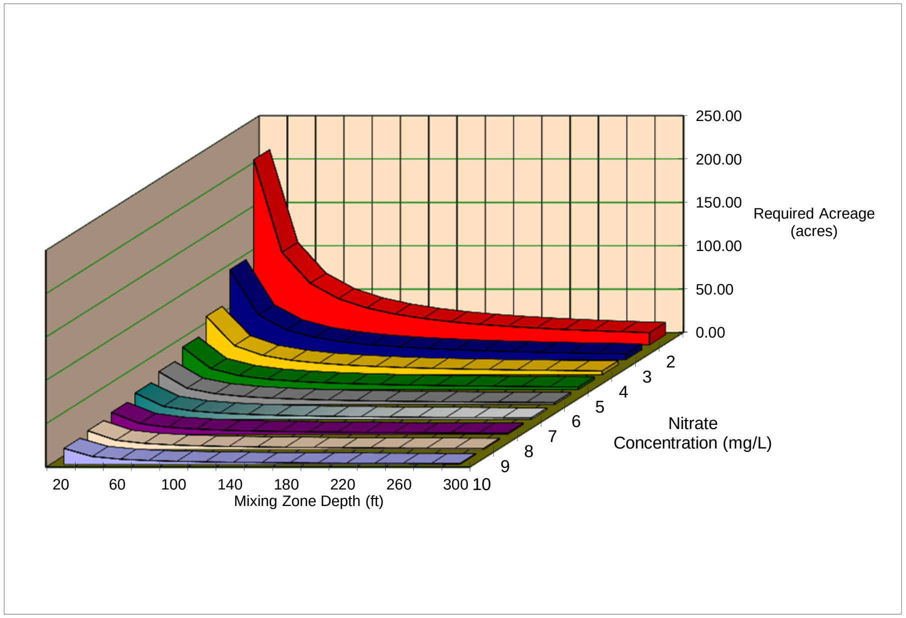
	Desired Downgradient NO_3 (mg/l):	2	3	4	5	6	7	8	9	10
	Mixing Depth	Acres required for each septic system								
	20	166.23	80.93	52.49	38.28	29.75	24.06	20.00	16.95	14.58
	40	83.11	40.46	26.25	19.14	14.87	12.03	10.00	8.48	7.29
	60	55.41	26.98	17.50	12.76	9.92	8.02	6.67	5.65	4.86
	80	41.56	20.23	13.12	9.57	7.44	6.01	5.00	4.24	3.65
------->	100	33.25	16.19	10.50	7.66	5.95	4.81	4.00	3.39	2.92
	120	27.70	13.49	8.75	6.38	4.96	4.01	3.33	2.83	2.43
	140	23.75	11.56	7.50	5.47	4.25	3.44	2.86	2.42	2.08
	160	20.78	10.12	6.56	4.78	3.72	3.01	2.50	2.12	1.82
	180	18.47	8.99	5.83	4.25	3.31	2.67	2.22	1.88	1.62
	200	16.62	8.09	5.25	3.83	2.97	2.41	2.00	1.70	1.46
	220	15.11	7.36	4.77	3.48	2.70	2.19	1.82	1.54	1.33
	240	13.85	6.74	4.37	3.19	2.48	2.00	1.67	1.41	1.22
	260	12.79	6.23	4.04	2.94	2.29	1.85	1.54	1.30	1.12
	280	11.87	5.78	3.75	2.73	2.12	1.72	1.43	1.21	1.04
	300	11.08	5.40	3.50	2.55	1.98	1.60	1.33	1.13	0.97

HANSEN ALLEN & LUCE INC ENGINEERS

TOOELE COUNTY HEALTH DEPARTMENT
SEPTIC SYSTEM DENSITY STUDY - EAST ERDA AREA
MASS BALANCE ANALYSIS

$$A_{mls} = \frac{q_s A\left(C_F - C_S\right)\cdot\left(ft^3/7.4805\,gal\right)}{Q_B\left(C_B - C_F\right) + \left[PF_P A\left(C_P - C_F\right) + IF_I AF_{AI}\left(C_I - C_F\right)\right]\cdot\left(\frac{9.9452\ ft^3/day}{acre\cdot in/year}\right)}$$

A_{mls} =	(calculated)	acres	Minimum lot size for septic systems
A =	4642	acres	Area of transect
Q_B =	(k*i*w*d)	ft3/day	Groundwater flow within mixing depth (calculated)
k =	80	ft/day	average hydraulic conductivity
i =	0.0018	ft/ft	hydraulic gradient of the aquifer
w =	11500	ft	width of transect
d =	(see below)	ft	mixing depth of the aquifer
q_s =	300	gal/day	Flow from each individual septic system
P =	0	in/year	Annual precipitation over study area (already included in flow)
F_P =	0		Fraction of precipitation entering groundwater (" " ")
I =	0	in/year	Total applied irrigation depth (already included in flow)
F_I =	0		Fraction of irrigation entering groundwater (" " ")
F_{AI} =	0		Fraction of study area irrigated (" " ")
C_B =	1	mg/l	Background concentration of NO_3 (as N) in groundwater
C_S =	40	mg/l	NO_3 (as N) concentration in septic system effluent
C_P =	0	mg/l	NO_3 (as N) concentration in precipitation
C_I =	0	mg/l	NO_3 (as N) concentration in irrigation
C_F =	(see below)	mg/l	Final downstream concentration of NO_3 (as N) in groundwater



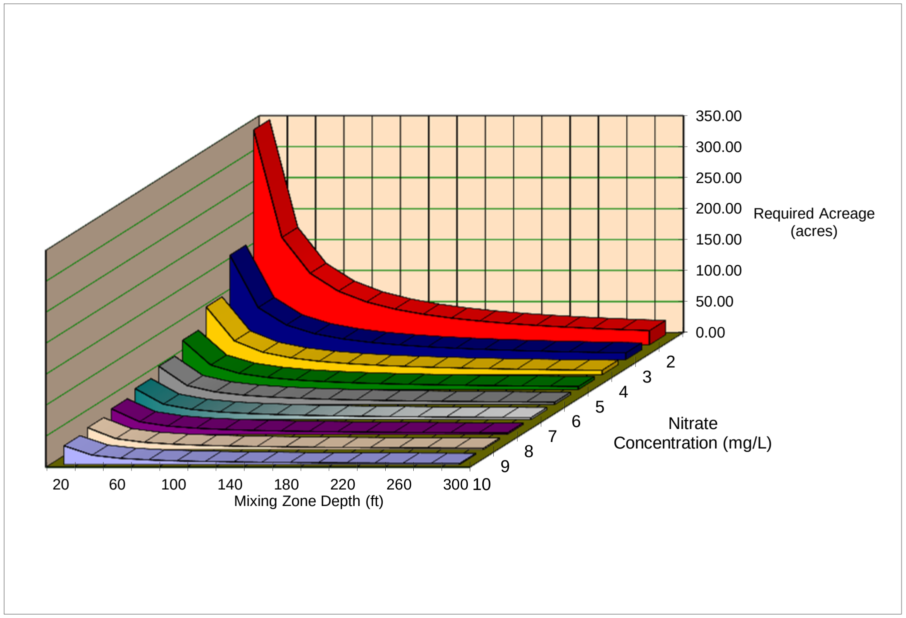
Desired Downgradient NO_3 (mg/l):	2	3	4	5	6	7	8	9	10
Mixing Depth	Acres required for each septic system								
20	213.59	103.99	67.45	49.18	38.22	30.91	25.70	21.78	18.74
40	106.80	51.99	33.73	24.59	19.11	15.46	12.85	10.89	9.37
60	71.20	34.66	22.48	16.39	12.74	10.30	8.57	7.26	6.25
80	53.40	26.00	16.86	12.30	9.56	7.73	6.42	5.45	4.68
100	42.72	20.80	13.49	9.84	7.64	6.18	5.14	4.36	3.75
120	35.60	17.33	11.24	8.20	6.37	5.15	4.28	3.63	3.12
140	30.51	14.86	9.64	7.03	5.46	4.42	3.67	3.11	2.68
160	26.70	13.00	8.43	6.15	4.78	3.86	3.21	2.72	2.34
180	23.73	11.55	7.49	5.46	4.25	3.43	2.86	2.42	2.08
-------> 200	21.36	10.40	6.75	4.92	3.82	3.09	2.57	2.18	1.87
220	19.42	9.45	6.13	4.47	3.47	2.81	2.34	1.98	1.70
240	17.80	8.67	5.62	4.10	3.19	2.58	2.14	1.82	1.56
260	16.43	8.00	5.19	3.78	2.94	2.38	1.98	1.68	1.44
280	15.26	7.43	4.82	3.51	2.73	2.21	1.84	1.56	1.34
300	14.24	6.93	4.50	3.28	2.55	2.06	1.71	1.45	1.25

HANSEN ALLEN & LUCE inc
ENGINEERS

TOOELE COUNTY HEALTH DEPARTMENT
SEPTIC SYSTEM DENSITY STUDY - ERDA/LINCOLN AREA
MASS BALANCE ANALYSIS

$$A_{mls} = \frac{q_s A\left(C_F - C_S\right)\cdot\left(ft^3/7.4805\,gal\right)}{Q_B\left(C_B - C_F\right) + \left[PF_P A\left(C_P - C_F\right) + IF_I AF_{AI}\left(C_I - C_F\right)\right]\cdot\left(\dfrac{9.9452\ ft^3/day}{acre\cdot in/year}\right)}$$

A_{mls} =	(calculated)	acres	Minimum lot size for septic systems
A =	7525	acres	Area of transect
Q_B =	(k*i*w*d)	ft3/day	Groundwater flow within mixing depth (calculated)
k =	80	ft/day	average hydraulic conductivity
i =	0.0016	ft/ft	hydraulic gradient of the aquifer
w =	12900	ft	width of transect
d =	(see below)	ft	mixing depth of the aquifer
q_s =	300	gal/day	Flow from each individual septic system
P =	0	in/year	Annual precipitation over study area (already included in flow)
F_P =	0		Fraction of precipitation entering groundwater (" " ")
I =	0	in/year	Total applied irrigation depth (already included in flow)
F_I =	0		Fraction of irrigation entering groundwater (" " ")
F_{AI} =	0		Fraction of study area irrigated (" " ")
C_B =	1	mg/l	Background concentration of NO_3 (as N) in groundwater
C_S =	40	mg/l	NO_3 (as N) concentration in septic system effluent
C_P =	0	mg/l	NO_3 (as N) concentration in precipitation
C_I =	0	mg/l	NO_3 (as N) concentration in irrigation
C_F =	(see below)	mg/l	Final downstream concentration of NO_3 (as N) in groundwater

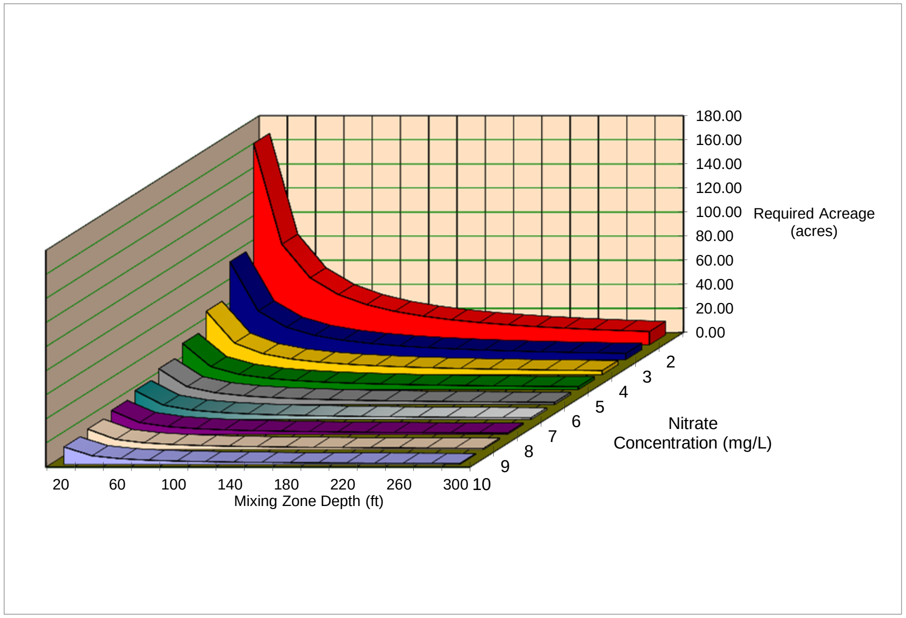


Desired Downgradient NO_3 (mg/l):	2	3	4	5	6	7	8	9	10
Mixing Depth	Acres required for each septic system								
20	347.26	169.06	109.66	79.96	62.14	50.26	41.78	35.41	30.46
40	173.63	84.53	54.83	39.98	31.07	25.13	20.89	17.71	15.23
60	115.75	56.35	36.55	26.65	20.71	16.75	13.93	11.80	10.15
80	86.81	42.26	27.42	19.99	15.54	12.57	10.44	8.85	7.62
100	69.45	33.81	21.93	15.99	12.43	10.05	8.36	7.08	6.09
120	57.88	28.18	18.28	13.33	10.36	8.38	6.96	5.90	5.08
140	49.61	24.15	15.67	11.42	8.88	7.18	5.97	5.06	4.35
160	43.41	21.13	13.71	10.00	7.77	6.28	5.22	4.43	3.81
180	38.58	18.78	12.18	8.88	6.90	5.58	4.64	3.93	3.38
200	34.73	16.91	10.97	8.00	6.21	5.03	4.18	3.54	3.05
220	31.57	15.37	9.97	7.27	5.65	4.57	3.80	3.22	2.77
240	28.94	14.09	9.14	6.66	5.18	4.19	3.48	2.95	2.54
260	26.71	13.00	8.44	6.15	4.78	3.87	3.21	2.72	2.34
280	24.80	12.08	7.83	5.71	4.44	3.59	2.98	2.53	2.18
-------> 300	23.15	11.27	7.31	5.33	4.14	3.35	2.79	2.36	2.03

TOOELE COUNTY HEALTH DEPARTMENT
SEPTIC SYSTEM DENSITY STUDY - WEST ERDA AREA
MASS BALANCE ANALYSIS

$$A_{mls} = \frac{q_s A\left(C_F - C_S\right)\cdot\left(ft^3/7.4805\,gal\right)}{Q_B\left(C_B - C_F\right) + \left[PF_P A\left(C_P - C_F\right) + IF_I AF_{AI}\left(C_I - C_F\right)\right]\cdot\left(\dfrac{9.9452\ ft^3/day}{acre\cdot in/year}\right)}$$

A_{mls} =	(calculated)	acres	Minimum lot size for septic systems
A =	4777	acres	Area of transect
Q_B =	(k*i*w*d)	ft^3/day	Groundwater flow within mixing depth (calculated)
k =	80	ft/day	average hydraulic conductivity
i =	0.0017	ft/ft	hydraulic gradient of the aquifer
w =	16000	ft	width of transect
d =	(see below)	ft	mixing depth of the aquifer
q_s =	300	gal/day	Flow from each individual septic system
P =	0	in/year	Annual precipitation over study area (already included in flow)
F_P =	0		Fraction of precipitation entering groundwater (" " ")
I =	0	in/year	Total applied irrigation depth (already included in flow)
F_I =	0		Fraction of irrigation entering groundwater (" " ")
F_{AI} =	0		Fraction of study area irrigated (" " ")
C_B =	1	mg/l	Background concentration of NO_3 (as N) in groundwater
C_S =	40	mg/l	NO_3 (as N) concentration in septic system effluent
C_P =	0	mg/l	NO_3 (as N) concentration in precipitation
C_I =	0	mg/l	NO_3 (as N) concentration in irrigation
C_F =	(see below)	mg/l	Final downstream concentration of NO_3 (as N) in groundwater



	Desired Downgradient NO_3 (mg/l):	2	3	4	5	6	7	8	9	10
	Mixing Depth	Acres required for each septic system								
	20	167.28	81.44	52.82	38.52	29.93	24.21	20.12	17.06	14.67
	40	83.64	40.72	26.41	19.26	14.97	12.11	10.06	8.53	7.34
	60	55.76	27.15	17.61	12.84	9.98	8.07	6.71	5.69	4.89
	80	41.82	20.36	13.21	9.63	7.48	6.05	5.03	4.26	3.67
	100	33.46	16.29	10.56	7.70	5.99	4.84	4.02	3.41	2.93
	120	27.88	13.57	8.80	6.42	4.99	4.04	3.35	2.84	2.45
	140	23.90	11.63	7.55	5.50	4.28	3.46	2.87	2.44	2.10
------->	160	20.91	10.18	6.60	4.81	3.74	3.03	2.52	2.13	1.83
	180	18.59	9.05	5.87	4.28	3.33	2.69	2.24	1.90	1.63
	200	16.73	8.14	5.28	3.85	2.99	2.42	2.01	1.71	1.47
	220	15.21	7.40	4.80	3.50	2.72	2.20	1.83	1.55	1.33
	240	13.94	6.79	4.40	3.21	2.49	2.02	1.68	1.42	1.22
	260	12.87	6.26	4.06	2.96	2.30	1.86	1.55	1.31	1.13
	280	11.95	5.82	3.77	2.75	2.14	1.73	1.44	1.22	1.05
	300	11.15	5.43	3.52	2.57	2.00	1.61	1.34	1.14	0.98