Prepared in cooperation with Deschutes County and the Oregon Department of Environmental Quality

Questions and Answers About the Effects of Septic Systems on Water Quality in the La Pine Area, Oregon

Nitrate levels in the ground-water aquifer underlying the central Oregon city of La Pine and the surrounding area are increasing due to contamination from residential septic systems. This contamination has public health implications because ground water is the sole source of drinking water for area residents. The U.S. Geological Survey, in cooperation with Deschutes County and the Oregon Department of Environmental Quality, studied the movement and chemistry of nitrate in the aquifer and developed computer models that can be used to predict future nitrate levels and to evaluate alternatives for protecting water quality. This fact sheet summarizes the results of that study in the form of questions and answers.

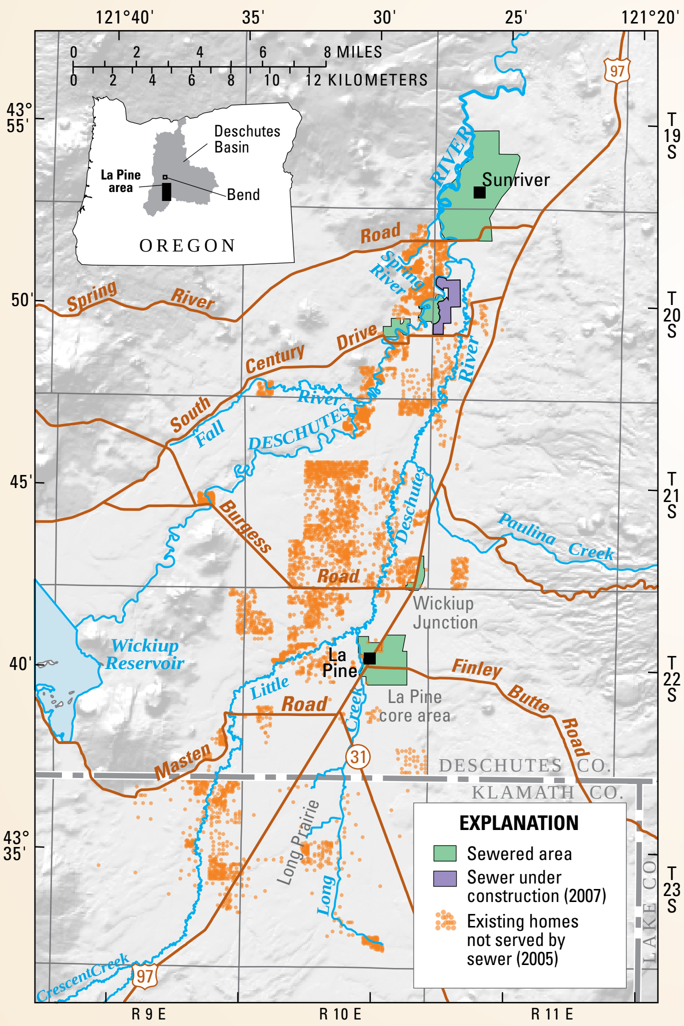


Figure 1. *Residential development near La Pine, Oregon, is proceeding at a rapid pace. This map of the area shows the boundary of a USGS study to examine the processes that affect the movement and chemistry of nitrogen in the ground-water system.*

The population of rural residential areas near La Pine in southern Deschutes County and northern Klamath County, Oregon, has grown rapidly since the 1960s. Most of these areas lie within a tract adjacent to the Deschutes and Little Deschutes Rivers that extends roughly 25 miles south of Sunriver (fig. 1). Existing and future homes on more than 9,300 residential lots in the area now use or will use individual, on-site septic systems for wastewater disposal and shallow wells for water supply. At least 50 percent of these wells draw ground water from the upper 50 feet of the shallow aquifer that underlies the area (Morgan and others, 2007).

Vulnerability of the shallow aquifer to contamination has led to concern by residents, County planners and resource managers, and State regulators that wastewater from septic systems may pose a threat to the primary drinking water supply if residential development continues at planned densities using conventional septic systems. Another concern is the quality of local streams (Hinkle, Morgan, and others, 2007). The Deschutes and Little Deschutes Rivers, which flow through the developed areas near La Pine, already have excessive algae in some reaches, possibly due to nutrient (nitrogen and phosphorus) contributions from ground water (Anderson, 2000; Jones, 2003).

Septic system being installed near La Pine, Oregon.

Conventional residential septic systems are the principal source of nitrogen to the shallow aquifer in the La Pine area (Century West Engineering, 1982; Oregon Department of Environmental Quality, 1994; Hinkle, Böhlke, and others, 2007), and the nitrate contribution (loading) to the aquifer from these septic systems has increased rapidly as a result of ongoing residential development (fig. 2). Conventional septic systems, including sand filter and pressure distribution systems, are not designed to remove nitrogen from wastewater. Nitrate is a human health concern because it can cause methemoglobinemia (Blue-Baby Syndrome) in infants (*http://www.atsdr.cdc.gov/HEC/CSEM/nitrate/*). The U.S. Environmental Protection Agency has established 10 parts per million (ppm) of nitrogen as the maximum allowable nitrate concentration in drinking water for public water supply systems. Oregon law sets a nitrate concentration of 7 ppm as the level at which regulatory action must be taken to control water-quality degradation.

The city of La Pine was the location of the first concentrated development within the area. The first building permits, recorded in what was then called the core area, date from 1910. In 2006, the core area was incorporated as the City of La Pine. The Oregon Department of Environmental Quality (ODEQ) issued an administrative rule requiring community sewage treatment for the core area after studies in 1979 and 1982 documented nitrate contamination in drinking water wells (Century West Engineering, 1982; Cole, 2006).

Surveys of wells outside of the core area by ODEQ between 1993 and 1995 found unnaturally elevated nitrate concentrations in several of the most densely developed parts of the region

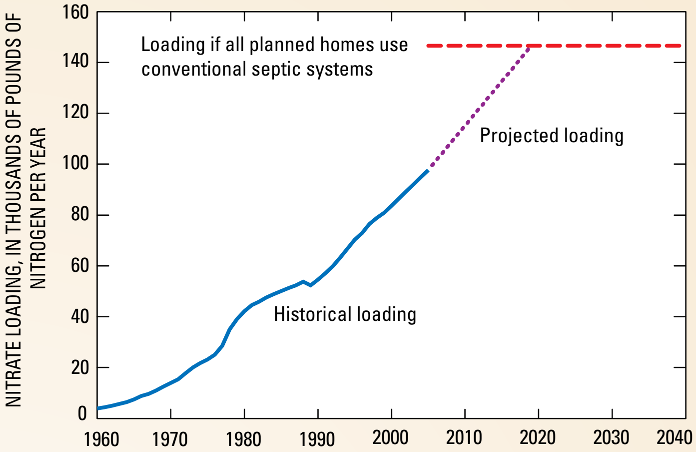


Figure 2. *The rapid increase in nitrate loading to the aquifer that supplies drinking water to homes in the La Pine area is due to the rapid pace of residential development.*

(R.J. Weick, ODEQ, written commun., 1998; Cole, 2006). The high concentrations were attributed to contamination by effluent from septic systems.

In 1999, Deschutes County and ODEQ identified the need for a better understanding of the processes that affect the movement and chemistry of nitrogen in the aquifer underlying the La Pine area in order to develop strategies for managing ground-water quality. In response, the USGS, in cooperation with Deschutes County and ODEQ, began a study in 1999 to examine the hydrologic and chemical processes that affect the movement and fate (chemical transformation) of nitrogen within the aquifer (Hinkle, Böhlke, and others, 2007; Morgan and others, 2007). A primary objective was to provide tools for evaluating the effects of existing and future residential development on water quality. The study has provided area residents and local and State agencies the information and tools needed to make informed decisions about the future of development in the La Pine area. Results from the study have been published in several reports (see References Cited). This fact sheet summarizes the results that relate to the effects of septic systems on water quality in the area.

As part of the La Pine area ground-water study, the USGS drilled wells to collect geologic and water-quality data.

Geologists examined drill-core samples to define the geology at different depths.

Is shallow ground water in the vicinity of La Pine vulnerable to contamination from on-site wastewater systems?

Yes, several factors contribute to the vulnerability:

1. The ground-water table is shallow, typically less than 20 feet below land surface and seasonally rising to within 2 feet in low-lying areas (fig. 3).
2. The sandy soils allow rapid infiltration of septic system effluent to the water table.
3. The amount of rain and snowmelt that enters the aquifer is small, which limits dilution of septic system effluent.
4. Most existing drinking-water wells draw water from shallow sand and gravel deposits within 50 feet of land surface. These deposits form the primary aquifer in the area.
5. Fifty-eight percent of lots are less than 1 acre and 82 percent are less than 2 acres, making residential densities relatively high for an area where homes are dependent on individual septic systems and wells.

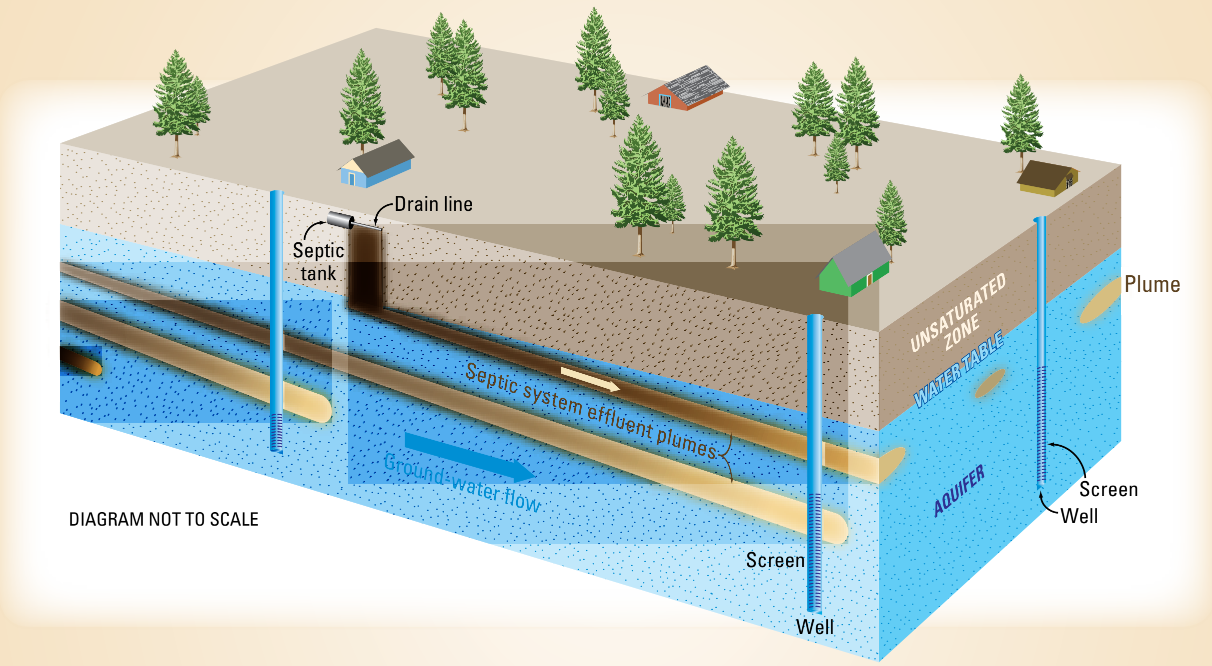


Figure 3. *Wastewater from septic systems contains nitrogen in the forms of ammonia and organic nitrogen. As wastewater leaves the septic system drainfield and percolates through the unsaturated zone, these forms of nitrogen are converted to nitrate. When the wastewater reaches the water table it forms plumes of elevated nitrate within the aquifer. The plumes move downward with the ground water and slowly spread. Currently, relatively few wells have water with high nitrate concentrations because these plumes have not had time to reach the depths where most domestic supply wells draw water. As more homes are built, and as plumes move deeper and spread, many more supply wells will be affected.*

Why don't more domestic wells in the area have high nitrate levels?

Ground water moves slowly through the shallow aquifer. Because ground water moves slowly, it takes a long time for nitrate to appear in well water.

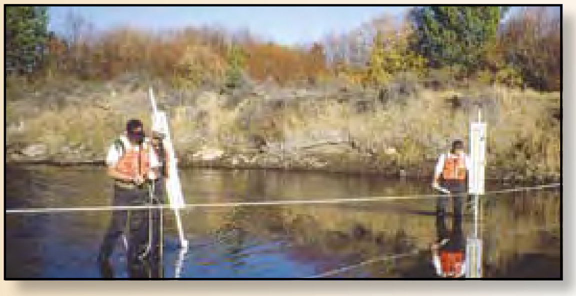
For example, the severity of nitrate contamination in the La Pine core area did not become evident until 1979, nearly 70 years after development of that area began. Away from the core area, most wells currently provide drinking water that percolated to the water table decades ago, when there were very few homes and septic systems. Nitrate plumes, however, are beginning to affect a significant number of drinking-water wells. Of nearly 200 well samples collected by ODEQ in 2000, over 10 percent had nitrate concentrations above 4 ppm, indicating contamination from septic systems.

Much of the nitrate in the aquifer currently is confined to plumes less than about 30 feet below the water table, so not all supply wells are drawing water from affected areas of the aquifer (fig. 3). As development proceeds and the nitrate plumes expand and move deeper into the aquifer, more wells will be affected. Age dating of ground water in the La Pine area provides additional insight into this process. USGS scientists determined the age of ground water by sampling special monitoring wells and analyzing the water for tracers called chlorofluorocarbons (common refrigerant gases found in the atmosphere). These tracers indicate that nitrate from septic systems is moving downward into deeper parts of the aquifer where more wells will be affected in the future (Hinkle, Böhlke, and others, 2007; Morgan and others, 2007).

Could other sources of nitrate, like agriculture, animals, golf courses, or lawns, cause water-quality problems?

Probably not. Several lines of evidence point to septic systems as the main source of the nitrate (Hinkle, Böhlke, and others, 2007):

1. Agriculture (primarily pasture) represents only about 4 percent of the study area. The four golf courses in the area cover less than 0.4 percent of the study area and are located where they would affect few if any wells. Animal waste contribution is much less than that of humans, and it is deposited on the land surface, where various processes remove nitrogen. Most homes in the area have natural landscaping or small lawn areas; assuming fertilizer is applied at recommended rates, very little nitrogen infiltrates below the root zone and into the ground water.
2. Nitrogen isotope (^{15}N) concentrations can be used to identify the source of nitrate in ground water; nitrogen isotope data for the La Pine area indicate that septic systems are the source of nitrate in the shallow ground water.
3. The occurrence of nitrate in distinct plumes is consistent with localized sources (individual septic systems) and is not consistent with dispersed sources, such as agricultural fields, golf courses, or livestock pasture.
4. Chloride, a wastewater component, is present in the shallow aquifer at higher concentrations than seen outside of the La Pine area or in deep ground water beneath the area. Other sources of chloride, such as agriculture or road salt, are not common in the area. Therefore, the elevated chloride concentrations indicate that the shallow ground water contains a proportion of septic system effluent.



These scientists are measuring the flow of ground water into the Little Deschutes River through the streambed.

The USGS measured water levels in the aquifer under the La Pine area to determine the direction of ground-water flow.

What will happen to water quality if nitrate loading from septic systems continues at projected rates?

Large areas of the shallow aquifer will have nitrate concentrations above 10 ppm, and more nitrate will be carried into streams by ground water.

If residential development proceeds as planned and no efforts are made to reduce the rates of nitrate loading from septic systems, loading is projected to increase 52 percent above 2005 rates (fig. 2). Computer model simulations of this future scenario show that:

1. Peak nitrate concentrations will exceed 10 ppm over large areas of the shallow aquifer (fig. 4). On average, drinking water in those areas will be composed of at least 22 percent septic system effluent.
2. The highest nitrate concentrations will be near the water table, but many wells that draw water from the upper 50 feet of the aquifer will be at risk for nitrate contamination.
3. It will take decades for peak concentrations to occur and decades for concentrations to subside if nitrate loading is reduced.
4. Increasing amounts of nitrate from septic systems will be carried into the Deschutes and Little Deschutes Rivers by ground water.

The computer model integrates the current understanding of nitrogen geochemistry, hydrology, and geology of the aquifer underlying the La Pine area. The model was tested by simulating past ground-water levels, ground-water travel times, ground-water discharge to streams, and ground-water-quality conditions and then comparing the model results with measurements made in the study area. The simulated conditions, including past ground-water nitrate concentrations, matched measured conditions within acceptable limits. These results indicate that the model has sufficient accuracy to be a valid tool for evaluating the potential effects of septic systems on future ground-water quality.

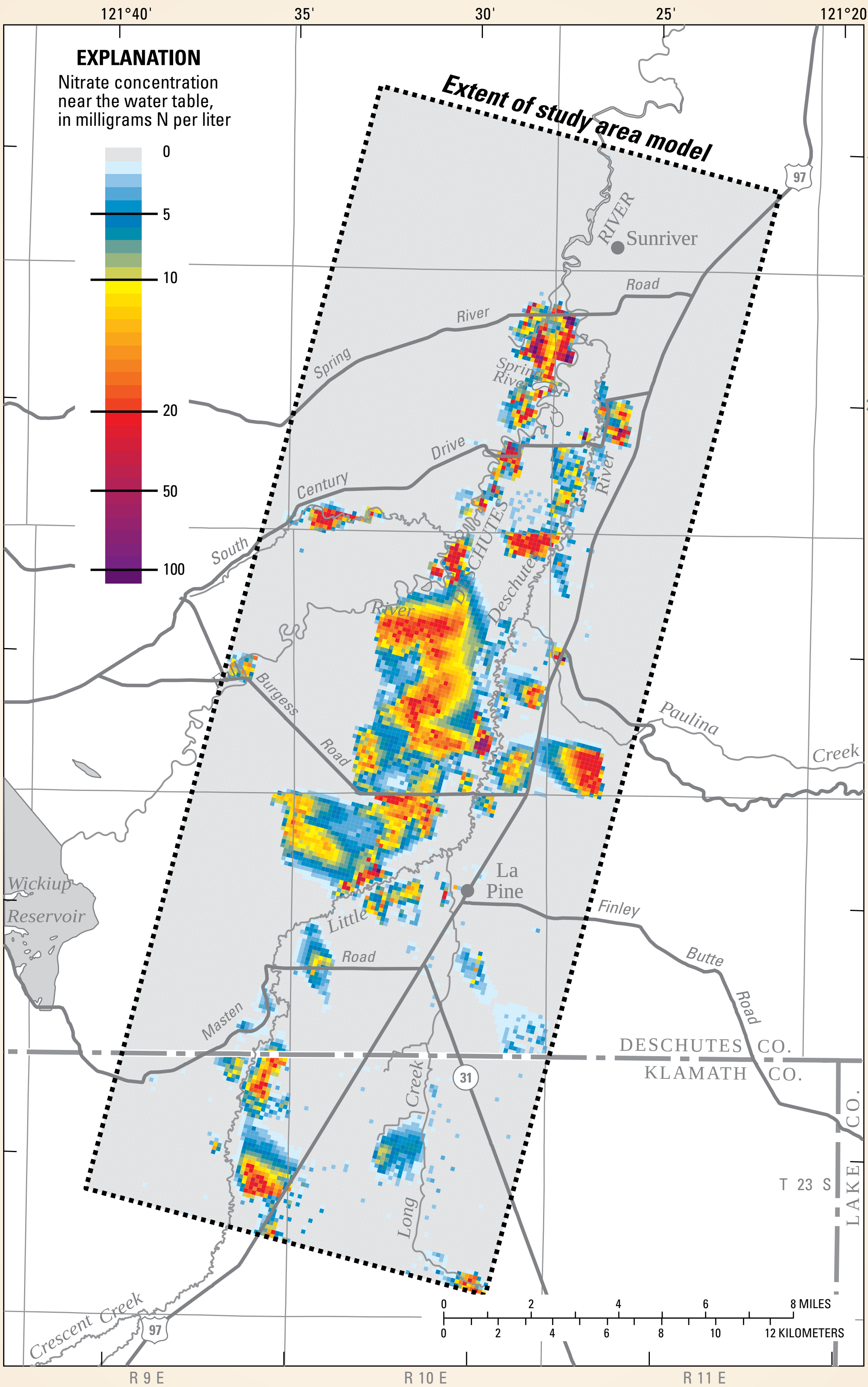


Figure 4. *Ground water in much of the shallow aquifer underlying residential areas will exceed State and Federal water-quality standards for nitrate if existing and future homes continue to use conventional septic systems.*

How much nitrate can be put into the aquifer while still protecting water quality?

The computer model is a tool that can be used to help answer this question.

The capacity of the aquifer to receive nitrate varies throughout the area and depends on factors related to geology, climate, chemistry, and nearby development. These factors are accounted for by the model, allowing it to compute the maximum sustainable nitrate loading capacity in each of 95 subareas ranging in size from 160 to 640 acres. The maximum sustainable loading capacity also depends on the water-quality protection goals for the aquifer. Model users set the values of water-quality goals, which can be the maximum acceptable nitrate concentration in ground water, the maximum acceptable discharge of nitrate to streams, or both. Goals that are more protective, such as limiting nitrate concentrations in ground water to 7 ppm instead of 10 ppm, reduce the sustainable loading capacity of the aquifer (fig. 5). The model can be used to examine the trade-offs between more stringent water-quality goals and the costs of limiting nitrate loading. Planners and resource managers also can use the model to identify areas where loading from planned or existing development exceeds the sustainable nitrate loading capacity of the aquifer and devise appropriate strategies for reducing loading.

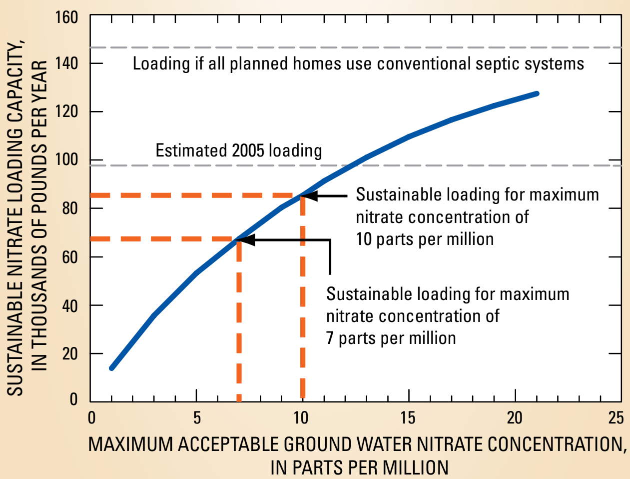


Figure 5. *This graph shows the relation between maximum acceptable nitrate concentration in ground water and the sustainable nitrate loading capacity of the aquifer, as determined using the computer model. The graph illustrates that there is a trade-off between the sustainable loading capacity and water quality goals.*

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Base modified from U.S. Geological Survey
1:500,000 state base map, 1982 with digital data from U.S. Bureau of the Census, TIGER/Line (R), 1990 and U.S. Geological Survey Digital Line Graphs published at 1:100,000
Publication projection is Lambert Conformal Conic, Standard parallels 42°20′ and 44°40′, central meridian -120°30′. Datum is NAD83

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