White Paper Subject: SCATTER CREEK AQUIFER WATER QUALITY
For: Thurston County Planning Commission
By: Thurston County Environmental Health Division
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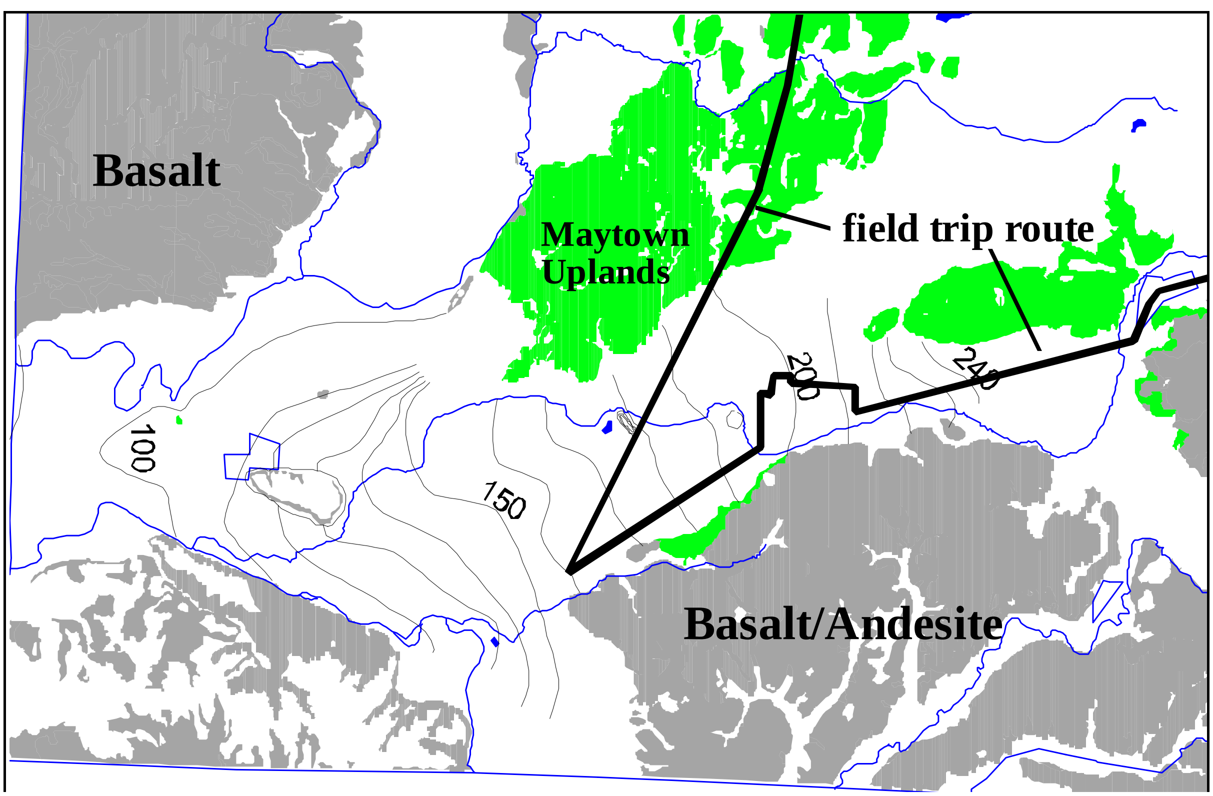
Geology of Scatter Creek Aquifer

The Scatter Creek Aquifer is comprised of sand and gravel deposited by glacial flooding 13,000-15,000 years ago. During the Vashon stage of the Fraser glaciation, glacial ice blocked the northward drainage of water within Thurston County. As the glacier advanced, the ice front diverted the water from the areas now drained by the Deschutes and Nisqually Rivers, and many smaller streams, into a series of roughly east-west drainages that finally drained out the Chehalis River Valley. These east-west drainage routes are visible as an alignment of prairies, under which **the soils are so coarse and well-drained that grass is the dominant vegetation**.

The drainage route that formed the Scatter Creek Aquifer was fairly well constrained by the Maytown Uplands to the north and the Bald Hills to the south, which is reflected in the relatively coarse materials of the aquifer. The large volume of glacial melt waters that flooded through the Grand Mound / Rochester area left behind major gravel and sand deposits that provided gravel mining resources and a major groundwater resource for high volume users such as aquaculture. It also formed **a single aquifer that is highly vulnerable to contamination**.



Groundwater in the Scatter Creek Aquifer generally flows from the east, near Tenino, to the west-southwest toward the Chehalis River, as described in Sinclair and Hirschey (1992). The lines shown in the figure on page 1 are contoured elevations of the hydraulic head measured in wells. The direction of groundwater flow is perpendicular to the contours in the direction of lower head. Flow directions change slightly throughout the year due to seasonal changes in recharge and discharge to streams.

Tenino and Bucoda are both situated above narrow, shallow aquifers surrounded by tertiary bedrock, as evidenced by the sandstone quarries and sandstone-front buildings in these towns. The maximum thickness of the alluvial aquifer penetrated by wells in both the Bucoda and Tenino vicinities is approximately 100 feet. The aquifer width is generally one-quarter to one-third mile.

Several wells in the Grand Mound area have intersected bedrock at depths from 45-140 feet. A depth range of 90-120 feet is typical in the central part of the aquifer channel. Static water levels between 20-30 feet below ground surface are common, although in some areas water levels are greater than 40 feet or less than 10 feet below the surface. This means that typical saturated thicknesses for the aquifer usually range from 60-100 feet. Sinclair and Hirschey (1992) found saturated aquifer thicknesses that ranged from 41-115 feet.

Static water levels in Mound Prairie generally range from 20-45 feet and the underlying bedrock is found at approximately 100 feet. Groundwater flows to the west-southwest under Mound Prairie with a gradient of 10-13 feet per mile. **Groundwater flow velocities for the Scatter Creek Aquifer were estimated by Sinclair and Hirschey (1992) to range from 1.3-60 feet/day with a mean of approximately 16 feet/day.**

Land Use

The Scatter Creek Aquifer area contains a mix of land uses, including residential tracts, dairy, poultry, alpaca farms, cattle ranches, fish farms, gravel pits, an automobile raceway, day care facilities, an airport, scattered retail and wholesale commercial operations, log home manufacturing, and a sludge composting facility. The current land use trend is a rapid conversion of the agricultural uses and open space to residential development at densities as high as one-half acre lots with community water service.

Nitrate Contamination

Water quality in the aquifer has been degraded by nitrate contamination. An assessment of nitrate data from 1993-1995 showed that nitrate concentrations upgradient (east) from Tilley Road were generally below 3.0 ppm. West of Tilley Road, nitrate levels increased dramatically, reaching a high of 30.6 ppm. Southwest of Scatter Creek, nitrate levels gradually decrease down to a range of 2 to 4 ppm (Mead, et al, 1996). A sampling of single-family wells across the eastern portion of the aquifer in late 2004 found a similar distribution of nitrate concentrations from east to west. The results ranged from 0.3 to 11.6 mg/L with an overall average of 3.3 mg/L (Davis, 2005). The distribution of results was as follows:

Nitrate Results Category	Number of Samples
0 – 1.9 mg/L	17
2 – 3.9 mg/L	22
4 – 9.9 mg/L	12
10 mg/L or greater	1

A 1996 study by Mead, Cramer, and Tayne reported that the most probable cause of the nitrate increase in groundwater as it passes through Violet Prairie is from the concentrated agricultural activities occurring there. The nitrate data for Violet Prairie were highly variable in time and space. Rather than comprising a single contaminant plume, the nitrate contamination appeared to occur in numerous smaller plumes coming from numerous sources. The report provides the following possible reasons to explain the documented nitrate variability:

- **Variable nitrate loading**. Manure is applied to the land at varying rates. The number of livestock varies, and the operators do not apply manure evenly over their property. The operators sometimes contract with other property owners to apply manure onto their property sporadically.

- **Plants take up the nitrogen from manure at varying rates through the growing cycle.** During the growing season, uptake of nitrogen is high. In the winter, when the plants are dormant, uptake is low. Nitrate that is not taken up by plants can be washed downward into groundwater.

- **Variable recharge**. During periods of high rainfall, more nitrate is washed downward through the shallow soils of Violet Prairie. These "bursts" of nitrate enter ground water and move with it, causing an uneven distribution of nitrate in the aquifer.

- **A rapidly moving aquifer with relatively lateral dispersion.** Sinclair and Hirschey (1992) estimated an average groundwater flow velocity of 16 feet per day for the Scatter Creek Aquifer. The high transmissivity of the aquifer means that contaminant plumes will travel a relatively long distance without spreading out much perpendicular to the flow direction. This produces long "pencil-like" contaminant plumes that may affect one well while completely bypassing its neighbor.

- **Variable flow directions**. Sinclair and Hirschey (1992) constructed seasonal ground-water head elevation contour maps that show that groundwater flow directions vary significantly throughout the years. This is caused by changes in recharge and patterns of discharge to streams. The variability in flow directions means that the pencil-like contaminant plumes may intersect a given well during one season and bypass it during the next season.

- **Nitrate concentrations probably vary with depth**. Nitrogen is applied to the surface as manure. As groundwater flows away from the contaminant source, clean recharge may be applied on top of the nitrates as rainfall. In addition, some natural denitrification may be taking place in the aquifer. A decrease in nitrate in progressively deeper wells was not documented during this study, but was found in northern Thurston County (Dion and others, 1994).

Based on the characteristics and vulnerability of this aquifer, it is likely that as the land use patterns across the aquifer shift from rural residential development and a few large agricultural operations to higher density residential developments and many smaller livestock operations, a change in the nitrate patterns will occur.

The table below shows the amount of **total nitrogen** contained in the waste of various types of livestock and in human sewage.

Comparison of Nitrogen Generated by Livestock and Humans

Source	Total Nitrogen (pounds/day)
Dairy Cow (per 1000 pound wt.)	0.45*
Beef Cow (per 1000 pound wt)	0.31*
Horse (per 1000 pound wt)	0.28*
Poultry (layer, per 1000 wt)	0.83*
Human (family of 4 persons)	0.14**

Ref. *Agricultural Waste Management Field Handbook, USDA, SCS, April 1992
**"Nitrogen Reducing Technologies for On-site Wastewater Treatment Systems", WDOH, pg. 8, June 2005.

In terms of total amount of nitrogen generated, the waste from one dairy cow is the equivalent of about 12 to 13 people. However, in managing the waste from both livestock and septic systems, not all of the nitrogen generated results in transport and subsequent contamination of ground-water. A percentage of the nitrogen is lost to volatilization, mineralization, uptake by vegetation/crops, or retention in septic tanks or waste storage facilities. The percentage of the nitrogen reduction/removal is highly dependent on the type and quality of the waste management system. For example, for a livestock operation with a fully designed and implemented waste management system, the goal is to lose or utilize all of the nitrogen before it migrates below the root zone of the plants. However, not all operations use the most up-to-date practices and equipment. Also, it is not possible to control all of the factors necessary to achieve that goal, such as the weather, nor to have a manure management system that is 100 percent efficient. As a result, there are measurable losses in the form of increased groundwater nitrate concentrations down-gradient of some operations in Thurston County.

For conventional septic tank/gravity drainfield on-site sewage systems, the nitrogen removal is about 10 to 30 percent, the majority of which is trapped in the scum and sludge layers in the septic tank. Nitrogen removal beyond the septic tank is dependent on the type of system. Nitrogen removal efficiency of on-site sewage systems can be much greater (up to 90%) with more advanced technologies (WDOH, June 2005). However, in Thurston County these advanced technologies are not routinely required for nitrogen reduction purposes under current regulations. Several studies suggest that the best way to control groundwater degradation from on-site sewage systems is through appropriate densities. A 2002 research report written by Washington Department of Health cites several studies indicating that a minimum lot size of 0.5 to 1 acre is adequate to protect groundwater. There are areas of high nitrates in groundwater in Thurston County where the primary land uses are high density residential served by on-site sewage systems.

Another potential source of nitrate contamination associated with both residential and agricultural land use is commercial fertilizers. There are studies across the nation that document nitrate contamination of groundwater in association with both agricultural and residential uses of commercial fertilizers.

Coliform Bacteria Contamination

Coliform contamination in the Scatter Creek Aquifer appears to be increasingly prevalent. A bacteriological investigation in the southeast corner of the aquifer near Tenino was conducted in 2000 and 2001 by Thurston County Public Health and Social Services Department staff in response to the discovery that a small public water system routinely had sample results containing coliform bacteria. The outcome of the investigation was inconclusive, as the results were inconsistent both spatially throughout the study area as well as temporally. To protect the health of the residents served by that public water system, disinfection was added to the system. However, there remains a public health concern for the single family well owners residing in the area who are not required to sample nor are there water quality regulations that apply to their wells.

As part of the single family well sampling project conducted by Thurston County Public Health and Social Services staff in 2004, 81 wells were sampled for coliform bacteria across the aquifer from Tenino to Interstate-5. **Thirty-eight percent of those 81 wells were positive for total coliform bacteria** (Davis, 2005). A review of the area's public water system records showed that at least **20 public water systems in this area have disinfection units as part of the water system to address chronic coliform bacteria problems**. This is a disproportionate number of systems with disinfection compared to the county as a whole (Brinker, October 2005).

Unlike the nitrate concentrations, there is no obvious spatial pattern to the coliform-positive well locations. Also unlike the nitrate issue, the coliform positive wells do not appear to be directly related to large agricultural operations or the particularly high densities of on-site sewage systems. It is most likely that the bacteria contamination is a direct result of the coarse sand and gravel material underlying the areas, the shallow depth of the water, and the inability of the material to adequately filter out the organisms before reaching the water table. As the area continues to develop, ensuring safe drinking water will be an increasing challenge, whether it be single family wells, small community water systems, or large utility-managed water systems.

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