GROUND MOUND/ROCHESTER AQUIFER SURVEY

FINAL REVIEW DRAFT

THURSTON COUNTY HEALTH DEPARTMENT

1984

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INTRODUCTION

Substantial interest in the residential, commercial and industrial development of the Grand Mound/Rochester Area has existed for many years. The Rochester Sub-Area Plan which was completed in February of 1978 summarized this interest and identified goals, objectives and subsequent land use policies to direct the future growth of the area.

The stated goal for residential policies was: "To encourage decent housing and a suitable housing environment for all socio-economic groups." A major objective was: "To prevent contamination of the water supply and aquifer by septic tanks," and thus housing density standards were adopted.

1. One unit per acre when septic systems utilized for sewage disposal; and

2. Two to six units per acre when "other methods" are utilized for sewage disposal.

It was recognized that some areas may have soil limitations for on-site sewage disposal and that sufficient engineering to overcome the limitations should be required.

Additionally, the policy goal for industrial growth was to provide for employment, community needs and broader tax base for services in the Rochester area; however, the stated objectives were to exclude industry which emits toxic waste and excessive pollutants into the environment (air, soil, surface waters or aquifer). A secondary objective was to encourage the design of industrial facilities that would be aesthetically compatible with the environment and have minimal effect upon existing water supplies.

The community interest in the area development was demonstrated in the many community meetings and public hearings which preceded the adoption of the Sub-Area Plan. Concern has been identified via specific land use projects proposed in the area, ongoing sales of existing property, and creation of new lots for residential and commercial purposes.

Much information is known about the area and the underlying aquifer which serves as the sole source of drinking water for domestic and commercial supplies alike. Most people agree that the soils, in general, are quite permeable and rapid drainage of surface water predominates on the prairies.

Septic system installers and others involved in excavation projects have known for years of the characteristic gravelly nature of the soils. Excavations for gravel pits are common on the prairies, and observation of the resultant holes show profiles of loose sands and gravels. Often it is noted that the excavations are seasonally innundated with the rise and fall of the ground waters. Well drillers and those in the water supply business and agriculture are aware of the shallow depth to a vast resource of ground water and the fact that a consolidated soil formation is seldom penetrated in the drilling of wells.

Technical information is available which indicates septic effluent, soluable chemicals and other products which are produced from increased human activities can impact shallow water tables in unconfined aquifers. Laboratory and field studies have repeatedly demonstrated the movement of contaminants through rapidly-drained soils, although many such field studies have fallen short of proving a defined cause and effect relationship between a specific activity and an increase in ground water degradation.

Studies of comparable areas of the state have been examined with respect to superficial similarities of geological conditions, land use activities, and findings to expand the base of knowledge without great expenditures for exhaustive field study of the Grand Mound Area. A preponderance of the information at hand suggests that the area is fragile and environmentally sensitive to increased human activities. Substantial information regarding the movement of water in the aquifer, recharge, and concentration of contaminants in the ground water is still lacking, however.

The purpose of this report, therefore, is an attempt to summarize the known information regarding the Grand Mound/Rochester aquifer so that a reasonable approach can be implemented to balance the increased demand for residential, commercial and industrial growth with legitimate concerns for protection of health and valuable natural resources. In addition, the Thurston County Health Department and other governmental bodies involved in land use decisions have statutory responsibilities to provide for the protection of public health and public resources.

EXECUTIVE SUMMARY

This report represents a review of other similar areas, literature search, investigation of the area geology, hydrology and surface soils. A water sampling and quality testing survey of selected wells was conducted and a review of existing water quality data from public wells in the area was performed to expand the information base. Even though specific cause and effect relationships were not developed, several important findings were arrived at through a preponderance of the compiled information.

The findings support the conclusion that the area is environmentally sensitive. The soils above the aquifer do not provide substantial protection of the ground water which is utilized as a primary drinking water source. Nitrate contamination of the ground water is occurring. It is probable that other chemical contaminants and possibly viruses can also leach into the ground water. An imminent health hazard has not been demonstrated; however, the available information indicates the potential for such a condition. Management decisions are therefore necessary to reduce the potential health hazards and protect the valuable water resource.

Designation of the Ground Mound/Rochester aquifer study area as "geologically sensitive" and the subsequent creation of specific development standards would be beneficial in limiting the impact of land use activities upon the aquifer. Again, it must be emphasized that the data presented is not adequate to establish cause with existing land use activities. Thus, it is quite possible that ground water quality degradation will still increase as human activity increases on the study area. It is, therefore, important that a continuing water quality monitoring program is also implemented so that serious contamination does not occur undetected.

CONCLUSIONS

The following conclusions have been reached upon the analysis of the water quality survey data and other information researched as part of this project:

1. The geology of the study area generally does not provide ground water protection from contamination.

   The information reviewed indicates the loose sand and gravel outwash materials predominate in the soil horizons above the water table with few exceptions.

2. The surface soils generally meet the definition of Type I soils.

   The textural classification of the soils is found to be coarse sands or coarser with percolation rates of less than one minute per inch.

3. Removal of larger bacteriological organisms via soil treatment of waste waters may be somewhat effective. The ability of the soils to remove viruses, however, is questionable and it is demonstrated that chemical removal is not effective.

   The survey data does not reflect a serious problem with bacteriological contamination, only six wells were found to exhibit coliform bacteria on a single occasion and no fecal coliforms were isolated from the samples. The removal of viruses is questioned upon the evaluation of soils information and literature review; no testing was performed in this regard. The indicator of chemical contamination, nitrate-nitrogen, was detected in levels of concern.

4. The levels of contamination detected in this random survey of well water is dependent upon many variables; the contamination levels may, therefore, vary substantially from those identified.

   The specific characteristics of each sampling location determine the level of contamination detected. The well depth, level and amount of water withdrawal, water table depth, distance to and type of contaminant sources and plume formations among other things have a significant effect. Such factors were not evaluated in this study.

5. No imminent health hazard with regard to bacteriological or chemical contamination has been demonstrated by this survey at the present time.

   It should be emphasized that the scope, methodology, and use of indicators in this survey was limited, however.

6. Much more information regarding the geohydrology of the study area is necessary and more intensive study would be required to identify specific cause and effect relationships.

   This survey demonstrates the general susceptibility of the aquifer to contamination and associations between land use activities and elevated contaminant levels were observed. The proving of cause and effect relationships would require exhaustive study of information not yet available (WDOE Hydrology Study), specific land use activities, and much more intensive water sampling and analyses. Generally such studies are performed to prove that a significant health hazard exists and not to show potential for future concern.

7. Continuous monitoring of the water quality is necessary so that more severe contamination does not go undetected.

   The nitrate-nitrogen values from some samples are at levels at or approaching the maximum contaminant levels for drinking water. If this represents a trend of increasing levels, it can be assumed that the 10 mg/l standard will be exceeded by wells water in the future.

RECOMMENDATIONS FOR FURTHER ACTION

It is recommended that:

1. The Grand Mound/Rochester Study Area be designated "Geologically Sensitive" by the Thurston County Board of Health.

   The Thurston County Sanitary Code, Article 4, Section 16 allows the Health Officer to require "such reasonable standards adopted by the Board of Health as are necessary to prevent health hazards and water pollution" within areas designated as geologically sensitive. The conclusions of the water quality survey support such a designation.

2. Two interim measures be implemented, prior to the adoption of ground water protection standards:

   a. The Board of Health direct the Environmental Health staff to review all new land use applications with respect to use and disposal of hazardous materials.

      Maintain the use of Method I lot size requirements in accordance with the standards of the Thurston County Sanitary Code, Article IV, and WAC 248-96-090.

   It should be noted that the Method II lot size determination can only be utilized when engineering justification can be provided which fully supports the conclusion that sewage can be retained and treated properly on site. The feasibility of such justification, especially for smaller projects, is rarely demonstrated.

3. The Environmental Health staff be directed to work with other County and State agencies in the development of standards for protection of the ground water. Such standards be presented to the Board for consideration.

   Although many standards for measures to protect against ground water contamination exist, it is important that improved standards be adopted at the local level because County agencies have the most direct control over the implementation of management alternatives. These should include: (a) materials storage tank policy; (b) review of land use density recommendations; and (c) commercial and industrial review standards.

4. Routine monitoring of the aquifer for nitrate-nitrogen be implemented so that significant ground water degradation does not occur undetected.

   A system for annual review of the DSHS computer monitoring of chemical water analyses could be implemented with minimal resource time and money. The 35 public wells surveyed in this report, and possibly many other Class 4 water wells, could be used. The department could consider an increased sample frequency requirement and alternatives for sample collection.

relationships would require exhaustive study of information not yet available (WDOE Hydrology Study), specific land use activities, and much more intensive water sampling and analyses. Generally such studies are performed to prove that a significant health hazard exists and not to show potential for future concern.

7. A preponderance of information regarding the area geology, chemical removal processes of soils and other case studies indicates that contamination of the ground water by chemicals other than those found in sewage effluent is quite possible. Additionally, secondary treatment of septic effluent or alternative methods of sewage disposal may not be totally effective in protection of the ground water.

The nitrate concentrations found in the survey demonstrate that some chemicals, especially soluable contaminants, can and do leach into the ground water. The Fords Prairie Study and a recent Thurston County occurrence show that leakage of gasoline tanks and oil spillage respectively contaminate ground waters in areas of permeable soils.

Secondary treatment of sewage effluent, and specifically the aeration process as suggested by the TESC Study, may decrease one contaminant parameter (i.e., B.O.D.) while increasing another (i.e., NO_3) and yet do nothing for others (i.e., organic cleaners/degreasers). Alternative methods of sewage disposal--especially sewers--may offer substantial protection from sewage contaminants, but would do little with regard to protection from pesticides, leaking fuel tanks, stormwater runoff and associated contaminants, and other chemical products.

Routine monitoring of the water quality is necessary so that more severe contamination does not go undetected.

The nitrate-nitrogen values from some samples are at levels at or approaching the maximum contaminant levels for drinking water. If this represents a trend of increasing levels, it can be assumed that the 10 mg/l standard will be exceeded by wells water in the future.

OTHER STUDIES

Several studies of areas with geologic and aquifer conditions similar to or part of Grand Mound were reviewed in the process of this study. The Ground Water Quality in Grand Mound Study and the Determination of the Pollution Potential of Grand Water in the Vicinity of Rochester, Washington were examinations of selected areas within this study area and, therefore, had direct influence. The Survey of Ground Water Quality in the Fords Prairie Area, Lewis County was performed on an area of nearly identical geologic formation and consistency and, thus, direct correlations could be drawn.

The study of the Chambers Creek/Clover Creek Drainage Basin, an area with substantially greater urban development but similar geological conditions, serves as an interim example of what may be expected as growth occurs.

The following brief summaries are enclosed to provide a background for material presented later in this text. No attempt was made to critique or verify the findings and/or conclusions of these selected studies; they are provided to give examples of the concerns and attempts by other agencies to evaluate the existence, causes and possible remedies of ground water contamination in areas of unprotected aquifers.

GROUND WATER QUALITY IN GRAND MOUND

A study of a small portion of the aquifer in the area of Grand Mound was conducted by a group of students from The Evergreen State College in the spring of 1978. The study examined the general geologic/hydrologic characteristics of the area and the relationship between ground water quality and housing density. The physical, geological and hydrological factors were researched, a water sampling program was conducted, and an investigation of housing density levels--both existing and projected--was performed.

A relationship between housing density and ground water contamination was suggested and recommendations based upon physical data, existing legal policies, and community values were established. The study concluded that:

1. The shallow, porous soils drain rapidly, posing a hazard of untreated effluents reaching the water table.

2. Soils in the Grand Mound are aerobic, facilitating the breakdown of contaminants.

3. Effluents may reach the aquifer in high concentrations because of rapid percolation in subsurface gravels and the proximity of the water table to the ground surface.

4. Pollutant levels tend to be localized because of the slow velocity of the Grand Mound's aquifer.

5. Generally, bacterial and chemical contamination levels tend to correlate with housing densities.

Four general recommendations were advocated by the study group as a result of the findings. The recommendations are summarized as follows:

Area Development. The clustering of residences serviced by septic systems, even at one acre per unit gross density as encouraged by the Rochester Sub-Area Plan (Objective 3a) may lead to ground water degradation.

Sewage Treatment Alternatives. Secondary treatment of sewage should be required in areas developed at a density greater than one unit per acre. Jet aeration and intermittent sand filters were suggested as possibilities that should be studied further.

Public Information. A program should be instituted to: (a) improve communication between County government and the residents of Grand Mound; (b) promote the active involvement of residents in land use planning; and (c) use available local and human resources if and when major developments are undertaken.

Further Research. More study is necessary to determine what factors other than housing density have an influence upon the ground water quality. The influences such as septic system setbacks from wells, static water level depth, and efficiency of septic systems should be studied in depth. Nitrate monitoring should be continued and ground water movement should be studied to determine flow rates and dilution of contaminants. Finally, the impact of activities not a part of the study "should not be underestimated." Research was suggested to determine the impact of commercial, agricultural and industrial practices upon the local water supplies.

Determination of the Pollution Potential of Ground Water in the Vicinity of Rochester, Washington

Vosse-Rosbach and Associates developed an engineering report in October 1979 which addressed the potential for ground water contamination of the Ground Mound Aquifer. The report was intended to supply engineering justification to reduce the gross land area per living unit from that required for excessively drained soils (Method I of the State Regulations and the Thurston County Sanitary Code). The document was submitted for review to the Thurston County Health Department in conjunction with the development proposal.

The report focused upon potential ground water pollution as a result of the installation/use of septic systems and briefly discussed such factors as biological and chemical constituents of septic effluent, indicators of ground water contamination, accumulation of nitrate in the aquifer, and aquifer transmissibility to "determine the maximum, safe population density" over the aquifer area.

It was stated that biological organisms found in septic effluent are readily removed through soil filtration, absorption and organism "die-off" in soils of significant depths before entering the water table. Chemical pollutants, especially those which are highly soluble, "can reach the aquifer in measurable quantities." From this premise the report was directed to the determination of acceptable or "safe" level of contamination that could be measured by the content of an indicator--Nitrate (NO_3).

Although much data and significant information regarding the hydraulic transmissibility of the aquifer were provided, the validity of determining land use density based upon the premise of indicator contaminant dilution was discounted by the reviewing agencies. The project of Grandale was therefore not approved.

Surveys of Ground Water Quality in Fords Prairie Area, Lewis County, 1972-1974

The outwash of the Vashon glacier which produced the Grand Mound aquifer also created the geological area known as Fords Prairie in Northern Lewis County. The alluvial materials, loose sands and gravels which overlay more consolidated materials, compose a relatively thin formation which harbors an aquifer unprotected from the ground surface.

The depth to the water table varies seasonally from 10 to 20 feet, and the aquifer receives substantial recharge via percolation from the ground surface. The permeable soils in Fords Prairie, similarly classified by the USDA Soil Conservation Service to those in the Grand Mound study area, are excessively drained. The water resource value of the aquifer is recognized by the statement: "Eventually the aquifer underlying Fords Prairie must be extensively utilized either by the neighboring cities or by developments on the prairie."

Two surveys of the ground water quality were conducted by the Lewis County Health District and the Department of Social and Health SErvices (November 1972 and April 1974). Water from selected wells was analyzed for coliform bacteria, nitrate, nitrite, chlorides, phosphates, M.B.A.S. detergents and calcium carbonate. A significant number of samples in each study were found to have coliform bacteria in excess of the limits established for drinking water. Strong conclusions regarding coliform contamination, however, could not be drawn because possible causes of contamination (i.e., poor well construction) could not be evaluated.

There was noted an increase in the nitrate concentrations from 1972 and 1974. The most significant finding was that of "a higher degree of ground water degradation (increased concentration of NO_3 editorial note) in the more densely populated areas of Fords Prairie, indicating a correlation of ground water quality deterioration with the density of on-site waste water disposal."

It was concluded that the only way to completely protect the aquifer "is to halt further development until an adequate sewer system is installed." Recognizing the implications of such a measure, the ensuing recommendation was to allow development of an interim basis with lot sizes determined by Method I of the State Board of Health Rules and Regulations for On-Site Sewage Disposal Systems. Routine water quality monitoring was suggested, public water supplies were recommended for areas with a high nitrate (NO_3) concentration, and sewers were recommended as soon as possible.

Survey of Ground Water and Surface Water Quality for the Chambers Creek/Clover Creek Drainage Basin, Pierce County, November 1980-February 1981

This survey was initiated following an evaluation of existing ground water quality data which showed increased levels of contamination in selected areas of the basin, the ground waters of which serve as the source of drinking water for the area residents. The purpose was to: (a) establish a water quality data base line for surface and ground waters; (b) identify the most seriously contaminated areas and quantify the levels; and (c) to identify the extent and significance of existing or potential health problems based upon the survey results.

Existing information regarding the geology of the basin was examined and revealed the area was mantled by Steilacoom gravels which overly thick deposits of glacial outwash and till composed of sands, gravels, silts and clays of various proportions. The layers of gravels were noted to be more extensive in some areas providing large volumes of water for high-yield wells. It was concluded that "because of high permeability and rapid infiltration rate, the Steilacoom gravels are susceptible to contamination from the land surface and must be considered as highly sensitive environmentally."

Even though a direct cause and effect relationship between specific land use activities and water quality contamination was not identified, the association between urbanization and water quality was observed: "As basin ground water quality has deteriorated, the population within the basin has grown, and so have the related aspects of urbanization which may be considered as sources of contamination." It was found, based upon bacteriological testing, that a potential health hazard for water supplies existed within the basin. The report also concluded, among other things, that an evaluation of programs for management of activities which impact the aquifer was necessary and an ongoing monitoring should be implemented to insure that changes in the ground water quality do not occur undetected.

GEOLOGY/HYDROLOGY

The Grand Mound/Rochester Study Area is a relatively level, well-drained prairie which is a composite of five separately-named areas: Violet Prairie, Mound Prairie, Grand Mound Prairie, Baker Prairie and Mima Prairie. Upland surface water drains into Scatter Creek, Prairie Creek, the Black River, and the Chehalis River which cross or border the area. The prairies are bordered to the south, east and west by formations of igneous, sedimentary and metamorphic rocks of somewhat mountainous areas (Reference 7). The northern and northwestern borders are comprised of similar such materials.

The 1978 TESC Study (Reference 3) describes one theory of the geological formation of the prairies:

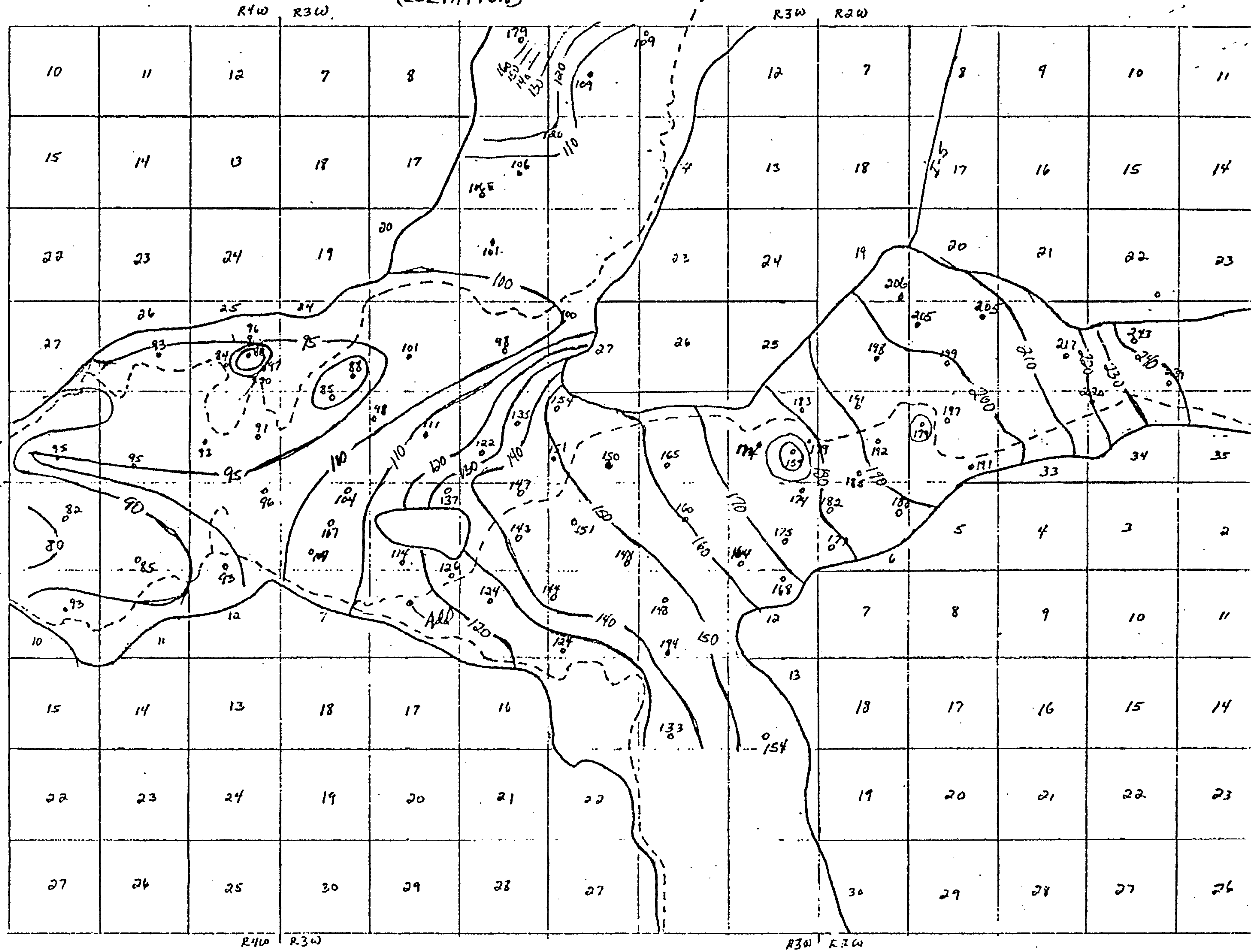
> There were two glacial episodes during which material was deposited in the area. During the Salmon Springs glacial period, ending 35,000 years ago, a lobe of the continental glacier advanced across the area that is now Grand Mound Prairie. Meltwater streams deposited glacial sand and gravel, forming a glacial outwash plain. When the glacier retreated about 35,000 years ago, these deposits were weathered and eroded. The deposits which weathered into clays became compressible.
>
> During the Vashon glacial period, ending 12,000 years ago, a glacial lobe extended as far as the Maytown Uplands, north of Grand Mound Prairie. New outwash was deposited by meltwater streams, and the weathered Salmon Springs sand and gravel was compressed into a hardpan layer in many places by the weight of the younger outwash. Well logs for the Grand Mound area frequently indicate the presence of a layer of cemented sand and gravel within 40 feet of the surface. Above and below this layer are sand and gravel.
>
> Soil on Grand Mound Prairie reflects the drainage characteristics of its parent material (outwash gravel). Like the glacial outwash, soils on the prairie are porous and drain rapidly. Since water drains rapidly away from the surface, prairie vegetation, adapted to dry conditions, has predominated.

Though there may be other explanations of the formation, substantial information is available to substantiate the geology described in the TESC Report.

The outwash materials are very permeable and allow rapid surface and perimeter drainage to the underlying aquifer. The recharge of the aquifer is thus presumed to be accomplished by (a) precipitation and waters placed upon the land surface (irrigation); and (b) upland drainage via surface and subsurface runoff. The Washington State Department of Ecology preliminary hydrology study (Reference 8) gives some insight into the major recharge areas and resultant aquifer flows (Figure 1). It should be noted that the aquifer levels and resultant flows change seasonally.

The underlying gravels of the prairie in which these waters collect form one of the most productive aquifers in the country (Reference 18). It is common for the prairie wells to produce 50 to 250 GPM while those wells that penetrate the surrounding formations are of much less development potential (Reference 7). A review of well test pumping data indicates some wells have a capacity in excess of 500 GPM. Sample well logs, one located in the study area and one outside, are enclosed for a comparison of the geological differences (Examples 1 and 2).

Preliminary NDSE HEAD MAP
(ELEVATION)



Second Copy — Owner's Copy
Third Copy — Driller's Copy

STATE OF WASHINGTON

Prairie Well

(1) OWNER: Name al Cornwell Address 9117 James RD SW Rochester Wa

(2) LOCATION OF WELL: County Thurston — ¼ ¼ Sec 1 T 15 N., R 3W W.M.
Bearing and distance from section or subdivision corner Jackson Fruit tracks lot 3 and 4 Vol 8 of plats page 54

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☒
Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one)....
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 67 ft. Depth of completed well 66 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6 " Diam. from 01 ft. to 66 ft.
Threaded ☐ ...... " Diam. from ...... ft. to ...... ft.
Welded ☒ ...... " Diam. from ...... ft. to ...... ft.

Perforations: Yes ☐ No ☒
Type of perforator used ......
SIZE of perforations ...... in. by ...... in.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.

Screens: Yes ☐ No ☒
Manufacturer's Name ......
Type ...... Model No. ......
Diam. ...... Slot size ...... from ...... ft. to ...... ft.
Diam. ...... Slot size ...... from ...... ft. to ...... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: ......
Gravel placed from ...... ft. to ...... ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ...... Depth of strata ......
Method of sealing strata off ......

(7) PUMP: Manufacturer's Name Jacuzzi
Type: Sub HP 1 HP

(8) WATER LEVELS: Land-surface elevation above mean sea level.... ft.
Static level 30 ft. below top of well Date 7-15-80
Artesian pressure ...... lbs. per square inch Date ......
Artesian water is controlled by ...... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☒ No ☐ If yes, by whom? driller
Yield: 30 gal./min. with 7 ft. drawdown after 4 hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
1 pm	30	5 pm	37	5:05	30

Date of test 7-15-80
Bailer test 40 gal./min. with 8 ft. drawdown after 1 hrs.
Artesian flow ...... g.p.m. Date 7-15-80
Temperature of water ...... Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
Rocks gravel	0	19
gravel	19	41
packed gravel	41	47
gravel	47	66

SEP 1980

Work started 7-12 1980 Completed 7-15 1980

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME ANDERSON DRILLING (Person, firm, or corporation) (Type or print)

Address 1911 APRICOT ROCHESTER WA

[Signed] William Anderson (Well Driller)

License No. 0685 Date 8-14, 1980

Second Copy — Owner's Copy
Third Copy — Driller's Copy

STATE OF WASHINGTON

Well outside of Prairie

(1) OWNER: Name KEVIN NELSON Address 123 Elma-McCleary Rd, McCleary, WA.

(2) LOCATION OF WELL: County THURSTON — ¼ ¼ Sec 27 T 16 N., R 3W W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one)....

New well ☒ Deepened ☐ Reconditioned ☐

Method: Dug ☐ Cable ☒ Rotary ☐ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 314 ft. Depth of completed well 314 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6" Diam. from +1 ft. to 175 ft.
Threaded ☐ 5.00" Diam. from 170 ft. to 314 ft.
Welded ☒ " Diam. from ft. to ft.

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☐ No ☒
Manufacturer's Name
Type Model No.
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☒ Size of gravel:
Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? 30 ft.
Material used in seal BENTONITE
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level 63' ft. below top of well Date 4-25-80
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test 10 gal./min. with 226 ft. drawdown after 1 hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
GRAVELLY TOPSOIL, BLACK	0	3
GRAVELLY CLAY & COBBLES, BROWN	3	23
CLAY, BROWN, SAND & GRAVEL	23	79
SANDY CLAY, BROWN	79	86
SANDY CLAY, YELLOW & WATER	86	91
CLAY, BLUE	91	[illegible]
SHALE, GRAY	150	[illegible]
SHALE, GRAY, WATER BEARING	[illegible]	[illegible]
TOTAL	314	

Work started 3-26, 1980 Completed 4-25, 19

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Williams Well Drilling Co. (Person, firm, or corporation) (Type or print)

Address 957 Jackson Hwy. So., Toledo

[Signed] [signature] (Well Driller)

License No. 0313 Date 5-12, 19

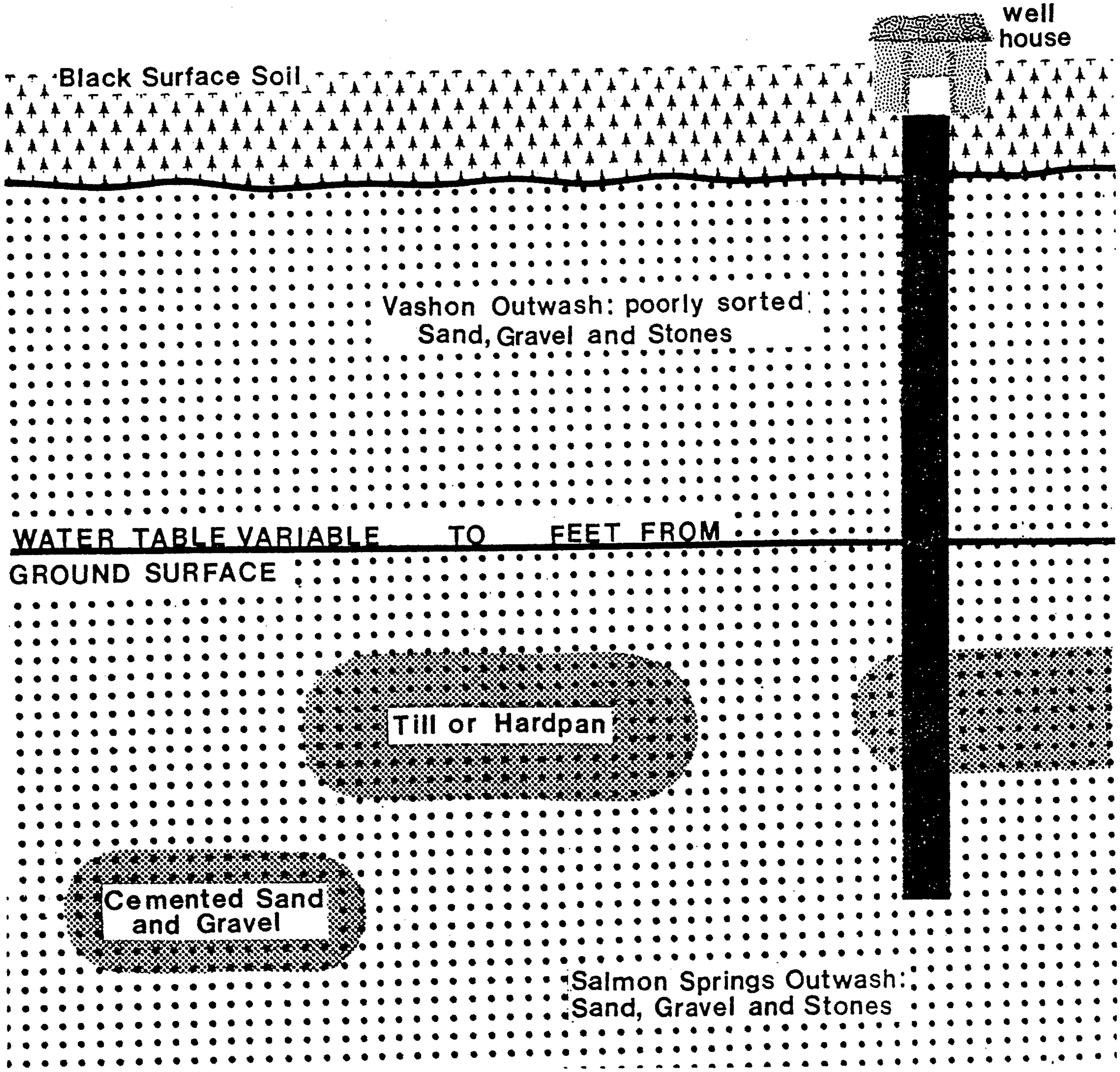
(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

FIGURE 2 :

REPRESENTATIVE CROSS SECTION OF GEOLOGICAL FORMATION

IN THE GRAND MOUND-ROCHESTER AREA



WELL LOG REVIEW

Well logs from water well drillers reports on file at the Washington State Department of Ecology were examined to determine the degree of aquifer confinement and possible protection due to the cemented sand and gravel/hardpan or glacial till noted in many drilling reports. Three hundred eighty-nine reports of the approximately 650 wells within the study area were scanned for (a) the number of wells with no reported restrictive material above the water table; (b) the number of wells with restrictive material above the water table; and (c) of those with compact material, the number of wells with a static water level substantially above the lower limit of the suspected confining layer.

The report is totaled in "c" above indicate wells with significant piezometric head[1] which suggests confinement, at least locally, which may indicate some aquifer protection. It must be noted that a very liberal definition of "confining layer" was utilized for the report comparisons. This is assumed to have increased the number of wells indicating such confinement and implied protection. Conversely, the number of wells without such protection are assumed to be greater than reported. Also, many of the well logs with assumed piezometric head were noted to be in soils with substantial silt and clay mixtures indicating the wells were located on the fringe of the study area or within inclusion areas of different soil composition. Again, this inconsistency would tend to increase the number of wells indicating a protected aquifer and decrease the number indicating no aquifer protection.

The results of the well logs are summarized as follows:

A	B	C	D	E
Wells with no Protection	Wells with Restrictive layer above the Water Table	Number of wells from "B" with Piezometric Head	Number/ Percent of Protected Wells	Number/ Percent of Unprotected Wells
207	182	108	$\frac{108}{389} = 28\%$	$\frac{(182-108)+207}{389}$ $\frac{281}{389} = 72\%$

The reports showing a restrictive layer above the water table without significant piezometric head are indicative of wells which penetrate one or more non-continuous lenses (see Figures 2 and 3).

<u>Conclusion</u>. It can be concluded using the criteria for assumed piezometric head, therefore, that in excess of 72 percent of the well driller reports indicate the presence of an unconfined or unprotected aquifer.

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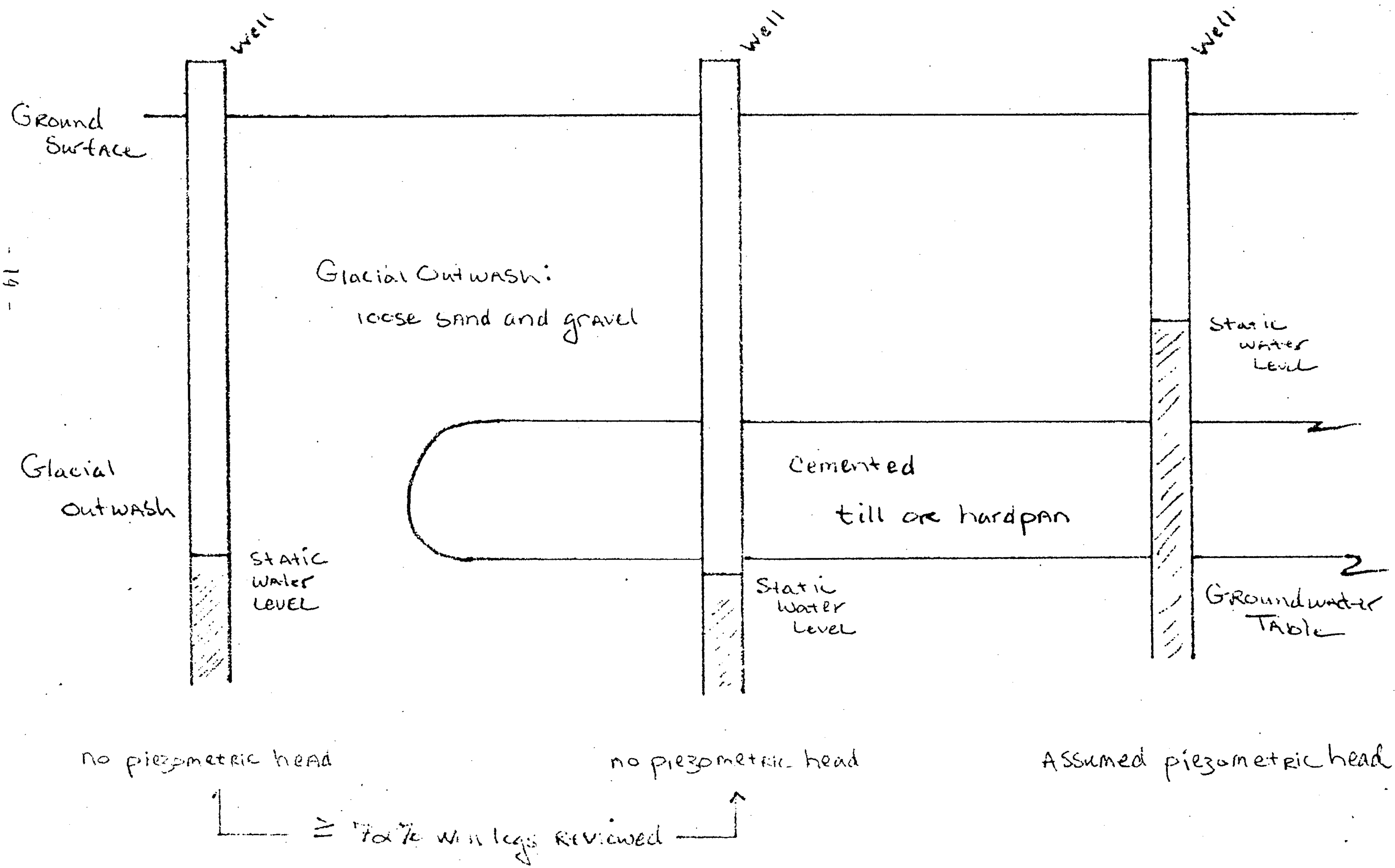
[1]Assumed piezometric head was defined as a condition where the static well water was at least 10 feet or greater above the lower limit of a restrictive geological layer (hardpan, till) when the first water encountered was also at or deeper than the restrictive layer.

Figure 3

Assumed Piezometric Head Determination



SURFACE SOILS IN THE STUDY AREA

A predominance of soils within the study area are known to be excessively to moderately well-drained sand and gravel outwash materials (Type 1, Table 1) overlain by a black, sooty gravelly sandy loam (12"-24"). The sooty loam is known to clog or restrict downward percolation of waste water; therefore, septic system installers and persons installing surface drains commonly penetrate this soil horizon. Once into the loose sand and gravel, water drains rapidly (Reference 13).

The Spanaway soil series accounts for approximately 80 percent of the soils within the study area (Table 1). Other soil types of lesser permeability may be found in close proximity to creeks and rivers; however, their significance is much less for two reasons. Generally they are (a) within areas restricted for development because of the proximity to waterways and wetlands; and (b) they also overlay the unprotected aquifer which is the subject of this report.

Table 1 shows the comparison between the USDA Soil Conservation Service soil designations; new SCS soil series groupings, permeability, textural classifications, ratings; and the On-Site Sewage Disposal Regulations soil type number. Table 2 is the soil type table from the State Regulations (Reference 17, page 14).

It is, therefore, apparent from the review of the study map soils overlay and Tables 1 and 2 that most surface soils in the study area fall within the textural classification of Type 1 soils.

TABLE 1

Surface Soil Classifications and Types

Soil Series[1]	Mapping Symbol[2]	Permeability[3] in/hr	Permeability[3] min/inch	Textural Classification[3]	Septic effluent Rating (USDA)[3]	Soil Type[4]
Spanaway*	Sh Sk Sl Sm	20	3	extremely gravelly sand	severe--poor filter	1
Nisqually	Nc Nd	20	3	loamy sand	severe--poor filter	1 or 2
Everett	Ek El Em En Fa Fb	6-20	10-3	extremely gravelly sand to 60" or more	0-8% slight 8-15% moderate 15% severe slope	1
Newberg Cool	Cb	6-20	10-3	coarse sandy loam	severe flooding poor filter	1 or 2
Grove	Gh	20	3	very gravelly coarse sand	severe poor filter	1
Yelm	Ee Gc Gd	2-6 6-20**	30-10 10-3	loamy sand	severe wetness	1 or 2

[1]Reference 14 [2]Reference 13
[3]USDA SCS soil interpretations record (SCS-5), Reference 14
[4]Reference 4 (page 14)
*Spanaway soil series accounts for approximately 80% of the study area.
**Depth = 46"-60"

TABLE 2

Soil Type Numbers by Textural Classifications

Soil Type	Soil Textural Classifications[1]
1[2]	Coarse sands or coarser
2	Medium sand
3	Fine sand, loamy sand
4	Sandy loam, loam
5	Porous, well-developed structure in silt and silty loams
6	Other silt loams, silty clay loams, and clay loams

[1] According to the United States Department of Agriculture, soil conservation service's soil classification system.

[2] Includes other soils and/or conditions where the treatment potential is ineffective in retaining and/or removing substances of public health significance to underground sources of drinking water.

(Reference 17)

MICROORGANISM REMOVAL IN SOILS

The protection of ground water from contamination via septic effluent, waste waters and other contaminated surface water is dependent upon the capability of soils in the disposal area to retain or remove pathogenic organisms and viruses. The efficiency of soils in retention and removal is related to soil morphology (structure, texture and consistency), adsorption, and soil moisture content. The removal of microorganisms is accomplished by two methods: filtration/entrapment of larger organisms and adsorption of viruses to soil particles or peds. The degree of adverse environmental conditions then determines the ultimate survival time of the organisms. These conditions include pH (acidity/alkalinity), temperature, nutrient content and biological antagonisms (Reference 9).

Fine-textured soils such as clays and silts (Type 5 and 6, Table 2) offer the greatest removal because of the low soil permeability which increases mechanical filtration and adsorption. Contaminants are entrapped in the small voids and passages between the soil particles and biological clogging of the soil increases the efficiency.

Soils with higher fractions of silt and clay particles than sand have higher capacities for virus removal (Reference 11). The small passageways increase the potential contact between viruses and soil particles thus increasing the potential for adhesion or adsorption. Once entrapped or adsorbed, the die-off of potential pathogens is determined by the new complex physical and chemical environment.

While the properties of silt and clay soils are beneficial in the treatment of waste waters, soils consisting of only silt and clay often retard water movement to the extent that water ponds on the ground surface or perches in the upper horizons and drainage systems do not function adequately.

Soils consisting of coarse sands and gravels (Type 1, Table 2) drain rapidly in comparison, and water retention on the ground surface or in the upper soil horizons is normally not encountered. The relatively large voids between the single-grained soil particles and gravels allow water and other liquids to move downward freely with little restriction. Mechanical filtration and entrapment of microorganisms is less efficient and the distances of travel, as compared to those encountered in finer-textured soils, is greatly increased. Travel distances of bacteria in coarse sand and gravel have been observed in extreme circumstances to be in excess of 1,500 feet (Reference 10).

In addition, the ionic properties of sands and gravels are minimal and viral adhesion is not accomplished easily within short distances. Adsorption of viruses to large-grained soil particles becomes the principal method of removal. When such soils are saturated with water, the movement of microorganisms and especially viruses is even less restricted. Viral adsorption is greatly reduced and travel distances are subsequently increased. Field experience with relatively low waste water application rates and low influent virus numbers does not encourage confidence in the ability of the soil environment to reduce viral numbers to zero under marginal conditions (Reference 11).

The conditions which provide the optimal benefits of adequate surface and subsurface drainage for waste water disposal and protection of an underlying water table or aquifer would include the following:

A. Soils with properties which are adequate for microorganism removal (see Table 2).

B. Unsaturated soil conditions in the disposal area.

C. A controlled rate of waste water application.

D. Application of the highest quality waste water possible.

CHEMICAL REMOVAL IN SOILS

Ground water protection from chemical contamination has been studied less extensively. Most studies of domestic waste waters have concentrated upon nitrogen which can enter ground water in sufficient quantities to cause concern. Nitrogen in the form of nitrate or nitrite has been linked to cases of methemoglobenemia in infants (Groundwater Contamination, 1961--Reference 9). The maximum contaminant level for NO_3 as N has been set at 10 mg/l in the Federal Safe Drinking Water Act of 1974 and the Washington State Board of Health Regulations for Drinking Water. Obviously other chemicals which may threaten ground water quality are of concern and will be discussed briefly later in this report.

Nitrogen in septic effluent is about 80 percent ammonium and 20 percent organic nitrogen. Adsorption of ammonia onto clay and organic matter occurs in slowly permeable soils where anaerobic soils conditions may exist (Bouma et al 1972; Dudley and Stephenson, 1973; Preul, 1966--Reference 9). The ammonium tends to travel slowly or creep as adsorption sites are exhausted; however the area of contamination in clay soils is usually limited.

Adsorption fields located in aerobic soils where several feet of unsaturated flow can occur allows nitrification (biological conversion of nitrogen to nitrate; NH_4---NO_2---NO_3) to take place. Nitrate in solution moves freely through the soil and leaching of nitrate into the ground water results in obvious ground water pollution and possible public health problems (Walter et al, 1973, IES 1973--Reference 12). Dilution is then the primary mechanism available to reduce nitrate concentrations to safe levels (Reference 9).

The significance of heavy metals and complex organic compounds in septic effluent has not yet been determined (Reference 9). It is known, however, that toxic chemicals are found in chemical additives for holding tanks and porti-potties for recreational vehicles and various household cleaners and commercial degreasers. Reports of toxic solvents from commercial and industrial uses and petroleum products from leaking underground storage tanks contaminating unprotected ground water are not uncommon locally and nationally.

PLUMES: DISTRIBUTION OF CONTAMINANTS

When biological or chemical contaminants are not removed from liquids entering an aquifer, the dispersion of contaminants is dependent upon many interrelating factors. The specific properties of the contaminant, physical characteristics of the aquifer, and the aquifer flow determine the size and shape of the plume. The following statements give some insight into the formation and dispersion of contaminant plumes (Reference 16).

1. Low density percolates will tend to float on the water table (Figures 4 and 5).

2. High density percolates will tend to sink to the bottom of the aquifer (Figure 4).

3. The shape and size of contaminant plumes depend upon local geology, ground water flow, the types and concentrations of contaminants, and the continuity of leachate formation (Figure 6).

4. Rates of contaminant movement are determined by ground water flow rates, chemical and physical interactions with aquifer materials, and changes in water chemistry.

5. Pumping of wells can affect the movement of contaminants (Figure 7).

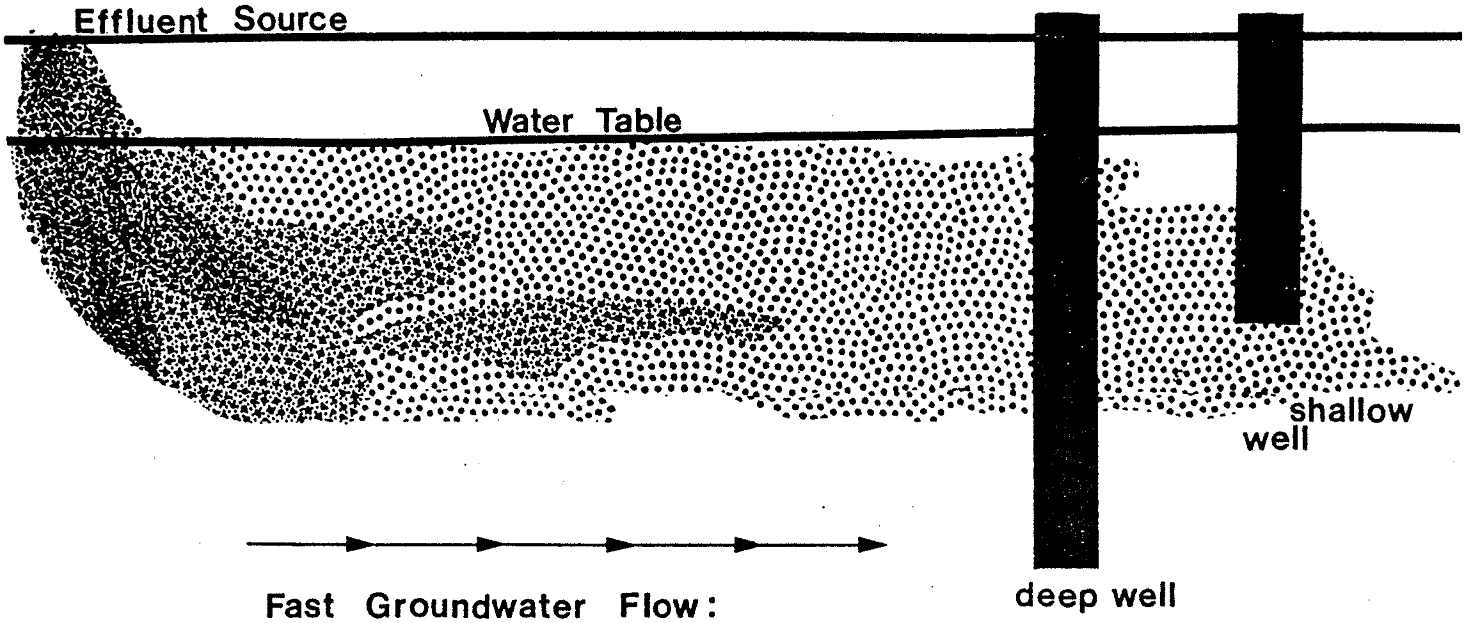
6. In addition to dispersion, other mechanism involved include molecular diffusion, adsorption, and decay.

The finding of contaminants in well water, based upon the information presented above, is dependent upon the location of a particular well with respect to the contaminant plume. The concentration of contamination in a sample from a well may vary substantially due to: the density and concentration of the contaminant, the depth of the well, the pumping rate of the well or adjacent wells, the distance from the contaminant source, the hydraulic gradient from the source to the receiving well, and the duration of contaminant application (one event versus continuous).

FIGURE 4 :

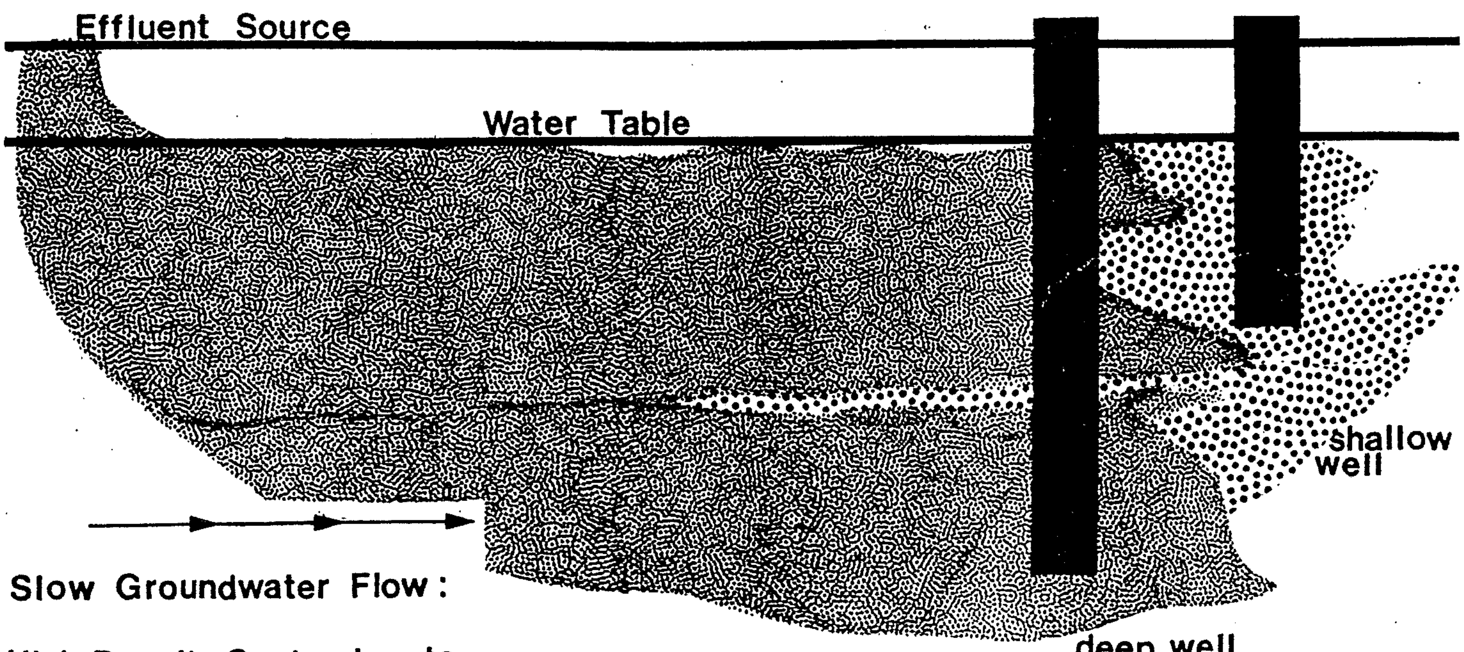
PLUME MODELS OF

CONTAMINANT DISPERSION IN GROUNDWATER



Fast Groundwater Flow :

Low Density Contaminants

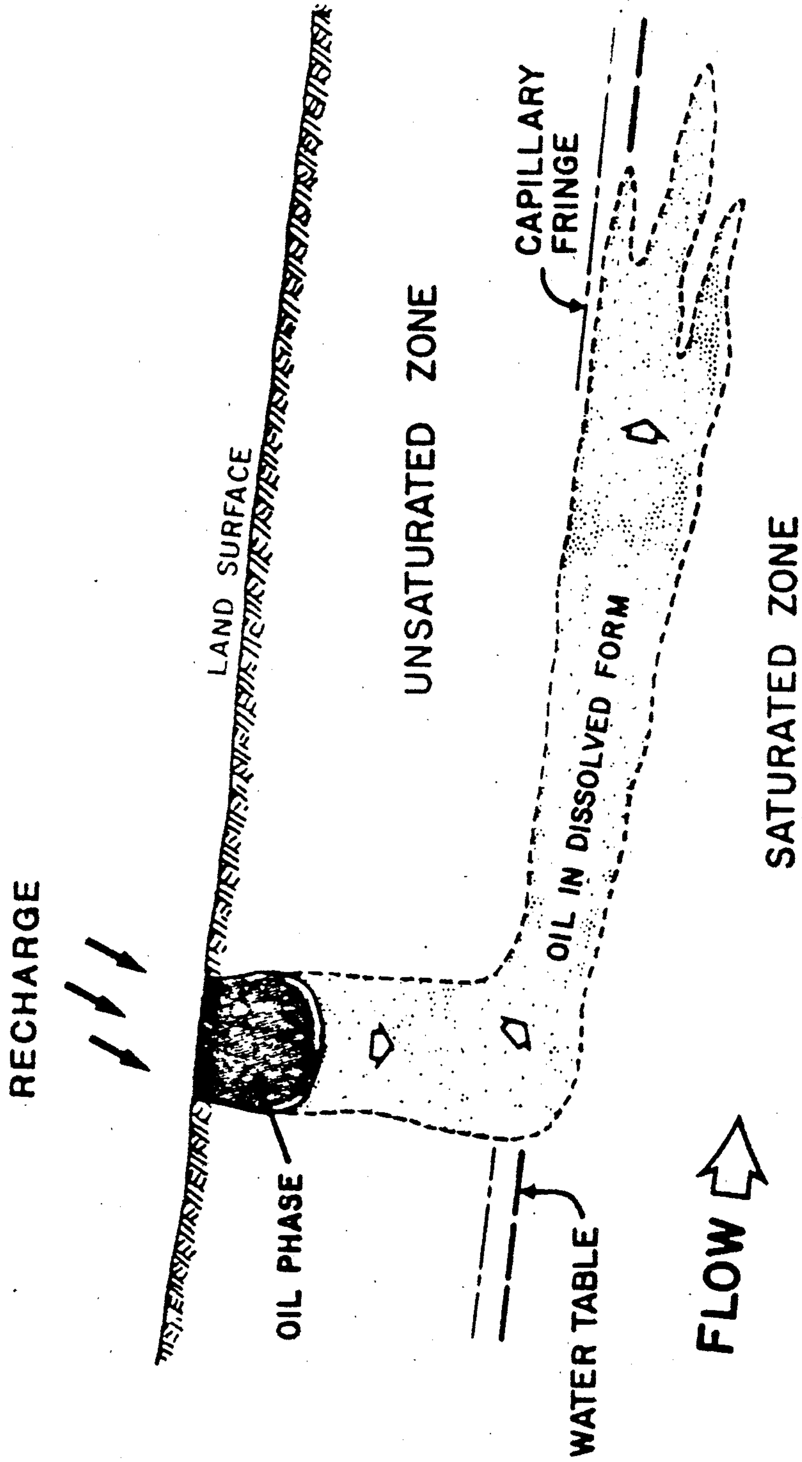


Slow Groundwater Flow :

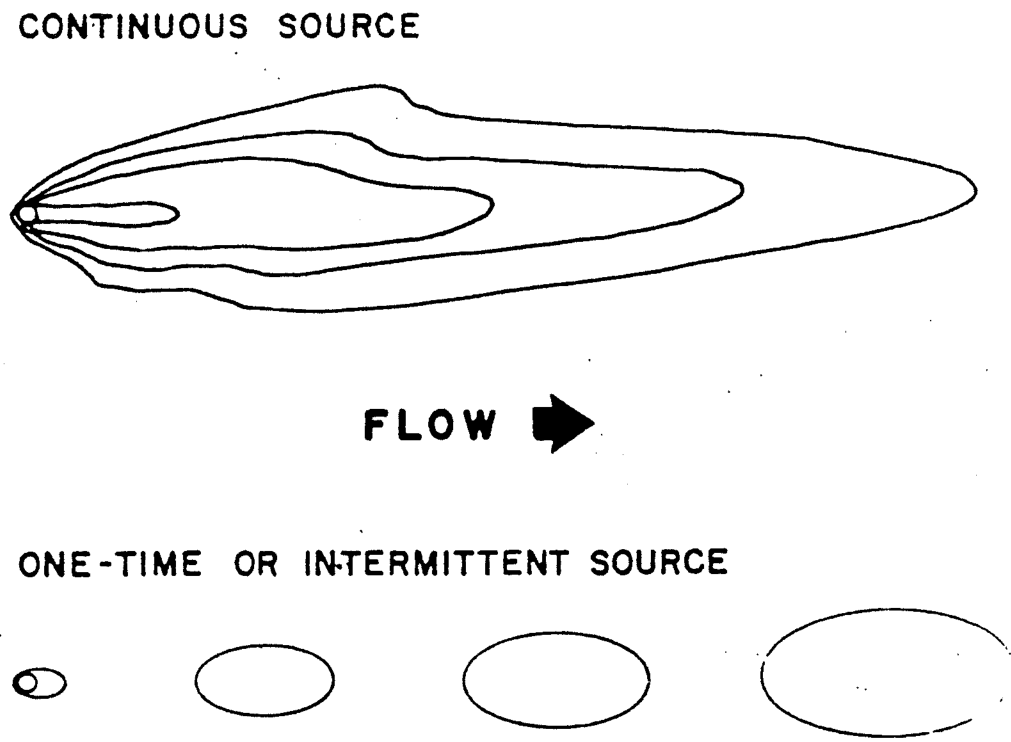
High Density Contaminants

FIGURE 5

Low Density Plume

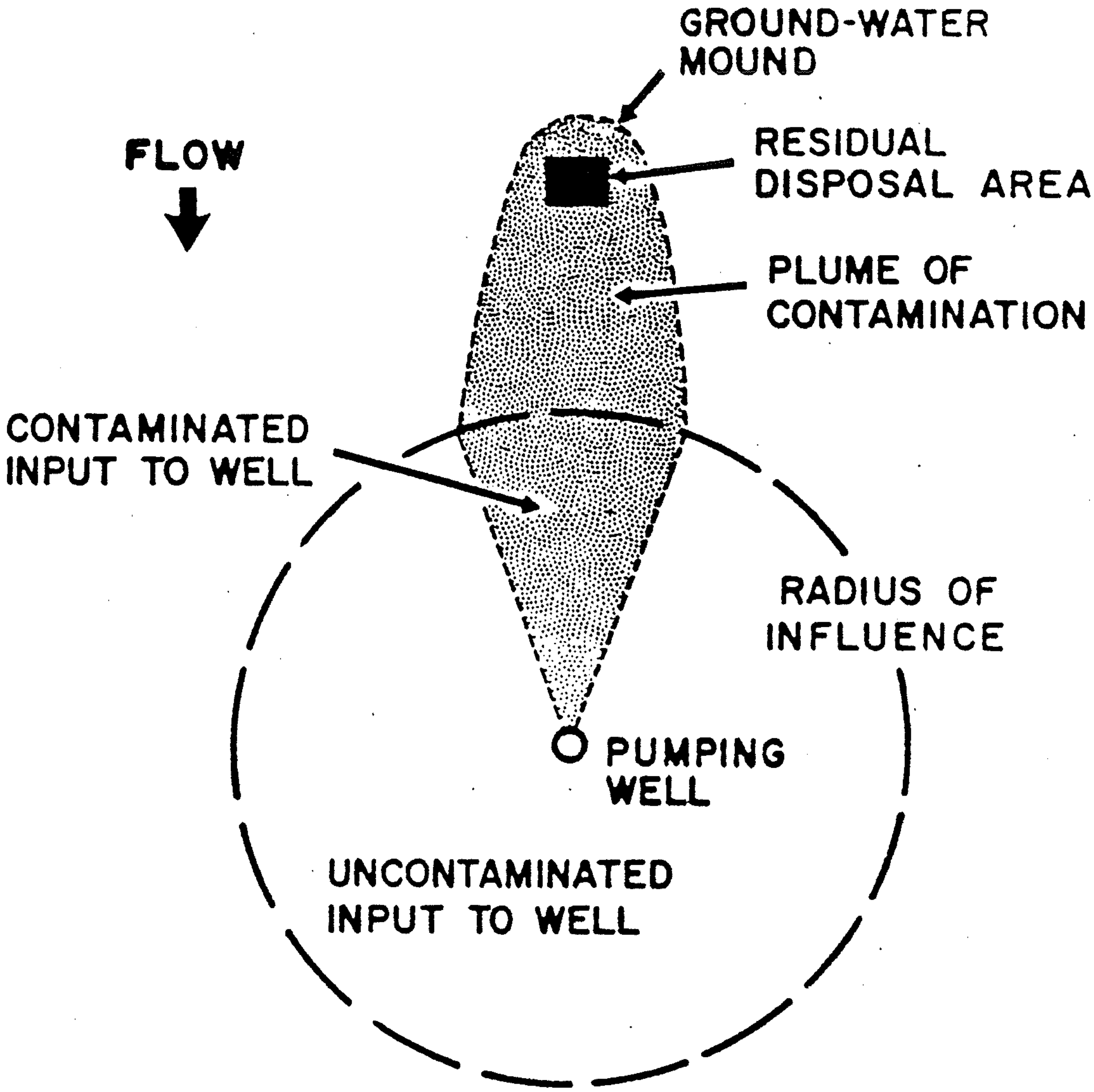


Petroleum product limited to unsaturated zone (after Schwille, 1975).



A. The development of a contamination plume from a continuous point source;
B. The travel of a contaminant slug(s) from a one-time point source or an intermittent source (after Fetter, 1980).

Figure No. 6 (Reference 16)



Dilution effects of natural ground water on contaminants at a pumping well (Braids et al., 1977).

Figure No. 7 (Reference 16)

AQUIFER SURVEY AND SAMPLING

METHODOLOGY

The study area was established by an evaluation of USDA-SCS soils information, USGS geology reports, USGS and WDOE aquifer maps, water well drillers reports, and preliminary WDOE hydrology information. The boundaries of the glacial outwash soils, an area encompassing roughly 44 square miles, were identified and established on the aquifer study map.

Wells used in the WDOE hydrology study were evaluated for water sampling points. An attempt was made to select a uniform distribution of wells over the entire study area. A sanitary survey was conducted at each well site to assess sanitary protection and only wells which exhibited a sealed casing, sanitary well seal, and construction to prevent surface contamination were ultimately selected for water quality testing.

The timing of water sampling from the 50 selected wells was chosen to determine if an association exists between contaminant concentrations and seasonal water table fluctuations. Thus, it was decided to collect water samples for analyses in a month of lowest anticipated water table conditions (August 1982) and a month of highest anticipated water level conditions (March 1983).

The water samples were initially scheduled to be analyzed for coliform bacteria (total and fecal groups) and nitrate-nitrogen. The samples were to be collected, transported and analyzed in accordance with the Standard Methods for Examination of Water and Waste Water (Reference 15). State and EPA certified laboratories were utilized for the analyses, bacteriological: Thurston County Health Department Lab and Chemical; Washington State DSHS lab. The coliform group of bacteria is used universally as an indicator of drinking water contamination. Fecal coliform bacteria is a more select sub-group which is indicative of recent water contamination via feces of warm-blooded animals. Nitrate-nitrogen levels in excess of naturally occurring background concentrations can be indicative of contamination via septic effluent although other sources such as fertilizers, manure, animal wastes, etc. can contribute substantially to ground water concentrations.

The laboratory results of the initial water sampling (August 1982) were tabulated, evaluated and the strategy for the second scheduled sampling of wells (March 1983) was developed jointly by representatives of DSHS Water Supply and Waste Section and Thurston County Environmental Health. It was decided to test the second group of samples for chlorides in addition to the original parameters. The second sampling was conducted in March 1982 and again the samples were collected, transported and analyzed by Standard Methods. The chemical analysis reports were received from the DSHS lab in August 1983 and the results were tabulated with those of the previous sampling period.

The sample locations were plotted on the study map and overlays were prepared to show (a) soil types (surface soils--References 13 and 14); (b) preliminary ground water flow information (Reference 8); and (c) combined nitrate values (both sampling periods) by concentration groupings.

A review of the routine chemical monitoring of 35 public water wells (Class 2, 3 and 4 public water supplies) within the study area for the period 1979 to early 1984 was conducted to expand the well sampling information. The wells were identified by a computer search of the DSHS Water Facilities Inventory monitoring system. The nitrate-nitrogen concentrations of samples submitted by the water supply purveyors were tabulated (Table ____).

FINDINGS

The results of the initial 45 bacteriological analyses were negative for the presence of coliform bacteria except for six samples. The second round of analyses showed all but 4 wells to be free of coliform bacteria and, therefore, within drinking water standards (see Table 2). Of the 4 samples showing coliforms, all were relatively low level contamination and no samples exhibited fecal coliforms; none were from wells which had coliform contamination in the original sampling period. No correlations between high nitrate values and coliform values were observed.

The results of the nitrate-nitrogen analyses in both sampling regimes and public water supplies monitoring were within the standards for drinking water (10 mg/l NO_3-N) with the exception of one well which had a concentration of 10 mg/l (sample location #47, March 1983). The same sample point exhibited a value of 7.3 mg/l in August 1982. Three other wells showed values equal to or greater than 4.0 mg/l in both sample periods. The results are tabulated by groupings in Table 2. Significant differences between sample dates was not observed and due to the small number of samples taken and the fact that only two sampling runs were performed, no conclusions regarding the seasonal water table fluctuations and nitrate-nitrogen could be established.

A brief look at the land use in the areas near the well locations exhibiting an NO_3 concentration of 4 or greater revealed observations which could explain the elevated values. Commercial chicken brooder facilities were noted near the two highest NO_3 value wells (24 and 47). Sample location 24A (NO_3 values 8.5 and 8.5) is located hydraulically downstream (Reference 8) from a chicken brooder facility, and property owners acknowledge that spreading of chicken manure on local fields is common. Sample location 25 (NO_3 values 5.2 and 5.2) is located hydraulically downstream (Reference 8, see study overlay) from 24A and the same brooder and is also hydraulically below the Scatter Creek I-5 rest stop facilities. It is possible that a nitrate-nitrogen plume exists with decreasing contaminant level resulting from contaminant dispersion and dilution (SP 24A, 8.5 mg/l--SP 25, 5.2 mg/l--SP 43, 4.0 mg/l).

The results of the total dissolved solids and chloride analyses did not produce values of great significance. Since background levels for these chemical parameters were not available. No specific conclusions can be developed from these data. The results were incorporated into this report to show that the values did not exceed drinking water standards and to document information which may be useful for comparison at some future date.

CONCLUSIONS

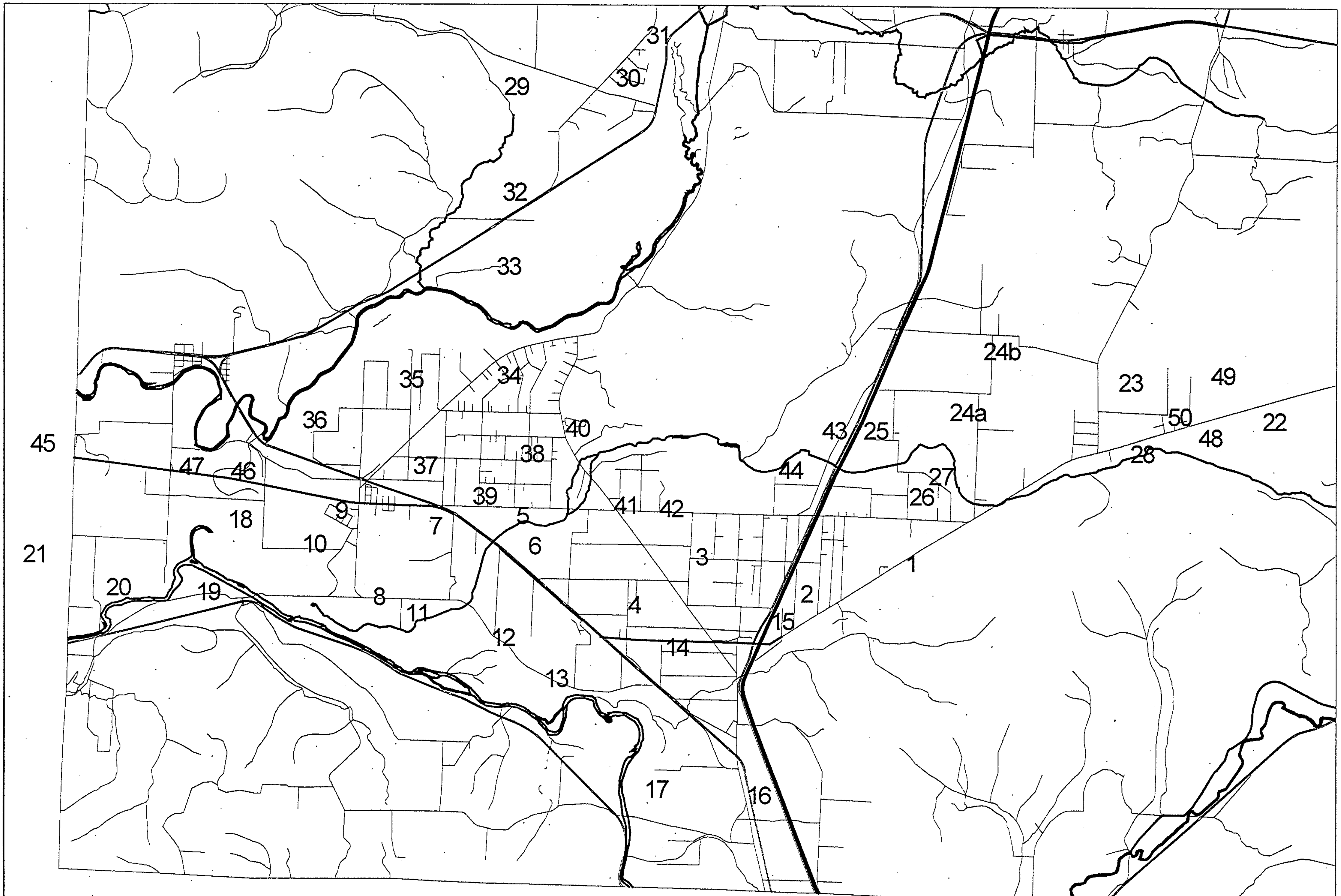
The bacteriological and chemical results of this survey provide a limited assessment of the general condition of the ground water quality at a particular point in time. While the information is not substantial enough to prove cause and effect relationships or accurately predict trends, some conclusions and associations can be made.

A. The bacteriological information suggests that the ground water is free of coliform bacteria.

B. The nitrate-nitrogen analyses demonstrates that nitrates are reaching the ground water. The majority of sample locations produce samples in the 1 to 3.9 mg/l range; however, 4 locations produce samples of 4 mg/l or greater. One location has exceeded drinking water standards.

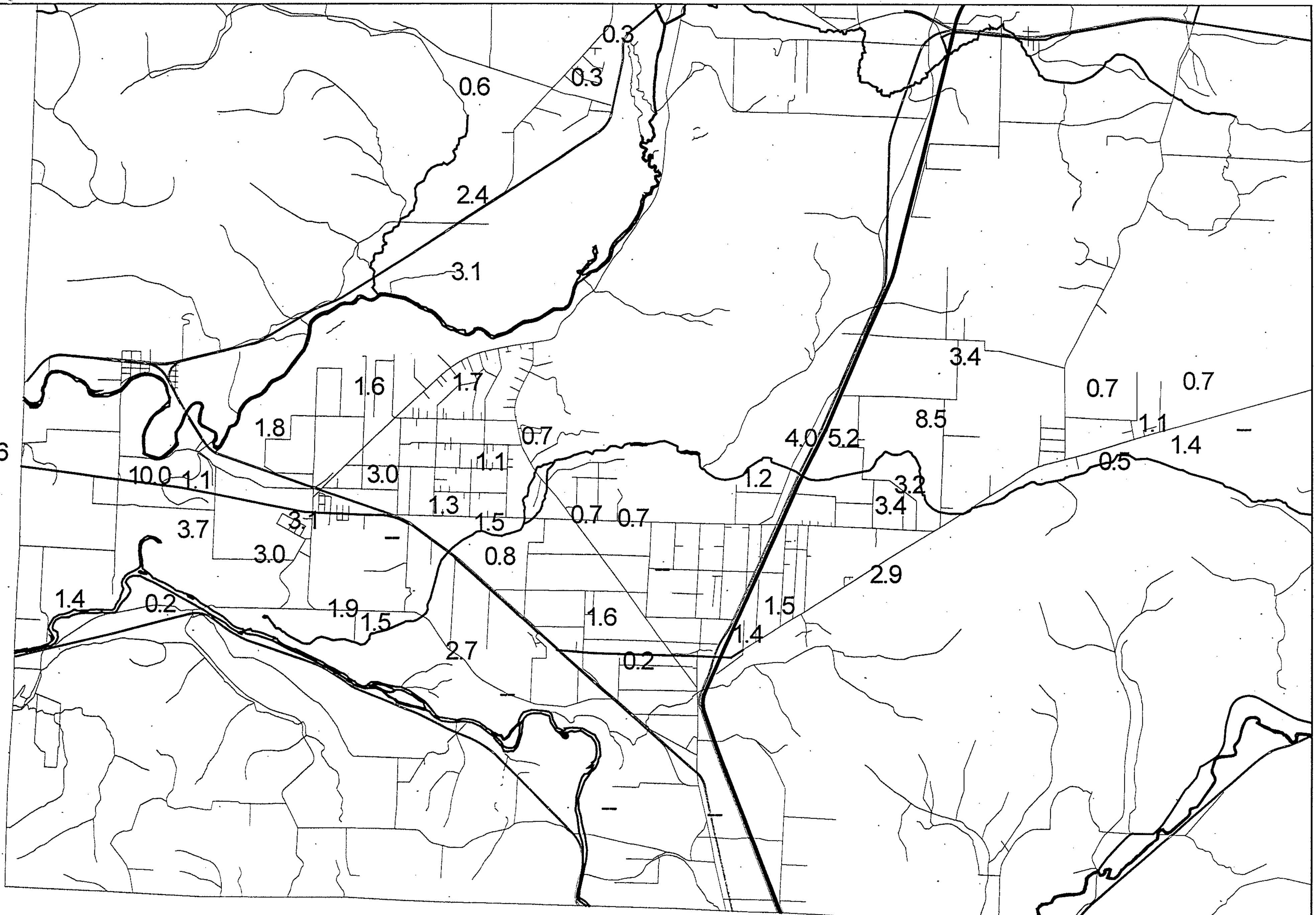
C. Observation of land use activities in areas of sample locations with elevated nitrogen-nitrate values suggests a possible association. Exhaustive study would be necessary to substantiate a cause and effect relationship, however.

D. Some concentrating of nitrate-nitrogen may be occurring in the aquifer. Close scrutiny of the study map with the nitrate and WDOE flow overlays shows a general trend of increasing nitrate values from areas of assumed aquifer recharge in the outer reaches to areas of concentrated aquifer flow. Again much more information and study would be necessary to substantiate this beyond a casual observation.



Grand Mound/Rochester Aquifer Survey
Well Locations

R. D. Mead
Map printed 1/25/1999



Grand Mound/Rochester Aquifer Survey

March 1983 Nitrate Data

R. D. Mead
Map printed 1/25/1999

TABLE 2

Grand Mound/Rochester Study Area Water Analyses
Nitrate-Nitrogen Results (mg/l) By Sample Collection Period

Evergreen Study--Spring 1978: 75 wells

Number of Wells	Nitrate Level
1	18 ppm
4	6 - 10 ppm
7	4 - 6 ppm
26	1 - 4 ppm
37	Less than 1 ppm

Existing data from public water systems -- 1979-1984.

35 wells/39 samples

Number of Wells	Nitrate Level
1	10
2	6-9.9
2	4-5.9
29	1-3.9
5	1

Wells Sampled in August 1982: 45 wells sampled

Number of Wells	Nitrate Level
0	10
2	6-9.9
3	4-5.9
25	1-3.9
15	1

Wells Sampled in March 1982: 50 wells sampled

Number of Wells	Nitrate Level
1	10
1	6-9.9
2	4-5.9
33	1-3.9
13	1

For General Comparison: Survey of Wells in Chambers Creek/Clover Creek Drainage Basin--Pierce County (112 wells)

Number of Wells	Nitrate Level
8	5 ppm
8	4 - 5 ppm
10	3 - 4 ppm
86	Less than 3 ppm

TABLE 3

Grand Mound/Rochester Water Quality Survey

Sample Location Number	Total Dissolved Solids 3/83	Total Dissolved Solids 8/82	Chlorides 3/83	Chlorides 8/82	Nitrate-Nitrogen 3/83	Nitrate-Nitrogen 8/82
1	90	71	7.0	--	2.9	3.5
2	70	65	5.0	--	1.5	1.5
3	--	108	--	--	--	1.2
4	80	63	5.0	--	1.6	1.1
5	60	73	5.0	--	1.5	0.9
6	70	70	5.0	--	0.8	0.8
7	--	43	--	--	--	0.8
8	70	43	5.0	--	1.9	1.7
9	80		6.0	--	3.1	
10	90	71	5.0	--	3.0	2.3
11	70	47	5.0	--	1.5	1.5
12	80	67	8.0	--	2.7	2.0
13	--	92	--	--	--	1.7
14	70	53	5.0	--	0.2	1.5
15	80	70	5.0	--	1.4	1.5
16	--	--	--	--	--	--
17	--	88	--	--	--	3.9
18	90	89	5.0	--	3.7	4.3
19	70	63	5.0	--	0.2	0.2
20	80	50	5.0	--	1.4	1.2
21	60	52	5.0	--	1.1	1.6
22	--	24	--	--	--	0.8
23	50	48	5.0	--	0.7	1.0
24A	120	169	6.0	--	8.5	8.5
24B	80	51	10.0	--	3.4	3.3
25	120	100	6.0	--	5.2	5.2
26	80	85	5.0	--	3.4	2.4
27	60	93	5.0	--	3.2	2.3
28	60	79	5.0	--	0.5	0.6
29	50	34	5.0	--	0.6	0.5
30	30	38	5.0	--	0.3	0.2
31	60	55	5.0	--	0.3	0.3
32	70	77	7.0	--	2.4	2.1
33	90	87	5.0	--	3.1	3.3
34	70	67	13.0	--	1.7	1.0
35	70	61	5.0	--	1.6	1.6
36	70	72	5.0	--	1.8	1.9
37	90	45	15.0	--	3.0	1.7
38	70	53	5.0	--	1.1	0.9
39	60	59	5.0	--	1.3	1.3
40	80	50	5.0	--	0.7	0.4
41	70	--	5.0	--	0.7	--
42	60	55	5.0	--	0.7	0.6
43	110	86	5.0	--	4.0	4.0
44	60	62	5.0	--	1.2	0.8
45	90	87	5.0	--	1.6	0.3
46	90	102	5.0	--	1.1	0.8
47	185	156	6.0	--	10.0	7.3
48	10	--	5.0	--	1.4	--
49	60	--	5.0	--	0.7	
50	70	--	5.0	--	1.1	

TABLE 4

Bacteriological Analysis Summary Grand Mound/Rochester Study Area

(Total Coliform Bacteria; Membrane Filter Technique)

Wells Sampled: August 1982

45 wells sampled

38 analyses satisfactory (0 MF coliform)

1 sample = 47 MF coliform (sample point #13)

1 sample = 188 MF coliform (sample point #12)

2 samples = confluent growth (sample points #2 and #8)

3 samples = TNTC (sample points #15, #23 and #28)

*Samples which exhibited coliform bacteria were tested for fecal coliform bacteria.

Wells Sampled: March 1983

50 wells samples

46 analyses satisfactory (0 MF coliform)

1 sample = 2 MF coliform (sample point #14)

2 samples = 4 MF coliform (sample points #2 and #46)

1 sample = 19 MF coliform (sample point #19)

*No samples which exhibited coliform bacteria were found to have fecal coliform bacteria.

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