

WASHINGTON STATE
DEPARTMENT OF
E C O L O G Y

**PESTICIDE RESIDUES IN THE WOODLAND
SURFICIAL AQUIFER, PESTICIDE REPORT NO. 6**

Water Body No. WA-27-2010GW
Publication #94-128

August 1994

printed on recycled paper

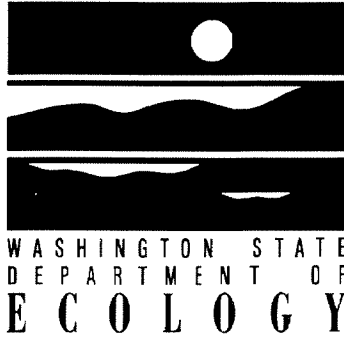


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**PESTICIDE RESIDUES IN THE WOODLAND SURFICIAL AQUIFER
PESTICIDE REPORT NO. 6**

By
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Environmental Investigations and Laboratory Services Program
Toxics Investigations Section
Olympia, Washington 98504-7710

August 1994

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Acknowledgements

I thank the owners of the wells for allowing me to sample and for providing background information on their wells. I also thank Stuart Magoon for tracking my samples, and providing the quality assurance review, and Dickey Huntamer for supervision of the pesticide analyses. The first draft review by Pam Marti and Barb Carey is appreciated as is the typing and proofing by Kelly Carruth. Peer review was provided by Denis Erickson, Larry Goldstein, and Karol Erickson of the Environmental Investigations and Laboratory Services Program and by Linton Wildrick of the Water Resources Program.

Finally, David Nash of the Washington State Department of Health reviewed all results for health implications and wrote letters to well owners explaining these implications.

Abstract

Fourteen wells near Woodland, Washington, were sampled during May and June 1993 for 124 pesticides and nitrate+nitrite as nitrogen. Field measurements of water temperature, pH, and specific conductance were also made. Seven pesticides were detected in the initial samples; **atrazine, simazine, diuron, bromacil, tebuthiuron, pentachlorophenol, and 1,2-dichloropropane**. One or more of these chemicals were detected in nine wells, however, concentrations were below health related levels set by the EPA. A second sample from the nine wells confirmed the presence of these pesticides. In one well, the nitrate+nitrite as N concentration exceeded the 10 mg/L standard for public drinking water.

Introduction

In May and June 1993, I sampled fourteen (14) wells near Woodland, Washington, for pesticides and nitrate+nitrite as nitrogen. Wells were located in the Woodland Surficial Aquifer underlying the Lewis River delta at the river's confluence with the Columbia River (Figure 1). The aquifer, situated along the Cowlitz and Clark County boundary, underlies the largest agricultural area south of Lewis County. Crops grown in the valley include peas, carrots, sweet corn, silage corn, strawberries, raspberries, blueberries, bulbs, and hay. The study area includes several dairies, and pasturing of cattle and sheep is common. Although farming is still the major activity, industrial development is expanding near the I-5 corridor. As a consequence of this development, local farm land is being subdivided for housing.

Background

Agricultural chemicals, specifically pesticides, are used throughout Washington. Although pesticides are used extensively on farm lands, they are also applied in the urban and forest environment. Population growth and increasing urbanization are placing increasing demands on the ground water resource. At the same time, the effect of pesticide use on the State's ground water quality is largely unknown.

In 1987, the Washington State Legislature asked the Department of Ecology to investigate whether pesticides were contaminating ground water. The resultant project became known as the Washington State Agricultural Chemicals Pilot Study.

Erickson and Norton (1990) investigated ground water at three sites and published the initial results in 1990. Sites were:

1. near Lynden in Whatcom County,
2. near Sunnyside in Yakima County, and
3. near Pasco in Franklin County.

Additional sites have been sampled since this initial work. A portion of the East Naches Aquifer near Glead was sampled in 1990 (Erickson, 1992), a portion of the Quincy Surficial Aquifer was sampled in 1991 (Larson and Erickson, 1993), portions of the Ahtanum and Moxee Surficial Aquifers were sampled in 1992 (Larson, 1993), and a portion of the East Chehalis Surficial Aquifer was sampled in 1993 (Larson, 1994). Each study represents a different crop type, climatic condition, or aquifer.

Purpose

Sampling of the Woodland Surficial Aquifer is part of ongoing efforts to monitor pesticides in ground water, statewide. It provides data on the concentrations of pesticides in ground

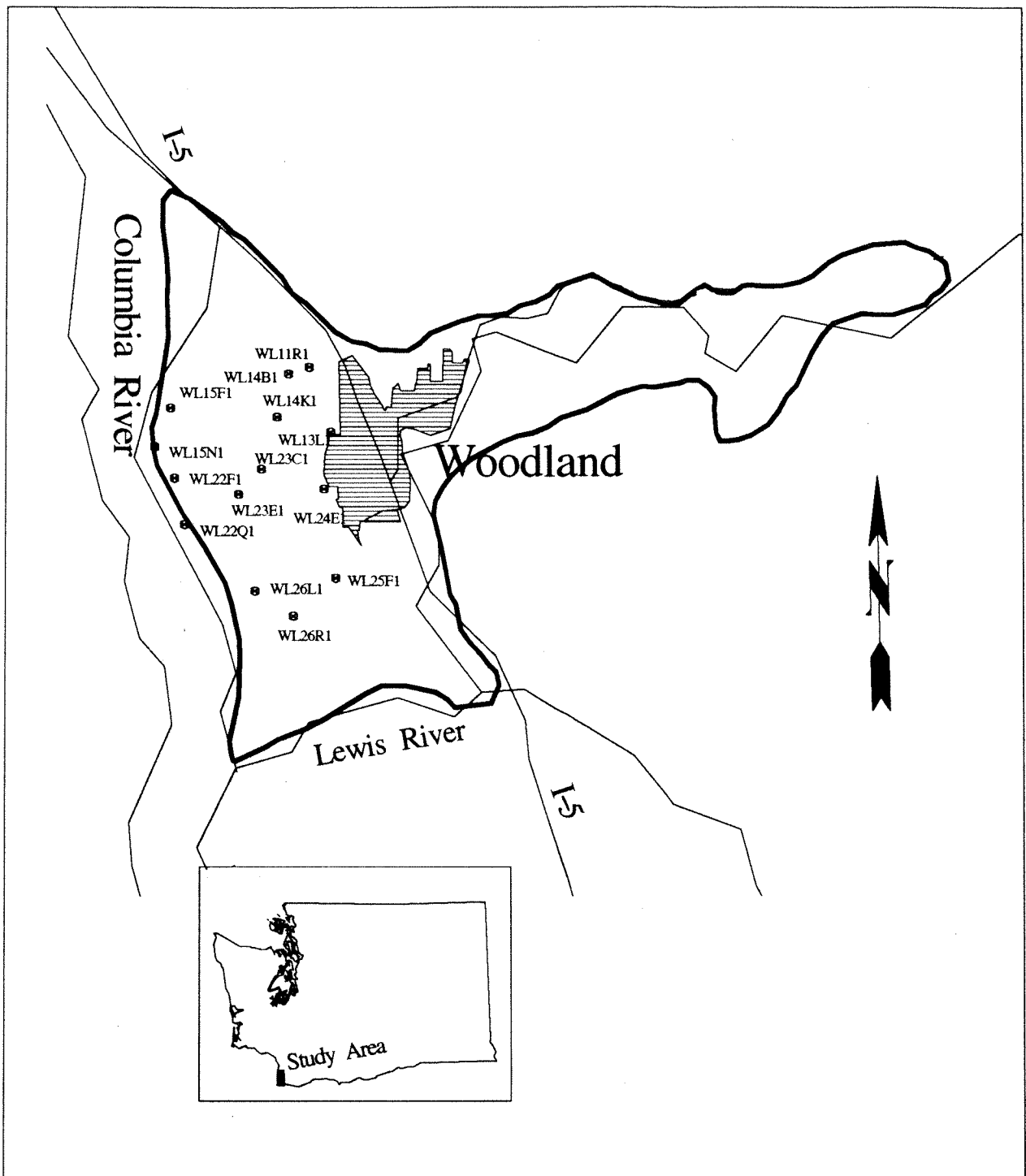


Figure 1. Location of sample wells within the Woodland Aquifer.

water where agriculture is interspersed with residential and industrial development. The shallow Woodland Surficial Aquifer discharges to both the Lewis River and the Columbia River.

Woodland Aquifer

The Woodland Surficial Aquifer is the uppermost aquifer in the lower valley of the Lewis River. The 24-square-mile aquifer extends upstream from the river's mouth to the head of the Lewis River delta, several miles east of Woodland. The aquifer is unconfined, with a relatively shallow water table (generally less than 10 feet to ground water). Soils have been drained by ditches that criss-cross the valley. A dike protects the lowland from flooding of the Lewis and Columbia Rivers. Excess water in drainage ditches is pumped over the dike into the Columbia River. The water table is hydraulically connected to the local surface water and readily influenced by the stage of the Lewis and Columbia Rivers. At any given time, the water-table elevation reflects pumpage, irrigation, precipitation, and the stage of the nearby rivers.

Hydrogeology

The water table, generally within ten feet of the land surface, has a gradient less than one foot per mile, and discharges slowly to the Columbia River. The water-table elevation is limited by rapid drainage by ditches. The aquifer, primarily river-delta and flood-plain deposits, is composed mostly of sand, although silt and clay layers are present. Well logs (Appendix A) indicate that water-bearing sands are common from 10 feet to, at least, 50 feet in depth.

Soils

Major soils are flood-plain soils formed in alluvium, primarily silt to fine sandy loams (SCS, 1974). The soils are somewhat-poorly to poorly-drained and slowly permeable. A common soil is the Caples silt loam, a somewhat-poorly drained soil which holds about 11 inches of water that plants can use. Development of deep rooted plants is restricted by a seasonal high water table at a depth of 1 to 3 feet. This soil, which may develop to a depth of six feet, is found at elevations less than 25 feet. At slightly higher elevations (only one to two feet higher), the Newberg silt loam is common. This soil is prominently mottled below a depth of 30 inches, and strongly acid to neutral throughout the profile. It holds about ten inches of water that plants can use.

Methods

To select appropriate wells for sampling, I searched the well log files located at Ecology's Southwest Regional Office. I selected well logs based on shallow depth, high water table, and location within the aquifer. Once an adequate number of well logs were selected, I visited each well.

Criteria used in the well selection included:

- water pumped only from the Woodland Surficial Aquifer,
- location of the well away from aquifer boundaries and from wells already selected,
- a shallow well,
- ease of collecting a representative water sample, and
- the owner's permission to sample.

Wells

I selected 14 wells for sampling the Woodland Surficial Aquifer; thirteen domestic and one irrigation. Wells were located in an eight square-mile area between the town of Woodland and the Columbia River. Woodland and the aquifer area east of Woodland are served by "City Water" and shallow wells were not found in these areas. The well locations and aquifer boundaries are shown in Figure 1.

The majority of study wells were shallow "driven" wells (sand points). Wells ranged from 15 to 57 feet deep and averaged 26 feet. Screens, when present, usually allowed water to enter the well over the last four to five feet of the depth. The type of well, surface elevation, total depth, and depth to water for the individual wells are presented in Appendix B.

Sampling

Initial sampling occurred in late May and early June 1993. Wells in which pesticides were detected were resampled in February, 1994 (verification sampling), to confirm the initial analyses.

Sampling Procedures

Before sampling, I purged all wells until the temperature, pH, and specific conductance had stabilized and at least three casing volumes of water had been removed. I used an Orion meter for pH and temperature measurements and a Beckman meter to measure specific

conductance. I purged and sampled the wells from existing faucets located as close to the well as possible and upstream of any pressure tanks, where feasible.

Analytes Tested

Ground water was analyzed for 124 pesticides and pesticide-breakdown products (Appendix C) and for nitrate+nitrite as nitrogen. Most of the pesticides were chosen from the Environmental Protection Agency's (EPA) list of leachable pesticides which have properties conducive to migration through soil to ground water (Cohen, 1985). Additional pesticides were added when available from the same analyses for little additional cost.

Nitrate was tested to investigate any link between elevated concentrations and pesticide detections. Can I use nitrate to predict where pesticides are most likely to be found?

Samples were analyzed by the Ecology/EPA Manchester Laboratory. Carbamates, analyzed in prior studies, were not tested due to a laboratory oversight.

Quality Assurance

The quality of the results is generally good. The qualitative and quantitative accuracy, validity, and usefulness of data were independently reviewed by Stuart Magoon of the Ecology/EPA Manchester Laboratory (Appendix D).

Results

In the initial sampling, one or more pesticides were detected in nine of the 14 study wells. Pesticides detected were **atrazine, simazine, bromacil, tebuthiuron, diuron, pentachlorophenol** and **1,2-dichloropropane**. The concentrations of detected pesticides are presented in Table 1., including both the results of the initial and the verification sampling.

Of the seven pesticides detected, five (atrazine, simazine, bromacil, tebuthiuron, and diuron) are herbicides used to control perennial and annual weeds such as crabgrass, foxtail, horsetail, and chickweed (Thomson, 1986). Pentachlorophenol is generally used as an insecticide but is also commonly applied as a herbicide. 1,2-dichloropropane is present as a contaminant in some soil fumigants.

Table 1. Concentrations of pesticides detected ($\mu\text{g/L}$).							
Site ID	Atrazine	Simazine	Bromacil	Tebuthiuron	Diuron	Penta	1,2-D
WL14B1			0.22/0.17J	0.91/1.90			
WL14K1			0.23/0.17J	0.081U/0.027J			
WL15F1	0.02J/0.077						
WL22F1	0.02J/0.04J						
WL22Q1	0.04J/0.05J						
WL23E1							2.4/1.6
WL25F1						0.038/0.036	
WL26L1		0.03J/0.05J	0.45U/1.10		0.33J/0.36J	0.018/0.019U	
WL26R1	0.14/0.11						

/=initial value followed by verification value.
 J= Positively identified but the value is an estimate.
 U=The analyte was not detected above the detection limit shown.
 1,2-D=1,2-Dichloropropane, Penta=Pentachlorophenol.

Atrazine

Atrazine was initially detected in four wells: WL15F1, WL22F1, WL22Q1, and WL26R1. Although positively identified in all four samples, concentrations were low enough in three samples that only an estimate of the concentration was possible. Concentrations ranged from 0.02 to 0.14 $\mu\text{g/L}$.

Atrazine was also detected in the verification samples. Concentrations were low in two samples and only an estimated concentration was reported. However, concentrations were high enough in two samples for a confirmed quantification. Concentrations ranged from 0.04 to 0.11 $\mu\text{g/L}$.

Simazine

Simazine was positively identified in one well (WL26L1) in both the initial and verification samples. Both concentrations were below the quantification limit and could only be estimated (0.03/0.05 $\mu\text{g/L}$).

Bromacil

Bromacil was found in two wells during initial sampling, WL14B1 and WL14K1, located about 1/2 mile apart. Both wells are within 100 feet of 10- to 40-acre vegetable and berry fields. Bromacil was detected in the verification samples, but at a concentration that could only be estimated. Bromacil was also found in the verification sample for well WL26L1, although it was not detected in the initial sample. Concentrations ranged from 0.17 to 1.10 $\mu\text{g/L}$.

Tebuthiuron

Tebuthiuron was found in the same two wells as bromacil. In the initial samples, tebuthiuron was only quantified in well WL14B1. However, in the verification samples, tebuthiuron was again quantified in WL14B1 and was also detected in well WL14K1. It had not been detected in WL14K1 during initial sampling. Concentrations ranged from 0.027 to 1.90 $\mu\text{g/L}$.

Diuron

Diuron was detected in well WL26L1 in the initial sampling and was also positively identified in the verification sample. Concentrations of diuron in both samples were low enough that it could only be estimated (0.33/0.36 $\mu\text{g/L}$).

Pentachlorophenol

Pentachlorophenol (Penta) was found in two wells in the initial sampling, WL25F1 and WL26L1. Concentrations were great enough to be quantified. Penta was again found in well WL25F1 in the verification sample but was not detected in the verification sample from WL26L1. Concentrations ranged from 0.018 to 0.038 $\mu\text{g/L}$.

1,2-Dichloropropane

Dichloropropane was found in one well, WL23E1. It was detected at quantifiable concentrations in both the initial and verification samples (2.4/1.6 $\mu\text{g/L}$).

Nitrate + Nitrite as N

Nitrate+nitrite as N was detected in 12 of the 14 wells sampled (Table 2). Initial concentrations ranged from <0.01 to 11.8 mg/L. The maximum concentration of nitrate + nitrite as N occurred in well WL22F1, 11.8 mg/L (initial) and 14.3 mg/L (verification).

Atrazine was also detected in this well. The average concentration of nitrate in all wells was 4.2 mg/L, reflecting the effects of agriculture.

The average nitrate+nitrite as N concentration for wells with pesticides was 5.2 mg/L. This was greater than the 2.3 mg/L average for wells without pesticides. However, nitrate concentrations were not useful in predicting in which well I would detect pesticides. The wells with a detected pesticide included the well with the greatest nitrate concentration and one of the two wells without detectable nitrate. Although not defensible from this study alone, an average nitrate concentration greater than 2 or 3 mg/L may indicate that detection of pesticides is likely in the area.

Well depth did not have a consistent influence on nitrate concentrations. The two wells with non-detectable nitrate+nitrite as N concentrations were deeper wells, 57 and 44 feet deep. However two other wells at 48 and 45 feet deep had concentrations of 4.3 mg/L and 6.7 mg/L, respectively.

Health Concerns

The Environmental Protection Agency (EPA) has set Maximum Contaminant Levels (MCLs) or Lifetime Health Advisory Levels (LHALs) for all of the detected pesticides. None of the pesticide concentrations exceeded these levels of concern.

The MCL for atrazine in drinking water is 3.0 µg/L and the MCL for simazine is 4.0 µg/L. Detected atrazine concentrations were 20 times lower than the MCL and simazine detections were 60 times lower than the MCL. The MCL for 1,2-dichloropropane is 5 µg/L, twice the concentration found in this study. Detected concentrations of pentachlorophenol were less than four percent of the 1.0 µg/L MCL.

The EPA has set a LHAL for bromacil in drinking water at 90 µg/L, 36 times greater than concentrations detected. The LHAL for diuron in drinking water is 10 µg/L, but diuron was detected at less than four percent of this value. Tebuthiuron was detected at concentrations less than one percent of the 500 µg/L LHAL.

Table 2. Nitrate - nitrite as N.

Site ID	mg/L
WL11R1	0.34
WL13L1	4.65
WL14B1	4.59
WL14K1	6.59
WL15F1	4.18
WL15N1	<0.01
WL22F1	11.8/14.3*
WL22Q1	4.31
WL23C1	6.20
WL23E1	<0.01
WL24E1	0.09
WL25F1	0.59
WL26L1	6.73
WL26R1	8.39
* Initial and verification value.	

The MCL for public drinking-water systems for nitrate as N is 10.0 mg/L. The nitrate+nitrite as N concentration exceeded 10 mg/L in one well, and 5.0 mg/L (1/2 the MCL) in five wells.

Field Measurements

The water temperature, pH, and specific conductance of study wells are shown in Table 3. All parameters showed seasonal variation. The average temperature of the ground water was 13.4°C during the initial sampling (early summer), cooling to 11.5°C by the date of verification sampling (winter). Verification samples from wells less than 20 feet deep were cooler than the original samples by an average of 2.3°C, while deeper ground water was cooler by less than 0.5°C. The average pH was 6.3 and the average specific conductance was about 250 μ mhos/cm. Seasonal variations in pH and conductance between initial and verification samples are less obvious than temperature differences.

Conclusions

1. Seven pesticides were detected in ground water from the Woodland Surficial Aquifer: **atrazine, simazine, bromacil, tebuthiuron, diuron, pentachlorophenol, and 1,2-dichloropropane.** The presence of these pesticides was confirmed by the verification sampling.
2. None of these pesticides were detected above concentrations established by the EPA for health protection.
3. No impairment of water use is warranted based on concentrations of pesticides.

Table 3. Temperature ($^{\circ}$ C), pH (standard units), and specific conductance (μ mhos/cm) of ground water samples.

Site ID	Temp.	pH	Cond.
WL11R1	13.1	6.5	185
WL13L1	13.7	5.8	230
WL14B1	13.3/11.9	5.9/6.8	245/225
WL14K1	13.4/10.6	6.2/6.1	230/180
WL15F1	14.4/12.2	6.0/6.3	330/230
WL15N1	14.7	6.5	250
WL22F1	14.0/11.3	6.0/6.3	310/270
WL22Q1	14.2/11.8	6.3/6.4	400/410
WL23C1	12.6	6.6	180
WL23E1	12.3/11.5	6.7/6.6	220/210
WL24E1	13.3	6.6	130
WL25F1	13.0/10.6	6.1/6.7	245/195
WL26L1	12.0/12.1	6.4/6.7	270/270
WL26R1	13.6/11.2	6.0/6.7	380/280

/ initial followed by verification value.

4. Nitrate concentrations were greater than the natural background levels. In one well, the nitrate+nitrite as N concentration exceeded the 10.0 mg/L drinking water standard. Five wells had concentrations greater than 5 mg/L. Although elevated average nitrate concentrations may indicate an area where pesticides will be detected, an individual high nitrate concentration does not indicate a well in which we will necessarily detect a pesticide.

5. Neither the depth of the well nor the depth of the screened interval was a good indicator of pesticide detection. Four pesticides were detected in well WL26L1, one of the deeper wells (45 feet). This well also had a nitrate+nitrite as N concentration of 6.73 mg/L. Pesticides were detected in wells from 15 feet to 48 feet deep. However, two of the deeper wells, 48 feet and 44 feet deep, were screened starting at 32 feet and 34 feet, respectively. No pesticides were detected in the deepest well (57 feet - screened at 51-56 feet).

References

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- SCS, 1974. Soil Survey of Cowlitz Area, Washington. USDA Soil Conservation Service, 112p. with plates.
- Thomson, W.T., 1986. Agricultural Chemicals, Book II Herbicides, Thomson Publications, Fresno, CA 93791. 301 p.

Appendices

Appendix A. Well Logs

WELL REPORT

Application No.

WASHINGTON

Permit No.

(1) OWNER: N

Well WL15N1

Address:

(2) LOCATION

2-1/4 Sec. 215 T. 5 N., R. 1 W.M.

Bearing and distance to

450' of Gov. Lot 4

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

(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
Dredged sand	0	16
Brown clay & sand	16	29
Sand, wood & water	29	32
Grey clay	32	40
Grey sand & water	40	57

(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 57 ft. Depth of completed well 57 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6" Diam. from 0 ft. to 51 ft.
Threaded 5" Diam. from 56 ft. to 57 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 UOP Johnson
Type Stainless steel Model No
Diam. 6 Slot size 30 from 51 ft. to 56 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? 20 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: HP

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level 22 ft. below top of well Date 2-9-77
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 20 gal./min. with 0 ft. drawdown after 1 hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes No

Work started Feb 4, 1977 Completed Feb 9, 1977

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 Hansen Drilling Co. Inc.
(Person, firm, or corporation) (Type or print)

Address 6711 N.E. 58th Ave. Vancouver, Wa 98

o211 Rex Ireton
[Signed] Rex Ireton
(Well Driller) RM Hansen

License No. C-51 Date February 11, 1977
223-02HA-NS-ED-*377NT

(1) **OWNER:** No Well WL23E1

(2) **LOCATION**

Bearing and distance fr. _____

SE $\frac{1}{4}$ NW $\frac{1}{4}$ Sec. 23 T. 5 N., R. 1W W.M.

(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 44 ft. Depth of completed well 44 ft.

(6) **CONSTRUCTION DETAILS:**

Casing installed: 6" Diam. from 0 ft. to 33 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 UOP Johnson
 Type stainless steel Model No. 304
 Diam. 6 Slot size 15 from 34 ft. to 39 ft.
 Diam. _____ Slot size _____ from _____ ft. to _____ ft.

Riser = 2" - 3", Screen = 5" - 4", Blank = 5" - 0"
 Gravel packed: Yes No Size of gravel: _____
 Gravel placed from _____ ft. to _____ ft.

Surface seal: Yes No To what depth? 20 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 Fairbanks Morse
 Type: submersible HP 1

(8) **WATER LEVELS:** Land-surface elevation above mean sea level _____ ft.
 Static level 10 ft. below top of well Date 3/21/77
 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 60 gal./min. with 0 ft. drawdown after 2 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
Topsoil, sand & silt, gray	0	11'
Sand & silt, gray	11'	16'
Sand, gray, water bearing	16'	39'
Clay, gray	39'	44'

RECEIVED

APR 21 1977

DEPARTMENT OF ECOLOGY
 SOUTHWEST REGIONAL OFFICE

5' - 0"

Work started 3/18, 1977. Completed 3/21, 1977

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 NORRIS DRILLING & PUMP CO., INC.
 (Person, firm, or corporation) (Type or print)
11026 N.E. St. Johns Blvd.
 Address Vancouver, Washington 98665

[Signed] O. J. Norris
 (Well Driller)

License No. 0366 Date April 12, 1977

(1) OWNER: Well WL22Q1

(2) LOCATIO

NE ¼ SW ¼ Sec 22 T 5 N, R 1W W.M.

Bearing and distance

(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 42 ft. Depth of completed well 42 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6 " Diam. from 0 ft. to 32 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 UOP Johnson
Type Stainless steel Model No. 304
Diam. 6 Slot size 15 from 32 ft. to 37 ft.
Diam. 8 Slot size 18 from 37 ft. to 42 ft.

Screen = 10'-8", riser = 2'-7"
Gravel packed: Yes No Size of gravel:
Gravel placed from ft. to ft.

Surface seal: Yes No To what depth? 20 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 HP
Type: HP

(8) WATER LEVELS: Land-surface elevation above mean sea level. ft.
Static level 9 ft. below top of well Date 3/29/74
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 50 gal./min. with 6 ft. drawdown after 2 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
Topsoil	0	2'
Brown sand & silt	2'	24'
Sand, black, cemented with silt	24'	28'
Sand, black, water bearing	28'	42'

Work started 3/26, 1974 Completed 3/29, 1974

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 NORBIS DRILLING & PUMP CO., INC.
11026 NE St. Johns Blvd.
Address Vancouver, Washington 98665
[Signed] Orin J. Norris (Well Driller)
License No. 0366 Date April 1, 1974



WATER WELL REPORT
STATE OF WASHINGTON

Start Card No. 061935
Water Right Permit No.

(1) OWNER: Name FIRCREST FARMS Address P.O. BOX 8 CRESWELL, OR 97426-

(2) LOCATION OF WELL: County COMLITZ - 1/4 1/4 Sec 14 T 5 N., R 1 W WM
(2a) STREET ADDRESS OF WELL (or nearest address) 1711 GUILD ROAD

(3) PROPOSED USE: COMMERCIAL

(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 in formation.

(4) TYPE OF WORK: Owner's Number of well (If more than one) Method: ROTARY
NEW WELL

(5) DIMENSIONS: Diameter of well 8 inches
Drilled 41 ft. Depth of completed well 33 ft.

MATERIAL	FROM	TO
TOP SOIL	0	02
SANDY SILT	02	06
SAND FINE MEDIUM	06	15
SAND COURSE	15	33
CLAY	33	41

(6) CONSTRUCTION DETAILS:
Casing installed: 8 " Dia. from +2 ft. to 24.5 ft.
WELDED " Dia. from ft. to ft.
" Dia. from ft. to ft.

Perforations: 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
Manufacturer's Name JOHNSON
Type TELESCOPING Model No. STAINLESS STEEL
Diam. 8 slot size 30 from 22.6 ft. to 33 ft.
Diam. slot size from ft. to ft.

Gravel packed: YES Size of gravel 1/2-
Gravel placed from 33 ft. to 41 ft.

Surface seal: YES To what depth? 18 ft.
Material used in seal CEMENT GROUT
Did any strata contain unusable water? NO
Type of water? Depth of strata ft.
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 4.5 ft. below top of well Date 05/04/90
Artesian Pressure lbs. per square inch Date
Artesian water controlled by

Work started 04/24/90 Completed 05/03/90

(9) WELL TESTS: Drawdown is amount water level is lowered below static level.

WELL CONSTRUCTOR CERTIFICATION:
I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

Was a pump test made? YES If yes, by whom? JERRY MCGHEE
Yield: 93 gal./min with 3.6 ft. drawdown after 1 hrs.

Recovery data
Time Water Level Time Water Level Time Water Level

NAME DALE MCGHEE & SONS, INC.
(Person, firm, or corporation) (Type or print)

Date of test
Bailer test gal/min: ft. drawdown after hrs.
Air test gal/min. w/ stem set at ft. for hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? YES

ADDRESS 3032 ALLEN STREET
[SIGNED] *J. Dale McGhee* License No. 0298
Contractor's
Registration No. DALEMI#212MC Date 05/10/90

WATER WELL REPORT

STATE OF WASHINGTON

Application No.

Permit No.

(1) **OWNER:** Name United Bulb Farm Address P.O. Box E, Woodland, WA.

(2) **LOCATION OF WELL:** County Cowlitz - NW 1/4 NW 1/4 Sec. 13, T. 5 N., R. 1W 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 Method: Dug Bored
Deepened Cable Driven
Reconditioned Rotary Jetted

(5) **DIMENSIONS:** Diameter of well 8 inches.
Drilled 56 ft. Depth of completed well 56 ft.

(6) **CONSTRUCTION DETAILS:**
Casing installed: 8" Diam. from 0 ft. to 35 ft.
Threaded 7" Diam. from 45 ft. to 56 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 Johnson
Type stainless steel Model No.
Diam. 8" Slot size .025 from 35 ft. to 45 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? 20 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 ft.
above mean sea level ft.
Static level 4 ft. below top of well Date 5-17-76
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? Hansen Drilling
Yield: 350 gal./min. with 4 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
0 min.	12'	3 min.	14'	15 min.	11'
1 min.	12'	5 min.	13'	30 min.	10'
0 min.	15'	10 min.	12'	1 hr.	7 1/2'

Bailer test gal./min. with ft. drawdown after 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
Greyish sandy topsoil	0	3
Brown sandy clay	3	8
Silty grey sand	8	18
Greyish blue sand & water	18	32
Coarser sand & pumice	32	48
Packed sand	48	49
Silty grey sand	49	50
Blueish sandy clay	50	56

COWLITZ COUNTY
APPROVED FOR INSTALLATION
MAY 17 1976
SHELDON S. STUBBS
COUNTY CLERK

Work started 5-10 1976 Completed 5-17 1976

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 Hansen Drilling Co., Inc.
(Person, firm, or corporation) (Type or print)

Address 6711 NE 58th Ave., Vancouver, WA.
0221 Burnett Johnson

[Signed] Murritt Johnson
(Well Driller) RM Hansen

License No. 251 Date May 19 1976
223-02HA-NS-ED-*377NT

WATER WELL REPORT

STATE OF WASHINGTON

Application No. _____
Permit No. _____

(1) **OWNER:** Name Roger Smith Address _____
(2) **LOCATION OF WELL:** County Cowlitz NW 1/4 Q1 1/4 Sec 13 T 5 N, R. 1 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 Method: Dug Bored
Deepened Cable Driven
Reconditioned Rotary Jetted

(5) **DIMENSIONS:** Diameter of well 6 inches.
Drilled 37 ft. Depth of completed well 37 ft.

(6) **CONSTRUCTION DETAILS:**
Casing installed: 6" Diam. from 1 ft. to 31-6 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 Johnson
Type PVC Model No. _____
Diam. 4 in Slot size 20 from 31 ft. to 36 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? 25 ft.
Material used in seal benzene & drill cuttings
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: _____ HP _____

(8) **WATER LEVELS:** Land-surface elevation above mean sea level _____ ft.
Static level 4 ft. below top of well Date 5/14/79
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 5 gal./min. with _____ ft. drawdown after _____ 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
silt brown	0	5
silt fine sand	-5	15
sand fine to medium gray	15	22
sand medium to coarse & water	22	36 4
silt gray	36 4	37

Work started 5/14/79, 19____ Completed: 5/14/79, 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 Zent Drilling, Inc. (Person, firm, or corporation) (Type or print)
Address 7310 St. Johns Vancouver, Wash. 98666
[Signed] Wendell K. Peters (Well Driller)
License No. 223-02-28500 Date 5/15/79, 19____

WATER WELL REPORT

Start Card No. 025968

STATE OF WASHINGTON

Water Right Permit No. _____

(1) OWNER: Name Bob Smith Address 1331 Caples Rd. Woodland, Wa. 98674

(2) LOCATION OF WELL: County Cowlitz SE $\frac{1}{4}$ NW $\frac{1}{4}$ Sec 23 T. 5N N., R. 1W W.M.

(2a) STREET ADDRESS OF WELL (or nearest address) Same

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

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

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 information.

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

MATERIAL	FROM	TO
Brown sandy clay	0	2
Grey sandy clay	2	19
Grey sand (water)	19	31

(5) DIMENSIONS: Diameter of well 8 inches.
Drilled 31 feet. Depth of completed well 30'10" ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 8 in. diam. from + 1' ft. to 20'7" ft.
Welded
Liner installed
Threaded

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 Johnson
Type Stainless Steel Model No. _____
Diam. 8 Slot size 40 from 20'7" ft. to 25'7" ft.
Diam. 8 teils Slot size 35 from 25'7" ft. to 30'10" ft.

Sand gravel packed: Yes No
Size of gravel 6x12 Monterey
Gravel placed from 20 ft. to 30'10" ft.

Surface seal: Yes No To what depth? 20 ft.
Material used in seal Hole plug
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 8'9" ft. below top of well Date 5-23-89
Artesian pressure _____ lbs. per square inch Date _____
Artesian water is controlled by _____ (Cap, valve, etc.)

Work started May 22, 89, 19. Completed May 23, 89, 19

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes No If yes, by whom? Johnson
Yield: 80 gal./min. with 2'9" ft. drawdown after 1 hrs.
" "

WELL CONSTRUCTOR CERTIFICATION:
I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

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 min.	2'5"	2 mins.	2'8"	3 mins.	2'9"

NAME Hansen Drilling Co. Inc. (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 6711 NE. 58th Ave. Vancouver, Wa. 9866
(Signed) [Signature] License No. 0236
Contractor's Registration No. HANSED*37/NT Date May 30, 1989, 19

Date of test _____
Bailer test _____ gal./min. with _____ ft. drawdown after _____ hrs.
Airtest _____ gal./min. with stem set at _____ ft. for _____ hrs.
Artesian flow _____ g.p.m. Date _____
Temperature of water _____ Was a chemical analysis made? Yes No

(USE ADDITIONAL SHEETS IF NECESSARY)

WATER WELL REPORT

STATE OF WASHINGTON

(1) OWNER: Name Robert Smith Address 1331 Caples Road, Woodland, WA
(2) LOCATION OF WELL: County Cowlitz - SE 1/4 NW 1/4 Sec 23 T 5 N, R 1W 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) 3
 New well Method: Dug Bored
 Deepened Cable Driven
 Reconditioned Rotary Jetted

(5) DIMENSIONS: Diameter of well 10 inches.
 Drilled 40 ft. Depth of completed well 40 ft.

(6) CONSTRUCTION DETAILS:
 Casing installed: 16" Diam. from 0 ft. to 18 ft.
 Threaded 10" Diam. from 0 ft. to 20 ft.
 Welded 10" Diam. from 30 ft. to 40 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 UQP Johnson
 Type Irrigator Model No. 100
 Pipe size Diam. 10" Slot size 100 from 20 ft. to 30 ft.
 Diam. _____ Slot size _____ from _____ ft. to _____ ft.

Gravel packed: Yes No Size of gravel: pea gravel
 Gravel placed from 1 ft. to 40 ft.

Surface seal: Yes No To what depth? 18 ft.
 Material used in seal cement & 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: _____ HP

(8) WATER LEVELS: Land-surface elevation above mean sea level _____ ft.
 Static level 4'-5" ft. below top of well Date 1/28/80
 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: 265 gal./min. with 14'-9" 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
0	14'-9"				
15min.	5'-3"				
5 Hr.	15min.		4'-5"		

Date of test 4/11/80
 Bailor test 90 gal./min. with 4 ft. drawdown after 3 hrs.
 Artesian flow _____ g.p.m. Date 1/28/80
 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
Clay, brown; sand, seams of gray	0'	2'
Sand, gray; brown; silt, loose	2'	19'
Sand, gray; cemented, water-bearing	19'	30'
Clay, gray	30'	40'

RECEIVED

MAY 2 1980

DEPARTMENT OF ECOLOGY
SOUTHWEST REGIONAL OFFICE

Work started 1/7 1980 Completed 2/4 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 Norris Drilling & Pump Co., Inc.
11026 NE St. 30th Ave. Rb. (Type or print)

Address Vancouver, WA 98665

[Signed] Stephen R. Payne
 (Well Driller)

License No. 0386 Date 4/11 19 80

WATER WELL REPORT

STATE OF WASHINGTON

Application No.

Permit No.

(1) OWNER: Name Northwest Rose Growers Inc. Address P.O. Box 810, Woodland, WA 98674

(2) LOCATION OF WELL: County Cowlitz - 14 14 Sec. 13 T. 5 N., R. 1W 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) 2
New well Method: Dug Bored
Deepened Cable Driven
Reconditioned Rotary Jetted

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 25 ft. Depth of completed well 25 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6" Diam. from 2'11" ft. to 20'6" ft.
Threaded " Diam. from " ft. to " ft.
Welded 5" Diam. from 19 ft. to 20 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
Figure k packer from 18'6"-19'
Manufacturer's Name Johnson
Type Telescope Model No. Stainless
Diam. 6 Slot size 18 from 20 ft. to 25 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 Cement grout
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 7 ft. below top of well Date 4-19-85
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: 50 gal./min. with 3 ft. drawdown after 1 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 gal./min. with ft. drawdown after hrs.

Artesian flow g.p.m. Date

Temperature of water Was a chemical analysis made? Yes No

Field check

(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
Top Soil	0	2
Sandy-silt	2	14
Sand fine blue-gray	14	19
Sand fine to med	19	25

85 MAY -6 A10:21
FITTING

Work started 4-17, 19 85 Completed 4-19, 19 85

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 Dale McGhee & Sons Well Drilling, Inc.
(Person, firm, or corporation) (Type or print)

Address 3032 Allen St., Kelso, WA 98626

[Signed] J. Steve McGhee
(Well Driller)

License No. 0298 Date 4-30-, 19 85



Appendix B. Woodland Surficial Aquifer study wells.

Site ID	Water Use	Ground Elevation (ft.)	Well Depth (ft.)	Depth to Water (ft.)
WL11R1	Domestic	10	20	<10
WL13L1	Domestic	22	15	<15
WL14B1	Domestic	12	15	<10
WL14K1	Domestic	15	18	<15
WL15F1	Domestic	9	15	<10
WL15N1	Domestic	12	57 ¹	22*
WL22F1	Domestic	10	17	<10
WL22Q1	Irrigation	12	48 ²	<10*
WL23C1	Domestic	12	14	<10
WL23E1	Domestic	12	44 ³	10*
WL24E1	Domestic	25	16	<15
WL25F1	Domestic	25	20	9.4
WL26L1	Domestic	12	45	
WL26R1	Domestic	18	18	<10

* Well log attached (Appendix A).

¹ Screened at 51-56 feet.

² Screened at 32-42 feet.

³ Screened at 34-39 feet.

Appendix C. Target pesticides, test methods, and quantitation limits ($\mu\text{g/L}$).

EPA method 1618.

Abate (Temephos)	0.75
Alachlor	0.19
Ametryn	0.085
Atraton (Atron, Atratone)	0.25
Atrazine	0.086
Avadex (Di-Allate)	0.32
Azinphos (Guthion)	0.16
Benefin	0.13
Bolstar (Sulprofos)	0.053
Bromacil	0.47
Butachlor	0.28
Butifos (Def)	0.11
Butylate	0.13
CIPC (Chlorpropham)	0.4
Carbophenothion	0.081
Carboxin	0.85
Chlorothalonil (Daconil)	0.19
Chlorpropham	0.4
Chlorpyrifos (Chlorpyrifos)	0.059
Coumaphos	0.098
Cycloate	0.13
Demeton-O	0.06
Demeton-S	0.058
Devrinol (Napropamide)	0.25
Di-allate(Avadex)	0.32
Diazinon	0.067
Dichlobenil	0.1
Dichlorvos (Ddvp)	0.068
Dimethoate	0.062
Dioxathion	0.14
Diphenamid	0.23
Disulfoton (Di-Syston)	0.051
Epn	0.087
Eptam (EPTC)	0.13
Ethalfuralin (Sonalan)	0.13
Ethion	0.057
Ethoprop	0.065
Ethyl Azinphos (Ethyl Guthion)	0.14
Fenamiphos	0.12
Fenarimol	0.25
Fenitrothion	0.059
Fensulfothion	0.085
Fenthion	0.058
Fenvalerate	0.34
Fluridone	1.4
Fonofos	0.047
Hexazinone	0.12

Imidan	0.09
Malathion	0.07
Merphos I	0.12
Metalaxyl	0.58
Methyl Chlorpyrifos	0.061
Methyl Paraoxon	0.14
Methyl Parathion	0.058
Metolachlor	0.25
Metribuzin	0.081
Mevinphos	0.085
Mgk 264	0.6
Molinate (Ordram)	0.22
Napropamide (Devrinol)	0.25
Norflurazon	0.12
Oxyfluorfen (Goal)	0.22
Parathion	0.062
Pebulate (S-Propyl butylethylthiocarbamate)	0.19
Pendimethalin (Prowl)	0.13
Permethrin (CIS and trans)	0.17
Phenothrin	0.17
Phorate	0.059
Phosphamidan	0.2
Profluralin	0.2
Prometon (Pramitol 5p)	0.084
Prometryn (Caparol, Gesagard, Primatol Q)	0.084
Pronamide (Kerb)	0.25
Propachlor (Ramrod)	0.17
Propargite	0.18
Propazine	0.085
Propetamphos	0.16
Resmethrin	0.17
Ronnel	0.054
Simazine	0.086
Sulfotepp (Tetraethyl dithiopyrophosphate)	0.052
Tebuthiuron	0.087
Terbacil	0.42
Terbutryn (Igran)	0.084
Tetrachlorvinphos (Gardona, Strifos)	0.16
Treflan (Trifluraline)	0.12
Triadimefon	0.22
Triallate	0.22
Vernolate	0.12

Appendix C. Continued.

Chlorinated Herbicides by method EPA SW 8150.

2,3,4,5-Tetrachlorophenol	0.026
2,4,5-T	0.036
2,4,5-Tb	0.042
2,4,5-Tp (Silvex)	0.036
2,4,5-Trichlorophenol	0.027
2,4,6-Trichlorophenol	0.029
2,4-D	0.047
2,4-Db	0.061
3,5-Dichlorobenzoic	0.05
4-Nitrophenol	0.087
5-Hydroxydicamba	0.046
Acifluorfen (Blazer)	0.19
Bentazon	0.068
Bromoxynil	0.038
Chloramben	0.05
Dacthal (DCPA)	0.037
Dalapon (Dpa)	0.033
Dicamba	0.049
Dichloroprop	0.051
Diclofop-Methyl	0.07
Dinoseb	0.068
Ioxynil	0.04
Mcpa	0.094
Mcpp	0.094
Pentachlorophenol	0.023
Picloram	0.047
Triclopyr (Garlon)	0.039

Volatile Organics by method EPA SW 846

1,2-Dichloropropane	0.5
Cis-1,3-Dichloropropene	0.26
Total Xylenes	1
Trans-1,3-Dichloropropene	0.24

Urea pesticides by method NPS-4.

Cyanazine	0.12
Diuron	0.48

Ethylene Dibromide by method EPA 504

1,2-Dibromo-3-Chloropropane (Dbcp)	2.5
EDB (Ethylene Dibromide)	0.5

Appendix D. Quality Assurance Review

Analyses were conducted at the Ecology/EPA Manchester Laboratory. The qualitative and quantitative accuracy, validity, and usefulness of data were reviewed by Stuart Magoon of Manchester Laboratory. Laboratory quality control (QC) followed standard Manchester guidelines and included laboratory blanks, surrogate spikes, and pesticide matrix spikes. The relative percent difference (RPD) was used to estimate analytical precision. The RPD is the ratio of the difference and the mean of duplicate (or replicate) samples expressed as a percentage.

In addition to laboratory QC samples, a single duplicate sample was collected for field quality assurance (QA). A duplicate sample consisted of an identical sample submitted to the laboratory with different sample identification. Because of the preponderance of below quantitation limit results, duplicate and replicate samples were not useful in determining precision of most analyses. However, bromacil was detected in both the initial and duplicate samples at concentrations of 0.23 and 0.24 $\mu\text{g/L}$ respectively, and nitrate-nitrite as N was detected at 6.59 and 6.57 mg/L, respectively.

In general, the quality of the results are good. Specific comments on each laboratory method follow:

Chlorinated herbicides by EPA Method 8150: All sample extraction and analysis holding times were met. No target compounds were detected in the laboratory blanks. Surrogate spike recoveries for 2,4,6-tribromophenol ranged from 17% to 72% for the initial samples and 48% to 64% for the verification samples. No recovery limits have been established for this method. Matrix spike recoveries ranged from 21% to 90%. The lowest recoveries were for Dalapon at 21% and Dacthal (DCPA) at 22%. The relative percent differences (RPD) ranged from 25% to 73%. No matrix spike recovery limits or RPD have been established for this method.

Volatile organics by EPA SW 846 Method 8260: All samples were analyzed within the recommended 14-day holding time. No pesticides were detected in the laboratory blanks, although low levels of the common laboratory solvents acetone and methylene chloride were found. Surrogate recoveries for p-bromofluorobenzene; 1,2-dichloroethane-d4; 1,2-dichlorobenzene-d4; toluene-d8; and fluorobenzene were within acceptable limits, ranging from 93% to 103% for the initial samples and 100% to 108% for the verification samples. Matrix spikes were within acceptable limits for both percent recovery and RPD with the exception of two compounds. Trans-1,3-dichloropropene and naphthalene were outside recommended limits, however, neither of these compounds was detected in any sample. Percent recovery for the remaining compounds ranged from 57% to 147%.

Ethylene dibromide(EDB) and dibromochloropropane (DBCP) by EPA Method 504: All samples were extracted and analyzed within the recommended holding times. No target compounds were detected in the laboratory blanks. Surrogate recoveries for methylated

dalapon ranged from 86% to 103%. No recovery limits have been established for this method. No matrix spikes were analyzed with these samples.

Nitrogen containing pesticides by EPA Method 1618: All samples were extracted within seven days and extracts were analyzed within the recommended holding time. No target analytes were detected in laboratory blanks. Dimethylnitrobenzene was used as the surrogate compound. No specific nitrogen containing pesticide surrogates were available for this analysis. Surrogate recoveries ranged from 49% to 86% for the initial samples and 82% to 108% for the verification samples. No surrogate recovery limits have been established for this method. Matrix spike recoveries for the eight nitrogen containing compounds spiked, ranged from 46% to 98%, and the RPD from 3.1% to 23%. No recommended recovery limits or RPD have been established for this method.

Urea pesticides by modified EPA 1618 Method: All samples were extracted within seven days and extracts were analyzed within the recommended holding time. No target analytes were detected in laboratory blanks. Surrogate recoveries for dimethylnitrobenzene ranged from 49% to 86%. No surrogate recovery limits have been established for this method.

Both of the target compounds, diuron and cyanazine, were used in the matrix spikes. The spike recoveries were 56% to 58% with a RPD of 3.5% for diuron, and 77% to 84% with a 8.7% RPD for cyanazine. No recommended recovery limits or RPD have been established for this method.

Organo-phosphorous pesticides by EPA 1618 Method: All samples were extracted within seven days and extracts were analyzed within the recommended holding time. No target analytes were detected in the laboratory blanks. Surrogate recovery for triphenyl phosphate (TPP) ranged from 67% to 105%. No recommended recovery limits have been established for this method. Matrix spike recoveries for nine organo-phosphorous pesticide compounds spiked, ranged from 85% to 108% and the RPD ranged from 1.1% to 15%. No recommended recovery limits or RPD have been established for this method.

Pyrethrin pesticides by modified EPA 1618 Method: All samples were extracted within seven days and analyzed within the recommended holding time. No target analytes were detected in the laboratory blanks. No specific surrogates were available for this method. Matrix spike recoveries for the pyrethrin, fenvalerate (2 isomer) ranged from 46% to 98% and the RPD was 72%. No recommended recovery limits or RPD have been established for this method.

Nitrate-nitrite as nitrogen by EPA Method 353.2: All samples were analyzed within recognized holding times. No laboratory blank was analyzed, but a field duplicate was within 1% of the original sample value.