GROUND WATER QUALITY TECHNICAL REPORT NO. 7

MOSCOW BASIN GROUND WATER QUALITY STUDY

NORTH CENTRAL IDAHO

IDAHO DIVISION OF ENVIRONMENTAL QUALITY
NORTH CENTRAL IDAHO REGIONAL OFFICE
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ACKNOWLEDGMENTS

Many people made significant contributions to this report. **Dr. Robert Mahler** (U of I Extension Service) compiled a list of potential sampling sites from 175 volunteer well owners. **Kyle Hawley** (Latah Soil & Water Conservation District) and **Rich Gabriel** (North Central District Health Department) and others selected 27 sites from the 85 sites initially screened by Dr. Robert Mahler. Rich Gabriel (NCDHD) and **Tom Lance, Kevin Duffey, Kevin Brackney, Elizabeth Brackney, and Begona Garcia** of the Hydrology Program at the School of Mines, University of Idaho, assisted with field efforts. **Dr. Roy Mink**, Director of the Idaho Water Resource Research Institute, was instrumental in developing the student assistance aspect of the study. The Idaho Bureau of Laboratories analyzed samples for all of the sites. Special thanks go to **Dr. Jerry Exon, Dr. Greg Moller, and Dr. Kim Anderson at the** University of Idaho Analytical Laboratory which donated resources to conduct QA/QC analyses and supplemented the analyses provided by the Idaho Bureau of Laboratories. Special thanks are given to these contributors and the organizations they represent.

ABSTRACT

The Division of Environmental Quality, North Central Idaho Regional Office (DEQ, NCIRO) in Lewiston proposed to investigate the ground water quality in the Moscow Basin. The study originally was designed to focus on shallow wells completed in the basalts; the source of drinking water for most rural residents in the basin The focus of the study was changed to include wells completed in the surrounding granitics and deeper wells completed in the basalts. Several entities assisted in conducting this study. The specific objectives include:

1. collecting ground water samples from representative, existing wells completed as shallow domestic wells,
2. analyzing the samples for common ions,
3. analyzing samples for commonly used pesticides used in the basin, and
4. assessing the impact of man's activities on the aquifers in the basin.

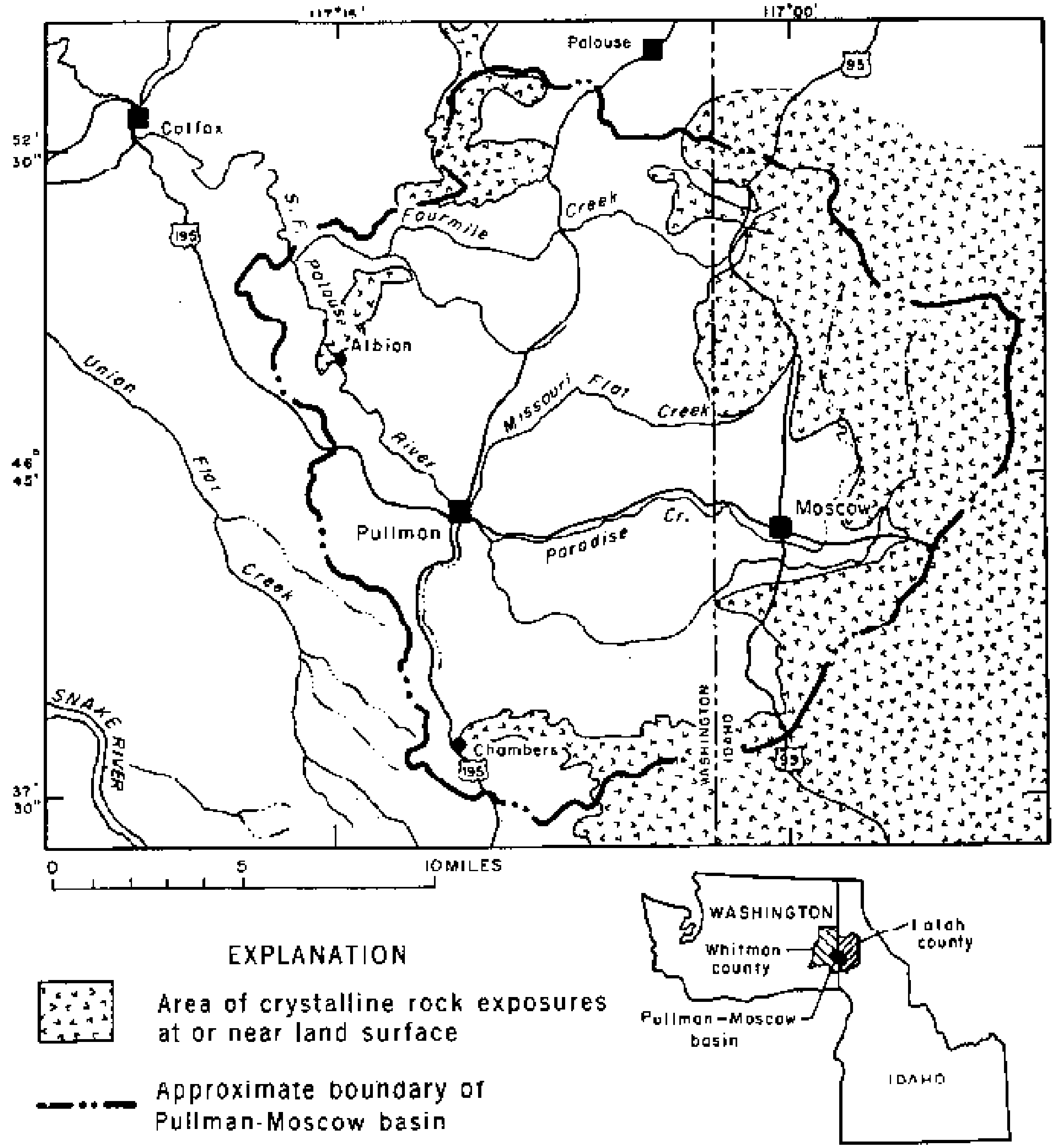
The Moscow Basin (Figure 1) includes approximately 256 miles^2 in Idaho and Washington; only 83 miles^2 lie in Idaho (Barker 1979). Elevations in the basin range from about 2,500 feet m.s.l. to over 4,500 feet m.s.l. at Moscow Mountain. The interior lowland of the basin consists of moderately dissected Columbia River Basalts that are covered by wind blown silt deposits (loess) (Barker, 1979). The rounded hills generally rise less than 200 feet above the intervening depressions

The ground water samples collected suggest that there is little, if any, ground water contamination occurring from the routine use of pesticides investigated. It should be noted that the samples were not analyzed for the presence of other man made chemicals. The source of nitrogen found in ground water can be man made but is not included in this statement.

The elevated concentrations of nitrate are probably caused by man's activities in the basin.

The use of shallow wells for drinking water and completed in the alluvium on top of the basalt should be discouraged as this surficial aquifer appears to be susceptible to ground water contamination. The highest concentration of nitrate occurs in such a well. The deeper wells that have been drilled into the basalts are within the limit of the standard for drinking water (10 mg/l) although several of these wells have elevated concentrations of nitrate.

FIGURE 1. LOCATION OF MOSCOW BASIN SHOWING STREAMS AND CRYSTALLINE ROCK EXPOSURES (BARKER, 1979)



INTRODUCTION

The Moscow Basin is located north of the Clearwater River in Latah County. The primary aquifers are located in the flat lying Columbia River Basalts and associated interbeds. The basin is surrounded by old granitic highs that isolated the local ground water flow systems of the basin from adjacent basins and similar age basalt flows.

The area receives approximately 20 inches of precipitation per year. Dry land farming dominates land use activities in the basin outside the urban/suburban area of Moscow. Principal crops include winter wheat, dry peas, and lentils.

The DEQ, NCIRO proposed to investigate the ground water quality in the Moscow Basin in 1991 because information available on ground water quality at that time was limited. The study originally was designed to focus on shallow wells completed in the basalts; the source of drinking water for most rural residents in the basin. The focus of the study was changed to include wells completed in the surrounding granitics and deeper wells completed in the basalts.

Several entities assisted in conducting this study. These entities included:

- Idaho Division of Environmental Quality,
- North Central District Health Department,
- Latah Soil & Water Conservation District,
- Idaho Soil Conservation Commission,
- U.S. Soil Conservation Service,
- University of Idaho Analytical Laboratory,
- University of Idaho Agricultural Extension Service,
- Idaho Water Resource Research Institute, and
- Latah County Commissioners.

PURPOSE AND OBJECTIVES

The purpose of the study is to evaluate the quality of the ground water in the shallow and deep ground water systems of the Moscow Basin.

Specific objectives include: collecting ground water samples from representative, existing wells completed in shallow and deep aquifers, analyzing the samples for common ions, analyzing samples for commonly used pesticides used in the basin, and assessing the impact of man's activities on the aquifer in the basin.

PAST PROJECT AND LITERATURE REVIEW

Crosby and Chatters (1965) age dated the ground waters of the basin. Their tritium analyses provide an estimate of the age of ground waters from the basalt system which discharges toward the Pullman, Washington, area which lies west of Moscow.

Jones and Ross (1969) described a conceptual model for the hydrogeology of the basin. This model includes three principal producing zones within the basalts; the zones are referred to as the upper, middle, and lower artesian zones.

Crosthwaite (1975) compiled additional basic hydrogeologic and hydrochemical data on the Moscow Basin. Crosthwaite used the same conceptual model for the basin as proposed by Jones and Ross (1969).

Yee and Souza (1987) compiled and present basic ground water quality data for the major aquifers for the state. They described the ground water in the Columbia River Basalts of the Moscow Basin as a sodium bicarbonate type.

The ground water flow system(s) within the basalt aquifers of the Moscow Basin have been investigated and the results have been compiled into modeling studies by Barker (1979) and Lum, Smoot, and Ralston (1990).

STUDY AREA

The Moscow Basin (Figure 1) includes approximately 256 miles^2 in Idaho and Washington; only 83 miles^2 lie in Idaho (Barker 1979). Elevations in the basin range from about 2,500 feet m.s.l. to over 4,500 feet m.s.l. at Moscow Mountain. The interior lowland of the basin consists of moderately dissected Columbia River Basalts that are covered by wind blown silt deposits (loess) (Barker, 1979). The rounded hills generally rise less than 200 feet above the intervening depressions

CLIMATE

Lum, Smoot, and Ralston (1990) summarized the primary climatic features of the basin. Precipitation increases from about 22 inches per year in Pullman to about 24 inches per year in Moscow. Moscow Mountain receives about 40 inches per year as the altitude abruptly increases. Most of the precipitation falls between November and April. Monthly precipitation in Moscow ranges from 0.7 inches (July) to 3.3 inches (December).

SOILS

The Moscow Basin is dominated by gently sloping to moderately steep silt loam soils on uplands. The following descriptions are derived from the *Soil survey of Latah County Area, Idaho* (U.S. Department of Agriculture, April 1981). The soils were formed from loess. These soils include the Palouse-Naff, which is very deep and well drained, the Southwick-Larkin, which is very deep and moderately well drained to well drained, and the Taney-Joel which is very deep and moderately well drained or well drained.

The Vassar-Uvi is found along the flank of Moscow Mountain along the northern edge of the basin. These are deep and very deep, well drained soils that formed in volcanic ash, in loess, and in granitic residuum.

GEOLOGY

The Moscow Basin is surrounded by Upper Cretaceous granodiorites (Hubbard, 1957). Moscow Mountain on the north side of the basin is composed primarily of granitic rocks (University of Idaho, 1977) and is part of Mesozoic Era intrusive activity; the major intrusive activity in the area probably occurred 60-80 million years ago. The intrusion was responsible for metamorphism of many Belt Series rocks. It is reported that many exposures on Paradise Ridge show the effects of "high" grade metamorphism.

The basin was filled by extensive basalt flows of mid-Miocene age, about 16 million years ago (University of Idaho, 1977). These flows were extruded from narrow fissures centered in the Grande Ronde area to the south and in a narrow, linear northwest-southeast trending zone that passes just west of Pullman. Basalts flowed from the fissures for about 2 million years. Lava dams formed that trapped sediments between the basalt flows. A stratigraphic section (Figure 2) illustrates the sequence of basalt flows and interbeds that is typical of the Moscow Pullman Basin.

Major folding and faulting of the basalts occurred after extrusion and before 8 million years ago (University of Idaho, 1977). The Lewiston Monocline which separates the Moscow Basin from the Lewiston Basin is one of the deformation structures. Differential subsidence of the Columbia River Basin caused the formation of extensive shallow lakes in southeastern Washington. These lakes and other lakes in Oregon provided a source for the loess that covers the basalts in the Moscow area.

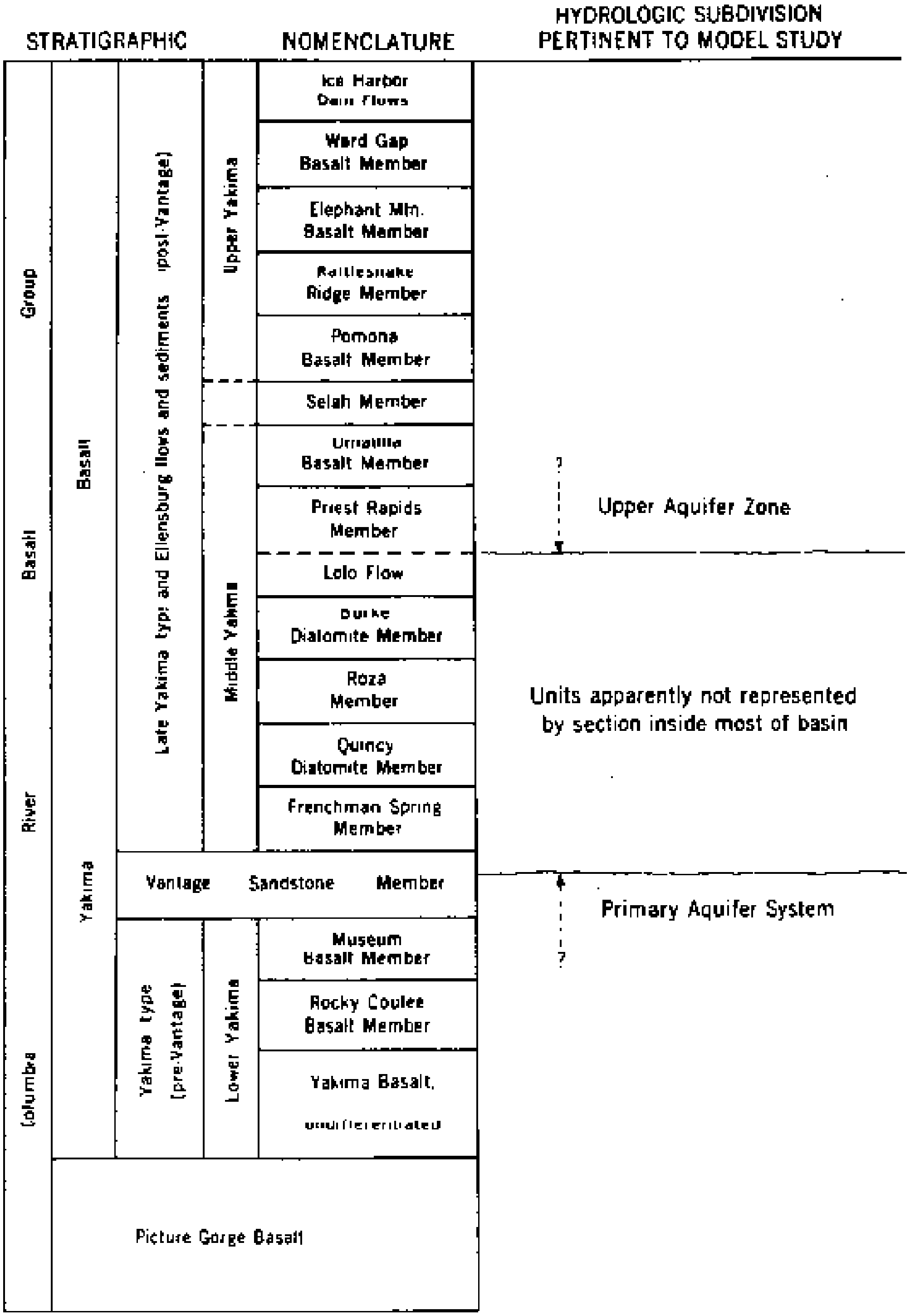
Ash deposits are found in the Moscow Basin. The most recent came from Mt. St. Helens. The most prominent layer is attributed to the volcano that became Crater Lake (University of Idaho, 1977).

HYDROLOGY

The major drainages in the basin are the South Fork Palouse River, Paradise Creek, and Missouri Flat Creek. Only Paradise Creek is shown as a perennial stream on the 7½ quadrangle maps for the basin where the streams flow into the state of Washington.

The conceptual model for ground water flow in Columbia River Basalts has been fairly consistent over time. The dense flow interiors are believed to restrict the vertical movement of ground water between the more permeable cooling zones. The cooling zones are located at the tops and bottoms of the flows and they are characterized by interconnecting fractures caused by the rapid cooling of the flows upon contact with air (top of flow) and underlying strata (bottom of flow). Sedimentary interbeds frequently occur between basalt flows. Fine grained interbeds will tend to restrict the movement of

FIGURE 2. STRATIGRAPHIC NOMENCLATURE OF COLUMBIA RIVER BASALT GROUP WITH RELATIONSHIP TO HYDROGEOLOGIC SUBDIVISION WITHIN THE MOSCOW BASIN (BARKER, 1979)



ground water although course grained interbeds can be quite permeable.

Investigators have defined three primary aquifers in the Moscow Basin (Figure 3) and a surficial aquifer. The primary aquifers are artesian and supply the majority of ground water for the city of Moscow, the University of Idaho, and domestic water supply wells in the basin. The surficial aquifer occurs in the sediments and the top of the underlying basalts nearest the ground surface. It is this aquifer that commonly supplies base flow to streams as the elevations associated with the artesian aquifers often lies below the bottom of the streams in the basin.

The wells completed in the shallowest artesian aquifer and the surficial aquifer are of interest because of the potential susceptibility of those aquifers to contamination. Artesian aquifers can be susceptible because confining layers have a finite vertical hydraulic conductivity and declining water levels (potentiometric surface) can reverse the potential for vertical flow. In other words, the direction of ground water flow can change from upward to downward as water levels decline in the aquifer.

LAND USE

The basin is dominated by dry land farming. The primary crops include wheat, dry peas, barley, lentils, oats, hay, and pasture (U.S. Department of Agriculture, April 1981). Alfalfa, grass, rape, and clover seed are raised but on a smaller scale.

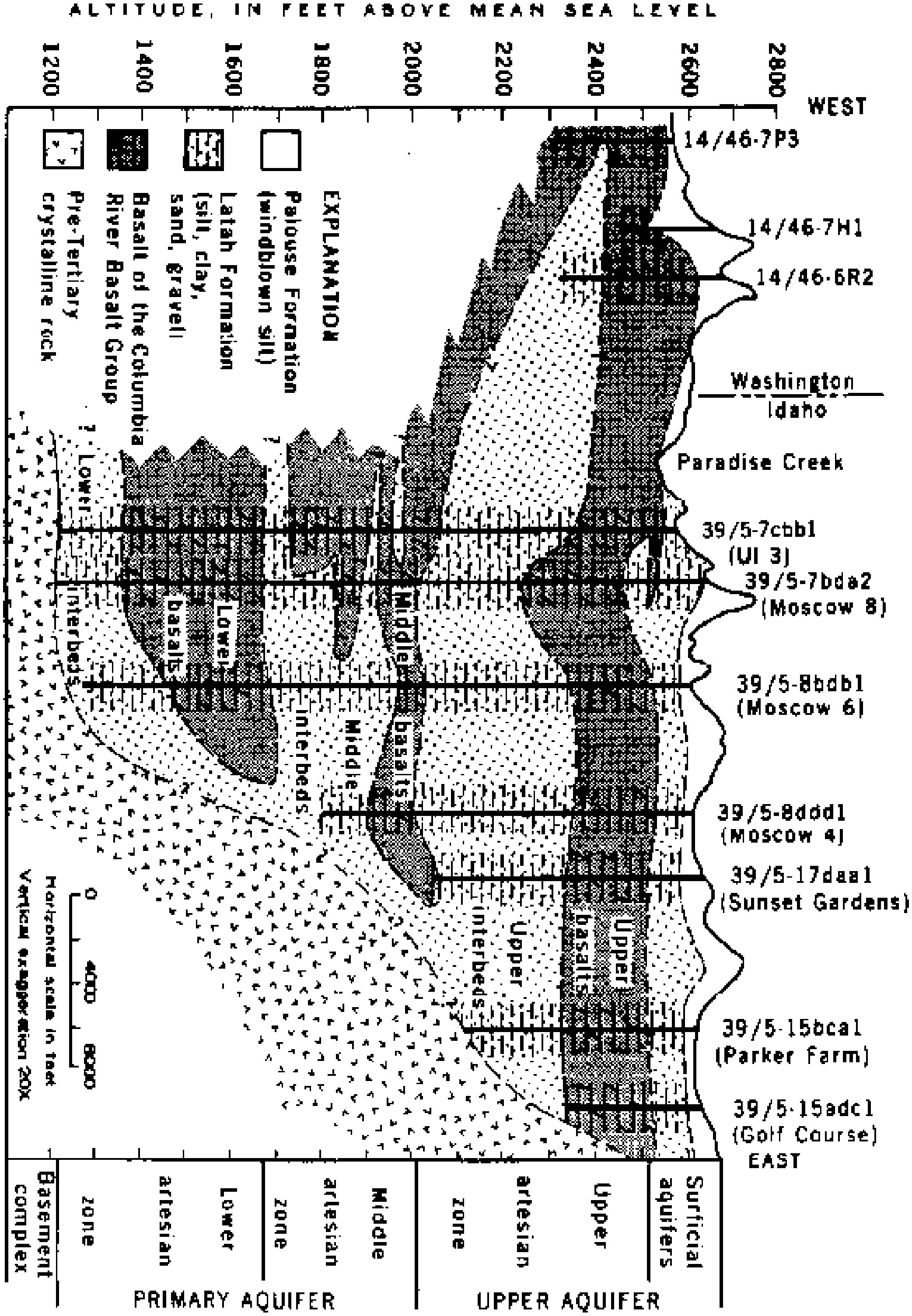
The other major land use in the basin is associated with the city of Moscow and the University of Idaho. These uses include residential areas, both sewered and nonsewered, light industry, agricultural chemical and related industries, and experimental farms. The municipal waste water treatment plant for the city is located near the Idaho-Washington state line by Paradise Creek.

WATER USE

Ground water is not pumped for irrigation of crop lands in the basin. The city and the university are the main ground water users in the basin. Extensive efforts have been made to understand the hydrogeology of the basin to predict the future of the ground water system that supports the city and the university.

The Pullman-Moscow Water Resources Committee was formed to evaluate the aquifer system upon which Moscow, Pullman, the University of Idaho, and Washington State University depend for their water supplies. Their report (1993) indicates an increasing demand that is lowering ground water levels in the main aquifer. Pumping from the aquifer for the two cities and the two universities has increased from about 400 million gallons per year in 1910 to 2,000 million gallons per year in 1970. Pumping has continued to increase; pumping exceeded 2,400 million gallons per year in 1989. This pumping has resulted in ground water levels declining in the artesian aquifer from an elevation of about 2,350 feet (MSL) to below an elevation of 2,250 feet (MSL) since 1979.

FIGURE 3. WEST-TO-EAST SCHEMATIC GEOLOGIC SECTION THROUGH MOSCOW BASIN (BARKER, 1979)



MATERIALS AND METHODS

Sites were selected for sampling by requesting volunteers from the general populace of the basin (Figure 4). Site selection was based on the rational that both deep and shallow wells and springs should be represented. In addition, the advisory group decided to include sites located both on the basalts and on the surrounding granitic-metamorphic highlands. One site (Site 23) was selected east of the Moscow Basin: it will not be discussed in this report.

Pesticides commonly used in the basin were compiled by the University of Idaho Agricultural Extension Service. This list (Appendix A) was used as a basis for maximizing requested laboratory services.

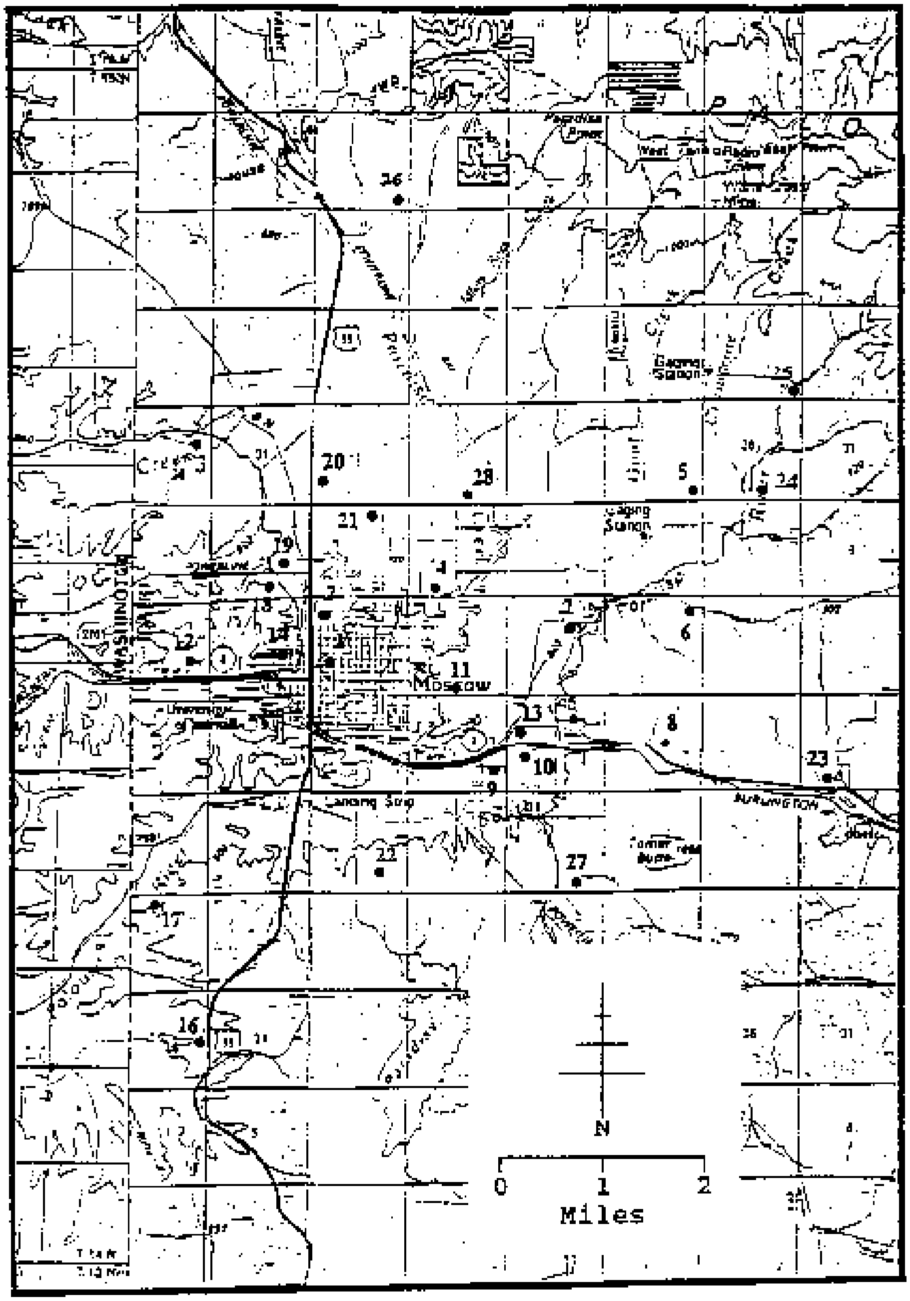
Samples were submitted to the Idaho Department of Health and Welfare, Bureau of Laboratories in Boise. The University of Idaho Analytical Laboratory provided analyses for additional analytes not conducted by the Bureau of Laboratories and to provide additional quality assurance/quality control (QA/QC).

Samples were collected by George Dekan (DEQ) between September 10th and the 26th, 1991. Students from the University of Idaho assisted with the collection, record keeping, and logistics of the project. Replicate samples were collected at three sites (10% of samples collected) and one spike was prepared for submission to the State Laboratory (4% of samples collected). Standard containers and preservatives (acidification and chilling to 4° C) were used for the samples sent to the Bureau of Laboratories. Field spikes were prepared for ammonia and nitrate. The Bureau of Laboratories prepared matrix spikes for potassium, sodium, magnesium, calcium, and sulfate. Sample analyses are reported in Appendix B.

QA/QC samples were not collected for the metals analyses provided by the University of Idaho Analytical Laboratory. These data can be compared to data provided by the Idaho Bureau of Laboratories for the same sites and analytes for QA/QC comparison.

Results of the QA/QC comparisons are provided in Appendix C. Comparisons are provided for replicate analyses conducted by the Idaho Bureau of Laboratories. In general, the results are excellent. The greatest disparity occurs where concentrations are near detection limits.

FIGURE 4. SAMPLE SITE LOCATIONS FOR MOSCOW BASIN STUDY CONDUCTED IN 1991.



RESULTS AND DISCUSSION

The objectives of the study were met. Samples were collected across the basin from a mixture of hydrogeologic sources.

PESTICIDES

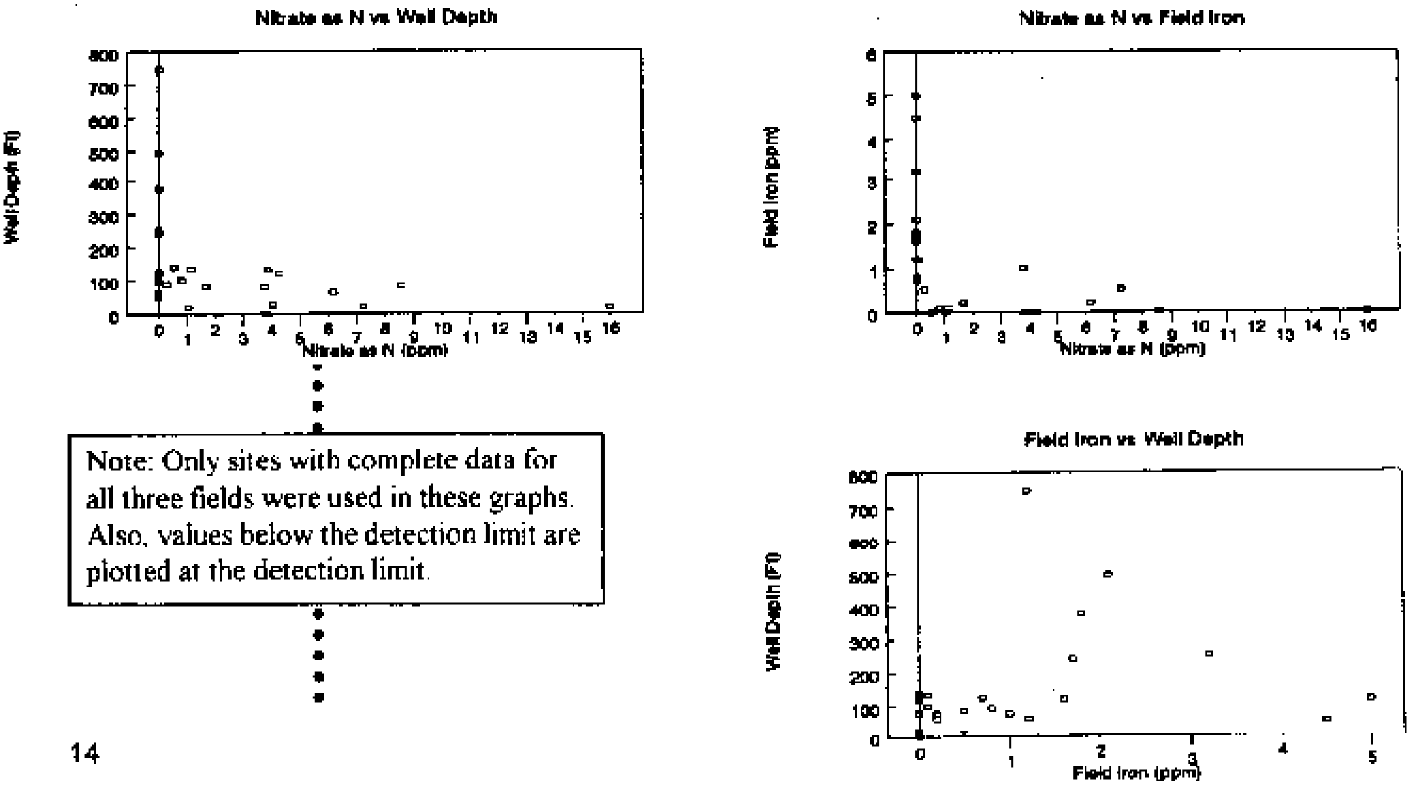
A wide range of pesticides were included in the analytical procedures employed by the Idaho Bureau of Laboratories and the University of Idaho Analytical Laboratory. There were no detections of pesticides in the samples collected and analyzed regardless of well depth or hydrogeologic environment.

NITRATE

Background concentrations of nitrate appear to be less than 0.005 mg/l in the Moscow Basin as 22% of the analyses result in concentrations below the detection limit (0.005 mg/l). The highest concentration of nitrate (16 mg/l) occurs in the shallowest well (16 ft. depth). Four sites (15%) had concentrations in excess of 5 mg/l.

Nitrate concentrations can be compared to field analyses for iron and to well depth (Figure 5). Nitrate concentrations appear to have an inverse

FIGURE 5. COMPARISON OF NITRATE AS N CONCENTRATIONS VERSUS FIELD ION CONCENTRATIONS AND WELL DEPTHS



Note: Only sites with complete data for all three fields were used in these graphs. Also, values below the detection limit are plotted at the detection limit.

relationship to the iron concentrations at sites sampled; generally, nitrate concentrations increase as iron concentrations decrease. Iron concentrations increase with increasing well depth below a depth of about 200 feet but decrease after reaching an approximate depth of 500 feet. Nitrate concentrations decrease with increasing depth as expected.

VULNERABILITY

Ground water susceptibility (vulnerability) to contamination has not been mapped in the Moscow Basin. One of the reasons to conduct this study was to determine if ground water contamination has occurred. The occurrence of contamination and the degree to which it occurs directly indicates the susceptibility of the ground water to contamination.

An assessment of land use in the vicinity of the sampled well or spring was conducted at the time the sample was collected. Distance categories used in the assessment are "Within 20 feet", "Within 200 feet", and "Within sight of the well" as compiled in Appendix D. The primary categories for the land use in which the sites that had a nitrate concentration greater that 1.0 mg/l are "Cropland", Farm agricultural chemical or fertilizer operations, "Animal feedlot or barnyard", and "Septic tank and leach field" "Within 200 feet of well."

Those sites that had a nitrate concentration greater than 5 mg/l are within 200 feet of cropland (sites 9, 21, and 24), within 200 feet of an agricultural chemical or fertilizer operation (sites 21 and 24), within 200 feet of a feedlot or barnyard (sites 9, 11, 21, and 26), within 20 feet of occasional pasture (site 24), within 200 feet of a fertilizer dealer or elevator (site 9), had chemical lawn treatment within 20 feet of the well (sites 9 and 11), and/or are within 200 feet of a septic tank and leach field (sites 11, 21, and 24). These higher concentration sites have multiple potential sources of nitrogen within 200 feet of the sampled well or spring. The highest concentration site (#24) has adjacent land used occasionally as pasture for sheep within 20 feet of the well and is within 200 feet of cropland, an agricultural chemical or fertilizer operation, and a septic tank and leach field.

The lack of widespread contamination suggests that land use practices and the hydrogeologic characteristics of the basin are relatively protective. Evidence of extensive ground water contamination does not exist. The surficial aquifer appears to be impacted by man's activities because of the presence of elevated nitrate concentrations.

CONCLUSIONS

The ground water samples collected for this study suggest that there is little, if any, ground water contamination occurring from the routine use of pesticides investigated in this study. It also should be noted that no conclusions can be drawn about any point sources of potential contamination as the study was designed to look for non-point sources of contamination.

The elevated concentrations of nitrate may be caused by the application of nitrogen fertilizer at improper agronomic rates or at inappropriate times or by the on-site disposal of sewage (septic systems). Either source or both sources may be affecting the ground water quality in the basin but the source(s) cannot be determined from the data collected in this study. Livestock were pastured within 200 feet of the four most elevated concentration sites and may be the cause or contribute to the elevated nitrate concentrations.

The use of shallow wells for drinking water that are completed in the alluvium on top of the basalt should be discouraged as this surficial aquifer appears to be susceptible to ground water contamination. The highest concentration of nitrate occurs in such a well (16 feet deep). The deeper wells that have been drilled into the basalts are within the limit of the standard for drinking water (10 mg/l) although several of these wells have very elevated concentrations of nitrate. Wells that had concentrations in excess of about 2 mg/l should be routinely checked to ensure that concentration are not increasing. This concentration is particularly alarming as they show significant impact from man's activities.

LITERATURE CITED

Barker, R.A. 1979. *Computer Simulation and Geohydrology of a Basalt Aquifer System in the Pullman-Moscow Basin, Washington and Idaho*, Washington State Department of Ecology, Water Supply Bulletin 48, 110 p.

Ground Water Quality Council. April 1992. *Idaho Ground Water Quality Plan*, prepared in cooperation with Idaho Department of Health and Welfare, Division of Environmental Quality, Idaho Department of Water Resources, and the Idaho Department of Agriculture, 109 p.

Hubbard, Charles R. March 1957. *Mineral Resources of Latah County*, Idaho Bureau of Mines and Geology, County Report No. 2, 29 p.

Lum, W.E. II, Smoot, J.L., and Ralston, D.R. 1990. *Geohydrology and Numerical Model Analysis of Ground-Water Flow in the Pullman-Moscow Area, Washington and Idaho*, U.S. Geological Survey, Water-Resources Investigations Report 89-4103, 73 p.

Pullman-Moscow Water Resources Committee. 1992. *Groundwater Management Program*, Kay Packer coordinator

Yee, Johnson J.S. and Souza, William R. 1987. *Quality of Ground Water in Idaho*, U.S. Geological Survey, Water-Supply Paper 2272, 53 p.

University of Idaho. 1977. *Generalized Geologic History for the Pullman-Moscow Area*, unpublished summary produced by the Hydrology Program in the School of Mines, Moscow, Idaho, 7 p.

U.S. Department of Agriculture. April 1981. *Soil Survey of Latah County Area, Idaho*, Soil Conservation Service, 166 pages plus plates.

GLOSSARY OF TERMS AND ACRONYM LIST

Aquifer: a geological formation of permeable saturated material, such as rock, sand, gravel, etc. capable of yielding economically significant quantities of water to wells and springs.

Background concentration: [1] natural background ground water quality - the ground water quality unaffected by man, or [2] site background ground water quality - the water quality directly up gradient of a site.

Baseline: ground water quality at a point in time and place that is used as a point of reference.

BDL: Below detection limits, for nitrates BDL is usually less than 0.005 mg/L

Beneficial uses: various uses of ground water in Idaho including, but not limited to, domestic water supplies, industrial water supplies, agricultural water supplies, aquacultural water supplies and mining. A beneficial use is defined by actual current uses or future uses of the ground water.

Contaminant: any chemical, ion, radionuclide, synthetic organic compound, microorganism, waste or other substance which does not occur naturally in ground water or which naturally occurs at a lower concentration.

Contamination: the direct or indirect introduction into ground water of any contamination caused in whole or in part by human activities.

Confined aquifer: a geological formation in which water is isolated from the atmosphere by an overlying less permeable geologic formation. Confined ground water is generally subject to pressure greater than atmospheric; thus, the water level rises above the top of the aquifer.

Crop root zone: the zone that extends from the surface of the soil to the depth of the deepest crop root and is specific to a species of plant, group of plants or crop.

Ground water: any water of the state which occurs beneath the surface of the earth in a saturated geological formation of rock or soil.

IDWR: Idaho Department of Water Resources.

Level of confidence: reflects the confidence level that is appropriate for data. It in turn reflects the quality assurance level achieved during data collection and the analytical level achieved during sample analysis.

Perched aquifer: unconfined ground water separated from an underlying main body of ground water by an unsaturated zone.

* The majority of these definitions are quoted from the *Idaho Ground Water Quality Plan* (Ground Water Quality Council, April 1992).

APPENDIX A. PESTICIDES USED IN THE MOSCOW BASIN

Method 507 - Analyte Name	Trade Name
Amitrol	Amitrol
Atrazine*	AAtrex, Atratol, Atranex, Crisazina
Carboxin	Vitavax, D735, DCMO, Carbathin
Chlorpyrifos	Lorsban, Brodan, Eradex
Diazinon*	Knox out, Spectracide
Dimethoate	Cygon
Disulfoton	Disyston, Dithiodemeton
Hexizinone*	Velpar
Malathion	Calmathion, Detmol, Emmatos
Metolachlor	Dual, Primextra
Metribuzin*	Sencor, Lexone
Mevinphos	Phosdrin, Menite, Phosfene
Parathion*	Phoskil, Alkron, Alleron, Aphamite
Pronamide	Kerb, Propyzamide
Simazine*	Cekusim, Princep, Aquazine
Tebuthiuron	Spike, Brush Bullet
Terbacil*	Sinbar
Triadimefon	Bayleton

Method 508 - Analyte Name	Trade Name
Chlorothalonil	Bravo, Daconil
Endosulfan*	Thiodam, Beosit, Chlorophenothane
Etridiazole	Terrazole, Ethazol
Simazine	Aquizine
Trifluralin	Treflan
Hexachlorobenzene	HCB
HCH-gamma*	Lindane

* Analytes analyzed by Idaho Bureau of Laboratories

Method 531 - Analyte	Trade Name
Carbofuran	Furadan
Carbaryl	Sevin

Other Analytes	Trade Name
Diclofop-methyl	Hoelon
Chlorsulfuron	Glean
Difenzoquat methyl sulfate	Avenge
Diuron	Karmex
Bromoxynil	Buctril
Clopyralid	M-Stinger
Sulfonylurea	Harmony
Assert	Assert
Paraquat	Gramoxone
Benomyl	Benlate
Thiabendazole	Mertect
Fenvalerate	Pydrin
Propiconazole	Tilt
Thiophanate	Topsin
Imazalil	Flo-Pro
Thiram	Thiram
Captan	Captan
Metalaxyl	Apron
Surflan	Surflan
Phosmet	Imidan
Methidathion	Supracide
Dodine	Cyprex
Triclopyr	Garlon
Benefin	Balan
Sethoxydim	Poast
Bromoxynil	Brominal
Ethalfluralin	Sonalan
Pursuit	Pursuit

⋮

Method 515 - Analyte	Trade Name
Bentazon	Basagran
2,4-D*	Dacamine, Weedone, Weedar, Weed-B-Gone, Dormone
Dicamba*	Banvel, Trooper
MCPA	Weedar, Weedone, Amine, Banlene, Bordermaster
Picloram*	Tordone

⋮

APPENDIX B. LABORATORY SAMPLE ANALYSIS

Moscow Basir Ground Water Quality Data – Common Ions

SITE NUMBER	WELL ID (T,R,SEC,Q,#)	WELL DEPTH (FT)	CO. CODE	PROG CODE	LAB USED	DATE (YYMMDD)	LAB Ca (MG/L)	LAB Mg (MG/L)	LAB Na (MG/L)
01	5W39N07DDD0	115	LATAH	MOS	SL	910916	56	19.5	19
02	5W39N07ADD0	131	LATAH	MOS	SL	910916	20	5	13
03	6W40N36BDD0	120	LATAH	MOS	SL	910916	24	10.5	13
04	5W39N09BDC0	-	LATAH	MOS	SL	910916	28	7	14
05	5W39N02AAD0	140	LATAH	MOS	SL	910917	10	2.5	11
06	5W39N11ACD0	60	LATAH	MOS	SL	910917	27	6.5	18
07	5W39N10CAD0	18	LATAH	MOS	SL	910917	39	9.5	49
08	5W39N13CDA0	125	LATAH	MOS	SL	910917	25	7.5	14
09	5W39N20ABA0	60	LATAH	MOS	SL	910917	33	9.0	21
10	5W39N14CCC0	250	LATAH	MCS	SL	910919	42	13	16
11	5W39N15BAC0	18	LATAH	MCS	SL	910919	59	16.5	29
12	6W39N11DAB0	-	LATAH	MCS	SL	910919	23	9.5	22
13	5W39N14CBB0	492	LATAH	MCS	SL	910919	25	8.0	13
14	5W39N07CAD0	240	LATAH	MCS	SL	910919	36	12.5	16
15	5W39N07CAD0	-	LATAH	MCS	SL	910919	36	12.5	16.0
16	6W39N36ADC0	120	LATAH	MCS	SL	910923	42	10.5	20
17	6W39N25BAC0	135	LATAH	MCS	SL	910923	32	6.5	16
18	5W39N07BAB0	370	LATAH	MCS	SL	910923	29	6.0	13
19	5W39N06CAA0	25	LATAH	MCS	SL	910923	23	5.0	19
20	5W40N31DDA0	50	LATAH	MOS	SL	910923	32	10.5	14
21	5W39N05BAD0	80	LATAH	MOS	SL	910924	24	6.5	18
22	5W39N20CCC0	100	LATAH	MOS	SL	910924	27	5.0	17
23	5W39N24AAA0	94	LATAH	MOS	SL	910924	31	8.5	17
24	5W39N01ABB0	16	LATAH	MOS	SL	910924	58	13	47
25	5W40N36AAA0	87	LATAH	MOS	SL	910924	14	2	8
26	5W40N17DDB0	8	LATAH	MOS	SL	910926	16	4.5	12
27	5W39N27ABB0	250	LATAH	MOS	SL	910926	9	1.5	10
28	5W39N04BAA0	75	LATAH	MOS	SL	910926	30	8.5	13

Moscow Basin Ground Water Quality Data - Common Ions

SITE NUMBER	LAB K (MG/L)	LAB Hrdns CaCO3 (MG/L)	LAB Cl (MG/L)	LAB S04 (MG/L)	LAB NO3 (MG/L)	LAB NH4 (MG/L)	LAB PH (PH UNITS)
01	3	288	3.6	70	<0.005	0.053	6.9
02	0.3	72	1.6	<1	3.88	0.053	7.3
03	2.6	102	1.8	1	<0.005	0.116	7.4
04	0.5	102	1.4	<1	1.67	0.057	7.3
05	0.1	46	1.3	<1	0.535	0.053	6.8
06	2.3	98	2.2	20	<0.005	0.054	7.4
07	1.0	144	13.8	17	1.06	0.124	7.0
08	3.3	100	2.5	10	0.020	0.148	7.4
09	0.6	124	13.0	3	6.17	0.040	7.0
10	2.9	164	3.7	75	0.012	0.033	7.1
11	0.6	208	36.9	44	7.23	0.021	7.2
12	5.6	100	3.7	2	0.032	0.091	7.6
13	2.8	108	2.8	21	0.010	0.177	7.5
14	3.2	140	4.6	46	0.011	0.037	7.4
15	3.1	148	4.6	47	0.008	0.015	7.3
16	1.9	152	18	13	4.26	0.656	7.2
17	1.5	120	2	<5	1.14	0.123	7.5
18	1.7	110	2	3	<0.005	0.692	7.4
19	0.3	84	3	2	4.05	0.016	7.1
20	2	122	2	19	<0.005	0.026	7.3
21	0.2	84	6	<5	8.56	0.032	7.0
22	1.5	92	2	9	0.815	0.012	7.6
23	2.9	110	2	15	<0.005	0.022	7.9
24	0.5	204	23	27	16.0	0.022	7.1
25	1.1	50	2	<5	0.264	0.027	6.6
26	0.1	64	1.6	3.8	3.78	0.020	6.6
27	0.5	30	1.2	2.5	0.739	0.042	6.8
28	0.7	110	5.5	8.8	3.68	<0.005	7.2

Moscow Basin Ground Water Quality Data - Common Ions

SITE NUMBER	LAB COND (UMHOS/CM)	FIELD PH (PH UNITS)	FIELD COND (UMHOS/CM)	FIELD TEMP (DEG.C.)
01	457	6.5	367	12
02	188	6.6	158	15
03	224	7.3	160-181	12.5
04	228	6.7	174	11.7
05	110	6.5	82	11.5
06	244	6.5	90	12
07	213	6.5	327	12.5
08	303	6.8	183	12.1
09	221	6.7	249	13
10	364	6.9	290	13
11	511	6.5	395	12.5
12	262	7.6	252	20
13	228	7.3	190	13
14	311	6.8	263	14
15	316	6.7	260	14
16	358	7.0	276	12.5
17	268	6.8	212	13.3
18	250	6.5	203	14
19	224	7.0	162	10.7
20	275	6.8	222	13.3
21	239	6.8	177	10.8
22	233	7	180	12
23	268	7.6	205	12.5
24	565	6.5	436	11.5
25	122	6.5	100	13.3
26	158	6.2	134	16
27	98	6.1	87	16.6
28	228	6.5	203	13.5

Moscow Basin Ground Water Quality Data - Total Trace Elements

SITE NUMBER	LAB V (MG/L)	LAB Zn (MG/L)
03	<0.100	<0.050
07	<0.100	<0.050
13	<0.100	<0.050
16	<0.100	0.14
23	<0.100	<0.050
26	<0.100	<0.050

Moscow Basin Ground Water Quality Data – Total Trace Elements

SITE NUMBER	LAB Mg MG/L)	LAB Mn (MG/L)	LAB Mo (MG/L)	LAB Ni (MG/L)	LAB K (MG/L)	LAB Na (MG/L)
03	17	<0.050	<0.050	<0.100	6.3	25
07	12	<0.050	<0.050	<0.100	2.1	56
13	12	0.22	<0.050	<0.100	4.6	16
16	15	<0.050	<0.050	<0.100	3.5	25
23	11	<0.050	<0.050	<0.100	4.9	20
26	6.2	<0.050	<0.050	<0.100	<1.000	13

SITE NUNBER	WELL ID (T,R,SEC,Q,#)	WELL DEPTH (FT)	CO. CODE	PROG CODE	LAB USED	DATE (YYMMDD)	LAB Ba (MG/L)	LAB Be (MG/L)
03	6W40N36BDD0	120	LATAH	MOS	U of I	910916	0.15	<0.010
07	5W39N10CAD0	18	LATAH	MOS	U of I	910917	0.10	<0.010
13	5W39N14CBB0	492	LATAH	MOS	U of I	910919	0.08	<0.010
16	6W39N36ADC0	120	LATAH	MOS	U of I	910923	<0.050	<0.010
23	5W39N24AAA0	94	LATAH	MOS	U of I	910924	<0.050	<0.010
26	5W40N17DDB0	8	LATAH	MOS	U of I	910926	<0.050	<0.010

SITE NUMBER	LAB Cd (MG/L)	LAB Ca (MG/L)	LAB Cr (MG/L)	LAB Co (MG/L)	LAB Cu (MG/L)	LAB Fe (MG/L)
03	<0.050	37	<0.100	<0.100	<0.050	0.1
07	<0.050	41	<0.100	<0.100	<0.050	<0.100
13	<0.050	26	<0.100	<0.100	<0.050	1.0
16	<0.050	41	<0.100	<0.100	<0.050	<0.100
23	<0.050	30	<0.100	<0.100	<0.050	0.3
26	<0.050	15	<0.100	<0.100	<0.050	<0.100

APPENDIX C.
QUALITY ASSURANCE/ QUALITY CONTROL (QA/QC) RESULTS

RELATIVE PERCENT DIFFERENCE (RPD)

PD – [(Value A - Value B)/((Value A + Value B)/2)] X 100
Total NO_3+NO_2 as N

Site #14

RPD = [(0.011 - 0.008)/((0.011 + 0.008)/2) X 100 = 32%

Site #26

RPD = [(3.78 - 3.65)/((3.78 + 3.65)/2) X 100 = 3%

Site #28

RPD = [(3.77 - 3.68)/((3.77 + 3.68)/2) X 100 = 2%

Calcium

Site #14

RPD = [(36 - 36)/((36 + 36)/2) X 100 = 0%

Site #26

RPD = [(16 - 16)/((16 + 16)/2) X 100 = 0%

Site #28

RPD = [(30 -29)/((30 + 29)/2) X 100 = 3%

Magnesium

Site #14

RPD = [(12.5 - 12.5)/((12.5 + 12.5)/2 X 100 = 0%

Site #26

RPD = [(4.5 - 4.5)/((4.5 + 4.5)/2) X 100 = 0%

Site #28

RPD = [(8.5 - 7)/((8.5 + 7)/2) X 100 = 19%

Sodium

Site #14

RPD = [(16 - 16)/((16 + 16)/2) X 100 = 0%

Site #26

RPD = [(12 - 11)/((12 + 11)/2) X 100 = 9%

Site #28

RPD = [(15 - 13)/((15 + 13)/2) X 100 = 14%

Potassium

Site #14

RPD = [(3.2 - 3.1)/((3.2 + 3.1)/2) X 100 = 3%

Site #26

RPD = [(0.2 - 0.1)/((0.2 + 0.1)/2) X 100 = 67%

Site # 28

RPD = [(0.7 - 0.7)/((0.7 + 0.7)/2) X 100 = 0%

Chloride

Site #14

RPD = [(4.6 - 4.6)/((4.6 + 4.6)/2) X 100 = 0%

Site #26

RPD = [(2 - 1.8)/((2 + 1.8)/2) X 100 = 3%

Site #28

RPD = [(5.7 - 5.5)/((5.7 + 5.5)/2) X 100 = 4%

Sulfate

Site #14

RPD = [(47 - 46)/((47 + 46)/2) X 100 = 2%

Site #26

RPD = [(3.8 - <2 as 0)/((3.8 + <2 as 0)/2) X 100
= 100%

Site #28

RPD - no duplicate

MATRIX SPIKE RECOVERY (P_i)

P_i = [100 X (A_i - B_i)]/T_i

Where:

P_i = percent recovery

A_i = analytical results from spiked sample

B_i = analytical results from separate analysis of the unspiked sample

T_i = the known true value of the spike

Calcium

P_i = [100 X (36 - 16)]/20
= 100%

Magnesium

$P_i = [100 \times (14.5 - 4.5)]/10$

$= 100\%$

Sodium

$P_i = [100 \times (31 - 11)]/20$

$= 100\%$

Potassium

$P_i = [100 \times (5.2 - 0.2)]/5$

$= 100\%$

Chloride

$P_i = [100 \times (21.4 - 2)]/20$

$= 97\%$

Sulphate

$P_i = [100 \times (44.5 - {<}2 \text{ as } 0)]/47$

$= 95\%$

Note: spikes were prepared from matrix sample from site #26

APPENDIX D. LAND USE ACTIVITIES NEAR WELL OR SPRING

LAND USE	WITHIN 20'	WITHIN 200'	WITHIN SIGHT
cropland	5, 8, 13, 27	6, 7, 9, 10, 12, 16, 18, 19, 20, 21, 24, 25, 26, 28	6, 10
farm agricultural chemical operation	3, 5, 8, 27	4, 7, 16, 17, 18, 19, 20, 21, 23, 24, 25, 26, 28	1, 17, 22
farm fertilizer operation	3, 5, 8, 13, 18, 27	4, 10, 17, 18, 19, 20, 21, 23, 24, 25, 26, 28	1, 12, 22
animal feedlot, barnyard, or pasture	26 and 24 (occasional pasture)	2, 9, 10, 11, 16, 21, 23, 26, 28	7, 18, 23, 25
animal waste holding tank or pond	6	--	7, 12
fertilizer dealer or elevator	--	9	22
chemical lawn treatment	3, 6, 9, 11, 22, 23	7, 25, 26	13
septic tank and leach field, lagoons included	--	2, 3, 4, 5, 6, 7, 11, 16, 18, 19, 21, 22, 23, 24, 27, 28	7, 12, 13, 20, 26
river, stream, or drainage	26	19, 23, 28	3, 7, 11, 20, 22, 27

Notes: Only those land use categories that appear to be related to the reported nitrate concentrations are shown in this table. Numbers in the table refer to sampling sites. See figure 4 on page 13 for a map identifying sampling sites.