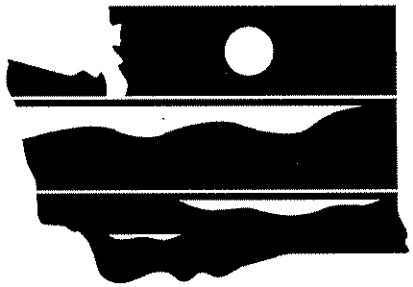

WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

Basic American Foods
Class II Groundwater Inspection

October 1998

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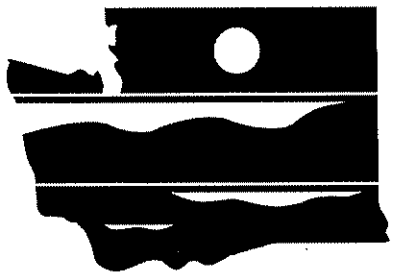

Basic American Foods
Class II Groundwater Inspection

by
Kirk Sinclair

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

October 1998

Water Body No. WA-41-9280GW

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Abstract

The Washington State Department of Ecology (Ecology) conducted an NPDES Class II inspection of the Basic American Foods (BAF) vegetable processing facility in Moses Lake on April 27-29, 1998. The groundwater portion of the inspection consisted of:

- an audit of BAF groundwater sampling procedures
- evaluation of the BAF groundwater monitoring network
- comparison of Ecology and BAF split samples results
- evaluation of BAF compliance with the NPDES permit effluent limits

BAF land applies an annual average of approximately 1.3 million gallons of wastewater per day to roughly 1,755 acres of agricultural farmland and treatment fields. The wastewater is high in chemical and biochemical oxygen demand, ammonia and organic nitrogen, phosphorous, total solids, and inorganic salts.

The facility groundwater monitoring network consists of 12 dedicated monitoring wells and three irrigation wells. The monitoring well network adequately defines groundwater flow directions and facility impacts to groundwater quality within the sprayfield area. However, the network does not adequately characterize background conditions. All but two of the monitoring wells were constructed in accordance with Washington State well construction standards. BAF groundwater sampling procedures are consistent with current industry protocols.

Differences between Ecology and BAF split sample results were generally within acceptable limits for all parameters except chloride, sulfate, and ortho-phosphate. BAF is complying with permit limits for annual and monthly discharge volumes. BAF wastewater management practices have resulted in degraded groundwater quality within the sprayfield vicinity. Groundwater nitrate+nitrite (N) concentrations exceeded the drinking water standard by more than 400 percent while TDS concentrations exceeded the standard by nearly 200 percent.

Introduction

The Washington State Department of Ecology (Ecology) conducted a National Pollution Discharge Elimination System (NPDES) Class II inspection of the Basic American Foods (BAF) vegetable processing facility in Moses Lake. The inspection was conducted between April 27 and April 29, 1998. It consisted of an engineering evaluation of the facility treatment process, calculation of agronomic rates for wastewater application, and an evaluation of the facility groundwater monitoring network. This report presents results of the groundwater portion of the inspection. The evaluation of facility treatment processes and agronomic rate calculations are contained in a companion report (Golding, 1998).

The groundwater inspection consisted of the following elements:

- an audit of BAF groundwater sampling procedures
- evaluation of the BAF groundwater monitoring network
- comparison of Ecology and BAF split samples results
- evaluation of BAF compliance with the NPDES permit effluent limits

The Ecology groundwater inspection was conducted by Kirk Sinclair of the Environmental Investigations and Laboratory Services Program, with assistance from Wayne Peterson, Ecology Eastern Regional Office site manager for BAF. Dan Nelson, of Soiltest Farm Consultants Inc., and Matt Madden, BAF facility maintenance lead, coordinated sampling for BAF.

Facility Description

The BAF processing plant lies adjacent to State Hwy 17, approximately three miles southeast of the city of Moses Lake (Figure 1). The plant converts an annual average of 1.1 million pounds per day of raw vegetables, primarily potatoes, into dehydrated food products. Process wastewater derives largely from washing and steam peeling potatoes, as well as routine equipment cleaning (Ecology, Fact Sheet, March 1993).

The wastewater generated by BAF is screened to remove grit. It is then land applied year round to 1,755 acres of agricultural farmland and treatment fields situated southwest of the main processing plant. Roughly 455 acres of the irrigated land is owned by BAF and managed for grass hay production. The remaining leased and privately owned land was recently put into service and is farmed in rotational crops including potatoes, corn, and wheat.

BAF wastewater disposal is subject to regulation under the State Waste Discharge Permit program (WAC 173-216). Permits issued under the program are intended to satisfy the requirements of state and federal water pollution control acts. BAF is regulated under permit number 5213 which restricts land application of wastewater to an average annual

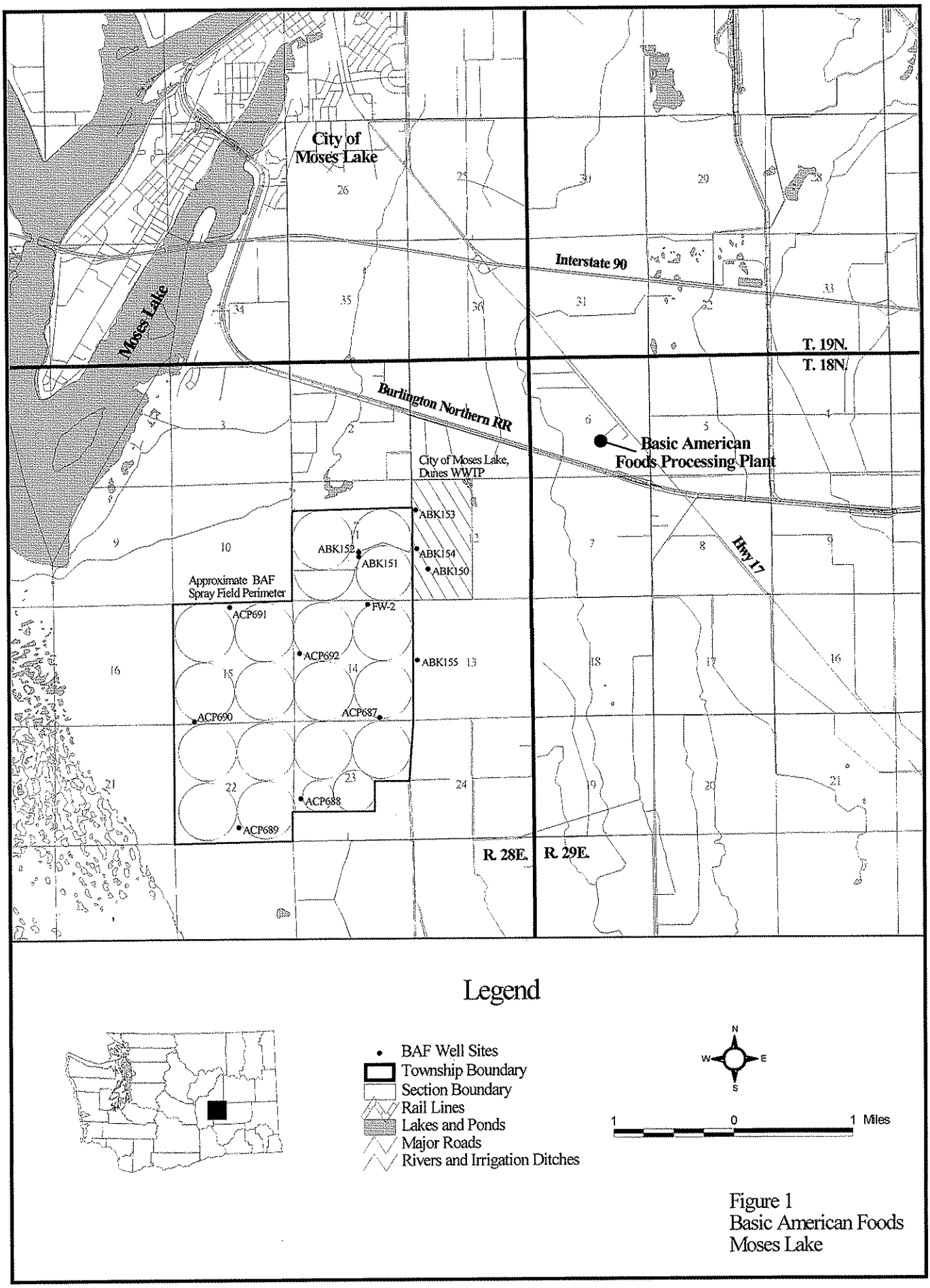


Figure 1
Basic American Foods
Moses Lake

discharge of 1.35 million gallons per day (mgd) and a monthly average of 1.66 mgd or less. The wastewater is high in chemical and biochemical oxygen demand, ammonia, phosphorous, total suspended solids, and inorganic salts (Table 1).

Table 1. Average effluent concentration for Basic American Foods, Moses Lake, for April 1, 1993 to December 1, 1997 (Luce, 1998)

Parameter	**Average Effluent Concentration**
Conductivity (umhos/cm)	1,036
Total Suspended Solids	1,910
BOD, 5-day (20 C°)	1,090
Chemical Oxygen Demand	2,026
Total Ammonia, as N	29.5
Nitrate + Nitrite as N	0.78
Total Kjeldahl Nitrogen *	81
Ortho-phosphate as P	8.6
Total Sodium	119
Total Calcium	15
Total Magnesium	14
Total Potassium	153
Chloride	84

All concentrations are reported as mg/L unless otherwise noted.
* The reported value is the average of mean monthly values for the reporting period.

Groundwater Monitoring Network

The BAF groundwater monitoring network consists of 12 dedicated monitoring wells, six of which were installed in 1997 to replace or supplement previously installed wells (Figure 1 and Table 2). During routine sampling BAF also monitors three on-site irrigation wells. Four wells – ABK150, ABK153, ABK154, and ABK155 – are considered upgradient wells with respect to BAF sprayfield activities (Figure 1).

Table 2. Basic American Foods, monitoring well construction details (Cascade Earth Sciences, Ltd., 1996)

Unique Well ID Tag No.	Facility Well ID No.	Land Surface Elevation at Well (feet above mean sea level)	Measuring Point Height Above Land Surface (feet)	Completed Casing Diameter (inches)	Grout Interval (feet)	Screen/perforation Interval (feet below land surface)	Filter Pack Interval (feet below land surface)	Cased Well Depth (feet)
ABK150	A1	1,156.6	2.4	5	0-35	111-116	none	125
ABK151	A2	1,149	1.7	4	0-25.5	104-111	none	114
ABK153	MW-1	1,153.92	1.84	2	0-20	23.4-33.4	20-33.4	33.4
ABK154	MW-2	1,158.18	2.08	2	0-28	31.2-46.2	28-46.2	46.2
ABK155	MW-3	1,151.42	2.27	2	0-36	39.1-54.1	36-55	54.1
ABK152	MW-6	1,143.97	2.02	2	0-27.5	30.5-40.5	27.5-40.5	40.5
ACP687	MW-8	1,140.6	2.5	2	0-57	60-80	57-80	80
ACP688	MW-9	1,114.94	2.5	2	0-50	53-73	50-73	73
ACP689	MW-10	1,097.53	2.5	2	0-47	50-70	47-70	70
ACP690	MW-11	1,113.65	2.5	2	0-51	54-74	51-74	74
ACP691	MW-12	1,122.08	2.5	2	0-24	27-47	24-47	47
ACP692	MW-13	1,110.08	2.5	2	0-31	34-44	31-44	44

Site Conditions

Hydrogeology

The BAF sprayfields lie within the interior of the Columbia River Plateau, an area formed through repeated extrusions of flood basalt during the Tertiary period. The basalts and interbedded sediments were subsequently folded and warped into a broad structural basin/subbasin complex. During the Pleistocene epoch, glaciofluvial deposits of gravel, sand, silt, clay, and wind-borne deposits of sand and silt accumulated on the basalt. These deposits were later reworked and scoured during catastrophic outburst floods of the late Pleistocene epoch. Eolian deposits of sand and silt continue to accumulate within the basin (Walters and Grolier, 1960).

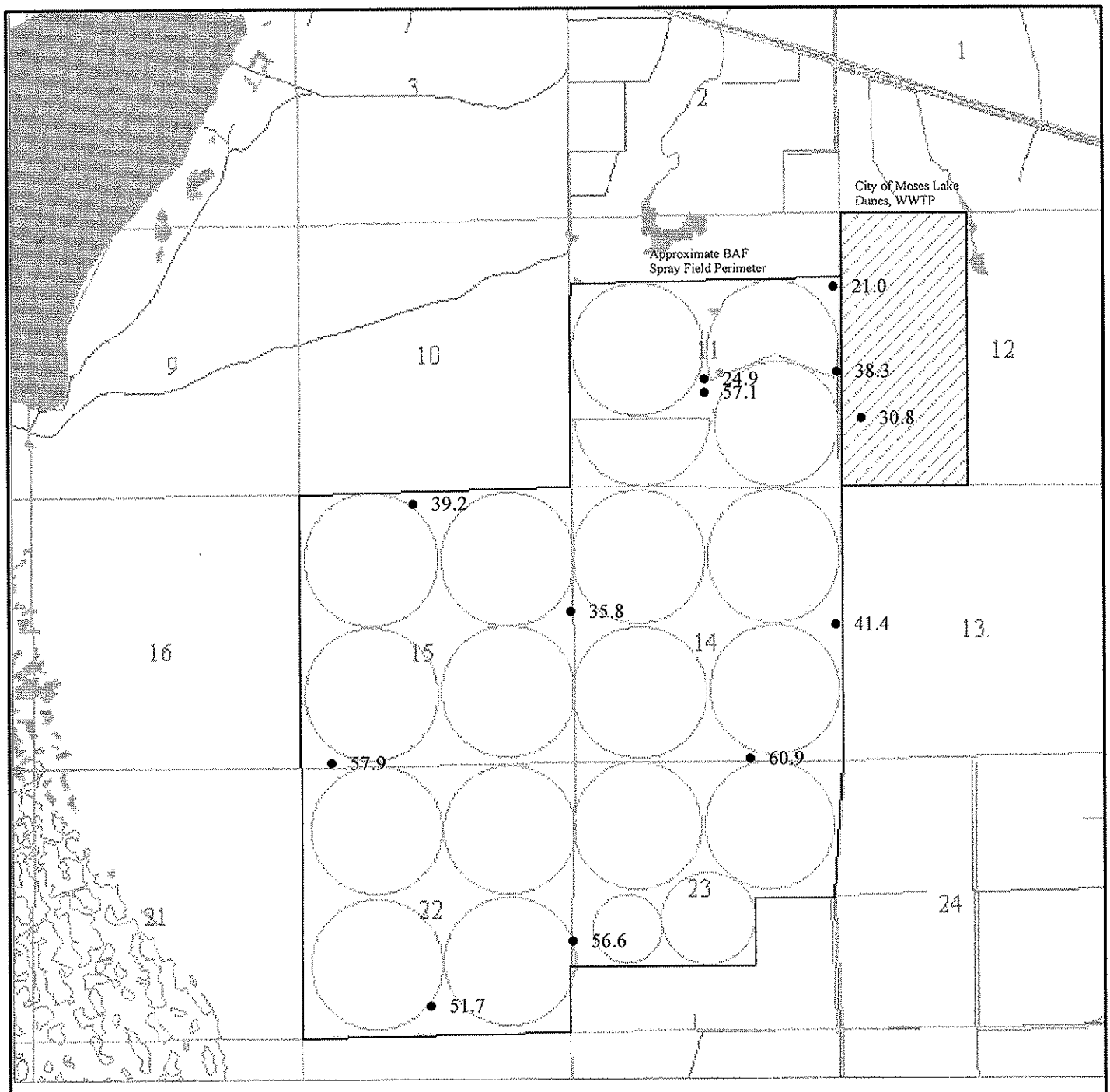
Within the BAF spray field area, this complex assortment of bedrock and sediments can be grouped into three hydrogeologic units: *Columbia River Basalts*, *Ringold Formation*, and *Glaciofluvial sand and gravel* (Cascade Earth Sciences, 1996).

1. The *Columbia River Basalt group*, which comprises area bedrock, underlies the site at depths ranging from 15 feet below ground surface at well ABK152 to greater than 90 feet at well ACP687. Depth to bedrock generally increases to the south/southwest within the spray field area. The Columbia River Basalts consist of numerous layered lava flows ranging from a few feet to 100 feet or more in thickness. The lava is typically a dense, dark, fine-grained basalt that often exhibits prominent vertical jointing. The upper surface of individual flows is commonly porous and vesicular. Sedimentary interbeds – consisting of tuffaceous material, volcanic ash, sand, and clay – separate individual basalt flows in some areas (Walters and Grolier, 1960).

2. The *Ringold Formation* directly overlies bedrock in some areas of the site. This unit is comprised of Pleistocene age deposits of fine sand, silt, clay, volcanic ash, and caliche. Locally, this unit may impede the downward movement of groundwater owing to its abundance of fine-grained sediments (Cascade Earth Sciences, 1996).

3. Where present, the Ringold Formation is overlain by fine to coarse-grained *glaciofluvial sand and gravel* and wind-blown dune sand. The combined thickness of the Ringold Formation and overlying glaciofluvial sediments varies from 15 feet at well ABK152 to more than 90 feet at well ACP687.

Based on the water levels measured during this inspection, groundwater lies at depths of approximately 20 to 60 feet below ground surface within the BAF sprayfield area. Depth to groundwater is shallowest in the northeastern corner of the site and increases toward the south and west (Figure 2). At the time of this inspection groundwater beneath the sprayfield was moving generally toward the west/southwest (Figure 3).



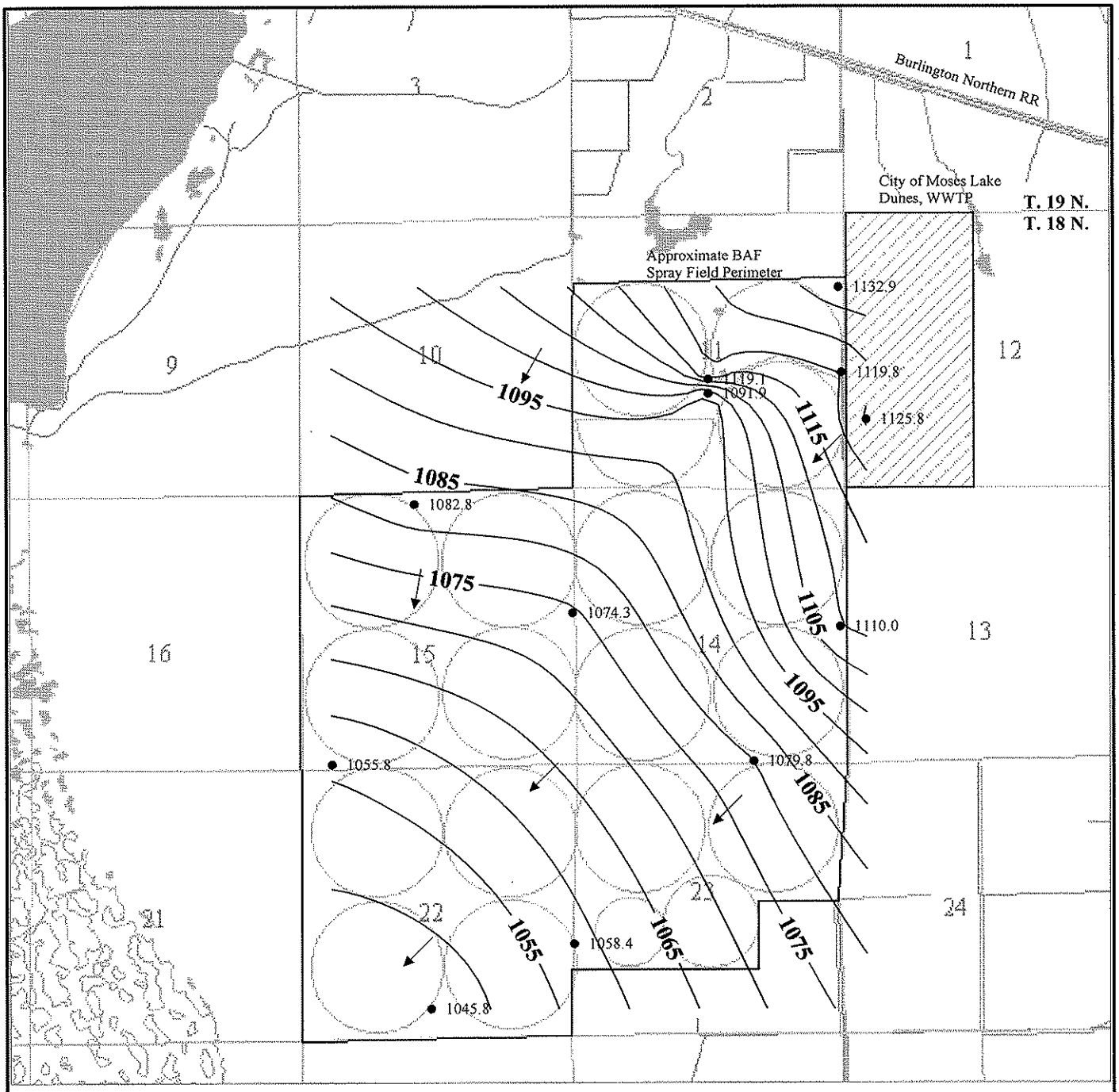
Legend

● Well Location and Measured Depth to Ground Water, in Feet, Below Land Surface

N
W E
S

0 ft 5,000 ft 10,000 ft

Figure 2
Measured Depth to Groundwater
in Selected BAF Wells for the Period
April 27-28, 1998



Legend

Approximate Direction of Ground-Water Flow

BAF Monitoring Well With Measured Water-Level Altitude
(Ft above mean sea level)

0 ft 5,000 ft 10,000 ft

N W E S

Figure 3
Water Table Elevation Contours and Approximate Direction of Groundwater Flow for the Period April 27-28, 1998

Soils

The BAF sprayfields are underlain by soils belonging to the Burbank and Quincy series. Burbank soils are characterized as very deep, excessively drained soils that formed on terraces from gravelly glacial outwash and eolian sand. These soils consist of variously colored fine sand and gravelly sand extending to depths of 60 inches or more. Below a depth of 36 inches, the gravel may be weakly cemented but does not prevent root penetration (Nelson, 1997).

Quincy soils are also very deep and somewhat excessively drained. They are found on terraces and active dunes, and formed in sand derived from mixed sources (Gentry, 1984). Both soil types are highly permeable, generate little runoff, and have low available water capacity (Gentry, 1984).

Methods

Groundwater-Sampling Procedures

We observed BAF sampling procedures, as described below, during the collection of split samples. We collected samples from the 12 dedicated monitoring wells and one irrigation well (Figure 1).

1. Depth to groundwater was measured twice at each well with an electronic well probe: once prior to initiating purging, and again immediately after the pump had been shut off following sampling. The well probe was rinsed with deionized water before and after each measurement.

2. Each well was purged just prior to sample collection using the well's dedicated pump. BAF monitoring wells are equipped with one of two pump types. Wells ABK150 and ABK151 (facility wells A1 and A2) are equipped with submersible pumps. The remaining monitoring wells are equipped with Waterra™ inertial pumps.

3. Wells were purged for a minimum of three casing volumes, or until field parameters (temperature, pH, and conductivity) had stabilized for a minimum of one casing volume. Field meters for pH and conductivity determinations were calibrated at the start of each sampling day and again in the afternoon to verify calibration. A calibrated plastic drum was used to measure the volume of water purged over time.

4. Split samples were collected by triple rinsing a one-gallon Teflon container with well water and then filling the container with water from the well. Ecology and BAF sample bottles were in turn incrementally filled from the Teflon container. Following sample collection, the Teflon container was triple rinsed with deionized water and capped for use at the next well. Ecology sample bottles were supplied by the Ecology/EPA Manchester Environmental Laboratory.

5. Samples were labeled and stored on ice until delivery to the laboratory. Ecology ortho-phosphate samples collected on April 27 were shipped to the Manchester Laboratory via air freight in order to meet sample holding time requirements. The remaining samples were transported to the laboratory by the sampling team and the Ecology courier service. Chain-of-custody procedures were maintained for all Ecology samples.

Table 3 is a list of target parameters, test methods and quantitation limits for the Ecology samples.

Table 3. Parameters, test methods, and practical quantitation limits

Parameter	Test Method	Quantitation Limit
Water Level	Electric Well Probe	0.1 feet
pH (Field)	Orion Model 290A	0.1 Std Units
Temperature	Orion Model 290A	0.1 °C
Specific Conductance (Field)	Orion	---
Specific Conductance (Lab)	EPA120.1	1 umhos/cm at 25 °C
Total Dissolved Solids	EPA160.1	1 mg/L
Total Alkalinity	EPA310.2	1 mg/L
Nitrate+Nitrite as N	EPA353.2	0.1 mg/L
Ammonia as N	EPA350.1	0.1 mg/L
Total Kjeldahl Nitrogen	EPA351.2M	0.5 mg/L
Ortho-Phosphate	EPA365.3M	0.1 mg/L
Chloride	EPA300.0	0.1 mg/L
Sulfate	EPA300.0	0.5 mg/L
Metals:		
Calcium (Total)	EPA200.7	50 ug/L
Magnesium (Total)	EPA200.7	50 ug/L
Potassium (Total)	EPA200.7	1000 ug/L
Sodium (Total)	EPA200.7	50 ug/L

Quality Assurance

The quality assurance methods and criteria employed during this inspection are discussed in detail in Appendix A. Based on the quality assurance results, the Ecology water quality data may be used without qualification.

Results and Discussion

Results for the four primary elements of this inspection are described below.

BAF Groundwater Sampling Procedures

BAF groundwater-sampling procedures are consistent with accepted sampling protocols as described by Barcelona, et al, 1985. No deficiencies in sampling procedures were noted during this inspection. The BAF written sampling plan requires removal of three casing volumes of well water prior to sample collection. BAF's present sampling procedure relies upon achieving stabilized field parameters (temperature, pH, and conductivity) to define the appropriate purge volume for an individual sampling event. The sampling plan should be updated to reflect this procedural change.

Adequacy of the BAF Monitoring Well Network

A properly installed and operated monitoring well network should be capable of providing sufficient high-quality information about the groundwater environment to enable Ecology and a regulated facility to track and modify, as necessary, the environmental effects of facility operations. In evaluating the BAF groundwater monitoring network, we considered the following factors:

◊ Is the monitoring network capable of defining the background or upgradient groundwater conditions over time? "Background" refers to groundwater conditions unaffected by BAF waste disposal practices.

◊ Does the monitoring network adequately characterize the horizontal/vertical direction of groundwater movement and depth to groundwater over time?

◊ Are the individual wells properly placed and constructed to enable early detection of possible groundwater problems associated with BAF waste disposal practices?

◊ Are background and downgradient wells screened over the same saturated zone? Is the screened zone appropriate for the site conditions and contaminants of interest?

◊ Are individual wells constructed in a manner that precludes the inadvertent cross contamination of aquifers or distinct groundwater zones penetrated during well construction?

◊ Are any of the wells downgradient from other facilities or activities that are known or suspected to have affected groundwater conditions?

The BAF monitoring network is generally adequate to characterize groundwater conditions beneath the sprayfield area. Noted deficiencies in the monitoring network are described below.

Well Construction

With the exception of wells ABK150 and ABK151 (facility wells A1 and A2), BAF monitoring wells are properly constructed and screened to detect constituents of interest. Wells ABK150 and ABK151 are screened within the upper portion of the Columbia River Basalt group, significantly below the water table at their respective locations. In addition, these wells are not constructed in accordance with current minimum well construction standards (WAC 173-160). Neither well is adequately sealed to preclude downward migration of contaminants along the well casing.

Well Placement

Wells ABK150, ABK153, ABK154, and ABK155 (BAF wells A-1, MW-1, MW-2, and MW-3 respectively) are considered upgradient wells with respect to BAF sprayfield operations. However, these wells are also immediately down gradient from infiltration basins at the city of Moses Lake wastewater treatment plant. Accordingly, these and other BAF wells are likely affected, at times, by on-site migration of infiltrated wastewater from the Moses Lake treatment plant. Based on the distribution of existing BAF monitoring wells, it is impossible to reliably determine actual background water quality conditions (i.e., water quality unaffected by either BAF or Moses Lake). Although BAF upgradient wells provide an indication of groundwater conditions at the northeast edge of the sprayfield, additional information on background conditions is needed for the area north and west of the present upgradient wells.

Ecology and BAF Split Sample Results

The water quality results for Ecology and BAF split samples are summarized in Appendix C. Variations are apparent between Ecology and BAF sample splits for several conventional parameters, in particular sulfate, chloride, and ortho-phosphate.

BAF sulfate determinations are consistently lower than those obtained by Ecology, by a factor of 2 or more. The relative percent difference[1] (RPD) between Ecology and BAF sulfate determinations ranged from 64 to 105 percent and averaged 94 percent for the 12 split samples (Table 4). Ecology internal duplicate analyses are in good agreement (as are other QA/QC measures). This consistent discrepancy between sample splits suggests a systematic error in BAF sulfate analyses.

A similar pattern is evident in the Ecology/BAF chloride analyses. The BAF results are consistently lower than Ecology results, which suggests a systematic error in BAF analytical procedures. For the 11 chloride sample splits, the RPD between Ecology and BAF samples averaged 20 percent, and ranged from 12 to 38 percent.

[1] Relative percent difference is the numeric difference between sample pairs divided by their mean, expressed as a percentage, i.e., RPD= (S2-S1)/[(S2+S1)/2] x100

The RPD between Ecology and BAF ortho-phosphate determinations ranged from 19 to 155 percent and averaged 104 percent for the five sample splits. There is no consistent pattern to the noted discrepancies.

Analyses for total metals, total dissolved solids, and nitrate+nitrite-N are generally consistent for the Ecology and BAF sample splits. The RPD between Ecology and BAF analyses for these constituents is generally less than the recommended maximum of 10 percent (Table 4 and Appendix C).

The BAF method detection limits for TKN and ammonia are quite high at 3.0 mg/L. While both constituents were below Ecology's detection limit of 0.5 mg/L, during this sample event, this may not be true at other times of the year. The BAF detection limit for these parameters should be lowered to 0.5 mg/L to provide more reliable early detection of these constituents.

Table 4. Summary of relative percent differences between Ecology and BAF split samples

Conventional Parameters (mg/L)	Number of Duplicate Analyses	Approximate Range in RPD (%)	Number of Split Samples Exceeding 10% RPD	Average RPD (%)	Median RPD (%)
Total Alkalinity	12	2-10	1	4.95	4.65
Total Dissolved Solids	12	0-14	3	5	3.15
Nitrate-Nitrite as N	12	09-51	1	8.97	5.85
Ammonia as N	0 *				
Total Kjeldahl Nitrogen	0 *				
Ortho-Phosphate	5	19-155	5	103.5	133
Chloride	11	12-38	11	19.9	17
Sulfate	12	64-105	12	93.7	94.3
Total Metals (ug/L)					
Calcium	12	0.1-9.5	0	5.5	6.45
Magnesium	12	0-6	0	3.45	3.4
Potassium	12	0.4-21	1	6.38	5.35
Sodium	12	0.9-7	0	4.38	5.15

* Relative percent differences were not calculated when one or both laboratories failed to identify an analyte at concentrations that exceeded their respective method detection limit. The number of duplicate analyses refers only to those samples where both splits yielded a value in excess of the method detection limit.

BAF Compliance with NPDES Permit Limitations

The present BAF discharge permit does not prescribe limitations for parameters other than discharge volume. However, BAF is mandated to manage its wastewater in a manner that protects existing and future beneficial uses of groundwater.

Monitoring data for the period January 1995 to December 1997 indicate BAF discharged an annual average of 1.26 mgd with a peak monthly average of 1.58 mgd (Luce, C., 1998). These values are below the maximum permitted discharge volumes.

BAF wastewater disposal practices have degraded groundwater quality in the vicinity of its sprayfields. Of the 12 wells sampled, nearly two-thirds exceeded drinking water standards for nitrate+nitrite-N (10 mg/L) and total dissolved solids (500 mg/L). Nitrate concentrations, in particular, tend to increase along groundwater flow lines beneath the sprayfield (Figure 4). The addition of significant new croplands this past year may help reduce impacts to groundwater over time. To realize this objective, BAF should consider developing a numerical model to help quantify the waste load that can safely be applied to the new croplands without further impacting groundwater quality.

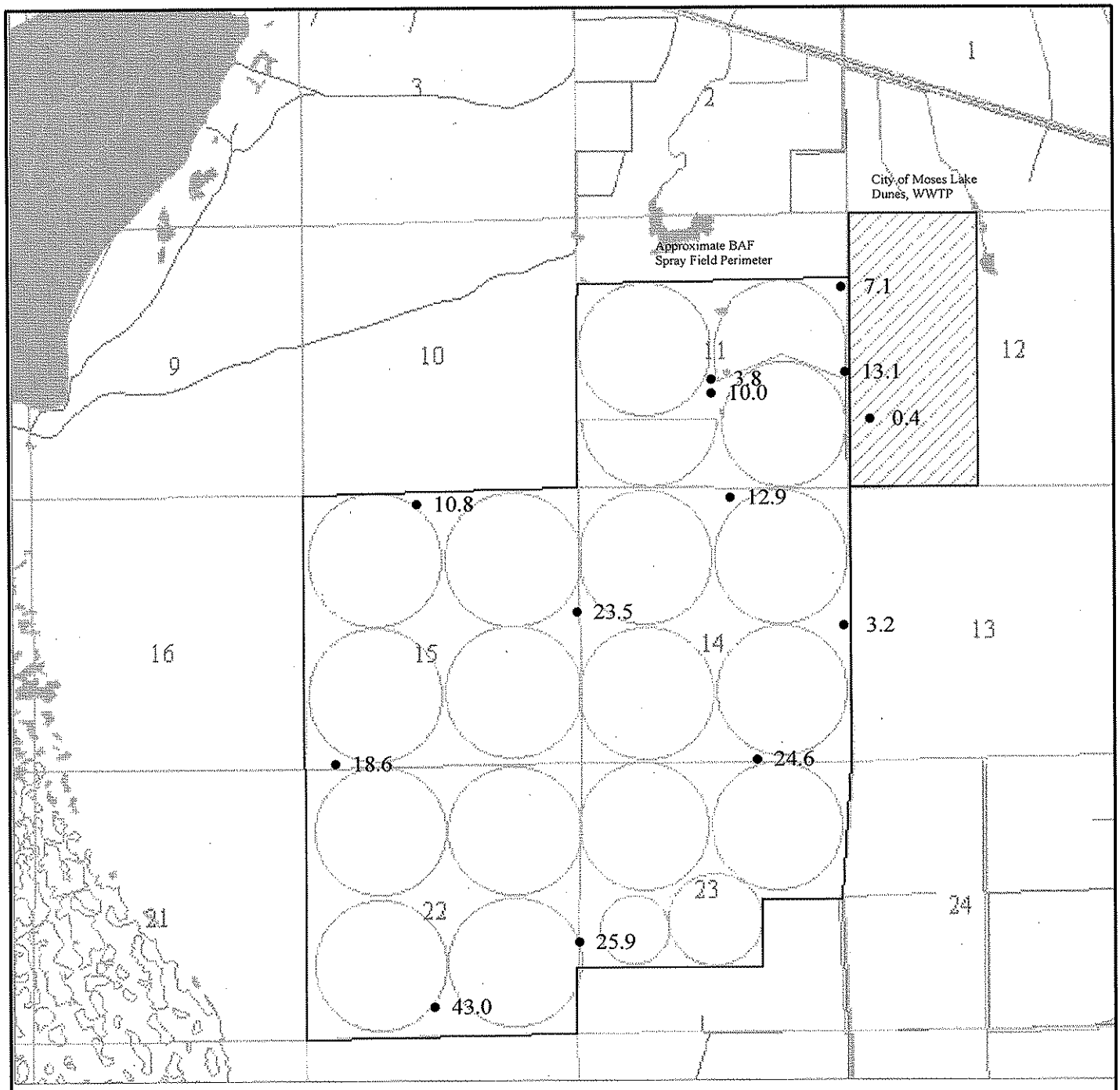


Figure 4
Nitrate + Nitrite (N) Concentrations in BAF Monitoring Wells for the Period April 27-28, 1998

Conclusions

- BAF groundwater-sampling procedures are consistent with current industry protocols. No deficiencies in sampling procedures were noted during this inspection. BAF's written *Sampling and Quality Assurance Plan* should be updated to accurately describe their present sampling procedures. An up-to-date Sampling and Quality Assurance Plan will help ensure consistency in sample collection and analysis during future staff changes.

- BAF's present monitoring well network is sufficient to characterize groundwater conditions throughout most of the sprayfield area. The monitoring network could benefit from the installation of additional upgradient wells near the north/northwest property boundary to help define background water quality conditions. All wells, with the exception of ABK150 and ABK151, are properly constructed and screened to detect parameters of concern. Wells ABK150 and ABK151 are not constructed in accordance with current well construction standards and are screened far below the water table at their respective locations.

- BAF is complying with effluent discharge limitations for annual and monthly discharge volumes. Their wastewater disposal practices have degraded groundwater quality to the extent that groundwater in the vicinity of their sprayfield fails to meet drinking water standards for nitrate+nitrite-N and total dissolved solids.

- Differences between Ecology/BAF split sample results for nitrogen, total metals, and most conventional parameters were generally small and within acceptable limits. Large differences between Ecology and BAF analyses for ortho-phosphate, chloride, and sulfate suggest a systematic error in BAF's analytical and/or sample handling procedures for these analytes.

Recommendations

Wells ABK150 and ABK151 (Facility wells A-1 and A-2) should be abandoned. Neither well is constructed in accordance with Washington State well construction standards.

BAF should consider installing at least one additional upgradient monitoring well to help define background conditions as they exist prior to the effects of waste disposal practices at the City of Moses Lake treatment plant. Such information would help differentiate the effects of the two waste streams. The well(s) should be constructed in accordance with Washington well construction standards (WAC 173-160). Ecology review and approval of potential well locations and designs should be obtained prior to construction, to ensure that the wells are appropriately located and designed to detect contaminants of interest.

BAF's laboratory analytical procedures for chloride, sulfate, and ortho-phosphate should be evaluated to determine the reason(s) for the disparity between Ecology and BAF sample results. Following corrective action, BAF should split samples with three accredited laboratories to verify the problem has been corrected. Ecology should be kept informed of the split sample results and the actions taken to resolve the problem.

The BAF detection limit for ammonia and TKN should be reduced to 0.5 mg/L to ensure the early detection of these constituents.

Careful attention should be paid to BAF wastewater management over the next few years to determine whether the substantial additional acreage added this year is sufficient to assimilate the facility wasteload without further adverse impacts to area groundwater quality.

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Appendices

Appendix A: Sampling Procedures and Quality Assurance for Ecology Analyzed Samples

We followed standard quality control procedures during the collection, transport, and analysis of Ecology split samples as specified in Barcelona and others, 1985. Samples were collected in pre-cleaned bottles supplied by the Manchester Environmental Laboratory (MEL). Samples for ammonia as N, nitrate + nitrite as N, and TKN were collected in pre-acidified bottles. Samples for metals analysis were acidified, in the field, with ultra-pure concentrated nitric acid. Filled sample bottles were labeled and stored on ice prior to being delivered to the laboratory. Chain of custody procedures were followed throughout sample collection and handling (Washington Department of Ecology, 1994). All samples arrived at the laboratory in good condition.

Internal quality control checks performed by laboratory staff included verification standards for instrument calibration, procedural blanks, laboratory control samples, and spiked/duplicate samples.

Field quality control checks consisted of a metals transfer blank and blind duplicate samples collected from well ACP692 (BAF well No. MW-13). The duplicate samples were collected as splits from the same sample and submitted to the laboratory under different sample numbers. The metals transfer blank was prepared using reagent grade water supplied by the MEL. The reagent grade water was poured from the laboratory supplied container into an empty metals container, at the sampling site, and then acidified in the same manner as other metals samples.

The data quality for this project met all quality control/assurance criteria and can be used without qualification. The following comments were included in the laboratory data submittal:

- Potassium recovery for the laboratory control sample was 121% -slightly higher than the control limit of 120%. Other potassium quality control results were acceptable.

- Sodium was found in the procedural blank at a concentration of 98 ug/L. The sodium level in samples are greater than 10 times that of the blank, so the data may be used without qualification.

- Calcium was found in the metals transfer blank at a concentration of 57 ug/L - slightly above the method detection limit of 50 ug/L. This difference is not significant. No other constituents were detected in the transfer blank.

Laboratory and field duplicate analyses were compared by determining the relative percent difference (RPD) between sample pairs. Relative percent difference is the numeric difference between sample pairs divided by their mean, expressed as a percentage. The RPD values for duplicate samples were less than 10% for all samples with the exception of one laboratory duplicate for ortho-phosphate (12.3%) (Table A-1) and one field duplicate for potassium (15.2%) (Table A-2).

Appendix A

Table A-1 Laboratory Duplicate Analyses and Relative Percent Difference (RPD) for Ecology Samples

Well No.	Specific Conductance (umhos/cm @ 25 C)	Total Dissolved Solids (mg/L)	Ortho-Phosphate (mg/L	Total Alkalinity (mg/L	Total Kjeldahl Nitrogen (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Nitrate + Nitrite (mg/L)	Ammonia (mg/L)
ABK150			0.069	355	0.500U	79.0	101	0.357	0.010 U
Lab duplicate			0.061	357	0.500U	78.2	100	0.364	0.010 U
RPD			12.3 %	0.6 %	0 %	1 %	1 %	1.9 %	0 %
ABK154			0.010 U						
Lab duplicate			0.010 U						
RPD			0 %						
ABK155				325					
Lab duplicate				326					
RPD				0.3 %					
ACP689						54.2	52.9	43	0.010 U
Lab duplicate						54.2	53.1	43	0.010 U
RPD						0 %	0.4 %	0 %	0 %
ACP691			0.017						
Lab duplicate			0.016						
RPD			6 %						
ACP692	504								
Lab duplicate	505								
RPD	0.2 %								
FW-2		527							
Lab duplicate		526							
RPD		0.2 %							

U – The alalyte was not detected at or above the reported value.

Appendix A

Table A-2 Field Duplicate Analyses and Relative Percent Difference (RPD) for Ecology Samples

Well No.	Specific Conductance (umhos/cm @ 25 C)	Total Dissolved Solids (mg/L)	Ortho-Phosphate (mg/L	Total Alkalinity (mg/L	Total Kjeldahl Nitrogen (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Nitrate + Nitrite (mg/L)	Ammonia (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Potassium (mg/L)	Sodium (mg/L)
ACP692	504	326	0.010 U	123	0.5 U	26.0	20.9	23.5	0.010 U	44.4	22.2	2.49	16.3
Field Dup.	511	331	0.010 U	122	0.5 U	26.2	20.9	23.8	0.010 U	44.2	22.2	2.9	16.3
RPD	1.4 %	1.5 %	0 %	0.8 %	0 %	0.8 %	0 %	1.3 %	0 %	0.5 %	0 %	15.2 %	0 %

U – The analyte was not detected at or above the reported value.

Appendix B: Ground-Water Level Measurements

Unique Well ID Tag No.	Facility Well No.	Measurement Date	Measurement Time	Water Level Below Measuring Point (Feet)	WL Altitude (Feet Above Mean Sea level)	Well Status at Time of WL measurement
ABK150	A1	4/27/1998	1:34 PM	33.2	1,125.8	
ABK151	A2	4/27/1998	3:48 PM	58.8	1,091.9	
ABK152	MW-6	4/27/1998	4:31 PM	26.9	1,119.1	
ABK153	MW-1	4/27/1998	5:37 PM	22.8	1,132.9	
ABK154	MW-2	4/28/1998	7:19 AM	40.4	1,119.8	
ABK155	MW-3	4/28/1998	8:35 AM	43.7	1,110.0	
ACP687	MW-8	4/28/1998	9:45 AM	63.4	1,079.8	
ACP688	MW-9	4/28/1998	11:45 AM	59.1	1,058.4	
ACP689	MW-10	4/28/1998	1:05 PM	54.2	1,045.8	
ACP690	MW-11	4/28/1998	2:07 PM	60.4	1,055.8	
ACP691	MW-12	4/28/1998	3:18 PM	41.7	1,082.8	
ACP692	MW-13	4/28/1998	4:26 PM	38.3	1,074.3	
----	FW-1	4/28/1998	11:18 AM	57.1	---	recently pumped
----	FW-2	4/28/1998	11:27 AM	59.5	---	recently pumped
----	FW-3	4/28/1998	11:18 AM	89.3	---	recently pumped

Note: All water levels were measured using an electric well probe or "E-tape". Measured values were rounded to the nearest 0.1 foot for reporting purposes.

Appendix C: Ecology and BAF Split-Sample-Water-Quality Results

Analyte	ABK150 (Well A-1) 04/27/1998 Ecology	BAF	RPD (%)*	ABK151 (Well A-2) 04/27/1998 Ecology	BAF	RPD (%)*
Field Measurements						
pH	---	7.7	---	---	7.3	---
Temperature (°C)	---	14.5	---	---	15.1	---
Specific Conductance (micromhos/cm @ 25 °C)	---	1000	---	---	950	---
Laboratory Analyses						
Specific Conductance (micromhos/cm @ 25 °C)	986	---	---	970	---	---
Conventionals (mg/L)						
Total Dissolved Solids	668	656	1.8	648	628	3.1
Ortho-Phosphate	0.069	0.03 **U**	---	0.078	0.04	64.4
Total Alkalinity	355	336	5.5	401	385	4.1
Total Kjeldahl Nitrogen	0.5 **U**	3.0 **U**	---	0.5 **U**	3.0 **U**	---
Chloride	79	69	13.5	52.1	42	21.5
Sulfate	101	37	92.8	52.6	18	98
Nitrate-Nitrite	0.357	0.6	50.8	9.97	9.6	3.8
Ammonia	0.01 **U**	3.0 **U**	---	0.01 **U**	3.0 **U**	---
Total Metals (mg/L)						
Calcium	67.3	72	6.7	73.7	79	6.9
Magnesium	34.4	36	4.5	46.5	48	3.2
Potassium	5.33	5.7	6.7	5.21	5.4	3.6
Sodium	90.8	96	5.6	64.4	68	5.4

U - *The analyte was not detected at or above the reported value.*
RPD - *The relative percent difference between Ecology and BAF sample split results expressed as a percentage*

Appendix C: Ecology and BAF Split-Sample-Water-Quality Results

Analyte	ABK152 Well MW-6 04/27/1998 Ecology	BAF	RPD (%)*	ABK153 Well MW-1 04/28/1998 Ecology	BAF	RPD (%)*
Field Measurements						
pH	---	7.3	---	---	8.1	---
Temperature (°C)	---	14.7	---	---	15.5	---
Specific Conductance (micromhos/cm @ 25 °C)	---	1524	---	---	410	---
Laboratory Analyses						
Specific Conductance (micromhos/cm @ 25 °C)	1480	---	---	378	---	---
Conventionals (mg/L)						
Total Dissolved Solids	977	937	4.2	259	254	1.9
Ortho-Phosphate	0.075	0.03 **U**	---	0.033	0.04	19.2
Total Alkalinity	592	565	4.7	145	148	2
Total Kjeldahl Nitrogen	0.528	3.0 **U**	---	0.5 **U**	3.0 **U**	---
Chloride	102	86	17	4.46	3.0 **U**	---
Sulfate	128	46	94.3	23.7	9	89.9
Nitrate-Nitrite	3.75	4.0	6.4	7.06	6.8	3.7
Ammonia	0.01 **U**	3.0 **U**	---	0.01 **U**	3.0 **U**	---
Total Metals (mg/L)						
Calcium	132	138	4.4	38.7	41	5.8
Magnesium	52.2	51	2.3	12.3	13	5.5
Potassium	7.22	7.7	6.4	5.07	4.9	3.4
Sodium	113	114	0.9	16.9	18	6.3

U - *The analyte was not detected at or above the reported value.*
RPD - *The relative percent difference between Ecology and BAF sample split results expressed as a percentage*

Appendix C: Ecology and BAF Split-Sample-Water-Quality Results

Analyte	ABK154 Well MW-2 04/28/1998 Ecology	BAF	RPD (%)*	ABK155 Well MW-3 04/28/1998 Ecology	BAF	RPD (%)*
Field Measurements						
pH	---	7.5	---	---	7.7	---
Temperature (°C)	---	14.0	---	---	14.9	---
Specific Conductance (micromhos/cm @ 25 °C)	---	1166	---	---	1030	---
Laboratory Analyses						
Specific Conductance (micromhos/cm @ 25 °C)	1130	---	---	993	---	---
Conventionals (mg/L)						
Total Dissolved Solids	760	747	1.7	643	643	0
Ortho-Phosphate	0.010 **U**	0.03 **U**	---	0.027	0.03 **U**	---
Total Alkalinity	365	352	3.6	325	313	3.8
Total Kjeldahl Nitrogen	0.5 **U**	3.0 **U**	---	0.5 **U**	3.0 **U**	---
Chloride	73.2	63	15	71.6	63	12.8
Sulfate	122	38	105	112	35	105
Nitrate-Nitrite	13.1	12.2	7.1	3.23	3.2	0.9
Ammonia	0.01 **U**	3.0 **U**	---	0.01 **U**	3.0 **U**	---
Total Metals (mg/L)						
Calcium	79.8	85	6.3	64.6	69	6.6
Magnesium	31.5	32	1.6	26.3	27	2.6
Potassium	5.8	6	3.4	7.79	8.4	7.5
Sodium	118	125	5.8	106	111	4.6

U - *The analyte was not detected at or above the reported value.*
RPD - *The relative percent difference between Ecology and BAF sample split results expressed as a percentage*

Appendix C: Ecology and BAF Split-Sample-Water-Quality Results

Analyte	ACP687 Well MW-8 04/28/1998 Ecology	BAF	RPD (%)*	ACP688 Well MW-9 04/28/1998 Ecology	BAF	RPD (%)*
Field Measurements						
pH	---	7.7	---	---	8.0	---
Temperature (°C)	---	15.4	---	---	16.0	---
Specific Conductance (micromhos/cm @ 25 °C)	---	699	---	---	516	---
Laboratory Analyses						
Specific Conductance (micromhos/cm @ 25 °C)	686	---	---	511	---	---
Conventionals (mg/L)						
Total Dissolved Solids	456	509	11	341	394	14.4
Ortho-Phosphate	0.010 **U**	0.04	---	0.010 **U**	0.03 **U**	---
Total Alkalinity	125	120	4.1	131	125	4.7
Total Kjeldahl Nitrogen	0.5 **U**	3.0 **U**	---	0.5 **U**	3.0 **U**	---
Chloride	81.6	70	15.3	21.3	16	28.4
Sulfate	21.9	7	103	11.6	6	63.6
Nitrate-Nitrite	24.6	22.7	8	25.9	25.0	3.5
Ammonia	0.01 **U**	3.0 **U**	---	0.01 **U**	3.0 **U**	---
Total Metals (mg/L)						
Calcium	66.8	68	1.8	46.2	50	7.9
Magnesium	27.8	27	2.9	21	21	0
Potassium	5.43	4.4	21	2.9	2.7	7.1
Sodium	20.5	22	7.1	16.6	17	2.4

U - *The analyte was not detected at or above the reported value.*
RPD - *The relative percent difference between Ecology and BAF sample split results expressed as a percentage*

Appendix C: Ecology and BAF Split-Sample-Water-Quality Results

Analyte	ACP689 Well MW-10 04/28/1998 Ecology	BAF	RPD (%)*	ACP690 Well MW-11 04/28/1998 Ecology	BAF	RPD (%)*
Field Measurements						
pH	---	8.0	---	---	7.9	---
Temperature (°C)	---	15.8	---	---	14.7	---
Specific Conductance (micromhos/cm @ 25 °C)	---	814	---	---	852	---
Laboratory Analyses						
Specific Conductance (micromhos/cm @ 25 °C)	816	---	---	835	---	---
Conventionals (mg/L)						
Total Dissolved Solids	551	575	4.3	562	568	1.1
Ortho-Phosphate	0.014	0.07	133	0.020	0.16	155
Total Alkalinity	155	148	4.6	308	289	6.4
Total Kjeldahl Nitrogen	0.5 **U**	3.0 **U**	---	0.5 **U**	3.0 **U**	---
Chloride	54.2	44	20.8	26.9	21	24.6
Sulfate	52.9	19	94.3	64.6	21	102
Nitrate-Nitrite	43	40.5	6	18.6	17.0	9
Ammonia	0.01 **U**	3.0 **U**	---	0.01 **U**	3.0 **U**	---
Total Metals (mg/L)						
Calcium	70.9	71	0.1	81.8	90	9.5
Magnesium	29.5	28	5.2	35.7	37	3.6
Potassium	5.21	5.4	3.6	5.3	5.8	9.1
Sodium	40.9	40	2.2	35.2	37	5

U - *The analyte was not detected at or above the reported value.*
RPD - *The relative percent difference between Ecology and BAF sample split results expressed as a percentage*

Appendix C: Ecology and BAF Split-Sample-Water-Quality Results

Analyte	ACP691 Well MW-12 04/28/1998 Ecology	BAF	RPD (%)*	ACP692 Well MW-13 04/28/1998 Ecology	BAF	RPD (%)*
Field Measurements						
pH	---	7.9	---	---	7.9	---
Temperature (°C)	---	15.5	---	---	15.3	---
Specific Conductance (micromhos/cm @ 25 °C)	---	732	---	---	519	---
Laboratory Analyses						
Specific Conductance (micromhos/cm @ 25 °C)	713	---	---	504	---	---
Conventionals (mg/L)						
Total Dissolved Solids	478	463	3.2	326	372	13.2
Ortho-Phosphate	0.017	0.11	146	0.010 **U**	0.08	---
Total Alkalinity	296	280	5.6	123	111	10.3
Total Kjeldahl Nitrogen	0.5 **U**	3.0 **U**	---	0.5 **U**	3.0 **U**	---
Chloride	14.7	10	38	26.0	23.0	12.2
Sulfate	48.4	19	87.2	20.9	8	89.3
Nitrate-Nitrite	10.8	10.5	2.8	23.5	22.2	5.7
Ammonia	0.01 **U**	3.0 **U**	---	0.01 **U**	3.0 **U**	---
Total Metals (mg/L)						
Calcium	73.7	81	9.4	44.4	44	0.9
Magnesium	28.7	30	4.4	22.2	21	5.6
Potassium	4.6	4.8	4.3	2.49	2.5	0.4
Sodium	31.3	33	5.3	16.3	16	1.9

U - *The analyte was not detected at or above the reported value.*
RPD - *The relative percent difference between Ecology and BAF sample split results expressed as a percentage*

Appendix C: Ecology and BAF Split-Sample-Water-Quality Results

Analyte	Irrigation Well No. 2 04/27/1998 Ecology
Field Measurements	
pH	7.99
Temperature (°C)	15.7
Specific Conductance (micromhos/cm @ 25 °C)	900
Laboratory Analyses	
Specific Conductance (micromhos/cm @ 25 °C)	814
Conventionals (mg/L)	
Total Dissolved Solids	527
Ortho-Phosphate	0.022
Total Alkalinity	221
Total Kjeldahl Nitrogen	0.5 **U**
Chloride	81.5
Sulfate	62.2
Nitrate-Nitrite	12.9
Ammonia	0.01 **U**
Total Metals (mg/L)	
Calcium	58.3
Magnesium	51.6
Potassium	4.1
Sodium	19.7

U - *The analyte was not detected at or above the reported value.*