GROUP A

Ground Water Contamination

Lesson Plan #3: What is Ground Water Contamination?

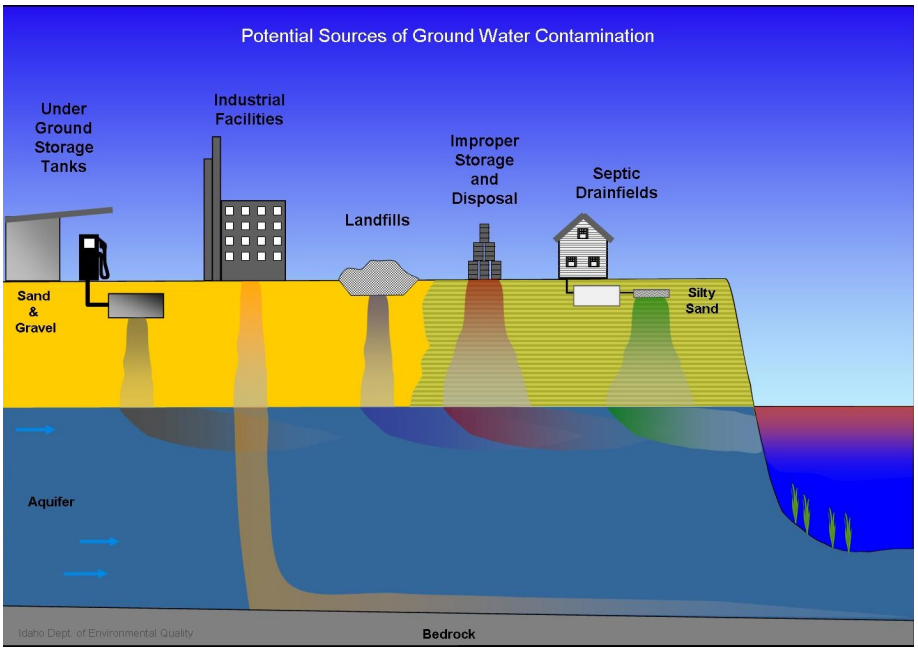
Objectives: Learn what a contaminant is and how contaminants flow through an aquifer.

- What is a contaminant?
- What are common sources of contaminants?
- What affects contaminant flow through an aquifer?
- How to sample ground water.
- How to predict downgradeint contaminant concentrations.

Grades: 10– 12

Materials:

- Calculator/spreadsheet



Ground Water Contamination:
Ground water contamination is generally the result of chemicals used by humans entering an aquifer. If ground water has chemicals from human activity it is said to be contaminated. If the concentration of one or more chemicals is too elevated it may not be safe to drink.

Where do these chemicals come from? Humans use a number of different materials that contain chemicals. These liquid or solid materials are often stored in large tanks. There are a number of different sources of potential contamination such as:

1. Underground Storage Tanks
2. Industrial Facilities
3. Landfills
4. Improper Storage or Disposal
5. Septic Drainfields

If these liquids or solids that contain chemicals are not used or stored properly they can leak into the soil and eventually into the ground water.





Underground Storage Tanks are commonly use to hold thousands of gallons of gasoline or diesel at gas stations. As the tanks age they may start to rust and corrode eventually forming holes. If the tank has holes then the gasoline or diesel will be released and infiltrate downward potentially contaminating the ground water.

Industrial Facilities often use large quantities of chemicals. Sometimes there are accidental spills of chemicals or improper storage that may result in releases to nearby rivers and streams, or may eventually seep into ground water.

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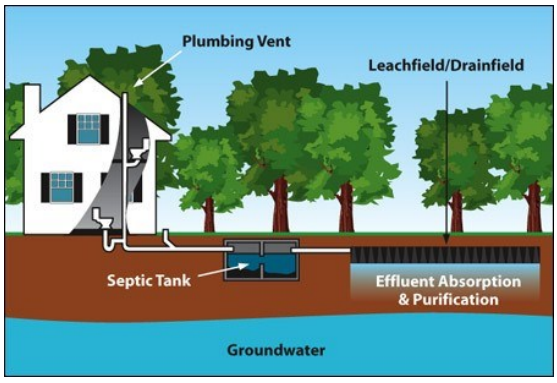


Landfills are places where household wastes go. Some household wastes contain chemicals that could be dangerous. If the household waste is allowed to sit outside, chemicals may seep out into the ground underneath. Most landfills have a low permeability layer underneath to keep chemicals from seeping into the ground water. Often after the waste is dumped a layer of low permeability soil will be placed on top to keep rain water from seeping into the waste and carrying chemicals into the soil. A number of cities have special hazardous waste drop off locations to put hazardous chemicals instead of throwing them into the garbage so that they stay out of the landfills.



Improper storage and disposal may cause chemicals to seep or leak into the soil and contaminate the ground water. Chemicals should always be stored in proper containers and the containers should often be kept inside and on floors that will hold any spills or leaks if they occur

Septic Drainfields are used to dispose of wastewater from houses into the ground. If built and maintained properly the septic system will keep most contaminants out of the ground water. If a septic system fails or is not built properly then it may introduce contaminants like bacteria or viruses into the ground water If the homeowner is pouring chemicals down the drain rather then taking them to the hazardous waste drop off locations the chemicals will go to the drainfield and seep into the ground water. If there is a water well nearby the bacteria, viruses or chemicals coming from the drainfield may end up in someone's drinking water.



The rate that contaminants will be transported through an aquifer is affected by four processes; 1) advection, 2) dispersion 3) retardation, and 4) degradation. Advection is a process were contaminants will be carried along with the ground water. Dispersion is a process that results in contaminants spreading out away from the source. Retardation is a broad term that includes a variety of process that causes contaminates to migrate slower then the ground water. Degradation describes how the contaminant will breakdown with time.

Contaminants will advect at the same rate as the velocity of ground water. Dispersion will occur longitudinally (along the flow path), laterally and vertically (both perpendicular to the flow path). Dispersion will cause an increase in the plume size and a decrease in concentration. Dispersion is caused by 1) mechanical mixing of water, 2) convoluted pathways around aquifer material, and 3) changes in hydraulic conductivity of the aquifer material.

The dispersion coefficient is estimated with the following equation;

$$D_L = \alpha_L v$$
$$D_T = \alpha_T v$$
$$D_V = \alpha_V v$$

Where;

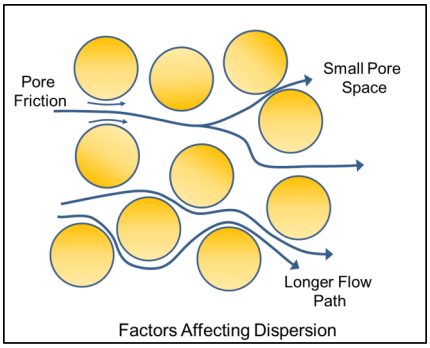
D_L, D_T, D_v= Longitudinal, transverse and vertical dispersion in $feet^2$/day.
v = average pore water velocity in feet/day.
α_L, α_T, α_V = Longitudinal, transverse and vertical dispersivity coefficient in feet.

Ground Water Contamination

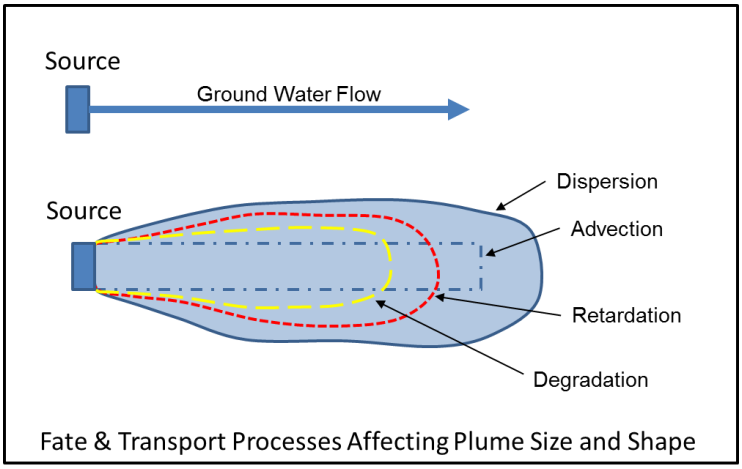
Lesson Plan #3: What is Ground Water Contamination?

Empirical evidence shows that the dispersion is scale dependent. The larger the plume the greater the dispersion. A general rule of thumb for estimating the longitudinal, transverse and vertical dispersvitiy is;

αL = 1/10th the plume length.
αT = αL /10
αV = αT /10



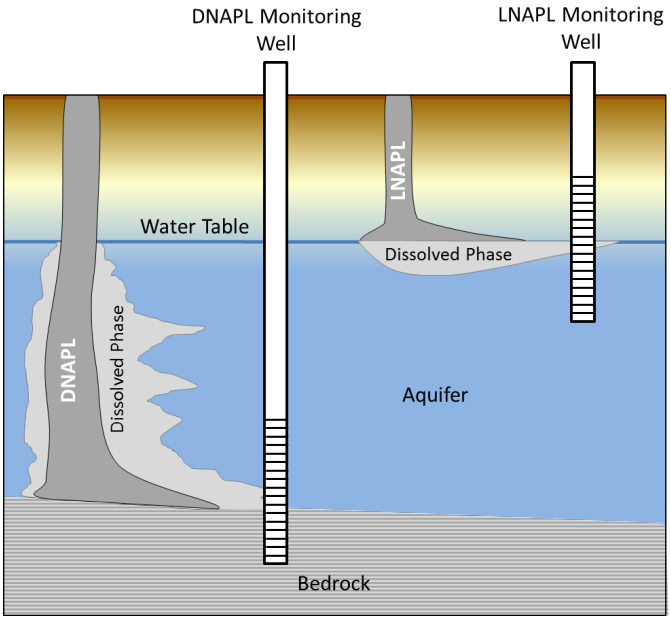
Factors Affecting Dispersion



Fate & Transport Processes Affecting Plume Size and Shape

There are many processes that affect retardation, generally the most significant process is sorption. Sorption is the process where contaminants will adhere to the aquifer sediments. Contaminants made up of cations (positively charged ions) can be sorbed onto clay minerals because clay minerals have a negative charge. Organic chemicals, such as benzene found in gasoline, can be sorbed onto organic carbon in soils. The process of sorption will slow the contaminant movement and reduce the dissolved concentration. Contaminants can undergo degradation. Degradation is the process of breaking down the contaminant into simpler compounds. The degradation process can occur chemically or can be facilitated by bacteria (biodegradation).

Contaminants may dissolve in ground water and are transported downgradeint. Other contaminants do not readily dissolve and are referred to as non-aqueous phase liquids. Some non-aqueous phase liquids are less dense then water and will float on top of the ground water, and are called light –non-aqueous phase liquids (LNAPL). Other s are more dense then water and will sink to the bottom of the aquifer and are called Dense Non-Aqueous Phase Liquids (DNAPL). Monitoring wells used to sample for each of these types of contaminants need to be constructed differently in order to be effective at detecting the contaminant. Monitoring wells constructed for detecting LNAPLs have the screens placed on top of the water table, and monitoring wells constructed to detect DNAPLs have the screens placed at the bottom of the aquifer.



GROUP A

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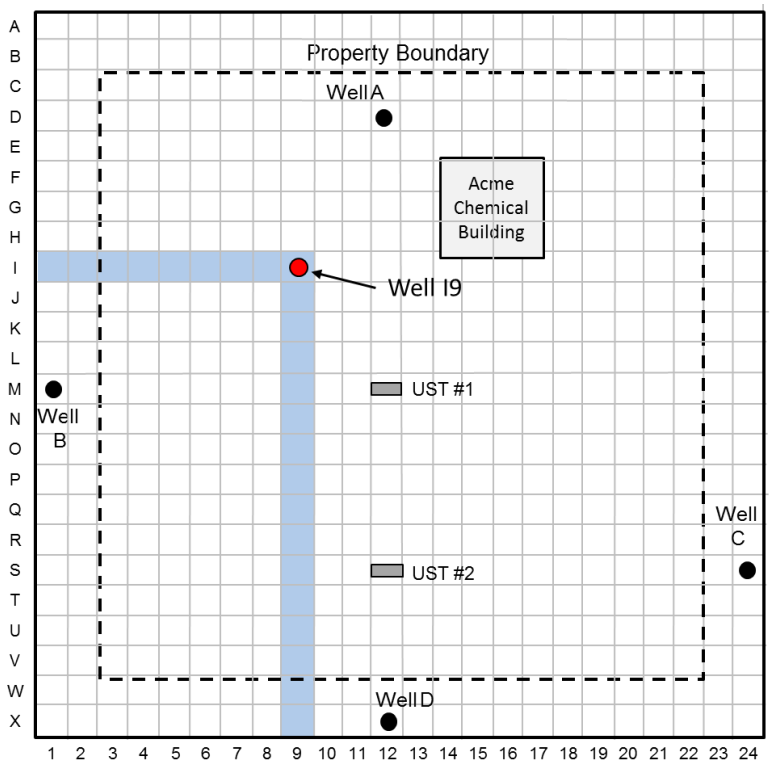
Exercise:
The Acme Chemical Company has discovered that after an bi-annual chemical inventory they cannot account for 26,280 gallons of chemical X that is stored in their 20,000 gallon underground storage tanks, as shown on the attached map. The Acme Chemical Co. does not know which UST could be leaking. Chemical X readily dissolves in water and does not sorb onto soil or the aquifer material.

The aquifer has the following characteristics;

- Thickness = 50 feet
- Hydraulic Conductivity = 300 feet/day
- αL = 50 feet
- αT = 5 feet
- αV = 0.5 feet
- Porosity = 0.25

Release characteristics;

- Duration of the Release = 180 days
- Conc. of chemical X = 1,000 milligrams/liter



They have hired you as an expert hydrogeologist to determine;

1. Which direction tis he contaminant plume headed?
2. Has the contaminant plume reached the property boundary?
3. How long will it take to reach the property boundary?
4. Is there the potential that any of the drinking water wells (A,B,C,D) may be contaminated?
5. What maybe the concentration in the drinking water well if the water becomes contaminated.?
6. The maximum concentration allowed in drinking water for Chemical X is 0.1 mg/l. Is there the potential that the UST release will cause the concentrations of Chemical X in the drinking water well to exceed this?
7. How could you reduce or eliminate the release of chemical X?



You have been given funding for a total of five monitoring wells to determine the ground water level and confirm contaminant concentration. You can only drill the wells on the Acme Chemical Co. property. Ground water flow direction can vary across a site and is unknown at the Acme Chemical Co. property.

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Exercise:

Your instructor will divide you into pairs or small groups each will be assign one of two different scenario's either A or B as seen at the top of the page.



As you drill each of your **five** wells well you can find out the water elevation and concentration of chemical X from someone in the other group. The location of each well will correspond to a grid defined by the letter on the vertical axis and a number on the horizontal axis. The groundwater elevations and contaminant concentrations for Group A are attached to the Group B lesson plans and vice versa. Once you determine the ground water flow direction and gradient, you should use the Contaminant Fate & Transport spreadsheet to help answer the questions and evaluate data if appropriate.

The spreadsheet has inputs for both source and aquifer characteristics. The resulting down gradient ground water concentrations are calculated using the Domenico Solution (see the calculations tab for the solution). Determine the gradient and flow direction from your five wells. Place the source and aquifer information into the spreadsheet and see what the resulting concentrations would be down gradient. See if the concentrations in your five wells match the concentrations calculated from the spreadsheet. Good luck!

2D - Fate and Transport of Chemical - No Retadation or Degradation

Project:	Fate and Transport Training
Date:	8/20/2002
Prepared by:	JNM
Contaminant:	Chemical X

Input

- Input Cell

Source Characteristics

Concentration (mg/l)	Width (ft)	Thickness (ft)	Duration of Release (days)
100	10	10	365

Aquifer Characteristics

Hydraulic Conductivity (ft/day)	Gradient (ft/ft)	Porosity	Dispersivity Longitudinal (ft)	Tranverse (ft)	Vertical (ft)
100	0.013	0.25	20	2	0.2

Model Domain

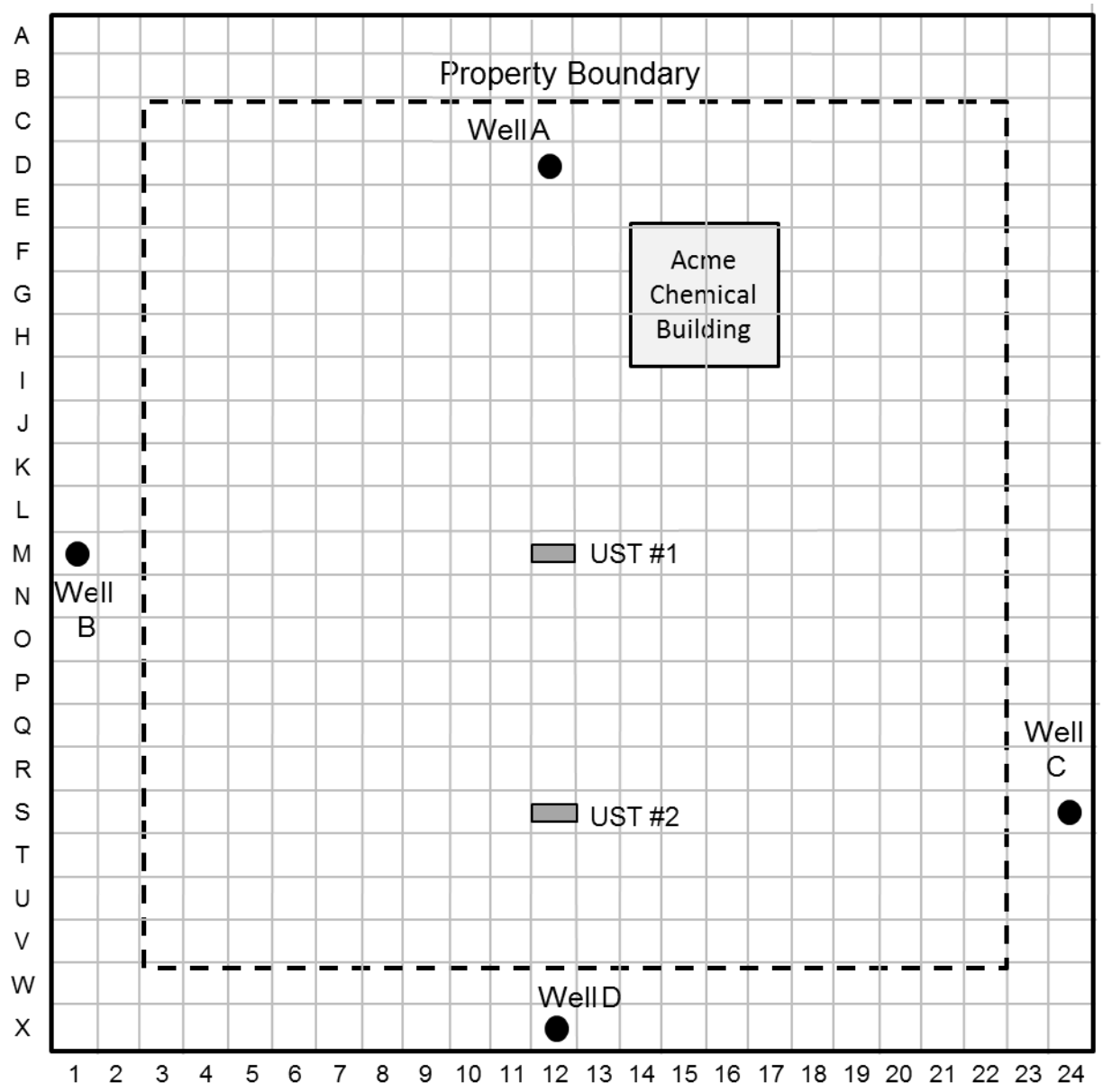
Length (ft)	Width (ft)
500	250

Results

Lateral Feet From Source	Horizontal Feet From Source: 50	100	150	200	250	300	350	400	450	500
250	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
200	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
150	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.005	0.010	0.017
100	0.000	0.000	0.003	0.021	0.060	0.117	0.183	0.253	0.321	0.384
50	0.066	0.818	1.662	2.198	2.479	2.601	2.630	2.606	2.552	2.482
0	26.897	17.470	12.975	10.319	8.564	7.319	6.389	5.669	5.094	4.626
-50	0.066	0.818	1.662	2.198	2.479	2.601	2.630	2.606	2.552	2.482
-100	0.000	0.000	0.003	0.021	0.060	0.117	0.183	0.253	0.321	0.384
-150	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.005	0.010	0.017
-200	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-250	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

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GROUP A

Group B

Water Elevetaions

Cell	Water Elevetaion (ft-msl)	Cell	Water Elevetaion (ft-msl)	Cell	Water Elevetaion (ft-msl)	Cell	Water Elevetaion (ft-msl)	Cell	Water Elevetaion (ft-msl)	Cell	Water Elevetaion (ft-msl)	Cell	Water Elevetaion (ft-msl)	Cell	Water Elevetaion (ft-msl)	Cell	Water Elevetaion (ft-msl)	Cell	Water Elevetaion (ft-msl)	Cell	Water Elevetaion (ft-msl)
A1	100.00	B1	99.92	C1	99.84	D1	99.76	E1	99.68	F1	99.60	G1	99.52	H1	99.44	I1	99.36	J1	99.28	K1	99.20	L1	99.12
A2	100.00	B2	99.92	C2	99.84	D2	99.76	E2	99.68	F2	99.60	G2	99.52	H2	99.44	I2	99.36	J2	99.28	K2	99.20	L2	99.12
A3	100.00	B3	99.92	C3	99.84	D3	99.76	E3	99.68	F3	99.60	G3	99.52	H3	99.44	I3	99.36	J3	99.28	K3	99.20	L3	99.12
A4	100.00	B4	99.92	C4	99.84	D4	99.76	E4	99.68	F4	99.60	G4	99.52	H4	99.44	I4	99.36	J4	99.28	K4	99.20	L4	99.12
A5	100.00	B5	99.92	C5	99.84	D5	99.76	E5	99.68	F5	99.60	G5	99.52	H5	99.44	I5	99.36	J5	99.28	K5	99.20	L5	99.12
A6	100.00	B6	99.92	C6	99.84	D6	99.76	E6	99.68	F6	99.60	G6	99.52	H6	99.44	I6	99.36	J6	99.28	K6	99.20	L6	99.12
A7	100.00	B7	99.92	C7	99.84	D7	99.76	E7	99.68	F7	99.60	G7	99.52	H7	99.44	I7	99.36	J7	99.28	K7	99.20	L7	99.12
A8	100.00	B8	99.92	C8	99.84	D8	99.76	E8	99.68	F8	99.60	G8	99.52	H8	99.44	I8	99.36	J8	99.28	K8	99.20	L8	99.12
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A11	100.00	B11	99.92	C11	99.84	D11	99.76	E11	99.68	F11	99.60	G11	99.52	H11	99.44	I11	99.36	J11	99.28	K11	99.20	L11	99.12
A12	100.00	B12	99.92	C12	99.84	D12	99.76	E12	99.68	F12	99.60	G12	99.52	H12	99.44	I12	99.36	J12	99.28	K12	99.20	L12	99.12
A13	100.00	B13	99.92	C13	99.84	D13	99.76	E13	99.68	F13	99.60	G13	99.52	H13	99.44	I13	99.36	J13	99.28	K13	99.20	L13	99.12
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A18	100.00	B18	99.92	C18	99.84	D18	99.76	E18	99.68	F18	99.60	G18	99.52	H18	99.44	I18	99.36	J18	99.28	K18	99.20	L18	99.12
A19	100.00	B19	99.92	C19	99.84	D19	99.76	E19	99.68	F19	99.60	G19	99.52	H19	99.44	I19	99.36	J19	99.28	K19	99.20	L19	99.12
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A22	100.00	B22	99.92	C22	99.84	D22	99.76	E22	99.68	F22	99.60	G22	99.52	H22	99.44	I22	99.36	J22	99.28	K22	99.20	L22	99.12
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M2	99.04	N2	98.96	O2	98.88	P2	98.80	Q2	98.72	R2	98.64	S2	98.56	T2	98.48	U2	98.40	V2	98.32	W2	98.24	X2	98.16
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M4	99.04	N4	98.96	O4	98.88	P4	98.80	Q4	98.72	R4	98.64	S4	98.56	T4	98.48	U4	98.40	V4	98.32	W4	98.24	X4	98.16
M5	99.04	N5	98.96	O5	98.88	P5	98.80	Q5	98.72	R5	98.64	S5	98.56	T5	98.48	U5	98.40	V5	98.32	W5	98.24	X5	98.16
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M8	99.04	N8	98.96	O8	98.88	P8	98.80	Q8	98.72	R8	98.64	S8	98.56	T8	98.48	U8	98.40	V8	98.32	W8	98.24	X8	98.16
M9	99.04	N9	98.96	O9	98.88	P9	98.80	Q9	98.72	R9	98.64	S9	98.56	T9	98.48	U9	98.40	V9	98.32	W9	98.24	X9	98.16
M10	99.04	N10	98.96	O10	98.88	P10	98.80	Q10	98.72	R10	98.64	S10	98.56	T10	98.48	U10	98.40	V10	98.32	W10	98.24	X10	98.16
M11	99.04	N11	98.96	O11	98.88	P11	98.80	Q11	98.72	R11	98.64	S11	98.56	T11	98.48	U11	98.40	V11	98.32	W11	98.24	X11	98.16
M12	99.04	N12	98.96	O12	98.88	P12	98.80	Q12	98.72	R12	98.64	S12	98.56	T12	98.48	U12	98.40	V12	98.32	W12	98.24	X12	98.16
M13	99.04	N13	98.96	O13	98.88	P13	98.80	Q13	98.72	R13	98.64	S13	98.56	T13	98.48	U13	98.40	V13	98.32	W13	98.24	X13	98.16
M14	99.04	N14	98.96	O14	98.88	P14	98.80	Q14	98.72	R14	98.64	S14	98.56	T14	98.48	U14	98.40	V14	98.32	W14	98.24	X14	98.16
M15	99.04	N15	98.96	O15	98.88	P15	98.80	Q15	98.72	R15	98.64	S15	98.56	T15	98.48	U15	98.40	V15	98.32	W15	98.24	X15	98.16

IDAHO Department of Environmental Quality

GROUP A

Group B

Contaminant Concentrations

Cell	Cont. Conc. (mg/l)	Cell	Cont. Conc. (mg/l)	Cell	Cont. Conc. (mg/l)	Cell	Cont. Conc. (mg/l)	Cell	Cont. Conc. (mg/l)	Cell	Cont. Conc. (mg/l)	Cell	Cont. Conc. (mg/l)	Cell	Cont. Conc. (mg/l)	Cell	Cont. Conc. (mg/l)	Cell	Cont. Conc. (mg/l)	Cell	Cont. Conc. (mg/l)	Cell	Cont. Conc. (mg/l)
A1	0.000	B1	0.000	C1	0.000	D1	0.000	E1	0.000	F1	0.000	G1	0.000	H1	0.000	I1	0.000	J1	0.000	K1	0.000	L1	0.000
A2	0.000	B2	0.000	C2	0.000	D2	0.000	E2	0.000	F2	0.000	G2	0.000	H2	0.000	I2	0.000	J2	0.000	K2	0.000	L2	0.000
A3	0.000	B3	0.000	C3	0.000	D3	0.000	E3	0.000	F3	0.000	G3	0.000	H3	0.000	I3	0.000	J3	0.000	K3	0.000	L3	0.000
A4	0.000	B4	0.000	C4	0.000	D4	0.000	E4	0.000	F4	0.000	G4	0.000	H4	0.000	I4	0.000	J4	0.000	K4	0.000	L4	0.000
A5	0.000	B5	0.000	C5	0.000	D5	0.000	E5	0.000	F5	0.000	G5	0.000	H5	0.000	I5	0.000	J5	0.000	K5	0.000	L5	0.000
A6	0.000	B6	0.000	C6	0.000	D6	0.000	E6	0.000	F6	0.000	G6	0.000	H6	0.000	I6	0.000	J6	0.000	K6	0.000	L6	0.000
A7	0.000	B7	0.000	C7	0.000	D7	0.000	E7	0.000	F7	0.000	G7	0.000	H7	0.000	I7	0.000	J7	0.000	K7	0.000	L7	0.000
A8	0.000	B8	0.000	C8	0.000	D8	0.000	E8	0.000	F8	0.000	G8	0.000	H8	0.000	I8	0.000	J8	0.000	K8	0.000	L8	0.000
A9	0.000	B9	0.000	C9	0.000	D9	0.000	E9	0.000	F9	0.000	G9	0.000	H9	0.000	I9	0.000	J9	0.000	K9	0.000	L9	0.000
A10	0.000	B10	0.000	C10	0.000	D10	0.000	E10	0.000	F10	0.000	G10	0.000	H10	0.000	I10	0.000	J10	0.000	K10	0.000	L10	0.000
A11	0.000	B11	0.000	C11	0.000	D11	0.000	E11	0.000	F11	0.000	G11	0.000	H11	0.000	I11	0.000	J11	0.000	K11	0.000	L11	0.000
A12	0.000	B12	0.000	C12	0.000	D12	0.000	E12	0.000	F12	0.000	G12	0.000	H12	0.000	I12	0.000	J12	0.000	K12	0.000	L12	0.000
A13	0.000	B13	0.000	C13	0.000	D13	0.000	E13	0.000	F13	0.000	G13	0.000	H13	0.000	IA13	0.000	J13	0.000	K13	0.000	L13	0.000
A14	0.000	B14	0.000	C14	0.000	D14	0.000	E14	0.000	F14	0.000	G14	0.000	H14	0.000	I14	0.000	J14	0.000	K14	0.000	L14	0.000
A15	0.000	B15	0.000	C15	0.000	D15	0.000	E15	0.000	F15	0.000	G15	0.000	H15	0.000	I15	0.000	J15	0.000	K15	0.000	L15	0.000
A16	0.000	B16	0.000	C16	0.000	D16	0.000	E16	0.000	F16	0.000	G16	0.000	H16	0.000	I16	0.000	J16	0.000	K16	0.000	L16	0.000
A17	0.000	B17	0.000	C17	0.000	D17	0.000	E17	0.000	F17	0.000	G17	0.000	H17	0.000	I17	0.000	J17	0.000	K17	0.000	L17	0.000
A18	0.000	B18	0.000	C18	0.000	D18	0.000	E18	0.000	F18	0.000	G18	0.000	H18	0.000	I18	0.000	J18	0.000	K18	0.000	L18	0.000
A19	0.000	B19	0.000	C19	0.000	D19	0.000	E19	0.000	F19	0.000	G19	0.000	H19	0.000	I19	0.000	J19	0.000	K19	0.000	L19	0.000
A20	0.000	B20	0.000	C20	0.000	D20	0.000	E20	0.000	F20	0.000	G20	0.000	H20	0.000	I20	0.000	J20	0.000	K20	0.000	L20	0.000
A21	0.000	B21	0.000	C21	0.000	D21	0.000	E21	0.000	F21	0.000	G21	0.000	H21	0.000	I21	0.000	J21	0.000	K21	0.000	L21	0.000
A22	0.000	B22	0.000	C22	0.000	D22	0.000	E22	0.000	F22	0.000	G22	0.000	H22	0.000	I22	0.000	J22	0.000	K22	0.000	L22	0.000
A23	0.000	B23	0.000	C23	0.000	D23	0.000	E23	0.000	F23	0.000	G23	0.000	H23	0.000	I23	0.000	J23	0.000	K23	0.000	L23	0.000
A24	0.000	B24	0.000	C24	0.000	D24	0.000	E24	0.000	F24	0.000	G24	0.000	H24	0.000	I24	0.000	J24	0.000	K24	0.000	L24	0.000
M1	0.000	N1	0.000	O1	0.000	P1	0.000	Q1	0.000	R1	0.000	S1	0.000	T1	0.000	U1	0.000	V1	0.000	W1	0.000	X1	0.000
M2	0.000	N2	0.000	O2	0.000	P2	0.000	Q2	0.000	R2	0.000	S2	0.000	T2	0.000	U2	0.000	V2	0.000	W2	0.000	X2	0.000
M3	0.000	N3	0.000	O3	0.000	P3	0.000	Q3	0.000	R3	0.000	S3	0.000	T3	0.000	U3	0.000	V3	0.000	W3	0.000	X3	0.000
M4	0.000	N4	0.000	O4	0.000	P4	0.000	Q4	0.000	R4	0.000	S4	0.000	T4	0.000	U4	0.000	V4	0.000	W4	0.000	X4	0.000
M5	0.000	N5	0.000	O5	0.000	P5	0.000	Q5	0.000	R5	0.000	S5	0.000	T5	0.000	U5	0.000	V5	0.000	W5	0.000	X5	0.000
M6	0.000	N6	0.000	O6	0.000	P6	0.000	Q6	0.000	R6	0.000	S6	0.000	T6	0.000	U6	0.000	V6	0.000	W6	0.000	X6	0.000
M7	0.000	N7	0.000	O7	0.000	P7	0.000	Q7	0.000	R7	0.000	S7	0.000	T7	0.000	U7	0.000	V7	0.000	W7	0.000	X7	0.000
M8	0.000	N8	0.000	O8	0.000	P8	0.000	Q8	0.000	R8	0.000	S8	0.000	T8	0.000	U8	0.000	V8	0.000	W8	0.000	X8	0.000
M9	0.000	N9	0.000	O9	0.000	P9	0.000	Q9	0.000	R9	0.000	S9	0.000	T9	0.000	U9	0.000	V9	0.000	W9	0.000	X9	0.000
M10	0.000	N10	0.000	O10	0.000	P10	0.000	Q10	0.000	R10	0.000	S10	0.000	T10	0.000	U10	0.005	V10	0.012	W10	0.006	X10	0.001
M11	0.000	N11	0.000	O11	0.000	P11	0.000	Q11	0.000	R11	0.000	S11	0.000	T11	0.608	U11	0.760	V11	0.365	W11	0.084	X11	0.009
M12	0.000	N12	0.000	O12	0.000	P12	0.000	Q12	0.000	R12	0.000	S12	0.000	T12	6.948	U12	3.449	V12	1.108	W12	0.201	X12	0.019
M13	0.000	N13	0.000	O13	0.000	P13	0.000	Q13	0.000	R13	0.000	S13	0.000	T13	0.608	U13	0.760	V13	0.365	W13	0.084	X13	0.009
M14	0.000	N14	0.000	O14	0.000	P14	0.000	Q14	0.000	R14	0.000	S14	0.000	T14	0.000	U14	0.005	V14	0.012	W14	0.006	X14	0.001
M15	0.000	N15	0.000	O15	0.000	P15	0.000	Q15	0.000	R15	0.000	S15	0.000	T15	0.000	U15	0.000	V15	0.000	W15	0.000	X15	0.000