Spring 2018

Life's a beach: Using role-playing scenarios to facilitate water quality studies, Supplementary materials

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Supplementary materials

Life's a beach: Using role-playing scenarios to facilitate water quality studies

This packet includes:

1. The environmental consulting scenario- this document explains the activity to the students, provides instructions on how to play the game, and gives an example worksheet that can be used alongside the activity.
2. Water quality test descriptions- this provides descriptions of the different tests the students can purchase and what can cause changes in the variables being tested.
3. Water quality tests fee schedule- the amount each team must pay per test per site.
4. Water quality testing limits- the range the measurements must fall within to be considered safe and appropriate for the recreation area.
5. A scenario map of the proposed locations.
6. An example of the "money" which can be used in the game.
7. Results for each test for each site.

- Each student team receives one copy of items 1-5 listed above.
- Each team also receives $4500 of the game "money".
- We cut the results into strips and store them in individually labelled envelopes (i.e., Site A- Basic Water test, Site A- Turbidity) so they can be easily handed out during the game.

Environmental consulting role-playing scenario

Congratulations! Your environment consulting firm has been selected to help the City of _____ decide where a new beach and recreation area will be located. Using everything that you know about water quality monitoring and the important factors in determining stream health, your team will need to choose which of the four proposed areas is the best fit for the project, all while spending the least amount of money possible. You do not have to do every test for every site- in fact you cannot spend more than the $4500 your team initially bid on the project. You must provide the City of _____ with your recommendation and explanation for why the proposed site is the best choice in terms of these three categories: chemical, bacterial, and macro-invertebrate testing results. Also provide a short 1-2 sentence explanation why you did not choose the other sites. Good luck!

Instructions – use the enclosed money to purchase testing results done at each of the four proposed sites. Spread out (you don't want the other groups hearing your strategy!) and work as a team to decide which tests are most appropriate for each of the locations. Remember to pick which tests will help you to determine whether a site has acceptable water quality AND spend as little money as possible. Tests do not need to be purchased in any particular order, and you do not have to purchase the same tests for every site. Once your team has decided to purchase a test, please give the appropriate amount of money to the mentor in exchange for the results. Compare these results to the acceptable limits to determine which site has the best water quality. You must provide specific explanations of results in each category for why the proposed location you select is the best choice as a new beach and recreation area. For the three locations not chosen, please write a brief response why you did not select that site.

Site descriptions –

Site A: This site is located closest to the City of _____ and is downstream from the main highway that crosses over the river. This highway is heavily used by both private commuters and commercial trucking operations. Its location near the highway and city makes it easily accessible to the residents of the City of _____ which would help boost tourism. Most people want this location because it is convenient, but is the water safe?

Site B: Located on the main channel immediately below the natural marshland that grew along the shallow sand bars in the middle of the river and an incoming tributary, this site has a higher flow of water. The neighboring cities favor this site as it across from their community boat dock and would be easy to access.

Site C: This proposed location is located on a tributary feeding into the river just past the main farmlands and livestock fields that provide food for the City of _____. These farmlands are used all year round due to the amazing climate in the City of _____. Choose this one, and have a beautiful view of the rolling hills and cattle while splashing in the water, plus it will be easy to access by boat from the main channel

Site D: This site is located downstream from a factory that is the main employer of the citizens of the City of _____. The factory diverts water from a major tributary of the river to use as a coolant. This heated water is then returned to the river just upstream of the proposed new beach and recreation area. The workers would love to be able to stop by the beach for a quick swim on their way home from work.

Materials – This document with the site descriptions and worksheet (reverse side), a map of proposed sites, $4500, the acceptable limits for water quality test results, and a fee schedule with test descriptions.

Complete this worksheet:

Total remaining $$:_____

Winning Site: ____

Why? Remember you have to mention at least one chemical, macro-invertebrate, and bacterial test and why the results are relevant to that location

Losing site: ___

Why (which limit did it surpass and what do you think caused the pollution)?

Losing site: ___

Why (which limit did it surpass and what do you think caused the pollution)?

Losing site: ___

Why (which limit did it surpass and what do you think caused the pollution)?

Below are the descriptions of the different tests and what can cause changes in the variables.

Basic Water Tests

pH:

•Acidity affects aquatic life

•Toxic chemicals can be released and affect our health

•Changes in pH are caused by acid rain, surrounding rocks and waste water discharge

Temperature:

•Changes affect aquatic life

•Cold water absorbs more oxygen than warm water

•Changes in temperature can be caused by changes in weather, exposing water to the sun, discharge of urban storm water or cooling water from industries

Phosphorus:

•Phosphorus is often the limiting nutrient for plant growth. Too much can lead to excessive algae growth.

•Caused by runoff from agricultural areas

Turbidity

•can promote regrowth of pathogens in the distribution system, leading to waterborne disease outbreaks

•increased sedimentation and siltation can result in harm to habitat areas for fish and other aquatic life

• Human activities that disturb land, such as construction, mining and agriculture, can lead to high sediment levels entering water bodies during rain storms due to storm water runoff.

Chlorophyll a

•Excess nutrients and sediment impact clarity of water and the amount of algae and oxygen it contains.

•The chlorophyll a (Chl a) concentration is a measure for the amount of algae in the water column.

• Caused by increased erosion and leaching from fertilized agricultural areas, and sewage from cities and industrial waste water.

Dissolved oxygen (DO)

•Stream water produces and consumes oxygen.

•Essential for respiration of aquatic life.

•Caused by changes in temperature, storm water run-off from farm land or urban streets, failing septic systems

Biochemical Oxygen Demand (BOD)

•BOD is the amount of oxygen consumed by bacteria in the decomposition of organic material

•Inputs into waterways, such as raw sewage, can increase BOD

Total Nitrate

•A limiting component in most ecosystems

•Excess amounts cause problems due to rapid growth and decay --> Eutrophication

•Changes caused by: geology of area, land use (farms, urban areas), wastewater treatment plants, industry

E. Coli

•Coliform bacteria are everywhere- good & bad

•One type of coliform bacteria are E. Coli

•E. Coli are not necessarily bad, but if in high enough levels, can indicate problems

•Changes caused by: land use (farms, urban areas), wastewater treatment plants

Priority Pollutants

These metallic pollutants are often found in industrial areas, cities or downstream of mines. They are used in a variety of products particularly alloys (i.e. batteries), semiconductors, paints, pesticides and many other applications. Though some are considered toxic only at high doses (antimony, silver, selenium, cadmium) others are very toxic (lead, arsenic) and can lead to a number of toxic effects and even death in a variety of organisms including humans. They are persistent in the environment, so even with discontinued use they continue to be observed in heavily impacted areas.

Chlorinated Hydrocarbon & Organic Phosphate Insecticide (Screen)

These chemicals are primarily used in agricultural areas to improve crop yield by killing targeted insects. These compounds cause death in insects (and macroinvertebrates) largely by effecting the nervous system and are considered toxic to humans (cause nervous system and reproductive issues). Although a number of these compounds (DDT, PCBs, parathion, metoxychlor) have been banned they remain in the environment for a long time and can accumulate up the food chain thus are considered persistent pollutants.

Herbicide Analysis

These chemicals are primarily used in agricultural areas to improve crop yield by killing off weeds pre and post emergence. These compounds are somewhat persistent and can remain in the soil for months or can be washed into local waterways. Although banned in other countries, they are still used in the U.S.A. and considered controversial; they are related to developmental issues in amphibians.

Volatile Organic Analysis

These pollutants are commonly emitted into the air in/around cities or in industrial areas. Some of them are heavier than air and will settle naturally onto land or in water, while others can attach to dust in the air and then settle out. They are commonly emitted from paints, fossil fuels (gasoline and exhaust), in aerosol sprays, etc. Some of the compounds are linked to cancer and tumor formation in mammals (benzene is a known carcinogen) and can also have effects on mucous membranes of aquatic organisms.

EPT Index

EPT index an index of water quality based on the abundance of three pollution-sensitive orders of macroinvertebrates relative to the abundance of a pollution-tolerant species of macroinvertebrate. It is calculated as the sum of the number of Ephemeroptera, Plecoptera, and Trichopteradivided by the total number of midges (Diptera: Chironomid).

Below are all of the possible tests your consulting team can purchase to determine which of the four proposed locations is the best choice for the new beach and recreation area. Tests do not need to be purchased in any particular order and you do not have to purchase the same tests for every site. Plan carefully so you do not overspend!

BASIC and EXPANDED ANALYSES

Basic Water Tests	$50	per site

Tests for all:
pH
Phosphorus (P)
Temperature

Turbity	$75	per site
Chlorophyll *a*	$100	per site
Dissolved oxygen (DO)	$50	per site
Biochemical Oxygen Demand (BOD)	$100	per site
Total Nitrates	$50	per site

BACTERIAL ANALYSES

E. Coli	$100	per site

TRACE LEVEL ANALYSES

Priority Pollutants	$150	per site

Tests for all:

Antimony (Sb)
Arsenic (As)
Cadmium (Cd)
Lead (Pb)
Selenium (Se)
Silver (Ag)

PESTICIDE AND ORGANIC ANALYSES

Chlorinated Hydrocarbon & Organic Phosphate Insecticide $200 per site

Tests for all:

Aldrin	DDT	Methoxychlor
Chlordane	Dieldrin	Parathion
DDD	Endrin	PCB
DDE		

Herbicide Analysis $200 per site

Tests for all:

Atrazine
Mirex
Simazine

Volatile Organic Analysis $200 per site

Tests for all:

Benzene	Ethylbenzene
Bromoform	Methyl Bromide
Butylbenzene	Methylene Chloride
Carbon Tetrachloride	Styrene
Chlorobenzene	Tetrachlorobenzene
Chloroform	Tetrachloroethane
Dibromochloromethane	Toluene
Dichlorobenzene	Trichloroethane
Dichloroethylene	Trichloroethylene
Dichloropropane	Vinyl Chloride

MACROINVERTEBRATE SAMPLING

EPT Index $125 per site

Below are the acceptable ranges for all of the possible water quality variables your team can test for at each site. If any result from a site falls outside of the range of any of these limits, you cannot chose that location for the new beach and recreation area as it may pose a danger to the citizens of the city.

Testing variable	**Acceptable ranges**		
Basic Water Tests			
pH	Between	6.0 and 8.5	
Phosphorus (P)	Less than	0.06 mg/L	
Temperature	Less than 2.8 C above natural temperature conditions and do not exceed a maximum of 32.2 C		
Turbidity	Less than	50	NTUs
Chlorophyll *a*	Less than	40	ug/L
Biochemical Oxygen Demand (BOD)	Less than	10	mg/L
Dissolved Oxygen (DO)	Daily average not less than 5.0 mg/l with a low of 4.0 mg/1		
Total Nitrates	Less than	10	mg/L
E. Coli	Not to exceed mean of 126/100 ml based on at least four samples collected over a 30 day period and a single sample can't exceed 349/100 ml		
Priority Pollutants (must be less than or equal to amount given)			
Antimony (Sb)		6	ug/L
Arsenic (As)		10	ug/L
Cadmium (Cd)		1300	ug/L
Lead (Pb)		14	ug/L
Selenium (Se)		50	ug/L
Silver (Ag)		0.37	ug/L
Chlorinated Hydrocarbon & Organic Phosphate Insecticide (must be less than or equal to amount given)			
Aldrin		0.000049	ug/L
Chlordane		0.0008	ug/L
DDD		0.00031	ug/L
DDE		0.00022	ug/L
DDT		0.00022	ug/L
Dieldrin		0.24	ug/L
Endrin		0.059	ug/L
Methoxychlor		40	ug/L
Parathion		0.065	ug/L
PCB		0.000064	ug/L

Herbicide Analysis (must be less than or equal to amount given)		
Atrazine	3	ug/L
Mirex	0.001	ug/L
Simazine	4	ug/L

Volatile Organic Analysis (must be less than or equal to amount given)		
Benzene	2.2	ug/L
Bromoform	4.3	mg/l
Butylbenzene	1500	mg/l
Carbon Tetrachloride	0.23	ug/L
Chlorobenzene	100	ug/L
Chloroform	5.7	ug/L
Dibromochloromethane	0.55	ug/L
Dichlorobenzene	420	ug/L
Dichloroethylene	330	ug/L
Dichloropropane	0.5	ug/L
Ethylbenzene	530	ug/L
Methyl Bromide	47	ug/L
Methylene Chloride	4.6	ug/L
Styrene	100	ug/L
Tetrachlorobenzene	0.97	ug/L
Tetrachloroethane	0.17	ug/L
Toluene	1000	ug/L
Trichloroethane	0.59	ug/L
Trichloroethylene	2.5	ug/L
Vinyl Chloride	0.025	ug/L

MACROINVERTEBRATE SAMPLING

EPT sampling Rating	Excellent	Good	Good-fair	Fair	Poor
EPT	>27	21-27	14-20	7-13	0-6

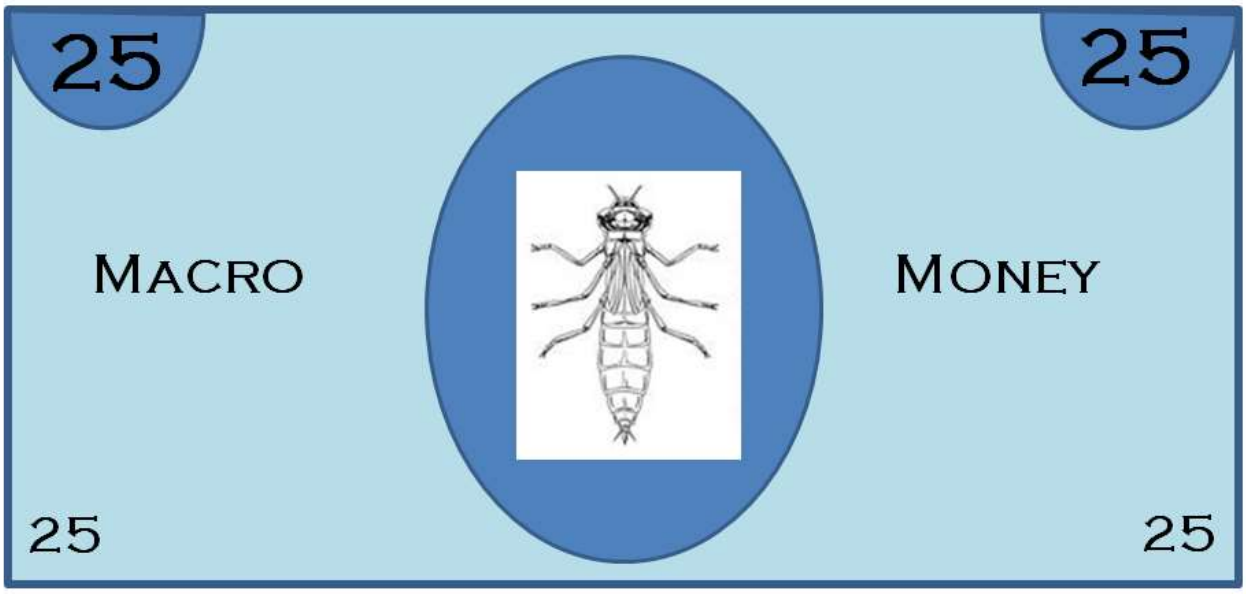
EPT rating must be between 7 - 27+

SITE A

SITE B

SITE C

SITE D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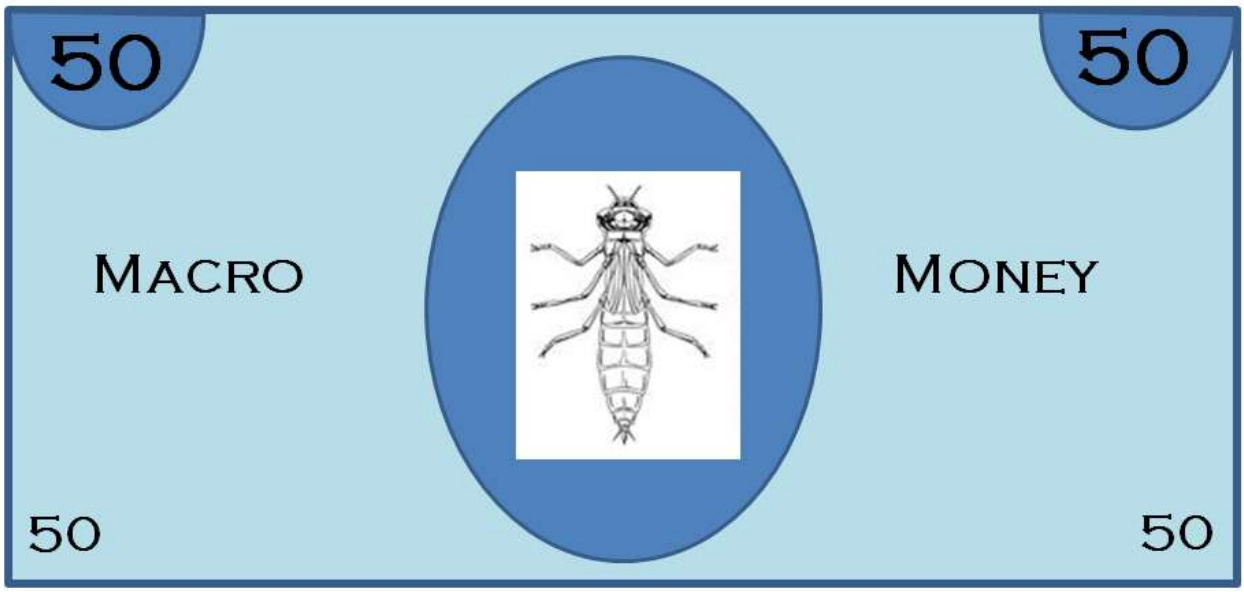
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MACRO MONEY

200 200

	Testing variable	Results
Site A: Highway/City	pH	6.1
	Phosphorus (P)	0.04 mg/L
	Temperature	0.1 C above natural temperature conditions, with a maximum of 28 C
Site A: Highway/City	Turbidity	48 NTUs
Site A: Highway/City	Chlorophyll *a*	42 ug/L
Site A: Highway/City	Biochemical Oxygen Demand (BOD)	12 mg/L
Site A: Highway/City	Dissolved Oxygen (DO)	Daily average 4.8 mg/l with a low of 3.8 mg/l
Site A: Highway/City	Total Nitrates	8 mg/L
Site A: Highway/City	*E. Coli*	Mean of 100/100 ml based on at least four samples collected over a 30 day period and single sample less than 200/100 ml
Site A: Highway/City	Antimony (Sb)	4 ug/L
	Arsenic (As)	15 ug/L
	Cadmium (Cd)	800 ug/L
	Lead (Pb)	20 ug/L
	Selenium (Se)	50 ug/L
	Silver (Ag)	0.2 ug/L
Site A: Highway/City	Aldrin	1E-05 ug/L
	Chlordane	0.0006 ug/L
	DDD	0.0003 ug/L
	DDE	0.0001 ug/L
	DDT	2E-05 ug/L
	Dieldrin	0.03 ug/L
	Endrin	0.012 ug/L
	Methoxychlor	28 ug/L
	Parathion	0.01 ug/L
	PCB	5E-05 ug/L

	Atrazine	1.8	ug/L
Site A: Highway/City	Mirex	0.0002	ug/L
	Simazine	0.9	ug/L

	Benzene	8.7	ug/L
	Bromoform	3.9	mg/l
	Butylbenzene	1000	mg/l
	Carbon Tetrachloride	0.21	ug/L
	Chlorobenzene	35	ug/L
	Chloroform	3.2	ug/L
Site A: Highway/City	Dibromochloromethane	0.51	ug/L
	Dichlorobenzene	289	ug/L
	Dichloroethylene	154	ug/L
	Dichloropropane	0.24	ug/L
	Ethylbenzene	416	ug/L
	Methyl Bromide	33	ug/L
	Methylene Chloride	2.5	ug/L
	Styrene	56	ug/L
	Tetrachlorobenzene	0.38	ug/L
	Tetrachloroethane	0.49	ug/L
	Toluene	1112	ug/L
	Trichloroethane	0.39	ug/L
	Trichloroethylene	2.6	ug/L
	Vinyl Chloride	0.014	ug/L

Site A: Highway/City	Pre-calculated EPT Index	9

Site A: Highway/City	EPT sampling	1 Cranefly
		3 Midge Fly Larvae
		2 Lunged Snail
		1 Dobsonfly
		5 Aquatic Worms
		1 Clam

	Testing variable	Results
Site B: Below City	pH	6.3
	Phosphorus (P)	0.012 mg/L
	Temperature	0.5 C above natural temperature conditions, with a maximum of 22 C
Site B: Below City	Turbidity	38 NTUs
Site B: Below City	Chlorophyll *a*	27 ug/L
Site B: Below City	Biochemical Oxygen Demand (BOD)	4.9 mg/L
Site B: Below City	Dissolved Oxygen (DO)	Daily average 7.0 mg/l with a low of 4.2 mg/l
Site B: Below City	Total Nitrates	9.5 mg/L
Site B: Below City	*E. Coli*	Mean of 96/100 ml based on at least four samples collected over a 30 day period and single sample less than 149/100 ml
Site B: Below City	Antimony (Sb)	2 ug/L
	Arsenic (As)	3 ug/L
	Cadmium (Cd)	259 ug/L
	Lead (Pb)	9.8 ug/L
	Selenium (Se)	36 ug/L
	Silver (Ag)	0.2 ug/L
Site B: Below City	Aldrin	1E-05 ug/L
	Chlordane	3E-05 ug/L
	DDD	1E-05 ug/L
	DDE	2E-06 ug/L
	DDT	1E-04 ug/L
	Dieldrin	0.14 ug/L
	Endrin	0.002 ug/L
	Methoxychlor	28 ug/L
	Parathion	7E-05 ug/L
	PCB	7E-06 ug/L

	Atrazine	0.75	ug/L
Site B: Below City	Mirex	1E-04	ug/L
	Simazine	1.13	ug/L

	Benzene	3.2	ug/L
	Bromoform	0.2	mg/l
	Butylbenzene	1232	mg/l
	Carbon Tetrachloride	0.001	ug/L
	Chlorobenzene	9	ug/L
	Chloroform	3.2	ug/L
Site B: Below City	Dibromochloromethane	0.47	ug/L
	Dichlorobenzene	183	ug/L
	Dichloroethylene	67	ug/L
	Dichloropropane	0.02	ug/L
	Ethylbenzene	94	ug/L
	Methyl Bromide	11	ug/L
	Methylene Chloride	0.58	ug/L
	Styrene	49	ug/L
	Tetrachlorobenzene	0.21	ug/L
	Tetrachloroethane	0.08	ug/L
	Toluene	256	ug/L
	Trichloroethane	0.31	ug/L
	Trichloroethylene	0.7	ug/L
	Vinyl Chloride	1E-04	ug/L

Site B: Below City	Pre-calculated EPT Index	17

Site B: Below City	EPT sampling	3 Stonefly Nymphs
		2 Net spinning Caddisflies
		1 Riffle Beetle
		2 Crayfish
		4 Dobsonfly
		2 Craneflies
		2 Mayfly Nymphs

	Testing variable	Results
Site C: Farmland	pH	7.1
	Phosphorus (P)	0.06 mg/L
	Temperature	1.8 C above natural temperature conditions, with a maximum of 22.7 C
Site C: Farmland	Turbidity	48 NTUs
Site C: Farmland	Chlorophyll *a*	35 ug/L
Site C: Farmland	Biochemical Oxygen Demand (BOD)	8 mg/L
Site C: Farmland	Dissolved Oxygen (DO)	Daily average 6.0 mg/l with a low of 4.8 mg/l
Site C: Farmland	Total Nitrates	22 mg/L
Site C: Farmland	*E. Coli*	Mean of 326/100 ml based on at least four samples collected over a 30 day period and single sample less than 487/100 ml
Site C: Farmland	Antimony (Sb)	5 ug/L
	Arsenic (As)	9 ug/L
	Cadmium (Cd)	567 ug/L
	Lead (Pb)	4 ug/L
	Selenium (Se)	21 ug/L
	Silver (Ag)	0.1 ug/L
Site C: Farmland	Aldrin	4E-05 ug/L
	Chlordane	0.0008 ug/L
	DDD	0.0041 ug/L
	DDE	0.0001 ug/L
	DDT	0.0001 ug/L
	Dieldrin	0.72 ug/L
	Endrin	0.009 ug/L
	Methoxychlor	32 ug/L
	Parathion	0.018 ug/L
	PCB	1E-05 ug/L

	Atrazine	5	ug/L
Site C: Farmland	Mirex	0.001	ug/L
	Simazine	2	ug/L

	Benzene	1.3	ug/L
	Bromoform	0	mg/l
	Butylbenzene	119	mg/l
	Carbon Tetrachloride	0.01	ug/L
	Chlorobenzene	85	ug/L
	Chloroform	0.12	ug/L
Site C: Farmland	Dibromochloromethane	0.1	ug/L
	Dichlorobenzene	36	ug/L
	Dichloroethylene	877	ug/L
	Dichloropropane	0.2	ug/L
	Ethylbenzene	500	ug/L
	Methyl Bromide	6	ug/L
	Methylene Chloride	3	ug/L
	Styrene	41	ug/L
	Tetrachlorobenzene	0.01	ug/L
	Tetrachloroethane	0.02	ug/L
	Toluene	652	ug/L
	Trichloroethane	0.025	ug/L
	Trichloroethylene	3.1	ug/L
	Vinyl Chloride	0.003	ug/L

Site C: Farmland	Pre-calculated EPT Index	14

Site C: Farmland	EPT sampling	4 Midge Fly Larve
		2 Net spinning Caddisflies
		1 Aquatic Sow Bug
		1 Stonefly
		2 Dragonfly
		6 Black Fly Larvae
		10 Lunged Snails
		3 Clams

	Testing variable	Results
Site D: Factory	pH	7.1
	Phosphorus (P)	0.03 mg/L
	Temperature	2.3 C above natural temperature conditions, with a maximum of 31 C
Site D: Factory	Turbidity	22 NTUs
Site D: Factory	Chlorophyll *a*	12 ug/L
Site D: Factory	Biochemical Oxygen Demand (BOD)	2 mg/L
Site D: Factory	Dissolved Oxygen (DO)	Daily average 5.0 mg/l with a low of 4.0 mg/l
Site D: Factory	Total Nitrates	3 mg/L
Site D: Factory	*E. Coli*	Mean of 76/100 ml based on at least four samples collected over a 30 day period and single sample less than 302/100 ml
Site D: Factory	Antimony (Sb)	3 ug/L
	Arsenic (As)	3 ug/L
	Cadmium (Cd)	526 ug/L
	Lead (Pb)	8 ug/L
	Selenium (Se)	36 ug/L
	Silver (Ag)	0.14 ug/L
Site D: Factory	Aldrin	9E-06 ug/L
	Chlordane	8E-05 ug/L
	DDD	0.0001 ug/L
	DDE	4E-05 ug/L
	DDT	9E-05 ug/L
	Dieldrin	0.13 ug/L
	Endrin	0.001 ug/L
	Methoxychlor	29 ug/L
	Parathion	0.0003 ug/L
	PCB	5E-06 ug/L

	Atrazine	0.6	ug/L
Site D: Factory	Mirex	0.0005	ug/L
	Simazine	0.02	ug/L

	Benzene	2.2	ug/L
	Bromoform	4.3	mg/l
	Butylbenzene	1500	mg/l
	Carbon Tetrachloride	0.23	ug/L
	Chlorobenzene	100	ug/L
	Chloroform	5.7	ug/L
Site D: Factory	Dibromochloromethane	0.55	ug/L
	Dichlorobenzene	420	ug/L
	Dichloroethylene	330	ug/L
	Dichloropropane	0.5	ug/L
	Ethylbenzene	530	ug/L
	Methyl Bromide	47	ug/L
	Methylene Chloride	4.6	ug/L
	Styrene	100	ug/L
	Tetrachlorobenzene	0.97	ug/L
	Tetrachloroethane	0.17	ug/L
	Toluene	249	ug/L
	Trichloroethane	0.24	ug/L
	Trichloroethylene	0.03	ug/L
	Vinyl Chloride	0.001	ug/L

Site D: Factory	Pre-calculated EPT Index	20

Site D: Factory	EPT sampling	4 Mayfly nymphs
		2 Crayfish
		2 Water Penny Larvae
		4 Net spinning Caddisflies
		3 Stonefly Nymphs
		1 Aquatic Snipe Fly
		6 Mussels
		1 Dobsonfly