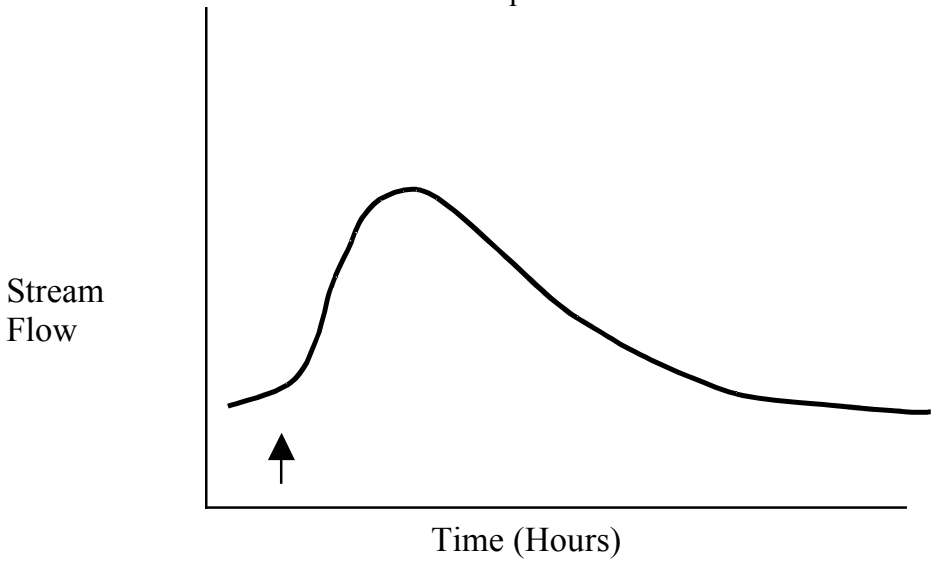
Name _____

Assorted questions

Below is a diagram of a storm hydrograph showing water flow in a stream in a largely undeveloped small watershed. The arrow indicates the beginning of a storm event.

a. Please add to the diagram a curve that depicts stream flow following development of the watershed to a level of 50% impervious surfaces.



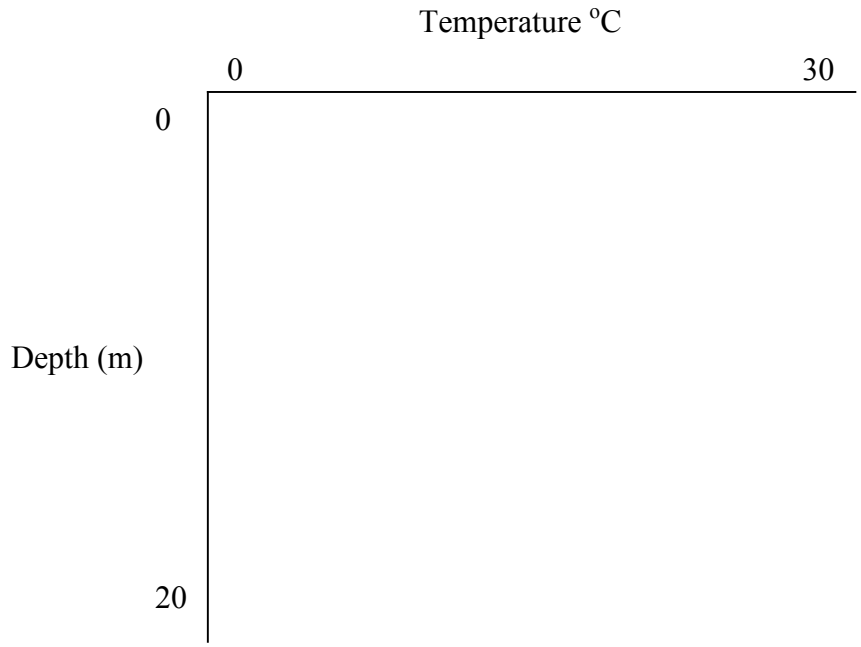
b. What is "base flow", and how does it change following development?

c. Will urbanization increase or decrease the amount of runoff in the watershed?

Basic Limnology

a) Sketch a line on the following axes depicting the vertical temperature profile as it occurs in a deep (more than 20 m) temperate lake during the late summer months.
b) Indicate the depth ranges that correspond to the hypolimnion and to the epilimnion of the lake.
c) Draw a second line on the following axes showing a typical winter temperature profile under the ice of a frozen lake. (Please clearly indicate which line is which).

Name _____



Stock and Flow Models at Steady State

Given a lake with volume V = 2.2 x $10^7 m^3$, draw a "stock and flow" diagram showing the major flows of water in and out of the lake. If the lake is at a steady state and has a total flow into the lake of 500,000 m^3 per year what is the residence time of the lake?

Estimation and Statistics

Fill in the blanks with the indicated words.

a) Standard Error vs. Standard Deviation

The _____ provides a description of variability among measurements.

Name _____

The _____ estimates how different a number you are estimating (e.g. an average or a sum) might turn out to be if you repeated the study many times.

Choices:
Standard Error
Standard Deviation

b) Sample Size

The accuracy of an average increases in proportion to the _____.

Choices:
Sample Size
Square root of Sample size

Name _____

Longer Questions (Answer Three out of Four. 25 Points Each)

Happy Valley Hydrology

A hypothetical development called "Happy Valleys" is being proposed near the bottom of a mountain valley. The entire watershed is 1000 ha with a 10 ha lake ("Happy Lake") at the bottom. The development covers approximately 100 ha with relatively low density housing (a house per 3 ha). Both pre-development and post-development, water levels in Happy Lake would be expected to rise following a "5 year storm", but the rise would be greater in the lake following development. (You may want to consult the data in the tables on the last page of the exam to help you answer this question.)

a) Estimate the increase in water level in the lake following a 5 year storm before the site is developed.

b) Estimate the increase in water level in the lake following a 5 year storm post-development.

c) Comment on your findings. Does development significantly increase the risk of flooding in and around Happy Lake?

d) What additional information, if any, would you like to have to help interpret your findings?

Name _____

Happy Valley Nutrient Impacts

Given the following land use data for the watershed around Happy Lake and the Phosphorus loading coefficients in the table on the last page of the exam, estimate annual loadings of P to the lake.

Post-development land use in the Happy Lake watershed

Land Use Category	**Area (Ha)**
Extractive	3.0
Cropland	9.4
Forest	800
Low density residential	100
Pond	10
Wetland	30
Field/pasture	47.6
Total	**1000**

What sorts of activities could lower or increase P inputs into the lake?

Why are people concerned about phosphorus inputs to lakes?

Why are people often more concerned about nitrogen inputs to marine systems than they are about nitrogen inputs to freshwater systems?

Name _____

Human Consumption of Net Primary Production
Assume that humans consume, on average, 10,000 J of food per day per person.

a) How much energy do all humans consume per year?

b) Assume 10% of the food humans consume comes from meat or animal products. To supply that 10%, it is thought that livestock consume on the order of 4×10^{19} J per year of net primary production. What is the total net primary production consumed directly and indirectly (via livestock) by humans per year?

c) If humans were to get more of their food from animal products – let's say 25% of their food – how much net primary production would be consumed directly and indirectly by humans per year?

d) Finally, assume that people directly consume and use about 2.5×10^{19} J of energy per year in the form of wood products, fuel, and paper. Assuming that net primary production is 4.7×10^{21} J per year, what percentage of primary production supports humans directly or indirectly through all our current consumption patterns?

Name _____

Policy Recommendation
Recommend a policy action to address the issue of the "dead zone" in the Gulf of Mexico. Explain why you chose the policy action you did and assess the feasibility of your proposed action. Keep in mind that taking no action at all is a possible choice. Be thoughtful in assessing feasibility and do not confuse what you think is the best idea with political feasibility.

YOU WILL NEED TO BE BRIEF TO KEEP WITHIN THE ALLOTTED TIME SO BE CLEAR AND CONCISE.

Name _____

Useful Tables

Table 1: Fate of Precipitation under different levels of imperviousness.

Percent impervious surfaces	Runoff	Evapotranspiration	Shallow Infiltration	Deep Infiltration
0	10	40	25	25
10 to 20%	20	38	21	21
35 to 50%	30	35	20	15
75 to 90%	55	30	10	5

Table 2: Storm return intervals for Androscoggin County.

Return Interval	24 Hour Storm (in)	24 Hour Storm (cm)
1	2.5	6.35
2	3	7.62
5	3.9	9.906
10	4.6	11.684
25	5.4	13.716
100	6.5	16.51
500	7.8	19.812

Table 3: Loading coefficients for various land uses.

	TP	TN
Forest	0.2	2.5
Wetlands	-0.25	0
Pasture	0.81	5.2
Low density residential	0.21	1.5
Med density residential	0.43	1.6
Cropland/bare ground	2.2	16.5
Commercial	0.66	4
Extractive	0.6	10

Please show your work, label your steps carefully, and include relevant units.

(1) What is the significance of the flux at which carbon is transported from the photic zone into the deep ocean? What factors might cause it to change? What might some of the consequences be if the flux of carbon to the deep ocean changed?

(2) List, and briefly describe, three pros and three cons to the idea of deep aquifer injection or carbon mineralization as a means of sequestering carbon. Describe the scientific principle that underlies whichever idea you select.

Name _____

(3) Calculate the blood lead levels for a 2 year old child who drinks water with 1 ppm lead in it and who lives in an environment where the soil and dust in her environment is 0.5% lead by weight. SHOW YOUR WORK! Annotate any assumptions that you make.

EPA estimates for Media Intake Rates (Pb intake rate = media Pb concentration * Media Intake Rates)

Soil/Dust	0-1 yr 0.085 g/d 1-2 yrs 0.135 g/d 2-3 yrs 0.135 g/d 3-4 yrs 0.135 g/d 4-5 yrs 0.100 g/d 5-6 yrs 0.09 g/d 6-7 yrs 0.085 g/d	This number reports a total value for soil intake. It is a ratio of soil ingestion (45%) to dust ingestion (55%)
Air	0 -1 yr 2 m^3/d 1-2 yrs 3 m^3/d 2-5 yrs 5 m^3/d 5-7 yrs 7 m^3/d	
Drinking Water	0-1 yr 0.2 L/d 1-2 yrs 0.5 L/d 2-3 yrs 0.52 L/d 3-4 yrs 0.53 L/d 4-5 yrs 0.55 L/d 5-6 yrs 0.58 L/d 6-7 yrs 0.59 L/d	
Diet	0-1 yr 5.53 µg Pb/d 1-2 yrs 5.78 µg Pb/d 2-3 yrs 6.49 µg Pb/d 3-4 yrs 6.24 µg Pb/d 4-5 yrs 6.01 µg Pb/d 5-6 yrs 6.34 µg Pb/d 6-7 yrs 7.00 µg Pb/d	Site specific data may be used to augment the default intake rates
Alternative sources	Site specific data may be used to account of intakes of Pb in sources such as Pb paint	EPA has written an exposure model to account for lead exposure from other sources (IEUBK)

Lead accessibility

Blood lead concentration (µg Pb/dL)	Dose of soluble lead to achieve this concentration (mg/kg/day)	Dose of soil lead to achieve this concentration (mg/kg/day)
1	0.03	0.04
2	0.07	0.1
3	0.11	0.17

4	0.15	0.27
5	0.20	0.40
6	0.25	0.60
7	0.30	0.93
8	0.36	1.60

(4) It would be unethical to dose children with potentially toxic levels of lead or place them in a potentially dangerous environment in order to learn what the causes and effects of lead poisoning are, yet we actually have pretty good information on major pathways of exposure and on the effects of lead poisoning on children. How can scientists get reliable information on risk factors and effects of lead poisoning without setting up profoundly unethical controlled-experiments? Please be specific about the types of data collected and how it is interpreted.

(5) Bush has proposed to encourage voluntary increases in the nation's economic efficiency of greenhouse gas use so that over the next ten years we go from emitting 183 metric tons of Carbon per million dollars of GDP to emitting only 151 metric tons of Carbon per millions dollars of GDP. The formula for solving exponential growth problems is $\ln[N(t)] = \ln[N_o] + rt$. (You may assume that the US population stays constant at about 285 million, and that the U.S. GDP is currently about $10 trillion)

a. Calculate the amount of CO_2 that the US will be emitting under the Bush plan in 2012 if GDP grows at a 4% annual growth rate.
b. Calculate the amount of CO_2 the US will be emitting in 2012 under the assumption that there is no increase in green house gas efficiency and GDP grows at 4%.
c. How much (in terms of mass of carbon reductions) would each American have to contribute via conservation to offset the increases in carbon emissions likely to occur under the Bush Plan?
d. Describe the fundamental difference between the Bush plan and the Kyoto protocol.

ES 203 Final Exam List of questions

You will be asked to answer six questions on the final exam during the allotted two hours. All the questions on the exam will come from the following list. You may discuss these questions with classmates and others prior to the exam. However, you may not use any resources during the exam itself.

1. Question from Mt. David Lab
   A group of students set out to measure the snow pack on Mount David. They collect 200 snow depths, from randomly selected locations on the mountain. Their measurements of snow depth had an average of 15.3 cm, with a standard deviation of 9.4 cm. They take just a single measurement of snow density from a point located at the summit of Mount David, reasoning that since the summit is centrally located, that

sample should be representative of conditions across the whole area. The sample has a (volumetric) snow density of 0.38 g/cm^3.

1. Assuming that Mount David has an area of 25,000 square meters, how much water is stored on Mount David, according to this group's data?
2. What is the standard error of that estimate?
3. Comment briefly on the methods they used. Is there anything they have done that might significantly bias their results? If so, what would you suggest they do differently next year?

2. Question from dissolved oxygen lab
   (A) State the hypothesis you developed for the oxygen lab, the measurements you planned to take to test the hypothesis, the interpretations you drew from your data, and an EXPERIMENT you could do to test another hypothesis that emerged from your work.
   (B) Dissolved oxygen concentrations vary seasonally in most lakes in Maine. Would you expect the amount of oxygen dissolved in the epilimnion of a lake to be greatest in the summer or in the fall? Why? Would you expect the concentration of dissolved oxygen in the hypolimnion to be greatest in the summer or in the winter? Again, why?

3. Question from phytoplankton lab/fertilization
   If ocean NPP would rise from ~25-40 Gt C/yr to 100 Gt C/yr through iron fertilization, proportionally, how much of an offset to anthropogenic carbon emissions would that offer? Be explicit about all the assumptions you are making.

4. Question from risk lab – Pb in ICP
   If you measured the concentration of Pb in a 400 mg chip of paint by digesting it with acid and then diluting the acid to 100 mL and then running the solution through the ICP and obtained a value of 200 ppm Pb from the ICP, estimate the blood lead levels for a child who ate 1 chip of paint per day.

Lead accessibility

Blood lead concentration (µg Pb/dL)	Dose of soluble lead to achieve this concentration (mg/kg/day)	Dose of soil lead to achieve this concentration (mg/kg/day)
1	0.03	0.04
2	0.07	0.1
3	0.11	0.17
4	0.15	0.27

Name _____

5	0.20	0.40
6	0.25	0.60
7	0.30	0.93
8	0.36	1.60

5. Questions about ecological footprint
   (A) Define an ecological footprint
   (B) Describe how the per capita ecological footprint for a nation is calculated.
   (C) How does that differ from how a personal or household ecological footprint is calculated?
   (D) Any ecological footprint calculation rests on many assumptions. Clearly identify one assumption used in the individual ecological footprint calculations you carried out in lab, and discuss the impact on the calculations if the assumption proves wrong or inaccurate.

6. Back of the envelop calculation
   Last month the US senate voted NOT to raise the average fleet miles per gallon from 24 mpg to 35 mpg by 2015. Estimate how much carbon would have been prevented from reaching the atmosphere had those requirements gone into effect. CLEARLY STATE ALL ASSUMPTIONS.

7. One problem on NPP connected to aquaculture.
   Shrimp aquaculture is globally one of the fastest growing and financially most significant forms of aquaculture.
   1. Roughly three quarters of shrimp produced by aquaculture are produced with artificial feeds, which average about 30% fish meal by weight. Shrimp are relatively efficient at converting feed into shrimp biomass, at least in the lab; for every kg of feed they consume, they produce about 0.5 kg of shrimp. Assuming that 5 kg of (live) fish goes into production of every kg of fish meal, does shrimp aquaculture produce more animal protein than it consumes?
   2. Wild shrimp are generalist carnivores. They feed on a complex mix of detritus, carrion, small fish, crustaceans and algae. Which do you think consumes more marine net primary production, a wild-caught shrimp, or a farmed shrimp? Explain. Be certain to identify your key assumptions.

8. Question about nutrients and toxins and order of magnitudes
   True or False – all substances are nutrients until they reach a certain concentration, at which point they become toxins. Explain your answer.

Name _____