ENVH 440-545 Take Home Midterm Exam Due: Nov. 16th, 2009

Directions: Answer each of the following questions completely. Answers should be typed and formatted using 10 pt font, 0.5 in margins, and 1.5 line-spacing. Limit your answers to **no more than**: 0.25 pages for a 5 point question, 0.5 pages per 10 point question, 0.75 pages for 15 point questions, and no more than 1 page for 20 point questions (excluding figures). Text longer than limits will be disregarded. Format abuses may be docked points. Most questions can be completely answered in less than half of a page. Diagrams are encouraged and should be used to support answers when appropriate. Cite any documents you rely on outside of your class notes. (150 points possible)

1. (15 points) Explain the basic process through which a compound would be considered for regulation in drinking water. What are the two major types of enforceable primary standards that might be set for a drinking water contaminant? How do they differ?

2. (10 points) What are the typical concerns of drinking water treatment facilities in regards to algae? Discuss the types of algae commonly implicated in each concern and give a specific example.

3. (15 points; 3 points each) Are the following statements true or false, explain your answers:
    a. Pesticides in drinking water are only a problem in rural agricultural areas.

    b. Contaminants on the CCL are regulated based on their human health impacts.

    c. TMDLs establish daily discharge limits for specific pollutants to a water body based on the designated use of the water body.

    d. National secondary drinking water standards are non-enforceable health-based standards.

    e. Under the SDWA, finished water monitoring requirements are the same for all public water systems.

4. (10 points) Describe the typical construction of a drinking water well. Include a discussion of the role of each component of the well in production and/or protection of the water.

5. (5 points) Aside from fecal waste, what are two potential sources of bacterial pathogens in water?

6.(5 points) A man in Denver, CO lives on a property with a shallow well. The water table is about 25 feet below the surface. The man's well system did not include a pressure tank; as a result his double jet pump eventually failed and had to be replaced. He found a single jet pump on Ebay and decided to buy it rather then pay the extra for a new double jet pump or a submersible pump. Answer the following:

a. Why did the lack of pressure tank damage his original pump?
b. Why was he unable to get water when he hooked up his new single jet pump?

7.(Total 20 points) Describe a typical drinking water treatment system from source to tap (Assume a surface water source, impacted by livestock agriculture and high density septic) (5 points). Describe each of the treatment processes, including any compounds added to the water (5 points). For the contaminants listed below, indicate: potential points of contaminant introduction through the system; discuss their removal/inactivation in the treatment chain; and discuss their potential health implications (10 points).

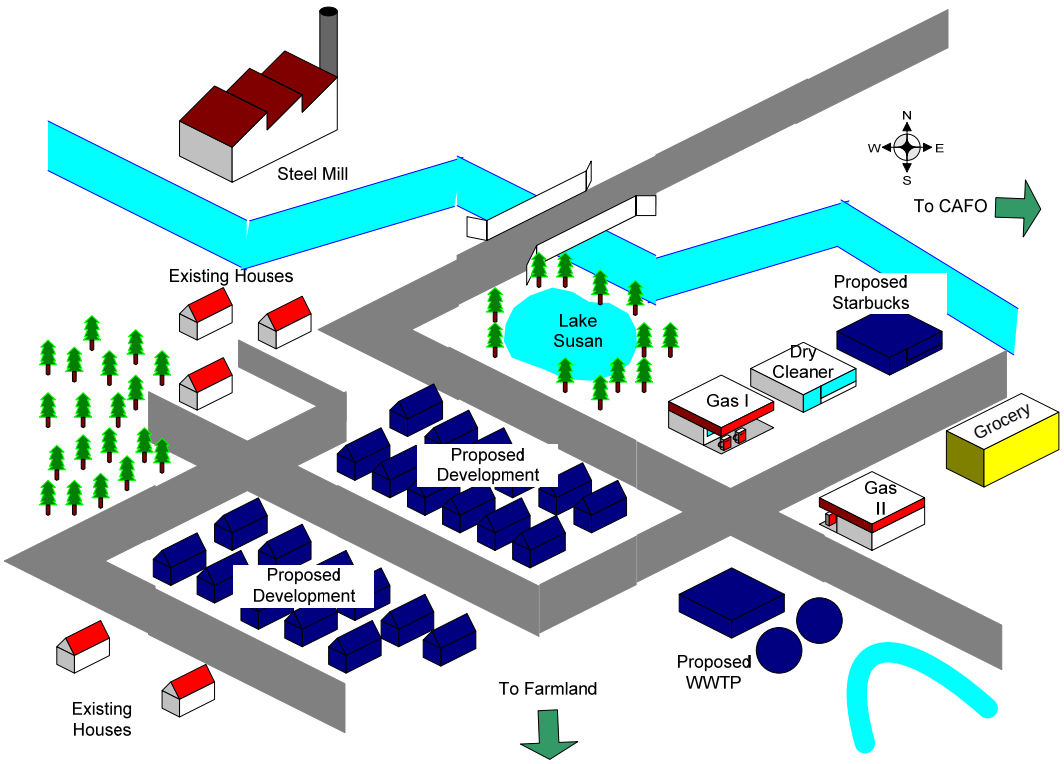
a. Cryptosporidium
*b. E. coli*
*c. Norovirus*
d. Lead
e. Chloroform

8. (10 points) Classify water treatment processes into three categories, and describe the primary purpose of these three categories.

9. (10 points) Describe and rank the following from best to least effective in their ability to prevent backflow: a)Pressure vacuum breaker, b)reduced pressure backflow preventer, c)air gap, d)double check valve, e)atmospheric pressure breaker.

10. (10 points) What are the key elements considered when establishing a water quality standard? How do the technology-based and water-quality based approaches to meeting water quality standards differ?

11. (Point breakdown below) Assume that you work for a developer who is planning to develop a small suburban community in southeastern Washington as depicted in the figure and described below. The developer has come to you (an expert in drinking water and health) and asked you several questions. Write a short response answering the developer's questions (that follow the figure and description) to the best of your ability.




Description of the location:

The northernmost existing houses were built on a single parcel of farmland 50 years ago. They are served by a single well that is screened in a moderately deep (~30 to 50 feet) unconfined sandy aquifer. Based on results of testing last year their water quality is generally good. However in times of severe drought, they have reported water production issues. Water quality was not tested in a time of drought or heavy rain. The houses have typical on-site (septic) systems for their waste treatment

The southernmost existing houses are each on individual parcels of land. They are served by deep wells (~175 feet) installed in a confined aquifer. The aquifer is consolidated and highly productive. Tests of their water have indicated elevated levels of Arsenic (~40ppb). No other water quality or water quantity issues have been reported although their water has not been tested in the last 8 years. The houses have typical on-site (septic) systems for their waste treatment.

The steel mill is an old plant (50+ years), but is still in operation. They produce a variety of chromed-steel products as well as bulk steel beams. They discharge their waste with minimal pre-treatment to the Large River, north of the proposed development. The Large River runs east to west.

The Large River is generally a minor source of groundwater under normal conditions. However under times of drought it becomes a sink and under times of heavy rain it is expected to contribute significantly to groundwater flow.

Lake Susan is a small lake that is hydrologically connected to the Large River and the shallow aquifer. The lake is home to a large population of Canadian geese. The lake is relatively shallow (30 feet), but stratifies in summer and winter. Water in the lake has been tested to determine the concentrations of carbon, nitrogen and phosphorus. It was found that the molar ratio of these three compounds was 100:1:1 – C:N:P; i.e., for every 100 moles of carbon (C) there was 1 mole of nitrogen (N) and 1 mole of phosphorus (P). The pH of the lake is slightly basic 8.3.

Gas Station 1 is an old "Mom and Pop" operation. They have been in operation for the last 43 years. Their tanks are unlined steel. They also operate a garage specializing in brake repair and oil changes.

Gas Station 2 is a new (4 years old) Texaco station with lined tanks. They do not offer any mechanical work, but do offer convenience store products and lottery tickets. They are also the only provider of biodiesel in the 50 mile radius.

The grocery store is a typical chain type store. It has been open for the last 20 years, but was just recently remodeled and had its stormwater control system replaced. Its stormwater control system now collects all the runoff from its parking lots and roof and diverts it into a retention pond (just out of the picture to the right of the grocery store) designed to settle out particulate matter before discharge to the large river.

The Dry Cleaner has been in operation for the last 30 years. It and Gas Station 1 were constructed on a parcel of land that once contained an old farmhouse. At the time of their construction, a new well was installed to serve both locations. The new well was tapped in the deep consolidated, confined aquifer. The old well was a hand dug well and is no longer used (though rumors persist that the dry cleaner has been using the shallow well for disposal of spent dry cleaning fluids.

The proposed development will consist of 23 single family dwellings. The expected demographics of the area will include young families who commute to work at the steel mill and local farms, and elderly retirees.

The proposed WWTP is being designed to serve the new development. It will be a small membrane bioreactor plant that discharges to Small Creek, which lies southeast of the proposed WWTP site.

The proposed Starbucks is planned to be built next to the Dry Cleaner. It plans to install its own well in the deep aquifer. This will be the only Starbucks (for that matter the only coffee shop) within 50 miles. It will feature a drive-through and is expected to serve over 100 persons per day from surrounding area.

To the northeast of the Large river as it passes under the mockingbird bridge (not pictured in figure; the proposed Starbucks, grocery store, dry cleaners and gas stations are located on mockingbird road which crosses the Large River on Mockingbird bridge) is a large CAFO houses nearly 6,000 head of pigs on average. These pigs are

maintained in long barns and their waste collected in large channels underneath the barn and delivered to anaerobic lagoons for treatment. The lagoons are 500 ft from the Large River in one location. Treated waste from the lagoons is transported and land applied to farmland south of the proposed development that is used for high intensity crop agriculture. The local crops include both fruit trees and hops. Pesticide use is very common on these crops.

The Stevens Road Bridge (pictured in figure) is the only direct route to the steel mill from the proposed community. Traffic on this bridge is expected to increase significantly and may result in improvements in the bridge being made. A local environmental group is against the proposed development based on the potential in crease in surface contamination runoff to the Large River and the potential impacts of the increased traffic and bridge improvements on the fish populations in the Large River.

The predominant surface flow of water is towards the Large River, with the exception of the area south of the proposed treatment plant and southernmost existing houses that drains to Small Creek. Small Creek winds to the south of the proposed development and eventually drains into to the Large River 15 Miles west of the proposed development.

The area is underlain by stratified aquifers. The upper aquifer is shallow to moderately deep, is hydraulically connected to the Large River and Small Creek, and is sandy to gravelly. It is unconfined and due to plentiful clay lenses is highly anisotropic. The predominant groundwater flow under normal conditions in the top aquifer tends to be parallel to the direction of the flow of the Large River, with a groundwater divide roughly 20-50 feet from the bank of the river. However, under conditions of drought or extreme rain, the groundwater divide can move as much as 50 feet in either direction (towards or away from the river).

The lower aquifer is a highly productive aquifer. It is confined under most of the area pictured by a granite aquiclude, however in some locations fracturing may result in a small amount of hydraulic connectivity with the upper aquifer. The aquifer is consolidated. It is homogenous and relatively isotropic, and the material is fractured/porous bedrock of volcanic origin. The predominant ground water flow of this aquifer is from Northeast to Southwest. The aquifer is recharged by mountainous regions surrounding the valley in which the proposed development lies.

Questions:

a. (15 points) What are the developer's options for a water supply for his proposed development? What are the potential water quality and water quantity/production concerns with each of the water supply options? Describe potential contaminants and sources. Which option is the best based on your analysis?

b. (5 points) Will the proposed water system designed to supply the proposed development be considered a public water supply (assume a single system to supply to proposed development)? What type?
c. (10 points) The owners of the northern most houses would like to sell their properties to the developer. The developer would like to use the existing wells (but will consider adding new wells to supplement) but increase the development on the properties (thus increasing overall production from the wells considerably). The developer has concerns over the potential for contamination of their well water from the steel mill. Consider their concerns and give your opinion as to the significance of the potential problem (include in the discussion a list of potential contaminants, health effects, and regulated levels, in addition to discussion of the hydraulic considerations).
d. (10 points) What is the dominant carbonate species that will be found in Lake Susan? If the lake were acidified by acid deposition resulting from emissions from the steel mill, would the alkalinity increase or decrease? Explain.