1. a. Define primary and secondary drinking water standards as these terms are used under the Safe Drinking Water Act. Be sure to specify the most important difference(s) between the two.

Primary standards are legally enforceable regulations based on protection of human health. Secondary standards are recommendations or guidelines that are not legally enforceable; they are based on aesthetics of the water, like taste, odor, and color.

b. Primary drinking water standards are generally specified in one of two ways. What are the two ways?

Primary standards take the form of a maximum contaminant level (MCL) or a treatment technique (TT).

c. Define maximum contaminant level (MCL) and maximum contaminant level goal (MCLG), specifying the most important difference(s) between the two. Find an example of a contaminant that has an MCL equal to its MCLG, and an example of a contaminant where the MCL is greater than the MCLG. Why is the MCLG never greater than the MCL?

The maximum contaminant level goal (MCLG) is the concentration of a contaminant that we believe to be safe for human consumption, i.e., no adverse health effects would be incurred by drinking water at that concentration. The MCLG is based only on health considerations and does not consider factors such as cost or feasibility. Therefore, the MCLG is not legally enforceable; it is just a target. The MCL is set as close as practicable to the MCLG when we consider cost and feasibility. The MCL is legally enforceable.

The MCL would never be set lower than the MCLG because the MCLG is a perfectly safe level – there would not be a need to do any better, because no additional health benefits would be gained.

Examples: antimony MCL = MCLG = 6 µg/L; barium MCL = MCLG = 2 mg/L. Most, but not all, inorganics have an MCL equal to the MCLG. benzene MCLG = 0, MCL = 5 µg/L; CCl₄ MCLG = 0, MCL = 5 µg/L. All carcinogens have an MCLG = 0, so MCL > MCLG for carcinogens.
2. a. What change was made to the MCL for arsenic in the early 2000’s? Why was this change delayed for a while, and why was it ultimately approved?

Right as President Clinton was ending his term in office (January 2001), EPA determined that the MCL for arsenic should be lowered from 50 µg/L (ppb) to 10 µg/L. When President Bush took office, he wanted to be sure that his new EPA Administrator would have the opportunity to review any last-minute decisions made by the outgoing administration. Therefore the new arsenic standard was delayed until May 2001, and then again until February 2002, so that the public could comment and so that the EPA could re-assess the new rule (including the science behind the rule and the costs and benefits associated with the proposed lower standard). Three expert panel reviews were conducted in 2001 to help EPA evaluate the proposed lower standard. In October 2001, the new EPA Administrator decided to let the proposed rule stand, affirming that the science was sound and that the more stringent standard would help protect public health.

b. What are some of the benefits of lowering the arsenic standard? What are some of the costs?

The benefits of lowering the arsenic MCL are dominated by the avoidance of certain cancers and non-cancer health effects. Several forms of cancer, including skin, liver, bladder, kidney, and lung cancers have been associated with arsenic exposure. Non-cancer health effects that would be avoided (and thus listed as benefits) include skin thickening, vascular and gastrointestinal effects, nervous system effects, developmental effects, and diabetes. EPA estimates these benefits to total between 59–86 deaths avoided each year, with a quantified annual benefit of $140 to $198 million. Other benefits include the reduction in risks for co-occurring contaminants that may be removed by installing new treatment technologies.

The costs of lowering the standard are substantial. The costs are dominated by the additional treatment that will be necessary to remove arsenic from contaminated drinking water supplies. Also included are costs relating to additional personnel needed to operate the new treatment facilities, additional training and oversight of these persons, and costs related to the increased production of materials and chemicals for treatment processes. EPA estimates these costs to be approximately $181 million each year.

c. Briefly explain why we are concerned about arsenic levels. What human health effects are associated with arsenic exposure?
We are concerned about arsenic because the estimated risks of cancer at the former MCL of 50 µg/L are quite high. High levels of arsenic in drinking waters in Bangladesh have led to very high levels of skin cancer, and similar situations have occurred in the past in Taiwan. Though we are not currently experiencing a crisis on the order of Bangladesh’s crisis, increased demand for water in western states will likely require the development of new sources of water.

d. Where does arsenic in drinking water come from?

Arsenic is a naturally occurring contaminant that is released to drinking water supplies primarily from the weathering of soils and minerals. Unfortunately, many of the same states that are likely to see growth in water demand also have high levels of arsenic in their groundwater supplies (e.g., in the Southwest). Thus more and more people would be exposed to arsenic at higher levels if a lower standard had not been adopted.
3. a. Why is there no MCL for microorganisms such as *Giardia lamblia*, *Legionella*, and viruses?

Laboratory tests to quantify these organisms are too expensive and difficult for routine water-quality monitoring. Therefore, they are regulated with a treatment technique (TT) rather than an MCL.

b. What types of treatment are required to remove these microorganisms? What are the required levels of inactivation for *Giardia*, viruses, and *Legionella*

Filtration and disinfection are required to remove these pathogens. *Giardia* requires three-log (99.9%) removal, and viruses require four-log (99.99%) removal. There is no removal level specified for *Legionella*. The rationale is that if the standard is met for *Giardia* and viruses, then it is quite likely that *Legionella* will be effectively removed as well.

c. Recently, EPA has been instituting a set of “enhanced surface water treatment rules” (ESWTR). What is the main objective or purpose of this set of rules?

These rules started coming on-line after the *Cryptosporidium* outbreak in Milwaukee in the mid-1990s. Their main purpose is to protect against *Cryptosporidium*. There is also an effort to reduce the risk from disinfection by-products, but the main driver for these rules is protection against Crypto.
4. (15 pts) Read the following article:

a. Summarize the approach and the specific steps used by EPA in setting a drinking water 
standard for trichloroethene (TCE).

The approach used by EPA in setting a drinking water standard for trichloroethylene (TCE) 
consists of the following basic steps:
1) Survey the occurrence of TCE in drinking water supplies and estimate the number of 
people exposed as a function of concentration;
2) Determine the individual exposure and the level of cancer risk imposed by varying 
concentrations in drinking water (i.e., develop dose-response curves);
3) Quantify the population risk by combining estimates of cancer risk with the estimates of 
the number of persons exposed; and
4) Estimate the total expected excess of cancer deaths due to TCE exposure, and set the 
standard based on maximum acceptable risk level. (e.g., $10^{-6}$ risk means that one person 
in a million will contract cancer as a result of a lifetime of exposure to this chemical in 
drinking water.)

b. In your opinion, is it reasonable to establish a MCL for this contaminant? In other words, 
is there need to regulate TCE specifically in public water supplies?

Opinions on whether it is reasonable to establish an MCL for TCE may vary. I agree with 
EPA that TCE should be regulated with an MCL. From my point of view, the relevant 
question is how we should act in the face of immense scientific uncertainty, and my opinion 
is that it is better to err on the side of stringency rather than leniency when it is a question of 
public health. (Of course, there is a practical limit to that – we can never make water 
perfectly “safe” – but establishment of an MCL for TCE has proven feasible without putting 
any significant financial burden on our water providers.)
5. (10 pts) Read the following short articles:

Based on what you read, do you think it is appropriate for EPA to set an MCL for perchlorate at this point? Why or why not? Hint: answer question 5 after you answer question 4, because question 4 will help you understand what is involved in setting an MCL.

A reasonable case could be made that, since we don’t yet know how much perchlorate is ingested in food versus water, it is premature to set a drinking water MCL for perchlorate. However, my personal opinion is that EPA should not wait until that knowledge is gained. Enough data already exist to go through the four-step process outlined above, and thereby determine a “safe” level of perchlorate in drinking water. Personally, I do not believe that it is an acceptable argument to say “since people are eating contaminated food, it is therefore OK if they drink contaminated water too.” Instead, I suggest that safeguards be put in place so that both our water and our food be safe for ingestion. There are costs associated with that, to be sure, but my opinion is that it is worth it.

6. Get a copy of the annual report that your city sends you about the quality of your drinking water. Turn in a photocopy of the report. Is your city in violation of any of the applicable regulations? Are there any contaminants that look like they might be cause for some concern? Explain briefly.

I live in Temple Terrace, so I have a drinking water report from the City of Temple Terrace from the year 2014. I don’t think the 2015 report is available yet. I will try to scan in the 2014 report and include the scanned report as part of my solution set. There do not appear to be any MCL violations in Temple Terrace during 2014. However, the levels of disinfection by-products are relatively high. The measured concentration of total trihalomethanes ranged from 24–53 µg/L, which isn’t terrible, but it isn’t great either. The MCL is 80 µg/L but might be reduced to 60 µg/L in the future. The measured concentration of HAA5 was not as bad, ranging from 7–22 µg/L with an MCL of 60 µg/L, but I still wouldn’t mind if the level of HAA5 were even lower, considering I drink a few glasses of this water on a daily basis. (Yes, I drink tap water from my kitchen sink.)

I was surprised to see that there are 900 µg/L of Sr in my water. I thought that sounded high, but some sources say that up to 4 mg/L is safe, so I guess 900 µg/L is (hopefully) not a problem.