CE 474/575: Unit Operations in Environmental Engineering

Checklist for Final Design
A complete design will address all of the items listed. You need not work out every minor detail (e.g., you don’t have to design a Parshall flume) but you should at least indicate the presence of a particular device or operation and indicate its location in a logical place in the system. [In the brackets I have provided some guidance as to the grade value of various overall features of your design report.]

OVERALL POINTS FOR BOTH WATER AND WASTEWATER SYSTEMS:

☐ Present in a scale drawing a logical layout that minimizes space use and piping, provides proximity of related units, yet allows access for maintenance and emergency operations. [This is worth about 0.5 of a letter grade; e.g. an otherwise “A” system with a haphazard layout drops to a B+.]

☐ Prepare formal mass balances (both liquid and solids streams) for each unit operation, and present this in away that it is easy to see where the water goes at each point, where the solids go at each point, and what the overall flows of solids and water are.

☐ Don’t forget that not all water follows the effluent train; some water exits with the sludge pathways. And then some of that water gets separated in later dewatering steps, and must be returned to an appropriate point in the treatment train (and accounted for in the water balance) [Mass balances are worth up to a full letter grade. Absence of clear and accurate mass balances will cost you a letter grade. The presence of mass balances, but poorly prepared and present can cost you up to 0.5 letter grade.]

☐ An “A+” design will include a simple but complete hydraulic profile (rounded to the nearest 0.5 or 1.0 foot). To develop this you can use the headloss values in Table 5-14 in the web posting on “Design Guidelines Part 1” (from Metcalf & Eddy). Although this info is only for wastewater operations, they can be used to approximate head loss in most water treatment units. Head loss through the sand filter has already been explicitly calculated in DA-6. [A hydraulic profile adds about 0.5 letter grade to any design.]

☐ It’s vitally important to plan for redundancy and maintenance. You must have a system where the peak daily flow can be accommodated such that at least one complete element of the treatment unit can be offline. Thus, if you have two units, one must be capable of handling the entire flow. It usually is cheaper to design a system where there are 3 or 4 units in parallel in which the total flow can be handled by 2 or 3, respectively. [Failure to deal with this throughout both systems drops you as much as a full letter grade].

☐ Summarize the total consumption of all chemicals by both facilities. If one chemical is used in both plants, lump them together to get a grand total for the municipal utility system. [Up to 0.5 letter grade].
WATER TREATMENT SYSTEM

SCOPE: Elk Creek source, coagulation, flocculation, and disinfection. No hardness removal.

☐ Water demand forecast; annual average and peak capacity required

☐ How big would a storage tank with a 3-day supply be? A 5-day supply? (Remember that storage comes at the end of the treatment chain but need to think about it up front when considering demand.)

☐ Inlet screening

☐ Flow measurement

☐ Coagulant addition and mixing

☐ Mixing system: Shape, volume, dimensions, operating parameters (detention time, power consumption, etc.)

☐ Chemical storage for coagulants (loading dock and truck access?)

☐ What coagulant(s) will be used?

☐ Supplemental chemicals: floc aids, pH control

☐ Total annual chemical usage for coagulation/flocculation

☐ Preliminary disinfection? [Your call, but think about pros & cons, why & where, and how much]

☐ Chlorine demand and chemical usage, storage, loading, access

☐ Flocculator system: shape, volume, dimensions, operating parameters (detention time, surface loading rate, power consumption, etc.)

☐ Clarifier design: shape, volume, dimensions, sludge collection apparatus, operating parameters (detention time, surface loading rate, etc.)

☐ Volume and mass of sludge from clarifier; annual average and peak day

☐ Basic flow path for sludge from clarifiers to thickening/dewatering equipment to final off-loading onto trucks for disposal. (Loading dock and truck access available?)

☐ Filter galleries: basic design, dimensions, headloss, etc.

☐ Include flow paths for backwash water to the clarifier and account for estimated backwash losses in you overall flow balance.

☐ Final disinfection, including information about dosing, chemical usage, suitable detention tanks (volume, dimensions, retention time)

☐ Storage facility, as per the discussion at the top of this section.
WASTEWATER TREATMENT SYSTEM

SCOPE: Serving the “Greater Drain” district as in the DA’s; pretreatment, primary, secondary aeration, P-removal via lime treatment of primary, nitrification and denitrification, and final disinfection (i.e., the Full Monty).

- Inlet facilities, pretreatment, grit removal, and flow measurement
- Access to pretreatment for removal of trash by carts or trucks
- Primary clarifiers that include lime dosing for P-removal
- Lime storage and mixing facilities (details of lime mixing not as critical as for coagulant addition in water system; just indicate presence and location.)
- Primary clarifier design: Shape, volume, dimensions, sludge collection apparatus, operating parameters (detention time, surface loading rate, etc.)
- Volume and mass of sludge from primary clarifier; solids content; annual average and peak day
- Basic flow path for sludge from primary and secondary clarifiers to digesters to thickening/dewatering equipment to final off-loading onto trucks for disposal. (Loading dock and truck access available?)
- Secondary aeration basins: Shape, volume, dimensions, operating parameters (detention time, surface loading rate, MLSS, return ratio, sludge age, sludge wastage rate, expected effluent quality, etc.)
- We really did not get into oxygen supply (aeration system). I’ll certainly give extra credit for providing information about aeration requirements(e.g., as in Example 12.2 in the text). At a minimum, note the presence and location of blowers to supply large volumes of air.
- Secondary clarifier design: Shape, volume, dimensions, sludge collection apparatus, operating parameters (detention time, surface loading rate, etc.)
- Volume and mass of sludge from secondary clarifier; solids content; annual average and peak day
- Characteristics of mixed sludge: volume, solids content, specific gravity
- Nitrification units: Shape, volume, dimensions, operating parameters (detention time, surface loading rate, expected effluent quality); chemical consumption.
- Chemical storage and delivery for pH control in nitrification unit.
- Denitrification units: Shape, volume, dimensions, operating parameters (detention time, surface loading rate, expected effluent quality); methanol consumption
- Anaerobic digestion: Include simple process design based on DA-9. Include info on shape, volume and dimensions of the digester.
- Indicate the expected flow and composition of offgas from the digester
☐ Account for disposal of methane by some means. (Consider something clever like generating CO₂ to supply the recarbonation step in the P-Removal process.

☐ Include appropriate thickening/dewatering operations. You need not size the equipment, but specify what type(s) you use, where it will be housed, etc.

☐ Your mass-balance on the solids will clearly indicate the volume and mass of solids to be sent to final disposal.

☐ Remember that final sludge offloading site mentioned above.

☐ Include a disinfection step for the effluent with the corresponding needed equipment.

☐ Consider the need for dechlorination, especially with a small, salmonid-bearing receiving water. If you include dechlorination, specify the chemical used, and not the presence and location of the unit.