CVEN 5534, Fall 2010

Homework 2 Solutions

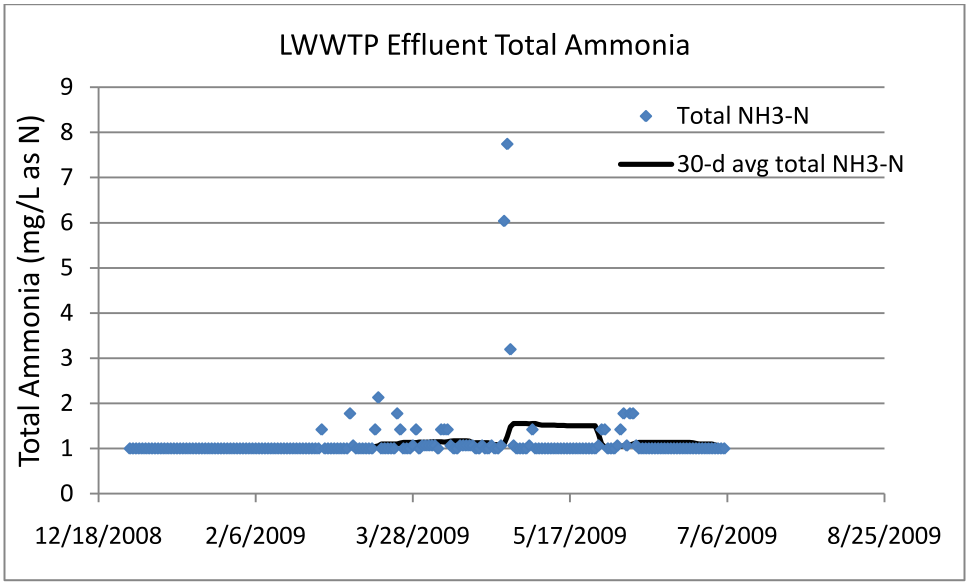
1. a. WWTPs keep record flow data more or less continuously so the average daily influent flow (“InfAvgFlo”) is the average of the flow measurements throughout a given day. The maximum daily flow is the highest daily average value over the period of record, and the average daily flow is the average of all the “InfAvgFlo” measurements reported. The maximum month average day (MMAD) is the average daily flow during the month with the highest average daily flow rate. In general plant capacity is rated in influent flow, not effluent. The reason for this is that plants must be designed to handle influent flow. Effluent flow rates are lower than influent due to losses of water primarily with sludge removal. Average daily flow values are used for almost all secondary process unit sizing. Clarifiers are designed to handle peak flows. For the Longmont WWTP data set

Parameter	MGD
Average daily flow	7.1
Maximum daily flow	9.7
MMAD (June)	7.7

Comments: The difference between the average and maximum daily flow are an indication of a flow peaking factor with a duration of a day or longer and the MMAD is an indicator of a seasonal peaking factor. The MMAD has been used for secondary process unit sizing with an hourly peak flow also used in clarifier design. At Longmont, the difference between the MMAD and the average daily flow is about 10%, indicating consistent wastewater flows and probably little infiltration/inflow even suring the high runoff period in June. The average maximum flow (~hourly peak) is 10 MGD, indicating a short-duration flow peak of 1.43, which is very moderate.

b. Influent COD:TBOD ratio calculated from averages of the measurements of the two parameters = 2.53, which is about 10 to 70% higher than reported typical values between 1.5 and 2.3. Explanations include either soluble or particulate organic matter in sewage which is not rapidly biodegradable under the conditions of a 5-day BOD test. That could be components like oil and grease from restaurants and cafeterias, industrial wastes like solvents and degreasers (although hopefully they would not comprise a large fraction of influent organics). There could be toxic organic compounds. Again one would hope not in the concentration that would produce a high COD:BOD ratio. One of the students in class, Mitch Clement, offered an excellent hypothesis: that the readily degradable matter in the sewage was degraded in the collection system before it reached the plant, and supported his explanation by evaluating the association of the COD:TBOD to flow. A few people mentioned agricultural drainage and nutrients to account for higher-than expected COD. First, the COD test does not measure nitrogen, phosphorus or salts, the commonest constituents of ag drainage. Second, what little agricultural drainage is generated in rapidly urbanizing Longmont would probably not find its way into a sanitary sewer.

c. Graph of total effluent ammonia (NH4-N + NH3-N) daily and 30-day average values are shown below.



General formula for going from water quality standard to permit limits:

Where C_w and Q_w are wastewater treatment plant ammonia-nitrogen species concentration and plant normalized effluent flow rate, respectively; C_{us} and Q_{us} are ammonia-nitrogen species concentration and normalized stream flow rate upstream of the plant discharge, respectively; C_{ds} and Q_{ds} are ammonia-nitrogen species concentration and normalized flow rate downstream (after discharge), respectively.

Upstream total ammonia-N (mg/l)[1]	0.53
Upstream unionized NH3-N (mg/l) [1]	0.026
Acute Water quality standard total ammonia (C_{ds}, mg/l)	8.4
Chronic Water Quality standard unionized ammonia (C_{ds}, mg/l)	0.06
WWTP average total ammonia-nitrogen (mg/l)	1.13
WWTP maximum 30-day average total ammonia-nitrogen (mg/l)	1.56
Calculated WWTP avg unionized NH3-N (mg/l)	0.07
Calculated WWTP max. 30-day average unionized NH3-N (mg/l)	0.09

[1] average from CDPHE stream water quality sampling, LWWTP permit rationale.

Normalized flows:
$Q_w = 1$; $Q_{us} = 0.54$ (low flow condition), $Q_{ds} = 1.54$

To meet acute standard = 8.4 mg/L total ammonia nitrogen, 30-day average effluent ammonia nitrogen must be less than:

This is no problem for the Longmont WWTP to meet the acute WQS for ammonia. This highest ever reported daily value for total ammonia nitrogen is 7.74 mg/l, and more relevant to the permit, the highest 30-day average value was 1.56 mg/l, significantly below where a WQS-based effluent limit would be set.

The chronic standard is another story.

The chronic limit would be associated with a total effluent ammonia limit of 1.3 mg/l. The plant average total ammonia nitrogen is 1.1 mg/l about 15% less than the WQBEL. More important their 30-day average total ammonia nitrogen exceeded the WQBEL for 29 days in April-May 2009. **Meeting a new WQBEL based on the chronic ammonia standard could be very problematic for the plant.**

d. For nitrate, the upstream average nitrate-nitrogen concentration is 3.2 mg/l, and the calculated new WQBEL for NO3-N is:

The 30-day average for NO3-N exceeded 13.7 mg/l for 25 days in April 2009, not surprisingly when ammonia was low. Also, the overall average effluent NO3-N for the entire data period was 13 mg/l – only 5% lower than the standard. Moreover, the 30-day average effluent nitrate nitrogen exceeded the WQBEL of 13.7 mg/l on 25 days in April 2009. With current treatment, the plant is in kind of a double bind. As they get better at meeting stringent ammonia WQBEL, their nitrate levels will increase. If a 10 mg/l NO3-N WQS were adopted – for example if there was a possibility for the St. Vrain getting a designated use as a drinking water supply, it would be very difficult for the Longmont WWTP to meet the new WQBEL for nitrate.

e. Effluent fecal coliform has two permit limits: 30-day average < 251 CFU/100 ml and 7-day average < 502 CFU/100 ml. The plant would have no problem meeting either of these standards, as well as new standards based on E. coli, by either conversion estimation method.

WWTP Data	Fecal Coliform	E. coli (0.63 conversion)	E. coli (0.77 conversion)
Plant effluent fecal coliform (avg CFU/100 ml)	28	18	22
Plant effluent fecal coliform (max 30-d avg CFU/100 ml)	60	38	46
Plant effluent fecal coliform (max 7-d avg CFU/100 ml)	117	74	90

Estimated discharge E. coli limits for 30-day average based on conversion of 251 CFU/100 ml fecal coliform limit would be 158 CFU/100 ml or 193 CFU/100 ml, depending on which conversion factor was used. For the 7-day average effluent limit, 502 CFU/100 ml fecal coliform, the new 7-day averages would be316 CFU/100 ml or 387 CFU/100 ml depending on which conversion factor was used. **In all cases: 30-day and 7-day average effluent limits, regardless of conversion factor used to estimate E. coli, the Longmont WWTP would have no problem meeting an E. coli based limit, just as it has no problem meeting the current fecal coliform limit.**

2. Factors to consider (by no means an exhaustive list).

Technology-based effluent limits (TBELs):

Merits	Problems
Typically national standards which are uniform and easy to understand (and hard to contest)	Do not consider unique receiving water conditions
Achievable with available technology which could consider secondary and tertiary treatment	May induce complacency with current technology
Historically have produced improved water quality	May not protect very high quality waters with anti-degradation goals
Consistency produces equal cost burdens on public treatment works	May not be easy to lower standards once they are set
Non-point source pollution not factored in – WWTPs responsible only for their own effluent	New designated uses such as water reuse are hard to add into permit limits. They become voluntary
Some improvements such as energy conservation, nutrient recovery, are technology based and could be encourage by TBELs	

Water quality-based effluent limits (WQBELS)

Merits	Problems
Based on scientific knowledge of physical, chemical, biological, ecological factors in particular stream	Require significant investment in research and many factors and combination of factors may be neglected. Example, alkalinity significantly changes toxicity of heavy metals.
Incorporate designated use for most waters (except antidegradation waters) which recognizes human factors	Changes to designated use offers opportunity to downgrade receiving water quality due to economic or social pressure
WQBELs can change to incorporate new science	Frequent changes (e.g., over 5- or 7-year permit cycle can impose significant hardship on WWTPs where major process changes take place over decadal or longer cycles.
Could inspire new technology based on emerging standards or contaminants	
Adding new contaminants can be done on a local level	Research costs linking contaminants to impacts would be borne locally
Non-point source (NPS) pollution may be factored in explicitly	Utilities bear the cost burden of NPS