Use of Periphytic Chlorophyll a in Application of AQUATOX in the Lower Boise River TMDL Analysis

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The representation of periphyton biomass for an entire reach by AQUATOX and the conversion of the USGS periphyton samples from pebbles in the Lower Boise River are consistent with the established procedures for determining periphyton biomass in the field (Stevenson and Bahls 1999).

Observed Data

The periphyton data were normalized to total unit area by multiplying by the percent substrate greater than sand-sized at a given site based on available pebble-count data. The pebble-count information for each site was provided by Dorene MacCoy. Conversion of the observed data enables comparison with model results given for an entire reach.

On 4/29/2013 Tom Dupuis wrote:

"Attached is the pebble count data that was used to normalize the measured periphyton data, this is the same data that showed on the screen in the last modeling meeting. On the "Overall Summary" sheet I've added an example of how the pebble counts were used to normalized measured data, namely, the fraction of the reach that was greater than sand and silt was simply multiplied by the measured data. For example, at Eckert, the measured value for this example event was 94 mg/m2, and 81% of the site was greater than sand and gravel, and so the normalized value was 81% of the measured value, or 76 mg/m2."

Table 1

Pebble Count		Eckert Rd	Glenwood	Middleton	Ft Boise WMA
Mean % size class		11/18/1997	2/27/1995	11/24/1997	1/26/1998
Mean % very large boulders	4096-2048 mm	0.00	0.00	0.98	0.00
Mean % large boulders	2047-1024 mm	0.00	0.00	0.00	0.00
Mean % medium boulders	1023-512 mm	0.00	0.00	0.00	0.00
Mean % small boulders	511-256 mm	1.68	0.62	0.00	0.00
Mean % large cobbles	255-128 mm	36.44	14.27	2.00	0.69
Mean % small cobbles	127-64 mm	29.10	33.91	14.43	7.59
Mean % very coarse gravel	63-32 mm	8.88	20.25	17.54	19.07
Mean % coarse gravel	31-16 mm	3.34	4.11	9.13	16.96
Mean % medium gravel	15-8 mm	1.45	5.83	5.36	8.70
Mean % fine gravel	7.9-4 mm	0.27	0.00	2.08	0.79
Mean % very fine gravel	3.9-2 mm	0.00	0.00	5.48	0.00
Mean % sand	1.9-0.062 mm	18.84	21.03	38.40	29.80
Mean % silt	<.062	0.00	0.00	4.61	16.41
% substrate greater than sand and silt		81	79	57	54
chl a (mg/m2) measured in Oct. 2005 in *riffles*		94	158	93	162
chl a (mg/m2) for *reach* (normalized by pebble count)		76	125	53	87
deconstructed chl a (mg/m2) for riffles		94	158	93	162

Sampling only the riffles is consistent with EPA guidance. "Variability due to differences in habitat between streams may be reduced by collecting periphyton from a single substrate/habitat combination that characterizes the study reach (Rosen 1995). For comparability of results, the same substrate/habitat combination should be sampled in all reference and test streams. Single habitat sampling should be used when biomass of periphyton will be assessed." (Stevenson and Bahls 1999)

Model Representation

AQUATOX is an ecosystem model that simulates all biotic and abiotic constituents in each riverine reach. It is required to maintain mass balance, accounting for all changes in concentrations of nutrients, algae, invertebrates, and fish. Its application cannot be restricted to only one part of a reach such as a riffle. Park and Clough (2012) state:

"Therefore, when modeling streams or rivers, animal and plant habitats are broken down into three categories: 'riffle,' 'run,' and 'pool.' The combination of these three habitat categories make up 100% of the available habitat within a riverine simulation. The preferred percentage of each organism that resides within these three habitat types can be set within the animal or plant data. Within the site data, the percentage of the river that is composed of each of these three habitat categories also can be set.

"Limitations on photosynthesis and consumption are calculated depending on a species' preferences for habitats and the available habitats within the water body. If the species preference for a particular habitat is equal to zero then the portion of the water body that contains that particular habitat limits the amount of consumption or photosynthesis accordingly. " The construct in AQUATOX is given in Equation 13 (Park and Clough 2012):

$$HabitatLimit = \sum_{Preference_{habitat}>0} \left(\frac{Percent_{habitat}}{100} \right) \tag{13}$$

where:

$HabitatLimit_{Species}$	=	fraction of site available to organism (unitless), used to limit ingestion, see **(91)**, and photosynthesis, see **(35)**, **(85)**;
$Preference_{habitat}$	=	preference of animal or plant for the habitat in question (percentage); and
$Percent_{habitat}$	=	percentage of site composed of the habitat in question (percentage).

Data "which is generally collected in a specific habitat type, cannot be used as input to AQUATOX until these values have been converted to represent the entire surface area. This is especially true in modeling habitats; for example, an animal could have a high density within riffles, but riffles might only constitute a small portion of the entire system." (Park and Clough 2012)

So implementation of the model requires that it represent average conditions for an entire reach. However, being averaged across habitats would be misleading for application in criteria analysis. Excessive periphyton growth has a direct bearing on aquatic life uses. "Recreational beneficial uses also apply to the Lower Boise River, and periphytic chlorophyll-a data are a direct indicator of algae, which can be a nuisance and affect recreational uses. Nuisance thresholds described in the literature for chlorophyll-a are useful as a baseline comparison to determine the degree of impairment." (U.S. Environmental Protection Agency Region 10 2008)

"Aesthetic impairment… usually is associated with filamentous algal forms. Nuisance levels may be reached somewhere between 100 and 200 mg/m^2 chlorophyll (Horner et al. 1983, Nordin 1985, Welch et al. 1988, Quinn 1991). Enriched waters often have benthic chlorophyll concentrations >150 mg/m^2, and many stream users find high levels of algal growth objectionable." (Dodds and Welch 2000)

Therefore, perceived nuisance levels are important rather than the average conditions represented by the model. The solution is to deconstruct the simulation results by saving the output to Excel and reversing the calculations used in normalizing the data. The last row in Table 1 exemplifies this by dividing the normalized result in the next-to-last row by the pebble count data.

In closing, we should consider the ways in which the data and model results are used in the initial calibration and verification and in the final application. In evaluating model results and assessing uncertainty, plotting individual samples against daily simulated results is most useful (Figure 1). However, mean values of observed periphytic chlorophyll a probably should be used as indicators of nuisance conditions. Furthermore, weekly means of simulation results probably are the equivalents of mean observations; due to sporadic localized sloughing, temporal variation in the model can be used as the equivalent of or surrogate for spatial variation observed in the field. The model can easily be set up to integrate the results on a weekly, biweekly or other temporal basis.

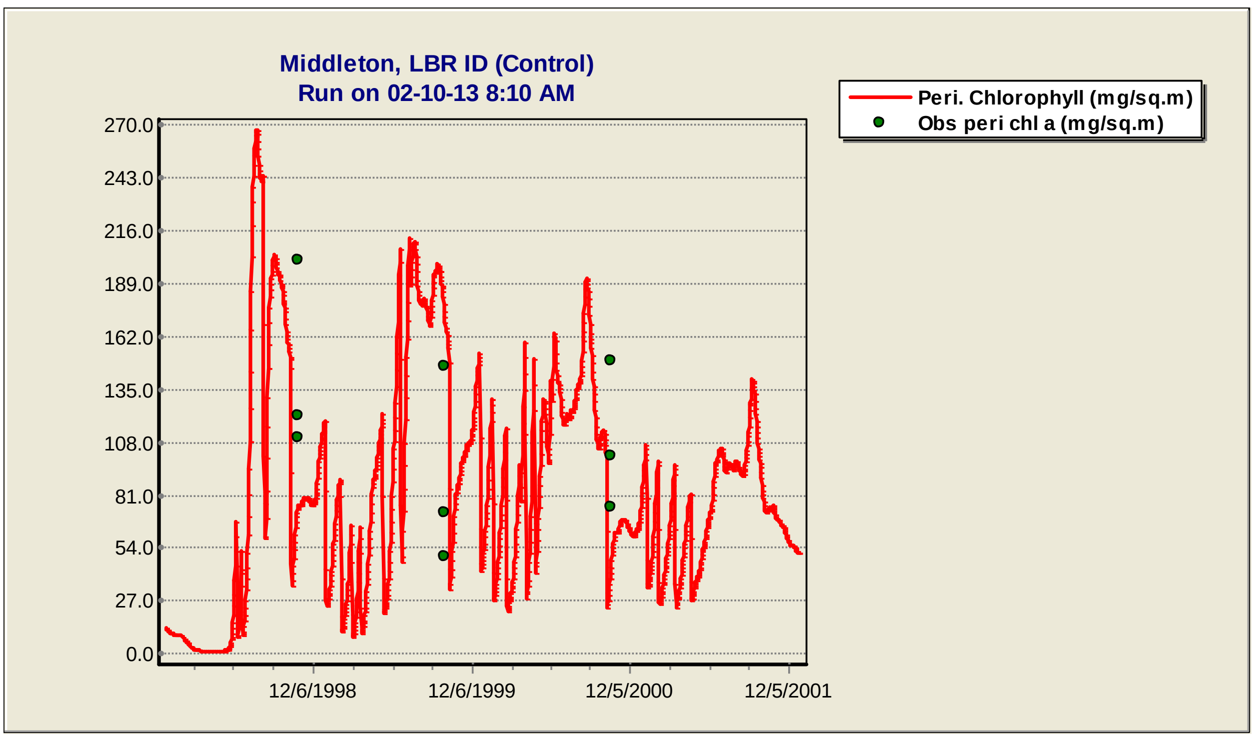

Figure 1. Simulation results shown on a daily basis. Observed data are normalized using pebble counts.

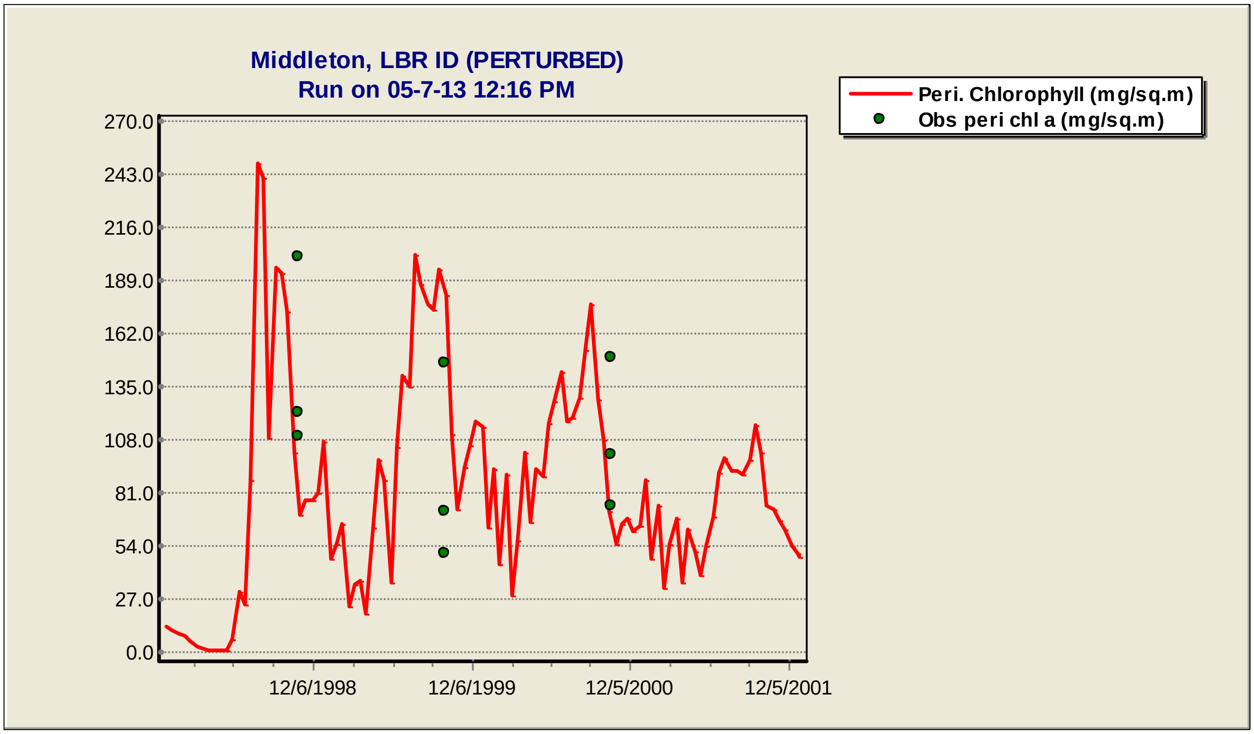

Figure 2. Simulation results integrated over a biweekly period.

References

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