Sewage Treatment Project Assignment

To get started on the project, go to these Internet sites for some additional background information:

http://www.shodor.org/refdesk/Resources/Activities/DissolvedOxygen/lesson.php

http://www.shodor.org/refdesk/Resources/Activities/DissolvedOxygen/materials.php

The second link will allow you to open a java applet which runs a simple version of the model. Use the applet to get some idea of the relationships among temperature, BOD load, and the nature of the DO sag curve.

You should start out by trying to program this simple DO model into MATLAB or Python. You can match the equation structure in the original model. For our example we will use a stream in Northeast Ohio called Sugar Creek where the main water pollution comes from the Brewster Village sewage treatment plant. That takes weighted averages of several quantities:

BOD_Start_ = (Sewage_Flow_*BOD_Sewage_+BOD_Stream*Stream_Flow)/(Sewage_Flow_+Stream_Flow)
For Brewster Village STP:
BOD_Sewage_ = 33
BOD_Stream = 5.95
Sewage_Flow_ = 25*10^5
Stream_Flow = 66.79*10^5

Initial_DO = (DO_effluent*Sewage_Flow_+DO_stream*Stream_Flow)/(Sewage_Flow_+Stream_Flow)

The BOD and DO for each time period is dependent upon that for the previous period:

BOD(t) = BOD(t - dt) + (- BOD_effects(t-1)) * dt
BOD_Effects(t) = (BOD_Decay_Rate*BOD(t-1))
Aeration = Reaeration_coef_*(DO_Saturation-Dissolved_Oxygen(t-1))

The DO at time t is:
Dissolved_Oxygen(t) = Dissolved_Oxygen(t - 1) + (Aeration - BOD_Effects(t-1)) * dt

Where:
dt is the time period for each time increment. In the java model this is 0.1 days.

The initial BOD level is the BOD_start level above

The other constants for this stream are:
BOD_Decay_Rate = .16
Channel_Depth = 0.1953768
Channel_Velocity = 0.3
DO_effluent = 6

For the java model, the Reaeration coefficient was calculated from this formula:
Reaeration_coef_ =
(5.026*(Channel_Velocity)^0.969*((Channel_Depth)^1.673)*2.31))*(1.025^(Temp_Stream_-20))

The critical period for the stream is in the summer when the water has the warmest temperature since the ability of the water to hold DO called the DO Saturation level is inversely related to temperature. The typical summer temperatures for a small stream range from 20 – 25 degrees centigrade. The DO Saturation was put in as a lookup function related to temperature. The more complete way to calculate this value can be found at:

http://waterontheweb.org/under/waterquality/oxygen.html

Here is the lookup function where the first number represent temperature and the second is the DO saturation level at that temperature (centigrade):

DO_Saturation = GRAPH(Temp_Stream_)
(0.00, 14.6), (1.00, 14.2), (2.00, 13.8), (3.00, 13.5), (4.00, 13.1), (5.00, 12.8), (6.00, 12.4), (7.00, 12.1), (8.00, 11.8), (9.00, 11.6), (10.0, 11.3), (11.0, 11.0), (12.0, 10.8), (13.0, 10.5), (14.0, 10.3), (15.0, 10.1), (16.0, 9.87), (17.0, 9.67), (18.0, 9.47), (19.0, 9.28), (20.0, 9.09), (21.0, 8.91), (22.0, 8.74), (23.0, 8.58), (24.0, 8.42), (25.0, 8.26), (26.0, 8.11), (27.0, 7.97), (28.0, 7.83), (29.0, 7.69), (30.0, 7.56), (31.0, 7.43), (32.0, 7.31), (33.0, 7.18), (34.0, 7.07), (35.0, 6.95), (36.0, 6.84), (37.0, 6.73), (38.0, 6.62), (39.0, 6.52), (40.0, 6.41).

You can find a lot of additional information in the manual for a very complex EPA DO model called Qual2E. The manual for that model shows the choices for many of the constants and parameters as well as a calculation strategy for the model. There are parts of the mathematics you probably will not understand but the instructors can point you to the sections that will be helpful in your model. There are also several other electronic documents with descriptions of related DO models.

Once you have the basic model running, you should add at least several of these capabilities:

1. Comparison graphs that allow you to compare scenarios for different stream temperatures, BOD loads, and BOD treatment levels.
2. Use the data in the spreadsheet DO data.xls to validate your model. The data are actual DO readings downstream of the sewage treatment plant. You will need to select data for summer period that matches the critical period you are simulating. How do your model results compare to the range and averages presented for that period by the monitoring data?
3. A way to add additional point sources to the model at different places along the stream.
4. A set of equations to represent oxygen added back by plants (see biomass calculations in the Qual2E model.
5. Adding a non-point stormwater load to the model at a specific point.
6. Now let's use the model to test a scenario for future development. Let's hypothesize that growth in Stark County in and around the Village of Brewster may cause a major increase in development and future demands on the waste treatment plant. If the plant were expanded to accommodate an average of an additional 5.5 cfs of flow and the same BOD concentrations, what would happen to the DO in Sugar Creek? Would the changes be acceptable? What if the plant upgrade were to reduce the concentration in pollutants by an additional 25% over the current values? Would this be acceptable? Finally, what if the development were channeled into a different area of the county and was to discharge instead at Beach City – an additional 1.1 miles downstream. Put an additional point source further downstream to represent this case, with the appropriate increment of point source loads and concentrations.