Memorandum

May 8, 2003

To: Curtis DeGasperi
King County Department of Natural Resources and Parks

From: Tim Kraft, Rob Annear, and Scott Wells
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RE: Green River Model Simulation; Data Gap Identification

King County provided a large majority of the data used in this project in database files. These data have been reviewed to determine data gaps during the model calibration period, and to determine how complete the data are for running the model between 1995 and 2002. This memo summarizes the available data, identifies data gaps, and identifies the model calibration period determined from this data analysis. This data gap analysis will also be provided in the Data Report.

1. Flow and Stage Data

Flow data has been obtained in 15-minute intervals for Green River at Palmer (the upstream boundary condition), Crisp Creek, Newaukum Creek, and Big Soos Creek. These data are complete, except for small periods, which can be filled in by CE-QUAL-W2 using interpolation.

HSPF model output has been provided for Mill Creek, Auburn Creek, Mullen Slough, and Midway Creek. This information set is complete between 1995 and 2002.

Stage data at USGS gage 13113500, near Tukwila, are available in hourly time intervals for the entire period, except for a period of missing or bad data from May 24, 1995 to May 8, 1996. Methods of estimating data for this time period are still being reviewed.

2. Temperature

Temperature is the limiting factor in determining the model calibration period. Table 1 shows the temperature monitoring done between 1995 and 2002, and Table 2 shows the monitoring stations used at each boundary and tributary location, along with the time period temperature was monitored for that station. Note that Table 2 does not address individual gaps within those time periods.

Table 1: Temperature data summary								
Location	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
U/S Boundary	May - Nov	Jan - Nov	None	None	None	None	Apr - Dec	Jan-Sept
D/S Boundary	June - Dec	Jan - Dec	Jan - Dec	Jan - Dec	Jan - Dec	Jan	None	None
Newaukum Creek	None	July - Dec	Jan - Dec	Jan - Oct	None	None	July - Dec	Jan - Sept
Crisp Creek	None	None	Oct - Dec	Jan - Dec	Jan - Dec	Jan - Dec	Jan - Dec	Jan - Aug
Big Soos Creek	Jan - Dec	Jan - Dec	Jan - Dec	Jan - Dec	Jan - Dec	Jan - Dec	Jan - Dec	Jan - Aug
Mill Creek	None	None	None	None	Oct - Dec	Jan - Dec	Jan - Dec	Jan - Aug
Mullen Slough	None	None	None	None	None	None	None	None
Auburn Creek	None	None	None	None	None	None	None	None
Midway Creek	None	None	None	None	None	None	None	None

Table 2. Temperature gages at modeling locations			
Location	**Time Period of Data**	**Monitoring Station**	**Missing Data Periods**
Green River Upstream Boundary	May 1995 – Nov. 1999	KC gage at Black Diamond (WHI)	Dec 1999 - April 2001
	July 24, 2001 – Aug. 2, 2002	GDWQA at Whitney Bridge (GRT10 and GRT10_2)	
	Apr 2001 – Sept 2002	UW Gage (GR3-4)	
Downstream Boundary	June 1995 – Nov 1996 Jan 1996 – Jan 2000	KC Gage (BIC) USGS Gage (12113390)	January – June 1995 February 2000 – Dec 2002
Crisp Creek	Oct 1997 – Aug 2002	KC gage at mouth (40d)	1995 to Sept. 1997
Newaukum Creek	July 1996 – Oct 1998 July 2001 – Sept 2002	USGS gage (12108500) GDWQA gage (GRT09)	Nov 1998 to June 2001
Big Soos Creek	Oct 1994 – Aug 2002	KC gage (54A)	Data set is complete
Mill Creek	Oct 1999 – Aug 2002	KC gage (41a)	1995 to Sept 1999
Mullen Slough	July 1996 – Nov 1996	KC gage (FRA)	Nov 1996 to Dec 2002

Based upon information in these 2 tables and the temperature data constraints, the model will be calibrated for 2 different time periods: May 1995 through November 1996, and April 2001 through July 2002.

To calibrate the model for November 1996 through April 2001, temperature data are needed for the upstream boundary and for Mill Creek.

Table 3 summarizes the temperature data gaps for each model calibration period. It's important to note the difference between the missing data listed in Table 2, and the data listed in Table 3. The missing data in Table 2 are where temperature was not monitored; the data gaps in Table 3 are when either temperature was not monitored, or there is bad or missing data within the monitoring period. Table 3 lists data for the model calibration periods, where Table 2 lists missing data between 1995 and 2002.

Table 3. Temperature data gaps for model calibration periods		
Location	**May 1995 - Nov 1999**	**April 2001 - July 2002**
Green River Upstream Boundary	May 1, 1996 - June 7, 1996 July 26, 1996 - Aug 13, 1996	June 20, 2001 - July 24, 2001 Oct 17, 2001 - Nov 16, 2001 Feb 22, 2002 - March 14, 2002
Downstream Boundary	May 1, 1995 - May 24, 1995 Nov 21 1996 - Nov 30, 1996	No data available
Crisp Creek	No data available	Data set is complete
Newaukum Creek	May 1995 - July 1996	April 1, 2001 - July 23, 2001 Oct 25, 2001 - Mar 14, 2002
Big Soos Creek	Data set is complete	Data set is complete
Mill Creek	No data available	Data set is complete
Mullen Slough	July 1996 – Nov 1996	No data available
Midway Creek	No data available	No data available
Auburn Creek	No data available	No data available

Temperature data gaps in Table 3 will be filled by establishing a correlation with data from the same time period in other years, or with data from the same year from nearby tributaries. Mill Creek temperature data will be used for Mullen Slough, Auburn Creek, and Midway Creek for the 2001-2002 data period. For the downstream boundary in the April 2001 - July 2002 calibration period other gages will be looked at, including GRT01, GRT30, and GRT31, which are farther downstream on the Duwamish River.

3. Water Quality

Table 4 lists the water quality constituents to be modeled. Monthly samples are available for all constituents except chlorophyll A, used for modeling nutrients and eutrophication processes. For the rest of the constituents monthly samples are available for 1995 through 2002 for the boundary conditions and all tributaries except Mullen Slough, Mill Creek, and Auburn Creek.

Table 4. Water Quality Constituents	
DO, Dissolved Oxygen	Residence time
NH3, Ammonia	Inorganic Carbon
NO2-NO3, Nitrite-Nitrate	Conductivity
PO4, Ortho-phosphorus	pH
Organic Matter - LDOM, RDOM, LPOM, RDOM	Alkalinity

4. Recommendations for additional data collection

Flow data are readily available for boundary conditions and tributaries, but the only available calibration location is the USGS gage at Auburn (1211300). Having additional flow information downstream, while staying above the tidal affects, would be helpful.

Temperature data are the limiting factor in available model data. King County has begun a more aggressive temperature collection study, and this is helpful for calibrating the model in years 2001 and 2002. Temperature data at the downstream boundary was discontinued in January 2000. Additional data would be useful at this location. Monitoring temperature farther downstream from Auburn (but still upstream from tidal affects) would be helpful for model calibration.

For the future, to improve the model calibration the upstream boundary condition of the model should be moved upstream to the gage station just below the Howard Hanson Reservoir (USGS: 12106700). This location will provide a more accurate boundary condition with flow, temperature and water quality data. Additionally it would allow model development and calibration to better characterize groundwater inflows to the river. Additional gage stations measuring stage and discharge along the Green River would provide more model calibration points and further identify where groundwater is entering the system and would provide a better understanding of the flows and tidal influences at the downstream model boundary. Moving the upstream boundary condition to below Hanson Reservoir would require additional bathymetric data to develop the model grid.

There are limited data on dissolved organic carbon and total organic carbon and no data measuring BOD_5, CBOD or chlorophyll a. Characterizing the organic matter and algal production is important in modeling the nutrients and eutrophication processes. Periodic grab samples of organic matter compartments and chlorophyll a in the Green River and major tributaries would be useful for the modeling effort.

Since flow data are minimal within the model domain, a dye study would be necessary to verify model travel times and dispersion characteristics. This would allow a much better check on the model predictive ability than currently exists. This is a very important part of river model development and should be performed at high and low flows.

To summarize, we recommend that the following additional data be developed to improve our understanding of the Green River system:

- Hydraulic and travel time data – provide another location for checking the flow rate within the model boundary or at the end of the model at the tidal boundary; perform a dye study to verify model hydraulics/travel time
- Temperature data – need to provide temperature data at lower tidal boundary. This may though not be important if flow does not reverse at the tidal boundary.
- Model development – extend the model to Hanson Reservoir
- Organic data – take systematic BOD_5/COD/TOC data to determine of this is an important source of oxygen depletion in the system
- Algae data - take systematic algae data to assess importance of algal blooms in the lower river