APPENDIX C

Proposed Storm Event Delineation Method for the Green-Duwamish Watershed Water Quality Assessment

Herrera Environmental Consultants, Inc.

Memorandum

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Subject	Proposed Storm Event Delineation Method for the Green–Duwamish Watershed Water Quality Assessment

The water quality assessment requires delineation of hydrographs into storm and base flow events for categorizing water quality sampling events. A method for defining storm events has been developed by separating base flow from the hydrograph, and then defining a storm event as the period when total flow exceeds base flow by a specified percentage. Various methods for estimating base flow have been used by others (e.g., HYSEP by USGS). With any method, estimation of base flow is a subjective process. HYSEP, for illustration, incorporates three alternative hydrograph separation methods but does not recommend the use of any particular method. The HYSEP program documentation cautions that "although HYSEP consistently applies various algorithms that are commonly used for hydrograph separation, hydrograph separation remains a subjective process."

The method described below was developed specifically for the water quality assessment using 2001 and 2002 discharge data for 11 stream gauging stations. This method uses a permutation of the sliding-interval method described in the HYSEP documentation. Specifically, it assigns a preliminary base flow equal to the minimum flow over a 3-day window, and then adjusts the base flow and identifies storm periods based on the following user input variables:

1. Starting base flow rate (cfs) if the initial flow value is missing from the hydrologic record
2. Maximum percent increase per day in base flow
3. Maximum amount (cfs) of increase per day in base flow
4. Minimum percent that the maximum daily discharge must exceed the daily average base flow rate to be categorized as a storm event.

In applying this method, user input variables were determined using daily maximum flow data for each of the 11 stream gauging stations. Daily data, rather than 15-minute data,

are used to assign base flow separation parameters because base flows are stable and can appropriately be assessed on a daily time step. In addition, daily data allow for efficient visual evaluation of storm delineation results for the entire 2-year period of record.

Initially, the average daily base flow rate is estimated as the minimum flow rate over a 3-day period, including one day prior and one day after the time step being evaluated. The method requires an input variable for starting the base flow rate if the first record is missing from the 2001/2002 data set. The starting base flow rate is normally estimated as the minimum base flow rate calculated for the period of record, but may be higher if the flow record appears to begin in the middle of a storm event already in progress.

The base flow rate is then subject to a user-defined daily maximum increase of 20 percent. The 20 percent maximum increase was selected from an initial range of 5 percent for large basins to 20 percent for small basins. However, increases of less than 20 percent result in a storm events that exceed a period of 30 days for some basins, and a maximum increase of 20 percent was selected for consistency between all basins. Alternatively (or in addition), a maximum absolute amount (cfs) of increase in base flow is specified because the percent increase alone is too restrictive for hydrographs with zero or near-zero base flows. (The adopted methodology sets an arbitrary minimum baseflow of 0.04 cfs to minimize zero flow complications.) The maximum absolute amount of increase in base flow is normally estimated as 20 percent of the mean base flow rate calculated for the period of record.

Storm events are identified as the period during which flows exceed the estimated base flow by a user-defined amount of 15 percent. The 15 percent amount was selected from an initial range of 10 to 20 percent and a subjective evaluation of the hydrograph plots. In the recession portion of a storm hydrograph, this variable causes the transition from storm event to base flow condition to occur at the time step when the hydrograph recession rate falls to below 15 percent per day. The link to the hydrograph recession rate is the 3-day window (including one day forward) considered in the initial baseflow estimate. During periods of relatively stable flow, the variable causes very minor events (with base flow accounting for at least 85 percent of total flow) to be included as baseflow periods.

The hydrographs in Attachment 1 were developed using this method and the four input variables described above. For each of the 11 gauging stations, daily maximum flow rates are plotted with calculated daily base flow rates for the 2-year period. Storm flows are plotted separately. An output summary is also presented on the hygrographs that includes the number of days with missing flow records, the number of storm events, the maximum duration of storm events, and base flow and storm flow statistics (i.e., minimum, mean, and maximum values). Output data are summarized in a table preceding the hydrographs in Attachment 1.

A detailed evaluation of selected hydrographs was performed to verify that the input variables resulted in a reasonable separation of storm events during the wettest winter period. This evaluation included a comparison of the calculated base flow rate to the 15-minute discharge and precipitation records for two representative gauging stations over a 2-month period. The mouth of Soos Creek (Gage 54A) was selected to represent a large basin and the Green

WQA-Residential site (Gage 54C) was selected to represent a small basin. The 2-month period from November through December 2001 was selected to represent a period that was comprised of multiple storm events of varied size.

The 2-month hydrographs are presented in Attachment 2 for the mouth of Soos Creek and in Attachment 3 for the Green WQA–Residential site. The 2-month hydrographs are followed by a series of 2-year hydrographs with varied input variables. The 2-year hydrographs include the following changes in input variables for each gauging station:

1. No change in input variables

2. Increase from 15 to 20 percent for the minimum percent that the maximum daily discharge must exceed the daily average base flow rate to be categorized as a storm event

3. Decrease from 20 to 10 percent for the maximum percent increase per day in base flow (and the associated decrease in the maximum absolute amount of increase)

4. Increase from 20 to 30 percent for the maximum percent increase per day in base flow (and the associated increase in the maximum absolute amount of increase)

5. Increase from 20 to 50 percent for the maximum percent increase per day in base flow (and the associated increase in the maximum absolute amount of increase).