SBC LTER Stream Stage and Discharge Measurement Protocol

General Notes

Stream gauging stations are located at each site where water samples are regularly collected. There are a total of 30 gauged sites. At 27 of these sites, the SBC LTER has installed transducers in the stream to record pressure (i.e., pressure of water column above transducer plus atmospheric pressure) and temperature measurements at continuous 5 minute intervals. The pressure data are then converted to stage by subtracting the local atmospheric pressure at corresponding times. Next, the stage data are converted to discharge using a rating curve created by the U.S. Army Corps of Engineers' HEC-RAS program. For the other three sites, US Geological Survey (USGS) stream gauge data at a 15 minute temporal resolution are used. General site descriptions are detailed in the Site Descriptions folder.

Stage and Temperature Measurement

Stream stage is determined by subtracting the corresponding atmospheric pressure from the pressure measured by the stream transducers. The pressure transducers are manufactured by Solinst Canada LTD. The instruments used are the Model 3001 Levelogger Mini LT F5, F15 and F30. The pressure transducers are self-contained instruments that take pressure and temperature measurements at specific time intervals. For our project, a 5 minute interval is used. These measurements are recorded along with date and time in an internal data logger (at a 5 minute interval, data can be stored for 83 days). The pressure transducers communicate with a laptop and can be programmed and downloaded in the field. Data are collected every 1-2 months.

The pressure transducers are placed inside a steel perforated pipe welded to a flat steel bracket that is bolted to a boulder or concrete surface on or near the channel bottom.

The pressure measured by the stream transducer represents the combined weight of water and atmosphere above the transducer. This combined weight is separated to reflect only the height of water above the transducer by subtracting out a coinciding barometric pressure reading. These barometric pressure readings are also measured at a 5 minute interval so that each "5 minute" stream pressure reading is compensated by a corresponding "5 minute" barometric pressure reading. Three barometric pressure transducers are located throughout the study region so that they are near the gauging sites but out of the stream channels (4 sites are 6.4 to 11.3 km (4 to 7 miles) away, and the other 23 sites are less than 6.4 km (4 miles) away). They are placed in a sheltered area out of direct sunlight.

During the installation and collection process, the height of the water surface is measured manually from an established datum near the transducer (often the top of pipe, top of the bracket, staff gauge or adjacent channel bottom is used). These water surface heights are then used to adjust the compensated data set to reflect the actual height of water in the stream channel cross section. The installation and collection schedules, manual water surface height measurements, and compensation/adjustment details for each site can be found in the file "Transducer_Log.xls."

Occasional irrational spikes (single data points) in the data are removed and noted in the comments (approximately 0.015% of readings). The general accuracy of the compensated and adjusted data

is +/- 0.05ft, but can reach +/- 0.10ft at some sites. Refer to "Transducer Accuracy.doc" for a summary of the accuracy.

Procedure for Stage

The pressure transducer (pt) is programmed with site number, stream name and set to a fixed sample rate of 5 minutes (a single measurement is taken every 5-minutes). The pt is then placed inside the perforated pipe. The pipe is closed on each end with a plug. A manual stage or depth of water measurement is taken from an established datum. The pt is then left to collect data.

Before the pt is removed for data retrieval, another manual stage measurement is taken. The pt is then removed and the inside of the pipe is cleaned with a brush. The data are downloaded and checked to ensure that the pt is operating properly before being reinstalled.

The barometric pressure transducers are also set to take measurements every 5 minutes.

The pt data are compensated for barometric pressure by subtracting out the coinciding barometric pressure measurements. The data are then adjusted to the manual stage readings by taking the difference between the pt measurement and the manual measurement from the same time. This difference is then added to each data point. Either the manual reading taken at installation or at collection of the pt data is used. The other manual measurement (the one not used for adjustment) is then compared to the corresponding calibrated pt measurement. A difference of less than 0.10ft is considered acceptable.

Rating Curves

Rating curves for each pressure transducer site are calculated using the River Analysis System program (HEC-RAS) developed by the U.S. Army Corps of Engineers' Hydrologic Engineering Center. Stream cross sections and slopes are surveyed and entered into the HEC-RAS program along with stream channel roughness (Manning's "n"). Based on this information, HEC-RAS can calculate stream height and velocity for a given discharge at each cross-section. HEC-RAS software can be downloaded at: http://www.hec.usace.army.mil/software/hec-ras/hecras-download.html and the user's manual can be downloaded at: http://www.hec.usace.army.mil/software/hec-ras/hecras-document.html

The surveying is conducted using a Nikon AZ-1S Automatic Level, a 16ft fiberglass leveling rod, and a 100 ft tape measure. Cross sections are measured at various intervals, capturing the changes in stream geometry. Distances between cross sections are also measured. Each site has 5-15 cross sections. Manning's "n" is determined by recording the channel roughness characteristics for each cross section and then using references such as Chow's "Open-Channel Hydraulics" [Chow, 1959], Geological Survey Water-Supply Paper 1849 "Roughness Characteristics of Natural Channels" [Barnes, 1967], and Water-Supply Paper 2441 "Estimation of Roughness Coefficients for Natural Stream Channels with Vegetated Banks" [Coon, 1998].

The accuracy of the rating curves will be assessed in the future by comparing stage to measured stream discharges using the velocity-area method. The velocity area method involves multiplying measured stream velocities and stream cross-sectional area to obtain a discharge. A rotor or

electromagnetic current meter will b e used to make a series of velocity profiles across the stream. At very low flow, discharge may be measured using continuous or slug dilution methods.

Procedure for Discharge

Cross sections are surveyed at the transducer, staff gage, and at various intervals approximately 300ft upstream and downstream from the transducer. A permanent benchmark is located and marked as a reference point for future surveys. For each cross section, the 100 ft tape measure is stretched along a transect that is perpendicular to stream flow direction. The surveying level is set on a tripod, leveled, and a back site reading is taken from the benchmark using the leveling rod (a turning point is used if the distance between the benchmark and cross section is too far to obtain an accurate reading). The leveling rod is then moved along the cross section line. Elevation readings are taken at each break in slope and the distance along the transect is recorded. Notes on channel roughness are taken at this time. Bridge and culvert dimensions are also measured.

The survey data for each cross section are converted to x-y coordinates and entered into HEC-RAS with a corresponding reach length (distance between cross sections). Manning's "n" values are assigned to the cross sections (channel and overbank areas). Bridge and culvert dimensions are also entered. HEC-RAS then calculates the stage for a range of discharges, creating a rating curve that can be used to convert the measured stage readings to discharge. Rating curves for each site are located in the site description portion of our data.