

# Santa Barbara Coastal Long Term Ecological Research (SBC-LTER) Project Discharge Measurement Protocol

## Stream Gauging Stations

- Stream gauging stations are located in watersheds representative of the full range of land usage in southern Santa Barbara County (see <http://sbc.lternet.edu/sites>).
- A stream gauging site consists of a stream pressure transducer (SPT) placed within a sealed, perforated steel pipe. The pipe is attached to a bracket that is bolted to a fixed object within the stream (i.e. weir, bridge, large boulder, etc.).
- A staff gauge for visual recording of stage height often accompanies the SPT placement, and is either painted or bolted onto bridge infrastructure.
- Data are available for additional stream gauging stations located throughout Santa Barbara County. These stream gauging stations are operated by the U.S. Geological Survey's National Streamflow Information Program (NSIP) (<http://waterdata.usgs.gov/nwis/nwis>).

## Pressure Transducer Specifications

*Manufacturer:* Solinst Canada, Ltd.

*Models:* (Stream) 3001 Levellogger LT (F15, F30);  
(Atmosphere) 3001 Barologger LT (F5)

*Materials:* 316 Stainless Steel/Ceramic

*Battery Life:* 10 years

*Operating Temperature:* -20 to 80 °C

*Communication:* RS232 (Optical Infra-Red)

*Dimensions:* 22 mm x 125 mm

*Weight:* 160 g

*Resolution:* 1 cm

*Accuracy:* 0.1% FS (-10 to 40 °C)

*Maximum # Readings:* 24,000

*Temperature Sensor:* Spreading Resistance Silicon

*Temperature Range:* -20 to 80 °C

*Temperature Accuracy:* 0.1 °C

*Temperature Resolution:* 0.01 °C

## Pressure Transducer Operation and Data Collection

- 3 atmospheric pressure transducers (APTs) are used throughout the SBC-LTER study region.
- The maximum distance between an APT and corresponding SPT is 14.8 km, and is on average 7.3 km for all stream gauging sites.
- APTs are used in combination with the SPTs to obtain stage height:
  - The SPTs record absolute pressure (combined atmospheric and water pressure).
  - SPTs and APTs are synchronously programmed to collect instantaneous pressure and temperature every 5 minutes.

- Synchronizing data recording of the SPTs and APTs ensures collection of simultaneous pressure readings for the calculation of water pressure (stage height) at data collection time points: (atmospheric pressure + water pressure) – atmospheric pressure = water pressure.
- A manual stage reading (water level in reference to the top of the SPT pipe) is recorded during field data collection approximately every 2 – 2.25 months. This manual stage reading is used in subsequent data processing (described in Data Processing Protocol).

## Discharge Measurement

### I. Stream Gauge Station Surveys

- Survey equipment: Nikon AZ-1S Automatic Level, fiberglass leveling rod, multiple measuring tapes
- A permanent benchmark is identified for future surveys.
- Stream channel morphological profiles (perpendicular to stream flow direction) are surveyed at the SPT, staff gauge, and at various intervals approximately 100 m upstream and downstream from the SPT.
- Distances between successive cross-sections are measured.
- For each cross section, a 30 m tape measure is stretched across a transect that is perpendicular to stream flow direction.
- The automatic 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 and distance along the transect readings are taken at each break in slope.
- Notes on channel roughness are taken for each cross-section.
- Bridge and culvert dimensions, if present, are measured.

### II. Creating Rating Curves

- The U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center's River Analysis System (HEC-RAS) is used to create rating curves for each stream gauging station.
- Determinations of appropriate Manning's n values (a measure of the roughness of the bottom, or friction factor) for each cross-section are made using 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].
- Comprehensive information regarding operation of the HEC-RAS program may be found in the USACE HEC-RAS Applications Guide ([http://www.hec.usace.army.mil/software/hec-ras/documents/HEC-RAS\\_4.0\\_Applications\\_Guide.pdf](http://www.hec.usace.army.mil/software/hec-ras/documents/HEC-RAS_4.0_Applications_Guide.pdf)) and the USACE HEC-RAS Hydraulic Reference

### III. Manual Discharge Measurements

- **Discharge equipment:** Marsh-McBirney FloMate 2000 (electromagnetic flowmeter).
- Velocity-Area Method is used to manually measure stream discharge. This involves wading the stream to collect hydrologic measurements.
- The Velocity-Area Method involves multiplying measured stream velocity and stream cross-sectional area to obtain discharge (Q) as follows:

$$Q = \sum_{i=1}^n \left( \frac{d_{i-1} + d_i}{2} \right) w_i \bar{V}_i$$

Where

$$A_i = \left( \frac{d_{i-1} + d_i}{2} \right) w_i$$

Therefore

$$Q = \sum_{i=1}^n A_i \bar{V}_i$$

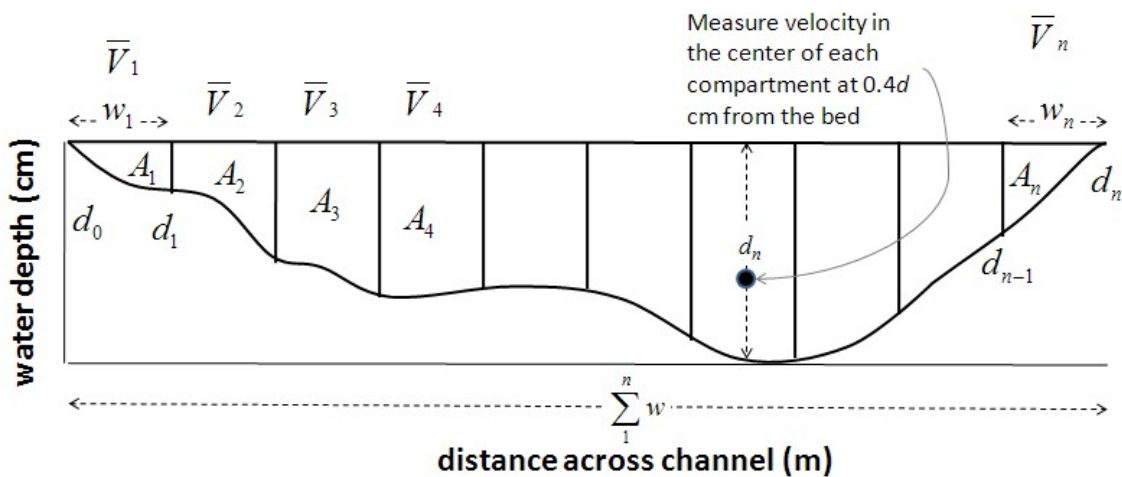


Image courtesy of Department of Earth Sciences, Montana State University

- Stage level is recorded at the time of manual discharge measurement with an engineer's rule.
- Manual discharge measurements are compared to rating curve discharge values (generated by HEC-RAS) for given measured stage levels, as detailed in the following example:
  - Stage level (manual measurement) = 0.20 m
  - Manual discharge measurement =  $10 \text{ L s}^{-1}$
  - Rating curve discharge @ 0.20 m stage level =  $12 \text{ L s}^{-1}$
  - Percentage error =  $(12 \text{ L s}^{-1} - 10 \text{ L s}^{-1}) / 10 \text{ L s}^{-1} * 100 = 20\%$
- Manual discharge measurements are taken during lower stream discharges in order to verify the accuracy of the HEC-RAS rating curve. For safety reasons, higher stream discharges preclude wading a stream for manual discharge measurement.
- If percentage errors are deemed significant, then either 1) the rating curve is modified or 2) a re-survey of the stream gauging site is performed and a new rating curve is generated using HEC-RAS.