



DISCHARGE MONITORING

MANUAL SALT DILUTION GAUGING



Salt dilution gauging is a method used to measure stream discharge (flow rate) that involves depositing (injecting) a known amount of salt (slug) into the stream and measuring its concentration at a downstream location. The process allows calculation of discharge based on the degree of dilution. It can be implemented over a large range of flows and does not require the technician to enter the stream. This summary focusses on manual slug injection using dry salt; however, other dilution methods exist, including slug injection of salt in solution, which can be automated (see related summary), slug injection using rhodamine dye (see related summary), and constant-rate injection of salt in solution.

SUMMARY OF METHOD

There are five main steps involved with discharge measurement using manual salt dilution gauging:

1. **Site selection:** Select a stream section (i.e., mixing reach) having a single channel with high turbulence and no major inflows, outflows, or storage zones between the injection (upstream) and measurement (downstream) points. It is ideal to have a constriction within the mixing reach.
2. **Inject salt:** Add a measured mass of table salt (NaCl) at the upstream point, injecting rapidly and ensuring it does not accumulate on the streambed.
3. **Recording:** Using an electrical conductivity probe, record conductivity at the downstream point over a regular time interval (e.g., 1 s) as the salt passes.
4. **Calibration:** Create a conversion coefficient by mixing in a bucket multiple increments of a known mass of salt in solution (using a pipette) with a known volume of water, and measuring the resulting change in conductivity.
5. **Data processing:** Use the coefficient to convert recorded conductivity into salt concentration over time. Applying the mass balance principle, compute discharge assuming the injected salt mass equals the mass measured downstream.

Photo credit: WaterSmith Research Inc.

IMPORTANT CONSIDERATIONS

Salt concentration is measurable in the stream through its effect of increasing the electrical conductivity of water. The method is complex and requires extensive training and experience, and a good understanding of flow hydraulics. Every site and flow level requires a unique decision on mass and location of salt injection. The data analysis is somewhat complex.

Full mixing of the salt across the stream is required at the measurement point. Generally, full mixing is confirmed when conductivity is recorded at different points in the stream (e.g., opposite banks) and the resulting discharge values are similar (e.g., within 5%).

The maximum measurable discharge is limited by the amount of salt that can be physically injected quickly. Measuring a discharge over 100 m³/s is possible under certain conditions (e.g., multiple technicians, rapid downstream mixing). A general guideline is to inject 0.5–2.0 kg of salt per 1 m³/s of flow.

Salt can be a contaminant in some streams, depending on the presence of sensitive organisms (e.g., early larval stages of freshwater molluscs). The risk is greatest for small streams. However, the optimal maximum concentration and exposure time of salt are very low, which limits the potential harm.

STREAM CHARACTERISTICS

- No lower limit on discharge that can be measured; upper limit is application specific (see Considerations)
- Well suited to highly turbulent flow
- Flatwater requires a long mixing reach (e.g., 25 wetted channel widths)
- Can be implemented under ice cover, but requires a longer mixing reach and can be complicated by slushy ice
- Not suited to streams losing substantial flow to the subsurface or with excessive pool storage

MEASUREMENT CHARACTERISTICS

- Manual data acquisition
- Integrated measurement across stream
- Point measurement along stream network
- Streams with naturally variable electrical conductivity require greater salt injection

SITE ACCESSIBILITY FACTORS

- Suitable for remote foot access
- Salt mass increases with increasing discharge
- Can avoid entering stream
- No permanent equipment for set up
- Ongoing monitoring involves small equipment (e.g., handheld conductivity probe, 2L bucket)

SCALE OF EFFORT: INITIAL SET UP

Equipment cost: moderate

Field time: low; ~2 hrs

Field expertise: high; see Considerations

SCALE OF EFFORT: ONGOING MONITORING

Equipment cost: low

Field time: low; <1 hr

Field expertise: high; see Considerations

Analysis time: low; <0.5 hr/measurement

Analysis expertise: moderate; see Considerations

PRODUCTS TO CONSIDER

Console: Fathom Scientific Ltd. QiQuac, WTW ProfiLine Cond 3310 Handheld Conductivity Meter, YSI Pro30 Conductivity Meter

ADDITIONAL RESOURCES

Dobriyal et al., 2017

Lapp, 2023

Moore, 2005

Resources Information Standards Committee, 2018

Richardson et al., 2017a,b

World Meteorological Organization, 2010