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USDA LTAR Common Experiment measurement: Overland flow

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Abstract

Overland flow is water that flows over a land surface (sheet flow) or in rills and gullies (concentrated flow) in response to rainfall or melting snow. Measuring overland flow on croplands and rangelands is important because it represents a key water pathway that controls pollutant losses from agricultural fields. When overland flow is accurately measured along with other water inputs and outputs, scientists can develop budgets describing how water and associated pollutants traverse cropland and rangeland systems. Tracking these budgets over extended time frames (years, decades) helps quantify the beneficial effects of improved agricultural management. In many edge-of-field and small watershed studies, overland flow measurements typically involve control structures such as flumes or weirs. Several hydrology textbooks and agency manuals (USDA, USGS) provide detailed guidance on weir and flume development, installation, and operation. In general, weirs and flumes are located at the outlets of drainage areas where overland flow exits an agricultural field. The devices are sized based on the range of expected flows. In most instances, weirs and flumes have preset equations that calculate discharge (the volume of overland flow leaving a field over a given unit of time) based on measurements of water height, or stage. A wide variety of sensors are useful in measuring stage in weirs and flumes, including floats, bubblers, and pressure transducers. Stage data from these sensors are then recorded at frequent time steps (seconds to hours) to provide continuous estimates of overland flow.

Materials

Equipment

i. Primary control structures such as weirs and flumes. Stilling wells are usually installed to provide a smooth water surface for water level measurements.

ii. Water level sensors such as bubbler stage sensors, submersible pressure transducers, floats, or ultrasonic sensors (minimum 0.003 meter accuracy).

iii. Rainfall sensor. Rainfall data help when reviewing flow data to evaluate whether stage sensors function correctly. Rainfall data are also used to trigger water sampling protocols.

iv. Air temperature sensor. Air temperature data are valuable in areas where freezing temperatures help ensure high-quality data by indicating snow melt and where freezing temperatures may cause stage sensors to report erroneous data.

v. Data logger

vi. Power source

1. Data collection

5m

1 **Measurement**

Collect sensor data every 5 minutes. More frequent measurements may be desirable in areas of very rapid runoff response.

> **Note**
>
> Please refer to the "Placement and site maintenance", "Data logger integrity", and "Equipment calibration" sections in the USDA LTAR Common Experiment measurement: Best practices for collection, handling, and analyses of water quantity measurements (Baffaut et al., 2024).

2 **Site Maintenance**

2.1 Visit weekly to ensure sensors (rain gauge and water level), flumes, and weirs are clear of debris and sediment.

2.2 Perform routine water level field verification and recalibration if needed. One method would be to physically block the primary control structure and then pump water above the structure to check stage readings.

2.3 Perform general site maintenance to prevent vegetation and debris from impeding site operation.

Data processing and quality control

3 Screen the data for out-of-range values due to debris or ice buildup.

> **Note**
>
> Please refer to the “Quality control” section in the USDA LTAR Common Experiment measurement: Best practices for collection, handling, and analyses of water quantity measurements (Baffaut et al., 2024).

4 Apply water level shifts because of field verification results.

5 Fill the data gaps and set quality flag. If gaps are detected during runoff events, use field notes and observations to try reconstructing data from manual stage readings or backup stage sensors. Set a quality flag for all data records with at least four levels, such as good, fair, estimated, and suspect.

Data file formats and metadata

6 Data format: Site identifier, datetime value, sensor values. Archive the data as raw or production (corrected).

Metadata: Unique site identifiers, spatial coordinates, description of primary control structure, drainage basin area, record of units, indication of accuracy, sensor type, data logger program reference. Record the data adjustments in the metadata.

Note

Please refer to the "Metadata" and "Data storage and accessibility" sections in the USDA LTAR Common Experiment measurement: Best practices for collection, handling, and analyses of water quantity measurements (Baffaut et al., 2024).

Illustrative media

7

Flume and water sampler during snowmelt event

Flume in grass waterway with rainfall sensors

Overland flow collector in a plot

Recommendations for data collection

8 Table 1. Summary of recommendations for measuring overland flow.

A	B	C
Attribute	**Preferred**	**Minimum**
Spatial scale	Plot and field	Plot
Frequency	Event	Daily
Covariate metrics	Precipitation, air temperature	Precipitation

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