Stormwater Monitoring Lessons Learned – Presentation Notes
Ryan Winston, NCSU
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Stormwater systems are monitored for a variety of reasons. These include learning how design affects performance, developing water budgets for urban sites, and understanding how BMPs on a catchment scale effect hydrology and water quality. NCSU utilizes a range of equipment that can be roughly divided into two categories. *Primary devices* such as weirs, flumes, or orifice plates are used to allow measurement of flow rate in an open conveyance. Flow determination is based on measurement of upstream head acting on the structure. *Secondary devices* are used to measure the depth of flow over a weir or other structure and include pressure transducers, bubblers, and area velocity meters. Rain gauges may also be used to measure diffuse flow, especially if the watershed is nearly 100% impervious. Considerations for equipment selection include design and construction of inlet and outlet structures, accuracy, accessibility, cost, monitoring goals (hydrology or water quality), and anticipated flow rates.

Primary devices allow measurement of flow rate in an open conveyance. Flow determination is based on measurement of the upstream head acting on the structure.

- *Weirs* are NCSU's preferred monitoring device. They are very accurate, cost effective, and can be constructed in house. Tabulated geometries and flow rates are available so flume studies are not required. However, they do have a high head requirement, as a minimum 3" drop is required for flow measurement. 6" or more is preferred to reduce the frequency of tailwater conditions that invalidate flow readings. Flow measurements must be made 4x head upstream to avoid drawdown in water level prior to the weir crest. Baffles can be installed upstream to reduce flow/velocity.

- *Flumes* are most useful for low head situations or in tailwater conditions. They are accurate but much more expensive than weirs and cannot be constructed in house. Typically ordered from manufacturers.

- *Orifice plates* are restrictions placed on larger orifices that basically create a weir until head is above the orifice at which point an orifice flow equation is used. They can be used for drawdown and are fairly accurate and inexpensive. Orifice plates are subject to clogging and require a stage discharge relationship to be determined.

Secondary Devices measure the depth of flow over a weir or other structure and include pressure transducers, bubblers, area velocity meters, and rain gauges.

- *Pressure transducers* use a strain gage determines differential pressure to measure depth of flow on a 2 min or 5 min interval to characterize the hydrograph. They are accurate up to a 30' depth, suspend with steel cables to prevent wildlife damage $500 each.

- *Bubblers* induce an air bubble into the flow every 30 seconds. The resistance encountered by the bubble is proportional to depth. These devices can be paired with a water quality sampler or they can be used separately to measure flow depth. They are more costly than pressure transducers, however at about $2000 each.

- *Area velocity meters* use sonar to measure flow velocity and a pressure transducer to measure depth. They are usable for high flows only in a known cross section and cannot be used in flow depths less than 1". Flow rate is calculated from velocity and depth measurements. AVMs can be used in tailwater, however they are less accurate than a weir. They cost ~$3,000 each.

Rain gauges

NCSU recommends redundancy and backup systems for rainfall measurement, placing gauges away from trees, power line, providing bird deterrents or alternate roosting options. Rain gages need to be visited as frequently as possible to ensure that they are not clogged.

- *Manual rain gauges* are reliable, inexpensive, and fairly accurate but can be labor intensive, non-continuous, and susceptible to evaporation, especially during summer. $20 apiece.

- *Automatic tipping bucket rain gauges* provide continuous measurement with low labor requirements. However they can provide a false sense of accuracy as the bucket may not tip quickly enough in heavy downpours, they require calibration, and are prone to failure due to wildlife deposits. Automatic rain gauges can be connected to water quality autosamplers and are advantageous for this type of monitoring because the data are stored in one place. Depending upon manufacturer, these types of rain gages retail for $100-1000. Tipping bucket rain gages are the only method to estimate rainfall intensity during a storm event, which may be important for peak flow estimation.

Data Analysis

Hydrologic monitoring data can be analyzed by importing flow rate as a function of time into Excel to create a hydrograph. Excel will automatically integrate the area under the hydrograph curve, which equals volume. Inflow and outflow hydrographs can be plotted together to determine lag time and differences in peak flow rate. Long term monitoring (>1 year) is necessary to understand BMP performance as a function of rainfall variability.

Monitoring Equipment Costs

- $100-300 for a metal v-notch weir plate constructed in house
- $500 for a pressure transducers with built in data logger
- Telemetry costs - modem ($1,000) and a cell phone plan ($60-$80/monthly)
- (see other costs listed above)