Assessment of Thermal Impacts of BMPs

While stormwater treatment BMPs are designed to remove pollutants from stormwater runoff, they may adversely affect the runoff temperature of receiving cold water streams which are the habitat of cold water fish species, e.g. trout. Wet ponds, infiltration ponds, wetlands and underground vaults are examples of stormwater BMPs with the potential to thermally pollute the nearby trout streams. To assess the thermal effects of BMPs on the nearby streams, the influent and effluent temperatures of the BMP should be monitored.

Prior to monitoring, the temperature probes need to be calibrated against an NIST (National Institute of Standards and Technology) traceable thermometer, or against 0 ^{o}C temperature by placing the probe in an ice-water mix jar.

To measure the effluent and influent temperatures, the probe should be placed in a shaded area of the sewer pipe, to avoid solar heating of the probe. It is preferable to place the probe inside a PVC pipe anchored to the sewer to protect it against debris, as shown in Figure 1. By using a pressure transducer or a probe equipped with a pressure transducer, as indicated in 5.1.5 of this protocol, the start of stormwater runoff can be recorded. When there is no runoff, the temperature probe records air temperature inside the storm sewer.

Figure 1. Installing a temperature probe in a sewer pipe.

For wet ponds, wetlands and underground vaults, a minimum of two probes will be adequate to determine the thermal impact of the BMP on the effluent. One probe will be installed upstream and one probe downstream of the BMP (Figure 2). The difference between the temperatures recorded by the two probes gives the impact of the BMP on the stormwater runoff.

Stream Monitoring

To assess the thermal impact of the BMP on the receiving stream, the BMP influent and effluent rates and temperatures as well as the discharge and temperature of the receiving stream at some point upstream of the outfall should be measured. To measure the water temperature of a stream or creek, the probe should be installed at least a few inches above the streambed and secured using stakes well inserted into the streambed. Since the cold water streams are mostly groundwater fed, it is not recommended to install the probe directly on or buried in the sediment bed. If it is intended to install the probe on the bed, prior to installation the bed water temperature should be compared with the water temperature a few inches below the surface water to ensure the probe records stream temperature instead of the localized groundwater inflow. Most streams are well-mixed water bodies, and the temperature at or above the sediment surface should well represent the temperature of the entire water column. If the stream is groundwater fed, there is a temperature gradient near the bed. For very shallow streams, e.g. less than 8” depth, it is recommended that the temperature probe be installed in a shaded area of the stream channel, to avoid direct solar heating of the probe.

The thermal impact of the BMP on the receiving stream at every time interval will then be estimated using the following equations:

$$T_0 = \frac{Q_s\ T_s + Q_u\ T_u}{Q_s + Q_u}$$

$$T_1 = \frac{Q_s\ T_s + Q_d\ T_d}{Q_s + Q_d}$$

$$\Delta T_{BMP} = T_1 - T_0$$

In the above equations Q is discharge, T is water temperature, and the subscripts s, u and d refer to the receiving stream, upstream and downstream of the BMP, respectively (Figure 2). T_1 and T_0 are temperatures of the receiving stream downstream of the outfall with and without the BMP in place, respectively. When stormwater runoff ceases, i.e. when discharge becomes zero upstream of the BMP, ΔT_{BMP} becomes the difference between T_1 and T_s.

The thermal impact of the BMP on the receiving stream can also be assessed by measuring water temperature at some points upstream and downstream of the outfall. The

probe downstream of the outfall should be placed at the downstream end of the mixing zone which depends upon the size of the stream, i.e. the base flow and the width of the stream, as well as the BMP effluent rate. Since a conservative estimate for the mixing zone during all flow conditions might be a challenging task for large streams, this method of assessment are only recommended for creeks and small streams. For large streams and rivers, the streamflow rate can be estimated using the discharge monitoring stations on the stream. The BMP influent and effluent rates can be assessed using the techniques described in Chapter 4.

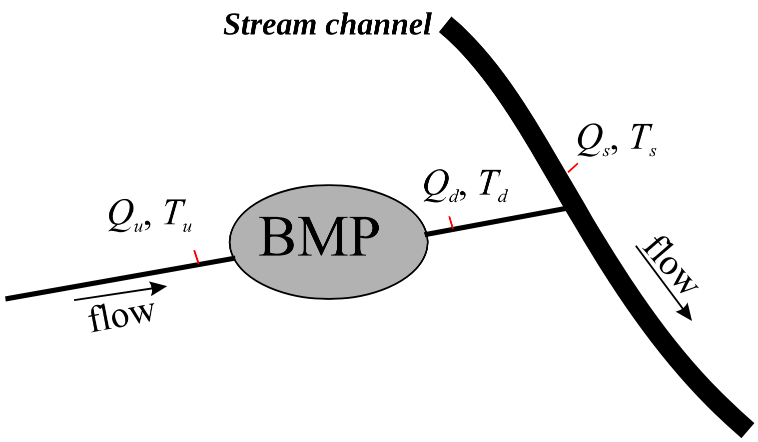

Figure 2. Schematic of locations where temperatures and flows should be measured to assess the thermal impacts of a BMP on a receiving stream.

Assessing the impacts of an infiltration pond constructed near a cold water stream can be a challenging task, and in many cases inconclusive. Since the thermal impact is via warmed groundwater, the impact may be a relatively small change in temperature over a relatively long time period compared to wet ponds. In this case, in addition to the BMP influent temperature and rate, water temperatures of the receiving stream should be measured at a minimum of two locations. The temperature probes in the receiving stream should be carefully calibrated and placed well upstream and downstream of the infiltration pond, as shown in Figure 3. Measurement of the water level and temperature within the infiltration pond may also be used to help quantify Q_u, the infiltration rate, and the temperature of the infiltrating water.

A measured difference in stream temperature (T_{sd}-T_{su}) may be due to atmospheric heating, surface inflow, or warmed groundwater feeding the stream from the BMP. During hot summer days, weather can heat up the stream such that the water temperature at the downstream point (T_{sd}) becomes warmer than at the upstream point (T_{su}). The temperature difference depends upon the distance, flow rate, stream width and stream depth, and can be identified as temperature difference that varies diurnally (Figure 4).

During storm events and for several hours after, inflow of surface runoff may have a significant impact on the temperature difference (T_{sd} - T_{su}). The thermal impact of surface inflow may be identified as transient change in the temperature difference (Figure 4). The thermal impacts due to an infiltration basin may be identified as a relatively constant temperature difference during periods of infiltration after storms. If both atmospheric heating and surface inflows are negligible, the thermal impact of the BMP on the receiving stream can be estimated using the following equations at every time step.

$$T_0 = \frac{Q_{su}\ T_{su} + Q_u\ T_u}{Q_{su} + Q_u}$$

$$\Delta T_{BMP} = T_{sd} - T_0$$

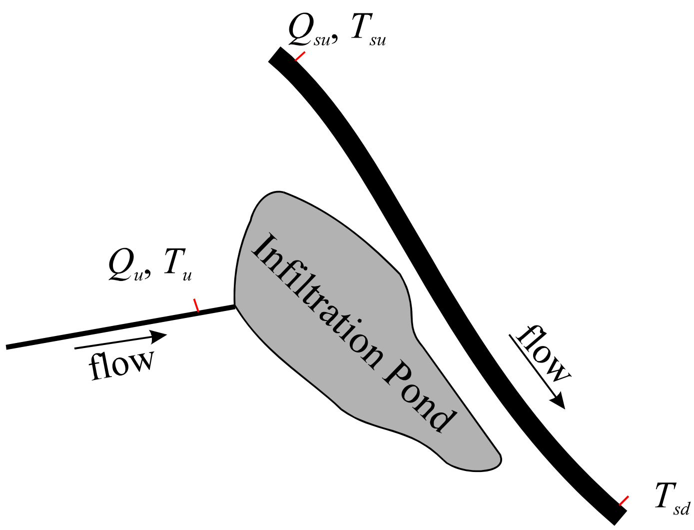

Figure 3. Schematic of locations where temperatures and flows should be measured to assess the thermal impacts of an infiltration pond on a receiving stream.

The temperature and runoff data collection should be conducted continuously during the warmer months of the year, i.e. from the end of May until the end of August for Minnesota. The recording time steps should be selected based on the capacity of the data storage system and the frequency of data retrieval. Nevertheless, a smaller time step, e.g. every 5 or 10 minutes, is preferred for the BMP influent. Since discharge from wet ponds, infiltration ponds and wetlands often occurs over longer periods, a longer time step, e.g. every half hour, can be used for measuring temperature and runoff downstream of the BMP and in the receiving stream.

Thermal pollution of stormwater BMPs are not necessarily detectable during every storm event. Small storms often do not provide any information regarding the effects of ponds on nearby streams. However, large storms with very warm weather patterns before and after storms do provide valuable information to assess the thermal impacts of ponds on stormwater runoff.

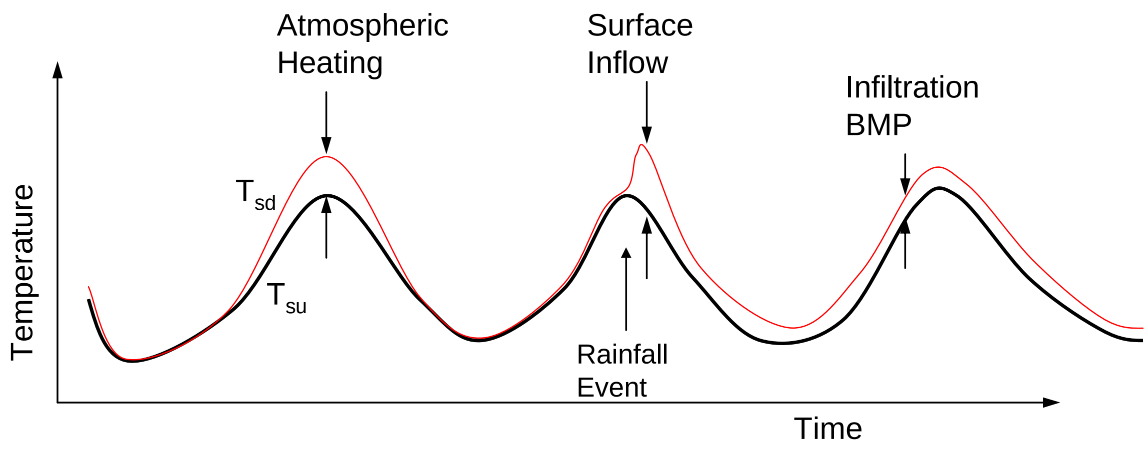

Figure 4. Typical characteristics of thermal impacts due to atmospheric heating, surface inflows, and warmed groundwater from an infiltration BMP.