ATTACHMENT B
Noncontact Cooling Water General Permit
Example Engineering and Dilution Factor Calculations

Dilution Factor Calculations for Massachusetts and New Hampshire

For the convenience of facilities that were granted coverage under the expired NCCW general permit, the 7Q10 estimates for those permits are posted at https://www.epa.gov/npdes-permits/notices-intent-archive-noncontact-cooling-water-general-permit-nccw-gp-massachusetts and can be used by those applicants if re-applying for coverage under this general permit.

Note that in New Hampshire the Dilution Factor is calculated using two different equations based on the use of the receiving water as the applicant's public water supply.

Massachusetts:
Equation used to calculate the dilution factor at a facility's outfall.

$$\text{Dilution Factor} = \frac{Q_R + Q_P}{Q_P}$$

where:
    Q_R = Estimated 7Q10 low flow for the receiving water at the facility's outfall, in million gallons per day (MGD).
    Q_P = Maximum design flow of NCCW discharge, in MGD.

New Hampshire:

Method 1: When the water supply is from outside the drainage basin.
Equation used to calculate the dilution factor at the facility's outfall.

$$\text{Dilution Factor} = \frac{Q_R + Q_P}{Q_P} * 0.9$$

where:
    Q_R = Estimated 7Q10 low flow for the receiving water at the facility's outfall, in MGD.
    Q_P = Maximum design flow of NCCW, in MGD.
    0.9 = Factor to reserve 10% of river's assimilative capacity for future use

Method 2: When the water supply is from the drainage basin.
Equation used to calculate the dilution factor at the facility's outfall.

$$\text{Dilution Factor} = \frac{Q_R}{Q_P} * 0.9$$

where:
    Q_R = Estimated 7Q10 low flow for the receiving water at the facility's outfall, in MGD.
    Q_P = Maximum design flow of NCCW, in MGD.
    0.9 = Factor to reserve 10 percent of river's assimilative capacity.

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<u>Receiving water temperature change calculations:</u>

Receiving water temperature change calculations may be used to waive the requirement in Massachusetts for in-stream waterbody temperature monitoring. The calculations must show that the discharge will not cause or contribute to a violation of the allowable water body temperature change. Note that calculations differ for surface water intakes and other intakes.

For surface water intakes:

The basic equations used for the calculation of river temperature rise are as follows:

$$Q_{plant} = C_p m_p \Delta T_p$$

$$Q_{river} = C_p m_r \Delta T_r$$

$$C_p m_p \Delta T_p = C_p m_r \Delta T_r$$

$$\Delta T_r = m_p/m_r \text{ x } \Delta T_p$$

Where
Q_{plant} = heat load discharged from facility (btu)
C_p = heat capacity of water = 1.0 btu/lb°F
m_p = mass of effluent, lbs (MGD if volume is used)
ΔT_p = change in temperature, effluent – influent, °F
m_r = mass of river, lbs (MGD if volume is used)
ΔT_r = change in river temperature, °F

Notes:

(1) Since both the effluent mass (m_p) and river mass (m_r) convert to volume by using the same factor of 1 gal/8.34 lbs, a volumetric unit may be substituted for mass in the above equation, as long as same units are consistently used for both the river and facility terms. It is assumed that the river and effluent volume change with temperature are negligible for the purposes of this calculation.

(2) The 7Q10 should be used as the mass (or volume) of the river. Typically, 7Q10 information is given in units of cubic feet per second (cfs), which can be converted to MGD. 7Q10 information for existing facilities is available on the NCCW General Permit website in MGD.

(3) The maximum allowed daily discharge for the facility (reported in NOI) should be used as the mass (or volume) of the facility.

(4) The change in temperature of the NCCW should be calculated using the maximum reported temperature for the facility (reported in the NOI).

(5) Use the conversion factor of 0.645 MGD/cfs to convert from cfs to MGD.

The waste heat from the facility can either be calculated using the maximum change in temperature and the maximum effluent flow or it can be determined by facility engineering personnel.

EXAMPLE 1:

A facility has a maximum reported effluent temperature of 85°. The maximum design flow of NCCW is 1 MGD. The 7Q10 is determined to be 80 MGD. The facility discharges to a Massachusetts cold water fishery with an average temperature of 50°F.

SOLUTION:

$$\Delta T_P = \text{effluent} - \text{influent} = 85°F - 50°F = 35°F$$

$$\Delta T_R = \frac{m_p}{m_r} * \Delta T_P = \frac{1 \text{ MGD}}{80 \text{ MGD}} * 35°F = 0.44°F$$

EXAMPLE 2:

A facility has a maximum permitted flow rate of 1 MGD. The maximum amount of heat that needs to be rejected from the facility is 10,000 btu/hr. The 7Q10 of the river has been determined to be 210 MGD. What is the maximum calculated change in river temperature? The facility discharges to a Massachusetts Class B warm water fishery.

SOLUTION:

Since all of the heat rejected by the plant is assumed to be absorbed by the river, $Q_p = Q_r$ and $Q_r = C_p M_r \Delta T_r$ or $\Delta T_r = Q_r / C_p M_r$

$Q_r = 10,000$ btu/hr

$$\Delta T_r = \frac{\frac{10,000 \text{ btu/hr}}{1 \text{ btu/lb°F}} * \frac{24 \text{ hr}}{1 \text{ day}} * \frac{1 \text{ gal}}{8.34 \text{ lb}}}{210 * 10^6 \text{ gal/day}} = 1.37 * 10^{-4} \text{ °F}$$

In this example, the facility has demonstrated that the receiving water will be protected, as the temperature change limit of no more than a 5 °F change, will not be exceeded. Therefore, no in-stream monitoring for temperature would be required.

For intakes from other than surface water:

The same equations apply, but the amount of heat transferred to the receiving water from the effluent is dependent on the temperature difference between the facility effluent and the receiving waterbody.

$$Q_{plant} = C_p m_p \Delta T_p$$

$$Q_{river} = C_p m_r \Delta T_r$$

Where

Q_{plant} = heat load discharged from facility (btu)
Q_{river} = heat load transferred to the river (btu)
C_p = heat capacity of water = 1.0 btu/lb°F
m_p = mass of effluent, lbs (MGD if volume is used)
ΔT_p = change in temperature, effluent – influent, °F
m_r = mass of river, lbs (MGD if volume is used)
ΔT_r = change in river temperature, °F

Notes: Volumes may be used in place of the discharge and river masses since it is assumed that volume change with temperature will be negligible for the expected range of temperatures associated with facilities and receiving waters. It is assumed that the facility effluent is warmer than the river water. If we assume that the heat load discharged by the facility is entirely transferred to the river, the effluent and the river will reach the same final temperature, T_F (in °F). Therefore, ΔT_p and ΔT_r are based on this final temperature:

$$\Delta T_p = T_p - T_F$$

$$\Delta T_r = T_F - T_r$$

Notes: the initial effluent temperature, T_p, is the maximum temperature discharged from the facility, while the background river temperature, T_r, is the measured upstream river temperature or temperature measured a sufficient distance away from the discharge (see State mixing zone requirements). The river mass or volume, m_r, is the 7Q10 flow rate of the river.

Since $Q_{plant} = Q_{river}$:

$$C_p m_p \Delta T_p = C_p m_r \Delta T_r$$

$$m_p\left(T_p - T_F\right) = m_r(T_F - T_r)$$

$$\frac{m_p T_p + m_r T_r}{m_p + m_r} = T_F$$

$$\Delta T_r = T_F - T_r$$

EXAMPLE:

A facility uses groundwater as a source of NCCW. The NCCW is discharged at a maximum temperature of 65°F. The facility discharges to a Class B cold water fishery in Massachusetts with an upstream measured temperature of 45°F and a 7Q10 of 51.6 MGD. The facility's maximum allowed discharge under the permit is 0.02 MGD.

SOLUTION:

Based on the information given,

$$T_p = 65°F$$
$$T_r = 45°F$$

Therefore,

$$T_F = \frac{m_p T_p + m_r T_r}{m_p + m_r} = \frac{(0.02 \text{ MGD} * 65°F) + (51.6 \text{ MGD} * 45°F)}{0.02 + 51.6 \text{ MGD}} = \frac{2323 \text{ MGD} * °F}{51.6 \text{ MGD}} = 45.02 °F$$

$$\Delta T_r = T_F - T_r = 45.02 °F - 45°F = 0.02 °F$$

With this calculation, the facility has demonstrated that the receiving waterbody temperature change of no more than 5 °F for a warm water Class B fishery, will not be exceeded. Therefore, no further in-stream monitoring for temperature is required for the facility.