Appendix A – Pre-submission Quality Assurance/Control Guideline

These guidelines were developed to ensure important aspects of drainage design are considered in the project development. Prior to submitting a project to the Hydraulics and Drainage Section for review, the designer should review these guidelines to ensure they are considered in the design.

Chapter 1 – Introduction

- Documentation is an important aspect of the design or analysis of any drainage/hydraulic facility. The major purpose of providing good documentation is to define the design procedure that is used and to show how the final design and decisions were arrived at.
- Consider construction and maintenance related issues when developing the drainage/hydraulic design.
- Temporary hydraulic facilities are to be designed with the same attention to detail that is used for the primary facility.

Chapter 2 – Legal Aspects

- Existing and proposed drainage rights should be shown on the plans.
- The course of flow beyond drainage outlets should be investigated for a sufficient distance to ensure that other downgrade owners will not be adversely affected.
- The direction of flow from the drainage outlet should be shown on the construction plans a minimum distance of 61 m (200 ft) or shown to terminate by dissipation or entrance into a watercourse or body of water. This will aid the Department in determining any property impacts and right of way obligations.
- If a pipe upgrade downstream of the project is necessary, then additional rights may need to be acquired.
- Any concentration of flow upon adjacent property requires an easement to discharge. Any changes in size or location of the outlet require new drainage rights. Diversions may require rights from all affected owners and thus should be avoided.
- Outlets should be appropriate to present land use and adaptable to possible future uses. Avoid any outlets where ponding will be created. Existing outlets should be reviewed carefully before utilizing them in a new design. Outlets onto steep slopes should be avoided as they lead to erosion problems. Extending the outlet to a flatter slope is desirable.
- Watercourses (perennial or intermittent) should be shown and labeled on the plans. This will define appropriate drainage rights that may be required. It will also define the design storm event. (See Chapter 6, Hydrology.)
- If Floodplain Management Certification or a Stream Channel Encroachment Line permit is required, we recommend coordination with the ConnDEP, Inland Water Resources Division early in the design phase to maintain the project schedule.
- Diversions should be avoided as they increase the likelihood of erosion and can cause changes to wetland characteristics.
- Any disturbances to septic systems or water supply wells must be avoided. Health regulations stipulate separation distance from septic systems to drainage systems and may control drainage system or channel locations. Maintenance chemicals splashed onto or flowing over adjacent surfaces can affect wells.

Chapter 3 – Design Development

- If a project involves work within a watercourse, the designer should coordinate with the ConnDEP Fisheries Division early in the design phase to address fish passage concerns.
- A separate drainage submission is recommended when the drainage aspects of the project appear to be complex or the drainage facilities may involve right of way impacts.
- Provide responses and justification for all review comments.

Chapter 4 – Culvert Repair, Materials, and Structural Design

- Existing pipes that are to remain in use should be visually inspected and analyzed to determine if they are structurally and hydraulically adequate or require replacement. The condition of the pipes should be documented accordingly.
- Use existing pipes if in good condition. With regard to existing systems which are to be discontinued, metal pipes under traveled ways in poor condition should be removed and concrete pipe should be plugged at ends.
- Use the appropriate type pipe in tidal areas.
- Check strength, installation conditions and bedding requirements if the cover is over 4.6m (15 ft.) or under 0.6m (2 ft.) for concrete pipes and any depth for metal pipe.
- Parallel pipe lines must be separated at least 1/2 the pipe diameter or 1 m (3 ft.), whichever is less.
- Connections of pipe to structures should be designed with all dimensions and structural details considered.

Chapter 5 – Data Collection

- A well planned data collection program leads to a more orderly and effective analysis, and a design that is commensurate with project scope, project cost, the complexity of site hydraulics and regulatory requirements.

Chapter 6 - Hydrology

- Rational Method - This method shall be used only for drainage areas less than 81 hectare (200 acres).
- Stream Gage Data - The U.S. Geological Survey maintains a network of stream gaging stations throughout Connecticut. From long term periods of observation and through statistical analysis of the resultant data, peak flow rates for various return frequencies can be developed. This data shall be used wherever possible in the design of hydraulic facilities.
- U.S.G.S. Regression Equations shall be used for all routine designs at sites greater than 2.59 km^2 (1 mi^2) in tributary area unless stream gage data is available or unique watershed characteristics, such as significant detention storage dictate otherwise. Refer to Water Resources Bulletin No. 36.

- Computer Models for Hydrograph Generation - Many watersheds exhibit characteristics which require the use of a computer model to estimate design discharge quantities from run-off hydrographs. Additionally, hydrograph generation models are useful in the analysis of "before and after" conditions as related to proposed activities within a given basin. Where use of a computer model is appropriate, the methods described in Section 6.14 shall be used.
- FEMA Flood Insurance Study Discharge Rates - Discharges specified in the appropriate Flood Insurance Study shall be used for ANALYSIS where the regulatory floodway is adopted. The DESIGN discharge may vary from the Flood Insurance Study quantity if the results of an independent analysis so indicate.
- SCEL – Stream Channel Encroachment Discharge Rates – Discharges specified in the appropriate Stream Channel Encroachment study shall be used for analysis where SCEL are established. The **Design**, FEMA and SCEL discharges may vary, as they are all developed independently and may use different methods.
- The hydrology for cross culverts conveying drainage areas greater than 81 ha (200 ac) should be submitted for review and approval prior to completing the hydraulic design.

Chapter 7 - Channels

- The channel design should ensure that the design flow in its flattest section is accommodated.
- Flexible lining is preferred over rigid to reduce velocity and for lower maintenance and installation cost. A closed drainage system should be used instead of steeply graded channels.
- Safety requirements will often dictate the location of roadside ditches or channels.
- Sharp bends and sudden grade changes should be analyzed for possible overtopping of channel lining during high flows. A lining change may be needed at bends due to velocity increases.
- At intersections of side and main channels, consider the velocity head and need for additional lining depth, or heavier lining, on the main channel opposite the junction.
- The location and alignment of a culvert should be consistent with the flow tendency of a stream. Inlet and outlet rechanneling should be held to a minimum.
- At severe transitions from cut to fill slopes, erosion can occur where roadside swales are used, unless short riprap channels, catch basins and pipes or paved ditches are employed to control the flow.

Chapter 8 - Culverts

- Available head should be checked by using cross sections, profiles, contour maps and a thorough field check.
- Allowable headwater elevation should be at least 0.3m (1 ft.) below the controlling elevation of a building or point where overflow could run over the road or to another watershed.
- Safety of the structure location must be considered in relation to pedestrian and vehicular traffic. Culvert ends are generally preferred to endwalls.
- Consider possible erosion around outlet structures from both high and low water in the stream. Provide riprap and channel improvements or energy dissipation where needed.
- Culverts providing for the passage of area drainage from one side of the highway to the other usually shall not be smaller than 600mm (24 in) for interstate systems and 450mm (18 in) for other systems.

- Fish passage through culverts should be considered where appropriate. Minimum depths of flow, low velocities and outlet pools are some methods employed.
- Avoid long skew crossings under traveled ways.

Chapter 9 - Bridges

- Occasionally, the waterway opening(s) for a highway-stream crossing can be provided for by either culvert(s) or bridge(s). Estimates of costs and risks associated with each will dictate which structure alternative should be selected. Other considerations which may influence structure-type selection are listed in Table 9-1 and Chapter 8, Culverts.
- The hydraulics of the highway-stream crossing system should be given considerable study in choosing the preferred design from the long list of available alternatives. **The selection should be based on a collective effort of bridge, soils and foundations, highway, and hydraulic engineers. This process is further outlined in Chapter 3, Design Development**.
- The final design selection should consider the maximum backwater allowed by the National Flood Insurance Program and Stream Channel Encroachment Lines unless exceedence of the limit can be justified by special hydraulic conditions.
- The final design should not significantly alter the flow distribution in the floodplain.
- A specified clearance should be established to allow for passage of ice and debris. For navigation channels, a vertical clearance conforming to Federal requirements should be established based on normally expected flows during the navigation season.
- Degradation or aggradation of the river as well as contraction and local scour shall be estimated. Appropriate positioning of the foundation, below the total scour depth, if practicable, shall be included as part of the final design.

Chapter 10 – Storage Facilities

- Preliminary approval of storage considerations should be obtained from Hydraulics and Drainage, before the actual storage computations are performed.
- Consider permanence of the storage, if already existing.
- Sedimentation basins and dams should not be used on watercourses.
- Sedimentation basins should be used to clarify runoff only from areas disturbed by construction. Runoff from adjacent undisturbed areas should be channeled or piped around the basins where possible.
- Field check the need for trash racks. If used they should not completely enclose the inlet but allow for overflow when clogged. Consider access for maintenance if used.

Chapter 11 – Storm Drainage Systems

- Any existing inlet structures should be checked for capacity if they will be used in a new design.
- Utility conflicts may require design changes. Keep at least 0.3m (1 ft) vertical and horizontal clearance between drainage systems and utilities.
- The most economical routing of pipes should be used. A different layout could save many feet of pipe.

- Consider hydraulic effects of tides on a drainage system outlet. Return frequency of tides vs. storm design frequency should be considered.
- Pipes on steep grades may require energy dissipation at the outlet - check possibility of reducing velocity through flatter grades, using rougher pipe or drop structures.
- Catch basins not located precisely in a low point of the gutter profile will create ponding and lead to icing conditions.
- Intersection grading plans (contours) may be required to assure proper grading to and around catch basins to ensure inlets are located at low points and to avoid snow melt and consequent icing across traveled ways.
- Catch basins are usually needed just upgrade from a bridge to avoid excess flow across the bridge or into expansion joints.
- Catch basins may be needed at downgrade ends of bridges where curbing is not used, to avoid erosion down the fill slope.
- Consider the effects of snow melt and refreezing at all traffic islands and superelevated sections.
- A reverse cross slope should be provided for superelevated sections to contain the flow in the shoulder and therefore not allow runoff or snow melt to sheet across the travelway.
- The designer should exercise particular care that medians, shelves, and channelization islands are drained so as not to cause icing hazards. Snow stored in these areas can melt and flow across a traveled roadway. A subsequent freezing can lead to dangerous icing conditions requiring constant attention by maintenance forces.
- On **depressed expressways**, where curbing is used, flanker basins will be placed in locations approximately 0.06m (0.2 ft) higher than the sag catch basin. These will collect debris and provide additional capacity if needed. Flanking inlets are not usually considered as intercepting flow in the design computations.
- Catch basins should be located a minimum of 1.5m (5 ft) from driveway returns to prevent loss of vehicular traction.
- All catch basins shall have standard 0.6m (2 ft) sumps to collect roadway sand except at pipes conducting watercourses or pipes 900mm (36") in diameter or larger.
- At an expressway low point where curbing is not used, a 'C-L' catch basin shall be located on the shoulder with the far edge of the catch basin at the outer edge of the shoulder. This inlet is intended for collection of snow melt and rain when plowing operations prevent water from leaving the pavement. No interception is to be calculated for this inlet. A 300mm (12") pipe will be used for the outlet.
- For sags in the gutter profile where excess flow cannot be relieved (cut sections), use a 25-year design frequency (50 for expressways) for the grate capacity of the inlet structure and for pipes leading away from the inlet structure to a clear outlet.
- For residential and business areas where grading will produce small pockets not drained, lawn drains of small pipe elbows connected to the nearest catch basins may be economical.
- Where a change in size of pipe is made at a structure, the crowns of these pipes will normally be aligned on grade.
- As a preliminary rough check on hydraulic design, pipe sizes should increase consistently with the direction of flow and added flow from branches to the system.
- Hoods at catch basins should be avoided as they create higher losses than a conventional inlet and are a clogging concern. When hoods are used in the storm system, then the losses and clogging potential associated with these structures must be considered when developing the hydraulic gradeline computations.

- Drainage should be brought to a suitable outlet. The system should be shown to its outlet or to its hydraulic control.
- Computations should be provided to verify that the proposed drainage will not adversely impact the existing downstream storm system.