March 2024

Drainage Design Manual

ILLINOIS STATE TOLL HIGHWAY AUTHORITY

INTRODUCTION

Drainage Design Manual

The Drainage Design Manual provides guidance on the Illinois Tollway standards for the design of drainage facilities. The manual's content provides a detailed listing of criteria, guidelines, policies and procedures to be followed throughout the design of drainage facilities in conjunction with new construction, rehabilitation and reconstruction of roadway facilities. The Design Section Engineer of drainage facilities is responsible for accounting for runoff generated within Illinois Tollway right-of-way, runoff from adjacent property that reaches and/or crosses Illinois Tollway right-of-way and subsurface drainage.

The Drainage Design Manual, dated March 2024, replaces the previous version dated March 2023.

Major Highlight Revisions

Section 1.0: Introduction	
Article 1.2	Added IEPA and TSS to the list of abbreviations and acronyms.
Article 1.3	Added definition for Edge of Traveled Way.
Section 2.0: Drainage Policies	
Article 2.1	Added drainage design guideline during construction.
Section 4.0: Water Quality	
Article 4.1	Revised General Considerations for clarity.
Article 4.2	Revised Stormwater Quality Design for clarity.
Article 4.3	Revised Application of Best Management Practices for clarity.
Section 5.0: Hydrology	
Table 5.0	Added a “C” coefficient of 0.3 for grassed areas.
Section 6.0: Ditch and Channel Design	
Article 6.3.1	Added ACB System application for embankment slope protection from bypass flow.
	Removed closed cell block application below the normal water level of streams.
Section 7.0: Culvert Design	
Article 7.5	Removed 3-sided culvert.
Table 7.0	Added reference to the *Environmental Studies Manual*.
Section 8.0: Bridge Hydraulics	
Table 8.0	Added reference to the *Environmental Studies Manual*.
Section 9.0: Roadway Drainage Design	
Article 9.4	Revised bridge scupper spacing rainfall intensity from 7 inches per hour to a 10-year 5-minute rainfall intensity.

Article 9.5.1	Noted that trench drains shall be limited to areas as described in the Illinois Tollway *Roadway Design Criteria*, Article 2.6.10.
Article 9.6.1	Provided reference to the Illinois Tollway *Roadway Design Criteria*, Article 2.6.6 for use of gutters.
Article 9.7.2	Noted minimum slope for pipe underdrains (0.5% desirable).
Article 9.8	Added reference to the Standard Drawings *Section F - Sign Structure*.
	Removed sentence allowing direct lateral pipe connections to storm sewers 60” or larger.
Table 9.0	Noted that coated corrugated galvanized steel pipes apply only to slope drains.
Article 9.9	Noted that open bottom manhole riser structures may be used instead of drainage structures for larger box culvert systems.
Figure 9-1	Added new figure.
Article 9.10	Added information required to be shown in the temporary drainage schedules.
	Noted that trench drains shall not be used on MOT travel lanes.
Table 9.3	Noted the storm sewer cover requirement as 6” minimum cover from bottom of subgrade aggregate or chemically stabilized subgrade (if applicable) to top of pipe.
Section 10.0: Stormwater Detention Storage	
Article 10.3	Added reference to the Illinois Tollway *Geotechnical Manual* for boring requirements and water table assessment at detention facilities.
Article 10.8	Added maintenance shelf criteria for detention basins and noted that profile gradients apply to maintenance access paths for detention basin bottoms and outlet structures.
Section 14.0: Submittal Requirements	
Article 14.4.1	Added link to the manhole sizing calculator.
Article 14.4.2	Added information required for the temporary drainage schedules.
	Added reference to the Illinois Tollway *Erosion Control and Landscape Manual* for MOT phasing plan requirements.
	Added reference to Appendix L for sample summary table for critical storm duration analysis.

Appendix L: Sample Summary Table for Critical Storm Duration Analysis	
Appendix L	Added new appendix.
Appendix M: Drainage Legend	
Appendix M	Moved from Appendix L.
Appendix N: Sample Contract Plan Drawings	
Appendix N	Moved from Appendix M.

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SECTION 1.0 INTRODUCTION

1.1 Purpose and Use

The criteria contained herein are intended to outline the general policies and procedures for design of Illinois State Toll Highway Authority (Illinois Tollway) drainage facilities. The design of drainage facilities for all Illinois Tollway projects shall be performed in accordance with these criteria and applicable references cited herein. The following publications shall be used in the design of drainage facilities:

- Illinois Tollway Design Section Engineer's Manual
- Illinois Tollway Erosion Control and Landscape Manual
- IDOT Standard Specifications
- Illinois Tollway Supplemental Specifications to IDOT Standard Specifications
- Standard Drawings (Illinois Tollway & IDOT)
- Other bulletins or publications as directed by Illinois Tollway

Drainage design shall account for, but not be limited to, consideration of the following:

- Runoff generated within Illinois Tollway right-of-way (ROW)
- Runoff from adjacent property that reaches and/or crosses Illinois Tollway right-of-way (ROW)
- Subsurface drainage

It is the responsibility of the Designer to provide a cost-effective method for handling stormwater runoff from Illinois Tollway facilities and follow the requirements of Illinois drainage law. The Designer shall be knowledgeable in current practices in the areas of hydrology, hydraulics and highway drainage design. Additionally, the Designer shall be familiar with the regulations and requirements of public agencies that regulate or issue permits necessary to construct drainage facilities.

The criteria provided herein were prepared as a guide to aid the Designer in the design of drainage facilities in conjunction with new construction, reconstruction and rehabilitation of existing roadway facilities. The application of these criteria shall depend on the scope and type of improvement as follows:

- Rehabilitation/Reconstruction Projects: The drainage design shall be performed in accordance with the criteria in use at the time of the most recent design modification of that Illinois Tollway facility. The Designer shall investigate the existing Illinois Tollway drainage system and identify flooding problems or inadequate drainage. The design criteria in this document shall be used to correct any deficiencies identified by the Designer involving Illinois Tollway drainage facilities.
- Widening or Lane Addition Projects: The design criteria in this document shall be used for the new or reconstructed portions of facilities. Drainage design of existing facilities shall not be modified unless a flooding problem is identified or if the existing design is incompatible with the proposed facilities. For example, the stormwater detention volume provided for a widening project would consist of the detention volume provided in the design of the existing facility plus additional detention required for the new pavement as determined by the criteria in this document.

- New Construction Projects: The design criteria in this document shall be used.

Previous Illinois Tollway Drainage Design Criteria compared to the current criteria are summarized in APPENDIX A. It is the responsibility of the Designer to use the correct design criteria in this document.

1.2 Abbreviations & Acronyms

ACB	Articulated Concrete Block
BFE	Base Flood Elevation
BMP	Best Management Practice
D/S	Downstream
DSE	Design Section Engineer
FBFM	Flood Boundary and Floodway Map
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FIRM	Flood Insurance Rate Map
HGL	Hydraulic Grade Line
HWE	Headwater Elevation
HWL	High Water Level
NHWE	Natural Highwater Elevation
IDNR–OWR	Illinois Department of Natural Resources – Office of Water Resources
IDOT	Illinois Department of Transportation
IEPA	Illinois Environmental Protection Agency
TSS	Total Suspended Solids
U/S	Upstream
USACE	United States Army Corps of Engineers
USDA-NRCS	The United States Department of Agriculture, Natural Resource Conservation Service
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WIT	Waterway Information Table
WQV	Water Quality Volume
WSEL	Water Surface Elevation

1.3 Definitions

Abrasion: Removal of stream bank material due to entrained sediment, ice, or debris rubbing against the bank.

Aggradation: The process by which a stream's gradient steepens due to increased deposition of sediment.

Approach Section: A stream channel cross section, normal to thread of current and for the discharge of interest, located in the approach channel. The approach section should be located sufficiently upstream from the opening that the flow is not affected by the structure but is fully expanded to natural floodplain width.

Apron: Protective material placed on a streambed to resist scour.

Armoring: Surfacing of channel bed, banks, or embankment slope to resist erosion and scour. May be a natural process whereby an erosion-resistant layer of relatively large particles is formed on a channel bank and/or channel bed due to the removal of finer particles by stream flow.

Backwater: The increase in WSEL induced upstream from a structure such as a bridge or culvert.

Bank: The sides of a channel between which the flow is normally confined.

Base Flood: The flood having a one percent probability of being equaled or exceeded in a given year. A 100-year flood.

Berm: A ledge or shelf that breaks the continuity of a slope, or delineates a detention basin, ditch, ditch check, dam or the shoulder along a paved road.

Best Management Practice (BMP): Design, construction and maintenance practices and criteria for stormwater facilities that promote infiltration, minimize impacts from stormwater runoff rates and volume, prevent erosion and capture pollutants.

Bioengineering: Restoration and stabilization techniques that use plants, often native species, to mimic natural functions and benefits.

Biofiltration: The use of vegetation (usually grasses) to filter and treat stormwater runoff as it is conveyed through an open channel or swale.

Bioretention: The use of vegetation in retention areas designated to allow infiltration of runoff into the ground. The plants provide additional pollutant removal and filtering functions while infiltration allows the reduction of the runoff rate.

Bioswale: A swale that utilizes vegetation and amended soils; to treat stormwater by filtering out contaminants being conveyed in the stormwater.

Building: A structure that is constructed or erected partially or wholly above ground and is enclosed by walls and a roof. The term "building" includes both the above-ground and the below-ground portions of the structure.

Bypass Flow: Flow which bypasses an inlet on grade and is carried in the street or channel to the next inlet downgrade.

Causeway: Rock or earth embankment carrying a temporary roadway into or across a waterway.

Chance of Exceedance: See Flow Frequency.

Channel Diversion: The removal of flows by natural or artificial means from a natural length of channel.

Channel Routing: The process whereby a peak flow and/or its associated stream flow hydrograph are mathematically transposed to another site downstream, taking into account the effect of channel storage.

Channelization: Straightening or deepening of a natural channel by artificial cutoffs, grading, flow-control measures, or diversion of flow into an engineered channel.

Check Valve: A mechanical device without moving parts usually made of rubber that may be put on the outlet end of a culvert or storm sewer to prevent backflow. A pipe fitting used to prevent backflow to the pumps and subsequent recirculation.

Clearance: Distance that the low beam is located above a given flood stage.

Compensatory Storage: An excavated hydrologically and hydraulically equivalent volume of storage created to offset the loss of existing flood storage.

Confluence: The junction of two or more streams.

Construction Manager: The Engineer or firm of engineers and their duly authorized employees, agents and representatives retained by the Illinois Tollway to observe the Work to determine whether-or-not it is being performed and constructed in compliance with the Contract.

Contract: The written agreement executed between the Illinois Tollway and the successful Bidder and any supplemental agreements duly executed, establishing the terms and conditions for the performance and construction of The Work and the furnishing of labor, materials and equipment by which the Contractor is bound to perform The Work and to furnish labor, equipment and materials and by which the Illinois Tollway is obligated to compensate the Contractor therefore at the established rate or price. The Contract includes the Advertisement to Bidders, Instructions to Bidders, the Proposal, Bonds, the Standard Specifications, the Illinois Tollway Supplemental Specifications, the Contract Plans, the Special Provisions, and all Addenda and any Extra Work Order, Change Order or Supplemental Agreements after execution of the Agreement.

Control Structure: A structure that is used to regulate the flow or stage of the stream, basin, reservoir, or drainage structure.

Created Head: See Head Loss.

Critical Depth: The depth at which the specific energy for a particular discharge is a minimum. It is the depth at which, for a given energy content of the water in a channel or conduit, maximum discharge occurs.

Critical Duration: Duration of rainfall needed to produce the maximum peak flow at any point in a drainage system; it is equal to the time of concentration of the drainage area.

Culvert: A conduit which conveys flow through a roadway embankment or past some other type of flow obstruction and having a regular, uniform shape, typically rectangular or circular.

Dam: Any obstruction, wall embankment, check dam or barrier, together with any abutments and appurtenant works, constructed to store or direct water or to create a pool (not including underground water storage tanks).

Degradation: The process by which a stream's gradient becomes less steep, due to the erosion of sediment from the stream bed. Generally follows a sharp reduction in the amount of sediment entering the stream.

Design Deviation: The process of requesting alternative design parameters to the Illinois Tollway Chief Engineer when the design criteria as described in the Illinois Tollway design manuals is not achieved. A written description is required stating reason why this deviation is required with alternative designs considered.

Design Section Engineer: The Engineer or firm of engineers and their duly authorized employees, agents and representatives retained by the Illinois Tollway to prepare the Contract Plans for a Design Section.

Designer: The person (or consultant team) responsible for performing a design task for an Illinois Tollway project. Although this is typically the DSE, it may also include a person (or consultant team) hired by a Contractor to perform design as part of a Value Engineering Proposal or part of a Performance Based Design. This document shall use the term “Designer” which covers anyone performing design and shall only use the term “DSE” when discussing tasks specific to the DSE.

Detention: The storage and slow release of stormwater following a precipitation event by means of excavated pond, enclosed depression, pipe or tank used for stormwater peak flow reduction, storage and pollutant removal. Both dry and wet detention facilities may be applied. Special conditions for wet detention ponds apply on the Illinois Tollway right-of-way.

Development: Any activity, excavation or fill, alteration, subdivision, change in land use, or practice, undertaken by private or public entities that affects the discharge of stormwater; or substantial improvement to any portion of a building in the floodplain. The term "development" does not include maintenance of stormwater facilities.

Ditch: A constructed channel used to convey runoff. Typically occurs as roadside and median ditches.

Drainage: The removal of excess surface or ground water from land or roadway pavement by means of surface or subsurface drains.

Drainage Channel: A type of open, vegetated channel designed solely to safely convey roadway runoff during the design storm event.

Drainage Divide: The rim of a drainage basin. The divide separating one drainage basin from another. Drainage divide, or just divide, is used to denote the boundary between one drainage area and another.

Drainage/Tributary Area: The area of land from which the water drains to a given point.

Edge of Traveled Way: The edge of roadway as viewed by the driver. Commonly, signified by the inside edge of a pavement marking edge line.

Effective Opening: The area of flow below the NHWE for a given flood stage measured along a plane across the structure that is perpendicular to the predominant direction of flow. The effective opening excludes any depressional areas and any part of the opening that is blocked or inaccessible to flow.

Emergency Overflow Spillway/Area: An area specially designed to convey the runoff exceeding a given design flood at a detention basin.

Erosion Control: Measures proposed and provided to prevent or reduce the displacement of soil by the running water on road embankment fills, banks and at various drainage structures (i.e., culvert inlets and outlets, channels, detention pond overflow areas, junctions, etc.).

Eutrophication: Increase of nutrient content (nitrogen, phosphorus and carbon) from runoff or other effluent sources that favors growth of aquatic plants and algae in lakes, detention basins or other water bodies.

Eutrophication Control Measures: Combination of bioengineering measures in order to prevent, limit and control the eutrophication process in lakes, detention basins or other water bodies. Use of buffer zones (filter strips) may also be applied to protect sensitive areas.

Field Tile: Buried pipe used to drain low or moisture laden areas in farm fields.

Filter Strip: A vegetative planting used to retard or to collect sediment or pollutants for protection of diversions, drainage basins or other drainage structures.

First Flush: Contains the majority of pollutants in stormwater runoff.

Flood Fringe: The area within the floodplain associated with the base flood exclusive of the floodway.

Flood Insurance Rate Map: An official map of a community or an area on which the FEMA has delineated both the special hazard areas and the risk premium zones applicable to that community or area. FIRMs typically identify the elevation of 1% chance of exceedance flood and delineate the areas that would be inundated by that flood.

Flooding: A general and temporary condition of partial or complete inundation of normally dry land areas from the unusual and rapid accumulation or runoff of surface waters from any source.

Floodplain: The channel and adjoining area which has been or may be subject to inundation by water exceeding a certain discharge. The floodplain is composed of floodway and the flood fringe. Unless qualified, “floodplain” shall correspond to the base flood discharge.

Floodway: The channel and that portion of the floodplain adjacent to a stream or watercourse that shall be kept free of any encroachment in order to convey the base flood without increase in flood height.

Flow Frequency: The probability of a peak discharge being exceeded in any year. For example, a 100-year flood has a 1% chance of exceedance in any given year. Although calculation of possible recurrence is often based on historical records, there is no guarantee that a 100-year flood may occur at all or it may not recur several times within any 100-year period.

Forebay: An artificial pool of water located in front of a larger reservoir. Typically used in flood control to act as a buffer during flooding or storm surges. They are also used upstream of a reservoir to trap sediment and debris in order to keep the reservoir clean.

Freeboard: The vertical distance between the maximum design WSEL and the top of the retaining bank, berm or structure.

Frequency Curve: A graphical representation of the frequency of occurrence of a specific event (i.e. flood peaks, precipitation amounts, WSELs, etc.).

Gabion: A basket or compartmented rectangular container made of wire mesh. When filled with cobbles or other rock of suitable size, the gabion becomes a flexible and permeable unit with which flow- and erosion- control structures may be built.

Grout: A fluid mixture of cement and water or of cement, sand and water used to fill joints and voids.

Head Loss: The energy of a given flow that is lost; expressed as head. That is, the height through which flow would have to fall to produce an equivalent amount of energy. For bridges and culverts, the increase in WSEL above the natural WSEL at an upstream location.

Highwater Elevation: The WSEL that results from the passage of flow. It may be an "observed highwater mark elevation" as a result someone actually viewing and recording a runoff event, or a "calculated highwater elevation" as part of a design process.

Huff Rainfall Distribution: Temporal distributions of rainfall events in Illinois based on data from a network of precipitation-reporting stations during a 69-year period (1948-2017). Includes distributions of point rainfall (0 to 10 square miles), medium-size areas (10 to 50 square miles) and large areas (50 to 400 square miles) for periods ranging from 5 minutes to 10 days and for recurrence intervals varying from 2 months to 500 years. They are the most commonly used relations used by hydrologists, soil scientists and others who need heavy rainfall data.

Hydraulic Grade Line: The surface or profile of water flowing in an open channel or a pipe flowing partially full. If a pipe is under pressure, the HGL is that level water would rise to in a small, vertical tube connected to the pipe.

Hydraulics: A topic of science and engineering dealing with the mechanical properties of liquids. Hydraulics topics range through most science and engineering disciplines and cover concepts such as pipe flow, dam design, fluid control circuitry, pumps, turbines, hydropower, computational fluid dynamics, flow measurement, river channel behavior and erosion.

Hydrograph: A graph showing the rate of flow (discharge) versus time past a specific point in river, or other channel or conduit carrying flow.

Hydrology: The science of the behavior of water, including its dynamics, composition and distribution in the atmosphere, on the surface of the earth and underground.

IDNR-OWR: The agency responsible for overseeing and regulating construction activities within the floodplains of streams and rivers in Illinois under their jurisdiction.

Ineffective Flow Area: That portion of a floodplain cross section where flow is considered to be stagnant or not moving in the predominant direction of flow. This area is typically blocked or removed from sections impacted by structures to represent the expansion and contraction of flow.

Inlet Control: A condition where the relation between the HWE and discharge is controlled by the upstream end of any structure through which water may flow. For example, a culvert on steep slope and flowing part full as in inlet control.

Land Surveyor: A person licensed under the laws of the State of Illinois to practice land surveying.

Levee: An artificial obstruction erected roughly parallel to a river or channel and used to confine flow.

Maintenance: The selective removal of woody material and accumulated debris from, or repairs to, a stormwater facility so that such facility may perform its natural functions or the functions for which it was designed and constructed.

Mapped Floodplain: The floodplain as determined by the BFE that has been mapped by FEMA, IDNR-OWR or municipal jurisdictions. This includes FIRM maps.

Mass Curve Routing: The process of computing the volume of outflow as a function of the inflow volume, pumping rates and storage.

Migration: Change in position by lateral erosion of one bank and simultaneous accretion of the opposite bank.

Mitigation: Any action taken to permanently eliminate or reduce the negative impacts caused by natural or technological hazards.

Municipality: Any community, or the unincorporated County, within Illinois acting as a unit of local government.

National Pollutant Discharge Elimination System (NPDES): A provision of the Clean Water Act that prohibits discharge of pollutants into waters of the United States unless a special permit is issued by the Environmental Protection Agency (EPA), a state or other designated regional agency.

Nonstructural Measures: A term devised to distinguish techniques that modify susceptibility to flooding (i.e., such as watershed management, land use planning, regulations, floodplain acquisitions, flood warning, flood proofing techniques and other construction practices) from structural methods used to control flooding (i.e. such as dams, levees, conveyance channels, etc.).

On-Line Detention: Where the site runoff storage required by the Ordinance is being provided within the regulatory floodway. The Illinois Tollway strongly discourages on-line storage for detention purposes.

Orifice: Two definitions are pertinent: 1. A hole or opening, usually in a plate, wall, or partition, through which water flows, generally for the purpose of control or measurement; 2. The end of a small tube, such as the orifice of a pitot tube, or piezometer.

Outlet Control: A condition where the relation between the HWE and discharge is controlled by the conduit, outlet, or downstream conditions of any structure through which water may flow.

Overtopping Flood: The frequency at which flood waters first flow over the roadway.

Parcel: Contiguous land under a single ownership or control.

Peak Discharge: The maximum instantaneous flow generated by a given storm conditions at a specific location.

Pressure Flow: Also denoted as orifice flow, pressure flow occurs when the WSEL at the U/S face of the bridge is greater than or equal to the low chord of the bridge superstructure. The pile up of water on the upstream bridge face and a plunging of the flow downward and under the bridge. Flow in a conduit that has no surface exposed to the atmosphere. The flow is driven by pressure forces.

Public Road: Any road, highway, street, alley or traveled way that is open, has been dedicated or is legally available to public use, regardless of by whom or by what agency or division of government it be owned, controlled, or maintained as used herein. This does not include any toll highway operated or to be operated by the Illinois Tollway.

Pump: A device that increases the static pressure of a fluid. A pump adds energy to a body of fluid in order to move it from one point to another.

Pump Cycling Time: Cycling refers to the time between starts of a given pump. The shorter the cycling time, the more frequent a pump shall start and stop.

Pump Station: The collection of components used to lift highway stormwater runoff. A station includes the storage unit, wells, pumps, pump house and ancillary equipment.

Rainfall Intensity: The rate in which the rain is falling at any given time interval, usually expressed in inches/hour.

Rating Curve: A plot of stage versus discharge.

Record Drawings: Drawings prepared, signed and sealed by a professional engineer or land surveyor representing the final "as-built" record of the actual in-place elevations, location of structures and topography.

Recurrence Interval: The statistically derived probability of occurrence of a flood event converted to a time interval, or the average time interval in which a flood of a given magnitude is equaled or exceeded (i.e., a 1% chance of exceedance flood has 100-year recurrence interval).

Regulatory Floodplain: The floodplain as determined by the BFE used as the basis for regulation in municipal jurisdictions or the state.

Regulatory Floodway: The floodplain area that is reserved in an open manner by Federal, State, or local requirements, i.e., unconfined or unobstructed either horizontally or vertically, to provide for the discharge of the base flood so that the cumulative increase in WSEL is no more than a designated amount (not to exceed 1 foot as established by the Federal Emergency Management Agency (FEMA) for administering the National Flood Insurance Program).

Reservoir: A pond, lake or basin, either natural or artificial, for the storage, regulation and control of water.

Riparian: Pertaining to anything connected with or adjacent to the banks of a stream (corridor, vegetation, zone, etc.).

Riprap: In the restricted sense, layer or facing of rock placed to protect a structure or embankment from erosion, also the rock suitable for such use. Riprap has also been applied to almost all kinds of armor, including wire-enclosed riprap and grouted riprap.

Roughness Coefficient: Numerical measure of the frictional resistance to flow in a channel, as in the Manning's or Chezy's formulas.

Routing: The process of transposing an inflow hydrograph through a structure and determining the outflow hydrograph from the structure.

Runoff: The waters derived from melting snow or rain falling within a tributary drainage basin that exceeds the infiltration capacity of the soils of that basin.

Scour: The displacement and removal of channel bed material due to flowing water; usually considered as being localized as opposed to general bed degradation or head-cutting.

Sediment: Mineral or organic soil material that was removed from the surrounding landscape and carried away by flowing water.

Sediment Discharge: The quantity of sediment (in dry weight or by its volume) transported, as a suspended or bed load, through a stream cross-section in a given time interval.

Sheet Flow/Overland Flow: Storm runoff flowing in a thin layer over the ground surface.

Special Flood Hazard Area: An area having special flood, mudslide or mudflow, or flood-related erosion hazards and which area is shown on a FIRM as Zone A, AO, A1-30, AE, A99, AH, VO, V1-30, VE, V, M, or E.

Special Management Areas: Regulatory floodplains or wetlands.

Special Provisions: Special clauses, directions and requirements supplemental to the Standard Specifications, setting forth requirements specific to the work included in the Construction Contract.

Specifications: The general term comprising the directions, provisions, instructions and requirements contained and labeled STANDARD SPECIFICATIONS, the Special Provisions, any Supplemental Specifications and Addenda.

Storage: Water artificially impounded in surface of underground reservoirs; water naturally detained in a drainage basin, such as groundwater, channel storage and depressions storage where the term "drainage basin storage" or simply "basin storage" is sometimes used to refer collectively to the amount of water in natural storage in a drainage basin.

Stormwater Facility: All ditches, channels, conduits, bridges, culverts, levees, ponds, natural and man-made impoundments, wetlands, riparian environment, tile, swales, sewers, or other natural or artificial structures or measures which serve as a means of draining surface and subsurface water from land.

Stream: A body of water that may range in size from a large river to a small rill flowing in a channel. By extension, the term is sometimes applied to a natural channel or drainage course formed by flowing water whether it is occupied by water or not.

Structure: Unless otherwise defined in the Specifications, structures shall comprise all objects constructed of materials other than earth, required by the contract to be built or to be removed, including: buildings, bridges, culverts, headwalls, sewers, constructed channels, outfalls, retaining walls and their appurtenances, but not including surfacing, base courses, subbases, gutters, curbs, sidewalks and driveway pavement.

Sub-base: The top surface of a roadbed upon which pavement and shoulders are constructed.

Sump Pump: A sump pump also called an intake sump or sludge pump, is designed to remove the solids and sediment that are conveyed by the storm water through the inlet conduits into the storage box.

Swale: A wide, shallow vegetated ditch without well-defined bed and banks. Often shaped to not provide a visual signature of a bank or shore.

Tailwater: The depth of flow in the channel directly downstream of a drainage facility. Often calculated for the discharge flowing in the natural stream without the highway effect (but may include other local effects from development), unless there is a significant amount of temporary storage that shall be (or is) caused by the highway facility; in which case, a flood routing analysis may be required. The tailwater is usually used in such things as culvert and storm drain design and is the depth measured from the downstream flow line of the culvert or storm drain to the water surface. May also be the depth of flow in a channel directly downstream of a drainage facility as influenced by the backwater curve from an existing downstream drainage facility.

Thalweg: An imaginary line extending down a channel that follows the lowest elevation of the channel bottom. The line does not include local depressions.

Three-Sided Structure: A precast structure consisting of two sides and a top and made up of several units usually taking the place of conventional bridge and culvert.

Toll Highway: The limited access highway built or proposed to be built by the Illinois Tollway, including all facilities and appurtenances thereto.

Unsteady Flow: Flow when discharge or rate of flow varies from one cross section to another with time.

Watershed: All land area drained by or contributing water to the same stream, lake, or stormwater facility.

Waterway Information Table: The summary table representing the natural flow conditions at the highway crossing and the backwater impact attributed to the subject bridge or culvert.

Weephole: A hole in an impermeable wall or revetment to relieve the neutral stress or pore pressure in the soil.

Weir: A dam across a channel for diverting flows, or for measuring the flow.

Wetted Perimeter: The wetted perimeter is the length of contact between the flowing water and the channel at a specific cross section.

Wet Well: A chamber of the pump station into which the storm water flows and from which it is pumped.

NOTE: This manual follows the traditional definitions for **shall, should and may**. **Shall** is used to mean something that is required or mandatory, while **should** is used to mean something that is recommended, but not mandatory and **may** is used to mean something that is optional and carriers no requirement or recommendation.

SECTION 2.0 DRAINAGE POLICIES

2.1 General Considerations

Drainage policy and criteria are defined as follows:

- Drainage Policy
  - A general principle, course or method of action that guides present and future decisions related to drainage projects.
- Design Criteria
  - The detailed standards and methods by which the drainage policy is implemented are listed below:
- Generally, Illinois Tollway Drainage Policy consists of the following:
  - Existing drainage patterns shall not be significantly altered by the design.
  - The Designer shall exercise good engineering judgment and early recognition of potential problem situations in order to minimize drainage liability and damages resulting from Illinois Tollway construction and maintenance activities. The courts look with disfavor upon injury or damage that may have reasonably been avoided through a prudent design, even when some alteration of flow conditions is legally permissible.
  - The descending order of law supremacy is Federal, State and local, except as provided for in the statutes of the constitution of the higher level of government. Laws, rules, or regulations of a lower level of government do not bind the superior level. The Illinois Tollway is a state agency and has jurisdiction over the entire Illinois Tollway system.
- Drainage designs for Illinois Tollway projects shall be developed with the following guidelines:
  - Existing drainage area boundaries shall be maintained with no diversion of water from one watershed to another. Roadway ditches shall not cut across watershed divides.
  - Increases in discharge runoff rates from existing to proposed conditions are not allowed. The need for stormwater detention with attenuated release rates shall be considered in all drainage designs.
  - When feasible and cost-effective, the off-site runoff should be kept separate from Illinois Tollway drainage facilities. The evaluation shall consider the cost(s) of separation, operation, detention requirements, stormwater quality and other factors required by the regulatory agencies.
  - Ponding of runoff on properties adjacent to and resulting from Illinois Tollway facilities is not permitted.
  - Designs shall incorporate provisions to prevent erosion within Illinois Tollway right-of-way, as well as properties immediately adjacent to but outside the right-of-way, which receive water from the Illinois Tollway right-of-way.
  - Where no defined channel is available to pass cross drainage or bypass flow, additional drainage structures and/or erosion protection shall be provided to prevent excess concentration of flows at a single location.
  - Any work to be performed outside the existing Illinois Tollway right-of-way requires verification of existing permanent easements or obtaining such permanent or construction easements from the owner(s) of the property affected.

- Designs should take into consideration the future maintenance of drainage systems in order to reduce the possibility of future damage to adjacent property and drainage systems during maintenance operations.
- The design shall incorporate existing field conditions to take into account any recorded pavement flooding or restricted outlets when developing the existing drainage models.
- Designs should take into consideration providing emergency overflow routes to reduce extensive pavement flooding if the downstream outlet is restricted during high frequency storm events.
- Designs shall maintain positive drainage and shall not negatively impact adjacent properties during construction.
- All elevations shall be in NAVD88 or correlated with the Highway Datum. Datum correlation shall be provided for projects referring to the FIS.

2.2 Governing Requirements within Multiple Jurisdictions

Illinois Tollway facilities interconnect with state, township, county and municipal roadways throughout northeastern Illinois. Many of the agencies charged with operating and maintaining these roadways have adopted policies/ordinances regulating stormwater management within their jurisdiction. The design criteria contained within this document are established as a minimum standard. Design criteria of superior levels of government shall be followed when they exceed Illinois Tollway criteria. Requirements established by agencies of a lower level of government that exceed or are more restrictive than Illinois Tollway criteria shall be followed for Illinois Tollway facilities located within that agency jurisdiction. The Illinois Tollway is exempt from permitting by lower levels of government and shall not apply for such permits. For non-Illinois Tollway facilities located within areas of multiple jurisdictions, the requirements of the agency charged with maintaining the facility shall be followed. If not meeting local criteria provide correspondence or letter of adherence.

Designs which include the removal, replacement, or reconstruction of facilities owned or maintained by agencies other than the Illinois Tollway, shall be approved by such agency. It is the responsibility of the Designer to obtain written approval for such designs from the agency or agencies involved in a timely manner to avoid delays and conflicting requirements.

It is the Designer’s responsibility to obtain the requirements from all agencies within the project limits. Furthermore, the Designer is responsible for evaluating these requirements, determining potential conflicts and coordinating the resolution of these conflicts. The Illinois Tollway Project Manager shall be informed of all coordination efforts.

2.3 Coordination with Other Regulatory Agencies

Proposed Illinois Tollway improvements may involve a significant number of public agencies that participate in the regulation of stormwater runoff and waterways.

The following is a list of agencies that may require approvals or permits prior to the construction of any improvements within areas of their respective jurisdictions:

- U.S. Coast Guard (USCG)
- U.S. Army Corps of Engineers (USACE)
- U.S. Department of the Interior, Fish and Wildlife Service (USDI-FWS)
- U.S. Environmental Protection Agency (USEPA)

- Federal Emergency Management Agency (FEMA)
- Federal Aviation Administration (FAA)
- Illinois Department of Transportation / Division of Highways (IDOT-DOH)
- Illinois Department of Natural Resources - Office of Water Resources (IDNR-OWR)
- Illinois Department of Natural Resources - Office of Conservation (IDNR-OC)
- Illinois Environmental Protection Agency (IEPA)
- Metropolitan Water Reclamation District of Greater Chicago (MWRD)

The scope and location of the proposed Illinois Tollway project shall determine the extent of regulatory agency involvement. During the development of the scope of work for DSE contracts, the Illinois Tollway shall attempt to identify those permits and review contacts, which shall be required for individual projects. This effort shall in no way eliminate the Designer's responsibility to identify the need for any and all such permits and to coordinate with the various regulatory agencies. The Illinois Tollway Project Manager shall be informed of all coordination efforts.

2.4 Analysis Procedures

The use of academically recognized or public agency accepted computer software for analyzing drainage hydrology and hydraulics is preferred. The use of recognized computer software provides more uniformity of design and facilitates interpretation of results. Software developed by the FHWA, NRCS, USGS, USACE, USEPA or commercial software, which is based on methods developed by these agencies, is preferred. Manual methods of analysis developed by these agencies are also acceptable. In-house spreadsheets developed by the Designer may be acceptable if proof of the accuracy of the methodology and precision of the spreadsheet is provided. Written approval by Illinois Tollway is required before the Designer may begin any work using in-house spreadsheet. Any method of analysis, whether manual or computerized, shall be applied within its established analytical limitations.

The Illinois Tollway continuously updates their pay items, standard details and specifications. The Illinois Tollway also utilizes some IDOT standards. Refer to subsequent sections of this *Drainage Design Manual* for additional information as to when IDOT design procedures and guidelines are used.

BMPs shall be included in the design of all Illinois Tollway drainage facilities. The Designer shall design drainage facilities for Illinois Tollway projects in a manner that allows for easy and low-cost maintenance.

The Designer shall provide the Illinois Tollway Project Manager with adequate documentation for all input values and assumptions used in the analysis to ensure that the assumptions are acceptable.

SECTION 3.0 FLOODWAY/FLOODPLAIN ENCROACHMENTS

3.1 General Considerations

A floodway/floodplain encroachment occurs whenever there is any construction or development in a mapped or regulatory floodway/floodplain. The location of floodways and floodplains may be determined from Federal Emergency Management Agency - Flood Insurance Studies (FEMA-FIS) maps including:

1. Flood Insurance Rate Maps (FIRM)
2. Regulatory Floodway Maps from IDNR-OWR or the municipal jurisdiction

The latest digital FEMA mapping is available online at the FEMA Map Service Center. IDNR-OWR issues permits for appropriate use and construction in floodways. All floodplain encroachment analyses shall meet requirements per IDNR-OWR and FEMA criteria.

The DSE may need to switch to a FEMA approved model if the existing model is no longer accepted by FEMA.

The Illinois Tollway may have flood record data available for areas within the individual Maintenance Sections. The Illinois Tollway PM may be contacted to obtain this information.

If a municipality has more restrictive floodplain criteria than IDNR-OWR or FEMA, the analysis shall be in accordance with the local requirements. Unless otherwise qualified, the “floodplain” shall correspond to base flood flow as defined below.

3.2 Method of Analysis

As part of the hydrologic analysis, the 100-year flood (i.e., the flood flow with a 1% chance of exceedance[1] in any given year) shall be determined using the appropriate methodology described in Section 5. If there is existing regulatory agency hydrology or hydraulic models available for the watershed affected by the proposed project, the model with appropriate changes to reflect existing, natural and proposed project conditions shall be used in hydrologic and hydraulic analysis.

HEC-RAS may be used to import HEC-2 and UNET data to convert the original FEMA software, but the resulting WSELs have to be consistent with the original regulatory model output file. Also, WRAS is an NRCS program used to convert WSP2 data.

The hydraulic conditions for the existing and proposed structures shall be analyzed using the appropriate methodology described in Sections 6, 7 and 8. If a project requires the use of a multi-dimensional flow or unsteady flow model, the selected computation software shall meet the requirements of Article 2.4. The Designer shall discuss and receive prior written approval from the Illinois Tollway Project Manager before any analysis using a multi-dimensional flow or unsteady flow model begins. Refer to the IDOT Drainage Manual Section 2-600 and the

[1] See Section 1 - Glossary for definitions

“Waterway Hydraulic Reports” section of the *ACEC-Illinois/IDOT 2014 Drainage Seminar* presentation for additional information.

Computation of encroachment volumes within the floodway/floodplain shall be calculated according to IDNR-OWR requirements of 1:1 compensatory storage for fill in the floodway between the normal to 10-year and 10-year to 100-year NHWEs (only for approved uses within the floodway), unless local requirements are more restrictive, where compensatory storage for fill in the floodplain shall also be required. The Designer shall check the local and/or county ordinances for the compensatory storage ratio required (1.2:1, 1.5:1, etc.) for fill in the floodplain. Refer to Article 2.2 for additional information on governing requirements.

The Designer is responsible for preparing all necessary permit applications required to construct within the floodway and/or floodplain limits. Encroachment volumes required for Illinois Tollway improvements shall be replaced by compensatory storage within Illinois Tollway ROW and adjacent to the floodplain. Replacement of encroachment volumes with compensatory storage shall be done in accordance to IDNR-OWR or local requirements, if more restrictive. Permit applications shall be reviewed and approved for submittal by the Illinois Tollway Environmental Unit and Illinois Tollway Project Manager. Permit applications are to be signed by the Illinois Tollway and submitted by the DSE, unless directed otherwise.

The Designer shall make every effort not to combine detention and compensatory storage within the same facility. If detention and compensatory storage must be combined in one facility then the Illinois Tollway recommends separating the 2 sites by a berm with an overflow weir set at the 100-year flood elevation.

A guidance list of the available hydrologic and hydraulic models that may be used in the design of Illinois Tollway drainage facilities is provided in APPENDIX B (B1 and B2). Also, refer to the “Floodway Permits in Illinois” section of the *ACEC-Illinois/IDOT 2014 Drainage Seminar* presentation for additional information and design criteria regarding floodway/floodplain encroachment.

SECTION 4.0 WATER QUALITY

4.1 General Considerations

Stormwater quality is a component of drainage design. All projects of one acre or more of soil disturbance require an NPDES permit. However, the Illinois Tollway is considered a small municipal separate storm sewer system and is covered under an MS4 NPDES permit which requires every project to consider post-construction water quality improvement practices.

Stormwater quality practices incorporated into the drainage design shall not impact traffic safety and shall provide a Value on Investment (VOI). The Designer shall use both temporary and permanent BMPs to improve stormwater quality when designing drainage facilities. Also, if the project has greater than 1 acre of soil disturbance an ILR10 NPDES permit is required and the Designer shall prepare a Notice of Intent (NOI) and Stormwater Pollution Prevention Plan (SWPPP) to be included in the contract documents (SP 111.2).

If the Environmental Studies Inventory Sheet (ESIS part 1 and 2) identifies the drainage area and watershed are impaired for a particular pollutant, then the post-construction BMPs shall be designed to reduce, remove or treat for that pollutant. Roadway activities typically produce pollutants such as Total Suspended Solids (TSS), heavy metals (Zn, Cr or Pb), road salt (NaCl or $CaCl_2$) and/or hydrocarbons. Therefore, most of the stormwater treatment should focus on reducing the impacts of these known pollutants. Appendix C provides a decision flow chart to be used by the Designer as a guide in the selection of BMPs.

4.2 Stormwater Quality Design

Prior to design, the Designer shall identify potentially critical water zones and determine activities associated with the construction and operation of the proposed project that may affect the water quality of those zones.

After the BMP decision flow chart is utilized for the proposed project, the Designer shall:

- Design the drainage facilities in accordance with the results of the BMP flow chart and any other permit requirements in effect at the time of design.
- Determine the most pollutant reducing and cost-effective permit compliance strategy.
- Prepare drainage plans and erosion control documents that address both temporary stormwater pollutants caused by construction activities (per the ILR10 permit) and also long-term pollution (per Section IV of the MS4 permit).
- Assist the Illinois Tollway with any documents necessary to secure environmental agency approvals.

Every effort to maximize the stormwater treatment train should be explored during the planning and design process. Close coordination between the environmental specialist, landscape designer and drainage lead will be needed at the 30% and 60% submittals and if needed, at the 95% submittal as design develops. The most desirable design includes infiltrating stormwater runoff into the ground as close to the source as possible using biofiltration practices. Pervious drainage conveyance and naturalized detention facilities shall be used to the maximum extent practicable to enhance biofiltration and bioretention. Detention basins shall be designed according to the criteria in Section 10. Eutrophication control measures shall be considered in the design of detention basins to enhance water quality and limit maintenance. Refer to green infrastructure guidance, the *Illinois Urban Manual* and criterion PD-30 of the Illinois Tollway *INVEST Project Development Manual* for a list of practices for maintaining or establishing a comprehensive stormwater treatment train. The Illinois Tollway recognizes that green infrastructure practices provide multiple benefits including flattening the hydrograph, reducing stormwater volume and filtering out pollutants. Wet basin bottoms provide the most significant pollution capture of chlorides or roadway metals but require a maintenance plan during the first few years of establishment and water depths need to consider barrier warrant analysis and errant vehicle recovery.

In addition to the controlled release outlet, dry detention basins shall be designed with a basin dewatering system that drains water remaining below the invert of the controlled release outlet without discharge of trapped sediment. Dry detention basins are effective at collecting and removing TSS from stormwater but may need modification to the soil profile or a subsurface management system. If underground pipe storage is used in lieu of a detention basin, the controlled release shall discharge to a grassed ditch prior to discharge off Illinois Tollway ROW.

Stormwater quality control measures should be considered in the design of toll plazas, oases and maintenance facilities. Wet detention basins may be provided for areas such as toll plazas and maintenance facilities if the basin location does not create an obstacle to traffic. Wet detention basins may be located in areas protected by barrier.

All storm sewer outlets tributary to Waters of the United States (WOUS) shall be designed to maximize the stormwater contact time in the ditches upstream of the WOUS. At a minimum, a 200-foot vegetated swale, or equivalent BMP, shall be provided. Coordinate with the Illinois Tollway Environmental Unit and USACE to establish a permissible equivalent BMP, if required.

The Designer shall identify maintenance requirements to enhance stormwater quality during the drainage design. Maintenance requirements may include, but not be limited to:

1. Regular catch basin cleaning
2. Detention basin maintenance and cleaning
3. Roadside litter pick-up
4. Weed control using Integrated Roadside Vegetative Maintenance (IRVM) for two growing seasons.

The Designer shall ensure that the design is adequate to allow for the recommended maintenance according to the criteria in Article 10.8.

The Illinois Tollway has initiated a program that utilizes recycled concrete for roadway rehabilitation projects. Excavated concrete is broken up and crushed into smaller pieces, often in situ, to create an aggregate base for new pavement. The use of recycled or rubblized concrete creates unique challenges for erosion and sediment control design. The Designer shall be mindful of the fine material that is washed away during storm events, often continuing beyond the completion of construction. In addition, the presence of limestone in the rubblized concrete may significantly alter the pH of the stormwater runoff. Where rubblization is to be utilized, the Designer shall investigate the current technology and identify locations and design devices that shall allow for the remediation of rubblized concrete fines prior to discharging stormwater to outside of the ROW. If stormwater discharged to sensitive ecological systems, such as creeks or wetlands, or interfere with the growth of adjacent plants and grasses, methods for neutralizing the pH shall also be assessed. The Designer shall identify methods for preventing impacts to stormwater discharging to outside the Illinois Tollway ROW from rubblized concrete and provide these to the Illinois Tollway for review and acceptance.

4.3 Application of Best Management Practices

When applying post-construction BMPs to improve stormwater quality, the Designer should consider maintenance, cost, VOI, effectiveness and traffic safety. BMPs shall be project-specific and watershed-specific and selected based on:

- Type of project
- Area available
- Receiving water body
- Drainage area
- Groundwater level
- Infiltration rates
- Design life of the BMP
- Sediment volume reduction

The Illinois Tollway uses BMPs to accomplish water quality goals based on capturing the first flush of rainfall per local, State or Federal requirements. Water treatment goals are identified during the Master Plan phase or ESIS process. Acceptable BMPs may include dry bottom basins, naturalized detention with diverse hydrologic zones and native plantings, underground infiltration systems, engineered basins, bioretention areas and bioswales. It is acceptable to use a combination of BMP types to treat stormwater above the outlet. If the water table is high and the project's water treatment goals cannot be achieved, the Designer shall coordinate with the Illinois Tollway Environmental Unit for alternative practices acceptable for treatment.

When no other BMP is feasible to meet the Illinois Tollway's water quality goals and permit commitments due to right-of-way constraints, underground or closed-system water quality treatment should be considered. Closed-system water quality treatment devices shall capture a minimum of 80% of the net annual TSS based on a particle size of 50-microns for impaired and threatened waters listed in IEPA's Clean Water Act (CWA) Section 303(d) and 110-microns for non-impaired waters. This information, as well as the device's tributary drainage area, weighted runoff coefficient, time of concentration and maximum (100-year) flow rate shall be provided by the Designer as noted in the Illinois Tollway special provision. The Designer shall receive approval from the Illinois Tollway Project Manager and/or the Environmental Unit prior to incorporating closed-system water quality treatment devices in the design. BMPs shall be maintained on a regularly scheduled basis in order to be fully effective.

A more detailed discussion of BMPs may be found in the USEPA National Menu of BMPs for Stormwater[2], the Illinois Tollway *Erosion Control and Landscape Manual*, the IDOT Drainage Manual Section 8-306 "Best Management Practices", the *ACEC-Illinois/IDOT 2014 Drainage Seminar* presentation and the *Illinois Urban Manual*.

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[2] National Menu of Best Management Practices (BMPs) for Stormwater | US EPA

SECTION 5.0 HYDROLOGY

5.1 General Considerations

The methodology selected by the Designer for the hydrologic analysis shall provide the runoff parameters required for the design and meet the requirements of Section 2. The Designer shall obtain the necessary information to model the watersheds under consideration. Runoff from outside of Illinois Tollway ROW, except for the passage of cross drainage or bypass flow, shall be kept separate when feasible. The Designer shall coordinate all efforts with the Illinois Tollway Project Manager.

5.2 Method of Analysis

The hydrologic analysis shall incorporate routings, duration analysis and loss functions appropriate to the design. The Designer shall use the applicable rainfall amounts and distributions shown in the Illinois State Water Survey, *Precipitation Frequency Study for Illinois* (ISWS *Bulletin 75*)[3] for all projects beginning in March 2020 or later.

For all projects involving stormwater detention, a single event hydrograph routing method shall be used with an antecedent moisture condition equal to 2. When peak discharge rates are needed for hydraulic analysis, a critical storm duration analysis shall be performed. Bridge deck and pavement drainage shall follow the methods described in the FHWA Hydraulic Engineering Circular 22, *Urban Drainage Design Manual*. See Table 5.0 for additional information on the Illinois Tollway design criteria for hydrology models.

Time of concentration and runoff curve number calculations shall be performed in accordance with procedures described in NRCS TR-55.[4]

[3] http://hdl.handle.net/2142/106653
[4] Tech Tools | Natural Resources Conservation Service (usda.gov)

Table 5.0
HYDROLOGY

Drainage Facility	Drainage Area Limitation	Preferred Methods of Analysis	Comments
General considerations	-	-	ISWS *Bulletin 75* precipitation data shall be used for all hydrologic analysis. Use a 0.95 "C" coefficient for impervious paved areas and 0.30 for grassed areas.
Roadway or bridge deck inlets	-	Rational Method, (FHWA HEC-22)	Use ISWS *Bulletin 75* rainfall intensities.
Storm sewers, roadside ditches and appurtenant culverts	≤ 200 acres	1. Rational Method 2. Hydrograph Method	A hydrograph method shall be used if the drainage area exceeds 200 acres. Use ISWS *Bulletin 75* rainfall intensities. It may be advisable for the Designer to use the hydrograph method for certain locations even if the tributary drainage area is less than 200 acres. Refer to Chapter 4 of the IDOT Drainage Manual for additional information regarding the limitations of certain drainage programs. The Rational Method is typically used for designing storm sewers and ditches within urban areas.
Bridges, culverts or channels	0.02 to 10,000 sq. mi. (Rural) 0.7 to 630 sq. mi. (Urban)	• IDNR-OWR Certified Discharges • USGS Regression Equations per the IDOT Drainage Manual for Urban areas and the StreamStats software for Rural Areas • Hydrograph Method	If a hydrograph method is used the appropriate Huff rainfall distributions and a critical storm duration analysis shall be utilized. Use ISWS *Bulletin 75* rainfall depths.
Detention systems or pump stations	-	Hydrograph Methods[5] • HEC-HMS • NRCS WIN TR-20 • XP SWMM / EPA-SWMM • Other methods with prior approval of Illinois Tollway	Appropriate Huff rainfall distributions and a critical storm duration analysis shall be utilized. Use ISWS *Bulletin 75* rainfall depths. The NRCS method shall be used to calculate Tc & runoff curve numbers for these models.

[5] For additional information regarding these programs see:
Tech Tools | Natural Resources Conservation Service (usda.gov)
http://www.hec.usace.army.mil/

SECTION 6.0 DITCH AND CHANNEL DESIGN

6.1 General Considerations

Roadway ditches and channels shall not cut across watershed divides or interrupt flow to critical water zones such as wetlands. The design flow shall be determined in accordance with the requirements mentioned in Section 5. Channels and ditches shall be grass lined unless hydraulic or other conditions require alternative channel lining materials.

Subject to ruling by the USACE, ditch wetlands are sometimes considered jurisdictional. If not jurisdictional under the Clean Water Act, IDNR may require replacement under the Interagency Wetland Policy Act (IWPA) of 1989 [Illinois Compiled Statutes (ILCS) 830]. Roadway ditches may be used to compensate impacted wetlands per the IWPA.

6.2 Hydraulic Design

Channels and ditches draining Illinois Tollway facilities shall be designed for the 50-year peak flow (i.e., flow with a 2% chance of exceedance in any given year). The design WSEL for ditch flows shall be at least 2.0 ft below the edge of pavement and 1.0 ft below adjacent ROW (to minimize impacts to adjacent properties). The minimum longitudinal slope for channels and ditches is 0.3% (0.5% desirable). If the minimum 0.3% longitudinal slope cannot be achieved, due to geometric and right-of-way constraints, additional landscape measures such as Articulated Concrete Block Revetment Systems (See Article 6.3.1) are recommended. The DSE shall coordinate with Illinois Tollway Environmental staff during the design phase to develop project specific landscaping measures to mitigate the deviation. The hydraulic design methods in the following references are acceptable:

- FHWA: “Hydraulic Toolbox (Current Version)”.
- USACE: "Hydraulic Design of Flood Control Channels" - EM 1110-2-1601[6]
- USDA. - Natural Resource Conservation Service: "Design of Open Channels" – Technical Release 25.
- Bentley: “Open Flows Flow Master Hydraulic Calculator Software”[7]

The Designer is not limited to the above references for selection of hydraulic methods.

6.3 Erosion Control in Ditches

The need for erosion protection shall be evaluated for all channel and ditch designs. A channel lining shall be required when the design discharge velocity exceeds the scour velocity for a grass lined ditch (See Table 6.0),or standing water resulting from flat ditch slopes. Paved ditches are discouraged from use as a channel lining and require a design deviation. It is recommended that the Designer use Articulated Concrete Block Revetment Systems (See Article 6.3.1) or ditch checks instead. For more detailed information regarding erosion control methods see *Erosion Control and Landscape Manual*.

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[6] https://www.publications.usace.army.mil/USACE-Publications/Engineer-Manuals/

[7] https://www.bentley.com/en/products/product-line/hydraulics-and-hydrology-software/flowmaster

Roadside safety and cost-effective construction and maintenance requirements for different treatments should be considered by the Designer in the selection of the lining. Riprap shall not be used around the perimeter of drainage structures. The preferred method for achieving erosion protection at end sections shall be through the use of products that promote revegetation within the area of concern. Extra measures may be necessary at base of sloped headwall for pipe underdrains in rubblized pavement (see Illinois Tollway Standard Drawing B24 for pipe underdrain details).

Table 6.0
PERMISSIBLE FLOW VELOCITIES FOR GRASS-LINED CHANNELS

Channel Slope	Lining	Permissible Velocity (ft/sec)
0-5%	Kentucky bluegrass (Silty clay)	7
	Tall fescue Kentucky bluegrass (Sandy silt)	5
	Grass-legume mixture	4
	Red fescue Redtop Sericea Lespedeza Annual Lespedeza	2.5
5-10%	Tall fescue Kentucky bluegrass	4
	Grass-legume mixture	3
Greater than 10%	Tall fescue Kentucky bluegrass	3

*For highly erodible soils, permissible velocities shall be decreased by 25%

Source: *Soil and Water Conservation Engineering*, by G. O. Schwab et al. (1981); Stream Restoration Design (National Engineering Handbook 654), Chapter 8, USDA NRCS, August 2007

NOTE: For Grass-lined Channels see also:

- *Stability Design of Grass-lined Open Channels*, by D. M. Temple, et al., USDA – ARS – Agriculture Handbook #667, September 1987.
- *IDOT Drainage Manual* (Section 9-500).
- Hydraulic Engineering Circular No. 15 (HEC-15), *Design of Roadside Channels with Flexible Linings*, Third Edition, September 2005.

Ditch checks may be used as a structural measure for flow velocity reduction and channel erosion control.

In locations where groundwater impacts the channel lining's stability, the Designer shall evaluate the use of and establish the need for subsurface drains and filter fabrics.

6.3.1 Articulated Concrete Block Revetment Systems

Articulated Concrete Block Revetment Systems (ACB Systems) are a flexible manufactured permanent erosion control system that is able to expand and contract with the subgrade. The systems are made of individual concrete block units, which are physically integrated through mechanical interlock, cables, grids or other means to produce an erosion-resistant lining.

ACB Systems should be utilized in the following cases:

- Where the ditch slope is below 0.3%.
- Where the water velocity is above the permissible limit for a grass lined ditch (See Table 6.0).
- For meandering channels where scour has been observed or is anticipated.
- As permanent erosion control for storm sewer and culvert headwall outlets where outlet velocity exceeds 5 ft/s (does not include underdrain outlets).
- For maintenance crossings as discussed in Article 6.3.2.
- For replacement of deteriorated or damaged concrete ditches during any reconstruction project.
- Where water is likely to fall over bridge joints or drain around wingwalls creating a potential for erosion.
- Near toe of MSE walls when walls are placed adjacent to the ditch flow line.
- Under bridge and building downspouts where erosion may occur.
- Emergency spillways, at the crest and at the downstream slope. For this application, the mat configuration shall be closed cell. A minimum 4-inch-deep bed of coarse aggregate (CA11) shall be provided under the ACB system to prevent uplift.
- At slopes where seepage is occurring.
- For embankment slope protection from bypass flow where no gutter is present at the end of the parapet (See Article 9.4).
- Other locations where recurrent slope failures have been identified by Illinois Tollway Maintenance.

ACB Systems may also be utilized for abutment slope protection.

The maximum bank slope for an ACB System shall be 1:2 (V:H). Geotextile fabric shall be placed immediately prior to the ACB System to prevent erosion and undermining unless a deep-rooted plant will be used.

Pre-cast revetments that are assembled without a physical connection between the blocks should not be used on slopes greater than 1:3 (V:H). Any system chosen shall have an open block design to allow vegetation to grow through, unless vegetation growth is not possible, such as below the normal water level of detention basins. In this case, a closed cell block or a combination of both should be used.

At storm sewer and culvert headwall outlets, the minimum recommended mat width is 3 times the pipe diameter or equal to the downstream width of the headwall, whichever is greater, and the minimum recommended mat length is 6 times the pipe diameter. A longer mat may be required depending on downstream conditions such as steep slopes.

Three classes of ACB systems are used on the Illinois Tollway system, varying in size and weight, meeting the permissible bed shear stress described in the table below. The bed shear stress exerted by the design flow shall be calculated using Equation 2.4 in HEC-15. The permissible bed shear stress is preferred over the permissible flow velocity because the bed shear stress is relatively constant for a product whereas the velocity varies depending on flow characteristics such as depth and turbulence. Where there is no defined channel and a bed shear stress cannot be calculated, the permissible flow velocity shall be used instead, to determine the required block type. Determine the type in accordance with the table below.

Type	Minimum Product Permissible Bed Shear Stress (lbs/sq.ft)	Velocity (Max, ft/sec)
1	5	10
2	15	18
3	20	24

In cases where higher than normal scour is anticipated due to steeper side slopes or meandering channels, engineering judgment shall be used to determine if heavier block systems are required.

All proposed block systems shall be tested in accordance with ASTM D7277 prior to being approved for a project. The tests shall be performed at an independent testing facility, with results reported by a licensed professional engineer.

6.3.2 Bioswales

Bioswales are a type of post-construction BMP that may be used to convey storm water runoff. Bioswales provide an alternative to closed storm sewers or typical roadside ditches when attempting to improve water quality in special management areas or immediately upstream and/or adjacent to Waters of the United States, wetlands, or special habitat areas.

Due to special maintenance needs, additional considerations shall be made when bioswales are specified in place of a traditional ditch application.

The Illinois Tollway has developed bioswale base sheets to facilitate design. It should be noted that the base sheets are not standard drawings but require customized design and completion prior to insertion into a contract. Bioswales may be designed to reduce runoff speed and promote infiltration. Base sheets are provided for three types of bioswales:

- Bioswale Type 1 may be used at locations where highly permeable soils are identified to be present (well drained sand and gravel).
- Bioswale Type 2 may be used at locations where soils are well drained or moderately drained with fine to moderately coarse texture and a relatively low water table.
- Bioswale Type 3 includes a pipe underdrain and may be used in locations where low permeable soils are present such as fine-grained silts and clays and fluctuating water tables (i.e., gravelly clays, sandy clays, or lean clays).

NOTE: Bioswales shall not be used in areas with significantly low infiltration rates, known ponding, permanent high-water tables, in areas with limited pavement runoff or over any known impervious material impeding downward movement of water (highly organic clays or clay layers).

For any length of bioswale longer than 1,200 feet without any other maintenance access crossing, crossings composed of revetment mats or grass berms shall be provided every 1,200 feet. These breaks shall be a minimum of 15 feet in width and shall allow maintenance vehicles the ability to cross the bioswales to reach the back slope without disturbing the vegetation or compacting of the soil.

Design considerations such as pipe underdrains, plant species and side slopes shall be considered. The existing infiltration rate should be determined at the start, end and at periodic intervals throughout the proposed bioswale corridor. Geotechnical borings are required to determine the groundwater table elevations and how the soil drains. These factors shall help determine which bioswale type is preferred for each particular location.

Bioswales reduce pollutants including oils, sediments, metals and nutrients through physical and biological processes. They typically include ditch checks to allow for added WQV. Pretreatment prolongs the bioswale life by reducing the amount of particulate matter entering the bioswale. Pretreatment includes catch basins, street sweeping, grass filter strips and furrows.

Bioswales may be utilized as a water quality feature and where the appropriate hydric soil conditions exist. First flush capture in the bioswales and other BMPs may be utilized to meet the WQV requirement described in Article 10.3. Designer Percolation tests shall be completed to ascertain the potential rate of infiltration expected. In cases where a high-water table is present, Designers may consider other design options or customize the bioswale appropriately per the given site conditions. Specific runoff quality improvements may be required, depending on the local conditions. When it is desired to mitigate the runoff of dissolved solids (TDS), Bioswale Type 2 may be preferable. When it is desired to mitigate runoff of TSS or accumulation of metals, Bioswale Type 3 may be preferable.

6.3.3 Furrows

Furrows are long, narrow, shallow trenches plowed into roadside embankment, often accompanied by a small ridge immediately adjacent to the furrow between the furrow and the bottom of the embankment. Furrows run on contour of the roadway embankment and promote stormwater infiltration and sediment or debris capture. The accompanying ridge checks sheet flows, allowing for runoff to be temporarily retained within the furrow, promoting percolation through the topsoil layer, thereby maximizing infiltration and reducing velocities prior to stormwater reaching any ditches or bioswale bottom.

The furrows shall be approximately four inches deep. Furrows and the accompanying ridge shall be vegetated with the same seed mix as the rest of the embankment. Furrows shall always be installed beyond the clear zone and should consider mowing needs before placement is defined.

Design considerations such as steepness of slope, maintenance mowing and downstream resources should be considered. Furrows may help reduce debris and pollutants, including oils, sediment and metals, as well as reduce flow volumes and velocities.

6.4 Typical Ditch Sections

When selecting a ditch section, the Designer shall consider roadside safety, maintenance requirements and hydraulic efficiency. Generally, the main geometric characteristics of Illinois

Tollway ditches shall be as shown in the *Illinois Tollway Roadway Design Criteria* Article 2.6.8 and the following table:

Ditch Bottom Width	See *Roadway Design Criteria* Articles 2.6.8 and 2.6.9
Ditch Foreslopes[8]	See *Roadway Design Criteria* Article 2.6.8
Ditch Backslopes	See *Roadway Design Criteria* Article 2.6.8
Maximum WSEL in Ditches	2.0 ft. below the edge of pavement 1.0 ft. below adjacent ROW[9] (50-year Design)

The ditch cross section shall be designed to allow for easy access by maintenance crews. If the ditch is located behind a noise or retaining wall then a gate with a door would be required to grant access. The proposed storm sewer and pipe underdrain outlet invert elevations shall be set approximately 6 inches above the bottom ditch invert elevation.

A check for hydraulic jump shall be performed by the Designer at the slope drain outlet. If a hydraulic jump occurs, appropriate measures shall be provided to eliminate the jump or dissipate the energy of flow.

6.5 Watercourse Confluences

The USACE EM 1110-2-1601, *Hydraulic Design of Flood Control Channels,* contains guidance for the design of watercourse confluences. The Designer shall design the confluence of channels, ditches, or sewer outfalls in such a way that scour potential at the confluence is minimized. Scour potential may be reduced by the use of channel linings. The products mentioned and shown in Table 6.1 shall be considered for channel lining.

[8] Ditches shall be designed to avoid the need for a Barrier Warrant, if possible. See Illinois Tollway *Traffic Barrier Guidelines* for details.

[9] If the ditch is outside of the ROW and within a permanent easement, the minimum freeboard requirement is relative to the permanent easement boundary.

Table 6.1
DITCH AND CHANNEL HYDRAULICS

	Design Criteria	Comments
1. Design Discharge	50-year (2% chance of exceedance)	Flow to be determined in accordance with Section 5.
2. Design Water Surface	Minimum 2.0’ below edge of pavement and 1.0’ below adjacent ROW.	The ditch freeboard requirement does not apply to swales that drain grassed areas within the ROW, have a flow depth less than 6 inches and are drained by catch basins.
3. Minimum Longitudinal Slope	0.5% desirable (0.3% minimum)	If longitudinal slope <0.3%, then the ditch/channel shall require special consideration to encourage positive flow.
4. Maximum Flow Velocity	3-5 fps depending on ditch slope	Maximum velocity is a function of the lining and/or soil type for vegetative linings.
5. Shape	Most efficient hydraulic section	Subject to safety and maintenance the section shall be in accordance with AASHTO's "Roadside Design Guide."
6. Lining	Grass lining is preferred	If the velocity exceeds the maximum allowed for grass lining, the ditch shall be lined with manufactured linings, or other available materials with Illinois Tollway approval[10].
7. Erosion Protection	As required	**References:** 1. Illinois Tollway Standard Drawings (Erosion and Sediment Control Standards) 2. "Procedures and Standards for Urban Soil Erosion and Sedimentation Control in Illinois” (Illinois Urban Manual / The Green Book)
8. Ditch Checks	The crest shall be a minimum of 1' above grated inlets within roadside ditches and 2.0’ below edge of pavement.	Ditch checks shall not be located within the clear zone, nor at the toe of unshielded non-recoverable slopes. The water depth at the ditch check shall not exceed 4 feet for safety concerns (especially if located within the clear zone).

[10] Additional information may be obtained at: http://www.aiswcd.org/illinois-urban-manual/

SECTION 7.0 CULVERT DESIGN

7.1 General Considerations

Culverts conveying cross drainage or bypass flow from outside of Illinois Tollway ROW shall be located on the natural drainage path of the flow. When the natural drainage path of the flow is a wide overland flow area, the Designer shall evaluate the need for multiple culverts in order to prevent concentrated flow at a single location. The proposed cross culvert shall be aligned with upstream and downstream channels. The Designer shall not change the existing skew angle without prior approval from the Illinois Tollway Project Manager. For all proposed culvert crossings where standing water exists upstream and downstream year-round, the Designer shall prepare an alternative analysis which documents why the use of an arch-span, bottomless culvert or bridging is not practicable. This analysis shall be provided at the pre-concept (or concept) stage of the design contract.

The Designer shall analyze the existing flow conditions of the areas located upstream and immediately downstream of proposed cross culverts. Land use conditions in upstream and downstream areas shall be clearly documented in the Drainage Report, including photo documentation of the areas, if possible. This documentation of existing conditions for the adjacent drainage areas, prior to implementation of Illinois Tollway improvements, may provide useful information for subsequent adjacent property owner inquiries. The Designer is responsible for determining if upsizing the cross culvert and reducing the created head to meet the design criteria is required, without creating a known flooding hazard downstream. If upsizing the cross culvert to meet Illinois Tollway freeboard criteria results in increasing the WSEL at sensitive outlets, the Designer shall provide the necessary hydrologic/hydraulic calculations to determine the extent of the impacts downstream. The Designer is responsible for evaluating each outlet separately and coordinating with the local municipality to determine whether (or not) there are existing flooding concerns downstream of each specific outlet. It should be noted that the Illinois Tollway system shall not act as a restriction for bypassing offsite runoff.

The designer should avoid significantly lowering the low road overtopping elevation within the floodplain limits, even if the Illinois Tollway freeboard criteria are achieved. Stream crossings are susceptible to upstream and downstream blockage (or other unforeseen activities) which may raise the flood profiles significantly, resulting in roadway overtopping and potential damage to downstream properties. The DSE shall check downstream impacts prior to lowering the profile.

Existing CMP pipes shall be replaced during any reconstruction/rubblization projects.

7.2 Hydraulic Design

Culverts shall be designed for the 50-year peak flow and shall be checked for the 10-year, 100-year and 500-year peak flows. HWEs shall not overtop the roadway for the 500-year peak flow (i.e., 0.2% chance of exceedance flow in any given year).

Culverts shall meet the following requirements:

- The design headwater depth does not exceed the barrel height, $HW/D \leq 1$
- 0.5 feet of created head maximum for new culverts or replacement culverts no more restrictive than existing

- 3.0 feet minimum freeboard between the design headwater elevation and the low edge of pavement

For proposed culverts conveying watercourses, the requirements for the "*maximum created head*" shown in Table 8.0 – Bridge Hydraulics shall apply.

The design HWE shall not adversely impact Illinois Tollway facilities and/or adjacent properties. The design headwater shall not cause flooding to adjacent properties. The created headwater under 100-year flow conditions shall not encroach on any adjacent properties.

The Designer shall verify that the 50-year design and 100-year check flow velocities from a culvert discharging from Illinois Tollway ROW shall not cause erosion to the adjacent property. At locations where culverts are located in floodplains under the jurisdiction of IDNR-OWR or other agencies, the culvert shall meet all applicable permits or other requirements.

For smaller diameter cross culverts that don't have a defined channel at the downstream end, computing the natural highwater elevation is not required. These cross culverts shall be designed to achieve a HW/D ≤ 1 ratio. If no defined channel is present the Designer shall note "N/A" for the "opening area" and "NHWE" in the WIT.

A summary table shall be provided listing all:

- Culvert crossing stations
- Existing/proposed sizes, invert elevations, lengths
- Design freeboard
- HW/D values
- Design discharges
- Existing/natural/proposed WSELs
- Any other relevant information, such as the hydrologic method used to calculate discharges.

A WIT shall also be included for major stream crossings with designated floodways and/or floodplains (see Appendix H). The design shall be in accordance with the methods in the FHWA Hydraulic Design Series Number 5 (HDS 5) *Hydraulic Design of Highway Culverts.* HY-8, Open Flows Culvert-Master (Bentley)[11], HEC-RAS (for major crossings with designated floodways and/or floodplains), or other computation program may be used for culvert design, with the Illinois Tollway Project Manager's approval. Refer to Appendix H for WIT examples.

Where feasible, the Designer may recommend the use of improved hydraulic culvert inlets. Improved culvert inlet designs shall be developed in accordance with FHWA-HEC No. 13, *Hydraulic Design of Improved Inlets for Culverts*.

The minimum size culvert crossing the Illinois Tollway pavement or ramps shall be 24 inches in diameter for lengths less than or equal to 200 feet and 30 inches in diameter for lengths over 200 feet. The minimum size for a pipe culvert located within roadside ditches shall be 18 inches in

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[11] Additional information regarding Culvert Master may be found at: https://www.bentley.com/en/products/product-line/hydraulics-and-hydrology-software/culvertmaster

diameter. No CMP pipes shall be allowed by the Illinois Tollway. Field verification is required to check condition of existing culvert and documented in the drainage reports.

7.3 Culvert Lining

When lining is necessary for culvert rehabilitation, the Designer shall field verify maximum outside diameter of liner that may be installed, then calculate the culvert hydraulic conveyance, to verify capacity is not decreased and the maximum design outflow velocity is not significantly increased with the proposed lining in place. A calculation is required to determine if the culvert may drain in a pressure or gravity flow condition, in a pressure flow condition a lining may reduce the hydraulic conveyance. The designer shall notify the Illinois Tollway if any culvert lining would result in an increased risk of flooding. The required field documentation and calculations shall be provided for Illinois Tollway approval, at or prior to concept submittal. Erosion control measures shall be provided, especially at the downstream end of a lined culvert as appropriate. A design deviation from the Illinois Tollway is required if an existing CMP culvert shall be lined instead of full replacement with RCP, within the limits of the roadway reconstruction or rubblization.

7.4 Installation of Culverts

Pipe culverts shall be constructed of reinforced concrete except at locations where this type of material would be unsuitable. If reinforced concrete culverts are unsuitable for a specific site, the Designer shall recommend another type of culvert material to be used. The Designer shall receive written approval from the Illinois Tollway Project Manager for culvert material substitutions.

Consider eliminating existing culvert crossings if only used to connect roadside ditches located on opposite sides of the Illinois Tollway pavement and without a defined outlet. These crossings may be combined with downstream outlets if located within the same watershed.

A proposed culvert headwall constructed without grating and a vertical drop greater than 4’ shall require a fence to be installed atop the headwall structure’s perimeter.

7.5 Special Installations of Culverts

Special studies shall be performed where fill heights exceed 20 feet and where soil conditions or other factors may indicate abnormal installation procedures. The Designer's recommendation for such special treatments shall be included in the preliminary drainage design.

For channel crossings located within or adjacent to WOUS the Designer shall utilize the Environmentally Sensitive Stream Crossing Design Matrix as described in Appendix K. In locations where the recommended alternative is an embedded culvert the proposed culvert shall be embedded by approximately 1 foot. This embedded portion shall be in addition to the required culvert size to meet hydraulic requirements. For instance, if a 6’ W x 5’ H box culvert is required for hydraulic purposes, then a 6’ W x 6’ H culvert shall be placed within the channel with 1 foot being buried. If multi-cell culverts are used, they shall be designed to have a low flow cell similar in width to the adjacent stream channel. For this multi-cell option, the natural water depth and velocity shall be mimicked throughout the structure. Also, use weir walls on flanking cells so that the culvert inverts and tops match while reflecting the natural channel/overbank shape.

Embedded culverts shall be designed with a natural soil “n” value (~ 0.03) instead of a typical “n” value (0.012) used for concrete. In hydraulically sensitive outfall locations, where providing additional hydraulic conveyance would result in downstream flooding, riprap may be provided at the upstream and downstream end treatments, to meet the hydraulic requirements. If utilized, the riprap shall not be placed throughout the entire length of the culvert but instead placed in a manner in which may be removed and replaced by Illinois Tollway Maintenance staff. The embedded culverts shall be designed so as not to impede low water flows or the safe passage of fish and aquatic organisms and allow for the natural substrate to colonize the structure's bottom, encourage fish movement and maintain the existing channel slope.

The Illinois Tollway has developed two methods for placing riprap at embedded culverts. In Figure 7-5A (Method 1), the riprap material shall protrude approximately 5 feet into the culvert at both the upstream and downstream ends and then taper off at a 1:10 (V:H) slope (which is intended to allow fish passage during flood events). In Figure 7-5B (Method 2), would install a concrete curb with low flow weir, at each end. This method may be desired in streams with higher flows, poor access for maintenance, or an unreliable/changing watershed upstream. Both methods utilize riprap to dissipate large inflow and outflow velocities and allow for soils to naturally fill up the embedded depth throughout the rest of the culvert bottom. These approaches adhere to the USACE requirement of allowing *the natural substrate to colonize the structure's bottom, encourage fish movement and maintain the existing channel slope*.

Figure 7-5A Riprap Design Method 1

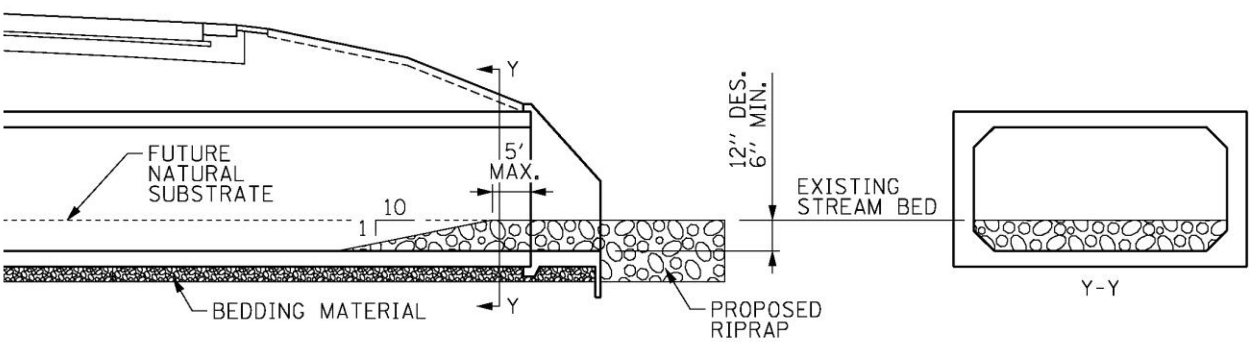
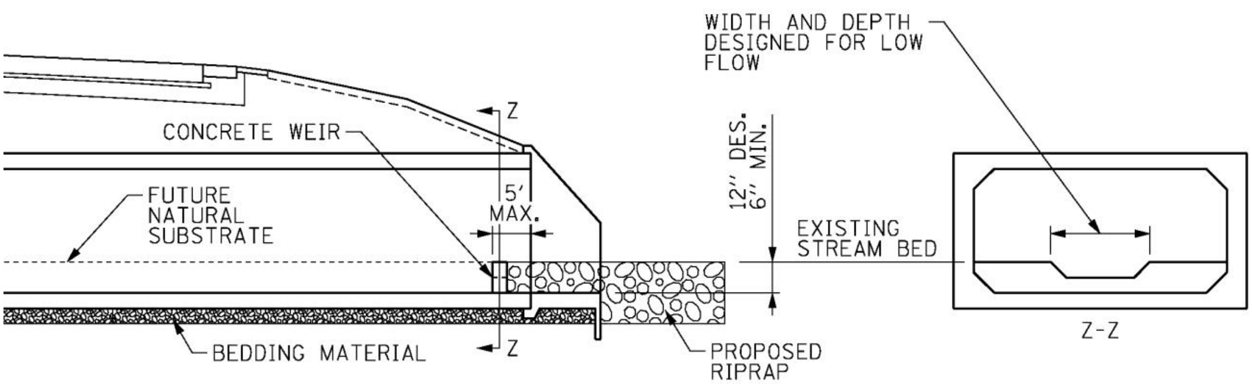


Figure 7-5B Riprap Design Method 2



7.6 Culvert End Treatment

The Designer shall establish the culvert end section stationing, offset distance and invert elevation based on the standard drawings. This information shall be provided for all drainage structures on the contract drawings.

Special attention shall be given to the culvert ends that are facing traffic. Culvert ends shall not be an obstacle to traffic. The *AASHTO Roadside Design Guide* shall be used for roadside safety design requirements. Adequate erosion control measures at the inlets and outlets shall be provided, if necessary. The Illinois Tollway does not recommend placing culvert headwalls parallel to the roadside ditch for safety concerns.

Culverts which are installed on a skew to the centerline of roadway shall be orientated into the direction of traffic. This is necessary to properly align the pipe runners for an errant vehicle to traverse.

The Illinois Tollway recommends using headwalls and/or sloped headwalls for embankment slopes as follows:

- Slopes Steeper than 1:3 (V:H): Headwall Type I & II and Sloped Headwall Type I & II
- Slope 1:3 (V:H): Headwall Type III and Sloped Headwall Type III (only utilized in lower barn roof foreslope locations)
- Slope 1:4 (V:H): Headwall Type III & IV and Sloped Headwall Type III
- Slope 1:6 (V:H): Headwall Type III and Sloped Headwall Type III
- Slope 1:10 (V:H): Headwall Type III

See Appendix E for the selection and use of Headwalls and Sloped Headwalls. Refer to Illinois Tollway Standard Drawings in Section B.

See Table 7.0 for additional information on Illinois Tollway criteria for culvert design.

7.7 Maintenance and Inspection Access

Culverts shall be designed for ease of maintenance access. The preferred profile gradient for maintenance access paths to culverts should be less than or equal to 8%. Where these grades are not achievable because of constraints, the maximum gradient shall be 1:4 (V:H). Grades steeper than 1:4 will require a design deviation. Maintenance access paths shall have a minimum 10 ft width and should be paved or built with material to provide traction in wet conditions, such as articulated concrete blocks seeded with low profile grasses. Gravel paths for maintenance access to culverts shall not be allowed.

Bridge culverts shall meet the clearance requirements for bridges shown on Table 8.0 and shall have a minimum cell height of 5 ft (6 ft desirable) to allow for maintenance and inspection access.

Table 7.0
CULVERT HYDRAULICS

	Design Criteria	Comments
1. Design Flood	50-Year (2% chance of exceedance)	Flows to be determined in accordance with Section 5. “Hydrology”
2. Check Floods	10-Year (10% chance of exceedance) 100-Year (1% chance of exceedance) 500-Year (0.2% chance of exceedance)	10-year storm design used to determine culvert outlet velocities. Meet all IDNR-OWR permit criteria for all storms up to and including the 100-year design storm, if applicable (See *Environmental Studies Manual* Article 6.4.2). Ensure no overtopping of roadway for 500-year design storm at low edge of pavement.
3. Minimum Diameter/Maximum Length for Roadway or Ramp Crossings	24” Ø / L ≤ 200’ 30” Ø / L > 200’	RCP pipe
4. Minimum Diameter for Ditch Culverts	18"	RCP pipe
5. Maximum Headwater for Design Flood	HW/D ≤ 1 0.5 feet of created head maximum for new culverts or replacement culverts no more restrictive than existing	HW/D > 1 may be allowed with prior approval of the Illinois Tollway Project Manager in cases where there is a controlling tailwater condition and increases in culvert size result in little or no impact to the created head. For culverts conveying watercourses, maximum created head criteria in Table 8.0 shall apply. Methods in FHWA HDS-5 are preferred. HY-8 is an automation of the HDS-5 methods. HEC-RAS should be used for major stream crossings.
6. Minimum Freeboard	3 ft.	Between the design headwater elevation and the low edge of pavement
7. Inlet / Outlet End Treatments	As needed for hydraulics, safety and erosion control	The safety end treatment of culverts shall be applied according to Illinois Tollway Standard Drawings.

SECTION 8.0 BRIDGE HYDRAULICS

8.1 General Considerations

Bridges conveying watercourse flow from outside of Illinois Tollway ROW shall not redirect the watercourse path or reduce the watercourse conveyance.

The Designer shall analyze the existing flow conditions of the areas located upstream and downstream of the proposed bridge. Land use conditions in the upstream and downstream areas shall be clearly documented in the Drainage Report, including photo documentation of the areas if possible. This documentation of the existing conditions on the adjacent drainage areas, prior to construction of the Illinois Tollway project, may provide useful information for subsequent adjacent property owner inquiries.

8.2 Hydraulic Design

Bridges shall be designed with waterway openings to pass the 50-year peak flow and shall be checked for the 100-year and 500-year peak flows. The bridge low chord elevation shall be set at least 2.0 feet above the (50-year) design natural high-water elevation with backwater effect if appropriate (i.e., the clearance under the bridge). The lower beam elevation of the bridge deck shall be set at or above the 100-year peak flood WSEL and the highest recorded or observed flood elevation at the bridge location, if available. The top of bridge deck or approach roadway shall not be overtopped by the 500-year flood event at the low edge of pavement.

In addition to these criteria the bridge waterway opening may have to meet the floodplain encroachment criteria described in Section 3 – Floodway/Floodplain Encroachments. The Designer shall provide a WIT for all bridge crossings (see Appendix H). The Designer shall also provide a WIT back-up calculation spreadsheet as outlined in the 2014 ACEC-Illinois / IDOT Drainage Seminar Manual. This spreadsheet shall include computed NHWEs, freeboards and clearances and the effective waterway opening area. The WIT shall also include the 2-year peak flow, as required for the in-stream work plan per USACE – Chicago District standards.[12]

8.3 Site Inspection and Bridge Survey

Site inspection of an existing or proposed bridge location is an important component of the hydrologic and hydraulic analyses, especially for those sites with increased risk of significant flood damages. During the site inspection, the following information shall be observed or obtained:

- Land use and related flood hazard
- The general flow pattern during floods
- Locations of the channel and valley cross sections that need to be surveyed
- Estimation of channel roughness coefficients
- Evaluation of the channel and banks for erosion and/or stability
- Evidence of drift and debris that may accumulate at the bridge during floods
- Identification of high-water marks
- Interviews with local-residents or construction and maintenance personnel on the flood history in the area

[12] https://www.lrc.usace.army.mil/Portals/36/docs/regulatory/pdf/cofferdam.pdf

- Upstream and downstream channel obstructions, such as beaver dams
- Current water depth at each channel cross section surveyed

The bridge survey performed by a professional land surveyor shall provide information as follows:

- Existing hydraulic structures immediately upstream and downstream of the proposed or existing bridge location (e.g., bridges, culverts, weirs/ spillways, inlets, outlets, drops, dams, blockages, etc.) including photos, sketches and topographic information (i.e., elevations, sizes, length, width, height, shape, type).
- Location and low entry elevations of buildings within the floodplain located between the proposed bridge location and nearest upstream and downstream hydraulic structure.
- Streambed and valley characteristics, including valley cross sections upstream and downstream of the proposed or existing bridge location. The number of cross sections surveyed should be sufficient to adequately model the bridge. At a minimum, cross sections shall be taken at the upstream and downstream bridge face, at the upstream and downstream Illinois Tollway ROW boundaries, 500’ upstream and downstream of the structure crossing and 1000’ upstream and downstream of the structure crossing (along the streambed channel alignment). If a new highway alignment is proposed, a cross section is required on that alignment. Other structures located within the limits mentioned above shall be surveyed. If there are additional structures located within 500’ upstream and/or downstream of the limits indicated, they should also be surveyed and included in the hydraulic modeling.
- A roadway profile shall be taken in the area of the crossing in order to establish the available freeboard and location of potential overtopping. The profile should be taken at the high point of the roadway.
- Existing vegetation in the floodplain and channel banks shall be characterized and photo documented for an estimation of the roughness coefficients.
- Plan view showing the locations of the cross sections and existing structures surveyed in the field.
- The stream survey shall include at least 4 surveyed points (which includes at least 2 points at the bottom) within the main channel and not be limited to only 3 points (2 overbanks and 1 bottom of channel elevation).

Aerial photographs, USGS and municipal maps should be consulted in order to have a good understanding of the geographic layout of the site. The aerial photographs may provide information on the properties adjacent to Illinois Tollway ROW prior to the proposed project construction. These may be extremely useful for the development of hydraulic computation models.

A FEMA Flood Insurance Study (FEMA-FIS), if available for the site, may provide additional data regarding peak flood discharges, water surface profile elevations and the limits of the regulatory floodways. This base data shall take precedence during the design stage. The Designer shall also perform a benchmark correlation with FEMA data.

8.4 Backwater Analysis

One-dimensional computation models such as the HEC-RAS and FHWA-WSPRO are preferred for analyzing the impact of the bridge on the water surface profile. The method of analysis may be dictated by IDNR-OWR requirements. When an unsteady flow computation model is required for the bridge site, the HEC-RAS version 4.0 or later or FEQ (required for DuPage County) computation software may be used. Other academically recognized or agency accepted dynamic models may also be used with prior Illinois Tollway approval. All methodologies shall meet the requirements of Section 2.

Hydraulic design of bridges requires analysis of both existing and proposed conditions at the bridge site. In some cases, especially for IDNR-OWR permit applications, the hydraulic calculations for natural conditions (i.e. without the proposed bridge or culvert included in the model) may be necessary. The natural conditions WSELs may change if the channel is re-graded under or above proposed streambed elevations. Starting WSELs for backwater analyses shall reflect appropriate downstream flow conditions. Backwater effects from the bridge waterway opening shall be determined by comparing the WSELs upstream of the structure for the natural, existing and proposed conditions. Negative created heads shall be shown as a “0” value in the WITs. Refer to the “Waterway Hydraulic Report” section of the *ACEC-Illinois/IDOT 2014 Drainage Seminar* manual for further discussion on how the created head should be calculated at the upstream face of bridge structures.

For bridges located near and upstream of a confluence with a larger or comparable watercourse, additional computations shall be required to evaluate, with and without backwater effects from the larger or comparable watercourse. The higher of the backwater elevations resulting from the computations shall control design. Also refer to Table 7-3 of the *Urban Drainage Design Manual (HEC-22)* for determining starting tailwater conditions at downstream confluences with other major streams. For very large floodplains constricted through a small bridge opening, the one-dimensional assumption used in the HEC-RAS and other one-dimensional computation methods/software may not apply. In these situations, for bridges over large rivers, where the floods have a complex flow pattern, a two-dimensional computation model may be necessary.

8.5 Scour Analysis

Scour at piers or abutments are a major bridge collapse hazard. Bridge scour is comprised of several interrelated components including long term profile changes, contraction scour and local scour. Bridge design shall incorporate scour analysis and protection where appropriate. The scour analysis shall be performed in accordance with the latest edition of FHWA publication Hydraulic Engineering Circular No. 18 (HEC-18) *Evaluating Scour at Bridges*. The latest editions of FHWA publications HEC-20 *Stream Stability at Highway Structures* and HEC-23 *Bridge Scour and Stream Instability Countermeasures* shall be used as a guidance for identifying stream instability problems at highway stream crossings and for countermeasures to mitigate potential scour damage.

The HEC-RAS computer software version 6.0 still uses the scour equations from the 2001 FHWA HEC-18 manual. HEC-RAS version 6.0 does not incorporate the updated procedures in the April 2012 HEC-18 Manual (Fifth Edition). Therefore, both IDOT and the Illinois Tollway do not currently accept the HEC-RAS scour calculations until the calculations are updated to the latest FHWA methodology. In order to reduce possible bridge scour, the piers and abutments shall be aligned as much as possible along the main direction of flood flow. Lateral channel movement upstream and downstream of the bridge is another element that shall be considered in the bridge design, especially when significant lateral channel migration may be expected. The top of footing elevations shall be set below the long-term degradation and contraction scour depth of the channel and overbanks. The bottom of footing elevations shall be set below the total calculated scour depth at the piers and abutments (i.e., long-term profile changes, contraction scour and local scour). Hydraulic countermeasures intended to protect the pier or stabilize channel alignment cannot be considered absolute safeguards against scour. It is unrealistic to expect these countermeasures to remain stable and in place throughout the service life of a structure.

Refer to the “Waterway Hydraulics Report” section of the *ACEC-Illinois/IDOT 2014 Drainage Seminar* manual for the design procedure required for scour analyses. See Table 8.0 for additional information on Illinois Tollway criteria for bridge hydraulic design.

Table 8.0
BRIDGE HYDRAULICS

	Design Criteria	Comments
1. Design Flood	50-Year (2% chance of exceedance flow)	Flows to be determined in accordance with Section 5.
2. Check Floods	100-Year (1% chance exceedance flow) 500-Year (0.2% chance exceedance flow)	Meet all IDNR-OWR permit criteria for all storms up to and including the 100-year design storm, if applicable (See *Environmental Studies Manual* Article 6.4.2). No overtopping of roadway at the low edge of pavement for 0.2% chance exceedance flow.
3. Minimum Low Chord	At least 2' above 50-year NHWE plus backwater effect	Must also be above recorded high water at site and check flood and the 100-year HWE.
4. Minimum Freeboard	3 ft above 50-year created head elevation	To the low edge of pavement
5. <u>Maximum Created Head</u>: a. In designated floodways in Cook, DuPage, Kane, Lake, McHenry and Will Counties b. In other urban areas c. In rural areas	<0.1 ft. (all storm events up to and including 100-year vs. existing) <0.5 ft. (all storm events up to and including 100-year vs. existing) <1.0 ft. (all storm events up to and including 100-year vs. existing)	Meet all IDNR-OWR permit criteria if applicable. Meet all IDNR-OWR permit criteria if applicable. Meet all IDNR-OWR permit criteria if applicable.
6. Scour Analysis and Protection Measures	100-Year Design 500-Year Check Scour New countermeasures and extensions of existing countermeasures: 500-Year Design	Design according to 2012 FHWA HEC-18 Manual (Fifth Edition).

SECTION 9.0 ROADWAY DRAINAGE DESIGN

9.1 General Considerations

All Illinois Tollway roadway drainage facilities (including oasis areas) shall be designed for a 50-year flood event. The design of all pavement medians, shoulders and associated drainage structures shall ensure that there is zero runoff encroachment on the traveled way. Stormwater shall remain on the shoulder no closer than 3' from the edge of pavement. The maximum depth of flow shall be limited to 0.35 feet, regardless of the calculated encroachment width. At locations where the shoulder width narrows or no shoulders are present, the Designer shall coordinate with the Illinois Tollway Project Manager to develop other options to mitigate pavement encroachment. For bridge decks the maximum spread of runoff shall not encroach onto the traveled way. Design flows shall be determined in accordance with Section 5. The analysis procedures used in the design shall be in accordance with Section 2.

9.2 Roadway Profile

In floodplains and at culverts and bridge crossings, the roadway profile shall be designed such that there is a minimum of three feet vertical freeboard from the peak 50-year flood elevation to the low side of edge of pavement, at the low road elevation. Avoid lowering the existing roadway profile at sag locations, unless existing overflows from offsite areas are analyzed for overtopping concerns to adjacent properties. Refer to the Illinois Tollway *Roadway Design Criteria* Manual for more information on designing the roadway profile and for determining minimum gutter slopes.

9.3 Pavement Drainage

Pavement cross slopes shall conform to the Illinois Tollway *Roadway Design Criteria*. For super-elevated transition sections, drainage structures shall be designed to avoid ponding of runoff and prevent flow from bypassing the last inlet prior to the transition. It is recommended that an inlet / catch basin structure be placed approximately 50 ft upstream of a 0% superelevation transition point to capture bypass runoff, since pavement storage is reduced to almost zero once the transition point reaches a 0% cross slope. The concentrated runoff draining across the superelevated roadway section shall be limited to 0.15 cfs. Inlets, catch basins, manholes, junction chambers, or vault access openings shall not be allowed in the pavement or shoulder sections. Structure openings shall be located within the gutter area or at edge of shoulder (where retaining / barrier walls are present). In situations where the two openings in a restrictor manhole cannot be located within the gutter area due to conflict with an adjacent retaining wall or noise wall, a rectangular structure with restrictor (M-DRN-604) shall be used. For stormwater treatment systems which may consist of multiple access openings, a bypass configuration or a combination of both, the units shall be placed in an adjacent infield area or a bump out for stormwater treatment system (M-DRN-605) shall be provided. For the placement of drainage structures in moment slabs to ensure the access opening can be located at the front face of the barrier wall, refer to M-DRN-606.

Pavement runoff and inlet spacing shall be calculated by the methods outlined in the FHWA Hydraulic Engineering Circular (HEC) No. 22 *Urban Drainage Design Manual* utilizing the Hydraulic Toolbox software (Current Version). In addition to the Hydraulic Toolbox software the Illinois Tollway recommends developing a separate spreadsheet to compute total flow to each inlet based on the tributary area and to note various input / output data, such as pavement & gutter cross slopes, actual and allowable encroachment widths, bypass runoff, water depth at gutter, Designer comments, etc. Refer to Appendix I for a sample spreadsheet providing this information.

In some instances where V-shaped grate types (e.g., G-2 or G-3) are not available in the Hydraulic Toolbox pull-down menu, it is recommended that separate calculations be performed via an Excel spreadsheet to determine the water depth at the gutter. The actual encroachment width may also vary slightly between these two computation methods.

9.4 Bridge Decks

Bridge deck cross slopes shall conform to the Illinois Tollway Bridge Design Criteria for bridge deck overlays. Superelevation transitions on bridges or bridge approaches may require further evaluation to avoid ponding of water and prevent runoff from bypassing the last inlet prior to the transition. Bridge scupper spacing for Illinois Tollway bridges shall be designed for a 10-year 5-minute rainfall intensity. Bypass runoff from the bridge deck shall still be designed for the 50-year storm event, to be intercepted by the roadway drainage system.

The Illinois Tollway recommends placing drainage structures off the bridge approach section if feasible. If not feasible, follow guidance provided in the base sheets (M-RDY-408) for drainage structure location. This may require additional drainage structures to be located outside the bridge approach section to limit the amount of bypass flow. Also, concrete flumes shall only be utilized as secondary overflow structures and not as the primary outlet. Drainage structures located at the end of the approach slab or gutter (when allowed) shall be utilized instead. Permanent erosion control measures such as turf reinforcement mat and open cell articulated concrete blocks or a drainage structure not accessible to traffic shall be used for embankment slope protection from bypass flow where no gutter is present at the end of the parapet.

Catch basins shall be provided along the edge of approach shoulder to intercept runoff from the bridge when the longitudinal grade is greater than 0.5% (when an open shoulder is present downstream of the bridge approach pavement, to prevent erosion). The Designer shall investigate and establish the need for approach inlets when the longitudinal grade is less than 0.5% and to intercept runoff before it leaves the bridge section.

Bridge deck runoff and inlet spacing shall be calculated by the methods outlined in the HEC No. 22, *Urban Drainage Design Manual*. Where runoff collected by inlets cannot be discharged directly to underlying areas, the inlet structures shall be located directly above downspouts attached to the substructure. A minimum of three inlets are required at the bottom of any sag vertical curve or at transverse slope reversals as protection in case the low inlet becomes clogged. The Designer shall design the safe conveyance of water from the structure to the natural outlet. The Designer shall also evaluate erosion potential at the downspout and incorporate remediation into the design when needed.

Inlet spacing and pavement encroachment requirements for local or State crossover bridges shall be designed based on IDOT criteria (not Illinois Tollway criteria). Due to difficulties in providing adequate deck drainage scupper spacing, as well as adequate maintenance of deck drainage systems, gutter flow from roadways shall be intercepted before reaching the bridge segment. Where practicable, all deck drainage shall be carried to the end of bridge for disposal. For similar reasons, zero gradients and sag vertical curves shall be avoided on bridges.

The downspouts for the bridge scuppers should not be outlet directly into waters of the U.S. It is recommended that they be drained into drainage structures with sumps or into vegetated ditches for water quality purposes.

9.5 Medians and Shoulders

9.5.1 General Design Requirements

The Illinois Tollway does not allow drainage structures to be placed within the traveled way or in the shoulder. If required, these structures shall be located within adjacent infield areas or at the edge of gutter. Grass median drainage shall be intercepted with flat grate inlets or catch basins, such as flush inlet boxes. All drainage structures shall be located along the gutter line with corresponding frames and grates. All outlet pipes shall be comprised of reinforced concrete (except at locations where this material is unsuitable), with a minimum diameter of 15 inches.

At sag vertical curve locations, a minimum of three inlet / catch basin structures are required along gutters where ponding is contained within the gutter section, concrete barrier walls, berms and cut slopes. The flanking inlet / catch basin structures shall be located at a maximum of 50 feet from the center inlet on either side of the sag structure, but no more than 0.2 feet above the low inlet rim elevation.

The Designer shall design the median, pavement grades and gore areas to eliminate or reduce the need for trench drains. Trench drains shall only be used when absolutely necessary and shall be limited to areas as described in the Illinois Tollway *Roadway Design Criteria*, Article 2.6.10.

The minimum inlet spacing on continuous grades shall not exceed 1,000 feet. Also, the first inlet shall not be located more than 1,200 feet from the crest of a vertical curve. This distance may be reduced if additional structures are required along the stormwater conveyance sewer system for maintenance purposes.

9.5.2 Grassed Medians

The design WSEL for median runoff shall be no higher than two feet below the edge of pavement. A ditch check may be located at grade to ensure that bypass flow is reduced prior to reaching drainage structures. The crest of the ditch check shall be at least one foot above the inlet and just below the pavement sub-base.

9.5.3 Paved Medians

The inlet spacing shall be computed using the methods described in FHWA HEC No. 22 *Urban Drainage Design Manual* or other available approved methodology. The Illinois Tollway recommends using the FHWA Hydraulics Toolbox software for inlet spacing design. A closed drainage system shall be designed for all paved medians with barrier wall and full shoulders.

9.6 Longitudinal Drainage Conveyance

9.6.1 General Design Requirements

An aggregate lining or other erosion control products shall be provided along the edge of all shoulders to control erosion at the top of side slopes. Side slopes and shoulder berms may require additional provisions to reduce erosion.

For cut slopes, top of slope ditches or swales shall be required if the cut slope receives stormwater runoff from beyond the top of slope. Erosion control measures described in *Illinois Tollway – Erosion Control and Landscape Manual*, in Illinois Tollway – Standard Drawings and in *Procedures and Standards for Urban Soil Erosion and Sedimentation Control in Illinois* shall be used for slope and shoulder berm protection.

Gutters shall be installed in accordance with the Illinois Tollway *Roadway Design Criteria*, Article 2.6.6. Inlets, catch basins and slope drain inlets shall be provided where gutter is proposed along outside shoulders to intercept pavement runoff and reduce concentrated flow onto unshielded slopes. Runoff shall not flow over the top of retaining walls and barriers.

The Designer shall attempt to limit the amount of slope drains used on a project since they're generally difficult to clean / televise.

Pipe outlets from shoulder inlets to side ditches shall be comprised of reinforced concrete pipe with a minimum diameter of 12 inches. The Designer shall design the pipe outlet to ensure that a hydraulic jump (if one does occur), is maintained within the pipe. Headwalls or sloped headwalls shall be provided for all pipe outlets. The outlet end treatments shall be in accordance with the safety considerations noted in AASHTO's *Roadside Design Guide.* Adequate erosion control shall also be provided, as necessary.

The Designer shall avoid increasing point discharges from pipe outlets. Level spreader designs may be required to dissipate the runoff offsite.

Reinforced concrete pipe is preferred for use on all Illinois Tollway closed drainage systems except for outside paved areas with steep grades. Written approval from the Illinois Tollway Project Manager shall be required in these instances.

9.6.2 Gore Areas

Gore areas shall be designed to slope towards the ramp pavement if hydraulically feasible. The Designer shall avoid grading the gore area towards the middle unless a meaningful swale is provided to reduce the need for trench drains. If required, trench drains with removable grates are preferred over slotted drains. Due to maintenance concerns trench drains shall be eliminated or reduced wherever possible (See Illinois Tollway Standard Drawing B12 for trench drain detail).

9.6.3 Retaining Walls

A gutter or curb and gutter shall be constructed along all roadway shoulders located at the top of fill sections adjacent to retaining walls. A closed drainage system shall be used to collect pavement runoff utilizing inlets, catch basins, or slope drain inlets to intercept runoff. Ditch drainage on the roadway side of retaining walls shall also be provided in accordance with Section 6.

Runoff generated on landside slopes (above retaining walls), shall be collected in paved gutters located on the landside of the wall. Inlets may be used to prevent concentrated flow from discharging at grade and undermining the retaining wall. Subsurface drainage behind retaining walls shall be provided in all instances. This may be accomplished either through a series of weep holes in conjunction with porous granular backfill and filter fabrics or via an underdrain system utilizing perforated pipe, porous granular backfill, filter fabrics and suitable outfalls. Avoid multiple pipe penetrations through a retaining wall, if possible, by combining catch basin outlet pipes into one storm sewer outlet. This design option also makes it easier to investigate, clean and/or televise the drainage system in the future.

9.6.4 Noise Abatement Walls

A ditch, gutter or pipe underdrain shall be provided on the high side of the noise abatement wall (residential side) to keep surface water from running under the wall and from encroaching onto adjacent property. Drainage structures shall be located at low points and other locations as required and connected to the side slope ditch or storm sewer. The Designer is responsible for designing and detailing all swales, ditches, drainage structures and storm sewers on the drainage plans and profiles. Refer to M-DRN-608 for typical drainage details.

9.7 Subsurface Drainage

9.7.1 Farm Tiles

Whenever existing farm tile systems are interrupted, they may be discharged into roadway ditches, if possible, with slope walls. When it is necessary to continue an existing drain beneath the Illinois Tollway pavement, inspection wells shall be provided just inside the ROW fence. The continuation pipe shall be reinforced concrete. No clay pipe shall be used under Illinois Tollway pavement and shoulders. The tops of inspection wells shall be set above the design high water elevation. In order to protect pipes from maintenance equipment, a concrete slab around inspection wells shall be provided in roadway ditches.

9.7.2 Subsurface Drains (Pipe Underdrains)

Subsurface drains beneath Illinois Tollway pavement and shoulders are required wherever flows through the free draining granular sub-base are interrupted, blocked or otherwise impaired. Locations where subsurface drains shall be provided include the following:

- Along the outside edge of mainline pavement.
- Along the low side of all ramp pavements.
- Along the paved gore areas.
- Wherever the sub-base is prevented from free draining.
- At other locations as determined by the Designer.

Subsurface drains shall be a minimum of six inches in diameter. The minimum slope shall be 0.3% (0.5% desirable). The maximum length of drain is dependent on the roadway PGL and shall not exceed 500 feet without an outlet or change in diameter. Subsurface drains shall be designed in accordance with the Illinois Tollway Standard Drawings (B24). The typical Illinois Tollway trench width for a 6” subsurface drain is 12”. However, if the subsurface drain is upsized to 8” in diameter, then a 16” wide trench would be required. The maximum length for any sized subsurface drain system shall be limited to 1000 feet in length.

If subsurface drains are to be used in reconstruction projects that employ the use of in-situ recycled concrete aggregate (RCA) for the new roadway base, care shall be given to the placement of the subsurface drain outlets. Subsurface drain outlets shall not be located within 200 feet upstream of the eventual watercourse. This allows the necessary spacing for the construction of any biological treatment feature downstream from the outlet to treat fine material which may wash out from the RCA.

If the outlet shall be constructed closer than 200 feet from a watercourse, the designer shall allow space for a Mechanical Sedimentation Trap to be constructed to remove the RCA fines.
The subsurface drainage pipe outlets shall be placed approximately 6 inches above the downstream bottom ditch elevation. Do not outlet subsurface drains at higher embankment elevations as this creates erosion control issues and would require an ACB system to be installed and maintained.

9.8 Storm Sewer Design

The hydraulic design of storm sewers shall conform to the methods described in the FHWA HEC No. 22 *Urban Drainage Design Manual* or other available approved methodology. Storm sewer placement shall be coordinated with the design and placement of guardrail, light poles, sign structures, noise walls, median barriers, retaining walls and utilities. Reinforced concrete pipe shall be used under all mainline and ramp pavement. Reinforced concrete pipe is preferred for use on all Illinois Tollway closed drainage systems except at locations outside paved areas with steep grades. Existing corrugated metal pipe (CMP) under Illinois Tollway travel lanes shall be replaced with reinforced concrete pipe (RCP) for reconstruction and rubblization projects. See Table 9.0 for recommended storm sewer materials.

The pipe class shall be in accordance with IDOT requirements. If reinforced concrete pipe cannot be used due to steep grades, other substitutes such as bituminous or epoxy coated corrugated galvanized steel pipe or high-density polyethylene smooth interior pipe may be used instead. Substitution of reinforced concrete pipe requires the written approval of the Illinois Tollway Project Manager.

The design WSEL shall be at least 2 feet below the rim elevation of manholes. For depressed roadways, the 100-year HGL shall be at or below the low edge of pavement in accordance to *ACEC-Illinois/IDOT 2014 Drainage Seminar* manual. Avoid reducing collector sewer pipe sizes from existing to proposed conditions if the tributary area is not reduced. The Illinois Tollway discourages the use of pipe bends due to increased junction losses and future silt build-up (making the sewer system difficult to clean / televise). Therefore, an access structure shall be added along the sewer system to eliminate the use of these pipe bends. In large culvert installations, pipe bends may be utilized if found cost effective. For overhead sign structure foundations designed to accommodate storm sewers, refer to the Illinois Tollway Standard Drawings Section F - Sign Structure. In situations where pipe bends are required to avoid sign structure foundations or other obstructions, prior approval is required from the Illinois Tollway Project Manager.

Table 9.0
RECOMMENDED MATERIALS FOR STORM SEWERS

Location	Pipe Material
Illinois Tollway Mainline Pavement	Reinforced Concrete Pipes (RCP)
Ramp Pavement	Reinforced Concrete Pipes (RCP)
Parking Lots, Toll Plazas (Outside of Mainline)	Reinforced Concrete Pipes (RCP) High Density Polyethylene Pipes (HDPE – with smooth interior)
Illinois Tollway R.O.W. (Outside of Mainline)	Reinforced Concrete Pipes (RCP)* High Density Polyethylene Pipes (HDPE – with smooth interior) Coated Corrugated Galvanized Steel Pipes**

*Except in areas with steep slopes (1:10 (V:H) and steeper). No RCP allowed for side slope drains regardless of the slope of the embankment.
**Applies only to slope drains.

Utilize manholes, inlets and catch basins in accordance with the Illinois Tollway Standard Drawings and the IDOT Highway Standards, when possible, to maintain a cost-effective design. Specially designed structures shall be used only in situations where the standard details are not suitable. These specially designed structures shall be justified by the Designer and approved by Illinois Tollway. Any drainage structure not included in the Illinois Tollway or IDOT Standards shall be detailed in the plans and specifications by the Designer. In projects where Catch Basins Type G-3 (Modified) or larger are common, the Designer shall consider graphically depicting the drainage structures rather than utilizing the IDOT standard catch basin symbol. Special design considerations are required where G-5 catch basins are utilized adjacent to guardrail installation, since the large structure size may conflict with the width of the guardrail post spacing.

Generally, catch basins shall be used on all travel lane and shoulder drainage systems, except in areas of rock cut, in which case inlets may be used instead. Lateral pipes shall connect to inlets, catch basins, manholes, other drainage structures. It is desirable to minimize lateral runs under the roadway pavement and to combine inside median gutter, outside gutter and ramp gutter drainage structures into one outlet if feasible. This approach also helps with construction staging. Storm sewer alignment, grade, or pipe size changes shall occur at drainage structures with open grates located in a gutter line, swale, or ditch bottom. Maximum spacing for various pipe diameters is given in Table 9.3 Roadway Drainage Design Criteria. An inlet structure shall drain into a catch basin (with a sump) prior to connecting into a manhole structure for water quality purposes.

The use of manholes to meet the maximum spacing requirements shall be minimized if possible. Locating manholes in unshielded traversable slopes is not desirable as they may pose an obstacle to encroaching vehicles and a hindrance to maintenance equipment. Diagonal transverse storm sewer crossings of the pavement shall be avoided. Longitudinal storm sewers shall be routed through catch basins first. The length of storm sewers and number of drainage structures should be minimized within the requirements of the drainage design criteria. Pipes or storm sewers shall be outlet approximately six inches above the ditch flow line or toe of slope elevation. Blind connections to storm sewer systems are not allowed by the Illinois Tollway. These sewer connections may require an access structure to be provided at the junction point.

Due to design, right-of-way constraints, utility or structural foundation conflicts and/or construction staging, if open cut is not an option for installing a new storm sewer system / cross culvert, then pipe jacking may be utilized instead. If pipe jacking is required to install the proposed pipe segments, the Designer shall identify the need during the design concept stage (or at the latest during the preliminary contract plan submittal) to determine ROW / construction easement requirement. Locations for jacking and receiving pits shall also be identified for potential traffic staging concerns and overall constructability. Formal approval from the Illinois Tollway Project Manager is required prior to proceeding with the pipe jacking design.

Storm sewers shall be located a minimum of 10 feet horizontally (outside wall to outside wall), otherwise, a minimum of 18 inches vertically above watermains. If these minimum clearances cannot be achieved, then watermain quality pipes shall be used at these locations instead or RCP. Refer to Section 8-003.02 of the *IDOT Drainage Manual* and the *Standard Specifications for Water and Sewer Construction in Illinois* (Current Edition) for additional information on horizontal and vertical separation requirements between storm sewers and water mains. Avoid placing drainage structures with their lids located within the traveled way or in paved shoulders.

Inverted siphons under pressure flow are not allowed by the Illinois Tollway unless a design deviation is obtained. The Designer shall also take into consideration removing existing siphons and replacing them with a drainage system conveyed via gravity flow.

For roadway resurfacing and reconstruction projects the Illinois Tollway recommends cleaning and televising all existing conveyance sewers to remain in place. The Illinois Tollway also recommends taking future improvements into consideration when designing or installing a proposed storm sewer system. For instance, if future improvements dictate that an additional lane be added in each direction, then the Designer should take into consideration upsizing the proposed trunk sewer further to handle the additional runoff from the added impervious area. The Designer shall also investigate the option of placing the trunk sewer outside the roadway pavement (within the infield area) to avoid having to remove and replace in a future contract if at that time it's located within the traveled way or shoulder limits. If right-of-way constraints prevent the proposed storm sewer system from being constructed outside of the roadway pavement and future improvements require the pipes to be removed and replaced in any case, the Designer shall only design the system for present hydraulic conditions. The same scenario applies to cross culverts, where future pavement widening should be taken into consideration so that the proposed culvert does not have to be further extended in a future contract. These design issues shall be coordinated with the Illinois Tollway Project Manager prior to implementation.

Recommended use of various drainage structures for Illinois Tollway projects is included in APPENDIX D and APPENDIX E of the Illinois Tollway Drainage Design Manual.

Table 9.1
MINIMUM SLOPES FOR PIPES FLOWING FULL

DIAMETER (inches)	DISCHARGE Q (cfs)	SLOPE (feet per foot)		
		n = 0.012	n = 0.013	n = 0.024
8	1.05	0.0064	0.0075	0.026
10	1.64	0.0048	0.0056	0.0056
12	2.36	0.0037	0.0044	0.0044
15	3.68	0.0028	0.0032	0.0032
18	5.30	0.0022	0.0026	0.0026
21	7.22	0.0018	0.0021	0.0021
24	9.43	0.0015	0.0017	0.0017
27	11.9	0.0013	0.0015	0.0015
30	14.7	0.0011	0.0013	0.0013
33	17.8	0.00097	0.0011	0.0011
36	21.2	0.00086	0.0010	0.0010
42	28.9	0.00070	0.00082	0.00082
48	37.7	0.00059	0.00069	0.00069
54	47.7	0.00050	0.00059	0.00059
60	58.9	0.00044	0.00051	0.00051
66	71.3	0.00038	0.00045	0.00045
72	84.8	0.00024	0.00040	0.00040

All pipe velocities are based on flowing full conditions. Minimum slopes required for a velocity of 3 ft/s may be computed using the Manning's equation (see Table 9.1).

The Illinois Tollway recommends developing a spreadsheet to summarize various input and output data for each pipe. Refer to Appendix J for a sample spreadsheet providing this information.

When outletting a roadway drainage system into an adjacent stream crossing, the tailwater condition shall be based be based Table 7-3 "Frequencies for Coincidental Occurrence" of the *HEC-22 Urban Drainage Design Manual*. As noted in Table 9.2, the stream design tailwater condition shall be based on the tributary area ratio between the roadway runoff and the main stream channel. Since the HEC-22 manual only provides comparisons for the 10 and 100-year storm events, a 50-year design table was developed for Illinois Tollway related projects (shown in Table 9.2, in addition to the 100-year ratios).

Table 9.2
FREQUENCIES FOR COINCIDENTAL OCCURRENCE

AREA RATIO	FREQUENCIES FOR COINCIDENTAL OCCURRENCE			
	50 Year Design		100-Year Design	
	Main Stream	Tributary	Main Stream	Tributary
10,000 to 1	2 50	50 2	2 100	100 2
1,000 to 1	5 50	50 5	10 100	100 10
100 to 1	10 50	50 10	25 100	100 25
10 to 1	25 50	50 25	50 100	100 50
1 to 1	50 50	50 50	100 100	100 100

9.9 Drainage Structures

Proposed pipe sizes and locations (e.g., gutter, infield area, barrier / retaining wall, etc.) should be taken into consideration when choosing between IDOT and Illinois Tollway drainage structure types. For instance, for proposed storm sewers located under G-Series type gutters, Illinois Tollway G-Series type drainage structures should be used instead of IDOT structures detailed in the Highway Standards. If a large diameter pipe cannot fit inside a G-2, G-3, or G-3 (Modified) catch basin, a G-4 or G-5 catch basin may be used instead (with the corresponding frame and grate). Use of IDOT structures in these situations should be considered if proven to be cost effective.

All Illinois Tollway drainage structures shall be constructed with a minimum 2 ft sump below the pipe invert elevation for conveyance system. This information is also provided in the corresponding Illinois Tollway special provisions. For larger diameter pipe connections, a drainage detail and special provision may be required if a typical standard detail structure cannot fit the larger diameter pipes, especially when the connection is perpendicular to the gutter flow. For larger box culvert systems used for stormwater conveyance, open bottom manhole riser structures may be used instead of drainage structures.

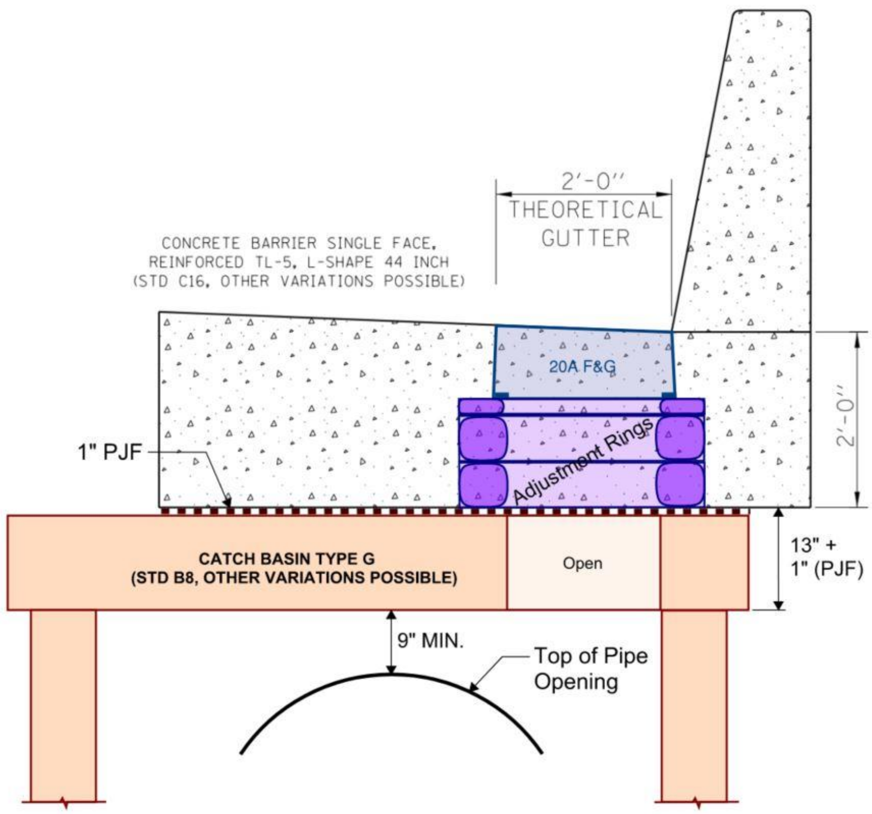
When placing access manholes near the top of a roadway embankment, ensure the manholes are accessible for routine inspections and/or for sewer televising purposes. The Illinois Tollway also recommends using IDOT Flush Inlet Boxes for grassed medians with unshielded slopes and where the tributary drainage area to the drainage structure is significant.

When IDOT Drainage Structures Types 4 and 5 are placed along median barrier walls, pipes shall be offset, if necessary, to avoid conflicts with light pole foundations.

When placing drainage structures in moment slabs, the Designer shall refer to the jointing plan to ensure a minimum 5 ft clearance is provided between the frame and grate and the expansion joint or the end of the slab.

When placing drainage structures within single face concrete barriers, the drainage structures shall be placed below the barrier base slab with adjustment rings to account for the thickness of the barrier base. The Designer shall provide a typical detail showing the placement of the drainage structure relative to the barrier (See example Figure 9-1). If it's not feasible to place the drainage structure below the barrier base slab, a special reinforcement detail around the drainage structure shall be provided by the Designer accounting for the barrier test level.

Figure 9-1 Example Detail of Catch Basin Type G Adjacent to TL-5 Barrier



No drainage structures shall be installed within traffic barrier terminal Type T6 limits. This includes catch basins, slope drain inlets, concrete flumes and curb/gutter outlets. Concrete flared end sections, including those used by IDOT, shall not be used along any Illinois Tollway facility, whether in the clear zone or not. Existing concrete flared end sections shall be removed unless located near the bottom of a critical foreslope and shielded by a barrier. Refer to the Illinois Tollway *Traffic Barrier Guidelines* for additional information on safety appurtenances and roadside obstacles.

9.10 Temporary Drainage

The Designer is responsible for developing a temporary drainage system for each Maintenance of Traffic (MOT) stage. A general note stating that the Contractor is responsible for maintaining drainage during each MOT stage may not be sufficient if a detailed temporary drainage system is required to maintain existing flow patterns. During construction staging the Illinois Tollway requires a temporary drainage system to be designed for the 2-year storm event. Sag locations and underpasses shall be designed for the 5-year event to reduce ponding at low points, which may result in temporary traffic closures. For inlet spacing analyses, the Designer shall ensure that the stormwater runoff allows for a minimum 8 feet of lane width to be open to vehicle movement but shall not exceed the IDOT pavement encroachment policy (*Drainage Manual* Section 1-304.01) of maximum traveled way encroachment of four (4) feet. This temporary drainage criteria shall be applied for both roadway and bridge sections on the Illinois Tollway. The Designer shall also ensure that newly created low points are drained properly during interim grading.

The temporary drainage system shall be shown with respect to each stage of construction. The construction staging shall also be developed to ensure that the drainage system is constructed to maintain flow from the downstream end to the upstream end (if feasible) to reduce the number of temporary pipe connections required. These temporary pipes and/or drainage structures shall be included in the temporary drainage schedules and labeled accordingly, including information on what construction stage temporary pipes and drainage structures need to be filled or removed and whether temporary covers are needed as part of the temporary drainage plan. The Designer has the option of showing the sequencing of drainage work on a separate set of Drainage or Erosion and Sediment Control Plan sheets for each stage of construction (instead of or in addition to the MOT sheets).

PVC and/or corrugated steel pipes are allowed for temporary drainage connections during construction staging. However, these pipes shall be replaced with reinforced concrete once the permanent system is in place. Drainage structures to be utilized during construction staging shall be secured if traversed by vehicles. Permanent drainage structures utilized during staging shall be cleaned prior to project completion. Special attention shall be given to crossover locations where vehicles are travelling directly over gore areas or the center median where the existing barrier wall has been removed, to reduce pavement flooding concerns. However, trench drains shall not be used on MOT travel lanes in any stage. The Designer shall check inlet spacing when traffic is shifted to shoulder sections. Additional inlets may be required and shall be evaluated based on updated temporary geometry. Attention shall be given to the placement of temporary concrete barriers and potential impacts to drainage. Temporary drainage shall be provided to drain low points created when the existing pavement is lower than the proposed pavement built adjacent to it. Stormwater detention storage should be considered for interim conditions (in lieu of future reconstruction) if the increased runoff to a sensitive outlet can potentially cause flood damage to adjacent properties.

The Designer shall coordinate with other agencies and/or property owners to ensure that the temporary drainage does not adversely impact their facilities. The temporary drainage shall be coordinated with the State and/or municipality prior to construction. The Designer shall inform other agencies of the proposed improvements and potential deficiencies within their downstream drainage system. Per recommendations made at these coordination meeting(s), additional action may be required by the Illinois Tollway to further reduce flooding concerns during construction staging. It shall be the Contractor’s responsibility to maintain drainage flows at all times during construction. Therefore, it is imperative that detailed information be provided in the contract drawings to aid the Contractors in maintaining the existing flow patterns during staging. Methods used by the Contractor shall be subject to approval by the Engineer.

Temporary drainage may not be applicable for short term projects such as pavement patching, minor bridge repairs, guardrail repairs, temporary lane closures for inspection, minor maintenance, cleaning, etc. Coordinate the need for temporary drainage with the Illinois Tollway PM prior to implementation.

See Section 12 for erosion control requirements for proposed drainage improvements.

Table 9.3
ROADWAY DRAINAGE DESIGN CRITERIA

	Design Criteria	Comments
1. Roadway Profile		
a. Design Flood	50-Year (2% chance of exceedance)	Use HY-22 to determine hydraulic gradient
b. Check Floods	500-Year (0.2% chance of exceedance)	No overtopping of roadway at the low edge of pavement for 500-yr (0.2% exceedance flow)
c. Minimum Freeboard	3 ft.	From the Design WSEL to the edge of pavement
2. Pavement		
a. Design Flood	50-Year (2% chance of exceedance)	Use FHWA Hydraulic Toolbox, Current Version (or sample spreadsheet in Appendix I)
b. Maximum Pavement Encroachment	Zero encroachment on traveled way. Water shall remain on shoulder and no closer than 3' from the edge of pavement.	For flex lanes, a minimum 8 feet of lane width shall be open to vehicle movement and encroachment into the traveled way shall not exceed 4 feet.
c. Inlet Spacing (Max. water depth)	0.35 feet	
d. Trench Pavement Drain	0.2% minimum slope	See *Roadway Design Criteria* Manual for profile information.
3. Bridge Deck		
a. Design Flood	10-year 5-minute rainfall intensity.	
b. Inlet Spacing	Zero encroachment on the traveled way. Minimum of 3 inlets at any sag vertical curve.	Use FHWA Hydraulic Toolbox, Current Version (or sample spreadsheet in Appendix I)
c. Bridge Approach Inlets	Required for longitudinal grades > 0.5%.	

	Design Criteria	Comments
4. Medians and Shoulders		
a. Grassed Areas		
a.1. Design Flood	50-Year (2% chance of exceedance)	
a.2. Inlet Spacing	Maximum of 1,000' (1st inlet may be as great as 1,200' from crest vertical curve).	Install structure along conveyance system to meet spacing requirements if less than 1000’.
a.3. Median Drains	Must use flat grate inlet. Outlet $\geq$15" RCP. Ditch check required.	
a.4. Minimum Grade	See *Roadway Design Criteria* Manual for grade information	
a.5. Median Water Surface	>2 ft. below edge of pavement	
b. Paved Areas		
b.1. Design Flood	50-Year (2% chance of exceedance)	Use FHWA Hydraulic Toolbox, Current Version
b.2. Inlet Spacing	Such that water stays on the shoulder and encroachment is $\geq$3' from the edge of pavement. Maximum of 1000’ (1st inlet may be as great as 1200’ from crest vertical curve).	Use FHWA Hydraulic Toolbox, Current Version (or sample spreadsheet in Appendix I) Minimum 3 (three) inlets or catch basin structures shall be provided in sag areas.
b.3 Inlets	Use Standard Illinois Tollway or IDOT median inlets or catch basins.	
b.4 Inlet Spacing Maximum Water Depth	0.35 ft	
5. Storm Sewers		
a. Design Flood	50-year (2% chance of exceedance) or the most restrictive feature drained by storm sewer whichever is greater.	
b. Inlet/Catch Basins	Use Standard Illinois Tollway or IDOT drainage structures.	Unless local conditions (i.e. at large pipe junctions/ connections or adjacent to a retaining wall) require the design of special structures.
c. Structure Spacing	At all changes in grade and: 350 ft. for d = 15” - 24” 400 ft. for d = 27” - 36”	Change in invert shall take place at a structure unless

	Design Criteria	Comments
	500 ft. for d = 42” - 54” 1000 ft. for d ≥ 60"	otherwise required by the drainage design.
d. Minimum Size	d = 12" d = 15”	For connecting a single structure to the storm sewer system (outside of traveled way) Under mainline or ramp pavement
e. Material	Reinforced Concrete Pipe (RCP) Bituminous or epoxy coated Corrugated Galvanized Steel Pipe or high-density polyethylene smooth interior pipe	RCP shall be used for placement under all mainline and ramp pavement.
f. Velocity Range	3 to 10 fps	Design velocity shall be self-cleaning.
g. Water Surface at Manholes	2' below rim elevation for the 50-year storm	For depressed roadways, the 100-year HGL shall be at or below the low edge of pavement.
h. Water Surface at Inlets	2’ below rim elevation for the 50-year storm	For depressed roadways, the 100-year HGL shall be at or below the low edge of pavement.
i. Junctions	Laterals shall connect at inlets, manholes, catch basins, or other drainage structures.	No blind connections into storm sewers allowed without Illinois Tollway approval.
j. Depth	6” minimum cover from bottom of subgrade aggregate or chemically stabilized subgrade (if applicable) to top of pipe.	
k. Outlet	Set approximately 6 inches above the bottom ditch invert elevation.	
	6. Pipe Underdrains	
a. Minimum Diameter	6"	Use Illinois Tollway Standard Detail
b. Minimum Slope	0.3% (0.5% desirable)	
c. Maximum Length	250’ if PGL ≤ 1%	

	Design Criteria	Comments
	375’ if 1% < PGL < 2% 500’ if PGL ≥ 2% 500' before increasing diameter (1000’ maximum) or outletting	
d. Outlet	Set approximately 6 inches above the bottom ditch invert elevation.	
7. Temporary Drainage		
a. Design Flood	2-Year (on grade) (50% chance of exceedance) 5-Year (at sag and underpass) (20% chance of exceedance)	
b. Maximum Pavement Encroachment	Allow for a minimum of 8 feet of lane width to be open to vehicular movement.	For temporary conditions, a maximum 4’ of pavement encroachment will be allowed per IDOT Drainage Manual Section 1-304.01.

SECTION 10.0 STORMWATER DETENTION STORAGE

10.1 General Considerations

The Designer shall evaluate and report the effect of increased runoff resulting from the proposed construction and need for stormwater detention. The proposed construction shall not increase the existing peak runoff from Illinois Tollway property. Where possible, off-site stormwater runoff that drains through Illinois Tollway right-of-way shall be designed to bypass Illinois Tollway detention facilities. This is the preferred design alternative, however, the evaluation shall consider cost of separation, operation in accordance with design criteria, municipal detention requirements, stormwater quality and other factors identified by the Designer.

See Table 10.0 for additional information on Illinois Tollway criteria for Stormwater Detention Storage.

10.2 Perforated Stand Pipes

Perforated standpipes as control structures for detention basin outlets are no longer allowed by the Illinois Tollway. All existing perforated stand pipes encountered within the project improvement limits shall be replaced with manholes with appropriately sized restrictor plates to maintain the allowable release rates. The restrictor plates shall also include an overflow weir.

10.3 Design Requirements

The detention facilities shall be designed for a 100-year flood event and for the critical storm duration. ISWS *Bulletin 75* precipitation data shall be used in computing storage requirements. Stormwater detention facility criteria for Illinois Tollway projects are as follows:

- Maximum allowable release rate of 0.04 cfs/acre for the 2-year flood event.
- Maximum allowable release rate of 0.15 cfs/acre for the 100-year flood event.
- Provide WQV to capture the first flush of rainfall (in accordance with local requirements).

If local drainage ordinance requirements are more restrictive than the Illinois Tollway's, then the Designer shall meet their release rate requirements instead. Refer to Article 2.2 for additional information on governing requirements.

If draw down time to drain a detention basin or WQV exceeds 5 days, wetland plantings or underdrains shall be required.

The runoff from the first flush rainfall shall be stored below the elevation of the primary gravity outlet of detention facility or within roadside ditches located upstream of the proposed detention facility. The WQV storage shall be designed to allow for evapotranspiration or infiltration of this volume into a subsurface drainage system and shall not be conveyed through a direct positive connection to downstream areas. It is preferred for the WQV storage to be designed as wetland facilities with small topographic variety to promote multiple plant community types. The WQV may be calculated based on the increased upstream impervious area. If possible, Designers shall have percolation tests completed to ascertain the potential rate of infiltration expected. In cases where a high-water table is present, Designers shall customize designs appropriately per the given site conditions. The amount of WQV required to capture the first flush of runoff varies from county to county. Refer to the Illinois Tollway *Geotechnical Manual* for boring requirements and water table assessment at detention facilities.

The volume of required detention storage (acre-feet) may be estimated using nomographs based on ISWS *Bulletin 75* precipitation data (graphic method). Refer to available documents from MWRD[13] and other agencies to meet local stormwater ordinance requirements.

For final design of the Illinois Tollway detention facilities, an appropriate hydrograph routing method such as WIN TR-20, HEC-HMS, Open Flows POND-PACK (Bentley), XP SWMM or other available commercial software shall be used, with prior review and approval of the Illinois Tollway Project Manager. The runoff hydrograph shall be routed through the proposed detention basin to ensure that the required volume and allowable release rate criteria are met for the peak flow.

The basin outlet structure design shall meet the requirements for Illinois Tollway maximum allowable release rates, as noted in Table 10.0 or per local regulations (if more restrictive). If existing downstream flow conditions influence the conveyance of the outlet structure, these conditions should be considered in the basin outlet design. The Designer may provide check valves to prevent backflow with prior approval of the Illinois Tollway Project Manager. The outlet structure shall be accessible at all times to facilitate cleaning (if clogging should occur). The basin and outlet structure shall be designed for ease of maintenance.

The Designer shall only provide detention storage for the added impervious area and not for the entire disturbed area within the Illinois Tollway right-of-way to meet Tollway criteria. If the existing impervious or pervious area remains the same under proposed conditions, no additional stormwater detention shall be required.

In addition to providing the required detention storage volume, the 2-year and 100-year release rates exiting Illinois Tollway right-of-way shall be determined as follows: The proposed 100-year release rate shall be calculated by multiplying the total added impervious area by a factor of 0.15 cfs/acre (0.04 cfs/acre for the 2-year storm) and added to the non-impacted existing discharge. The Designer shall also check whether the existing release rates have been modified due to converting open to closed drainage systems or by re-directing/diverting flow from adjacent reaches or watersheds under proposed conditions. Regional detention storage is accepted by the Illinois Tollway as a cost-effective measure and where there's limited ROW, as long as the 100-year release rate for the entire watershed does not exceed the allowable release rates mentioned above. Regional detention shall not be shared between 2 or more adjacent watersheds. The Designer shall verify that all upsized storage pipes are flowing full under the 100-year storm event and that a 2 ft/s self-cleaning velocity is achieved. The Designer shall provide a summary table describing all detention and release rate requirements for each outlet. This data shall be quantified per each watershed. If certain outlets are considered sensitive (private properties, subdivisions, areas with existing flooding concerns, etc.), the existing 100-year release rates shall not be exceeded under proposed conditions. Additional detention storage may be required at these sensitive outlets if the total impervious area is increased under proposed conditions. This work shall be performed during the concept stage to determine proposed ROW requirements.

When developing the concept drainage report, the Designer may use nomographs to determine the required stormwater detention storage volume. However, once the contract drawings are

[13] The MWRD *Technical Guidance Manual* provides a nomograph based on ISWS *Bulletin 75* precipitation data with release rates ranging from 0.00 to 0.30 cfs/acre.

developed during the design phase, the Designer shall ensure that the allowable 2-year and 100-year release rates are met. When modeling a detention basin using the hydrograph method, the required detention storage volume may vary from the storage volume computed in the concept report using the nomographs. If the Rational Formula is used to determine the allowable release rates at oversized storm sewers and/or ditches with ditch checks, the calculated nomograph volume is still applicable for the added impervious area.

Diverting runoff between two separate watersheds is not recommended by the Illinois Tollway. If a diversion cannot be avoided due to geometric or other constraints, prior approval from the Illinois Tollway Project Manager is required before proceeding further. If the proposed runoff is only being redirected to an adjacent outlet, but within the same watershed, this is not considered a diversion, so the Designer does not have to provide additional stormwater detention storage for the added drainage area. However, the Illinois Tollway does require the Designer to check all local outlets to determine that the added runoff does not have a negative impact to adjacent downstream properties.

Since providing stormwater detention to meet both storage volume and release rate requirements may be difficult to achieve, the Designer shall avoid routing offsite runoff into proposed detention storage facilities. In case of any discrepancies, the Designer shall coordinate with the Illinois Tollway Project Manager for further clarification.

The Illinois Tollway strongly discourages on-line storage for stormwater detention due to the following concerns:

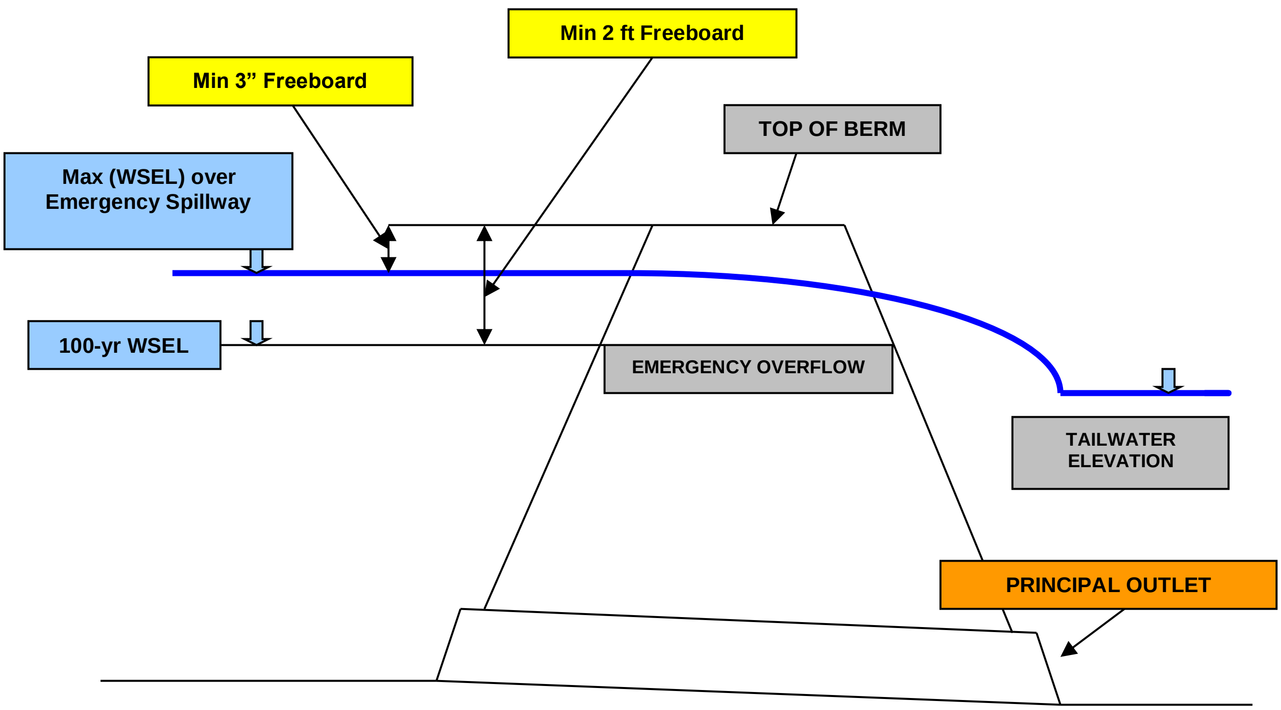
- Short term and long-term environmental impacts on water quality, wildlife habitat and sedimentation and erosion.
- Impossible to evaluate the offsite impacts of a proposed floodway modification without modeling the entire watershed.
- It is difficult to demonstrate that the runoff generated by the development site meets the 0.15 cfs/acre release rate requirement for the 100-year storm event.
- It is difficult to ensure that future upstream improvements would not have adverse impacts on the detention storage facility located within Illinois Tollway right-of-way.

A minimum of two feet of freeboard shall be provided above the 100-year high water level to the top of berm elevation for all detention basins (see Figure 10-1). The Designer shall provide an emergency overflow outlet for all detention basins unless otherwise directed by the Illinois Tollway Project Manager. The overflow outlet or emergency spillway shall be designed to pass the design flood without overtopping the basin berm (see Figure 10-1) if the outlet structure malfunctions. The downstream conveyance system shall be sized to adequately convey the design flood. An additional overflow pipe may be necessary if no overland conveyance system exists. Larger offsite areas shall be designed to bypass around detention facilities, unless offsite flows may be utilized to compensate for design flows from the project area when increases in total project discharge cannot be practicably detained. The designer shall ensure that detaining these offsite discharges would not adversely impact runoff from adjacent upstream properties and is limited to relatively small grassy areas already tributary to Illinois Tollway right-of-way. Drainage diversions shall be avoided.

During the design concept stage, the Designer shall evaluate the feasibility of the proposed detention storage location with respect to ROW access for constructability and maintenance; close proximity to flood hazard areas and/or wetlands; located near top of ridge where the tributary drainage areas are fairly small compared to the required stormwater detention volume and WQV; and where emergency overflow routes are not available.

Detention basins and outlets shall be designed to minimize sediment discharge and scour. Appropriate measures for erosion control shall be provided at the overflow outlet when necessary. The outlet location shall be selected so as to minimize adverse impacts and disruption to Illinois Tollway ROW. Discharge from Illinois Tollway detention basins shall not adversely impact downstream or adjacent properties.

Figure 10-1 Illinois Tollway Detention Basin Freeboard Requirement



10.4 Dry Basins and Wet Basins

Generally, dry detention basins have been preferred within Illinois Tollway ROW due to traffic safety and maintenance considerations. The Designer shall take into consideration maximizing water quality of stormwater prior to releasing flows into adjacent waterways; use infiltration techniques within detention facilities wherever soils and groundwater conditions allow; partner/coordinate with state and local agencies to provide regional stormwater management and provide a habitat for avian species and pollinators, as well as for smaller mammals and invertebrate communities.

Wet detention basins offer important water quality benefits but have roadside safety implications. Therefore, wet detention basins of greater standing water depth than 2 feet are undesirable, unless otherwise shielded from errant vehicles. Proposing a wet detention basin of greater depth than 2 feet is not a justification for shielding; implementing such a design would require a design deviation. If a wet detention basin is proposed in an otherwise shielded location, the Designer shall analyze the cost-effectiveness and feasibility of providing wet detention, including eutrophication control measures. Capturing of the first flush of rainfall, if provided at the bottom of the basin or within a forebay, shall be included in the hydrologic/hydraulic design.

10.4.1 Diverse Hydrologic Zones in Detention Ponds

In conjunction with providing the required WQV, the Illinois Tollway recommends proposed detention facilities with diverse hydrologic zones in wet detention basins for water quality purposes (See Figure 10-2). Standing water shall be minimized to what is necessary for local WQV requirements. In general, the designer shall coordinate planting applications with the Illinois Tollway to provide uniformity across the entire Illinois Tollway corridor. The following is a list of a few examples that should be taken into consideration:

<u>Upper Slope Buffer Planting Zone (1)</u>

Upper slope buffer plantings in this zone act as an initial filter for waterborne sediments and pollutants. They also slow the velocities of runoff, thereby limiting erosion. Generally composed of a native grass/forb population, this zone may also include shrub and tree species tolerant of soil moisture fluctuations. These areas provide an opportunity for retention of first flush and infiltration.

<u>Vegetated Swale Planting Zone (2)</u>

Vegetated swale plantings intercept and collect runoff, filtering up to 50% of sediments and nutrients. A meandering swale is more efficient at lowering runoff velocity. Deep-rooted native plantings stabilize soils from scouring by surface movement of runoff waters. Salt, sediment and nutrient tolerant native species are preferred.

<u>Upper Shoreline Planting Zone (3)</u>

Upper shoreline plantings rely on constant moisture, with water depths permanently ranging from 1” to 6”. This zone should be of sufficient width to buffer wave action. Deep-rooted, native plantings, including rush and sedge are instrumental at stabilizing the shoreline. A 10’ wide safety shelf within this zone eases transitions to deeper water.

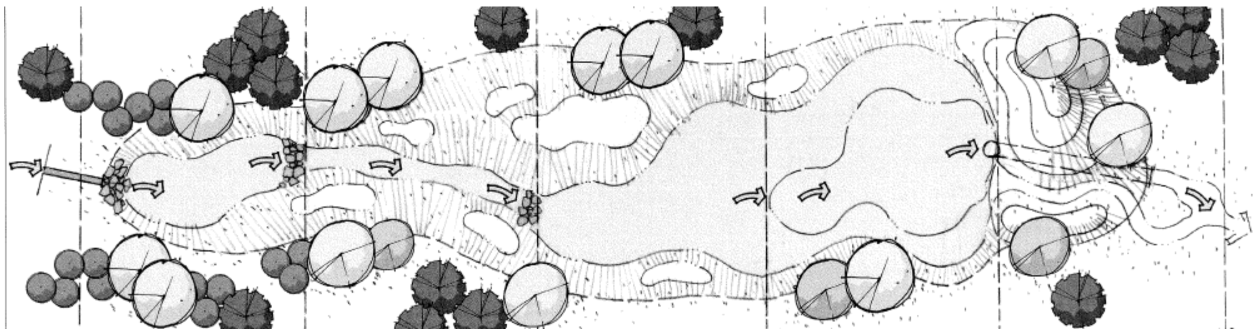
<u>Lower Shoreline Planting Zone (4)</u>

Lower shoreline plantings rely on constant moisture, with water depths largely ranging from 6”-24”. This area may have concentrated salt and pollutant levels, depending on the intervention and effectiveness of up-slope plantings. Salt, sediment and nutrient-tolerant native species are preferred. Detention areas in this planting zone provide an opportunity for detention and control the rate of discharge to downstream property.

Embankment Stabilization Planting Zone (5)

The plantings in this zone are deep-rooted plants that are tolerant of slope conditions with excessive drainage. Native plants with their inherent deep-rooting growth habit are best suited for use in this zone.

FIGURE 10-2 Planting Zones



10.5 Detention in Ditches and in Median Areas

Stormwater detention in oversized ditches or in grassed medians is acceptable if it does not cause an obstacle to traffic. The maximum 100-year WSEL in any detention facility located adjacent to the roadway shall be at least 2 feet below the edge of pavement. The Designer shall avoid designing more than 4 ft of water depth within a ditch section and a maximum of 2 feet of standing water for ground infiltration purposes due to roadside safety concerns.

A ditch check with a control structure outlet pipe shall be used to maintain the required 100-year allowable release rate. The minimum ditch check outlet pipe size shall be 12” in diameter to avoid clogging concerns. A manhole with a minimum 4” restrictor size shall be provided at the ditch check for maintenance purposes. The Designer shall use Base Sheet M-DRN-600 and provide the necessary information for the restrictor type in the summary table.

Additional storm water detention storage may be required to maintain the existing release rates to sensitive outlets when increasing the ditch or embankment slopes, since this change may potentially result in higher velocities and discharges.

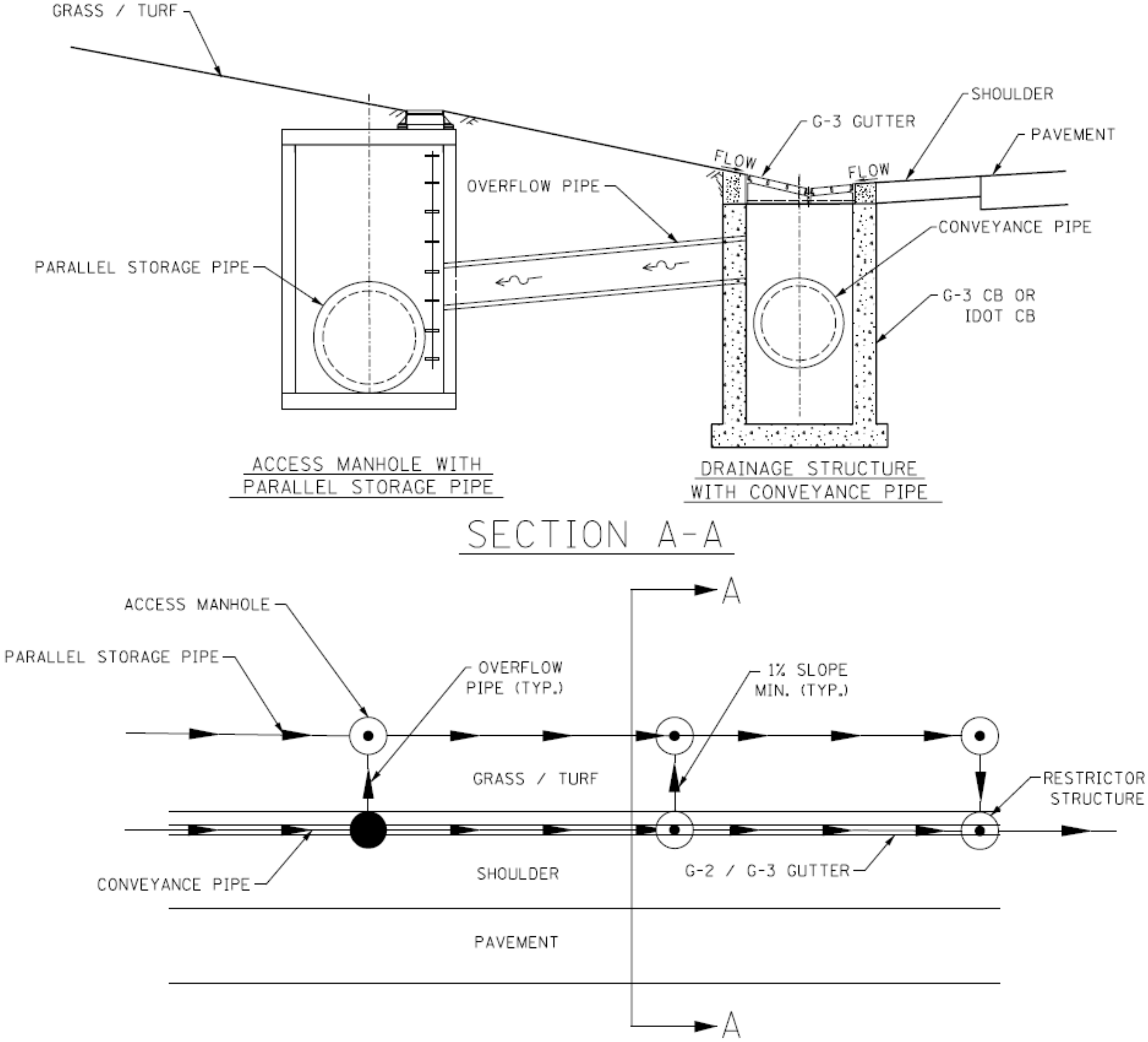
The Illinois Tollway recommends a 1 ft freeboard be provided between the design WSEL and the existing right-of-way ground elevation so that adjacent properties do not experience flooding, especially if there is silt or debris build-up within the Illinois Tollway ditch over time.

10.6 Detention in Storm Sewer Pipes

Stormwater detention storage in oversized storm sewer pipes may be used if it is cost effective or if the construction of detention facilities and roadside ditches with ditch checks is not feasible due to ROW constraints. If the proposed storage pipe is also being used for conveyance purposes, then a 2 ft/s self-cleaning velocity shall be maintained for flowing full conditions at the allowable release rate. The flowing full velocity is typically calculated by dividing the allowable release rate for the design storm by the oversized pipe cross sectional area. A design deviation is required if the 2 ft/s self-cleansing velocity cannot be achieved. When in-line detention storage is utilized in storm sewers, the Designer shall recognize placing that storage within the median is the least desirable location and shall only be designed upon receiving written approval from the Illinois Tollway Project Manager.

The downstream pipe diameter shall not be reduced in size if the upstream pipes are upsized for detention purposes. This pipe shall still convey the undetained design runoff in case the restrictor plate is removed in the future. A manhole/catch basin with an orifice outlet control structure shall be used instead, with a minimum 4” restrictor size. The top of the restrictor plate weir shall be designed to achieve a minimum 6” clearance from the bottom of the top slab within the manhole structure. A minimum 3 ft wide opening on either side of the restrictor plate shall be provided for inspection/maintenance purposes. If the control structure is the only feasible emergency overflow outlet for a detention basin, a minimum 8-foot diameter restrictor manhole shall be used. The Designer shall avoid using large conveyance pipes with small restrictors since a 2 ft/s cleansing velocity shall be achieved to reduce the chances of standing water, resulting in silt build up. Under such circumstances, the Illinois Tollway recommends using a parallel storm sewer system for storage purposes only (See Figure 10-3). Depending on the length, this storage pipe may require multiple overflow connections to the conveyance storm sewer system. A manhole with restrictor may be proposed at the downstream end of the conveyance system to maintain the allowable release rate. Pipe connections shall be sized to ensure that overflows reach the parallel storage pipe while maintaining the HGL freeboard requirements for design conditions. The Designer shall place the overflow pipe near the crown of the conveyance pipe so that the storage pipe is only utilized during high frequency storm events where the conveyance pipe has already reached capacity (as shown in Figure 10-3). This may reduce the amount of silt build-up within the storage pipe due to low velocities. If the storage pipe is being used in conjunction with a detention basin facility, the Designer shall ensure that the pipe is flowing full during the 100-year storm event. For instance, the Designer shall ensure that the detention basin does not overtop onto adjacent properties prior to the upstream storage pipe reaching full capacity.

Figure 10-3 Parallel Storage Pipe



If open space for detention storage is not available, underground systems (storage tanks, oversized box culverts, etc.) may be used instead with the written approval of the Illinois Tollway Project Manager.

10.7 Sedimentation in Detention Basins or Ditches

The design of detention basins or ditches shall permit easy removal of trapped sediment. If this is not possible or not cost effective, the storage volume should be increased by an amount equal to the estimated volume of sediment expected in a 5-year period. This design option shall have the written approval of the Illinois Tollway Project Manager.

10.8 Maintenance Access

Detention basins and outlet structures shall be designed for ease of maintenance access and should include a minimum 10 ft wide (15 ft desirable) maintenance shelf along the perimeter of the detention basin. A maintenance shelf shall be provided adjacent to residential areas. The preferred profile gradient for maintenance access paths to detention basin bottoms and outlet structures should be less than or equal to 8%. Where these grades are not achievable because of constraints, the maximum gradient shall be 1:4 (V:H). Grades steeper than 1:4 will require a design deviation. Maintenance access paths shall have a minimum 10 ft width and should be paved or built with material to provide traction in wet conditions, such as articulated concrete blocks seeded with low profile grasses. Gravel paths for maintenance access to detention basins shall not be allowed.

Table 10.0
STORMWATER DETENTION STORAGE

	Design Criteria	Comments
1. Water Quality Volume	Capture first flush of rainfall per local requirements.	USACE-Chicago District suggests 1.0 inch of WQV. DSE shall identify required storage by local and USACE permit requirements.
2. Maximum Release Rate	0.04 cfs/acre for 2-year flood 0.15 cfs/acre for 100-year flood	Must meet local requirements if more restrictive. (Refer to Article 2.2 for additional information on governing requirements).
3. Computation Method	Graphic Method or a hydrograph method such as Win TR-20, HEC-HMS, Open Flows POND-PACK, XP SWMM, etc.[14]	The critical duration storm shall be used for detention analysis to determine peak flows.
4. Precipitation	Use ISWS *Bulletin 75* rainfall depths.	
5. Freeboard To the edge of pavement To top of berm	Minimum 3 foot above 100-year WSEL Minimum 2 foot, above 100-year WSEL	See Figure 10-1

[14] For more information see:
https://www.bentley.com/software/openflows-pondpack/
http://www.hec.usace.army.mil/software/hec-hms/
https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/null/?cid=stelprdb1042793

	Design Criteria	Comments
6. Emergency Spillway (outlet)	Must pass the 100-year flood without overtopping basin berm or ditch if the outlet structure malfunctions.	See Figure 10-1 Erosion protection as needed.
7. Orifice Size	4" (minimum) 12" (minimum)	For manholes with restrictors and ditch checks. No manholes with restrictor plate provided.
8. Top of Weir Elevation	6" (minimum) clearance between top of weir and top slab.	

SECTION 11.0 TOLL PLAZAS, OASES AND MAINTENANCE FACILITIES

11.1 General Considerations

Drainage structures in oases, maintenance facilities and all parking areas shall be located away from vehicular wheel paths and outside of pedestrian activity areas to the best extent possible. Heavy-duty drainage structures shall be provided where vehicular traffic is present. The drainage design of toll plazas shall prevent water from ponding on pavement that may be a potential obstacle for traffic and/or pedestrians. Also, drainage structures are not allowed in lanes between islands.

Open Road Illinois Tollway (ORT) Plazas shall be designed per Section 9 as Illinois Tollway Mainline Pavement. Pavement shall be sloped to drain properly in accordance with the Illinois Tollway *Business Systems Toll Plaza Manual*. Drainage structures shall not be placed within the toll plaza area adjacent to the CRC pavement. The plaza shall be graded to prevent water from ponding adjacent to control buildings.

11.2 Hydraulic Design

A 50-year peak flow and elevation shall be used for the drainage design of toll plazas, oases and maintenance facilities. Runoff from Illinois Tollway facilities shall not encroach within 3 feet of the edge of pavement. Within parking and other areas, positive drainage shall be provided away from all buildings with the low entry elevation above the 100-year high water elevation.

If open space for detention storage is not available, underground systems may be used instead with the written approval of the Illinois Tollway Project Manager.

Water quality control measures shall be considered in the design of toll plazas, oases and maintenance facility drainage systems per the size of the roadway improvement areas. See Section 4 for further guidance.

Parking lots and areas adjacent to control building pads shall be designed to have a minimum 1% longitudinal slope between high point and drainage structure. Also, the maximum water depth on the pavement shall be limited to 4” for the design storm frequency.

Refer to Table 11.0 for additional information.

Table 11.0
TOLL PLAZAS, OASES and MAINTENANCE FACILITIES

	Design Criteria	Comments
A. Toll Plazas		
1. Design Flood	50-Year (2% chance of exceedance storm)	
2. Maximum Encroachment	≥3 ft. from traveled way. No encroachment on buildings	At design flood
3. Maximum Water Depth	0.35 ft	
4. ORT Plazas	Per Section 9 as Illinois Tollway mainline pavement.	Drainage structures shall not be placed within the toll plaza area adjacent to the CRC pavement.
5. Automatic / Manual Lanes	Per Section 9 as Illinois Tollway mainline pavement.	
B. Oasis, Maintenance Facilities and Parking Lots		
1. Design Flood	50-Year (2% chance of exceedance storm)	Storm sewers, if used, shall be sized to convey the 50-year storm frequency. No drainage structures shall be placed in walkways or vehicular wheel paths in parking areas.
2. Parking Lots	Longitudinal grades shall be set at a minimum 1% slope. Maximum 4" water depth on pavement	

SECTION 12.0 SOIL EROSION AND SEDIMENT CONTROL

12.1 General Considerations

Soil erosion and sediment control measures are required for any land disturbance activity associated with an Illinois Tollway project. Soil erosion and sediment control measures shall be designed for the construction and operation of all Illinois Tollway facilities. Temporary measures shall be used to control erosion and sedimentation while the project is under construction. Permanent measures shall be implemented as part of the completed project. These measures are detailed in the Illinois Tollway *Erosion Control and Landscape Manual* and are intended to prevent erosion and sediment damage to Illinois Tollway facilities and adjacent properties. The Designer shall use the above-mentioned document in conjunction with the Illinois Tollway Drainage Design Manual for the design of all erosion and sediment control measures.

12.2 Erosion and Sediment Control Design

The Designer shall perform an erosion and sediment control evaluation for the proposed project. Based upon this evaluation, specific measures shall be recommended for implementation. The Designer shall incorporate the appropriate information in the design plans and specifications. Temporary sediment and erosion control devices shall be functional before land is disturbed on the site. A maximum of 20 acres may be disturbed at a single time. In addition, stabilization of cut or fill slopes is required whenever the cut or fill activity reaches 15 feet vertically or the finished slope equals 50 feet in width, whichever is more restrictive.

Unanticipated site conditions or storm events may require special erosion control measures. Design criteria for temporary erosion and sediment control measures are as follows:

- For disturbed areas less than one (1) acre, filter barriers (including silt fences, or equivalent control measures) shall be provided and applied in the field.
- For disturbed areas more than one (1) acre but less than five (5) acres a sediment trap or sediment basin shall be constructed at the down slope point of disturbed area.
- For disturbed areas draining more than five (5) acres, a sediment basin shall be provided at the down slope point of disturbed area.

The sediment traps or basins shall be designed to store 3600 ft^3 per acre of area tributary to the basin, or as determined necessary by soil erosion calculations. If properly designed, located and maintained, permanent detention basins may be easily modified to serve as temporary sediment basins until the project area is stabilized. Procedures for maintenance of temporary measures shall be included in the design plans and specifications.

SECTION 13.0 PUMP STATION DESIGN

13.1 General Considerations

Pump stations shall be used only when there is no feasible gravity drainage alternative available. Alternatives to using a pump station or to minimize the size of a pump station shall be fully investigated by the Designer and documented in the necessary design deviation. The alternatives to pump stations may include diversion of flow to another watershed, changes in profile and/or alignment and/or changing to an overpass instead of underpass design. Also, every attempt shall be made to reduce overflows to the pump station facility (from adjacent areas not directly tributary) during high frequency storm events. The pump station design high water elevation shall not cause any tributary drainage facilities to exceed their design criteria.

13.2 Design Requirements

Pump stations shall be designed for a 50-year flood event to obtain 2-feet of freeboard to the low edge of pavement. Pump station operation shall be checked for the 100-year flood event to ensure that pavement flooding does not occur. Inflow hydrographs shall be used to design the pump station. The inflow hydrographs may be computed using an appropriate hydrograph method in accordance with the requirements of Sections 2 and 5.

Pump station capacity shall be selected based on the allowable release rate and amount of stormwater detention storage available to minimize the pump station outflow capacity. Pump station operation shall not cause flooding on adjacent properties for the check flood. The drainage area tributary to the pump station shall be limited to the underpass area only unless otherwise directed by the Illinois Tollway Project Manager. Avoid constructing a pump station within a floodplain. If the pump station has to be constructed adjacent to a floodplain, a berm with a minimum 1-foot buffer shall be provided above the 100-year flood elevation. Refer to the “Pump Station Hydraulic Reports” section of the *ACEC-Illinois/IDOT 2014 Drainage Seminar* manual for hydrology and pump cycling design procedures. Additional guidance is available in HEC-24 *Highway Stormwater Pump Station Design* and *IDOT District 1 General Guidelines for Pump Station Design*.

The design capacity of groundwater-only pump stations shall be based on field measurements of infiltration rates.

See Table 13.0 for additional information on Illinois Tollway criteria for pump station design.

Table 13.0
PUMP STATIONS

	Design Criteria	Comments
1. Design Flood	50-year (2% chance of exceedance)	Use hydrograph method (WIN TR-20, HEC-HMS, XPSWMM, etc.). Use separate spreadsheet for pump cycling analysis.
2. Check Flood	100-year (1% chance of exceedance)	No pavement flooding allowed
3. Design Capacity	Most economical system of pump capacity and storage	Use: 1. *ACEC-Illinois/IDOT 2014 Drainage Seminar* Manual, IDOT District 1 General Guidelines for Pump Station Design, IDOT Drainage Manual and HEC-24 *Highway Stormwater Pump Station Design* for additional guidance.
4. Design Water Surface	2 ft. below low edge of pavement	

SECTION 14.0 SUBMITTAL REQUIREMENTS

14.1 General Considerations

The submittal requirements for drainage designs are based on and in support of the requirements of the various Illinois Tollway project design phases, which are defined in the *Design Section Engineer's Manual* and briefly described below:

- **Pre-Concept Design (Master Plan) Submittal.** This submittal is required for selected projects only. It typically includes the development and analysis of possible major design alternatives. The deliverable for this phase is a *Master Plan Report* for the overall project submittal with exhibits and specific requirements as detailed in the *Scope of Services (see Pages Appendices E for specific Tasks)*.
    - Task 1 (General Location Drainage Map) – Designer to perform full scope.
    - Task 2 (Existing Drainage Plan) – Designer to perform full scope.
    - Task 3 (Identified Drainage Concerns) – Designer to perform full scope.
    - Task 4 (Identified Base Floodplains) – Designer to perform full scope.
    - Task 5 (Bridges and Culverts) – Designer to perform full scope.
    - Task 6 (Design Criteria) – Designer to perform full scope.
    - Task 7 (Outlet Evaluation) – Designer to perform full scope for first two "Specific Tasks".
    - Task 8 (Stormwater Detention Analysis) – Designer to perform full scope.
    - Task 9 (Right-of-Way Evaluation) – Designer to identify if right-of-way is needed, approximate size and recommended locations.
    - Task 10 (Drainage Alternatives) – Designer to perform full scope.
    - Task 11 (Local and Other Agency Coordination) – Not Applicable.
    - Task 12 (Proposed Drainage Plan) – Limit work for Task 12 to "Specific Tasks" (see Page E-12 & E-13 of the appendices) A through I except that the reference should be Chapter 3 of the IDOT Drainage Manual. Conceptual drawings of the proposed drainage work shall be included.
    - Task 13 (Floodplain Encroachment Evaluation) – As directed by the Illinois Tollway.
    - Task 14 (Permits) – Not Applicable.
    - Task 15 (Report Assembly) – Designer to perform full scope.
- **Design Concept Submittal**. This submittal is an initial stage of design, which allows the Designer to present the nature of the required improvement(s), demonstrate the intent of the proposed design and verify compliance with the established parameters and design criteria. This design phase shall include the proposed alternatives considered by the Designer and the recommended plan for achieving the goals of the project. The deliverable for this phase is a *Concept Drainage Report* with all supporting data, back-up information, exhibits and drawings. Hard copies are not required for hydraulic modeling performed for various alternatives. This information may be provided on a CD with the Concept Drainage Report.
- **Preliminary Design Submittal.** This submittal includes plans, quantities, special provisions, engineers estimate and disposition to all comments from the Concept Design Report and/or Concept Drainage Report. The drainage calculations are not required to be submitted with the preliminary drawings. However, the Designer shall provide a written description of any changes or deviations from the approved Concept Drainage Report at the preliminary stage to obtain Illinois Tollway approval.

- **Pre-Final Design Submittal.** This submittal includes the revised plans, special provisions, the corresponding design, quantities and the drainage design calculations with narrative description. It also includes all responses, revisions and corrections resulting from the previous review comments on the preliminary design submittal. The drainage calculations shall be submitted at the pre-final stage to allow the Designer to make the necessary updates prior to the final submittal. If the drainage design calculations are not submitted concurrently with the pre-final design submittal package, the pre-final drainage plans shall not be reviewed until the drainage design calculations are provided. If some of the drainage elements are not finalized at this stage, the Designer is still responsible for submitting the rest of the drainage calculations for review, with a brief description of which items are still missing or require updating. Once these drainage items are completed, they shall be submitted to the Illinois Tollway for review as soon as possible after the pre-final submittal.
- **Final Design Submittal**. This submittal includes the revised plans, quantities, special provisions and the Final Drainage Report addressing all previous submittal comments. It also includes all responses, revisions and corrections resulting from the previous review comments on the previous design submittals. Final Drainage Report shall be provided for Illinois Tollway record no later than date of construction contract bid opening. If changes to the roadway geometry result in modifying the drainage design after the pre-final submittal, the DSE shall complete the revised drainage calculations (including any required design deviations) and resubmit to the Illinois Tollway as soon as possible (and prior to the final review meeting), to obtain formal approval.

The Designer shall submit a written response addressing all Illinois Tollway drainage comments prior to or in concurrence with a later submittal. If the Designer does not agree with an Illinois Tollway comment an explanation shall be provided prior to the next submittal date and the Illinois Tollway Project Manager and drainage reviewer notified.

The drainage design submittal requirements contained in this section are for general guidance only. The nature and extent of the submittal requirements for each design phase may be extended and further detailed in the *Scope of Services* for each particular Illinois Tollway project or as directed by the Illinois Tollway Project Manager.

14.2 Pre-Concept Phase (Master Plan)

For the Pre-Concept Design phase, the Designer shall submit a Pre-Concept Drainage Report in the format and to the level of detail described in the *Scope of Services developed* for each specific project between the Illinois Tollway PM and the Designer. The Designer is responsible for initiating the permit process with the Illinois Tollway Environmental Department.

14.3 Concept Phase

For the Design Concept phase, the Designer shall submit a **Concept Drainage Report (CDR)** in accordance with the tasks and format described in **Appendix F** and **Appendix G**. If the Designer is proposing the use of a non-standard computer program, a written request including documentation shall be submitted for Illinois Tollway approval prior to its use.

The **CDR** shall be prepared and submitted prior to the Design Concept Report Submittal and shall contain an **Executive Summary** and the following completed tasks and their corresponding deliverables (unless otherwise noted below):

- **Task 1: General Location Drainage Map.**
- **Task 2: Existing Drainage Plan.**

- **Task 3: Identified Drainage Concerns.**
- **Task 4: Identified Base Floodplains.**
- **Task 5: Bridges and Culverts. This task shall be completed to a level that provides the following information:**
    - Narrative to describe existing conditions.
    - Complete survey required for hydrologic and hydraulic analysis.
    - Complete hydrologic and hydraulic analysis of existing conditions, documented in the WIT.
    - Preliminary proposed type and sizes for the structures.
    - Prepare an alternative analysis for proposed culvert crossings where standing water exists upstream and downstream year-round.
    - Identification of any constraints or required design variations.
- **Task 6: Design Criteria.**
- **Task 7: Outlet Evaluation.**
- **Task 8: Stormwater Detention Analysis. This task shall be completed to a level that provides the following:**
    - Required storage volumes per Illinois Tollway and/or local requirement (if more restrictive).
    - Concept plan for providing storage per reach.
- **Task 9: Right-of-Way Evaluation.** This task shall be completed to a level that provides the locations where additional right-of-way and/or easements are required for construction of proposed drainage facilities. Coordination with local communities and/or property owners is required to ensure that the recommended proposed right-of-way may be acquired and used for drainage purposes.
- **Task 10: Drainage Alternatives.** Inspect to evaluate re-use of existing drainage infrastructure. Provide documentation and engineer's estimate.
- **Task 11: Local and Other Agency Coordination.** This task shall be developed to a level required to support the completion of the Existing Drainage Plan, Identified Drainage Concerns and Design Criteria.
- **Task 12: Proposed Drainage Plan.** This task shall be completed to a level that provides the following:
    - Identification of the specific types of required drainage facilities (i.e., sewers, ditches, detention, retention and required stormwater storage volumes).
    - Conceptual layout of the proposed drainage system and the tributary drainage area to each proposed drainage facility (i.e., bridge, culvert, sewer, detention site, etc.). Preliminary sizing of each proposed drainage facility shall also be provided.
    - Preliminary storm sewer design (does not include inlet spacing analysis).
    - Floodplain limits and elevations.
    - Identification of stream crossings where detailed analysis shall be performed.
    - Identification of the need for additional right-of-way required for proposed drainage facilities.
    - Identification of all potential utility and structure foundation conflicts.
- **Task 13: Floodplain Encroachment Evaluation.** This task shall be completed based on the evaluation of preliminary proposed sizes.
- Task 14: Permits.
- **Task 15: Report Assembly.** This task shall be completed in support of the submittal of the "Draft" Concept Drainage Report.

Additional tasks may be added as noted in the project's *Scope of Services, Illinois Tollway-Design Section Engineer's Manual* (DSE Manual) or as directed by the Illinois Tollway Project Manager.

14.4 Preliminary Plans and Special Provisions Phase

After approval of the **CDR**, the following items shall be prepared and submitted as part of the **Preliminary Plans and Special Provisions Phase**:

14.4.1 Preliminary Plan Submittal

Disposition of Comments – The Designer shall include their dispositions addressing the Illinois Tollway Concept Drainage Report comments. "Open" items shall be addressed in future submittals by the Designer.

Drainage Survey / Field Visit / Inspection – The Designer is responsible for obtaining supplemental surveys, performing a field visit and noting any discrepancies or deficiencies (including failed drainage structures and additional right-of-way requirements) to the Illinois Tollway Project Manager, as early as possible in the design process. The Designer is responsible for following the drainage concept report or notifying the Illinois Tollway Project Manager regarding any design changes in review comment format. The Designer shall also coordinate with other design consultants working on adjacent contracts to ensure the proposed design is uniform for both sections.

Permitting – The Designer shall note and obtain any permits required at this stage. The Designer shall also coordinate with the village and other relevant agencies to ensure everyone is aware of the proposed improvements and agree on the recommendations.

Proposed Drainage Plan Sheets – Plans shall correspond to the scale and orientation of the roadway plans. A layout of the proposed storm sewer system, including drainage structures and culverts shall be included. All structure and pipe call-outs shall be provided on these sheets or separate drainage schedules. The drainage legend shall also be included. Proposed end treatment of culverts and other exposed pipes shall be coordinated with the barrier warrant analyses.

Storm Sewer Profiles – A general layout of the proposed storm sewer and ditch profiles shall be included. Profiles shall be shown at the flow line or invert elevations for ditches, storm sewers and any other moving bodies of water. Existing and proposed ponds shall be shown at the flow line or invert elevations. Storm sewer and structure rim and invert elevations, as well as paved or non-paved ditch grades shall be shown to the nearest 0.01'. All existing utility and culvert crossings shall also be shown on these sheets.

Drainage Schedules – The drainage structure schedules shall include the pay item, station, offset, invert and rim elevations, drainage structure, headwall and frame and grate types, height of monolithic reinforced concrete above pipe penetration holes > 15" and the total structure height. For all circular structures, the size determination and percent inside perimeter removal spreadsheets (Manhole Sizing Calculator)[15] shall be completed. The storm sewer schedules shall include the pay item, class, type, length, station to station notation, trench backfill quantity and size.

[15] Manuals Policies Guidelines - Illinois Tollway

Temporary Drainage – Temporary drainage typical sections shall be provided for each maintenance of traffic stage (as necessary), this information may be included in the proposed drainage or maintenance of traffic sheets.

Drainage Removal Sheets – The Designer has the option of creating separate drainage removal sheets or including this information on the roadway/drainage removal drawings. All removal patterns and call-outs shall be completed by the preliminary stage.

Existing / Proposed Typical Sections – These sections shall be completed to show all drainage related items (including pipe underdrains, trench drains, typical roadside ditch sections, etc.).

Summary of Quantities – The Designer is responsible for including pay items and summary of quantities with this submittal. Even though some of the major drainage details are not completed at this stage, the Designer should make every effort possible to account for any major items for cost estimate purposes.

Special Provisions – Any pay items that require special provisions shall be included with this submittal for preliminary Illinois Tollway review. This list shall be updated with the pre-final plans.

Design Deviations – The Designer shall provide the Illinois Tollway all design deviations at this stage of the project. The Designer shall also note any major problems with construction staging. Every effort shall be made by the Designer to eliminate or reduce the number of design deviations.

Cost Estimate – The Designer shall provide a preliminary cost estimate.

Concept Drainage Report (CDR) – Any significant modifications to the proposed drainage plan as documented in the **"Final" CDR** shall be incorporated into the **Final CDR** as an addendum along with all supporting calculations.

14.4.2 Pre-Final Plan Submittal

Drainage Design Calculations – This submittal includes a narrative description and subsequent storm sewer, gutter spread, ditch capacity and other drainage calculations either not included or updated since the CDR. It also includes all responses, revisions and corrections resulting from the previous review comments on the concept and preliminary drainage design submittal. The Designer shall review the approved CDR and note any design deficiencies and/or recent topographic changes noted during field visits that may change some of the proposed drainage recommendations. Any recommended design changes from the CDR shall be approved by the Illinois Tollway Project Manager first.

Disposition of Comments – The Designer shall include their dispositions addressing the Illinois Tollway preliminary plan submittal comments. All "open" items from the previous submittal shall be addressed. If the Designer disagrees with an Illinois Tollway comment it is recommended that they contact the Illinois Tollway Project Manager and/or drainage reviewer to obtain formal approval first, especially if the item requires significant design changes. This may facilitate the review process and avoid making major changes near the project completion date.

Proposed Drainage Plan Sheets – These sheets shall be completed at this stage. They shall include all proposed drainage work such as storm sewers, culverts, detention basins, ditch checks, control structure outlets, etc. Also, all existing sewers / structures to be removed or abandoned under proposed conditions shall be turned off on these sheets. Floodways / Floodplains limits shall also be noted.

Pipe Underdrain Plan Sheets – The Designer has the option of either creating separate sheets or including this information on the Proposed Drainage Plans. Provide call-outs and schedules.

Storm Sewer Profiles – The existing to remain and proposed storm sewers and ditch profiles shall be updated to include structure and pipe call-outs, cross culverts, utilities, ditch checks, etc.

Drainage Schedules – All drainage schedules shall be completed at this stage. This includes the drainage structure, storm sewer, removal items, drainage structure adjustment / reconstruction, pipe cleaning and pipe underdrain schedules. All rim elevations, pipe inverts, concrete headwalls, trench backfill, etc. shall be provided. Temporary drainage schedules shall include temporary pipes and/or drainage structures, including information on what construction stage temporary pipes and drainage structures need to be filled or removed and whether temporary covers are needed as part of the temporary drainage plan.

Drainage Details – All drainage details shall be provided with this submittal. These details may include special drainage structures for larger sewer connections, outlet control structures for in-line and detention basin storage, concrete collars for pipe connections, detention basin and proposed ditch grading plan, storage pipe connections, culvert extensions, slope drains, etc. Plans for stormwater detention ponds shall include the design volume, maximum release rate and the 2-year and 100-year high water elevations.

General Drainage Notes – The general drainage notes shall be provided with this submittal.

Temporary Drainage – Temporary drainage plans and details may require a separate section in the plans or included in the proposed drainage, erosion and sediment control or MOT sheets. Refer to the Illinois Tollway *Erosion Control and Landscape Manual* Article 3.1.4 for temporary erosion and sediment control MOT phasing plan requirements.

Cross Sections – Proposed cross sections shall include all pertinent drainage items, such as storm sewers, utilities, ditch invert elevations, etc., as well as sections cut along culvert crossings.

Drainage Calculations – Calculations shall be prepared in report format including cover, index, narrative/procedure and section divides for inlet spacing, storm sewer design, culvert design, ditch capacity and velocity analyses, stormwater detention storage, allowable release rate requirements, compensatory storage design, temporary drainage calculations, correspondence, etc. All relevant reference material (drainage survey, rainfall data, flooding history, etc.) and back-up mapping (drainage divides, outlet locations, tributary drainage areas, etc.) shall be provided. The Designer shall include a discussion explaining why modifications were made to the Drainage Concept Report and how they affect the overall design and scope. Also, provide critical storm duration analysis summary tables for each detention basin and supporting model input and output. Refer to Appendix L for a sample table.

Additional Tasks – As provided in the project's *Scope of Services, Illinois Tollway – Design Section Engineer's Manual* (DSE manual) or as directed by the Illinois Tollway's Project Manager.

14.4.3 Final Plan Submittal Checklist

All items noted in the pre-final plan submittal shall be updated and completed for the final submittal. Some of these items are not repeated below. The Designer is responsible for determining any drainage related issues and notifying the Illinois Tollway Project Manager prior to the final submittal.

Final Drainage Report – The FDR shall be prepared in accordance with the format and completion of all tasks described in Appendix F and shall have the general contents format shown in Appendix G. The FDR shall be the final compilation of the drainage design. Any recommended design changes from the CDR shall be approved by the Illinois Tollway.

Disposition of Comments – The Designer shall include their dispositions addressing all Illinois Tollway CDR, pre-final submittal comments, as well as any other “open” items from previous submittals.

Drainage Plans – The Illinois Tollway drainage reviewer has to be included in the final review meeting at the office for final approval to be given, unless otherwise stated by the Illinois Tollway.

SECTION 15.0 SELECTED REFERENCES

The following are suggested references that may be used in the design of drainage facilities for the Illinois Tollway.

American Association of State Highway and Transportation Officials (AASHTO):

- *Roadway Design Guide*, Washington, D.C., AASHTO, Current Edition.
- *AASHTO Drainage Manual*, Washington, D.C., AASHTO, Current Edition.

American Society of Civil Engineers (ASCE):

- *Design and Construction of Sanitary and Storm Sewers*, *ASCE Manuals and Reports on Engineering Practice No. 37,* New York, NY, ASCE, 1969.

Chow, V. T.: *Open Channel Hydraulics*, New York, McGraw-Hill, 1959.

Federal Highway Administration (FHWA) Publications, U.S. Department of Transportation, Washington D.C., U.S. Government Printing Office:

- Hydraulic Design Series (HDS-2): *Highway Hydrology*, Second Edition, 2002.
- HDS-4: *Introduction to Highway Hydraulics*, 2008.
- HDS-5: *Hydraulic Design of Highway Culverts*, Third Edition, 2012.
- HDS-6: *River Engineering for Highway Encroachments*, 2001.
- HEC No. 15: *Design of Roadside Channels with Flexible Linings*, Third Edition 2005.
- HEC No. 18: *Evaluating Scour at Bridges*, Fifth Edition, 2012.
- HEC No. 20: *Stream Stability at Highway Structures*, Fourth Edition, 2012.
- HEC No. 22: *Urban Drainage Design Manual*, Third Edition, 2009.
- HEC No. 23: *Bridge Scour and Stream Instability Countermeasures: Experience, Selection and Design Guidance*, Third Edition, 2009.
- HEC No. 24: *Highway Stormwater Pump Station Design*, 2001.

Illinois Department of Transportation (IDOT):

- *Drainage Manual*, Current Edition.
- *Bureau of Design and Environment Manual*, Current Edition.
- *Standard Specifications for Road and Bridge Construction*, Current Edition.
- *ACEC-Illinois/IDOT 2014 Drainage Seminar Manual*
- *District 1 General Guidelines for Pump Station Design*

Illinois Tollway:

- *Erosion Control and Landscape Manual*, Current Edition.
- *Geotechnical Manual,* Current Edition
- *Roadway Design Criteria*, Current Edition.
- *Standard Drawings*, Current Edition.
- *Structure Design Manual,* Current Edition.
- *Supplemental Specifications,* Current Edition.
- *Traffic Barrier Guidelines*, Current Edition.

Cook County Watershed Management Ordinance, Current Edition.

Metropolitan Water Reclamation District of Greater Chicago (MWRDGC):

- *Watershed Management Ordinance*, Current Edition.
- *Technical Guidance Manual*, Current Edition.

Natural Resources Conservation Service (NRCS). U.S. Department of Agriculture:

- *National Engineering Handbook Part 630, Hydrology*, Current Edition.
- *Engineering Field Handbook Part 650*, Current Edition.
- *Urban Hydrology for Small Watersheds*, Technical Release No. 55.
- *Design of Open Channels*, TR-25, National Engineering Handbook.

Northeastern Illinois Planning Commission (NIPC)

- *Best Management Practice Guidebook for Urban Development*, 1992.
- *Urban Stormwater Best Management Practices for Northeastern Illinois*

U.S. Army Corps of Engineers (USACE):

- *Hydraulic Design of Flood Control Channels*, USACE EM 1110-2-1601.

U.S. Geological Survey (USGS). U.S. Department of the Interior:

- *Effects of Urbanization on Magnitude and Frequency of Floods in Northeastern Illinois*, Washington, D.C., U.S. Government Printing Office, 1979.
- *Estimating Flood-Peak Discharge Magnitudes and Frequencies for Rural Streams in Illinois*, U.S. Geological Survey, Reston, Virginia, 2004.

Procedures and Standards for Urban Soil Erosion and Sedimentation Control in Illinois (The Green Book).

U.S. Department of Agriculture:

- *Stability Design of Grass-lined Open Channels*, ARS – Agriculture Handbook #667, September 1987.

North American Green Software:

- *Erosion Control Materials Design Software (ECMDSTM)*[16]

Illinois State Water Survey (ISWS):

- *Precipitation Frequency Study for Illinois: (ISWS Bulletin 75)*

Illinois Society of Professional Engineers:

- *Standard Specifications for Water and Sewer Construction in Illinois*, Current Edition.

Federal Aviation Administration (FAA)

- *Hazardous Wildlife Attractants on or Near Airports,* Advisory Circular 150/5200-33C, 2020.

[16] https://nagreen.com/ECMDS

APPENDIX A. ILLINOIS TOLLWAY DRAINAGE DESIGN CRITERIA SUMMARY

APPENDIX A: ILLINOIS TOLLWAY DRAINAGE DESIGN CRITERIA SUMMARY

	Current Methods of Analysis	**ILLINOIS TOLLWAY-DDC 2008**	**ILLINOIS TOLLWAY-DDC 2003**	**NORTH-SOUTH ILLINOIS TOLLWAY**	**ILLINOIS TOLLWAY-DDC 1983**	**ILLINOIS TOLLWAY-DDC 1970**
5.0 HYDROLOGY						
1. General Considerations	ISWS *Bulletin 75* rainfall depths. Use a 0.95 "C" coefficient for impervious areas.	ISWS *Bulletin 70* Sectional Rainfall Depths (Rational Method) & Isohyetal Rainfall Depths (Hydrograph Method)	ISWS *Bulletin* 70 precipitation shall be used for all methods	NWS TP-40 Precipitation	NWS TP-40 Precipitation	NWS TP-40 Precipitation
2. Roadways & Bridge Decks	Modified Rational Method Hydraulic Toolbox, Current Version	Modified Rational Method HY-22	Modified Rational Method FHWA HEC-12	FHWA HEC-12	FHWA HEC-12	None
3. Other Drainage Structures: 3.1 For D.A. ≤ 200 acres	Rational Method (for storm sewers and ditches) or Hydrograph Method	Rational Method (for storm sewers and ditches) or Hydrograph Method	Rational Method or Hydrograph Method	Rational Method	Rational Method	Rational Method
3.2 For D.A. < 2,000 acres	HEC-HMS WinTR20 NRCS TR-55 (only for determining Runoff Curve Number and Time of Concentration) Hydrograph Method (Detention)	NRCS TR-55 (only for determining Runoff Curve Number and Time of Concentration) Hydrograph Method (Detention)	NRCS TR-55 (Peak only) Hydrograph Method (Detention)	SCS TR-55	SCS TR-55	University of Illinois Bulletin 462 / Ven Te Chow (for D.A. = 200 to 6,000 acres)

	Current Methods of Analysis	ILLINOIS TOLLWAY-DDC 2008	ILLINOIS TOLLWAY-DDC 2003	NORTH-SOUTH ILLINOIS TOLLWAY	ILLINOIS TOLLWAY-DDC 1983	ILLINOIS TOLLWAY-DDC 1970
3.3 For D.A. = 0.02 to 10,000 sq. mi. (Rural) 0.7 to 630 sq. miles (Urban)	USGS Regression Equations (StreamStats) Frequency Analysis IDNR-OWR Certified Discharges Hydrograph Method	USGS Regression Equations (Soong 2004 version) Frequency Analysis IDNR-OWR Certified Discharges Hydrograph Method	USGS Regression Equations in IDOT Drainage Manual Frequency Analysis IDNR-OWR Certified Discharges Hydrograph Method	USGS Regression Equations	USGS Regression Equations	USGS Regression Equations >75 sq. mi.
3.4. Any Area	Methods: HEC-HMS XP SWMM WinTR-20 (the appropriate Huff rainfall distribution and a critical storm duration analysis shall be performed) Other Available Methods (with Illinois Tollway approval)	Hydrograph Methods: HEC-1 HEC-HMS SCS TR-20 (for major projects, the appropriate Huff rainfall distribution and the critical storm duration analysis should be performed. Use Isohyetal precipitation depths for 6 county area. Other Available Methods (with Illinois Tollway approval)	Hydrograph Methods: HEC-1 HEC-HMS SCS TR-20 (for major projects, the appropriate Huff rainfall distribution and the critical storm duration analysis should be performed) Other Available Methods (with Illinois Tollway approval)	TR-20 HEC-1 ILLUDAS	HEC-1	None

	Current Methods of Analysis	ILLINOIS TOLLWAY-DDC 2008	ILLINOIS TOLLWAY-DDC 2003	NORTH-SOUTH ILLINOIS TOLLWAY	ILLINOIS TOLLWAY-DDC 1983	ILLINOIS TOLLWAY-DDC 1970
6.0 DITCH AND CHANNEL HYDRAULICS						
1. Design Flood	50-Year (2% chance of exceedance)	50-Year (2% chance of exceedance)	50-Year (2% chance of exceedance)	50-Year (2% chance of exceedance)	50-Year (2% chance of exceedance)	50-Year (2% chance of exceedance)
2. Design Water Surface	At least 1.0' below adjacent ROW. 2.0' below edge of pavement	At least 1.0' below sub-base	At least 1.0' below subgrade	Below subgrade	Below subgrade	Below subgrade
3. Minimum Longitudinal Slope	0.5% desirable (0.3% minimum)	0.3% (0.5% desirable)	0.3%	0.3%	0.3%	0.3%
4. Maximum Flow Velocity	3-7 fps depending on ditch slope and lining	2-8 fps depending on lining	2-8 fps depending on lining	2-8 fps depending on lining	None	2-5 fps depending on lining
5. Shape	Most efficient hydraulic section	Most efficient hydraulic section	Most efficient hydraulic section	Most efficient hydraulic section	Channel section to carry discharge on available slope	Channel section to carry discharge on available slope
6. Lining	Grass lined is preferred	Grass lined is preferred	Grass lined is preferred	Ditch lining appropriate with design velocity	Sodding, ditch checks, concrete lining	Grass lined is preferred
7. Erosion Protection	As required using the available environmentally friendly products (with Illinois Tollway approval)	As required using the available environmentally friendly products (with Illinois Tollway approval)	As required using the available environmentally friendly products (with Illinois Tollway approval)	Ditch checks and concrete paving	Ditch checks and concrete paving	Ditch checks and concrete paving

	Current Methods of Analysis	ILLINOIS TOLLWAY-DDC 2008	ILLINOIS TOLLWAY-DDC 2003	NORTH-SOUTH ILLINOIS TOLLWAY	ILLINOIS TOLLWAY-DDC 1983	ILLINOIS TOLLWAY-DDC 1970
8. Ditch Checks	The crest shall be a minimum of 1' above grated inlets within roadside ditches and 2.0' below edge of pavement	The crest shall be a minimum of 1' above grated inlets within roadside ditches but below the roadway sub-base	The crest shall be a minimum of 1' above grated inlets but below the sub-base	None	None	The crest shall be a minimum of 1' above grated inlets but below the sub-base
7.0 CULVERT HYDRAULICS						
1. Design Flood	50-Year (2% chance of exceedance)	50-Year (2% chance of exceedance)	50-Year (2% chance of exceedance)	50-Year (2% chance of exceedance)	50-Year (2% chance of exceedance)	50-Year (2% chance of exceedance)
2. Check Floods	10, 100, 500-Year (no overtopping at low edge of pavement) (0.2% chance of exceedance)	500-Year (no overtopping) (0.2% chance of exceedance)	100-Year (1% chance of exceedance)	100-Year (1% chance of exceedance)	None	None
3. Minimum Diameter / Maximum Length for Illinois Tollway or Ramp Crossings	24" Ø RCP / for L ≤ 200' 30" Ø RCP / for L > 200'	24" Ø RCP / for L ≤ 200' 30" Ø RCP / for L > 200'	24" / for L ≤ 200' 30" / for L > 200'	24" / 200' 30" / >200'	24" / 200' 30" / >200'	24" / 200' 30" / >200'
4. Minimum Diameter for Ditch Culverts	18" RCP	18" RCP	18"	18"	18"	18"
5. Maximum headwater for design flood	HW/D≤1; 0.5 feet created head maximum; 3 feet to low edge of pavement	Culvert Crown Elevation (HW/D≤1) / 3 ft. to low road elevation	Culvert Crown Elevation (HW/D≤1)	Culvert Crown	Culvert Crown	1 ft. above crown

	Current Methods of Analysis	**ILLINOIS TOLLWAY-DDC 2008**	**ILLINOIS TOLLWAY-DDC 2003**	**NORTH-SOUTH ILLINOIS TOLLWAY**	**ILLINOIS TOLLWAY-DDC 1983**	**ILLINOIS TOLLWAY-DDC 1970**
6. Inlet / Outlet End Treatments	As needed for hydraulics, safety and erosion control	As needed for improved hydraulics and erosion control	As needed for improved hydraulics and erosion control	As needed	As needed	None
8.0 BRIDGE HYDRAULICS						
1. Design Flood	50-Year (2% chance of exceedance)	50-Year (2% chance of exceedance)	50-Year (2% chance of exceedance)	50-Year (2% chance of exceedance)	50-Year (2% chance of exceedance)	50-Year (2% chance of exceedance)
2. Check Floods	100-Year (meet IDNR requirements) (1% chance of exceedance) 500-Year (no roadway overtopping at low edge of pavement) (0.2% chance of exceedance)	100-Year (meet IDNR requirements) (1% chance of exceedance) 500-Year (no roadway overtopping) (0.2% chance of exceedance)	100-Year (1% chance of exceedance) 500-Year (0.2% chance of exceedance)	None	100-Year (1% chance of exceedance) 500-Year (0.2% chance of exceedance)	None
3. Minimum Low Chord	At least 2' above 2% exceedance stage for natural conditions at U/S face	At least 2' above 2% exceedance stage for natural conditions at U/S face	At least 2' above 2% exceedance stage plus backwater	At least 2' above 2% exceedance stage	At least 2' above 2% (50-Year) exceedance stage	None
4. Minimum Freeboard	3 ft above 50-year HWE at low edge of pavement	3 ft above 50-year HWE				

	Current Methods of Analysis	ILLINOIS TOLLWAY-DDC 2008	ILLINOIS TOLLWAY-DDC 2003	NORTH-SOUTH ILLINOIS TOLLWAY	ILLINOIS TOLLWAY-DDC 1983	ILLINOIS TOLLWAY-DDC 1970
5. Maximum Created Head: a. In designated floodways In Cook, DuPage, Kane, Lake, McHenry and Will counties b. Other urban areas c. Rural areas	< 0.1 ft. < 0.5 ft. < 1.0 ft.	< 0.1 ft. < 0.5 ft. < 1.0 ft.	< 0.1 ft. < 0.5 ft. < 1.0 ft.	IDOT Permit Requirements	None	None
6. Scour Analysis and Protective Measures	500-Year Design per HEC-18	As needed (HEC-RAS, HEC-18, HEC-20)	As needed (HEC-RAS, HEC-18, HEC-20)			
9.0 ROADWAY DRAINAGE						
1. Roadway Profile						
a. Design Storm	50-Year (2% chance of exceedance)	50-Year (2% chance of exceedance)	50-Year (2% chance of exceedance)	50-Year (2% chance of exceedance)	50-Year (2% chance of exceedance)	None
b. Check Storm	500-Year (0.2% chance of exceedance)	500-Year (0.2% chance of exceedance)	500-Year (0.2% chance of exceedance)	500-Year (0.2% chance of exceedance)	None	None
c. Minimum Freeboard	3 ft above headwater	3 ft above headwater	3 ft.	3 ft.	3 ft.	None
2. Pavement						
a. Design	50-Year (2% chance of exceedance)	50-Year (2% chance of exceedance)	50-Year (2% chance of exceedance)	50-Year (2% chance of exceedance)	10% chance of exceedance 2% median adjacent to barrier walls	None

	Current Methods of Analysis	ILLINOIS TOLLWAY-DDC 2008	ILLINOIS TOLLWAY-DDC 2003	NORTH-SOUTH ILLINOIS TOLLWAY	ILLINOIS TOLLWAY-DDC 1983	ILLINOIS TOLLWAY-DDC 1970
b. Maximum Pavement Encroachment	Water shall remain on shoulder and no closer than 3' from edge of traveled way	Water shall remain on shoulder and no closer than 3' from edge of pavement.	>3 ft. from pavement edge	>3 ft. from pavement edge	>3 ft. from pavement edge	None
c. Inlet Spacing Maximum Water Depth	0.35 ft	0.35 ft	N/A	N/A	N/A	N/A
d. Slotted Pavement Drains	No longer in use	0.2% minimum slope	N/A	N/A	N/A	N/A
e. Trenched Pavement Drains	0.6% minimum slope	N/A	N/A	N/A	N/A	N/A
3. Bridge Deck						
a. Design Storm	10-Year (10% chance of exceedance)	50-Year (2% chance of exceedance)	50-Year (2% chance of exceedance)	50-Year (2% chance of exceedance)	10% chance of exceedance, 2% median adjacent to barrier walls	None
b. Inlet Spacing	Maximum encroachment is the edge of pavement. Minimum of 3 inlets at any sag vertical curve.	Maximum encroachment is the edge of pavement. Minimum of 3 inlets at any sag vertical curve.	Maximum encroachment is the edge of pavement. Minimum of 3 inlets at any sag vertical curve.	>3 ft. from pavement edge Required for grades >0.5%.	Edge of pavement Required for grades >0.5%	None
c. Bridge Approach Inlets	Required for grades > 0.5%.	Required for grades > 0.5%.	Required for grades > 0.5%.	Required for grades > 0.5%.	Required for grades > 0.5%.	None

	Current Methods of Analysis	ILLINOIS TOLLWAY-DDC 2008	ILLINOIS TOLLWAY-DDC 2003	NORTH-SOUTH ILLINOIS TOLLWAY	ILLINOIS TOLLWAY-DDC 1983	ILLINOIS TOLLWAY-DDC 1970
4. Medians and Shoulders						
a. Grassed Medians (Rural)						
1. Design Storm	50-Year (2% chance of exceedance)	50-Year (2% chance of exceedance)	50-Year (2% chance of exceedance)	50-Year (2% chance of exceedance)	50-Year (2% chance of exceedance)	50-Year (2% chance of exceedance)
2. Inlet Spacing	Maximum of 1,000' (1st may be 1,200' from crest vertical curve).	Maximum of 1,000' (1st may be 1,200' from crest vertical curve).	Maximum of 1,000' (1st may be 1,200' from crest vertical curve).	Maximum of 1,000' (1st may be 1,200' from crest).	Maximum of 1,000' (1st may be 1,200' from crest).	None
3. Median Drains	Must use flat grate inlets. Outlet ≥ 15" RCP. Ditch check required. Minimum of 3 inlets at sag vertical curves	Must use flat grate inlets. Outlet ≥ 15" RCP. Ditch check required. Minimum of 3 inlets at sag vertical curves	Must use flat grate inlets. Outlet ≥ 15" RCP. Ditch check required. Minimum of 3 inlets at sag vertical curves	Outlet ≥15" RCP 3 inlets in sag	Outlet ≥15" RCP 3 inlets in sag	Outlet ≥15" RCP 3 inlets in sag
4. Minimum Grade	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%
5. Median Water Surface in ditch	> 2 ft. below edge of pavement	> 1 ft. below pavement subgrade	> 1 ft. below pavement subgrade	>1 ft. below pavement subgrade	>1 ft. below pavement subgrade	None
b. Paved Medians (Urban)						
1. Design Storm	50-Year (2% chance of exceedance)	50-Year (2% chance of exceedance)	50-Year (2% chance of exceedance)	50-Year (2% chance of exceedance)	50-Year (2% chance of exceedance)	50-Year (2% chance of exceedance)

	Current Methods of Analysis	ILLINOIS TOLLWAY-DDC 2008	ILLINOIS TOLLWAY-DDC 2003	NORTH-SOUTH ILLINOIS TOLLWAY	ILLINOIS TOLLWAY-DDC 1983	ILLINOIS TOLLWAY-DDC 1970
2. Inlet Spacing	Such that encroachment at least 3' from edge of pavement (on shoulder side) and water depth is ≤ 0.35 ft.	Such that encroachment at least 3' from edge of pavement (on shoulder side) and water depth is ≤ 0.35 ft.	Such that encroachment at least 3' from edge of pavement.	>3 ft. from pavement edge	>3 ft. from pavement edge	None
3. Inlets	Use Standard Illinois Tollway or IDOT median inlets or catch basins.	Use Standard Illinois Tollway or IDOT median inlets or catch basins.	Use Standard Illinois Tollway median inlets or catch basins.	Use Standard Illinois Tollway median inlets or catch basins.	Use Standard Illinois Tollway median inlets or catch basins.	None
5. Storm Sewers						
a. Design Storm	Based on most restrictive feature drained by storm sewer or 50-Year storm.	Based on most restrictive feature drained by storm sewer or 50-Year storm.	Based on most restrictive feature drained by storm sewer or 50-Year storm.	Based on most restrictive feature drained by storm sewer.	Based on most restrictive feature drained by storm sewer.	Based on most restrictive feature drained by storm sewer.
b. Inlet/Catch Basins	Use Standard Illinois Tollway or IDOT Drainage Structures.	Use Standard Illinois Tollway or IDOT Drainage Structures.	Use Standard Illinois Tollway designs.	Standard Illinois Tollway designs	Standard Illinois Tollway designs	Standard Illinois Tollway designs
c. Manhole Spacing	At all changes in grade and: 350 ft. for d = 12” - 24” 400 ft. for d = 27” - 36” 500 ft. for d = 42” - 54” 1000 ft. for d ≥ 60"	At all changes in grade and: 350 ft. for d = 12” - 24” 400 ft. for d = 27” - 36” 500 ft. for d = 42” - 54” 1000 ft. for d ≥ 60"	At all changes in grade and 350 ft./≤ 24” 400 ft./36" 500 ft./54" 1000 ft./≥60"	350 ft./≤ 24" 400 ft./36" 500 ft./54" 1,000 ft./≥60"	300 ft./< 54" 500 ft./≥54"	300 ft./<54" 500 ft./≥54"
d. Minimum Size	12” (15” under traveled way)	12” (15” under traveled way)	12"	12"	None	None
e. Material	RCP	RCP	RCP	RCP	RCP	RCP

	Current Methods of Analysis	ILLINOIS TOLLWAY-DDC 2008	ILLINOIS TOLLWAY-DDC 2003	NORTH-SOUTH ILLINOIS TOLLWAY	ILLINOIS TOLLWAY-DDC 1983	ILLINOIS TOLLWAY-DDC 1970
f. Velocity Range	3 to 10 fps	3 to 10 fps	3 to 10 fps	3 to 10 fps	3 to 10 fps	None
g. Water Surface at Manholes	2' below rim elevation	2' below rim elevation	2' below rim elevation	2' below rim	None	None
h. Water Surface at Inlets	2’ below rim elevation	2’ below rim elevation	0.3' below sewer crown	0.3' below crown	0.3' below crown	1 ft. above crown
i. Junctions	Laterals shall connect at inlets, manholes, catch basins, or other structures.	Laterals shall connect at inlets, manholes, catch basins, or other structures.	Laterals shall connect at inlets, manholes, catch basins, or other structures.	Laterals shall connect at manholes, catch basins, or other structures.	Laterals shall connect at manholes, catch basins, or other structures.	Laterals shall connect at manholes, catch basins, or other structures.
j. Depth	6” minimum cover from bottom of subgrade aggregate or chemically stabilized subgrade (if applicable) to top of pipe	6” minimum cover between bottom of sub-base and top of pipe	N/A	N/A	N/A	N/A
k. Outlet	Set approximately 6 inches above bottom ditch invert elevation	N/A	N/A	N/A	N/A	N/A
6. Pipe Underdrains						
a. Minimum Diameter	6"	6"	6"	6"	None	None
b. Minimum Slope	0.3% (0.5% desirable)	0.3%	0.2%	0.2%	None	None

	Current Methods of Analysis	ILLINOIS TOLLWAY-DDC 2008	ILLINOIS TOLLWAY-DDC 2003	NORTH-SOUTH ILLINOIS TOLLWAY	ILLINOIS TOLLWAY-DDC 1983	ILLINOIS TOLLWAY-DDC 1970
c. Maximum Length	250’ if PGL ≤ 1% 375’ if 1% < PGL < 2% 500’ if PGL ≥ 2% 500' before increasing diameter (1000’ maximum) or outlets	250’ if PGL ≤ 1% 375’ if 1% < PGL < 2% 500’ if PGL ≥ 2% 500' before increasing diameter (1000’ maximum) or outlets	500' before increasing diameter or outlets	500' before increasing diameter	None	None
d. Outlet	Set approximately 6 inches above bottom ditch invert elevation					
7. Temporary Drainage						
a. Design Flood	2-Year (on grade) (50% chance of exceedance). 5-Year (at sag and underpass) (20% chance of exceedance)					
b. Maximum Pavement Encroachment	4 ft within the traveled way					

	Current Methods of Analysis	ILLINOIS TOLLWAY-DDC 2008	ILLINOIS TOLLWAY-DDC 2003	NORTH-SOUTH ILLINOIS TOLLWAY	ILLINOIS TOLLWAY-DDC 1983	ILLINOIS TOLLWAY-DDC 1970
10.0 STORMWATER DETENTION						
1. Water Quality Volume	USACE-Chicago District suggests 1.0 inch of WQV. DSE shall identify required storage by local and USACE permit requirements.					
2. Maximum Release Rate	0.04 cfs/acre for 2-Year (50% chance of exceedance storm) 0.15 cfs/acre for 100-Year (1% exceedance storm) 0.10 cfs/acre for DuPage and Kane Counties	0.04 cfs/acre for 2-Year (50% chance of exceedance storm) 0.15 cfs/acre for 100-Year (1% exceedance storm) 0.10 cfs/acre for some counties	0.04 cfs/acre for 2-Year (50% chance of exceedance storm) 0.15 cfs/acre for 100-Year (1% chance of exceedance storm)	MWRD Method	MWRD Method	None
3. Computation Method	Hydrograph Method (such as WinTR-20, HEC-HMS, Open Flows Pond-Pack, XP SWMM, etc.), Use critical duration storm for analysis	Hydrograph Method (such as TR-20, HEC-1, Open Flows Pond-Pack, etc.), Use critical duration storm for analysis	NRCS TR-55 or Hydrograph Method such as (TR-20, HEC-1, Open Flows Pond-Pack, etc.)	MWRD Method	MWRD Method	None

	Current Methods of Analysis	ILLINOIS TOLLWAY-DDC 2008	ILLINOIS TOLLWAY-DDC 2003	NORTH-SOUTH ILLINOIS TOLLWAY	ILLINOIS TOLLWAY-DDC 1983	ILLINOIS TOLLWAY-DDC 1970
4. Precipitation	ISWS *Bulletin 75*	Circular 172 Isohyetal values (6 county area), Bulletin 70 Sectional values for other Counties	ISWS Bulletin 70	NWS TP-40	NWS TP-40	None
5. Freeboard To edge of shoulder To top of berm	Minimum 3 feet above 100-year WSEL Minimum 2 foot above 100-year WSEL	Minimum 3 feet above 100-year WSEL Minimum 1 foot above 100-year WSEL				
6. Emergency Spillway (outlet)	Must pass the 100-year flood without overtopping basin or ditch	Must pass the 100-year flood without overtopping basin or ditch				
7. Orifice Size	4” (Minimum)					
8. Top of Weir Elevation	6” (minimum) clearance between top of weir and top slab.					
11.0 TOLL PLAZAS, OASES and MAINTENANCE FACILITIES						
A. Toll Plazas						
1. Design Storm	50-Year (2% chance of exceedance)	50-Year (2% chance of exceedance)	50-Year (2% chance of exceedance)	50-Year (2% chance of exceedance)	50-Year (2% chance of exceedance)	None
2. Maximum encroachment	>3 ft. from traffic lanes. No encroachment on buildings	>3 ft. from traffic lanes. No encroachment on buildings	>3 ft. from traffic lanes. No encroachment on buildings	>3 ft. from traffic lanes	>3 ft. from traffic lanes	None

	Current Methods of Analysis	ILLINOIS TOLLWAY-DDC 2008	ILLINOIS TOLLWAY-DDC 2003	NORTH-SOUTH ILLINOIS TOLLWAY	ILLINOIS TOLLWAY-DDC 1983	ILLINOIS TOLLWAY-DDC 1970
3. Maximum Water Depth	0.35 ft	0.35 ft	N/A	N/A	N/A	N/A
4. ORT Plazas	Per Section 9 as Illinois Tollway mainline pavement	Per Section 9 as Illinois Tollway mainline pavement	N/A	N/A	N/A	N/A
5. Automatic / Manual Lanes	Per Section 9 as Illinois Tollway mainline pavement	Per Section 9 as Illinois Tollway mainline pavement	N/A	N/A	N/A	N/A
B. Oasis and Maintenance Facilities						
1. Design Storm	50-Year (2% chance of exceedance)	50-Year (2% chance of exceedance)	50-Year (2% chance of exceedance)	50-Year (2% chance of exceedance)	50-Year (2% chance of exceedance)	None
2. Parking Lots	1% Minimum Longitudinal Grades. Maximum 4” water depth on pavement	1% Minimum Longitudinal Grades. Maximum 6” water depth on pavement	N/A	N/A	N/A	N/A
13.0 PUMP STATIONS						
1. Design Flood	50-Year (2% chance of exceedance)	50-Year (2% chance of exceedance)	50-Year (2% chance of exceedance)	None	None	None
2. Check Flood	100-year (1% chance of exceedance)	100-year (1% chance of exceedance)	100-Year (1% chance of exceedance)	None	None	None
3. Design Capacity	Most economical system of pump capacity and storage	Most economical system of pump capacity and storage	Most economical system of pump capacity and storage	None	None	None

	Current Methods of Analysis	ILLINOIS TOLLWAY-DDC 2008	ILLINOIS TOLLWAY-DDC 2003	NORTH-SOUTH ILLINOIS TOLLWAY	ILLINOIS TOLLWAY-DDC 1983	ILLINOIS TOLLWAY-DDC 1970
4. Check Storm	2 ft. below edge of pavement	2 ft. below low road elevation	2 ft. below low road elevation	None	None	None

APPENDIX B. HYDROLOGIC/HYDRAULIC COMPUTATION MODELS (B1 AND B2)

APPENDIX B1: HYDROLOGIC COMPUTATION MODELS

Type	Program	Developed By	Available From	Comments*
Event Based	HEC-HMS	U.S. Army Corps of Engineers	U.S. Army Corps of Engineers Hydrologic Engineering Center 609 Second Street Davis, CA 95616-4687 http://www.hec.usace.army.mil/	The Hydrologic Modeling System provides a variety of options for simulating precipitation-runoff processes. It has a capability to use gridded rainfall data to simulate runoff.
	WIN TR-20	U.S. Dep. of Agriculture, Natural Resources Conservation Service	U.S. Natural Resources Conservation Service – Illinois State Office 2118 W Park Court, Champaign, IL 61821-2986 Tech Tools | Natural Resources Conservation Service (usda.gov)	Win TR-20 is a single event, watershed-scale runoff and routing model which applies to both urban and rural areas. Users develop runoff hydrographs for multiple sub-areas at selected points along the stream system. Calibration runs are preferred to determine model parameters.
	SWMM	U.S. Environmental Protection Agency	U.S. Environmental Protection Agency Office of Science Information Management 109 Alexander Drive (Mail Drop: D343-04), Durham, NC 27711 https://www.epa.gov/water-research/storm-water-management-model-swmm	SWMM is used for simulations of water runoff quantity and quality. Calibration or verification to the actual flood events highly recommended.
Continuous Flood Event	HSPF	U.S. Geological Survey	National Technical Information Service 5285 Port Royal Road Springfield, VA 22161 https://water.usgs.gov/software/lists/surface_water/	HSPF uses continuous rainfall and other meteorologic records to compute streamflow hydrographs and pollutographs. Calibration to actual flood events required.

APPENDIX B2: HYDRAULIC COMPUTATION MODELS (I)

Type	Program	Developed By	Available From	Comments*
One-dimensional Steady Flow Models	HEC-RAS	U.S. Army Corps of Engineers	Water Resources Support Center Corps of Engineers Hydrologic Engineering Center (HEC) 609 Second Street Davis, CA 95616-4687 http://www.hec.usace.army.mil/	A HEC-2 file may be imported into HEC-RAS; the user shall change the conveyance computations in HEC-RAS and make the necessary modifications to the bridge modeling before running HEC-RAS to duplicate the results obtained using HEC-2. The use of HEC-RAS for restudying a stream previously studied using HEC-2 is encouraged, as long as one of the following conditions is met: 1) the entire stream is rerun using HEC-RAS; or 2) the stream reach remodeled using HEC-RAS is hydraulically independent from the rest of the stream. The WSPRO bridge analysis is recommended for constricted floodplains under subcritical flow conditions. HEC-RAS warning messages and notes shall be addressed prior to submitting the model.
	WSPRO	US Geological Survey (USGS)	US Geological Survey Water Resources Software web page at: https://water.usgs.gov/software/lists/surface_water/	WSPRO computes water-surface profiles. Floodway option is available in June 1988 version. Use only for the conversion of regulatory models.
	OPEN FLOWS CULVERT MASTER	Bentley	Bentley Systems, Incorporated 685 Stockton Drive Exton, PA 19341 1-800-236-8539 https://www.bentley.com/software/openflows-culvertmaster/	Analysis and design of single or multiple barrel culverts with roadway overtopping.
	HY8	US Department of Transportation, Federal Highway Administration (FHWA)	Federal Highway Administration (FHWA) web page at: https://www.fhwa.dot.gov/engineering/hydraulics/software/hy8/	Analysis and design of single or multiple barrel culverts with roadway overtopping.

HYDRAULIC COMPUTATION MODELS (II)

Type	Program	Developed By	Available From	Comments*
One-dimensional Unsteady Flow Models	FEQ and FEQUTL	Delbert D. Franz, Linsley, Kraeger Associates; and Charles S. Melching, USGS	US Geological Survey 221 North Broadway Avenue Urbana, IL 61801 http://water.usgs.gov/software/feq.html	The FEQ model is a computer program for the solution of full, dynamic equations of motion for one-dimensional unsteady flow in open channels and control structures. The hydraulic characteristics for the floodplain (including the channel, overbanks and all control structures affecting the movement of flow) are computed by its companion program FEQUTL and used by the FEQ program. Calibration or verification to the actual flood events highly recommended. Floodway concept formulation is unavailable.
	HEC-RAS	U.S. Army Corps of Engineers	Water Resources Support Center Corps of Engineers Hydrologic Engineering Center (HEC) 609 Second Street Davis, CA 95616-4687 http://www.hec.usace.army.mil/	Performs unsteady flow analysis.
	XP SWMM	US Environmental Protection Agency and Oregon State University	Innovyze (an Autodesk Company) 221 SE Ankeny Street Portland, OR 97214 1-888-554-5022 XPSWMM - Innovyze	XP-SWMM is a 1D/2D modeling package that allows the integrated analysis of flow and pollutant transport in engineered and natural systems including ponds, rivers, lakes and floodplains. Calibration or verification to the actual flood events highly recommended.
	UNET	US Army Corps of Engineers	Water Resources Support Center Corps of Engineers Hydrologic Engineering Center (HEC) 609 Second Street Davis, CA 95616-4687	UNET is a numerical model that simulates one-dimensional unsteady flow through a full network of open channels. Calibration or verification to the actual flood events highly recommended. Comparison of bridge and culvert modeling to other numerical models reveals significant differences in results.

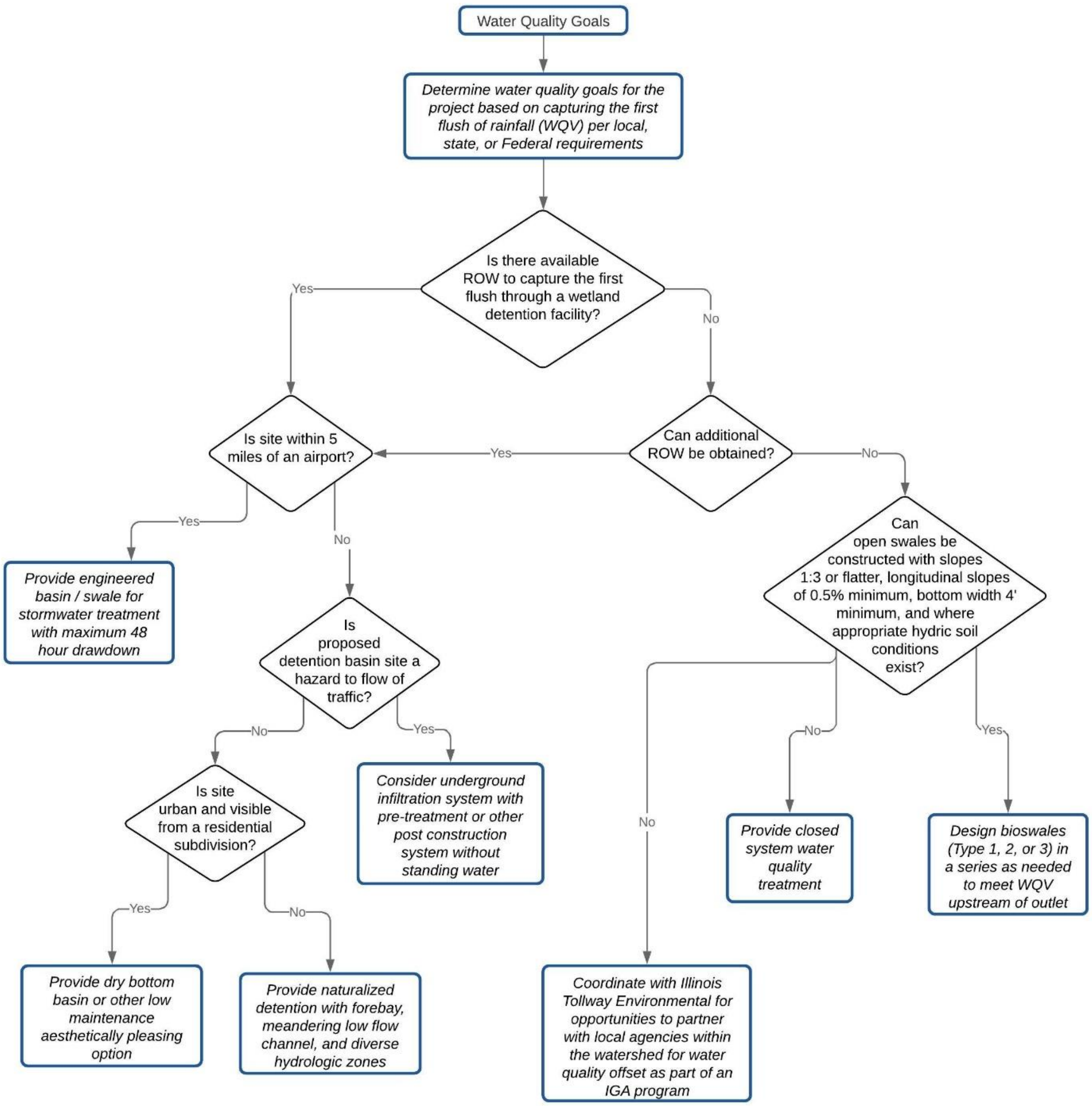
HYDRAULIC COMPUTATION MODELS (III)

Type	Program	Developed By	Available From	Comments*
Two-dimensional Steady/ Unsteady Flow Models	HEC-RAS	U.S. Army Corps of Engineers	Water Resources Support Center Corps of Engineers Hydrologic Engineering Center (HEC) 609 Second Street Davis, CA 95616-4687 http://www.hec.usace.army.mil/	Analysis of waterways that contain bridge crossings that are too complex to be modeled using conventional 1D models. HEC-RAS has 2D flow routing capabilities developed to allow the user to perform 2D or combined 1D/2D modeling. Prior coordination required with permitting agency if used for a permit.
	SMS SRH-2D	Aquaveo	Aquaveo, LLC 3210 N. Canyon Road, Suite 300 Provo, Utah 84604 1-801-691-5528 Downloads | Aquaveo.com	Analysis of waterways that contain bridge crossings that are too complex to be modeled using conventional 1D models. Prior coordination required with permitting agency if used for a permit.
Storm Sewer / Inlet Spacing Analysis	HYDRAULIC TOOLBOX (Current Version)	FHWA	Federal Highway Administration (FHWA) web page at: https://www.fhwa.dot.gov/engineering/hydraulics/software/toolbox404.cfm	Inlet spacing, channel and weir design software.
	OPEN FLOWS FLOW MASTER	Bentley	Bentley Systems, Incorporated 685 Stockton Drive Exton, PA 19341 1-800-236-8539 http://www.bentley.com	Simplified analysis for individual pipe systems.
	OPEN FLOWS CIVILSTORM			Comprehensive stormwater modeling and analysis software to analyze, design and operate stormwater systems.
	OPEN FLOWS STORMCAD			Storm sewer analysis and design software. Unlimited number of drainage structures.
	STORMCAD 100			Part of Open Roads Designer modeling of all underground utilities. Hydraulic analysis and design of storm gravity networks.

* NOTE: Designer shall refer to the software's User Manual for complete modeling capabilities.

APPENDIX C. BMP DECISION FLOW CHART

BMP DECISION FLOW CHART



APPENDIX D. ILLINOIS TOLLWAY STANDARD STRUCTURE APPLICATIONS

APPENDIX D
ILLINOIS TOLLWAY STANDARD STRUCTURE APPLICATIONS

Structure Name	Structure Type	Length	Width	Depth (FT) (B)	Sump Depth (FT) (C)	F&G	Frame Depth (FT) (A)	Distance ** (MIN.) From T/Grate to Invert (FT.)	IDOT / Illinois Tollway Standard	F&G Standard	Application
Manhole	A	4'-0" TO 10'-0" DIA.	4'-0" TO 10'-0" DIA.	(Var.)	0	R-1713	0.75	(Var.)	IDOT Standard 602401-07 602402-03 602406-11 602411-09 602416-09 602421-09 602426-03	Type 1	IDOT Standard Manhole
Inlet	A	2'-0" DIA.	2'-0" DIA.	1.33 (Min.)	0	R-4340-B	0.25	1.58	IDOT Standard 602301-04	Type 8	IDOT Standard Inlet. Used In Illinois Tollway Infield Areas
Inlet	D-1 *		4'-0" DIA.	(Var.)	0	R-2504 E	0.75	4.69	See Note	Type 1	Uses Same Structure As Manhole Type 1 , but with grate not cover
Inlet	D-2 *	23"	23"	(Var.)	0	R-3336	0.25	2.56	See Note	Type 2	For use in ditches, grate set 1" deep from bottom of ditch
Inlet	D-2, Modified *	23"	O.D. of Pipe	(Var.)	0	R-3336	0.25	2.56	See Note	Type 2	Same as D-2 but pipe > 23"
Inlet	D-3 *	22"	14"	1.792 (or var.)	0	R-3337-A	0.875	2.92	See Note	Type 3	Used in curbs
Inlet	D-4 *	23"	23"	(Var.)	0	R-3336	0.25	2.56	See Note	Type 2	For use in ditches, grate set 8" deep from bottom of one side of ditch
Inlet	D-4, Modified *	23"	O.D. of Pipe	(Var.)	0	R-3336	0.25	2.56	See Note	Type 2	Same as D-4 but pipe > 23"

ILLINOIS TOLLWAY STANDARD STRUCTURE APPLICATIONS

Structure Name	Structure Type	Length	Width	Depth (FT) (B)	Sump Depth (FT) (C)	F&G	Frame Depth (FT) (A)	Distance ** (MIN.) From T/Grate to Invert (FT.)	IDOT / Illinois Tollway Standard	F&G Standard	Application
Inlet	D-5 *	30"	22"	(Var.)	0	R-3227	0.5	2.94	See Note	Type 5	
Inlet	D-6 *	36"	36"	(Var.)	0	Class "P" Conc. Cover	0.33	2.77	See Note		Covered inlet
Inlet	M *	3'-4"	1'-8"	(Var.)	0	R-3346 C	0.625	3.71	See Note	NEENAH	1 F&G ON 1 Structure
Catch Basin	M-2 *	4'-10"	3'-4"	9 (Max.)	2 (MIN.)	R-3346 C	0.625	3.71	See Note	NEENAH	2 F&G ON 1 structure with Type I barrier in middle
Catch Basin	M-3 *	4'-10"	3'-4"	(Var.)	2 (MIN.)	R-3346 C	0.625	3.71	See Note	NEENAH	1 F&G on 1 structure
Inlet	M-2 *	4'-10"	3'-4"	7 (Max.)	0	R-3346 C	0.625	3.71	See Note	NEENAH	2 F&G on 1 structure with Type I barrier in middle
Inlet	M-3 *	4'-10"	3'-4"	5 (Max.)	0	R-3346 C	0.625	3.71	See Note	NEENAH	2 F&G on 1 structure W/ Type I barrier in middle placed on top of existing inlet
Inlet	Flush Inlet Box for Median	3'-0"	3'-0"	(Var.)	0	R-3807D	0.29	2.06	IDOT Standard 542546-01	Steel F&G	IDOT standard inlet. Used in Illinois Tollway grassed median
Catch Basin	A	. 4'-0" TO 5'-0" DIA	4'-0" TO 5'-0" DIA	4 (Min.)	2 (MIN.)	(Var.)	0.25 / 0.83	(Var.)	IDOT Standard 602001-02	TYPE 8 / TYPE 20A	IDOT standard inlet. Used in Illinois Tollway infield areas or along barrier wall

ILLINOIS TOLLWAY STANDARD STRUCTURE APPLICATIONS

Structure Name	Structure Type	Length	Width	Depth (FT) (B)	Sump Depth (FT) (C)	F&G	Frame Depth (FT) (A)	Distance ** (MIN.) From T/Grate to Invert (FT.)	IDOT / Illinois Tollway Standard	F&G Standard	Application
Catch Basin	C	2'-0" DIA.	2'-0" DIA.	3.83 (Min.) 10 (Max.)	1.25 (MIN.)	(Var.)	0.25 / 0.83	2.85 / 3.35	IDOT Standard 602011-02	TYPE 8 / TYPE 20A	IDOT standard inlet. Used in Illinois Tollway infield areas or along barrier wall
Catch Basin	B	3'-0"	2'-0"	4.5 (Min.)	2 (MIN.)	R-3455 C	0.75	3.27	B7-05	NEENAH	Structure is used in gore area and for heavy duty drain cleanout
Inlet	M, Modified *	2'-2"	1'-10 ½"	(Var.)	0	R-3527 V	0.75	2.44	See Note	NEENAH	1 F&G W/ curb box on 1 structure on one side of Type II barrier at sag locations
Inlet	M, Modified *	2'-2"	1'-10 ½"	(Var.)	0	R-3528 V	0.75	2.44	See Note	NEENAH	1 F&G W/O curb box on 1 structure on one side of Type II barrier
Catch Basin	M, Modified *	2'-2"	1'-10 ½"	(Var.)	2 (MIN.)	R-3527 V	0.75	2.44	See Note	NEENAH	1 F&G W/ curb box on 1 structure on one side of type II barrier. Used at SAG locations
Catch Basin	M, Modified *	2'-2"	1'-10 ½"	(Var.)	2 (MIN.)	R-3528 V	0.75	2.44	See Note	NEENAH	1 F&G W/O curb box on 1 structure on one side of type II barrier
Inlet	M-2, Modified *	6'-9 ¼"	1'-10 ½"	7 (Max.)	0	R-3527 V	0.75	4.19	See Note	NEENAH	2 F&G W/ curb box on 1 structure with Type II barrier in the middle. Used at SAG locations
Inlet	M-2, Modified *	6'-9 ¼"	1'-10 ½"	7 (Max.)	0	R-3528 V	0.75	4.19	See Note	NEENAH	2 F&G W/O curb box on 1 structure with Type II barrier in the middle
Catch Basin	M-2, Modified *	6'-9 ¼"	1'-10 ½"	9 (Max.)	2 (MIN.)	R-3527 V	0.75	4.19	See Note	NEENAH	2 F&G W/ curb box on 1 structure with TYPE II barrier in the middle. Also used at SAG locations

ILLINOIS TOLLWAY STANDARD STRUCTURE APPLICATIONS

Structure Name	Structure Type	Length	Width	Depth (FT) (B)	Sump Depth (FT) (C)	F&G	Frame Depth (FT) (A)	Distance ** (MIN.) From T/Grate to Invert (FT.)	IDOT / Illinois Tollway Standard	F&G Standard	Application
Catch Basin	M-2, Modified *	6'-9 ¼"	1'-10 ½"	9 (Max.)	2 (MIN.)	R-3528 V	0.75	4.19	See Note	NEENAH	2 F&G W/O curb box on 1 structure with Type II barrier in the middle
Catch Basin	G-1 *	2'-1"	1'-2"	(Var.)	2 (MIN.)			1.94	B8-09	NEENAH	In the swale on the high side of two-lane superelevated pavement
Catch Basin	G-2	1'-11"	1'-11"	9 (Max.)	2 (MIN.)	R-3508-A2	0.83	3.35	B8-09	NEENAH	along ramps where G-2 gutter is provided
Catch Basin	G-3	3'-0"	2'-0"	9 (Max.)	2 (MIN.)	R-3501-U	0.50	3.02	B8-09	NEENAH	Along mainline where G-3 gutter is provided
Catch Basin	G-3, Modified	6'-5"	2'-5"	9 (Max.)	2 (MIN.)	(Var.)	(Var.)	(Var.)	B8-09	NEENAH	Along mainline where G-3 or G-3 (Modified) gutter is provided. Used for larger pipe connections
Catch Basin	G-4	6'-5"	5'-0"	9 (Max.)	2 (MIN.)	(Var.)	(Var.)	(Var.)	B8-09	NEENAH	Along mainline where a G-type gutter is provided
Catch Basin	G-5	6'-5"	7'-0"	9 (Max.)	2 (MIN.)	(Var.)	(Var.)	(Var.)	B8-09	NEENAH	Along mainline where a G-type gutter is provided
Catch Basin (IDOT)	Drainage Structures Types 4, 5	7'-2"	3'-0"	4 (Min.) 10 (Max.)	2 (MIN.)	Type 20A Type 22A	0.83	3.56	IDOT Standard 602106-03	B25-01 B27-01	2 F&G W/ curb box on 1 structure with any double face concrete barrier

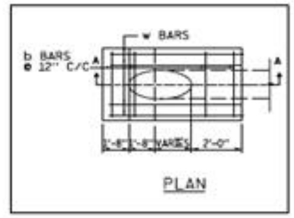
* NOTE: These structures are no longer included in Section B of the Illinois Tollway Drainage Standards. Alternative structures shall be used instead, otherwise, a special detail shall be provided.

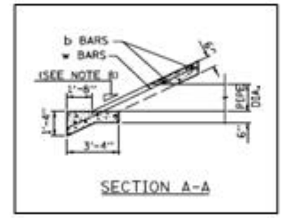
** Based on a 15" minimum pipe diameter. Larger sized pipes would require additional depth. Also, the minimum depth requirement is usually dictated by the 6" clearance between the bottom of sub-base and top of pipe.

APPENDIX E. ILLINOIS TOLLWAY STANDARD HEADWALLS AND SLOPED HEADWALLS

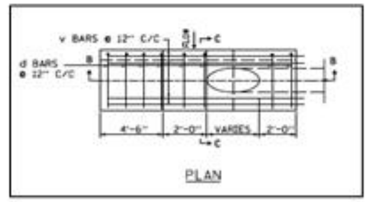
Headwalls and Sloped Headwalls
Features and Details

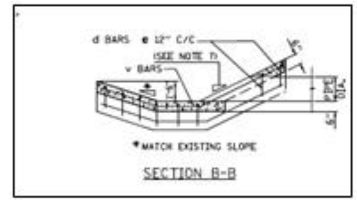
Sloped Headwall Type I
Standard B9
Pipe Diameter 6" to 18"
Pipe end is cut flush with slope
Slopes steeper than 1:3
Velocity < 5 ft/s



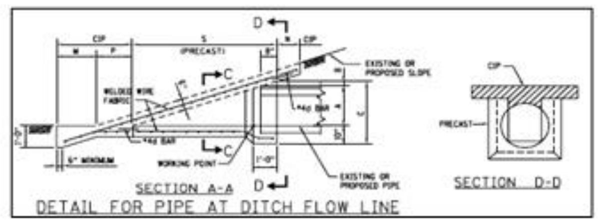


Sloped Headwall Type II
Standard B9
Pipe Diameter 12" to 18"
Pipe end is cut flush with slope
Slope Steeper than 1:3
Concrete Paved Ditch Lining
Velocity ≥ 5 ft/s



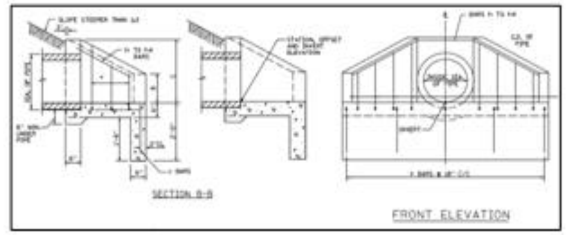


Slope Headwall Type III
Standard B10
Pipe Diameter 6" to 30"
Pipe end is vertical to slope
Slope 1:3, 1:4, 1:6
Wingwalls (Straight)
Velocity < 5 ft/s for 6" to 18"

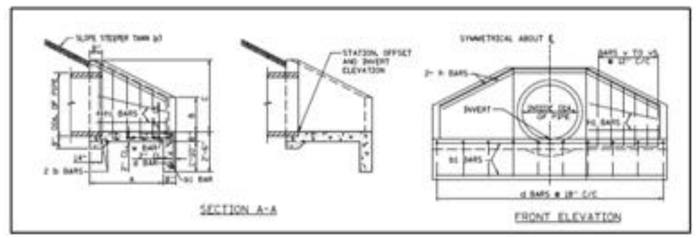


Headwalls and Sloped Headwalls
Features and Details

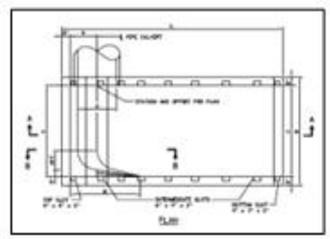
Headwall Type I
Standard B30
Pipe Diameter 21" to 36"
Slope Steeper than 1:3
Wingwalls (Flared)
Paved Apron

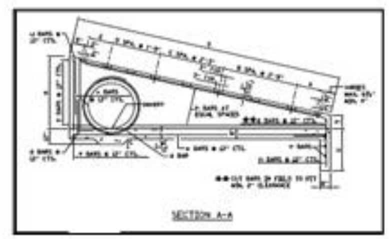


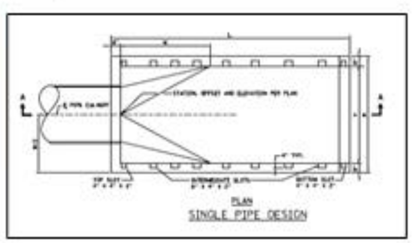
Headwall Type II
Standard B30
Pipe Diameter 42" - 84"
Slope Steeper than 1:3
Wingwalls (Flared)
Concrete Paved Apron

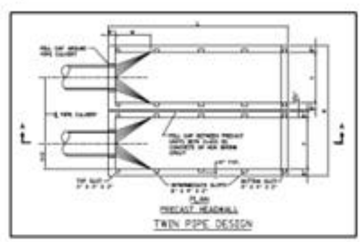


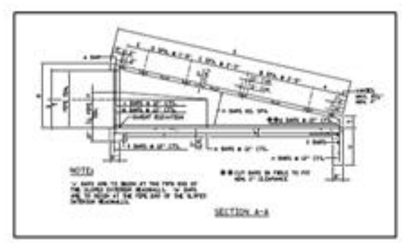
Headwall Type III
Standard B6
Pipe Diameter 18" to 60"
Slopes 1:3, 1:4, 1:6, 1:10
Front Design; Single or Twin Pipe
Side Design; Single Pipe
Concrete Paved Apron
Wingwalls (Straight)
Safety Grate





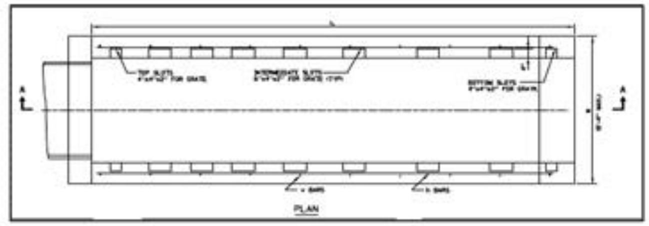


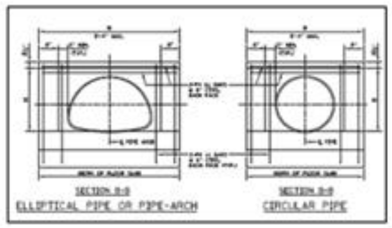


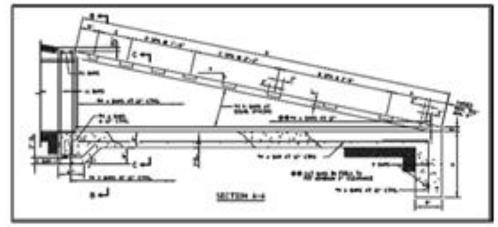


Headwalls and Sloped Headwalls
Features and Details

Headwall Type IV
Standard B22
Pipe Diameter 30"-66"
Slope 1:4
Circular or Elliptical Pipe
Concrete Paved Apron
Wingwalls (Straight)
Safety Grate

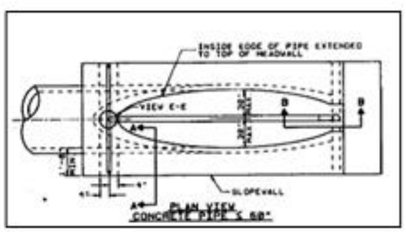


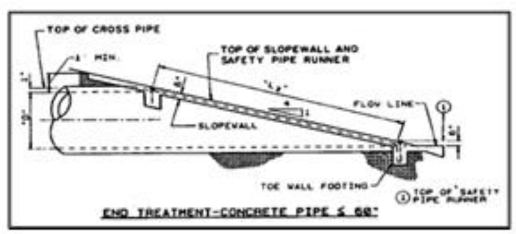




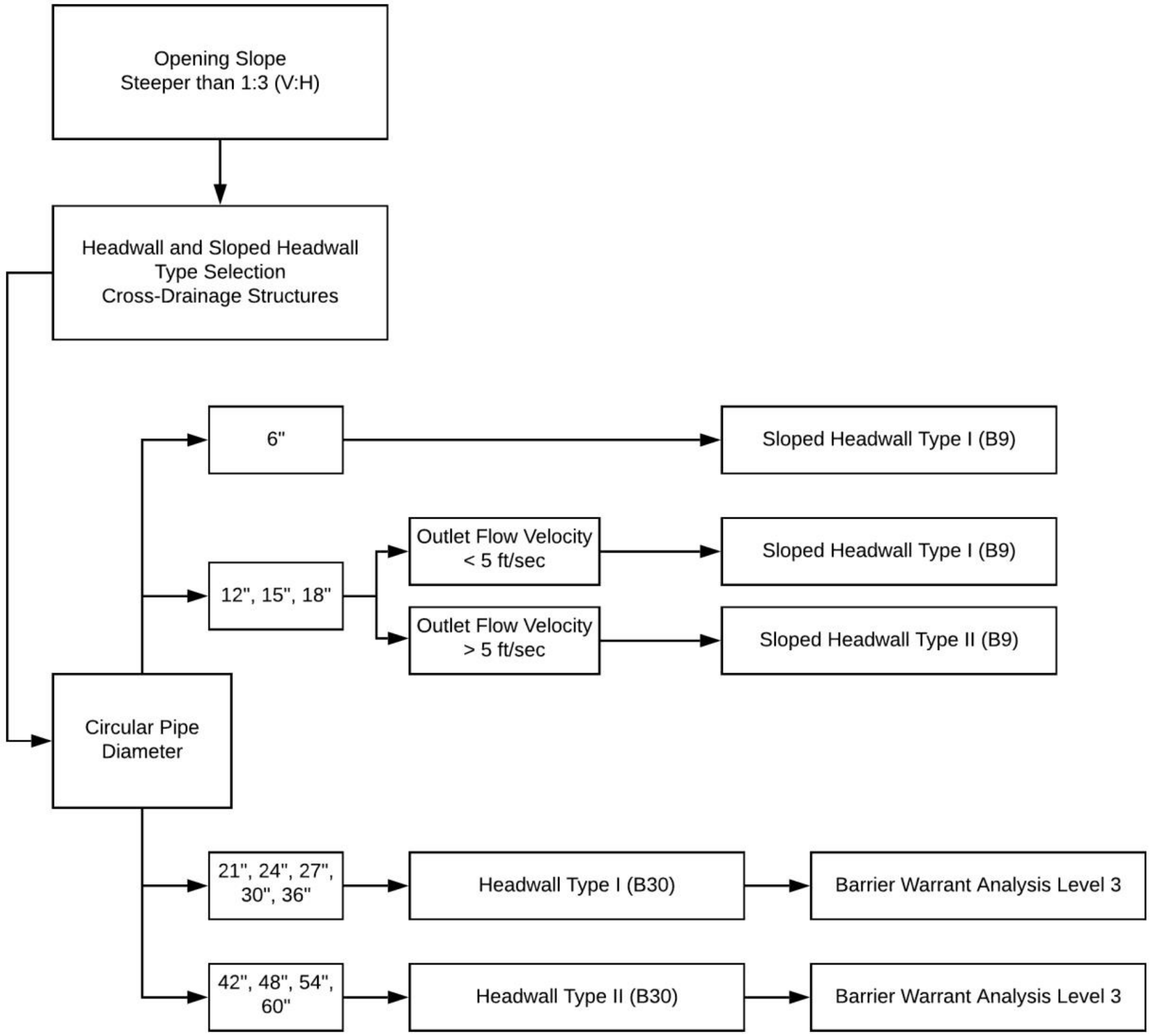
RETIRED DETAILS

Sloped Headwall Type V
Standard SD90-35D
Pipe Diameter 36"-60"
Slope 1:4
Wingwalls (Straight)
Safety Pipe Runner





APPENDIX E



Opening Slope
Steeper than 1:3 (V:H)
Headwall and Sloped Headwall
Type Selection
Cross-Drainage Structures
Circular Pipe
Diameter
6"
Sloped Headwall Type I (B9)
12", 15", 18"
Outlet Flow Velocity
< 5 ft/sec
Sloped Headwall Type I (B9)
Outlet Flow Velocity
> 5 ft/sec
Sloped Headwall Type II (B9)
21", 24", 27",
30", 36"
Headwall Type I (B30)
Barrier Warrant Analysis Level 3
42", 48", 54",
60"
Headwall Type II (B30)
Barrier Warrant Analysis Level 3

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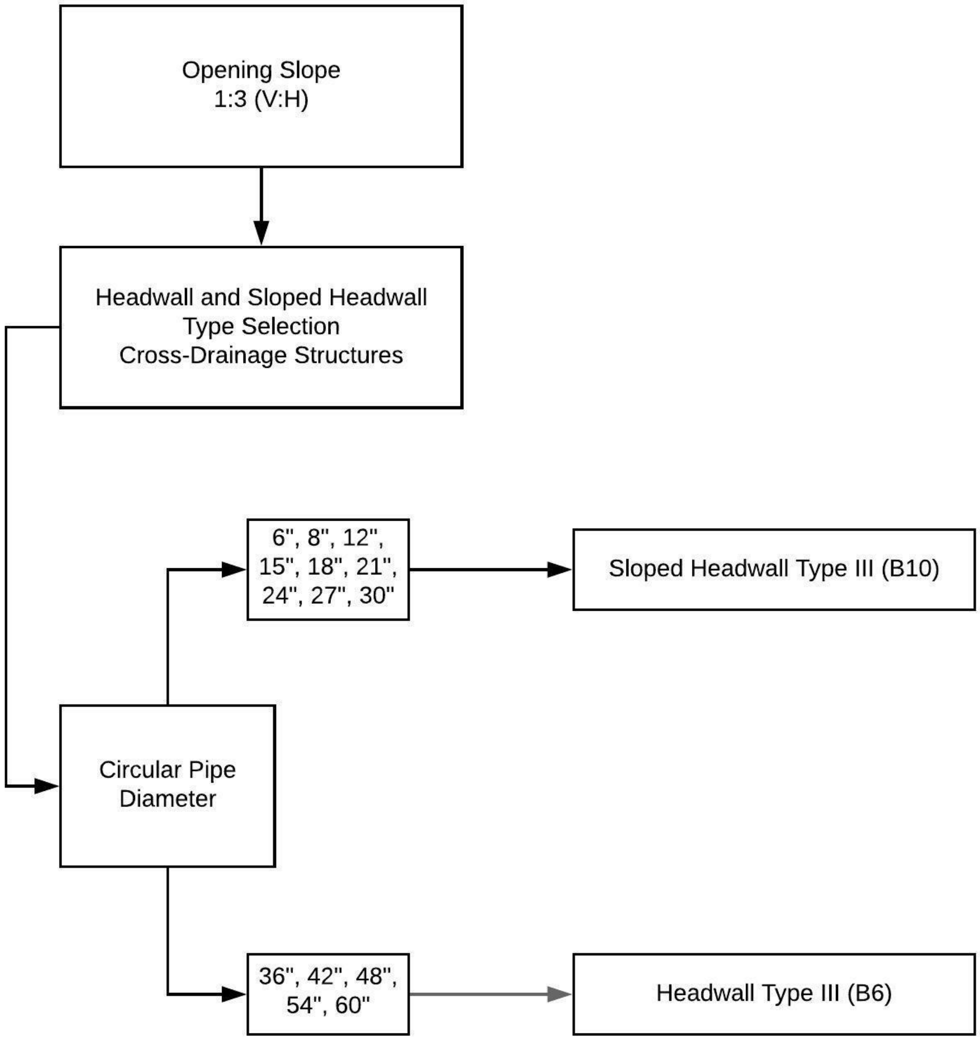
Opening Slope
1:3 (V:H)
Headwall and Sloped Headwall
Type Selection
Cross-Drainage Structures
6", 8", 12",
15", 18", 21",
24", 27", 30"
Sloped Headwall Type III (B10)
Circular Pipe
Diameter
36", 42", 48",
54", 60"
Headwall Type III (B6)

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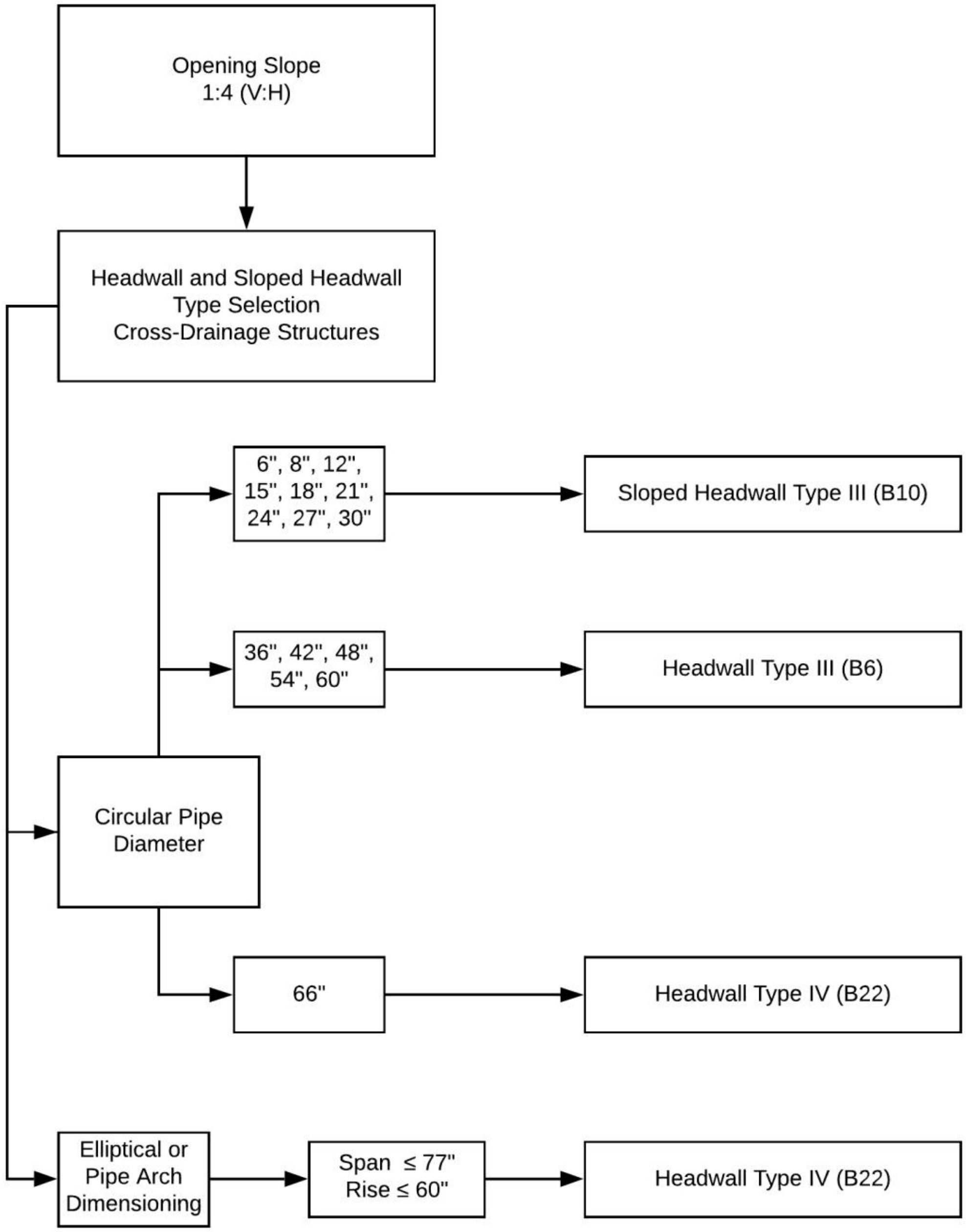
Opening Slope
1:4 (V:H)
Headwall and Sloped Headwall
Type Selection
Cross-Drainage Structures
6", 8", 12",
15", 18", 21",
24", 27", 30"
Sloped Headwall Type III (B10)
36", 42", 48",
54", 60"
Headwall Type III (B6)
Circular Pipe
Diameter
66"
Headwall Type IV (B22)
Elliptical or
Pipe Arch
Dimensioning
Span ≤ 77"
Rise ≤ 60"
Headwall Type IV (B22)

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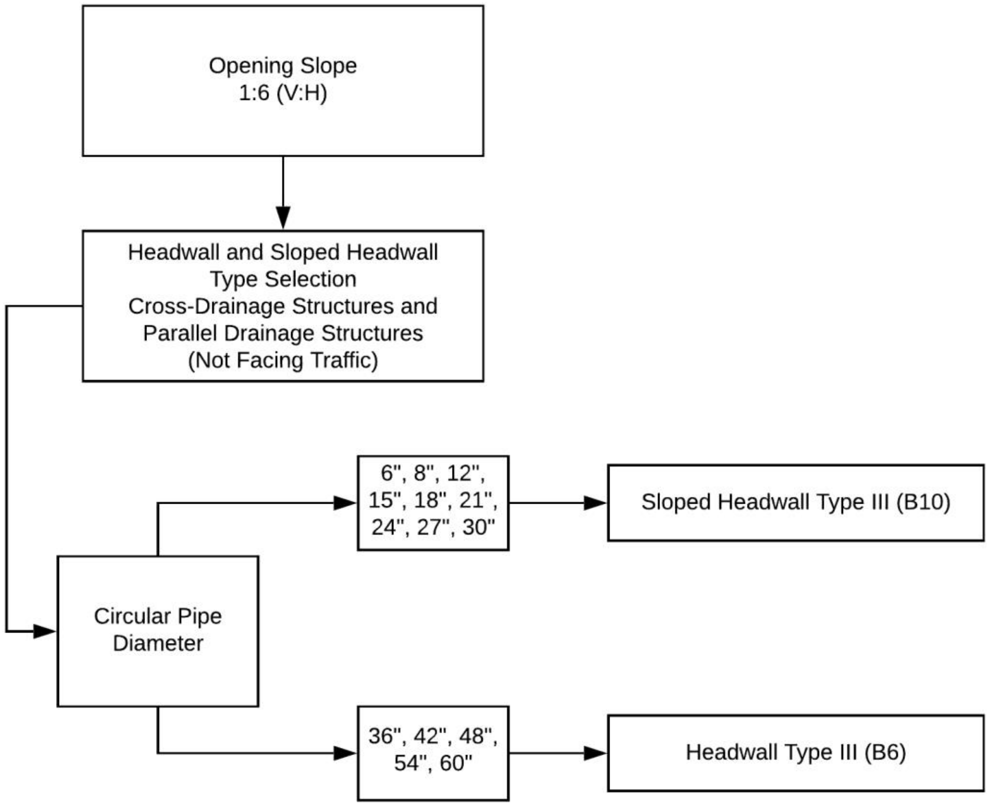
Opening Slope
1:6 (V:H)
Headwall and Sloped Headwall
Type Selection
Cross-Drainage Structures and
Parallel Drainage Structures
(Not Facing Traffic)
Circular Pipe
Diameter
6", 8", 12",
15", 18", 21",
24", 27", 30"
Sloped Headwall Type III (B10)
36", 42", 48",
54", 60"
Headwall Type III (B6)

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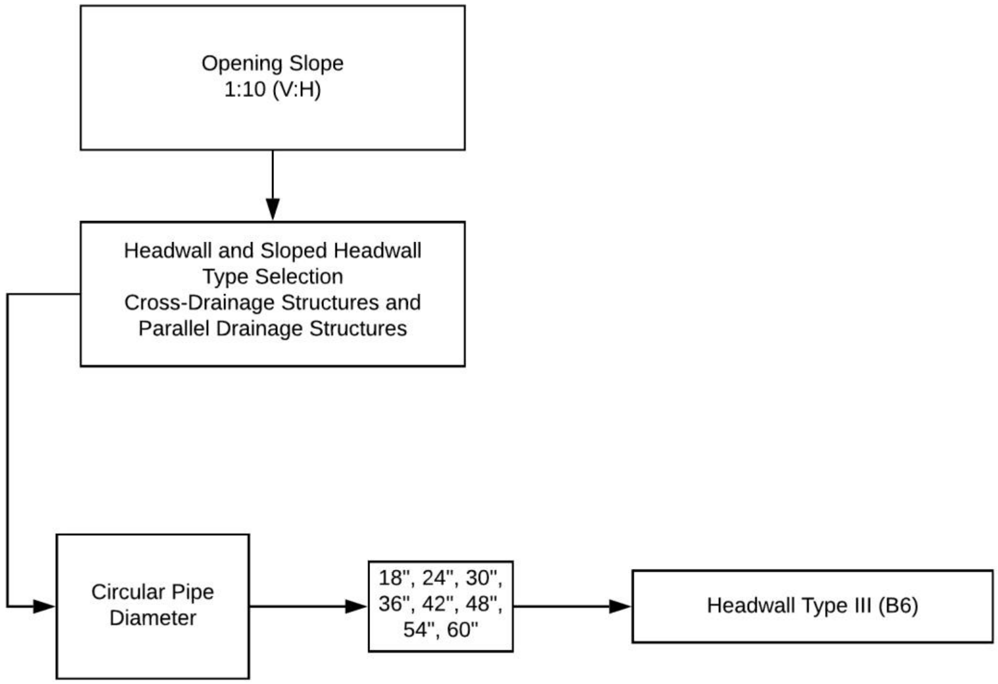
Opening Slope
1:10 (V:H)
Headwall and Sloped Headwall
Type Selection
Cross-Drainage Structures and
Parallel Drainage Structures
Circular Pipe
Diameter
18", 24", 30",
36", 42", 48",
54", 60"
Headwall Type III (B6)

APPENDIX F. SCOPE OF CONCEPT DRAINAGE REPORT

APPENDIX F
SCOPE OF CONCEPT DRAINAGE REPORT

This APPENDIX provides a detailed description of the scope of the DSEs services required for the preparation of a Concept Drainage Report. The individual tasks and deliverables for this report are described below:

Task 1: General Location Drainage Map

Description: This task involves the preparation of the General Location Drainage Map to show the overall drainage features of the project. The base map used for the General Location Drainage Map is a color copy of the USGS Hydrologic Atlas (HA), or a color copy of the USGS Quadrangle map[17] if the HA is not available. The scale of the base map (1 inch = 2000 feet) shall be maintained, unless the map needs to be enlarged to a convenient scale to adequately present the overall drainage features as described below.

Specific Tasks:

A. Show project limits and label the project route and crossroads. The major drainage divides shown on the HA map and all contours shall be legible. Additional sub-drainage divides shall be shown on the Existing Drainage Plan. Delineate drainage areas at each bridge or culvert crossing.
B. Show location of identified drainage concerns and number them sequentially. Label the receiving streams, bridges and culverts (include sizes) on the General Location Drainage Map. A legend shall be provided to indicate locations of identified drainage concerns.
C. Add north arrow, title, scale and flow direction.

Deliverable:
Exhibit 1-00: General Location Drainage Map to be included in the Concept Drainage Report.

Task 2: Existing Drainage Plan

Description: This task describes the requirements for developing an Existing Drainage Plan (EDP). The EDP sheets shall be prepared in digital format with 1 foot contour intervals and at a scale of 1”=50’. The purpose of the EDP is to illustrate the current drainage features and define the following:

- External areas tributary to Illinois Tollway right-of-way
- Sheet and concentrated flow entering and exiting Illinois Tollway right-of-way;
- Drainage summits along and adjacent to the Illinois Tollway right-of-way, including roadway crown. Drainage divides as indicated by Hydrologic Atlases (HA's) shall be shown; interpreted sub divides (summits) as determined by the DSE shall also be shown (including subdivides to each sewer or ditch);
- Existing closed drainage systems with pipe sizes and invert elevations (for the mainline/trunk sewers), which include local drainage facilities located within Illinois Tollway right-of-way. Local facilities are to be appropriately noted and labeled;
- Low flow and flood flow (overflow) directions;

[17] http://store.usgs.gov/

- All drainage outlets with interpreted tributary areas. These outlets shall also be numbered for reference in the report.
- Regulatory floodplain and floodway boundaries.
- The base map shall be comprised of digital contour mapping to be provided by the Illinois Tollway. The EDP shall be prepared in digital format.
- Delineate wetland locations and provide corresponding ID numbers where applicable.

Specific Tasks:

- Show project limits, project route, crossroads, existing roadway and ramp alignments and stream crossing names. The existing right-of-way, easements and roadway centerline shall also be shown on the base map. Coordinate any missing geometric information or mapping deficiencies with the Illinois Tollway Project Manager before the EDP is fully prepared.
- Obtain and review available contour mapping, record as-built plans, sewer atlases, drainage plans and existing and future drainage studies from local agencies and IDOT.
- Perform a field visit to verify all existing drainage features vs. as-built drawings, survey and previous studies. Conduct "plan in hand" field review to verify interpreted drainage divides per outlet and resolve identified inconsistencies per review of EDP's developed by other agencies. The Designer is responsible for checking the condition of the existing drainage infrastructure to be maintained under proposed conditions. This includes the identification of existing CMP pipes; any pipe lining that has been performed, failing drainage structures, frames and lids and/or culvert headwalls and significant ditch ponding or blockage. This information shall be presented to the Illinois Tollway PM to define the project improvement scope for the specific construction contract.
- Use the attached drainage legend when preparing the EDP's.
- Use the HA mapping as a guide to interpret the location of all drainage divides on the EDP sheets. Review all available information (contour mapping, record plans, cross sections, HA maps, drainage plans from local agencies and field notes) to interpret sub-divides and delineate the tributary drainage area to each outlet. Number all outlets (low flow outlets may not be at the same location as the flood flow outlets) for reference in the Concept Drainage Report. In cases where the HA or USGS Quadrangle maps shall be used to determine the tributary drainage area, a separate exhibit showing these tributary areas shall be included with the calculations.
- Transfer the floodplain and floodway boundaries to the EDP from FEMA maps. The floodplain boundaries shall be based on the profile elevations included in the FEMA hydraulic models. Transfer of the floodway boundaries may be accomplished by scaling directly off the FEMA maps. If an existing FEMA data is not available for a potential floodplain crossing, the floodplain boundaries shall be based on the hydraulic model prepared by the Designer per approval from IDNR. The limits of the floodplain and floodway boundaries shall be shown within the Illinois Tollway right-of-way. Hatching or shading shall be used to distinguish between floodway and flood fringe areas.
- Identify all sewers (types), label sizes and show flow direction. Identify all culverts/bridges and label types and sizes. Inverts for crossroad culverts and sewer outfalls shall be shown. Number all bridges over waterways and culvert crossings as a reference to the Concept Drainage Report.
- Identify and label any existing stormwater detention ponds, reservoirs, or pump stations. Call out limits, design WSELs, control structures and storage volumes.
- Identify and label any concrete channels or ditches.

- Add north arrow, title, scale and flow direction to all plan sheets. The drainage legend should appear on the first plan sheet at minimum.
- Show locations of all field tiles within existing and proposed right-of-way and within adjacent properties as indicated in record plans.
- Conduct "in situ" field review to verify interpreted drainage divides at each outlet and to resolve any other inconsistencies.
- Review survey data and identify the need for supplemental survey (i.e., pipe inverts, culvert sizes, etc.). Coordinate need for supplemental survey data with the Illinois Tollway Project Manager and perform the supplemental survey. If a drainage structure cannot be field verified or is full of silt or water, it shall be noted on the EDP sheets.
- Request a list of permits from the Illinois Tollway for area within the project limits. Label Illinois Tollway permit numbers at their respective locations on the EDP's.

<u>Deliverables</u>:

- Exhibit 1-01, Existing Drainage Plan to be bound separately in 11"x17" format. If larger drawings are necessary, they shall be folded and included within pockets as an appendix to the Concept Drainage Report.
- Supplemental survey as required. Survey data is to be included as an appendix to the Concept Drainage Report.
- Concept Drainage Report text and corresponding drawing(s) describing existing drainage patterns and features. Tables shall be used to note limits of ditches and sewers, outlet descriptions and locations and other existing drainage features.

Task 3: Identified Drainage Concerns

<u>Description</u>: This task involves the documentation of identified drainage concerns throughout the project limits. Identified drainage concerns may occur within or adjacent to the Illinois Tollway right-of-way. The DSE shall determine who is responsible for corrective measures.

<u>Specific Tasks</u>:

- Review Illinois Tollway permit data relative to any identified drainage concerns.
- Meet with Illinois Tollway Maintenance for review of identified drainage concerns within the project limits and prepare a meeting summary.
- The DSE shall be responsible for documenting those drainage concerns not identified by the Illinois Tollway personnel, but discovered via site investigations, local coordination and/or local testimony.
- Screen out all identified drainage problems that are due to maintenance issues and provide written notification to the Illinois Tollway Project Manager. These items shall be forwarded to the Illinois Tollway's Maintenance Section.
- Review documentation for the identified drainage concerns not related to maintenance issues. Request additional information (if available) to define the problem, the cause and develop a recommended solution. This information may include additional Illinois Tollway records, topographic mapping, survey data, local testimony and/or records.
- Define the factors leading to the drainage concern and determine the party responsible for corrective measures.
- Depending on the complexity of the identified drainage concern, it may be necessary to evaluate alternatives and determine the most cost-effective solution. This evaluation shall be completed as part of the Drainage Alternatives task.

- Identify existing sewers to be televised and/or cleaned if maintained under proposed conditions.

Deliverables:

- Concept Drainage Report text and corresponding drawing(s) that document the location, cause and recommendation/solution for each identified drainage concern.
- All correspondence and collected data shall be included as an appendix to the Concept Drainage Report.

Task 4: Identified Base Floodplains

Description: This task involves the identification and documentation, as well as providing an exhibit of base floodplains and regulatory floodways within the project limits. The base map for the exhibit shall be created using copies of the most recent FEMA maps or IDNR-OWR regulatory floodway maps, as applicable.

Specific Tasks:

- Consult the FEMA FBFM and the FIRM for each county and community that intersects the project limits.
- Develop a separate exhibit for each community and county that intersects the project limits. The base map for each exhibit shall be the FBFM, if available. The FIRM may be used as a base map if the FBFM is not available. The exhibits should show the project limits, with the project route, roadway alignment and crossroads clearly labeled. The north arrow, scale, flow directions, map key and map cover page should all be included on the exhibit. The map cover page shall include the community and panel numbers, as well as the effective date.

Deliverables:

- Exhibit 1-02 FBFM, FIS Map or IDNR-OWR Regulatory Floodway Map.
- Describe each base floodplain and regulatory floodway in the Concept Drainage Report.

Task 5: Bridges and Culverts

Description: This task involves surveying the project site and compiling data to describe the hydrologic and hydraulic features of existing, natural and proposed conditions for bridges and/or culvert crossings.

This task applies to all bridges over waterways, any single barrel crossroad culvert with a cross-sectional opening area greater than 7.5 square feet, any multi-barrel crossroad culvert, any crossroad culvert located within an identified floodplain or within an area of identified drainage concern and any crossings draining 20 or more acres in urban area.

The results of the hydrologic and hydraulic analysis for existing and proposed conditions shall be performed in accordance with Sections 8 and 9 of the Illinois Tollway Drainage Design Manual and included in the Concept Drainage Report.

Specific Tasks:

- Perform field survey to supplement the hydrologic and hydraulic analysis.
- Identify the design criteria for each bridge/culvert location (flood frequency, allowable freeboard, clearance, HW/D ratio, etc.)
- Prepare text to describe clearance, freeboard, roadway and bridge deck profile requirements, overtopping (if any), high water elevations and flooding under existing and proposed conditions.
- Prepare a plan and profile exhibit showing existing and proposed conditions for the bridge and/or culvert crossing in the Concept Drainage Report.
- Prepare a WIT for each bridge and/or culvert.
- Coordinate the hydraulic requirements with the geometric design for the project.
- Define constraints to substantiate any design deviations.

Deliverables:

- The Concept Drainage Report text shall include a narrative summary of the hydraulic performance (limited to one or two paragraphs) for existing and proposed conditions. Discuss design procedure and assumptions, waterway opening, overtopping, the 50-year flood event clearance and freeboard, flooding concerns, design deviations and low pavement elevations.
- Exhibit 1-03 WIT.
- Provide all calculations and exhibits, including the hydraulic and hydrologic analysis, the plan and profile exhibit showing existing and proposed conditions and survey as an appendix to the Concept Drainage Report. All data shall be organized per bridge or culvert. Copies of all computer software input and output files shall be provided on a CD.
- Benchmark correlation shall be provided by the DSE.

Task 6: Design Criteria

Description: This task involves documentation of the Illinois Tollway Drainage Design Manual, identification and review of all applicable local and other regulatory agency drainage design criteria, comparison to the Illinois Tollway design criteria, summary of recommended project drainage design criteria and justification for those cases requiring design deviations. The summary of drainage criteria is critical since the project's drainage design criteria may be a combination of the Illinois Tollway and local criteria.

Specific Tasks:

- Identify and review all drainage design criteria and summarize in tabular form by proposed drainage feature in the Concept Drainage Report.
- Identify cases where the design criteria cannot be met and coordinate with the Illinois Tollway Project Manager. The Illinois Tollway Project Manager shall process written documentation for non-compliance of design criteria.

Deliverables:

- Provide tabular summary of the Illinois Tollway, local and other regulatory agency drainage design criteria and the recommended project drainage design criteria with limits of application.

- Include justification for non-compliance of design criteria in the Concept Drainage Report, if applicable.

Task 7: Outlet Evaluation

Description: This task involves the evaluation of existing outlets. The outlets to be evaluated are identified on the EDP's and referenced in the Concept Drainage Report under Existing Drainage System. Outlets are defined as locations where runoff exits the Illinois Tollway right of way as concentrated flow (i.e., sewers, ditches, streams, etc.) or offsite runoff crossing the Illinois Tollway right-of-way.

Specific Tasks:

- Use data obtained during the development and coordination of the existing drainage plans and identified drainage concerns to evaluate whether or not each outlet is suitable for continued use. This data may include written or verbal input on the design capacity of the outlet, type of outlet, downstream sensitivity, drainage or flooding problems, field observations and the location of wetlands or other environmentally sensitive areas. Other data to be reviewed includes local ordinance, survey data, record plans, or sewer atlases.
- The outlet evaluation may include but is not limited to:
  - Analysis of the existing outlet with proposed flow rates to determine potential impacts.
  - Determination of the hydraulic capacity of the existing drainage system.
  - Development of feasible, cost effective recommendations based on results of the evaluation. The recommendations shall consider construction cost, cost participation (if any), right-of-way requirements and consistency with scope of improvements.
  - Coordinate with local village or community to determine if existing outlet is considered sensitive.
- The recommendations may include but are not limited to:
  - Maintaining and utilizing existing outlet structures.
  - Developing concept plans for an outlet improvement or utilization of an alternate outlet, which may entail redirection of runoff.
  - Document the evaluation and preferred recommendation for utilization of each outlet in the Concept Drainage Report.
  - Ensure that the existing 100-year release rate is maintained at all sensitive outlets even if regional stormwater detention storage is being provided elsewhere for the entire watershed per Illinois Tollway allowable release rate criteria.

Deliverables:

- Concept Drainage Report text and corresponding drawings(s) to describe conditions and recommendations for each outlet.
- Supporting calculations for the evaluation of outlet capacities and improvements (if necessary). These calculations shall be included as an appendix to the Concept Drainage Report.

Task 8: Stormwater Detention Analysis

Description: This task involves the evaluation of detention requirements in accordance with the project drainage design criteria.

Specific Tasks:

- Determine storage volume required based on project drainage design criteria.
- Develop a concept plan for providing the required storage volumes per each reach draining to each outlet. Determine if a "closed" or "open" storage facility is required. If stormwater detention cannot be provided cost effectively within the Illinois Tollway right-of-way, then off-site detention shall be considered.
- Refine concept plan and develop conceptual size and location drawings for detention storage facilities. Storage pipes and oversized sewers shall be shown on both plan and profile views of the Proposed Drainage Plan (PDP). Plot the HGL for the design storm frequency (50-year event) and check storm (100-year event).
- Where open detention is proposed, template cross sections shall be revised to show locations of oversized ditches or stormwater detention basins. These cross sections shall be included as an appendix to the Concept Drainage Report. Oversized ditches for detention purposes shall be shown on the PDP sheets with the size, limits, design high water elevations and design release rates noted.
- Develop control structure schematics and include the design data as an appendix to the Concept Drainage Report. The control structure schematics shall be shown on the PDP or on a separate exhibit if necessary. Low road and overflow elevations, as well as available freeboard shall be noted as well.

Deliverables:

- Concept Drainage Report text and corresponding drawing(s) that describe detention requirements and recommendations per each reach draining to each detention outlet.
- Detailed calculations for the required and provided detention storage shall be included as an appendix to the Concept Drainage Report. Copies of all computer software input and output files shall be provided on a CD.
- Site concept plan and control structure schematics (shown on PDP).
- Plot 50 and 100-year HGL (shown on PDP profile sheets).

Task 9: Right-of-Way Evaluation

Description: This task involves determining the drainage right-of-way and easement requirements. The proposed drainage improvements shall be evaluated to see if additional right-of-way or drainage easements are necessary.

Specific Tasks:

- Review the proposed roadway plan and template cross sections and how they correlate to the existing right-of-way. Review the right-of-way and easement requirements for outlet pipes, ditch drainage, culvert / bridge extensions, compensatory storage/detention facilities, water quality (BMPs) and permanent erosion / energy dissipation.
- Tabulate the right-of-way and easement requirements and include stations and offsets.
- Prepare a memorandum summarizing the right-of-way and easement requirements and coordinate these issues with the Illinois Tollway Project Manager.

Deliverables:

- A memorandum to the Illinois Tollway Project Manager summarizing the drainage right-of-way and easement requirements. This should be submitted prior to delivery of the final report.
- Concept Drainage Report text and corresponding drawing(s) describing right-of-way requirements and appropriate justification for required drainage right-of-way or easements.

Task 10: Drainage Alternatives

Description: This task involves the qualitative analysis of feasible alternative drainage concepts and recommendation of a preferred drainage alternative. The drainage alternatives are identified during the development of the PDP's.

Specific Tasks:

- Develop drainage alternatives (if any) and determine the level of evaluation required. Perform a qualitative evaluation of the drainage alternatives consistent with the Illinois Tollway-Drainage Design Criteria. Items to consider include reinstatement of existing drainage patterns, right-of-way requirements and consistency with the scope of improvements and cost.
- Document the evaluation of drainage alternatives and the preferred recommendation in the Concept Drainage Report.

Deliverable:

Concept Drainage Report text and corresponding drawings which document drainage alternatives and recommended option chosen.

Task 11: Local and Other Agency Coordination

Description: The purpose of this task is to document comments, drainage concerns and review of the EDP and PDP sheets by local and/or other agency (ies).

Specific Tasks:

- The DSE shall prepare a request for available drainage data, ordinances and any identified drainage problems from local and/or other agency (ies). The Illinois Tollway Project Manager shall transmit these requests to the corresponding agency (ies).
- The Illinois Tollway Project Manager shall distribute the EDP and PDP sheets to the agency (ies) for review and comments. The DSE shall provide the required attachments.
- The Illinois Tollway Project Manager shall make arrangements for a coordination meeting with the agency (ies). A meeting agenda shall be prepared by the DSE.
- At the coordination meeting, the DSE shall present the EDP and PDP sheets (if not completed, a conceptual plan is required), preliminary drainage alternatives (if any), right-of-way takes for special drainage features including stormwater detention and compensatory storage and the identified drainage concerns (if any) for discussion.

- The DSE shall prepare a meeting summary and document all relevant comments, concerns and drainage issues in a concise manner. Documentation of agency (ies) concurrence with the EDP and PDP is desired.
- The DSE shall prepare a follow-up disposition of comments and/or update the EDP and/or PDP as required in a timely manner and notify the participants of action(s) taken.
- The DSE shall attend and provide support activities for additional meetings as required.

Deliverables:

- Concept Drainage Report text documenting agency (ies) comments, concerns and concurrence on the EDP and PDP sheets.
- Copy of all pertinent correspondence such as telephone logs, letters and meeting minutes shall be included as an appendix to the Concept Drainage Report. This shall include a table of contents summarizing dates, contact names and topics.

Task 12: Proposed Drainage Plan

Description: This task involves the preparation of a Proposed Drainage Plan (PDP), with exhibit drawings and Concept Drainage Report text fully describing the proposed drainage concept. The preferred base map is the design contour map with the proposed geometric plan superimposed. The PDP sheets shall be prepared in digital format with 1' contour intervals and a scale of 1"=50'. The purpose of the PDP is to illustrate the proposed drainage features and overall concept to the extent necessary to identify:

- Reinstatement of the existing drainage patterns.
- Sub-areas draining to each outlet. Label as A, B, C, etc.
- Low and overflow (flood) flows.
- Diversions (shown as cross hatched).
- Potential utility conflicts.
- Maintenance, replacement, extension and/or construction of storm sewers, crossroad and appurtenant culverts and special drainage structures.
- Maintenance, re-grading and/or construction of ditches and/or swales.
- Location(s) for proposed stormwater detention and compensatory storage.
- Scour evaluation at bridges and the locations of bridges where scour evaluations were performed.
- Delineated wetland locations with ID numbers provided (where applicable).
- Provide preliminary BMP locations with the required proposed ROW shown.

Specific Tasks:

- DSE shall use the EDP, proposed geometric plan, existing and proposed roadway profiles, template roadway cross sections and any available contour mapping to develop the PDP. The PDP shall be developed utilizing the drainage symbols associated with the EDP sheets.
- Verify that the project limits, project route, crossroads and stream crossings have been identified. The existing right-of-way and centerline, along with the anticipated proposed right-of-way or drainage easements, shall be shown. Coordinate any missing geometric information or mapping deficiencies with the Illinois Tollway Project Manager before the PDP is fully prepared.

- The DSE shall utilize the EDP and the template cross sections to define the proposed tributary areas (sub-divides) to each outlet and identify any diversions. All outlets, including new ones, (if any) shall be identified and numbered for reference in the Concept Drainage Report. Existing and proposed outlet numbering shall match even if an existing outlet is removed under proposed conditions. In this scenario the existing outlet number may be omitted. Low flow outlets should not be at the same location as the flood flow outlets.
- Identify re-graded ditch locations and provide beginning and end stations. Identify proposed ditch and swale locations and identify beginning and end stations and proposed ditch slopes. Standard ditches shall be used for proposed conditions, especially when additional right-of-way is requested for drainage purposes. Ditches required for stormwater detention purposes are described in Section 10 of the Illinois Tollway Drainage Design Manual. All technical data and calculations prepared for the design of the ditches/swales shall be included as an appendix to the Concept Drainage Report. Copies of all computer software input and output files shall be provided on a CD.
- Identify all locations where sheet flow is to be reinstated or proposed.
- Identify existing storm sewers to be maintained or abandoned by beginning and end stations and offsets. Proposed storm sewers are to be designed (sized) based on Section 9 of the Illinois Tollway Drainage Design Manual. Sizes, inverts and longitudinal slopes of the proposed storm sewer systems shall be provided on the PDP sheets. Plan and profiles of the proposed storm sewer runs (not including lateral extensions) are required. The HGL for the design storm frequency and 100-year check shall be plotted on the storm sewer profile. Storm sewers required for stormwater detention storage purposes are described in Section 10 of the Illinois Tollway Drainage Design Manual. A detailed sketch of any special drainage features shall be provided on the PDP sheets or on a separate exhibit. All technical data and calculations prepared for the design of the storm sewers shall be included as an appendix to the Concept Drainage Report. Copies of all computer software input and output files shall be provided on a CD.
- The DSE shall indicate the proposed concept (i.e. maintain, replace, extend, etc.) for bridges and/or culverts.
- Add north arrow, title, scale and flow directions to all plan sheets. The drainage legend shall appear on the first sheet at a minimum.
- Prepare the Concept Drainage Report text to fully describe the proposed drainage design on a reach-by-reach basis per each outlet.

Deliverables:

- Concept Drainage Report text and corresponding drawing(s) that fully describe the proposed drainage plan on a reach-by-reach basis per each outlet.
- Calculations and technical data used in the design/sizing of the proposed drainage system to be included as an appendix to the Concept Drainage Report.
- Proposed Drainage Plan, Exhibit 2-00, to be bound separately in 11"x17" format. If a larger format is required, the drawings shall be folded and included within pockets of an appendix to the Concept Drainage Report.

Task 13: Floodplain Encroachment Evaluation

Description: This task involves the evaluation of encroachments on Base Floodplains and Regulatory Floodways in accordance with Section 3 of the Illinois Tollway Drainage Design

Manual and as described below. Base Floodplains and Regulatory Floodways are defined in Section 3 of the Illinois Tollway Drainage Design Manual.

Specific Tasks:

- Obtain and review the most recent available data, including the roadway plan and profile, cross sections and the FIS data.
- Determine the feasibility of the proposed action or work and provide recommendations for plan revisions or alternatives to avoid significant floodway/floodplain encroachment. Avoid longitudinal encroachments when practical and minimize the extent of such encroachments if they are unavoidable.
- When a transverse encroachment is required, minimize its extent and maintain floodway conveyance and floodplain volume.
- Review and consider IDNR-OWR permit requirements and local ordinances.
- Perform a qualitative evaluation of the extent and degree of encroachment and categorize the proposed action in accordance with IDOT BLE Procedure Memorandum 95-3. If the proposed work falls into Category I or 2 and there are no significant impacts, complete the evaluation by documenting the location in the Concept Drainage Report.
- If the proposed work falls into Category 3, 4, or 5 and there are potentially significant impacts, proceed with the additional tasks described below:
  - Perform hydraulic analysis for the proposed conditions to determine the magnitude of changes in WSELs for the 10-year, 50-year, 100-year and 500-year storm events with Base Floodplains and Regulatory Floodways.
  - Determine if there are any buildings or structures located within the floodplain that may be affected by the proposed action or work.
  - Inspect the floodplain to determine if increases in flood heights may result in significant damage not expected under current conditions.
  - Prepare a plan of the floodplain encroachment. Show the floodplain boundaries on contour maps including the right-of-way within the limits of floodplain encroachment.
  - Prepare cross sections of the floodplain. Using the roadway cross sections, show the floodplain boundaries within the Illinois Tollway right-of-way and the limits of floodplain encroachment. These cross sections shall include: surveyed normal WSELs, 10-year, 50-year and 100-year flood elevations, floodplain and floodway boundaries and areas of cut/fill within the floodplain and floodway boundaries.
  - Compute encroachment volumes between the normal and 10-year flood elevation and between the 10-year and 100-year flood elevations for floodway and floodplain. Note that compensatory storage is to be provided in accordance with IDNR-OWR or local criteria if more stringent.
  - Determine a suitable means of providing compensatory storage. This includes the evaluation of alternate sites, the development of a plan schematic and site cross sections and the determination of compensatory storage volume provided.
  - If the evaluation shows that there are minimal or insignificant changes in the flood heights or flood limits, complete the evaluation by documenting the location in the Concept Drainage Report. For most cases the evaluation does not extend beyond this step. However, if the evaluation shows that there is still potentially significant encroachment, proceed with the additional tasks described below:
    - Inspect the floodplain and identify all flood receptors that may experience significant adverse impacts as a result of the increases in flood heights.
    - Coordinate with IDNR-OWR and local agencies to determine the degree and significance of potential encroachment on the regulatory floodplain.

- Perform a Risk Assessment in accordance with Section 3-004.02 of the IDOT Drainage Manual. This may lead to the reiteration of the activities described above for design alternates. Document the location in the Concept Drainage Report and complete the Permit Summary Form and Attachment A, if required.

Deliverables:

- Concept Drainage Report text and corresponding drawing(s) to describe evaluation of each floodplain encroachment location.
- Supporting calculations for the hydraulic analysis, evaluation of floodway/floodplain encroachment and determination of fill in the floodplain and compensatory storage volumes. These calculations shall be included in an appendix to the Concept Drainage Report and organized per crossing.
- Permit Summary Form and Attachment A to be included in the Concept Drainage Report.

Task 14: Permits

Description: This task involves identifying any relevant permit requirements. The DSE is responsible for identifying all IDNR-OWR permits required for construction activity within designated floodways, floodplains and Public Bodies of Waters (including rivers, streams and lakes) within the State of Illinois.

Specific Tasks:

- If an affected river, stream, or lake is a Public Body of Water, then an Individual Permit from IDNR-OWR is required.
- If an affected river, stream, or lake is not a designated floodway and is a regulatory floodway, identify the appropriate Individual or Statewide Permit required.
- If an affected river, stream, or lake is a designated floodway, identify the appropriate Floodway Permit required. A completed Permit Summary Form (and its Attachment A) is required for each location involving a floodway. This form and attachment are included in the Floodplain Encroachment Evaluation task and the Concept Drainage Report.
- Document any coordination with IDNR-OWR or other agency (ies) regarding permits and include this correspondence as an appendix to the Concept Drainage Report.

Deliverables:

- Concept Drainage Report text to list and describe each permit required.
- Correspondence with IDNR-OWR and/or other agency (ies) to be included as an appendix to the Concept Drainage Report.

Task 15: Report Assembly

Description: This task involves the organization, preparation and assembly of the Concept Drainage Report. Concept Drainage Report revisions should be anticipated and the time required to implement those revisions are to be included in the individual tasks.

Specific Tasks:

- Prepare report cover and include draft date on the cover to facilitate identification of initial and subsequent revisions.
- Prepare a table of contents with page numbers.
- Prepare an Executive Summary.
- Compile necessary appendices including labeled tabs to separate sections. All supporting calculations included in an appendix should be bound separately. These calculations shall be approved by an Illinois Professional Engineer prior to submittal to the Illinois Tollway for review. Calculations shall be checked by a person other than the one who completed the calculations. The Designer shall also ensure that “done by” and “checked by” initials are provided for all calculations included in the report.
- Submit a “Draft” and “Final” copy of the Concept Drainage Report.
- Copy, collate and bind the appropriate number of documents.

Deliverable:

Copies of the Draft and Final Concept Drainage Report.

Permit Summary for Floodway Construction in Northeastern Illinois
(Attachment A -Compensatory Storage)

Application Agency: Illinois State Toll Highway Authority
Route: ___________________________
Contract No.:_______________________________ Structure Number:____________________
County:______________________________
Stream: _____________________________

Will fill or material be placed in the floodway due to the proposed work?

Yes ☐ No ☐

Provide the following information:

Flood Water Elevations: 100-year ________ ft 10-year ____________ ft

Normal ________ ft

Volume of fill or material being placed in the floodway:
Volume between the 10-year and the 100-year flood level ____________ yd3
Volume between the Normal and the 10-year flood level ____________ yd3

Excavation being removed from the floodway (for existing structures, embankments and for compensatory storage):
Volume between the 10-year and the 100-year flood level ____________ yd3
Volume between the Normal and the 10-year flood level ____________ yd3

Show the location and amount of compensatory storage to be excavated on exhibits (preferably on set of plans and cross-sections).

Attach a copy of Calculations and Exhibits reflecting the above findings.

All engineering analysis has been performed by me or under my direct supervision.

Signed by: __________________________
IL/P.E.#: _________________
Date: ______________________________

Permit Summary for Floodway Construction in Northeastern Illinois

Application Agency: Illinois State Toll Highway Authority
Route: ________________________
Contract No.:____________________________ Structure Number:________________
County:________________________
Stream: ________________________

General Description of Existing Facility:

General Description of Proposed Improvement:

1. Is the proposed work classified as repairs such as deck replacement, pavement resurfacing, or the armoring or filling of a scour hole with riprap?	☐ Yes ☐ No
2. Does the proposed work consist only of modifications to the existing structure which may occur above the regulatory profile? Note: If the answer to question 1 or 2 is yes, no permit is required and questions 3 through 12 may be omitted.	☐ Yes ☐ No
3. Does the proposed work below the regulatory profile consist of widening of the existing structure by 12 feet or less?	☐ Yes ☐ No
4. Is the proposed improvement, including the approach roadway, more restrictive to normal and flood flows than the existing structure?	☐ Yes ☐ No
5. Is Channel Modification proposed?	☐ Yes ☐ No
6. Are there any buildings or structures located upstream in the 100-year floodplain within the influence of the structure backwater?	☐ Yes ☐ No
6a. If no, does the backwater of the proposed improvement exceed the backwater of the existing structure by more than 0.1 ft.?	☐ Yes ☐ No
6b. If answer to (6) is yes, is the proposed backwater no greater than 0.1 ft. above the natural water elevation?	☐ Yes ☐ No
7. Are transition sections required for this project?	☐ Yes ☐ No
8. Is the flood profile at the project site impacted by backwater from a downstream receiving stream? If yes, list frequency of starting elevation for analysis: ______________	☐ Yes ☐ No
9. Is there a downstream structure which backwater affects the flood profile at the project site?	☐ Yes ☐ No

9a. If the answer to 9 is yes, is the downstream structure scheduled for improvement within the next 5 years? (Attach documentation)	☐ Yes ☐ No
9b. If answer to 9a is yes, was the existing downstream structure used in the analysis for determining flood profile at the project site?	☐ Yes ☐ No
9c. Was the proposed downstream improvement used in the analysis?	☐ Yes ☐ No
10. Is a floodway map change required due to the proposed project?	☐ Yes ☐ No
11. May fill or material be placed in the floodway due to the proposed work?	☐ Yes ☐ No
11a. If yes, is compensatory storage to be provided at the project location? (Attach a copy of completed Attachment A)	☐ Yes ☐ No
11b. If answer to 11a is no, is compensatory storage provided at another location? If yes, give location. Location: ______________________________	☐ Yes ☐ No
11c. Has compensatory storage relief been granted? (Attach documentation)	☐ Yes ☐ No
12. Has coordination occurred with Agency(ies)? (Attach documentation)	☐ Yes ☐ No
13. Is a permit required for this project?	☐ Yes ☐ No
13a. If yes, which permit is required? Individual Permit ☐ Yes ☐ No Statewide Permit# ____ ☐ Yes ☐ No Regulated Floodway Construction Permit ☐ Yes ☐ No Regional Permit # 3 ☐ Yes ☐ No	☐ Yes ☐ No

Signed by: ________________________
IL/P.E.#: ____________________
Date: __________________________

APPENDIX G. GENERAL CONTENTS OF CONCEPT DRAINAGE REPORT

ILLINOIS STATE TOLL HIGHWAY AUTHORITY

CONCEPT DRAINAGE REPORT
For
(Insert Title)

CONTRACT NO:
LIMITS:
LOCATION:
JOB NUMBER:

PREPARED BY:

DATE:

REVISIONS:

GENERAL CONTENTS OF THE
"CONCEPT DRAINAGE REPORT"[18]
FOR THE ILLINOIS TOLLWAY PROJECTS

1. Executive Summary

- Provide a brief description of the project scope, location, existing and proposed general drainage conditions and any special drainage features, requirements, or challenges.

2. Existing Drainage conditions

2.1 General Location Drainage Map

2.2 Existing Drainage Plans

- Describe the main components of the existing drainage system and include information regarding the following:

2.3 Identified Drainage Concerns

- Describe the drainage problems/concerns identified during field inspections or as mentioned by the Illinois Tollway maintenance personnel related to Illinois Tollway drainage facilities or per local agency coordination. Show these locations on the plans.
- Identify and describe the drainage concerns/deficiencies (i.e. flooding, malfunctioning, clogging, inadvertent invert elevations, etc.) mentioned by the local agencies in official documents or coordination meetings. Evaluate the Illinois Tollway involvement in solving these deficiencies, if they are within the scope of the Illinois Tollway project improvements.

2.4 Identified Base Floodplains

- Obtain and review the most recent available floodplain data, including the FIS for the project area.
- Identify and show on maps the possible areas where the floodplain limits do not correspond to the actual field conditions, if any.

2.5 Outlet Evaluation

- Use all data obtained through field inspections, survey coordination, existing drainage plans and the areas associated with identified drainage concerns to evaluate whether or not each existing outlet is suitable for continued use.
- Discuss options regarding the improvement of each outlet, if necessary.

2.6 Bridges and Culverts

- Prepare a short narrative describing the existing structures.
- Include hydrologic, hydraulic and structural design considerations
- Describe the method of analysis
- Include information regarding the Permit requirements, if necessary

3. DRAINAGE Design Criteria

- Summary of the Illinois Tollway Drainage Design Manual
- Summary of the local drainage criteria (if more restrictive than the Illinois Tollway Drainage Design Manual)

4. PROPOSED Drainage conditions

4.1 Short narrative describing the proposed drainage conditions

4.2 Proposed Drainage Plans (for Pre-Concept design phase; this typically includes the possible major design alternatives)

4.3 Proposed alternative for the areas with identified drainage concerns / problems

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[18] All sections shall be completed taking into account the requirements of the corresponding sections of the Illinois Tollway-Drainage Design Manual and the specific tasks mentioned in Appendix F and in the Scope of Services for each Illinois Tollway project. For Pre-Concept Drainage Reports see the indications included in the brackets.

4.4 Stormwater Detention Analyses

- Estimate the required storage volume using the graphic method.
- Determine the allowable release rates and provide outlet structure schematics.
- Develop a preliminary plan for providing the required storage volumes per each reach draining to each outlet. Determine the type of detention facility (i.e. "closed" or "open") that may be provided at each location. Determine if additional right-of-way acquisition is necessary for providing the detention requirements and show these locations on drainage exhibits.
- Perform the appropriate hydrograph method calculations in order to prove that the required storage and the allowable release rate criteria are met.
- Include a summary table with the main characteristics of the proposed detention facilities (i.e. volume, maximum WSEL, outlet inverts, allowable release rates and proposed release rates) in WIT's or summary tables (for smaller culverts).

4.5 Right of Way Analysis

- Review the proposed roadway plan and template cross sections and analyze how they correlate with the existing right-of-way. Review the right-of-way and easement needs for outlet pipes, ditch drainage, culvert extensions, compensatory storage and detention facilities. Prepare a plan showing the areas where additional right-of-way is needed, if any.

4.6 Drainage Alternatives

- Provide a narrative of potential drainage alternatives and design considerations for the proposed drainage plan (focusing on drainage concerns that were identified in Article 3.3).

4.7 Floodplain Encroachment Evaluation

- Based on the most recent available floodplain data (benchmark correlation shall be performed first), analyze the impacts of the proposed roadway plan, profile and cross sections on existing floodplain limits. Provide recommendations for plan revisions or alternatives to avoid significant encroachments.
- Discuss alternatives to avoid longitudinal encroachments when practical and minimize the extent of the longitudinal encroachment if it is unavoidable.
- When a transverse encroachment is necessary, discuss the alternatives or measures to minimize its extent and to maintain floodway conveyance and floodplain volume.

4.8 Bridges and Culverts (detailed proposed condition analysis not required for Pre-Concept design phase)

- Show the proposed structure locations on plans.
- Include information regarding the structure type and main characteristics (invert elevations, low chord elevation, top elevations, width, length, stream cross-sections at the structure location, etc.).
- Include all corresponding hydrologic and hydraulic calculations in Appendix B.

4.9 Permits

- List and describe the anticipated permit requirements.

Appendix A – Exhibits

- Table of Contents
- General Location Drainage Maps
- Existing Drainage Plan
- Identified Base Floodplain Maps
- WITs (not required for Pre-concept design phase)
- Proposed Drainage Plan (For Pre-concept design phase this typically includes the possible major design alternatives)
- Typical Existing Cross Sections
- Typical Proposed Cross Sections

- Detention Basin Layouts and Control Structure Schematics (not required for Pre-concept design phase)

Appendix B – Calculations

- Table of Contents
- Stormwater Detention Calculations (not required for Pre-concept design phase)
- Hydrologic and Hydraulic Calculations for Bridges and Culverts, including size and location drawings (not required for Pre-concept design phase)
- Hydrologic and Hydraulic Calculations for Conveyance Systems (sewers, ditches, etc.) This is not required for Pre-concept design phase
- Storm Sewer Inlet Spacing (not required for Pre-concept or Concept design phase)
- Compensatory Storage calculations and the locations where provided
- All other corresponding drainage calculations used in the Concept Drainage Design

Appendix C – Source Data Reviewed

Provide references for the following:

- USGS Maps (most recent available quadrangle map or hydrologic atlas maps)
- Survey Data (with originator and date)
- Local Drainage Plans (with location, originator, date)
- As-built or microfilm plans (with location, originator, date)
- FIS (with location, originator, date)

Appendix D – Correspondence

- Table of Contents
- Copies of letters, memorandums, facsimiles and transmittals (with date, to/from, subject)

Report Assembly

- Report cover including the draft date, to facilitate identification of initial and subsequent revisions
- Table of Contents with page numbers
- Corresponding drawings, figures, tables and graphics with tabs provided to separate each section of the report.

APPENDIX H. WATERWAY INFORMATION TABLES

WATERWAY INFORMATION TABLE

Route: ______________________ Existing SN: ______________________

Section: ______________________ Proposed SN: ______________________

County: ______________________ Waterway: ______________________

Prepared by: ____________ Date: ________ Checked by: ____________ Date: ________

Drainage Area = sq. mi.			Existing Overtopping Elev. = at Sta. Proposed Overtopping Elev. = at Sta.						
Flood Event	Freq. Yr.	Discharge Ft^3/s	Waterway Opening - ft^2		Natural H.W.E. ft.	Head – ft.		Headwater Elevation ft.	
			Existing	Proposed		Existing	Proposed	Existing	Proposed
Design									
Base									
Scour Design Check									
Overtop Existing									
Overtop Proposed									
Max. Calc.									

10 YEAR VELOCITY THROUGH EXISTING BRIDGE = ft/s 10 YEAR VELOCITY THROUGH PROPOSED BRIDGE = ft/s

ALL–TIME H.W.E. & DATE:

Scope of Work:

EXISTING STRUCTURE		PROPOSED STRUCTURE	
TYPE:		TYPE:	
LENGTH:		LENGTH:	
# SPANS:		# SPANS:	
LOW BEAM:		LOW BEAM:	
SKEW:		SKEW:	
LOW E.O.P.:		LOW E.O.P.:	

NOTE: PROPOSED STRUCTURE DETAILS ARE PRELIMINARY; SUBJECT TO REFINEMENT IN TSL STAGE.

Culvert Waterway Information Table

Route: S.N. Exist: Computed by: Date:
Section: S.N. Prop: Checked by: Date:
County: Waterway:
Station:

Drainage Area =		Square Miles	Existing Overtopping Elevation: Proposed Overtopping Evaluation:				ft. @ Sta ft. @ Sta		
Flood	Frequency Year	Discharge cfs	Waterway Opening (sq. ft.)		Natural H.W.E.	Head (ft.)		Headwater Elev. (ft.)	
			Existing	Proposed		Existing	Proposed	Existing	Proposed
	10								
Design	50								
Base	100								
OVT(E)									
OVT(P)									
Max Calc	500								

10-Year Outlet Velocity from Existing Structure = fps
10-Year Outlet Velocity from Proposed Structure = fps

OVT = Overtopping Event
(E) Existing (P) Proposed

DATUM:
ALL-TIME H.W.E. & DATE:

SCOPE OF WORK:

EXISTING STRUCTURE
Bridge or Culvert Type:
Cell Dimensions (W x H):
# of spans \ cells:
Length:
U/S Flowline:
D/S Flowline:
Skew:
Low EOP:

EXISTING DROPBOX
Dimensions:
Drop:
Weir Elevation:

PROPOSED STRUCTURE
Culvert Type:
Cell Dimensions (W x H):
# of cells:
Length:
U/S Flowline:
D/S Flowline:
Skew:
Low EOP:

PROPOSED DROPBOX
Dimensions:
Drop:
Weir Elevation:

NOTE(S): ____________________

MULTIPLE OPENINGS WATERWAY INFORMATION TABLE

Route: ______ Existing SN: ______

Section: ______ Proposed SN: ______

County: ______ Waterway: ______

Prepared by: ______ Date: ______ Checked by: ______ Date: ______

Existing Overtopping Elev. = at Sta.

Drainage Area = sq. mi. Proposed Overtopping Elev. = at Sta.

Flood Event		Discharge (cfs)		Waterway Opening (sq.ft.)		Natural H.W.E. ft.	Head – ft.		Headwater Elevation	
		Existing	Proposed	Existing	Proposed		Existing	Proposed	Existing	Proposed
10	Main Channel									
	Relief Structure									
	TOTAL									
50	Main Channel									
	Relief Structure									
	TOTAL									
100	Main Channel									
	Relief Structure									
	TOTAL									
200	Main Channel									
	Relief Structure									
	TOTAL									
Overtopping	Main Channel									
	Relief Structure									
	TOTAL									
500	Main Channel									
	Relief Structure									
	TOTAL									

10 Year Velocity Through Existing Bridge = ft/s

10 Year Velocity Through Proposed Bridge = ft/s

ALL–TIME H.W.E. & DATE:

Scope of Work:

EXISTING STRUCTURE	PROPOSED STRUCTURE
TYPE:	TYPE:
LENGTH:	LENGTH:
# SPANS:	# SPANS:
LOW BEAM:	LOW BEAM:
SKEW:	SKEW:
LOW E.O.P.:	LOW E.O.P.:

NOTE: PROPOSED STRUCTURE DETAILS ARE PRELIMINARY; SUBJECT TO REFINEMENT IN TSL STAGE

WATERWAY INFORMATION TABLE BACK-UP CALCULATIONS (EXAMPLES)

CREATED HEAD CALCULATIONS

Frequency	Natural H.W.E. (ft) (1)	Existing Headwater Elev. (Ft)	Proposed Headwater Elev. (Ft)	Created Head (Ft) (2)	
				Existing	Proposed
10-YEAR	635.19	635.21	635.21	0.02	0.02
50-YEAR	636.51	636.54	636.54	0.03	0.03
100-YEAR	637.08	637.11	637.12	0.03	0.04
500-YEAR	638.81	638.86	638.86	0.05	0.05

(1) The NHWE is the WSE at the U/S end of the crossing, as modeled in the natural condition of the stream, without the structure. The NHWE to be reported in the Waterway Information Table is the natural water surface elevation at the location of the upstream face of the proposed structure.

(2) The created head is computed as the largest change in water surface elevation from the existing condition and the proposed condition to the natural condition for each upstream cross section of the bridge or culvert. This method of calculating created head is only required for bridges and some major culvert crossings. The difference in elevation is then added to the NHWE at the U/S face of the structure (Headwater Elevation = NHWE + Created Head). Also, the created head should never be negative, so use a value of zero if a negative number is computed.

FREEBOARD AND CLEARANCE CALCULATIONS

Low Road Elevation (Ft) (3)		Low Beam Elevation (Ft)	
Existing	Proposed	Existing	Proposed
643.18	643.75	N/A	N/A
Low Road Station		**Low Beam Station**	
Existing	**Proposed**	**Existing**	**Proposed**
2037+54	2037+54	N/A	N/A

Frequency	Freeboard (Ft) (4)		Clearance (Ft) (5)	
	Existing	Proposed	Existing	Proposed
10-YEAR	7.97	8.54	N/A	N/A
50-YEAR	6.64	7.21	N/A	N/A
100-YEAR	6.07	6.63	N/A	N/A
500 - YEAR	4.32	4.89	N/A	N/A

(3) Low road elevation is calculated at the edge of pavement along the low side of the roadway.

(4) Freeboard is calculated from the 50-year design headwater elevation to the low road elevation in the floodplain.

(5) Vertical clearance is calculated from the 50-year NHWE to the proposed low chord (beam) bridge elevation (2 ft minimum requirement).

WATERWAY OPENING AREA CALCULATIONS (Culverts)

Frequency	Natural H.W.E. (ft)	Existing/Proposed U/S Invert Elevation (ft)		Box Culvert Size (ft x ft)		Opening Area (ft^2) (6)	
		Culvert 1	Culvert 2	Existing	Proposed	Existing	Proposed
10-YEAR	635.19	632.65	632.63	2-10.0'[(W) x 7.0'(H)]	2-10.0'[(W) x 7.0'(H)]	51	51
50-YEAR	636.51	632.65	632.63	2-10.0'[(W) x 7.0'(H)]	2-10.0'[(W) x 7.0'(H)]	77	77
100-YEAR	637.08	632.65	632.63	2-10.0'[(W) x 7.0'(H)]	2-10.0'[(W) x 7.0'(H)]	89	89
500 - YEAR	638.81	632.65	632.63	2-10.0'[(W) x 7.0'(H)]	2-10.0'[(W) x 7.0'(H)]	123	123

(6) The waterway opening area is computed using the NHWE at the U/S face of the culvert, and not the headwater elevation. The maximum opening area shall be less than or equal to the cross sectional area of the box culvert or circular/elliptical pipe. If the culvert is embedded to meet permit requirements, the embedment depth shall not be included in the opening area calculations.

BACK-UP CALCULATIONS FOR WIT (EXAMPLE)

SUMMARY TABLE COMPARING 100-YEAR NATURAL WSE TO PROPOSED WSE AND EXISTING WSE					
Cross Section	Existing WSE	Natural WSE	Proposed WSE	Existing-Natural WSE Difference	Proposed-Natural WSE Difference
12403	637.88	637.87	637.88	0.01	0.01
12298	637.87	637.86	637.87	0.01	0.01
11851	637.77	637.76	637.77	0.01	0.01
11478	637.73	637.72	637.73	0.01	0.01
11408	637.59	637.58	637.59	0.01	0.01
11377	Culvert				
11345	637.30	637.27	637.30	0.03	0.03
11242	637.35	637.32	637.35	0.03	0.03
10984	637.33	637.31	637.34	0.02	0.03
10703	637.32	637.29	637.32	0.03	0.03
10593	637.21	637.18	637.21	0.03	0.03
10470	Culvert				
10348	637.11	637.08	637.11	0.03	0.03
10283	637.14	637.11	637.14	0.03	0.03
10281.5	Bridge				
10280	637.12	637.09	637.13	0.03	0.04
10074	637.12	637.09	637.12	0.03	0.03
10009	637.12	637.09	637.12	0.03	0.03
9864	637.11	637.08	637.11	0.03	0.03
9664	637.10	637.08	637.11	0.02	0.03
9650	637.10	637.07	637.11	0.03	0.04
9588	637.09	637.08	637.09	0.01	0.01
9433	Culvert				
9278	637.07	-	-	-	-
9237	637.07	637.07	637.07	0.00	0.00
9188	637.07	637.07	637.07	0.00	0.00
9028	637.06	637.06	637.06	0.00	0.00
8961	637.06	637.06	637.06	0.00	0.00
8883	637.06	637.06	637.06	0.00	0.00
8840	636.97	636.97	636.97	0.00	0.00
8817	636.95	636.95	636.95	0.00	0.00
8770	636.91	636.91	636.91	0.00	0.00
8723	636.92	636.92	636.92	0.00	0.00

APPENDIX I. SAMPLE INLET SPACING SPREADSHEET

Designed By: ____________ Date: ____________
Checked By: ____________ Date: ____________

INLET SPACING FROM HIGH POINT TO SAG POINT: **GUTTER, TYPE G-3, 0.5% LONGITUDINAL SLOPE**

U/S Structure No.	D/S Structure No.	Begin Station	End Station	Length (ft)	Width (ft)	Area (acres)	C	Intensity (in/hr)	Discharge (cfs) Q=CIA	Discharge +Bypass (cfs)	Cross Slope Pavement (ft/ft)	Cross Slope Shoulder (ft/ft)	Longitudinal Grade (ft/ft)	Encroachment (ft)	Allowable Encroachment (ft)	Depth at Curb (in)	Depth at Curb (ft)	Allowable Depth of Flow at Curb (ft)	Q-by pass (cfs)
High Point	1	100+00	102+65	265	62	0.38	0.95	9.36	3.354	3.354	0.0200	0.0300	0.0050	**6.88**	9.25	3.53	0.294	0.35	**0.290**
1	2	102+65	105+30	265	62	0.38	0.95	9.36	3.354	3.644	0.0200	0.0300	0.0050	**7.27**	9.25	3.67	0.306	0.35	**0.374**
2	3	105+30	107+95	265	62	0.38	0.95	9.36	3.354	3.728	0.0200	0.0300	0.0050	**7.38**	9.25	3.71	0.309	0.35	**0.400**
3	4	107+95	110+60	265	62	0.38	0.95	9.36	3.354	3.754	0.0200	0.0300	0.0050	**7.41**	9.25	3.72	0.310	0.35	**0.408**
4	5	110+60	113+25	265	62	0.38	0.95	9.36	3.354	3.762	0.0200	0.0300	0.0050	**7.42**	9.25	3.72	0.310	0.35	**0.411**
5	6	113+25	115+90	265	62	0.38	0.95	9.36	3.354	3.765	0.0200	0.0300	0.0050	**7.42**	9.25	3.72	0.310	0.35	**0.412**
6	7	115+90	118+55	265	62	0.38	0.95	9.36	3.354	3.766	0.0200	0.0300	0.0050	**7.42**	9.25	3.72	0.310	0.35	**0.412**
7	Sag Point	118+55	120+00	145	62	0.41	0.95	9.36	3.670	4.494	0.0200	0.0300	0.0050	**8.25**	9.25	4.02	0.335	0.35	-

APPENDIX J. SAMPLE STORM SEWER DESIGN SPREADSHEET

Designed By: ____________ Date: ____________
Checked By: ____________ Date: ____________

STORM SEWER DESIGN SPREADSHEET

Pipe Number	Start Node	Stop Node	Pipe Length (ft)	Drainage Area "A" (acres)		Runoff Coefficient "C"	"A" x "C"		Flow Time (minutes)		Rainfall Intensity (in/hr)	Total Flow (cfs)	Pipe Diameter (in)	Pipe Capacity (Full Flow) (cfs)	Total Flow / Pipe Capacity (%)	Velocity (ft/s)	Rim Elevation (Start) (ft)	Hydraulic Grade Line (In) (ft)	Rim Elevation (Stop) (ft)	Hydraulic Grade Line (Out) (ft)
				Incremental	Total		Incremental	Total	Pipe	System										

APPENDIX K. GUIDELINES FOR THE DESIGN OF STREAM CROSSINGS FOR SENSITIVE RESOURCES

INTRODUCTION

This appendix has three primary goals: 1) provide CWA Section 404-related compliance guidance to engineers designing crossings for Illinois Tollway over streams regulated by the USACE Chicago District (USACE-CD), 2) aid Designers in achieving project needs while minimizing environmental impacts and 3) foster a broader and deeper understanding of sediment transport and fish passage design issues in stream crossing projects. The motivation for this appendix, described in detail below, is to both achieve compliance with USACE-CD guidance pertaining to stream crossings and to encourage Designers to implement environmentally appropriate stream crossing alternatives on Illinois Tollway projects.

This document describes the motivation behind its creation and presents a discussion of the regulatory framework that should be considered in the design of stream crossings of Waters of the United States (WOUS). Found later in the document, the Design Matrix shall be used to assess alternatives that consider the unique circumstances of a proposed stream crossing and arrive at a class of design solutions that achieve regulatory compliance while meeting project goals. It should be noted that the design matrix does not provide an explicit design solution for all circumstances a Designer may encounter at a given project site, but rather is intended to inform best alternative design solution types that may be utilized for a particular set of hydraulic and geomorphic stream conditions. Moreover, the matrix is intended to aid the design team at arriving at a design alternative that achieves project needs while minimizing hydraulic and environmental impacts. The methodology used to develop the design matrix and a description of its application in the alternatives analysis process is included.

The Design Alternatives section includes information about some possible design solutions that may be employed to achieve both the project goals, as well as the goals of this guidance. The Design Alternatives section is not intended to be a comprehensive list of design solutions that may be employed in a given setting, but rather is broadly intended to guide Designers in addressing some of the categories of challenges related to regulatory compliance and sediment transport that may be encountered on stream crossing projects. The final section is a detailed bibliography of the references used to develop the regulatory and design concepts presented herein. Should a design team require additional details about design elements, regulatory guidance or project setting, the references in the bibliography provide a useful aid.

MOTIVATION

The creation of this document was motivated by the overarching goal of providing engineers guidance to design stream crossing structures in a cost-effective manner while minimizing environmental impacts and maintaining hydraulic stability by:

1. Moving away from the implementation of the nearly ubiquitous four-sided culvert; and
2. Achieving parity with USACE regulatory guidance by minimizing impacts to WOUS.

Figure 1 - Example of soft-bottom, or open, culvert. Image from FHWA (2012B). Soft-bottomed culverts reduce impacts to stream beds, allow for natural bed movement and minimize impacts to WOUS.

The use of four-sided culverts in Illinois Tollway projects began following previous Illinois Tollway design guidance and became ubiquitous in part because of the relative ease of implementation of design. While four-sided culverts should still be considered a valid design alternative, engineers should be aware of some of the impacts caused by this design option. The greatest concern is the impacts to WOUS through altering the geomorphic conditions of the stream bed and the potential hindrance to animal (i.e., fish, invertebrates, amphibians, etc.) passage, either because of the structure's design, or because of post-construction hydraulic and geomorphic impacts.

From a regulatory standpoint, the potential impacts to WOUS from four-sided culverts were addressed in USACE-CD Regional General Permit 3 and Illinois Tollway guidance as outlined in Article 8.5 of this manual. Both documents stress the benefits of natural substrates to fish and animal passage and habitat integrity, as well as the absence of impacts to both high and low flows at stream crossings. Impacts to threatened or endangered species are specifically addressed in permit USACE-CD Regional General Permit General Condition 9 and 2, respectively, while obstruction of flows is covered in General Condition 17. General Condition 17 is also significant since it contains language directed at the design of stream crossings.

While both Illinois Tollway and USACE documents offer some suggestions for engineers in achieving the two goals described above, the documents do not contain descriptions of the types of hydraulic and geomorphic circumstances in which alternatives to four-sided culverts may be effective. The information provided in this document aims to address this absence by describing how stream crossing design alternatives analyses for the design of Illinois Tollway projects should be implemented.

REGULATORY FRAMEWORK

USACE was given jurisdiction over WOUS under the 1972 CWA. Under sections 301 and 502 of the CWA, any discharge of dredged or fill materials into WOUS is forbidden unless authorized by a permit issued by the USACE pursuant of section 404 of the Act. There are two main types of permits for dredge and fill activities in WOUS: general permits and individual permits. General permits cover broad categories of activities and require applicants to comply with stated conditions of the permit. Individual permits are more involved and are utilized for actions of greater impacts that are either not addressed or do not meet the conditions of a general permit.

USACE issues general permits regionally for, among other things, both dredge and fill activities and for stream crossings of WOUS. The authority to issue these permits comes in part from 33 United States Code (USC) 401 (construction of bridges, causeways, dams or dikes) and 33 USC 1344 (permits for dredge or fill). These Regional General Permits (RGP), as defined in 33 Code of Federal Regulations (CFR) 322.2, include conditions on stream crossings, culverts, sediment movement and fish passage (For example, see ACOE Chicago District RGP 3 and 12). Additional regulatory oversight may be found in Section 404 of the CWA, under other Federal regulations (i.e., National Flood Insurance Program) and through State or local agencies. It is this regulatory framework that primarily depicts the design alternatives process presented herein.

Figure 2 - Example of a structure that appears to span WOUS. Bebo pre-cast bridge. (pamonapipeproducts.com)

DESIGN MATRIX

PURPOSE

The overarching purpose of the design matrix is to provide engineers guidance under what conditions to consider alternatives to standard stream crossing designs, particularly the four-sided box culvert and specifically in circumstances where regulatory jurisdiction and environmental sensitivity warrants additional design care. The secondary purpose of the matrix is to provide a basis for selection of design alternatives and options when specific hydraulic and/or geomorphic conditions are present at the project site. For example, channels experiencing lateral erosion would require different solutions to achieve crossing stability (i.e., bank and abutment protection with additional erosion mitigation below and downstream of the structure) than channels with long-term aggradational trends (i.e., a design that includes local modification of longitudinal channel slope and/or section). Moreover, when there is an absence of federal jurisdiction at a proposed project site the matrix aims to provide recommendations for a crossing design that minimizes hydraulic, geomorphic and environmental impacts and provides value-added to the final design. Designers shall provide an alternative analysis, prior to or concurrently with the type study in accordance with this Manual and the *Structure Design Manual* and shall utilize the design matrix, where WOUS or other sensitive resources are present.

METHODOLOGY

The matrix was developed by determining the primary project drivers for stream crossings, particularly where regulated by the USACE. These drivers consist of the following:

1. Federal or State regulation;
2. Impacts on channel hydraulics and geomorphology;
3. Structural design;
4. Environmental impacts.

It is important to recognize that these drivers should be considered both independently of and in conjunction with one another and over multiple time periods. For example, the construction of a crossing may alter hydraulic and geomorphic characteristics of a channel, at least locally, which may subsequently have a significant environmental impact in response to the affected areas. Additionally, it should be understood that the typical existing-versus-proposed impacts might underestimate or overestimate project impacts in the examination of longer temporal changes within a watershed or stream. For example, a particular stream may have at the time of analysis a mid-term aggradational trend because of regular agricultural activities that deliver upland sediment to the stream, but development of the watershed over a longer period may have resulted in a concurrent long-term degradational trend created by reducing the watershed-wide sediment yield. In the present example the long-term signal in the overall data may be obscured in the medium-term trend. It is, therefore, important to consider multiple time periods when developing trend analysis for the project. It is left to the design team to quantify the temporal extent of analysis to address long-term factors at the project site.

For long-term rearward trends, 35 years of gage data is the recommended minimum duration. (For a full discussion of detecting trends in hydrologic data see Kundzewicz and Robson, 2000). It is important to consider the expected design life of the project and, when possible, long-term future-conditions analysis should have duration as long as the design life. The future conditions analysis may be extended beyond the design life of the structure to increase analytic assurance. The primary project drivers were identified by reviewing current literature related to channel design, federal regulatory guidance for WOUS and sub-disciplines related to stream crossing design. In particular, the American Society of Civil Engineers (ASCE) Manual 110 (ASCE 2007) provides useful understanding of stream sediment transport-related drivers for stream crossing design. Likewise, the National Cooperative Highway Research Program (NCHRP) Report 544 (McCullah and Gray 2005) has provided insight on developing environmentally sensitive engineering solutions and Ashton (2004) has been significant in describing the impacts of ice on channel hydraulics. The design engineer is encouraged to identify and/or utilize other references in addition to those listed herein, particularly where unique project criteria or site settings require specific considerations not addressed thoroughly in the matrix.

Alternatives analyses using the matrix should typically address three types of alternatives: a no-action condition, two or more design alternatives and a preferred project condition. In most cases the no-action alternative may fail to meet the goals of the project, which should be noted in the alternatives analysis text when applicable. The alternatives should be described in the text of the analysis, including a discussion of how the alternatives perform with the various levels of the matrix (i.e., the waterway is jurisdictional [regulatory level]; the considered alternative may span WOUS [hydraulic level, regulatory sublevel]; the alternative may impact the FEMA floodplain [hydraulic level, regulatory sublevel]; etc.). The discussion of the alternative evaluated within the matrix should address the extent to which design considerations in each matrix level may be impacted and the best practices employed to mitigate these impacts. In some circumstances the preferred alternative may result in the greatest environmental impacts. For example, structural considerations to address unique site conditions may require abutment design that significantly impacts WOUS and where the costs of other structural design approaches may increase project cost prohibitively. In such circumstances a description of the overriding factors in the preferred alternative should be clearly noted and discussed in the alternatives analysis text.

Figure 3 - Example of long-term degradation at a historic bridge. Image from Caltrans, Division of Maintenance (www.dot.ca.gov).

APPLICATION

Users should start the alternatives analysis at the entry (the first level) to the matrix for all projects. This matrix entry specifically addresses the regulatory setting of the project site. Generally, if the project site does not impact regulated waters, the project design engineer may exit the matrix at the first level. It may be useful to the project design engineer to continue though the subsequent matrix levels, however, particularly if the matrix considers expected project hydraulic and/or geomorphic impacts. Project Designers should also keep in mind that regulations exist at the State and local levels so that specific benefit may still be derived from completing the matrix for these jurisdictions.

The more matrix levels come into play the more the design team should avoid plug-and-play designs in the alternatives and strive toward less environmentally impactful, more hydraulically appropriate design solutions. Designers of stream crossings may consider the levels within the design matrix analogous to layers of complexity that need to be addressed during the alternative analysis process. It is important for matrix users to recognize that all levels that address conditions in a given project may not impact the project equally and it is left to the engineer's judgment to address each level appropriately within the context of the given alternative and project.

Each level within the matrix addresses a specific project driver and the levels take the form of questions about the presence of the driver at the project site. The questions are intended to address a broad range of conditions related to a given driver at the project site so that the Designer may address design solutions to the drivers individually and in coordination with solutions to other drivers. The questions within a given level are not written to cover every situation a Designer may encounter, but are written to address concepts that are important to developing appropriate design alternatives.

Designers may utilize the matrix in any way that suits the alternatives analysis for their project. For example, one design team may start with a common design element and develop different alternatives by moving through the matrix and adding additional design elements as appropriate. Another valid method to utilize the matrix is to develop alternatives such that each alternative is developed by moving through the matrix without a common starting element. Many other pathways to developing alternatives are available to stream crossing Designers which are equally valid. It is up to the stream crossing Designer to use the matrix to develop alternatives as best suited for their project.

It is important to note that all of the technical terms presented in the matrix are not defined explicitly in this document. It is expected for the Designers to be familiar with concepts related to stream crossing design such as geomorphology, structural engineering, hydrology and hydraulics, etc. Also, it is the intent of this document to classify drivers according to clear categories of design. In some circumstances drivers may overlap engineering practice areas. In this case the driver is placed in the matrix according to the aspect of stream crossing design that causes or initiates an impact. For example, backwatering upstream of a crossing is a hydraulic impact, however, backwatering is included with structural drivers since it is expected that the reduction in flow area created by the backwater is caused by the placement of the crossing.

Figure 4 – Environmentally Sensitive Stream Crossing Design Matrix

Level	Question	Answer	Action
1. Regulatory Level	Will the structure intrude upon a federally regulated water?	No	Go to level 2 or exit
		Yes	Alternatives Analysis (AA) required: Address and go to level 2
2. Hydraulic Level			
2.1 Regulatory sublevel:			
	Will the proposed structure intrude upon the WOUS or ordinary high water mark?	No	Go to next question
		Yes	Address in AA and go to next question
	Will the proposed structure intrude upon a FEMA floodway?	No	Go to next question
		Yes	Address in AA and go to level 2.2
2.2 Geomorphic sublevel:			
	Is the channel stable at the project site with respect to the following such that the proposed structure will require special countermeasures for the following conditions:		
	Hydraulic geometry?	No	Go to next question
		Yes	Address in AA and go to next question
	Long profile?	No	Go to next question
		Yes	Address in AA and go to next question
	Planform pattern?	No	Go to next question
		Yes	Address in AA and go to sub-level 2.2.a
2.2.a Geom-Impacts Sublevel:			
	Are the channel instabilities at the project site due to the following:		
	Temporal variation (i.e., seasonal variation)?	No	Go to next question
		Yes	Address in AA and go to next question
	Adjustment Series (i.e., flood, fire, drought)?	No	Go to next question
		Yes	Address in AA and go to next question
	Human Activity (i.e., infrastructure development, agriculture)?	No	Go to next level
		Yes	Address in AA and go to level 3
3. Stability Level — Deg	Will the construction of the proposed structure remove or modify habitat that may contribute to channel stability?	No	Go to next question
		Yes	Address in AA and go to next question
Agg/Deg	Will the proposed structure be subject to debris and/or ice flows?	No	Go to next question
		Yes	Address in AA and go to next question
Agg/Deg	Will the proposed structure be subject to tidal influence?	No	Go to next question
		Yes	Address in AA and go to next question
Agg/Deg	Will the proposed structure reside in a watershed subject to variation in watershed sediment supply?	No	Go to next level
		Yes	Address in AA and go to level 4
4. Structural Design Level	Will the proposed structure cause backwatering at or below the design discharge?	No	Go to next question
		Yes	Address in AA and go to next question
	Will the proposed structure be subject to orifice flow (contraction at the soffit)?	No	Go to next question
		Yes	Address in AA and go to next question
	Will the proposed structure be placed skew to the primary direction of flow?	No	Go to next question
		Yes	Address in AA and go to next question
	Will the proposed structure be placed on a geotechnically unstable soil?	No	Go to next level
		Yes	Address in AA and go to level 5
5. Environmental Design Level	Will the construction of the proposed project displace sensitive habitat?	No	Go to next question
		Yes	Address in AA and go to next question
	Will the proposed structure cause changes to local hydraulics that impact sensitive habitat?	No	Go to next question
		Yes	Address in AA and go to next question
	Will the construction of the proposed project impact water quality?	No	Go to next question
		Yes	Address in AA and go to next question
	Will the proposed structure negatively impact aquatic species migration?	No	Exit matrix
		Yes	Address in AA and exit matrix

DESIGN ALTERNATIVES

Alternatives to standard box culverts should be considered when the matrix identifies design element impacts to the continuity of sediment transport and to reduce impediments to fish passage within a stream. Generally, design alternatives include the following design considerations:

1. Designs with soft bottoms;
2. Designs that span the design discharge top width at the project site;
3. Designs that do not form a backwater upstream of the project site;
4. Designs that do not cause increased velocities through or downstream of the crossing;
5. Designs that do not locally cause significant changes in sediment transport capacity;
6. Designs that minimize or avoid impacts to habitat;
7. Designs that do not impede migration of fish and other species.

Design elements that may be utilized to address these considerations include the following, when appropriate:

1. Three sided structures;
2. Designs which include abutment placement outside WOUS;
3. Utilization of grade control elements;
4. Structures designed to avoid orifice flow;
5. Employment of lateral erosion protection;
6. Designs which avoid deposition upstream of the structure.

There are best practices to address specific drivers or combinations of drivers. While some of best practices are described below, it is left to the engineer to determine if and how to implement them. Moreover, many of the best practices listed here may not be suitable for every project or setting, therefore, engineers should determine which best practices may be most appropriate to the specific project design and location.

Best practices for aggrading channels or reaches are those that prevent or minimize the accumulation of sediments upstream or within the structure. These best practices may frequently include designs that increase velocity locally to minimize aggradation since aggradation may reduce capacity of the stream crossing. In contrast, the best practices for degrading systems are those that promote sediment aggradation through locally reduced velocities (e.g., reduced transport capacity) or include grade control. It is very important for Designers to recognize that promoting aggradation at specific locations may exacerbate degradation downstream by disrupting sediment transport continuity. Designs that promote local aggradation should be carefully employed to minimize downstream impacts. Alternatives analyses shall include best practices for aggrading and degrading channels where appropriate.

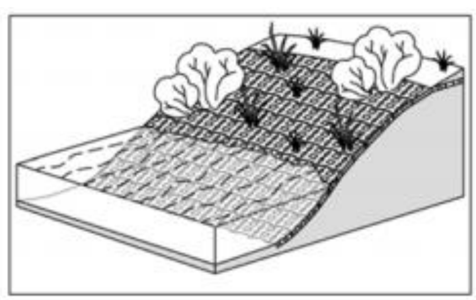

Figure 3 - Example of environmentally sensitive lateral erosion protection utilizing articulating concrete blocks. Note that the blocks have been vegetated following application to restore habitat. McCullah and Gray (2005).

The best practice for backwatering is to prevent it from occurring under the proposed conditions. If the proposed stream crossing is to be placed in a stream section that is already experiencing backwatering conditions, best practices shall be employed to prevent additional design WSEL rise and local reduction in sediment transport.

Much like degrading channels, the best practice for head cutting is typically grade control. Like degrading conditions, when head cutting is present it is important to prevent erosion downstream of grade controls due to sediment transport discontinuity. One solution for this may be a series of grade controls that gradually bring the bed elevation down to the elevation below the cut. Where backwatering and/or head cutting are present, the alternative analysis shall include best practices to mitigate or minimize these conditions.

Figure 4 - Culvert on Crossett Brook, Danbury, CT. This is an example of downstream grade control that allows for fish passage. (AP photo).

In the case of lateral erosion, engineers shall be aware of toe failure and water surface super elevations outside of bends in the waterway. Lateral erosion may be particularly problematic on the outside bank of channel bends or meanders. Many best practices related to lateral erosion are described in McCullah and Gray (2005); Designers should consider these practices individually, in combination, or in variation, particularly where the protection of crossing abutments is paramount to the long-term stability of the structure. Different approaches to mitigate lateral erosion should be presented in the alternatives analysis.

Debris and ice flows may impact WSEL and sediment transport in stream crossing projects. Debris (Simons and Senturk 1992) and ice (Ashton 2004) have periodic or seasonal impacts that significantly impact local channel hydraulics and stream bed response. Best practices to minimize, or mitigate for problems arising from these stream conditions shall be discussed in the alternatives analysis when present.

Pressure flow typically occurs when the capacity of the crossing is less than that required to pass given discharge. While pressure flow may be an intentional design condition in hard-bottomed crossings, it is not appropriate in soft-bottomed crossings. Soft-bottomed crossings with pressure flow may experience significant erosion of the soft bottom. This erosion may give rise to the failure of the crossing piers or abutments, as well as alterations of the bed that result in the reduced ability for the fish to migrate upstream. While there may be circumstances that use pressure flow in soft bottomed channels as an intentional design element (i.e., minimizing aggradation at the crossing), the best practice for reduction of pressure flow is to increase the hydraulic capacity of the stream crossing. Any alternatives analysis should discuss the use of pressure flow when present.

Finally, the direct environmental impacts of stream crossings shall be addressed in the alternatives analysis. While the best practices, noted above, imply reducing impacts to environmental integrity, including fish passage and loss of sensitive habitat, common sense should indicate that additional care shall be taken to minimize the environmental impacts of the project overall. In many cases the best practice for reducing environmental impacts is relocating a proposed stream crossing. While it is readily apparent that relocation is not always possible, measures to minimize removal or reduction of habitat and fish passage should be considered significant design elements in any alternatives analysis. One best practice to avoid habitat impacts is to span any sensitive channel sections completely. Another environmental impact is the placement of abutments and piers within sensitive habitats. This kind of impact should be avoided when possible and should also be addressed in an alternatives analysis.

MATRIX PROCESS

DETERMINE REGULATORY SETTING

A jurisdictional determination should be made by the USACE. Generally, if a stream is tributary to a WOUS and/or is navigable then it is jurisdictional. Likewise, if the proposed project encroaches on a wetland adjacent to WOUS the project is likely to be subject to regulatory oversight. Regardless of the regulatory setting of a project, a jurisdictional determination should be made as early in the project as possible. Once a determination has been made, avoidance of WOUS may be considered in the alternatives analysis.

CALCULATE EXISTING CONDITIONS HYDRAULICS

When required, calculations of the existing hydraulic conditions should typically be done using USACE's Hydraulic Engineering Center – River Analysis System (HEC-RAS) or an equivalent model. While it is possible to achieve reasonable results using hand calculations, basic one-dimensional modeling of the channel and crossing structure should be considered the minimum level of effort. Historical conditions may also be modeled if reliable topographic or bathymetric data are available for the stream channel. Historical conditions are an important tool in understanding the geomorphic change that occurred in the system and provide insight into channel stability, relating to a broad range of design elements. In any case, historical and existing conditions serve as a basis of comparison in any alternatives analysis.

Hydraulic calculations shall be run for a full range of conditions that may impact the structure. These include the daily flows (in perennial streams) and flow intervals typically up to the 100-year (1% annual probability) storm event. Calculations may be made using steady state assumptions. Unsteady flow calculations may be used, particularly if sediment transport analyses shall be required. In some cases, the FEMA or other agencies may require steady state discharge analyses of at least the 100- year (1.0% annual probability) storm event or less frequent (i.e., 200-year). Typically, the return periods analyzed in stream crossings include the daily and 2-, 5- 10-, 25-, 50-, 100-, 200- and 500-year storm events. The top width of flow for the daily discharge most frequently represents the absolute minimum that is typically allowed for the crossing length between abutments, while the 2- to 5-year discharge top width is typically the minimum crossing length in jurisdictional settings (please see section 404 of the CWA and related guidance). The 100-year or design discharge is utilized for numerous design elements, such as the minimum soffit elevation, abutment and pier scour calculations and other crossing features. Existing conditions hydraulics shall be developed by crossing Designers as early as possible in the project to minimize the potential for redesign.

EXAMINE GEOMORPHIC STABILITY

Streams are dynamic systems and stream crossing design should account for this dynamism since unanticipated or unconsidered change may lead to crossing failure. Therefore, the use of geomorphic methods, such as those described by Chang (1992), Jaffe (2007), Leopold et al. (1992), Simons and Senturk (1992), Yang (2003) and others, are important for understanding stream stability and time dependent variability in a system.

A project may be broken down into two different time periods: stream conditions up to the existing condition and the future expected condition. It may make sense for the engineer to consider other time periods, such as before development of the watershed or following the change in agricultural practices in the region. In any case, the concept of time frames employed to consider temporal variation in crossing design is important. Time dependent change in a stream may be as short as the time of concentration following a rain event to as long as geologic time scales (i.e., the formation of sedimentary materials as glaciers receded). While every time scale need not be examined in every project, some questions should be answered for typical crossing projects.

Typical time-scale-related geomorphic questions related to design include the following concepts:

1. What is the time scale for the long profile and planform pattern of the stream being crossed, particularly at the project site?
2. Are temporal variations evident seasonally (i.e., freeze/thaw cycles, agriculture), episodically (i.e., floods, fires), or over longer periods (i.e., watershed development, changes to habitat)?
3. What is the existing condition in regard to these geomorphic trends and with respect to aggradation, degradation, meandering and overall stability?

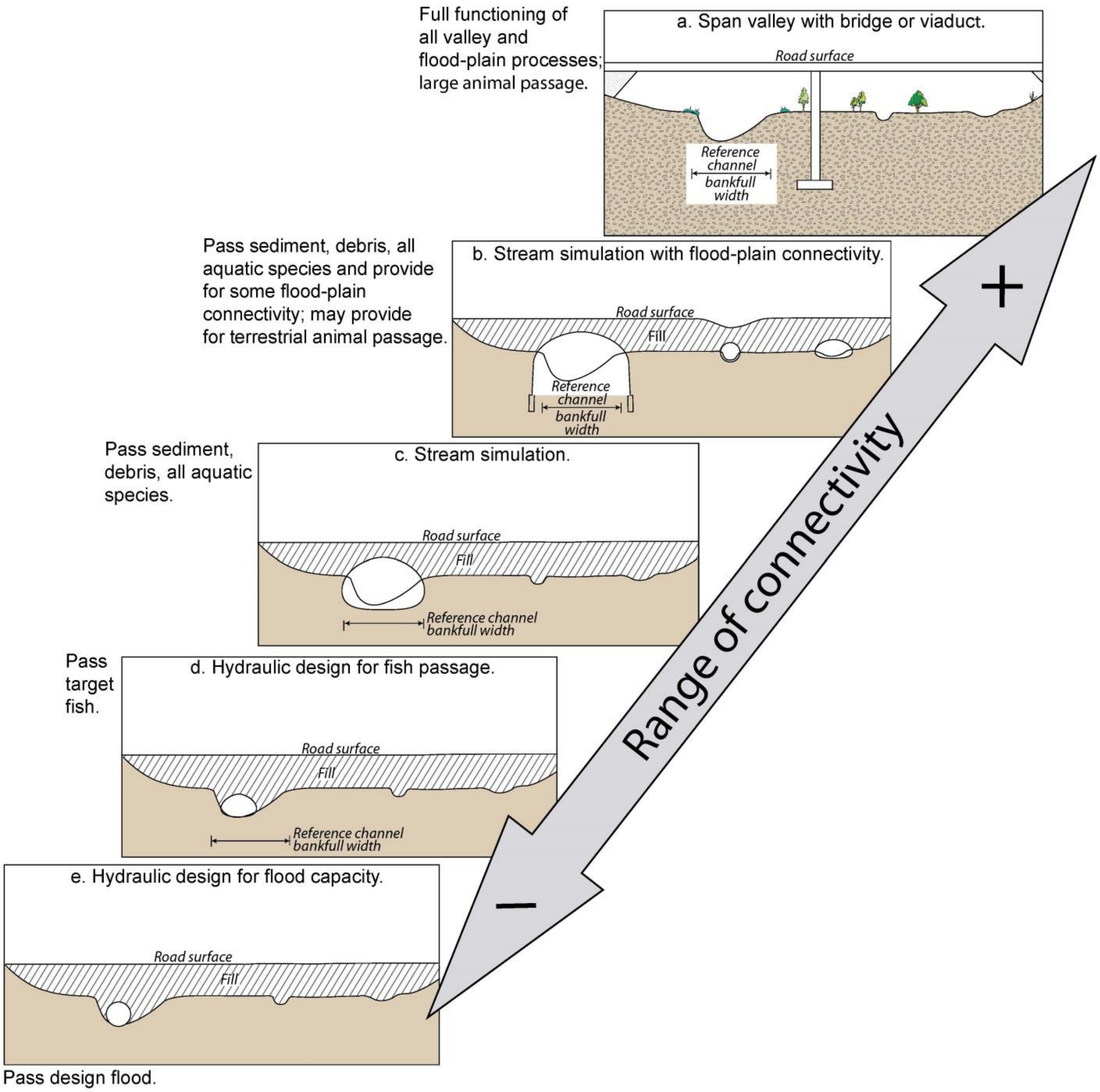

Figure 7 – Range of crossing ecological objectives and examples of corresponding design approaches, Image from USFS (2008).

While every project may not need to have detailed answers to each question, the concepts described above shall be applied to the design of every project and it is left to the Designer to determine in what circumstances they should be answered in detail.

To address these concepts it is useful to employ historic topography, aerial photography, empirical equations and when available, as-built drawings. Other methods include more frequently employed techniques by geologists, planners and other professionals. With historic and analytic data the Designer should be able to understand the extent of change in the stream and the time scales on which it occurs. For example, does the Designer need to consider bank failure caused by lateral erosion; or has the planform stability of the stream been impacted by long-term, historic development of the watershed such that future changes may require countermeasures at the project site; or may head cutting trends impact the ability to provide fish passage at the crossing? Also, when employing predictive techniques such as hydraulic geometry relationships, values may be computed for the existing and proposed conditions in an alternatives analysis to estimate the potential changes to bed geomorphology in the vicinity of the project site.

REVIEW STRUCTURAL DESIGN

Proposed hydraulics conditions and scour design should both be reviewed subsequently to determine if and to what extent the proposed conditions may alter local stream hydraulics and sediment transport. All alternative analyses shall examine the various impacts caused by the structure and discuss the best practices employed in each scenario to mitigate those impacts.

DETERMINE ENVIRONMENTAL IMPACTS

Environmental impacts shall be covered under environmental permitting, but should also be considered as part of design, particularly with respect to fish passage and minimizing impacts to habitat. For example, is the proposed structure expected to create an impediment to fish migration and spawning by increasing velocity or reducing quiescent zones for fish resting? Is the proposed structure to be placed within sensitive or endangered habitat? An alternatives analysis cannot be considered complete without a discussion of these impacts for each alternative considered.

DESIGN PROCESS EXAMPLE

The following example is a previously completed project and represents the kind of processes that go into the selection of stream crossing designs at various locations. While the details are not included herein for brevity, the important elements of the design decision process are retained for clarity.

The project team has determined that the project site may cross jurisdictional water and USACE has concurred with this finding. A HEC-RAS model of existing conditions is run to determine the baseline project hydraulics. Historic topography obtained from USACE, USGS and the local flood agency suggests that changes to the watershed from agriculture to suburban development in the 1970s and 1980s, as well as the development of an upstream reservoir in the 1940s, led to a significant reduction in sediment supply at the project site. Bed degradation at the project site increased as a result. Recent aerial photography obtained from the local flood agency indicates that the watershed and stream are nearing equilibrium with respect to sediment balance, as indicated by decreased frequency of bank failures and longitudinal profiles, while the operators of the reservoir have also become more efficient in sluicing sediment from behind the dam, as indicated by a geology study commissioned by the reservoir’s owners.

A railroad crossing exists upstream of the proposed project, but that structure is undersized relative to contemporary design standards. The structure is inundated during large design events, but no formal studies have been conducted to determine the discharge magnitude or return period of the inundation event. A review of the railroad structure’s maintenance records, provided by the structure’s owner, indicates that significant woody debris needs to be cleared from the piers following events greater than approximately a 10-year return period. The crossing as-builds, obtained with the maintenance records, suggest that on average, the bed underneath the structure receives approximately one quarter inch of degradation annually over the period of record.

The proposed project includes the placement of three crossings within the stream. One crossing, the most downstream, may be made with a precast three-sided structure where the abutment is to be placed on the banks outside of the channel. The remaining two crossings are on straight reaches, the most upstream of which has one bank made of artificial fill placed during a previous unrelated project. A geological engineering report prepared by the existing project's owner has been prepared for the fill and the stream banks and the report finds that fill section may require additional stabilization measures, while the natural banks may not require special measures and standard abutment design is sufficient.

Preliminary designs for the upper and middle crossings are developed and a proposed conditions hydraulic analysis is prepared for each crossing. The preliminary proposed conditions HEC-RAS modeling indicates that the upstream crossing should be redesigned since the structure is being over-topped during the design (100-year) event. To accommodate the design discharge the structure soffit elevation may be raised and the abutment may be pulled back from the channel. Additionally, the modeling indicates that high velocities may exacerbate the previously noted geotechnical instability on the fill bank, therefore scour and slope failure protection may also be included in the final design. This change becomes the preferred alternative in the alternatives analysis. The middle crossing preliminary design was found to be hydraulically adequate during numerical modeling as only a small backwater is expected to be caused by the placement of the structure during the design discharge (Δh_{max}=0.1 feet). Other design alternatives incurred greater backwatering as shown in the alternatives analysis.

A scour analysis was performed for the upper and middle crossings based on the existing and proposed conditions HEC-RAS models for the preferred alternatives. Sediment data from the geotechnical reports, augmented with additional sediment sampling, was used to perform the scour analysis. The modeling of general bed adjustment (that which occurs during a single design event) found that little change in sediment transport may be expected in the proposed condition since the primary impact of the proposed condition is reduced velocity upstream of the crossings. A long-term bed adjustment analysis was also completed that projected the long-term change in bed expected based on proposed hydraulics. The long-term analysis utilized historical gage data as a proxy for future conditions under the assumption that future runoff events would have the same relative frequency and magnitude compared to those in the gage record. A Spearman-Conley test (McCuen 1998) was performed on the gage data to ensure the reasonableness of this assumption. The general and long-term bed adjustment modeling results were combined with local scour calculations and railroad maintenance records for debris blockage to arrive at a total scour depth using the procedures defined in HEC-18 (FHWA 2012). The toe-down depths of the crossing abutments were determined with this data.

Finally, an environmental hydraulic impacts study was performed to assess the hydraulic impacts to sensitive habitats in the vicinity of the project. The analysis followed the procedure set forth by Jaffe (2013, 2007) and Jaffe and Rovansek (2004) using HEC-RAS model output and GIS-based habitat maps. The analysis showed that the locations of expected hydraulic impacts during the design event were collocated with non-native species and the project would not negatively impact sensitive habitats through hydraulic changes. An alternative analysis design report was prepared that summarized the findings.

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APPENDIX L. SAMPLE SUMMARY TABLE FOR CRITICAL STORM DURATION ANALYSIS

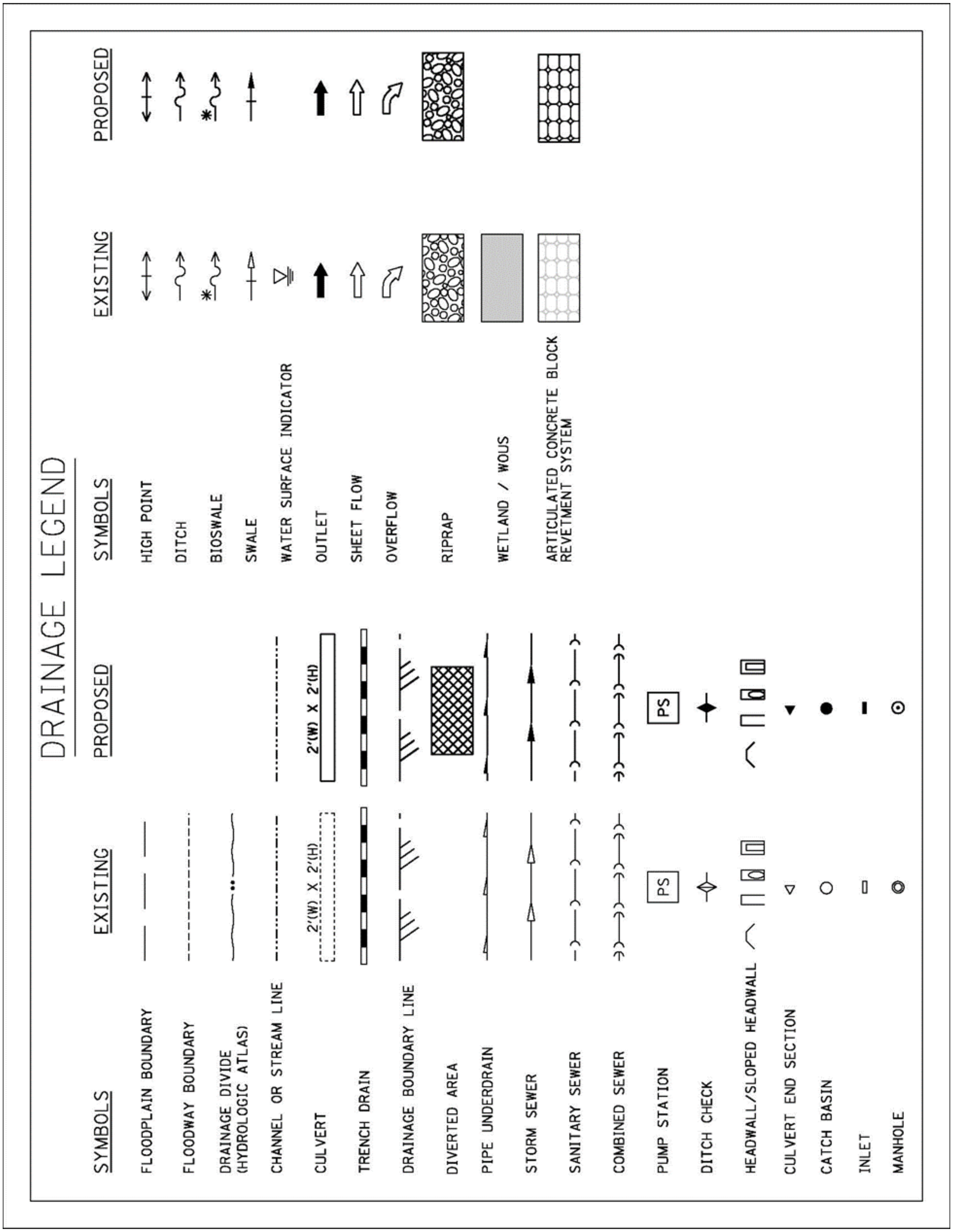
Critical Storm Duration Analysis (2-yr Flood Event)

Storm Duration (hr)	Allowable Release Rate (cfs)	Peak Discharge (cfs)	Maximum Water Surface Elevation (ft)	Detention Volume (acre-ft)
0.5				
1				
2				
3				
6				
12				
24				
48				
72				

Critical Storm Duration Analysis (100-yr Flood Event)

Storm Duration (hr)	Allowable Release Rate (cfs)	Peak Discharge (cfs)	Maximum Water Surface Elevation (ft)	Detention Volume (acre-ft)
0.5				
1				
2				
3				
6				
12				
24				
48				
72				

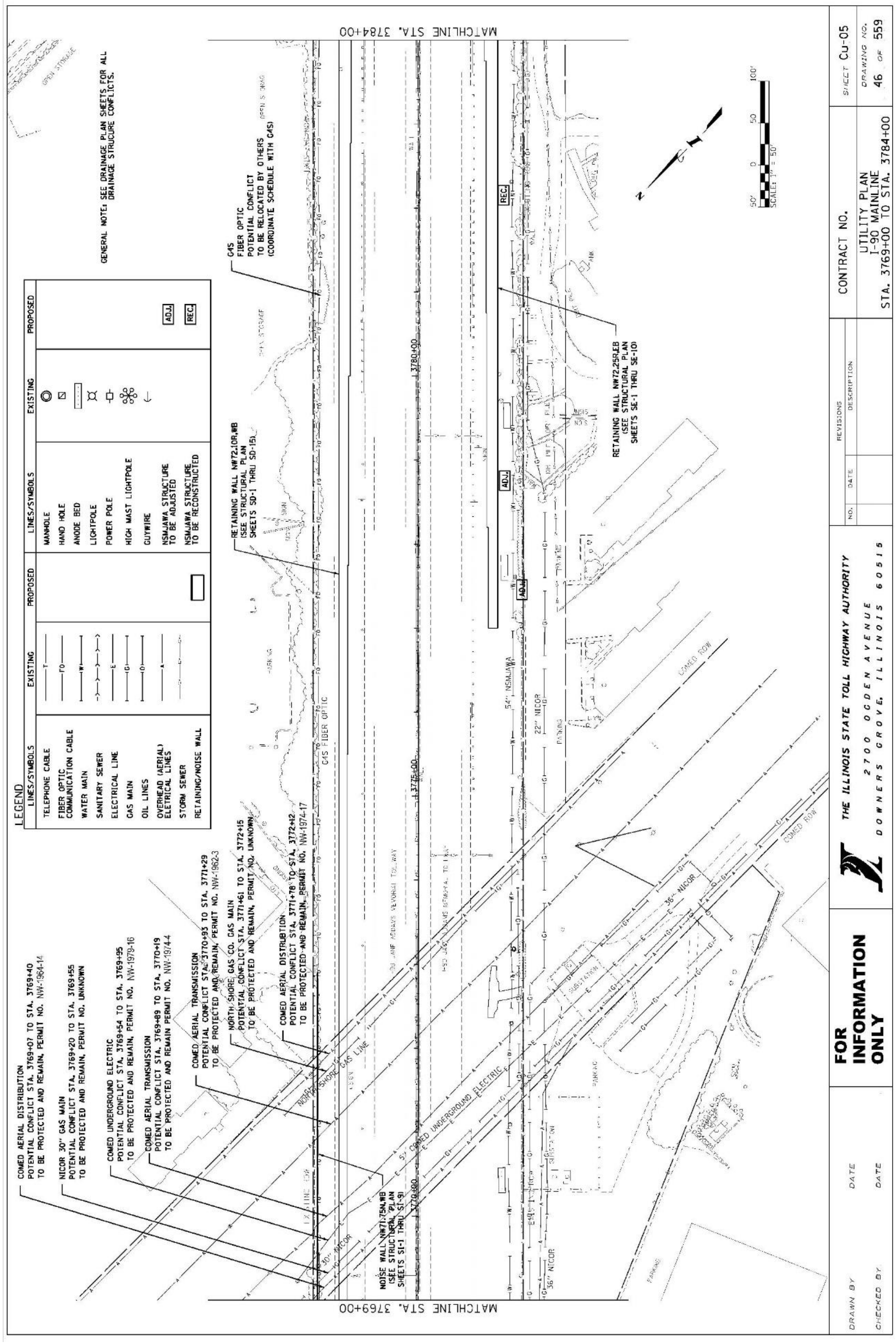
APPENDIX M. DRAINAGE LEGEND

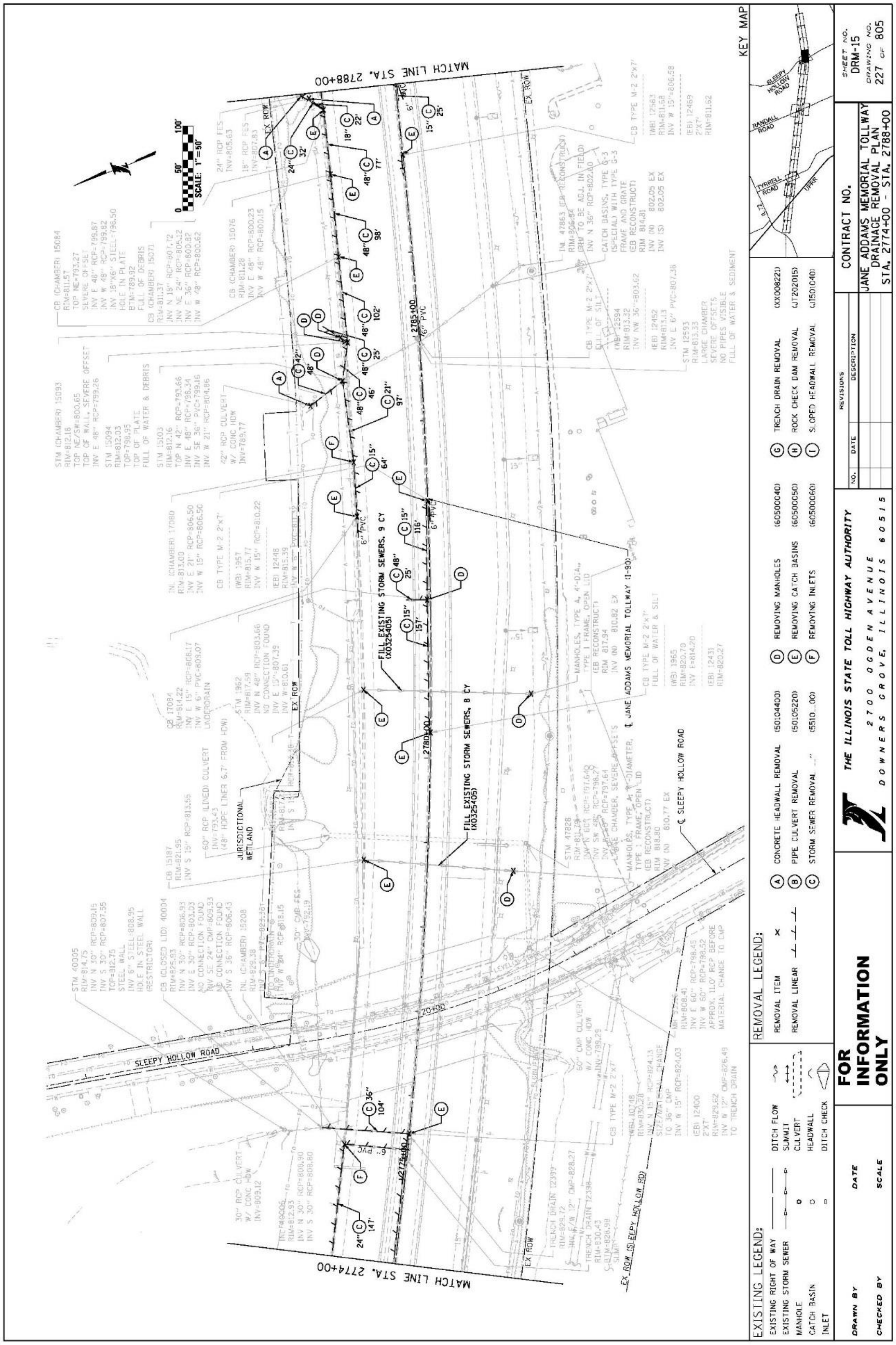

DRAINAGE LEGEND
SYMBOLS
EXISTING
PROPOSED
FLOODPLAIN BOUNDARY
FLOODWAY BOUNDARY
DRAINAGE DIVIDE (HYDROLOGIC ATLAS)
CHANNEL OR STREAM LINE
CULVERT
2'(W) X 2'(H)
2'(W) X 2'(H)
TRENCH DRAIN
DRAINAGE BOUNDARY LINE
DIVERTED AREA
PIPE UNDERDRAIN
STORM SEWER
SANITARY SEWER
COMBINED SEWER
PUMP STATION
PS
PS
DITCH CHECK
HEADWALL/SLOPED HEADWALL
CULVERT END SECTION
CATCH BASIN
INLET
MANHOLE
SYMBOLS
EXISTING
PROPOSED
HIGH POINT
DITCH
BIOSWALE
SWALE
WATER SURFACE INDICATOR
OUTLET
SHEET FLOW
OVERFLOW
RIPRAP
WETLAND / WOUS
ARTICULATED CONCRETE BLOCK REVETMENT SYSTEM

APPENDIX N. SAMPLE CONTRACT PLAN DRAWINGS

(FOR INFORMATION ONLY)

MATCH LINE SEE SHEET 18
SEE SHEET 132
SEE SHEET 132
RAMP
RAMP
ELGIN O'HARE EXPY W.B.
ELGIN O'HARE EXPY E.B.
MEACHAM CREEK
MEACHAM CREEK
OUTLET ME 10
OUTLET ME 5
COOK
DuPAGE
COUNTY LINE
KEY PLAN
EXISTING DRAINAGE PLAN
MEACHAM CREEK WATERSHED
ELGIN O'HARE EXPRESSWAY
FOR INFORMATION ONLY
MATCH LINE SEE SHEET 16


MATCHLINE STA. 3784+00
MATCHLINE STA. 3769+00
GENERAL NOTE: SEE DRAINAGE PLAN SHEETS FOR ALL DRAINAGE STRUCURE CONFLICTS.
FOR INFORMATION ONLY
THE ILLINOIS STATE TOLL HIGHWAY AUTHORITY
2700 OGDEN AVENUE
DOWNERS GROVE, ILLINOIS 60515
CONTRACT NO.
UTILITY PLAN
I-90 MAINLINE
STA. 3769+00 TO STA. 3784+00
SHEET CU-05
DRAWING NO.
46 OF 559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MATCH LINE STA. 2774+00
KEY MAP
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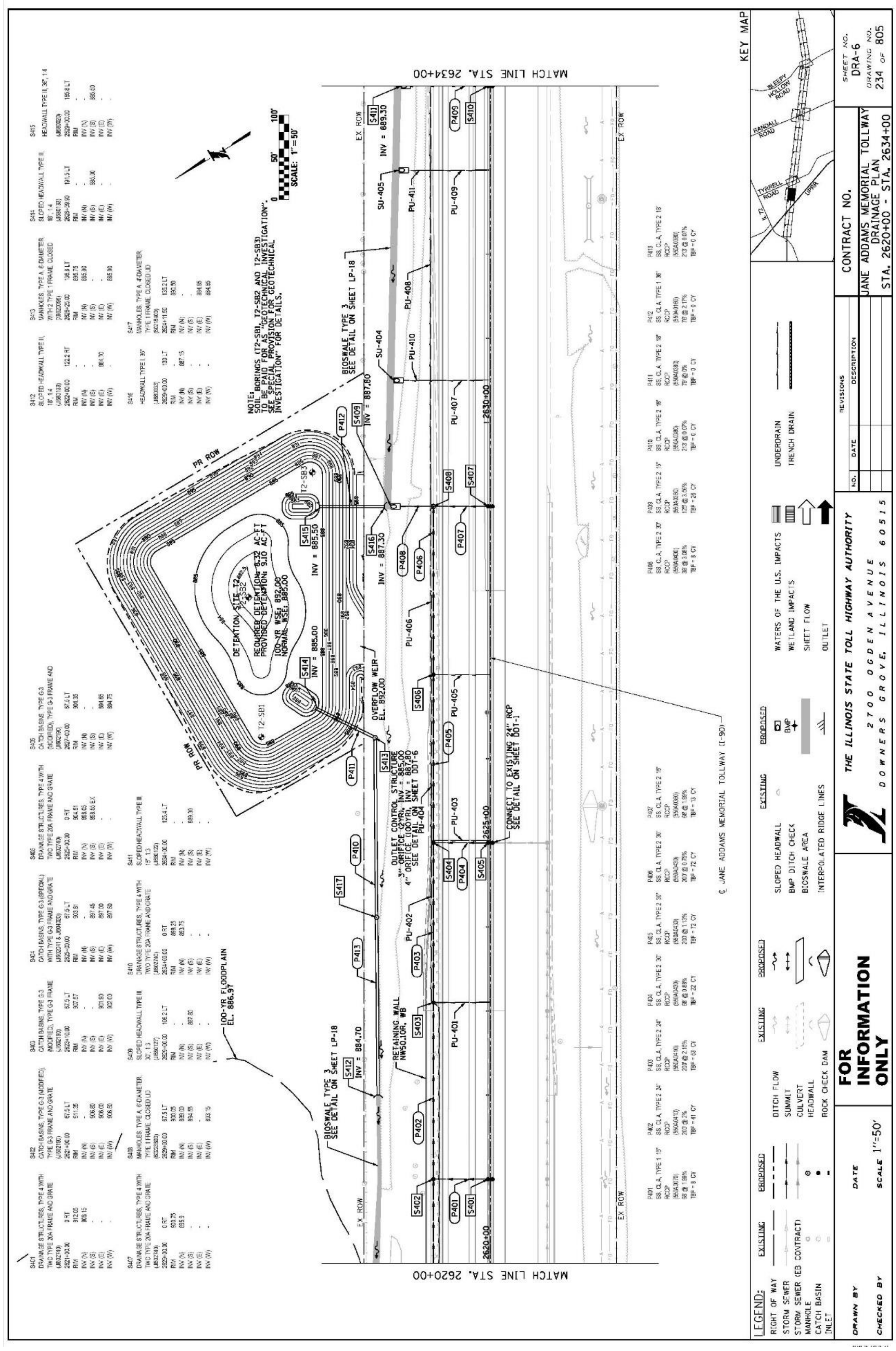
SLEEPY HOLLOW ROAD
EXISTING LEGEND:
EXISTING RIGHT OF WAY
EXISTING STORM SEWER
MANHOLE
CATCH BASIN
INLET
DITCH FLOW
SUMMIT
CULVERT
HEADWALL
DITCH CHECK
REMOVAL LEGEND:
REMOVAL ITEM
REMOVAL LINEAR
CONCRETE HEADWALL REMOVAL (50104400)
PIPE CULVERT REMOVAL (50105220)
STORM SEWER REMOVAL (5510...00)
REMOVING MANHOLES (60500040)
REMOVING CATCH BASINS (60500050)
REMOVING INLETS (60500060)
TRENCH DRAIN REMOVAL (XX008221)
ROCK CHECK DAM REMOVAL (JT202015)
SLOPED HEADWALL REMOVAL (JT501040)
FILL EXISTING STORM SEWERS, 9 CY
FILL EXISTING STORM SEWERS, 8 CY
JURISDICTIONAL WETLAND
FOR INFORMATION ONLY
THE ILLINOIS STATE TOLL HIGHWAY AUTHORITY
2700 OGDEN AVENUE
DOWNERS GROVE, ILLINOIS 60515
CONTRACT NO.
JANE ADDAMS MEMORIAL TOLLWAY
DRAINAGE REMOVAL PLAN
STA. 2774+00 - STA. 2788+00
SHEET NO. DRM-15
DRAWING NO. 227 OF 805
DRAWN BY
CHECKED BY
DATE
SCALE
REVISIONS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MATCH LINE STA. 2620+00
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2700 OGDEN AVENUE
DOWNERS GROVE, ILLINOIS 60515
CONTRACT NO.
JANE ADDAMS MEMORIAL TOLLWAY
DRAINAGE PLAN
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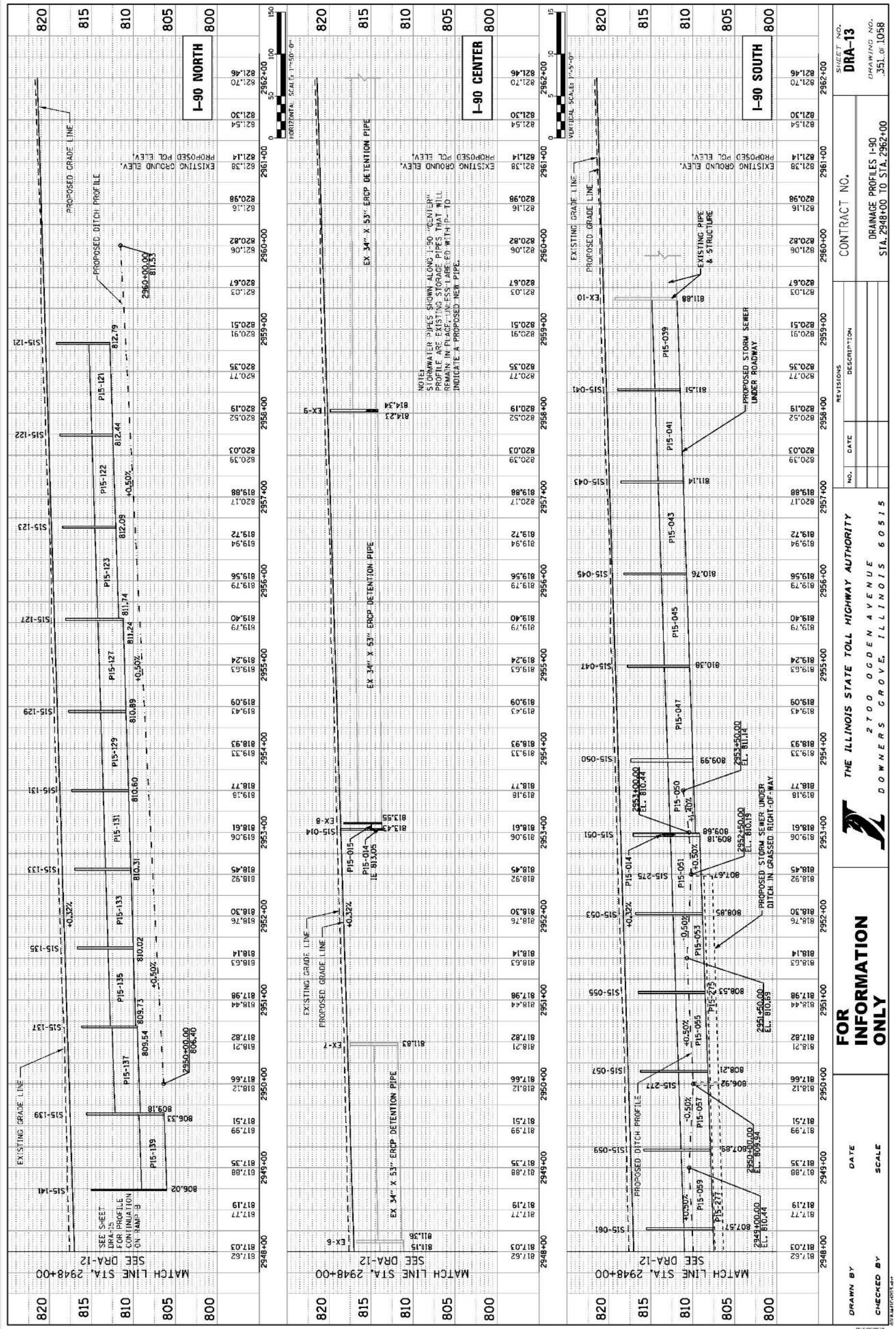
SCALE 1"=50'


I-90 NORTH
I-90 CENTER
I-90 SOUTH
FOR INFORMATION ONLY
THE ILLINOIS STATE TOLL HIGHWAY AUTHORITY
2700 OGDEN AVENUE
DOWNERS GROVE, ILLINOIS 60515
CONTRACT NO.
DRAINAGE PROFILES I-90
STA. 2948+00 TO STA. 2962+00
SHEET NO.
DRA-13

DRAINAGE STRUCTURE TABLE										
STRUCTURE	STRUCTURE TYPE	STATION	OFFSET (LT)	RIM	INV (N)	INV (S)	INV (E)	INV (W)	STANDARD #	FRAME & GRATE
S1501	CATCH BASINS, TYPE G-3 (MODIFIED), TYPE G-3 FRAME AND GRATE	2761+00.82	79.5 LT	858.75	-	-	849.90	853.70	B8-03	B8-03
S1502	CATCH BASINS, TYPE G-3 (MODIFIED), TYPE G-3 FRAME AND GRATE	2763+00.82	79.5 LT	854.79	-	-	847.85	849.05	B8-03	B8-03
S1503	CATCH BASINS, TYPE G-3 (SPECIAL) WITH TYPE G-3 FRAME AND GRATE	2764+05.18	79.5 LT	852.96	844.60	843.80	-	847.30	SEE DOT-4	B8-03
S1504	DRAINAGE STRUCTURES, TYPE 4 WITH TWO TYPE 20A FRAME AND GRATE	1764+05.18	0.0 LT	853.65	844.10	844.50	-	-	602106-01	B25-00
S1505	CATCH BASINS, TYPE G-3, TYPE G-3 FRAME AND GRATE	2765+00.00	79.5 LT	850.83	-	-	846.60	-	B8-03	B8-03
S1506	CATCH BASINS, TYPE G-3, TYPE G-3 FRAME AND GRATE	2767+00.00	79.5 LT	846.87	-	842.65	842.55	842.65	B8-03	B8-03
S1507	DRAINAGE STRUCTURES, TYPE 4 WITH TWO TYPE 20A FRAME AND GRATE	2767+00.00	0.0 LT	847.81	843.35	-	-	-	602106-01	B25-00
S1508	CATCH BASINS, TYPE G-3, TYPE G-3 FRAME AND GRATE	2769+00.00	79.5 LT	842.91	-	-	838.60	838.70	B8-03	B8-03
S1509	CATCH BASINS, TYPE G-3 (MODIFIED), TYPE G-3 FRAME AND GRATE	2770+25.00	79.5 LT	840.43	-	-	835.60	835.85	B8-03	B8-03
S1510	DRAINAGE STRUCTURES, TYPE 4 WITH TWO TYPE 20A FRAME AND GRATE	2770+36.95	0.0 LT	841.18	834.50	834.50	-	836.55	602106-01	B25-00
S1511	CATCH BASINS, TYPE A, 4'-DIAMETER, TYPE 20A FRAME AND GRATE	2773+21.58	3.5 RT	836.35	823.95	823.95	823.95	-	602001-02	B25-00
S1512	CATCH BASINS, TYPE G-3 (MODIFIED), TYPE G-3 FRAME AND GRATE	2773+30.07	79.6 LT	833.55	-	-	824.95	824.50	B8-03	B8-03
S1513	CATCH BASINS, TYPE B, TYPE 7 GRATE	2760+80.00	110.7 LT	855.33	-	-	840.00	-	B7-01	604031-02
S1514	SLOPED HEADWALL TYPE III, 30", 1:4	2761+74.73	191.9 LT	-	-	-	-	837.50	B10-05	-
S1515	HEADWALL TYPE III, 36", 1:4	2764+05.18	178.2 LT	-	-	844.50	-	-	B6-03	-
S1516	SLOPED HEADWALL TYPE III, 24", 1:3	2766+17.79	169.7 LT	-	-	-	837.00	-	B10-05	-
S1517	MANHOLES, TYPE A, 6'-DIAMETER, WITH 2 TYPE 1 FRAME, CLOSED LID, RESTRICTOR PLATE	2766+61.18	163.2 LT	843.00	-	-	837.00	837.00	SEE DOT-6	604001-03
S1518	SLOPED HEADWALL TYPE III, 24", 1:3	2767+20.50	153.3 LT	-	-	-	-	835.00	B10-05	-
S1519	DRAINAGE STRUCTURES, TYPE 4 WITH TWO TYPE 20A FRAME AND GRATE	2768+80.00	0.0 LT	844.25	-	-	839.75	-	602106-01	B25-00
S1601	CATCH BASINS, TYPE G-3 (MODIFIED), TYPE G-3 FRAME AND GRATE	2774+25.00	79.5 LT	831.92	-	-	825.40	825.30	B8-03	B8-03
S1602	CATCH BASINS, TYPE G-3 (MODIFIED), TYPE G-3 FRAME AND GRATE	2776+00.00	79.5 LT	828.90	-	-	-	826.86	B8-03	B8-03
S1603	CATCH BASINS, TYPE A, 4'-DIAMETER, TYPE 20A FRAME AND GRATE	2774+75.00	3.5 RT	832.27	-	-	825.65	825.55	602001-02	B25-00
S1604	CATCH BASINS, TYPE A, 4'-DIAMETER, TYPE 20A FRAME AND GRATE	2776+00.00	3.5 RT	829.79	-	-	-	825.65	602001-02	B25-00
S1605	SCUPPER, DS-12M10	2778+00.00	49.5 LT	824.20	-	820.40	-	-	SEE RWE-4	-
S1606	CATCH BASINS, TYPE A, 4'-DIAMETER, TYPE 20A FRAME AND GRATE	2778+00.00	3.5 RT	825.83	820.00	-	820.00	-	602001-02	B25-00
S1607	CATCH BASINS, TYPE A, 4'-DIAMETER, TYPE 20A FRAME AND GRATE	2779+50.00	3.5 RT	822.87	817.15	-	816.40	817.15	602001-02	B25-00
S1608	SCUPPER, DS-12M10	2779+50.00	79.5 LT	821.27	-	817.61	-	-	SEE RWE-4	-
S1609	CATCH BASINS, TYPE A, 4'-DIAMETER, TYPE 20A FRAME AND GRATE	2781+00.00	3.5 RT	819.89	814.20	-	813.45	813.45	602001-02	B25-00
S1610	SCUPPER, DS-12M10	2781+00.00	79.5 LT	818.31	-	814.66	-	-	SEE RWE-4	-
S1611	CATCH BASINS, TYPE A, 4'-DIAMETER, TYPE 20A FRAME AND GRATE	2782+00.00	3.5 RT	817.91	-	-	812.65	812.65	602001-02	B25-00
S1612	CATCH BASINS, TYPE G-3 (MODIFIED), TYPE G-3 FRAME AND GRATE	2782+00.00	79.5 LT	816.33	-	-	811.80	-	B8-03	B8-03
S1613	CATCH BASINS, TYPE A, 4'-DIAMETER, TYPE 20A FRAME AND GRATE	2783+00.00	3.5 RT	815.95	-	-	810.70	810.70	602001-02	B25-00
S1614	CATCH BASINS, TYPE G-3 (MODIFIED), TYPE G-3 FRAME AND GRATE	2783+00.00	79.5 LT	814.36	-	-	809.85	809.85	B8-03	B8-03
S1615	CATCH BASINS, TYPE A, 5'-DIAMETER, TYPE 20A FRAME AND GRATE	2784+00.00	3.5 RT	814.29	809.00	-	-	809.00	602001-02	B25-00
S1616	CATCH BASINS, TYPE G-3 (MODIFIED), TYPE G-3 FRAME AND GRATE	2784+00.00	79.5 LT	812.70	-	-	806.55	806.55	B8-03	B8-03
S1617	CATCH BASINS, TYPE G-3 (MODIFIED), TYPE G-3 FRAME AND GRATE	2785+00.00	79.5 LT	811.43	-	-	-	810.70	B8-03	B8-03
S1618	CATCH BASINS, TYPE A, 4'-DIAMETER, TYPE 20A FRAME AND GRATE	2786+00.00	3.5 RT	812.14	807.75	-	-	-	602001-02	B25-00
S1619	CATCH BASINS, TYPE G-3 (MODIFIED), TYPE G-3 FRAME AND GRATE	2786+00.00	79.5 LT	810.56	805.80	807.05	-	805.80	B8-03	B8-03
S1620	SLOPED HEADWALL TYPE III, 30", 1:3	2786+00.00	98.5 LT	-	-	805.57	-	-	B10-05	-
S1621	CATCH BASINS, TYPE G-3 (MODIFIED), TYPE G-3 FRAME AND GRATE	2786+48.00	79.8 LT	810.27	-	-	806.55	-	B8-03	B8-03
S1622	CATCH BASINS, TYPE G-3 (MODIFIED), TYPE G-3 FRAME AND GRATE	2786+70.00	79.8 LT	810.21	806.05	806.30	806.30	806.45	B8-03	B8-03
S1623	CATCH BASINS, TYPE G-3 (MODIFIED), TYPE G-3 FRAME AND GRATE	2787+11.00	81.3 LT	810.28	806.05	806.30	806.30	806.30	B8-03	B8-03
S1624	CATCH BASINS, TYPE G-3 (MODIFIED), TYPE G-3 FRAME AND GRATE	2787+50.00	82.1 LT	810.46	-	-	-	806.45	B8-03	B8-03
S1625	DRAINAGE STRUCTURES, TYPE 5 WITH ONE TYPE 22A FRAME AND GRATE	2787+54.00	3.5 RT	811.72	-	-	-	807.30	602106-01	B27-00
S1626	DRAINAGE STRUCTURES, TYPE 5 WITH ONE TYPE 22A FRAME AND GRATE	2787+33.00	3.5 RT	811.71	-	-	807.20	807.20	602106-01	B27-00
S1627	SLOPED HEADWALL TYPE III, 18", 1:3	2787+11.00	102.5 LT	-	-	805.68	-	-	B10-05	-
S1628	HEADWALL TYPE III, 48", 1:10	2785+75.00	116.5 LT	-	-	-	-	805.05	B6-03	-
S1629	MANHOLES, TYPE A, 6'-DIAMETER, WITH 2 TYPE 1 FRAME, CLOSED LID, RESTRICTOR PLATE	2785+55.00	95.8 LT	809.35	-	-	805.00	805.00	SEE DOT-6	604001-03
S1630	MANHOLES, TYPE A, 6'-DIAMETER, TYPE 1 FRAME, CLOSED LID	2784+53.00	93.6 LT	810.80	-	-	804.80	793.00	602406-05	604001-03
S1631	MANHOLES, TYPE A, 6'-DIAMETER, TYPE 1 FRAME, CLOSED LID	2783+84.70	134.0 LT	804.44	785.87	-	792.80	-	602406-05	604001-03
S1632	HEADWALL TYPE II, 48"	2783+84.70	161.2 LT	-	-	785.55	-	-	B30-01	-
S1633	DRAINAGE STRUCTURES, TYPE 5 WITH ONE TYPE 22A FRAME AND GRATE	2787+11.00	3.5 RT	811.72	807.10	-	807.10	-	602106-01	B27-00

STORM SEWER SCHEDULE											
PIPE #	FROM	TO	LENGTH (FT)	DIA (IN)	PIPE TYPE	SLOPE (%)	UPSTREAM	DOWNSTREAM	TBF (CY)	Pay Item #	CLASS
P1501	S1501	S1502	200	30	2	0.4%	849.90	849.05	132	550A0430	III
P1502	S1502	S1503	105	30	2	0.5%	847.85	847.30	31	550A0430	III
P1503	S1504	S1503	77	30	2	0.4%	844.10	843.80	86	550A0430	III
P1504	S1505	S1506	200	15	1	2.0%	846.60	842.65	24	550A0070	IV
P1505	S1507	S1506	77	15	1	0.9%	843.35	842.65	8	550A0070	IV
P1506	S1506	S1508	200	15	1	1.9%	842.55	838.70	24	550A0070	IV
P1507	S1508	S1509	130	15	2	2.1%	838.60	835.85	16	550A0360	III
P1508	S1510	EX	77	18	2	1.2%	834.50	833.60	29	550A0380	III
P1509	EX	S1510	12	15	2	0.3%	834.64	834.60	4	550A0360	III
P1510	EX	S1511	12	15	3	0.2%	823.98	823.95	16	550A0660	IV
P1511	S1511	EX	80	18	3	1.0%	823.95	823.15	122	550A0680	IV
P1512	S1601	S1512	93	15	2	0.4%	825.30	824.95	66	550A0360	III
P1513	S1603	S1511	153	15	2	0.4%	825.55	825.00	151	550A0360	III
P1514	EX	S1504	12	24	2	0.8%	844.60	844.50	16	550A0410	III
P1515	S1513	S1514	105	30	2	2.4%	840.00	837.50	0	550A0430	III
P1516	S1503	S1515	99	36	2	0.6%	838.10	837.50	17	550A0450	III
P1517	S1516	S1517	44	24	1	0.0%	837.00	837.00	0	550A0120	IV
P1518	S1517	S1518	50	24	1	4.0%	837.00	835.00	0	550A0120	IV
P1519	S1509	EX	9	18	2	1.1%	835.60	835.50	1	550A0380	III
P1520	S1512	EX	9	18	2	1.1%	824.50	824.40	10	550A0380	III
P1521	S1519	S1510	157	15	2	2.0%	839.75	836.55	19	550A0360	III
P1601	S1602	S1601	125	15	2	0.4%	825.85	825.40	18	550A0360	III
P1602	S1604	S1603	125	15	2	0.4%	826.10	825.65	24	550A0360	III
P1603	S1605	S1606	72	10	2	0.6%	820.40	820.00	12	DIP	I
P1604	S1606	S1607	150	15	2	1.9%	820.00	817.15	39	550A0360	III
P1605	S1608	S1607	82	10	2	0.6%	817.61	817.15	12	DIP	I
P1606	S1607	S1609	150	24	2	2.0%	816.40	813.45	53	550A0410	III
P1607	S1610	S1609	82	10	2	0.6%	814.66	814.20	11	DIP	I
P1608	S1609	S1611	100	24	2	0.8%	813.45	812.65	26	550A0410	III
P1609	S1611	S1613	100	24	2	1.9%	812.65	810.70	18	550A0410	III
P1610	S1612	S1614	100	15	2	1.9%	811.80	809.86	12	550A0360	III
P1611	S1614	S1616	100	15	1	1.3%	809.85	808.55	12	550A0070	IV
P1612	S1613	S1645	100	24	1	1.7%	810.70	809.00	0	550A0120	IV
P1613	S1615	S1616	82	24	1	1.5%	809.00	807.80	10	550A0120	IV
P1614	S1616	S1617	100	30	1	0.8%	807.30	806.55	12	550A0140	III
P1615	S1617	S1619	100	30	1	0.8%	806.55	805.80	12	550A0140	III
P1616	S1618	S1619	82	15	2	0.9%	807.75	807.05	10	550A0360	III
P1617	S1619	S1620	18	30	1	1.3%	805.80	805.57	1	550A0140	III
P1618	S1621	S1622	22	15	1	0.5%	806.55	806.45	3	550A0070	IV
P1619	S1622	S1623	40	15	1	0.4%	806.40	806.30	0	550A0070	IV
P1620	S1625	S1626	23	15	2	0.4%	807.30	807.20	3	550A0360	III
P1621	S1626	S1633	22	15	2	0.5%	807.20	807.10	3	550A0360	III
P1622	S1633	S1623	79	15	1	1.0%	807.10	806.30	10	550A0070	IV
P1623	S1624	S1623	39	15	1	0.4%	806.45	806.30	5	550A0070	IV
P1624	S1623	S1627	21	18	1	1.8%	806.05	805.68	1	550A0090	IV
P1625	S1628	S1629	24	48	1	0.2%	805.00	805.00	0	550A0480	II
P1626	S1629	S1630	100	48	1	0.2%	805.00	804.80	0	550A0480	II
P1627	S1630	S1631	78	48	3	0.3%	793.00	792.80	0	550A0480	IV
P1628	S1631	S1632	30	48	2	1.1%	785.87	785.55	0	550A0480	III

DRAWN BY	DATE	FOR INFORMATION ONLY	THE ILLINOIS STATE TOLL HIGHWAY AUTHORITY 2700 OGDEN AVENUE DOWNERS GROVE, ILLINOIS 60515	REVISIONS (NO. / DATE / DESCRIPTION)	CONTRACT NO. JANE ADDAMS MEMORIAL TOLLWAY DRAINAGE SCHEDULE SHEETS DRA-16 & DRA-18	SHEET NO. DRA-19 DRAWING NO. 247 OF 805
CHECKED BY	SCALE					