Glossary of Terms

The definitions in this Glossary are for use with this Chapter and the references cited. They are not necessarily definitions as established by case or statutory law.

Acre-Foot: A unit of measurement for volume of water. It is equal to the quantity of water required to cover one acre to a depth of one foot and is equal to 43,560 cubic feet or 325,851 gallons. The term is commonly used in measuring volumes of water used or stored.

Annual Flood: The highest peak discharge in a water year.

Antecedent Precipitation Index: An index of moisture stored within a drainage basin before a storm (Linsley and others, 1949, p. 414).

Area-Capacity Curve: A graph showing the relation between the surface area of the water in a reservoir and the corresponding volume.

Average Discharge: In the annual series of the Geological Survey's reports on surface water supply, the arithmetic average of all complete water years of record, whether or not they are consecutive. Average discharge is not published for less than five years of record. The term "average" is generally reserved for averages of record and "mean" is used for averages of shorter periods, namely, daily mean discharge.

Backwater: An unnaturally high stage in a stream caused by obstruction or confinement of flow, as by a dam, bridge, or levee. Its measure is the excess of unnatural over natural stage, not the difference in stage upstream and downstream from its cause.

Bank: The lateral boundary of a stream confining water flow. The bank on the left side of a channel looking downstream is called the left bank, etc.

Bank Storage: The water absorbed into the banks of a stream channel when the stages rise above the water table in the bank formations, then returns to the channel as effluent seepage when the stages fall below the water table (After Houk, 1951, p. 179.).

Base Flow: See "Base Runoff."

Base Runoff: Sustained or fair-weather runoff. In most streams, base runoff is composed largely of groundwater effluent (Langbein and others, 1947, p. 6). The term "base flow" is often used in the same sense as base runoff. However, the distinction is the same as that between stream flow and runoff. When the concept in the terms "base flow" and base runoff is that of the natural flow in a stream, base runoff is the logical term (also see "Groundwater Runoff" and "Direct Runoff").

Bulking: The increase in volume of flow due to air entrainment, debris, bedload, or sediment in suspension.

Capacity: The effective carrying ability of a drainage structure. Generally measured in cubic feet per second.

Catch Basin: A drainage structure that collects water. May be either a structure where water enters from the side or through a grating.

Cfs: Abbreviation of cubic feet per second.

Cfs-Day: The volume of water represented by a flow of one cubic foot per second for 24 hours. It equals 86,400 cubic feet, 1.983471 acre-feet, or 646,317 gallons.

Cfsm (cubic feet per second per square mile): The average number of cubic feet of water per second flowing from each square mile of area drained by a stream, assuming that the runoff is distributed uniformly in time and area.

Channel Storage: The volume of water at a given time in the channel or over the floodplain of the streams in a drainage basin or river reach. Channel storage is great during the progress of a flood event (see Horton, 1935, p. 3).

Coefficient Runoff: Percentage of gross rainfall that appears as runoff.

Concentrated Flow: Flowing water that has been accumulated into a single, fairly narrow stream.

Concentration: In addition to its general sense, means the unnatural collection or convergence of waters so as to discharge in a narrower width and at greater depth or velocity.

Control: A natural constriction of the channel, a long reach of the channel, a stretch of rapids, or an artificial structure downstream from a gaging station that determines the stage-discharge relation at the gage. That section which determines the stage for a particular reach of a drainage system.

Critical Depth (depth at which specific energy is a minimum):
The depth of water in a conduit at which under certain other conditions the maximum flow will occur. These other conditions are when the conduit is on the critical slope with the water flowing at its critical velocity and when there is an adequate supply of water. The depth of water flowing in an open channel or a conduit partially filled for which the velocity head equals one-half the hydraulic mean depth.

Critical Flow: A condition that exists at the critical depth. Under this condition, the sum of the velocity head and static head is a minimum.

Critical Slope: That slope at which the maximum flow will occur at the minimum velocity. The slope or grade that is exactly equal to the loss of head per foot resulting from flow at a depth that will give uniform flow at critical depth; the slope of a conduit that will produce critical flow.

Critical Velocity: Mean velocity of flow when flow is at critical depth.

Cubic Feet Per Second: A unit expressing rates of discharge. One cubic foot per second is equal to the discharge of a stream of rectangular cross section, one foot wide and one foot deep, flowing water an average velocity of one foot per second.

Culvert: A closed conduit, other than a bridge, that allows water to pass under a highway. A culvert has a span of 20 feet or less as measured between the interior walls of the outside bents.

Depression Storage: The volume of water contained in natural depressions in the land surface, such as puddles (After Horton, 1935, p. 2).

Design Discharge: The quantity of flow that is expected at a certain point as a result of a design storm. Usually expressed as a rate of flow in cubic feet per second.

Design Frequency: The recurrence interval for hydrologic events used for design purposes. As an example, a design frequency of 50 years means a storm of a magnitude that would be expected to recur on the average of once every 50 years.

Design Storm: That particular storm that contributes runoff that the drainage facilities were designed to handle. This storm is selected for design on the basis of its probable recurrence; i.e., a 50-year design storm would be a storm for which its maximum runoff would occur on the average of once every 50 years.

Direct Runoff: The runoff entering stream channels promptly after rainfall or snowmelt. Superposed on base runoff, it forms the bulk of the hydrograph of a flood. Also see "Surface Runoff." The terms base runoff and direct runoff are time classifications of runoff. The terms groundwater runoff and surface runoff are classifications according to source.

Discharge: A volume of water flowing out of a drainage structure or facility. Measured in cubic feet per second.

Discharge Rating Curve: See "Stage-Discharge Relation."

Drainage: (1) The process of removing surplus groundwater or surface water by artificial means. (2) The system by which the waters of an area are removed. (3) The area from which waters are drained; a drainage basin.

Drainage Area (Drainage Basin) (Basin):
That portion of the earth's surface upon which falling precipitation flows to a given location. With respect to a highway, this location may be either a culvert, the farthest point of a channel, or an inlet to a roadway drainage system.

Drainage Divide: The rim of a drainage basin. A series of high points from which water flows in two directions, into the basin and away from the basin.

Drainage System: Usually a system of underground conduits and collector structures that flow to a single point of discharge.

Eddy Loss: The energy lost (converted into heat) by swirls, eddies, and impact, as distinguished from friction loss.

Effective Precipitation - (rainfall):
(1) That part of the precipitation that produces runoff. (2) A weighted average of current and antecedent precipitation that is "effective" in correlating with runoff. (3) As described by U.S. Bureau of Reclamation (1952, p. 4), that part of the precipitation falling on an irrigated area that is effective in meeting the consumptive use requirements.

Energy Grade Line: A hydraulic term used to define a line representing the total amount of energy available at any point along a watercourse, pipe, or drainage structure. Where the water is motionless, the water surface would coincide with the point or the energy grade line. As the flow of water is accelerated, the water surface drops further away from the energy grade line. If the flow is stopped at any point, the water surface jumps back to the energy grade line.

Energy Head: The elevation of the hydraulic grade line at any section plus the velocity head of the mean velocity of the water in that section.

Entrance Head: The head required to cause flow into a conduit or other structure. It includes both entrance loss and velocity head.

Entrance Loss: The head lost in eddies and friction at the inlet to a conduit or structure.

Equalizer: A drainage structure similar to a culvert but different in that it is not intended to pass a design flow in a given direction. Instead, it is often placed level so as to permit passage of water in either direction. It is generally used where there is no place for the water to go. Its purpose is to maintain the same water surface elevation on both sides of the highway embankment.

Evaporation: A process whereby water as a liquid is changed into water vapor through heat supplied by the sun.

Flood-Frequency Curve:
(1) A graph showing the number of times per year on the average, plotted as abscissa, that floods of magnitude, indicated by the ordinate, are equaled or exceeded. (2) A similar graph but with recurrence intervals of floods plotted as abscissa (see Dalrymple, 1960).

Flood Peak: The highest value of the stage or discharge attained by a flood, thus peak stage or peak discharge. Flood crest has nearly the same meaning, but since it connotes the top of the flood wave, it is properly used only in referring to stage, thus crest stage but not crest discharge.

Floodplain: Strip of land adjacent to a river or channel that has a history of overflow.

Flood Profile: A graph of elevation of the water surface of a river in flood, plotted as ordinate, against distance, measured in the downstream direction, plotted as abscissa. A flood profile may be drawn to show elevation at a given time, crests during a particular flood, or to show stages of concordant flows.

Flood Routing: The process of determining progressively the timing and shape of a flood wave at successive points along a river (see Carter and Godfrey, 1960).

Flood Stage: The elevation at which overflow of the natural banks of a stream begins to cause damage in the reach in which the elevation is measured.

Flow Line: A term used to describe the line connecting the low points in a watercourse.

Freeboard : The distance between the normal operating level and the top of the sides of an open conduit; the crest of a dam, etc., designed to allow for wave action, floating debris, or any other condition or emergency, without overtopping the structure.

Flow-Duration Curve: A cumulative frequency curve that shows the percentage of time that specified discharges are equaled or exceeded.

Free Outlet: A condition under which water discharges with no interference such as a pipe discharging into open air.

Gage Height: The water surface elevation referred to some arbitrary gage datum. Gage height is often used interchangeably with the more general term stage, although gage height is more appropriate when used with a reading on a gage.

Gaging Station: A particular site on a stream, canal, lake, or reservoir where systematic observations of gage height or discharge are obtained (also see "Stream Gaging Station").

Grade to Drain: A construction note often inserted on a plan for the purpose of directing the contractor to slope a certain area in a specific direction so that the storm waters will flow to a designated location.

Gradient (Slope): The rate of ascent or descent, expressed as a percent or as a decimal as determined by the ratio of the change in elevation to the length.

Groundwater Runoff : That part of the runoff that passed into the ground, has become groundwater, and has been discharged into a stream channel as spring or seepage water (also see "Base Runoff" and "Direct Runoff").

Head: When used as a hydraulic term, this represents an available force equivalent to a certain depth of water. This is the motivating force in effecting the movement of water. The height of water above any point or plane of reference. Used also in various compound expressions, such as energy head, entrance head, friction head, static head, pressure head, lost head, etc.

Hydraulic Gradient: A line which represents the relative force available due to the potential energy available. This is a combination of energy due to the height of the water and the internal pressure. In any open channel, this line corresponds to the water surface. In a closed conduit, if several openings were placed along the top of the pipe and open tubes inserted, a line connecting the water surface in each of these tubes would represent the hydraulic grade line.

Hydraulic Jump (or Jump): Transition of flow from the rapid to the tranquil state. A varied flow phenomenon producing a rise in elevation of water surface. A sudden transition from supercritical flow to the complementary subcritical flow, conserving momentum and dissipating energy.

Hydraulic Mean Depth: The area of the flow cross section divided by the water surface width.

Hydraulic Radius: The cross-sectional area of a stream of water divided by the length of that part of its periphery in contact with its containing conduit; the ratio of area to wetted perimeter.

Hydrograph: A graph showing stage, flow, velocity, or other properties of water with respect to time.

Hydrography: Water surveys. The art of measuring, recording, and analyzing the flow of water, and of measuring and mapping watercourses, shorelines, and navigable waters.

Hydrology: The science dealing with the occurrence and movement of water upon and beneath the land areas of the earth. Overlaps and includes portions of other sciences such as meteorology and geology. The particular branch of hydrology that a drainage section is generally interested in is surface runoff that is the result of excessive precipitation.

Hyetograph: Graphical representation of rainfall intensity against time.

Infall: Point of entrance into a storm sewer system through an apron endwall or pipe opening.

Infiltration: The passage of water through the soil surface into the ground.

Infiltration Capacity: The maximum rate at which the soil, when in a given condition, can absorb falling rain or melting snow (After Horton, 1935, p. 2).

Infiltration Index: An average rate of infiltration, in inches per hour, equal to the average rate of rainfall such that the volume of rainfall at greater rates equals the total direct runoff (Langbein and others, 1947, p. 11).

Inlet Time (i.e., Time of Concentration): The time required for storm runoff to flow from the most remote point, in flow time, of a drainage area to the point where it enters a drain or culvert.

Interception: The process and the amount of rain or snow stored on leaves and branches and eventually evaporated back to the air. Interception equals the precipitation on the vegetation minus stemflow and throughfall (after Hoover, 1953, p. 1).

Invert: The bottom of a drainage facility along which the lowest flows would pass.

Isohyetal Line: A line drawn on a map or chart joining points that receive the same amount of precipitation.

Isohyetal Map: A map containing isohyetal lines and showing rainfall intensities.

Isovel: Line on a diagram of a channel connecting points of equal velocity.

Lag: Variously defined as time from beginning (or center of mass) of rainfall to peak (or center of mass) of runoff.

Laminar Flow: That type of flow in which each particle moves in a direction parallel to every other particle and in which the head loss is approximately proportional to the velocity (as opposed to turbulent flow).

Mass Curve: A graph of the cumulative values of hydrologic quantity (such as precipitation or runoff), generally as ordinate, plotted against time or date as abscissa (see "Double-Mass Curve" and "Residual-Mass Curve").

Mean Velocity: Average velocity within a cross section.

Meander: The winding of a stream channel.

Normal: A central value (such as arithmetic average or median) of annual quantities for a 30-year period ending with an even 10-year period, thus 1921-50, 1931-60, and so forth. This definition accords with that recommended by the Subcommittee on Hydrology of the Federal Inter-Agency Committee on Water Resources.

Normal Depth: The depth at which flow is steady and hydraulic characteristics are uniform.

Outfall: Discharge or point of discharge of a culvert or other closed conduit.

Partial-Duration Flood Series: A list of all flood peaks that exceed a chosen base stage or discharge, regardless of the number of peaks occurring in a year (also called basic stage flood series or floods above a base).

Peak Flow: Maximum momentary stage or discharge of a stream in flood. Design discharge.

Perched Water: Groundwater located above the level of the water table and separated from it by a zone of impermeable material.

Percolating Waters: Waters that have infiltrated the surface of the land and moved slowly downward and outward through devious channels (aquifers) unrelated to stream waters until they reach an underground lake or regain and spring from the land surface at a lower point.

Permeability: The property of soils that permits the passage of any fluid. Permeability depends on grain size, void ratio, shape, and arrangement of pores.

Point of Concentration: That point at which the water flowing from a given drainage area concentrates. With reference to a highway, this would generally be either a culvert entrance or some point in a roadway drainage system.

Potamology: The hydrology of streams.

Precipitation: Rainfall, snow, sleet, fog, dew, and frost.

Rainfall: Point Precipitation: That which registers at a single gauge. Area Precipitation: Adjusted point rainfall for area size.

Rainfall Excess: The volume of rainfall available for direct runoff. It is equal to the total rainfall minus interception, depression storage and absorption (see American Society of Civil Engineers, 1949, p. 106).

Rainfall, Excessive: Rainfall in which the rate of fall is greater than certain adopted limits, chosen with regard to the normal precipitation (excluding snow) of a given place or area. In the U.S. Weather Bureau, it is defined for states along the southern Atlantic Coast and the Gulf Coast as rainfall in which the depth of precipitation is 0.90 inch at the end of 30 minutes and 1.50 inches at the end of an hour, and for the rest of the country as rainfall in which the depth of precipitation at the end of each of the same periods is 0.50 inch and 0.80 inch, respectively.

Reach: The length of a channel uniform with respect to discharge, depth, area, and slope. More generally, any length of a river or drainage course.

Recession Curve: A hydrograph showing the decreasing rate of runoff following a period of rain or snowmelt. Since direct runoff and base runoff recede at different rates, separate curves, called direct runoff recession curves or base runoff recession curves, are generally drawn. The term "depletion curve" in the sense of base runoff recession is not recommended.

Recurrence Interval (return period): The average interval of time within which the given flood will be equaled or exceeded once (American Society of Civil Engineers, 1953, p. 1221).

Regimen: The characteristic behavior of a stream during ordinary cycles of flow.

Runoff: The portion of precipitation that appears as flow in streams. Drainage or flood discharge which leaves an area as surface flow or as pipeline flow, having reached a channel or pipeline by either surface or subsurface routes, and includes underflow in some cases.

Scour: Wearing of the bed of a stream by entrainment of alluvium and erosion of native rock. Also caused by excessive velocities at the entrance of a concentrated stream of water onto unstable material. Wearing away by abrasive action.

Second-Foot: Same as cfs. This term is no longer used in published reports of the U.S. Geological Survey.

Silt: (1) Water-Borne Sediment: Detritus carried in suspension or deposited by flowing water, ranging in diameter from 0.0002 to 0.002 inch. The term is generally confined to fine earth, sand, or mud, but is sometime's broadened to include all material carried, including both suspended and bed load. (2) Deposits of Water-Borne Material: As in a reservoir, on a delta, or on floodplains.

Skew: When a drainage structure is not normal (perpendicular) to the longitudinal axis of the highway, it is said to be on a skew. The skew angle is the smallest angle between the perpendicular and the axis of the structure.

Slope: (1) Gradient of a stream. (2) Inclination of the face of an embankment, expressed as the ratio of horizontal to vertical projection. (3) The face of an inclined embankment or cut slope. In hydraulics it is expressed as percent or in decimal form.

Slugflow : Flow in culvert or drainage structure that alternates between full and partly full. Pulsating flow--mixed water and air.

Soffit: The bottom of the top - (1) With reference to a bridge, the low point on the underside of the suspended portion of the structure. (2) In a culvert, the uppermost point on the inside of the structure.

Specific Energy: The energy of a stream referred to its bed, namely, depth plus velocity head of mean velocity.

Stage: The elevation of a water surface above its minimum; also above or below an established "low water" plane; hence above or below any datum of reference; gage height.

Stage-Capacity Curve: A graph showing the relation between the surface elevation of the water in a reservoir, usually plotted as ordinate, against the volume below that elevation, plotted as abscissa.

Stage-Discharge Curve (rating curve):

A graph showing the relation between the gage height, usually plotted as ordinate, and the amount of water flowing in a channel, expressed as volume per unit of time, plotted as abscissa.

Storage: Detention or retention of water for future flow, naturally in channel and marginal soils or artificially in reservoirs.

Storage Basin: Space for detention or retention of water for future flow, naturally in channel and marginal soils or articifically in reservoirs.

Relation to time:

Perennial: One that flows continuously.

Intermittent or Seasonal:

One that flows only at certain times of the year when it receives water from springs or from some surface source, such as melting snow in mountainous areas.

Ephemeral: One that flows only in direct response to precipitation and whose channel is above the water table at all times.

Relation to space:

Continuous: One that does not have interruptions in space.

Interrupted: One that contains alternating reaches that are either perennial, intermittent, or ephemeral.

Relation to groundwater:

Gaining: A stream or reach of a stream that receives water from the zone of saturation.

Losing: A stream or reach of a stream that contributes water to the zone of saturation.

Insulated: A stream of reach of a stream that neither contributes water to the zone of saturation nor receives water from it. It is separated from the zones of saturation by an impermeable bed.

Perched: A perched stream is either a losing stream or an insulated stream that is separated from the underlying groundwater by a zone of saturation.

Stream Gaging: The process and art of measuring the depths, areas, velocities, and rates of flow in natural or artificial channels (see Corbett and others, 1943).

Stream Gaging Station: A gaging station where a record of discharge of a stream is obtained. Within the Geological Survey this term is used only for those gaging stations where a continuous record of discharge is obtained.

Subcritical Flow: Flow with a velocity head less than half the hydraulic mean depth of water.

Supercritical Flow: Flow with a velocity head more than half the hydraulic mean depth of the water.

Surface Runoff: The movement of water on the earth's surface, whether flow is over surface of ground or in channels.

Tapered Inlet: A transition to direct the flow of water into a channel or culvert. A smooth transition to increase hydraulic efficiency of an inlet structure.

Time of Concentration: The time required for storm runoff to flow from the most remote point, in flow time, of a drainage area to the point under consideration. It is usually associated with the design storm (see Inlet Time).

Total Storage: The volume of reservoir below the maximum controllable level, including dead storage (Thomas and Harbeck, 1956, p. 13).

Trunk (or Trunk Line): In a roadway drainage system, the main conduit for transporting the storm waters. This main line is generally quite deep in the ground so that laterals coming from fairly long distances can drain by gravity into the trunk line.

Turbulent Flow: That type of flow in which any particle may move in any direction with respect to any other particle, and in which the head loss is approximately proportional to the square of the velocity.

Unit Hydrograph: The hydrograph of direct runoff from a storm uniformly distributed over the drainage basin during a specified unit of time; the hydrograph is reduced in vertical scale to correspond to a volume of runoff of one inch from the drainage basin (after American Society of Civil Engineer, 1949, p. 105). The hydrograph of surface runoff (not including groundwater runoff) on a given basin due to an effective rain falling for a unit of time (Sherman, 1949, p. 514) (also see Hoyt and others, 1936, p. 124).

Velocity Head: A term used in hydraulics to represent the kinetic energy of flowing water. This "head" is represented by a column of standing water equivalent in potential energy to the kinetic energy of the moving water calculated as V2/2g, where "V" represents velocity in feet per second and "g" represents potential acceleration due to gravity in feet per second per second.

Watershed: The area drained by a stream or stream system.

Water Year: In Geological Survey reports dealing with surface water supply, the 12-month period, October 1 through September 30. The water year is designated by the calendar year in which it ends and which includes nine of the 12 months. Thus, the year ended September 30, 1959, is called the "1959 water year."

SURFACE DRAINAGE STUDIES

Input - Output Data & Design Aids

	INPUT Data	 SOURCE
	Drainage Area	USGS Quadrangles, Aerial Photo or other sources
	Land Use	" " "
Watershed	Watershed Steepness	" " "
Information	Soils, Types	" " "
	Covers	" " "
Climate	Rainfall Intensity	Weather Charts
Information	Storm Frequency	Design Criteria
Limiting Design	Allowable High Water	Local Records
Factors	Gradeline Control	Design Criteria
	Description of Existing	Records
Existing	Str. & O. Section	
Facilities	High Water of Exist.	Local Records
	Structure	
	OUTPUT Data	 SOURCE
Design	**Design**	**Design computations applying the**
Discharge	Discharge	input to pertinent charts, etc.
Proposed	Type	Design Criteria
Facilities	Size	Design Computations
Drainage Easements	Size	R/W Manual
	Location	Design Computations
Cost	Cost, including	Design Computations
	Channel changes and	
	other related items	
	DESIGN AIDS Data	 SOURCE (FILES)
	Rational Method	**Facilities Development Manual**
Estimating	N.R.C.S. Methods - TR55 *	" " "
Run-Off	USGS Flood Frequency	" " "
	Equations for Wisconsin	" " "
	Gaging Station	U.S.G.S
	Published Watershed Studies	Regional Planning Agencies, U.S. C.O.E., U.S. N.R.C.S., U.S.G.S., etc.
	Culvert Capacity	FHWA Hydraulic Engineering Circular
	Inlet Control	" " "
Structure	Outlet Control	" " "
Design	Critical Depth	" " "
	Headwater Depth	" " "

* NRCS is Natural Resources Conservation Service, the new name for the Soil Conservation Service (SCS)

COMPUTER REFERENCES

Public Domain Software	TR55		P.C. program that mirror procedures in Urban Hydrology for Small Watershed Technical Release 55, June 1986
	Hydrain * HYDRA		Storm/sanitary sewers
		WSPRO	Step backwater and bridge hydraulics
		HYDRO	IDF curves, hyetographs, peak flows
		HYCLV	Culvert analysis and Design
HEC-15			HYCHL Lining stability - based on HEC-11 and
on			HY8 Culvert system performance - based HDS-5, HEC-14, HEC-19
		NFF	U.S.G.S. National Flood Frequency Model
		HYEQT	Analyze user supplied Equations

* This software package is available from Mctrans which is at the University of Florida.

Telephone: 1-(352)-392-0378

email: uftrc@ce.ufl.edu

web site: http://mctrans.ce.ufl.edu/

Alternate	---------------------	**Schedule No.**	---------------------	**District No.**	---------------------
Project No.	---------------------	**County**	---------------------	**Designer**	---------------------
Name of Road	---------------------	**Hwy.**	---------------------		
Design Frequency	---------------------	**Date**	---------------------		

Major Drainage Summary Sheet

Input						**Output**			**Remarks**
Sat. or Loc.	Drainage Area (Acres)	Chief Land Use or Cover	Description of Terrain	Head-Water Allow-able	Existing Facility Size & Type	Design Dis-charge	Proposed Facility Size & Type	Cost	Remarks Special Limita-tion, Channel Changes

Sample Stormwater-Drainage-WQ Report Spreadsheet: Drainage-Summary Worksheet
Download a zipped working copy of the spreadsheets at:
http://wisconsindot.gov/rdwy/fdm/files/WisDOT-Stormwater-Drainage-WQ-Channel-Spreadsheets.zip

9/12/2012

Basic Project Information

Project ID: XXXX-XX-XX
Title: Example Project
Designer/Checker:
DOT Region/Firm Name:
Date:

HIGHWAY:	
LIMITS:	
COUNTY:	
DESCRIPTION OF WORK:	
PROJECT MANAGER:	
PS&E DATE:	
DESIGN STAGE	☐ Planning ☐ 30% ☐ 60% ☐ 90% ☐ Final

Drainage Summary
IS THERE A SIGNIFICANT FLOW INCREASE OR DECREASE WITHIN ANY SUB BASIN OF THE PROJECT? IF YES, DESCRIBE THE CAUSE OF THE CHANGE AND WHY IT IS NECESSARY.
IS THERE A SIGNIFICANT IMPERVIOUS AREA CHANGE TO ANY SUB BASIN OF THE PROJECT? IF YES, DESCRIBE THE CAUSE OF THE CHANGE AND WHY IT IS NECESSARY.
HAVE THE DRAINAGE SUB BASIN AREAS OR FLOW PATHS CHANGED SIGNIFICANTLY? IF YES, DESCRIBE THE CAUSE OF THE CHANGE AND WHY IT IS NECESSARY.
DESCRIBE THE PROPOSED DRAINAGE CONVEYANCE AND CONTROL SYSTEMS FOR THE PROJECT.
DESCRIBE THE AQUATIC ORGANISM PASSAGE ISSUES FOR THE PROJECT, IF ANY.
IF THE DESIGN DOES NOT MEET THE DOT FDM CHAPTER 13 DRAINAGE REQUIREMENTS, EXPLAIN HOW AND WHY.
DESCRIBE WDNR COORDINATION. PROVIDE NAME OF WDNR CONTACT AND DATE, AND ATTACH ANY CORRESPONDENCE.
IF THE DRAINAGE DESIGN MEETS LOCAL, MUNICIPAL OR REGIONAL GUIDELINES THAT EXCEED FDM CHAPTER 13 DRAINAGE REQUIREMENTS, EXPLAIN HOW AND WHY.
IF A SIGNIFICANT IMPACT TO THE PROJECT OCCURS DUE TO DRAINAGE, PROJECT MANAGER CONCURRENCE IS REQUIRED. (PM SIGN AND DATE)

Page 1

Sample Stormwater-Drainage-WQ Report Spreadsheet: Data Worksheet
(Use link on FDM 13-1 Attachment 10.1 to download a zipped working copy of the spreadsheets.

1	**Drainage Data**						
2	**Project ID: XXXX-XX-XX**						
3	**Title: Example Project**						
4	**Designer/Checker:**						
5	**DOT Region/Firm Name:**						
6	**Date:**						
7	**OUTFALL INFORMATION**						
8	Outfall number	**1**	**2**	**3**	**4**	**5**	**6**
9	Outfall discharges to:						
10	Waterway crossing type	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
11	If discharging to environmentally sensitive area, what kinds of buffers were used at outfall?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
12	Previous flooding issues or flow restrictions?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
13	Is the drainageway in the DOT ROW a navigable waterway?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
14	Classify the drainageway in the DOT ROW	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
15	**BASIC SUB BASIN DRAINAGE INFORMATION**						
16	Outfall number	**1**	**2**	**3**	**4**	**5**	**6**
17	Stormwater conveyance type	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
18	Outfall station						
19	Subbasin starting station						
20	Subbasin ending station						
21	Proposed roadway length (ft)	0	0	0	0	0	0
22	Flow conveyance change						
23	Flood design frequency (yrs)						
24	Check design frequency (yrs)						
25	Is the check design storm safely passed?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
26	DOT right-of-way area (acres)						
27	Subbasin drainage area (acres)						
28	DOT right-of-way compared to subbasin drainage area (%)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
29	DOT impervious area - existing (acres)						
30	DOT impervious area - proposed (acres)						
31	Change in impervious area (acres)	0	0	0	0	0	0
32	Percent change in DOT impervious area	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
33	Design software used						
34	Method used to estimate peak flows						
35	*Complete lines 36-46 for culverts only*						
36	Existing peak flow (cfs)						
37	Proposed peak flow (cfs) (before detention)						
38	Proposed peak flow (cfs) (after detention/in-line storage/other)						
39	Change in peak flow (cfs)	0	0	0	0	0	0
40	Percent change in peak flow	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
41	Existing 2-yr peak flow (cfs)						
42	Proposed 2-yr peak flow (cfs) (before detention)						
43	Proposed 2-yr peak flow (cfs) (after detention/in-line storage/other)						
44	Change in 2-yr peak flow (cfs)	0	0	0	0	0	0
45	Percent change in 2-yr peak flow	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
46	Existing Tc (min)						
47	Proposed Tc (min)						
48	C or CN (existing)						
49	C or CN (proposed)						
50	Rainfall intensity (in/hr) (rational method only)						
51	Rainfall depth used for design storm, if applicable (in)						

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52	**CULVERT DESIGN**						
53	**Existing Culvert**						
54	Outfall number	1	2	3	4	5	6
55	Culvert present? (Yes or No)	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
56	Existing culvert shape	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
57	Existing culvert material	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
58	Existing culvert size (ft)						
59	Existing number of culverts						
60	Existing Manning's n						
61	Inlet entrance type	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
62	Inlet loss coefficient (Ke)						
63	Upstream invert (ft)						
64	Downstream invert (ft)						
65	Length (ft)						
66	Slope (%)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
67	**Floodplain Management**						
68	Is culvert in a mapped floodplain?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
69	Will proposed culvert increase water surface profile?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
70	**Drainage District Issues**						
71	Is culvert in a drainage district?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
72	Drainage District Name						
73	Will proposed culvert raise the culvert invert or increase water surface profile?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
74	Has drainage board approved increases?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
75	**Aquatic Organism Passage**						
76	Is aquatic organism passage a concern?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
77	Does WDNR agree with AOP design?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
78	**Proposed Culvert Design**						
79	Design ADT						
80	Design flow						
81	Design year frequency						
82	Hydrological method used						
83	Assumed tailwater condition						
84	Maximum allowable headwater						
85	Maximum allowable headwater design criteria	DDMenu	DDMenu	DDMenu	DDMenu	DDMenu	DDMenu
86	Proposed culvert shape	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
87	Proposed culvert material	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
88	Proposed culvert size						
89	Proposed number of culverts						
90	Manning's n						
91	Type of endwalls	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
92	Inlet loss coefficient (Ke)						
93	Proposed upstream invert (ft)						
94	Proposed downstream invert (ft)						
95	Proposed length (ft)						
96	Proposed slope (%)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
97	Embedment depth (ft)						
98	Embedment material						
99	Discharge velocity (ft/s)						
100	Riprap outfall (Size riprap or None)						
101	Station of lowest subgrade shoulder point in subbasin (0+00)						
102	Elevation of lowest subgrade shoulder point in subbasin (ft)						
103	Headwater distance below subgrade shoulder point (ft)						
104	Headwater to pipe diameter ratio						
105	Design software used						
106	Proposed tailwater condition						
107	Discharge pipe end submerged?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
108	Assumed tailwater elevation (ft)						

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109	**CULVERT LINER DESIGN**						
110	**Existing Culvert**						
111	Outfall number	**1**	**2**	**3**	**4**	**5**	**6**
112	Does WDNR agree with use the of a liner?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
113	Existing culvert size (ft)						
114	Pipe material						
115	Pipe condition						
116	Any collapse?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
117	Any deflection?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
118	Are ends crushed?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
119	*n* value existing pipe						
120	Pipe geometry (i.e. circular)	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
121	Pipe inlet invert elevation (ft)						
122	Pipe outlet invert elevation (ft)						
123	Length (ft)						
124	Slope (%)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
125	Depth of cover over culvert (ft)						
126	Is overtopping an issue?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
127	Are there hydraulically sensitive structures or property up-stream that could be flooded if water surface profile is increased?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
128	If existing culvert diameter > 48", hydraulic design is required. Has this been done?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
129	Are any of the culverts greater than 48" in diameter?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
130	Field verify dimension?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
131	**Floodplain Management**						
132	Is culvert in a mapped floodplain?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
133	Will proposed liner increase water surface profile?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
134	**Drainage District Issues**						
135	Is culvert in a drainage district?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
136	Drainage District Name						
137	Has drainage board approved use of a liner?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
138	**Aquatic Organism Passage**						
139	Is aquatic organism passage a concern?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu
140	Does WDNR agree with AOP design?	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu	DD Menu

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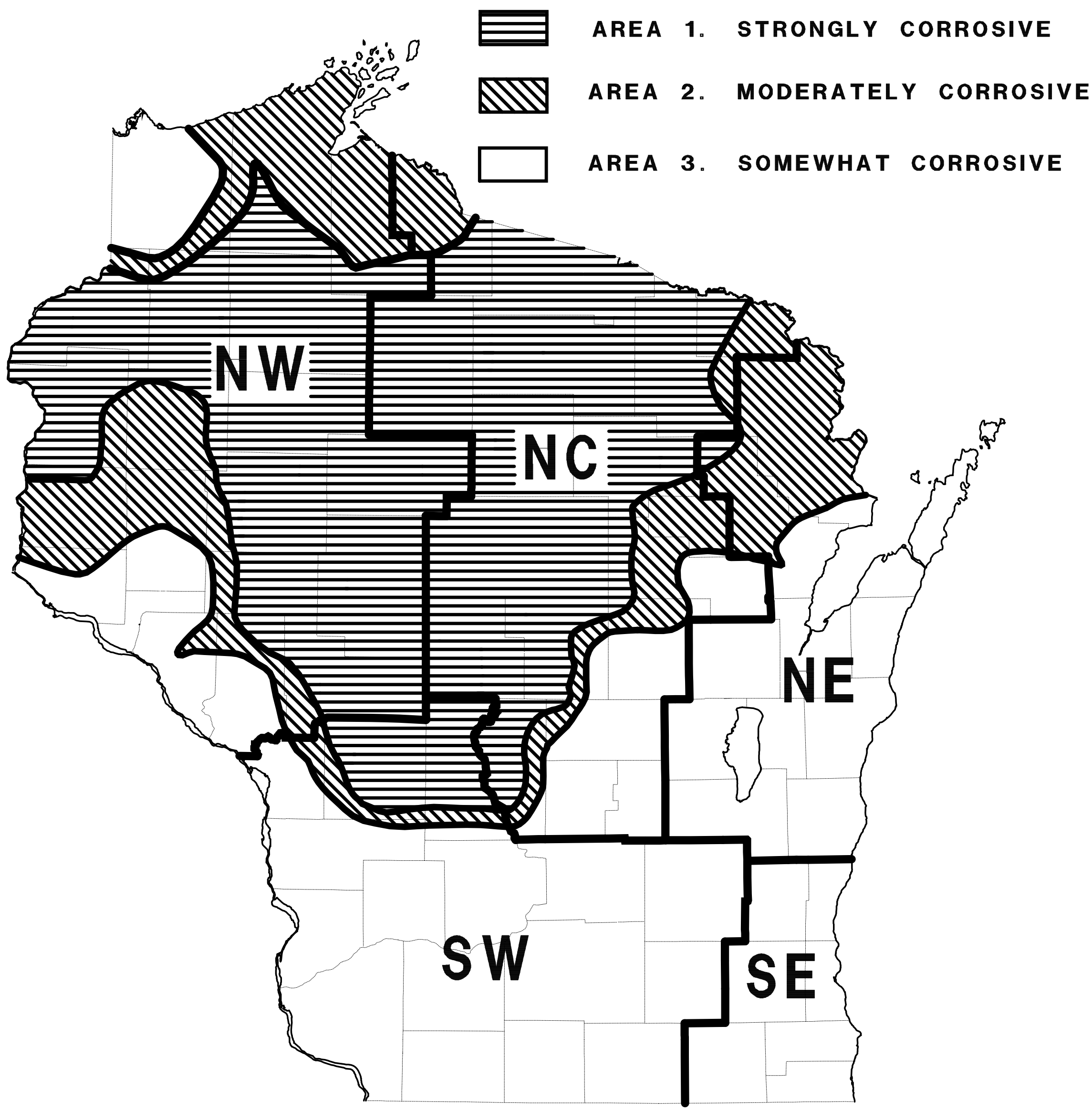
POTENTIAL FOR BACTERIAL CORROSION OF ZINC GALVANIZED STEEL CULVERT PIPE



INDIVIDUAL SITES IN AREA 3 MAY BE STRONGLY TO MODERATELY CORROSIVE DUE TO LOCAL CONDITIONS SUCH AS FARM RUNOFF, ANAEROBIC BACTERIA IN THE SOIL, ETC.

STORM SEWER - FILL HEIGHT TABLE FOR CONCRETE PIPE

Type/Class of Pipe	AASHTO Materials Designation	Pipe Size I.D. (inches)	Maximum Height of Cover Over Top of Pipe (feet)
Reinforced Concrete Class II	M 170	12- 108	11
Reinforced Concrete Class III	M 170	12- 108	15
Reinforced Concrete Class IV	M 170	12- 84	25
Reinforced Concrete Class V	M 170	12- 72	35

Surface Loadings

The minimum concrete pipe class required based on depth to subgrade is as follows:

Depth of Subgrade Cover (feet)	0 to 2	2 to 3	3 to 6
Minimum Class of Concrete Pipe Required	IV	III	II

The desired minimum cover is 2 feet below subgrade. Where less than two feet of cover is provided special measures may be required during construction to minimize equipment loading impacts on the pipe. At a minimum, locations with reduced subgrade cover should be identified on the plans so that the contractor can take precautionary measures.

Design Criteria

The above table refers to Class C bedding using sand/gravel backfill weighing 120 lb/ft^3 with zero projecting embankment condition and trench widths as specified Standard Spec 608.

FILL HEIGHT TABLE 1

Corrugated Steel, Aluminum, Polyethylene, Polypropylene and Reinforced Concrete Pipe

HS20 Loading 2" x 2/3" Corrugations - Standard Specification Bedding Unless Otherwise Noted

		Height of Cover Over Top Pipe in Feet - "H"																	
		Min. to 15' **(2)**			16' to 20'			21' to 25'			26' to 30'			31' to 35'			36' to 40'		
Dia. In. **(5)**	Area S.F.	Thickness		RCCP Class Pipe	Thickness		RCCP Class Pipe	Thickness		RCCP Class Pipe	Thickness		RCCP Class Pipe	Thickness		RCCP Class Pipe	Thickness		RCCP Class Pipe
		Steel	Alum		Steel	Alum		Steel	Alum		Steel	Alum		Steel	Alum		Steel	Alum	
12 *	0.8	0.064	0.060	III	0.064	0.060	IV	0.064	0.060	IV	0.064	0.060	V	0.064	0.060	V	0.064	0.075	V **(4)**
15 *	1.2	0.064	0.060	III	0.064	0.060	IV	0.064	0.060	IV	0.064	0.060	V	0.064	0.075	V	0.064	0.105	V **(4)**
18 *	1.8	0.064	0.060	III	0.064	0.060	IV	0.064	0.060	IV	0.064	0.075	V	0.064	0.105	V	0.064	0.135	V **(4)**
21 *	2.4	0.064	0.060	III	0.064	0.060	IV	0.064	0.075	IV	0.064	0.105	V	0.064	0.135	V	0.079	X	V **(4)**
24 *	3.1	0.064	0.075	III	0.064	0.075	IV	0.079	0.075	IV	0.079	0.105	V	0.079	0.164	V	0.079	X	V **(4)**
30 *	4.9	0.079	0.075	III	0.079	0.075	IV	0.079	0.105	IV	0.079	0.135	V	0.109	X	V	0.109	X	V **(4)**
36 *	7.1	0.079	0.105	III	0.079	0.105	IV	0.109	0.135	IV	0.109	0.164	V	0.138	X	V	0.138	X	V **(4)**
42	9.6	0.109	0.105	III	0.109	0.135	IV	0.109	0.164	IV	0.138	0.164	V	0.138	X	V	0.168	X	V **(4)**
48	12.6	0.109	0.105	III	0.109	0.135	IV	0.138	0.164	IV	0.168	X	V	0.168	X	V	0.138 E	X	V **(4)**
54	15.9	0.109	0.105	III	0.138	0.135	IV	0.168	0.164	IV	0.168	X	V	0.109 E	X	V	0.138 E	X	V **(4)**
60	19.6	0.138	0.164	III	0.138	X	IV	0.168	X	IV	0.138 E	X	V	0.138 E	X	V	0.168 E	X	V **(4)**
66	23.8	0.138	0.164	III	0.168	X	IV	0.168	X	IV	0.138 E	X	V	0.138 E	X	V	0.168 E	X	V **(4)**
72	28.3	0.138**(3)**	0.164	III	0.168	X	IV	0.168	X	IV	0.138 E	X	V						
78	33.2	0.168	X	III	0.168	X	IV	0.168 E	X	IV	**(1)**								
84	38.5	0.168	X	III	0.168	X	IV												

E = Elongated, Vertical Axis 5% greater than Horizontal.
(1) Any pipe under the heavy line will require a special design.
(2) 12" minimum cover, top of pipe to top of subgrade for steel, aluminum and concrete. 24" required minimum cover for Class IIIA and IIIB pipe under Standard Spec 520 or 608, or as polyethylene and polypropylene pipe under Standard Spec 530.
(3) A thickness of 0.138" may be used for fill heights of minimum to 10 Ft. a thickness of 0.168" may be used for fill heights of greater than 10 Ft. but less than 26 feet.
(4) Class "B" Bedding required.
NOTE: For steel and aluminum pipe in the shaded portion of the table (>60 in. dia.), a corrugation size of 3" by 1" is generally more economical than 2 2/3" by 1/2". See Tables 2 and 7.

X = Do not use
(5) For corrugated steel pipe in a 6", 8", or 10" diameter, the minimum thickness is 0.052" and 0.064" respectively.
For corrugated aluminum pipe in 6", 8" or 10" diameter, the minimum thickness is 0.048", 0.048" and 0.06" respectively.
* Corrugated polyethylene and corrugated polypropylene pipe in these diameters are available for use under the Class III-A and Class III-B bid items as specified in FDM 13-1-15 and FDM 13-1-17. Minimum fill height shall be 24 inches and maximum fill height shall be 11 feet for polyethylene (Class III-A) and 15 feet for polypropylene (Class III-B). It is not necessary to specify thickness for polyethylene or polypropylene pipe.

FILL HEIGHT TABLE 2 (1)
Corrugated Steel Pipe - 3" x 1" Corrugations - H20 Live Load

Pipe Dia. In.	Waterway Area Sq. Ft.	Min. Cover In. (3)	Maximum Height of Fill - Ft.				
			Metal Thickness in Inches (2)				
			0.064	0.079	0.109	0.138	0.168
60	19.6	12	24	30	44	53	58
66	23.8	12	22	27	40	48	53
72	28.3	12	20	25	37	44	49
78	33.2	12	18	23	34	40	45
84	38.5	12	17	22	32	37	42
90	44.2	12	16	20	29	35	39
96	50.3	12	X	19	28	33	37
102	56.7	24	X	17	26	31	34
108	63.6	24	X	X	24	29	32
114	70.9	24	X	X	23	27	31
120	78.5	24	X	X	X	26	29

FILL HEIGHT TABLE 3 (1)
Structural Plate Pipe 6" x 2" Corrugations - H20 Live Load

Pipe Dia. In.	Waterway Area Sq. Ft.	Min. Cover In. (3)	Maximum Height of Fill - Ft. (4)						
			Metal Thickness in Inches (2)						
			0.10	0.138	0.168	0.188	0.218	0.249	0.280
60	19.6	12	35	51	67	77	87 (93)	96 (110)	106 (120)
72	28.3	12	29	43	54	57 (64)	62 (77)	67 (91)	73 (100)
84	38.5	12	25	36	44	46 (55)	49 (66)	53 (78)	56 (85)
96	50.3	12	22	32	39	40 (48)	42 (58)	44 (68)	47 (75)
102	56.7	24	20	30	37	38	40 (55)	42 (64)	43 (70)
108	63.6	24	19	28	35	36	38 (52)	39 (61)	41 (66)
120	78.5	24	17	25	33	34	35 (46)	36 (55)	37 (60)
132	95.0	24	16	23	30	32	33 (42)	34 (50)	35 (54)
144	113.1	24	14	21	28	31	32	32 (45)	33 (50)
156	132.7	24	13	19	25	29	31	31 (42)	32 (46)
168	153.9	24	12	18	24	27	30	31	31 (42)
180	176.7	24	11	17	22	25	30	30	30 (40)

(1) Table 2 is valid for 5” x 1” corrugations which may be used in lieu of 3" x 1" corrugations for fill heights to 30 feet.
(2) The steel thicknesses shown are adequate for structural requirements only. Where corrosive and/or abrasive conditions exist, greater thicknesses should be specified.
(3) Minimum cover top of pipe to top of subgrade.
(4) Maximum fill heights shown in parentheses are permitted if the pipe is elongated - Vertical axis 5% greater than the horizontal axis.

NOTE: Corrugated steel pipe (CSCP) is normally more economical to use than structural plate pipe (SPP) for installations where either type will satisfy fill height requirements. The potential cost savings of the CSCP is possible because CSCP is factory assembled into transportable lengths whereas SPP must be field assembled from plates.

FILL HEIGHT TABLE 4
Corrugated Steel Pipe Arch - 2" x 1/2" Corrugations - H20 Live Load

Size: Span x Rise (Inches)	Min. Thickness In. (1)	Min. Cover In. (2)	Max. Height of Fill Ft. (3)	Waterway Area Sq. Ft.	Round Pipe of Equal Periphery	
					Waterway Area Sq. Ft.	Dia. Inches
17 X 13	0.064	18	13	1.1	1.23	15
21 x 15	0.064	18	12	1.6	1.77	18
24 x 18	0.064	18	10	2.2	2.41	21
28 x 20	0.064	18	9	2.8	3.14	24
35 x 24	0.079	18	9	4.4	4.91	30
42 x 29	0.079	18	7	6.4	7.07	36
49 x 33	0.109	18	7	8.7	9.62	42
57 x 38	0.109	18	7	11.4	12.57	48
64 x 43	0.109	18	7	14.3	15.90	54
71 x 47	0.138	18	7	17.6	19.64	60
77 x 52	0.168	18	7	21.3	23.76	66
83 x 57	0.168	18	8	25.3	28.27	72

FILL HEIGHT TABLE 5
Corrugated Steel Pipe Arch (4) - 3" x 1" Corrugations - H20 Live Load

Size: Span x Rise (Inches)	Min. Thickness In. (1)	Min. Cover In. (2)	Max. Height of Fill Ft. (3)	Waterway Area Sq. Ft.	Round Pipe of Equal Periphery	
					Waterway Area Sq. Ft.	Dia. Inches
40 x 31	0.064	18	12	6.4	7.07	36
46 x 36	0.064	18	12	8.7	9.62	42
53 x 41	0.064	18	12	11.4	12.57	48
60 x 46	0.064	18	12	14.3	15.90	54
66 x 51	0.064	18	12	17.6	19.64	60
73 x 55	0.064	18	15	22.0	23.76	66
81 x 59	0.079	18	15	26.0	28.27	72
87 x 63	0.079	18	14	31.0	33.18	78
95 x 67	0.109	18	12	35.0	38.48	84
103 x 71	0.109	24	11	40.0	44.18	90
112 x 75	0.109	24	10	46.0	50.27	96
117 x 79	0.109	24	10	52.0	56.74	102
128 x 83	0.138	24	9	58.0	63.62	108

(1) The steel thicknesses shown are adequate for structural requirements only. Where corrosive and/or abrasive conditions exist, greater thicknesses should be specified.
(2) Minimum cover top of pipe to top of subgrade.
(3) Allowable fill heights are computed on the basis that corner bearing pressure will not exceed two tons per square foot.
(4) Table 5 is also valid for the metric 125 mm x 25 mm corrugation which may be used in lieu of the 3" x 1" corrugations.

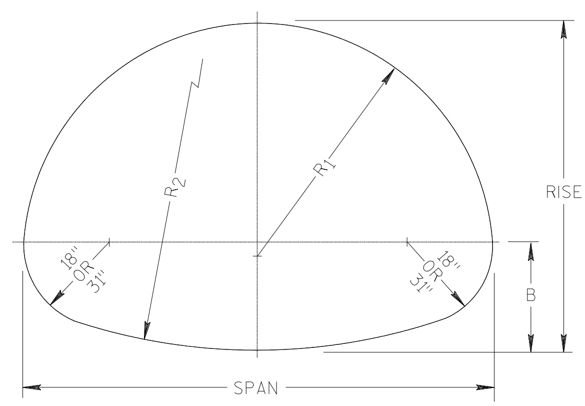
Fill Height Table 6
Structural Plate Pipe Arch - 6" x 2" Corrugations - H20 Live Load

Bid Item Number	Size Span x Rise (Ft. - Inches)	Waterway Area Sq. Ft.	Min. Thickness Inches (1)	Min. Cover Inches (2)	Max. Height of Fill Ft. (3)	Corner Radius Inches	Lay out Dimensions B Inches	R1 Feet	R2 Feet
527.0305	6-1 x 4-7	22	0.109	18	15	18	21.0	3.07	6.36
527.0310	7-0 x 5-1	28			15		21.4	3.53	8.68
527.0315	8-2 x 5-9	38		24	12		20.9	4.08	15.24
527.0320	8-10 x 6-1	43			11		21.8	4.24	14.89
527.0325	9-9 x 6-7	52			10		21.9	4.86	18.98
527.0330	11-5 x 7-3	64			8		27.4	5.78	13.16
527.0335	11-10 x 7-7	71			7		25.2	5.93	18.03
527.0340	12-10 x 8-4	85			6		24.0	6.44	26.23
SPV.0090	13-3 x 9-4	97		36	13	31	38.5	6.68	16.05
SPV.0090	14-2 x 9-10	109			12		38.8	7.13	18.55
SPV.0090	15-4 x 10-4	123	0.138		11		41.8	7.76	17.38
SPV.0090	16-3 x 10-10	137			10		42.1	8.21	19.67
SPV.0090	17-2 x 11-4	151			10		42.3	8.65	22.23
SPV.0090	18-1 x 11-10	167	0.168		9		42.4	9.09	24.98
SPV.0090	19-3 x 12-4	182			8		45.9	9.75	23.22
SPV.0090	19-11 x 12-10	200			7		42.5	9.98	31.19
SPV.0090	20-7 x 13-2	211	0.188		6		43.7	10.33	31.13

(1) The metal thickness shown are adequate for structural requirements only. Where corrosive and/or abrasive conditions exist, greater thicknesses should be specified at least for the bottom plates.

(2) Minimum cover top of pipe to top of subgrade.

(3) Allowable fill heights are computed on the basis that corner bearing pressure will not exceed two tons per square foot.



LAYOUT DIMENSIONS

FILL HEIGHT TABLE 7

Corrugated Aluminum Pipe 3" x 1" Corrugations - H20 Live Load

Pipe Dia. In.	Waterway Area Sq. Ft.	Min. Cover In. (2)	Maximum Height of Fill - Ft. Metal Thickness in Inches (1)				
			0.060	0.075	0.10	0.13	0.164
60	19.6	12	12	17	23	31	32
66	23.8	12	13	16	21	31	31
72	28.3	12	12	14	19	30	30
78	33.2	18	X	13	18	30	30
84	38.5	18	X	X	17	29	30
90	44.2	18	X	X	16	29	29
96	50.3	18	X	X	16	29	29
102	56.7	18	X	X	X	27	29
108	63.6	18	X	X	X	25	28
114	70.9	18	X	X	X	X	28
120	78.5	18	X	X	X	X	28

FILL HEIGHT TABLE 8

Aluminum Alloy, Structural Plate Pipe 9" x 2 1/2" Corrugations - H20 Live Load

Pipe Dia. In.	Waterway Area Sq. Ft.	Minimum Cover In. (2)	Maximum Height of Fill - Ft. Metal Thickness in Inches (1)						
			0.10	0.12	0.15	0.17	0.20	0.22	0.250
60	19.6	15	22	29	37	44	55	59	61
72	28.3	21	18	24	31	37	44	46	48
84	38.5	21	15	21	26	31	37	39	40
96	50.3	24	14	19	23	28	35	35	36
102	56.7	24	13	17	22	26	34	34	35
108	63.6	27	12	16	21	24	33	33	34
120	78.5	27	11	14	19	22	31	32	32
132	95.0	30	X	13	17	20	28	31	31
144	113.1	30	X	12	15	18	25	29	30
156	132.7	30	X	11	14	17	24	27	30
168	153.9	30	X	X	13	16	22	25	28
180	176.7	30	X	X	X	15	20	23	26

Note: X = Do not use - design strengths exceeded.

(1) The metal thicknesses shown are adequate for structural requirements only. Where corrosive and/or abrasive conditions exist, greater thickness should be specified.

(2) Minimum cover top of pipe to top of subgrade.

FILL HEIGHT TABLE 9
Corrugated Aluminum Pipe Arch, 2 - 2/3" X 1/2" Corrugations - H20 Live Load

Size					Round Pipe of Equal Periphery	
Span x Rise Inches	Min. Thickness In. (1)	Min. Cover In. (2)	Max. Height of Fill ft. (3)	Waterway Area Sq. Ft.	Waterway Area Sq. Ft.	Dia. Inches
17 x 13	0.060	18	12	1.1	1.23	15
21 x 15	0.060		10	1.6	1.77	18
24 x 18	0.060		8	2.2	2.41	21
28 x 20	0.075		7	2.8	3.14	24
35 x 24	0.075		6	4.4	4.91	30
42 x 29	0.105		6	6.4	7.07	36
49 x 33	0.105		5	8.7	9.62	42
57 x 38	0.135		6	11.4	12.57	48
64 x 43	0.135		6	14.3	15.90	54
71 x 47	0.164		7	17.6	19.64	60

(1) The metal thicknesses shown are adequate for structural requirements only. Where corrosive and/or abrasive conditions exist, greater thicknesses should be specified.

(2) Minimum cover top of pipe to top of subgrade.

(3) Allowable fill heights are computed on the basis that corner bearing pressure will not exceed two tons per square foot.

FILL HEIGHT TABLE 10

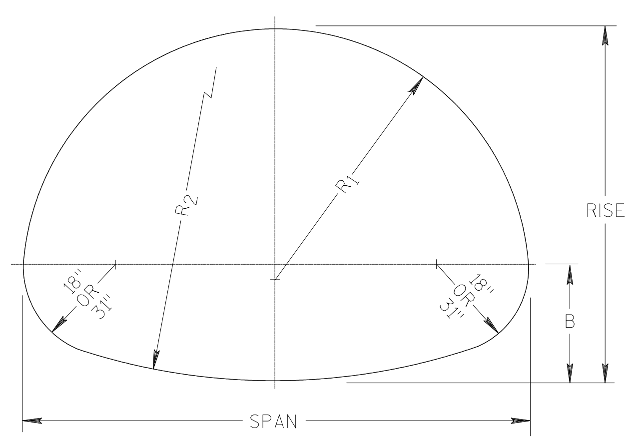
Aluminum Alloy Structural Plate Pipe Arch - 9" X 2 1/2" Corrugations - H20 Live Load

Size: Span x Rise Ft-In	Waterway Area Sq. Ft.	Min. Thickness, In. (1)	Min. Cover (2)	Max. Height of Fill (3)	Corner Radius	Layout Dimensions: B Inches	Layout Dimensions: R_1 Feet	Layout Dimensions: R_2 Feet
6-2 x 5-0	25	0.100	24 Inches	18	27 Inches	27.2	3.25	24.93
6-7 x 5-8	30			16	31.8 Inches	32.5	3.46	5.82
8-1 x 6-1	39			13		33.5	4.44	9.00
8-10 x 6-4	44		30 Inches	11		35.6	5.27	7.75
9-11 x 6-8	53			10		34.2	5.53	15.72
11-5 x 7-1	64			9		35.3	6.51	18.50
12-3 x 7-3	70		36 Inches	8		38.4	7.57	13.77
13-1 x 8-4	87			8		42.0	7.40	11.97
14-0 x 8-7	94	0.125		10		39.4	7.52	17.92
14-8 x 9-8	110	0.125		10		44.0	7.57	13.85
15-7 x 10-2	123	0.150		10		44.4	8.03	15.80
16-9 x 10-8	137	0.150		10		47.9	8.75	15.52
17-9 x 11-2	152	0.175		9		48.2	9.20	17.40
18-8 x 11-8	167	0.175		8		48.5	9.65	19.44
19-10 x 12-1	183	0.225		8		52.3	10.39	18.97
20-10 x 12-7	200	0.250		8		52.5	10.83	20.93
21-6 x 12-11	211	0.250		7		53.9	11.23	21.43

(1) The metal thicknesses shown are adequate for structural requirements only. Where corrosive and/or abrasive conditions exist, greater thicknesses should be specified at least for the bottom plates.

(2) Minimum cover top of pipe to top of subgrade.

(3) Allowable fill heights are computed on the basis that corner bearing pressure will not exceed two tons per square foot.



LAYOUT DIMENSIONS

Dimensions for Reinforced Concrete Arch and Elliptical Pipe

	Arch			Vertical Elliptical			Horizontal Elliptical		
Equivalent Round Size (Inches)	**Rise x Span (Inches)**	**Waterway Area (Sq. Ft).**	**Minimum Wall Thickness (Inches)**	**Rise x Span (Inches)**	**Waterway Area (Sq. Ft.)**	**Minimum Wall Thickness (Inches)**	**Rise x Span (Inches)**	**Waterway Area (Sq. Ft.)**	**Minimum Wall Thickness (Inches)**
15	11 x 18	1.1	2.25						
18	13 x 22	1.6	2.5				14 x 23	1.8	2.75
21	15 x 26	2.2	2.75						
24	18 x 28	2.8	3.0				19 x 30	3.3	3.25
27							22 x 34	4.1	3.5
30	22 x 36	4.4	3.5				24 x 38	5.1	3.75
33							27 x 42	6.3	3.75
36	27 x 44	6.4	4.0	45 x 29	7.4	4.5	29 x 45	7.4	4.5
39				49 x 32	8.8	4.75	32 x 49	8.8	4.75
42	31 x 51	8.8	4.5	53 x 34	10.2	5.0	34 x 53	10.2	5.0
48	36 x 58	11.4	5.0	60 x 38	12.9	5.5	38 x 60	12.9	5.5
54	40 x 65	14.3	5.5	68 x 43	16.6	6.0	43 x 68	16.6	6.0
60	45 x 73	17.7	6.0	76 x 48	20.5	6.5	48 x 76	20.5	6.5
66				83 x 53	24.8	7.0	53 x 83	24.8	7.0
72	54 x 88	25.6	7.0	91 x 58	29.5	7.5	58 x 91	29.5	7.5
78				98 x 63	34.6	8.0	63 x 98	34.6	8.0
84	62 x 102	34.6	8.0	106 x 68	40.1	8.5	68 x 106	40.1	8.5
90	72 x 115	44.5	8.5	113 x 72	46.1	9.0	72 x 113	46.1	9.0
96	77 x 122	51.7	9.0	121 x 77	52.4	9.5	77 x 121	52.4	9.5
102				128 x 82	59.2	9.75	82 x 128	59.2	9.75
108	87 x 138	66.0	10.0	136 x 87	66.4	10.0	87 x 136	66.4	10.0
114				143 x 92	74.0	10.5	92 x 143	74.0	10.5
120	97 x 154	81.8	11.0	151 x 97	82.0	11.0	97 x 151	82.0	11.0
132	106 x 169	99.1	10.0	166 x 106	99.2	12.0	106 x 166	99.2	12.0
144				180 x 116	118.6	13.0	116 x 180	118.6	13.0

Fill Height Table 11

Reinforced Concrete Arch and Elliptical Pipe (All Sizes)

Type of Pipe	**Maximum Height of Fill - Ft.**			
	Class of Pipe (0.01" Crack D-Load)			
	Class A-III Class VE-III Class HE-III (1350 D)	**Class A-IV Class VE-IV Class HE-IV (2000 D)**	**Class VE-V (3000 D)**	*Class VE-VI* **(4000 D)**
Arch	15	25		
Vertical Elliptical	15	25	35	45
Horizontal Elliptical	15	25		

NOTES:

(1) Minimum cover excluding pavement shall be 1 ft.

(2) Fill Heights were computed assuming Class "C" bedding. If Class "B" bedding is used, increase maximum height of fill by 20%.

Materials shall conform to AASHTO designation M206 for reinforced concrete arch pipe and AASHTO designation M207 for reinforced concrete elliptical pipe. Requires special provision. Use SPV.0090 Bid Item.

Guidelines for Determining a Rural Area

The following is meant to assist in the defining a “rural area” for the purposes of “in-kind” culvert replacement. This guidance is not all inclusive. Good engineering judgement should be employed in determining rural versus urban or urbanizing areas of a project.

A Rural Area is:

A project area that is not within a defined municipal boundary, or an area where the population density averages 1000 or more persons per square mile of urban area.

- The population density must correlate to the project area. If the project area covers only part of a populated area or municipal boundary, only those culverts within those areas require full H&H analysis.
- For annually revised population estimates, refer to the Wis. Department of Administration, Division of Inter-Governmental Relation’s Website at: https://doa.wi.gov/demographics and reference the applicable population or population estimates. Other population projections may be obtained from the applicable Regional Planning Commission.

An area of the project in which the adjacent land is not used for commercial or industrial land uses.

- This includes a variety of commercial land uses such as strip commercial, office parks, shopping centers and downtown commercial.
- This classification also includes governmental, institutional, transportation and recreational uses that contain source areas (such as parking lots, streets, storage areas, large landscaped areas) generating an above average amount of rainfall runoff volumes and/or pollutant loads.

An area that is not surrounded by an area described above. Island parcels of land that are completely surrounded by urban land covers may also be considered urban, even though the existing land cover may be something else.

Culvert Sizing Quick Check

To confirm field observations, or where visual observation of a culvert is inconclusive, these tables in offer a check of culvert size for "replace in kind" structures. The tables trend towards being conservative and are intended for small watersheds typical to the maximum "replace in kind" culvert size described in this part. These tables shall not be used to size culverts requiring complete hydrology and hydraulic analysis. The tables can be used however as part of the QA/QC of the H&H drainage design.

The tables require the user to have a general idea of land cover, soil type, and watershed area. This does not have to be an extensive delineation and characterization of the watershed. Only the basic characteristics of the watershed are required. The tables assume a time of concentration based on the size of the watershed. For additional information on selection of a curve number ("C") refer to FDM 13-10-5.3 and FDM 13-10 Attachment 5.2 Runoff Coefficients (C), Rational Formula; and Runoff Coefficients for Specific Land Uses.

This check should also be only part of the evaluation of "in kind" replacement. The tables are not meant to dictate the need to increase or reduce the size of an existing culvert, they are intended as a check. Still, in the event the in-place culvert size and the tabulated size are substantially different, a full H&H analysis may be appropriate.

Typical Culvert Sizing – Western and Southwestern Wisconsin – Corrugated Metal Culverts

Drainage Area (acres)	Diameter of Culvert (inches)			
	Wooded/ Gentle Slope (C=0.2)	Mixed Wooded/Open Space. Low to Medium Density Development (C=0.4)	Steeper Slopes with limited vegetative cover, Commercial Areas (C=0.7)	Impervious (C=0.9)
0-2	24	24	24	24
2-5	24	30	36	36
5-10	30	36	42	48
10-15	30	36	42	48
15-20	30	42	48	Perform H&H
20-30	36	48	Perform H&H	Perform H&H
30-40	36	48	Perform H&H	Perform H&H
40-50	42	Perform H&H	Perform H&H	Perform H&H
50-75	48	Perform H&H	Perform H&H	Perform H&H
75-100	Perform H&H	Perform H&H	Perform H&H	Perform H&H

Additional Notes:

1. Assumes 25-year storm for rural class roadway with ADT <7,000.
2. 25-year rainfall was derived from typical volumes in updated IDF curves, NOAA Atlas 14, Volume 8.
3. Time of concentration is assumed to increase and therefore design rainfall intensity decreases with drainage area size.
4. The pipes are assumed to not be completely submerged by backwater.
5. A maximum HW/D of 1.5 is assumed per FDM 13-15-5.5.
6. For culverts up to 100 feet.

Typical Culvert Sizing – Far Northwestern and Southeastern Wisconsin – Corrugated Metal Culverts

	Diameter of Culvert (inches)			
Drainage Area (acres)	Wooded/ Gentle Slope (C=0.2)	Mixed Wooded/Open Space. Low to Medium Density Development (C=0.4)	Steeper Slopes with limited vegetative cover, Commercial Areas (C=0.7)	Impervious (C=0.9)
0-2	24	24	24	24
2-5	24	30	30	36
5-10	30	36	42	48
10-15	30	36	42	48
15-20	30	42	48	Perform H&H
20-30	36	48	Perform H&H	Perform H&H
30-40	36	48	Perform H&H	Perform H&H
40-50	42	48	Perform H&H	Perform H&H
50-75	48	Perform H&H	Perform H&H	Perform H&H
75-100	48	Perform H&H	Perform H&H	Perform H&H

Typical Culvert Sizing – Northeast Wisconsin – Corrugated Metal Culverts

	Diameter of Culvert (inches)			
Drainage Area (acres)	Wooded/ Gentle Slope (C=0.2)	Mixed Wooded/Open Space. Low to Medium Density Development (C=0.4)	Steeper Slopes with limited vegetative cover, Commercial Areas (C=0.7)	Impervious (C=0.9)
0-2	24	24	24	24
2-5	24	24	30	36
5-10	24	36	42	42
10-15	30	36	42	48
15-20	30	36	48	48
20-30	36	42	Perform H&H	Perform H&H
30-40	36	42	Perform H&H	Perform H&H
40-50	36	48	Perform H&H	Perform H&H
50-75	42	Perform H&H	Perform H&H	Perform H&H
75-100	48	Perform H&H	Perform H&H	Perform H&H

Additional Notes:

1. Assumes 25-year storm for rural class roadway with ADT <7,000.
2. 25-year rainfall was derived from typical volumes in updated IDF curves, NOAA Atlas 14, Volume 8.
3. Time of concentration is assumed to increase and therefore design rainfall intensity decreases with drainage area size.
4. The pipes are assumed to not be completely submerged by backwater.
5. A maximum HW/D of 1.5 is assumed per FDM 13-15-5.5.
6. For culverts up to 100 feet.

Typical Culvert Sizing – Western and Southwestern Wisconsin – Concrete and Thermoplastic Culverts

Drainage Area (acres)	Diameter of Culvert (inches)			
	Wooded/ Gentle Slope (C=0.2)	Mixed Wooded/Open Space. Low to Medium Density Development (C=0.4)	Steeper Slopes with limited vegetative cover, Commercial Areas (C=0.7)	Impervious (C=0.9)
0-2	24	24	24	24
2-5	24	24	30	36
5-10	24	36	42	48
10-15	30	36	42	48
15-20	30	36	48	Perform H&H
20-30	36	48	Perform H&H	Perform H&H
30-40	36	48	Perform H&H	Perform H&H
40-50	42	48	Perform H&H	Perform H&H
50-75	48	Perform H&H	Perform H&H	Perform H&H
75-100	48	Perform H&H	Perform H&H	Perform H&H

Typical Culvert Sizing – Far Northwestern and Southeastern Wisconsin – Concrete and Thermoplastic Culverts

Drainage Area (acres)	Diameter of Culvert (inches)			
	Wooded/ Gentle Slope (C=0.2)	Mixed Wooded/Open Space. Low to Medium Density Development (C=0.4)	Steeper Slopes with limited vegetative cover, Commercial Areas (C=0.7)	Impervious (C=0.9)
0-2	24	24	24	24
2-5	24	24	30	36
5-10	24	30	42	42
10-15	24	36	42	48
15-20	30	36	48	48
20-30	36	42	Perform H&H	Perform H&H
30-40	36	48	Perform H&H	Perform H&H
40-50	36	48	Perform H&H	Perform H&H
50-75	42	Perform H&H	Perform H&H	Perform H&H
75-100	48	Perform H&H	Perform H&H	Perform H&H

Additional Notes:

1. Assumes 25-year storm for rural class roadway with ADT <7,000.
2. 25-year rainfall was derived from typical volumes in updated IDF curves, NOAA Atlas 14, Volume 8.
3. Time of concentration is assumed to increase and therefore design rainfall intensity decreases with drainage area size.

4. The pipes are assumed to not be completely submerged by backwater.
5. A maximum HW/D of 1.5 is assumed per FDM 13-15-5.5.
6. For culverts up to 100 feet.

Typical Culvert Sizing – Northeast Wisconsin – Concrete & Thermoplastic Culverts

Drainage Area (acres)	Diameter of Culvert (inches)			
	Wooded/ Gentle Slope (C=0.2)	Mixed Wooded/Open Space. Low to Medium Density Development (C=0.4)	Steeper Slopes with limited vegetative cover, Commercial Areas (C=0.7)	Impervious (C=0.9)
0-2	24	24	24	24
2-5	24	24	30	30
5-10	24	30	36	42
10-15	24	30	42	42
15-20	30	36	42	48
20-30	30	42	48	Perform H&H
30-40	36	42	Perform H&H	Perform H&H
40-50	36	48	Perform H&H	Perform H&H
50-75	42	Perform H&H	Perform H&H	Perform H&H
75-100	48	Perform H&H	Perform H&H	Perform H&H

Additional Notes:

1. Assumes 25-year storm for rural class roadway with ADT <7,000.
2. 25-year rainfall was derived from typical volumes in updated IDF curves, NOAA Atlas 14, Volume 8.
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6. For culverts up to 100 feet.