CITY UTILITIES
DESIGN STANDARDS MANUAL

Book 2
Stormwater (SW)
SW7 Inlets

September 2017

SW7.01 Purpose

The purpose of this Chapter is to establish a basis for inlet design utilizing City of Fort Wayne standard inlets and castings.

Stormwater inlets are a vital component of the urban stormwater collection and conveyance system. Inlets intercept excess stormwater from streets and developed areas and transition surface flow into storm sewers.

Proper inlet design includes both the proper inlet hydraulic capacity and appropriate inlet placement.

If too few inlets are provided, if inlets are placed in the wrong location, or if inlets do not have adequate hydraulic capacity then even amply sized pipes in the storm sewer system will not function as intended.

Methods for determination of stormwater runoff are presented in the Chapter SW5 - Hydrology.

SW7.02 Standard Inlets

There are three general types of inlets acceptable for use in Fort Wayne, including curb opening, valley (grate), and combination inlets. Inlet components can be made of cast-iron, steel, concrete, and/or pre-cast concrete.

Typical installation settings include:

- Street curb and gutter
- Pavement depression
- Drainage swale or channel
- Greenspace or undeveloped area

The standard inlets permitted for use in Fort Wayne are provided in Exhibit MA5-1. Standard casting types are provided for each structure type.

SW7.03 Inlet Placement

Inlets must be placed at each location where surface runoff flow should be interrupted and transitioned into storm sewer system pipe flow. Inlets can be placed in roadside ditches, grass or lined swales, parking or pavement area depressions, and in roadway or parking area curb and gutters.

The following location requirements must be considered during the design of inlets.

1. In developed areas, inlets shall be located in all pavement and green space depression areas where surface runoff collects and transitions to storm sewer pipe flow.
2. Inlets shall be placed in grass or lined swales and open channels where concentrated flow transitions to storm sewer pipe flow.
3. Inlets shall be placed in all streets and roadway sags. For the 10-year design storm, the depth of ponded water at the inlet shall not exceed the values shown in Figure SW7.2. For the 100-year design storm, the depth of ponded water at the inlet shall not exceed the values shown in Figure SW7.3.

4. Inlet grate capacities shall be designed to adequately pass the storm sewer pipe design storm event flow with 50% of the inlet grate free open areas clogged.
5. An emergency overland flow path shall be included at street and roadway sags in the event that the inlet or storm sewer is not functioning. The depth of ponded water at the inlet shall not exceed twelve inches (12”).
6. Depth of ponded water shall not exceed eight inches (8”) in private development parking areas, except in areas used as detention. See Chapter SW11 - Stormwater Management for parking lot surface detention requirements.
7. Depth of ponded water shall not exceed twenty-four inches (24”) in green space areas, except in areas used as detention.
8. In streets and roadways, inlets shall be placed immediately upstream of intersections, pedestrian walkways, and handicap ramps. Required inlets shall be placed not closer than two feet (2') from the upstream edge of walkways and handicap ramps. See Detail SW-4 for placement of inlets at intersections.
9. In pedestrian traveled areas, install ADA compliant inlet grates and pick hole plugs.
10. In streets or roadways where opposing lanes are separated by a grass median or concrete center curb, inlets shall be placed upstream of a crossover.
11. On continuous roadway or street grades, inlet spacing is determined by limiting maximum width of gutter flow (Tmax). Inlets shall be spaced to collect a minimum of 75 percent (75%) of the watershed design flow. Bypass flow, flow not intercepted by an individual inlet, shall not exceed 25 percent (25%). Bypass flow shall be considered when determining the location of the next downstream inlet. General inlet spacing on continuous grades is 300 feet to 600 feet (300' to 600') provided the Tmax criteria are not exceeded. Exact spacing shall be computed by the designer. See the Section SW7.05 Gutter Flow for more information on Tmax design.
12. Uniform inlet and casting types should be used on individual street and roadway projects. Uniformity limits confusion and misplacement of proper inlet types during construction.

Figure SW7.2 Allowable Use of Streets for Minor Storm Runoff

Street Classification	Maximum Street Encroachment	Street Width Face of Curb to Face of Curb, (ft)	Maximum Top Width from Gutter, T_{max} (ft)	Maximum Depth in Gutter Flow, d (ft)
Local	No curb overtopping. ½ Driving Lane	30	7.5	0.15
		32	8	0.16
		36	9	0.18
Collector (< 45 mph)	No curb overtopping. ½ Driving Lane	36	9	0.18
		40	10	0.2
		44	11	0.22
Arterial & Collector > 45 mph	No curb overtopping. Flow spread must leave at least two 10-foot lanes free of water with 10 feet on each side of the street crown.	Coordinate allowable use with agency having jurisdictional authority on roadway.		

Figure SW7.3 Allowable Use of Streets for Major Storm Runoff

Street Classification	Maximum Depth and Inundated Area
Local and Collector	The maximum Depth of water: 1. shall not exceed 12-inches above the gutter flowline and, 2. shall not reduce the localized Flood Protection Grade to less than 12-inches. (Whichever is more restrictive)
Arterial	The maximum Depth of water: 1. shall not exceed 12-inches above the gutter flowline and, 2. shall not reduce the localized Flood Protection Grade to less than 12-inches and, 3. shall not exceed the street crown (to allow for emergency vehicles) (Whichever is most restrictive)

SW7.04 Inlet Hydraulic Capacity

1. Introduction

   All stormwater runoff that enters a sump or gutter must pass through an inlet to enter the storm sewer system. In most situations stormwater is laden with debris and the inlet will be susceptible to clogging. Therefore, the capacity of inlets must account for this clogging potential.

Design of inlet hydraulic capacity is separated into either a sump or continuous grade situation. The following sections include design considerations and Figures for inlet capacity for those two situations.

2. Sump Condition

Inlets in depressions or sumps function like weirs for shallow flow, but as the depth of stormwater increases inlets begin to function like an orifice. Figures SW7.4 through SW7.7 provide the allowable inlet capacities in sump conditions.

Figure assumptions:

- Weir flow assumed for water depths below 2”.

  Weir Equation:

  $Q_1 = 3.30 \times P \times d^{1.5}$

  Q_1 = Rate of flow into the inlet, cfs
  P = perimeter of grate, ft
  d = depth of water surface above inlet, ft

- Orifice flow assumed for water depths above 4”

  Orifice Equation:

  $Q_1 = 4.81 \times A \times d^{0.5}$

  Q_1 = Rate of flow into the inlet, cfs
  A= net open area of grate, ft
  d = depth of water surface above inlet, ft

- Transition flows assumed between 2” and 4” water depth
- Clogging reduces weir length by 50%
- Clogging reduces free open area by 50%

3. Continuous Grade Condition

Inlet Hydraulic Capacity on a continuous grade is designed as a function of depth of water flow in the street gutter and the inlet grate constant. The grate constant is determined empirically by the inlet manufacturer.

Note that inlets shall be spaced so that allowable inlet capacity intercepts at least 75% of the gutter flow during the 10-year rain event.

Figures SW7.8 through SW7.10 provide the allowable inlet capacities in continuous grade conditions:

Figure SW7.4

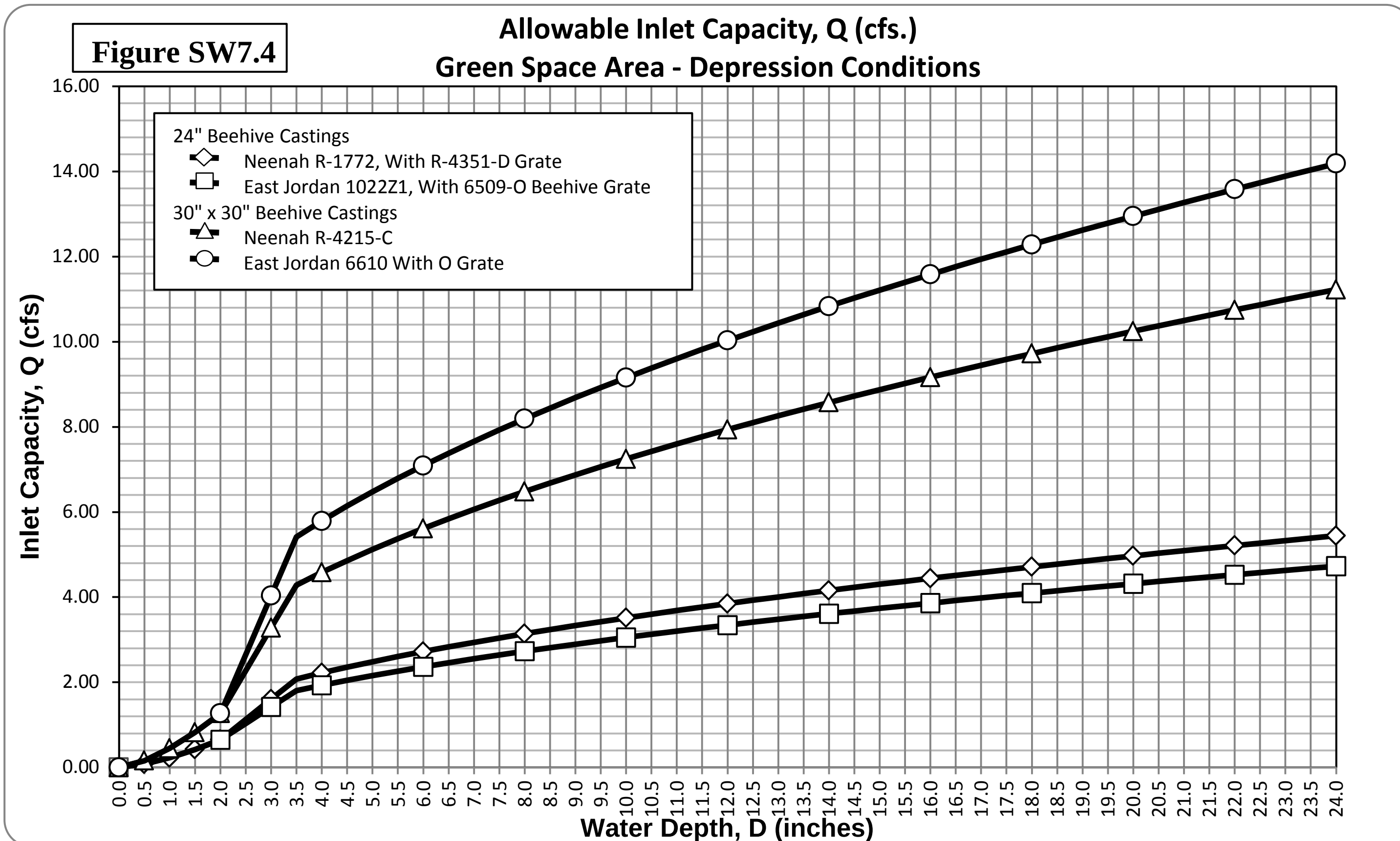


Figure SW7.5

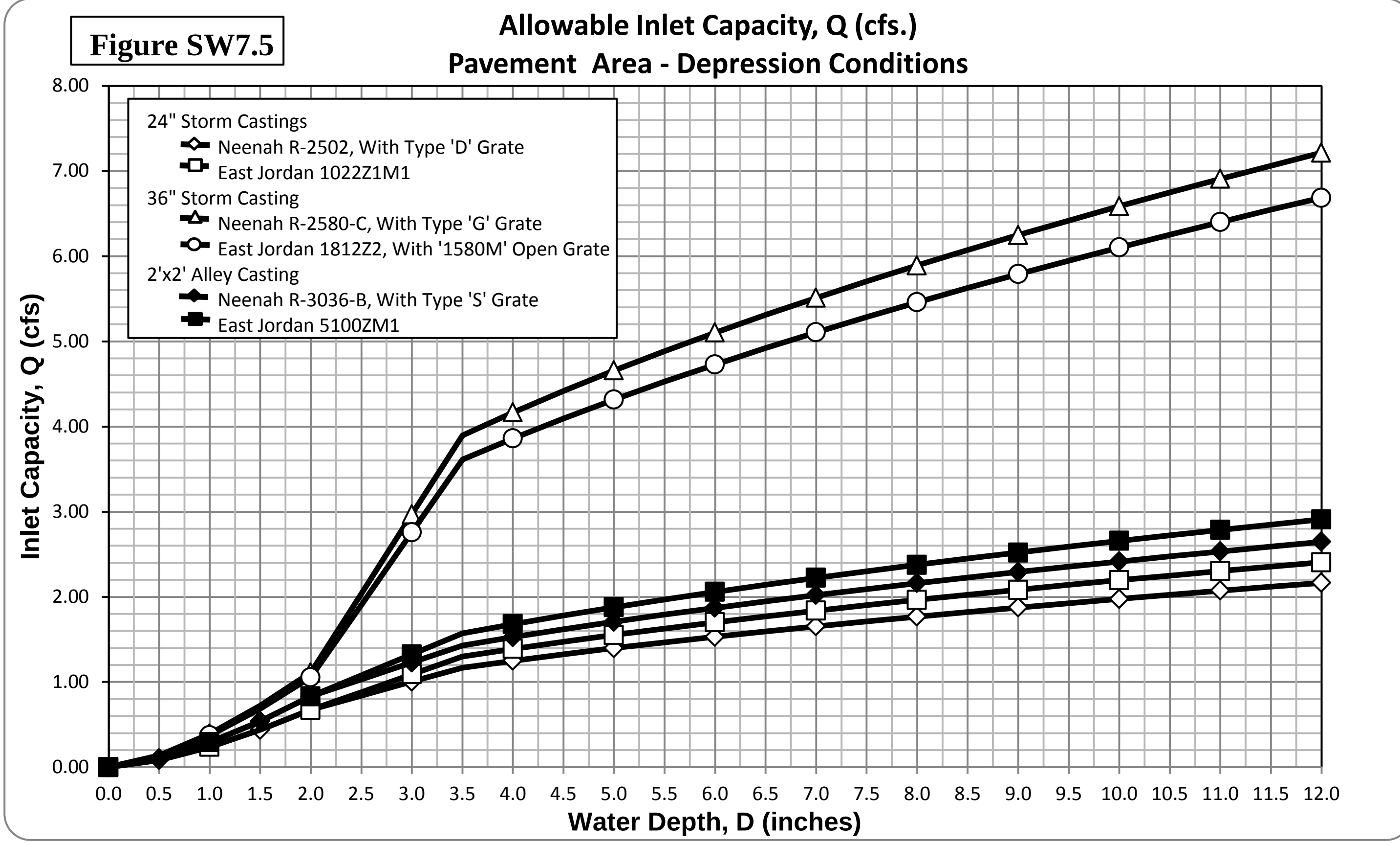


Figure SW7.6

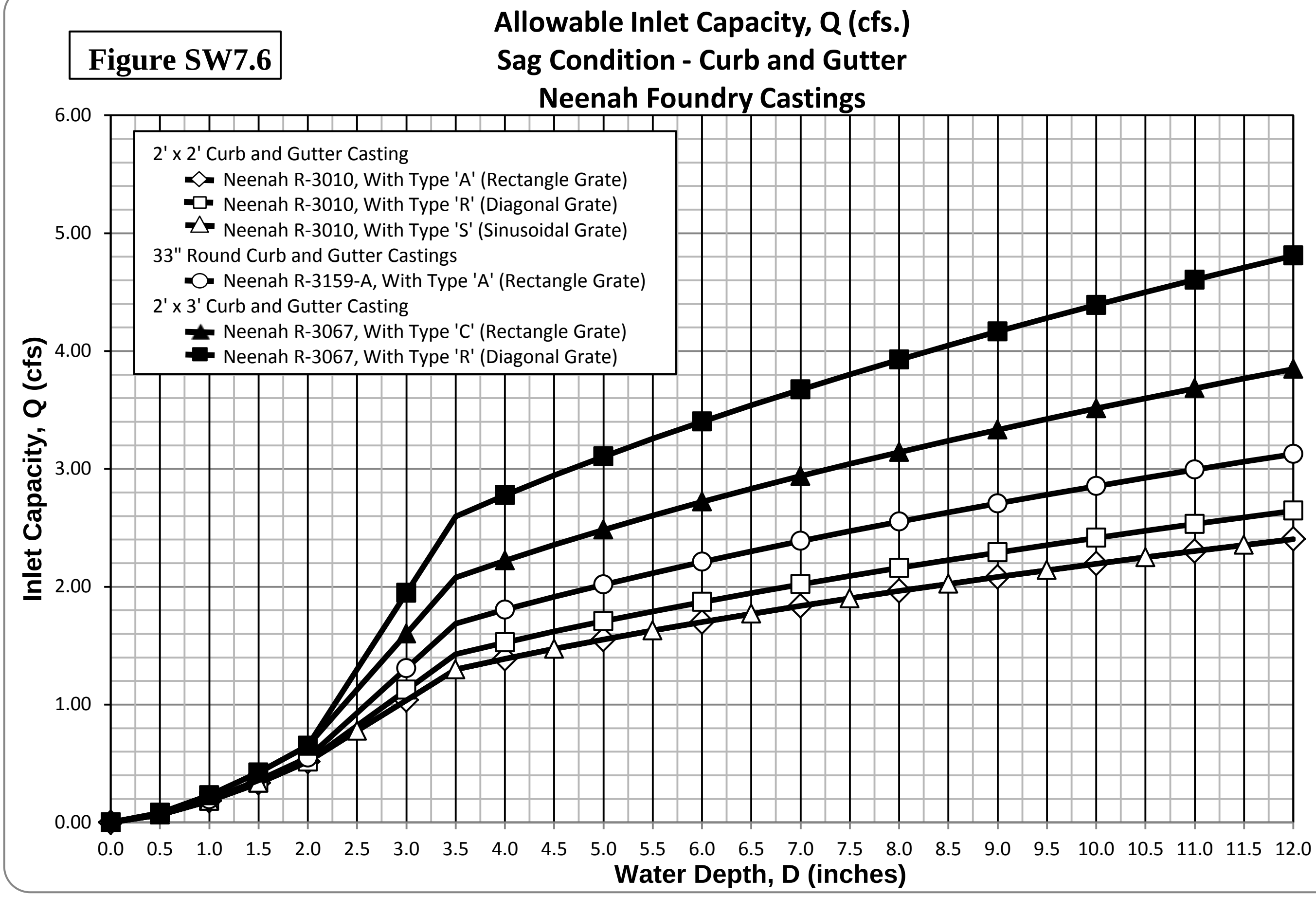


Figure SW7.7

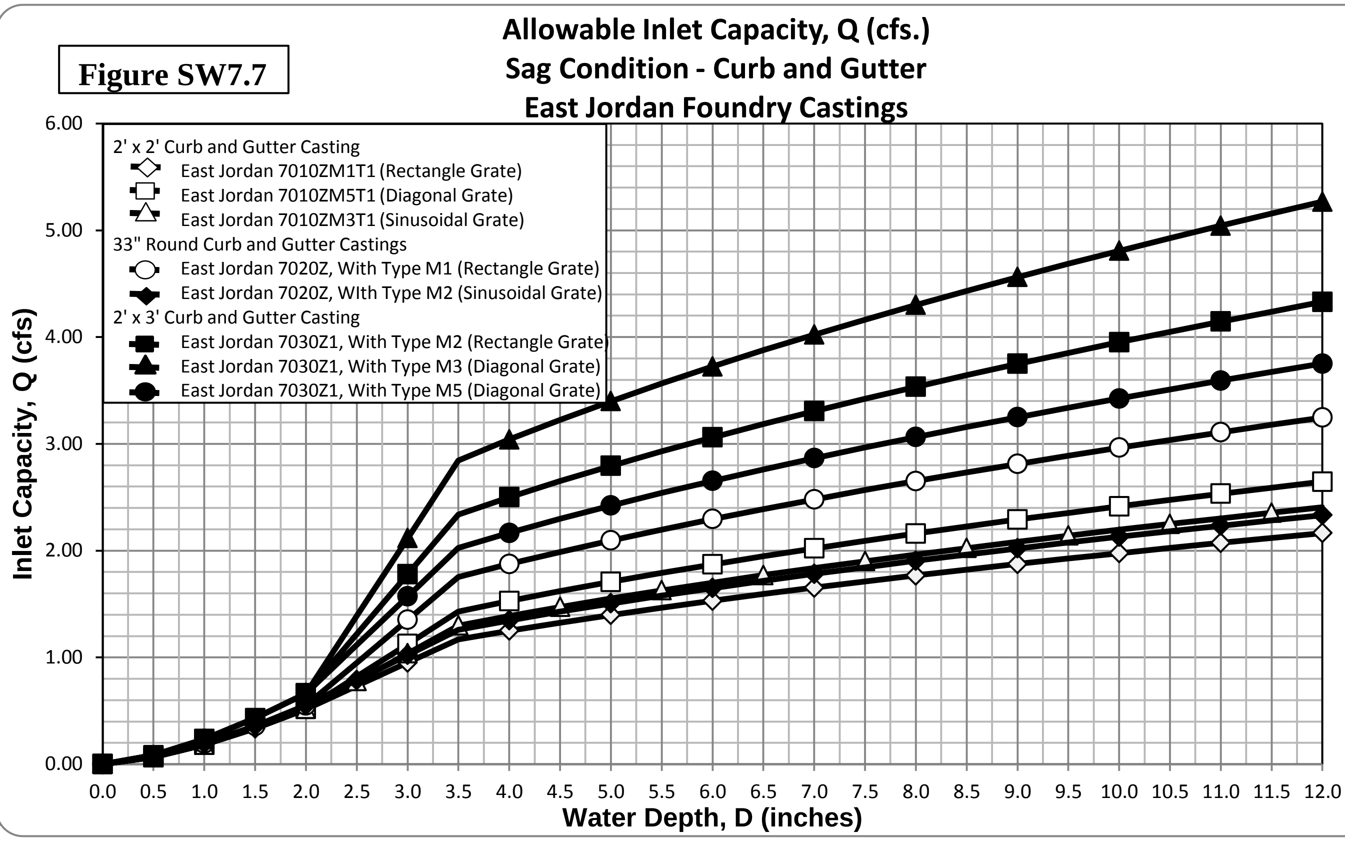


Figure SW7.8

Allowable Inlet Capacity, Q (cfs.) - Continuous Grade Condition

2' x 2' Curb and Gutter Combination Casting
Neenah R-3010, Type 'A', 'R' and 'S' Grates
East Jordan 7010Z, Type M1T1, M5T1 and M3T1 Grates

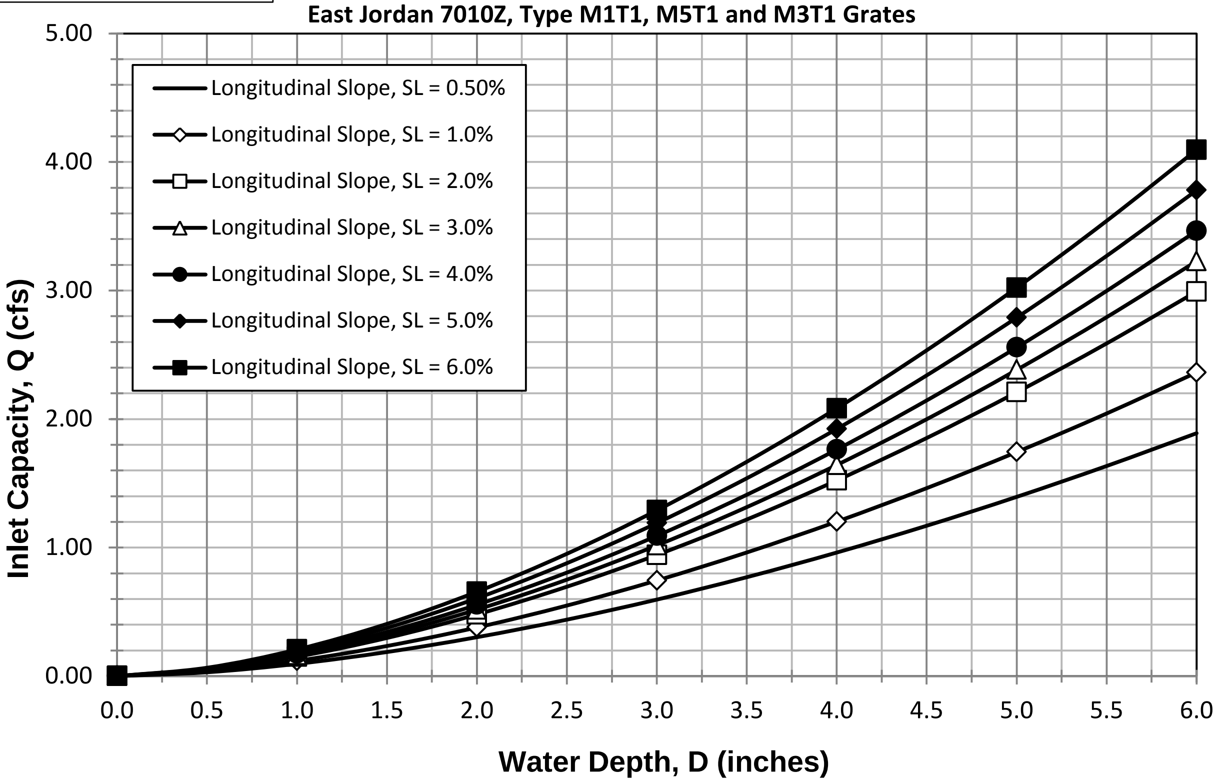
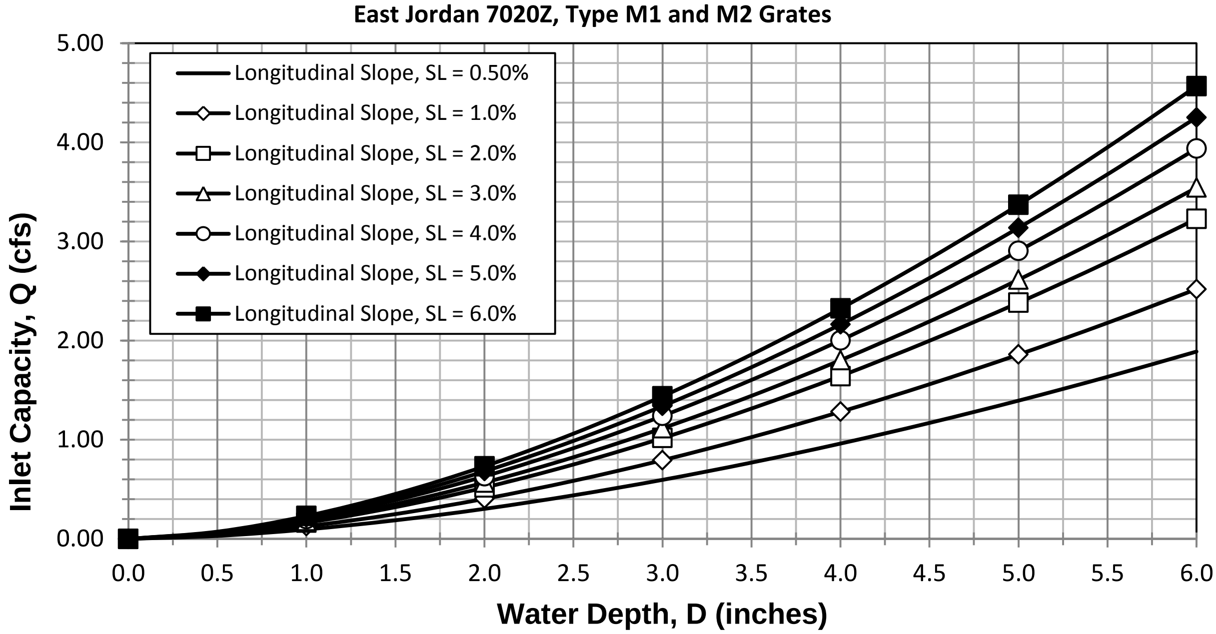


Figure SW7.9

Allowable Inlet Capacity, Q (cfs.) - Continuous Grade Condition

33" Round Curb and Gutter Combination Casting
Neenah R-3159-A, Type 'S' Grate
East Jordan 7020Z, Type M1 and M2 Grates



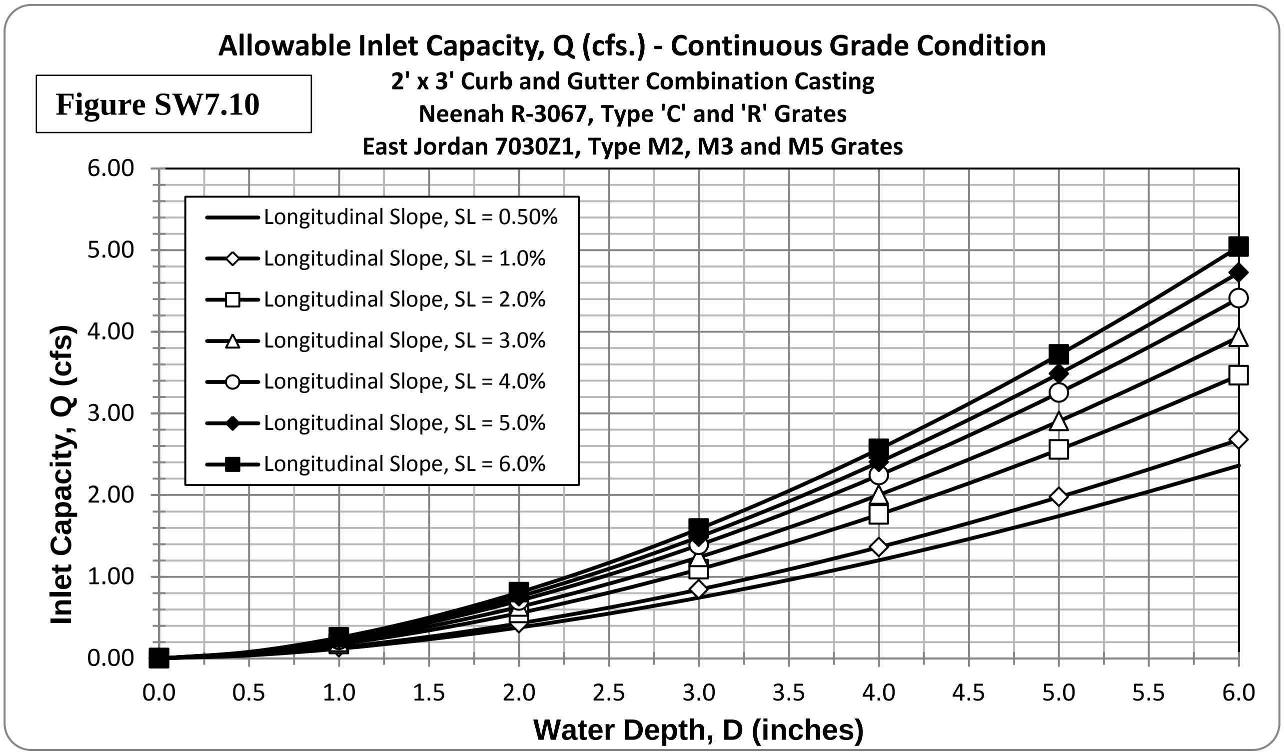


Figure SW7.10

Continuous Grade Condition Figure assumptions:

Inlet Capacity on a continuous grade Equation:

$Q_i = K * d^{(5/3)}$

- Q_i = Rate of flow into the inlet, cfs
- K = Inlet grate constant based on grade geometry and longitudinal and transverse slopes (provided by manufacturer)

  (Neenah inlet constants are utilized for comparable East Jordan grates)
- d = maximum depth of water surface above inlet, ft

Casting capacity reduced by 50% for clogging.

Continuous grade capacity curves only apply when street flow is at the maximum allowable depth. For lower gutter depths, the inlet interception rate will decrease.

SW7.05 Gutter Flow

1. Introduction

   The capacity of gutter flow in curbed pavement helps determine proper inlet casting and inlet spacing designs. Many factors affect the flow capacity of gutters. These factors work together to provide a safe limit on stormwater encroachment into driving lanes and parking areas.

2. Allowable Use of Streets for Stormwater Flows

   See Figure SW7.2 and SW7.3 for a description of the allowable encroachment into driving lanes for various street types and widths. The minor and major storm events are to be defined and calculated per the methods described in Chapter SW5 - Hydrology.

3. Gutter Flow Capacity

Figure SW7.11 may be used in lieu of separate calculations unless the actual street design is not represented by the assumptions listed.

Gutter Flow Equation (Modified Manning's Equation)

$Q = 0.56\ (S_x^{1.67}\ S_L^{0.50}\ T^{2.67})/n$

Where:

Q = Flow, (cfs)
S_x = pavement cross slope, (ft/ft)
S_L = average longitudinal slope of gutter, (ft/ft)
T = top width of flow extending from face of curb to street, (ft)
n = Manning's roughness coefficient

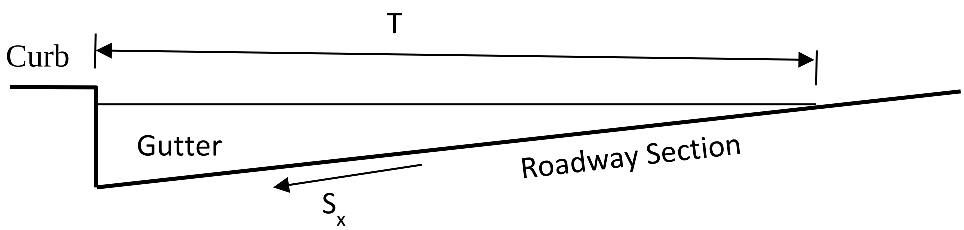


Figure SW7.11 Allowable Gutter Capacity

	GUTTER CAPACITY, Q (cfs)									
Longitudinal Gutter Slope, S_L (%)	Top Width of Gutter Flow, T (ft)	5.0	7.5	10.0	12.5	15.0	17.5	20.0	22.5	25.0
	Depth of Gutter Flow, d (ft)	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50
0.50		0.3	0.8	1.7	3.1	5.0	7.5	10.0	10.0	10.0
0.75		0.3	1.0	2.1	3.7	6.1	9.2	10.0	10.0	10.0
1.0		0.4	1.1	2.4	4.3	7.0	10.0	10.0	10.0	10.0
1.5		0.5	1.4	2.9	5.3	8.6	10.0	10.0	10.0	10.0
2.0		0.5	1.6	3.4	6.1	9.9	10.0	10.0	10.0	10.0
2.5		0.6	1.7	3.8	6.8	10.0	10.0	10.0	10.0	10.0
3.0		0.6	1.9	4.1	7.5	10.0	10.0	10.0	10.0	10.0
3.5		0.7	2.1	4.5	8.1	10.0	10.0	10.0	10.0	10.0
4.0		0.7	2.2	4.8	8.6	10.0	10.0	10.0	10.0	10.0
4.5		0.8	2.3	5.1	9.2	10.0	10.0	10.0	10.0	10.0
5.0		0.8	2.5	5.3	9.7	10.0	10.0	10.0	10.0	10.0

Gutter Capacity Figure Notes and Assumptions:

S_x = 2.0% or 0.020 ft/ft
n = 0.016
A minimum of 75% of design flow shall be intercepted by inlet
Gutter width = 1.5 feet
Maximum allowable gutter flow for minor storm event = 10 cfs
S_x is equivalent across both the pavement and gutter