FHWA HYDRAULIC ANALYSIS TOOLS

NASECA ANNUAL CONFERENCE
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CONTACT INFORMATION

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FHWA Tools and Services

- Hydraulic Toolbox
- Other FHWA H&H Analysis Software
- Training Opportunities
  - Introduction to Highway Hydraulics
  - Culvert Design
  - Urban Drainage Design

3

Other Tools and Services

- Inlet Spacing Spreadsheet
- WisDOT SharePoint site

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Hydraulic Toolbox

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Toolbox

What is it?

- Public Domain (Free!)
- Series of Calculators Including:
  - Channel Analysis
  - Inlet Design

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Toolbox

Where Can I Find it?

- https://highways.dot.gov/federal-lands/hydraulics

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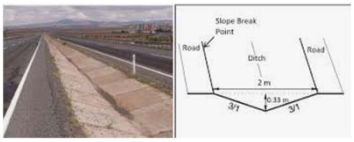
Ditch and Pipe Capacity



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Channel Analysis

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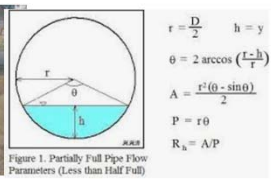
Ditch and Pipe Capacity



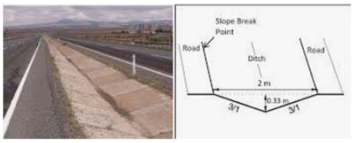
$r = \frac{D}{2}$ $h = y$

$\theta = 2 \arccos\left(\frac{r-h}{r}\right)$

$A = \frac{r^2(\theta - \sin\theta)}{2}$

$P = r\theta$

$R_h = A/P$



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Ditch and Pipe Capacity

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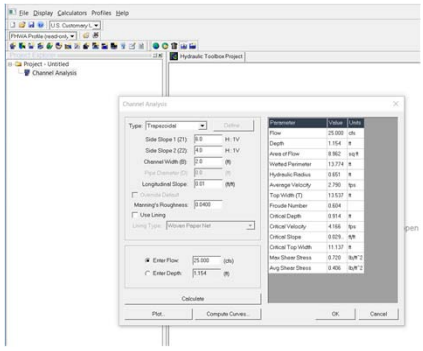
Determine Capacity for:

- Trapezoidal



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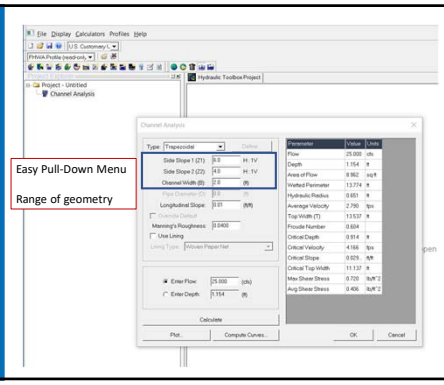
Determine Capacity for:
- Trapezoidal



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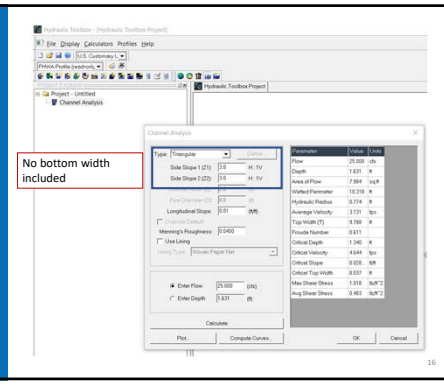
Determine Capacity for:
- Trapezoidal
- Triangular



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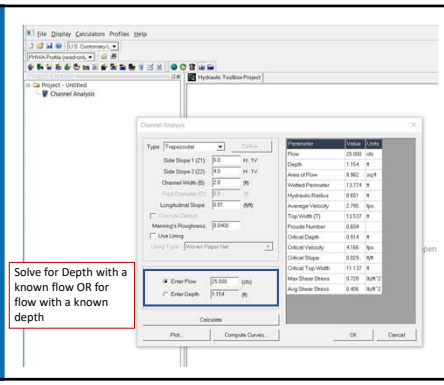
Determine Capacity for:
- Trapezoidal



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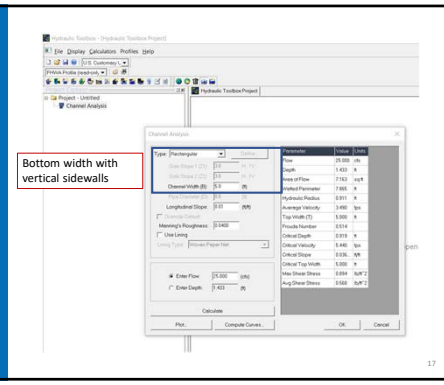
Determine Capacity for:
- Trapezoidal
- Triangular
- Rectangular



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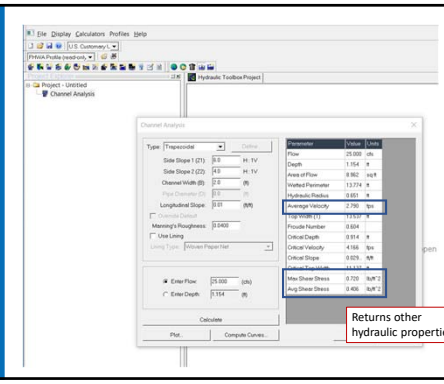
Determine Capacity for:
- Trapezoidal



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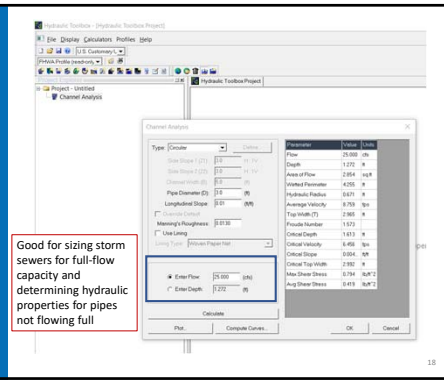
Determine Capacity for:
- Trapezoidal
- Triangular
- Rectangular
- Circular (pipes not flowing under pressure



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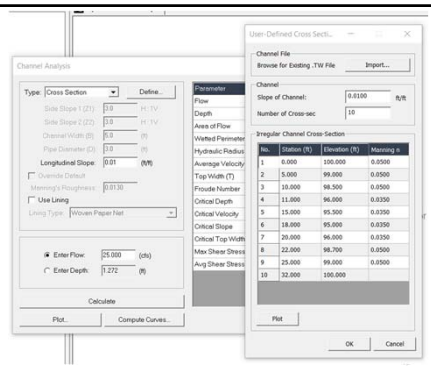
Determine Capacity for:
- Trapezoidal
- Triangular
- Rectangular
- Circular (pipes not flowing under pressure
- Irregular Cross Sections



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Channel Lining

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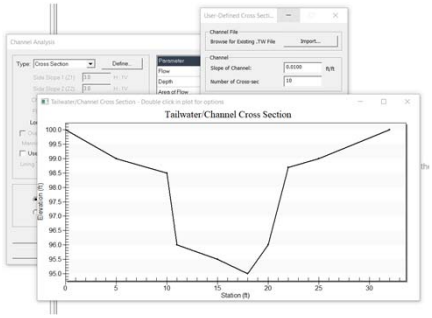
Determine Capacity for:
- Trapezoidal
- Triangular
- Rectangular
- Circular (pipes not flowing under pressure
- Irregular Cross Sections



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Channel Lining Analysis

Benefits

- Same procedure as FDM

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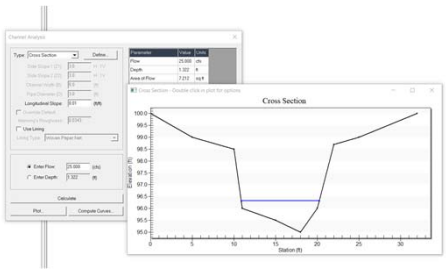
Determine Capacity for:
- Trapezoidal
- Triangular
- Rectangular
- Circular (pipes not flowing under pressure
- Irregular Cross Sections



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Channel Lining Analysis

Benefits

- Same procedure as FDM
- Easy to analyze different channel sections

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Channel Lining Analysis

Benefits

- Same procedure as FDM
- Easy to analyze different channel sections
- All the math is done in the program

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Lining Materials:
- Riprap or stone

26

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Lining Materials:
- Riprap or stone
- Vegetation


27

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Lining Materials:
- Riprap or stone
- Vegetation
- Rolled Erosion Control Products



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Lining Materials:
- Riprap or stone
- Vegetation
- Rolled Erosion Control Products
- Gabions




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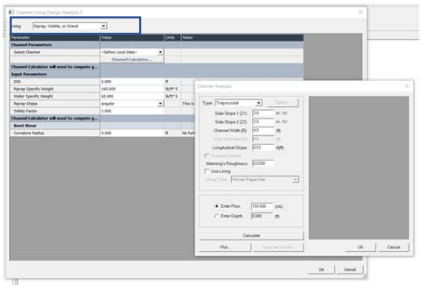
Process:
- Select Lining Material



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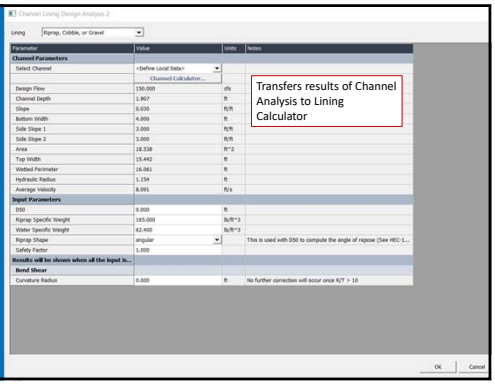
Process:
- Select Lining Material
- Channel Analysis



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Culvert Outlet Protection

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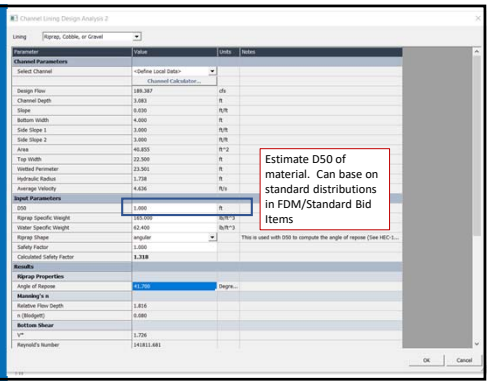
Process:
- Select Lining Material
- Channel Analysis
- Riprap Size



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Is outlet protection required?

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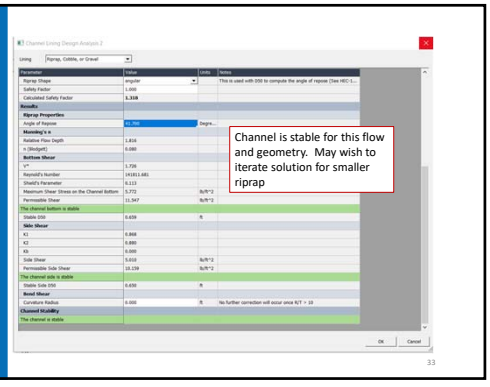
Process:
- Select Lining Material
- Channel Analysis
- Riprap Example
- Compute



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Is outlet protection required?

What size of stone?

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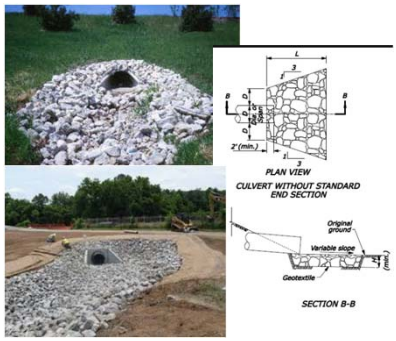
Is outlet protection required?

What size of stone?

Dimension of pad?



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Process:
- Define Channel Geometry

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Process:
- Define Channel Geometry
- Edit Culvert Data

This data is obtained from HY-8 or other culvert analysis program

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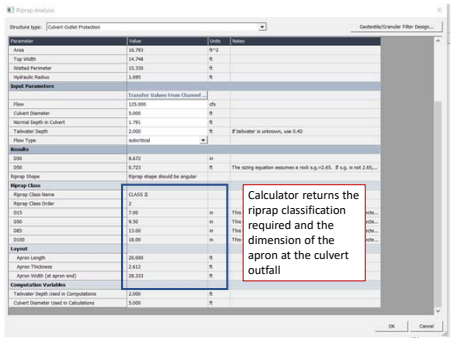
Process:
- Define Channel Geometry
- Edit Culvert Data
- Review Results



Calculator returns the riprap classification required and the dimension of the apron at the culvert outfall

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Gradation Analysis

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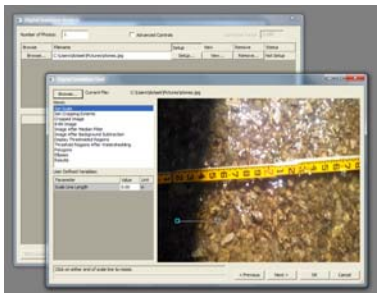
Gradation Analysis

- Upload Photo(s)



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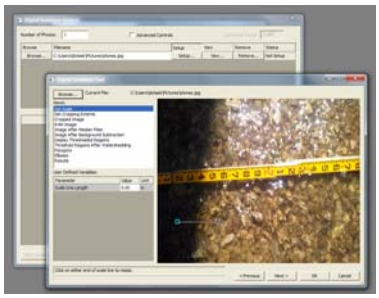
Gradation Analysis

- Upload Photo(s)
- Requires scale or scalable object



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Gradation Analysis

- Upload Photo(s)
- Requires scale or scalable object
- Channel substrate

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Gradation Analysis

- Upload Photo(s)
- Requires scale or scalable object
- Channel substrate
- Material delivered to site

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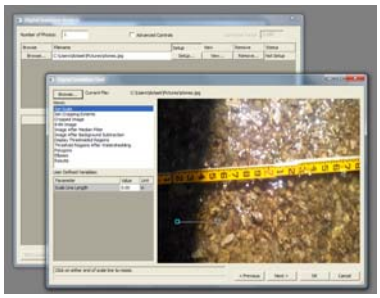
Gradation Analysis

- Upload Photo(s)
- Requires scale or scalable object
- Channel substrate
- Material delivered to site
- Follow prompts to complete computations



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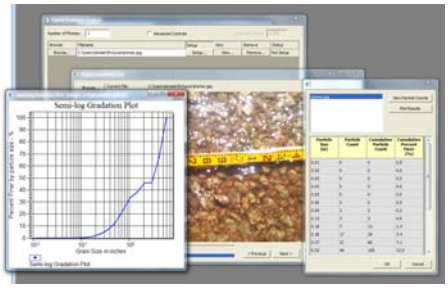
Gradation Results

Results include particle size distribution



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Curb and Gutter Analysis

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Curb and Gutter Analysis

Inlet Sizing

49

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Curb and Gutter Analysis

Inlet Sizing

50

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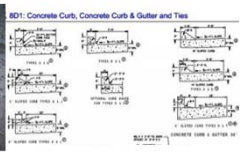
Curb and Gutter Analysis

Inlet Sizing



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Curb and Gutter Analysis

Benefits

- Easy to calculate encroachment

52

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Curb and Gutter Analysis

Benefits

- Easy to calculate encroachment
- Evaluates depth at curb

53

53

Curb and Gutter Analysis

Benefits

- Easy to calculate encroachment
- Evaluates depth at curb
- Allows for different transverse slopes between roadway and gutter

54

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Curb and Gutter Analysis

Benefits

- Easy to calculate encroachment
- Evaluates depth at curb
- Allows for different transverse slopes between roadway and gutter
- Great for calculating inlet sizing at sags and curb opening inlets (rare in Wisconsin)

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Curb and Gutter Analysis

Inlet Sizing

Benefits

- Easy to calculate encroachment
- Evaluates depth at curb
- Allows for different transverse slopes between roadway and gutter
- Great for calculating inlet sizing at sags and curb opening inlets (rare in Wisconsin)

Drawbacks

- Inlets on grade
  - Doesn't use Neenah inlets

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Curb and Gutter Analysis

Inlet Sizing

Benefits

- Easy to calculate encroachment
- Evaluates depth at curb
- Allows for different transverse slopes between roadway and gutter
- Great for calculating inlet sizing at sags and curb opening inlets (rare in Wisconsin)

Drawbacks

- Inlets on grade and in sag
  - Doesn't use Neenah inlets
  - Uses FHWA inlets and methodology

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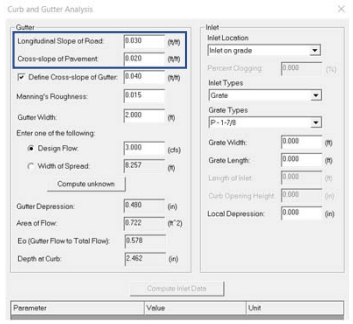
Curb and Gutter Process:

- Roadway Geometry



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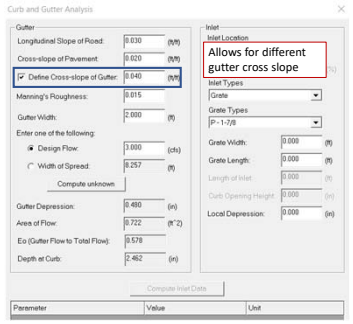
Curb and Gutter Process:

- Roadway Geometry



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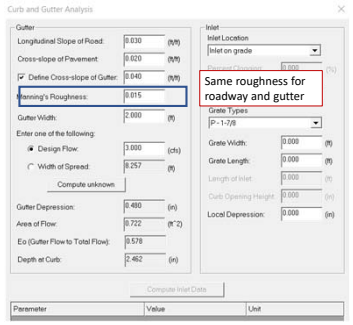
Curb and Gutter Process:

- Roadway Geometry
- Gutter Geometry
- Roughness



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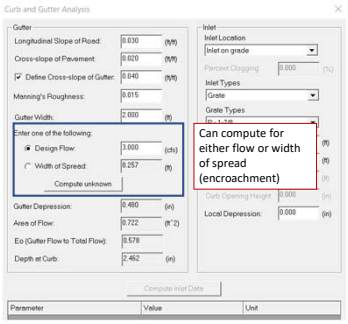
Curb and Gutter Process:
- Roadway Geometry
- Gutter Geometry
- Roughness
- Compute



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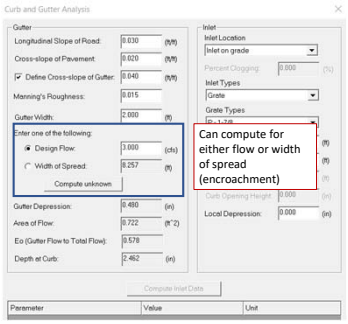
Curb and Gutter Process:
- Roadway Geometry
- Gutter Geometry
- Roughness
- Compute



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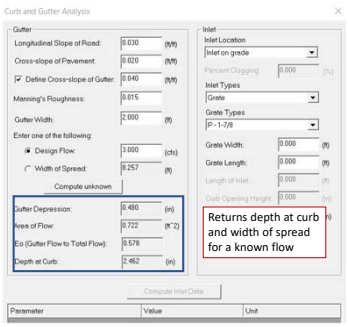
Curb and Gutter Process:
- Roadway Geometry
- Gutter Geometry
- Roughness
- Compute
- Results



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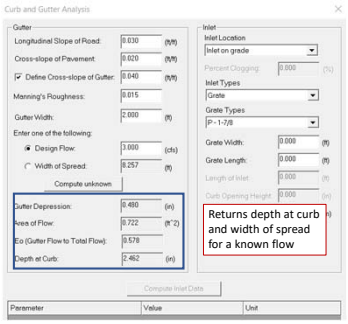
Inlets in Sag Process:
- Roadway Geometry
- Gutter Geometry
- Roughness
- Compute
- Results



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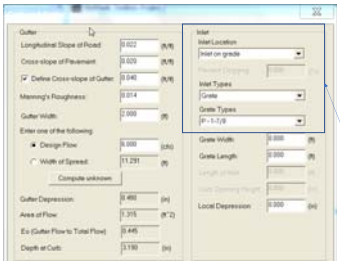
Inlet Spacing



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WisDOT Inlet Spacing Spreadsheet

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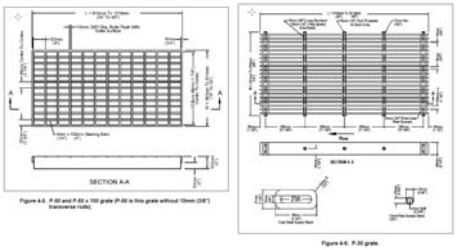
Wisconsin Doesn't Use "FHWA" Inlets



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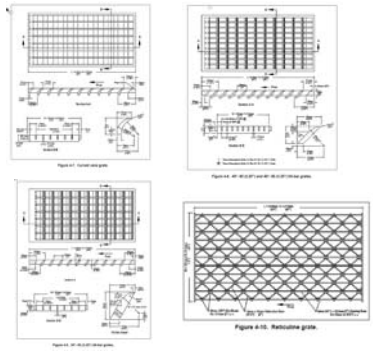
Other Typical FHWA Inlet Types

Found in FHWA HEC-22



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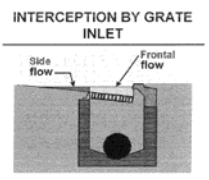
FHWA Methodology

- Capacity determined by:
  - Amount of flow intercepted
  - Amount of flow bypassing
- Interception depends on:
  - Flow in the gutter section
  - Size and configuration of the grate
  - Flow velocity



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Neenah Foundry

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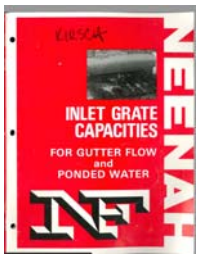
Neenah Foundry



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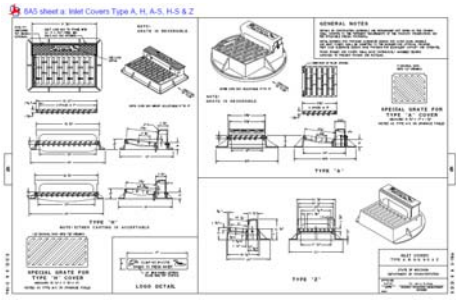
WisDOT SDDs Correspond to Neenah Catalog Items



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Grate Testing

Empirical testing developed inlet capacity curves

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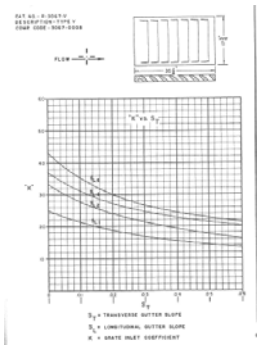
Testing Developed Efficiency Curves



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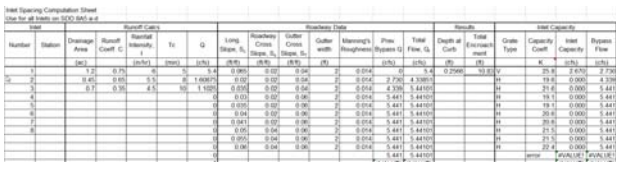
WisDOT Spreadsheet for Neenah Inlets



Performs calculations and documents design for project files

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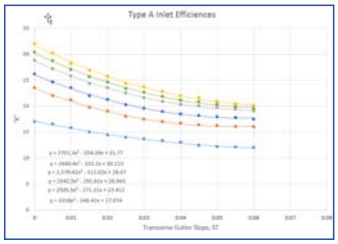
Capacity Curves and Equations



- Developed for each inlet to be used on grade
- R^2 value of > 0.99 for each equation
- K values plotted as a function of cross slope for six longitudinal slopes
- Interpolated values for 3% and 5% slopes

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Spreadsheet Details

- Available on WisDOT SharePoint:
- https://wigov.sharepoint.com/sites/dot-dtsd/bpd/drainage/SitePages/Home.aspx

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- Moving to Box for easier access

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- Contact Ed Lilla for access: Edward.Lilla@dot.wi.gov

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Spreadsheet Details

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- Contact Ed Lilla for access: Edward.Lilla@dot.wi.gov
- Spreadsheet includes detailed instructions and inlet capacity curves

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- Spreadsheet includes detailed instructions and inlet capacity curves
- Reviewed by Neenah product engineers

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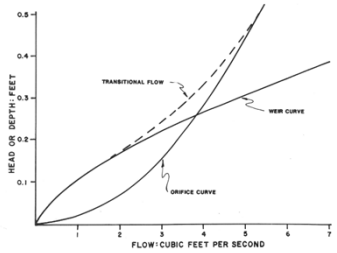
Inlet Spacing in a Sag

Use spreadsheet to calculate
- Weir Flow
- Orifice Flow
- Minimum Controls



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Other Resources

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NHI

FHWA NHI Training

- Online Courses https://www.nhi.fhwa.dot.gov/home.aspx

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NHI

FHWA NHI Training

- Online Courses https://www.nhi.fhwa.dot.gov/home.aspx
- Culvert Design

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NHI

FHWA NHI Training

- Online Courses https://www.nhi.fhwa.dot.gov/home.aspx
- Culvert Design
- Introduction to Highway Hydraulics

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NHI

FHWA NHI Training

- Online Courses https://www.nhi.fhwa.dot.gov/home.aspx
- Culvert Design
- Introduction to Highway Hydraulics
- Urban Drainage Design

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HY-8

Other FHWA Tools

Culvert Design

- Free!

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HY-8

Other FHWA Tools

Culvert Design

- Free!
- Standard software incorporated into other tools

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HY-8

Other FHWA Tools

Culvert Design

- Free!
- Standard software incorporated into other tools
- Energy dissipation design

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HY-8

Other FHWA Tools

Culvert Design
- Free!
- Standard software incorporated into other tools
- Energy dissipation design
- Aquatic Organism Passage consideration

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WisDOT

Drainage Design SharePoint

- NOAA Atlas 14 IDF Curves

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WisDOT

Drainage Design SharePoint

- NOAA Atlas 14 IDF Curves
- Previous Presentations

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WisDOT

Drainage Design SharePoint

- NOAA Atlas 14 IDF Curves
- Previous Presentations
- Neenah Inlet Capacity Publication

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WisDOT

Drainage Design SharePoint

- NOAA Atlas 14 IDF Curves
- Previous Presentations
- Neenah Inlet Capacity Publication
- Inlet Spreadsheet Tool

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WisDOT

Drainage Design SharePoint

- NOAA Atlas 14 IDF Curves
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- Neenah Inlet Capacity Publication
- Inlet Spreadsheet Tool

- https://wigov.sharepoint.com/sites/dot-dtsd/bpd/drainage/SitePages/Home.aspx

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Questions?

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Contact

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