



# FY21 RSM Mid-Year IPR

## Riprap and Scour Calculator:

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**BLUF:** We developed and documented a Riprap and Toe Scour calculator that computes riprap size based on HEC-RAS hydrodynamics.

The screenshot displays the software interface for the Riprap and Scour Calculator. The top menu bar includes 'File', 'Type', 'Edit', and 'Gradations'. The main window is divided into several sections:

- Upstream Reference Cross Section:** Shows 'Riprap Examp' and 'Riprap Reach' set to 3800.
- Design Cross Section:** Shows 'Riprap Examp' and 'Riprap Reach' set to 3800.
- Channel Type:** Includes options for 'Natural', 'Trapazoidal', 'Angular', and 'Rounded'.
- Site Alignment:** Includes options for 'Outside Bend', 'Straight', and 'DS of Concrete End of Dike'.
- Input Data:**
  - Radius of Curvature: 300 ft
  - Side Slope Angle: 24 deg
  - Safety Factor: 1
  - Unit Weight: 150 lb/cf
  - Angle of Repose: 40 deg
- Intermediate Computations:**
  - $V_{ss}$ : 13.074 ft/s
  - $D_{ss}$ : 9.532 ft
  - $V_{ss} / V_{avg}$ : 1.343
  - SS Corr. Factor (K1): 0.914
  - Stability Coeff (Cs): 0.3
  - Vert Vel Dist (Cv): 1.13
  - Radius / Width: 5.802
- Gradation Results:**

	D30	D100	Thickness	Source Gradation	Selecting
Bed	6.8444 in	15 in	15	EM1601 3	⊞
Side Slope	13.6677 in	27 in	27	EM1601 7	⊞
- Gradations Plot:** A graph showing 'Percent Finer by Weight' vs 'Stone Size (mm)'. The plot includes several curves representing different gradations. A legend on the right identifies the curves: EM1601 1, EM1601 2, EM1601 3, EM1601 5, EM1601 7, D30 Side Slope, and D30 Bed. The D30 Side Slope curve is highlighted in pink.

### Activities:

1. Software Release
  - ▶ Riprap
  - ▶ Scour
2. Documentation
3. Training Videos



# FY21 RSM Mid-Year IPR Riprap and Scour Calculator:

## “Headline Feature” in HEC-RAS 6.1 Redesigned with Modern Look/Feel

The screenshot displays the Riprap and Scour Calculator interface. The top bar shows 'Profile 4000', 'HD File', and 'Plan 4000'. The 'Edit' tab is active, showing 'Riprap Examp' and 'Riprap Reach' settings for both 'Upstream Reference Cross Section' and 'Design Cross Section'. The 'Channel Type' is set to 'Natural', and 'Rock Type' is 'Angular'. The 'Site Alignment' is 'Straight'. The 'K1 Method' is 'Analytical'. The 'Riprap' and 'Scour Depth' tabs are visible.

**Hydraulic Data**

Design Q	4000	cfs
Design Depth	12.276	ft
Velocity	7.614	ft/s
Top Width	42	ft
Energy Slope	0.001539	
Hydr Radius	9.775	ft
Design Depth	16.289	ft
Manning n-value	0.035	

**Upstream Reference XS**

Design Q	4000	ft/s
Depth	11.644	ft
Velocity	8.064	ft/s
Top Width	42	ft
Energy Slope	0.0019	
Hydr Radius	9.268	ft
Depth	15.668	ft

**Neill Bankfull Incised Data**

Bankfull Q	3200	ft/s
Bankfull Average Width	42	ft
Bankfull Hydraulic Depth	14	ft
Neill Exponent	0.7	

**Results**

- Bend Scour**
  - Maynard: 7.03 ft
  - Zeller: 1.044 ft
  - Thorne: 10.88 ft
  - USACE Curve: 7.938 ft
- General Scour**
  - Zeller: -1.799 ft
  - Neill: 9.82 ft
  - Lacey: 3.09 ft
  - USBR Env: 7.313 ft
  - USBR Vel: 3.972 ft

**Bend Scour Visualization**

Toe Point X: 165

**Evaluation Point (Design XS) Crossing Reference**

**Legend**

- WS 4000
- WS 4000
- Ground
- Bank Sta
- Thorne Bend
- Zeller Bend
- USACE Bend
- Maynard Bend
- Toe Point
- Closest Toe Point

# FY21 RSM Mid-Year IPR Riprap and Scour Calculator: Documentation



HEC-RAS User's Manual

HEC Home RAS Docs Downloads 6.1

## Step 5: Select Gradation to Compute Thickness

The Maynard equation and the riprap calculator compute a stable  $d_{30}$ . But you will have to select a gradation to find the  $d_{30}$  and  $d_{100}$  required to compute the design riprap thickness. The riprap calculator uses an interactive plot tool to select a gradation for the bed and side slope computations, to complete the analysis.

Select a Gradation to Compute Thickness  
d30 Cross Section  
Sensitivity Analysis  
Add New Gradations  
Gradation Curves  
Gradation Polygons  
Managing Gradations

### Select a Gradation to Compute Thickness

The riprap calculator plots the computed  $d_{30}$ s with the selected or user-input gradations. To associate a gradation with the bed or side slope analysis, click the radio button under selecting, and then click on the curve or polygon associated with the gradation.

Upstream Reference XS Intermediate Computations Gradations

View: 4.750 m/s, 7.000 m/s, 10.000 m/s

Depth: 1.000 m, 2.000 m, 3.000 m

Width: 10.000 m, 20.000 m, 30.000 m

Input Data: SS Coef. Factor (Ks), Stability Coef. (Cs), Vert. Vel. Dist. Coef., Radius / (d30)S

Gradation Results: Bed, Side Slope

Legend: D1000 1, D1000 2, D1000 3, D1000 4, D1000 5, D1000 7, D30 Side Slope, D30 Bed

User Manual:  
-Online  
-Stand-Alone (56p)

Example Project

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## Riprap and Scour Calculator:

### Validation and Verification: V&V



The screenshot shows the software interface with the following data:

Upstream Reference XS		Intermediate Computations	
V <sub>avg</sub>	7.1 ft/s	V <sub>ss</sub>	10.54 ft/s
Depth	15 ft	D <sub>ss</sub>	12 ft
Width	200 ft	V <sub>st</sub> / V <sub>avg</sub>	1.484
Input Data		SS Corr. Factor (K1)	0.88
Radius of Curvature	620 ft	Stability Coeff (Cs)	0.3
Side Slope Angle	26.57 deg	Vert Vel Dist (Cv)	1.185
Safety Factor	1.1	Radius / Width	3.1
Unit Weight	165 lb/cf	Gradation Results	
Angle of Repose	40 deg	D30	D100
		Thickness	Source Gradation
		Selecting	
		Bed	2.6338 in
		Side Slope	7.4776 in

$$\frac{V_{ss}}{V_{avg}} = 1.74 - 0.52 \log \left( \frac{R}{W} \right) = 1.484$$

$$V_{ss} = 1.484 V_{avg} = 1.484 * 7.1 \frac{ft}{s} = 10.5 \frac{ft}{s}$$

$$D_{ss} = D - 0.2 \sqrt{D^2 + \left( \frac{D}{\tan(\theta)} \right)^2} * \sin(\theta)$$

$$D_{ss} = 15 \text{ ft} - 0.2 \sqrt{15 \text{ ft}^2 + \left( \frac{15 \text{ ft}}{\tan(26.57^\circ)} \right)^2} * \sin(26.57^\circ) = 12 \text{ ft}$$

$$d_{30(SS)} = SF \cdot C_s C_v D_{ss} \left[ \frac{\gamma_w}{\gamma_s - \gamma_w} \frac{V_{ss}}{\sqrt{K_1 g D_{ss}}} \right]^{2.5}$$

$$7.5 \text{ in} \leftarrow 0.623 \text{ ft} = 1.0 \cdot 0.3 \cdot 1.185 \cdot 12 \text{ ft} \left[ \frac{62.4 \frac{lb}{ft^3}}{165 \frac{lb}{ft^3} - 62.4 \frac{lb}{ft^3}} \frac{10.5 \text{ ft/s}}{\sqrt{0.9 \cdot 32.2 \frac{ft}{s^2} \cdot 12 \text{ ft}}} \right]^{2.5}$$

EM 1601  
Example  
+ Several  
Others

# FY21 RSM Mid-Year IPR Riprap and Scour Calculator: Training Videos



The screenshot shows the Riprap and Scour Calculator software interface. The top menu includes File, Type, Edit, and Gradations. The main workspace is divided into several panels:

- Upstream Reference XS:** Shows  $V_{avg}$  (8.417 ft/s), Depth (11.295 ft), and Width (42 ft).
- Intermediate Computations:** Shows  $V_{max}$ ,  $D_{25}$ ,  $V_{ex} / V_{avg}$ , SS Corr. Factor (K1) (1), Stability Coeff (Cs) (0.3), Vert Vel Dist (Cv), and Radius / Width.
- Input Data:** Shows Radius of Curvature (300 ft), Side Slope Angle, Safety Factor (1), Unit Weight (150 lb/cf), and Angle of Repose (40 deg).
- Gradation Results:** A table with columns for d30, d100, Thickness, Source Gradation, and Selecting. It shows settings for Bed and Side Slope.
- Gradations Panel:** A graph showing Percent Finer by Weight versus particle size.
- Ruler Dialog:** A dialog box for measuring a circle on the ground, showing a Radius of 838.78 Feet, Area of 204,621.27 Square Meters, and Circumference of 5,260.43 Feet.
- Aerial View:** A satellite image of a river bend with a yellow circle highlighting the "Critical Bend Radius" and a red arrow pointing to the "Evaluation Cross Section".

A video inset in the top right corner shows a presenter wearing a headset, speaking and gesturing.

Upstream Reference  
"Approach"  
Cross Section

Critical  
Bend  
Radius

$\frac{R_c}{W} = 3.3$   
"Severe Bend"

"Evaluation"  
Cross Section

- Alpha Release Quick Start Guide
- Full Release Riprap Video
- Scour Video (in progress)

# FY21 RSM Mid-Year IPR

## Riprap and Scour Calculator:

### Live Demo



Profile: 4000 | HD File | None | Plan | None | BETA

File | Type | **Edit** | Gradations

Apply Defaults | Riprap Examp | Hydraulics | Channel | Riprap Examp | Hydraulics | Channel | Natural | Angular | Outside Bend | DS of Concrete | Graphical  
 Riprap Reach | Riprap Reach | Trapazoidal | Rounded | Straight | End of Dike | Analytical  
 3800 | 3800 | Channel Type | Rock Type | Site Alignment | K1 Method  
 Upstream Reference Cross Section | Design Cross Section | Riprap

Riprap | Scour Depth

**Upstream Reference XS**

V<sub>avg</sub> 9.735 ft/s  
 Depth 7.944 ft  
 Width 51.71 ft

**Input Data**

Radius of Curvature 300 ft  
 Side Slope Angle 25 deg  
 Safety Factor 1  
 Unit Weight 150 lb/cf  
 Angle of Repose 40 deg

**Intermediate Computations**

V<sub>ss</sub> 13.074 ft/s  
 D<sub>ss</sub> 9.532 ft  
 V<sub>ss</sub> / V<sub>avg</sub> 1.343  
 SS Corr. Factor (K1) 0.9  
 Stability Coeff (Cs) 0.3  
 Vert Vel Dist (Cv) 1.13  
 Radius / Width 5.802

**Gradations** | Crossing XS | Design XS

Keep Prev D30 Plots |

**Legend**

- EM1601 1
- EM1601 2
- EM1601 3
- EM1601 5
- EM1601 7
- D30 Side Slope
- D30 Bed

**Gradation Results**

	D30	D100	Thickness	Source Gradation	Selecting
Bed	6.9798 in	12 in	12	EM1601 2	<input type="radio"/>
Side Slope	13.938 in	27 in	27	EM1601 7	<input checked="" type="radio"/>

# FY21 RSM IPR

## District, Title



**What challenges did you face to get your project to implementation and how did you move past them?**

- **Software Development Resources**
- **Loss of Institutional Expertise**

# FY21 RSM IPR

## District, Title



**How is this project benefiting the USACE and Nation?**

- **The USACE places millions of dollars of rock per year.**
- **This calculator will help save money on those annual efforts in three ways:**
  - **Improve the efficiency of the calculations**
  - **Improve the accuracy of the calculations and formalize an institutional process, which will...**
    - ▶ **Save money from costly overdesigns**
    - ▶ **Avoid costly and embarrassing failures**