Michael Baker
INTERNATIONAL
We Make a Difference

Smooth Transition

Adjusting Manning's n values for 2D modeling

Andrew Friend, P.E., and Mark McBroom, P.E.

HEC-RAS Reference Manual

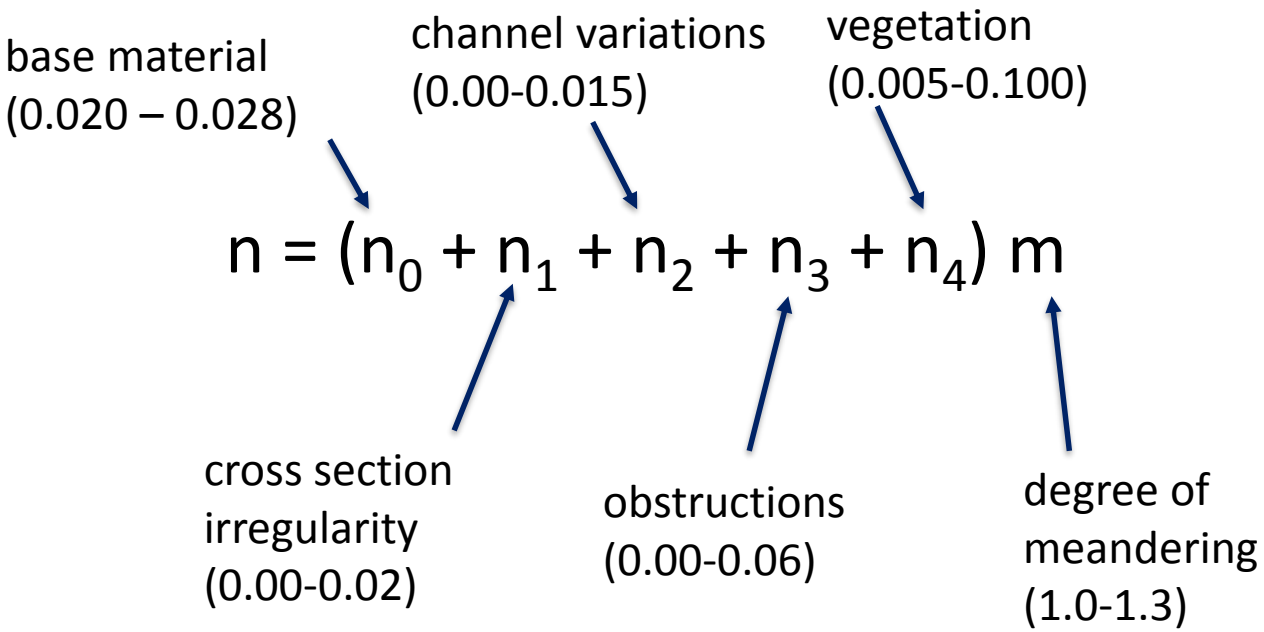
Table 3-1 Manning's 'n' Values

Type of Channel and Description	Minimum	Normal	Maximum
A. *Natural Streams*			
1. **Main Channels**			
a. Clean, straight, full, no rifts or deep pools	0.025	0.030	0.033
b. Same as above, but more stones and weeds	0.030	0.035	0.040
c. Clean, winding, some pools and shoals	0.033	0.040	0.045
d. Same as above, but some weeds and stones	0.035	0.045	0.050
e. Same as above, lower stages, more ineffective slopes and sections	0.040	0.048	0.055
f. Same as "d" but more stones	0.045	0.050	0.060
g. Sluggish reaches, weedy. deep pools	0.050	0.070	0.080
h. Very weedy reaches, deep pools, or floodways with heavy stands of timber and brush	0.070	0.100	0.150
2. **Flood Plains**			

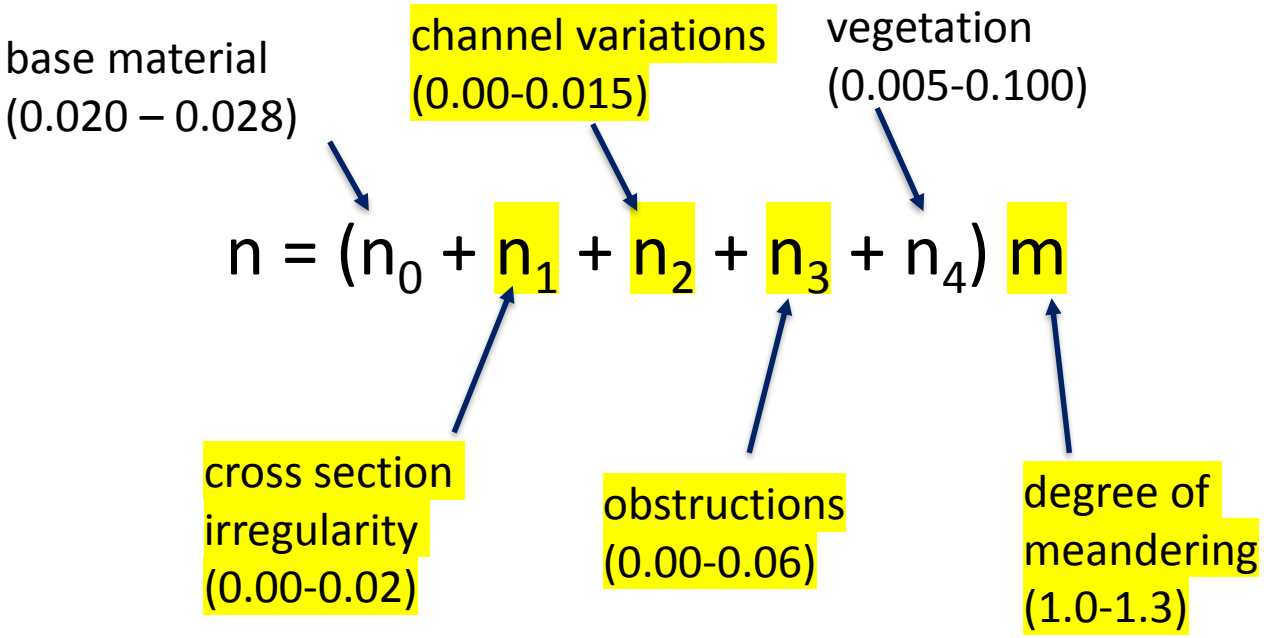
Cowan [1956] and Chow [1959]

$$n = (n_0 + n_1 + n_2 + n_3 + n_4)\, m$$

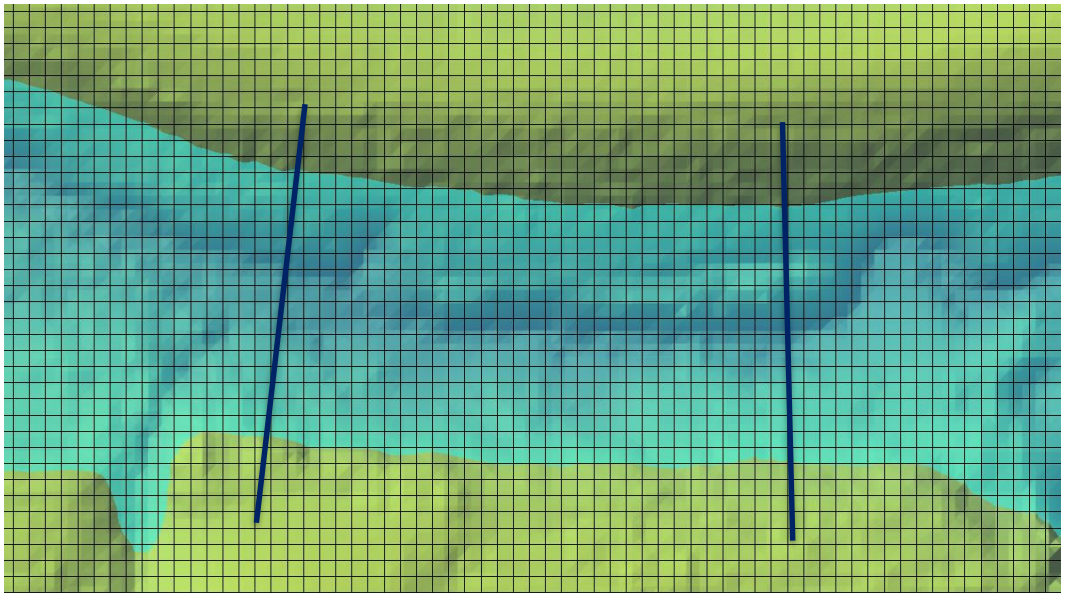
Cowan [1956] and Chow [1959]



Cowan [1956] and Chow [1959]

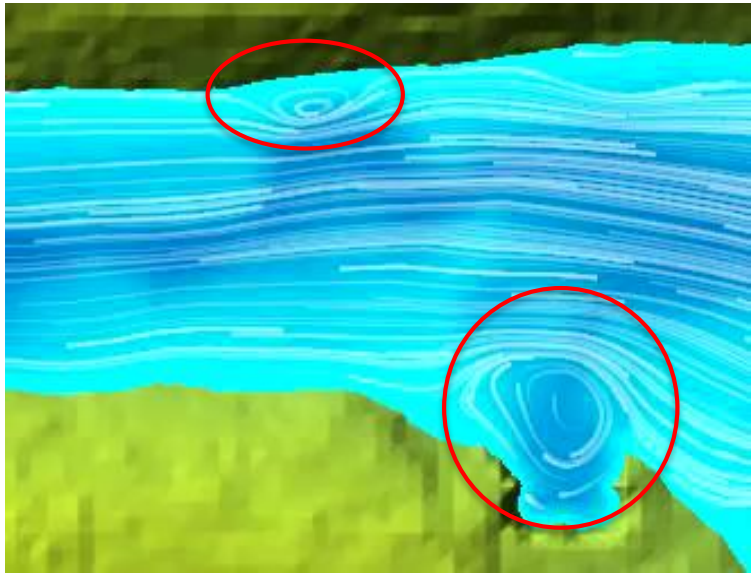


Losses between Cross Sections



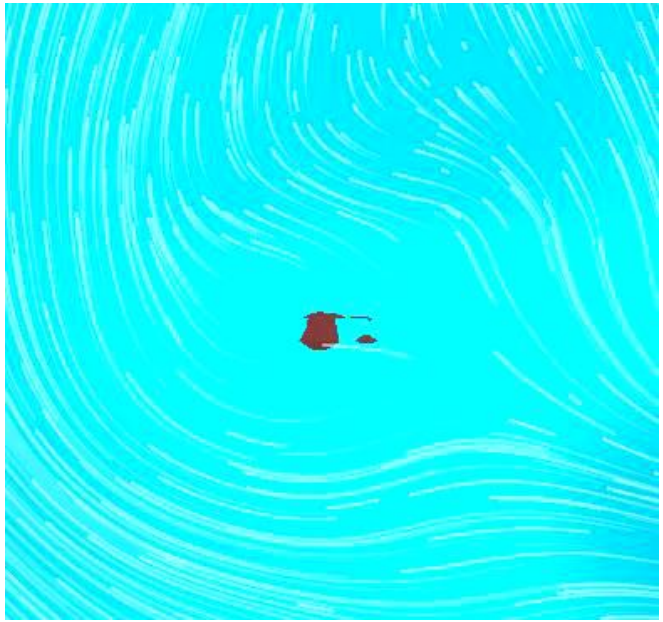
Cross Section Irregularities

$$n = (n_0 + n_1 + n_2 + n_3 + n_4)\, m$$



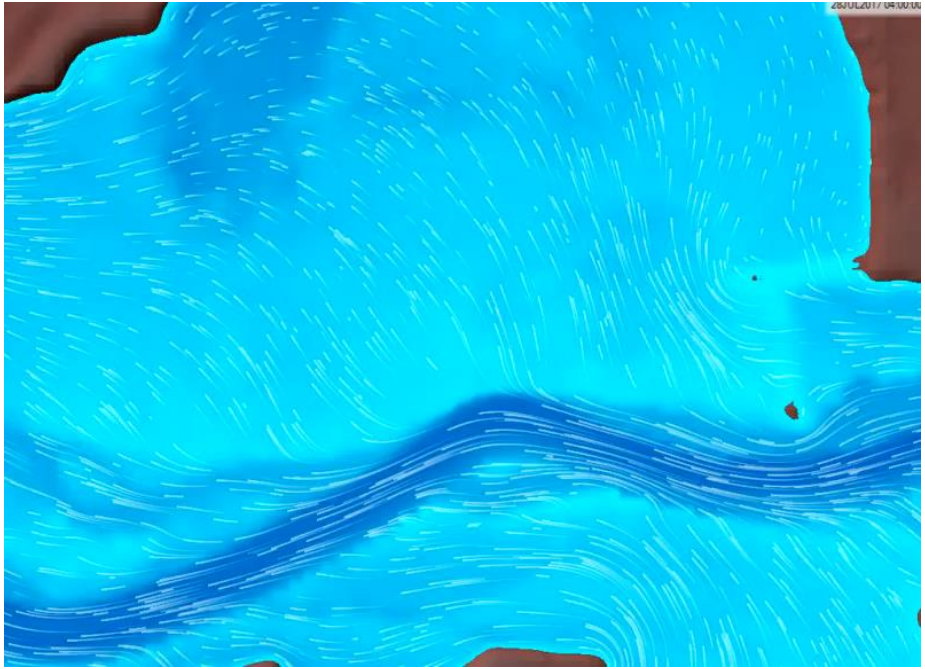
Obstructions

$$n = (n_0 + n_1 + n_2 + n_3 + n_4)\, m$$

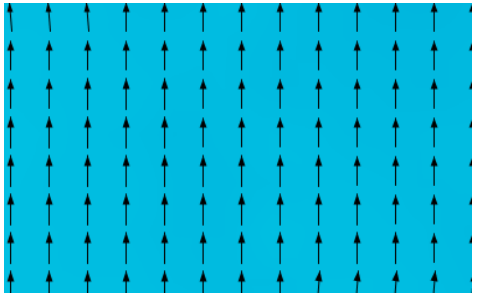


Meandering

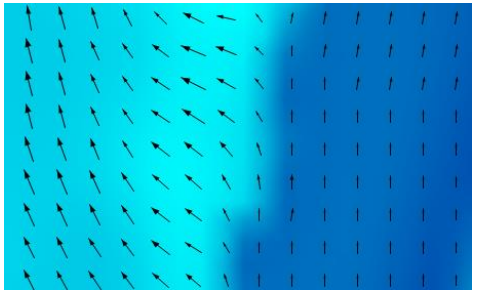
$n = (n_0 + n_1 + n_2 + n_3 + n_4)\ m$



A 1D model uses the Manning's n term to *implicitly* model more than just "roughness" – it also captures energy lost due to lateral flow and complex flow paths.



A 2D model represents this energy loss due to lateral flow and more complex flow paths *explicitly*.



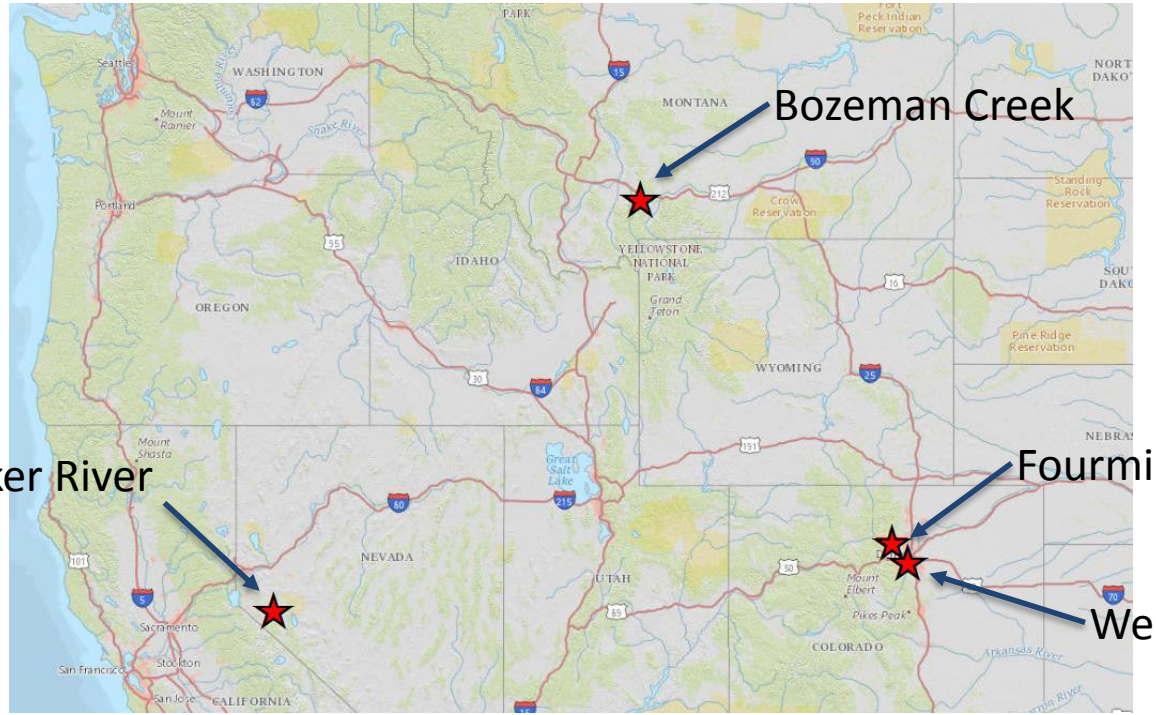
What Manning's n values should be used for 2D models?

(it's not in the HEC-RAS manual)

Experiment Details

- Reaches were modeled three times
  - HEC-RAS 1D
  - SRH 2D
  - HEC-RAS 2D (Saint Venant) (aka "Full Momentum" setting)
- Reaches without hydraulic structures were chosen

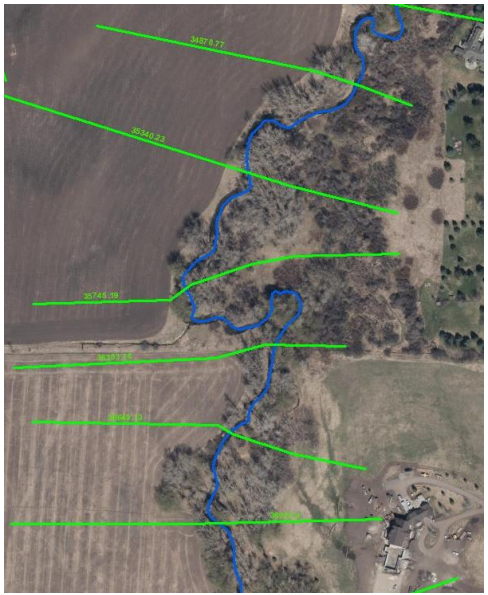
Four Case Studies



Walker River

- Lyon County, NV
- Larger River, bigger flows (Q100 = 6000 cfs)
- Desert/plain, flat slope very broad floodplain, unpredictable flow paths

Bozeman Creek



- Gallatin County, MT
- Smaller stream, lower flows (Q100 = 777 cfs)
- Moderate slope, transitions from heavily wooded area to agricultural areas

Fourmile Creek

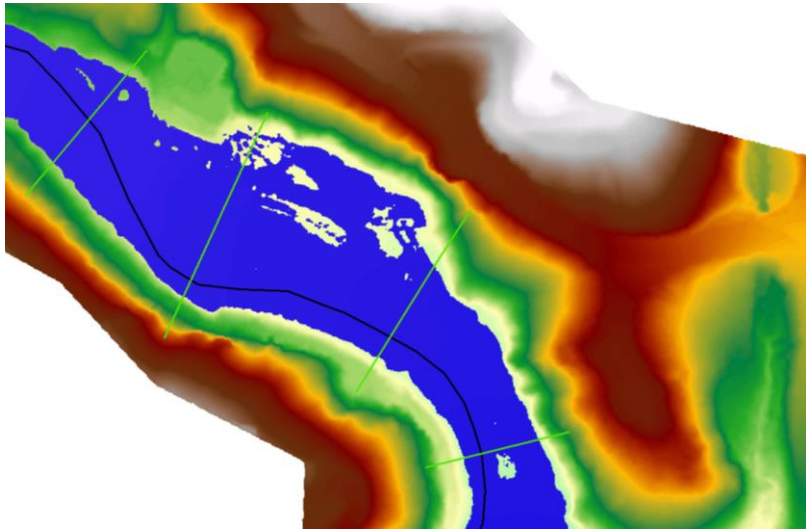
- Boulder County, CO
- Very steep mountain canyon with Q100 = 2799 cfs

Weir Gulch

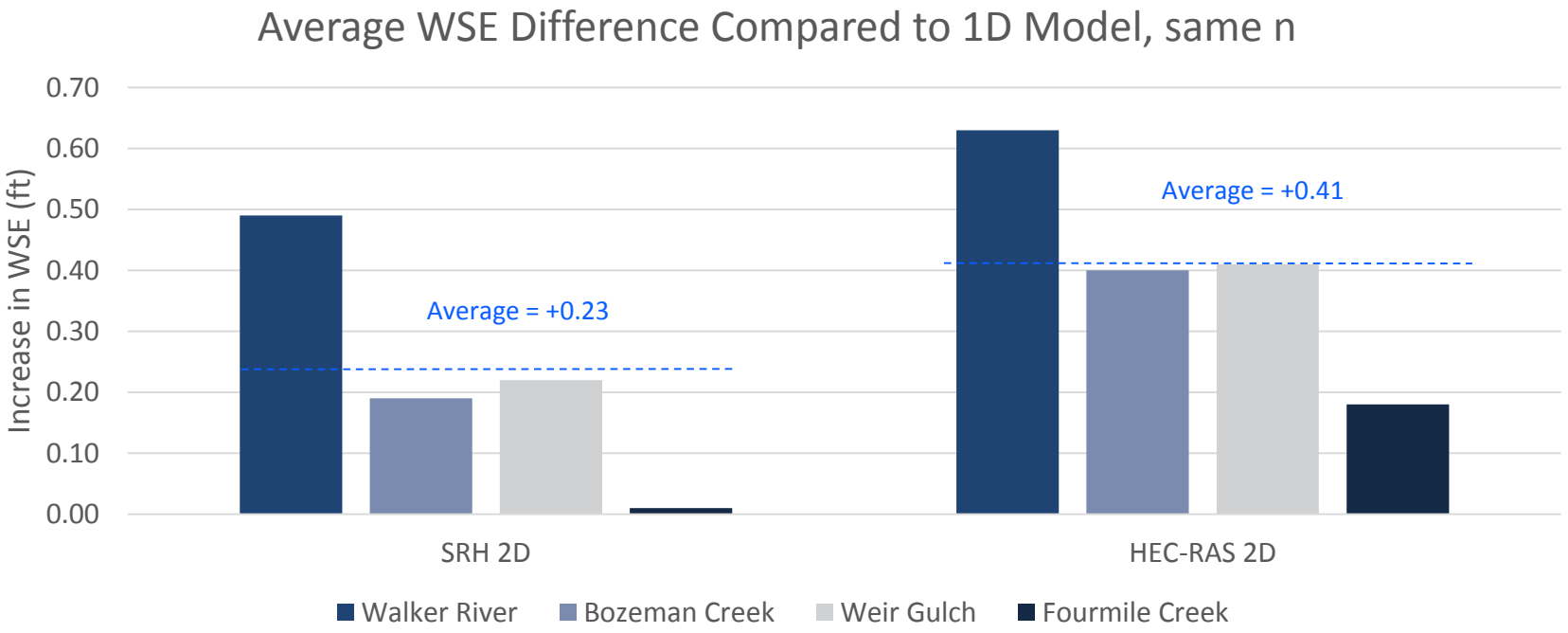
- Lakewood, CO
- Small, urbanized watershed (Q100 = 1388 cfs)
- Moderate slope, grassy “greenbelt” floodplain area

Study Details

- 1-percent-annual-chance event
- Each of the 1D and 2D models was created and run with a baseline Manning's n value
- First, we made a comparison between each of the 2D models and the 1D model results using identical n values
- Second, Manning's n values were adjusted at each cross section in the HEC-RAS 1D model until the water surface elevation matched the 2D model

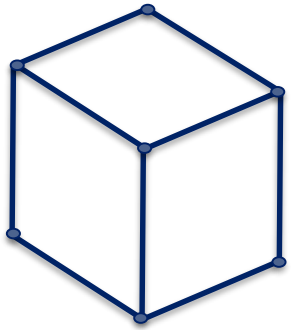


Results - WSE

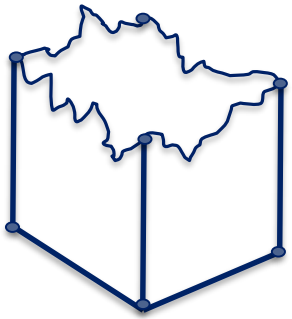

Average WSE Difference Compared to 1D Model, same n
Increase in WSE (ft)
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Average = +0.23
Average = +0.41
SRH 2D
HEC-RAS 2D
Walker River
Bozeman Creek
Weir Gulch
Fourmile Creek

SRH 2D vs HEC-RAS 2D

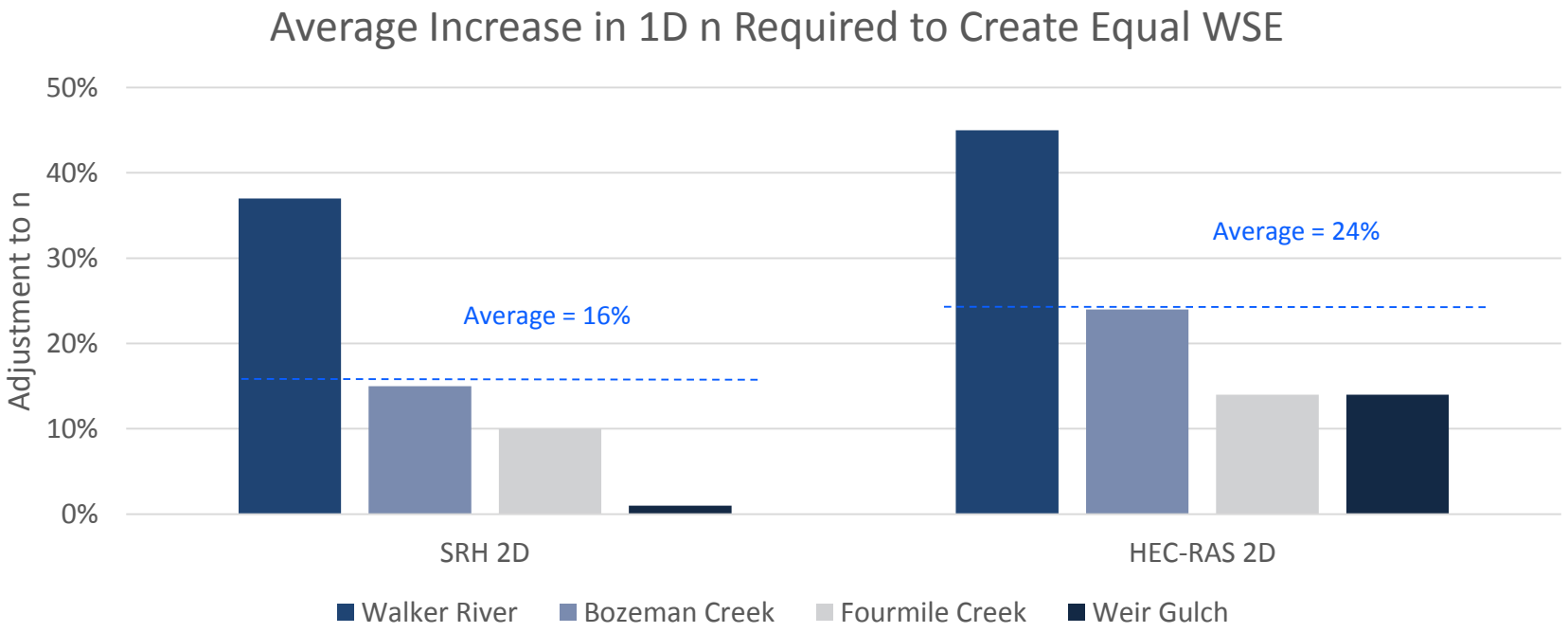
SRH 2D



HEC-RAS 2D



Results - n


Average Increase in 1D n Required to Create Equal WSE
Adjustment to n
50%
40%
30%
20%
10%
0%
Average = 16%
Average = 24%
SRH 2D
HEC-RAS 2D
Walker River
Bozeman Creek
Fourmile Creek
Weir Gulch

Theoretical reality check

base material (0.020 – 0.028)

channel variations (0.00-0.015)

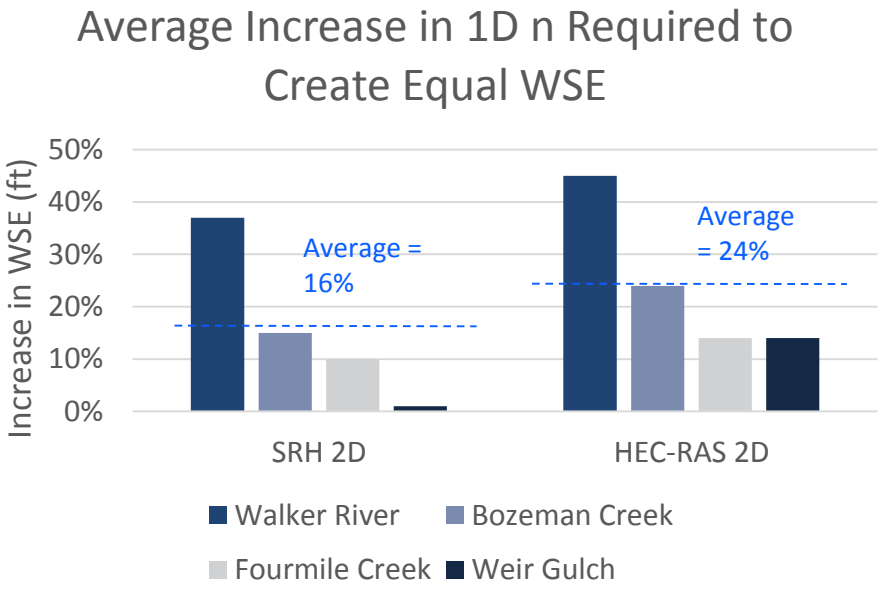
vegetation (0.005-0.100)

$$n = (n_0 + n_1 + n_2 + n_3 + n_4)\, m$$

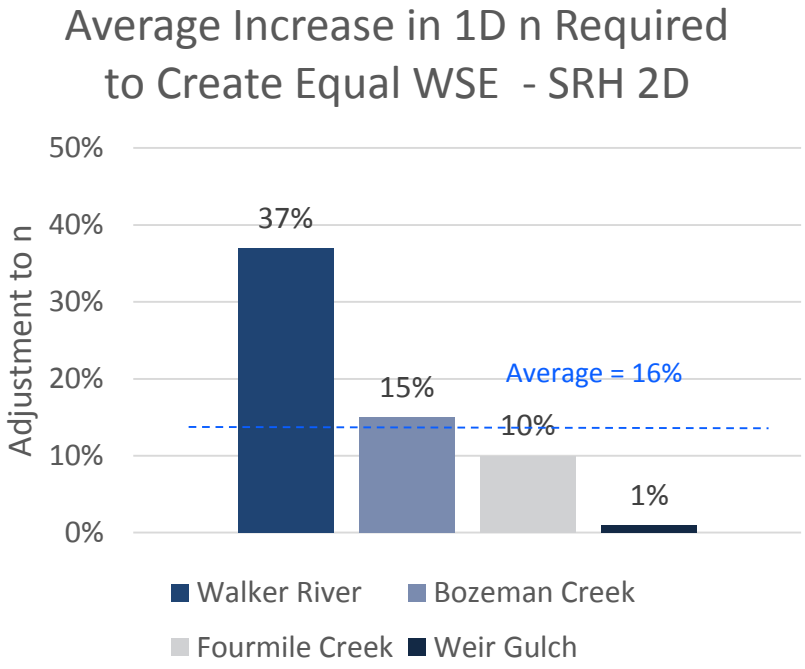
cross section irregularity (0.00-0.02)

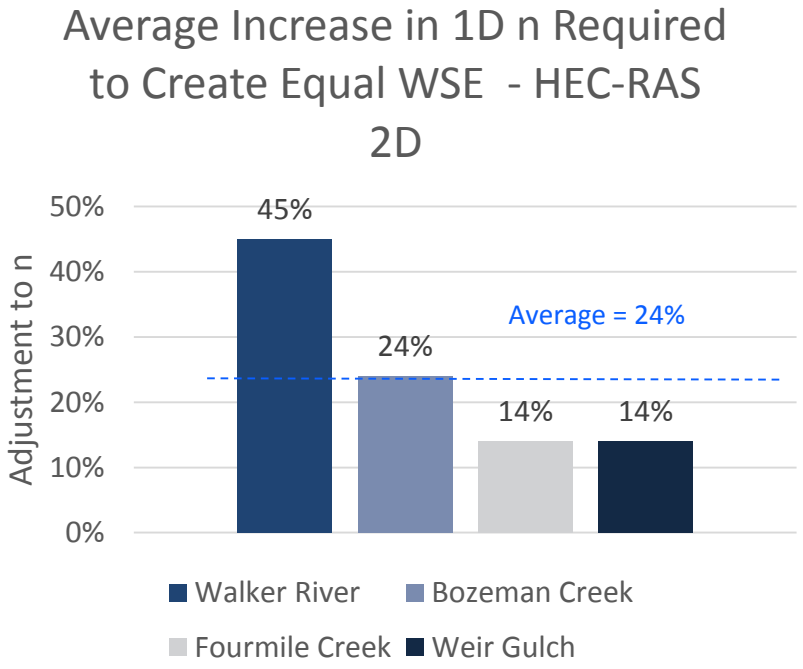
obstructions (0.00-0.06)

degree of meandering (1.0-1.3)



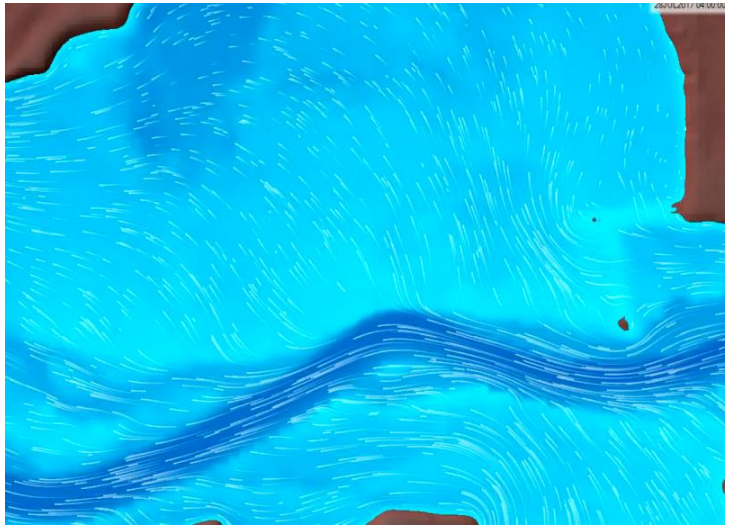
Range of Adjustments



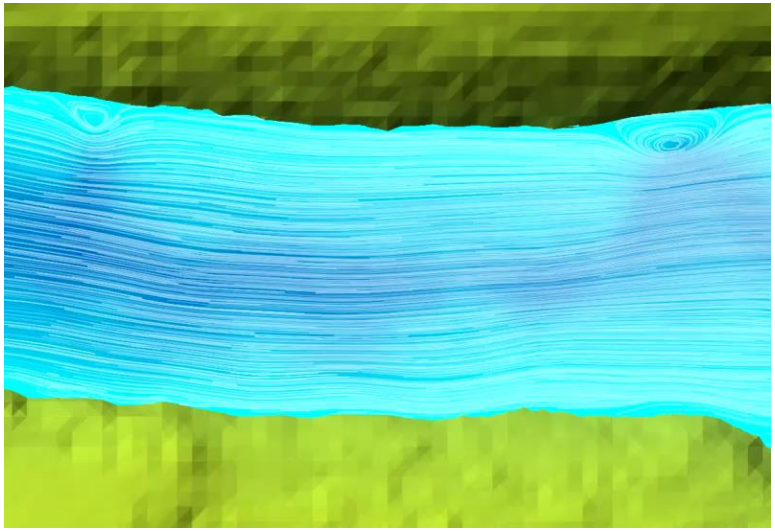


Complex Flow Path Comparison

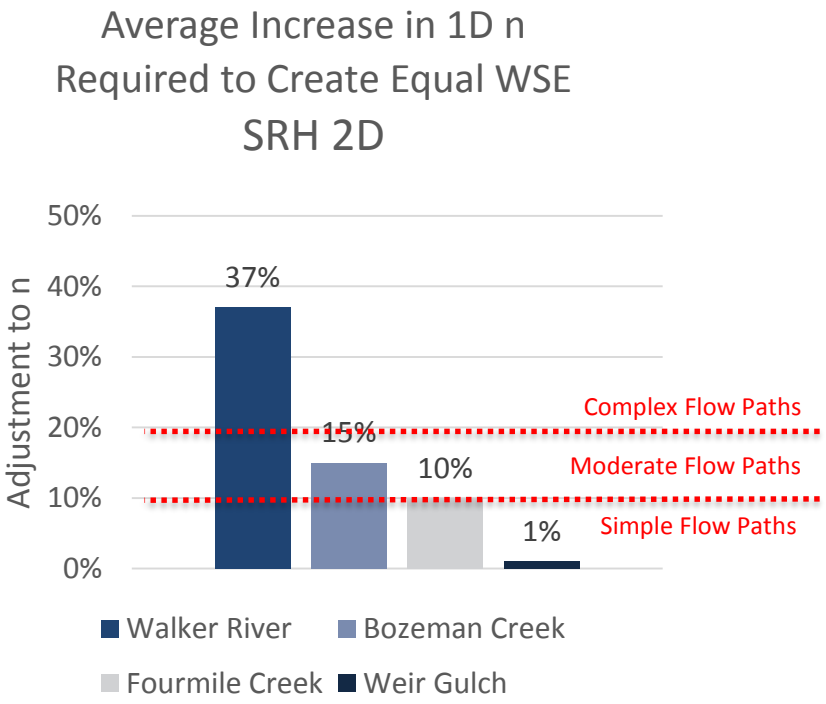
Walker River

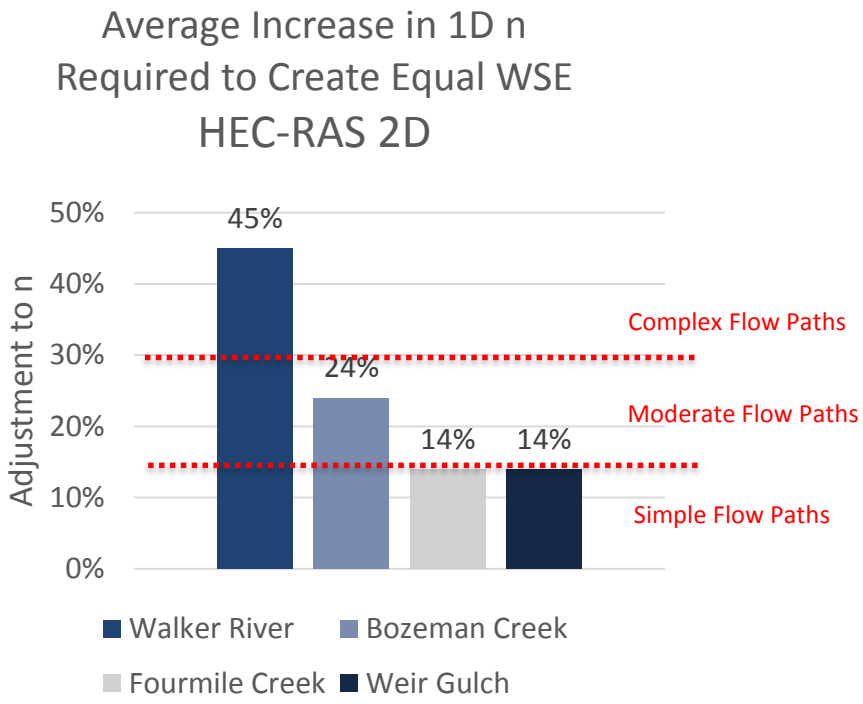


Weir Gulch



Range of Adjustments





Recommendation

When adjusting Manning's n values for the creation of a 2D model, DECREASE Manning's n values (compared to comparable 1D values) by…

2D Model	Simple Flow Paths	Moderate (Default)	Complex Flow Paths
SRH 2D	0% - 10%	10% - 20%	20% - 40%
HEC-RAS 2D	0% - 15%	15% - 30%	30% - 50%