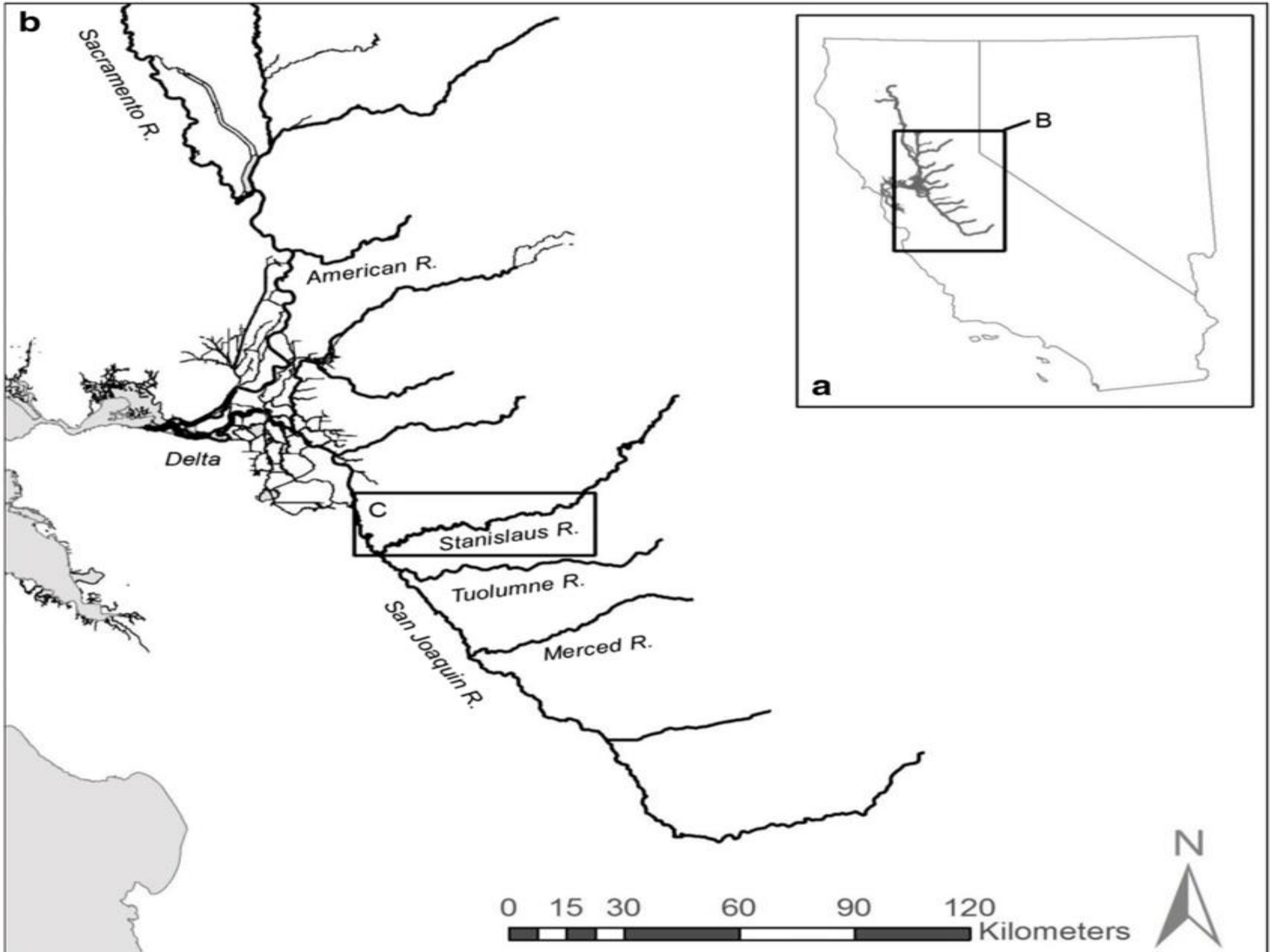
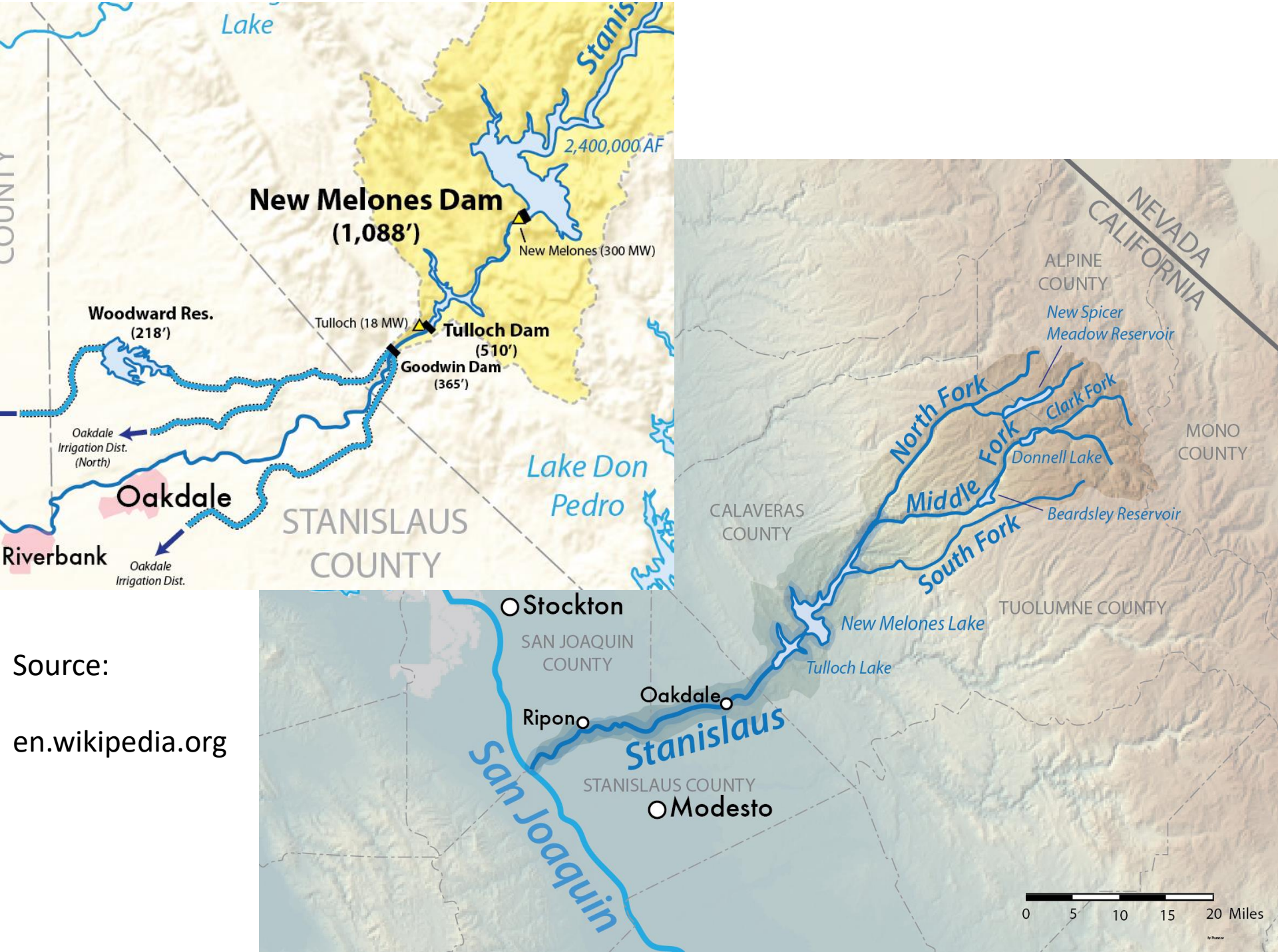
BUREAU OF RECLAMATION

Geomorphic Response to Gravel Augmentation in the Stanislaus River Downstream of Goodwin Dam

Jianchun "Victor" Huang P.E., Ph.D.
Sedimentation and River Hydraulics Group
Technical Service Center
Denver, Colorado

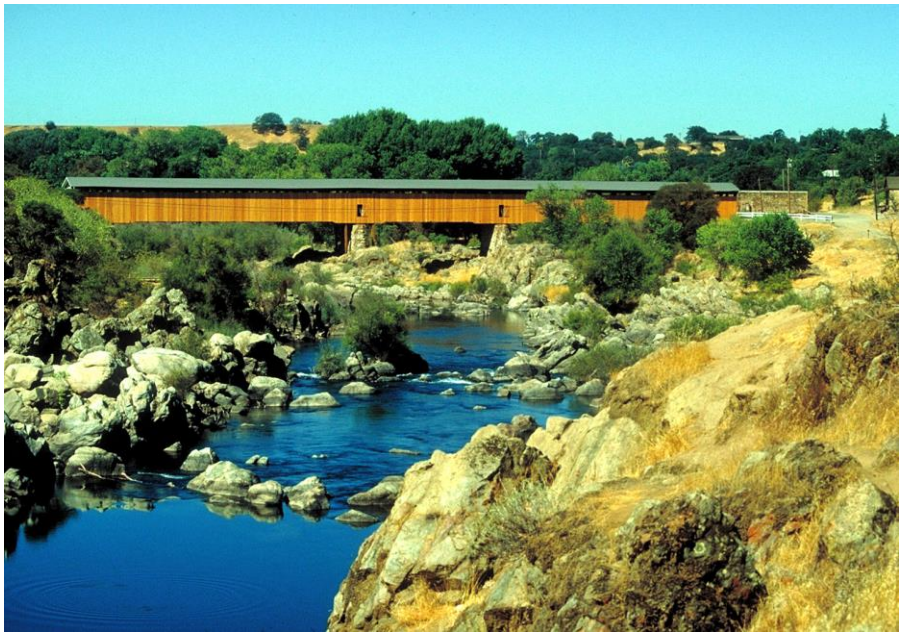
April 2023


b
Sacramento R.
American R.
Delta
C
Stanislaus R.
Tuolumne R.
San Joaquin R.
Merced R.
a
B
0 15 30 60 90 120
Kilometers
N



Source:

en.wikipedia.org



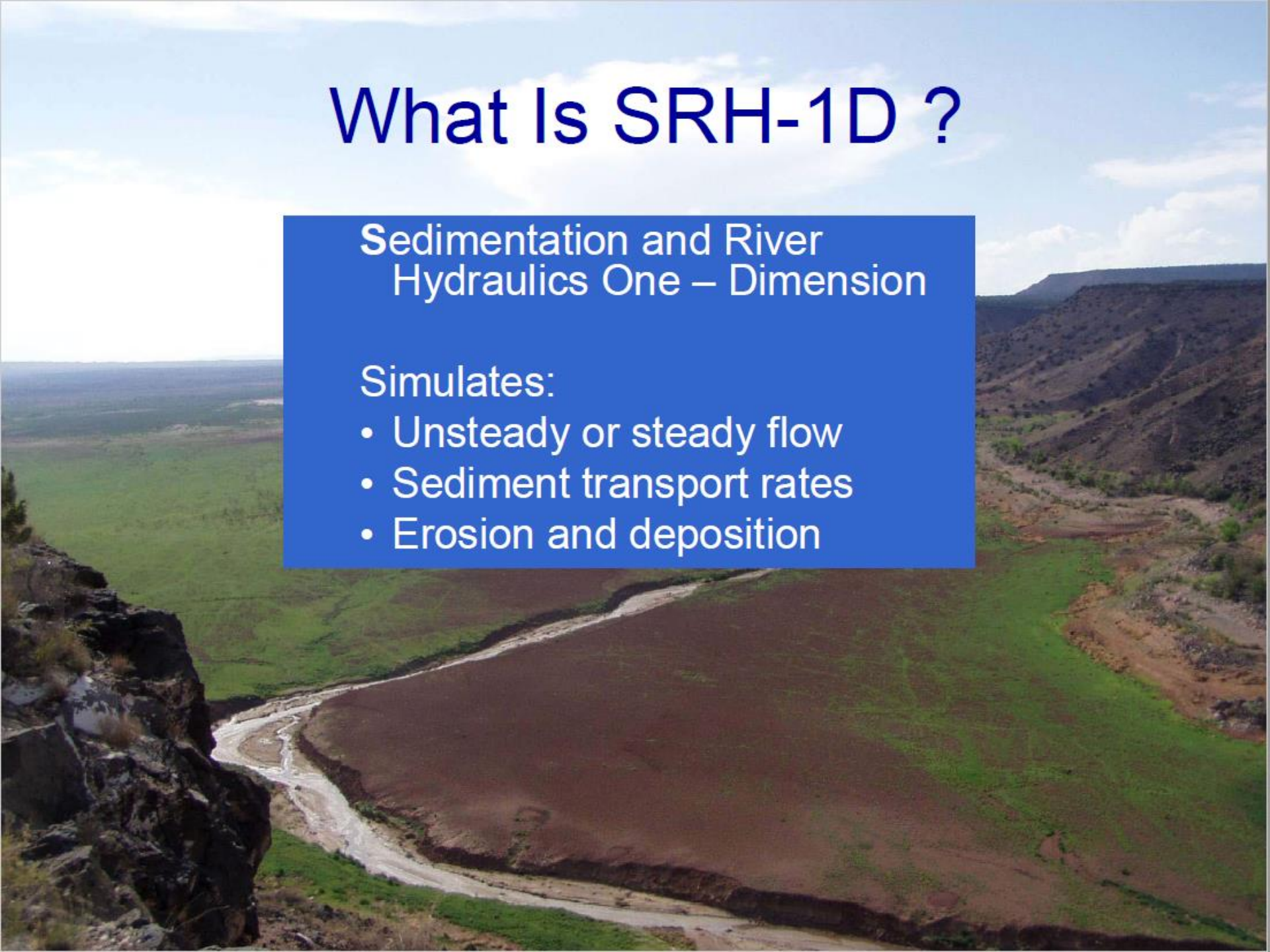
wikimedia.org

What Is SRH-1D ?

Sedimentation and River Hydraulics One – Dimension

Simulates:

- Unsteady or steady flow
- Sediment transport rates
- Erosion and deposition



Geomorphic Response to Gravel Augmentation in the Stanislaus River Downstream of Goodwin Dam

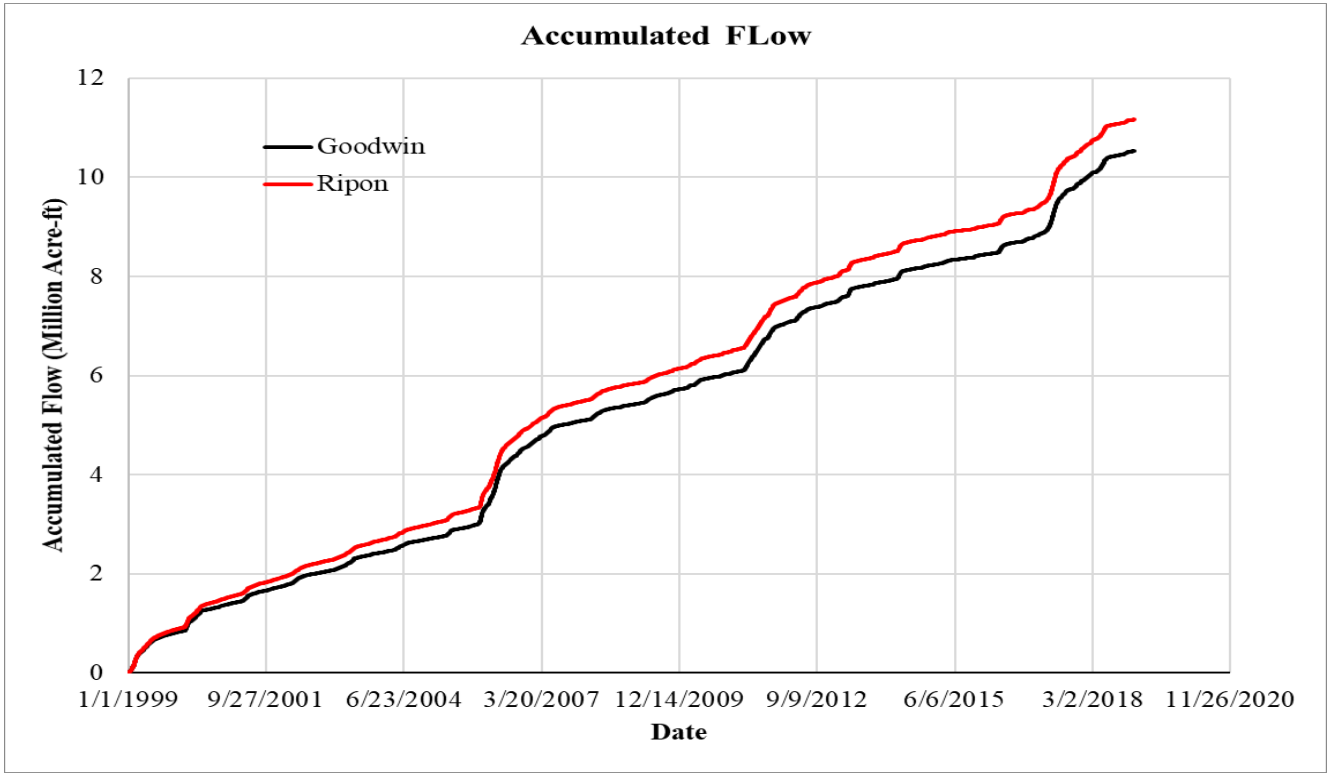
- Two Objectives:
  - Sediment Balance
  - Flood Control

Model Inputs

- Incoming Flow Rate
- Incoming Sediment Load
- Bathymetry
- Downstream Boundary Condition
- Bed Material
- Model Parameters

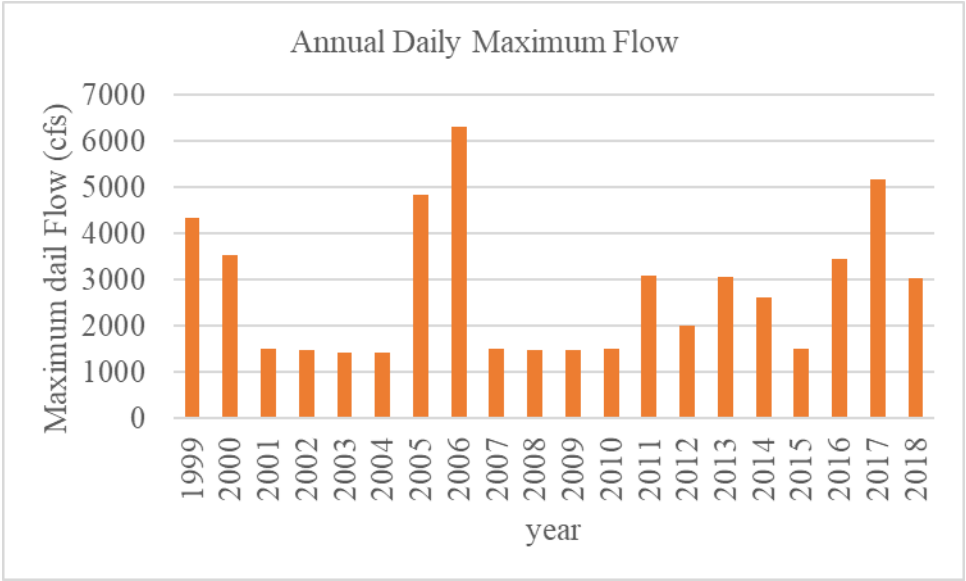
Model Inputs

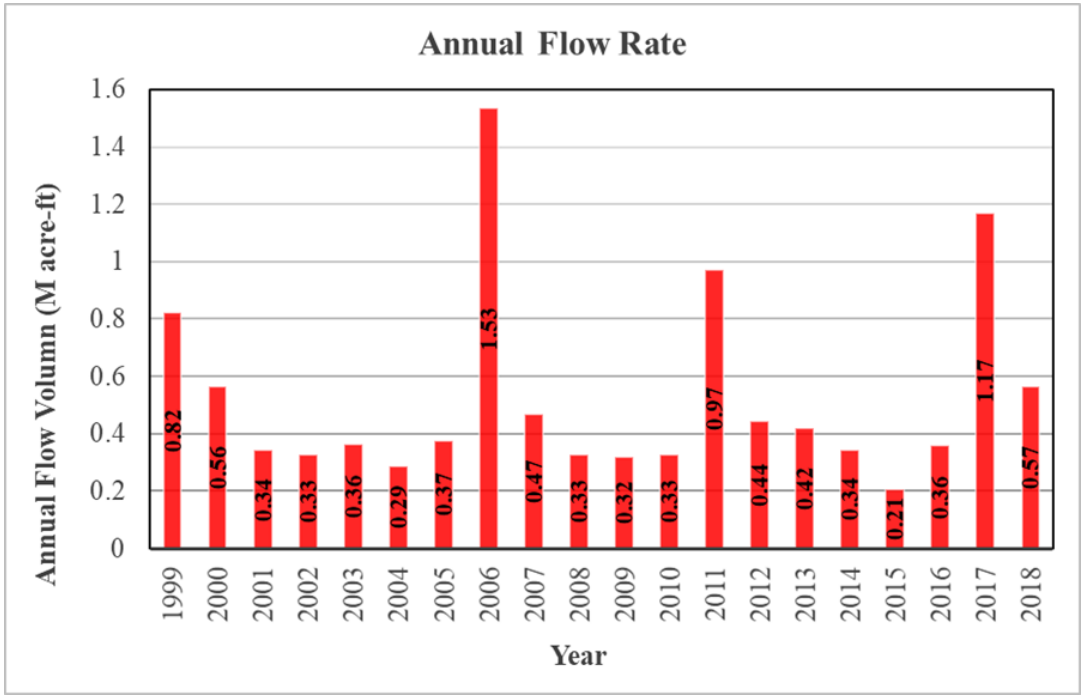
- Incoming Flow Rate
  - USGS 11302000 STANISLAUS R BL GOODWIN DAM NR KNIGHTS FERRY CA
    - Available from February 1 1957
  - USGS 11303000 STANISLAUS R A RIPON CA
    - Available from October 1 1940



Model Inputs

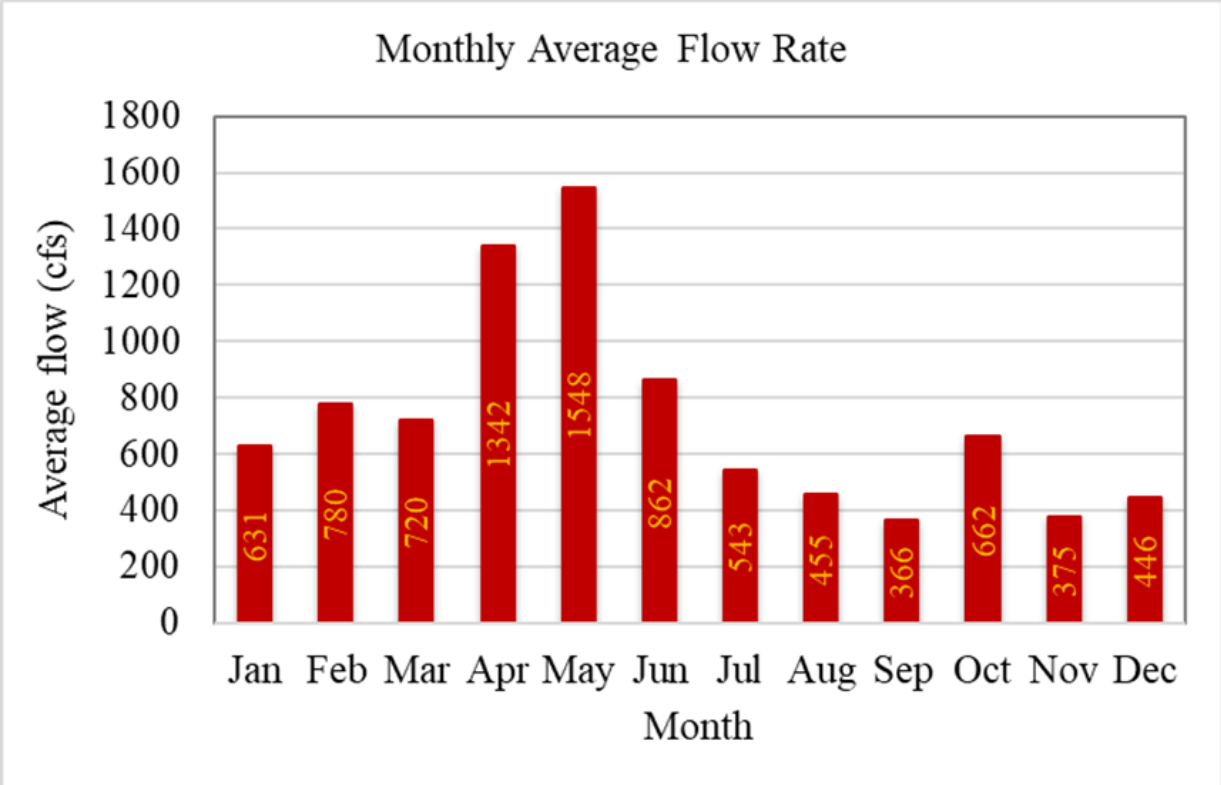
- Incoming Flow
  - USGS 11302000 STANISLAUS R BL GOODWIN DAM NR KNIGHTS FERRY CA





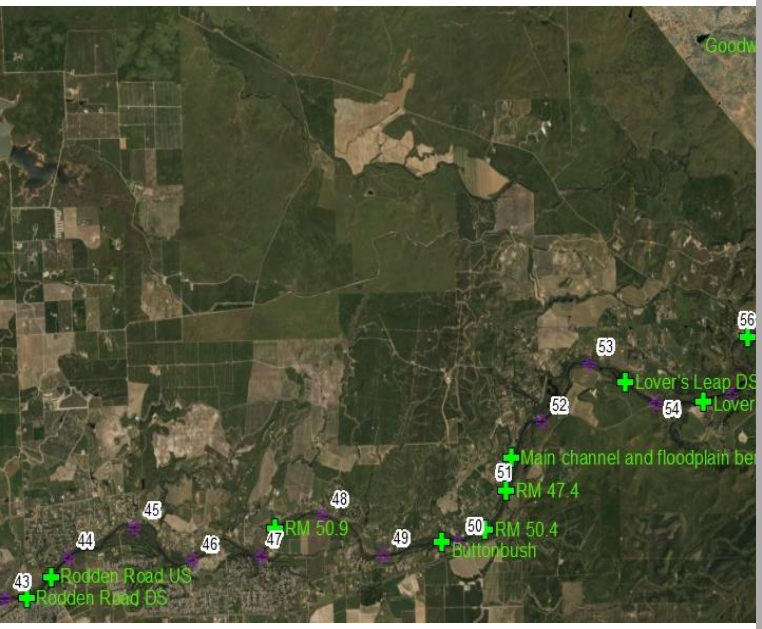
Model Inputs

- Incoming Flow Rate
  - USGS 11302000 STANISLAUS R BL GOODWIN DAM NR KNIGHTS FERRY CA



Model Inputs

- Upstream Sediment Loads – added on July 15th



Year	Amount (yd^3)	Gravel Injection Location
1994	3,070	Stanislaus River at RM 47.4, 50.4, and 50.9
1995	0	
1996	0	
1997	13,181	Goodwin Cable Crossing area
1998	4,444	Goodwin Cable Crossing area
1999	7,647	18 riffles in lower Stanislaus River (Two-Mile Bar to city of Oakdale)
2000	1,432	Goodwin Cable Crossing area
2001	488	Goodwin Float Tube Pool - helicopter
2002	2,353	Goodwin Cable Crossing area
2003	0	
2004	700	Goodwin Float Tube Pool - sluice
2005	1,471	Goodwin Float Tube Pool - helicopter
2006	1,471	Goodwin Cable Crossing area
2007	3,000	Goodwin Cable Crossing area
2007	11,412	Lover's Leap
2008	0	Knight's Ferry fire station
2009	0	
2010	0	
2011	2,941	Goodwin Cable Crossing area
2012	1,765	Goodwin Float Tube Pool - sluice
2012	8,000	Main channel and floodplain bench at Honolulu Bar
2013	0	
2014	0	
2015	4,706	Goodwin and cable crossing
2017	2,838	Buttonbush
2018	1,250	Rodden Road
TOTAL	**72,169**	

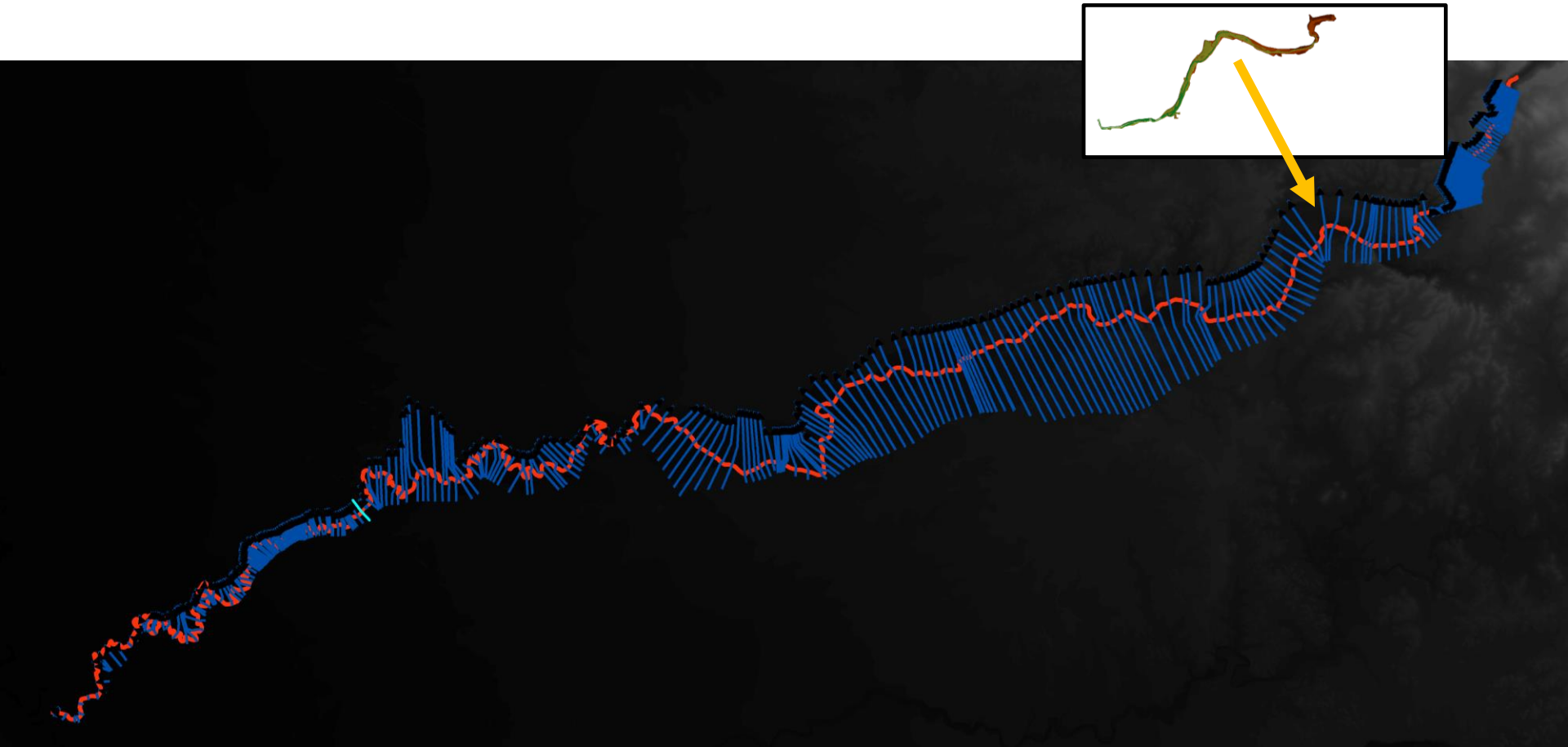
Model Inputs

- Upstream Sediment Loads – added on July 15th

Year	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
	yd^3	yd^3	yd^3	yd^3	yd^3	yd^3
1	20,000	25,000	10,000	40,000	15,000	15,000
2	20,000	8,000	10,000	10,000	15,000	8,000
3	10,000	8,000	10,000	10,000	15,000	8,000
4	8,000	8,000	10,000	10,000	15,000	8,000
5	8,000	8,000	10,000	10,000	15,000	8,000
6	8,000	8,000	10,000	10,000	0	8,000
7	8,000	8,000	10,000	10,000	0	8,000
8	8,000	25,000	10,000	10,000	0	8,000
9	8,000	8,000	10,000	10,000	0	8,000
10	8,000	8,000	10,000	10,000	0	8,000
11	8,000	8,000	10,000	10,000	0	8,000
12	8,000	8,000	10,000	10,000	0	8,000
13	8,000	8,000	10,000	10,000	0	8,000
14	8,000	8,000	10,000	10,000	0	8,000
15	8,000	8,000	10,000	10,000	0	8,000
Max	20,000	25,000	10,000	40,000	15,000	15,000
Average	9,733	10,267	10,000	12,000	5,000	8,467
Min	8,000	8,000	10,000	10,000	0	8,000

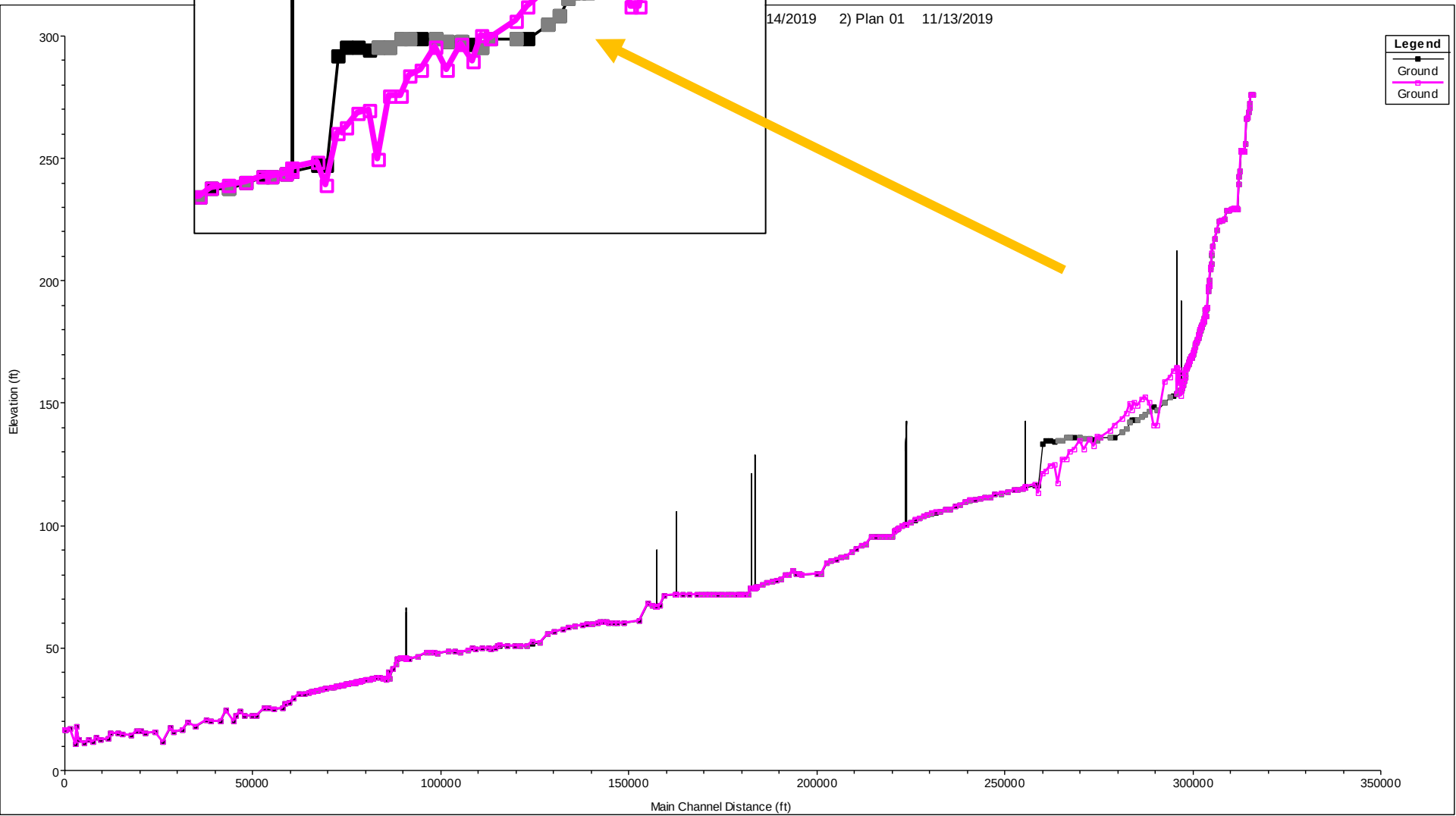
Model Inputs

- Replace With 2009 survey bathymetry



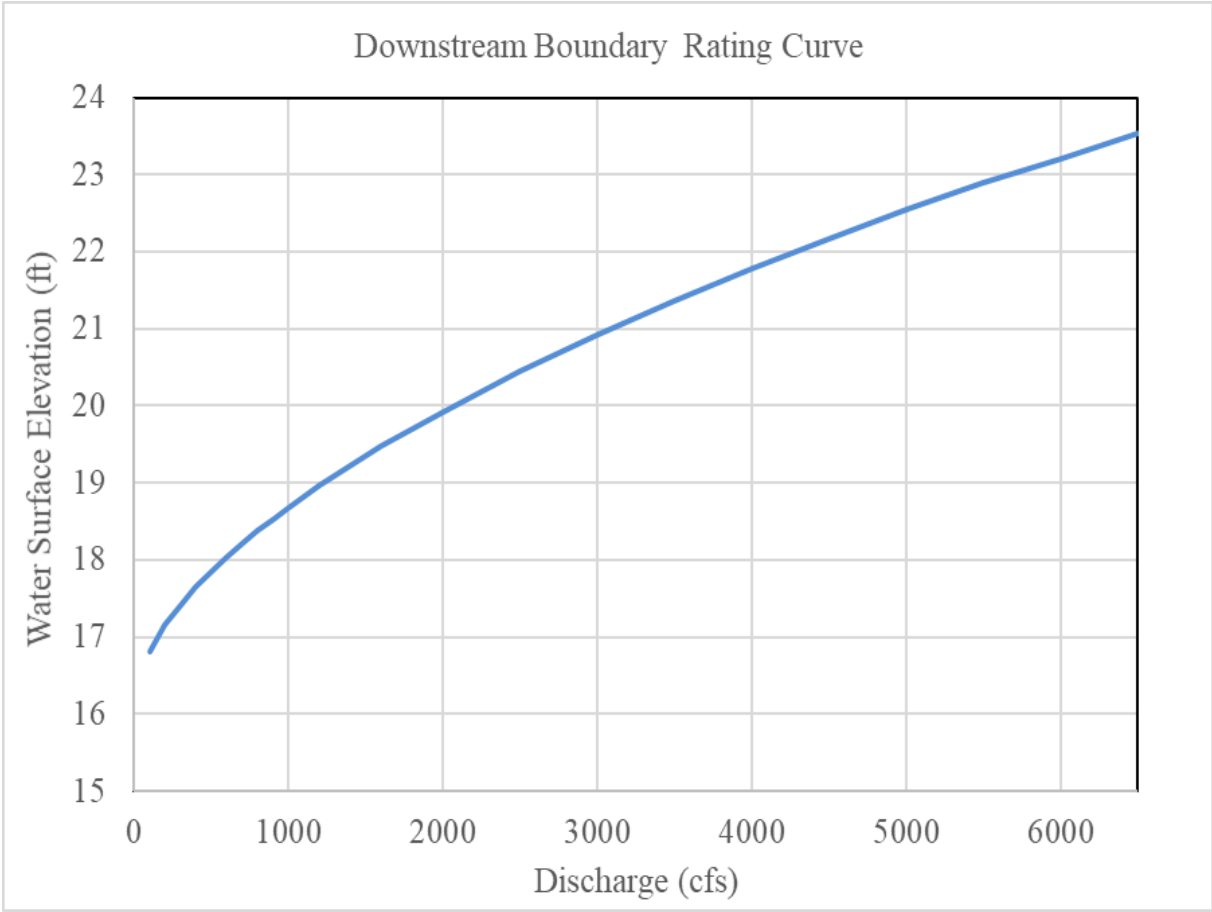
Model Inputs-Cross Sectional Geometry

- Update original COE HEC_RAS Geometry from RM 56 to RM 49 with new geometry
- Edit bank stations, levees, etc
- Interpolation


14/2019 2) Plan 01 11/13/2019
Legend
Ground
Ground
Elevation (ft)
300
250
200
150
100
50
0
0
50000
100000
150000
200000
250000
300000
350000
Main Channel Distance (ft)

Model Inputs-Cross Sectional Geometry

- Normal depth @ slope at 0.00026



Model Inputs-Bed Material

- Kondolf, G.M., Falzone, A., and Schneider, K.S. (2001). *Reconnaissance-Level Assessment of Channel Change and Spawning Habitat on the Stanislaus River Below Goodwin Dam.* Barkeley CA 94

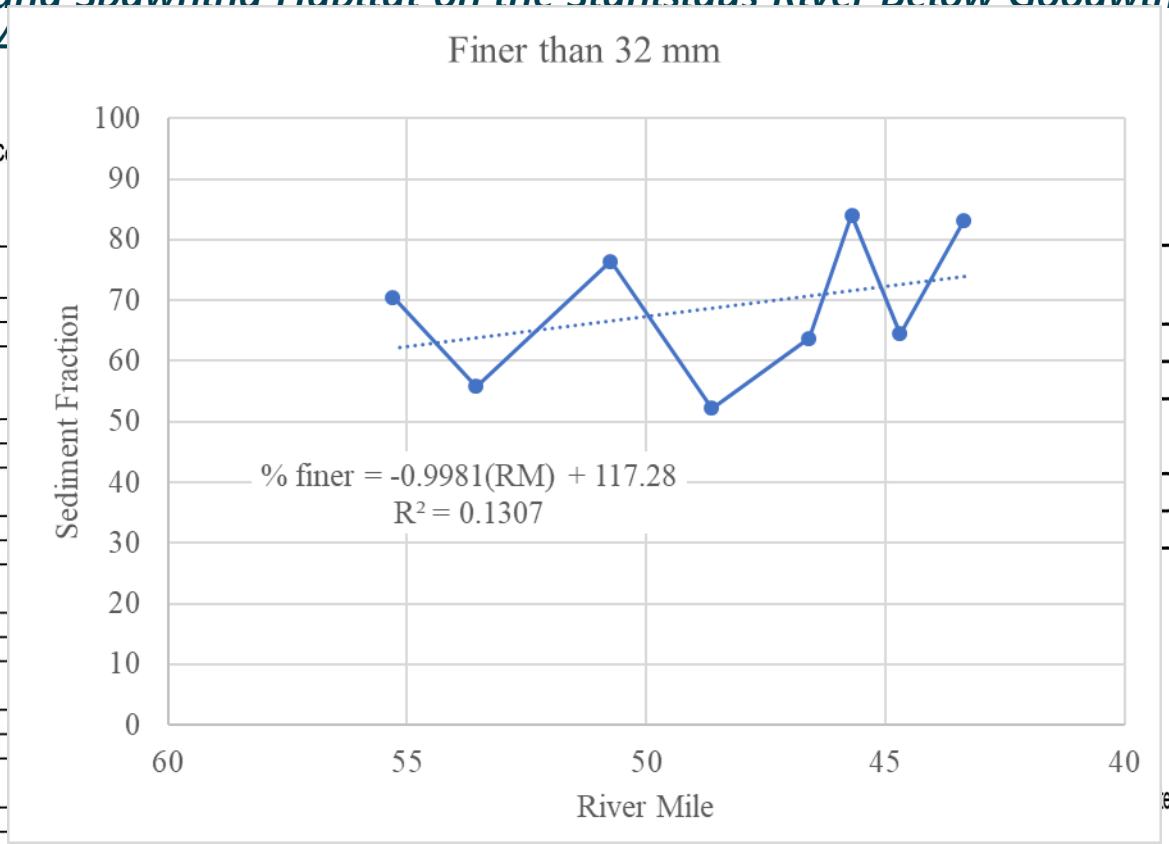


Table 6.4: Summary Statistics Comparing Pebble C

Riffle #	River Mile	Year of Study	D10	D16	D25						
R10	53.4	1993	24.5	28.0	31.0						
		2000	<4	4.4	6.1						
Difference			--	-23.6	-24.9						
R20	51.9	1993	5.1	8.9	17.0						
		2000	<4	5.5	8.3						
Difference			--	-3.4	-8.7						
R34	49.2	1993	12.0	18.5	25.0						
		2000	<4	4.7	6.7						
Difference			--	-13.8	-18.3						
R42	47	1993	12.5	18.0	24.0						
		2000	8.1	12.2	17.3						
Difference			-4.4	-5.8	-6.7						
R56	45.2	1993	<4	<4	4.2						
		2000	<4	<4	7.4						
Difference			--	--	3.2						
R59	44.2	1993	12.0	17.5	22.5						
		2000	<4	<4	8.3						
Difference			--	--	-14.2	-16.4	-20.6	-27.0	-30.1	--	--
R65	43.2	1993	16.5	21.5	27.5	44.0	68.0	76.0	86.0	40.42	1.88
		2000	<4	4.3	11.9	23.6	39.9	47.6	56.4	--	--
Difference			--	-17.2	-15.6	-20.4	-28.1	-28.4	-29.6	--	--

dg^1	sg^2
14.05	3.56
--	--
--	--
51.38	1.71
45.54	2.29
-5.8	0.6

egories

Model Inputs-Bed Material

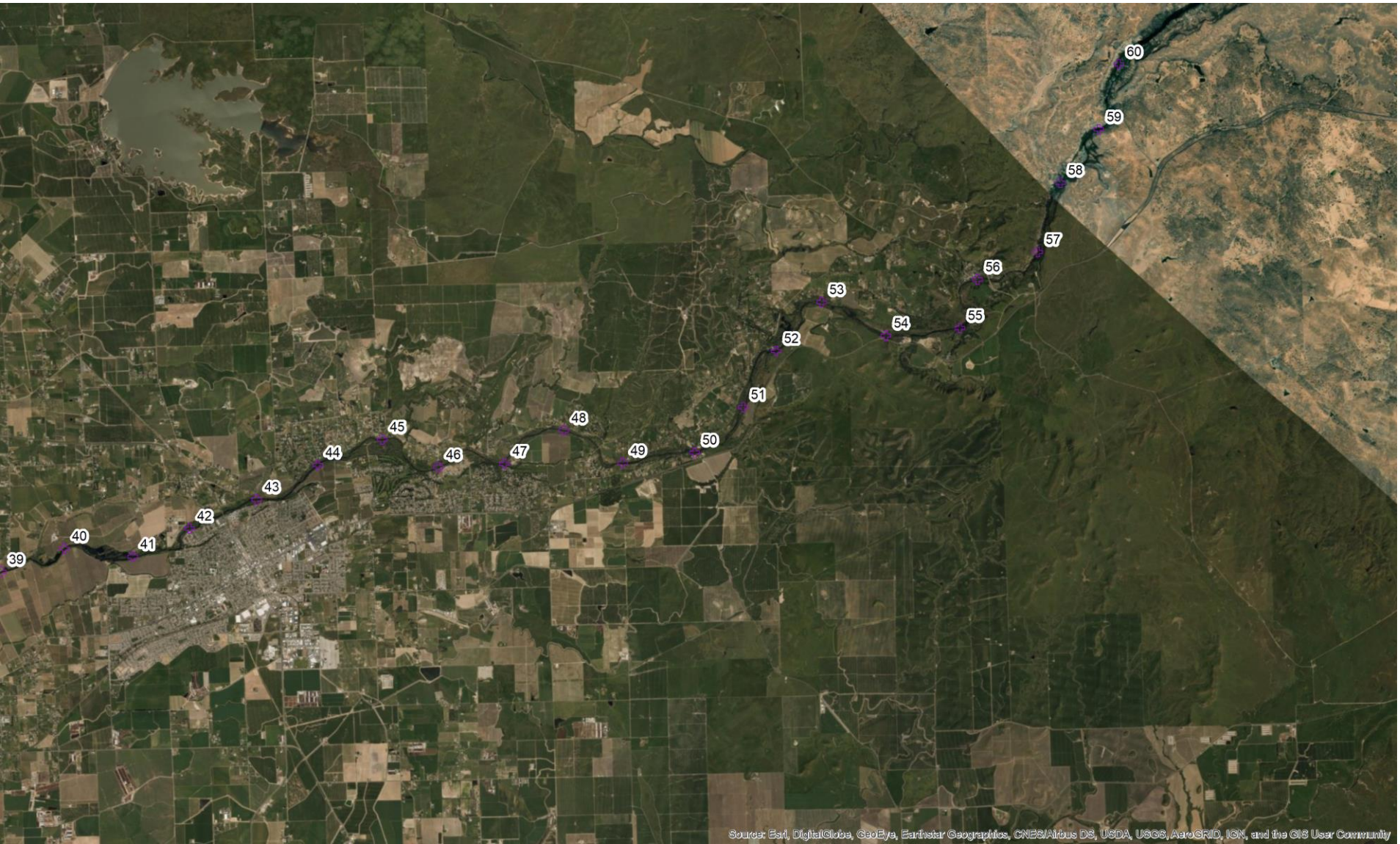
For future simulation: Bed gradations estimated from Pebble Counts on November 19, 2019

Lower Size (mm)	1	2	4	8	16	32	64
Upper Size (mm)	2	4	8	16	32	64	128
	vcsnd	vfgrv	fgrv	mgrv	cgrv	vcgrv	sc
Knight's Ferry Bridge	5.8	2.9	15.4	17.9	19.2	18.3	20.5
Honolulu Bar	9.8	4.3	12.0	17.4	22.6	20.2	13.8
Valley Oak	14.4	5.8	8.1	17.0	26.3	22.3	6.3
Oakdale Rec Area	18.2	7.0	4.9	16.5	29.4	23.9	0.0

Model Inputs-Other Parameters

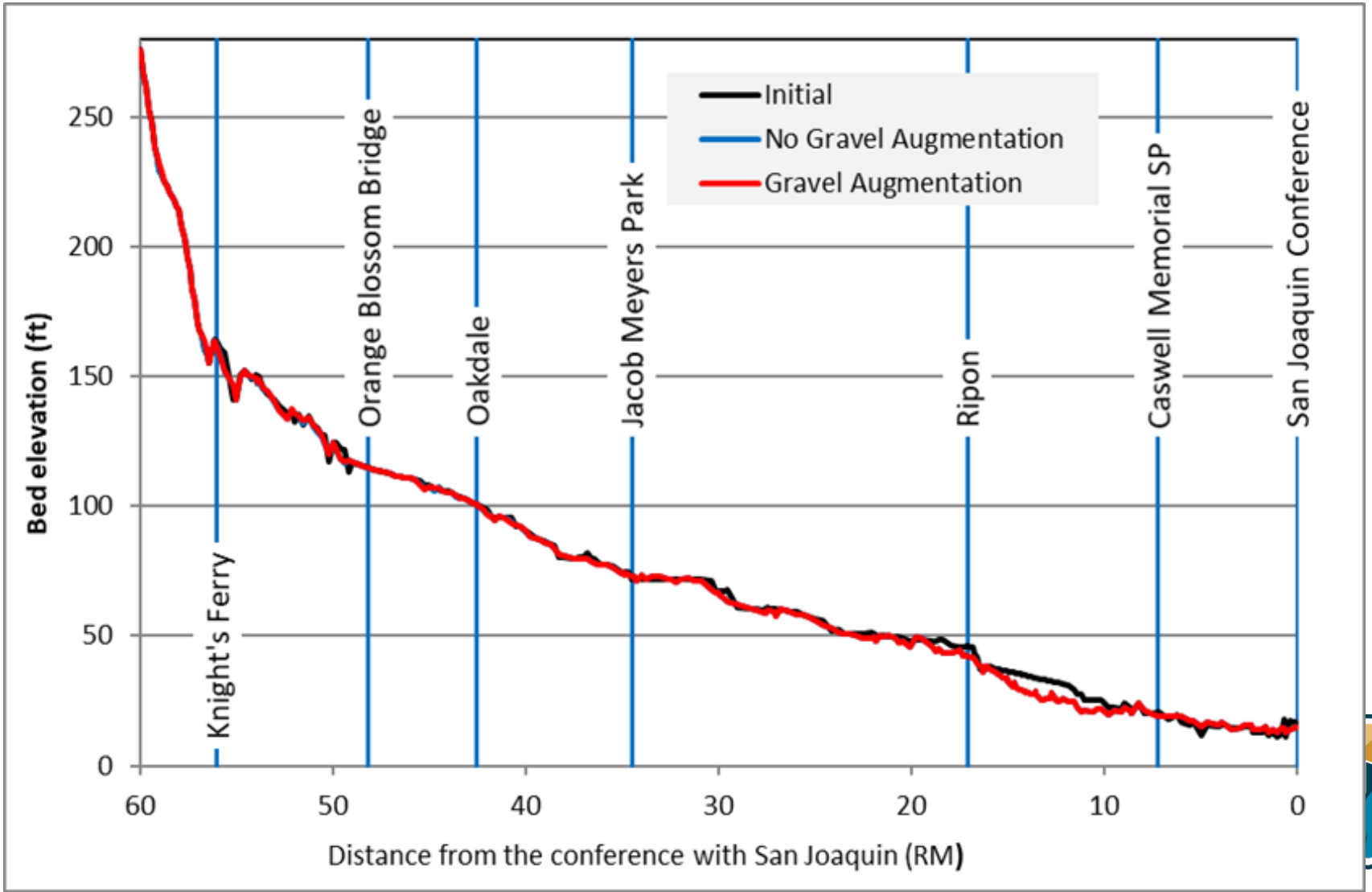
- Different sediment transport equations
  - Parker combined with Engelund-Hansen
  - Wilcock combined with Engelund–Hansen
  - Wu's
  - Yang1973's

Results

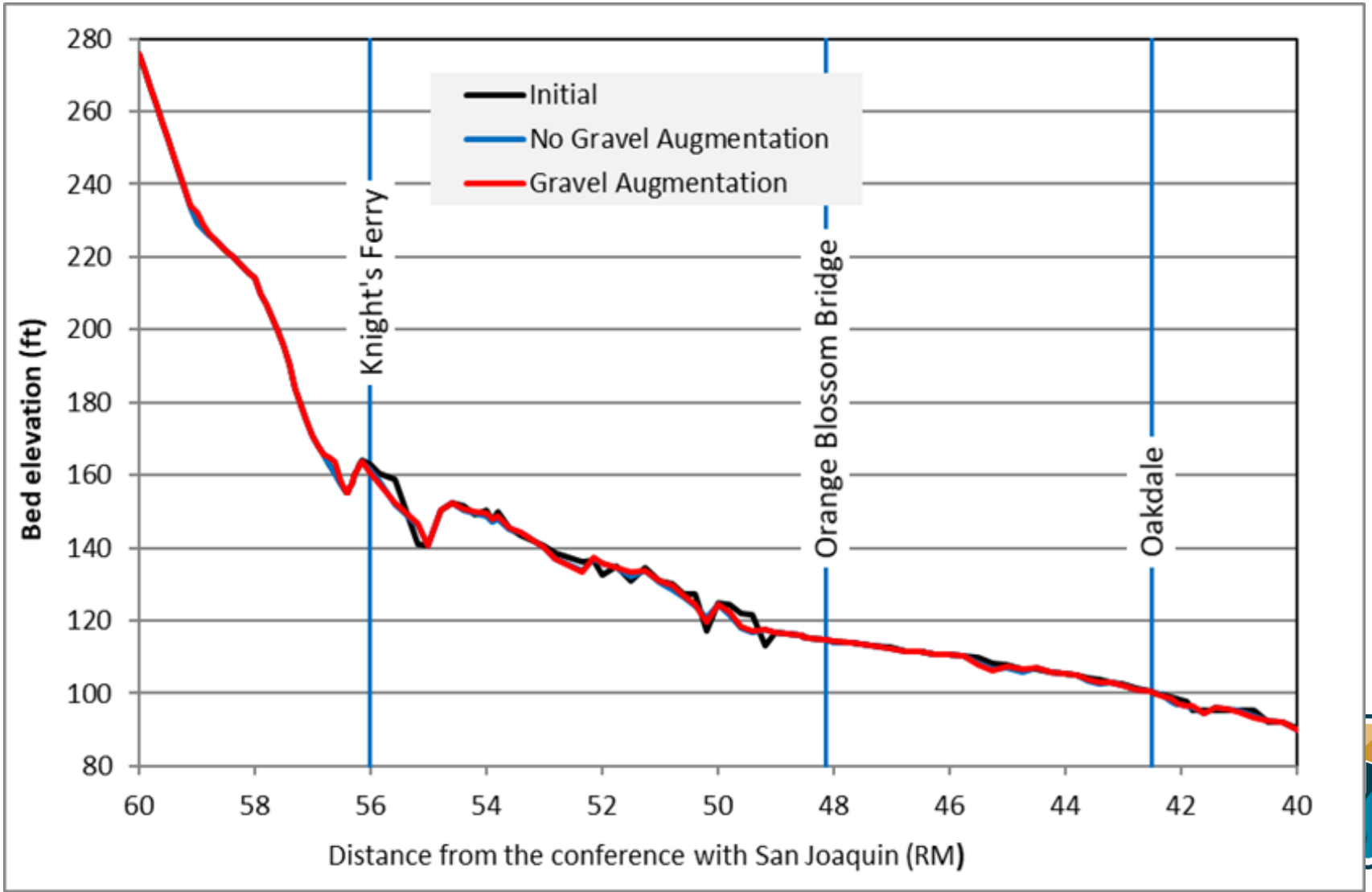

39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Results for Historical Gravel Augmentation

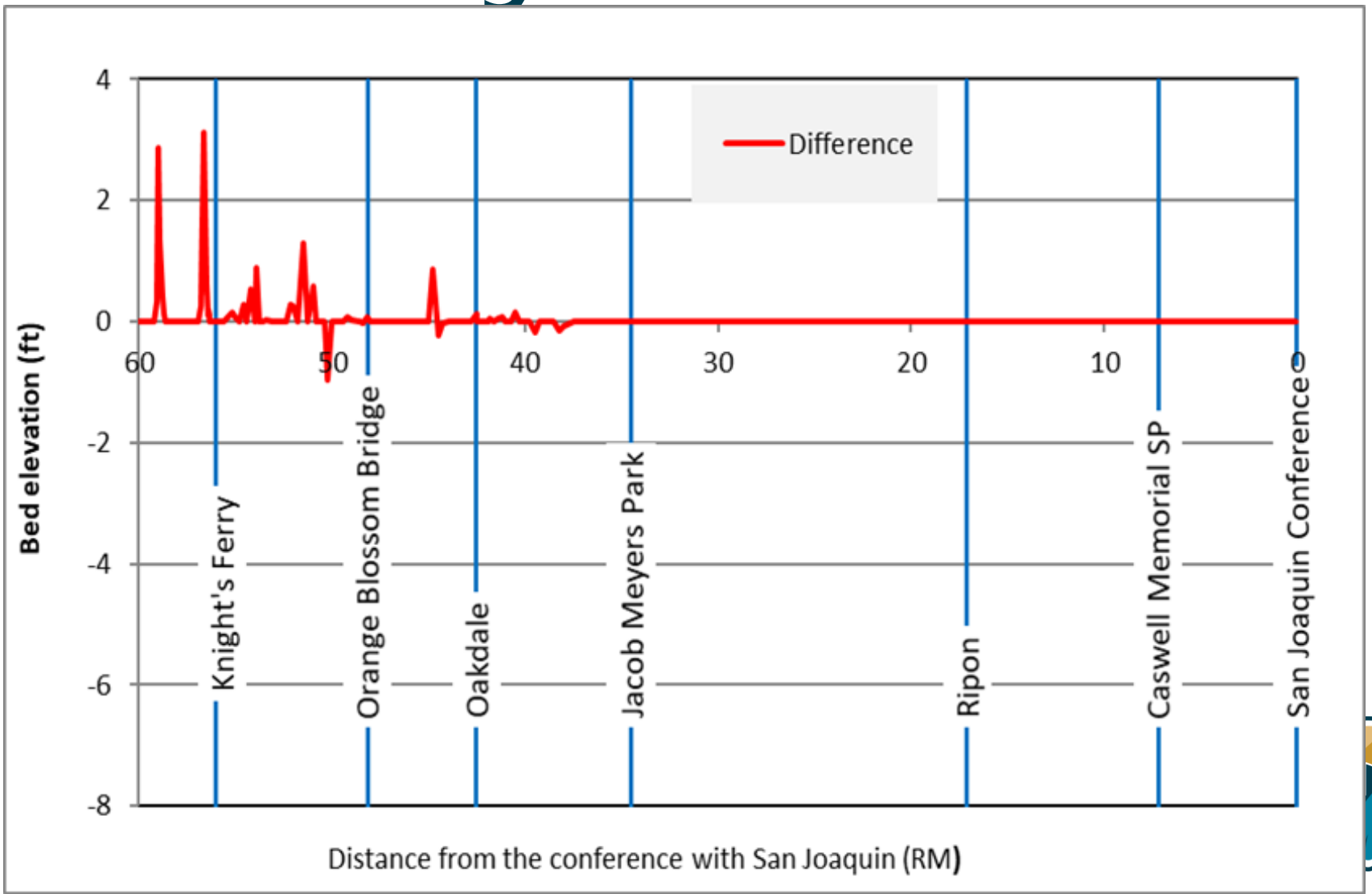
Historical Simulation – Bed Profile



Historical Simulation – Bed Profile



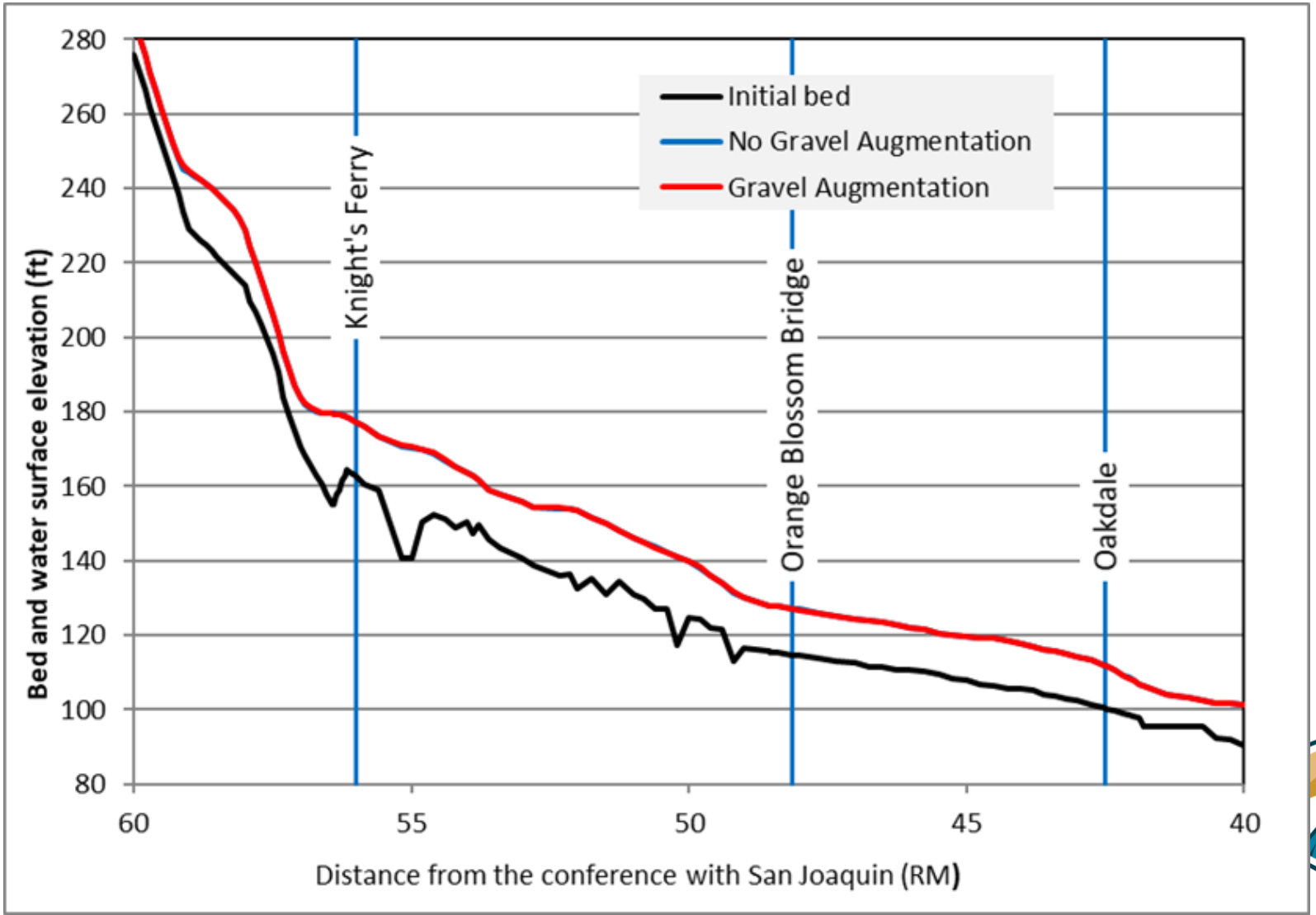
Historical Simulation – Bed Profile Change



Historical Simulation – Bed Profile Change

Reach	Goodwin Dam to Knight's Ferry	Knight's Ferry to Orange Blossom Bridge	Orange Blossom Bridge to Oakdale	Oakdale to Jacob
	Average Change (ft)			
No Gravel Augmentation	-0.1	-0.5	-0.3	-0.5
With Gravel Augmentation	0.2	-0.3	-0.2	-0.5
	Maximum Change (ft)			
No Gravel Augmentation	0.0	5.5	0.7	1.4
With Gravel Augmentation	3.1	5.7	0.4	1.2

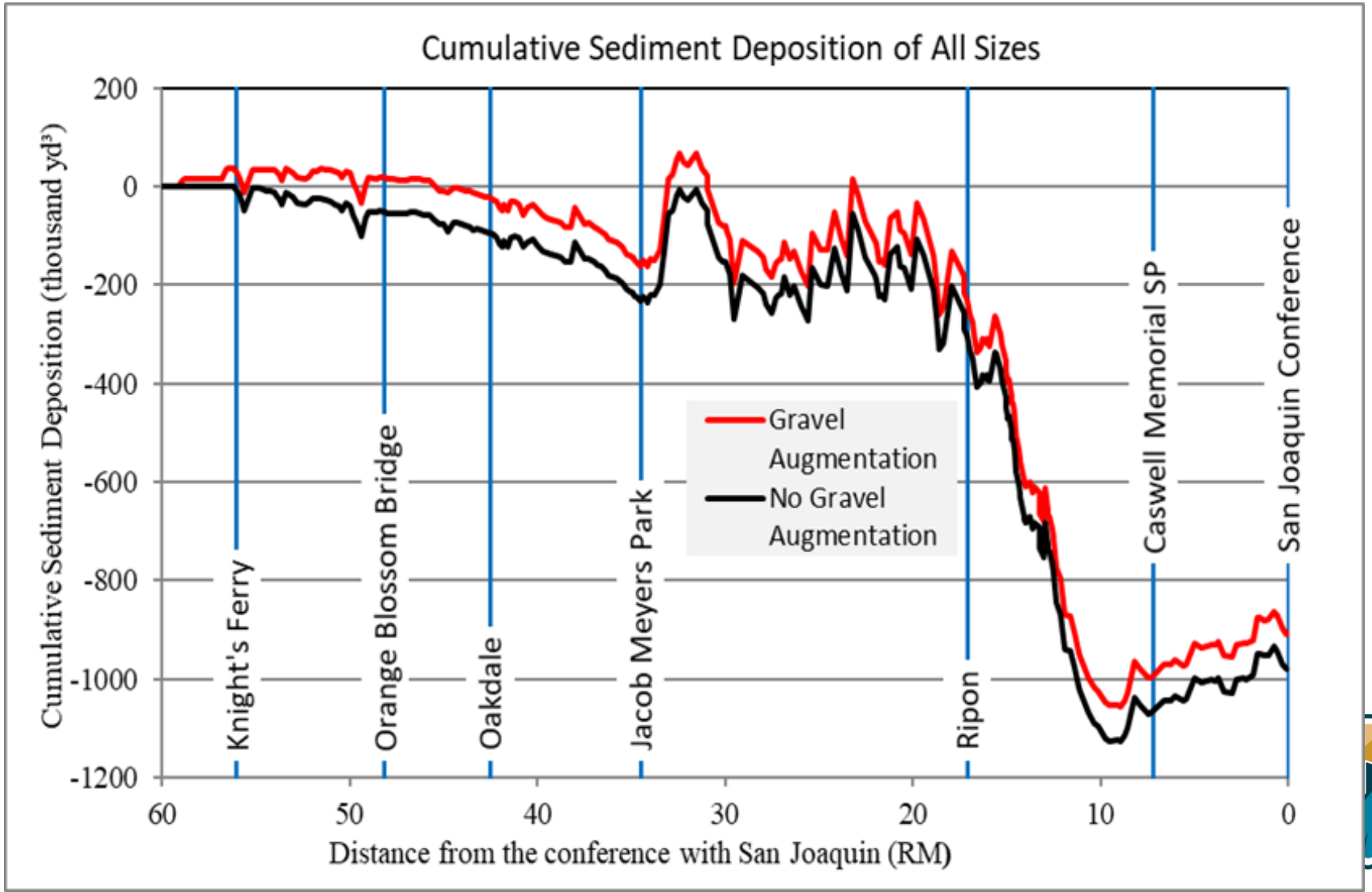
Historical Simulation – Water Surface Elevation @ 8000 cfs



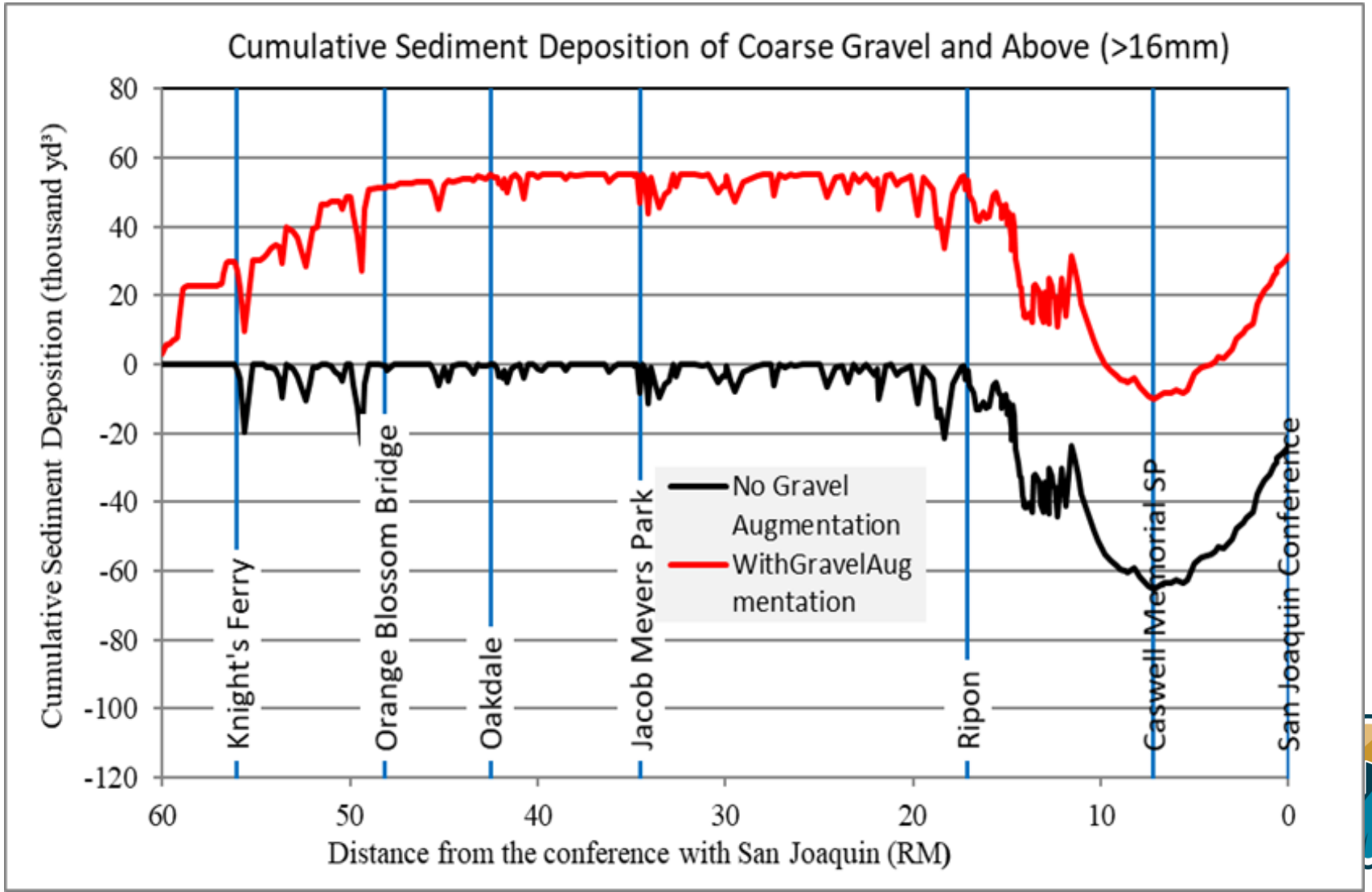
Historical Simulation – Water Surface Elevation Change @ 8000 cfs

Reach	Goodwin Dam to Knight's Ferry	Knight's Ferry to Orange Blossom Bridge	Orange Blossom Bridge to Oakdale	Oakdale to Jacob
	(ft)	(ft)	(ft)	(ft)
Average WSE change relative to No Augmentation	0.1	0.1	0.0	0.0
Average WSE change relative to initial WSE	-0.1	-0.1	-0.1	-0.2
Maximum WSE change relative to No Augmentation	0.9	0.2	0.0	0.0
Maximum WSE change relative to initial WSE	0.9	1.0	-0.1	0.2

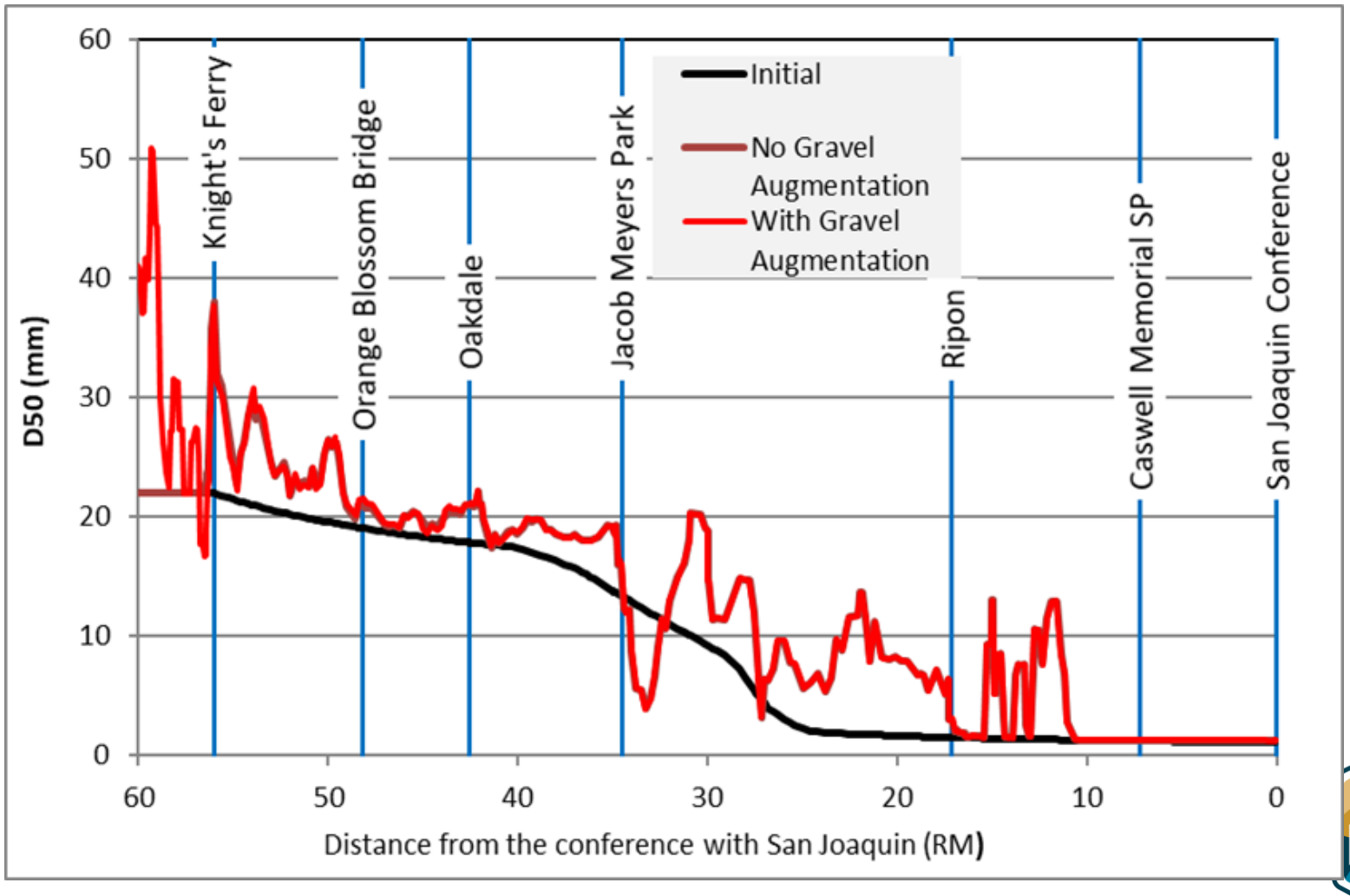
Historical Simulation – 3.3. Cumulative Sediment Deposition



Historical Simulation – Cumulative Sediment Deposition

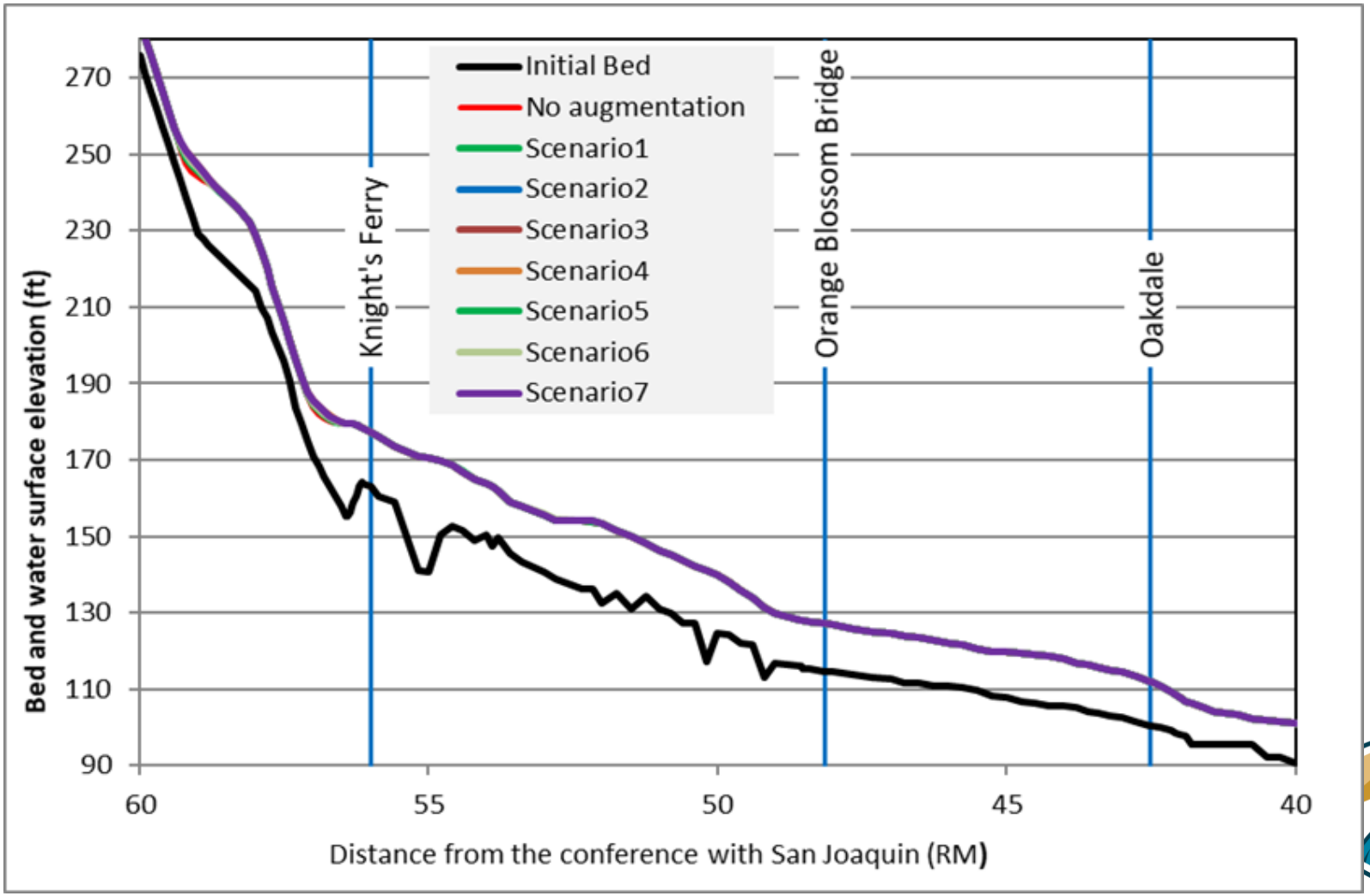


Historical Simulation – Sediment Size D50

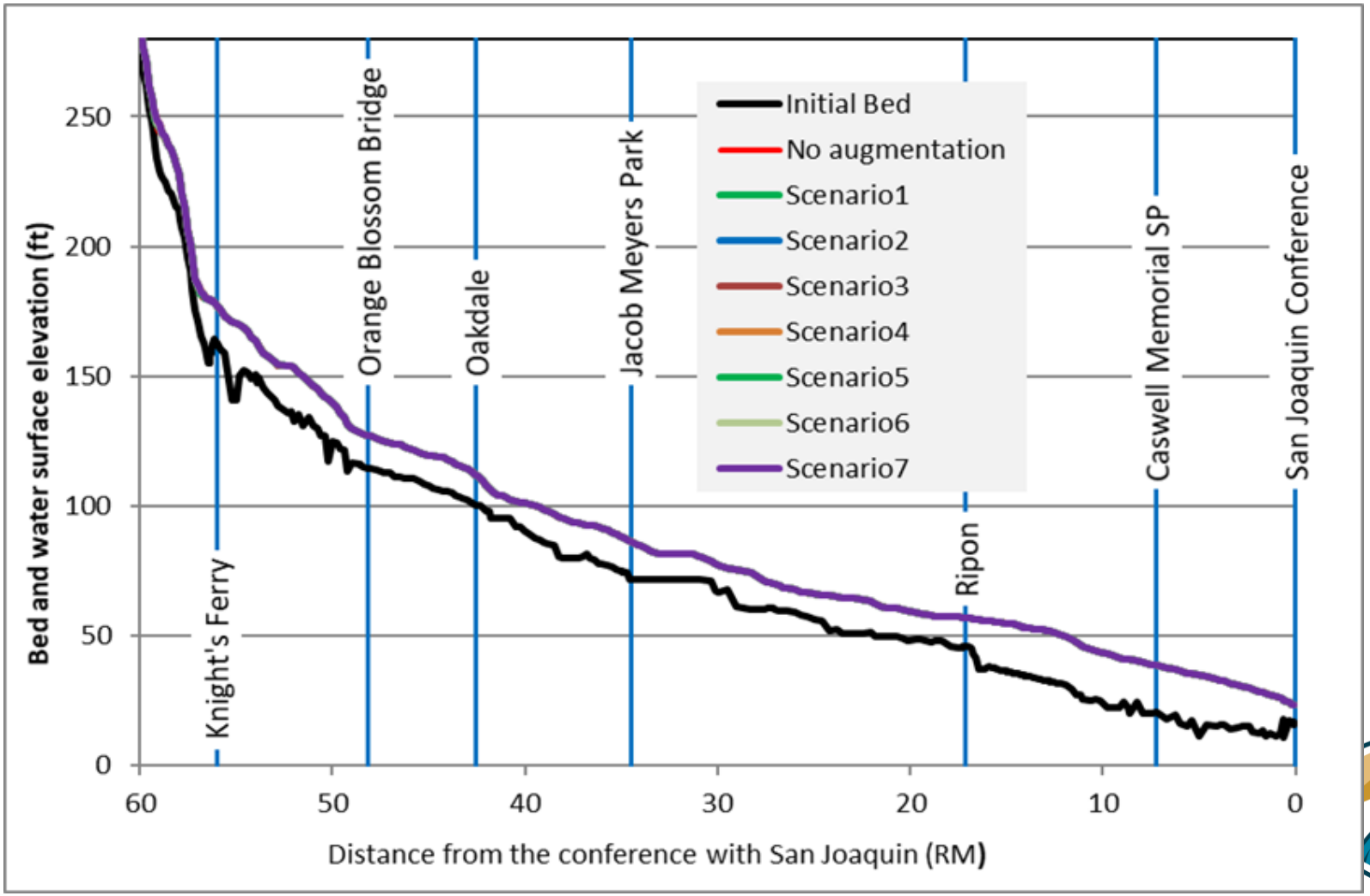


Results for Future Gravel Augmentation

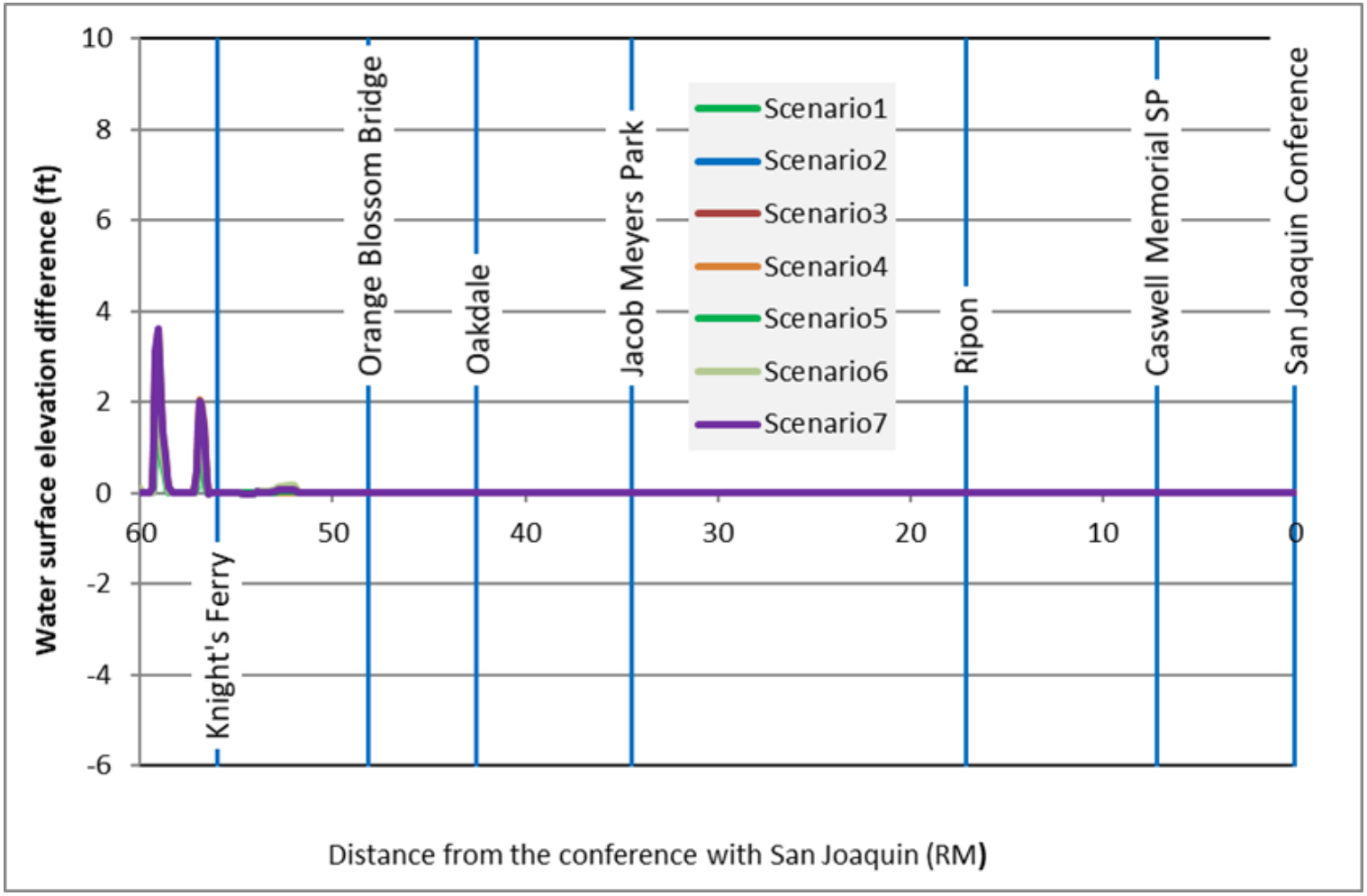
Future Simulation – Water Surface Elevation @ 8000 cfs



Future Simulation – Water Surface Elevation @ 8000 cfs



Future Simulation – Water Surface Elevation Change @ 8000 cfs



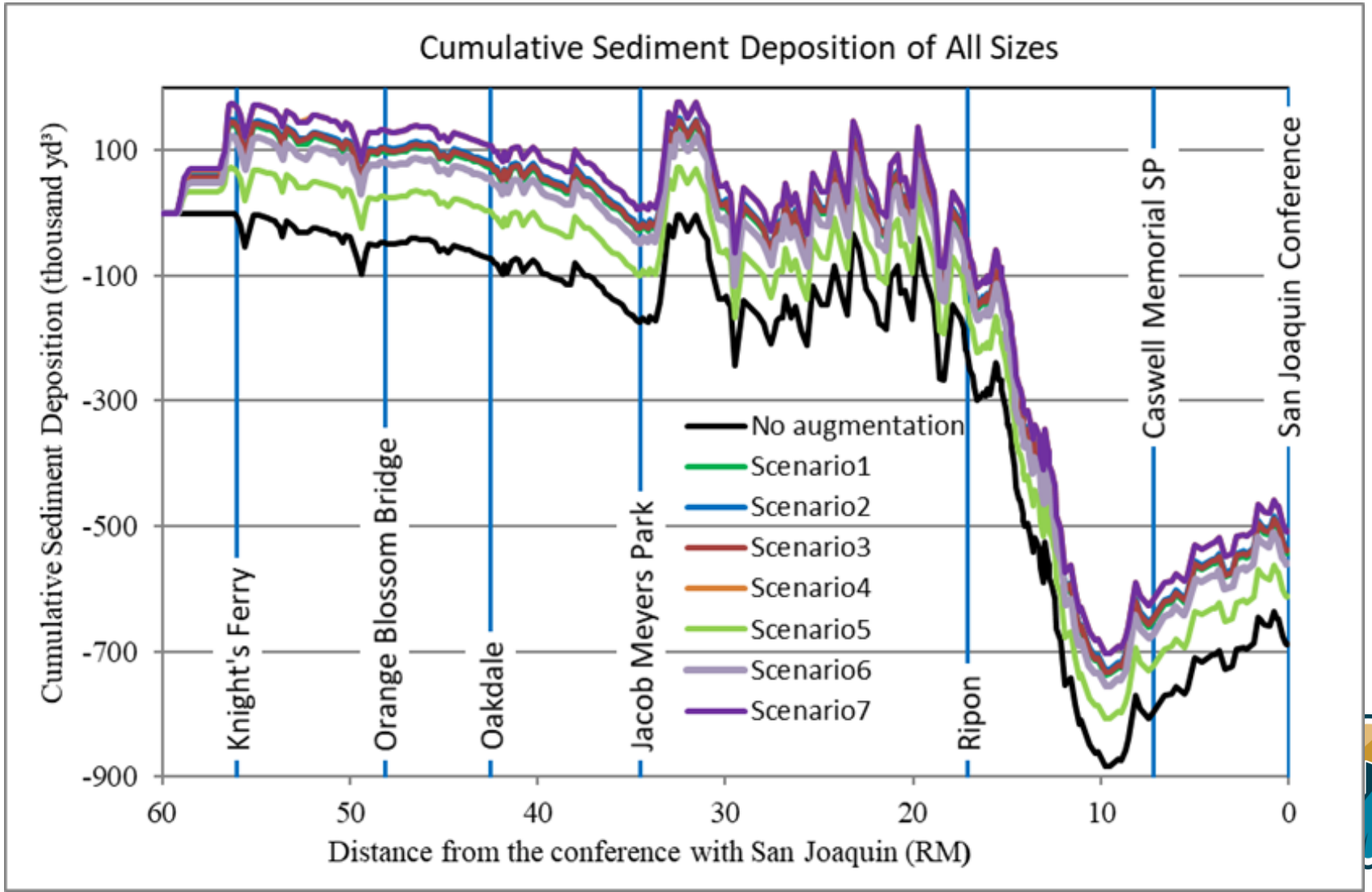
Future Simulation – Average Water Surface Elevation Change @ 8000 cfs Compared with no gravel augmentation scenario

Reach	Average Increase in Water Surface Elevation (ft)			
	Goodwin Dam to Knight's Ferry	Knight's Ferry to Orange Blossom Bridge	Orange Blossom Bridge to Oakdale	Oakdale to Jacob
	Change (ft)	Change (ft)	Change (ft)	Change (ft)
Scenario1	0.4	0.01	0.0	0.0
Scenario2	0.4	0.01	0.0	0.0
Scenario3	0.4	0.00	0.0	0.0
Scenario4	0.5	0.00	0.0	0.0
Scenario5	0.2	0.00	0.0	0.0
Scenario6	0.3	0.02	0.0	0.0
Scenario7	0.5	0.01	0.0	0.0

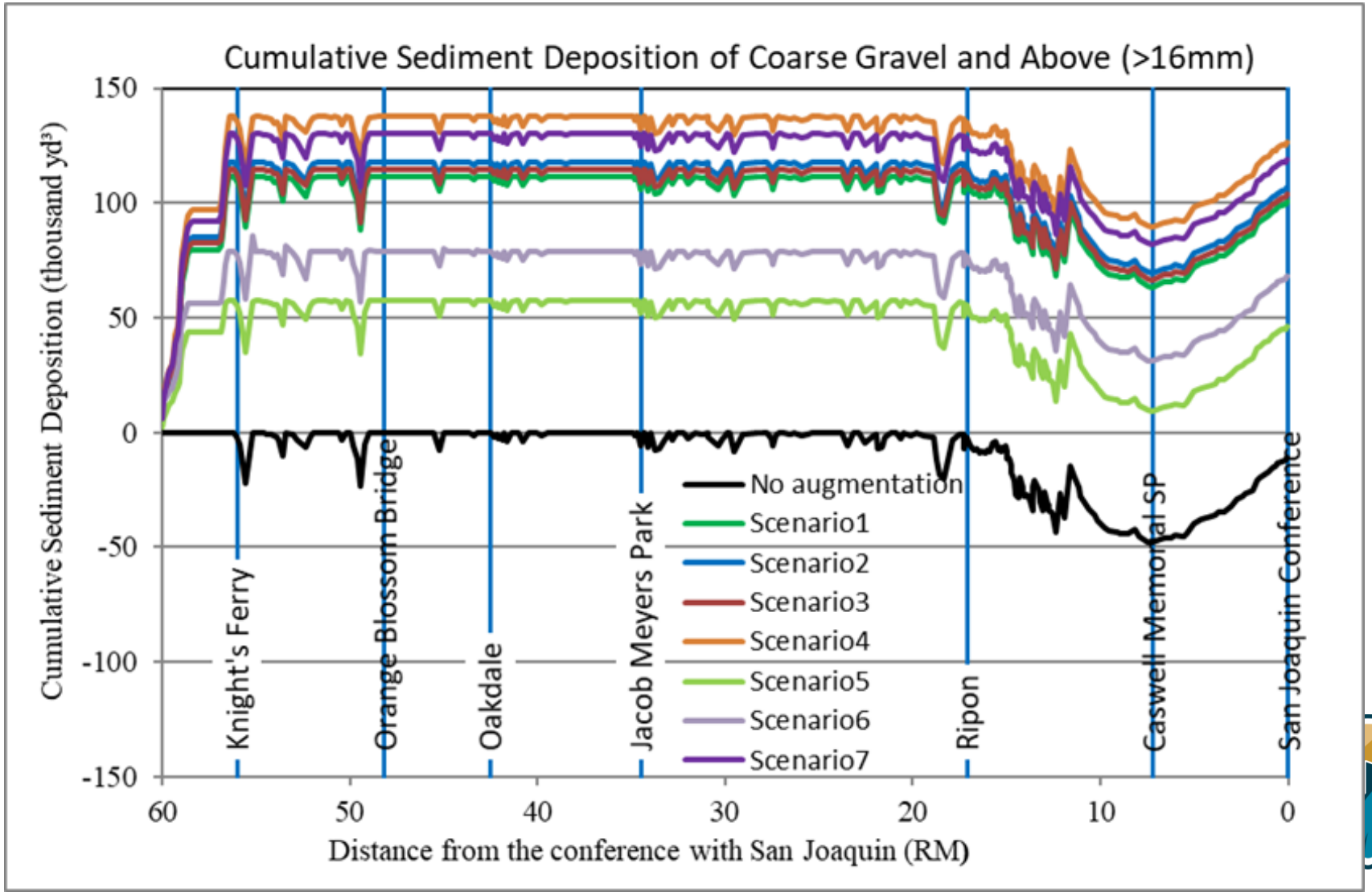
Future Simulation – Average Water Surface Elevation Change @ 8000 cfs compared to the current water surface profile

	Average Increase in Water Surface Elevation (ft) as compared with current condition			
Reach	Goodwin Dam to Knight's Ferry	Knight's Ferry to Orange Blossom Bridge	Orange Blossom Bridge to Oakdale	Oakdale to Jacob
	Change (ft)	Change (ft)	Change (ft)	Change (ft)
Scenario1	0.2	-0.2	-0.1	-0.1
Scenario2	0.3	-0.2	-0.1	-0.1
Scenario3	0.3	-0.2	-0.1	-0.1
Scenario4	0.3	-0.2	-0.1	-0.1
Scenario5	0.0	-0.2	-0.1	-0.1
Scenario6	0.2	-0.2	-0.1	-0.1
Scenario7	0.4	-0.2	-0.1	-0.1

Future Simulation – 3.3. Cumulative Sediment Deposition



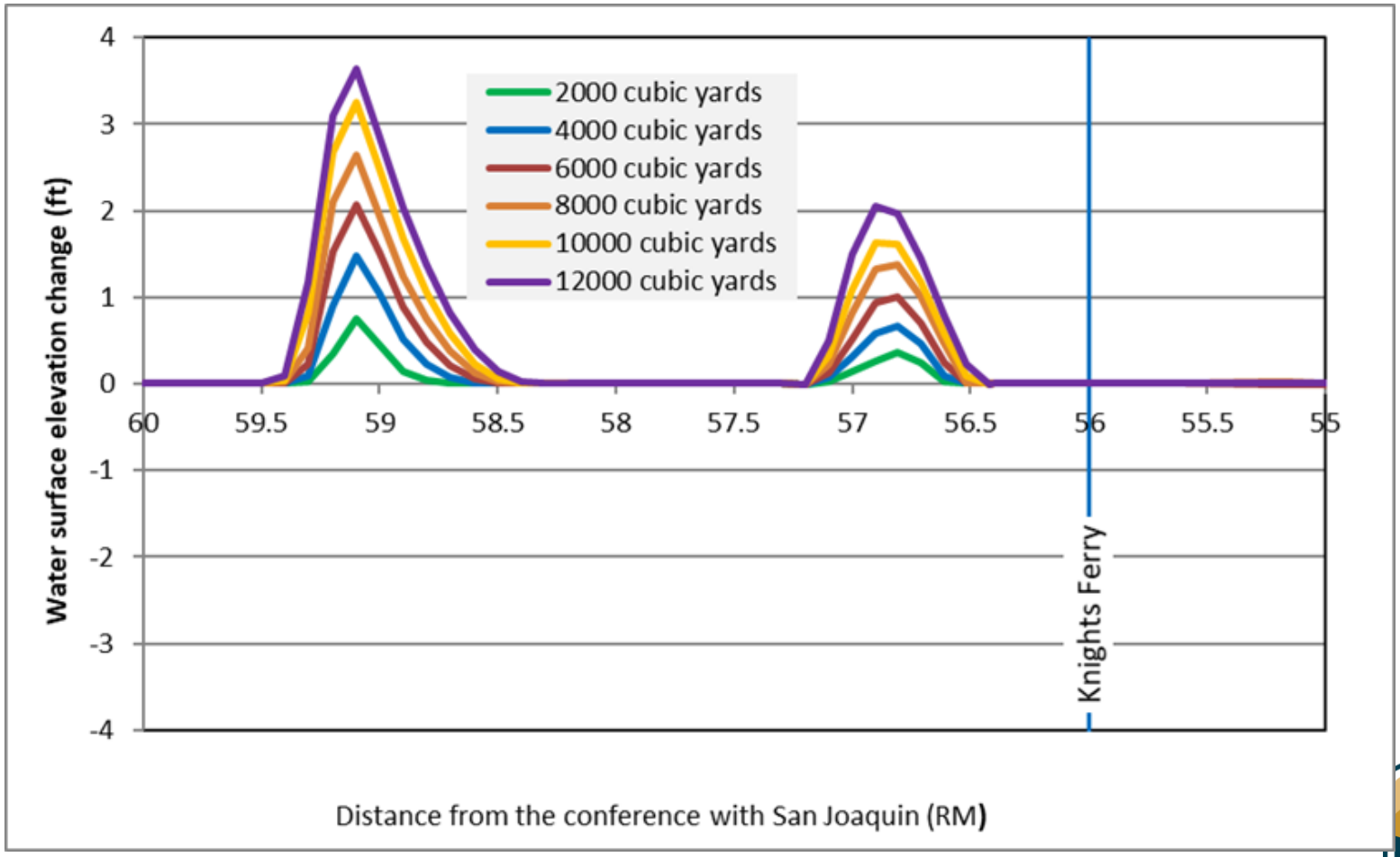
Future Simulation – Cumulative Sediment Deposition



Future Simulation – Gravel Deposition

Reach	Goodwin Dam to Knight's Ferry	Knight's Ferry to Orange Blossom Bridge	Orange Blossom Bridge to Oakdale	Oakdale to Jacob
No Sed	-1,754	1,754	0	-5,669
Scenario1	103,495	1,759	0	-5,669
Scenario2	109,347	1,759	0	-5,669
Scenario3	106,350	1,756	0	-5,669
Scenario4	127,635	1,759	0	-5,669
Scenario5	53,050	1,756	0	-5,669
Scenario6	71,388	1,740	0	-5,669
Scenario7	121,910	1,759	0	-5,669

Future Simulation – Various Gravel Augmentation Amounts



Summary

- Gravel Augmentation helps maintain a better sediment mass balance in the river.
  - Build gravel bars in the reach from Goodwin Dam to Knight's Ferry Bridge
  - Relive the sediment starvation conditions downstream of Knight's Ferry Bridge
- Water Surface Elevation increases only in the reach Goodwin Dam to Knight's Ferry Bridge

Special Thanks to Reclamation's Bay-Delta Office