Hydrometrics, Inc.
consulting scientists and engineers

TECHNICAL MEMORANDUM

DATE: October 21, 2014

TO: Heidi Kaiser, Hydrometrics, Inc.

FROM: Gregory Lorenson, P.E., Hydrometrics, Inc.

SUBJECT: Impacts of Mining and Reclamation on Surface Water Runoff and Sediment Transport

INTRODUCTION

This memorandum has been prepared to summarize the results of the surface water runoff and sediment transport modeling conducted as part of Exhibit 315A to the Otter Creek Mine permit to show how these results impact surface water quality and the hydrologic balance during mining and after reclamation of the project is complete.

IMPACTS TO THE HYDROLOGIC BALANCE

Hydrologic models for the 2-year, 24-hour; 10-year, 24-hour; and 100-year, 6-hour storm events for each of the watersheds impacted by the Otter Creek project were created using the hydrology and sedimentology input parameters discussed in Exhibit 315A. The peak flow and runoff volume results for each of these storm events within each watershed is presented on Table 1 (Attachment 1). Attachment 2 includes the hydrographs for the models presented in Table 1.

As discussed in Exhibit 315A and shown on Table 1 (Attachment 1), during active mining there will be very little runoff from the project area during storm events smaller than the 100-year, 24-hour storm, due to containment of storm water runoff and sediment. Since this 8.6 square mile project area is approximately 1.0% of the entire 711 square mile Otter Creek watershed, decreases in storm water runoff during mining should have little impact on the overall hydrologic balance of the watershed.

As shown on Table 1 (Attachment 1), changes in topography, vegetation, and mixing of soils due to mining will have little impact the overall hydrologic balance once reclamation is complete. Post reclamation runoff models predict cumulative increases in the pre mining peak flow from the entire project area of 16.1 cfs or 40% during the 2-year, 24-hour storm; 34.6 cfs or 7% during the 10-year, 24-hour storm; and 57.2 cfs or 5% during the 100-year, 6-hour storm. The cumulative runoff volume from the entire project area also increases by 4.1 acre-ft or 21% during the 2-year, 24-hour storm; 11.1 acre-ft or 10% during the 10-year, 24-hour storm; and 13.4 acre-ft or 9% during the 100-year, 6-hour storm.

Regression equations developed by the USGS for predicting stream velocity based on storm events, where the peak flow and drainage area is known, were used to predict the stream flow velocities prior to mining and after reclamation for the 2-year, 24-hour; 10-year, 24-hour; and 100-year, 6-hour storm events for each of the watersheds impacted by the Otter Creek project. As shown on Table 1, the storm derived peak flow velocities are predicted to be similar in the post mining condition as they are in the pre mining condition. In addition, post mining topography creates drainage channels with shallower gradients than those found prior to mining, which will generate similar or slightly lower stream channel velocities for peak flows of a similar magnitude.

IMPACTS TO SEDIMENT TRANSPORT

Sediment models for the 2-year, 24-hour; 10-year, 24-hour; and 100-year, 6-hour storm events for each of the watersheds impacted by the Otter Creek project were created using the hydrology and sedimentology input parameters discussed in Exhibit 315A. The peak total suspended solids (TSS) and sediment yield results for each of these storm events within each watershed is presented on Table 1 (Attachment 1). Attachment 2 includes the sedimentgraphs for the models presented in Table 1.

As discussed in Exhibit 315A and shown on Table 1 (Attachment 1), during active mining there will be very little to zero sediment yield or TSS from the project area during storm events smaller than the 100-year, 24-hour storm, due to containment of storm water runoff and sediment.

As shown on Table 1 (Attachment 1), changes in topography, vegetation, and mixing of soils due to mining will decrease sediment yields and TSS concentrations once reclamation is complete. Over time vegetation and topography will reach equilibrium with the natural environment, producing sediment yields similar to that of the pre mining environment. In Watersheds 1, 5, 7, 12, and 15, permanent ponds provide further reduction of sediment during post mining, since they act as a sediment trap for the drainage area above the pond. Although the overall sediment load, determined through modeling will be lower in the post mining condition, TSS loads from storm derived runoff and large peak TSS runoff will still exist. In addition, permanent ponds have been designed to allow sediment to flush through the system and provide discharge that includes large amounts of TSS. Although the overall sediment yields are reduced in the post mining state, significant peak TSS still discharges from these drainages and provides sediment to Otter Creek during storm runoff, necessary for maintaining fish spawning habitat and minimizing erosion due to runoff void of sediment.

ATTACHMENT 1

TABLE 1. SURFACE WATER RUNOFF AND SEDIMENT TRANSPORT MODEL RESULTS

		2-year, 24-hour					10-year, 24-hour					100-year, 6-hour				
Watershed	Area (ac)	Peak Flow (cfs)	Runoff Vol (ac-ft)	Predicted Stream Velocity (ft/sec)	Sediment (ton)	Peak TSS (mg/L)	Peak Flow (cfs)	Runoff Vol (ac-ft)	Predicted Stream Velocity (ft/sec)	Sediment (ton)	Peak TSS (mg/L)	Peak Flow (cfs)	Runoff Vol (ac-ft)	Predicted Stream Velocity (ft/sec)	Sediment (ton)	Peak TSS (mg/L)
Pre-Mining																
1	574.2	8.7	3.4	1.4	46.7	15,712	77.8	15.3	3.3	372.2	33,043	160.3	20.4	4.4	656.0	35,068
1B	199.8	4.0	1.2	1.4	6.8	7,068	41.9	5.3	3.5	58.7	15,910	87.3	7.1	4.7	104.0	16,726
2	191.7	1.9	0.8	1.1	14.0	18,304	30.9	4.4	3.2	168.0	54,157	68.2	5.9	4.3	311.0	57,567
3	293.7	0.2	0.1	0.4	0.6	8,557	6.1	2.6	1.5	36.9	15,481	23.5	4.0	2.5	100.5	23,751
4	79.1	0.0	0.0	0.3	0.0	13,893	1.5	0.6	1.3	5.3	9,329	7.3	1.0	2.3	16.8	17,514
5	657.8	1.2	1.0	0.6	9.0	7,568	26.0	9.5	2.1	182.3	23,383	70.0	13.7	3.1	391.4	29,088
6	108.7	0.2	0.2	0.5	0.8	3,850	8.9	1.6	2.3	23.1	20,579	24.7	2.3	3.4	50.1	24,545
7	2093.1	8.0	5.8	1.0	123.2	19,027	147.3	38.9	3.0	1900.1	69,906	351.8	54.3	4.1	3732.7	79,259
8	30.6	0.0	0.0	0.3	0.0	5,808	2.7	0.3	2.1	4.3	25,320	11.2	0.5	3.6	12.3	36,213
9	63.5	1.1	0.3	1.2	2.0	8,194	13.9	1.6	3.2	20.1	19,093	29.5	2.2	4.2	36.1	19,997
10	78.5	1.7	0.5	1.3	3.0	7,204	15.6	2.2	3.1	23.7	15,258	31.9	2.9	4.1	41.4	16,019
11	106.3	0.4	0.3	0.7	0.8	2,518	8.3	1.9	2.3	13.6	8,897	20.1	2.7	3.2	27.1	10,285
12	285.6	3.4	1.4	1.2	12.0	8,868	37.0	7.1	3.0	111.9	20,595	78.3	9.5	4.1	201.3	22,180
13	4.7	0.0	0.0	0.0	0.0	0	0.0	0.0	0.4	0.0	826	0.1	0.0	1.1	0.1	2,101
14	35.1	0.1	0.0	0.4	0.1	2,053	2.0	0.4	1.8	3.1	8,970	6.0	0.7	2.7	7.2	11,697
15	651.6	9.9	4.2	1.5	93.6	24,844	76.7	18.2	3.2	684.1	47,776	154.6	24.2	4.2	1188.7	50,597
Pre-Mining Total			**19.1**		**312.6**			**109.9**		**3607.4**			**151.4**		**6876.7**	
Mining																
1	587.5	0.0	0.0		0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0		0.0	0.0
1B	186.8	0.0	0.0		0.0	0.0	0.0	0.0		0.0	0.0	15.5	1.8		0.0	1.4
2	264.3	0.0	0.0		0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0		0.0	0.0
3	405.0	0.0	0.0		0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0		0.0	0.0
4	62.0	0.0	0.0		0.0	0.0	0.0	0.0		0.0	0.0	3.2	0.3		0.0	1.7
5	498.3	0.0	0.0		0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0		0.0	0.0
6	189.9	0.0	0.0		0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0		0.0	0.0
7	2038.2	0.0	0.0		0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0		0.0	0.0
8	32.5	0.0	0.0		0.0	0.0	0.0	0.0		0.0	0.0	2.1	0.4		0.0	4.7
9	42.2	0.0	0.0		0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0		0.0	0.0
10	147.8	0.0	0.0		0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0		0.0	0.0
11	101.6	0.0	0.0		0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0		0.0	0.0
12	166.0	0.0	0.0		0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0		0.0	0.0
13	0.0	0.0	0.0		0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0		0.0	0.0
14	31.0	0.0	0.0		0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0		0.0	0.0
15	715.6	0.0	0.0		0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0		0.0	0.0
Mining Total			**0.0**		**0.0**			**0.0**		**0.0**			**2.5**		**0.0**	
Post Mining																
1	587.5	6.8	3.1	1.3	6.1	3,905	67.6	14.7	3.1	69.2	8,893	142.5	19.8	4.2	137.8	11,340
1B	186.8	2.9	1.0	1.3	3.0	3,690	36.5	4.8	3.4	28.1	8,603	77.1	6.4	4.5	50.2	9,037
2	264.3	4.2	1.5	1.3	7.6	10,143	36.1	7.0	3.1	68.5	23,751	74.4	9.4	4.1	123.0	26,310
3	393.3	0.5	0.4	0.5	1.7	3,318	16.5	5.0	2.0	49.1	11,441	48.7	7.4	3.1	114.0	15,149
4	73.7	0.1	0.1	0.4	0.1	3,612	3.5	0.9	1.8	4.9	7,329	11.5	1.3	2.8	12.4	10,205
5	498.3	1.5	1.2	0.8	1.1	1,161	32.0	8.6	2.5	34.8	5,715	79.2	12.2	3.5	88.4	8,495
6	189.9	0.8	0.6	0.8	0.3	510	15.5	3.7	2.4	4.9	1,674	36.6	5.1	3.4	9.5	1,912
7	2038.2	8.6	5.9	1.0	9.0	2,031	171.1	38.8	3.2	620.0	17,482	406.7	54.0	4.4	1804.2	50,368
8	32.5	0.0	0.0	0.4	0.0	10,001	4.2	0.4	2.4	4.6	21,301	14.1	0.6	3.9	11.9	27,667
9	42.2	2.0	0.3	1.7	1.9	8,516	12.8	1.3	3.5	12.2	14,003	25.8	1.7	4.5	21.1	14,657
10	147.8	5.6	1.4	1.8	4.4	4,374	32.1	5.0	3.5	23.0	6,126	61.1	6.5	4.4	37.9	6,265
11	101.6	1.3	0.5	1.1	1.4	4,584	13.2	2.6	2.7	11.1	5,828	27.7	3.4	3.6	19.5	6,075
12	166.0	6.4	1.5	1.8	1.1	746	37.8	5.5	3.6	20.6	4,915	72.8	7.2	4.6	45.1	7,236
13	0.0	.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	31.0	0.1	0.1	0.6	0.1	1,224	4.5	0.6	2.5	2.4	6,557	11.0	0.8	3.5	4.8	7,242
15	715.6	15.9	5.6	1.7	2.0	377	47.8	22.1	2.6	35.5	4,040	92.8	29.0	3.3	114.3	10,534
Post Mining Total			**23.2**		**39.8**			**121.0**		**988.9**			**164.8**		**2594.1**	

ATTACHMENT 2

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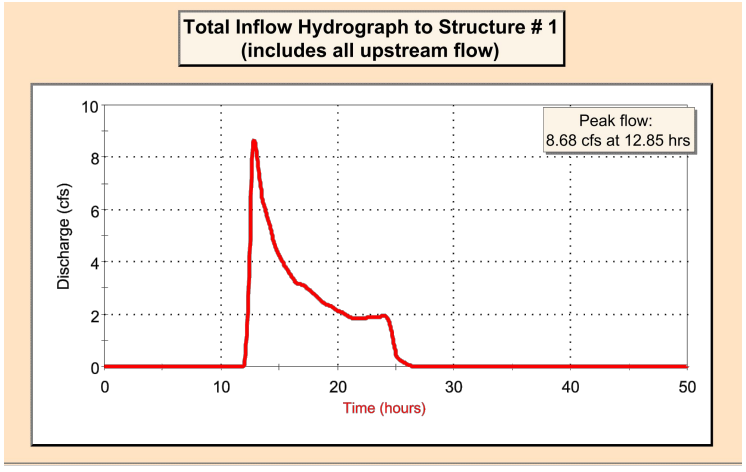
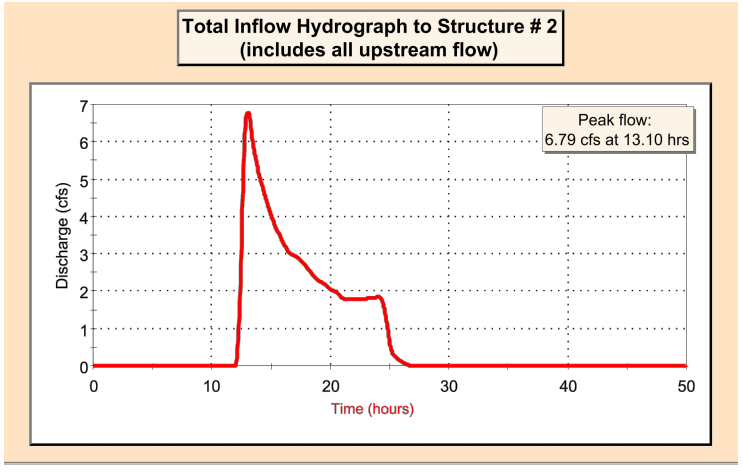


WATERSHED 1 PRE MINING HYDROGRAPH (2 YEAR, 24 HOUR STORM)



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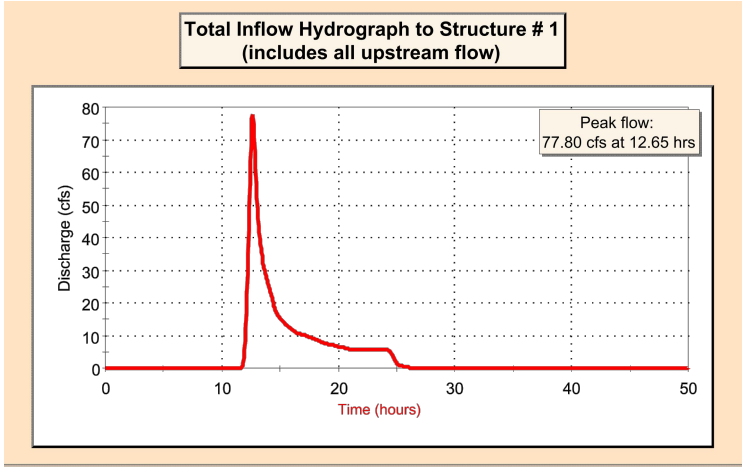

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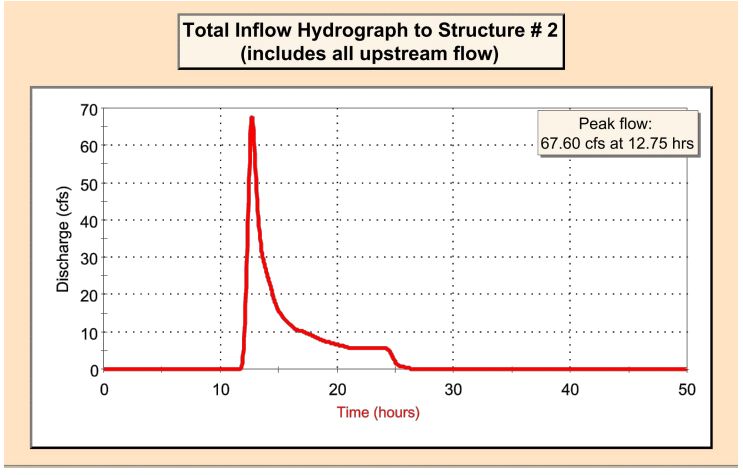

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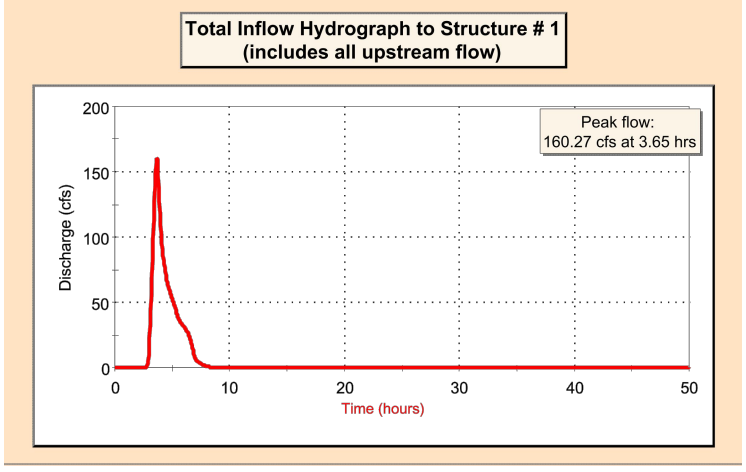

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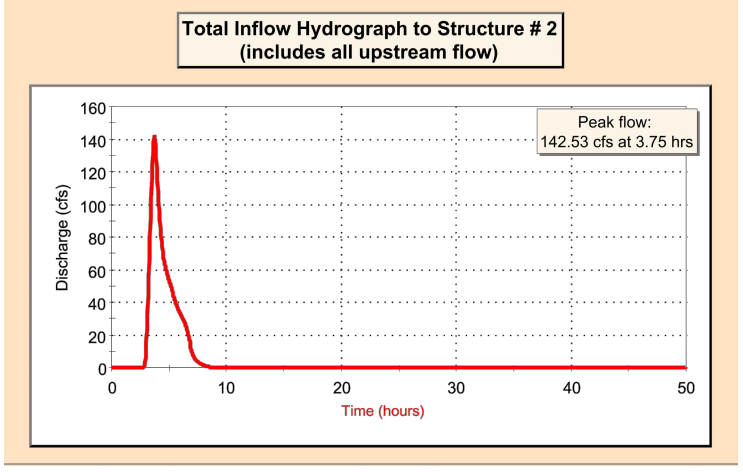

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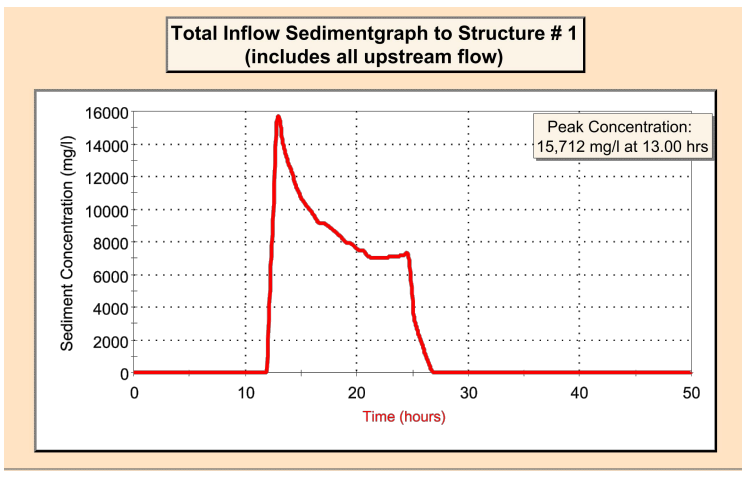

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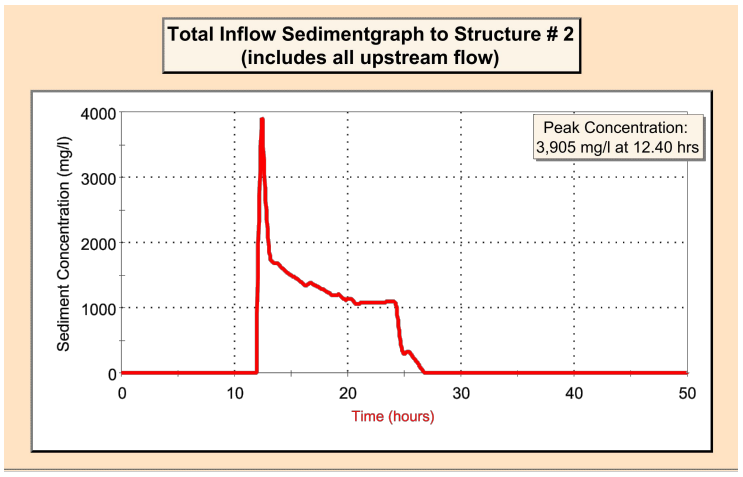

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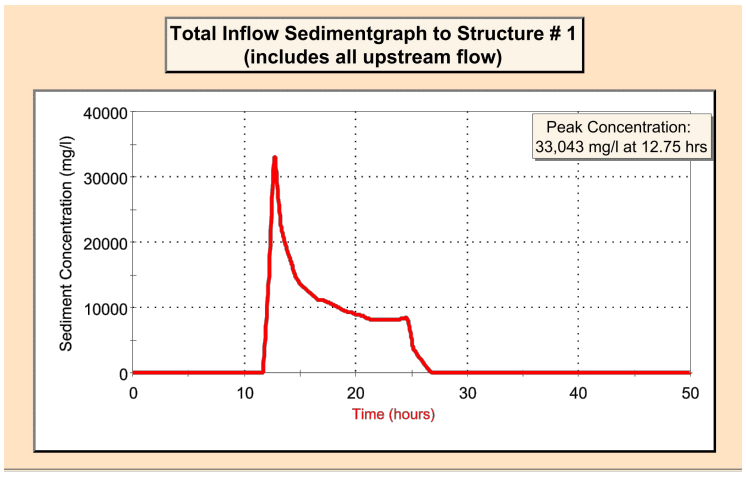

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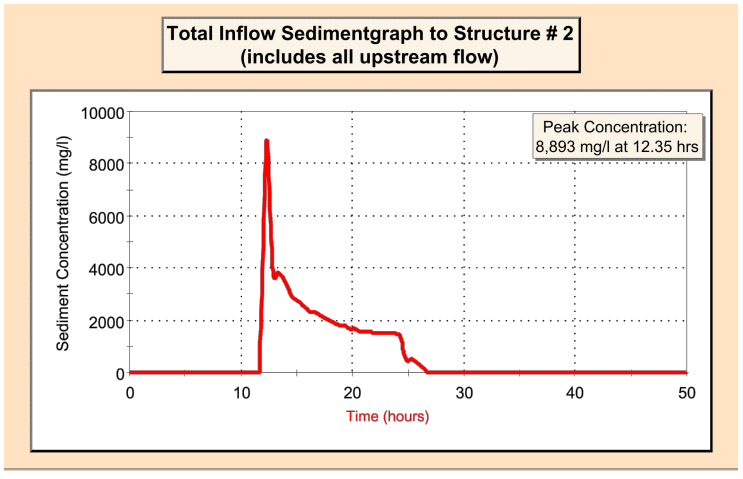

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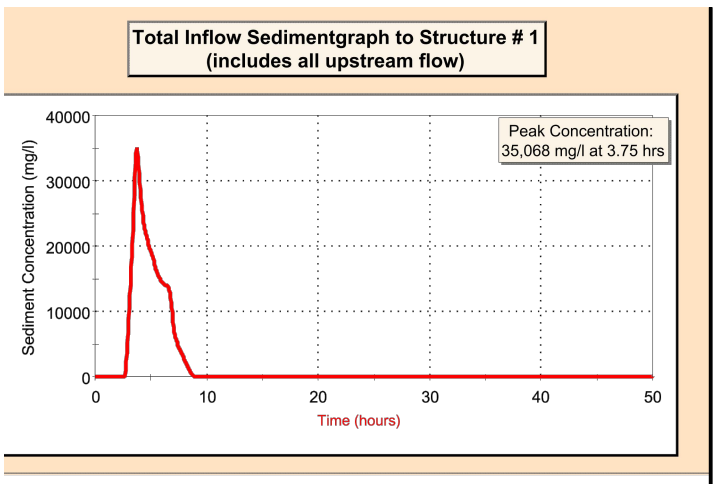

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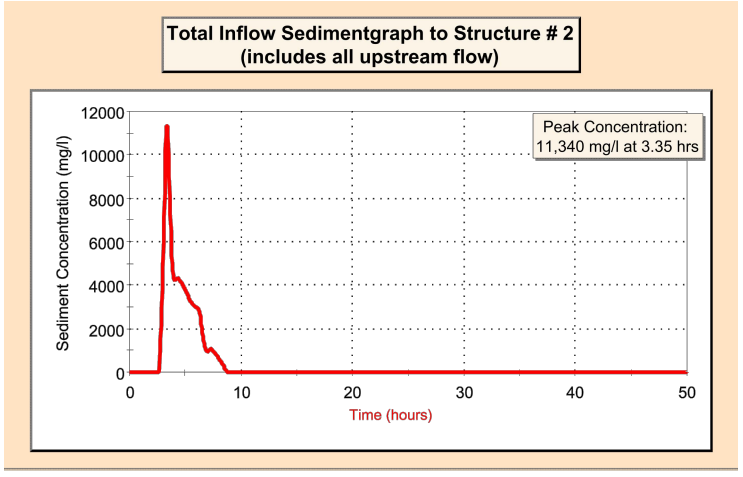

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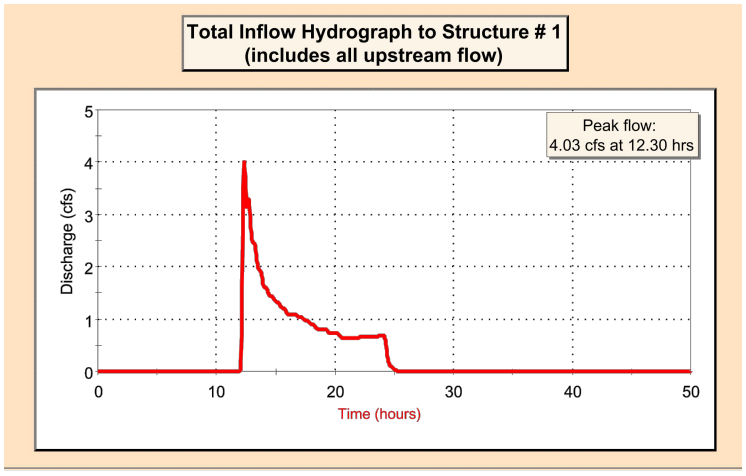

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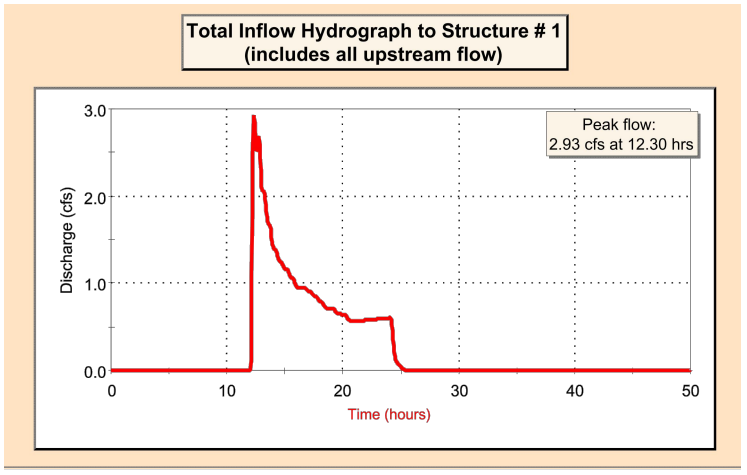

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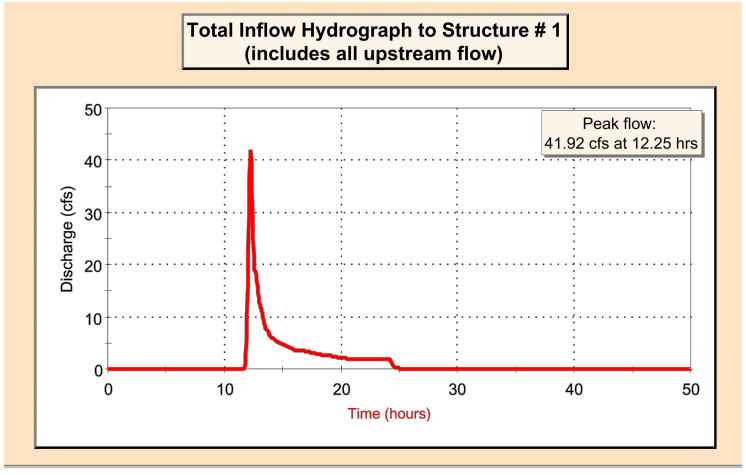

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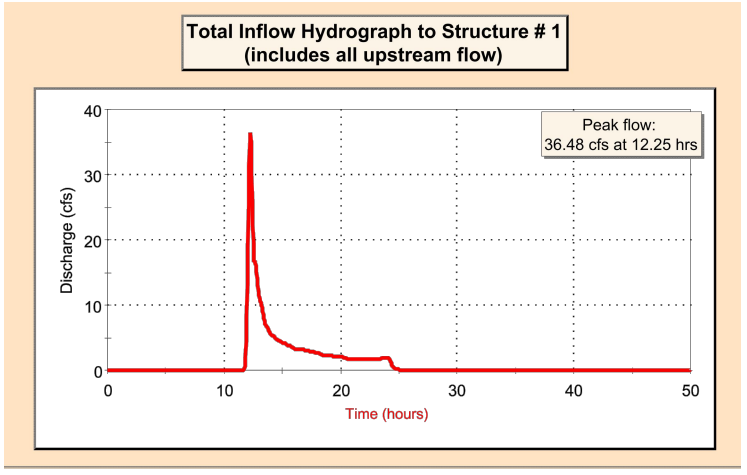

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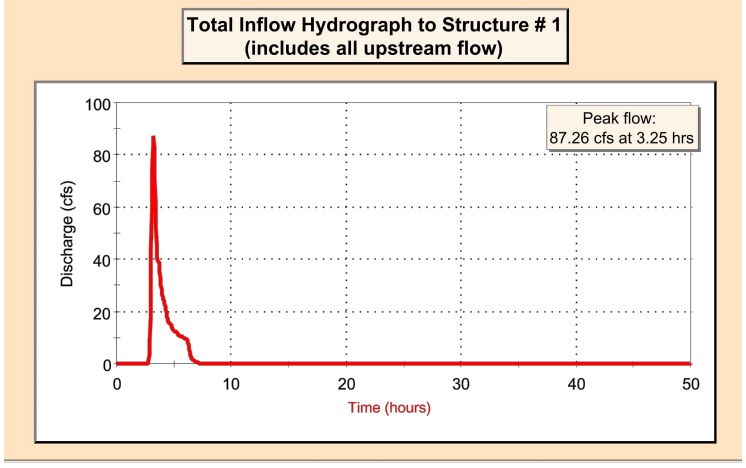

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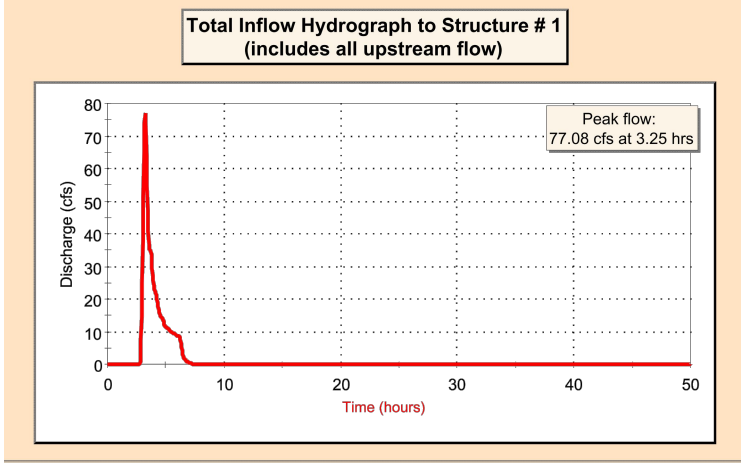

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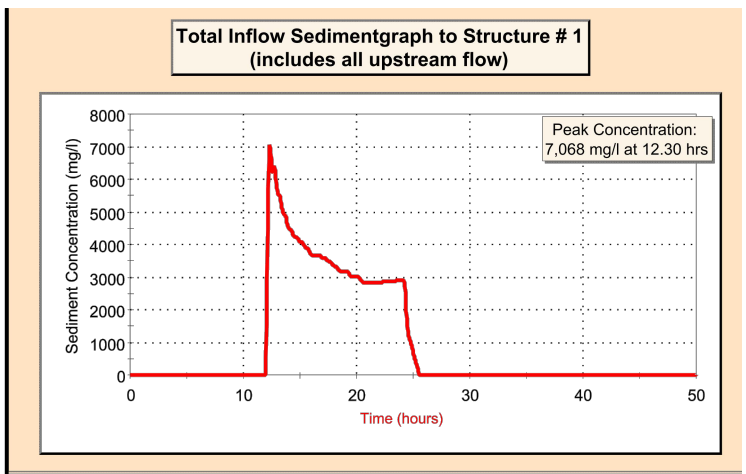

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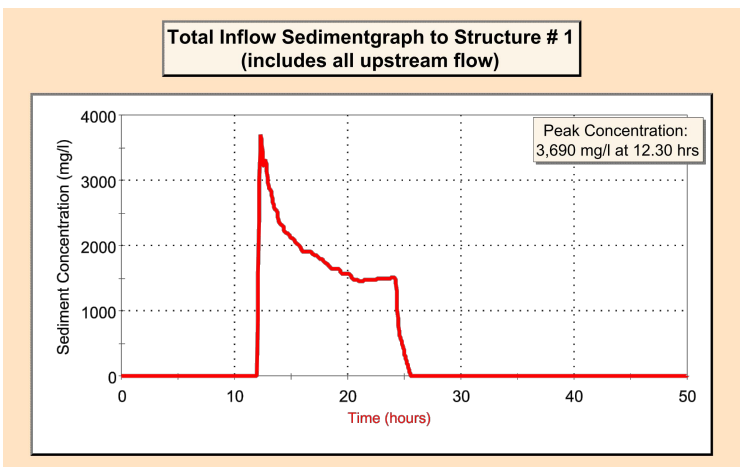

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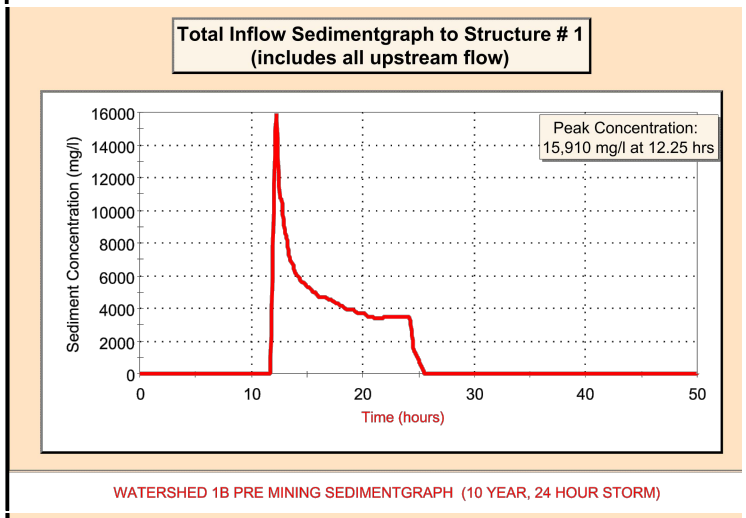
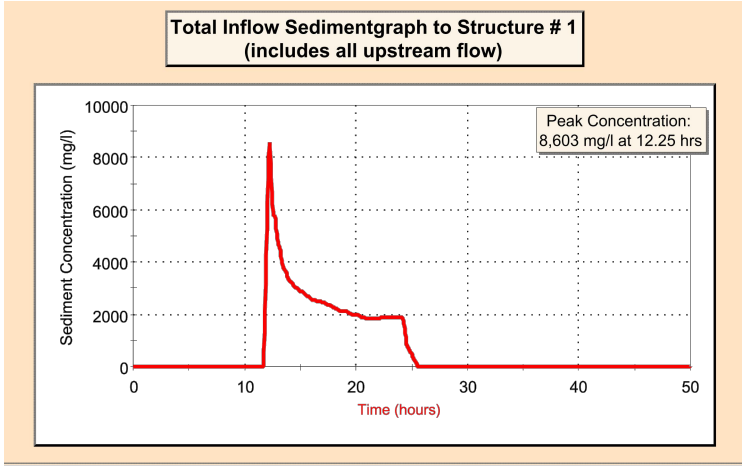
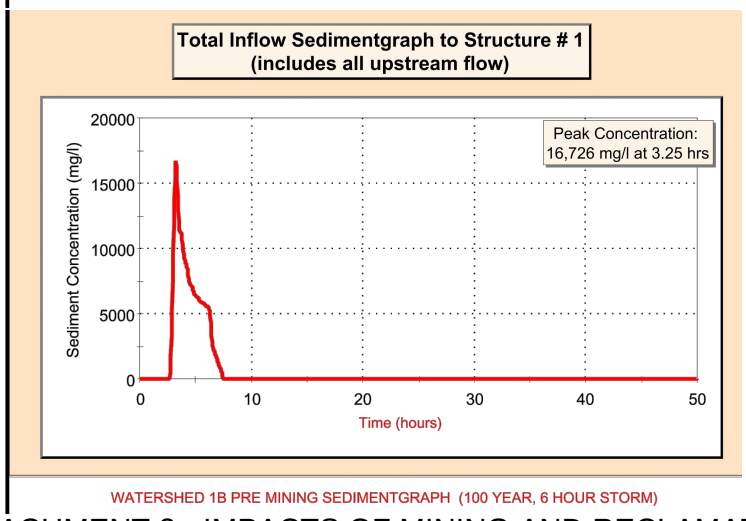


WATERSHED 1B PRE MINING SEDIMENTGRAPH (10 YEAR, 24 HOUR STORM)



WATERSHED 1B POST MINING SEDIMENTGRAPH (10 YEAR, 24 HOUR STORM)



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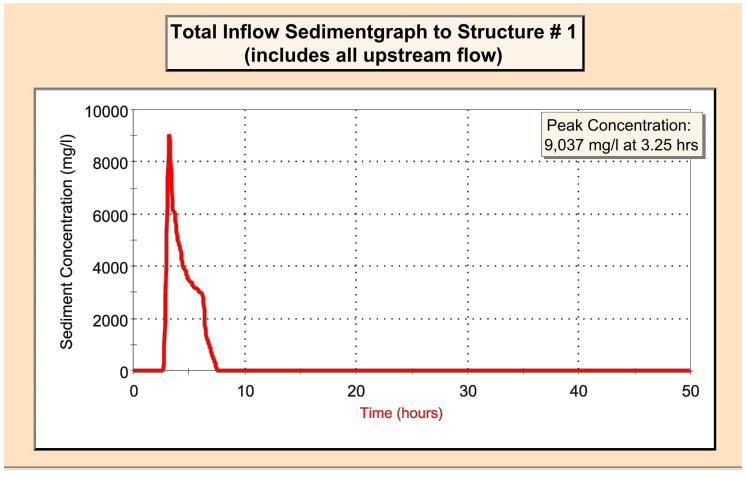

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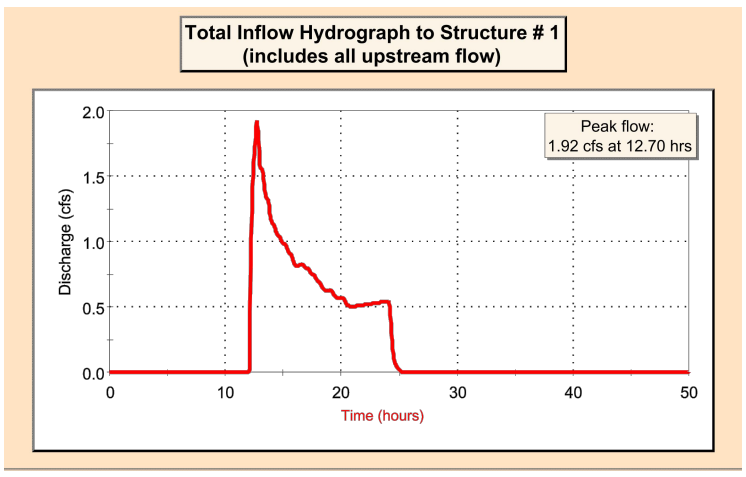

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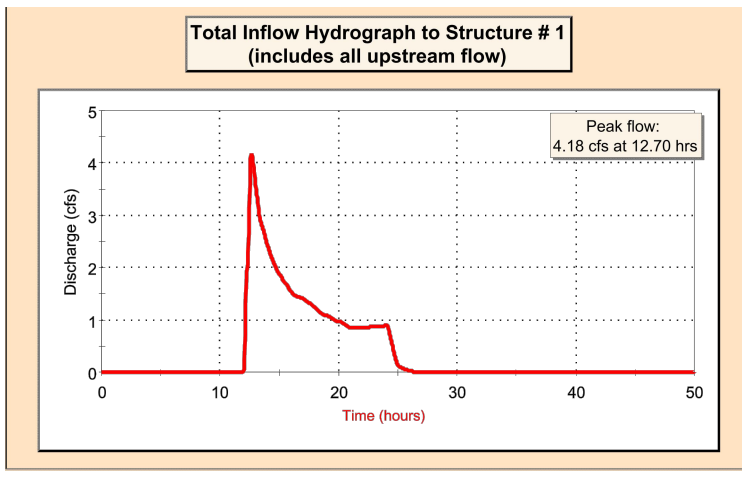

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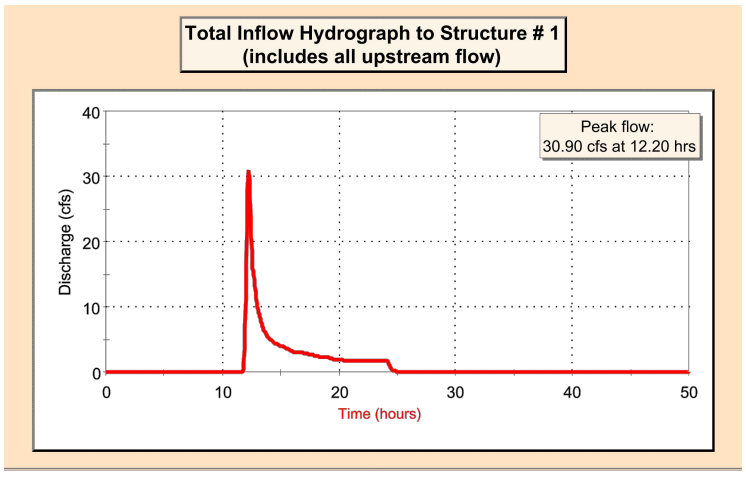

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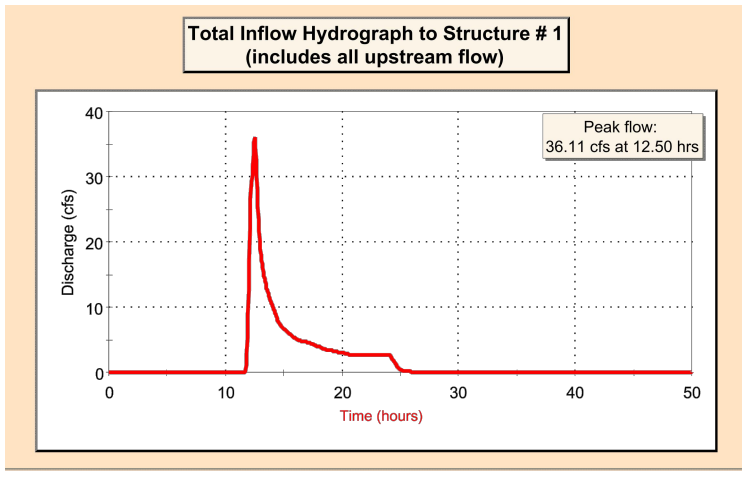

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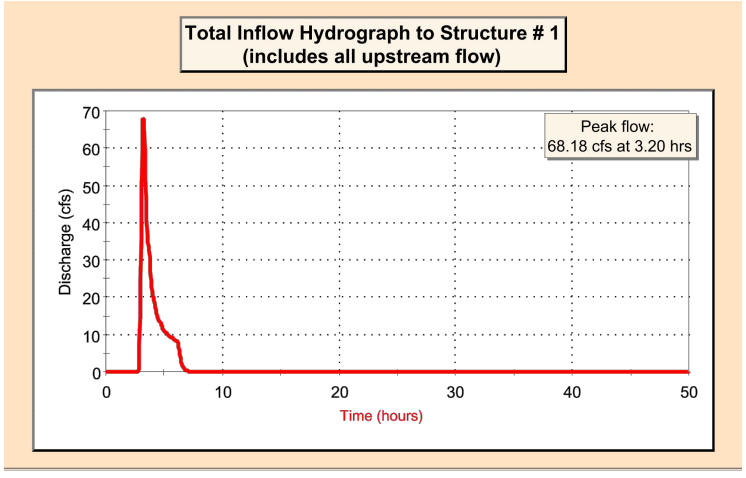

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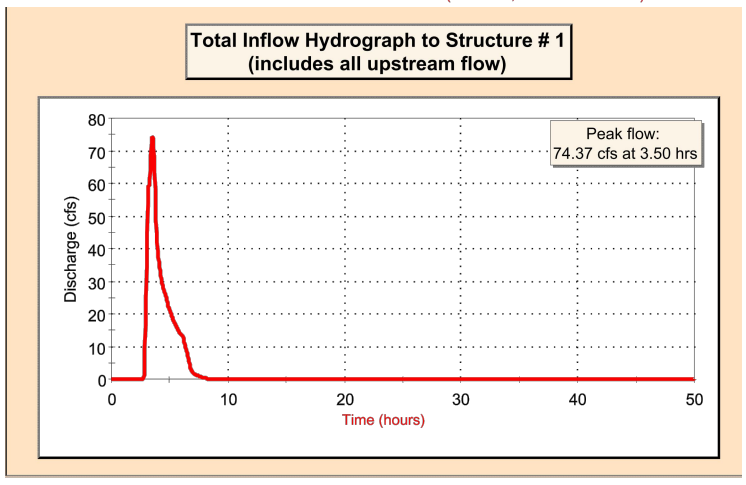

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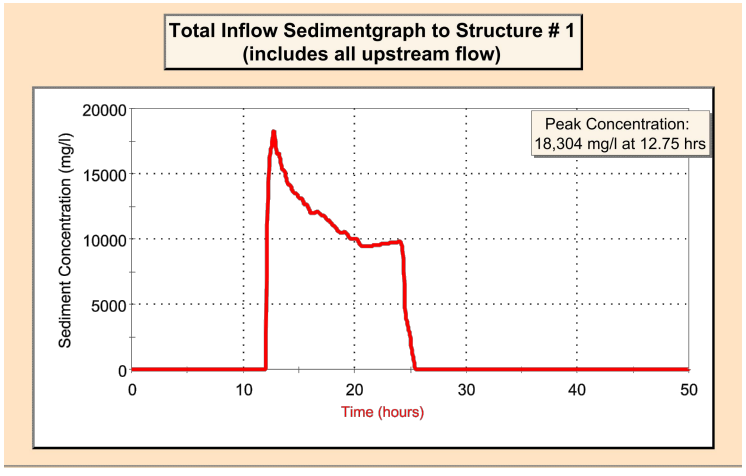

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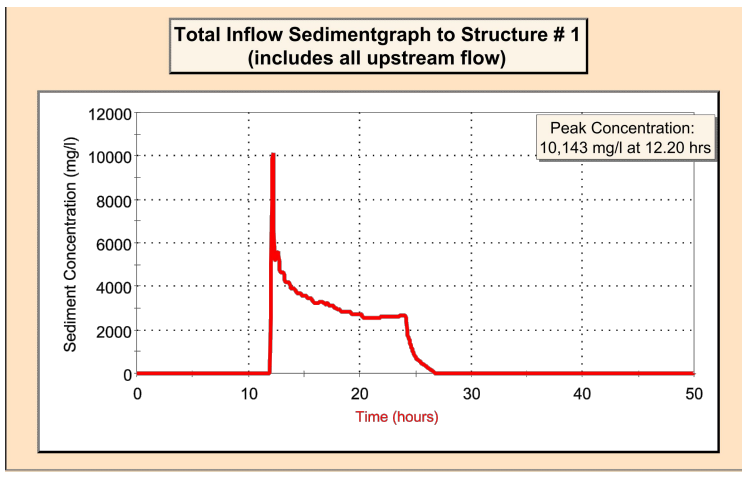

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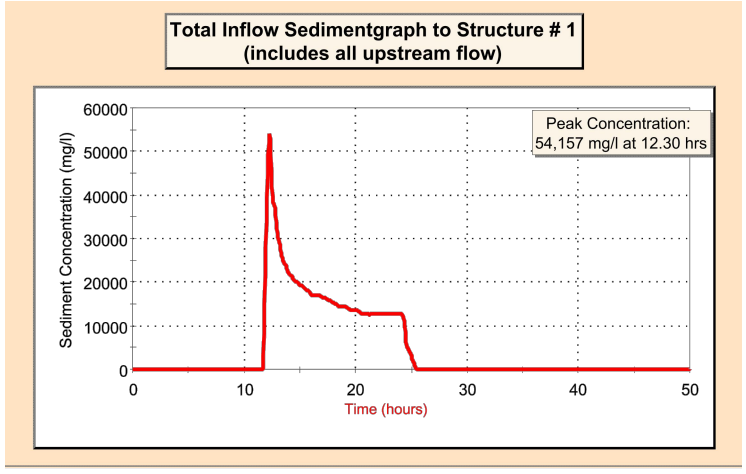

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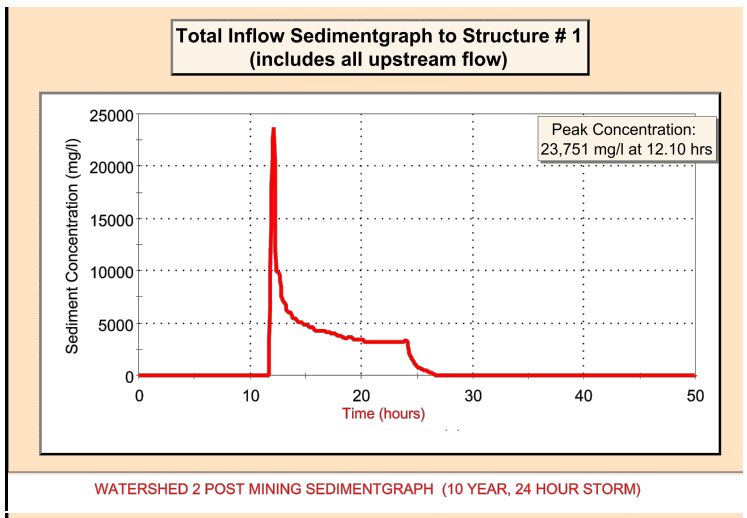

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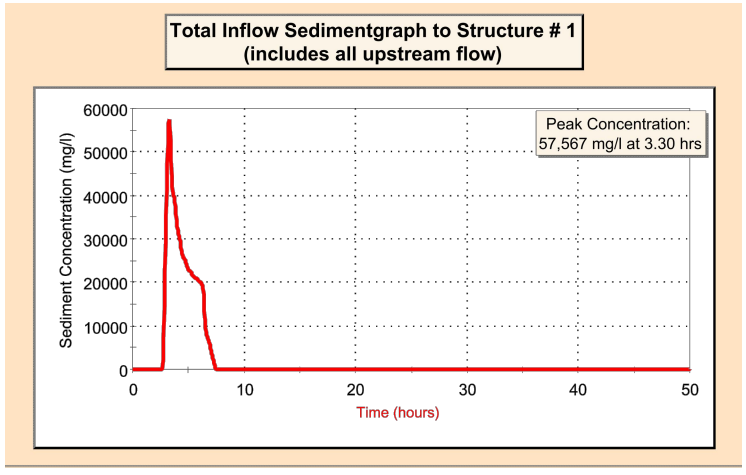

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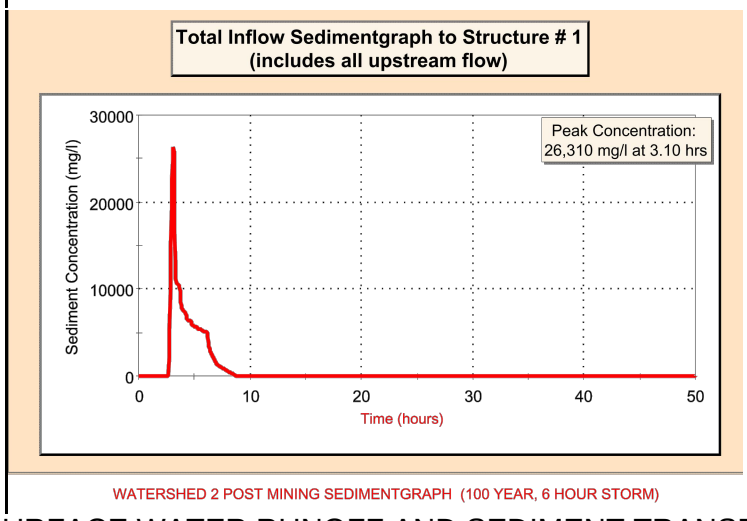

WATERSHED 2 POST MINING SEDIMENTGRAPH (100 YEAR, 6 HOUR STORM)

ATTACHMENT 2 - IMPACTS OF MINING AND RECLAMATION ON SURFACE WATER RUNOFF AND SEDIMENT TRANSPORT
OTTER CREEK MINE

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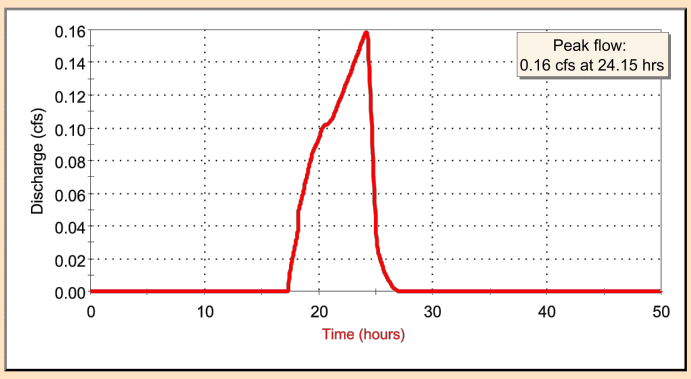

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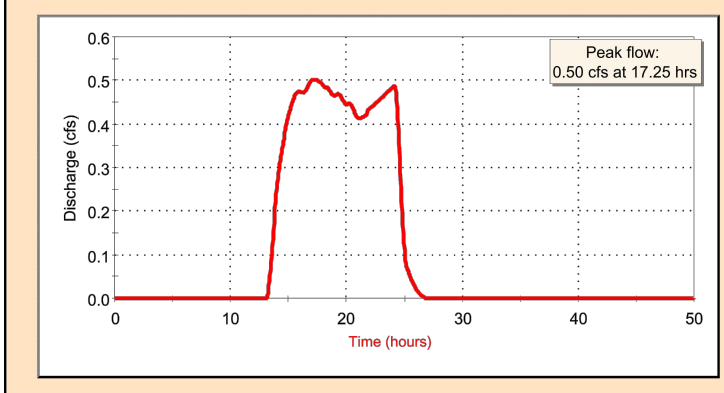

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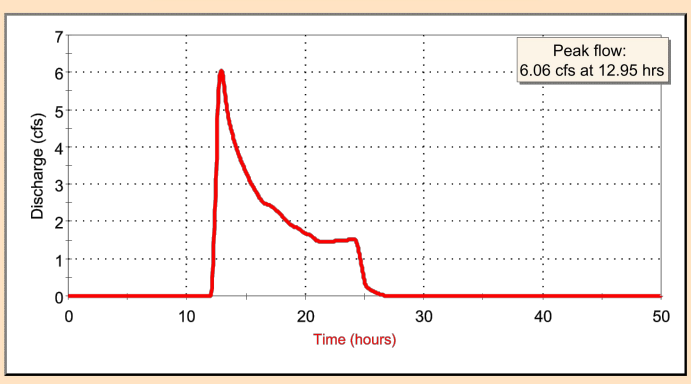

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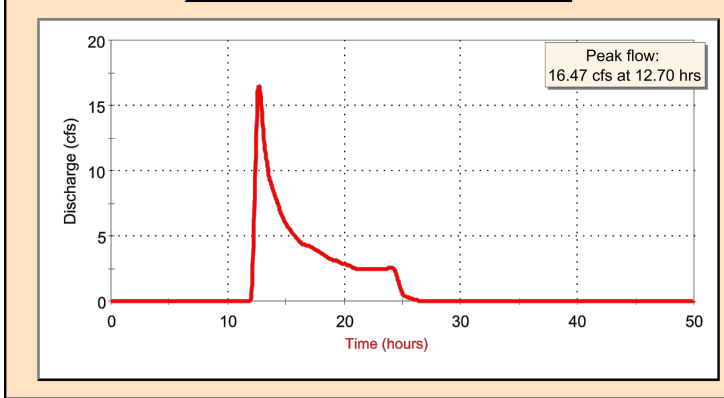

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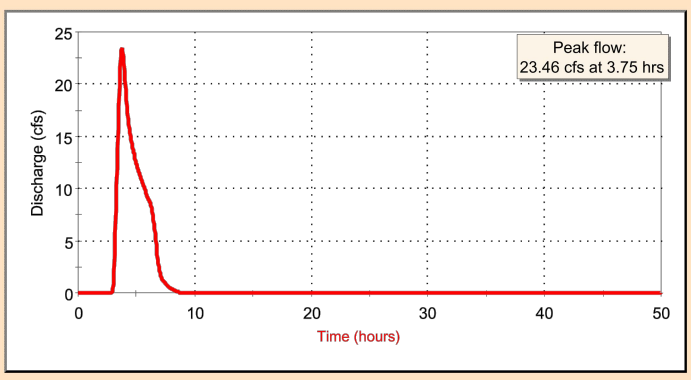

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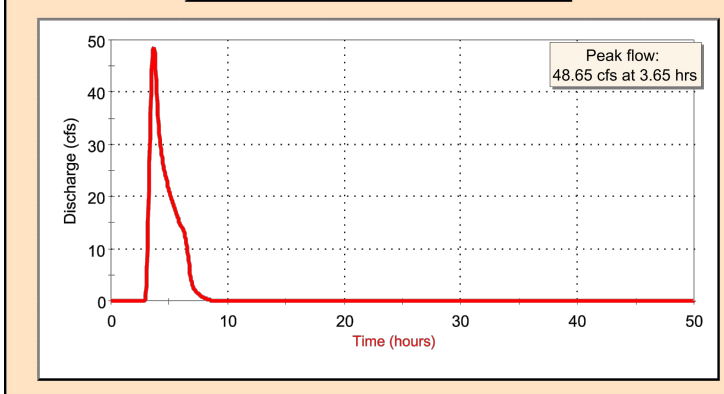

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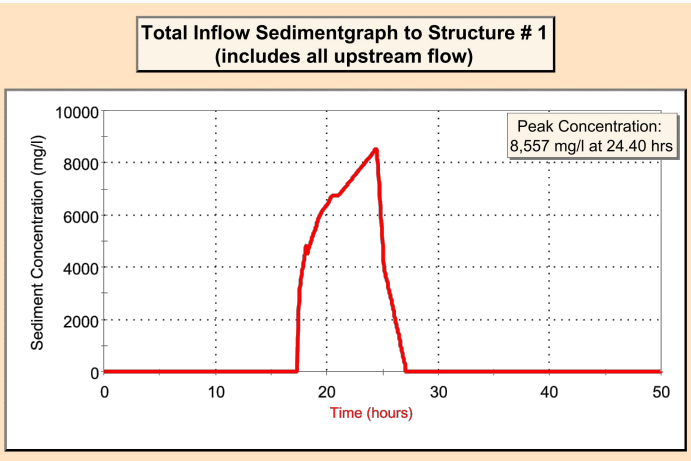

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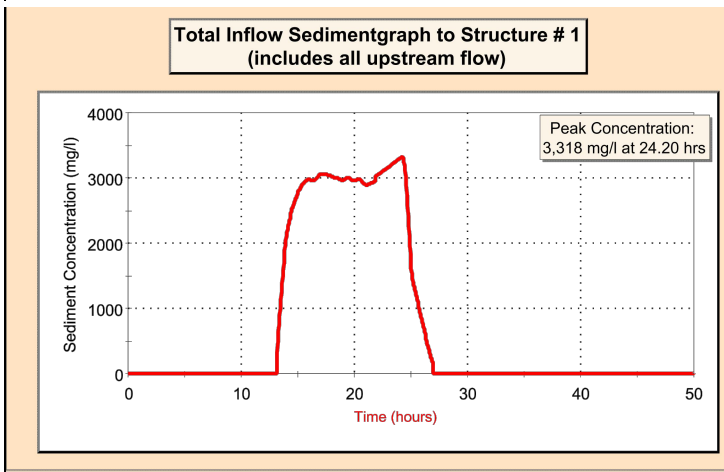

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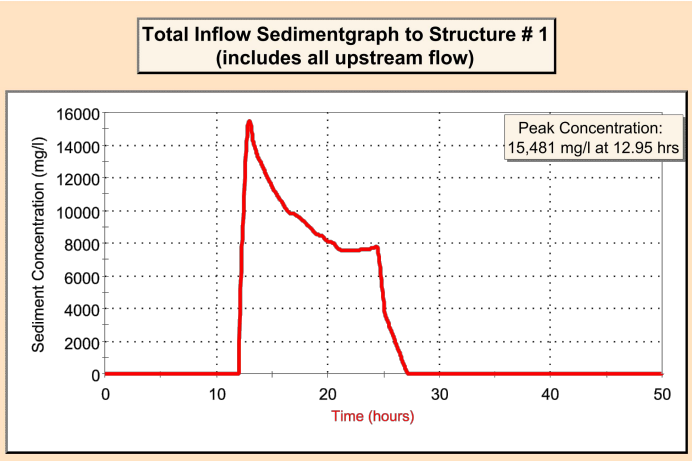

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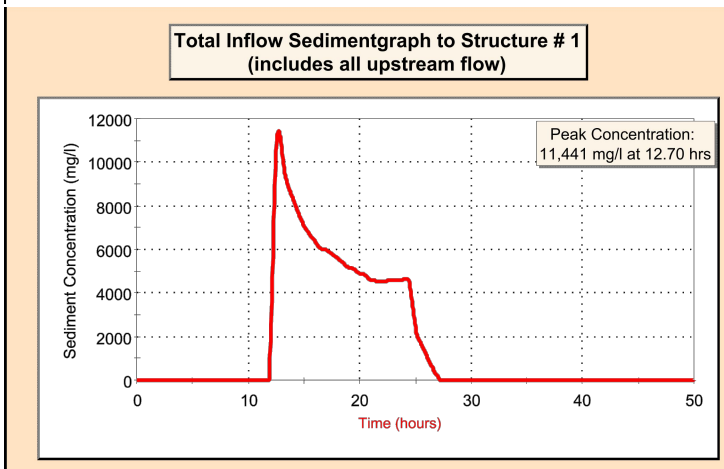

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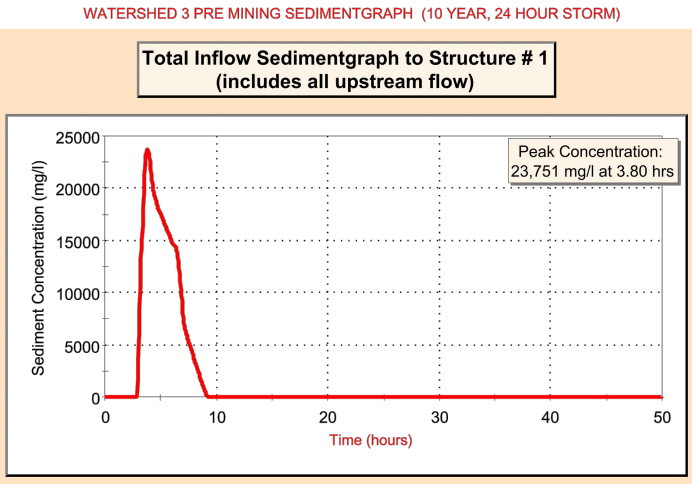

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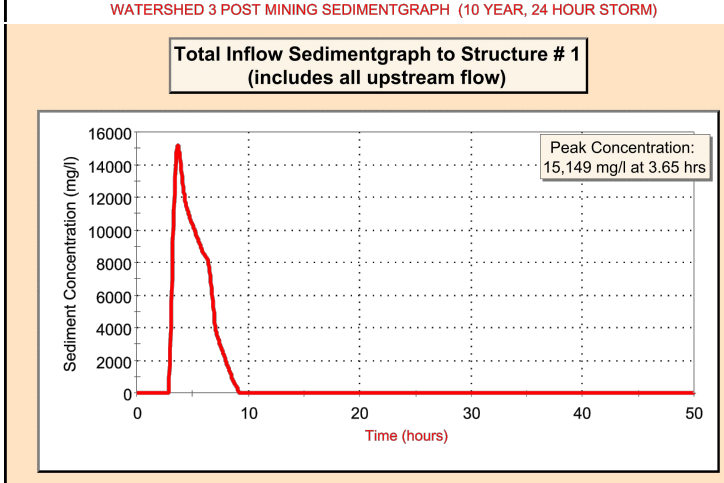

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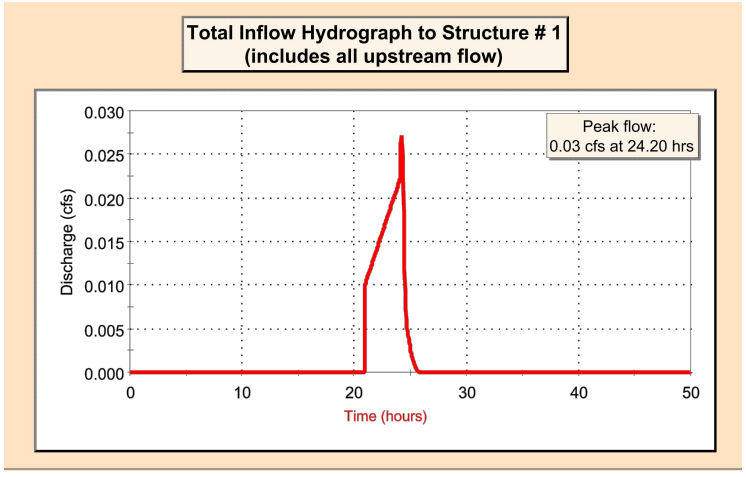

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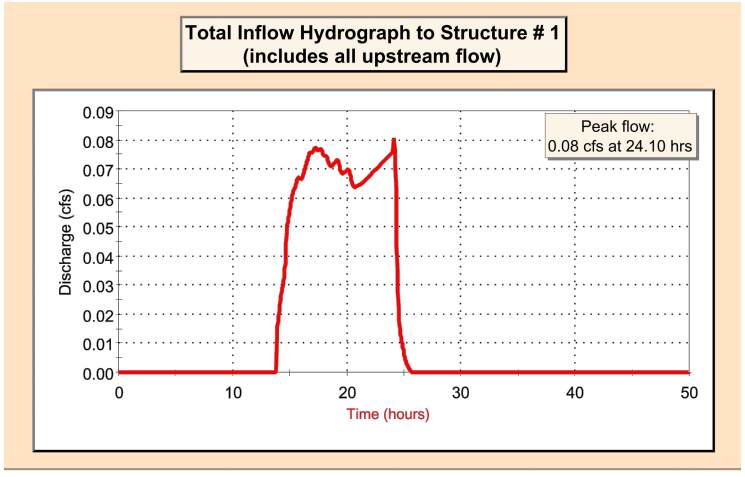

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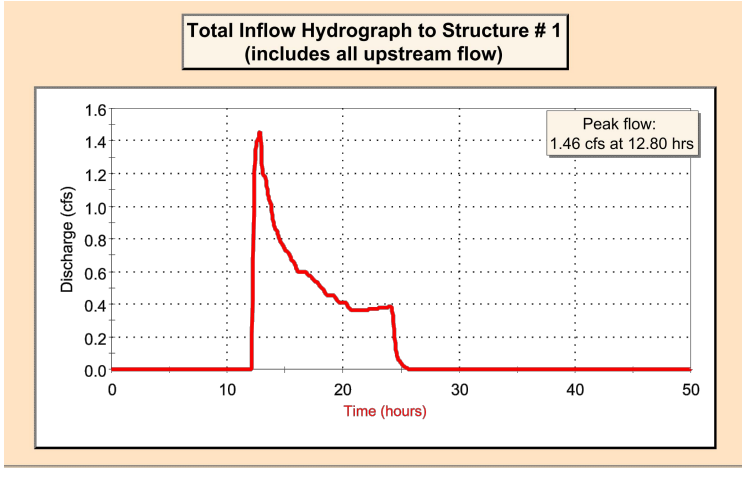

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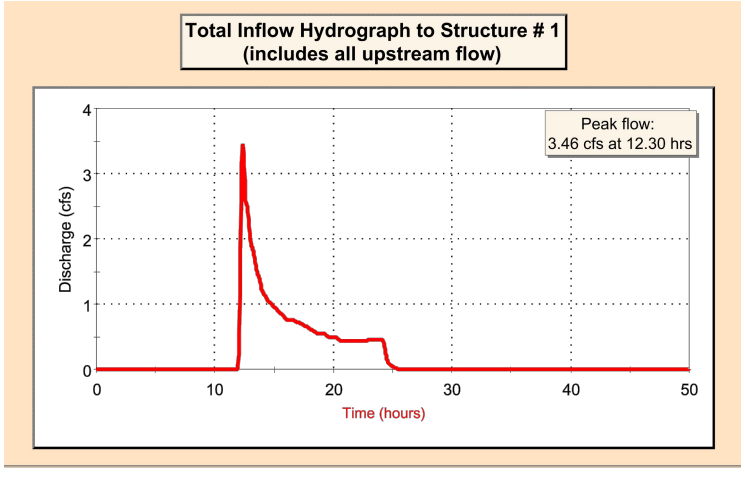

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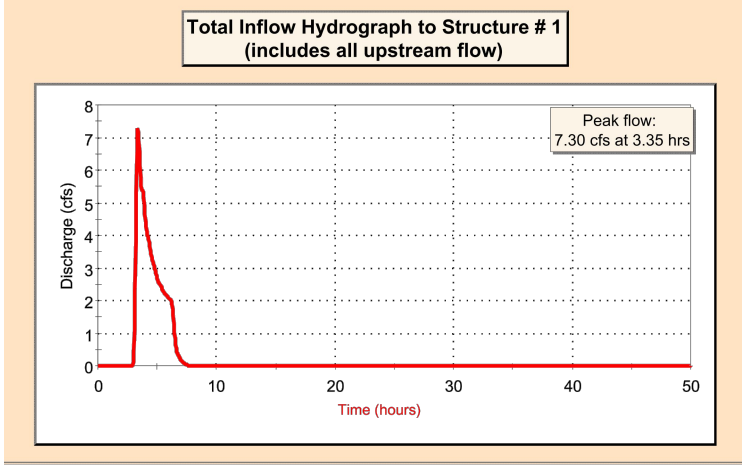

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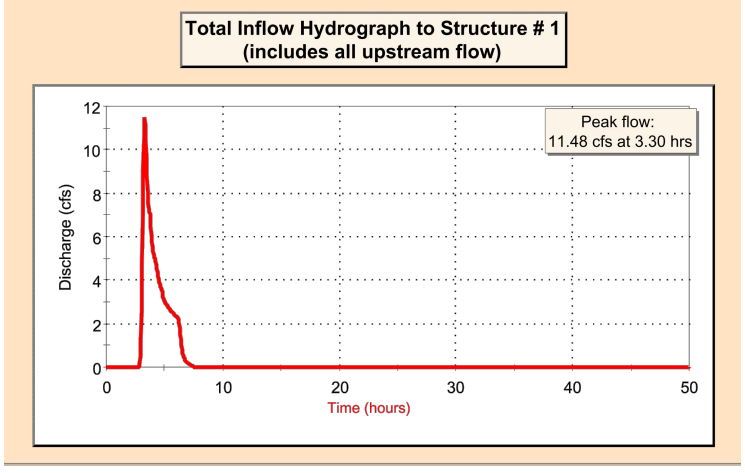

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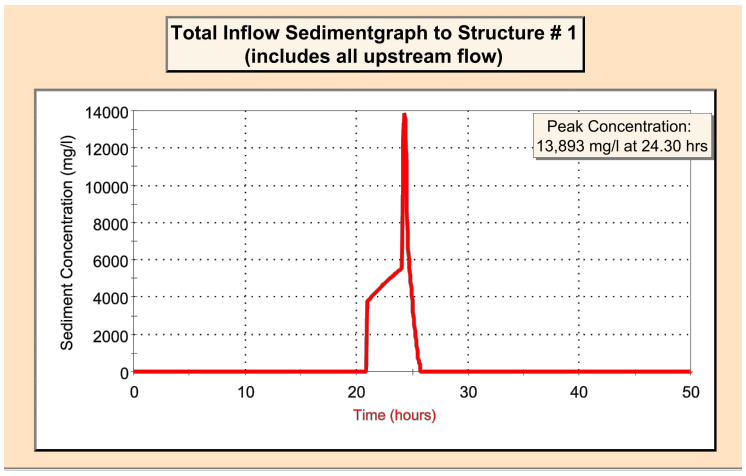

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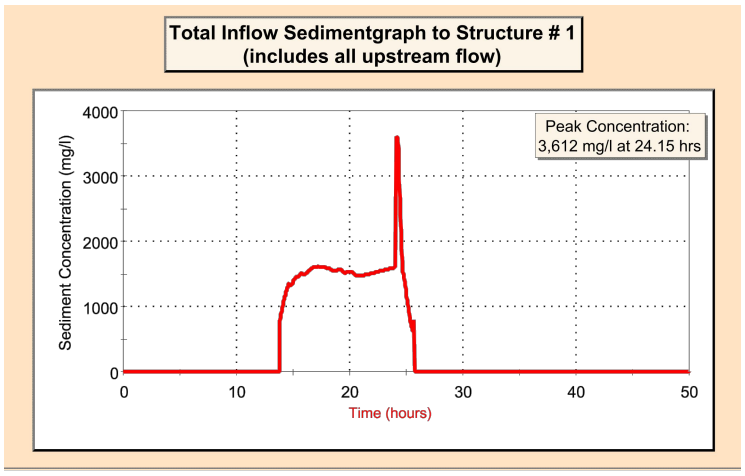

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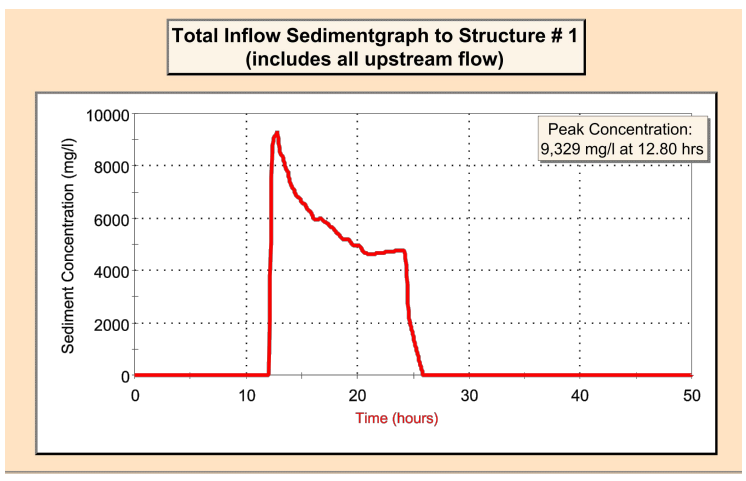

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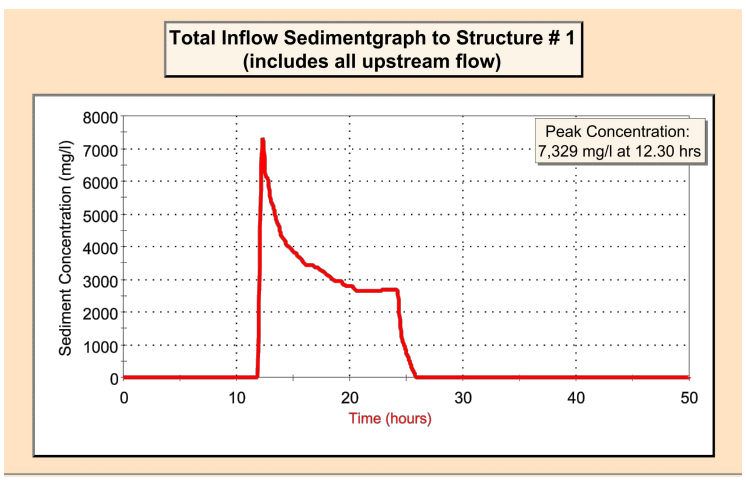

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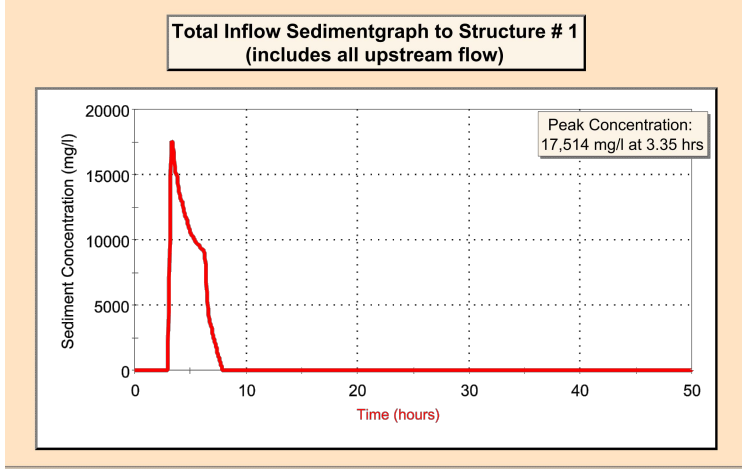

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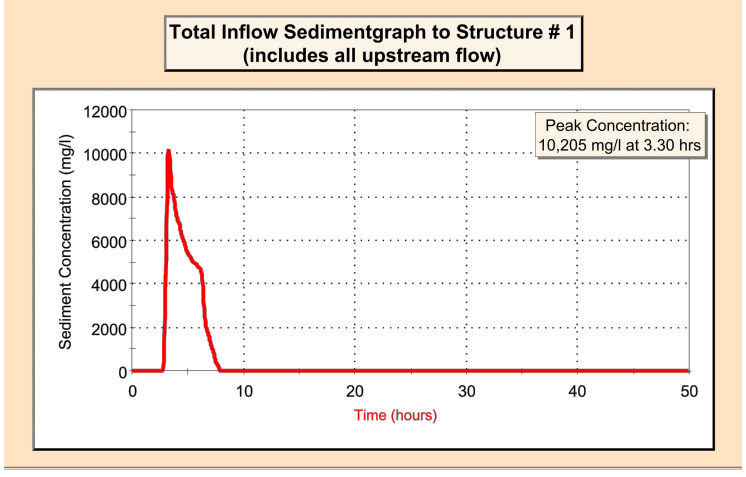

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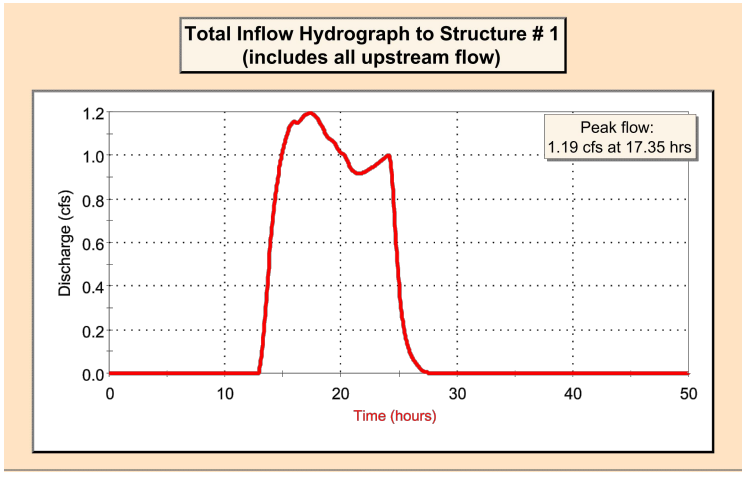

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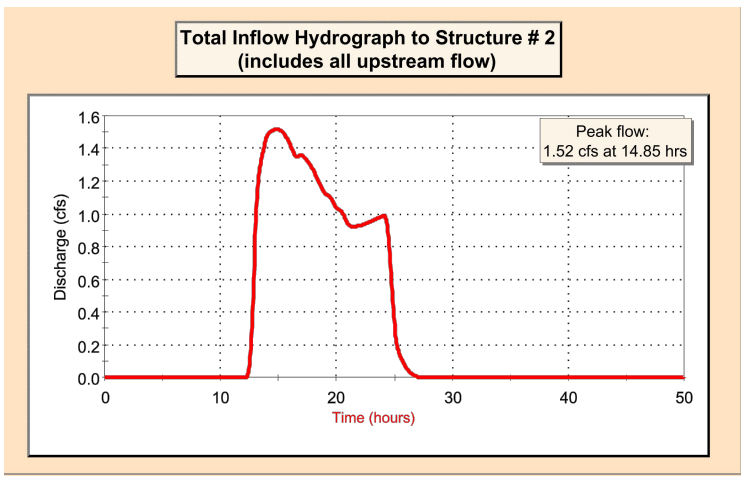

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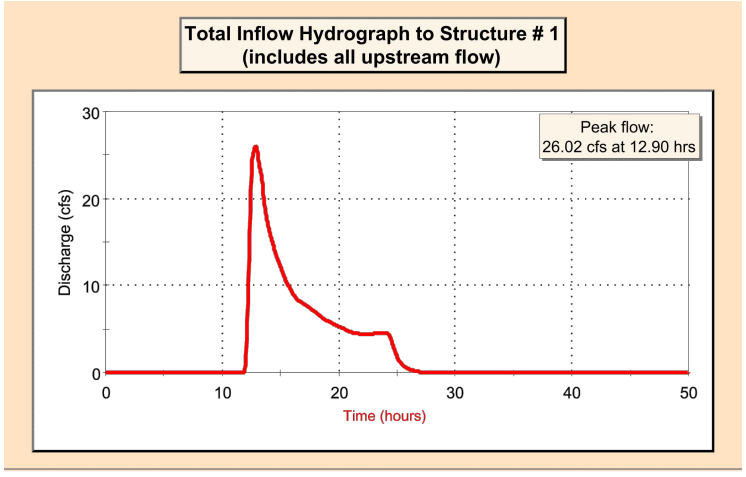

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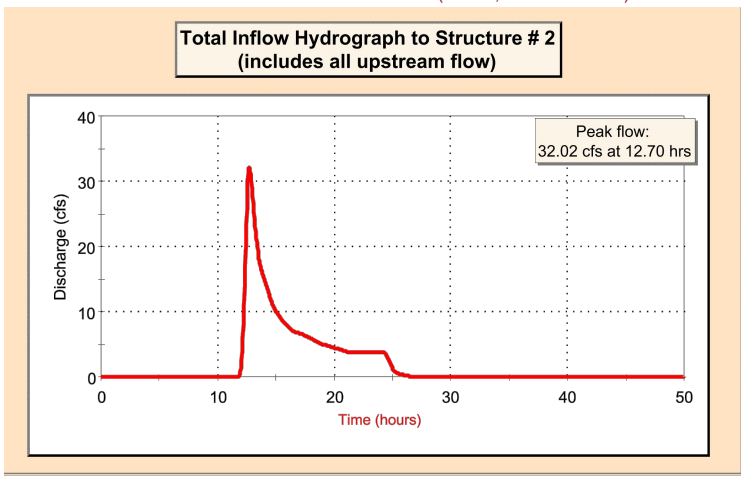

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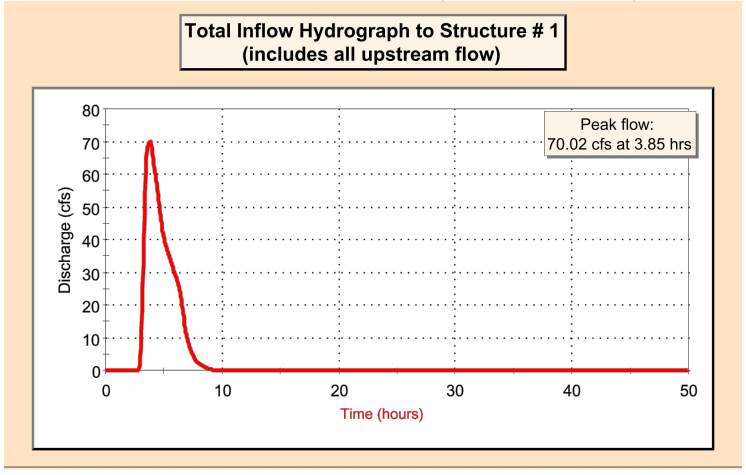

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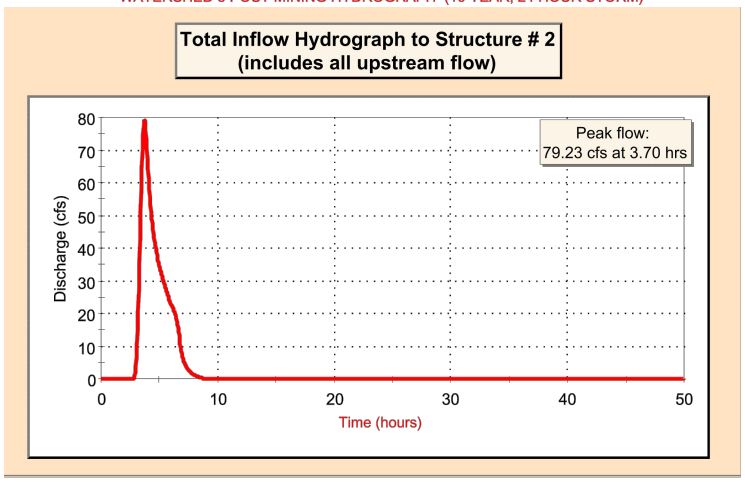

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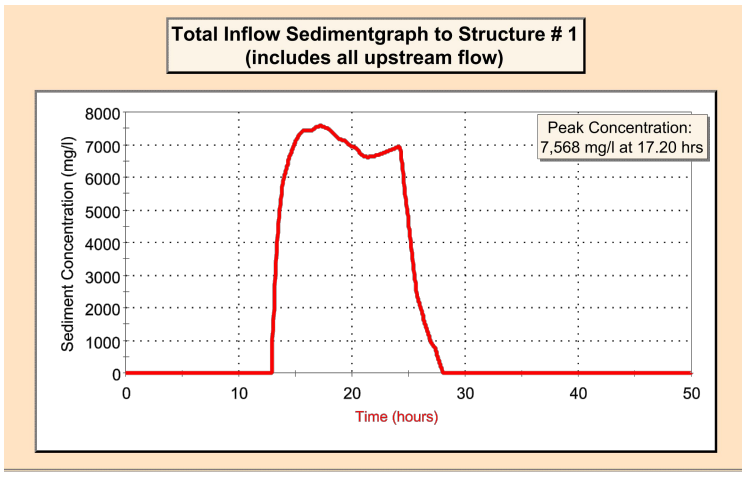

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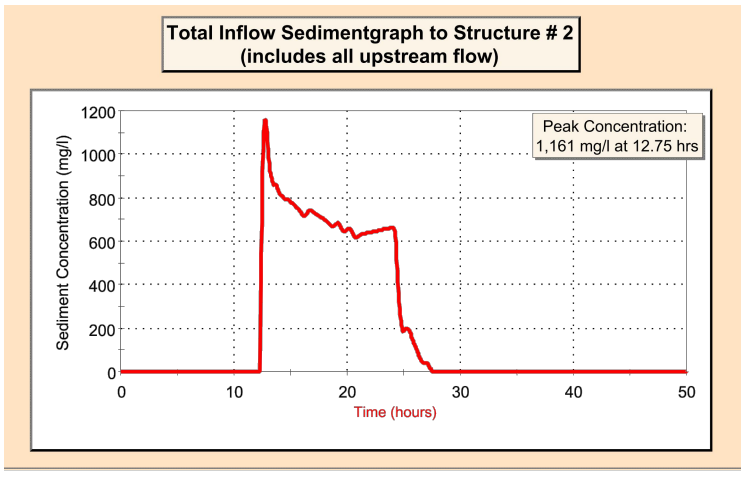

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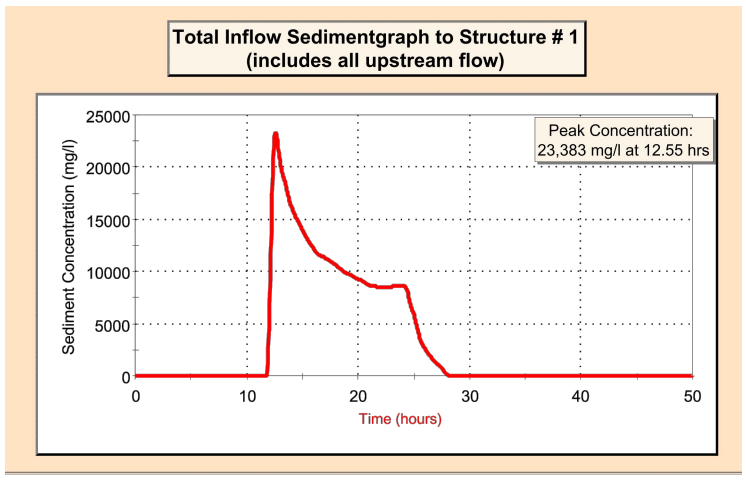

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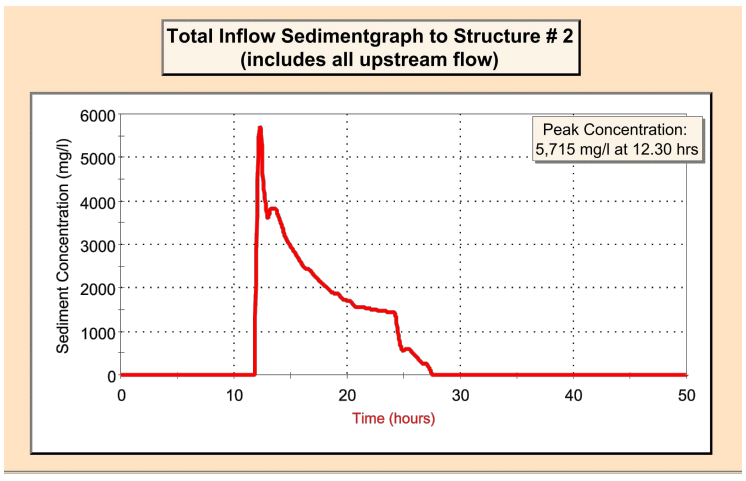

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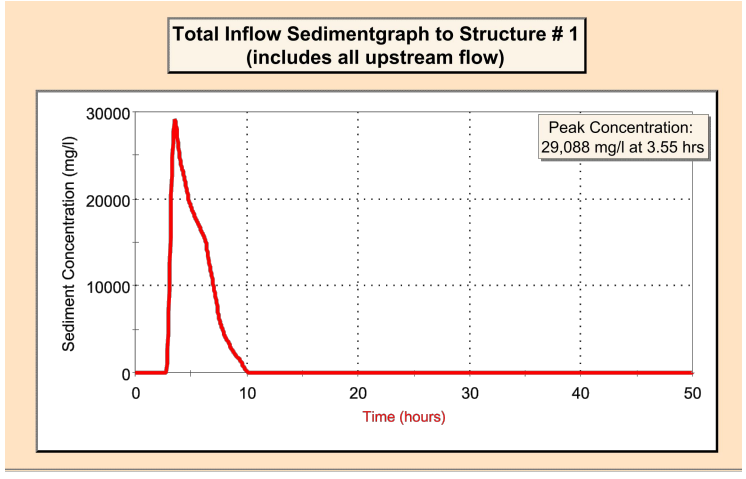

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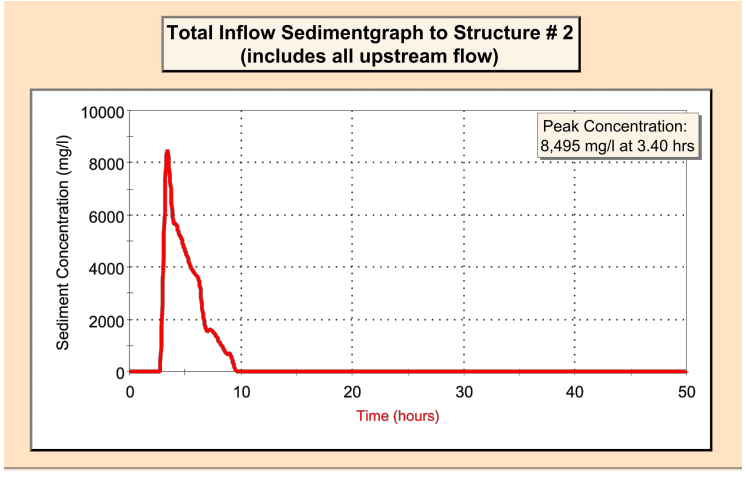

WATERSHED 5 POST MINING SEDIMENTGRAPH (100 YEAR, 6 HOUR STORM)

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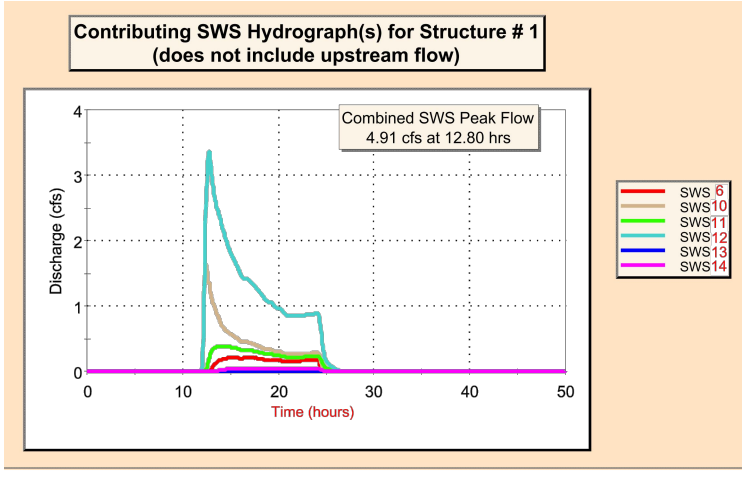
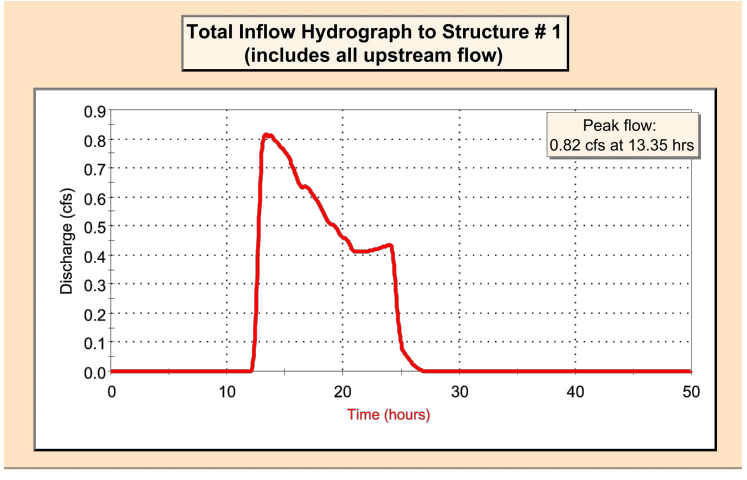
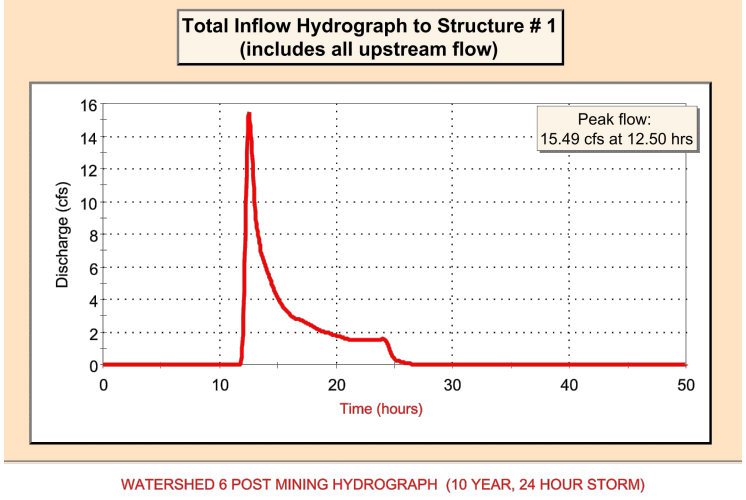


WATERSHEDS 6, 10, 11, 12, 13, AND 14 PRE MINING HYDROGRAPH (2 YEAR,



WATERSHED 6 POST MINING HYDROGRAPH (2 YEAR, 24 HOUR STORM)



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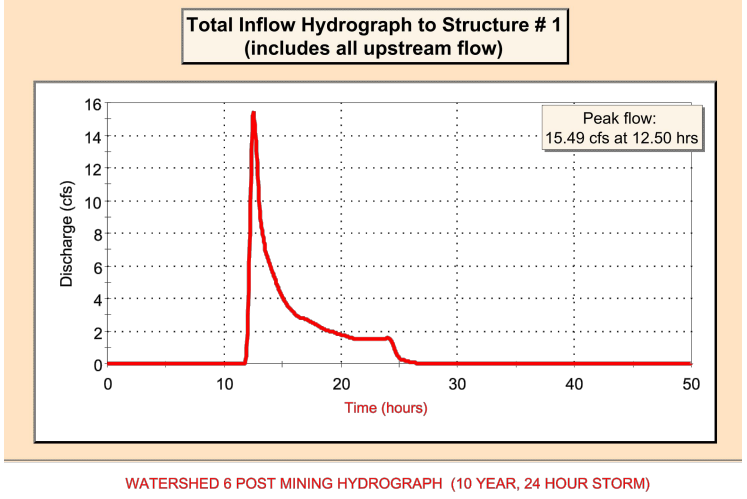

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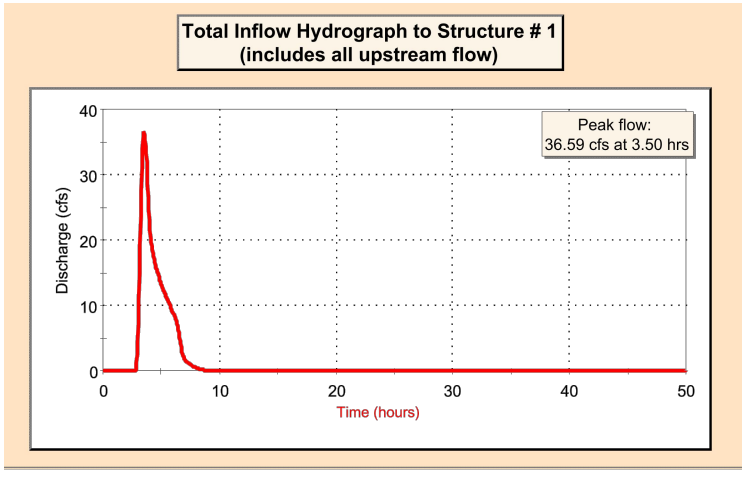

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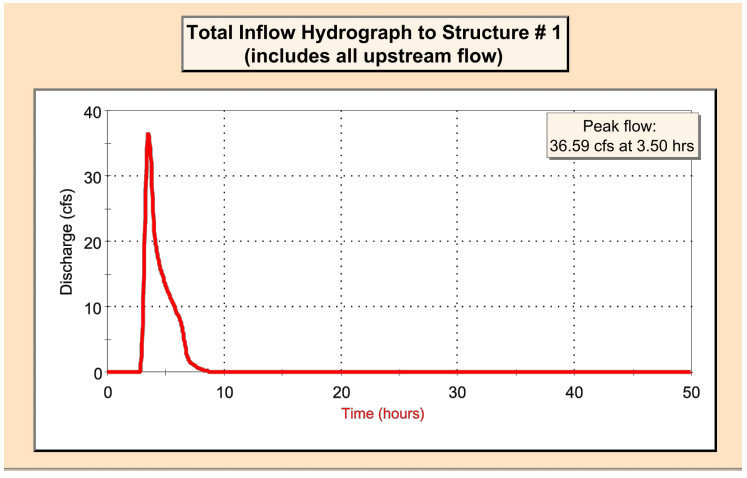

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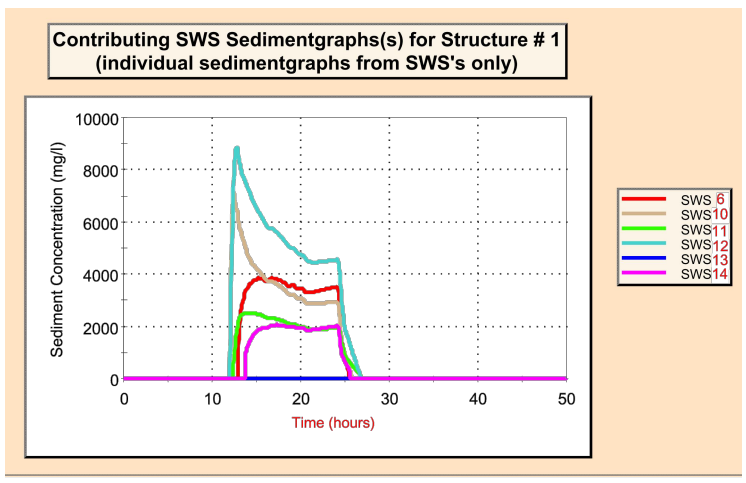

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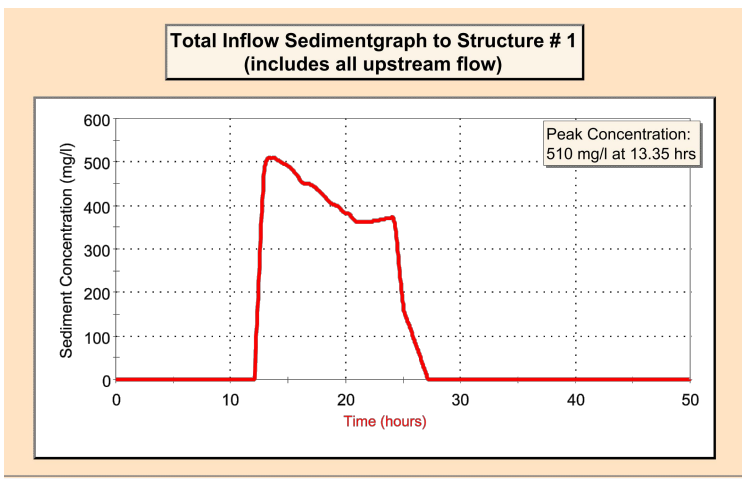
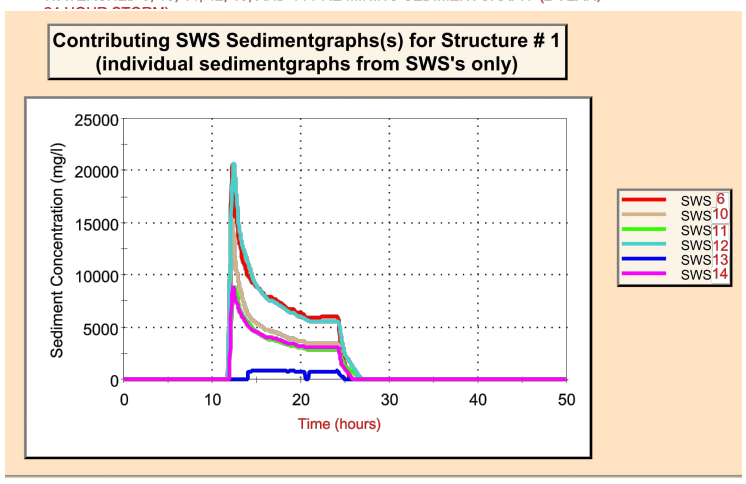


WATERSHED 6 POST MINING SEDIMENTGRAPH (2 YEAR, 24 HOUR STORM)



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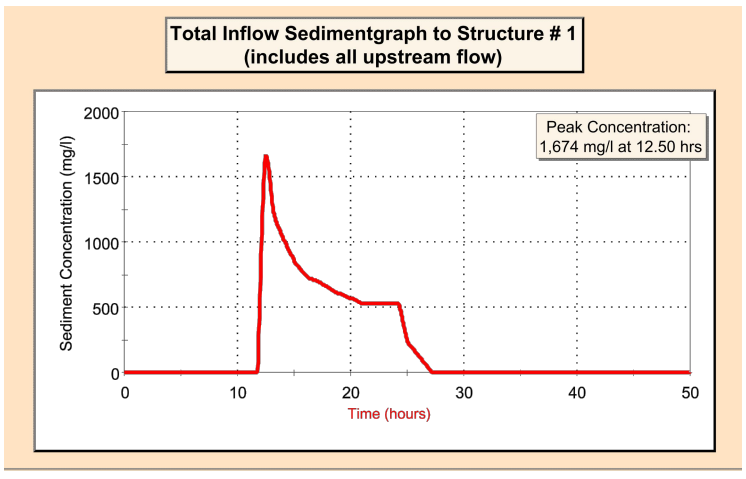

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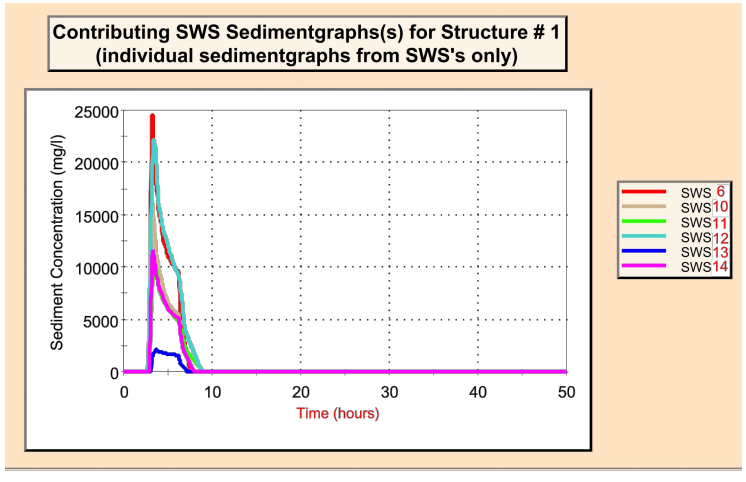
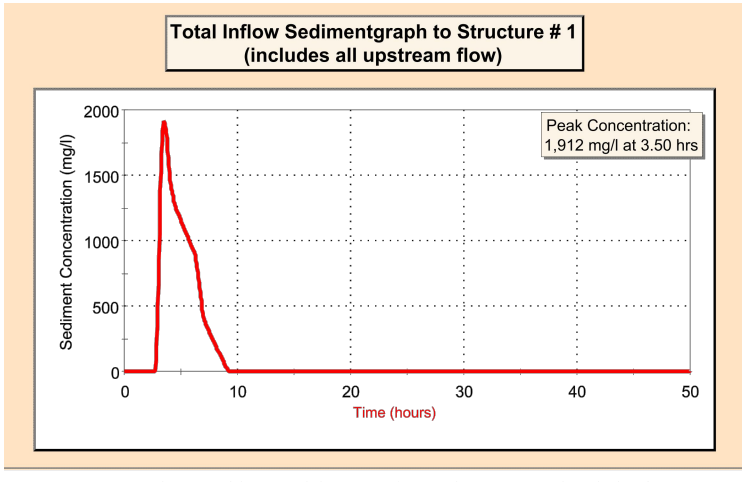


WATERSHED 6, 10, 11, 12, 13, AND 14 PRE MINING SEDIMENTGRAPH (100



WATERSHED 6 POST MINING SEDIMENTGRAPH (100 YEAR, 6 HOUR STORM)

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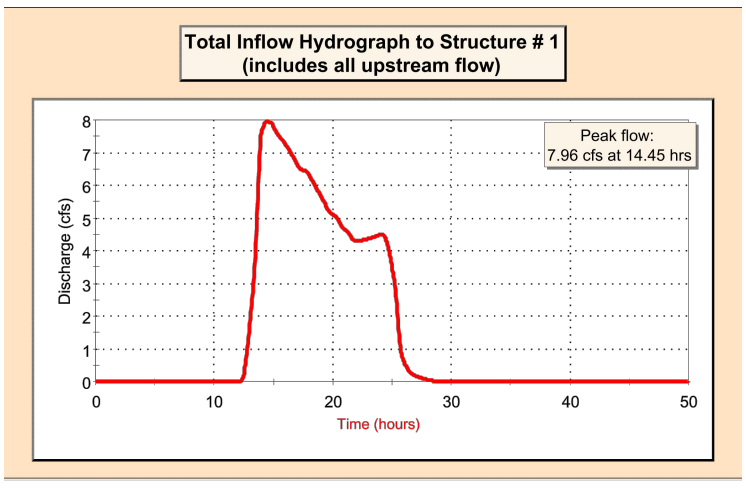
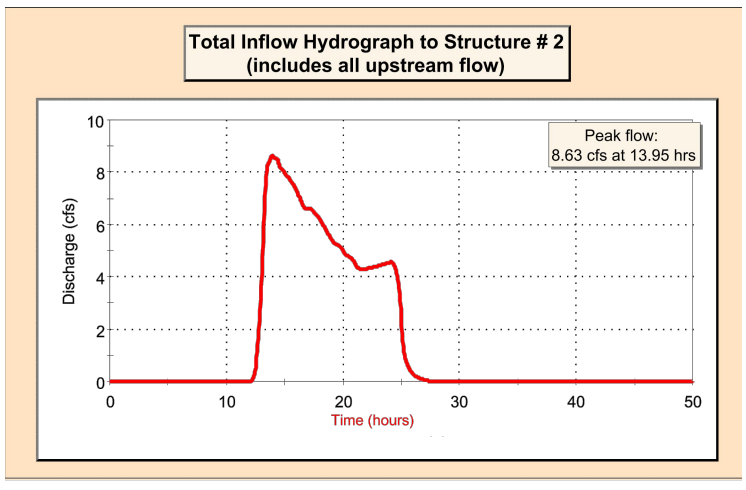


WATERSHED 7 PRE MINING HYDROGRAPH (2 YEAR, 24 HOUR STORM)



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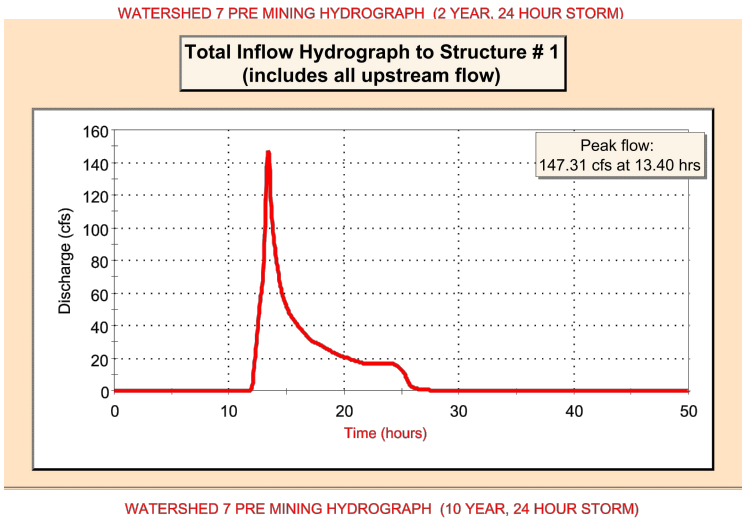

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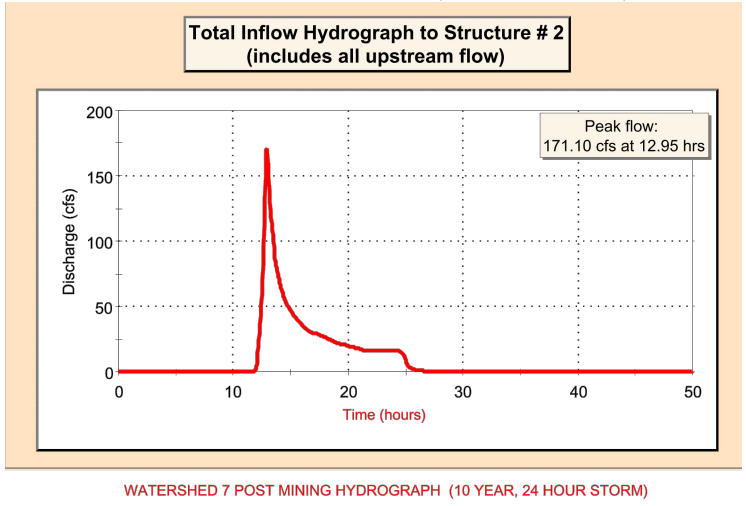

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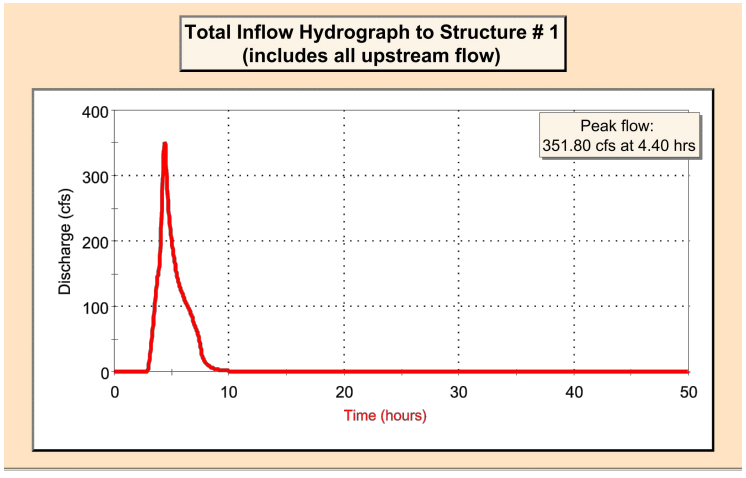

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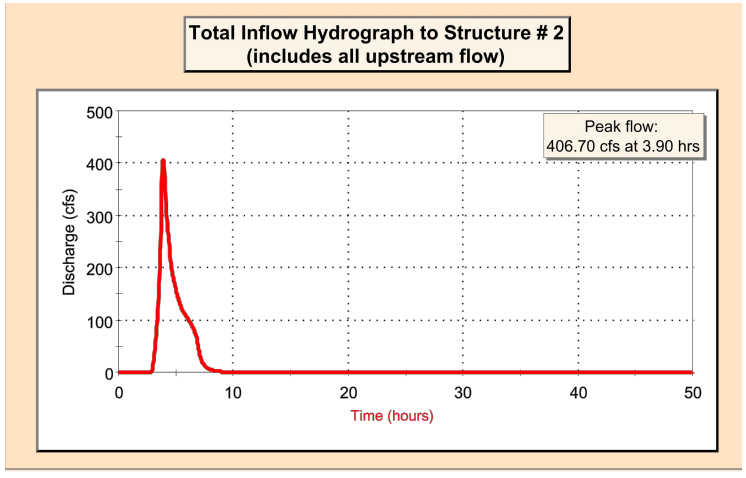

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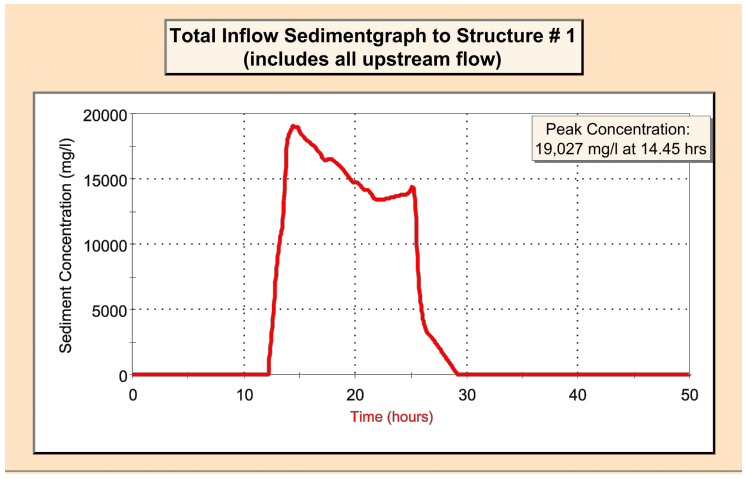

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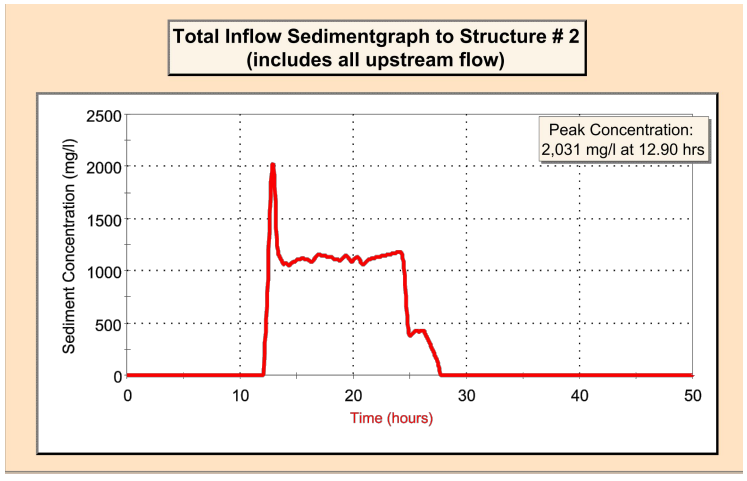

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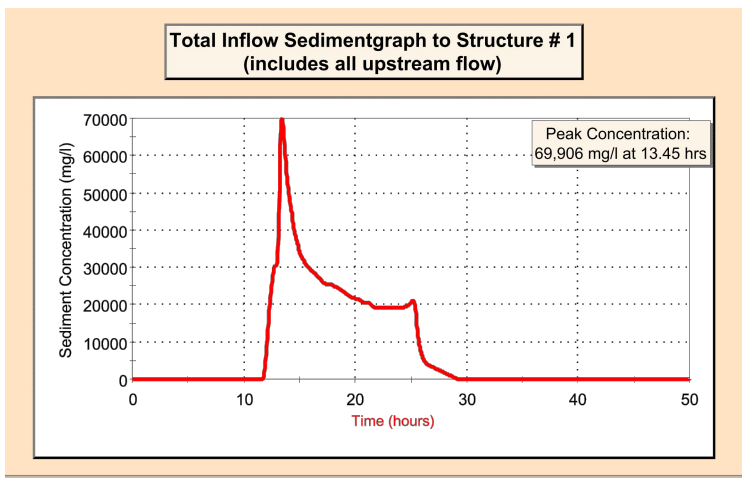

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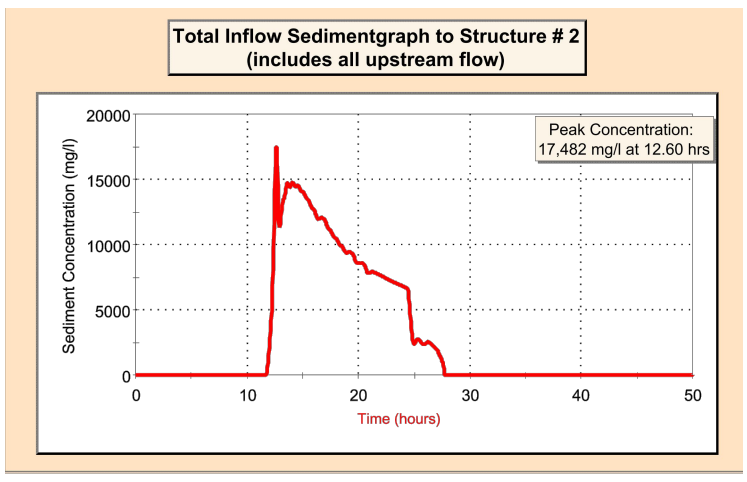

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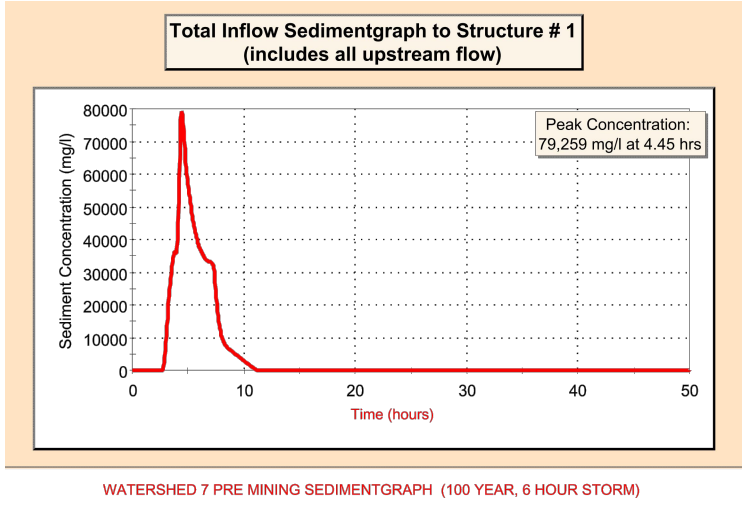

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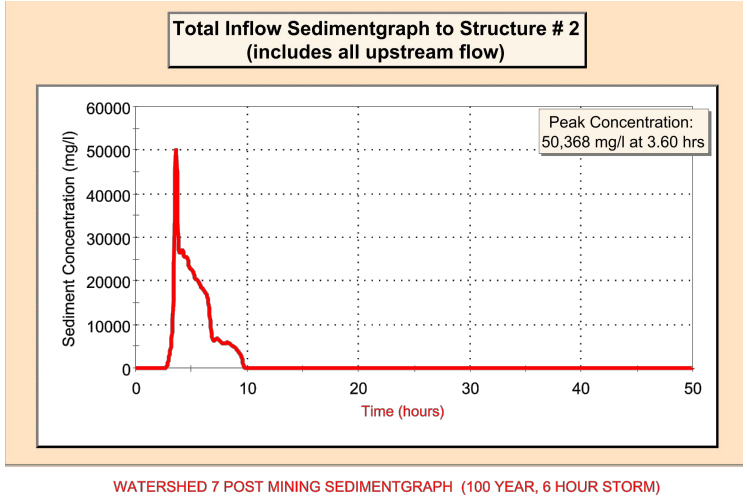

WATERSHED 7 POST MINING SEDIMENTGRAPH (100 YEAR, 6 HOUR STORM)

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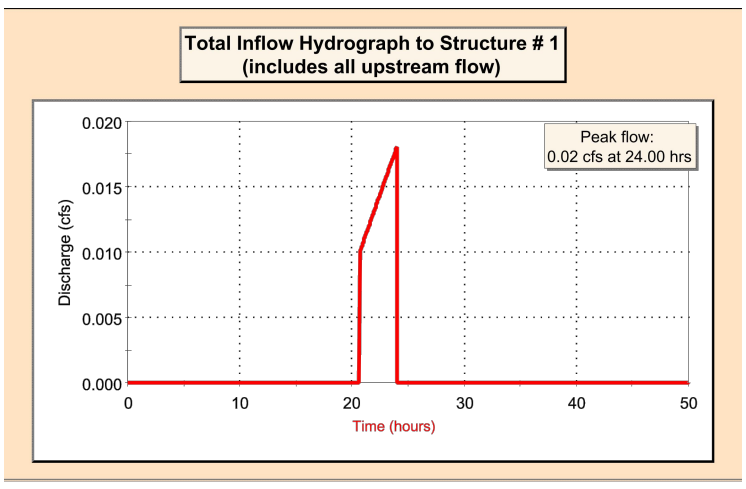

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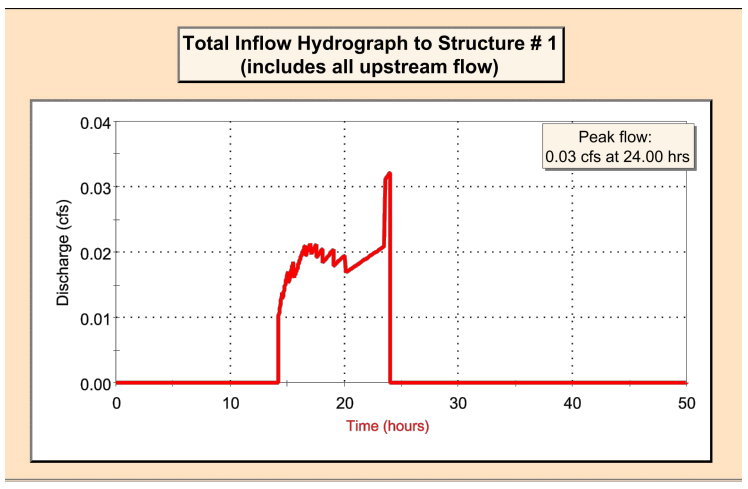

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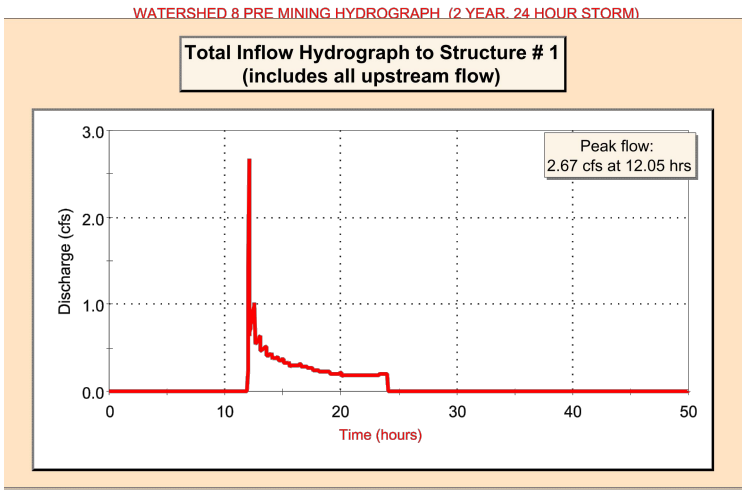

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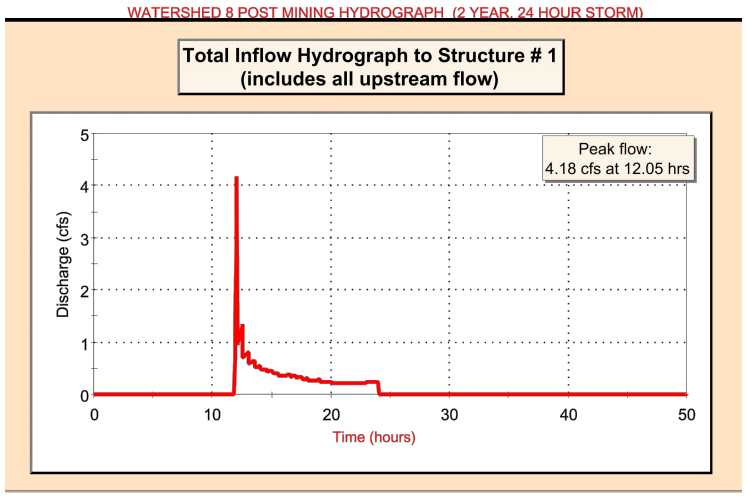

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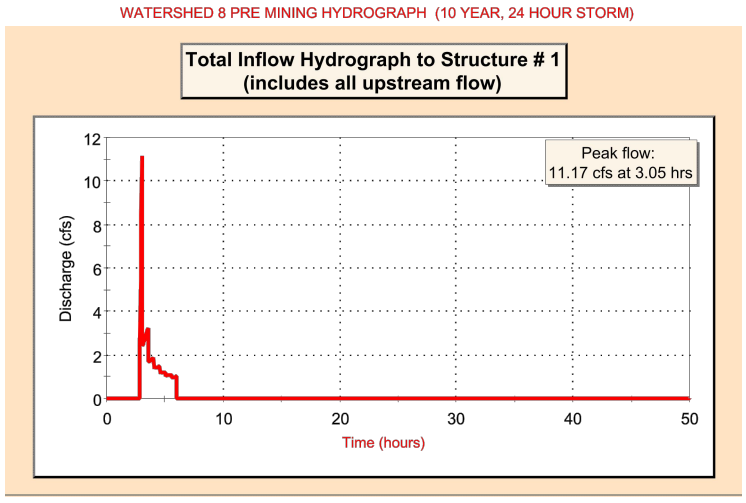

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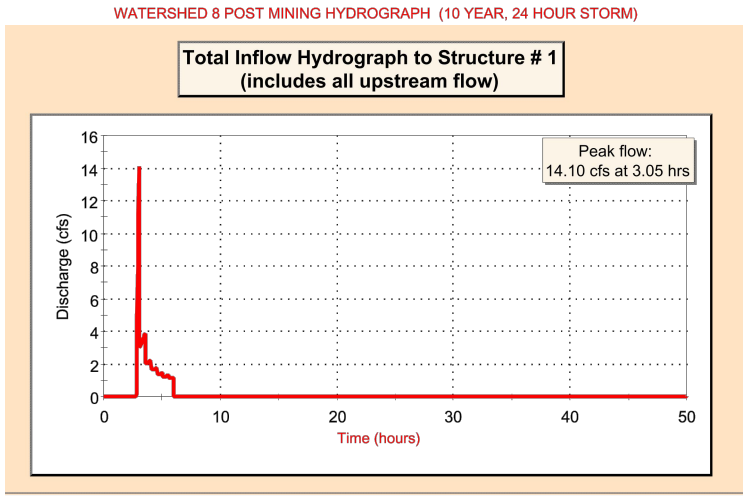

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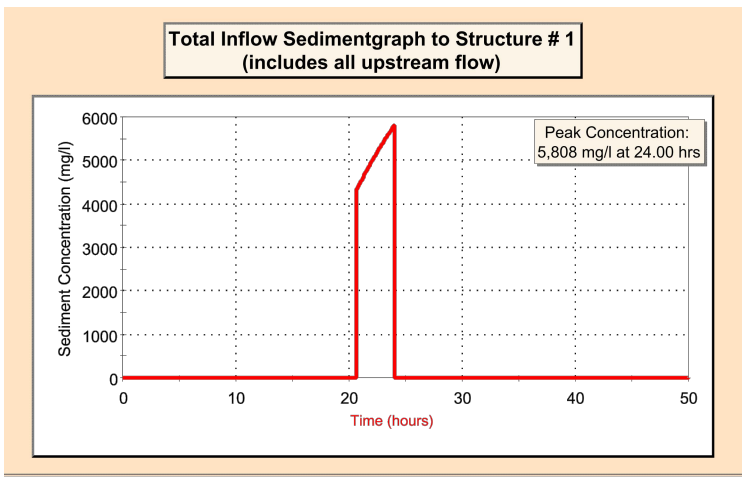

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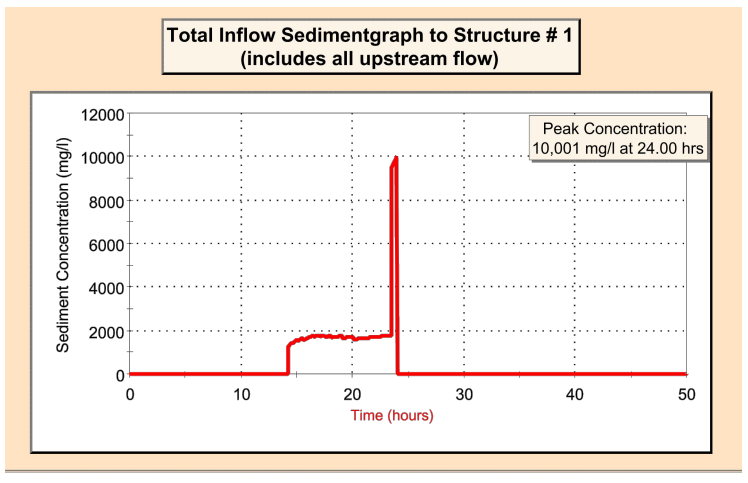

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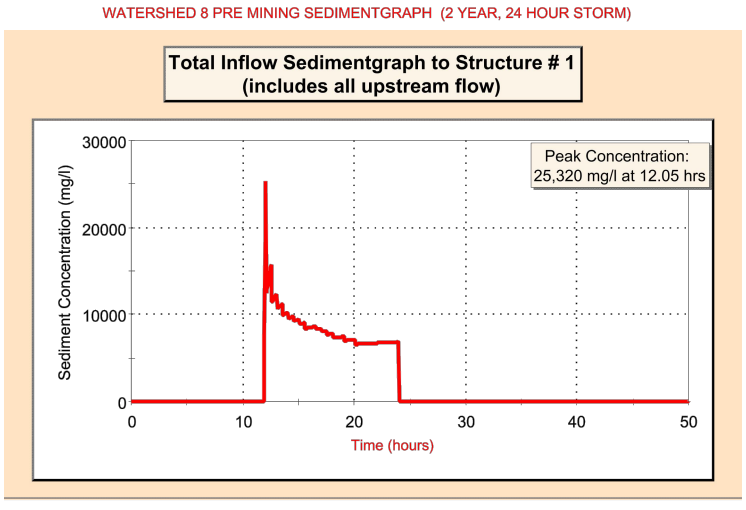

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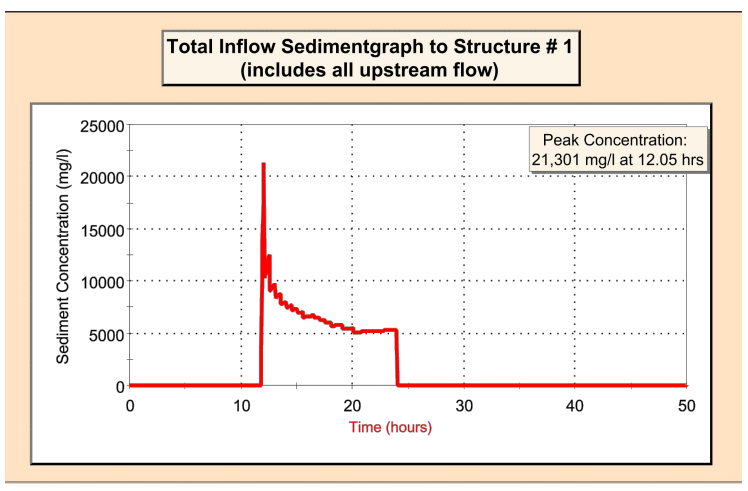

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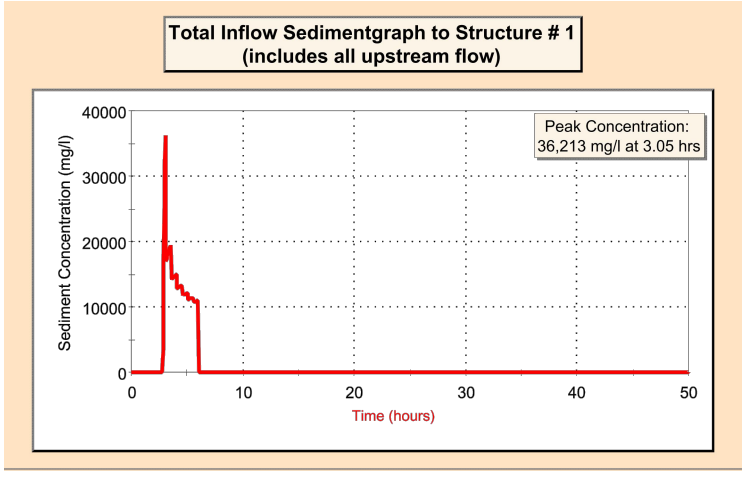

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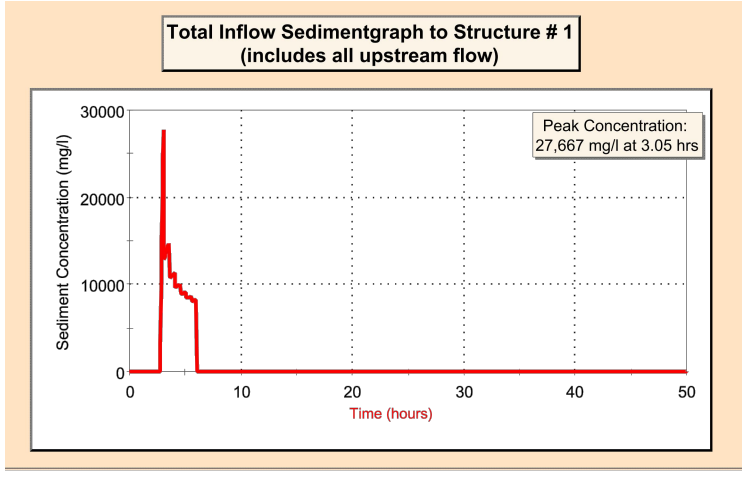

WATERSHED 8 POST MINING SEDIMENTGRAPH (100 YEAR, 6 HOUR STORM)

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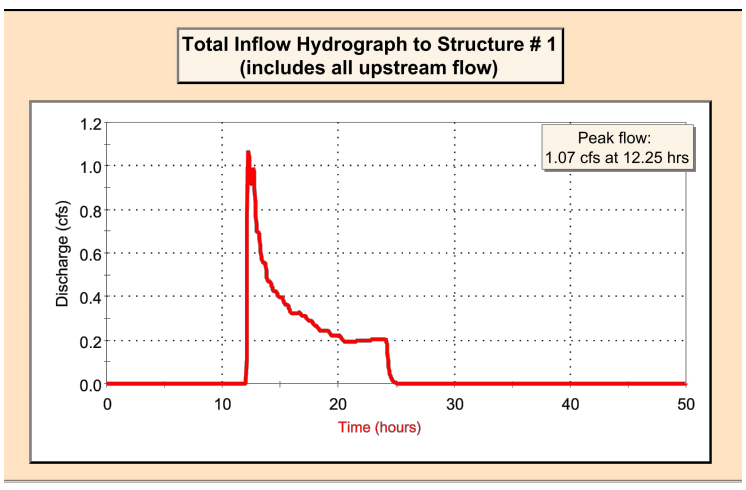

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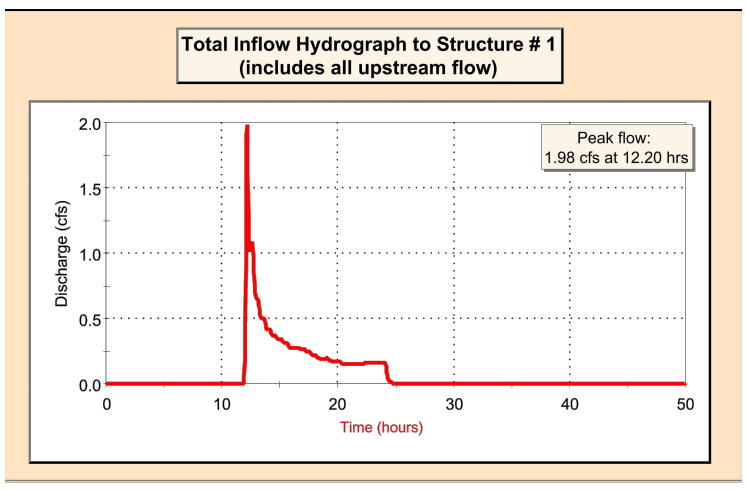

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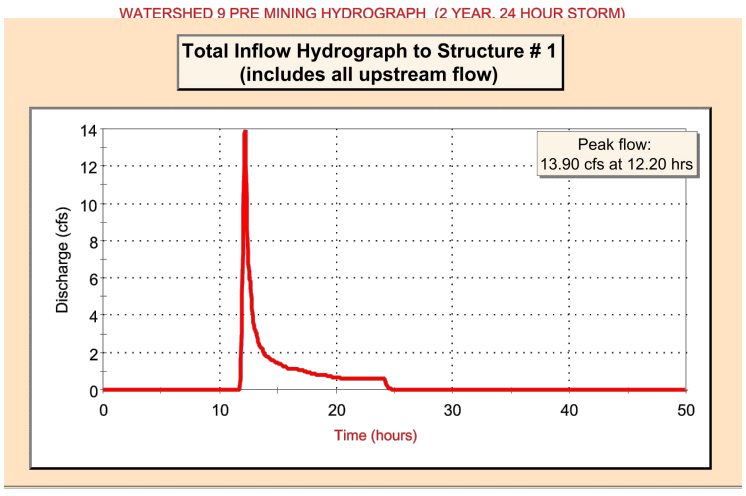

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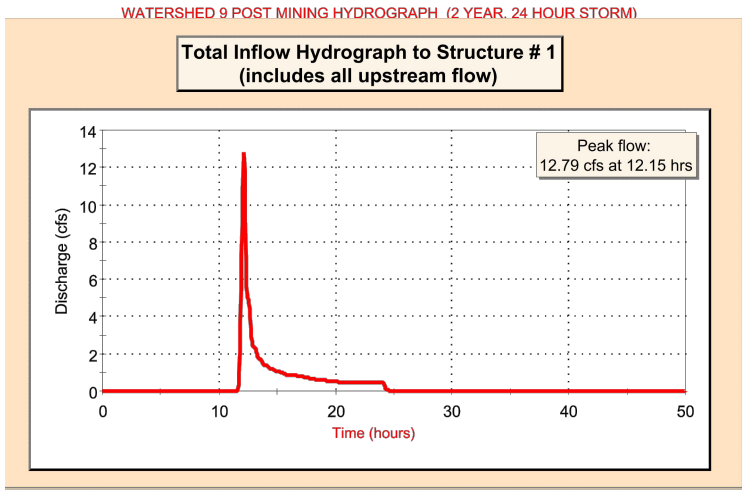

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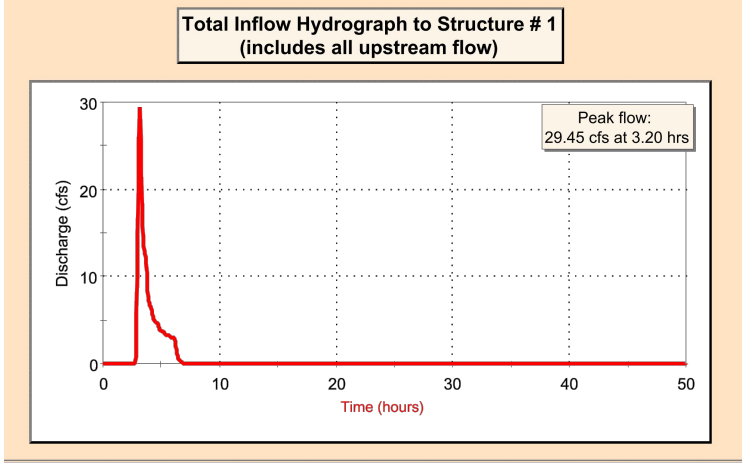
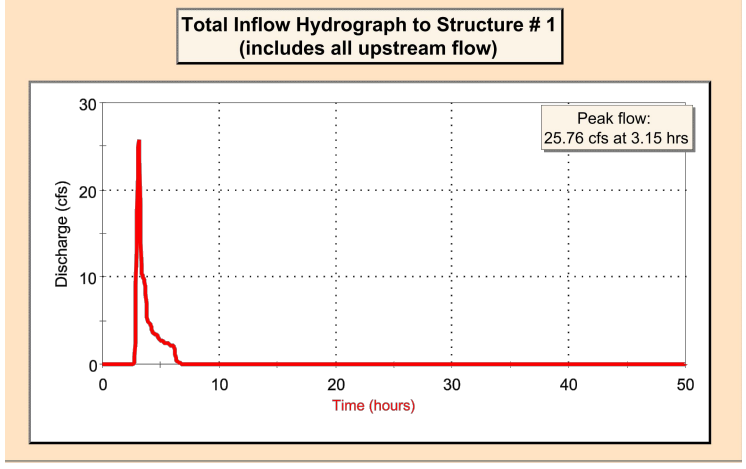


WATERSHED 9 PRE MINING HYDROGRAPH (100 YEAR, 6 HOUR STORM)



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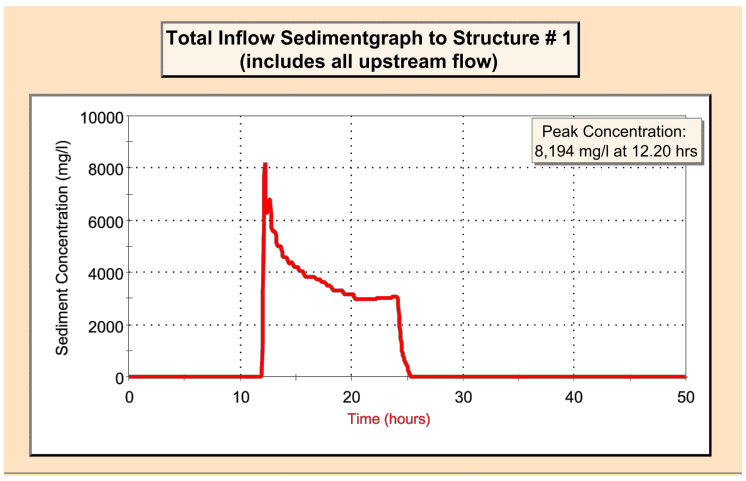
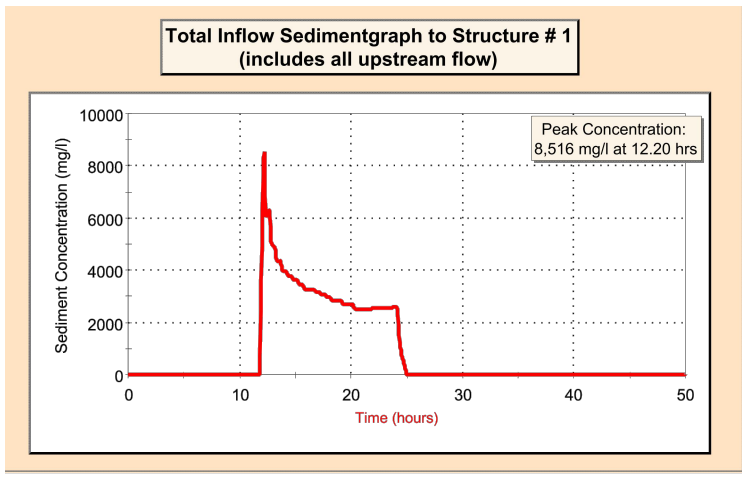


WATERSHED 9 PRE MINING SEDIMENTGRAPH (2 YEAR, 24 HOUR STORM)



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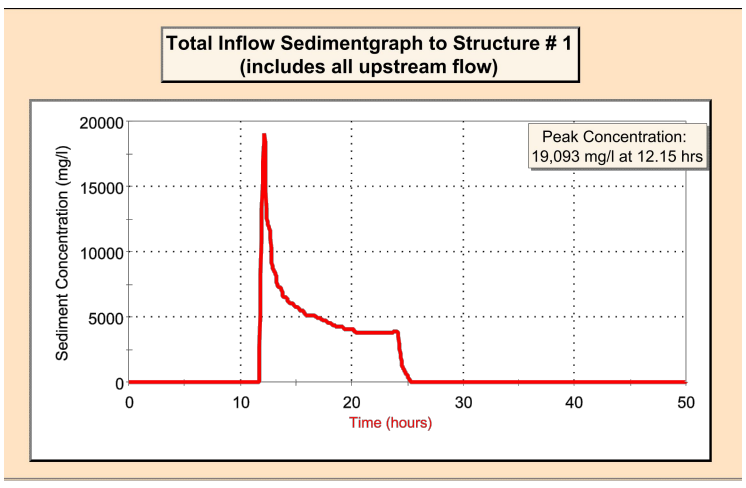

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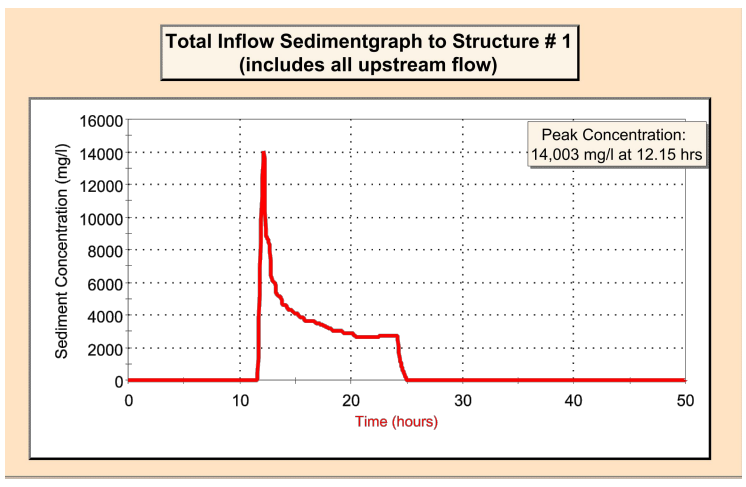

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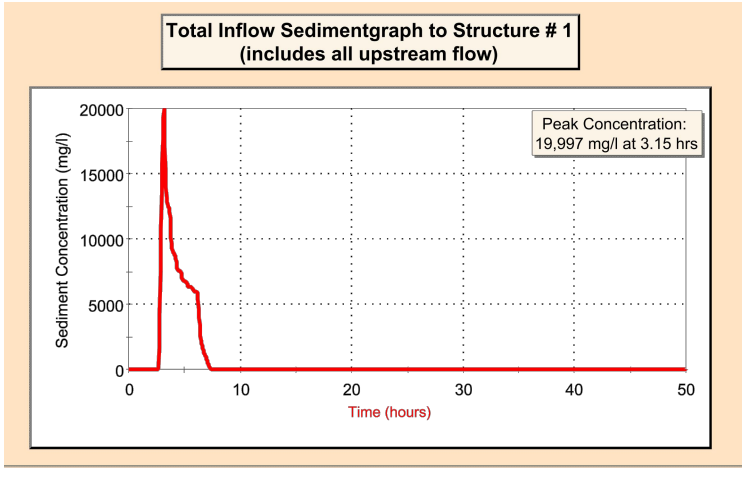

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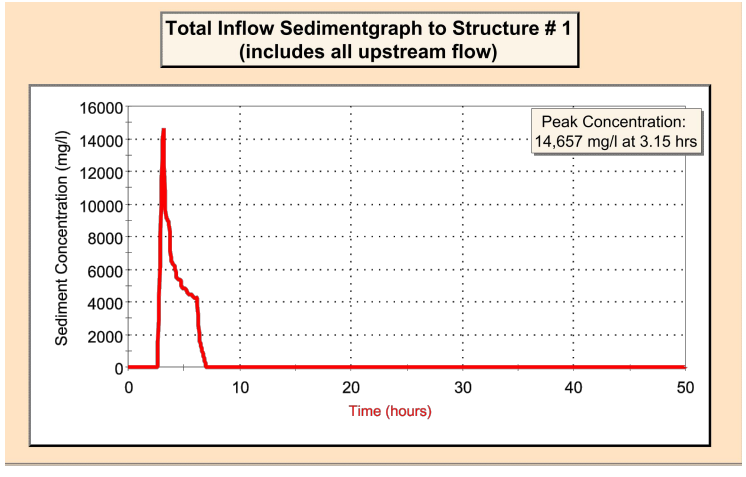

WATERSHED 9 POST MINING SEDIMENTGRAPH (100 YEAR, 6 HOUR STORM)

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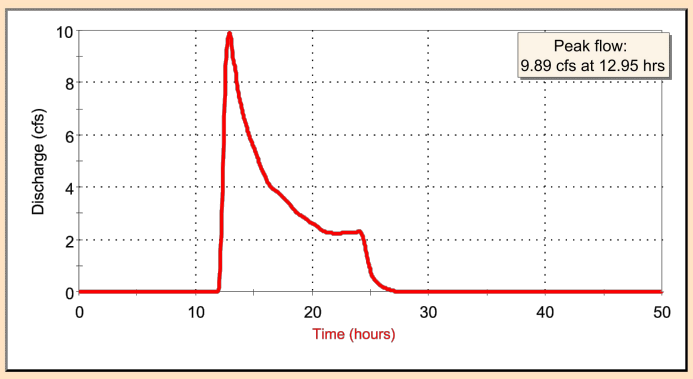
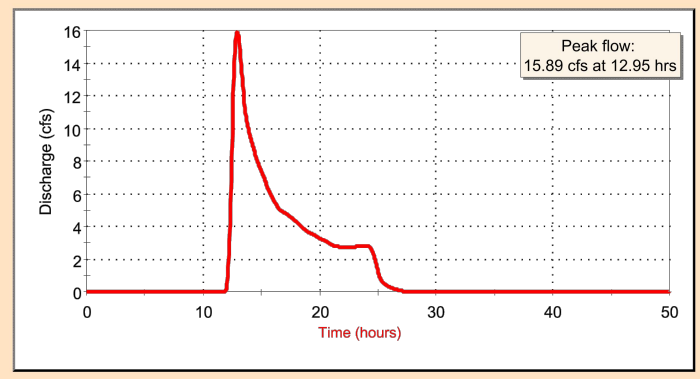
Total Inflow Hydrograph to Structure # 1 (includes all upstream flow)



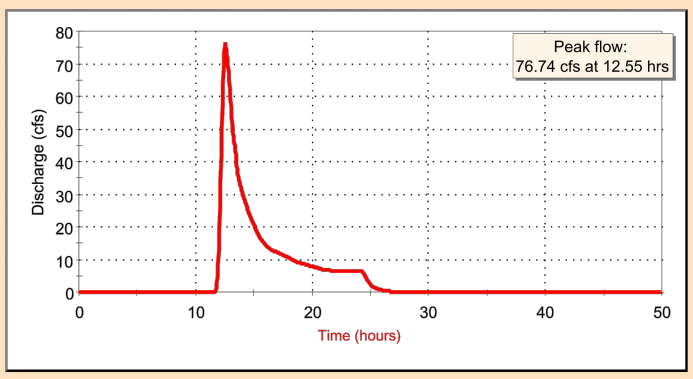
WATERSHED 15 PRE MINING HYDROGRAPH (2 YEAR, 24 HOUR STORM)

Total Inflow Hydrograph to Structure # 3 (includes all upstream flow)



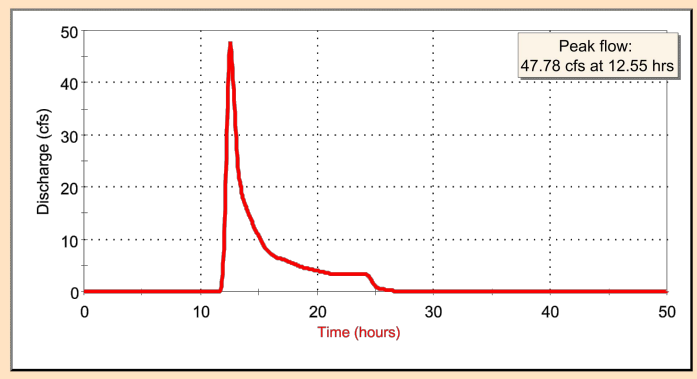
WATERSHED 15 POST MINING HYDROGRAPH (2 YEAR, 24 HOUR STORM)

Total Inflow Hydrograph to Structure # 1 (includes all upstream flow)



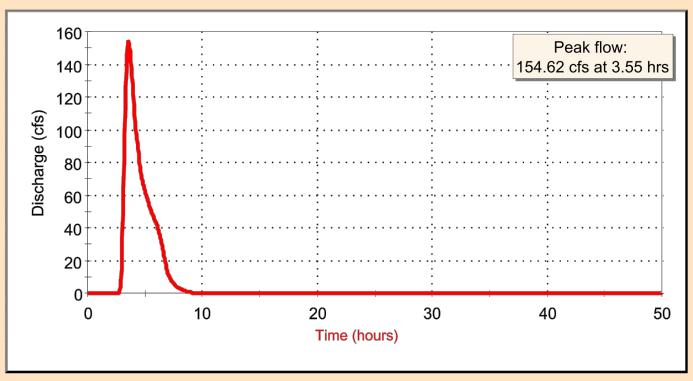
WATERSHED 15 PRE MINING HYDROGRAPH (10 YEAR, 24 HOUR STORM)

Total Inflow Hydrograph to Structure # 3 (includes all upstream flow)



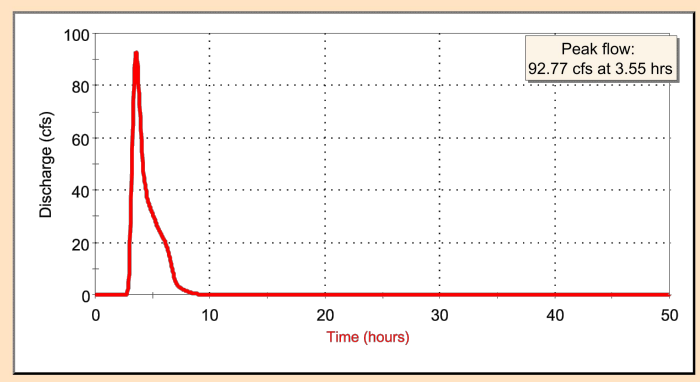
WATERSHED 15 POST MINING HYDROGRAPH (10 YEAR, 24 HOUR STORM)

Total Inflow Hydrograph to Structure # 1 (includes all upstream flow)



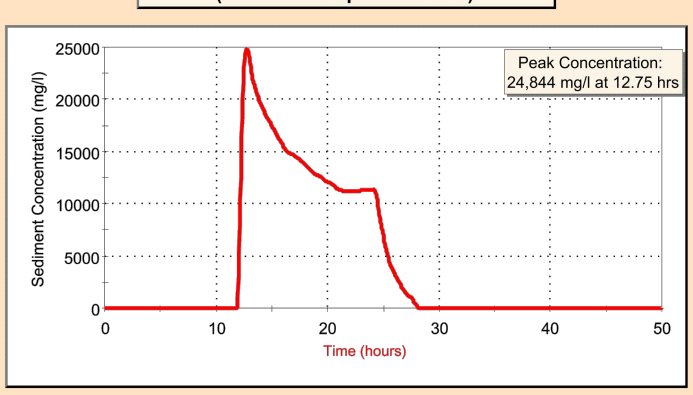
WATERSHED 15 PRE MINING HYDROGRAPH (100 YEAR, 6 HOUR STORM)

Total Inflow Hydrograph to Structure # 3 (includes all upstream flow)



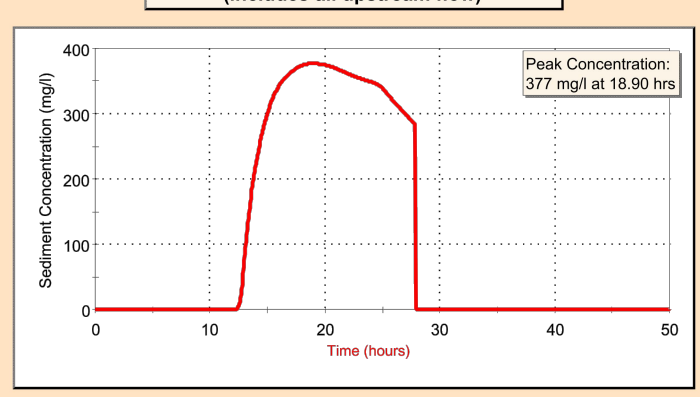
WATERSHED 15 POST MINING HYDROGRAPH (100 YEAR, 6 HOUR STORM)

Total Inflow Sedimentgraph to Structure # 1 (includes all upstream flow)



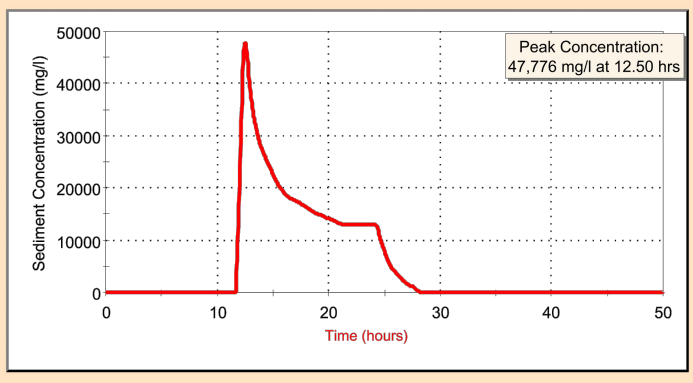
WATERSHED 15 PRE MINING SEDIMENTGRAPH (2 YEAR, 24 HOUR STORM)

Total Inflow Sedimentgraph to Structure # 3 (includes all upstream flow)



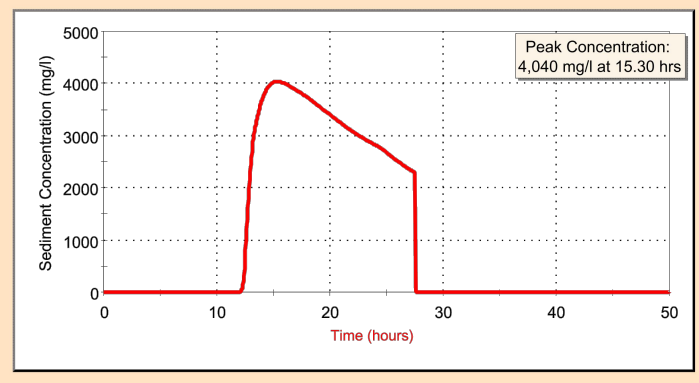
WATERSHED 15 POST MINING SEDIMENTGRAPH (2 YEAR, 24 HOUR STORM)

Total Inflow Sedimentgraph to Structure # 1 (includes all upstream flow)



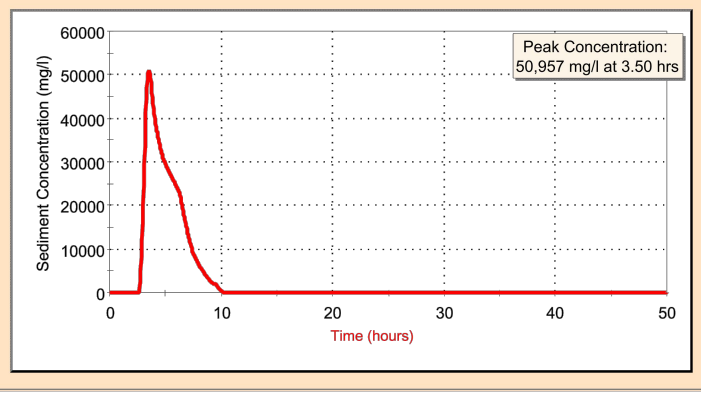
WATERSHED 15 PRE MINING SEDIMENTGRAPH (10 YEAR, 24 HOUR STORM)

Total Inflow Sedimentgraph to Structure # 3 (includes all upstream flow)



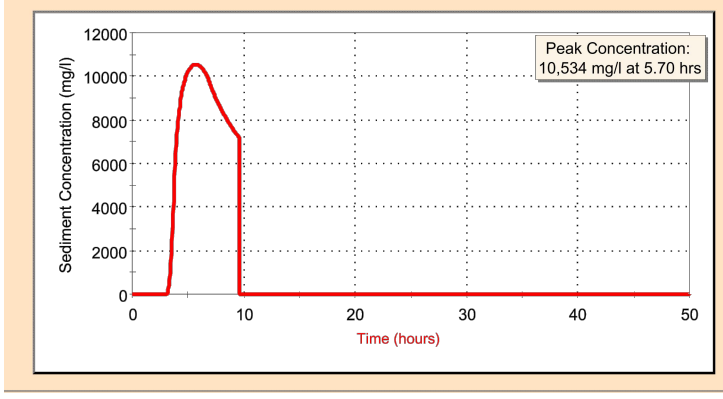
WATERSHED 15 POST MINING SEDIMENTGRAPH (10 YEAR, 24 HOUR STORM)

Total Inflow Sedimentgraph to Structure # 1 (includes all upstream flow)



WATERSHED 15 PRE MINING SEDIMENTGRAPH (100 YEAR, 6 HOUR STORM)

Total Inflow Sedimentgraph to Structure # 3 (includes all upstream flow)



WATERSHED 15 POST MINING SEDIMENTGRAPH (100 YEAR, 6 HOUR STORM)