Creating Value …

… Delivering Solutions

Mountain State Takes Eco-Friendly High Road
"Tale of a Sensitive Watershed"

NHEC Conference, August 2014

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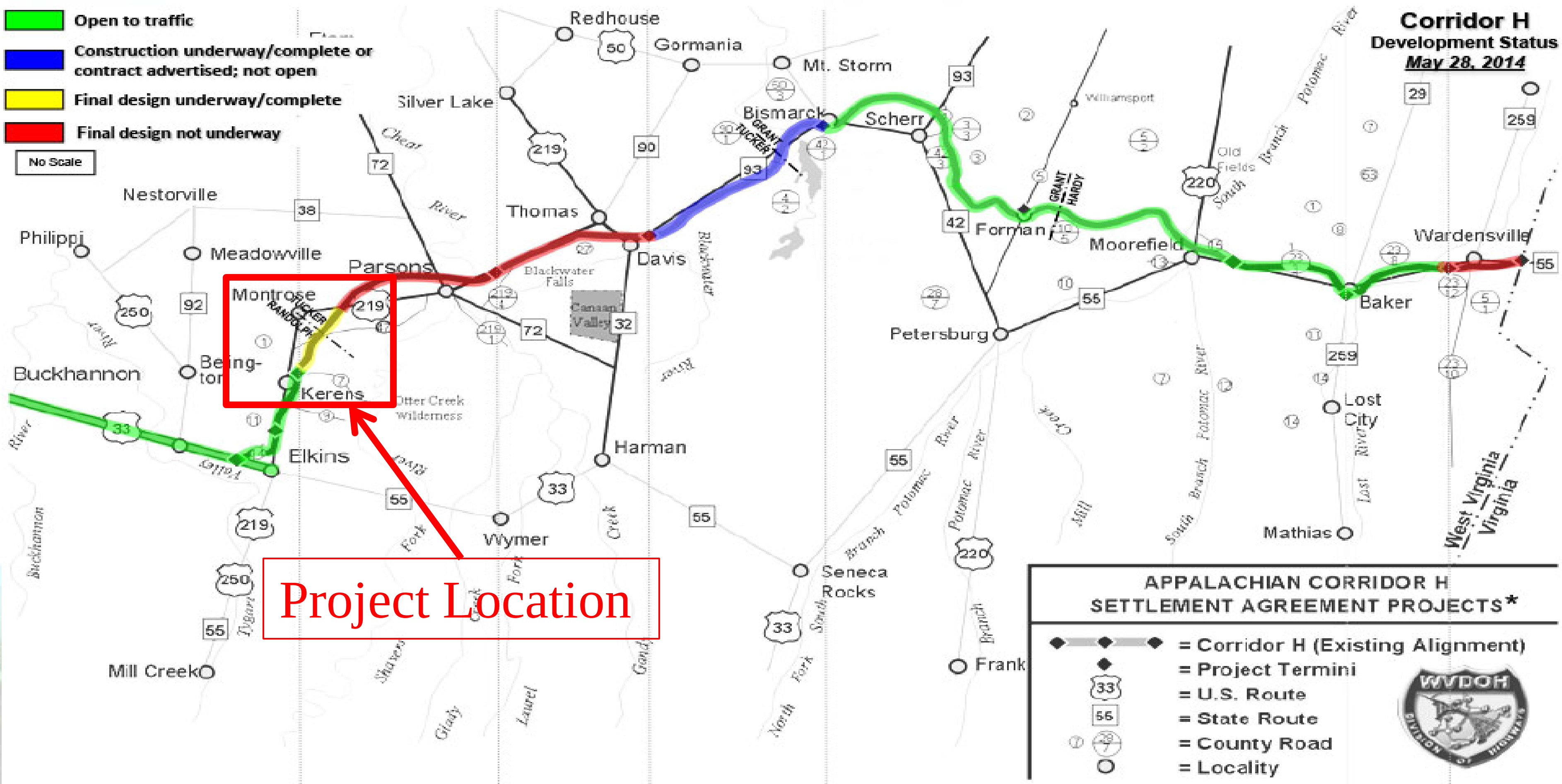
Presentation Layout

- Project Background
- Hydrologic Modeling
- Hydraulic Modeling
- Mitigation Strategy
- Water Exposure Analysis
- Shadow Modeling
- Summary and Discussion

Project Background

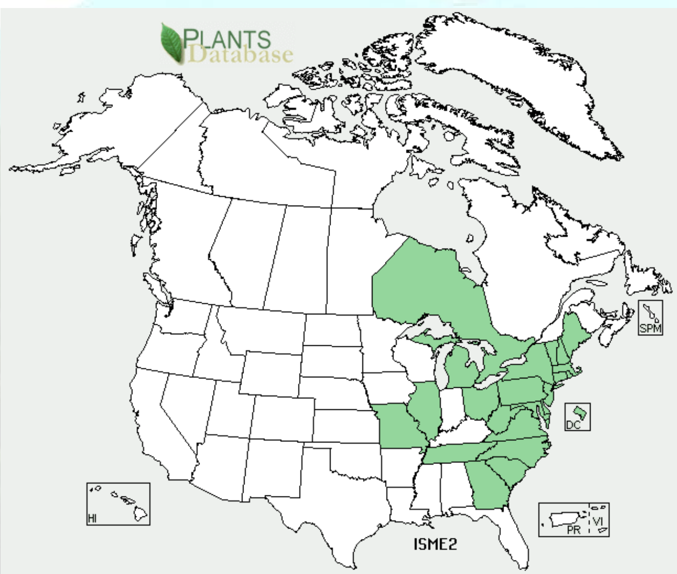
- Project Route – Kerens to Parsons
- 7.5-mile Roadway Section
- Anticipated Construction Start: Spring 2016
- Integral part of Corridor H
- Corridors established under the Appalachian Development Highway System (ADHS)
- One of six transportation corridors in WV
- Last corridor yet to be fully constructed
- www.wvcorridorh.com

Current Development Status



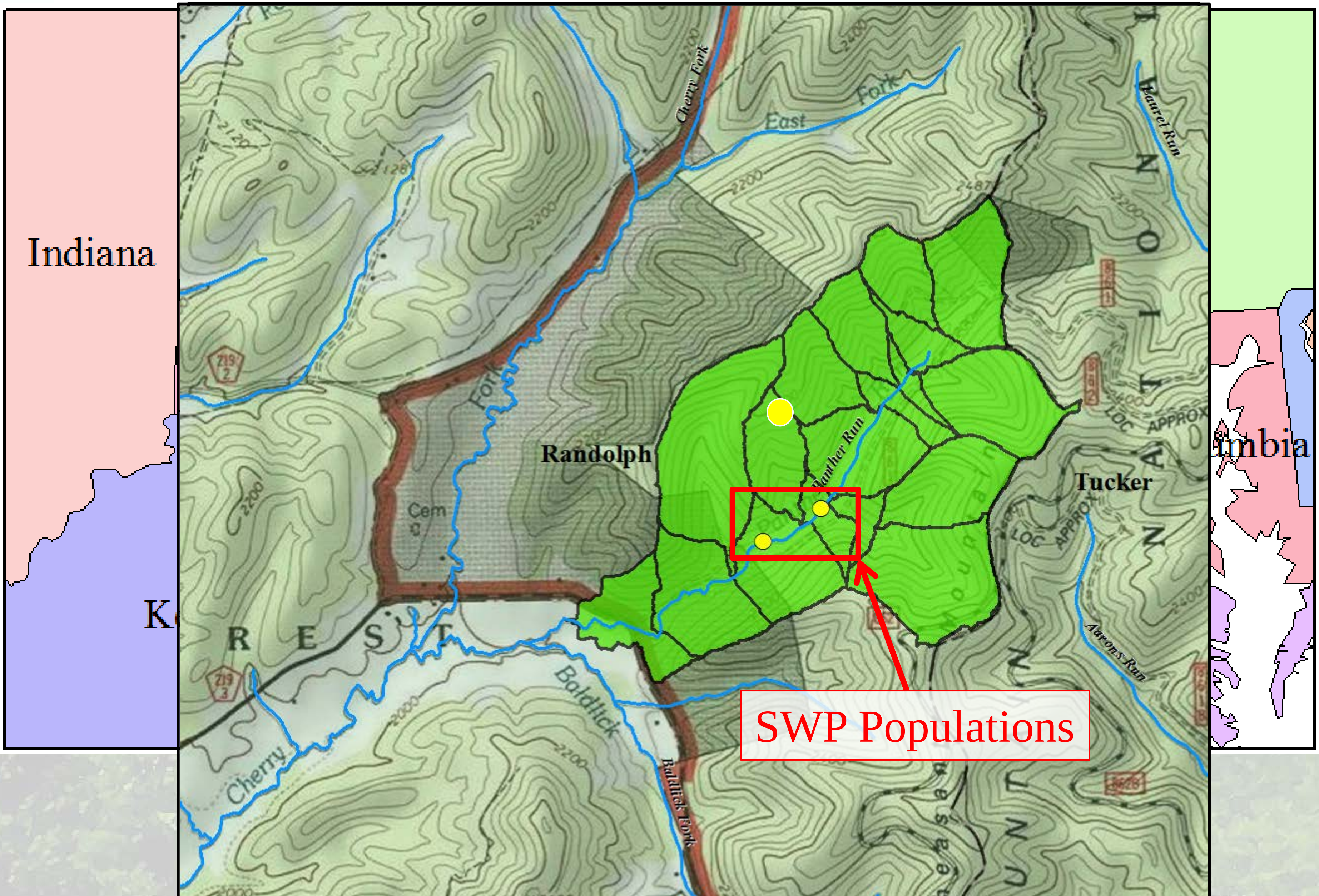
Sensitive Watershed

- Monongahela National Forest
- Environmental Studies
- Small Whorled Pogonia
  - Threatened Species
  - Member of the orchid family
  - Widely distributed, but rare
  - cessfully cultivated



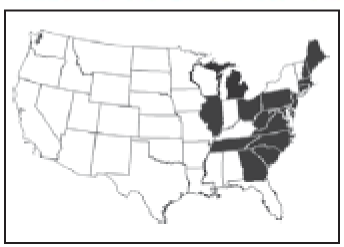
Images courtesy Doug Goldman, hosted by the USDA-NRCS PLANTS Database / USDA-NRCS-NPDT

Location


Indiana
Randolph
Tucker
SWP Populations
Cherry Fork
East Fork
Laurel Run
Panther Run
Baldlick
Baldlick Fork
Aarons Run
Cherry
Cem
LOC APPROX
R E S T

Hydrology and Hydraulics Study

Small Whorled Pogonia
Isotria medeoloides



States where the small whorled pogonia, an orchid, is found.

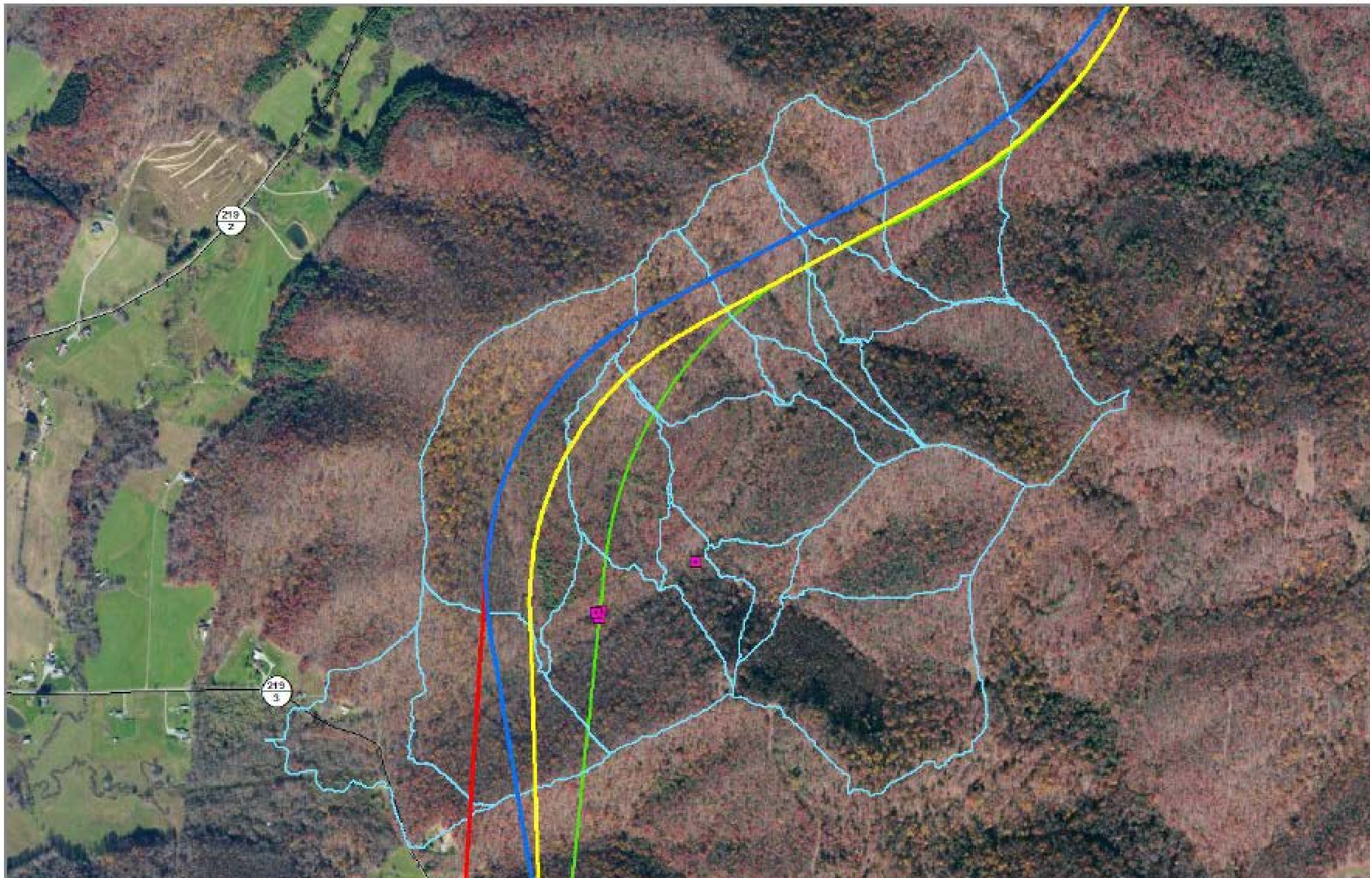


Figure 2: SWP locations relative to proposed highway alignments

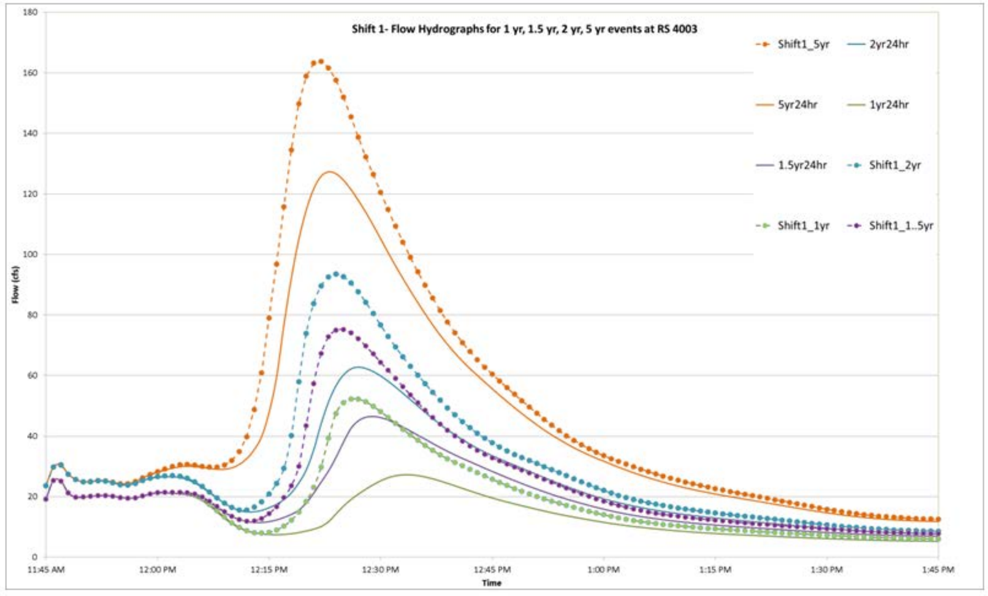
Purpose

Panther Run Watershed Hydrologic & Hydraulic analyses performed to:

1. Establish existing (baseline) hydrologic & hydraulic (H&H) conditions at SWP Locations
2. Establish proposed conditions due to roadway construction
3. Predict changes due to the proposed roadway construction
4. Conceptualize mitigation measures and demonstrate their effectiveness

H&H Models developed to predict changes in key H&H variables

- Peak Discharges
- WSEL or Stage
- Flow Depth
- Velocities
- Shear Stress
- Water Exposure Analysis



Example Hydrograph (Peak Discharge)

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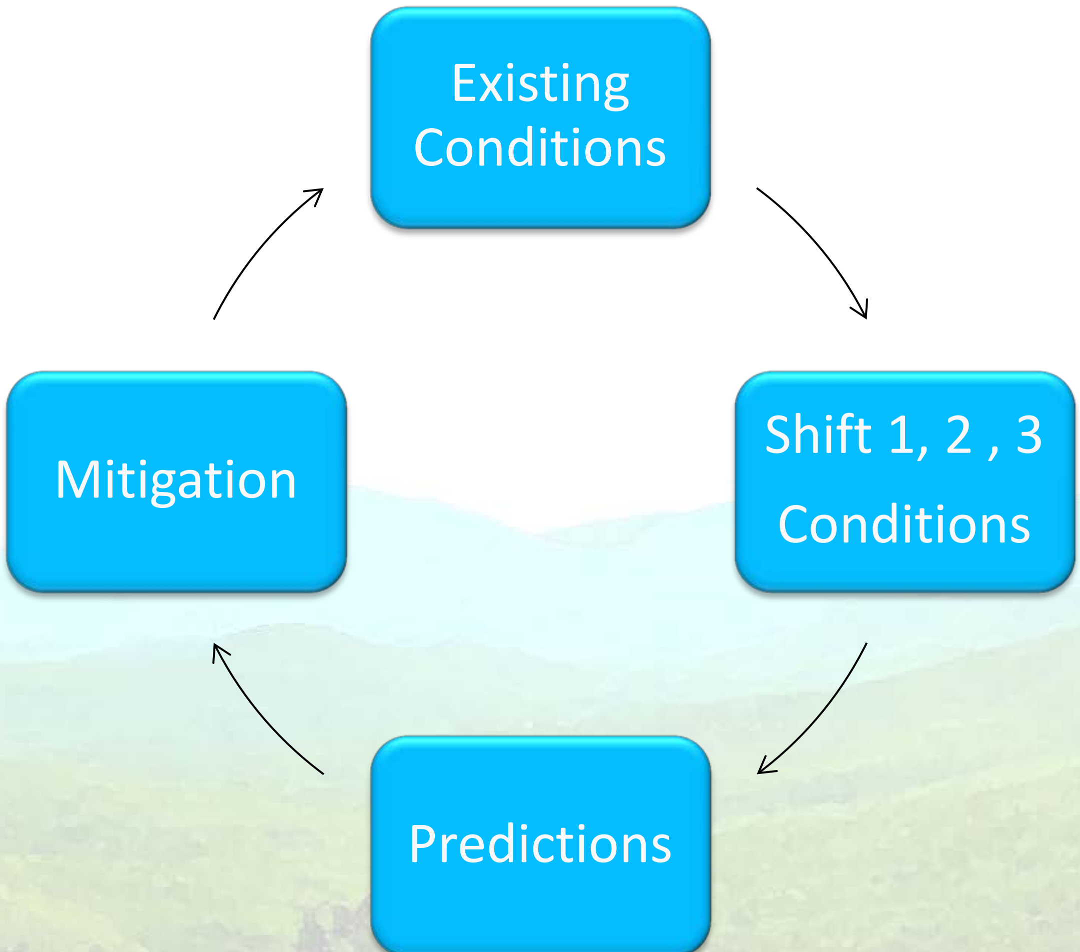
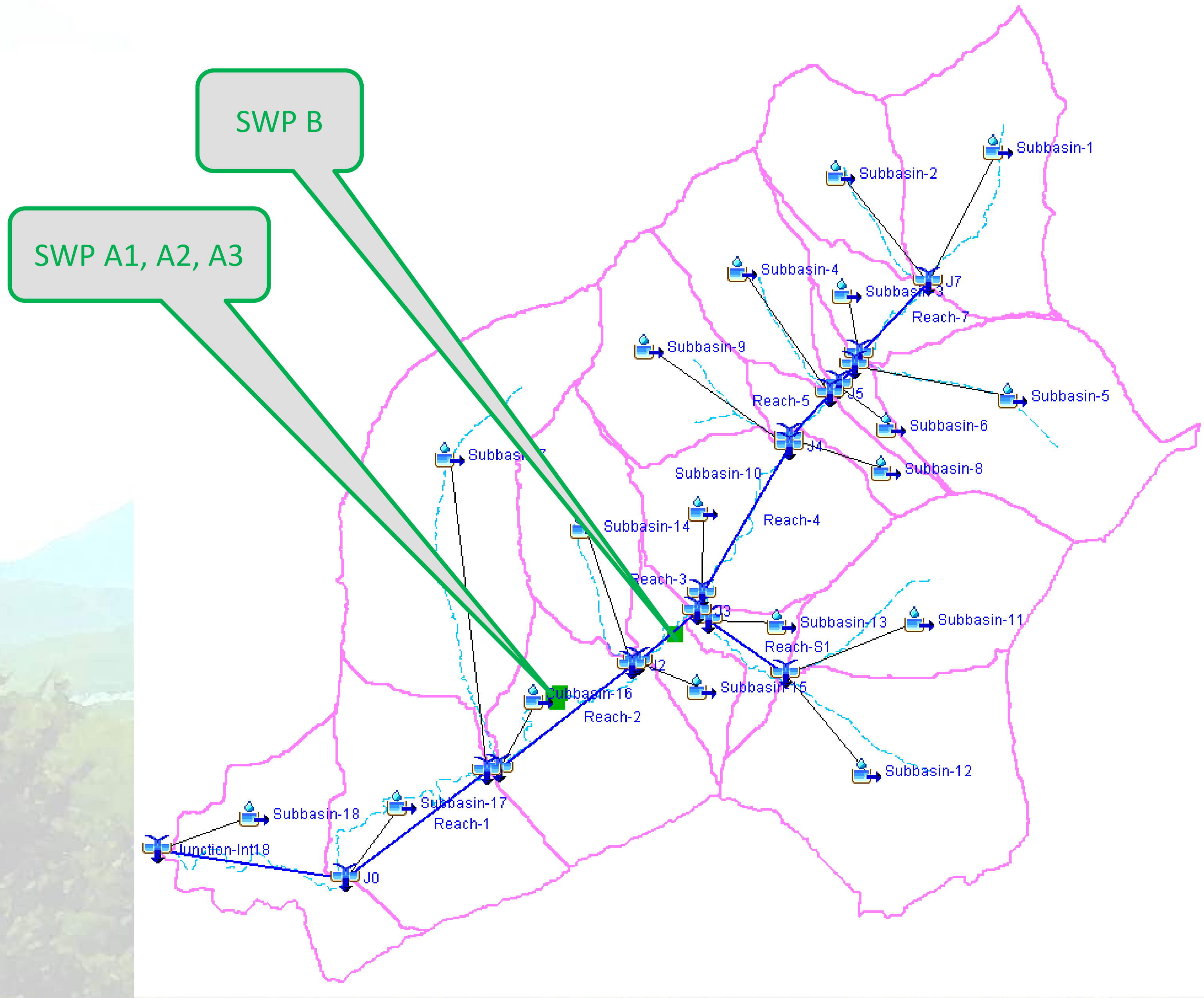
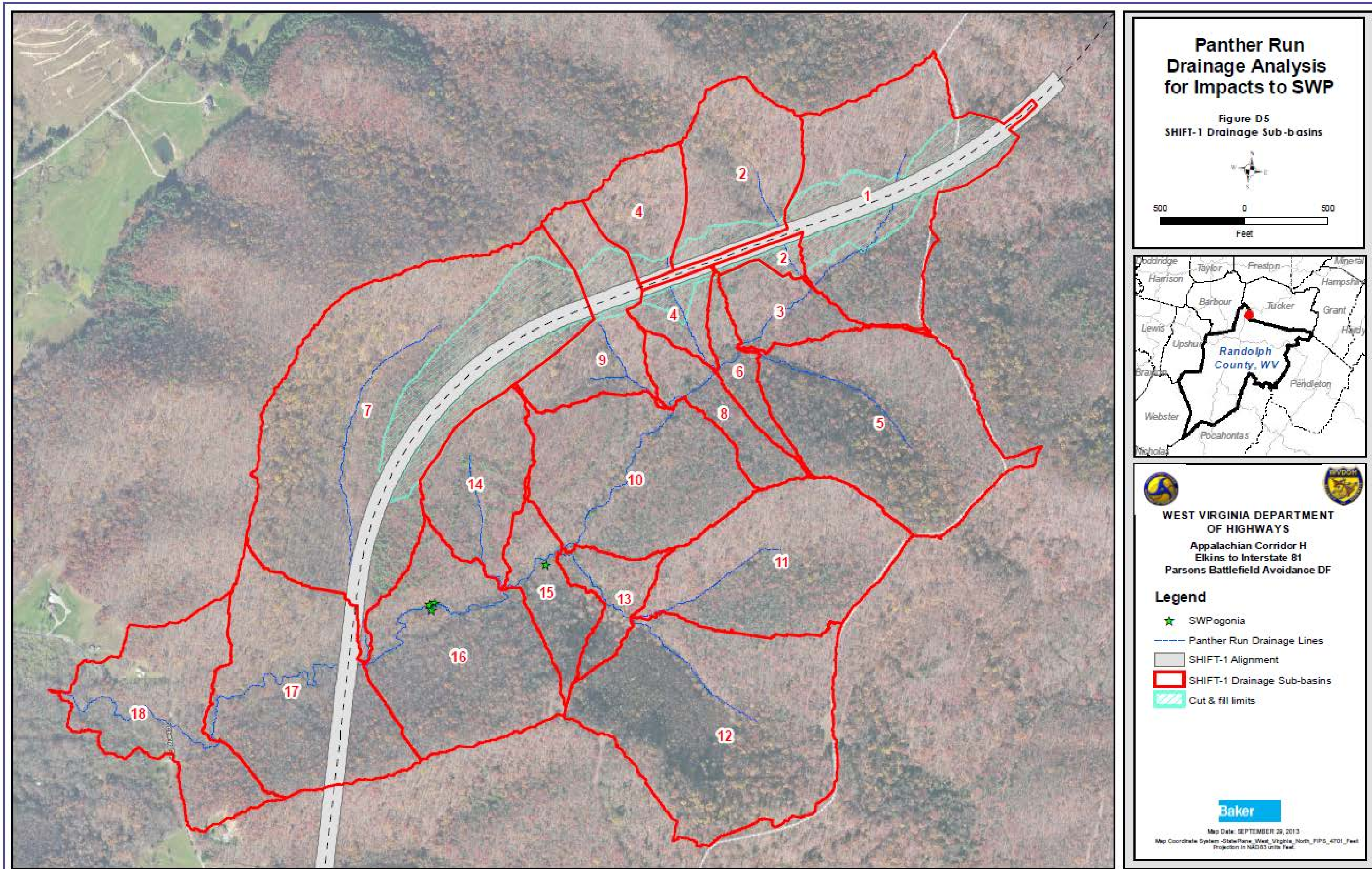
Panther Run Project



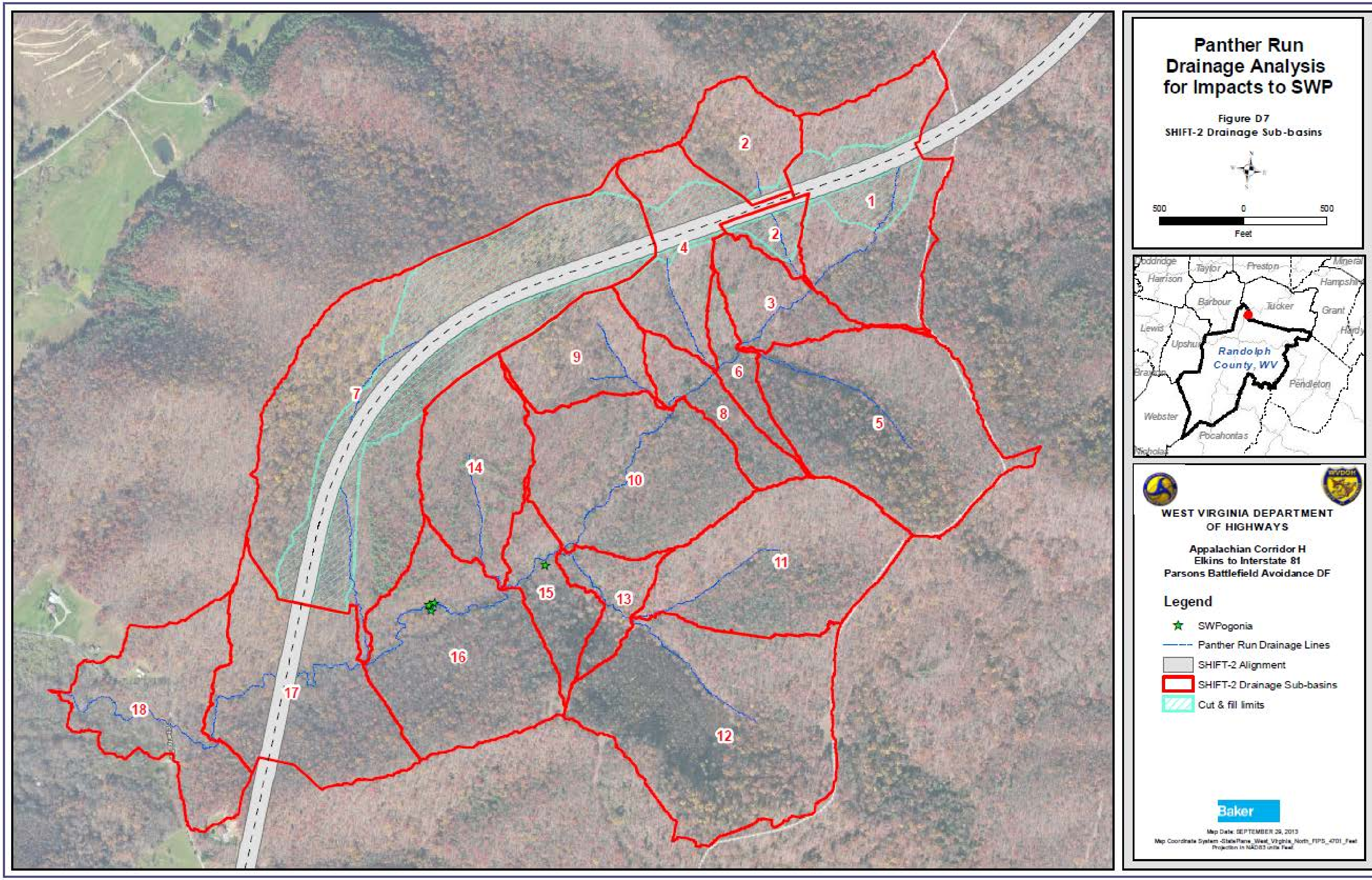
Hydrology - Existing Conditions



Hydrology - Shift 1

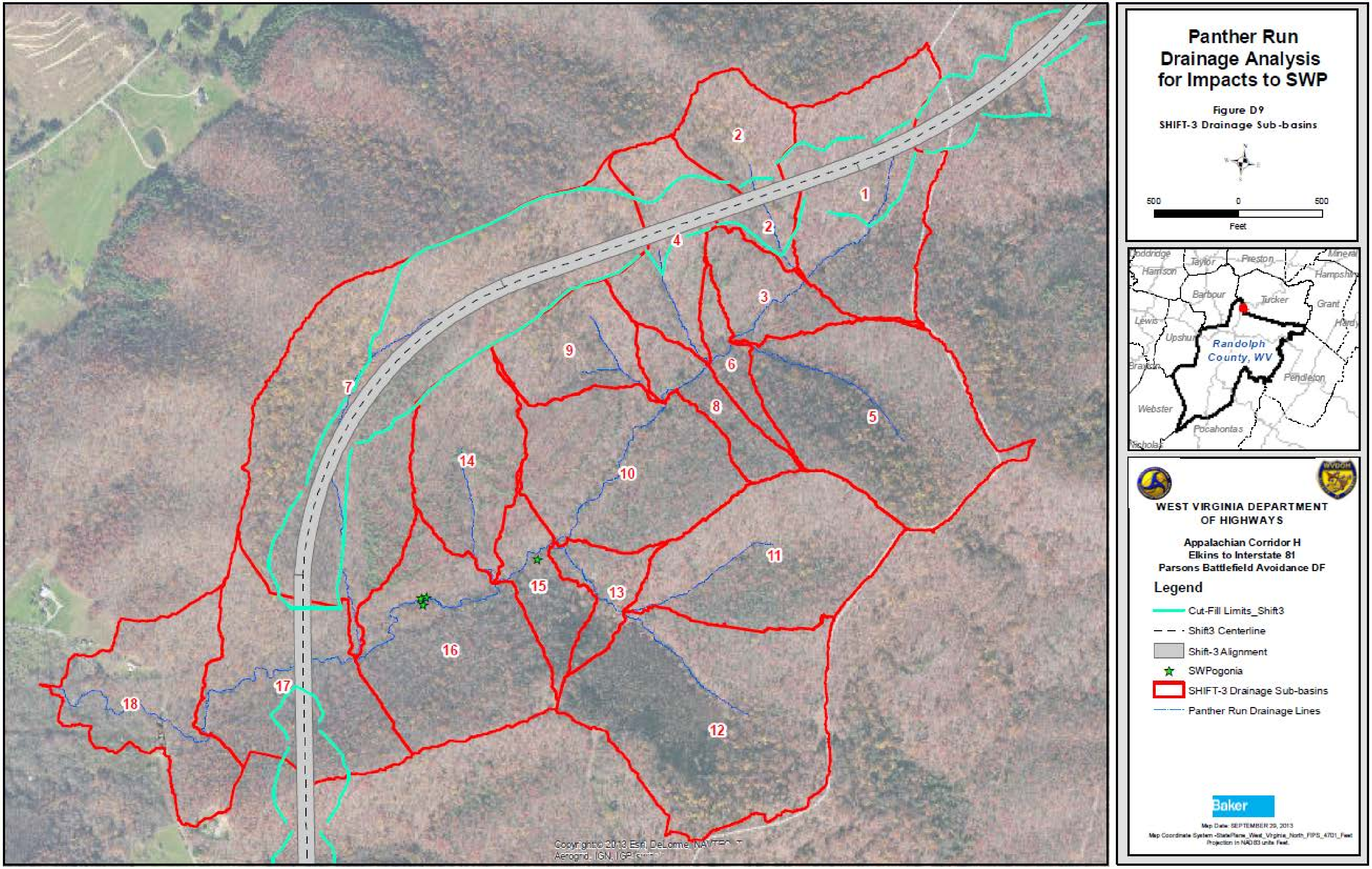


Hydrology - Shift 2



Baker

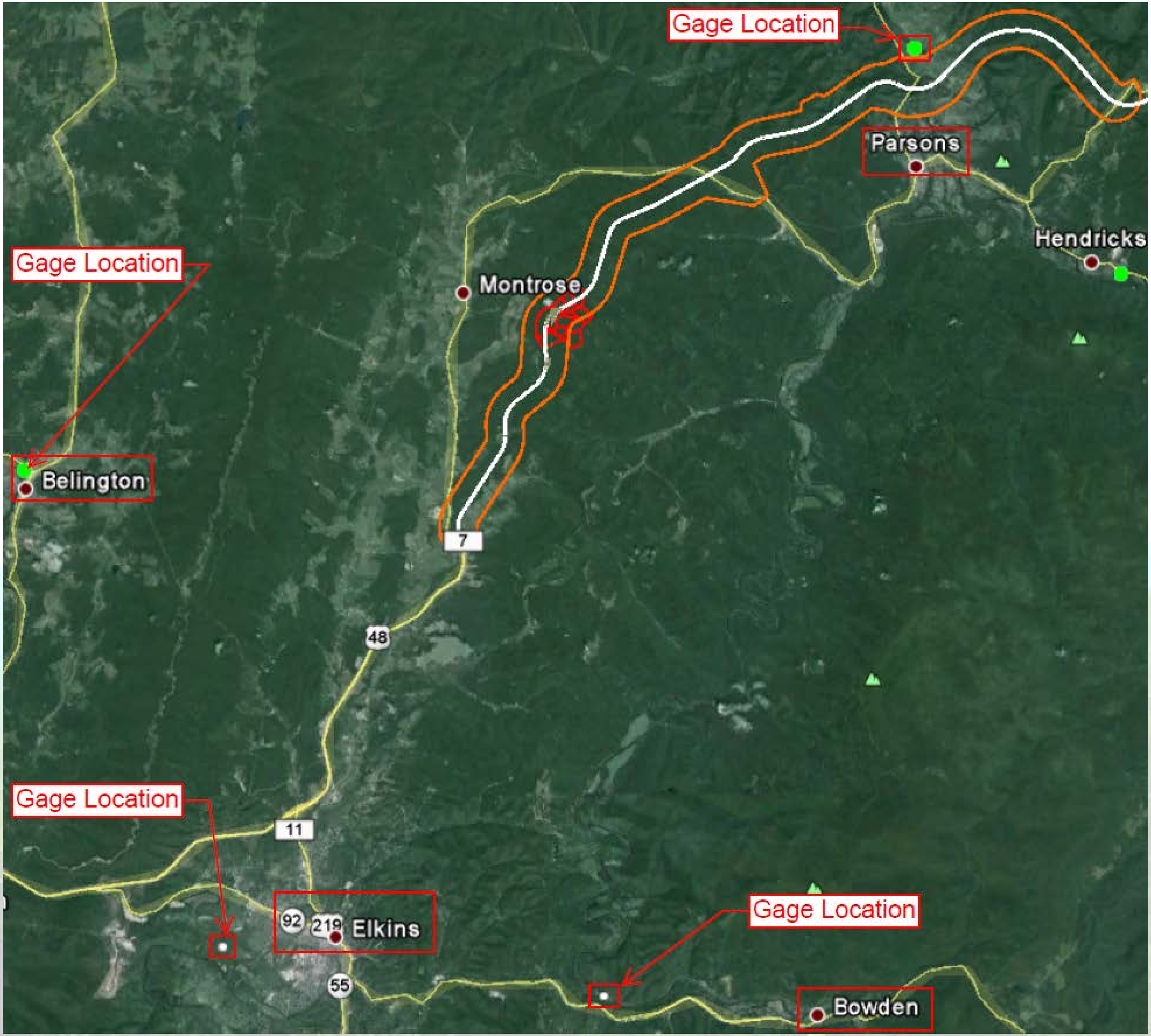
Hydrology - Shift 3



Historical Gage Data

Peak-FQ Bulletin 17B Analysis of Gages in Surrounding Areas

Baker


Gage Location
Parsons
Hendricks
Gage Location
Montrose
Belington
7
48
Gage Location
11
92
219
Elkins
55
Gage Location
Bowden

PeakFQ Gage Analysis Summary

Baker

ELKINS TYGART RIVER GAGE BULLETIN 17 B ANALYSIS

Randolph County	ANNUAL	EXPECTED	271 Sq. Miles DA	
	EXCEEDANCE	BULL.17B	Occurrence	
Event	PROBABILITY	ESTIMATE	All Data (60-yrs)	1994-2004
Year	AEP	cfs	Times	Times
1.005	0.995	3791	60	11
1.010	0.99	3980	60	11
1.053	0.95	4618	57	11
1.111	0.9	5048	55	11
1.250	0.8	5678	46	10
1.500	0.6667	6399	40	9
2.00	0.5	7332	31	8
2.33	0.4292	7783	28	8
5.00	0.2	9882	12	2
10.00	0.1	11760	4	1
25.00	0.04	14350	2	1
50.00	0.02	16450	1	0
100.00	0.01	18690	1	0
200.00	0.005	21110	1	0
500.00	0.002	24610	0	0

BOWDEN,SHAVERS FORK GAGE BULLETIN 17 B ANALYSIS

Randolph County	ANNUAL	EXPECTED	151 Sq. Miles DA	
	EXCEEDANCE	BULL.17B	Occurrence	
Event	PROBABILITY	ESTIMATE	All Data (22-yrs)	1998-2011
Year	AEP	cfs	Times	Times
1.005	0.995	4287	22	14
1.010	0.99	4685	22	14
1.053	0.95	6027	21	14
1.111	0.9	6933	19	12
1.250	0.8	8257	16	12
1.50	0.6667	9773	15	12
2.00	0.5	11730	11	9
2.33	0.4292	12670	10	9
5.00	0.2	17030	5	4
10.00	0.1	20880	3	3
25.00	0.04	26130	1	1
50.00	0.02	30320	0	0
100.00	0.01	34740	0	0
200.00	0.005	39450	0	0
500.00	0.002	46130	0	0

BELINGTON,TYGART RIVER GAGE BULLETIN 17 B ANALYSIS

Barbour County	ANNUAL	EXPECTED	406 Sq. Miles DA	
	EXCEEDANCE	BULL.17B	Occurrence	
Event	PROBABILITY	ESTIMATE	All Data (104-yrs)	1994-2011
Year	AEP	cfs	Times	Times
1.005	0.995	4995	104	18
1.010	0.99	5310	103	18
1.053	0.95	6327	98	18
1.111	0.9	6981	93	18
1.250	0.8	7902	86	15
1.500	0.6667	8914	73	13
2.00	0.5	10170	55	9
2.33	0.4292	10750	43	9
5.00	0.2	13340	20	4
10.00	0.1	15500	10	2
25.00	0.04	18310	4	2
50.00	0.02	20460	2	1
100.00	0.01	22660	1	0
200.00	0.005	24930	1	0
500.00	0.002	28060	1	0

PARSONS CHEAT RIVER GAGE BULLETIN 17 B ANALYSIS

Tucker County	ANNUAL	EXPECTED	722 Sq. Miles DA	
	EXCEEDANCE	BULL.17B	Occurrence	
Event	PROBABILITY	ESTIMATE	All Data (99-yrs)	1994-2012
Year	AEP	cfs	Times	Times
1.005	0.995	11920	97	19
1.010	0.99	12480	97	19
1.053	0.95	14530	96	19
1.111	0.9	16030	91	19
1.250	0.8	18390	81	19
1.50	0.6667	21300	67	18
2.00	0.5	25370	**53**	13
2.33	0.4292	27440	46	10
5.00	0.2	38040	**16**	6
10.00	0.1	48730	**7**	3
25.00	0.04	65260	4	2
50.00	0.02	80090	3	1
100.00	0.01	97340	**1**	0
200.00	0.005	117400	1	0
500.00	0.002	149200	1	0

Hydraulic Analysis

HEC-RAS Steady
and
Unsteady Models

Hydraulic – HEC-RAS Models

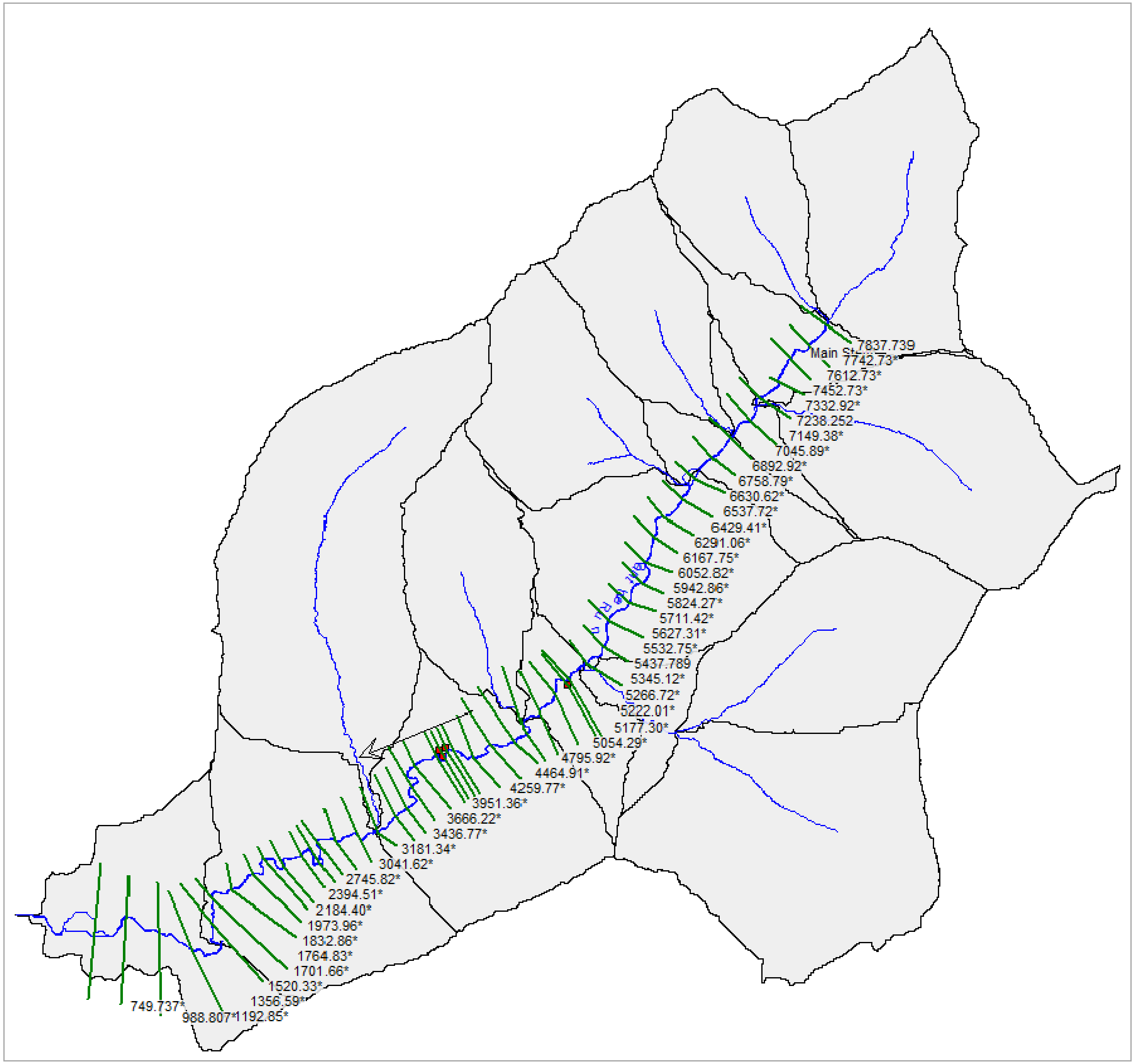


Figure 9: Unsteady Hydraulic Model Geometric Data Schematic

Hydraulic Analysis

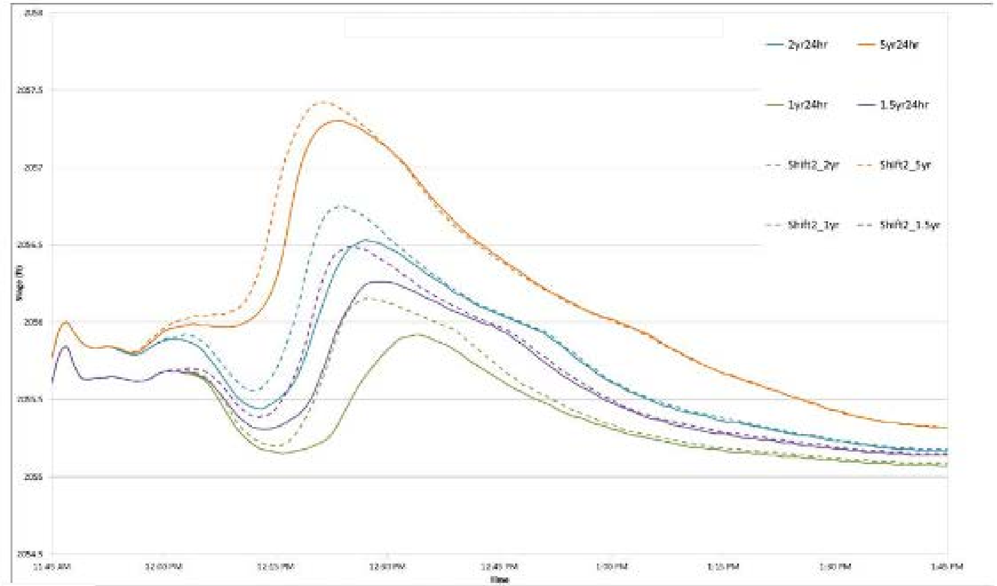
Predicted Changes in Key Hydraulic Variables
at
SWP Locations

Predicted Changes at SWP A1

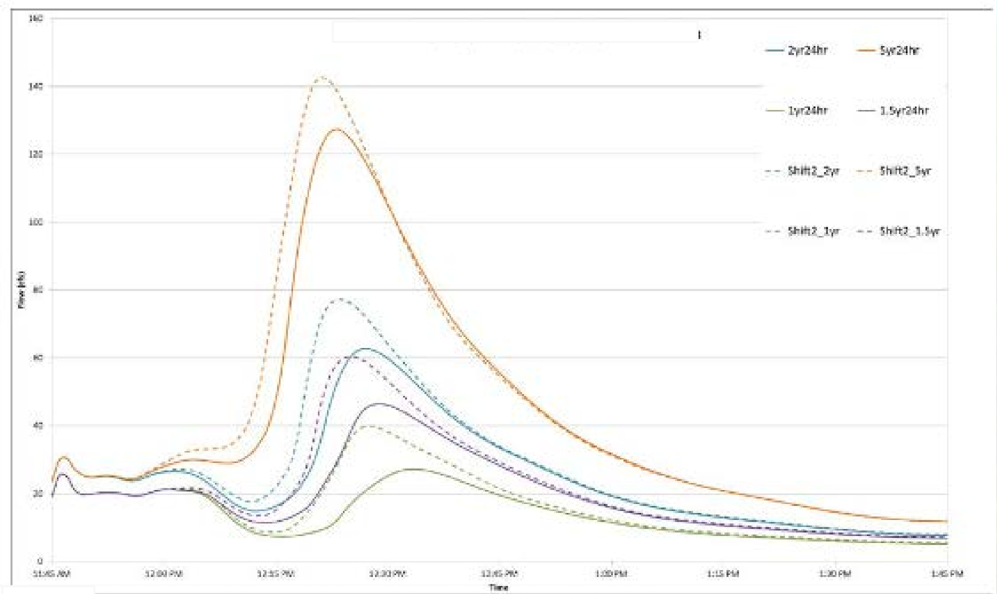
SWP A1	Condition/Event	1-yr	1.5-yr	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
Peak Discharge (cfs)	Ex Cond	27.22	46.45	62.76	127.3	258.28	383.3	483.2	602.98	853.4
	Shift 1	52.35	75.23	93.43	163.9	301.26	427.3	526.4	643.53	891.39
	Shift 2 and 3	39.85	60.41	77.21	142.5	273.81	399.1	496	611.24	855.68
Flow Depth (ft)	Ex Cond	0	0	0.14	0.91	1.85	2.4	2.81	3.11	3.72
	Shift 1	0	0.33	0.6	1.2	2.04	2.6	2.92	3.21	3.8
	Shift 2 and 3	0	0.1	0.36	1.04	1.92	2.47	2.84	3.13	3.72
Velocity (ft/s)	Ex Cond	0	0	0.7	1	1.39	1.68	1.81	2.03	2.36
	Shift 1	0	0.81	0.89	1.14	1.51	1.74	1.9	2.09	2.4
	Shift 2 and 3	0	0.68	0.82	1.07	1.43	1.7	1.84	2.04	2.36
Shear Stress (lb/sq ft)	Ex Cond	0	0	0.26	0.42	0.65	0.88	0.98	1.19	1.51
	Shift 1	0	0.3	0.33	0.5	0.74	0.92	1.06	1.25	1.56
	Shift 2 and 3	0	0.25	0.31	0.45	0.68	0.9	1	1.2	1.52

SWP A1 and SWP A2 Hydrographs

Comparison of Shift 2/3 and Existing Hydrographs for
1, 1.5, 2, 5-yr events



Shifts 2 and 3 Stage Hydrographs at RS 4003 (SWP A1 and SWP A2)



Shifts 2 and 3 Flow Hydrographs at RS 4003 (SWP A1 and SWP A2)

Mitigation
of
Predicted Changes

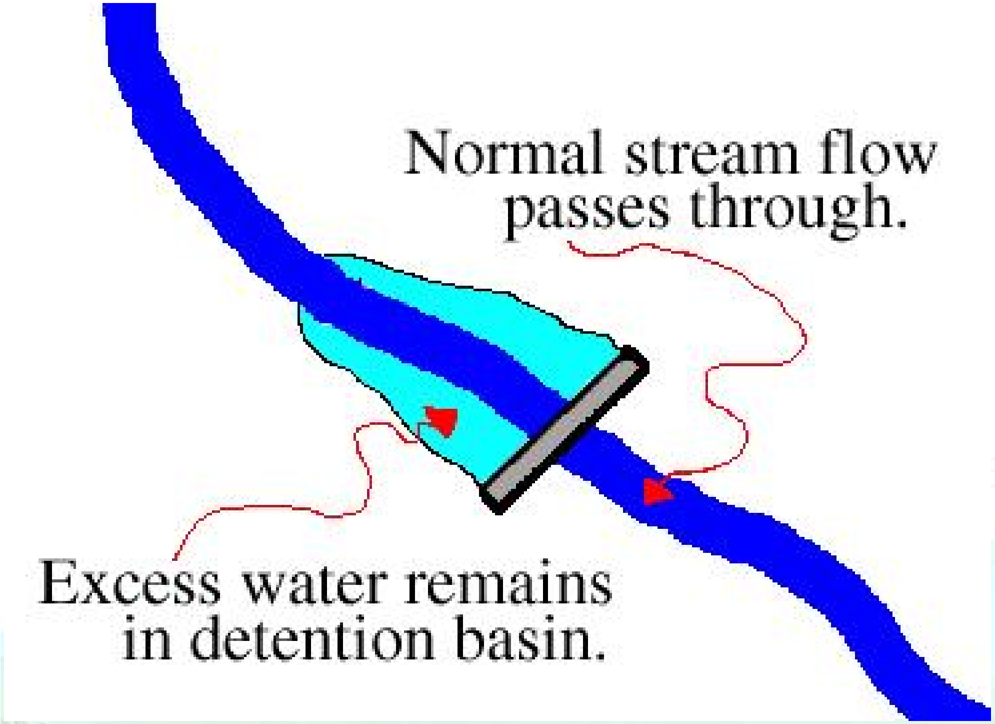
Mitigation

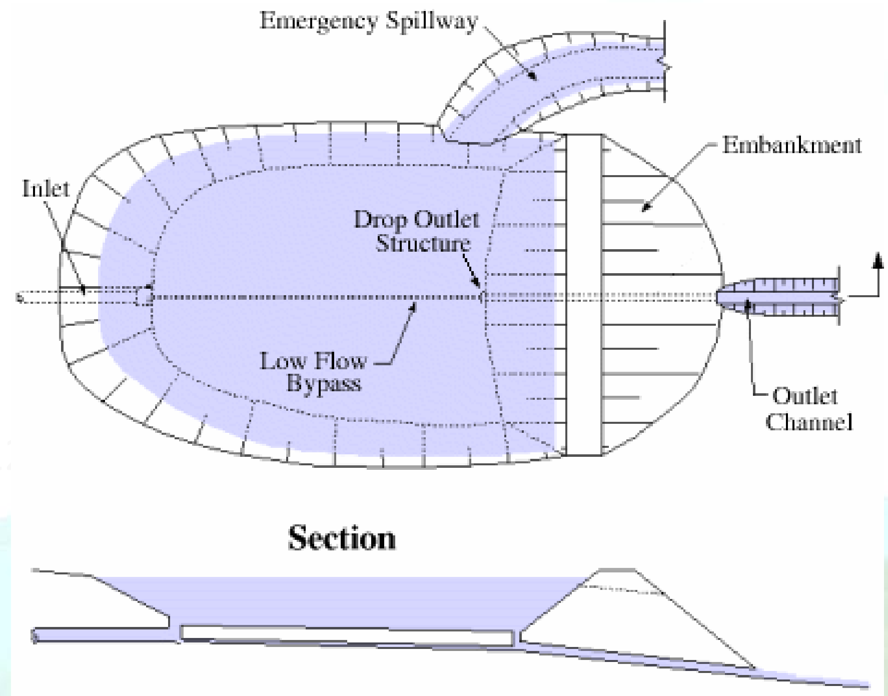
Shift 3 Selected for Mitigation and **1.5-year event** Identified for Mitigation – Channel forming, Stream Stabilizing flow event

Mitigation Strategies Considered:

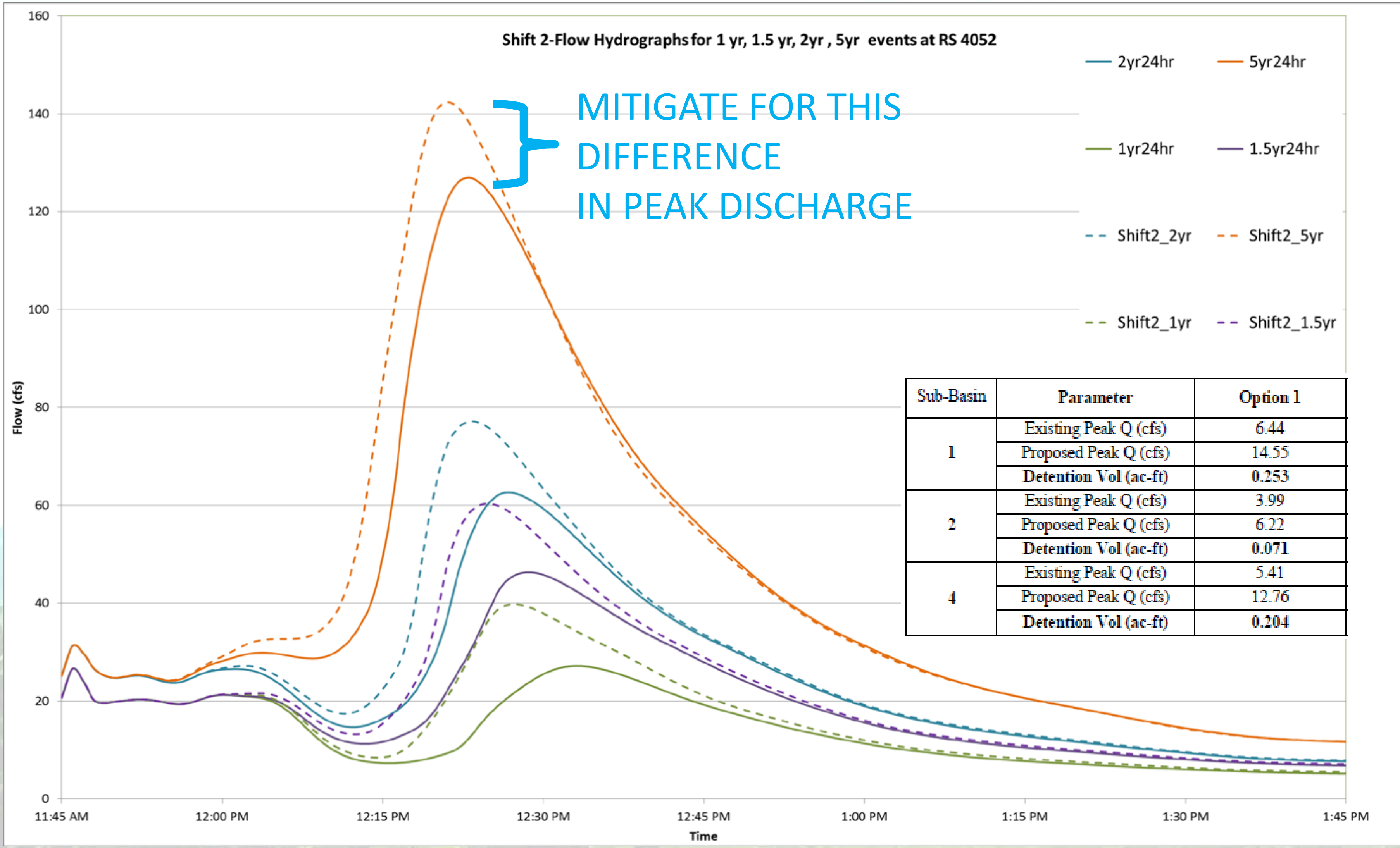
- Offline detention
- **Inline detention**
- **Inlet re-routing to allocate additional roadway drainage areas to trunk lines that discharge further downstream of plant location**
- Retention
- Bio-retention

Inline Detention – Modeled Option





Mitigation - Detention Storage



Sub-Basin	Parameter	Option 1
1	Existing Peak Q (cfs)	6.44
	Proposed Peak Q (cfs)	14.55
	Detention Vol (ac-ft)	**0.253**
2	Existing Peak Q (cfs)	3.99
	Proposed Peak Q (cfs)	6.22
	Detention Vol (ac-ft)	**0.071**
4	Existing Peak Q (cfs)	5.41
	Proposed Peak Q (cfs)	12.76
	Detention Vol (ac-ft)	**0.204**

Predicted Changes (at SWP A1) and Mitigation

SWP A1	Condition/Event	1-yr	1.5-yr	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
Peak Discharge (cfs)	Ex Cond	27.22	46.45	62.76	127.3	258.28	383.3	483.2	602.98	853.4
	Shift 1	52.35	75.23	93.43	163.9	301.26	427.3	526.4	643.53	891.39
	Shift 2 and 3	39.85	60.41	77.21	142.5	273.81	399.1	496	611.24	855.68
	With Mitigation	29.26	46.11	60	125	269.47	398.7	495.9	611.1	855.37
Flow Depth (ft)	Ex Cond	0	0	0.14	0.91	1.85	2.4	2.81	3.11	3.72
	Shift 1	0	0.33	0.6	1.2	2.04	2.6	2.92	3.21	3.8
	Shift 2 and 3	0	0.1	0.36	1.04	1.92	2.47	2.84	3.13	3.72
	With Mitigation	0	0	0.09	0.92	1.9	2.47	2.84	3.13	3.72
Velocity (ft/s)	Ex Cond	0	0	0.7	1	1.39	1.68	1.81	2.03	2.36
	Shift 1	0	0.81	0.89	1.14	1.51	1.74	1.9	2.09	2.4
	Shift 2 and 3	0	0.68	0.82	1.07	1.43	1.7	1.84	2.04	2.36
	With Mitigation	0	0	0.68	0.99	1.42	1.7	1.84	2.04	2.36
Shear Stress (lb/sq ft)	Ex Cond	0	0	0.26	0.42	0.65	0.88	0.98	1.19	1.51
	Shift 1	0	0.3	0.33	0.5	0.74	0.92	1.06	1.25	1.56
	Shift 2 and 3	0	0.25	0.31	0.45	0.68	0.9	1	1.2	1.52
	With Mitigation	0	0	0.25	0.41	0.67	0.9	1	1.2	1.52

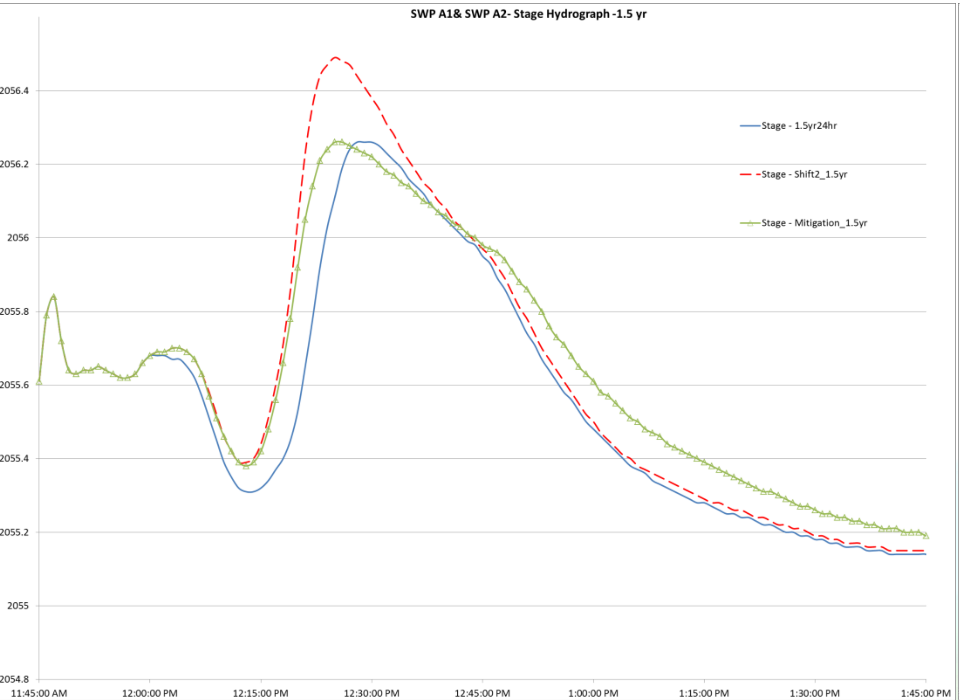
Mitigation of Shift 2/3

Predicted Changes (at SWP A1) and Mitigation

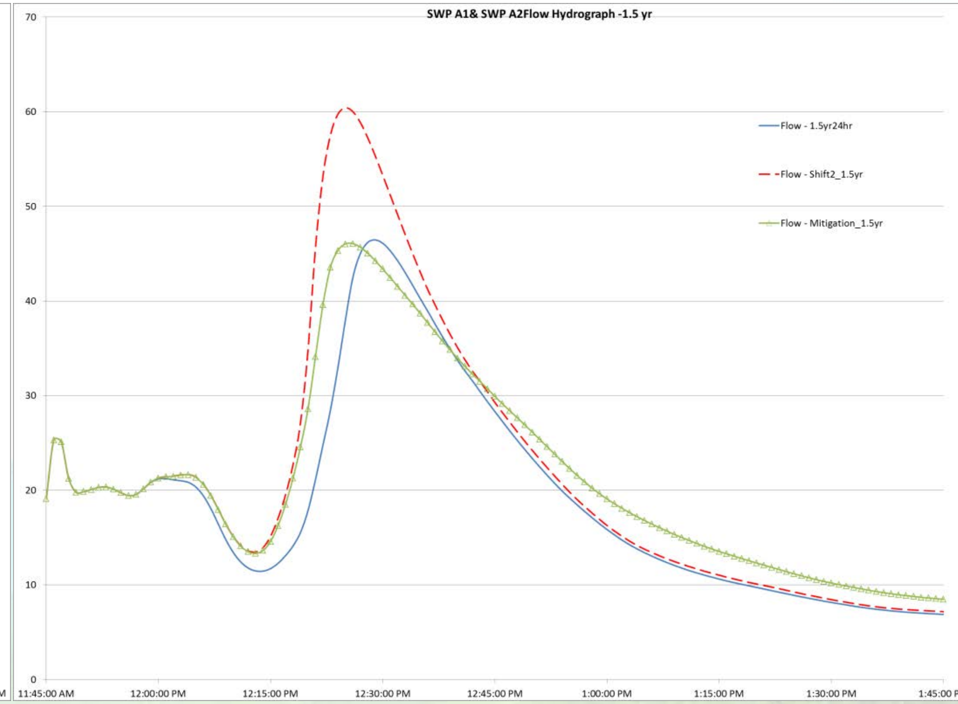
SWP A1	Condition/Event	1-yr	1.5-yr	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
Peak Discharge (cfs)	Ex Cond	27.22	46.45	62.76	127.3	258.28	383.3	483.2	602.98	853.4
	Shift 3	37.56	57.53	73.74	136.3	259.77	376.6	468.5	579.35	807.89
	With Mitigation	29.57	46.18	59.87	113.6	237.84	363.9	456	564.32	786.7
Flow Depth (ft)	Ex Cond	0	0	0.14	0.91	1.85	2.4	2.81	3.11	3.72
	Shift 3	0	0.05	0.3	0.99	1.86	2.38	2.77	3.06	3.61
	With Mitigation	0	0	0.09	0.8	1.74	2.32	2.72	3.02	3.56
Velocity (ft/s)	Ex Cond	0	0	0.7	1	1.39	1.68	1.81	2.03	2.36
	Shift 3	-	0.68	0.8	1.04	1.39	1.67	1.79	1.99	2.31
	With Mitigation	0	0	0.68	0.94	1.33	1.65	1.77	1.97	2.28
Shear Stress (lb/sq ft)	Ex Cond	0	0	0.26	0.42	0.65	0.88	0.98	1.19	1.51
	Shift 3		0.25	0.3	0.44	0.65	0.87	0.95	1.15	1.46
	With Mitigation	0	0	0.25	0.38	0.61	0.85	0.94	1.12	1.44

SWP A1 and SWP A2 - 1.5yr Hydrographs

Existing, Shift 2/3 and Mitigation 1
Stage Hydrograph 1.5-yr



Existing, Shift 2/3 and Mitigation 1
Flow Hydrograph 1.5-yr



Water Exposure Duration Analysis at SWP

Water Exposure Times at SWP in Minutes

Water Exposure Duration (Minutes) at SWP A1

Event	Existing (min)	Shift 1 (min)	Shift 2 (min)	Shift 3 (min)	With Mitigation (min)
1-year	0	0	0	0	0
1.5-year	0	11	4	0	0
2-year	7	17	13	12	5
5-year	29	33	30	29	29
10-year	50	52	52	49	49
100-year	74	73	72	72	72

Water Exposure Duration (Minutes) at SWP A2

Event	Existing (min)	Shift 1 (min)	Shift 2 (min)	Shift 3 (min)	With Mitigation (min)
1-year	0	0	0	0	0
1.5-year	0	0	0	0	0
2-year	0	7	0	0	0
5-year	18	22	19	18	17
10-year	38	41	39	38	37
100-year	63	62	61	61	61

Water Exposure Times at SWP in Minutes

Water Exposure Duration (Minutes) at SWP A3

Event	Existing (min)	Shift 1 (min)	Shift 2 (min)	Shift 3 (min)	With Mitigation (min)
1-year	0	0	0	0	0
1.5-year	0	2	0	0	0
2-year	0	11	5	0	0
5-year	21	25	23	21	22
10-year	42	44	43	41	41
100-year	66	66	64	64	64

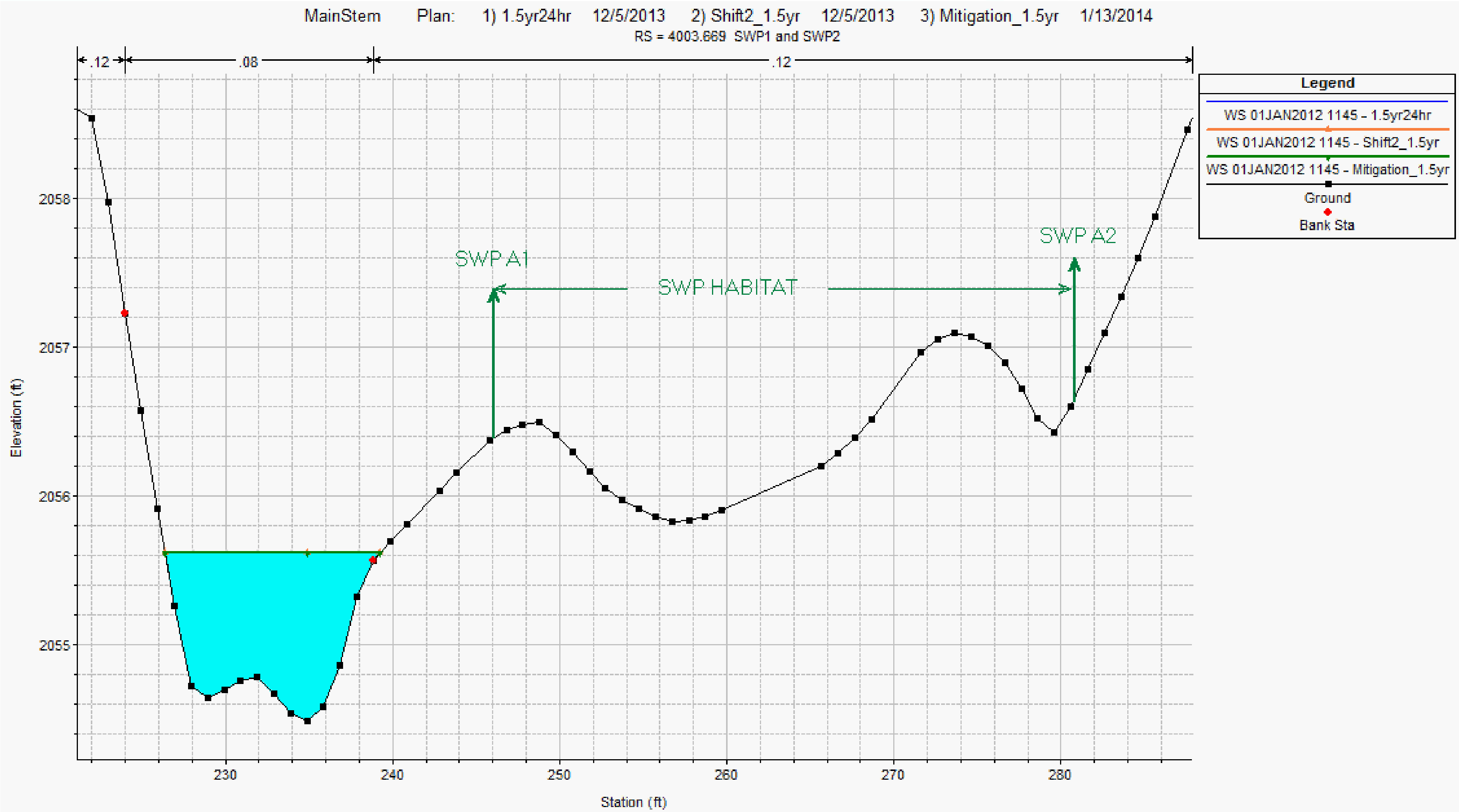
Water Exposure Duration (Minutes) at SWP B

Event	Existing (min)	Shift 1 (min)	Shift 2 (min)	Shift 3 (min)	With Mitigation (min)
1-year	0	0	0	0	0
1.5-year	0	8	0	0	0
2-year	0	13	8	7	0
5-year	22	28	25	23	23
10-year	42	44	42	41	41
100-year	66	66	64	64	65

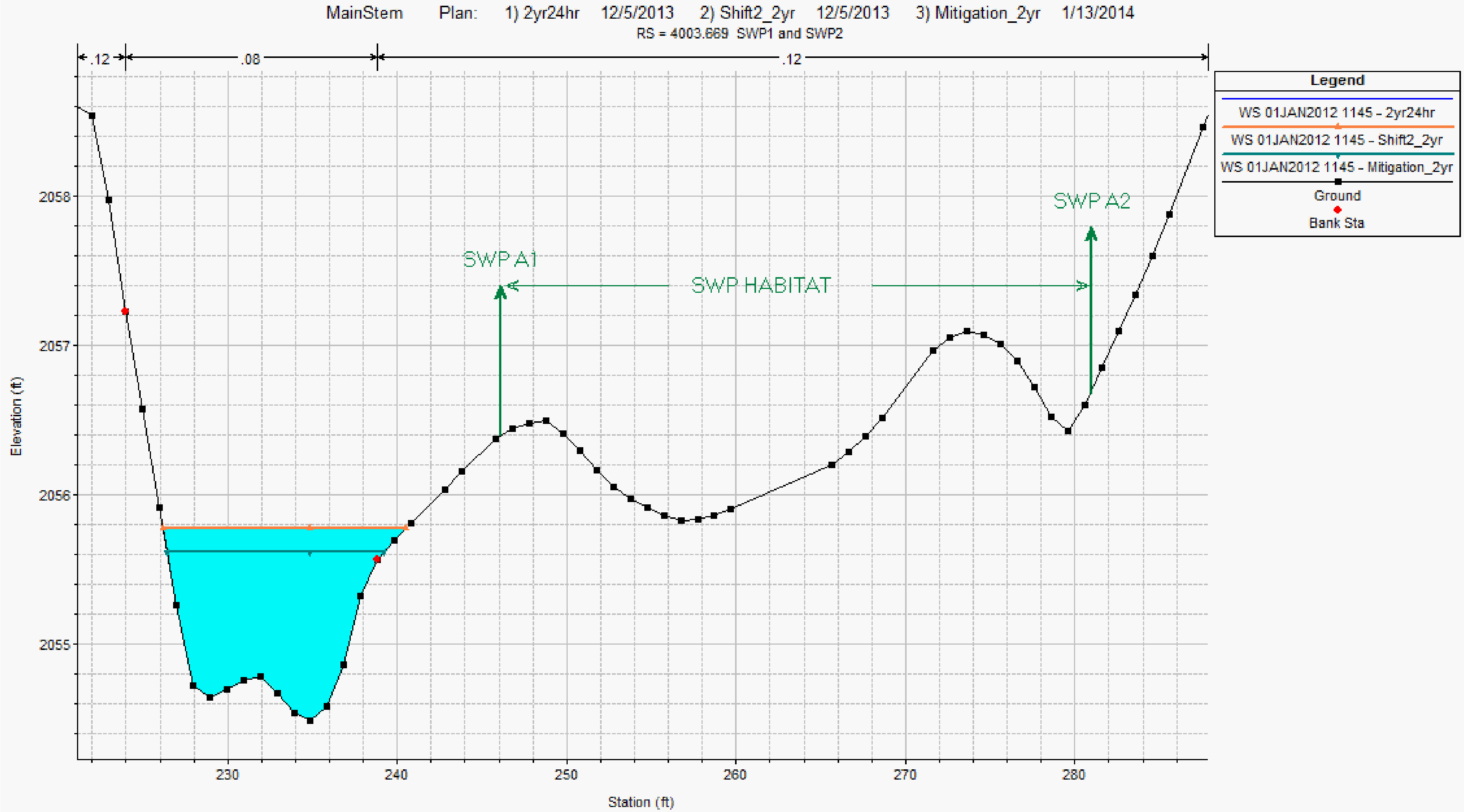
Baker

Water Surface Elevation (WSEL) Animations at SWP A1 and SWP A2 (1.5, 2, 5, 100-year events)

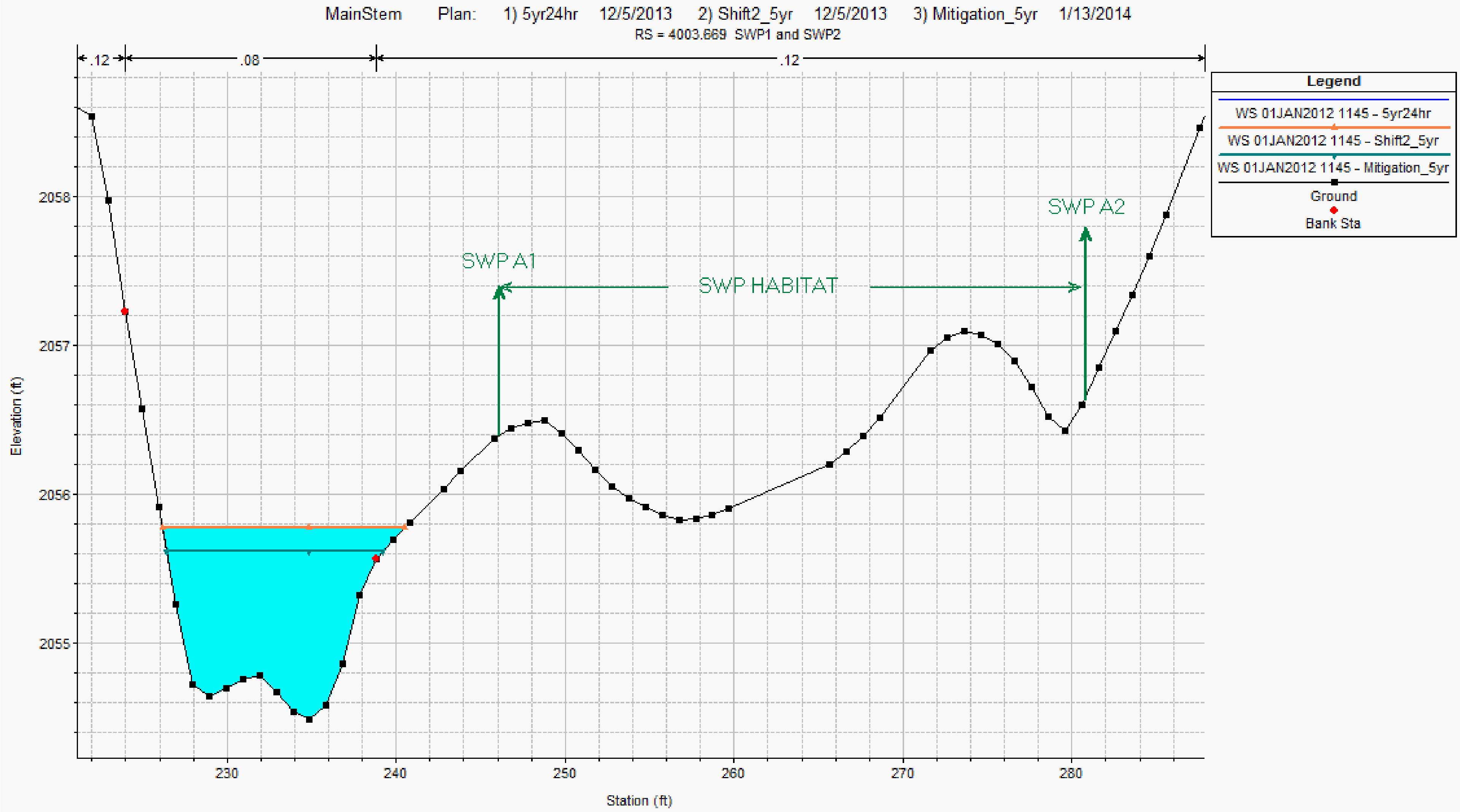
1.5-yr WSEL Animation at SWP A1, and A2



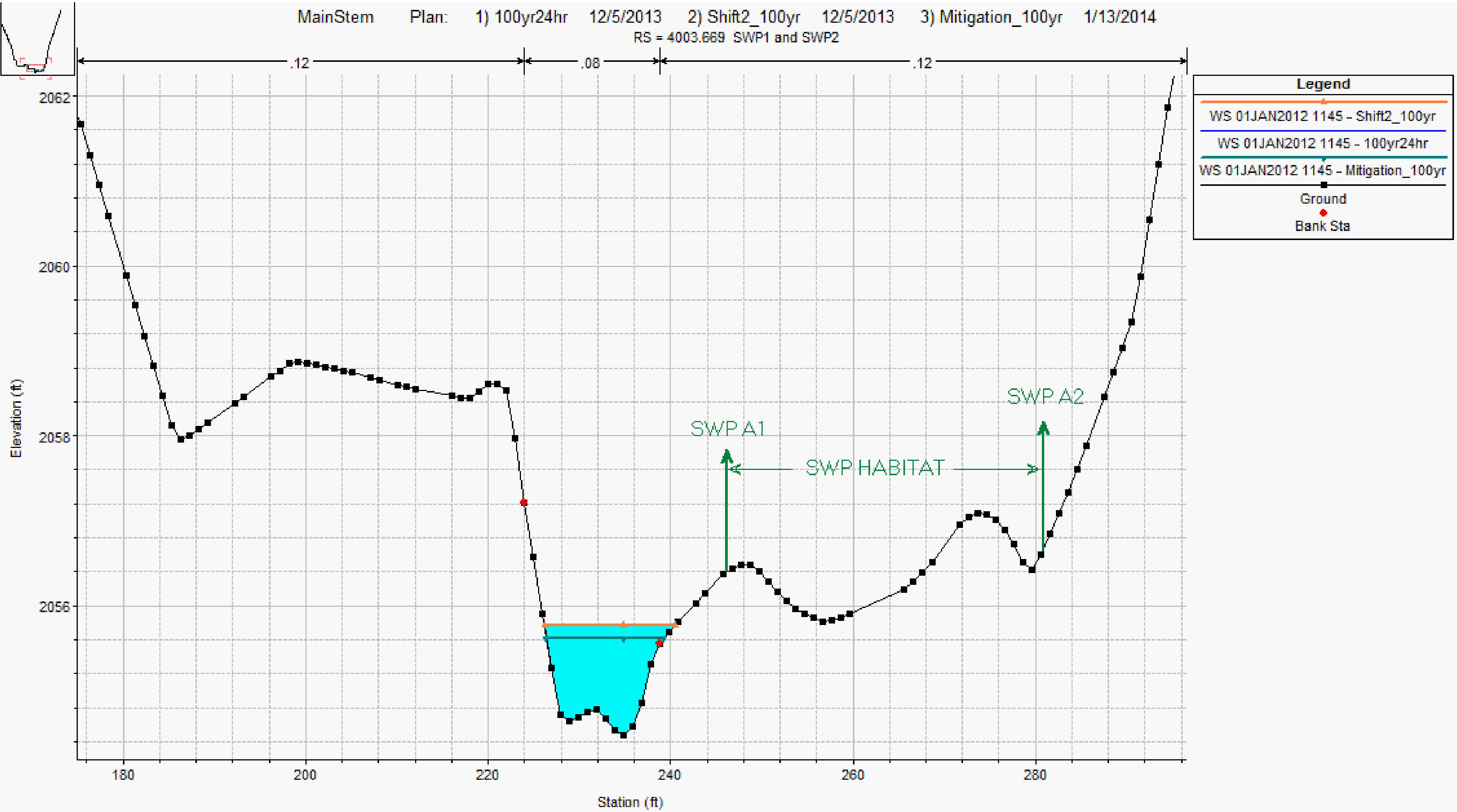
2-yr WSEL Animation at SWP A1 and A2



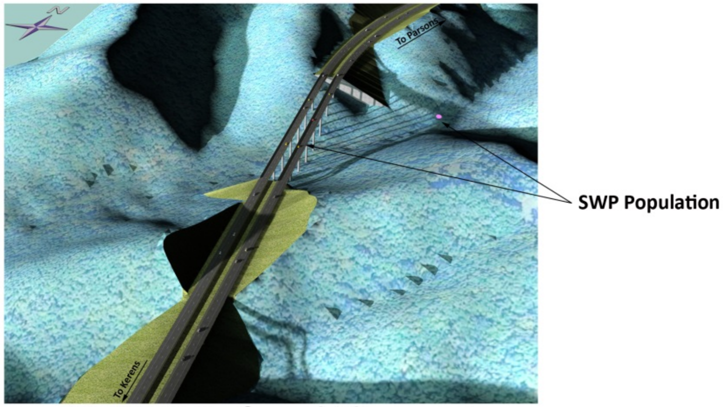
5-yr WSEL Animation at SWP A1 and A2



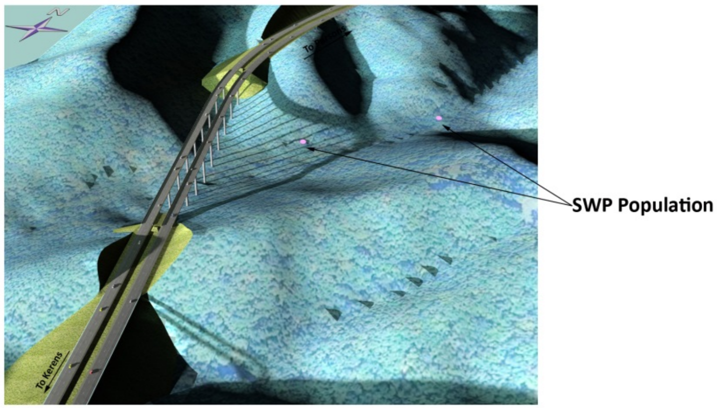
100-yr WSEL Animation at SWP A1 and A2



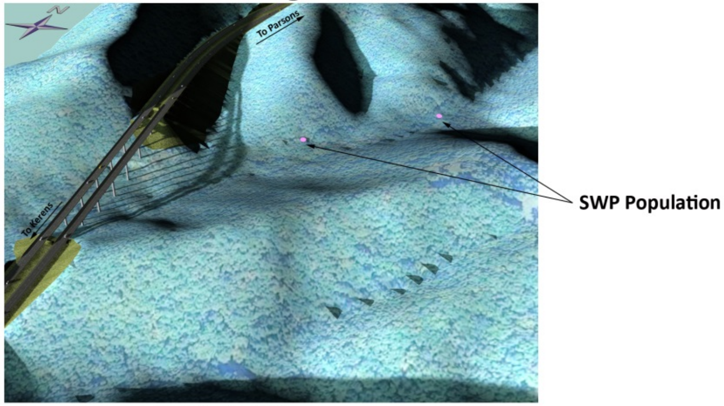
Shadow Modeling Study at SWP



PA-SDEIS Preferred Alignment

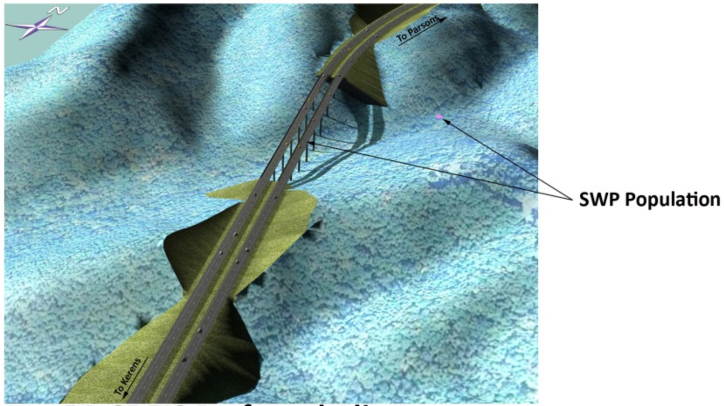


Shift 1 Alignment

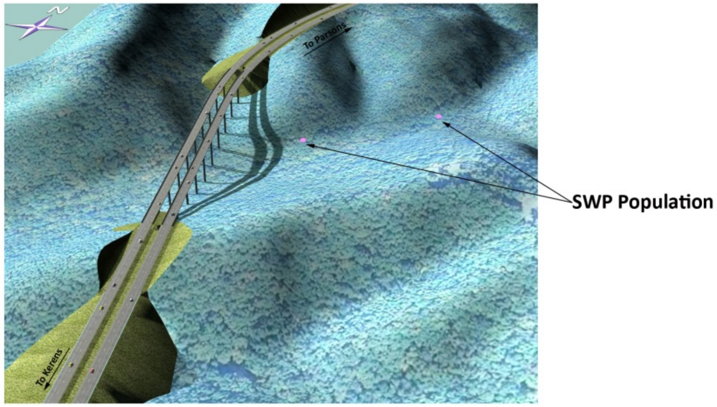


Shift 2 Alignment

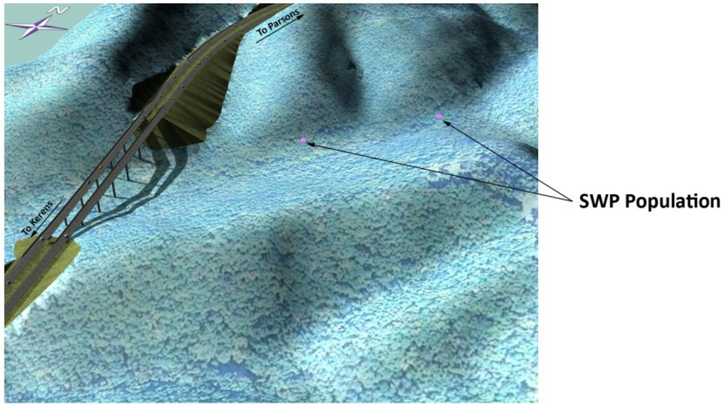
Panther Run Shadow Study
December 21st at 5:00 PM



PA-SDEIS Preferred Alignment

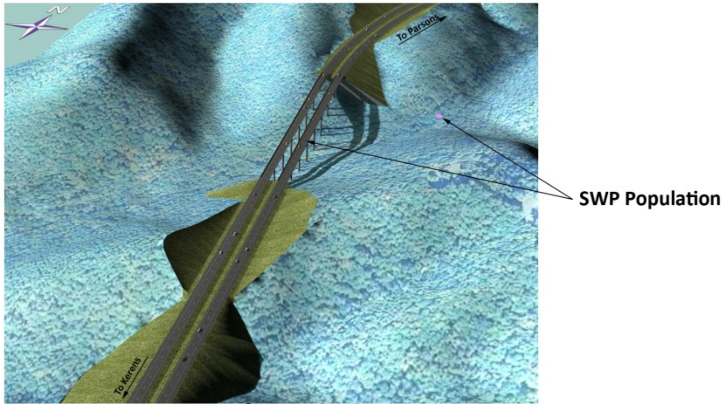


Shift 1 Alignment



Shift 2 Alignment

Panther Run Shadow Study
June 21st at 6:00 PM



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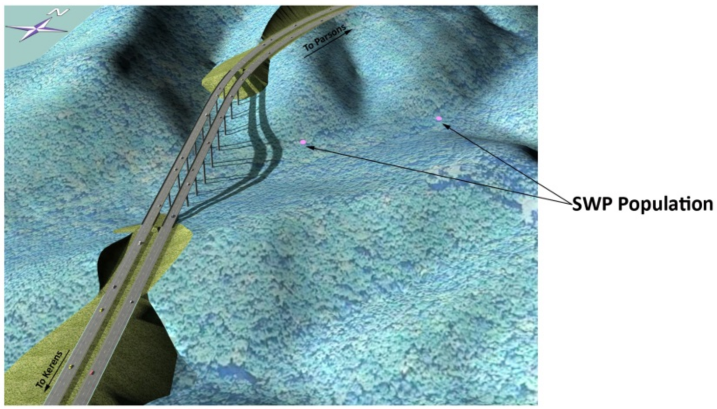

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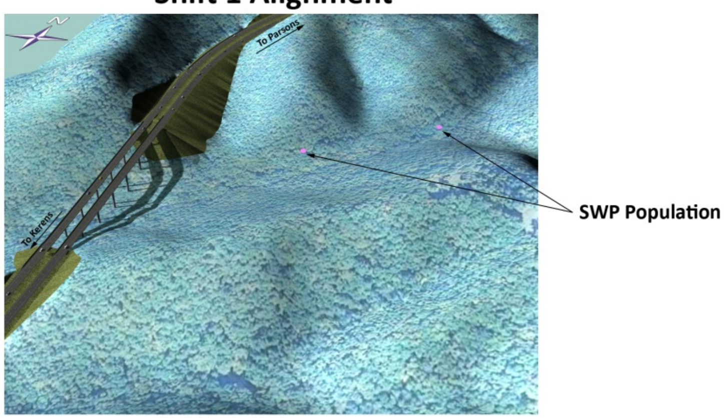
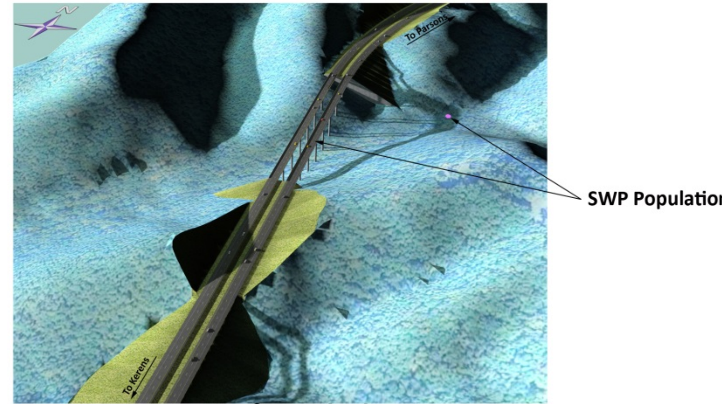
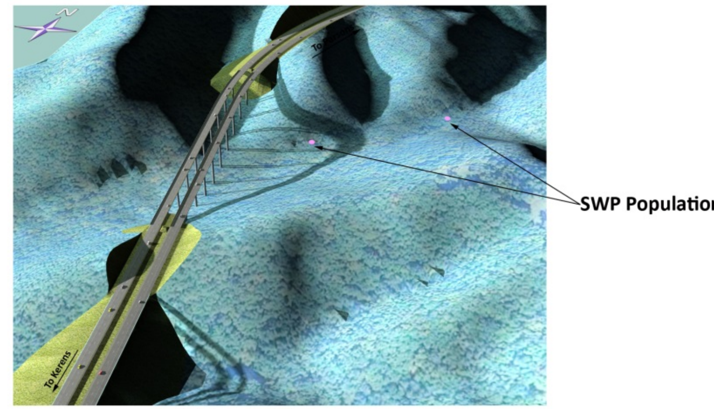


Shift 2 Alignment

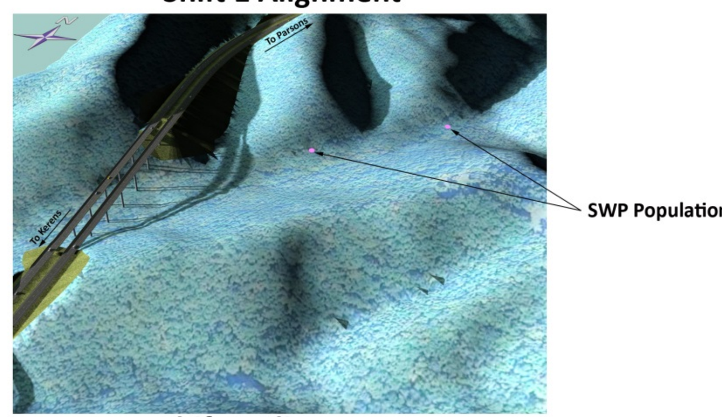
Panther Run Shadow Study
March 21st at 5:00 PM



PA-SDEIS Preferred Alignment



Shift 1 Alignment



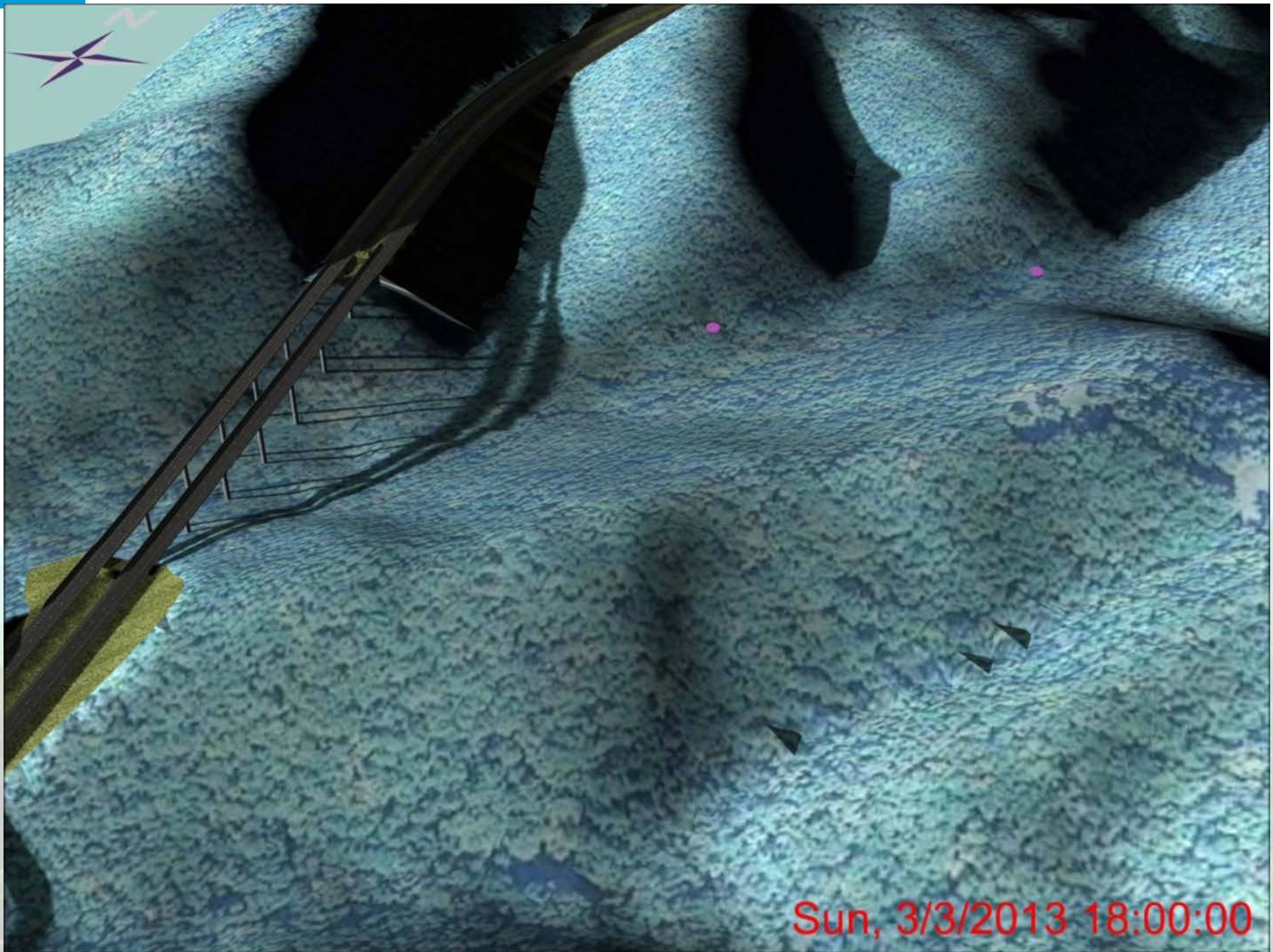
Shift 2 Alignment

Panther Run Shadow Study
September 22st at 6:00 PM

Baker

Shadow Study – Original Alignment – March to October

Shadow Study – Shift 3 Alignment – March to October



Panther Run
Storm Water Pollution Prevention Plan (SWPPP)

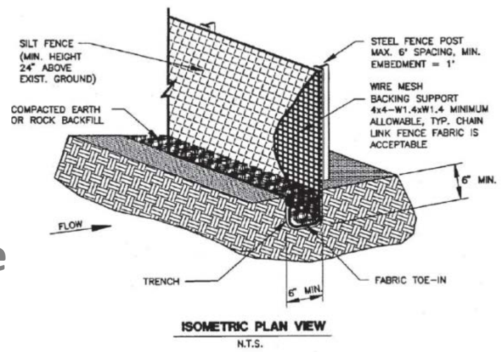
Potential Strategies

General Management Controls

Critical Source Control Elements to prevent rainfall and runoff from contacting potential pollutants

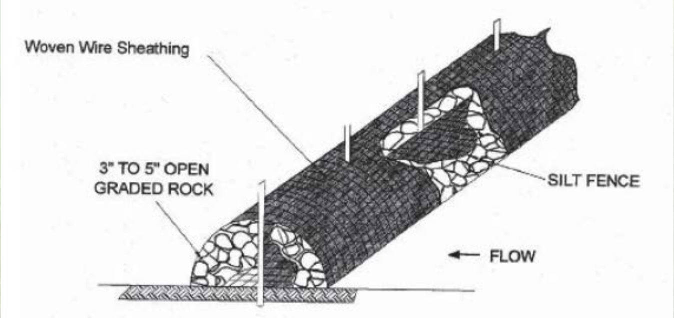
- **Site Management – Good Housekeeping**
  - Inventory on-site products and store chemicals safely
  - Cover and berm stockpiles
- **Non-storm Water Management**
  - Eliminate non-stormwater (SW) un-permitted discharge
  - Minimize allowable non-SW discharge
- **Erosion and Sediment Controls**
  - Referenced in SWPPP Maps
  - Limit disturbance of vegetation and topsoil where possible (perimeter controls)
  - Using SWPPP development and BMP guidance documents from:
    - California Stormwater Quality Association (CASQA)
    - TCEQ Edwards Aquifer Guidance
    - Dr. Michael Barrett (University of Texas)
    - California Department of Transportation

Silt Fence



Complying with the Edward Aquifer Rules (TCEQ)

Rock Berm



Complying with the Edward Aquifer Rules (TCEQ)

Structural BMPs

Baker

Project could incorporate the most effective controls to protect sensitive habitat, including consideration of:

- **Pre-Construction BMPs:**
  - Silt Fence
  - Check Dams
  - Fiber Rolls
  - Storm Drain Inlet Protection
- **Post-Construction BMPs:**
  - Detention Ponds
  - Infiltration Basin / Trench
  - Retention / Irrigation
  - Wet Basins
  - Vegetated Strips and Swales
  - Bio-retention
  - Media Filter

Media Filter TC-40

Design Considerations

- Aesthetics
- Hydraulic Head

Description

Stormwater media filters are usually two-chambered including a pretreatment settling basin and a filter bed filled with sand or other absorptive filtering media. As stormwater flows into the first chamber, large particles settle out, and then finer particles and other pollutants are removed as stormwater flows through the filtering media in the second chamber. There are a number of design variations including the Austin sand filter, Delaware sand filter, and multi-chambered treatment train (MCTT).

California Experience

Caltrans constructed and monitored five Austin sand filters, two MCTTs, and one Delaware design in southern California. Pollutant removal was very similar for each of the designs; however operational and maintenance aspects were quite different. The Delaware filter and MCTT maintain permanent pools and consequently mosquito management was a critical issue, while the Austin style which is designed to empty completely between storms was less affected. Removal of the top few inches of sand was required at 3 of the Austin filters and the Delaware filter during the third year of operation; consequently, sizing of the filter bed is a critical design factor for establishing maintenance frequency.

Targeted Constituents

☑	Sediment	■
☑	Nutrients	●
☑	Trash	■
☑	Metals	■
☑	Bacteria	▲
☑	Oil and Grease	■
☑	Organics	■

Legend *(Removal Effectiveness)*

● Low ■ High

▲ Medium

Advantages

- Relatively high pollutant removal, especially for sediment and associated pollutants.
- Widespread application with sufficient capture volume can provide significant control of channel erosion and enlargement caused by changes to flow frequency relationships resulting from the increase of impervious cover in a watershed.

Limitations

CASQA
CALIFORNIA STORMWATER QUALITY ASSOCIATION

Structural BMPs

Infiltration Basin

Source: Caltrans

Media Filter

Source: Stanard et al. (2008)

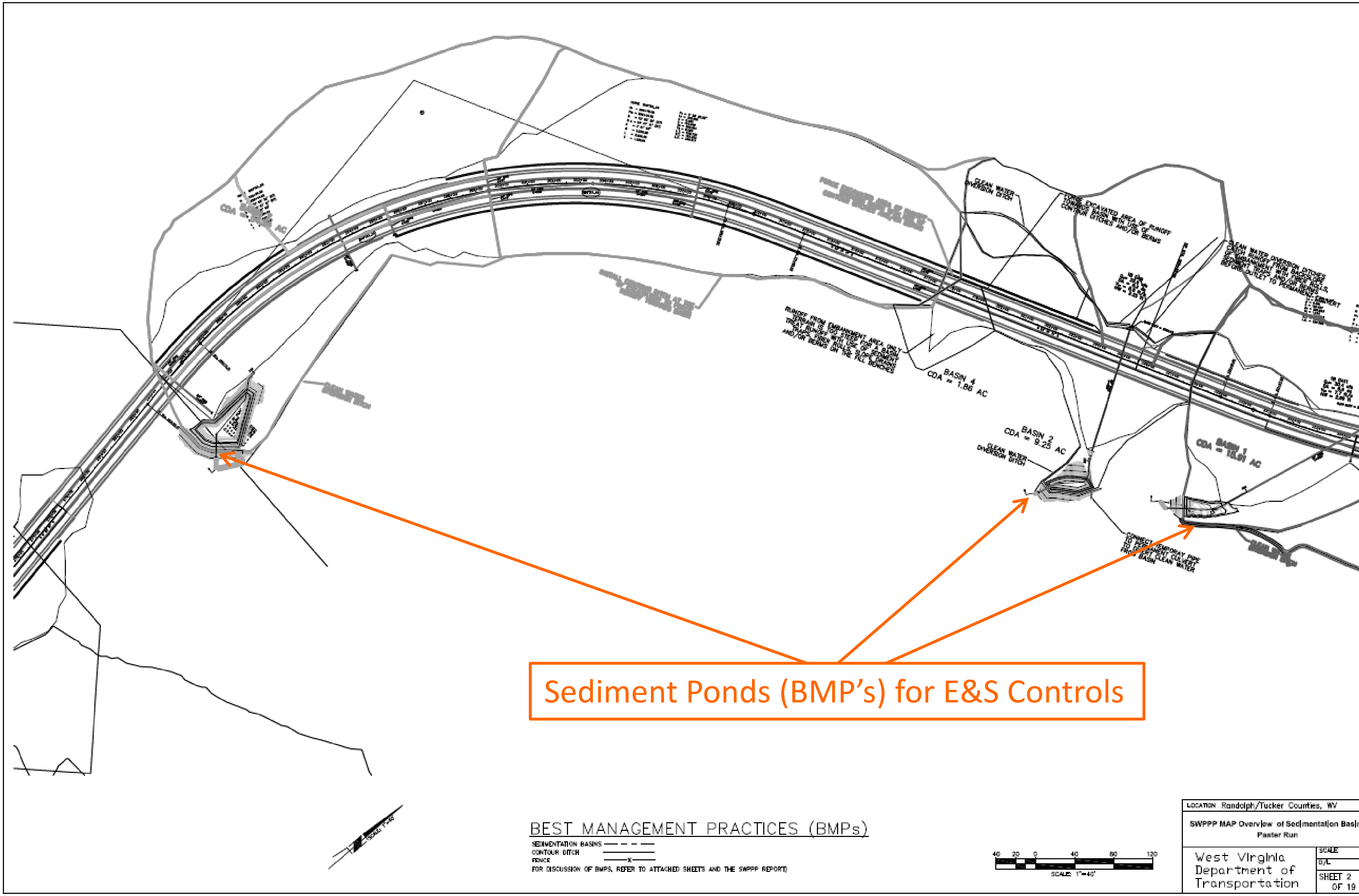
Sand Filter

Source: Caltrans

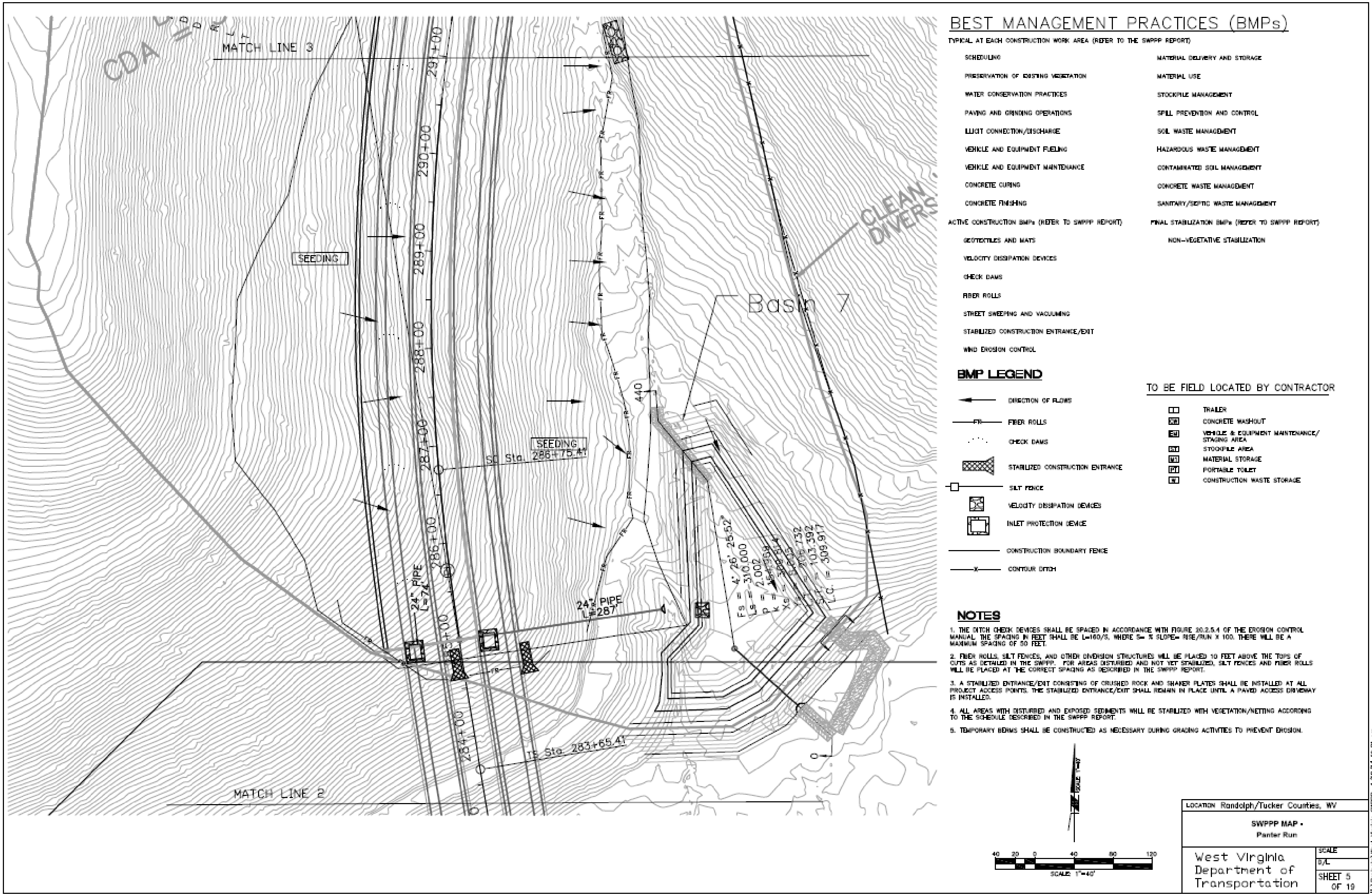
Vegetated Swale

Source: Caltrans

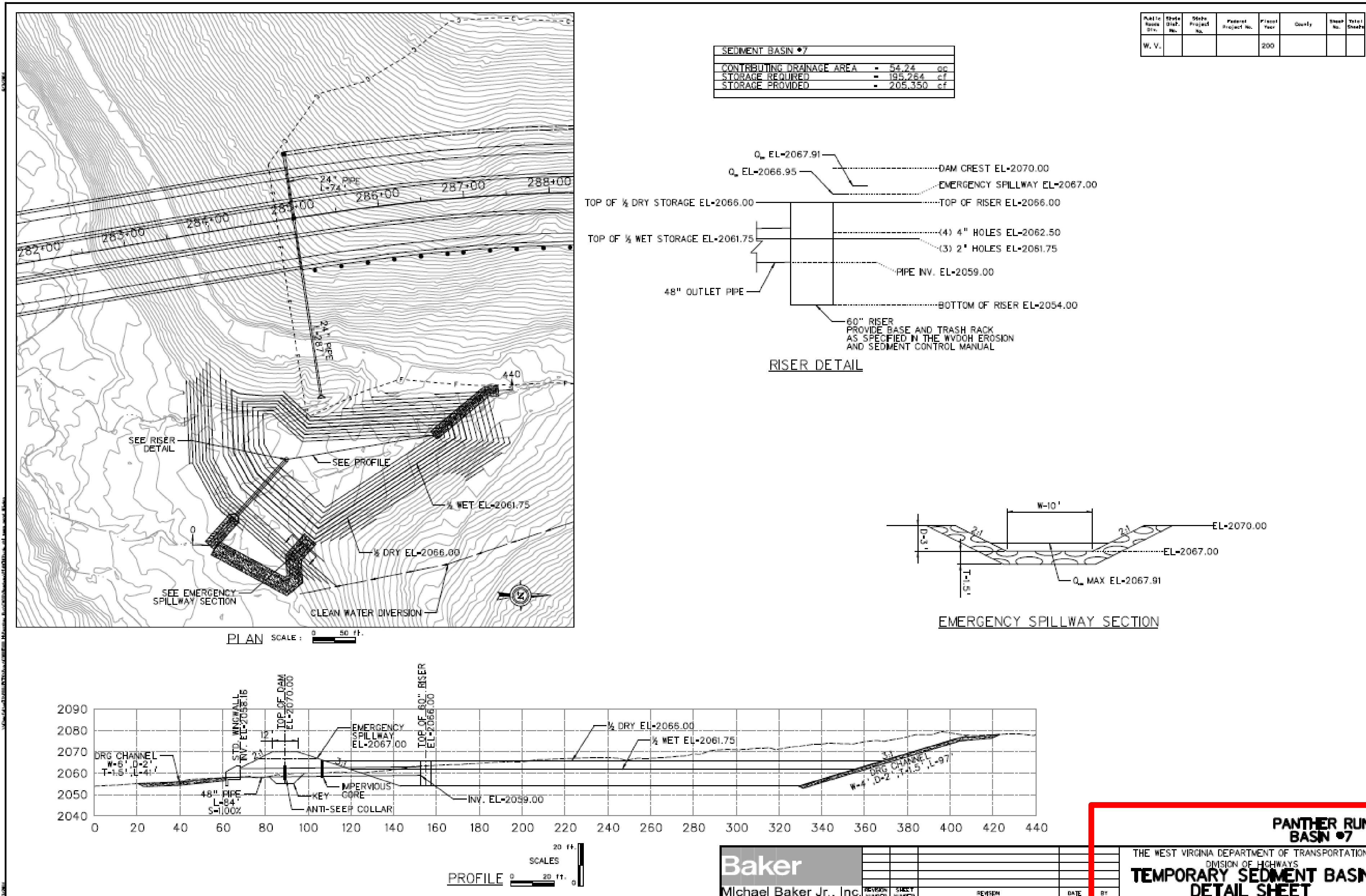
Shift 3 BMP's Conceptual Plan - Overview Map



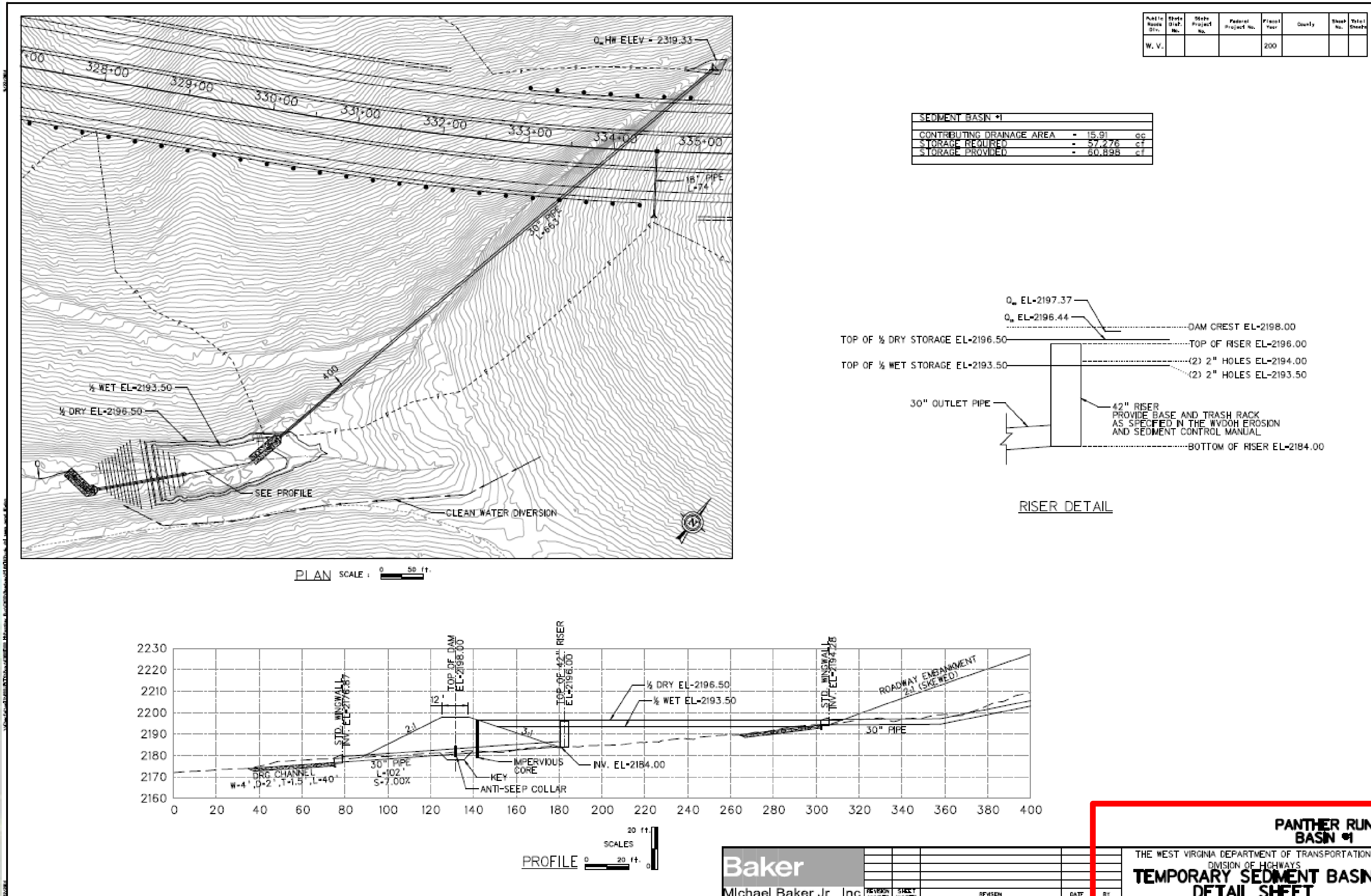
Shift 3 BMP's Conceptual Plan – Basin 7



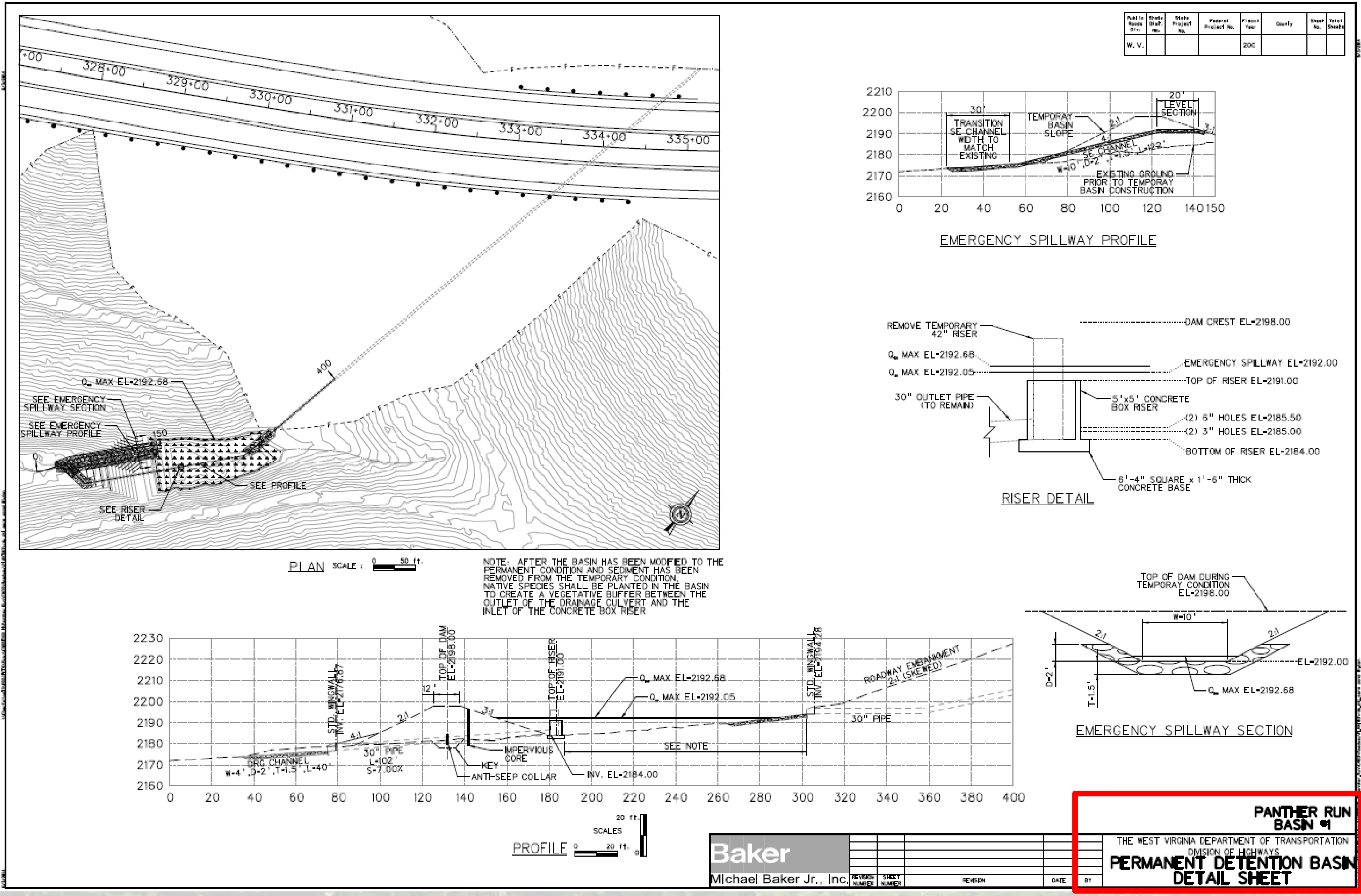
Shift 3 BMP's Conceptual Plan – Basin 7



Shift 3 BMP's Conceptual Plan – Basin 1



Shift 3 BMP's Conceptual Plan – Basin 1



Modeling Effort in Numbers

Hydrology- HEC-HMS :

- **45** hydrologic elements (sub-basins, junctions, reaches, reservoirs) in hydrologic model.
- **8,496** Flow hydrographs generated in the HMS.
- **450MB** output file. (HEC-DSS)

Hydraulics- HEC-RAS Unsteady

- **82** Unsteady Hydraulic model runs
- **97MB** – at **4.5 hours** when the runoff from the hypothetical 24-hr storm event is at its peak.
- **500MB –** for **24 hour** time period would result in each output file exceeding
- **8GB** plus Output data

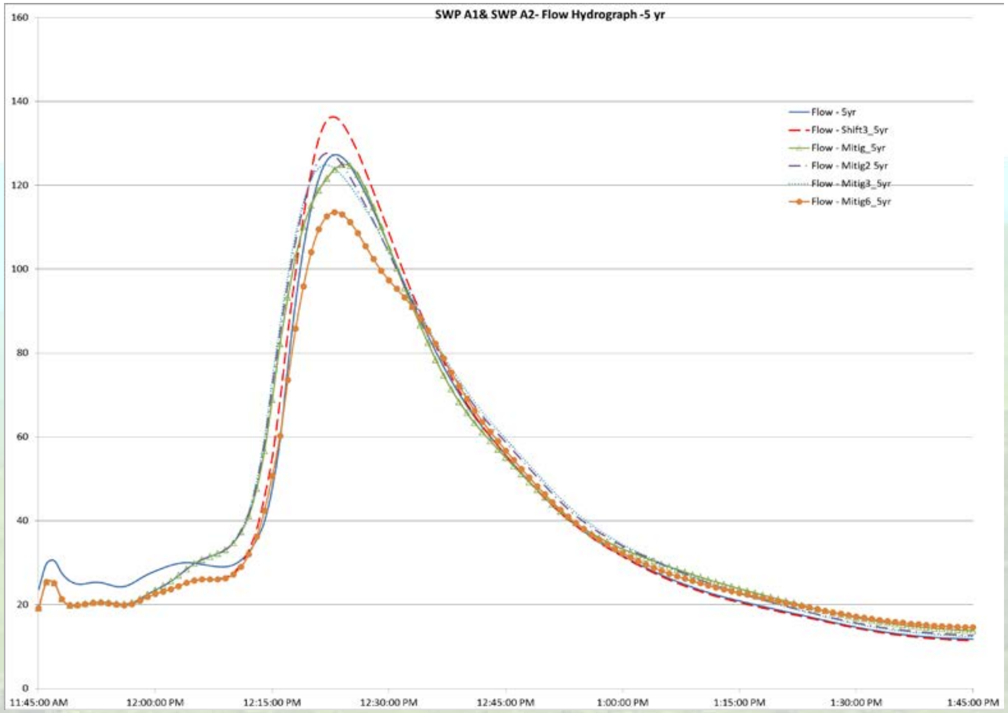
Summary and Discussion

Panther Run Watershed H&H analyses performed to:

1. **Established existing** hydrologic & hydraulic conditions at SWP Locations
2. **Established proposed** conditions due to roadway construction
3. **Predicted changes** due to the proposed roadway construction
4. **Conceptualized** mitigation measures and **Demonstrated** their effectiveness

H&H Models developed to predict changes in key H&H variables

- Peak Discharges
- WSEL or Stage
- Flow Depth
- Velocities
- Shear Stress
- Water Exposure Analysis



Hydrograph (Peak Discharge) – Comparing Existing/Shifts/Mitigation Conditions

Project Team

- **Presenters – Baker/WVDOH Key Team Members**

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