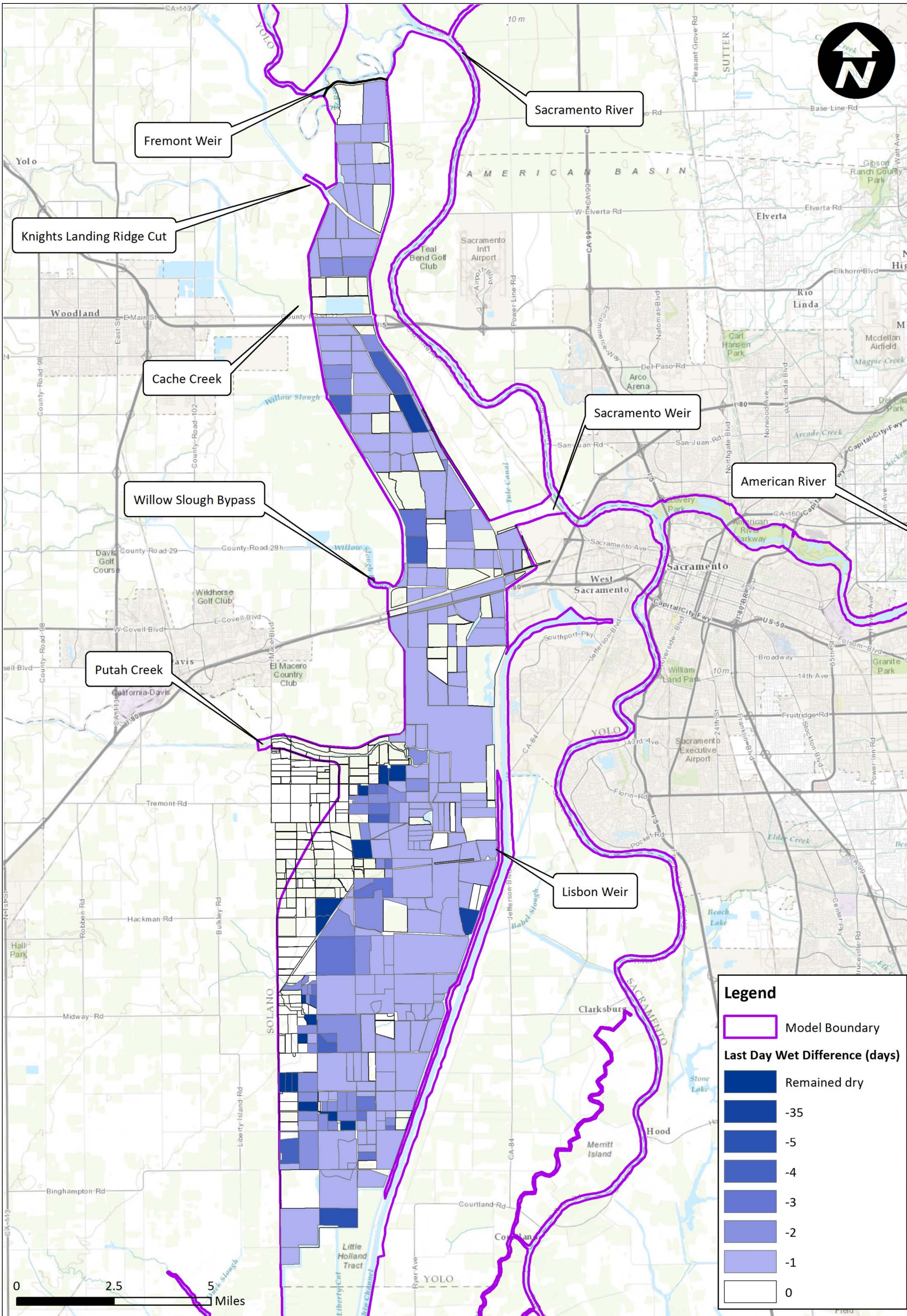

Notes: Differences to Last Day Wet for existing conditions when decreasing inflows 10%. Negative values indicate earlier Last Day Wet.

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Existing LDW Sensitivity to 10% Decrease in Flow WY 2011

Prepared for DWR | Created By: RDJ | **Figure 8-12**

9.0 Conclusions

A TUFLOW classic hydrodynamic model has been developed to help evaluate impacts and benefits of potential alternatives for the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project. Three alternatives for channel and gate designs at the Fremont Weir and an alternative with channels and gates at the Sacramento Weir were evaluated. The model domain extends along the Sacramento River just South of Tisdale Bypass to near Rio Vista, includes the Yolo Bypass, and includes portions of the Feather River, Sutter Bypass, American River and various North Delta sloughs.

Model results have been provided for use in analyses to quantify the impacts and benefits of the four alternatives modeled. While the benefits and impacts will be evaluated by other analyses, some observations can be made from the TUFLOW model results. All of the alternatives increase the extent and duration of inundation events within the Bypass. The three Fremont Weir alternatives provide similar increases in inundation. The FreLg alternative provides the largest inundation benefit of 7,700 acres in 2 out of 3 years. The SacW alternative typically provides half the inundation increase of the Fremont Weir alternatives.

Potential changes to sediment erosion and deposition within the Bypass and in the Sacramento River are currently being evaluated.

The comprehensive nature of the model makes it a useful tool to serve as a basis for future analyses.

9.1 Summary of Modeling Work/Data Passed Along

Post-processed model results have been provided to other teams to inform other analyses. The Agriculture Economics team has been provided GIS data indicating the last day of inundation anticipated for individual field units within the Bypass. The fisheries team has been provided daily GIS raster data for depths and velocity magnitudes within the Bypass and time-series discharge data at specific locations within the model. The CALSIM Modeling team has been provided discharge versus discharge scatter plots for the each of the modeled alternatives to define rating curves for CALSIM model input.

9.2 Recommendations for Future Model Improvements

The gate/channel designs and operations used for this study are preliminary and this modeling effort focused on identifying the relative differences between alternatives. Changes to the design and operation may impact the results.

A datum error for some of the water years at the downstream WSE versus time boundary condition at Rio Vista are discussed in Section 6.2. Sensitivity analysis confirmed that the change would have had little impact on the results but future analyses should use the corrected boundary data.

Bridges inside and outside of the Bypass were not represented in the model. Most bridges are not submerged even in large floods but pier losses could be added in appropriate places. It was learned through the modeling that the County Road 22 bridge over the Tule Canal is low enough to become submerged in large floods. Model calibration suggests that incorporating this change is not important for large scale analysis. Should the need for bridges or bridge piers to be incorporated more explicitly in model arise, it should be recognized that calibration may need to be revisited.

The number and length of simulations greatly constrained cell sizes and time steps. Smaller cells within the Bypass would have better represented the topography, particularly features incorporated using polylines which are smaller than the 100 feet elevation spacing (i.e., berms and drainage ditches). Local WSE oscillations which occurred near 1D/2D domain boundaries during high discharge periods due to differences in the 1D/2D time steps may benefit from adjusting 2D cell-sizes and time steps. Future modeling efforts involving fewer simulations and/or shorter durations should attempt to make this refinement.

Hydraulic structures (e.g., culverts, gates) along the drainage features within the Bypass could be added to more accurately represent flow constrictions and impediments to drainage, however, it should be recognized that culverts and gates for individual fields may change from season to season.

The model was calibrated to three events specifically chosen to represent a high flow period, a low-flow period, and a receding limb period. Data is available for other flood events such as the 2006 flood which could be used to further calibrate or validate the model. In addition, the USGS maintains a comprehensive network of gauges recording stage and flow in the slough system south of the Stair Step and Courtland that can be used to calibrate the flow splits within the Cache Slough Complex.

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Appendix A

Sacramento Slough and Willow Slough Bathymetric Survey

Technical Memorandums

TECHNICAL MEMORANDUM

Date:	June 6, 2014
To:	Project File
From:	Chris Campbell, MS, Benjamin Taber, BS, PE
Project:	13-1027 – Yolo Bypass Salmonid Habitat Restoration and Fish Passage
Subject:	Sacramento Slough Bathymetric Survey

1 INTRODUCTION

cbec, inc., eco engineering (cbec) performed a bathymetric survey of Sacramento Slough on September 6th, 2013 to support hydrodynamic model development for the Yolo Bypass Modeling Project. The objective of the survey was to define the geometry of the slough channel bed such that the slough could be represented in 1D as a series of cross sections or transects. The surveyed reach extends from the confluence with the Sacramento River upstream approximately 8.5 miles. Transects were taken at select locations with a spacing of approximately 2,000 feet on the lower reach (from the confluence to the RD 1500 pumps) and a spacing of approximately 4,000 feet on the upper reach (upstream of the RD 1500 pumps). Transects were field fitted to select areas with minimal riparian vegetation on the banks with the assumption that the Central Valley Floodplain Evaluation and Delineation (CVFED) LiDAR data would be used to represent the overbank areas at each transect. Transects on the upper section were chosen to capture the constrictions in channel geometry where the existing earthen spur dikes protrude into the channel, and also because dense aquatic vegetation was present between the spur dikes, which preclude bathymetric data collection. Additional cross sections were recorded on the upstream and downstream sides of the two bridges within the study reach, as well as additional survey data to characterize the bridge geometry. See Figure 1 for a map of Sacramento Slough showing the extents of the surveyed reach and transect locations.

2 METHODS

2.1 BATHYMETRY

The bathymetric survey was performed utilizing an Ohmex Sonarmite echosounder integrated with a Trimble R8 Global Navigation Satellite System (GNSS) receiver mounted to a boat. The echosounder produces sound pulses that measure the distance from the transducer to the bottom of the water body being surveyed. Real Time Kinematic (RTK) Global Positioning System (GPS) was used in conjunction with

California Survey and Drafting Supply (CSDS) VSN mobile base network to provide positional corrections to the Trimble receiver. Both position and depth were recorded on a mobile data collector in real time while performing the survey. Equipment data sheets are provided in Appendix A.

2.2 CONTROL AND DATUMS

Prior to surveying, the cbec field crew occupied two benchmarks reported in the CVFED LiDAR survey control documentation (see Table 1) to correct for horizontal and vertical variations in the observations. These variations are caused by atmospheric conditions as well as specific satellite geometry at the time of data acquisition.

Table 1. CVFED benchmarks (this survey)

Benchmark	Reported Northing[1]	Reported Easting[1]	Reported Elevation (ft,NAVD88)[2]	Observed Northing[1]	Observed Easting[1]	Observed Elevation (ft,NAVD88)[2]
NGS (AI5071)	2067336.22	6632368.27	25.09	2067336.26	6632368.19	25.12
WR168	2034616.71	6649412.49	42.74	2034594.71	6648606.76	42.71
[1] California State Planes, Zone 2, NAD 83, US Survey feet [2] North American Vertical Datum 1988 (NAVD88), Geoid 2009						

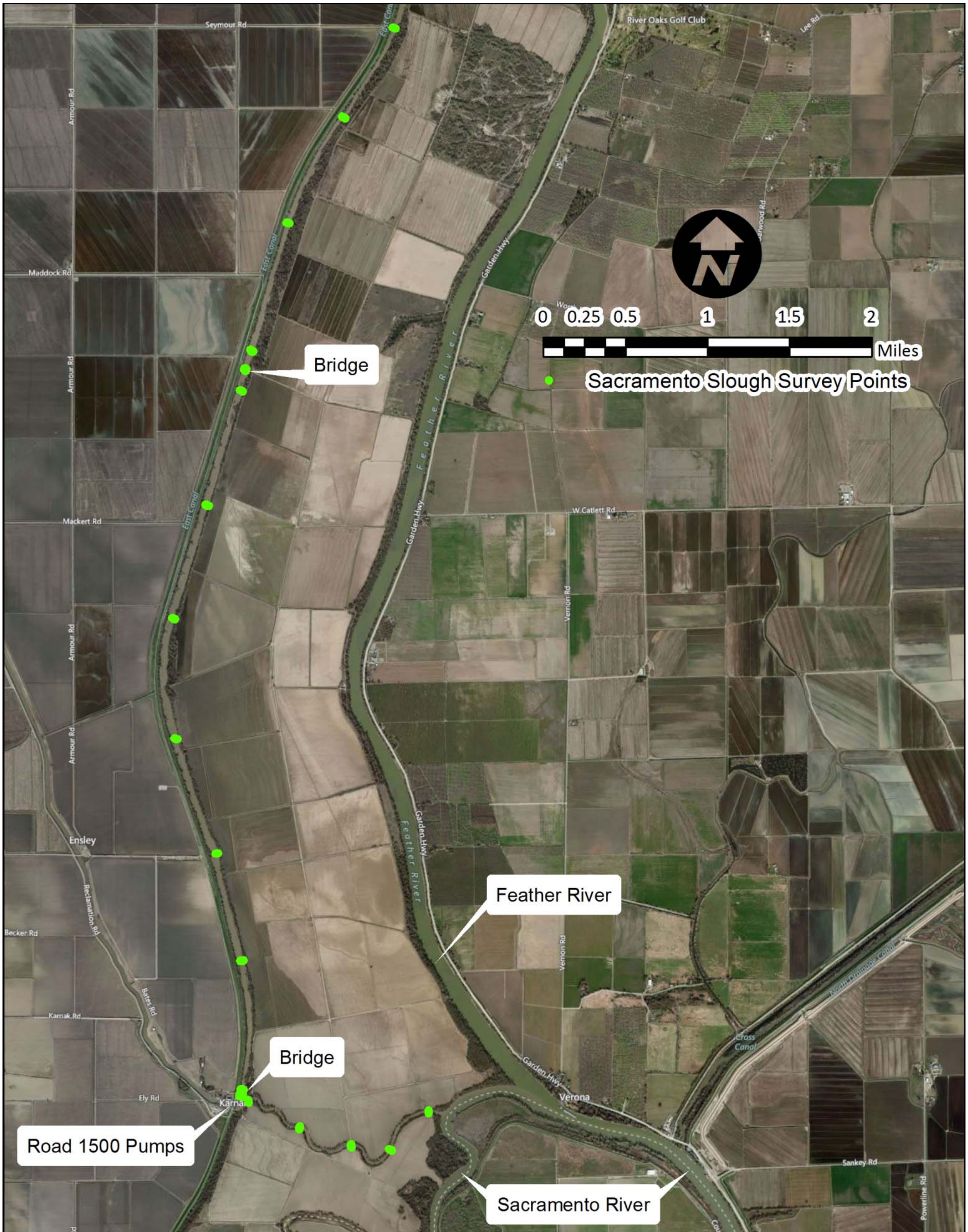
2.3 QUALITY ASSURANCE / QUALITY CONTROL

Quality assurance and quality control is a priority task when performing bathymetric surveys. A standard bar check was performed prior to collecting data to calibrate the sonar for local site conditions as they relate to sound velocity. As transects were being recorded, recorded depths and positions were reviewed for irregularities and the potential effects of submerged aquatic vegetation. Once in the office, post processing involved calibrating the positional data to the local CVFED benchmarks and visually inspecting the data for erroneous readings.

3 RESULTS SUMMARY

Quality control results showed an acceptable range when tying into control less than or equal to the accuracy of the instrumentation (i.e., H: 0.10 ft and V: 0.15 ft). The sounding data also passed an in-house quality control standard of less than 5% bad or missing depths. All suspected vegetation returns were manually filtered from the data set prior to exporting and the corrected points are provided in the attached file. Twenty cross sections and two bridges were recorded in total. The surveyed transects provide sufficient channel geometry to characterize 1D flows in Sacramento Slough for the purpose of the Yolo Bypass Fish Passage Project.

Attachment: 13-1027_SacSl_090613_88_g09_QCcadeport.csv



Notes: image courtesy of Bing Maps		*Yolo Bypass Salmonid Habitat Restoration and Fish Passage* **Sacramento Slough Transect Locations**		
		Prepared for DWR	Created By: BST	**Figure 1**

APPENDIX A

DATASHEET

TRIMBLE R8 GNSS RECEIVER

KEY FEATURES

Advanced Trimble R-Track technology

Unmatched GNSS tracking performance

Includes Trimble Maxwell 6 chip with 220 channels

Remote configuration and access

Base and rover communications options to suit any application

The Trimble® R8 GNSS Receiver sets the new standard for full-featured GNSS (Global Navigation Satellite System) receiver technology. This integrated system delivers unmatched power, accuracy and performance in a rugged, compact unit.

ADVANCED TRIMBLE R-TRACK TECHNOLOGY

The Trimble R8 GNSS delivers the latest advancements in R-Track™ technology, designed to deliver reliable, precise positioning performance. In challenging areas for GNSS surveying, such as tree cover or limited sky view, Trimble R-Track provides unmatched tracking performance of GNSS satellite signals.

Trimble R-Track with Signal Prediction™ compensates for intermittent or marginal RTK correction signals, enabling extended precision operation after an RTK signal is interrupted.

The new CMRx communications protocol provides unprecedented correction compression for optimized bandwidth and full utilization all of the satellites in view, giving you the most reliable positioning performance.

Featuring the Trimble Maxwell™ 6 chip, the Trimble R8 GNSS advances the industry with more memory and more GNSS channels. Trimble delivers business confidence with a sound GNSS investment for today and into the future.

Broad GNSS Support

The Trimble R8 GNSS supports a wide range of satellite signals, including GPS L2C and L5 and GLONASS L1/L2 signals. In addition, Trimble is committed to the next generation of modernized GNSS configurations by providing Galileo-compatible products available for customers well in advance of Galileo system availability[1,2]. In support of this plan, the new Trimble R8 GNSS is capable of tracking the experimental GIOVE-A and GIOVE-B test satellites for signal evaluation and test purposes.

FLEXIBLE SYSTEM DESIGN

The Trimble R8 GNSS receiver combines the most comprehensive feature set into an integrated and flexible system for demanding surveying applications. The Trimble R8 GNSS includes a built-in transmit/receive UHF radio, enabling ultimate flexibility for rover or base operation. As a base station, the internal NTRIP caster provides you with customized access[3] to base station corrections via the internet.

Trimble's exclusive, Web UI™ eliminates travel requirements for routine monitoring of base station receivers. Now you can assess the health and status of base receivers and perform remote configurations from the office. Likewise, you can download post-processing data through Web UI and save additional trips out to the field.

ENABLING THE CONNECTED SITE

Pair the speed and accuracy of the Trimble R8 GNSS receiver with flexibility and collaboration tools of Trimble Access™ software. Trimble Access brings field and office teams closer by enabling data sharing and collaboration in a secure, web-based environment. With optional streamlined workflows, Trimble Access further empowers surveyors and survey teams for success. Now it is easier than ever to realize the potential of the Trimble Connected Site. Connecting the right tools, techniques, services and relationships enables surveying businesses to achieve more every day.

1 ***Galileo Commercial Authorization***
Receiver technology having Galileo capability to operate in the Galileo frequency bands and using information from the Galileo system for future operational satellites is restricted in the publicly available Galileo Open Service Signal-In-Space Interface Control Document (GAL OS SIS ICD) and is not currently authorized for commercial use.
Receiver technology that tracks the GIOVE-A and GIOVE-B test satellites uses information that is unrestricted in the public domain in the GIOVE A + B Navigation Signals-In-Space Interface Control Document. Receiver technology having developmental GIOVE-A and B capability is intended for signal evaluation and test purposes.

2 *For more information about Trimble and GNSS modernization, please visit* ***http://www.trimble.com/srv_new_era.shtml****.*

3 *Cellular modem required.*

Trimble.

PERFORMANCE SPECIFICATIONS

Measurements

- Trimble R-Track technology
- Advanced Trimble Maxwell 6 Custom Survey GNSS chip with 220 channels
- High precision multiple correlator for GNSS pseudorange measurements
- Unfiltered, unsmoothed pseudorange measurements data for low noise, low multipath error, low time domain correlation and high dynamic response
- Very low noise GNSS carrier phase measurements with <1 mm precision in a 1 Hz bandwidth
- Signal-to-Noise ratios reported in dB-Hz
- Proven Trimble low elevation tracking technology
- Satellite signals tracked simultaneously:
  - GPS: L1C/A, L2C, L2E (Trimble method for tracking L2P), L5
  - GLONASS: L1C/A, L1P, L2C/A (GLONASS M only), L2P
  - SBAS: L1C/A, L5
  - Galileo GIOVE-A and GIOVE-B

Code differential GNSS positioning[1]

Horizontal .... 0.25 m + 1 ppm RMS
Vertical .... 0.50 m + 1 ppm RMS
WAAS differential positioning accuracy[2] .... typically <5 m 3DRMS

Static and FastStatic GNSS surveying[1]

Horizontal .... 3 mm + 0.1 ppm RMS
Vertical .... 3.5 mm + 0.4 ppm RMS

Kinematic surveying[1]

Horizontal .... 10 mm + 1 ppm RMS
Vertical .... 20 mm + 1 ppm RMS
Initialization time[3] .... typically <10 seconds
Initialization reliability[4] .... typically >99.9%

HARDWARE

Physical

Dimensions (W×H) .... 19 cm × 11.2 cm (7.5 in x 4.4 in), including connectors
Weight .... 1.34 kg (2.95 lb) with internal battery, internal radio, standard UHF antenna.
3.70 kg (8.16 lb) entire RTK rover including batteries, range pole, controller and bracket
Temperature[5]
Operating .... –40 °C to +65 °C (–40 °F to +149 °F)
Storage .... –40 °C to +75 °C (–40 °F to +167 °F)
Humidity .... 100%, condensing
Water/dustproof .... IP67 dustproof, protected from temporary immersion to depth of 1 m (3.28 ft)
Shock and vibration .... Tested and meets the following environmental standards:
Shock .... Non-operating: Designed to survive a 2 m (6.6 ft) pole drop onto concrete. Operating: to 40 G, 10 msec, sawtooth
Vibration MIL-STD-810F, FIG.514.5C-1

Electrical

- Power 11 to 28 V DC external power input with over-voltage protection on Port 1 (7-pin Lemo)
- Rechargeable, removable 7.4 V, 2.4 Ah Lithium-Ion battery in internal battery compartment. Power consumption is 3.2 W, in RTK rover mode with internal radio. Operating times on internal battery:
  - 450 MHz receive only option .... 5.8 hours[7]
  - 450 MHz receive/transmit option .... 3.7 hours[8]
  - GSM/GPRS .... 4.1 hours[7]
- Certification Class B Part 15, 22, 24 FCC certification, 850/1900 MHz. Class 10 GSM/GPRS module. CE Mark approval, and C-tick approval

Communications and Data Storage

- 3-wire serial (7-pin Lemo) on Port 1. Full RS-232 serial on Port 2 (Dsub 9 pin)
- Fully Integrated, fully sealed internal 450 MHz receiver/transmitter option:
  - Transmit power: 0.5 W
  - Range[6]: 3–5 km typical / 10 km optimal
- Fully integrated, fully sealed internal GSM/GPRS option[7]
- Fully integrated, fully sealed 2.4 GHz communications port (Bluetooth®)[9]
- External cellphone support for GSM/GPRS/CDPD modems for RTK and VRS operations
- Data storage on 57 MB internal memory: 40.7 days of raw observables (approx. 1.4 MB /Day), based on recording every 15 seconds from an average of 14 satellites
- 1 Hz, 2 Hz, 5 Hz, 10 Hz, and 20 Hz positioning
- CMR+, CMRx, RTCM 2.1, RTCM 2.3, RTCM 3.0, RTCM 3.1 Input and Output
- 16 NMEA outputs, GSOF, RT17 and RT27 outputs. Supports BINEX and smoothed carrier

1 Accuracy and reliability may be subject to anomalies due to multipath, obstructions, satellite geometry, and atmospheric conditions. Always follow recommended survey practices.
2 Depends on WAAS/EGNOS system performance.
3 May be affected by atmospheric conditions, signal multipath, obstructions and satellite geometry.
4 May be affected by atmospheric conditions, signal multipath, and satellite geometry. Initialization reliability is continuously monitored to ensure highest quality.
5 Receiver will operate normally to –40 °C, internal batteries are rated to –20 °C.
6 Varies with terrain and operating conditions.
7 Varies with temperature.
8 Varies with temperature and wireless data rate.
9 Bluetooth type approvals are country specific. Contact your local Trimble Authorized Distribution Partner for more information.

Specifications subject to change without notice.

PN 022543-079J (11/09)

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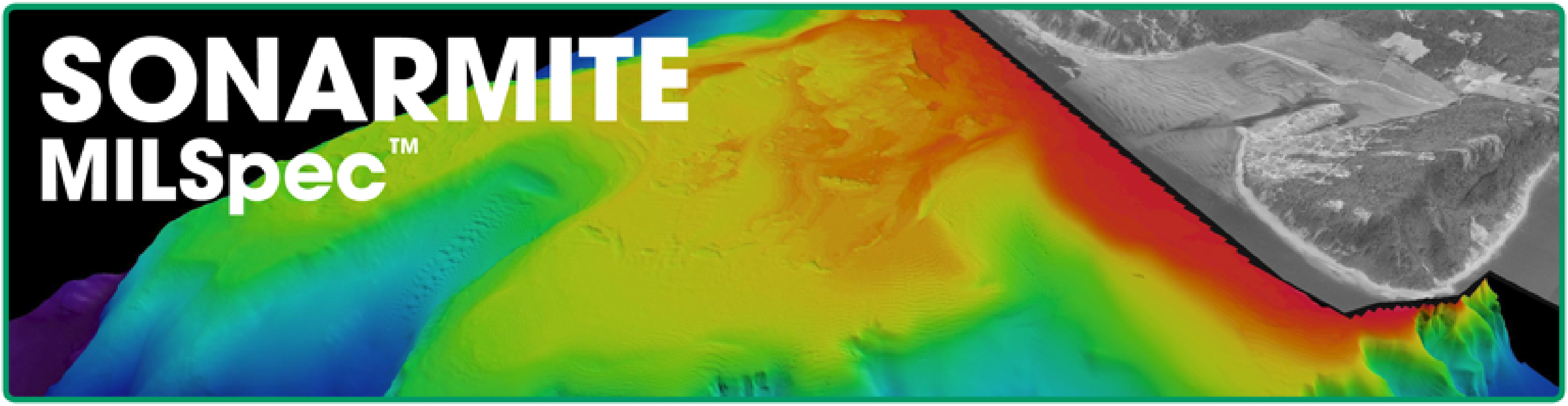
PRODUCT DATASHEET

SONARMITE MILSpec™



ABOUT

The SonarMite MILSpec™ Echo Sounder is result of nearly two years research and development tofurther extend the boundaries of shallow water hydrographic surveying equipment. The introduction by Ohmex in 1997 of the SonarLite, the worlds first truly portable echo sounder system, has been a hard act to follow and it remains the portable instrument of choice in many survey companies around the world. The release of the SonarMite instrument marks the next stage introducing a series of equipment designed around the WinSTRUMENT concept using the latest portable computer integrated with new measurment technologies.

FEATURES

- Rugged, field-proven survey grade echosounder
- Bluetooth technology integrated with Windows Pocket PC devices
- Proven 'Smart' transducer design with QA output
- Internal rechargeable battery for all day use
- Easily integrated with other modern software & GPS technology

OPTIONS

- Data collection software
- Heave, Pitch and Roll measurements
- Sound velocimeter
- Portable mounting bracket
- Rugged shipping case
- Extended warranty

SPECS

ECHOSOUNDER

- Frequency: 200-KHz
- Beam width: 4-degrees
- Ping Rate: 6 Hz
- Depth Accuracy: 1cm /0.1% of depth
- Output Formats: NMEA, ASCII
- Range: 0.3m-75m
- I/O: Serial, Bluetooth
- Environmental: IP-65
- Power: Rechargable 12V battery

PHOTOS

3941 Park Drive, Suite 20-218. El Dorado Hills, CA 95762 | info@seafloorSystems.com, www.seafloorsystems.com | (530) 677-1019

TECHNICAL MEMORANDUM

Date:	June 6, 2014
To:	Project File
From:	Chris Campbell, MS, Benjamin Taber, BS, PE
Project:	13-1027 – Yolo Bypass Salmonid Habitat Restoration and Fish Passage
Subject:	Willow Slough Bathymetric Survey

1 INTRODUCTION

cbec, inc., eco engineering (cbec) performed a bathymetric survey of Willow Slough on October 8th, 2013 to support hydrodynamic model development for the Yolo Bypass Modeling Project. The objective of the survey was to define the geometry of the slough channel bed such that the slough could be represented in 1D as a series of cross sections or transects. The surveyed reach extends from the confluence with the Tule Canal upstream approximately 3.75 miles where transects were taken at select locations with a spacing of approximately 2,000 feet. Surveyed cross sections were field fitted to select areas with minimal riparian vegetation on the banks with the assumption that the Central Valley Floodplain Evaluation and Delineation (CVFED) LiDAR data would be used to represent the overbank areas at each transect. Additional cross sections were recorded on the upstream and downstream sides of the two bridges within the study reach, as well as additional survey data to characterize the bridge geometry. See Figure 1 for a map of Willow Slough showing the extents of the surveyed reach and transect locations.

2 METHODS

2.1 BATHYMETRY

The bathymetric survey was performed utilizing Real Time Kinematic (RTK) Global Positioning System (GPS) terrestrial wading, as well as employing an inflatable kayak with a longer stadia rod for areas with greater depths. RTK GPS was used in conjunction with California Survey and Drafting Supply (CSDS) VSN mobile base network to provide positional corrections to the Trimble receiver. Equipment data sheets are provided in Appendix A.

2.2 CONTROL AND DATUMS

Prior to surveying, the cbec field crew occupied one benchmark reported in the CVFED LiDAR survey control documentation (see Table 1) to correct for horizontal and vertical variations in the observations. These variations are caused by atmospheric conditions as well as specific satellite geometry at the time of data acquisition.

Table 1. CVFED benchmarks (this survey)

Benchmark	Reported Northing[1]	Reported Easting[1]	Reported Elevation (ft,NAVD88)[2]	Observed Northing[1]	Observed Easting[1]	Observed Elevation (ft,NAVD88)[2]
WR145	1967746.71	6664280.36	24.777	1967746.896	6664280.142	24.491
[1] California State Planes, Zone 2, NAD 83, US Survey feet [2] North American Vertical Datum 1988 (NAVD88), Geoid 2009						

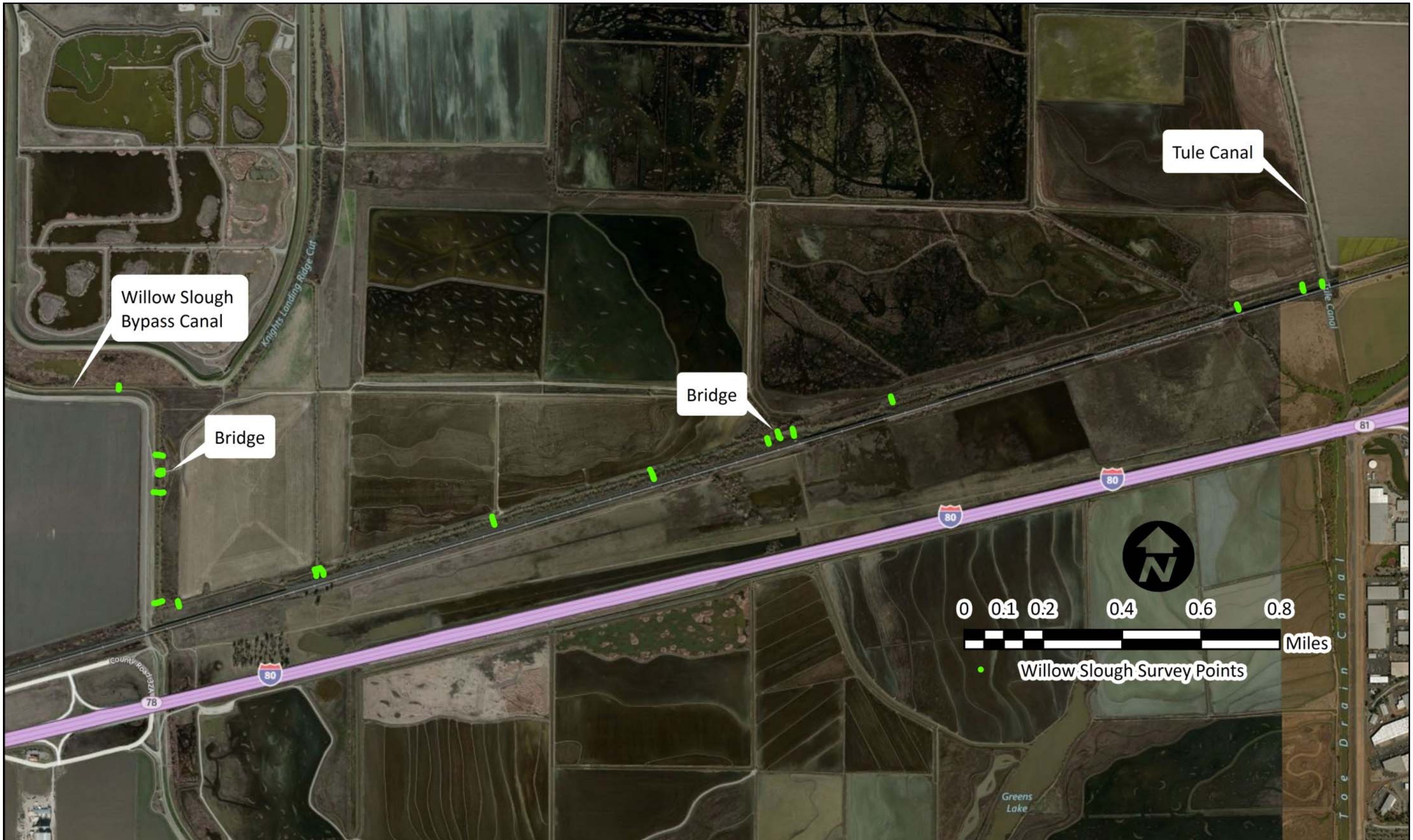
2.3 QUALITY ASSURANCE / QUALITY CONTROL

Quality assurance and quality control is a priority task when performing bathymetric and topographic surveys. Field software is programmed to only store points within the accuracy of the instrumentation (i.e., H: 0.10 ft and V: 0.15 ft). Upon completion of the survey, cbec staff provided an in house visual inspection of the field data in order to identify potentially erroneous data by plotting cross sections in processing software. All observed data was calibrated in order to match the local CVFED benchmark.

3 RESULTS SUMMARY

Sufficient data to characterize nineteen cross sections and two bridges/crossings were recorded in total. The surveyed transects provide sufficient channel geometry to characterize 1D flows in Willow Slough for the purpose of the Yolo Bypass Salmonid Habitat Restoration and Fish Passage.

Attachment: 13-1027_WillowSl_100813_88_g09.csv



Notes: image courtesy of Bing Maps

HDR cbec eco engineering

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Willow Slough Transect Locations

Prepared for DWR	Created By: BST	**Figure 1**

APPENDIX A

DATASHEET

TRIMBLE R8 GNSS RECEIVER

KEY FEATURES

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Unmatched GNSS tracking performance

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Trimble R-Track with Signal Prediction™ compensates for intermittent or marginal RTK correction signals, enabling extended precision operation after an RTK signal is interrupted.

The new CMRx communications protocol provides unprecedented correction compression for optimized bandwidth and full utilization all of the satellites in view, giving you the most reliable positioning performance.

Featuring the Trimble Maxwell™ 6 chip, the Trimble R8 GNSS advances the industry with more memory and more GNSS channels. Trimble delivers business confidence with a sound GNSS investment for today and into the future.

Broad GNSS Support

The Trimble R8 GNSS supports a wide range of satellite signals, including GPS L2C and L5 and GLONASS L1/L2 signals. In addition, Trimble is committed to the next generation of modernized GNSS configurations by providing Galileo-compatible products available for customers well in advance of Galileo system availability[1,2]. In support of this plan, the new Trimble R8 GNSS is capable of tracking the experimental GIOVE-A and GIOVE-B test satellites for signal evaluation and test purposes.

FLEXIBLE SYSTEM DESIGN

The Trimble R8 GNSS receiver combines the most comprehensive feature set into an integrated and flexible system for demanding surveying applications. The Trimble R8 GNSS includes a built-in transmit/receive UHF radio, enabling ultimate flexibility for rover or base operation. As a base station, the internal NTRIP caster provides you with customized access[3] to base station corrections via the internet.

Trimble's exclusive, Web UI™ eliminates travel requirements for routine monitoring of base station receivers. Now you can assess the health and status of base receivers and perform remote configurations from the office. Likewise, you can download post-processing data through Web UI and save additional trips out to the field.

ENABLING THE CONNECTED SITE

Pair the speed and accuracy of the Trimble R8 GNSS receiver with flexibility and collaboration tools of Trimble Access™ software. Trimble Access brings field and office teams closer by enabling data sharing and collaboration in a secure, web-based environment. With optional streamlined workflows, Trimble Access further empowers surveyors and survey teams for success. Now it is easier than ever to realize the potential of the Trimble Connected Site. Connecting the right tools, techniques, services and relationships enables surveying businesses to achieve more every day.

1 ***Galileo Commercial Authorization***
Receiver technology having Galileo capability to operate in the Galileo frequency bands and using information from the Galileo system for future operational satellites is restricted in the publicly available Galileo Open Service Signal-In-Space Interface Control Document (GAL OS SIS ICD) and is not currently authorized for commercial use.
Receiver technology that tracks the GIOVE-A and GIOVE-B test satellites uses information that is unrestricted in the public domain in the GIOVE A + B Navigation Signals-In-Space Interface Control Document. Receiver technology having developmental GIOVE-A and B capability is intended for signal evaluation and test purposes.

2 *For more information about Trimble and GNSS modernization, please visit* ***http://www.trimble.com/srv_new_era.shtml***.

3 *Cellular modem required.*

Trimble.

PERFORMANCE SPECIFICATIONS

Measurements

- Trimble R-Track technology
- Advanced Trimble Maxwell 6 Custom Survey GNSS chip with 220 channels
- High precision multiple correlator for GNSS pseudorange measurements
- Unfiltered, unsmoothed pseudorange measurements data for low noise, low multipath error, low time domain correlation and high dynamic response
- Very low noise GNSS carrier phase measurements with <1 mm precision in a 1 Hz bandwidth
- Signal-to-Noise ratios reported in dB-Hz
- Proven Trimble low elevation tracking technology
- Satellite signals tracked simultaneously:
  - GPS: L1C/A, L2C, L2E (Trimble method for tracking L2P), L5
  - GLONASS: L1C/A, L1P, L2C/A (GLONASS M only), L2P
  - SBAS: L1C/A, L5
  - Galileo GIOVE-A and GIOVE-B

Code differential GNSS positioning[1]

Horizontal . . . . 0.25 m + 1 ppm RMS
Vertical . . . . 0.50 m + 1 ppm RMS
WAAS differential positioning accuracy[2] . . . . typically <5 m 3DRMS

Static and FastStatic GNSS surveying[1]

Horizontal . . . . 3 mm + 0.1 ppm RMS
Vertical . . . . 3.5 mm + 0.4 ppm RMS

Kinematic surveying[1]

Horizontal . . . . 10 mm + 1 ppm RMS
Vertical . . . . 20 mm + 1 ppm RMS
Initialization time[3] . . . . typically <10 seconds
Initialization reliability[4] . . . . typically >99.9%

HARDWARE

Physical

Dimensions (W×H) . . . . 19 cm × 11.2 cm (7.5 in x 4.4 in), including connectors
Weight . . . . 1.34 kg (2.95 lb) with internal battery, internal radio, standard UHF antenna.
3.70 kg (8.16 lb) entire RTK rover including batteries, range pole, controller and bracket
Temperature[5]
Operating . . . . –40 °C to +65 °C (–40 °F to +149 °F)
Storage . . . . –40 °C to +75 °C (–40 °F to +167 °F)
Humidity . . . . 100%, condensing
Water/dustproof . . . . IP67 dustproof, protected from temporary immersion to depth of 1 m (3.28 ft)
Shock and vibration . . . . Tested and meets the following environmental standards:
Shock . . . . Non-operating: Designed to survive a 2 m (6.6 ft) pole drop onto concrete. Operating: to 40 G, 10 msec, sawtooth
Vibration MIL-STD-810F, FIG.514.5C-1

Electrical

- Power 11 to 28 V DC external power input with over-voltage protection on Port 1 (7-pin Lemo)
- Rechargeable, removable 7.4 V, 2.4 Ah Lithium-Ion battery in internal battery compartment. Power consumption is 3.2 W, in RTK rover mode with internal radio. Operating times on internal battery:
  - 450 MHz receive only option . . . . 5.8 hours[7]
  - 450 MHz receive/transmit option . . . . 3.7 hours[8]
  - GSM/GPRS . . . . 4.1 hours[7]
- Certification Class B Part 15, 22, 24 FCC certification, 850/1900 MHz. Class 10 GSM/GPRS module. CE Mark approval, and C-tick approval

Communications and Data Storage

- 3-wire serial (7-pin Lemo) on Port 1. Full RS-232 serial on Port 2 (Dsub 9 pin)
- Fully Integrated, fully sealed internal 450 MHz receiver/transmitter option:
  - Transmit power: 0.5 W
  - Range[6]: 3–5 km typical / 10 km optimal
- Fully integrated, fully sealed internal GSM/GPRS option[7]
- Fully integrated, fully sealed 2.4 GHz communications port (Bluetooth®)[9]
- External cellphone support for GSM/GPRS/CDPD modems for RTK and VRS operations
- Data storage on 57 MB internal memory: 40.7 days of raw observables (approx. 1.4 MB /Day), based on recording every 15 seconds from an average of 14 satellites
- 1 Hz, 2 Hz, 5 Hz, 10 Hz, and 20 Hz positioning
- CMR+, CMRx, RTCM 2.1, RTCM 2.3, RTCM 3.0, RTCM 3.1 Input and Output
- 16 NMEA outputs, GSOF, RT17 and RT27 outputs. Supports BINEX and smoothed carrier

1 Accuracy and reliability may be subject to anomalies due to multipath, obstructions, satellite geometry, and atmospheric conditions. Always follow recommended survey practices.
2 Depends on WAAS/EGNOS system performance.
3 May be affected by atmospheric conditions, signal multipath, obstructions and satellite geometry.
4 May be affected by atmospheric conditions, signal multipath, and satellite geometry. Initialization reliability is continuously monitored to ensure highest quality.
5 Receiver will operate normally to –40 °C, internal batteries are rated to –20 °C.
6 Varies with terrain and operating conditions.
7 Varies with temperature.
8 Varies with temperature and wireless data rate.
9 Bluetooth type approvals are country specific. Contact your local Trimble Authorized Distribution Partner for more information.

Specifications subject to change without notice.

PN 022543-079J (11/09)

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Appendix B

Sacramento Weir Information

E. Pratt

SUPPLEMENT TO STANDARD OPERATION AND MAINTENANCE MANUAL

SACRAMENTO RIVER
FLOOD CONTROL PROJECT
UNIT NO. 158
SACRAMENTO WEIR
SACRAMENTO RIVER, CALIFORNIA

SACRAMENTO DISTRICT

CORPS OF ENGINEERS

U. S. ARMY

SACRAMENTO, CALIFORNIA

CORPS OF ENGINEERS
U. S. ARMY

SUPPLEMENT TO STANDARD OPERATION AND MAINTENANCE MANUAL SACRAMENTO RIVER FLOOD CONTROL PROJECT

UNIT NO. 158
SACRAMENTO WEIR
SACRAMENTO RIVER, CALIFORNIA

Prepared by the Sacramento District
Corps of Engineers, U. S. Army
August 1955

UNIT NO. 158
TABLE OF CONTENTS
SUBJECT
SECTION I - INTRODUCTION

SECTION II - FEATURES OF THE PROJECT
SUBJECT TO FLOOD CONTROL REGULATIONS

SECTION III - REPAIR OF DAMAGE TO PROJECT WORKS
AND METHODS OF COMBATING FLOOD CONDITIONS

TABLE OF CONTENTS
(Continued)

EXHIBITS

SUPPLEMENT TO STANDARD
OPERATION AND MAINTENANCE MANUAL
SACRAMENTO RIVER FLOOD CONTROL PROJECT

UNIT NO. 158
SACRAMENTO WEIR
SACRAMENTO RIVER, CALIFORNIA

SECTION I - INTRODUCTION

1-01. Location. - The improvement covered by this manual is that part of the Sacramento River Flood Control Project which comprises the Sacramento Weir together with its adjoining channel, levees at the abutments, railroad bridge, highway bridge and appurtenances, as shown on the location map, Exhibit A-1 and drawings of Exhibit B. The weir is located in Yolo County, California along the right bank of the Sacramento River near Bryte, California and about 3.1 miles northwesterly from the City of Sacramento.

1-02. Project Works. - The Sacramento Weir is a reinforced concrete weir with wooden needles that provide a movable crest. There are 48 weir sections each 38 feet long. A highway bridge 20 feet wide and a single track railroad traverses the length of the weir. Concrete abutments at each end tie into the west levee of the Sacramento River and the north and south levees of the Sacramento Bypass. For more complete details of these structures see drawings of Exhibit B.

1-03. Protection Provided. - The Sacramento Weir is designed to protect the City of Sacramento and adjacent area from flood damage by providing means for release of excess over-flow waters of the Sacramento and American Rivers into the Yolo Bypass system. The project design capacity of the Sacramento Weir is 112,000 cubic feet per second.

1-04. Construction Data and Contractor. - The Sacramento Weir was constructed by Teichert & Ambrose under contract which was awarded by the City of Sacramento in June 1916. Subsequently the City was reimbursed for the costs of construction by the Sacramento District.

1-05. Flood Flows. - For purpose of this manual, the term "flood" or "high water period" shall refer to flows when the water surface in the Sacramento River reaches or exceeds the reading of 25.0 on the continuous water stage recorder and staff gage of the U. S. Weather Bureau and State Division of Water Resources located on the left bank of the Sacramento River at the foot of "I" Street, City of Sacramento. Zero of staff gage and recorders is set at elevation 3.10 U. S. Corps of Engineers datum and 0.03 foot U.S.G.S. datum. The term "flood" or "high water period" may also apply when the water surface in the Sacramento River reaches or exceeds the reading of 29.0 on the continuous water stage recorder and staff gage of the U. S. Corps of Engineers and the State Division of Water Resources located on a pile dolphin on the right bank of the Sacramento River 100 feet downstream from the Sacramento Weir. Zero of this gage is set at 0.00 feet U. S. Corps of Engineers datum and minus 3.07 feet U.S.G.S. datum.

1-06. Assurances Provided by Local Interests. - Assurances of cooperation by local interests is provided by State legislation as contained in Chapter 3, Part 2, Division 5 of the State Water Code (see paragraph 2-02a of the Standard Manual).

1-07. Acceptance by State Reclamation Board. - Responsibility for operating and maintaining the completed works was officially accepted by the Reclamation Board of the State of California on 18 December 1951, as shown on the attached letter of acceptance, Exhibit F.

1-08. Superintendent. - The name and address of the Superintendent appointed by the State or acting as a representative of the State Division of Water Resources for the continuous inspection, operation and maintenance of the Project works shall be furnished the District Engineer, and in case of any change of Superintendent, The District Engineer shall be so notified.

SECTION II

FEATURES OF THE PROJECT SUBJECT TO FLOOD CONTROL REGULATIONS

2-01. Drainage and Weir Structure.

a. Description. The Sacramento Weir is a reinforced fixed concrete structure located along the right bank of the Sacramento River about 3.1 miles northwesterly from the City of Sacramento. A concrete sheet pile cut-off wall extends the full length of the weir, a distance of 1,980 feet. The weir crest elevation is 24.75 feet. Hinged 3" x 12" wooden needles backed by a 20" x 28" wooden needle beam make it possible to raise the crest to elevation 31.0. ~~A float-release mechanism capable of dropping the needle gates to elevation 25.0 can be adjusted to release when the water level reaches any elevation from 31.0 to 38.0.~~ Concrete piers on 41.25 foot centers carry highway and railroad bridges across the weir. Concrete abutments at each end of the weir tie into the levees on the west side of the Sacramento River at this location. The abutments also tie into the north and south levees of the Sacramento Bypass. The leveed bypass has an average channel width of 1,800 feet and extends southwesterly from the weir to the Yolo Bypass. For more complete details of these structures see drawings of Exhibit B.

b. For pertinent Requirements of the Code of Federal Regulations and other requirements see the following:

(1) Maintenance - Paragraph 5-02 of the Standard Manual.

24.75

(2) Check Lists - Exhibit E of this Supplement Manual.

(3) Operation - Paragraph 5-04 of the Standard Manual.

(4) Additional Requirements - Paragraph 5-05 of the Standard Manual.

(5) Safety Requirements - Paragraph 5-06 of the Standard Manual.

c. Special requirements pertaining to the Sacramento Weir:

(1) All missing parts of the hinged needles shall be replaced immediately following each flood period and that another inspection is made prior to the next flood season to be certain that all missing posts have been replaced.

(2) On the tripping devices the Superintendent shall make certain that:

(a) No parts are missing.

(b) Metal parts are adequatly covered with paint.

(c) All movable parts are in satisfactory working order.

(d) All padlocks are not corroded and can be opened with a proper key.

(e) Sufficient replacement materials are on hand and will be readily available in times of emergency.

(3) A sufficient stockpile of needle beams, hinged needles, and cable is available for replacement in times of emergency. The extra beam used for raising needles is readily available and in good operating condition at all times. Make certain that arrangements have been made to employ a mobile crane capable of handling the needle beams if and when needed.

(4) There are no encreachments upon the right-of-way which might endanger the structure or hinder its functioning in time of flood.

(5) A schedule of operation for the movable top of the Sacramento Weir is contained in Exhibit H of this manual.

2-02. Channel.

a. Description. For purpose of this manual the channel will be considered as that portion which extends from the Sacramento River to a point 200 feet downstream from the lower face of the weir structure. Beyond this point the channel maintenance is covered by other manuals.

b. For pertinent Requirements of the Code of Federal Regulations and other requirements see the following:

(1) Maintenance - Paragraph 6-02 of the Standard Manual.

(2) Check Lists - Exhibit E of this Supplement Manual.

(3) Operation - Paragraph 6-04 of the Standard Manual.

(4) Safety Requirements - Paragraph 6-05 of the Standard Manual.

It shall be the duty of the Superintendent to maintain a patrol of the project works during all periods of flood flow in excess of a reading of 25.0 on the gage located at the foot of "I" Street or 29.0 on a gage located 100 feet downstream from the Sacramento Weir, as indicated in paragraph 1-05 of this manual. The Superintendent shall dispatch a message by the most suitable means to the District Engineer whenever the water surface in the Sacramento River reaches the gage readings indicated above. The Superintendent shall cause readings to be taken at intervals of two to four hours during the period when the water surface is above flood-flow stage and record the time of the observations. One copy of the readings shall be forwarded to the District Engineer immediately following the flood, and a second copy transmitted as an inclosure to the semi-annual report in compliance with paragraph 3-06 of the Standard Manual.

2-03. Levees.

a. Description. The bypass levees will not be described in this manual, except that portion of the north and south levees of the Sacramento Weir north and south abutments and which may be considered a part thereof.

b. For pertinent Requirements of the Code of Federal Regulations and other requirements see the following:

(1) Maintenance - Paragraph 4-02 of the Standard Manual.

(2) Check Lists - Exhibit E of this Supplement Manual.

(3) Operation - Paragraph 4-04 of the Standard Manual.

(4) Special Instructions - Paragraph 4-05 of the Standard Manual.

2-04. Miscellaneous Facilities.

a. Description. Miscellaneous structures or facilities which were constructed as a part of, or in conjunction with, the protective works, and which might affect their functioning, include the following:

(1) Bridges.

(a) A reinforced concrete bridge over the Sacramento Weir 20 feet wide that carries traffic of State Highway No. 16 and No. 24.

(b) A steel plate girder single track, bridge of the Sacramento Northern Railroad.

(2) Utility Relocation.

(a) A power pole line anchored to four wing walls. This line crosses the Sacramento Bypass channel and is parallel to and about 400 feet downstream from the railroad trestle.

(3) Hydrographic Facilities. Water level gages to be maintained by the following Government agencies within this unit are listed as follows:

(a) U. S. Weather Bureau and State Division of Water Resources gage located on the Sacramento River at the foot of "I" Street, City of Sacramento.

(b) U. S. Corps of Engineers and State Division of Water Resources gage located on the right bank of the Sacramento River about 100 feet downstream from the Sacramento Weir.

b. For pertinent Requirements of the Code of Federal Regulations and other requirements see the following:

(1) Maintenance - Paragraph 7-02 of the Standard Manual.

(2) Check Lists - Paragraph 7-03 of the Standard Manual.

(3) Operation - Paragraph 7-04 of the Standard Manual.

SECTION III
REPAIR OF DAMAGE TO PROJECT WORKS AND METHODS OF COMBATING FLOOD CONDITIONS

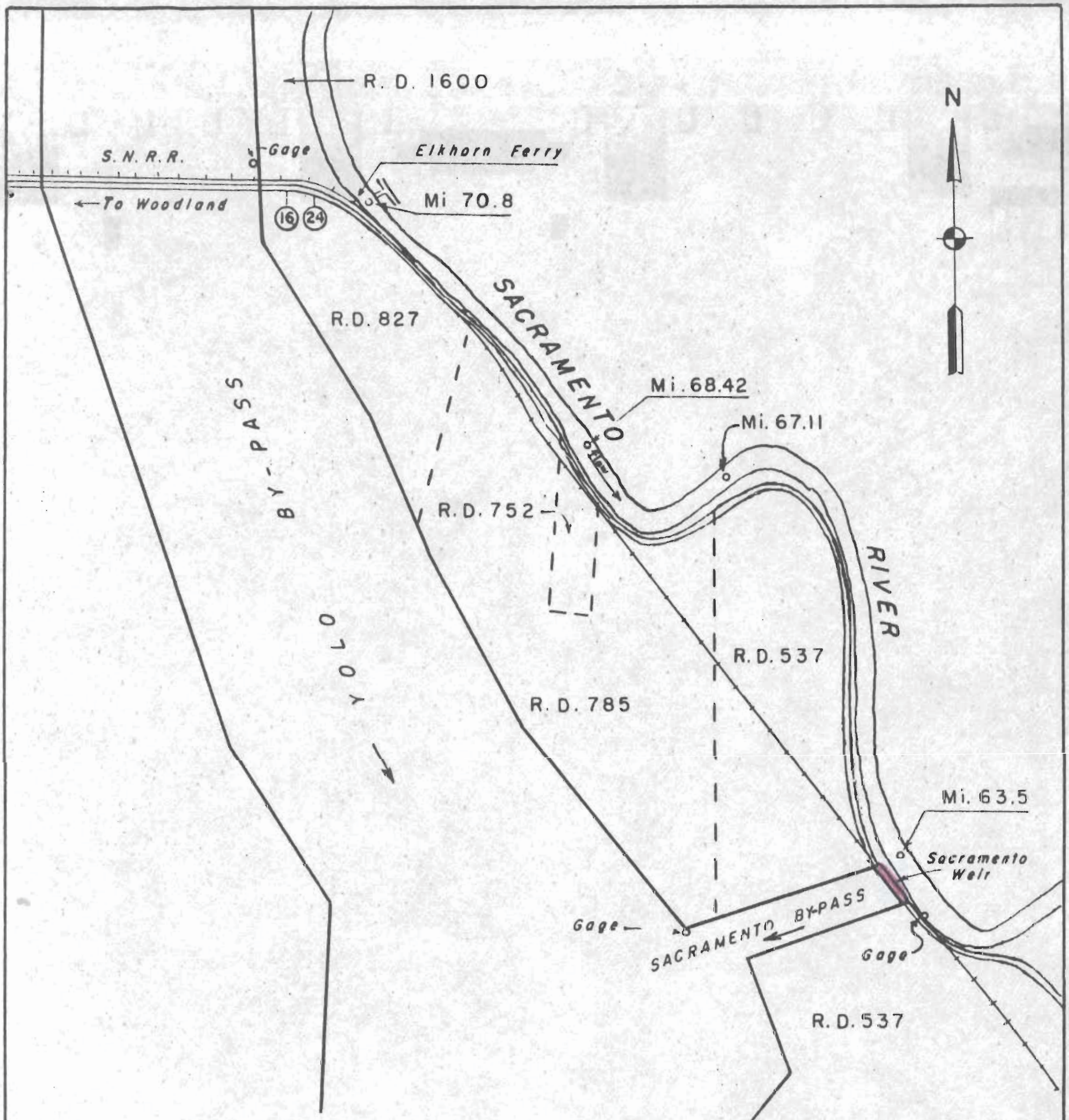
3-01. Repair of Damage. In the event of damage to the project works, whether due to flood conditions or other causes, and which may be beyond the capability of local interests to repair, the Superintendent will contact a representative of the Division of Water Resources, State of California, who coordinates maintenance of project works of the Sacramento River Flood Control Project. The State representative will give assistance or advice, or will determine appropriate action to be taken.

3-02. Applicable Methods of Combating Floods. For applicable methods of combating flood conditions reference is made to Section VIII of the Revised Standard Manual, where the subject is fully covered.

EXHIBIT A

FLOOD CONTROL REGULATIONS

(See Standard Manual)



Approx. Scale
One inch = One Mile

LEGEND

Area covered by this Manual.

LOCATION MAP

SACRAMENTO WEIR

SACRAMENTO RIVER,
CALIFORNIA
UNIT NO. 158

EXHIBIT A-1

EXHIBIT B

"AS CONSTRUCTED"
DRAWINGS

See separate folder for the following drawings:

File No.	Title
50-9-2985	General Location Plan - - - - - 1 sheet
50-9-2985	General Plan and Arrangement of Weirs and Levees - - - - - - - Sheet No. 1c
50-9-2985	General Plan for Weir and Piers Sheet C2
50-9-2985	Details of Abutments - - - - - Sheet C3
50-9-2985	Details of Hinged Needle Connections - - - - - - - - - - Sheet C4
50-9-2985	General Details of Railway and Highway Bridges - - - - - - Sheet C5
50-9-2985	Details of Float and Tripping Device - - - - - - - - - - - Sheet C6
50-9-2985	Details of Highway Bridge Skew Spans - - - - - - - - - - - - Sheet C7

EXHIBIT B
Unattached

EXHIBIT D

CHECK LIST NO. 1
LEVEE INSPECTION REPORT

(See Standard Manual)

EXHIBIT E

CHECK LISTS OF LEVEES,
CHANNEL AND STRUCTURES

For definition of "flood" or "high water period" see paragraph 1-05 of this manual

CHECK LIST NO. 2

SACRAMENTO WEIR

Inspector's Report Sheet No. ______ Inspector ______________

Date ________________________ Superintendent ______________

Item	Remarks
(a) Location by Station	
(b) Settlement, sloughing, or loss of grade	
(c) Erosion of both slopes	
(d) Condition of roadways, including ramps	
(e) Evidence of seepage	
(f) Condition of gates and fencing	
(g) Maintenance measures taken since last inspection	
(h) Comments	

INSTRUCTIONS FOR COMPLETING SHEET 2, EXHIBIT E
(To be printed on back of sheet 2)

Item (a) Indicate levee station of observation, obtained by pacing from nearest reference point; indicate right or left Bank.

Item (b) If sufficient settlement of earthwork has taken place to be noticeable by visual observation, indicate amount of settlement in tenths of a foot. If sloughing has caused a change in slope of the embankment sections, determine the new slope. Note areas where erosion or gullying of the section has occurred.

Item (c) If sufficient erosion or gullying of back face of back toe of levee has taken place to be noticeable by visual inspection, indicate area affected and depth.

Item (d) Note any natural change in any section of roadway or ramps. Indicate any inadequacy in surface drainage system.

Item (e) Indicate any evidence of seepage through the embankment section.

Item (f) Indicate the serviceability of all farm gates across the embankments and roadway, and indicate if repainting is required.

Item (g) Indicate maintenance measures that have been performed since last inspection and their condition at the time of this inspection.

Item (h) Record opinion, if any, of contributory causes for conditions observed and also any observations not covered under other columns.

NOTE: One copy of the Inspector's Report is to be mailed to the District Engineer immediately on completion, and one copy is to be attached to and submitted with the Superintendent's semi-annual report.

INSTRUCTION FOR COMPLETING SHEET 4, EXHIBIT E
(To be printed on back sheet 4)

Item (a) Indicate station of observation obtained by pacing from nearest reference point.

Item (b) Note nature, extent, and size of vegetal growth within the limits of flood flow channel.

Item (c) Note nature and extent of debris and refuse that might cause fouling of the bridges over the channel.

Item (d) Report any construction along or above the diversion channel that has come to the attention of the inspector and that might affect the functioning of the project.

Item (e) Indicate any change in grade or alignment of the channels, either by deposition of sediment or scour, that is noticeable by visual inspection. Estimate amount and extent.

Item (f) Indicate any change that has taken place in the riprap such as disintegration of the rock, erosion, or movement of the rock. Note the presence of vegetal growth through the riprap.

Item (g) Note any damage or settlement of the footings of the bridges. Indicate condition of wooden structures and if repainting is required. Indicate condition of bridge approaches, headwalls, other appurtenances.

Item (h) Indicate maintenance measures that have been performed since the last inspection and their condition at time of this inspection.

Item (i) Record opinion, if any, of contributory causes for conditions observed, also any observations not covered under other columns.

NOTE: One copy of the Inspector's Report is to be mailed to the District Engineer immediately on completion and one copy is to be attached to and submitted with the Superintendent's semi-annual report.

CHECK LIST NO. 4

WEIR STRUCTURE

SACRAMENTO WEIR

Inspector's Report Sheet No. ________ Inspector ________________

Date ____________________________ Superintendent ________________

Item	Remarks
(a) Condition of concrete weir section stilling basin and abutments	
(b) Condition of concrete highway bridge	
(c) Condition of railroad bridge	
(d) Condition of needles, beams and tripping devices	
(e) Condition of concrete revetment	
(f) Vegetal growth	
(g) Accumulation of trash and debris	
(h) Measures taken since last inspection	
(i) Comments	

INSTRUCTIONS FOR COMPLETING SHEET 6, EXHIBIT E
(To be printed on back of sheet 6)

Item (a) Inspect condition of concrete weir, stilling basin and abutments with respect to abraision, chipping or spalling and record observations.

Item (b) Note condition of highway bridge for abraision, chipping, road surfacing or damage due to traffic.

Item (c) Note condition of railroad tracks, ties and beams or structural members of bridge.

Item (d) Note conditions of needles and beams as to state of preservation of wood and mechanical tripping mechanism.

Item (e) Note condition of concrete revetment such as erosion, undue settlement or mis-alignment.

Item (f) Note nature, extent, and size of vegetal growth in and around the weir structure with particular emphasis on growth on the upstream side between the weir and the Sacramento River.

Item (g) Note nature and extent of debris that might cause scour around the weir section or abutments or tend to decrease the channel capacity.

Item (h) Indicate maintenance measures that have been performed since the last inspection and their condition at time of this inspection.

Item (i) Record opinion, if any, of contributory causes for conditions observed, also any observations not covered under other items. A copy of the Inspector's Report is to be mailed to the District Engineer immediately on completion.

EXHIBIT F

LETTER OF ACCEPTANCE
BY STATE RECLAMATION BOARD

THE RECLAMATION BOARD
OF THE
STATE OF CALIFORNIA

March 11, 1953

District Engineer
Sacramento District
Corps of Engineers, U.S. Army
P.O. Box 1739
Sacramento 8, California

Dear Sir:

Reference your letters file No. SPKKO-P 824.3 (Sac. R.F.C.P.) dated 1 December 1951, 3 December 1951, 4 December 1951, three letters dated 6 December 1951, 7 December 1951 and six letters dated 8 December 1951. Subject letters transferred to The Reclamation Board for operation and maintenance, various levee units of the Sacramento River Flood Control Project.

The Reclamation Board at its 18 December 1951 meeting, on behalf of the State of California, accepted certain of the transferred units together with their contiguous banks for operation and maintenance, and rejected others. A tabulation of the units so accepted or rejected is attached hereto.

Yours very truly,

THE RECLAMATION BOARD
A. M. BARTON
Chief Engineer and General Manager

Signed D. M. Carr
D. M. CARR

EXHIBIT F
Sheet 1 of 2

December 18, 1951

The Board accepted the transfer from the Corps of Engineer, in letters of dates listed below, the following reaches of levees and their contiguous waterway banks where applicable for flood control operation and maintenance, as complete and meeting the requirements of the Sacramento River Flood Control Project.

No.	Date of letter	Levee Location	Remarks
*	************	***************	******************
11	8 Dec. 1951	Sacramento Weir	Maintained by State
*	************	***************	******************

NOTE: Only item pertaining to Operation and Maintenance Manual No. 158 is included in the above copy.

EXHIBIT F
Sheet 2 of 2

EXHIBIT G

SUGGESTED SEMI-ANNUAL REPORT FORM

TO: The District Engineer
Sacramento District
Corps of Engineers
1209 - 8th Street
Sacramento, California

(1 May 19____)
(1 Nov 19____)

Dear Sir:

The semi-annual report for the period (1 May 19___ to 31 October 19___) (1 November 19___ to 30 April 19___) Sacramento River Flood Control Project, Sacramento Weir is as follows:

a. The physical condition of the protective works is indicated by the inspector's report, copies of which are inclosed, and may be summarized as follows:

(Superintendent's summary of conditions)

It is our intention to perform the following maintenance work in order to repair or correct the conditions indicated:

(Outline the anticipated maintenance operations for the following 6 months.)

b. During this report period, major high water stages (water level at 25.0 on the gage at foot of "I" Street or 29.0 on the gage 100 feet downstream from Sacramento Weir) occurred on the following dates:

Dates	Maximum Elevation
________	________
________	________
________	________

EXHIBIT G
Sheet 1 of 2

Comments on the behavior of the protective works during such high water periods are as follows:

(Superintendent's log of flood observations)

During the high water stages when the water level reached a height of _________, on the gage or excess thereof (dates)________, it was necessary to organize and carry out flood operations as follows:

(See Maintenance Manual____________.)

c. The inspections have indicated (no) or (the following) encroachments or trespasses upon the project right-of-way.

d. (No) (___________) permits have been issued for (the following) improvements or construction within the project right-of-way.

Executed copies of the permit documents issued are transmitted for your files.

e. The status of maintenance measures, indicated in the previous semi-annual report as being required or as suggested by the representatives of the District Engineer, is as follows:

(Statement of maintenance operations, item by item with percent completion.)

f. The fiscal statement of the Superintendent's operations for the current report period is as follows:

	Labor	Material	Equipment	Overhead	Total
1. Inspection					
2. Maintenance					
3. Flood fighting operations					
TOTAL					

Respectfully submitted,

____
Superintendent of Works

EXHIBIT G
Sheet 2 of 2

EXHIBIT H

SCHEDULE OF OPERATION, SACRAMENTO WEIR

(Letterhead) November 25, 1940

WAR DEPARTMENT
Calif. Debris Comm.
Sacramento, Calif.

File No. 662.8 (FC)1

Subject: Schedule of Operation, Sacramento Weir.

Mr. Edward Hyatt, State Engineer
Division of Water Resources
401 Public Works Building
Sacramento, Calif.

Dear Sir:

Reference is made to the proposed schedule for the operation of the movable top of the Sacramento Weir, ad outlined in our letter of November 4, 1940.

The California Debris Commission has formally adopted this schedule, which reads as follows:

> "None of the weir gates shall be opened before a gage height of 27.5 feet is reached on the U. S. Weather Bureau gage at Sacramento, and the movable crest shall be operated in such a manner that the maximum flood height in the Sacramento River does not exceed 29.0 feet on this gage insofar as this is possible. In any event, on a rising stage only such gates shall be opened as required to hold the water surface in the river at Sacramento Weir at Elevation 31.0 U.S.E.D. Datum. The closing of the gates opened to effect the control outlined above shall be started as soon as the river stage at Sacramento Weir recedes to Elevation 28.5 U.S.E.D. Datum, and shall be prosecuted with faithfulness and energy, using adequate equipment, so that all gates are closed within as short a period as practicable."

In accordance with the terms and provisions of the existing law, it is requested that the State of California operate the Sacramento Weir in accordance with the above schedule.

FOR THE CALIFORNIA DEBRIS COMMISSION:

Yours very truly

R. C. Hunter
Lt. Col., Corps of Engineers
Member and Secretary

EXHIBIT H

Sheet 1 of 1

STANDARD OPERATION PROCEEDURES

FOR THE

SACRAMENTO WEIR

SACRAMENTO RIVER FLOOD CONTROL PROJECT

NOVEMBER 1965

MANUAL NO.158

FOLDER NO. 63

STANDARD OPERATION PROCEDURES FOR THE

SACRAMENTO WEIR,

SACRAMENTO RIVER FLOOD CONTROL PROJECT

STANDARD OPERATION PROCEDURES FOR THE SACRAMENTO WEIR, SACRAMENTO RIVER FLOOD CONTROL PROJECT

Purpose

The purpose of the Standard Operation Procedures for the Sacramento Weir is to set forth the operational criteria and procedures to be followed by the Department of Water Resources during high water periods.

Additional miscellaneous information concerning the Sacramento Weir, including a description of the facilities, maintenance and inspection requirements, and various check lists and reports is contained in the "Supplement to Standard Operation and Maintenance Manual, Sacramento River Flood Control Project, Unit No. 158, Sacramento Weir," a publication of the Corps of Engineers.

Authority

State legislation authorizing the Department to maintain and operate the Sacramento Weir with its adjoining channel is contained in Sections 8360 and 8361 under Division 5, Part 2, Chapter 3, Article 2 of the Water Code.

Schedule of Operation

The recommendation to the Chief of Flood Operations for the opening or closing of either all or part of the 48 flood gates comprising the Sacramento Weir shall be determined by the Forecasting Unit of the Flood Operations Center. This recommendation will be made using criteria as set forth in the letter from the Corps of Engineers on schedule of operation, Sacramento Weir, dated November 19, 1963, as follows:

"The objectives of the operation of Sacramento Weir are to limit flood stages in Sacramento River from Verona to Isleton to the project flood plane, insofar as possible, with maximum feasible utilization of the flood capacity of the Sacramento River channel below that weir. In order to accomplish these objectives, the following schedule of operation shall be used. None of the weir gates shall be opened before a gage height of 28.0 feet m.s.l. datum is reached on the I Street Gage at Sacramento. When this 28.0 foot stage at I Street Gage is exceeded with a further rise anticipated, the gates shall be opened progressively to maintain the I Street stage between 28.0 and 29.0 feet and to limit the maximum I Street stage to 29.0 feet, insofar as this is possible. The number of gates opened to accomplish these criteria shall be kept to a practical minimum. After the peak of the flood has passed and the river stage at Sacramento Weir has receded to 28.0 feet C of E datum, the closing of the gates shall be initiated and prosecuted with dispatch so that, insofar as practicable, all gates in excess of minimum anticipated requirements are closed before the arrival of the next flood wave that might require a new cycle of weir operation in accordance with the provisions of these regulations.

"This schedule of operation is subject to temporary modification by the District Engineer, Corps of Engineers, if found necessary."

Chain of Command

Upon the recommendation of the Forecasting Unit, the Chief of Flood Operations or his appointed assistant will make the decision for the opening or closing of the flood gates and transmit the command to the person in charge at the Sacramento Weir Maintenance Yard. The number of gates to be opened or closed and time of same will be given to the person in charge at the Maintenance Yard by the Chief of Flood Operations by radio or phone and confirmed in writing. The physical operation of the flood gates will be carried out by personnel from the Sacramento Weir Maintenance Yard.

Safety Requirements

Only those personnel trained in the proper operation of the weir and instructed in the proper safety measures to be employed may participate in operating the flood gates. Stringent safety measures will be adhered to which will be the responsibility of the person in charge at the Sacramento Maintenance Yard. The person in charge of the physical opening and closing of the weir gates shall provide any necessary precautions with regard to traffic control.

Forms

Attached are samples of two forms which are for use in recording data pertinent to the operation of the weir. The first, DWR 1886, "Weir and Flood Data," shall be used to record date and time of opening or closing of individual weir gates, with the corresponding staff gage reading. On the second form, DWR 2127, "Flood Data - Gage Heights," a gage height reading of the Sacramento Weir staff gage shall be noted hourly during the entire period of flow over the weir.

After the flood gates of the weir are secured in a closed position, copies of both forms shall be transmitted in duplicate to the Flood Operations Center.

Responsibility of the Flood Operations Center

The Chief of Flood Operations shall be responsible for transmitting a report to the Corps of Engineers, Sacramento, after the operation of the flood gates. The report shall contain all pertinent data concerning the operation of the weir.

The Flood Operations Center shall be responsible for disseminating information and coordination of efforts regarding the operation of the weir.

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES
FLOOD OPERATIONS CENTER

WEIR AND FLOOD DATA

Sacramento Weir
Sacramento River Flood Control Project

Date	Time	Gate No.* (opened or closed)	Sacto. Weir Staff Reading	Entered by	Remarks

*Gates numbered consecutively from north end

DWR 1886

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES
FLOOD OPERATIONS CENTER

FLOOD DATA – GAGE HEIGHTS–

Sacramento Weir
Sacramento River Flood Control Project

Number of Gates Opened During Period____________________

Number of Gates Closed During Period____________________

Date________________, 19_____

GAGE HEIGHTS

Time	G.H.	Time	G.H.	Time	G.H.	Time	G.H.
0000		0600		1200		1800	
0030		0630		1230		1830	
0100		0700		1300		1900	
0130		0730		1330		1930	
0200		0800		1400		2000	
0230		0830		1430		2030	
0300		0900		1500		2100	
0330		0930		1530		2130	
0400		1000		1600		2200	
0430		1030		1630		2230	
0500		1100		1700		2300	
0530		1130		1730		2330	

DWR 2127

STATE OF CALIFORNIA—RESOURCES AGENCY

EDMUND G. BROWN, Governor

DEPARTMENT OF WATER RESOURCES
P. O. BOX 388
SACRAMENTO

December 19, 1966

Mr. A. Gomez, Chief
Engineering Division
Sacramento District, Corps of Engineers
650 Capitol Mall
Sacramento, California 95814

Attention: Hydrology Section

Dear Mr. Gomez:

The purpose of this letter is to clarify operational procedures necessitated by the datum change at the Sacramento Weir staff gage.

As you are aware, Standard Operating Procedures for the Sacramento Weir were reviewed and minor revisions made in the fall of 1963. These revised operating procedures were documented in a letter from the Corps of Engineers dated November 19, 1963.

Subsequent to that date all staff gages in the Sacramento-San Joaquin tidal influence area set at, or near, U.S.E.D. datum were reset. These gages were reset so that zero on the gage equals -3.00 feet U.S.C. & G.S. datum.

The gage at the Sacramento Weir was one of those that was reset. The effect of this resetting is that a stage of 28.0 feet as previously set would now read 27.5 feet.

The Standard Operating Procedures for the Sacramento Weir (as referred to above) require that gate closing activities begin when the stage has receded to 28.0 feet at the weir. The equivalent stage of 27.5 feet will, therefore, be used henceforth as the stage to initiate gate closing activities.

In summary, it seems pertinent to note that this stage of 27.5 feet (with the changed datum) results in the same flow of water over the weir as resulted from the previous stage of 28.0 feet. As documented in previous operating procedures, it is this flow of water over the weir which has been established as being most effective and safe for gate closing operations.

Sincerely yours,

William L. Horn, Chief
Flood Operations
Statewide Operations Office

December 1966

UNIT NO. 158

SACRAMENTO WEIR

The Sacramento Weir will be operated by the Department of Water Resources of the State of California in accordance with the following schedule adopted in 1963:

SCHEDULE OF OPERATION - SACRAMENTO WEIR

The objectives of the operation of Sacramento Weir are to limit flood stages in Sacramento River from Verona to Isleton to the project flood plane, insofar as possible, with maximum feasible utilization of the flood capacity of the Sacramento River channel below that weir. In order to accomplish these objectives, the following schedule of operation shall be used. None of the weir gates shall be opened before a gage height of 28.0 feet m.s.l. datum is reached on the I Street Gage at Sacramento. When this 28.0 foot stage at I Street Gage is exceeded with a further rise anticipated, the gates shall be opened progressively to maintain the I Street stage between 28.0 and 29.0 feet and to limit the maximum I Street stage to 29.0 feet, insofar as this is possible. The number of gates opened to accomplish these criteria shall be kept to a practical minimum. After the peak of the flood has passed and the river stage at Sacramento Weir has receded to 27.5 feet C of E datum, the closing of the gates shall be initiated and prosecuted with dispatch so that, insofar as practicable, all gates in excess of minimum anticipated requirements are closed before the arrival of the next flood wave that might require a new cycle of weir operation in accordance with the provisions of these regulations.

This schedule of operation is subject to temporary modification by the District Engineer, Corps of Engineers, if found necessary.

EXHIBIT H

SCHEDULE OF OPERATION, SACRAMENTO WEIR

December 1966

UNIT NO. 158

SACRAMENTO WEIR

The Sacramento Weir will be operated by the Department of Water Resources of the State of California in accordance with the following schedule adopted in 1963:

SCHEDULE OF OPERATION - SACRAMENTO WEIR

The objectives of the operation of Sacramento Weir are to limit flood stages in Sacramento River from Verona to Isleton to the project flood plane, insofar as possible, with maximum feasible utilization of the flood capacity of the Sacramento River channel below that weir. In order to accomplish these objectives, the following schedule of operation shall be used. None of the weir gates shall be opened before a gage height of 28.0 feet m.s.l. datum is reached on the I Street Gage at Sacramento. When this 28.0 foot stage at I Street Gage is exceeded with a further rise anticipated, the gates shall be opened progressively to maintain the I Street stage between 28.0 and 29.0 feet and to limit the maximum I Street stage to 29.0 feet, insofar as this is possible. The number of gates opened to accomplish these criteria shall be kept to a practical minimum. After the peak of the flood has passed and the river stage at Sacramento Weir has receded to 27.5 feet C of E datum, the closing of the gates shall be initiated and prosecuted with dispatch so that, insofar as practicable, all gates in excess of minimum anticipated requirements are closed before the arrival of the next flood wave that might require a new cycle of weir operation in accordance with the provisions of these regulations.

This schedule of operation is subject to temporary modification by the District Engineer, Corps of Engineers, if found necessary.

EXHIBIT H
Sheet 1 of 1
(revised 1966)

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
650 CAPITOL MALL
SACRAMENTO, CALIFORNIA 95814

IN REPLY REFER TO
SPKGD-L

4 January 1967

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Department of Water Resources
State of California
ATTN: Mr. W. L. Horn
Sacramento, California

Gentlemen:

Reference is made to your letter of 19 December 1966 requesting a revision for Standard Operating Procedures for the Sacramento Weir.

In compliance with your request a revision has been made to our Standard Operating Procedures for the Sacramento Weir to conform to the new gage setting so that a stage of 28.0 feet as previously set would now read 27.5 feet. There are inclosed four copies of a revision for Unit No. 158 of the Supplement to the Standard Operation and Maintenance Manual for the Sacramento River Flood Control Project, and eleven copies of a corresponding revision of page 20-a in the Master Manual of Reservoir Regulation for Sacramento River Basin, California.

Copies of the revision to Unit No. 158 are also being furnished the State Reclamation Board at this time.

Sincerely yours,

A. GOMEZ
Chief, Engineering Division

2 Incl
1. Revision to Unit No. 158 (4 cys)
2. Revision to R.R. Manual (11 cys)

C
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STATE OF CALIFORNIA - RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

C
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January 28, 1975

Mr. George C. Weddell
Chief of Engineering Division
Sacramento District, Corps of Engineers
Department of the Army
650 Capitol Mall
Sacramento, California 95814

Dear Mr. Weddell:

This letter is in regard to the proposal considered by our staffs to modify the operating criteria for the Sacramento Weir to reduce the effects on improvements within the channel in the vicinity of the Weir.

We have no objection to reverting back to the approved weir operating criteria that were used for operation of the Weir from 1940 to 1963, as set forth in the War Department's letter of November 25, 1940, subject to a one-half foot datum change that was made at the Weir in 1966.

We understand that you intend to document in a memorandum the reasons for reverting back to the earlier operating criteria, and that you will coordinate this with the Department of Water Resources and the State Reclamation Board.

We have appreciated your close coordination on this subject, and will work with you as necessary to complete action on it.

Sincerely yours,

/s/ Herbert W. Greydanus
HERBERT W. GREYDANUS
Division Engineer
Division of Resources
Development

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
650 CAPITOL MALL
SACRAMENTO, CALIFORNIA 95814

REPLY TO
ATTENTION OF SPKED-T

28 January 1975

Mr. Stanley J. Gale
Gale & Goldstein, Inc.
1214 F Street
Sacramento, CA 95814

Dear Mr. Gale:

This is in further reply to your prior letters regarding operation of the Sacramento Weir.

We have completed an investigation of the operation of the Sacramento Weir. The study has included an evaluation of the existing operating criteria and of the effects that modifications of these criteria (including your proposal) would have on the flow regimen of the Sacramento River. The study was conducted with the objective of determining the operating schedule that would best serve the overall public interest. Our findings have been coordinated with the California Department of Water Resources and with the California State Reclamation Board.

In your initial letter you requested two specific modifications to the existing criteria:

a. Operating the Weir to maintain a maximum stage of 26 feet m.s.l. in the Sacramento River between the Sacramento Weir and I Street gage, insofar as possible.

b. Using an upstream gage (at either the Interstate 880 Bridge or the Elkhorn Bridge) as an index in addition to the I Street gage. Adoption of these suggestions would reduce river stages up to 3 feet in the vicinity of your property during moderate flood events. River stages would not be reduced during large floods (February 1963 and December 1964 events for example) nor during small floods where flows below Verona do not exceed 70,000 cfs (approximately 50% of the years). This plan of operation would have detrimental effects both to landowners along the Sacramento River and landowners in the Yolo Bypass. During those years in which a stage reduction would be effected, the velocities in the Sacramento River could be increased approximately 20 to 25% in the channel between Verona and the Sacramento Weir.

These increased velocities would accelerate bank and channel erosion. In addition, the peak and volume of flows to the bypass would be substantially increased during these same years, thereby increasing the frequency, depth and duration of flooding in the bypass, which affects landowners there. Primarily because of these hydraulic factors, together with legal and operational considerations, adoption of your proposed modifications is not considered to be in the overall public interest.

During investigation of your suggested proposal we studied several other possible modifications to the existing criteria, in addition to an intensive study of existing criteria. On the basis of these studies we have concluded that substantially following the operating criteria in effect prior to 1963 would best serve all interests. These criteria are as follows:

a. No gates shall be opened until the stage at the I Street gage exceeds 27.5 feet m.s.l.

b. Gates shall be opened so that the stage at I Street does not exceed 29 feet m.s.l., insofar as possible.

c. Subject to provisions a. and b. above, the stage at the Sacramento Weir shall be maintained during the gate-opening period at 30.5 feet CofE Datum (equivalent to 27.5 feet m.s.l.) insofar as possible.

d. Gates shall be closed as rapidly as practicable when the stage drops below 28.0 feet CofE Datum (25.0 m.s.l.) at the Sacramento Weir.

Reverting to the pre-1963 operating criteria will provide a river stage reduction in the vicinity of the Sacramento Weir of 1.5 feet (maximum). This is in addition to the stage reduction presently provided under existing criteria. The maximum reduction will only be achieved or approached during certain moderate floods. We plan to change the operation of the Sacramento Weir in the near future to the operation described in the preceding paragraph. The criteria may be modified in the future as additional data are obtained.

Again, I would like to stress that our primary objective in prescribing operating criteria for the Sacramento River Flood Control project is to serve the overall public interest, giving consideration to all concerns of interested groups and agencies.

SPKED-T
Mr. Stanley J. Gale

28 January 1975

Should you wish further discussions on the operation of the Sacramento Weir, I would be happy to meet with you.

Sincerely yours,

F. G. Rockwell, Jr.

F. G. ROCKWELL, JR.
Colonel, CE
District Engineer

CF:
DWR
Rec Board

SUPPLEMENT TO STANDARD
OPERATION AND MAINTENANCE MANUAL
SACRAMENTO RIVER FLOOD CONTROL PROJECT

UNIT NO. 158

SACRAMENTO WEIR
SACRAMENTO RIVER, CALIFORNIA

REVISIONS OR ADDITIONS

REVISIONS	DATE
Delete Exhibit H dated December 1966	May 1975
*Add Exhibit H dated March 1975	May 1975
Add letter from State Department of Water Resources dated 28 January 1975	May 1975

* This revision for operation of the Sacramento Weir was made to conform with the revision (sheet 20a) dated March 1975, to the Master Manual of Reservoir Regulation, Sacramento River Basin, California.

UNIT NO. 158

SACRAMENTO WEIR

The Sacramento Weir will be operated by the Department of Water Resources of the State of California in accordance with the following schedule adopted in 1975:

SCHEDULE OF OPERATION - SACRAMENTO WEIR

The operational objectives of the Sacramento Weir are to limit flood stages in the Sacramento River to the project flood plane, insofar as possible, with maximum feasible utilization of the flood capacity of the Sacramento River Channel below the weir. In order to accomplish these objectives, the following schedule of operation shall be used.

1. Opening of the weir gates will not be initiated until a stage of 27.5 feet msl datum is exceeded at the I Street gage, Sacramento.

2. As many gates as necessary shall be opened so that the stage at I Street does not exceed 29.0 feet msl datum, insofar as possible.

3. Subject to provisions 1 and 2 above, the stage at the Sacramento Weir shall be maintained during the gate opening period at 27.5 feet msl datum, insofar as practicable.

4. Gates shall be closed at the stage drops below 25.0 feet msl datum at the Sacramento Weir. The gate closing shall be prosecuted with dispatch so that all gates are closed within as short a period as practicable.

This schedule of operation is subject to temporary modification by the District Engineer, Corps of Engineers, if found necessary.

Sacramento Weir		Flow in 1000 cfs																							
Flow per Gate	Sac Weir Stage	# of Gates opened																							
		2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
0	22	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	22.1	0.01	0.02	0.04	0.05	0.06	0.07	0.08	0.1	0.11	0.12	0.13	0.14	0.16	0.17	0.18	0.19	0.2	0.22	0.23	0.24	0.25	0.26	0.28	0.29
12	22.2	0.02	0.05	0.07	0.1	0.12	0.14	0.17	0.19	0.22	0.24	0.26	0.29	0.31	0.34	0.36	0.38	0.41	0.43	0.46	0.48	0.5	0.53	0.55	0.58
18	22.3	0.04	0.07	0.11	0.14	0.18	0.22	0.25	0.29	0.32	0.36	0.4	0.43	0.47	0.5	0.54	0.58	0.61	0.65	0.68	0.72	0.76	0.79	0.83	0.86
24	22.4	0.05	0.1	0.14	0.19	0.24	0.29	0.34	0.38	0.43	0.48	0.53	0.58	0.62	0.67	0.72	0.77	0.82	0.86	0.91	0.96	1.01	1.06	1.1	1.15
30	22.5	0.06	0.12	0.18	0.24	0.3	0.36	0.42	0.48	0.54	0.6	0.66	0.72	0.78	0.84	0.9	0.96	1.02	1.08	1.14	1.2	1.26	1.32	1.38	1.44
40	22.6	0.08	0.16	0.24	0.32	0.4	0.48	0.56	0.64	0.72	0.8	0.88	0.96	1.04	1.12	1.2	1.28	1.36	1.44	1.52	1.6	1.68	1.76	1.84	1.92
50	22.7	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2	2.1	2.2	2.3	2.4
60	22.8	0.12	0.24	0.36	0.48	0.6	0.72	0.84	0.96	1.08	1.2	1.32	1.44	1.56	1.68	1.8	1.92	2.04	2.16	2.28	2.4	2.52	2.64	2.76	2.88
70	22.9	0.14	0.28	0.42	0.56	0.7	0.84	0.98	1.12	1.26	1.4	1.54	1.68	1.82	1.96	2.1	2.24	2.38	2.52	2.66	2.8	2.94	3.08	3.22	3.36
80	23	0.16	0.32	0.48	0.64	0.8	0.96	1.12	1.28	1.44	1.6	1.76	1.92	2.08	2.24	2.4	2.56	2.72	2.88	3.04	3.2	3.36	3.52	3.68	3.84
96	23.1	0.19	0.38	0.58	0.77	0.96	1.15	1.34	1.54	1.73	1.92	2.11	2.3	2.5	2.69	2.88	3.07	3.26	3.46	3.65	3.84	4.03	4.22	4.42	4.61
111	23.2	0.22	0.44	0.67	0.89	1.11	1.33	1.55	1.78	2	2.22	2.44	2.66	2.89	3.11	3.33	3.55	3.77	4	4.22	4.44	4.66	4.88	5.11	5.33
127	23.3	0.25	0.51	0.76	1.02	1.27	1.52	1.78	2.03	2.29	2.54	2.79	3.05	3.3	3.56	3.81	4.06	4.32	4.57	4.83	5.08	5.33	5.59	5.84	6.1
142	23.4	0.28	0.57	0.85	1.14	1.42	1.7	1.99	2.27	2.56	2.84	3.12	3.41	3.69	3.98	4.26	4.54	4.83	5.11	5.4	5.68	5.96	6.25	6.53	6.82
158	23.5	0.32	0.63	0.95	1.26	1.58	1.9	2.21	2.53	2.84	3.16	3.48	3.79	4.11	4.42	4.74	5.06	5.37	5.69	6	6.32	6.64	6.95	7.27	7.58
177	23.6	0.35	0.71	1.06	1.42	1.77	2.12	2.48	2.83	3.19	3.54	3.89	4.25	4.6	4.96	5.31	5.66	6.02	6.37	6.73	7.08	7.43	7.79	8.14	8.5
197	23.7	0.39	0.79	1.18	1.58	1.97	2.36	2.76	3.15	3.55	3.94	4.33	4.73	5.12	5.52	5.91	6.3	6.7	7.09	7.49	7.88	8.27	8.67	9.06	9.46
216	23.8	0.43	0.86	1.3	1.73	2.16	2.59	3.02	3.46	3.89	4.32	4.75	5.18	5.62	6.05	6.48	6.91	7.34	7.78	8.21	8.64	9.07	9.5	9.94	10.4
236	23.9	0.47	0.94	1.42	1.89	2.36	2.83	3.3	3.78	4.25	4.72	5.19	5.66	6.14	6.61	7.08	7.55	8.02	8.5	8.97	9.44	9.91	10.4	10.9	11.3
255	24	0.51	1.02	1.53	2.04	2.55	3.06	3.57	4.08	4.59	5.1	5.61	6.12	6.63	7.14	7.65	8.16	8.67	9.18	9.69	10.2	10.7	11.2	11.7	12.2
278	24.1	0.56	1.11	1.67	2.22	2.78	3.34	3.89	4.45	5	5.56	6.12	6.67	7.23	7.78	8.34	8.9	9.45	10	10.6	11.1	11.7	12.2	12.8	13.3
300	24.2	0.6	1.2	1.8	2.4	3	3.6	4.2	4.8	5.4	6	6.6	7.2	7.8	8.4	9	9.6	10.2	10.8	11.4	12	12.6	13.2	13.8	14.4
323	24.3	0.65	1.29	1.94	2.58	3.23	3.88	4.52	5.17	5.81	6.46	7.11	7.75	8.4	9.04	9.69	10.3	11	11.6	12.3	12.9	13.6	14.2	14.9	15.5
345	24.4	0.69	1.38	2.07	2.76	3.45	4.14	4.83	5.52	6.21	6.9	7.59	8.28	8.97	9.66	10.4	11	11.7	12.4	13.1	13.8	14.5	15.2	15.9	16.6
368	24.5	0.74	1.47	2.21	2.94	3.68	4.42	5.15	5.89	6.62	7.36	8.1	8.83	9.57	10.3	11	11.8	12.5	13.2	14	14.7	15.5	16.2	16.9	17.7
394	24.6	0.79	1.58	2.36	3.15	3.94	4.73	5.52	6.3	7.09	7.88	8.67	9.46	10.2	11	11.8	12.6	13.4	14.2	15	15.8	16.5	17.3	18.1	18.9
420	24.7	0.84	1.68	2.52	3.36	4.2	5.04	5.88	6.72	7.56	8.4	9.24	10.1	10.9	11.8	12.6	13.4	14.3	15.1	16	16.8	17.6	18.5	19.3	20.2
445	24.8	0.89	1.78	2.67	3.56	4.45	5.34	6.23	7.12	8.01	8.9	9.79	10.7	11.6	12.5	13.4	14.2	15.1	16	16.9	17.8	18.7	19.6	20.5	21.4
471	24.9	0.94	1.88	2.83	3.77	4.71	5.65	6.59	7.54	8.48	9.42	10.4	11.3	12.2	13.2	14.1	15.1	16	17	17.9	18.8	19.8	20.7	21.7	22.6
497	25	0.99	1.99	2.98	3.98	4.97	5.96	6.96	7.95	8.95	9.94	10.9	11.9	12.9	13.9	14.9	15.9	16.9	17.9	18.9	19.9	20.9	21.9	22.9	23.9

Flow per	Sac Weir	# of Gates opened																							
Gate	Stage	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
526	25.1	1.05	2.1	3.16	4.21	5.26	6.31	7.36	8.42	9.47	10.5	11.6	12.6	13.7	14.7	15.8	16.8	17.9	18.9	20	21	22.1	23.1	24.2	25.2
555	25.2	1.11	2.22	3.33	4.44	5.55	6.66	7.77	8.88	9.99	11.1	12.2	13.3	14.4	15.5	16.7	17.8	18.9	20	21.1	22.2	23.3	24.4	25.5	26.6
583	25.3	1.17	2.33	3.5	4.66	5.83	7	8.16	9.33	10.5	11.7	12.8	14	15.2	16.3	17.5	18.7	19.8	21	22.2	23.3	24.5	25.7	26.8	28
612	25.4	1.22	2.45	3.67	4.9	6.12	7.34	8.57	9.79	11	12.2	13.5	14.7	15.9	17.1	18.4	19.6	20.8	22	23.3	24.5	25.7	26.9	28.2	29.4
641	25.5	1.28	2.56	3.85	5.13	6.41	7.69	8.97	10.3	11.5	12.8	14.1	15.4	16.7	17.9	19.2	20.5	21.8	23.1	24.4	25.6	26.9	28.2	29.5	30.8
673	25.6	1.35	2.69	4.04	5.38	6.73	8.08	9.42	10.8	12.1	13.5	14.8	16.2	17.5	18.8	20.2	21.5	22.9	24.2	25.6	26.9	28.3	29.6	31	32.3
705	25.7	1.41	2.82	4.23	5.64	7.05	8.46	9.87	11.3	12.7	14.1	15.5	16.9	18.3	19.7	21.2	22.6	24	25.4	26.8	28.2	29.6	31	32.4	33.8
736	25.8	1.47	2.94	4.42	5.89	7.36	8.83	10.3	11.8	13.2	14.7	16.2	17.7	19.1	20.6	22.1	23.6	25	26.5	28	29.4	30.9	32.4	33.9	35.3
768	25.9	1.54	3.07	4.61	6.14	7.68	9.22	10.8	12.3	13.8	15.4	16.9	18.4	20	21.5	23	24.6	26.1	27.6	29.2	30.7	32.3	33.8	35.3	36.9
800	26	1.6	3.2	4.8	6.4	8	9.6	11.2	12.8	14.4	16	17.6	19.2	20.8	22.4	24	25.6	27.2	28.8	30.4	32	33.6	35.2	36.8	38.4
834	26.1	1.67	3.34	5	6.67	8.34	10	11.7	13.3	15	16.7	18.3	20	21.7	23.4	25	26.7	28.4	30	31.7	33.4	35	36.7	38.4	40
868	26.2	1.74	3.47	5.21	6.94	8.68	10.4	12.2	13.9	15.6	17.4	19.1	20.8	22.6	24.3	26	27.8	29.5	31.2	33	34.7	36.5	38.2	39.9	41.7
903	26.3	1.81	3.61	5.42	7.22	9.03	10.8	12.6	14.4	16.3	18.1	19.9	21.7	23.5	25.3	27.1	28.9	30.7	32.5	34.3	36.1	37.9	39.7	41.5	43.3
937	26.4	1.87	3.75	5.62	7.5	9.37	11.2	13.1	15	16.9	18.7	20.6	22.5	24.4	26.2	28.1	30	31.9	33.7	35.6	37.5	39.4	41.2	43.1	45
971	26.5	1.94	3.88	5.83	7.77	9.71	11.7	13.6	15.5	17.5	19.4	21.4	23.3	25.2	27.2	29.1	31.1	33	35	36.9	38.8	40.8	42.7	44.7	46.6
1009	26.6	2.02	4.04	6.05	8.07	10.1	12.1	14.1	16.1	18.2	20.2	22.2	24.2	26.2	28.3	30.3	32.3	34.3	36.3	38.3	40.4	42.4	44.4	46.4	48.4
1047	26.7	2.09	4.19	6.28	8.38	10.5	12.6	14.7	16.8	18.8	20.9	23	25.1	27.2	29.3	31.4	33.5	35.6	37.7	39.8	41.9	44	46.1	48.2	50.3
1084	26.8	2.17	4.34	6.5	8.67	10.8	13	15.2	17.3	19.5	21.7	23.8	26	28.2	30.4	32.5	34.7	36.9	39	41.2	43.4	45.5	47.7	49.9	52
1122	26.9	2.24	4.49	6.73	8.98	11.2	13.5	15.7	18	20.2	22.4	24.7	26.9	29.2	31.4	33.7	35.9	38.1	40.4	42.6	44.9	47.1	49.4	51.6	53.9
1160	27	2.32	4.64	6.96	9.28	11.6	13.9	16.2	18.6	20.9	23.2	25.5	27.8	30.2	32.5	34.8	37.1	39.4	41.8	44.1	46.4	48.7	51	53.4	55.7
1198	27.1	2.4	4.79	7.19	9.58	12	14.4	16.8	19.2	21.6	24	26.4	28.8	31.1	33.5	35.9	38.3	40.7	43.1	45.5	47.9	50.3	52.7	55.1	57.5
1236	27.2	2.47	4.94	7.42	9.89	12.4	14.8	17.3	19.8	22.2	24.7	27.2	29.7	32.1	34.6	37.1	39.6	42	44.5	47	49.4	51.9	54.4	56.9	59.3
1274	27.3	2.55	5.1	7.64	10.2	12.7	15.3	17.8	20.4	22.9	25.5	28	30.6	33.1	35.7	38.2	40.8	43.3	45.9	48.4	51	53.5	56.1	58.6	61.2
1312	27.4	2.62	5.25	7.87	10.5	13.1	15.7	18.4	21	23.6	26.2	28.9	31.5	34.1	36.7	39.4	42	44.6	47.2	49.9	52.5	55.1	57.7	60.4	63
1350	27.5	2.7	5.4	8.1	10.8	13.5	16.2	18.9	21.6	24.3	27	29.7	32.4	35.1	37.8	40.5	43.2	45.9	48.6	51.3	54	56.7	59.4	62.1	64.8
1392	27.6	2.78	5.57	8.35	11.1	13.9	16.7	19.5	22.3	25.1	27.8	30.6	33.4	36.2	39	41.8	44.5	47.3	50.1	52.9	55.7	58.5	61.2	64	66.8
1434	27.7	2.87	5.74	8.6	11.5	14.3	17.2	20.1	22.9	25.8	28.7	31.5	34.4	37.3	40.2	43	45.9	48.8	51.6	54.5	57.4	60.2	63.1	66	68.8
1476	27.8	2.95	5.9	8.86	11.8	14.8	17.7	20.7	23.6	26.6	29.5	32.5	35.4	38.4	41.3	44.3	47.2	50.2	53.1	56.1	59	62	64.9	67.9	70.8
1518	27.9	3.04	6.07	9.11	12.1	15.2	18.2	21.3	24.3	27.3	30.4	33.4	36.4	39.5	42.5	45.5	48.6	51.6	54.6	57.7	60.7	63.8	66.8	69.8	72.9
1560	28	3.12	6.24	9.36	12.5	15.6	18.7	21.8	25	28.1	31.2	34.3	37.4	40.6	43.7	46.8	49.9	53	56.2	59.3	62.4	65.5	68.6	71.8	74.9
1604	28.1	3.21	6.42	9.62	12.8	16	19.2	22.5	25.7	28.9	32.1	35.3	38.5	41.7	44.9	48.1	51.3	54.5	57.7	61	64.2	67.4	70.6	73.8	77
1648	28.2	3.3	6.59	9.89	13.2	16.5	19.8	23.1	26.4	29.7	33	36.3	39.6	42.8	46.1	49.4	52.7	56	59.3	62.6	65.9	69.2	72.5	75.8	79.1
1692	28.3	3.38	6.77	10.2	13.5	16.9	20.3	23.7	27.1	30.5	33.8	37.2	40.6	44	47.4	50.8	54.1	57.5	60.9	64.3	67.7	71.1	74.4	77.8	81.2

Appendix C

Gate Technical Memorandums

TECHNICAL MEMORANDUM

Date:	April 14, 2014
To:	Project File
From:	Chris Campbell
Project:	13-1027 – Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project
Subject:	Sacramento Weir Alternative and Gate Configuration

1 SACRAMENTO WEIR GATED CHANNEL

This Technical Memorandum (TM) details the development of the Sacramento Weir Gated Channel Alternative in HEC-RAS (RAS) for use in the calibrated and validated TUFLOW Classic hydrodynamic model developed to support the California Department of Water Resources (DWR) and US Bureau of Reclamation (USBR) Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project (Project) Environmental Impact Statement and Environmental Impact Report (EIS/EIR). The Sacramento Weir Gated Channel Alternative is one of four alternatives being carried forward through the screening phase.

The Sacramento Weir Gated Channel Alternative was assumed to be constructed just north of the southern Sacramento Bypass levee, connecting the Sacramento River with the Tule Canal (see Figure 1). The proposed channel has an invert elevation of 7 feet NAVD88 with a 225 foot bottom width and 3:1 side slopes (see Figure 2). The channel profile and the gate configuration were analyzed in RAS to 1) understand the backwater effects on the gates from Yolo Bypass inundation given that proposed upstream inverts at the river are below the baseline water levels in the Tule Canal, and 2) optimize the gate openings for non-overtopping flows with the objective to maximize diversions from the Sacramento River up to 6000 cfs while minimizing head losses across the gate. Gate optimization was performed in RAS because such a function is not yet available in TUFLOW and gate logic is relatively new in TUFLOW.

2 WATER SURFACE PROFILES

For this analysis, the Tule Canal was assumed to have baseline flow contributions of 500 cfs, 350 cfs, 50 cfs, and 300 cfs from KLRC, Cache Creek Settling Basin, Willow Slough, and Putah Creek, respectively. To better understand system performance and hydraulic constraints prior to proceeding with configuring the gates, three steady state inflows of 500cfs, 1500 cfs and 6000 cfs were introduced into the

Sacramento Bypass. The water surface elevations in the RAS model at the confluence with the Tule Canal were based on calibrated TUFLOW simulations using the above stated flow conditions. Steady state water surface profiles for the Sacramento Bypass Gated Channel Alternative are shown in Figure 3.

Water surface profiles in the Sacramento Bypass are controlled by the low flow conveyance capacity within Tule Canal and the Yolo Bypass. The minimum water surface elevation in Tule Canal at the confluence with the Sacramento Bypass during baseline flows (i.e., 850 cfs as contributed by KLRC and Cache Creek) was 10.65 feet NAVD88. At stages below 11 feet NAVD88, flow through the Sacramento Bypass was limited due to the assumed backwater from Tule Canal, and was not included in the reported tables. It should also be noted that 2300 feet downstream of the gated channel connection to the Tule Canal is an agricultural crossing maintained by Swanston Ranch. The earthen crossing impounds water in the canal for diversion and consists of three culverts, one six foot open culvert and two four foot culverts with boards at the intakes and earth fill. If the earthen fill is not removed and stockpiled at the beginning of the wet season, it will be washed out as flows increase in the canal. The culvert features are more permanent. The washed out condition is included in the TUFLOW model based on the cbec 2010 survey with the invert measuring 8.5 feet NAVD88, which is approximately 5 feet higher than the bed profile in the vicinity of the gated channel connection to the canal.

3 GATE CONFIGURATION

A series of 6 new gates at the Sacramento Weir were used to regulate flows into the Sacramento Bypass up to 6000 cfs. For this analysis, it was assumed that the new gates were installed directly below the existing bays of the Sacramento Weir on the southern end of the weir (see Figure 4). The new gate dimensions are provided in Table 1, and generally consist of 30 foot wide gates with inverts of 7 feet NAVD88. Gate operations were optimized to maximize discharges into the Sacramento Bypass up to 6000 cfs for river stages in front of the Sacramento Weir up to elevations corresponding to the I Street water surface elevation trigger of 30.04 feet NAVD88. After the I Street elevation trigger is met, the Sacramento Weir is opened and the new gates will remain open per their last know configuration.

Sluice gates or radial gates could be used, but radial gates may offer the greatest flexibility in terms of real-time operations as well as constructability to minimize debris accumulation on the lift components. A gate optimization routine in RAS (see Section 4) was used to configure the size and number of gates as well as determine the individual gate openings relative to river stage. In general, gate widths were limited to 30 feet with 12 foot pillars between them. The pillars are wider than the Fremont Weir alternatives because the 30 foot new gates are situated directly beneath individual bays of the Sacramento Weir which are generally 40 feet wide. Gates 1 and 2 were limited in height to prevent the top of the gate from extending above the existing weir sill (24 feet NAVD 88) during a flood event when the Sacramento Weir is open and the new gate is open. The resulting gate configuration is shown in Table 1 and depicted in Figure 4. The gate opening schedules are shown in Table 2. The river stage versus total gate flow relationship is shown in Figure 5.

Table 1. Gate Configuration

Gate #	Gate Invert (NAVD 88 ft)	Gate Height (ft)	Gate Width (ft)
Gate 1	7	7	30
Gate 2	7	11	30
Gate 3 to Gate 6	7	14	30

Table 2. Gate Operations

Sacramento River Stage (ft)	Total flow (cfs)	Gate 1 Opening (ft)	Gate 2 Opening (ft)	Gate 3 Opening (ft)	Gate 4 Opening (ft)	Gate 5 Opening (ft)	Gate 6 Opening (ft)	Gate 1 Velocity (fps)	Gate 2 Velocity (fps)	Gate 3 Velocity (fps)	Gate 4 Velocity (fps)	Gate 5 Velocity (fps)	Gate 6 Velocity (fps)
11.0	131	7	11	14	14	14	14	0.2	0.2	0.2	0.2	0.2	0.2
12.0	498	7	11	14	14	14	14	0.6	0.6	0.6	0.6	0.6	0.6
13.0	1005	7	11	14	14	14	14	0.9	0.9	0.9	0.9	0.9	0.9
14.0	1566	7	11	14	14	14	14	1.24	1.2	1.2	1.2	1.2	1.2
15.0	2715	7	11	14	14	14	14	1.79	1.9	1.9	1.9	1.9	1.9
16.0	3719	7	11	14	14	14	14	1.73	2.5	2.5	2.5	2.5	2.5
17.0	5180	7	11	14	14	14	14	2.08	3.2	3.2	3.2	3.2	3.2
17.1	5387	7	11	14	14	14	14	2.13	3.3	3.3	3.3	3.3	3.3
17.2	5623	7	11	14	14	14	14	2.20	3.4	3.4	3.4	3.4	3.4
17.3	5852	7	11	14	14	14	14	2.29	3.5	3.5	3.5	3.5	3.5
17.4	5952	7	11	14	14	9.8	0	2.80	4.4	4.4	4.4	4.22	
17.5	5955	7	11	14	9.8	0	0	3.45	5.8	5.8	5.41		
17.6	5952	7	11	14	7.5	0	0	4.01	6.6	6.6	4.01		
17.7	5953	7	11	14	2.5	0	0	4.49	7.3	7.3	4.49		
17.8	5965	7	11	10.5	0	0	0	4.91	7.8	7.65			
17.9	5973	7	11	9.8	0	0	0	5.30	8.2	7.41			
18.0	5983	7	11	9.3	0	0	0	5.68	8.49	6.86			
18.1	5965	7	11	9.1	0	0	0	6.04	8.77	6.61			
18.2	5957	7	11	8.6	0	0	0	6.38	9.00	6.38			
18.3	5958	7	11	7.5	0	0	0	6.70	9.23	6.70			
18.4	5961	7	11	6.6	0	0	0	6.99	9.42	6.99			
18.5	5958	7	11	5.8	0	0	0	7.29	9.57	7.29			
18.6	5958	7	11	5.1	0	0	0	7.56	9.73	7.56			

Table 2. Gate Operations (continued)

Sacramento River Stage (ft)	Total flow (cfs)	Gate 1 Opening (ft)	Gate 2 Opening (ft)	Gate 3 Opening (ft)	Gate 4 Opening (ft)	Gate 5 Opening (ft)	Gate 6 Opening (ft)	Gate 1 Velocity (fps)	Gate 2 Velocity (fps)	Gate 3 Velocity (fps)	Gate 4 Velocity (fps)	Gate 5 Velocity (fps)	Gate 6 Velocity (fps)
18.7	5952	7	11	4.5	0	0	0	7.84	9.84	7.84			
18.8	5955	7	11	4	0	0	0	8.09	9.95	8.09			
18.9	5951	7	11	3.5	0	0	0	8.35	10.07	8.35			
19.0	5959	7	11	3.1	0	0	0	8.58	10.18	8.58			
20.0	5960	7	10.9	0	0	0	0	10.82	11.28				
21.0	5953	7	8.2	0	0	0	0	13.06	13.06				
22.0	5976	7	6.2	0	0	0	0	15.09	15.09				
23.0	5968	7	5.4	0	0	0	0	16.04	16.04				
24.0	5953	7	5	0	0	0	0	16.54	16.54				
25.0	5973	7	4.7	0	0	0	0	17.02	17.02				
26.0	5979	7	4.4	0	0	0	0	17.48	17.48				
27.0	5973	7	4.1	0	0	0	0	17.94	17.94				
28.0	5955	7	3.8	0	0	0	0	18.38	18.38				
29.0	5982	7	3.6	0	0	0	0	18.81	18.81				
30.0	6001	7	3.3	0	0	0	0	19.24	19.24				

4 GATE LOGIC

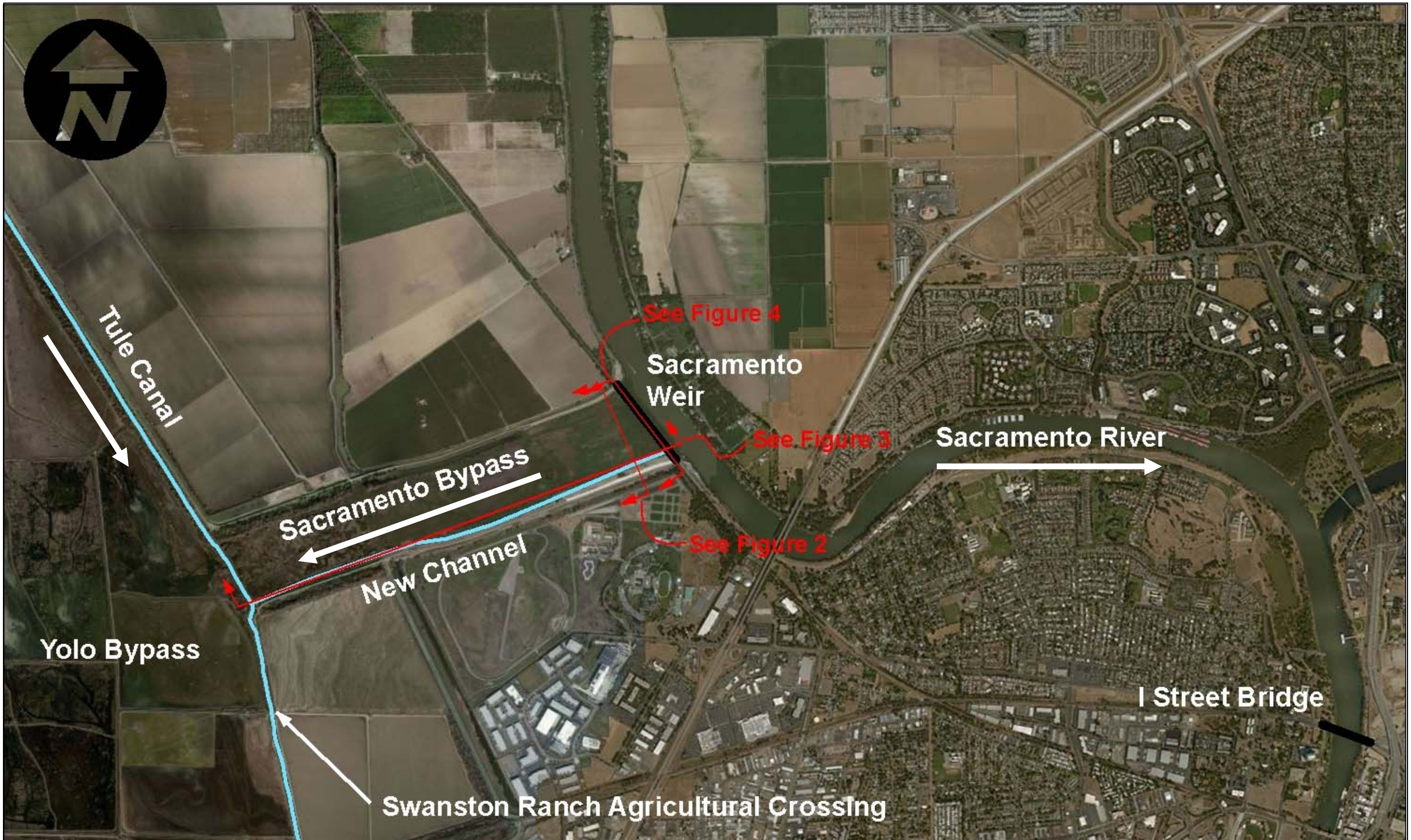
Rule operations in the RAS unsteady flow editor were used to optimize gate operations. For this analysis, the gates were allowed to open and close at a rate of one foot per minute during an unsteady flow analysis that used a stepped stage time series at the Sacramento River and a stage-discharge rating curve at Tule Canal based on calibrated TUFLOW simulations. The relatively quick opening rate of one foot per minute was used to speed up solution convergence, but can be set to something larger in TUFLOW to represent realistic rates or to accommodate model stability. The following logic was used in RAS to determine gate operations to maximize flows up to 6000 cfs based on Yolo Bypass and Sacramento River water surface elevations:

Define variable: TotalGateFlow = Sum of flow for all gates at current time step
Define variable: Gate1Opening = Opening of gate 1 at current time step
Define variable: Gate2Opening = Opening of gate 2 at current time step
Define variable: Gate3Opening = Opening of gate 3 at current time step
Define variable: Gate4Opening = Opening of gate 4 at current time step
Define variable: Gate5Opening = Opening of gate 5 at current time step
Define variable: Gate6Opening = Opening of gate 6 at current time step
Define variable: MaximumGateOpening = maximum gate opening of gates 3 to 6
Define variable: MaximumGateOpening1 = maximum gate opening of gate 1
Define variable: MaximumGateOpening2 = maximum gate opening of gate 2

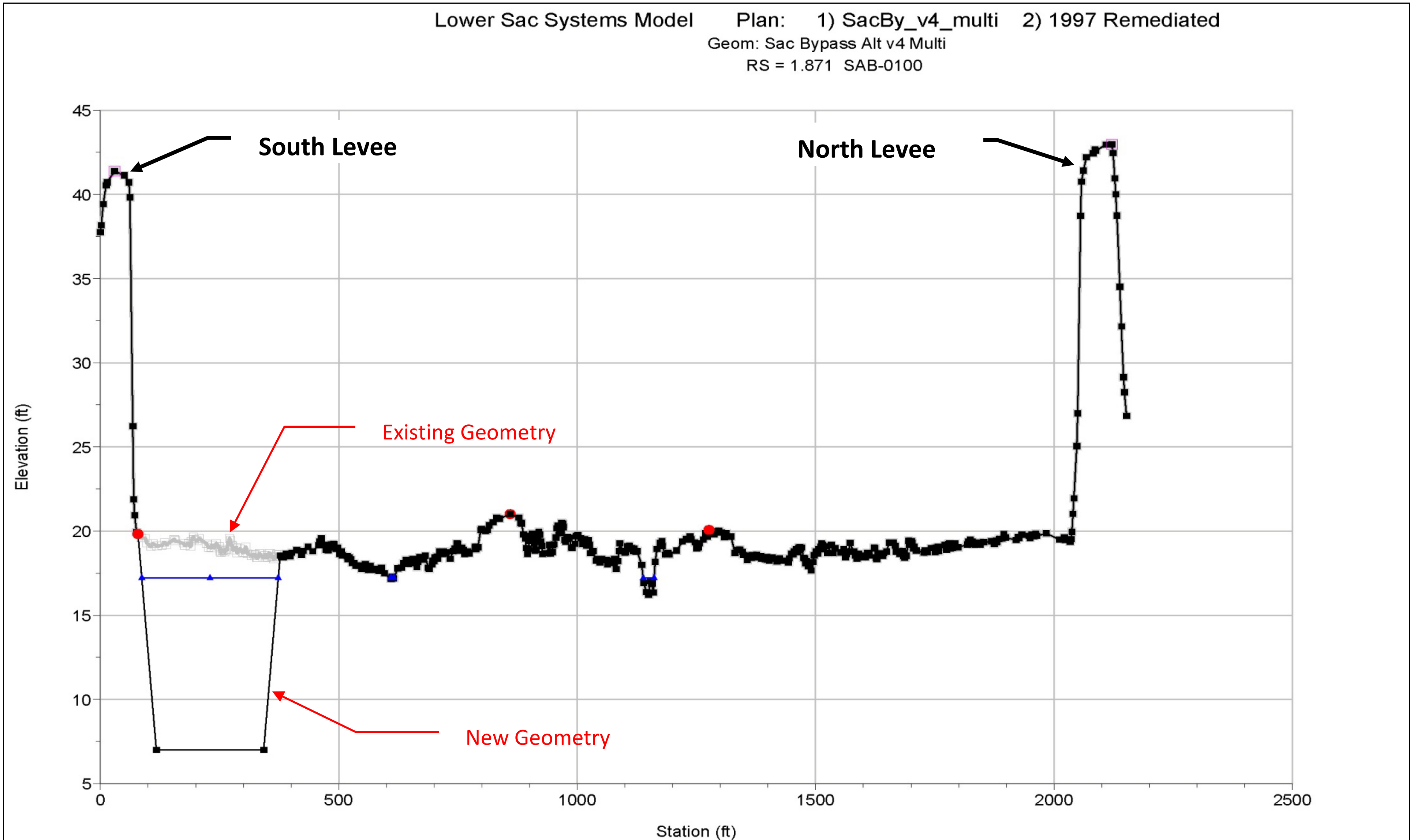
If TotalGateFlow < 5950 Then
If Gate1Opening < MaximumGateOpening1 Then
Set Opening of Gate 1 = Gate1Opening + 0.5
Else, If Gate2Opening < MaximumGateOpening2 Then
Set Opening of Gate 2 = Gate2Opening + 0.5
Else, If Gate3Opening < MaximumGateOpening Then
Set Opening of Gate 3 = Gate3Opening + 0.5
Else, If Gate4Opening < MaximumGateOpening Then
Set Opening of Gate 4 = Gate4Opening + 0.5
Else, If Gate5Opening < MaximumGateOpening Then
Set Opening of Gate 5 = Gate5Opening + 0.5
Else, If Gate6Opening < MaximumGateOpening Then
Set Opening of Gate 6 = Gate6Opening + 0.5
End If
Else, If TotalGateFlow > 6000 Then
If Gate6Opening > 0 Then
Set Opening of Gate 6 = Gate6Opening - 0.5
Else, If Gate5Opening > 0 Then
Set Opening of Gate 5 = Gate5Opening - 0.5
Else, If Gate4Opening > 0 Then
Set Opening of Gate 4 = Gate4Opening - 0.5

Else, If Gate3Opening > 0 Then
Set Opening of Gate 3 = Gate3Opening - 0.5
Else, If Gate2Opening > 0 Then
Set Opening of Gate 2 = Gate2Opening - 0.5
Else, If Gate1Opening > 0 Then
Set Opening of Gate 1 = Gate1Opening - 0.5
End If

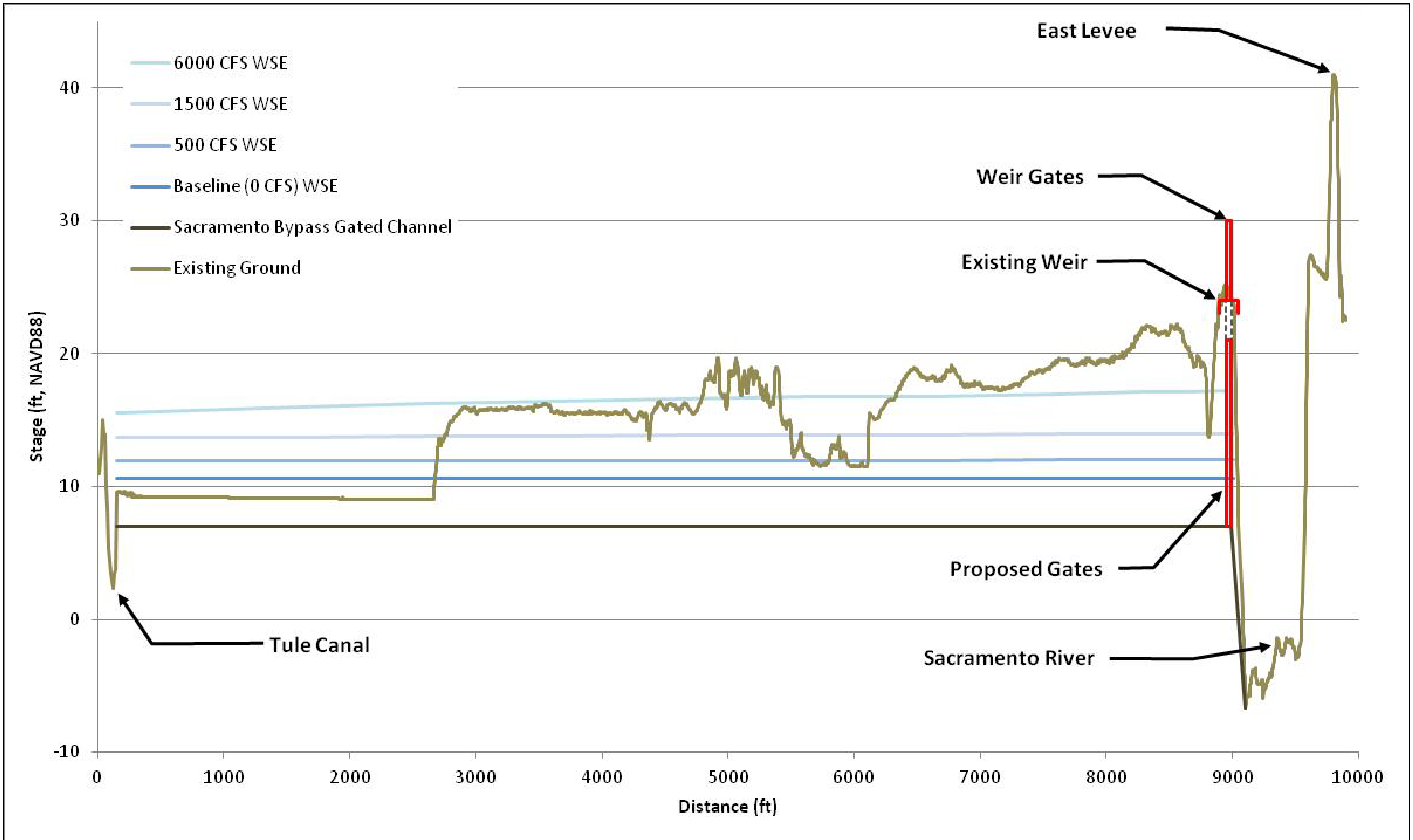
End If



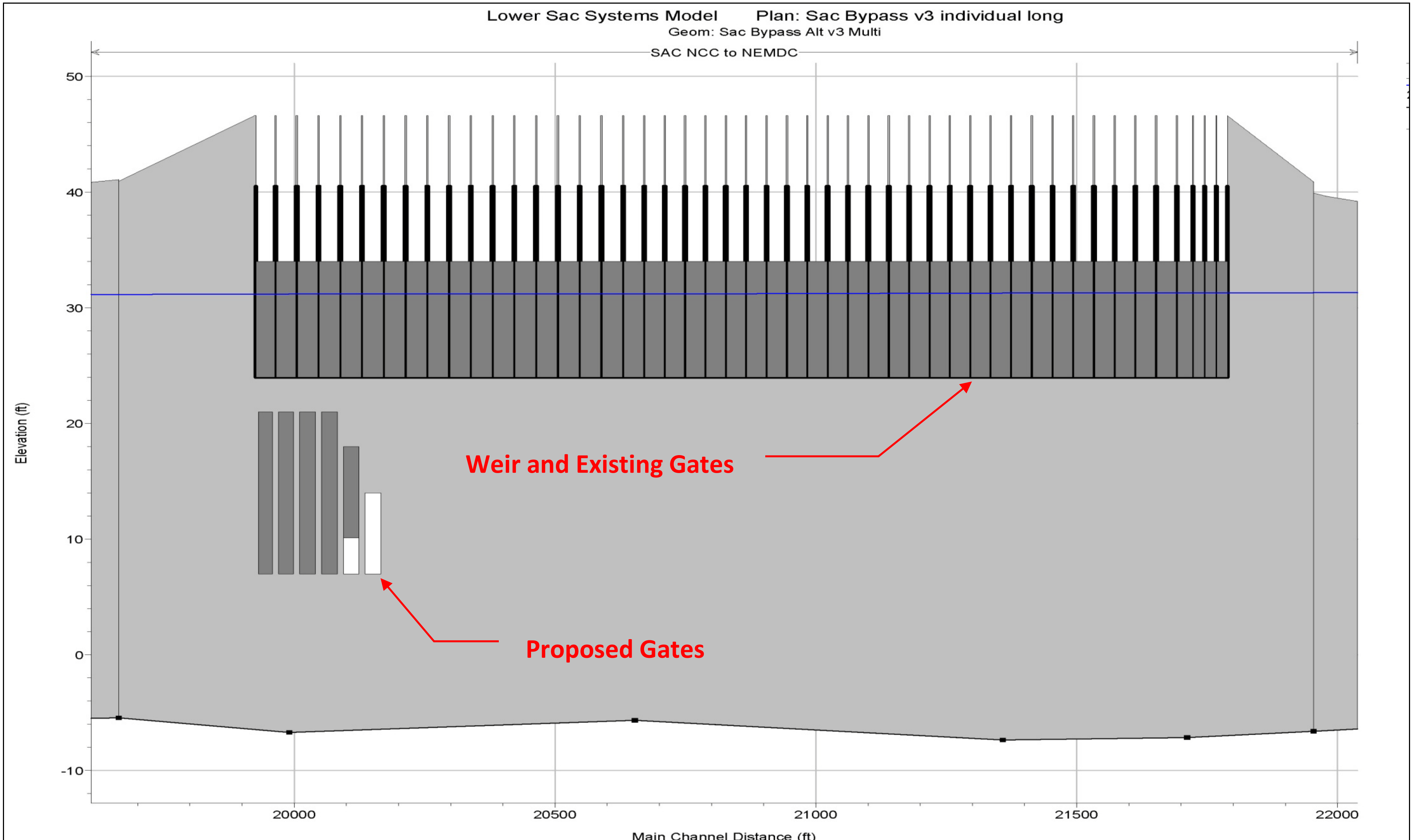
Notes: background courtesy of Bing Maps	cbec eco engineering	*Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project* **Sacramento Weir Alternative Location Map**		
		Project No. 13-1027	Created By: CRC	**Figure 1**



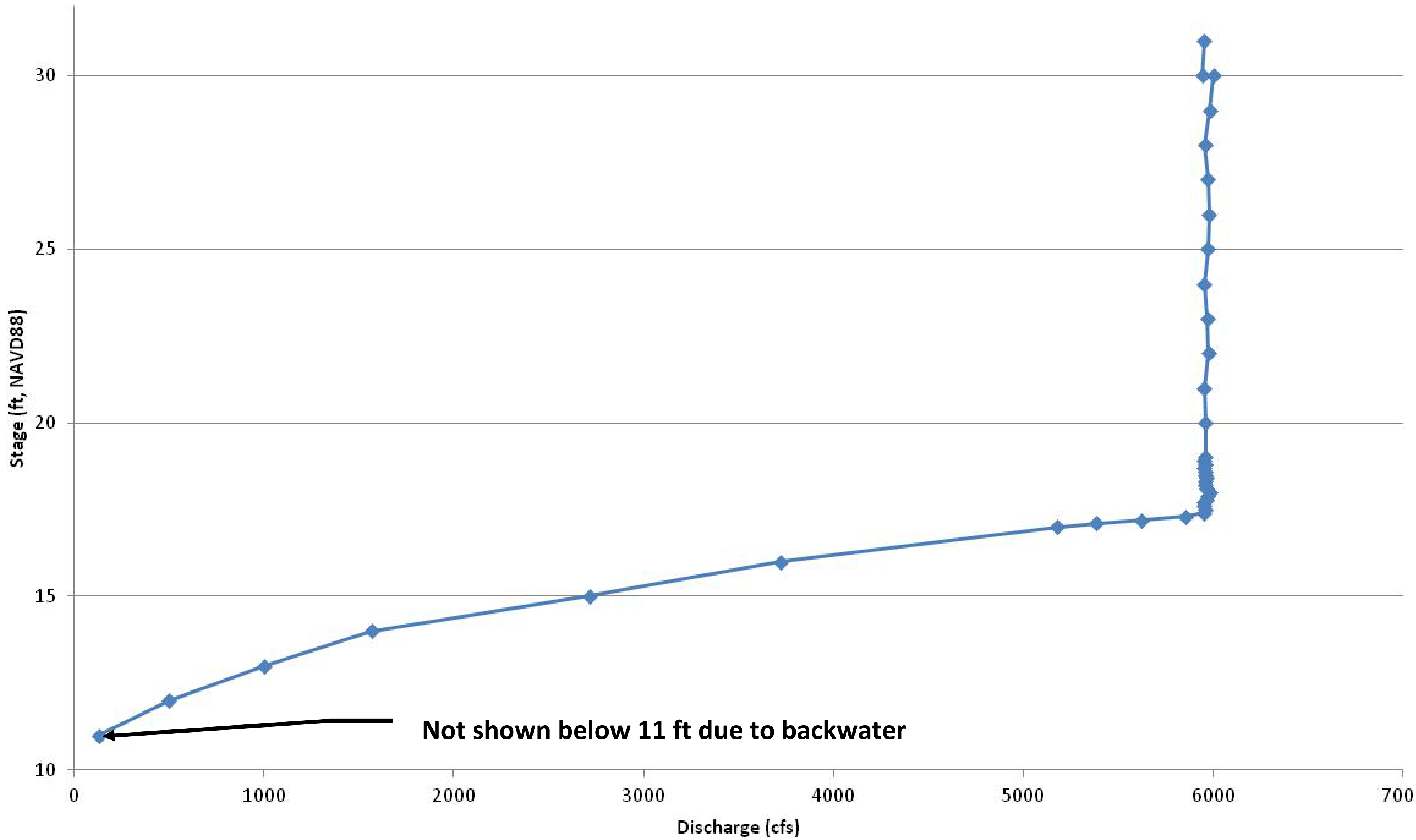
Notes: elevations are NAVD 88		*Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project* **Sacramento Bypass Channel Cross Section**		
		Project No. 13-1027	Created By: CRC	**Figure 2**



Notes:	cbec eco engineering	*Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project* **Sacramento Bypass Water Surface Profiles**		
		Project No. 13-1027	Created By: CRC	**Figure 3**



Notes: Elevations are NAVD 88	cbec eco engineering	*Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project* **Sacramento Weir Alternative – Proposed Gates**
		Project No. 13-1027 / Created By: CRC / **Figure 4**



Notes: gate operations are optimized for 6000 cfs flow rate

Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project

Sacramento Weir Alternative Gate Rating Curve

Project No. 13-1027 | Created By: CRC | **Figure 5**

TECHNICAL MEMORANDUM

Date:	April 14, 2014
To:	Project File
From:	Chris Campbell
Project:	13-1027 – Yolo Bypass Salmonid Habitat Restoration and Fish Passage Projects
Subject:	Fremont Weir Channel Alternatives and Gate Configurations

1 CHANNEL ALTERNATIVES

This Technical Memorandum (TM) details the development of the Fremont Weir Gated Channel Alternatives in HEC-RAS (RAS) for use in the calibrated and validated TUFLOW Classic hydrodynamic model developed to support the California Department of Water Resources (DWR) and US Bureau of Reclamation (USBR) Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project (Project) Environmental Impact Statement and Environmental Impact Report (EIS/EIR). The Fremont Weir Gated Channel Alternatives include three of four alternatives being carried forward through the screening phase.

For the Fremont Weir Gated Channel Alternatives, each alternative was assumed to be graded along the east end of Fremont Weir and parallel to the flood levee, connecting the Sacramento River with the Tule Canal (see Figure 1). The channel profile and the gate configuration were analyzed in RAS to 1) understand the backwater effects on the gates from Yolo Bypass inundation given that proposed upstream inverts at the river are below the baseline water levels in the Tule Canal, and 2) optimize the gate openings for non-overtopping flows with the objective to maximize diversions from the Sacramento River up to 6000 cfs while minimizing head losses across the gate. Gate optimization was performed in RAS because such a function is not yet available in TUFLOW and gate logic is relatively new in TUFLOW.

The channel dimensions of the three Fremont Weir alternatives are provided in Table 1. For the reach of the proposed channels between the Sacramento River and Fremont Weir, a length of approximately 800 feet, the channel was graded from Fremont Weir to the Sacramento River at a slope of 0.0025 with a bottom width of 225 feet and 3:1 side slopes. This was done to reduce head losses within the channel upstream of the gate and minimize the change in the water surface elevation between the river and the weir.

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Table 1. Fremont Weir Alternatives Channel Dimensions

Channel Size	Invert at Fremont Weir (ft, NAVD88)	Bottom Width (ft)	Slope	Side Slopes
Small	14.0	20	0.00016	3:1
Medium	17.5	225	0.00035	3:1
Large	14.0	225	0.00016	3:1

Downstream of the gated channel, there are three agricultural crossings on the Tule Canal between Tule Pond and the confluence with Knights Landing Ridge Cut (KLRC) (see Figure 1). Ag Crossing #1 is an earthen berm at the bottom of Tule Pond that impounds irrigation water for RD 1600 so it can be conveyed through the levee to the Elkhorn Basin. This berm can become degraded during Fremont Weir overtopping events. Ag Crossing#2 is 0.5 miles further south and is an earthen berm with one 32-inch culvert. Ag Crossing #3 is 0.6 miles further south and is an earthen berm with three 24-inch culverts.

The Small and Large channels tie into the Tule Canal just downstream of Ag Crossing #2. The Medium channel ties into the Tule Canal just upstream of Ag Crossing #2. As a result, all three channel alternatives require the partial removal and modification of the earthen berm forming Ag Crossing #1, but only the Small and Large channels require the additional modification to Ag Crossing #2. For the purposes of this analysis, and as demonstrated by the backwater effects from the existing channel capacity on the future gate location at the river during low flows in the canal (see Section 2), it was assumed that all three agricultural crossings were replaced with railcar bridges as part of the alternatives to maximize the frequency of inundation from the Sacramento River. The railcar bridges were assumed to be 90 feet long, 3 feet deep, and situated on 2 foot wide abutments with wing walls. Figures 2 to 7 show the paired existing and future crossings for Ag Crossing #1, #2, and #3, respectively. Under gate operations, all future agricultural crossings were assumed to be fully open. Only Ag Crossing #1 has a hardened bed or concrete sill to accommodate the potential use of flashboards for water level control during the irrigation season.

2 WATER SURFACE PROFILES

For this analysis, the Tule Canal was assumed to have flow contributions of 500 cfs, 350 cfs, 50 cfs, and 300 cfs from KLRC, Cache Creek Settling Basin, Willow Slough, and Putah Creek, respectivley, for existing conditions and all three alternatives. To better understand system performance and hydraulic constraints prior to proceeding with configuring the gates, three steady state inflows of 500 cfs, 1,500 cfs, and 6,000 cfs were introduced at the northern end of Tule Pond. The water surface elevations in the RAS model at the confluence with KLRC were based on calibrated TUFLOW simulations using the above stated flow conditions. Water surface profile comparisons for existing conditions and the Small, Medium, and Large channel alternatives are shown in Figures 8 to 10, respectively. Table 2 lists the water surface elevations at the northern limit of Tule Pond as well as at Ag Crossing #1, #2, and #3.

The differences in water surface elevations between existing conditions and the alternatives are largely controlled by the backwater effects from the limited capacity of the Tule Canal downstream of KLRC and the agricultural crossings upstream of KLRC. For gate flows of 500 cfs, the existing agricultural crossings, especially Ag Crossing #1, control the water surface condition upstream of Tule Pond near the proposed gate and create as much as 3 feet of backwater relative to the Large channel. This is somewhat reduced for the Small channel with only 2 feet of backwater, but this is because the capacity of the Small channel is the limiting factor. For gate flows of 1,500 cfs, backwater from KLRC and Ag Crossing #1 create as much as 1 foot of backwater relative to the Large channel. For gate flows of 6,000 cfs under non-overtopping events, backwater from KLRC and Ag Crossing #1 create as much as 1 foot of backwater relative to the Large channel. Due to the desire to maximize the frequency of Yolo Bypass inundation, and limit backwater effects during gate operations, this water surface profile comparison reinforces the need to improve the conveyance capacity at the three agricultural crossings (i.e., rail car bridges).

Table 2. Water Surface Elevation Comparisons

Water Surface Elevation at Northern Limit of Tule Pond (ft, NAVD88)			
Channel / Discharge (cfs)	**500**	**1500**	**6000**
Existing	21.1	21.9	24.4
Small	19.3	21.3	24.3
Medium	18.6	21.0	23.9
Large	18.3	20.7	23.5
Water Surface Elevation at Ag Crossing #1 (ft, NAVD88)			
Channel / Discharge (cfs)	**500**	**1500**	**6000**
Existing	21.0	21.6	23.0
Small	18.4	20.6	23.0
Medium	18.4	20.8	22.9
Large	18.3	20.6	22.9
Water Surface Elevation at Ag Crossing #2 (ft, NAVD88)			
Channel / Discharge (cfs)	**500**	**1500**	**6000**
Existing	18.4	20.4	22.8
Small	18.3	20.5	22.8
Medium	18.3	20.6	22.8
Large	18.2	20.4	22.8
Water Surface Elevation at Ag Crossing #3 (ft, NAVD88)			
Channel / Discharge (cfs)	**500**	**1500**	**6000**
Existing	18.3	20.4	22.7
Small	18.2	20.4	22.7
Medium	18.2	20.4	22.7
Large	18.2	20.4	22.7

3 GATE CONFIGURATION

A series of gates at the channel connection with the Sacramento River were used to maximize the flow into the Yolo Bypass for non-overtopping flow events up to 6,000 cfs. A gate optimization routine in RAS (see Section 4) was used to configure the size and number of gates as well as determine the individual gate openings relative to river stage. In general, gate widths were limited to 30 ft in width with 3 ft pillars between them. Some of the gates were limited in height to prevent them from extending above the existing weir crest (32.8 feet NAVD 88) during an overtopping event. After Fremont Weir overtops, the gates will remain open per their last know configuration. Sluice gates or radial gates could be used, but radial gates may offer the greatest flexibility in terms of real-time operations as well as constructability to minimize debris accumulation on the lift components. The gates could also be operated individually or in unison. For the Small channel, the bottom width of the channel was widened to accommodate three gates to minimize the head loss across the gate structure. The resulting gate configurations are shown in Table 3 for individual and unison operations. The gate configurations for individual operation are shown in Figures 11, 14, and 16 for the Small, Medium, and Large channels, respectively. The gate configurations for the unison operation are shown in Figures 12, 15, and 17 for the Small, Medium, and Large channels, respectively. The resulting gate opening schedules are shown in Tables 4, 5, and 6 for the Small, Medium, and Large channels, respectively. However, for the purposes of the TUFLOW modeling, the gates were assumed 1) to be radial such that lift components do not protrude above the top of the weir crest, and 2) operate individually assuming that a few gates with taller openings would be more favorable to fish passage than all gates open with potentially very short openings.

The river stage versus gate flow relationships are shown in Figure 18. For example, at a river stage of 24 feet NAVD88, the Small, Medium, and Large gated channels can convey 2201 cfs, 4313 cfs, and 5886 cfs, respectively. Relative to the Small channel, the Medium channel conveys twice as much flow and the Large channel conveys three times as much flow at elevation 24 feet.

Table 3. Gate Configurations

Channel Size	Invert at River (ft, 88)	Bottom Width at Gate (ft)	Gate Invert (ft)	Gate Height (ft)	Gate Width (ft)	Number of Gates
Individual Operation						
Small	14	115	14	8, 14	30	3
Medium	17.5	225	17.5	6, 12	30	6
Large	14	225	14	7.5, 10	30	6
Unison Operation						
Small	14	115	14	11.5	30	3
Medium	17.5	225	17.5	7.5	30	6
Large	14	225	14	10	30	6

Table 4. Small Individual Gate Operations

Sacramento River Stage (ft, 88)	Total Gate Flow (cfs)	Gate 1 Opening (ft)	Gate 2 Opening (ft)	Gate 3 Opening (ft)	Gate 1 Velocity (fps)	Gate 2 Velocity (fps)	Gate 3 Velocity (fps)
15.5	5	8	8	14	0.04	0.04	0.04
16.0	42	8	8	14	0.2	0.2	0.2
17.0	112	8	8	14	0.4	0.4	0.4
18.0	198	8	8	14	0.5	0.5	0.5
19.0	321	8	8	14	0.7	0.7	0.7
20.0	518	8	8	14	1.0	1.0	1.0
21.0	805	8	8	14	1.3	1.3	1.3
22.0	1111	8	8	14	1.5	1.5	1.5
23.0	1590	8	8	14	2.1	2.1	2.2
24.0	2201	8	8	14	2.3	2.3	3.6
25.0	2957	8	8	14	3.0	3.0	4.6
26.0	3910	8	8	14	3.7	3.7	5.9
27.0	5001	8	8	14	4.6	4.6	7.2
27.1	5119	8	8	14	4.7	4.7	7.3
27.2	5237	8	8	14	4.7	4.7	7.5
27.3	5355	8	8	14	4.8	4.8	7.6
27.4	5473	8	8	14	4.9	4.9	7.8
27.5	5591	8	8	14	5.0	5.0	7.9
27.6	5706	8	8	14	5.1	5.1	8.0
27.7	5822	8	8	14	5.2	5.2	8.1
27.8	5938	8	8	14	5.3	5.3	8.2
27.9	5951	8	8	13.01	5.6	5.6	7.8
28.0	5951	8	8	12.47	6.0	6.0	7.3
28.1	5952	8	8	12.14	6.3	6.3	8.0
28.2	5950	8	8	11.87	6.6	6.6	7.8
28.3	5951	8	8	11.66	6.9	6.9	7.5
28.4	5951	8	8	11.43	7.2	7.2	7.2
28.5	5950	8	8	10.4	7.5	7.5	7.5
28.6	5951	8	8	9.5	7.8	7.8	7.8
28.7	5951	8	8	8.68	8.0	8.0	8.0
28.8	5951	8	8	7.93	8.3	8.3	8.3
28.9	5951	8	8	7.25	8.5	8.5	8.5
29.0	5951	8	8	6.62	8.8	8.8	8.8
29.1	5951	8	8	6.04	9.0	9.0	9.0
29.2	5951	8	8	5.50	9.2	9.2	9.2

Sacramento River Stage (ft, 88)	Total Gate Flow (cfs)	Gate 1 Opening (ft)	Gate 2 Opening (ft)	Gate 3 Opening (ft)	Gate 1 Velocity (fps)	Gate 2 Velocity (fps)	Gate 3 Velocity (fps)
29.3	5951	8	8	5.00	9.4	9.4	9.4
29.4	5950	8	8	4.53	9.7	9.7	9.7
29.5	5951	8	8	4.10	9.9	9.9	9.9
29.6	5951	8	8	3.68	10.1	10.1	10.1
29.7	5951	8	8	3.29	10.3	10.3	10.3
29.8	5951	8	8	2.92	10.5	10.5	10.5
29.9	5952	8	8	2.58	10.7	10.7	10.7
30.0	5952	8	8	2.25	10.9	10.9	10.9
30.1	5950	8	8	1.93	11.1	11.1	11.1
30.2	5951	8	8	1.64	11.2	11.2	11.2
30.3	5952	8	8	1.36	11.4	11.4	11.4
30.4	5952	8	8	1.09	11.6	11.6	11.6
30.5	5951	8	8	0.78	11.8	11.8	11.8
30.6	5952	8	8	0.49	12.0	12.0	12.0
30.7	5950	8	8	0.20	12.2	12.2	12.2
30.8	5950	8	7.93	0.00	12.5	12.5	0.0
30.9	5952	8	7.68	0.00	12.7	12.7	0.0
31.0	5952	8	7.43	0.00	12.9	12.9	0.0
31.1	5952	8	7.19	0.00	13.1	13.1	0.0
31.2	5952	8	6.96	0.00	13.3	13.3	0.0
31.3	5952	8	6.74	0.00	13.5	13.5	0.0
31.4	5950	8	6.52	0.00	13.7	13.7	0.0
31.5	5952	8	6.32	0.00	13.9	13.9	0.0
31.6	5951	8	6.12	0.00	14.0	14.0	0.0
31.7	5952	8	5.93	0.00	14.2	14.2	0.0
31.8	5951	8	5.7399	0.00	14.4	14.4	0.0
31.9	5950	8	5.5599	0.00	14.6	14.6	0.0
32.0	5951	8	5.3899	0.00	14.8	14.8	0.0
32.1	5951	8	5.22	0.0	15.0	15.0	0.0
32.2	5952	8	5.06	0.0	15.2	15.2	0.0
32.3	5951	8	4.90	0.0	15.4	15.4	0.0
32.4	5952	8	4.75	0.0	15.6	15.6	0.0
32.5	5951	8	4.60	0.0	15.7	15.7	0.0
32.6	5953	8	4.46	0.0	15.9	15.9	0.0
32.7	5953	8	4.32	0.0	16.1	16.1	0.0
32.8	5998	8	4.32	0.0	16.2	16.2	0.0

Table 5. Medium Individual Gate Operations

Sacramento River Stage (ft, 88)	Total Gate Flow (cfs)	Gate 1 Opening (ft)	Gate 2 Opening (ft)	Gate 3 Opening (ft)	Gate 4 Opening (ft)	Gate 5 Opening (ft)	Gate 6 Opening (ft)	Gate 1 Velocity (fps)	Gate 2 Velocity (fps)	Gate 3 Velocity (fps)	Gate 4 Velocity (fps)	Gate 5 Velocity (fps)	Gate 6 Velocity (fps)
17.8	60	6	6	6	12	12	12	1.1	1.1	1.1	1.1	1.1	1.1
18.0	150	6	6	6	12	12	12	1.7	1.7	1.7	1.7	1.7	1.7
19.0	466	6	6	6	12	12	12	1.7	1.7	1.7	1.7	1.7	1.7
20.0	841	6	6	6	12	12	12	1.9	1.9	1.9	1.9	1.9	1.9
21.0	1286	6	6	6	12	12	12	2.0	2.0	2.0	2.0	2.0	2.0
22.0	1995	6	6	6	12	12	12	2.5	2.5	2.5	2.5	2.5	2.5
23.0	3079	6	6	6	12	12	12	3.1	3.1	3.1	3.1	3.1	3.1
24.0	4313	6	6	6	12	12	12	3.8	3.8	3.8	3.8	3.8	3.8
25.0	5549	6	6	6	12	12	12	3.9	3.9	3.9	5.1	5.1	5.1
25.3	5925	6	6	6	12	12	12	3.8	3.8	3.8	5.5	5.5	5.5
25.4	5952	6	6	6	12	12	5.5	4.2	4.2	4.2	6.3	6.3	4.2
25.5	5952	6	6	6	12	12	0.7	4.7	4.7	4.7	6.9	6.9	4.7
25.6	5951	6	6	6	12	7.0	0	5.1	5.1	5.1	7.3	6.7	0.0
25.7	5937	6	6	6	12	6.5	0	5.6	5.6	5.6	7.6	5.8	0.0
25.8	5952	6	6	6	12	4.6	0	5.9	5.9	5.9	7.8	5.9	0.0
25.9	5956	6	6	6	12	3.0	0	6.2	6.2	6.2	8.0	6.2	0.0
26.0	5953	6	6	6	12	1.6	0	6.6	6.6	6.6	8.2	6.6	0.0
26.1	5952	6	6	6	12	0.4	0	6.9	6.9	6.9	8.3	6.9	0.0
26.2	5960	6	6	6	8.0	0.0	0	7.2	7.2	7.2	8.6	0.0	0.0
26.3	5959	6	6	6	7.5	0.0	0	7.5	7.5	7.5	8.5	0.0	0.0
26.4	5966	6	6	6	7.2	0.0	0	7.8	7.8	7.8	8.2	0.0	0.0
26.5	5954	6	6	6	6.6	0.0	0	8.1	8.1	8.1	8.1	0.0	0.0
26.6	5951	6	6	6	5.8	0.0	0	8.3	8.3	8.3	8.3	0.0	0.0

Sacramento River Stage (ft, 88)	Total Gate Flow (cfs)	Gate 1 Opening (ft)	Gate 2 Opening (ft)	Gate 3 Opening (ft)	Gate 4 Opening (ft)	Gate 5 Opening (ft)	Gate 6 Opening (ft)	Gate 1 Velocity (fps)	Gate 2 Velocity (fps)	Gate 3 Velocity (fps)	Gate 4 Velocity (fps)	Gate 5 Velocity (fps)	Gate 6 Velocity (fps)
26.7	5951	6	6	6	5.1	0.0	0	8.6	8.6	8.6	8.6	0.0	0.0
26.8	5956	6	6	6	4.4	0.0	0	8.9	8.9	8.9	8.9	0.0	0.0
26.9	5957	6	6	6	3.7	0.0	0	9.2	9.2	9.2	9.2	0.0	0.0
27.0	5952	6	6	6	3.0	0.0	0	9.4	9.4	9.4	9.4	0.0	0.0
27.1	5953	6	6	6	2.4	0.0	0	9.7	9.7	9.7	9.7	0.0	0.0
27.2	5961	6	6	6	1.9	0.0	0	10.0	10.0	10.0	10.0	0.0	0.0
27.3	5951	6	6	6	1.3	0.0	0	10.3	10.3	10.3	10.3	0.0	0.0
27.4	5966	6	6	6	0.9	0.0	0	10.5	10.5	10.5	10.5	0.0	0.0
27.5	5960	6	6	6	0.4	0.0	0	10.8	10.8	10.8	10.8	0.0	0.0
27.6	5967	6	6	6	0.0	0.0	0	11.0	11.0	11.0	0.0	0.0	0.0
27.7	5952	6	6	5.5	0.0	0.0	0	11.3	11.3	11.3	0.0	0.0	0.0
27.8	5968	6	6	5.2	0.0	0.0	0	11.6	11.6	11.6	0.0	0.0	0.0
27.9	5962	6	6	4.8	0.0	0.0	0	11.8	11.8	11.8	0.0	0.0	0.0
28.0	5952	6	6	4.4	0.0	0.0	0	12.1	12.1	12.1	0.0	0.0	0.0
29.0	5978	6	6	2.7	0.0	0.0	0	13.6	13.6	13.6	0.0	0.0	0.0
30.0	5984	6	6	2.1	0.0	0.0	0	14.1	14.1	14.1	0.0	0.0	0.0
31.0	5958	6	6	1.5	0.0	0.0	0	14.7	14.7	14.7	0.0	0.0	0.0
32.0	5995	6	6	1.1	0.0	0.0	0	15.3	15.3	15.2	0.0	0.0	0.0
32.8	5972	6	6	0.7	0.0	0.0	0	15.7	15.7	15.7	0.0	0.0	0.0

Table 6. Large Individual Gate Operations

Sacramento River Stage (ft, 88)	Total Gate Flow (cfs)	Gate 1 Opening (ft)	Gate 2 Opening (ft)	Gate 3 Opening (ft)	Gate 4 Opening (ft)	Gate 5 Opening (ft)	Gate 6 Opening (ft)	Gate 1 Velocity (fps)	Gate 2 Velocity (fps)	Gate 3 Velocity (fps)	Gate 4 Velocity (fps)	Gate 5 Velocity (fps)	Gate 6 Velocity (fps)
15.5	15	7.5	7.5	7.5	10	10	10	0.1	0.1	0.1	0.1	0.1	0.1
16.0	94	7.5	7.5	7.5	10	10	10	0.3	0.3	0.3	0.3	0.3	0.3
17.0	260	7.5	7.5	7.5	10	10	10	0.5	0.5	0.5	0.5	0.5	0.5
18.0	434	7.5	7.5	7.5	10	10	10	0.6	0.6	0.6	0.6	0.6	0.6
19.0	725	7.5	7.5	7.5	10	10	10	0.8	0.8	0.8	0.8	0.8	0.8
20.0	1138	7.5	7.5	7.5	10	10	10	1.1	1.1	1.1	1.1	1.1	1.1
21.0	1713	7.5	7.5	7.5	10	10	10	1.4	1.4	1.4	1.4	1.4	1.4
22.0	2899	7.5	7.5	7.5	10	10	10	2.1	2.1	2.1	2.1	2.1	2.1
23.0	4335	7.5	7.5	7.5	10	10	10	2.5	2.5	2.5	3.3	3.3	3.3
24.0	5886	7.5	7.5	7.5	10	10	10	2.9	2.9	2.9	4.4	4.4	4.4
24.1	5951	7.5	7.5	7.5	10	10	4.7	3.3	3.3	3.3	5.4	5.4	3.3
24.2	5955	7.5	7.5	7.5	10	9	0	3.9	3.9	3.9	6.2	5.4	0
24.3	5952	7.5	7.5	7.5	10	6.9	0	4.4	4.4	4.4	7.0	4.4	0
24.4	5952	7.5	7.5	7.5	10	3.1	0	4.8	4.8	4.8	7.5	4.8	0
24.5	5954	7.5	7.5	7.5	10	0.4	0	5.2	5.2	5.2	7.8	5.2	0
24.6	5960	7.5	7.5	7.5	9.5	0	0	5.6	5.6	5.6	7.6	0	0
24.7	5946	7.5	7.5	7.5	9.1	0	0	6.0	6.0	6.0	7.3	0	0
24.8	5958	7.5	7.5	7.5	8.7	0	0	6.3	6.3	6.3	6.5	0	0
24.9	5958	7.5	7.5	7.5	7.5	0	0	6.6	6.6	6.6	6.6	0	0
25.0	5959	7.5	7.5	7.5	6.2	0	0	6.9	6.9	6.9	6.9	0	0
25.1	5954	7.5	7.5	7.5	5	0	0	7.2	7.2	7.2	7.2	0	0
25.2	5957	7.5	7.5	7.5	4	0	0	7.5	7.5	7.5	7.5	0	0
25.3	5958	7.5	7.5	7.5	3.1	0	0	7.8	7.8	7.8	7.8	0	0

Sacramento River Stage (ft, 88)	Total Gate Flow (cfs)	Gate 1 Opening (ft)	Gate 2 Opening (ft)	Gate 3 Opening (ft)	Gate 4 Opening (ft)	Gate 5 Opening (ft)	Gate 6 Opening (ft)	Gate 1 Velocity (fps)	Gate 2 Velocity (fps)	Gate 3 Velocity (fps)	Gate 4 Velocity (fps)	Gate 5 Velocity (fps)	Gate 6 Velocity (fps)
25.4	5962	7.5	7.5	7.5	2.3	0	0	8.0	8.0	8.0	8.0	0	0
25.5	5956	7.5	7.5	7.5	1.5	0	0	8.3	8.3	8.3	8.3	0	0
25.6	5955	7.5	7.5	7.5	0.8	0	0	8.5	8.5	8.5	8.5	0	0
25.7	5959	7.5	7.5	7.5	0.2	0	0	8.8	8.8	8.8	8.8	0	0
25.8	5957	7.5	7.5	7.1	0	0	0	9.0	9.0	9.0	0	0	0
25.9	5963	7.5	7.5	6.6	0	0	0	9.2	9.2	9.2	0	0	0
26.0	5964	7.5	7.5	6.1	0	0	0	9.4	9.4	9.4	0	0	0
26.1	5959	7.5	7.5	5.6	0	0	0	9.6	9.6	9.6	0	0	0
26.2	5966	7.5	7.5	5.2	0	0	0	9.8	9.8	9.8	0	0	0
26.3	5952	7.5	7.5	4.7	0	0	0	10.1	10.1	10.1	0	0	0
26.4	5963	7.5	7.5	4.3	0	0	0	10.3	10.3	10.3	0	0	0
26.5	5953	7.5	7.5	3.8	0	0	0	10.6	10.6	10.6	0	0	0
26.6	5956	7.5	7.5	3.4	0	0	0	10.8	10.8	10.8	0	0	0
26.7	5955	7.5	7.5	3	0	0	0	11.0	11.0	11.0	0	0	0
26.8	5970	7.5	7.5	2.7	0	0	0	11.2	11.2	11.2	0	0	0
26.9	5962	7.5	7.5	2.3	0	0	0	11.5	11.5	11.5	0	0	0
27.0	5970	7.5	7.5	2	0	0	0	11.7	11.7	11.7	0	0	0
27.1	5954	7.5	7.5	1.6	0	0	0	12.0	12.0	12.0	0	0	0
27.2	5956	7.5	7.5	1.3	0	0	0	12.2	12.2	12.2	0	0	0
27.3	5954	7.5	7.5	1	0	0	0	12.4	12.4	12.4	0	0	0
27.4	5973	7.5	7.5	0.8	0	0	0	12.6	12.6	12.6	0	0	0
27.5	5966	7.5	7.5	0.5	0	0	0	12.8	12.8	12.8	0	0	0
27.6	5956	7.5	7.5	0.2	0	0	0	13.1	13.1	13.1	0	0	0
27.7	5968	7.5	7.5	0	0	0	0	13.3	13.3	0	0	0	0

Sacramento River Stage (ft, 88)	Total Gate Flow (cfs)	Gate 1 Opening (ft)	Gate 2 Opening (ft)	Gate 3 Opening (ft)	Gate 4 Opening (ft)	Gate 5 Opening (ft)	Gate 6 Opening (ft)	Gate 1 Velocity (fps)	Gate 2 Velocity (fps)	Gate 3 Velocity (fps)	Gate 4 Velocity (fps)	Gate 5 Velocity (fps)	Gate 6 Velocity (fps)
27.8	5952	7.5	7.2	0	0	0	0	13.5	13.5	0	0	0	0
27.9	5960	7.5	7	0	0	0	0	13.7	13.7	0	0	0	0
28.0	5965	7.5	6.8	0	0	0	0	13.9	13.9	0	0	0	0
29.0	5960	7.5	5.3	0	0	0	0	15.5	15.5	0	0	0	0
30.0	5964	7.5	4.9	0	0	0	0	16.0	16.0	0	0	0	0
31.0	5950	7.5	4.5	0	0	0	0	16.5	16.5	0	0	0	0
32.0	5970	7.5	4.2	0	0	0	0	17.0	17.0	0	0	0	0
32.8	5997	7.5	4	0	0	0	0	17.4	17.4	0	0	0	0

Table 7. Small Unison Gate Operations

Sacramento River Stage (ft, 88)	Total Gate Flow (cfs)	Gate Opening (ft)	Gate Velocity (fps)
14.1	1	11.5	0.08
14.3	2	11.5	0.09
14.5	5	11.5	0.11
14.8	11.4	11.5	0.16
15	15.8	11.5	0.18
16	39.8	11.5	0.22
17	107	11.5	0.39
18	190	11.5	0.53
19	308	11.5	0.68
20	491	11.5	0.91
21	759	11.5	1.21
22	1030	11.5	1.43
23	1325	11.5	1.64
24	1806	11.5	2.01
25	2458	11.5	2.48
26	3248	11.5	3.14
27	4151	11.5	4.01
28	4988	11.5	4.82
29	5725	11.5	5.53
29.1	5801	11.5	5.60
29.2	5877	11.5	5.68
29.3	5951	11.5	5.76
29.4	5951	10.8	6.11
29.5	5951	10.3	6.43
29.6	5952	9.8	6.75
29.7	5951	9.4	7.05
29.8	5951	9.0	7.34
29.9	5951	8.7	7.62
30.0	5952	8.4	7.88
30.1	5951	8.1	8.14
30.2	5952	7.9	8.39
30.3	5952	7.7	8.63
30.4	5951	7.5	8.87
30.5	5950	7.3	9.11
30.6	5952	7.1	9.33
30.7	5953	6.9	9.54

Sacramento River Stage (ft, 88)	Total Gate Flow (cfs)	Gate Opening (ft)	Gate Velocity (fps)
30.8	5954	6.8	9.76
30.9	5951	6.6	9.97
31.0	5953	6.5	10.18
31.1	5951	6.4	10.38
31.2	5950	6.3	10.58
31.3	5952	6.1	10.77
31.4	5955	6.0	10.95
31.5	5950	5.93	11.15
31.6	5954	5.84	11.33
31.7	5955	5.75	11.51
31.8	5954	5.66	11.69
31.9	5956	5.58	11.86
32.0	5950	5.49	12.04
32.1	5954	5.42	12.21
32.2	5953	5.33	12.41
32.3	5950	5.24	12.62
32.4	5951	5.16	12.81
32.5	5956	5.09	13.00
32.6	5953	5.01	13.20
32.7	5955	4.94	13.39
32.8	5999	4.94	13.49

Table 8. Medium Unison Gate Operations

Sacramento River Stage (ft, 88)	Total Gate Flow (cfs)	Gate Opening (ft)	Gate Velocity (fps)
17.6	11	7.5	0.87
17.8	50	7.5	0.93
18	109	7.5	1.21
19	466	7.5	1.73
20	842	7.5	1.87
21	1286	7.5	2.04
22	1995	7.5	2.46
23	3070	7.5	3.10
24	4321	7.5	3.69
25	5635	7.5	4.17
25.1	5773	7.50	4.28
25.2	5910	7.50	4.38
25.3	5951	6.75	4.90

Sacramento River Stage (ft, 88)	Total Gate Flow (cfs)	Gate Opening (ft)	Gate Velocity (fps)
25.4	5952	6.49	5.10
25.5	5957	6.40	5.17
25.6	5955	6.35	5.21
25.7	5951	5.97	5.54
25.8	5953	5.60	5.91
25.9	5954	5.29	6.25
26.0	5952	5.02	6.59
26.1	5955	4.79	6.91
26.2	5952	4.58	7.22
26.3	5952	4.40	7.52
26.4	5952	4.24	7.80
26.5	5954	4.10	8.07
26.6	5953	3.97	8.33
26.7	5951	3.85	8.59
26.8	5953	3.73	8.87
26.9	5952	3.61	9.16
27.0	5952	3.50	9.45
27.1	5953	3.40	9.73
27.2	5956	3.31	10.00
27.3	5954	3.22	10.27
27.4	5956	3.14	10.54
27.5	5954	3.06	10.81
27.6	5957	2.99	11.07
27.7	5955	2.92	11.33
27.8	5960	2.86	11.58
27.9	5962	2.80	11.83
28	5960	2.74	12.08
29	5954	2.44	13.56
30	5958	2.34	14.15
31	5958	2.25	14.71
32	5958	2.17	15.25
32.8	5981	2.12	15.67

Table 9. Large Unison Gate Operations

Sacramento River Stage (ft, 88)	Total Gate Flow (cfs)	Gate Opening (ft)	Gate Velocity (fps)
15.5	15	10.0	0.06
16	94	10.0	0.26

Sacramento River Stage (ft, 88)	Total Gate Flow (cfs)	Gate Opening (ft)	Gate Velocity (fps)
17	260	10.0	0.48
18	434	10.0	0.60
19	725	10.0	0.81
20	1138	10.0	1.05
21	1713	10.0	1.36
22	2901	10.0	2.01
23	4360	10.0	2.69
24	5951	9.18	3.60
24.1	5953	8.39	3.94
24.2	5955	8.20	4.03
24.3	5951	7.54	4.38
24.4	5951	6.84	4.83
24.5	5951	6.30	5.25
24.6	5952	5.88	5.62
24.7	5951	5.53	5.98
24.8	5952	5.24	6.31
24.9	5953	4.99	6.63
25.0	5952	4.77	6.93
25.1	5952	4.58	7.22
25.2	5952	4.41	7.50
25.3	5954	4.26	7.76
25.4	5952	4.12	8.03
25.5	5956	4.00	8.27
25.6	5952	3.88	8.52
25.7	5956	3.78	8.75
25.8	5954	3.68	8.99
25.9	5954	3.59	9.21
26.0	5957	3.51	9.43
26.1	5956	3.43	9.65
26.2	5959	3.36	9.85
26.3	5958	3.29	10.06
26.4	5956	3.21	10.31
26.5	5960	3.14	10.55
26.6	5960	3.07	10.79
26.7	5955	3.00	11.03
26.8	5958	2.94	11.26
26.9	5958	2.88	11.49

Sacramento River Stage (ft, 88)	Total Gate Flow (cfs)	Gate Opening (ft)	Gate Velocity (fps)
27	5953	2.82	11.73
28	5960	2.38	13.91
29	5978	2.14	15.52
30	5973	2.07	16.03
31	5979	2.01	16.53
32	5970	1.95	17.01
32.8	5976	1.91	17.38

4 GATE LOGIC

Rule operations in the RAS unsteady flow editor were used to optimize gate operations for the various gated channel alternatives. A special operational parameter available in RAS called *Structure-Flow (Desired)* was used to determine gate operations to maximize a flow up to 6,000 cfs. The operational parameter *Structure-Flow (Desired)* adjusts the gate openings based on the Sacramento River water surface elevations and the gate characteristics. For this analysis, the gates were allowed to open and close at a rate of one foot per minute during an unsteady flow analysis that used a stepped stage time series at the river and a stage-discharge rating curve as the downstream boundary condition at KLRC. The relatively quick opening rate of one foot per minute was used to speed up solution convergence, but can be set to something larger in TUFLOW to represent realistic rates or accommodate model stability. The following logic was used in RAS to determine gate operations to maximize flows up to 6000 cfs based on Yolo Bypass and Sacramento River water surface elevations:

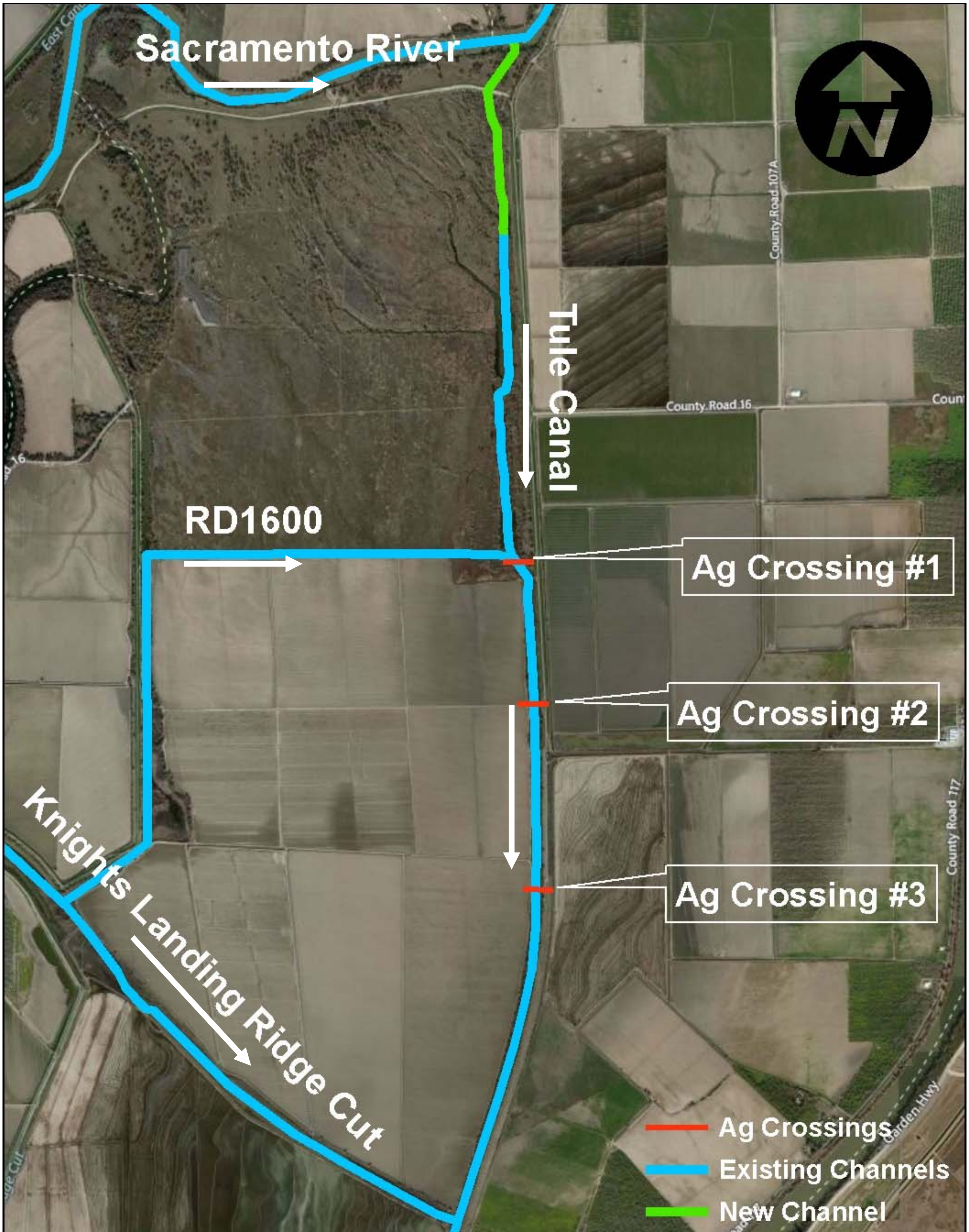
Define variable: TotalGateFlow = Sum of flow for all gates at current time step
Define variable: Gate1Opening = Opening of gate 1 at current time step
Define variable: Gate2Opening = Opening of gate 2 at current time step
Define variable: Gate3Opening = Opening of gate 3 at current time step
Define variable: Gate4Opening = Opening of gate 4 at current time step
Define variable: Gate5Opening = Opening of gate 5 at current time step
Define variable: Gate6Opening = Opening of gate 6 at current time step
Define variable: MaximumGateOpening1 = maxium gate opening (size 1)
Define variable: MaximumGateOpening2 = maxium gate opening (size 2)

If TotalGateFlow < 5950 Then
    If Gate1Opening < MaximumGateOpening1 Then
    Set Opening of Gate 1 = Gate1Opening + 0.1
    Else, If Gate2Opening < MaximumGateOpening1 Then
    Set Opening of Gate 2 = Gate2Opening + 0.1
    Else, If Gate3Opening < MaximumGateOpening1 Then
    Set Opening of Gate 3 = Gate3Opening + 0.1

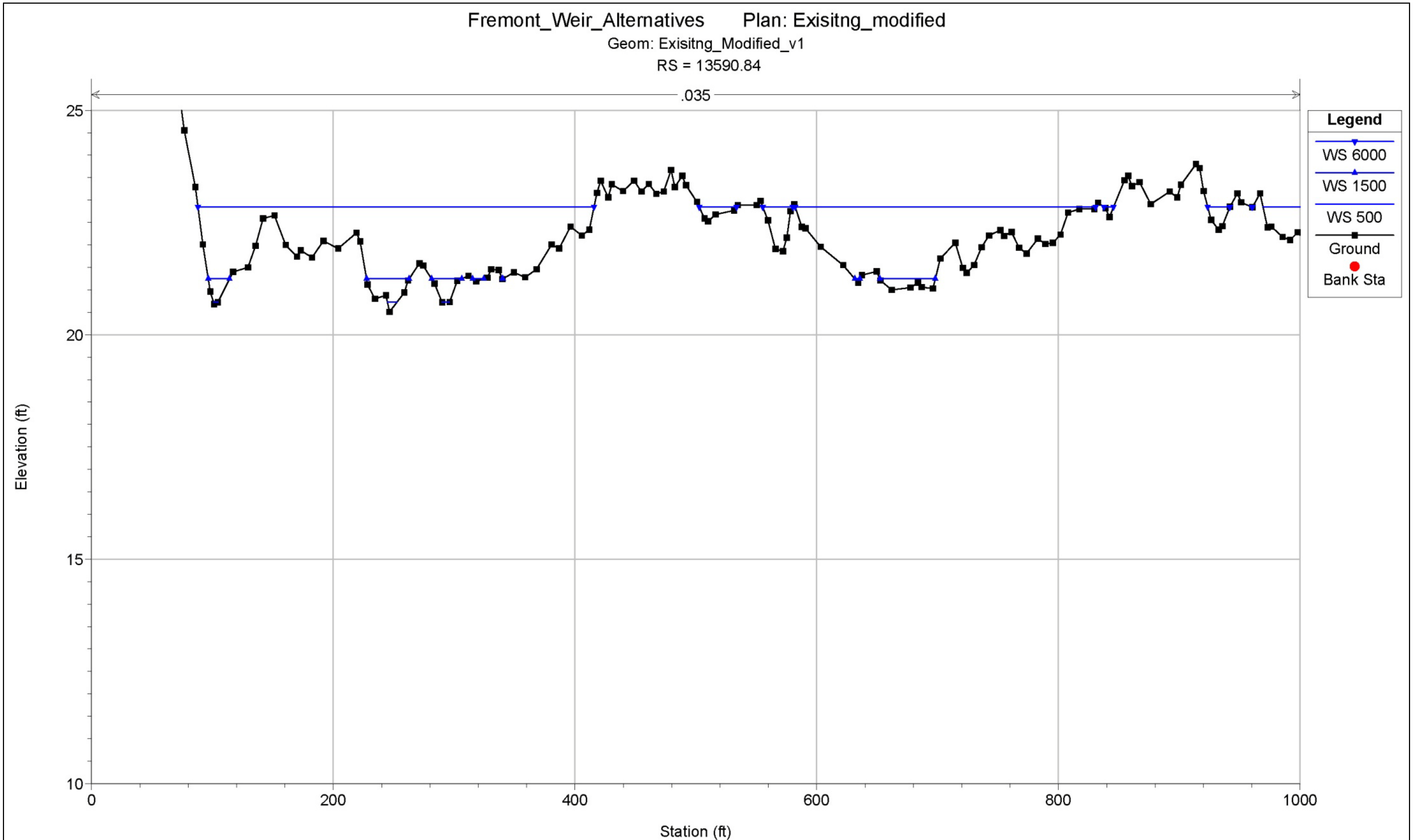
Else, If Gate4Opening < MaximumGateOpening2 Then
Set Opening of Gate 4 = Gate4Opening + 0.1
Else, If Gate5Opening < MaximumGateOpening2 Then
Set Opening of Gate 5 = Gate5Opening + 0.1
Else, If Gate6Opening < MaximumGateOpening2 Then
Set Opening of Gate 6 = Gate6Opening + 0.1
End If

Else, If TotalGateFlow > 6000 Then
If Gate6Opening > 0 Then
Set Opening of Gate 6 = Gate6Opening - 0.1
Else, If Gate5Opening > 0 Then
Set Opening of Gate 5 = Gate5Opening - 0.1
Else, If Gate4Opening > 0 Then
Set Opening of Gate 4 = Gate4Opening - 0.1
Else, If Gate3Opening > 0 Then
Set Opening of Gate 3 = Gate3Opening - 0.1
Else, If Gate2Opening > 0 Then
Set Opening of Gate 2 = Gate2Opening - 0.1
Else, If Gate1Opening > 0 Then
Set Opening of Gate 1 = Gate1Opening - 0.1
End If

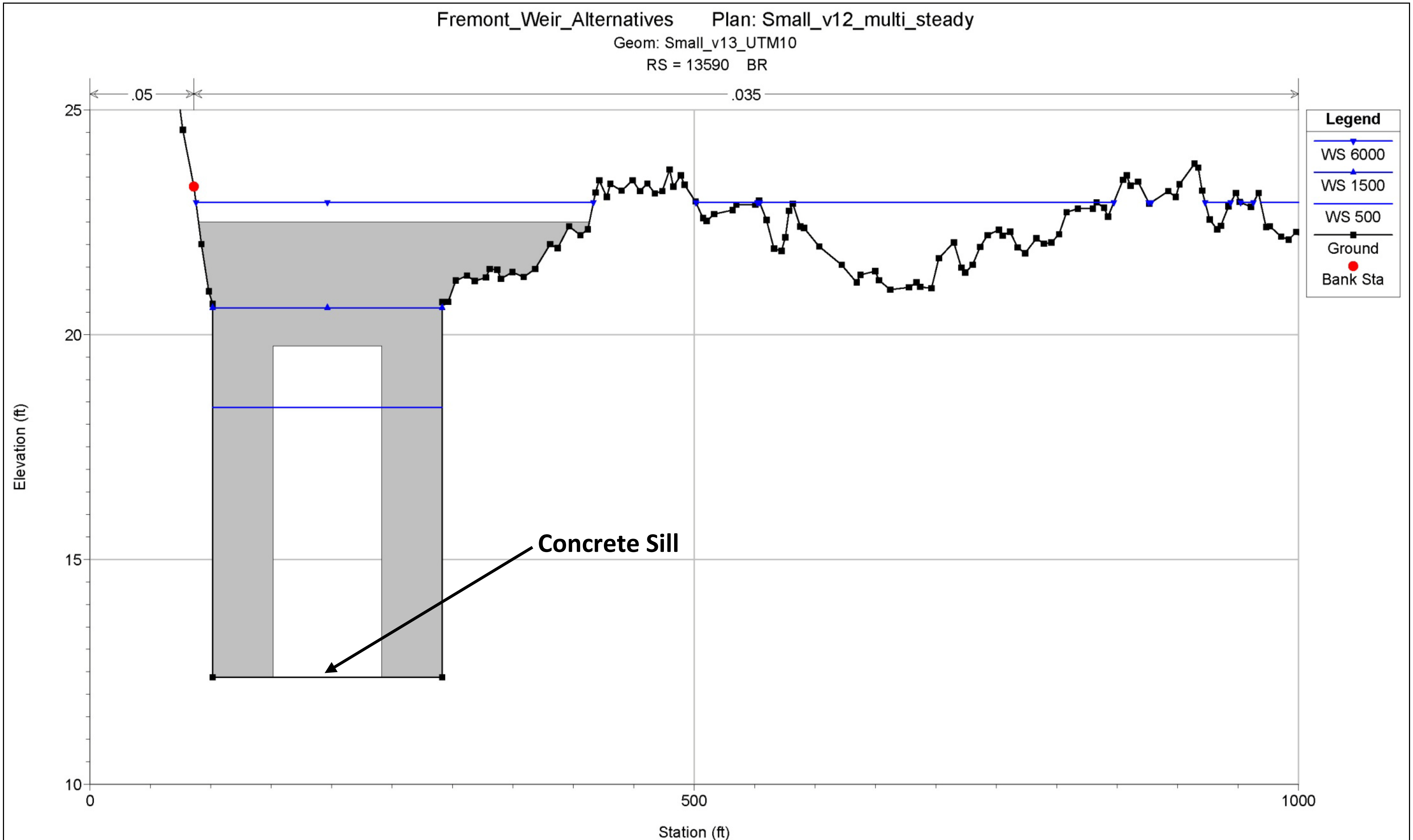
End If



Notes: background courtesy of Bing Maps	cbec eco engineering	*Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project* **Channel and Ag Crossing Locations**	
		Project No. 13-1027	Created By: CRC	**Figure 1**



Notes:	cbec eco engineering	*Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project* **Ag Crossing #1 - Existing**		
		Project No. 13-1027	Created By: CRC	**Figure 2**

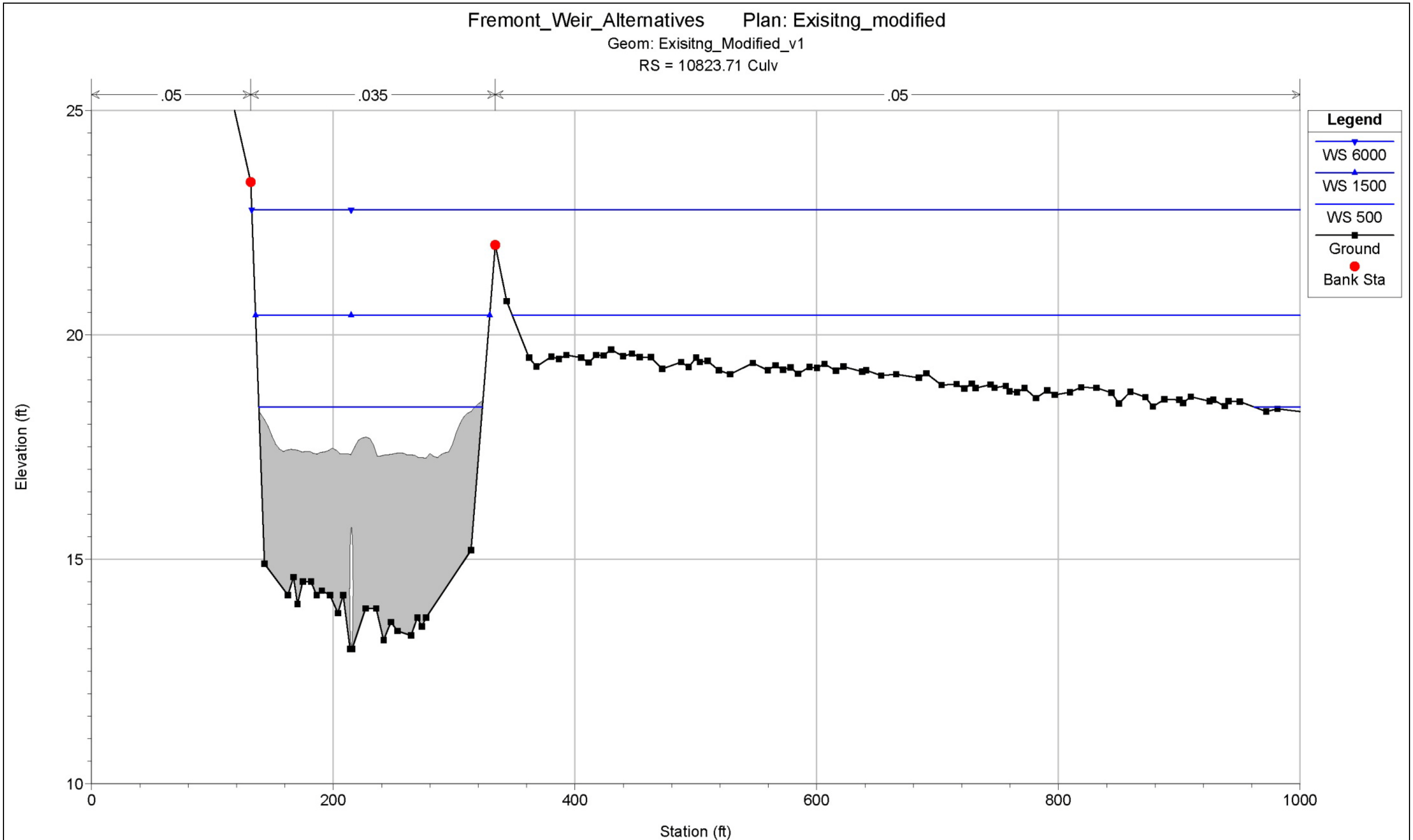


Notes: 90 foot long, 3 foot deep railcar bridge

Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project

Ag Crossing #1 - Project

Project No. 13-1027	Created By: CRC	**Figure 3**

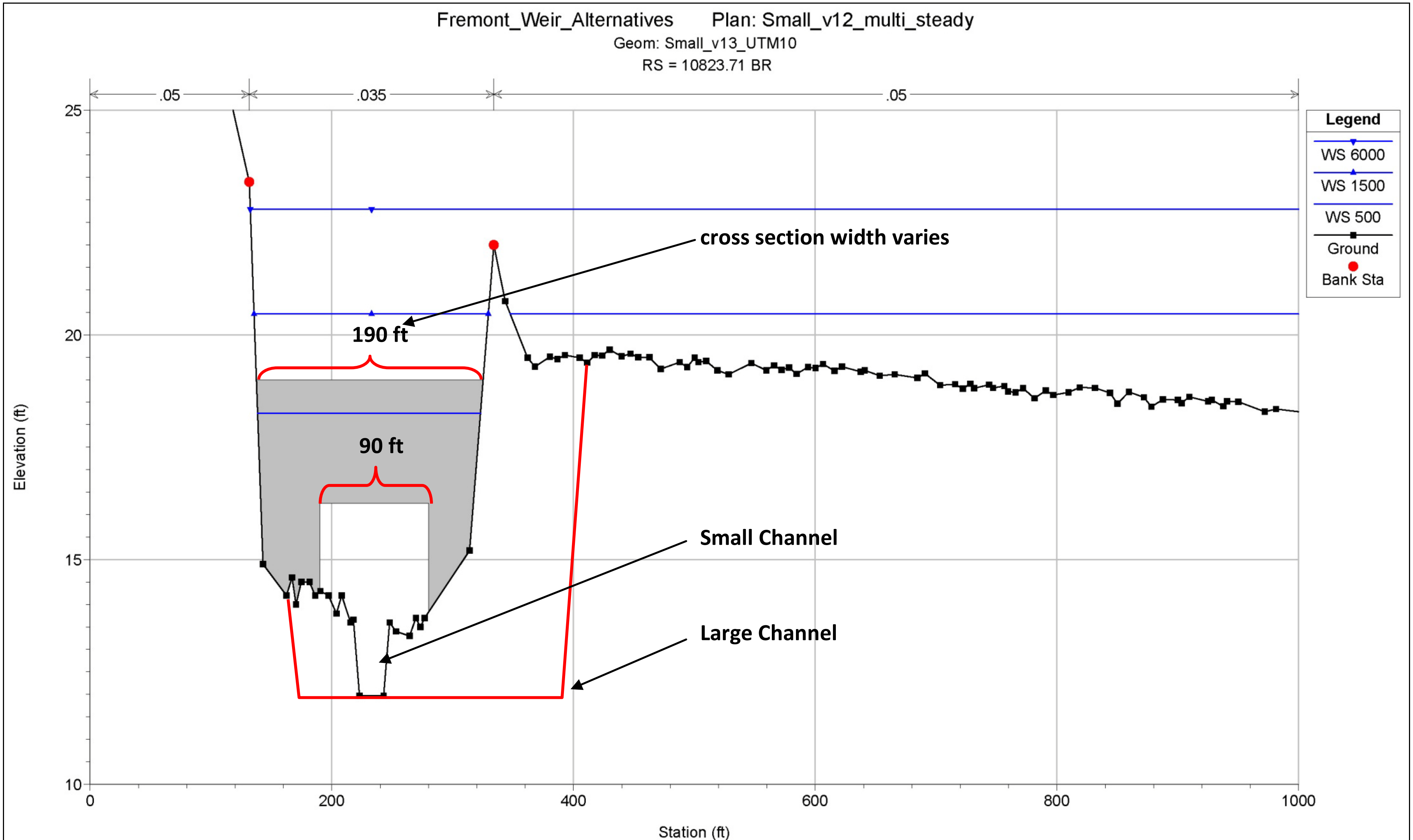


Notes: earthen berm with 1, 2.7 foot diameter culvert

Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project

Ag Crossing #2 - Existing

Project No. 13-1027	Created By: CRC	**Figure 4**

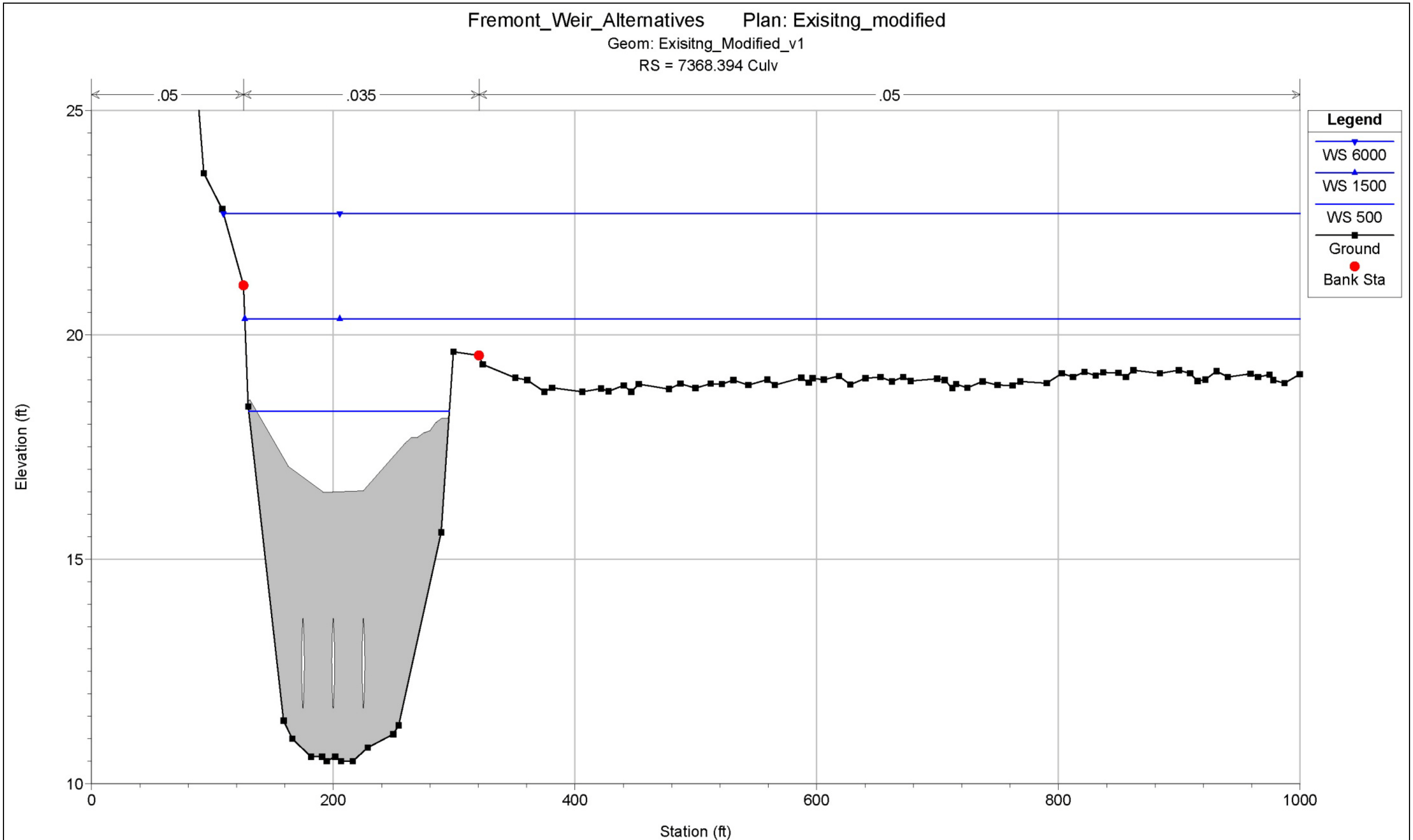


Notes: 90 foot long, 3 foot deep railcar bridge

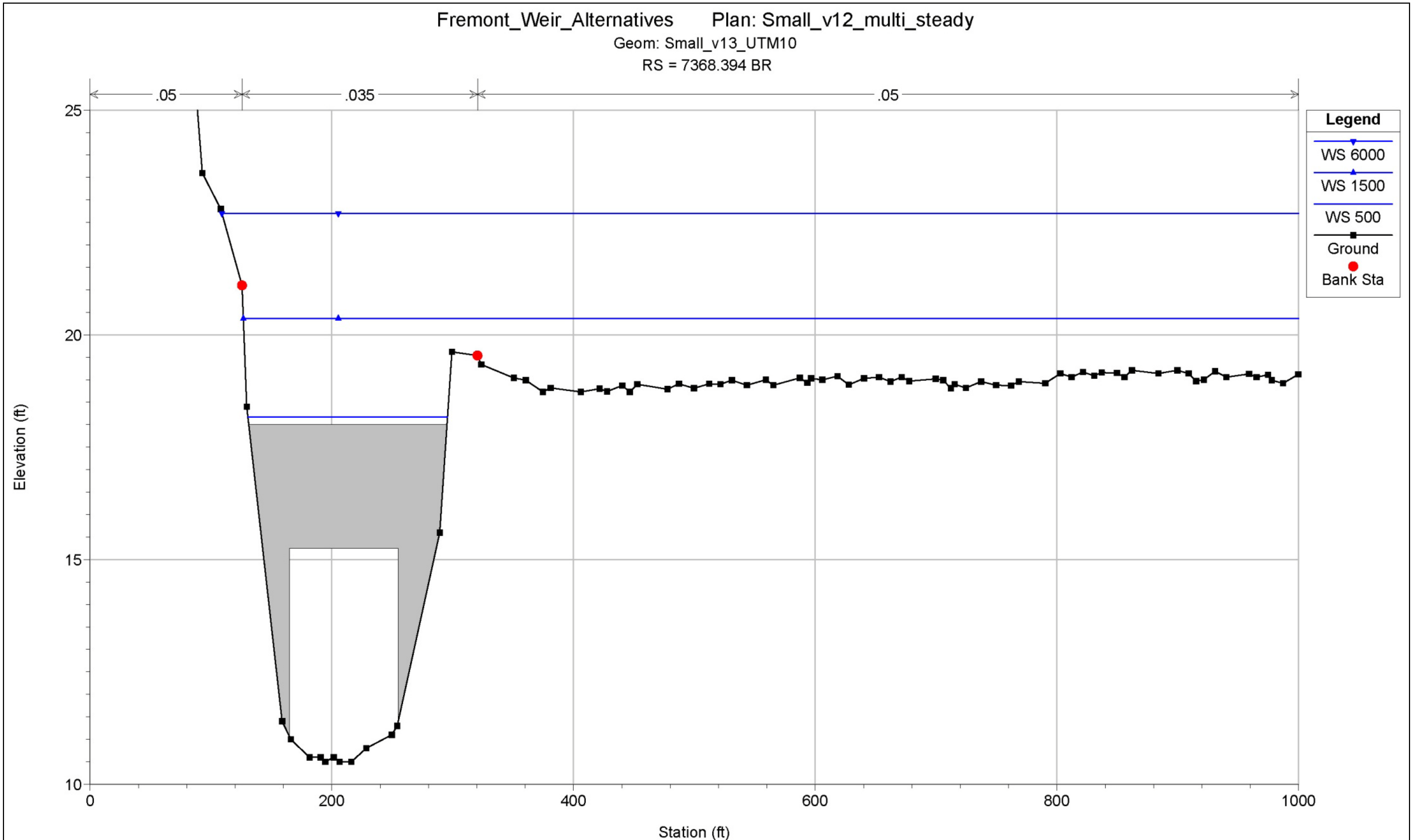
Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project

Ag Crossing #2 - Project

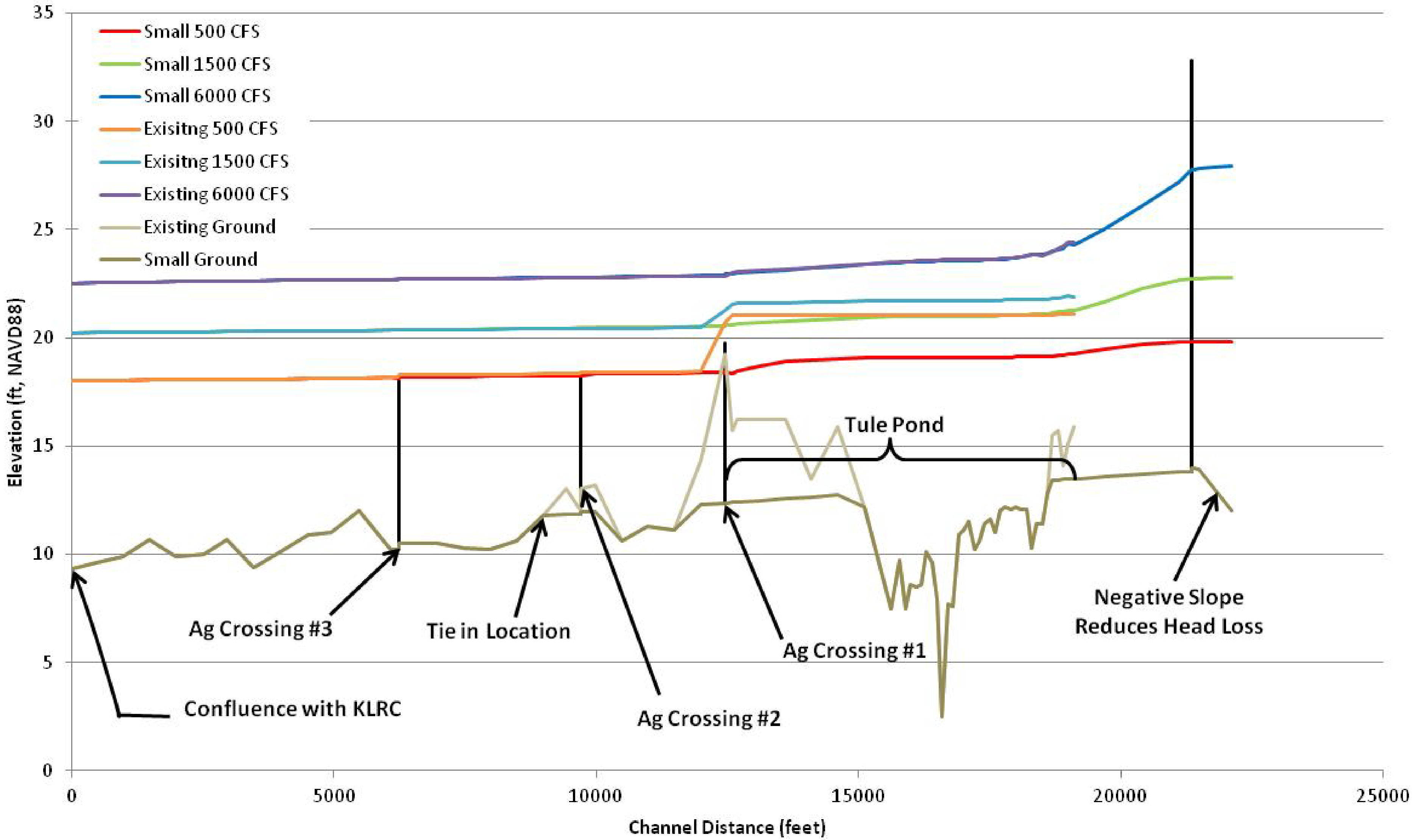
Project No. 13-1027 | Created By: CRC | **Figure 5**



Notes: earthen berm with 3, 2 foot diameter culverts	cbec eco engineering	*Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project* **Ag Crossing #3 - Existing**		
		Project No. 13-1027	Created By: CRC	**Figure 6**



Notes: 90 foot long, 3 foot deep railcar bridge	cbec eco engineering	*Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project* **Ag Crossing #3 - Project**		
		Project No. 13-1027	Created By: CRC	**Figure 7**



Notes: Water surface profile comparison between existing conditions and the Small Channel alternative.

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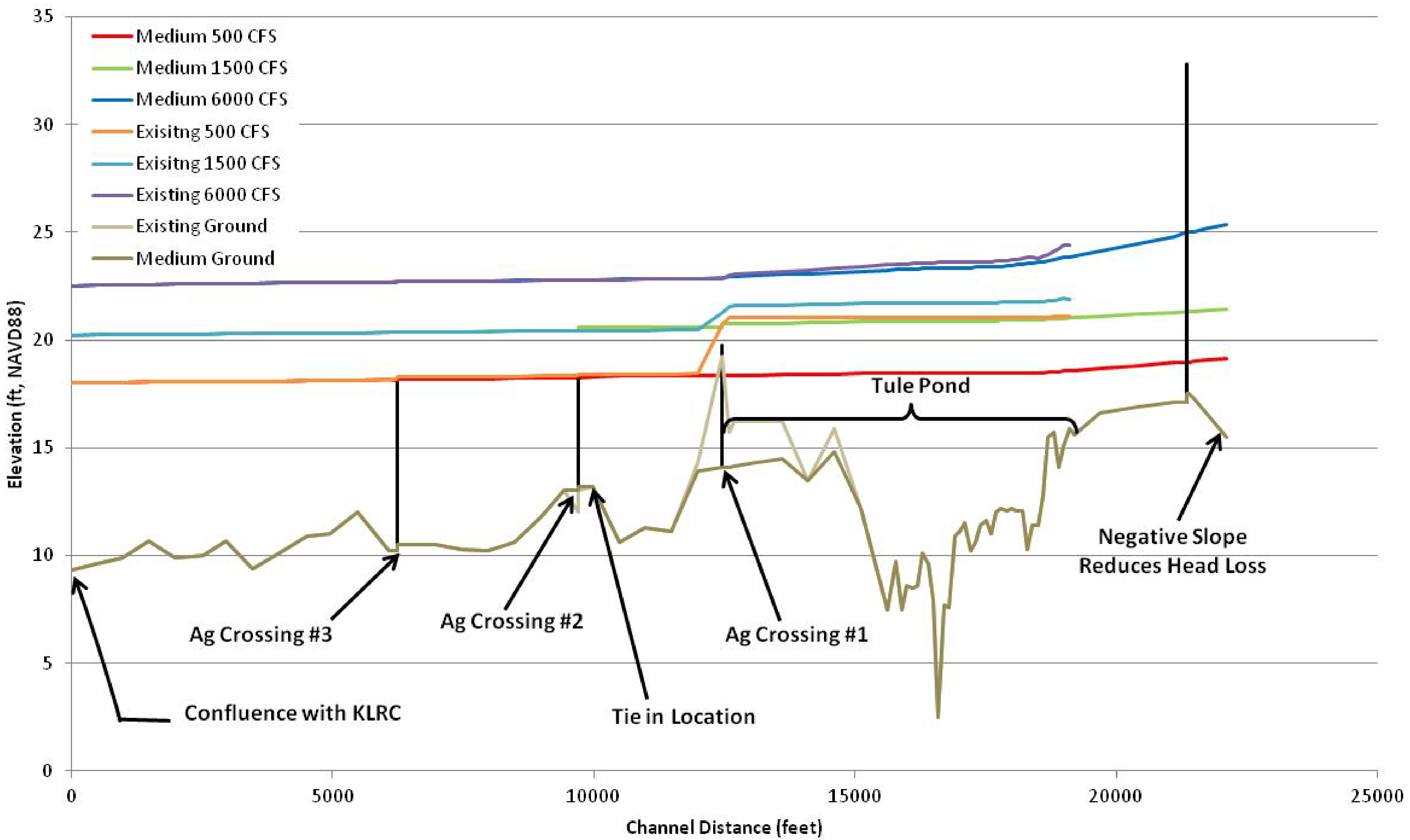
Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project

Small Channel Water Surface Profile Comparison

Project No. 13-1027	Created By: CRC	**Figure 8**

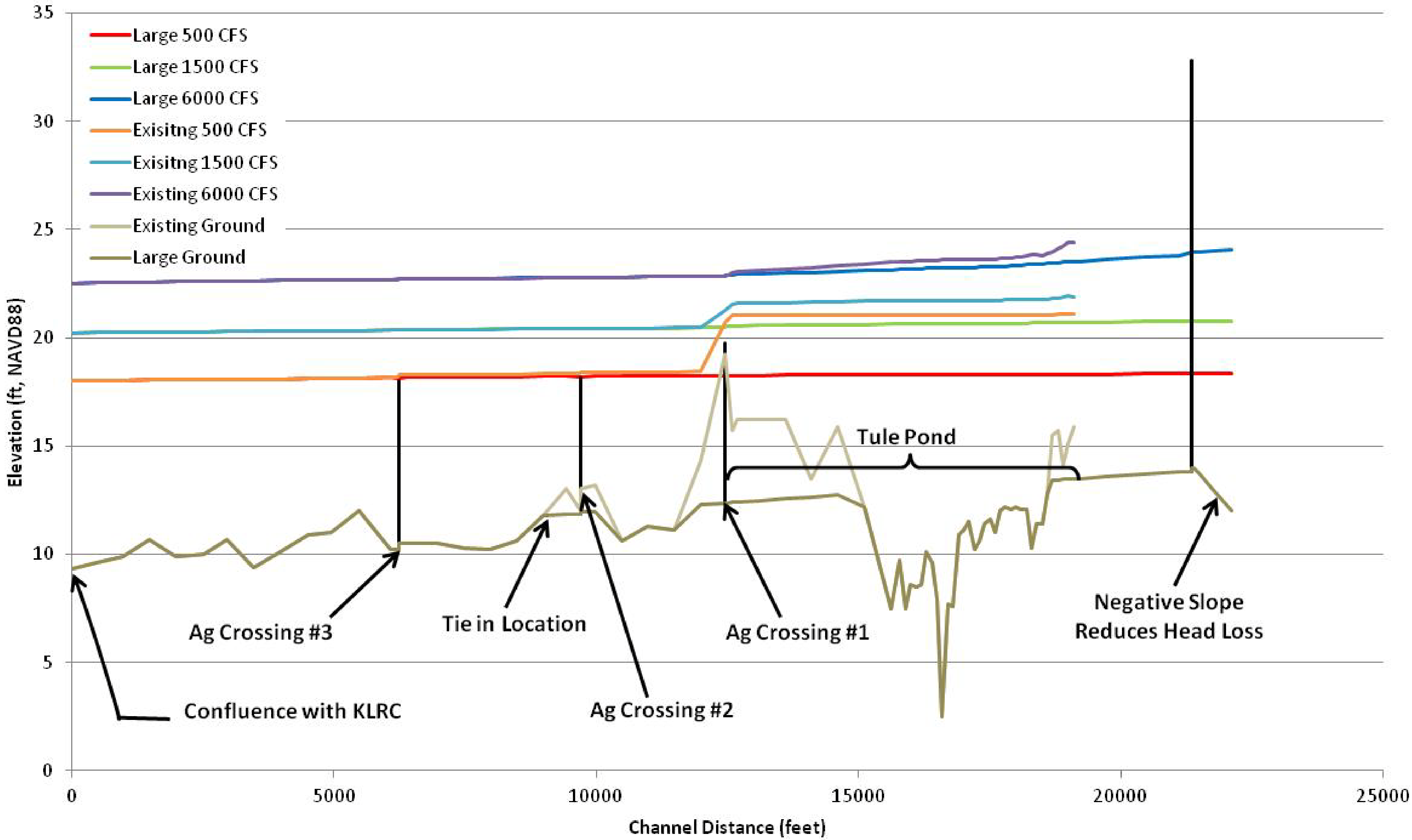


Notes: Water surface profile comparison between existing conditions and the Medium Channel alternative.

Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project

Medium Channel Water Surface Profile Comparison

Project No. 13-1027	Created By: CRC	**Figure 9**

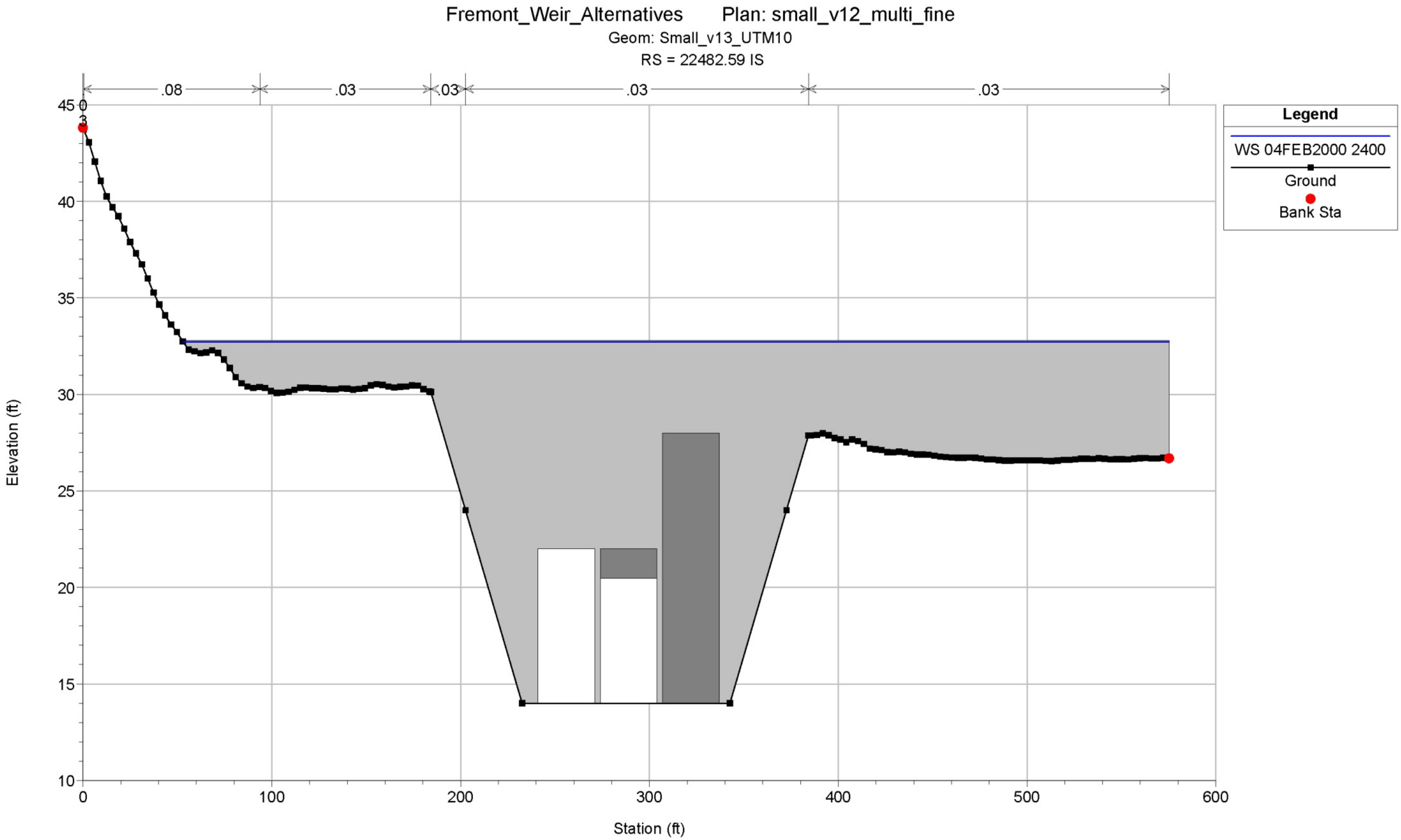


Notes: Water surface profile comparison between existing conditions and the Large Channel alternative.

Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project

Large Channel Water Surface Profile Comparison

Project No. 13-1027 | Created By: CRC | **Figure 10**

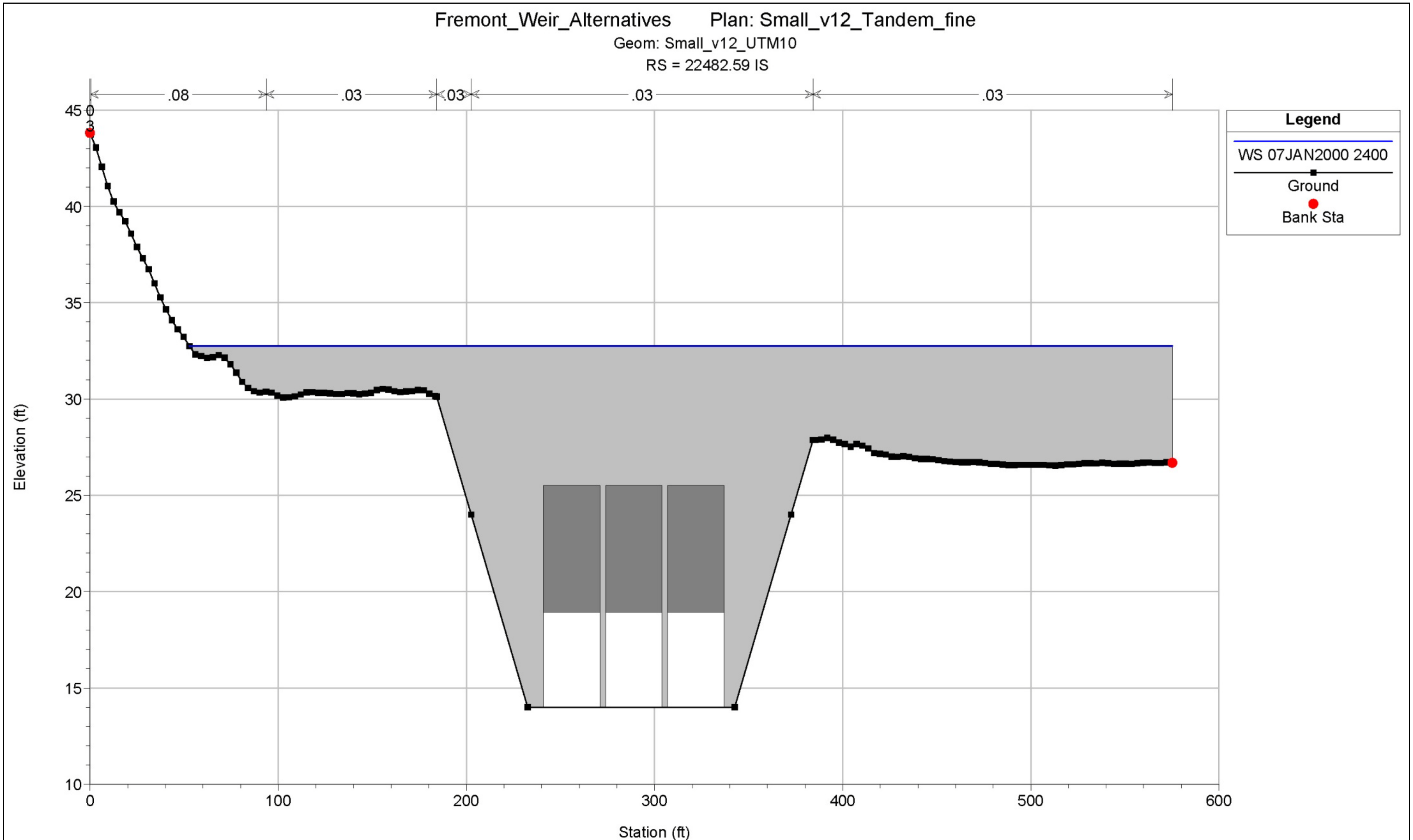


Notes: Gate closure shown represents 6000 cfs at maximum Sacramento River Stage before Fremont Weir begins to overtop for gates operated individually.

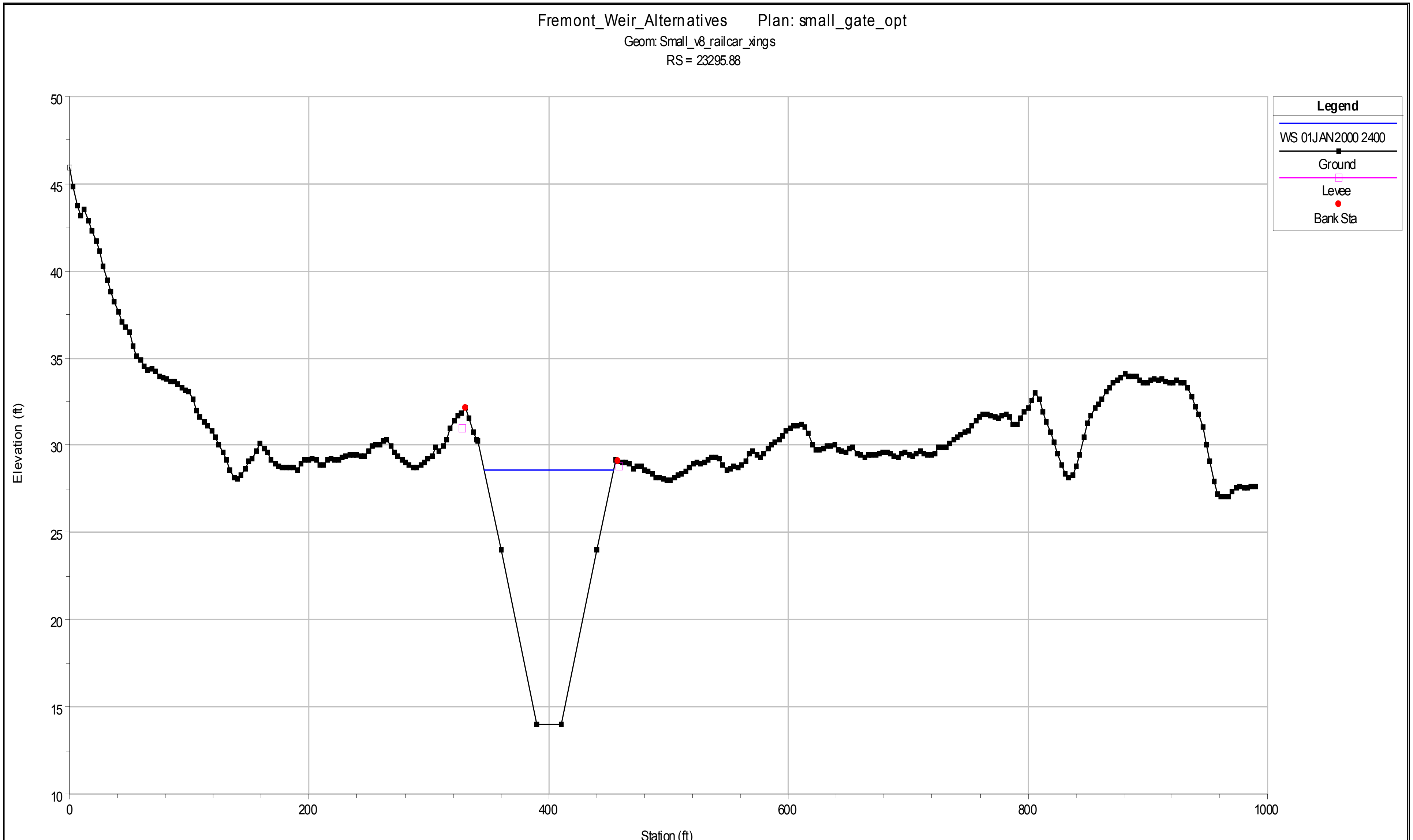
Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project

Small Individual Gate Configuration

Project No. 13-1027	Created By: CRC	**Figure 11**



Notes: Gate closure shown represents 6000 cfs at maximum Sacramento River Stage before Fremont Weir begins to overtop for gates operated in tandem.	cbec eco engineering	*Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project* **Small Unison Gate Configuration**
		Project No. 13-1027 | Created By: CRC | **Figure 12**

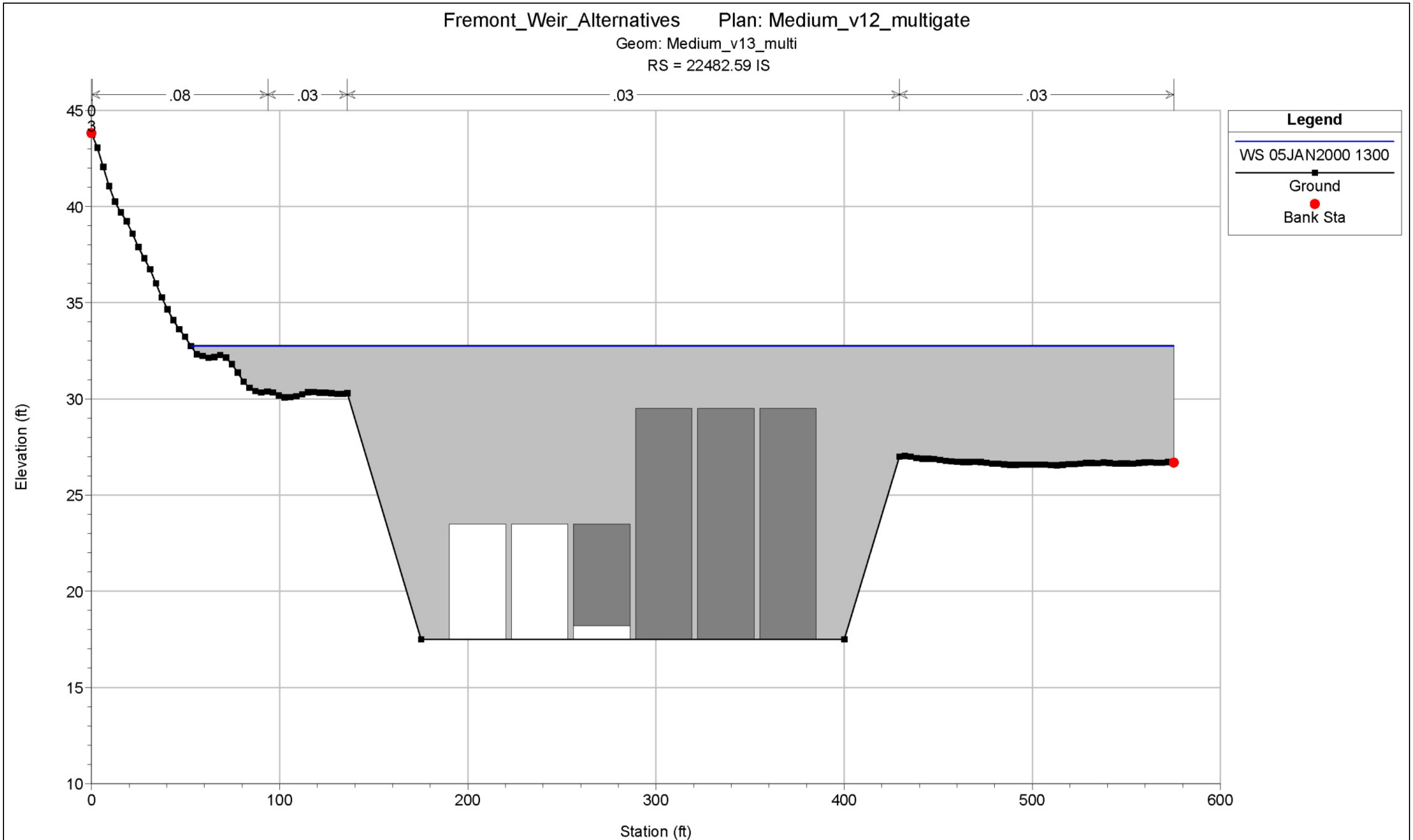


Notes:

Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project

Cross Section Downstream of Small Gate Structure

Project No. 13-1027 | Created By: CRC | **Figure 13**



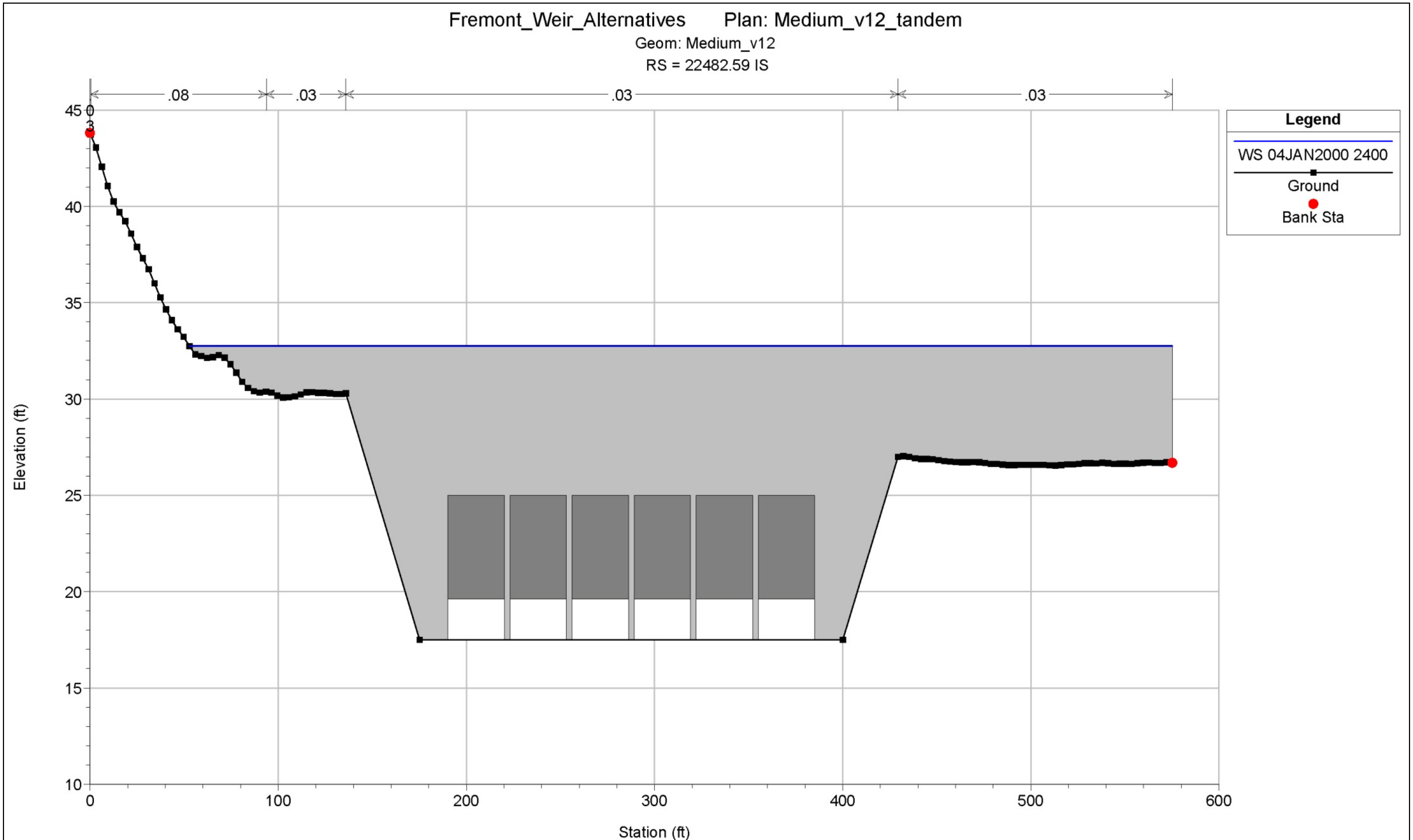
Notes: Gate closure shown represents 6000 cfs at maximum Sacramento River Stage before Fremont Weir begins to overtop for gates operated individually.

cbec eco engineering

Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project

Medium Individual Gate Configuration

Project No. 13-1027	Created By: CRC	**Figure 14**

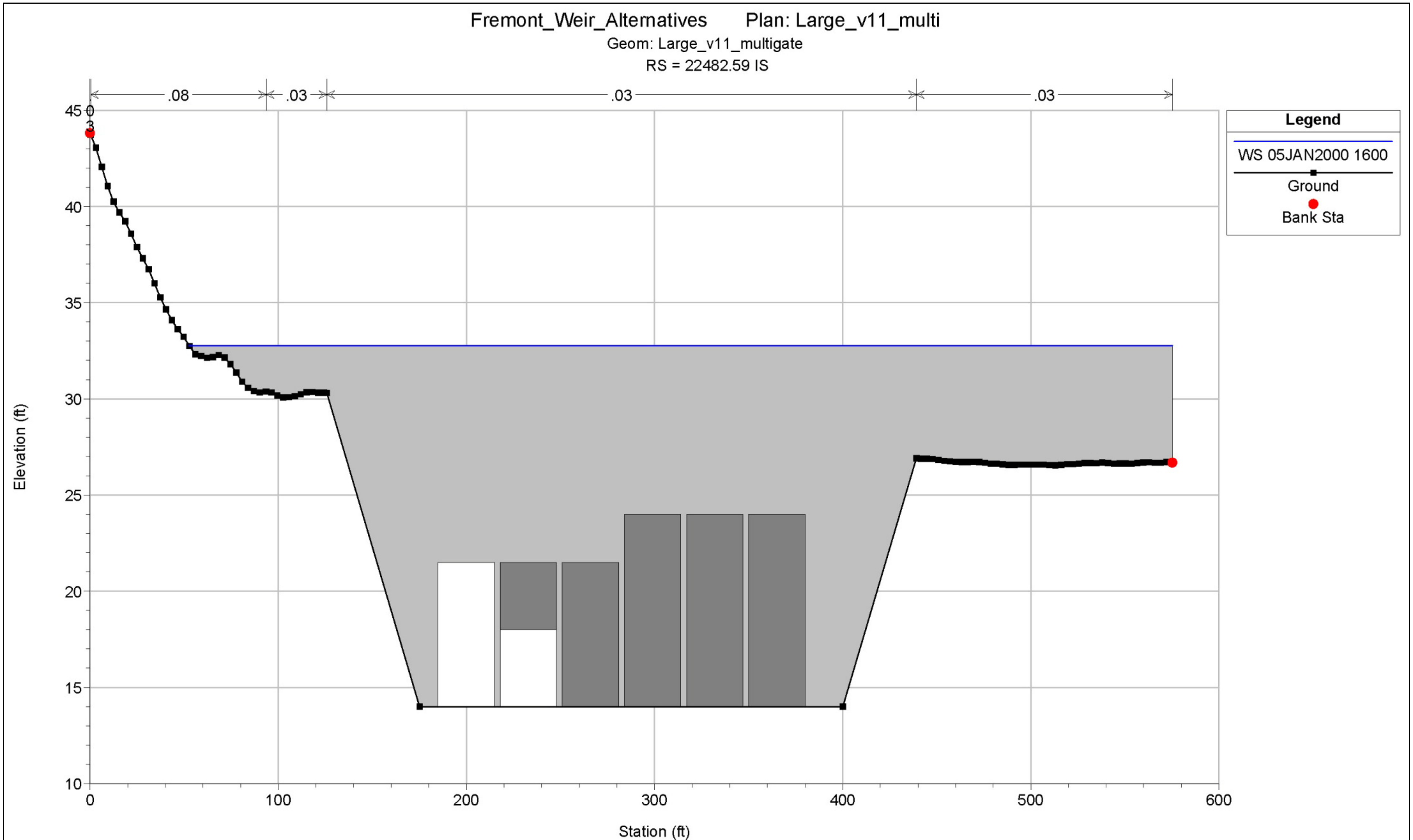


Notes: Gate closure shown represents 6000 cfs at maximum Sacramento River Stage before Fremont Weir begins to overtop for gates operated in tandem.

Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project

Medium Unison Gate Configuration

Project No. 13-1027	Created By: CRC	**Figure 15**

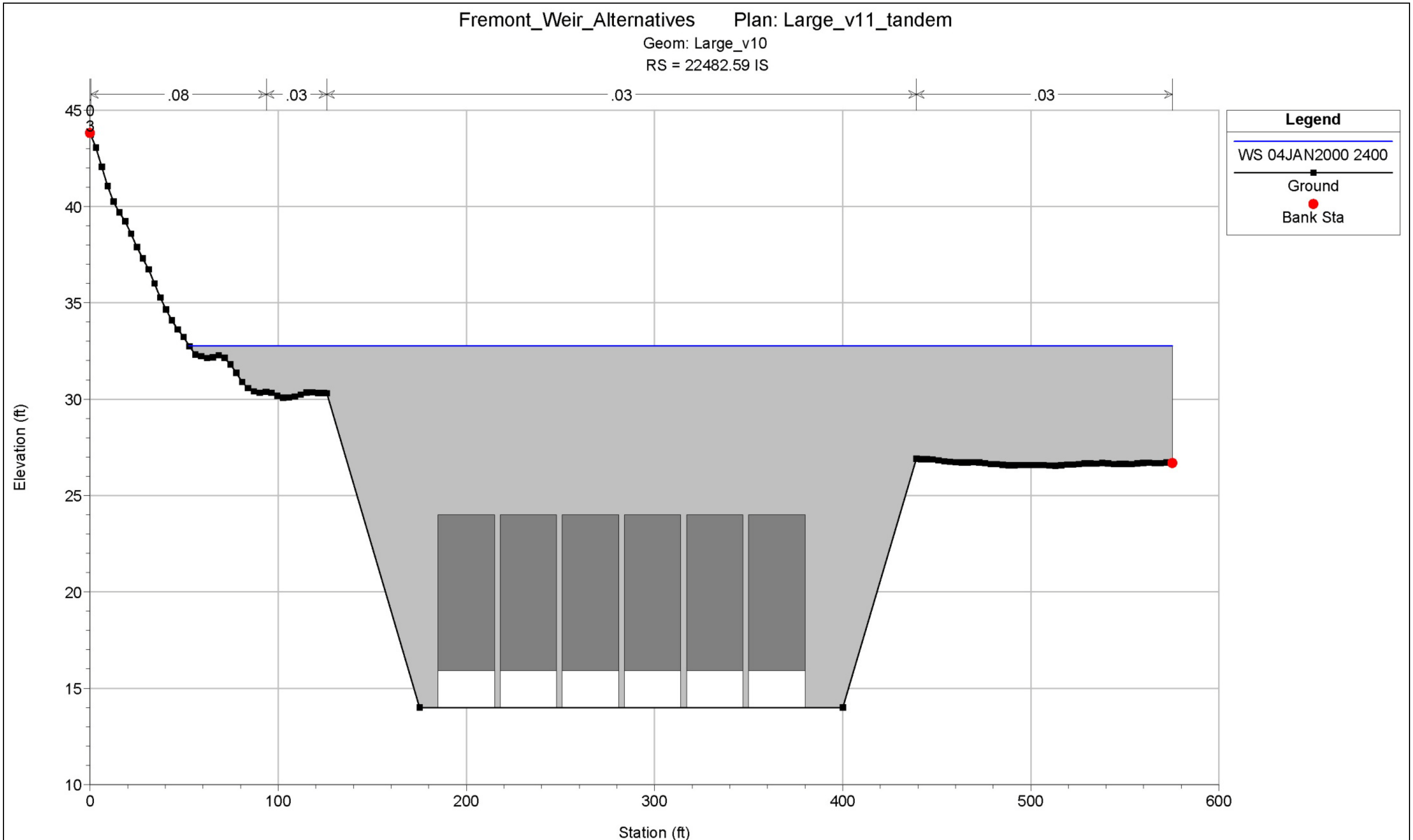


Notes: Gate closure shown represents 6000 cfs at maximum Sacramento River Stage before Fremont Weir begins to overtop for gates operated individually.

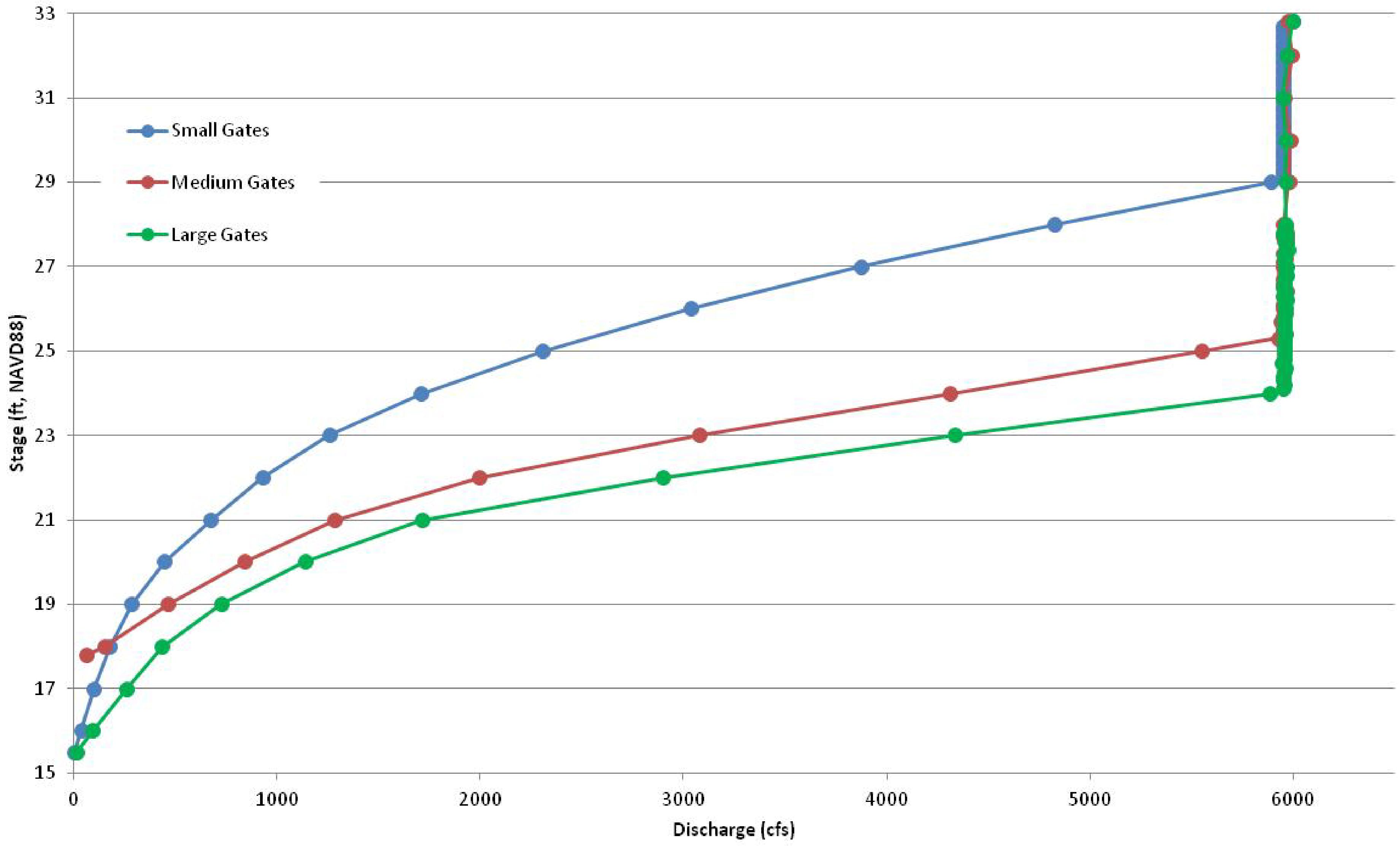
Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project

Large Individual Gate Configuration

Project No. 13-1027	Created By: CRC	**Figure 16**



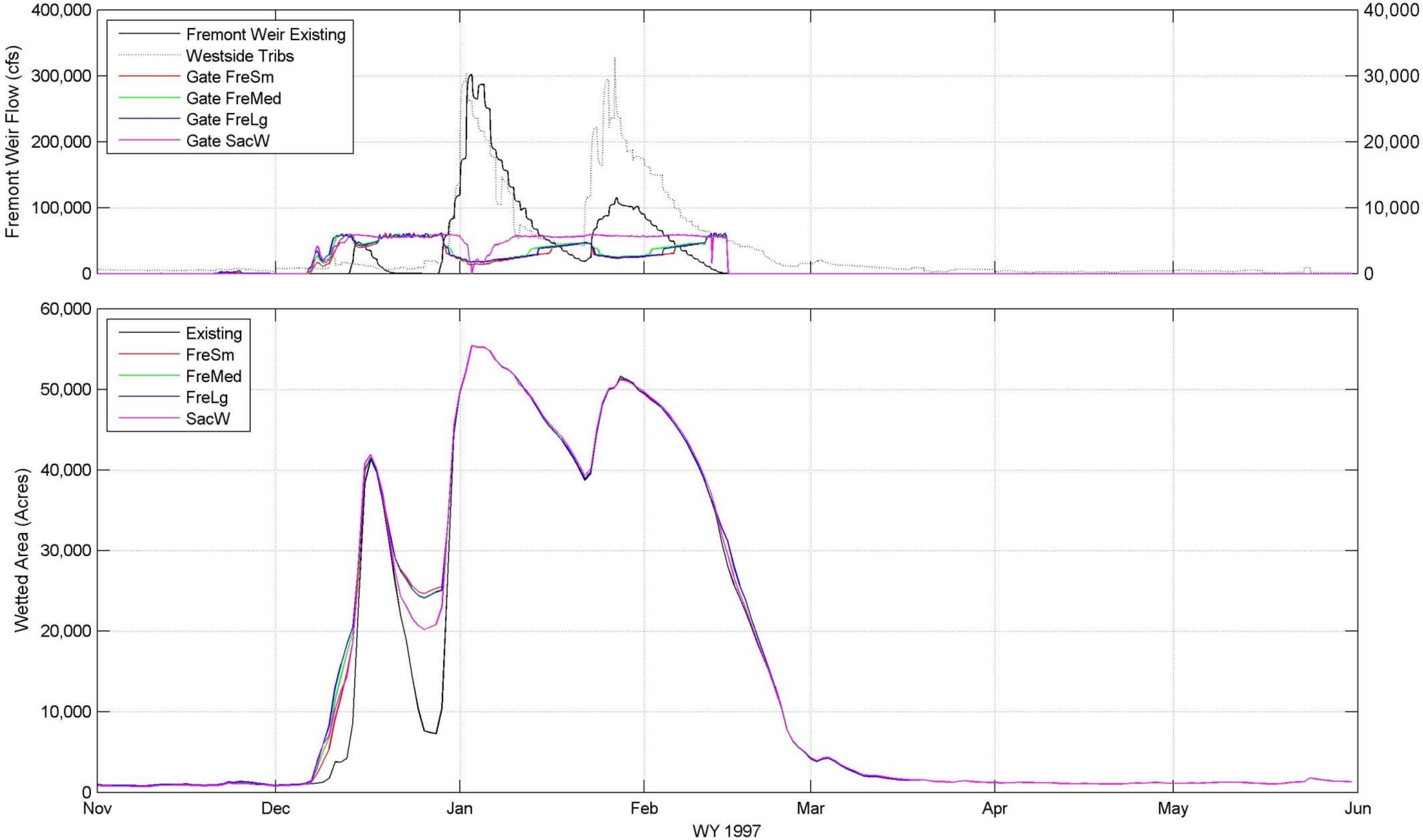
Notes: Gate closure shown represents 6000 cfs at maximum Sacramento River Stage before Fremont Weir begins to overtop for gates operated in tandem.	cbec eco engineering	*Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project* **Large Unison Gate Configuration**
Project No. 13-1027	Created By: CRC	**Figure 17**



Notes: assumes gate operations are optimized for 6000 cfs flow rate	cbec eco engineering	*Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project* **Gate Rating Curves**		
		Project No. 13-1027	Created By: CRC	**Figure 18**

Appendix D

All WY and Gate Closures



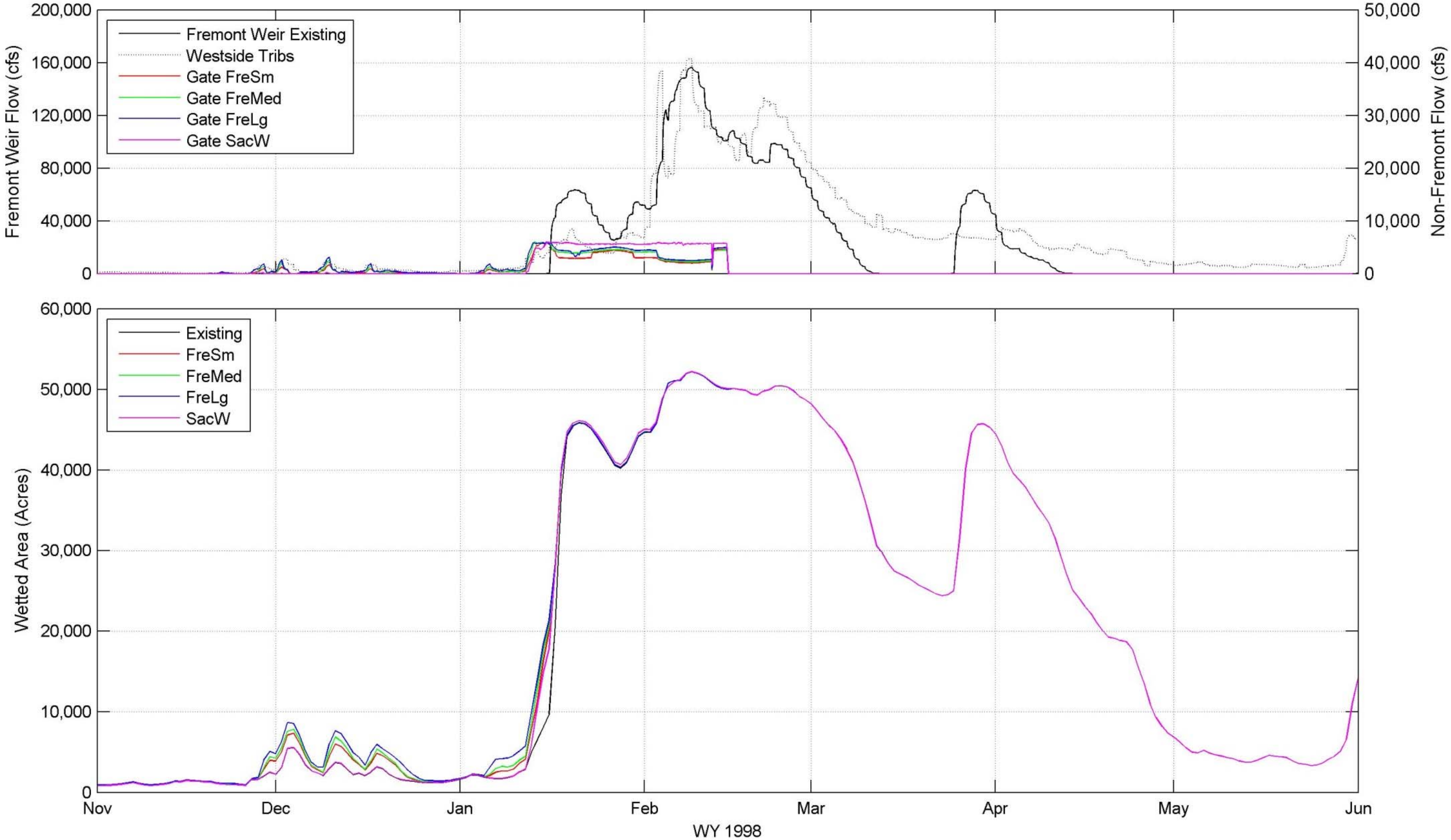
Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

HDR cbec eco engineering

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 1997 for Feb 15 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D1**

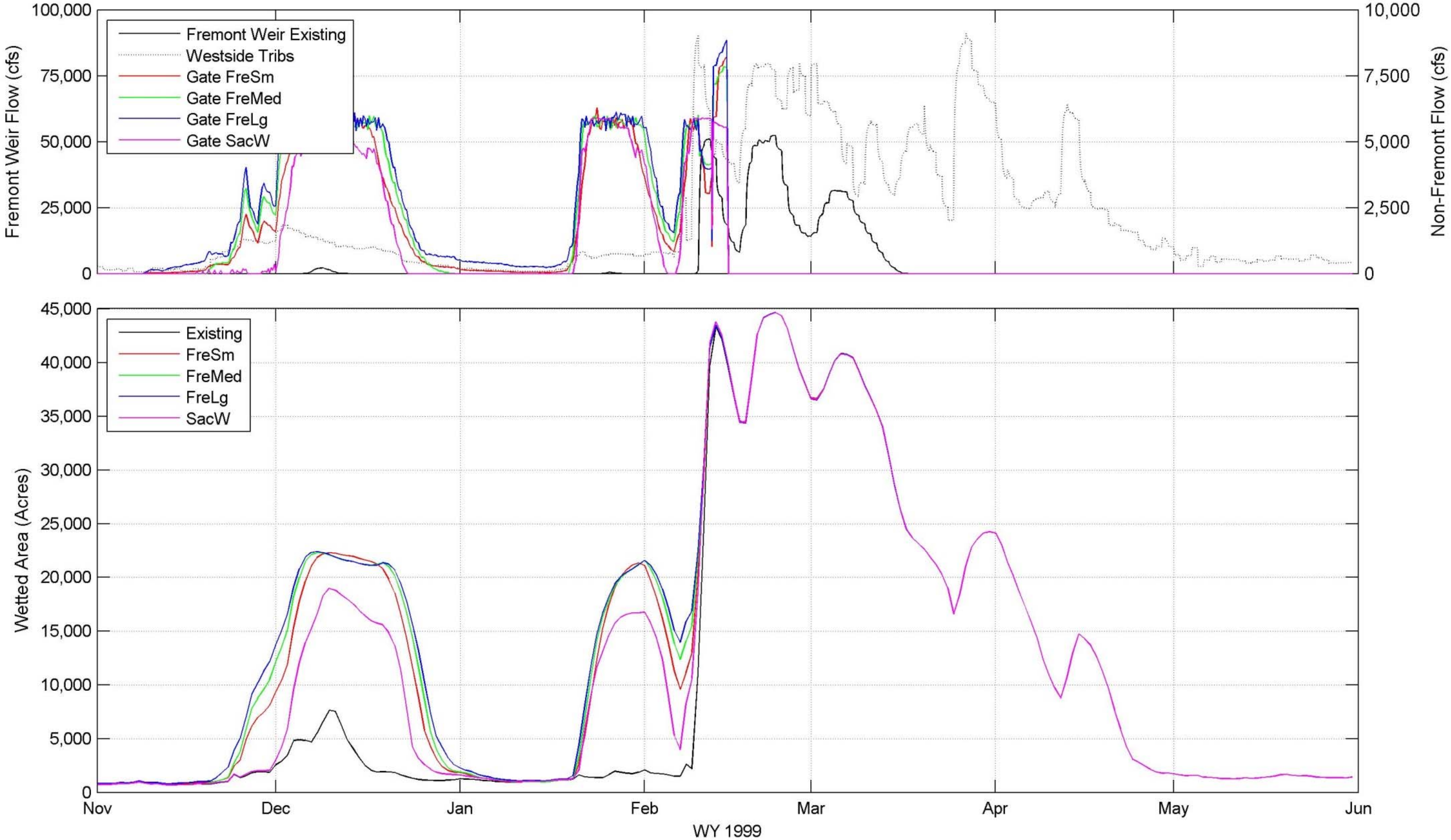


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 1998 for Feb 15 Gate Closure

Prepared for DWR | Created By: SJB | **Figure D2**

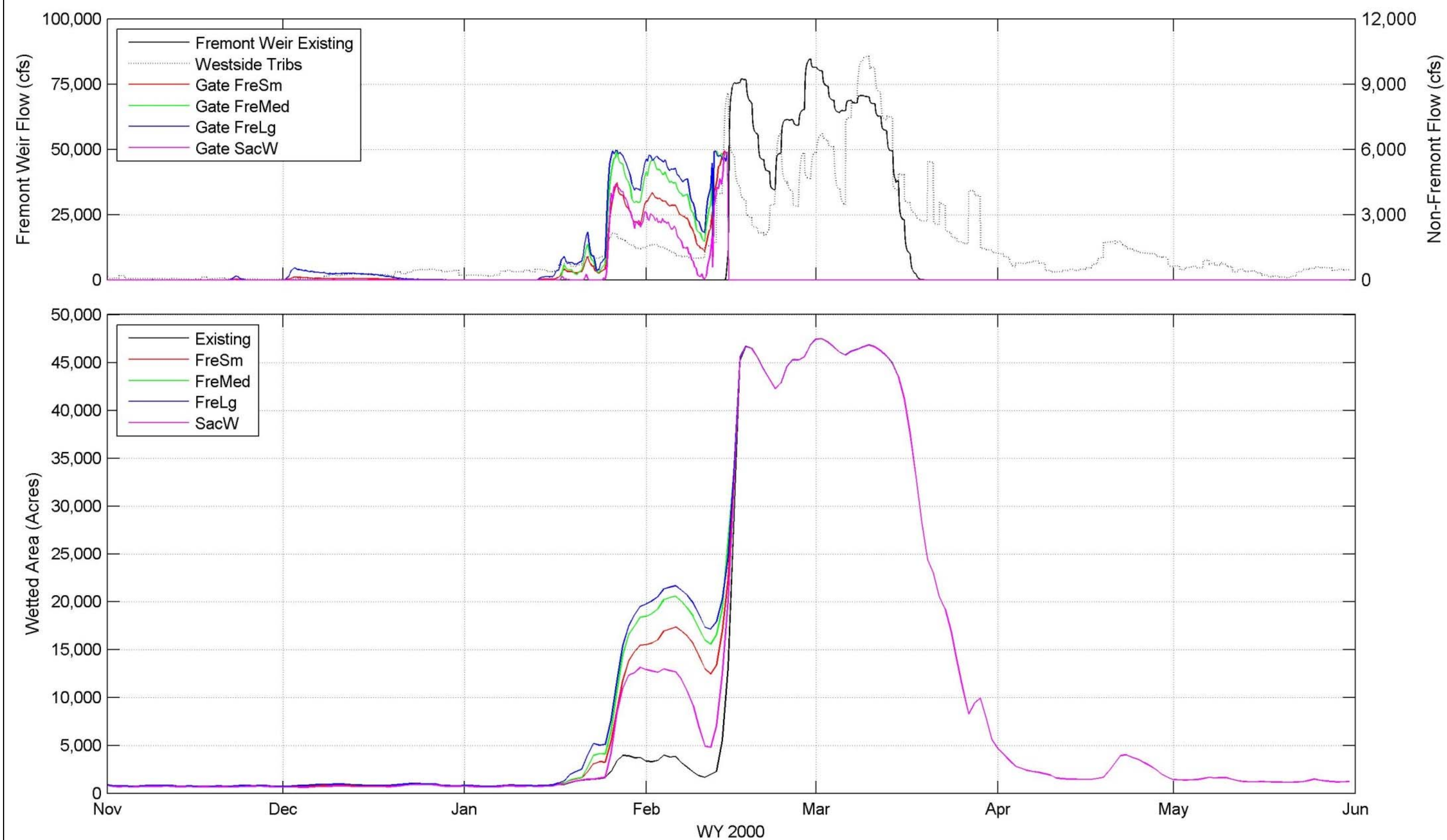


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 1999 for Feb 15 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D3**

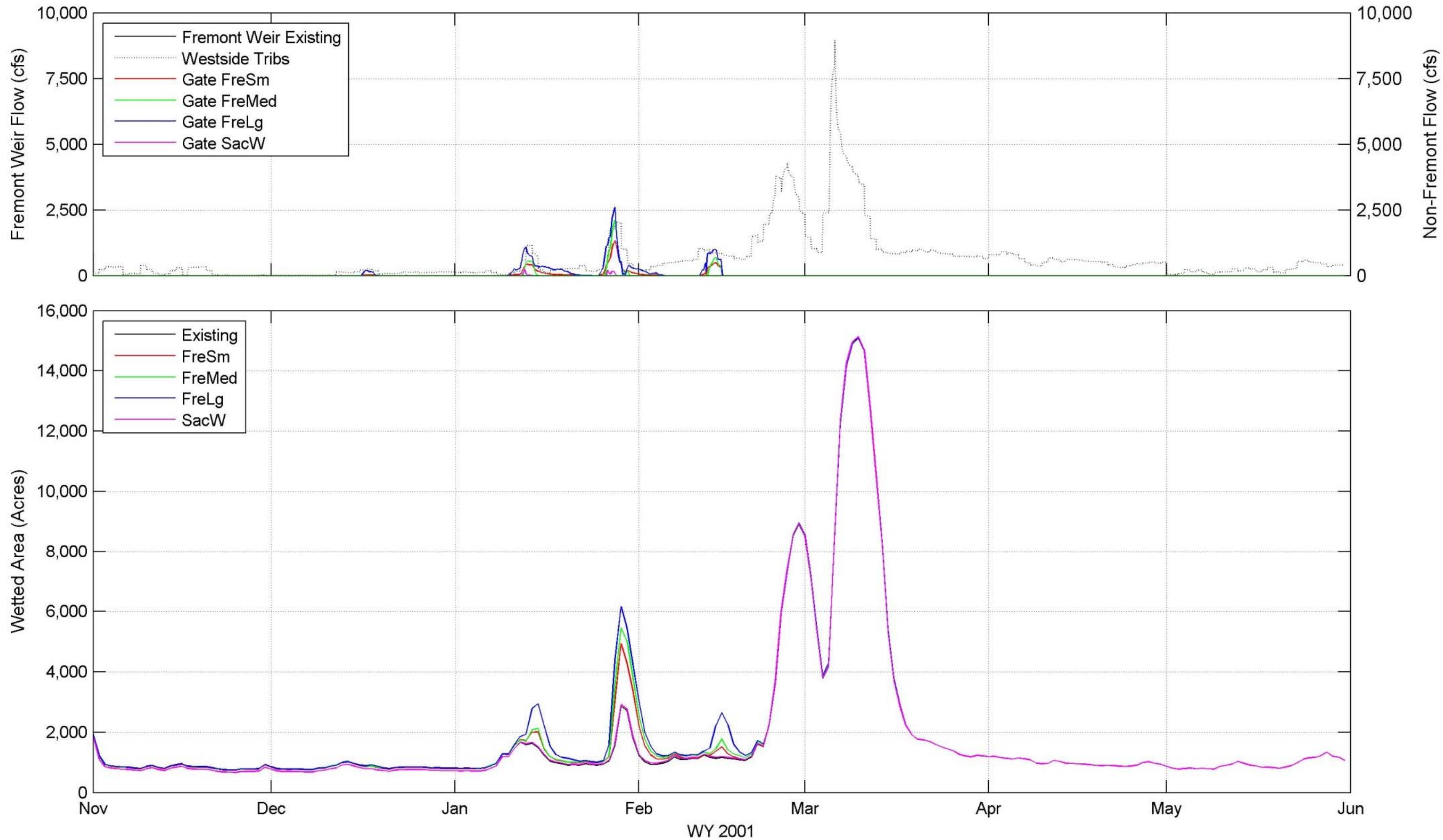


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2000 for Feb 15 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D4**

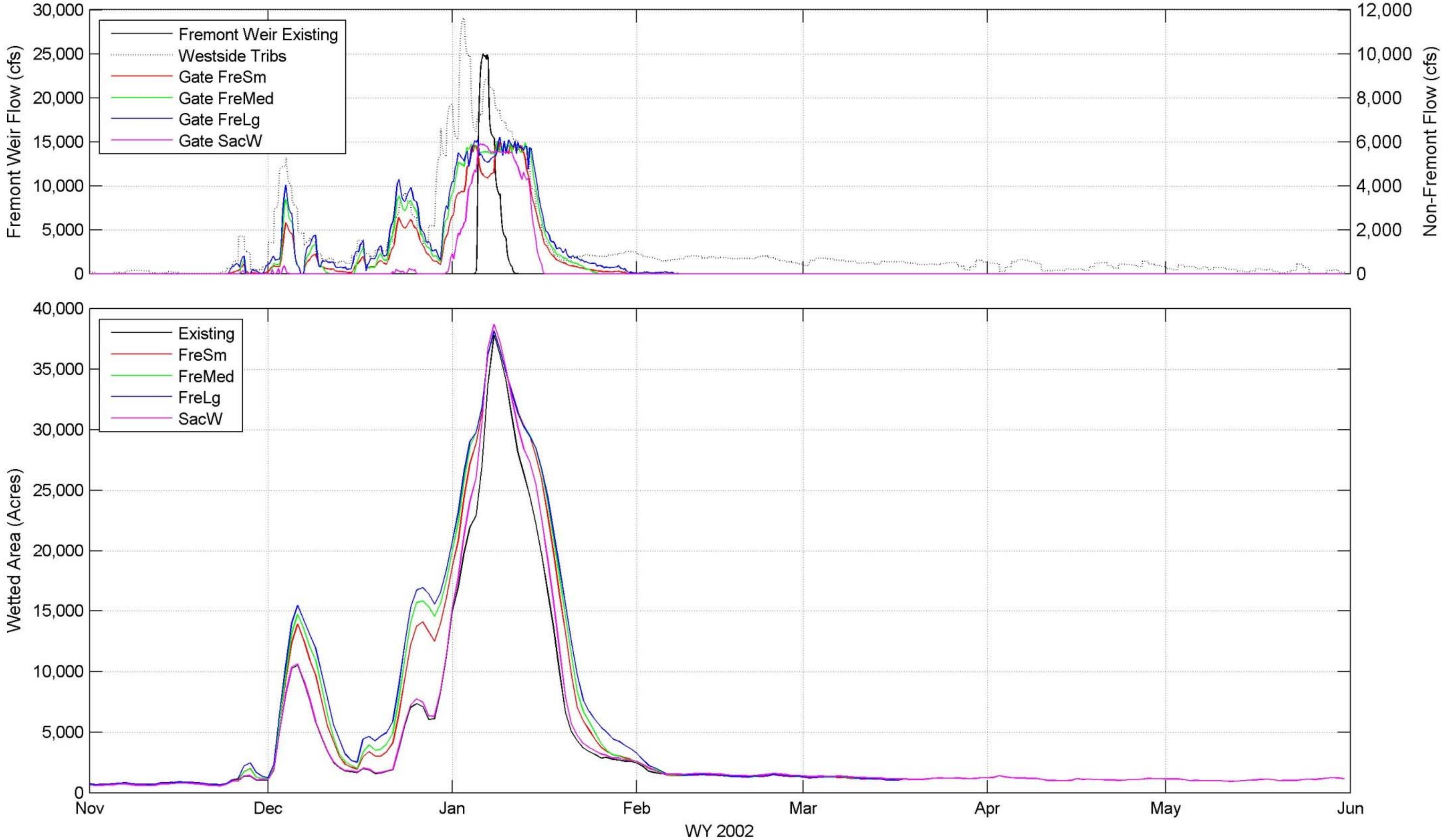


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2001 for Feb 15 Gate Closure

Prepared for DWR | Created By: SJB | **Figure D5**

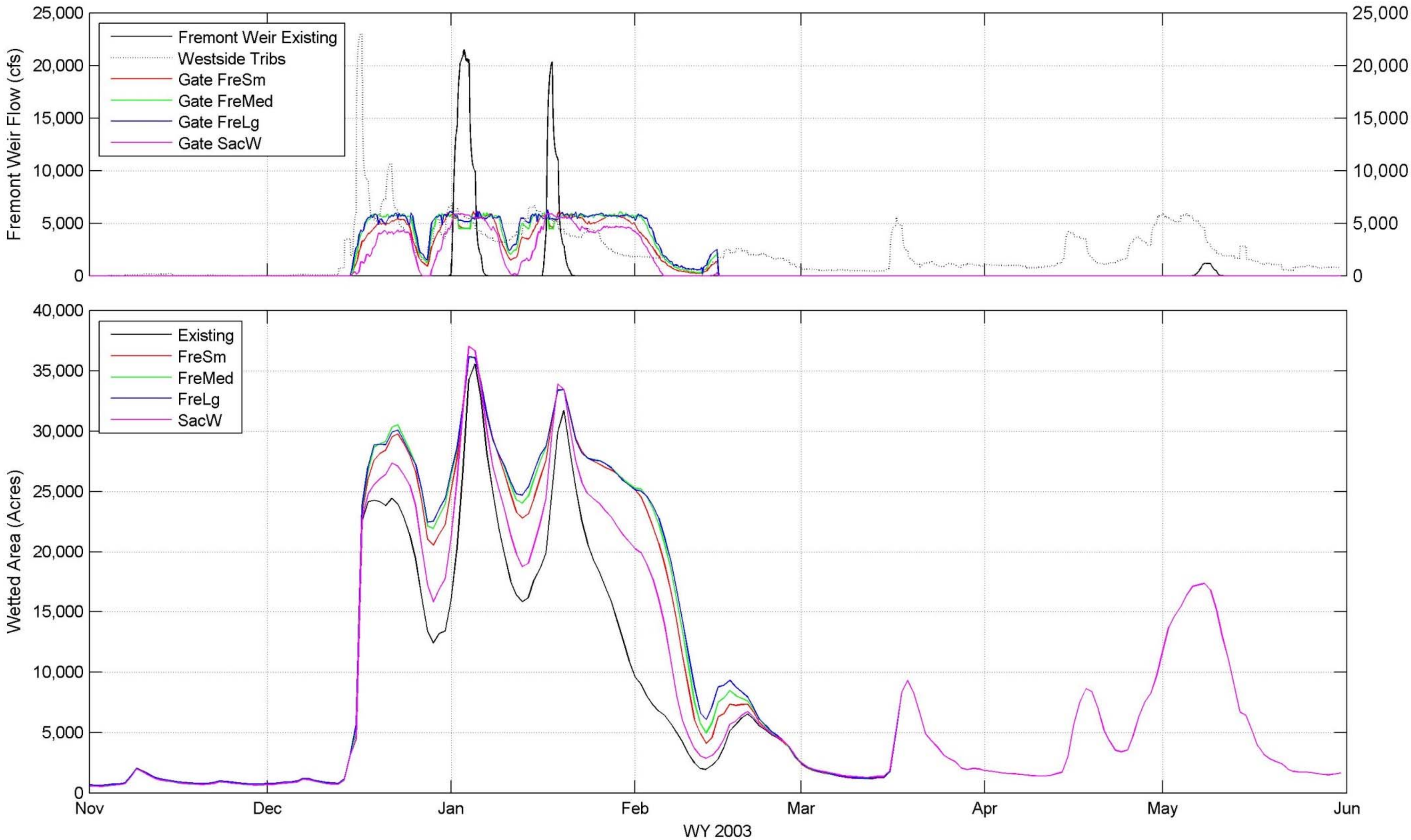


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2002 for Feb 15 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D6**

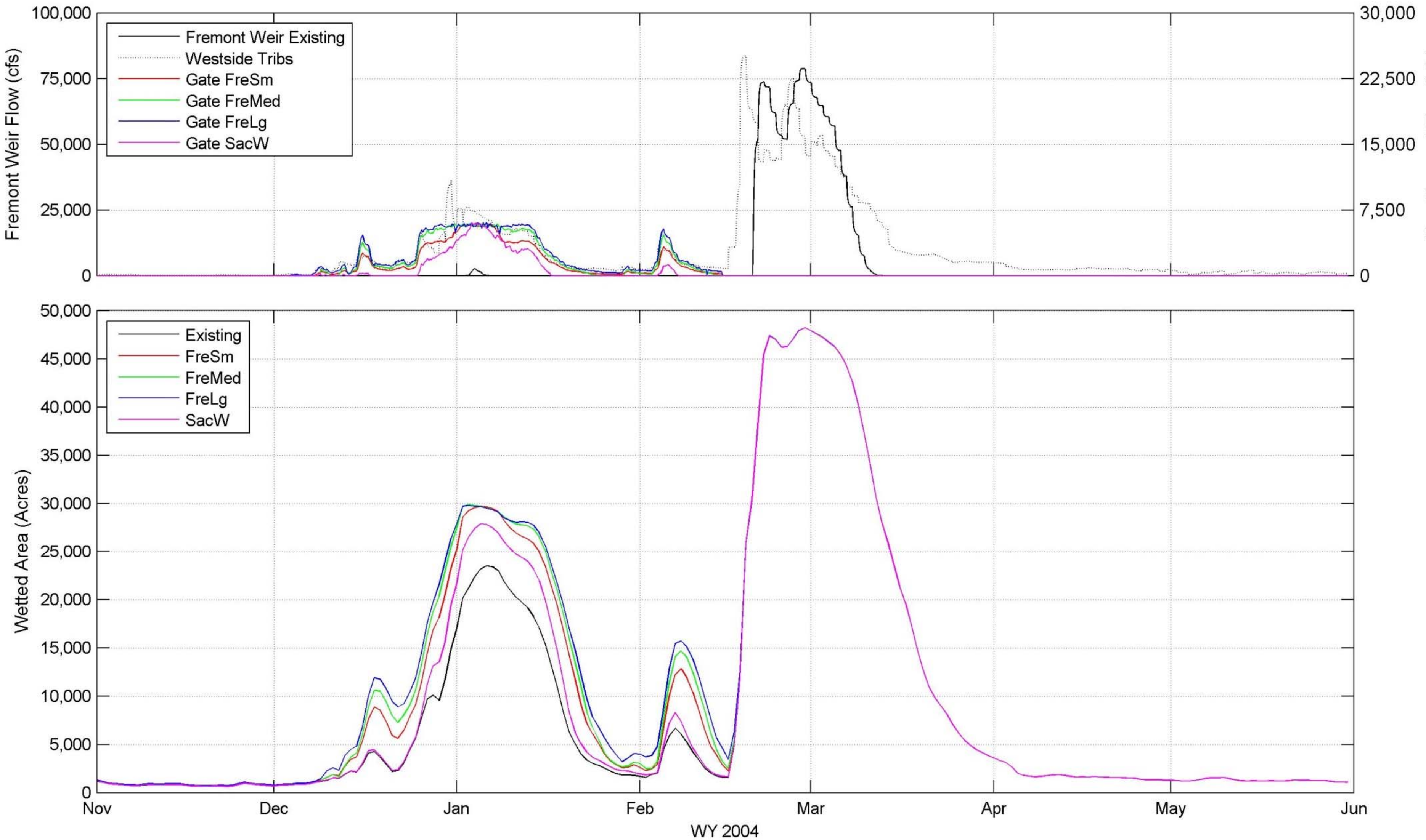


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2003 for Feb 15 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D7**

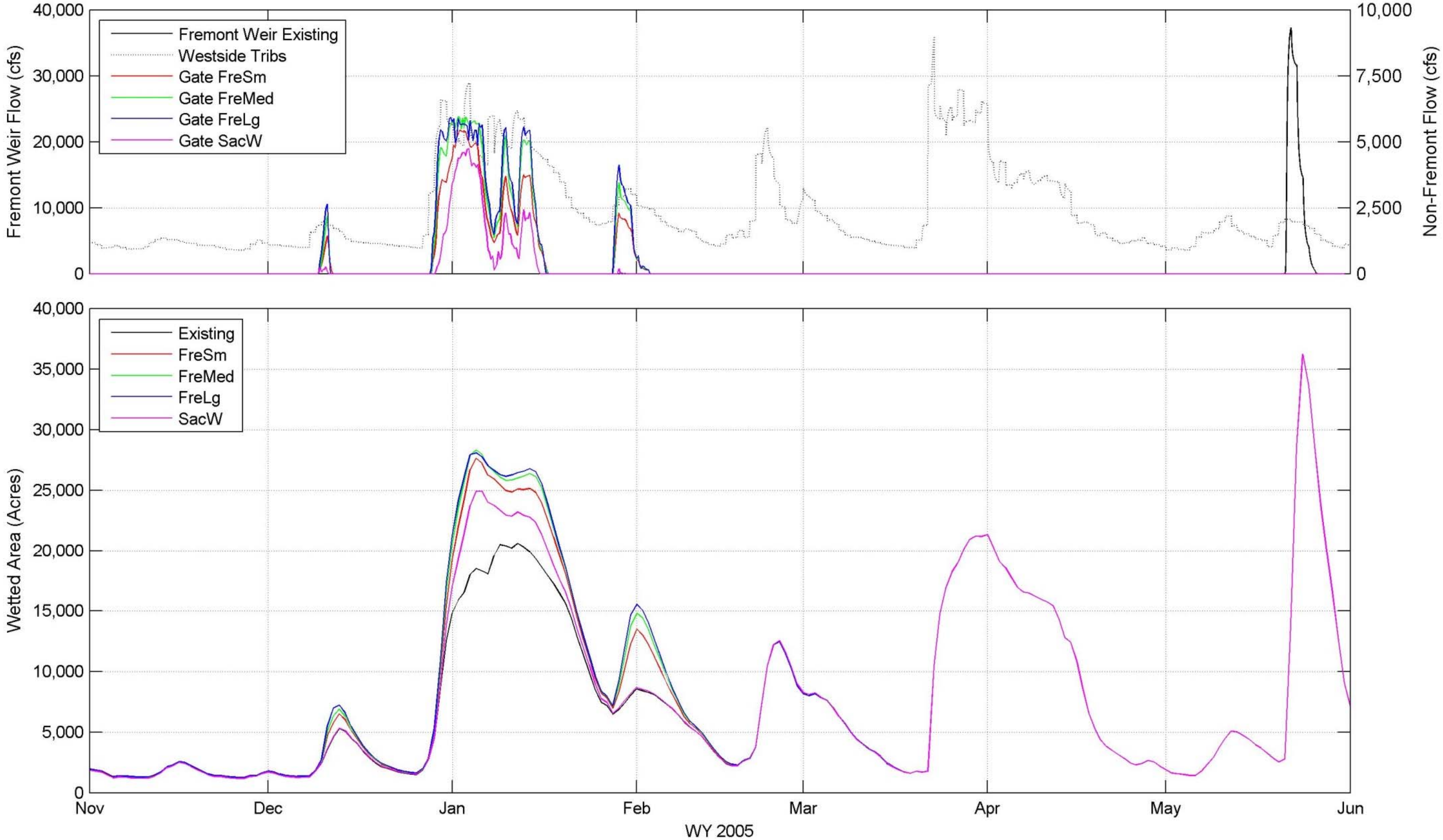


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

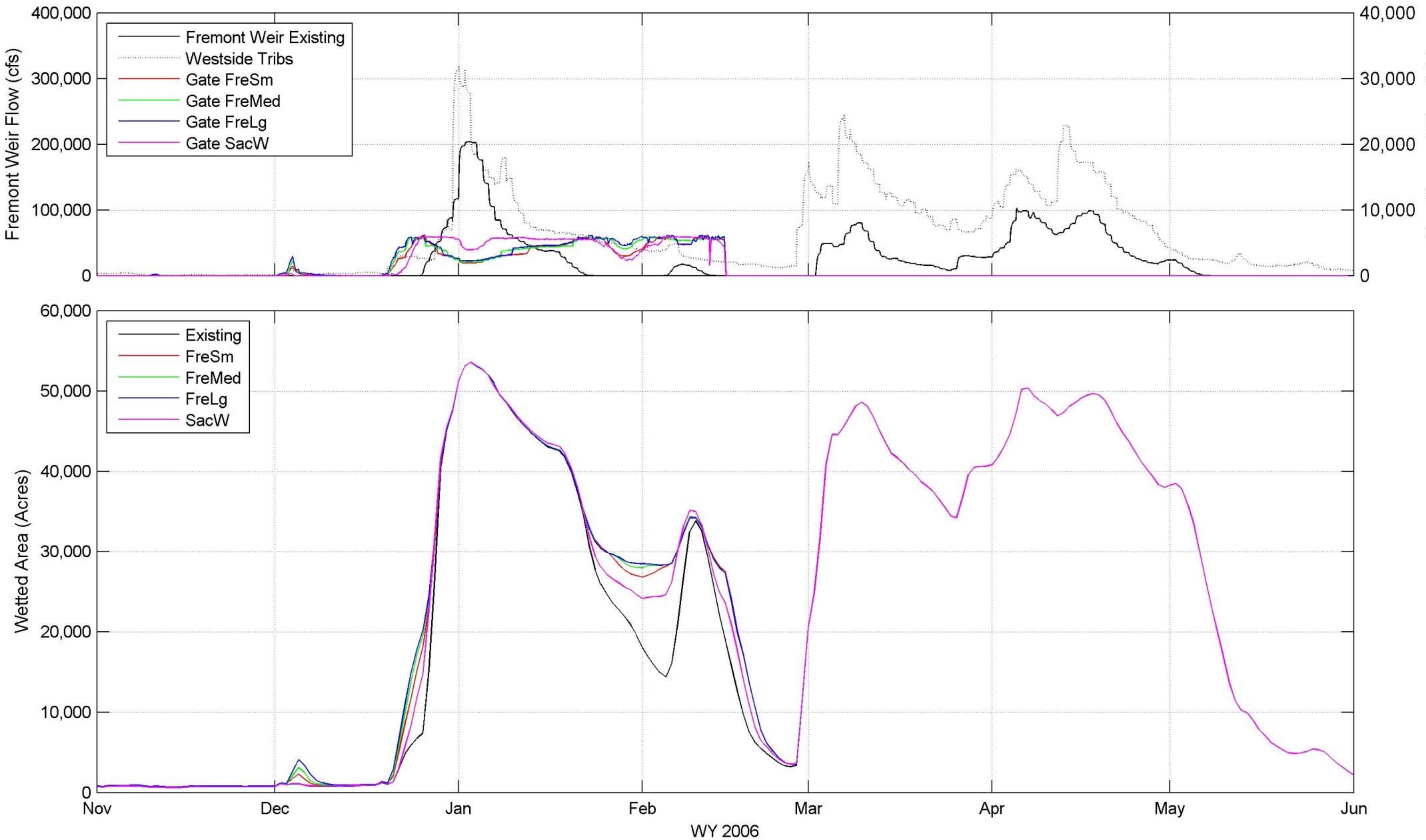
Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2004 for Feb 15 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D8**



Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)	HDR cbec eco engineering	*Yolo Bypass Salmonid Habitat Restoration and Fish Passage* **Wetted Area for WY 2005 for Feb 15 Gate Closure**
		Prepared for DWR / Created By: SJB / **Figure D9**

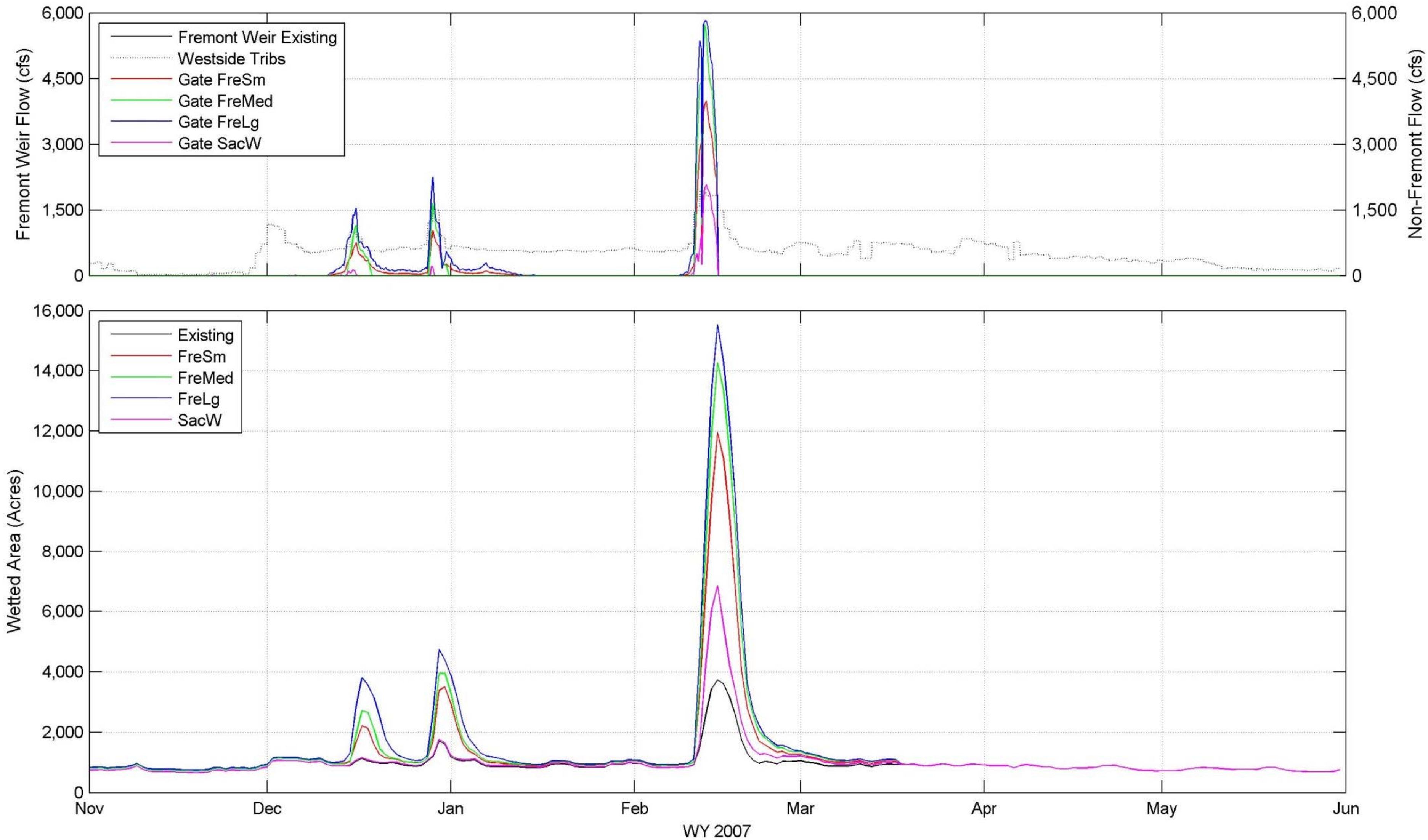


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2006 for Feb 15 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D10**

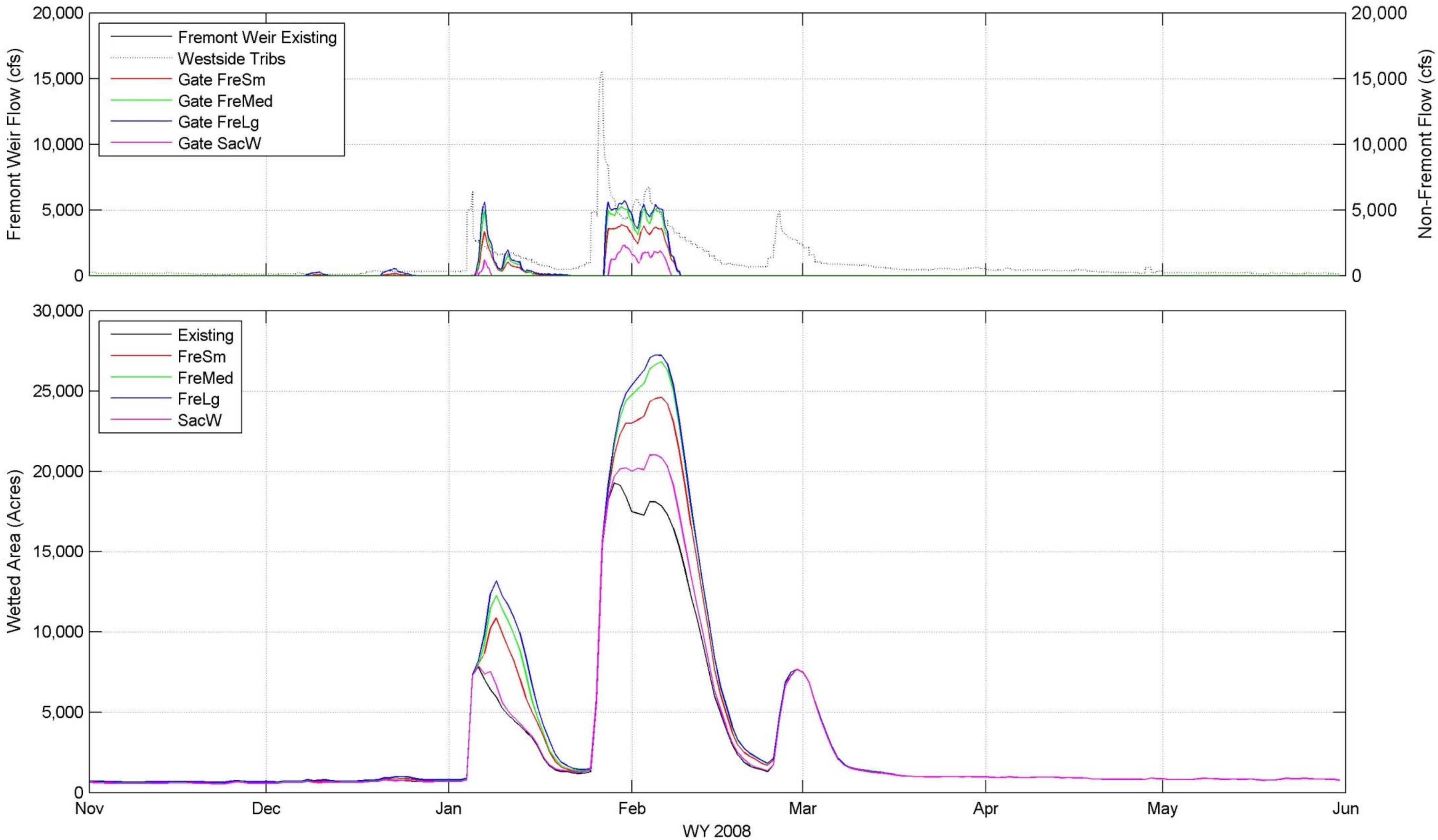


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2007 for Feb 15 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D11**

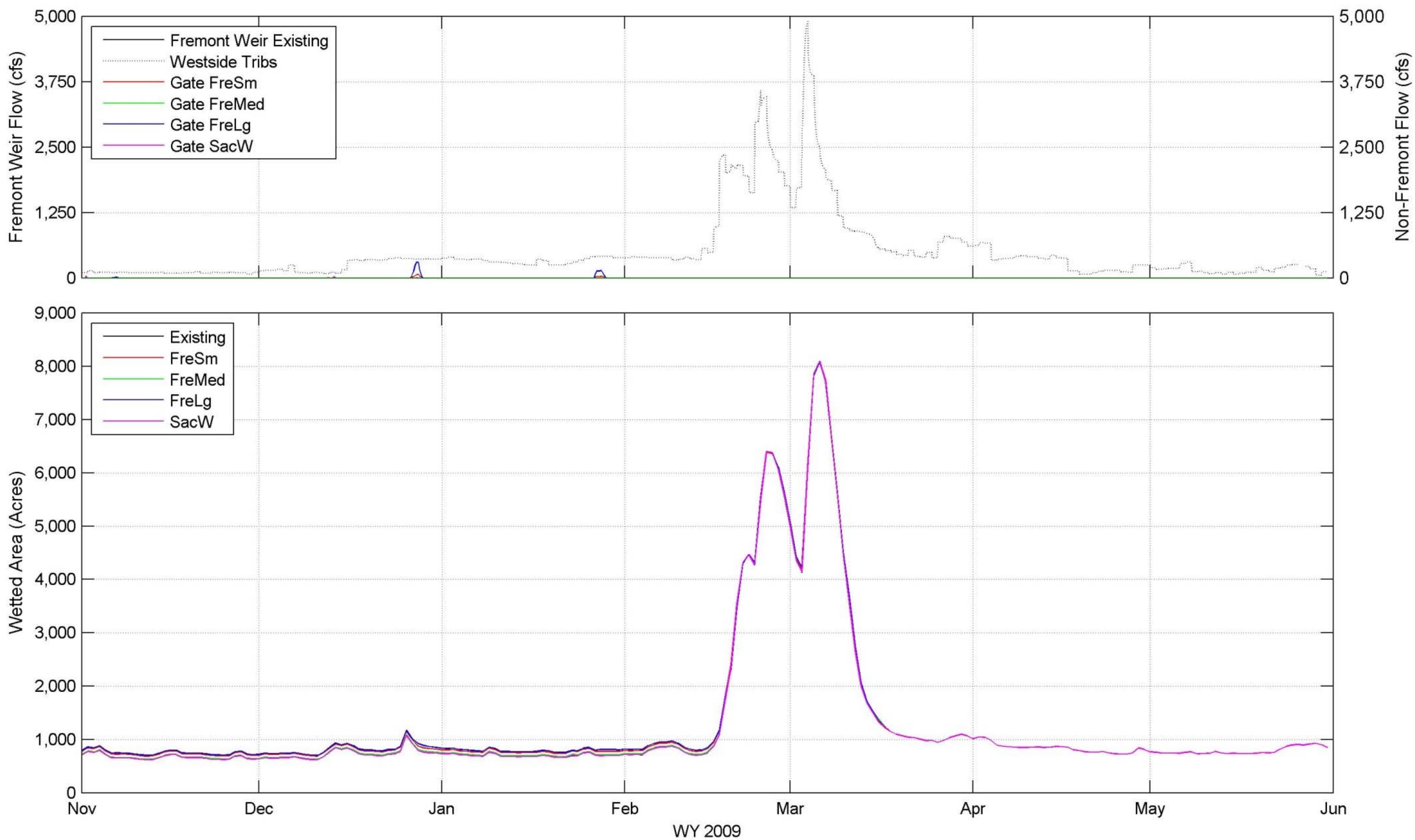


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2008 for Feb 15 Gate Closure

Prepared for DWR | Created By: SJB | **Figure D12**

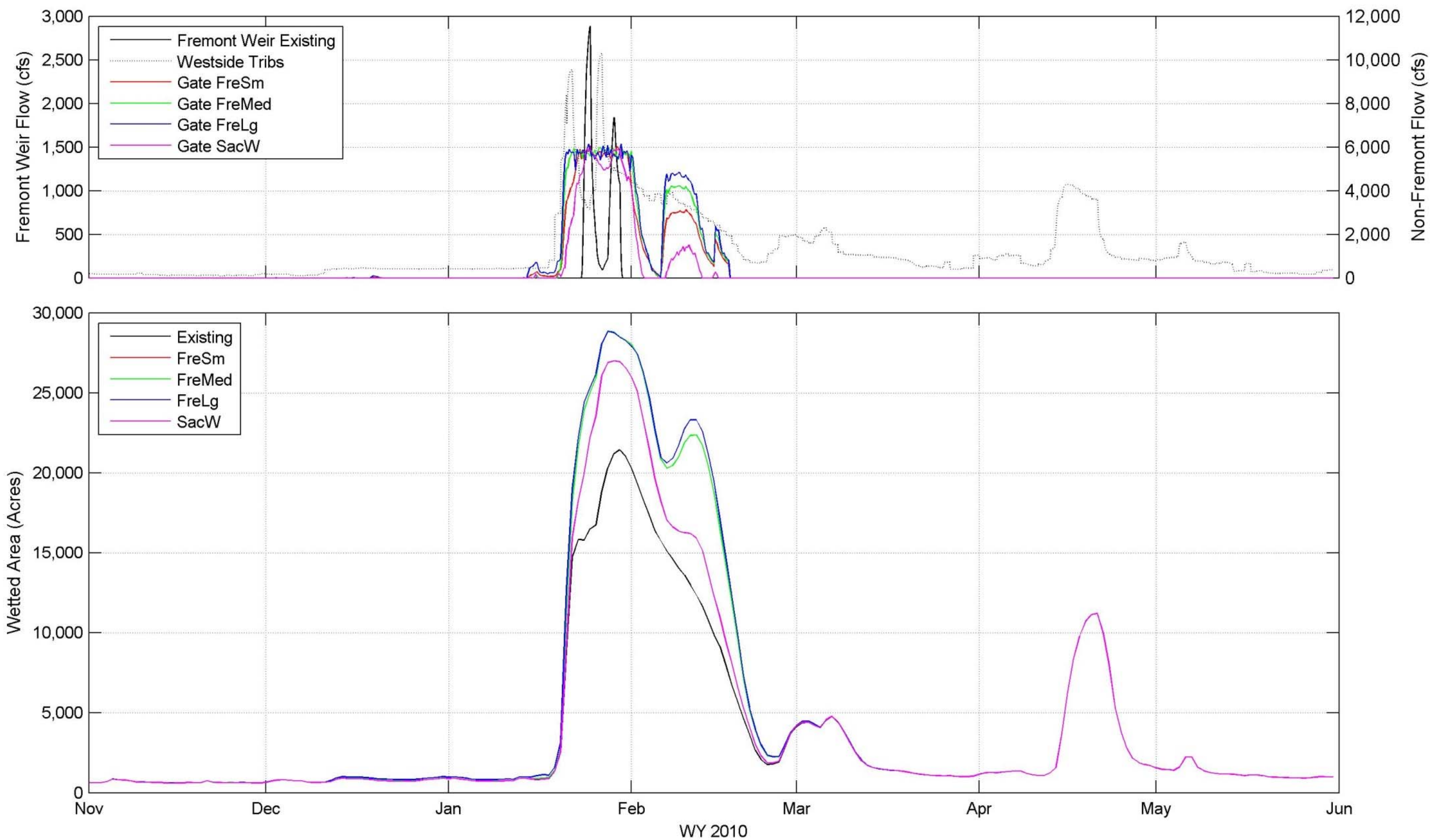


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2009 for Feb 15 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D13**

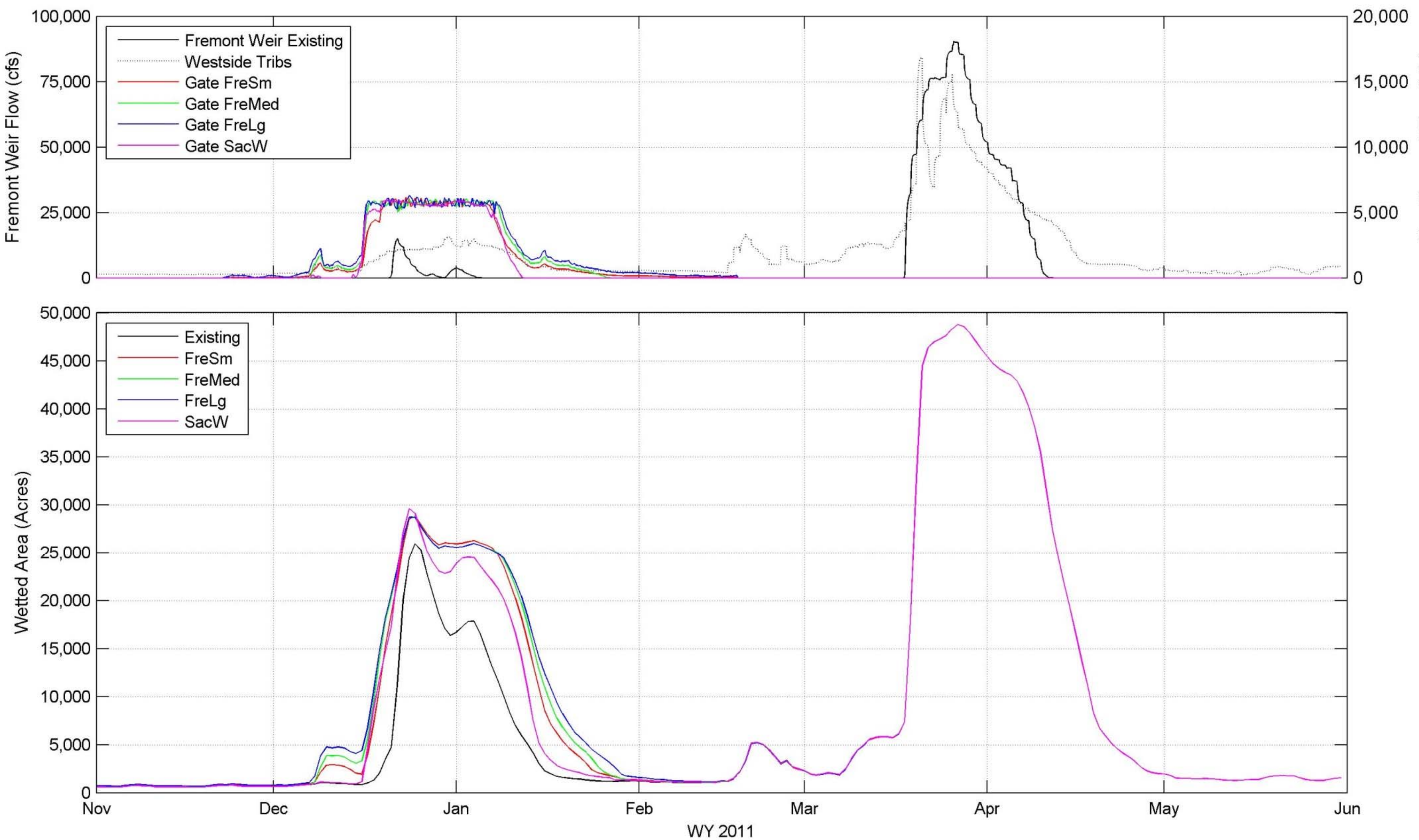


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2010 for Feb 15 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D14**

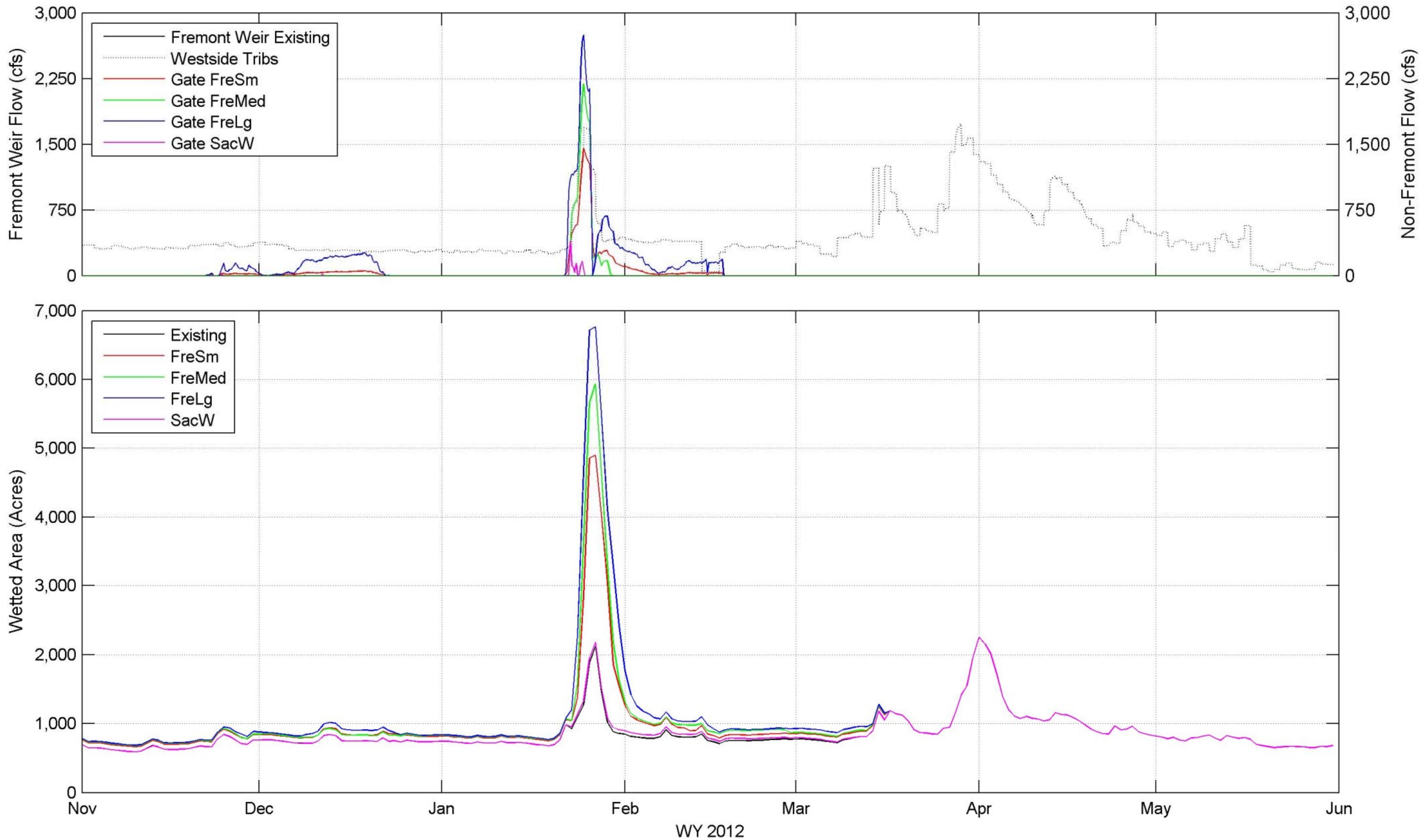


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2011 for Feb 15 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D15**



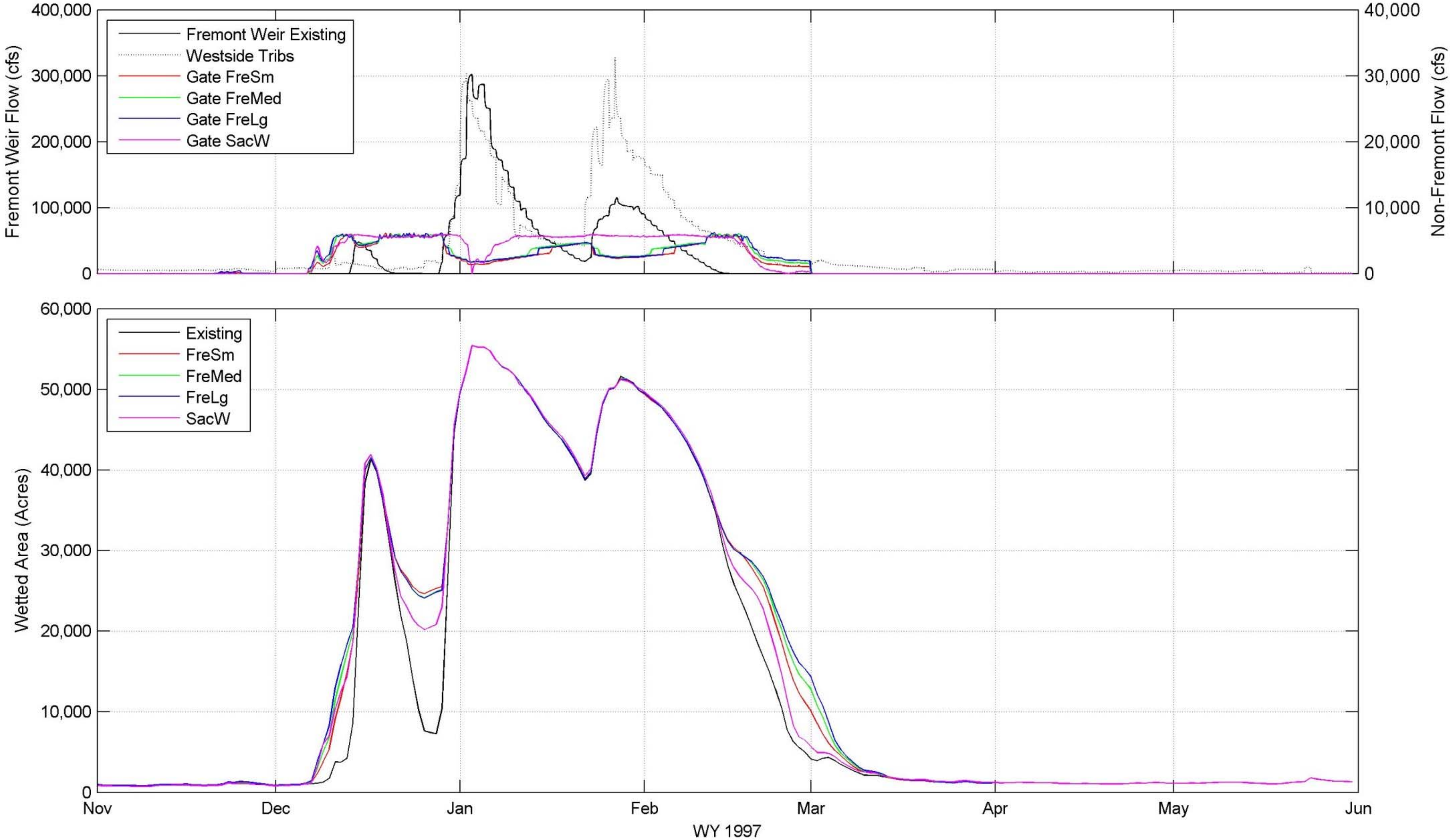
Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

HDR cbec eco engineering

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2012 for Feb 15 Gate Closure

Prepared for DWR | Created By: SJB | **Figure D16**

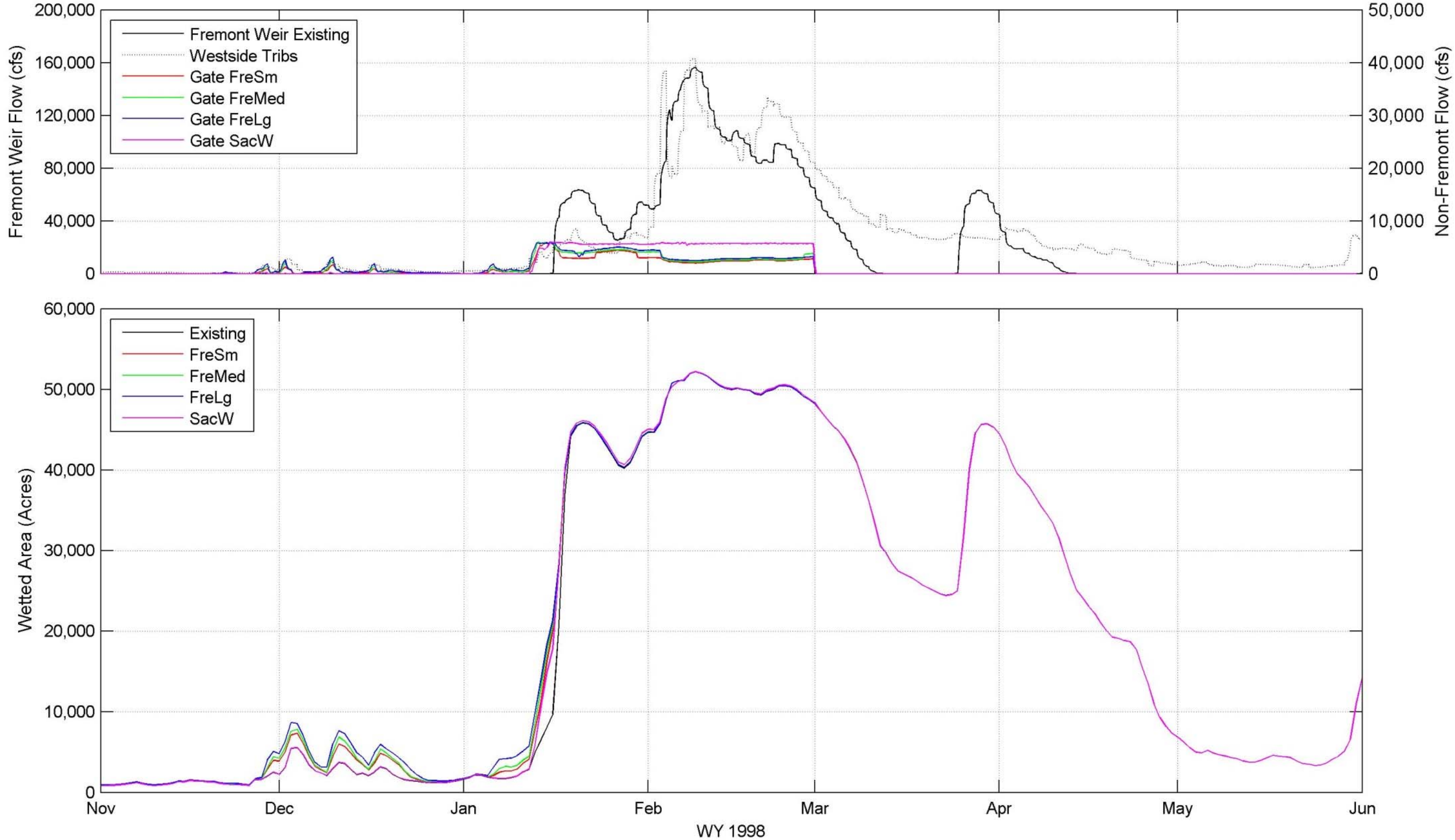


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 1997 for Mar 1 Gate Closure

Prepared for DWR | Created By: SJB | **Figure D17**

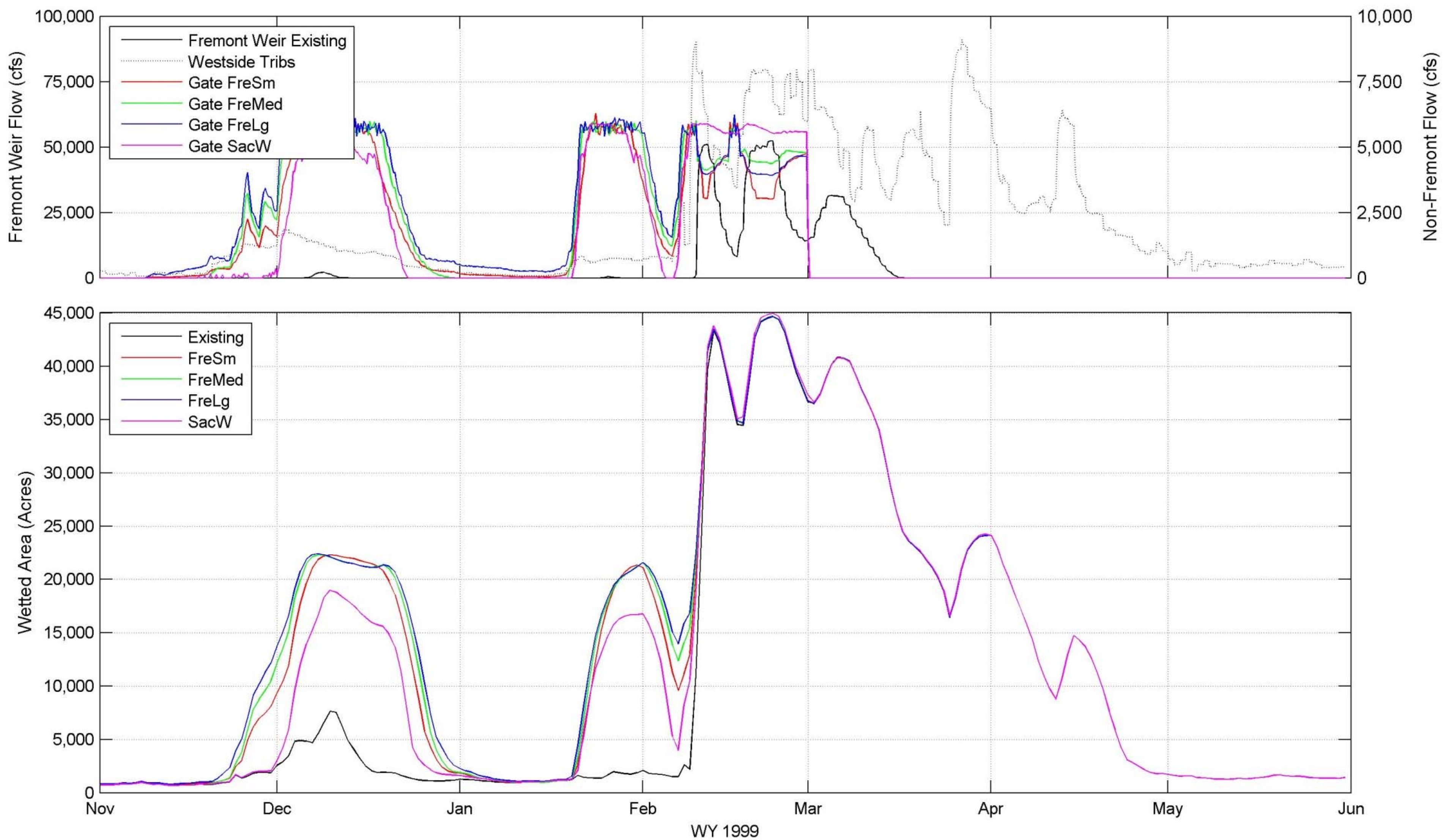


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 1998 for Mar 1 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D18**

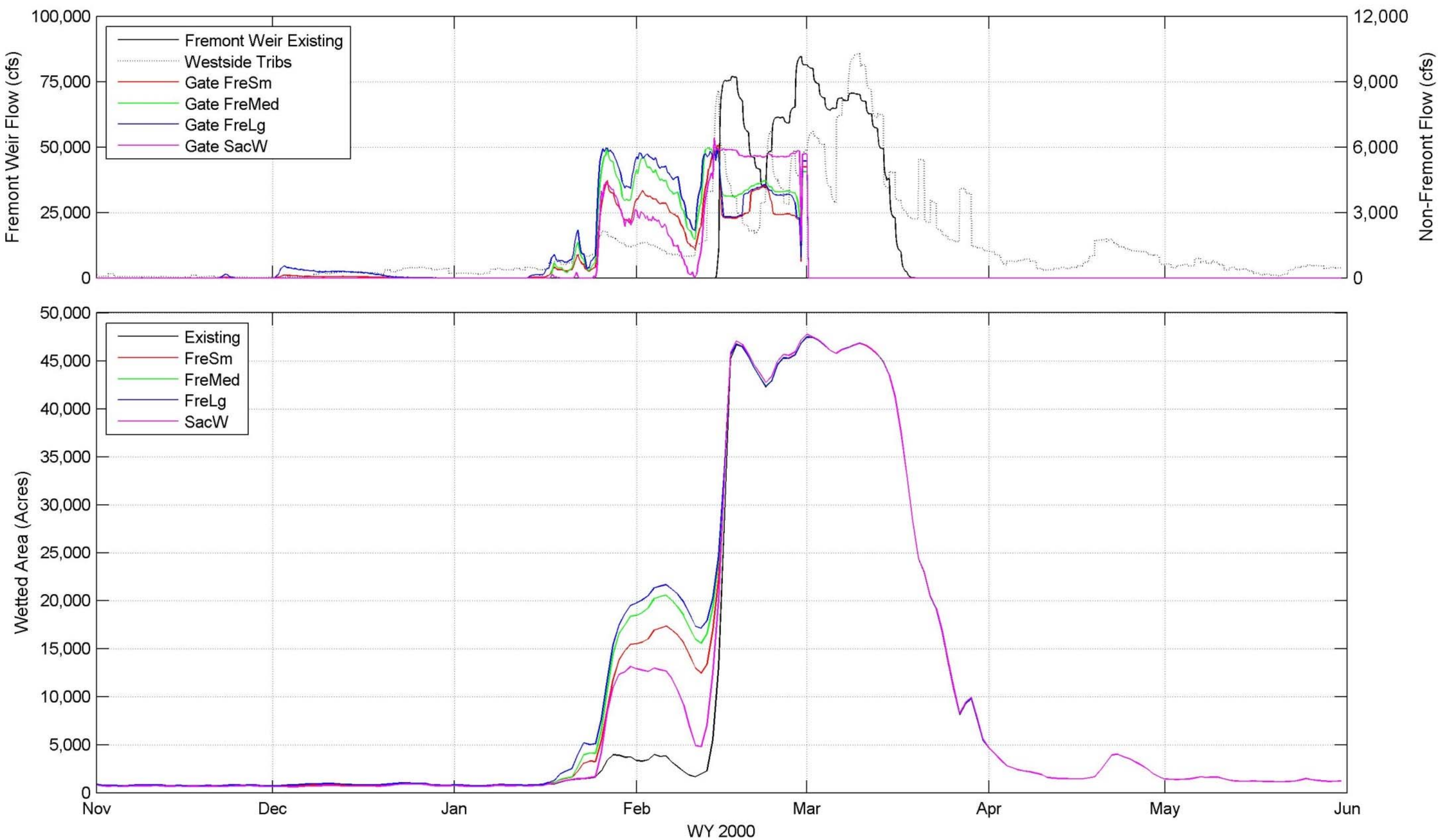


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 1999 for Mar 1 Gate Closure

Prepared for DWR | Created By: SJB | **Figure D19**

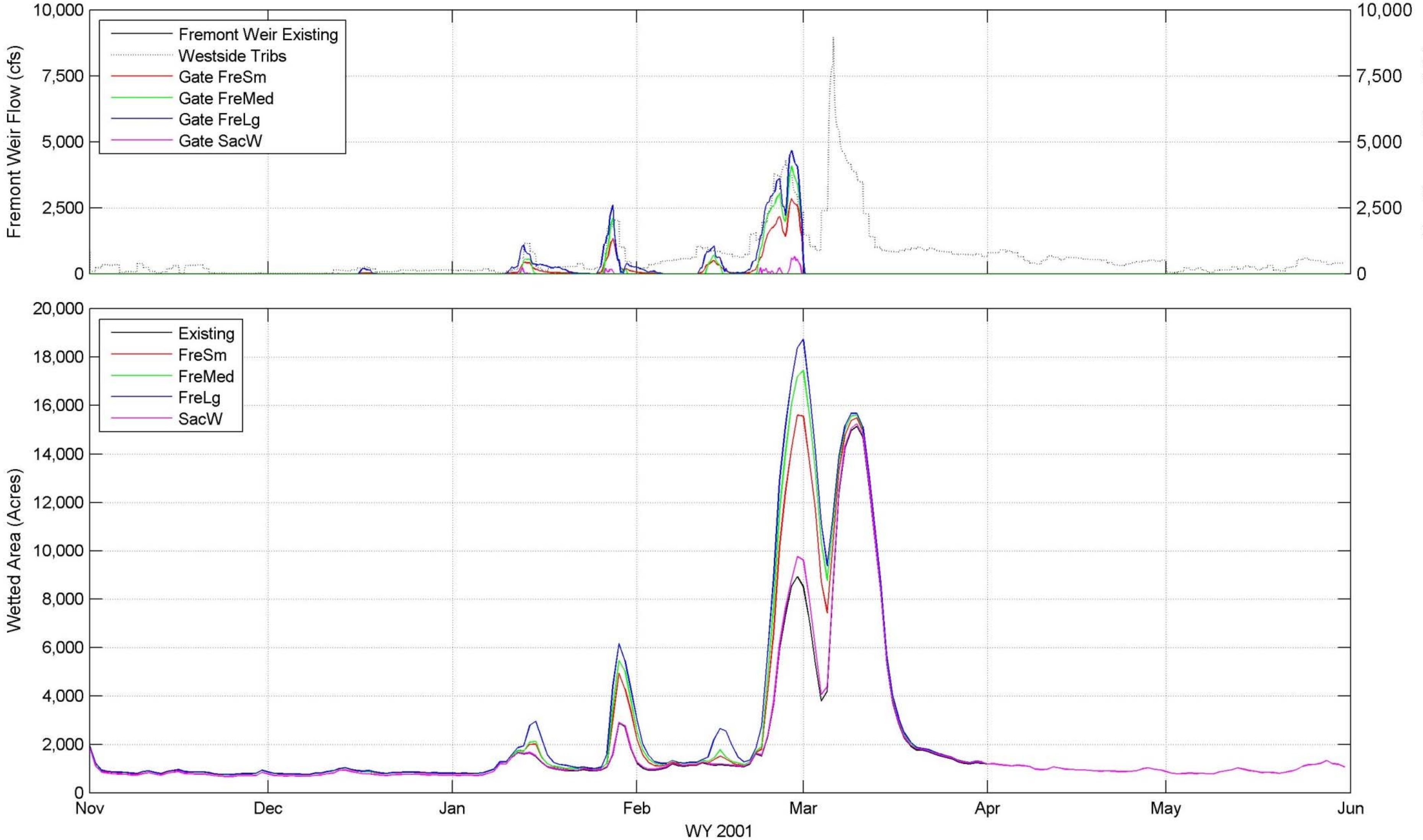


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2000 for Mar 1 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D20**

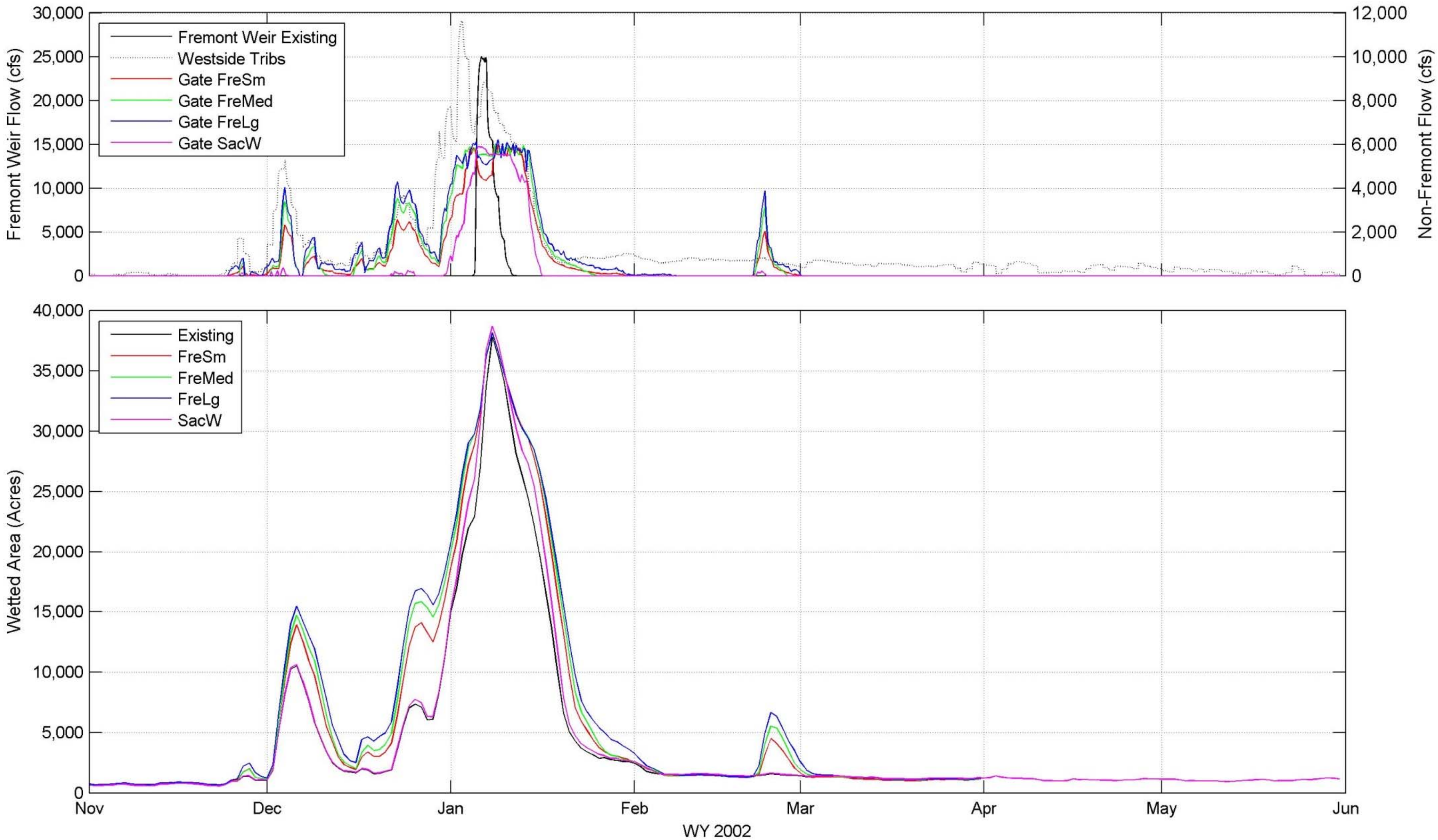


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2001 for Mar 1 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D21**

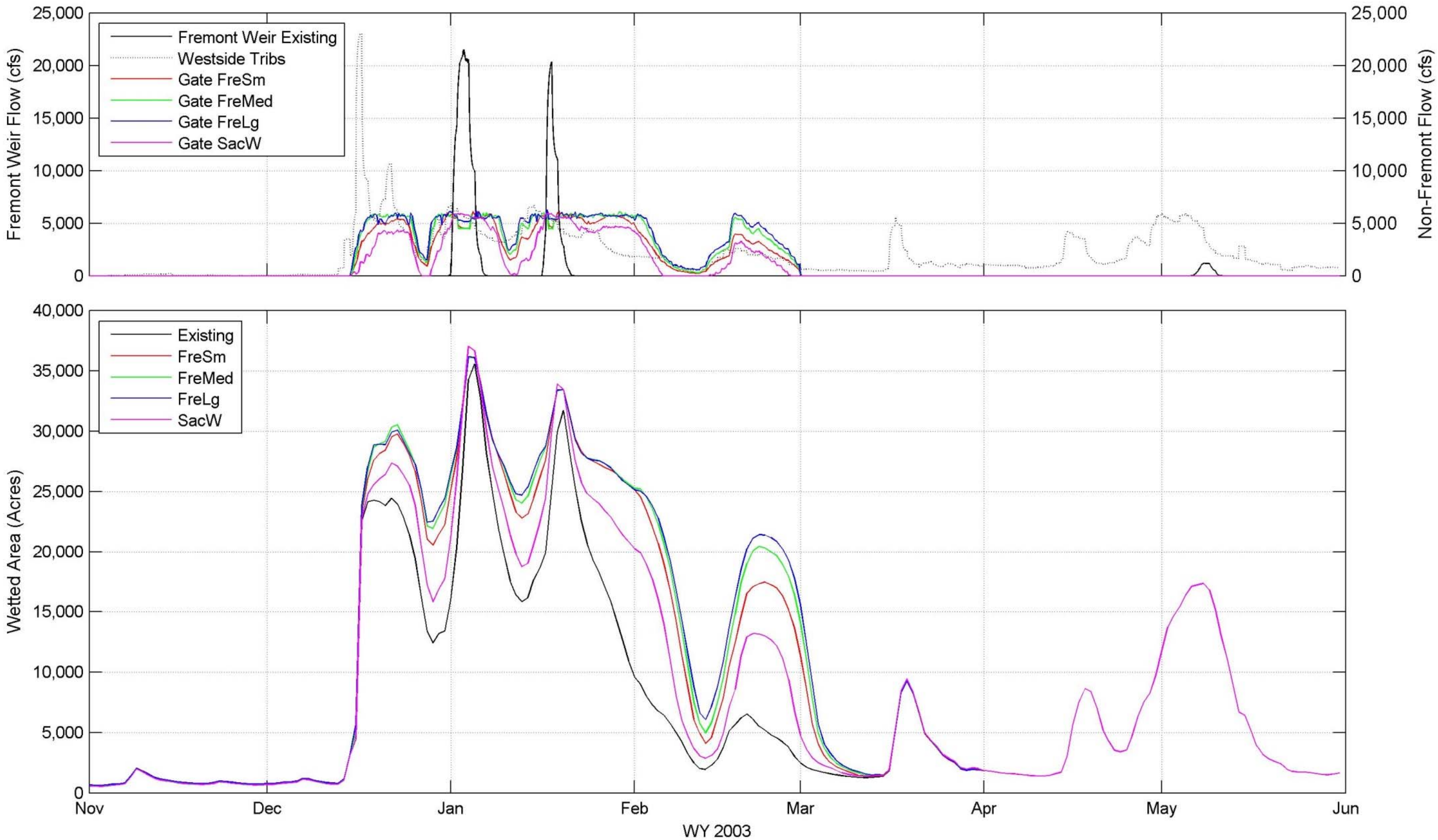


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2002 for Mar 1 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D22**

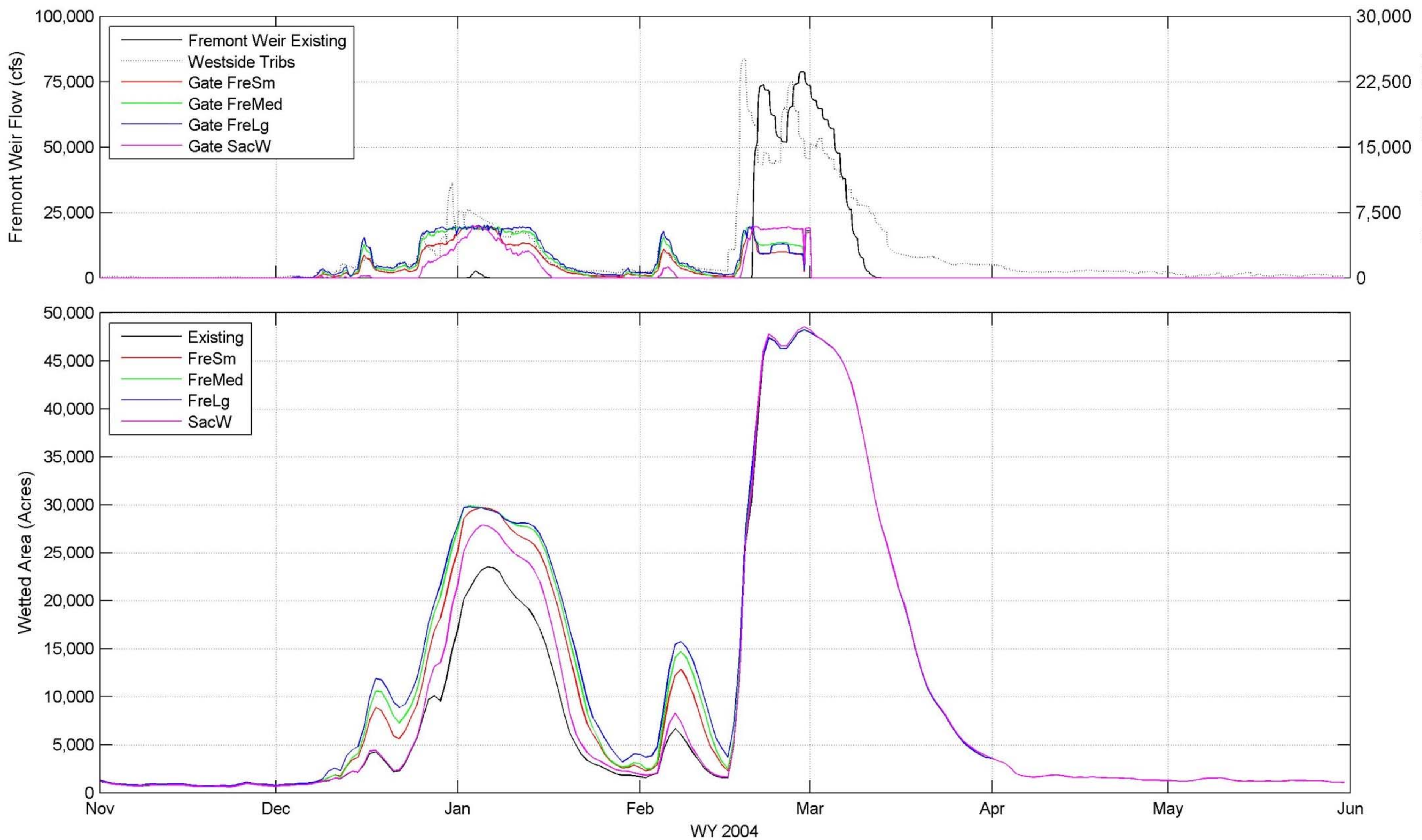


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2003 for Mar 1 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D23**

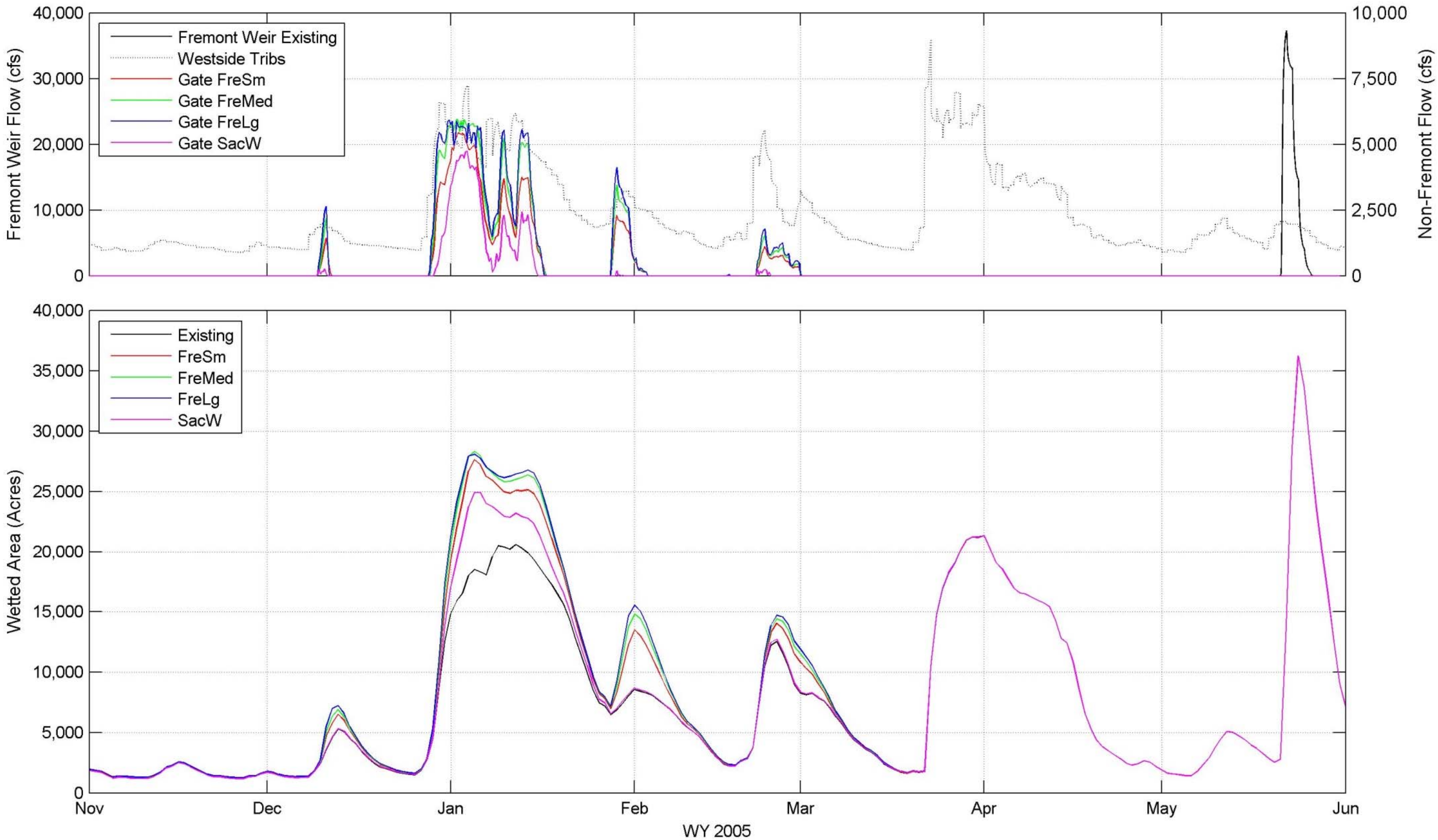


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2004 for Mar 1 Gate Closure

Prepared for DWR | Created By: SJB | **Figure D24**

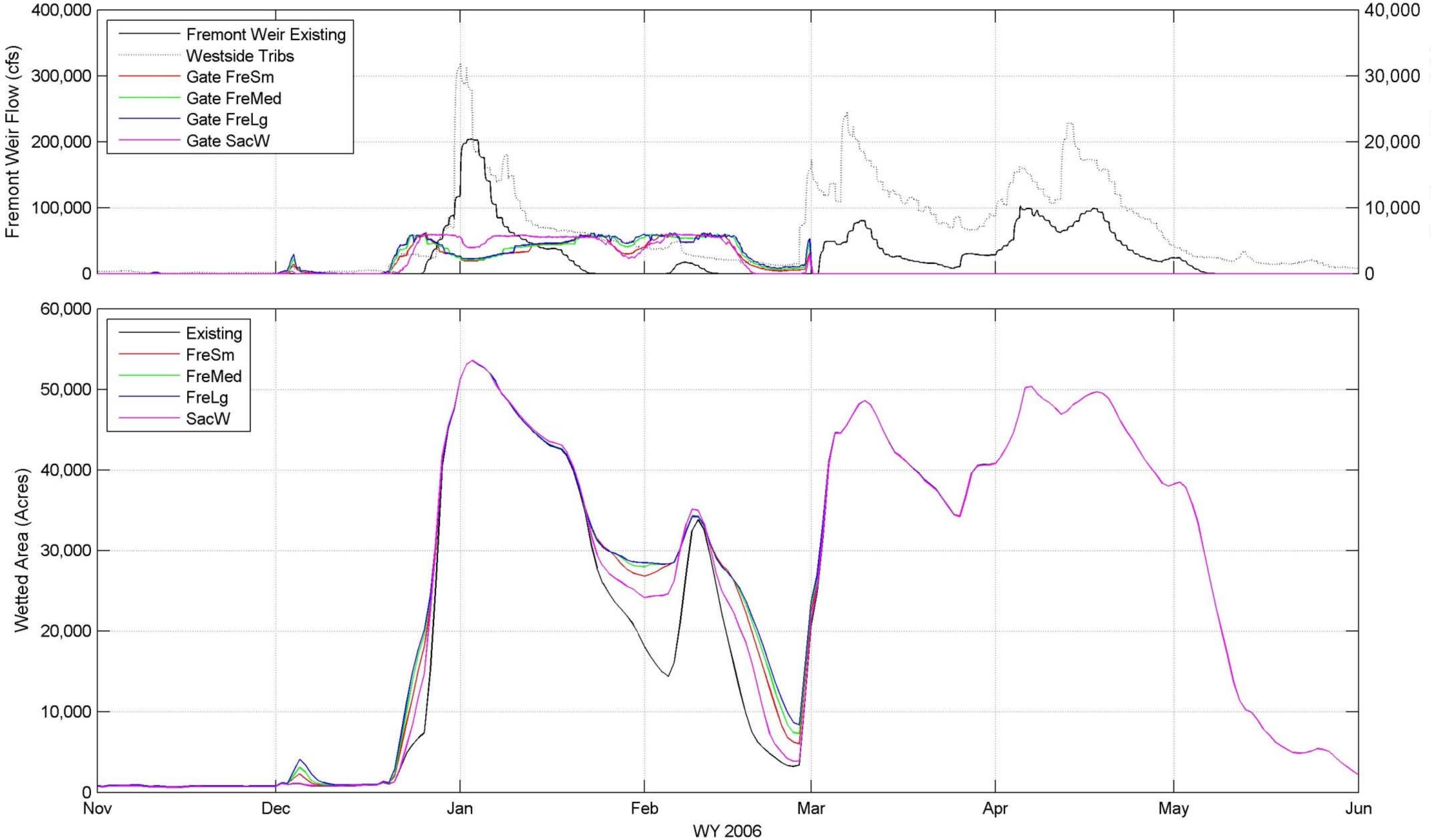


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2005 for Mar 1 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D25**

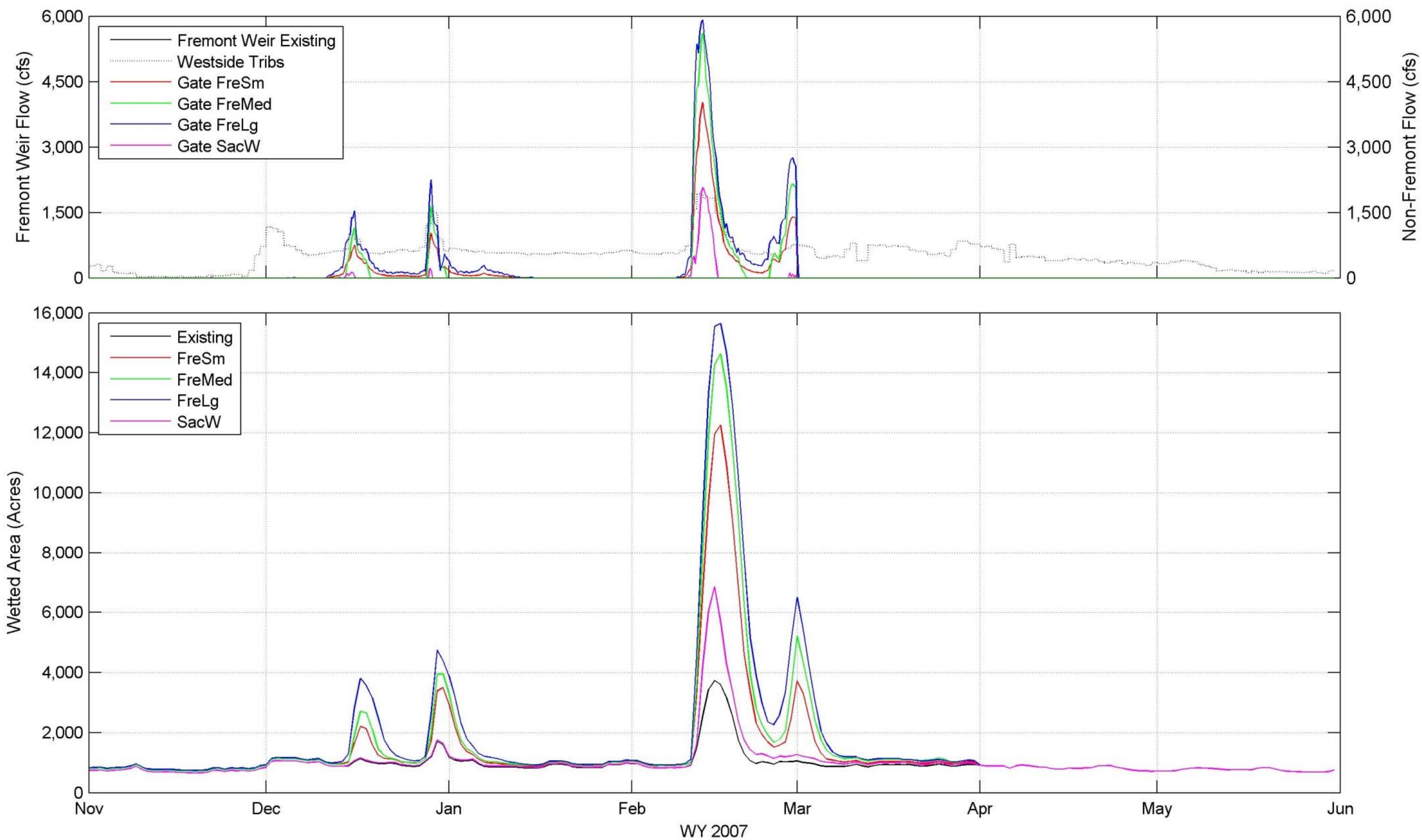


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2006 for Mar 1 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D26**

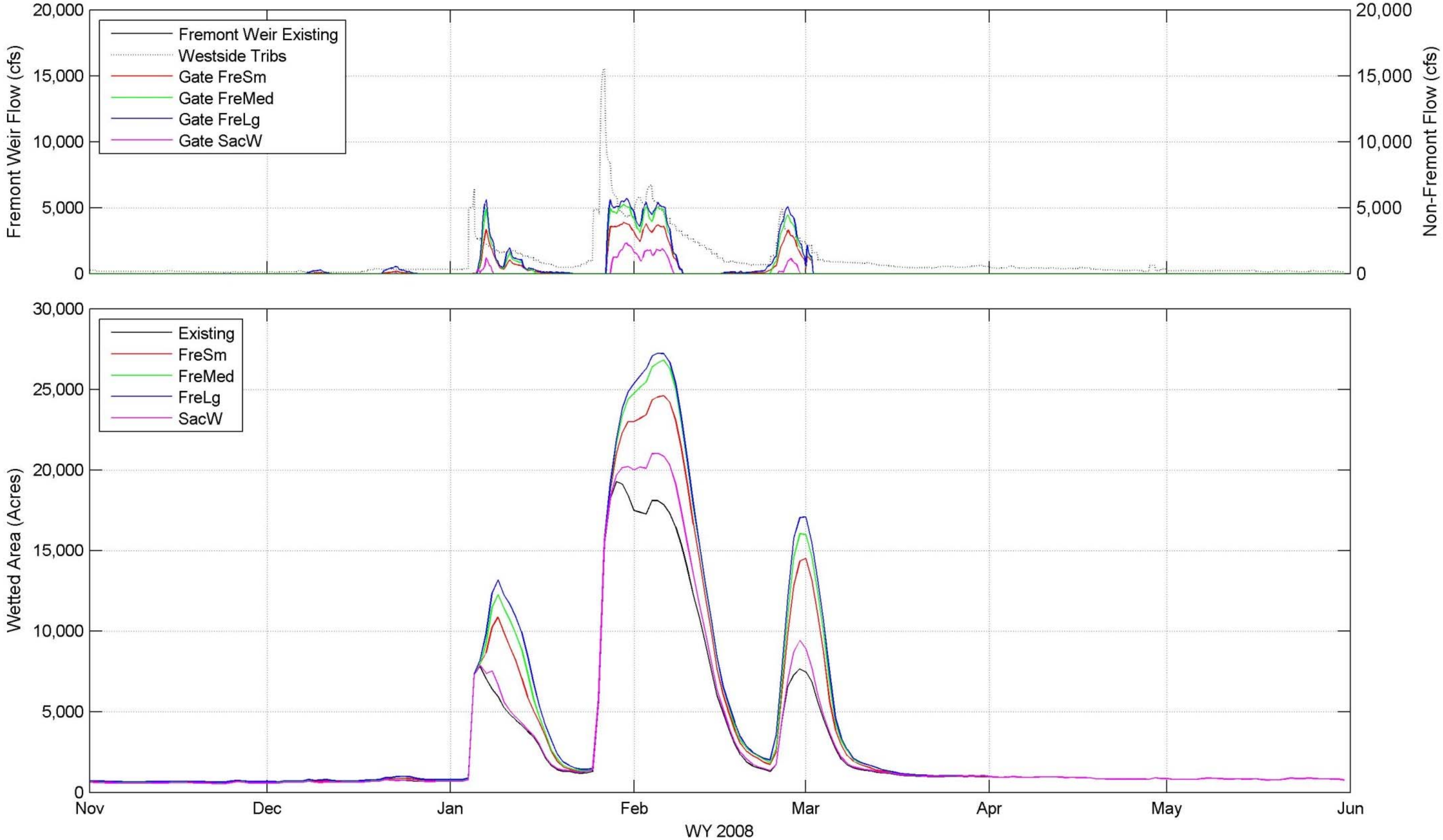


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

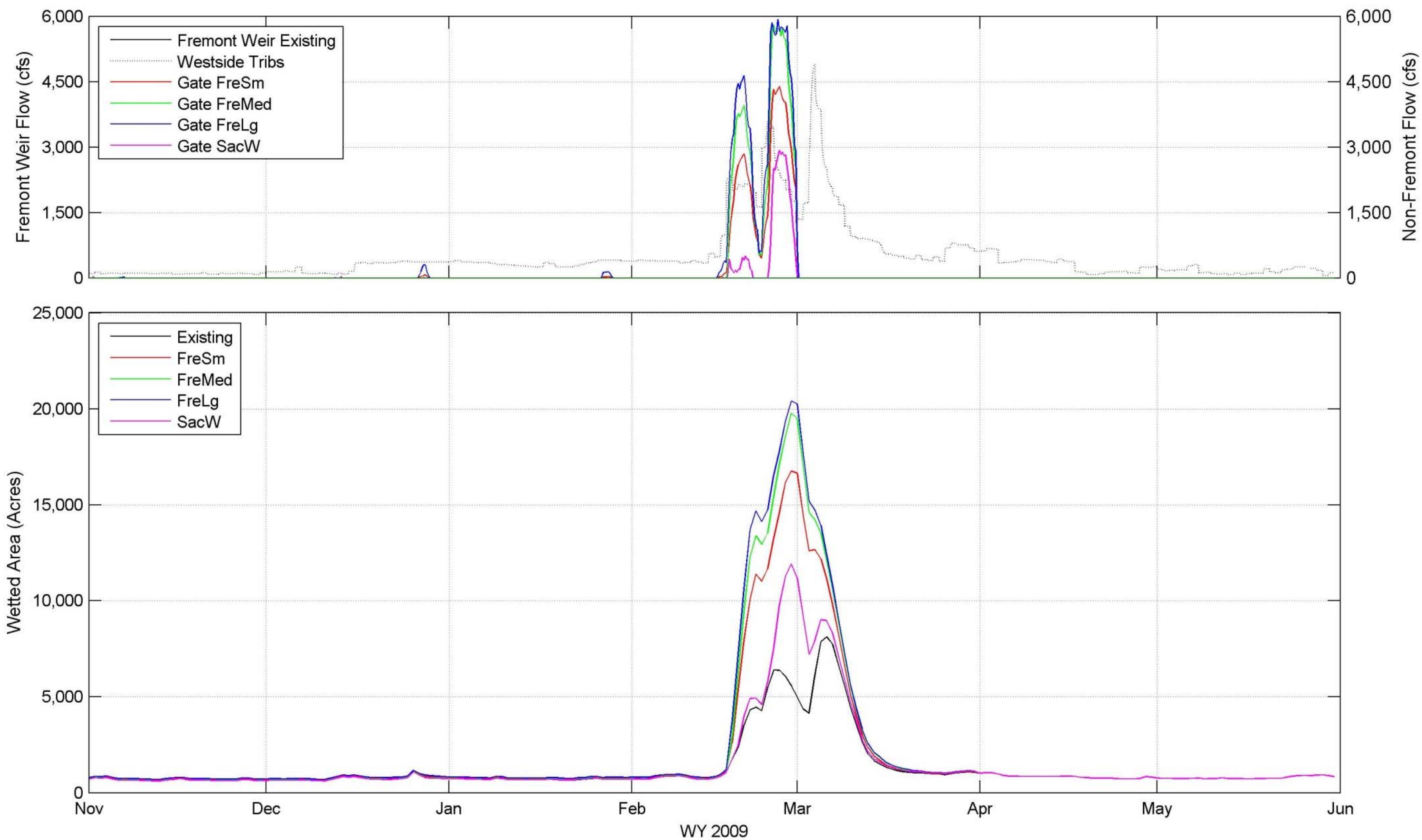
Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2007 for Mar 1 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D27**



Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)	*Yolo Bypass Salmonid Habitat Restoration and Fish Passage*
	Wetted Area for WY 2008 for Mar 1 Gate Closure
Prepared for DWR	Created By: SJB
	Figure D28

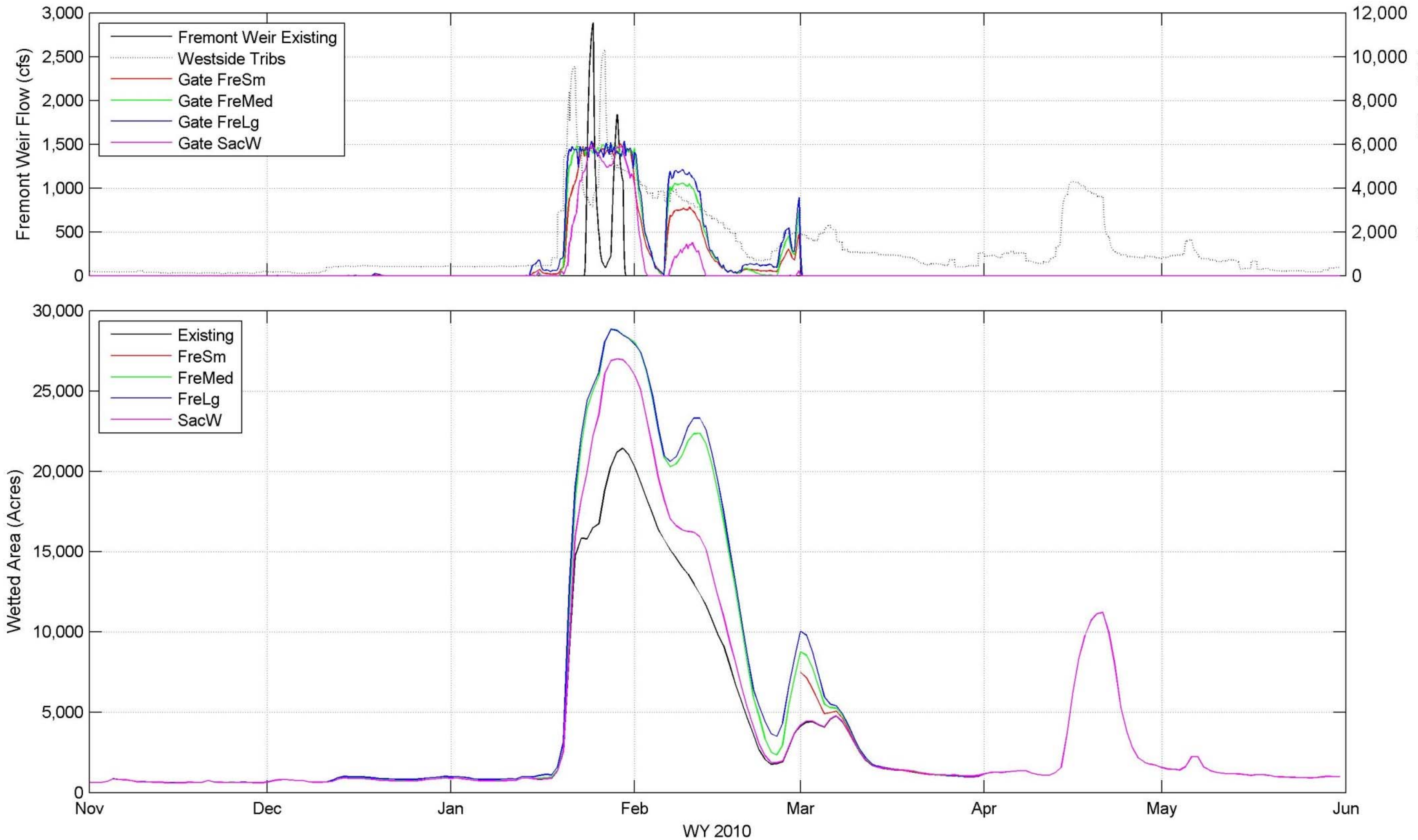


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2009 for Mar 1 Gate Closure

Prepared for DWR | Created By: SJB | **Figure D29**

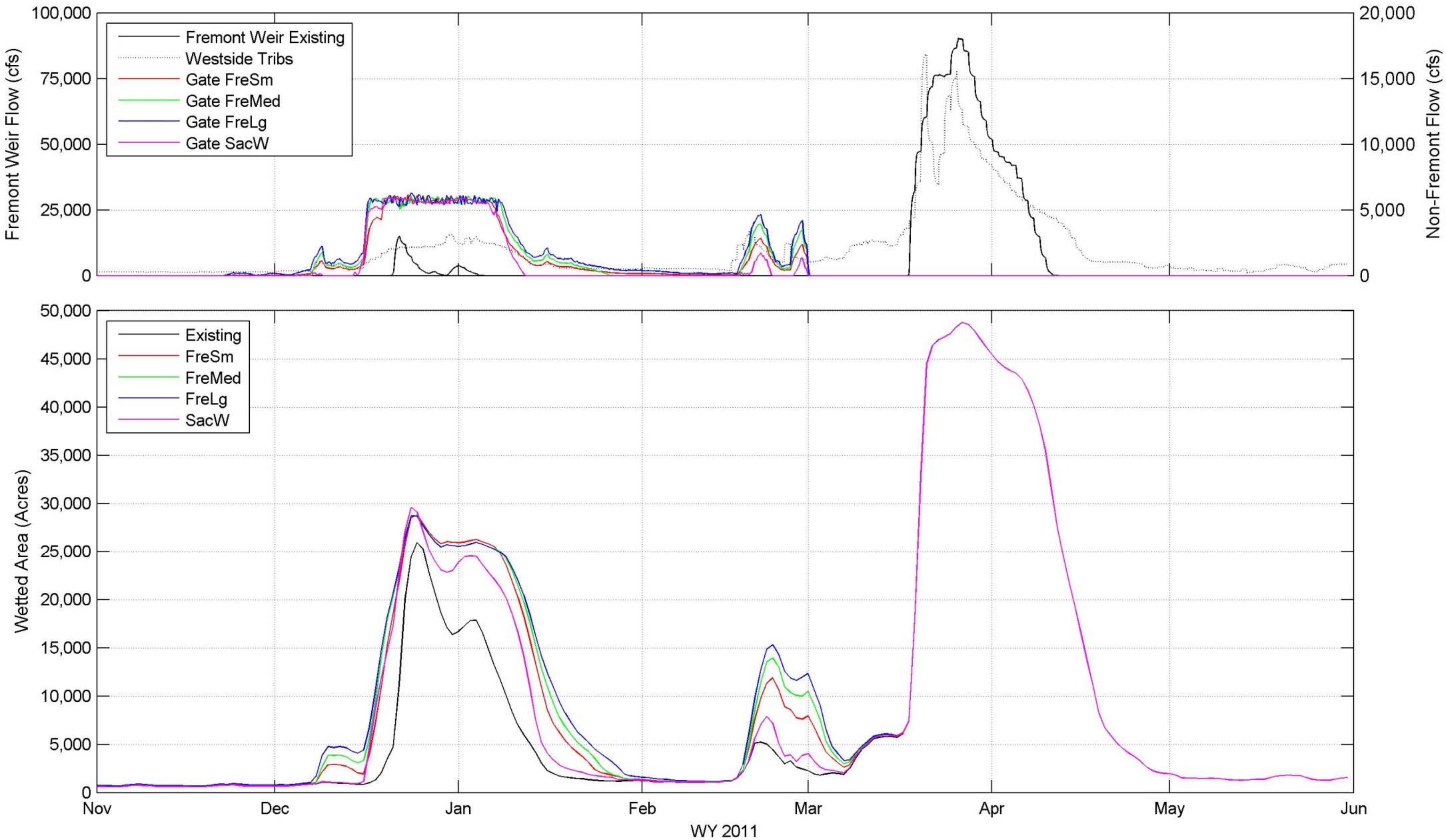


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2010 for Mar 1 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D30**

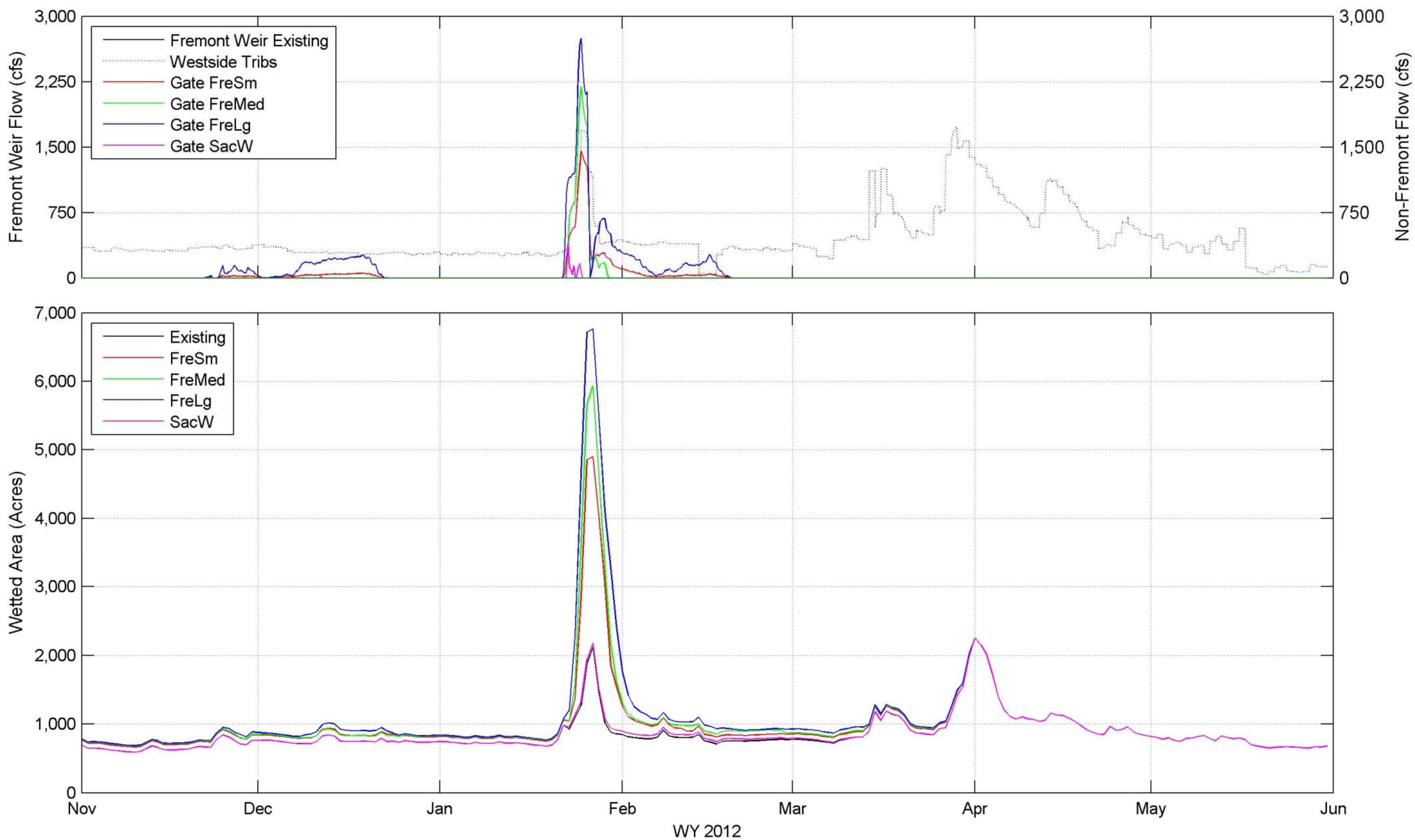


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2011 for Mar 1 Gate Closure

Prepared for DWR | Created By: SJB | **Figure D31**

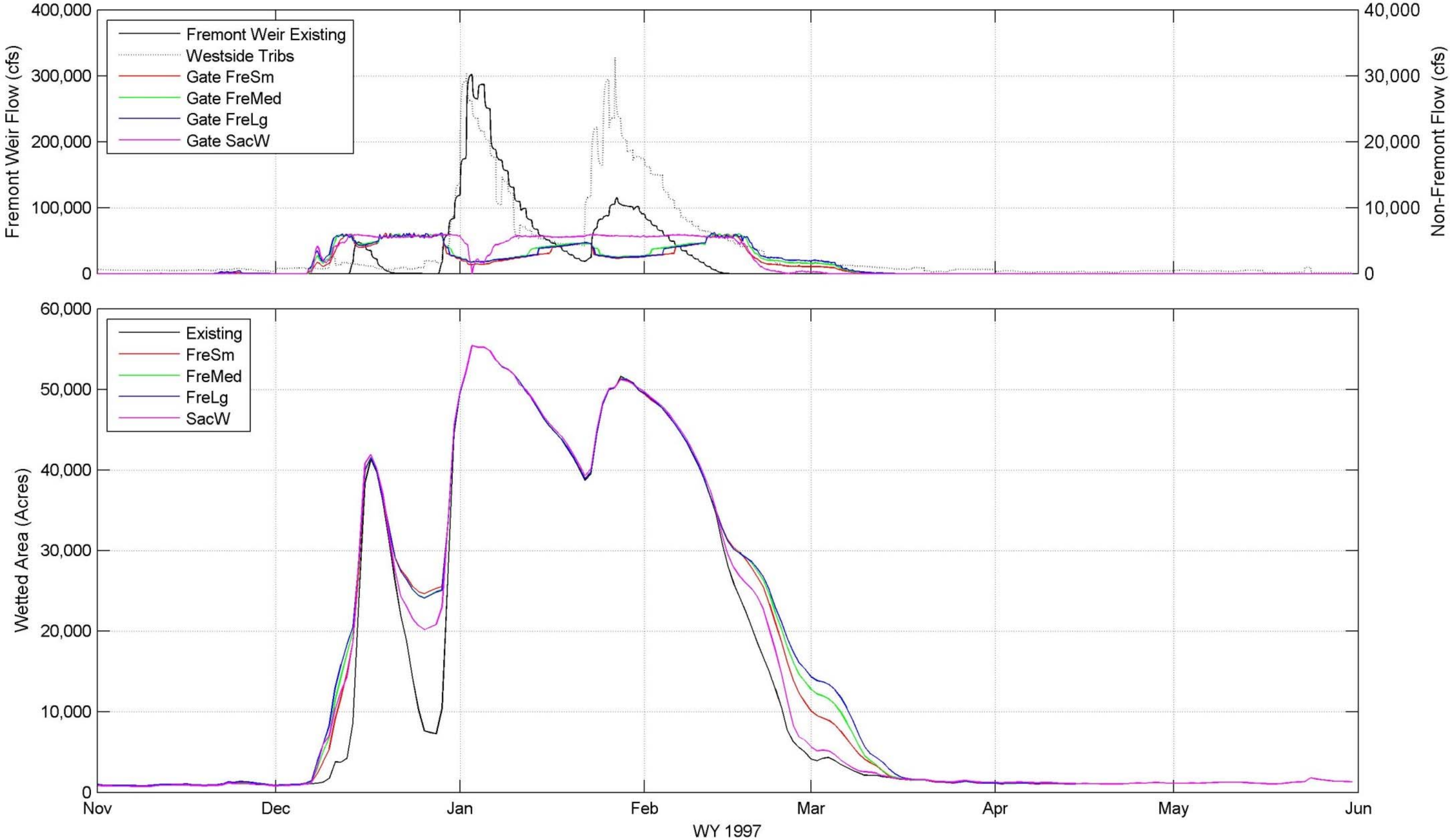


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2012 for Mar 1 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D32**

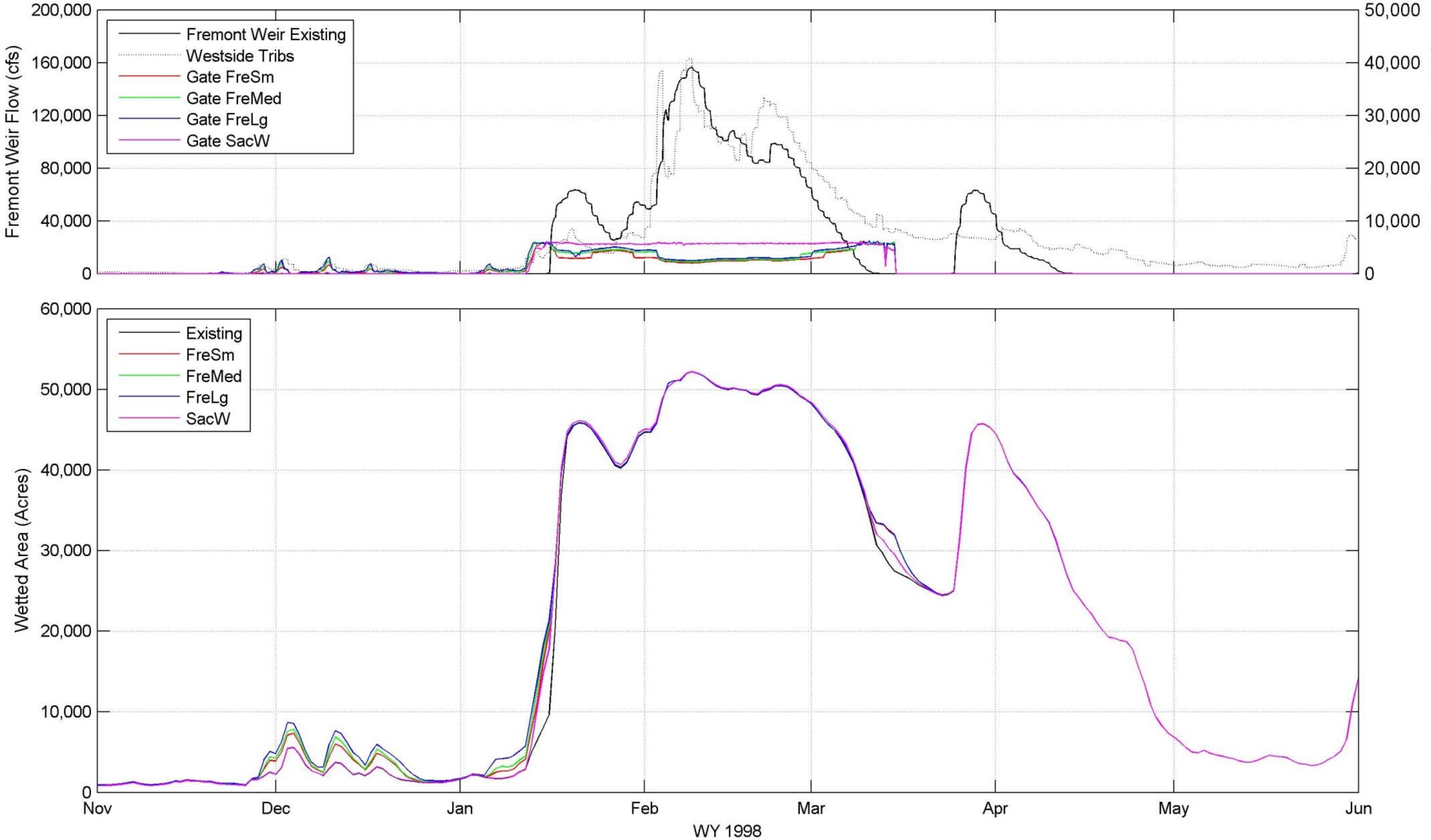


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 1997 for Mar 15 Gate Closure

Prepared for DWR | Created By: SJB | **Figure D33**

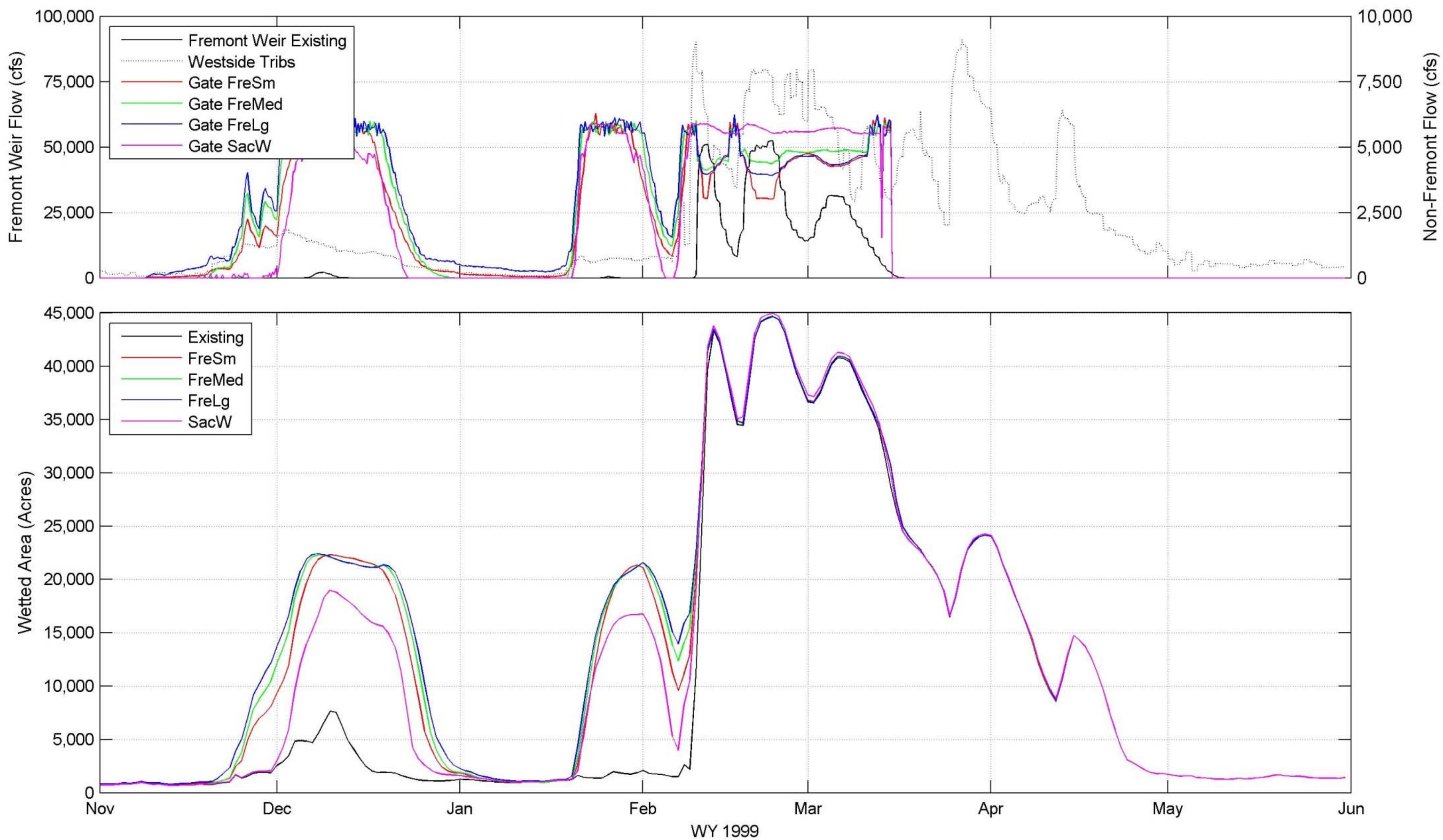


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 1998 for Mar 15 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D34**

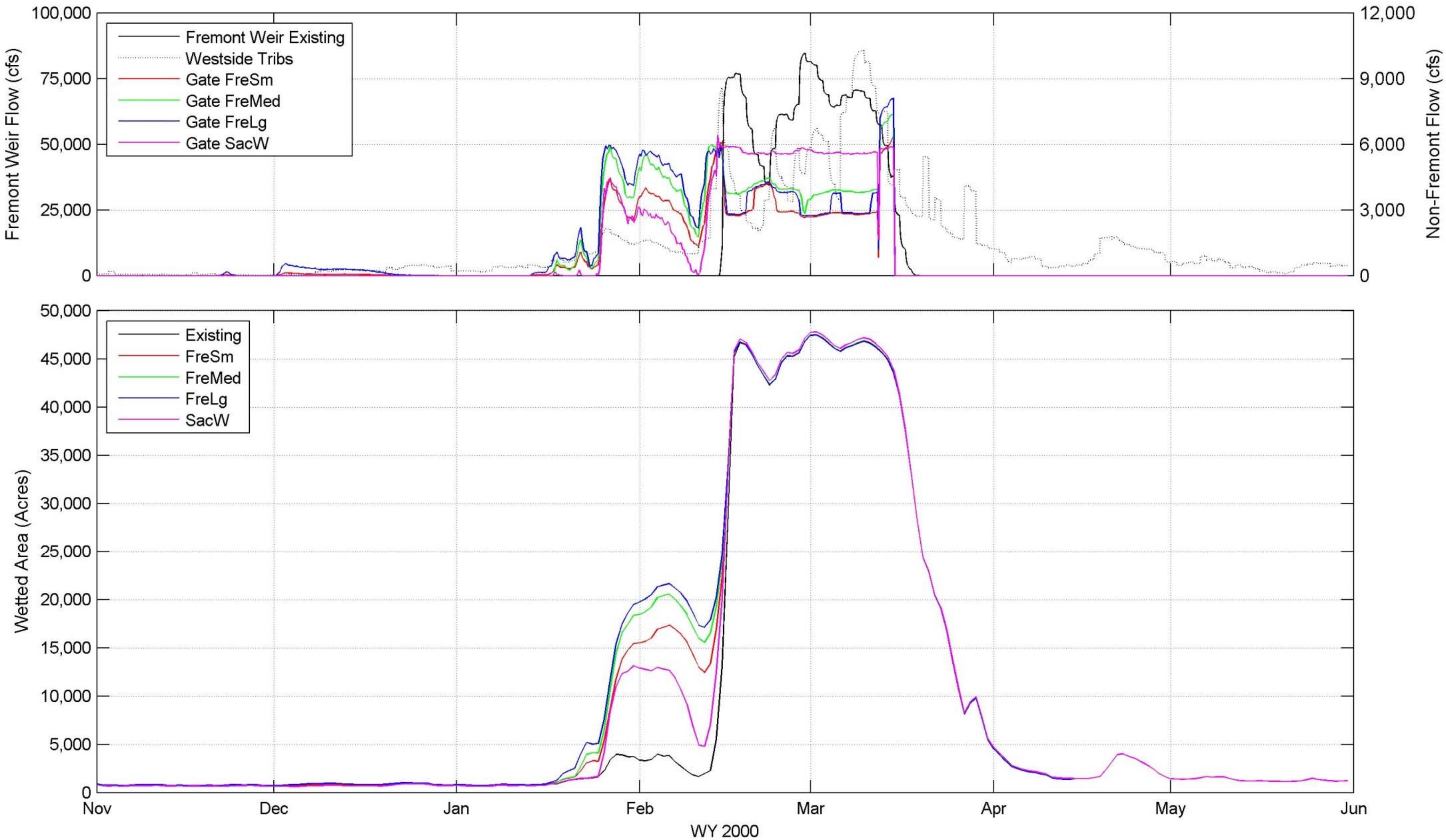


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 1999 for Mar 15 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D35**

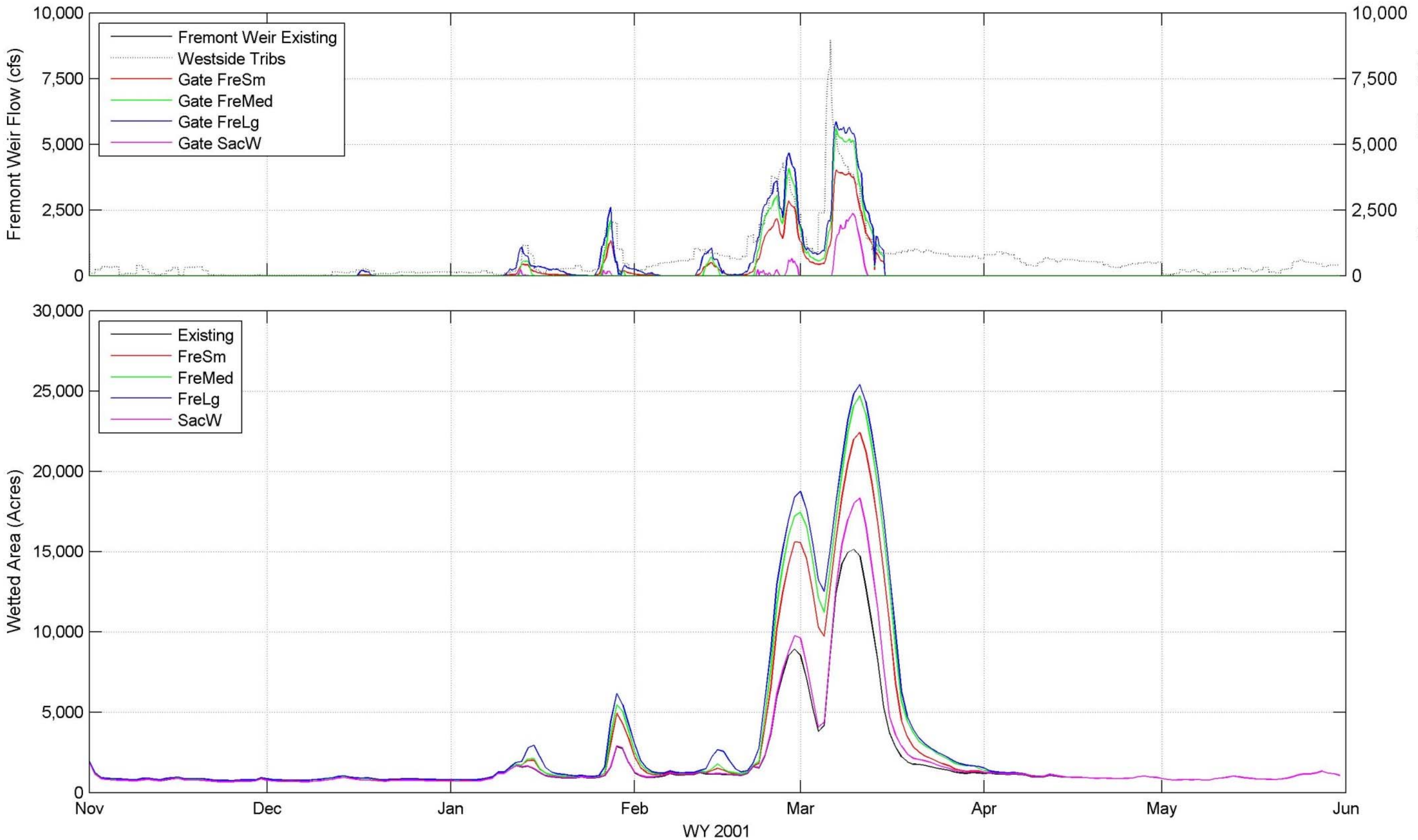


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2000 for Mar 15 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D36**

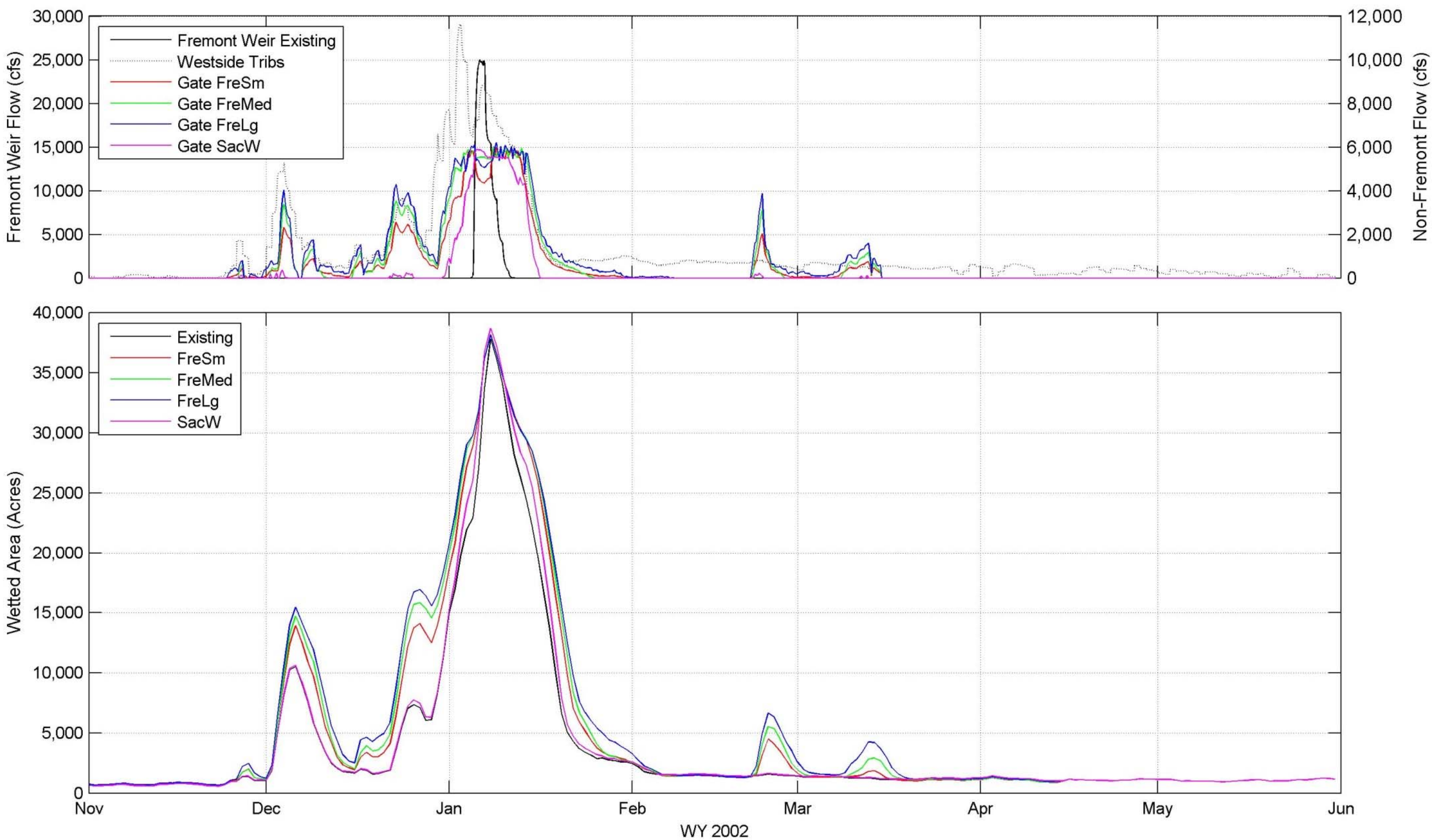


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2001 for Mar 15 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D37**



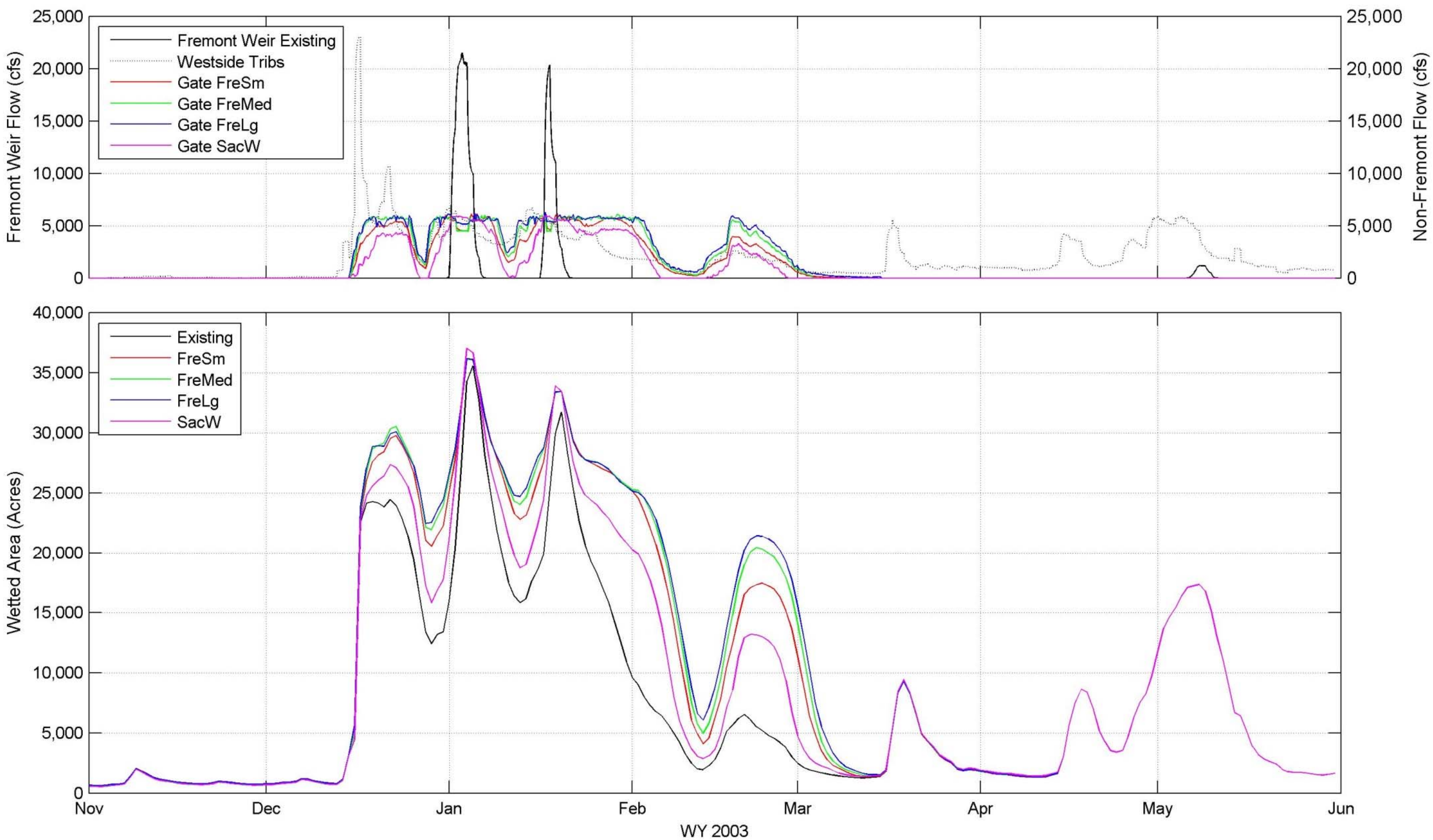
Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

HDR cbec eco engineering

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2002 for Mar 15 Gate Closure

Prepared for DWR | Created By: SJB | **Figure D38**

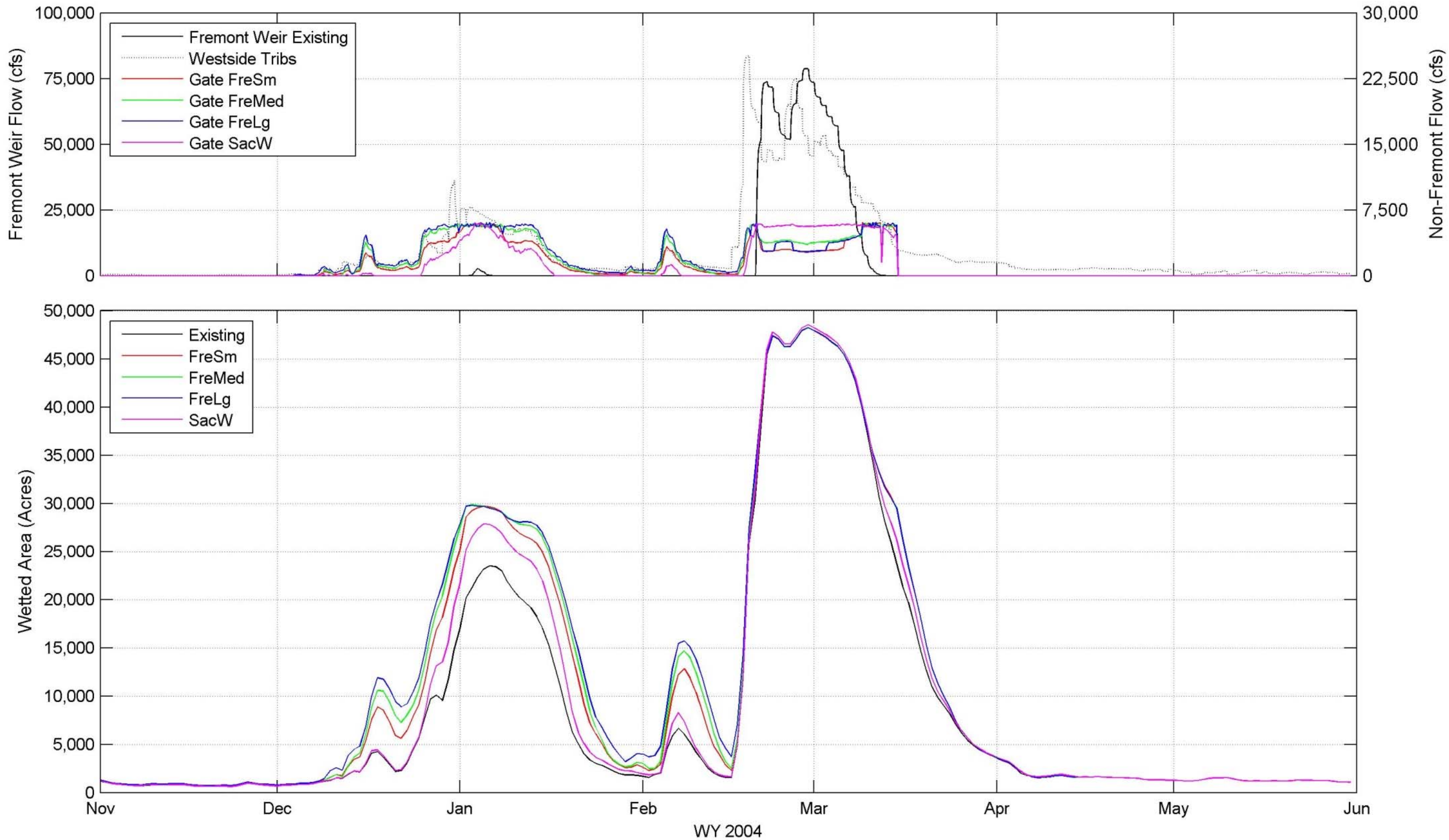


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2003 for Mar 15 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D39**

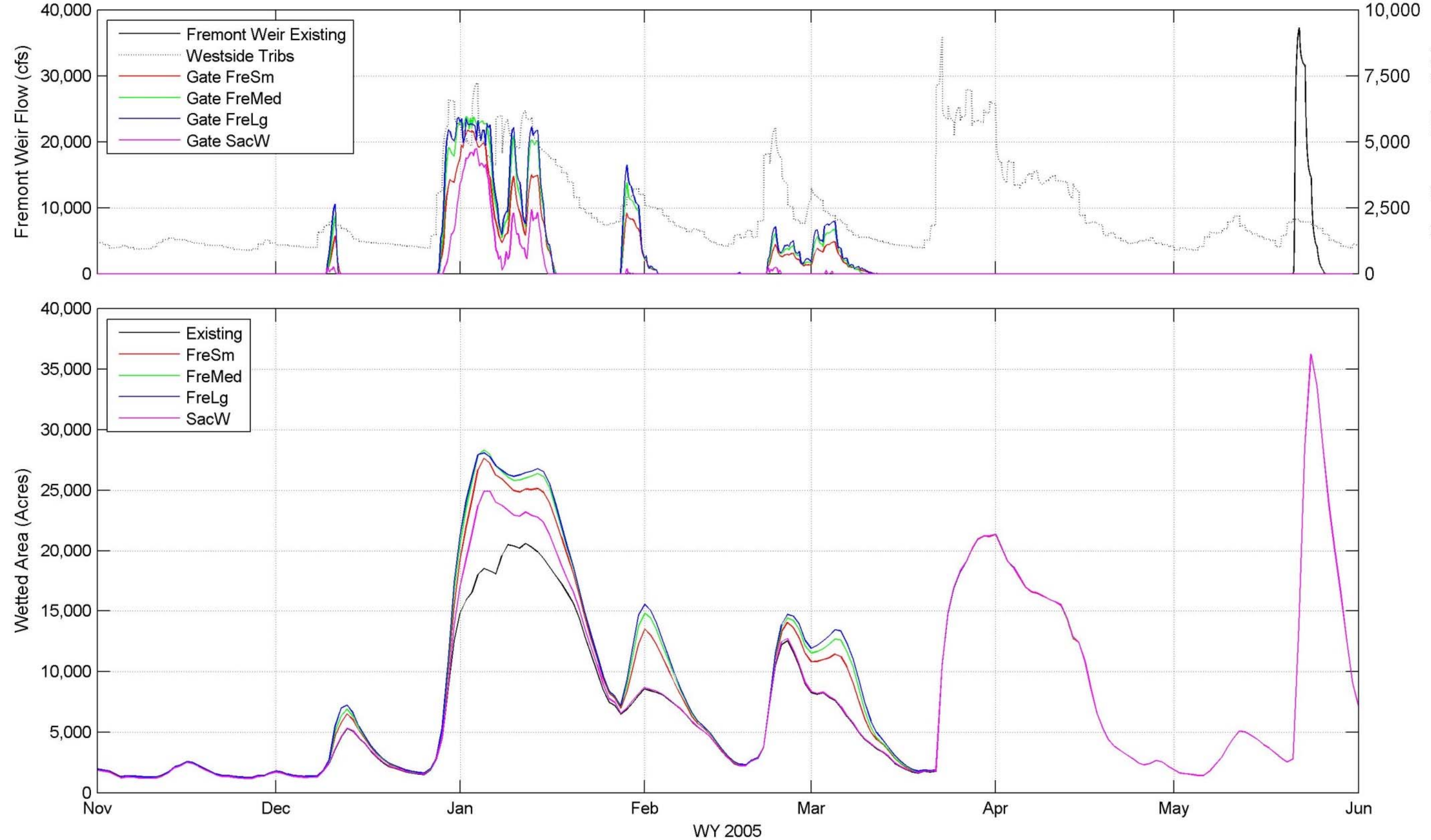


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2004 for Mar 15 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D40**

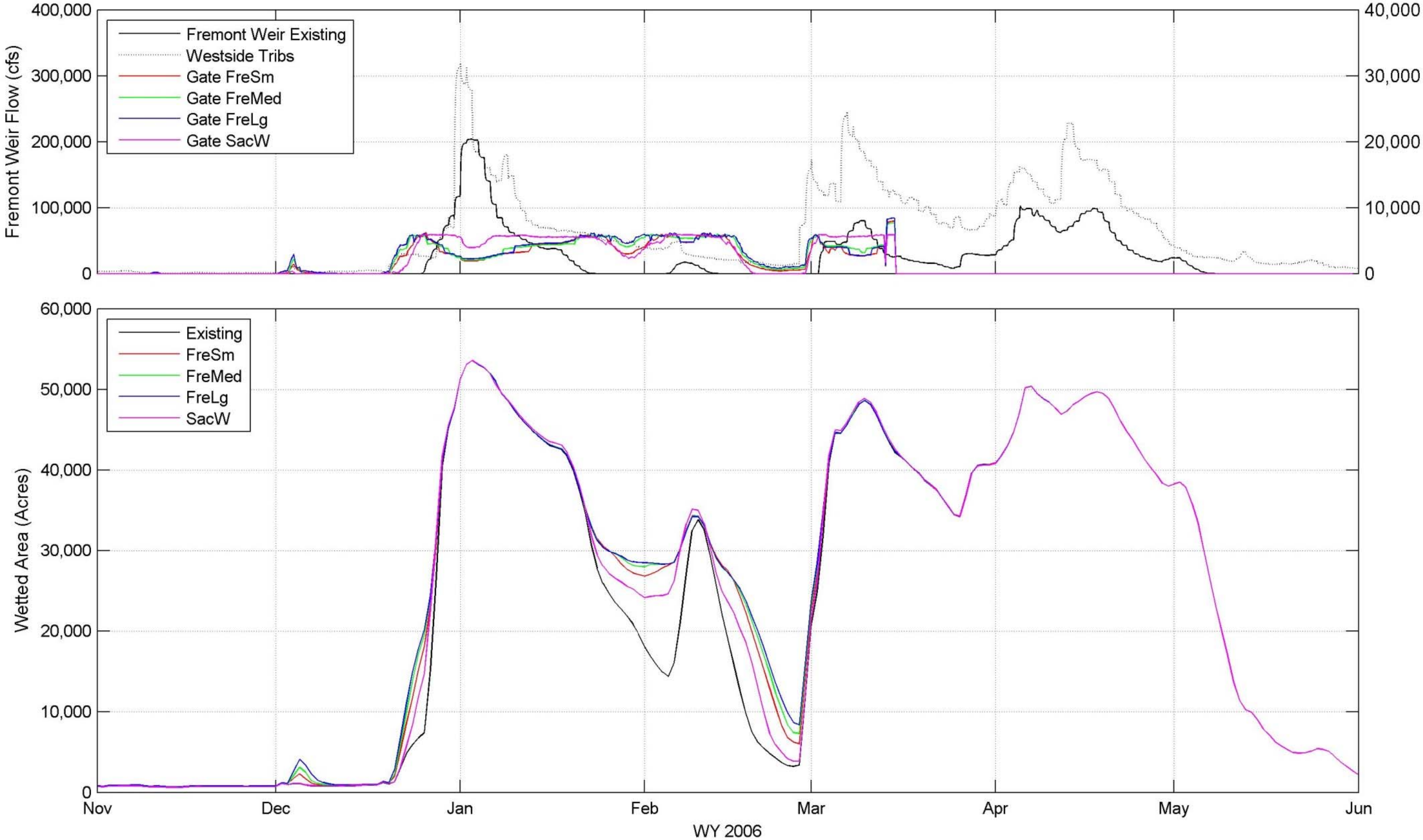


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2005 for Mar 15 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D41**

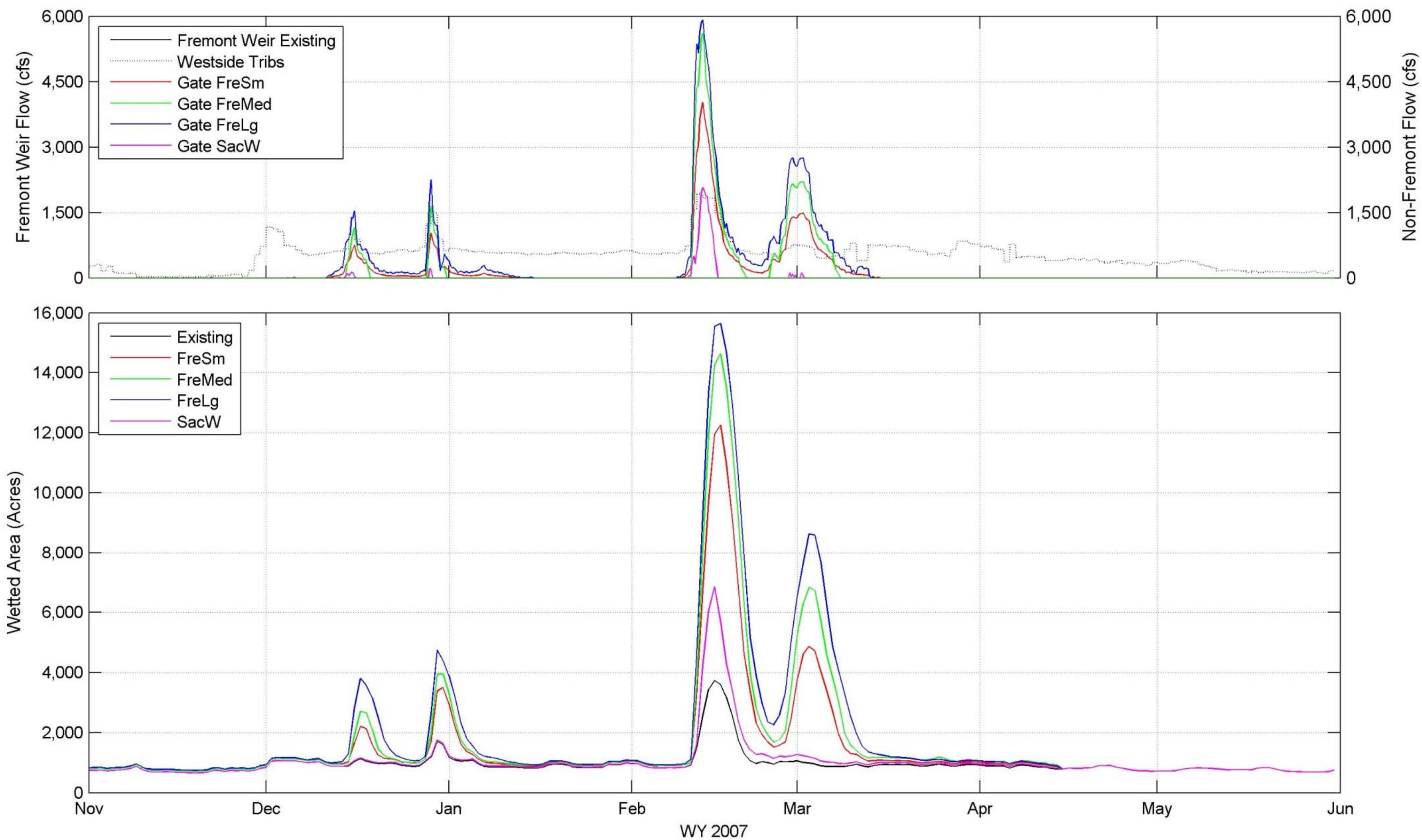


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2006 for Mar 15 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D42**

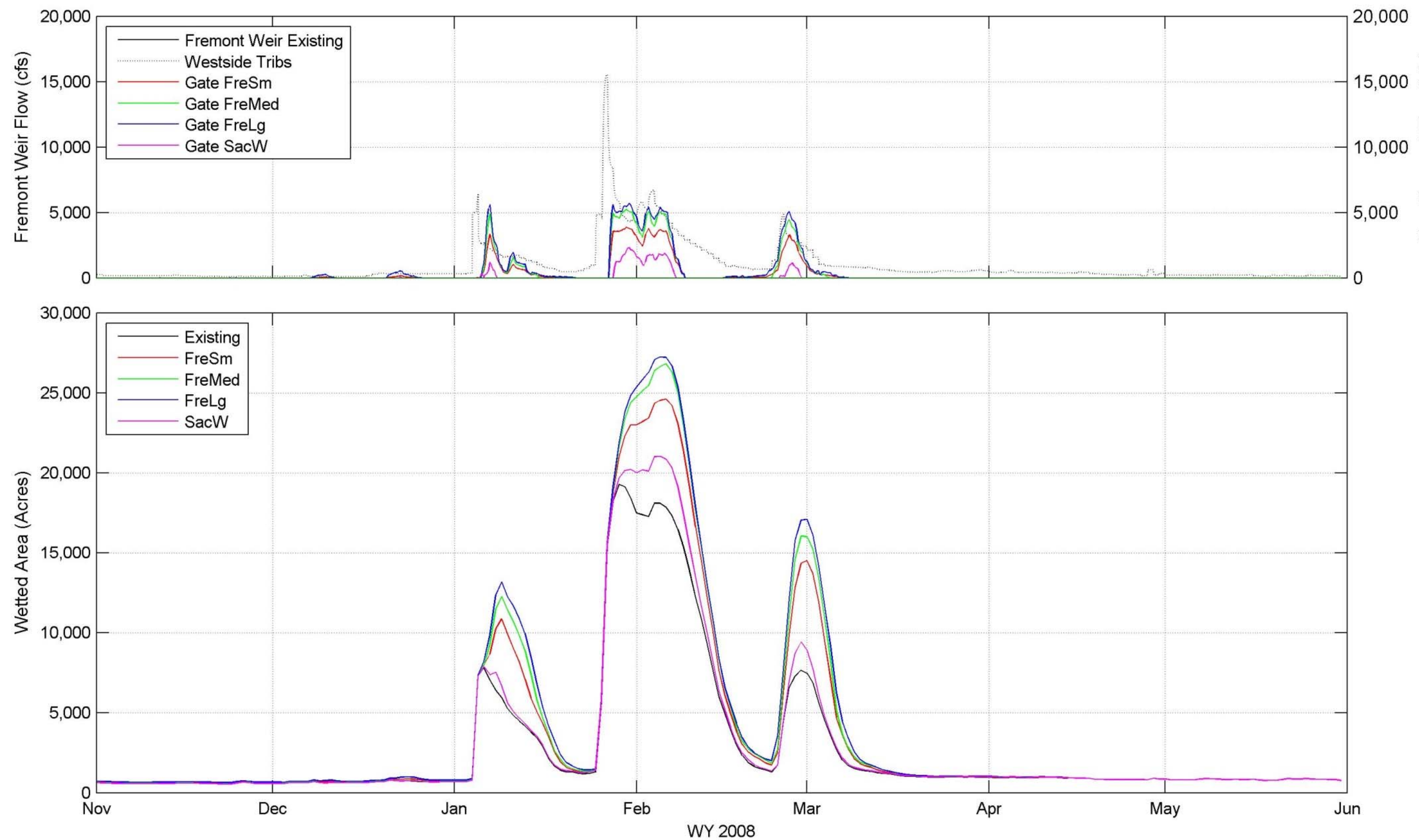


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2007 for Mar 15 Gate Closure

Prepared for DWR | Created By: SJB | **Figure D43**

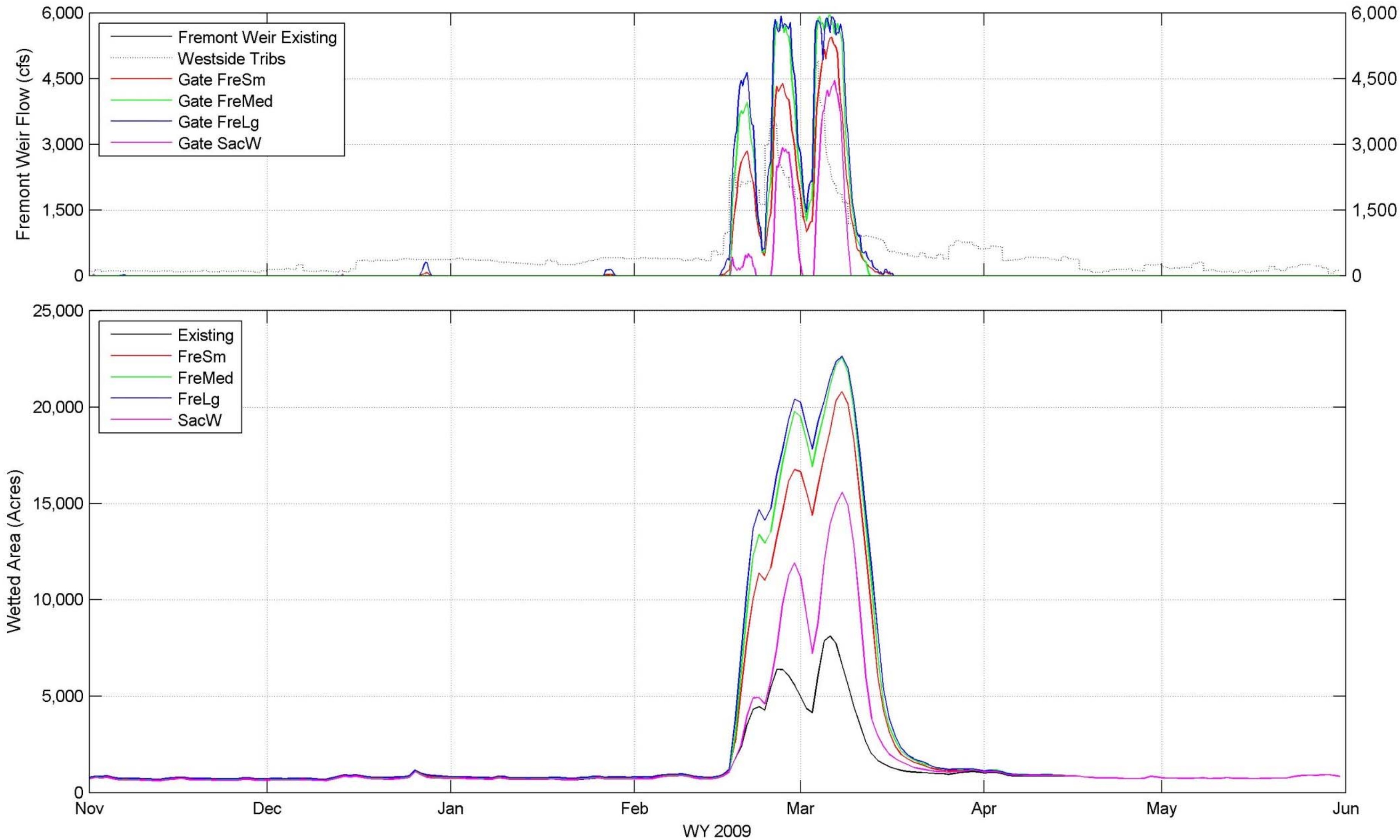


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2008 for Mar 15 Gate Closure

Prepared for DWR | Created By: SJB | **Figure D44**

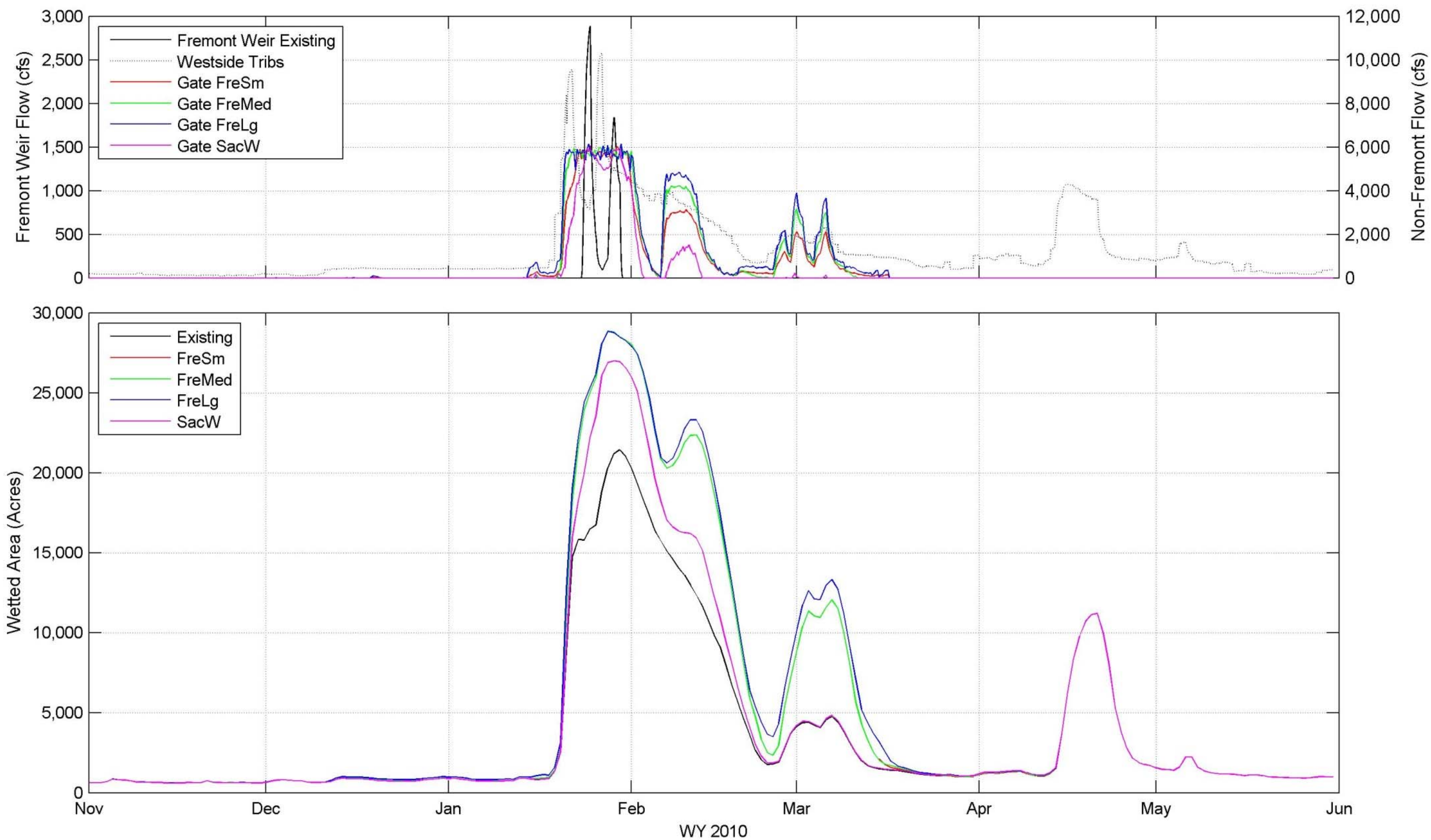


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2009 for Mar 15 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D45**

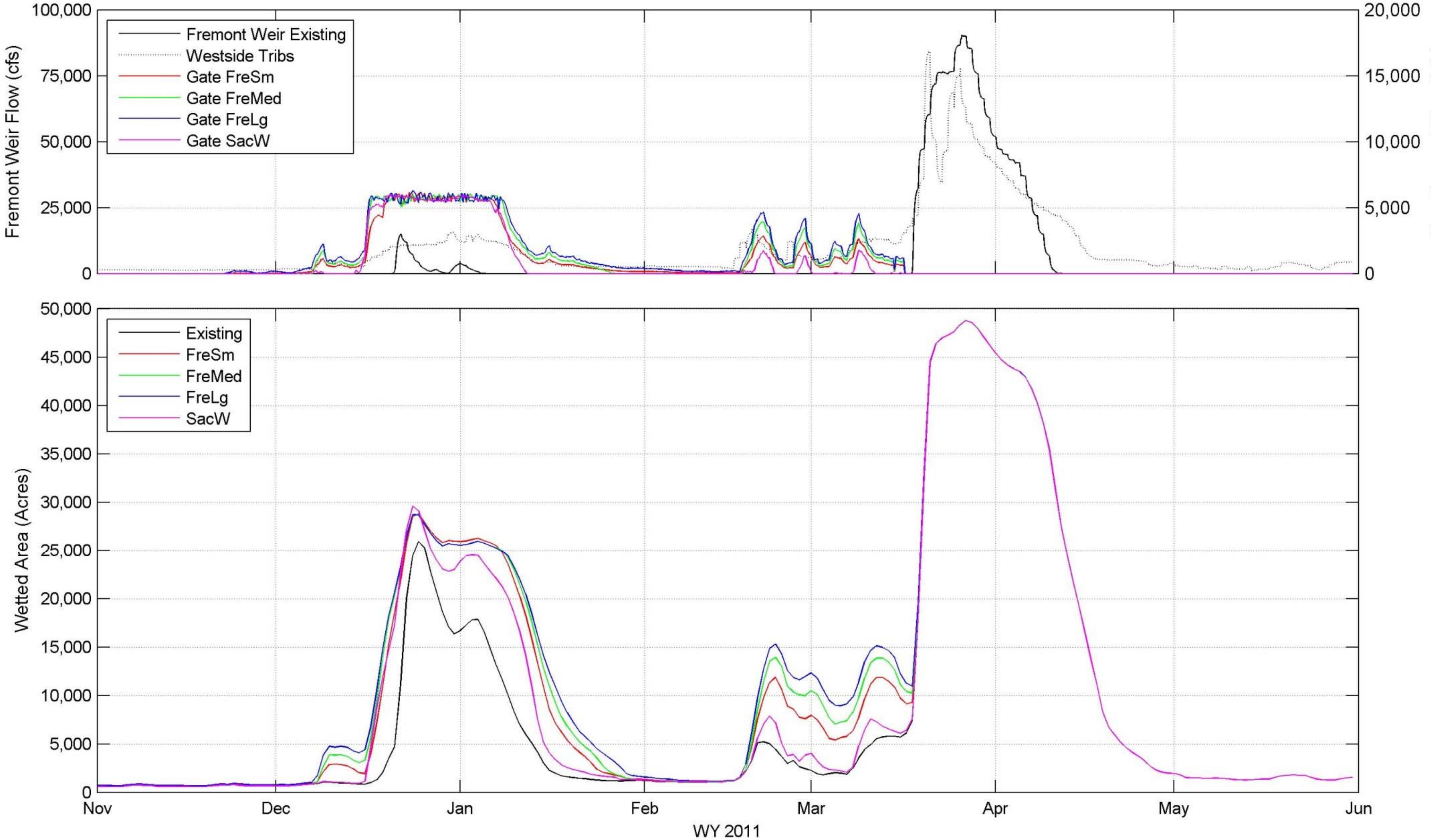


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2010 for Mar 15 Gate Closure

Prepared for DWR | Created By: SJB | **Figure D46**

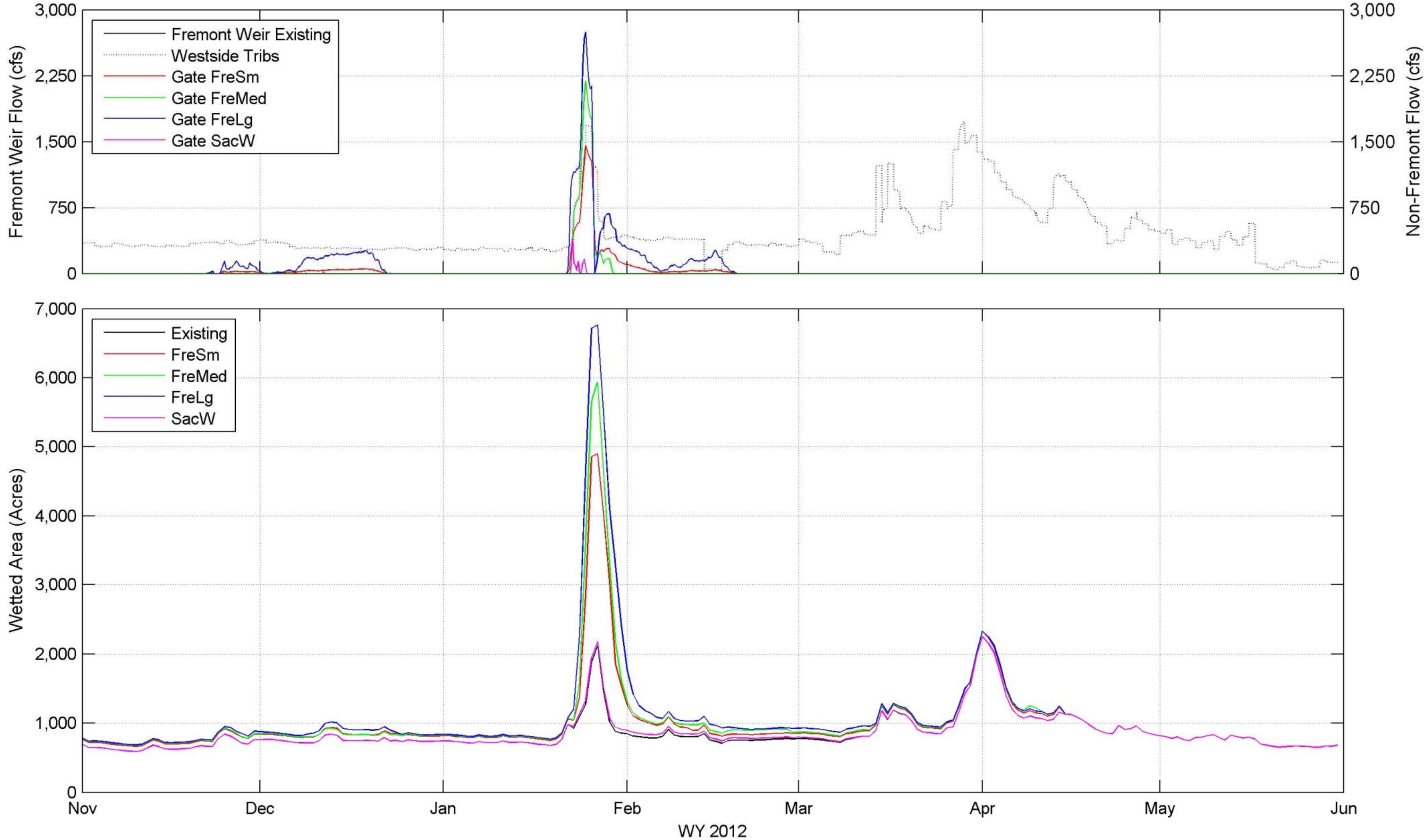


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2011 for Mar 15 Gate Closure

Prepared for DWR | Created By: SJB | **Figure D47**

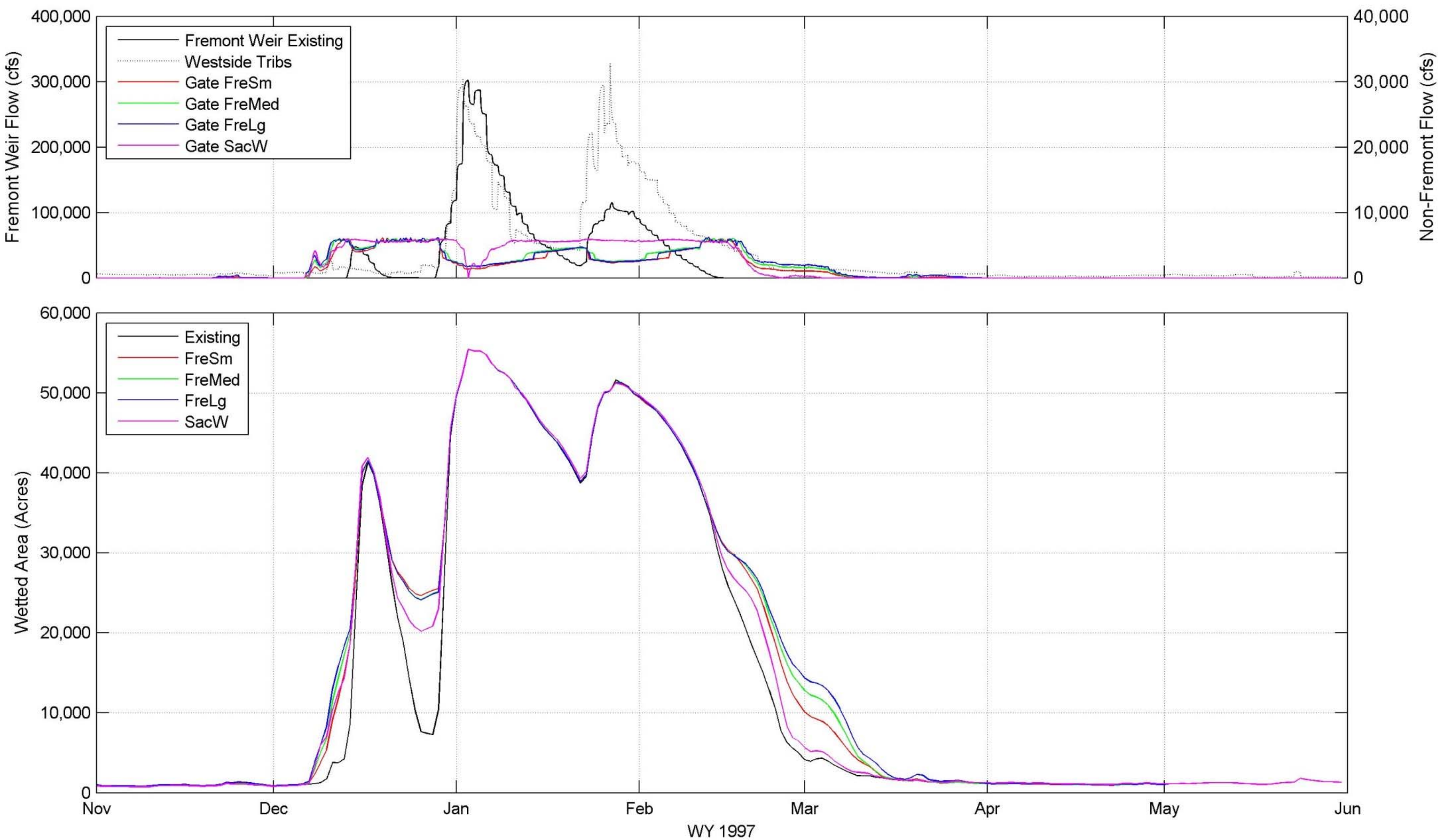


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2012 for Mar 15 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D48**



Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

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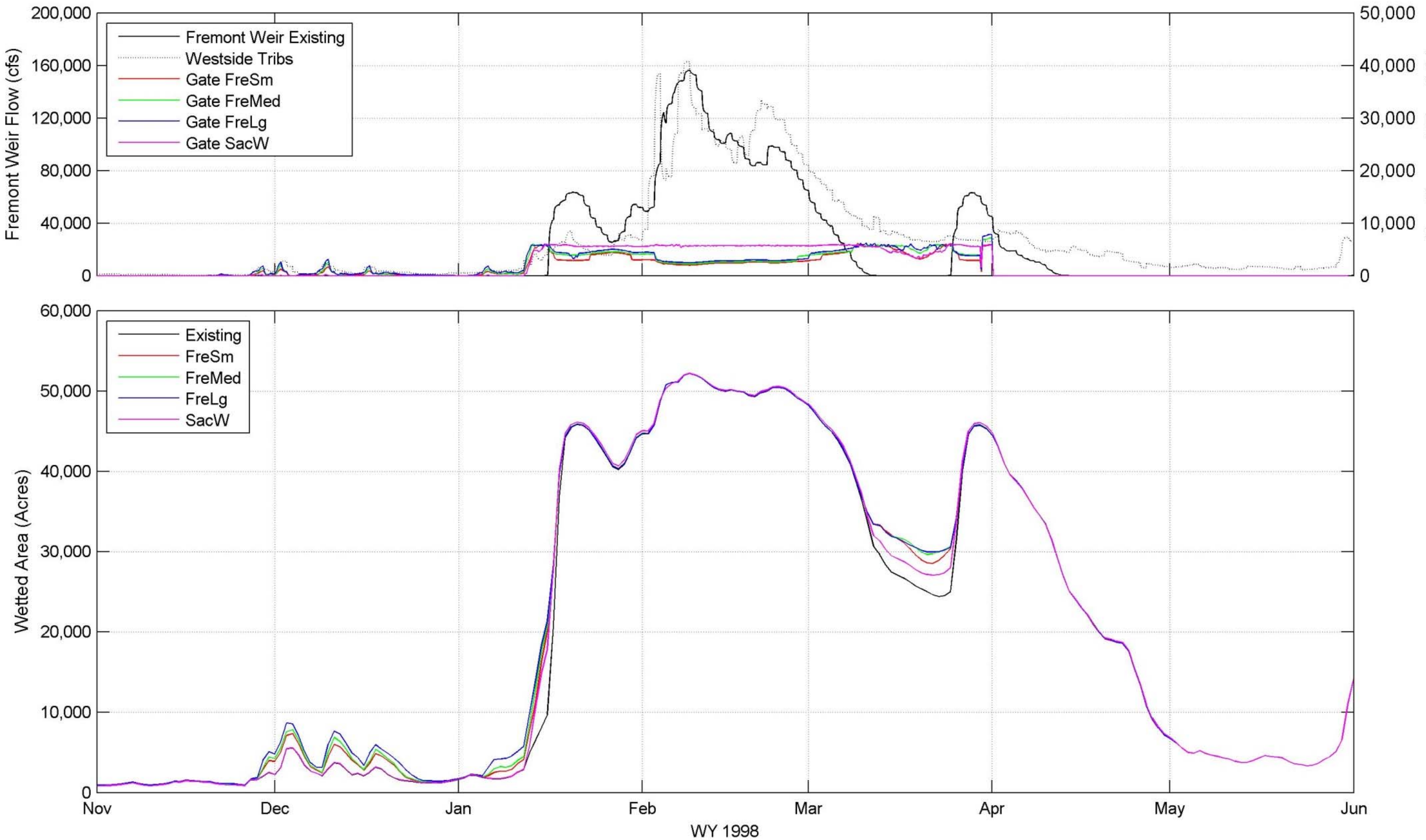
Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 1997 for Apr 1 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D49**

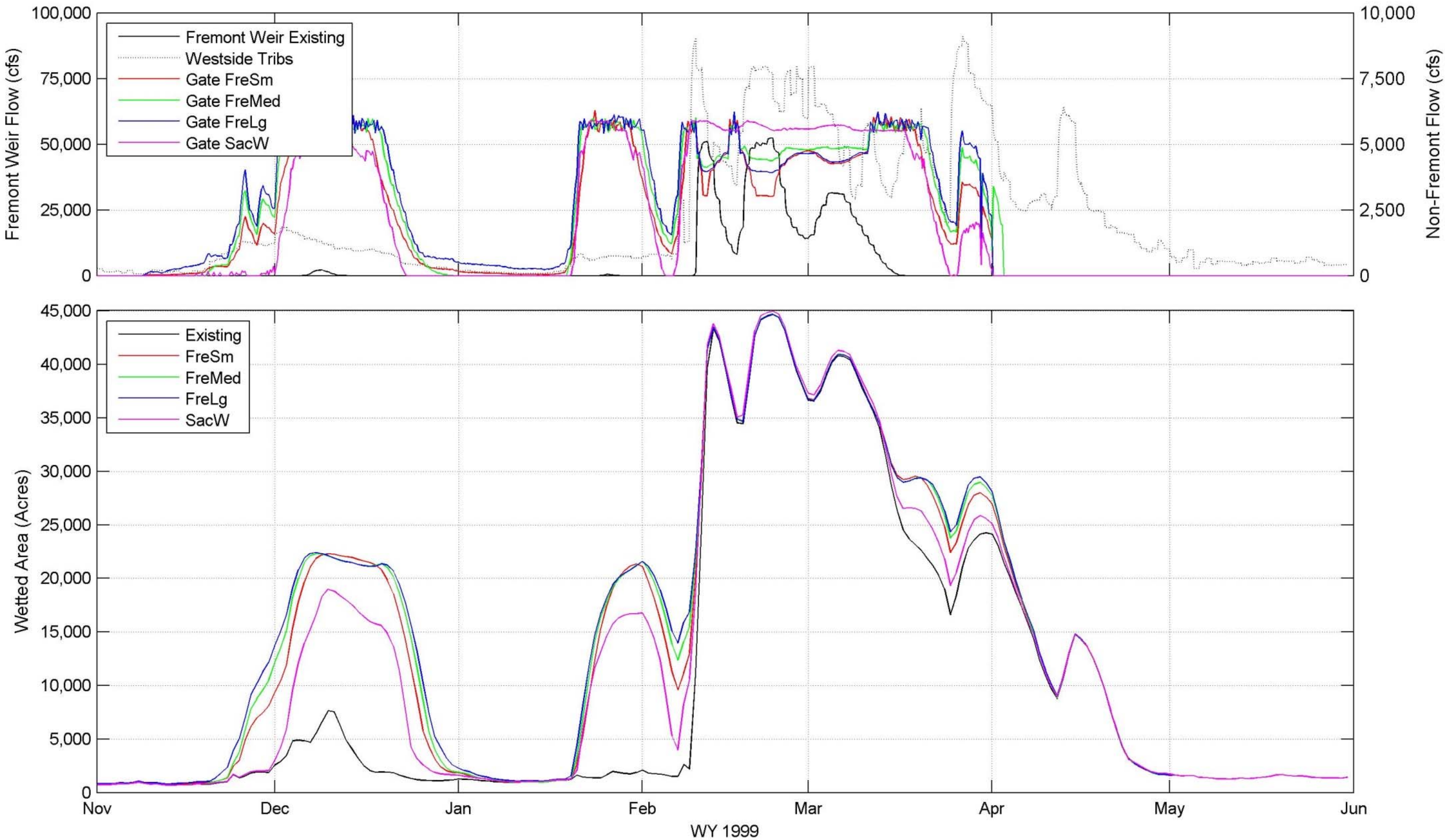


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 1998 for Apr 1 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D50**

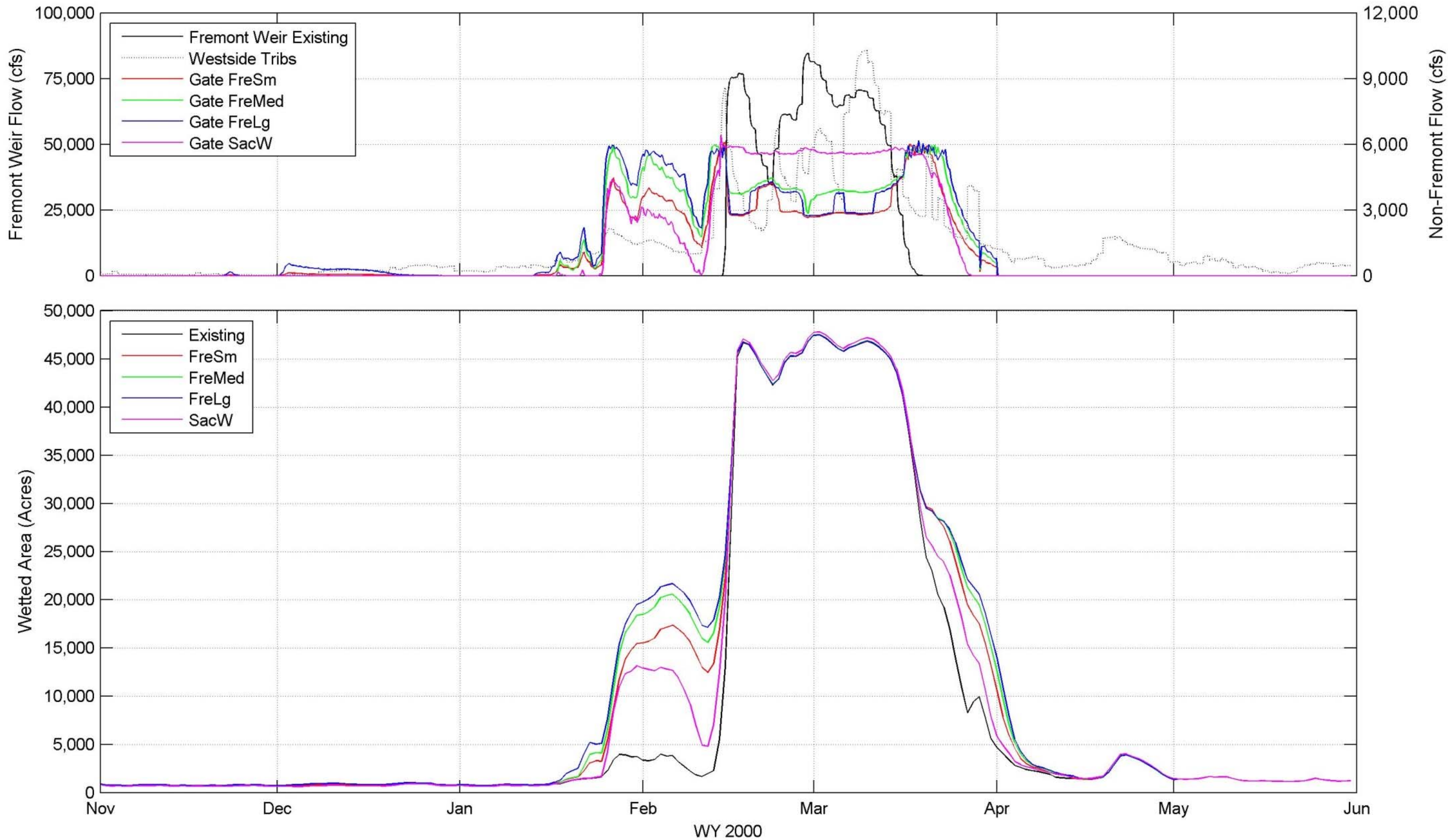


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 1999 for Apr 1 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D51**

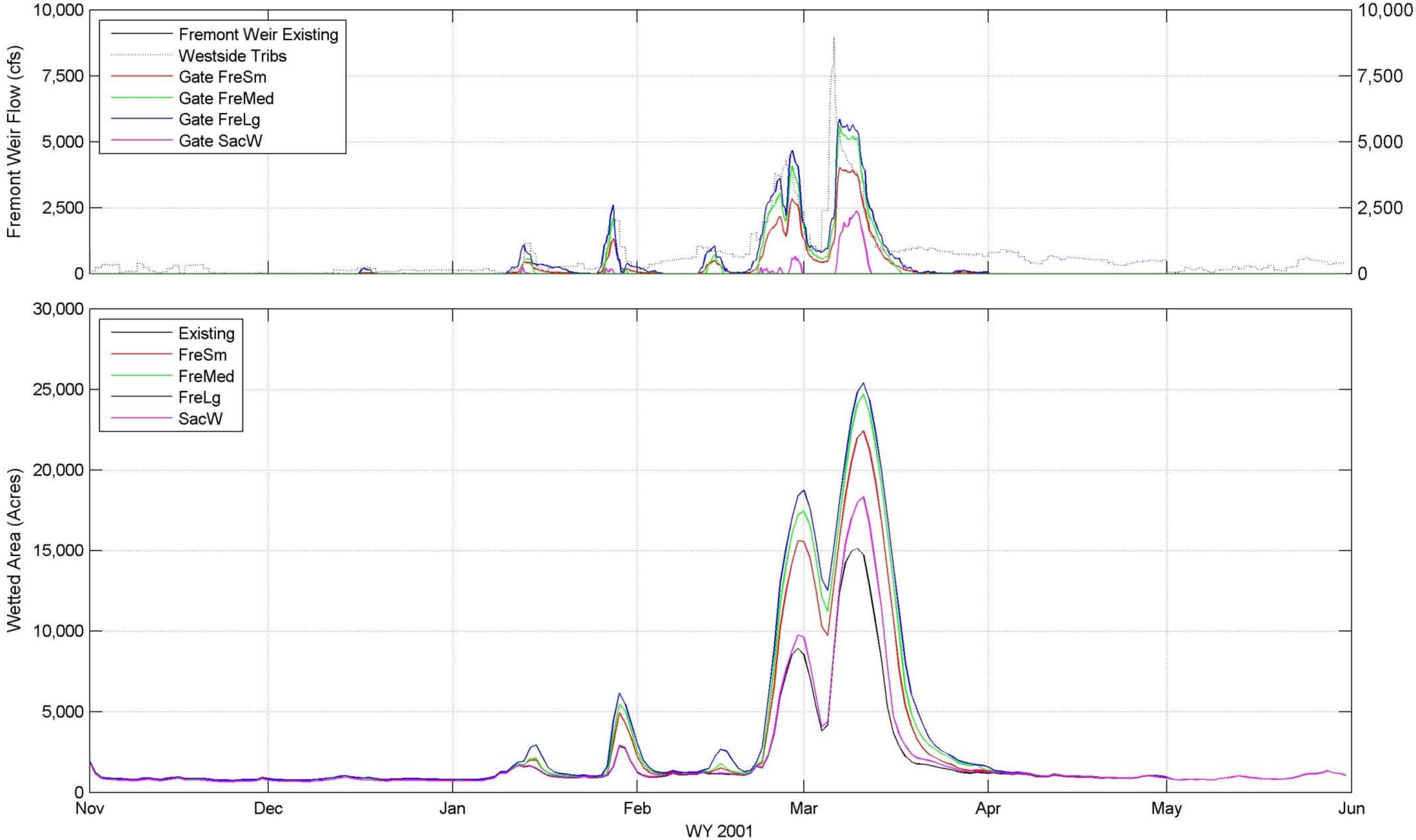


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2000 for Apr 1 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D52**

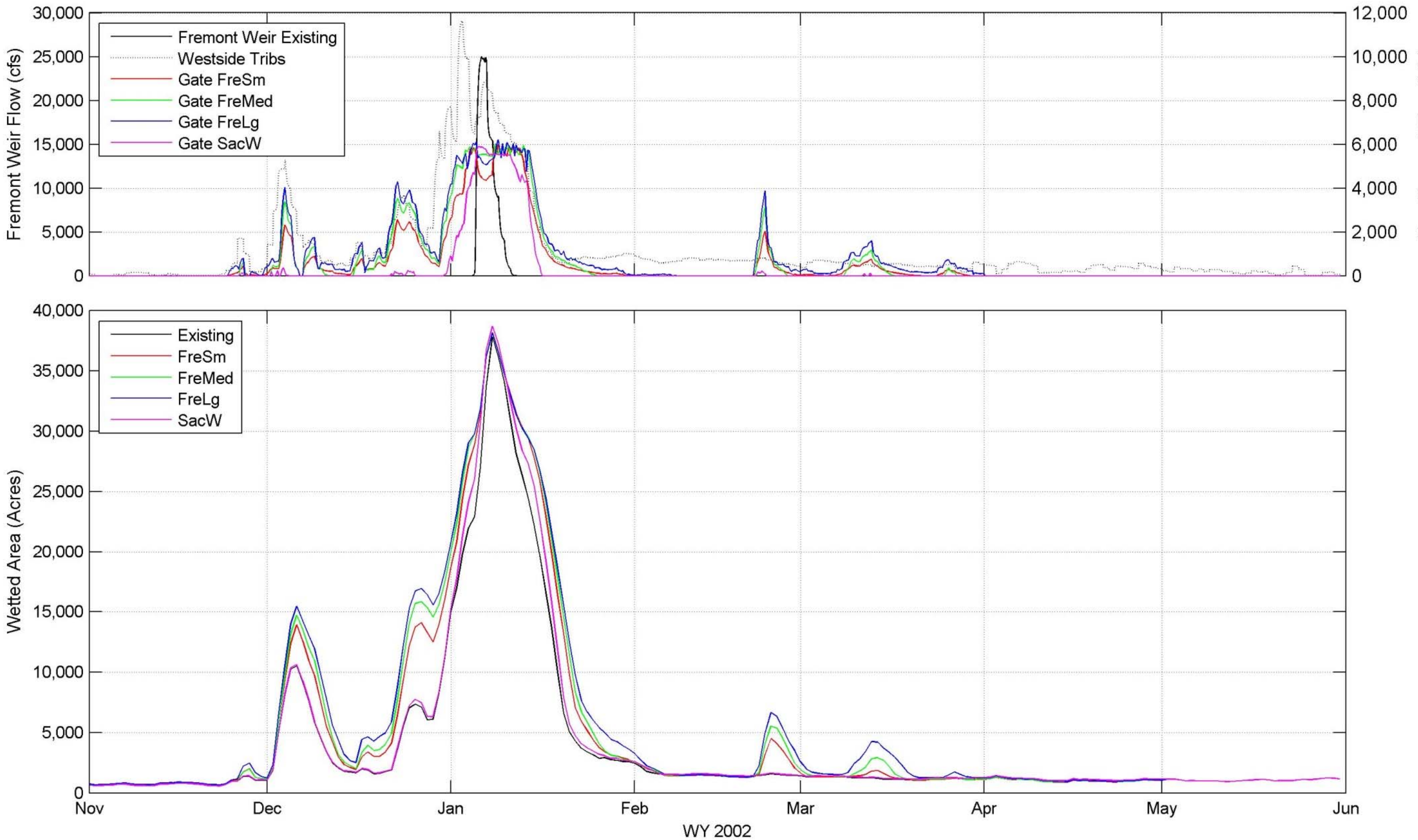


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2001 for Apr 1 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D53**

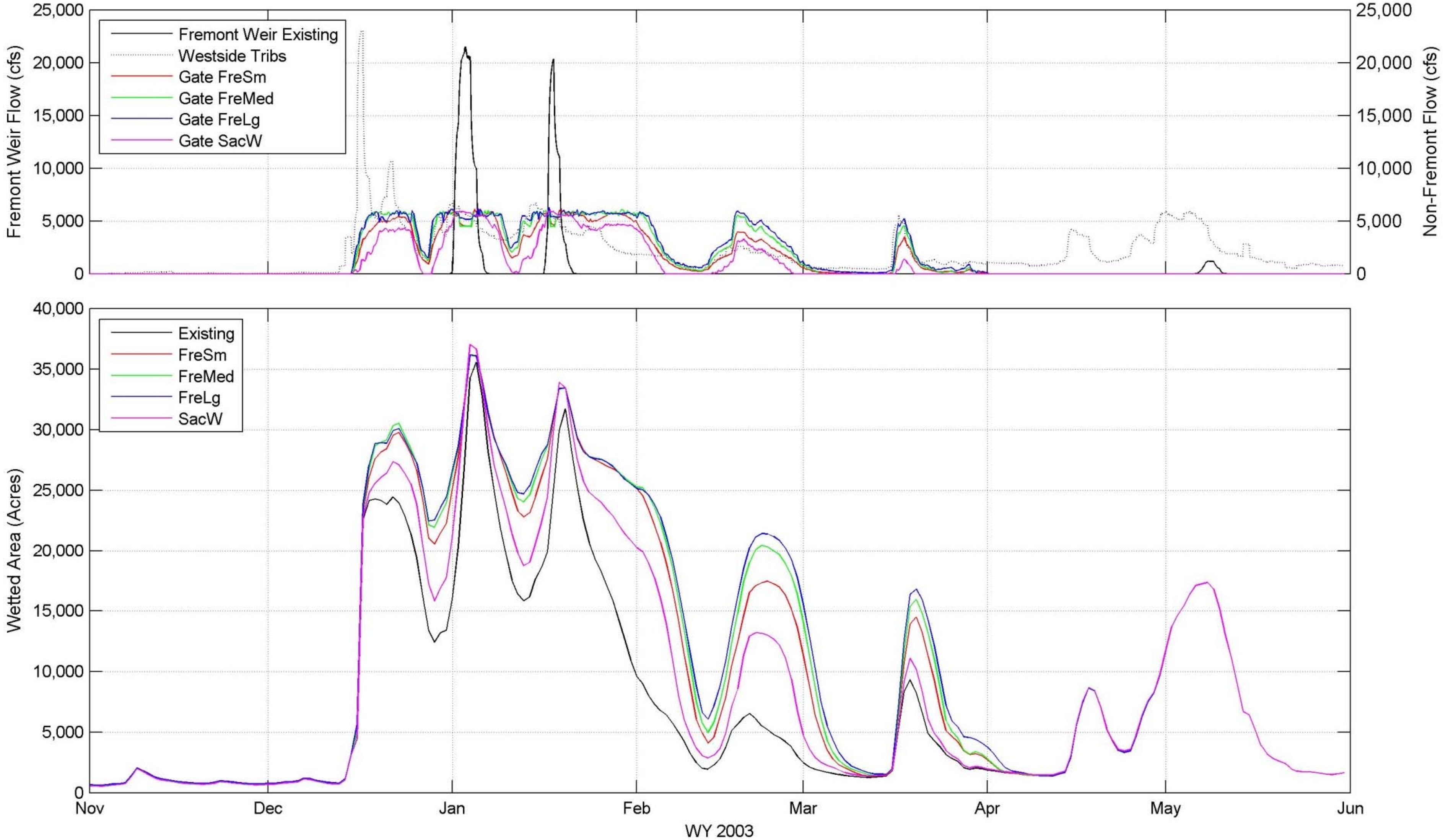


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2002 for Apr 1 Gate Closure

Prepared for DWR | Created By: SJB | **Figure D54**

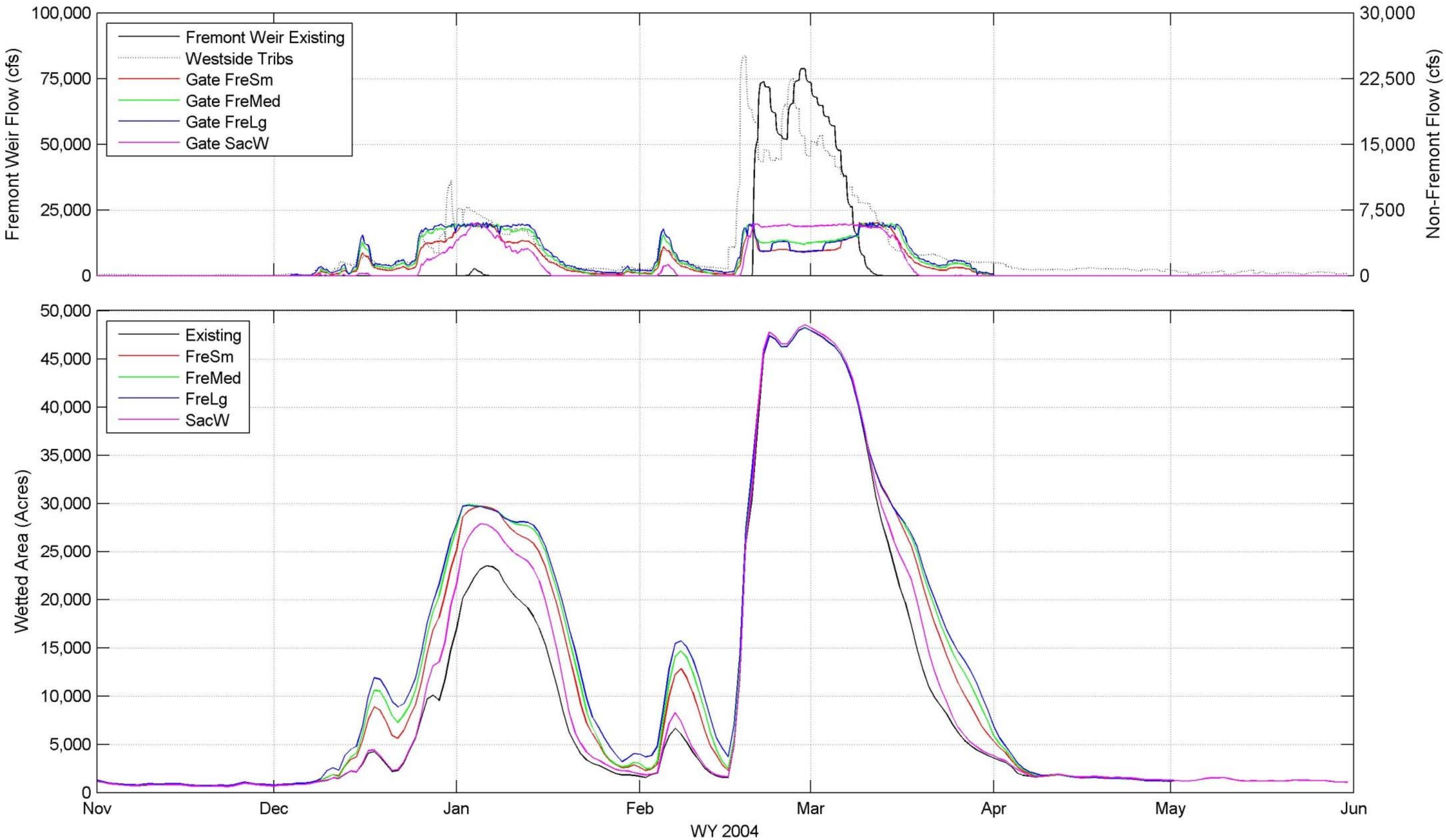


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2003 for Apr 1 Gate Closure

Prepared for DWR | Created By: SJB | **Figure D55**

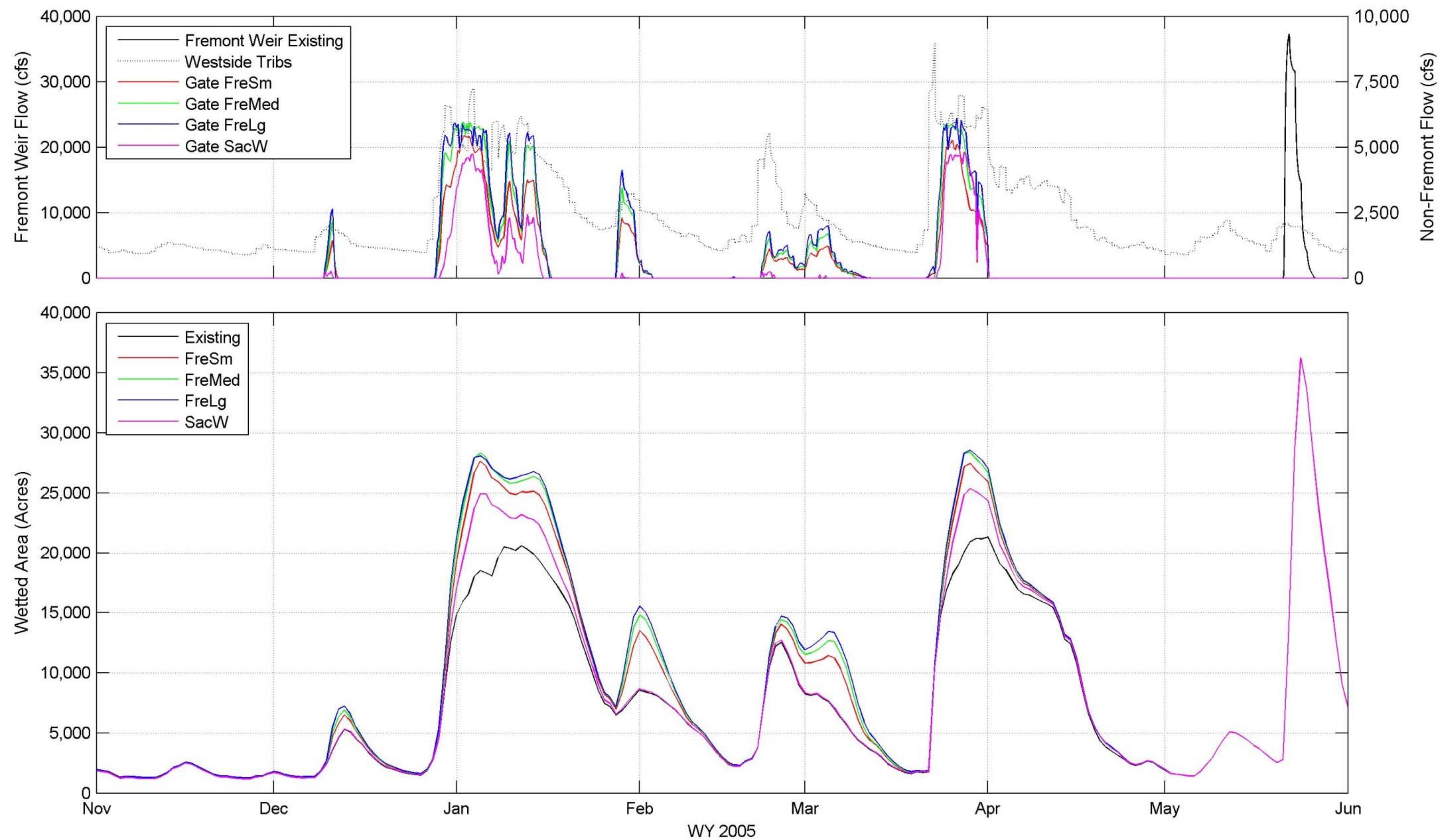


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2004 for Apr 1 Gate Closure

Prepared for DWR | Created By: SJB | **Figure D56**

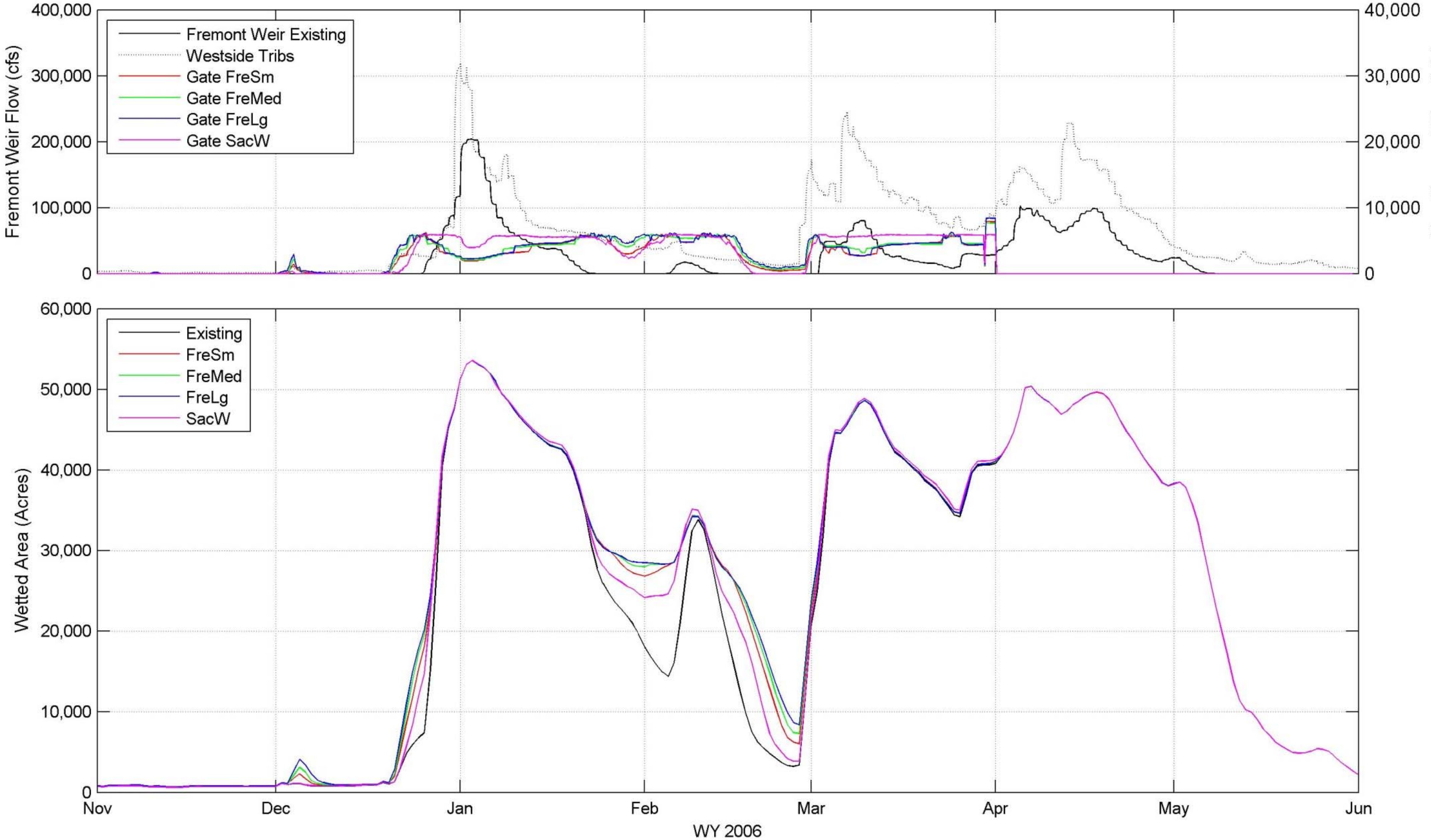


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2005 for Apr 1 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D57**

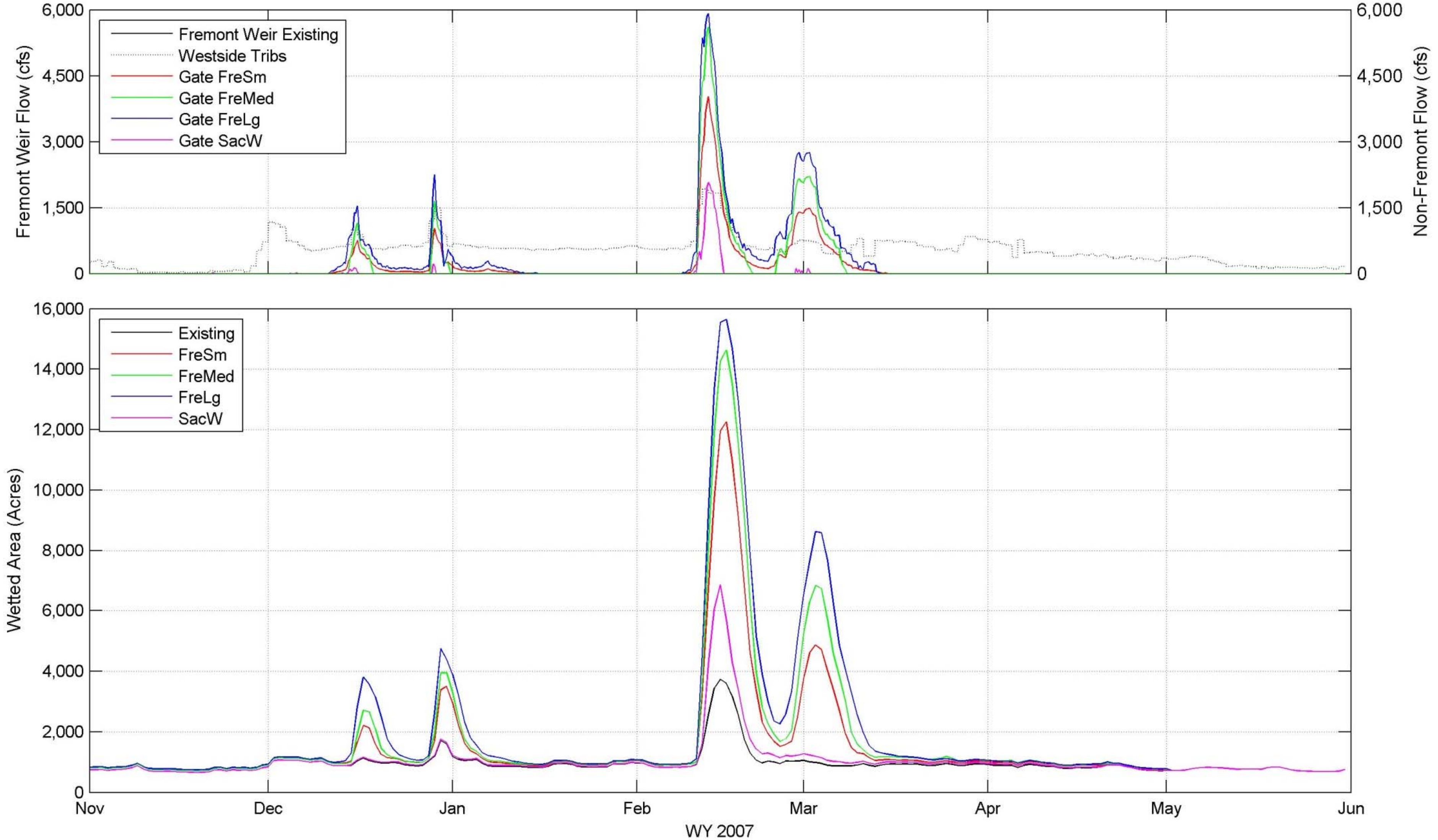


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2006 for Apr 1 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D58**



Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

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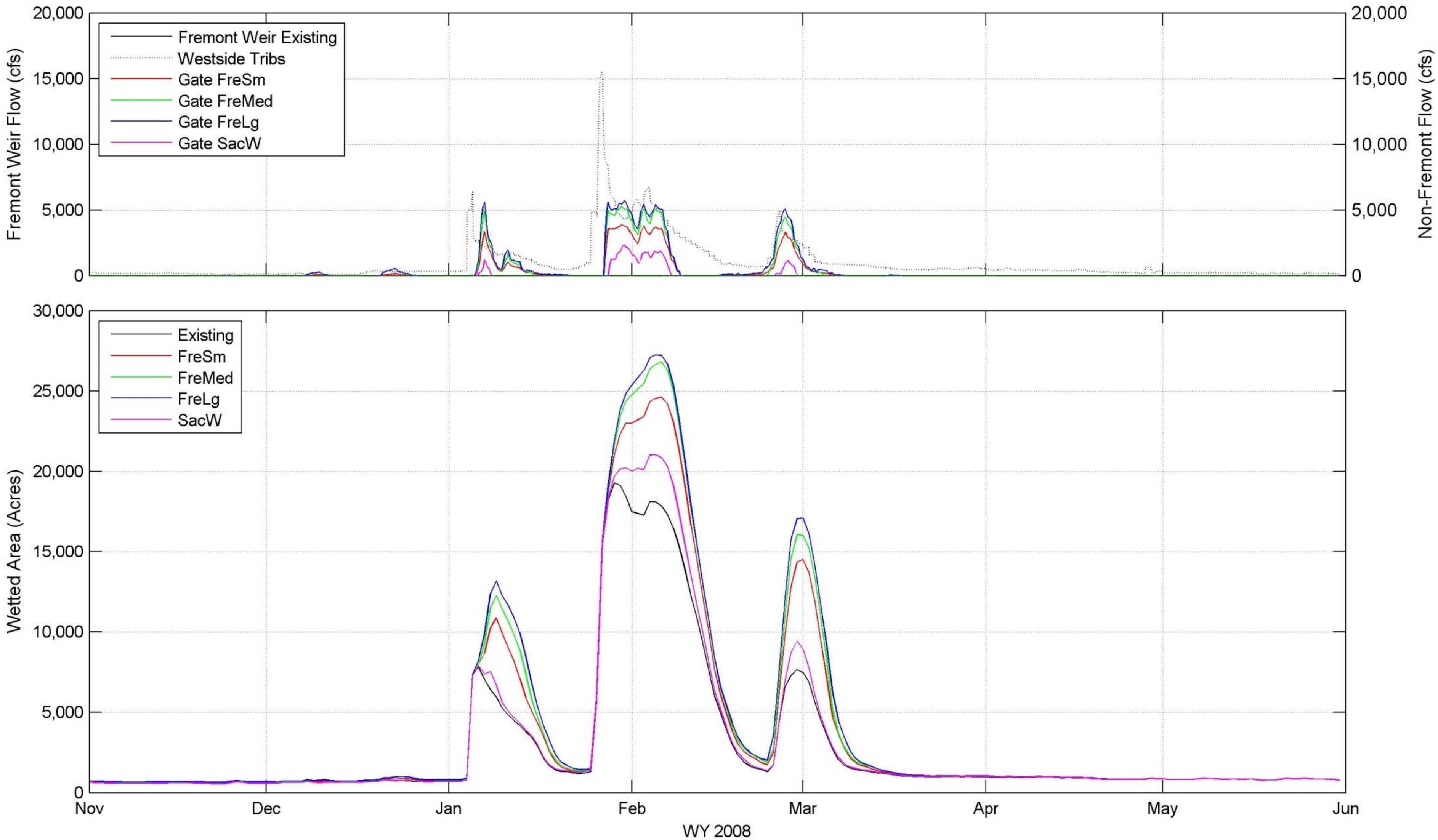
Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2007 for Apr 1 Gate Closure

Prepared for DWR | Created By: SJB | **Figure D59**

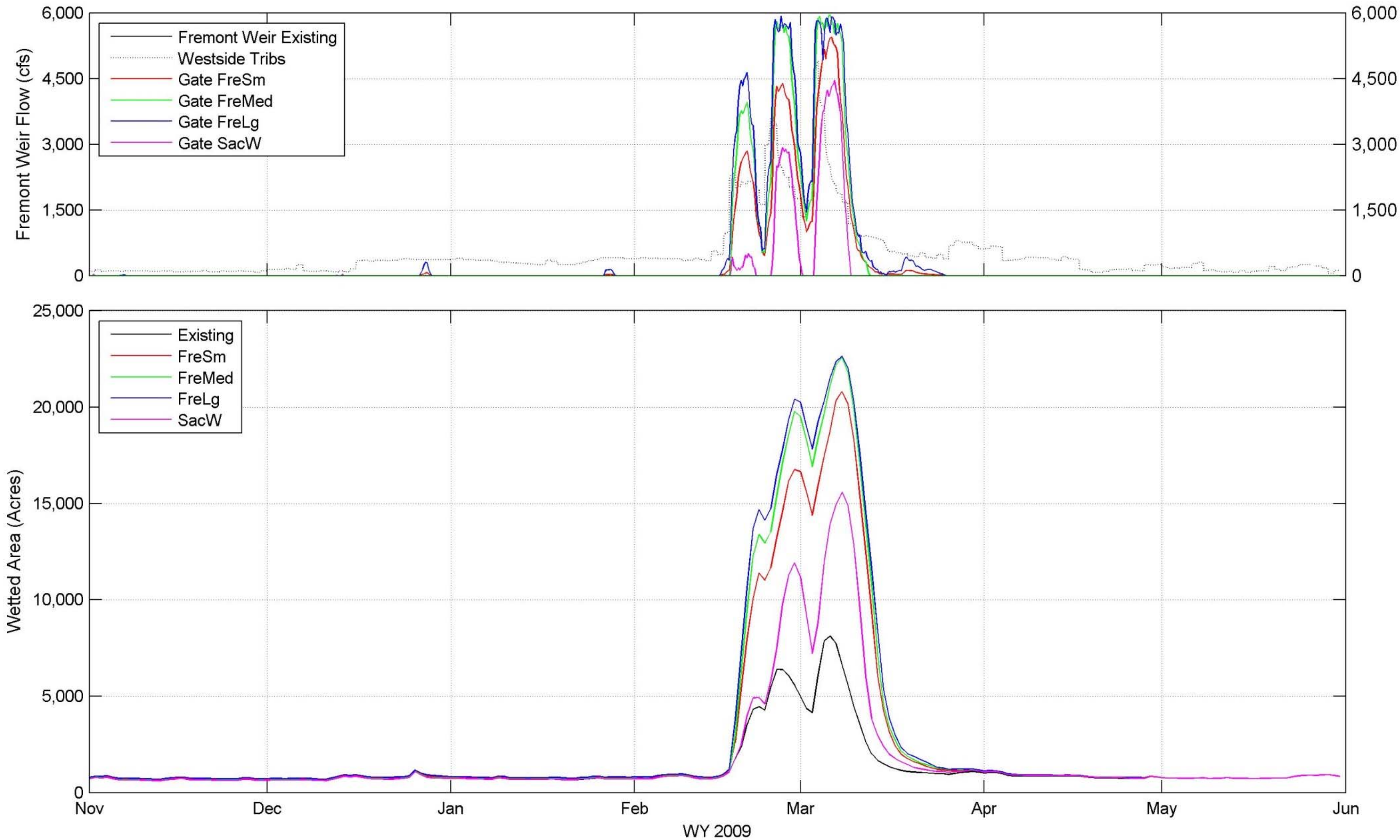


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2008 for Apr 1 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D60**

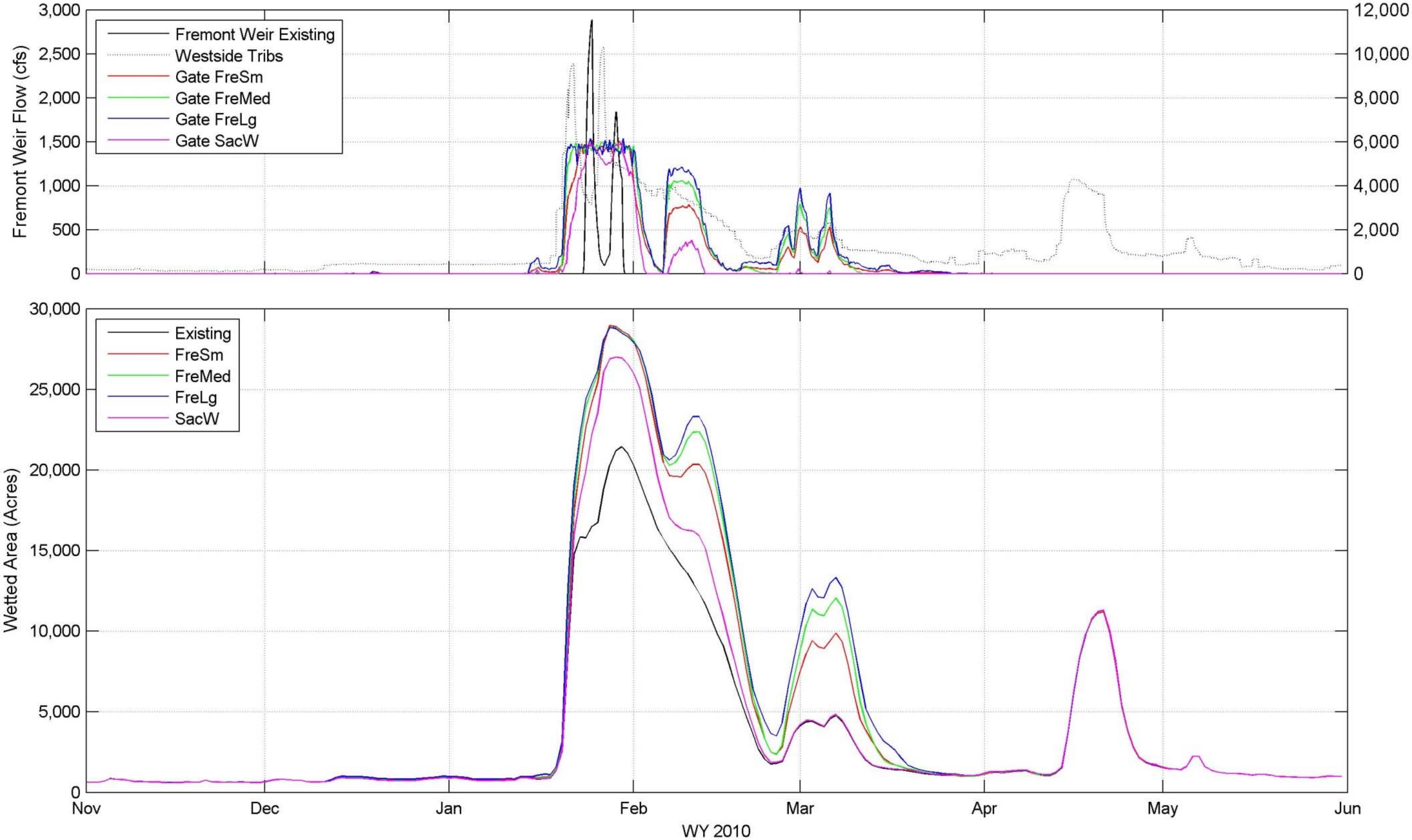


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2009 for Apr 1 Gate Closure

Prepared for DWR | Created By: SJB | **Figure D61**

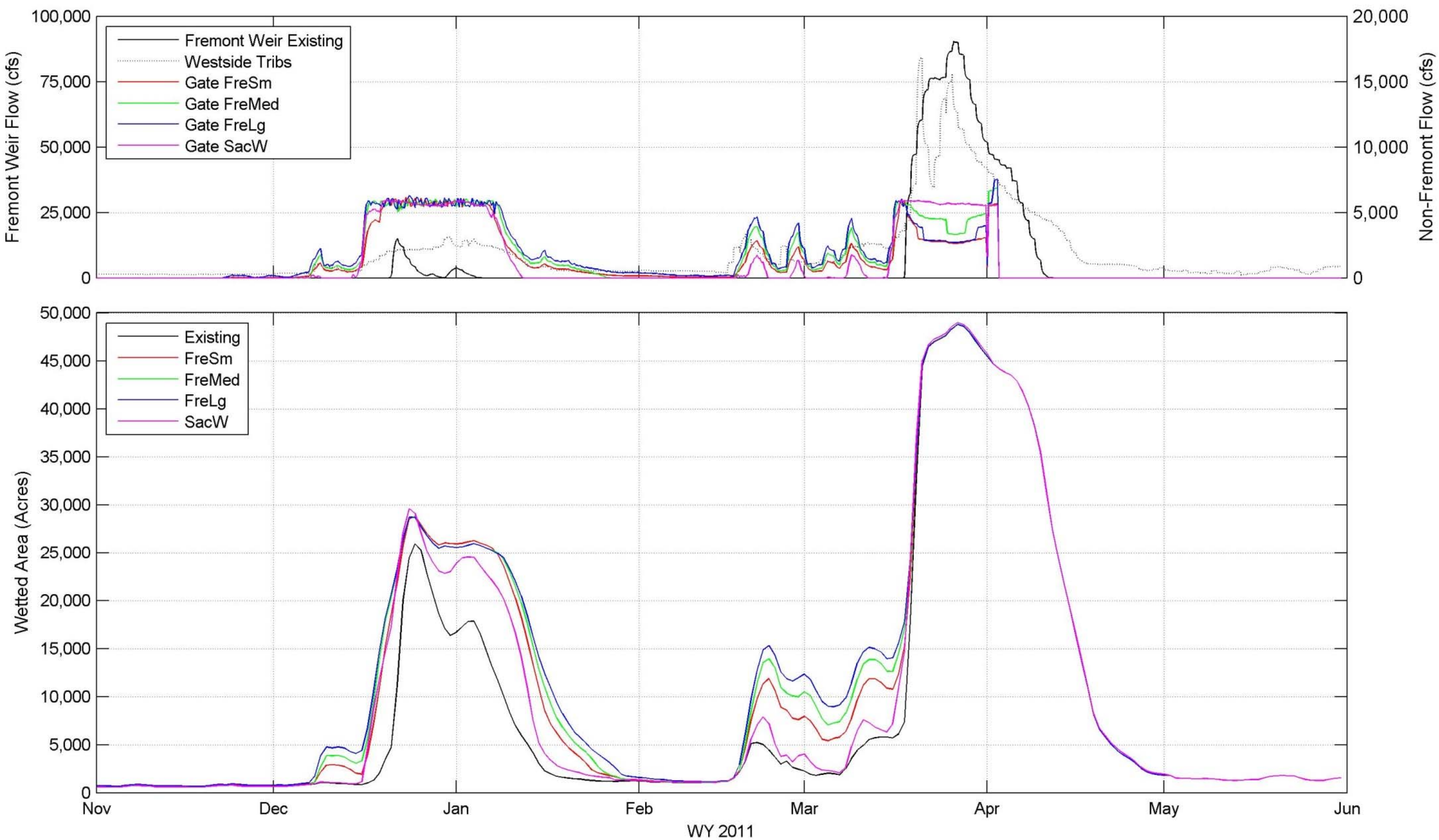


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2010 for Apr 1 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D62**

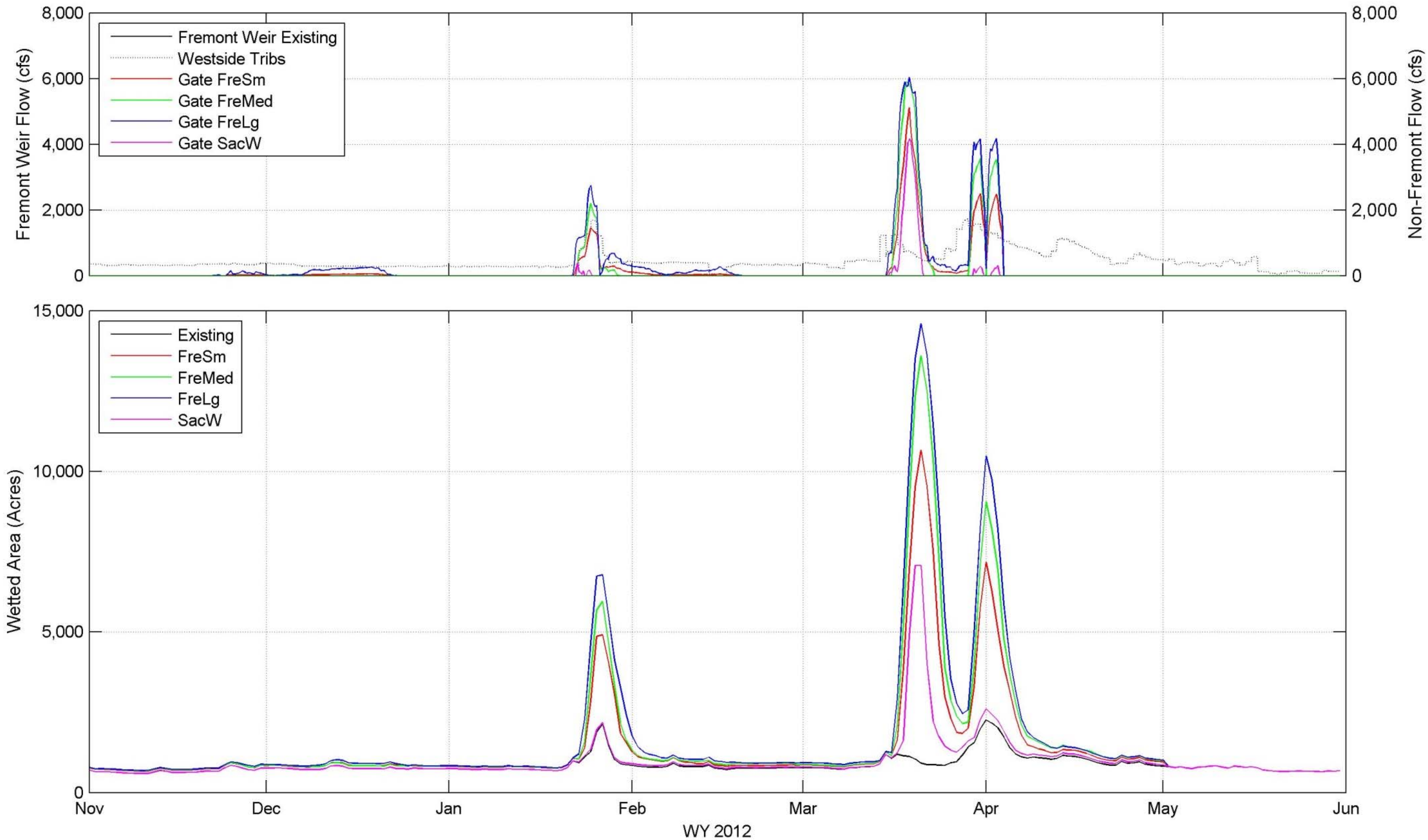


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2011 for Apr 1 Gate Closure

Prepared for DWR | Created By: SJB | **Figure D63**

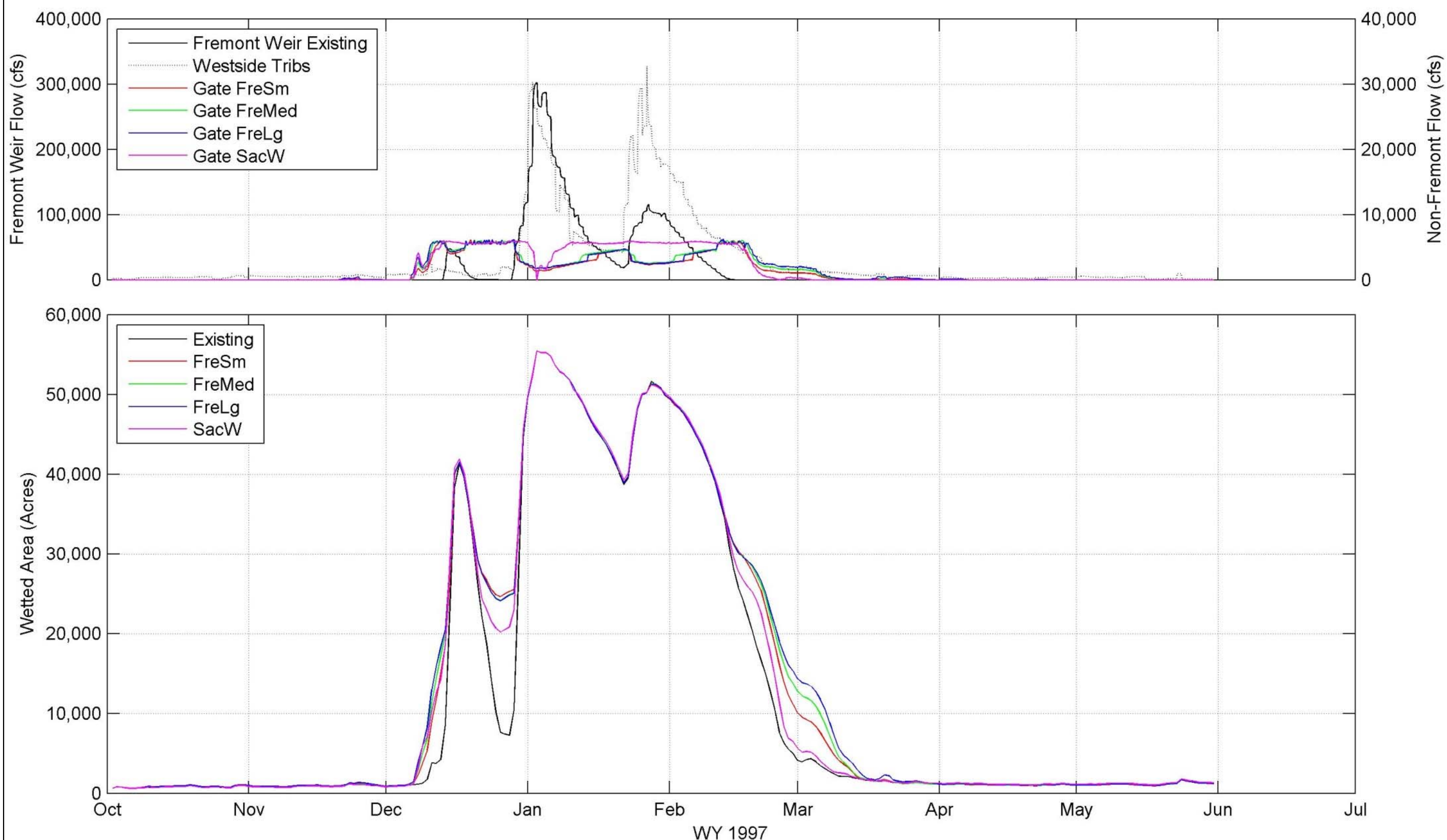


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2012 for Apr 1 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D64**

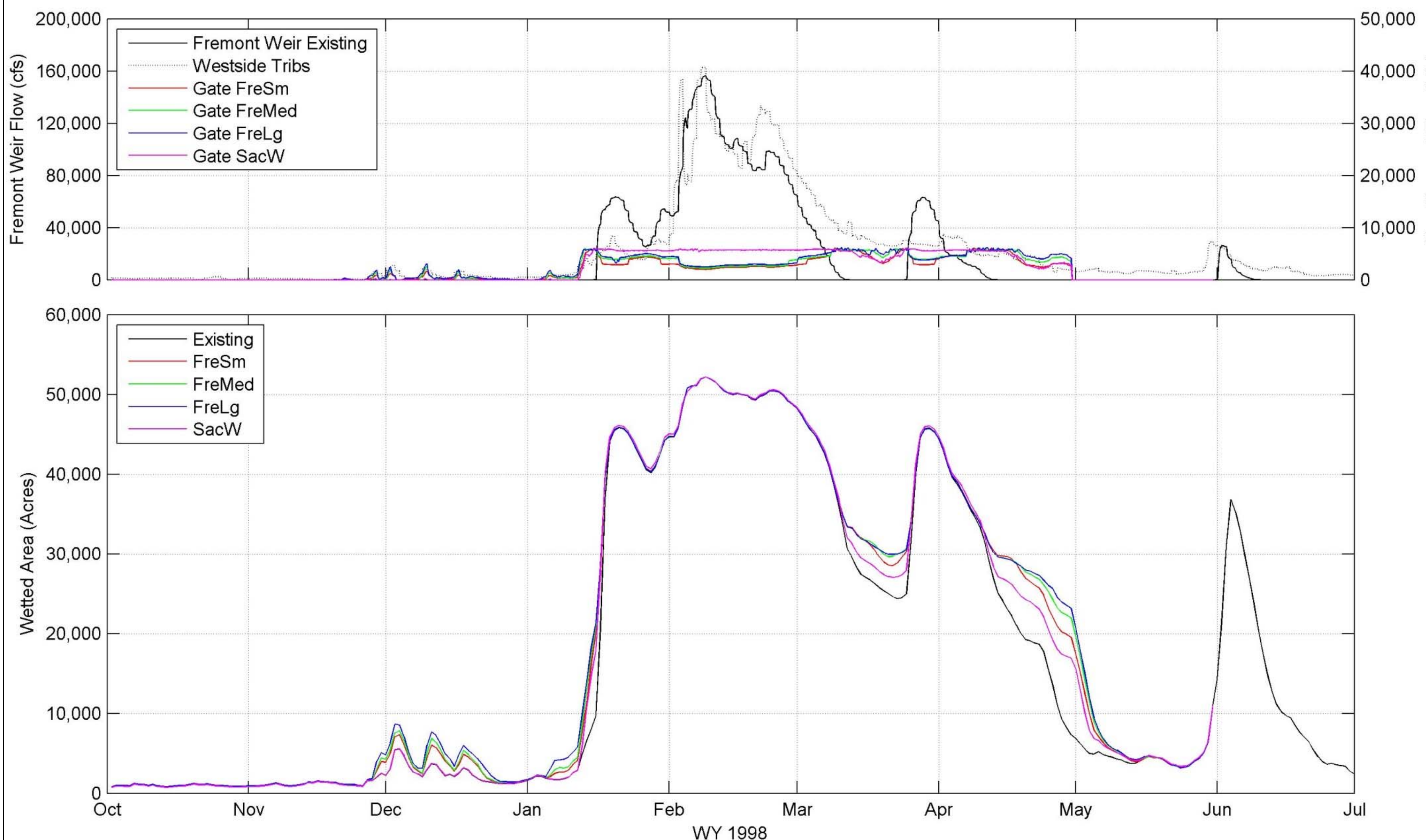


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 1997 for Apr 30 Gate Closure

Prepared for DWR | Created By: SJB | **Figure D65**

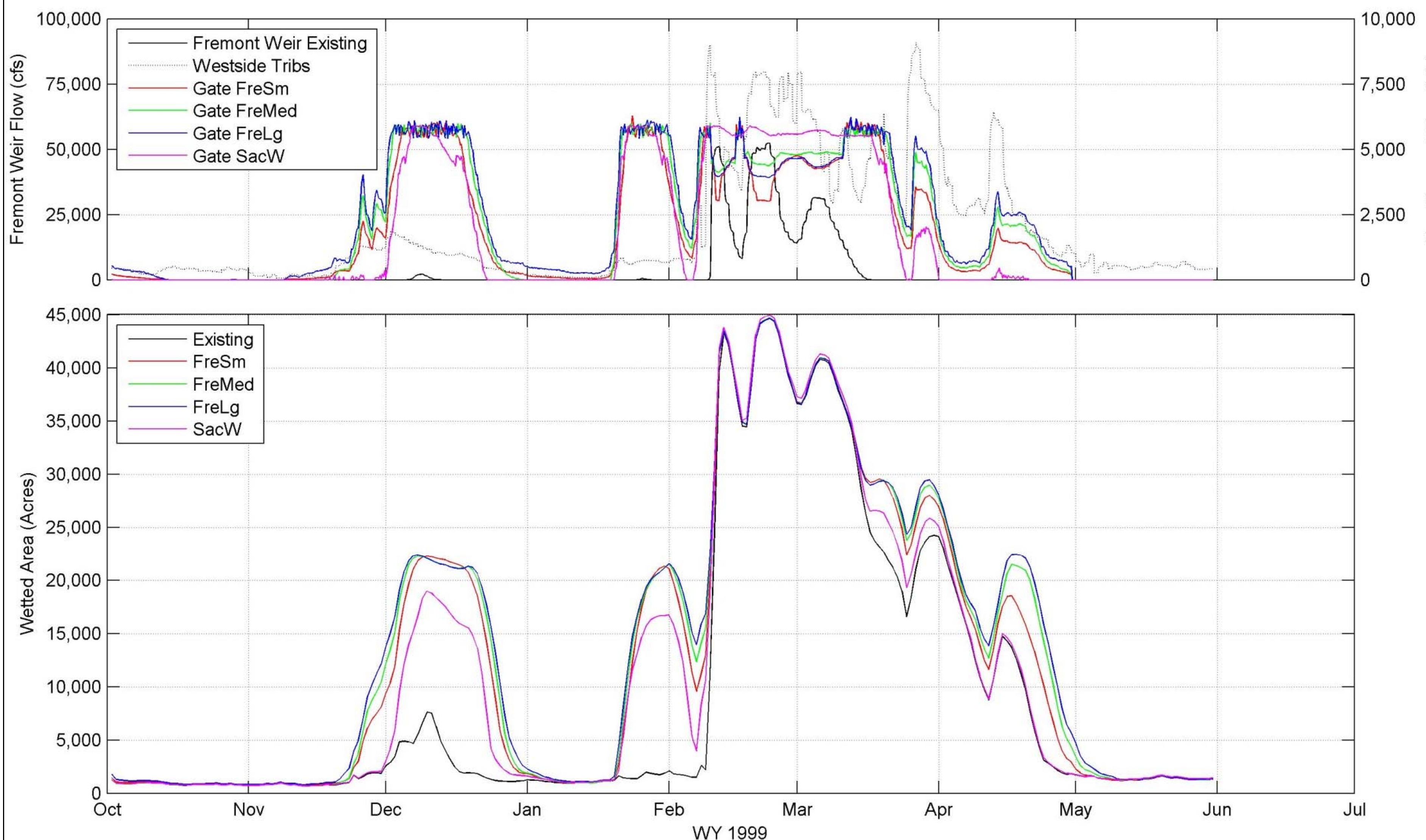


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 1998 for Apr 30 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D66**

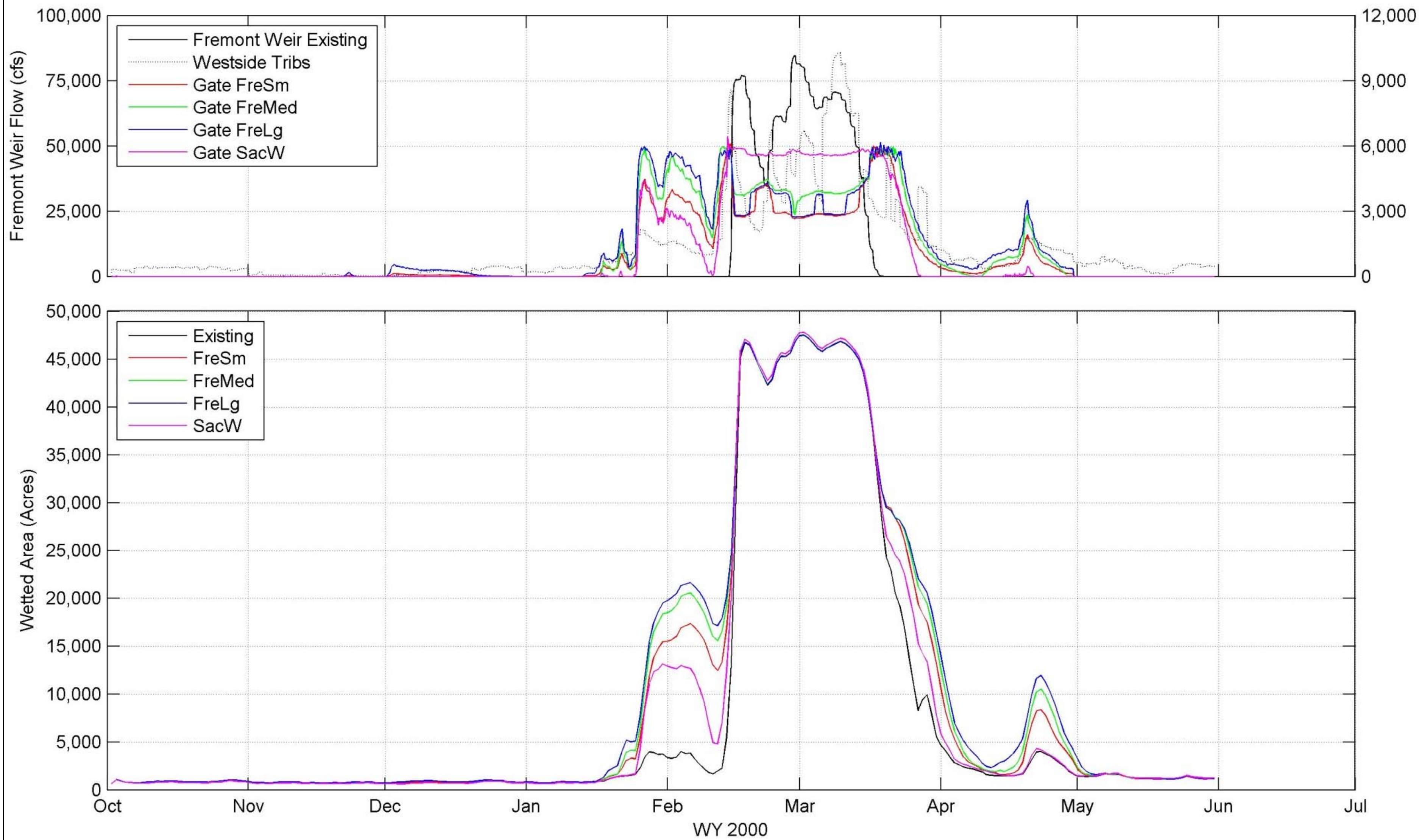


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 1999 for Apr 30 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D67**

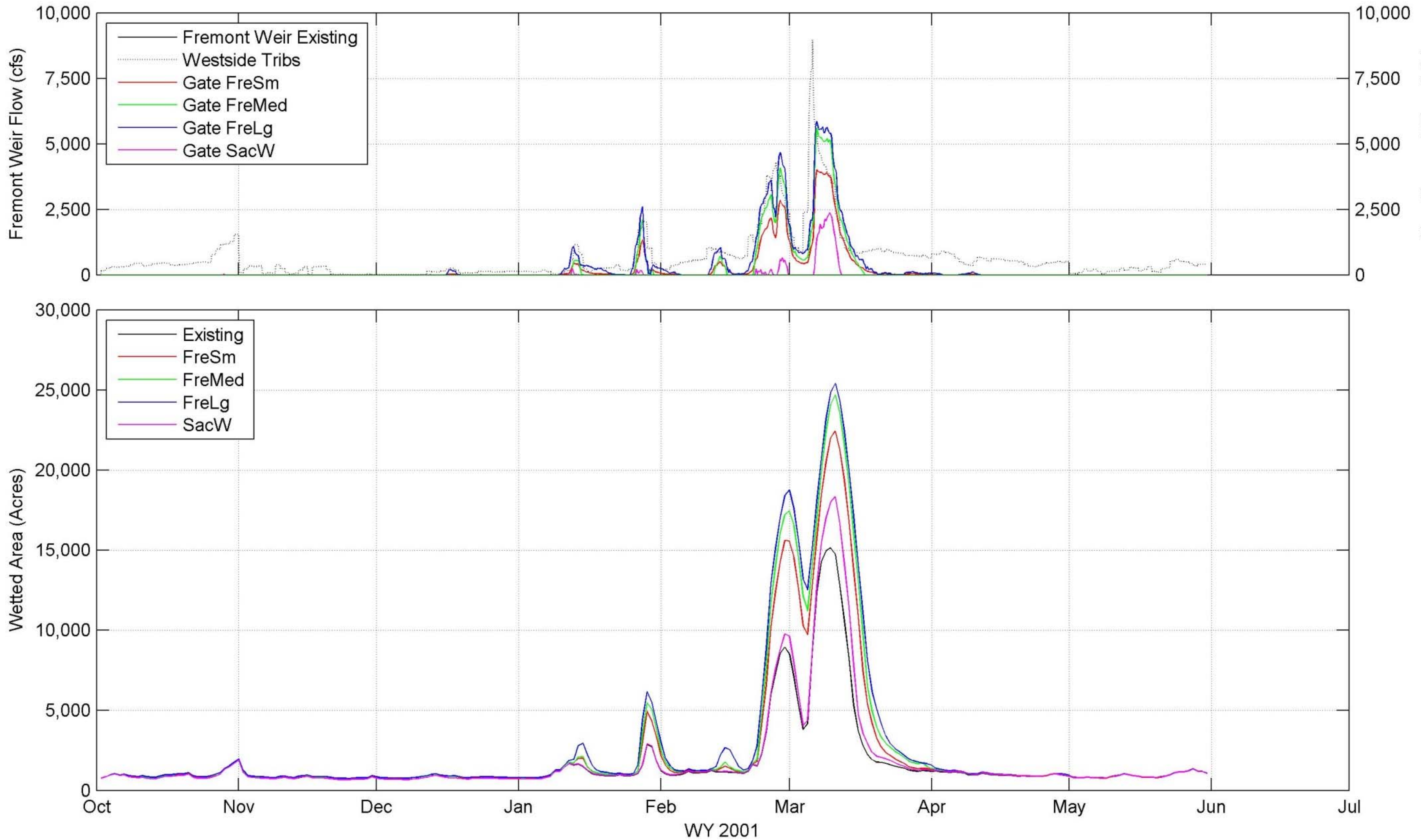


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2000 for Apr 30 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D68**

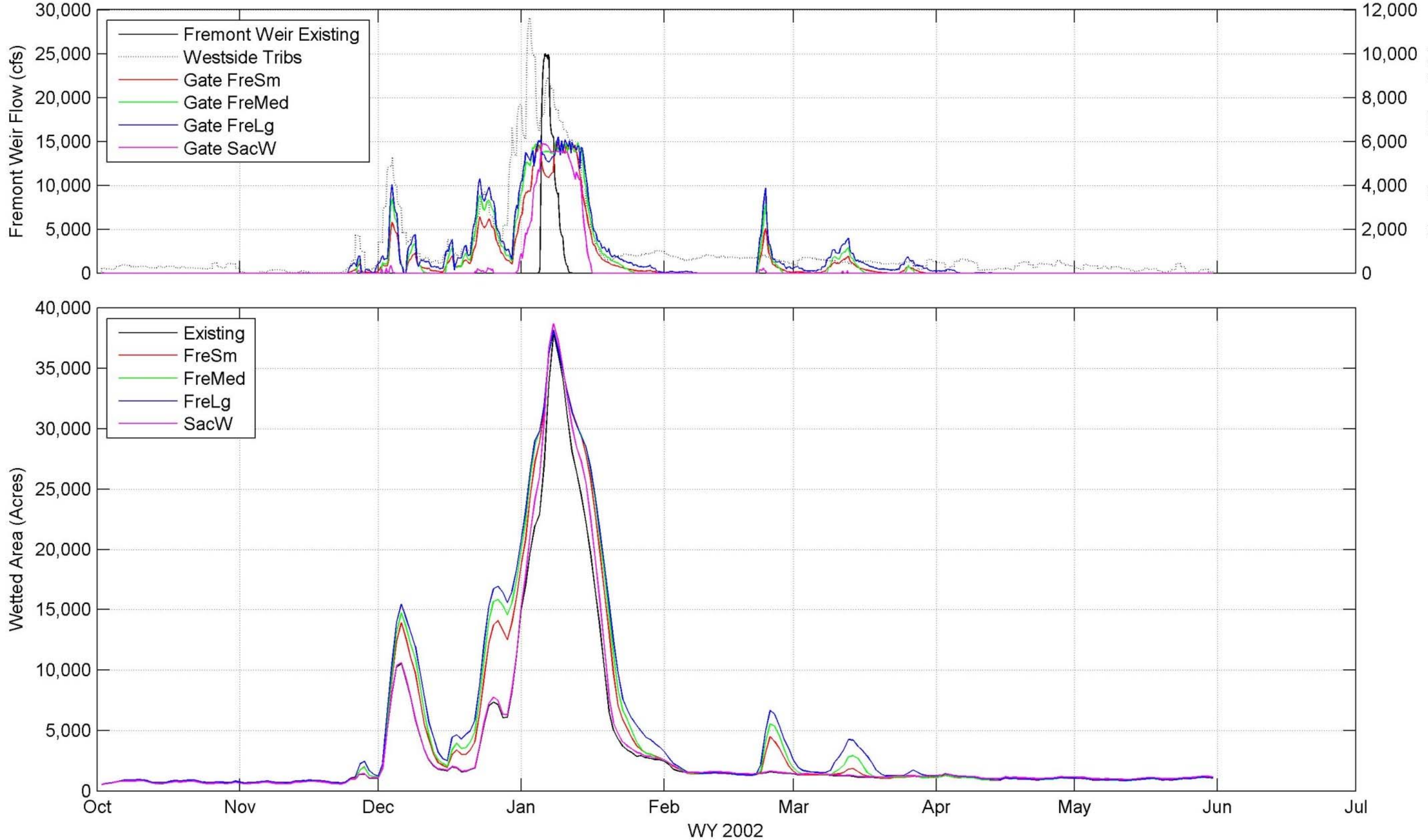


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2001 for Apr 30 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D69**

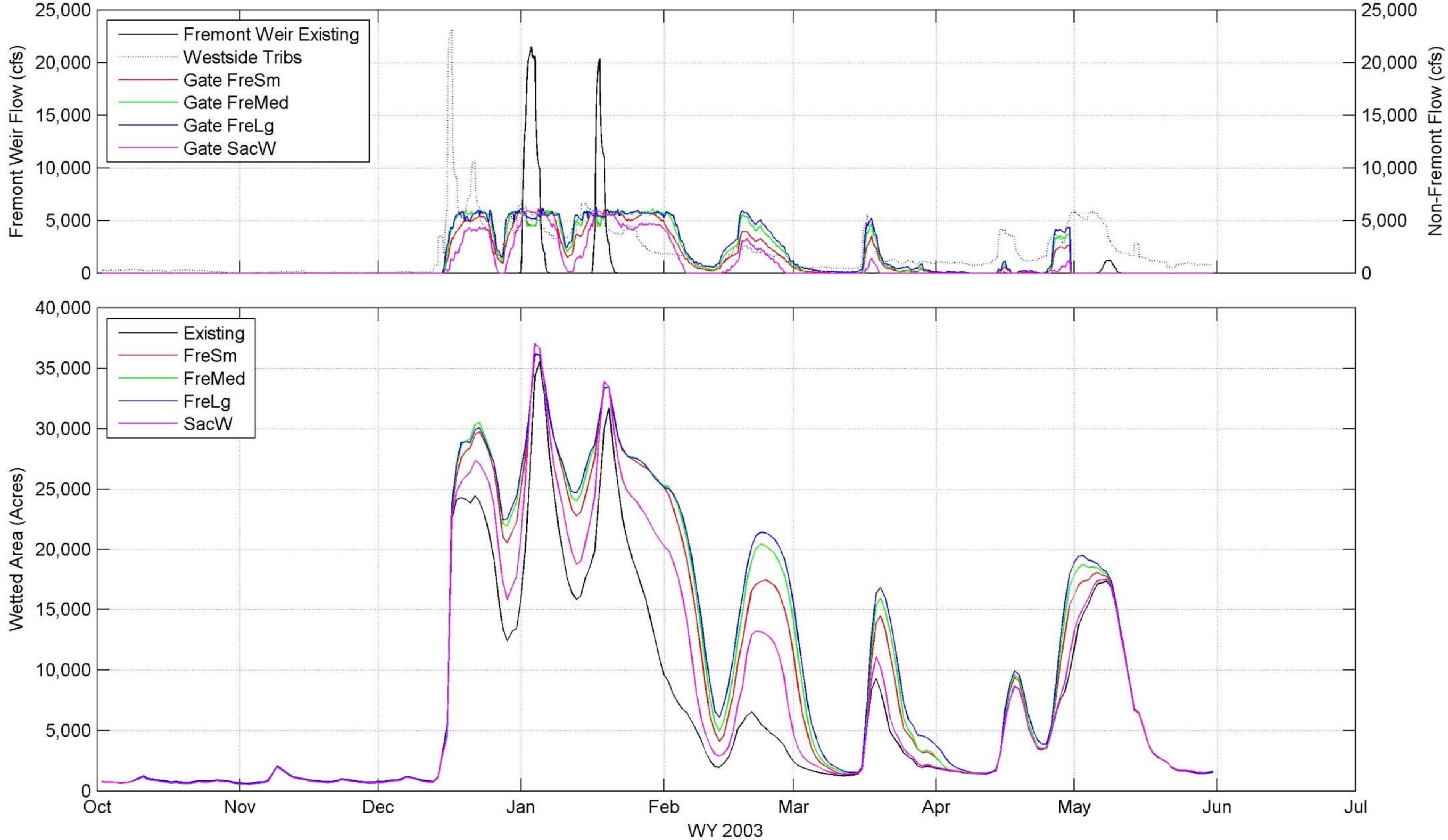


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2002 for Apr 30 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D70**

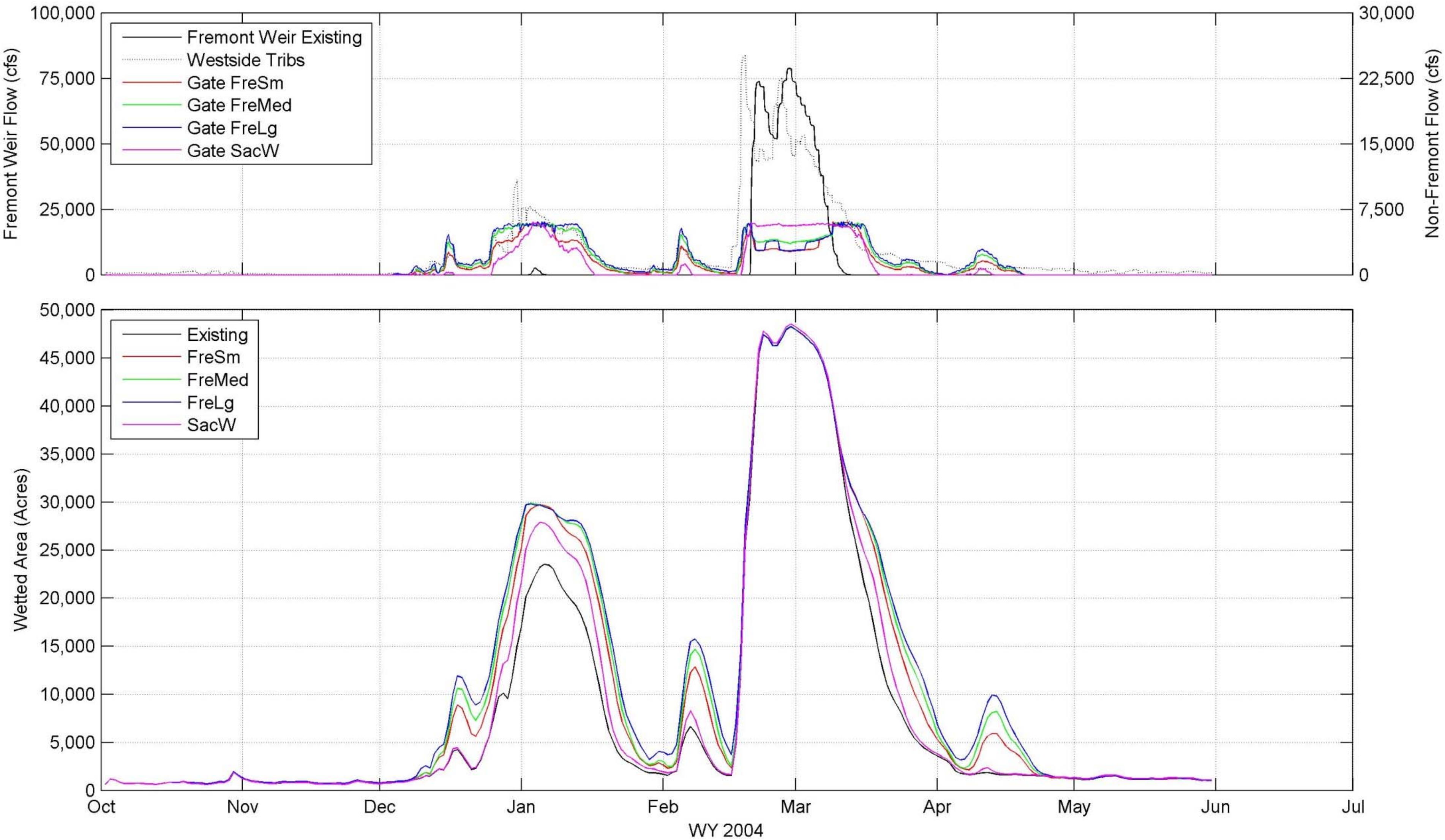


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2003 for Apr 30 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D71**

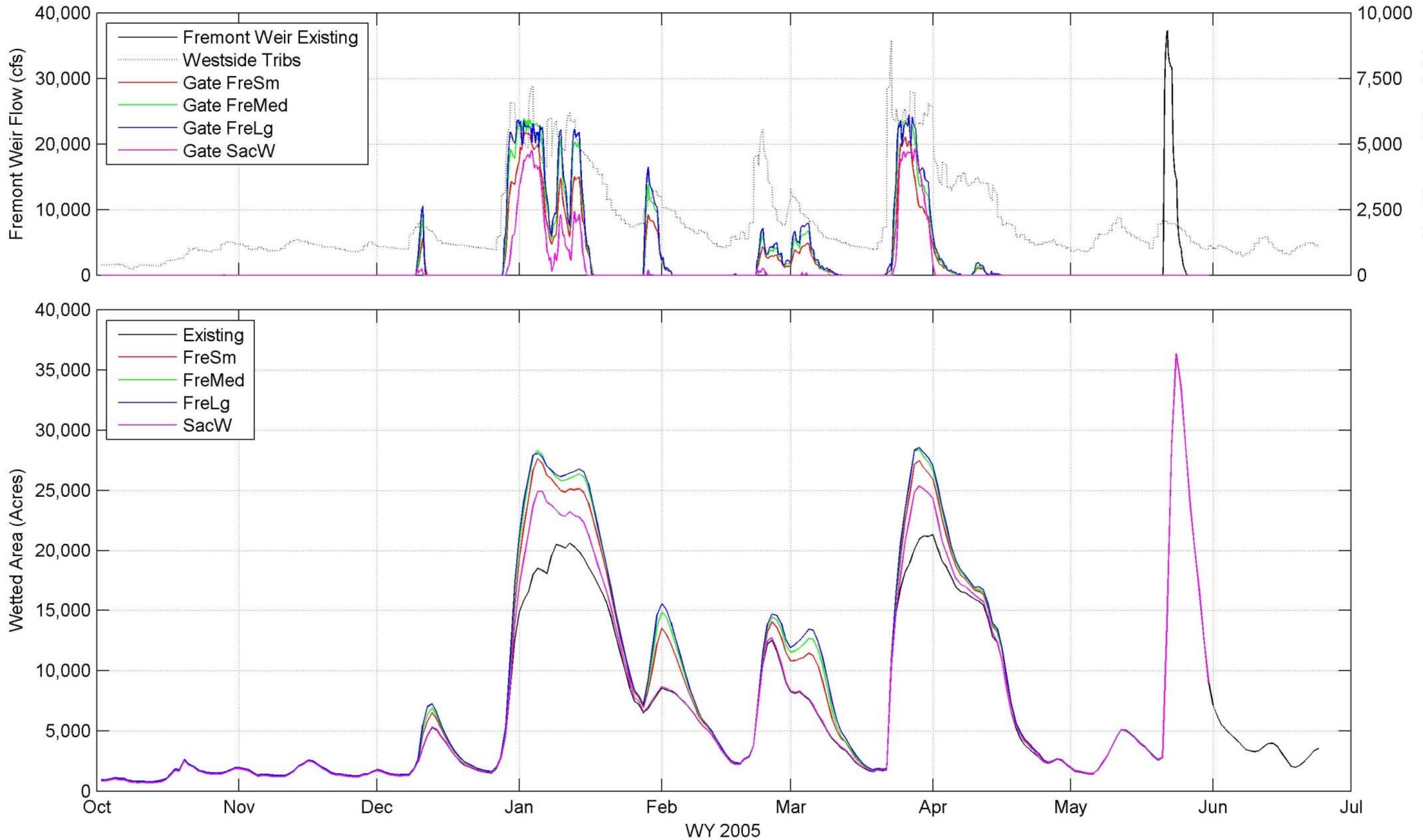


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2004 for Apr 30 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D72**

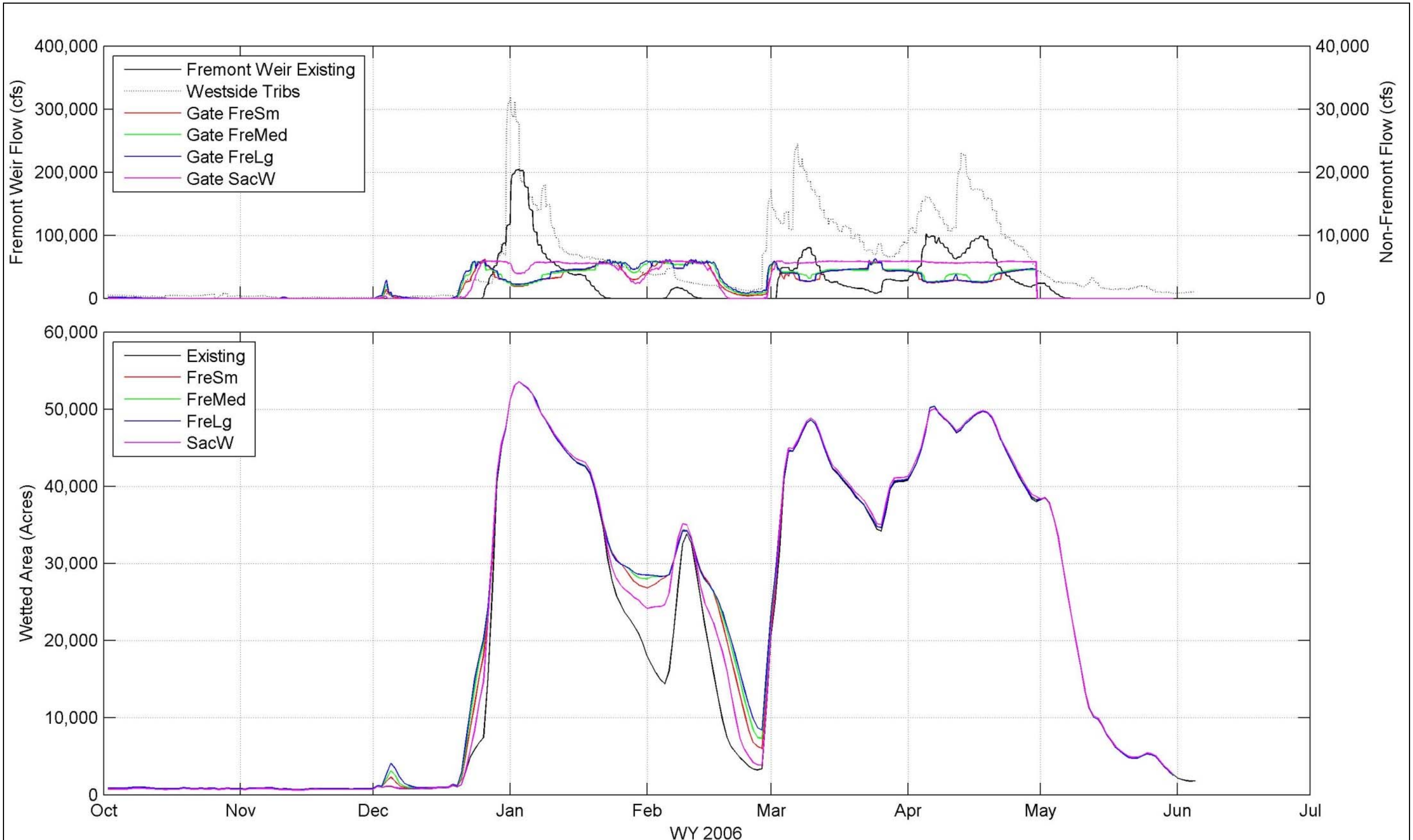


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2005 for Apr 30 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D73**

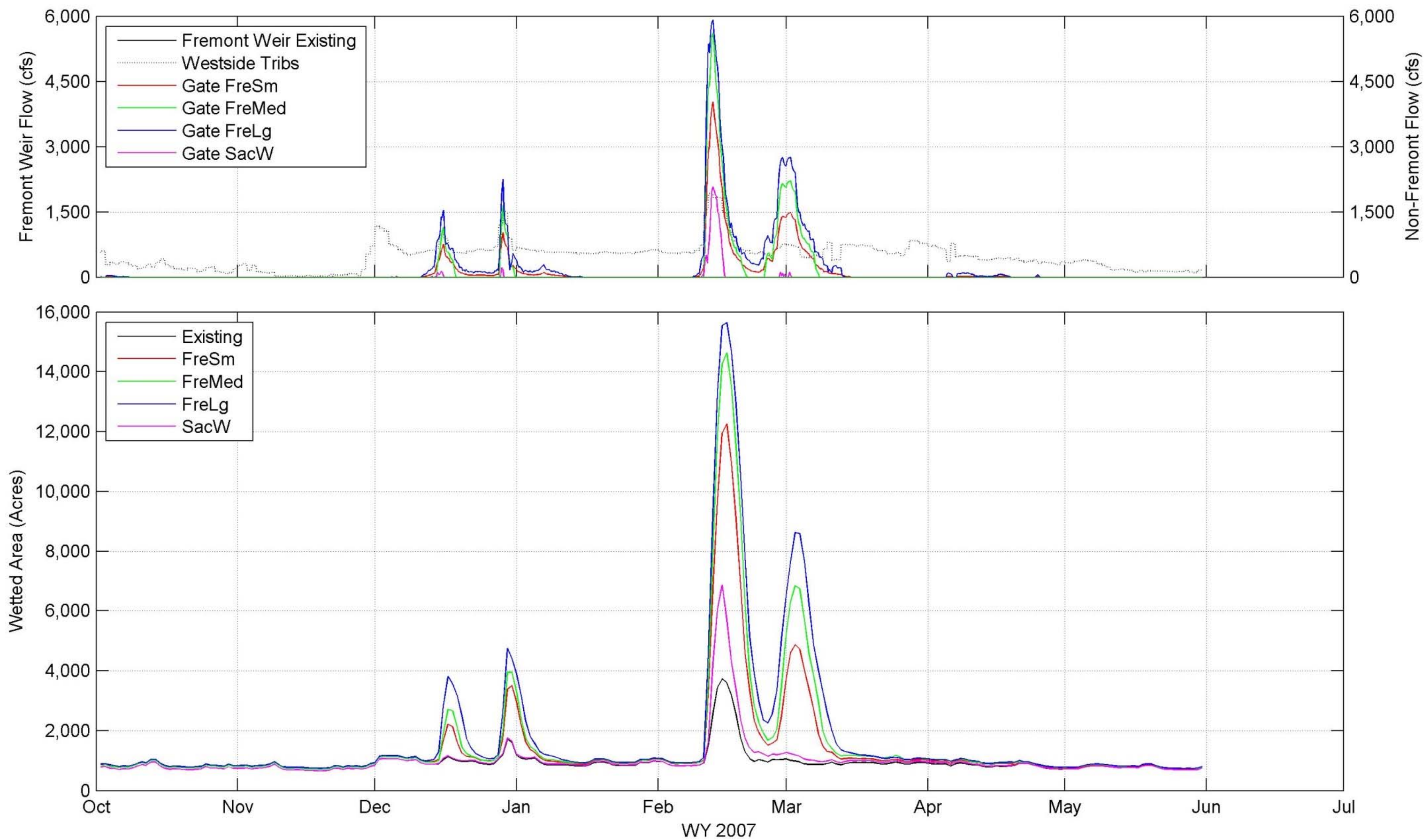


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

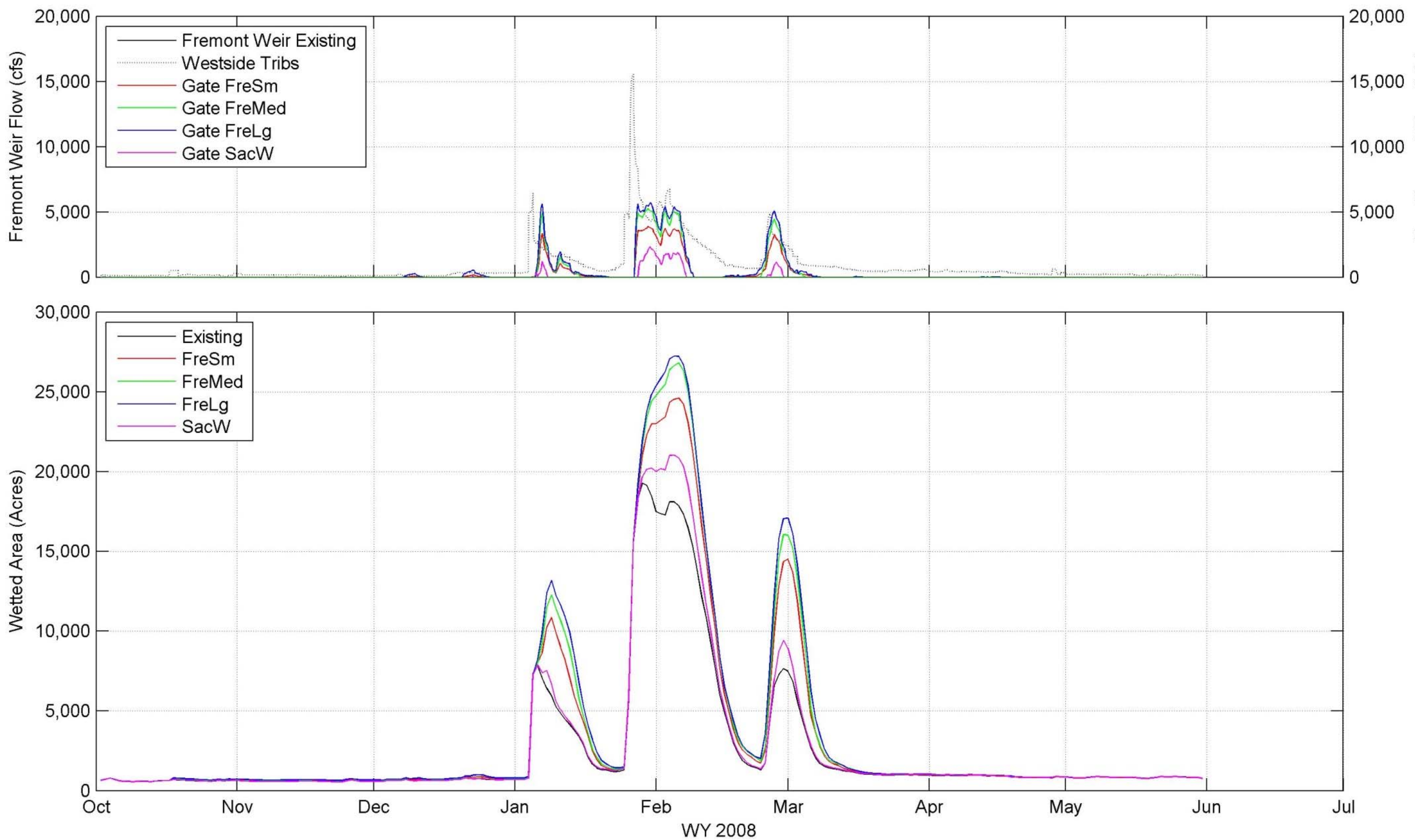
Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2006 for Apr 30 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D74**



Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)	HDR cbec eco engineering	*Yolo Bypass Salmonid Habitat Restoration and Fish Passage* **Wetted Area for WY 2007 for Apr 30 Gate Closure**
		Prepared for DWR · Created By: SJB · **Figure D75**

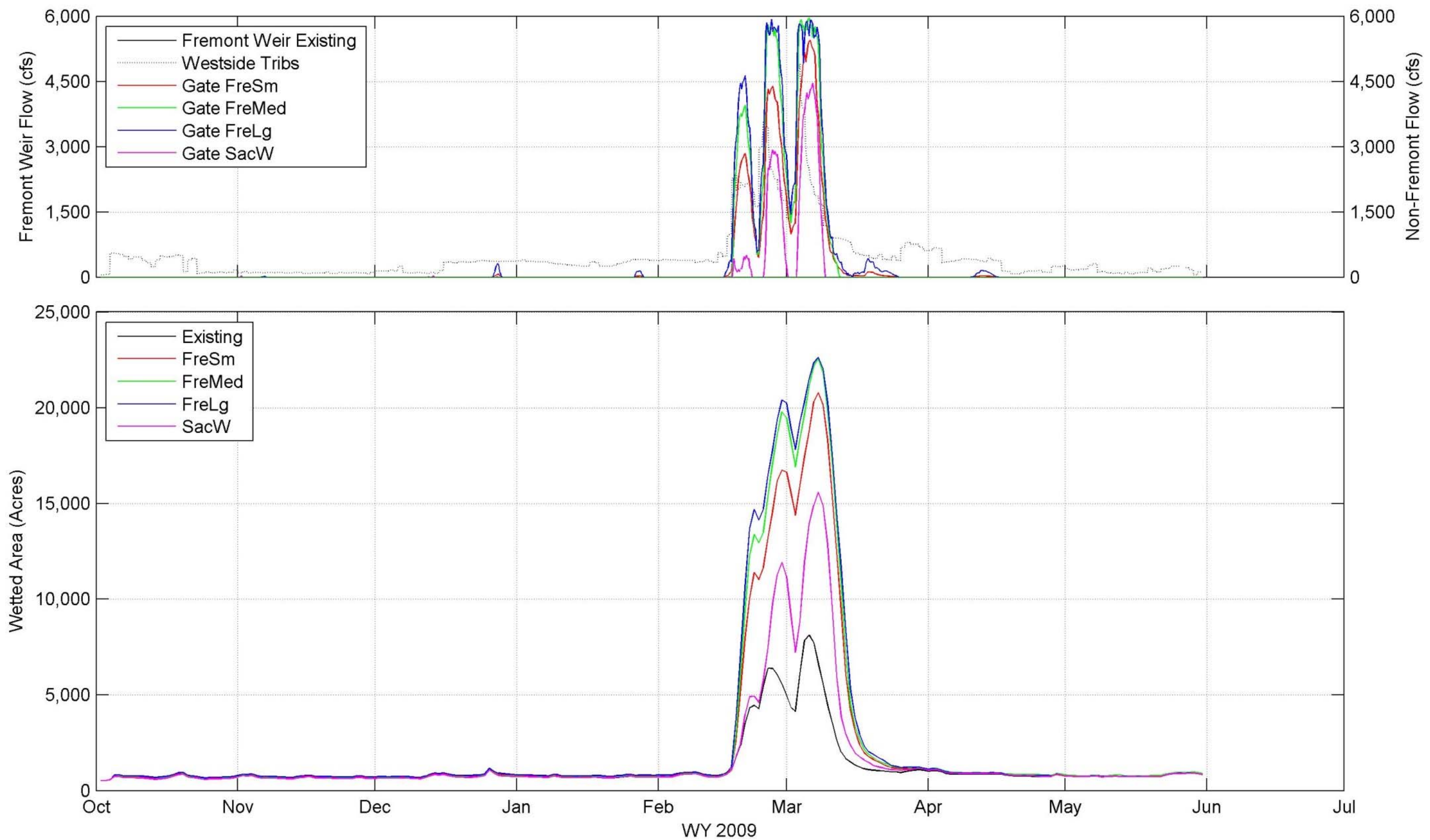


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2008 for Apr 30 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D76**

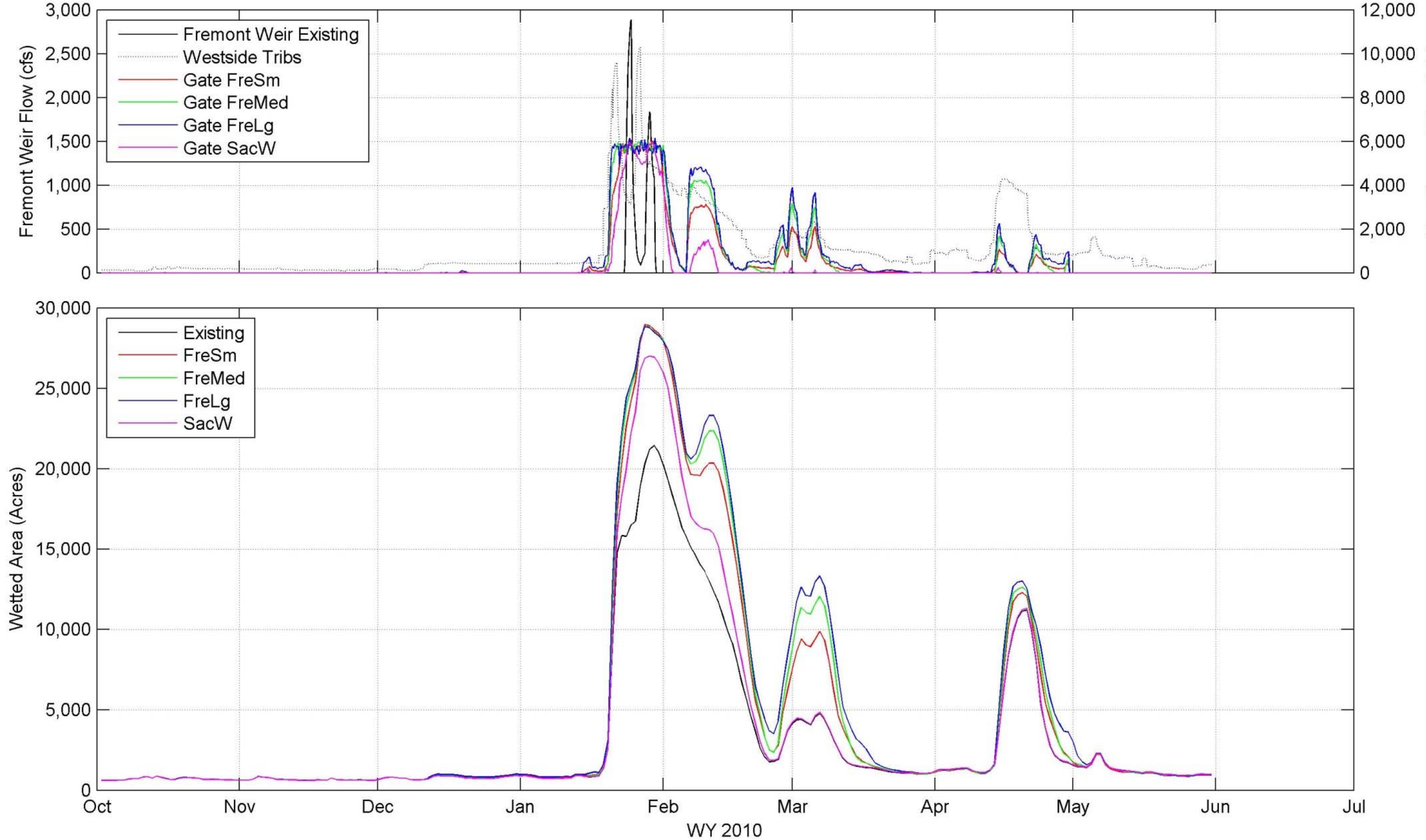


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2009 for Apr 30 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D77**

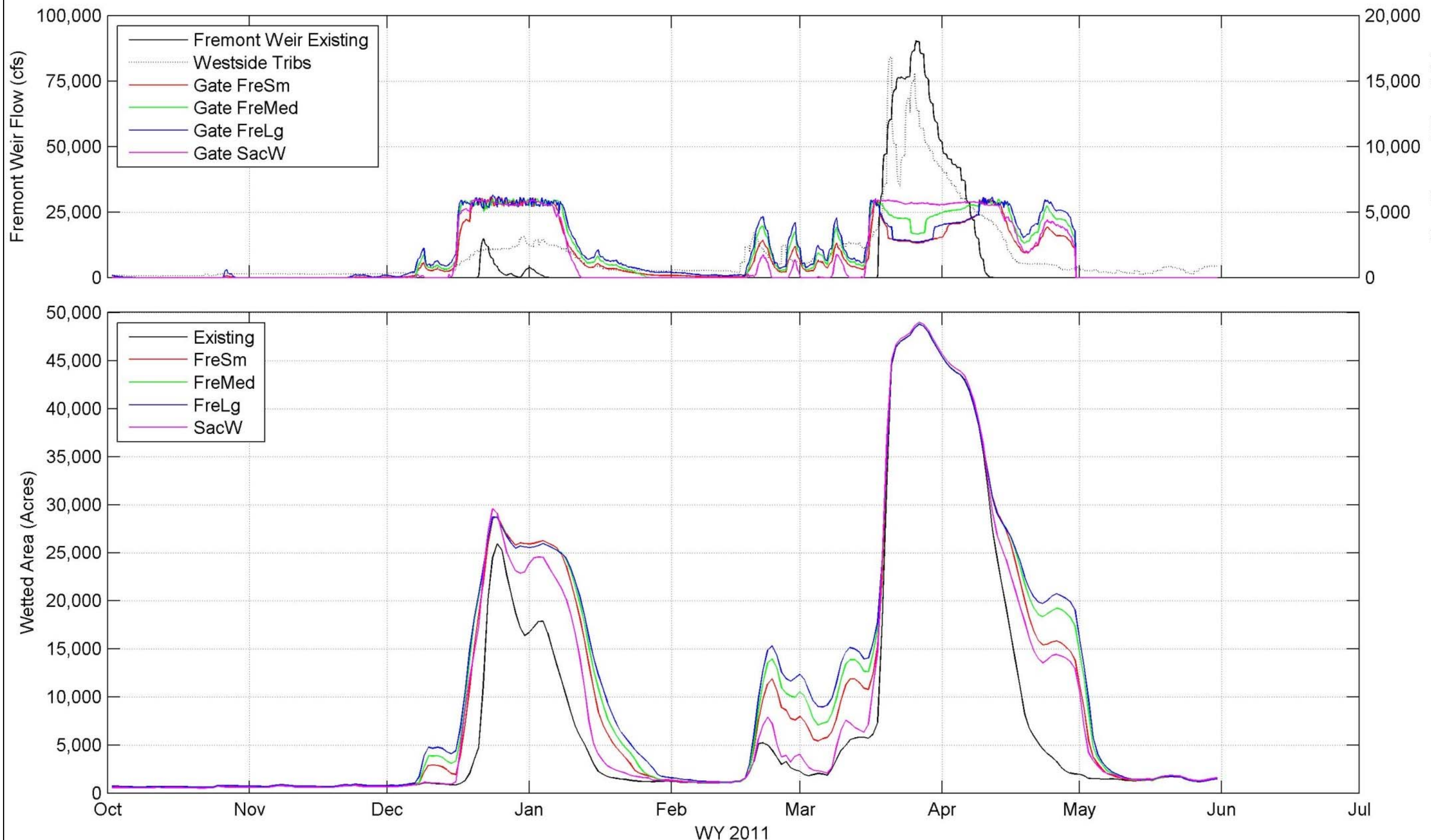


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2010 for Apr 30 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D78**

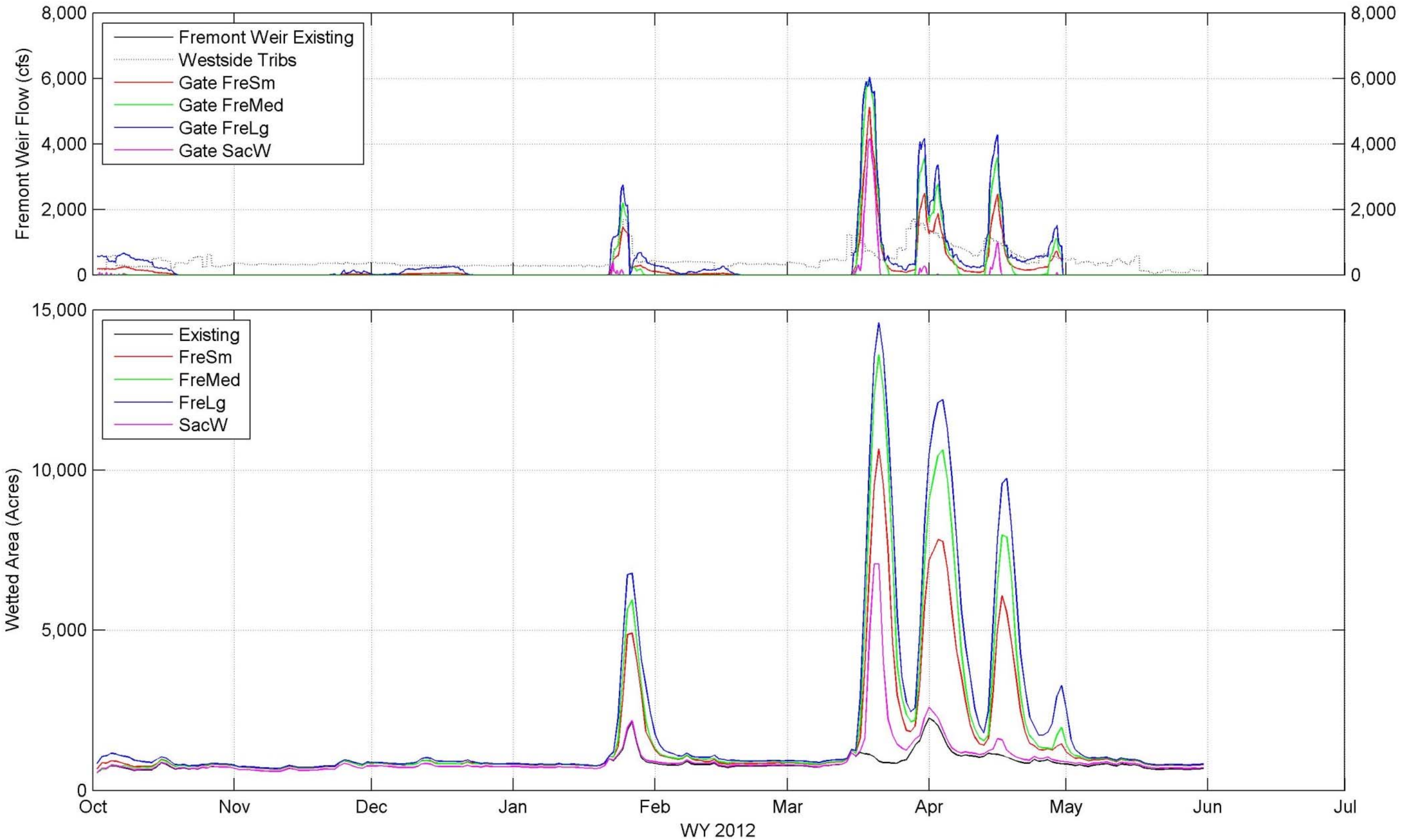


Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2011 for Apr 30 Gate Closure

Prepared for DWR	Created By: SJB	**Figure D79**



Notes: TUFLOW model results showing wetted area (lower) and gate flows (upper)

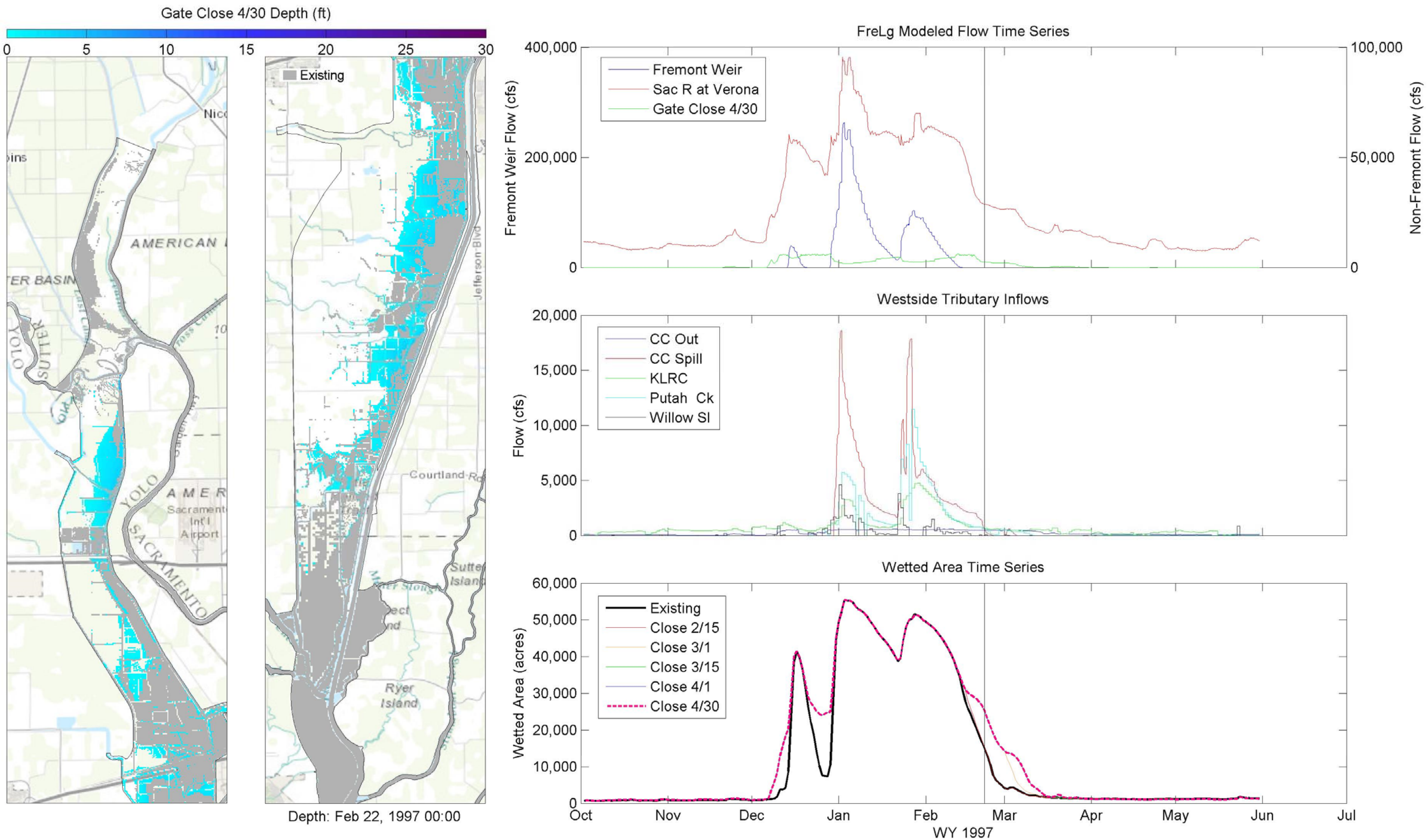
Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area for WY 2012 for Apr 30 Gate Closure

Prepared for DWR | Created By: SJB | **Figure D80**

Appendix E

Animation Snapshots



Notes: TUFLOW model results showing 2D inundation patterns (at specified time stamp) for existing and 4/30 gate closure (left panes), Yolo Bypass inflows (upper right panes), and wetted area for all five gate closures (lower right pane). The vertical bar in the right panes corresponds to the time stamp below the left panes, whereby the blue hatching represents 4/30 gate closure conditions as overlain by the grey hatching representing existing conditions.

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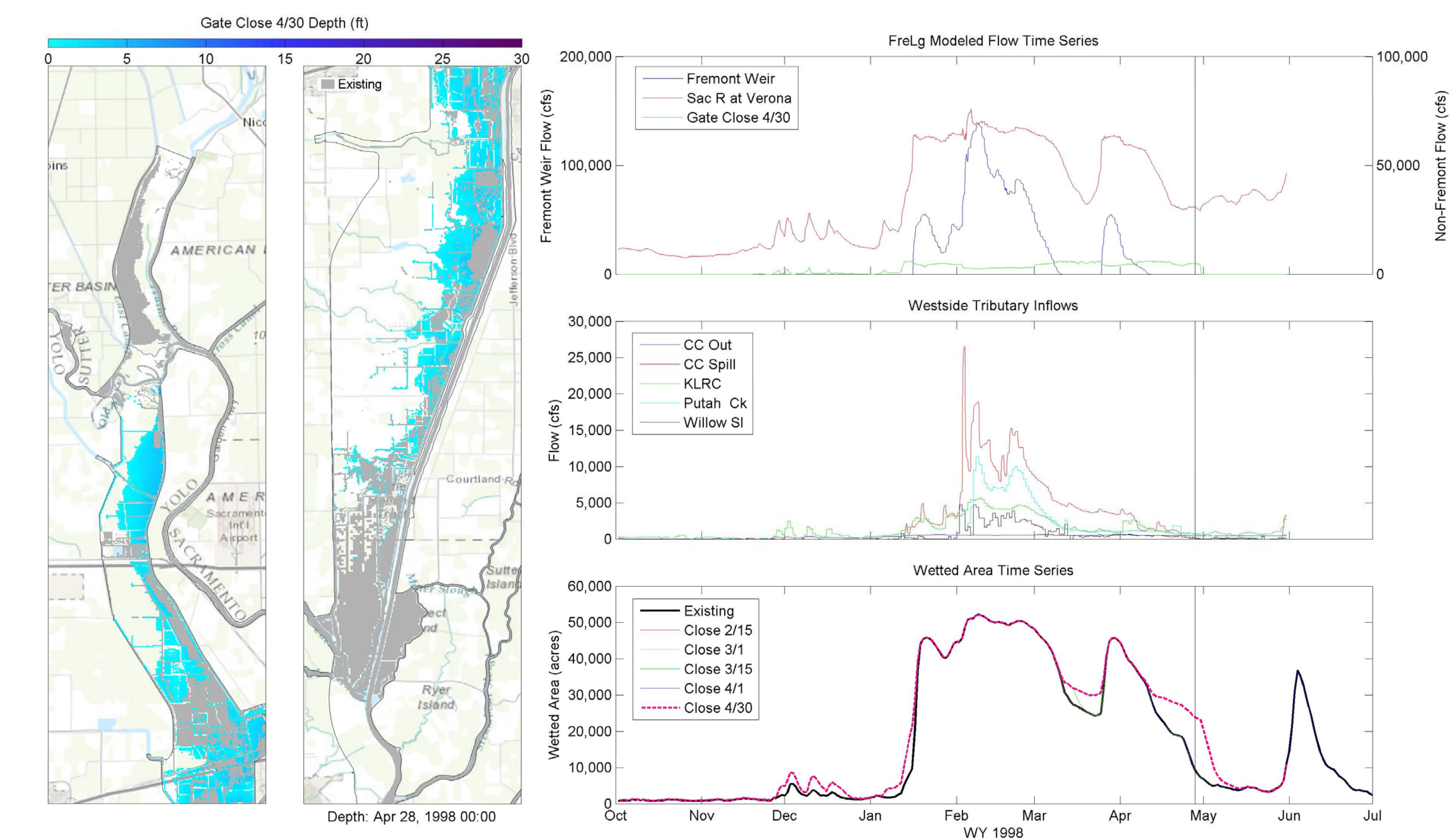
Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area Comparison for WY 1997 for FreLg

Prepared for DWR	Created By: SJB	**Figure E1**



Notes: TUFLOW model results showing 2D inundation patterns (at specified time stamp) for existing and 4/30 gate closure (left panes), Yolo Bypass inflows (upper right panes), and wetted area for all five gate closures (lower right pane). The vertical bar in the right panes corresponds to the time stamp below the left panes, whereby the blue hatching represents 4/30 gate closure conditions as overlain by the grey hatching representing existing conditions.

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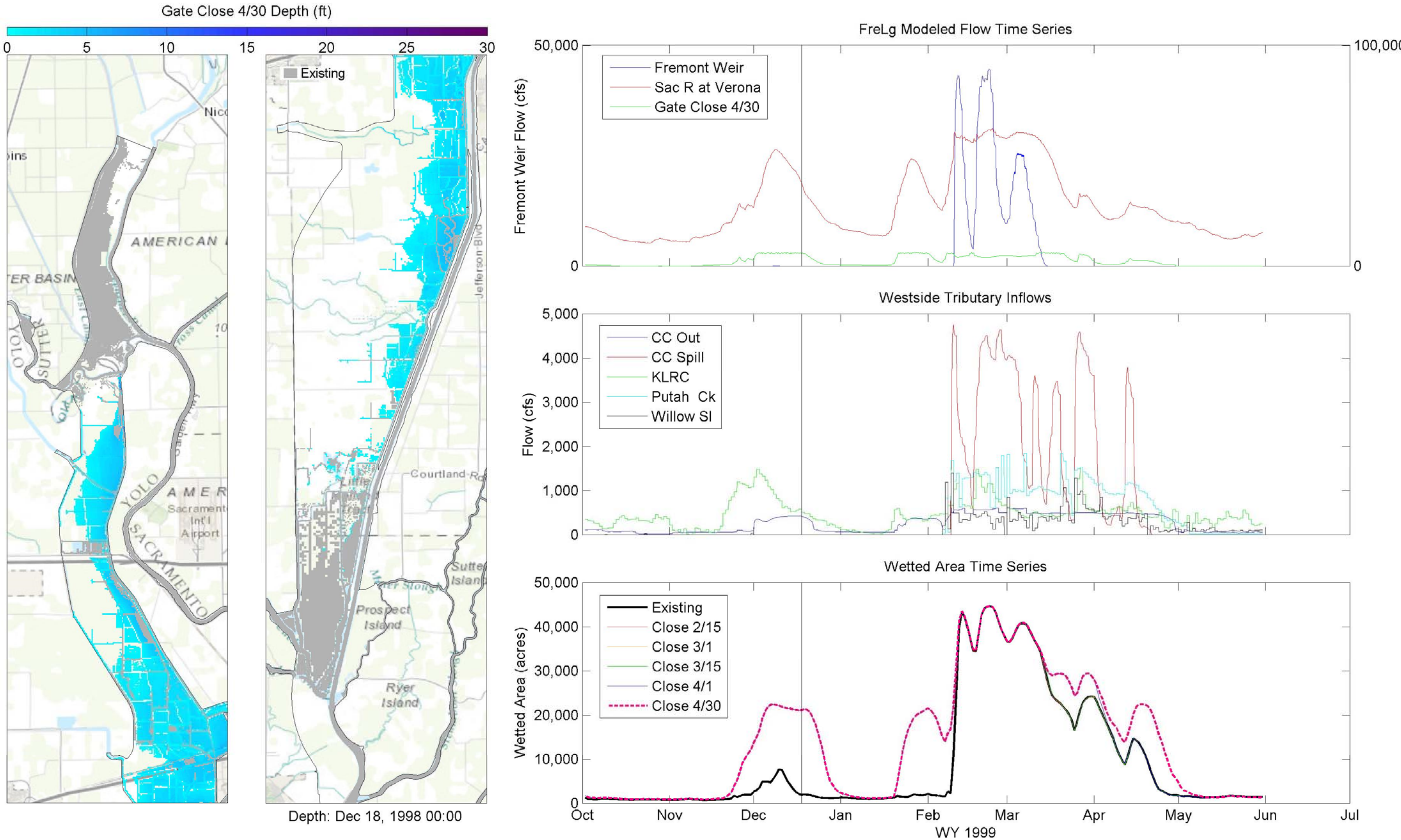
Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area Comparison for WY 1998 for FreLg

Prepared for DWR	Created By: SJB	**Figure E2**

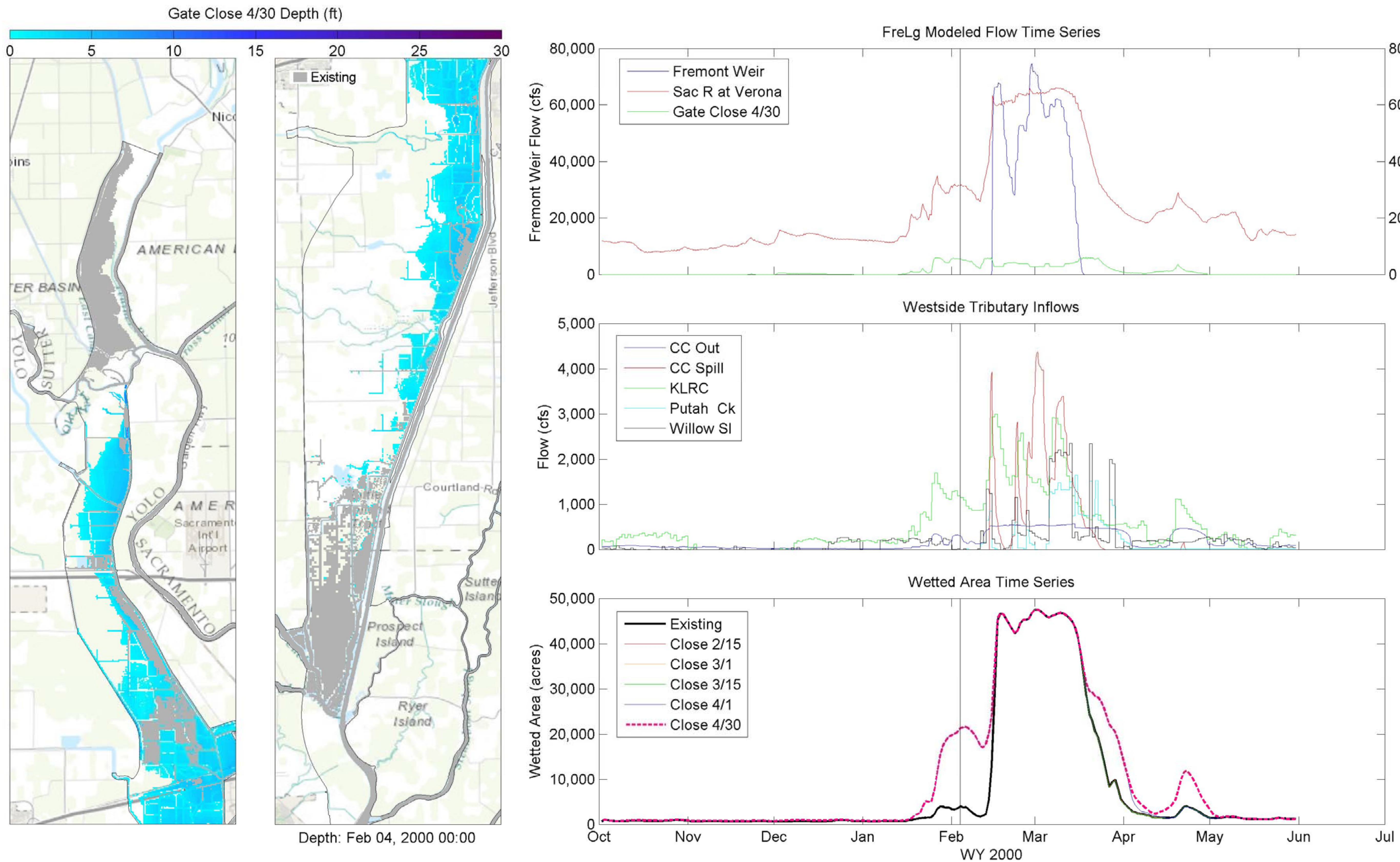


Notes: TUFLOW model results showing 2D inundation patterns (at specified time stamp) for existing and 4/30 gate closure (left panes), Yolo Bypass inflows (upper right panes), and wetted area for all five gate closures (lower right pane). The vertical bar in the right panes corresponds to the time stamp below the left panes, whereby the blue hatching represents 4/30 gate closure conditions as overlain by the grey hatching representing existing conditions.

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area Comparison for WY 1999 for FreLg

Prepared for DWR	Created By: SJB	**Figure E3**



Notes: TUFLOW model results showing 2D inundation patterns (at specified time stamp) for existing and 4/30 gate closure (left panes), Yolo Bypass inflows (upper right panes), and wetted area for all five gate closures (lower right pane). The vertical bar in the right panes corresponds to the time stamp below the left panes, whereby the blue hatching represents 4/30 gate closure conditions as overlain by the grey hatching representing existing conditions.

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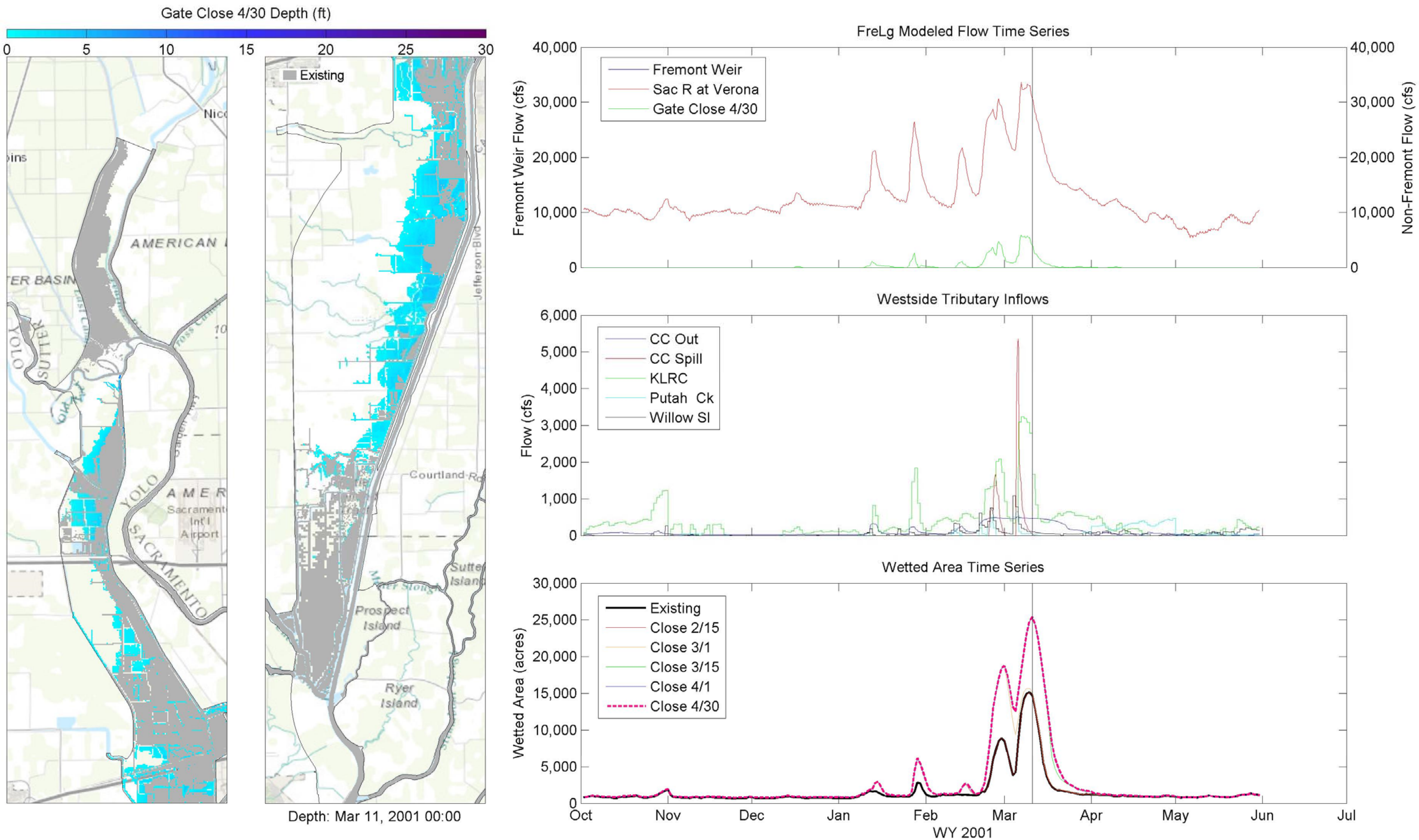
Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area Comparison for WY 2000 for FreLg

Prepared for DWR | Created By: SJB | **Figure E4**



Notes: TUFLOW model results showing 2D inundation patterns (at specified time stamp) for existing and 4/30 gate closure (left panes), Yolo Bypass inflows (upper right panes), and wetted area for all five gate closures (lower right pane). The vertical bar in the right panes corresponds to the time stamp below the left panes, whereby the blue hatching represents 4/30 gate closure conditions as overlain by the grey hatching representing existing conditions.

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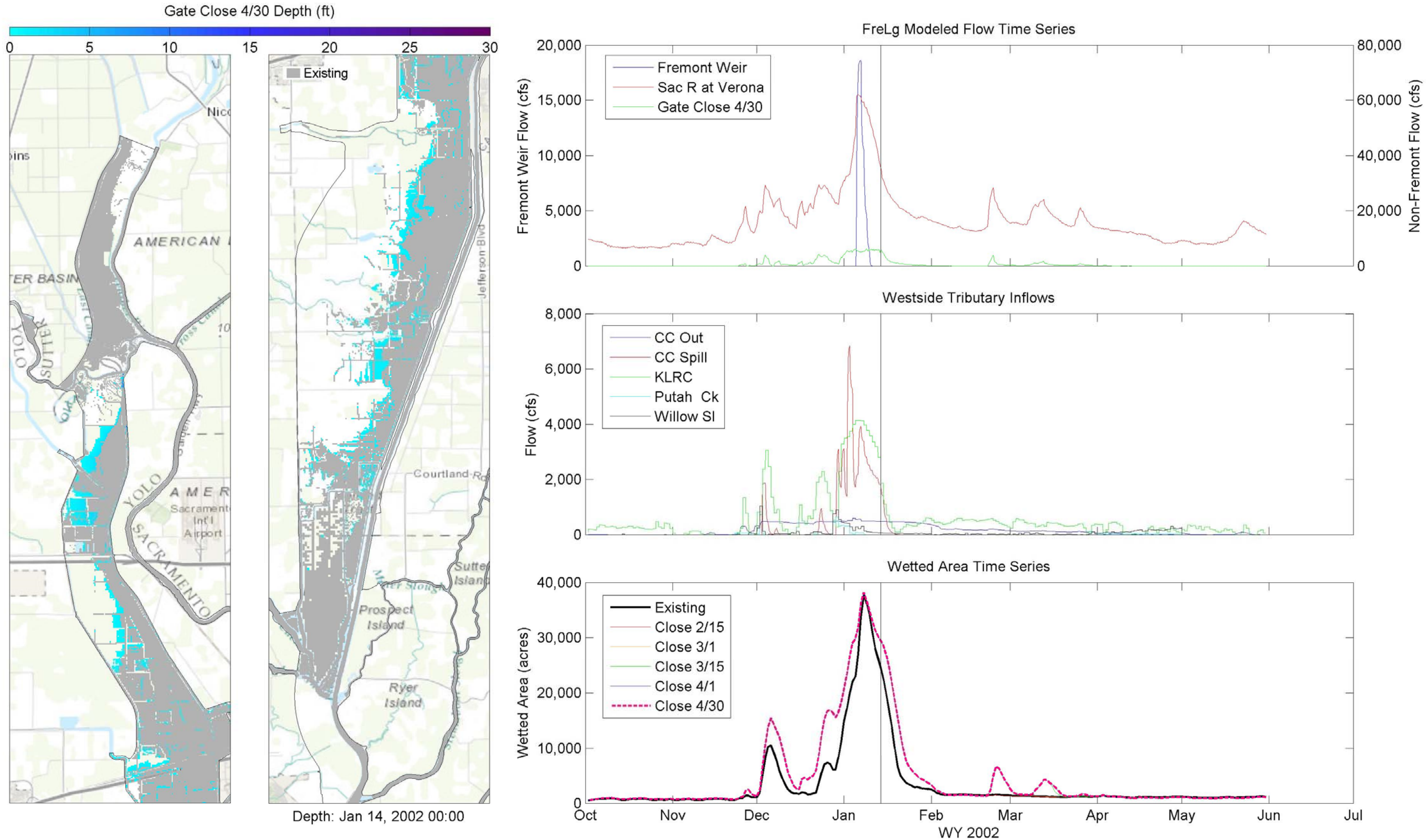
Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area Comparison for WY 2001 for FreLg

Prepared for DWR	Created By: SJB	**Figure E5**



Notes: TUFLOW model results showing 2D inundation patterns (at specified time stamp) for existing and 4/30 gate closure (left panes), Yolo Bypass inflows (upper right panes), and wetted area for all five gate closures (lower right pane). The vertical bar in the right panes corresponds to the time stamp below the left panes, whereby the blue hatching represents 4/30 gate closure conditions as overlain by the grey hatching representing existing conditions.

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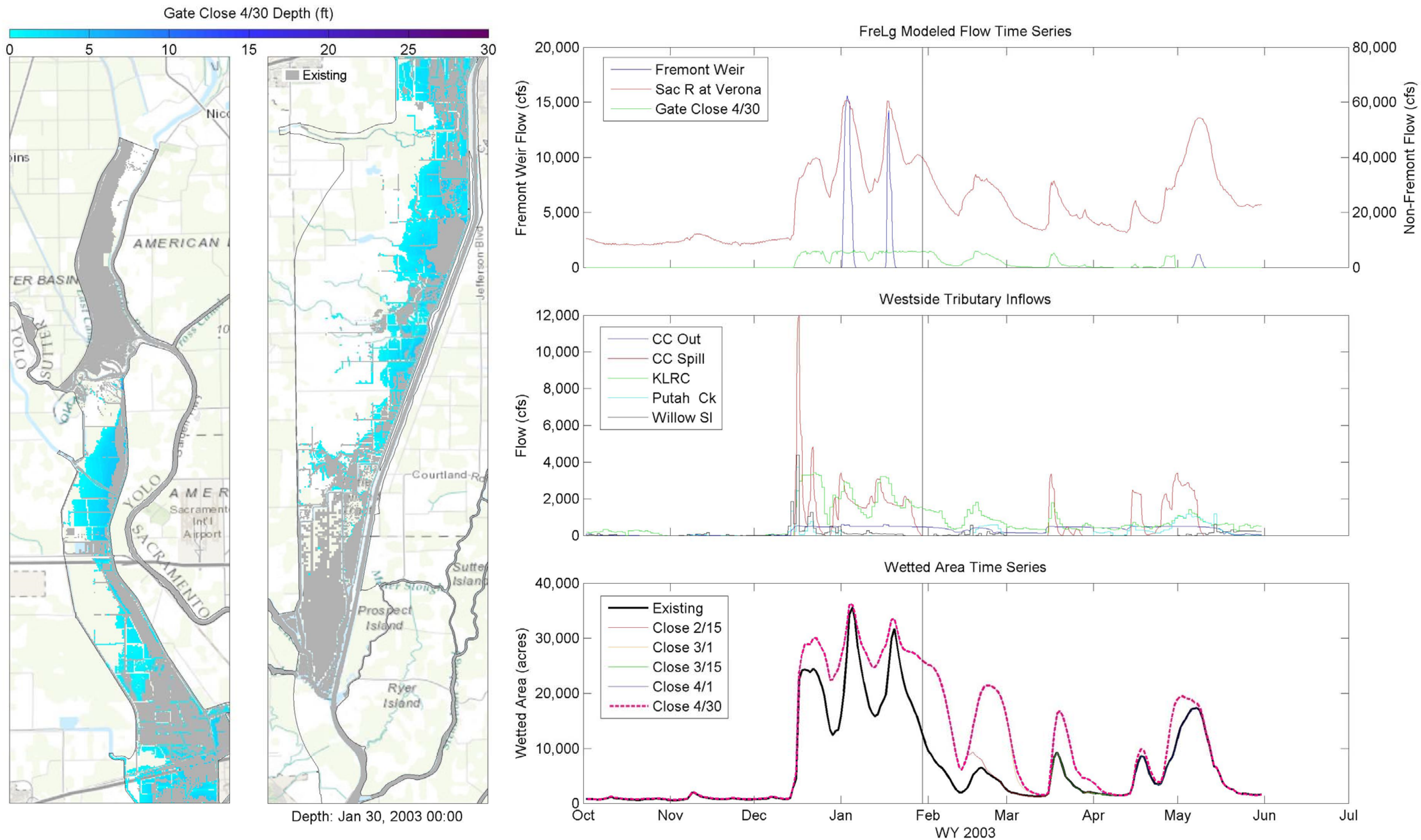
Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area Comparison for WY 2002 for FreLg

Prepared for DWR	Created By: SJB	**Figure E6**



Notes: TUFLOW model results showing 2D inundation patterns (at specified time stamp) for existing and 4/30 gate closure (left panes), Yolo Bypass inflows (upper right panes), and wetted area for all five gate closures (lower right pane). The vertical bar in the right panes corresponds to the time stamp below the left panes, whereby the blue hatching represents 4/30 gate closure conditions as overlain by the grey hatching representing existing conditions.

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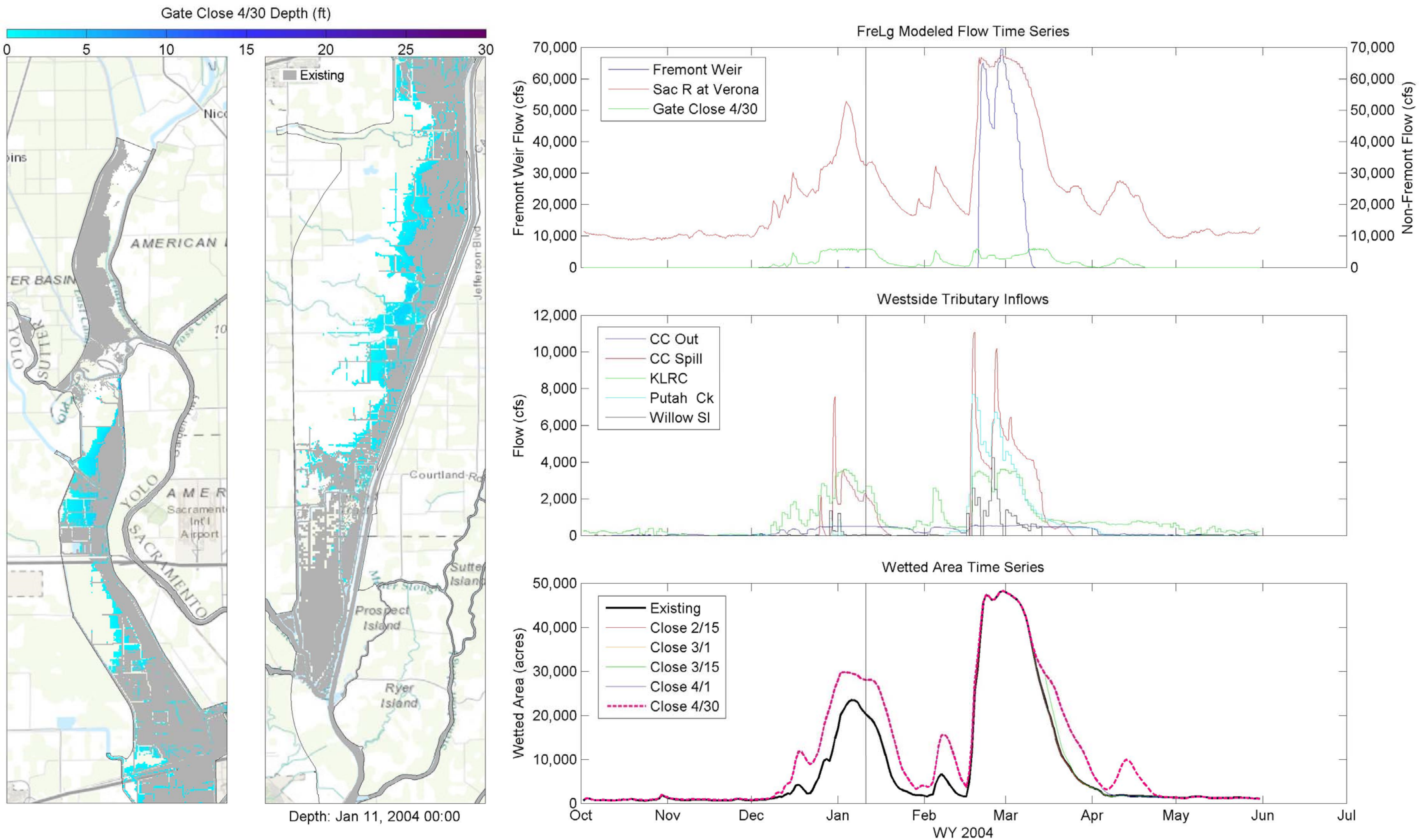
Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area Comparison for WY 2003 for FreLg

Prepared for DWR | Created By: SJB | **Figure E7**



Notes: TUFLOW model results showing 2D inundation patterns (at specified time stamp) for existing and 4/30 gate closure (left panes), Yolo Bypass inflows (upper right panes), and wetted area for all five gate closures (lower right pane). The vertical bar in the right panes corresponds to the time stamp below the left panes, whereby the blue hatching represents 4/30 gate closure conditions as overlain by the grey hatching representing existing conditions.

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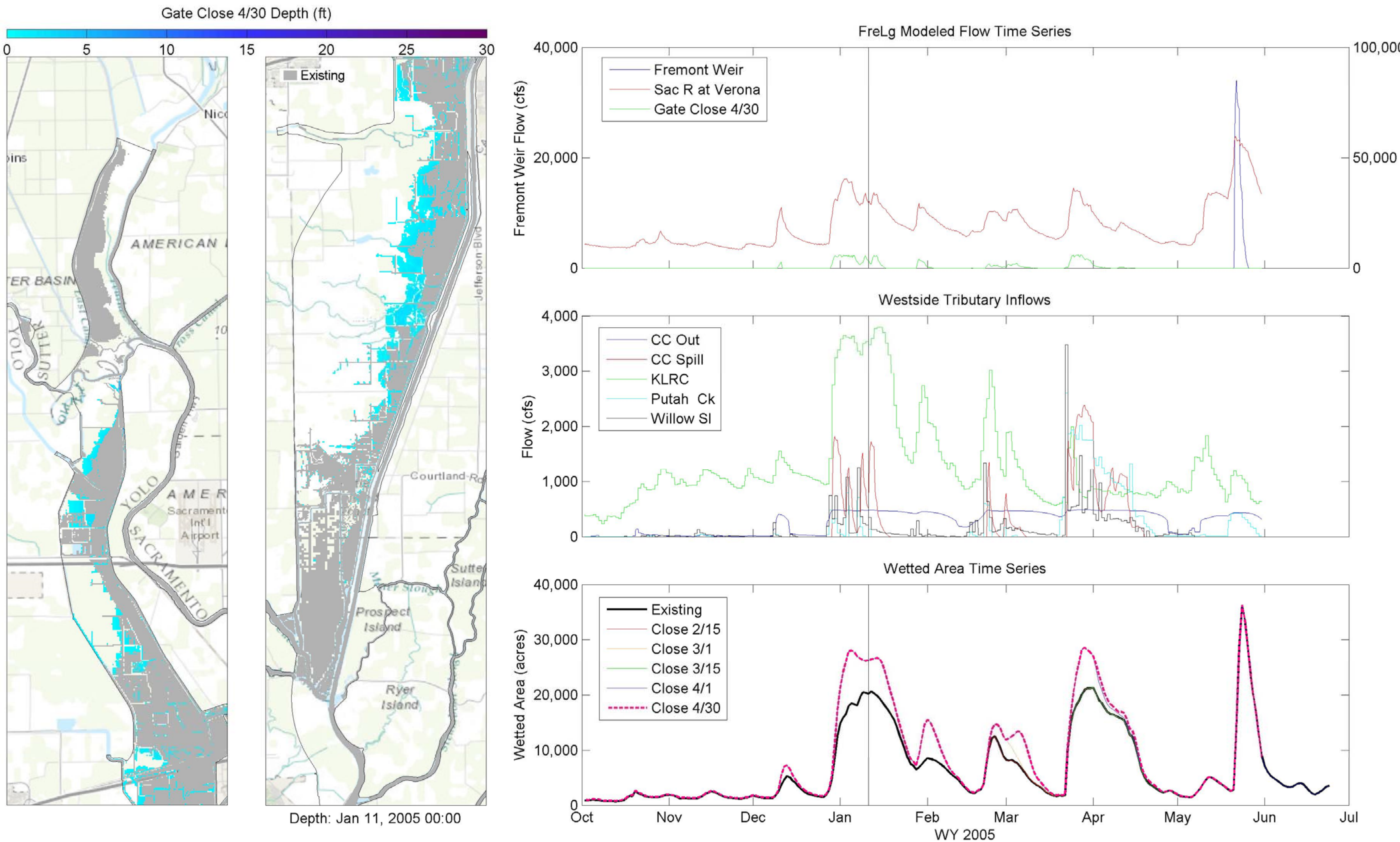
Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area Comparison for WY 2004 for FreLg

Prepared for DWR | Created By: SJB | **Figure E8**

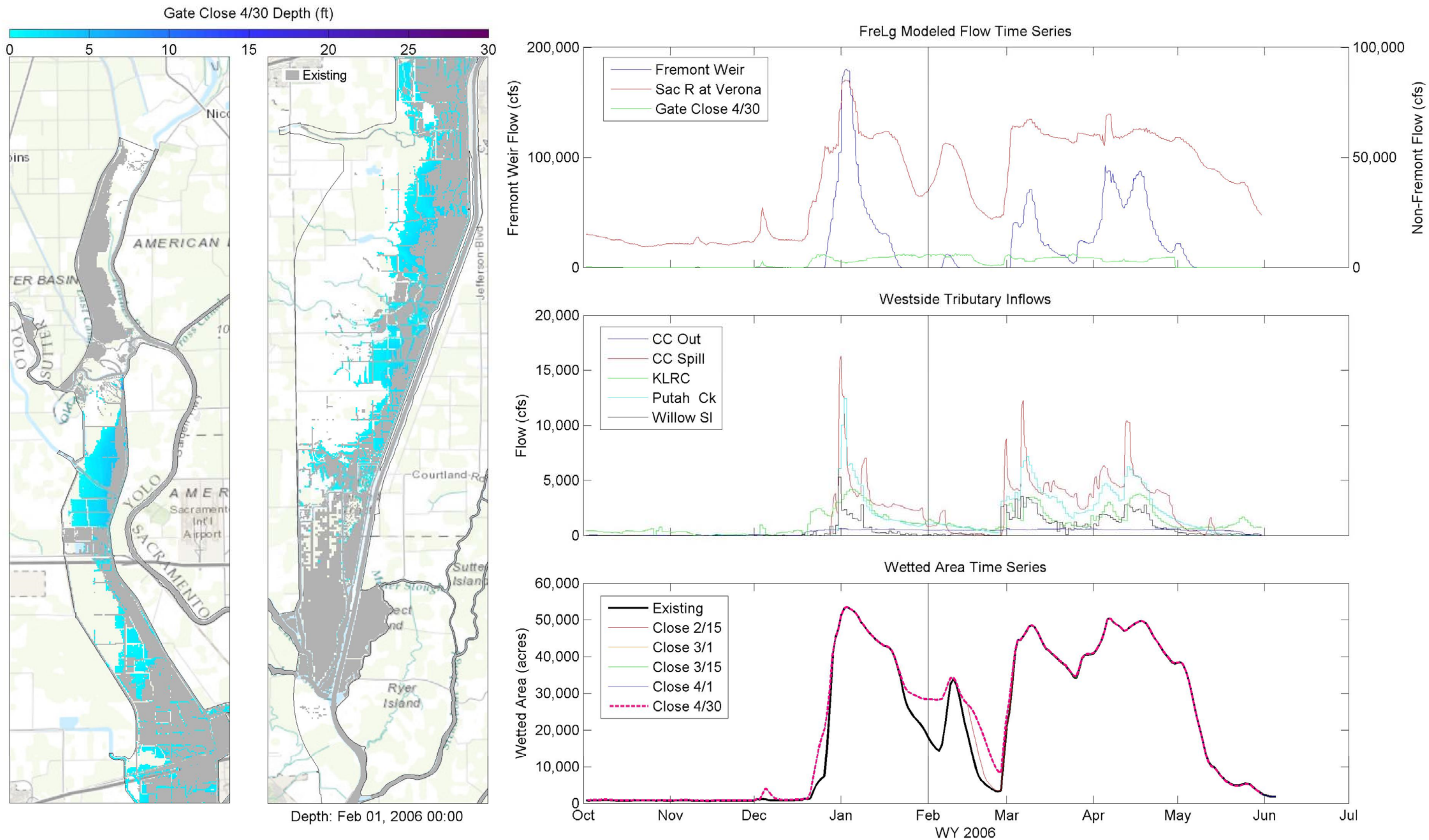


Notes: TUFLOW model results showing 2D inundation patterns (at specified time stamp) for existing and 4/30 gate closure (left panes), Yolo Bypass inflows (upper right panes), and wetted area for all five gate closures (lower right pane). The vertical bar in the right panes corresponds to the time stamp below the left panes, whereby the blue hatching represents 4/30 gate closure conditions as overlain by the grey hatching representing existing conditions.

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area Comparison for WY 2005 for FreLg

Prepared for DWR | Created By: SJB | **Figure E9**

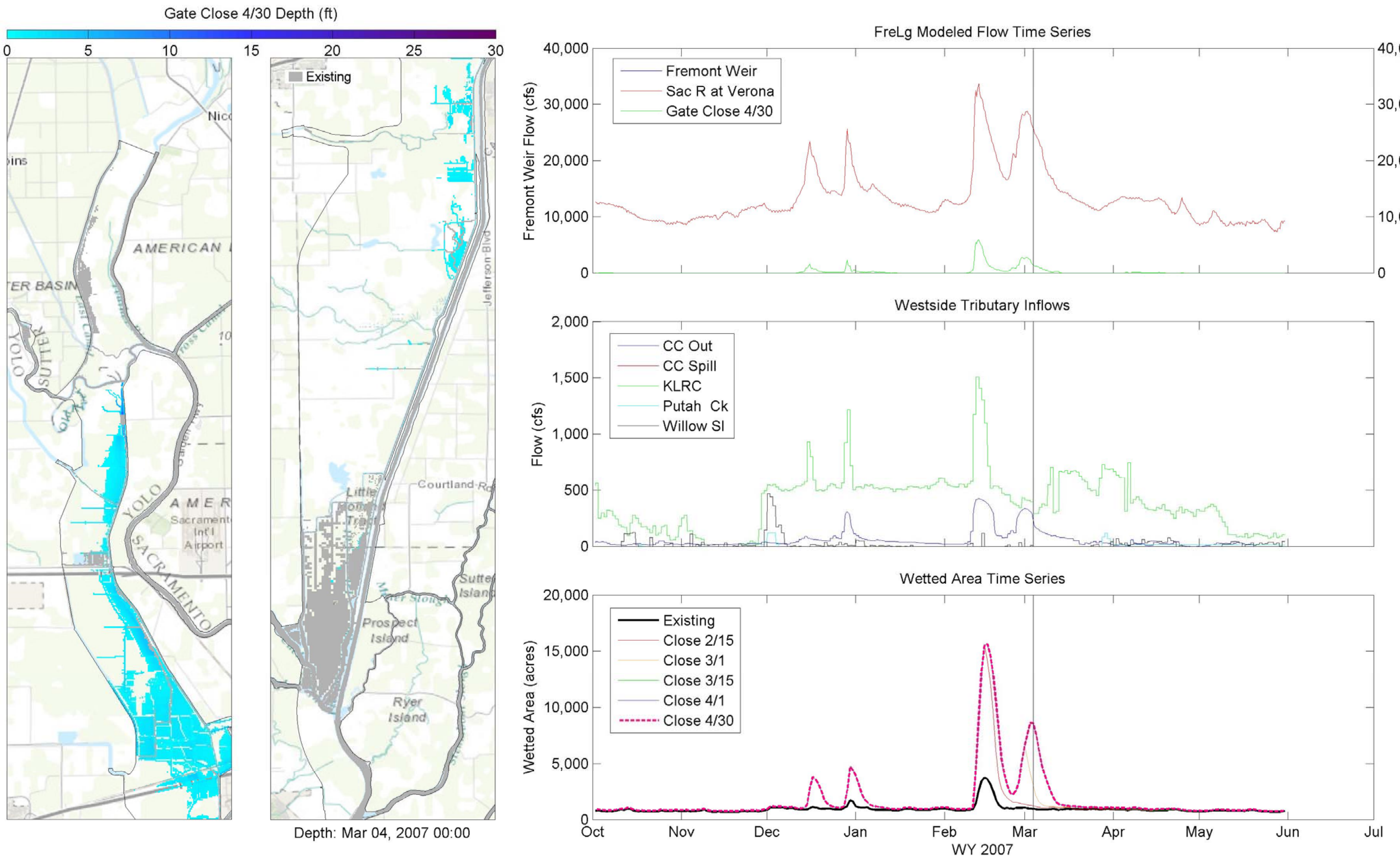


Notes: TUFLOW model results showing 2D inundation patterns (at specified time stamp) for existing and 4/30 gate closure (left panes), Yolo Bypass inflows (upper right panes), and wetted area for all five gate closures (lower right pane). The vertical bar in the right panes corresponds to the time stamp below the left panes, whereby the blue hatching represents 4/30 gate closure conditions as overlain by the grey hatching representing existing conditions.

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area Comparison for WY 2006 for FreLg

Prepared for DWR | Created By: SJB | **Figure E10**



Notes: TUFLOW model results showing 2D inundation patterns (at specified time stamp) for existing and 4/30 gate closure (left panes), Yolo Bypass inflows (upper right panes), and wetted area for all five gate closures (lower right pane). The vertical bar in the right panes corresponds to the time stamp below the left panes, whereby the blue hatching represents 4/30 gate closure conditions as overlain by the grey hatching representing existing conditions.

Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Wetted Area Comparison for WY 2007 for FreLg

Prepared for DWR | Created By: SJB | **Figure E11**