APPENDIX A
ENGINEERING (MODELING ANNEX)

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HYDRODYNAMIC MODELING AND DESIGN EVALUATION OF CANAL PLUG ALTERNATIVES FOR THE BLUE SHANTY FLOWWAY

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EXECUTIVE SUMMARY

The Blue Shanty Flowway (BSF) is a major restoration component of the Central Everglades Planning Project – South (CEPP-S), intended to restore historic sheet-flow connectivity between Water Conservation Areas (WCA) 3A and 3B. Within the BSF, the L-67C Canal is expected to concentrate flow into a preferential conveyance pathway, reducing marsh-to-marsh exchange and increasing the mobilization and transport of canal-derived phosphorus-enriched sediments. Insights from the Decomp Physical Model (DPM) studies provide supporting evidence for this behavior, showing that where canal segments remain unfilled, residual canal conveyance persists, sustaining channelized flow and continued transport of phosphorus-enriched sediments, thereby limiting restoration effectiveness.

A two-dimensional hydrodynamic model (HEC-RAS 2D v6.5) was developed to evaluate restoration alternatives across approximately 64 square miles of WCA-3B. The model was validated against DPM study field data collected during S-152 operations from October–December 2016. Simulated water levels matched observations within ±0.15 ft, and canal discharge comparisons showed excellent agreement (R^2 = 0.99; average difference approximately 6 cfs). Ridge–slough velocity contrasts were reproduced by the model, with root-mean-square errors near 0.02 ft/s. These results confirm that the model reliably represents canal–marsh exchange and marsh hydraulics and is suitable for restoration design evaluation.

Under the CEPP-S future conditions without canal plugs, the L-67C canal continues to function as a dominant conveyance pathway. Simulated canal discharges at multiple transects exceed the ecological performance target of 20 cfs, particularly in southern and mid-canal reaches, and velocities remain substantially higher than adjacent marsh values. Flow fields show persistent longitudinal channelization with limited lateral redistribution. Such channelization also occurs in canal sections where large Active Marsh Improvement (AMI) sloughs span both upstream and downstream sides of the canal. Although CEPP-S structures increase total flow delivery, they do not eliminate residual canal dominance. The baseline future condition therefore fails to meet canal discharge criteria and does not sufficiently reduce channelized transport potential. Consequently, canal plugs were identified as a necessary restoration measure to meet hydraulic performance targets, and multiple plug configurations were evaluated.

Alternative plug configurations demonstrate that four 500-ft or 1000-ft plugs concentrated in the southwestern reach reduced velocities locally but fail to achieve system-wide targets. Long uninterrupted canal segments between plugs allow flow to re-accelerate and maintain preferentially channelized routing indicating that increasing plug length without minimizing uninterrupted canal lengths between the plugs results in concentrating resistance rather than redistributing it, permitting residual channelization to persist.

In contrast, the configuration of four 500-ft marsh-grade plugs supplemented by 28 “mini-plugs” distributed at approximately 1000 ft apart, along the full canal length - achieves sustained system-wide attenuation of flows. In this configuration, canal discharges are reduced below the 20-cfs target at key southern, middle, and northern transects, and slough velocities remain near or below the target 0.1 ft/s, required to minimize ecological damage from internal phosphorous (P) enrichment. Relative to baseline, canal discharges were reduced by over 50% in southern canal segments, and flow fields had consistent lateral redistribution into adjacent marsh and AMI sloughs. Sensitivity analyses evaluating vegetation roughness uncertainty, plug-interface Manning’s *n*, and constructability refinements confirm that this configuration performance is robust. Discharge and velocity targets were consistently maintained across the tested conditions, indicating that hydraulic effectiveness is governed primarily by the cumulative distributed resistance created along the canal system and the interruption of long continuous flow paths, rather than by total fill volume alone. These results suggest that the spatial distribution of resistance features is a key factor controlling overall hydraulic performance.

The modeling results demonstrate that restoration success depends on interrupting conveyance through the L-67C canal. Fewer long plugs provide localized effects but allow flow to re-establish channelized conditions between plug locations. In contrast, distributed resistance from multiple mini-plugs increases energy dissipation along the entire canal, limits re-acceleration, and promotes sustained canal–marsh exchange. Among evaluated alternatives, scenario with seven 500-ft long plugs and twenty-seven 10-ft and one 70 ft mini-plugs, provides the most effective balance between hydraulic performance, ecological protection, robustness, and constructability and offers a defensible basis for advancing restoration design within the Blue Shanty Flowway.

ACKNOWLEDGEMENTS

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Special thanks are extended to Lucine Dadrian for her leadership and support, as well as to the project management team—particularly Julie Mitchell—for her coordination in advancing this effort from initial concept through completion.

Contents

List of Figures

List of Tables

1. BACKGROUND

1.1 Historical Background

The Central Everglades Planning Project – South (CEPP-S) aims to restore more natural sheet-flow patterns and hydrologic connectivity within the central Everglades. A key component within CEPP-S is the Blue Shanty Flowway (BSF), where new flow structures and levee removal are proposed to reestablish connectivity across basins that were compartmentalized and disconnected decades ago. To understand the need for the proposed restoration measures, it is important to briefly review how historical water management practices altered the region's natural hydrology.

Prior to large-scale water management modifications, the Everglades system functioned as an expansive, low-gradient wetland characterized by broad, shallow sheet-flow extending southward from Lake Okeechobee to Florida Bay (**Figure 1**). This natural hydrologic regime sustained a mosaic of ridges, sloughs, and tree islands, with seasonal variations in flow depth and duration that supported diverse ecological communities and maintained sediment and nutrient balance.

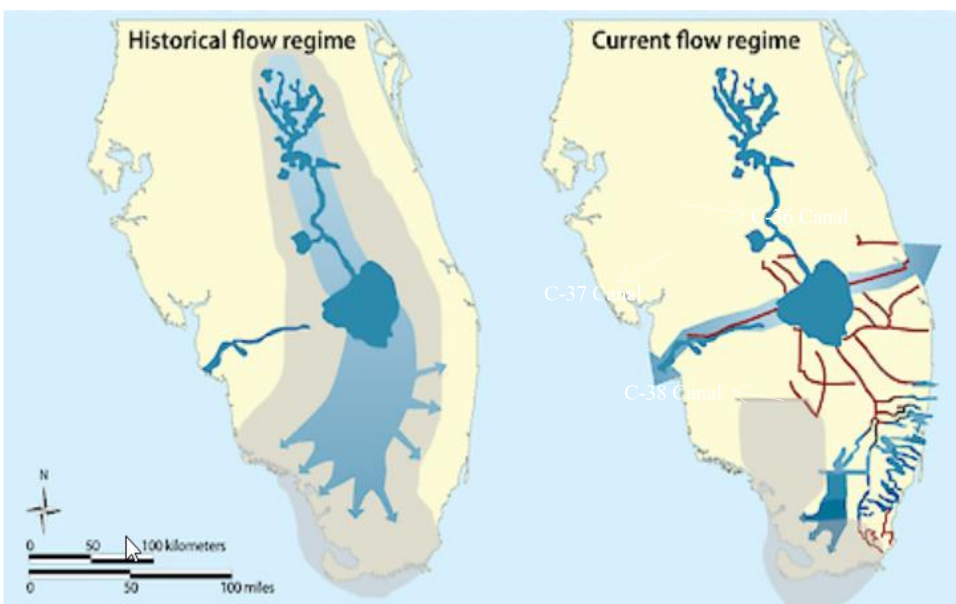


Figure 1. Comparison of Historical and Current Flow Pattern in South Florida

Beginning in the mid-20th century, regional flood control and water-supply projects led to the construction of levees, canals, and control structures that compartmentalized the landscape into distinct Water Conservation Areas (WCAs). These features—including the L-67A, L-67C, and L-

29 canals and levees diverted water from diffuse overland sheet-flow into channelized pathways, fundamentally altering hydropatterns and disrupting the connectivity of ridge-and-slough ecosystems. As a result, wetland hydroperiods were shortened in some areas and lengthened in others, contributing to vegetation shifts, habitat degradation, and localized phosphorus enrichment.

1.2 Central Everglades Planning Project – South (CEPP-S)

The Central Everglades Planning Project (CEPP) is a major component of the Comprehensive Everglades Restoration Plan (CERP), jointly implemented by the U.S. Army Corps of Engineers (USACE) and the South Florida Water Management District (SFWMD). The overarching goal of CEPP is to restore the quantity, quality, timing, and distribution of freshwater flows through the central and southern Everglades, reconnecting Lake Okeechobee and the WCAs to the downstream wetlands of Everglades National Park (ENP) and Florida Bay.

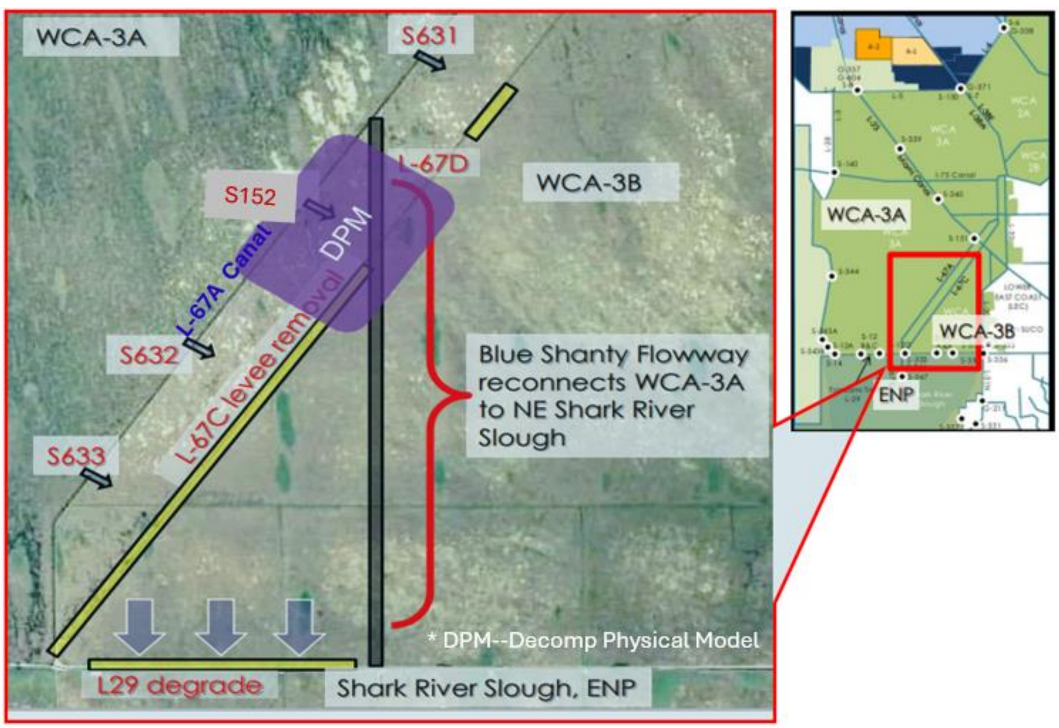


Figure 2. The location of CEPP-S.

The goal of CEPP-S (**Figure 2**) is to restore natural hydrologic patterns, sheet-flow, and connectivity between WCA-3A and WCA-3B, areas that have been hydrologically isolated by mid-century flood-control infrastructure. The project includes a suite of structural and operational measures intended to re-establish overland flow connectivity and improve water distribution across the marsh. Key components include:

- Construction of new flow conveyance structures (S-631, S-632, and S-633) along the L-67A Levee.
- Degradation of several miles of the L-67C Levee to enhance marsh exchange.
- Construction of the L-67D Levee and removal of a portion of the L-29 Levee to promote southward flow (from WCA-3B to ENP).
- Optimize flow through the operations at key structures (e.g., S-152, S-631, S-632, and S-633) to increase southward delivery of clean freshwater.

Together, these actions are designed to alleviate over-drainage in northern WCAs, restore more natural hydroperiods, enhance habitat connectivity, and support the broader CEPP objective of increasing freshwater flow to the central and southern Everglades.

1.3 Blue Shanty Flowway (BSF) - Overview

The Blue Shanty Flowway (BSF) (**Figure 2**) is one of the major restoration features in CEPP-S, located between the L-67A Levee to the west and the new L-67D Levee to the east, and extending south to the L-29 Canal. The project is designed to re-establish natural sheet-flow pathways and improve hydrologic connectivity between WCA 3A and WCA 3B by removing artificial barriers and restoring the landscape's hydraulic continuity.

Prior to implementation of CEPP-S, a landscape-scale field test, known as the Decomp Physical Model (DPM), was conducted to evaluate the benefits of restoring sheet-flow within the Everglades ridge and slough landscape and the effectiveness of canal backfilling. The DPM study was implemented within "The Pocket," a test area situated between the L-67A and L-67C Levees, which included the S-152 culvert structure at the north end, three 1000-ft backfill treatments (Complete-Fill, Partial-Fill, and No-Fill) within the L-67C Canal, and a 3000-ft degraded section of the levee adjacent to the backfill treatments.

DPM results demonstrated that restored sheet-flow can yield ecological benefits, including the re-establishment of sediment-transport processes that maintain natural microtopography and improvement of habitat quality for both aquatic and terrestrial organisms. However, the experiment also revealed that areas with concentrated, high-velocity flows (> 0.1 ft/s), typically occurring near the S-152 culvert outflow, resulted in damaging phosphorus loading, phosphorus-enrichment of sediments, and eventual cattail invasion. In the unfilled sections of the L-67C Canal, high canal velocities mobilized phosphorus-enriched sediments that were subsequently deposited in downstream marshes. Total phosphorus (TP) concentrations exceeded 500 mg/kg in flocculent sediments downstream of the No-Fill canal treatment, coinciding with visible invasion of cattails into the adjacent marsh (**Figure 3** & **Figure 4**). Together, these findings demonstrated that successful flow restoration efforts must also minimize the occurrence of marsh velocities >0.1 ft/s and minimize channelized conveyance in canals that can transport nutrient-enriched sediments.

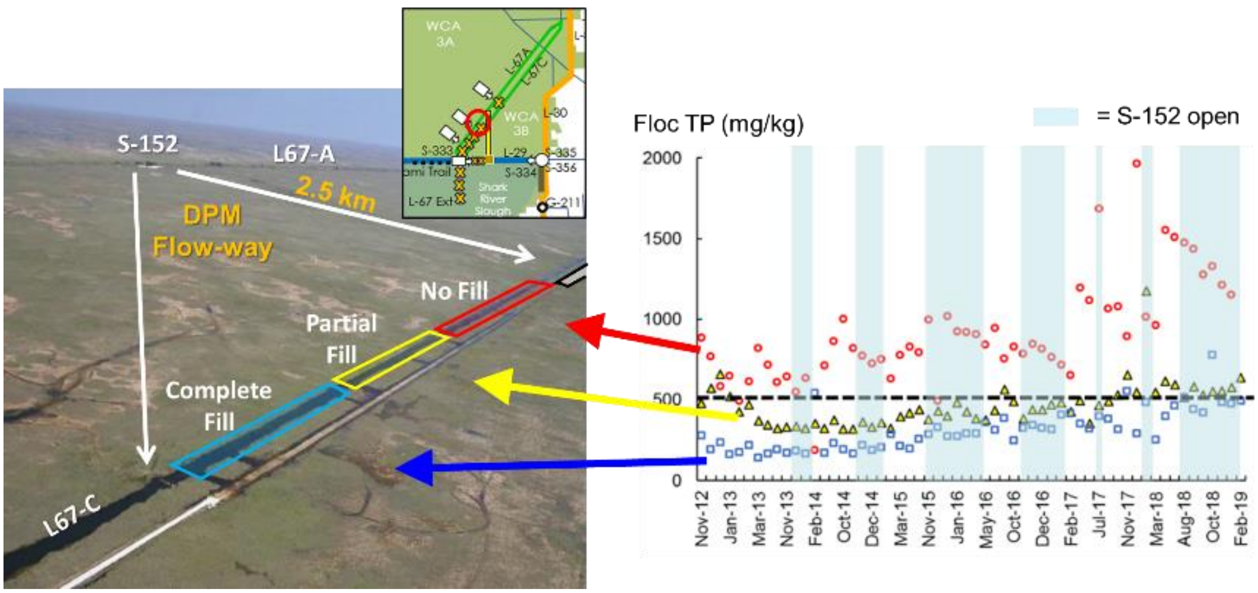


Figure 3. Total phosphorus (TP) Levels in Flocculent Sediments Downstream of the No-Fill Canal

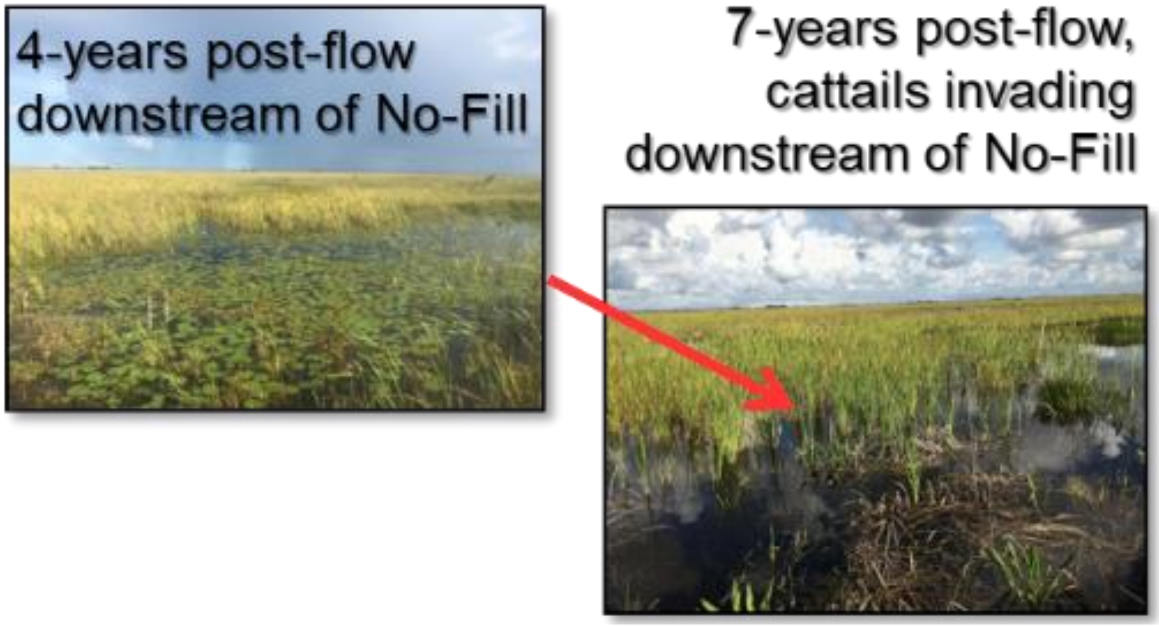


Figure 4. Invasion of Cattails in Marshes Downstream of the No-Fill treatment in The DPM Study

While the DPM experiment provided valuable empirical understanding of flow redistribution and ecological response, its footprint and treatments were limited in spatial scale. As documented in the South Florida Environmental Report, these findings cannot be directly extrapolated to the full CEPP-S project area, where additional levee degradation, canal backfilling, and operational modifications are expected to alter flow patterns at a broader landscape scale (Sklar, 2023; SFWMD, 2025). Consequently, a numerical hydrodynamic modeling framework was required to evaluate how proposed restoration configurations would influence water distribution and canal–marsh exchange across the entire BSF.

1.4 Purpose and Modeling Objectives

The hydrodynamic Blue Shanty Flowway Model (BSFM) was developed and applied to support the evaluation of restoration alternatives within the BSF. The model serves as a screening-level analytical tool to assess alternative design scenarios, including: (i) L-67C levee degradation extents; (ii) L-67C canal backfilling and plug configurations; and (iii) swale and conveyance alignments associated with the S-152, S-631, S-632, and S-633 inflow structures.

Although the broader CEPP-S design includes several structural modifications intended to promote sheet-flow continuity, the current plan does not extend canal backfilling beyond the original DPM

(S-152) treatment area. Consequently, residual canal conveyance may continue diverting water away from adjacent marshes, potentially reducing restoration effectiveness. The hydrodynamic model provides a technical framework for evaluating canal-plug alternatives that can reduce residual canal flow, enhance marsh-to-marsh hydraulic connectivity, and minimize downstream transport of phosphorus-enriched sediments, thus improving the capacity to achieve restoration goals.

The modeling effort is part of SFWMD technical evaluation of CEPP-S design concepts. The model represents overland sheet-flow, canal conveyance, and canal–marsh exchange processes that govern the hydrodynamics of the BSF and adjacent WCAs. Model selection and development details are discussed in subsequent sections of this report.

The modeling study has two primary objectives:

1) Model Reality Check — To develop and calibrate a model that can reproduce observed hydrologic conditions from October through December 2016, ensuring that simulated stages, discharges, and velocity fields reflect measured system behavior, within reasonable accuracy (hence the term reality check).
2) Restoration Design Evaluation — To apply the calibrated model as a screening tool to assess alternative canal-backfilling and plug configurations aimed at reducing channelized flow, improving marsh-to-marsh connectivity, and limiting downstream transport of nutrient-enriched sediments.

Through the integration of field observations, numerical simulation, and ecological performance benchmarks, this study supports CEPP-S implementation by identifying effective canal-plug and backfill design concepts that promote sheet-flow restoration and long-term ecological recovery in the central Everglades.

2. HYDRODYNAMIC MODEL DEVELOPMENT AND REALITY CHECK

2.1 Modeling Approach using HEC-RAS 2D

The hydrodynamic modeling for the BSFM was conducted using the HEC-RAS two-dimensional (2D) unsteady flow model (version 6.5) developed by the USACE Hydrologic Engineering Center. HEC-RAS 2D solves the depth-averaged shallow water equations and is well suited for simulating overland sheet-flow, canal conveyance, and canal–marsh exchange processes that govern hydrodynamic behavior in the BSF. The model is capable of representing the interaction between microtopography, wetland vegetation flow resistance, and channelized flow pathways, which collectively determine both natural and restoration-altered flow responses.

A key advantage of HEC-RAS 2D is the adaptive mesh refinement, which allows the model grid to be selectively refined along hydrologically sensitive features such as the L-67C Canal, AMI slough alignments, and proposed canal plug and backfill locations. This refinement approach preserves computational efficiency without compromising the ability to resolve localized velocity gradients and flow transitions. In addition, HEC-RAS employs a sub-grid hydraulic property method, in which terrain and vegetation characteristics at a finer resolution than the computational mesh is used to calculate conveyance and wetted area. This approach improves representation of ridge-and-slough topography, marsh roughness, and canal geometry while reducing numerical instability.

The modeling workflow and review structure associated with HEC-RAS align with established SFWMD and USACE hydrologic and hydraulic evaluation practices, allowing the model to be readily documented, communicated, and reviewed. HEC-RAS 2D has been applied in multiple SFWMD studies, including canal conveyance capacity evaluations, Kissimmee River Restoration hydrodynamics, dam breach simulations, and several Everglades wetland flow analyses. Because of this institutional familiarity and proven capability to represent canal–marsh connectivity, HEC-RAS 2D was selected as the modeling platform for the BSF.

2.2 Reality Check Study – Overview and Objectives

The first stage of model application involved a Reality Check to assess whether the calibrated modeling framework described in Section 2.1 could accurately reproduce observed hydrologic conditions in the BSF under real operational drivers. The period from October through December 2016 was selected because it captured a complete operational cycle at S-152, including initial low flows, increasing discharge during gate opening, peak discharge conditions, and subsequent decline during gate closure.

The Reality Check therefore served two primary purposes: (1) to verify that simulated stages, discharges, and velocity fields reflect measured system behavior during a well-documented hydrologic event; and (2) to establish confidence in applying the model as a screening-level analytical tool for evaluating alternative canal-backfilling, plug configurations, and related restoration design measures.

Model performance was evaluated by comparing simulated water levels, canal discharges, and velocity patterns with field measurements collected from hydrologic monitoring stations and Acoustic Doppler Current Profiler (ADCP) transects. The model was intended to simulate water surface elevations that generally agreed with observed water levels within approximately 0.15 ft, both near S-152 and within Interior WCA 3B. In addition, the model was expected to successfully reproduce the ~90–100 cfs peak discharge measured in the L-67C Canal, downstream of S-152, as well as the progressive attenuation of flow along the canal with distance from S-152. Simulated velocity patterns were expected to show clear differentiation between sloughs and emergent marsh areas, consistent with observed ridge-and-slough hydraulic behavior.

Because of the importance of assessing backfilling in future scenarios, the Reality Check model also aimed to reproduce the observed reductions in canal flow velocity in reaches where partial backfilling had previously been implemented in the DPM study area, demonstrating accurate representation of canal-to-marsh hydraulic exchange and attenuation of channelized flow. Achieving these model performance objectives was necessary to confirm that the model successfully captured the dominant hydrodynamic processes governing water movement within the BSF and could provide a reliable foundation for subsequent evaluation of CEPP-S restoration scenarios.

2.3 Reality Check Model development

2.3.1 Model Domain, Terrain, land use and Geometry

The model domain encompasses approximately 64 square miles of WCA 3B. It is bounded by the L-67A Levee to the west, the L-29 Canal to the south, a marsh boundary to the north, and a marsh boundary approximately 4 miles east of the proposed L-67D Levee. These boundaries were established through coordination meetings among project team members to ensure inclusion of all hydraulically significant features influencing the BSF. The domain also captures adjacent marsh areas necessary to simulate canal–marsh exchange and regional boundary interactions.

The base terrain is derived from the CEPP Watershed Digital Terrain Model (DTM) at 5-ft horizontal resolution (USACE, 2020). This elevation dataset was augmented with surveyed bathymetry of the L-67C Canal, as well as detailed elevation data representing levee degradations, backfill treatments, and canal gaps (SFWMD, C. Carlson) (**Figure 5**). These refinements ensure accurate hydraulic representation of channel geometry and topographic variation within the flowway.

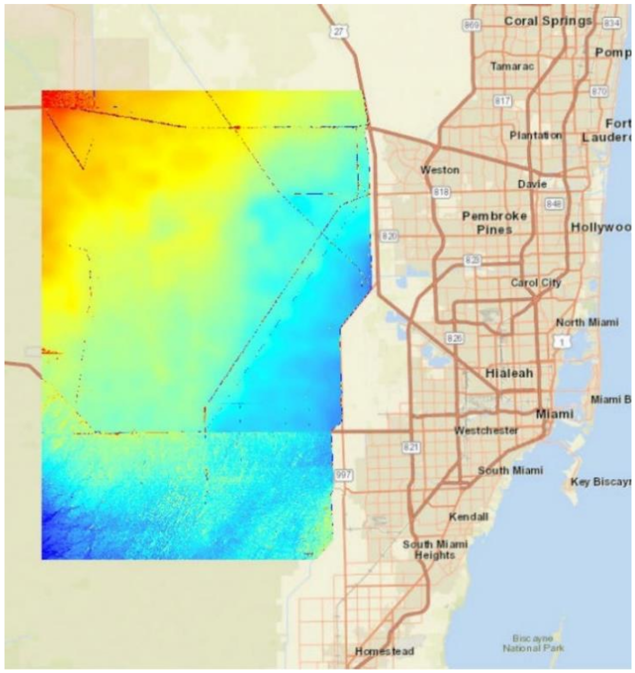


Figure 5. CEPP Digital Elevation Model (DEM)

The hydrodynamic model employs a two-dimensional (2D) unsteady-flow domain discretized using an adaptive mesh refinement approach. Cell resolution is locally refined along hydraulically sensitive features, including: the L-67C Canal and Levee; DPM backfill treatments; marsh areas adjacent to the L-67C Canal; and marsh areas near the S-152 (**Figure 6**). This refinement strategy enables the model to resolve local hydraulic gradients and flow transitions while maintaining computational efficiency at the landscape scale.

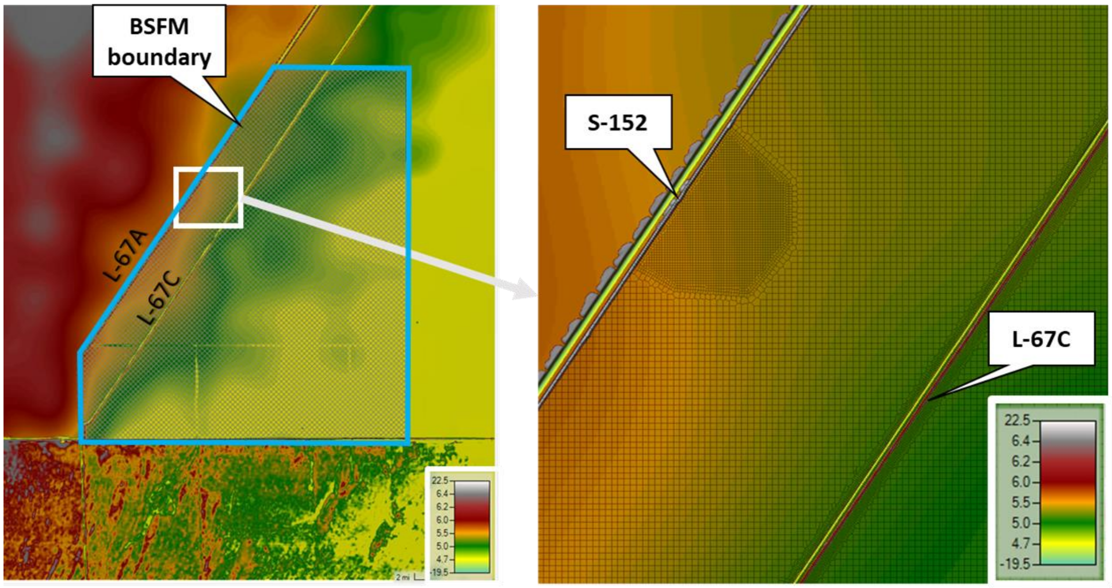
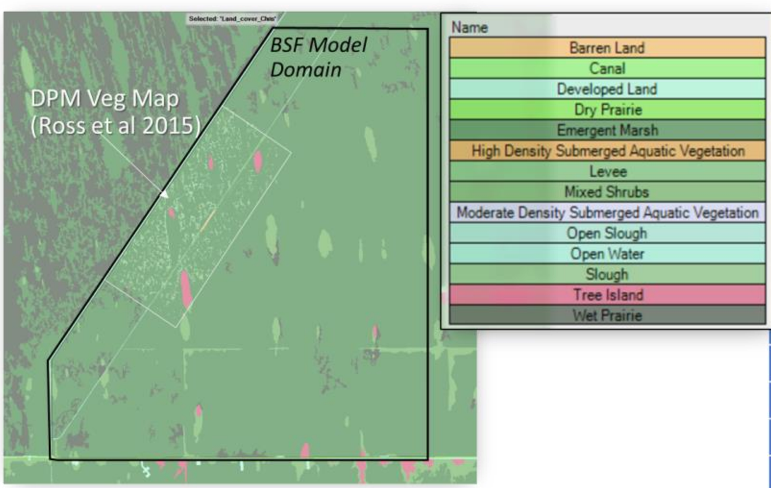


Figure 6. Model Domain and Finer Grid around Culverts, Canal/Levee

Land cover within the model domain was represented using a composite dataset combining the 2017–2019 SFWMD Land Cover Map (SFWMD 2022) with the DPM vegetation classification (Ross et al., 2015). The domain includes 14 land-use and vegetation types; each assigned an initial Manning's *n* roughness coefficient based on SFWMD (2005) guidance (**Figure 7**).



	Land use Classification	Manning's *n*
1	Barren Land	0.06
2	Canal	0.04
3	Developed Land	0.07
4	Dry Prairie	0.85
5	Emergent Marsh	1.15
6	High Density SAV	1.2
7	Levee	0.07
8	Mixed Shrubs	1.5
9	Moderate Density SAV	1.0
10	Open Slough	0.13
11	Open Water	0.04
12	Slough	0.35
13	Tree Island	1.5
14	Wet Prairie	0.85

Figure 7. Manning's n Map & Values (Local Adjustment Values Not Included)

During model calibration, these coefficients were iteratively adjusted to reproduce observed hydrologic responses, including water-level distributions, ridge-and-slough velocity contrasts, and attenuation of canal flow. In particular, emergent marsh vegetation in WCA 3B imposes high hydraulic resistance due to combined effects of surface roughness and vegetation drag. The final calibrated roughness coefficients ensure that simulated marsh hydraulics and canal–marsh exchange behavior are consistent with the 2016 field observations.

2.3.2 Boundary Conditions and Forcing

Simulation Period

The Reality Check simulation covered the period from October 1 through December 31, 2016, which captured a complete operational cycle at Structure S-152. During this interval, operations progressed from minimal inflow conditions to a peak discharge exceeding 300 cubic feet per second (cfs), followed by gradual gate closure. This period provided a representative dataset for assessing hydrodynamic response under variable flow conditions.

It is also important to note that the existing WCA 3B system is primarily a rainfall-driven basin, with structural inflows mainly from S-152 and S-151, in addition to seepage and direct rainfall contributions. Outflows are generally limited to seepage and evapotranspiration (ET). This reality check scenario differs from the completed Blue Shanty Flowway future plan condition, which includes additional outflow pathways associated with the degraded L-29 levee configuration.

Boundary Condition Framework

A total of seven boundary conditions were applied to define inflows, outflows, and internal hydraulic exchanges within the model domain (**Figure 8**). These boundaries include both observed time-series inputs and distributed flux representations derived from regional model outputs.

Inflow Boundary

S-152 Inflow Time Series – The principal inflow boundary was applied at the S-152 culvert structure, using the observed flow record from SFWMD field monitoring stations (**Figure 9**). The time-varying discharge hydrograph was directly imposed as an inflow condition to simulate water entering the BSF.

Seepage and Internal Exchange Boundaries:

- West Boundary Seepage Inflow – Seepage inflow across the western domain boundary (along the L-67A Levee) was represented as a distributed flux condition. Initial seepage rates were directly adopted from the Regional Simulation Model – Glades-LECSA (RSM-GL) and subsequently refined during calibration by distributing the seepage uniformly along the L-67A Levee to better match observed interior stages.
- Internal Seepage Outflow from the Pocket (~200 cfs) – Outflow from the central Pocket area was represented by a distributed seepage boundary, with an approximate magnitude of 200 cfs, based on observed gradients and regional model estimates.
- Internal Seepage Inflow to Interior WCA 3B (~200 cfs) – A corresponding inflow boundary of similar magnitude was applied from the Pocket area into Interior WCA 3B to maintain mass balance and replicate observed internal exchange between compartments.

Stage (Water-Level) Boundaries:

- North-West Stage Boundary Condition – Water levels along the northwestern boundary were defined using stage data from station 3-69E, modified to reflect the hydraulic influence of the 1,000-ft L-67C Levee gap.
- North-East Stage Boundary Condition – The northeastern boundary was specified using station 3-71 data. To account for the hydraulic influence of the adjacent L-67C Levee gap, the Station 3-71 stage was slightly reduced by 0.05 ft to better reproduce the observed L-67C Levee gap outflow conditions during model calibration. East Stage Boundary Condition – The eastern boundary incorporated observed water-level data from stations 3-71 and SRS-1, ensuring accurate representation of hydraulic gradients along the L-67D alignment and the eastern marsh interface.

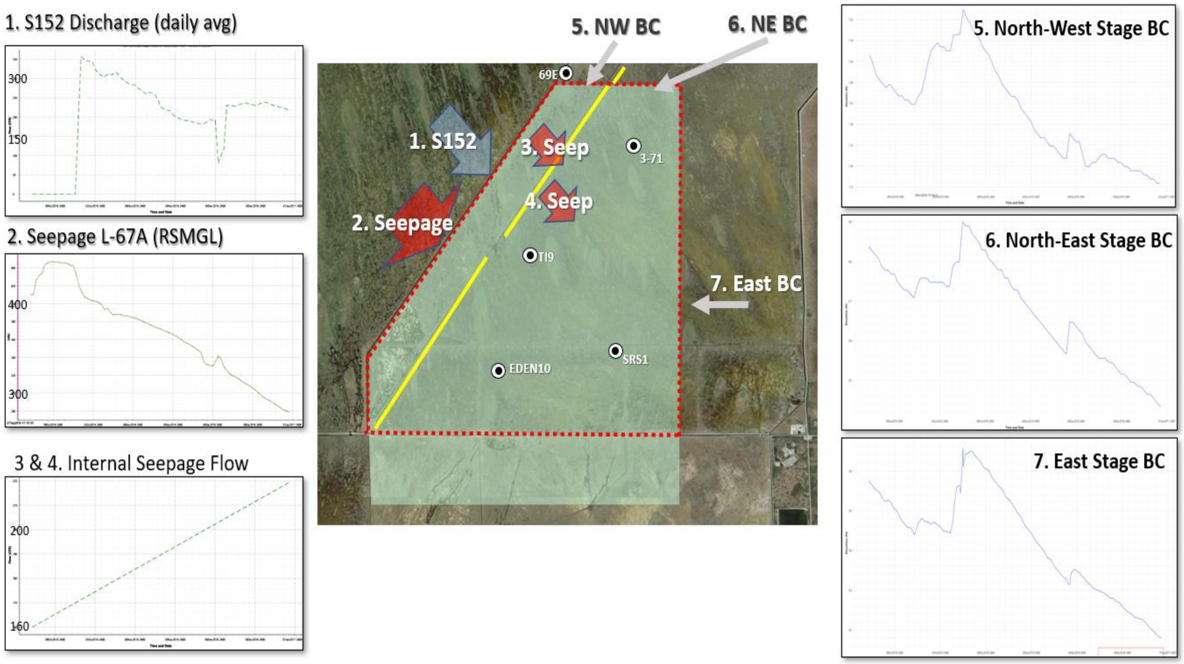


Figure 8. Boundary Conditions of the Model

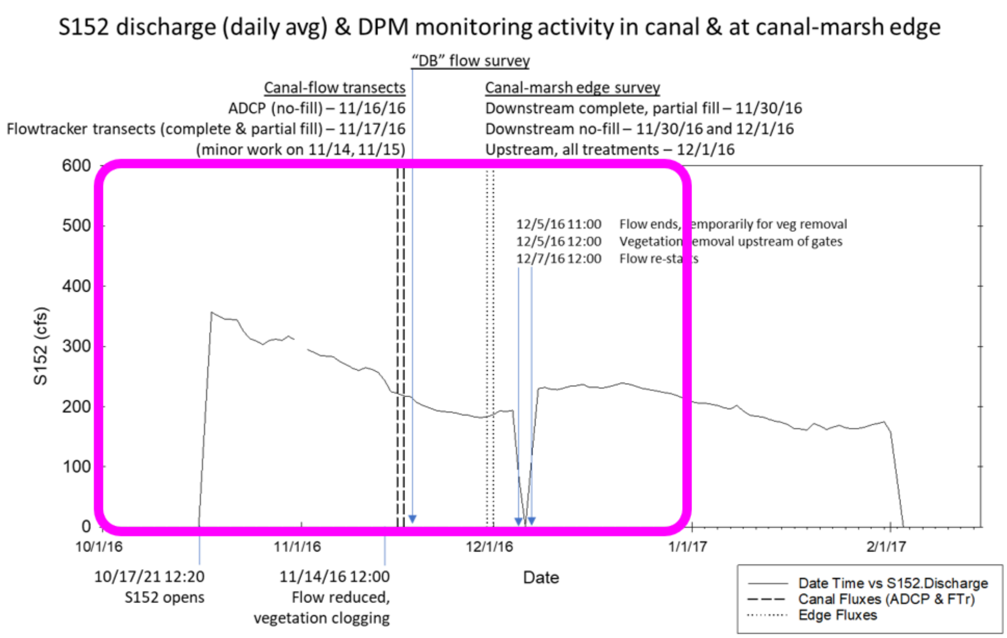


Figure 9. S-152 Inflow Time Series

2.4 Reality Check model Results

Model performance during the October–December 2016 Reality Check period is summarized below. During this period, gate operations transitioned from no initial inflow to a peak discharge exceeding 300 cubic feet per second (cfs), followed by gradual closure. This event provided an ideal dataset for validating the model's ability to reproduce measured hydrodynamic conditions across the BSF.

The Reality Check evaluation focused on comparing simulated and observed water stages, canal discharges, and flow velocities collected from fixed monitoring stations and field surveys within the L-67C Canal and adjacent marshes. The objective was to verify that the calibrated hydrodynamic model accurately reproduces the hydraulic behavior observed in the field and provides a defensible foundation for subsequent restoration-scenario evaluations.

2.4.1 Water-Stage Comparison and Validation

Good agreement between simulated and observed stages was demonstrated at representative stations in the Pocket and Interior 3B (**Figure 10)**. In the near-field region around S-152, the difference between simulated and observed stages averaged approximately 0.15 ft. This difference decreased to 0.10 ft at sites upstream and downstream of the levee gap. South of the Pocket, the average deviation further reduced to 0.05 ft. In the Interior WCA 3B marshes, simulated and observed stages at stations TI-9, 3-71, SRS-1, and EDEN-10 differed by less than 0.10 ft, demonstrating that the model successfully reproduced the downstream attenuation of stage gradients. Overall, the simulated water-surface elevations closely follow the measured hydrographs, with consistent timing and amplitude of stage fluctuations, indicating strong model performance over the entire domain.

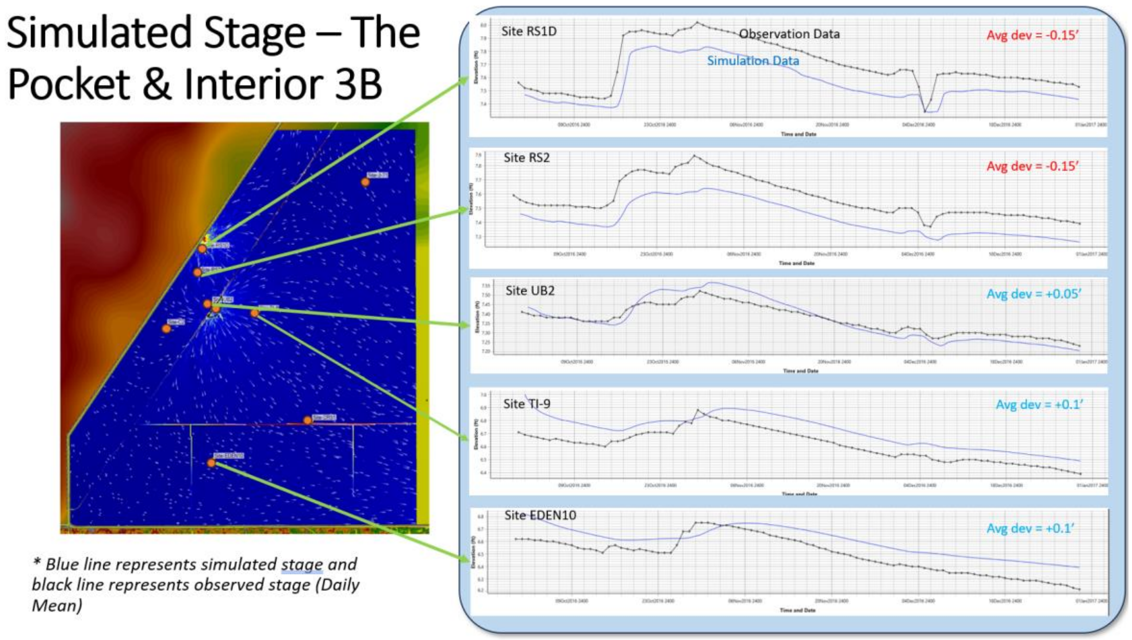


Figure 10. Reality Check: Water-Stage Comparison at Representative Sites

The magnitude of agreement observed here is significantly better than the commonly accepted 0.5-ft head-difference criterion used in comparable regional hydrodynamic studies. This high level of consistency demonstrates that the model faithfully reproduces stage propagation, spatial gradients, and marsh-canal hydraulic coupling, thereby validating its capability for CEPP-South restoration design analysis.

2.4.2 Flow and Velocity Evaluation

Flow-field comparisons between model results and field measurements confirmed that the model captures the key hydraulic patterns within the BSF. At the system scale, the simulated velocity vectors depict radial flow dispersion near S-152, preferential eastward flow along the L-67C Canal, and progressive velocity attenuation toward the south, matching field observations and DPM study results (**Figure 11**).

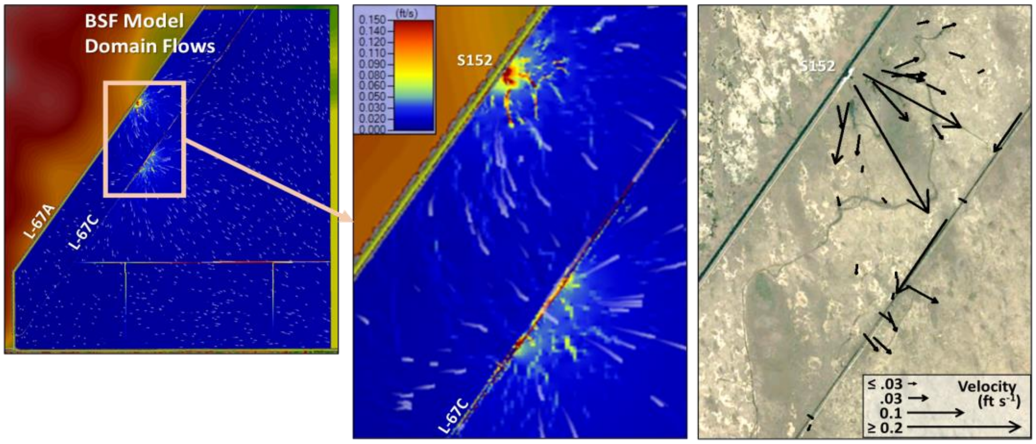


Figure 11. Flow fields simulated by the BSFM ac4, the full model domain (left) and within the DPM study area (middle). (Right) Observed flowfields from the DPM study averaged over the 2013, 2014, and 2015 flow events (adapted from Sklar and Dreschel 2017; site location indicated by arrow base).

DPM Pocket Outflow and Northern Canal Reaches: Simulated outflow through the DPM levee gap was 267 cfs, similar in magnitude to observations of 230–250 cfs. Outflow at the northern boundary, 170 cfs also showed good agreement with measured values (150 cfs; **Figure 12**). Canal discharge near the northern boundary of the model was 65 cfs, consistent with the 2022 observed estimates of 60 cfs (**Figure 13**). At a canal location approximately 3,000 ft north of the levee gap, the simulated discharge was 55 cfs, similar to a 2019 observed value of 63 cfs (**Figure 13**). This close agreement indicates that the model accurately represents flow redistribution from the S-152 throughout the Pocket and far reaches of the L-67C Canal.

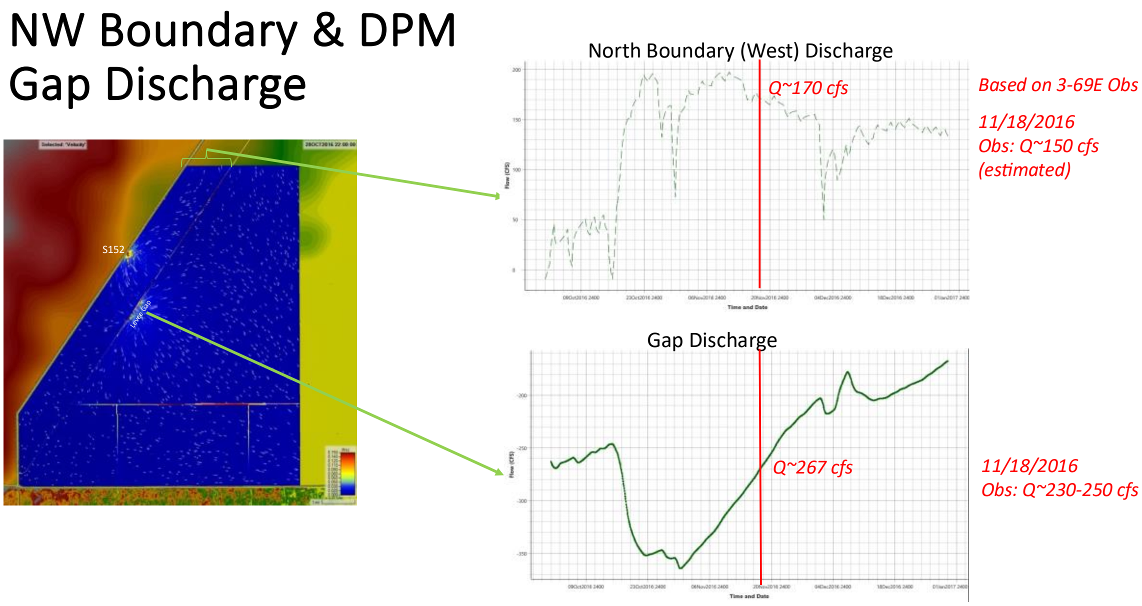


Figure 12. Reality Check: Comparison of DPM Pocket Outflow

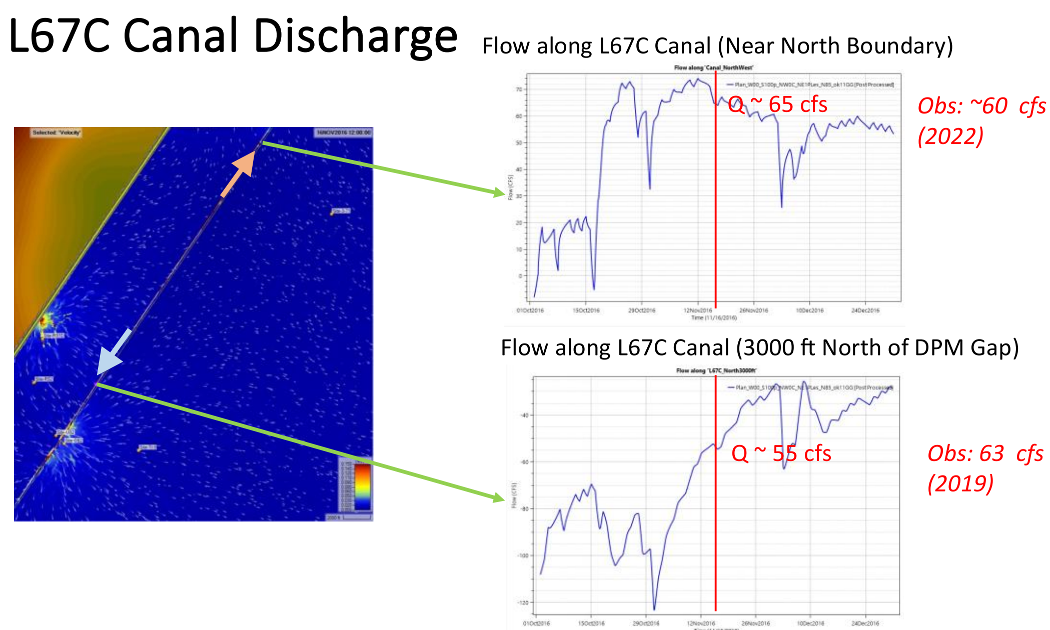
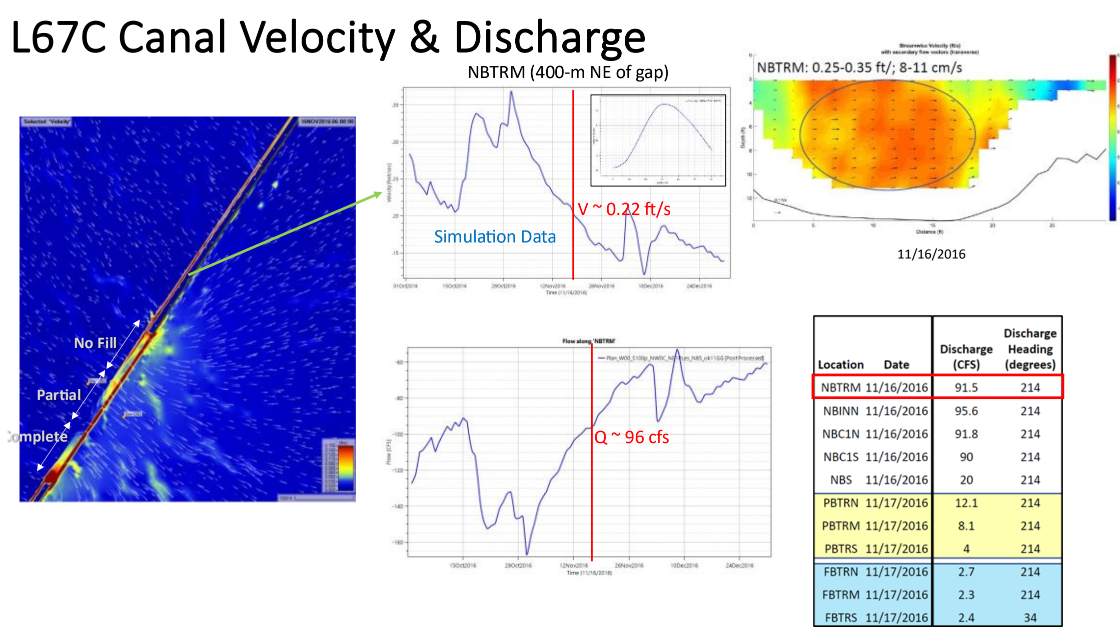


Figure 13. Reality Check: L67C Canal Discharge Comparison

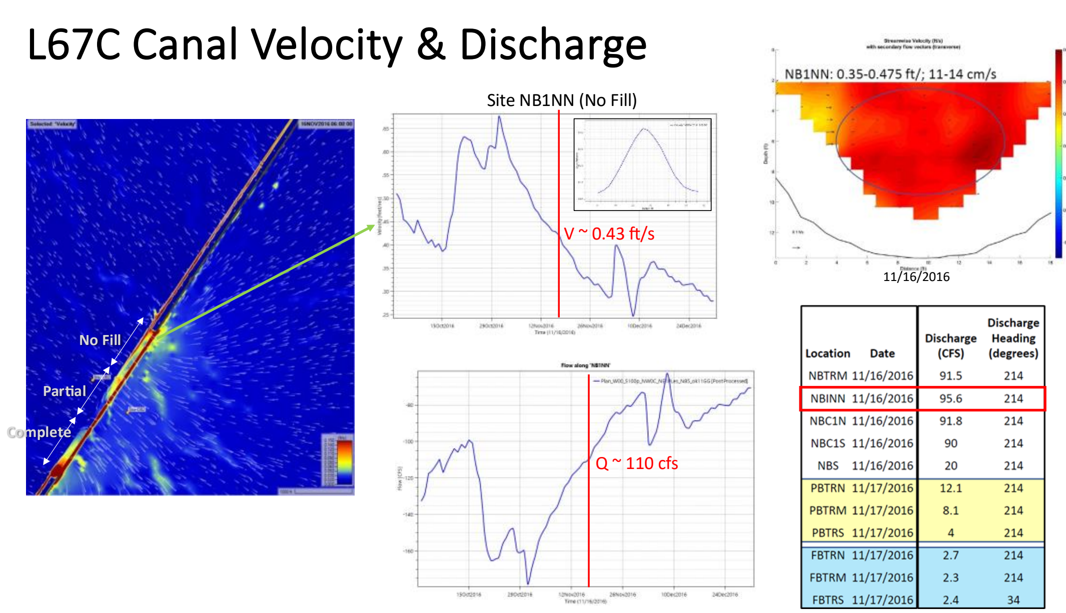
Canal Flow at the DPM Levee Gap. The BSFM successfully reproduced canal discharges at sites located near (within 500-ft) the canal backfills treatments. At a site ~500-ft north of the No-Fill treatment (NBTRM Transect, **Figure 14**) the simulated mid-channel velocity of 0.22 ft/s, closely matched the ADCP-measured range of 0.25–0.35 ft/s, with simulated and observed discharges of

96 and 91.5 cfs, respectively. At another site ~100-ft north of the No-Fill treatment (NB1NN, **Figure 15**) the simulated velocity (0.43 ft/s) and discharge (110 cfs) compared favorably with observed values (0.35–0.48 ft/s and 95.6 cfs, respectively), confirming accurate representation of concentrated flow conditions in unfilled canal segments.



Location	Date	Discharge (CFS)	Discharge Heading (degrees)
NBTRM	11/16/2016	91.5	214
NBINN	11/16/2016	95.6	214
NBC1N	11/16/2016	91.8	214
NBC1S	11/16/2016	90	214
NBS	11/16/2016	20	214
PBTRN	11/17/2016	12.1	214
PBTRM	11/17/2016	8.1	214
PBTRS	11/17/2016	4	214
FBTRN	11/17/2016	2.7	214
FBTRM	11/17/2016	2.3	214
FBTRS	11/17/2016	2.4	34

Figure 14. Reality check: Canal Velocity and Discharge at NBTRM Transect (No-Fill Reach)



Location	Date	Discharge (CFS)	Discharge Heading (degrees)
NBTRM	11/16/2016	91.5	214
NBINN	11/16/2016	95.6	214
NBC1N	11/16/2016	91.8	214
NBC1S	11/16/2016	90	214
NBS	11/16/2016	20	214
PBTRN	11/17/2016	12.1	214
PBTRM	11/17/2016	8.1	214
PBTRS	11/17/2016	4	214
FBTRN	11/17/2016	2.7	214
FBTRM	11/17/2016	2.3	214
FBTRS	11/17/2016	2.4	34

Figure 15. Reality check: Canal Velocity and Discharge at NB1NN Transect (No-Fill Reach)

Simulated canal discharge at sites adjacent to the levee gap also demonstrated good agreement with observations. Near the canal plug separating the No-Fill and Partial-Fill treatments (NBS Transect, (**Figure 16**) modeled mid-channel velocity (0.07 ft/s) and discharge (17 cfs) matched measured values (0.1–0.2 ft/s, 20 cfs), illustrating the model's ability to reproduce flow attenuation and lateral redistribution into adjacent marsh areas.

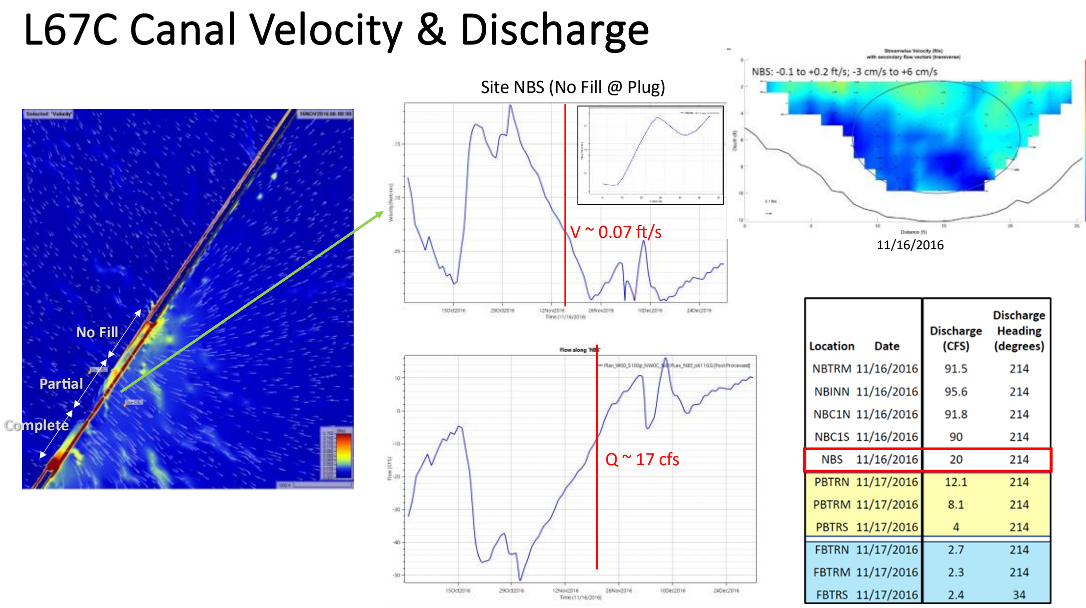
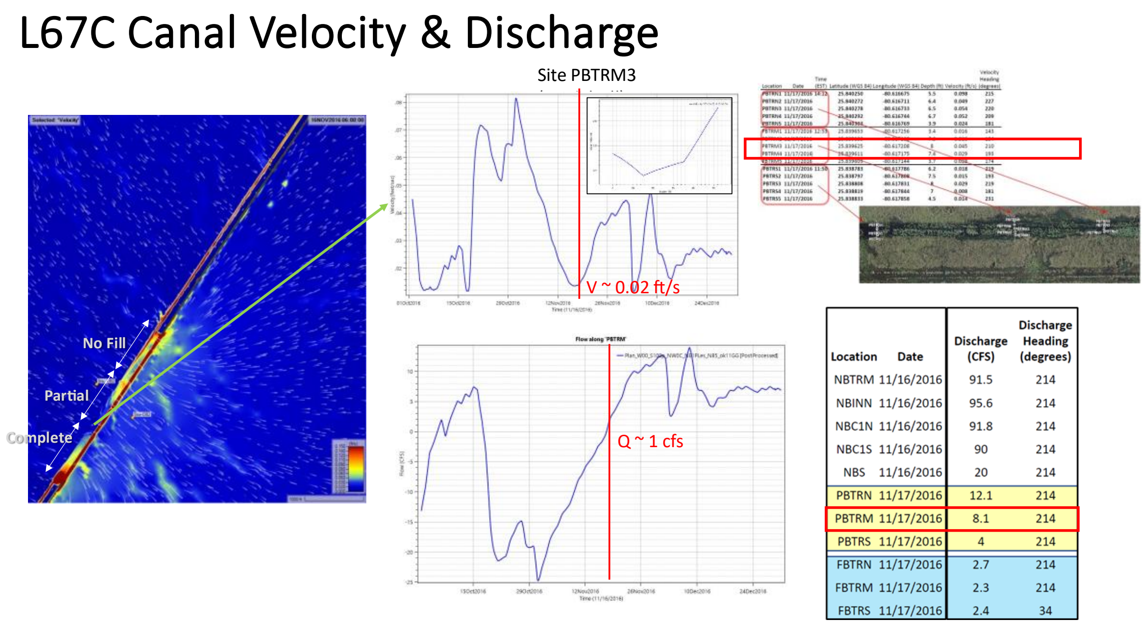


Figure 16. Reality check: Canal Velocity and Discharge at NBS Transect (Near Canal Plug)

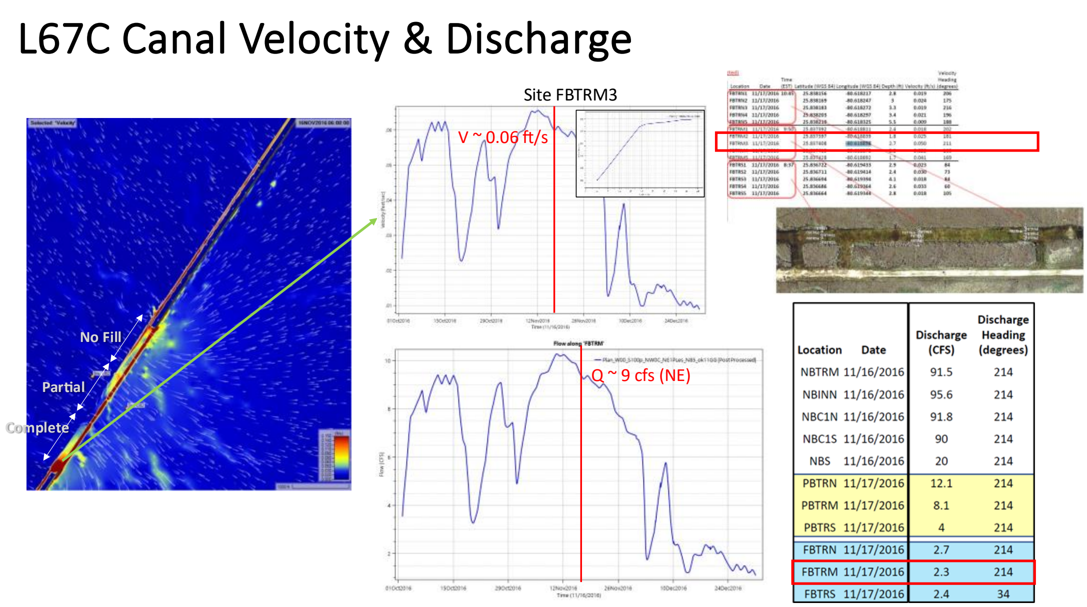
For PBTRM3 (Partial-Fill Reach), the model simulated a mean velocity of 0.02 ft/s and discharge of 1 cfs, compared to observed 0.03–0.05 ft/s and 8 cfs, confirming substantial hydraulic energy loss across the partial-fill treatment (**Figure 17**).



Location	Date	Discharge (CFS)	Discharge Heading (degrees)
NBTRM	11/16/2016	91.5	214
NBINN	11/16/2016	95.6	214
NBC1N	11/16/2016	91.8	214
NBC1S	11/16/2016	90	214
NBS	11/16/2016	20	214
PBTRN	11/17/2016	12.1	214
PBTRM	11/17/2016	8.1	214
PBTRS	11/17/2016	4	214
FBTRN	11/17/2016	2.7	214
FBTRM	11/17/2016	2.3	214
FBTRS	11/17/2016	2.4	34

Figure 17. Reality Check: Canal Velocity and Discharge at PBTRM3 (Partial-Fill Reach)

At location FBTRM3 (Complete-Fill Reach), simulated velocity (0.06 ft/s) and discharge (9 cfs) were consistent with observed values (0.03–0.05 ft/s, 2.3 cfs), indicating near-stagnant flow and verifying that complete backfilling effectively eliminated channelized conveyance (**Figure 18**).



Location	Date	Discharge (CFS)	Discharge Heading (degrees)
NBTRM	11/16/2016	91.5	214
NBINN	11/16/2016	95.6	214
NBC1N	11/16/2016	91.8	214
NBC1S	11/16/2016	90	214
NBS	11/16/2016	20	214
PBTRN	11/17/2016	12.1	214
PBTRM	11/17/2016	8.1	214
PBTRS	11/17/2016	4	214
FBTRN	11/17/2016	2.7	214
FBTRM	11/17/2016	2.3	214
FBTRS	11/17/2016	2.4	34

Figure 18. Reality check: Canal Velocity and Discharge at FBTRM3 (Complete-Fill Reach)

These results collectively demonstrate that the model accurately replicates the transition from concentrated canal flow in unfilled reaches to diffused sheet-flow in backfilled and marsh areas, consistent with field observations.

2.4.4 Statistical Performance

Quantitative comparison of simulated and observed discharges and velocities were performed to evaluate the statistical reliability of the model during the 2016 Reality Check period. The analyses focused on monitoring sites within DPM study area, including marsh sites in the Pocket and interior WCA 3B and backfill sites in the L-67C Canal.

Discharge Comparison

Scatter-plot analyses of simulated versus observed canal discharges show that the model reproduced field-measured flows with excellent agreement across all sites (**Figure 19**). The average difference between simulated and observed discharges was approximately 6 cfs, with a strong linear relationship ($R^2 = 0.99$; $F_{1,6} = 587.8$; $p < 0.0001$). Simulated results correctly represented the spatial trend of flow attenuation along the L-67C Canal—from concentrated discharge near the S-152 culvert to progressively smaller flows downstream within the Partial-Fill and Complete-Fill reaches.

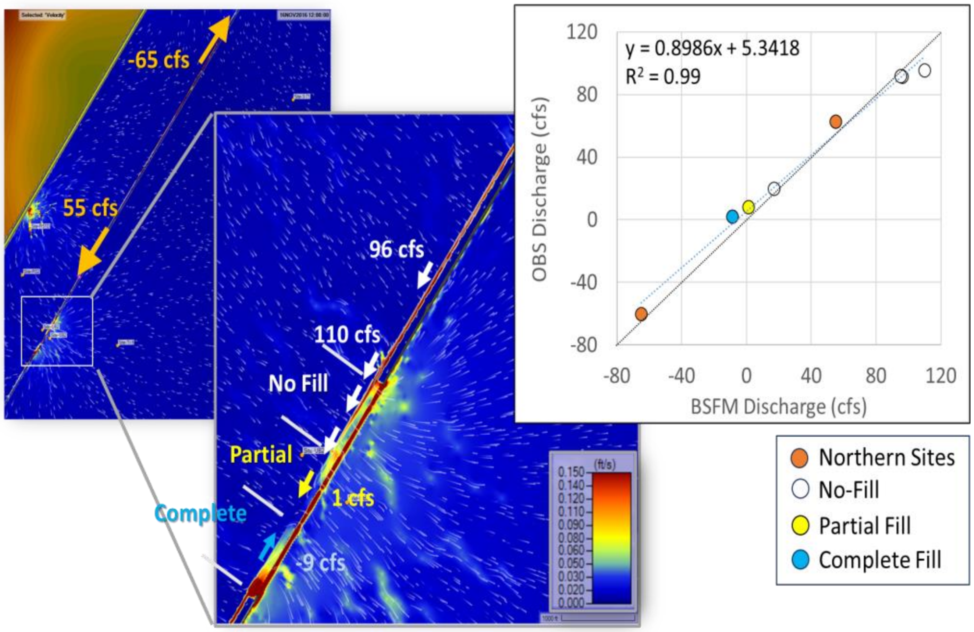


Figure 19. Simulated and Observed Canal Discharges within and North of the DPM Canal Backfill Treatments. All observed discharges were from the 2016 POR except for the two northernmost sites (2019 and 2022).

Velocity Comparison

Due to limited field data availability, velocity validation for ridge and slough habitats relied on discrete and continuous measurements from Acoustic Doppler Velocimeter (ADV) and Sontek FlowTracker instruments. Near the S-152 inflow zone (RS1D Slough, RS1D Ridge, RS2 Slough) and downstream of the levee gap (DB2 Slough, C2), the simulated velocity time series matched observed patterns closely, capturing both timing and magnitude of low-velocity marsh flow (< 0.1 ft/s) (**Figure 20**). As noted above (**Figure 18**), simulated mean velocity in the Complete-Fill treatment, effectively a deep slough, was 0.06 ft/s, while observations ranged 0.03–0.05 ft/s.

The applicability of the model in reproducing the spatial variability across the domain was assessed by comparing BSFM output with a more spatially extensive dataset, which necessitated including observations made outside the Reality Check's Period of Record. This analysis utilized data obtained from all sites where velocities were observed during flow conditions, spanning 2013 to 2020. Despite the widely ranging hydrologic conditions (e.g., S-152 discharge ranged 157 to 358 cfs) and the different POR between observed and model conditions, the model still demonstrated strong correlations with observed values in both slough and ridge habitats (**Figure 21**). In the

Figure 21, observed velocities are site-specific averages during flow. 60% of observations (n=36) were obtained within the Reality Check Period of Record or the following month (January 2017), and the remainder (n=30) from other flow events (2013-2020). Average S-152 discharge was calculated from the corresponding days when marsh velocities were measured. BSFM values represent site-specific, average velocities during flow conditions within the Reality Check Period of Record.

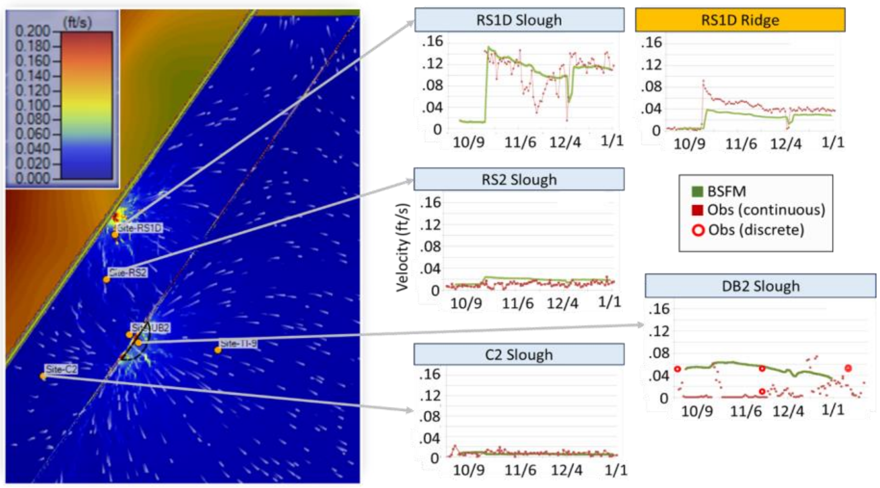


Figure 20. Simulated and Observed Velocity Time Series During the 2016 POR. Continuous Observations Were Made

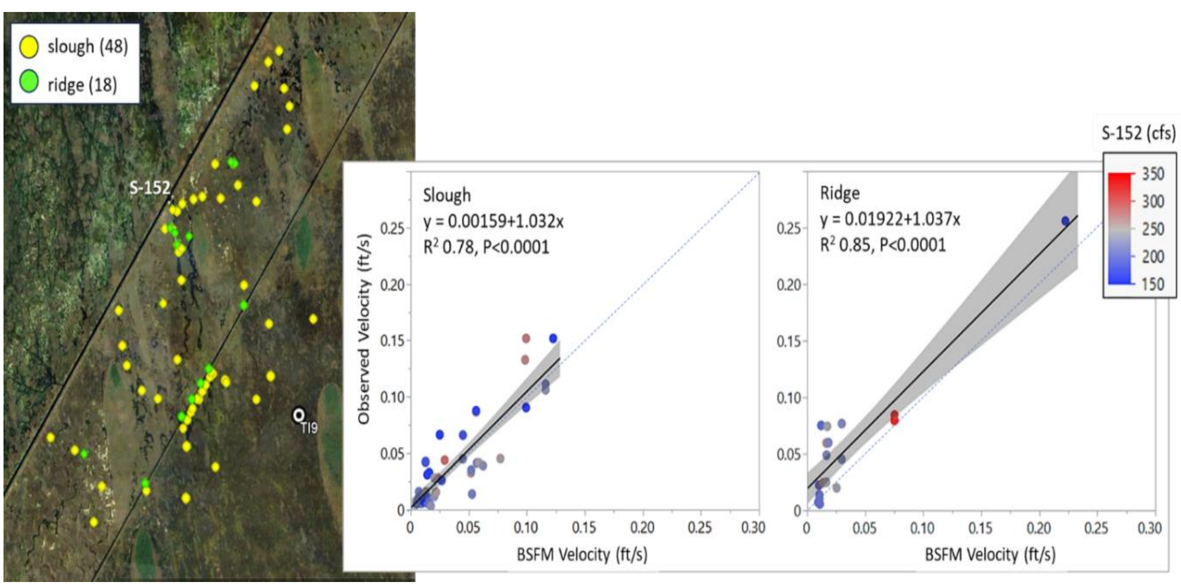


Figure 21. Observed Velocities in Slough and Ridge Sites from the DPM Study Area.

2.4.5 Summary and Model Confidence

The Reality Check results demonstrate that the hydrodynamic model provides a robust and reliable representation of hydraulic processes within the BSF. Key findings include:

- Excellent agreement in water levels throughout the domain, with deviations < 0.15 ft at all sites.
- Accurate reproduction of flow distribution from the S-152 inflow through canal and marsh pathways.
- Realistic velocity attenuation along the L-67C Canal in response to backfill and plug treatments.
- Strong statistical correlation between simulated and measured discharges and velocities, confirming physical realism.

Quantitative evaluation of the Reality Check simulation confirmed strong statistical agreement between simulated and measured data, shown in **Table 1**.

Table 1. Quantitative evaluation of the Reality Check simulation

Metric	Comparison Variable	Observed Range	Simulated Range	Correlation (R^2)	RMSE
Water Stage Deviation	Domain-wide (Stages)	–	±0.15 ft	—	—
Canal Discharge Error	L-67C Canal (2016 POR)	—	±6 cfs avg. difference	0.99 ($p < 0.0001$)	—
Slough Velocity	DPM Study 2013–2020	<0.01–0.15 ft/s	<0.01–0.11 ft/s	0.78	0.02 ft/s
Ridge Velocity	DPM Study 2013–2020	<0.01–0.25 ft/s	<0.01–0.22 ft/s	0.85	0.02 ft/s

Discharges along the L-67C Canal and at backfill treatment locations were within approximately 6 cfs of measured values, exhibiting an exceptionally high correlation ($R^2 = 0.99$). Comparison with long-term DPM data confirmed that the model reproduced both the magnitude and spatial variability of velocity fields across multiple hydrologic regimes. Root-mean-square errors of 0.02

ft/s for both ridge and slough habitats indicate that simulated velocities fall well within observational uncertainty.

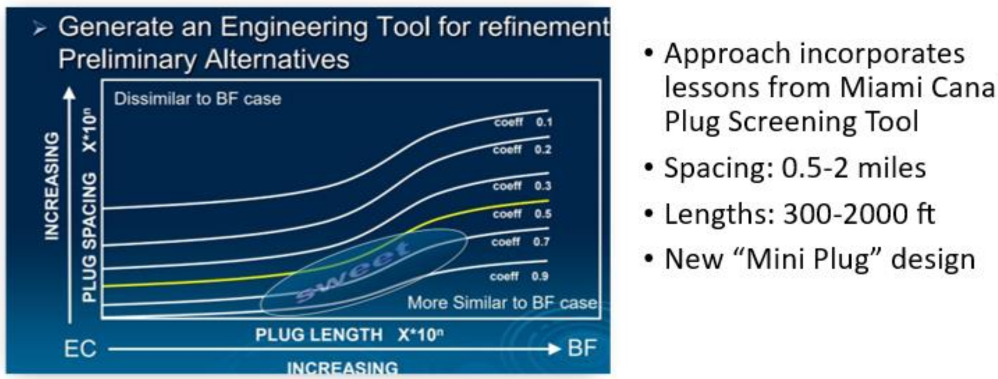
Overall, the model effectively reproduces observed canal-marsh exchange, vegetation-induced resistance, and ridge-and-slough flow dynamics. While the calibration relied on limited field datasets and simplified seepage assumptions, the model achieved high fidelity across all evaluation metrics. The validated configuration therefore provides a sound technical foundation for the next phase of CEPP-S analysis, including evaluation of canal-plug configurations, levee-degrade alternatives, and marsh flow restoration designs.

3. FUTURE SCENARIOS BACKGROUND AND CONCEPTUAL FRAMEWORK

3.1 Rationale and Conceptual Basis for Canal Plug Scenarios

Findings from the Decomp Physical Model (DPM) study and subsequent field monitoring have shown that while increased freshwater delivery promotes ecological recovery, excessive or concentrated flows can generate unintended consequences. Localized high-velocity discharges near culverts and unfilled canal reaches have been shown to mobilize phosphorus-enriched sediments and promote cattail expansion in adjacent marshes. In the absence of additional redistribution measures, restoration flows conveyed through the L-67C Canal are likely to remain partially channelized, reducing the effectiveness of CEPP-S sheet-flow restoration objectives.

Canal plugs are therefore considered a critical design element to attenuate canal velocities, limit downstream sediment transport, and redistribute flow laterally into surrounding marshes. Rather than completely eliminating canal conveyance, strategically placed plugs increase hydraulic resistance along the canal corridor, promoting controlled overtopping, enhanced canal–marsh exchange, and more spatially distributed sheet-flow.



From *2014 CEPP Final PIR and EIS*, App (Annex A-1) Section 2.2 Decomp RMA-2 Screening of Miami Canal Plug Configurations.

Figure 22. Future Scenarios Canal-plug Conceptual Design Guideline

Design guidance for the L-67C canal-plug concepts draws from prior restoration efforts in the central Everglades, particularly the CEPP-North Miami Canal plug studies (**Figure 22**). These studies demonstrate that plug effectiveness based on comparison of the full backfill configuration depends not only on total fill volume, but also on the balance between plug length, spacing, and alignment with natural slough features. Longer plugs can provide strong localized resistance but may concentrate flow around their ends, while shorter, more frequent plugs tend to distribute resistance more evenly along the canal. Consistent with these findings, previous studies recommend increasing plug spacing as plug length increases to balance hydraulic performance and construction cost . For the BSF, these lessons informed the selection of plug lengths ranging from approximately 300 ft to 2,000 ft, with spacing between 0.5 mile and 2 miles, as a reasonable design dimension envelope for scenario testing.

A typical proposed canal plug configuration (**Figure 23**) consists of three longitudinal segments: a northern end section, a middle section, and a southern end section. The end sections are relatively short (in order of 50 ft each) and are raised approximately 1 ft above surrounding marsh elevation to limit direct channel bypass and reduce localized erosion. The middle section comprises much of the plug length and is constructed at marsh grade, often aligned with existing sloughs, shown in **Figure 23**, to facilitate lateral flow redistribution. This composite geometry is intended to balance hydraulic control with ecological connectivity by providing resistance while allowing overtopping and exchange during high-flow conditions.

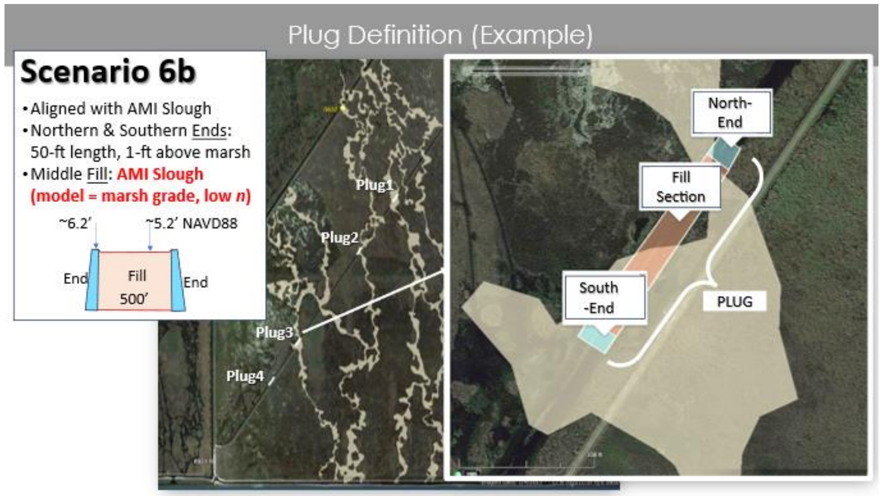


Figure 23. Typical Canal Plug Design Configuration

3.2 Canal Plug Scenario Development and Evaluation Framework

Based on the above design concepts, four primary canal-plug scenarios were developed by the USACE and SFWMD project team for evaluation (**Figure 24**), in addition to a baseline condition with no canal modifications. These scenarios were designed to systematically explore the effects of plug length, spacing, and plug density on flow redistribution within the BSF. Scenario 1a represents a distributed small-plug approach, consisting of nine 300-ft-long plugs spaced approximately one mile apart. Scenario 6b includes four medium-length (500-ft) plugs with one-mile spacing, while Scenario 7b evaluates fewer but larger plugs, consisting of four 1,000-ft-long plugs with similar spacing. Scenario 6d combines elements of these approaches by incorporating multiple 500-ft plugs supplemented with a series of short mini-plugs placed between the larger plugs to provide additional distributed resistance.

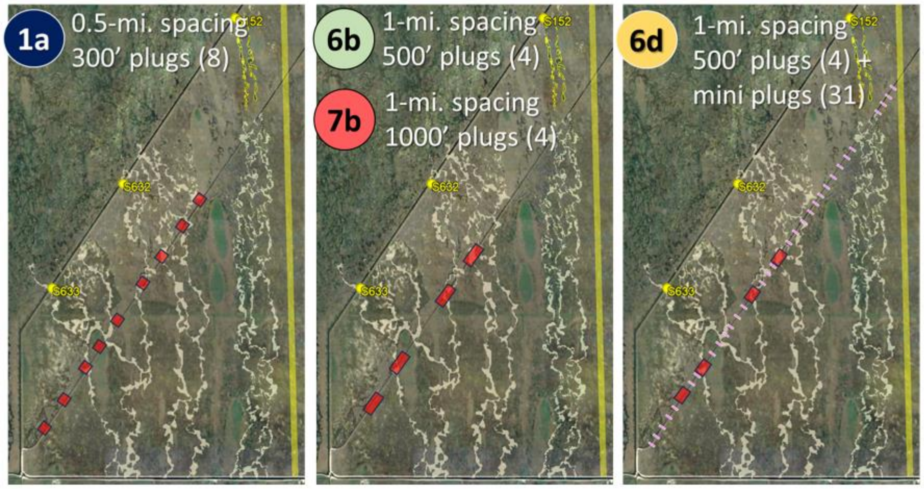


Figure 24. Scenarios 1a, 6b, 7b, and 6d Plug Design

The mini-plug concept introduced in Scenario 6d represents a hybrid design strategy intended to increase total hydraulic resistance along the canal while minimizing localized flow acceleration. Initially, the mini-plugs were conceptualized by the modeling team to help moderate the high flow velocities within the canal system and were not specifically based on AMI slough locations. Later, as part of the final design recommendation, the mini-plug concept was confirmed by the science team, and the locations were refined and adjusted to better align with the AMI slough features. In this configuration, as shown in **Figure 25**, raised end sections are removed, and all long plugs are set at marsh elevation. Short, low-profile mini-plugs (initially assumed 3 ft in length with gentle side slopes with a total number of 31 mini-plugs) are placed at approximately 1,000-ft intervals between long plugs and are set at marsh-grade elevation, consistent with the long plugs. By distributing resistance across multiple locations, this approach aims to reduce canal discharge, attenuate velocities, and promote more uniform marsh sheet-flow across the entire BSF.

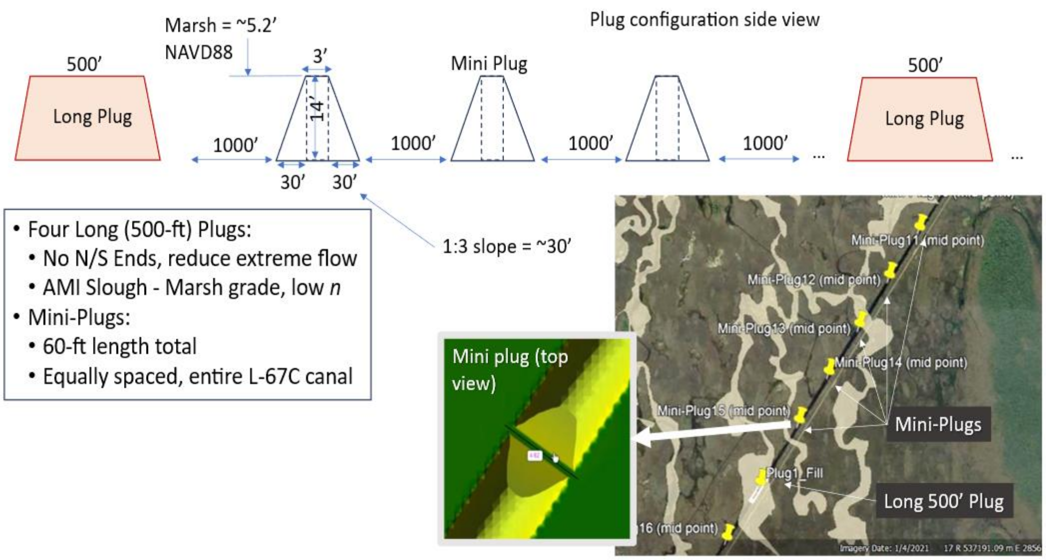


Figure 25. Plug Configuration of Scenario 6d with initial thirty-one 3-ft mini-plug design (Elevation in ft-NAVD88)

3.3 Scenario Evaluation Criteria

To objectively compare scenario performance, quantitative hydraulic and ecological metrics were established in coordination with the project science team. Ecological targets for canal discharge and marsh velocity were established based on DPM findings indicating thresholds, above which ecological damage was observed. First, a canal discharge target of < 20 cfs was established based on the maximum discharge observed in the Partial-Fill canal treatment. Second, a velocity target of ≤ 0.1 ft/s (applicable to ridge or slough habitats) was based on the threshold velocity above which P-enrichment impacts were observed (Sklar, 2023). Model scenarios were evaluated based on canal discharge and marsh velocity criteria. Scenarios that remained at or below the defined thresholds were ranked higher, while those that exceeded the thresholds—either more frequently or by greater magnitude—were ranked lower.

Because the vegetation map used for the BSFM had relatively lower resolution in the southern half of the model domain (note resolution differences in vegetation map in **Figure 7**), remnant sloughs were often excluded in the south and southwest portions of the model domain. Therefore, in such areas, slough velocity for a given location (other than AMI sloughs) was inferred from ridge velocity, as follows: first, simulated ridge velocity was transformed into observed ridge velocity (following model~observed ridge velocity regression; **Figure 21**); and second, ridge velocity was then transformed to a slough velocity using the empirically determined slough:ridge velocity ratio (2.5).

Future Scenario performance was evaluated at a series of predefined transects along the L-67C Canal and adjacent marshes, with reference distances measured due north from the L-29 Canal, ranging from approximately 0.7 km due north to 9.2 km due north of the L-29 at the northern extent of the L-67-C Canal (**Figure 26**). These transects provide a consistent spatial framework for comparing canal velocity, canal discharge, marsh velocity, and marsh flow across all scenarios.

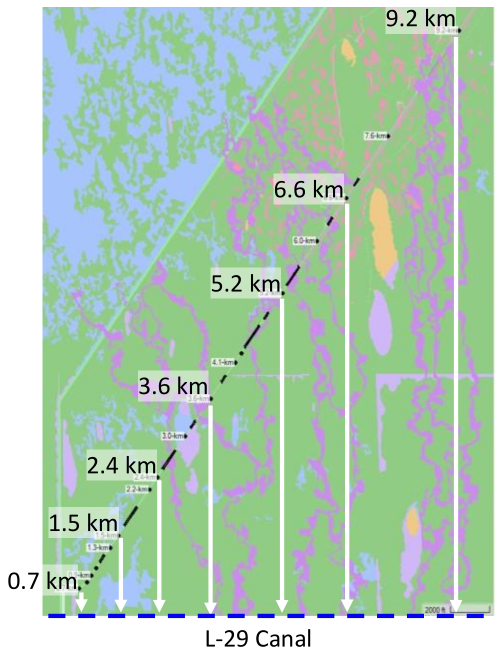


Figure 26. The Location of Transects along L-67C Canal.

4. FUTURE SCENARIO MODEL RECALIBRATION

Although the Reality Check model was fully calibrated for existing conditions, evaluation of Future Scenarios requires several modifications to the model configuration (**Figure 27**). To support the assessment of these alternatives, the model was updated to reflect proposed project conditions, including removal of the L-67C and L-29 levees within the Blue Shanty Flowway, addition of the S-631, S-632, and S-633 culvert structures, representation of flow exchange across the L-67D levee alignment, and application of stage boundary conditions derived from Regional

Simulation Model (RSM) outputs. Boundary conditions inflows from S-631, S-152, S-632, and S-633 were obtained from the RSM-GL BBSEER FWO runs for the period from September through October 2008. The latter time period was chosen as it was representative of high discharges through the BSF for the RSM-GL period of record (**Figure 27**). Because the BSFM included 3 structures in the BSF, the RSM-GL based inflows for S-632 and S-633 were divided equally among the S-152, S-632, and S-633 for the BSFM simulation. In addition, the vegetation layer was refined to include AMI sloughs (lighter shaded regions in **Figure 27**).

Collectively, these modifications altered the hydraulic connectivity, boundary forcing, and internal flow pathways within the model domain and therefore necessitated additional setup and recalibration prior to scenario testing. To confirm consistency in basin-scale hydrologic response, the BSFM outputs of interior marsh stages and outflows to the L-29 Canal were compared against corresponding RSM-GL results.

A baseline future-condition simulation, for the period from September through October 2008, without canal plugs was first established and used for recalibration. Simulated stages and flows closely matched RSM results at interior and boundary monitoring locations (**Figure 28**), indicating that the recalibrated model appropriately represents future-condition hydrologic forcing and is suitable for evaluation of plug alternatives. In the southern and near-field portions of the domain, including Site 3-71 and Site BSFM-1, stages closely track the RSM hydrographs, with differences generally within 0.10–0.15 ft over the period of simulation. Minor deviations occur primarily during periods of rapidly rising or falling stages and do not exhibit systematic bias. Within the interior marsh areas, including Sites SRS-1, EDEN-10, and BSFM-2, agreement between BSFM and RSM simulations remain strong, with stage differences typically less than 0.10 ft. The BSFM successfully reproduces both the timing and magnitude of stage fluctuations across the domain, including peak stages and subsequent recession trends.

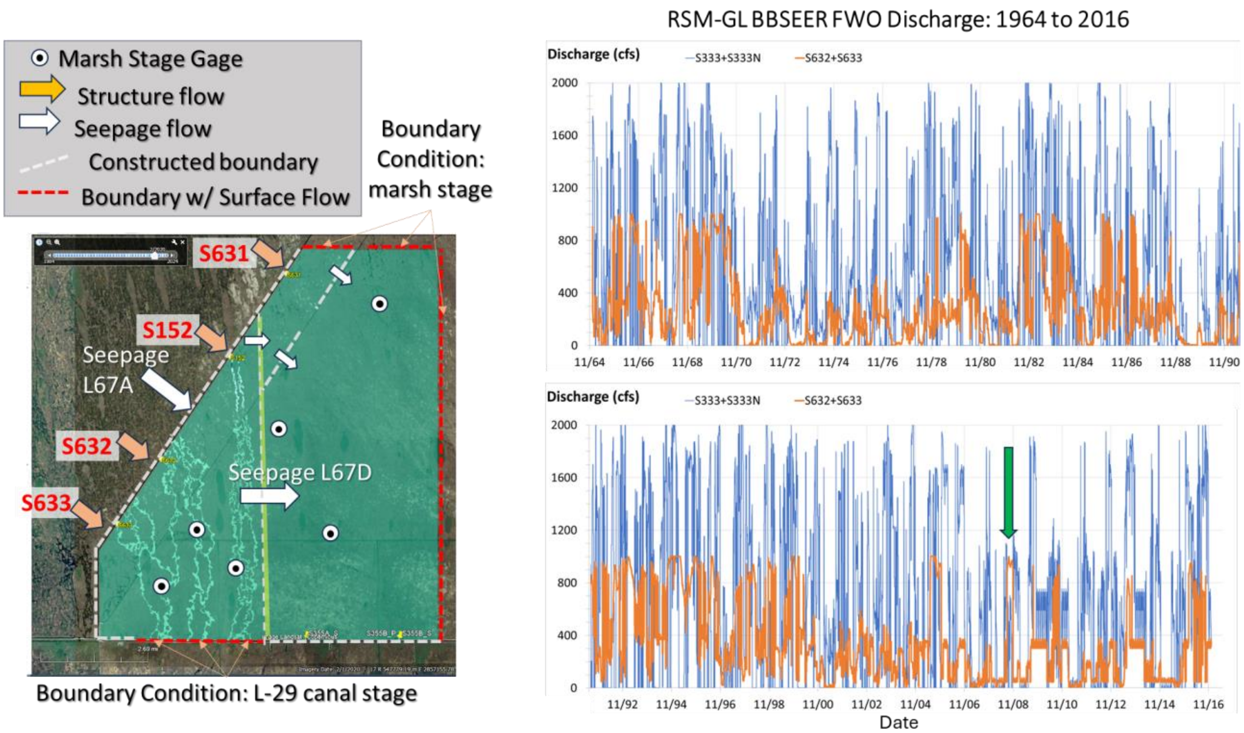


Figure 27. (left) Detailed BSFM Domain and Boundaries for the Future Scenarios. (Right) Time Series of RSM-GL BBSEER FWO Simulated Inflows to BSF (orange line). Green Arrow Highlights the Period of Record (Sep-Oct, 2008) used for Future scenarios.

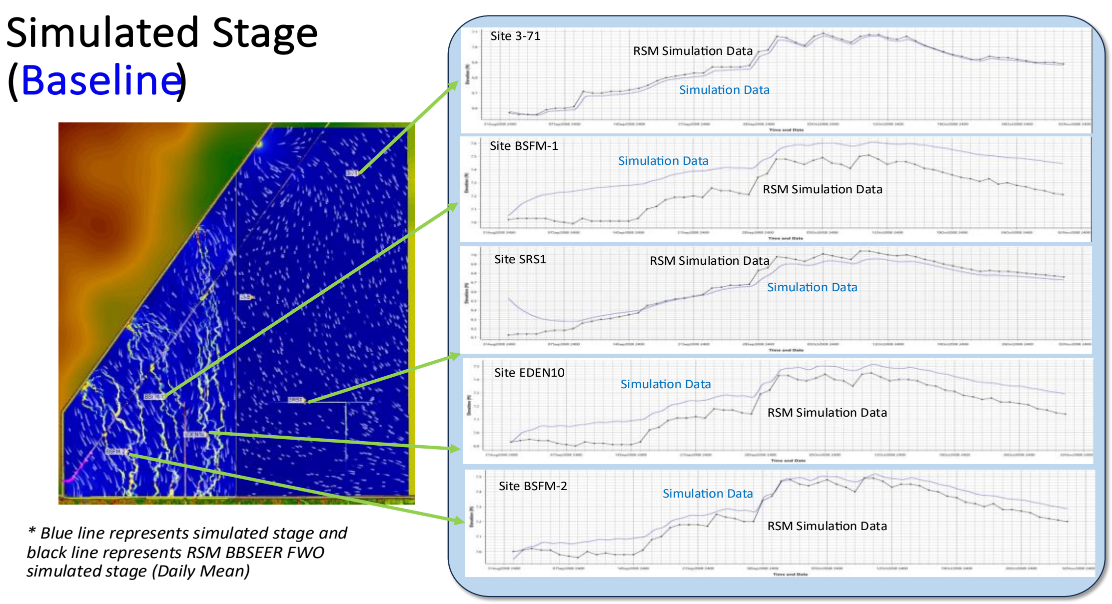


Figure 28. Future Scenario Water-stage Comparison at Representative Sites

Overall, the close correspondence between BSFM-simulated stages and RSM-derived stages demonstrates consistency between the two modeling frameworks and confirms that the BSFM adequately represents basin-scale hydrologic forcing under baseline future-condition assumptions. This agreement provides confidence in applying the recalibrated BSFM for subsequent evaluation of alternative canal plug scenarios.

5. FUTURE SCENARIO EVALUATION

This section presents the initial assessment of the future canal plug scenarios evaluated using the recalibrated BSFM. The analysis builds on the validated future-condition baseline simulation and examines how alternative L-67C canal plug configurations influence canal hydraulics, marsh sheet-flow, and canal–marsh exchange under representative high-flow conditions associated with full CEPP-S implementation.

5.1 Baseline Future-Condition Performance

The baseline future-condition simulation, which includes CEPP-S structural modifications but no additional L-67C canal plugs, exhibits strong canal-dominated flow along the L-67C Canal. Simulated velocities and discharges indicate rapid southward conveyance toward the southwest canal terminus, with canal velocities substantially exceeding adjacent marsh velocities. Flow fields in the BSF Baseline scenario demonstrated some desired preferential flow in AMI sloughs (yellow coloring in **Figure 29**) and the flow fields at the intersection of an AMI slough and the L-67C Canal. Consistent red coloration and flow direction within the canal, however, show canal flow is largely unaffected by AMI. This behavior confirms that, in the absence of additional backfilling or plugs, residual channelized flow persists and may continue to divert water away from marsh sheet-flow pathways.

5.2 Canal Plugs Scenario Evaluations

Four primary canal plug scenarios were evaluated against the baseline condition: Scenario 1a, Scenario 6b, Scenario 7b, and Scenario 6d (refer to Section 3.2 for plug scenario description). These scenarios represent a progression from fewer, longer plugs to more numerous, shorter plugs with distributed resistance. Performance was evaluated using consistent transects along the L-67C Canal and adjacent marshes (**Figure 26**), with emphasis on southern reaches near the L-29 Canal.

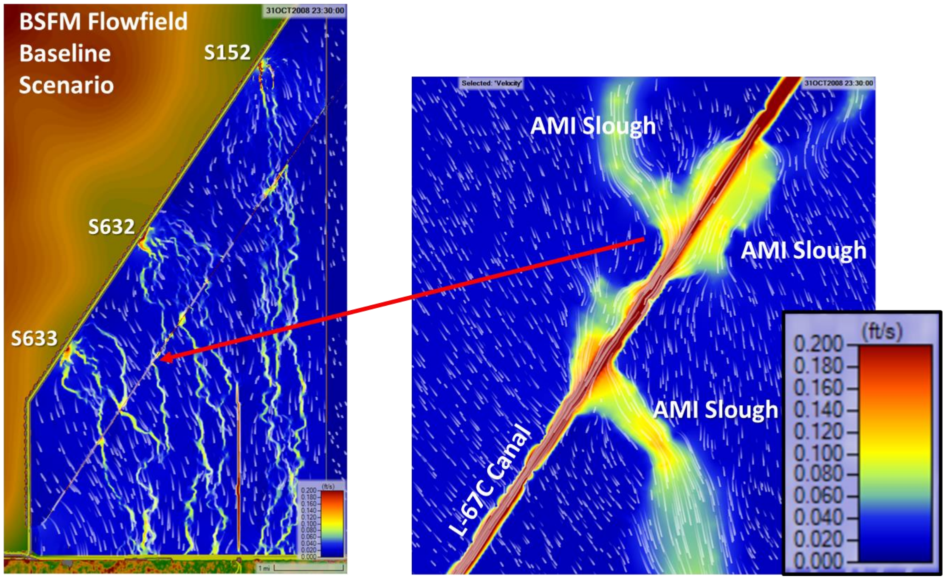


Figure 29. (Left) Flow fields in the BSF Baseline scenario. (Right) Flow fields at the intersection of an AMI slough and the L-67C Canal. Note: scale on the right applies to both images

5.2.1 Canal Velocity and Discharge Comparison

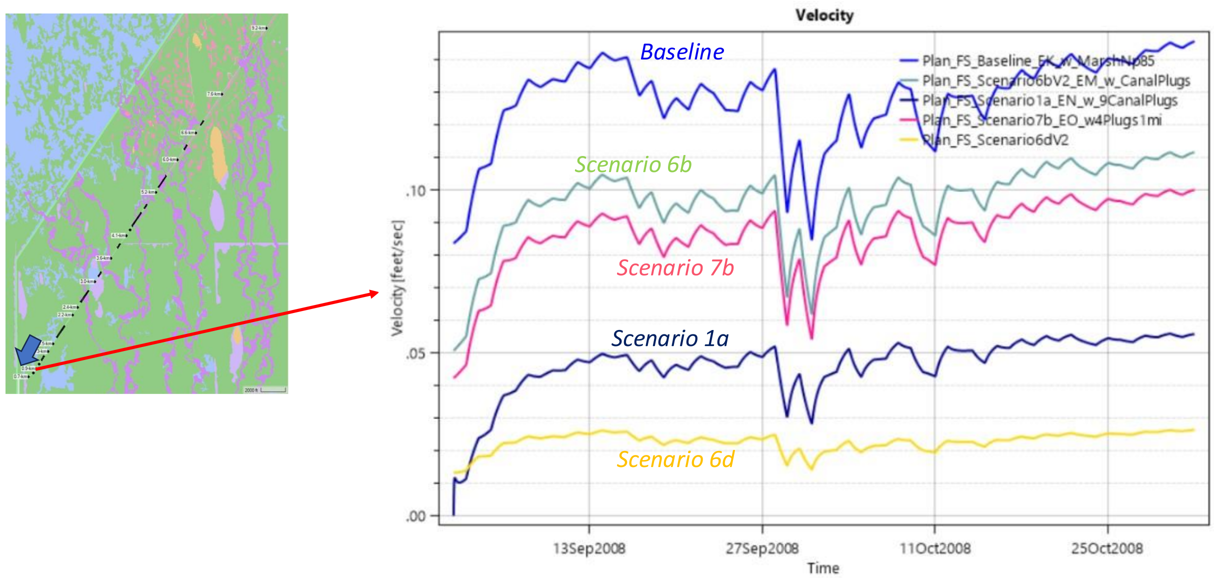
Scenarios 6b and 7b, which include four medium- to long-length plugs concentrated in the southwest portion of the canal, reduce canal velocities locally but remain above the target discharge threshold of 20 cfs at multiple transects. These configurations also show limited influence on northern canal reaches, where canal-dominated flow persists. In contrast, Scenario 1a, consisting of nine shorter plugs distributed along the southwest canal reach, and Scenario 6d, incorporating distributed of 31 mini plugs, provides improved attenuation of canal discharge and velocity relative to Scenarios 6b and 7b.

For the southernmost canal section, comparisons of scenarios show that Scenarios 1a and 6d demonstrate the best performance in reducing canal discharges. At the 0.9-km canal transect, the baseline scenario exhibits the highest canal velocities, while Scenarios 1a and 6d show the largest reductions, indicating improved hydraulic control (**Figure 30 (a)**). Similarly, scenarios 1a and 6d reduce discharge below the 20-cfs target, whereas Scenarios 6b and 7b exceed the criterion (**Figure**

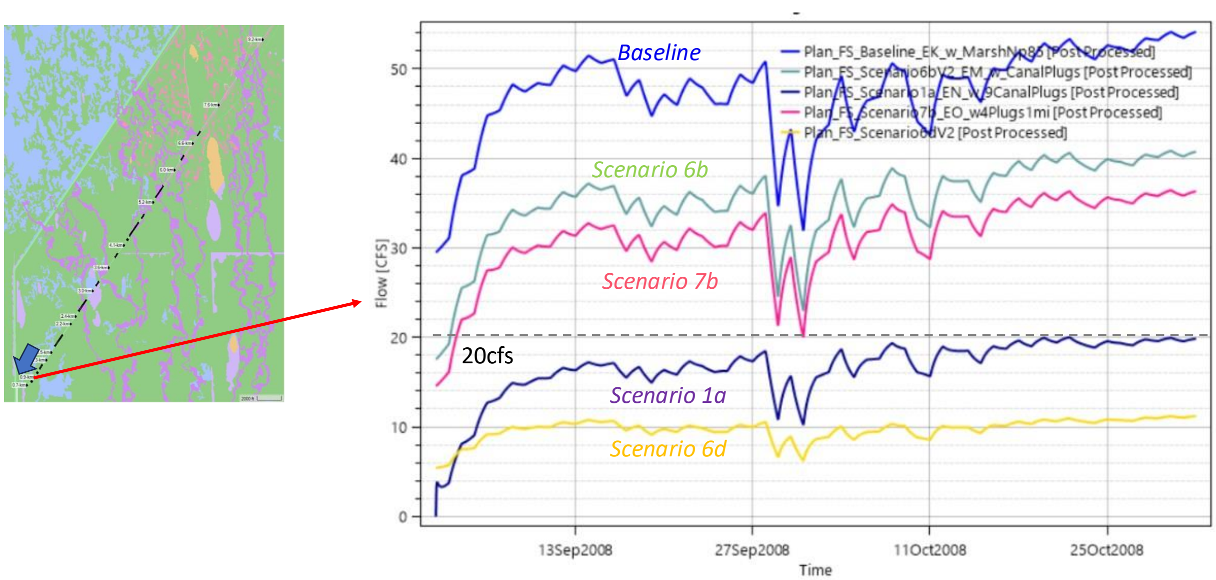
30 (b)). These results were consistent with comparisons of canal velocity and discharge time series at the 1.3-km canal transect (**Figure 31**).

Canal velocity and discharge comparisons at mid- and northern-canal transects (**Figure 32 & Figure 33)** confirm that Scenario 6d maintains lower velocities and discharges over the entirety of the canal reach. The relatively poor performance of all but Scenario 6d in the northern canal reflects the concentration of long plugs in the southwest. Only Scenario 6d, with mini-plugs throughout the L-67C Canal, successfully reduces velocities and discharge in northern reaches.

Scenario 6d demonstrates the strongest overall performance among the initial alternatives. By combining several marsh-grade 500-ft plugs with a series of short, distributed mini-plugs along the full length of L-67C, this scenario achieves sustained reductions in canal discharge and velocity across southern, middle, and northern canal reaches. Canal flows are reduced to ≤ 20 cfs at key transects.

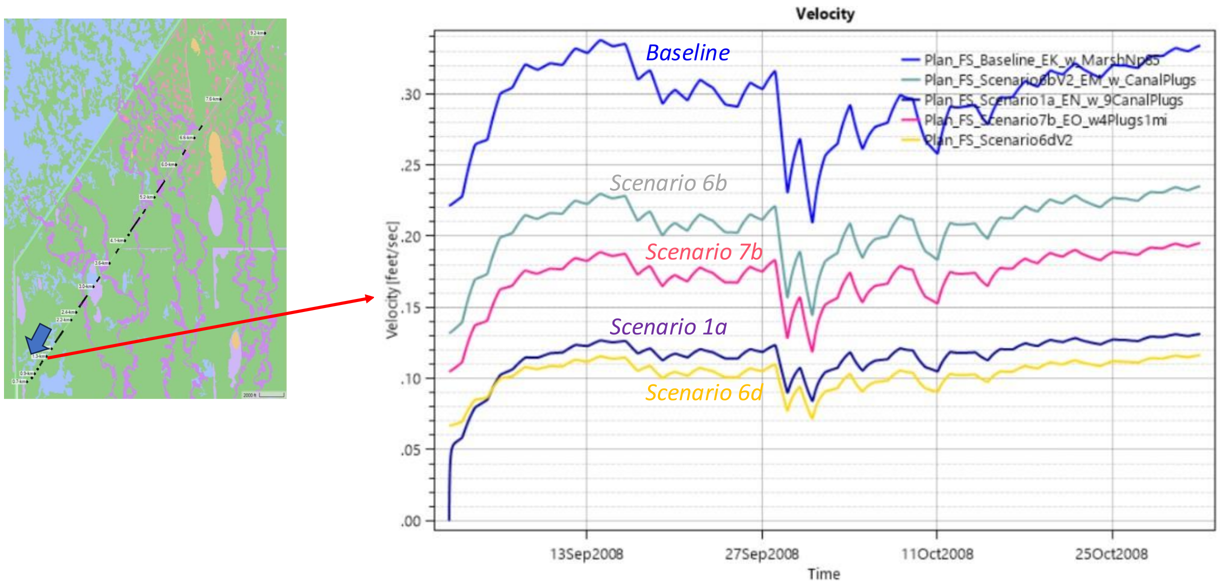


(a)

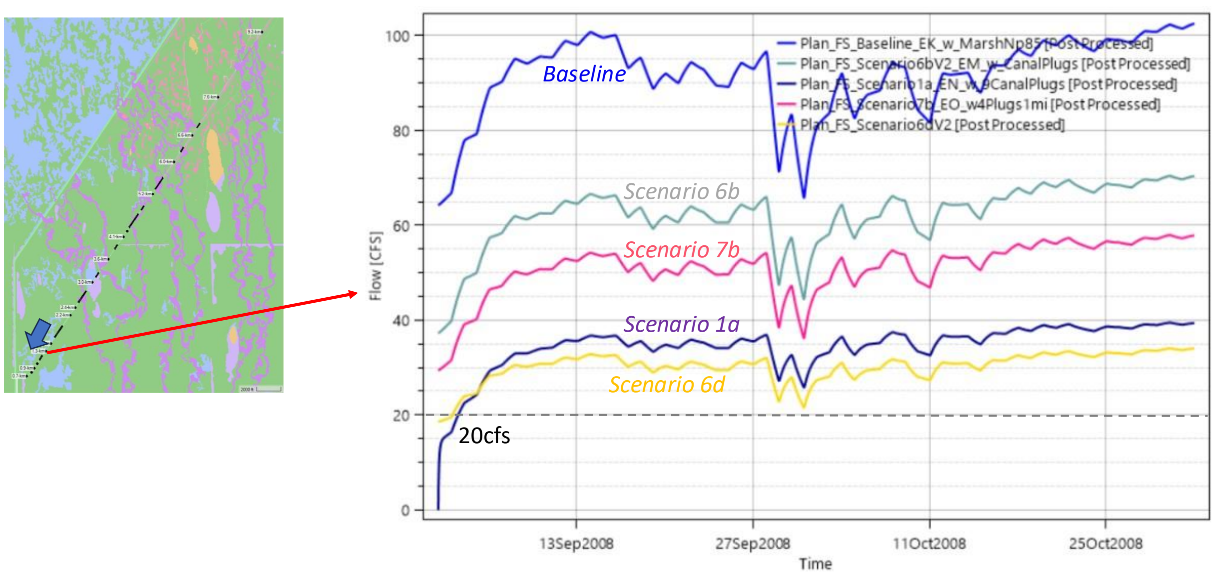


(b)

Figure 30. L-67C Canal Velocity (a) and Discharge (b) Time Series at 0.9km Canal Transect

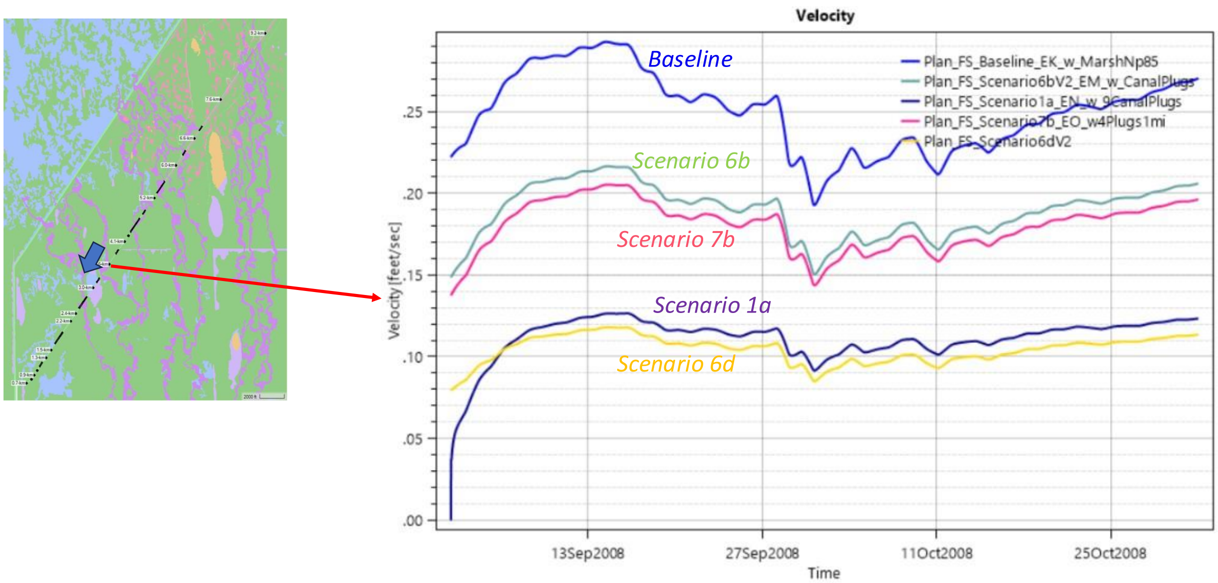


(a)

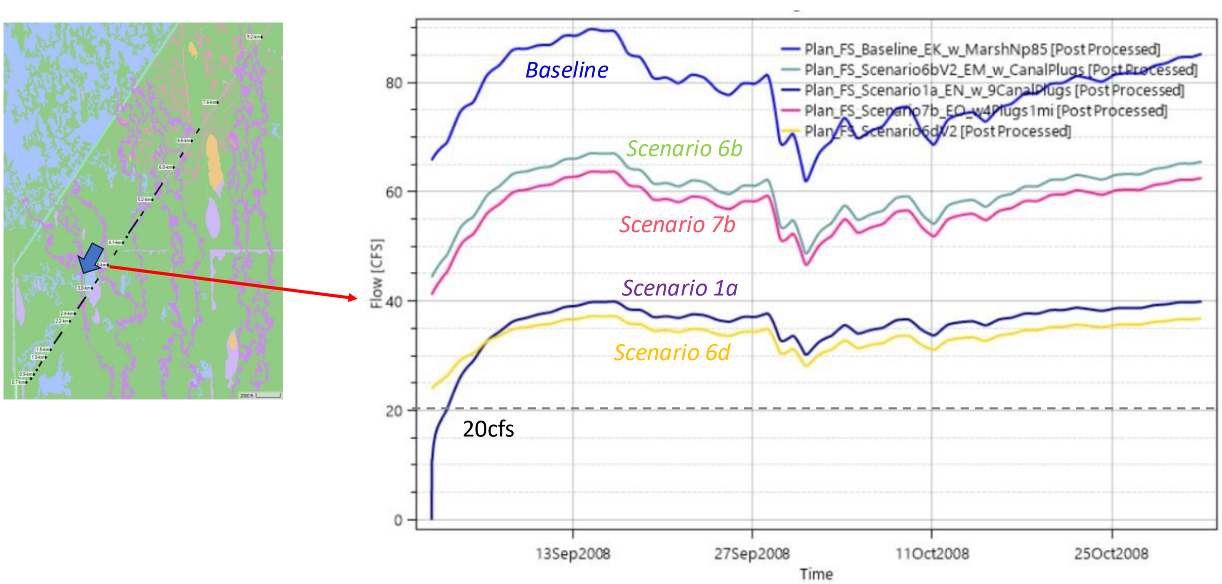


(b)

Figure 31. L-67C Canal Velocity (a) and Discharge (b) Time Series at 1.3 km Canal Transect

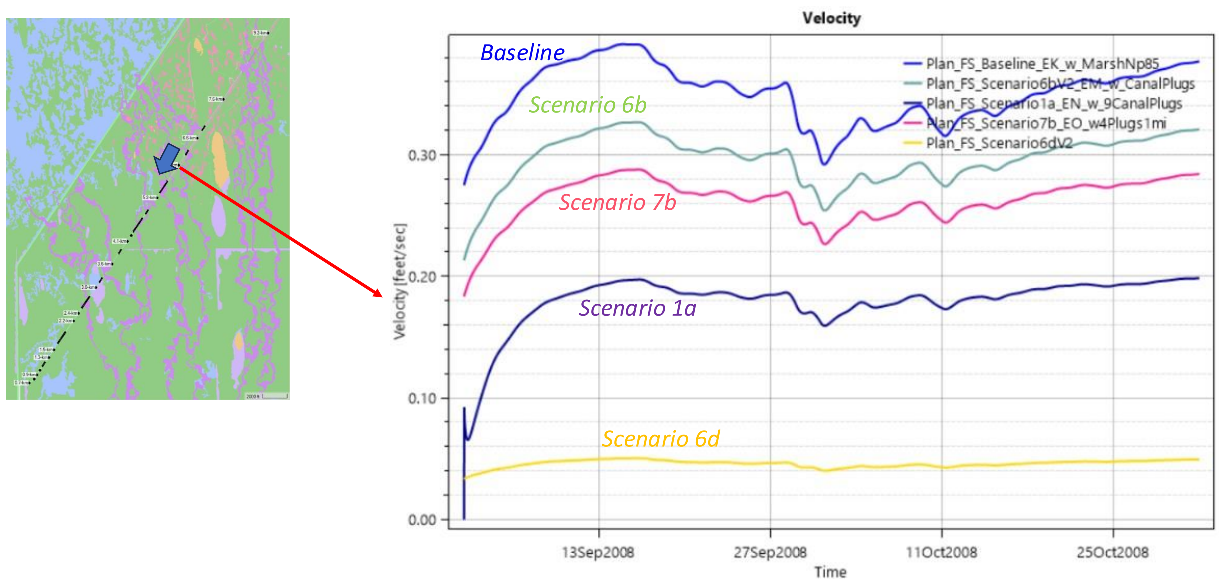


(a)

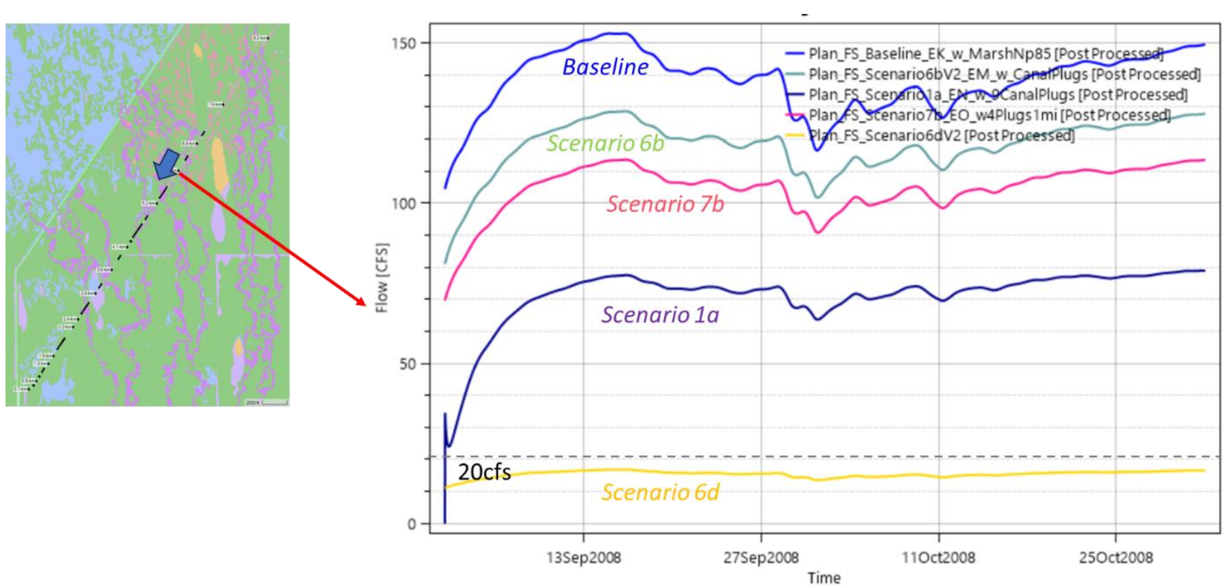


(b)

Figure 32. L-67C Canal Velocity (a) and Discharge (b) Time Series at 3.6 km Canal Transect



(a)



(b)

Figure 33. L-67C Canal Velocity (a) and Discharge (b) Time Series at 6.0 km Canal Transect

5.2.2 Marsh Flow and Velocity Response

Across all evaluated scenarios, marsh velocities, about 180 ft downstream (east) of the L-67C Canal exhibited ridge velocities below the velocity indicative of enrichment (< 0.024 ft/s, equivalent to 0.1 ft/s in a slough) for the central and northern portions of the BSF; however, velocities above the threshold were evident in some scenarios near the southwest terminus (**Figure 34**). With more distributed resistance, Scenarios 1a and 6d produce the most uniform and lower marsh flow fields. Scenario 6d, in particular, minimizes localized velocity spikes and promotes lateral flow redistribution aligned with existing AMI slough features. This distributed response reduces the risk of localized scour and excessive hydraulic loading near canal margins.

Near the southwestern terminus of the L-67C levee degrade, approximately 700 meters north of L-29, Scenarios 1a and 6d, with many smaller plugs, successfully achieved slough velocities below the 0.1-ft/s threshold (**Figure 35**). By contrast, slough velocities from scenarios with only four large plugs (6b and 7b), and the baseline scenario, often exceeded this threshold during the simulation period.

The baseline and four alternative canal plug scenarios revealed important insights into the existing flow dynamics in the BSF and the effectiveness of canal plugs in reducing canal flow. In the baseline scenario, while AMI sloughs facilitated preferential (southward) flow throughout the BSF, such flows were inadequate to minimize the preferential flow and discharge down the length of the L-67C Canal. This result emphasized the necessity of structural interventions to control canal flow in the BSF.

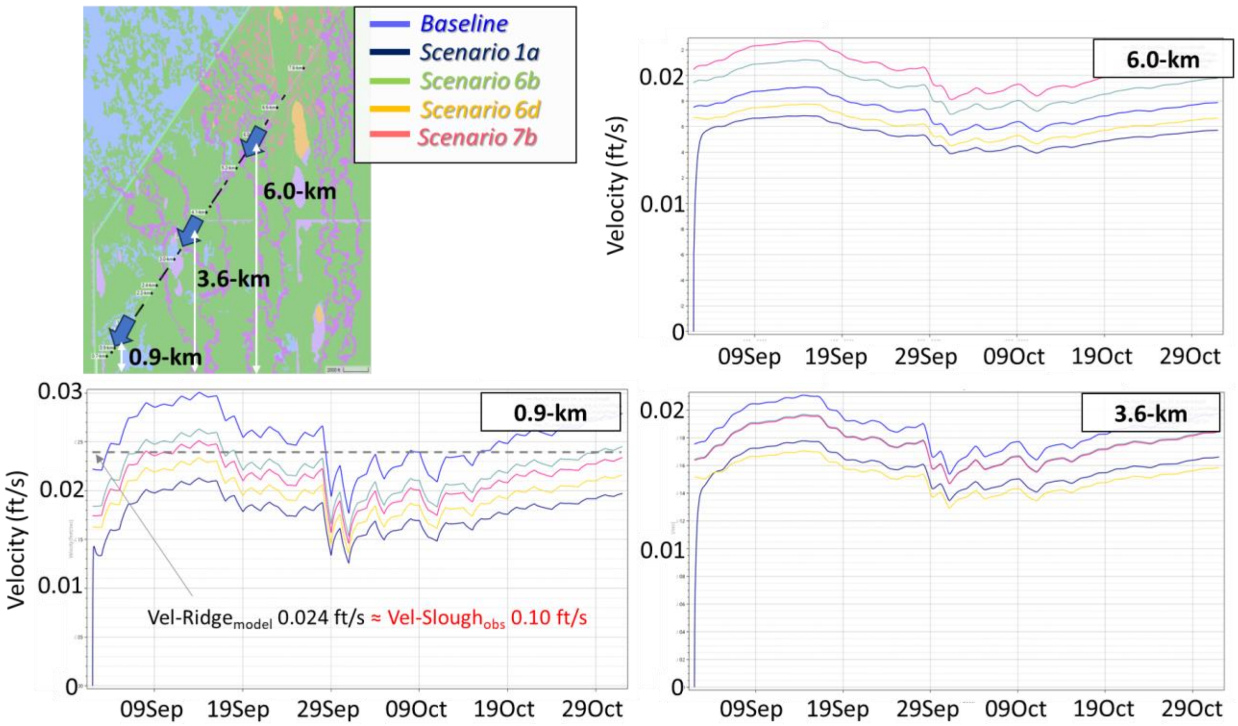


Figure 34. L-67C Marsh Velocity at 0.9 km, 3.6 km and 6.0 km Marsh Transects. Note the smaller scale at transects 3.6-km and 6.0-km.

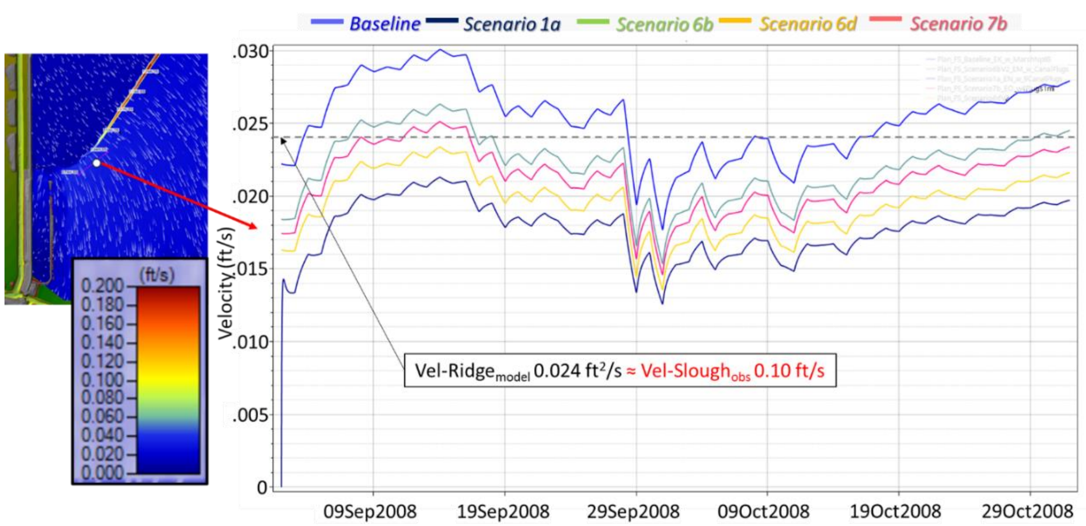


Figure 35. Simulated Ridge Velocities Downstream of the Southwestern Terminus of the L-67C Canal for the Baseline and Four Canal Plug Scenarios. Note that the dashed line represents the threshold ridge velocity corresponding to a slough velocity of 0.10 ft/s

5.2.3 Flow around the Canal Plugs

In all four canal plug designs, simulated flow fields showed the large plugs (ranging from 300 to 1,000 ft) were successful in reducing canal discharge and promoting marsh-to-marsh connectivity through the AMI sloughs where these intersected with plugs (**Figure 36).** Relative to baseline conditions, each configuration substantially attenuates longitudinal canal velocities and redirects flow laterally into the adjacent slough network. High-velocity channelized flow upstream of the plug transitions to lower-velocity, more diffuse flow downstream, demonstrating effective hydraulic resistance and energy dissipation. Enhanced north–south velocity vectors within the AMI slough indicate improved marsh-to-marsh connectivity across the former canal corridor.

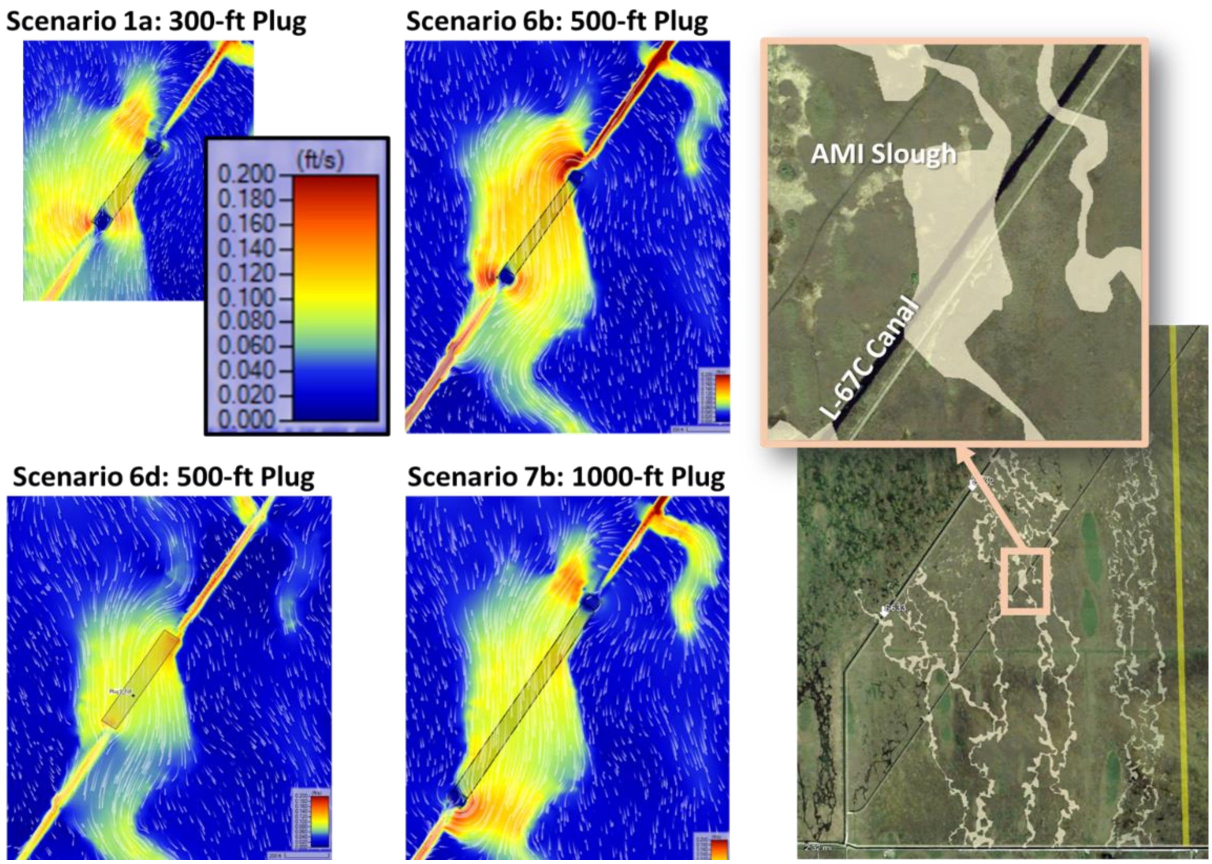


Figure 36. Flow Fields at the Intersection of an AMI Slough and the L-67C Canal for the 4 Plug Scenarios. (Note: Flowfield Scale in the Center Applies to All Four Scenario Flowfields.)

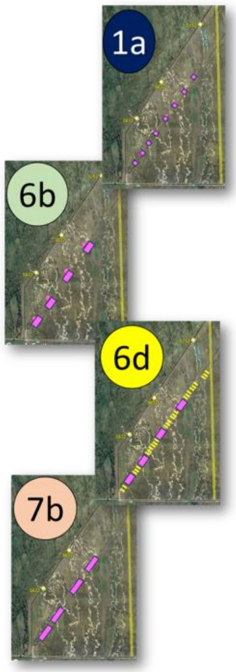
Differences among plug lengths primarily affect spatial uniformity of flow redistribution rather than overall effectiveness in reducing canal velocity. Shorter 300-ft plug initiates lateral spreading but exhibits localized acceleration near plug termini. Longer 500-ft and 1,000-ft plugs generate broader zones of reduced velocity but also concentrate flow near their ends, consistent with end-effect behavior observed in prior canal-plug studies. Scenario 6d, which incorporates distributed resistance through supplemental mini-plugs, produces the most spatially- uniform transition, minimizing localized high-velocity jets while maintaining strong lateral exchange into the marsh.

5.2.4 Summary of Scenario Evaluation Results

Table 2 summarizes plug configurations, fill volumes, and scenario performance relative to canal discharge and slough velocity targets across the southern, central, and northern portions of the BSF. The baseline future-condition scenario, in which there is no plug or fill component, fails to meet the canal performance criteria throughout all sections of the L-67C Canal, confirming that residual channelized flow persists without additional measures to redistribute canal flow. Scenario 1a improves hydraulic performance in the southern reach but does not consistently meet canal discharge targets in the middle and northern reaches. Scenario 6b provides limited velocity attenuation and fails to achieve discharge targets across the domain, with slough velocity exhibiting temporal variability. Scenario 7b increases total fill volume but similarly fails to meet discharge criteria and shows localized flow concentration near plug termini.

Scenario 6d demonstrates the strongest overall performance. By combining seven 500-ft marsh-grade plugs with distributed mini-plugs along the full length of the L-67C Canal, this configuration achieves sustained reductions in canal discharge and velocity across southern, middle, and northern reaches. Slough velocity targets are consistently attained, with minor temporal exceedance in the southern reach. Importantly, this performance is achieved with moderate total fill volume, indicating efficient hydraulic benefits relative to material investment. Distributed hydraulic resistance provides more uniform and reliable performance than fewer long plugs, and Scenario 6d represents the best balance among hydraulic effectiveness, ecological performance, and constructability. Based on these results, a modified Scenario 6d configuration, consisting of multiple 500-ft marsh-grade plugs supplemented with inter-distributed mini-plugs, is identified as the preferred configuration alternative for further refinement (**Table 3**).

Table 2. Summary of Scenario Fill volumes (approximate cubic yards), Plug Configurations, and Performance. "Y/N" Indicates Temporal Variability above and below Target.



Scenario	Volume (cubic yards)	Plug Fill Length (ft)	Plug Spacing (miles)	Canal Discharge <20 cfs			Slough Velocity <0.1 ft/s		
				South	Middle	North	South	Middle	North
Baseline	-	-	-	No	No	No	Y/N	Yes	Yes
Scen 1a	**74,034**	300	0.5	Yes	No	No	Yes	Yes	Yes
Scen 6b	**55,170**	500	1.0	No	No	No	Y/N	Yes	Yes
Scen 6d	**83,829**	500	1.0 + mini-plugs	Yes	No	Yes	Yes	Yes	Yes
Scen 7b	**100,552**	1000	1.0	No	No	No	Y/N	Yes	Yes

Table 3. Summary of Scenario Performance Relative to Design Criteria

Scenario	**Canal Discharge (<20 cfs)**	**Marsh Velocity (~0.03 ft/s)**
Baseline	No	No
1a	Partial	Yes
6b	No	Yes
7b	No	Yes
6d	Yes	Yes

5.3 Programmatic and Restoration Implications

When the original CEPP implementation plan was developed, limited data were available to assess the long-term hydraulic and ecological consequences of leaving the L-67C Canal partially unfilled. More than a decade of DPM monitoring has since demonstrated that persistent canal conveyance can mobilize phosphorus-enriched sediments, redirect sheet-flow into channelized pathways, and concentrate hydraulic loading near the southwestern terminus of the canal, with downstream implications for marsh condition, nutrient transport, and water quality entering the L-29 Canal and Everglades National Park.

The modeling presented herein substantially reduces uncertainty regarding plug configurations that best mitigate these risks. Results indicate that smaller, more numerous plugs out-perform fewer, large plugs in regulating both canal and marsh hydraulics. Scenario 6d, characterized by distributed resistance along the canal corridor, provides consistent system-wide performance, while shorter plug configurations provide localized benefit near the southern reach. Notably, the best-performing configurations require intermediate fill volumes, highlighting the importance of plug placement and spatial distribution rather than total material quantity.

These findings underscore the necessity of additional canal modifications to achieve ecologically protective hydrodynamic targets identified through the DPM program. More broadly, this study demonstrates the value of integrating models across spatial scales to resolve fine-scale hydraulic processes relevant to restoration performance, including habitat-scale velocity thresholds and canal–marsh exchange dynamics. The modeling framework developed for the BSF provides a transferable methodology for evaluating flow restoration strategies across other CERP projects. The hydraulic improvements under the distributed plug configuration directly support ecological restoration objectives. Reduced canal velocities limit mobilization of phosphorus-enriched sediments documented in the DPM No-Fill reach and decrease the potential for downstream nutrient transport toward the L-29 Canal and Everglades National Park. Maintaining slough velocities less than 0.1 ft/s supports ridge–slough stability and minimizes erosive stress. The distributed resistance strategy therefore provides both hydraulic compliance and measurable protection of sediment stability and downstream water quality.

6. PREFERRED CONFIGURATION REFINEMENT EVALUATION

Having identified Scenario 6d as the preferred configuration alternative based on the evaluation criteria results detailed above, further modeling was conducted to evaluate potential design refinements and the robustness under conditional uncertainty. The following section presents the refinements for the supplemental sensitivity evaluations.

6.1 Plugs and Mini Plugs Erosion Potential Evaluation

Canal plugs are assessed for erosion potential. Erosion typically occurs during flow conditions of higher discharge and lower stage. To represent the response under these conditions, Scenario 6d was simulated for the period of record (POR) from July 12, 1982, to August 12, 1982. During July-August 1982 time period, BSF inflow discharge and interior marsh stage showing higher discharge and lower stage, compared to the Future Scenarios (Septem-October 2008) (**Figures 37**). Boundary conditions were updated based on the new POR similar to previous runs. Topology, land cover, and plug designs remained the same as the previous simulation.

Velocities around the plugs and mini plugs analyzed in the erosion sensitivity run demonstrated relatively little change from the original run (**Figures 37 and 38**). However, higher velocity was observed on the north side of mini plug 13. As a result, mini plug 13 length was subsequently extended to 70-ft to minimize erosion potential (**Figure 39**). Velocity was evaluated around the 500-ft plugs, and no substantial changes were observed (**Figure 40**). Therefore, it can be concluded that, with exception of mini plug 13, erosion was not a concern at the plugs.

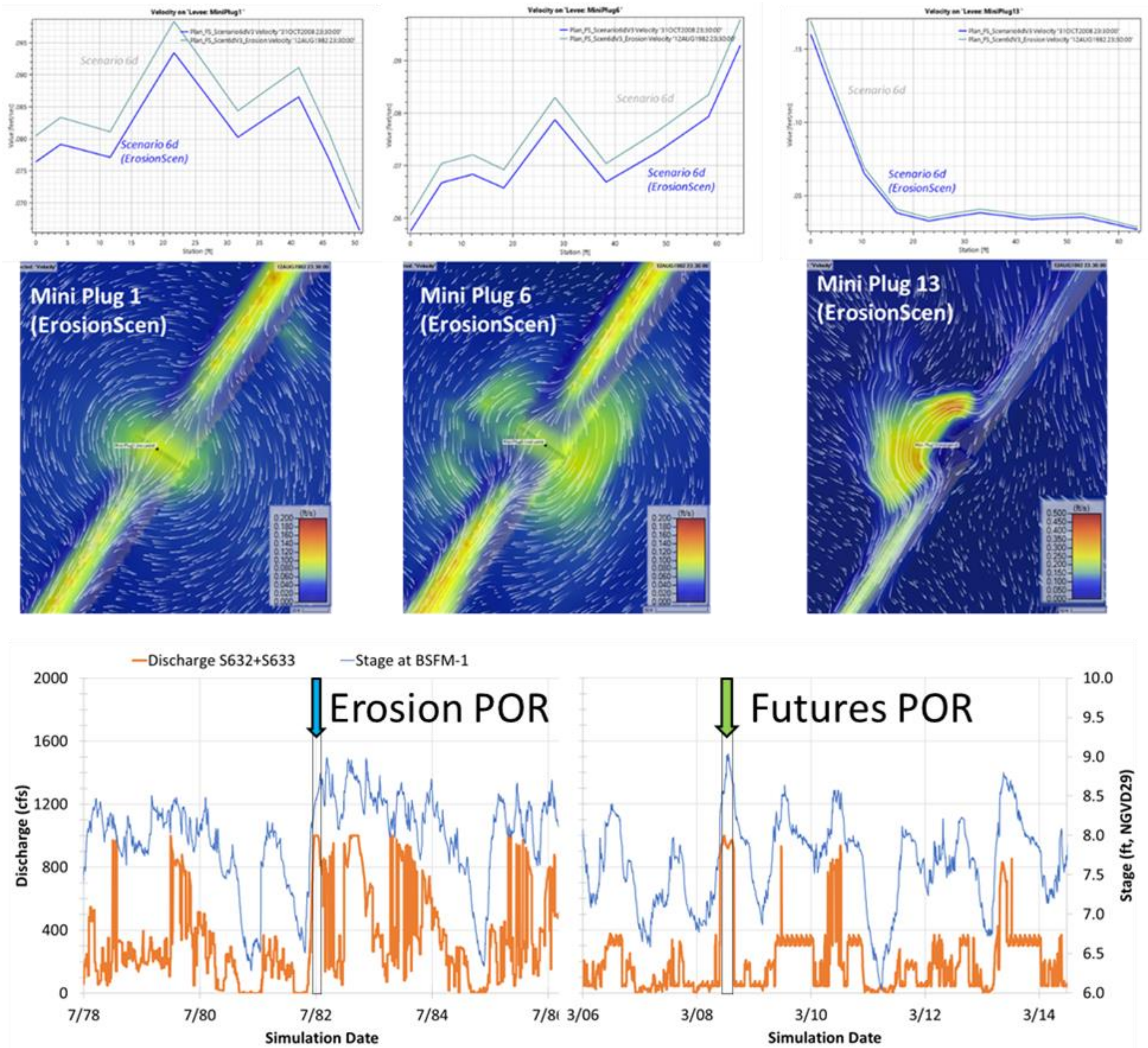


Figure 37. (Top) Velocity Comparison and Flow Fields around Selected Mini Plugs. (Bottom) BSF inflow discharge and interior marsh stage for the Erosion Period of Record (Jul-Aug 1982, blue arrow) and for the Future Scenarios period of record (Sep-Oct, 2008, green arrow).

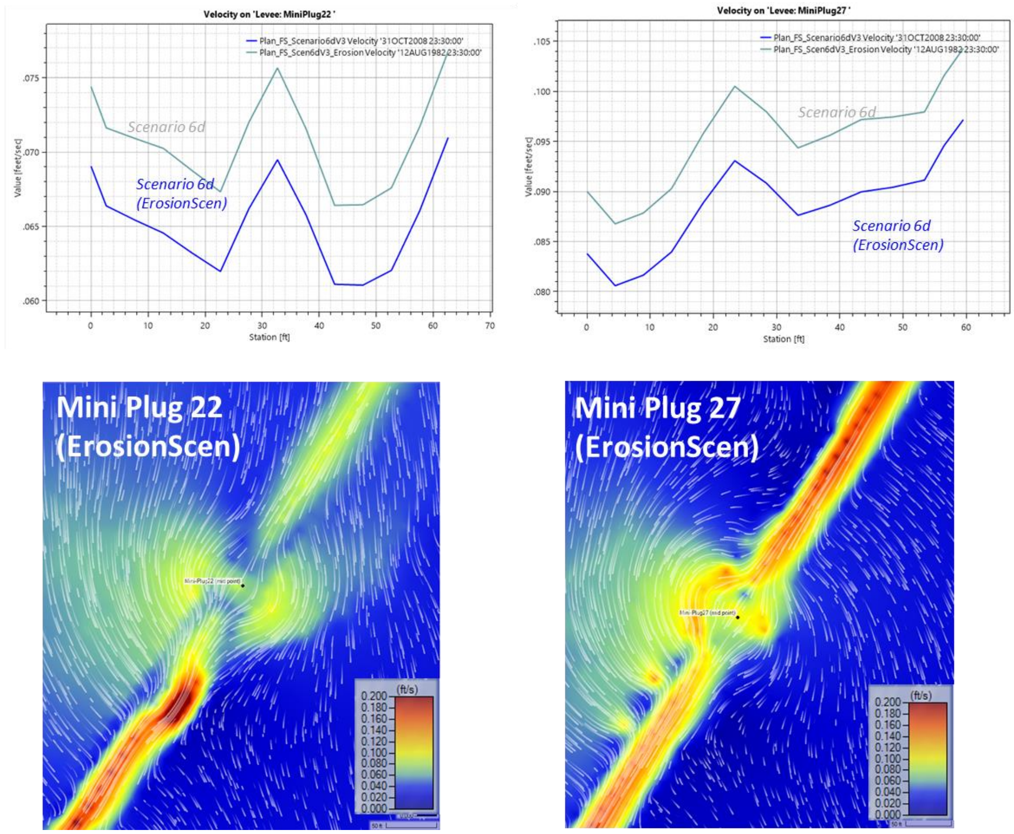


Figure 38. Velocity Comparison and Flow Fields around Selected Mini Plugs

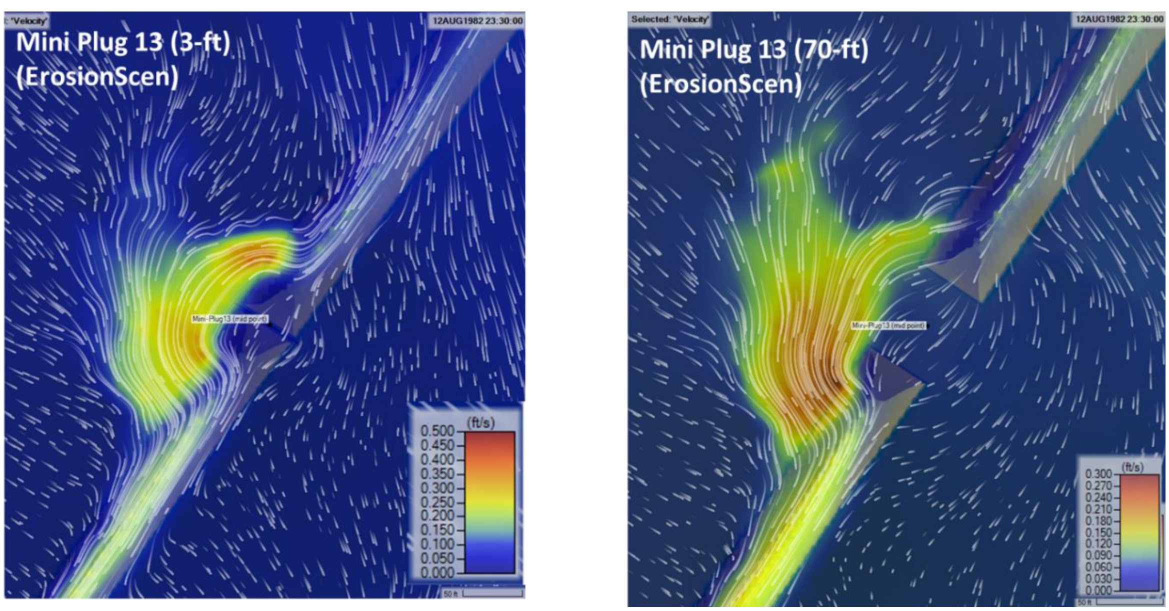


Figure 39. Flow Fields around Mini Plug 13

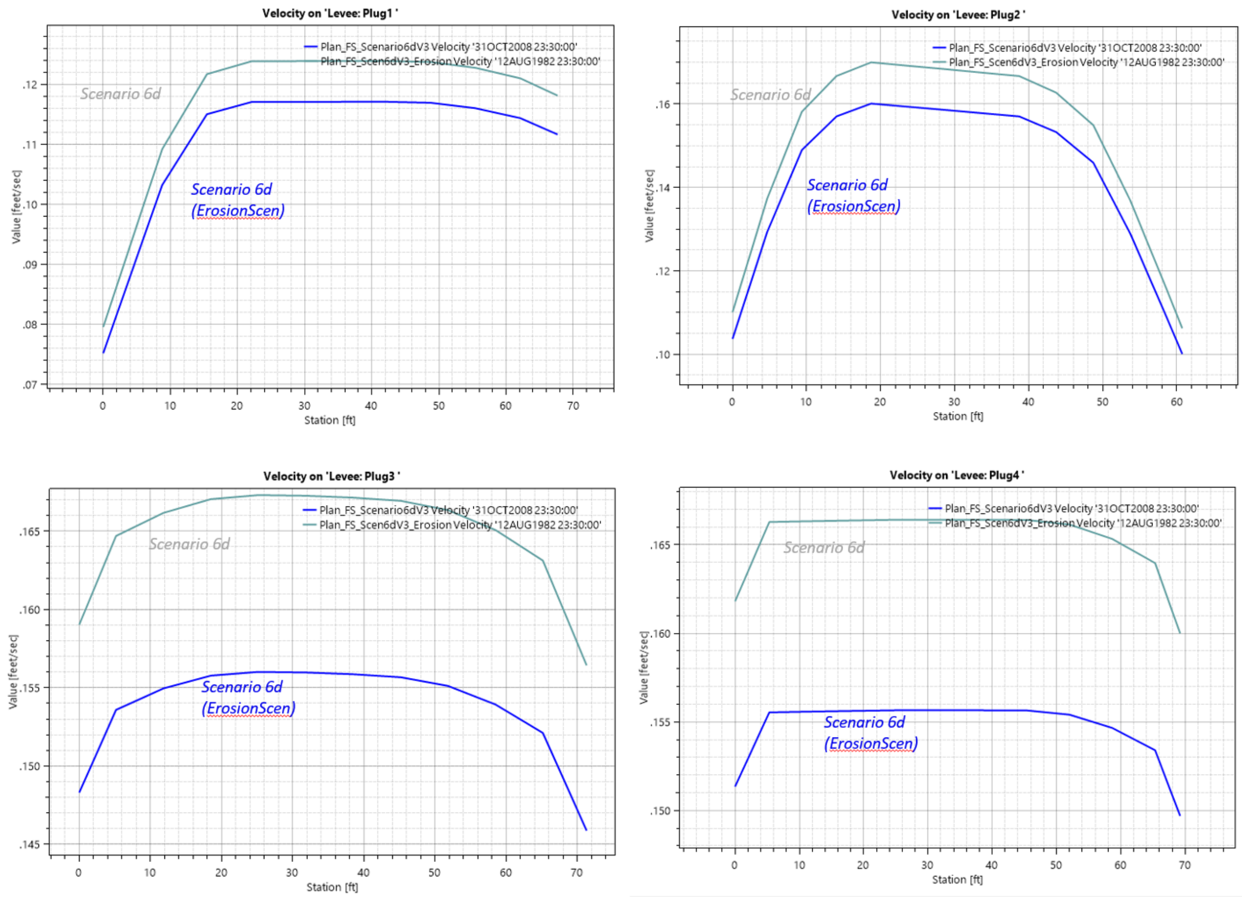


Figure 40. Velocity Comparison around 500-ft Plugs

6.2 Additional Scenarios to Evaluate the Preferred Configuration

Following identification of Scenario 6d as the preferred configuration, additional scenarios were developed to address remaining uncertainties. These supplemental evaluations were not intended to redefine the primary design objective, but rather to ensure constructability and that the recommended configuration maintains acceptable canal and marsh performance under plausible future conditions and reasonable design modifications.

The additional scenarios focused on three primary sources of uncertainty:

1. Hydraulic representation of AMI sloughs and wet prairie vegetation, which may evolve over time as restoration matures.
2. Localized concentration of residual canal flow in the southwestern reach of the L-67C Canal, closest to the L-29 Canal and Everglades National Park.

3. Constructability refinements to plug geometry and spacing, including alternative roughness assignments and supplemental plug placement.

6.3 Sensitivity to Vegetation Roughness Changes of AMI and Wet Prairie

In Scenario 6d configuration, AMI sloughs were parameterized hydraulically as open sloughs, consistent with field observations from the DPM studies and early AMI performance indicating reduced submerged vegetation resistance during high-flow periods (**Figure 1**). However, long-term vegetation development within AMI features remains uncertain. To evaluate potential sensitivity, an alternative configuration was simulated in which all AMI sloughs and wet prairie areas were assigned hydraulic roughness values (Manning's n of 0.35) consistent with normal slough conditions, which exhibit intermediate vegetation densities (and Manning's n) relative with open sloughs and wet prairies. This assumption was applied domain-wide except for AMI sloughs within approximately 400 m of the inflow structures, which remained classified as open sloughs to preserve near-field calibration fidelity. This scenario was referred to as Scenario 6d alternative configuration 1, in short Scenario 6dAC1.

Results indicate that the change to roughness in AMI and wet prairie areas produces noticeable velocity reduction in AMI sloughs, but a modest increase in ridge velocities and a corresponding slight increase in localized canal conveyance (**Figure 41, Figure 42, and 43**). However, canal discharge and velocity metrics remain below the established ecological targets at all primary transects. Spatial flow patterns remain dominated by distributed sheet-flow rather than channelized conveyance, and no systematic re-emergence of preferential canal routing was observed. These results suggest that Scenario 6dAC1 performance is not highly sensitive to reasonable uncertainty in vegetation hydraulic representation and remains robust across plausible future vegetation states.

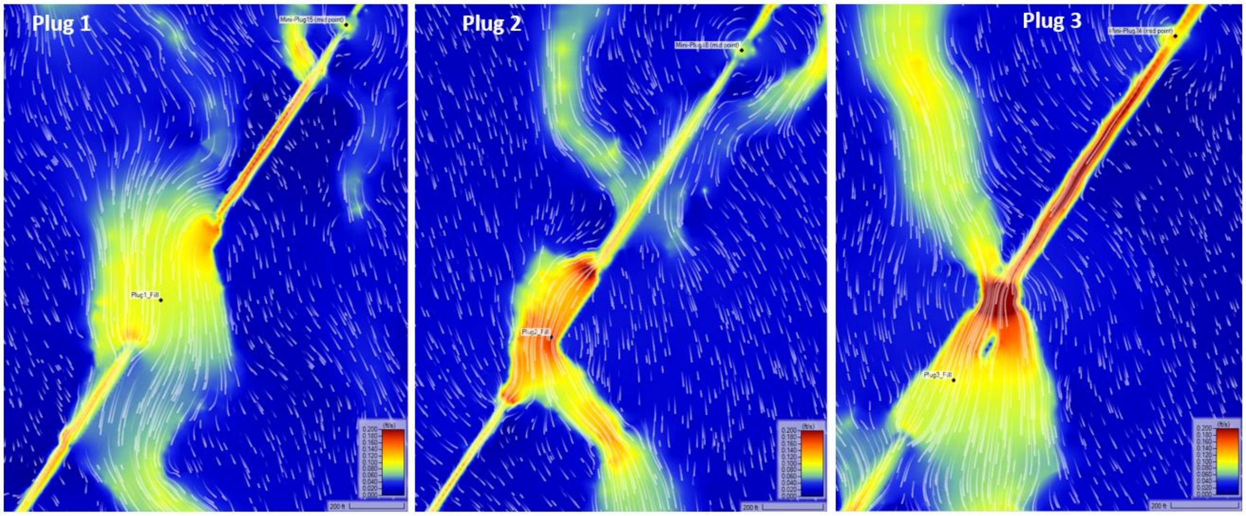


Figure 41. Simulated Flows near Canal Plugs in Base Scenario 6d

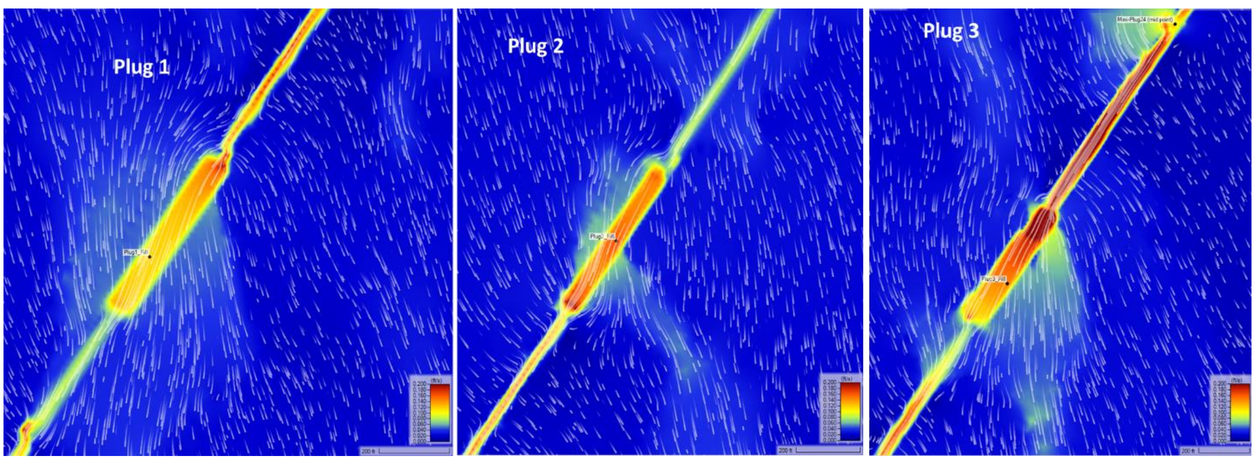


Figure 42. Simulated Flows near Canal plugs in Scenario 6dAC1

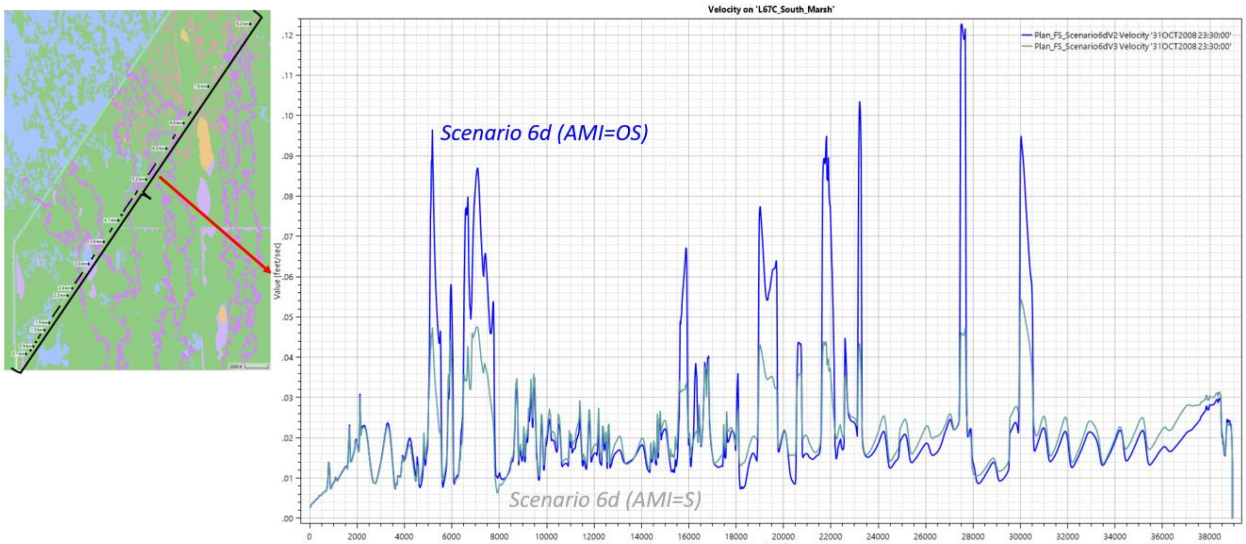


Figure 43. Comparison of Marsh Velocities (Transect is parallel to and 200 ft from L67C) for Base Scenario 6d (Blue) and Scenario 6dAC1 (Light Green)

6.4 Additional Plugs in the Southwestern Canal Reach

Although Scenario 6dAC1 achieved target canal discharge and marsh velocity criteria across most of the domain, localized sensitivity was observed near the southwestern terminus of the L-67C Canal, where hydraulic gradients are highest and proximity to the L-29 Canal increases the importance of limiting residual canal conveyance. To further evaluate this area, three additional 500-ft plugs were introduced in the southwest reach of the canal (Scenario 6dAC2).

The supplemental plugs further reduced canal velocities and discharges at downstream transects and improved uniformity of marsh flow redistribution. The added resistance decreased the spatial variability of canal flow and reduced localized acceleration between existing plugs. Marsh velocities remained within preferred ecological thresholds, although there are minor increases around to the added plugs but overall added plugs reduced inferred slough velocities.

From a hydraulic perspective, the added plugs provide incremental benefit in the most hydraulically sensitive reach of the canal; however, the magnitude of improvement relative to the base Scenario 6d configuration is moderate. These results indicate that although the base configuration already achieves acceptable performance, supplemental plugs improve performance and needed to consider with the base option should future monitoring indicate localized exceedance of performance targets in the southwest corridor.

6.5 Sensitivity to Manning's *n* Assignment at Plug Interfaces

Additional sensitivity simulations were performed to evaluate uncertainty in hydraulic roughness at the plug–marsh transition zones. In these cases, selected plugs were assigned alternative Manning's *n* values representing marsh (Manning's *n* of 0.85) and normal slough (Manning's *n* of 0.35) conditions to reflect potential variability in substrate consolidation, vegetation colonization, and long-term maintenance conditions (Scenario 6dAC3).

The simulations indicate that reasonable variation in plug-interface roughness produces only secondary effects on system-scale performance. Canal discharge reductions and marsh velocity targets remain satisfied across all evaluated transects. Localized velocity gradients near plug shoulders exhibit minor variation but remain well below thresholds associated with sediment mobilization or vegetation stress.

These findings suggest that the overall hydraulic effectiveness of the distributed plug strategy is primarily influenced by cumulative resistance and plug spacing, as demonstrated by the improved performance of scenarios incorporating more uniformly distributed plugs. In contrast, variations associated with individual plug-scale features appear to have a secondary influence on system-scale flow redistribution.

6.6 Combined Sensitivity: Additional Plugs and Modified Roughness

A combined scenario incorporating both additional southwest plugs and modified roughness assignments was also evaluated to assess potential compounding effects (Scenario 6dCombined). Extra AMI was also added to the southwest corner of BSF near L-29 Canal (**Figure 44**). This configuration represents a conservative upper-bound condition with increased resistance in both the canal corridor and adjacent marsh areas. Configurations of the four scenarios for sensitivity runs are summarized in **Table 4** .

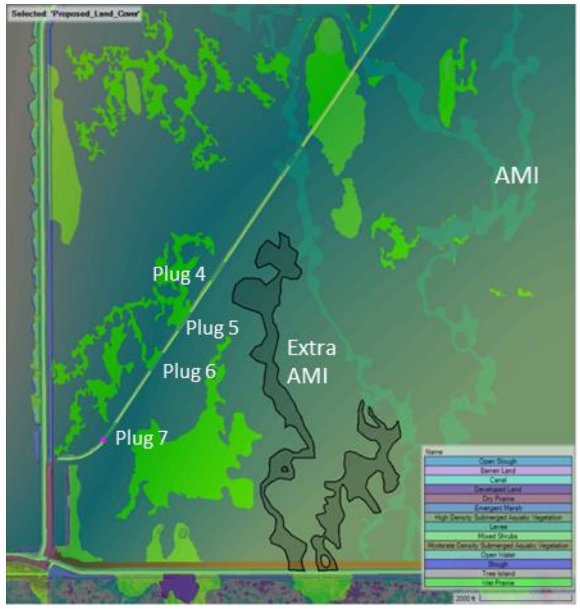


Figure 44. Location of the Extra AMI Introduced in Scenario 6dCombined

Table 4. Configurations of the four scenarios for Sensitivity Runs

Scenarios	Configurations
Scenario 6dAC1	• 500-ft fill (No adjacent N/S plug) • 31 Mini-Plugs (3-ft), equally spaced through entire L-67C canal • Fill elevation and mini plugs elevation are same as nearby marsh • AMI sloughs are treated as normal sloughs, except AMI sloughs within 400-m of S-632, S-633 are open sloughs • Wet Prairies are treated as normal sloughs
Scenario 6dAC2	• Three additional 500-ft plugs added to southwest corner of L67C canal • 28 Mini-Plugs (3-ft)
Scenario 6dAC3	• Three additional 500-ft plugs added to southwest corner of L67C canal • Marsh conditions at plugs 4 & 7, and normal slough conditions at plug 5 & 6
Scenario 6dCombined	• Extra AMI added to the southwest corner of BSF near L29 canal

Most of the configuration changes are made at the south of the L67-C canal and south-west corner of BSFW area. Flow and velocity were compared for additional scenarios at the south-west. **Figure 45** showed the marsh flow comparison between 0.7 km and 0.8 km marsh transects. Marsh flows are well below the target flow for all the scenarios, but the Scenario 6dCombined performed best.

Comparing marsh velocity among the scenarios at the 0.9-km transect (**Figure 46**) demonstrated that Scenario 6dCombined and Scenario 6dAC3 performed better than the other scenarios. Adding extra AMI features reduces velocities relative to the original Scenario 6d. A comparison of scenario velocities along a north-south transect downstream of the L-67C Canal and spanning the L-67D and L-67A levees demonstrated that velocity differences across scenarios were most noticeable in the southwest area. Some local velocity increases correspond to plug and mini-plug locations. While most of the domain demonstrates velocities < 0.1 ft/s in the slough (inferred from 0.024 ft/s in ridge locations), Scenario 6dCombined and Scenario 6dAC3 tended to perform better near the southwest terminus (**Figure 47**).

Flow and velocity comparisons at 0.8 km canal transect point demonstrate that Scenario 6dCombined performs better, meeting target velocities (**Figure 48** & **Figure** 49). Adding three plugs and land-cover adjustments in the southeast yield the lowest velocities and substantially reduced discharge to below 20 cfs.

Results show Scenario 6dCombined consistently meets canal discharge and marsh velocity targets, with slightly enhanced attenuation of discharge in the southwestern-most reach of the canal. Marsh flow fields remain spatially more uniform, and minimal adverse hydraulic side effects were identified. The Scenario 6dCombined configuration demonstrates robust hydraulic performance and is considered suitable for advancement as the preferred alternative for further design refinement.

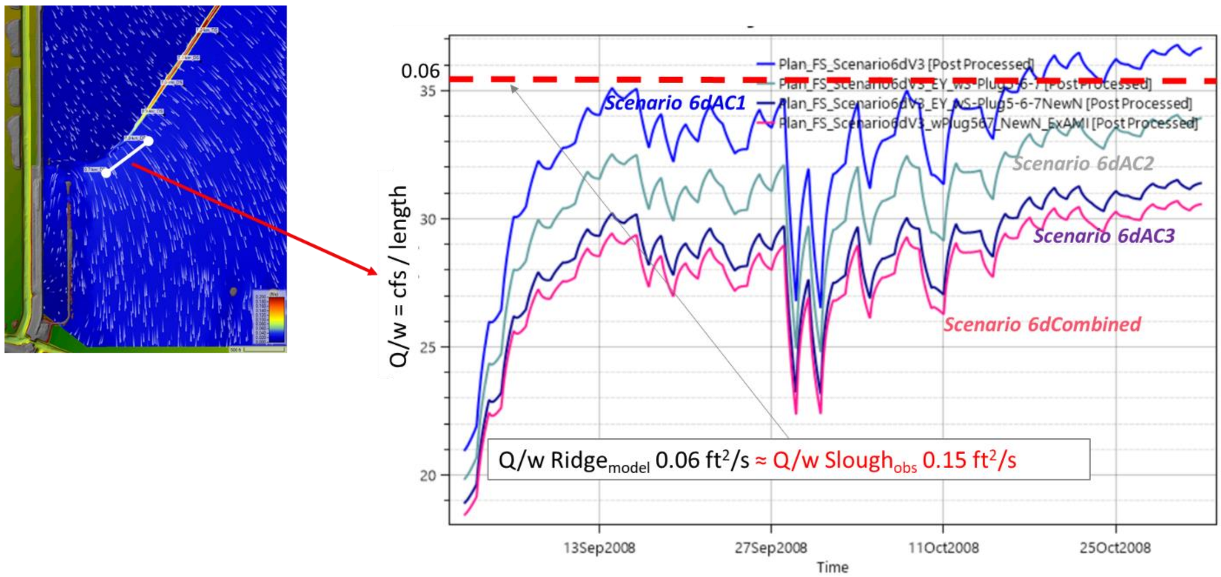


Figure 45. Marsh Flow between 0.7-0.8 km Marsh Transects

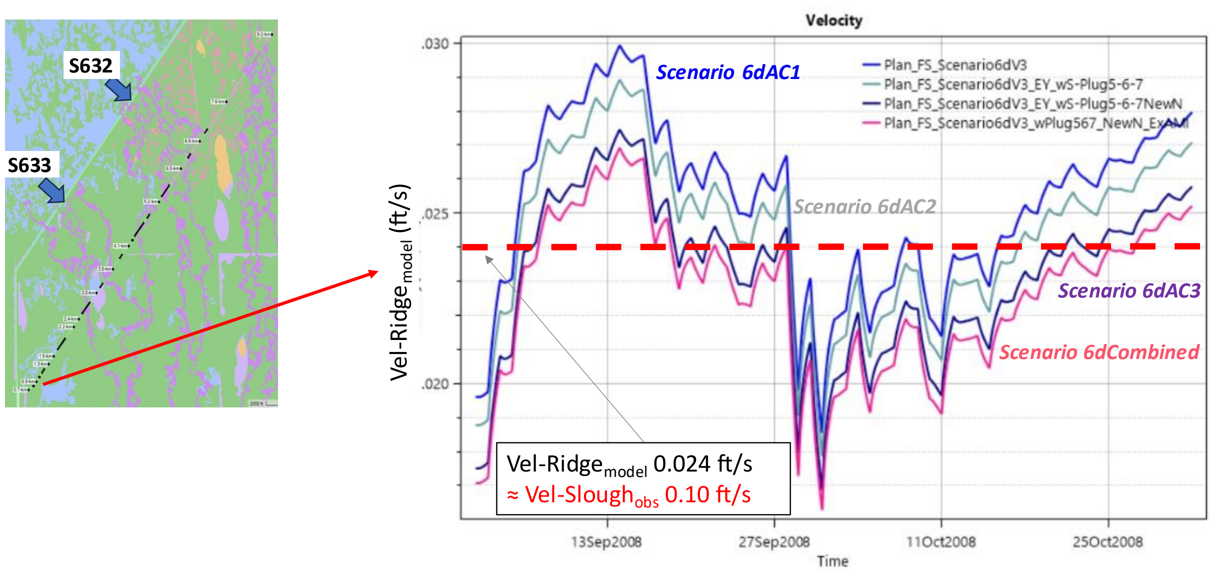


Figure 46. Marsh velocity at 0.9 km Marsh transects

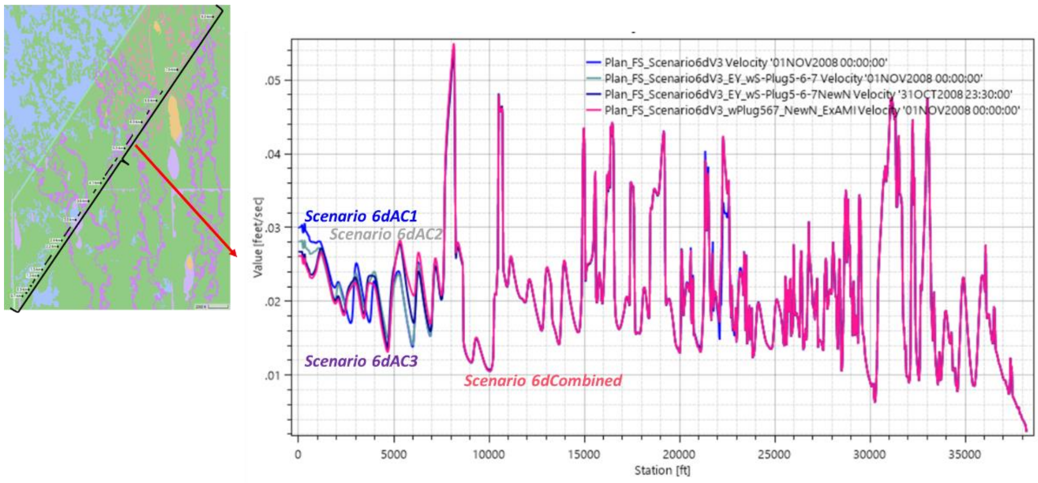


Figure 47. Transect Marsh Velocity between L67D and L67A

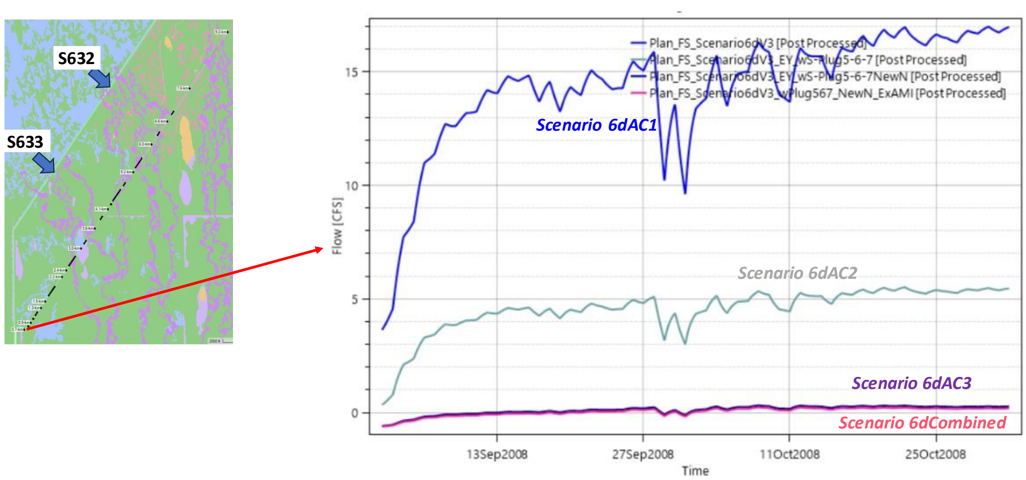


Figure 48. Canal Flow Comparison at 0.8-km Transect Point

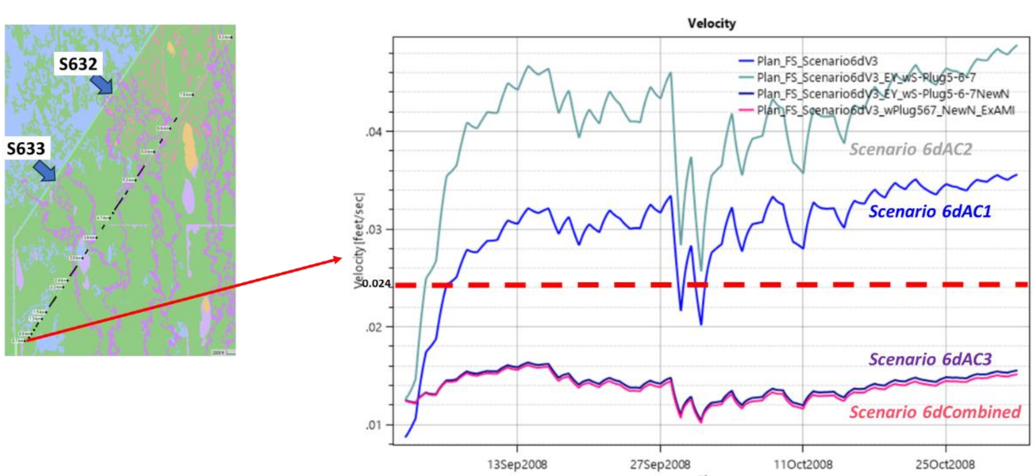


Figure 49. Canal Velocity Comparison at 0.8-km Transect Point

6.7 Implications for Design Robustness and Adaptive Management

Collectively, the additional scenarios demonstrate that the recommended distributed plug configuration exhibits strong robustness to address uncertainty in vegetation hydraulic properties, localized hydraulic gradients, and constructability refinements. The dominant hydraulic mechanisms controlling performance are the cumulative resistance provided by distributed plugs and the avoidance of long uninterrupted canal reaches that promote preferential channelized flow.

Key implications include:

Hydraulic Stability: Scenario 6d consistently maintains canal discharges below ecological targets and marsh velocities within preferred thresholds across a wide range of plausible parameter variations.

Limited Sensitivity to Roughness Uncertainty: Reasonable variation in vegetation and plug roughness does not materially degrade system performance, reducing long-term operational risk associated with vegetation succession or maintenance variability.

Targeted Flexibility in the Southwest Reach: Additional plugs in the southwest corridor provide incremental benefit and achieve baseline performance objectives. These features may be considered as adaptive enhancements if future monitoring identifies localized exceedance.

Constructability Compatibility: Modest changes in plug geometry and roughness do not compromise hydraulic performance, supporting flexibility during final design refinement.

Overall, the sensitivity analyses confirm that the recommended distributed plug strategy provides a resilient and adaptable framework for achieving marsh to marsh connectivity, minimizing residual canal conveyance, and supporting long-term ecological restoration objectives within the Blue Shanty Flowway.

6.8 Constructability Alternatives Evaluated

The preceding sensitivity analyses focused on hydraulic and ecological robustness under parameter uncertainty. The next step is to evaluate practical implementation considerations to ensure that hydraulic performance can be maintained while accommodating construction feasibility and operational constraints.

Based on constructability screening and coordination with design and operations staff, two refined mini-plug configurations were developed and evaluated using the BSFM. Both alternatives retain the seven 500-ft marsh-grade long plugs used in Scenario 6d and focus exclusively on modifying mini-plug length and spatial distribution to improve constructability while preserving hydraulic performance. Configurations of Alternative A & B described below are shown in **Figure 50**. These two alternatives explicitly isolate the relative sensitivity of canal hydraulics to mini-plug spacing versus mini-plug length. Performance was evaluated using canal velocity and discharge responses at the 6.6-km and 7.6-km canal transects, together with marsh velocity responses at the 0.9-km marsh transect, consistent with the constructability assessment framework.

The constructability alternatives were as follows:

Alternative A:

Mini-plug length was increased from 3 ft to 10 ft while maintaining the same number of mini-plugs (28) and the same longitudinal spacing and locations as Scenario 6d configuration. Mini-plugs remain distributed along the full length of the L-67C Canal at approximately 1000-ft intervals between the seven 500-ft marsh-grade plugs and the L-67D and L-67A levees. This alternative of extending the mini plugs was intended to improve constructability, placement tolerances, and long-term durability of the mini-plug features without altering the cumulative distributed hydraulic resistance provided by the original layout.

Alternative B:

Mini-plug length was increased to 20 ft; and a reduction in number of mini-plugs in the northern reach of the L-67C Canal, resulting in increased spacing between adjacent mini-plugs. Mini-plug locations in the southern reach were maintained consistent with Scenario 6d, while the northern reach experienced reduced plug density (approximately seven 500-ft long plugs supplemented by ~20 mini-plugs). This alternative was designed to evaluate whether increased individual plug length could compensate for reduced plug density while further improving constructability.

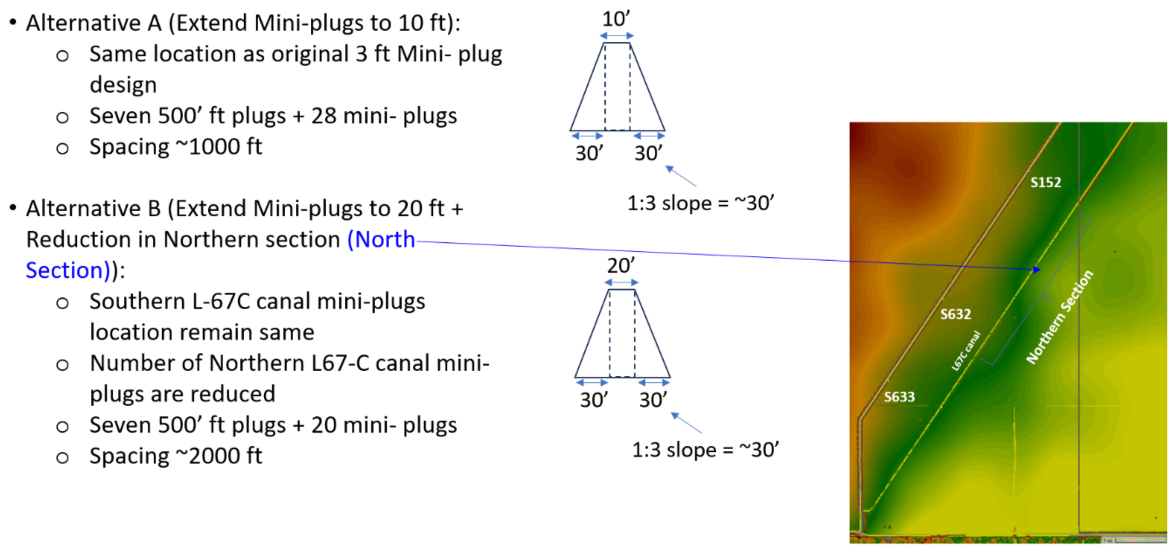


Figure 50. Mini Plugs – Design Alternative 6d+: Configurations of Alternative A & B

At the 6.6-km canal transect, Alternative B configurations increased canal velocity as a result of increased spacing of the mini plugs (**Figures 51 & 52**). For the same reason, canal discharge also increased for Alternative B compared to Alternative A. In Alternative B, canal discharge was 3-fold higher than the ecological target of 20 cfs. Similar findings were observed at 7.6-km Canal transect (**Figure 53**).

Marsh velocity was compared at 6-km and 7.6-km transects, both points located approximately 50-ft south of nearby mini plugs (**Figure 54** & **Figure 55**). At both points, increased marsh velocity was observed for Alternative B with increased spacing between mini plugs. No differences in marsh velocity were evident at the southwestern-most transect at 0.9-km (**Figure 56**). As there were no changes made in south section of the model, no significant change in velocity was expected.

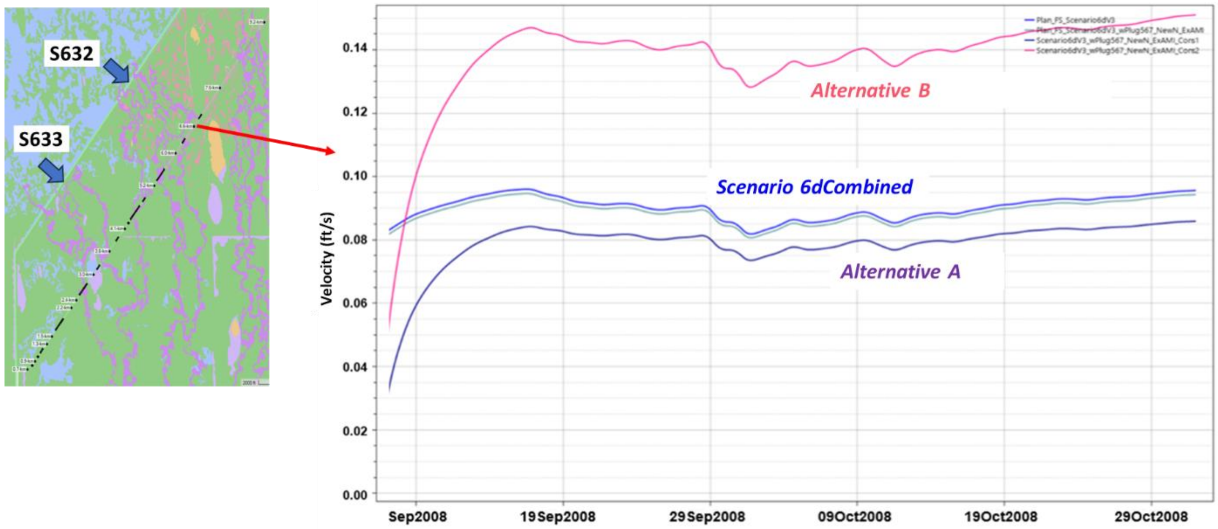


Figure 51. Comparison of Velocity at 6.6-km Canal Transect

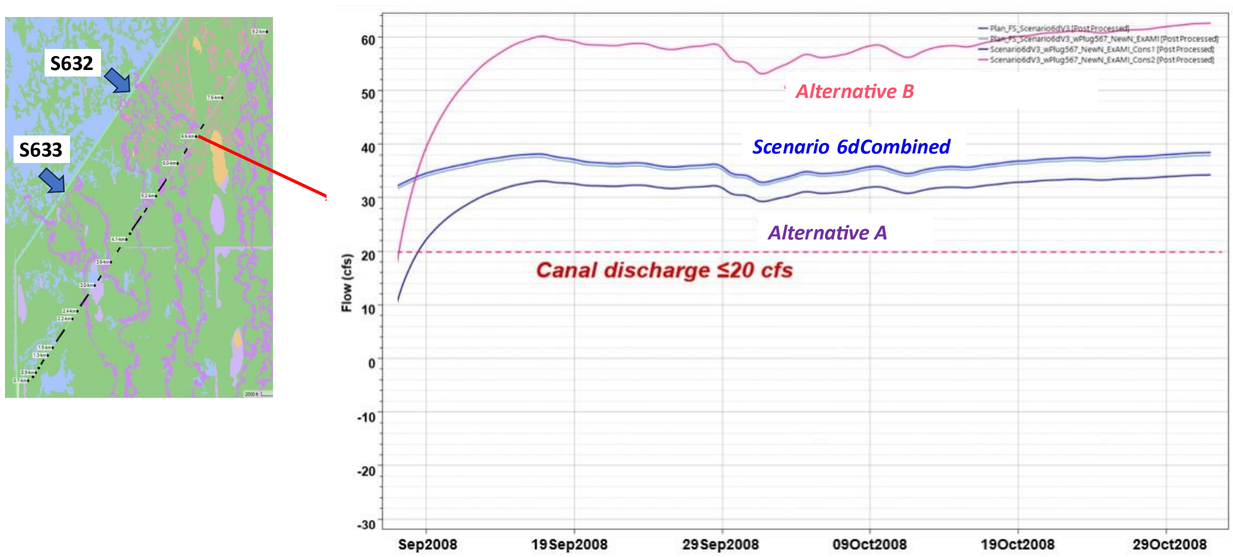


Figure 52. Comparison of Flow around 6.6-km Canal Transect

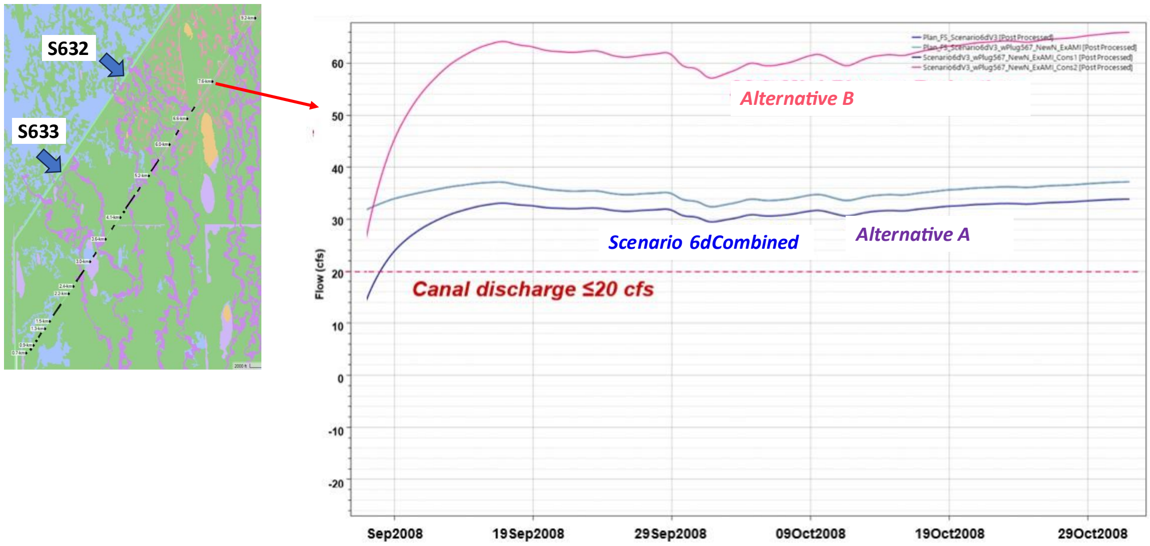


Figure 53. Comparison of Flow at 7.6-km Canal Transect

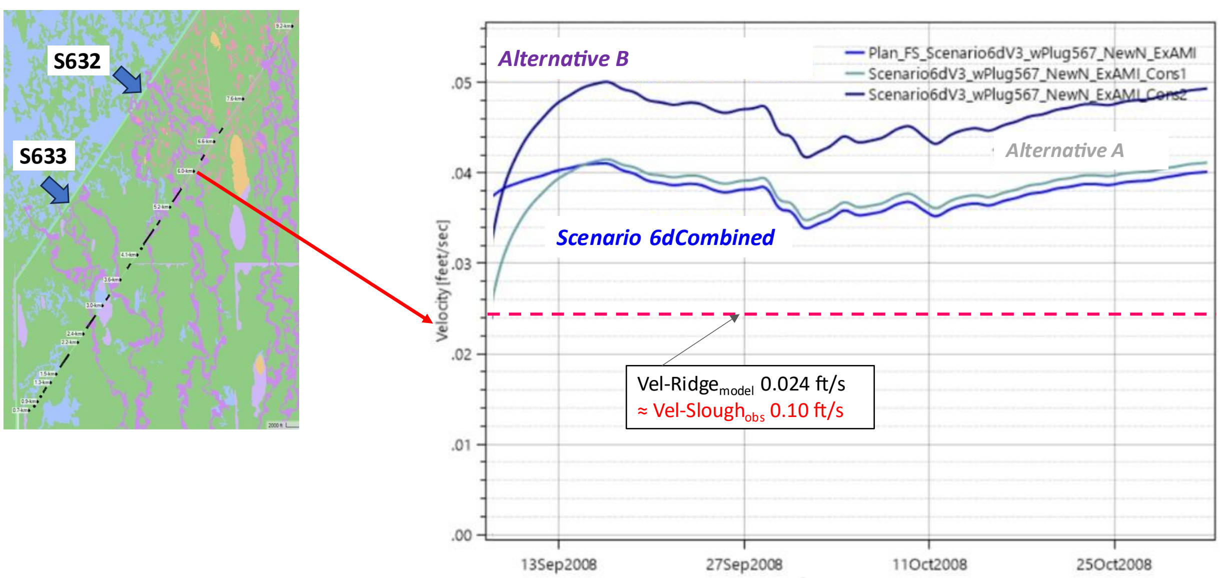


Figure 54. Comparison of Velocity at 6-km Marsh Transect

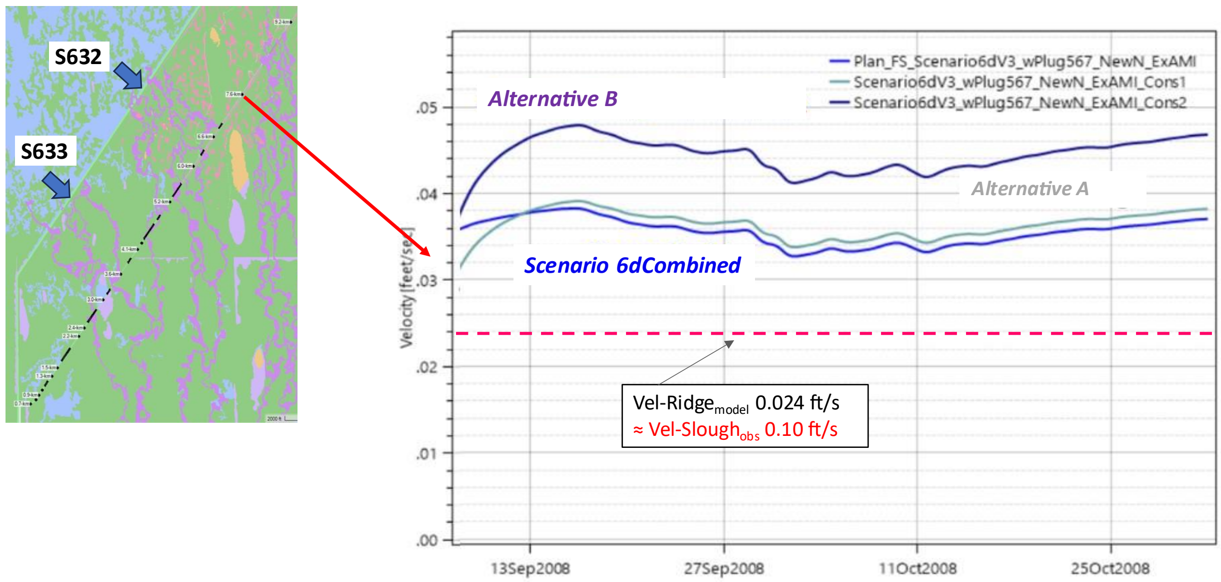


Figure 55. Comparison of Velocity at 7.6-km Marsh Transect

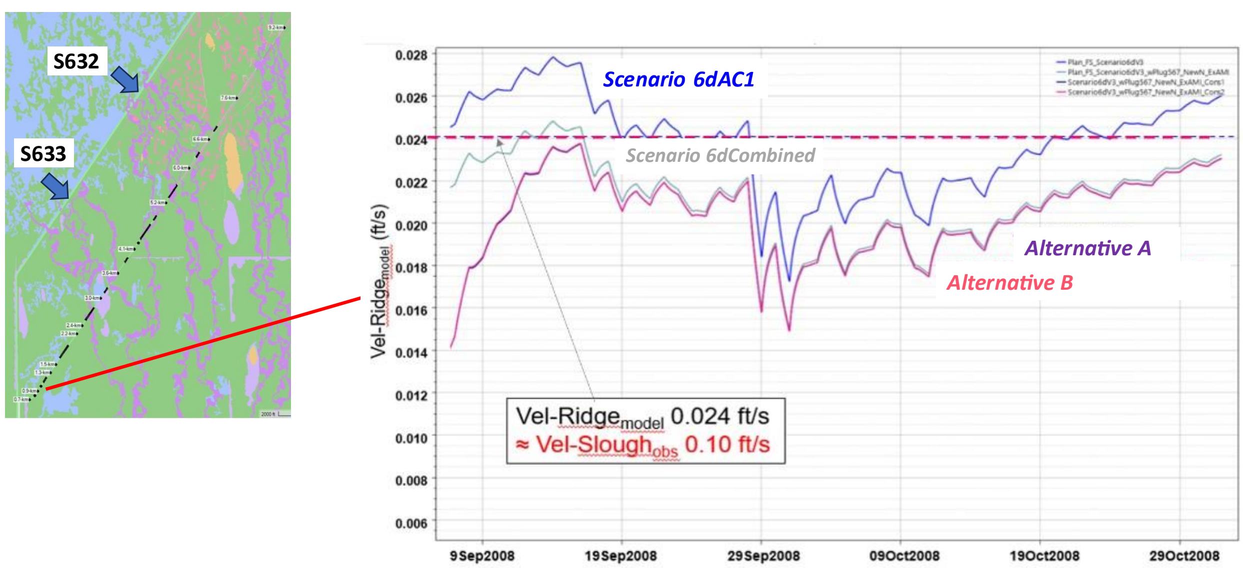


Figure 56. Comparison of Velocity at 0.9-km Marsh Transect

The results indicate that increasing the spacing between mini plugs significantly increases canal discharge, which fails to meet the ecological targets. Therefore, Alternative A (Extend Mini-plugs to 10 ft, maintaining the same location and about 1000-ft spacing (seven 500' ft plugs + 28 mini- plugs) is recommended.

For the final mini-plugs design, changes in the location of 10 mini-plugs, seven in the north and three in the middle section of the L-67C canal, were recommended by the science team of

Everglades Systems Assessment (ESA). Several of the original mini-plug locations intersected the primary AMI slough flow path and created undesirable, high canal loading into the sloughs. Alternative A, simulated with these revised mini-plug locations, demonstrated a reduction in localized canal-to-slough loading and some localized flow changes. Results indicated that, overall, the flow field did not change with these adjustments.

The District's Engineering & Construction Bureau wanted to further evaluate the L-67C Canal flow by increasing the spacing between mini-plugs by 250 ft, from 1000 ft to 1250 ft, at the northern reach. Mini-plug length remained 10 ft. As a result of the increased spacing, the number of mini-plugs in the northern reach of the L-67C canal was reduced by four. L-67C canal flows were compared at different canal transects. The 250-ft increase in spacing resulted in a 8 to 13 cfs increase in flows in the canal compared to Alternative A (**Figure 57**). Although the increase in canal flow was not as substantial as in Alternative B, increased flows in the canal failed to meet the ecological target similar to the Alternative B results.

Final recommended configurations with plugs and mini-plugs locations are shown in **Figure 58**.

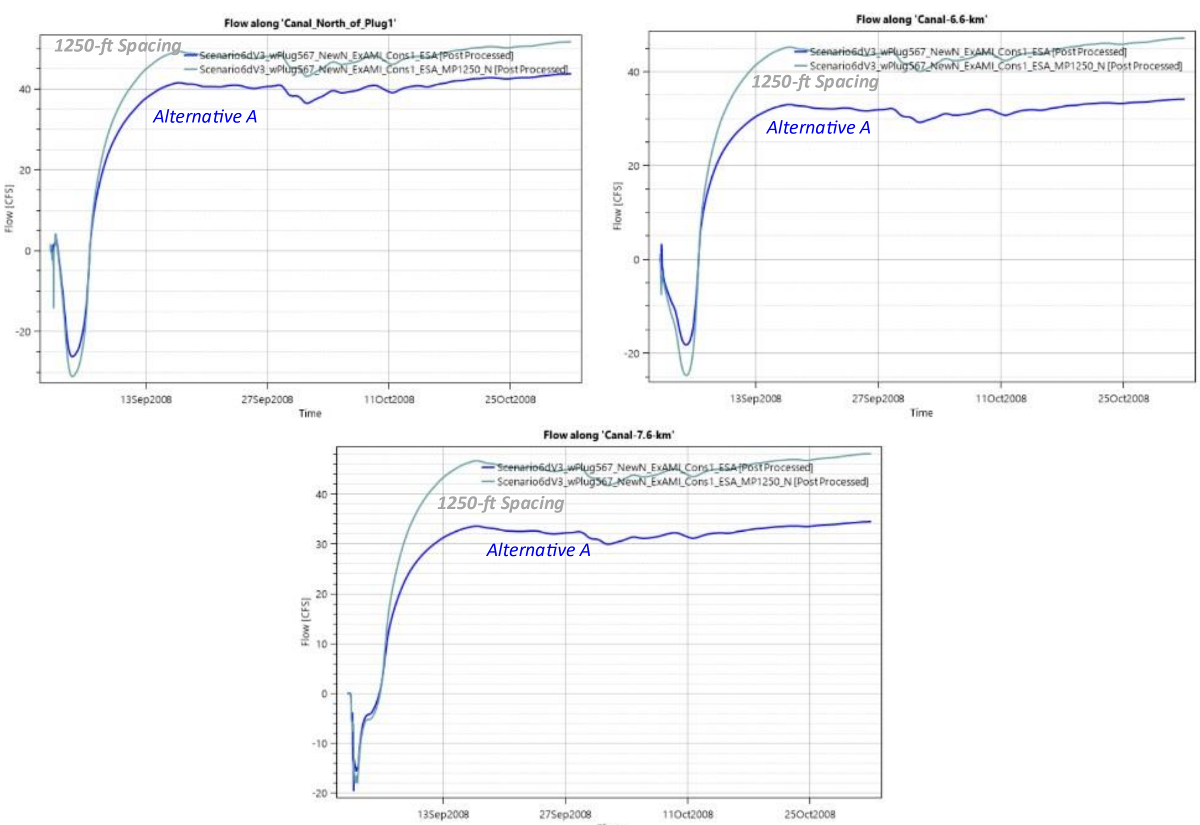
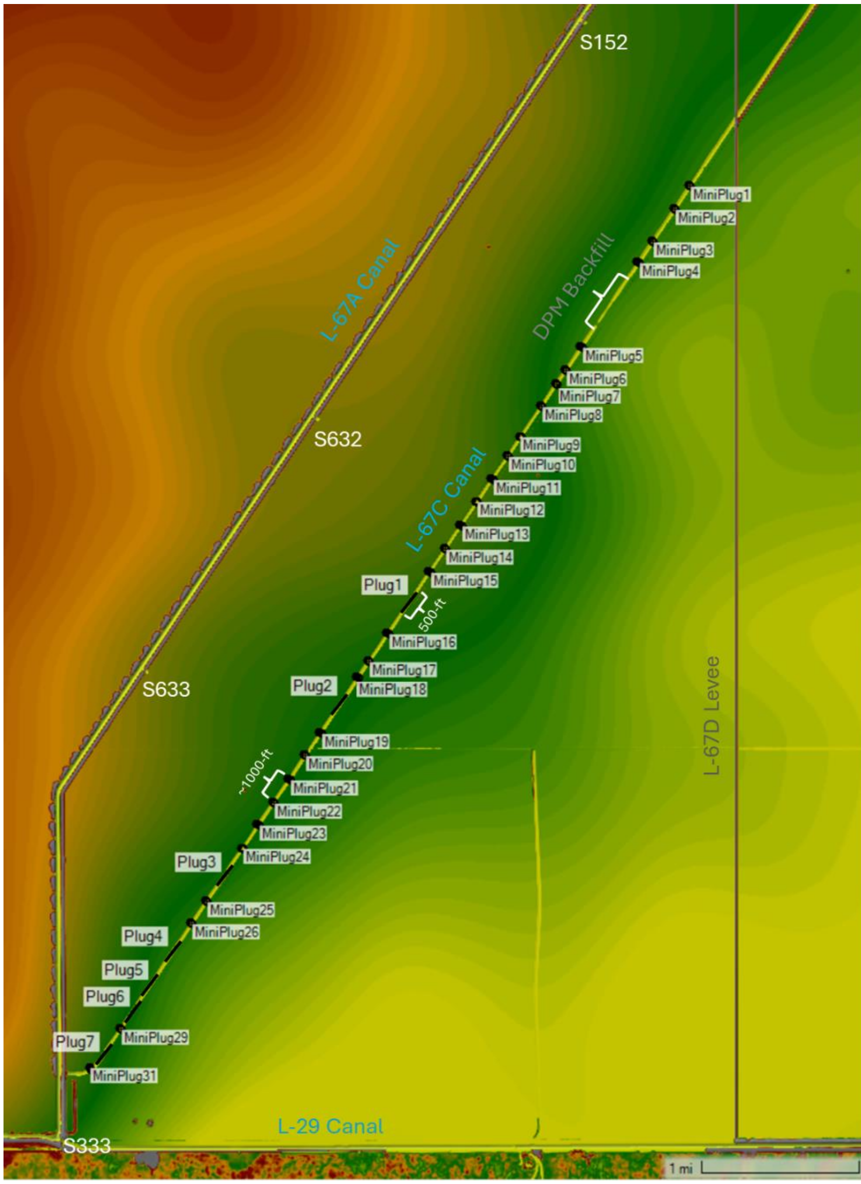


Figure 57. Flow Comparisons at L-67C Canal Transects



Name	Central Point Location	
	Lattitude (DD)	Longtitude (DD)
Plug1	25.811313	-80.638456
Plug2	25.801964	-80.645483
Plug3	25.78601	-80.65748
Plug4	25.779129	-80.662652
Plug5	25.776152	-80.664866
Plug6	25.773737	-80.666682
Plug7	25.769565	-80.66984
MiniPlug1	25.849094	-80.610061
MiniPlug2	25.846964	-80.611668
MiniPlug3	25.844019	-80.613876
MiniPlug4	25.842093	-80.615326
MiniPlug5	25.834361	-80.621134
MiniPlug6	25.832252	-80.622717
MiniPlug7	25.830989	-80.623671
MiniPlug8	25.828997	-80.625156
MiniPlug9	25.826163	-80.627286
MiniPlug10	25.824458	-80.62857
MiniPlug11	25.822348	-80.630164
MiniPlug12	25.82024	-80.631758
MiniPlug13	25.818105	-80.633358
MiniPlug14	25.816	-80.634945
MiniPlug15	25.813876	-80.636529
MiniPlug16	25.808222	-80.640771
MiniPlug17	25.805713	-80.64267
MiniPlug18	25.804202	-80.643818
MiniPlug19	25.799167	-80.647578
MiniPlug20	25.79707	-80.649171
MiniPlug21	25.794928	-80.650768
MiniPlug22	25.792819	-80.652366
MiniPlug23	25.790717	-80.653941
MiniPlug24	25.78859	-80.655524
MiniPlug25	25.783783	-80.659152
MiniPlug26	25.781727	-80.6607
MiniPlug29	25.772137	-80.667898
MiniPlug31	25.768494	-80.670881

Figure 58. Recommended Final Plugs Design and Coordinates of the Plugs

7. SUMMARY

A two-dimensional hydrodynamic model was developed and validated to evaluate canal-plug configurations within the Blue Shanty Flowway. During the 2016 Reality Check period, simulated water stages matched observations within ±0.15 ft, canal discharge comparisons yielded an R^2 of 0.99, and ridge–slough velocity contrasts were reproduced with root-mean-square errors near 0.02 ft/s. These results confirm that the model reliably represents canal–marsh exchange and marsh hydrodynamics, providing a defensible basis for restoration design evaluation.

Under the CEPP-S future condition without additional measures to redistribute canal flow the L-67C Canal remains a dominant conveyance pathway. Canal discharges exceed the 20-cfs ecological target at multiple transects, and longitudinal channelization persists despite AMI slough features. The baseline condition therefore fails to sufficiently reduce residual canal dominance or associated sediment transport risk.

Scenarios consisting of fewer medium- or long-length plugs reduced velocities locally but did not achieve system-wide compliance. Long uninterrupted canal segments allow flow to re-accelerate between plugs, maintaining preferential routing and limiting marsh redistribution. Increasing plug length alone concentrates resistance rather than distributing it and does not eliminate residual channelization.

In contrast, distributed resistance fundamentally alters canal hydraulics. Scenario 6d, which combines seven 500-ft marsh-grade plugs with distributed mini-plugs along the full canal length, interrupts conveyance continuity and increases cumulative energy dissipation. Canal discharges are reduced below the 20-cfs target across the southern, middle, and northern reaches, and slough velocities remain near the preferred basin-wide target of <0.1 ft/s. Sensitivity analyses indicate that this performance is robust under variations in vegetation roughness, localized plug modifications, and constructability considerations.

Based on optimization and sensitivity evaluations, a conceptual design configuration is identified consisting of seven 500-ft plugs concentrated in the southern portion of the L-67C Canal, supplemented by approximately twenty-seven 10-ft mini-plugs spaced at ~1,000-ft intervals and one 70-ft mini-plug along the canal from the L-67D levee to the L-67A levee. This configuration provides a practical basis for advancing design and informing LRR development by defining both the magnitude and spatial distribution of required flow redistribution features.

The results demonstrate that restoration effectiveness depends on preventing re-establishment of continuous canal conveyance. Distributed resistance provides consistent hydraulic attenuation, promotes marsh-to-marsh connectivity, and supports long-term ecological stability. The Scenario 6dCombined with 10-ft mini plugs configuration represents a hydraulically efficient and ecologically protective design that is robust to parameter uncertainty and constructability refinement, and it provides a technically defensible basis for advancing restoration implementation within the Blue Shanty Flowway.

8. REFERENCES

Ross, M.S., J.B. Heffernan, J.P. Sah, E. Isherwood, and J. Blanco. 2015. Everglades Ridge, Slough, and Tree Island Mosaics Year 4 Report (2010–2014). Submitted under Cooperative Agreement #: W912HZ-10-2-0030. Modification # P00002 to United States Army Engineer Research and Development Center.

SFWMD. 2005. Documentation of the South Florida Water Management Model, Version 5.5. Table 2.4.2.1: "Overland Flow Coefficients for Effective Roughness as Used in the South Florida Water Management Model (cell-to-cell overland flow)." South Florida Water Management District, West Palm Beach, FL.

SFWMD. 2022. SFWMD Land Cover Land Use 2017–2019 Geodatabase. SFWMD, West Palm Beach, FL. Available online at:

https://services1.arcgis.com/sDAPyc2rGRn7vf9B/arcgis/rest/services/SFWMD_LCLU_2017_2019/FeatureServer

Sklar, F.H. (ed.). 2023. Chapter 6: Everglades Research and Evaluation. 2023 South Florida Environmental Report – Volume I, South Florida Water Management District, West Palm Beach, FL.

USACE. 2020. *Central Everglades Planning Project – PPA South, Broward and Miami-Dade counties, Florida, Central Everglades Restoration Plan, Design Documentation Report, Appendix*

A – Hydrologic and Hydraulic Modeling Analysis. United States Army Corps of Engineers, Jacksonville, FL

SFWMD. 2025. 2025 South Florida Environmental Report. South Florida Water Management District, West Palm Beach, FL. Available online at:

https://sfer-docs.sfwmd.gov/2025_sfer_final/2025_SFER_full_report.pdf