2023 COASTAL MASTER PLAN

EXTENDED PROJECT NARRATIVES - ICM

ATTACHMENT C4

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COASTAL PROTECTION AND RESTORATION AUTHORITY

This document was developed in support of the 2023 Coastal Master Plan being prepared by the Coastal Protection and Restoration Authority (CPRA). CPRA was established by the Louisiana Legislature in response to Hurricanes Katrina and Rita through Act 8 of the First Extraordinary Session of 2005. Act 8 of the First Extraordinary Session of 2005 expanded the membership, duties, and responsibilities of CPRA and charged the new authority to develop and implement a comprehensive coastal protection plan, consisting of a master plan (revised every six years) and annual plans. CPRA's mandate is to develop, implement, and enforce a comprehensive coastal protection and restoration master plan.

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AAL .... AVERAGE ANNUAL LAND
AD .... ATCHAFALAYA RIVER DIVERSION
ATD.......... ATCHAFALAYA DELTA
BFD.......... BIRD'S FOOT DELTA
CAL.......... CALCASIEU
CCGHR .... CAMERON-CREOLE TO THE GULF HYDROLOGIC RESTORATION
CFS .... CUBIC FEET PER SECOND
CHS.......... CHANDELEUR SOUND
CM .... CENTIMETER
CPRA .... COASTAL PROTECTION AND RESTORATION AUTHORITY
ETB.......... EASTERN TERREBONNE
FFIBS .... FRESH, FORESTED, INTERMEDIATE, BRACKISH, SALINE
FWIP1.......... FUTURE WITH IMPLEMENTATION PERIOD 1
FWOA .... FUTURE WITHOUT ACTION
FWA .... FUTURE WITH ACTION
GIWW.......... GULF INTRACOASTAL WATERWAY
HNC .... HOUMA NAVIGATION CANAL
HSI .... HABITAT SUITABILITY INDEX
IAFT .... INCREASE ATCHAFALAYA FLOW TO TERREBONNE
IP1 .... IMPLEMENTATION PERIOD 1
IP2 .... IMPLEMENTATION PERIOD 2
KM .... KILOMETER
LBAne.......... LOWER BARATARIA (NE)
LBAnw.......... LOWER BARATARIA (NW)
LBAse.......... LOWER BARATARIA (SE)
LBAnw.......... LOWER BARATARIA (NW)
LBO.......... LAKE BORGNE
LBR .... LOWER BRETON
LPO .... LAKE PONTCHARTRAIN

M .... METER
MBA .... MID BARATARIA
MBHR .... MERMENTAU BASIN HYDROLOGIC RESTORATION
MG/L .... MILLIGRAMS PER LITER
MEL .... MERMENTAU/LAKES
MRP .... MAUREPAS
PEN .... PENCHANT
PPT .... PARTS PER THOUSAND
SAB .... SABINE
SEA LEVEL RISE .... SLR
TSS .... TOTAL SUSPENDED SEDIMENT
TVB .... TECHE/VERMILLION/BAYS
UBA .... UPPER BARATARIA
UBR .... UPPER BRETON
VRT .... VERRET BASIN
WTE .... WESTERN TERREBONNE

1.0 INTRODUCTION

Analysis for the 2023 Coastal Master Plan focused on a regional approach to understanding the dynamics of a changing coastal Louisiana landscape. This report examines representative datasets from the Integrated Compartment Model (ICM) simulations of a future without action (FWOA), under two scenarios of possible future environmental conditions. Across all five coastal regions, model outputs are shown to provide a thorough understanding of how, and why the future landscape will look different from what it looks like today. Rather than simply reporting the same datasets at fixed locations in a repetitive format, this report instead is structured such that the data will tell a compelling narrative of one, or a few, of each coastal region and how that region may experience change in the future.

This report is specifically focused on the 2023 Coastal Master Plan FWOA under the lower and higher project selection environmental scenarios. These are outputs from the FWOA simulations that were directly used to assess a candidate project's robust performance under both scenarios. These simulations represent two possible outcomes for coastal Louisiana if we were to put our shovels (and dredges) down after we finish building all of the projects that we currently having funding (and permits) to construct. While we know that these two scenarios are not exact forecasts of the next 50 years, they are based upon real potential future climates, and were developed from the latest available data provided by international climate change modeling efforts.

The five regions examined are: Chenier Plain, the Central Coast, Terrebonne Basin, Barataria Basin, and the Pontchartrain/Breton. This report will discuss all five subroutines of the ICM that interact to update the coastal landscape: the hydrology model (**ICM-Hydro**), the wetland vegetation model (**ICM-LAVegMod**), the wetland morphology model (**ICM-Morph**), the barrier island and tidal inlet models (**ICM-BI and ICM-BITI**). The sixth, and final, ICM subroutine does not provide feedback to the landscape, but instead uses environmental and landscape outputs to calculate habitat suitability indices for a variety of important fish, fowl, and wildlife species in coastal Louisiana (**ICM-HSI**).

SPATIAL UNITS AND TERMINOLOGY

To understand interactions among ICM subroutines, it is important to recognize that the different subroutines act on separate, overlapping grids with different resolutions (Figure 1). ICM-Hydro **compartments** are the largest (i.e., the lowest resolution) and are irregularly shaped to account for landscape features. These compartments were refined for 2023 Coastal Master Plan to more closely align with expected flows due to known hydrologic features (*e.g.*, natural ridges, control structures, etc.). ICM-Morph **pixels** are the smallest (i.e., highest resolution) at 30 m x 30 m and make up a regular grid. Elevation and land cover type is calculated and tracked, with the existing conditions digital elevation model (DEM) as the starting point, at this finer scale and then aggregated up as needed to inform calculations for other subroutines. ICM-LAVegMod **grid cells** are sized in between at 480 m x 480 m and are aligned with the ICM-Morph pixels such that 256 are captured in each ICM-

LAVegMod grid cell. The ICM-HSI subroutine uses the same grid cells as ICM-LAVegMod.

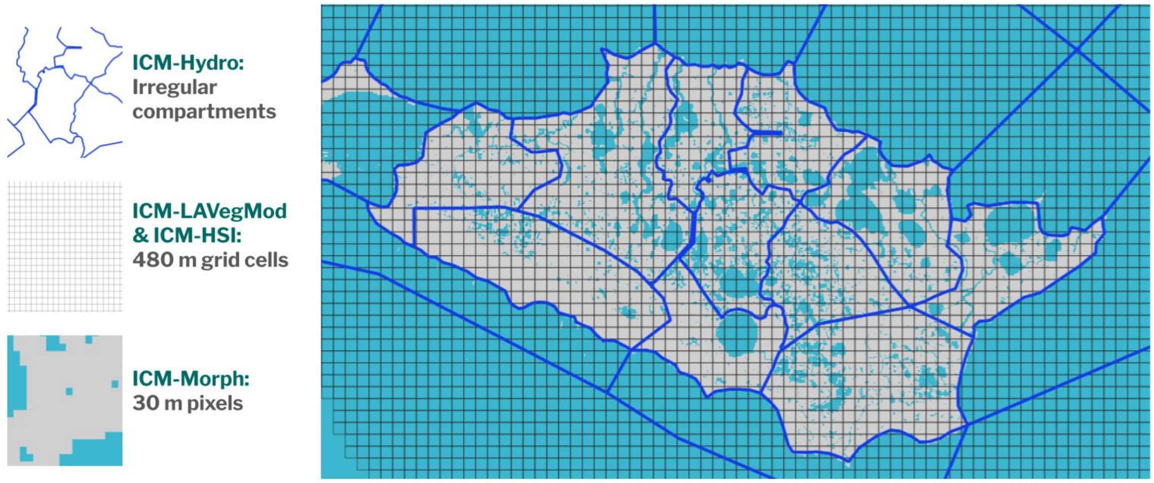


Figure 1. Spatial resolution for ICM subroutines in the area around Marsh Island in Vermilion Bay.

Throughout this report, model output will often be referred to via the model resolution that was used to derive the data. For instance, if discussing water levels, the report may reference the water level in a specific *compartment/ICM-Hydro compartment*. Similarly, vegetation coverages will be discussed at for a specific *grid cell/grid/ICM-LAVegMod grid*.

Prior to starting simulations for the 2023 Coastal Master Plan, a number of locations were identified as ‘model save points’. These would be locations at which all model data, down to a specific pixel, would be saved in order to conduct quality assurance and quality control (QAQC) on model processes and simulations. These **QAQC save points** were located following three different criteria:

- **CRMS locations** – every observation station within the Coastwide Reference Monitoring System (CRMS) was selected as a save point. These are labeled following the CRMS convention and will appear in this report as a four digit integer appended to “CRMS”, i.e., **CRMS1234**
- **Transects** – several transects were deliberately placed at a variety of locations around the coastal domain. These included areas such as in the outfall locations of planned sediment diversion projects, across the interior of the Cameron-Creole Watershed, and other similar points of interest across the coast. These are labeled by appending a four digit integer to “TRNS”, i.e., **TRNS0701**. The first two digits indicate the transect ID, and the last two digits identify the location along the transect. Therefore TRNS0701 is the first point in transect 7, TRNS0702 is the next location, followed by TRNS0703, etc.
- **QAQC points** - the third category of save points was randomly placed. A random placement geospatial algorithm was used to place 100 locations within each

ecoregion. These randomly placed locations were also numbered with a four digit integer, i.e., QAQC1234.

Following the method above, there are 2,941 QAQC save points with archived annual data from every ICM simulation. These data timeseries are used throughout the report and will be labeled as coming from a location with a name such as CRMS1234, TRNS1234, or QAQC1234.

ECOREGION AND REGIONAL BOUNDARIES

The 2023 Coastal Master Plan analysis, stakeholder engagement, and document layout are structured around the five primary regions of coastal Louisiana: the Chenier Plain, the Central Coast, Terrebonne Basin, Barataria Basin, and the Pontchartrain/Breton basins (Figure 2). Model data for each of these regions is further subdivided into ecoregions (Figure 3), which are an amalgamation of ICM-Hydro compartments that are conterminous and all located with a specifically unique portion of the coast. The number of ecoregions varies per region, but they were delineated following physical barriers (such as landbridges), flowpaths (such as a bayou or river), natural demarcations such as ridges, or even human-made delineators (such as shipping lanes). Throughout this report, the model outputs will be summarized by region, with discussion often referring to these finer scale ecoregion boundaries. The ecoregions in this report will be referenced using an abbreviation, as listed in Table 1.

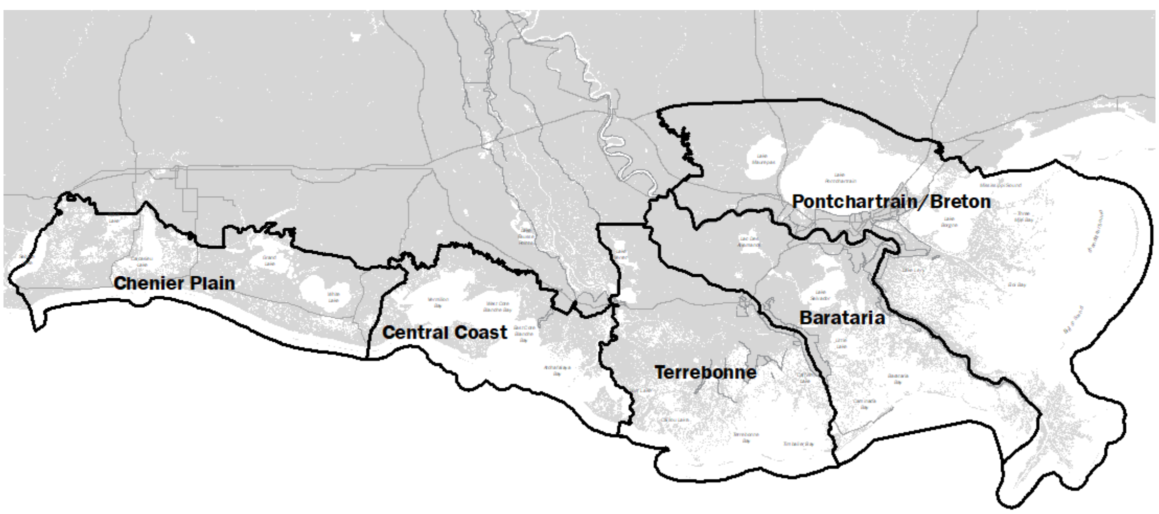


Figure 2. Master plan regions of coastal Louisiana.

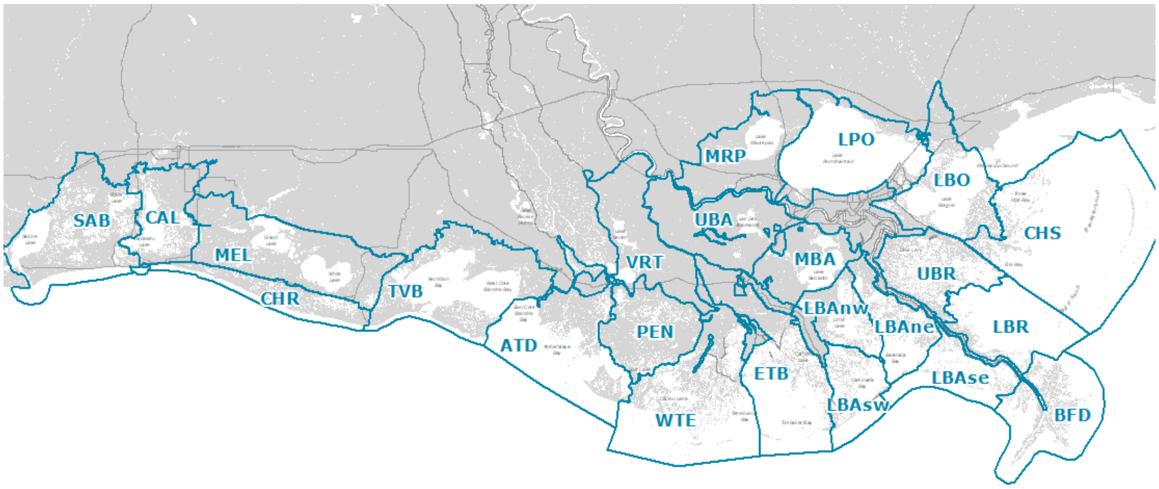


Figure 3. Ecoregions used in modeling analyses for the 2023 Coastal Master Plan.

Table 1. Ecoregion abbreviations and the region in which they are located

Abbreviation	Ecoregion	Region
ATD	Atchafalaya Delta	Central Coast
BFD	Bird’s Foot Delta	Pontchartrain/Breton
CAL	Calcasieu	Chenier Plain
CHR	Chenier Ridges	Chenier Plain
CHS	Chandeleur Sound	Pontchartrain/Breton
ETB	Eastern Terrebonne	Terrebonne
LBAne	Lower Barataria (NE)	Barataria
LBAnw	Lower Barataria (NW)	Barataria
LBAse	Lower Barataria (SE)	Barataria
LBAsw	Lower Barataria (SW)	Barataria
LBO	Lake Borgne	Pontchartrain/Breton
LBR	Lower Breton	Pontchartrain/Breton
LPO	Lake Pontchartrain	Pontchartrain/Breton
MBA	Mid Barataria	Barataria
MEL	Mermentau/Lakes	Chenier Plain
MRP	Maurepas	Pontchartrain/Breton
PEN	Penchant	Terrebonne
SAB	Sabine	Chenier Plain

TVB	Teche/Vermilion/Bays	Central Coast
UBA	Upper Barataria	Barataria
UBR	Upper Breton	Pontchartrain/Breton
VRT	Verret Basin	Terrebonne
WTE	Western Terrebonne	Terrebonne

VEGETATION SPECIES ABBREVIATIONS

Throughout this report, the vegetation model (ICM-LAVegMod) results will be discussed both as the overall species mixture/assemblage, as well as the relative cover of the individual plant species included in the model. When referring to individual species, the results are reported in the text using a shorthand code as listed in Table 2.

Table 2. Symbol codes used in ICM-LAVegMod to represent each modeled species

Code	**Vegetation species**	**Code**	**Vegetation species**
AVGE	*Avicennia germinans*	QUNI	*Quercus nigra*
BAHABI	*Baccharis halimifolia*	QUTE	*Quercus texana*
CLMA10	*Cladium mariscus*	QUVI	*Quercus virginiana*
COES	*Colocasia esculenta*	SALA	*Sagittaria lancifolia*
DISP	*Distichlis spicata*	SALA2	*Sagittaria latifolia*
DISPBI	*Distichlis spicata*	SANI	*Salix nigra*
ELBA2_Flt	*Eleocharis baldwinii*	SCAM6	*Schoenoplectus americanus*
ELCE	*Eleocharis cellulose*	SCCA11	*Schoenoplectus californicus*
IVFR	*Iva frutescens*	SCRO5	*Schoenoplectus robustus*
JURO	*Juncus roemerianus*	SOSE	*Solidago sempervirens*
MOCE2	*Morella cerifera*	SPAL	*Spartina alterniflora*
NOTMOD	Not Modeled	SPCY	*Spartina cynusuroides*
NYAQ2	*Nyssa aquatica*	SPPA	*Spartina patens*
PAAM2	*Panicum amarum*	SPPABI	*Spartina patens*
PAHE2	*Panicum hemitomon*	SPVI3	*Sporobolus virginicus*
PAHE2_Flt	*Panicum hemitomon*	STHE9	*Strophostyles helvola*
PAVA	*Paspalum vaginatum*	TADI2	*Taxodium distichum*
PHAU7	*Phragmites australis*	TYDO	*Typha domingensis*
POPU5	*Polygonum punctatum*	ULAM	*Ulmus americana*
QULA3	*Quercus laurifolia*	UNPA	*Uniola paniculate*
QULE	*Quercus lyrate*	ZIMI	*Zizaniopsis miliacea*

2.0 LOWER BRETON DIVERSION

PROJECT OVERVIEW

The Lower Breton Diversion project (#006) is a sediment diversion into lower Breton Sound to build and maintain land (Figure 4). The maximum discharge is 50,000 cfs (modeled at 50,000 cfs when the Mississippi River flow equals 1,000,000 cfs; open with a variable flow rate calculated using a linear function from 0 to 50,000 cfs for river flow between 200,000 cfs and 1,000,000 cfs; constant flow rate of 50,000 cfs for river flow above 1,000,000 cfs. No operation below 200,000 cfs). The project is fully constructed and operational at Year 9 in Implementation Period 1 (IP1) and Year 29 in Implementation Period 2 (IP2).

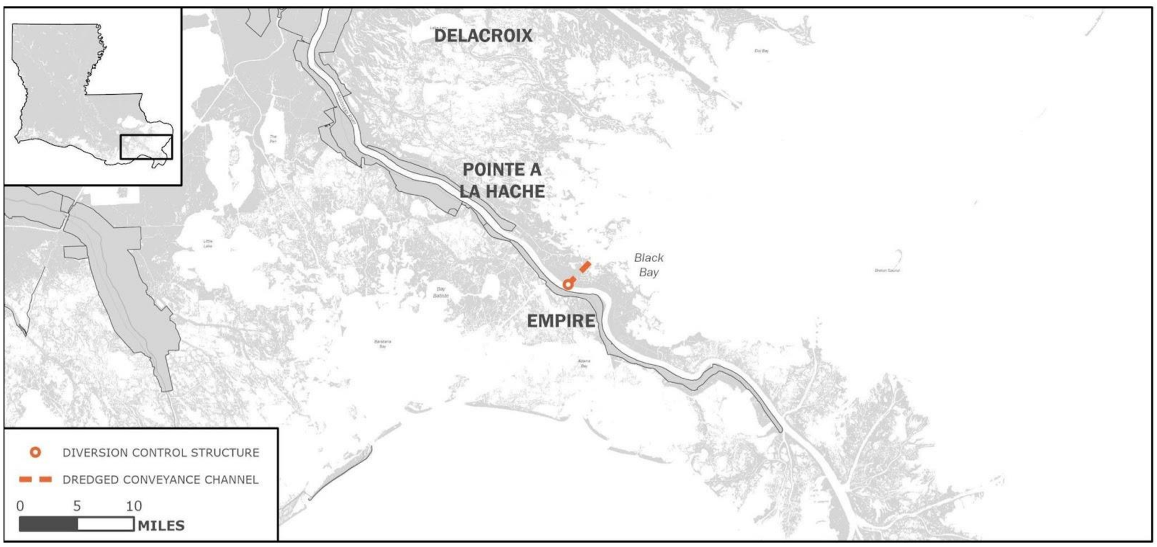


Figure 4. Location of the Lower Breton Diversion project.

The project cost is $395.20 million in IP1 and $369.86 million in IP2 due to fewer years for operations and maintenance. The cost of the project does not vary by scenario as no dredging or marsh creation is included.

This project was evaluated for inclusion in the 2023 Coastal Master Plan for both the first and second implementation period and was not selected. The model runs were G601 and G655, respectively. The project results presented here discuss the way in which the project changes the coastal landscape in terms of hydrology, morphology, vegetation, and habitats, with examples from the two environmental scenarios and from both IP1 and IP2. The examples have been selected to illustrate the dynamics of the project based on available data, rather than to provide a comprehensive description of all areas, scenarios, and implementation period comparisons.

HYDROLOGY

WATER LEVELS AND INUNDATION

The Lower Breton Diversion decreases inundation in the outfall area in the Breton Basin, and this effect becomes larger over time, as indicated by Figure 2 and Figure 3 for Years 10 and 25, respectively. The decrease in inundation is the result of an increase in the bed elevation in the same area, as shown in Figure 4. Annual mean water levels do not appear to increase noticeably, as indicated in Figure 5 showing water levels near the Lower Breton Diversion outfall. There is also little difference in areas more distant from the diversion (Figure 6 and Figure 7).

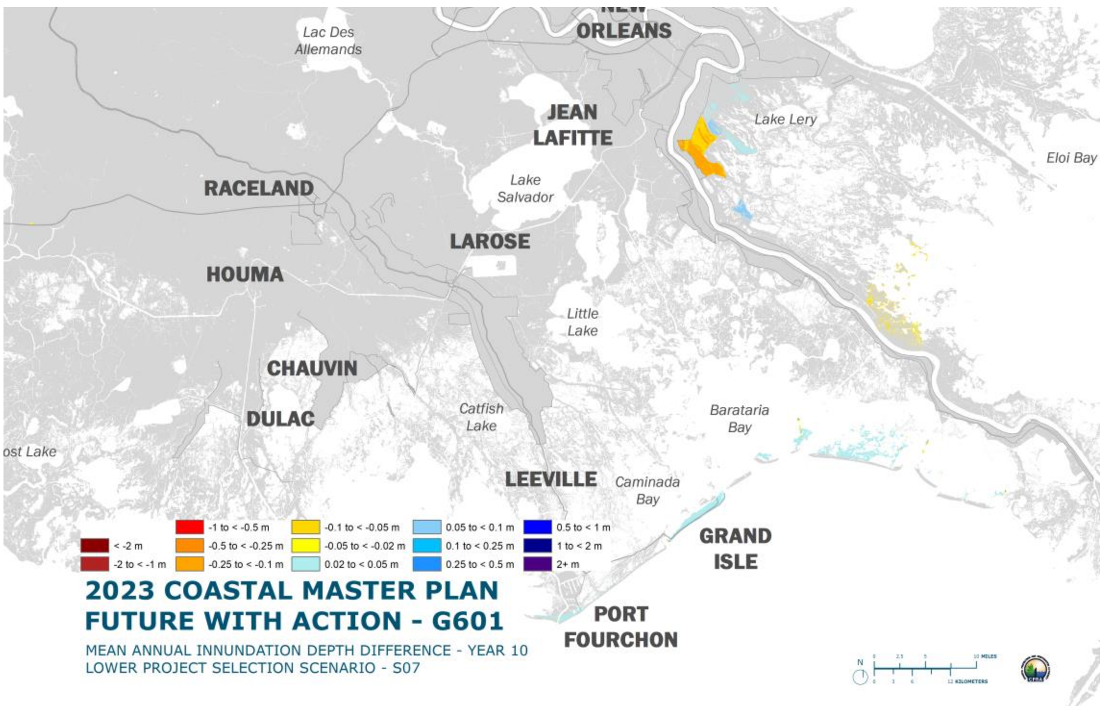


Figure 5. Difference map of mean annual inundation depth between future without action (FWOA; G500) and future with action (FWA; G601) in Year 10 of the lower (S07) scenario, indicating little to no impacts from the diversion on inundation. Similar results are found for the higher (S08) scenario.

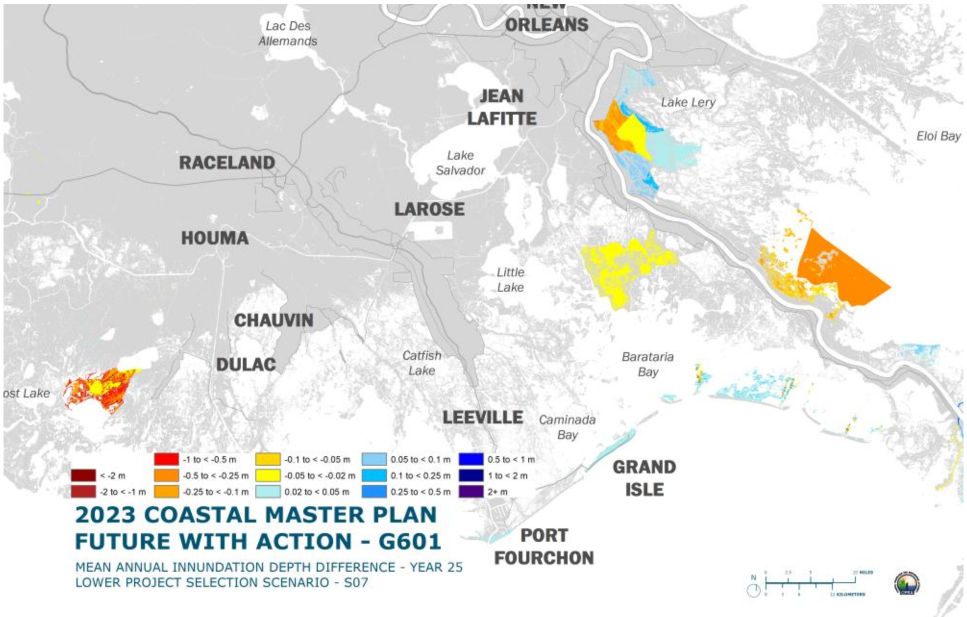


Figure 6. Difference map of mean annual inundation depth between FWOA (G500) and FWA (G601) in Year 25 of the lower (S07) scenario, indicating a reduction of inundation near the diversion. Similar results are found for the higher (S08) scenario.

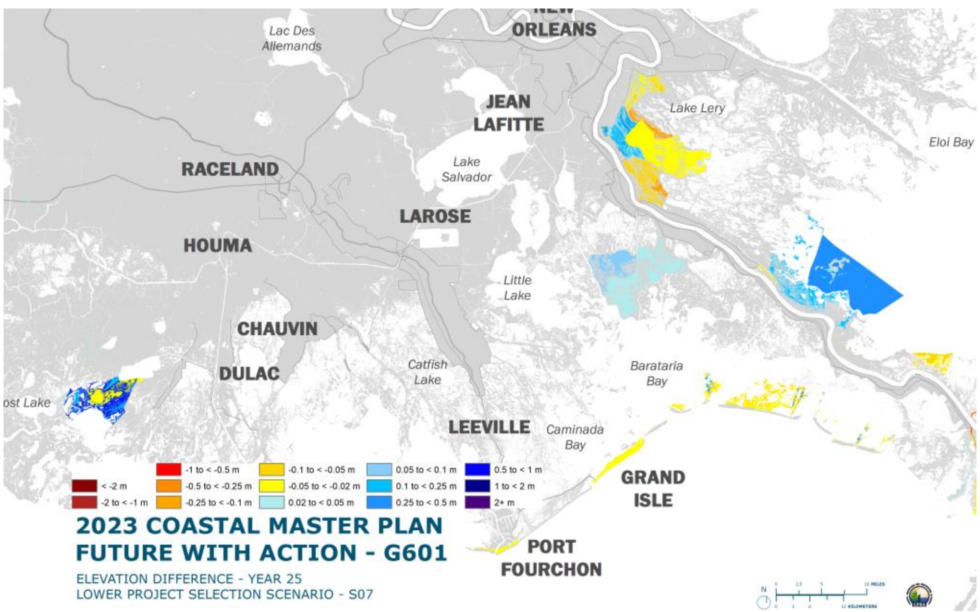


Figure 7. Difference map of elevation between FWOA (G500) and FWA (G601) in Year 25 of the lower (S07) scenario, indicating an increase in bed elevation near the diversion. Similar results are found for the higher (S08) scenario.

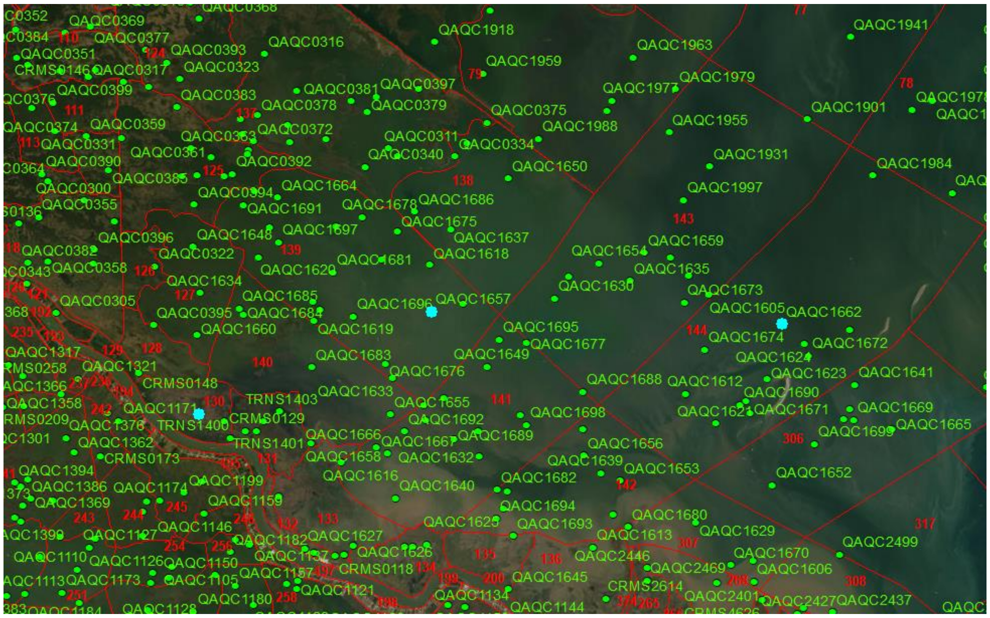


Figure 8. Map indicating the location of QAQC1668 (blue dot) in compartment 130 situated near the Lower Breton Diversion outfall, the location of QAQC1657 (blue dot) in compartment 139 situated 20 km away from the diversion in the Breton Sound, and the location of QAQC1662 in compartment 144 near Breton Island.

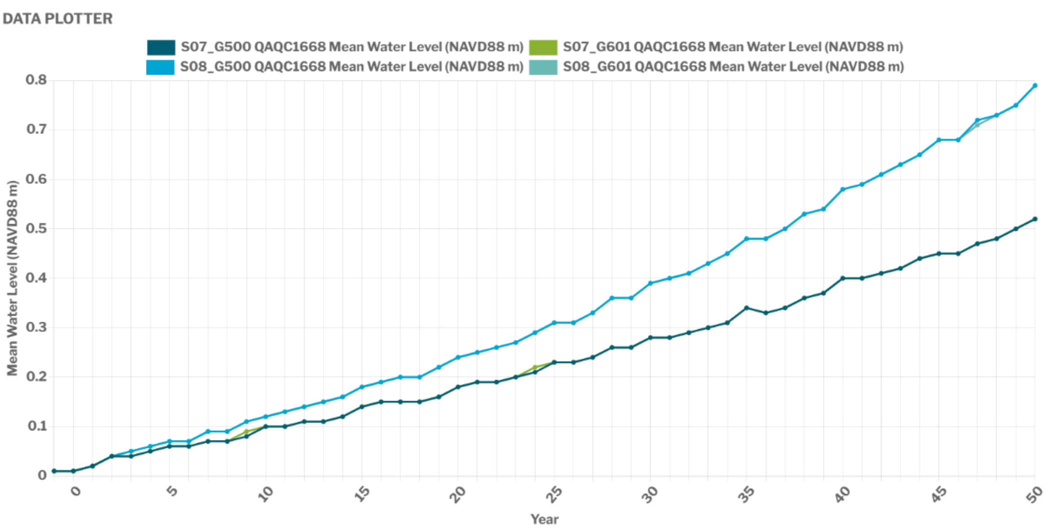


Figure 9. Annual mean water level timeseries comparison between FWOA (G500) and FWA (G601) for lower (S07) and higher (S08) scenarios in QAQC1668 near the Lower Breton Diversion outfall (location indicated in Figure 5). No noticeable effects are seen on annual mean water levels all throughout the post-

construction part of the 50-year simulation period, for both the lower (S07) and higher (S08) scenarios.

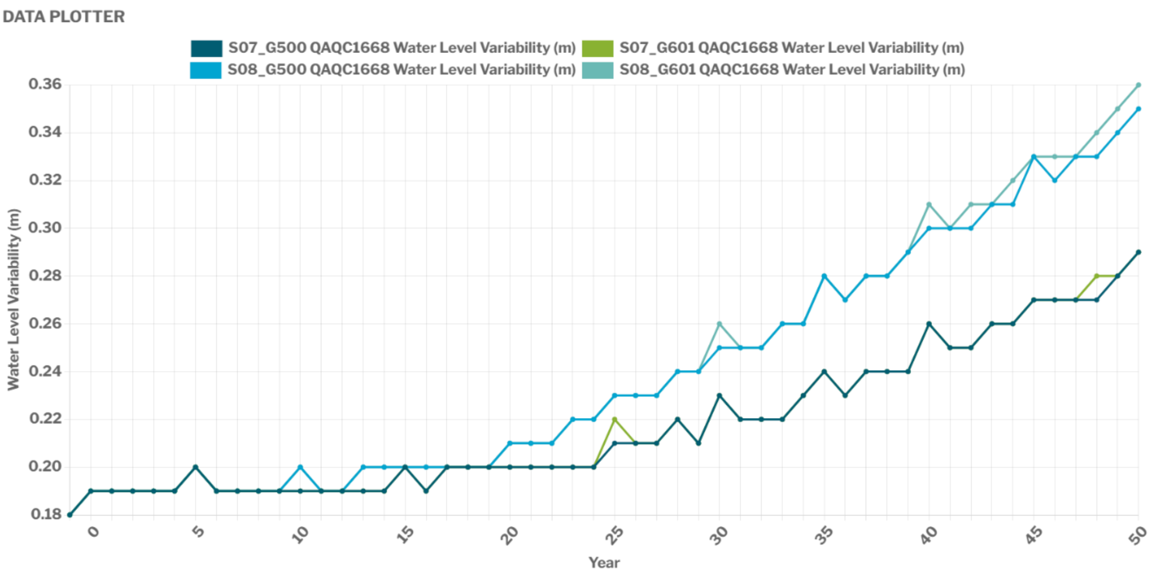


Figure 10. Annual water level variability timeseries comparison between FWOA (G500) and FWA (G601) for lower (S07) and higher (S08) scenarios in QAQC1668 near the Lower Breton Diversion outfall (location indicated in Figure 5). Little to no noticeable effects are seen on water level variability all throughout the post-construction part of the 50-year simulation period, with the exception of the last 10 years of the higher (S08) scenario.

SALINITY

Salinity impacts due to the Lower Breton Diversion operation are noticeable in most of the Breton Basin as well as adjacent areas such as parts of the Bird's Foot Delta and Chandeleur Sound; however, reductions of annual mean salinity remain limited to 2 ppt (Figure 8 and Figure 9). A minor increase in salinity (<0.5 ppt) can be observed in the Bird's Foot Delta and nearshore due to reduced freshwater volumes resulting from upstream diversion operations.

The immediate outfall area is already (nearly-) fresh in FWOA causing mean annual salinity reductions to be limited to 1 ppt (Figure 10). Impacts are somewhat larger as shown in Figure 11 for the brackish Breton Sound, where reductions in mean annual salinity amount up to 2 ppt. The influence of the Lower Breton Diversion can still be noticed near Breton Island where mean annual salinity is reduced up to 1 ppt (Figure 12). The impacts in both the near-field and far-field are similar between the lower (S07) and higher (S08) scenarios and remain consistent over time. Note that the overall salinities in Breton Sound are decreasing in the last 10 years of the simulation, due to sea level rise (SLR) in the Mississippi River increasing the flow through some of the distributary channels into Breton Sound. This phenomenon is more noticeable in the higher (S08) scenario.

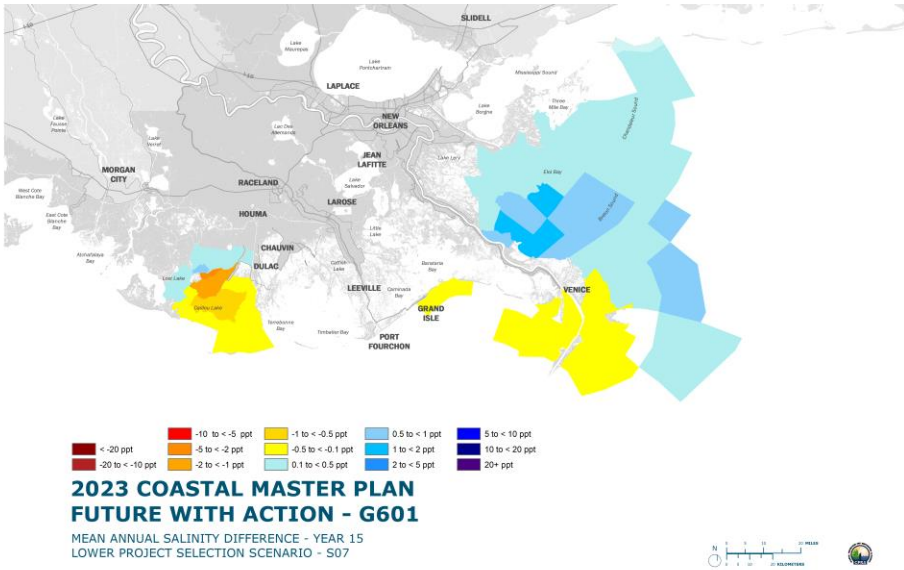


Figure 11. Difference map of mean annual salinity between FWOA (G500) and FWA (G601) at Year 15 of the lower (S07) scenario, indicating a salinity decrease up to 2 ppt in and around the Breton Basin. Contrastingly, a minor salinity increase amounting up to 0.5 ppt is found for the Bird's Foot Delta due to reduced freshwater volumes resulting from upstream diversion operation. Similar results are found for the higher (S08) scenario.

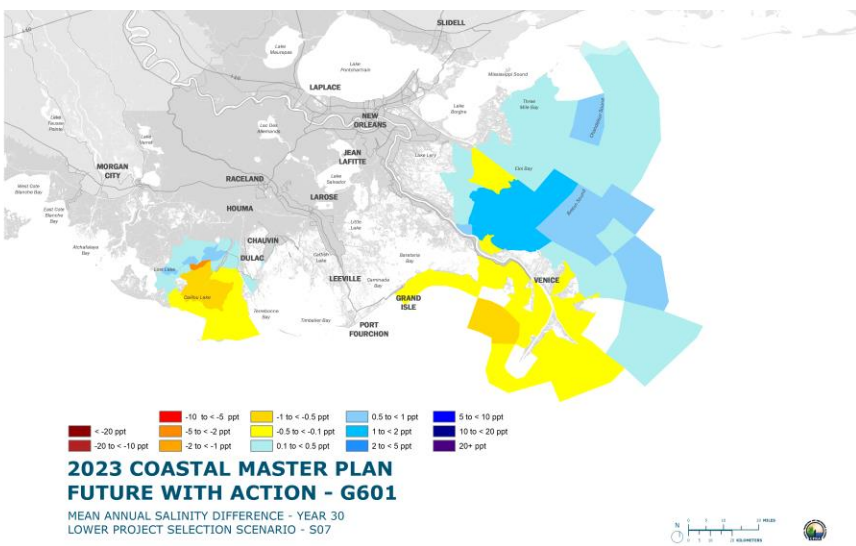


Figure 12. Difference map of mean annual salinity between FWOA (G500) and FWA (G601) at Year 30 of the lower (S07) scenario, showing the similar magnitude and a slightly larger extent of salinity differences compared to Year 15 as shown in Figure 8. Similar results are found for the higher (S08) scenario.

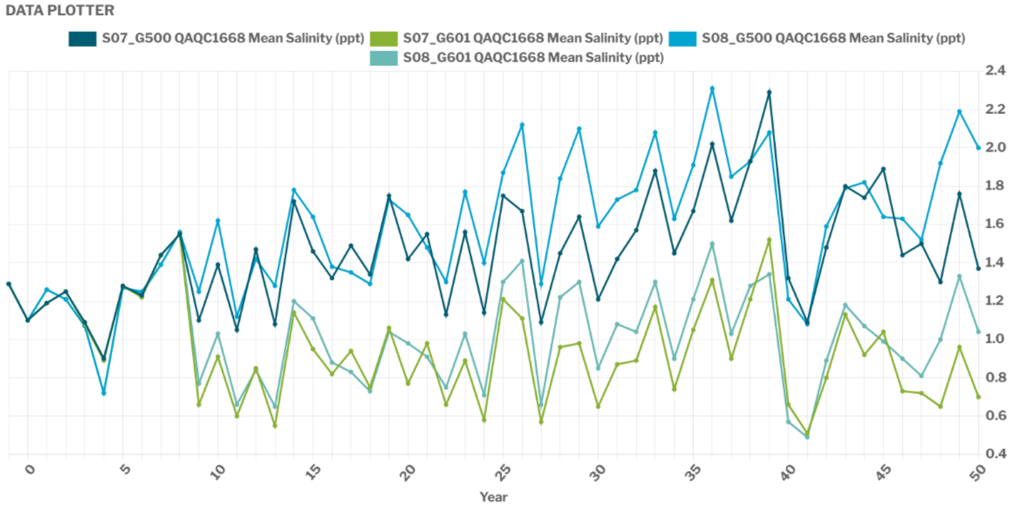


Figure 13. Annual mean salinity timeseries comparison between FWOA (G500) and FWA (G601) for lower (S07) and higher (S08) scenarios in QAQC1668 near the Lower Breton Diversion outfall (location indicated in Figure 5), showing for both scenarios a ~1 ppt salinity reduction that increases over time.

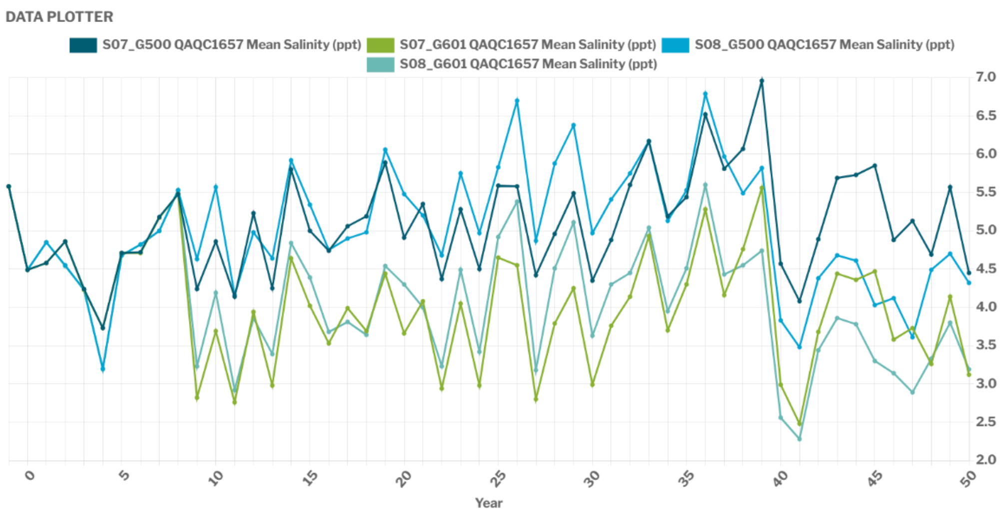


Figure 14. Annual mean salinity timeseries comparison between FWOA (G500) and FWA (G601) for lower (S07) and higher (S08) scenarios in QAQC1657, located in the Breton Sound at a distance of 20 km from the diversion (location indicated in Figure 5). Salinity is reduced by about 1-2 ppt for both scenarios.

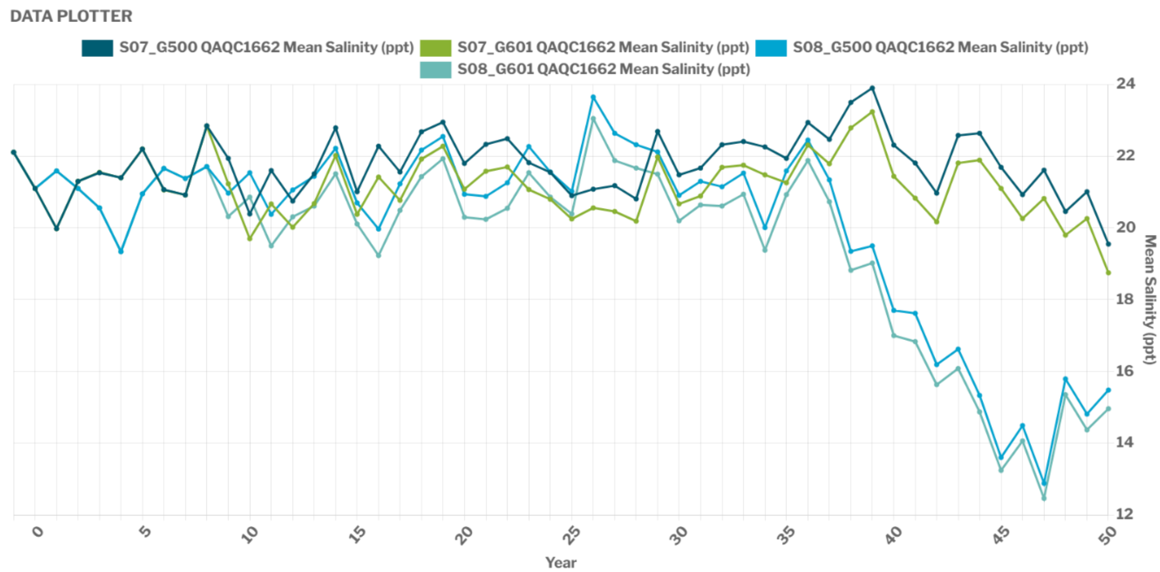


Figure 15. Annual mean salinity timeseries comparison between FWOA (G500) and FWA (G601) for lower (S07) and higher (S08) scenarios in QAQC1662 located near Breton Island (location indicated in Figure 5). Salinity is reduced up to ~1 ppt for both scenarios throughout the post-construction part of the 50-year simulation period. The area freshens drastically in the final 15 years of the higher (S08) scenario due to the effect of SLR in the Mississippi River on freshwater distribution.

SUSPENDED SEDIMENT

Mean annual total suspended sediment (TSS) concentrations in the Breton Basin are increased by the Lower Breton Diversion. Increases in mean annual TSS in the range of 1-2 mg/L are observed in both the Lower Breton Diversion outfall area (Figure 13) as well as the Breton Sound (Figure 14). The opposite is found near Breton Island as indicated in Figure 15, where mean annual TSS concentrations are slightly lower for FWA. The difference is limited to 0.5 mg/L and could be a consequence of reduced sediment loading downstream of the Lower Breton Diversion. The FWA versus FWOA TSS differences remain consistent (i.e., do not become larger or smaller) over the years and are very similar between the lower (S07) and higher (S08) scenarios.

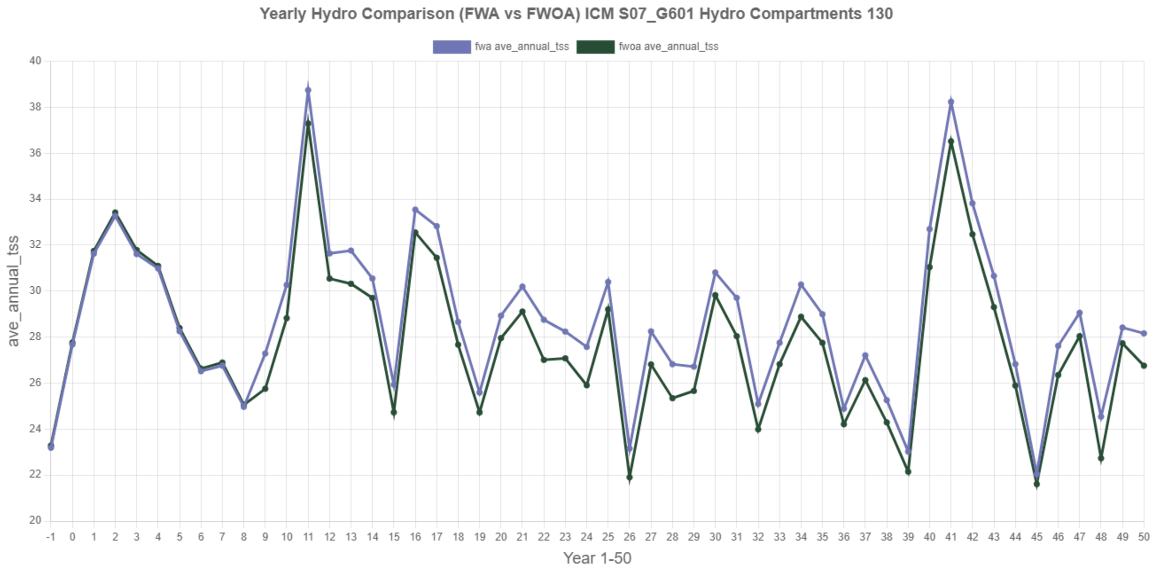


Figure 16. Mean annual TSS concentration timeseries comparison between FWOA (G500) and FWA (G601) for the lower (S07) scenario in compartment 130 (Lower Breton Diversion outfall area; Figure 5), showing a 1-2 mg/L concentration increase that remains consistent over time. Similar results are found for the higher (S08) scenario.

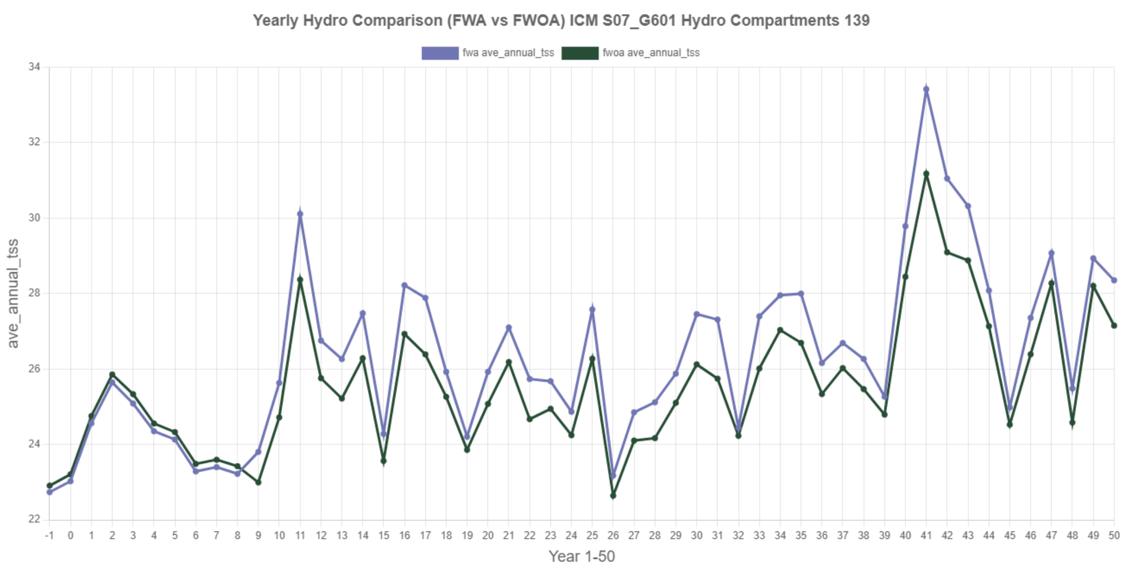


Figure 17. Mean annual TSS concentration timeseries comparison between FWOA (G500) and FWA (G601) for the lower (S07) scenario in compartment 139 (Breton Sound; Figure 5), showing a 1-2 mg/L concentration increase that remains consistent over time. Similar results are found for the higher (S08) scenario.

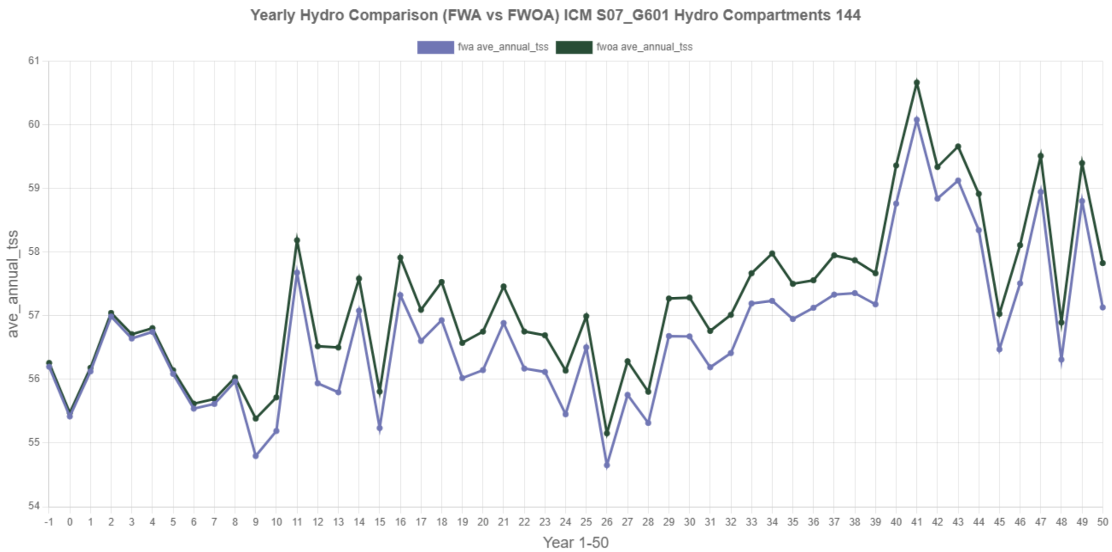


Figure 18. Mean annual TSS concentration timeseries comparison between FWOA (G500) and FWA (G601) for the lower (S07) scenario in compartment 144 (near Breton Island; Figure 5), showing a <1 mg/L concentration decrease that remains consistent over time. Similar results are found for the higher (S08) scenario.

MORPHOLOGY

IMPLEMENTATION PERIOD 1

In the first implementation period there is a dramatic difference between the benefits, relative to FWOA, for the lower versus the higher scenario (Figure 16). Under the lower scenario, the project has negative benefits throughout most of the simulation following construction.

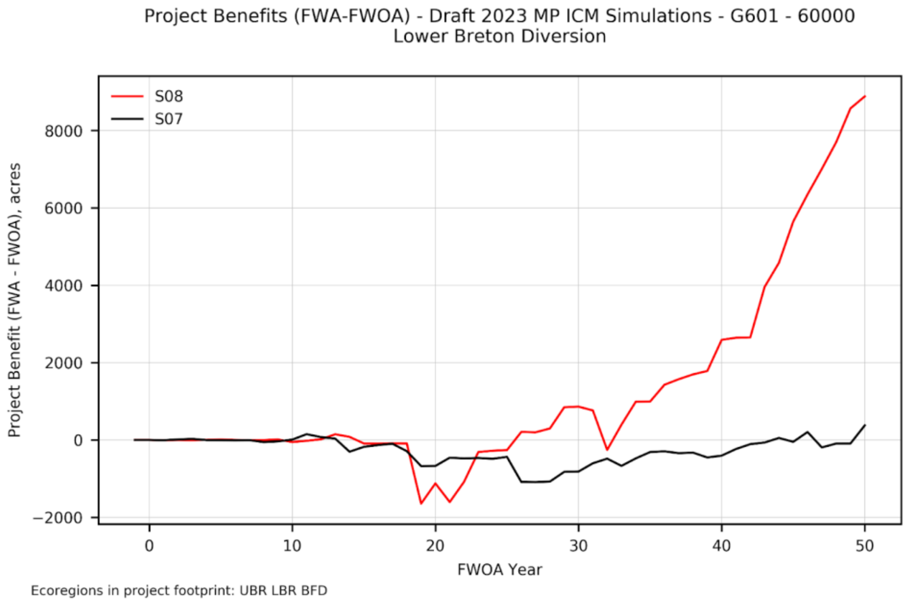


Figure 19. Net land (FWA-FWOA) over time for the lower (S07) and higher (S08) scenarios for the Lower Breton Diversion for IP1.

In the earlier years, much of this loss is in the Bird's Foot Delta. Land change in compartment 278, south of Pass a Loutre (Figure 17) shows this loss as the diversion reduces the amount of water reaching the delta and salinity increases. Higher salinity leads to reduced organic matter accretion and lowers the marsh tolerance for inundation. Later in the simulation, the diversion also causes loss in the upper Breton Basin due to complex interactions with the Mid-Breton Diversion (not shown).

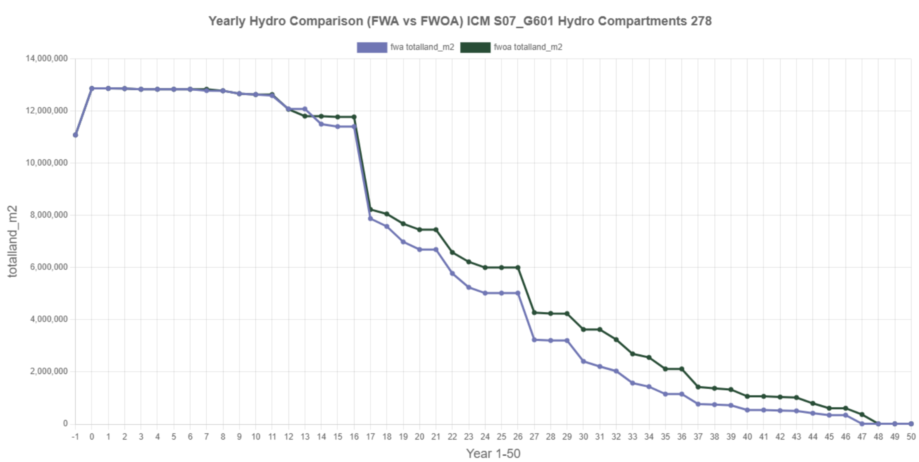


Figure 20. Comparison of land area (FWA vs. FWOA) for compartment 278 in the Bird's Foot Delta for the Lower Breton Diversion for the lower scenario.

In the later years, in the immediate outfall area of the diversion, under the lower scenario, there is some land gain relative to FWOA as water bodies become shallower (see Hydrology discussion of changes in bed elevation) and the diversion prevents land loss which would have occurred in FWOA (Figure 18).

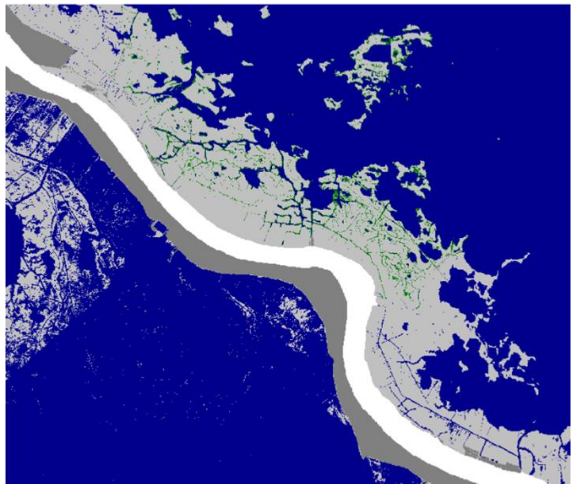


Figure 21. Land gain (FWA-FWOA) for the Lower Breton Diversion at Year 50 for the lower scenario.

The net effect for the lower scenario for IP1 is net land gain in the Lower Breton ecoregion (LBR) with loss in the Bird's Foot Delta (BFD) and the Upper Breton (UBR) ecoregions (Figure 19). Table 1 shows a net loss of land of ~1.3 km^2 per year on average.

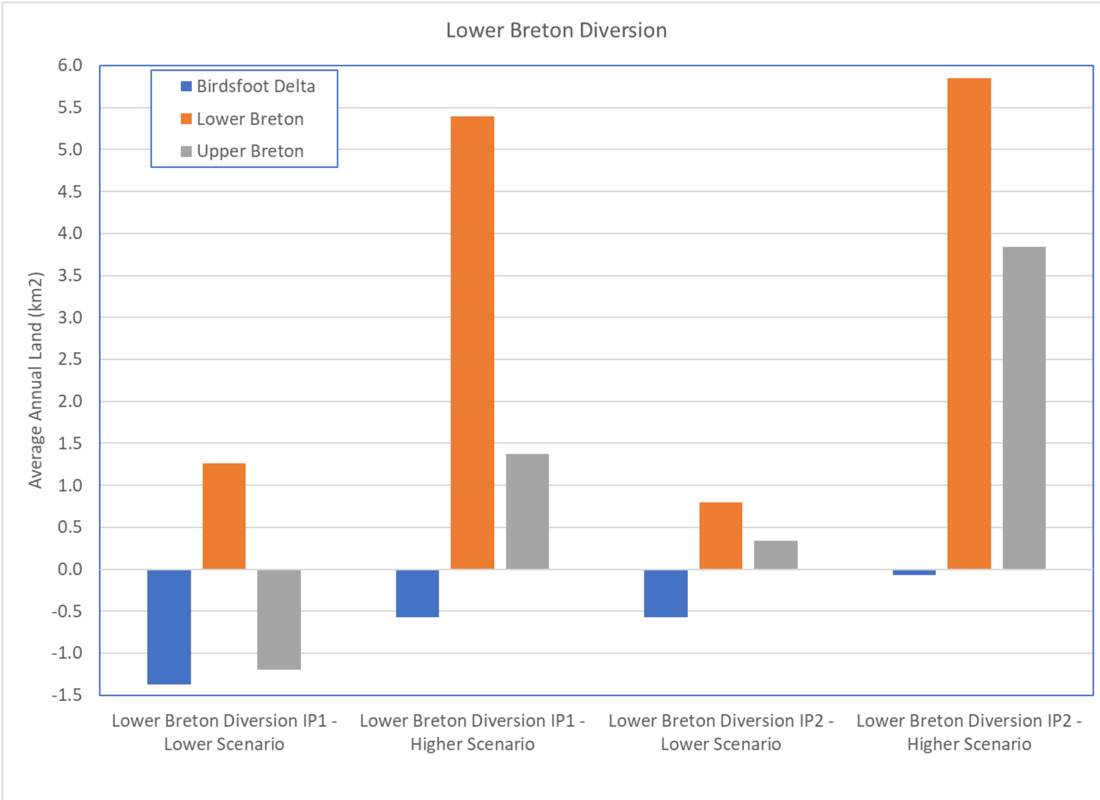


Figure 22. Average annual land (AAL) by ecoregion for the Lower Breton Diversion by scenario and implementation period.

Table 3. AAL (FWA-FWOA) for the Lower Breton Diversion by scenario and implementation period

Implementation Period	**IP1**		**IP2**	
Scenario	Lower	Higher	Lower	Higher
Lower Breton Diversion	-1.31	6.2	0.51	9.37

Figure 16, Figure 19 and Table 1 also show the difference for the higher scenario. While there is loss in the BFD ecoregion (Figure 19), this is offset by greater gain in LBR and some net gain in UBR. Figure 16 also shows how the magnitude of the benefit relative to FWOA increases in the later years of the simulation. The main area of net benefit is close to the diversion where compartments are designated as ‘active delta’ under FWOA and so receive much higher rates of organic matter accumulation in the soils as long as the fresh, forested, intermediate, brackish, saline marshes (FFIBS) score remains low.

Figure 20 illustrates the effects of this change on pixel elevation, which begins to increase once the diversion begins operation, and the rate of increase in inundation depth slows. The change in organic accretion is one of the main reasons why the diversion gains an average of 6.2 km^2 per year under the higher scenario (Table 1).

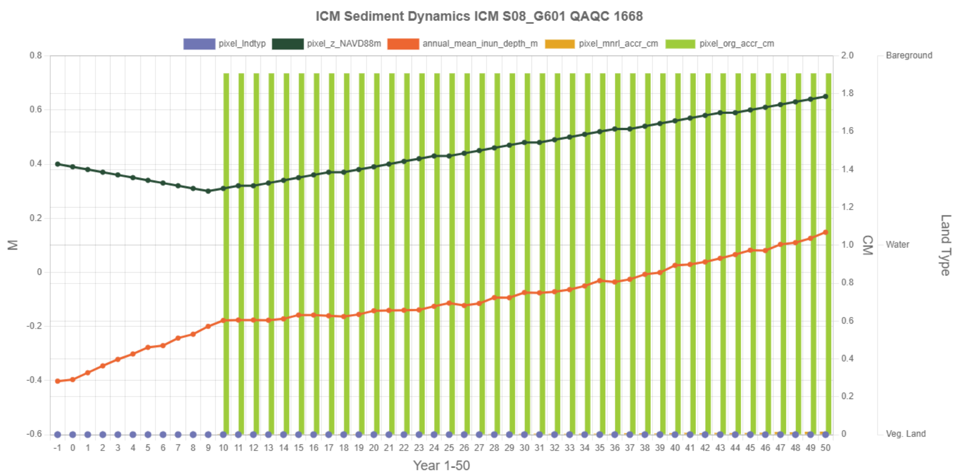


Figure 23. ICM sediment dynamics for QAQC1668 near the Lower Breton Diversion outfall for the higher scenario.

IMPLEMENTATION PERIOD 2

In the second implementation period, the diversion begins operation in Year 29, and the land area response, relative to FWOA is minor for the first few years (Figure 21). Indeed, the diversion has very little effect relative to FWOA for the lower scenario.

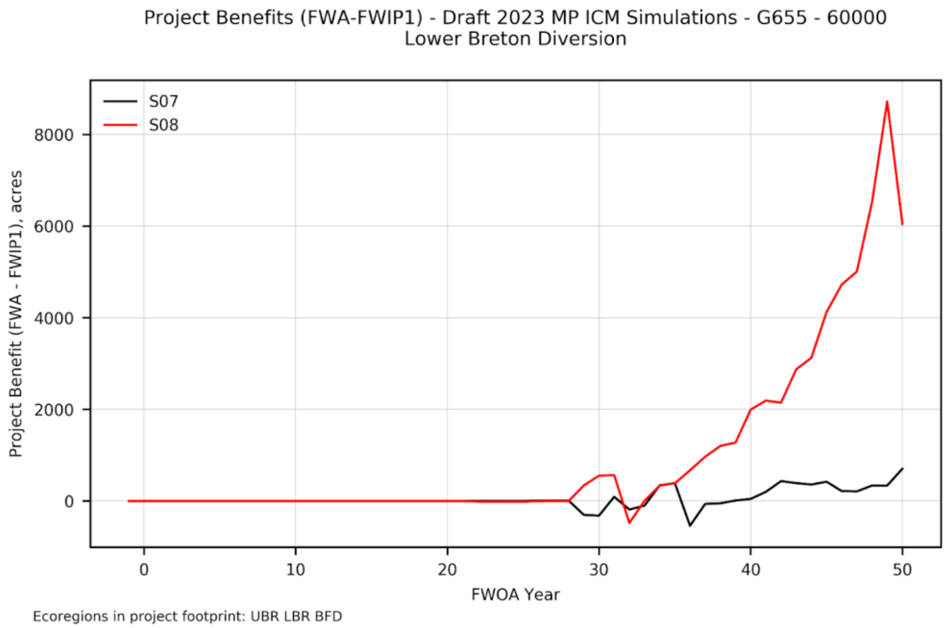


Figure 24. Net land (FWA-FWOA) over time for the lower (S07) and higher (S08) scenarios for the Lower Breton Diversion for IP2.

Table 1 and Figure 19 show the overall effect on AAL and the distribution by basin. In contrast to IP1, there is land gain in UBR rather than loss. This appears to be because the IP2 simulation includes all the projects selected for IP1 and that includes a number of marsh creation and ridge restoration features between the Lower Breton Diversion and the Mid-Breton Diversion thus modulating any interaction. The negative impact on the Bird's Foot Delta remains in IP2 in the lower scenario but is less on an average annual basis. Later operation of the diversion means the effects of SLR and subsidence in the Bird's Foot have already started to have an impact, and there is for example, only a very minor change in land area due to the diversion in IP2 in compartment 278 (not shown).

Under the higher scenario, there is very little change in the BFD ecoregion (Figure 19) with substantial benefit in both UBR and LBR. The main effects of the projects are near the diversion (Figure 22), and some of the benefits are a result of the diversion allowing some marsh creation projects included in IP1 to be sustained in the later years, e.g., Sunrise Point Marsh Creation and Belle Pass Island Marsh.

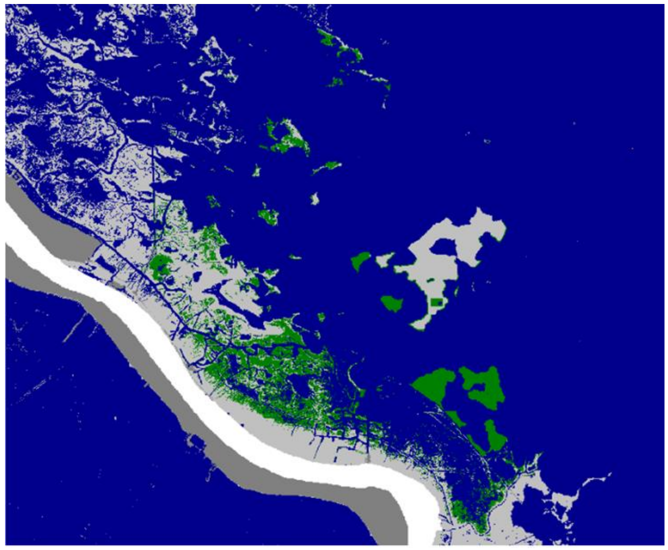


Figure 25. The net benefit of the Lower Breton Diversion (FWA IP2-FW IP1) under the higher scenario for Year 48.

VEGETATION

The Lower Breton Diversion reduces the cover of brackish marsh species in the LBR ecoregion under the lower scenario (Figure 23). Under the higher scenario, the Lower Breton Diversion seems to have less effect on species composition on the regional scale (Figure 23). However, at the local scale, it is apparent that close to the diversion the input of freshwater prevents the expansion of PHAU7 observed in FWOA and preserves the dominance of SALA (Figure 24). Further away from the diversion under the lower scenario, PHAU7 increases as SCAM6 decreases with the diversion relative to FWOA (Figure 25). This changes the marsh from brackish to intermediate. Under the higher scenario, there is less increase in PHAU7, and the area away from the diversion remains a brackish marsh (Figure 25).

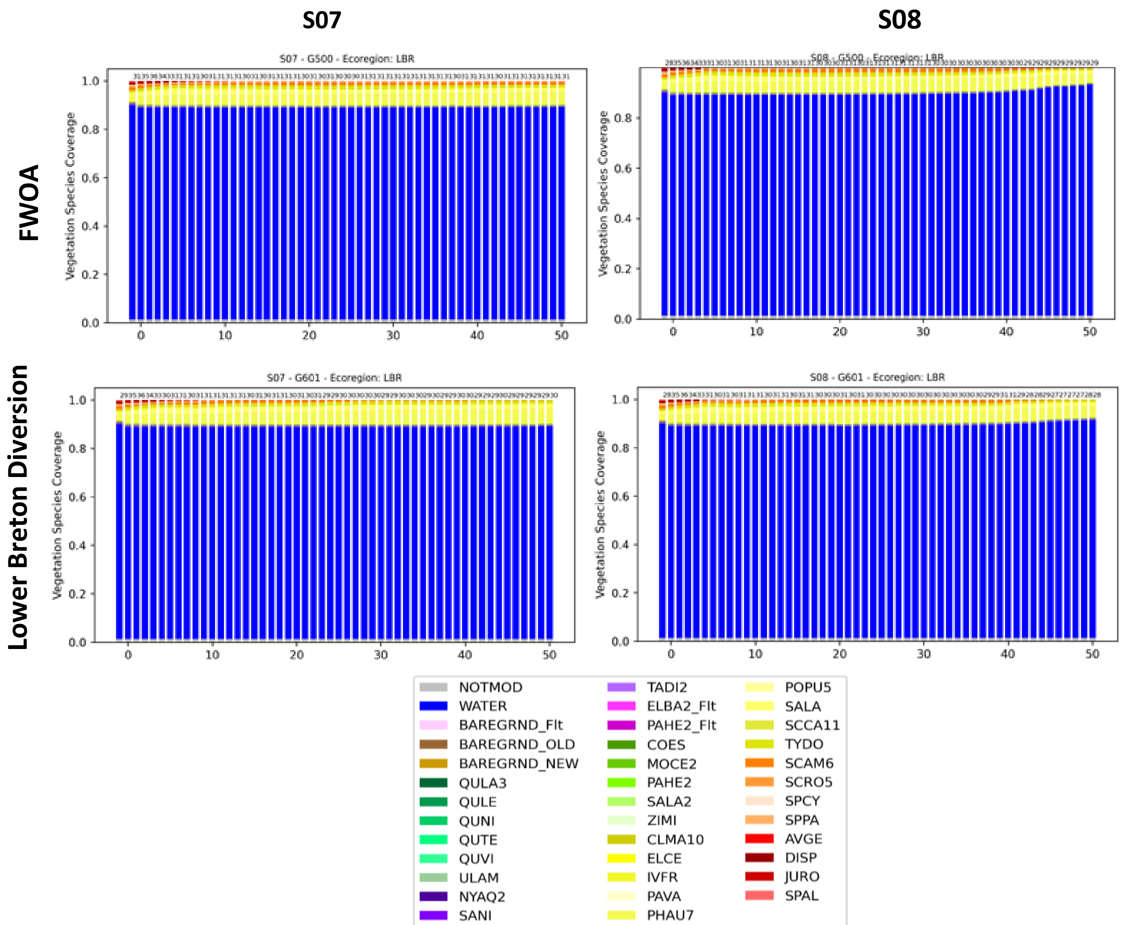


Figure 26. Change in species composition in the entire Lower Breton ecoregion with and without the Lower Breton Diversion under two scenarios.

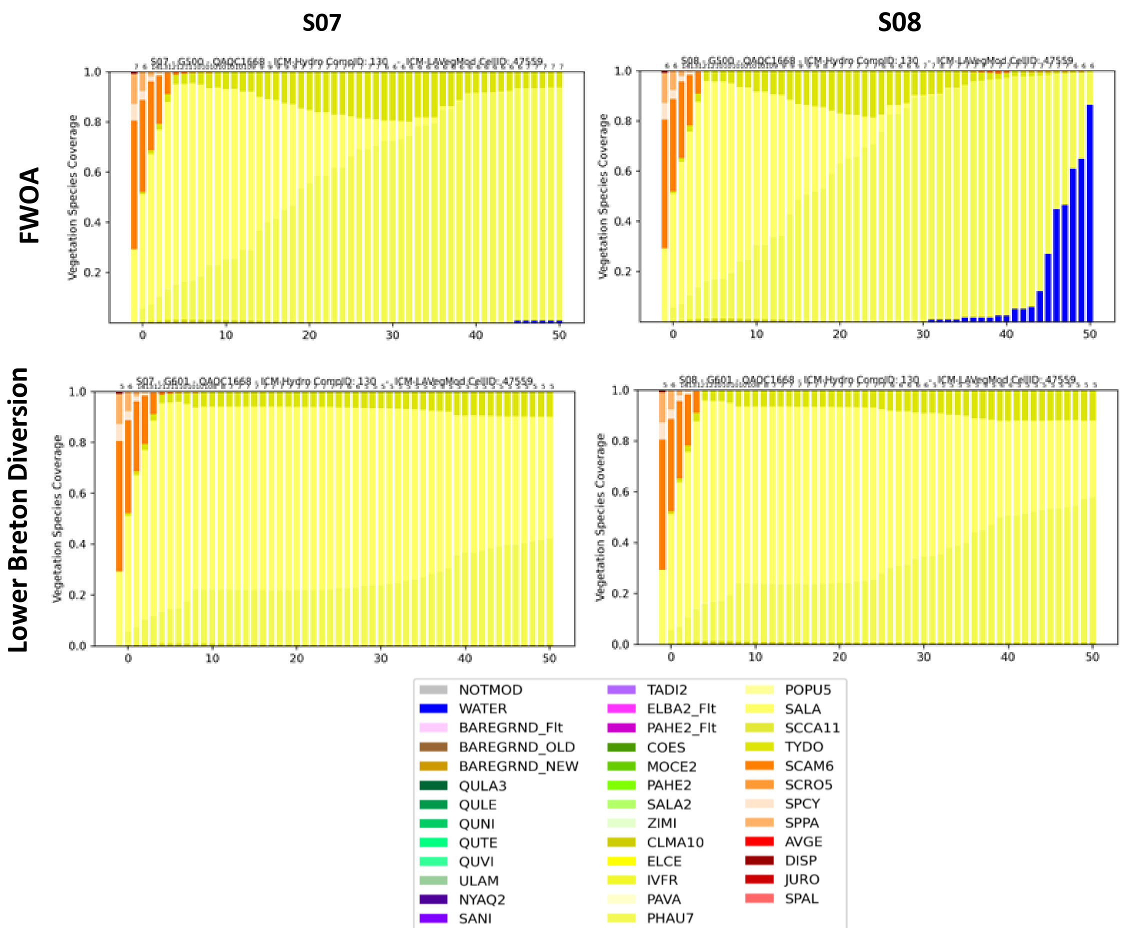


Figure 27. Change in species composition in the Lower Breton ecoregion at QAQC1668 with and without the Lower Breton Diversion under two scenarios.

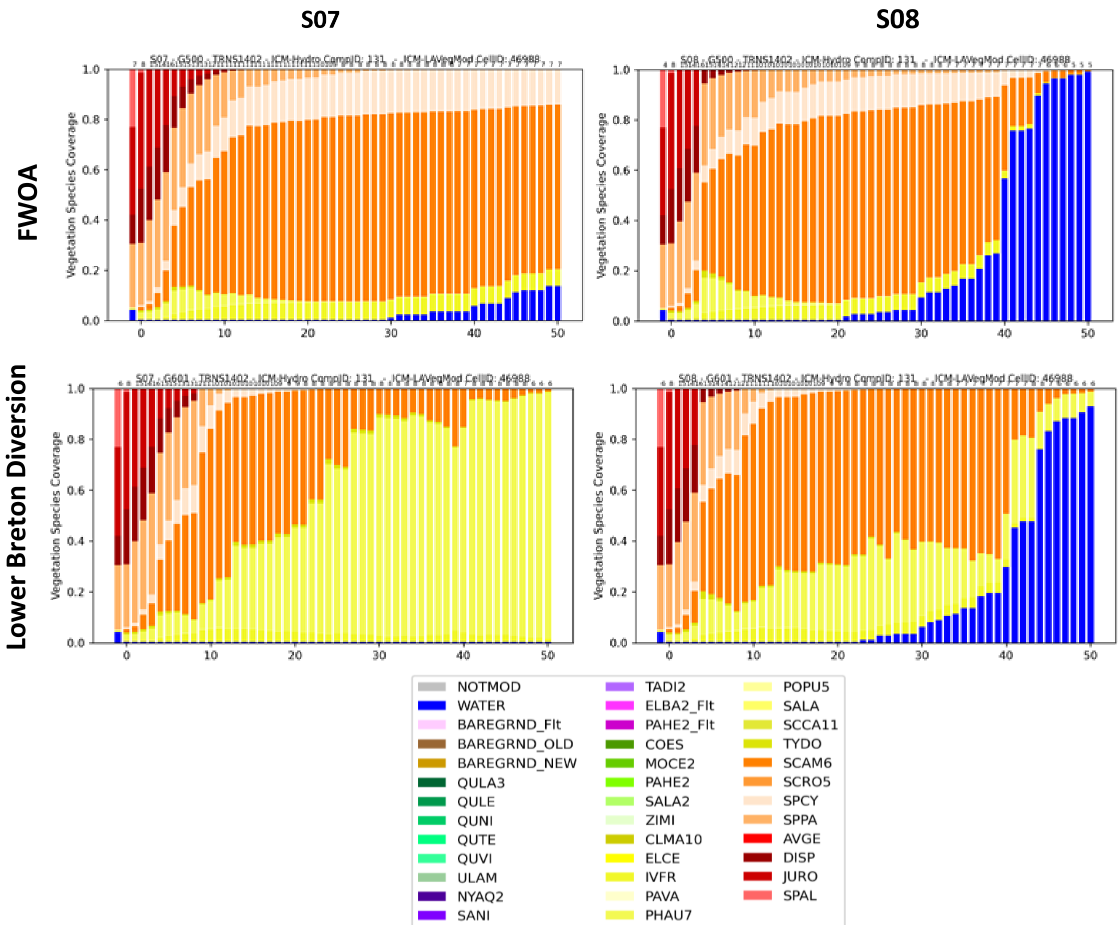


Figure 28: Change in species composition at TRNS1402 (3.5 km from the diversion outfall) with and without the Lower Breton Diversion under two scenarios.

HABITAT SUITABILITY

RESULTS AND DISCUSSION

The Lower Breton Diversion did not have a large effect on habitat suitability for fish, shellfish, and wildlife for either scenario. This was largely because the Breton Sound Basin received freshwater from a number of sources before project implementation, and thus had primarily low-salinity habitats at the start of the simulation. As a result, in the areas closest to the diversion, minor salinity reduction from the project only resulted in minor increases in habitat suitability for species associated with lower salinities (i.e., <5 ppt) and minor decreases in habitat suitability for higher-salinity species. However, in areas farther from the diversion, such as lower Breton Sound and Chandeleur Sound, there was a notable increase in habitat suitability for most fish and shellfish. These areas had average annual salinities >15 ppt before project implementation, and freshwater discharge from the diversion reduced salinities such that habitat conditions were slightly more suitable for species, including higher-salinity species such as brown shrimp and oysters (Figure 26).

The project had even less effect on habitat suitability in the Bird's Foot Delta during either scenario. Even though the Lower Breton Diversion resulted in a minor increase in salinity in the delta, there was almost no difference in habitat suitability for fish, shellfish, and wildlife between FWOA and the project simulations (e.g., juvenile blue crab; Figure 27).

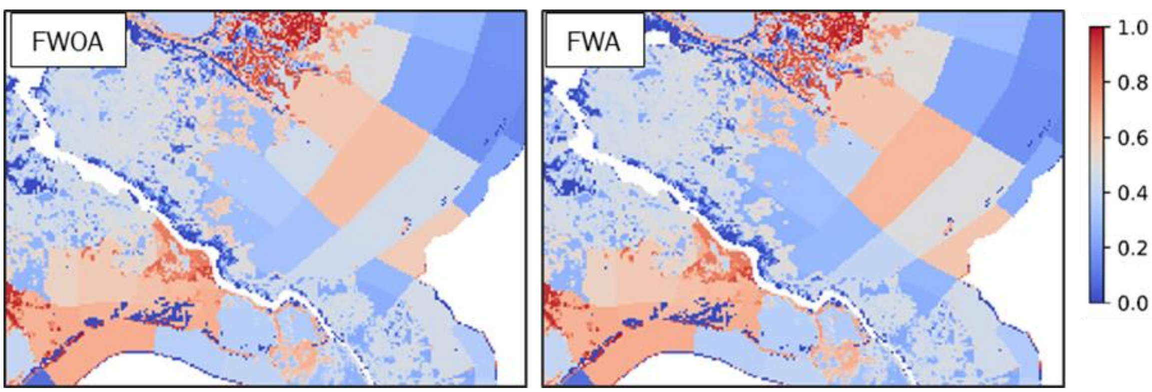


Figure 29. Small juvenile brown shrimp Habitat Suitability Index (HSI) scores across the Breton Sound Basin for Year 30 of FWOA and Lower Breton Diversion (FWA) S07 environmental scenario simulations. Scores range from 0.0, completely unsuitable habitat, to 1.0, optimal habitat.

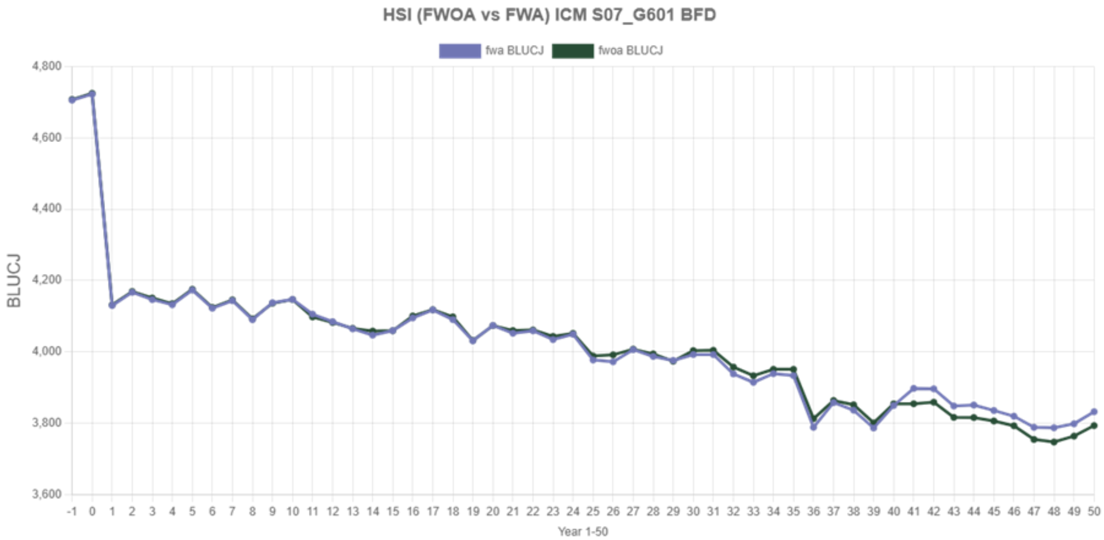


Figure 30. Total HSI score for juvenile blue crab in the BFD ecoregion for the 50-year FWOA and FWA S07 environmental scenario simulations. The total HSI score was calculated by summing the individual scores for each ICM model cell within the ecoregion.

3.0 BAYOU L'OURS RIDGE RESTORATION

PROJECT OVERVIEW

The Bayou L'Ours Ridge Restoration project (#334) involves restoration of approximately 54,000 ft of historic ridge along Bayou L'Ours (Figure 28) to provide coastal upland habitat, restore natural hydrology, and provide wave and storm surge attenuation. The project is fully constructed and on the landscape in the model at Year 5. The costs of the project is $9.53 million, and the costs does not vary by scenario as there is no use of a distant borrow source.

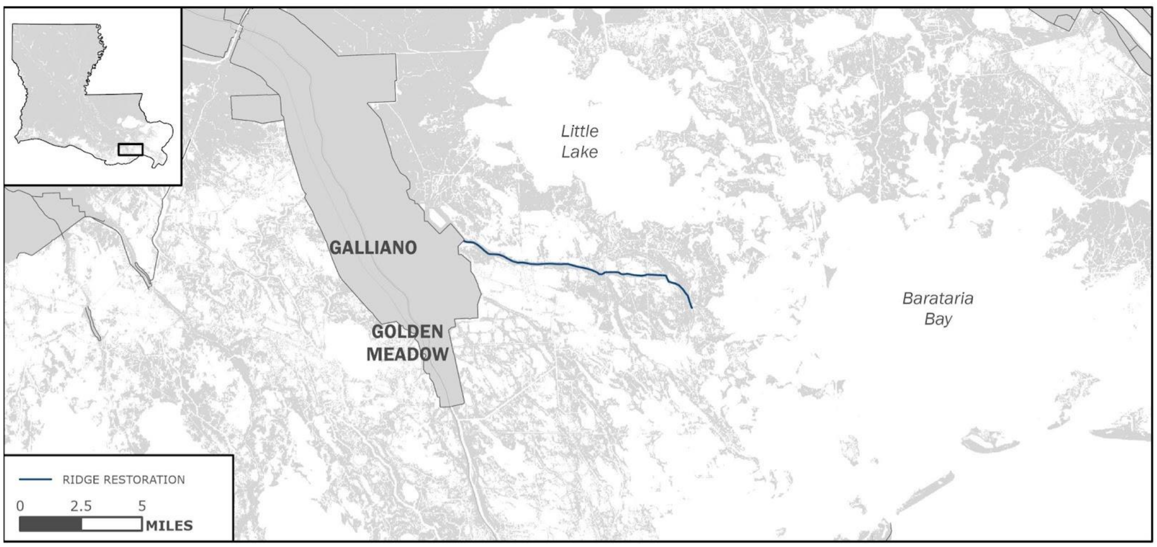


Figure 31. Location of the Bayou L'Ours Ridge Restoration project.

The project was modeled as G616 and was selected for the 2023 Coastal Master Plan in the first implementation period.

The results presented here discuss the way in which the project changes the coastal landscape in terms of hydrology, morphology, vegetation, and habitats, with examples from the two environmental scenarios. The examples have been selected to illustrate the dynamics of the project based on available data, rather than to provide a comprehensive description of all areas, scenarios, and temporal comparisons.

HYDROLOGY

RESULTS AND DISCUSSION

The restoration of the Bayou L'Ours Ridge limits all connectivity from the south of the ridge. The only connection to the marsh north of the project is through the channels to Little Lake. As a result, salt water is prevented from going across the ridge which leads to a larger salinity difference between the fresher northern side and more saline southern side of the ridge.

The overall impact of the project on water levels in the Barataria Basin is estimated to be very small, as indicated by Figure 29 and Figure 30 which show almost no difference in annual inundation depth outside of the ridge footprint at Year 15 and 30 of the lower scenario (S07) when compared to FWOA. The impact on water level is also very small for the higher scenario (S08).

Timeseries are extracted at two selected locations on the north (QAQC1226) and south (QAQC1447) sides of the project as shown in Figure 31. FWA versus FWOA comparisons of annual mean water level and variability are shown in Figure 32 and Figure 33 for the location north of the project and Figure 34 and Figure 35 for the location south of the project. Little to no impact on annual mean water level and variability is seen for either location, for both the lower scenario as well as the higher scenario.

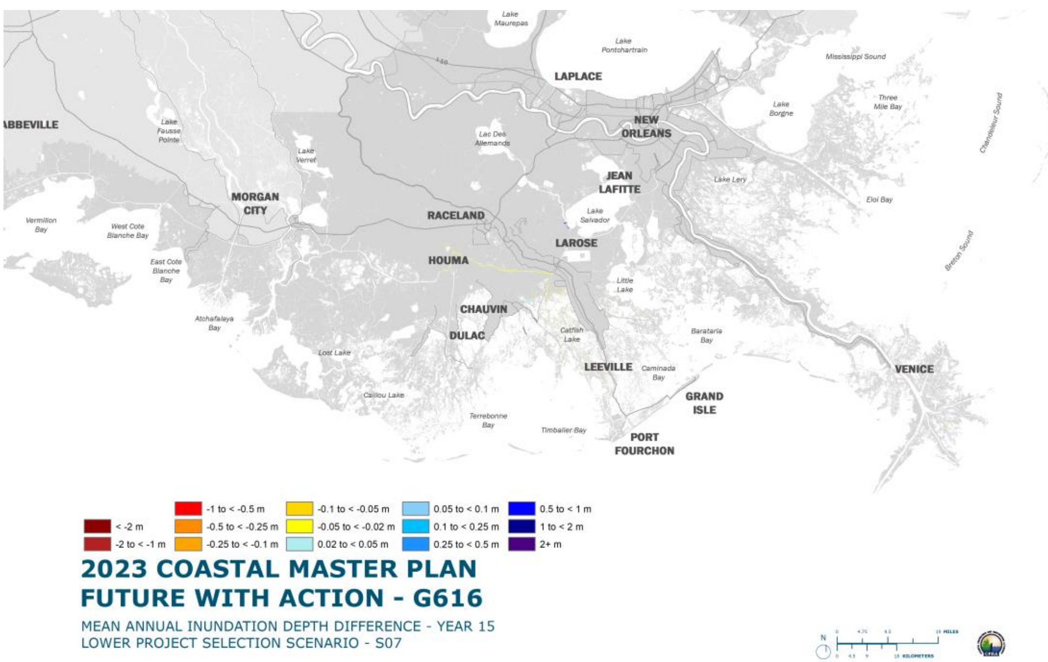


Figure 32. Difference map of mean annual inundation depth between FWOA (G500) and FWA (G616) at Year 15 of the lower (S07) scenario, indicating no changes in inundation depth outside of the ridge footprint. The same results are found for the higher (S08) scenario.

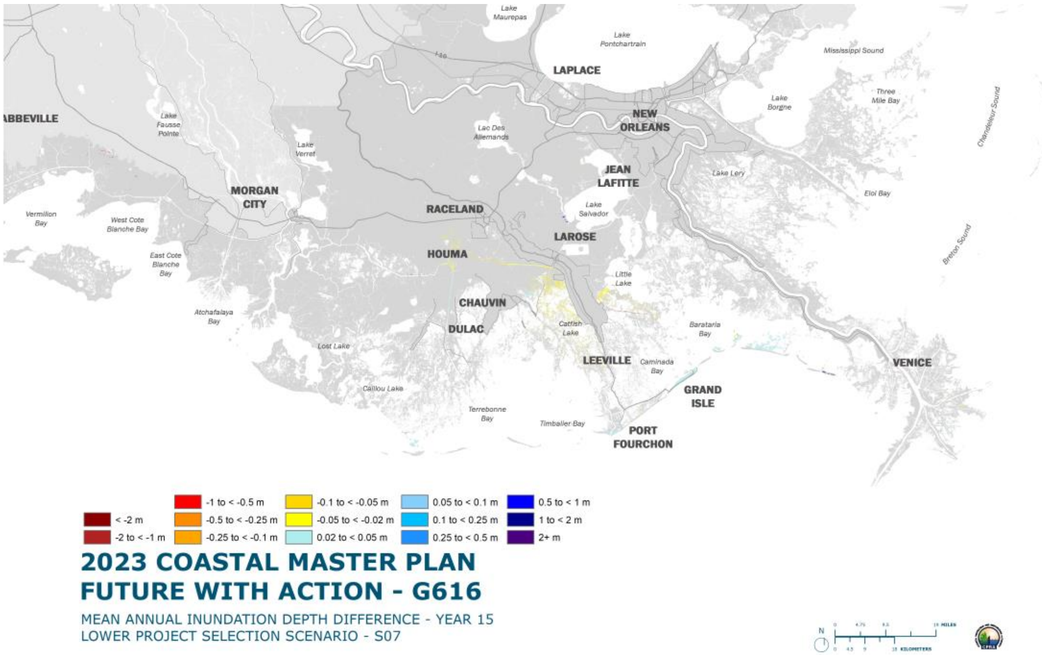


Figure 33. Difference map of mean annual inundation depth between FWOA (G500) and FWA (G616) at Year 30 of the lower (S07) scenario, indicating no changes in inundation depth outside of the ridge footprint. The same results are found for the higher (S08) scenario.

Figure 34. Map indicating the location of the data extraction sites.

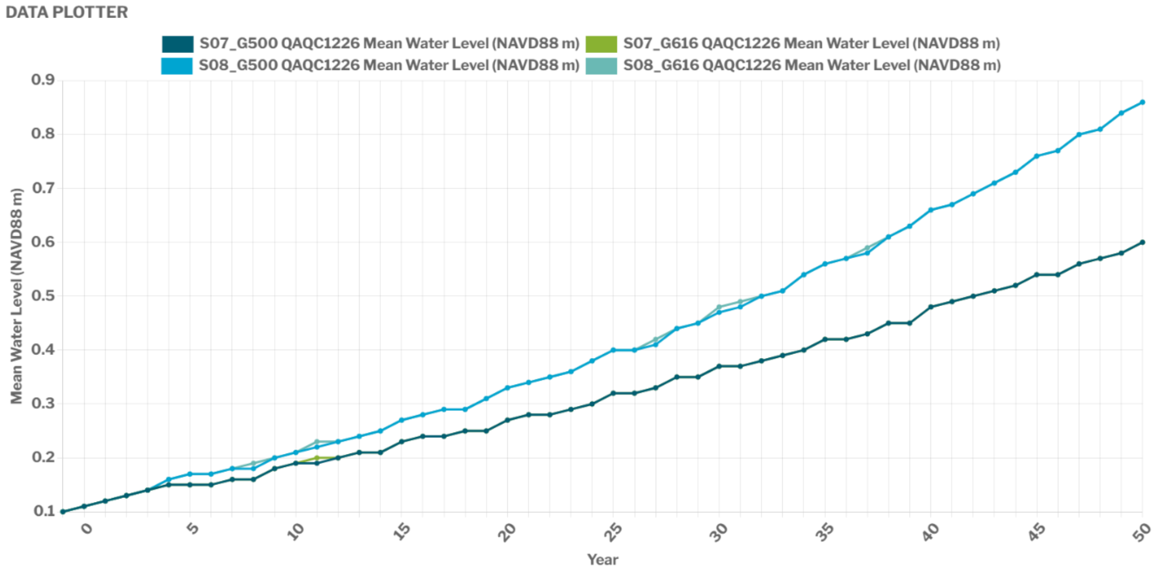


Figure 35. Annual mean water level timeseries comparison between FWOA (G500) and FWA (G616) for lower (S07) and higher (S08) scenarios in compartment 213 located north of the ridge (location indicated in Figure 31), showing negligible to no FWA vs. FWOA differences in mean water level due to the ridge.

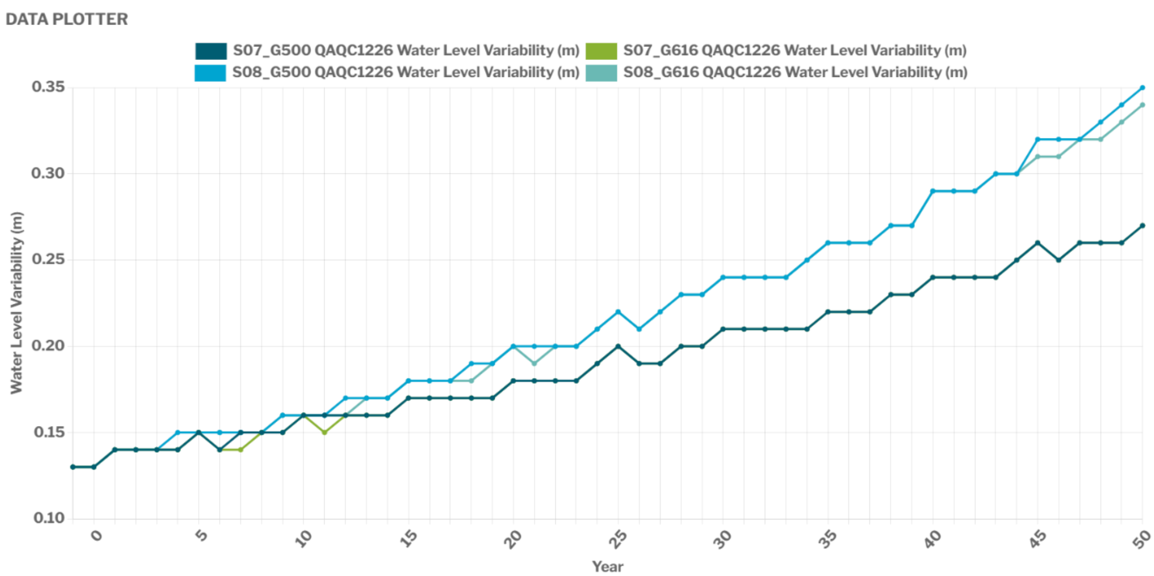


Figure 36. Annual mean water level variability comparison between FWOA (G500) and FWA (G616) for lower (S07) and higher (S08) scenarios in compartment 213 located north of the ridge (location indicated in Figure 31), showing negligible to no FWA vs. FWOA differences in water level variability due to the ridge.

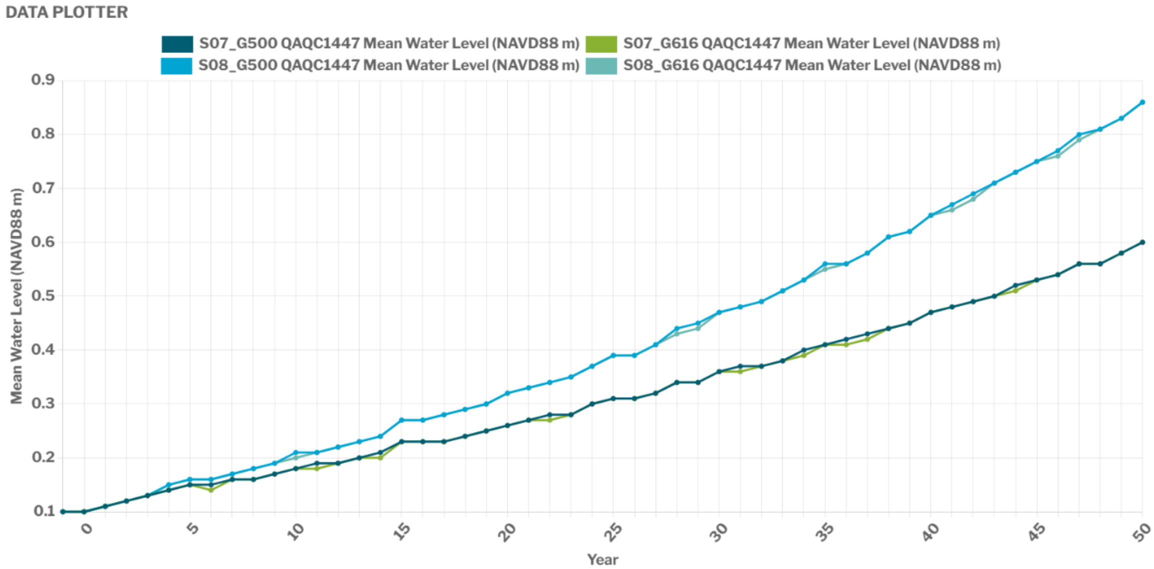


Figure 37. Annual mean water level comparison between FWOA (G500) and FWA (G616) for lower (S07) and higher (S08) scenarios in compartment 222 located south of the ridge (location indicated in Figure 31), showing negligible to no FWA vs. FWOA differences in mean water levels due to the ridge.

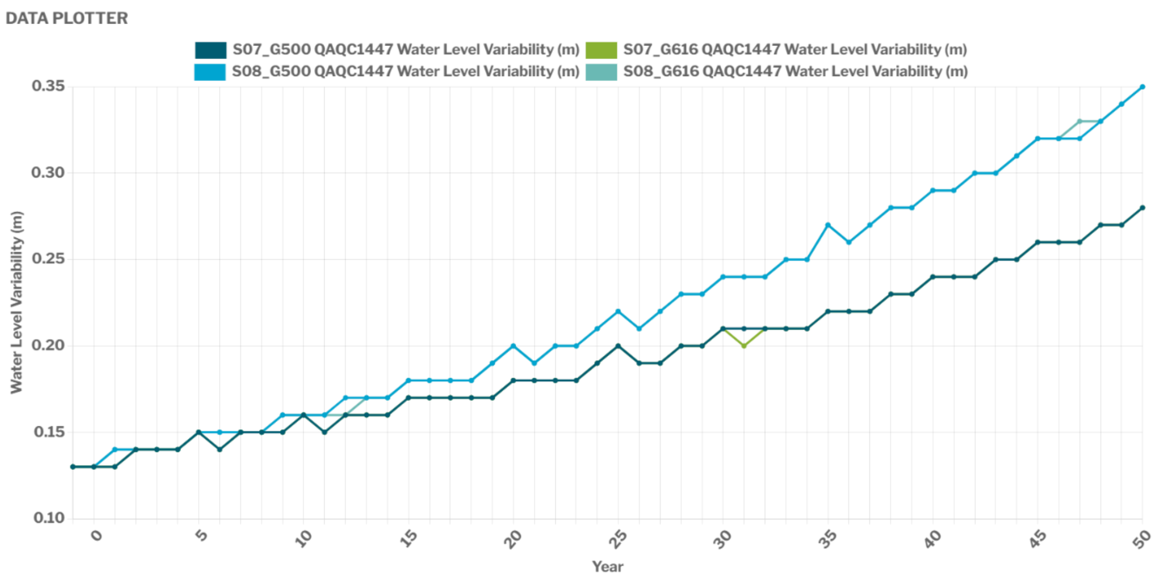


Figure 38. Annual mean water level variability comparison between FWOA (G500) and FWA (G616) for lower (S07) and higher (S08) scenarios in compartment 222 located south of the ridge (location indicated in Figure 31), showing negligible to no FWA vs. FWOA differences in water level variability due to the ridge.

Salinity patterns and dynamics are more noticeably affected as shown in Figure 36 and Figure 37 indicating the FWA versus FWOA difference in mean annual salinity for the lower scenario (S07) at Years 15 and 30, respectively. A decrease of salinity concentrations can be seen north of the project along with a salinity increase south of the project. The areal extent of salinity differences does not change drastically over time. The FWA versus FWOA salinity reduction increases over time at the location north of the ridge, as shown in Figure 38, which indicates a project-related reduction of salinity concentrations by 2-4 ppt in the early years after construction for both scenarios (lower and higher), up to a reduction of 6 ppt (lower scenario) and 15 ppt (higher scenario) in the last decade. The increase of the salinity reduction over time can mostly be explained by increasing salinity in FWOA, with annual mean salinity increasing significantly for both scenarios after Year 25, in contrast to FWA which barely increases over time.

On the contrary, FWA versus FWOA salinity differences are much smaller in the area south of the ridge, which are limited to 1 ppt for both scenarios and remain constant over time (Figure 39).

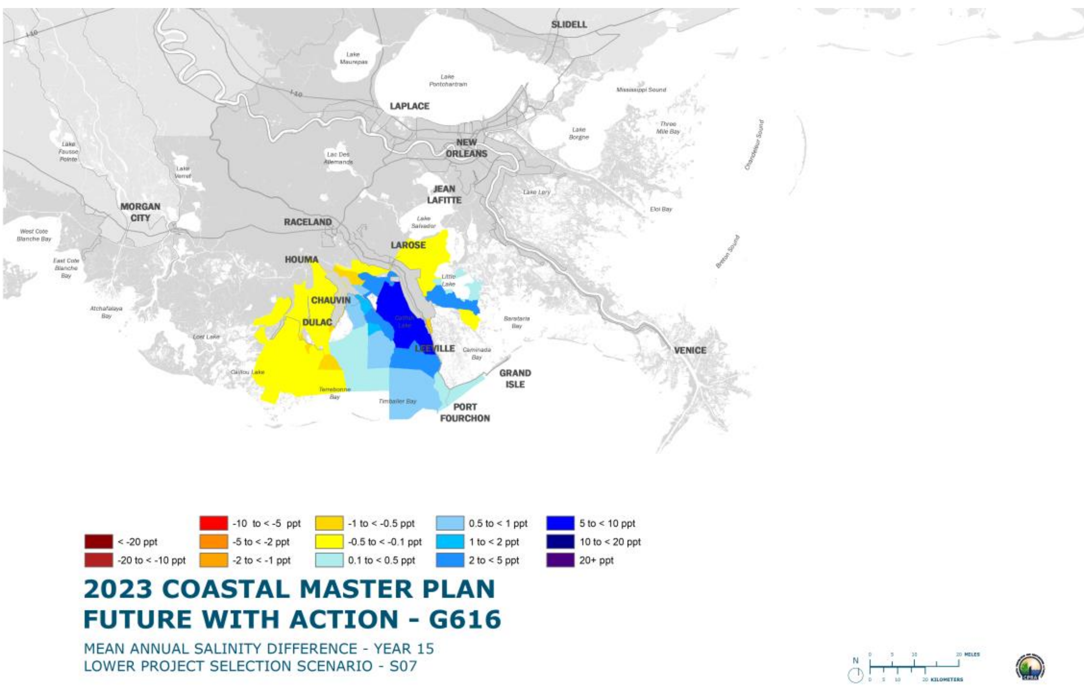


Figure 39. Difference map of mean annual salinity between FWOA (G500) and FWA (G616) at Year 15 of the lower (S07) scenario, indicating a small salinity decrease directly north of the Bayou L’Ours Ridge, along with a small salinity increase south of the ridge. The salinity differences in the Terrebonne Basin can be attributed to the Grand Bayou Hydrologic Restoration project, which is unrelated to the Bayou L’Ours Ridge Restoration but was run as part of the same model group (G616).

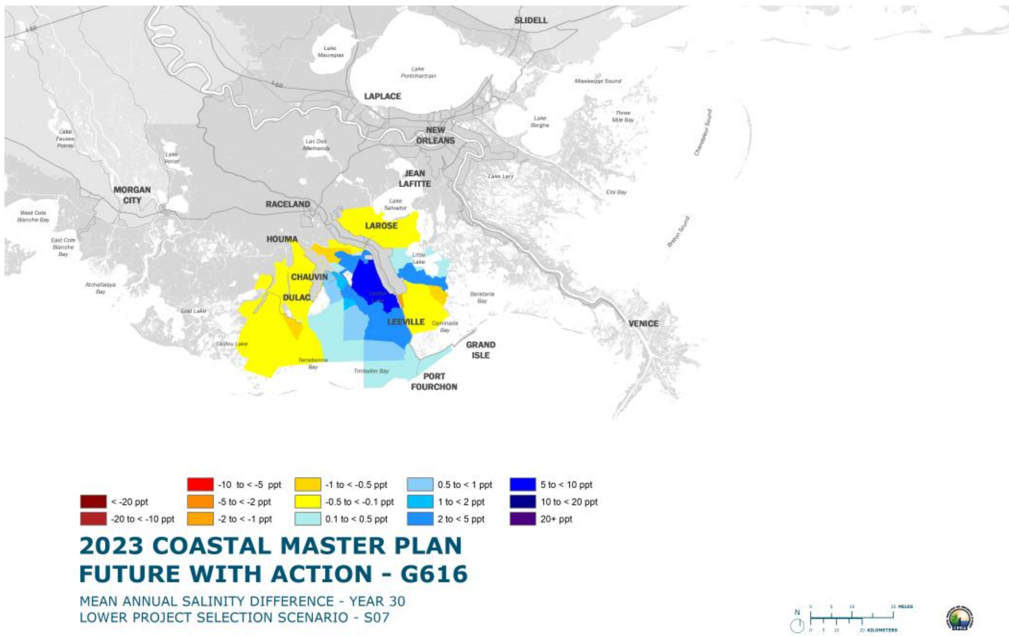


Figure 40. Difference map of mean annual salinity between FWOA (G500) and FWA (G616) at Year 30 of the lower (S07) scenario, indicating a small salinity decrease directly north of the Bayou L'Ours Ridge, along with a small salinity increase south of the ridge. The salinity differences in the Terrebonne Basin can be attributed to the Grand Bayou Hydrologic Restoration project, which is unrelated to the Bayou L'Ours Ridge Restoration but was run as part of the same model group (G616).

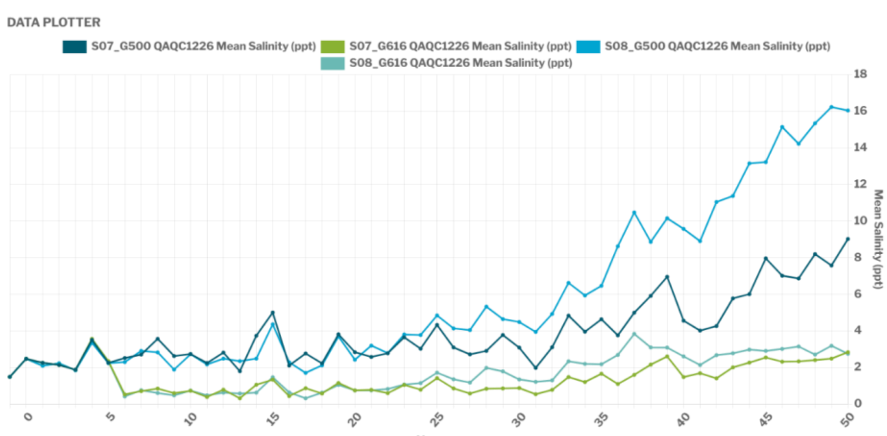


Figure 41. Annual mean salinity comparison between FWOA (G500) and FWA (G616) for lower and higher scenarios in compartment 213 located north of the ridge (location indicated in Figure 31), showing a salinity reduction after construction of the ridge in Year 6 that amounts to almost 15 ppt for the higher scenario in the last decade.

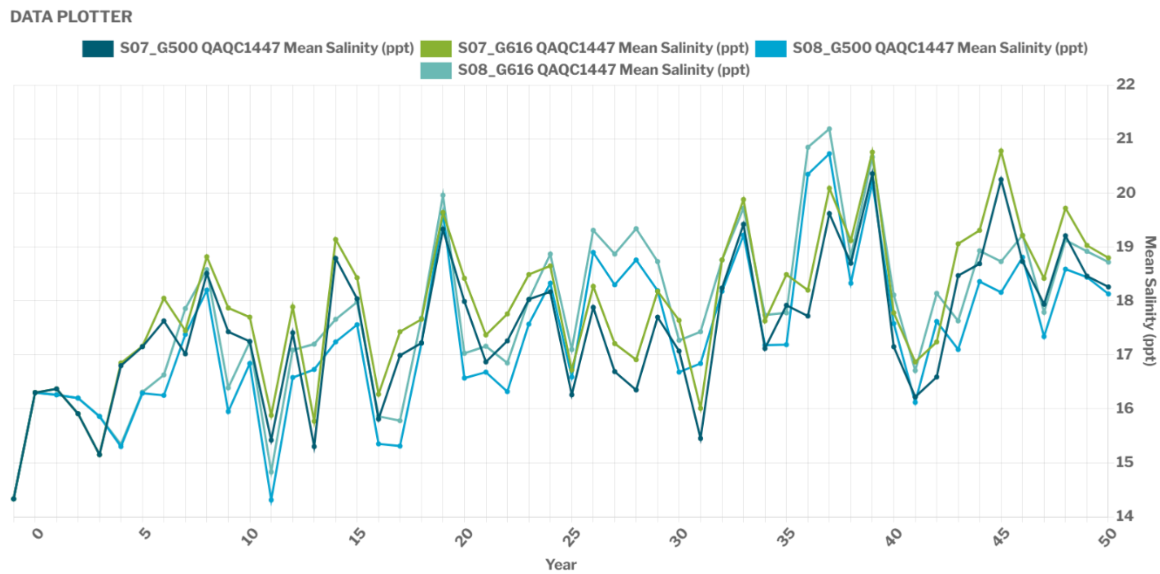


Figure 42. Annual mean salinity comparison between FWOA (G500) and FWA (G616) for lower (S07) and higher (S08) scenarios in compartment 222 located south of the ridge (location indicated in Figure 31), showing a small salinity increase after construction of the ridge in Year 6 that remains limited to 1 ppt for both lower and higher scenarios.

MORPHOLOGY

The net effect of this project on the landscape varies by scenario (Table 2) with more AAL under the higher scenario compared to the lower, but more net land at Year 50 for the lower scenario.

Table 4. Net effect of the Bayou L'Ours Ridge Restoration project (FWA-FWOA) by scenario in terms of AAL and net land at Year 50

	Average Annual Net Land (km^2)		Net Land at Year 50 (km^2)	
Scenario	Lower	Higher	Lower	Higher
Bayou L'Ours Ridge Restoration	3.7	6.5	11.9	5.9

However, examination of the differences over time (Figure 40) shows that the benefit under the higher scenario peaks near the start of the last decade and then declines, whereas the net benefit under the lower scenario peaks near the end of the simulation. Much of the benefit for this project occurs in the area north of the ridge. The differences in land area for compartment 213 across scenarios are shown in Figure 41 and Figure 42. In the lower scenario, the project maintains land that would otherwise be lost with the effect increasing over time (Figure 41). However, under the higher scenario, the rate of land loss under FWOA declines after Year 38 and almost all the land area in the compartment is lost by Year 47, so the relative benefit of the project decreases in the last decade.

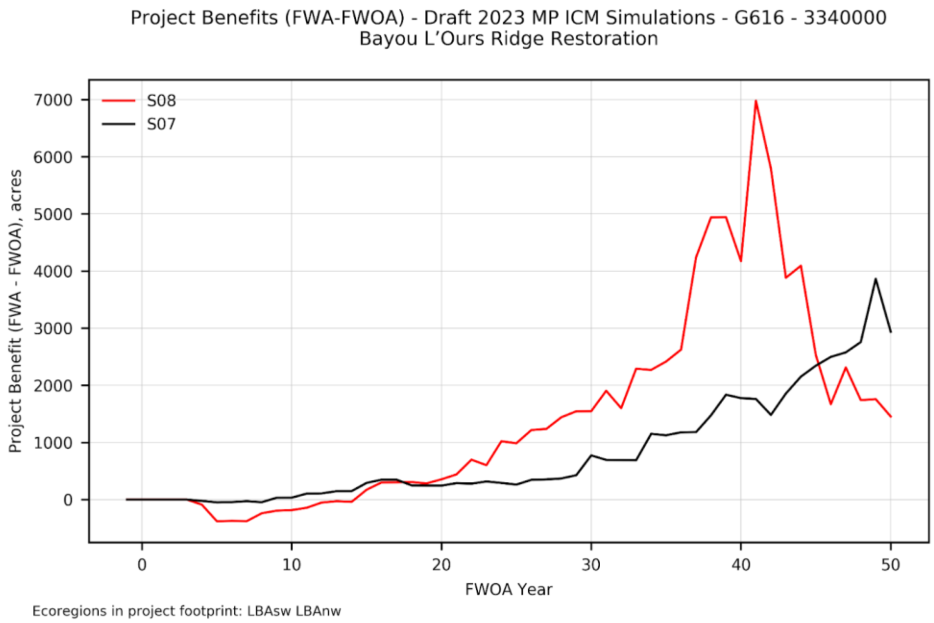


Figure 43. Net land (FWA-FWOA) over time for the Bayou L'Ours Ridge Restoration project.

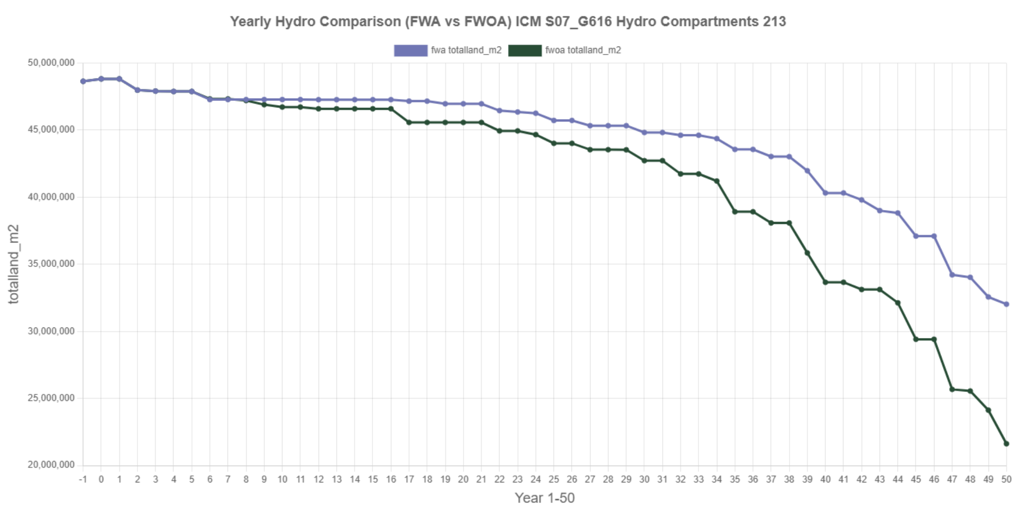


Figure 44. Difference in land area between FWA and FWOA for compartment 213 north of the Bayou L'Ours Ridge (lower scenario).

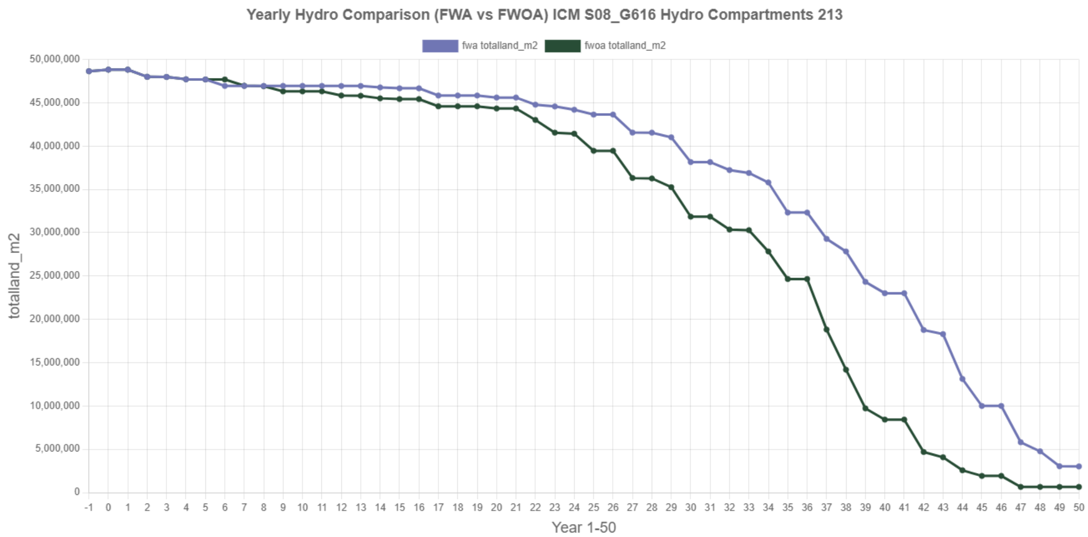


Figure 45. Difference in land area between FWA and FWOA for compartment 213 north of the Bayou L'Ours Ridge (higher scenario).

The reduction in land loss is due to the effect of the ridge on salinity distribution in the Barataria Basin. As described above, under FWOA conditions, even though the Mid-Barataria Sediment Diversion (MBSD) is operational, there is still an increase in salinity on the western side of the basin. At QAQC1241, west of Little Lake in compartment 213, salinity increases in both the lower and higher scenarios after Year 30 under FWOA (Figure 43). The ridge project keeps the salinity below 4 ppt in both scenarios through the simulation (Figure 43).

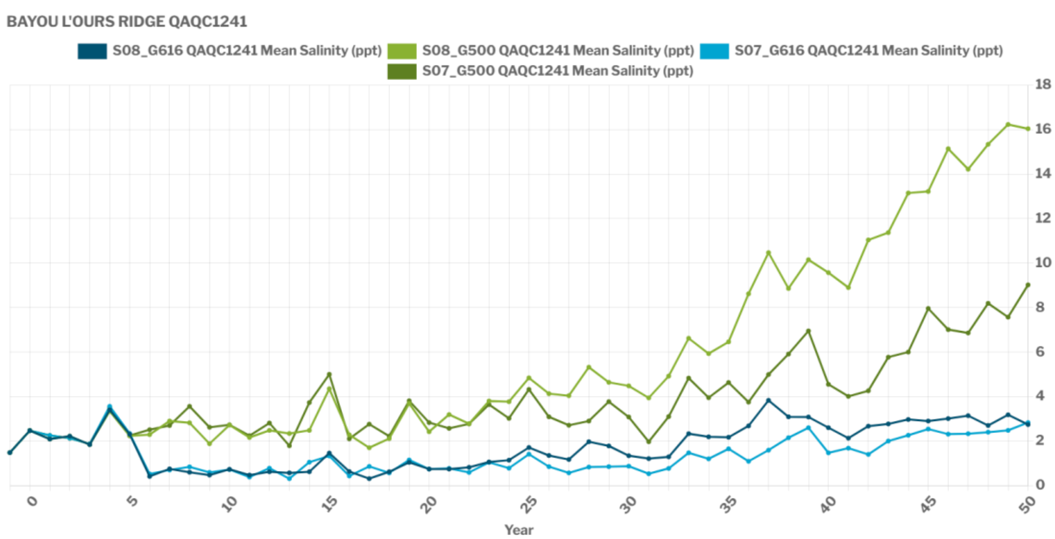


Figure 46. Changes in salinity over time at QAQC1241 for both the lower and higher scenarios with (G616) and without (G500) the Bayou L'Ours Ridge Restoration project.

Such a decrease in salinity impacts land loss in two ways. At lower salinities, herbaceous marshes are more tolerant of inundation (see Figure 3 in Baustian et al., 2020). For the higher scenario, a decrease in salinity from 15 ppt to 3 ppt would increase inundation tolerance by approximately 5 cm. Further, salinity also influences vegetation cover and thus organic matter accretion. Figure 44 shows FFIBS scores for QAQC1241. Under FWOA for both scenarios, FFIBS scores reach 7 (until the marsh is lost under S08), while with the project in place, the score is between 2 and 3 for most of the simulation after the project is constructed. FFIBS score influences organic accretion, and in the Delta Plain, there is an increase in organic accretion as scores decrease below 11.

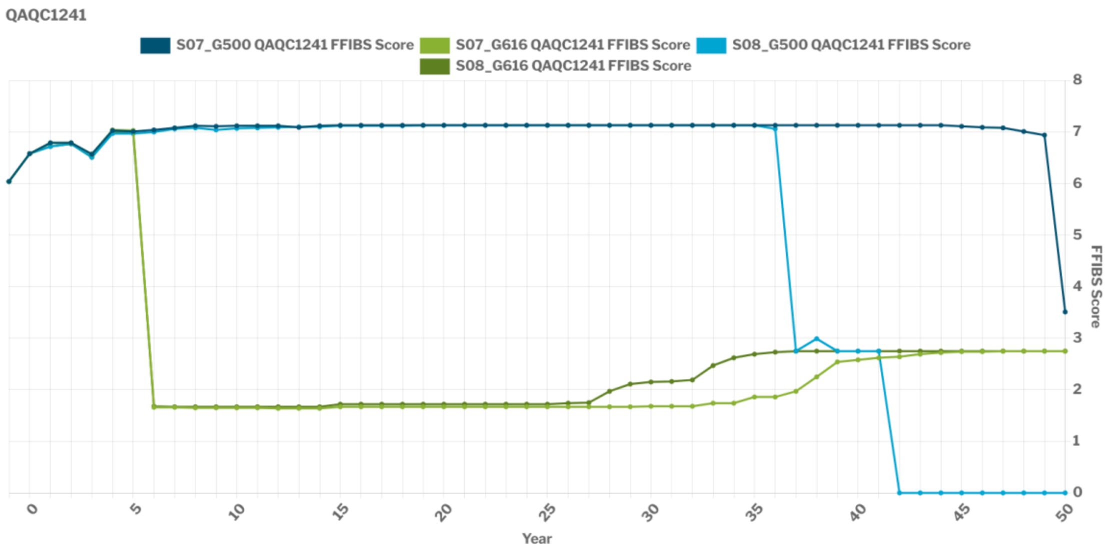


Figure 47. Changes in FFIBS scores over time at QAQC1241 for both the lower and higher scenarios with (G616) and without (G500) the Bayou L'Ours Ridge Restoration project.

At CRMS6303, also west of Little Lake and in compartment 213, this results in 0.5 mm/yr more accretion under the higher scenario once the marsh is inundated in Year 10. This allows surface elevation to be maintained for longer as shown in Figure 45, and the marsh is lost to open water in Year 46 with the project and at Year 39 under FWOA.

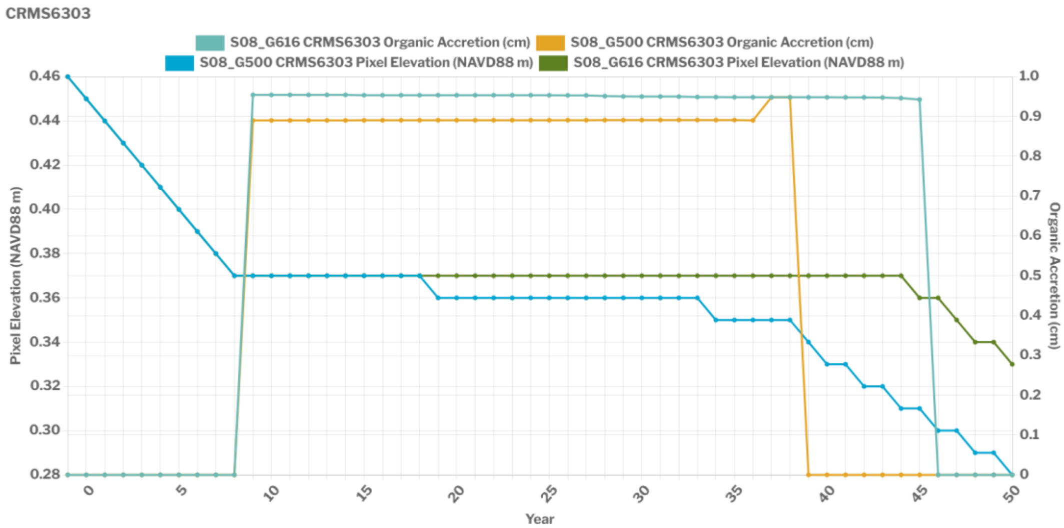


Figure 48. Changes in organic accretion and pixel elevation over time at CRMS6303 for the higher scenario with (G616) and without (G500) the Bayou L'Ours Ridge Restoration project.

In summary, the land area benefits of the project occur within the Lower Barataria Northwest (LBAnw) ecoregion and are associated with the interruption of increased salinity from the south and potentially with interaction of the ridge with the fresh inflows from MBSD as they distribute through the basin. Figure 46 shows the distribution of the land change benefits at Year 40 for the higher and the lower scenario.

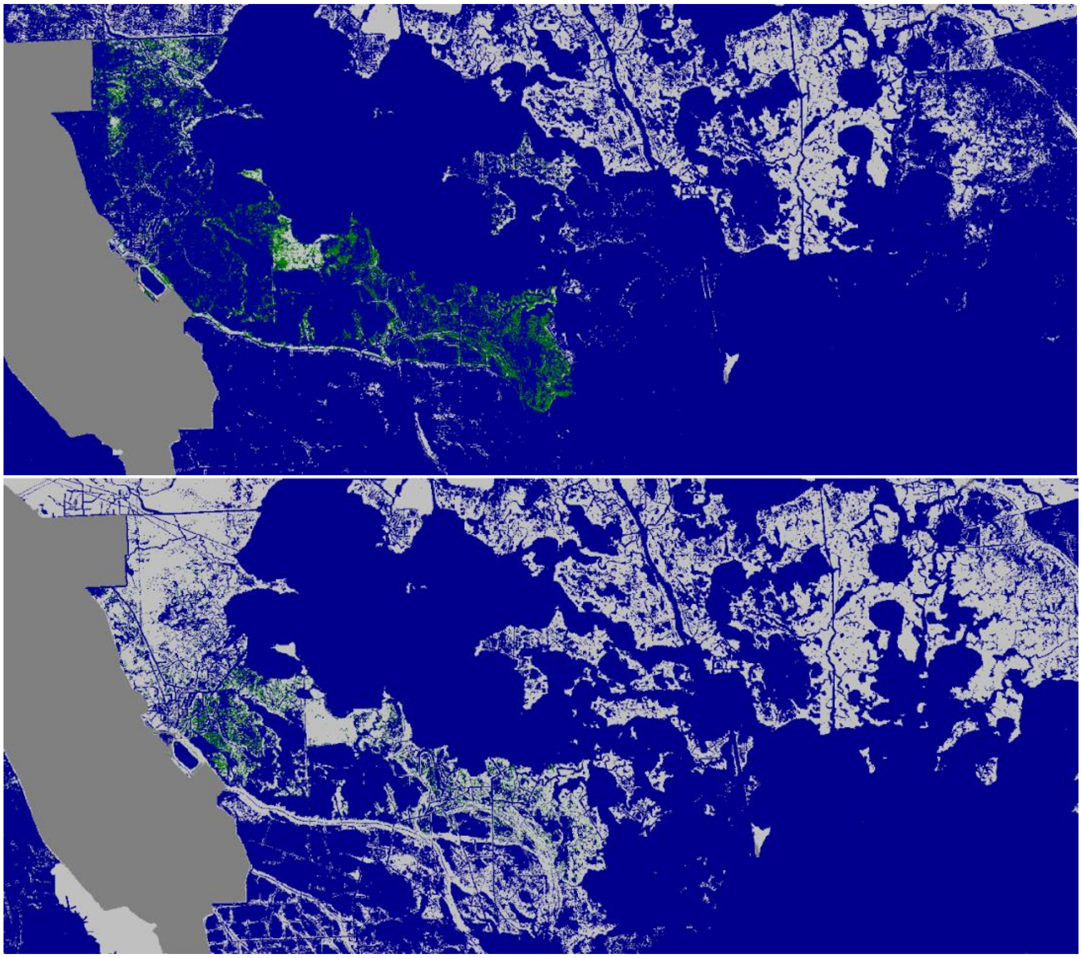


Figure 49. Land change compared to FWOA for the Bayou L'Ours Ridge Restoration project at Year 40 for both the lower and the higher scenarios.

VEGETATION

The effects of the Bayou L'Ours Ridge Restoration project are primarily in the LBAnw ecoregion north of the ridge. In this ecoregion, the construction of ridge and the resulting reduction in salinity decreases the cover of SCAM6, which occurs at an average annual salinity between 1.6 and 5.8 ppt (see Baustian et al., 2020), and primarily replaces it with TYDO, which occurs at average annual salinity between 0.4 to 1.8 ppt (Figure 47). These changes are mostly immediately north of the ridge changing what was brackish marsh in FWOA to intermediate marsh with the restored ridge (Figure 48). This is the area where land loss is reduced with the project. South of the Bayou L'Ours Ridge, saline marshes are unaffected by the slight rise in salinity associated with the ridge restoration.

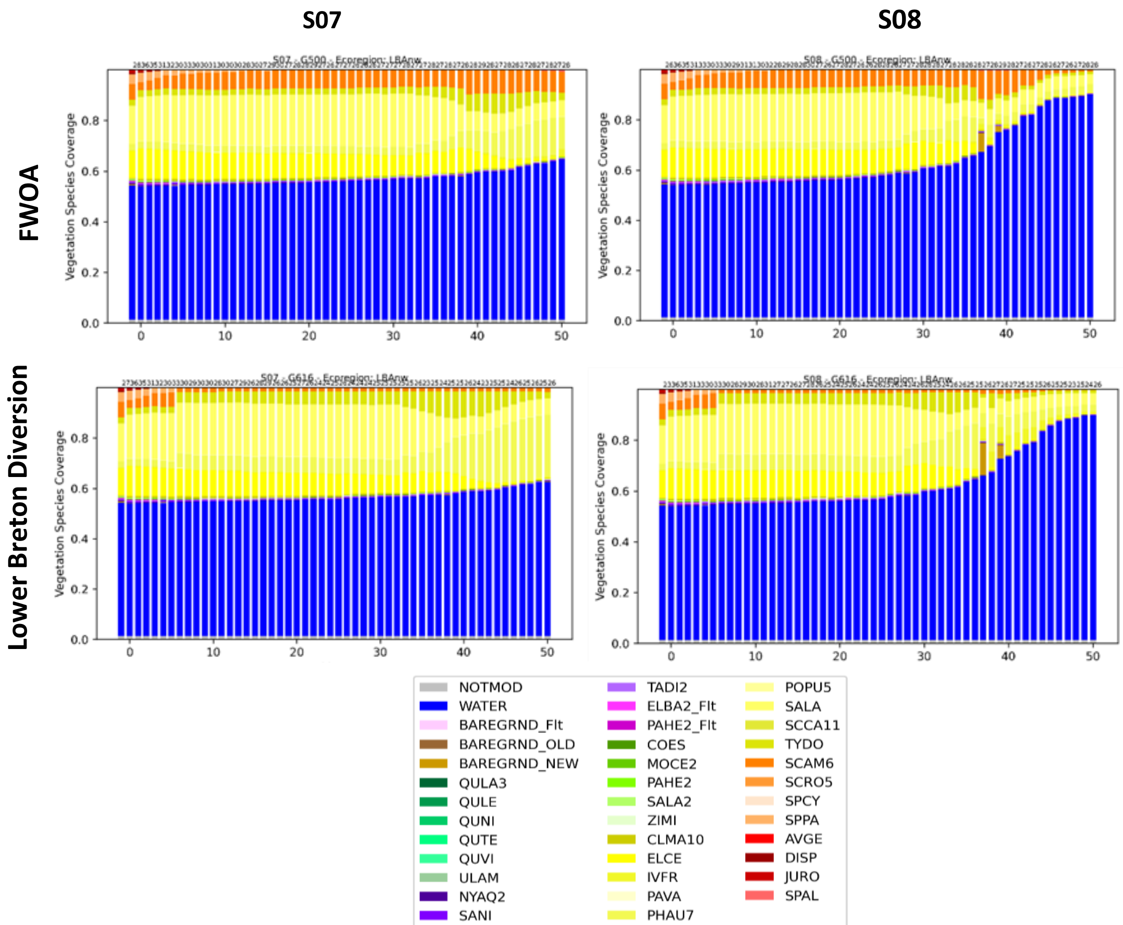


Figure 47. Change in vegetation in LBAnw ecoregion, with and without the Bayou L’Ours Ridge Restoration project under two scenarios

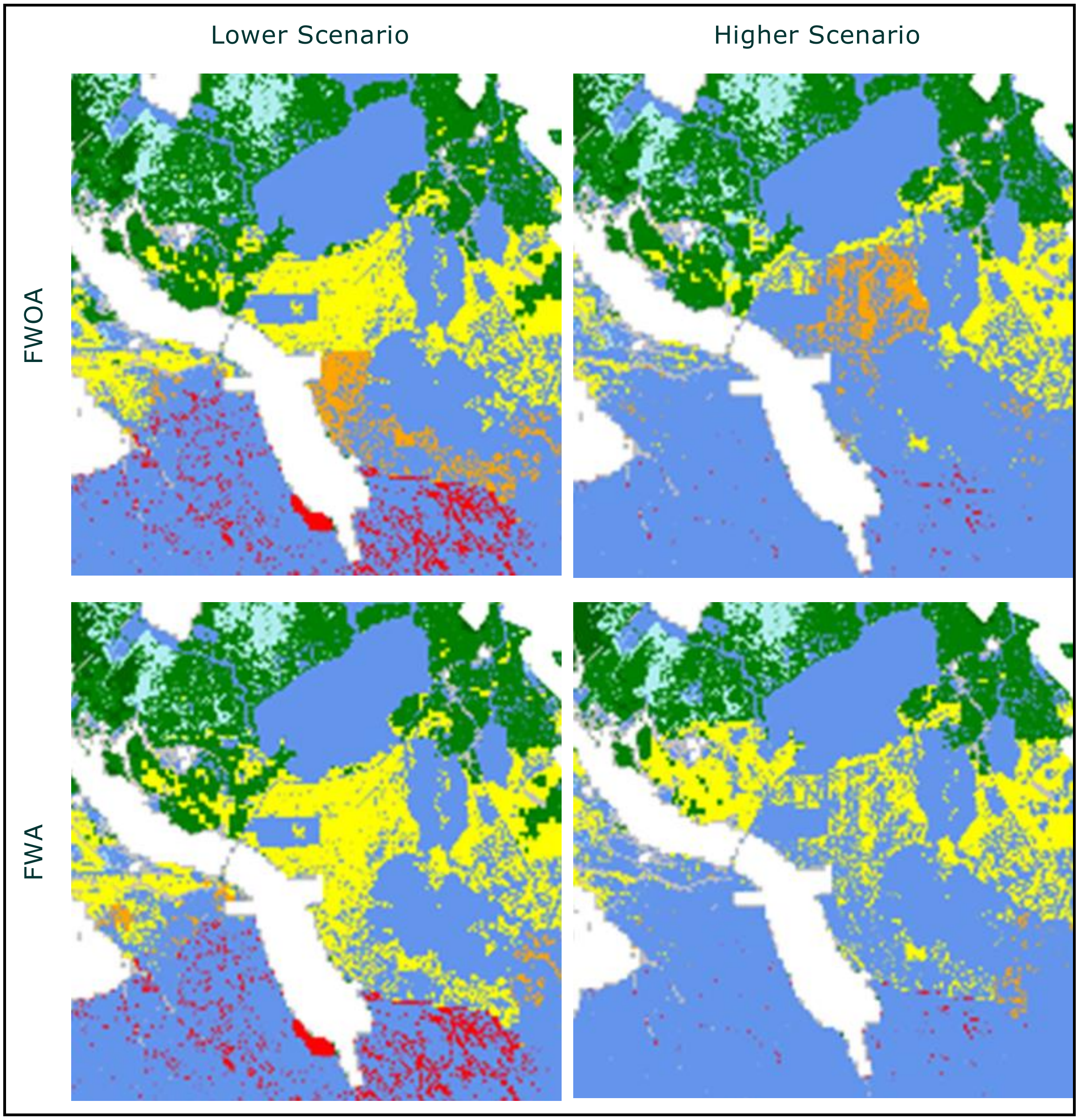


Figure 50. Change in habitat for LBAnw ecoregion in Year 40 with and without the Bayou L'Ours Ridge Restoration project under both scenarios.

HABITAT SUITABILITY

RESULTS AND DISCUSSION

The Bayou L'Ours Ridge Restoration project did not have a large effect on habitat suitability for fish, shellfish, and wildlife during either scenario in the Lower Barataria Southwest (LBAsw) ecoregion. However, salinity impacts were seen to the north of the project. Within the LBAnw ecoregion, salinities were reduced and provided suitable habitat for species with freshwater preference, such as, the mottled duck, gadwall, and largemouth bass (Figure 49).

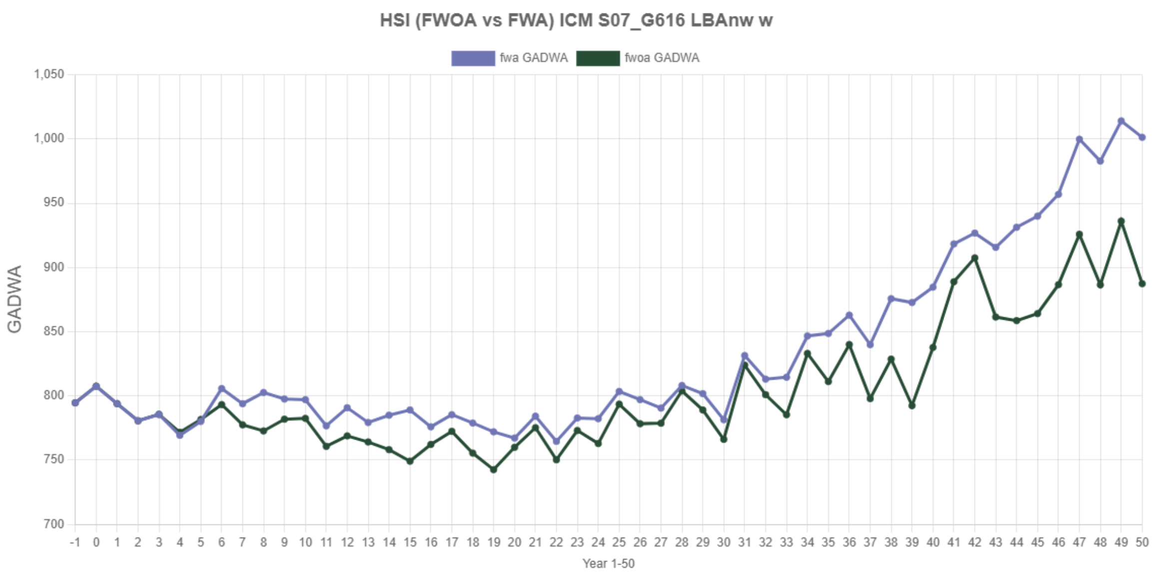


Figure 51. Total HSI score for the gadwall in the LBAnw ecoregion for the 50-year FWOA and Bayou L'Ours Ridge Restoration project (FWA) lower environmental scenario simulations. The total HSI score was calculated by summing the individual scores for each ICM model cell within the ecoregion.

On the other hand, these salinity decreases reduced habitat suitability for species with affinity for higher salinities, such as juvenile white shrimp and adult spotted seatrout (Figure 50). With the higher scenario, the reduced salinity effects diminished over time and created more favorable habitat (relative to FWOA) for higher salinity species (Figure 50). This was particularly evident in the last decade of the project.

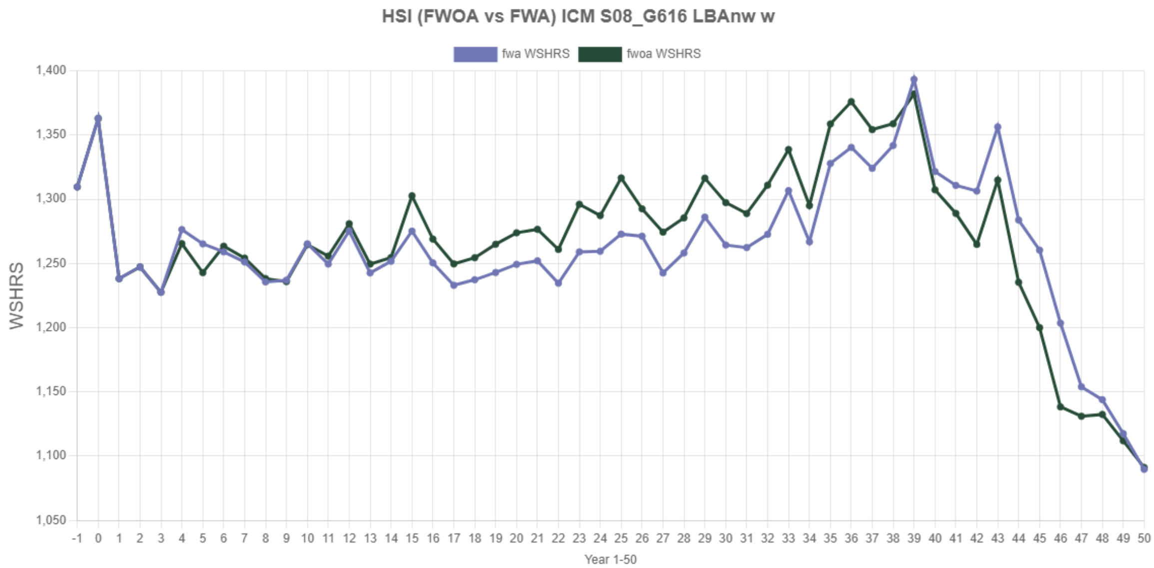


Figure 52. Total HSI score for small juvenile white shrimp in the LBAnw ecoregion for the 50-year FWOA and Bayou L'Ours Ridge Restoration project (FWA) higher environmental scenario simulations. The total HSI score was calculated by summing the individual scores for each ICM model cell within the ecoregion.

4.0 LOWER BARATARIA LANDBRIDGE

PROJECT OVERVIEW

The Lower Barataria Landbridge (#325a) is an integrated project that includes the creation of marsh within a footprint of approximately 10,000 acres including filling areas deeper than 2.5 ft, across the lower Barataria Basin along the bay rim (Figure 53A). There is also 150,000 ft of shoreline revetment to limit erosion in exposed areas and channel armoring to maintain channels at current dimensions at Wilkinson Canal, Wilkinson Bayou, Bay Chene Fleur, multiple channels north of Bay Batiste, Two Sisters Bayou, Socola Canal, and Grand Bayou. The purpose of the project is to reduce the tidal prism, create new wetland habitat, restore degraded marsh, and reduce wave erosion. The project is modeled as G618 and is fully constructed by Year 9 of the model run.

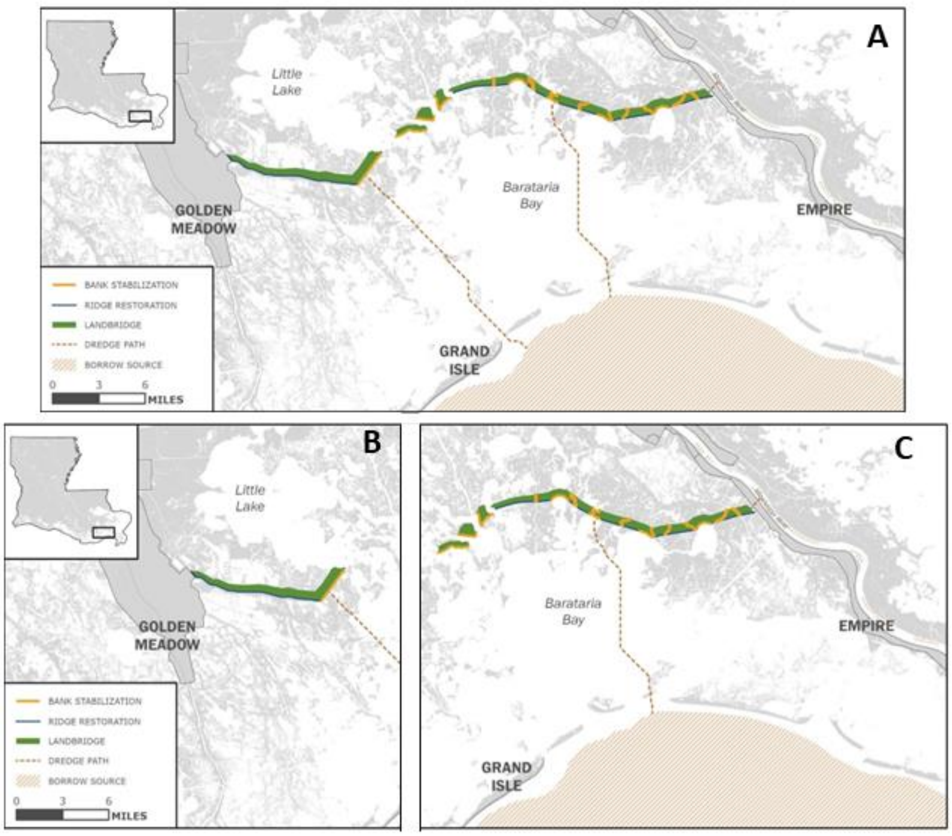


Figure 53. Location of the Lower Barataria Landbridge project (Panel A), the Lower Barataria Landbridge - West project (Panel B), and the Lower Barataria Landbridge - East project (Panel C).

The Lower Barataria Landbridge - West project (#325b) includes creation of marsh within a footprint of approximately 3,600 acres including filling areas deeper than 2.5 ft, from Bayou L'Ours Ridge to Snail Bay to reduce the tidal prism and to create new wetland habitat, restore degraded marsh, and reduce wave erosion (Figure 53B). There is also 13,000 ft of shoreline revetment to limit erosion in exposed areas and channel armoring to maintain channels at current dimensions. The project is modeled as G642 and is fully constructed by Year 6 of the model run.

The Lower Barataria Landbridge - East project (#325c) includes creation of marsh within a footprint of approximately 6,900 acres including filling areas deeper than 2.5 ft, from Bayou Dogris to Port Sulphur (Figure 53C). There is also 130,000 ft of shoreline revetment to limit erosion in exposed areas and channel armoring to maintain channels at current dimensions at Wilkinson Canal, Wilkinson Bayou, Bay Chene Fleur, multiple channels north of Bay Batiste, Two Sisters Bayou, Socola Canal, and Grand Bayou to reduce the tidal prism, create new wetland habitat, restore degraded marsh, and reduce wave erosion. The project is modeled as G643 and is fully constructed by Year 8 of the model run.

The costs of the project varies by scenario (Table 3) as the amount of dredged material required varies according to water depth.

Table 5. Maximum costs for each of the Lower Barataria Landbridge projects by scenario

Project	Lower Scenario	Higher Scenario
Lower Barataria Landbridge	$1.1 billion	$1.17 billion
Lower Barataria Landbridge - West	$346.8 million	$365.5 million
Lower Barataria Landbridge - East	$747.4 million	$790.4 million

These projects were each evaluated for inclusion in the 2023 Coastal Master Plan for both the first and second implementation periods. None of the projects were selected in IP1, and in IP2 the Lower Barataria Landbridge - East was selected. The project results presented here focus on IP1 and discuss the way in which the project changes the coastal landscape in terms of hydrology, morphology, vegetation, and habitats, with examples from the two environmental scenarios. The examples have been selected to illustrate the dynamics of the project based on available data, rather than to provide a comprehensive description of all areas, scenarios, and temporal comparisons.

HYDROLOGY

WATER LEVEL AND INUNDATION

The overall impact of the project on water levels in the Barataria Basin is estimated to be very small, as indicated by Figure 54, which shows almost no difference in annual inundation depth outside of the project footprint at Year 15 of the lower scenario (S07) when compared to FWOA. The impact on water level remains small in the later years for the lower scenario as well as for the higher scenario (S08).

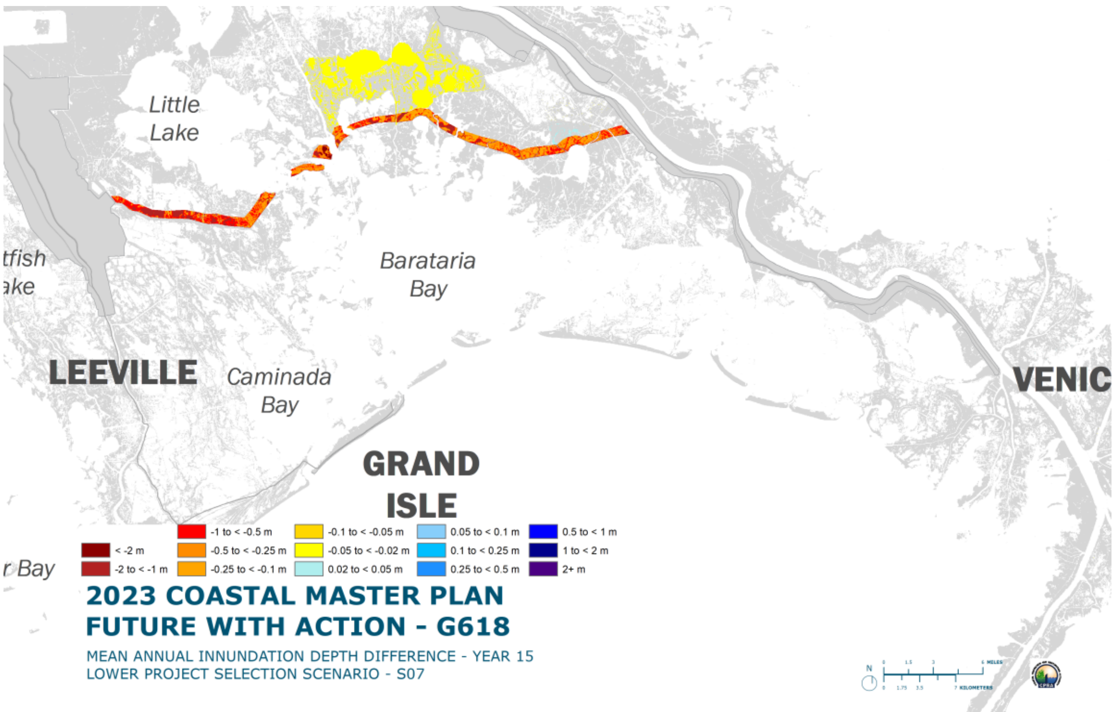


Figure 54. Difference map of mean annual inundation depth between FWOA (G500) and FWA (G618) at Year 15 of the lower scenario (S07), indicating no significant changes in inundation depths outside of the project footprint. Similar results are found in later years and for the higher scenario (S08).

Time series at four selected locations (Figure 55) on the landward and seaward sides of the project show the changes over time.

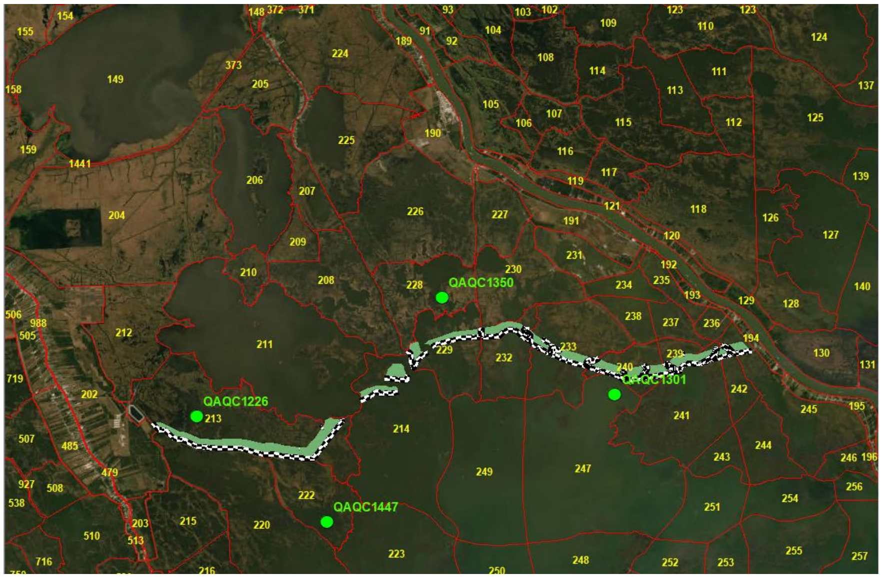


Figure 55. Map indicating the location of the data extraction sites.

Water level and variability with and without the projects at the north of the western section of the landbridge (QAQC1226) are shown in Figure 54 and Figure 55, respectively. As shown in these figures, little to no impact on annual mean water levels and variability is found in the model results. The daily maximum stage comparison in the same area (Figure 56) indicates slightly lower peaks and higher troughs for FWA.

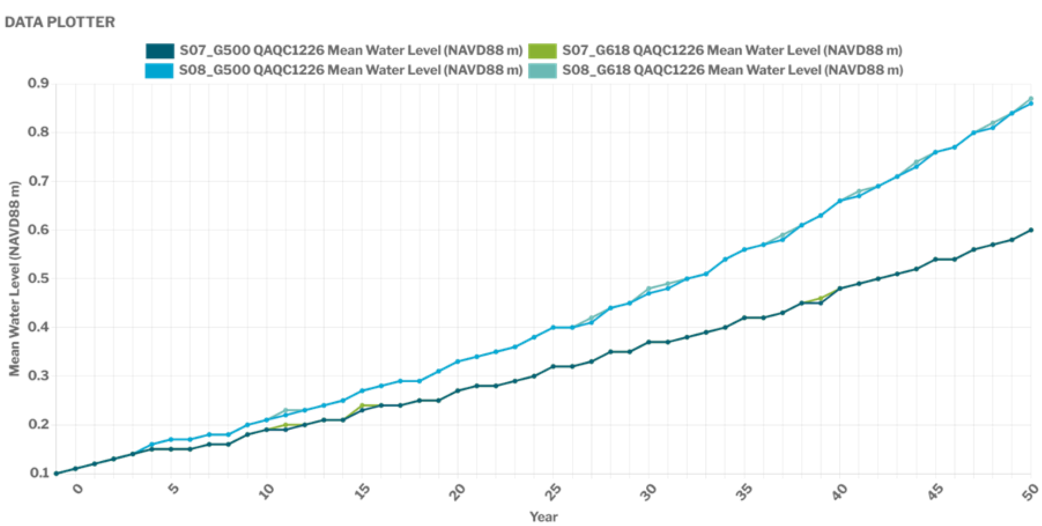


Figure 56. Annual mean water level comparison between FWOA (G500) and FWA (G618) for lower (S07) and higher (S08) scenarios in compartment 213 located north of the western section of the landbridge (location indicated in Figure 53), showing negligible to no increase of mean water levels due to the landbridge.

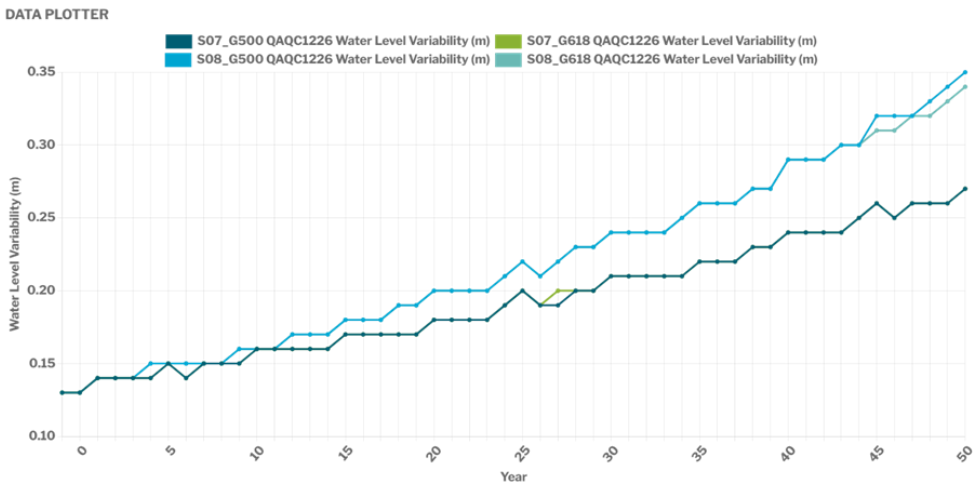


Figure 57. Annual water level variability comparison between FWOA (G500) and FWA (G618) for lower (S07) and higher (S08) scenarios in compartment 213 located north of the western section of the landbridge (location indicated in Figure 53), showing negligible to no impacts on water level variability.

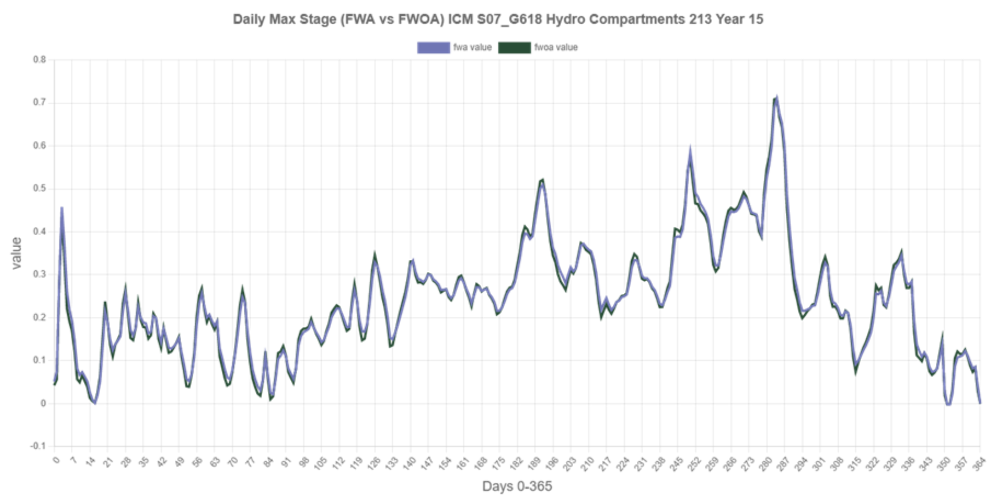


Figure 58. Daily max stage comparison between FWOA (G500) and FWA (G618) for Year 15 in compartment 213 located north of the western section of the landbridge (location indicated in Figure 53), showing a slight decrease of variability (i.e., peak attenuation) of daily max stages due to the project.

Water level comparisons for the area north of the eastern section of the landbridge show more noticeable yet still small differences compared to FWOA. Annual water level variability (Figure 57) is not affected substantially. However, annual mean water levels (Figure 58) are higher for FWA relative to FWOA, with a difference of 1-2 cm initially that increases to up to 5 cm over time. Figure 59, showing daily max stages for Year 15, indicates that FWA only experiences higher water levels during springtime, overlapping with the high flow period of MBSD.

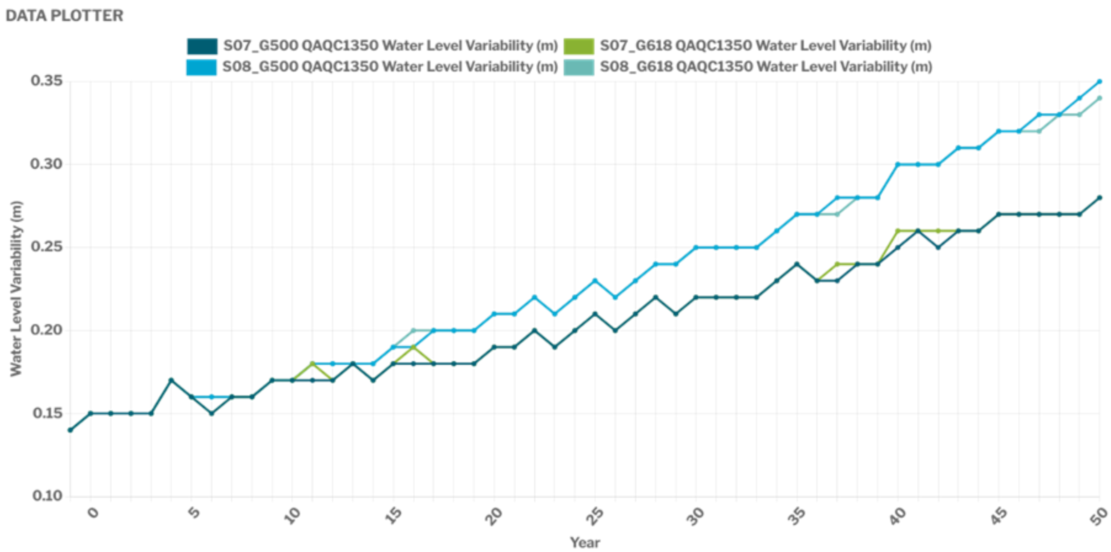


Figure 59. Annual water level variability comparison between FWOA (G500) and FWA (G618) for lower (S07) and higher (S08) scenarios in compartment 228 located north of the eastern section of the landbridge (location indicated in Figure 53), showing negligible to no project impacts on water level variability.

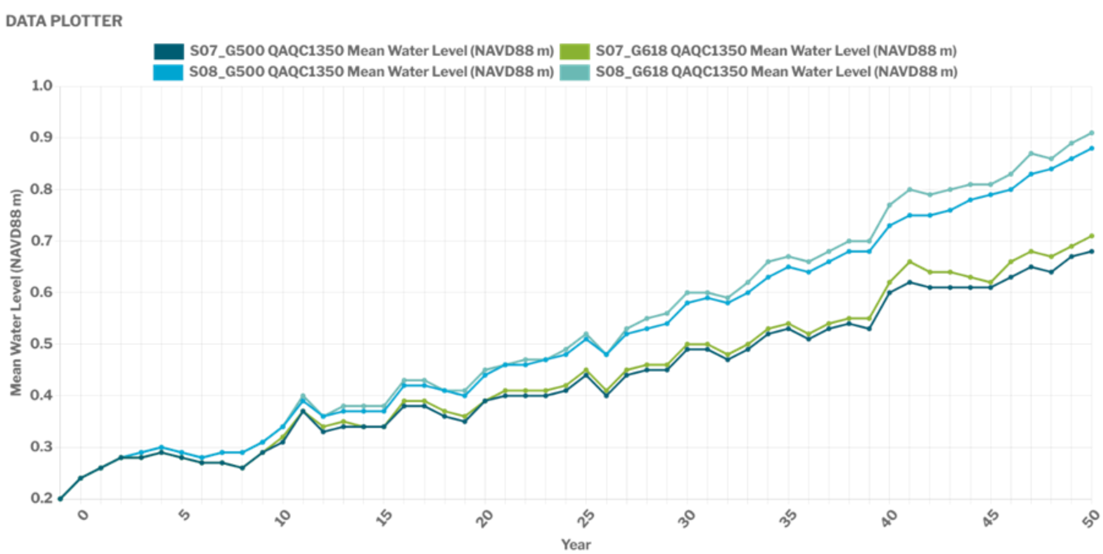


Figure 60. Annual mean water level comparison between FWOA (G500) and FWA (G618) for lower (S07) and higher (S08) scenarios in compartment 228 located north of the eastern section of the landbridge (location indicated in Figure 53), showing a slight increase of mean water levels for both scenarios due to the landbridge.

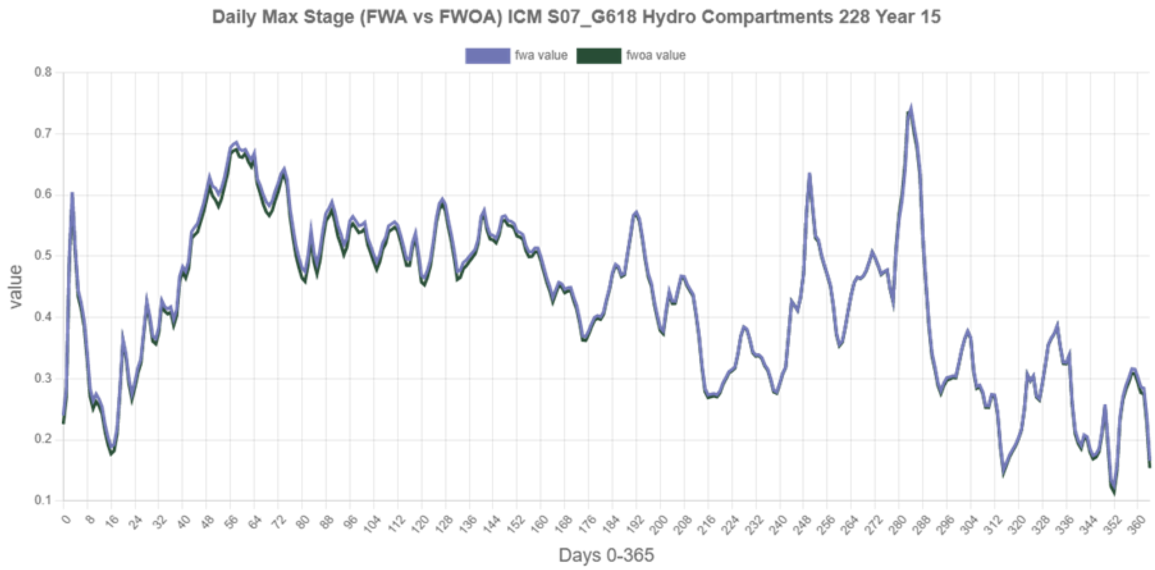


Figure 61. Daily max stage comparison between FWOA (G500) and FWA (G618) for Year 15 in compartment 228 located north of the eastern section of the landbridge (location indicated in Figure 55) showing a slight increase of daily max stages during the high flow period of the MBSD operation.

SALINITY

The project's impact on salinity is more noticeable than on water levels. Salinity differences between FWA and FWOA as shown in Figure 60 at Year 30 of the higher scenario (S08), indicate a reduction of salinity immediately north of the landbridge, along with an increase of salinity south of the landbridge, resulting in a more pronounced salinity gradient in the Barataria Basin.

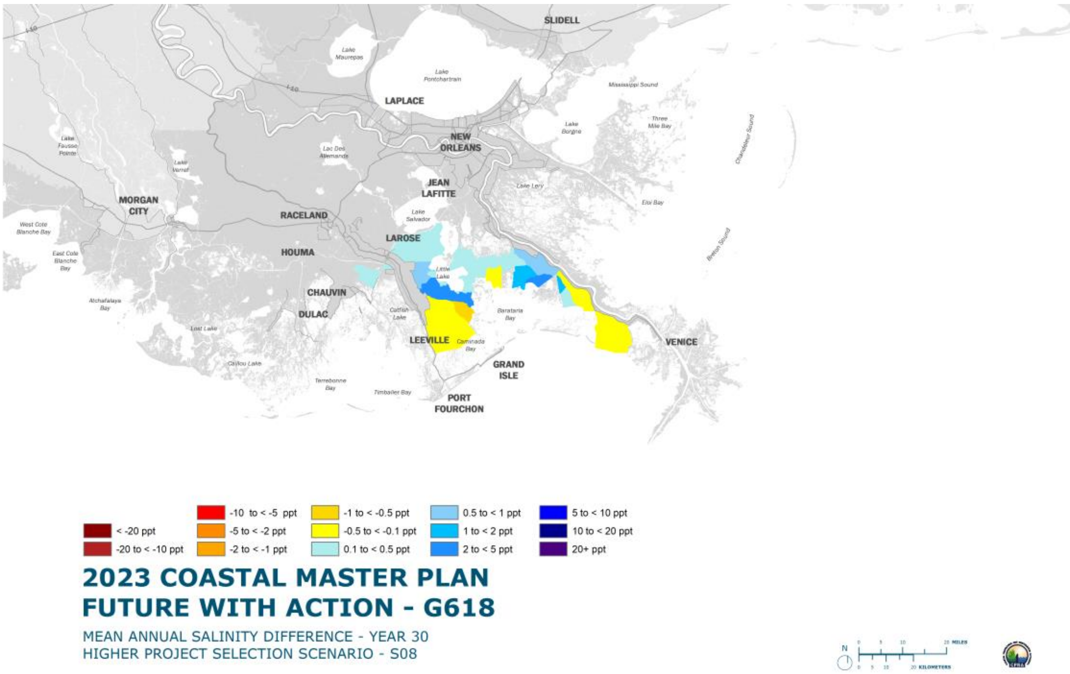


Figure 62. Difference map of mean annual salinity between FWOA (G500) and FWA (G618) at Year 30 of the higher scenario (S08), indicating reduced salinities north and increased salinities south of the landbridge. Similar results are found for other years and for the lower scenario (S07).

The most pronounced salinity differences are found in the area north of the western part of the landbridge, where the project reduces salinity between 2-4 ppt in the early years after construction for both scenarios (S07 and S08), up to a reduction of 8 ppt (S07) and 15 ppt (S08) in the last decade (Figure 61). The extending impact over time can mostly be explained by increasing salinity in FWOA, with annual mean salinity increasing significantly for both scenarios after Year 25, in contrast to FWA which barely increases over time. On the contrary, when comparing FWA to FWOA, the increase of annual mean salinity is much smaller in the area south of the west part of the landbridge, being limited to 1 ppt for both scenarios (S07 and S08) and staying constant over time (Figure 62).

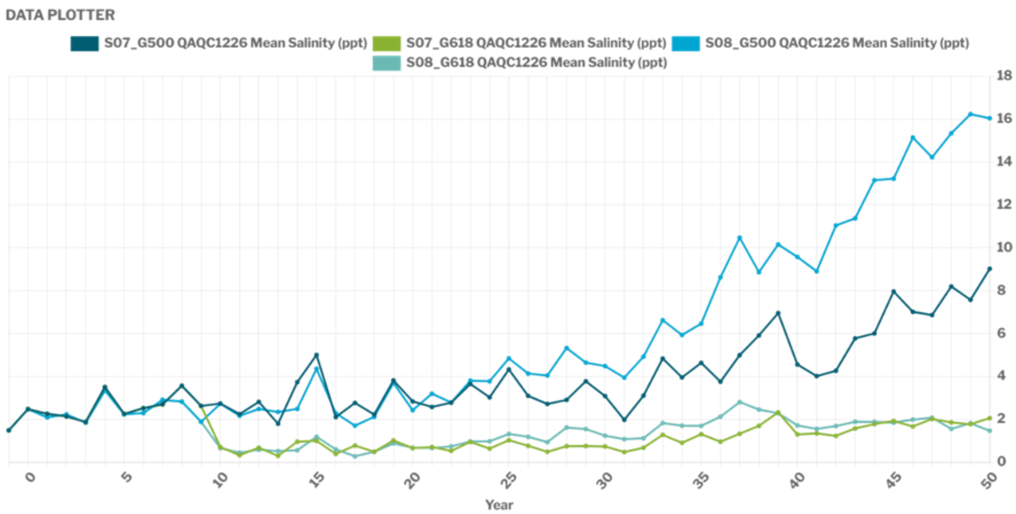


Figure 63. Annual mean salinity comparison between FWOA (G500) and FWA (G618) for lower (S07) and higher (S08) scenarios in compartment 213 located north of the western section of the landbridge, showing a salinity reduction up to 15 ppt due to the landbridge project after construction is finished in Year 9.

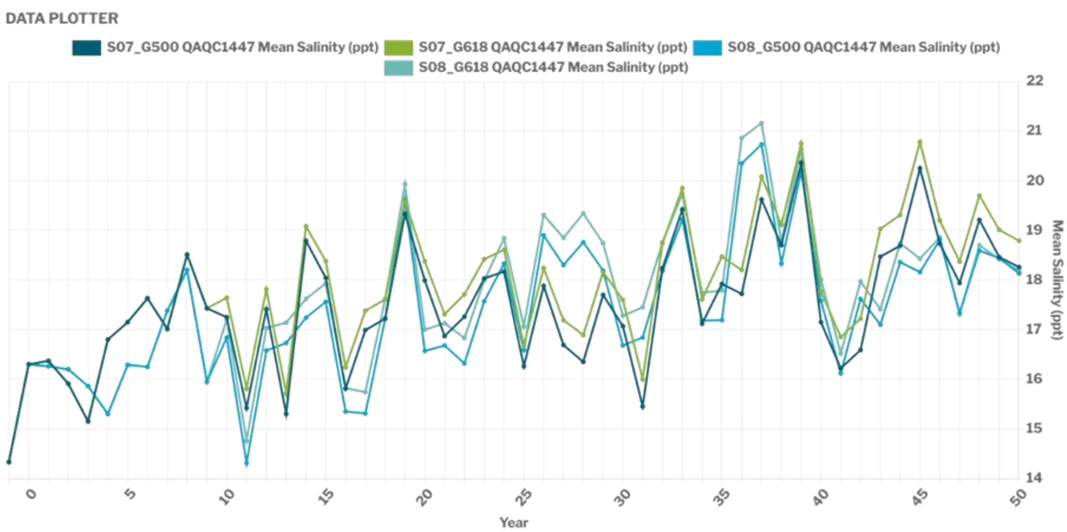


Figure 64. Annual mean salinity comparison between FWOA (G500) and FWA (G618) for lower (S07) and higher (S08) scenarios in compartment 222 located south of the western section of the landbridge, showing a salinity increase up to 1 ppt due to the landbridge project after construction is finished in Year 9.

Less pronounced salinity differences are found near the eastern part of the landbridge, in part because this area is typically fresher than the previously discussed western part. At QAQC1350 (Figure 53), just north of the landbridge, the project reduces salinity less than 1 ppt for the lower scenario and less than 2 ppt for the higher scenario (Figure 63), with relatively smaller reductions in early years compared to later years, because FWOA salinity increases at a higher rate than FWA. Small to negligible impacts are found south of this part of the landbridge, with differences in mean salinity remaining limited to 0.5 ppt for both scenarios throughout the entire 50-year simulation period (Figure 64).

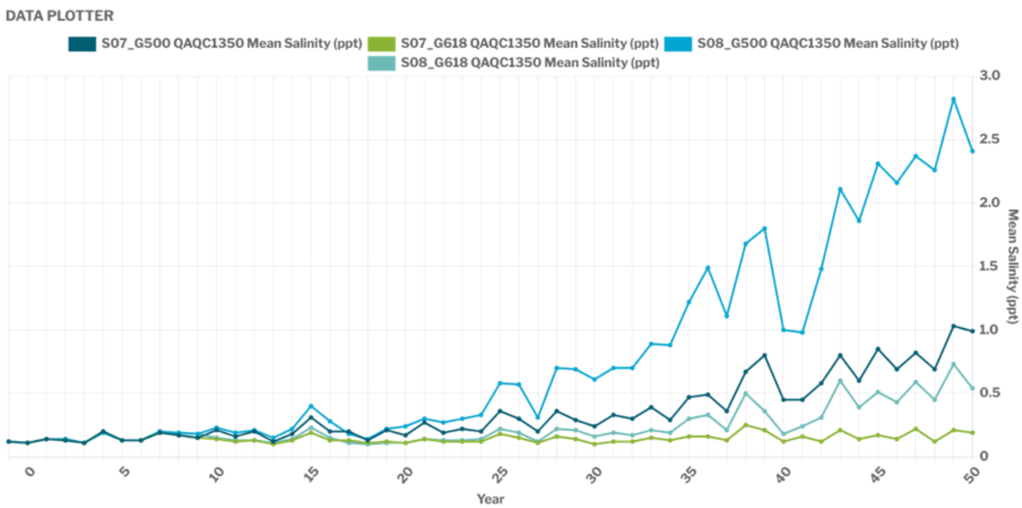


Figure 65. Annual mean salinity comparison between FWOA (G500) and FWA (G618) for lower (S07) and higher (S08) scenarios in compartment 228 located north of the eastern section of the landbridge, showing a salinity reduction up to 2 ppt due to the landbridge project after construction is finished in Year 9.

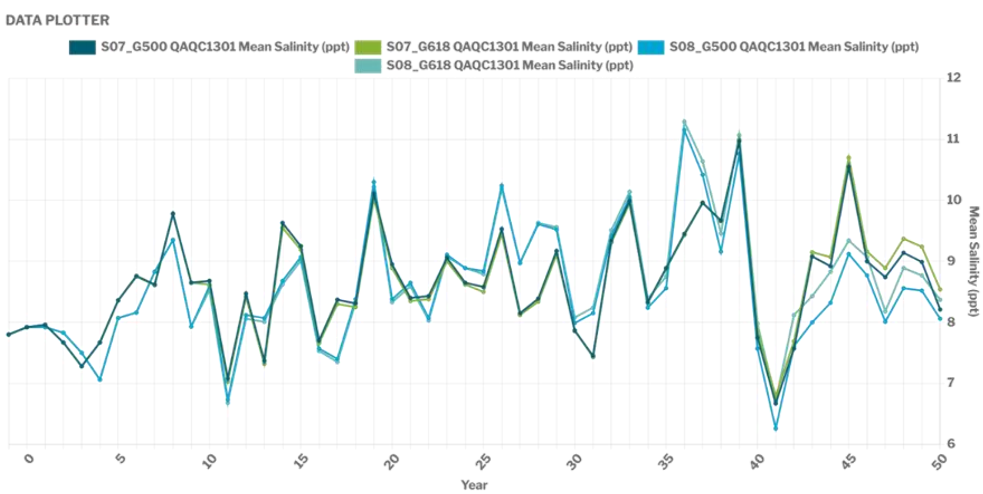


Figure 66. Annual mean salinity comparison between FWOA (G500) and FWA (G618) for lower (S07) and higher (S08) scenarios in compartment 247 located south of the eastern section of the landbridge, showing negligible or no differences between FWOA and FWA the first decades after construction (Year 9-30), and a slight increase of salinity (up to 1 ppt) due to the landbridge after Year 30.

These salinity differences are mostly found in compartments directly adjacent to the landbridge, and only start to expand in area in the last decade of the simulation.

EFFECTS OF WEST AND EAST COMPONENTS

When only implementing the western part (325b) or eastern part (325c) of the project, model results show that local impacts on water levels are consistent with the entire project (325a), for both lower or higher scenarios as shown in Figure 65 for 325b compared to 325a, and Figure 67 for 325c compared to 325a. The same findings apply to salinity as shown in Figure 66 (325a and 325b) and Figure 68 (325a and 325c).

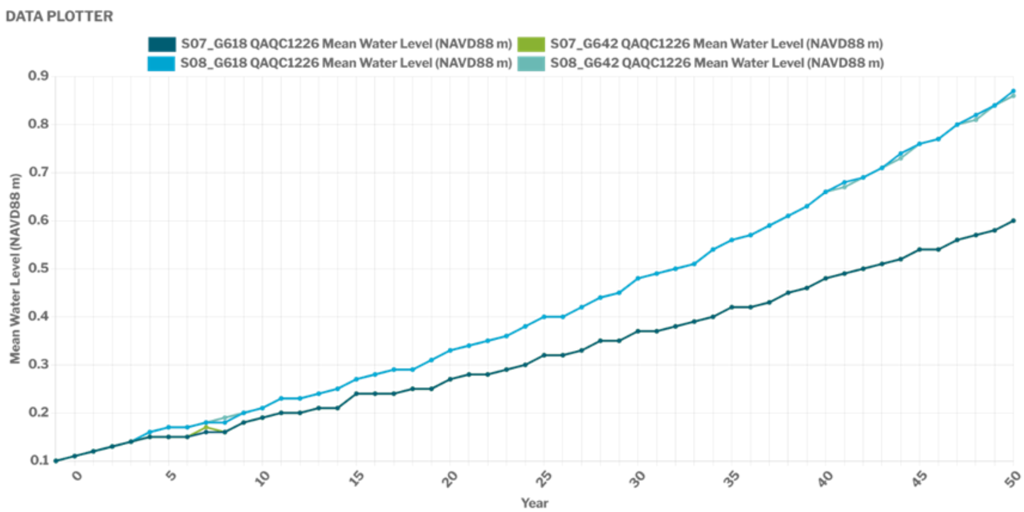


Figure 67. Annual mean water level comparison between projects 325a (G618) and 325b (G642) for lower (S07) and higher (S08) scenarios in compartment 213 located north of the western section of the landbridge (location indicated in Figure 55), showing negligible or no local differences in water level between the complete Lower Barataria Landbridge (325a, G618) and the west part only (325b, G642).

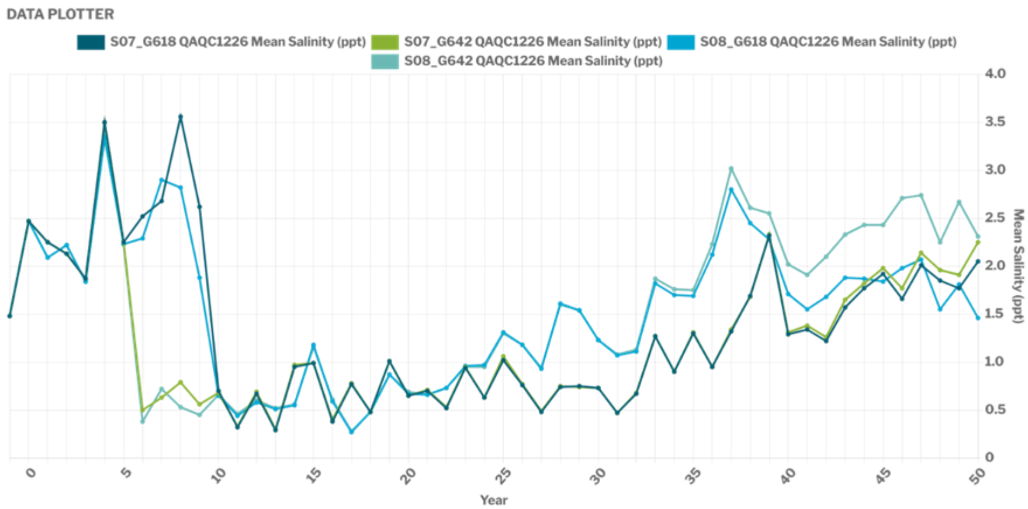


Figure 68. Annual mean salinity comparison between projects 325a (G618) and 325b (G642) for lower (S07) and higher (S08) scenarios in compartment 213 located north of the western section of the landbridge (location indicated in Figure 55), showing negligible local differences in salinity between the complete Lower Barataria Landbridge (325a, G618) and the west part only (325b, G642).

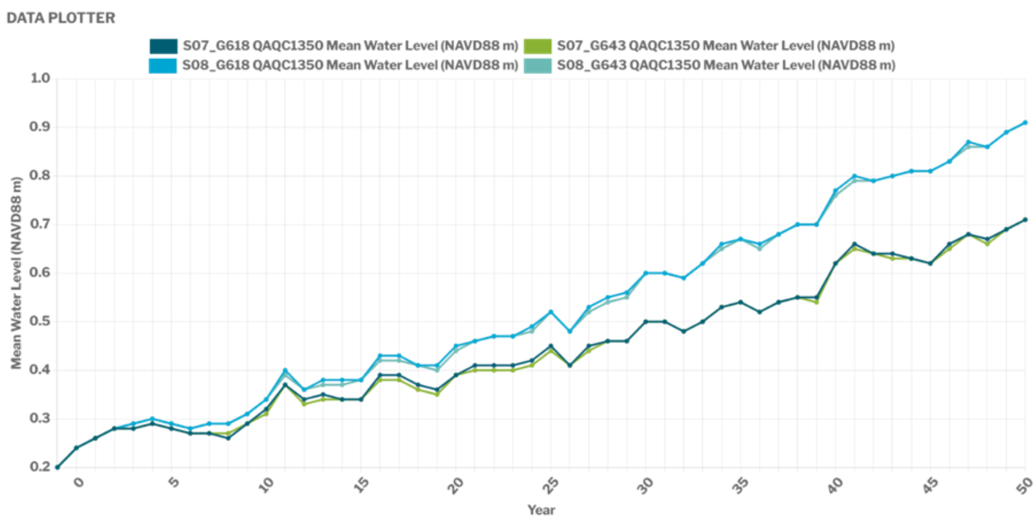


Figure 69. Annual mean water level comparison between projects 325a (G618) and 325c (G643) for lower (S07) and higher (S08) scenarios in compartment 228 located north of the eastern section of the landbridge (location indicated in Figure 55), showing negligible or no local differences in water level between the complete Lower Barataria Landbridge (325a, G618) and the east part only (325c, G643).

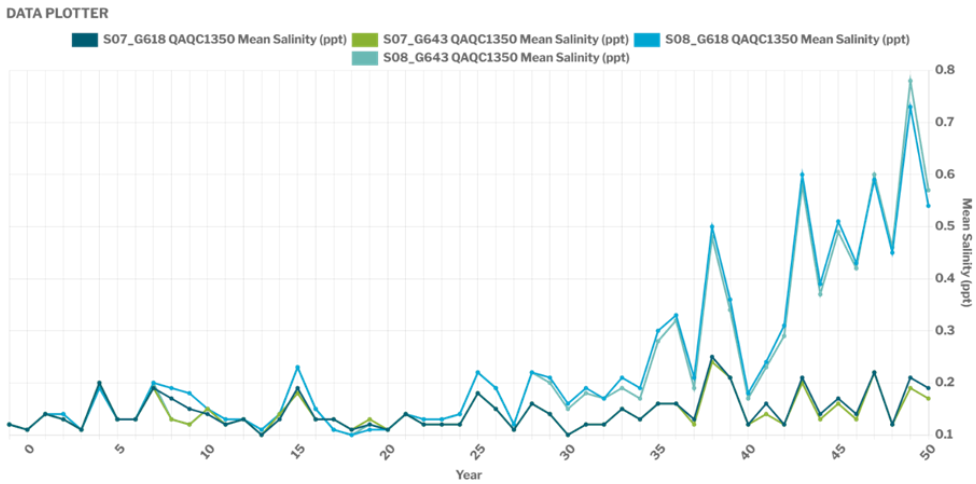


Figure 70. Annual mean salinity comparison between projects 325a (G618) and 325c (G643) for lower (S07) and higher (S08) scenarios in compartment 228 located north of the eastern section of the landbridge (location indicated in Figure 55), showing negligible or no local differences in salinity between the complete Lower Barataria Landbridge (325a, G618) and the east part only (325c, G643).

MORPHOLOGY

The net effect of the project on the landscape varies by scenario (Table 4). AAL benefits are greater under the higher scenario for all three versions of the project, likely due to their effect in maintaining land which is lost in FWOA. However, each of the component projects, west and east, has much lower net land at Year 50 under the higher scenario than the lower scenario.

Table 6. Net effect of the Lower Barataria Landbridge project, and the west and east components, (FWA-FWOA) by scenario in terms of AAL and net land at Year 50

	Average Annual Net Land (km^2)		Net Land at Year 50 (km^2)	
Scenario	Lower	Higher	Lower	Higher
Lower Barataria Landbridge	23.4	36.6	46.5	48.7
Lower Barataria Landbridge - West	10.9	17.6	23.0	4.4
Lower Barataria	10.2	14.0	19.5	3.8

Landbridge - East				

Examination of the benefits streams over time shows the reason for this difference between performance under AAL and net land at Year 50. Under the lower scenario, there is a progressive increase in the net effect of the project, and the components, on land area over the 50 years (Figure 69). However, under the higher scenario, while the magnitude of benefits is greater for several decades there is a dramatic decrease after ~ year 45.

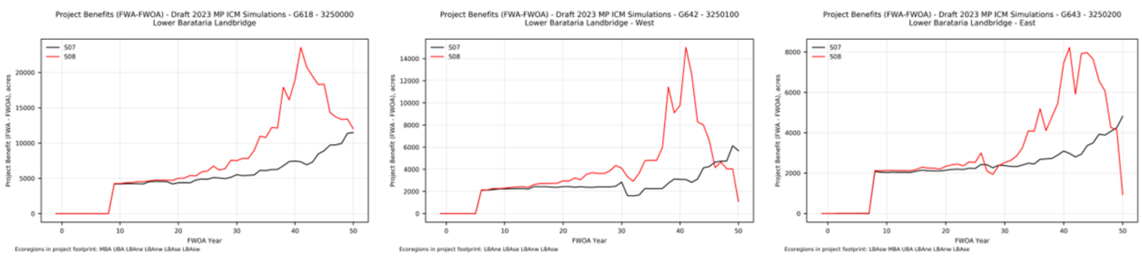


Figure 71. Net land (FWA-FWOA) over time for the Lower Barataria Landbridge project (left), and the west (center) and east (right) components (note the change in the vertical axis).

The net benefits shown in Figure 69 sum the difference between FWA and FWOA for each year across all ecoregions affected by the projects. This includes areas of induced land loss as well as areas of relative land gain. Note that relative loss or gain in any individual year could represent a delay or an acceleration in some aspect of landscape dynamics, rather than a fundamental shift. The differences in AAL by ecoregion for each scenario are summarized in Figure 70. For both scenarios, most of the benefits for the complete landbridge project are in Lower Barataria Northeast (LBAne) and LBAnw - the ecoregions that include the landbridge footprints. Under the higher scenario, changes extend into the upper parts of the basin, the Upper Barataria (UBA) and Mid Barataria (MBA) ecoregions, although the effects in those areas are mostly negative. Figure 70 also shows the differences between the components and the complete landbridge. The west component has benefits in LBAnw as might be expected but results in greater loss than FWOA in LBAne, Lower Barataria Southeast (LBAse), and LBAsw under both scenarios. In contrast, for the east component, while most of the benefit is in LBAne, there are also benefits in LBAnw and in LBAse.

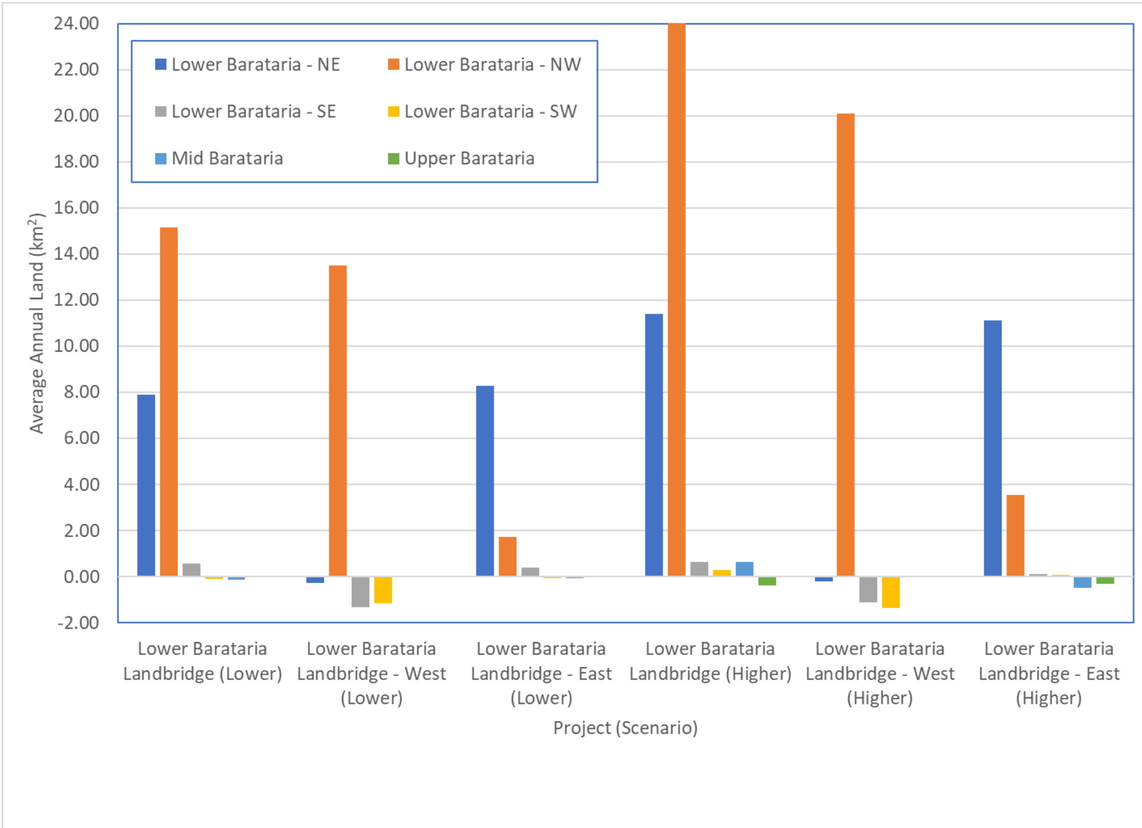


Figure 72. Effects of the Lower Barataria Landbridge project, and the west and east components, by ecoregion for the lower and higher scenarios.

The effects on land area within the project footprint are illustrated in compartment 213, on the western side of the basin southwest of Little Lake. Figure 71 shows the change in land area in the compartment for FWA and FWOA for the complete landbridge project. The increase in land area associated with construction is clear at Year 10 in the simulation as open water areas are filled. As areas of marsh within the footprint are also increased in elevation during construction, the benefit provided by that increase in elevation occurs later in the simulation, as land that would otherwise be lost is made higher and can better endure future effects of SLR and subsidence. For the lower scenario (Figure 71 upper panel), this effect begins in the third decade of the simulation, and the lines for FWA and FWOA begin to diverge. For this scenario at Year 50, just over 20 km^2 of land remain at Year 50 under FWOA compared to over 43 km^2 with the project. Much more rapid land loss under FWOA in the higher scenario (Figure 71 lower panel) shows that very little land remains in the compartment by the last five years of the simulation, whereas almost 20 km^2 remain with the project.

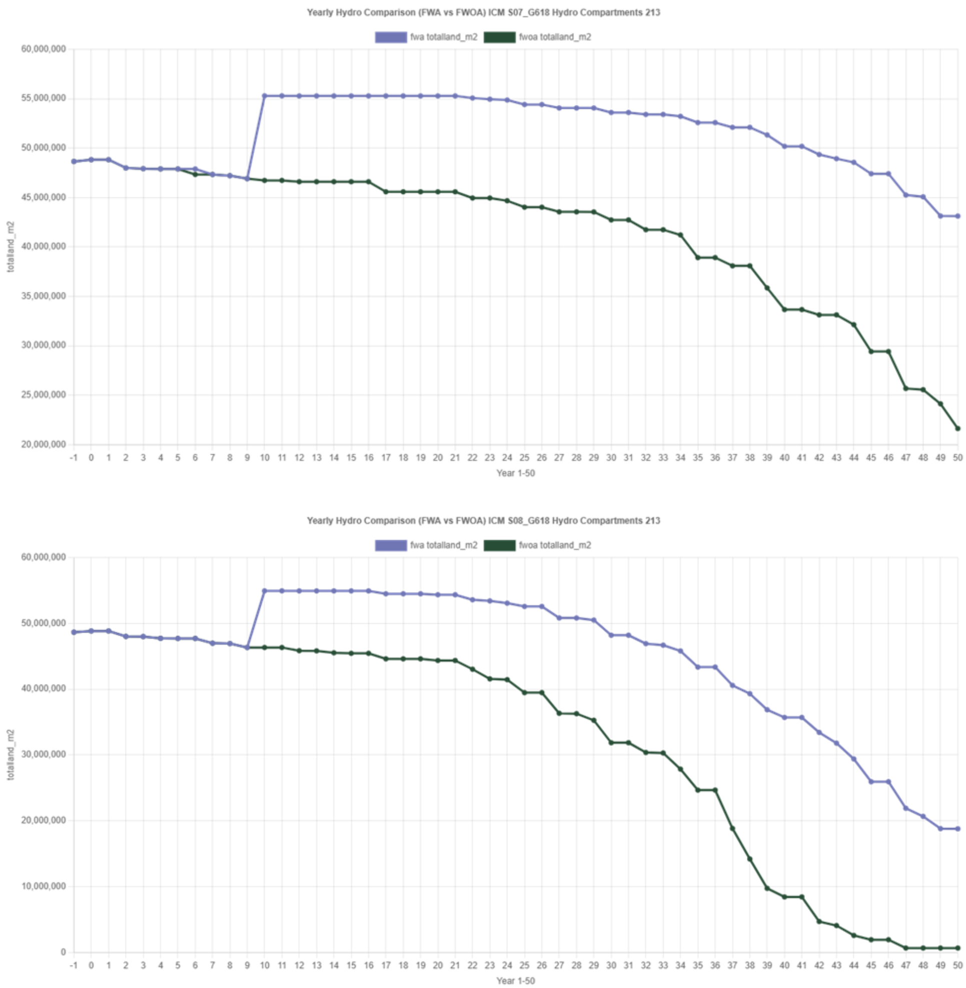


Figure 73. Difference in land area between FWA and FWOA for compartment 213 for the Lower Barataria Landbridge project (lower scenario - upper panel, higher scenario - lower panel).

These differences are due to the effect of infilling and elevating marshes within the footprint but also to the effect of the project on salinity in the basin. MBSD provides freshwater to the basin up-estuary of the landbridge. The project results in a decrease in salinity in compartment 213 and other up-estuary areas (Figure 72), and the landbridge limits the penetration of saline water up-estuary and retains the freshwater from the diversion. The greatest effects are in the compartments immediately up-estuary of the landbridge.

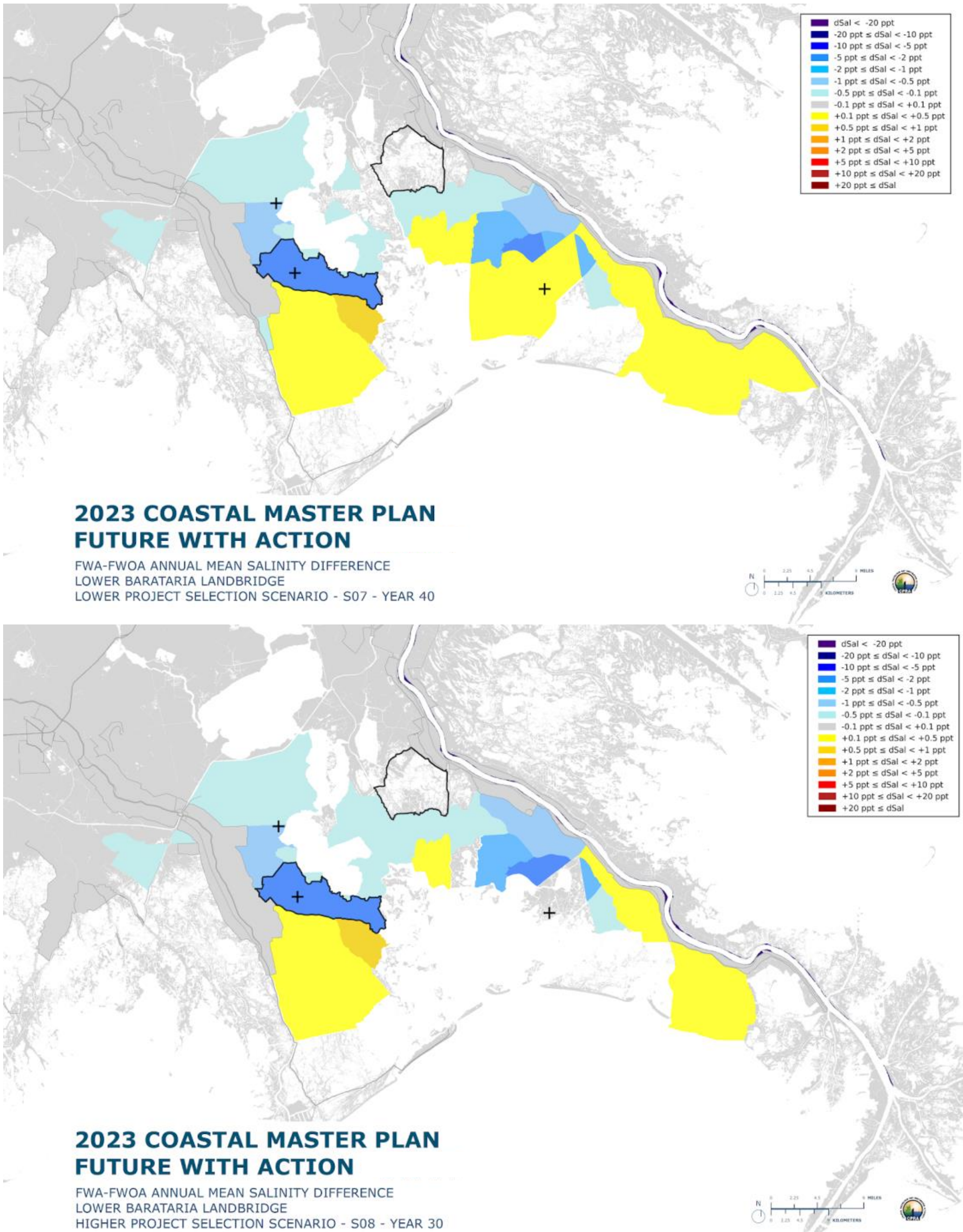


Figure 74. Differences in mean annual salinity (FWOA-FWA) by compartment for the Lower Barataria Landbridge project. Upper panel: Lower scenario for Year 40. Lower panel: Higher scenario for Year 30.

A decrease in salinity impacts land loss in two ways. At lower salinities, herbaceous marshes are more tolerant of inundation (see Figure 3 in Baustian et al., 2020). At QAQC1226 in compartment 213, the landbridge reduces salinity slightly when it comes online at Year 10 and maintains salinities at around 2 ppt for the entire simulation for both the lower and higher scenarios (Figure 73). Without the project, salinities increase after Year 30 reaching 9 ppt in the lower scenario and 16 ppt in the higher scenario at Year 50. For the higher scenario, a decrease in salinity from 16 ppt to 2 ppt would increase inundation tolerance by approximately 5 cm. Further, salinity also influences vegetation cover and thus organic matter accretion, and a change from 16 ppt to 2 ppt means an increase of over 1 mm/yr.

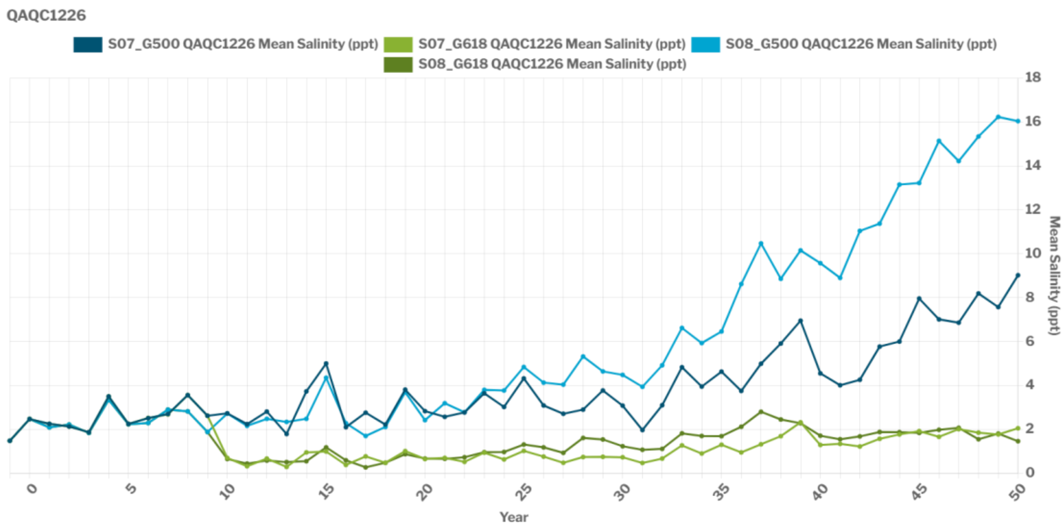


Figure 75. Salinity over time at QAQC1226 for FWA and FWOA for higher and lower scenarios for the Lower Barataria Landbridge project.

The net effect of the landbridge at Year 50 is shown in Figure 74 for both scenarios. Indirect effects of the project on maintaining land up-estuary of the landbridge can be seen for the lower scenario, especially on the western side of the basin. As indicated on Figure 74, there is less effect immediately up-estuary of the landbridge in the higher scenario by Year 50 as extensive loss occurs in both FWOA and FWA. Of particular note is a decrease in land near MBSD (compartment 226) and the maintenance of flotant west of Lake Salvador (compartment 159).

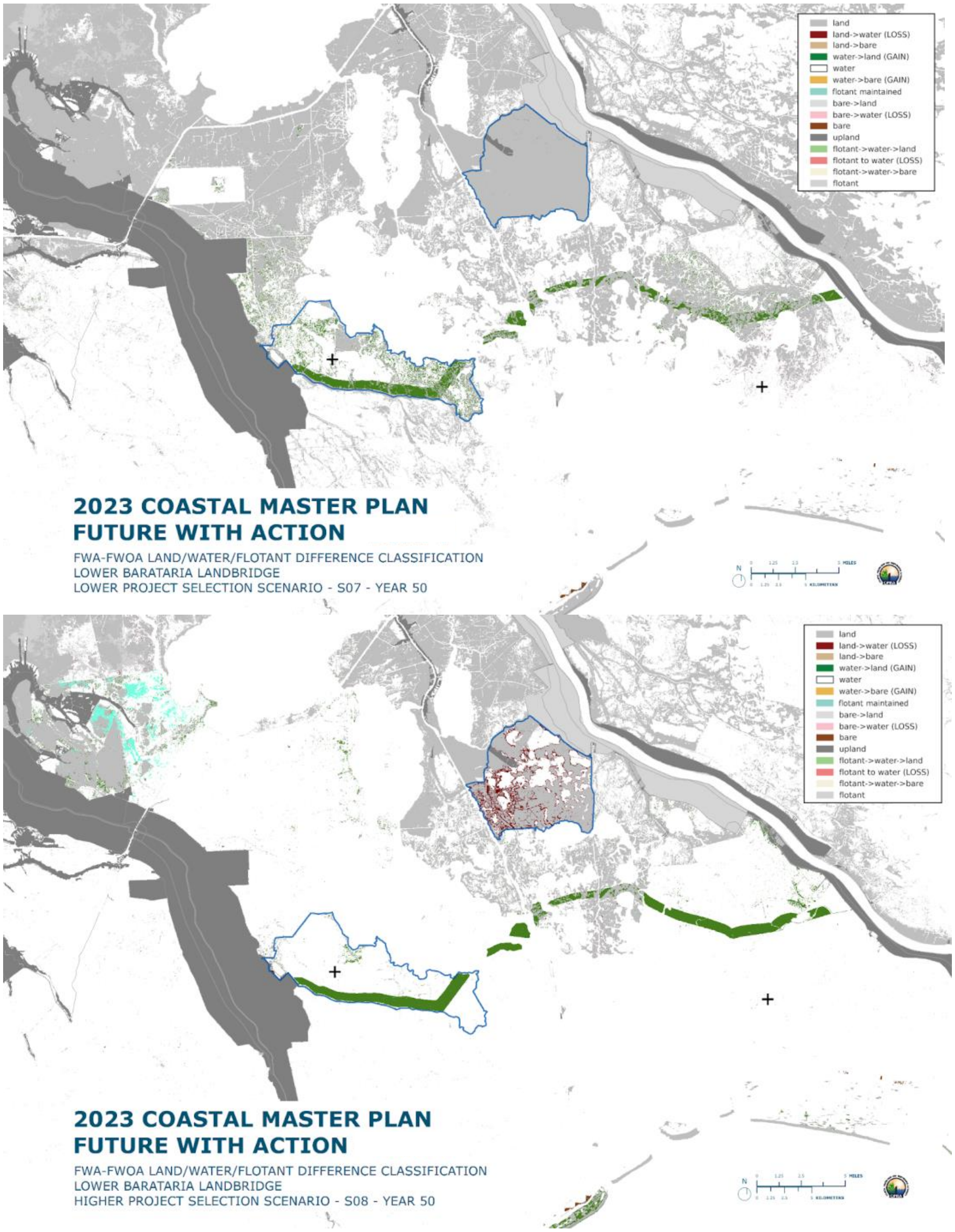


Figure 76. Differences in land-water (FWA-FWOA) at Year 50 for the lower scenario (upper panel) and the higher scenario (lower panel) for the Lower Barataria Landbridge project.

The dynamics near MBSD are related to small changes in water level due to the project in the higher scenario. Over time, as the basin opens up even though land is being maintained behind the landbridge, there is a very slight increase (~ 5 cm on the annual mean stage) in interior water levels between the diversion outfall and the eastern portion of the landbridge. This results in a slight difference in the transition from water to land near MBSD due to the diversion. Some of the lowest elevations of FWOA land are considered too deep under FWA to become land (which shows as a relative 'loss' of land under FWA). This also impacts the open water area that is available for mineral deposition, so there is a decrease in deposition at some locations in compartment 226 since there is a larger footprint for the essentially unchanged mineral load to settle out onto. The maintenance of flotant west of Lake Salvador is related to the effects of the landbridge on salinity in the upper basin and differences in salinity across the scenarios. Under the lower scenario, the maximum 2-week salinity exceeds 5.5 ppt in Year 7 for both FWOA and FWA which results in loss of flotant (Figure 75). The salinity does not exceed the threshold in the higher scenario due to differences in precipitation across the scenarios, and the flotant is maintained in the early decades of the simulation. However, in Year 47 the 5.5 ppt threshold is exceeded under FWOA in the higher scenario (Figure 75), but the landbridge project reduces the salinity and the threshold is not exceeded leading to a 'relative gain' of flotant in the area (Figure 74).

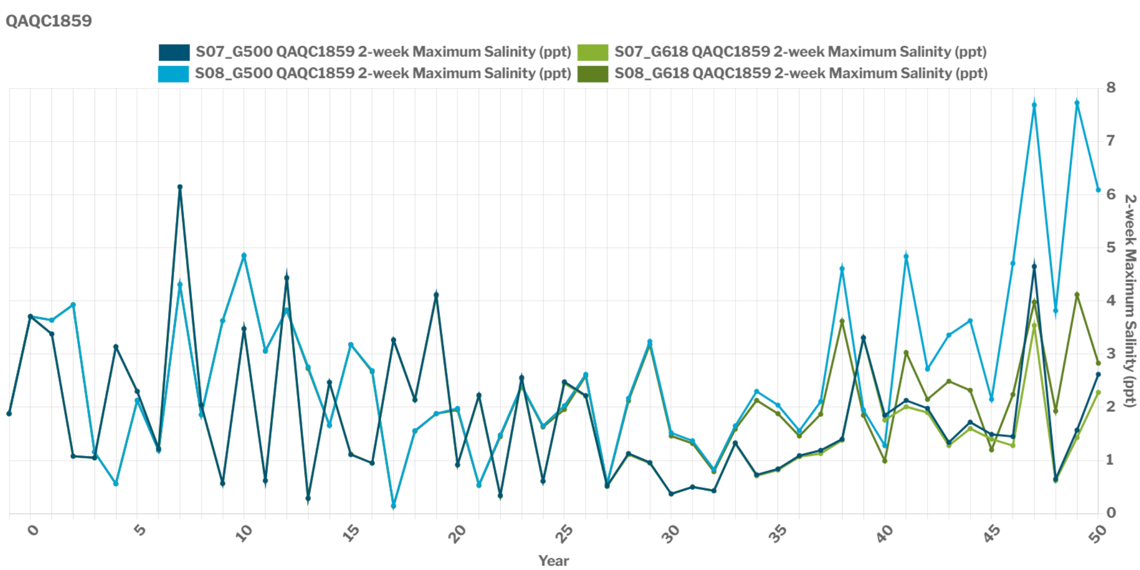


Figure 77. Salinity over time at QAQC1859 with and without the Lower Barataria Landbridge project for the higher and lower scenarios.

Figure 76 compares the Year 50 outcomes for the entire landbridge and the east and west components. The reduction on land loss on the western side of the basin is similar for the entire landbridge and if only the western component is built. If only the eastern section of the landbridge is built, the indirect benefit up-estuary is retained, but beneficial effects in the west are diminished.

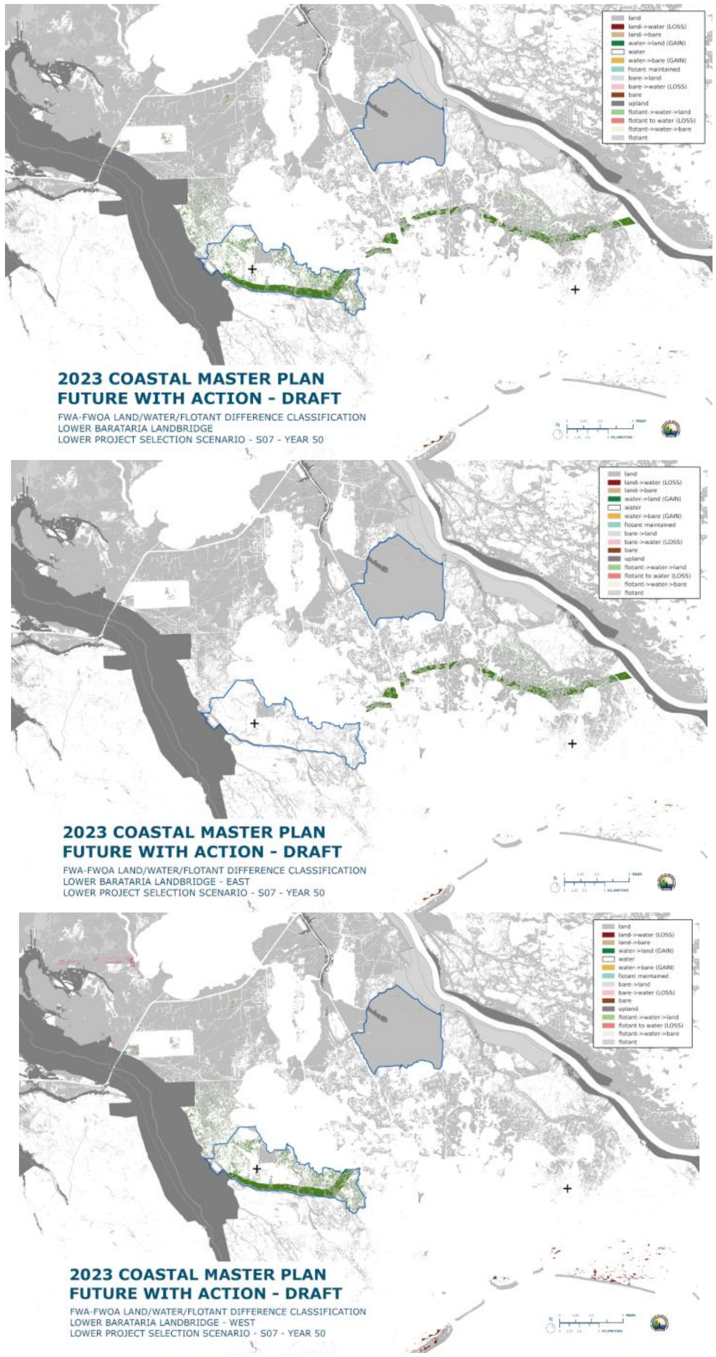


Figure 78. Difference maps (FWA-FWOA) for Year 50 for the lower scenario. Upper panel: Lower Barataria Landbridge. Center panel: Lower Barataria Landbridge - East. Lower panel: Lower Barataria Landbridge - West.

VEGETATION

RESULTS

In LBAnw ecoregion, the full implementation of the Lower Barataria Landbridge leads to a reduction in the extent of brackish marshes (Figure 77). With only the eastern part implemented, there is little effect on vegetation cover in the LBAnw ecoregion (Figure 77). Implementing only the western part of the landbridge has a similar effect on species composition to that observed with the full landbridge (Figure 77).

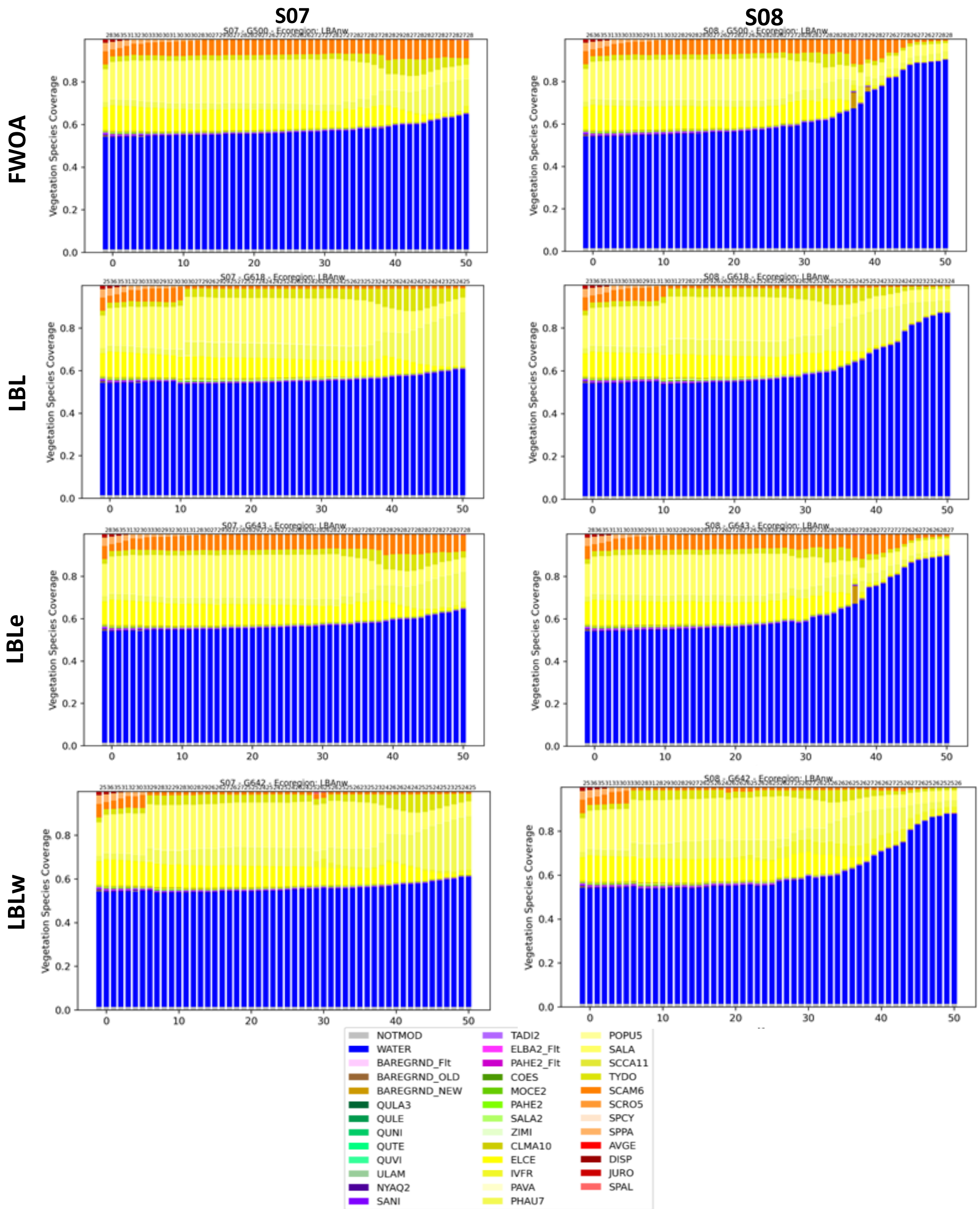


Figure 77. Change in species composition for the LBAnw ecoregion under two scenarios for FWOA, Lower Barataria Landbridge, Lower Barataria Landbridge - East, and Lower Barataria Landbridge - West.

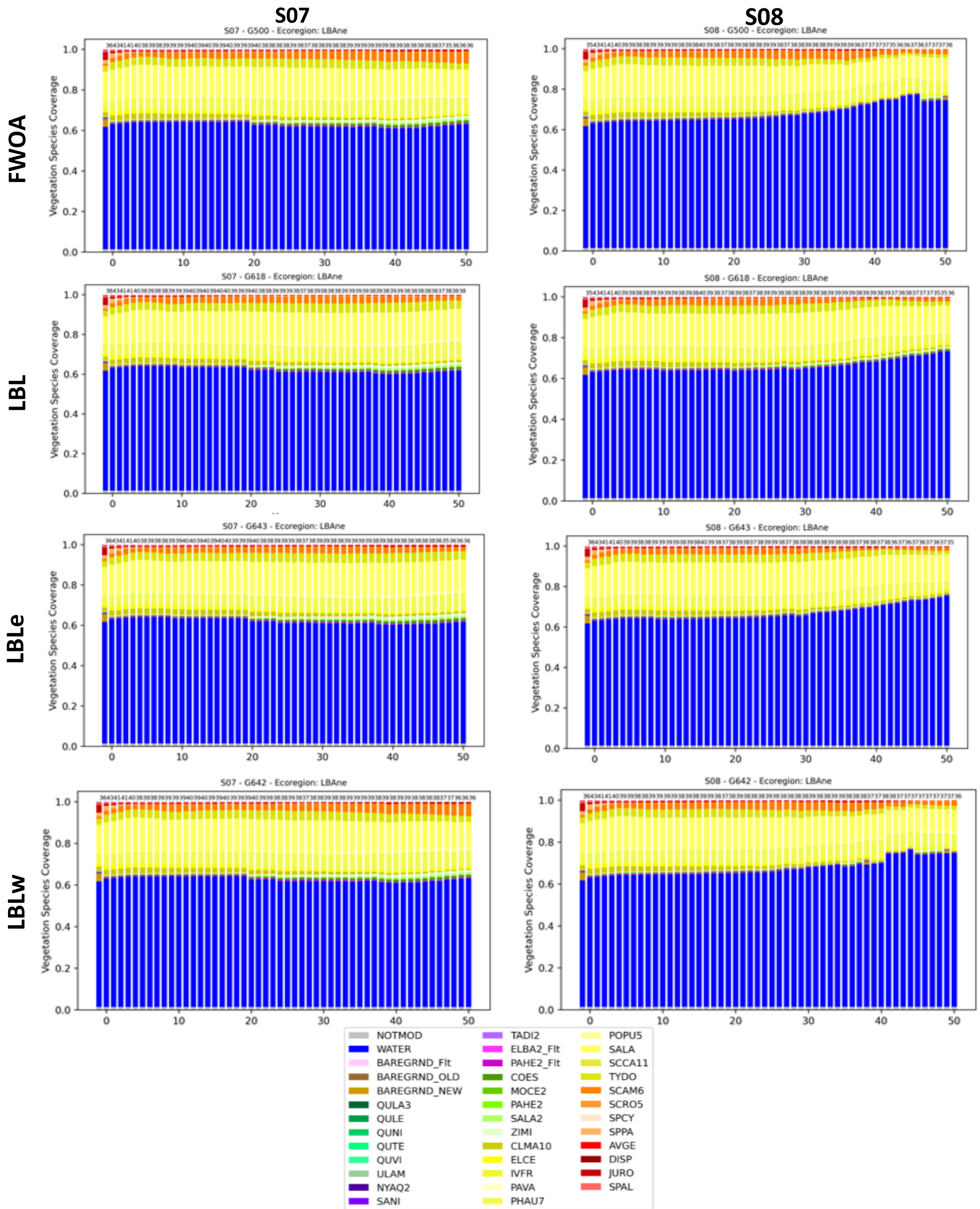


Figure 78. Change in species composition for the LBAne ecoregion under two scenarios for FWOA, Lower Barataria Landbridge, Lower Barataria Landbridge - East, and Lower Barataria Landbridge - West.

In LBAne ecoregion, there is a very small reduction of brackish marsh species with all versions of the Lower Barataria Landbridge project (Figure 78).

HABITAT SUITABILITY

The Lower Barataria Landbridge project had effects on the suitability of habitats for fish, shellfish, and wildlife during both scenarios. The most evident effect of the projects was related to reductions in salinity in areas north of the project. This caused increases in the habitat suitability for lower salinity species, particularly in the last decade (Figure 79 and Figure 80).

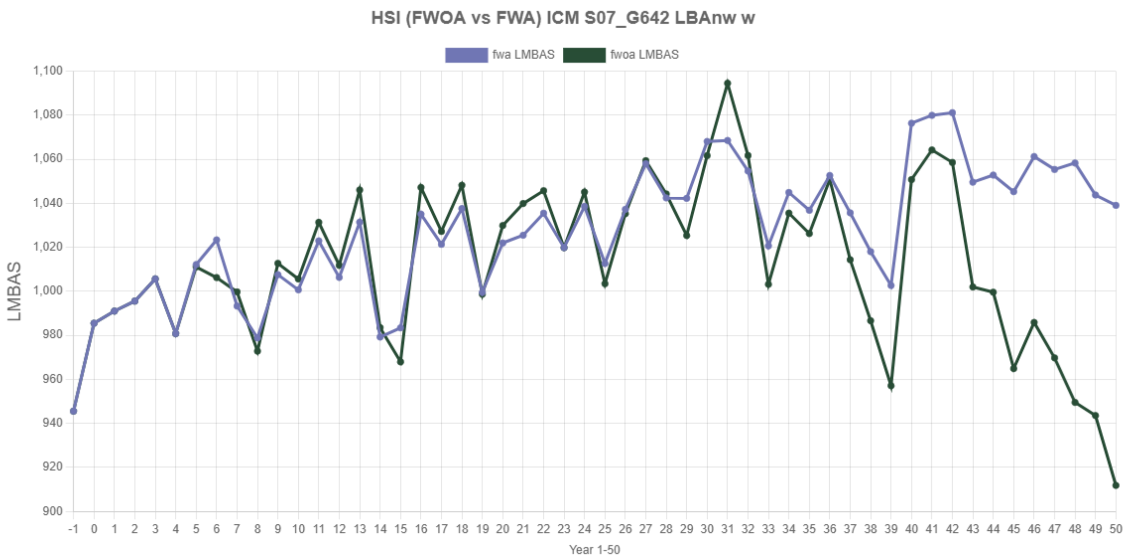


Figure 79. Total HSI score for largemouth bass in the LBAnw ecoregion for the 50-year FWOA and Lower Barataria Landbridge (FWA) S07 environmental scenario simulations. The total HSI score was calculated by summing the individual scores for each ICM model cell within the ecoregion.

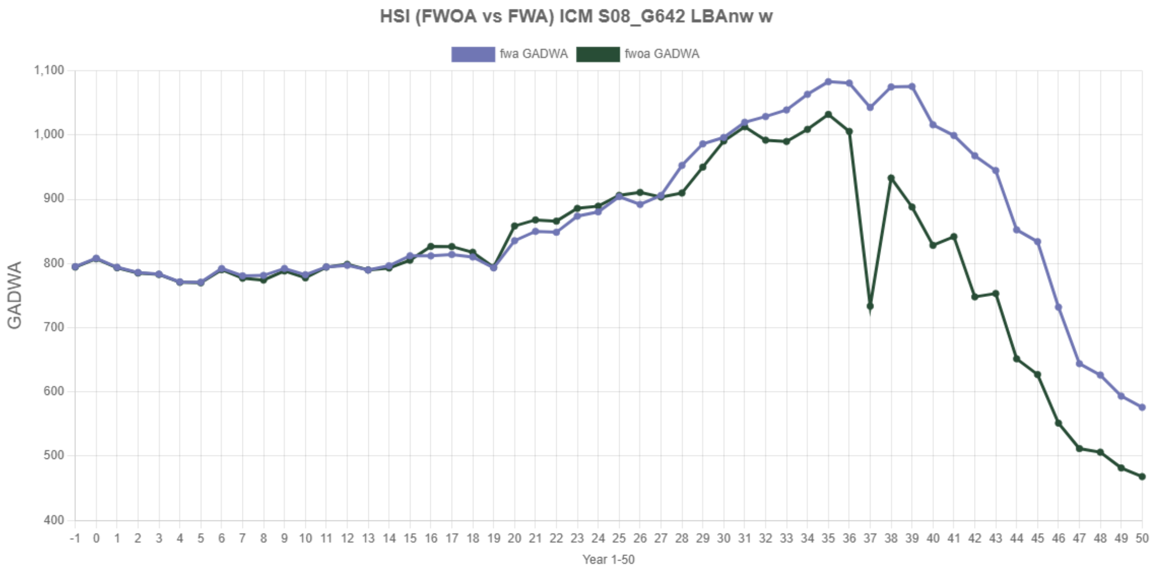


Figure 80. Total HSI score for gadwall in the LBAnw ecoregion for the 50-year FWOA and Lower Barataria Landbridge (FWA) S08 environmental scenario simulations. The total HSI score was calculated by summing the individual scores for each ICM model cell within the ecoregion.

The effects of the Lower Barataria Landbridge project due to changes in land area were less noticeable but still present. The infilling of fragmented marshes in lower Barataria caused a clear decrease in suitability for species reliant on shallow open water (e.g., juvenile blue crab; Figure 81). However, in the last decade of the simulation, the habitat suitability increased relative to FWOA (Figure 81) due to land loss within the project area in the later years.

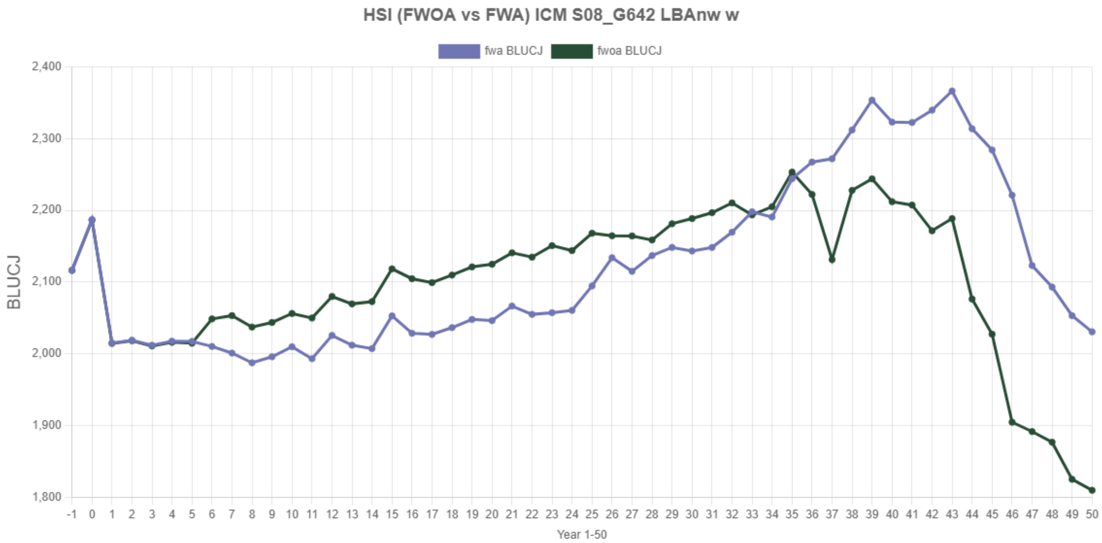


Figure 81. Total HSI score for juvenile blue crab in the LBAnw ecoregion for the 50-year FWOA and Lower Barataria Landbridge (FWA) higher environmental scenario simulations. The total HSI score was calculated by summing the individual scores for each ICM model cell within the ecoregion.

HYDROLOGY

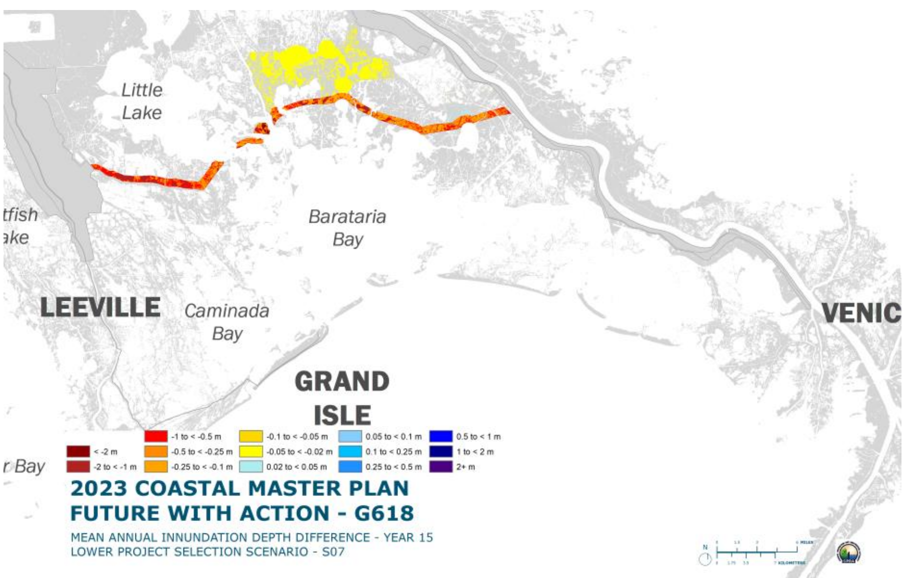


Figure 82. Difference map of mean annual inundation depth between FWOA (G500) and FWA (G618) at Year 15 of the lower scenario (S07), indicating no significant changes in inundation depths outside of the project footprint. Similar results are found in later years and for the higher scenario (S08).

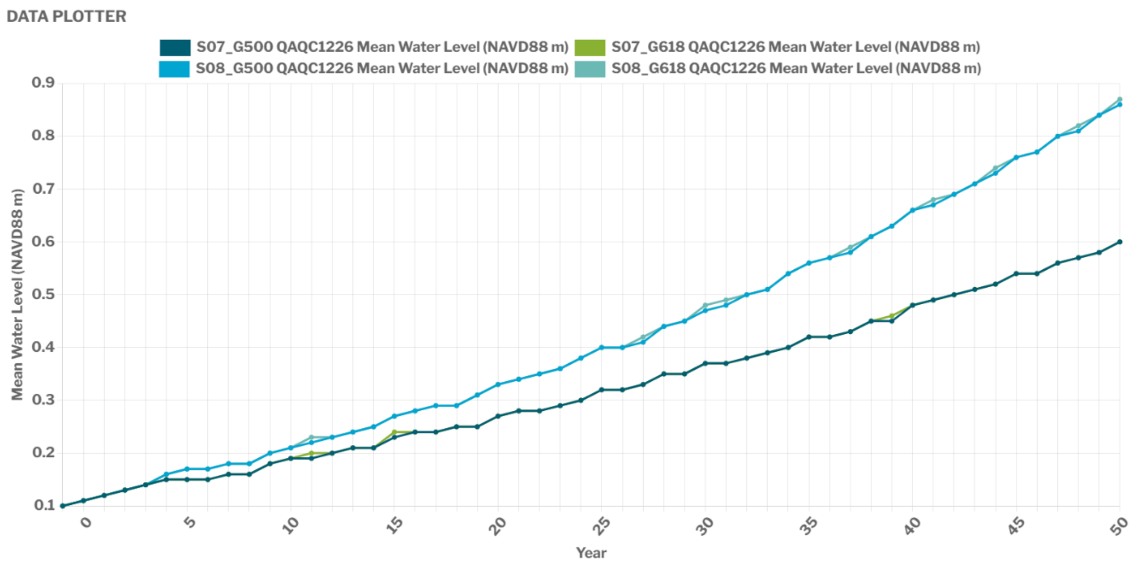


Figure 83. Annual mean water level timeseries comparison between FWOA (G500) and FWA (G618) for lower (S07) and higher (S08) scenarios in compartment 213 located north of the western section of the landbridge (location indicated in Figure 55), showing negligible to no increase of mean water levels due to the landbridge.

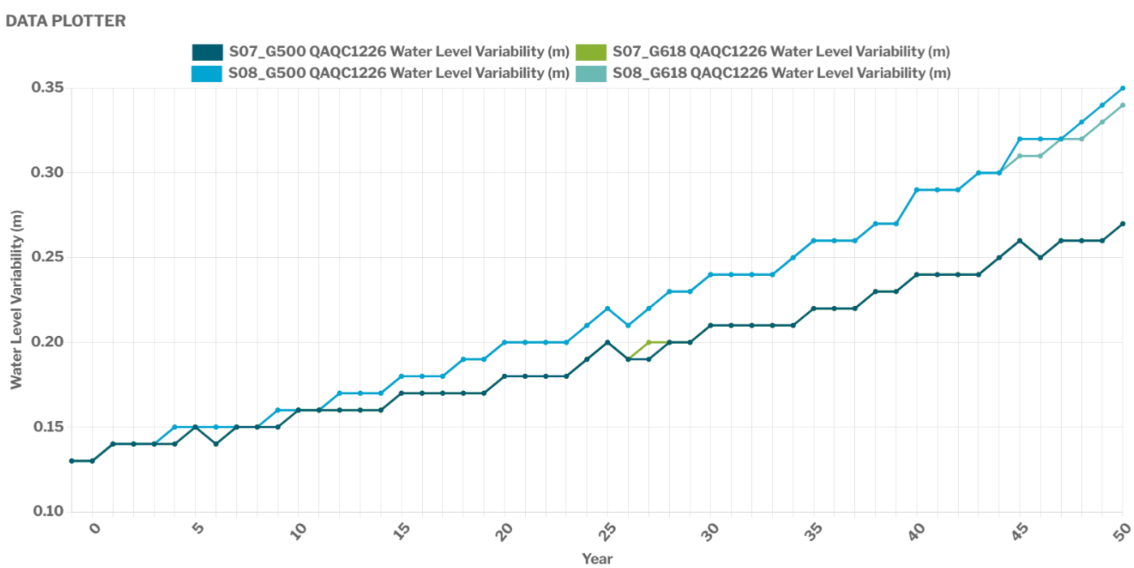


Figure 84. Annual water level variability timeseries comparison between FWOA (G500) and FWA (G618) for lower (S07) and higher (S08) scenarios in compartment 213 located north of the western section of the landbridge (location indicated in Figure 55), showing negligible to no impacts on water level variability.

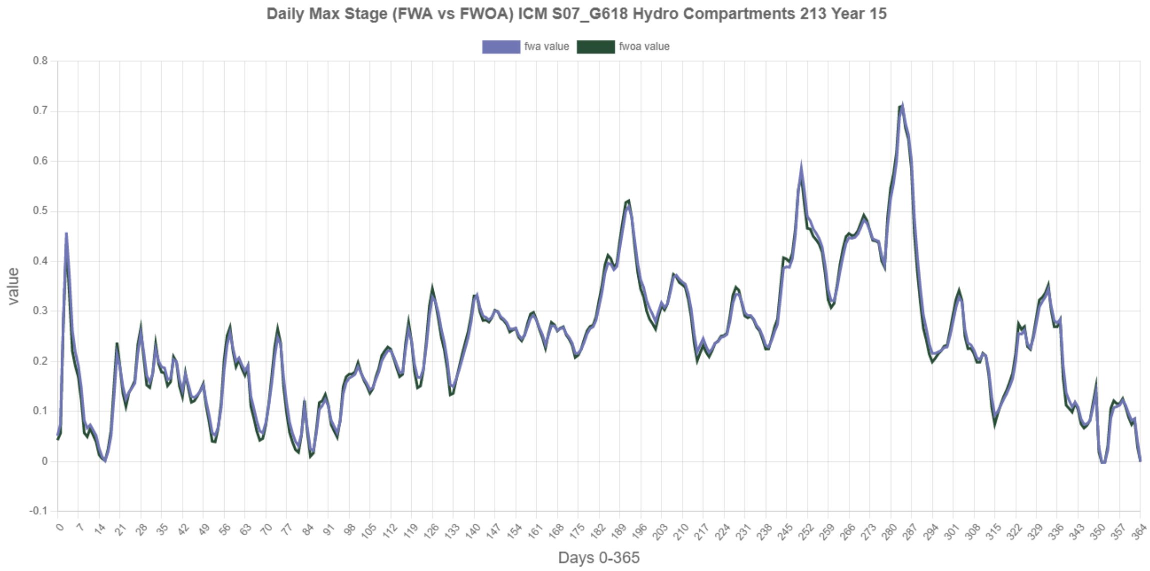


Figure 85. Daily max stage timeseries comparison between FWOA (G500) and FWA (G618) for Year 15 in compartment 213 located north of the western section of the landbridge (location indicated in Figure 55), showing a slight decrease of variability (i.e., peak attenuation) of daily max stages due to the project.

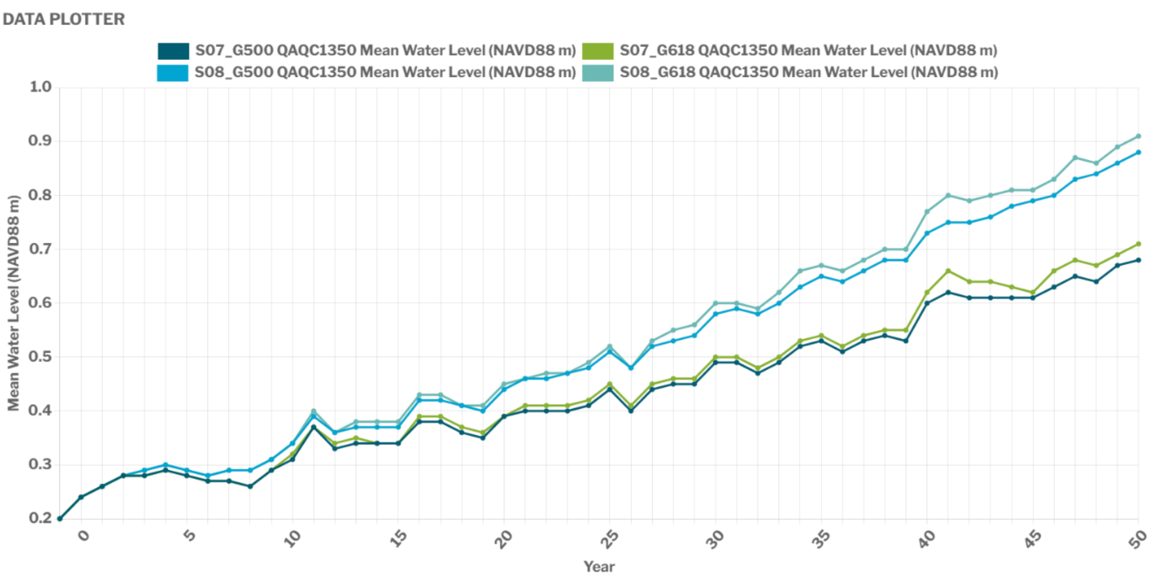


Figure 86. Annual mean water level timeseries comparison between FWOA (G500) and FWA (G618) for lower (S07) and higher (S08) scenarios in compartment 228 located north of the eastern section of the landbridge (location indicated in Figure 55), showing a slight increase of mean water levels for both scenarios due to the landbridge.

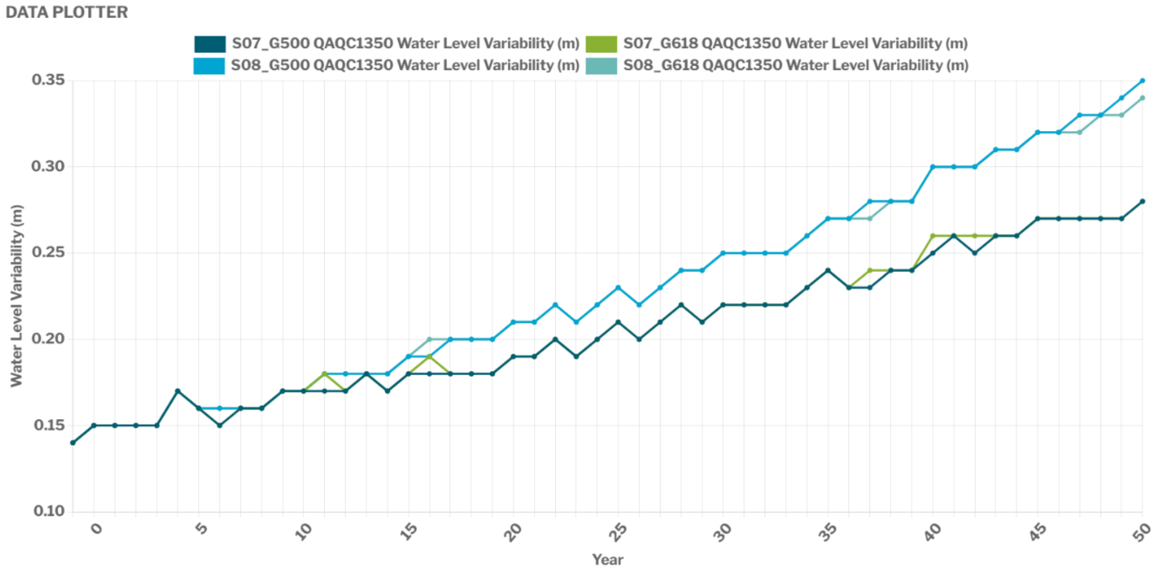


Figure 87. Annual water level variability timeseries comparison between FWOA (G500) and FWA (G618) for lower (S07) and higher (S08) scenarios in compartment 228 located north of the eastern section of the landbridge (location indicated in Figure 55), showing negligible to no project impacts on water level variability.

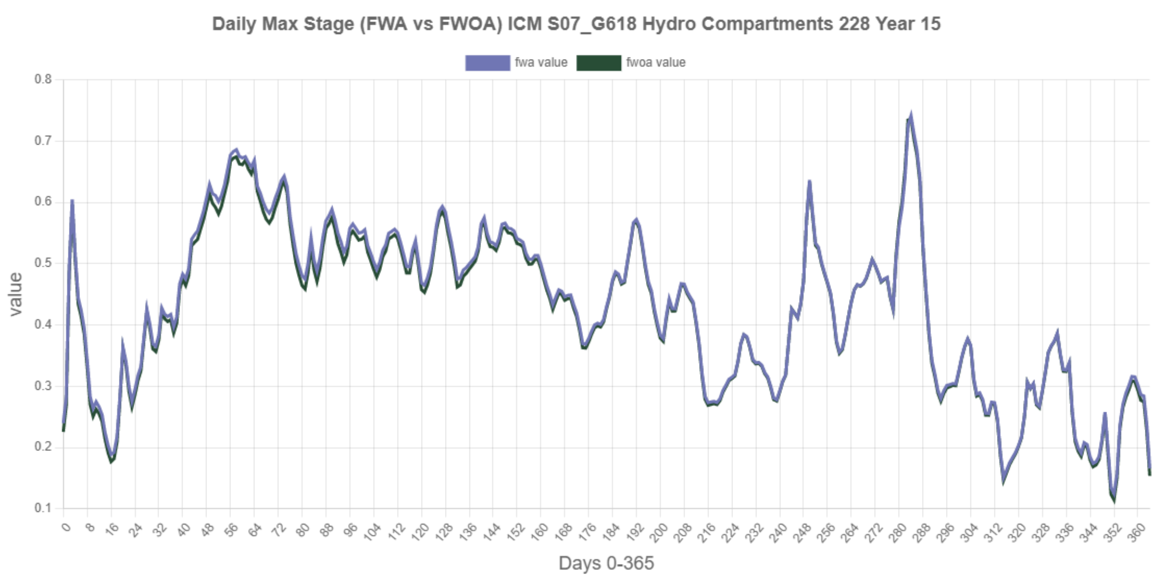


Figure 88. Daily max stage timeseries comparison between FWOA (G500) and FWA (G618) for Year 15 in compartment 228 located north of the eastern section of the landbridge (location indicated in Figure 55), showing a slight increase of daily max stages during the high flow period of MBSD operation.

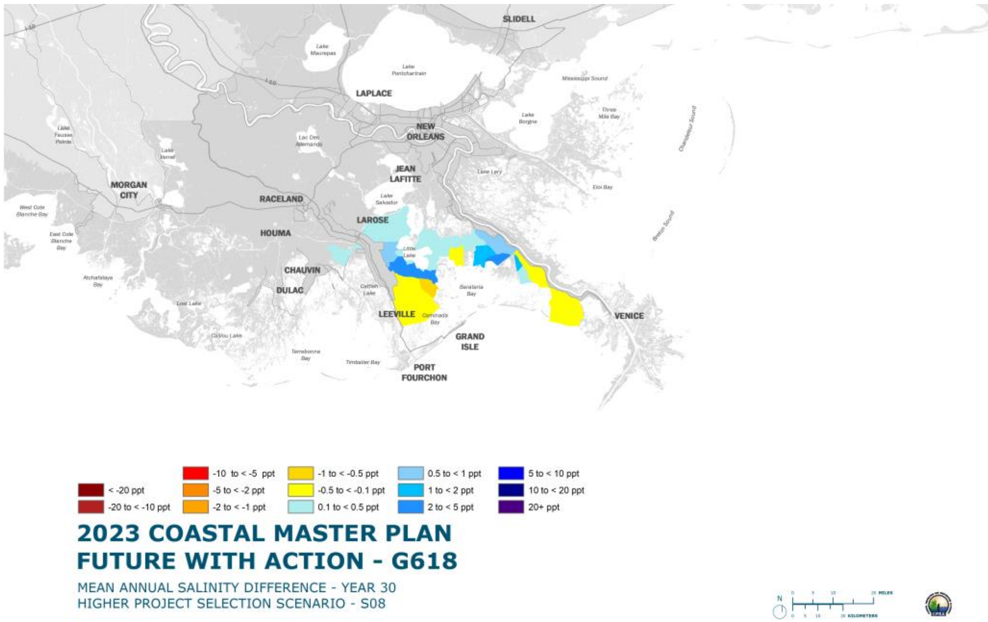


Figure 89. Difference map of mean annual salinity between FWOA (G500) and FWA (G618) at Year 30 of the higher scenario (S08), indicating reduced salinities north and increased salinities south of the landbridge. Similar results are found for other years and for other years and for the lower scenario (S07).

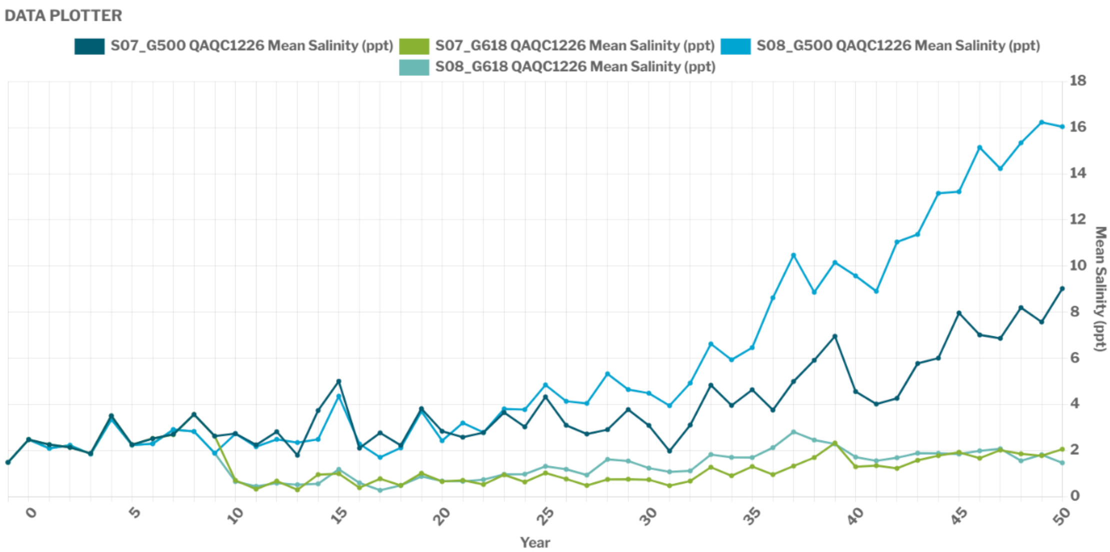


Figure 90. Annual mean salinity timeseries comparison between FWOA (G500) and FWA (G618) for lower (S07) and higher (S08) scenarios in compartment 213 located north of the western section of the landbridge, showing a salinity reduction up to 15 ppt due to the landbridge project after construction is finished in Year 9.

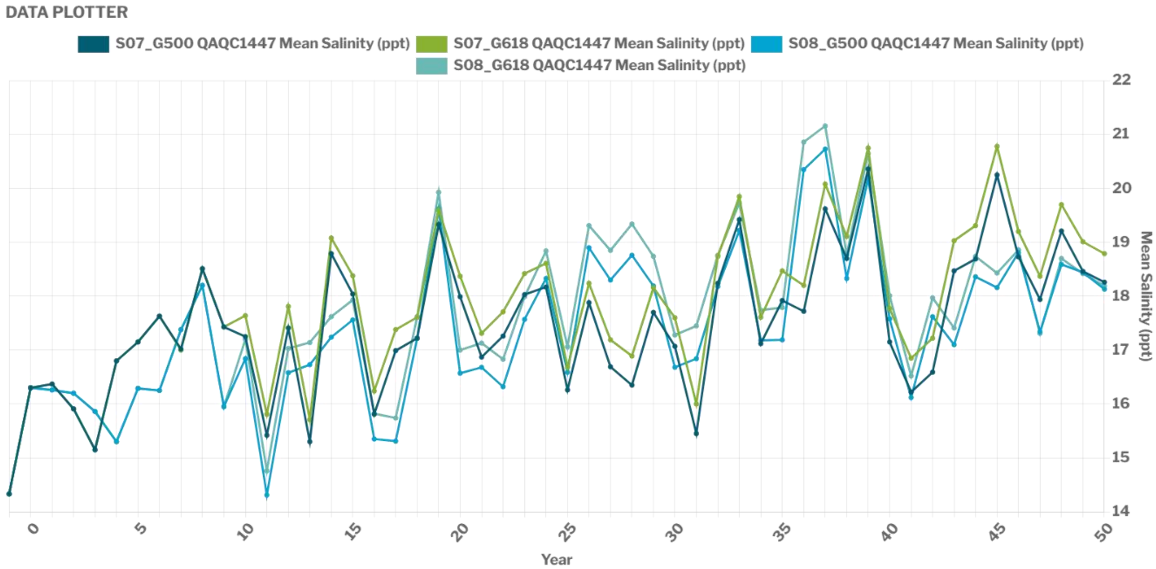


Figure 91. Annual mean salinity timeseries comparison between FWOA (G500) and FWA (G618) for lower (S07) and higher (S08) scenarios in compartment 222 located south of the western section of the landbridge, showing a salinity increase up to 1 ppt due to the landbridge project after construction is finished in Year 9.

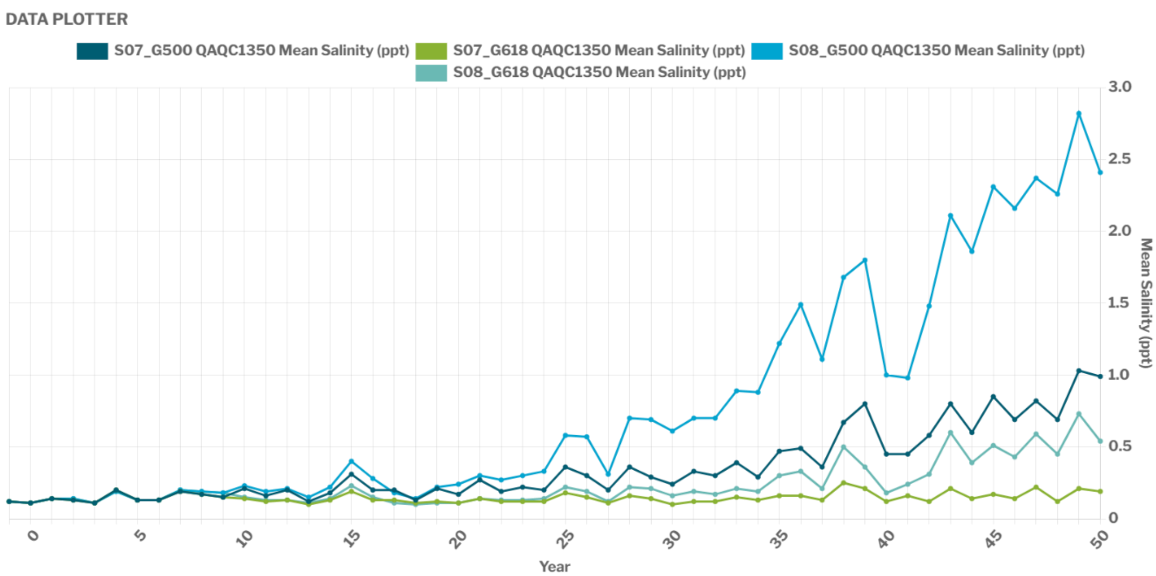


Figure 92. Annual mean salinity timeseries comparison between FWOA (G500) and FWA (G618) for lower (S07) and higher (S08) scenarios in compartment 228 located north of the eastern section of the landbridge, showing a salinity reduction up to 2 ppt due to the landbridge project after construction is finished in Year 9.

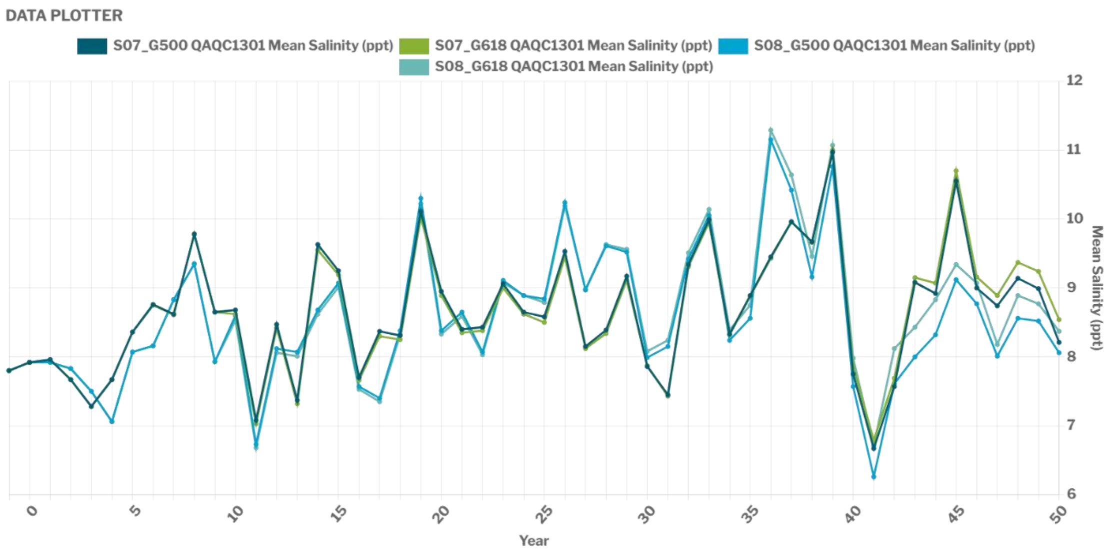


Figure 93. Annual mean salinity timeseries comparison between FWOA (G500) and FWA (G618) for lower (S07) and higher (S08) scenarios in compartment 247 located south of the eastern section of the landbridge, showing negligible or no differences between FWOA and FWA the first decades after construction (Year 9-30), and a slight increase of salinity (up to 1 ppt) due to the landbridge after Year 30.

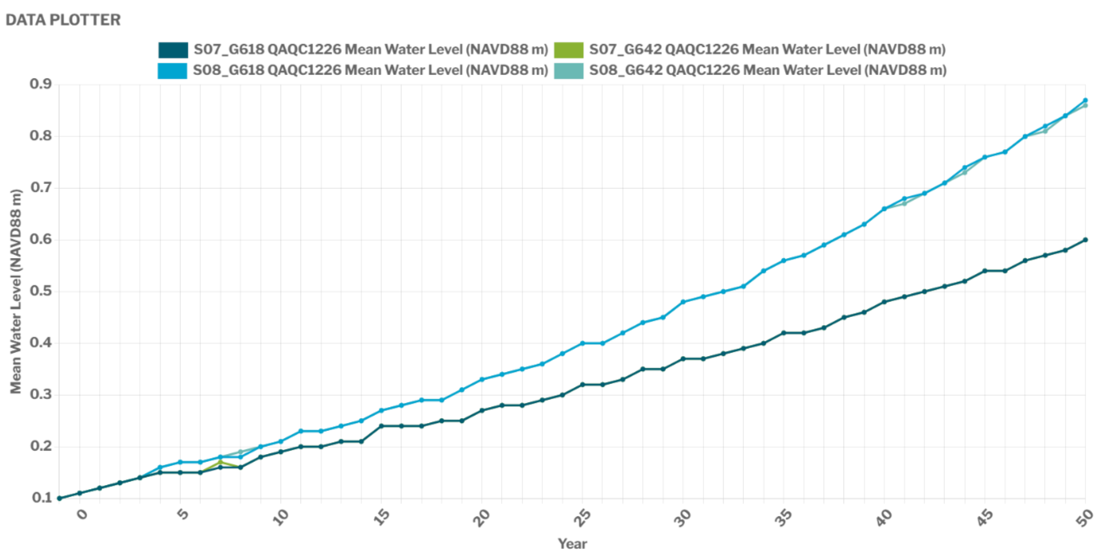


Figure 94. Annual mean water level timeseries comparison between projects 325a (G618) and 325b (G642) for lower (S07) and higher (S08) scenarios in compartment 213 located north of the western section of the landbridge (location indicated in Figure 55), showing negligible or no local differences in water level between the complete Lower Barataria Landbridge (325a, G618) and the west part only (325b, G642).

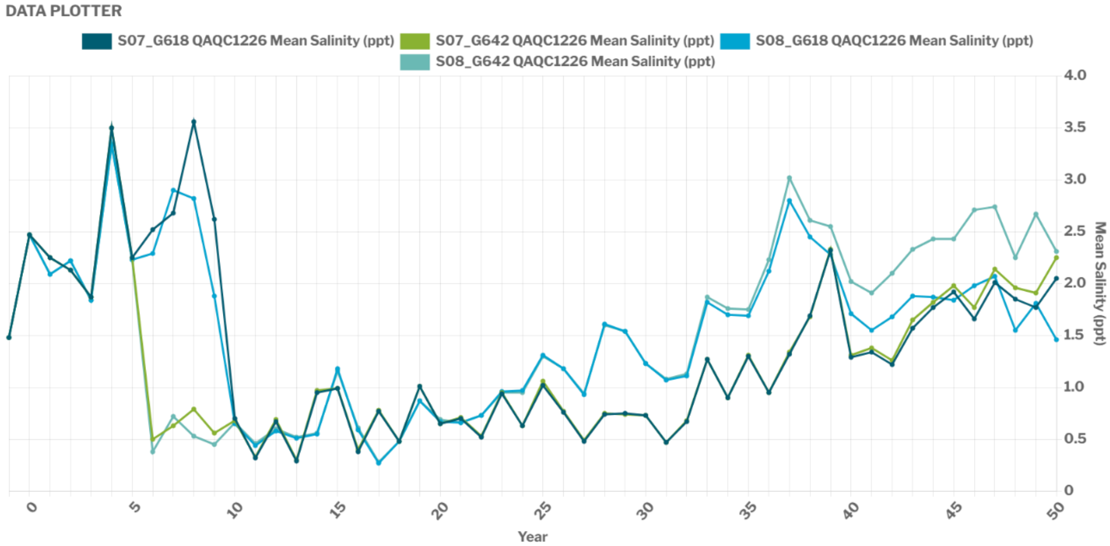


Figure 95. Annual mean salinity timeseries comparison between projects 325a (G618) and 325b (G642) for lower (S07) and higher (S08) scenarios in compartment 213 located north of the western section of the landbridge (location indicated in Figure 55), showing negligible local differences in salinity between the complete Lower Barataria Landbridge (325a, G618) and the west part only (325b, G642).

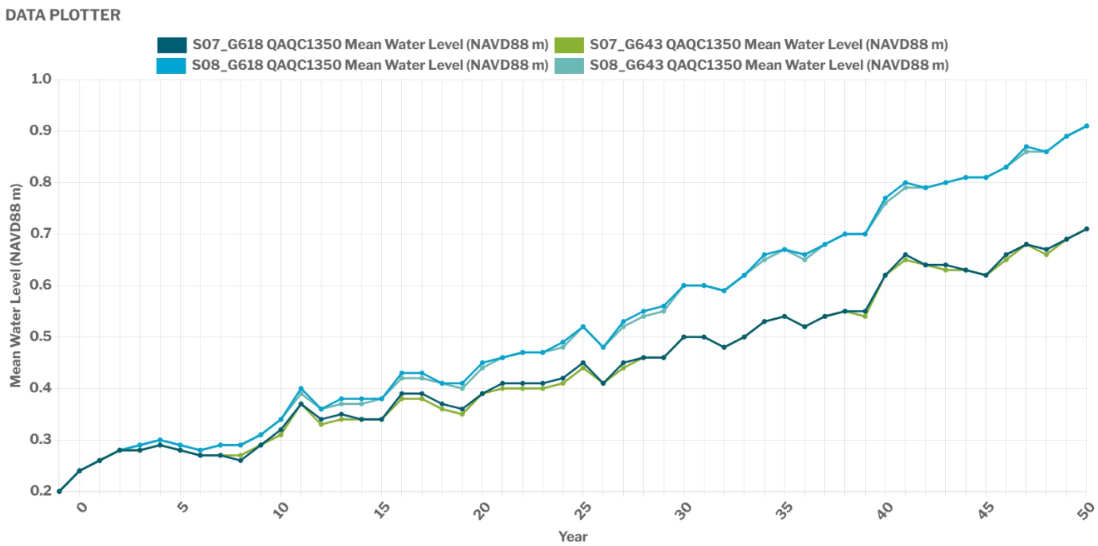


Figure 96. Annual mean water level timeseries comparison between projects 325a (G618) and 325c (G643) for lower (S07) and higher (S08) scenarios in compartment 228 located north of the eastern section of the landbridge (location indicated in Figure 55), showing negligible or no local differences in water level between the complete Lower Barataria Landbridge (325a, G618) and the east part only (325c, G643).

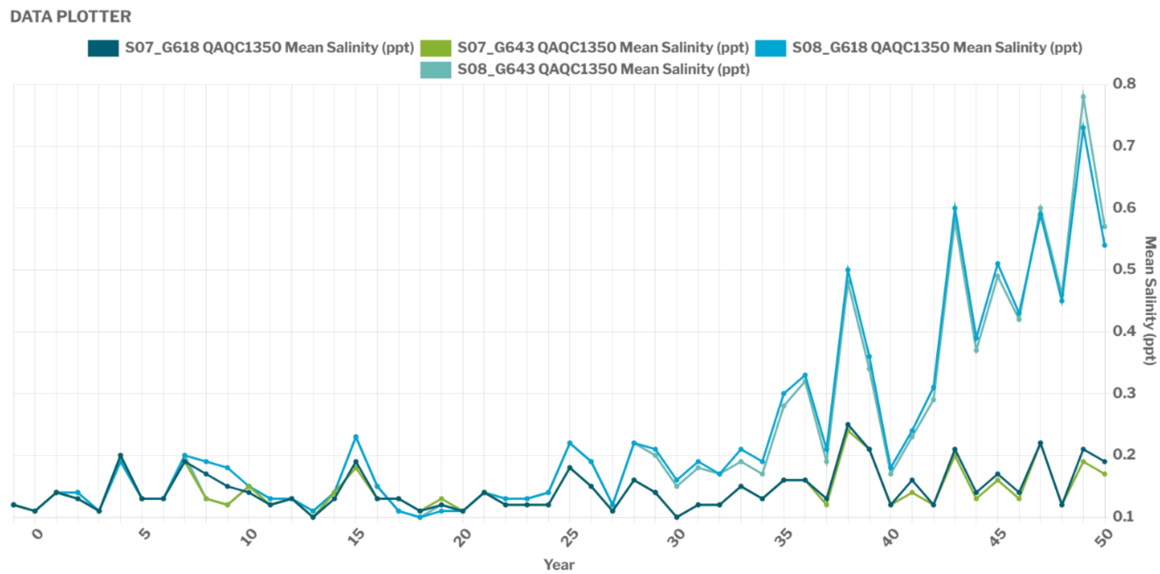


Figure 97. Annual mean salinity timeseries comparison between projects 325a (G618) and 325c (G643) for lower (S07) and higher (S08) scenarios in compartment 228 located north of the eastern section of the landbridge (location indicated in Figure 55), showing negligible or no local differences in salinity between the complete Lower Barataria Landbridge (325a, G618) and the east part only (325c, G643).

5.0 EASTERN TERREBONNE LANDBRIDGE

PROJECT OVERVIEW

This report describes the modeling results for the Eastern Terrebonne Landbridge (#335a), an integrated project that includes the creation of marsh within a footprint of approximately 11,000 acres including filling areas deeper than 2.5 ft, from Bayou Terrebonne to the South Lafourche Levee near Catfish Lake (Figure 98A). The project also includes 70,000 ft of shoreline revetment to limit erosion in exposed areas and channel armoring to maintain channels at current dimensions at Bayou Jean Lacroix, Bayou Pointe aux Chenes, and Bayou Blue. The purpose of the project is to reduce the tidal prism, create new wetland habitat, restore degraded marsh, and reduce wave erosion. The project is modeled as G620 and is fully constructed by Year 9 of the model run.

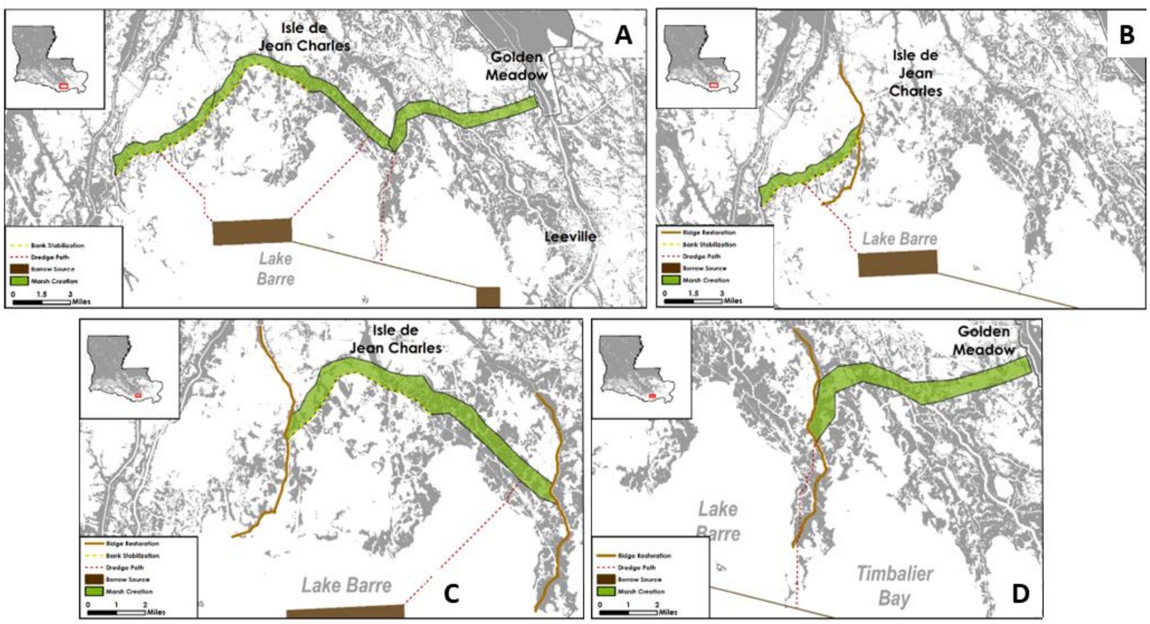


Figure 98. Location of the Eastern Terrebonne Landbridge projects (Panel A), the Eastern Terrebonne Landbridge - West (Panel B), the Eastern Terrebonne Landbridge - Central (Panel C) and the Eastern Terrebonne Landbridge - East (Panel D).

The Eastern Terrebonne Landbridge - West project (#335b) includes creation of marsh within a footprint of approximately 2,500 acres including filling areas deeper than 2.5 ft, from Bayou Terrebonne to Bayou Barre (Figure 98B). The project also includes restoration of approximately 49,000 ft of Bayou Barre Ridge and 22,000 ft of shoreline revetment. The project is modeled as G633 and is fully constructed by Year 7 of the model run.

The Eastern Terrebonne Landbridge - Central project (#335c) includes creation of marsh within a footprint of approximately 4,500 acres including filling areas deeper than 2.5 ft, from Bayou Barre to Bayou Pointe aux Chenes (Figure 98C) as well as channel armoring to maintain channels at current dimensions at Bayou Jean Lacroix and Bayou Pointe aux Chenes. The project also includes restoration of approximately 49,000 ft of Bayou Barre Ridge and 44,000 ft of Bayou Pointe aux Chenes Ridge and 22,000 ft of shoreline revetment. The project is modeled as G634 and is fully constructed by Year 7 of the model run.

The Eastern Terrebonne Landbridge - East project (#335d) includes creation of marsh within a footprint of approximately 3,800 acres including filling areas deeper than 2.5 ft, from Bayou Pointe aux Chenes to the south Lafourche Levee near Catfish Lake (Figure 98D) as well as channel armoring to maintain channels at current dimensions at Bayou Pointe aux Chenes and Bayou Blue. The project also includes restoration of approximately 44,000 ft of the Bayou Pointe aux Chenes Ridge. The project is modeled as G635 and is fully constructed by Year 7 of the model run.

The cost of the projects varies by scenario (Table 5) as the amount of dredged material required varies according to the water depth. Note that these are maximum costs based on the most expensive borrow source for the project. The actual project costs depend upon the borrow source assigned to the project by the Planning Tool during project selection.

Table 7. Maximum costs for each of the Eastern Terrebonne Landbridge projects by scenario

Project	Lower Scenario	Higher Scenario
Eastern Terrebonne Landbridge (IP1)	$1.27 billion	$1.34 billion
Eastern Terrebonne Landbridge – West (IP1)	$311 million	$326 million
Eastern Terrebonne Landbridge – Central (IP1)	$539 million	$566 million
Eastern Terrebonne Landbridge – East (IP1)	$436 million	$457 million
Eastern Terrebonne Landbridge – West (IP2)	$343 million	$407 million
Eastern Terrebonne Landbridge – Central (IP2)	$607 million	$668 million
Eastern Terrebonne Landbridge – West and Central (IP2)	$940 million	$1.04 billion

Each of these projects was evaluated for inclusion in the 2023 Coastal Master Plan for IP1, and Eastern Terrebonne Landbridge - East (#335d) was selected. For IP2, the west and central components (#335b and #335c) were evaluated. However, as the restoration of the Bayou Point aux Chenes ridge was already included in the east component, the costs for this were removed from the central component for IP2. In addition, the Eastern Terrebonne Landbridge (#335a) was thus partly implemented in IP1 and so for IP2 a new project - Eastern Terrebonne Landbridge - West and Central (#335e) was considered and was selected. Table 5 also shows how maximum project costs changed for the projects evaluated for IP2. These changes are due to increased water depths; fewer years of Operations, Maintenance, and Monitoring, and adjustments such as the removal of the ridge feature mentioned above.

The results presented here discuss the way in which the projects change the coastal landscape in terms of hydrology, morphology, vegetation, and habitats, with examples from the two environmental scenarios. The examples have been selected to illustrate the dynamics of the project based on available data, rather than to provide a comprehensive description of all areas, scenarios, and implementation period comparisons.

STAGE

The project has negligible impacts on annual inundation depth outside of the project footprint in Year 10 of the low scenario (S07) when compared to FWOA (Figure 99Figure 99. Mean annual inundation depth difference (FWA-FWOA) in Year 10 of the lower scenario (S07).). The impact on annual inundation depth remains small in the later years for the low scenario as well as for the high scenario (S08).

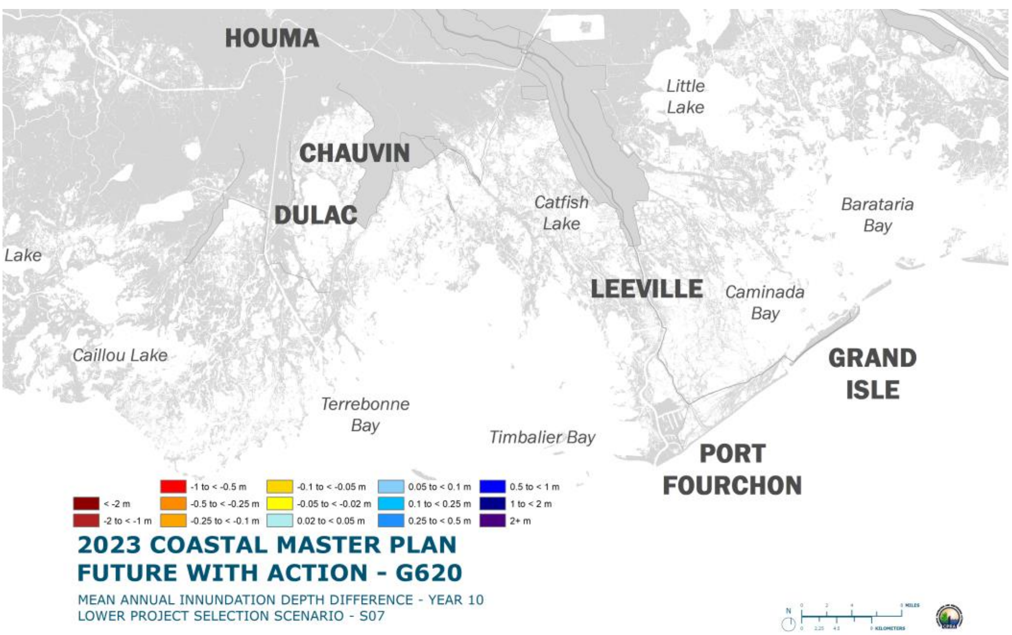


Figure 99. Mean annual inundation depth difference (FWA-FWOA) in Year 10 of the lower scenario (S07).

Annual mean water levels with and without the entire landbridge project and the western section at CRMS0315 near Bayou Terrebonne are shown in Figure 100. The project has little impact on the mean water levels landside of the projects; however, the project has large impacts on tidal ranges. Figure 101 and Figure 102 present the daily average tidal range results at compartment 701 where CRMS0315 is located for the full project 335a (G620) and west segment 335b (G633), respectively. The full project 335a reduces the tidal range slightly more than the west segment 335b when implemented alone.

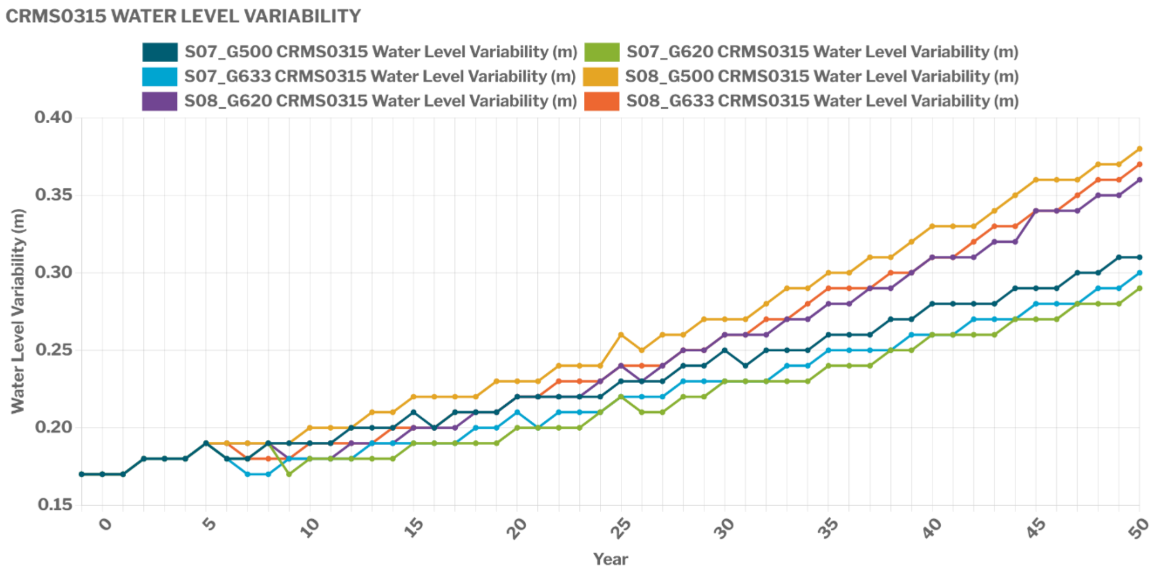


Figure 100. Annual mean water level at CRMS0315 north of the western section, for the projects and FWOA, for the lower and higher scenarios.

Figure 101. Daily average tidal range at compartment 701 (western section) for lower (upper panel) and higher (lower panel) scenarios for the full project 335a (G620).

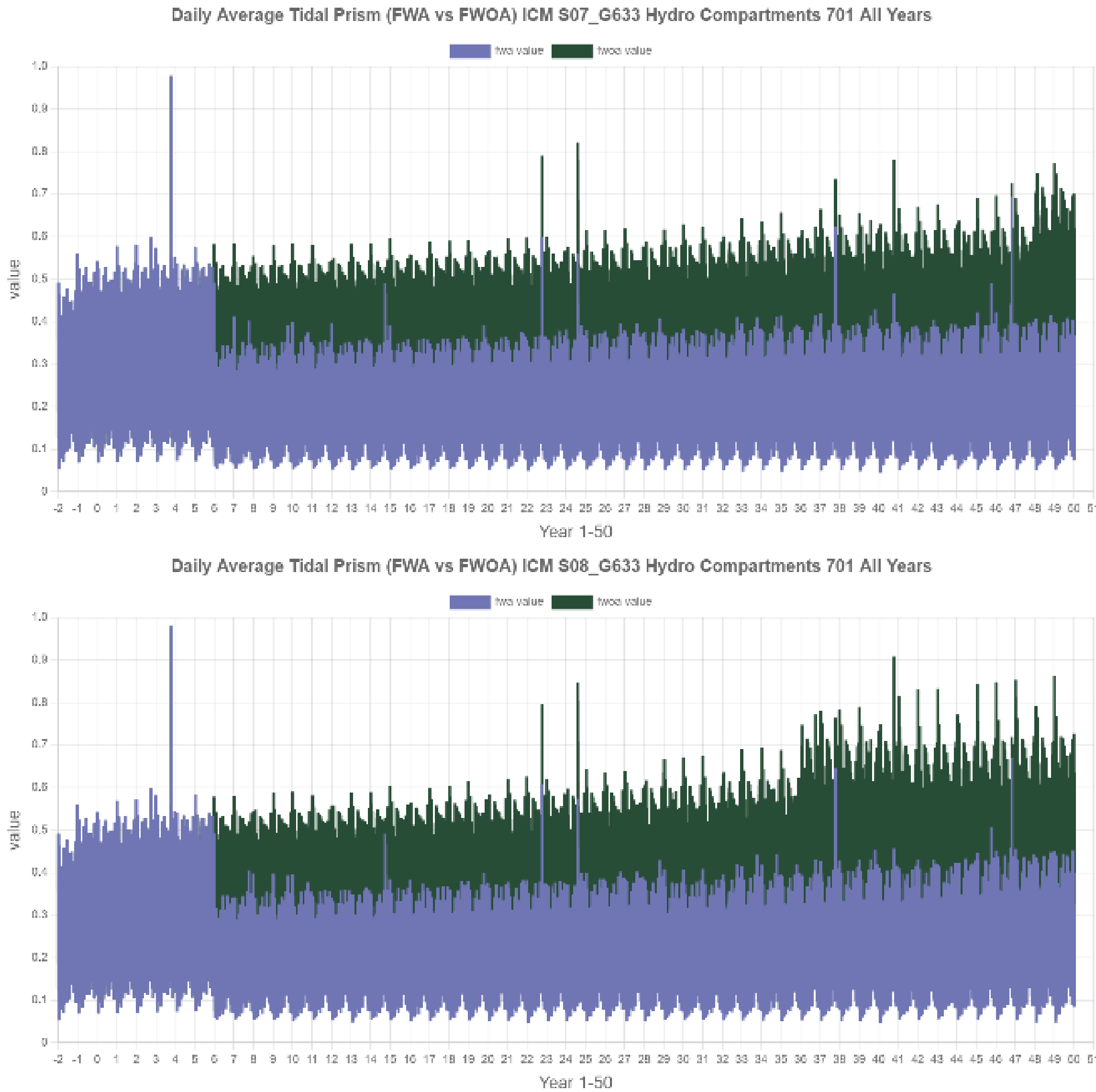


Figure 102. Daily average tidal range at compartment 701 (western section) for lower (upper panel) and higher (lower panel) scenarios for the west segment 335b (G633).

At the central section of the landbridge, both the full project 335a (G620) and the central segment 335c (G634) have little impact on mean water levels as illustrated in Figure 103 at CRMS3296 north of the projects. The projects reduce the tidal ranges directly to the north similarly except in the last decade of the higher scenario when the impacts of central project 335c are much less than the full project (see Figure 104 and Figure 105 for full project 335a and central segment 335c for compartment 509 where CRMS3296 is located).

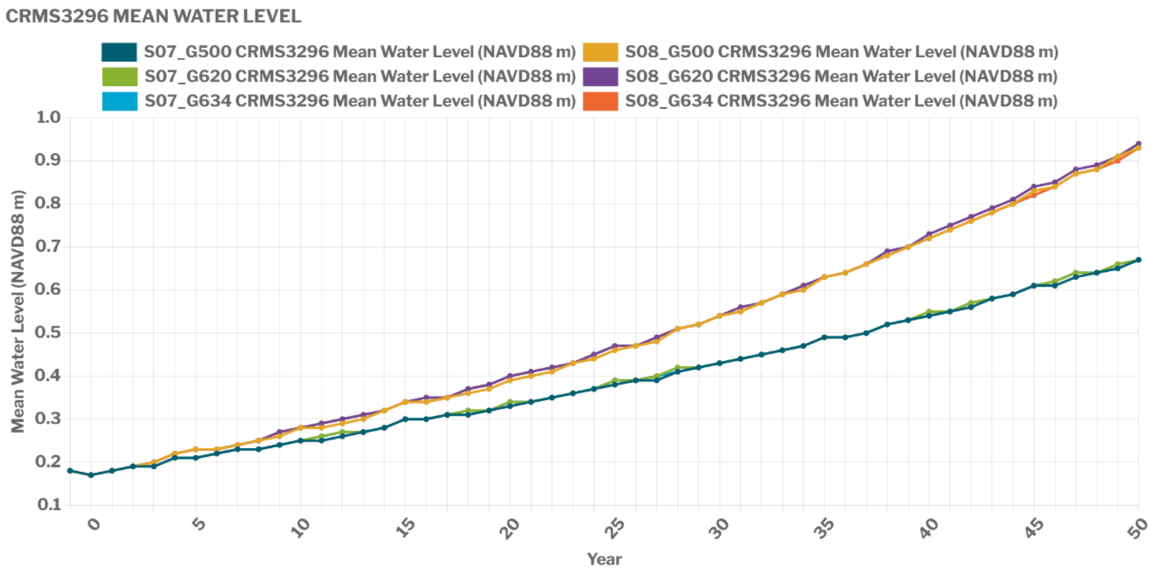
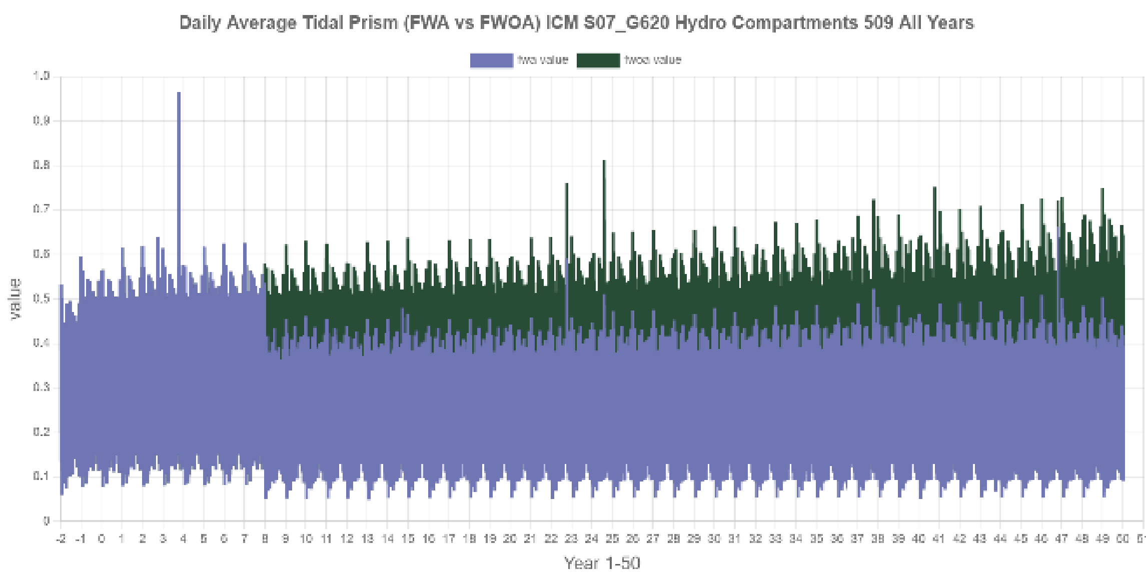


Figure 103. Annual mean water level at CRMS3296 (central section).



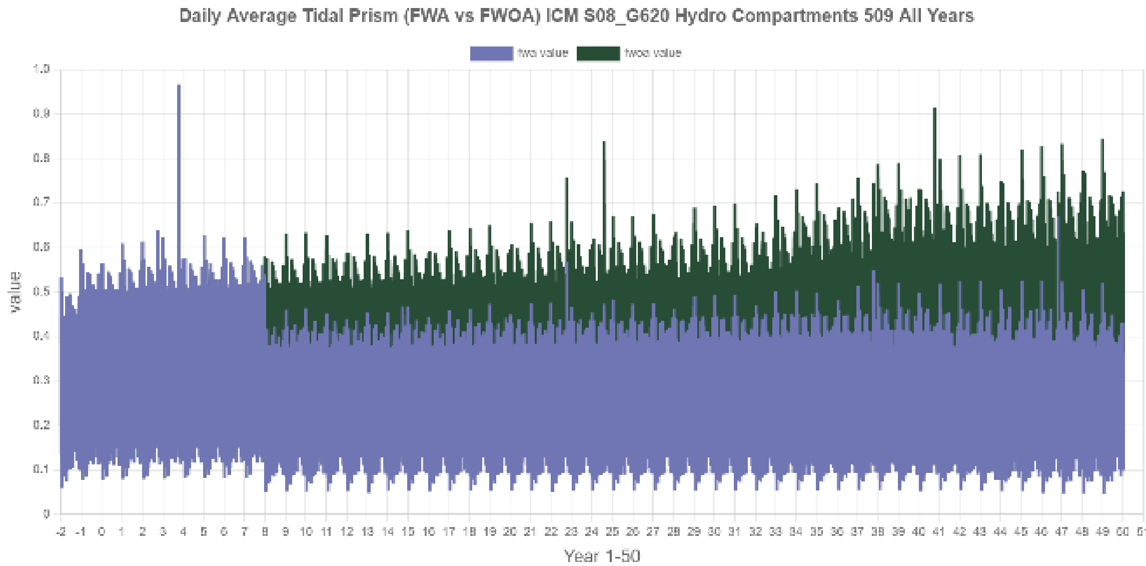


Figure 104. Daily average tidal range at compartment 509 (central section) for lower (upper panel) and higher (lower panel) scenarios for the full project 335a (G620).

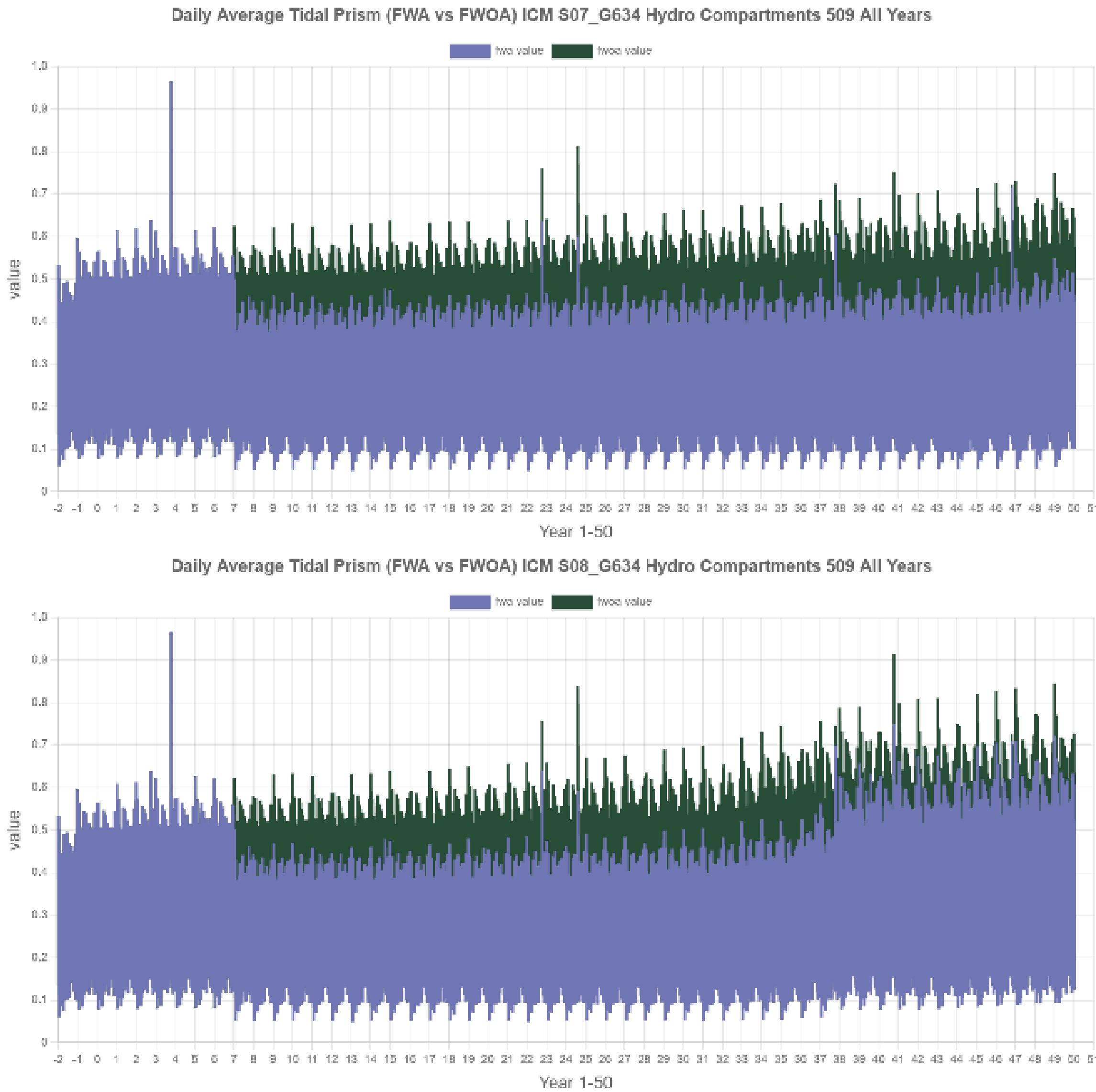


Figure 105. Daily average tidal range at compartment 509 (central section) for lower (upper panel) and higher (lower panel) scenarios for the central segment 335c (G634).

At the eastern section of the landbridge, both the full project 335a (G620) and the east segment 335d (G635) have little impact on the mean water level as illustrated in Figure 106 at CRMS0387 north of the projects. Figure 107 and Figure 108 present the full project 335a and east segment 335d impacts on tidal ranges at compartment 508 where CRMS0387 is located. The east project 335d reduces the tidal range substantially, whereas the full project has much less impact except during the last decade of higher scenario (S08).

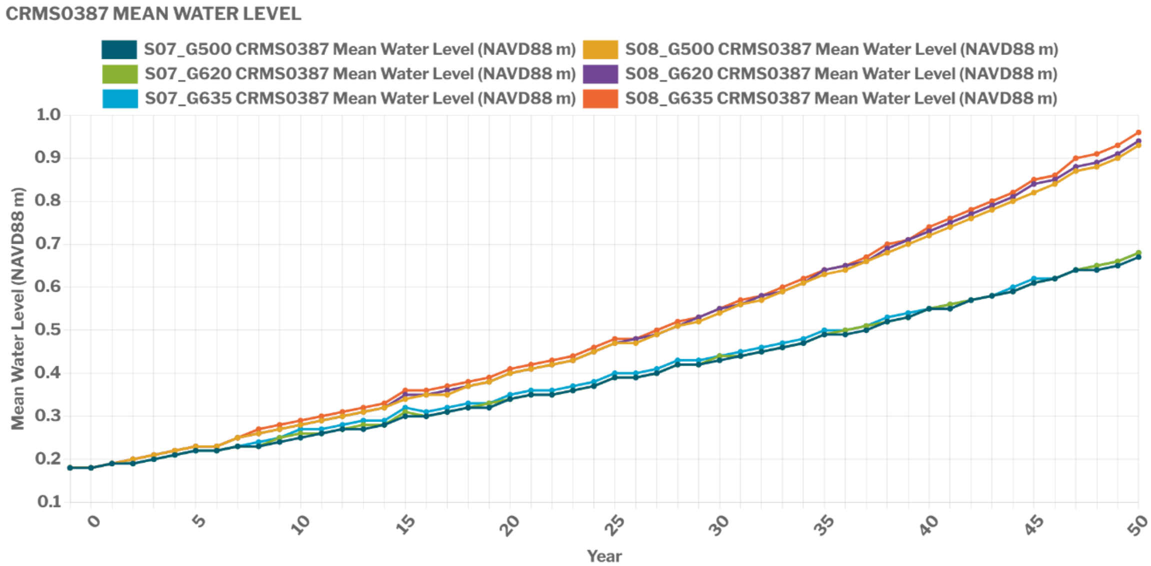


Figure 106. Annual mean water level at CRMS0387 (eastern section).

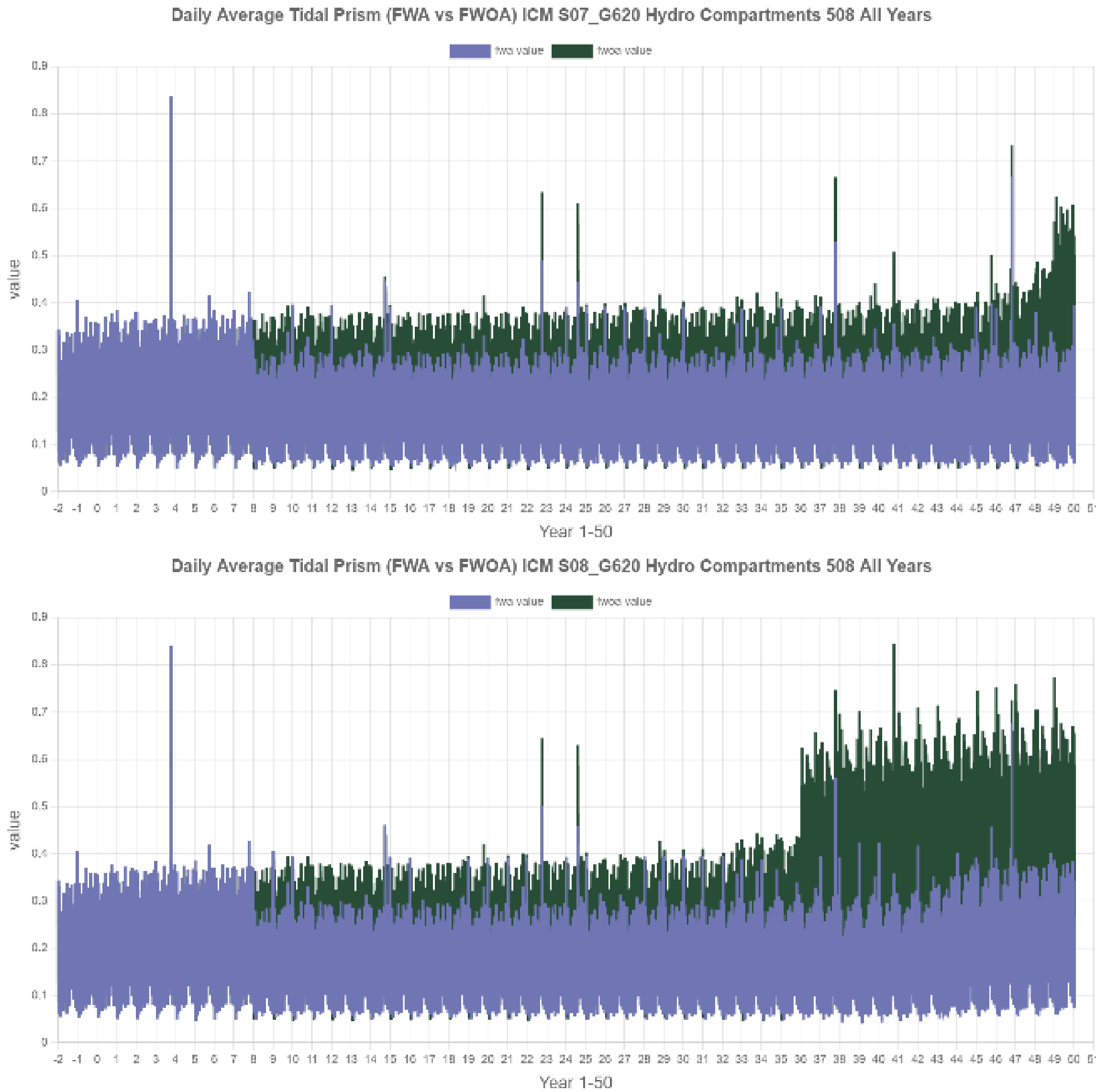
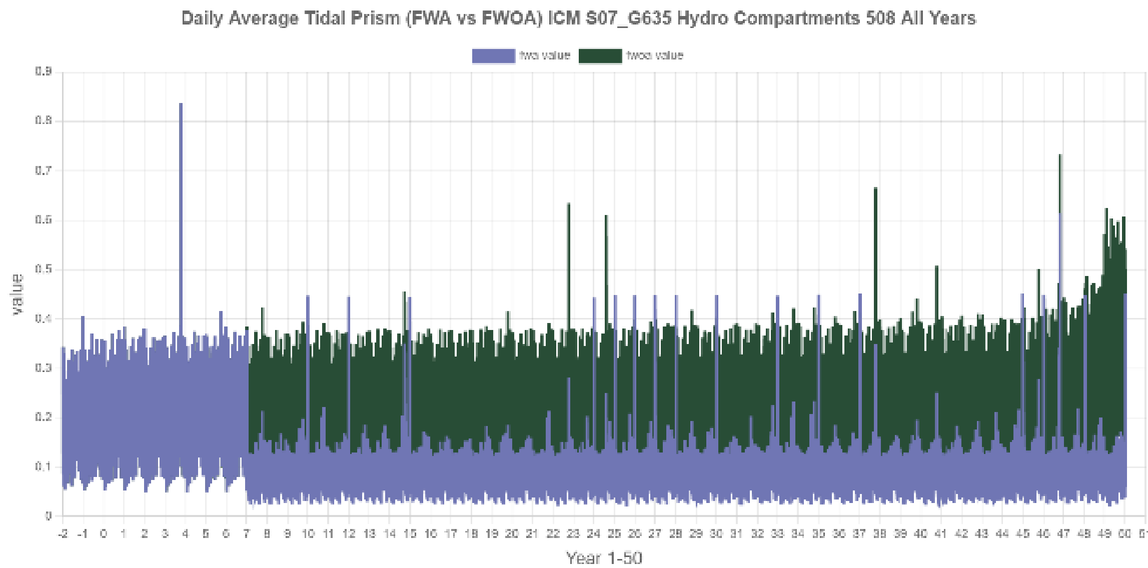


Figure 107. Daily average tidal range at compartment 508 (eastern section) for lower (upper panel) and higher (lower panel) scenarios for the full project 335a (G620).



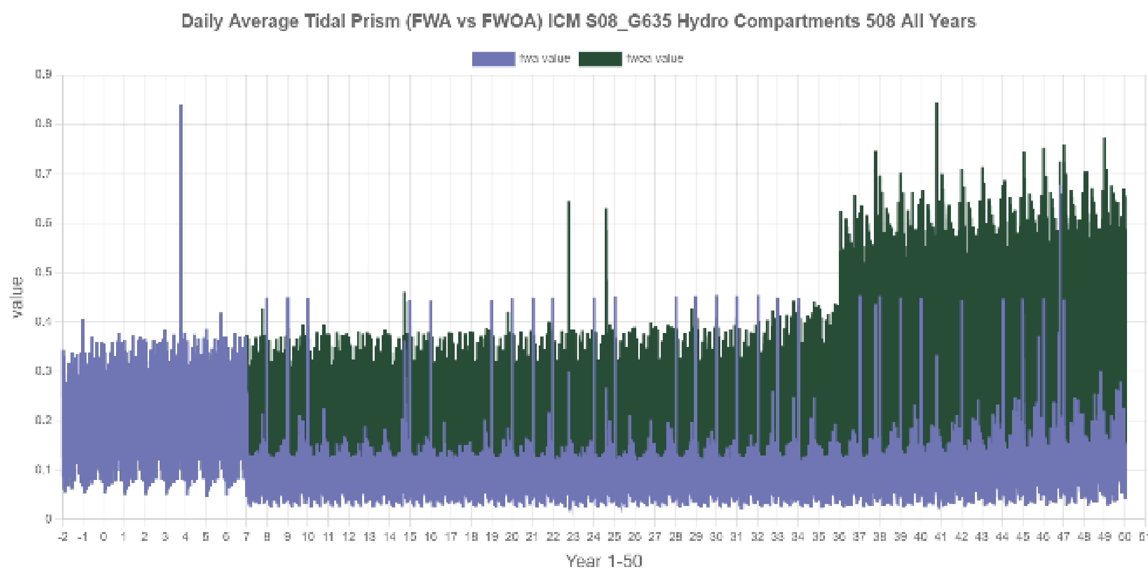
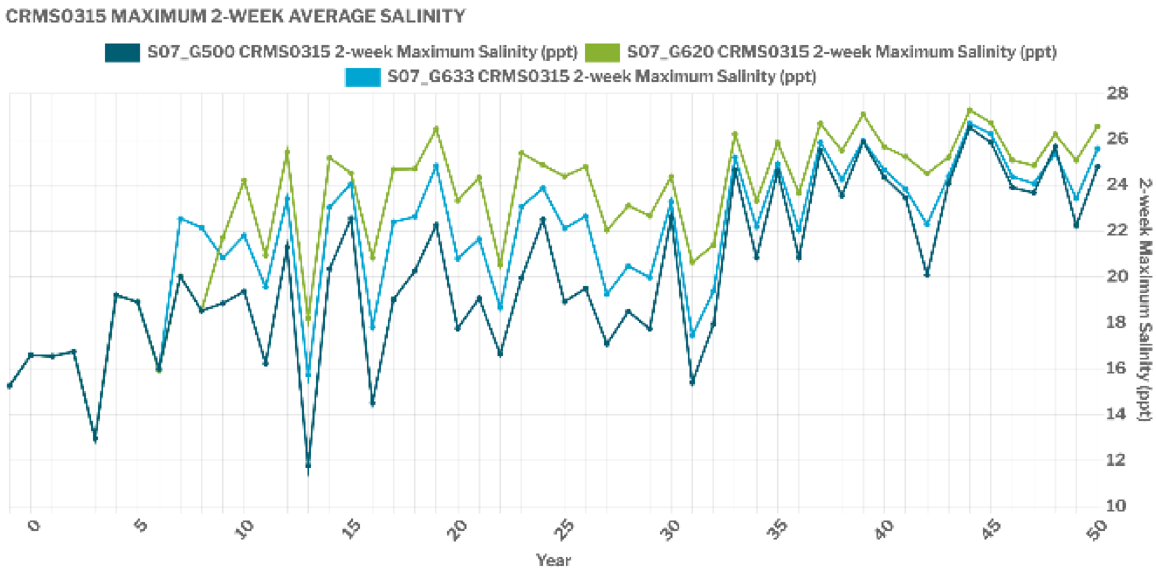


Figure 108. Daily average tidal range at compartment 508 (eastern section) for lower (upper panel) and higher (lower panel) scenarios for the east segment (G635).

SALINITY

Figure 109 to Figure 111 present the annual maximum 2-week average salinity north of the western, central, and eastern section of the landbridge project, respectively. At the western section, the project causes salinity increases, especially during the early years when salinity can go up by 4 ppt due to the full project 335a (G620) under both environmental scenarios. The salinity increase here is greater for the full project than for just the western section. However, in the central and eastern sections, salinity is slightly reduced by no more than 2 ppt. The spatial extents of project impacts on salinity in Year 20 for the full project 335a are shown in Figure 112. The western section causes salinity increases to the north by blocking basinward flushing of saline waters after intrusion via adjacent flowpaths including Bayou Terrebonne, Petit Caillou, and the Houma Navigation Canal.



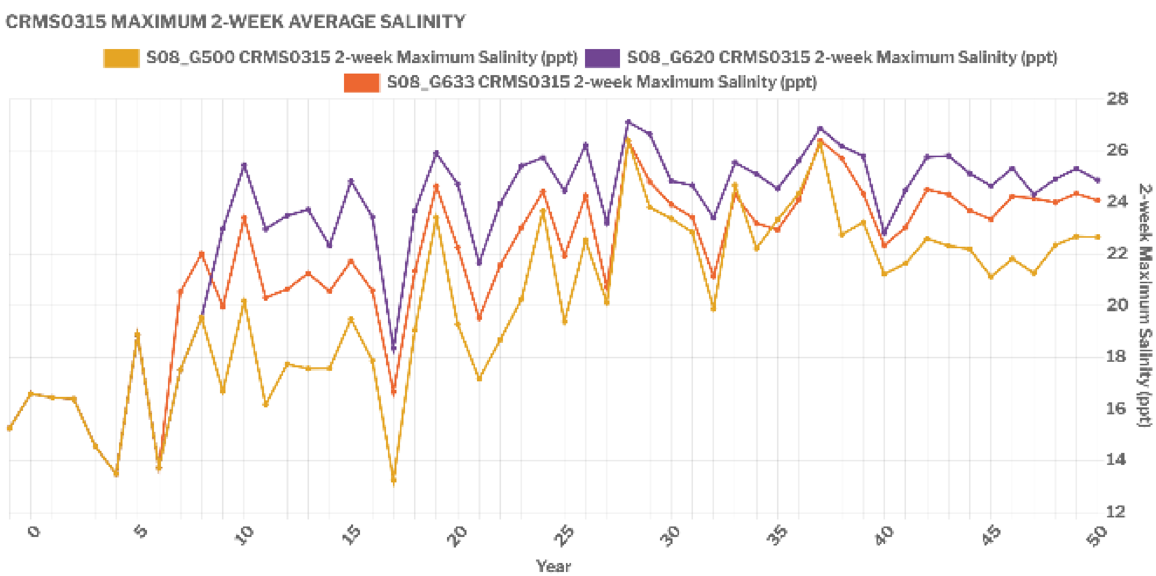


Figure 109. Annual maximum 2-week average salinity at CRMS0315 (western section) for lower (upper panel) and higher (lower panel) scenarios.

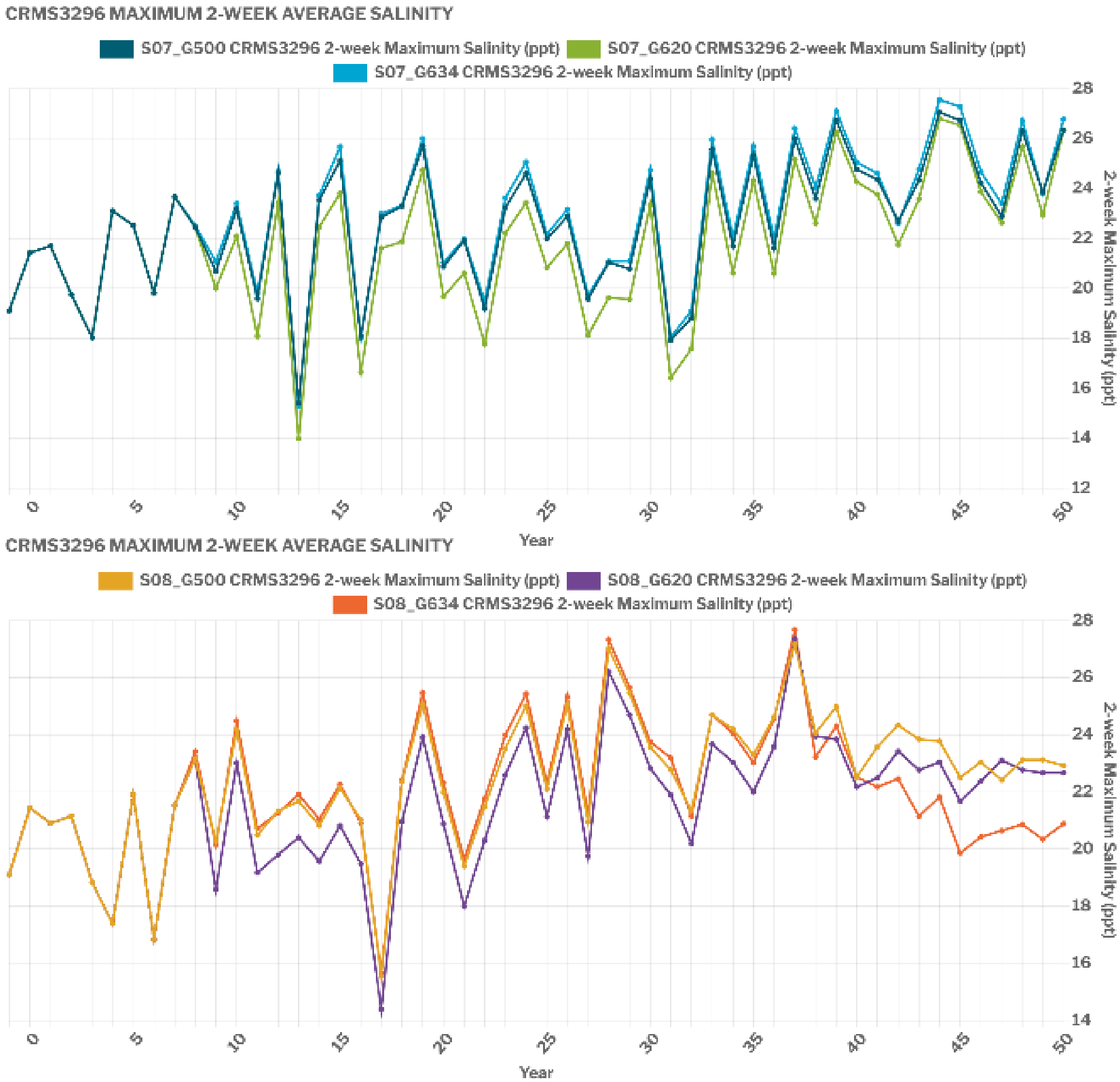


Figure 110. Annual maximum 2-week average salinity at CRMS3296 (central section) for lower (upper panel) and higher (lower panel) scenarios.

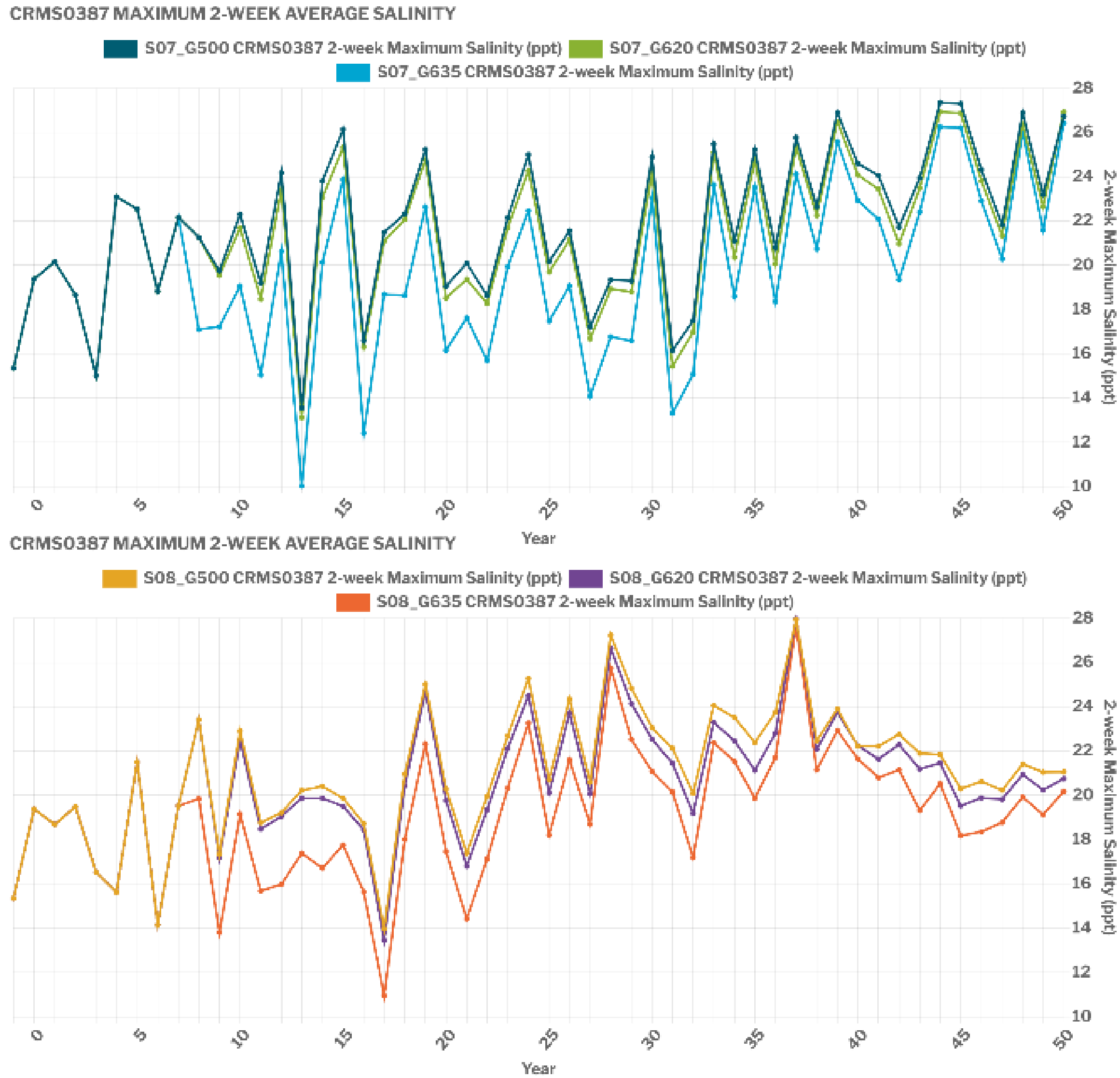


Figure 111. Annual maximum 2-week average salinity at CRMS0387 (eastern section) for lower (upper panel) and higher (lower panel) scenarios.

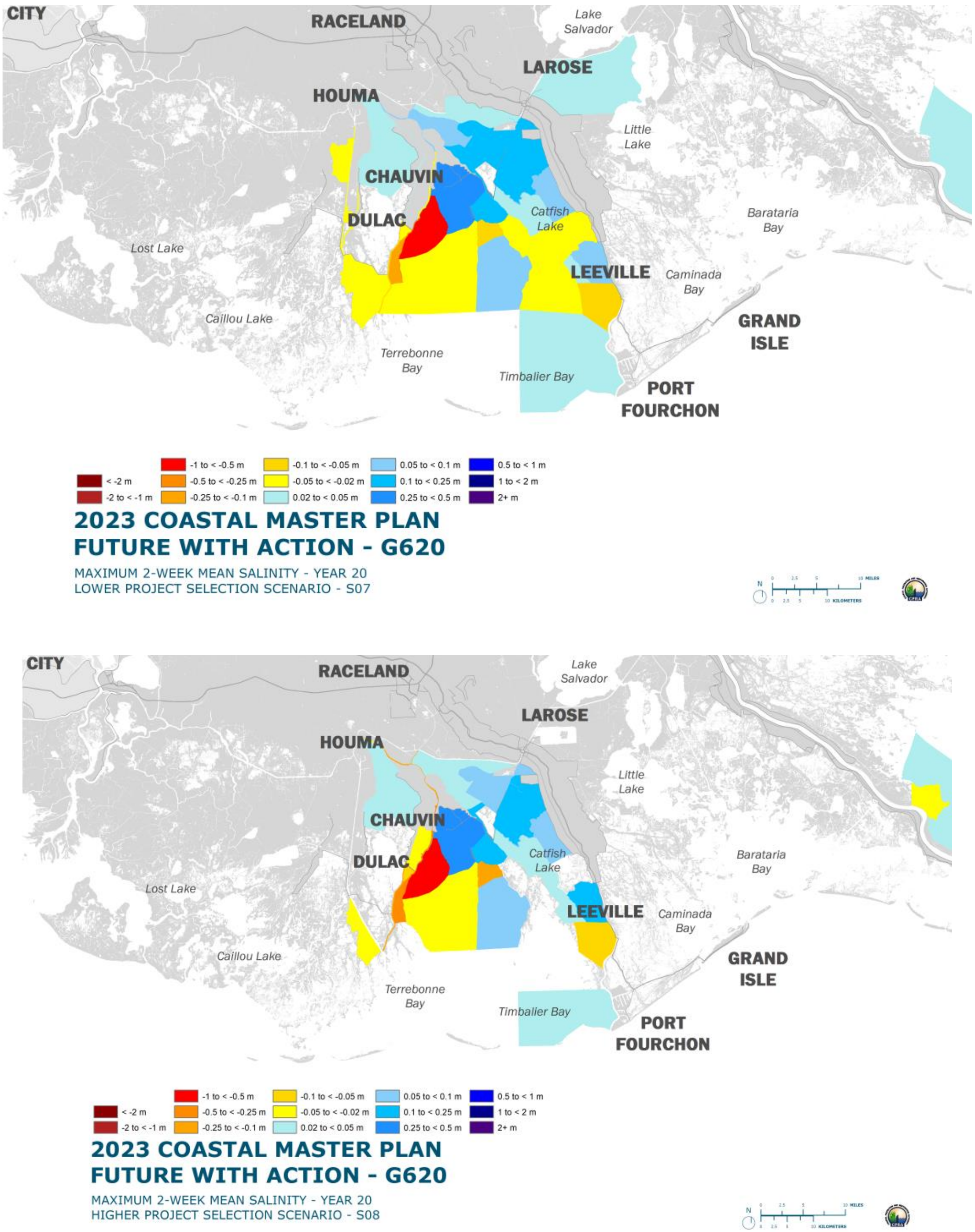


Figure 112. Maximum 2-week average salinity difference (FWA-FWOA) in Year 20 for the full project 335a (G620) for lower (upper panel) and higher (lower panel) scenarios.

MORPHOLOGY

RESULTS AND DISCUSSION

The Eastern Terrebonne Basin Landbridge project, and each of its subcomponents, were evaluated for selection in IP1 for a full 50 years as standalone projects assuming implementation at the start of the simulation, with construction complete by Year 9 for the complete landbridge and Year 7 for the components. The effect of the projects on the landscape differs by scenario Table 6). In terms of AAL, all projects result in more land under the lower scenario compared to the higher scenario except for Eastern Terrebonne Basin Landbridge - West where the results are very similar for the two scenarios. There is also more net land at Year 50 for the lower scenario compared to the higher.

Table 8. Net effect of the Eastern Terrebonne Basin Landbridge projects (FWA-FWOA) and three subsections by scenario in terms of AAL and net land at Year 50

	Average Annual Net Land (km^2)		Net Land at Year 50 (km^2)	
Scenario	Lower	Higher	Lower	Higher
Eastern Terrebonne Basin Landbridge	32.11	28.37	41.85	0.87
Eastern Terrebonne Basin Landbridge - West	5.44	5.46	6.00	0.63
Eastern Terrebonne Basin Landbridge - Central	12.05	10.32	17.88	2.34
Eastern Terrebonne Basin Landbridge - East	15.68	12.89	18.13	0.71

Note that the AAL benefits of the three component projects sum to a slightly greater value than that shown for the complete project. This is because ridge restoration is included in the west, central, and east projects to ensure the landbridge provides hydrologic ‘control’ within the subbasin. The overall project is bounded on the west by Bayou Terrebonne and on the east by Bayou Lafourche. The west component includes the landbridge and restoration of the Bayou Barre Ridge. The central component includes the landbridge and the Bayou Barre Ridge and the Pointe aux Chenes Ridge, and the east component includes the Bayou Pointe aux Chenes Ridge. Thus, the effects on land area of the ridge projects are included in the results for the separate components, but these are not included in the overall project.

The change over time in net land (FWA - FWOA) for the complete landbridge is shown for both scenarios in Figure 113. The rapid increase in land in the year of construction is associated with the footprint of the landbridge itself, where open water is filled to create land. For both scenarios, there is an increase in net benefit through the next three decades. This may be due to indirect effects of the project on basin hydrology or a result of the parts of the footprint which were already land at the time of construction but which were nourished or increased in elevation. The increase in elevation allows areas to survive longer than they would under FWOA resulting in a net land benefit for the project. Figure 113 also shows a difference between scenarios in the last decade with a rapid drop in benefits under the higher scenario at about Year 43.

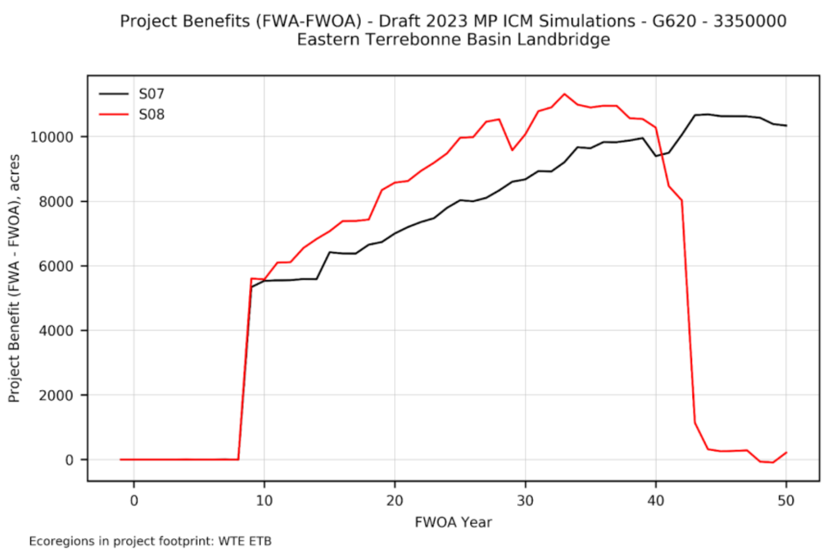


Figure 113. Net land benefits (FWA-FWOA) over time for both the higher and lower scenarios for the Eastern Terrebonne Basin Landbridge project.

The same general pattern for benefits over time for the component projects is shown in Figure 114. There is an increase in benefits following construction. For the lower scenario, this is less pronounced and more complex for west, compared to central and east. Under the higher scenario, all three components show a rapid decline in land benefits in Years 40-43, with west and central showing a net loss of land in some years in the last decade.

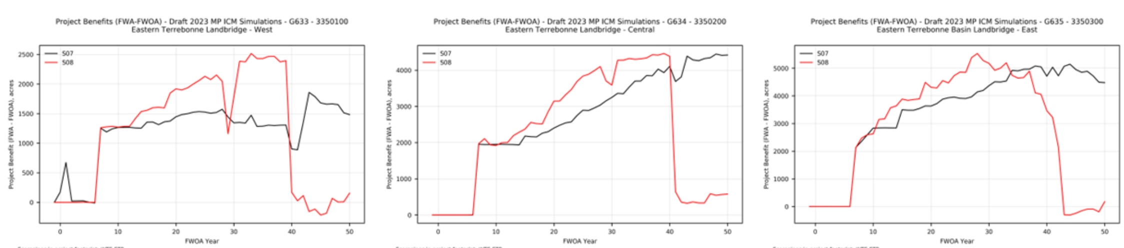


Figure 114. Net land benefits (FWA-FWOA) over time for both the higher and

lower scenarios for the west (left), central (center) and east (right) components of the Eastern Terrebonne Basin Landbridge project.

These dynamics are illustrated at QAQC1094, which is within the footprint of the eastern component of the project. The trend of increasing inundation depth over time is similar in both G500 and G620 for each scenario, with more increase in the higher scenario versus the lower. However, the effect of construction is to dramatically reduce the inundation in Year 9. Inundation depth is negative for G620 as the project is built to an elevation that is higher than the tidal frame. Subsidence reduces elevation and thus increases inundation, together with SLR, until the land starts to be inundated at some point during the year (note that this may not show as a positive mean annual inundation depth). This appears to occur in Year 21 when the rate of increase in inundation decreases as tidal flooding results in organic accretion that somewhat offsets the effects of subsidence and SLR.

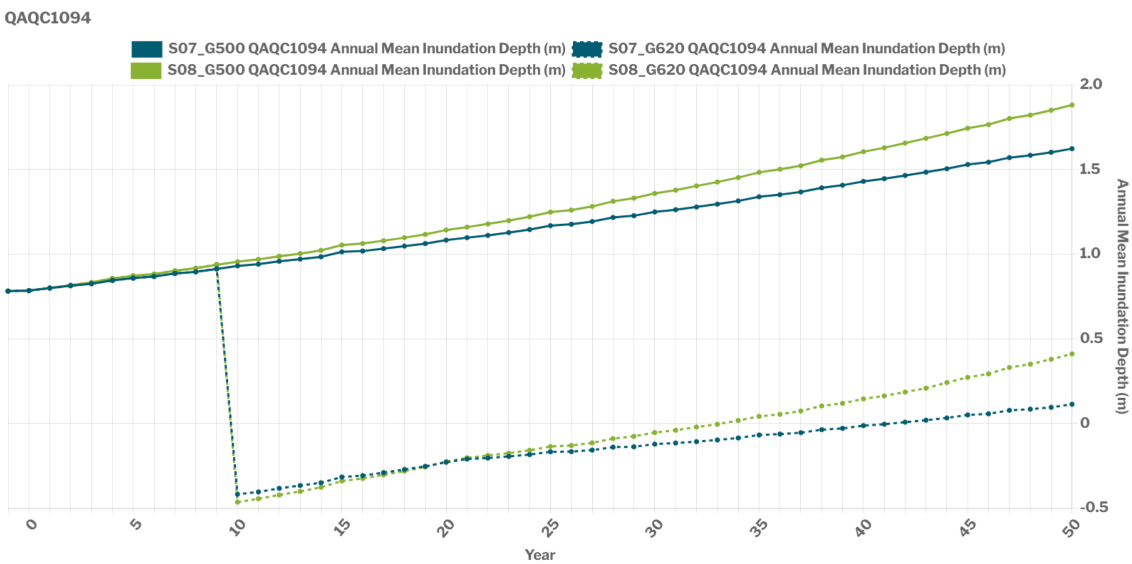


Figure 115. Differences in mean annual inundation depth between FWOA (G500) and FWA (G620) for the two scenarios at QAQC1094.

The landbridge can cause changes in water levels and salinity inland of the main project footprint. This is illustrated in compartment 701, which is landward of the western portion of the landbridge where there is a slight increase in water level with the project compared to FWOA (not shown). There is a FWOA project (Terrebonne Basin Ridge and Marsh Creation – Bayou Terrebonne increment) in compartment 701. In FWOA the project is lost in Year 42/43 in the lower scenario and Year 30/31 in the higher scenario (Figure 116.) The changes in water level associated with the landbridge project cause the FWOA project to be lost faster in the lower scenario, although beginning in the same year, and two years earlier in the higher scenario. This additional loss is offset by the effects of the land building associated with the project footprint in compartment 701 which, as shown in Figure 116, is sustained through the 50 years in the lower scenario but is lost in Year 42-43 in the higher scenario.

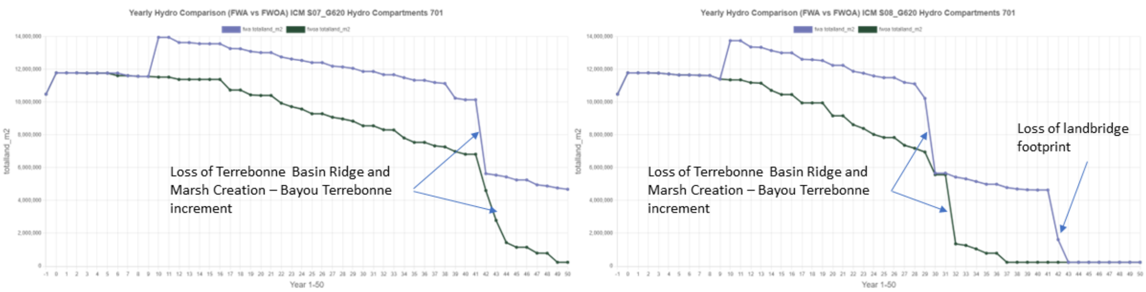


Figure 116. Land area change in Compartment 701 for FWA and FWOA under the lower scenario (left) and the higher scenario (right) for the Eastern Terrebonne Basin Landbridge projects.

Eastern Terrebonne Basin Landbridge - East is chosen for the master plan IP1, thus is included in the future with implementation period 1 (FWIP1) against which candidate projects for IP2 are compared. Also chosen is North Terrebonne Bay Marsh Creation (Figure 117). Because this is a marsh creation project, only water less than 2.5 ft is filled to create marsh (vs. the landbridge projects where deeper water is filled), and the footprint somewhat overlaps with that of the central component of the landbridge near Isles de Jean Charles.

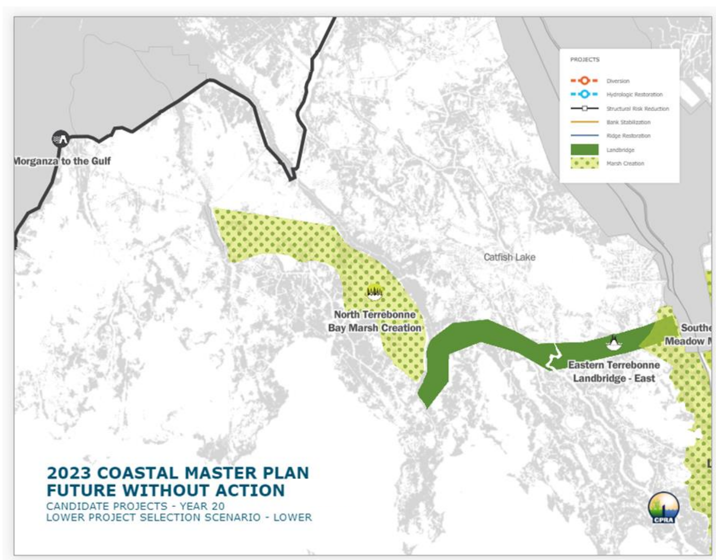


Figure 117. Projects implemented in IP1 in the eastern Terrebonne Basin.

As the eastern component has already been selected (including the Pointe aux Chenes Ridge), projects evaluated for IP2 are the west and central components and a reduced complete landbridge that is composed of the west and central components but without the Bayou Barre Ridge. Both complete construction in Year 28. Table 7 shows the performance of these projects in IP2 in relation to FWIP1. In contrast to their performance in IP1 (Table 6), the projects all have greater AAL under the higher scenario versus the lower. This may be a result of greater land loss in FWIP1 in the higher scenario within the project footprint that the landbridge retains. Further, in IP2, the west and central project performs better than the sum of the west and central components independently even though the separate components each include the Bayou Barre Ridge. However, the differences are very small.

Table 9. Net effect of the Eastern Terrebonne Basin Landbridge projects (FWA-FWIP1) modeled for IP2 by scenario in terms of AAL and net land at Year 50

IP2	Average Annual Net Land (km^2)		Net Land at Year 50 (km^2)	
Scenario	Lower	Higher	Lower	Higher
Eastern Terrebonne Basin Landbridge - West and Central	23.41	26.01	25.96	25.57
Eastern Terrebonne Basin Landbridge - West	8.59	9.24	9.23	8.65
Eastern Terrebonne Basin Landbridge - Central	14.40	16.48	16.07	17.09

Figure 118 shows the net change in land area relative to FWIP1 over time. In contrast to IP1 (Figure 113 and Figure 114), all the projects retain the initial footprint through the end of the simulation. The projects are built high enough to account for subsidence and relative SLR from the time of construction through Year 50.

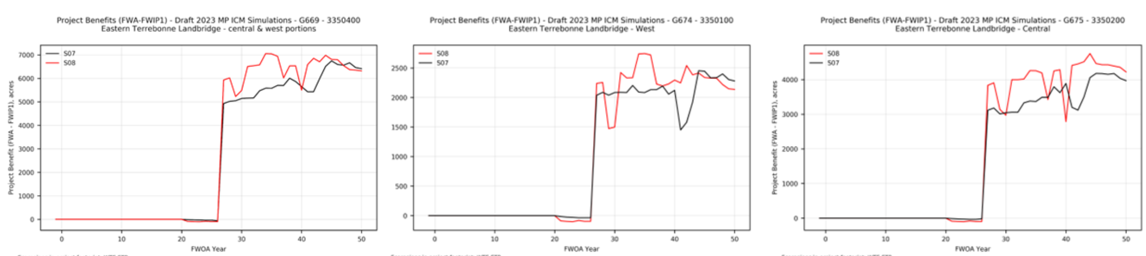


Figure 118. Net land benefits (FWA-FWIP1) over time for both the higher and lower scenarios for the west and central (left), west (center) and central (right) IP2 components of the Eastern Terrebonne Basin Landbridge project (note change in vertical scale).

There are a number of fluctuations shown in Figure 118, and for the most part, these are associated with changes in other projects in the ecoregion. As described above, the loss of the FWOA project (Terrebonne Basin Ridge and Marsh Creation – Bayou Terrebonne increment) is impacted by minor changes in flooding associated with the landbridges. An example is shown in Figure 119. Changes in water levels slightly increase inundation on the FWOA project relative to FWIP1 (not shown), and with the landbridge, the Terrebonne Basin Ridge and Marsh Creation project is lost to open water 2-3 years before the loss occurs in FWIP1. The net benefit in any year is the vertical difference between the lines in Figure 119, and it accounts for the dip in land benefits for the lower scenario in Figure 118 (right panel) after Year 40, and the subsequent rise.

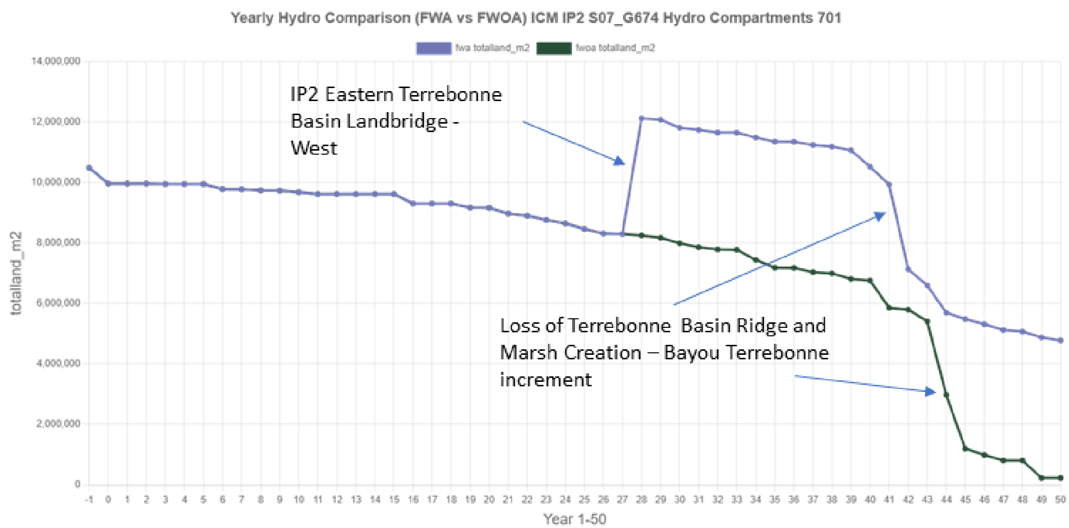


Figure 119. Land area change in compartment 701 for FWA and FWIP1 under the lower scenario for the Eastern Terrebonne Basin Landbridge - West project.

There is also some interaction with the North Terrebonne Bay Marsh Creation project. Compartment 540 is north of the central component of the landbridge, west of Bayou Pointe aux Chenes, and includes much of the marsh creation project. Figure 120 shows the increase in land area associated with the IP1 North Terrebonne Bay Marsh Creation project and a later increase in land area compared to FWIP1 for the central component of the landbridge. Compared to FWIP1, the landbridge project causes a minor increase in stage in compartment 540 of around 1 mm (Figure 120 right panel). This appears to result in land loss in G675 (with the landbridge component) in Year 40, the year before similar loss occurs in FWIP1. Inspection of land loss maps (Figure 121) show the difference is in the loss of part of the North Terrebonne Bay Marsh Creation project.

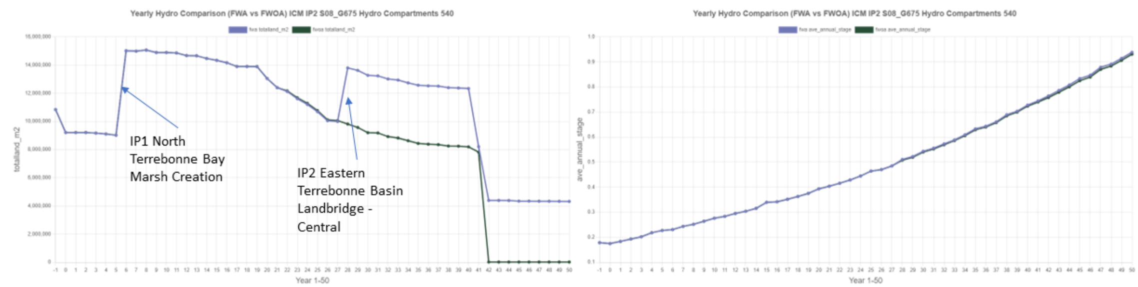


Figure 120. Land area change in compartment 540 for FWA and FWIP1 under the higher scenario for the Eastern Terrebonne Basin Landbridge - Central project (left) and mean annual stage for FWA and FWIP1 (right).

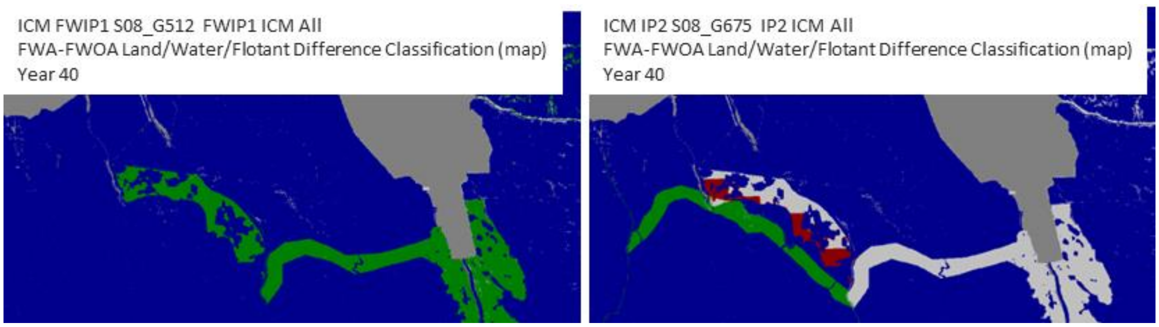
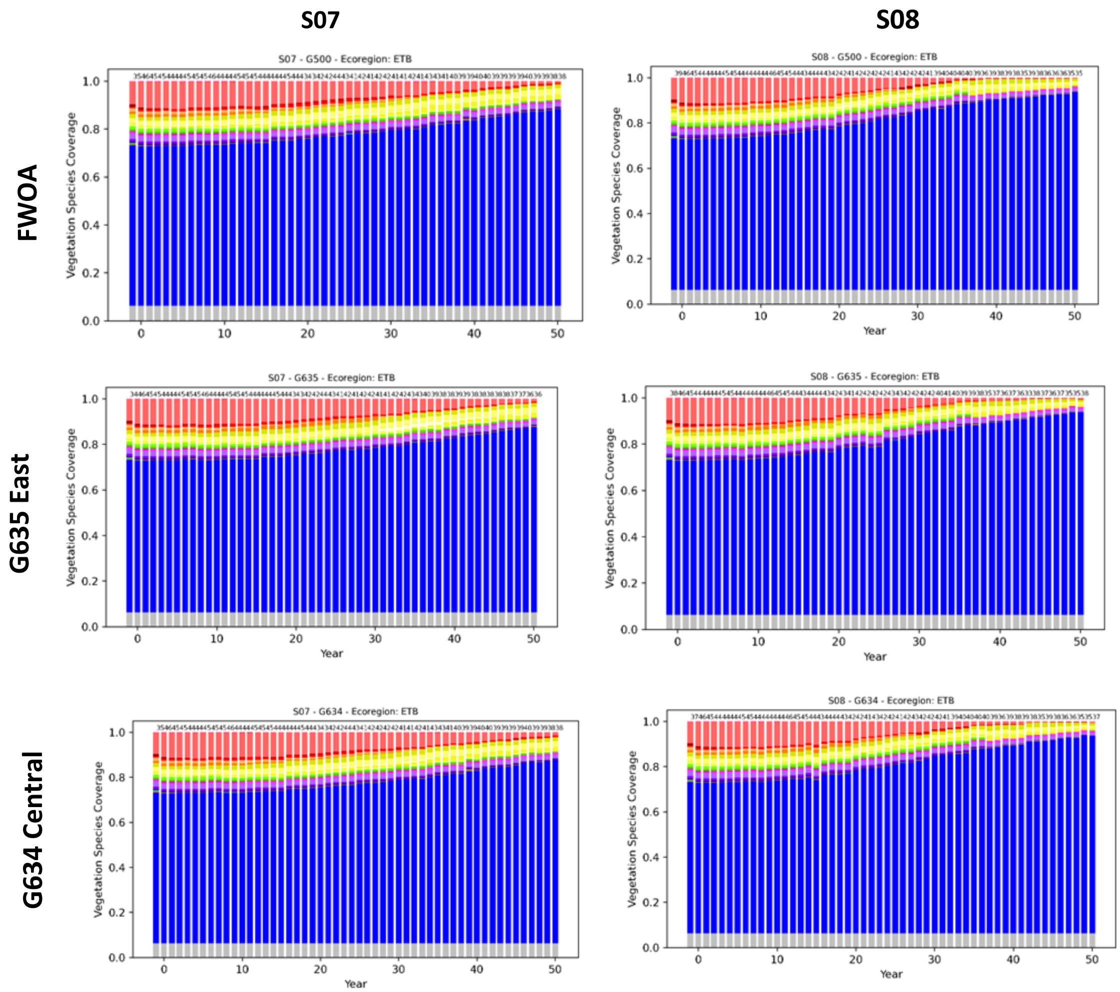


Figure 121. Changes in land/water in eastern Terrebonne for FWIP1 vs. FWOA (left) and IP2 FWA vs. FWIP1 for the Eastern Terrebonne Basin Landbridge - Central (right).

As a result of this analysis, the remaining components (west and central) of the Eastern Terrebonne Basin Landbridge were selected for the master plan in IP2.

VEGETATION

The different components of the Eastern Terrebonne landbridge have negligible effects on the vegetation cover in Eastern Terrebonne (ETB) (Figure 122). This is primarily because salinity reduction due to this project (full or components) occurs in areas dominated by SPAL. The reductions are insufficient to allow the replacement of SPAL with less salt tolerant species.


S07
S08
FWOA
G635 East
G634 Central
S07 - G500 - Ecoregion: ETB
S08 - G500 - Ecoregion: ETB
S07 - G635 - Ecoregion: ETB
S08 - G635 - Ecoregion: ETB
S07 - G634 - Ecoregion: ETB
S08 - G634 - Ecoregion: ETB
Vegetation Species Coverage
Year

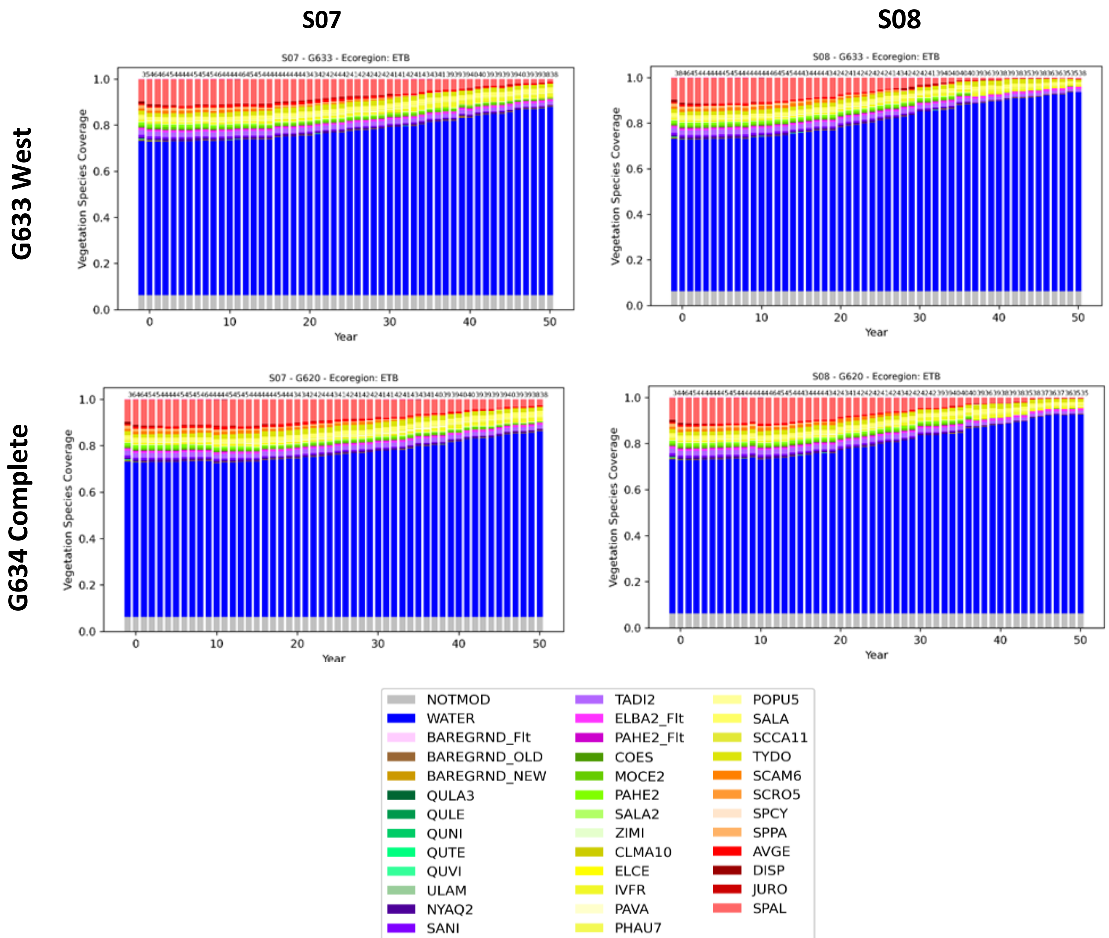


Figure 122. Changes in vegetation cover in ETB as a result of different versions of the East Terrebonne Landbridge project.

HABITAT SUITABILITY

The Eastern Terrebonne Basin Landbridge project had very little effect on the suitability of habitats for fish, shellfish, and wildlife. The primary effect was related to project implementation itself, which replaced highly suitable fragmented marsh habitat with a solid marsh platform extending across the upper ETB ecoregion. As a result, there was a clear decrease in the suitability of habitats along the project alignment for nearly all species in the analyses (e.g., juvenile blue crab; Figure 123). The exception was for seaside sparrow, because the relatively solid, saline marsh created by the project represented optimal habitat for this more terrestrial species.

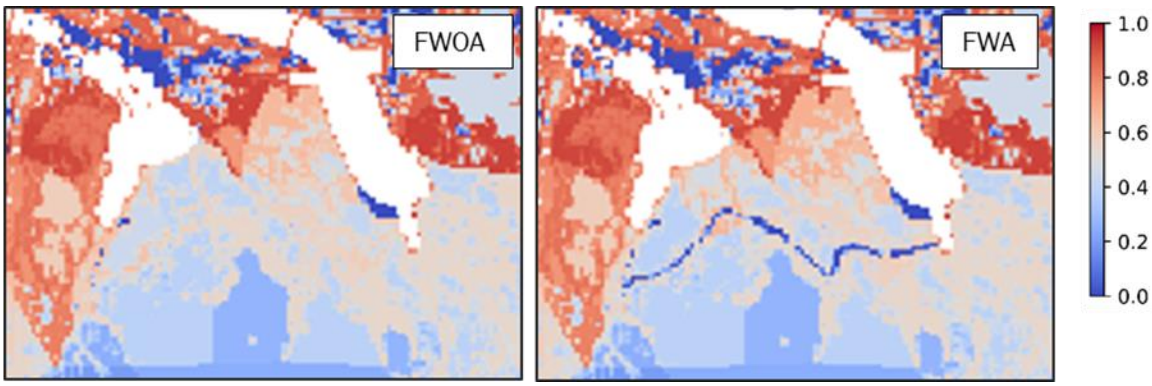


Figure 123. Juvenile blue crab HSI scores across Terrebonne Basin for Year 20 of FWOA and Eastern Terrebonne Basin Landbridge full project (FWA) S08 environmental scenario simulations. Scores range from 0.0, completely unsuitable habitat, to 1.0, optimal habitat.

Otherwise, the project's effect on the salinity regime only had minor effects on habitat suitability. This was because even though the project generally reduced mean annual salinities by up to 5 ppt in areas north of the project alignment, conditions were still relatively saline (>10 ppt) and thus higher than optimal for most of the species in the analysis. Nonetheless, these areas became slightly more suitable for species associated with low salinities (i.e., <5 ppt), such as juvenile blue crab (Figure 123), and slightly less suitable for higher-salinity species, such as brown shrimp. However, there was one area near the western end of the project where salinities increased as a result of the project, and this caused a localized decrease in habitat suitability for nearly all fish and shellfish. These salinity effects diminished over time due to SLR, and as a result there was little difference in habitat suitability between the project and FWOA during the latter part of the simulations.

The individual components of the Eastern Terrebonne Basin Landbridge project, i.e., eastern, central, and western, similarly had minor effects on habitat suitability for fish, shellfish, and wildlife. In general, the central and western components resulted in very small changes in habitat suitability primarily in the early part of the simulations. The effects of the eastern component, however, were more notable. The eastern component (in combination with the ridge restoration associated with each component) reduced salinities by up to 5 ppt across a larger area of Eastern Terrebonne than the full landbridge project. As a result, there was a greater increase in the suitability of this area for low-salinity species as compared to the full project (Figure 123 and Figure 124).

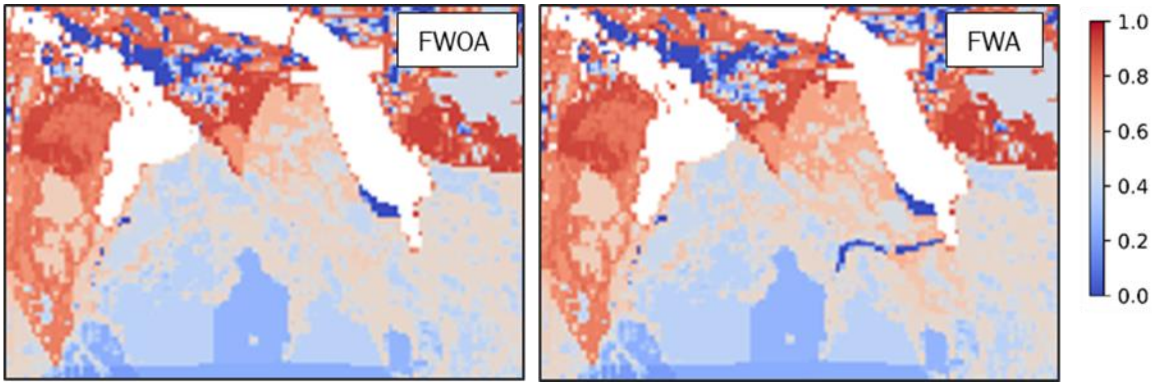


Figure 124. Juvenile blue crab HSI scores across Terrebonne Basin for Year 20 of FWOA and Eastern Terrebonne Basin Landbridge – East (FWA) higher environmental scenario simulations. Scores range from 0.0, completely unsuitable habitat, to 1.0, optimal habitat.

6.0 AMA SEDIMENT DIVERSION AND EDGARD DIVERSION

PROJECTS OVERVIEW

This report describes the modeling results for two diversion projects into the upper Barataria Basin, with different characteristics and operating regimes: the Ama Sediment Diversion project (# 243) and the Edgard Diversion project (#323).

The Ama Sediment Diversion moves freshwater and sediment into upper Barataria near Ama (Figure 125) to provide sediment for emergent marsh creation and freshwater to sustain existing wetlands. The maximum capacity is 50,000 cfs, and it is modeled at 50,000 cfs when the Mississippi River flow equals 1,000,000 cfs; open with a variable flow rate calculated using a linear function from 0 to 50,000 cfs for river flow between 200,000 cfs and 1,000,000 cfs; constant flow rate of 50,000 cfs for river flow above 1,000,000 cfs; and no operation below 200,000 cfs (Figure 125). The project is fully constructed and operational at Year 9 and was modeled in G613. The project was also not selected in IP1 and was not modeled in IP2 as it will become part of the Upper Basins Diversion Program for the 2023 Coastal Master Plan.

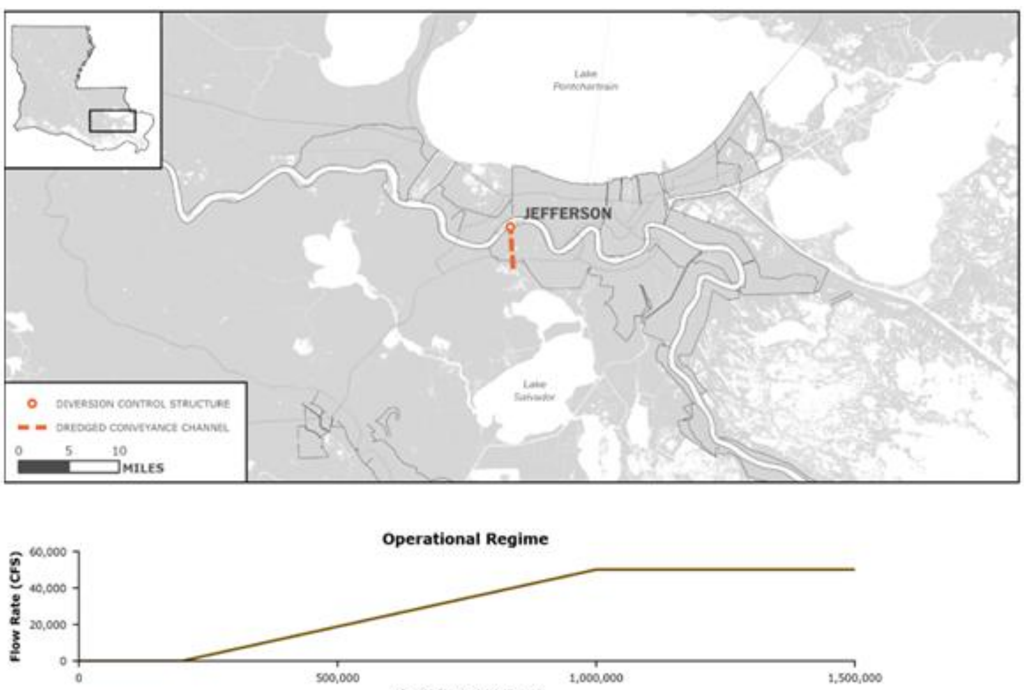


Figure 125. Location and operating regime of the Ama Sediment Diversion.

The project cost is $1.04 billion in IP1. The cost of the project does not vary by scenario as no marsh creation is included.

The Edgard Diversion also moves water and sediment from the Mississippi River into the upper Barataria Basin (Figure 126). The purpose of the project is to provide sediment for emergent marsh creation and freshwater and fine sediment to sustain existing wetlands and to provide flood control in high river conditions. The maximum capacity is 35,000 cfs, and it is modeled at 25,000 cfs when Mississippi River flow equals 600,000 cfs; open with a variable flow rate calculated using a linear function from 0 to 25,000 cfs for river flow between 200,000 cfs and 600,000 cfs; no flow between 600,000 cfs and 1,250,000 cfs; constant flow rate of 35,000 cfs when river is above 1,250,000 cfs; and no operation below 200,000 cfs (Figure 126).

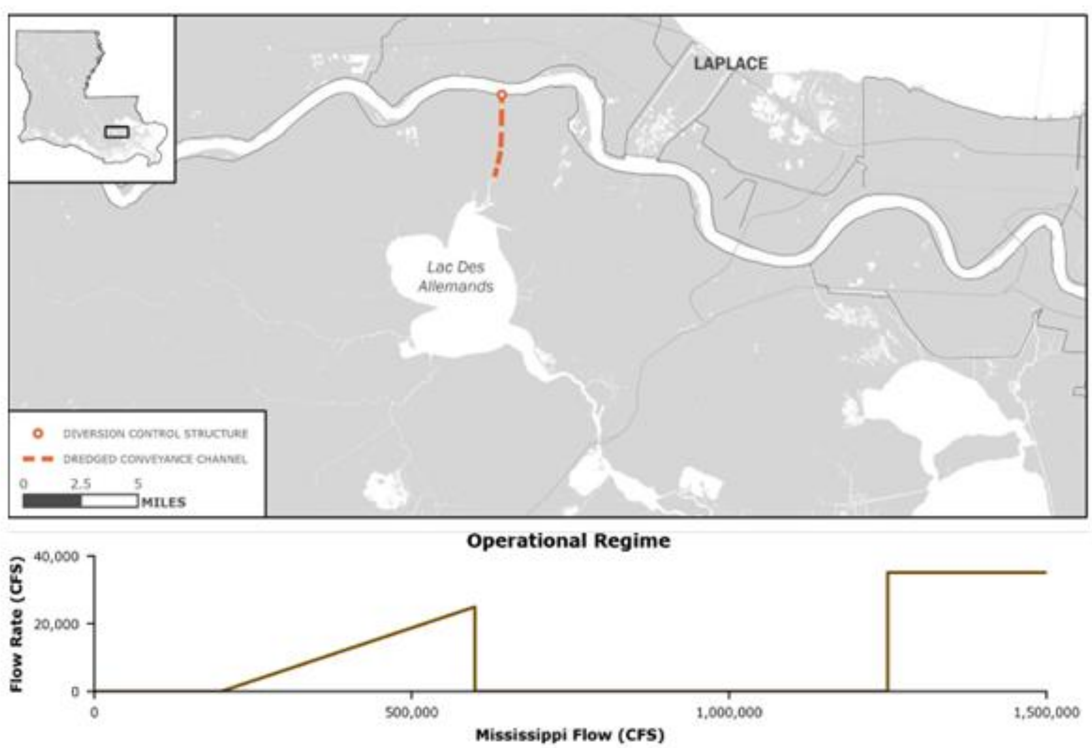


Figure 126. The location and operating regime of the Edgard Diversion.

The project is fully constructed and operational at Year 9 and was modeled in G605. The project was not selected in IP1 and was modeled in IP2, but not selected. It will also become part of the Upper Basins Diversion Program for the 2023 Coastal Master Plan. The project cost is $625 million in IP1. The cost of the project does not vary by scenario as no marsh creation is included.

The results presented here discuss the way in which the projects change the coastal landscape in terms of hydrology, morphology, vegetation, and habitats, with examples from the two environmental scenarios. The examples have been selected to illustrate the dynamics of the project based on available data, rather than to provide a comprehensive description of all areas, scenarios, and implementation period comparisons.

HYDROLOGY

These two diversion projects are designed to provide freshwater and sediments to the outfall regions, impacting the water level, salinity, and sediment supplies in the receiving basins. At the same time, the flow downstream of these projects will be reduced due to the operation of these projects.

STAGE

The Ama Sediment Diversion substantially impacts mean annual inundation depths across the entirety of upper Barataria, with increases ranging from up to 0.5 m in the immediate outfall area to 0.1-0.25 m in the remainder of upper Barataria (Figure 127). This effect can also be recognized from the annual mean water level time series for Lake Cataouatche (Figure 128), indicating a consistent water level increase varying from about 30 cm directly post-construction reducing to around 20 cm in later decades, indicating that FWA versus FWOA water level differences slightly decrease over time. Annual water level variability increases up to around 7.5 cm in the same area as shown in Figure 130; this increase also slightly decreases over time.

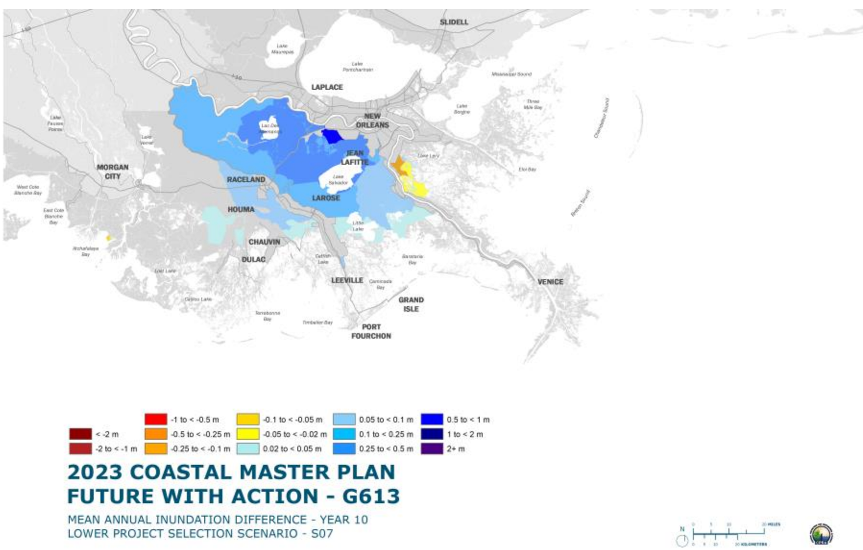


Figure 127. Difference map of mean annual inundation depth between FWOA (G500) and FWA (G613) for the Ama Sediment Diversion at Year 10 of the lower (S07) scenario, indicating a significant increase of mean annual inundation depths resulting from the operation of the Ama Sediment Diversion, ranging from 0.25 m to 0.5 m in the immediate outfall area, to 0.1 to 0.25 in most of upper Barataria, and up to 0.1 m in parts of Mid Barataria. Similar results are found in later years and for the higher (S08) scenario.

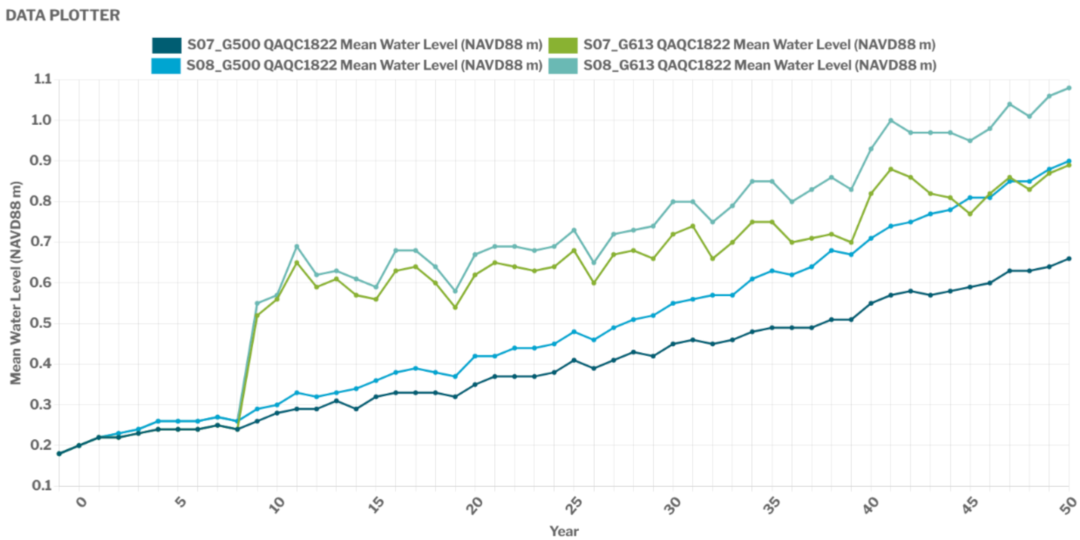


Figure 128. Annual mean water level comparison between FWOA (G500) and FWA (G613) for the Ama Sediment Diversions for lower (S07) and higher (S08) scenarios in compartment 150 (Lake Cataouatche; Figure 129), showing a mean water level increase that varies between 30 cm initially to up to 20 cm in later decades. Similar results are found for the area west of Lake Cataouatche, including Lac Des Allemands.

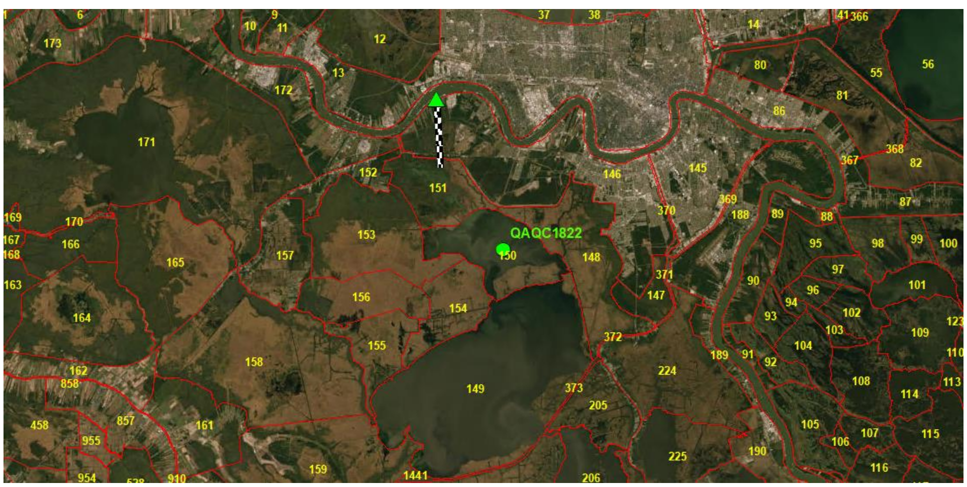


Figure 129. Map indicating the location of QAQC1822 (blue dot) in compartment 150 located within Lake Cataouatche.

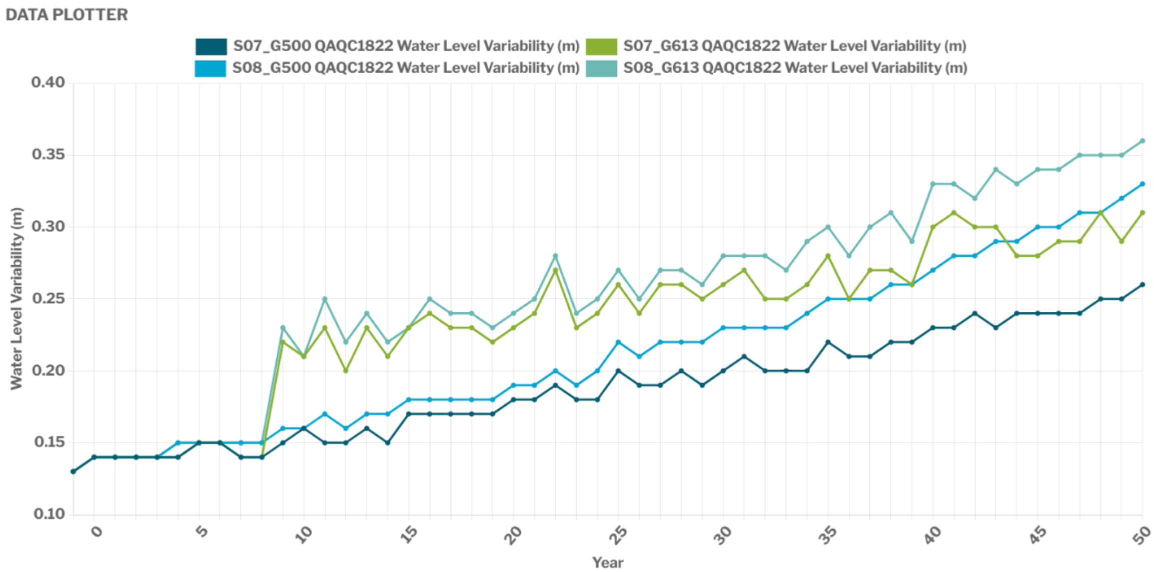


Figure 130. Annual water level variability comparison between FWOA (G500) and FWA (G613) for the Ama Sediment Diversion for lower (S07) and higher (S08) scenarios in compartment 150 (Lake Cataouatche; Figure 129), showing an annual water level variability increase up to 10 cm. Similar results are found for the area west of Lake Cataouatche, including Lac Des Allemands.

There is an increase in mean annual inundation depths of up to 10 cm in upper Barataria due to the operation of the Edgard Diversion (Figure 131). FWA versus FWOA differences in mean annual inundation depths for the two diversions remain consistent across the region over time. Compared to the Ama Sediment Diversion (Figure 132) impacts from the Edgard Diversion on water levels are less pronounced albeit still noticeable (Figure 133). Annual mean water level time series confirm this by showing an increase of up to about 20 cm in Lac Des Allemands for FWA (Figure 134). Annual water level variability increases up to 5 cm in the same area as shown in Figure 136. The FWA versus FWOA differences in mean annual inundation depths and water level variability remain consistent over time (Figure 134 and Figure 136) and space (Figure 131 and Figure 133).

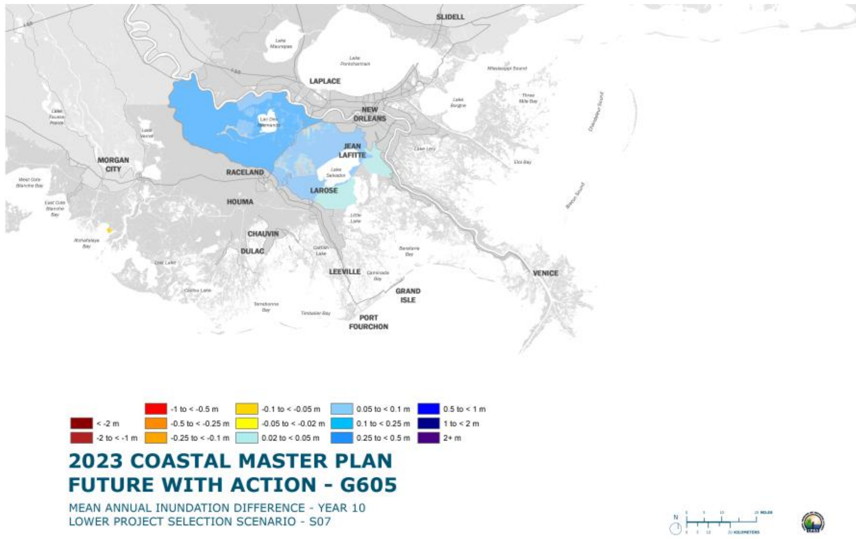


Figure 131. Difference map of mean annual inundation depth between FWOA (G500) and FWA (G605) at Year 10 of the lower (S07) scenario, indicating a significant increase of mean annual inundation depths resulting from the operation of the diversion, ranging up to 0.1 m most of upper Barataria. Similar results are found in later years and for the higher (S08) scenario.

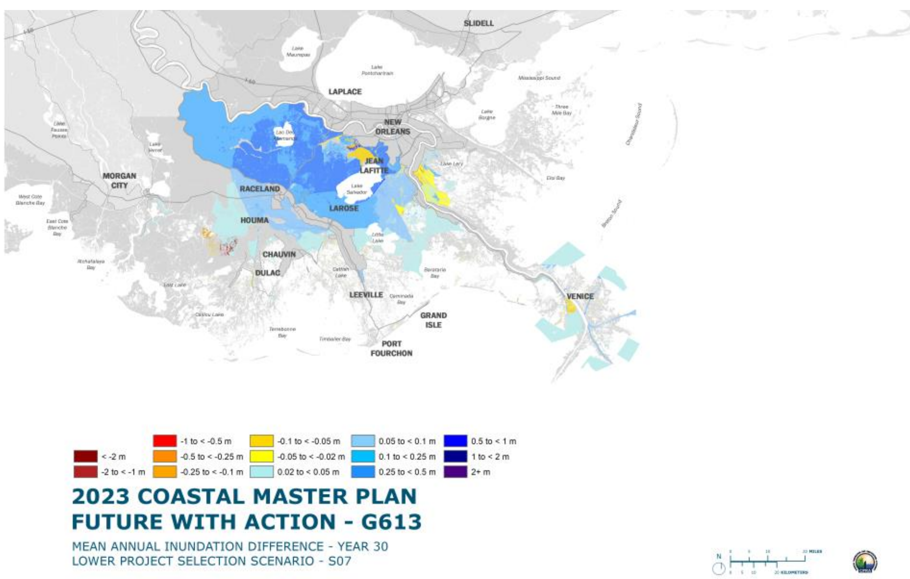


Figure 132. Difference map of mean annual inundation depth between FWOA (G500) and FWA (G605) for the Ama Sediment Diversion at Year 30 of the lower (S07) scenario, indicating a similar magnitude and extent of inundation changes as shown for Year 15 for the Ama Sediment Diversion in Figure 127.

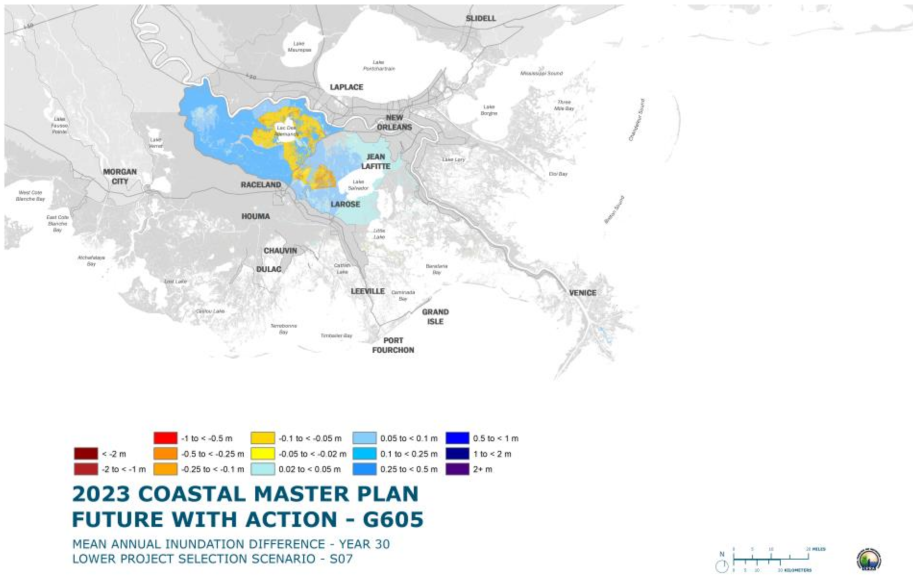


Figure 133. Difference map of mean annual inundation depth between FWOA (G500) and FWA (G605) at Year 30 of the lower (S07) scenario, indicating a similar magnitude and extent of inundation changes as shown for Year 15 in Figure 131, outside of the Lake Cataouatche area where elevation changes are found.

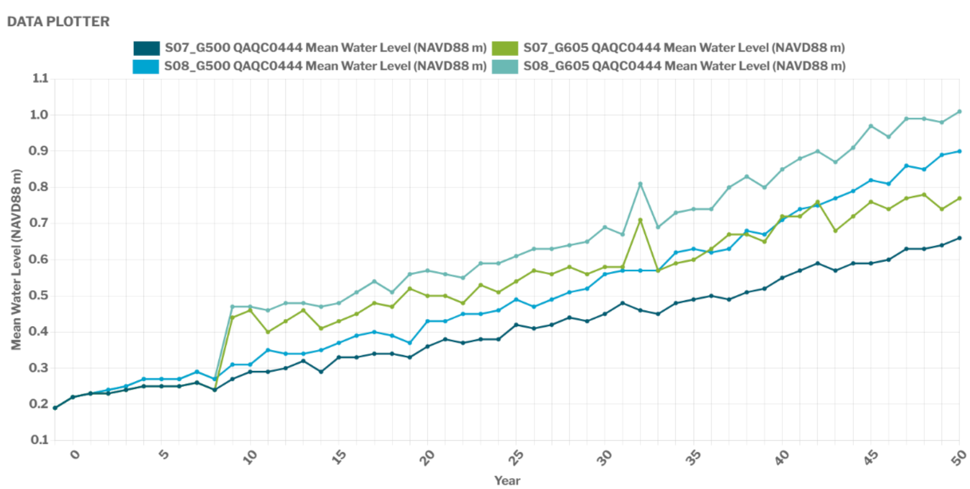


Figure 134. Annual mean water level comparison between FWOA (G500) and FWA (G605) for lower (S07) and higher (S08) scenarios in compartment 171 (Lac Des Allemands; Figure 135), showing a mean water level increase of up to 20 cm.

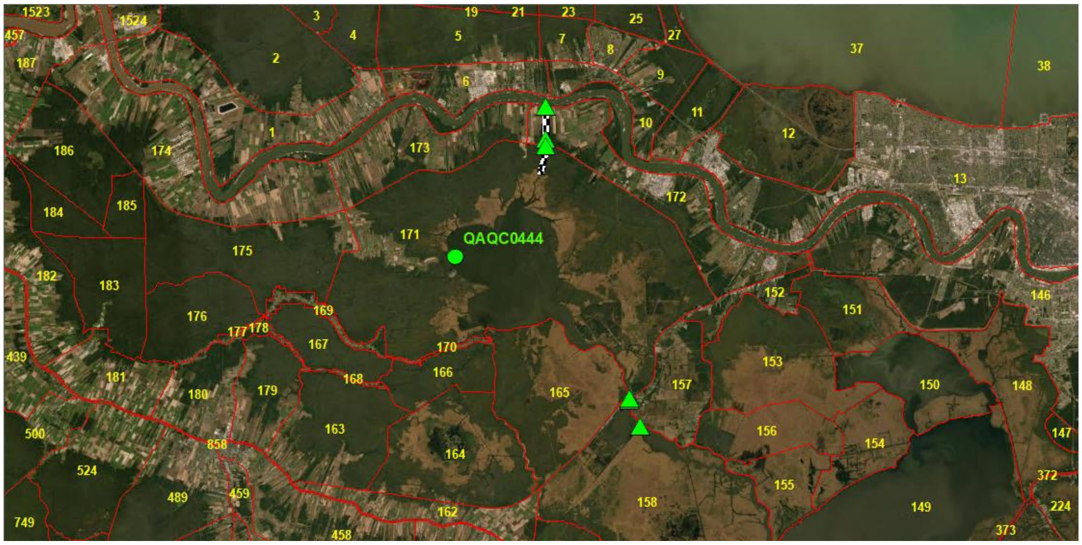


Figure 135. Map indicating the location of QAQC0444 (green dot) in compartment 171, located within Lac Des Allemands.

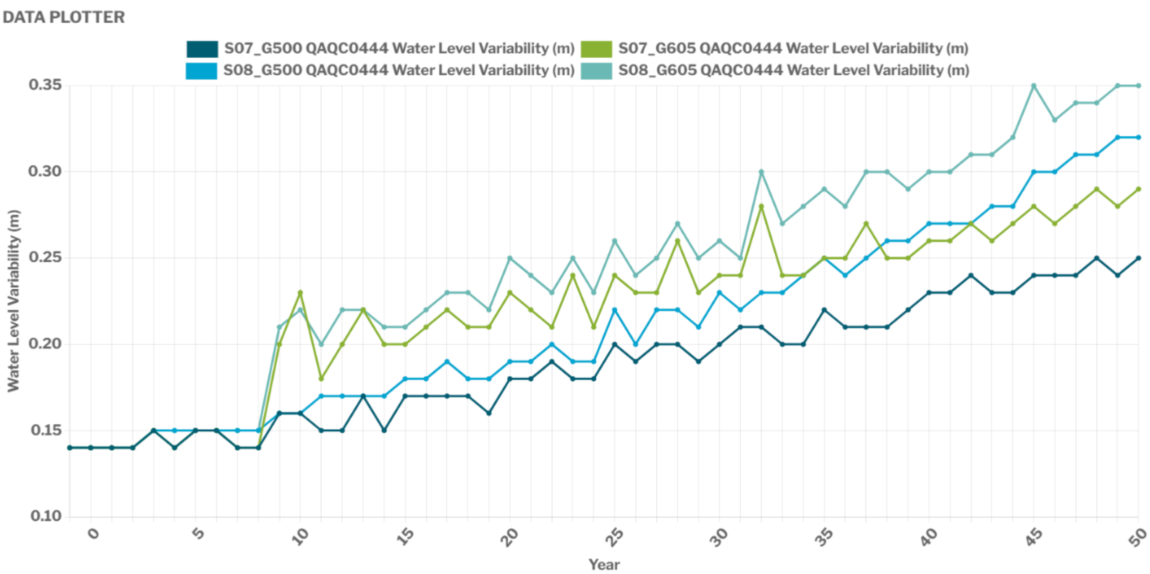


Figure 136. Annual water level variability comparison between FWOA (G500) and FWA (G605) for lower (S07) and higher (S08) scenarios in compartment 171 (Lac Des Allemands; Figure 135), showing an annual water level variability increase up to 5 cm.

SALINITY

Salinity patterns and dynamics are affected by both diversions as shown by a significant reduction of salinity in Lower Barataria amounting up to 5 ppt for the Ama Sediment Diversion (Figure 137 and

Figure 138) and up to 2 ppt for the Edgard Diversion (Figure 140 and Figure 141). Similar effects are also found in the Terrebonne Basin. No salinity differences are found for upper Barataria because this area is typically already fresh in FWOA scenarios. A small but noticeable increase of salinity (<0.5 ppt) can be seen for the Bird's Foot Delta and Breton Sound, which is likely caused by a reduction of locally available freshwater due to upstream diversion operation. The extent and magnitude of FWA versus FWOA differences in mean annual salinity remain consistent over time (Figure 137 and Figure 142) for the Ama Sediment Diversion and for the Edgard Diversion (Figure 140 and Figure 143).

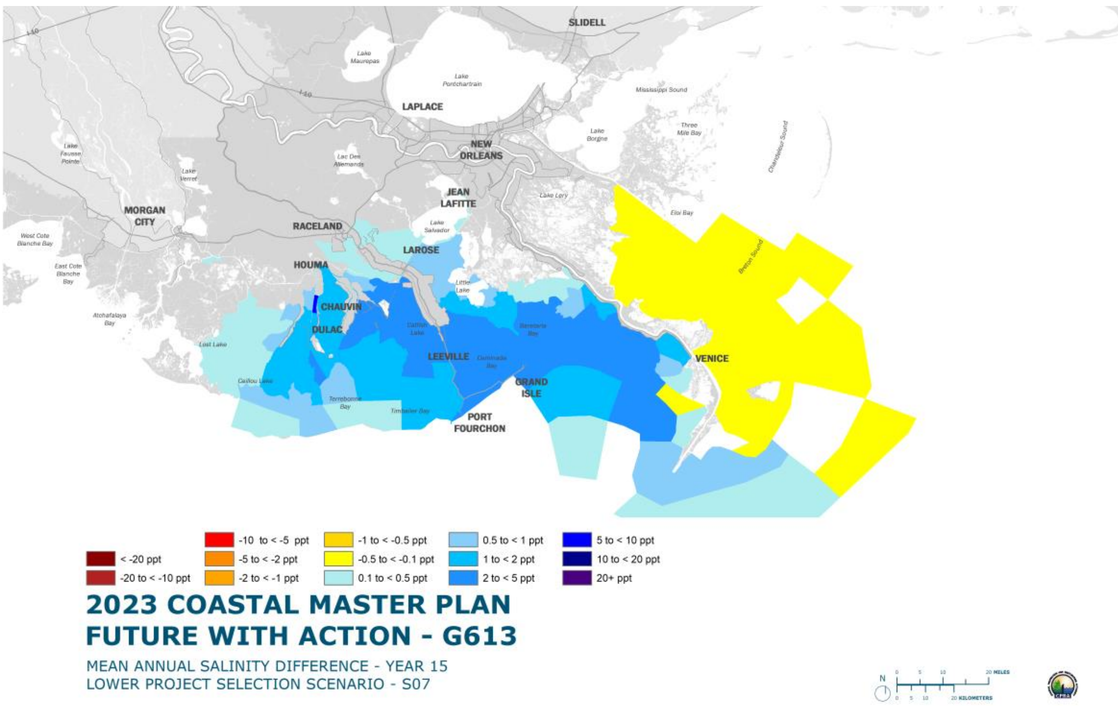


Figure 137. Difference map of mean annual salinity between FWOA (G500) and FWA (G613) at Year 15 of the lower (S07) scenario, indicating a significant salinity decrease amounting up to 5 ppt in the Terrebonne and Lower Barataria basins due to operation of the Ama Sediment Diversion. Contrastingly, a slight salinity decrease amounting up to 0.5 ppt is found for the Bird's Foot Delta and Breton Sound areas, due to reduced freshwater volumes resulting from upstream diversion operation.

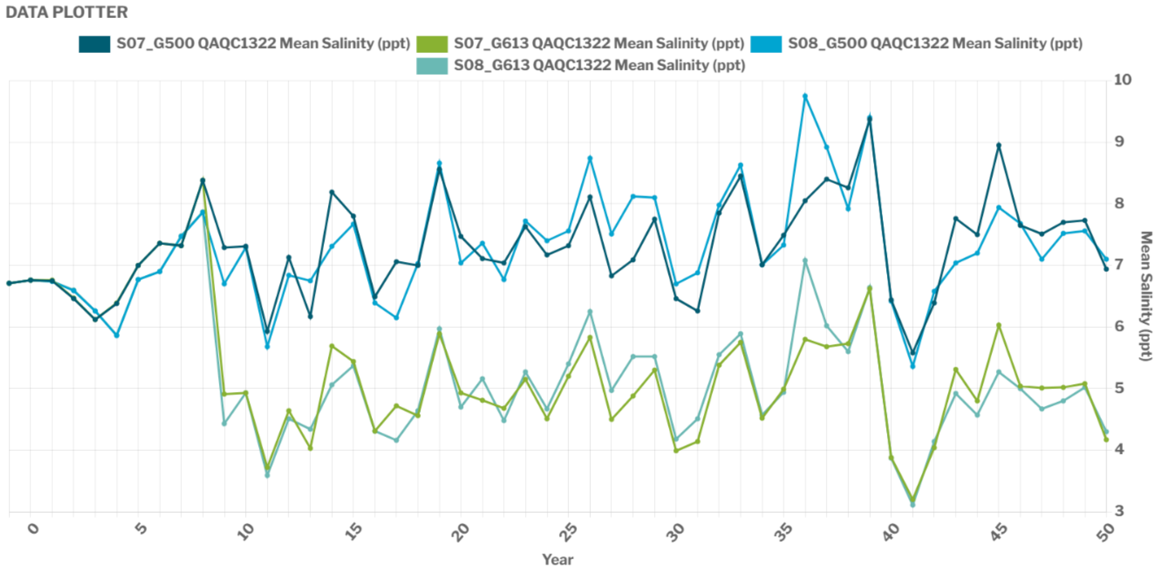


Figure 138. Annual mean salinity comparison between FWOA (G500) and FWA (G613) for lower (S07) and higher (S08) scenarios in compartment 249 located in Barataria Bay (location indicated in Figure 139), showing the 2-3 ppt salinity reduction in Barataria Bay resulting from the operation of the Ama Sediment Diversion.

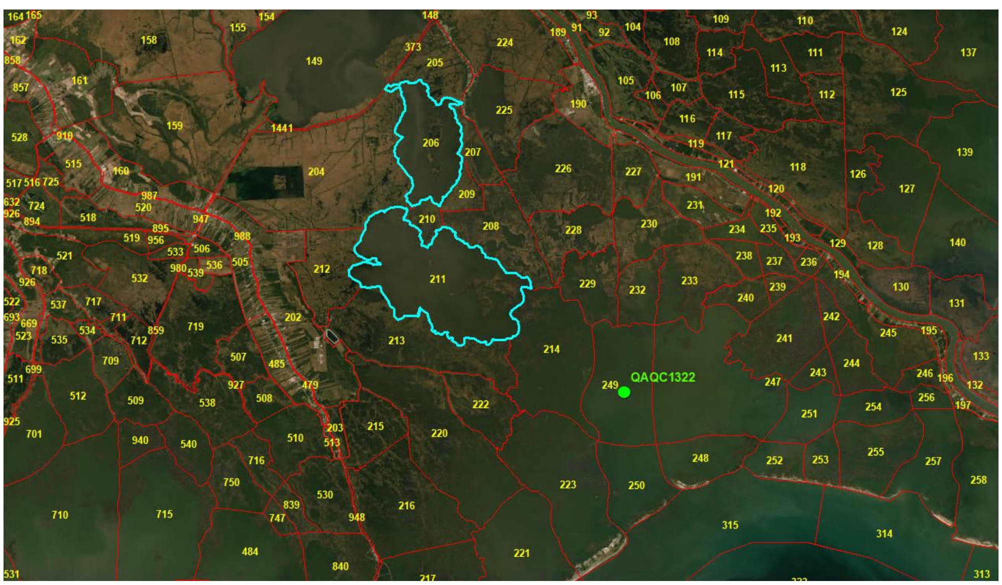


Figure 139. Map indicating the location of QAQC1322 (green dot) in compartment 249, located within Barataria Bay. Compartments 206 and 211 are highlighted.

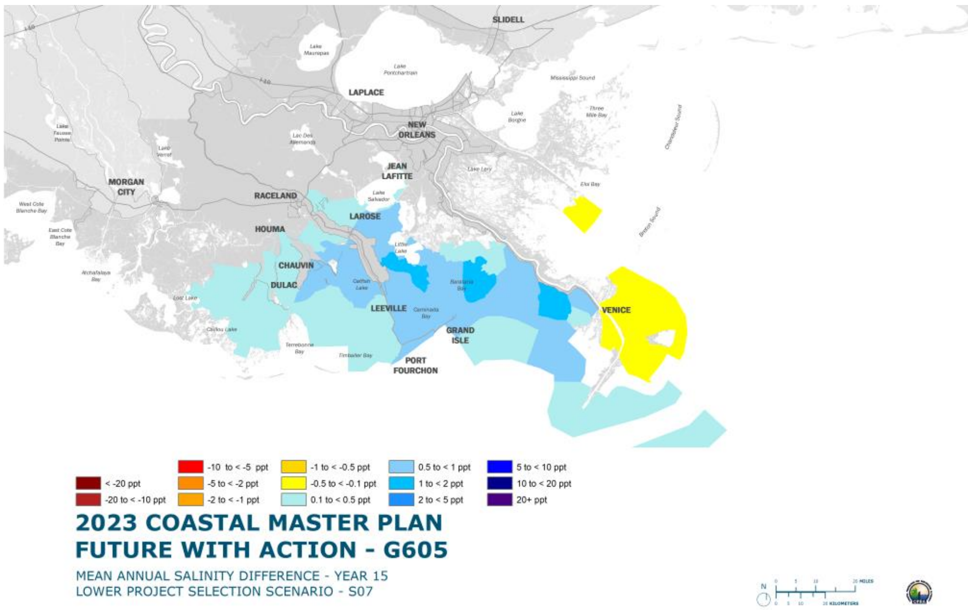


Figure 140. Difference map of mean annual salinity between FWOA (G500) and FWA (G605) at Year 15 of the lower (S07) scenario, indicating a significant salinity decrease amounting up to 2 ppt in the Terrebonne and Lower Barataria basins due to operation of the Edgard Diversion. Contrastingly, a slight salinity decrease amounting up to 0.5 ppt is found for the Bird’s Foot Delta and Breton Sound areas, due to reduced freshwater volumes resulting from upstream diversion operation.

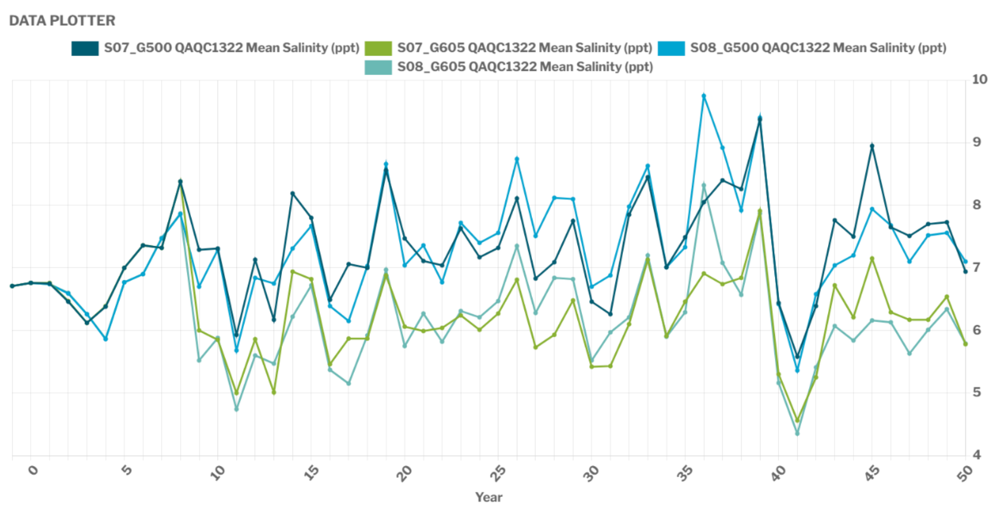


Figure 141. Annual mean salinity comparison between FWOA (G500) and FWA (G605) for lower (S07) and higher (S08) scenarios in compartment 249 located in Barataria Bay (location indicated in Figure 139), showing the 1-2 ppt salinity reduction in Barataria Bay resulting from the operation of the Edgard Diversion.

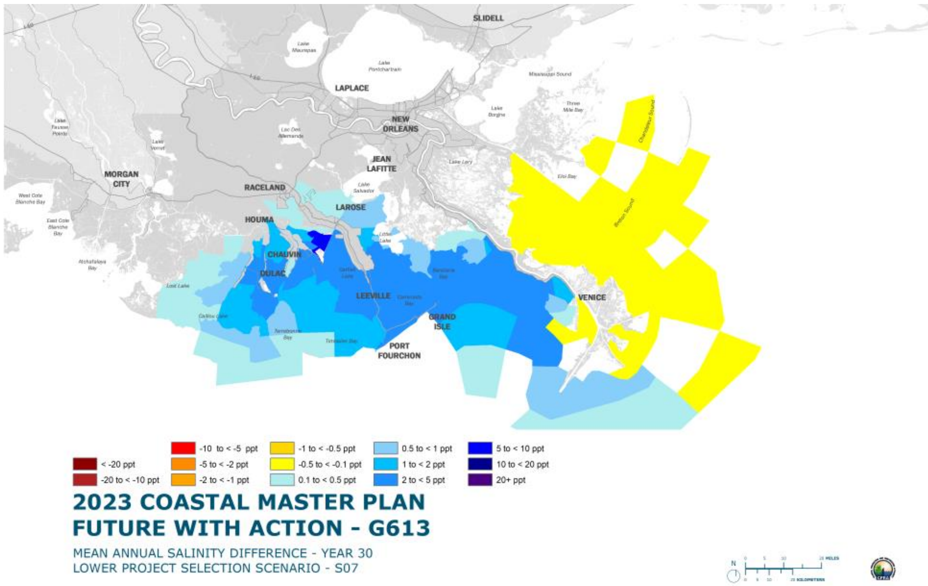


Figure 142. Difference map of mean annual salinity between FWOA (G500) and FWA (G613) at Year 30 of the lower (S07) scenario, indicating a similar magnitude and extent of salinity changes as shown for Year 15 in Figure 137.

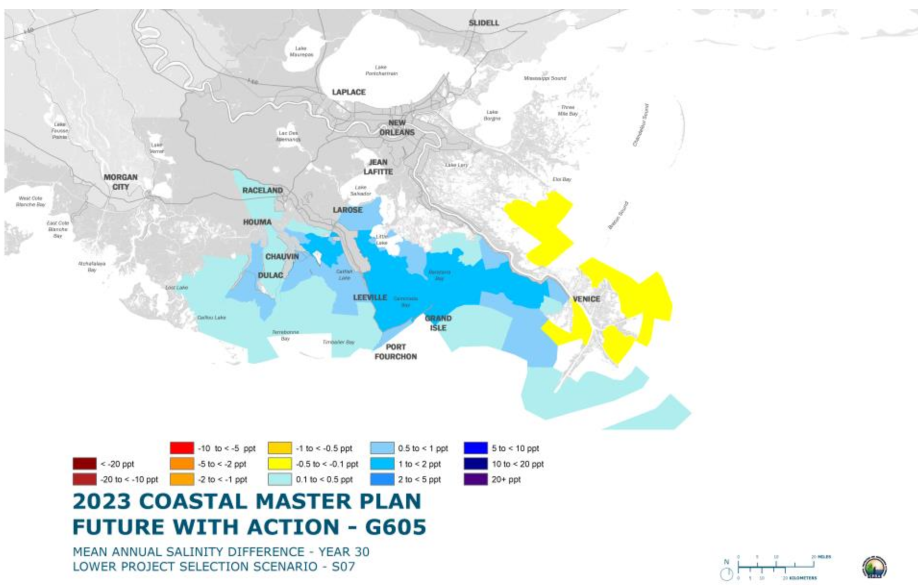


Figure 143. Difference map of mean annual salinity between FWOA (G500) and FWA (G605) at Year 30 of the lower (S07) scenario, indicating a similar magnitude and extent of salinity changes as shown for Year 15 in Figure 140.

The effect of the diversions on the maximum two-week mean salinity are illustrated for the Ama Sediment Diversion. Figure 144 illustrates the impacts of the diversion on maximum two-week mean salinities in the Barataria Basin and beyond. UBA and MBA ecoregions are mostly fresh during the 50-year simulation in FWOA, so the additional freshwater from the diversion does not impact salinities that much until the final decades when some intrusion is prevented as shown in Figure 145 for salinities at Lake Salvador (QAQC1810). Instead, the Ama Sediment Diversion reduces salinities broadly across the lower Barataria Basin. With operation of the diversion lowering the residual Mississippi River flows slightly, there is a slight increase in salinities to the east of the Bird's Foot due to reduced outflows.

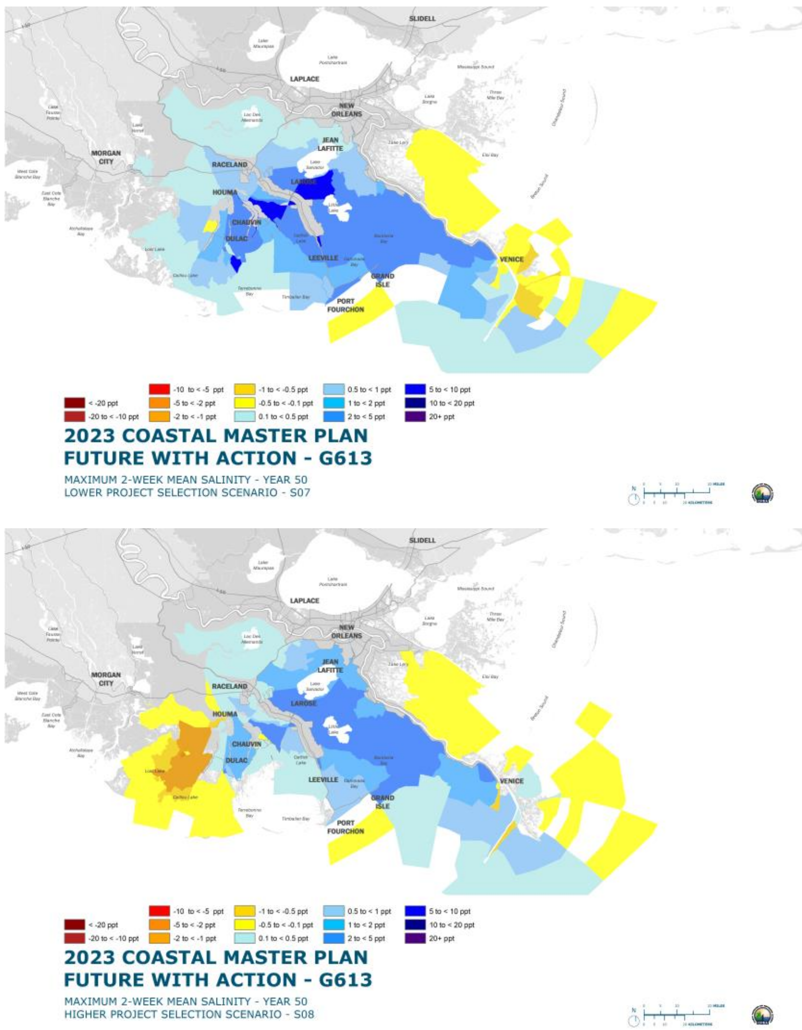


Figure 144. Maximum 2-week mean salinity differences (FWA-FWOA) in Year 50 due to the Ama Sediment Diversion for lower (upper panel) and higher (lower panel) scenarios.

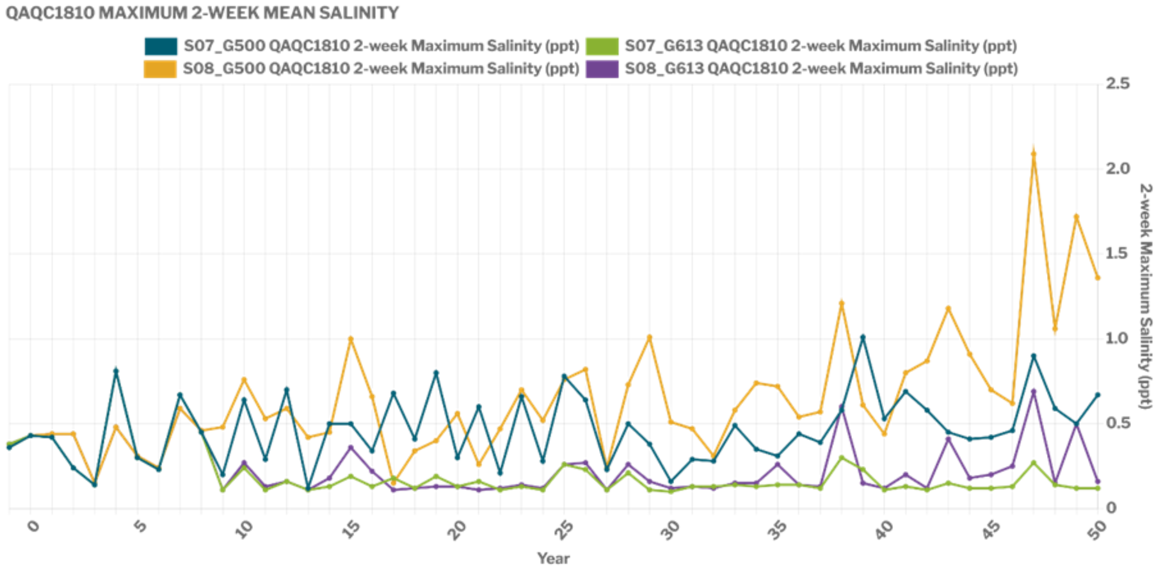


Figure 145. Maximum 2-week mean salinity at Lake Salvador QAQC1810 due to Ama Sediment Diversion.

TOTAL SUSPENDED SEDIMENT (TSS)

Mean annual TSS concentrations are significantly affected by both diversions. The Ama Sediment Diversion most noticeably impacts the immediate outfall area, for Lake Cataouatche (Figure 146) where concentrations increase by 10-20 mg/L. This increase remains consistent (i.e., does not become larger or smaller) over the years and is very similar between the lower (S07) and higher (S08) scenarios. Smaller changes in concentration are found farther away from the diversion, as far as in the Little Lake area (Figure 147), where TSS concentrations increase by 2-6 mg/L. The increase remains consistent over time also in this area. No significant concentration differences (i.e., >1 mg/L) are found in Barataria Bay for either the lower (S07) or higher (S08) scenario.

The Edgard Diversion also impacts TSS concentrations in the Barataria Basin albeit to a lesser extent than the Ama Sediment Diversion. Mean annual TSS concentrations near the immediate outfall area (Lac Des Allemands) show a 10-15 mg/L increase for FWA (Figure 148). The impact extends up to the Bayou Perot and Bayou Rigolettes area (Figure 149), where concentrations are 1-3 mg/L higher for FWA. No significant concentration differences (i.e., >1 mg/L) are found south of Bayou Perot. Similar to the Ama Sediment Diversion, the increases in TSS remain consistent over time and are similar between the lower (S07) and higher (S08) scenarios.

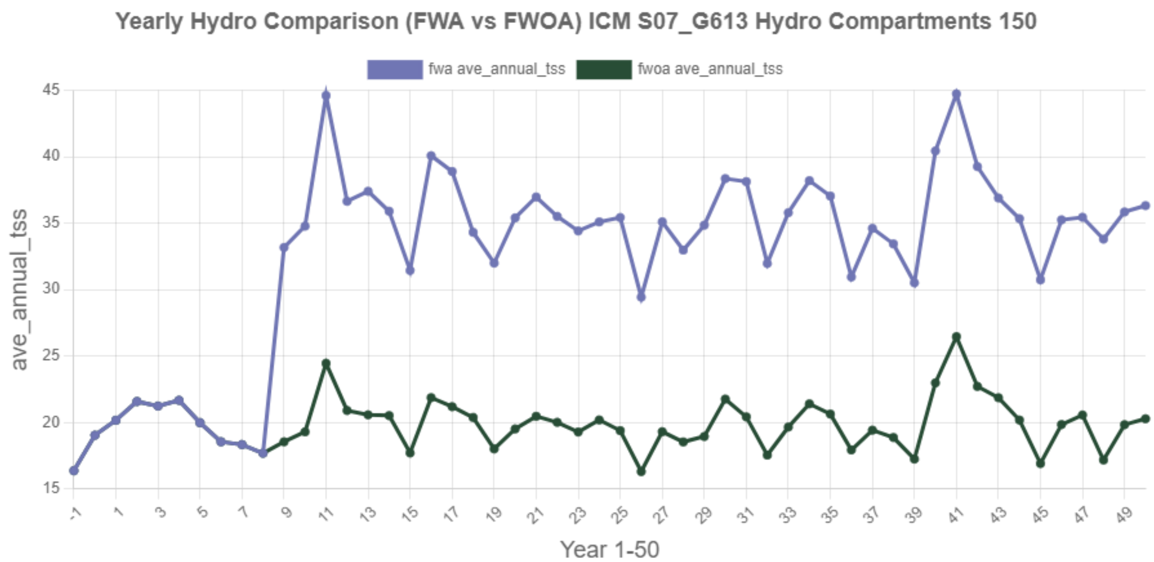


Figure 146. Mean annual TSS concentration comparison between FWOA (G500) and FWA (G613) for the lower (S07) scenarios in compartment 150 (Lake Cataouatche; Figure 129), showing a 10-20 mg/L concentration increase that remains consistent over time. Similar results are found for the higher (S08) scenario.

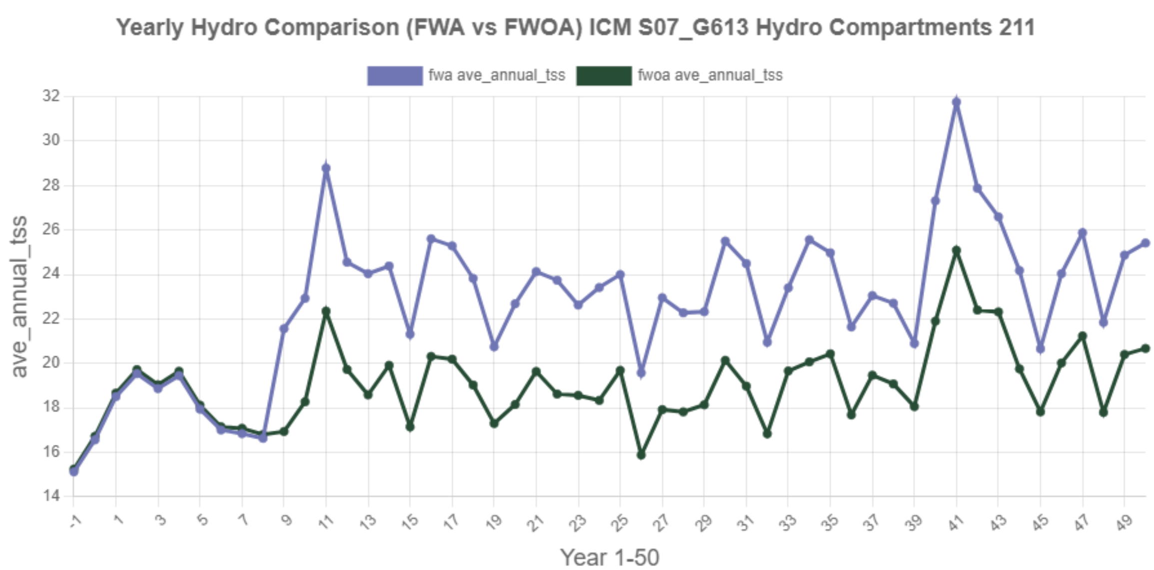


Figure 147. Mean annual TSS concentration comparison between FWOA (G500) and FWA (G613) for the lower (S07) scenarios in compartment 211 (Little Lake; Figure 139), showing a 2-6 mg/L concentration increase that remains consistent over time. Similar results are found for the higher (S08) scenario.

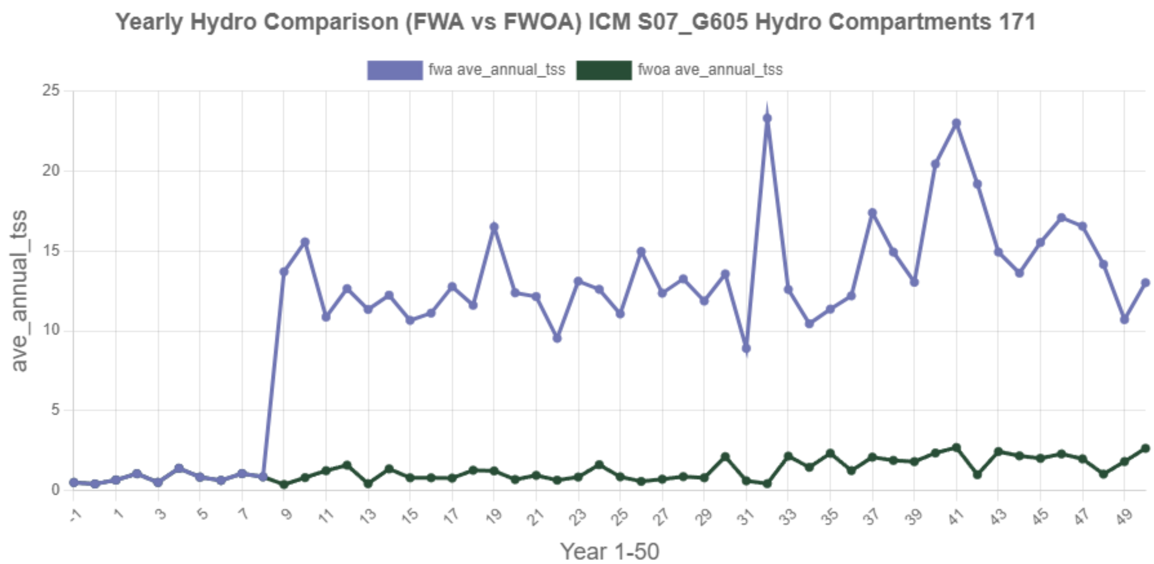


Figure 148. Mean annual TSS concentration comparison between FWOA (G500) and FWA (G605) for the lower (S07) scenarios in compartment 171 (Lac Des Allemands; Figure 135), showing a 10-15 mg/L concentration increase that remains consistent over time. Similar results are found for the higher (S08) scenario.

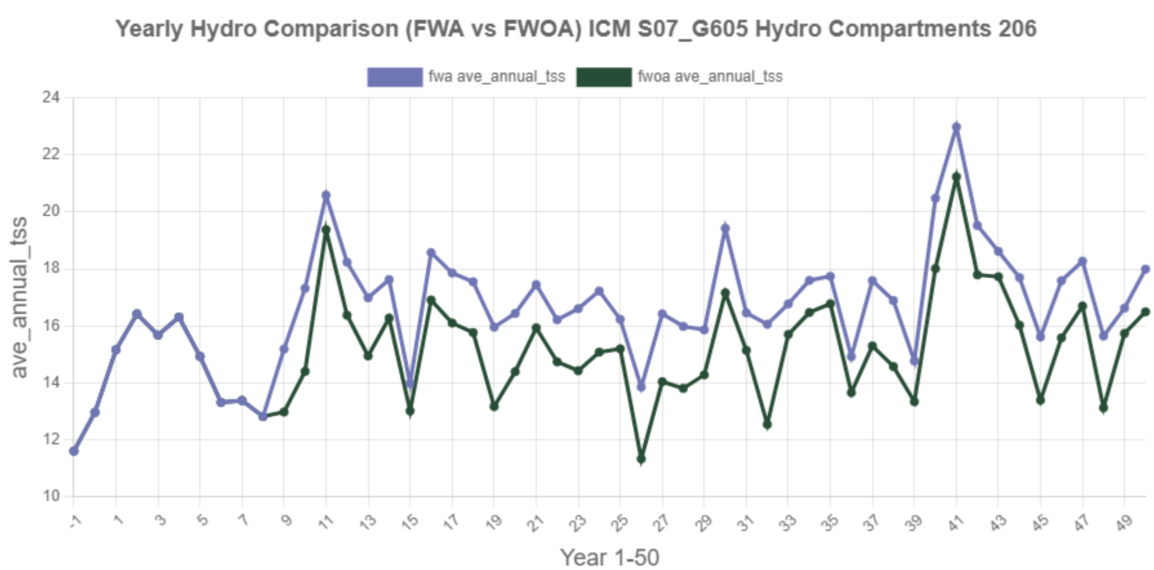


Figure 149. Mean annual TSS concentration comparison between FWOA (G500) and FWA (G605) for the lower (S07) scenarios in compartment 206 (Bayou Perot and Bayou Rigolettes; Figure 139), showing a 1-3 mg/L concentration increase that remains consistent over time. Similar results are found for the higher (S08) scenario.

MORPHOLOGY

The Ama Sediment Diversion and Edgard Diversion have mixed results depending on the scenario (Table 8). The Ama Sediment Diversion results in a net loss in both scenarios, but the loss in the higher scenario is an order of magnitude greater. For the Edgard Diversion, the changes are small but with opposite outcomes: a net gain in the lower scenario and a net loss in the higher scenario. The dynamics that create these outcomes vary over time (Figure 150) and location.

Table 10. Net effect of the projects (FWA-FWOA) by scenario in terms of AAL and net land at Year 50

	Average Annual Net Land (km^2)		Net Land at Year 50 (km^2)	
Scenario	Lower	Higher	Lower	Higher
Ama Sediment Diversion	-35.8	-130.4	-44.1	-381.2
Edgard Diversion	1.9	-1.7	20.9	-12.7

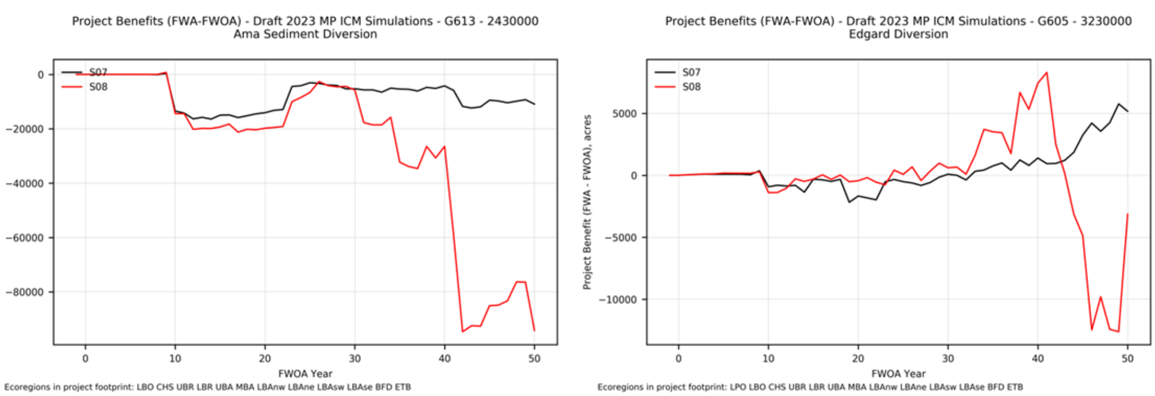


Figure 150. Net land (FWA-FWOA) over time for the two projects.

For the Ama Sediment Diversion, there is immediate land loss close to the outfall due to the increased inundation (dip in both scenarios at Year 10), but this area starts to revegetate in Year 23. Examining the elevation at a point 1.22 km from the outfall (TRNS0901; Figure 151), it is clear that even for points that convert to open water and back to vegetated land, the elevation remains on a positive trajectory due to increased mineral accretion, and the project causes a large increase in elevation (0.81 and 0.75 m difference in Year 50 for lower and higher scenarios, respectively). Since this area remains land in FWOA scenarios, it is not considered land gained, but the elevation is greater.

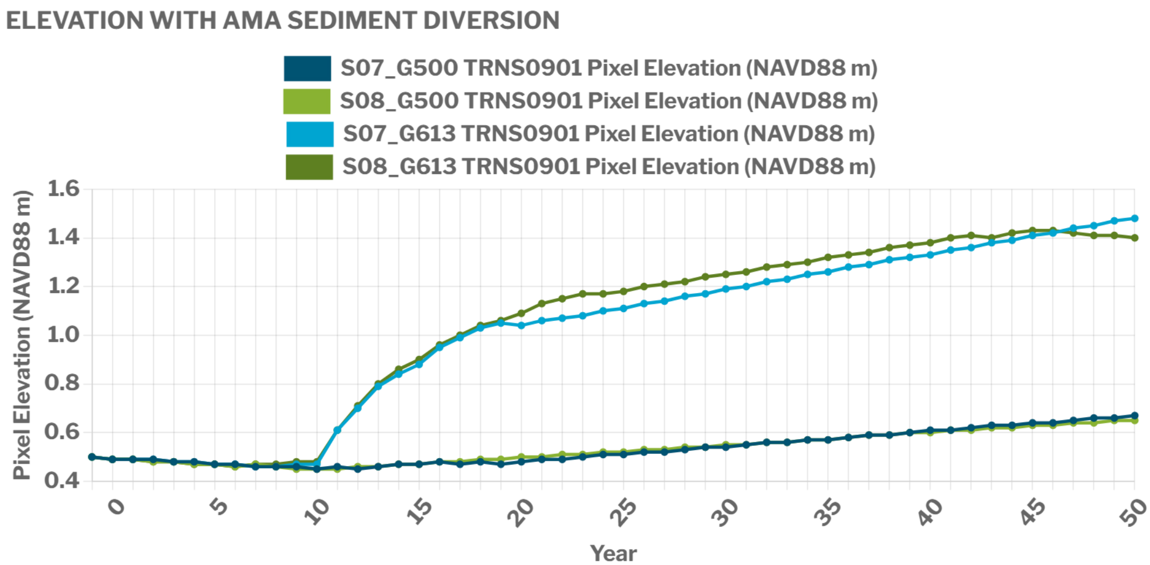


Figure 151. Surface elevation at TRNS901 near the outfall of the Ama Sediment Diversion for both the higher and lower scenarios compared to FWOA.

There are similar dynamics but less dramatic changes in the outfall of the Edgard Diversion. The inundation increases with the project but does not cause widespread land loss, and the elevation gain is smaller. The point shown in Figure 152 (QAQC0490) is 195 m from the outfall and ends with 0.3 m and 0.35 m greater elevation in the lower and higher scenario, respectively, as compared to FWOA. In all cases shown, the point remains vegetated land.

ELEVATION IN EDGARD DIVERSION OUTFALL

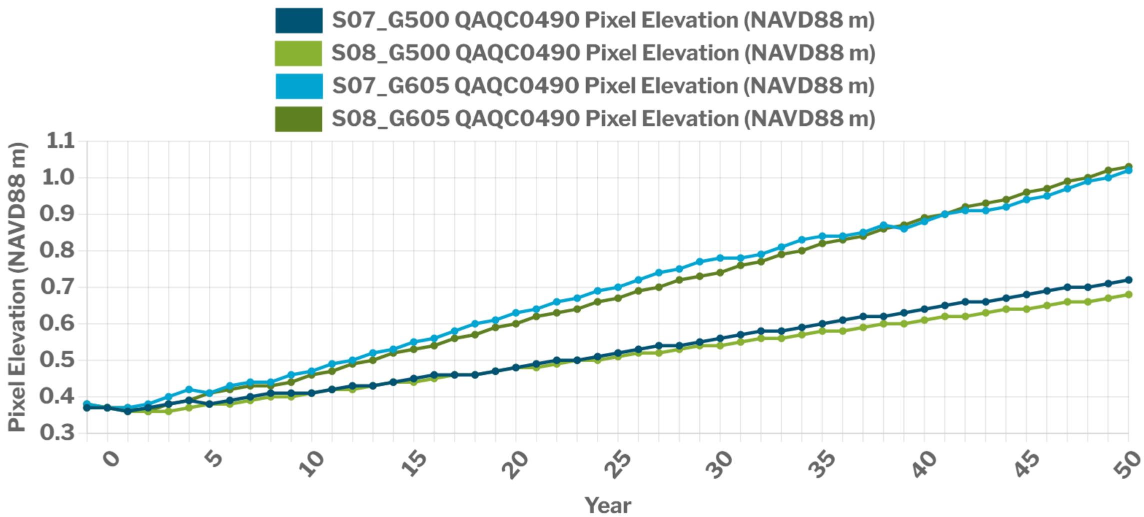


Figure 152. Surface elevation at QAQC0490 near the outfall of the Edgard Diversion for both the higher and lower scenarios compared to FWOA.

Farther down the Barataria Basin, there is additional land loss with the projects, which is driven by greater inundation and is amplified by the higher scenario conditions. The loss is greatest with the Ama Sediment Diversion in the higher scenario. Figure 153 shows the inundation at an example location (QAQC1823) north of Lake Salvador in the higher scenario. This point has a small inundation increase (7 cm) from Edgard Diversion, which allows it to remain land, and a moderate increase (24 cm) from Ama Sediment Diversion, which leads to conversion to open water in Year 42.

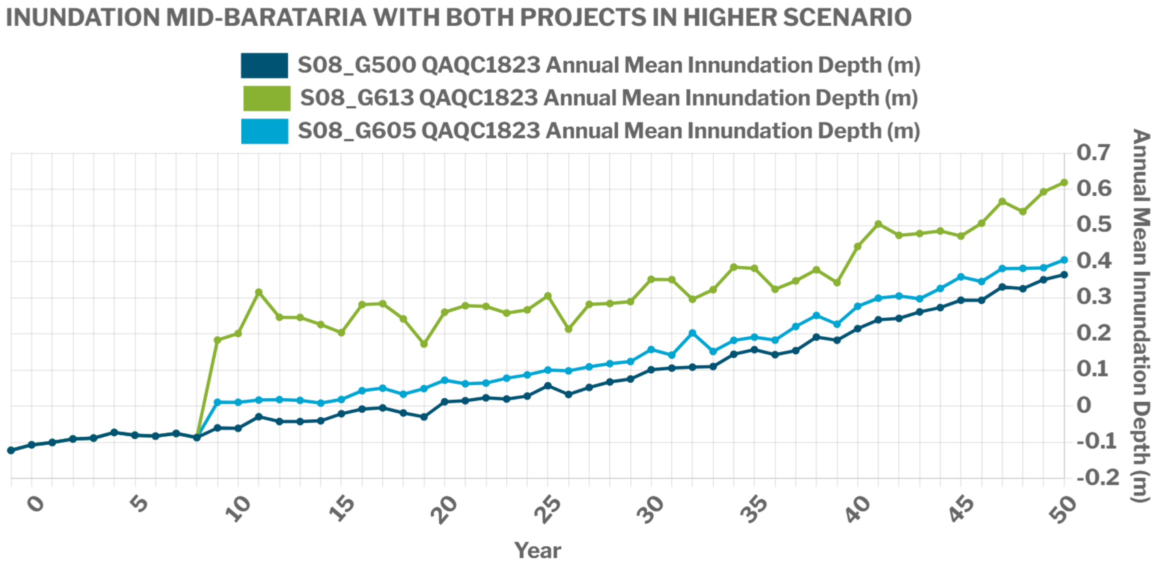


Figure 153. Inundation in the Mid-Barataria Basin at QAQC1823 (north of Lake Salvador) for FWOA, the Ama Sediment Diversion (G613), and the Edgard Diversion (G605) for the higher scenario.

Both projects prevent a minor amount of land loss in the Lower Barataria ecoregions. For the four Lower Barataria ecoregions, the Ama Sediment Diversion increases AAL by 2.6 and 10.4 km^2/yr for the lower and higher scenarios respectively, and Edgard increases AAL by 5.6 and 10.4 km^2/yr. This is mainly because they keep the area fresher, maintaining a higher organic accretion rate. Unlike the Mid Barataria ecoregion, the salinity in this area increases without the projects. The higher organic accretion is seen in both scenarios with the projects, but the inundation is too great in the higher scenario to prevent land loss. For the Ama Sediment Diversion, the point shown in Figure 154 remains land only in the lower scenario (S07) with the Ama Sediment Diversion and converts to open water in the other conditions shown. The same land type outcomes are true for this point with the Edgard Diversion.

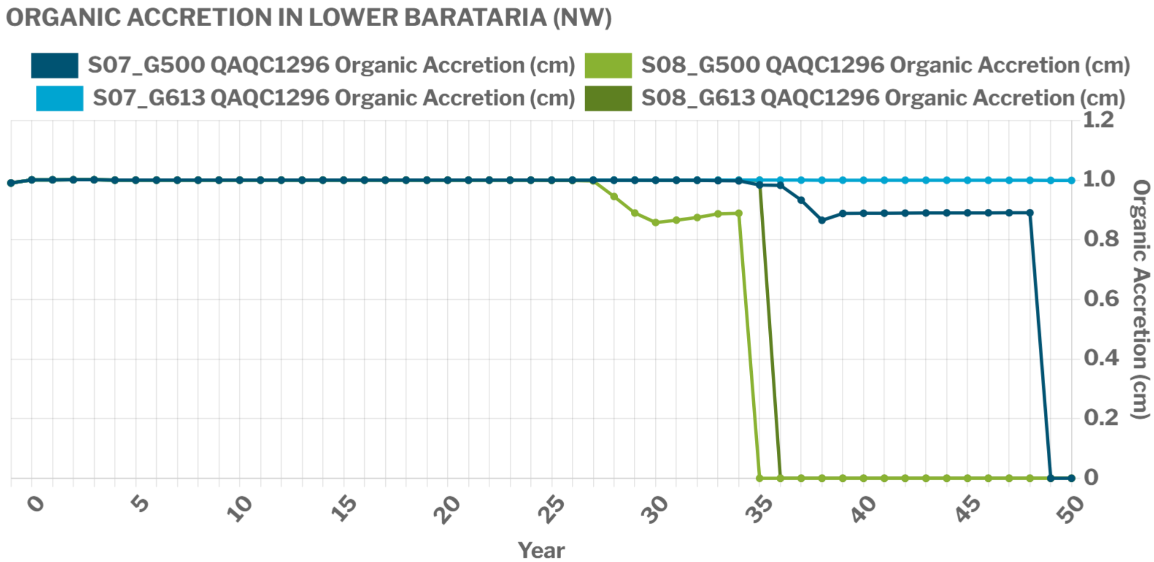


Figure 154. Organic accretion at QAQC1296, west of Little Lake, for the Ama Sediment Diversion (G613) and FWOA for the lower and higher scenarios.

The Edgard Diversion was modeled in IP2 (G656) due to its positive performance in the lower scenario. Similar dynamics occur as in IP1 with increased accretion leading to a gain in elevation (Figure 155). The elevation difference by Year 50 is about half as much as in IP1 (about 17 cm difference vs. about 30 cm difference) due to the later implementation time.

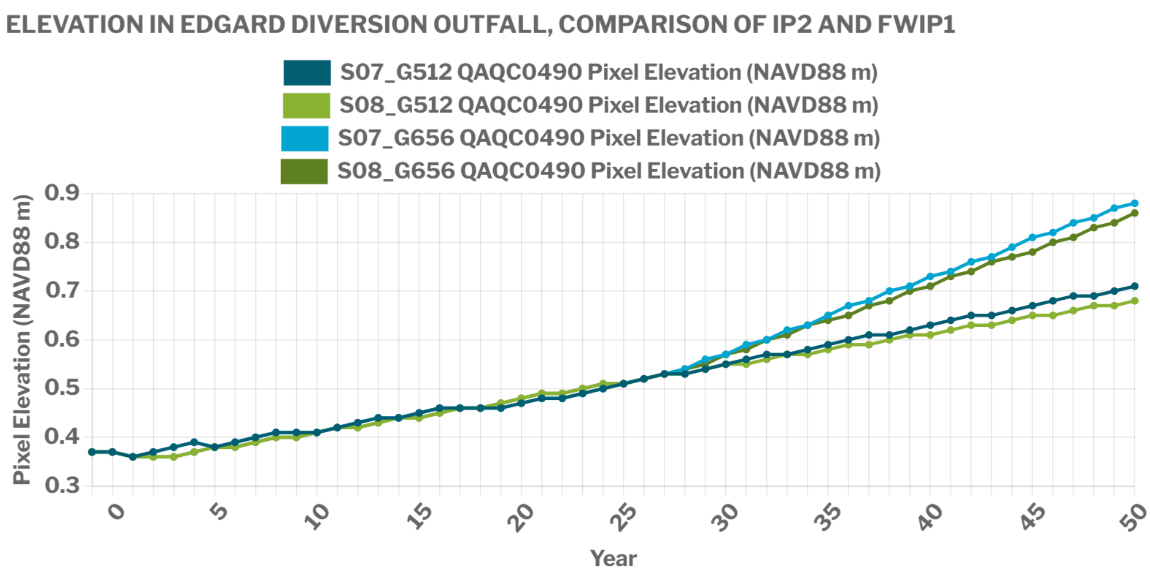


Figure 155. Surface elevation at QAQC0490 near the outfall of the Edgard Diversion in IP2 for both the higher and lower scenarios compared to FWIP1.

The area impacted largely remains land in FWIP1, and therefore, the addition of this project makes a small increase in land retained in the lower scenario (Figure 156 left) and little to no impact in the higher scenario (Figure 156 right). The nearest project included in FWIP1 is the Upper Barataria Risk Reduction project (~ 20 km south). Since there are not many projects in this area included in FWIP1, there are little to no project interactions seen in IP2.

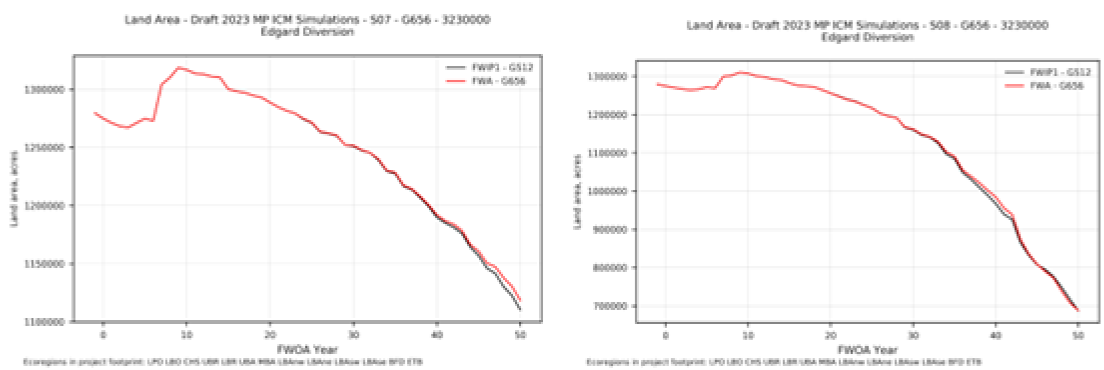


Figure 156. Land area over time for the Edgard Diversion in IP2 and FWIP1 for the lower scenario (left) and the higher scenario (right).

VEGETATION

INDIVIDUAL PROJECT RUNS

In the UBA ecoregion, the negative effects of both the Ama and Edgard diversions are small under the lower scenario and slightly higher under the higher scenario, especially during the last decade of the model run (Figure 157). However, under all circumstances, the UBA ecoregion remains dominated by swamp forest. Under both scenarios, there is more conversion of swamp to fresh marsh with the diversions than in FWOA. Under the higher scenario, some of this fresh marsh is lost to open water due to inundation. Because the Edgard Diversion outfall is located in the UBA ecoregion, it has higher inundation levels in UBA under the higher scenario than the Ama Sediment Diversion and therefore higher loss rates.

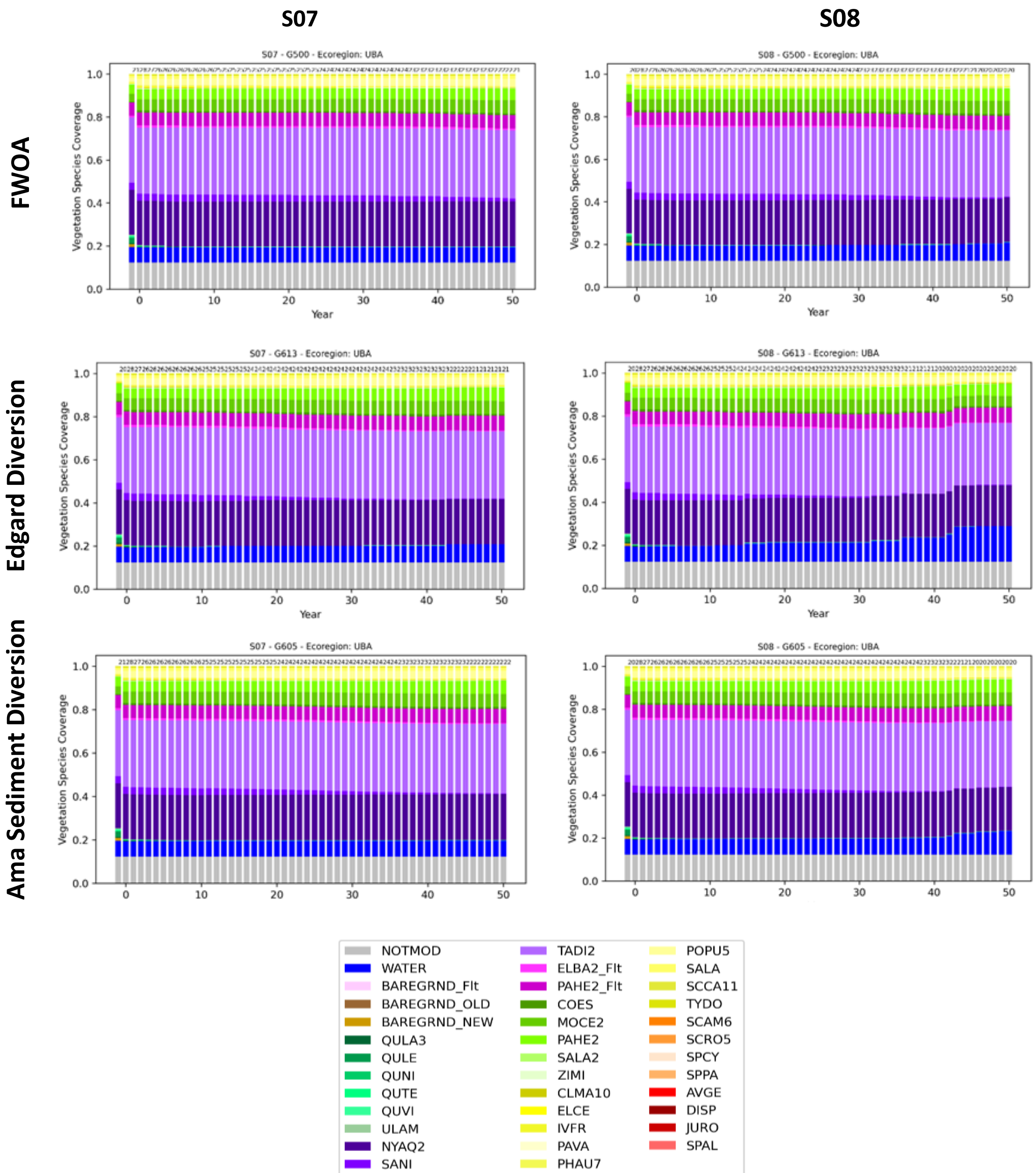


Figure 157. Vegetation changes in the UBA ecoregion under two scenarios for IP1.

In the MBA ecoregion, the Edgard Diversion has minimal effect on vegetation cover under the lower scenario (Figure 158). Under the higher scenario, the Edgard Diversion increases the cover of fresh marsh species, while in FWOA there is a slow increase of intermediate marsh species coverage (Figure

158). This keeps some marshes, especially near Gheens, from converting to open water. The Ama Sediment Diversion leads to inundation-caused land loss in MBA during the first 14 years of operation but no large changes in species composition under both scenarios (Figure 158). There is some recovery from this loss due to sediment deposition in the immediate outfall area of the Ama Sediment Diversion. However, inundation leads to loss, especially in areas dominated by intermediate marsh species (Figure 158).

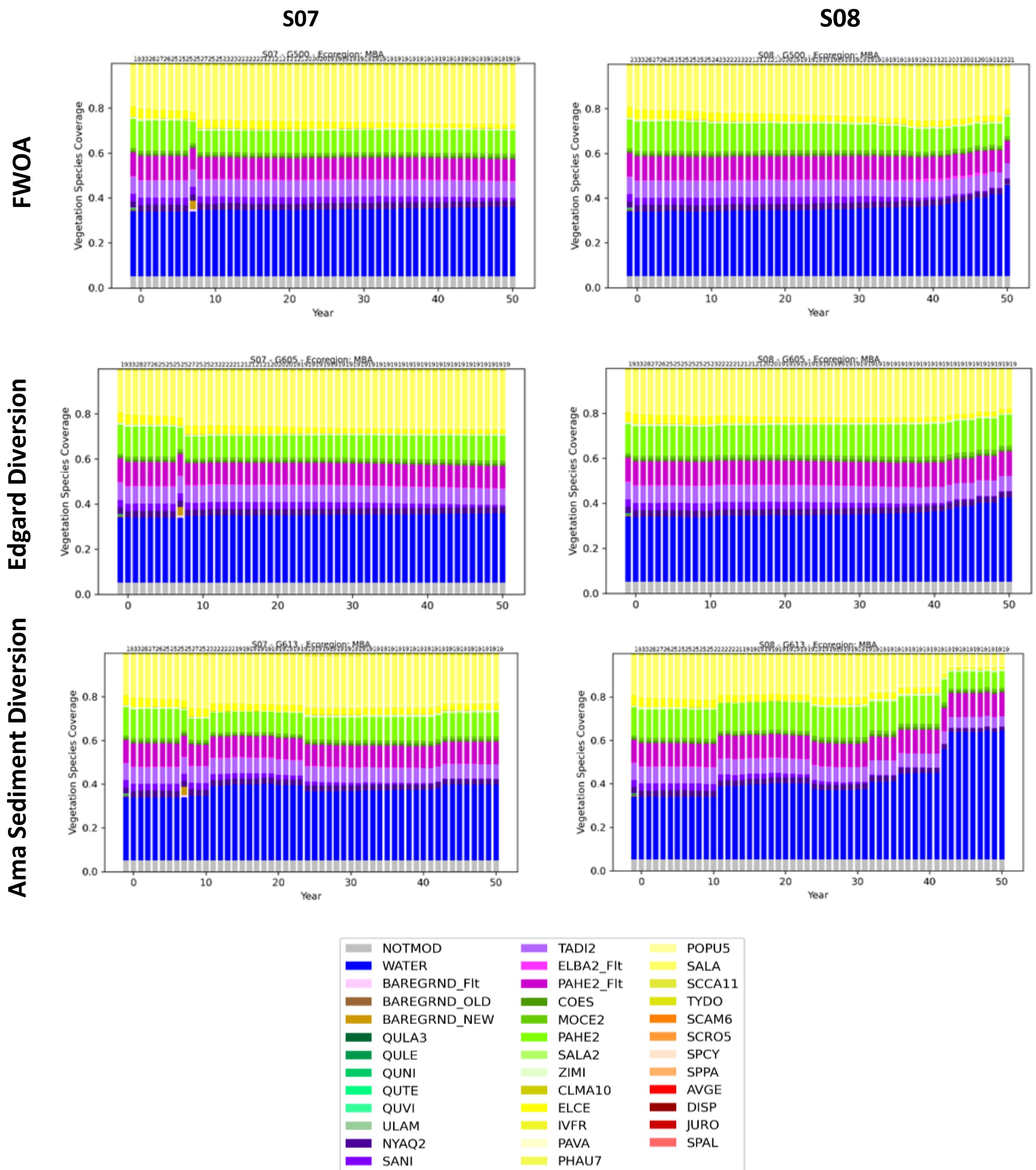


Figure 158. Vegetation changes in the MBA ecoregion under two scenarios for IP1.

Most of the land gain associated with both the Edgard and Ama diversions occurs in LBAnw ecoregion. In LBAnw, the diversions freshen the area enough that intermediate marsh species outcompete brackish marsh species (Figure 159).

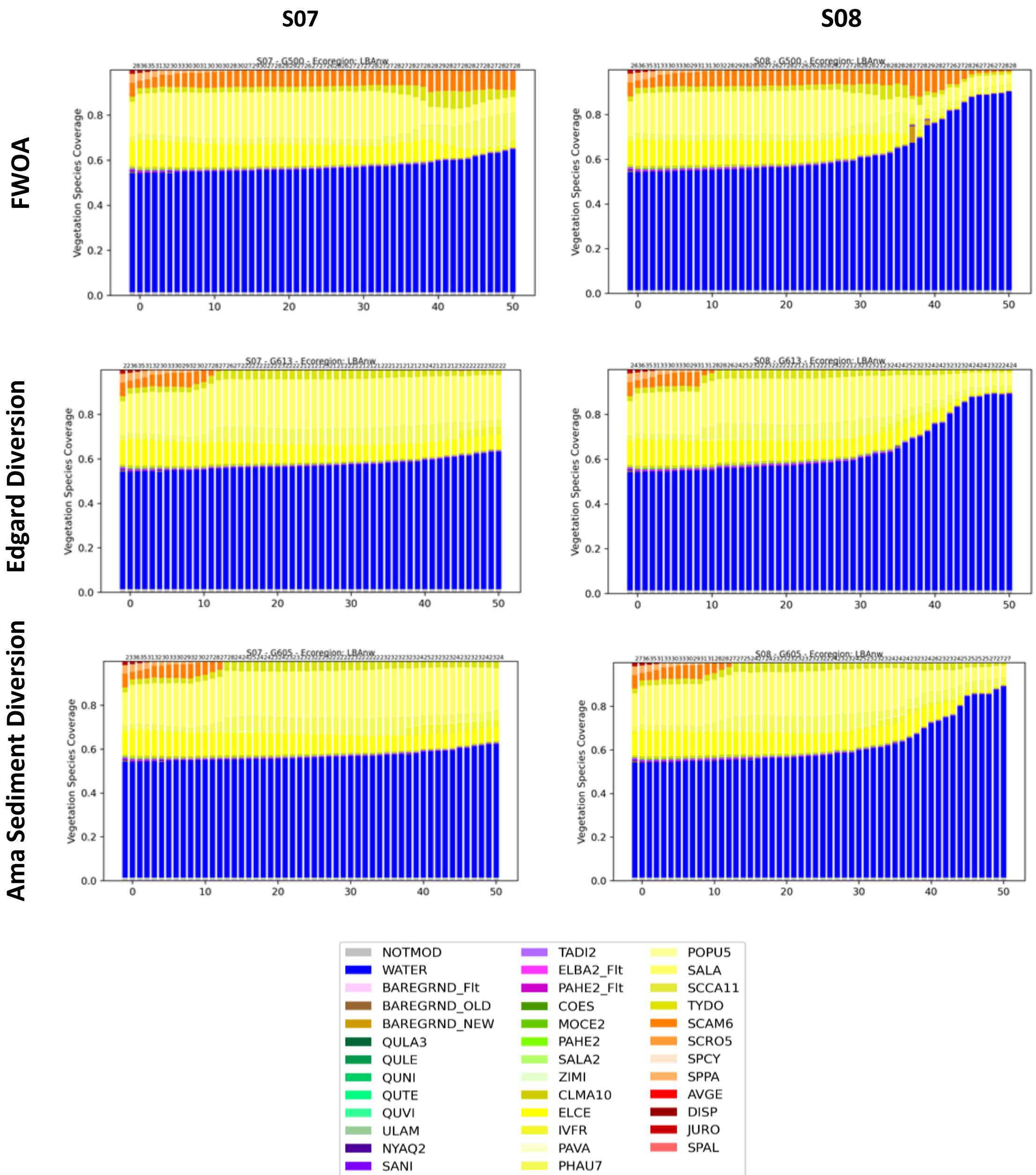


Figure 158. Vegetation changes in the LBAnw ecoregion under two scenarios IP1.

Adding the Edgard diversion to FWIP1 in IP2 reduces the expansion of SALA as PAHE2 declines in the MBA ecoregion (Figure 160). Under the lower scenario, adding the Edgard Diversion keeps the vegetation composition in the MBA ecoregion relatively stable. Without the Edgard Diversion, SALA starts expanding around Year 38 under the lower scenario. Under the higher scenario without the

Edgard diversion, SALA starts expanding and replacing PAHE2 around Year 35. Adding the Edgard Diversion under the higher scenario keeps PAHE2 stable, while SALA dominated marsh is slowly lost over the last decade.

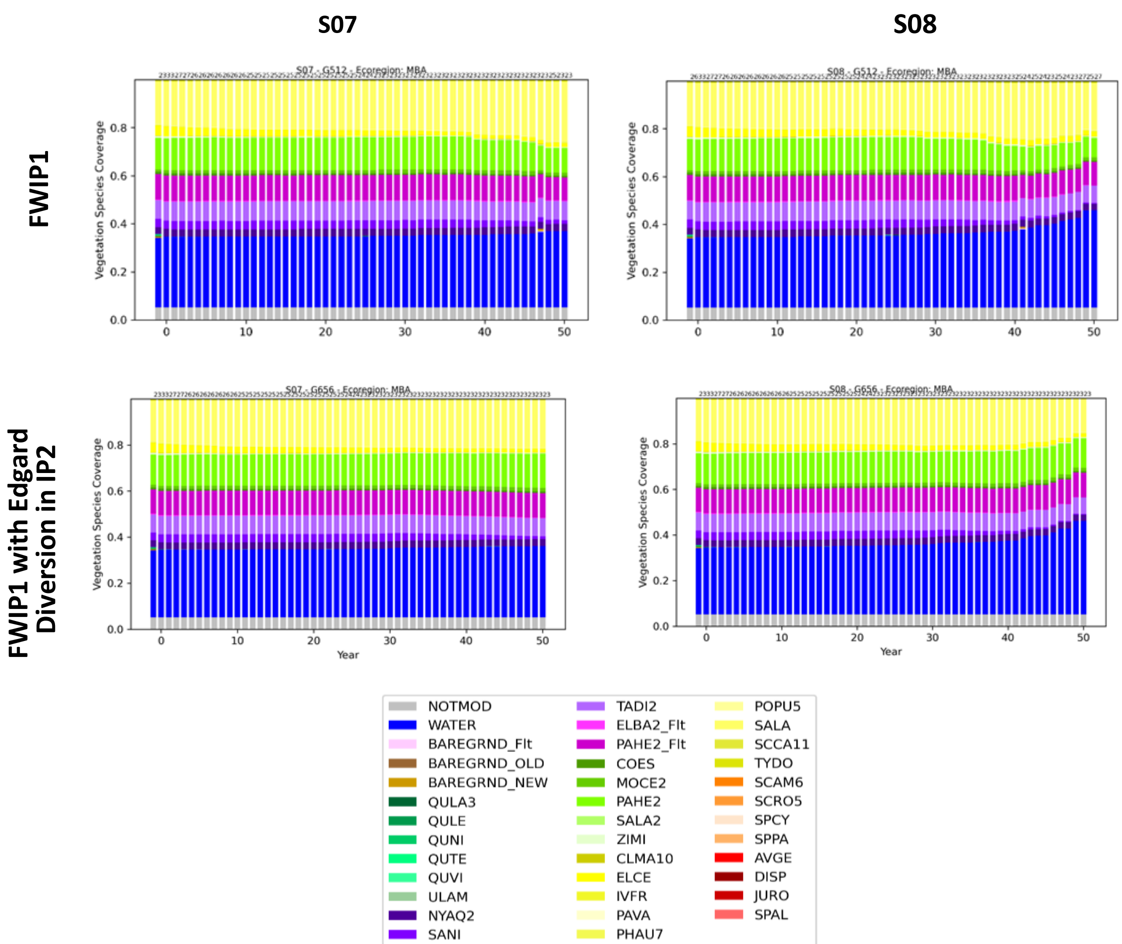


Figure 159. Vegetation changes in the MBA ecoregion under two scenarios for IP2.

Adding the Edgard Diversion in IP2 reduces the expansion of SCAM6 (starting around Year 38 in both scenarios) observed in LBAnw under FWIP1 (Figure 161). Adding the Edgard Diversion in IP2 keeps the vegetation composition relatively stable in the last two decades of the simulation.

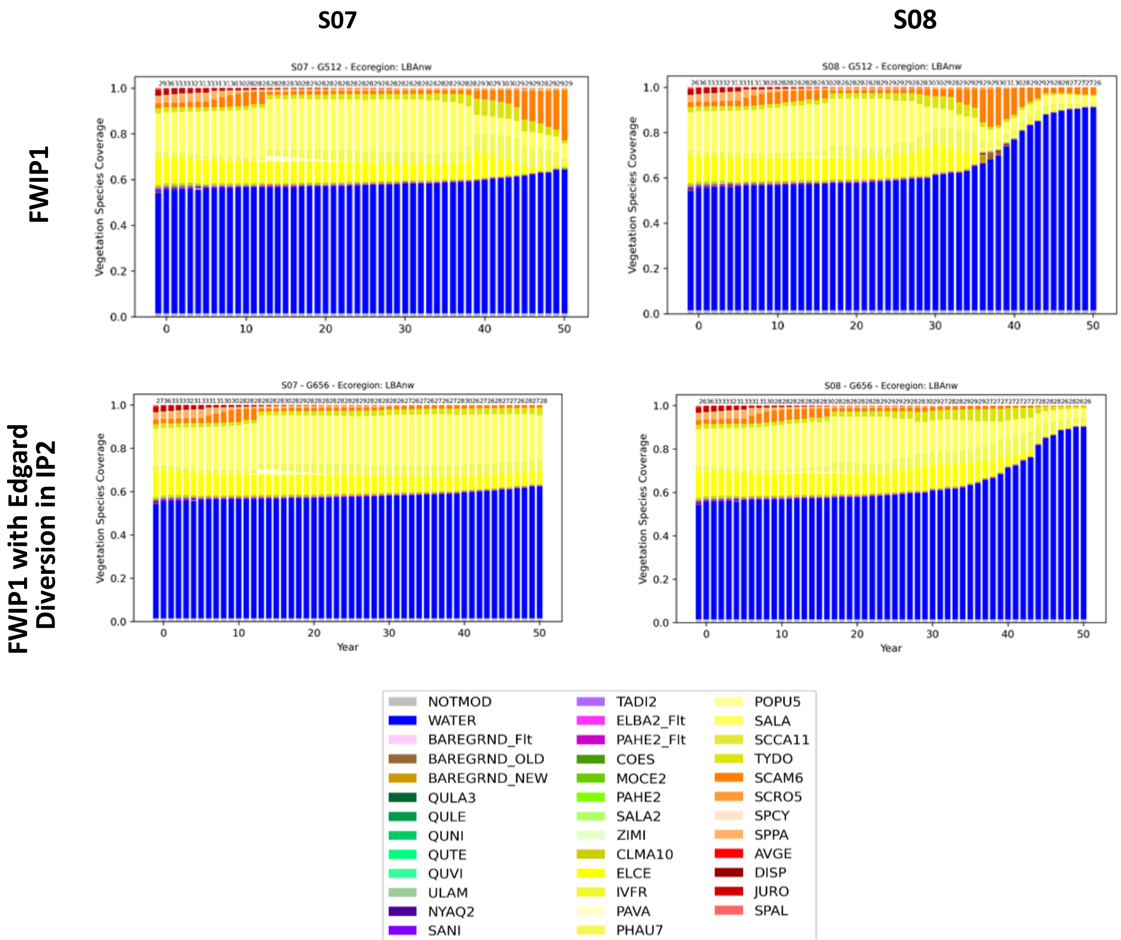


Figure 160. Vegetation changes in the LBAnw ecoregion under two scenarios for IP2.

HABITAT SUITABILITY

The Ama Sediment Diversion and Edgard Diversion projects had similar effects on the suitability of habitats for fish, shellfish, and wildlife. In the upper part of Barataria Basin (i.e., north of Little Lake), both diversions resulted in wetland loss, which created new aquatic habitat. These new habitats were largely freshwater, and thus represented highly suitable habitat for species associated with low salinities, such as largemouth bass, gadwall, and mottled duck. As a result, there was a relatively large increase in habitat suitability scores for these species, particularly for the Ama Sediment Diversion because of the greater amount of wetland loss and aquatic habitat created from this project (e.g., largemouth bass; Figure 162). Much of this loss was concentrated near the diversion outfall, but this area eventually filled with sediment and became new wetland habitat around Year 23. This resulted in a reduction in aquatic habitat, and habitat suitability decreased accordingly.

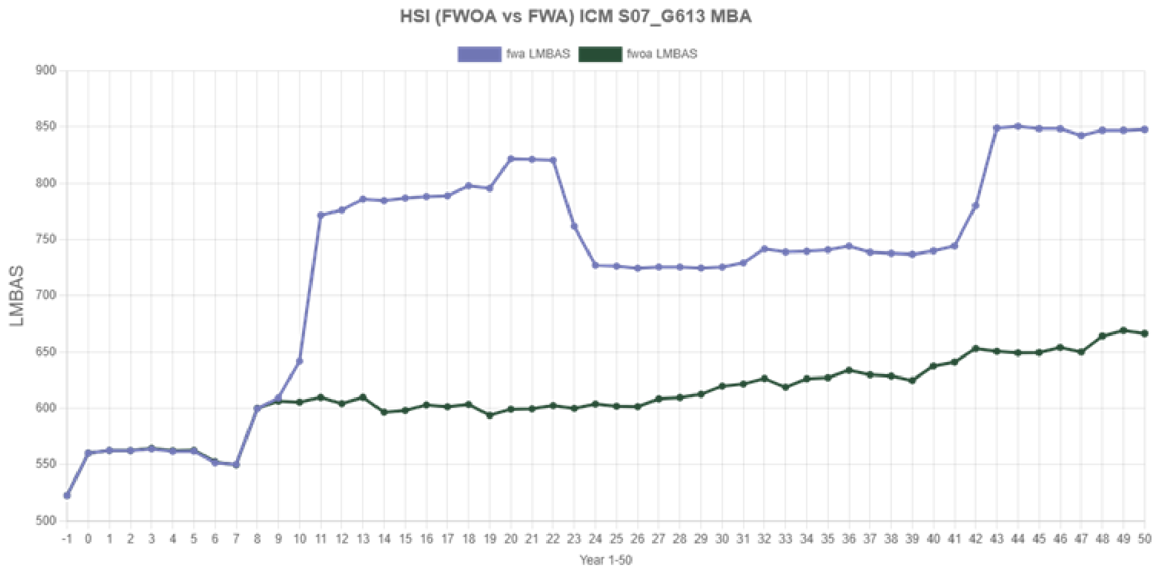


Figure 161. Total HSI score for largemouth bass in the Mid Barataria ecoregion for the 50-year FWOA and Ama Sediment Diversion (FWA) lower environmental scenario simulations. The total HSI score was calculated by summing the individual scores.

Both diversions also increased water levels across the upper part of Barataria Basin, which contributed to the changes in habitat suitability for wildlife species. Higher water levels from the diversions inundated wetlands to a greater depth than without the diversions. This resulted in an overall decrease in habitat suitability for alligator because deeper marsh inundation would negatively affect foraging and nesting success for this species. In contrast, habitat suitability increased for gadwall and mottled duck because marsh inundation resulted in a greater amount of shallow water habitat available for these species (Figure 163 and Figure 164). However, as water levels increased over time due to SLR, the additional increase in water levels from the diversions eventually made water depths too deep for the waterfowl in many areas. This resulted in a decline in habitat suitability during the latter part of the simulations. This was most evident in the Mid Barataria ecoregion and during the higher scenario, where habitat suitability with the diversions was lower than without the diversions during the last 20 years of the simulations (Figure 163 and Figure 164).

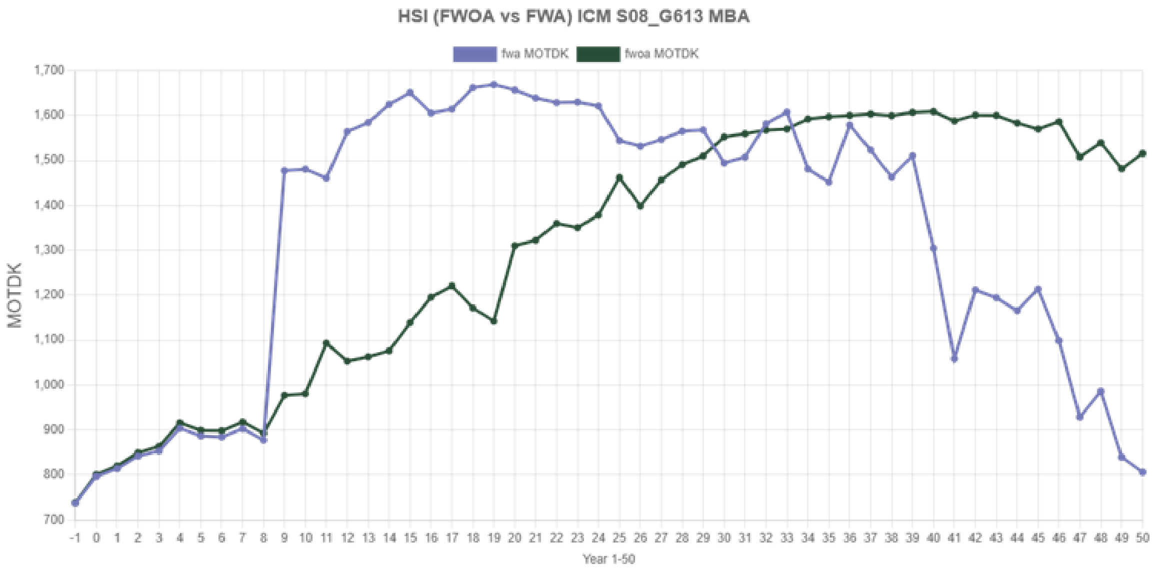


Figure 162. Total HSI score for mottled duck in the Mid Barataria ecoregion for the 50-year FWOA and Ama Sediment Diversion (FWA) higher environmental scenario simulations. The total HSI score was calculated by summing the individual scores for each ICM model cell within the ecoregion.

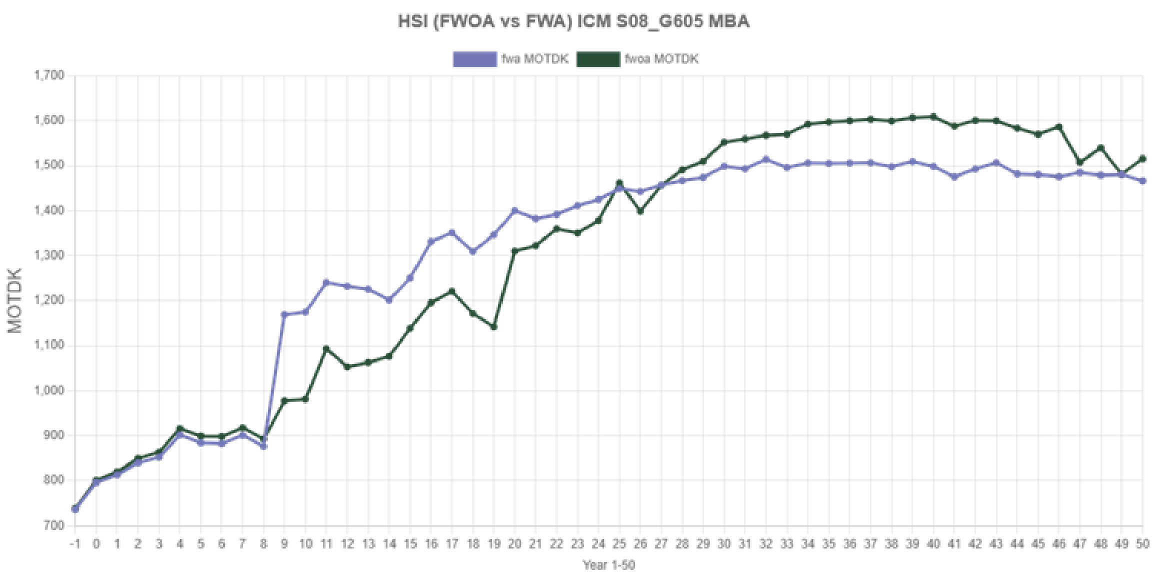


Figure 163. Total HSI score for mottled duck in the Mid Barataria ecoregion for the 50-year FWOA and Edgard Diversion (FWA) higher environmental scenario simulations. The total HSI score was calculated by summing the individual scores for each ICM model cell within the ecoregion.

The effects of the diversions on habitat suitability in the lower Barataria Basin (i.e., south of Little Lake) were largely related to salinity reduction. In the LBAnw ecoregion and the upper part of the LBAne ecoregion, diversion discharge reduced salinities to fresh or near fresh conditions. As a result, the marsh and open water habitats in these areas became less suitable for all fish and shellfish species in the analysis except largemouth bass. The decrease, however, was relatively small considering salinities in these areas were already low due to discharge from MBSD. The fresher conditions also allowed for an increase in coverage of fresh and intermediate marshes, particularly in the LBAnw ecoregion. These marsh types represent optimal habitat for mottled duck and gadwall, and their increase in coverage contributed to the increase in habitat suitability seen for these species in the ecoregion.

Salinity reduction was much greater in the areas closer to the Gulf of Mexico, and this resulted in more notable changes in habitat suitability for fish and shellfish. These changes were greater for the Ama Sediment Diversion, which reduced salinities in these areas by up to 5 ppt, as compared to the Edgard Diversion, which reduced salinities by up to 2 ppt. As a result, marsh and open water habitats in the southeastern part of Barataria Basin became more suitable for species associated with lower salinities (i.e., salinities ≤5 ppt), such as juvenile gulf menhaden, and less suitable for higher-salinity species, such as brown shrimp (Figure 165 and Figure 166). However, in the southwestern part of Barataria Basin and adjacent areas of Terrebonne Basin, habitat conditions improved for all species except the adult stages of gulf menhaden and spotted seatrout (Figure 165 and Figure 166). Average annual salinities in these areas were typically >18 ppt, and the diversion discharge reduced salinities such that conditions were more suitable for the fish and shellfish.

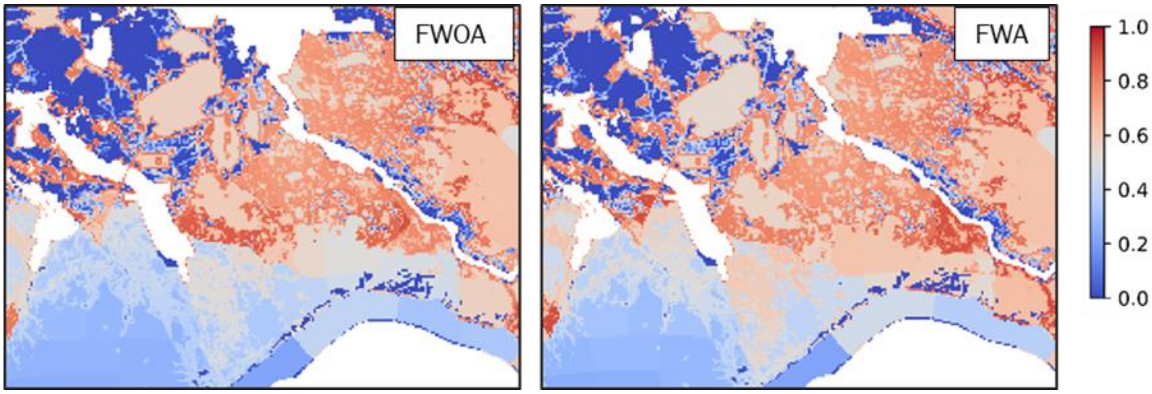


Figure 164. Juvenile gulf menhaden HSI scores across the Barataria Basin for Year 15 of FWOA and Ama Sediment Diversion (FWA) lower environmental scenario simulations. Scores range from 0.0, completely unsuitable habitat, to 1.0, optimal habitat.

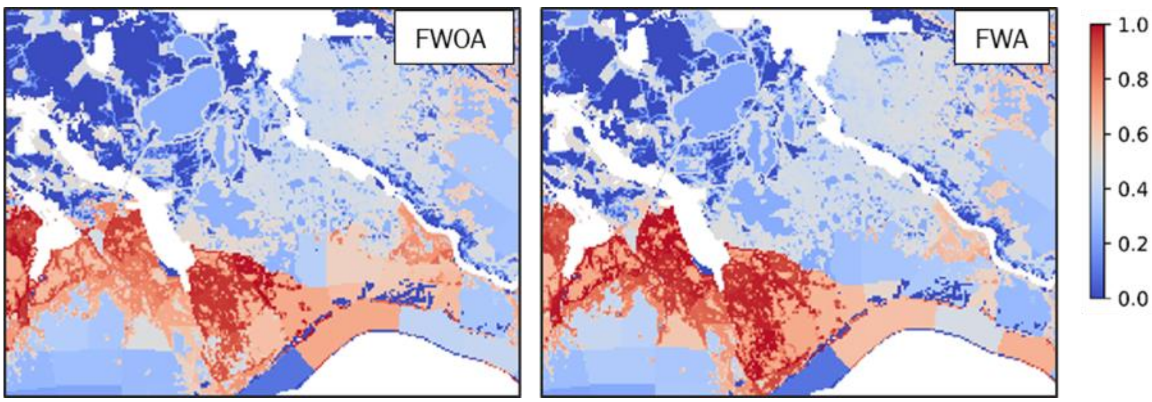


Figure 165. Small juvenile brown shrimp HSI scores across the Barataria Basin for Year 15 of FWOA and Ama Sediment Diversion (FWA) lower environmental scenario simulations. Scores range from 0.0, completely unsuitable habitat, to 1.0, optimal habitat.

7.0 UNION FRESHWATER DIVERSION AND WESTERN MAUREPAS SEDIMENT DIVERSION

PROJECTS OVERVIEW

This report describes the modeling results for two diversion projects, with different characteristics and operating regimes that are at the same location: the Union Freshwater Diversion project (# 244) and the West Maurepas Sediment Diversion project (#305).

The Union Freshwater Diversion moves water from the Mississippi into West Maurepas swamp near Burnside (Figure 167) to provide sediment for emergent marsh creation and freshwater and fine sediment to sustain existing wetlands. The maximum capacity is 25,000 cfs, and it is modeled at 25,000 cfs when Mississippi River flow equals 400,000 cfs; closed when river flow is below 200,000 cfs or above 600,000 cfs; a variable flow rate calculated using a linear function from 0 to 25,000 cfs for river flow between 200,000 cfs and 400,000 cfs; and held constant at 25,000 cfs for river flow between 400,000 cfs and 600,000 cfs (Figure 167). The project is fully constructed and operational at Year 9 and was modeled in G602. The project was not selected in IP1 and was not modeled in IP2 as it will become part of the Upper Basins Diversion Program for the 2023 Coastal Master Plan.

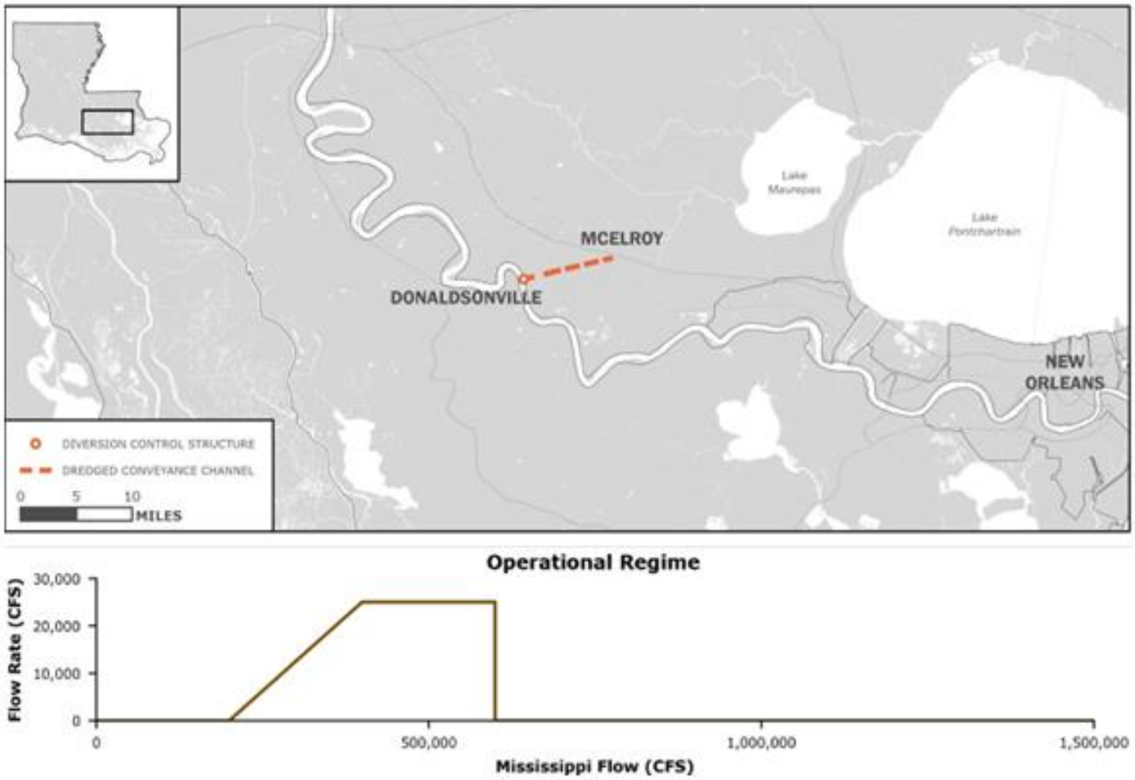


Figure 166. The location and operational regime of the Union Freshwater Diversion.

The project cost is $1.22 billion in IP1. The cost of the project does not vary by scenario as no marsh creation is included.

The Western Maurepas Sediment Diversion also moves water from the Mississippi River into west Maurepas swamp near Burnside (Figure 168) to provide sediment for emergent marsh creation and freshwater and fine sediment to sustain existing wetlands. The maximum capacity is 50,000 cfs, and it is modeled at 50,000 cfs when the Mississippi River flow equals 1,000,000 cfs; open with a variable flow rate calculated using a linear function from 0 to 50,000 cfs for river flow between 200,000 cfs and 1,000,000 cfs; constant flow rate of 50,000 cfs for river flow above 1,000,000 cfs; and no operation below 200,000 cfs (Figure 168). The project is fully constructed and operational at Year 9 and was modeled in G647. The project was also not selected in IP1 and was not modeled in IP2 as it will become part of the Upper Basins Diversion program for the 2023 Coastal Master Plan.

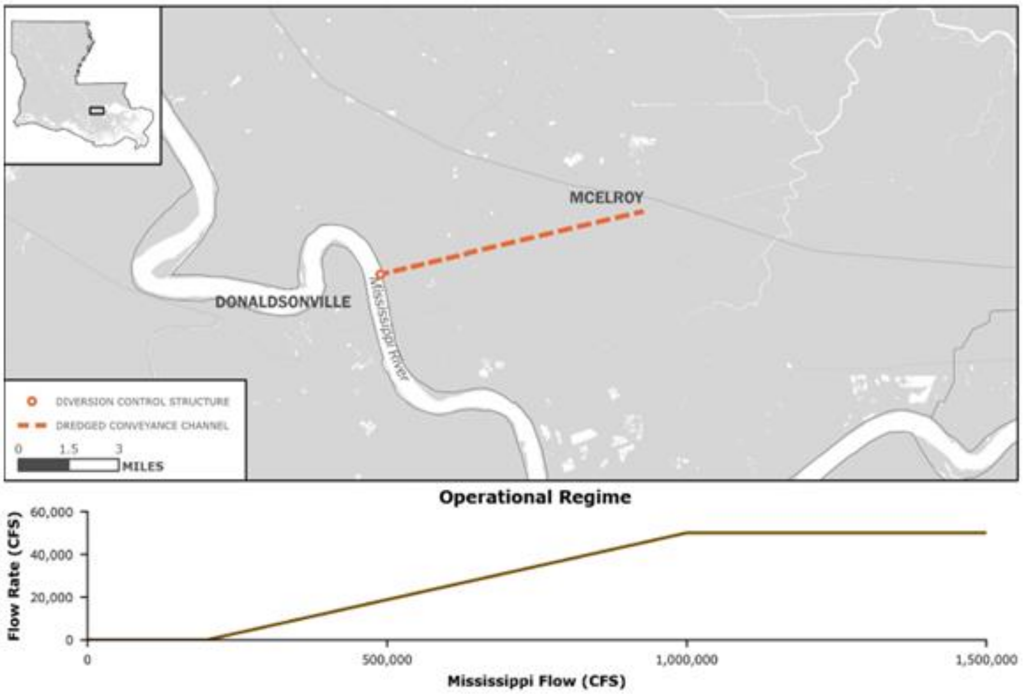


Figure 167. The location and operational regime of the Western Maurepas Sediment Diversion project.

The project cost is $1.22 billion in IP1. The cost of the project does not vary by scenario as no marsh creation is included.

The results presented here discuss the way in which the projects change the coastal landscape in terms of hydrology, morphology, vegetation, and habitats, with examples from the two environmental scenarios. The examples have been selected to illustrate the dynamics of the project based on available data, rather than to provide a comprehensive description of all areas, scenarios, and implementation period comparisons.

HYDROLOGY

STAGE

Both diversion projects cause stage increases in receiving compartments relative to FWOA; however, the Western Maurepas Sediment Diversion project causes stage increases at least two times larger than for the Union Freshwater Diversion due to the higher diversion flows (see Figure 169 comparing stages at QAQC0823 in the diversion outfall compartment 15). Thus, the diversion induced inundation impacts are more severe and broad with the Western Maurepas Sediment Diversion compared to the Union Freshwater Diversion. Figure 170 and Figure 171 present the inundation increases relative to FWOA caused by Union Freshwater Diversion and Western Maurepas Sediment Diversion at Year 10, respectively.

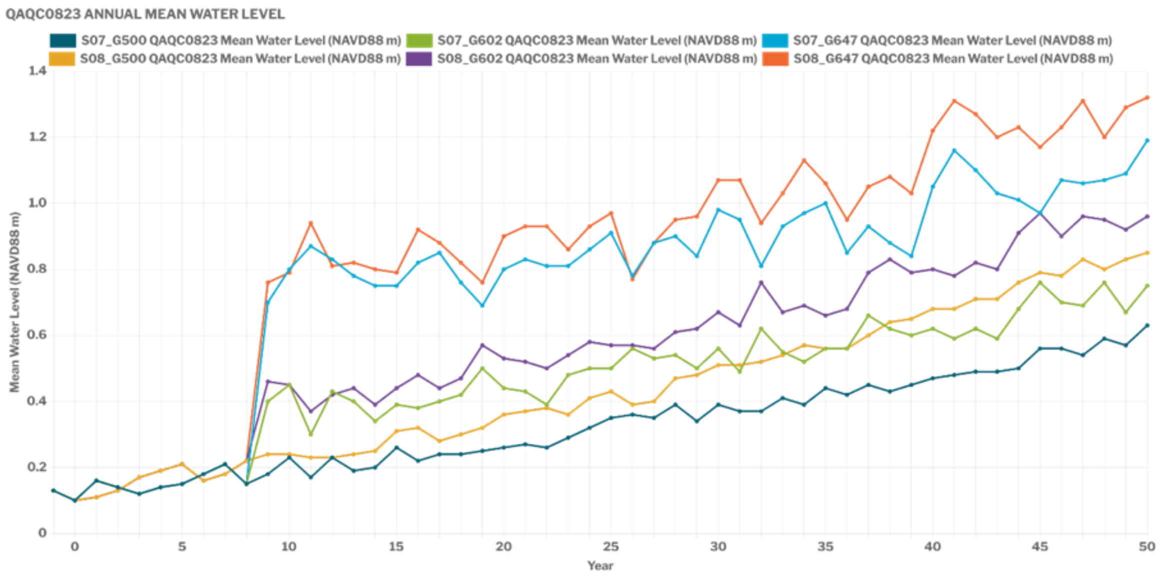


Figure 168. Annual mean water levels at diversion outfall compartment (FWA vs. FWOA).

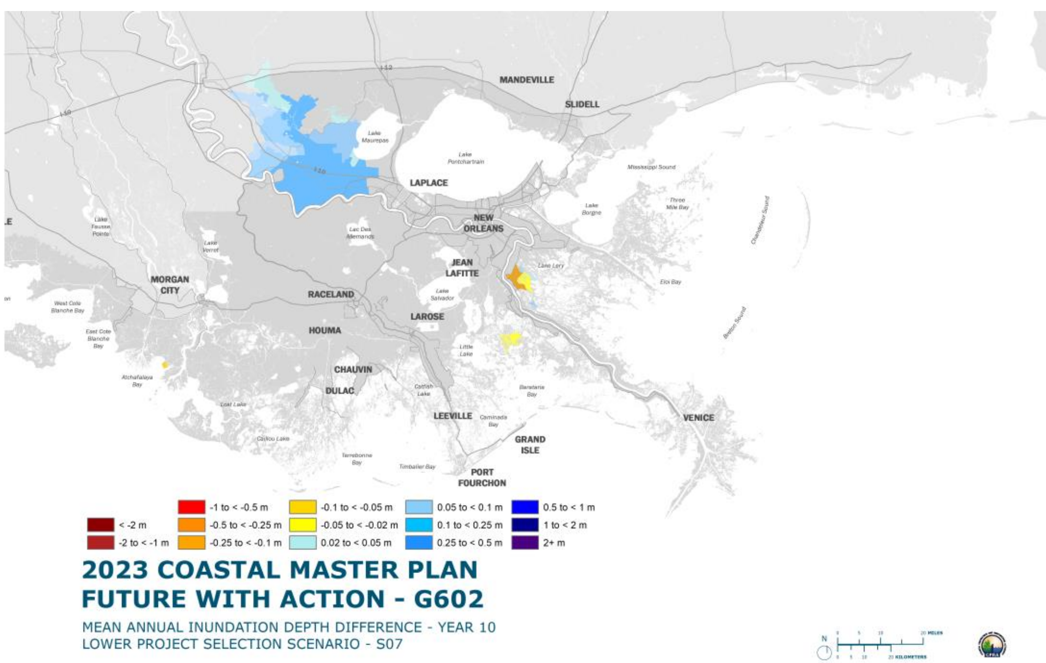


Figure 169. Mean annual inundation differences (FWA-FWOA) caused by Union Freshwater Diversion at Year 10.

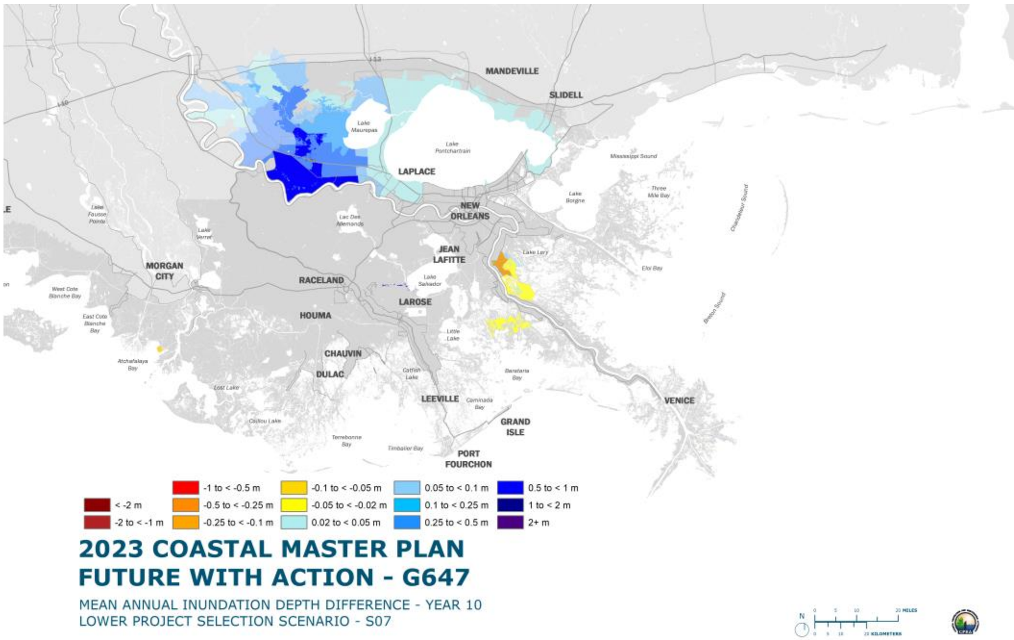


Figure 170. Mean annual inundation differences (FWA-FWOA) caused by Western Maurepas Sediment Diversion at Year 10.

SALINITY

The salinity reduction due to freshwater input from both diversions reaches to the Lake Borgne/Chandeleur Sound and Breton Sound areas. The Western Maurepas Sediment Diversion causes larger salinity reductions than the Union Freshwater Diversion again due to the higher diversion flows. Figure 172 and Figure 173 present the maximum 2-week mean salinity differences (FWA-FWOA) caused by Union Freshwater Diversion and Western Maurepas Sediment Diversion at Year 50, respectively, under the lower scenario (S07). Maximum salinities are reduced throughout the Pontchartrain Basin, Lake Borgne, and in Breton, Chandeleur, and Mississippi Sounds, with the greatest reductions in Lake Borgne and eastern Lake Pontchartrain where salinities are highly variable. However, the salinities in Lower Barataria and Bird's Foot are increased compared to FWOA due to reduced downstream Mississippi flows caused by the diversions. Increases in the maximum 2-week mean salinities in these areas are greater with the Union Freshwater Diversion compared to the Western Maurepas Sediment Diversion, as it has higher diversion flows during lower Mississippi flow periods when basin salinities are highest.

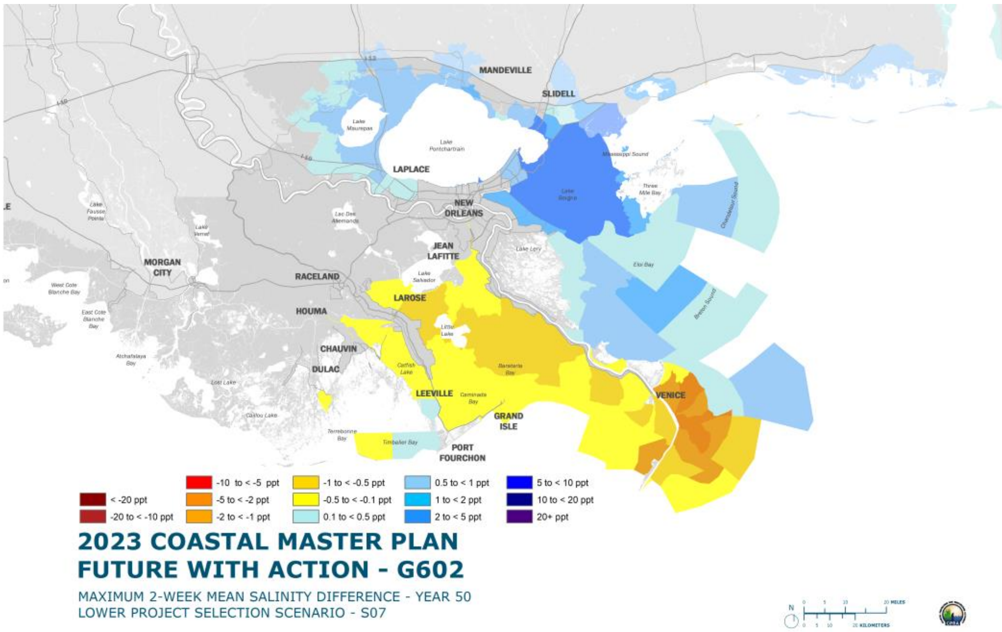


Figure 171. Maximum 2-week mean salinity differences (FWA-FWOA) caused by Union Freshwater Diversion at Year 50.

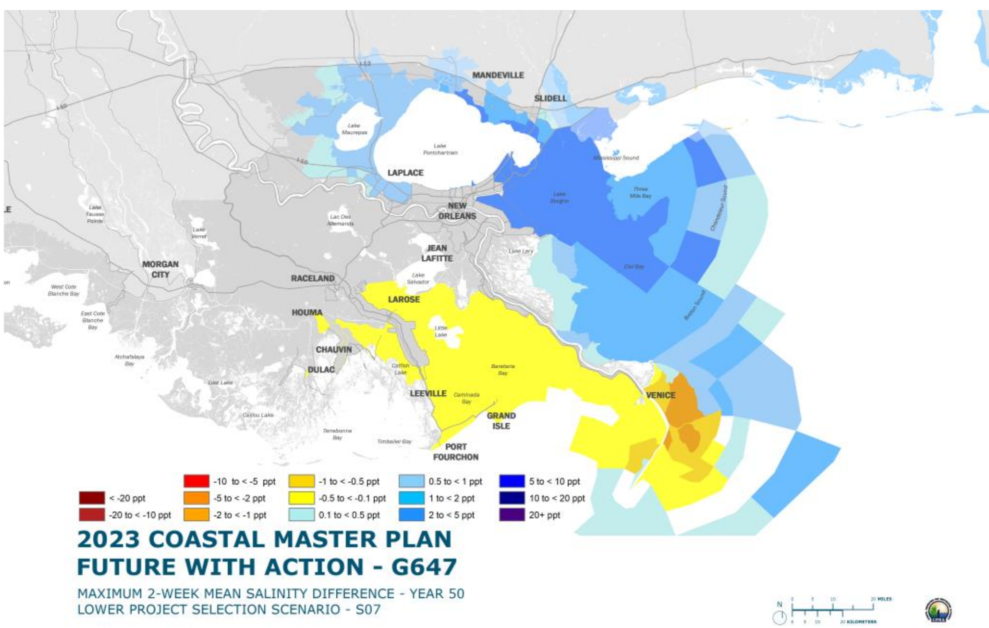


Figure 172. Maximum 2-week mean salinity differences (FWA-FWOA) caused by Western Maurepas Sediment Diversion at Year 50.

TOTAL SUSPENDED SEDIMENT (TSS)

The Mississippi River sediments from both diversions are spread eastward to Lake Maurepas and then to adjacent wetlands following the major flow pathways. Figure 174 to Figure 176 present the average annual TSS at the outfall (compartment 15), Lake Maurepas (compartment 33), and Lake Pontchartrain (compartment 37), respectively, for the Western Maurepas Sediment Diversion for the lower scenario. The average annual TSS decreases from about 75 g/L at diversion outfall to 35 g/L at Lake Maurepas and then to 13 g/L at Lake Pontchartrain. Average annual TSS increases for the Union Freshwater Diversion are lower, as the diversion is not operated during high Mississippi River flows when river TSS is highest.

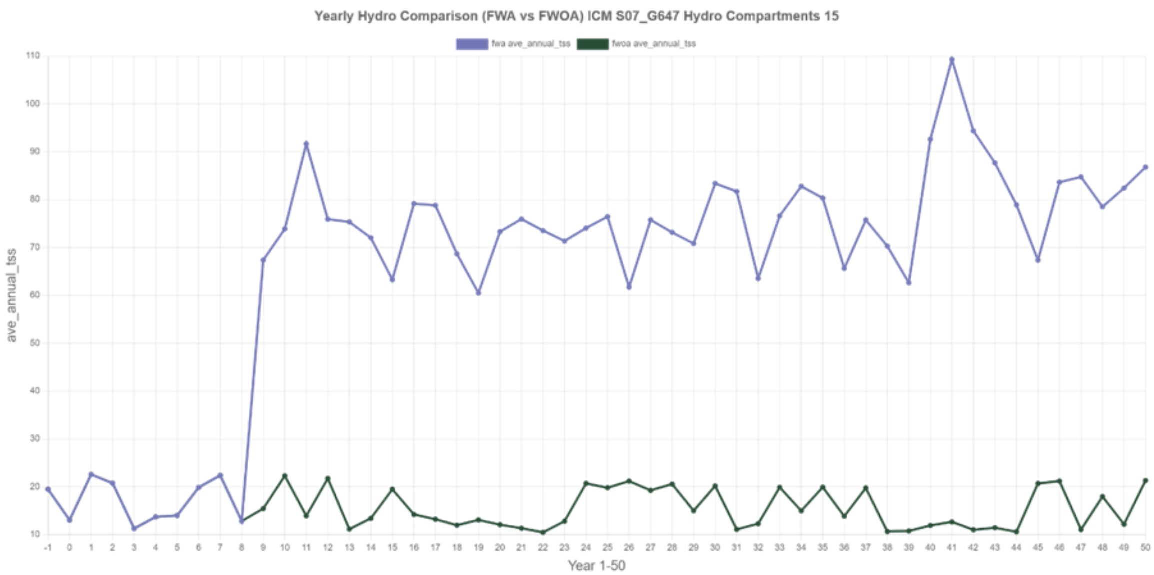


Figure 173. Average annual TSS at diversion outfall due to Western Maurepas Sediment Diversion.

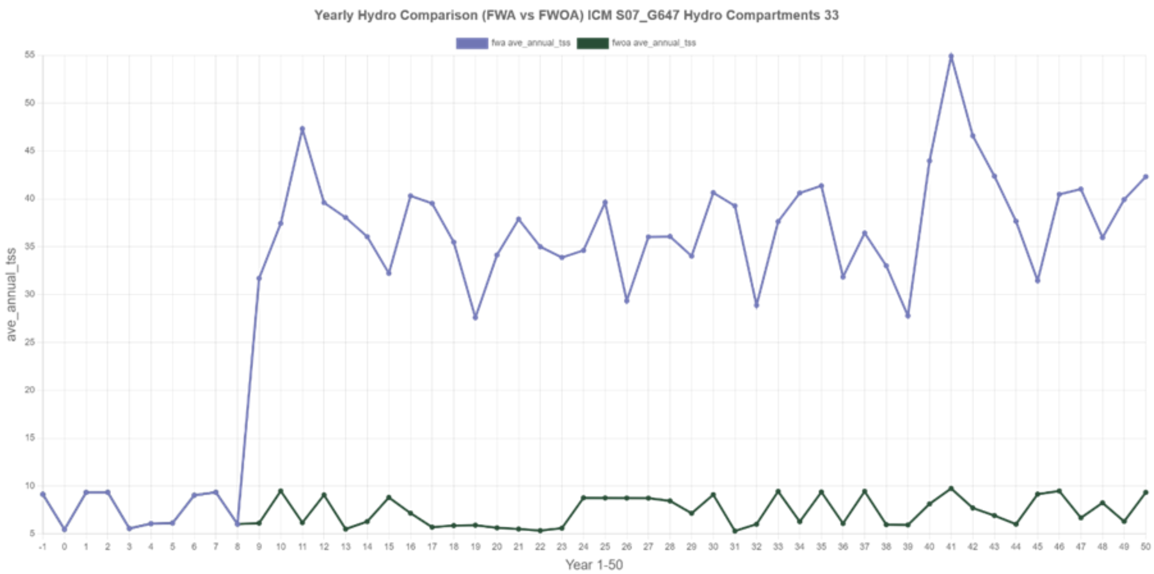


Figure 174. Average annual TSS at Lake Maurepas due to Western Maurepas Sediment Diversion.

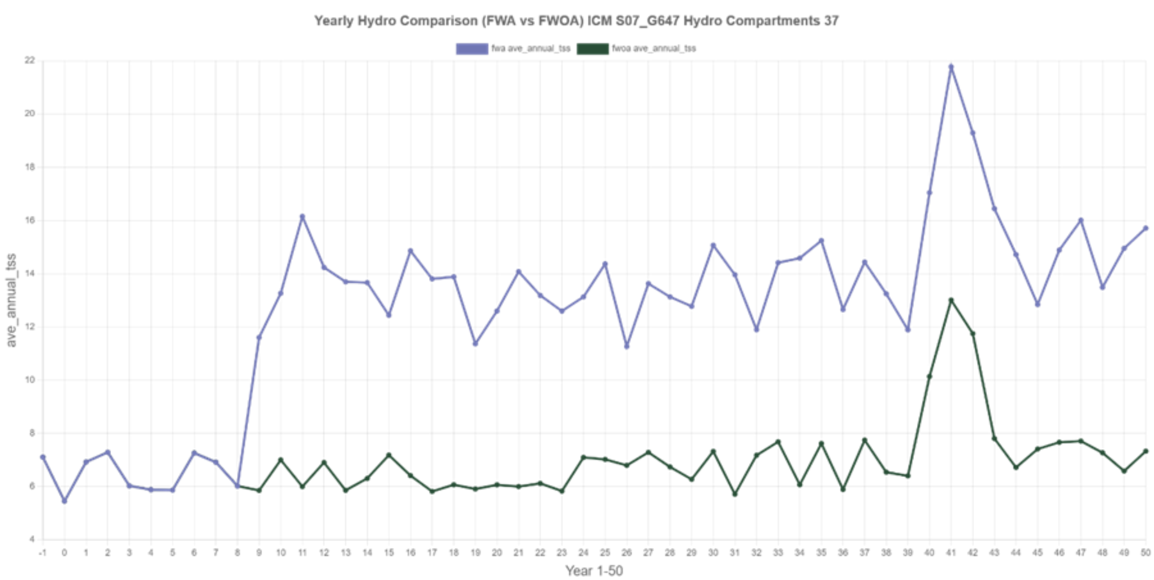


Figure 175. Average annual TSS at Lake Pontchartrain due to Western Maurepas Sediment Diversion.

DOWNSTREAM FLOWS TO MID-BASIN DIVERSIONS AND BIRD'S FOOT DELTA

Both Mid-Breton and Mid-Barataria diversion flows depend on available Mississippi River flows; thus they are impacted by upstream river diversions. Figure 177 and Figure 178 present the effects of both Union Freshwater Diversion and Western Maurepas Sediment Diversion on diversion flows at Mid-

Breton Diversion and MBSD, respectively. The peak flows are reduced by approximately 70 m³/s and 90 m³/s at Mid-Breton and Mid-Barataria, respectively due to Western Maurepas Sediment Diversion.

Figure 179 shows the impacts on residual river flows to Bird's Foot area including Pass a Loutre, South Pass, and Southwest Pass. The peak flows are reduced by approximately 700 m³/s due to Western Maurepas Sediment Diversion.

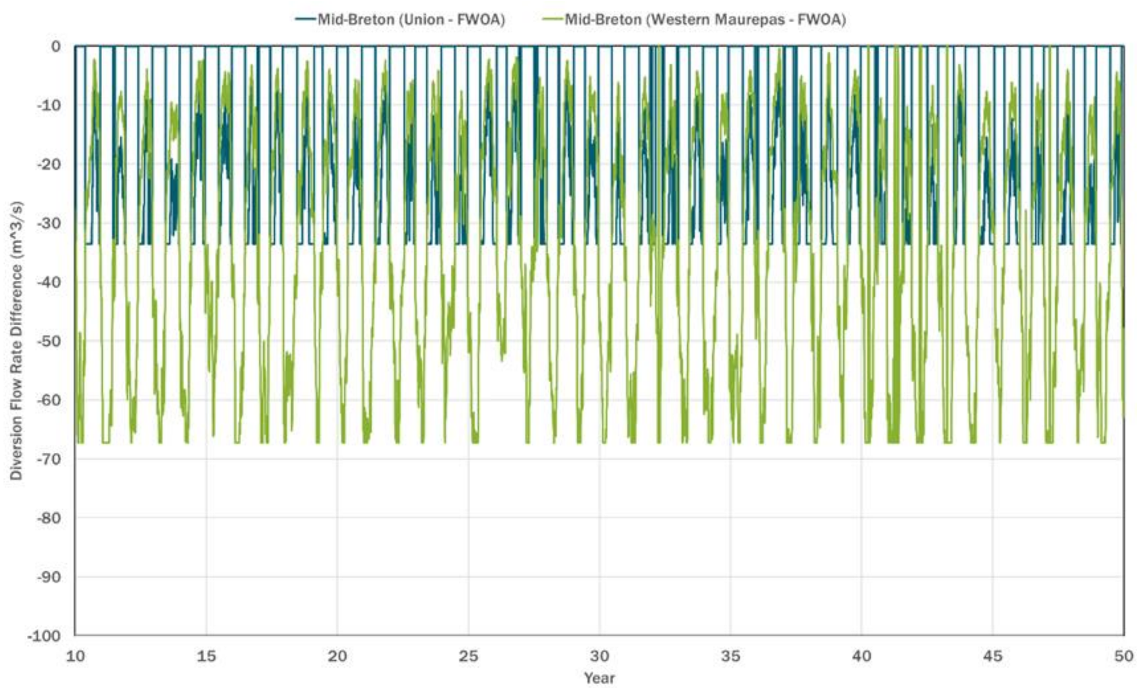


Figure 176. Mid-Breton Diversion flow reductions.

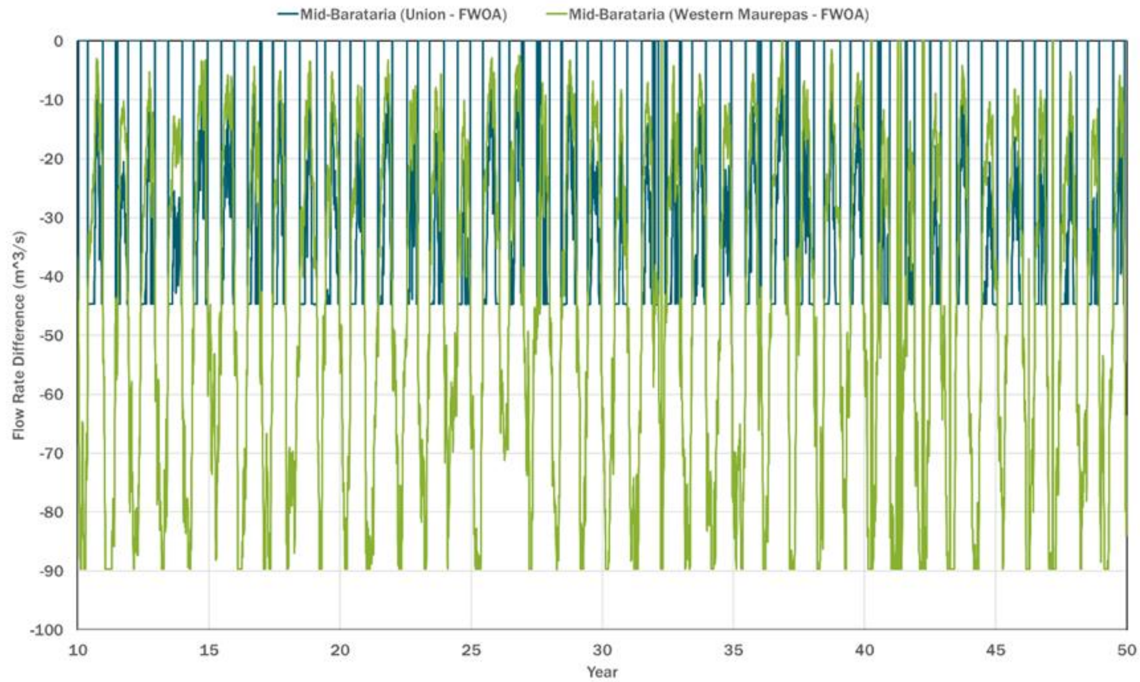


Figure 177. MBSD flow reductions.

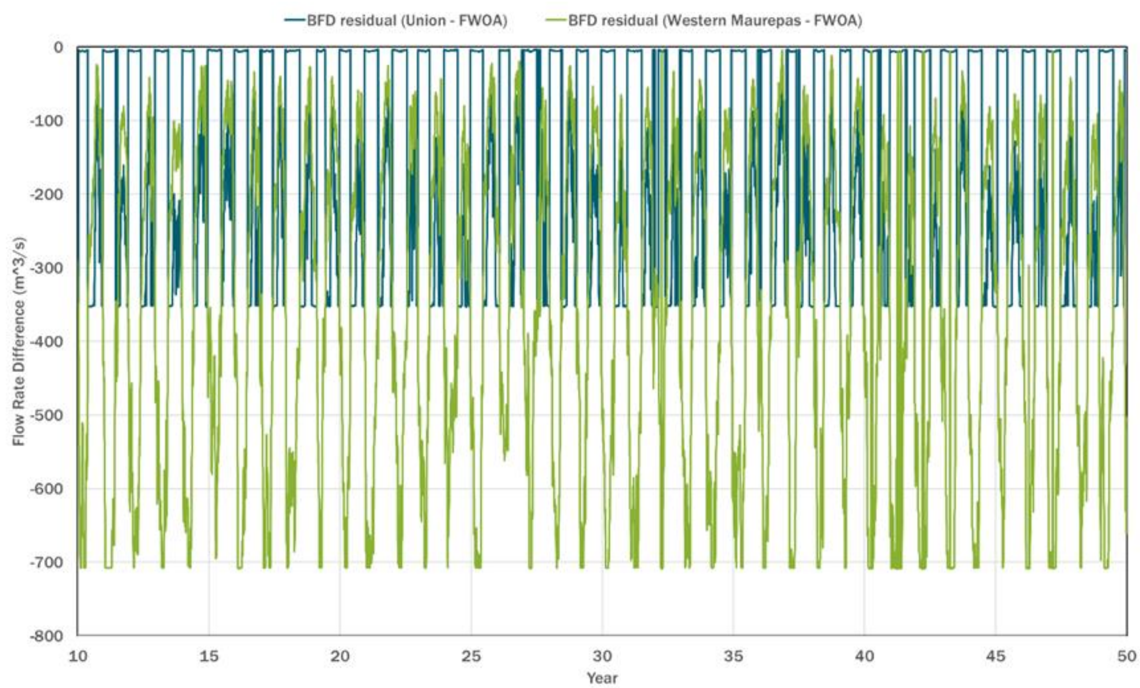


Figure 178. Bird’s Foot flow reductions.

MORPHOLOGY

The net effect of these projects on the landscape varies by scenario (Table 9). The Union Freshwater Diversion has a positive effect in the higher scenario for AAL but is negative for the lower scenario. The Western Maurepas Sediment Diversion, however, has negative effects in both scenarios. Figure 180 shows that Union produces net land loss for the first decade or so after construction; for the higher scenario, benefits relative to FWOA then increase. For the lower scenario, Union shows periods of relative land gain and relative land loss. However, Western Maurepas shows almost immediate land loss, which is of similar magnitude across both scenarios. For the lower scenario, there is some fluctuation over time, but benefits are not positive at any point in the 50 years. For the higher scenario, Western Maurepas shows increasing land loss over time.

Table 11. Net effect of the projects (FWA-FWOA) by scenario in terms of AAL and net land at Year 50

	Average Annual Net Land (km^2)		Net Land at Year 50 (km^2)	
Scenario	Lower	Higher	Lower	Higher
Union Freshwater Diversion	-1.3	5.4	11.3	32.9
Western Maurepas Sediment Diversion	-30.0	-51.6	-18.2	-64.7

Figure 179. Net land (FWA-FWOA) over time for the two projects.

The positive effects of the Union Freshwater Diversion are mostly in the Lake Borgne (LBO) and UBA ecoregions where the diversion reduces salinities in the later part of the simulation, especially in the higher scenario. The Western Maurepas Sediment Diversion has similar effects. QAQC1558 is in the Central Wetlands and illustrates the effects on vegetation and FFIBS scores. Once the diversions begin operating, FFIBS scores are reduced relative to FWOA and remain low after Year 25 when there is a steep increase in FFIBS for FWOA (Figure 181). FFIBS scores do increase with the diversions in place, but the effects are later, after Year 35 for Union and after Year 45 for Western Maurepas. Lower FFIBS scores mean greater organic accretion and an increased ability to keep pace with SLR and subsidence. Also, lower salinities give wetlands an increased tolerance for flooding.

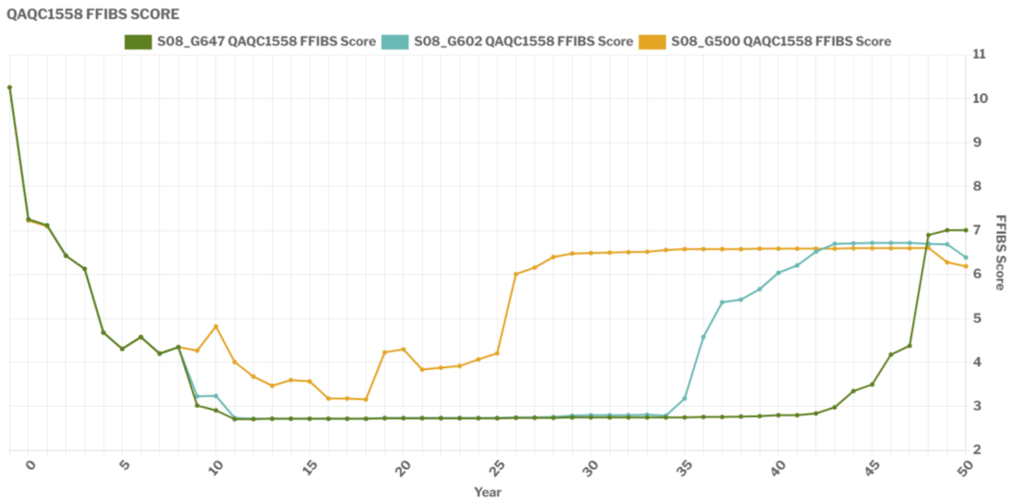


Figure 180. Changes in FFIBS score for FWOA (G500), the Union Freshwater Diversion (G602), and Western Maurepas Sediment Diversion (G647) at QAQC1558 in the Central Wetlands for the higher scenario.

Both diversions show negative effects in the Barataria Basin, as the removal of water from the Mississippi upstream reduces the flow through MBSD compared to FWOA and slows land building (Figure 182). Interestingly, the reduced flow through the Mid-Breton Diversion (into the UBR ecoregion) results in relative land gain for both Union and Western Maurepas as they alleviate the excess flooding that causes land loss in many parts of the UBR ecoregion (Figure 182). Both diversions also cause relative land loss in the Bird's Foot Delta as less freshwater and sediment reaches that area (see Hydrology section above). However, there are some differences. Union has relatively greater land loss in the BFD and less in LBAne for both scenarios, whereas Western Maurepas causes greater relative loss in LBAne and less in the BFD. This appears to be a result of the differing operational regimes. Union does not operate at high discharges, while Western Maurepas does. Western Maurepas therefore causes less flow through MBSD at times of high sediment availability, thus reducing the sediment delivery to LBAne more than Union. Union reduces flow to the BFD when outflows from other diversions are relatively low and there is greater potential for salinity incursion, which results in lower accretion and a reduced flooding tolerance. This effect is shown at CRMS4448 where there is little difference between the diversion and FWOA in mean annual salinity, but the maximum 2-week salinity is consistently higher for Union than Western Maurepas and FWOA (Figure 183).

Figure 181. Net AAL by ecoregion for the Union Freshwater Diversion and the Western Maurepas Sediment Diversion for the higher and lower scenarios.

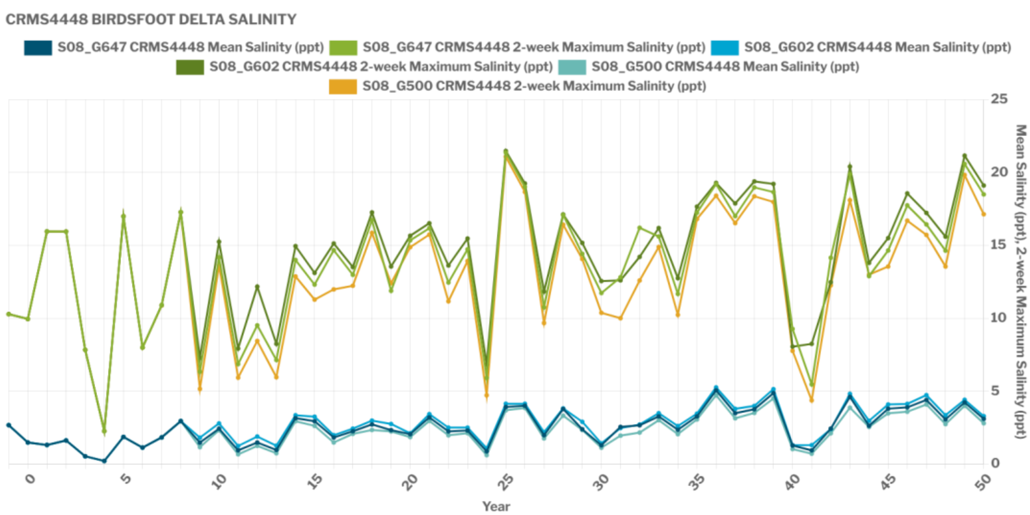


Figure 182. Mean annual salinity and maximum 2-week salinity at CRMS4448 in the Bird's Foot Delta for both diversion projects for the higher scenario.

However, the largest negative impact of the Western Maurepas Sediment Diversion is in the Maurepas (MRP) ecoregion (Figure 182). Figure 183 shows extensive land loss in the MRP ecoregion by Year 50 under the higher scenario. This loss is a result of excessive flooding in the basin.

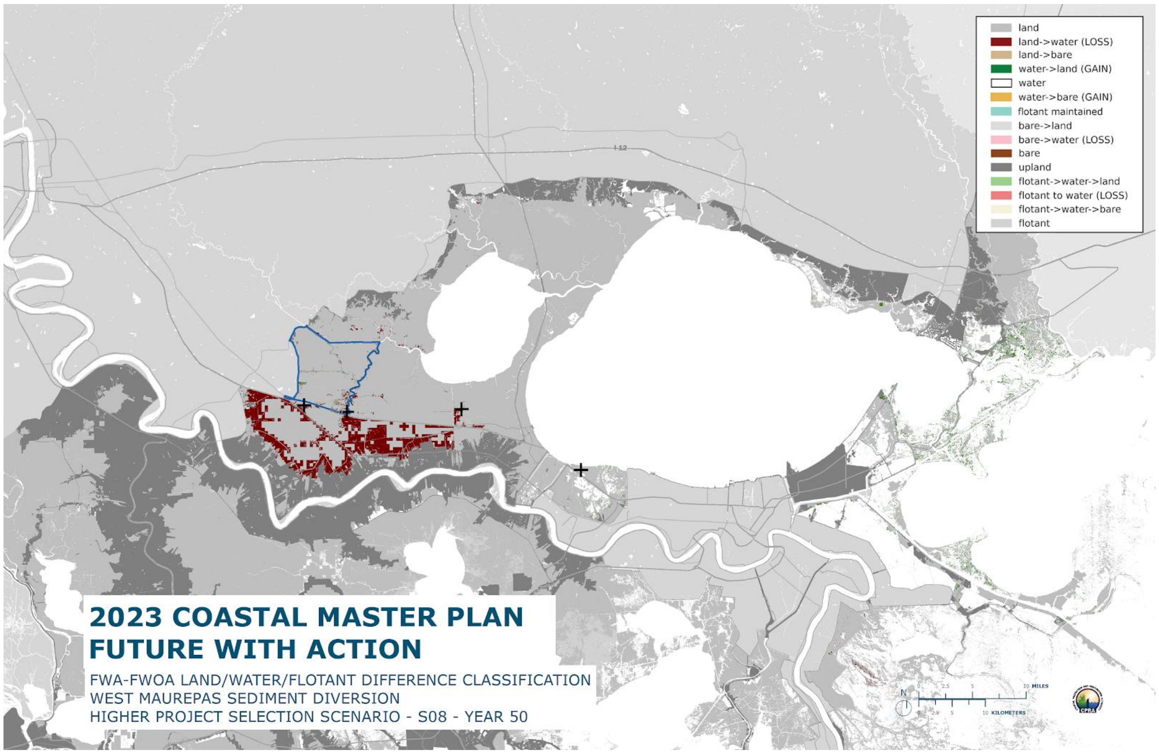


Figure 183. Land loss at Year 50 for the Western Maurepas Sediment Diversion for the higher scenario.

The diversions discharge into compartment 3 that includes CRMS5167. This compartment is one of two that receive active delta designations for the diversion. This means that as long as the FFIBS score remains below 3, they receive higher rates of organic accretion. Figure 185 shows these compartments and compartments to the east which are designated active delta in FWOA associated with the River Reintroduction into Maurepas Swamp project. Matching this with the land loss map shows that much of the loss associated with Western Maurepas is south of these compartments where organic accretion remains at level used in relation to the FFIBS score for the Delta Plain.

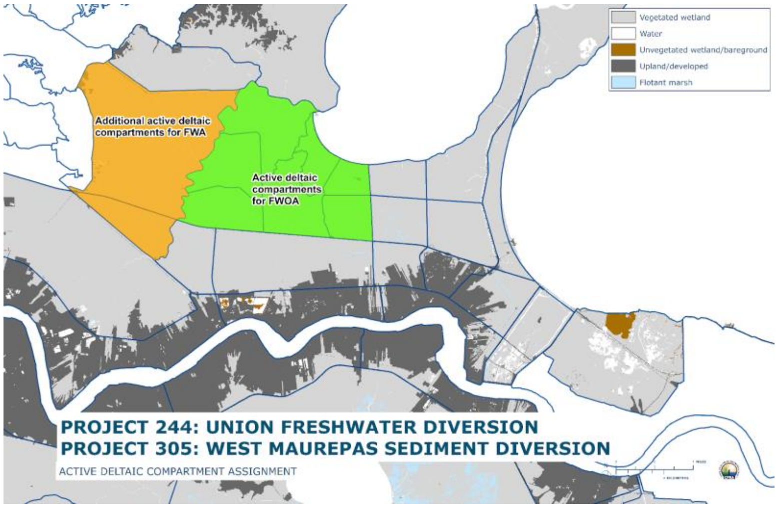


Figure 184. Compartments designated as active delta for the three diversion projects: River Reintroduction into Maurepas Swamp, Union Freshwater Diversion and Western Maurepas Sediment Diversion.

Within the compartments designated as active delta for the Union and Western Maurepas projects, pixel elevation increases at higher rates than under FWOA (Figure 186 and Figure 187). Mean annual inundation increases above FWOA levels when the Union Freshwater Diversion comes online in Year 9 (Figure 186). However, inundation is less than 0.2 m, which is below the inundation loss threshold for fresh marshes. As elevation continues to increase, driven mainly by high active delta organic accretion, inundation depths stabilize with the Union Freshwater Diversion in place. This is substantially different from FWOA when inundation continues to increase throughout the simulation due to the effects of SLR and subsidence being greater than accretion.

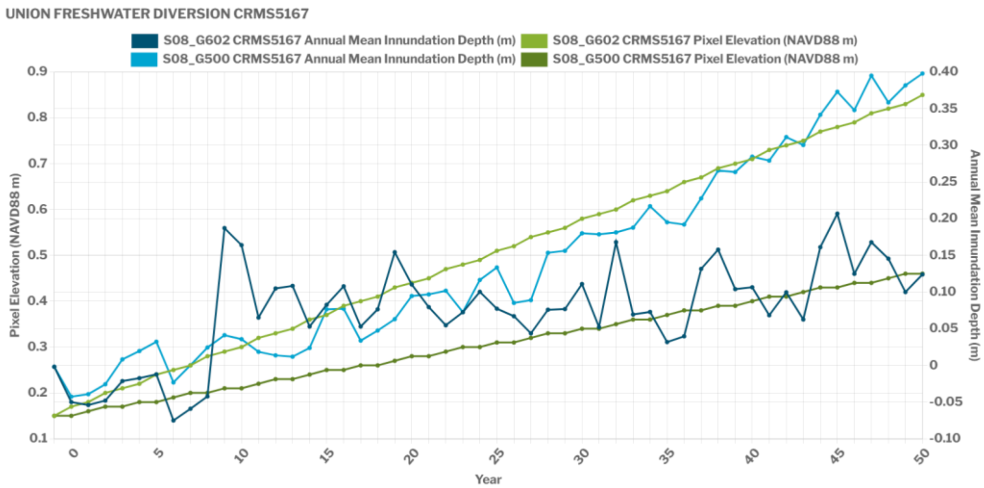


Figure 185. Comparison of inundation depth and pixel elevation for the Union Freshwater Diversion vs. FWOA at CRMS5167 under the higher scenario.

The Western Maurepas Sediment Diversion also results in an increase in inundation depth (Figure 187), although depths exceed 0.6 m, which is sufficient to result in land loss even in this fresh upper basin area. Land loss occurs in Year 10 (Figure 188). Organic accretion stops, but mineral accretion increases to 2-4 cm in most years. The increase in elevation decreases inundation depths, and at Year 37, the pixel is considered high enough to be bare ground and available for vegetation (Figure 188). Organic accretion is able to keep pace with SLR and subsidence and keep inundation levels below the inundation threshold.

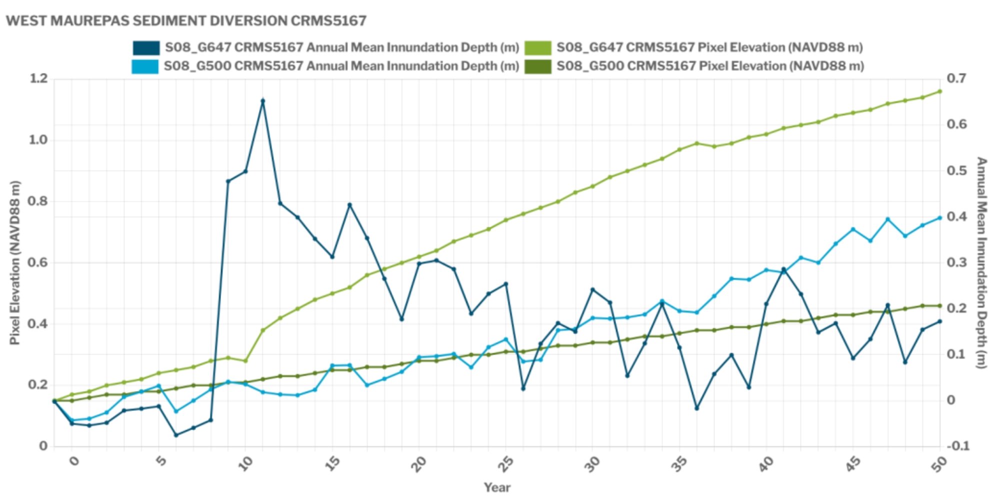


Figure 186. Comparison of inundation depth and pixel elevation for the Western Maurepas Sediment Diversion vs. FWOA at CRMS5167 under the higher scenario.

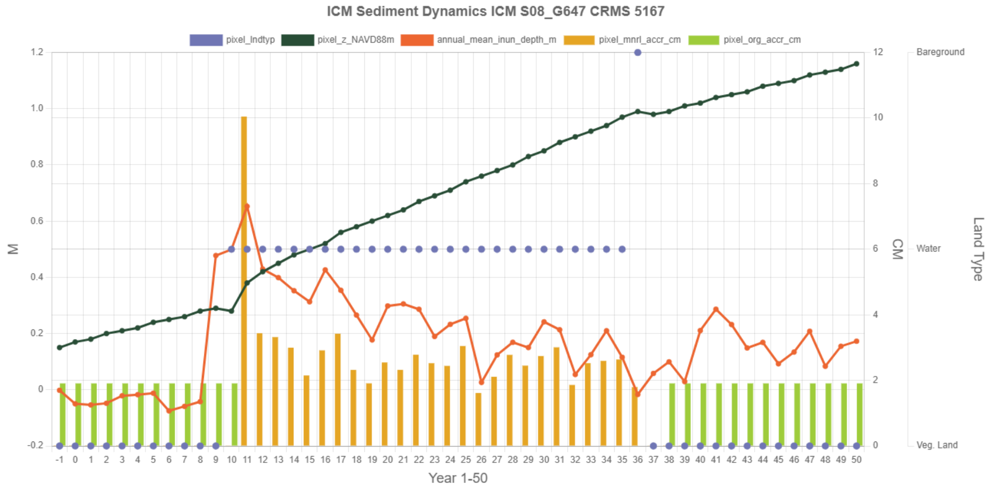


Figure 187. Sediment dynamics at CRMS 5167 for the Western Maurepas Sediment Diversion in the higher scenario.

VEGETATION

In FWOA, land area in the MRP ecoregion is relatively stable under both scenarios, but the region experiences some conversion of swamp to marsh (Figure 189). Under the lower scenario, conversion of swamp to marsh starts around Year 35. While in the higher scenario, the conversion starts around Year 25. With the Union Freshwater Diversion, the ICM predicts less marsh expansion under both scenarios. With the Western Maurepas Sediment Diversion, some of the swamp and marsh are converted to open water due to changes in water level variability (Figure 187).

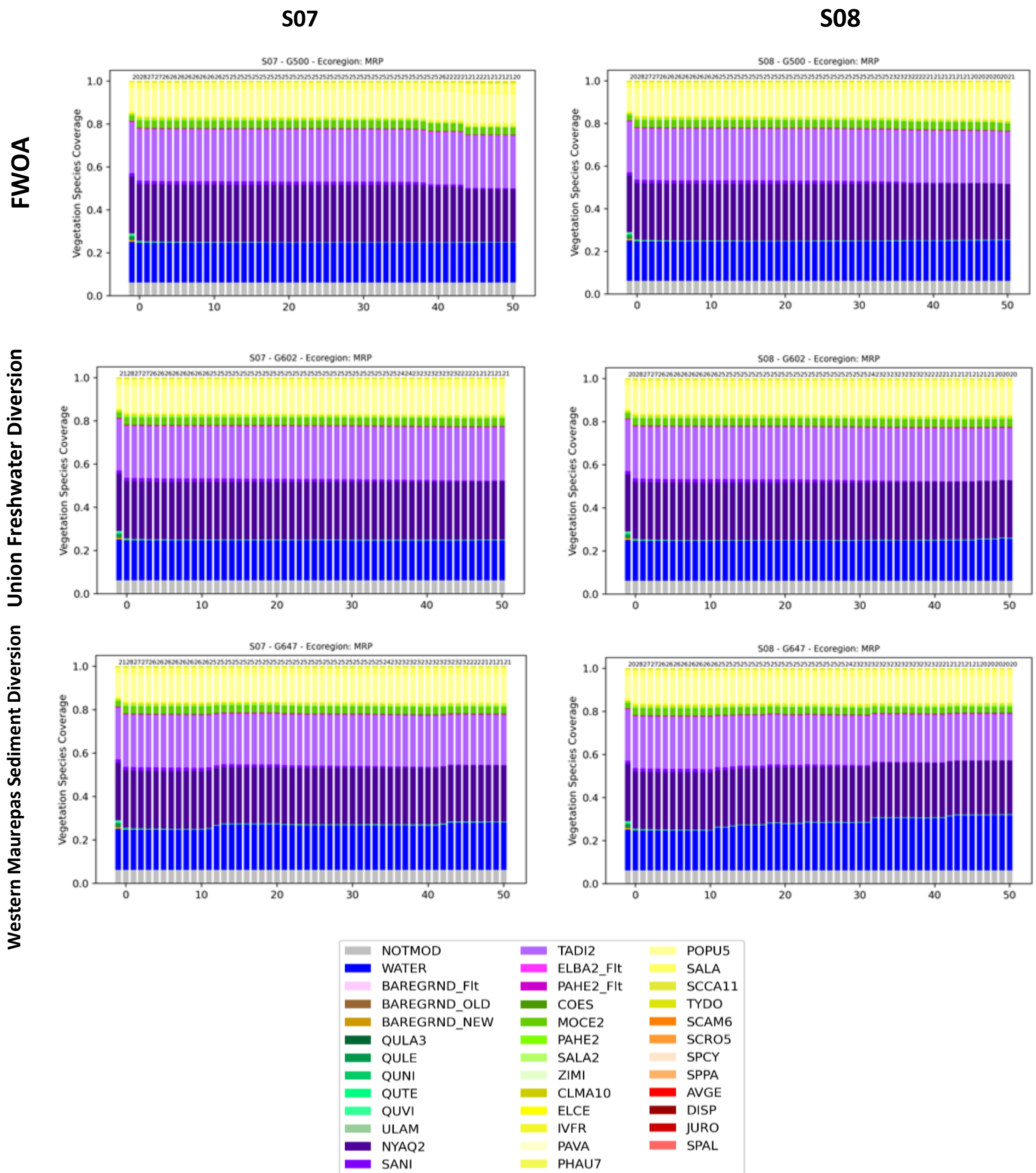


Figure 188. Changes in vegetation cover in the MRP ecoregion are shown for FWOA, Union Freshwater Diversion, and Western Maurepas Sediment Diversion under two scenarios.

In the LBO ecoregion, both projects have a positive effect (Figure 190). The first effect is the expansion of intermediate marsh species, which for the Union Freshwater Diversion is most pronounced from Year 10 to Year 35, while for the Western Maurepas Sediment Diversion, it is most pronounced from Year 10 to Year 50 under the lower scenario and Year 10 to 45 under the higher scenario. Secondly, the freshening allows bottomland hardwoods to survive longer. Under the lower scenario, bottomland hardwoods last 10 years longer for Union and 18 years longer for Maurepas. While under the higher scenario, bottomland hardwoods last 1 year longer for Union and 13 years longer for Maurepas.

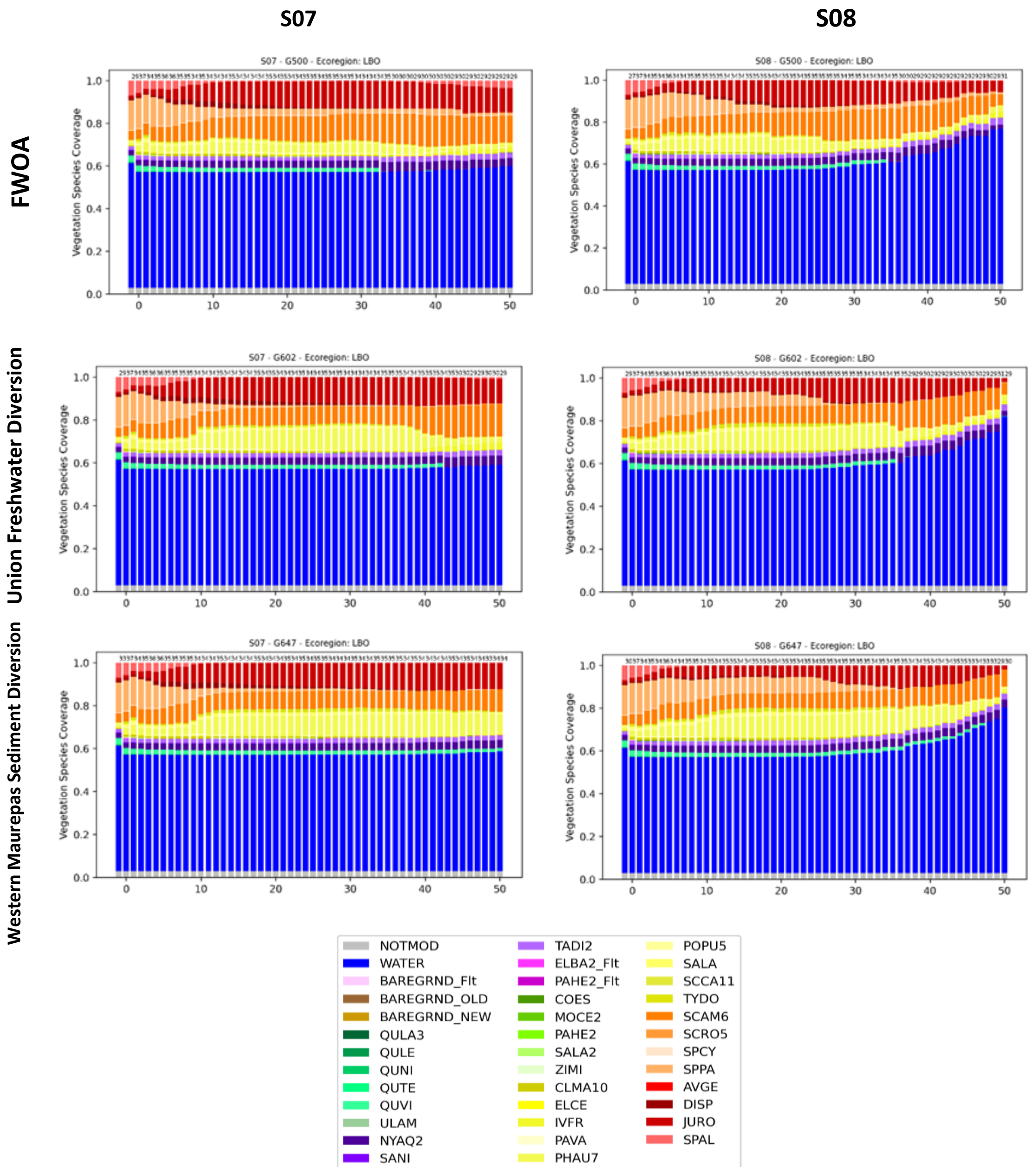


Figure 189. Changes in vegetation cover in the LBO ecoregion are shown for FWOA, Union Freshwater Diversion, and Western Maurepas Sediment Diversion under two scenarios.

HABITAT SUITABILITY

RESULTS AND DISCUSSION

The Western Maurepas Sediment Diversion and the Union Freshwater Diversion both had extensive effects on the habitat suitability for fish, shellfish, and wildlife in the MRP ecoregion. Both projects caused large salinity decreases in the ecoregion, which created new habitat for species tolerant of lower salinities, such as the gadwall, mottled duck, and juvenile blue crab. Freshwater input from both diversions also caused down-basin salinity reductions to Lakes Pontchartrain and Borgne. These reductions decreased habitat suitability for higher salinity species (Figure 191 and Figure 192).

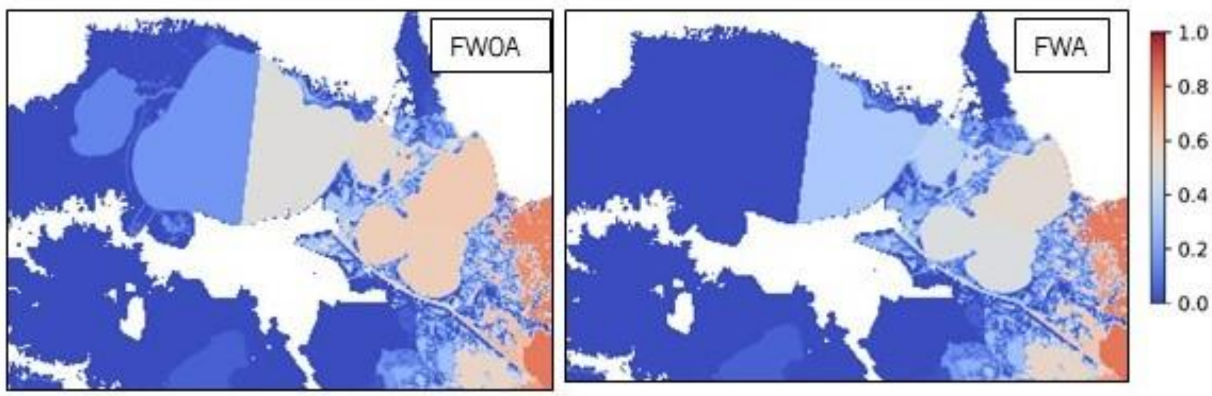


Figure 190. Adult gulf menhaden HSI scores across the MRP, Lake Pontchartrain (LPO), and LBO regions for Year 10 of FWOA and Union Freshwater Diversion (FWA) higher environmental scenario simulations. Scores range from 0.0, completely unsuitable habitat, to 1.0, optimal habitat.

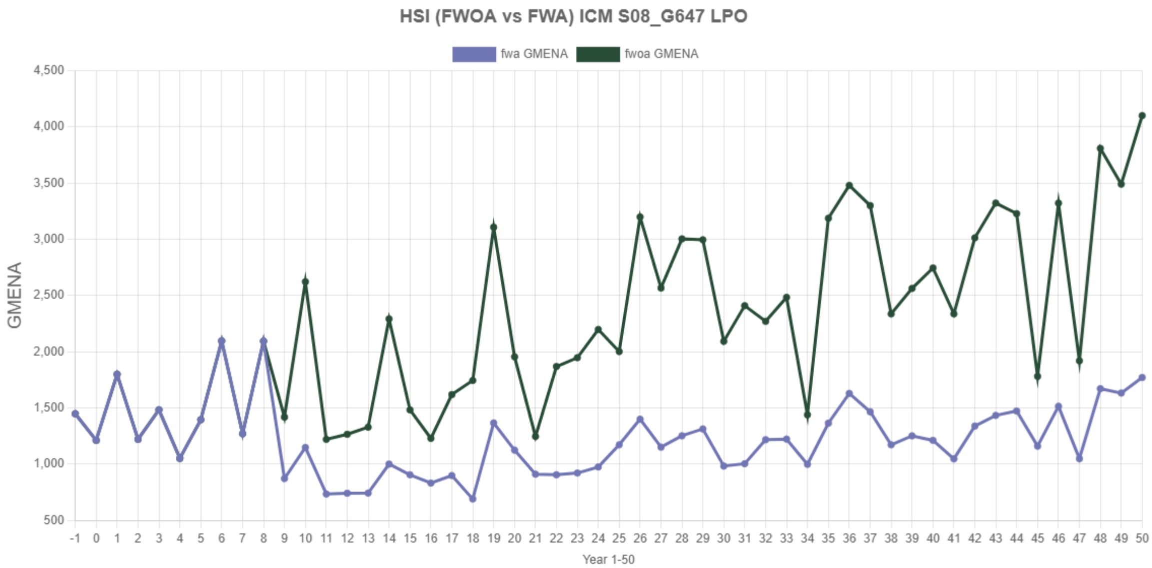


Figure 191. Total HSI score for adult gulf menhaden in the LPO ecoregion for the 50-year FWOA and Western Maurepas Sediment Diversion (FWA) higher environmental scenario simulation. The total HSI score was calculated by summing the individual scores for each ICM model cell within the ecoregion.

Both projects also caused land loss throughout the MRP ecoregion. This had negative effects in later years for species reliant on wetland habitat but also resulted in new aquatic habitat. There were relatively large increases in habitat suitability scores for some species, particularly for the Western Maurepas Sediment Diversion due to increased wetland loss and aquatic habitat created (e.g., juvenile blue crab; Figure 193). Much of this loss was concentrated near the diversion outfall, but this area eventually filled with sediment and became new wetland habitat around Year 25. This resulted in a reduction in aquatic habitat, and habitat suitability decreased accordingly. This was reversed in the last decade when SLR overtook land building.

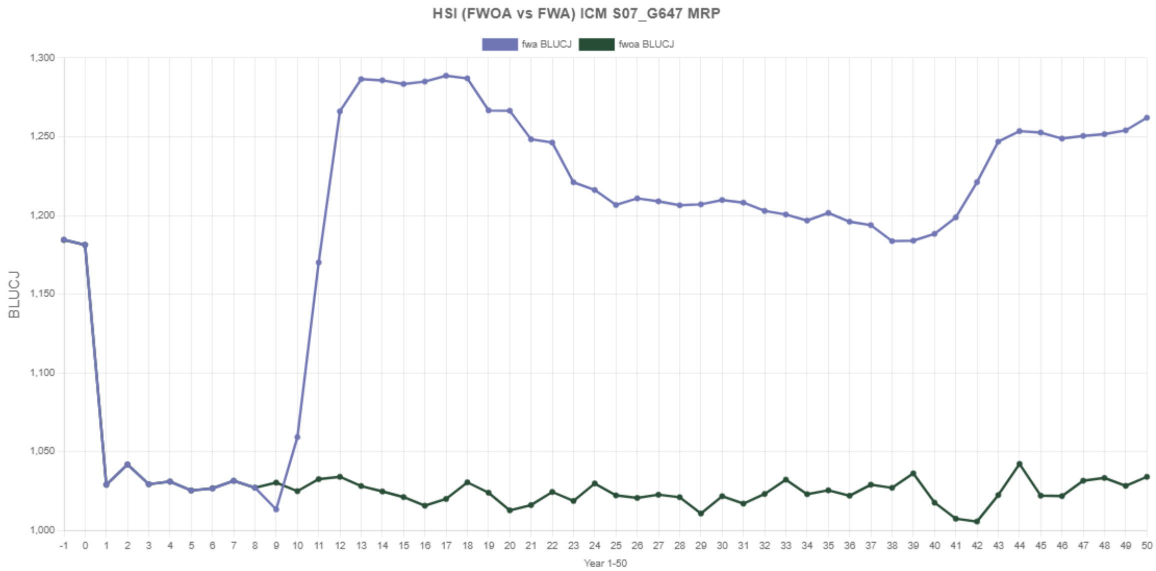


Figure 192. Total HSI score for the juvenile blue crab in the MRP ecoregion for the 50-year FWOA and Western Maurepas Sediment Diversion (FWA) lower environmental scenario simulation. The total HSI score was calculated by summing the individual scores for each ICM model cell within the ecoregion.

Both diversions also increased water depths across the Maurepas Basin, which contributed to the changes in habitat suitability for wildlife species. Higher water levels from the diversion inundated wetlands to a greater depth than without the diversion. This resulted in an overall decrease in habitat suitability for the alligator because the deeper marsh inundation negatively affected nesting success for this species. In contrast, habitat suitability increased for the gadwall and mottled duck because marsh inundation resulted in a greater amount of shallow water habitat available for these species (Figure 194 and Figure 195). However, as water levels increased over time due to SLR, the additional increase in water levels from the diversions made water depths too deep for waterfowl in many areas. This resulted in a decline in habitat suitability (relative to FWOA) during the last decade of the simulations (Figure 194 and Figure 195).

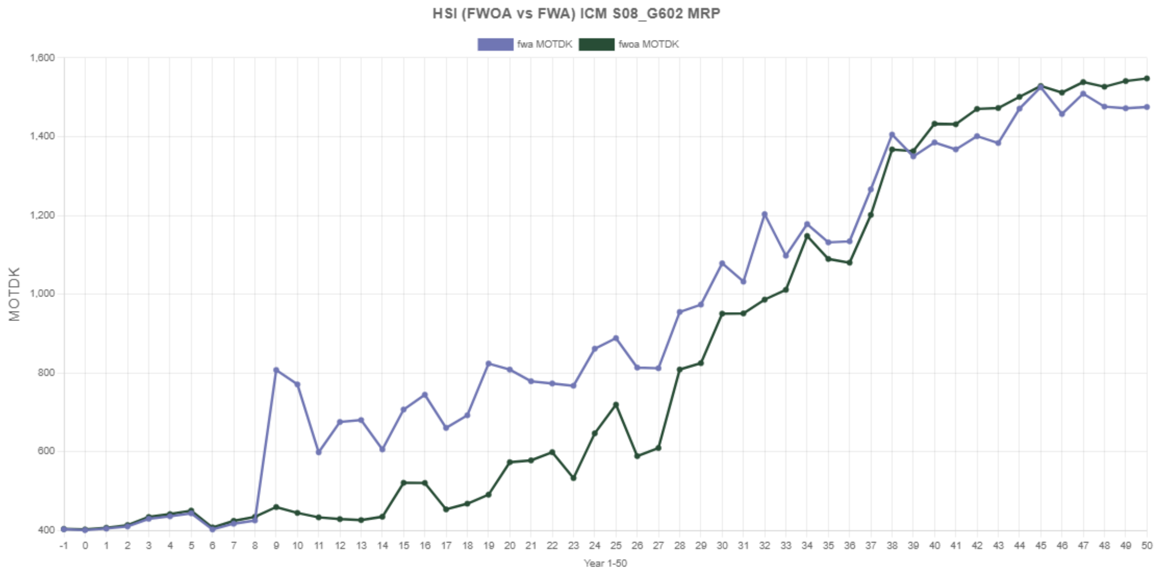


Figure 193. Total HSI score for mottled duck in the MRP ecoregion for the 50-year FWOA and Union Freshwater Diversion (FWA) higher environmental scenario simulations. The total HSI score was calculated by summing the individual scores for each ICM model cell within the ecoregion.

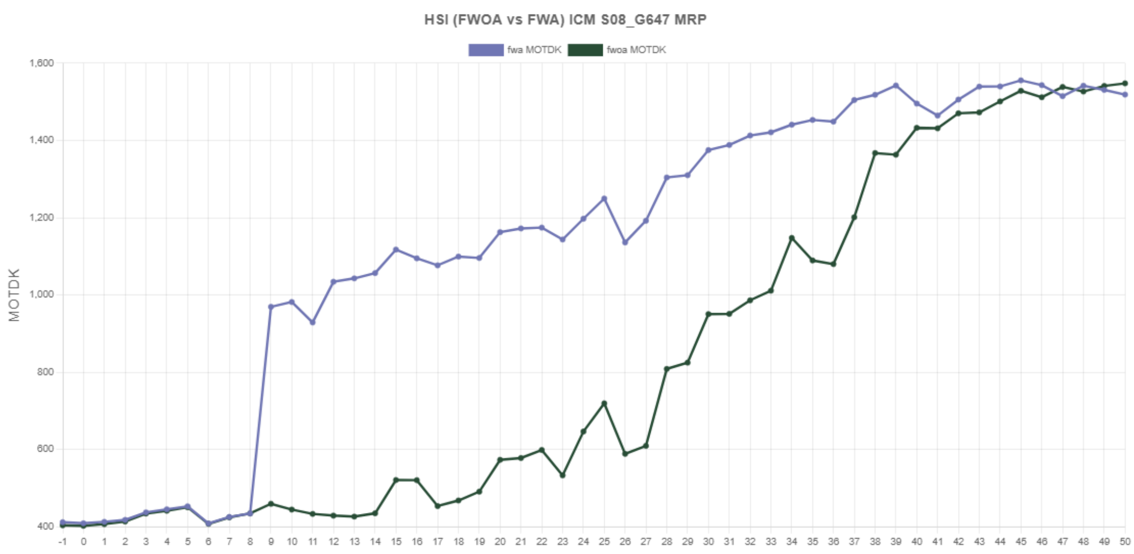


Figure 194. Total HSI score for mottled duck in the MRP ecoregion for the 50-year FWOA and Western Maurepas Sediment Diversion (FWA) higher environmental scenario simulations. The total HSI score was calculated by summing the individual score for each ICM model cell within the ecoregion.

8.0 ATCHAFALAYA RIVER DIVERSION AND INCREASE ATCHAFALAYA FLOW TO TERREBONNE

PROJECTS OVERVIEW

This report describes the modeling results for two diversion projects that both move water from the Atchafalaya River eastward but through different pathways: the Atchafalaya River Diversion project (#108) and the Increase Atchafalaya Flow to Terrebonne project (#139).

The Atchafalaya River Diversion (AD) project (Figure 196) is a sediment diversion that moves water into the Penchant Basin and southwest Terrebonne marshes with 30,000 cfs capacity (modeled at 26% of the Atchafalaya River flow upstream of the confluence with Bayou Shaffer). The project is fully constructed and operational at Year 9 and was modeled in G607. The project was selected in IP1. The project cost is $787.6 million in IP1. The cost of the project does not vary by scenario as no marsh creation is included.

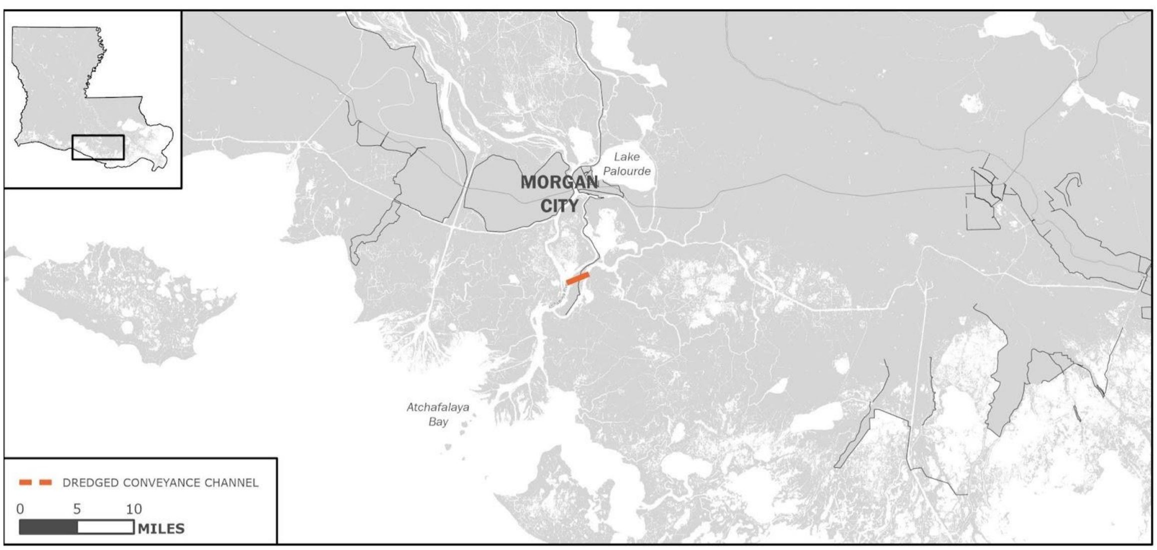


Figure 195. The location of the AD project.

The Increase Atchafalaya Flow to Terrebonne (IAFT) project involves dredging of the Gulf Intracoastal Waterway (GIWW) and construction of a bypass structure at the Bayou Boeuf Lock to move water from the Atchafalaya River to Terrebonne marshes (Figure 197). The diversion is operated with a linear rating curve diverting approximately 11% of the Atchafalaya River flows at Morgan City when Atchafalaya River flows are less than 250,000 cfs, with a maximum diversion flow rate of 30,000 cfs (modeled as G608). The project is fully constructed and operational at Year 9. The project was not selected in IP1 due to the negative effects on land area described in this report. To try and address these issues, the project was also modeled as G654 with revised project operations (see Hydrology section below), which further limited diversion peak flows, with a linear rating curve diverted approximately 11% of the Atchafalaya River flows at Morgan City when Atchafalaya River flows are less than 200,000 cfs, with a maximum diversion flow rate of 25,000 cfs.

The project cost is $458 million in IP1. The cost of the project does not vary by scenario as no marsh creation is included.

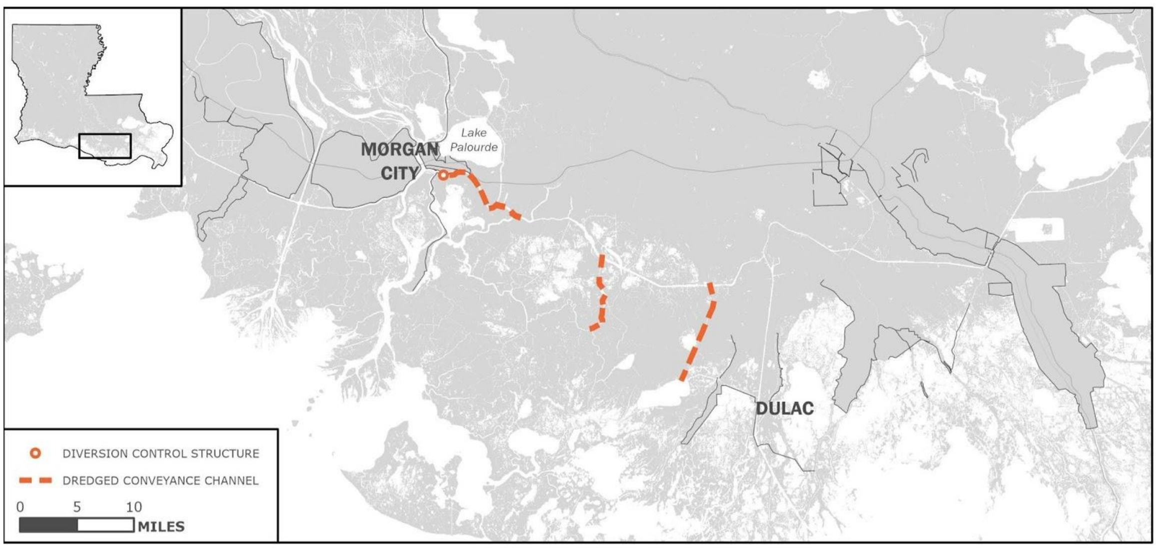


Figure 196. Location of the features of the IAFT project.

The results presented here discuss the way in which the projects change the coastal landscape in terms of hydrology, morphology, vegetation, and habitats, with examples from the two environmental scenarios, and for IAFT, the two operational regimes. The examples have been selected to illustrate the dynamics of the project based on available data, rather than to provide a comprehensive description of all areas, scenarios, and implementation period comparisons.

HYDROLOGY

INCREASE ATCHAFALAYA FLOW TO TERREBONNE (IAFT)

Figure 198 shows the IAFT Diversion flow time series implemented in the two operational regimes.

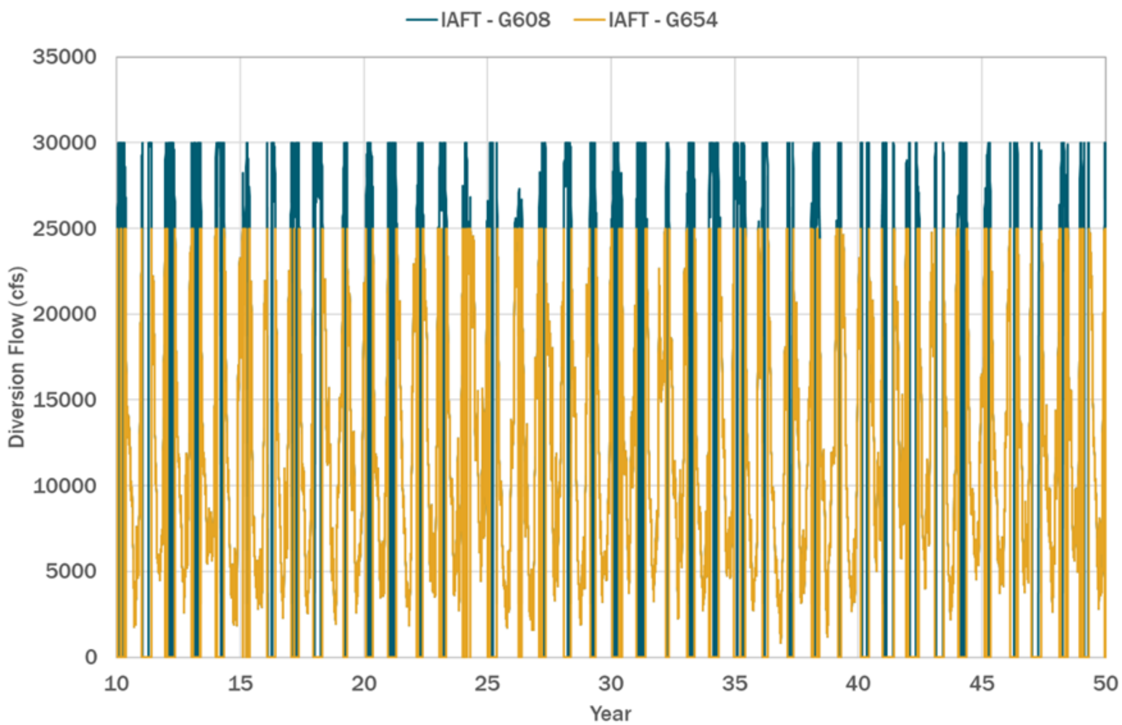
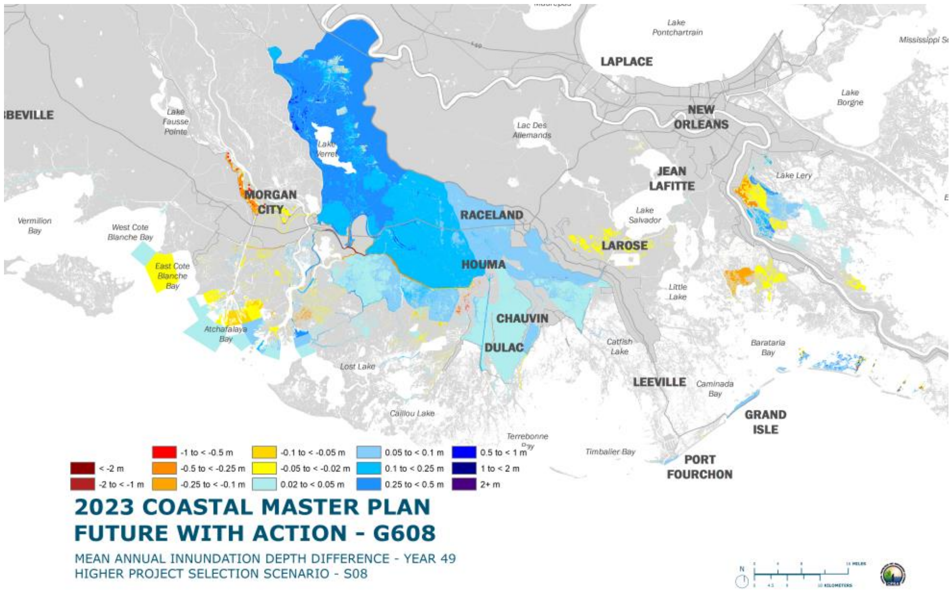


Figure 197. IAFT Diversion flows.

STAGE

IAFT increases stages in the Verret Basin (VRT) and Penchant Basin (PEN) when operating. The stage increases in G654 are generally lower than G608. Figure 199 presents the mean annual inundation differences (FWA-FWOA) at Year 49 of the higher scenario for both IAFT operation schemes. Figure 200 to Figure 203 present the time series of annual mean water levels at several locations to demonstrate the IAFT operation impacts on stages across various regions. Water level increases caused by IAFT operations are more severe in VRT than PEN. Even in Western Terrebonne (WTE) and ETB ecoregions, the project can cause a small amount of water level increases. In general, the revised operations to limit peak flows in G654 decrease project inundation impacts by approximately half compared to G608.



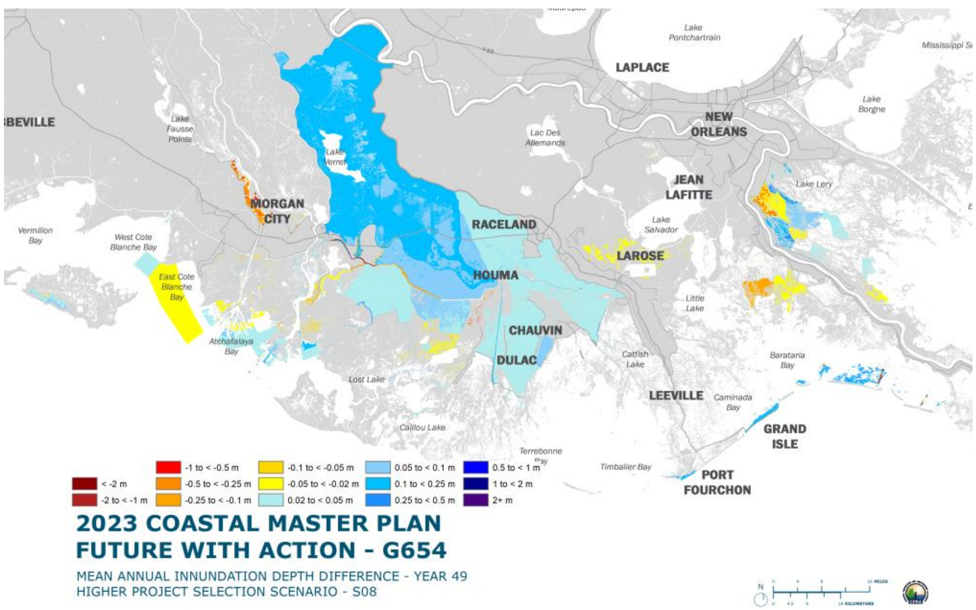


Figure 198. Annual mean inundation differences (FWA-FWOA) at Year 49 of the higher scenario S08 for both IAFT Diversion schemes (upper panel – G608; lower panel – G654).

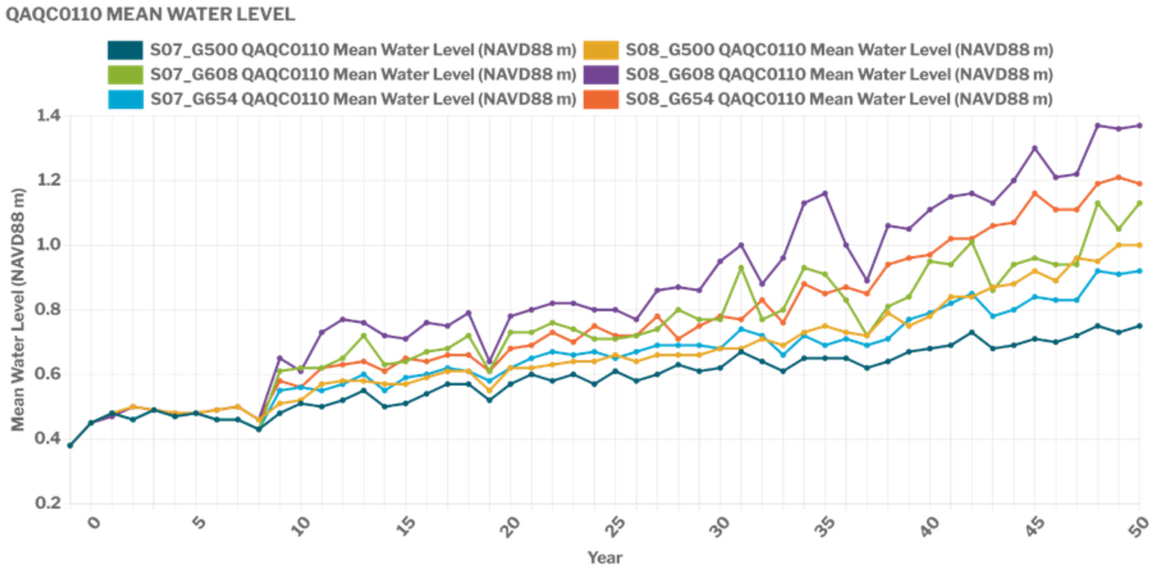


Figure 199. Mean water levels at QAQC0110 in VRT caused by IAFT operations.

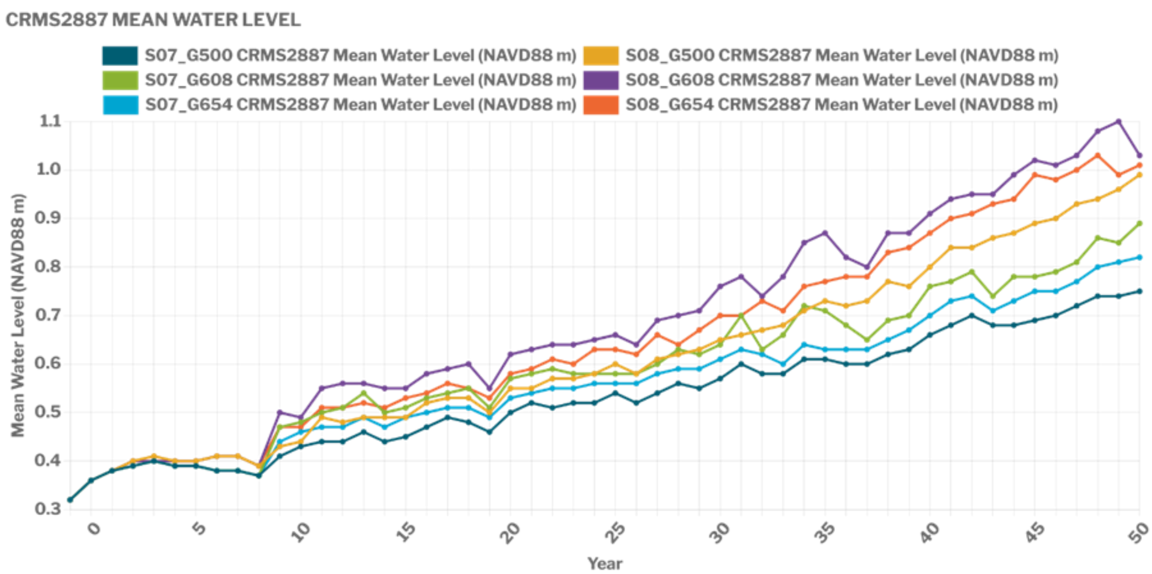


Figure 200. Mean water levels at CRMS2887 in PEN caused by IAFT operations.

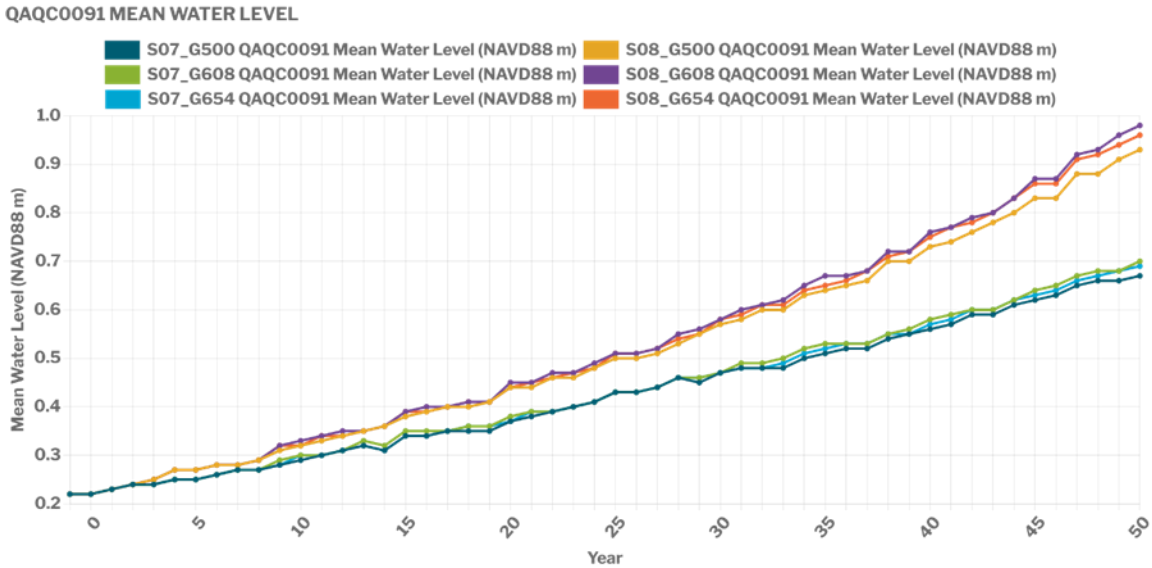


Figure 201. Mean water levels at QAQC0091 in WTE caused by IAFT operations.

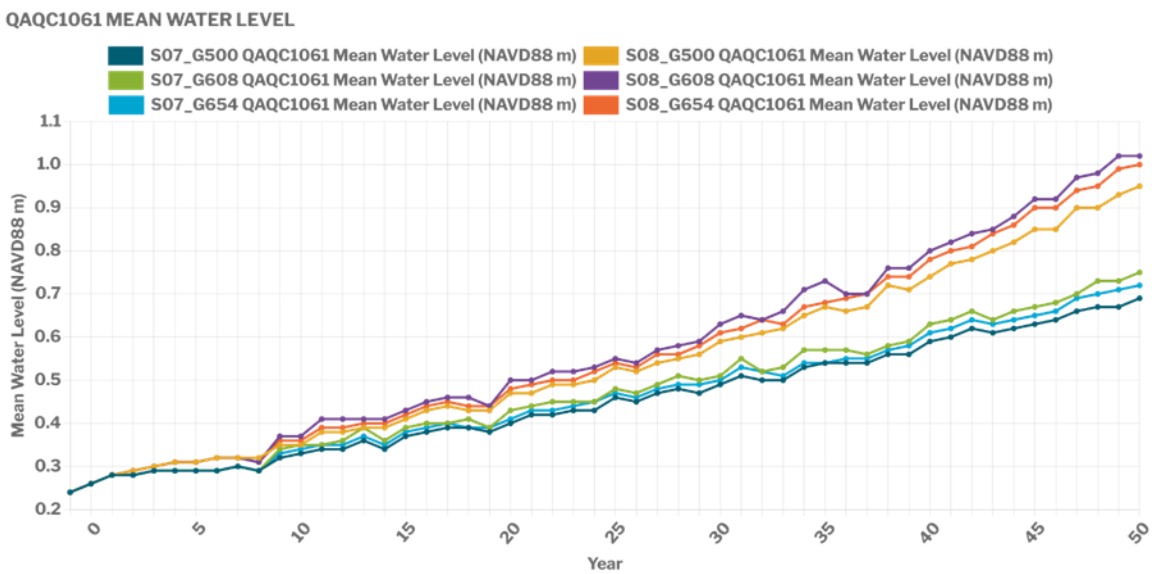


Figure 202. Mean water levels at QAQC106 in ETB caused by IAFT operations.

SALINITY

After project implementation, there are broad reductions in salinities within the full Terrebonne basin (PEN, WTE, and ETB). Mean values are reduced by up to 5 ppt, while maximum 2-week average values are reduced by up to 10 ppt. There are some slight salinity increases in the Atchafalaya Bay complex due to the project. The project prevents some amount of saline intrusion via the Houma Navigation Canal (HNC) and has a greater impact on salinities along the northern HNC in later years. Figure 204 presents the maximum 2-week average salinity difference (FWA-FWOA) at Year 50 of the higher scenario for both IAFT operations. The time series of annual maximum 2-week average salinity at several locations within PEN, WTE, and ETA are shown in Figure 205 to Figure 207, respectively. The alternative operations in G654 meant to limit inundation impacts still reduces salinities in target areas with little difference with the reductions simulated in G608.

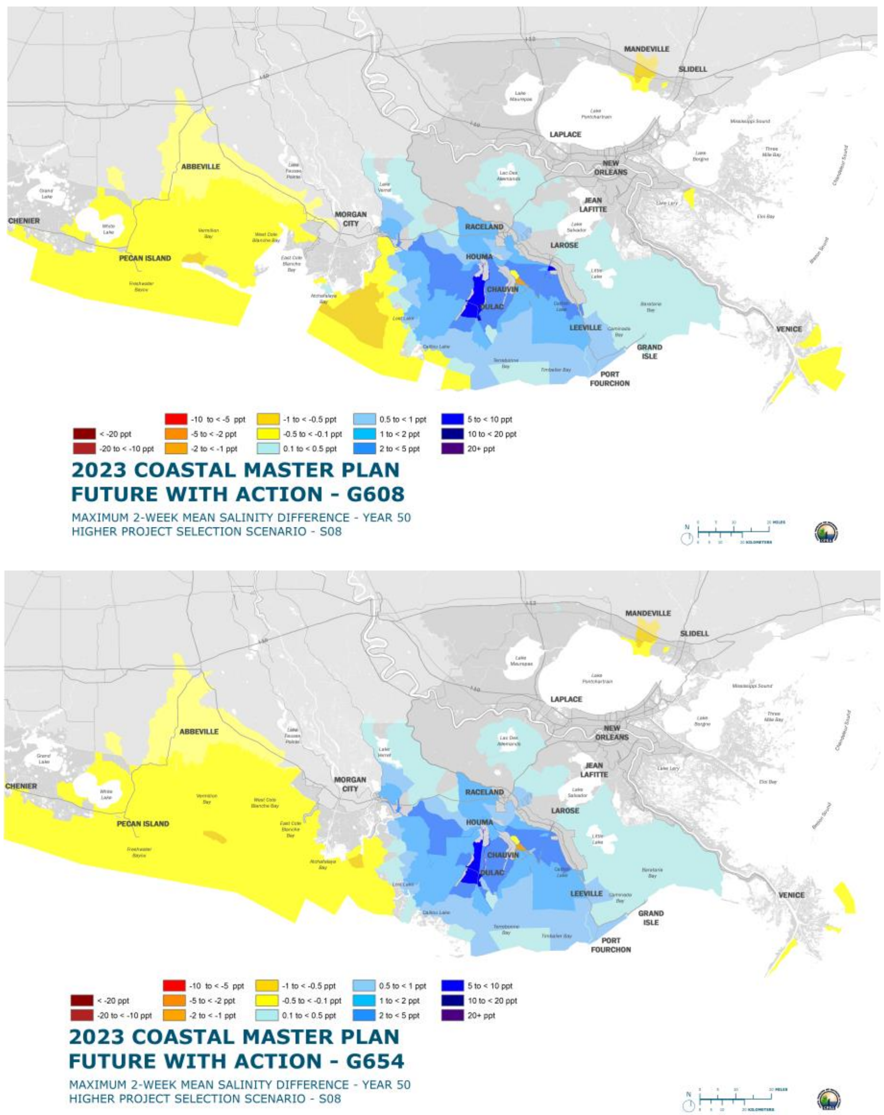


Figure 203. Maximum 2-week average salinity differences (FWA-FWOA) at Year 50 of the higher scenario S08 for both IAFT Diversion schemes (upper panel – G608; lower panel – G654).

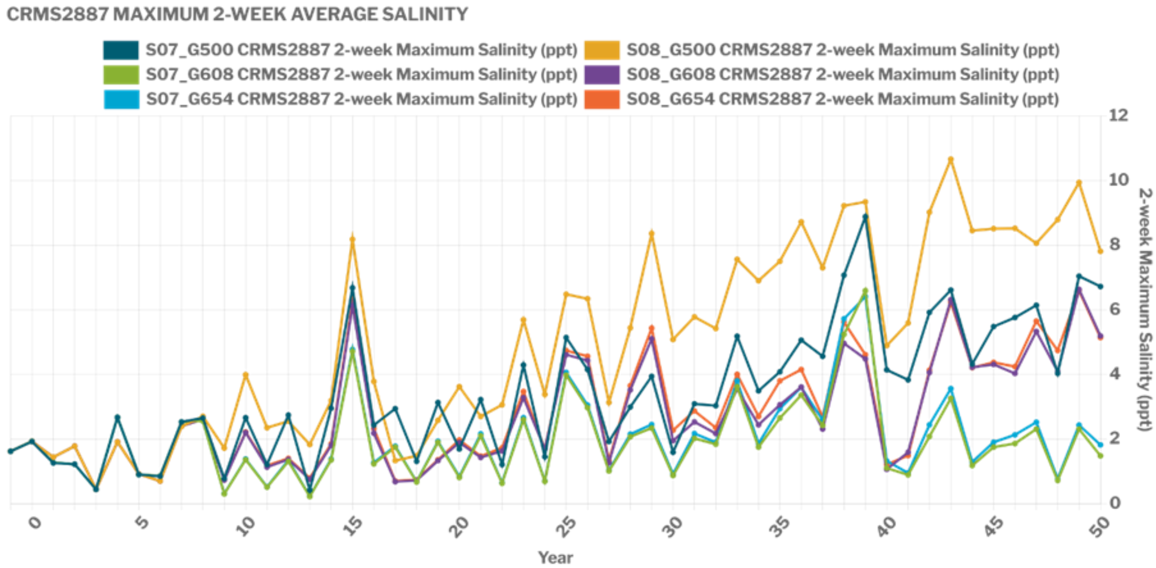


Figure 204. Maximum 2-week average salinity at CRMS2887 in PEN caused by IAFT operations.

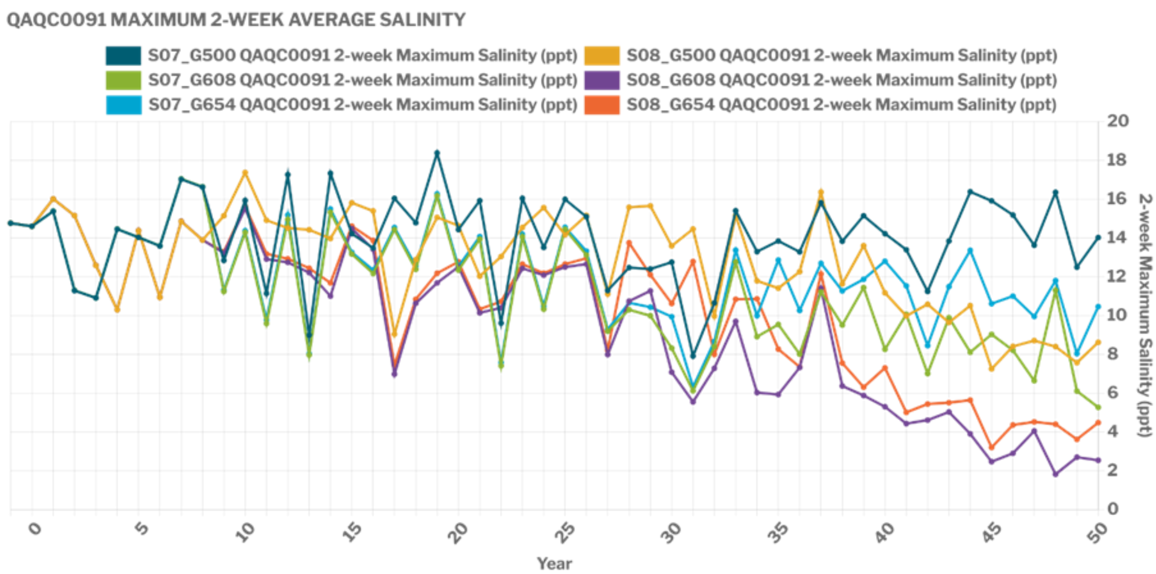


Figure 205. Maximum 2-week average salinity at QAQC0091 in WTE caused by IAFT operations.

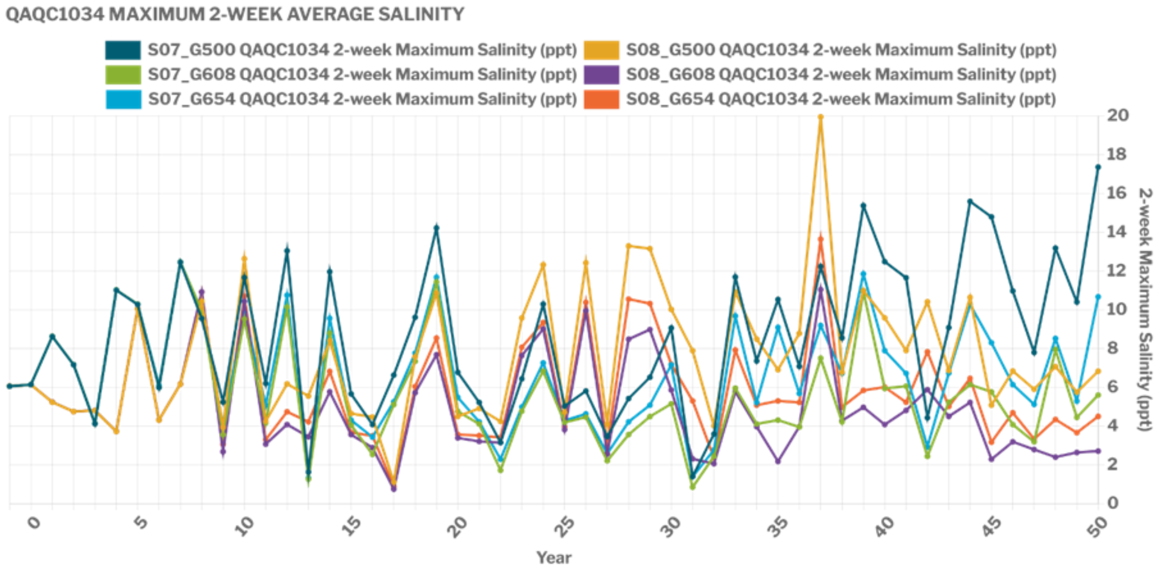


Figure 206. Maximum 2-week average salinity at QAQC1034 in ETB caused by IAFT operations.

TOTAL SUSPENDED SEDIMENT (TSS)

In diverting freshwater from the Atchafalaya River, the project also broadly increases suspended sediment concentrations and sediment accumulation throughout Terrebonne. Figure 208 to Figure 210 present examples of the annual average TSS at Avoca Island Cutoff south of the GIWW (compartment 637 within PEN), HNC north of the HNC lock (compartment 913 within WTE), and Grand Bayou south of the GIWW (compartment 980 within ETB), respectively from the lower diversion flow operation G654 in the higher scenario. The higher diversion flow operation in G608 provides slightly higher average annual TSS concentrations.

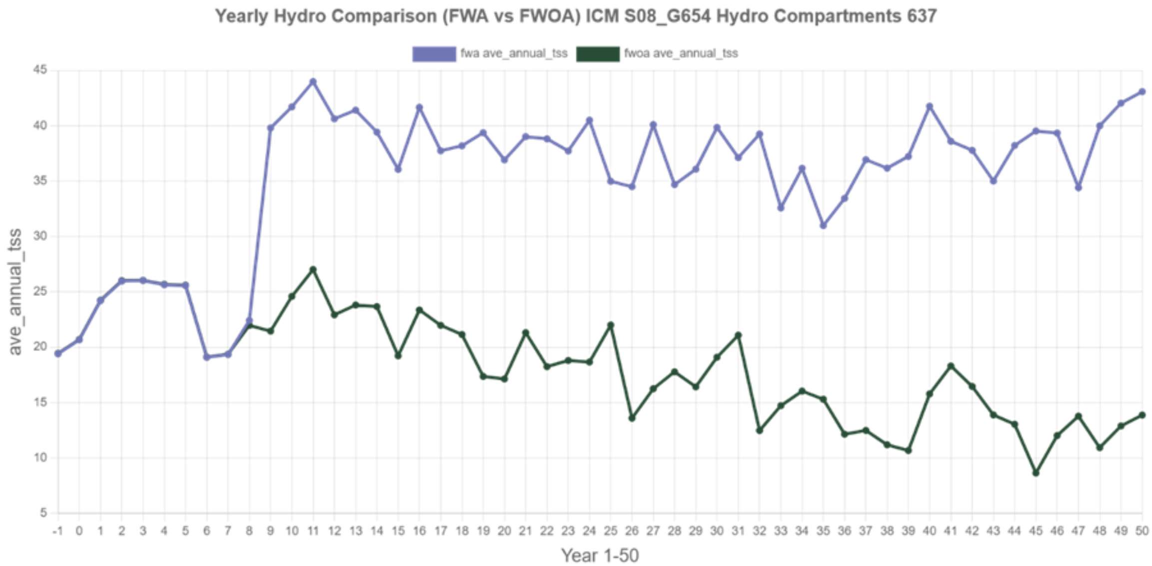


Figure 207. Average annual TSS at Avoca Island Cutoff south of the GIWW (PEN).

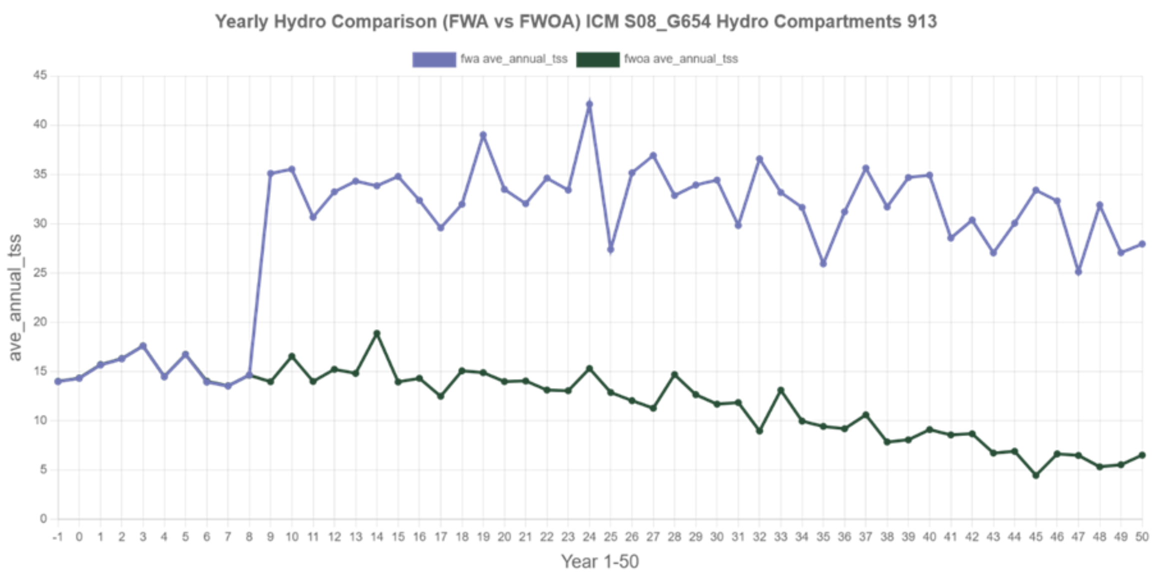


Figure 208. Average annual TSS at HNC north of the HNC lock (WTE).

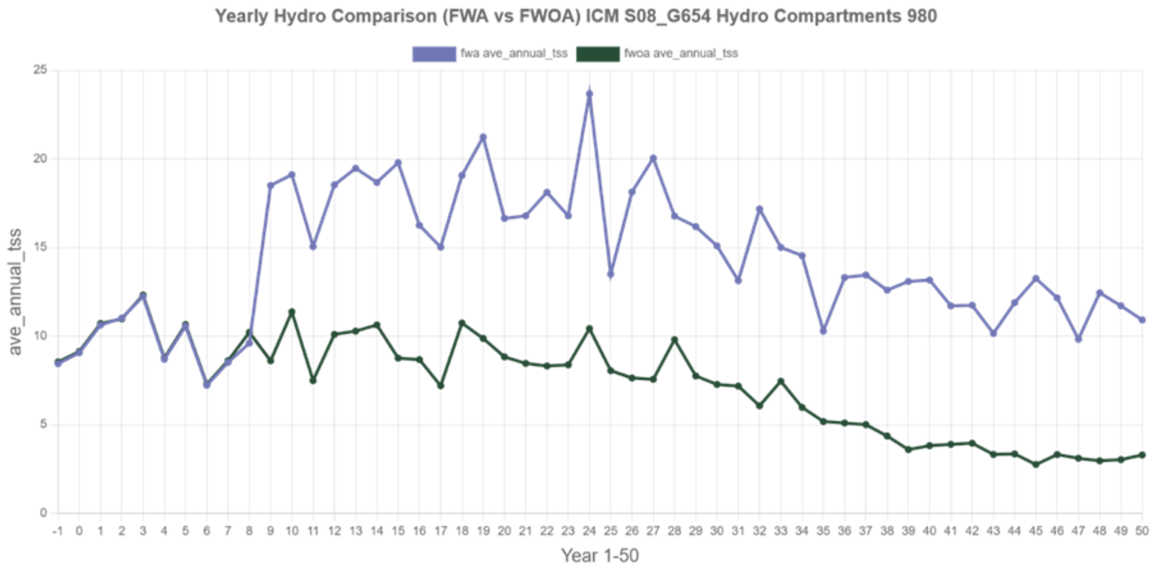


Figure 209. Average annual TSS at Grand Bayou south of the GIWW (ETB).

ATCHAFALAYA RIVER DIVERSION (AD)

Upon AD project implementation, stages and inundation in the immediate diversion outfall are increased by small amounts with the diverted flows as illustrated in Figure 211. Unlike IAFT, there is no widespread inundation increase in VRT and PEN. Figure 212 presents the annual mean water levels at QAQC0736 (compartment 612) in the outfall area. The annual mean water levels are increased by 0.05 m with AD operation. The annual water levels at CRMS2887 (15 miles east of the diversion outfall adjacent to the GIWW) are presented in Figure 213. The project impact on stages is negligible farther away from the outfall.

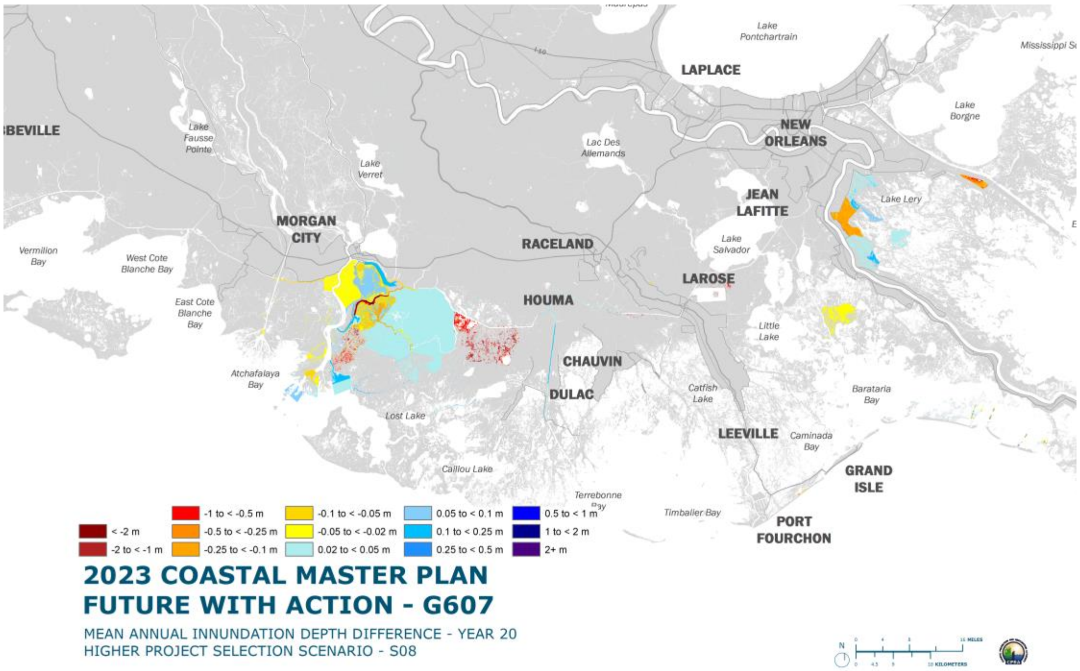


Figure 210. Mean annual inundation difference (FWA-FWOA) at Year 20 of the higher scenario S08 due to AD.

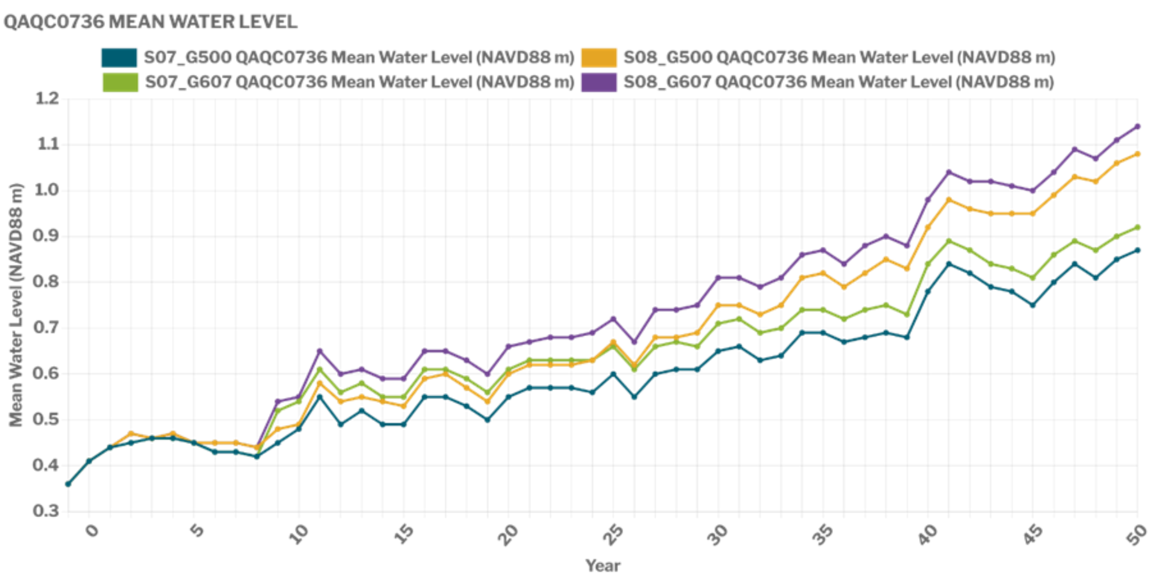


Figure 211. Mean annual water levels at QAQC0736 with AD.

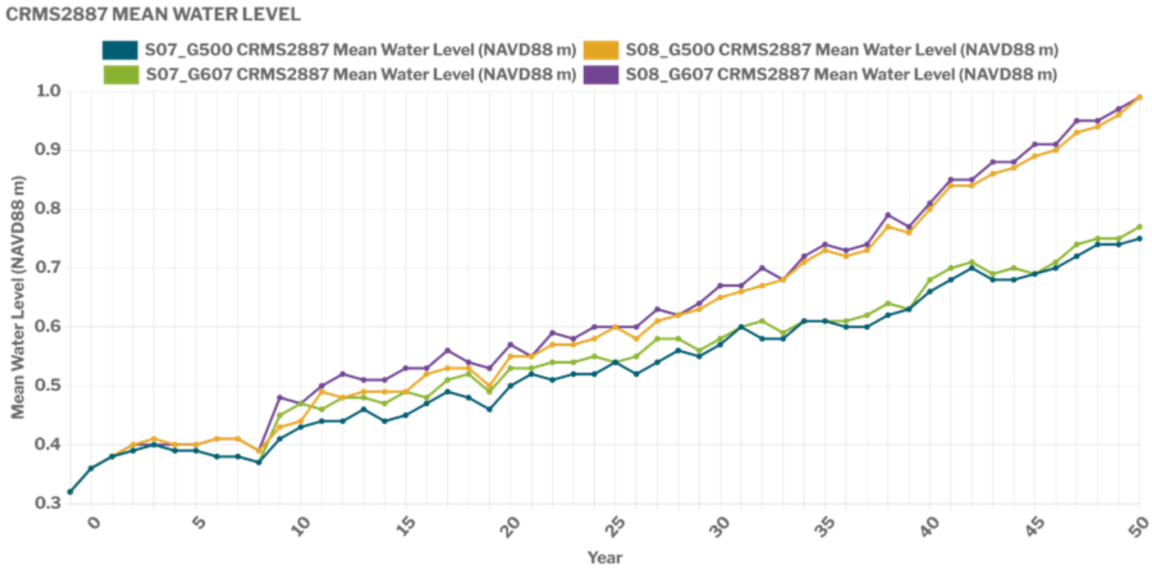


Figure 212. Mean annual water levels at CRMS2887 with AD.

The project broadly decreases salinities in the Terrebonne Basin with annual mean salinities reduced by up to 2 ppt, while maximum 2-week average values are reduced by up to 5 ppt as illustrated in Figure 214 at Year 20 of the higher scenario S08. There is also an associated slight increase in salinities in western Atchafalaya Bay due to the reduced river flow through the Atchafalaya Delta. In the final two decades of simulation of both the lower scenario and the higher scenario, there are isolated years where the project increases salinities in WTE and ETB while continuing to decrease salinities in PEN as shown in Figure 215 at Year 30 of the higher scenario. The cause of this salinity increase in WTE and ETB appears to be the diversion of additional water into the Penchant Basin with a concomitant reduction in eastern flow through the GIWW, and then south through the HNC. The increases in WTB and ETB are relatively small and are occurring in later years of the simulation when there would be more intrusion up the HNC into these areas (and small reductions in flows would be more impactful). The timeseries of maximum 2-week average salinity at locations within PEN, WTE and ETB are presented in Figure 216 to Figure 218, respectively.

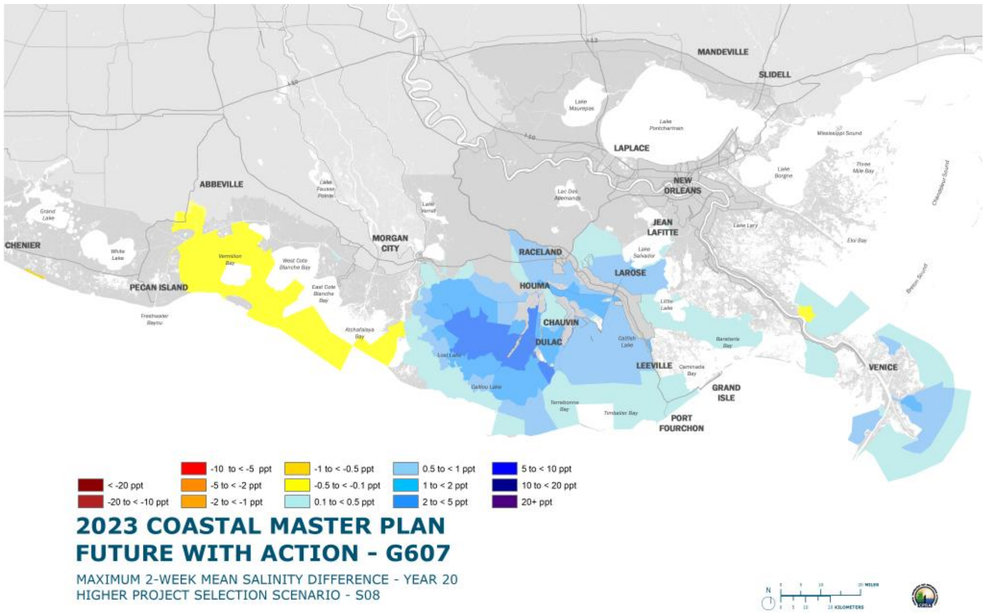


Figure 213. Maximum 2-week average salinity difference (FWA-FWOA) at Year 20 of the higher scenario S08 with AD.

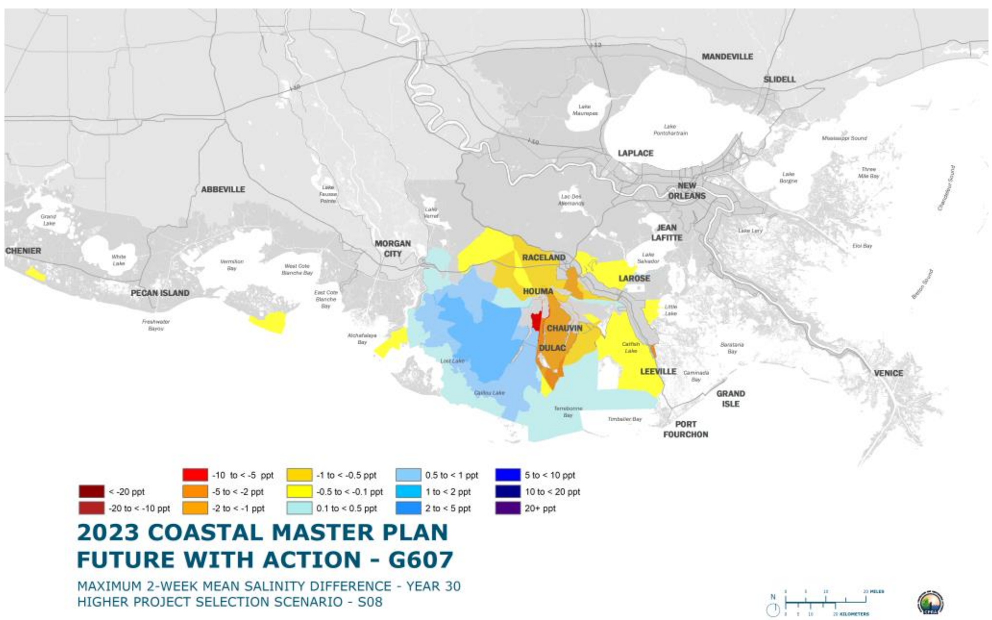


Figure 214. Maximum 2-week average salinity difference (FWA-FWOA) at Year 30 of the higher scenario S08 with AD.

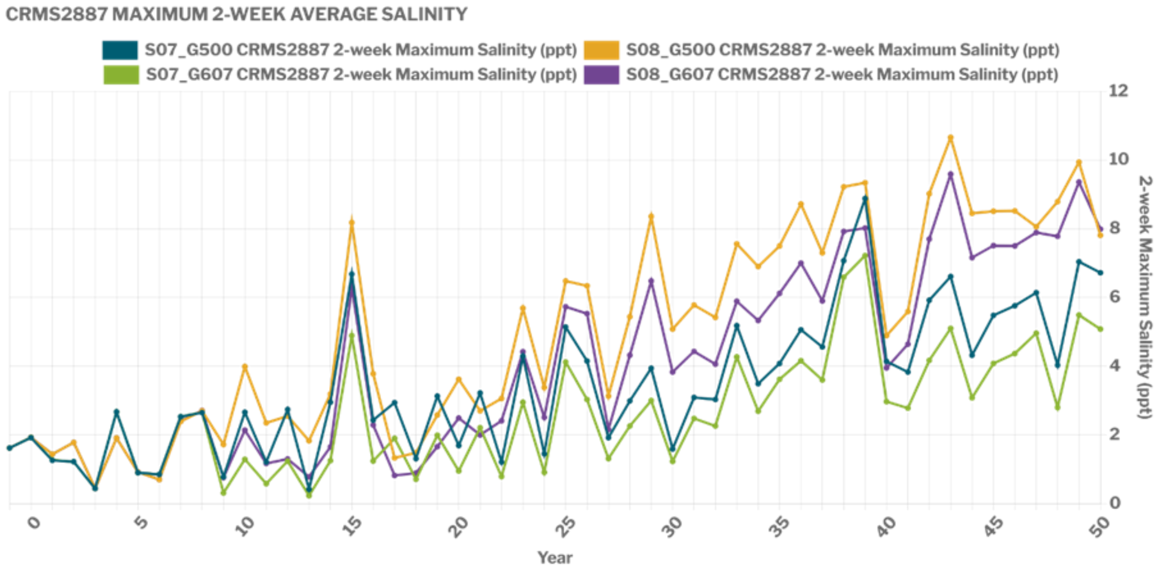


Figure 215. Maximum 2-week average salinity at CRMS2887 in PEN with AD.

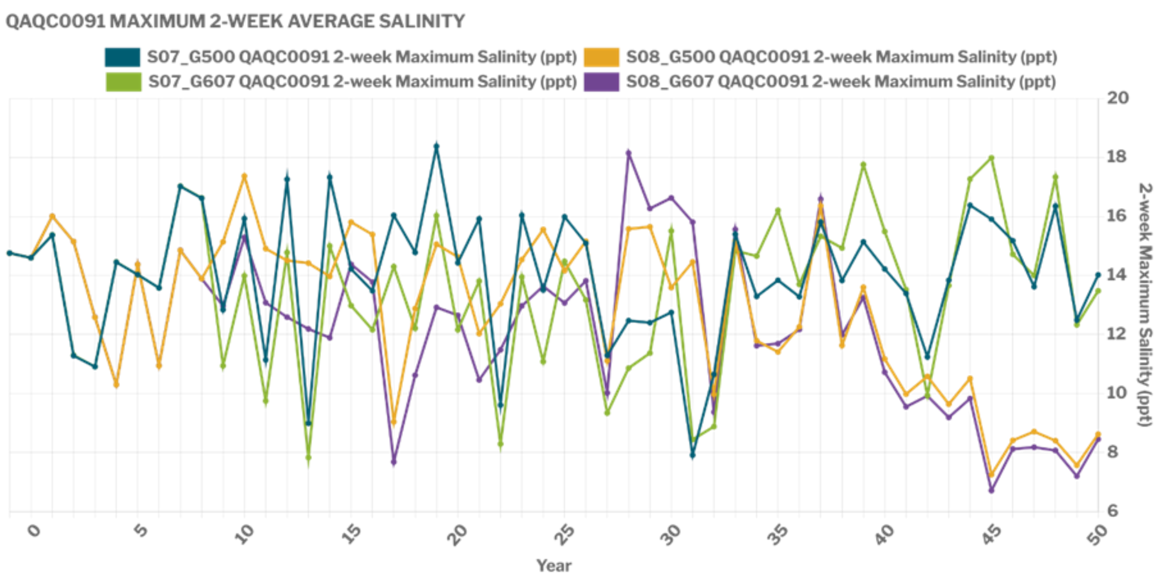


Figure 216. Maximum 2-week average salinity at QAQC0091 in WTE with AD.

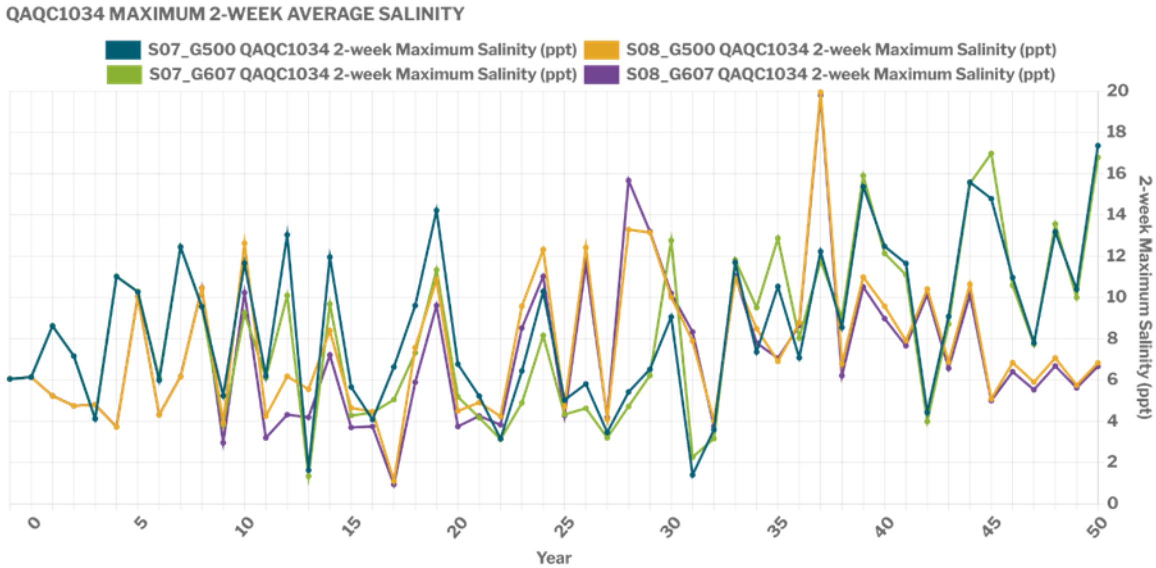


Figure 217. Maximum 2-week average salinity at QAQC1034 in ETB with AD.

Large increases in TSS concentration due to the project are observed in the outfall area in PEN as shown in Figure 219. To demonstrate the project impacts on TSS away from the outfall, Figure 220 to Figure 222 present examples of the annual average TSS at Avoca Island Cutoff south of the GIWW (compartment 637 within PEN), HNC north of the HNC lock (compartment 913 within WTE), and Grand Bayou south of the GIWW (compartment 980 within ETB), respectively from the higher scenario.

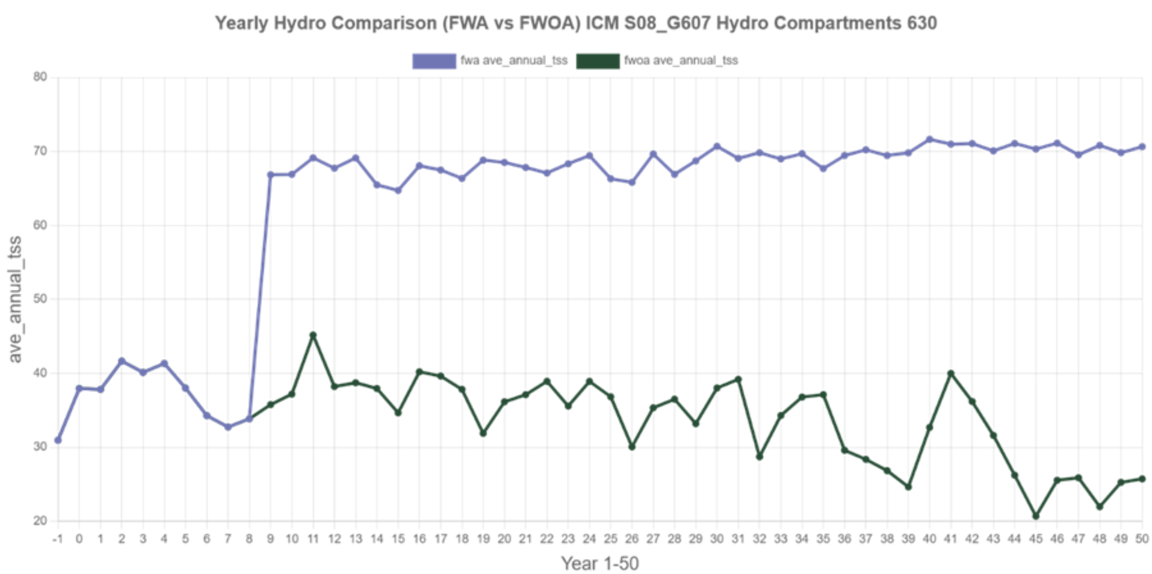


Figure 218. Average annual TSS at outfall (PEN) with AD.

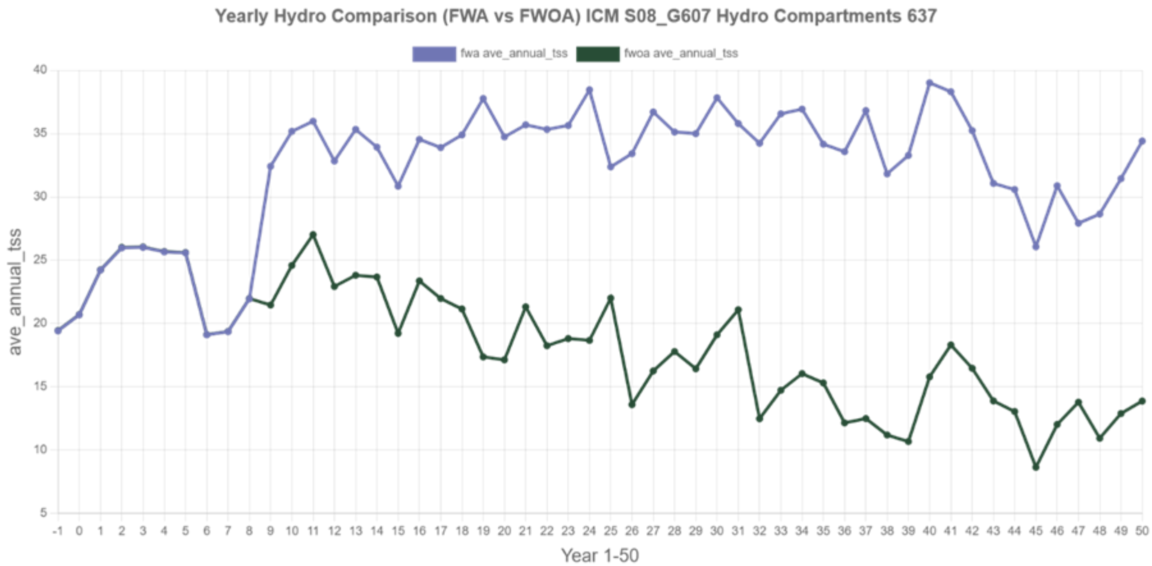


Figure 219. Average annual TSS at Avoca Island Cutoff south of the GIWW (PEN) with AD.

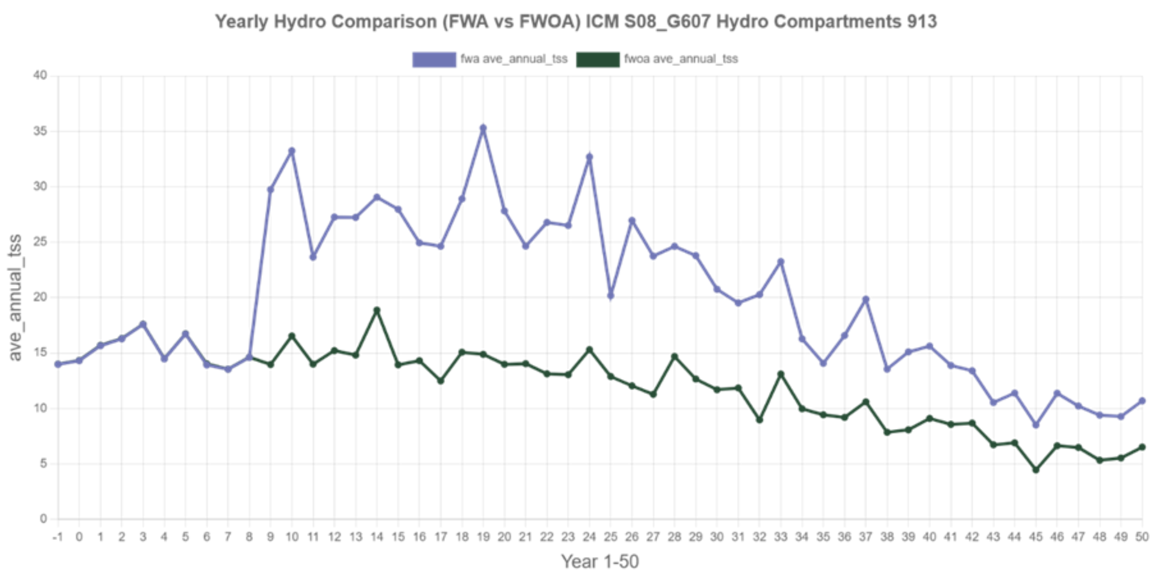


Figure 220. Average annual TSS at HNC north of the HNC lock (WTE) with AD.

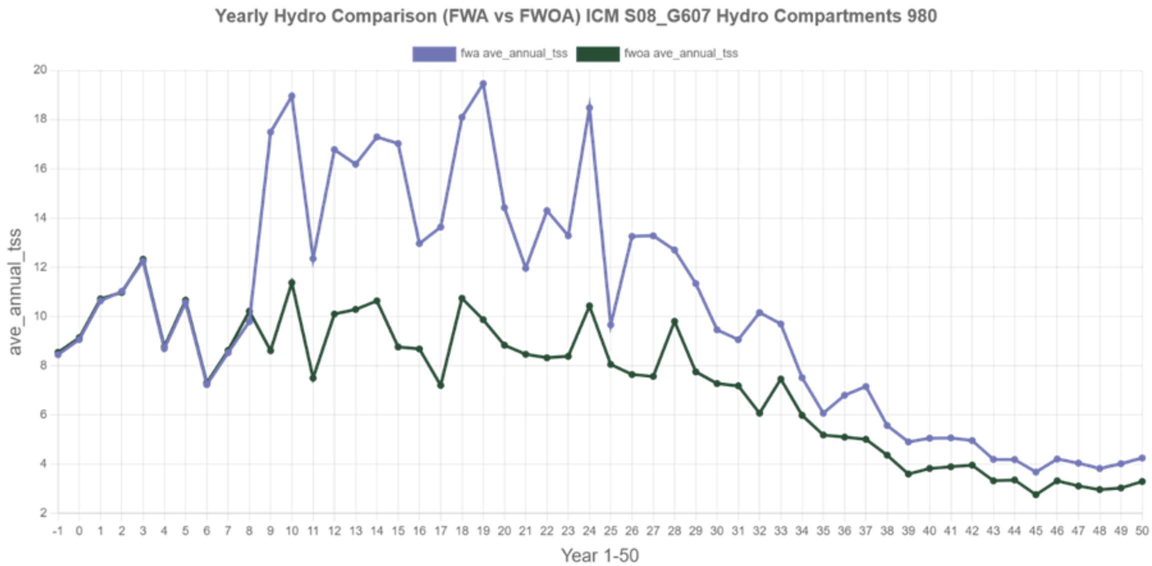


Figure 221. Average annual TSS at Grand Bayou south of the GIWW (ETB) with AD.

COMPARISON OF FLOWS

The annual average flows calculated from the 50-year project simulations are presented at several locations (as shown in Figure 223) east of both projects to further illustrate their impacts.

Figure 222. Flow link locations.

Figure 224 shows the annual average flows through GIWW east to Houma (Link1986) from the higher scenario. The increased flows from the AD project (G607) are much smaller than IAFT for both operation schemes (G608 and G654). Flows in the late years are decreasing in both FWOA and with AD. However, IAFT operations cause increases of freshwater flow to eastern Terrebonne in later years. As shown in Figure 225 and Figure 226, the impacts on flows are similar through HNC (Link2033) and in the mid-PEN (Link1376).

IAFT diverted flows are distributed broadly throughout the PEN, WTE, and ETB ecoregions, whereas AD flows are more localized to the outfall in PEN, with much of the diverted flows routed back to the Atchafalaya River through Avoca Island Cutoff.

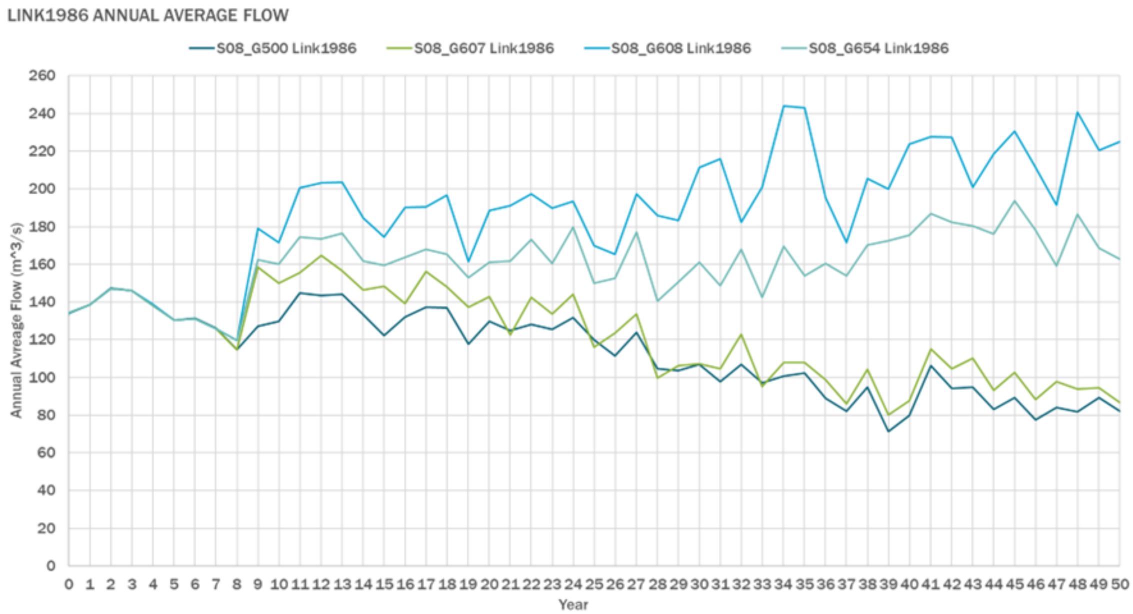


Figure 223. Annual average flows through Link1986 (GIWW east) with positive values indicating west to east.

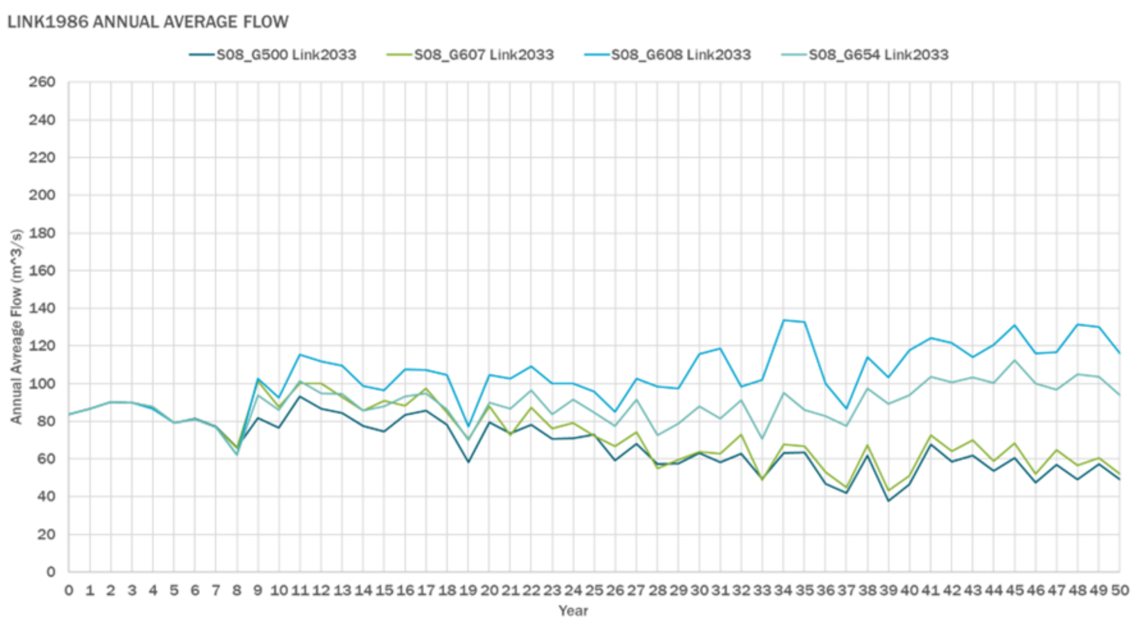


Figure 224. Annual average flows through Link2033 (HNC) with positive values indicating north to south.

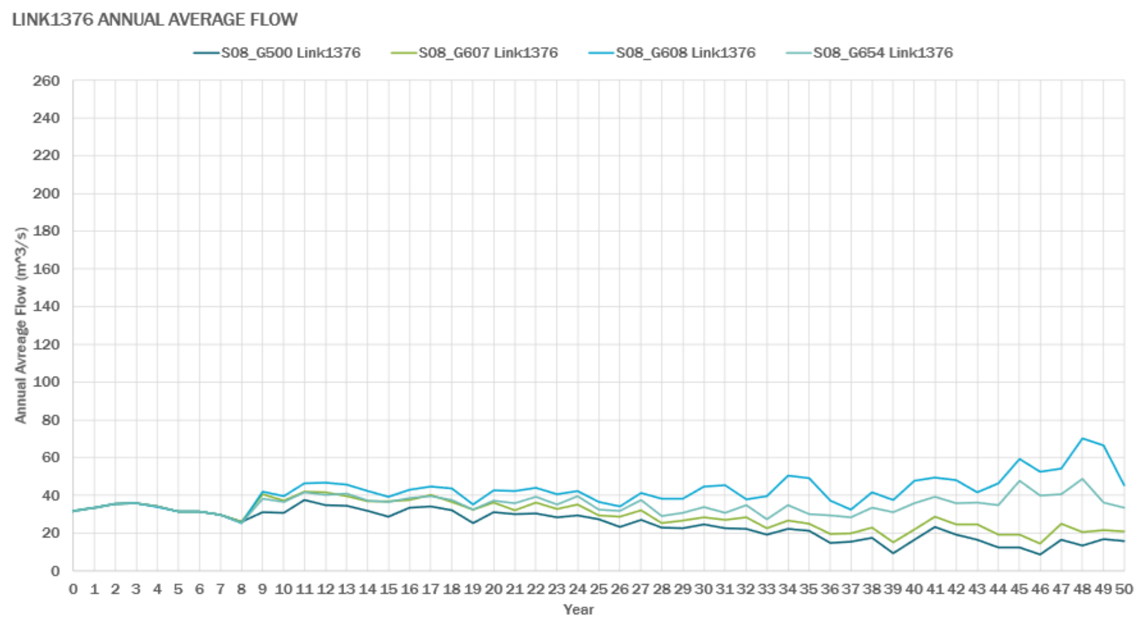


Figure 225. Annual average flows through Link1376 (PEN) with positive values indicating north to south.

MORPHOLOGY

Both the AD and IAFT projects were evaluated for a full 50 years as standalone projects assuming implementation at the start of the simulation, with construction complete and the start of operation in Year 9 for both projects. AD has a larger discharge at maximum capacity than IAFT, but the water is moved from the Atchafalaya River into the Penchant Basin, whereas the IAFT project introduced water further north into the GIWW.

The effect of AD and the lower operational regime for IAFT on the landscape differs by scenario (Table 10). Under the lower scenario, both projects produce benefits in AAL and result in more land at Year 50 than under FWOA. However, under the higher scenario, IAFT has negative AAL and results in almost 170 km^2 less land at Year 50 than under FWOA. These results led to the development of the lower operational regime for IAFT described above.

Table 12. Net effect of the AD and IAFT projects (FWA-FWOA) by scenario in terms of AAL and net land at Year 50

	Average Annual Net Land (km^2)		Net Land at Year 50 (km^2)	
Scenario	Lower	Higher	Lower	Higher
Atchafalaya Diversion	29.1	27.9	32.6	65.0
Increase Atchafalaya Flow to Terrebonne	13.0	-36.7	11.7	-168.2

The distribution of the land change over time for AD is shown in Figure 227. AD has a positive effect on land area throughout the 50-year simulation for both scenarios, although the magnitude of the benefit changes over time. For IAFT higher operational regime (G608) (Figure 228), there are positive benefits consistently for the lower scenario. However, for the higher scenario after Year 12, the effects are negative with substantial decreases in net land area after Year 35. Figure 228 also shows results for IAFT with the lower operational regime (G654). Both scenarios show net positive benefits through the simulation until the last decade, when benefits are negative for the higher scenario.

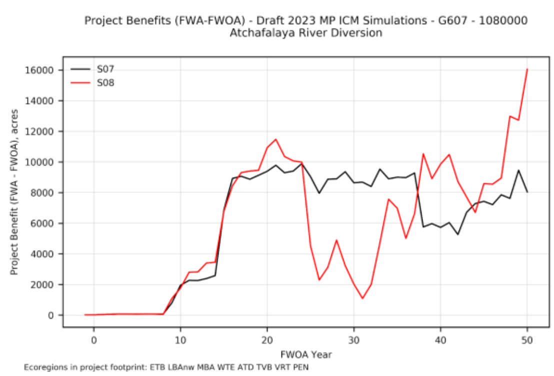


Figure 226. Net land benefits (FWA-FWOA) over time for both the higher and lower scenarios for the AD project.

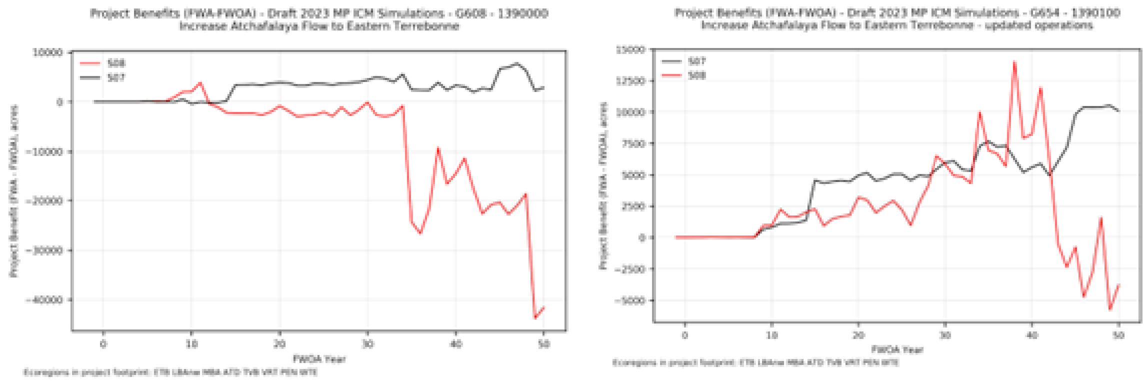


Figure 227. Net land benefits (FWA-FWOA) over time for both the higher and lower scenarios for the two versions of the IAFT project: G608 with higher flow (left) and G654 with lower flow (right).

The effects of both projects are widespread. Figure 229 shows the effects by ecoregion for AD and IAFT higher operations. Both projects result in slight negative effects in the Teche Vermilion Bays (TVB) to the west. This is to be expected as both projects move freshwater to the east resulting in less freshwater input to TVB. Both projects also show benefit for both scenarios for the Atchafalaya Delta (ATD), WTE, ETB, and LBAnw ecoregions, with IAFT having a slight negative effect on land area in MBA under the lower scenario. The benefits to the east, in ETB, MBA, and LBAnw, are generally greater for IAFT than AD. As IAFT moves water directly into the GIWW, it moves more effectively to the east, and then south through HNC. These effects are illustrated at QAQC1061 (south of the GIWW west of Bayou Lafourche) for the lower scenario in Figure 230. AD (G607) reduces salinity by less than 1 ppt until about Year 33 when salinity starts to increase both with the project and in FWOA. AD has very little effect on salinity in the last decade. However, while IAFT has similar salinities to AD through Year 33, it maintains salinity at QAQC 1061 more than 2 ppt less than FWOA. While the lower operations (G654) have slightly higher salinities in the last two decades, there is still a large reduction compared to AD and FWOA. FFIBS score rises up to 2.6 under FWOA and AD after Year 33 (not shown) while IAFT keeps it below 2 throughout the simulation. Lower salinities lead to increased tolerance of inundation and lower FFIBS score result in greater organic accretion. Figure 231 similarly shows a greater effect of IAFT compared to AD west of HNC at QAQC0091 for the higher scenario. Here salinities are approximately 4 ppt lower for the higher operation of IAFT compared to FWOA and AD for the last two decades of the simulations. Lower operations for IAFT reduce the effect to about 3 ppt.

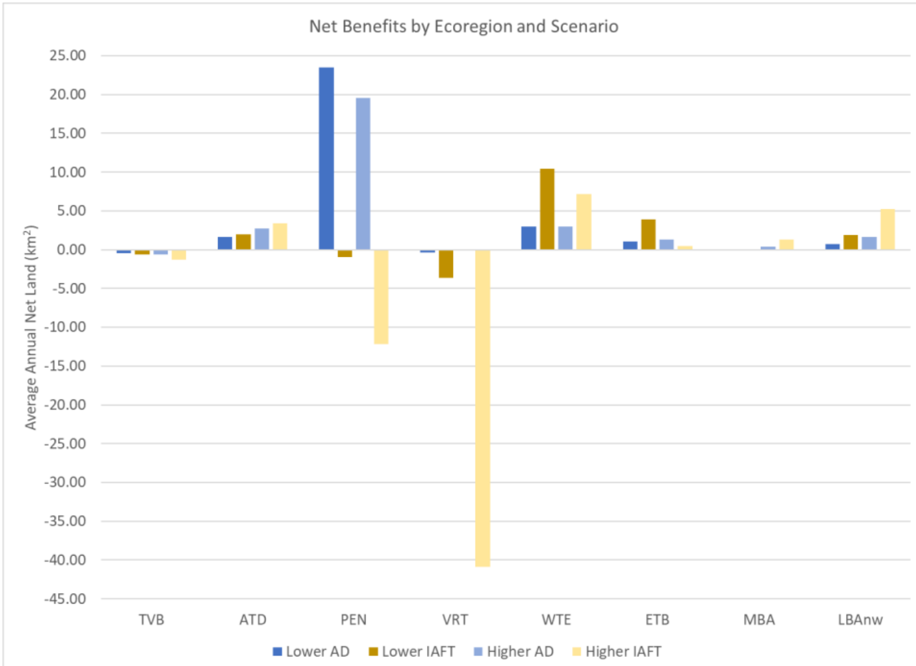


Figure 228. Net benefits of the AD and IAFT projects (FWA-FWOA) by ecoregion for the lower and higher scenario.

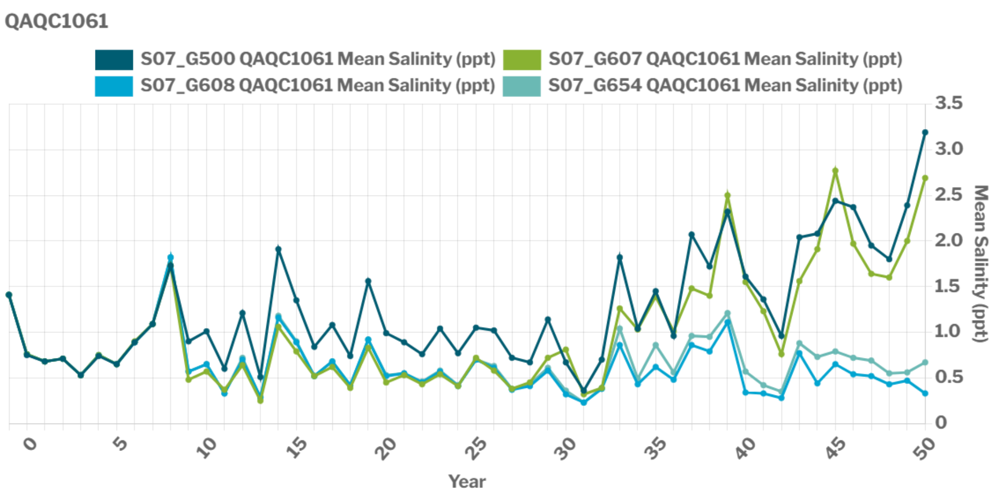


Figure 229. Effects of the AD and IAFT (higher and lower operations) projects on mean annual salinity at QAQC1061 (south of the GIWW west of Bayou Lafourche) for the lower scenario.

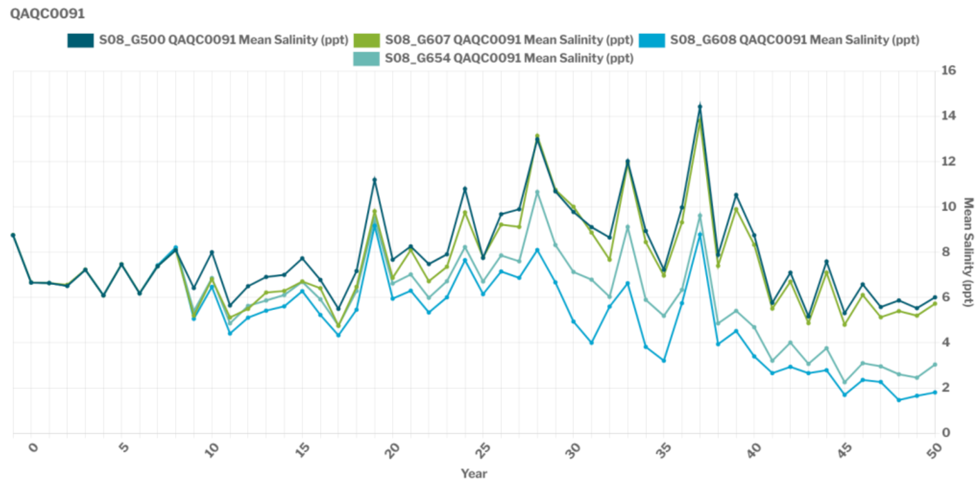


Figure 230. Effects of the AD and IAFT (higher and lower operations) projects on mean annual salinity at QAQC0091 (east side of the HNC) for the higher scenario.

The biggest differences across ecoregions in Figure 229 are in the way the projects change the landscape in PEN and VRT ecoregions. For both scenarios, most of the benefits of AD are in the PEN ecoregion (Figure 229). Many of these benefits are associated with the effect of AD on salinity in the basin and the prevention of flotant loss (Figure 232). In the later years of both scenarios, AD prevents loss in other areas of the PEN ecoregion by reducing salinities, thus increasing the tolerance for flooding and increasing organic accretion.

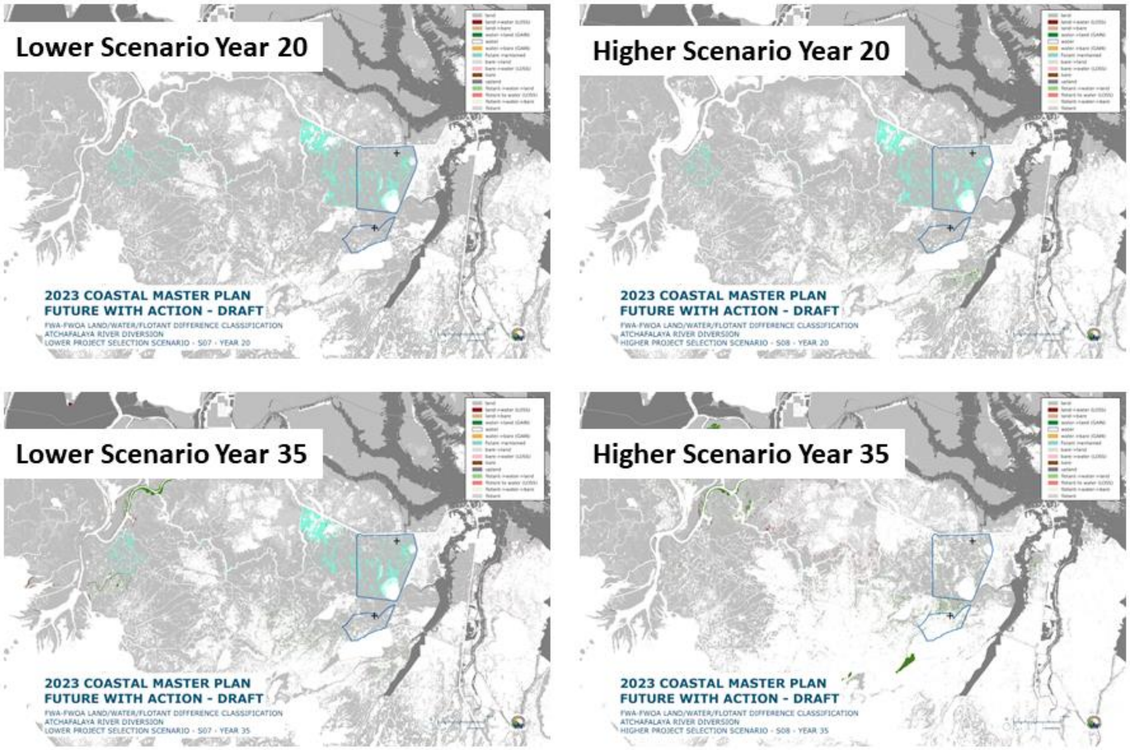


Figure 231. The effects of the AD project on preventing flotant loss in the PEN ecoregion.

IAFT has some similar effects on flotant. Figure 233 shows the prevention of flotant loss in the lower scenario just south of the GIWW and the effects of the project on the 2-week maximum salinity. Under both operational regimes, the IAFT effectively keeps the 2-week maximum salinity below the 5.5 ppt threshold, when it impacts flotant marsh, until Year 39 of the simulation. By reducing the spike in salinity at Year 15, the project maintains the flotant marsh in this area. Under the lower scenario, IAFT has a net benefit in PEN until Year 28, and thereafter there is more loss than in FWOA (not shown). For the lower scenario, IAFT with the higher operational regimes results in a net loss of just less than 1 km^2 of land in PEN (Figure 229).

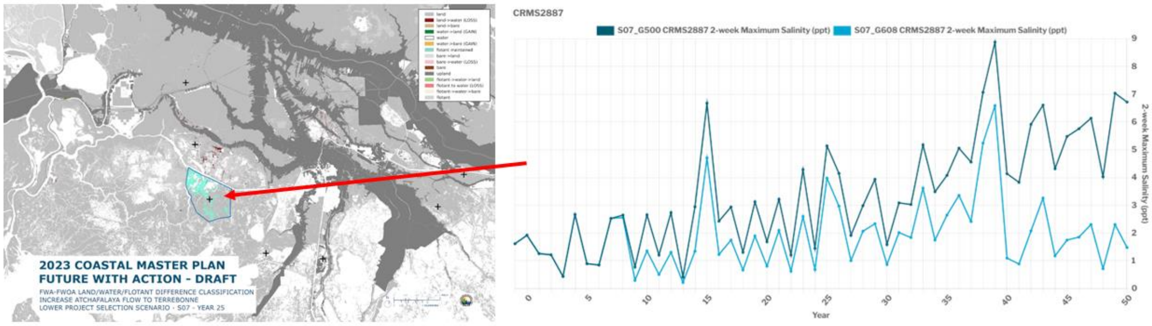


Figure 232. Prevention of flotant loss by the IAFT project (higher operational regime) at Year 25 and the 2-week maximum salinity for CRMS2887 for the lower scenario.

In VRT, AD has only very minor negative impacts, 0.36 km^2 for the lower scenario and 0.15 km^2 for the higher scenario. In contrast, the higher operational regime for IAFT has negative impacts of 3.61 km^2 under the lower scenario and 40.87 km^2 under the higher scenario. This is a result of substantial increases in inundation in VRT discussed in the Hydrology section above. The increase in inundation is a direct result of increased water levels in the GIWW in the immediate vicinity of the diversion outfall (e.g., Morgan City lock/Bayou Boeuf) and is exacerbated in the higher scenario in later years due to the effects of greater SLR increasing water levels in the lower estuary and limiting drainage. The effect is mitigated in the lower operational regime for IAFT, as illustrated at QAQC0149 north of Lake Verret (Figure 234).

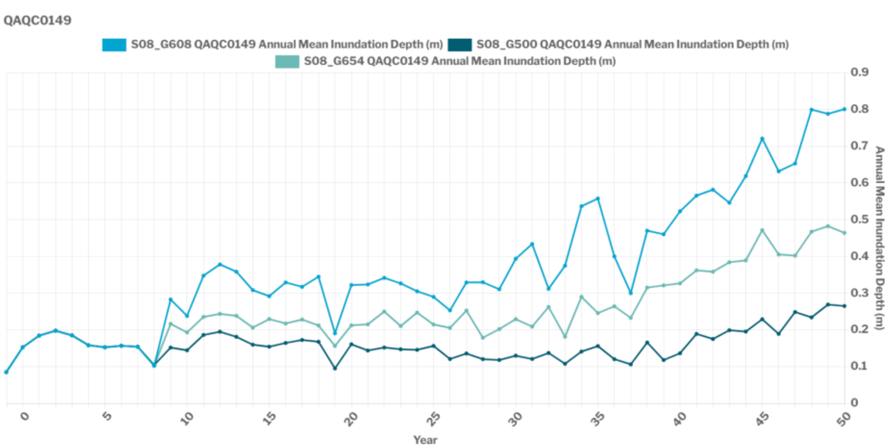


Figure 233. Changes in annual mean inundation at QAQC0149 for FWOA and the two operational regimes for the IAFT project (G608 higher operation, G654 lower operation).

Much of the Verret basin is swamp forest and so is not subject to loss due to inundation, although change in water level variability may result in transition to herbaceous marsh, which is subject to inundation loss. Thus, despite widespread increases in inundation under the higher operation for IAFT, land loss is restricted mostly to the area north of Lake Verret where there is more herbaceous coverage. QAQC0176, just northwest of Lake Verret and west of Highway 70, illustrates the effect of the project on inundation (Figure 235). The project immediately causes an increase in inundation and the difference versus FWOA is approximately 20 cm through about Year 30. The marsh is lost to open water in Year 34, and the lack of organic accretion thereafter further increases inundation. The vegetation plot (Figure 235 right panel) shows increasing open water in the grid cell that includes QAQC0176 and a decrease in herbaceous coverage (light green and yellow shading).

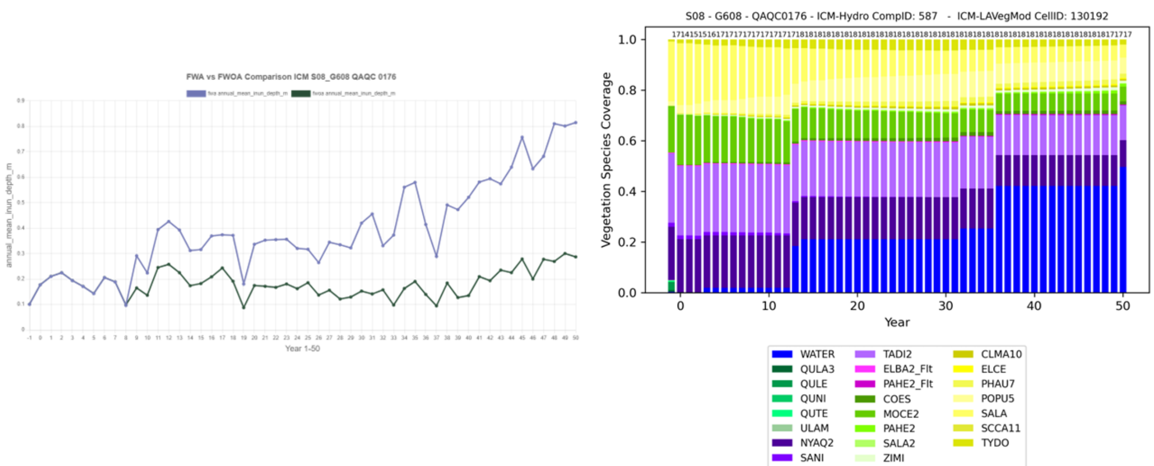


Figure 234. The effects of the IAFT project (higher operation) on inundation at QAQC0176 (northwest of Lake Verret) vs. FWOA (left) and vegetation change over time at the same location (right).

INTERACTION WITH OTHER PROJECTS

As AD performs well under both scenarios, it was selected for inclusion in the 2023 Coastal Master Plan in IP1. In addition to AD, a number of other projects were selected in IP1 for the Penchant Basin (Figure 236). All the projects selected in IP1 were included in a single model run for each scenario, FWIP1.

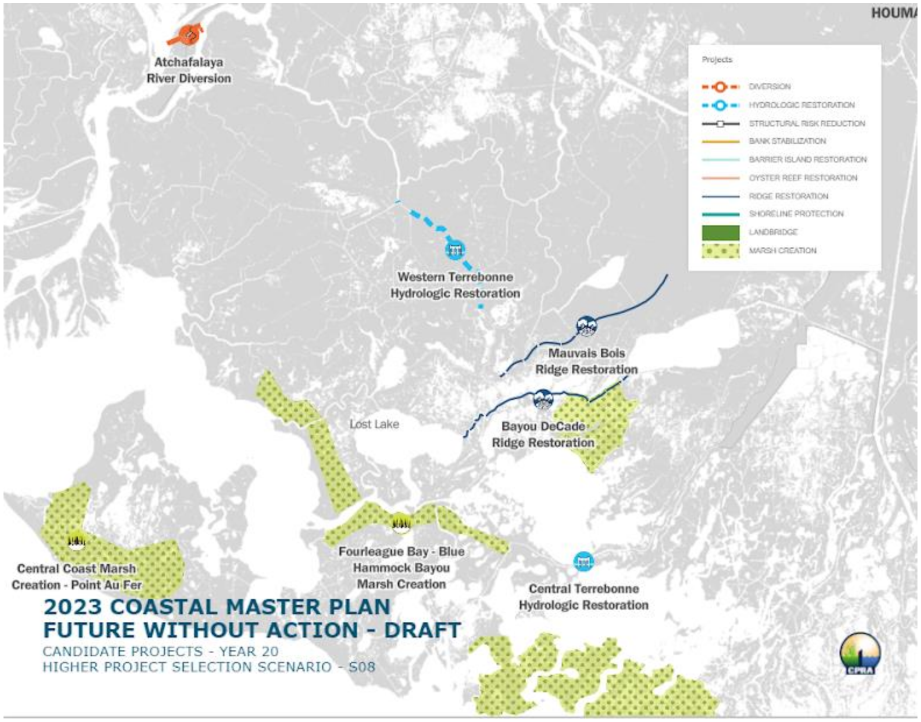


Figure 235. Projects selected for the 2023 Coastal Master Plan in IP1 in the Penchant Basin.

As discussed above, AD introduces freshwater into Bayou Penchant. The Western Terrebonne Hydrologic Restoration project seeks to increase the movement of water from Bayou Penchant to the southeast. Further south, the Central Terrebonne Hydrologic Restoration project aims to limit exchange between Lake Mechant and Bayou DuLarge, potentially limiting the incursion of saltwater. Between those hydrologic restoration projects are two ridge projects (Mauvais Bois and Bayou Decade) and the North Lake Mechant Marsh Creation project, which reduces the amount of open water between Lake Mechant and the Bayou Decade Ridge. Each of these projects individually has positive effects of AAL. The FWIP1 runs allow exploration of their interactive effects, with the additional freshwater introduced by AD.

Figure 237 illustrates the project interactions with AD for QAQC0016, between Lake Mechant and the Bayou Decade Ridge. AD alone reduces salinity in this area compared to FWOA by ~2 ppt. Salinity is further reduced in FWIP1 (G512) with the other projects in place until the last decade. Salinity differences between FWOA/AD and FWIP1 in the last decade are due to interactions between ridge projects and wetland collapse dynamics immediately north of Lake Mechant. In both FWOA and FWIP1, marsh loss in this area, largely in Years 37 and 45 (not shown), decreases the salinity due to more connectivity with the interior. Under FWIP1, the salinity is greater in the last decade compared to FWOA and AD alone as the presence of the ridges to the north of this location limits mixing of fresher waters to the north as more saline waters penetrate from the Gulf due to SLR and land loss.

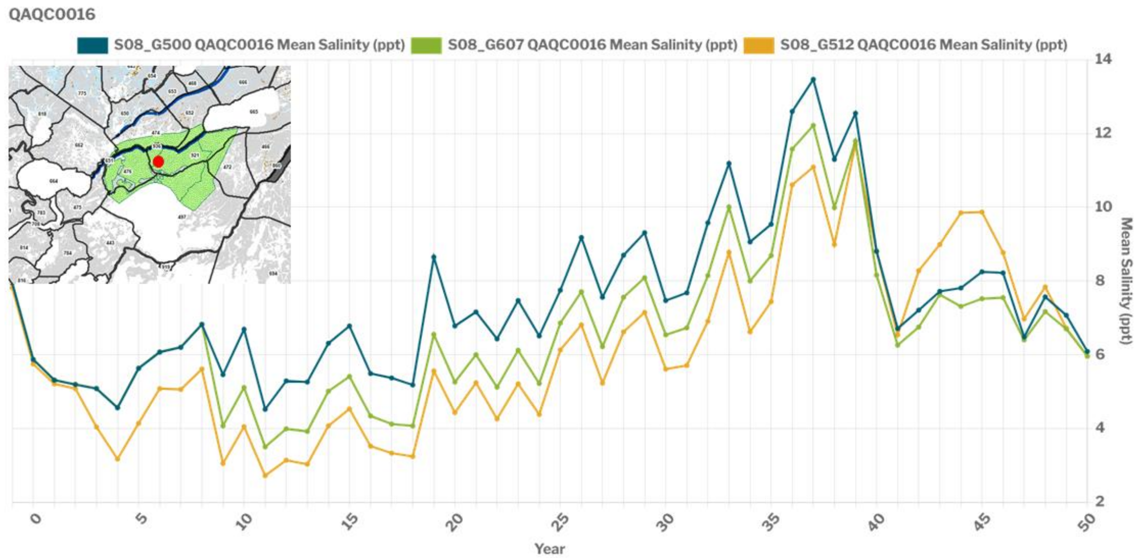


Figure 236. Mean annual salinity at QAQC0016 in FWOA (G500), FWIP1 (G512), and with AD (G607) under the higher scenario.

On the interior/northern side of the ridge projects (e.g., CRMS0294 shown in Figure 238), the salinity pre-loss increase is greater in magnitude under FWOA, as compared to FWIP1, due to the influence of the ridges to the south. However, after the collapse in this area, in Years 37 and 45 the salinity differences among FWOA, AD, and FWIP1 remain approximately the same since this area was already more impacted by freshwater connectivity than the lower location shown in Figure 237.

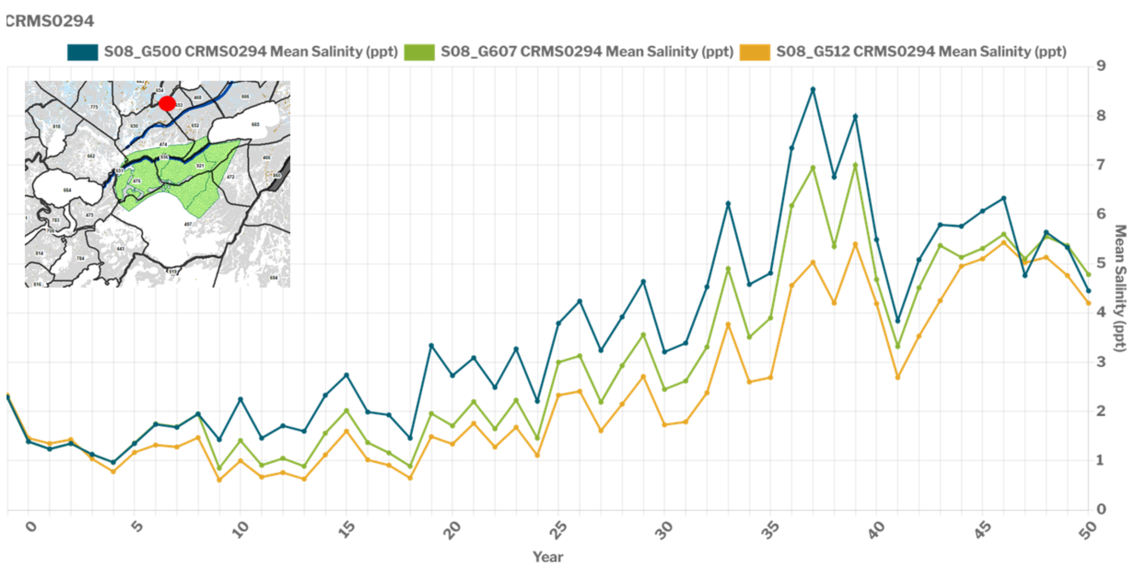


Figure 237. Mean annual salinity at CRMS0294 in FWOA (G500), FWIP1 (G512), and with AD (G607) under the higher scenario.

VEGETATION

With the AD, there is less expansion of brackish marsh species starting around Year 10 in the PEN ecoregion compared to FWOA under both scenarios with both projects, illustrating the slight freshening. Although land change maps (Figure 232) show that the main effect of these projects is preserving floating marshes in the PEN ecoregion, the differences appear relatively small on the vegetation cover scale (Figure 239).

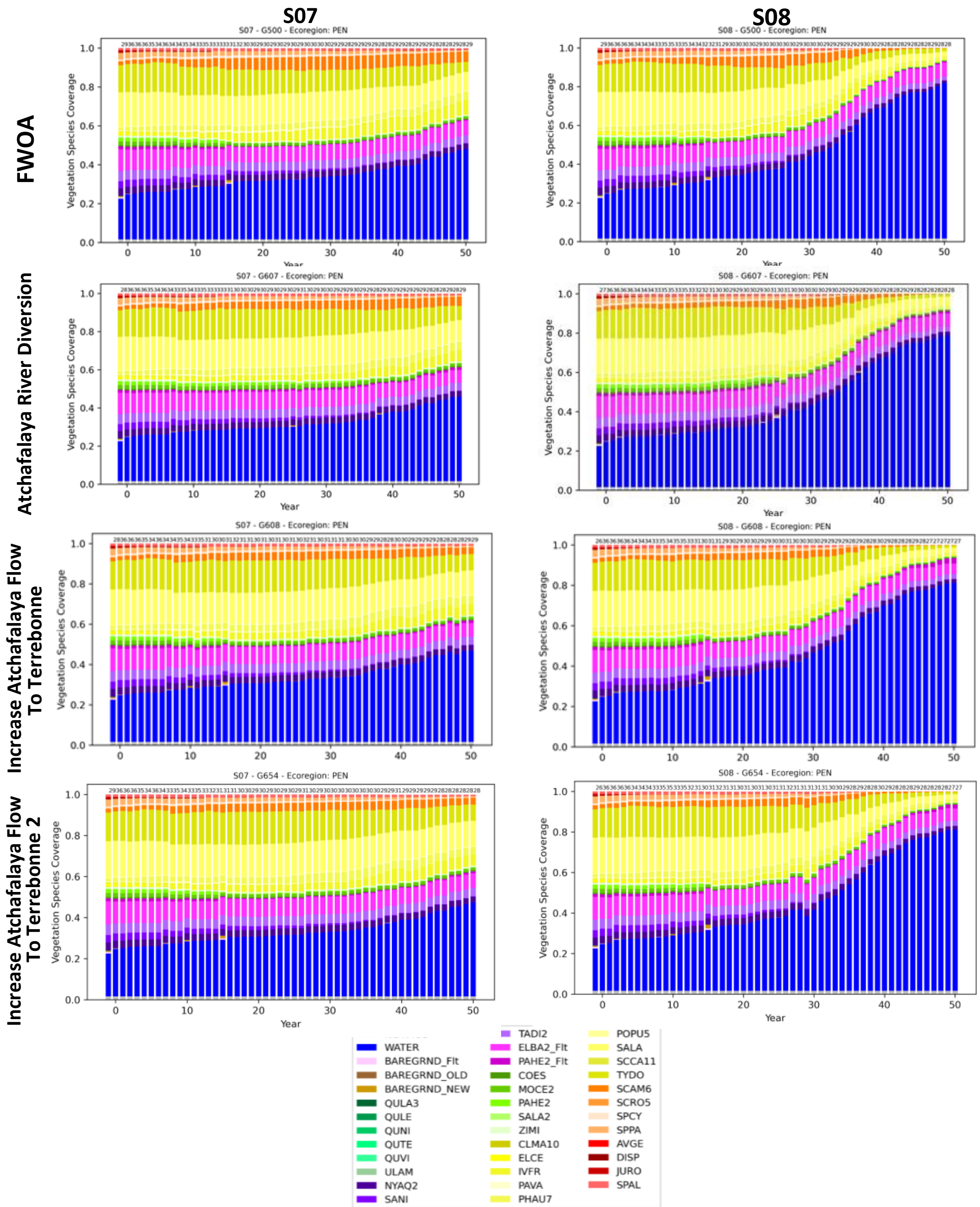


Figure 238. Vegetation changes in the PEN ecoregion are shown for two scenarios for FWOA, future with the AD, and with two operational regimes for IAFT.

At the scale of an individual grid cell (Figure 240), it is apparent that floating marsh survives longer with the two projects under the lower scenario than in FWOA. At CRMS2887, flotant disappears at Year 14 of FWOA, while with both projects, flotant survives through Year 38 under the lower scenario. Operational regime of IAFT seems to make no difference. Attached fresh marsh species follow the same pattern as the floating marsh, but when they disappear, bare ground results. This indicates that these disappearances are associated with a salinity pulse in the region. Figure 233 shows that 2-week maximum salinity almost reached 9 ppt in Year 39 with IAFT under the lower scenario.

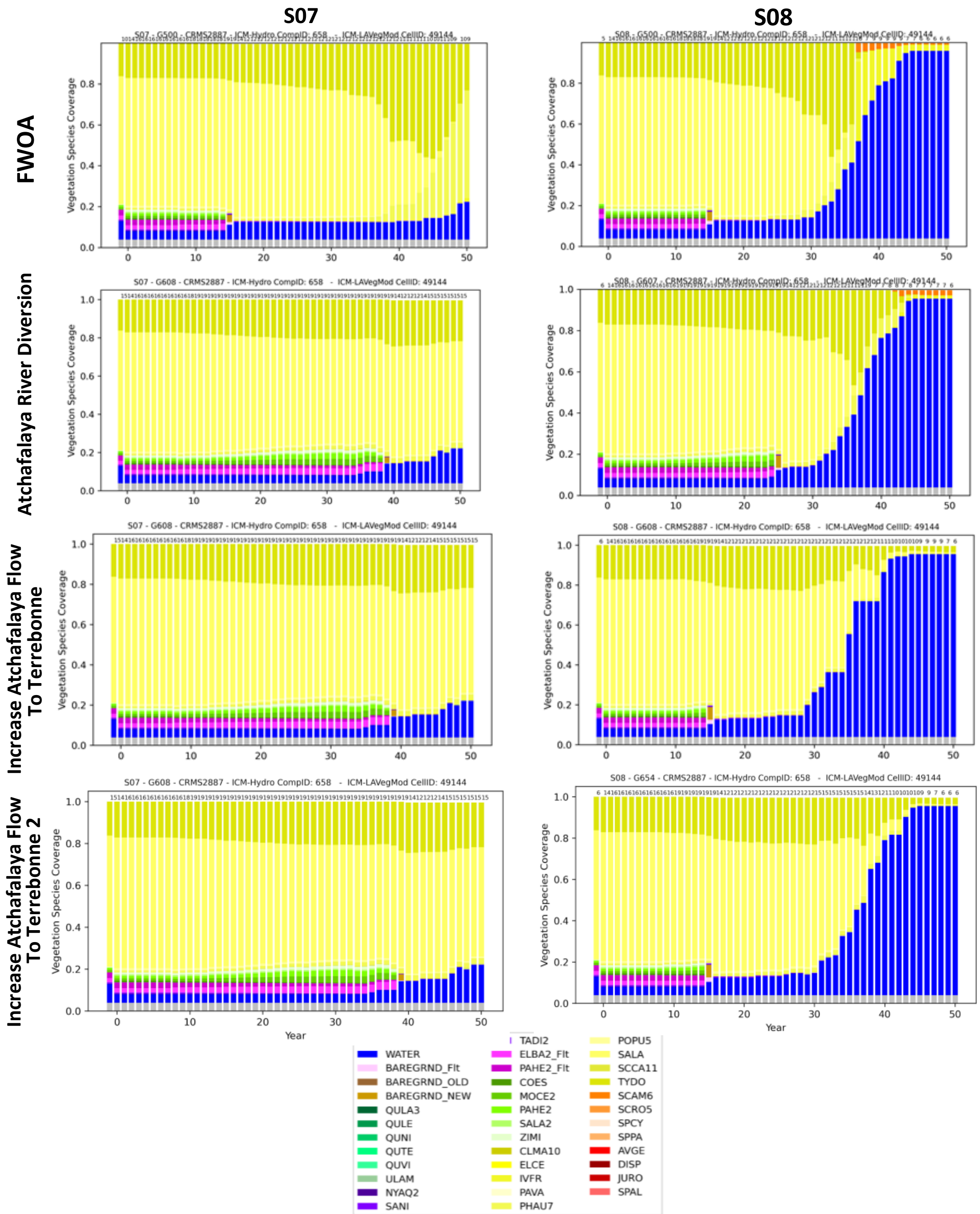


Figure 239. Vegetation changes at CRMS2887 are shown for two scenarios for FWOA, future with the AD, and with two operational regimes for IAFT.

HABITAT SUITABILITY

The AD and IAFT projects both had widespread effects on habitat suitability for fish, shellfish, and wildlife in Terrebonne Basin. In the PEN ecoregion, where the projects were located, changes in habitat suitability were primarily related to patterns of wetland loss and gain over time. Both projects prevented the loss of flotant marshes in the northern part of the ecoregion during the early part of the simulations. Consequently, these areas remained relatively solid marsh with little aquatic habitat, resulting in a decrease in suitable habitat for fish and shellfish compared to FWOA (e.g., juvenile blue crab; Figure 241). The flotant marshes were eventually lost over time so that there was little difference between the project and FWOA during the middle part of the simulations (Figure 242). However, toward the end of the AD project simulations, there was another net gain in wetland area as the project created and maintained marshes near the diversion outfall. This similarly resulted in a decrease in suitable habitat for fish and shellfish during the last 10 years of the simulations (Figure 242). By comparison, the IAFT project caused a net loss of wetlands in the PEN ecoregion toward the end of the simulations, which resulted in new aquatic habitat and localized, minor increases in habitat suitability for many species.

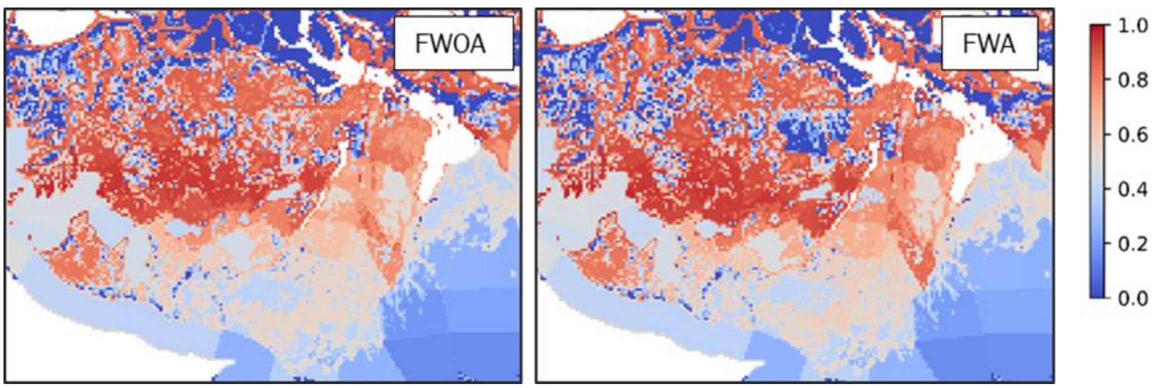


Figure 240. Juvenile blue crab HSI scores across Terrebonne Basin for Year 20 of FWOA and AD (FWA) lower environmental scenario simulations. Scores range from 0.0, completely unsuitable habitat, to 1.0, optimal habitat.

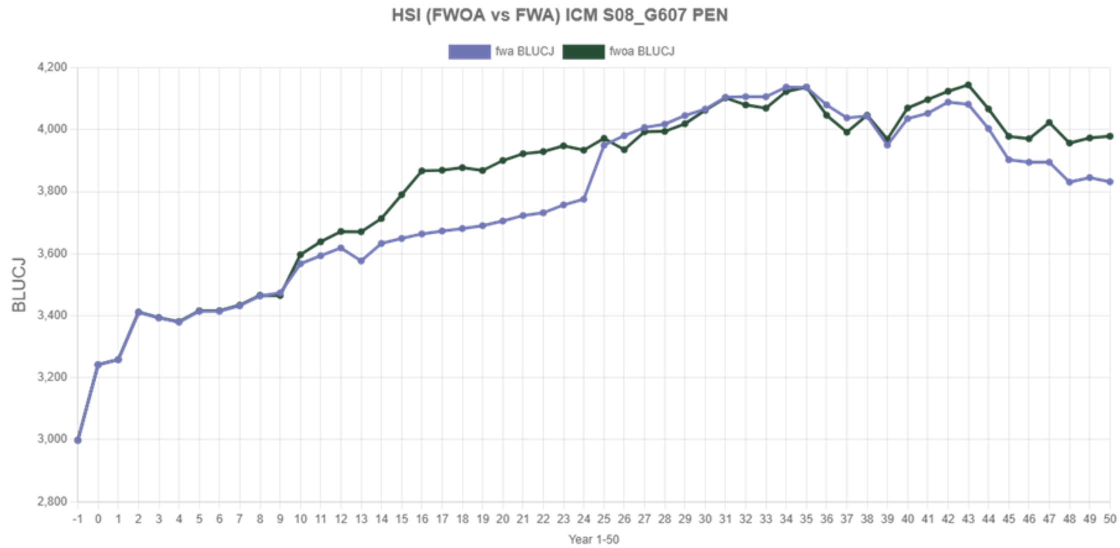


Figure 241. Total HSI score for juvenile blue crab in the PEN ecoregion for the 50-year FWOA and AD (FWA) higher environmental scenario simulations. The total HSI score was calculated by summing the individual scores for each ICM model cell within the ecoregion.

Habitat suitability in the PEN ecoregion was also somewhat affected by the increased water levels from the projects. These effects were most notable for the IAFT project, which increased water levels by up to 15 cm during the higher discharge G608 simulation. In general, increased water levels from the project resulted in increased water depths over the marshes and water bodies of the ecoregion. The impact on habitat suitability for wildlife species, though, was dependent on initial elevations. For example, in the relatively high-elevation marshes of eastern PEN, marshes were inundated to a greater extent and thus there was an increase in the amount of shallow water habitat for waterfowl. This resulted in the area becoming slightly more suitable for gadwall and mottled duck with the project (Figure 243). In contrast, in the lower-elevation habitats of northern PEN, water depths became too deep and this area became slightly less suitable for the species with the project (Figure 243). However, as sea level rose over time in the simulations, the additional water level from the IAFT project gradually increased water depths such that suitability decreased across the entire ecoregion. As a result, habitat suitability with the project was lower than FWOA during the latter half of the simulations.

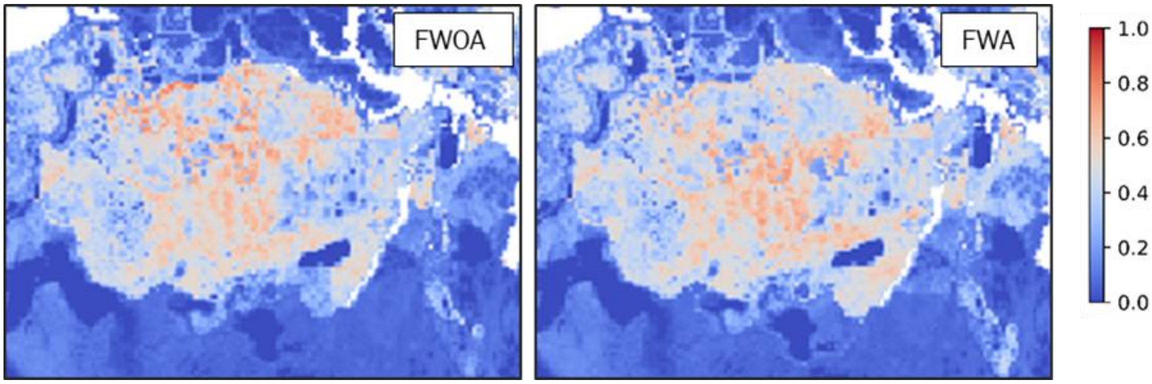


Figure 242. Gadwall HSI scores across the PEN ecoregion for Year 30 of FWOA and IAFT (FWA) lower environmental scenario simulations. Scores range from 0.0, completely unsuitable habitat, to 1.0, optimal habitat.

The IAFT project appeared to have a much greater effect on habitat conditions in the VRT ecoregion than the PEN ecoregion. Water levels increased in the VRT ecoregion by up to 25 cm during the higher discharge simulation. These water levels inundated the high-elevation swamps and marshes in the ecoregion and thus provided a large amount of shallow water habitat for waterfowl, particularly near the uplands in the eastern parts of the ecoregion. The increased inundation also caused a large amount of wetland loss in the ecoregion, which created new aquatic habitat. As a result, there was an increase in suitable habitat for gadwall and mottled duck, as well as a number of fish and shellfish species.

The effects of the AD and IAFT projects on habitats in the more far-field areas of Terrebonne Basin were primarily related to changes in the salinity regime. These salinity changes were much greater for the IAFT project, which reduced mean annual salinity by up to 5 ppt across much of the area, compared to the AD project, which reduced mean annual salinity by up to 2 ppt. Lower salinities across the southern PEN, upper WTB, and upper ETB ecoregions resulted in these areas becoming slightly more suitable for species associated with low salinities (i.e., <5 ppt), such as juvenile blue crab (Figure 241), and slightly less suitable for higher-salinity species, such as brown shrimp (Figure 244). Meanwhile, in areas adjacent to Terrebonne and Timbalier Bays, the salinity reduction resulted in an increase in habitat suitability for all species except the adult stages of gulf menhaden and spotted seatrout. Mean annual salinities in these areas were typically >15 ppt, and the projects reduced salinities such that they were closer to optimal levels for the fish, shellfish, and wildlife in the analyses.

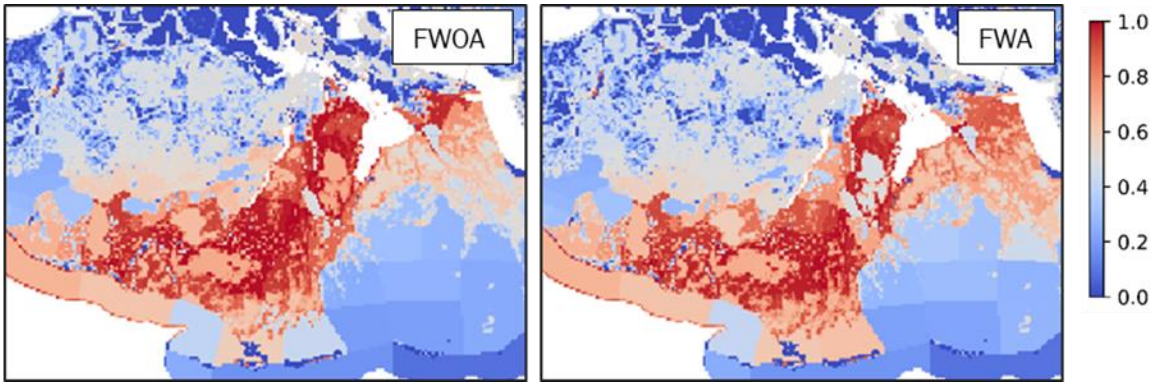


Figure 243. Small juvenile brown shrimp HSI scores across the Terrebonne Basin for Year 30 of the FWOA and IAFT (FWA) lower environmental scenario simulations. Scores range from 0.0, completely unsuitable habitat, to 1.0, optimal habitat.

9.0 CHARENTON DIVERSION

PROJECT OVERVIEW

This report describes the modeling results for the Charenton Diversion project (#341a). The project moves sediment and freshwater through Bayou Teche and the Charenton Navigation Channel to West Cote Blanche Bay (Figure 245). The goal is to supply sediment and freshwater to the Jaws and Cote Blanche and Cypremort marshes. Discharge is based on stage at Grand Lake in the Atchafalaya Basin and in the receiving area, Bayou Teche, and Cote Blanche Bay.

Figure 244. The location of the Charenton Diversion project.

The project is fully constructed and operational at Year 6 and was modeled in G609. The project was not selected in IP1 or in IP2. The project cost is $253 million in IP1 and $223 million in IP2 due to fewer years of Operations, Maintenance, and Monitoring costs. The cost of the project does not vary by scenario as no marsh creation is included.

The results presented here discuss the way in which the project changes the coastal landscape in terms of hydrology, morphology, vegetation, and habitats, with examples from the two environmental scenarios. The examples have been selected to illustrate the dynamics of the project based on available data, rather than to provide a comprehensive description of all areas, scenarios, and implementation period comparisons.

HYDROLOGY

STAGE

The Charenton Diversion affects local inundation patterns with a reduction of inundation in the Grand Lake area upstream of the diversion along with an increase of inundation in the receiving area around the Charenton Navigation Canal, as shown in Figure 246. The FWA versus FWOA differences in annual mean water levels are relatively small, i.e., no more than 5 cm, and remain consistent over time as indicated by Figure 247 for the Grand Lake area and Figure 249 for the area around the Charenton Navigation Canal.

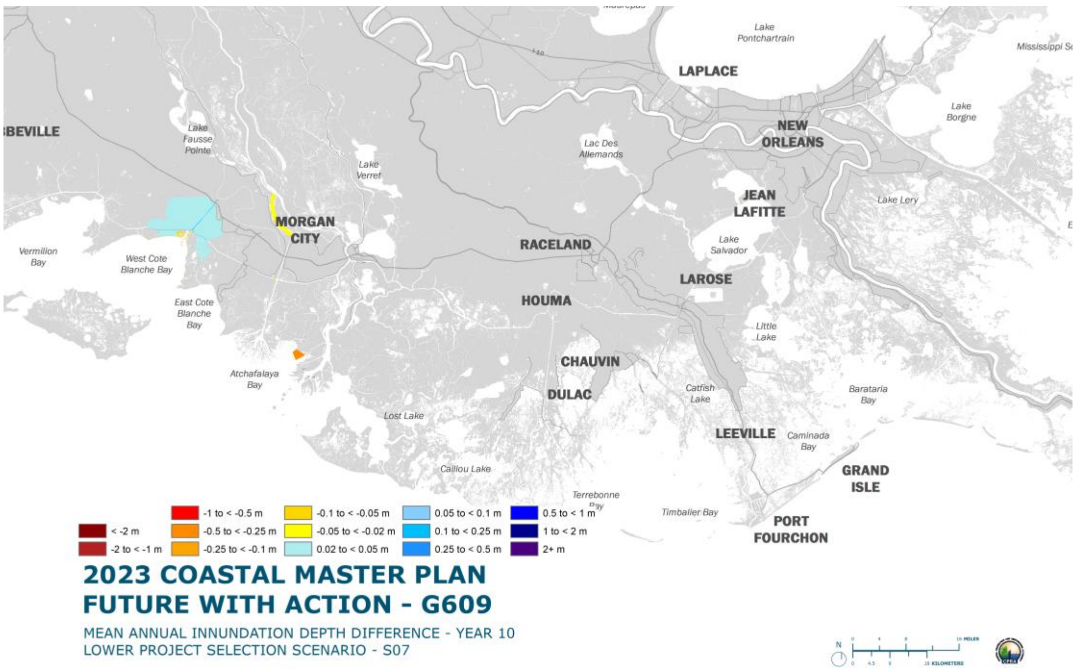


Figure 245. Difference map of mean annual inundation depth between FWOA (G500) and FWA (G609) in Year 10 of the lower (S07) scenario, indicating reduced mean annual inundation depths in the Grand Lake area upstream of the diversion, along with increased inundation in the area around the Charenton Navigation Canal. Similar results are found in later years and for the higher (S08) scenario.

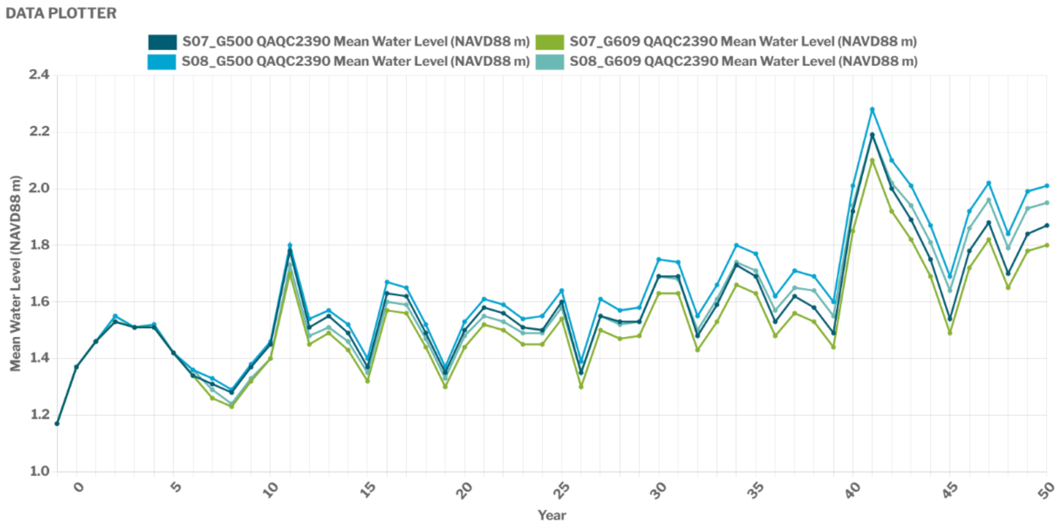


Figure 246. Annual mean water level comparison between FWOA (G500) and FWA (G609) for lower (S07) and higher (S08) scenarios in QAQC2390 in Grand Lake (location indicated in Figure 248). Annual mean water levels are reduced by the project by up to 10 cm all throughout the post-construction part of the 50-year simulation period, for both the lower (S07) and higher (S08) scenarios.

Figure 247. Map indicating the location of QAQC2390 (blue dot) in compartment 405 situated in the Grand Lake area, CRMS0513 (blue dot) in compartment 430 situated near the Charenton Diversion Channel, and QAQC0513 near Marsh Island in West Cote Blanche Bay.

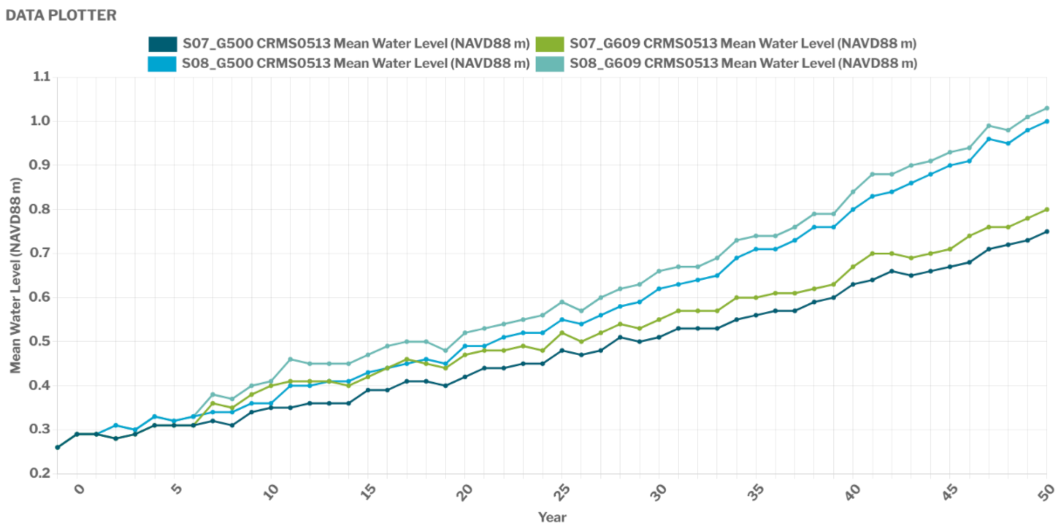


Figure 248. Annual mean water level comparison between FWOA (G500) and FWA (G609) for lower (S07) and higher (S08) scenarios in CRMS0513 near the Charenton Navigation Canal (location indicated in Figure 248). Annual mean water levels are increased by the project by about 5 cm all throughout the post-construction part of the 50-year simulation period, for both the lower (S07) and higher (S08) scenarios.

Annual water level variability is affected by the project albeit by a small magnitude, with increases up to 3 cm in the Grand Lake area (Figure 250) and up to 1 cm near the Charenton Navigation Canal (Figure 251). These increases persist over time, but the magnitude of increase remains consistent over time.

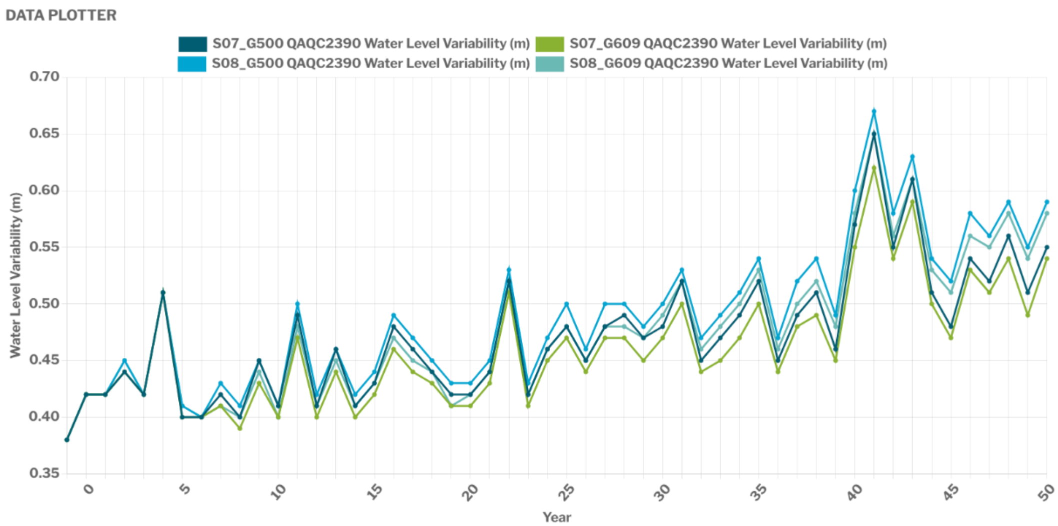


Figure 249. Annual water level variability comparison between FWOA (G500) and FWA (G609) lower (S07) and higher (S08) scenarios in QAQC2390 in Grand Lake (location indicated in Figure 248), showing a small decrease of annual water level variability amounting up to 3 cm, for both the lower (S07) and higher (S08) scenarios.

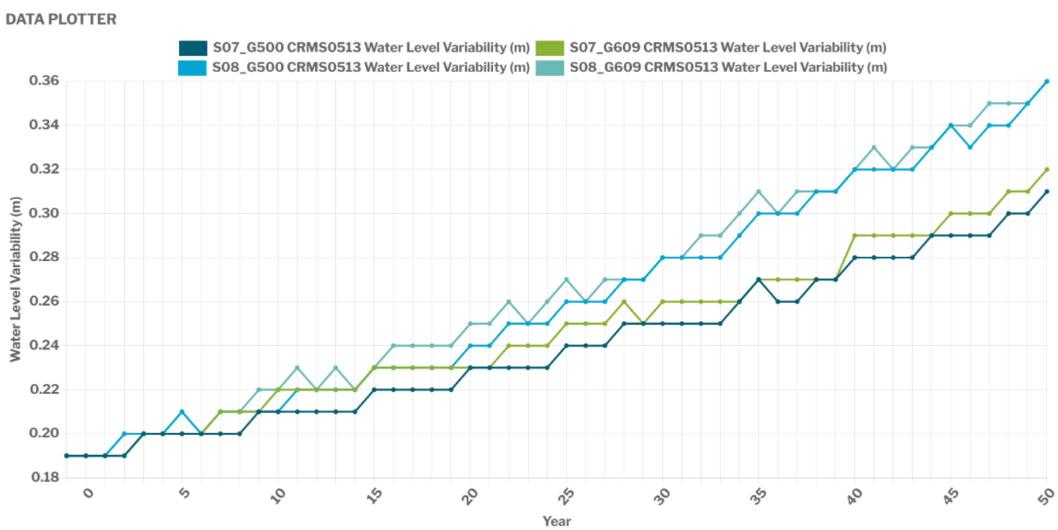


Figure 250. Annual water level variability comparison between FWOA (G500) and FWA (G609) lower (S07) and higher (S08) scenarios in CRMS0513 near the Charenton Navigation Canal (location indicated in Figure 248), showing a minor increase of annual water level variability amounting up to 1 cm, for both the lower (S07) and higher (S08) scenarios.

SALINITY

Salinity impacts are relatively small (<1 ppt) and concentrated in and around Vermilion Bay and West Cote Blanche Bay (Figure 252 and Figure 253). Mean annual salinity timeseries (Figure 254) for West Cote Blanche Bay show a salinity reduction of up to 0.5 ppt for FWA. The extent and magnitude of FWA versus FWOA differences in mean annual salinity are similar between the lower (S07) and higher (S08) scenarios and remain consistent over time. The areas around the diversion, i.e., Grand Lake, the Charenton Diversion Channel, and the GIWW, are already fresh in FWOA and remain fresh over the 50-year simulation period, which therefore do not change in the case of FWA. A minor increase of salinity (<0.5 ppt) can be observed in Atchafalaya Bay, Caillou Bay, and much of the Terrebonne Basin, due to reduced freshwater volumes as a consequence of diversion operation moving water to the west.

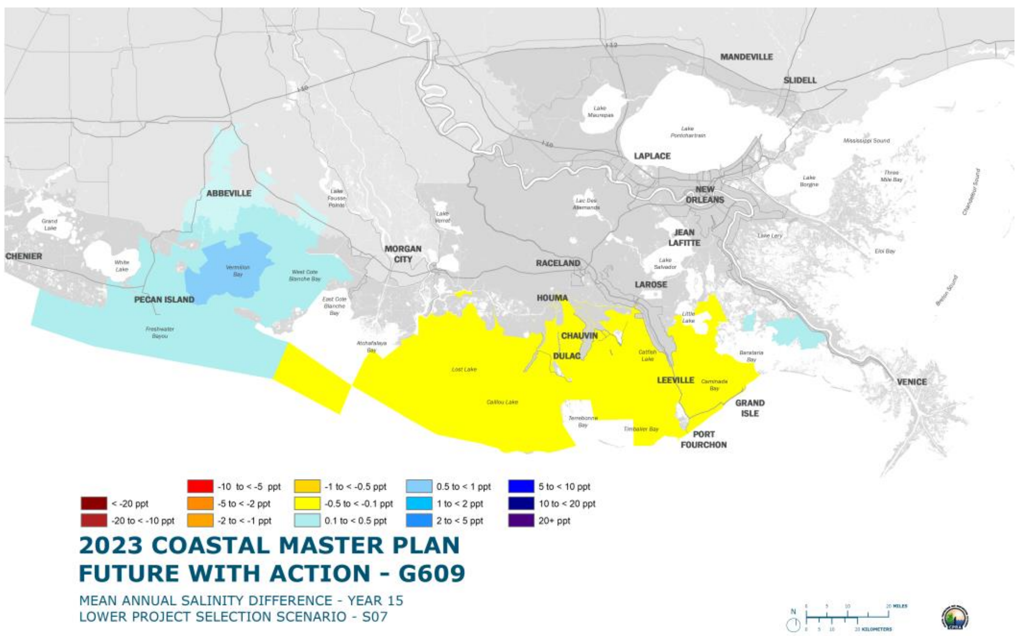


Figure 251. Difference map of mean annual salinity between FWOA (G500) and FWA (G609) at Year 15 of the lower (S07) scenario, indicating a salinity decrease amounting up to 1 ppt in Vermilion Bay, West Cote Blanche Bay, and surrounding marshes. Contrastingly, a minor salinity increase amounting up to 0.5 ppt is found for Atchafalaya Bay, Caillou Bay, and much of the Terrebonne Basin, due to reduced freshwater volumes as a consequence of upstream diversion operation. Similar results are found for the higher (S08) scenario.

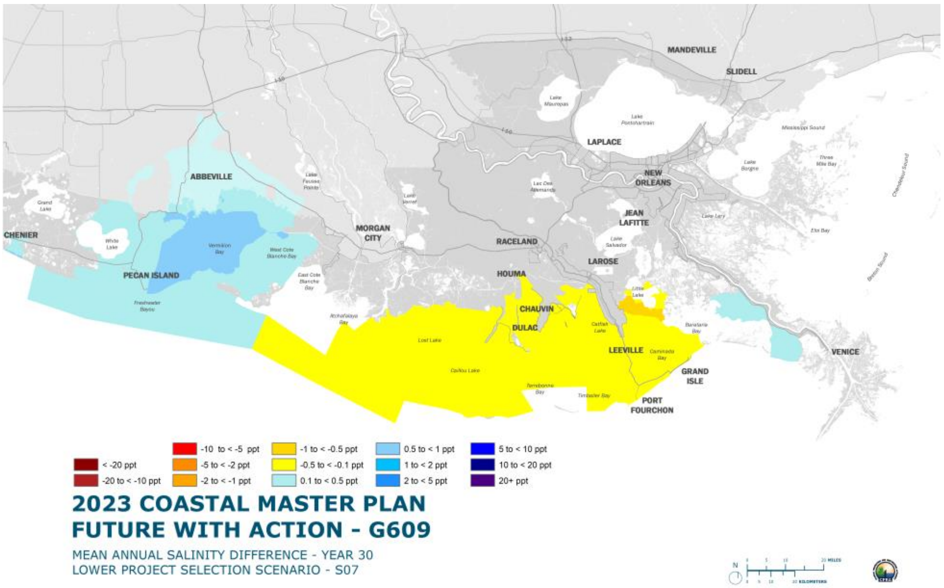


Figure 252. Difference map of mean annual salinity between FWOA (G500) and FWA (G609) at Year 30 of the lower (S07) scenario, showing similar magnitude and a slightly larger extent of salinity differences compared to Year 15 (Figure 252). Similar results are found for the higher (S08) scenario.

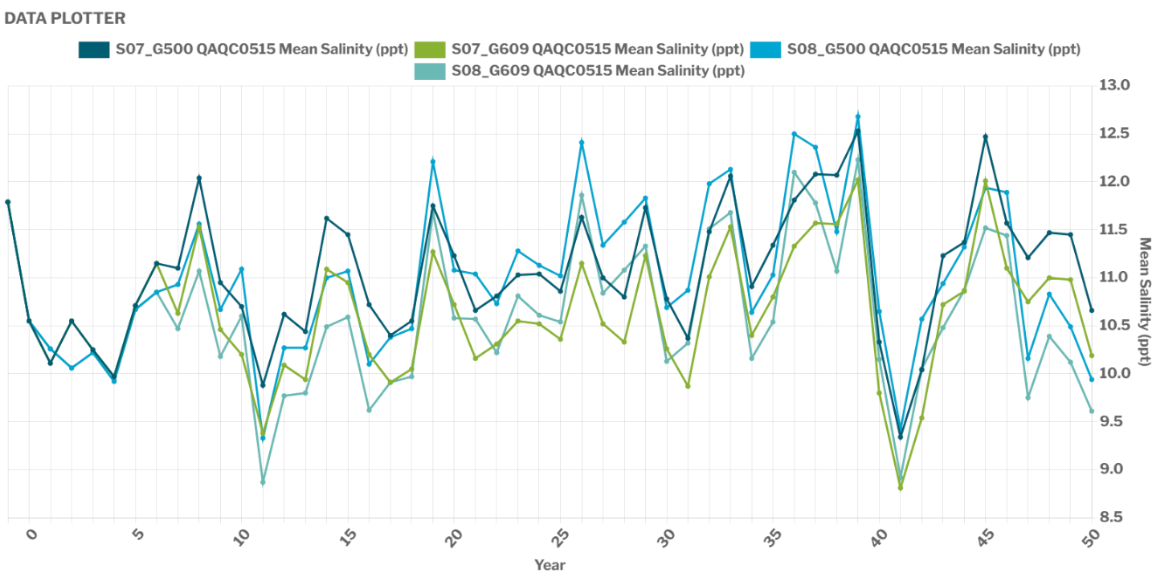


Figure 253. Annual mean salinity comparison between FWOA (G500) and FWA (G609) for lower (S07) and higher (S08) scenarios in QAQC0515 in Grand Lake (location indicated in Figure 248), showing the ~0.5 ppt salinity reduction in West Cote Blanche Bay resulting from operation of the Ama Sediment Diversion.

TOTAL SUSPENDED SEDIMENT (TSS)

Mean annual TSS concentrations are more noticeably affected by the Charenton Diversion in comparison to water level or salinity. Timeseries of mean annual TSS are shown for the locations indicated in Figure 255. The immediate outfall area is affected most significantly with mean annual TSS concentration increases amounting up to 10 mg/L, as shown for the Jaws Bay area (Figure 256). Smaller but still noticeable increases of 1-2 mg/L are found further away, as shown for the GIWW west of Charenton (Figure 257) as well as West Cote Blanche Bay (Figure 258). The TSS increases remain consistent (i.e., do not become larger or smaller) over the years and are very similar between the lower (S07) and higher (S08) scenarios.

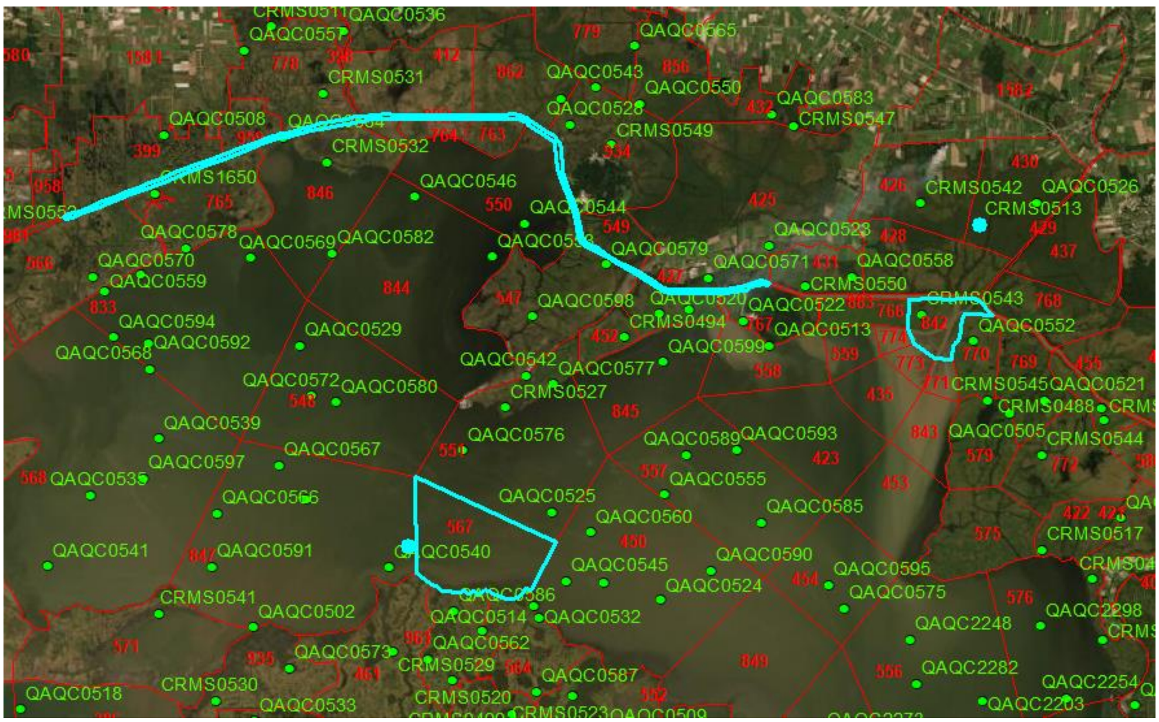


Figure 254. Map indicating the location of compartment 842 (blue dot) in the Jaws Bay area, compartment 882 situated in a section of the GIWW located west of the diversion channel, and compartment 507 near Marsh Island in West Cote Blanche Bay.

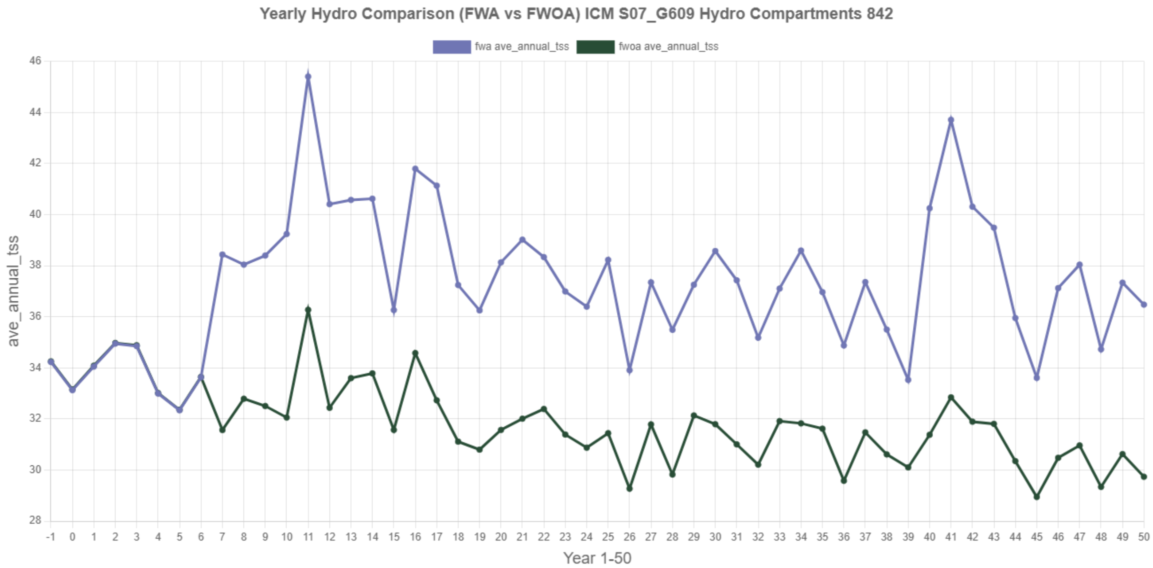


Figure 255. Mean annual TSS concentration timeseries comparison between FWOA (G500) and FWA (G609) for the lower (S07) scenario in compartment 842 (Jaws Bay; Figure 255), showing a 4-10 mg/L concentration increase that remains consistent over time. Similar results are found for the higher (S08) scenario.

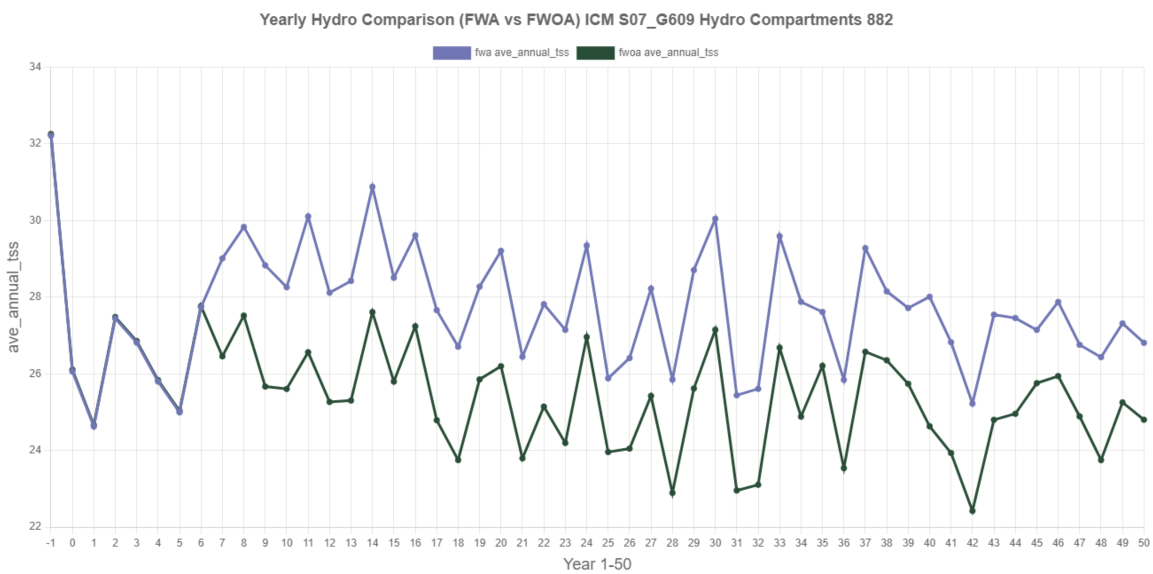


Figure 256. Mean annual TSS concentration timeseries comparison between FWOA (G500) and FWA (G609) for the lower (S07) scenario in compartment 882 (GIWW west of Charenton; Figure 255), showing a 1-2 mg/L concentration increase that remains consistent over time. Similar results are found for the higher (S08) scenario.

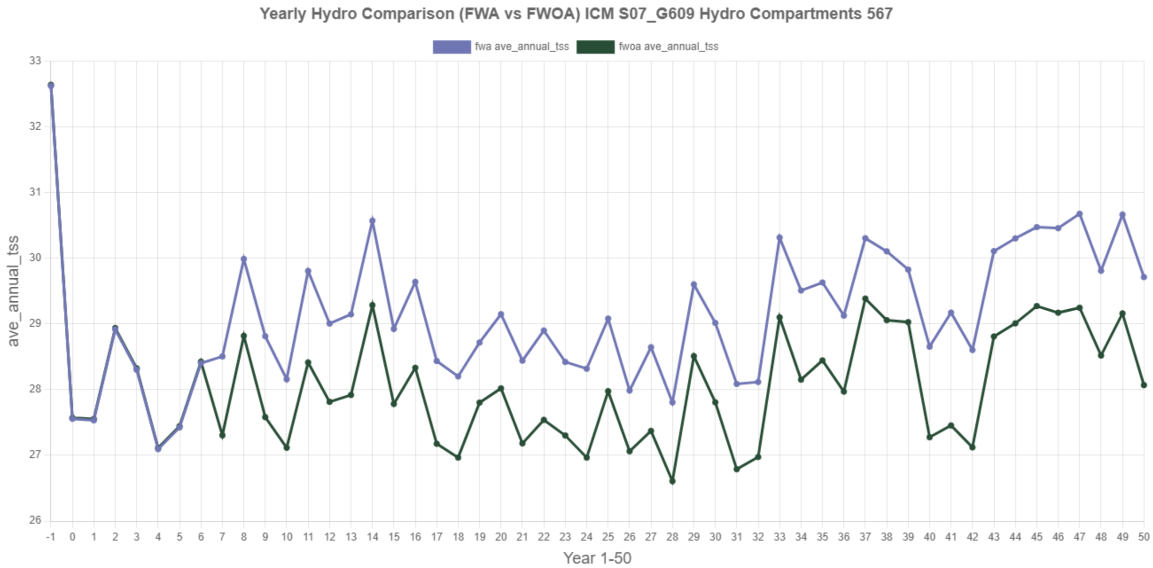


Figure 257. Mean annual TSS concentration timeseries comparison between FWOA (G500) and FWA (G609) for the lower (S07) scenario in compartment 567 (West Cote Blanche Bay; Figure 255), showing a 1-2 mg/L concentration increase that remains consistent over time. Similar results are found for the higher (S08) scenario.

MORPHOLOGY

RESULTS

Charenton Diversion creates a net benefit in the lower scenario, leading to 3.8 km^2 of additional land by Year 50 but results in a net loss of 51.8 km^2 in the higher scenario (Table 11). The annual net benefit compared to FWOA is shown in Figure 259.

Table 13. Net effect of the project (FWA-FWOA) by scenario in terms of AAL and net land at Year 50 based on IP1

	Average Annual Net Land (km^2)		Net Land at Year 50 (km^2)	
Scenario	Lower	Higher	Lower	Higher
Charenton Diversion	-0.9	-10.5	3.8	-51.8

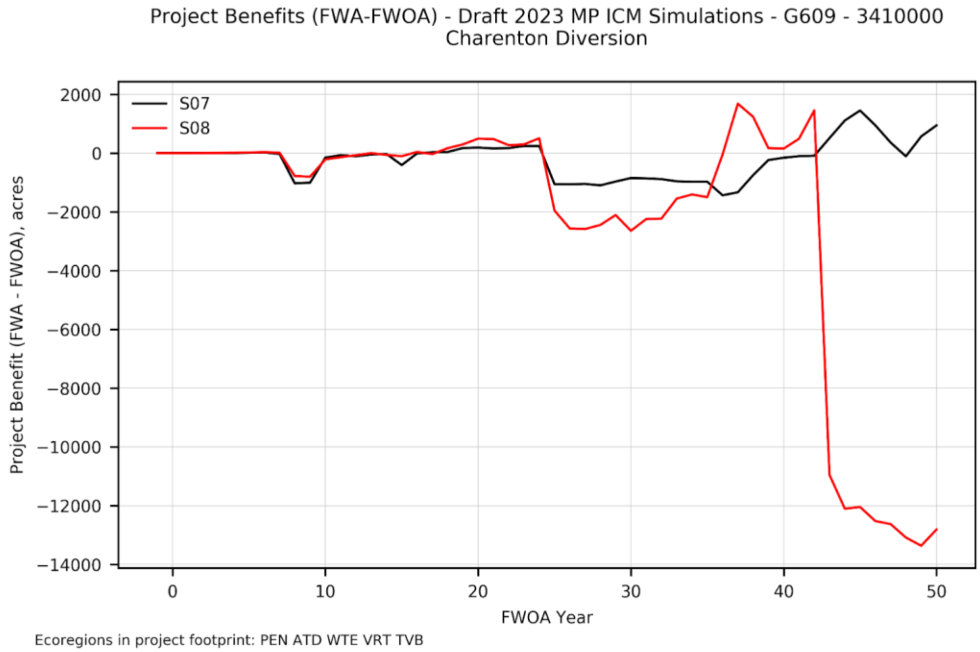


Figure 258. Net land (FWA-FWOA) over time for the lower and higher scenarios.

The project impacts two regions, the Central Coast and Terrebonne, in opposing ways. In the Central Coast, particularly near the project outfall in the Jaws and Cote Blanche and Cypremort marshes areas (TVB ecoregion), the project brings more freshwater and sediment, and it has a net benefit of 3.24 km^2 and 5.18 km^2 of AAL in the lower and higher scenarios, respectively. Since this diversion is stimulating processes akin to delta formation and growth, the compartments in the outfall region have a higher organic accretion rate, termed active delta accretion. The elevation at CRMS0543 demonstrates this effect (Figure 260). The increase in elevation with the project is driven by the organic accretion. Without the project, subsidence is the dominant process, and the area loses elevation. It converts to open water in Year 39 of the higher scenario and begins to receive greater mineral deposition, which increases its elevation. With the project, it remains vegetated land and continuously gains elevation.

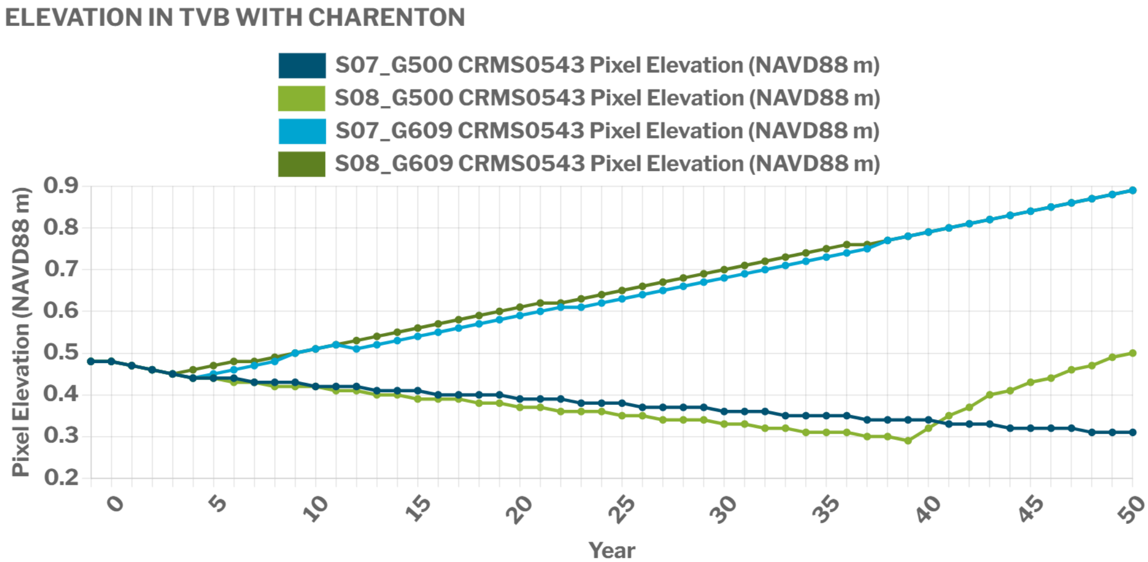


Figure 259. Surface elevation at CRMS0543 near the Jaws for the Charenton Diversion (G609) and FWOA for the lower and higher scenarios.

The project causes a small increase in inundation, but the total inundation is more influenced by the scenario. For example, the mean water level at CRMS0550 (Figure 261) shows a greater difference due to the scenario than presence of the project. The increase due to the project is seen throughout the simulation, and by Year 50 this increase is 5 cm in the lower scenario and 3 cm in the higher scenarios. This small increase in inundation is enough to cause some additional land loss, particularly north of the GIWW.

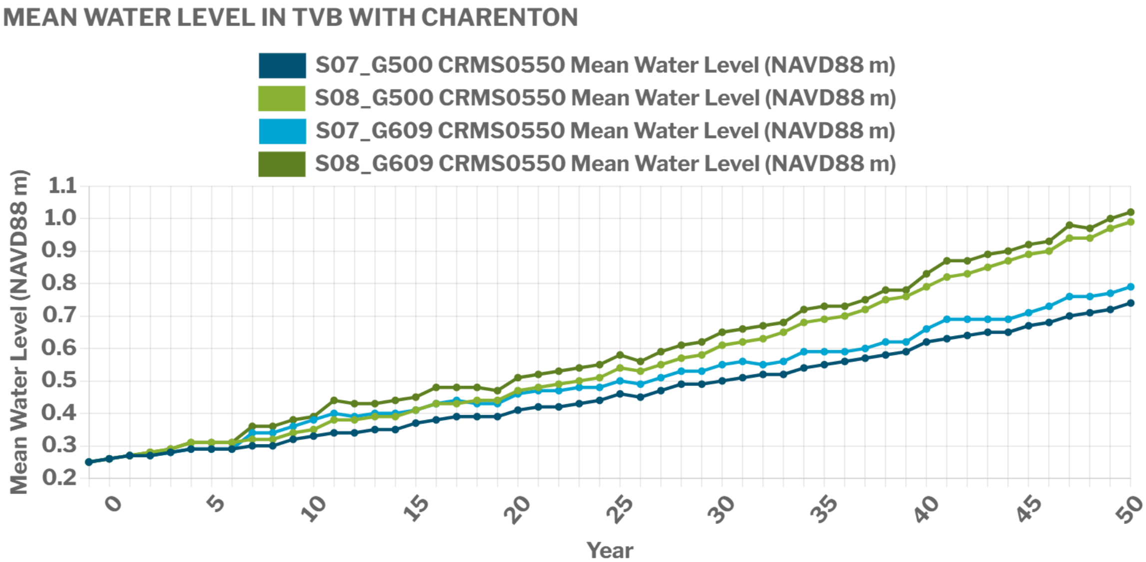


Figure 260. Mean annual water level for CRMS0550 north of Cote Blanche Island for the Charenton Diversion (G609) and FWOA for the lower and higher scenarios.

Land gain occurs along the outfall channel (Figure 262) due to increased organic and mineral accretion. In the higher scenario, the inundation from SLR is the dominant impact, and areas of land gain are isolated.

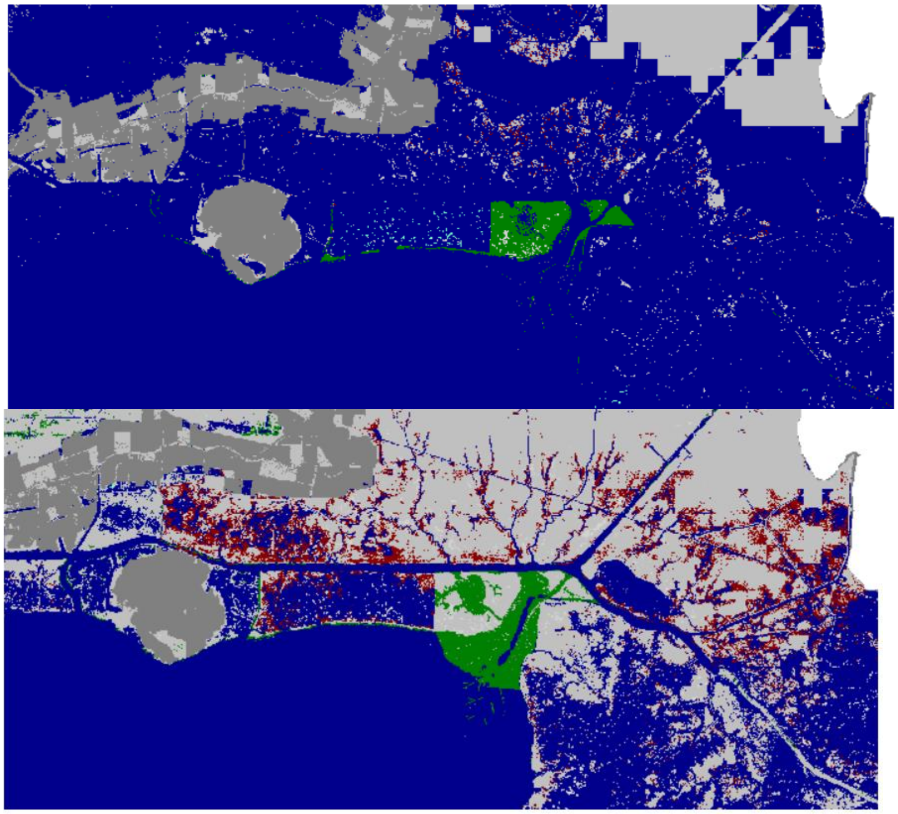


Figure 261. Difference in land-water at Year 50 north of West Cote Blanche Bay for the lower (upper panel) and higher (lower panel) scenario.

In Terrebonne, the project has a net negative impact. Diverting water to the Charenton Navigation Canal means reducing the freshwater and sediment making it west. Although the salinity changes are small, it is enough to increase the 2-week maximum salinity values beyond the 5.5 ppt threshold and trigger a loss in fresh marsh vegetation and flotant in parts of the Penchant Basin. This impact can be seen in QAQC0793 Year 43, which reaches a 2-week maximum salinity of 5.68 ppt in the higher scenario with the project and 5.27 ppt without the project (Figure 263). Increases in mean annual salinity are minor and generally remain within a tolerable range for flotant, which allows some to remain (see overall impacts in PEN in vegetation section). With the project, the AAL loss in the PEN ecoregion is -5.63 km^2 and -17.50 km^2 in the lower and higher scenarios, respectively.

FLOTANT LOSS IN PEN WITH CHARENTON, ACUTE SALINITY

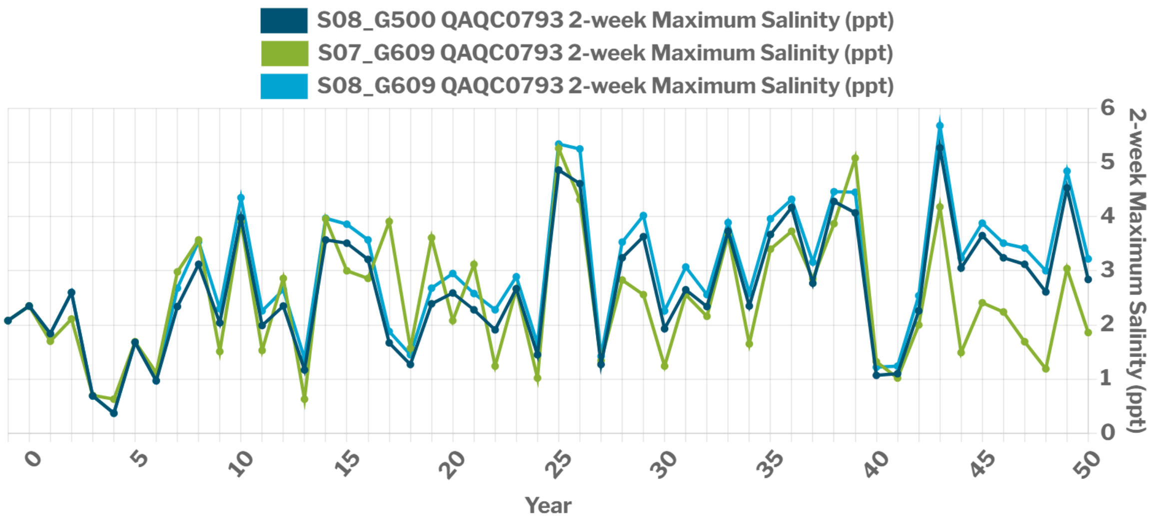


Figure 262. Maximum two-week mean salinity at QAQC0793 in the Turtle Bayou area for the Charenton Diversion and FWOA for the lower and higher scenarios.

This project did not have great enough benefits to be selected in IP1 and to be included in FWIP1, but it was modeled for IP2. There are no projects in the area included in FWIP1, limiting project interactions and making the results from FWOA similar to FWIP1. The elevation of CRMS0543, the same point shown above, which is in the wetlands to the west of the outfall, shows the area experiences a decrease in elevation without the project (Figure 264). Once the project is implemented (Year 26 in IP2), accretion increases, as described above. When the area converts to open water in FWIP1 higher scenario, the mineral accretion increases, just as it did in the higher scenario of FWOA. With the delay of project implementation, there is a longer period of subsidence prior to the project, and the elevations in Year 50 are more similar between IP2 and FWIP1 (Figure 264) than IP1 and FWOA (Figure 260).

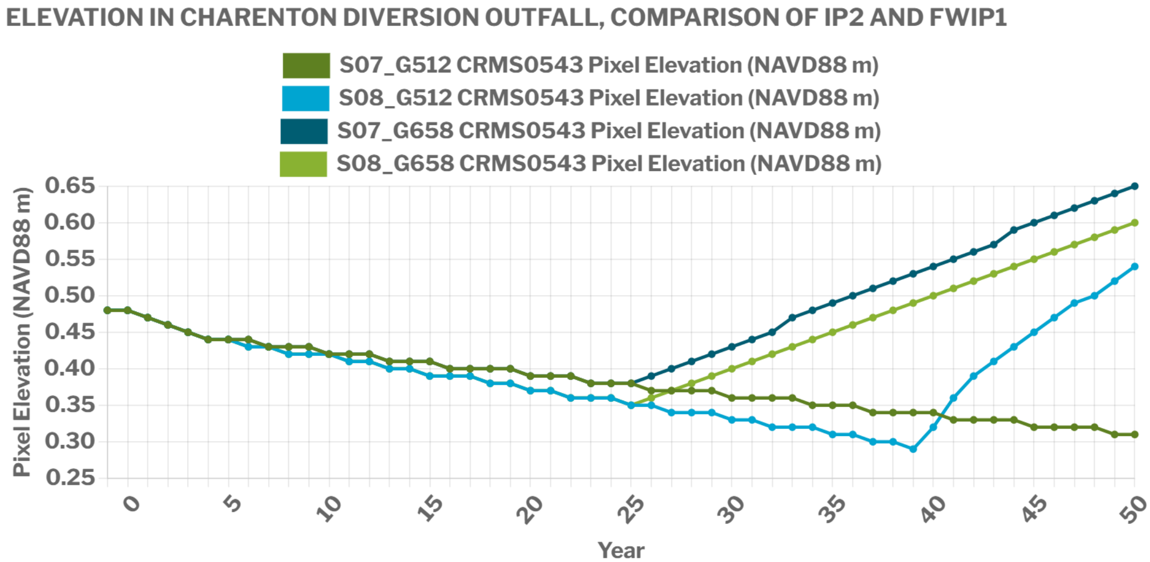


Figure 263. Elevation at CRMS0543 for IP2 Charenton Diversion and FWIP1 for the lower and higher scenarios.

The benefit curves show little to no change in land area between the model simulations (Figure 265).

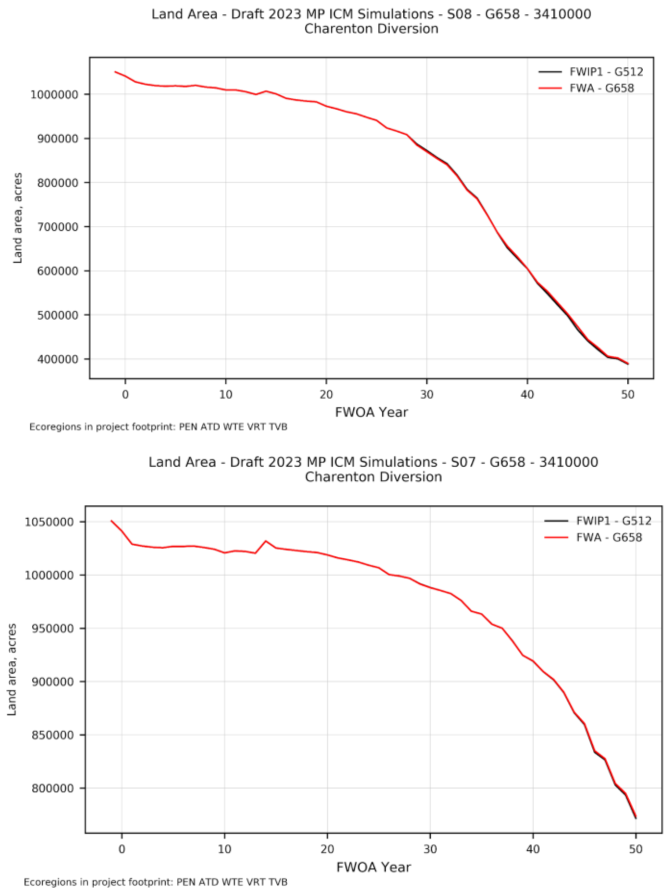


Figure 264. Land area change over time for the IP2 Charenton Diversion and FWIP1 for the lower scenario (lower panel) and the higher scenario (upper panel).

VEGETATION

On a regional scale, there is very little change in species composition in the TVB ecoregion. At a closer look, the Charenton Diversion increases fresh marsh in the small area surrounding the Jaws and reduces land loss of intermediate marsh in this area. This is illustrated with patterns observed at CRMS0543 (Figure 266). At CRMS0543, sediment from the Atchafalaya River starts forming some deltaic marsh under the lower scenario in FWOA. However, sediment input is insufficient and intermediate marsh is lost due to inundation. Under the higher scenario, there is no land building and intermediate marsh decreases overtime. With the Charenton Diversion, there is higher sediment input at this site and under both scenarios land is gained relative to the initial land area in this cell.

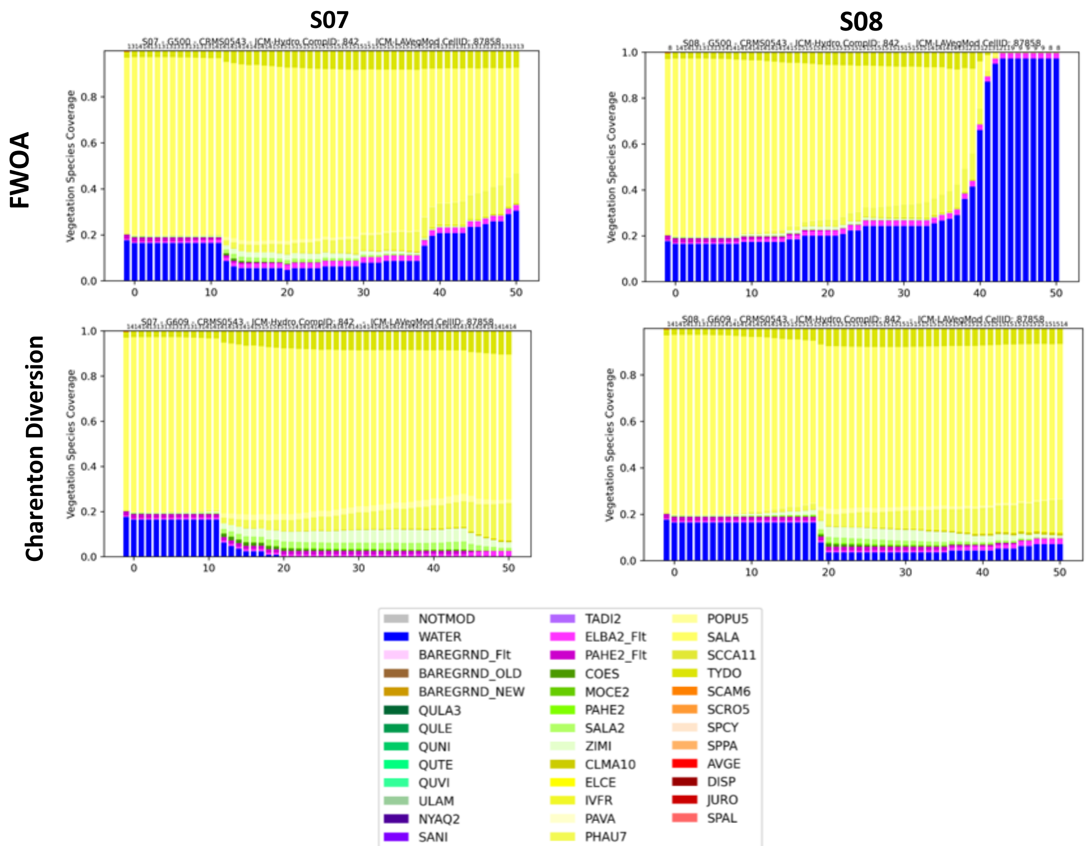


Figure 265. Vegetation cover changes observed at CRMS0543 under two scenarios with and without the Charenton Diversion.

In the PEN region, the westward diversion of the Atchafalaya River leads to a small increase in salinity that is sufficient to increase mortality of floating marshes (relative to FWOA). This negative effect is most pronounced in the last decade under the higher scenario (Figure 267).

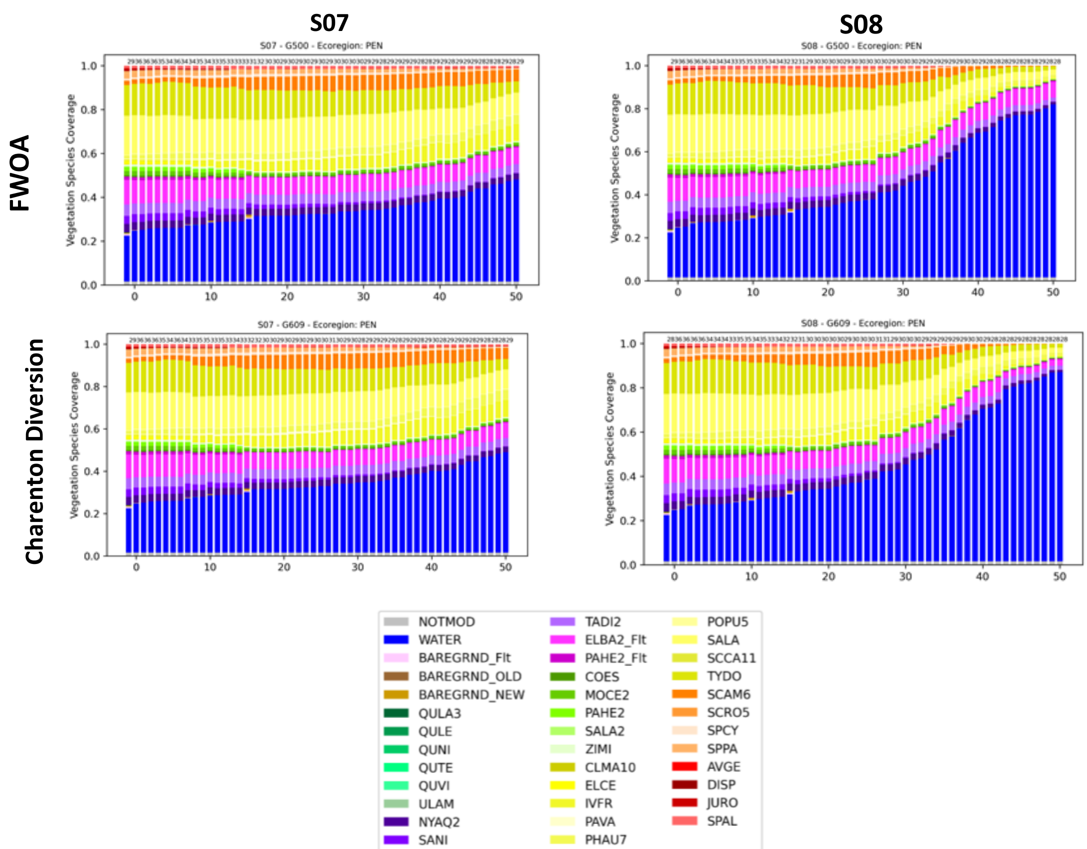


Figure 266. Vegetation cover changes observed in the PEN ecoregion under two scenarios with and without the Charenton Diversion.

Implementing the Charenton Diversion in IP2 does not have large-scale effects on vegetation composition. However, it reduces the loss of intermediate marshes near the outfall relative to the FWIP1, which is shown at CRMS0543 (Figure 268).

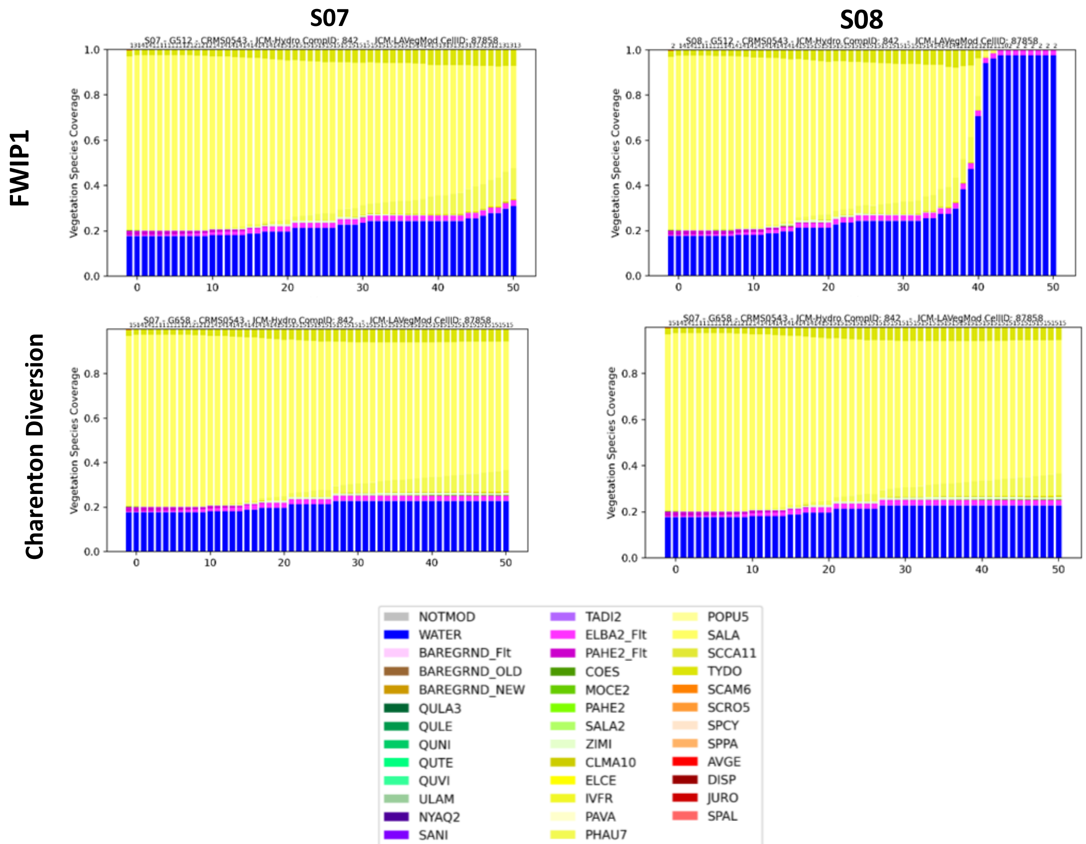


Figure 267. Vegetation cover changes observed at CRMS0543 under two scenarios with and without the Charenton Diversion.

HABITAT SUITABILITY

The Charenton Diversion project had minor effects on the suitability of habitats for fish, shellfish, and wildlife during both scenarios. The most apparent effect of the project was the increase in mean water levels within the TVB ecoregion. However, this water level variability was of a small magnitude (<5 cm), and the habitat suitability of wildlife reflected that. The slight increase in open water areas provided some benefit for waterfowl (Figure 269).

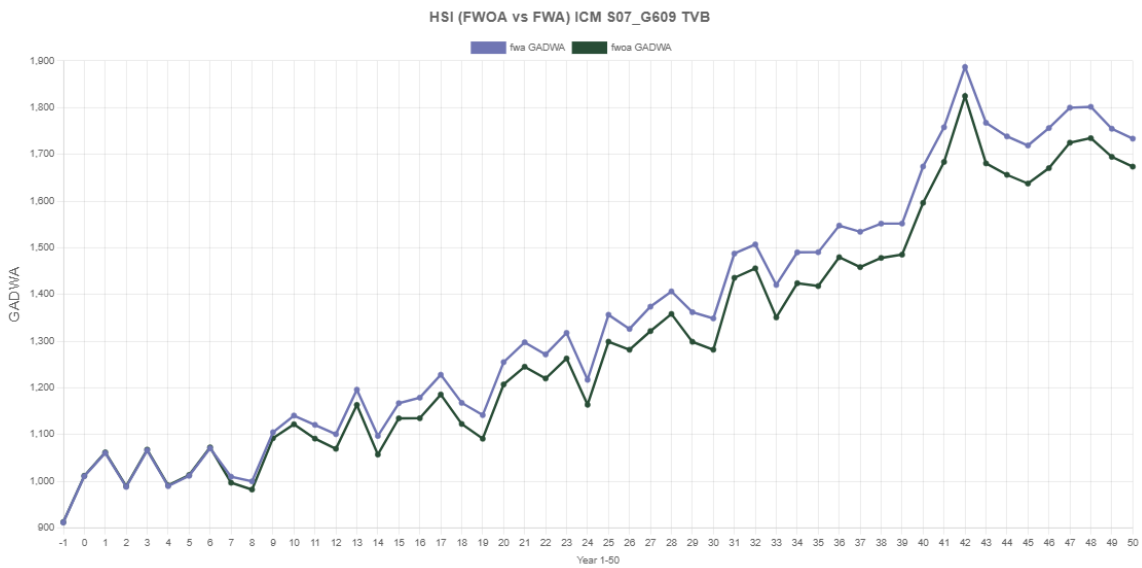


Figure 268. Total HSI score for the gadwall in the TVB ecoregion for the 50-year FWOA and Charenton Diversion (FWA) lower scenario. The total HSI score was calculated by summing the individual scores for each ICM model cell within the ecoregion.

Within the outfall area, salinities were decreased and therefore decreased suitability for some higher salinities, such as the eastern oyster (Figure 270).

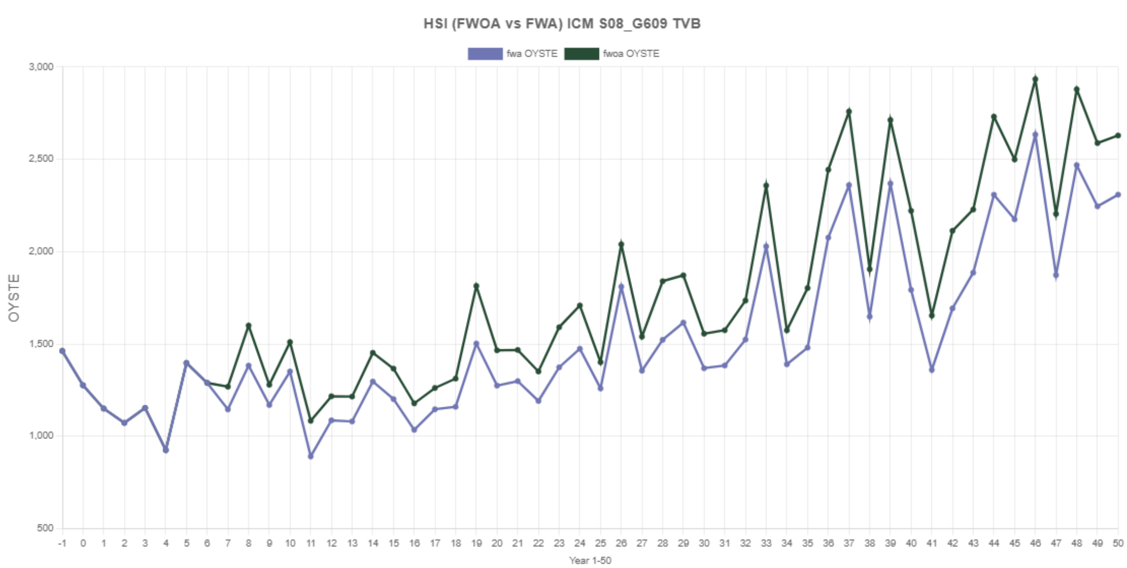


Figure 269. Total HSI score for the oyster in the TVB ecoregion for the 50-year FWOA and Charenton Diversion (FWA) higher scenario. The total HSI score was calculated by summing the individual scores for each ICM model cell within the ecoregion.

10.0 MARSH ISLAND BARRIER MARSH CREATION

PROJECT OVERVIEW

The Marsh Island Barrier Marsh Creation project (#346) involves the creation of marsh within a footprint of approximately 16,000 acres on Marsh Island (Figure 271) to create new wetland habitat, restore degraded marsh, and reduce wave erosion. The project was modeled as G634 and is fully constructed on the landscape in Year 11.

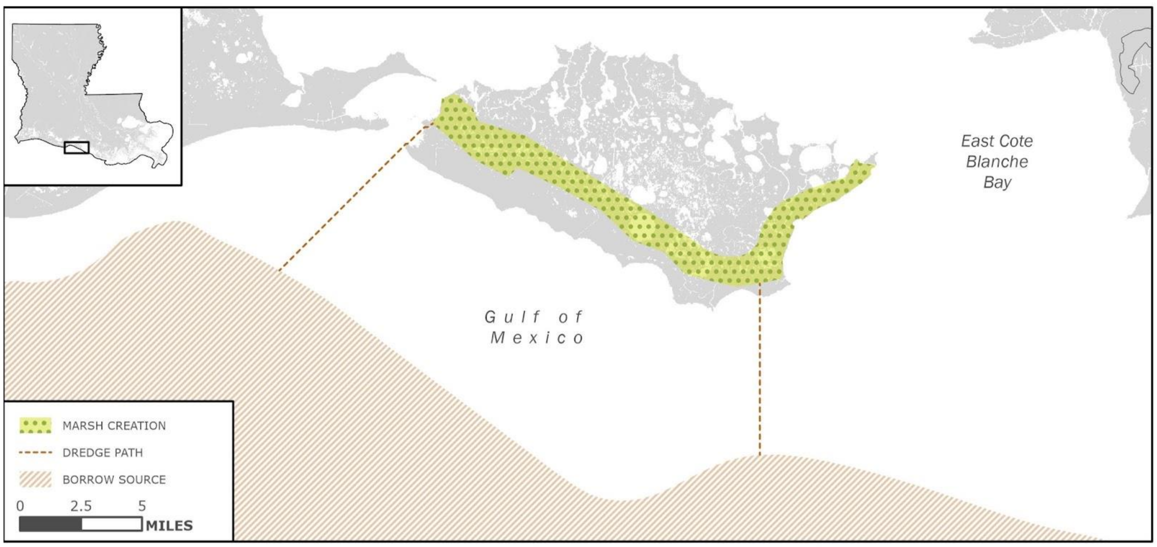


Figure 270. The location of the Marsh Island Barrier Marsh Creation project and associated potential borrow sources.

The project cost is $621.25 million for the lower scenario and $698.61 million for the higher scenario. The cost varies by scenario as water depths change, and the result is the need for a greater volume of sediment in the higher scenario. The project was selected for inclusion in the 2023 Coastal Master Plan in IP1.

The project results presented here discuss the way in which the project changes the coastal landscape in terms of hydrology, morphology, vegetation, and habitats, with examples from the two environmental scenarios. The examples have been selected to illustrate the dynamics of the project based on available data, rather than to provide a comprehensive description of all areas, scenarios, and temporal comparisons.

HYDROLOGY

WATER LEVELS AND INUNDATION

The overall impact of the Marsh Island Barrier Marsh Creation project on water levels is estimated to be very small, as indicated by Figure 272 and Figure 273 which show little to no difference in mean annual inundation depth outside of the marsh creation footprint, for both Year 15 and 30 of the lower scenario (S07) when compared to FWOA. The impact on water level is also very small for the higher scenario (S08).

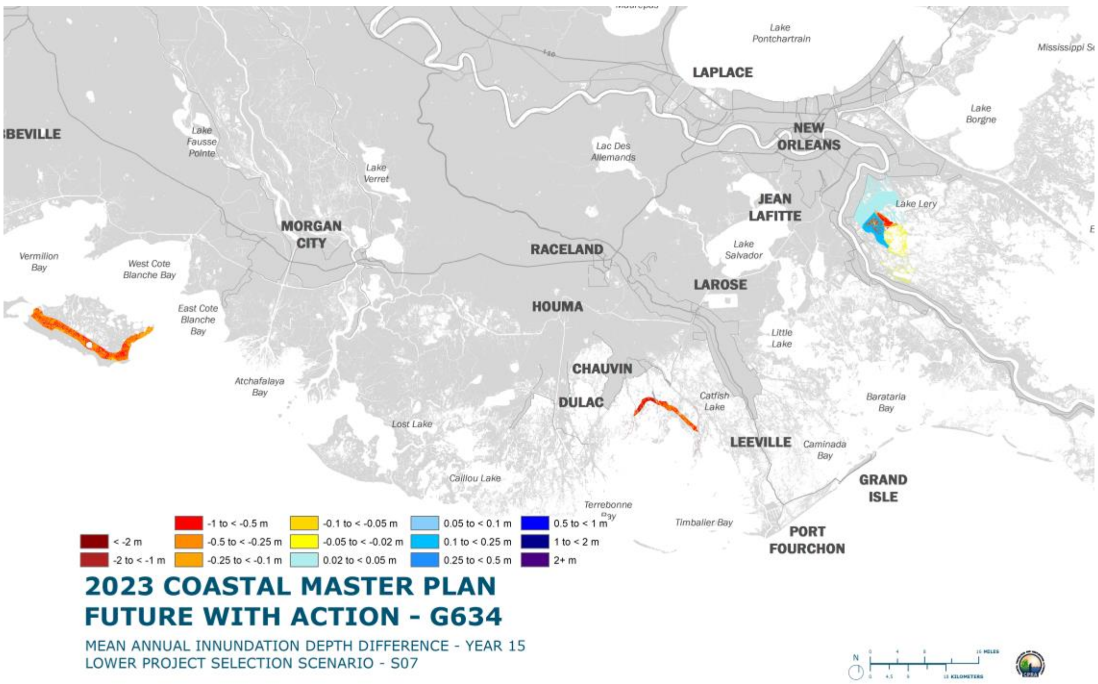


Figure 271. Difference map of mean annual inundation depth between FWOA (G500) and FWA (G634) at Year 15 of the lower scenario (S07), indicating no changes in inundation depths outside of the project footprint. Similar results are found for the higher scenario (S08).

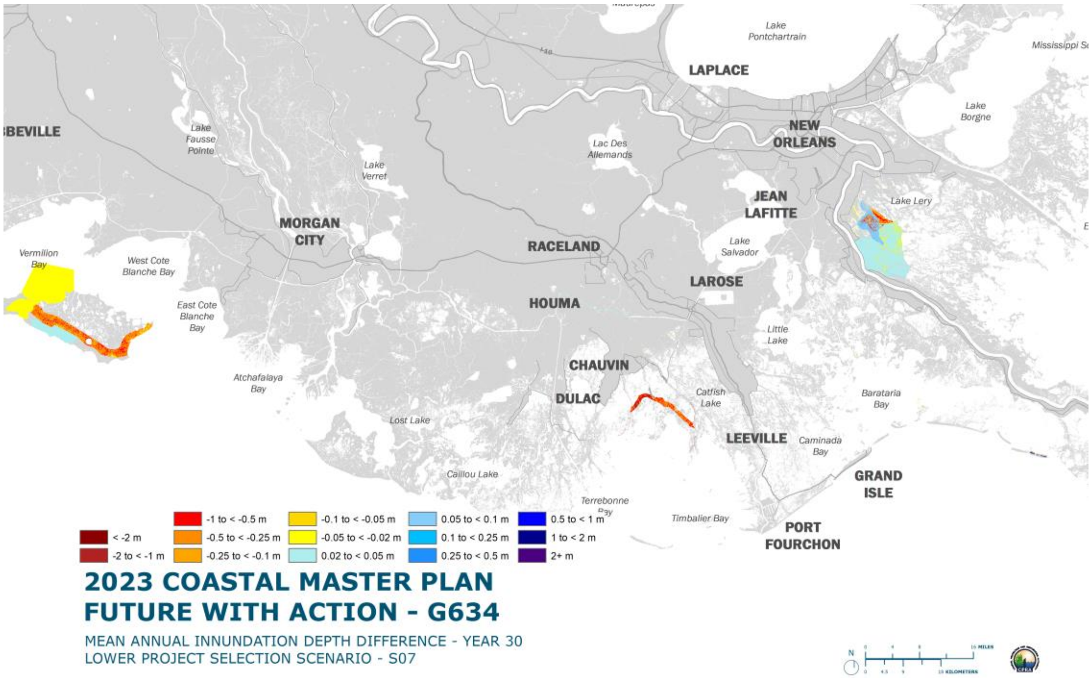


Figure 272. Difference map of mean annual inundation depth between FWOA (G500) and FWA (G634) at Year 30 of the lower scenario (S07), indicating little to no change in inundation depths outside of the project footprint, apart from a slight increase in inundation southwest of the project. Similar results are found for the higher scenario (S08).

Water level timeseries are extracted at two selected locations on Marsh Island, namely CRMS0498 at the seaward side and CRMS0520 at the bay side of the marsh creation project as shown in Figure 274. Two FWA versus FWOA comparisons of annual mean water level are shown in Figure 275 and Figure 297 for each of the aforementioned two locations, as well as comparisons for annual water level variability in Figure 277 and Figure 278. Little to no impact on annual mean water level is seen for either location, other than a slight (<2 cm) increase at the seaward station during Years 40-50 of the higher scenario. The same largely applies to the annual water level variability comparisons, with little to no noticeable increases (i.e., <1 cm) when comparing FWA against FWOA, for both the lower scenario as well as the higher scenario. A slightly disrupted pattern in the annual water level variability is found for FWOA during Years 45-48, due to the inundation loss at the Marsh Island in this period.

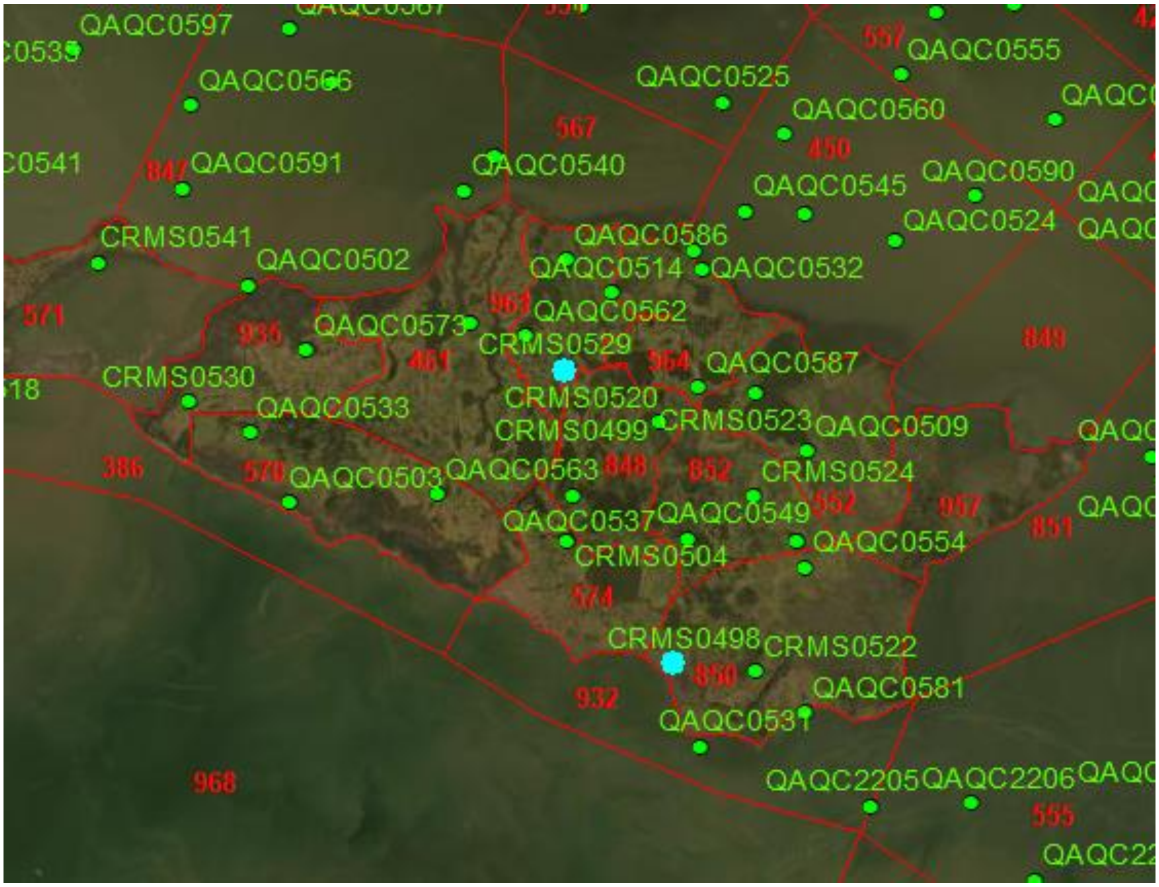


Figure 273. Map indicating the location of CRMS0498 (blue dot) in compartment 850 on Marsh Island at the seaward side of the marsh creation project and CRMS0520 in compartment 961 on Marsh Island at the bay side of the project.

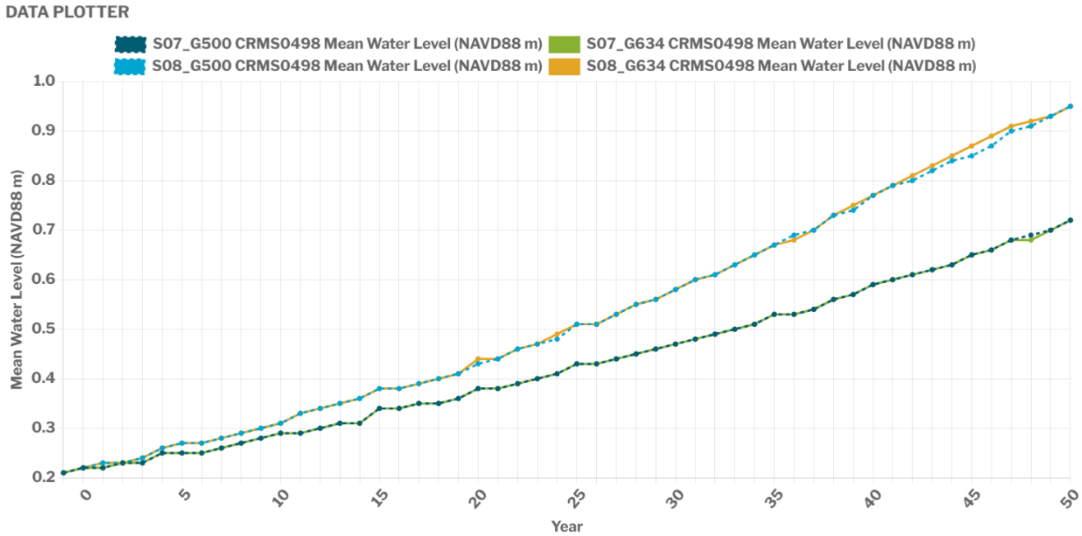


Figure 274. Annual mean water level comparison between FWOA (G500) and FWA (G634) for lower (S07) and higher (S08) scenarios in CRMS0498 located seaward of the marsh creation project (location indicated in Figure 274). Annual mean water levels are not or barely affected by the project, all throughout the post-construction part of the 50-year simulation period, for both the lower (S07) and higher (S08) scenarios.

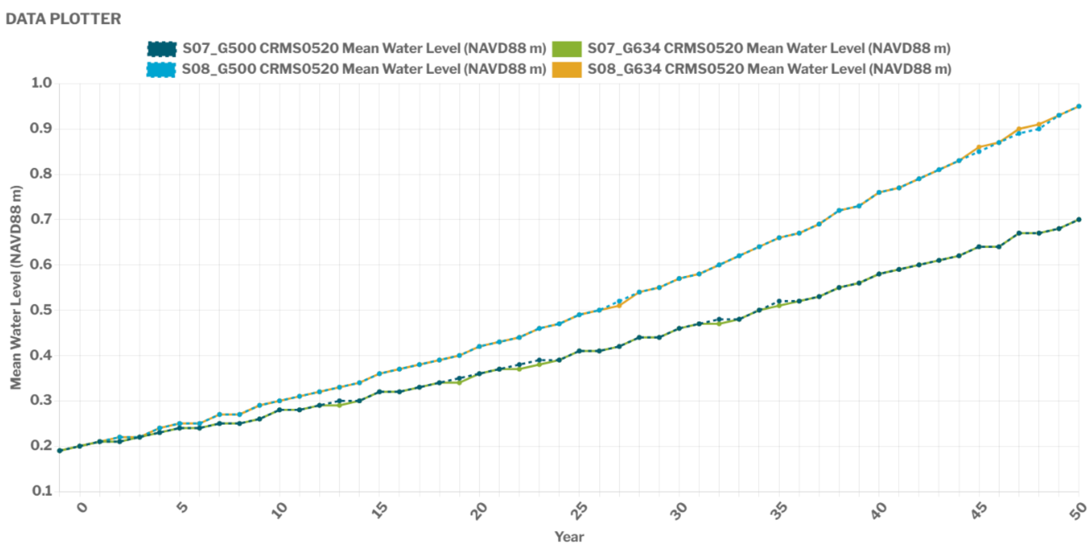


Figure 275. Annual mean water level comparison between FWOA (G500) and FWA (G634) for lower (S07) and higher (S08) scenarios in CRMS0520 located at the bay side of the marsh creation project (location indicated in Figure 274). Annual mean water levels are not or barely affected by the project, all throughout the post-construction part of the 50-year simulation period, for both the lower (S07) and higher (S08) scenarios.

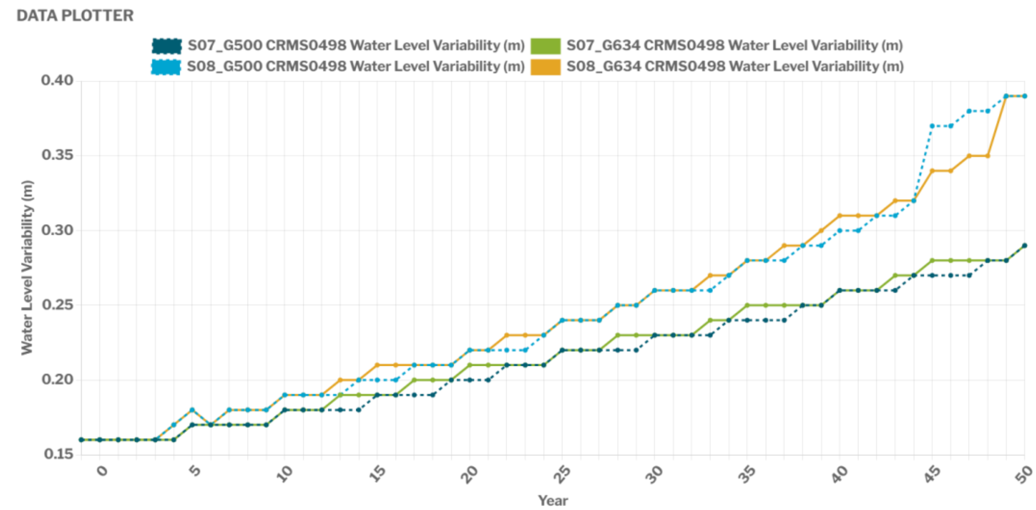


Figure 276. Annual water level variability comparison between FWOA (G500) and FWA (G634) for lower (S07) and higher (S08) scenarios in CRMS0498 located seaward of the marsh creation project (location indicated in Figure 274). Water level variability is not or barely affected by the project, all throughout the post-construction part of the 50-year simulation period, for both the lower (S07) and higher (S08) scenarios, except for the final five years of the higher (S08) scenario due to marsh inundation loss.

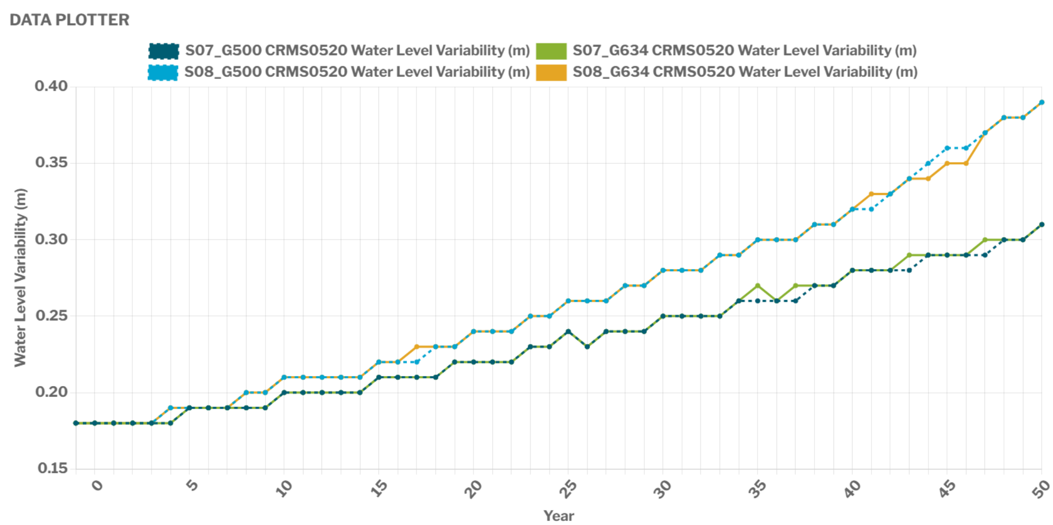


Figure 277. Annual water level variability comparison between FWOA (G500) and FWA (G634) for lower (S07) and higher (S08) scenarios in CRMS0520 located at the bay side of the marsh creation project (location indicated in Figure 274). Water level variability is not or barely affected by the project, all throughout the post-construction part of the 50-year simulation period, for both the lower (S07) and higher (S08) scenarios, except for the final five years of the higher (S08) scenario due to marsh inundation loss.

SALINITY

Salinity patterns and dynamics are barely affected by the marsh creation project, as shown in Figure 279 and Figure 280 indicating FWA versus FWOA differences in mean annual salinity for the lower scenario (S07) in Years 15 and 30, respectively. The differences are limited to a small (<0.5 ppt) reduction of mean annual salinity at Marsh Island, which can be seen more clearly in the annual mean salinity timeseries figures from the CRMS stations located seaward (Figure 281) and at bay side (Figure 282) of Marsh Island (indicated in Figure 274). No differences in salinity concentrations are observed in the surrounding open water areas (Figure 279 and Figure 280). The areal extent and magnitude of salinity differences do not change over time and are similar between the lower (S07) and higher (S08) scenarios.

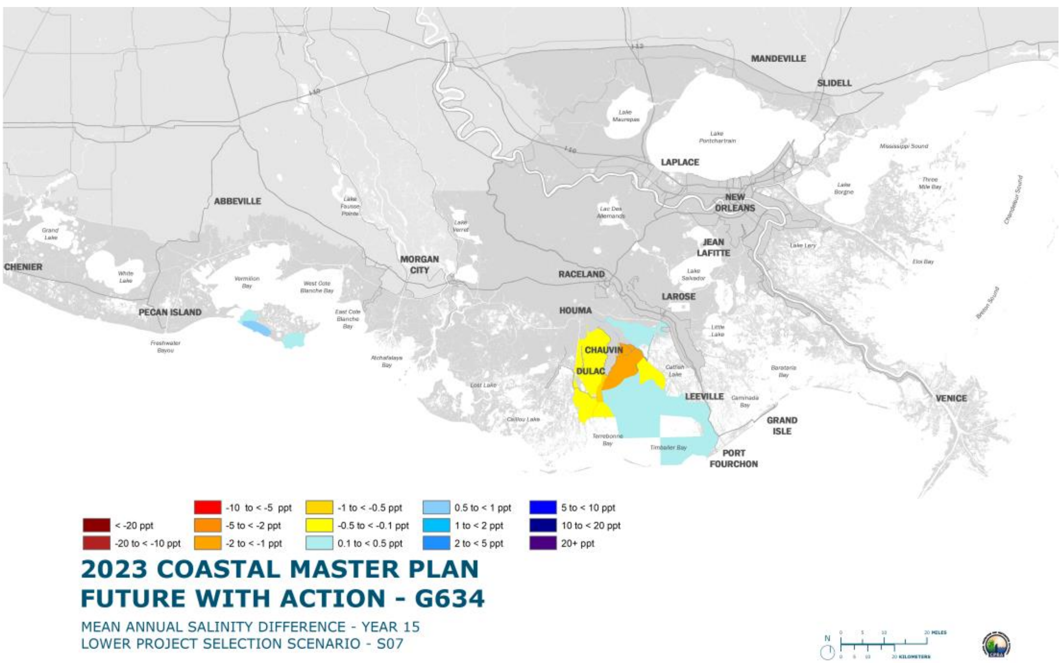


Figure 278. Difference map of mean annual salinity between FWOA (G500) and FWA (G634) at Year 15 of the lower (S07) scenario, indicating a small local salinity decrease in some parts of Marsh Island. Similar results are found for the higher (S08) scenario.

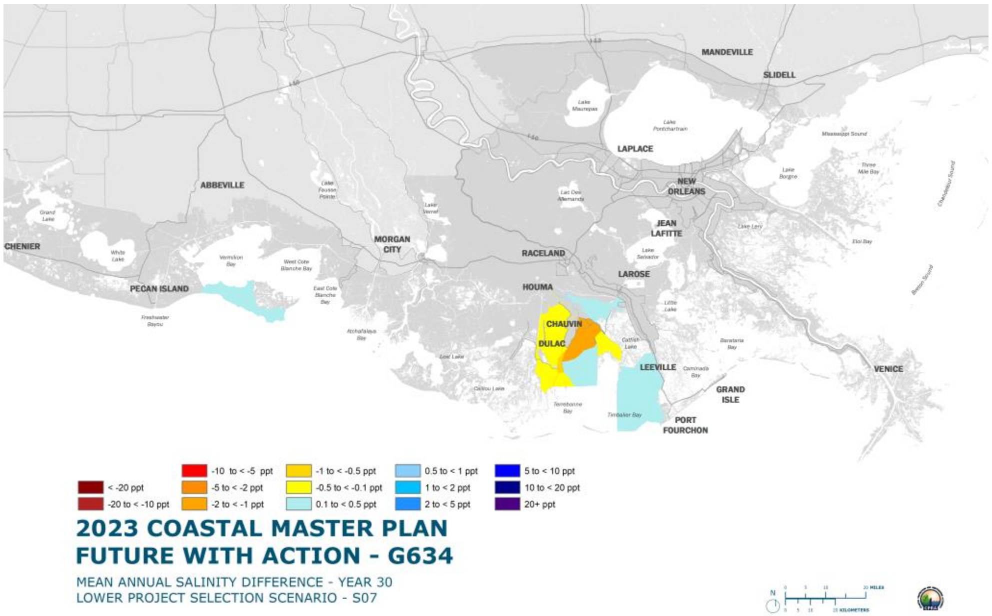


Figure 279. Difference map of mean annual salinity between FWOA (G500) and FWA (G634) at Year 30 of the lower (S07) scenario, indicating a small local salinity decrease in some parts of Marsh Island. Similar results are found for the higher (S08) scenario.

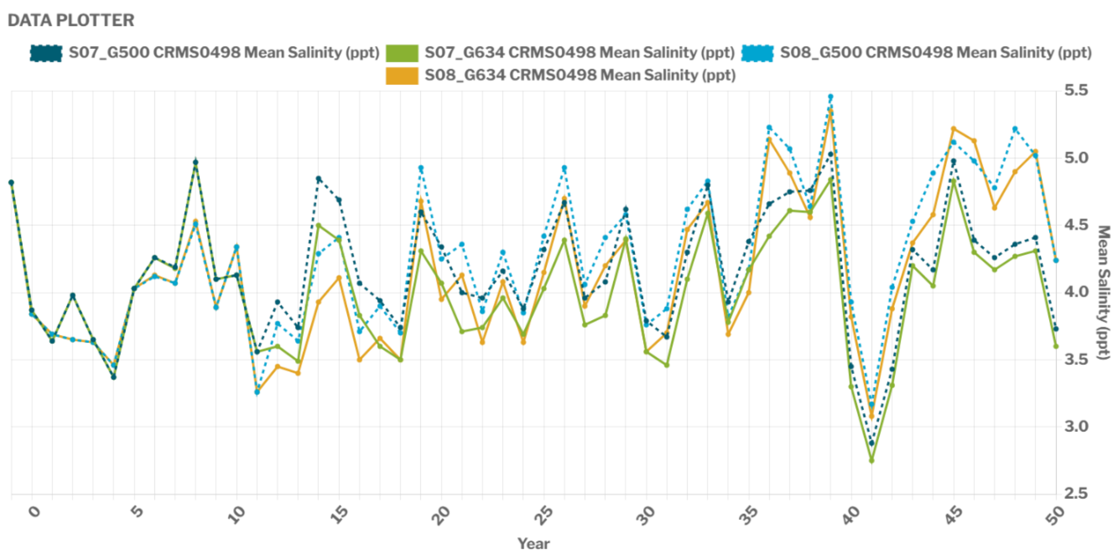


Figure 280. Annual mean salinity comparison between FWOA (G500) and FWA (G634) for lower (S07) and higher (S08) scenarios in CRMS0498 located seaward of the marsh creation project (location indicated in Figure 274), showing a small salinity reduction after construction of the marsh in Year 11 that remains limited to 0.5 ppt for both the lower (S07) and higher (S08) scenarios.

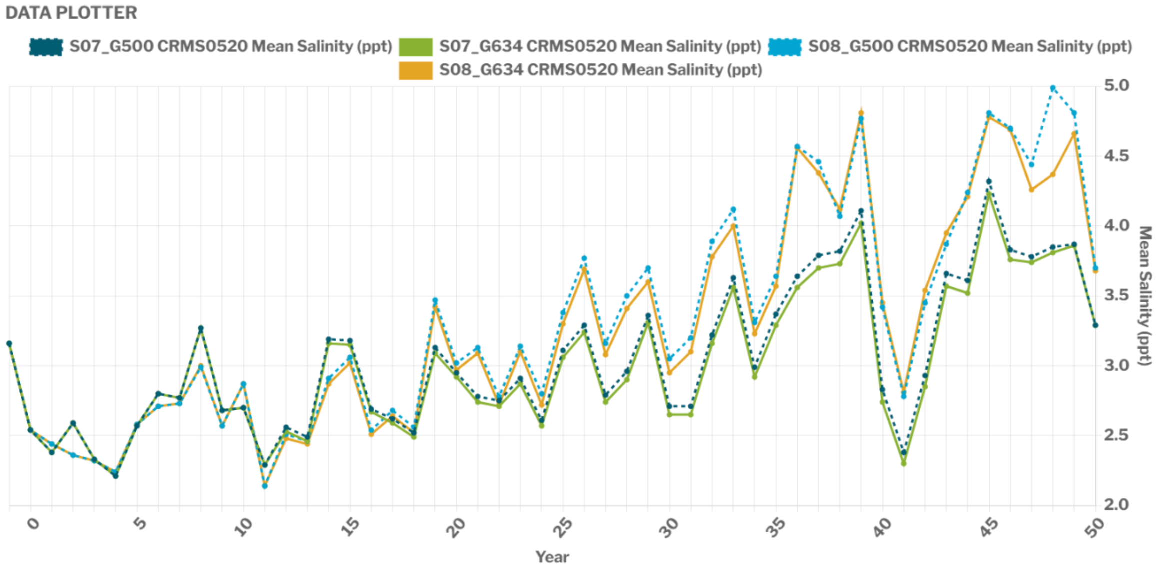


Figure 281. Annual mean salinity comparison between FWOA (G500) and FWA (G634) for the lower (S07) and higher (S08) scenarios in CRMS0520 located at the bay side of the marsh creation project (location indicated in Figure 274), showing a negligible decrease (<0.1 ppt) in salinity after construction of the marsh in Year 11, for both the lower (S07) and higher (S08) scenarios.

MORPHOLOGY

The Marsh Island Barrier Marsh Creation increases the land maintained within the project footprint. There is a large difference between the high and low scenarios due to increased SLR in the higher scenario in the last decade of the simulation (Figure 283). The net land at Year 50 is 50.3 km^2 and 0.4 km^2 for the lower and higher scenarios, respectively (Table 12).

Table 14. Net AAL and net land at Year 50 (FWA-FWOA) for the Marsh Island Barrier Marsh Creation project by scenario

	Average Annual Net Land (km^2)		Net Land at Year 50 (km^2)	
Scenario	Lower	Higher	Lower	Higher
Marsh Island Barrier Marsh Creation	21.7	24.4	50.3	0.4

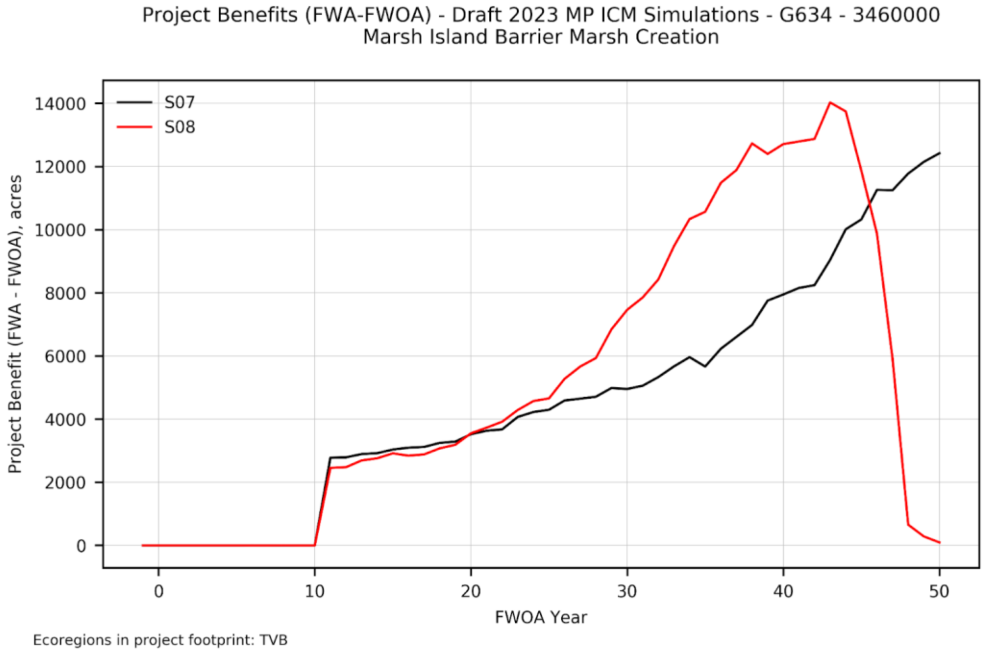


Figure 282. Net land (FWA-FWOA) over time for the lower scenario (S07) and the higher scenario (S08) for the Marsh Island Barrier Marsh Creation project.

The elevation within the project footprint is increased following the standard method for marsh creation projects. Elevation decreases rapidly at first since there is not enough inundation to stimulate organic accretion (Figure 284). It then slows once organic accretion begins. Subsidence is the dominant effect, and elevation steadily decreases across scenarios with and without the project. The mineral accretion is small in this area (about 0.001 cm annually). The elevation capital created by the project is enough to maintain the majority of the land in the lower scenario but not in the higher scenario (Table 12).

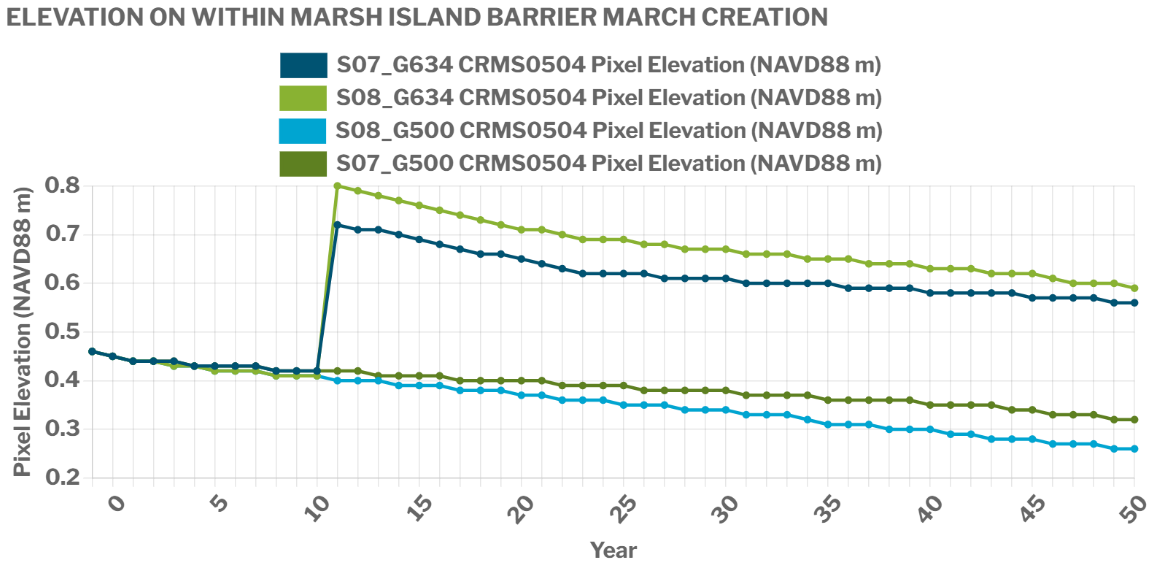


Figure 283. Elevation over time at CRMS0504 within the project footprint of the Marsh Island Barrier Marsh Creation project for FWA (G643) and FWOA (G500) for the lower and higher scenarios.

VEGETATION

RESULTS

The barrier marsh creation on Marsh Island has very little effect on the species composition in the TVB ecoregion (Figure 285). However, CRMS0504 (Figure 286) shows that the marsh creation sites are initially colonized by more weedy intermediate marsh species (primarily PHAU7). Under the lower scenario, the marsh creation stops the loss of surrounding marsh that occurred without the project (Figure 286). Under the higher scenario, marsh is lost at CRMS0504 in Year 49 when increasing salinity and inundation exceed the limits that can support marsh vegetation.

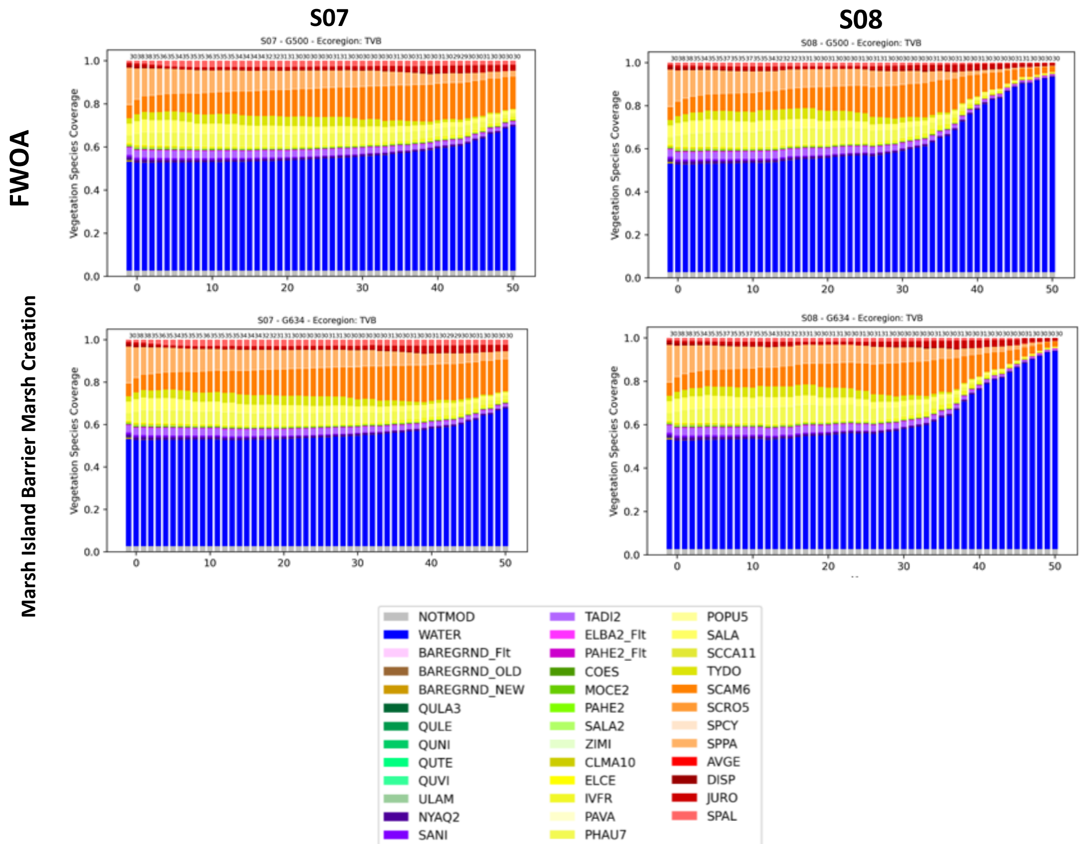


Figure 284. Change in species composition in the TVB ecoregion with and without the Marsh Island Barrier Marsh Creation project under two scenarios.

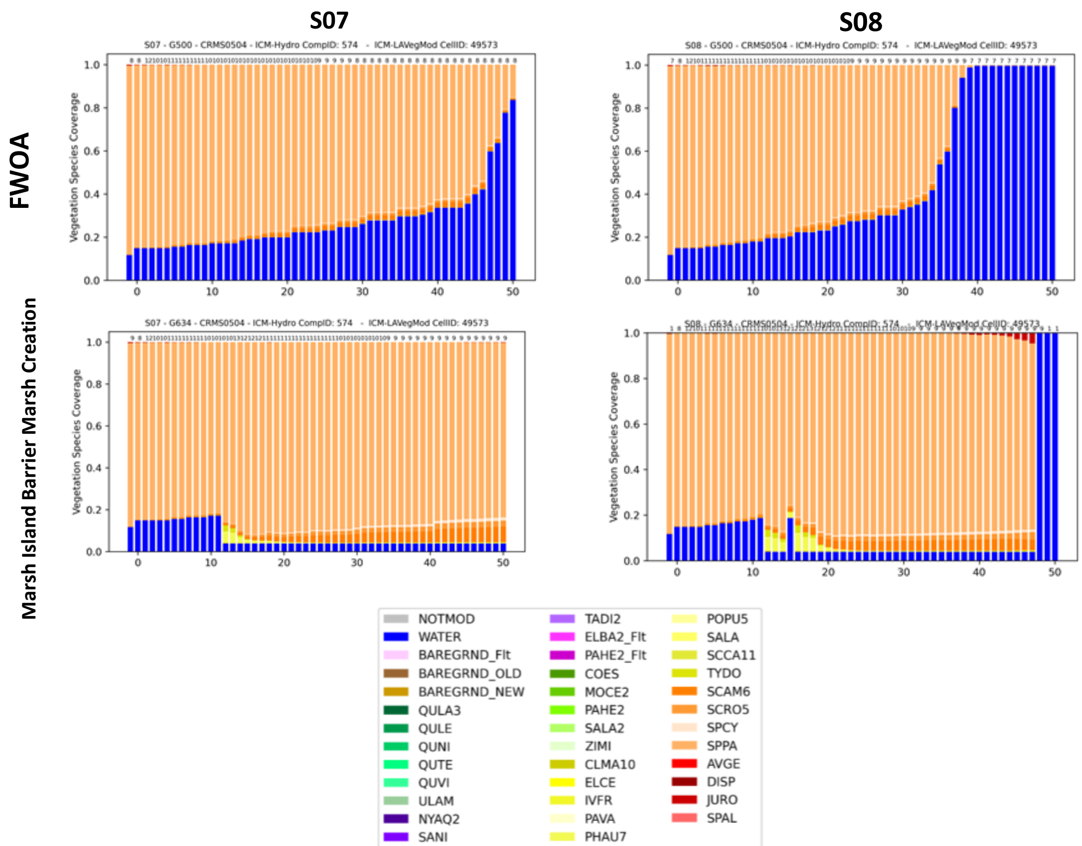


Figure 285. Change in species composition at CRMS0504 with and without the Marsh Island Barrier Marsh Creation project under two scenarios.

HABITAT SUITABILITY

RESULTS AND DISCUSSION

The Marsh Island Barrier Marsh Creation project leads to an increase in marsh within the TVB ecoregion under both the lower (S07) and higher (S08) scenarios. This increase in solid marsh caused a decrease in habitat suitability for nearly all species. This was due to lack of aquatic habitat for fish, shellfish, alligator, and waterfowl. However, the increase in land area in early decades was beneficial for the seaside sparrow because the solid marsh platform increased nesting and foraging habitat (Figure 287). There are large differences between the lower (S07) and higher (S08) scenarios due to increased SLR in the last decade of the higher simulation.

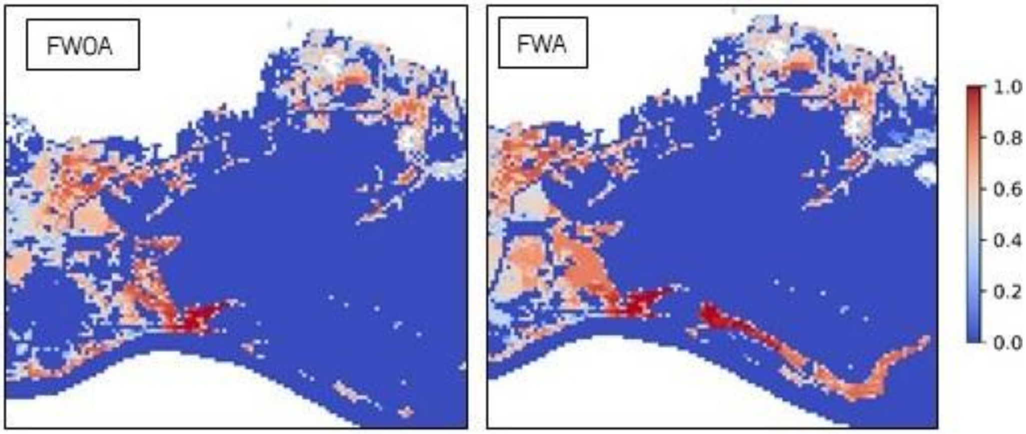


Figure 286. Seaside sparrow HSI scores across the TVB region for Year 30 of the FWOA and Marsh Island Barrier Marsh Creation (FWA) lower scenario. Scores range from 0.0, completely unsuitable habitat, to 1.0, optimal habitat.

Under the higher scenario, the land is fragmented due to SLR, which opens up some habitat for waterfowl in Year 40 (Figure 288). However, SLR eventually creates negative effects on the habitat suitability for waterfowl, most likely due to increased water levels and salinity. Even with this decrease in suitability, the FWA runs were slightly more favorable for waterfowl when compared to FWOA runs (Figure 288).

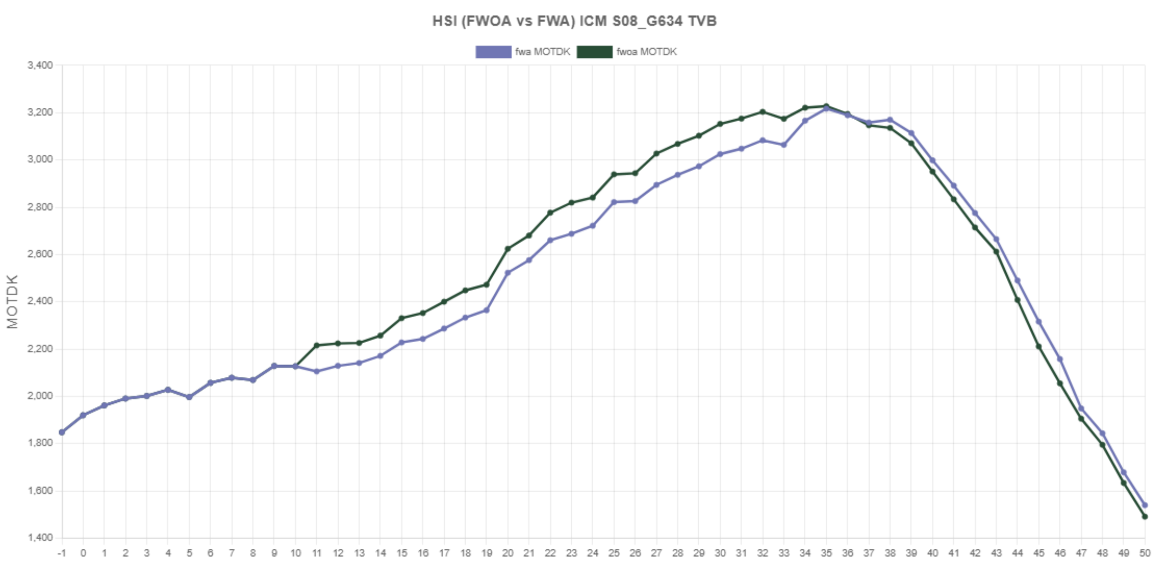


Figure 287. Total HSI score for mottled duck in the TVB ecoregion for the 50-year FWOA and Marsh Island Barrier Marsh Creation (FWA) higher scenario. The total HSI score was calculated by summing the individual scores for each ICM model cell within the ecoregion.

11.0 MERMENTAU BASIN HYDROLOGIC RESTORATION AND CAMERON-CREOLE TO THE GULF HYDROLOGIC RESTORATION

PROJECTS OVERVIEW

This report describes the modeling results for two hydrologic restoration projects in the Chenier Plain: the Mermentau Basin Hydrologic Restoration project (#347) and the Cameron-Creole to the Gulf Hydrologic Restoration project (#349).

The Mermentau Basin Hydrologic Restoration (MBHR) project includes a series of hydrologic features designed to facilitate drainage from the upper Mermentau Basin south to the Gulf (Figure 289). Components include channel dredging and cleanout in Little Chenier Canal and Kings Bayou as well as improving three road crossings and increasing capacity at the Kings Bayou Control Structures with 15, 60-inch flap gated culverts to increase drainage to the Mermentau River. There are 105, 60-inch flap gated culverts under Highway 82 and 120, 60-inch flap gated culverts on the south and west boundaries of the Rockefeller Wildlife Refuge to move water south across Highway 82. The project is fully constructed and operational at Year 8 and is modeled as G630. The project was selected in IP1. The project cost is $133 million and does not vary by scenario as no marsh creation is involved.

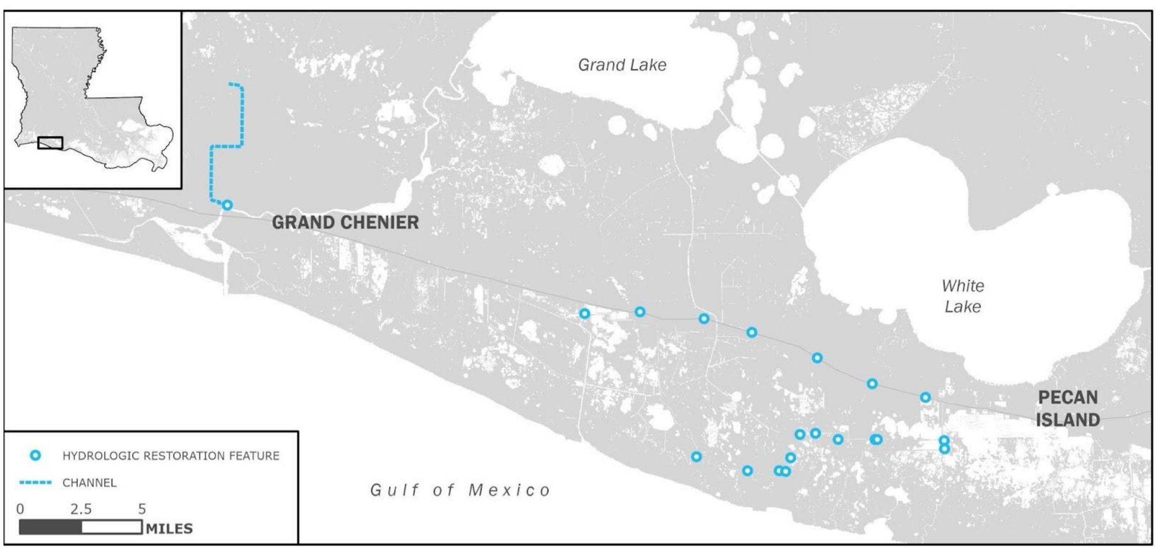


Figure 288. Location of features for the MBHR project.

The Cameron-Creole to the Gulf Hydrologic Restoration (CCGHR) project focuses on increasing the capacity for drainage from the Cameron-Creole Watershed to the Gulf through Creole Canal (Figure 290). It involves dredging and cleanout of Creole Canal, increasing cross-section at two road crossings, construction of a receiving pond in the western end of the Mermentau River, and installing a 750 cfs pump station from the receiving pond to the Gulf to maintain the receiving pond stage at mean low water. The project is fully constructed and operational at Year 5 and is modeled as G626. The project was selected in IP1. The project cost is $59 million and does not vary by scenario as no marsh creation is involved.

Figure 289. Location of features for the CCGHR project.

HYDROLOGY

WATER LEVEL

MERMENTAU BASIN HYDROLOGIC RESTORATION (G630)

The MBHR project leads to a decrease in inundation around Little Chenier Canal as well as the Rockefeller Wildlife Refuge, as shown in Figure 291. A small increase in inundation is also found in the receiving region of the hydrologic restoration project. Water level timeseries at locations shown in Figure 292 confirm this finding. For example, at the upstream end of the Little Chenier Canal, where annual mean water levels decrease up to 15 cm after construction of the project. However, this effect becomes smaller over time. By the end of the 50-year simulation period, annual mean water level reductions remain limited to 5-10 cm for both the lower (S07) and higher (S08) scenarios (Figure 293). In the center of the Rockefeller Wildlife Refuge, annual mean water levels initially decrease up to 8 cm after construction of the project, however, the effect also wanes over time with decreases that remain limited to 2-5 cm in later decades, for both the lower (S07) and higher (S08) scenarios (Figure

294). The project also reduces water level variability by 1-3 cm around Little Chenier Canal and the Rockefeller Wildlife Refuge (Figure 295 and Figure 296).

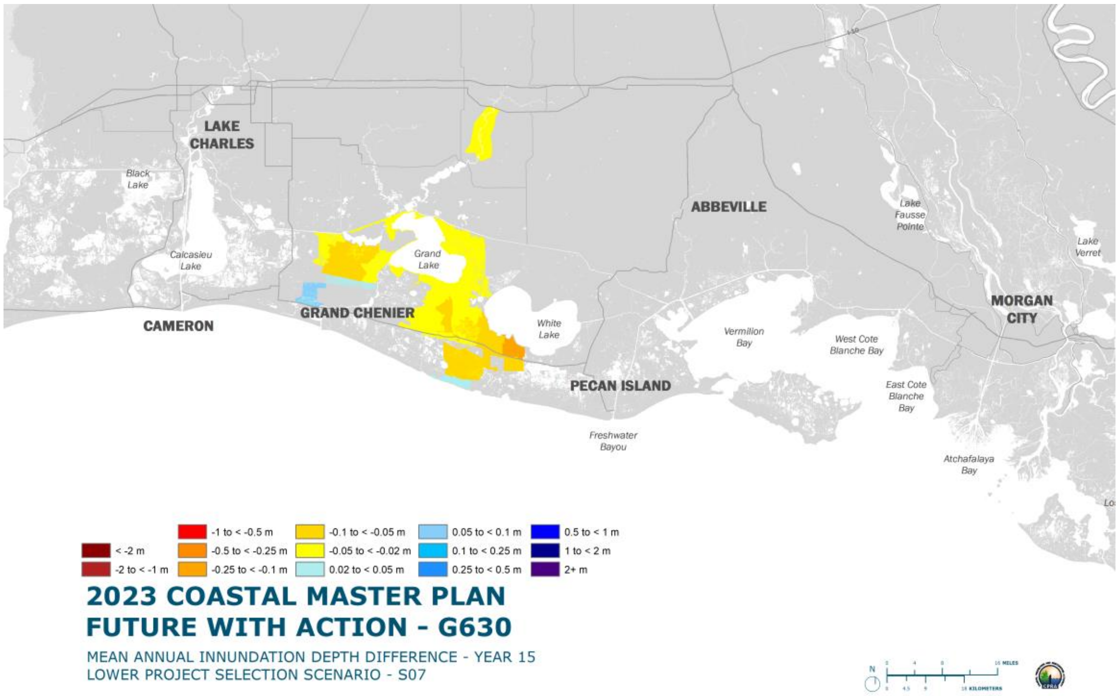


Figure 290. Difference map of mean annual inundation depth between FWOA (G500) and FWA (G630, MBHR) at Year 15 of the lower scenario (S07), indicating a reduction of inundation depths up to 10 cm around Kings Bayou and the Rockefeller Wildlife Refuge. A small increase in inundation is found in the receiving areas of the hydrologic restoration activities. Similar results are found for the higher scenario (S08).

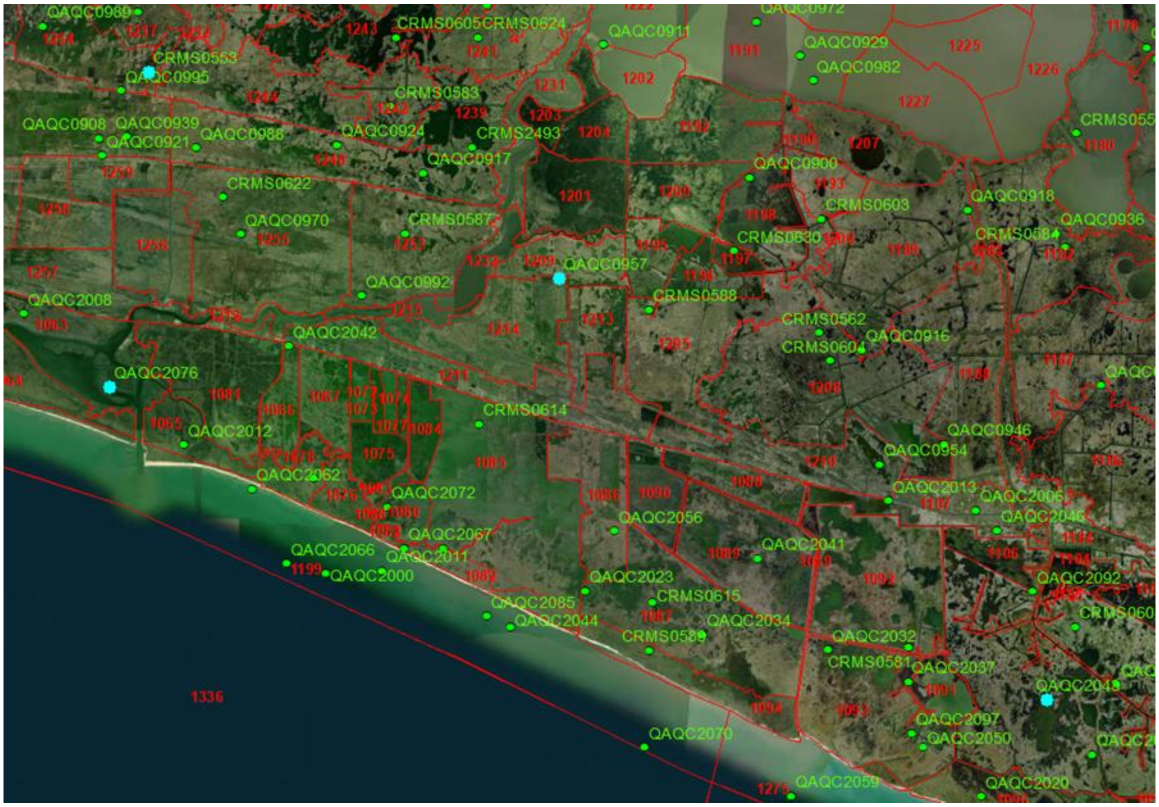


Figure 291. Map indicating timeseries locations in the Mermentau Basin.

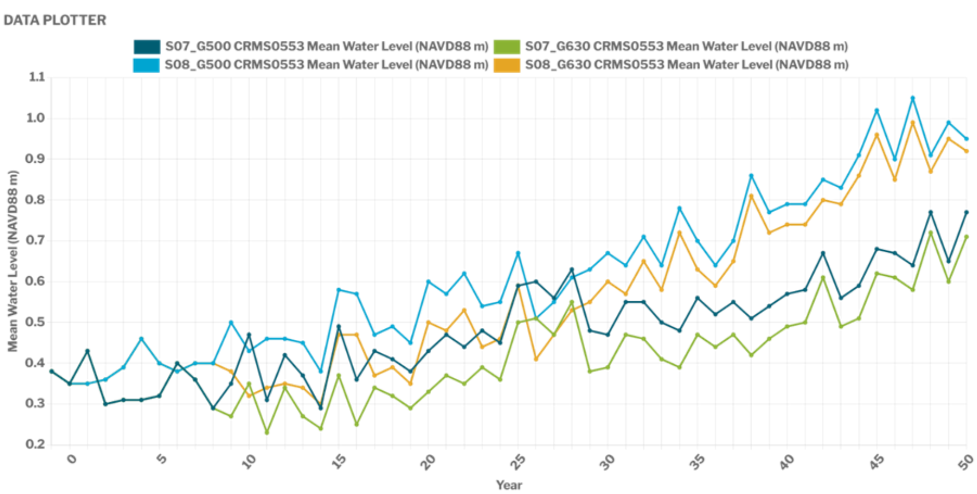


Figure 292. Annual mean water level comparison between FWOA (G500) and FWA (G630, MBHR) for lower (S07) and higher (S08) scenarios in CRMS0553 located upstream of Little Chenier Canal (location indicated in Figure 292). Annual mean water levels initially decrease up to 15 cm after construction of the project; however, the effect wanes over time with decreases that remain limited

to 5-10 cm in later decades, for both the lower (S07) and higher (S08) scenarios.

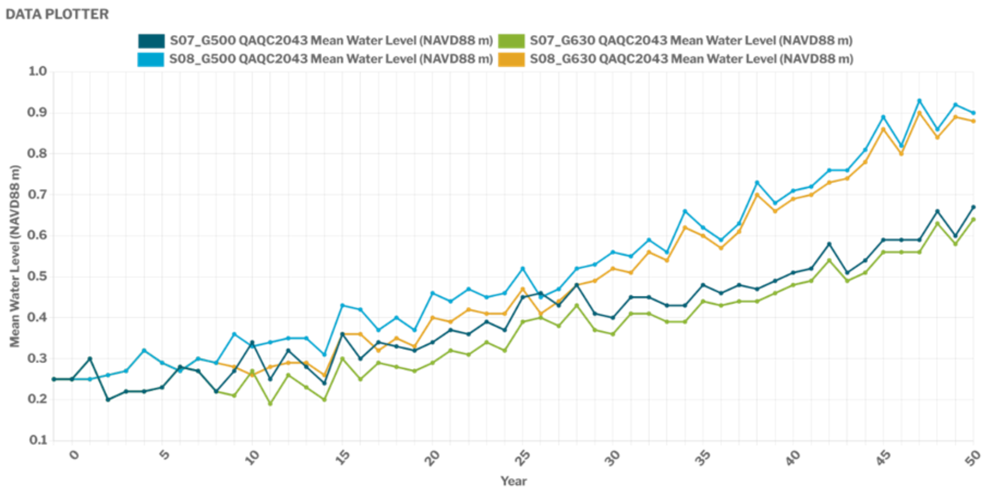


Figure 293. Annual mean water level comparison between FWOA (G500) and FWA (G630, MBHR) for lower (S07) and higher (S08) scenarios in QAQC2043 located in compartment 1095 in the center of the Rockefeller Wildlife Refuge (location indicated in Figure 292). Annual mean water levels initially decrease up to 8 cm after construction of the project; however, the effect wanes over time with decreases that remain limited to 2-5 cm in later decades, for both the lower (S07) and higher (S08) scenarios.

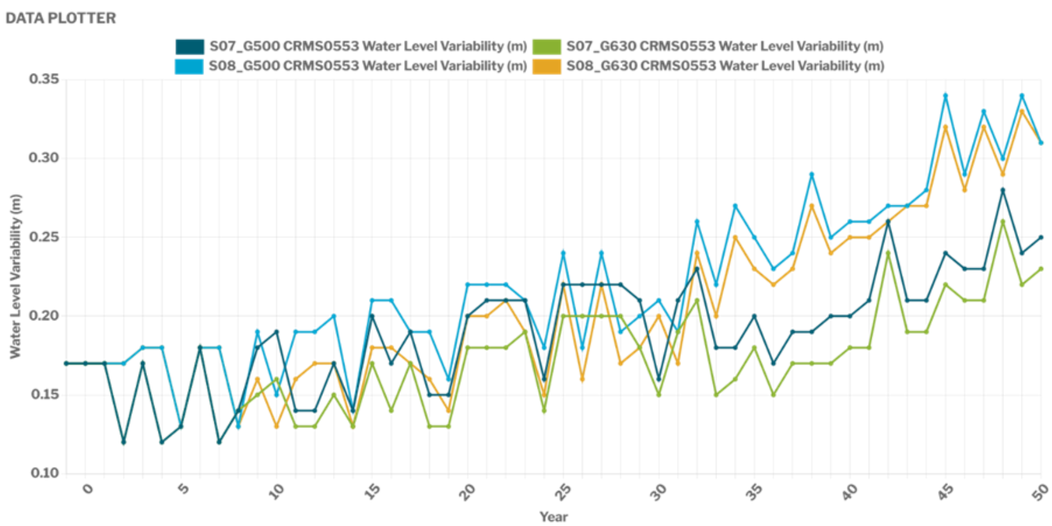


Figure 294. Annual water level variability comparison between FWOA (G500) and FWA (G630, MBHR) for lower (S07) and higher (S08) scenarios in CRMS0553 located upstream of Little Chenier Canal (location indicated in Figure 292). Water level variability decreases between 1 to 3 cm after construction of the project, for both the lower (S07) and higher (S08) scenarios.

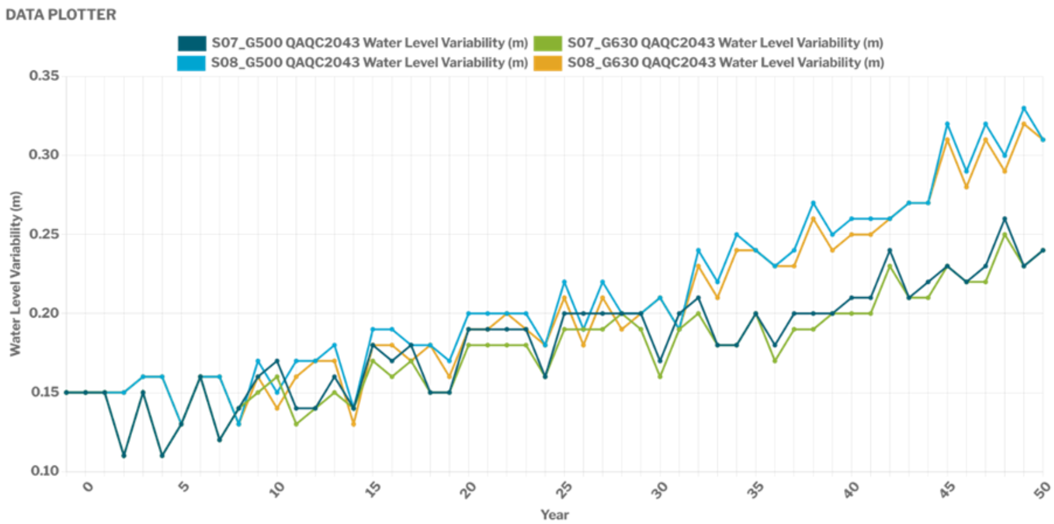


Figure 295. Annual water level variability comparison between FWOA (G500) and FWA (G630, MBHR) for lower (S07) and higher (S08) scenarios in QAQC2043 located in compartment 1095 in the center of the Rockefeller Wildlife Refuge (location indicated in Figure 292). Water level variability decreases up to 1 cm after construction of the project, for both the lower (S07) and higher (S08) scenarios.

CAMERON-CREOLE TO THE GULF HYDROLOGIC RESTORATION (G626)

Annual mean water levels are significantly reduced around Creole Canal as a result of the CCGHR project, as shown in Figure 297. Water level timeseries at the locations indicated in Figure 298 show a reduction of annual mean water levels up to 60 cm at the upstream and downstream ends of Creole Canal (Figure 299 and Figure 300). Because a pump is modeled at the Lower Mud Lake to maintain the stage in the receiving pond, water level in the project region responds slower to SLR when compared to the FWOA condition, resulting in a higher reduction over time. This applies for the entire simulation period of both scenarios, except for the final decade of the higher (S08) scenario where the project is unsuccessful in draining the canal due to increasing access to the Gulf. The project also reduces water level variability around the Creole Canal at a rate of several cm initially increasing up to 20 cm in later decades (Figure 301 and Figure 302).

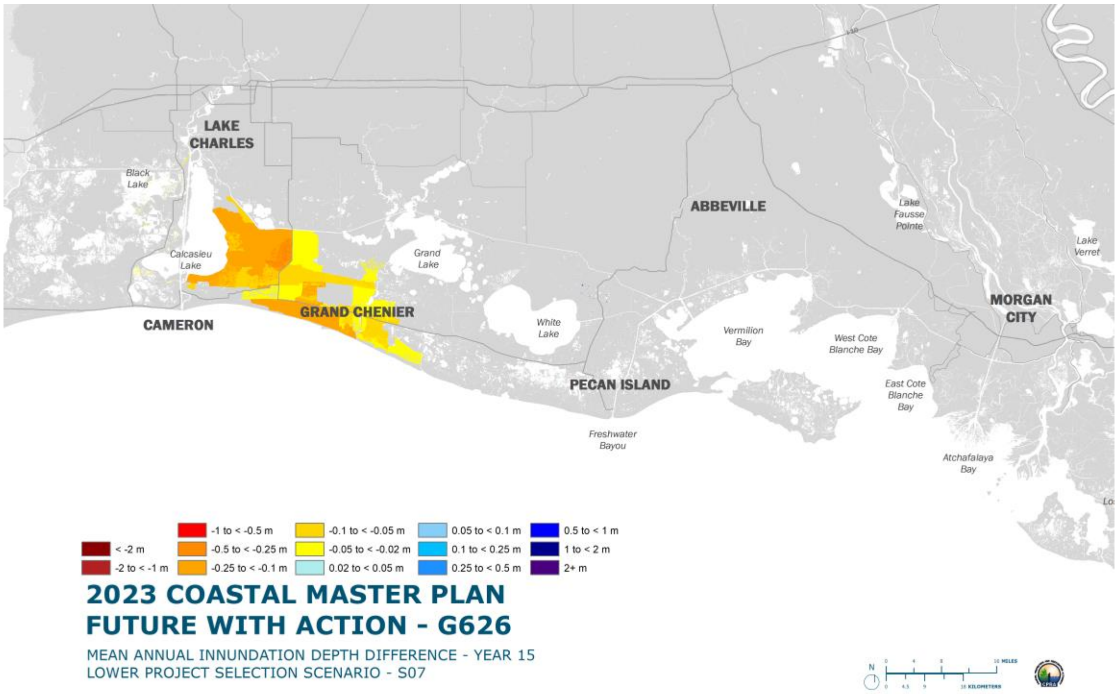


Figure 296. Difference map of mean annual inundation depth between FWOA (G500) and FWA (G626, CCGHR) at Year 15 of the lower scenario (S07), indicating a reduction of inundation depths up to 25 cm around the Creole Canal. Similar results are found in later years and for the higher scenario (S08).

Figure 297. Map indicating timeseries locations in the Cameron-Creole Watershed.

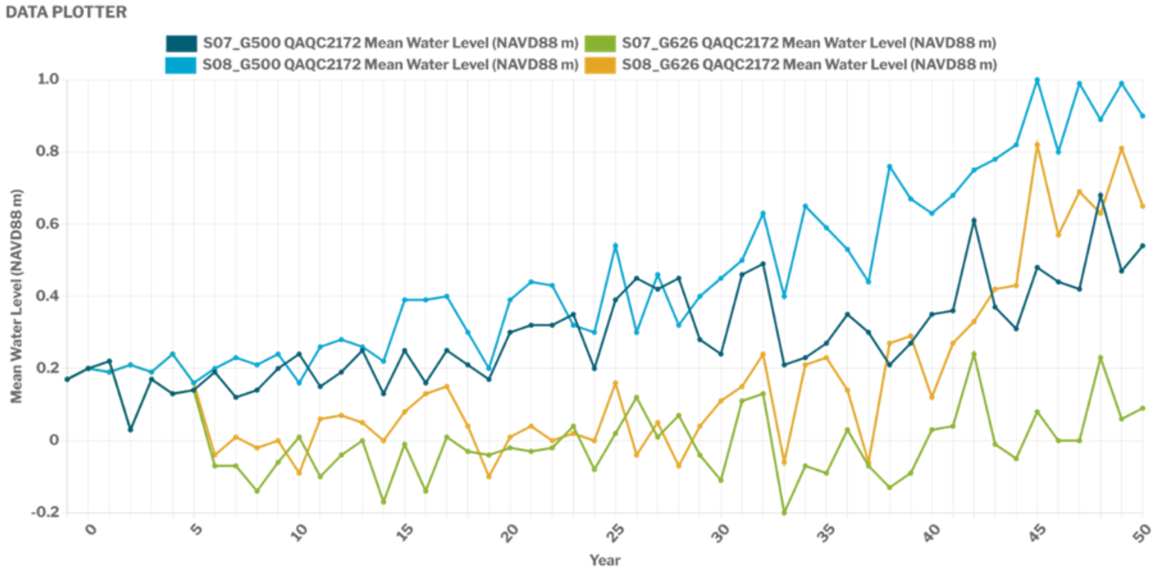


Figure 298. Annual mean water level comparison between FWOA (G500) and FWA (G626, CCGHR) for lower (S07) and higher (S08) scenarios in QAQC2172 located in compartment 1034 at the upstream side of Creole Canal (Figure 298). Annual mean water levels decrease between 20-50 cm after construction of the project. These effects remain similar over time for both scenarios, except for the final decade of the higher (S08) scenario where the project appears to be unsuccessful in draining the area.

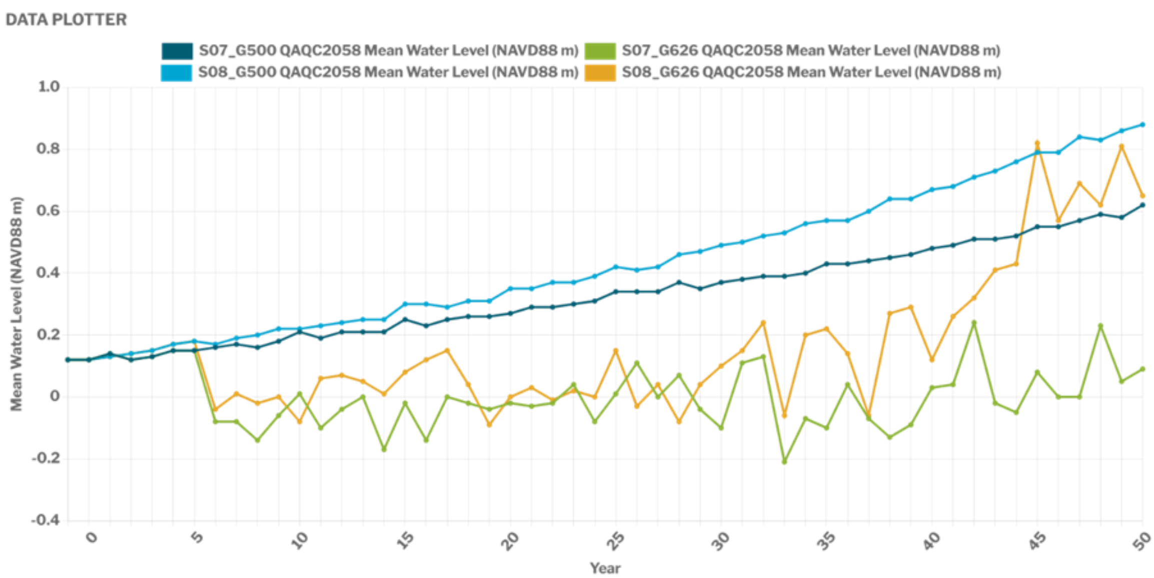


Figure 299. Annual mean water level comparison between FWOA (G500) and FWA (G626, CCGHR) for lower (S07) and higher (S08) scenarios in QAQC2058 located in compartment 1063 at the downstream end of Creole Canal (Figure

298). Annual mean water levels decrease by about 30 cm initially and up to 60 cm in the later decades, except for the final decade of the higher (S08) scenario where the project appears to be unsuccessful in draining the area.

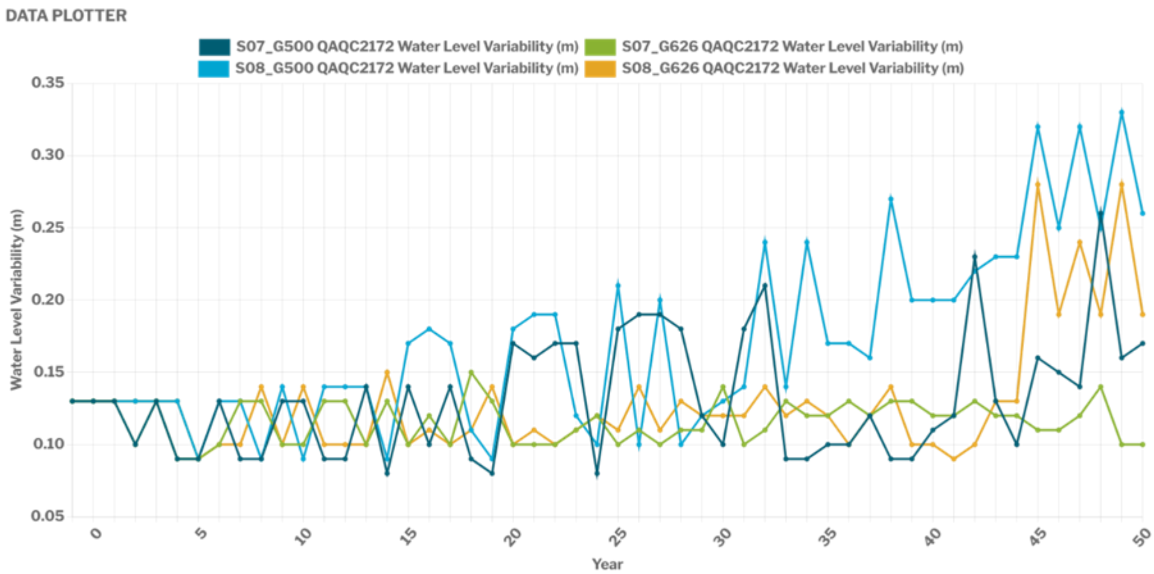


Figure 300. Annual water level variability comparison between FWOA (G500) and FWA (G626, Cameron-Creole to the Gulf Hydrologic Restoration) for lower (S07) and higher (S08) scenarios in QAQC2172 located in compartment 1034 at the upstream side of Creole Canal (Figure 298). Water level variability is typically lower after construction of the project and shows less interannual variation, except for the final decade of the higher (S08) scenario where the project appears to be unsuccessful in draining the area.

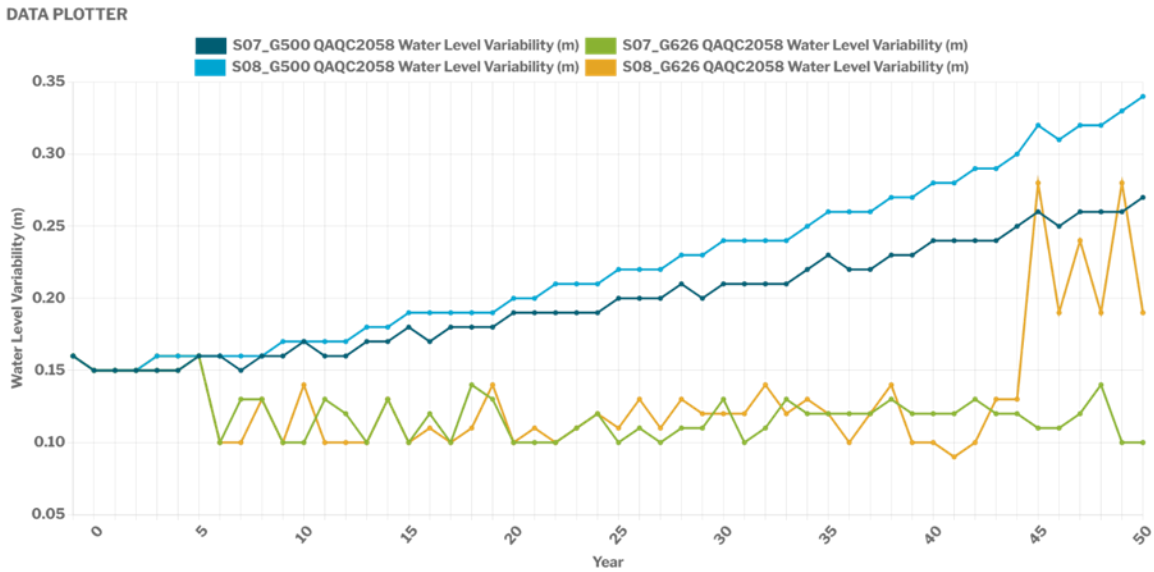


Figure 301. Annual water level variability comparison between FWOA (G500) and FWA (G626, CCGHR) for lower (S07) and higher (S08) scenarios in QAQC2058 located in compartment 1063 in at the downstream end of Creole Canal (Figure 298). Water level variability is reduced increasingly over time after construction of the project, except for the final decade of the higher (S08) scenario where the project appears to be unsuccessful in draining the area.

The effects of the project are not only noticeable in the Creole Canal but also in the surrounding area, as shown in Figure 303 for a more distant location at more than 10 km from Creole Canal where annual mean water levels are reduced by up to 5 cm. Water level variability only changes slightly in this area with increases up to 2 cm (Figure 304).

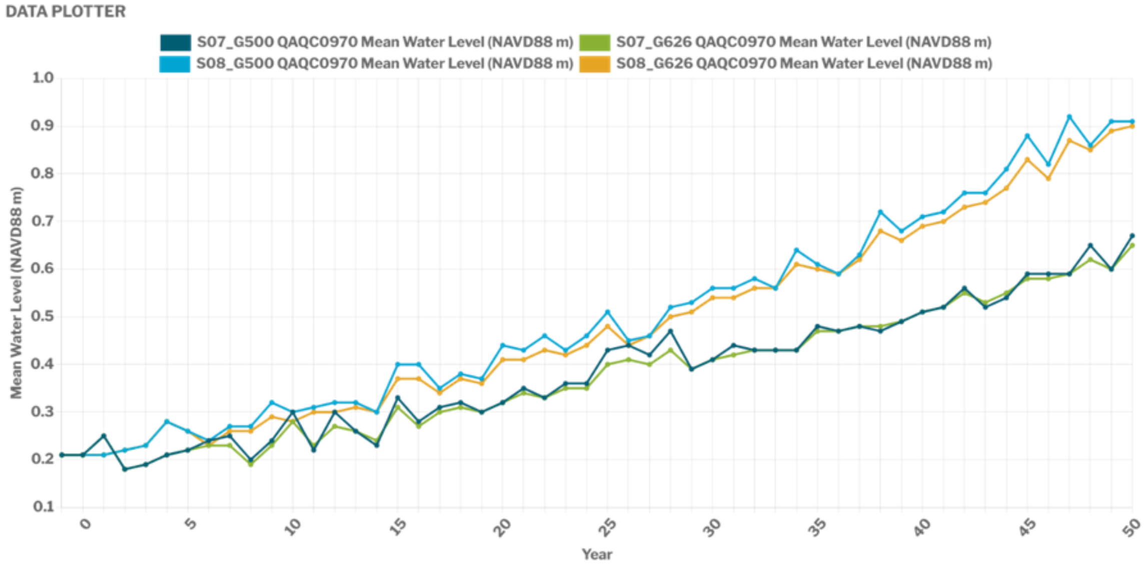


Figure 302. Annual mean water level comparison between FWOA (G500) and FWA (G626, CCGHR) for lower (S07) and higher (S08) scenarios in QAQC0970 located in compartment 1255 east of the Creole Canal and north of the Mermentau River (Figure 298). Annual mean water levels decrease up to 5 cm after construction of the project. These effects remain similar over time for both scenarios.

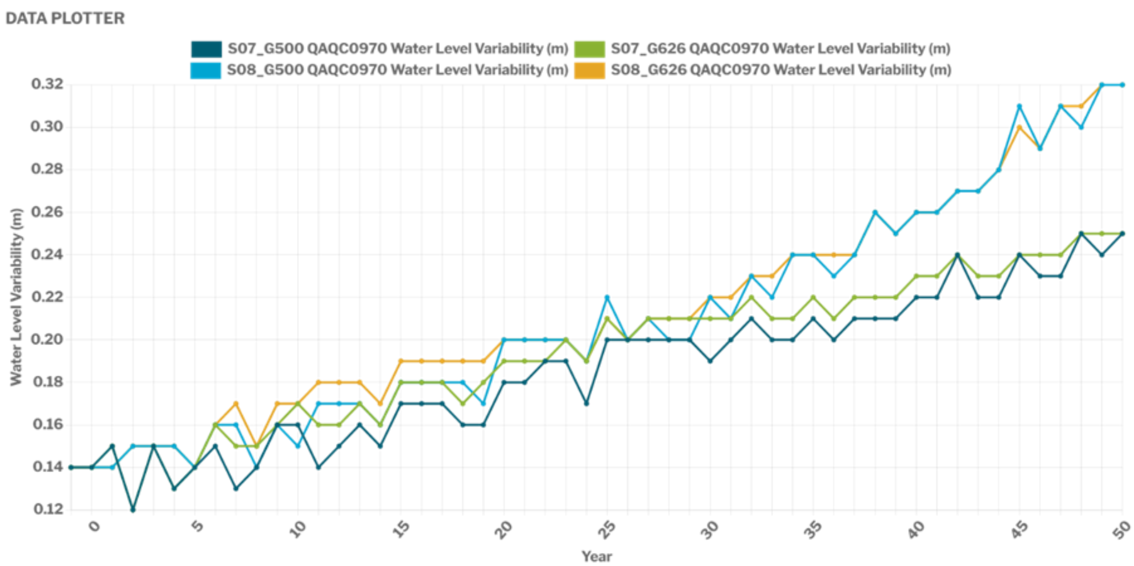


Figure 303. Annual water level variability comparison between FWOA (G500) and FWA (G626, CCGHR) for lower (S07) and higher (S08) scenarios in QAQC0970 located in compartment 1255 east of the Creole Canal and north of the Mermentau River (Figure 298). Water level variability increases slightly (up to 2 cm) after construction of the project.

SALINITY

MERMENTAU BASIN HYDROLOGIC RESTORATION (G630)

The MBHR project changes local salinity patterns around the project sites as shown in Figure 305 and Figure 306, which also indicate that differences become larger over time. Salinities are decreased in areas near the project that are located between the Gulf and Highway 82, possibly due to more available freshwater due to enhanced up-basin drainage. The salinity in the open water area around Lower Mud Lake, located downstream of Little Chenier Canal, is barely affected by the project (Figure 307).

In contrast, Figure 305 and Figure 306 show increased salinity because of the project in areas north of Highway 82, indicating higher rates of saltwater intrusion resulting from the project. Higher salinities are found in the area east of the Mermentau River and north of Highway 82, where salinity increases up to 2 ppt as shown in Figure 308. Similar results were found for the Rockefeller Wildlife Refuge (Figure 309). For both locations, salinity concentrations are more affected in the second half of the 50-year simulation period, and differences are more noticeable for the higher (S08) scenario compared to the lower (S07) scenario. The project includes dredging of King's Bayou with one-way culverts added to allow flow across the Highway 82. Freshwater is drained from the north to the south. However, some salt water intruded from the Vermilion Bay is drawn west to the area and causes an increase in salinity when compared to FWOA.

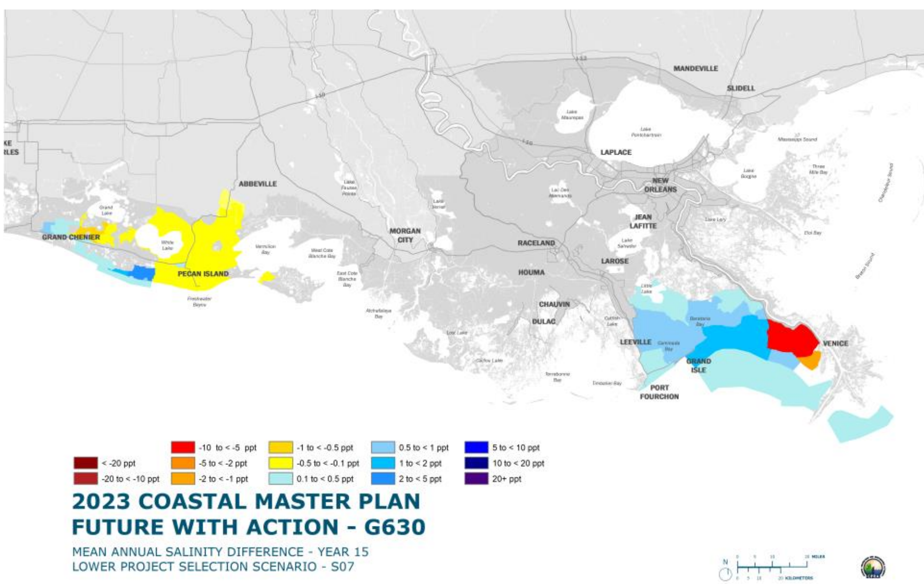


Figure 304. Difference map of mean annual salinity between FWOA (G500) and FWA (G630, MBHR) at Year 15 of the lower scenario (S07), indicating a reduction of salinity up to 5 ppt in parts of the Mermentau Basin near the coastline, along with a small increase of salinity up to 1 ppt in more upland parts of the basin. Similar results are found for the higher scenario (S08).

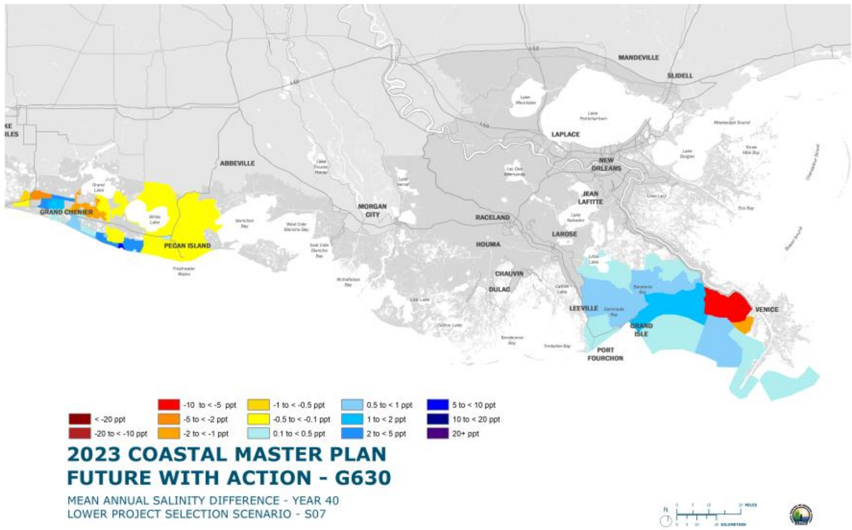


Figure 305. Difference map of mean annual salinity between FWOA (G500) and FWA (G630, MBHR) at Year 40 of the lower scenario (S07), indicating similar patterns as found for Year 15 (Figure 305), albeit more pronounced with a reduction of salinity up to 10 ppt in parts of the Mermentau Basin near the coastline, along with an increase of salinity up to 5 ppt in more upland parts of the basin. Similar results are found for the higher scenario (S08).

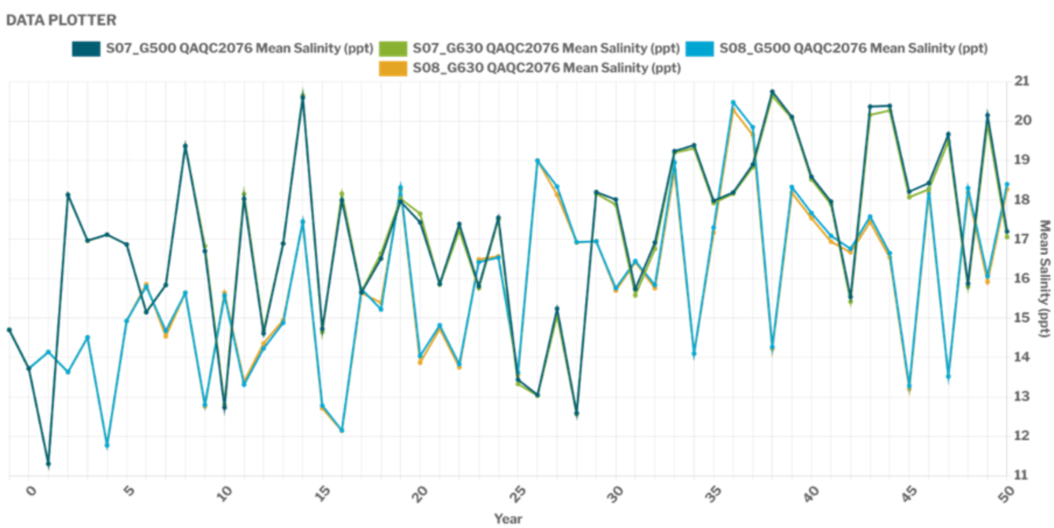


Figure 306. Annual mean salinity comparison between FWOA (G500) and FWA (G630, Mermentau Basin Hydrologic Restoration) for lower (S07) and higher (S08) scenarios in QAQC2076 located in compartment 1063 in Lower Mud Lake (downstream of Little Chenier Canal, location indicated in Figure 292). The project does not or barely (<1 ppt) affect annual mean salinity at this location as well as other locations along Little Chenier Canal, for both the lower (S07) and higher (S08) scenarios.

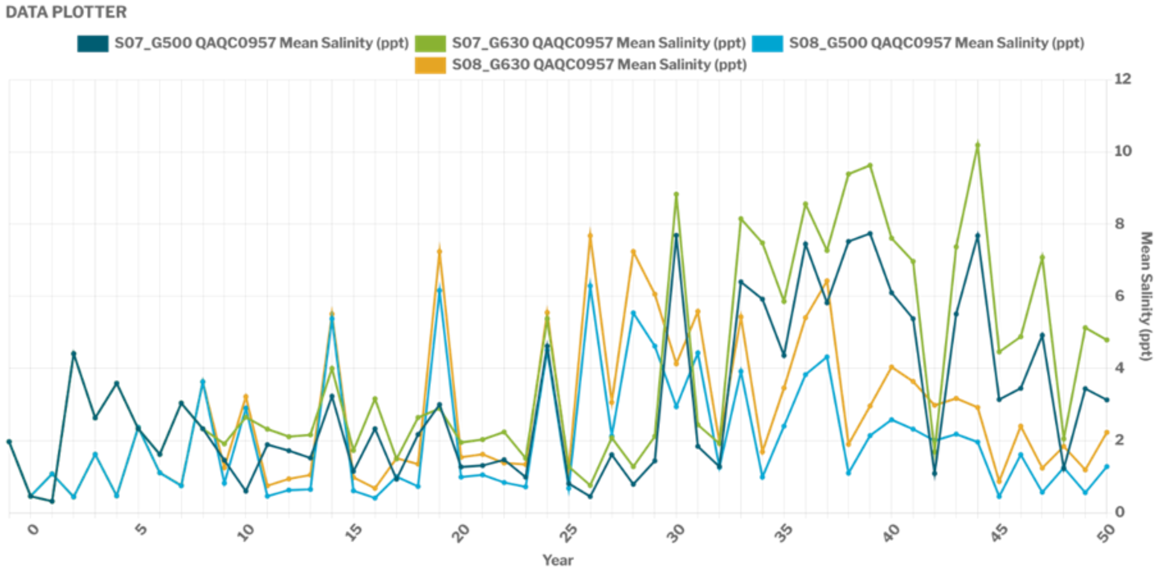


Figure 307. Annual mean salinity comparison between FWOA (G500) and FWA (G630, MBHR) for lower (S07) and higher (S08) scenarios in QAQC0957 located in compartment 1214 east of the Mermentau River and north of Highway 82 (location indicated in Figure 292). Annual mean salinity concentrations increase after construction of the project at a minor rate (<1 ppt) in the first 25 years and a somewhat larger rate (up to 2 ppt) in the second 25 years when concentrations are higher overall.

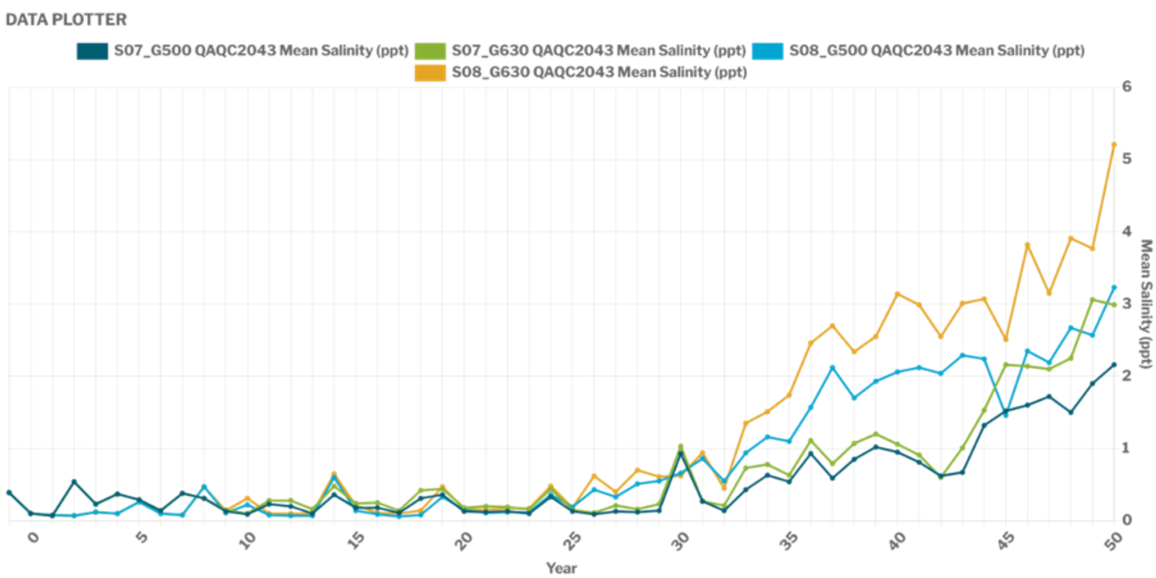


Figure 308. Annual mean salinity comparison between FWOA (G500) and FWA (G630, Mermentau Basin Hydrologic Restoration) for lower (S07) and higher (S08) scenarios in QAQC2043 located in compartment 1095 in the center of the

Rockefeller Wildlife Refuge (location indicated in Figure 292). Annual mean salinity concentrations remain close to 0 ppt in the first 25 years for both FWOA and FWA and both the lower (S07) and higher (S08) scenarios. However, concentrations start to increase in the following 25 years, with FWA concentrations being up to 2 ppt higher compared to FWOA concentrations during this timeframe.

CAMERON-CREOLE TO THE GULF HYDROLOGIC RESTORATION (G626)

Annual mean salinity changes are very substantial around the Creole Canal because of the CCGHR project, with local changes that amount up to 20 ppt as indicated in Figure 310 and Figure 311. Salinity increases at the upstream side of Creole Canal as indicated in Figure 312, especially for the second half of the 50-year simulation period, and more noticeably for the higher (S08) scenario compared to the lower (S07) scenario. This could be due to salinity intrusion resulting from enhanced hydraulic connectivity through the Creole Canal. The opposite is observed at the downstream end of the Creole Canal, where salinity is reduced to near-0 ppt concentrations, as indicated in Figure 313. This reduction remains consistent over time for both the lower (S07) and higher (S08) scenarios.

The project also affects salinity farther away from the project as shown in Figure 314 for a location more than 10 km east of the Creole Canal, where annual mean salinity concentrations increase by 2-6 ppt after construction of the project, possibly because previously available freshwater is now instead drained through the Creole Canal. This increase remains consistent over time for both the lower (S07) and higher (S08) scenarios.

The drainage capacity of Creole Canal was increased by the project, and a one-way culvert added to allow more water flow from the marsh west of the canal to the Gulf. As more freshwater was delivered directly through the canal to the Gulf, less freshwater is available to dilute salinity intrusion from the Mermentau River and Mud Lake. At the same time, because the water in the Cameron Creole marsh is draining into the canal, more salt water from the Calcasieu Lake moves into the Cameron Creole marsh through the lake rim.

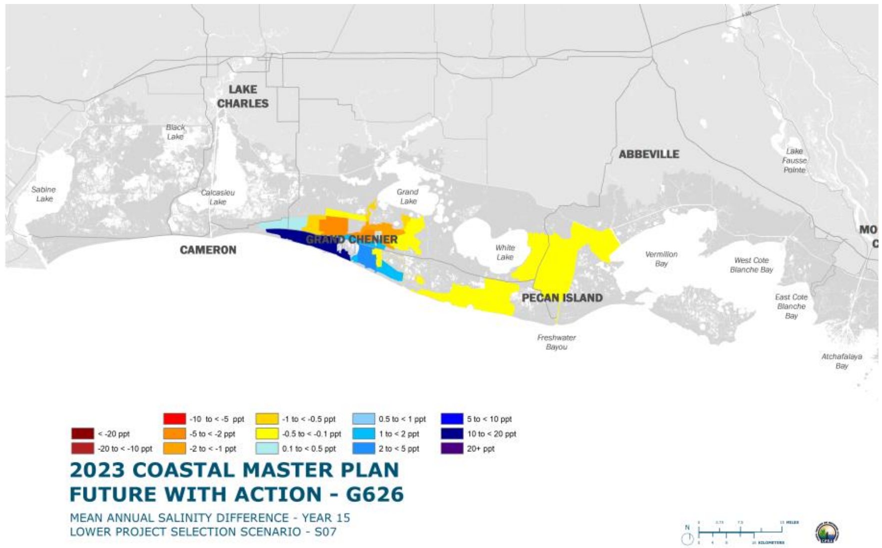


Figure 309. Difference map of mean annual salinity between FWOA (G500) and FWA (G626, CCGHR) at Year 15 of the lower scenario (S07), indicating a reduction of salinity up to 20 ppt in areas near the coastline of the eastern Cameron-Creole Watershed and western Mermentau Basin, along with salinity increases up to 5 ppt mostly concentrated in the area east of the Creole Canal. Similar results are found for the higher scenario (S08).

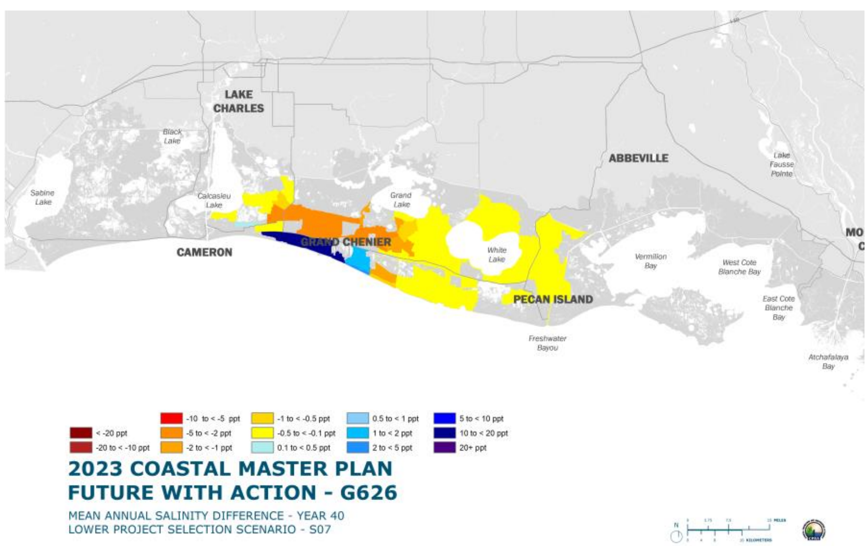


Figure 310. Difference map of mean annual salinity between FWOA (G500) and FWA (G626, CCGHR) at Year 40 of the lower scenario (S07), indicating similar patterns as found for Year 15 (Figure 310), albeit more extensive with salinity differences found in larger parts of the region. Salinity differences extend even further for the higher scenario (S08), mostly in westward direction.

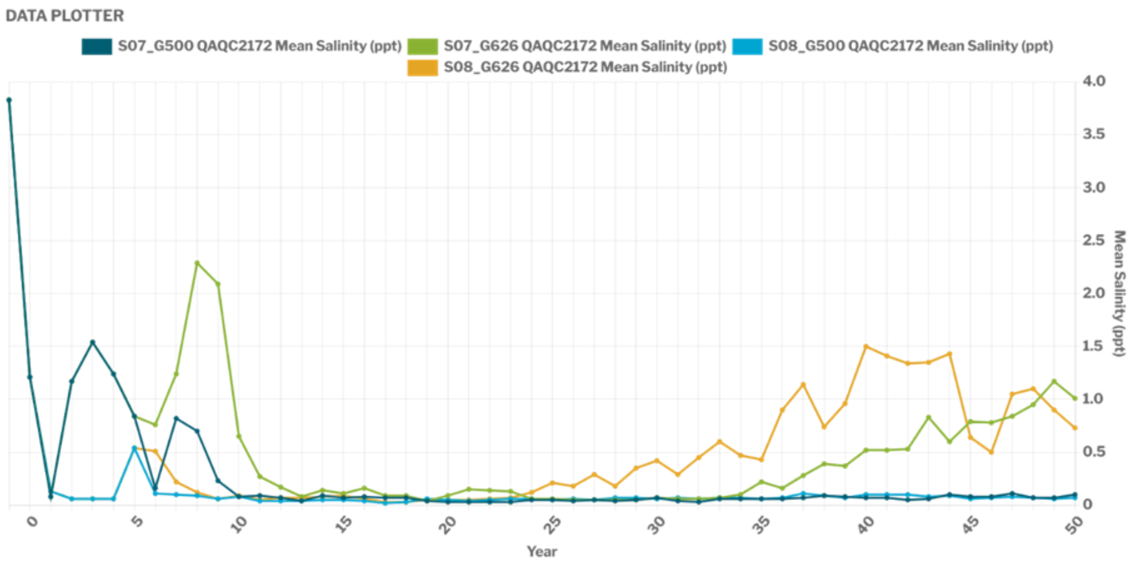


Figure 311. Annual mean salinity comparison between FWOA (G500) and FWA (G626, CCGHR) for lower (S07) and higher (S08) scenarios in QAQC2172 located in compartment 1034 at the upstream side of Creole Canal (Figure 298). Mean salinity increases by up to 2 ppt in the period after construction and in the final decades.

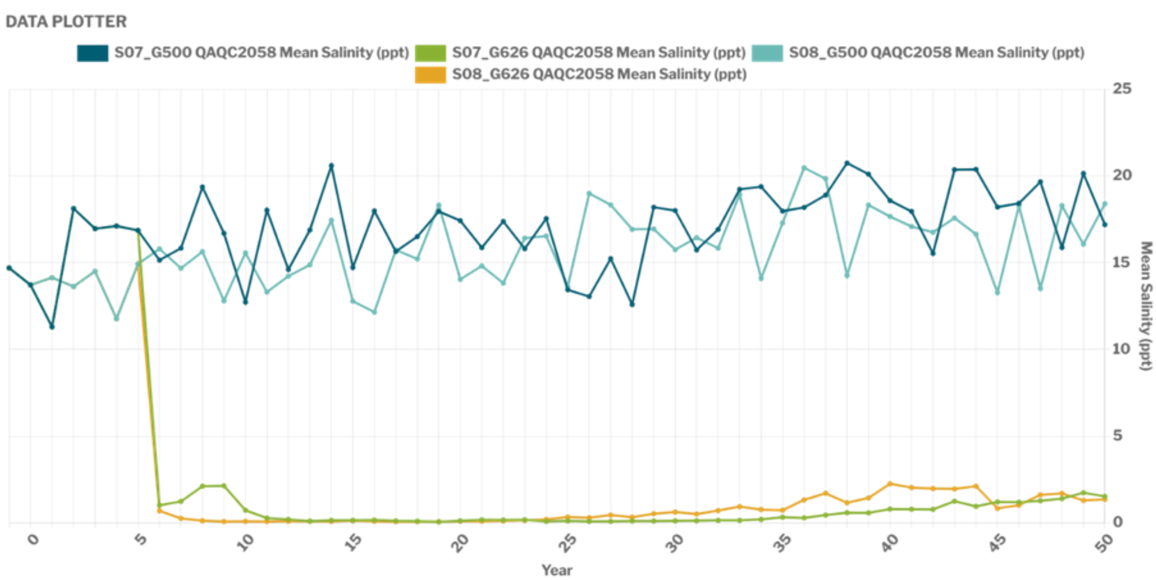


Figure 312. Annual mean salinity comparison between FWOA (G500) and FWA (G626, CCGHR) for lower (S07) and higher (S08) scenarios in QAQC2058 located in compartment 1063 at the downstream end of Creole Canal (Figure 298). Mean salinity is lowered substantially in FWA. After construction of the project, salinity is reduced to concentrations lower than 2 ppt, whereas FWOA concentrations remain in the range of 15-20 ppt.

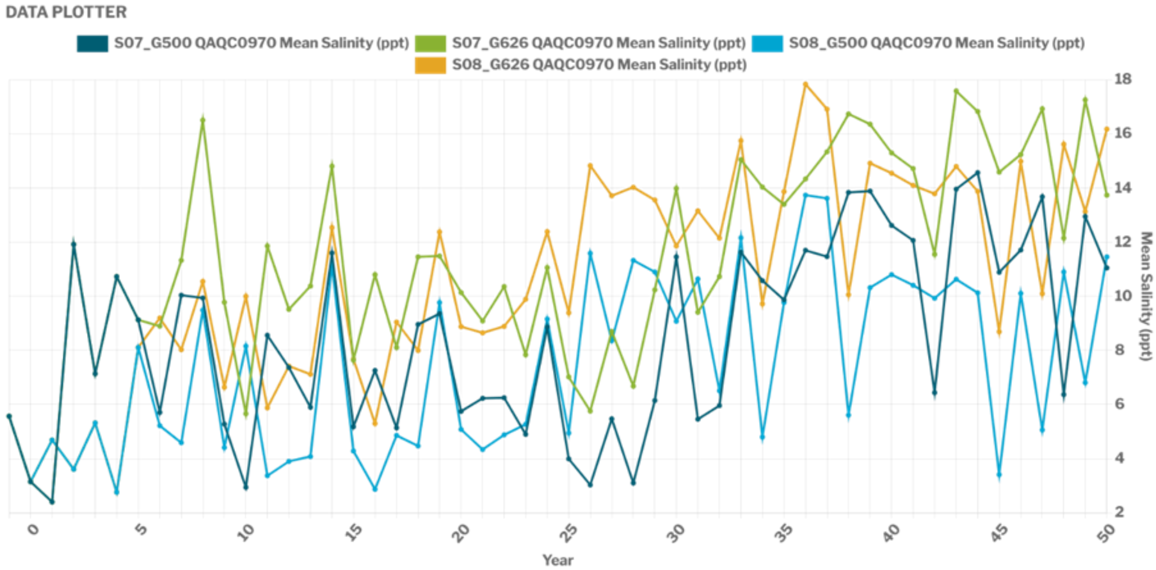


Figure 313. Annual mean salinity comparison between FWOA (G500) and FWA (G626, CCGHR) for lower (S07) and higher (S08) scenarios in QAQC0970 located in compartment 1255 east of the Creole Canal and north of the Mermentau River (Figure 298). Mean salinity increases by 2-6 ppt after construction of the project. These effects remain similar over time for both scenarios.

MORPHOLOGY

The AAL values are positive for the lower and higher scenarios for both projects, CCGHR and MBHR. Net land at Year 50 values are positive for both scenarios for CCGHR and the higher scenario of MBHR, meaning more land was retained compared to FWOA (Table 13 and Figure 315). These projects are similar, as they focus on controlling the hydrology and lowering water levels.

Table 15. Net effect of the projects (FWA-FWOA) by scenario in terms of AAL and net land at Year 50

	Average Annual Net Land (km^2)		Net Land at Year 50 (km^2)	
Scenario	Lower	Higher	Lower	Higher
Cameron-Creole to the Gulf Hydrologic Restoration	30.5	59.2	58.5	82.7
Mermentau Basin Hydrologic Restoration	4.0	15.7	-0.5	6.4

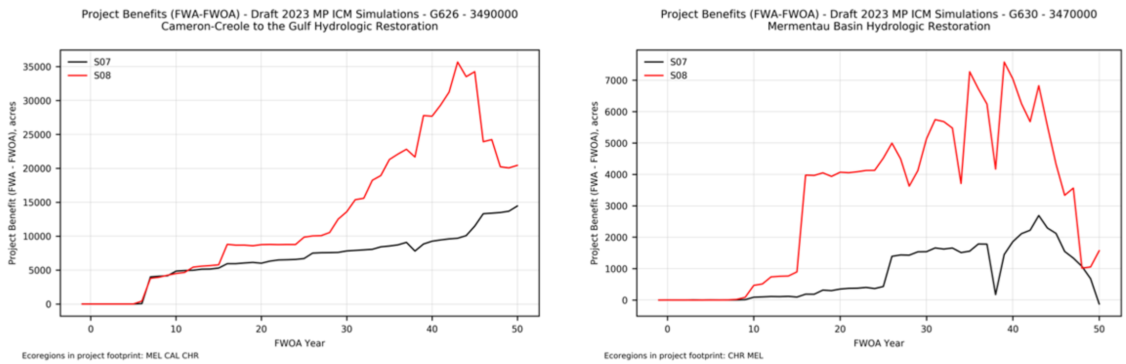


Figure 314. Net land area benefits (FWA-FWOA) for the Cameron Creole to the Gulf Hydrologic restoration project (left) and the MBHR project (right).

CCGHR has a substantial impact across the Mermentau Basin by maintaining water levels in the Creole Canal around mean low water. By lowering the water level, less land is lost to inundation stress. In the western portion of Chenier Ridges (CHR), QAQC2058 is an example of how a decrease in inundation leads to land maintenance (Figure 316). This location converts to water in Year 9 and 14 in FWOA for the lower and higher scenario, respectively, and in Year 43 for the higher scenario with the project. It is maintained as land in the lower scenario with the project. Water level decreases and area of land maintained are substantial in CHR. The eastern portion of Calcasieu (CAL) and western portion of Mermentau/Lakes (MEL) also benefit, although to a lesser degree. The project does not significantly alter accretion, except that by maintaining land it maintains organic accretion. Mineral accretion is not significant in this area.

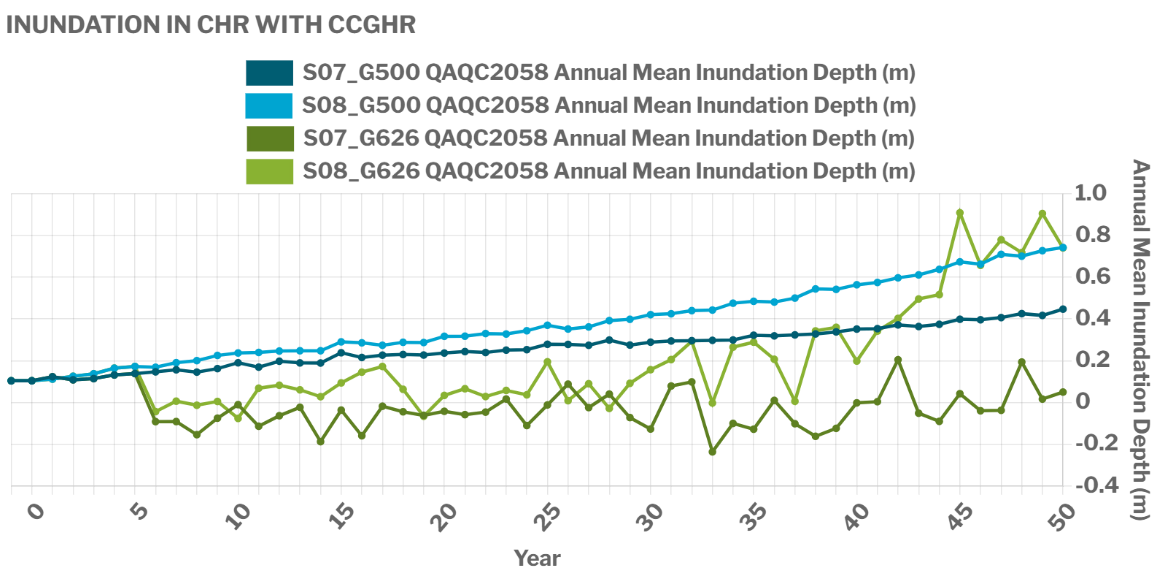


Figure 315. Mean annual inundation at QAQC2058 (lower Creole Canal) for FWOA and the CCGHR project for the lower and higher scenarios.

MBHR creates a smaller difference in the water level, and therefore, has a smaller impact on land maintained. As shown in Figure 317, the scenario is more important in determining the water level, and the presence of the project causes about a 10 cm reduction in inundation. For the higher scenario, this reduction is enough to delay the conversion to water by two years, from Year 39 in FWOA to Year 41 with the project. In the lower scenario, this point is maintained as land.

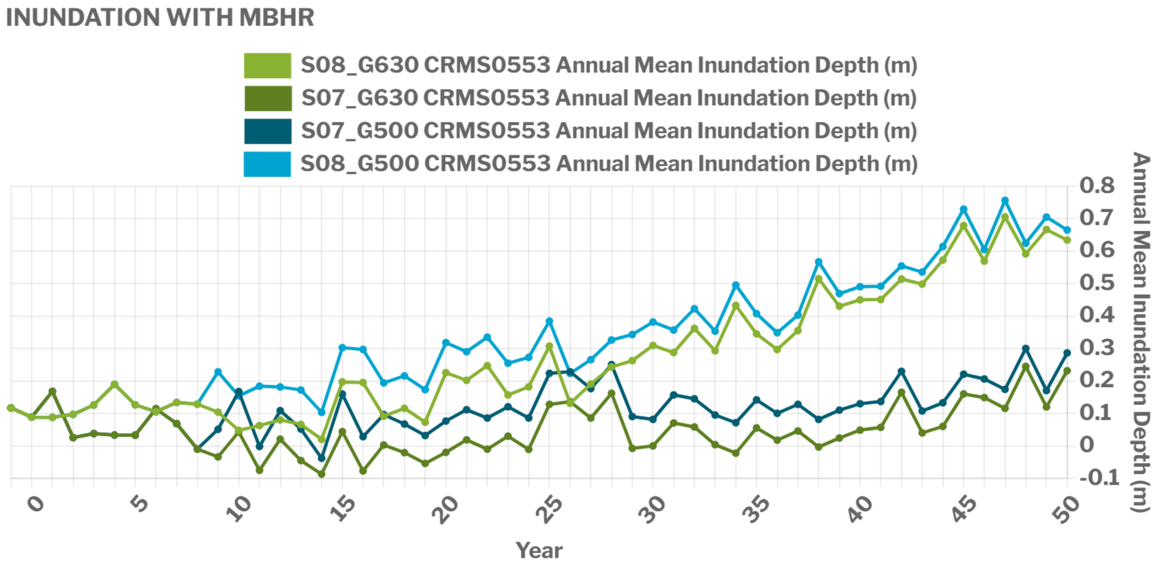


Figure 316. Mean annual inundation at CRMS0553 (north of Highway 1143) for FWOA and the MBHR project for the lower and higher scenarios.

Due to the positive project performances, both of these projects were selected for inclusion in FWIP1. Other projects included in this region are marsh creation projects (e.g., South Grand Chenier, Calcasieu Ship Channel, and East Calcasieu Lake marsh creations), whose benefit is large but generally confined to the project footprints and have less interaction with MBHR and CCGHR (Figure 318).

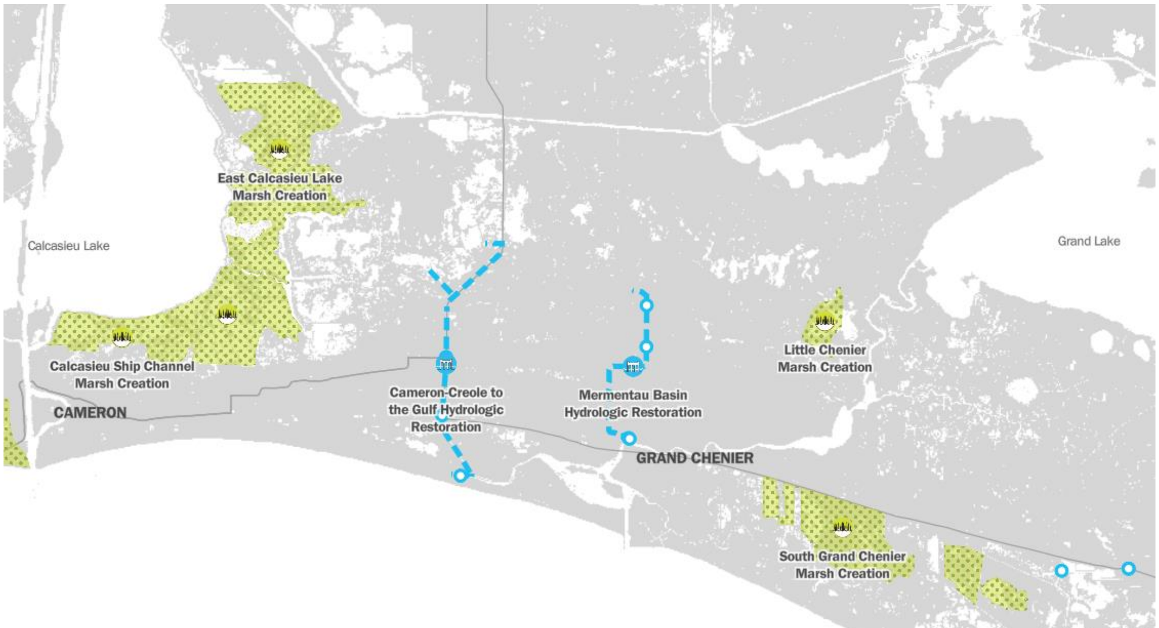


Figure 317. Projects included in IP1 and modeled in FWIP1 for the central Chenier Plain.

The interaction of the projects only leads to small changes in inundation (Figure 319), and land change patterns largely hold (Figure 320 a, b, c).

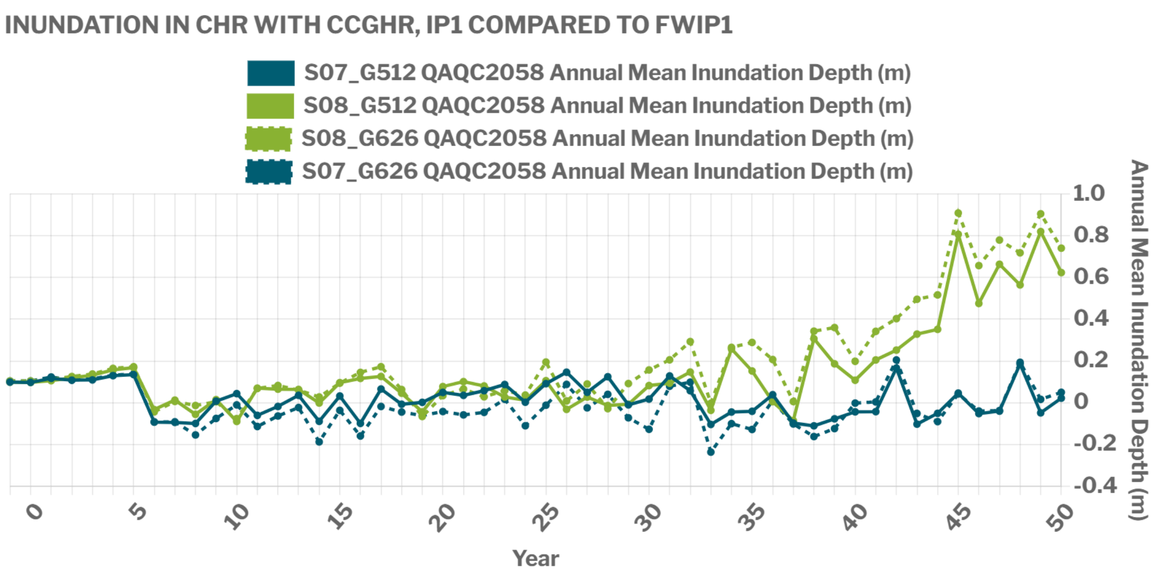


Figure 318. Comparison of mean annual inundation for the CCGHR project in isolation (G626) and FWIP1 for the lower and higher scenarios.

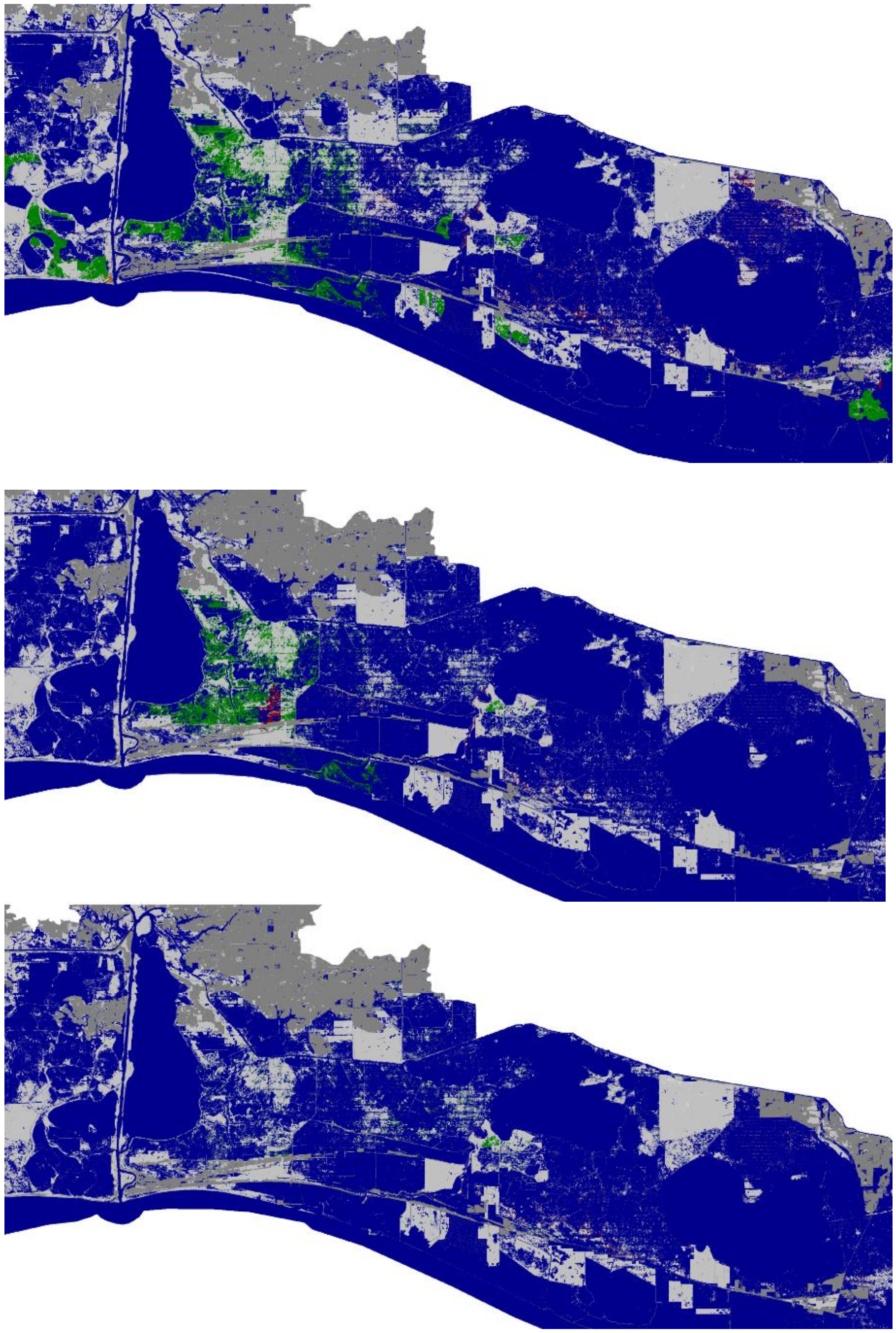


Figure 319. Land change maps for Year 50 for the high scenario for A: FWIP1, B: the Cameron Creole to the Gulf Hydrologic Restoration project, and C: the MBHR project.

VEGETATION

The MBHR has minimal effects on species composition in the MEL ecoregion when compared to FWOA. However, in the CHR ecoregion the MBHR decreases the cover of SPAL and increases cover of DISP and JURO compared to FWOA (Figure 231). These changes in species cover due to MBHR are mostly located closer to the coast as illustrated with CRMS0610 (Figure 322). These vegetation changes move these areas from saline marsh towards brackish marsh. Changes in vegetation cover due to the CCGHR are even more pronounced, with SPAL decreasing and TYDO increasing. These effects are most pronounced in the western part of the CHR and are represented by QAQC2058 (Figure 323). At QAQC2058, the implementation of CCGHR leads to conversion from saline marsh to intermediate marsh in Year 6 and land gain in Year 8, while in FWOA the marsh remains saline and loses land. Under the lower scenario, the intermediate marsh is dominated by TYDO with POPU5 as the most common other species. Under the higher scenario, the marsh changes from SPAL dominated to a mixture of TYDO, POPU5, and COES up to Year 40, when land decreases due to inundation and the remaining marsh is dominated by TYDO.

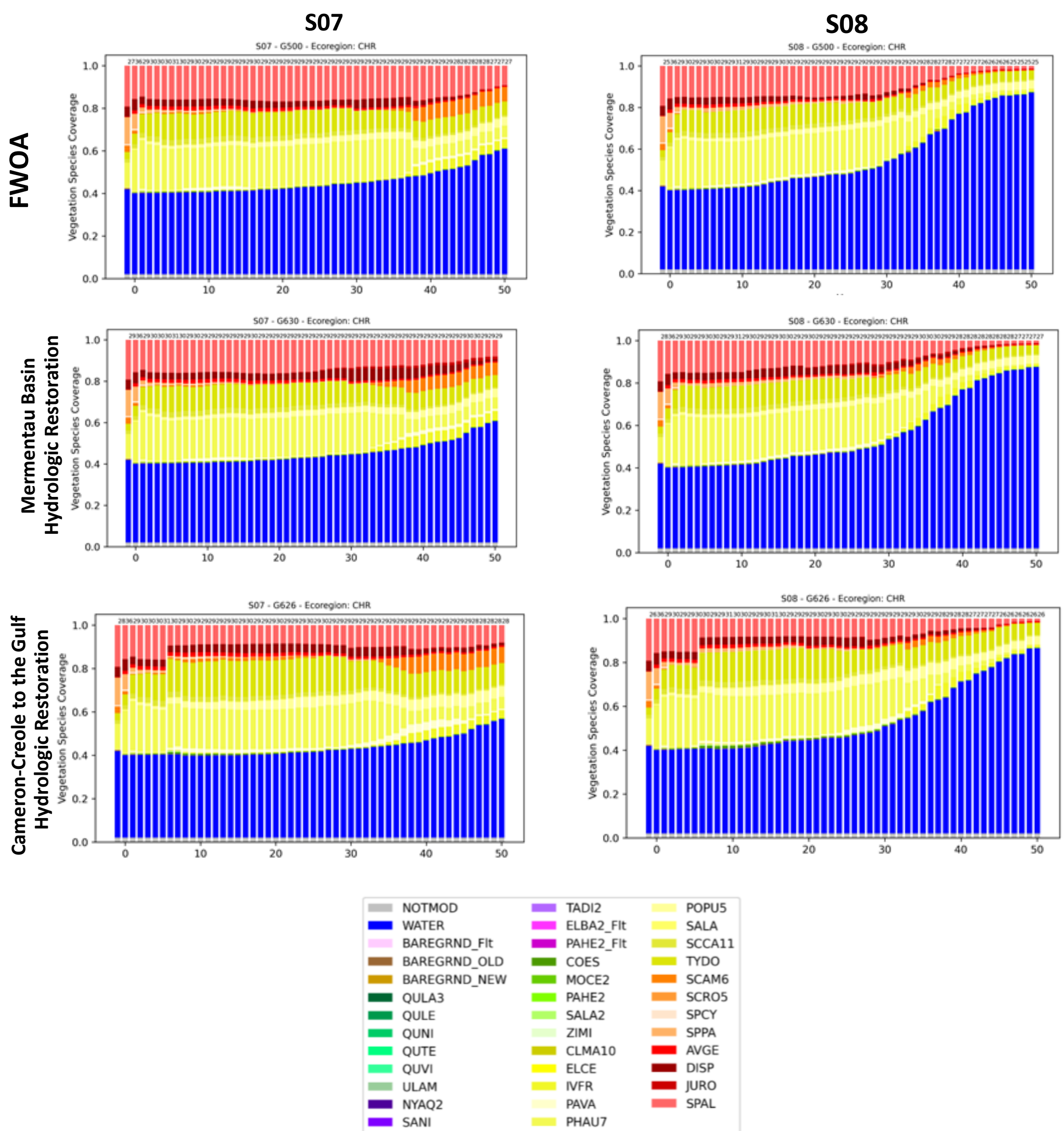


Figure 320. Changes in species cover in the CHR ecoregion are shown without and with the hydrologic restoration projects under two different scenarios.

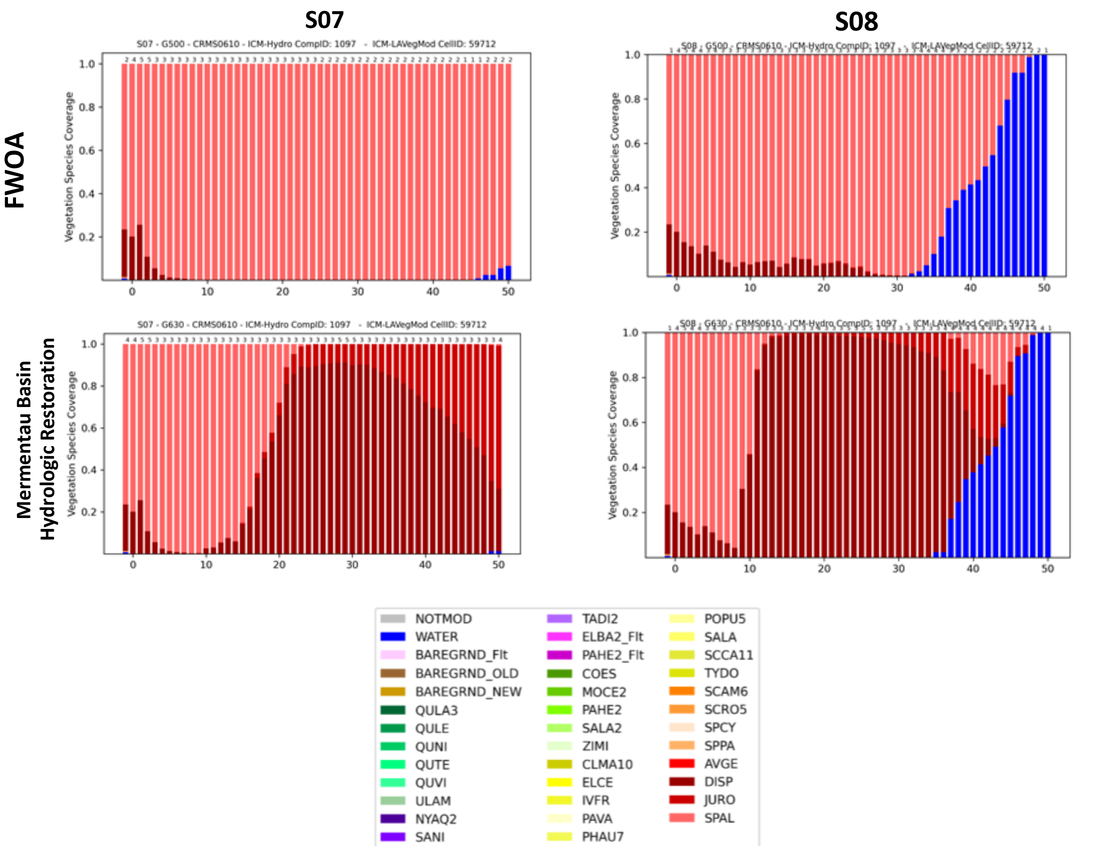


Figure 321. Changes in species cover at CRMS0610 are shown with and without the MBHR under two different scenarios.

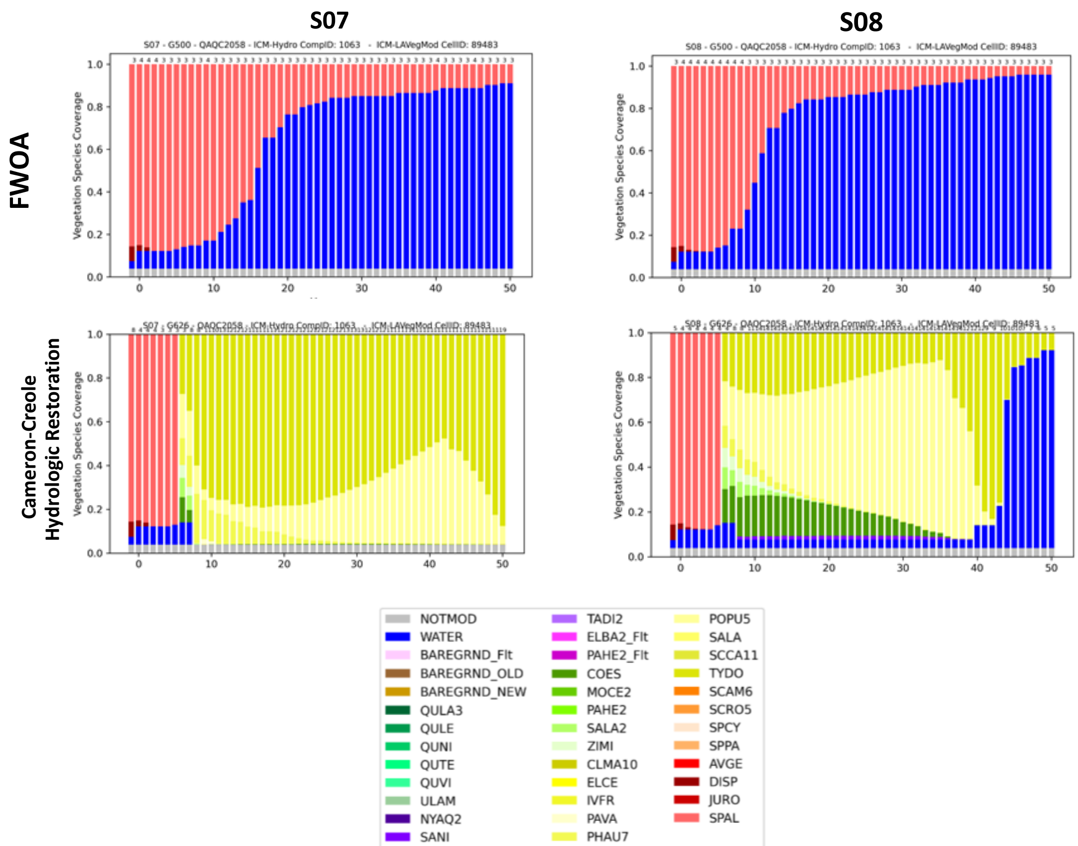


Figure 323. Changes in species cover at QAQC2058 are shown with and without the CCGHR under two different scenarios.

HABITAT SUITABILITY

The MBHR project had only minor effects on the suitability of habitats for fish, shellfish, and wildlife during both scenarios. The most apparent effect of the project was related to the changes in salinity concentrations that occurred. The project reduced salinities in parts of the Rockefeller Wildlife Refuge in the CHR ecoregion by up to 5 to 10 ppt. This resulted in small, localized increases in habitat suitability for juvenile blue crab, juvenile gulf menhaden, and juvenile spotted seatrout, because salinities were reduced such that they were closer to optimal levels for these species (e.g., juvenile spotted seatrout; Figure 324). Habitat suitability for other fish and shellfish species were less affected by the salinity change in this ecoregion. Meanwhile, salinities increased slightly over time south of Grand Lake in the MEL ecoregion. However, this salinity change did not appreciably change the suitability of the area for species.

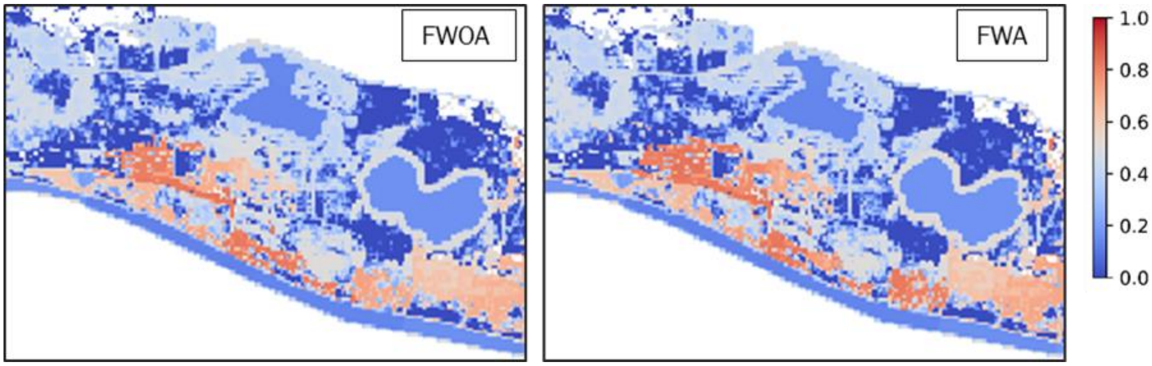


Figure 322. Juvenile spotted seatrout HSI scores across the Chenier Plain for Year 30 of the FWOA and MBHR (FWA) higher environmental scenario simulations. Scores range from 0.0, completely unsuitable habitat, to 1.0, optimal habitat.

The effects of water level reduction from the MBHR project on habitat suitability were less apparent. Lower water levels caused a concomitant decrease in water depths across parts of the MEL ecoregion, which, depending on the initial elevation of a location, resulted in both decreases and increases in the amount of shallow water habitat for waterfowl. The net effect across the ecoregion, however, was a small decrease in habitat suitability scores with the project compared to FWOA, particularly during the first half of the simulations (e.g., mottled duck; Figure 325). Over time, the project effect on water levels decreased and there was less of a difference in habitat suitability between the simulations. Toward the end of the simulation, though, habitat suitability scores were slightly greater with the project, due to the project maintaining marsh and shallow water habitats in the western MEL ecoregion.

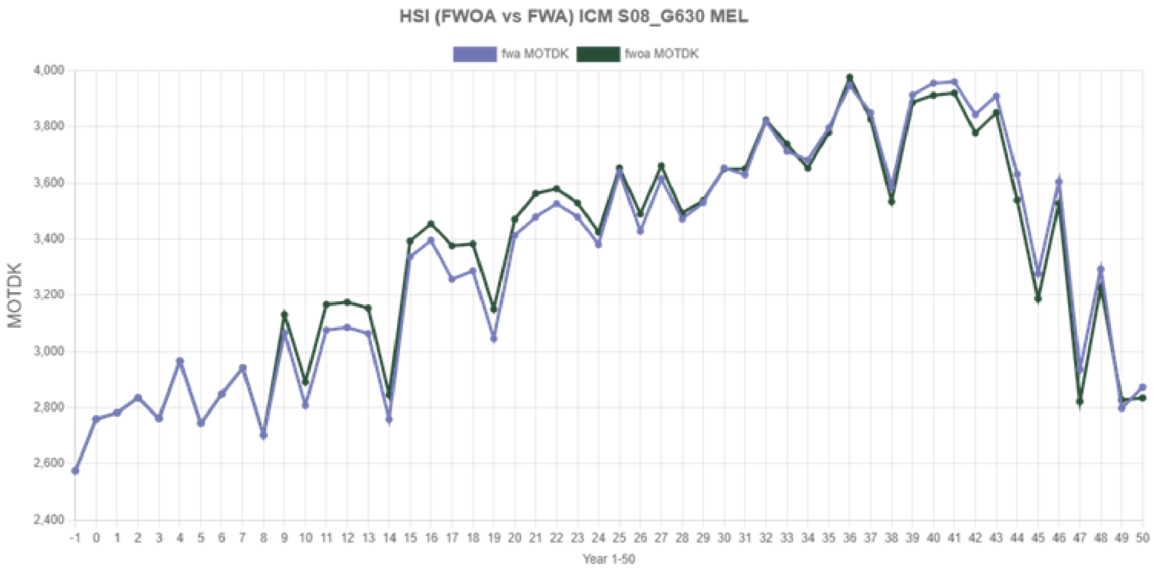


Figure 323. Total HSI score for mottled duck in the MEL ecoregion for the 50-year FWOA and MBHR (FWA) higher environmental scenario simulations. The total HSI score was calculated by summing the individual scores for each ICM model cell within the ecoregion.

The effects of the CCGHR project on the suitability of habitats were much greater than for the MBHR project. These effects were concentrated in the western CHR and western MEL ecoregions, as well as the Cameron-Creole Watershed in the CAL ecoregion. The CCGHR project did not greatly affect habitats elsewhere in the Chenier Plain.

The changes in salinity concentrations due to the CCGHR project had a large impact on habitat suitability for fish and shellfish. The project reduced salinities in the western CHR ecoregion by up to 15 to 20 ppt, resulting in freshwater conditions across much of this area. As a result, there were large decreases in the suitability of habitats in the area for species associated with higher salinities (i.e., >5 ppt), such as juvenile spotted seatrout (Figure 324). In contrast, there were localized increases in suitability for juvenile blue crab, juvenile gulf menhaden, and largemouth bass, which are more associated with low-salinity habitats. The CCGHR project also increased salinities over time in the wetlands north of Grand Chenier in the MEL ecoregion and in the Cameron-Creole Watershed. Although this resulted in minor changes in habitat suitability in both areas, the changes were more notable in the Cameron-Creole Watershed. Average annual salinities in the watershed were generally <1 ppt in FWOA, but with the project salinities increased such that habitats became more suitable over time for all fish and shellfish species in the analysis, except largemouth bass.

In several areas of the Chenier Plain, decreased habitat suitability was also due to the marsh acreage maintained by the CCGHR project. The project prevented the loss of large areas of marsh in the western CHR ecoregion and the Cameron-Creole Watershed, particularly during the higher scenario.

Because these areas remained relatively solid marsh with little open water, they were much less suitable habitat for fish and shellfish compared to FWOA simulation, during which these areas were converted into new aquatic habitat.

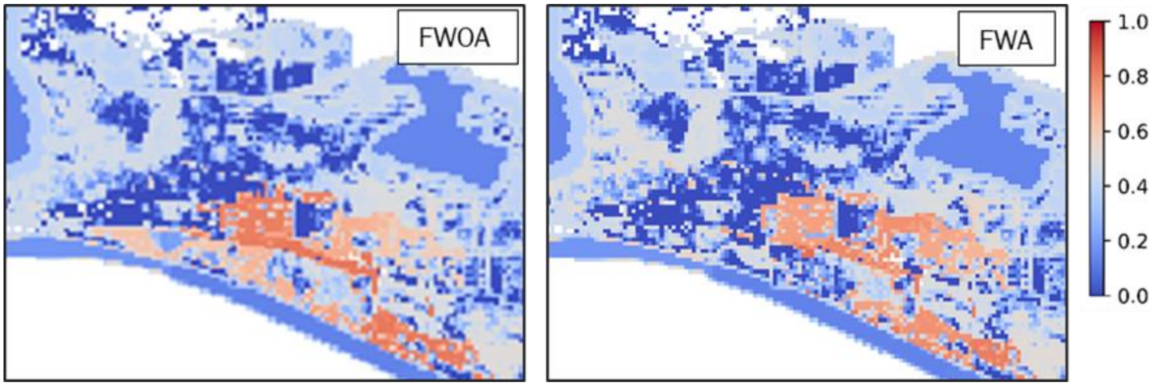


Figure 324. Juvenile spotted seatrout HSI scores across the Chenier Plain for Year 30 of the FWOA and CCGHR (FWA) higher environmental scenario simulations. Scores range from 0.0, completely unsuitable habitat, to 1.0, optimal habitat.

The water level reduction from the CCGHR project also had a large impact on habitat suitability. In the FWOA simulation, large areas of the Chenier Plain were flooded to shallow depths by SLR, which resulted in a large amount of shallow water habitat for waterfowl. The project reduced water levels by up to 50 cm across much of the western MEL ecoregion and the Cameron-Creole Watershed. This resulted in a reduction in shallow water habitat and a decrease in suitability in these areas for gadwall and mottled duck (Figure 325). Large water level reductions were also apparent in the western CHR ecoregion; however, the overall suitability of this area for gadwall and mottled duck increased with the project (Figure 325). This was because water depths in the western CHR ecoregion were relatively deep, and the project decreased these depths such that they were closer to optimal levels for these species. The suitability of this area also increased with the project because saline marshes were converted to intermediate marsh, which are a more suitable habitat type for gadwall and mottled duck.

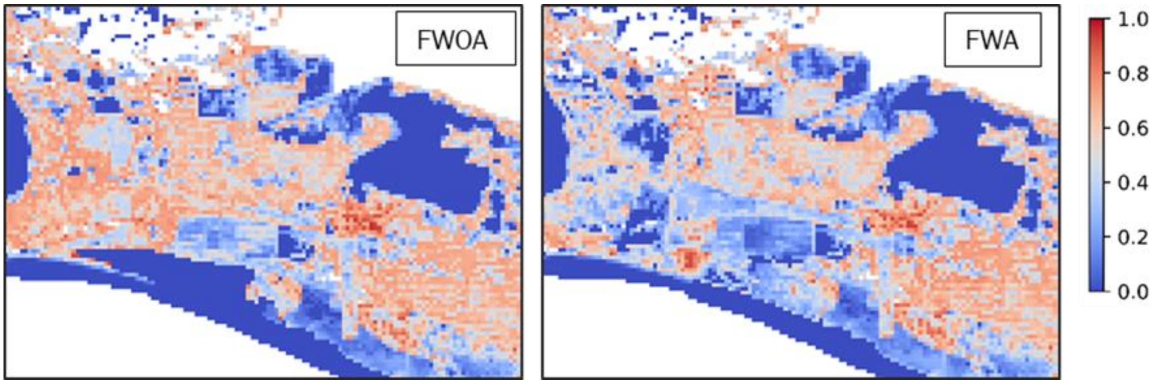


Figure 325. Mottled duck HSI scores across the Chenier Plain for Year 40 of the FWOA and CCGHR (FWA) higher environmental scenario simulations. Scores range from 0.0, completely unsuitable habitat, to 1.0, optimal habitat.