2023 COASTAL MASTER PLAN

DECISION-MAKING

APPENDIX G

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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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LIST OF ABBREVIATIONS

AAL .... AVERAGE ANNUAL LAND

AEP .... ANNUAL EXCEEDANCE PROBABILITY

B .... BILLION

CPRA .... COASTAL PROTECTION AND RESTORATION AUTHORITY

EADD .... EXPECTED ANNUAL DAMAGE IN DOLLARS

EASD .... EXPECTED ANNUAL STRUCTURAL DAMAGE

FWIP1 .... FUTURE WITH IMPLEMENTATION PERIOD 1

FWOA .... FUTURE WITHOUT ACTION

IP .... IMPLEMENTATION PERIOD

IP1 .... IMPLEMENTATION PERIOD 1

IP2 .... IMPLEMENTATION PERIOD 2

MDT .... MODELING DECISION TEAM

MCDA .... MULTI-CRITERION DECISION ANALYSIS

RDM .... ROBUST DECISION MAKING

1.0 INTRODUCTION

Coastal Louisiana is facing long-term sustainability challenges due to severe coastal land loss and increasing flood risk. For more than four decades, national and state government agencies, state and local organizations, corporations, and citizen's groups have invested significant resources in ecosystem restoration and flood risk reduction. Following the devastating 2005 hurricane season, the Louisiana State Legislature stipulated that CPRA develop a comprehensive coastal master plan to be updated regularly to ensure that the state was effectively building on success and taking advantage of new science and innovation.

The first coastal master plan in 2007 established high-level objectives to guide development of a comprehensive strategy. These objectives have been refined and added to in subsequent plans:

- Flood Protection. Reduce economic losses from storm surge-based flooding to residential, public, industrial, and commercial infrastructure.
- Natural Processes. Promote a sustainable coastal ecosystem by harnessing the natural processes of the system.
- Coastal Habitats. Provide habitats suitable to support an array of commercial and recreational activities coastwide.
- Cultural Heritage. Sustain the unique cultural heritage of coastal Louisiana by protecting historic properties and traditional living cultures and their ties and relationships to the natural environment.
- Working Coast. Promote a viable working coast to support regionally and nationally important businesses and industries.

The Planning Tool was developed for the 2012 Coastal Master Plan to evaluate and compare projects against their ability to achieve the objectives and formulate groups of projects (i.e., alternatives) (Groves et al., 2012). The Planning Tool was further developed and applied for the 2017 Coastal Master Plan. It is part of a deliberation-with-analysis approach to support the state's complex planning challenge.

The decision-making process starts with the development of candidate projects (Figure 1), which are drawn from previous master plans and through public solicitation and Regional Workgroups. These projects are evaluated using the predictive models (see Appendix C: Use of Predictive Models in the 2023 Coastal Master Plan) under different environmental scenarios (see Appendix B: Scenario Development & Future Conditions). Model outputs are then passed to the Planning Tool where benefits are assessed in the face of constraints, such as funding.

This appendix outlines the Planning Tool framework and how it was applied in the 2023 Coastal Master Plan. Attachment G1: Planning Tool Methods and Results describes the Planning Tool in more detail and Attachment G2: Metrics/Special Interests provides more information about metrics used to assess how projects and the plan relate to the master plan objectives.

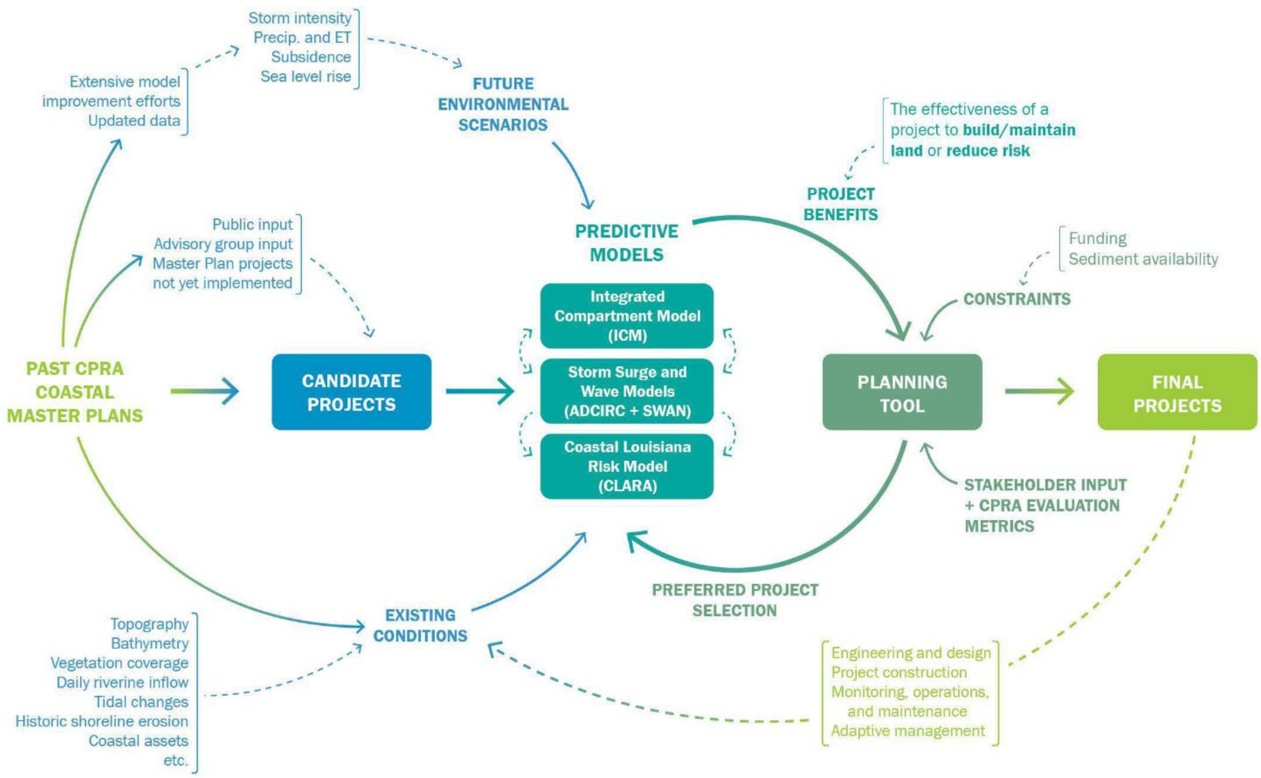

Figure 1. The master plan development process.

2.0 PLANNING TOOL

2.1 OVERVIEW

The Planning Tool is a computer-based decision support software system, composed of a database of predictive model results, an optimization model to define groups of projects (or alternatives) subject to planning constraints, and an interactive visualization package to support deliberations between different alternatives and elicit stakeholder preferences. The Planning Tool helps enable the state to formulate a long-term plan objectively and transparently. In this framework, a suite of predictive models developed by CPRA are used to estimate how the coastal system and associated flood risks would change over the next 50 years under different scenarios, reflecting uncertainty about key drivers, such as sea level rise. The models also estimate the effects of different restoration and risk reduction projects on a wide range of landscape-, ecosystem-, and risk-related outcomes.

The Planning Tool and the supporting predictive models are designed to help CPRA design a $50 billion (B), 50-year investment plan to address coastal land loss and flood risk challenges in Louisiana. To do so, they consider how the coast would change in the coming five decades with respect to a wide range of ecological and flood outcomes. The drivers of coastal change are impossible to predict with certainty, so the planning process (Figure 1) evaluates projects under different scenarios representing different plausible futures. The predictive models evaluate hundreds of different projects individually and then as groups – or alternatives. Summaries of these results are provided to the Planning Tool. The Planning Tool generates alternatives that maximize the goals of the 2023 Coastal Master Plan while satisfying a wide range of constraints.

The Planning Tool combines elements of Multi-Criterion Decision Analysis (MCDA) and Robust Decision Making (RDM) within an overarching deliberation-with-analysis process. It uses a simplified MCDA methodology. Rather than including all decision drivers within an objective function, the Planning Tool uses a simple and easily understood objective function. For the 2023 Coastal Master Plan the objective function uses equally weighted yearly damage reduction and equally weighted yearly land building. For risk reduction projects, expected annual structural damage (EASD) and expected annual damage in dollars (EADD) can both be used. The weighting of the EASD term, relative to average EADD reduction, is determined as part of the Planning Tool analysis.

For both restoration and risk reduction projects, for the 2023 Coastal Master Plan the Planning Tool uses two defined periods of implementation:

- Implementation Period 1 (IP1): Years 1 – 20
- Implementation Period 2 (IP2): Years 21 – 50

Two environmental scenarios are defined for the 2023 Coastal Master Plan and used to evaluate future without action (FWOA) conditions as well as future with project conditions for both risk reduction and restoration projects. The Planning Tool formulates alternatives for each of the two scenarios and informs the formulation of a single final robust alternative – one that would perform well across both scenarios.

The Planning Tool presents the results of these analyses to CPRA and stakeholders through interactive computer-based visualizations to support deliberations over the many different approaches and possible outcomes.

2.2 PLANNING TOOL APPLICATION

Several aspects of the previously applied Planning Tool approach were refined for the 2023 Coastal Master Plan to support improved decision-making. The overall approach used is outlined in Figure 2. While the process is similar to that used in the 2017 Coastal Master Plan (Groves et al., 2017), several features were adjusted.

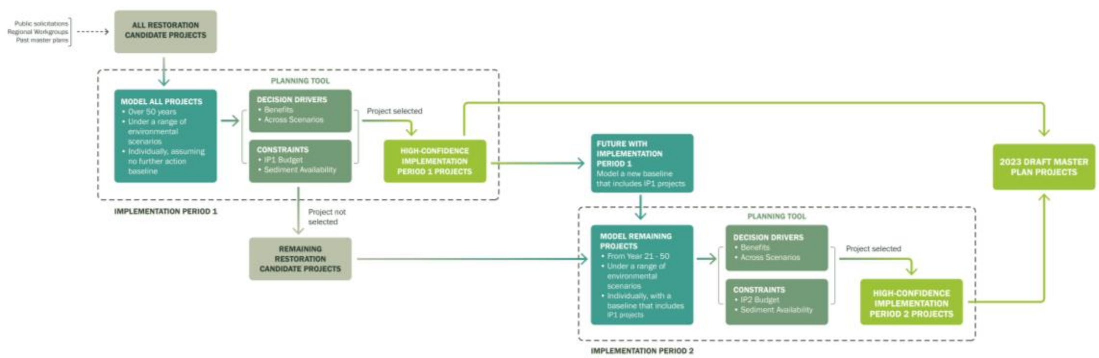

Figure 2. The use of the Planning Tool in the 2023 Coastal Master Plan.

ROBUST PROJECT SELECTION

In previous master plans, projects were selected based on a single environmental scenario. For the 2023 Coastal Master Plan, the Planning Tool uses a robust selection process that considers two environmental scenarios. This process first identifies high-confidence projects by formulating alternatives for each of the two scenarios - called "optimal" alternatives. Projects common to both optimal alternatives are referred to as high-confidence projects (see Figure 2). The Planning Tool then iteratively increases the budgets for each optimal alternative until a set of high-confidence projects are defined that expend that original amount of funding. This process was applied for both IP1 and IP2 for restoration project selection. For structural risk reduction, fewer candidate projects were considered, and the same set of projects was chosen for each scenario for IP1.

PROJECT INTERACTIONS

Another important aspect of the project selection process is the inclusion of an intermediate modeling step in which restoration projects selected for IP1 are assumed to be on the future landscape for the basis of evaluating the remaining projects for IP2. Once restoration projects are identified for IP1, they are assumed to be built and therefore included when the predictive models are run to evaluate the effects of the remaining candidate projects. The remaining candidate projects are eligible to be selected for IP2, and the new project evaluations are used to determine which remaining projects to select (see Figure 2).

SEDIMENT BORROW SOURCES

Sediment is an important resource for some types of restoration projects and cost-effective sources in coastal Louisiana are limited. For the 2023 Coastal Master Plan, the Planning Tool was configured to allow an individual project or project element to borrow from more than one source, if cost efficient to do so. Thus, sediment availability is a factor in the cost of a project and is reflected in the budget constraint, rather than being a separate constraint. For the 2023 analysis, 41 individual sediment sources were defined. For sources that are not within the Mississippi River channel, a single amount of sediment was specified that can be drawn upon until exhausted. For Mississippi River-based sources, sediment was considered renewable. These sources were assigned a 10-year renewable fill volume available at any time in those 10 years.

NONSTRUCTURAL RISK REDUCTION

Risk reduction projects can be either structural or nonstructural. Previous master plans selected specific projects in both categories. In the 2023 Coastal Master Plan, the state recognizes that nonstructural damage mitigation is often carried out at the local scale through a number of different state and federal programs, and that its effectiveness is highly dependent on local participation that may not be well characterized in the predictive models. Nonstructural projects are considered programmatically consistent, i.e., the plan does not identify individual communities as 'selected' or ‘not selected’. However, nonstructural projects for each community were designed and evaluated as a way to help prioritize structural risk reduction projects and identify how much of the total budget could cost-effectively be invested in nonstructural. In IP1, nonstructural projects were identified, defined by 1% annual exceedance probability (AEP) flood depths at initial conditions and a 75% participation rate, and their benefits compared to those of structural protection projects by community. In IP2, the flood depths used to define nonstructural projects were adjusted to account for future conditions, and the participation rate was adjusted based on the selection of projects in IP1.

The Planning Tool used these to support the selection of structural risk reduction projects in two ways:

- For a single community, the Planning Tool could select only the structural or the nonstructural project, not both.

- A structural project for a given community must perform favorably against all potential nonstructural projects, anywhere on the coast. In other words, if any nonstructural project was higher-performing than a given structural project, the structural project would be lower priority in the Planning Tool selection process.

For both IP1 and IP2, the Planning Tool identified the best set of projects – from both structural and nonstructural options – to reduce storm surge-based flood damages.

METRICS

In addition to the decision drivers and constraints used in the Planning Tool, metrics were developed based on model outputs and used community characteristics, such as demographic information and major industries, to better understand how the changing coast and the projects being evaluated impact different communities and resources. Ecosystem metrics consider the ability of projects to create or maintain suitable habitat for various species. Community metrics combine ecosystem outputs and risk outputs to characterize how certain communities, like those associated with traditional fishing or agriculture, may be impacted. Demographic data supports understanding of how structural risk reduction projects impact more vulnerable communities. During the project selection process, these were used as a check on the Planning Tool optimization to make sure decision-making is directly addressing questions of equity and resilience and not selecting suites of projects that disproportionately impact certain communities.

3.0 PLANNING TOOL ANALYSIS

The results of the Planning Tool analysis are presented in a Tableau workbook. This describes the following elements of the analysis for each IP:

- Restoration project descriptions of costs and benefits,
- Restoration alternative costs, projects, benefits, and methodological comparisons,
- Risk project descriptions of costs and benefits, and
- Risk alternative costs, projects, benefits, nonstructural programs, and demographic comparisons.

Benefits for restoration were characterized as average annual land (AAL), with additional tests for land created in the last decade and that remaining in Year 50. Benefits for risk were assessed as both EADD and EASD.

3.1 RESTORATION

For IP1, alternative explorations focused on three key decisions – budget, whether a robustness consideration was potentially beneficial to decision-making, and if so, how it should be implemented. A range of budgets were evaluated for IP1 from $7.5 B to $15 B, including $10 B, $12 B, $12.5 B, $12.75 B, $13 B, $13.5 B, $14 B, and $14.5 B. The higher budgets were set by overall master plan considerations, whereas others were used to test the sensitivity of the optimization with different amounts set aside for programmatic projects. Based on initial analysis CPRA used $12.5 B. Benefits by each alternative, derived using a single-step selection process (Groves et al., 2021), demonstrated that robustness could be beneficial, as some projects dropped in or out based on the assumed future.

The general robustness approach is to optimize for each environmental scenario the target budget (e.g., $12.5 B) and then compare the costs of the projects selected in common. If this list meets the budget, then that is the robust alternative. Otherwise – as was the case –the Planning Tool increased the budget by a modest increment, optimizing again for additional projects, repeating as necessary. The question was whether the projects should be fixed after each iteration or free to be unselected. Fixing projects after each iteration is sensitive to the size of the budget increment; however, allowing projects to be reselected (free) could lead to a less optimal solution as the tool replaces initially selected large projects that might not have strong benefits in one of the scenarios with multiple small projects that emerge to be in common with larger budgets. Testing showed that the deleterious effect of the free approach was small, on the order of one or two projects. As a result, a hybrid approach was used to limit the arbitrariness of fixed and potential suboptimization of the free approach by locking in the first-round selection of common projects, and then allowing the tool to pick freely after that initial iteration. In coastwide and regionalized comparisons, this hybrid method ultimately tracked the free approach, increasing confidence in our optimization constraint.

Restoration projects in IP2 were remodeled to include changes in the coastal landscape due to the IP1 selected projects as well as changing sediment borrow sources. IP2 benefits are calculated against a future with IP1 projects (FWIP1) baseline, as opposed to FWOA. The optimization criteria remained AAL but calculated over the 30 years of project performance in IP2.

For IP2, the Planning Tool was used to explore two budgets – $8.5 B and $9.5 B – and assumed a robust (fixed, then free) optimization criterion. The additional $1 B added four projects – Bayou Dularge Ridge Restoration, Golden Triangle Marsh Creation, East Calcasieu Lake Marsh Creation, and North Lake Mechant Marsh Creation, resulting in only a modest difference in benefit.

3.2 RISK REDUCTION

For IP1, the comparison of risk alternatives focused on four key decisions: budget, relative weighting of EADD versus EASD objective functions, participation rate in nonstructural programs, and formulation of environmental scenario/robustness. A range of budgets from $10 B to $17.5 B in $2.5 B increments were evaluated, with an eventual focus on $12.5 B.

Project selection differed depending on the relative weight of EADD versus EASD objective functions. For example, for a $12.5 B budget, Iberia/St. Mary Upland Levee, Lake Pontchartrain Barrier, Morganza to the Gulf, Slidell Ring Levees, and Upper Barataria Risk Reduction were selected in both scenarios. For the lower scenario, with 100% weight on EADD, no additional projects were selected. With a 30% weight shifted to EASD, Braithwaite to White Ditch was chosen, and there was no change with the weight increased to 50%. With either 70% or 100% weight on EASD, Franklin and Vicinity was added. Given stability around an even weighting, and absent a theoretical reason to bias more toward EADD or EASD, an EADD 50% / EASD 50% balance was used.

As no one community would have 100% compliance with a nonstructural risk mitigation program, projects were evaluated at 50% or 75% participation rates. For example, at a $12.5 B budget level, the higher nonstructural participation rate had the effect of forcing out the Lafitte Ring Levee from selection, except for EASD-preferred higher scenario alternatives. Assuming a 75% participation rate for selected communities created a larger nonstructural budget affording more flexibility in implementation and reducing more residual risk.

The structural project selection was the same for both environmental scenarios – perhaps due to fewer project choices each with larger budgets – and robust optimization was unnecessary for IP1.

In the IP2 analysis, the nonstructural participation rate was adjusted to account for whether the community was associated with a structural risk reduction project in IP1, and whether either that structural or nonstructural project was selected in IP1. If it was, and the structural project was selected in IP1, then nonstructural participation in that community was assumed to be only 25%. If either the nonstructural project or neither nonstructural nor structural project was selected, the participation rate was assumed to be 50 or 75%, depending on the amount of residual risk available to be addressed at a given cost-effectiveness. For communities that were not associated with structural projects, Table 1 shows how we then developed two options for those places who had nonstructural projects selected in IP1.

Table 1. Nonstructural participation rate options.

IS THE COMMUNITY ASSOCIATED WITH A STRUCTURAL PROJECT?	WAS A NONSTRUCTURAL PROJECT SELECTED IN IP1?	PARTICIPATION RATE	
		OPTION 1	OPTION 2
NONSTRUCTURAL COMMUNITIES ASSOCIATED WITH STRUCTURAL PROJECTS	STRUCTURAL PROJECT SELECTED IN IP1	25%	25%
	NONSTRUCTURAL PROJECT SELECTED IN IP1	50/75%	50/75%
	NEITHER NONSTRUCTURAL NOR STRUCTURAL PROJECT SELECTED IN IP1	50/75%	50/75%
NONSTRUCTURAL COMMUNITIES NOT ASSOCIATED WITH STRUCTURAL PROJECTS	NONSTRUCTURAL PROJECT SELECTED IN IP1	25%	50/75%
	NONSTRUCTURAL PROJECT NOT SELECTED IN IP1	50/75%	50/75%

As many of the nonstructural projects were selected in IP1, these nonstructural projects under Option 1 in IP2 are at a 25% participation rate and therefore require less funding but are less effective at reducing risk. As a result, the Planning Tool picked additional structural projects in Option 1 compared to Option 2, which diminished the amount of overall risk reduction.

Budget tests for IP2 focused on $12.5 B and $15 B given the findings in IP1. Following the same logic of EADD and EASD both receiving 50% weighting, with a budget of $12.5 B, Lafitte Ring Levee was the only project in common across both environment scenarios and nonstructural participation options.

4.0 RESULTS

The 2023 Coastal Master Plan represents a $50 billion investment in coastal Louisiana over 50 years. It includes 61 restoration projects and 12 structural risk reduction projects distributed across the coast (Figure 3), and allocates $11 billion for nonstructural risk reduction.

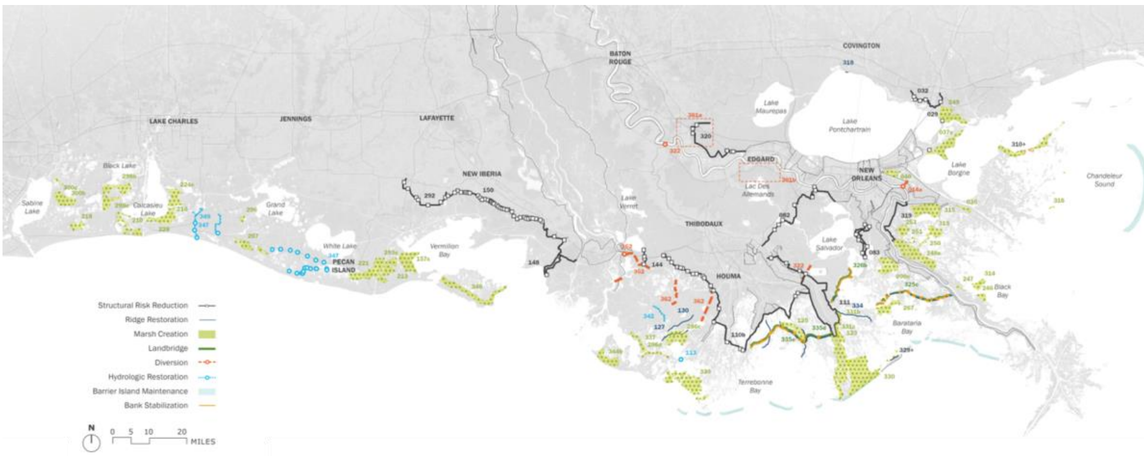

Figure 3. Project selected in the 2023 Coastal Master Plan.

Under the lower environmental scenario, implementation of the plan would result in over 7,000 avoided annual structure losses, over $7.5 billion in avoided annual damages, and 310 sq mi of avoided land loss. For the higher scenario, the results would be over 9,500 avoided annual structure losses, $11 billion in avoided annual damages, and 230 sq mi of land compared to not implementing the master plan.

5.0 REFERENCES

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