REPORT

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TASK 4.1 TECHNICAL MEMORANDUM: ADAPTATION PLANNING REPORT

C-8 and C-9 Watersheds Flood Protection Level of Service Adaptation Planning and Mitigation Projects Study

Task 4.1 Technical Memorandum
Adaptation Planning Report

C-8 and C-9 Watersheds Flood Protection Level
of Service Adaptation Planning and Mitigation Projects Study

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1.0 INTRODUCTION

The South Florida Water Management District (SFWMD or District) is conducting a system-wide review of the regional water management infrastructure to determine which mitigation projects may maintain or improve the current flood protection level of service (FPLOS). The FPLOS Phase 1 Study describes the level of protection provided by the water management facilities within a watershed considering sea level rise (SLR), future development, and known water management issues in each watershed. This study is part of the FPLOS Phase 2 for the C-8 and C-9 basins. The District's objective of the Phase 2 studies is to identify mitigation activities that may reduce flooding impacts and predict reductions in economic consequences. This technical memorandum is Deliverable 4.1 of Task 4 Adaptation Pathway Planning and Workshops.

This memorandum details the application of the Dynamic Adaptive Policy Pathways framework (Haasnoot et al, 2013) and the use of the "Pathways Generator" (developed and copyrighted by Deltares and Carthago Consultancy) to the C-8 and C-9 basins, along with selected focus area census tracts.

2.0 DYNAMIC ADAPTIVE POLICY PATHWAYS: A POLICY AND PLANNING FRAMEWORK

The Dynamic Adaptive Policy Pathways (DAPP) was developed as an analytical framework that facilitates decision-making under deep uncertainty. Given the uncertainties that exist with future sea level rise, future development and land use conditions, and future water management constraints, the FPLOS studies are suited to the use of DAPP to develop plausible mitigation scenarios. Potential actions are visually depicted with an Adaptations Pathway Map (**Figure 2.1**) that indicates the effectiveness of the action to achieve the desired performance level.

DAPP relies on a few key concepts:

- Thresholds: A pre-specified minimum performance level. In this study, the threshold is determined by the expected annual flood damage (EAD), further discussed in this technical memorandum.
- Adaptation Tipping Points (ATP): The point at which the proposed action exceeds the threshold. This means that the performance of that action fails to meet the objective. In this study, with the threshold represented as a level of EAD; reaching the tipping point indicates higher estimated annual damages.
- Pathways: Any proposed action or sequence of actions that forms a roadmap for future are known as a pathway on the Adaptations Pathway Map.

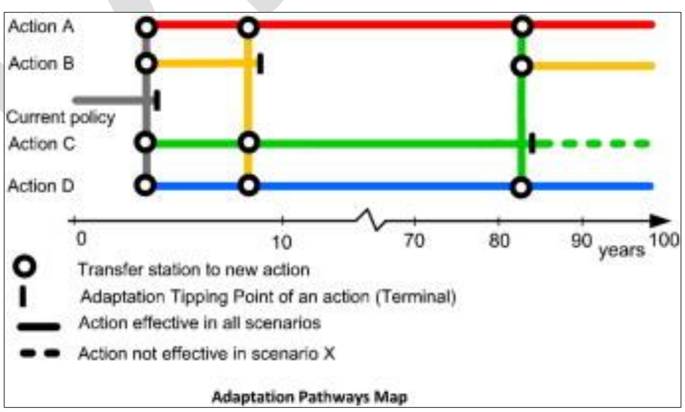

Figure 2.1 Example of an Adaptations Pathway Map

Adaptation pathways can represent multiple sequences of adaptation measures to adjust to changing conditions. In **Figure 2.1**, the example depicts that Action B is effective for almost 10 years. At this tipping point, other actions would need to be taken for the objectives to be met. This approach does not dictate a fixed way to respond. A pathway map shows all the potential options and their combinations. Different maps allow for examining these adaptation decisions under different assumptions about timing and or physical conditions. Thereby, the map shows how far one option (or sequence of options) can perform.

3.0 C-8/C-9 DAPP FRAMEWORK

For the C-8 and C-9 study, the DAPP analyzes how much sea level rise can be accommodated by each of the mitigation measures (or sequence of measures) based on the threshold (the pre-specified minimum performance level performance criteria). For example, how long will an action last (e.g., 10 years or 20 years) until it does not function anymore, at which time another action must be implemented. This allows decision-makers to determine the functional lifetime of different mitigation scenarios based on the assumptions about the rate of sea level rise. Demonstrating the potential timing of options can allow decision makers the ability to develop an adaptation plan. By examining the path dependency, it is possible to see which short-term actions are needed to keep long-term options open. The plan also indicates which triggers should be monitored to determine the appropriate timing to implement different actions. In this case, triggers could be, for example, a change in the rate of sea level rise.

For the C-8 and C-9 Basin study, the DAPP analysis includes these inputs:

- Sea level rise (SLR) curves
- Estimated Annual Damages (EAD)
- Thresholds and Tipping Points

3.1 Sea Level Rise Curves

The SLR projections (**Figure 3.1**) are derived from the Unified Sea Level Rise Projection: 2019 Update, by the Southeast Florida Regional Climate Change Compact Sea Level Rise Work Group (2020). The SLR curves have the following characteristics:

- Estimates future local SLR using the Key West NOAA Tide Gauge water level trends, and
- Recommends using one of the following SLR scenarios for estimating flood risk:
    - For non-critical, low-risk projects with less than a 50-year design life, use the Intergovernmental Panel on Climate Change Fifth Assessment Report 2013 (IPCC AR5) Median curve, or
    - For non-critical infrastructure with design life estimated to end prior to or after 2070, use the NOAA 2017 Intermediate High curve, or
    - For critical high-risk infrastructure with design life ending after 2070, use the NOAA 2017 High SLR curve.

Two SLR curves were used for the DAPP analysis: (1) the NOAA 2017 Intermediate High; and (2) the NOAA 2017 High. They were interpolated for 2021 start year to estimate a rise of 1-, 2-, and 3-ft (**Table 3.1**).

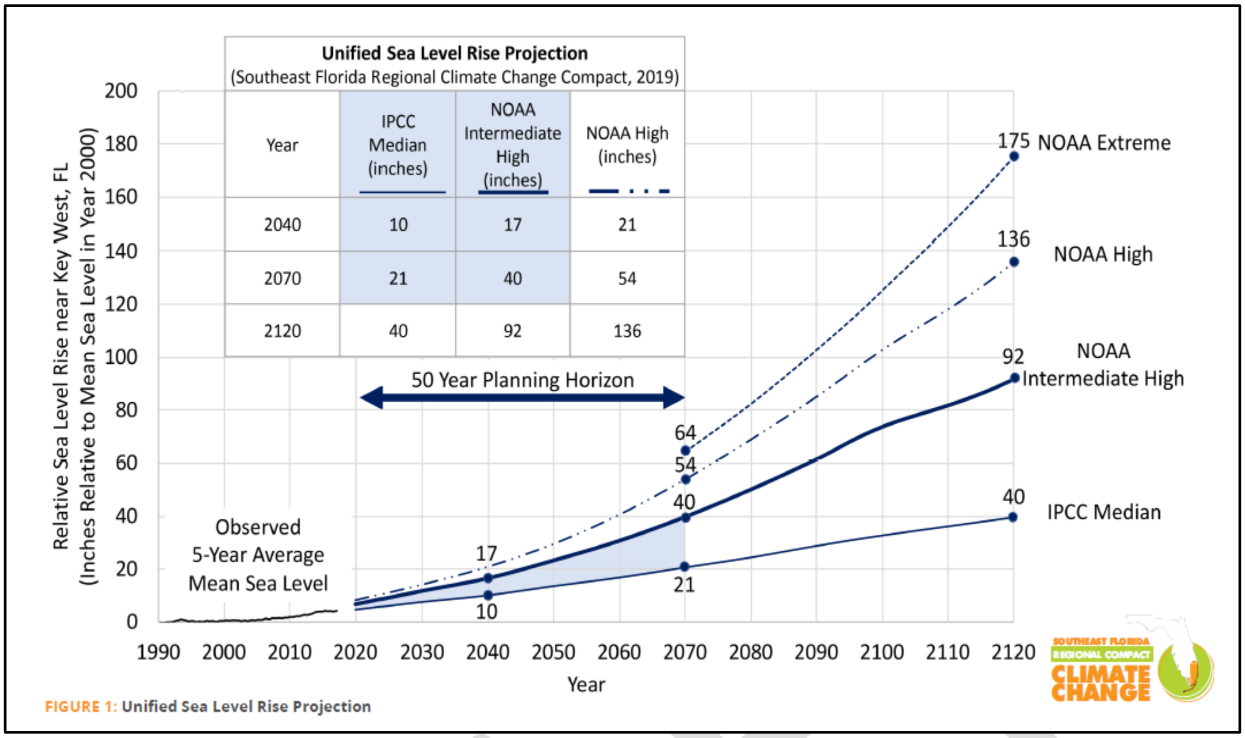

Figure 3.1 Southeast Florida Regional Climate Change Compact (2020)
Unified Sea Level Rise Projection: 2019 Update

Table 3.1 Estimated Year of Anticipated Sea Level Rise

SLR (ft above 2021)	NOAA 2017 Intermediate High Interpolated Year	NOAA 2017 High Interpolated Year
1	2044	2040
2	2060	2053
3	2073	2063

Source: Southeast Florida Regional Climate Change Compact (2020)

3.2 Estimated Annual Damages (EAD)

The EADs used for the DAPP analyses were derived from the SFWMD Flood Impact Assessment Tool (SFWMD-FIAT). Designed specifically for the District, the SFWMD-FIAT provides a user-friendly platform to expeditiously estimate economic damages from flooding due to rainfall runoff and sea level rise. The tool allows for multiple scenarios to run simultaneously and allows for easy comparison between mitigation scenarios. SFWMD-FIAT uses three datasets: depth damage functions, exposure data, and flood (or water depth) hazard data to calculate economic damages. The approach is described more fully in the *Task 3.2 Technical Memorandum: Expected Annual Damage and Benefit Cost Calculations.*

The EADs produced by the SFWMD-FIAT can also highlight the differences in the effectiveness of the mitigation alternatives by basins or another geographic boundary. For this study, we selected some focus areas by census tracts within each basin.

3.2.1 Census Tract Focus Areas

Focus area analysis provides a method to examine trends in EAD differences based on the effects of different mitigation scenarios in different geographic areas. There are several options to examine when considering geographic boundaries to determine comparative analysis areas, such as subbasin boundaries, census tract boundaries, or equal area grids (1km x 1km). District staff and project team decided on the analysis of areas using census tract boundaries given the familiarity of this designation in current political jurisdictions and broader economic studies.

The team originally selected census tracts with the highest EADs, based on the SFWMD-FIAT aggregated outputs. This method exposed the limitations when selecting census tracts with large geographic areas containing a small number of structures and roads relative to a small census tract with a large number of structures and roads. Analysis showed that the density within different census tracts caused disparate EADs and could not be compared. Further discussion with District staff concluded that it would be best to analyze census tracts based on an area-weighted EAD (EAD per acre).

EAD per acre calculations were performed for each census tract using the following steps:

1. Output shapefiles from the SFWMD-FIAT were grouped using ESRI's Dissolve tool to merge all structures and roads by common census tract name.
2. ESRI's Calculate Geometry tool was used to determine the acreage of all structures and roads within each census tract area. Using this calculated developed area as a ratio of each census tract provides more accurate area-weighted calculations because of the varied density of census tract land use.
3. A final calculation was performed to define the area-weighted EAD of each census tract using the acreage of merged structures and roads.

To select the final census tracts for this task, the project team examined area-weighted EAD to find census tracts with the highest EAD per acre. In this analysis, several census tracts with extremely high EAD per acre were excluded. Some of these outliers include census tracts whose edges do not coincide with the basin boundaries, resulting in high density small areas (> 0.01 acre) with extremely high EAD per acre.

3.2.2 Mitigation Strategies included in DAPP

There are 4 levels of mitigation strategies included in the FPLOS program. Three of those mitigation strategies (M0, M1, and M2) were included in the DAPP analysis (**Table 3.2**). A fourth level of strategies, M3, were included at planning level mitigation studies, but not included in the DAPP analysis. M3 strategies involve land elevation changes that can be either regional or local in nature. Examples may include raising buildings, finished floor elevations, seawall or flood wall elevations, raising roadways, or other administrative or regulatory changes. Because the M3 scenarios did not exceed the thresholds under 1-, 2-, or 3- ft of SLR, they were not included in the adaptive pathways.

The M0 strategy reflects the current conditions with no changes to existing infrastructure or regulations and no mitigation improvements. M1 strategy mitigates flooding within the secondary or tertiary flood control system and is implemented by the local partners. The M2 mitigation actions are regional and are implemented as part of the primary flood control system which allows the basin to store during peak runoff or discharge to tide under flooding conditions, including SLR.

Table 3.2 Mitigation Strategies Included in DAPP Analysis

Scenario	Distributed Storage	Pumps & Structural Improvements	Canal Improvements & Drainage Changes
M0 (Current Conditions)	None	None	None
M1 (Local)	11-acres	Stormwater projects, sluice gates and pump stations	Reduces flooding by 0.25 ft
M2A	500 ac-ft	1550 cfs harden and elevate downstream structure	None
M2B	500 ac-ft	2550 cfs harden and elevate downstream structure	Improved geometry, raised banks Internal drainage to accommodate raised banks
M2C	500 ac-ft	3550 cfs harden and elevate downstream structure	Improved geometry, raised banks, and widened banks Internal drainage to accommodate raised banks

3.2.3 C-8 and C-9 Thresholds and Tipping Points

For each basin, thresholds were set to the EAD from the M0 scenario. By using the current conditions under current sea level rise conditions, with no mitigation, we can compare the anticipated effectiveness of the mitigation strategies. The thresholds used for the C-8 and C-9 Basins, shown as a dashed line in **Figure 3.2** and **Figure 3.3**, respectively, are:

- C-8 Basin Threshold: $31.7 million EAD, and,
- C-9 Basin Threshold: $114.8 million EAD.

The figures also spotlight that the M3 strategies do not pass the threshold even with 3-ft SLR, and are, therefore, not included in the adaptive pathways analysis, as previously mentioned. In other words, the M3 scenarios reduced risk well and can accommodate the SLR under each elevation scenario M3(1ft), M3(2ft), and M3(3ft) for both C-8 and C-9 basin-wide. **Appendix A** contains the mitigation strategies with their thresholds, and SLR at which the thresholds are surpassed for both basins.

Because the DAPP analysis incorporates two SLR curves (the NOAA 2017 Intermediate High and the NOAA 2017 High), the timing of the tipping point of threshold exceedance varies. It will also vary based on the mitigation strategy being implemented. The tipping point indicates that the strategy exceeds the current level of damages, suggesting the strategy is not performing, or has exceeded its capacity to accommodate additional flooding, and additional flood mitigation measures are needed.

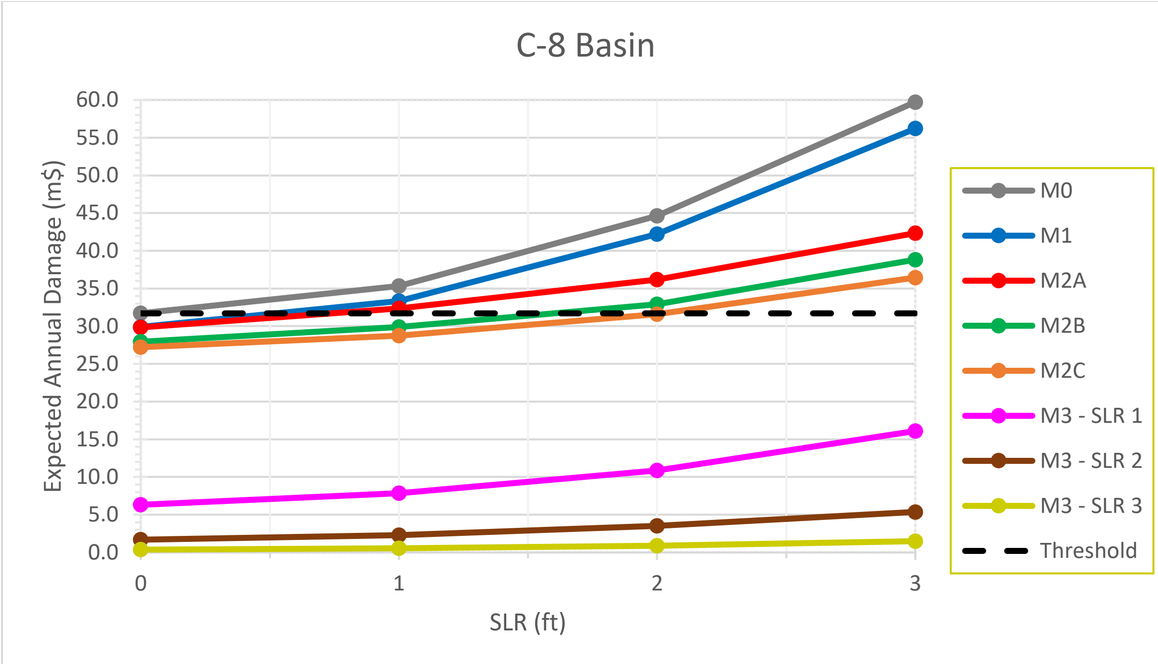

Figure 3.2 C-8 Basin Estimated Annual Damages for Flood Mitigation Strategies With 1-, 2-, 3-ft Sea Level Rise (ft, msl)

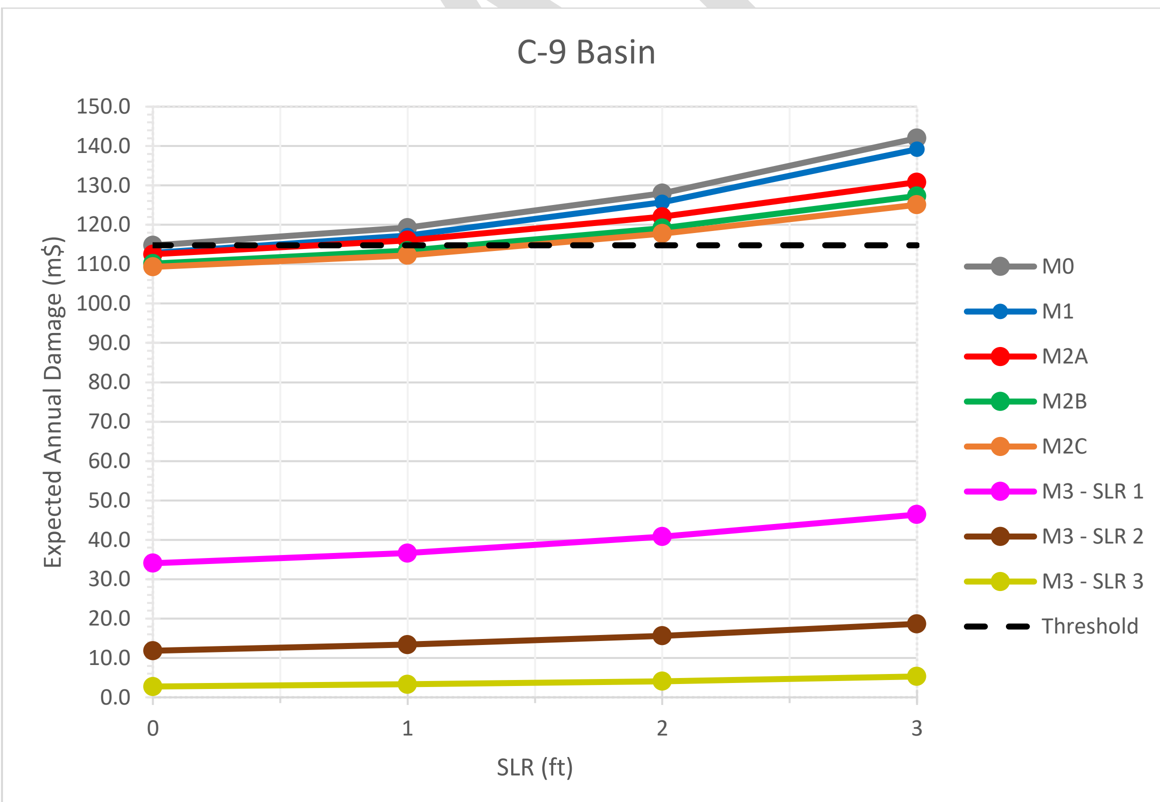

Figure 3.3 C-9 Basin Estimated Annual Damages for Flood Mitigation Strategies With 1-, 2-, 3-ft Sea Level Rise (ft, msl)

4.0 ADAPTIVE PATHWAY MAPS

This section contains the results of the C-8 and C-9 DAPP Analysis, as performed with the Pathways Generator. Basin-wide results are presented first, followed by census tract areas.

4.1 Basin-wide Pathways

The adaptation pathways map for C-8, **Figure 4.1**, indicates that all strategies accommodate some degree of SLR with M2B and M2C providing long-term risk reduction.

1. M1: It can accommodate up to 0.5-ft SLR to year 2032 (NOAA Intermediate High) or to year 2030 (NOAA High).
2. M2A: It can accommodate up to 0.8-ft SLR to year 2038 (NOAA Intermediate High) or to year 2035 (NOAA High).
3. M2B: It can accommodate up to 1.7-ft SLR to year 2054 (NOAA Intermediate High) or to year 2048 (NOAA High).
4. M2C: It can accommodate up to 2 -ft SLR by 2060 (NOAA Intermediate High) or to year 2053 (NOAA High).

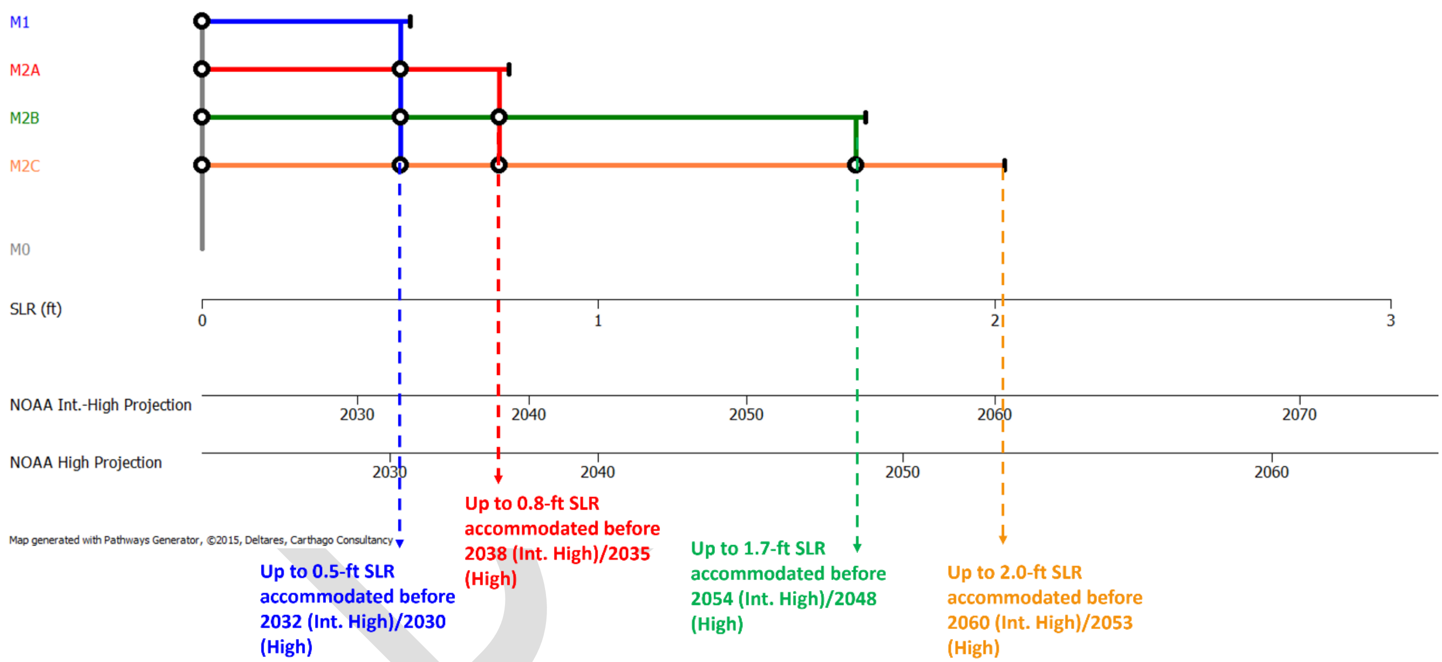

Figure 4.1 C-8 Basin-Wide Adaptation Pathway Map

The adaptation pathways map for C-9, **Figure 4.2**, indicates that all strategies accommodate some degree of SLR with M2B and M2C providing long-term risk reduction, though less than in C-8.

1. M1: It can accommodate up to 0.4-ft SLR to year 2030 (NOAA Intermediate High) or to year 2029 (NOAA High).

2. M2A: It can accommodate up to 0.7-ft SLR to year 2036 (NOAA Intermediate High) or to year 2033 (NOAA High).

3. M2B: It can accommodate up to 1.3-ft SLR to year 2048 (NOAA Intermediate High) or to year 2043 (NOAA High).

4. M2C: It can accommodate up to 1.5-ft SLR by 2052 (NOAA Intermediate High) or to year 2046 (NOAA High).

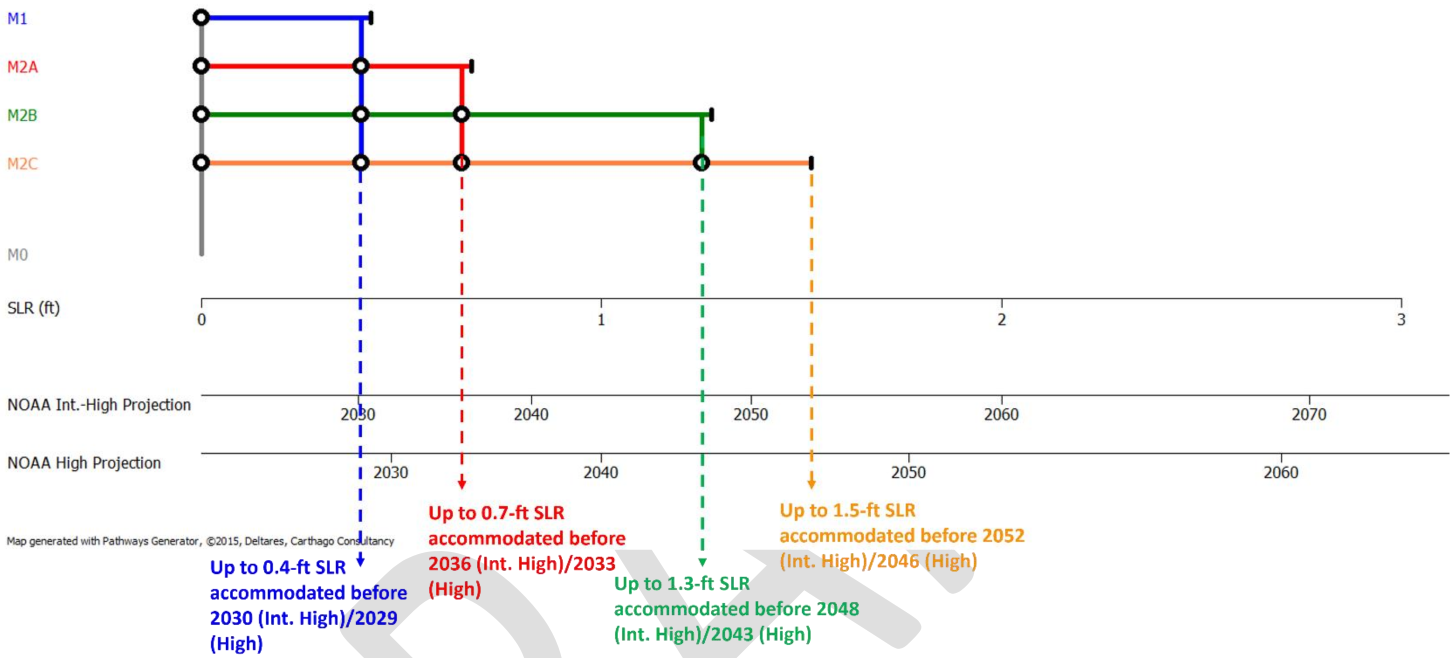

Figure 4.2 C-9 Basin-Wide Adaptation Pathway Map

4.2 Census Tract Pathways

The impacts of the alternative mitigation strategies vary spatially. To illustrate this spatial variability, this section contains the pathway maps for specific C-8 and C-9 census tracts. For C-8, census tracts 309, 310, and 312 were selected. For C-9, census tracts 213, 225, and 9602 were selected. These are representative tracts of highest EAD per acre, consistently throughout various return periods. Census tracts where the total area was very small were not included. Based on the damages to roads and structures that were calculated from the FIAT model within each of the selected census tracts, the anticipated SLR tipping points were determined. **Appendix A** includes the tipping points for each census track; they were derived with the same methodology used for the basin-wide analysis.

4.2.1 C-8 Census Track Pathway Maps

Figure 4.3 shows the location of the census tracks included in the analysis, with the 3 census tracts adjacent to each other and the C-8 canal.

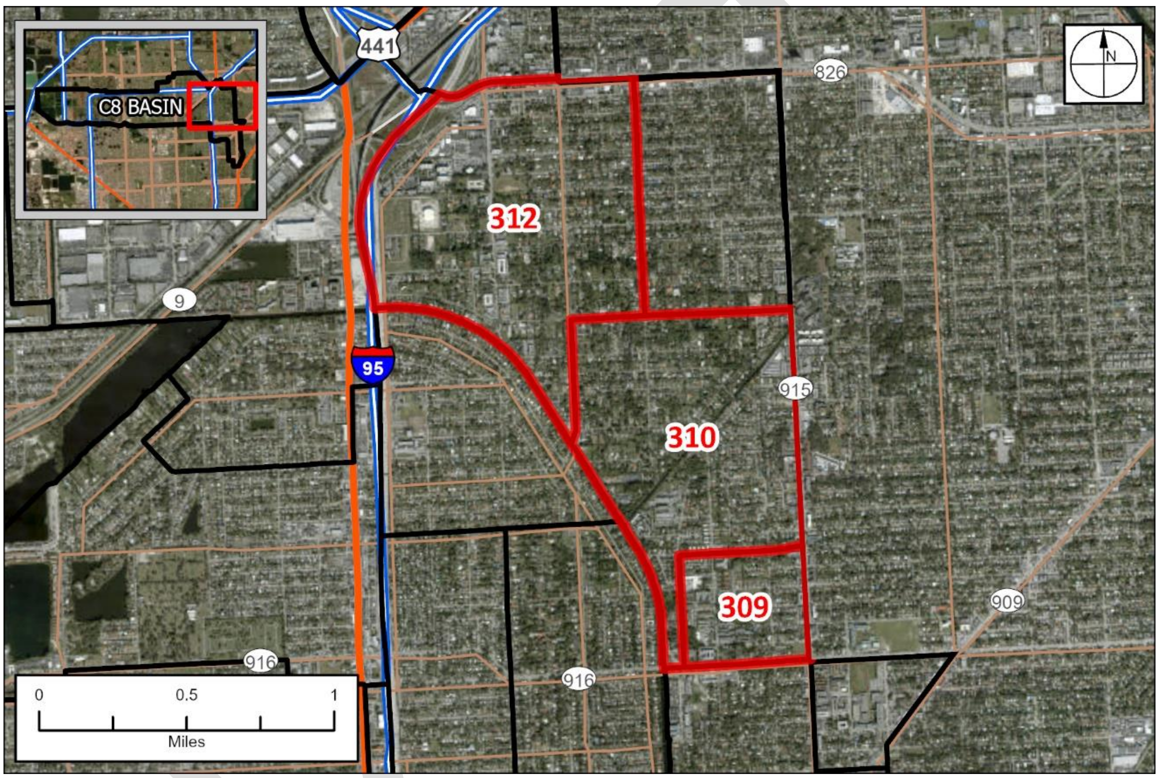

Figure 4.3 C-8 Basin Focus Area Census Tracts 309, 310, and 312

For census tract 309 (**Figure 4.4**), implementing the M1 (local strategy) is not sufficient much past current levels. M2A provides a short-term impact but only accommodates up to 0.2-ft of SLR. Implementation of M2B (increasing pump flow to 2,550 cfs) reduces risk levels by accommodating 2.1-ft of SLR, which is slightly greater than at basin scale. Consequently, for this census tract, M1 and M2A are not effective. Implementation of M2B would reduce risk to approximately 2061 (NOAA Intermediate High) and 2054 (NOAA High). M2C could be considered for additional risk reduction. One potential option could be to design and implement M2B such that M2C's increased pump capacity can be later added.

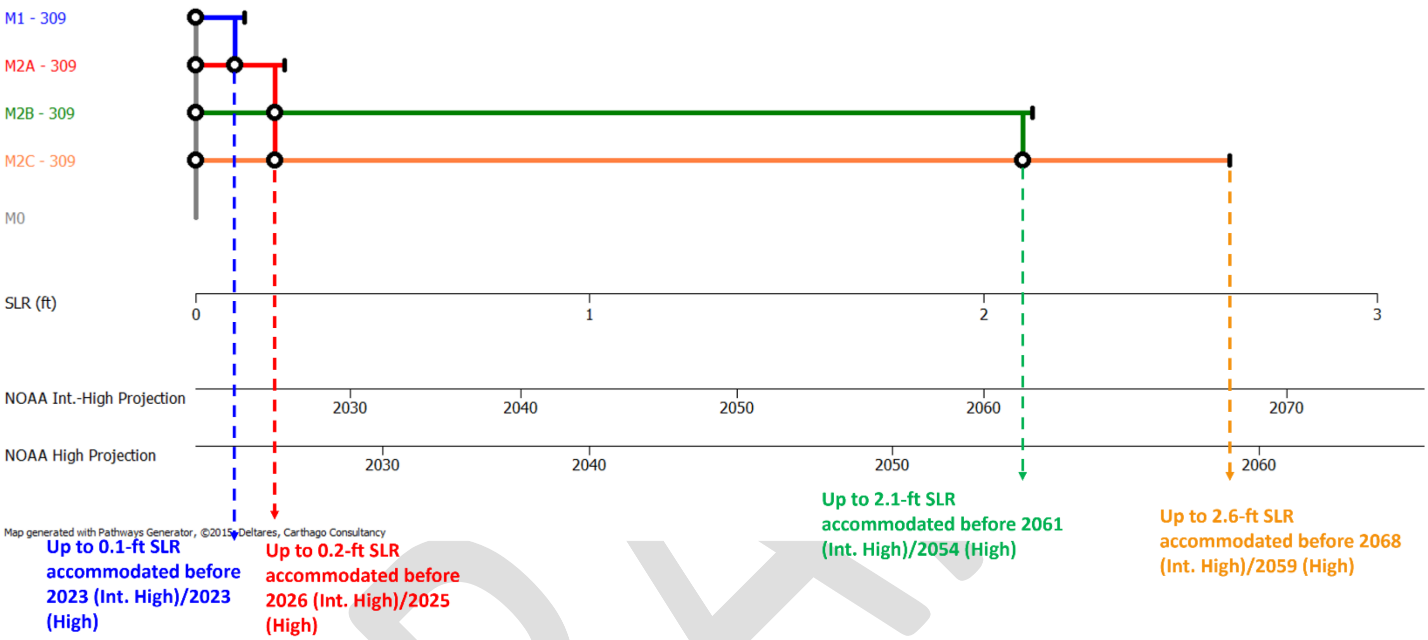

Figure 4.4 Census Tract 309 Adaptation Pathways Map

For census tract 310 (

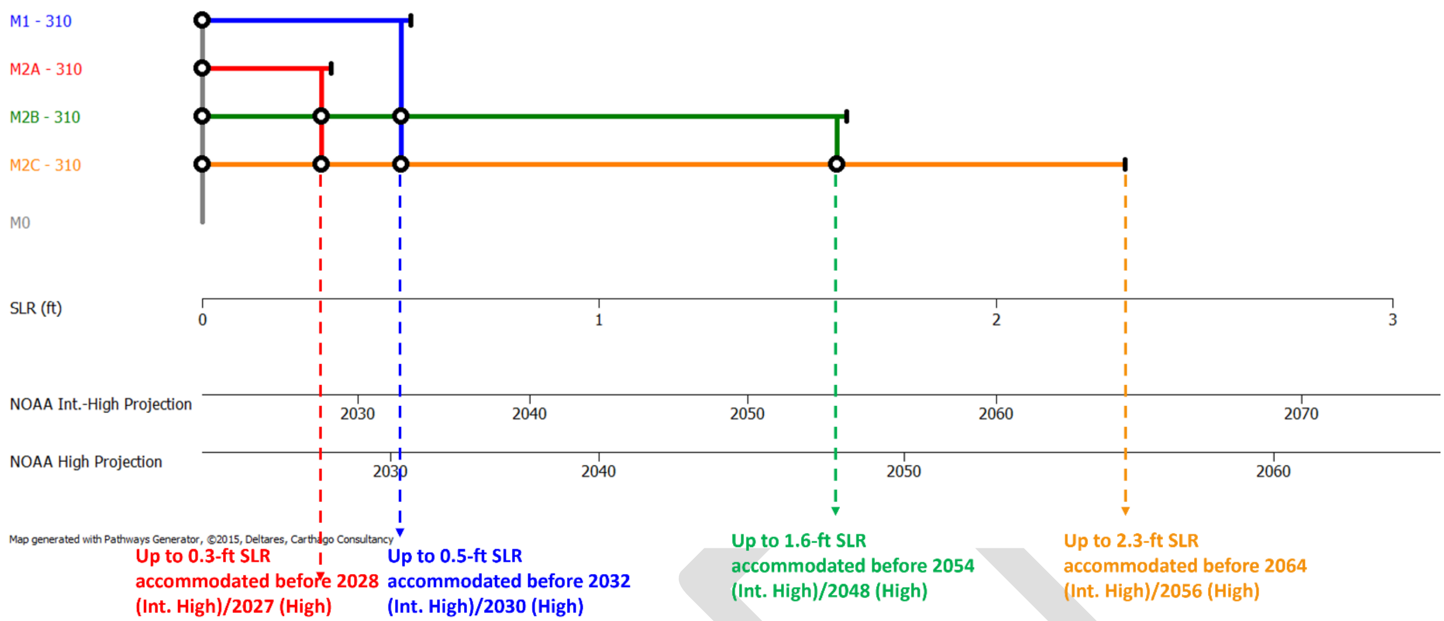

Figure 4.5), implementing the M1 strategy accommodates 0.5-ft SLR, 0.2-ft more than M2A. This highlights the importance of localized actions. A proposed pump station at the confluence of the C-8 Canal and the Spur 4 Canal reduces EADs in tract 310 and 312. At the census tract level, M2A accommodates less SLR than at the basin scale. Implementation of M2B (increasing pump flow to 2,550 cfs) reduces risk levels by accommodating up to 1.6-ft of SLR, same as the basin scale. The additional increase in pumping capacity of M2C accommodates 2.3-ft of SLR.

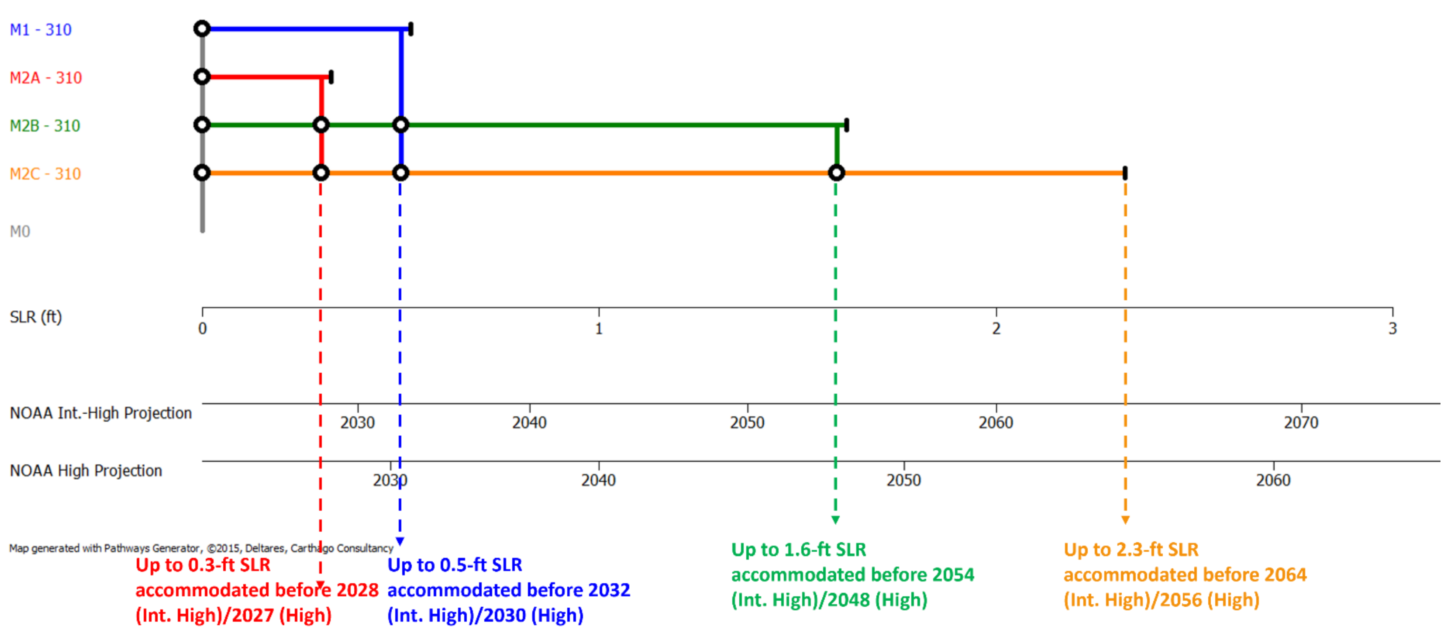

Figure 4.5 Census Tract 310 Adaptation Pathways Map

For census tract 312 (**Figure 4.6**), implementing M1 may provide risk reduction up to 1-ft SLR, double the basin-scale. As noted for census tract 310, a proposed pump station at the confluence of the C-8 Canal and the Spur 4 Canal reduces EADs for 310 and 312. M2A alone effectively does not provide any risk reduction, when considering the time scale. While our modeling and other analyses were not geared toward determining the cause of this localized condition, it could be that given that the topography is very low in census tract 312, the proposed pump capacity is insufficient. The location of the coastal structure where the potential pump would be located is approximately 3.3 miles to the southeast along the canal. The 1550 cfs anticipated for M2A is possibly not enough to reduce the risk to this low-lying area. Immediate implementation of strategy M1 would provide time (approximately 20 years based on the NOAA Intermediate High SLR projections) for planning and implementation of M2B or M2C in the future.

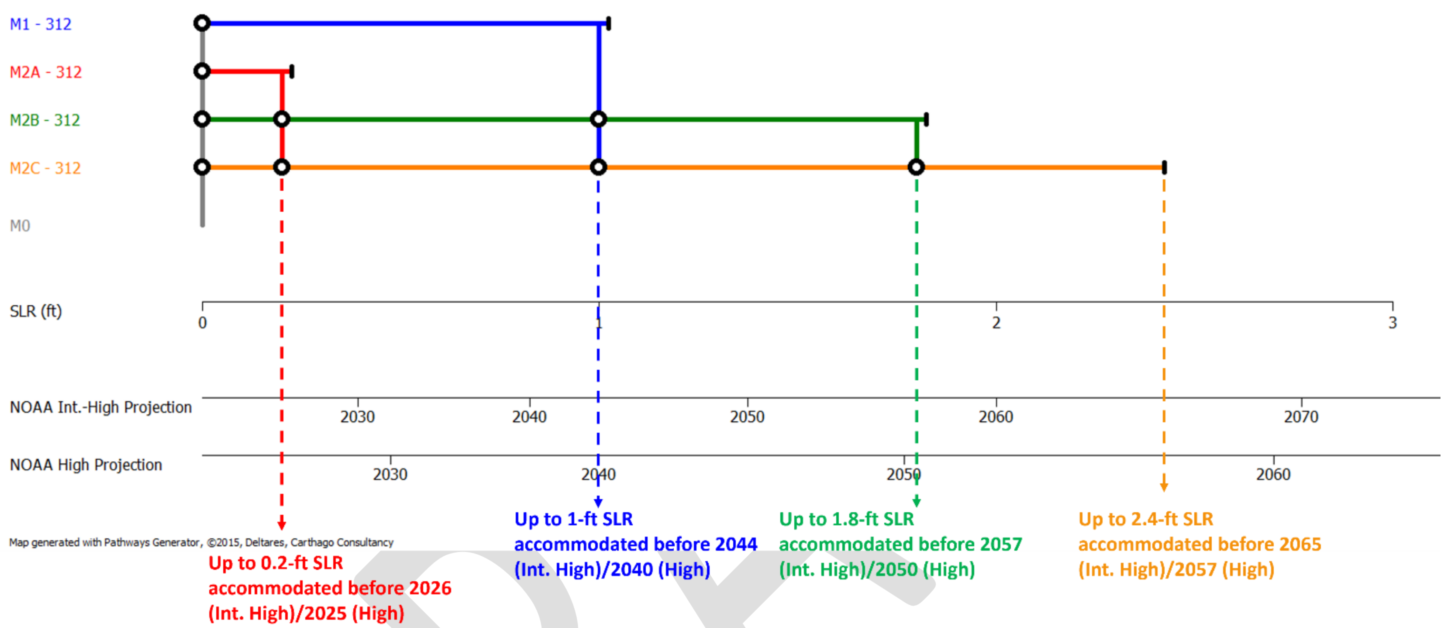

Figure 4.6 Census Tract 312 Adaptation Pathways Map

4.2.2 C-9 Census Track Pathway Maps

For the C-9 Basin, census tracts 213, 225, and 9602 were selected for DAPP, based on the EAD/acre derived from the FIAT model, described in Section 3.2.1 of this technical memorandum (**Figure 4.7**).

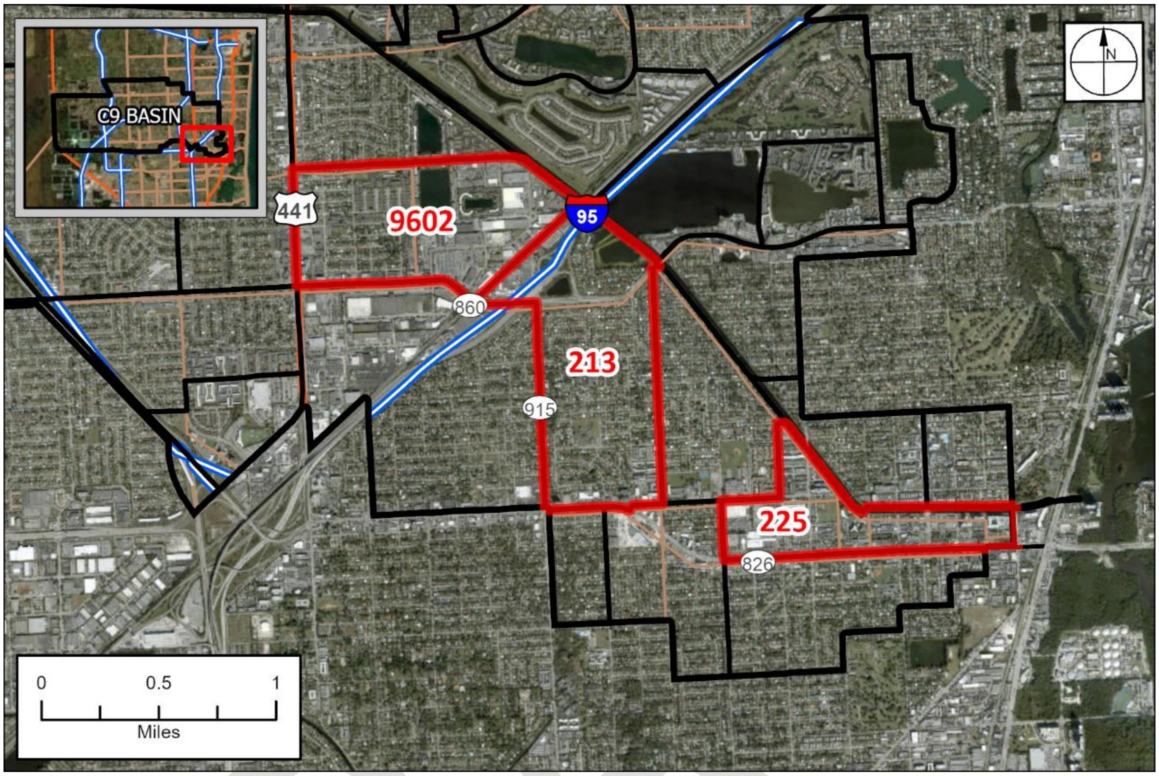

Figure 4.7 C-9 Basin Focus Area Census Tracts 213, 225, and 9602

For census tract 213 (**Figure 4.8**), implementing the M1 strategy accommodates approximately 1-ft of SLR, which is double the basin scale. Implementation of M2A reduces risk levels considerably to 1.25-ft of SLR to nearly 2040 (NOAA Intermediate High), which is greater than at basin scale. Immediate implementation of strategy M2A would provide time (over 20 years based on the NOAA Intermediate High SLR projection) for planning and implementation of M2C in the future. Interestingly M2A and M2B accommodate the same amount of SLR.

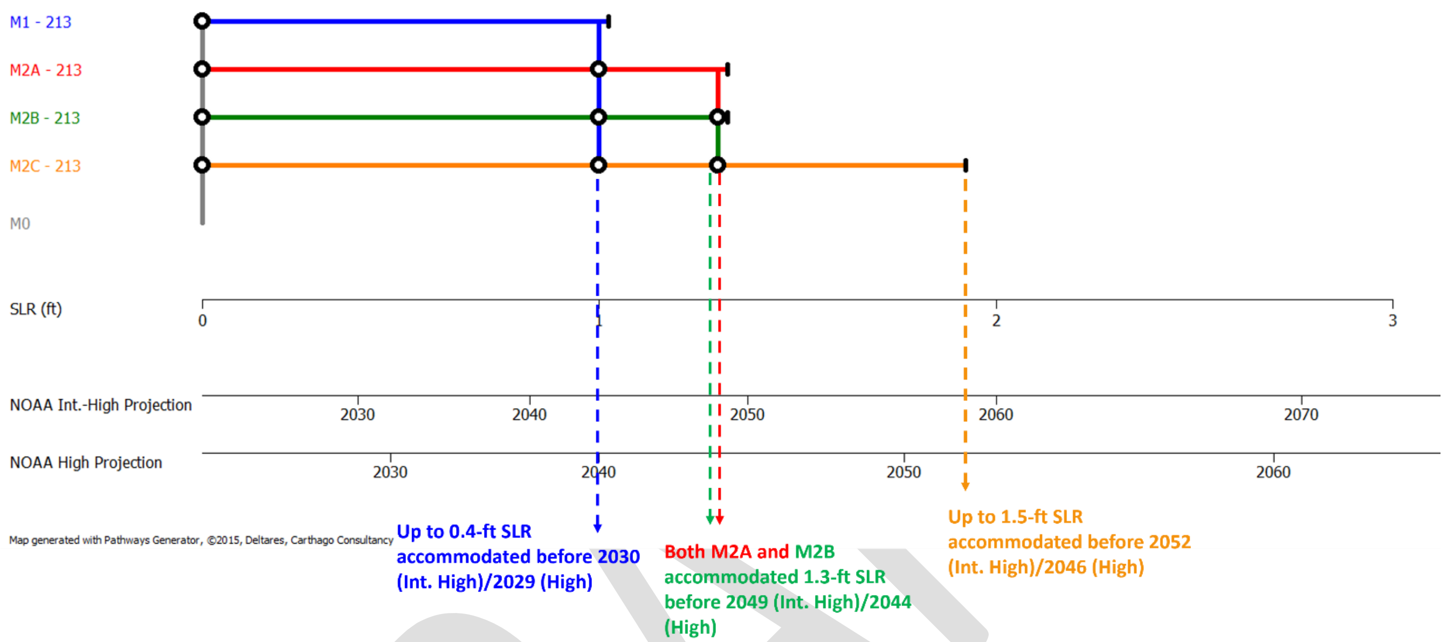

Figure 4.8 Census Tract 213 Adaptation Pathways Map

For census tract 225 (**Figure 4.9**), implementing the M1 strategy accommodates only 0.2-ft of SLR, which is less than at basin scale. Implementation of M2A reduces risk levels considerably to 1.3-ft of SLR to nearly 2049 (NOAA Intermediate High), which is much greater than at basin scale. Immediate implementation of strategy M2A would provide time (approximately 25 years based on the NOAA Intermediate High SLR projections) for planning and implementation of M2B or M2C in the future. Both M2B and M2C provide risk reduction over 2-ft of SLR.

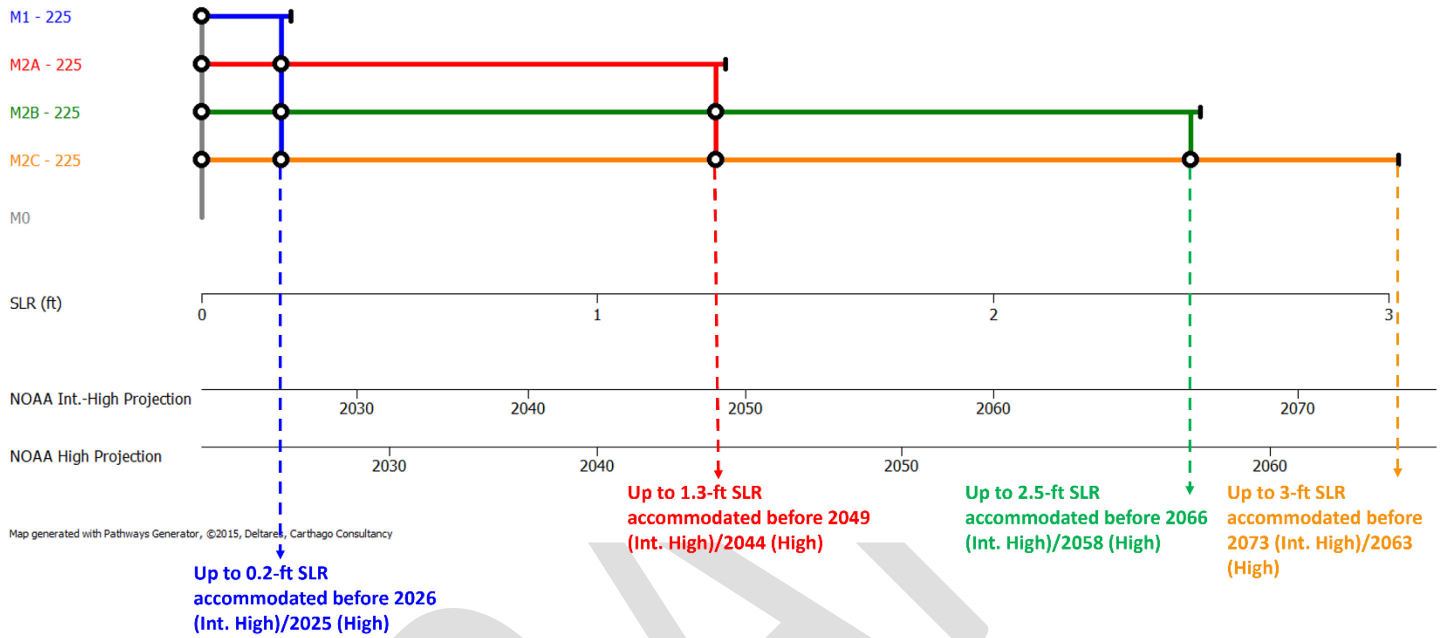

Figure 4.9 Census Tract 225 Adaptation Pathways Map

For census tract 9602 (**Figure 4.10**), implementing the M1 strategy accommodates only 0.1-ft of SLR, while M2A accommodates only up to 0.2-ft SLR, which is less than at basin scale. Implementation of M2B (increasing pump flow to 2,550 cfs) reduces risk levels considerably up to 2.1-ft of SLR to nearly 2061 (NOAA Intermediate High), approximating basin scale results.

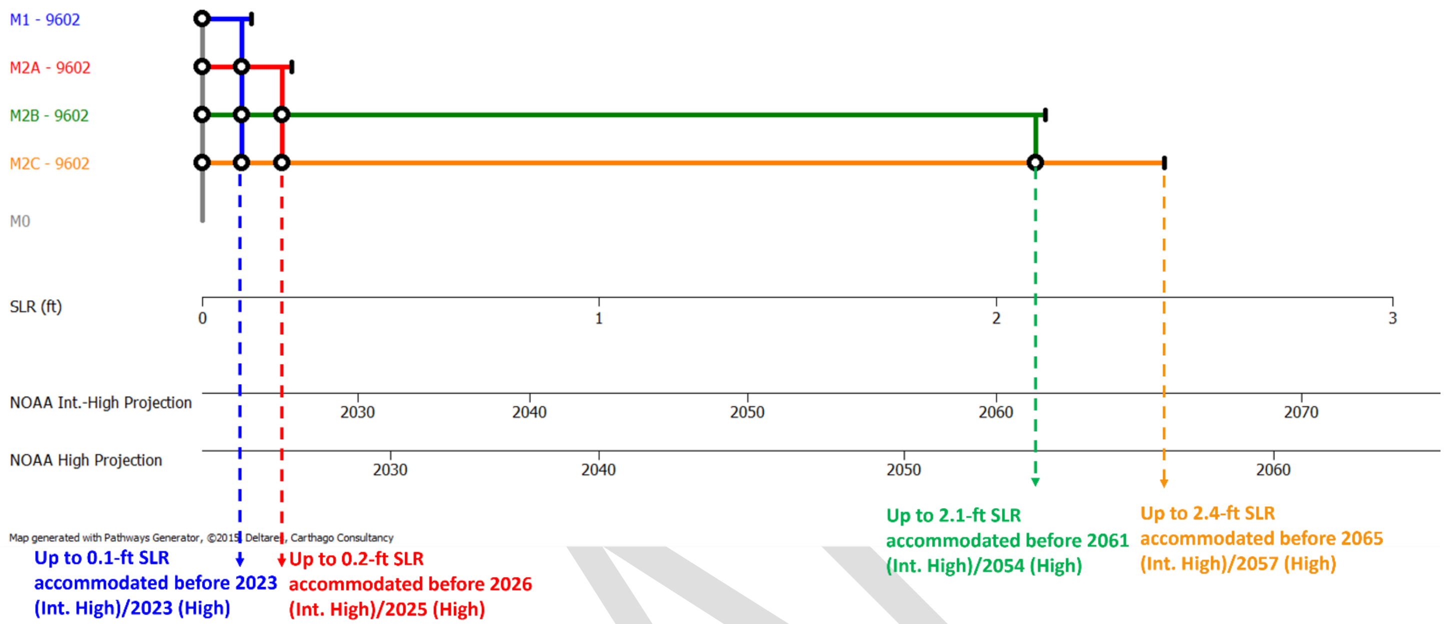

Figure 4.10 Census Tract 9602 Adaptation Pathways Map

5.0 DISCUSSION

One of the strengths in using the DAPP framework is the level of transparency available to decision makers. As previously mentioned, the DAPP process does not result in an exclusive answer; it does not determine which pathways are optimal. It serves to clarify the anticipated performance of mitigation options for decision-makers to be more informed. The data can be viewed with different time scales, varied geographic or jurisdictional boundaries, or different SLR projection. Each lens can yield valuable information on the anticipated impact and duration of the mitigation actions.

We cannot overstate the importance of having regional and local projects and initiatives that can complement each other. Our analysis showed the impact of the mitigation actions differs if considered at the basin scale or at the census tract. Some alternatives can be very effective up to a high sea level rise in some census tracts but can only accommodate a limited amount of sea level rise in others before the risk thresholds are reached again. Smaller, targeted actions that can reduce flooding risk at the neighborhood or census tract scale may prove to be highly effective in providing near-term relief. Such is the case for census tracts 310 and 312, in the C-8 basin. A proposed pump station at the confluence of the C-8 Canal and the Spur 4 Canal reduces EADs in those tracts. While the benefits of M1 actions may not be effectively captured at the larger basin scale because they do not influence the basin, their local influence may be highly beneficial to specific communities. They may also provide the near-term risk reduction sufficient for the duration necessary for the larger projects to be planned and implemented.

This analysis also supports two implementation approaches for adaptation strategies:

1. Adaptable mitigation solutions, i.e., those mitigation actions that can be adapted over time and space, and,

2. Phased implementation approaches, i.e., match the timing of mitigation actions with the timing of actual risk.

For example, for the C-8 and C-9 Basins, the M2C accommodates higher levels of SLR under both NOAA scenarios. However, implementing the mitigation strategy under M2C, which includes hardening and elevating of structures downstream and increasing pump output to 3,550 cfs may not be immediately possibly to implement due to funding constraints. It could be that M2B (2,550 cfs) may be a more attainable option while some shorter-term options, such as M1 and M2A, are implemented. Also, in all cases, new pump stations can be designed and built with the intent of future expansion to M2C. This allows for the adaptability of the additional pumping capacity to match flood risk posed with the future conditions of higher sea level.

Future analyses can incorporate changes to any of the inputs and would benefit from a sensitivity analysis to understand what variables influence the outcomes in the different scenarios. For example, in this task, the mitigation strategies contain various elements (e.g., distributed storage, pumping and structural changes, etc.), yet the elements were not analyzed individually but rather as one cohesive strategy. There may be benefits for individual projects to be analyzed and potentially combined for an increased level of detail for each strategy. Also, while the analyses rely on the FIAT to derive EADs, it would be beneficial to expand the definition of "estimated annual damages" to arrive at a more comprehensive benefits analysis of the mitigation activities. Presently, the EADs do not include other flood induced losses such as lost workforce productivity or preservation/decline of a tax base. Expanding the categories that derive risk reduction benefits would more clearly represent the benefits of the SFWMD investments.

Finally, the analyses show there are areas that are presently, or forecast to be, flooding more extensively. It would be beneficial for the stakeholders that have jurisdiction over portions of the secondary and tertiary system to continue to explore the data generated from this study. As they review the data, the added level of granularity may yield information on local mitigation strategies that can work better for them.

6.0 REFERENCES

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APPENDIX A
MITIGATION STRATEGIES WITH THEIR THRESHOLDS AND SLR TIPPING POINTS

The threshold for the C-8 basin is based on the EAD at the M0 with 0-ft of SLR, which in this case is $31.7 million. **Table A.1** lists the EADs for each foot of SLR per strategy. It also lists the amount of SLR the strategy can accommodate before it reaches the tipping point of the threshold value.

Table A.1 Threshold and SLR Tipping Points for C-8 Basin Mitigation Strategies

Mitigation Strategy	SLR (ft)	EAD (m $)	Tipping Point/SLR (ft) at Threshold
M0	**0**	**31.7 (threshold)**	N/A
	1	35.3	
	2	44.6	
	3	59.7	
M1	**0**	29.9	0.5
	1	33.3	
	2	42.2	
	3	56.2	
M2A	**0**	29.8	0.8
	1	32.4	
	2	36.2	
	3	42.3	
M2B	**0**	27.9	1.7
	1	29.9	
	2	32.9	
	3	38.8	
M2C	**0**	27.2	2
	1	28.7	
	2	31.6	
	3	36.4	
M3 (1ft)	**0**	6.3	>3
	1	7.8	
	2	10.9	
	3	16.1	
M3 (2ft)	**0**	1.7	>3
	1	2.3	
	2	3.5	
	3	5.4	
M3 (3ft)	**0**	0.4	>3
	1	0.5	
	2	0.9	
	3	1.5	

The threshold for the C-9 basin is based on the EAD at the M0 with 0-ft of SLR, which in this case is $114.8 million. **Table A.2** lists the EADs for each foot of SLR per strategy. It also lists the amount of SLR the strategy can accommodate before it reaches the tipping point of the threshold value.

Table A.2 Thresholds and SLR Tipping Points for C-9 Basin Mitigation Strategies

Mitigation Strategy	SLR (ft)	EAD (m $)	Tipping Point/SLR (ft) at Threshold
M0	**0**	**114.8 (threshold)**	N/A
	1	119.3	
	2	128.0	
	3	142.0	
M1	**0**	112.9	0.4
	1	117.3	
	2	125.7	
	3	139.2	
M2A	**0**	112.5	0.7
	1	116.1	
	2	122.0	
	3	130.8	
M2B	**0**	110.1	1.3
	1	113.4	
	2	119.1	
	3	127.3	
M2C	**0**	109.3	1.5
	1	112.3	
	2	117.8	
	3	125.1	
M3 (1ft)	**0**	34.1	>3
	1	36.6	
	2	40.8	
	3	46.4	
M3 (2ft)	**0**	11.8	>3
	1	13.4	
	2	15.6	
	3	18.7	
M3 (3ft)	**0**	2.8	>3
	1	3.3	
	2	4.1	
	3	5.3	

Table A.3 Thresholds and SLR Tipping Points for Census Tract 309, C-8 Basin

Mitigation Strategy	SLR (ft)	EAD (k $)	Tipping Point/SLR (ft) at Threshold
M0	**0**	**682.7 (threshold)**	N/A
	1	997.8	
	2	1620.8	
	3	2824.8	
M1	**0**	682.7	0.1
	1	997.8	
	2	1620.8	
	3	2824.8	
M2A	**0**	649.0	0.2
	1	830.3	
	2	1130.0	
	3	1584.0	
M2B	**0**	416.1	2.1
	1	516.4	
	2	660.9	
	3	1052.8	
M2C	**0**	378.6	2.6
	1	441.5	
	2	556.6	
	3	781.9	

Table A.4 Thresholds and SLR Tipping Points for Census Tract 310, C-8 Basin

Mitigation Strategy	SLR (ft)	EAD (k $)	Tipping Point/SLR (ft) at Threshold
M0	**0**	**881.4 (threshold)**	N/A
	1	1234.2	
	2	2003.9	
	3	3533.5	
M1	**0**	731.3	0.5
	1	1052.5	
	2	1744.1	
	3	3090.5	
M2A	**0**	807.6	0.3
	1	1022.1	
	2	1352.9	
	3	1899.4	
M2B	**0**	570.2	1.6
	1	719.9	
	2	962.4	
	3	1477.7	
M2C	**0**	519.1	2.3
	1	610.8	
	2	801.2	
	3	1134.0	

Table A.5 Thresholds and SLR Tipping Points for Census Tract 312, C-8 Basin

Mitigation Strategy	SLR (ft)	EAD (k $)	Tipping Point/SLR (ft) at Threshold
M0	**0**	**971.8 (threshold)**	N/A
	1	1261.0	
	2	1759.6	
	3	2753.2	
M1	**0**	755.5	1
	1	972.8	
	2	1379.3	
	3	2186.2	
M2A	**0**	937.2	0.2
	1	1128.1	
	2	1411.5	
	3	1775.2	
M2B	**0**	659.3	1.8
	1	783.0	
	2	996.3	
	3	1424.8	
M2C	**0**	619.7	2.4
	1	695.7	
	2	858.4	
	3	1135.1	

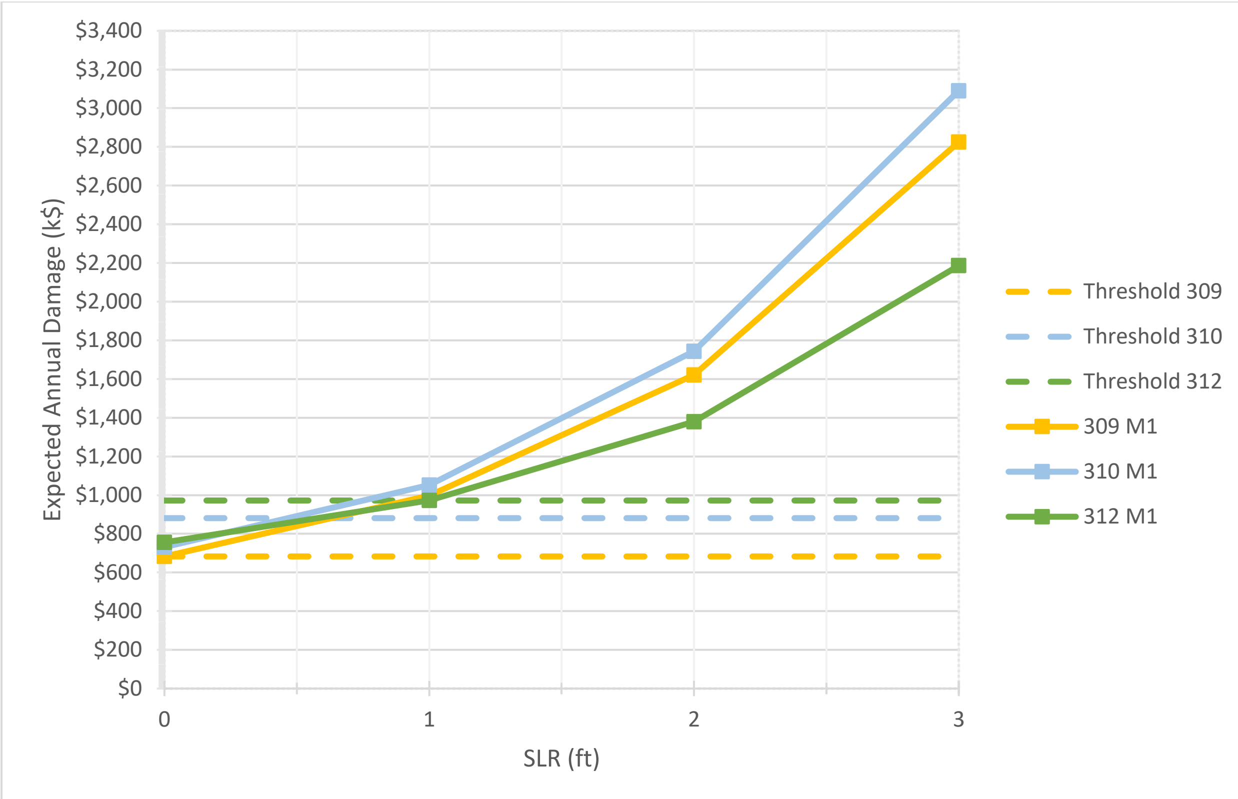

Figure A.1 C-8 Basin Census Tracts Estimated Annual Damages for Strategy M1 with 1-, 2-, 3-ft Sea Level Rise (ft, msl)

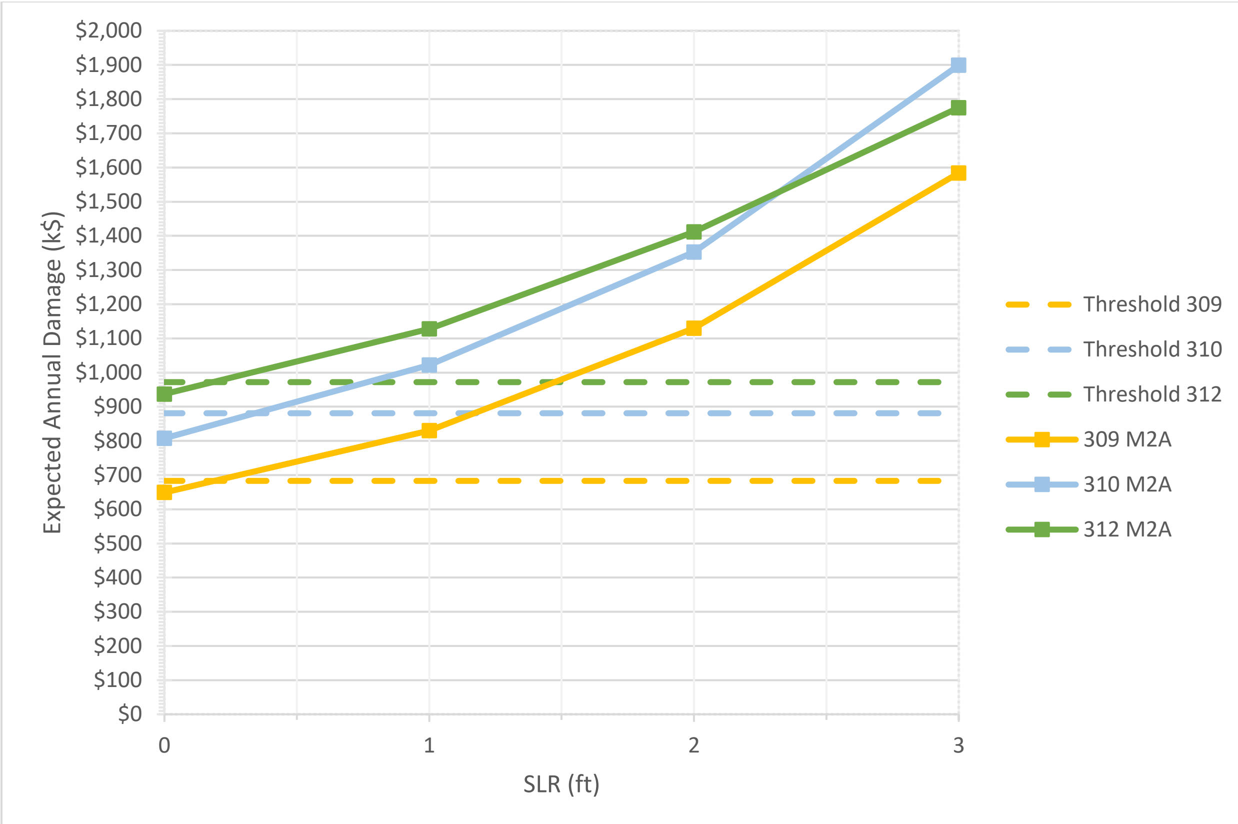

Figure A.2 C-8 Basin Census Tracts Estimated Annual Damages for Strategy M2A with 1-, 2-, 3-ft Sea Level Rise (ft, msl)

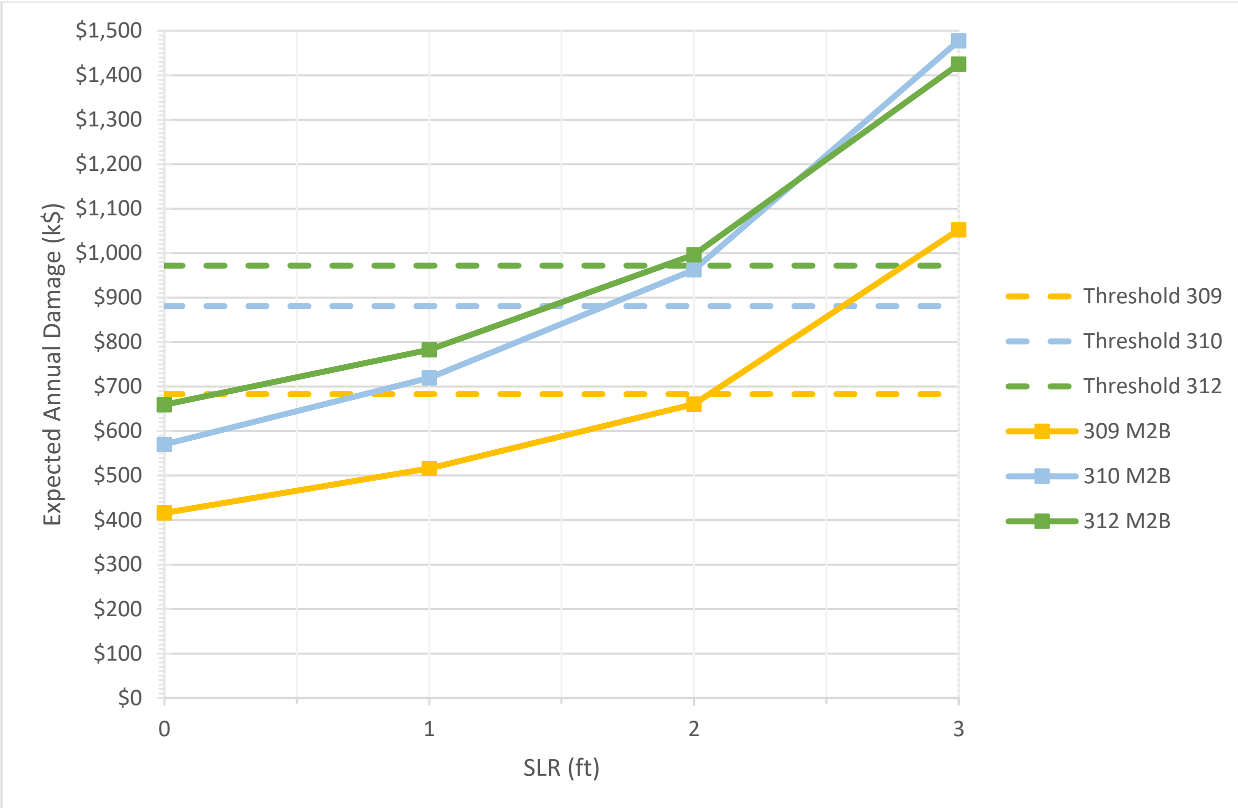

Figure A.3 C-8 Basin Census Tracts Estimated Annual Damages for Strategy M2B with 1-, 2-, 3-ft Sea Level Rise (ft, msl)

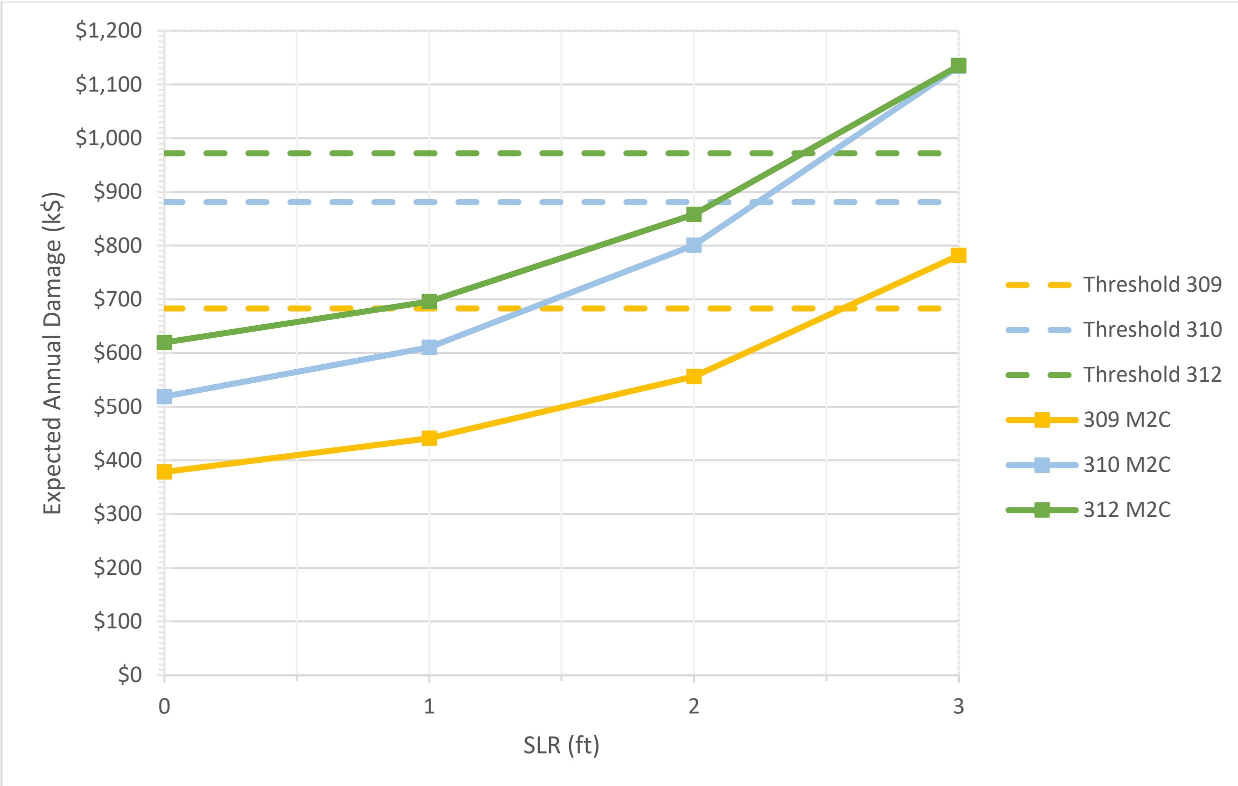

Figure A.4 C-8 Basin Census Tracts Estimated Annual Damages for Strategy M2C with 1-, 2-, 3-ft Sea Level Rise (ft, msl)

Table A.6 Thresholds and SLR Tipping Points for Census Tract 213, C-9 Basin

Mitigation Strategy	SLR (ft)	EAD (k $)	Tipping Point/SLR (ft) at Threshold
M0	**0**	**831.1 (threshold)**	N/A
	1	833.5	
	2	846.9	
	3	881.4	
M1	**0**	831.1	1
	1	833.5	
	2	846.9	
	3	881.4	
M2A	**0**	830.0	1.3
	1	832.4	
	2	837.2	
	3	845.9	
M2B	**0**	821.5	1.3
	1	825.1	
	2	829.8	
	3	830.1	
M2C	**0**	820.8	1.9
	1	823.0	
	2	829.6	
	3	830.9	

Table A.7 Thresholds and SLR Tipping Points for Census Tract 225, C-9 Basin

Mitigation Strategy	SLR (ft)	EAD (k $)	Tipping Point/SLR (ft) at Threshold
M0	**0**	**543.9 (threshold)**	N/A
	1	639.3	
	2	1050.7	
	3	2001.1	
M1	**0**	526.6	0.2
	1	623.6	
	2	1034.1	
	3	1980.7	
M2A	**0**	495.1	1.3
	1	524.0	
	2	596.0	
	3	862.3	
M2B	**0**	452.8	2.5
	1	455.0	
	2	489.0	
	3	605.6	
M2C	**0**	452.1	3
	1	452.9	
	2	466.5	
	3	537.5	

Table A.8 Thresholds and SLR Tipping Points for Census Tract 9602, C-9 Basin

Mitigation Strategy	SLR (ft)	EAD (k $)	Tipping Point/SLR (ft) at Threshold
M0	**0**	**1263.0 (threshold)**	N/A
	1	1549.9	
	2	2062.3	
	3	3018.1	
M1	**0**	1263.0	0.1
	1	1549.9	
	2	2062.3	
	3	3018.1	
M2A	**0**	1229.2	0.2
	1	1423.1	
	2	1773.7	
	3	2293.9	
M2B	**0**	985.6	2.1
	1	1049.9	
	2	1240.0	
	3	1563.3	
M2C	**0**	982.5	2.4
	1	1040.7	
	2	1169.7	
	3	1394.5	

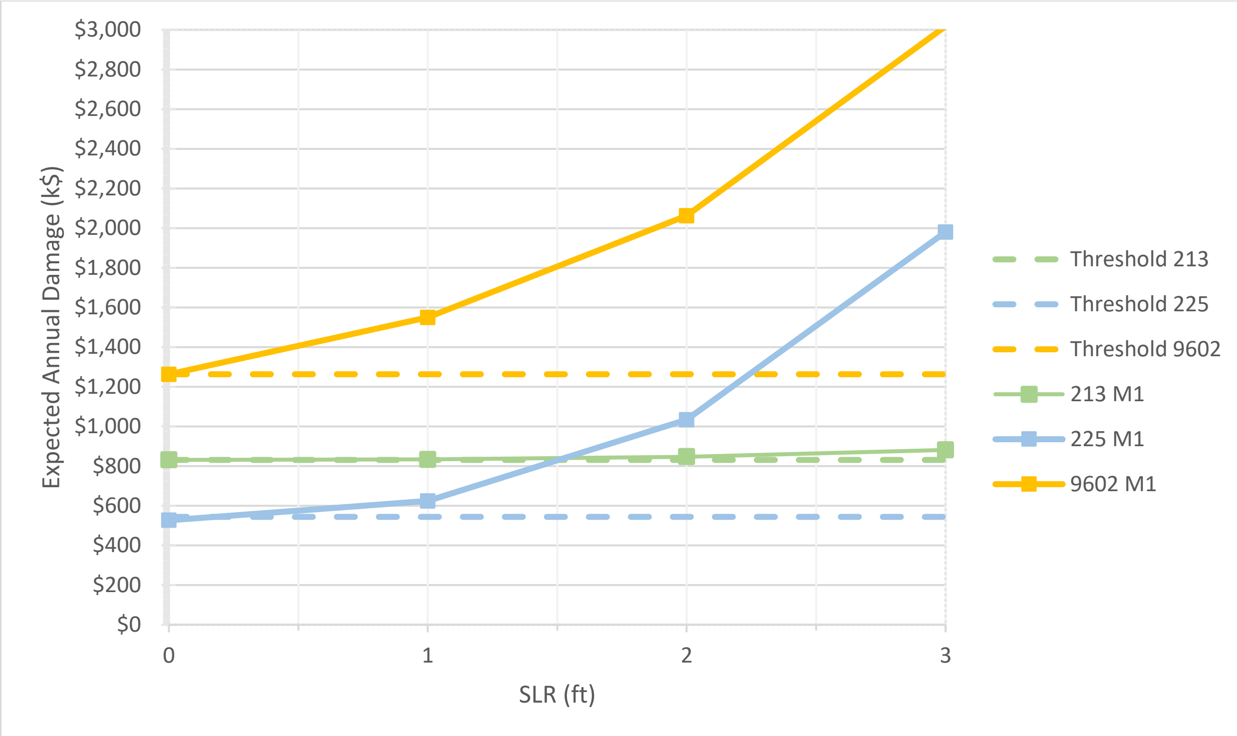

Figure A.5 C-9 Basin Census Tracts Estimated Annual Damages for Strategy M1 with 1-, 2-, 3-ft Sea Level Rise (ft, msl)

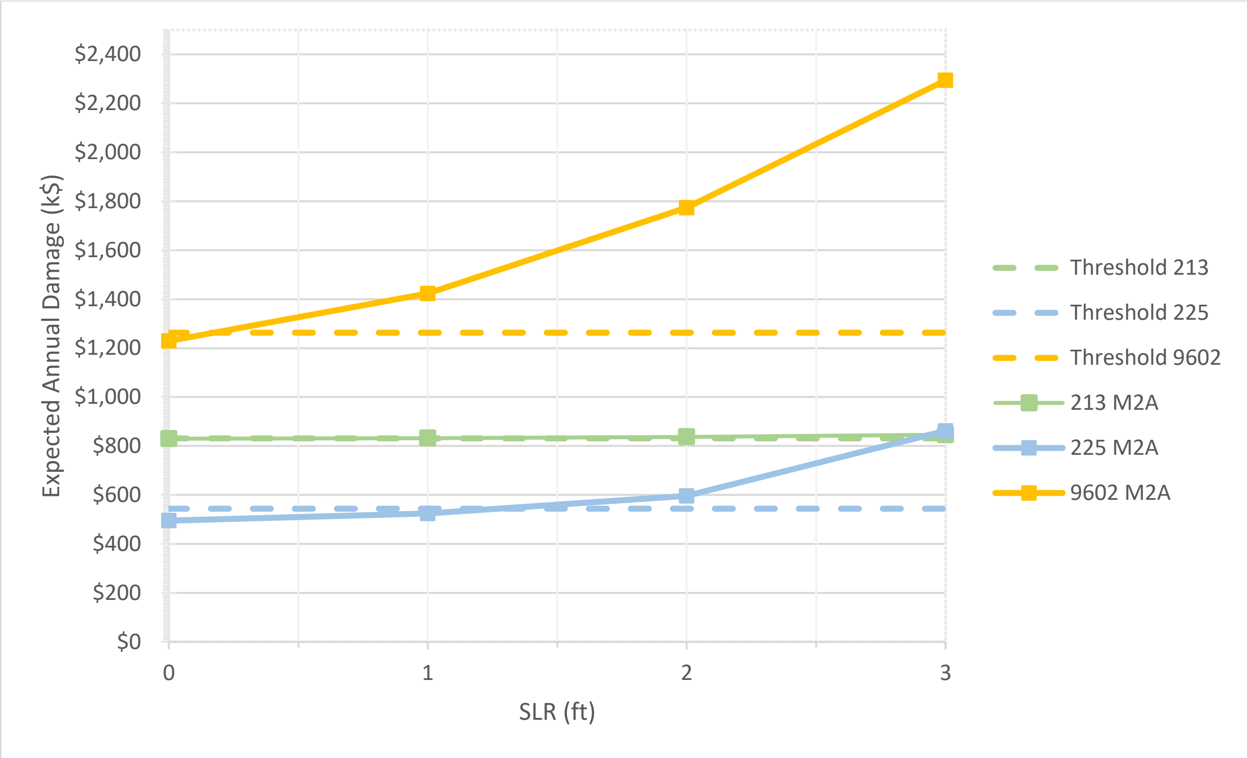

Figure A.6 C-9 Basin Census Tracts Estimated Annual Damages for Strategy M2A with 1-, 2-, 3-ft Sea Level Rise (ft, msl)

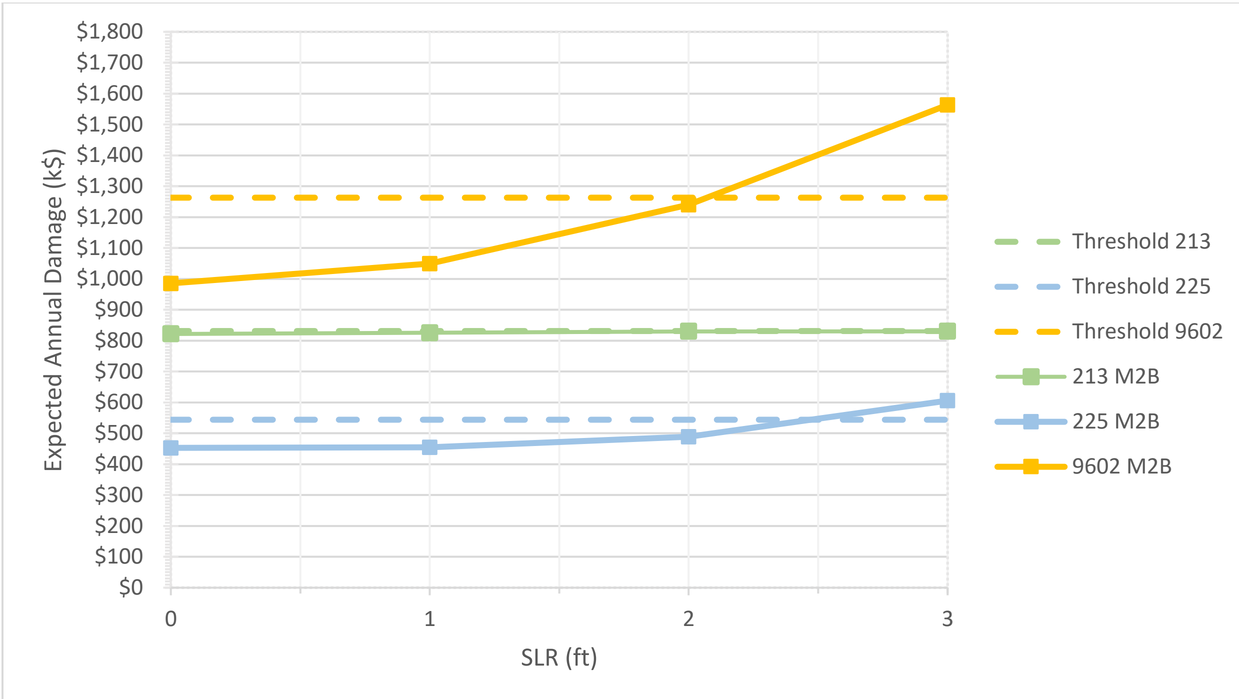

Figure A.7 C-9 Basin Census Tracts Estimated Annual Damages for Strategy M2B with 1-, 2-, 3-ft Sea Level Rise (ft, msl)

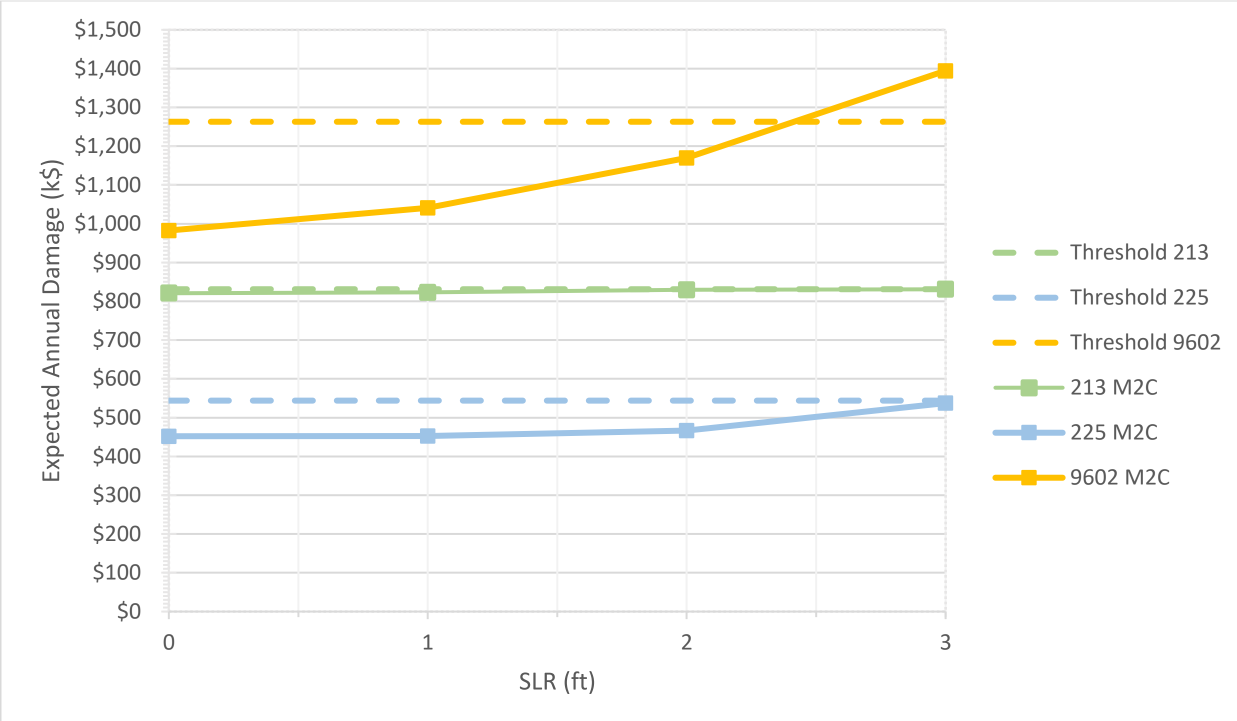

Figure A.8 C-9 Basin Census Tracts Estimated Annual Damages for Strategy M2C with 1-, 2-, 3-ft Sea Level Rise (ft, msl)