

Appendix A

Natural Valley Procedure for South Laguna Madre Watershed, Texas

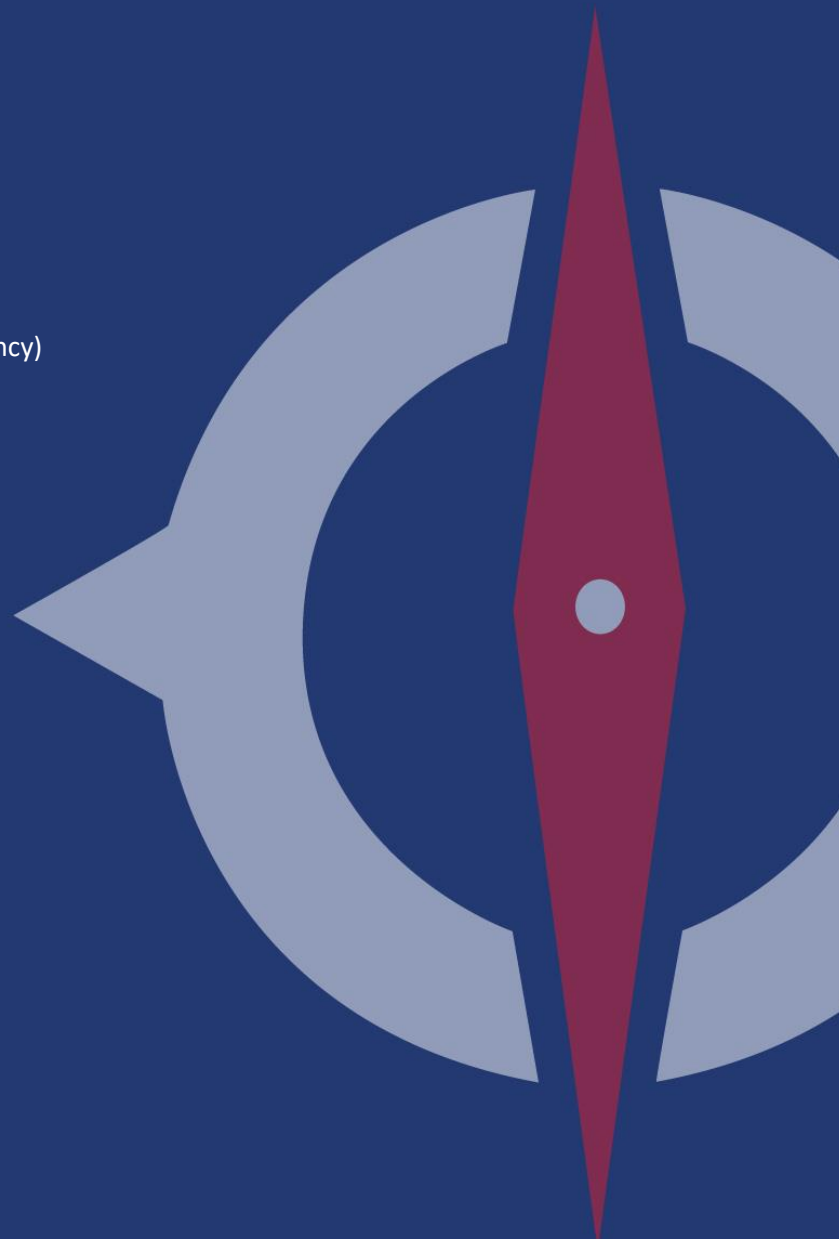
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Task Order 70FA6019F00000035
October 2021

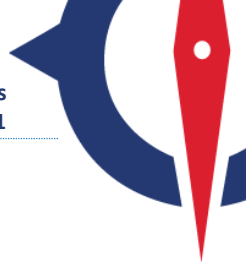
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CLIENT DISTRIBUTION

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FEMA's MIP	Region VI	See path above
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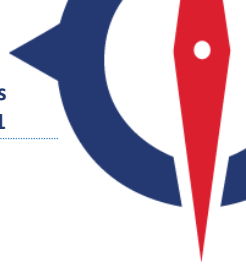


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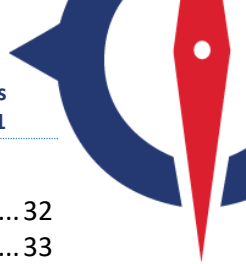


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01 Introduction/Project Overview

Compass prepared this document in accordance with FEMA Contract # HSFE60-15-D-0003, Task Order 70FA6019F00000035.

The purpose of this appendix is to detail the Natural Valley Procedure (NVP) that was performed in conjunction with the South Laguna Madre (SLM) HUC8 2D BLE study (12110208). All technical processes outlined in that report were followed for the hydraulic and hydrologic modeling to support this NVP. The model used for NVP scenarios was built from the Rio Grande Inflow Model developed as part of the SLM Study.

Levee reaches that do not meet the NFIP regulatory requirements of 44 CFR 65.10 and that are not shown on a FIRM as reducing the base flood hazard are deemed Non-accredited levee reaches per FEMA requirements. The NVP procedures are intended to study non-accredited levee reaches to help determine flood risk in the watershed. This procedure helps establish areas that can be flooded if the levee reach were to breach, overtop, or fail completely. The NVP was performed along all non-accredited levees within the South Laguna Madre HUC-8 watershed, obtained from the U.S. Army Corps of Engineers (USACE) National Levee Database (NLD) (February 2021).

In accordance with FEMA NVP process outlined in section 6.11 of the *Guidance for Flood Risk Analysis and Mapping – Levees*, the purpose of a NVP is to establish potential inundation locations that are outside Special Flood Hazard Areas (SFHA). Once established, the NVP can help determine additional risk areas within the modeled area. Area communities can then decide to proceed with further levee analysis and accreditation.

The NVP includes multiple scenarios based on each levee reach in the HUC. Since NVP is associated with identifying risk in addition to the SFHA, only the 100-year event was studied. The floodplains of each scenario are then combined to create a maximum floodplain extent for the HUC.

The project area included portions of the Rio Grande River, Main, North and Arroyo Colorado Floodways, which are included in the South Laguna Madre watershed, covering areas in Cameron, Hidalgo, Kenedy, and Willacy Counties. The study extents along the Rio Grande began just upstream of the city of Penitas and extended downstream to the Laguna Madre Bay and the Gulf of Mexico. Study stream lengths were 214.9 miles for the Rio Grande, 27.7 miles for the Main Floodway, 47.3 miles for the North Floodway, and 19.5 miles for the Arroyo Colorado. See **Exhibit 1** for a location map of the study stream extents.

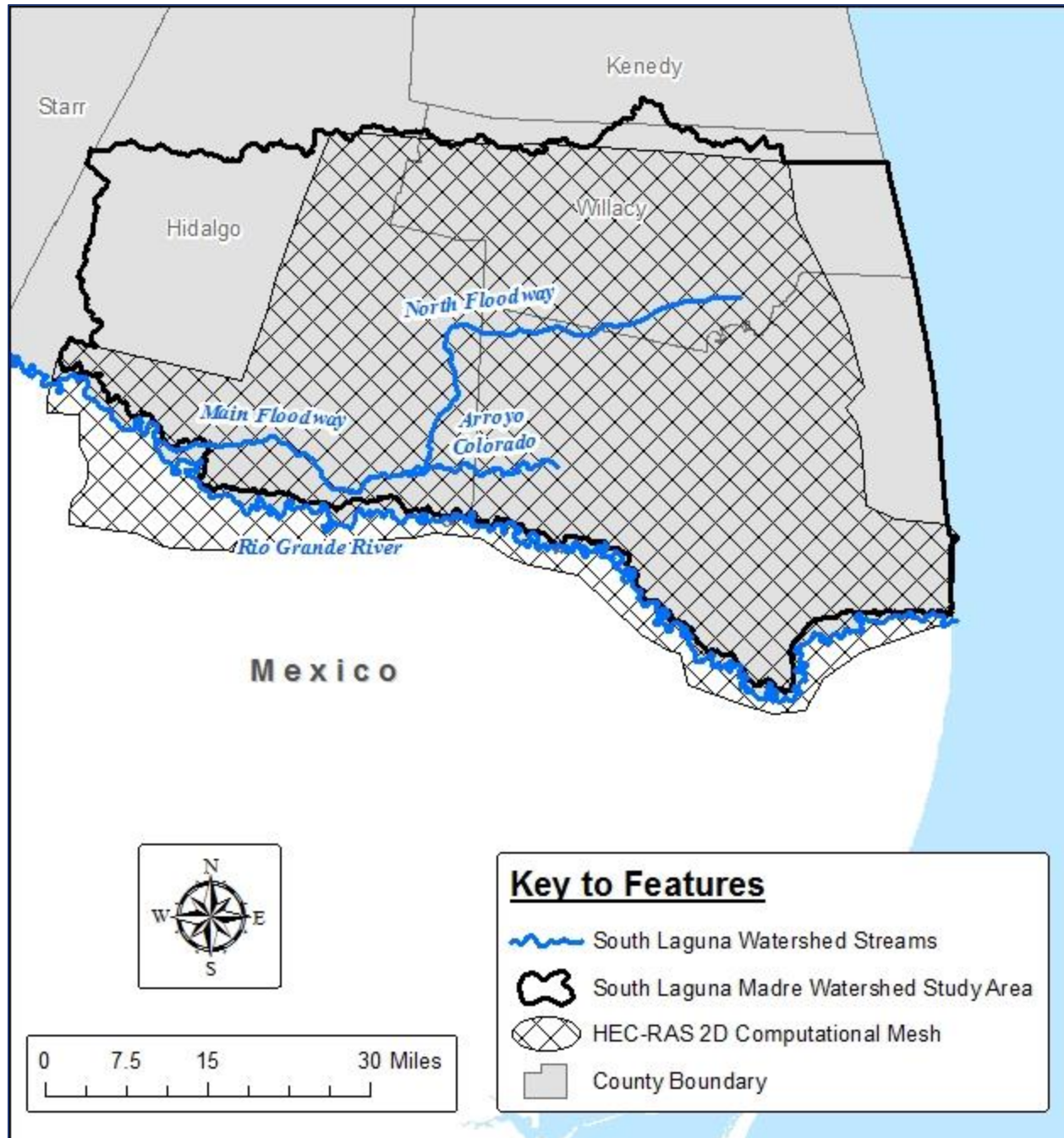


Exhibit 1: South Laguna Madre Natural Valley Procedure Study Streams



02 Natural Valley Approach

A natural valley approach was applied to all hydraulically significant non-accredited levees in accordance with FEMA's LAMP guidance. The NVP established an independent scenario for each of these levees that assumed full hydraulic conveyance on the landward side and assumed all other levee reaches remained in place.

Other NVP analyses have been done with 1D RAS models. The flat terrain and presence of the levee and floodway systems in this area require a 2D model approach to accurately depict the effects of storm events, particularly outside the banks of the levees where water typically ponds instead of moving downstream with the floodways.

All hydraulic modeling for this study was completed in the USACE's Hydraulic Engineering Center River Analysis System, version 5.0.7 (HEC-RAS). All reaches were modeled using 2D unsteady state analysis. Mesh grid size was set to 300 ft x 300 ft. The approximate run times for all 11 NVP models were between 10-18 hours. These parameters are consistent with the Rio Grande Inflow model associated with the main report.

There are 10 hydraulically significant non-accredited levee reaches identified from the National Levee Database (NLD), as of February 2021. These levee reaches are comprised of multiple NLD levee components, which have been simplified into grouped reaches for NVP analysis, in coordination with the US Section of the International Boundary and Water Commission (USIBWC) in the South Laguna Madre Watershed, listed in **Table 1**. The Rio Grande Inflow model developed for the watershed assumed all non-accredited levees remained in place. The HEC-RAS geometry associated with that model represented baseline conditions from which each independent natural valley scenario was developed. In addition to the 10 model runs for each levee reach, which removed individual levees from the terrain, a HEC-RAS model was also developed to include terrain modifications that modeled the effects of flooding as if all non-accredited levees were removed (named "All Levee Protection Removed"). This represents natural valley conditions for the entire system of levee reaches. See **Exhibit 2** below, showing all non-accredited levees within the study extents. Per Section 6.11 of the *Guidance for Flood Risk Analysis and Mapping – Levees*, only the event associated with the SFHA was mapped.

There are 12 areas identified by USIBWC where there is a known gap in a levee reach or there is a working project in the area. These are referred to as levee gaps, shown in **Exhibit 3** through **Exhibit 6**. If USIBWC identified gaps were at grade with the existing terrain, they were left at grade for all scenarios. This could cause leakage from the floodway in situations where the at-grade terrain is lower than the surrounding levee elevation. If a USIBWC levee gap appeared to be among a levee reach, not part of a roadway, irrigation channel, or other structure, then the assumption was made that these areas would be considered non-accredited and therefore removed during the natural valley procedure. For levee gaps that were part of ponding embankments or irrigation canals, no terrain changes were made during the natural valley procedure.

Levee segment breaks are in sections where the levees are not continuous but tied into existing terrain. These types of gaps, as seen in the Arroyo Colorado North levee reach, have large spacing between start and end points of the levee reach components. See **Exhibit 7**. - **Exhibit 16** for a visual representation of each levee reach with reach segment start and end points. For levee segment breaks, the high natural terrain was left in place for the NVP scenarios.



Table 1: South Laguna Madre Levee Reaches

Levee Reach	Levee Abbreviation	Length (mi)
Arroyo Colorado North	ACN	10.15
Lower Rio Grande Levees - I	LRGI	24.67
Lower Rio Grande Levees - II	LRGII	15.38
Lower Rio Grande Levees - III	LRGIII	50.72
Main Floodway and Arroyo Colorado South	MACS	37.77
Mission Levee	ML	22.93
North Floodway Left Bank - I	NFLI	33.45
North Floodway Left Bank - II	NFLII	25.42
North Floodway Right Bank - I	NFRI	17.38
North Floodway Right Bank - II	NFRII	27.08

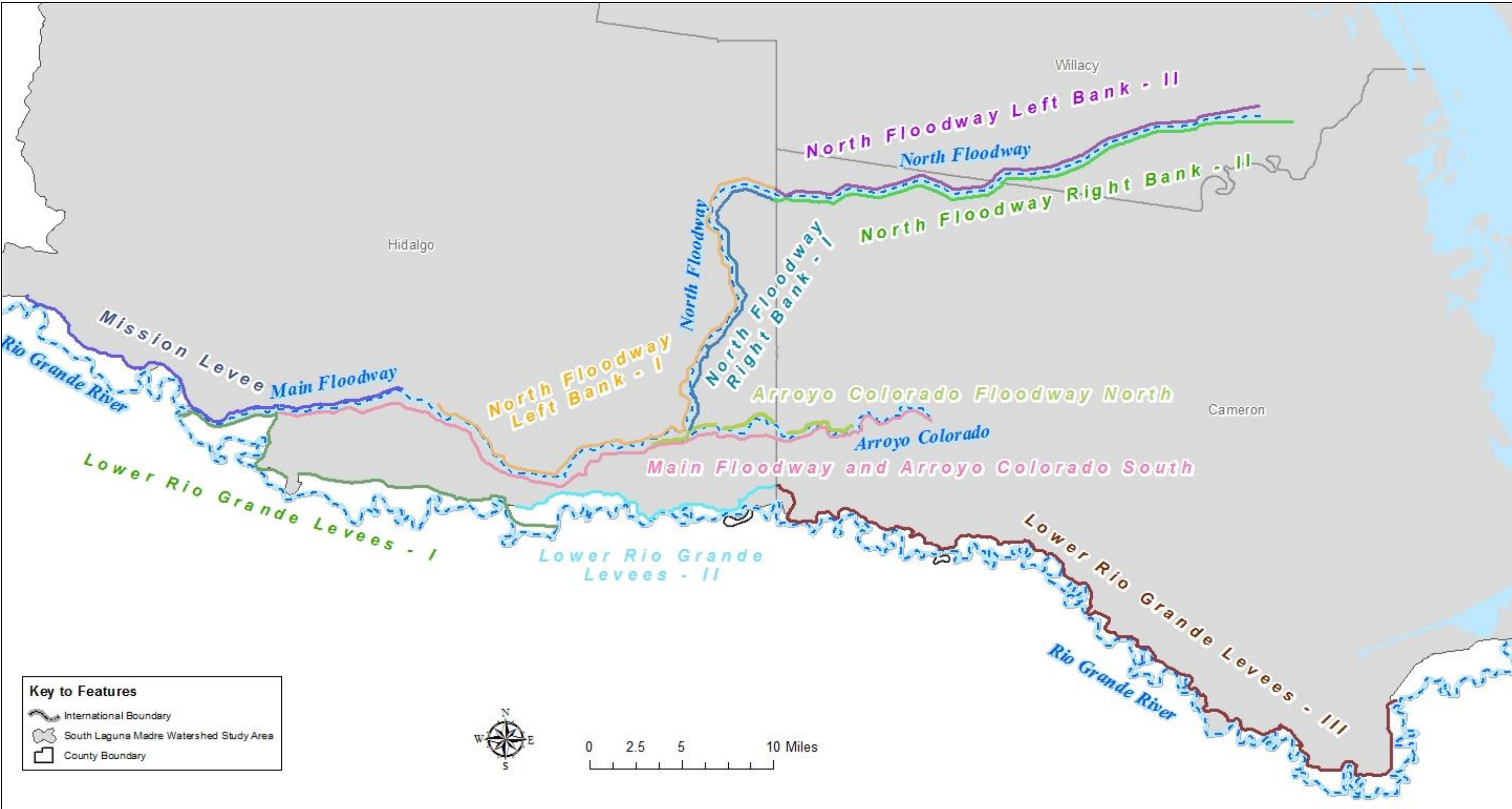


Exhibit 2: South Laguna Madre Levee Reaches

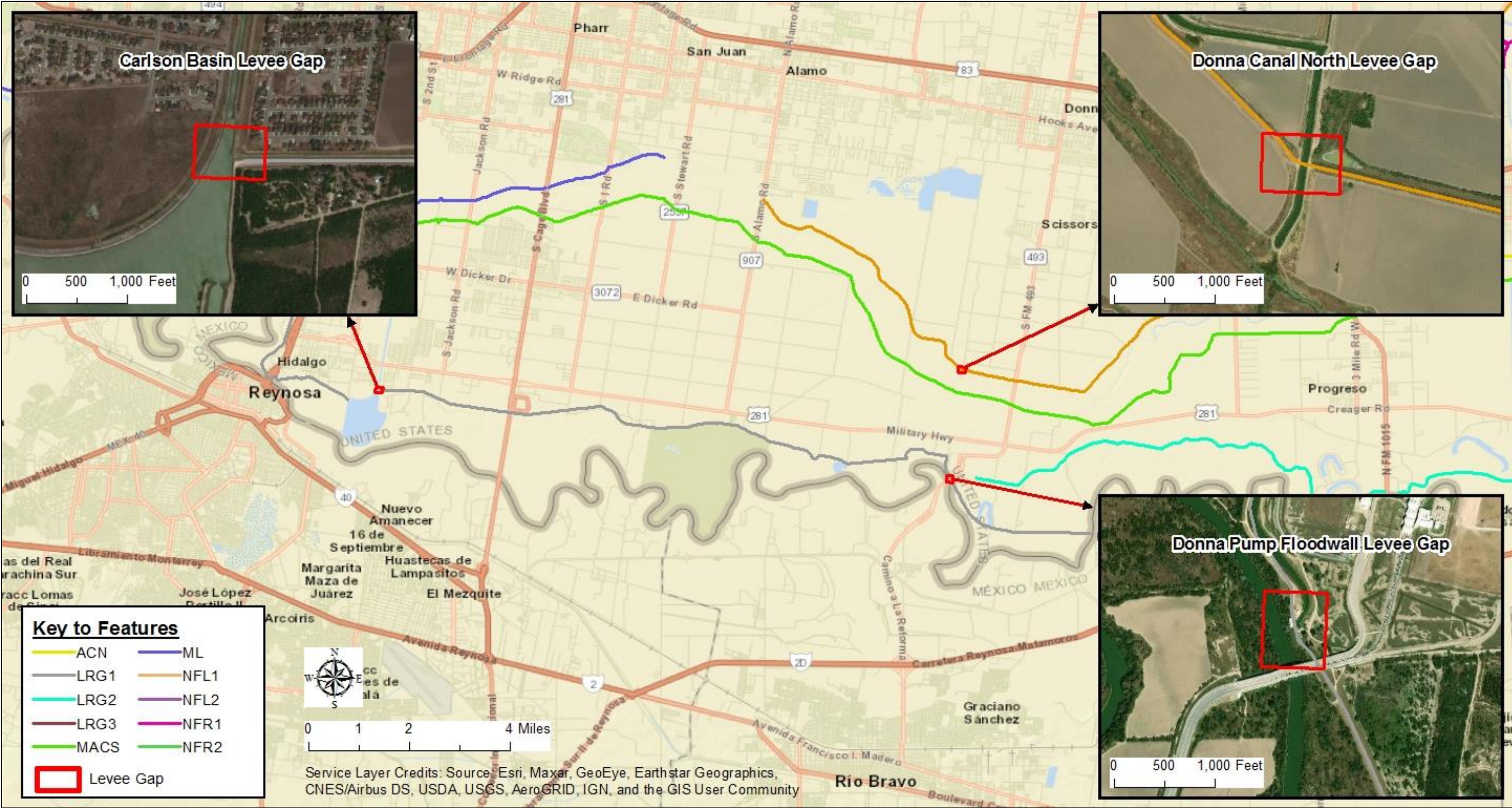


Exhibit 3: Gap Exhibit 1 of 4

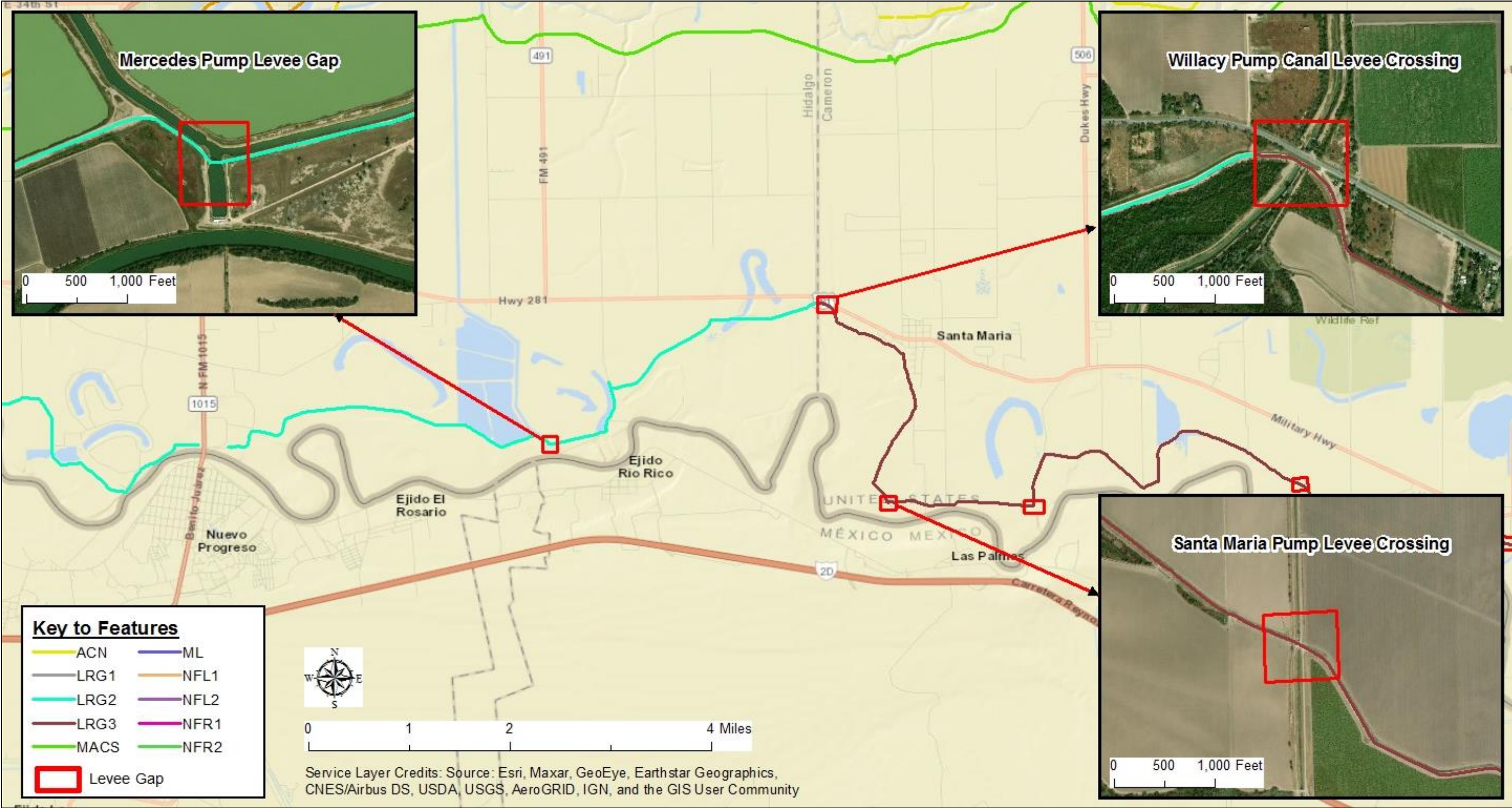


Exhibit 4: Gap Exhibit 2 of 4

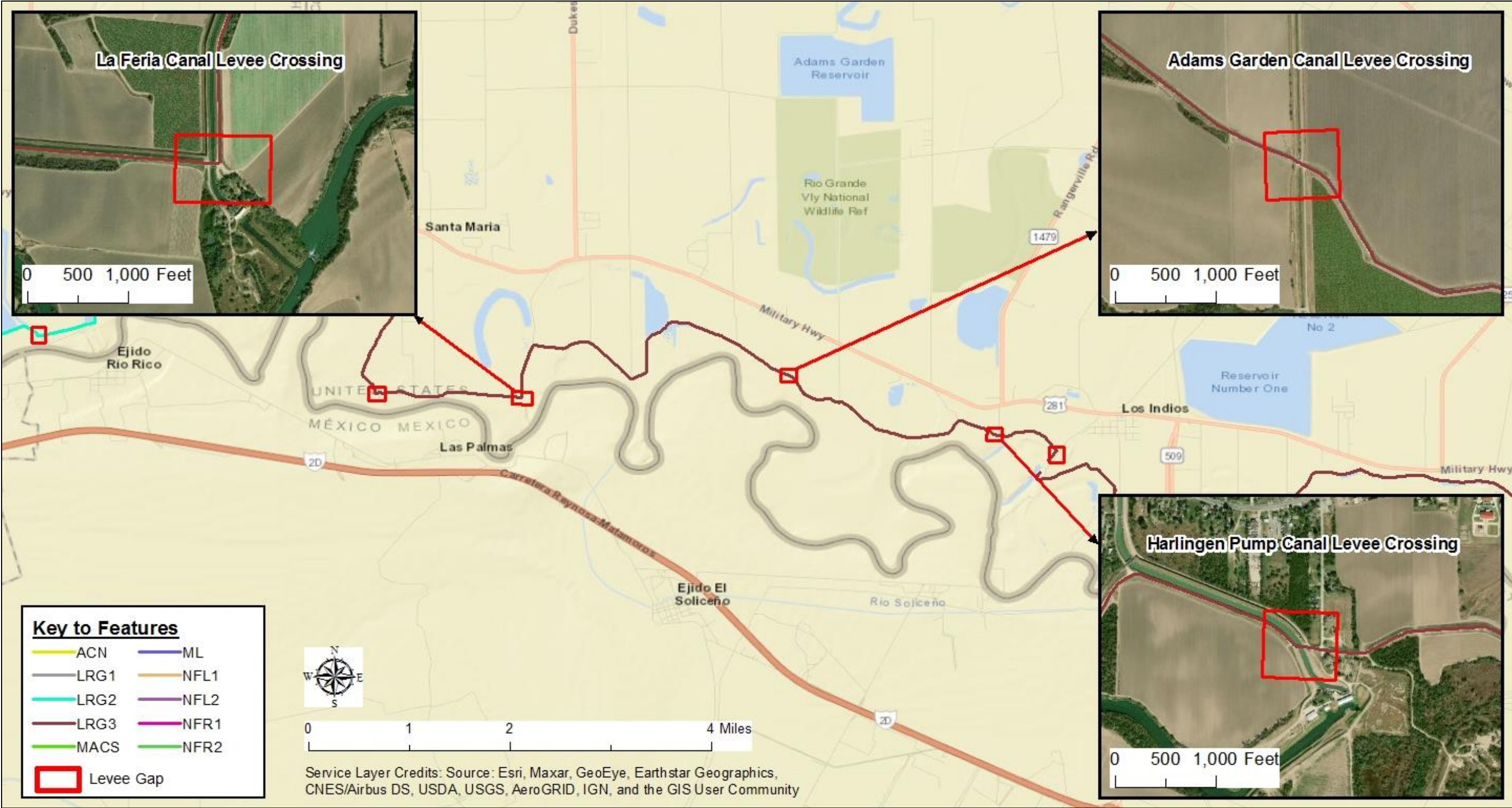


Exhibit 5: Gap Exhibit 3 of 4

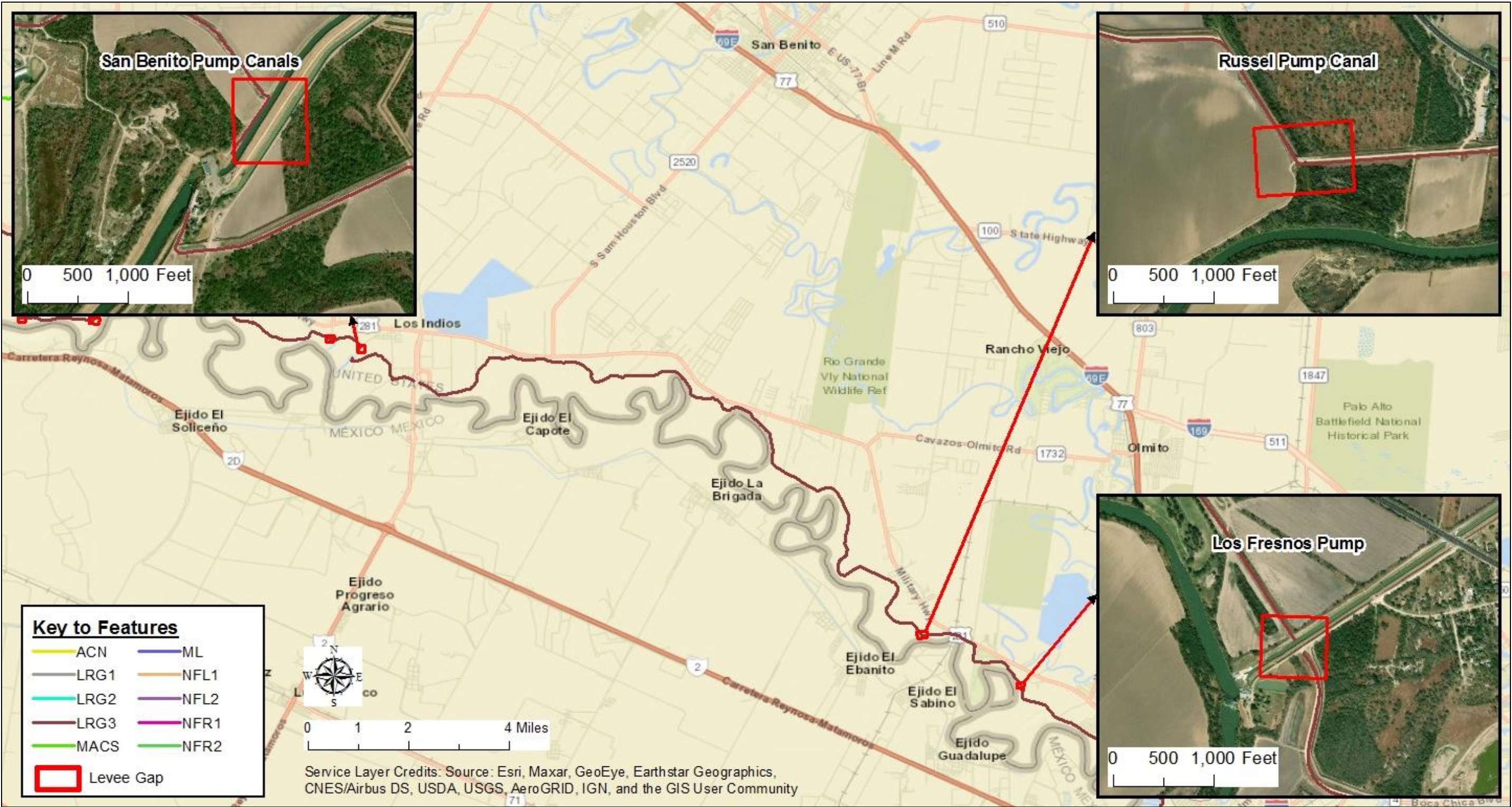


Exhibit 6: Gap Exhibit 4 of 4

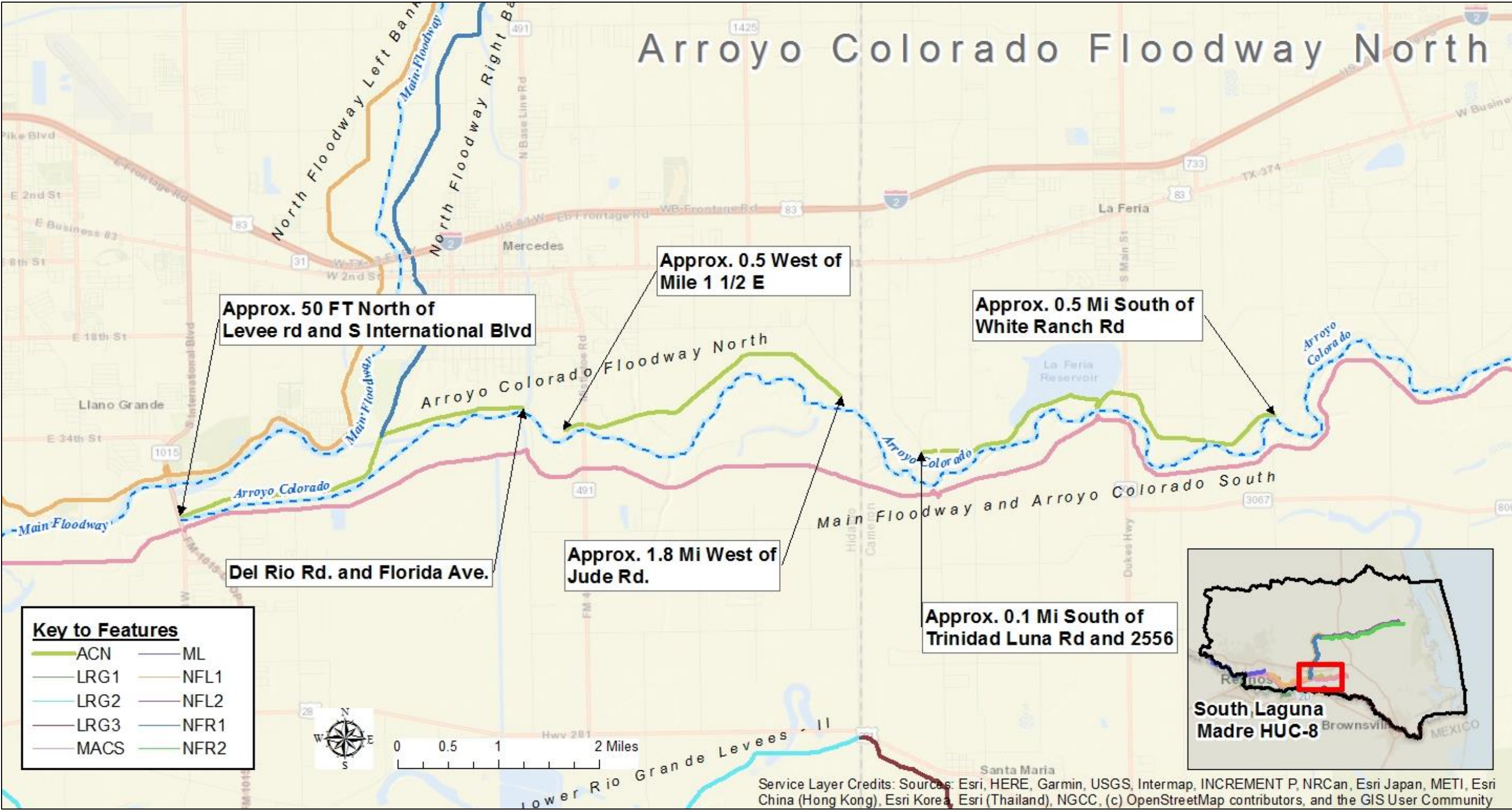


Exhibit 7: Arroyo Colorado Floodway North

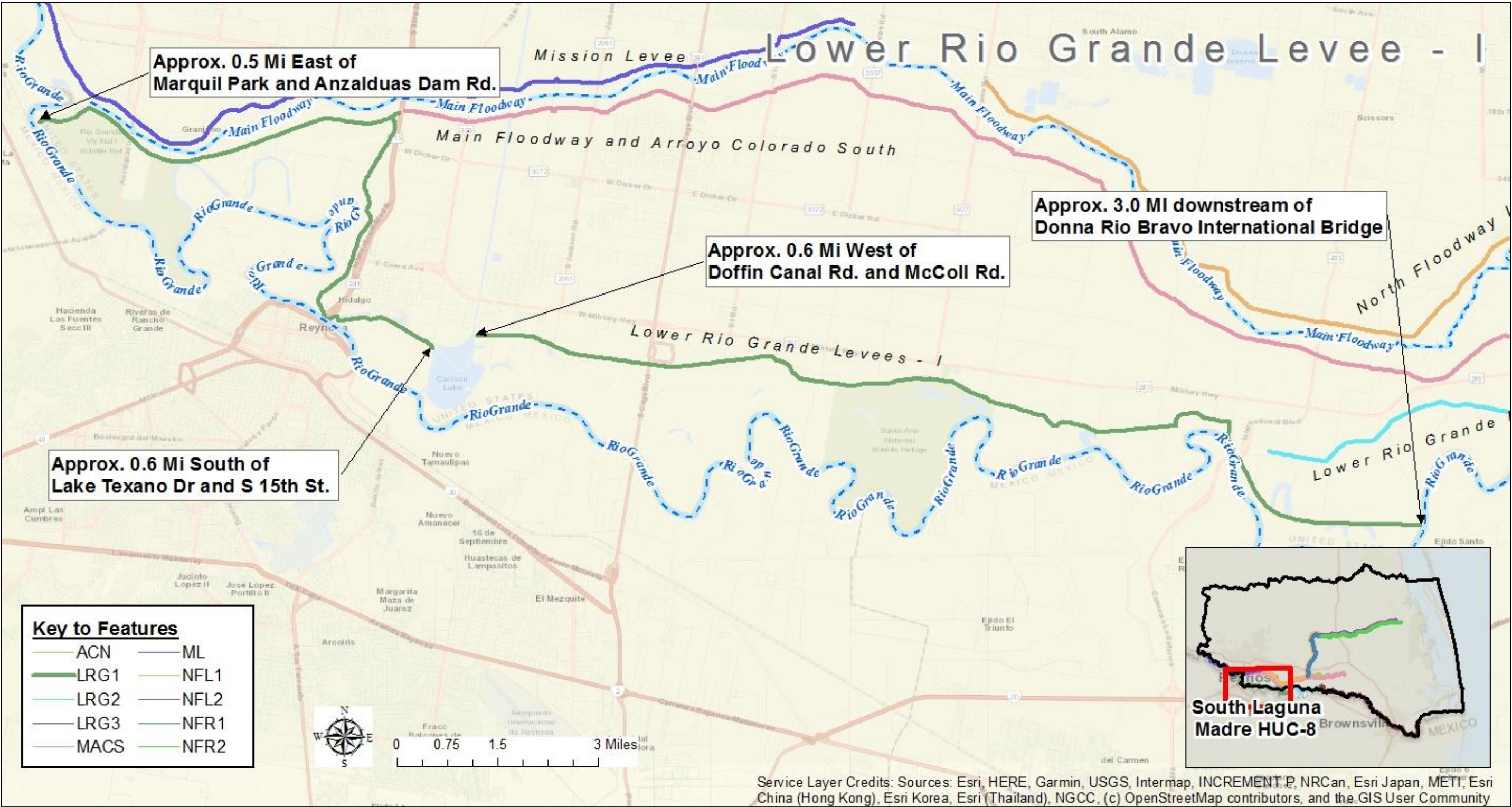


Exhibit 8: Lower Rio Grande Levee - I

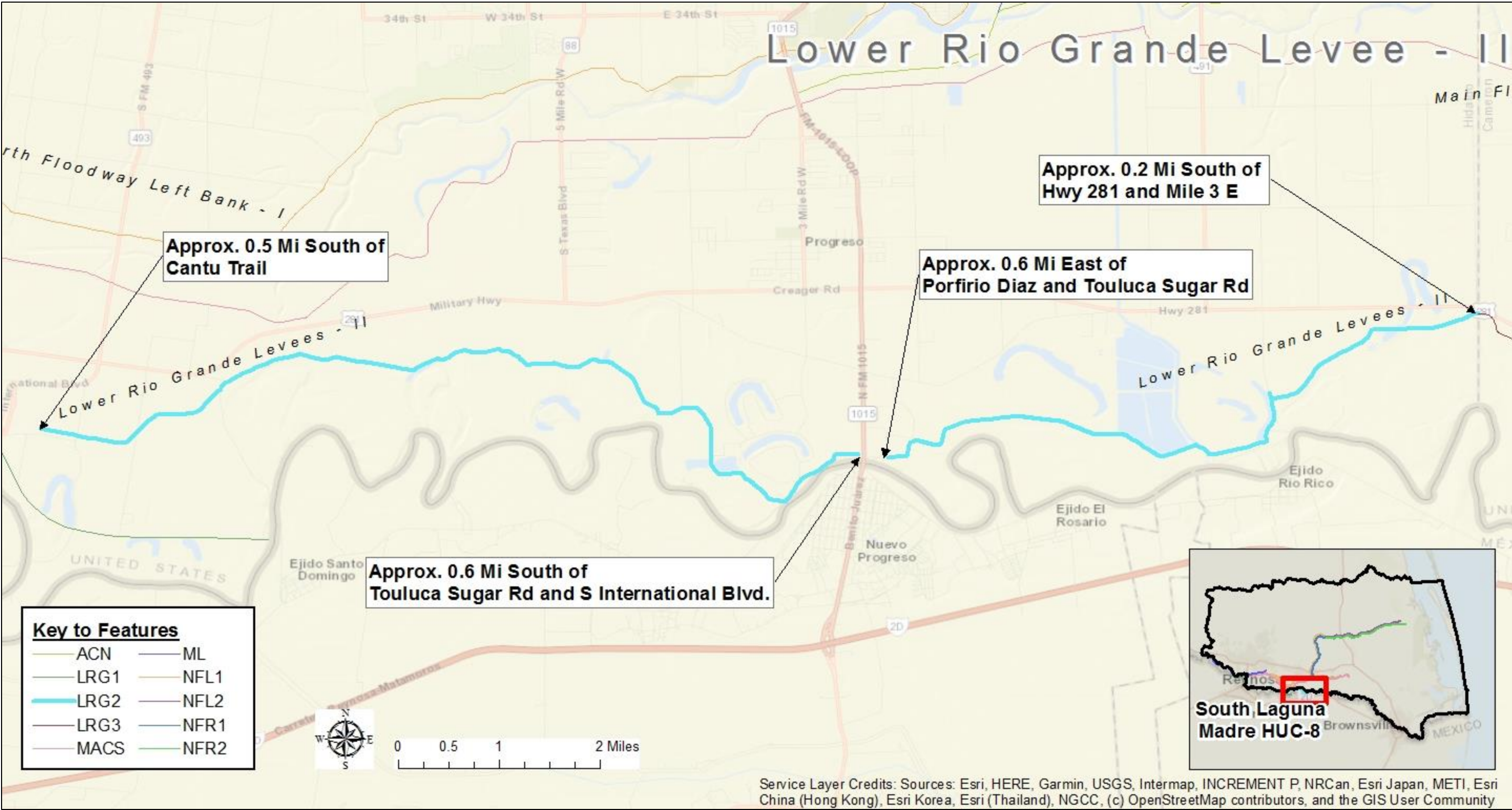


Exhibit 9: Lower Rio Grande Levee - II



Exhibit 10: Lower Rio Grande Levee - III

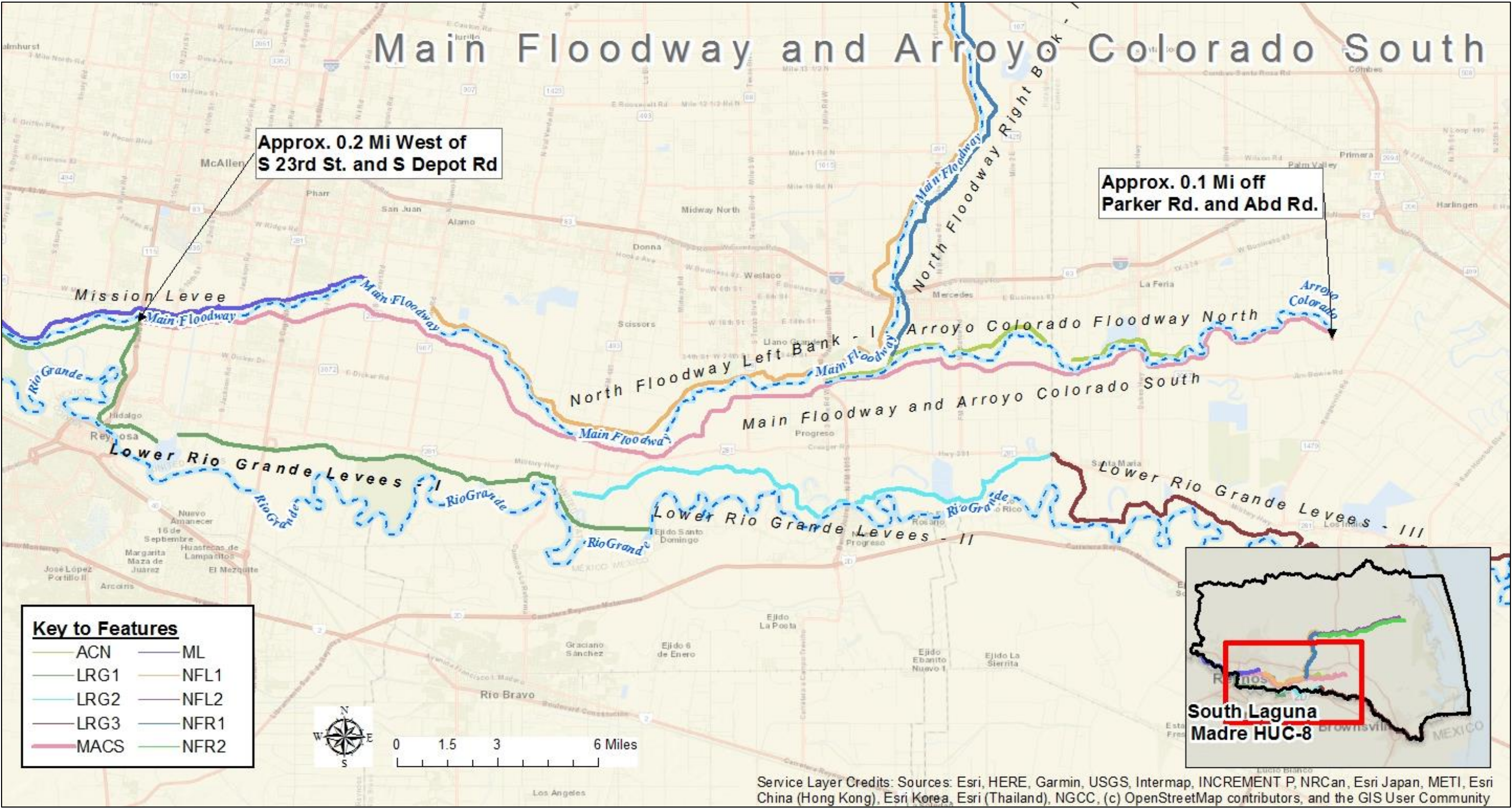


Exhibit 11: Main Floodway and Arroyo Colorado South



Exhibit 12: Mission Levee

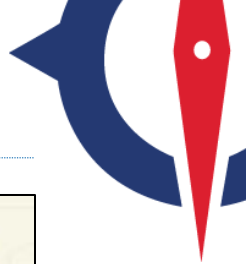


Exhibit 13: North Floodway Left Bank - I

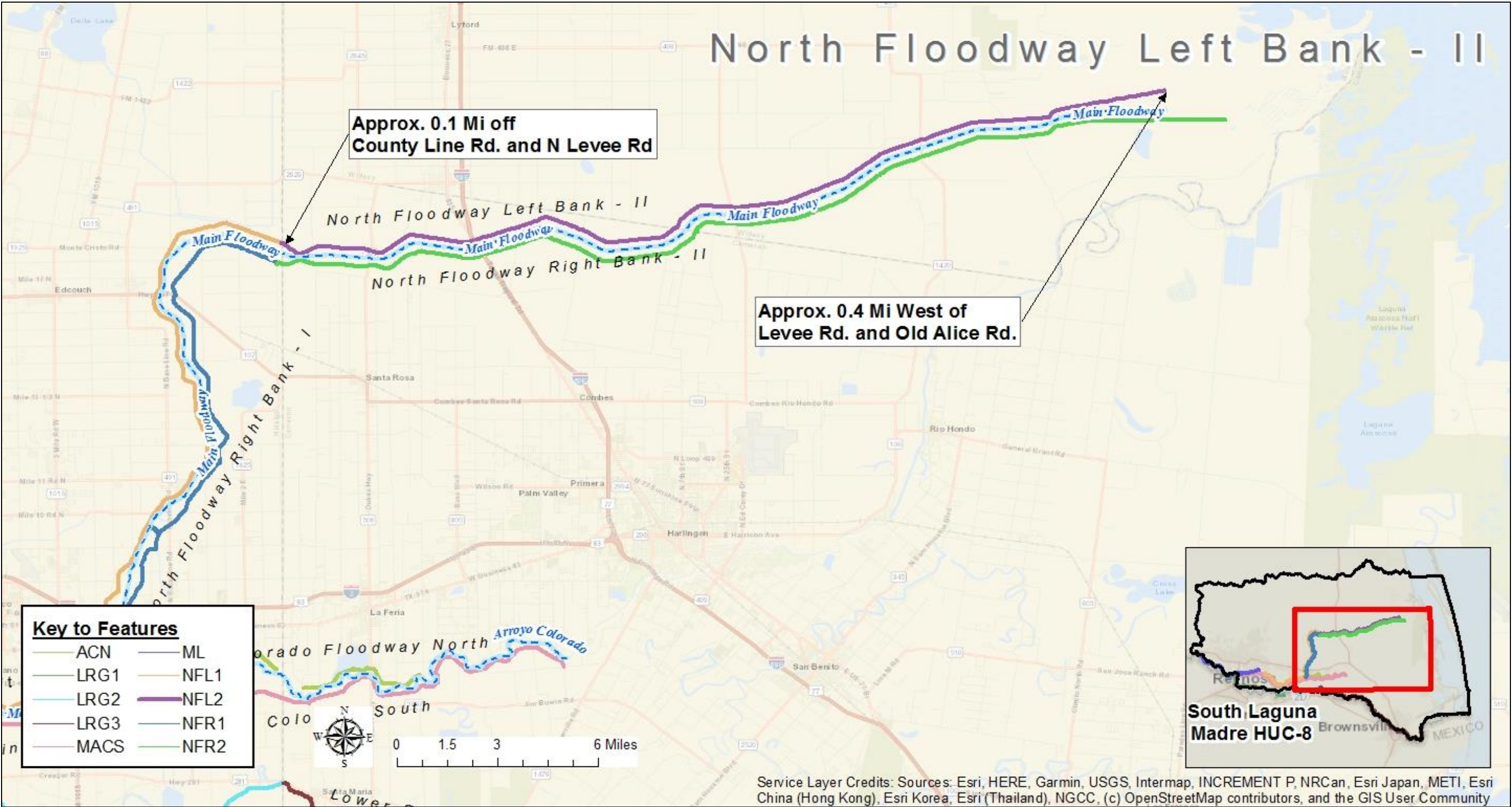


Exhibit 14: North Floodway Left Bank - II

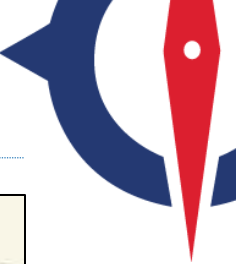


Exhibit 15: North Floodway Right Bank – I

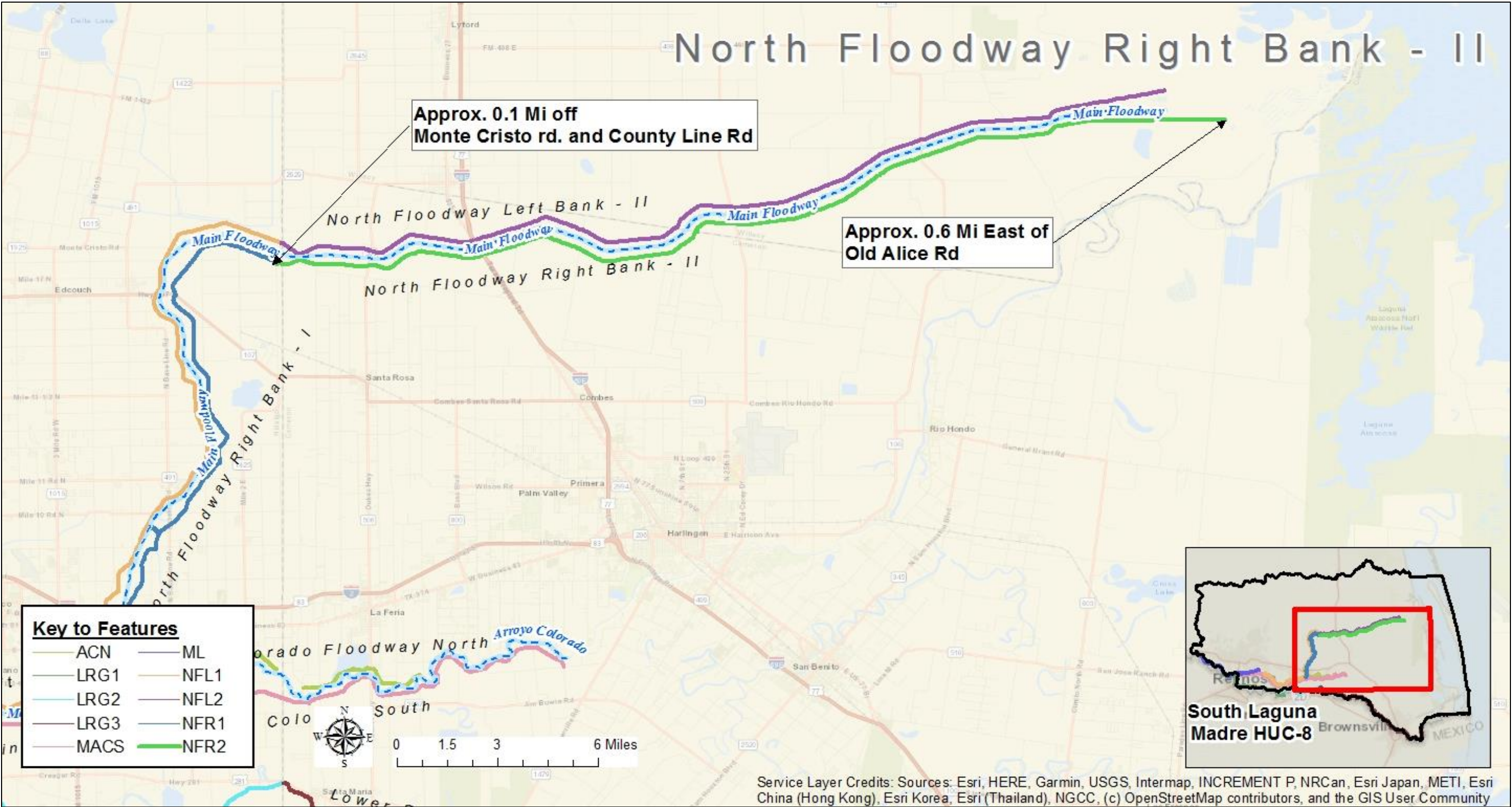
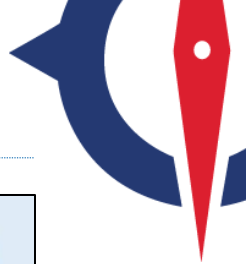


Exhibit 16: North Floodway Right Bank – II



For an NVP, FEMA recommends leaving the topographic features of the levee in place if doing so would not allow for the obstruction of lateral flow. As stated below:

“Using the Natural Valley Procedure, the Project Team will model the flooding along the levee reach by allowing the discharge to flow freely on either side of the levee for the entire levee reach. The levee will not impede conveyance in the model. For riverine levee reaches, topographic features of the levee should be in-place in the model if possible, but not allowed to obstruct lateral flow.” (FEMA, December 2020).

One-dimensional NVPs are able to remove levee stations within geometry to remove the levee protection. For this project area landward flooding does not follow the main channel flow patterns and are heavily impacted by lateral flows. Topographic removal of the levees provided a better representation of the natural valley condition and allowed lateral flow of the floodway system. Removing the levees, rather than adjusting the breaklines and cells to force leakage provided a consistent geometry for all the natural valley scenarios for better comparisons.

To accomplish a consistent topographic removal of the levees, the terrain was artificially dropped between the base of the levee on the landward side and the base of the levee on the water side. Sections of terrain were adjusted within 3ft intervals based on the elevation of the landward side elevation. High points that were not identified as part of the levee reaches were left in place for all terrain modifications. These areas include roadways and high natural grade. **Exhibit 17 and Exhibit 18** below is an example of levee reach removal.

As previously mentioned, each of the 11 modeled scenarios represented a removal of levee protection from the terrain. They are labeled for the levee reach protection removed. The base model associated with each levee reach NVP is the Rio Grande Inflow model. For every levee reach NVP, the selected levee reach is removed while all other levee reaches are left in place. This process of modeling each reach separately allows for future mapping partners to work on one reach at a time. In addition to the 10 levee reaches, another NVP was performed on the entire network of levee reaches and is referred to as the “All Levee Protection Removed” scenario. In this model the terrain was adjusted to remove all levee reaches. The analysis and results of the “All Levee Protection Removed” differs from the overall combined mapping associated with the individual levee reaches NVP labeled “All NVP Scenarios.” These differences can be seen in **Exhibit 19** and **Exhibit 30** respectively. All associated NVP terrains are provided within each NVP HEC-RAS model.

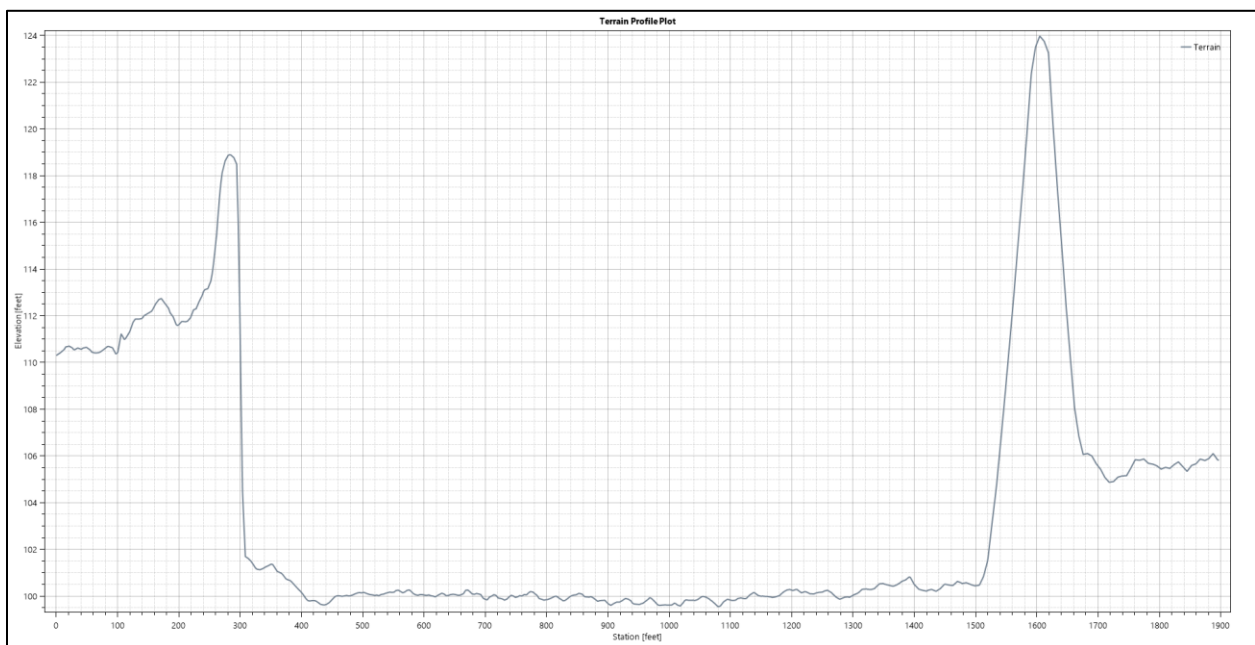
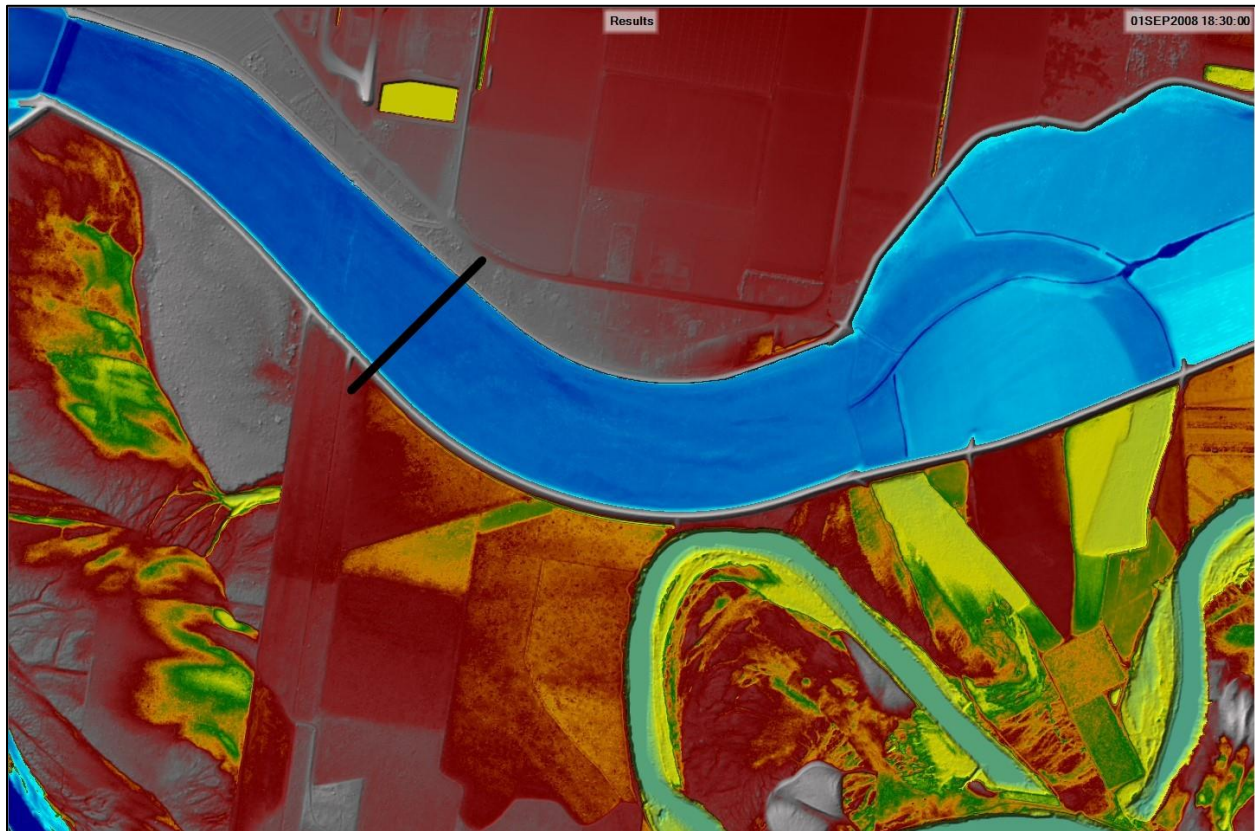


Exhibit 17: Example Levee Reach In Place

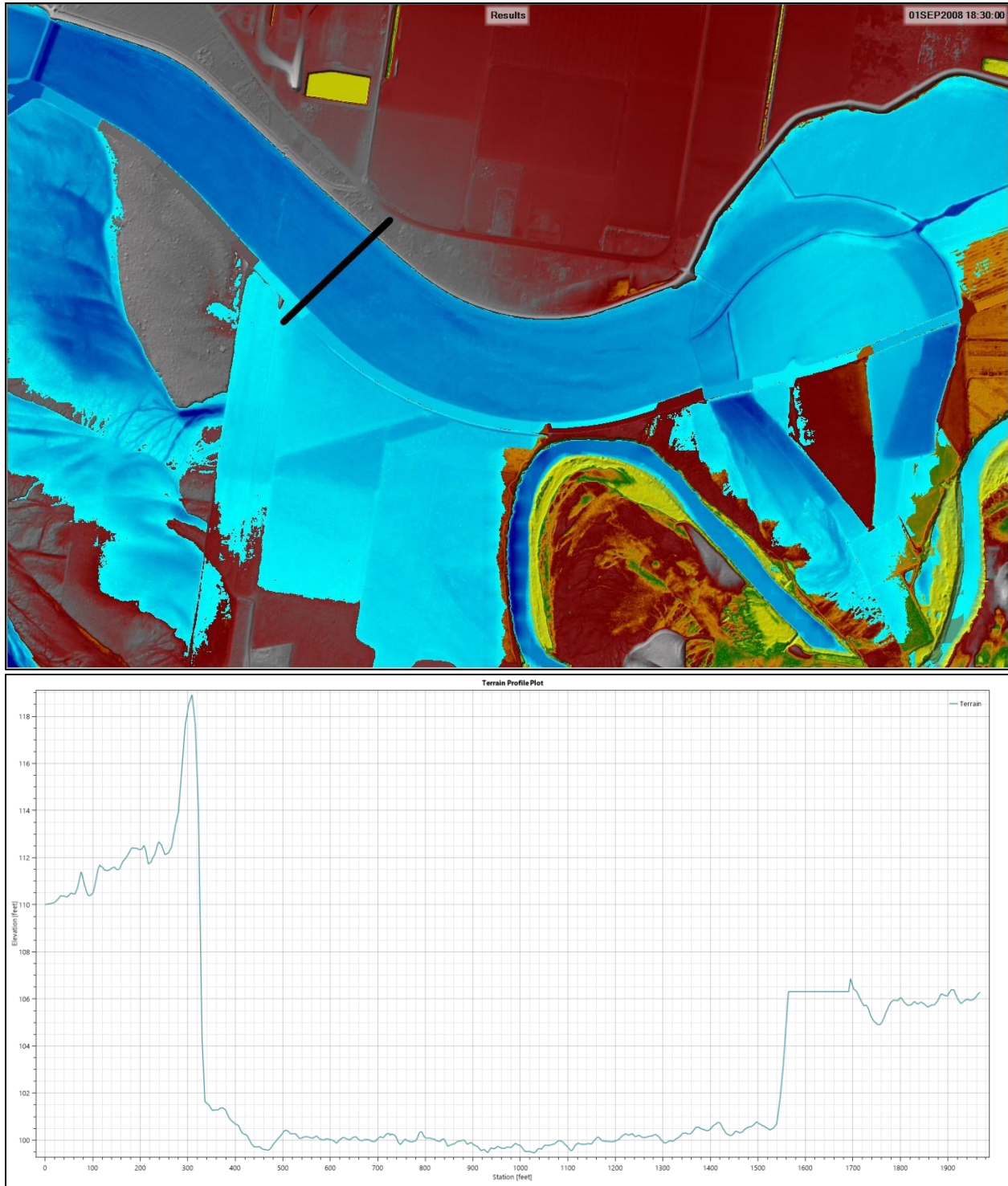


Exhibit 18: Example Levee Reach Removed



03 Results

The BLE SFHA mapping is based on hydrologic data with hydraulically significant topographic features as detailed in the SLM report. The results of this NVP provides the community with the additional risk boundaries associated with a levee reach failure. Inundation boundaries for the 100-year event and the related depth and water surface elevation grids were provided with this report for all 11 scenarios. A combined mapping inundation area was also provided. Mapping was not refined to typical BLE standards but shows the potential impact area for the Natural Valley procedure. Eleven (11) NVP 2D models have been provided representing each scenario event.

NVP results show multiple areas of increased flood risks for large population areas throughout the South Laguna Madre watershed based on the floodplain mapping comparisons of the NVP and the BLE 100yr SFHA. The communities most impacted by each levee reach NVP are identified in **Table 2**.

Exhibit 19 - Exhibit 30 show floodplain mapping for each Natural Valley Scenario as well as the FEMA 2D BLE 100-year mapping from the SLM study.

Multiple assumptions were made to account for dam and sluice gate operations, as well as structure elevation and gaps in terrain.

At Anzalduas Dam, a missing structure was identified where flow was leaving the reach, which was assumed to be contribution to an irrigation channel. Another structure was incorporated at the confluence of a stormwater channel and the main floodway, located 1,155 feet southwest of West Hall Acres road. Both structures were incorporated to prevent flow from freely leaving the floodway systems. Terrain was also adjusted along the Rio Grande at Anzalduas Dam as raised terrain to normal pool elevation, to match design flows for the Main Floodway.

When available, incorporating new LiDAR to the model, especially for the Mexico portion of the project area, will provide more detailed results. The modeling approach for the structures was also limited and additional detail should be added in the future to better represent the geometry and the conveyance at these approximated areas. This includes surveyed structure data, Anzalduas and Retamal dam operations and sluice gate operations.



Table 2: Natural Valley Process Impacts per Community

Communities	Levee System									
	Arroyo Colorado North	Lower Rio Grande Levees - I	Lower Rio Grande Levees - II	Lower Rio Grande Levees - III	Main Floodway and Arroyo Colorado South	Mission Levee	North Floodway Left Bank - I	North Floodway Left Bank - II	North Floodway Right Bank - I	North Floodway Right Bank - II
Combes	✓					✓			✓	✓
Donna							✓			
Edcouch							✓			
Harlingen	✓	✓	✓	✓	✓	✓			✓	✓
Hidalgo		✓			✓					
La Feria									✓	
La Villa						✓	✓	✓		
Llano Grande							✓			
Lyford							✓	✓		
McAllen						✓				
Mercedes	✓					✓	✓		✓	
Mission						✓				
Palm Valley									✓	
Palmview						✓				
Pharr		✓			✓					
Primera	✓								✓	✓
Progreso Lakes			✓			✓				
Progreso		✓	✓		✓	✓				
Rangerville		✓	✓	✓	✓	✓				
Raymondville							✓	✓		
Rio Hondo	✓								✓	
San Benito	✓	✓	✓			✓				
San Juan		✓	✓	✓	✓					
San Perlita							✓	✓		
Santa Maria				✓						
Santa Rosa						✓			✓	✓
Scissors							✓			
Weslaco						✓	✓			



04 Considerations for Future Mapping Partners

The South Laguna Madre Natural Valley Procedure was developed to provide potential inundation areas to depict the flood inundation limits of the natural valley of the floodplain if the levees were not in place and identify and communicate these potential risks. In the South Laguna Madre 2D BLE study, the NVP floodplains were not included in the mapping product and therefore do not show the full level of risk that may be present. The BLE results excluded the NVP floodplains to provide separate, complimentary, datasets which can be leveraged and combined with more detailed modeling scenarios. This supplemental report is intended to provide area communities with additional understanding of risk associated with the non-accredited levee reaches, as well as an opportunity to support future refinement and improvements to be the technical basis for accreditation submittals or mapping updates.

05 References

1. FEMA, “Guidance for Flood Risk Analysis and Mapping – Levees”, December 2020 (https://www.fema.gov/sites/default/files/documents/fema_levee-guidance.pdf).

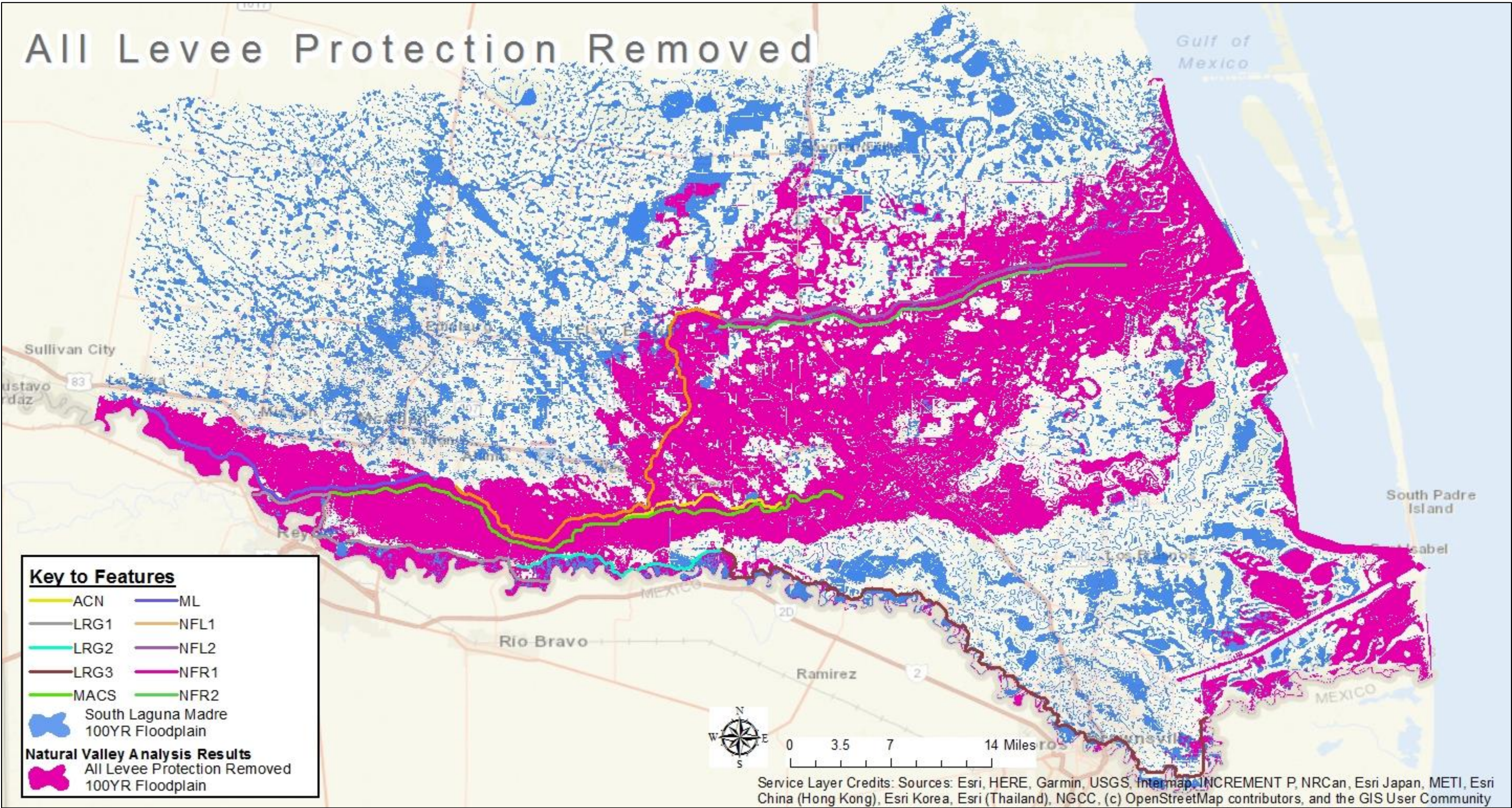


Exhibit 19: All Levee Protection Removed 100-year Depth

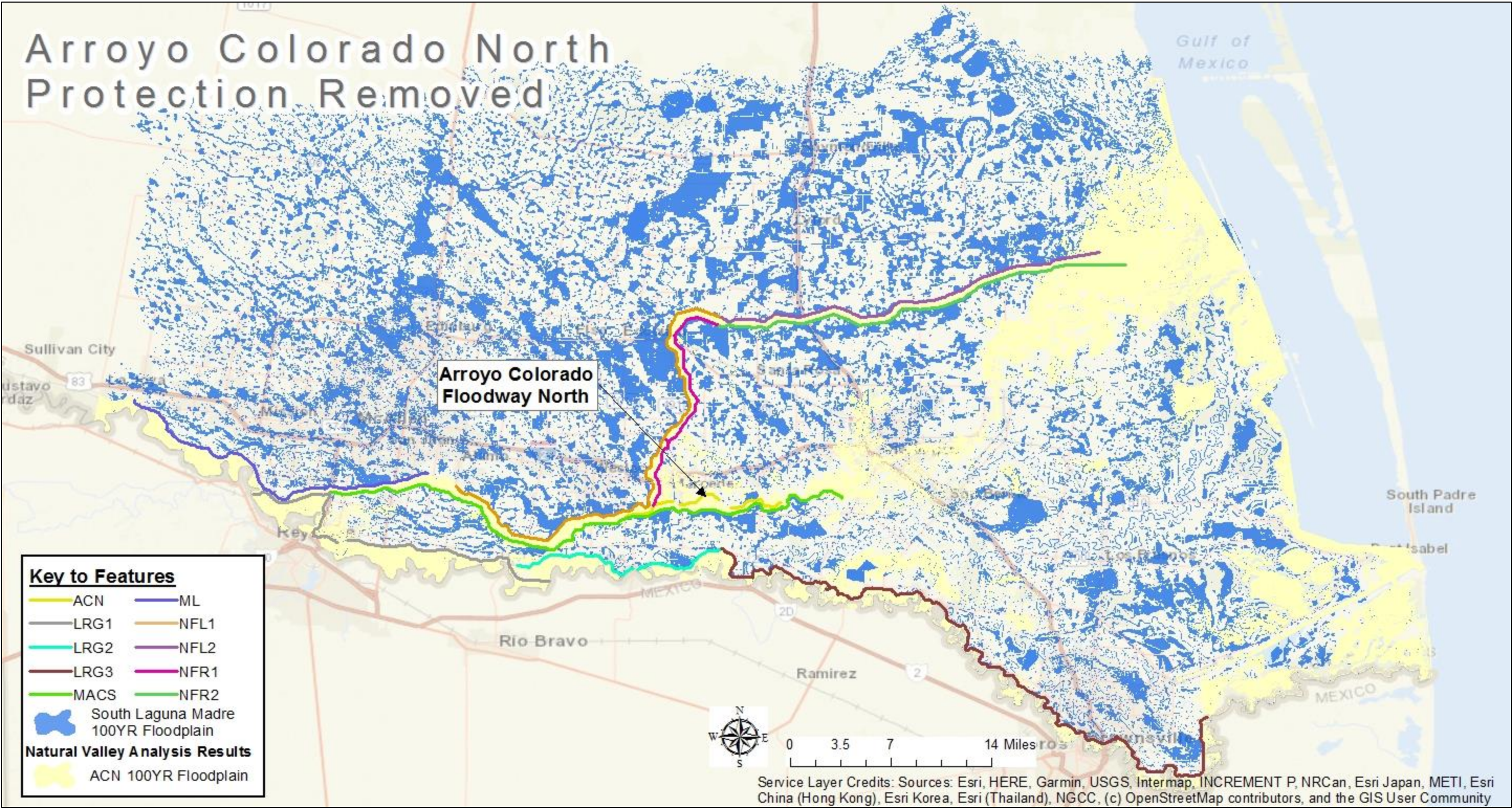
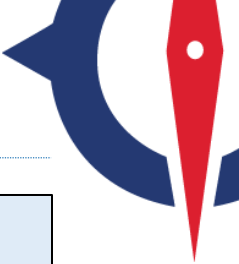


Exhibit 20: Arroyo Colorado North Protection Removed 100-year Depth

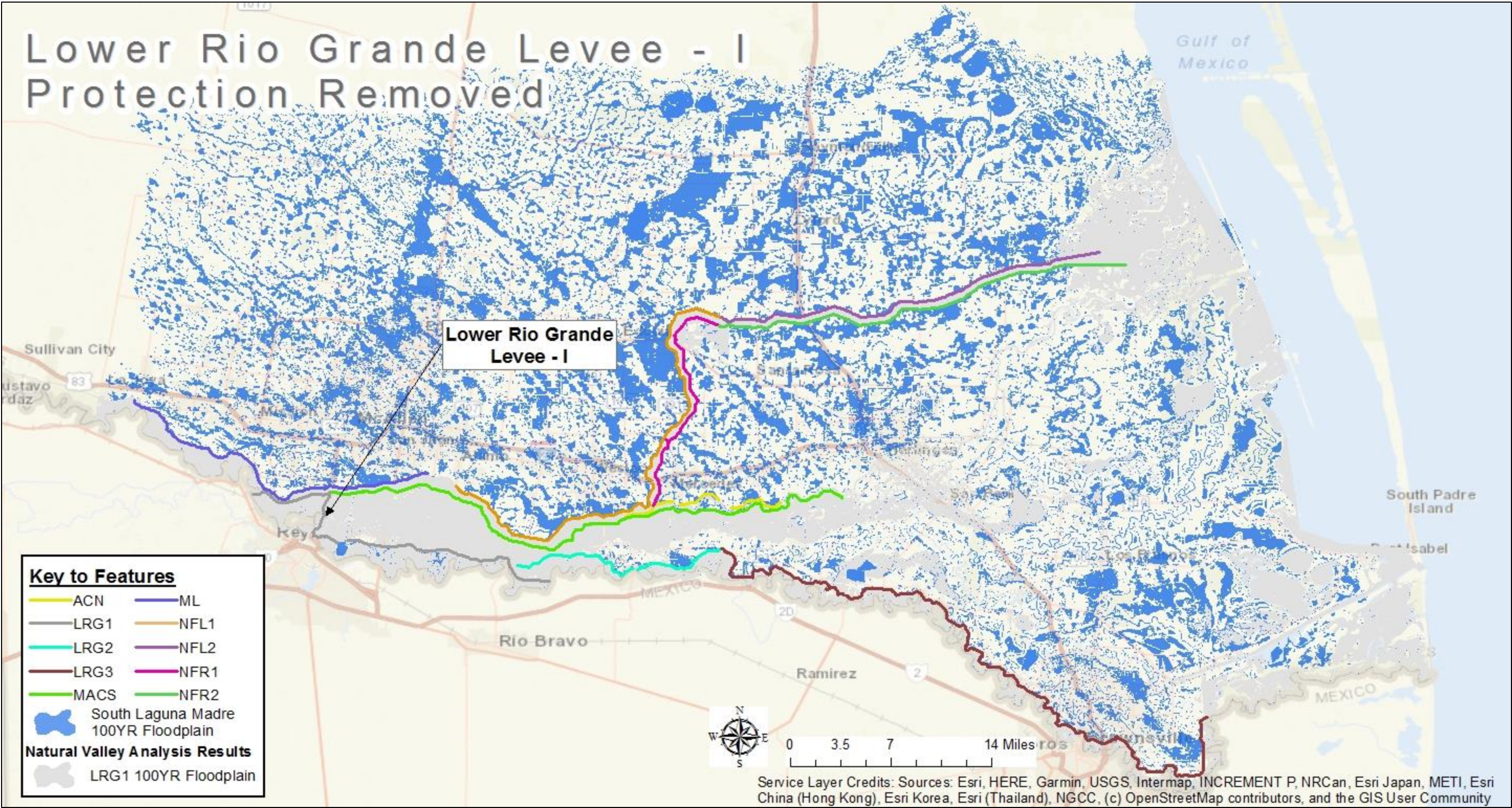
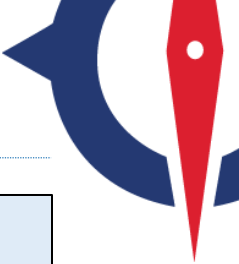


Exhibit 21: Lower Rio Grande Levees - I Protection Removed 100-year Depth

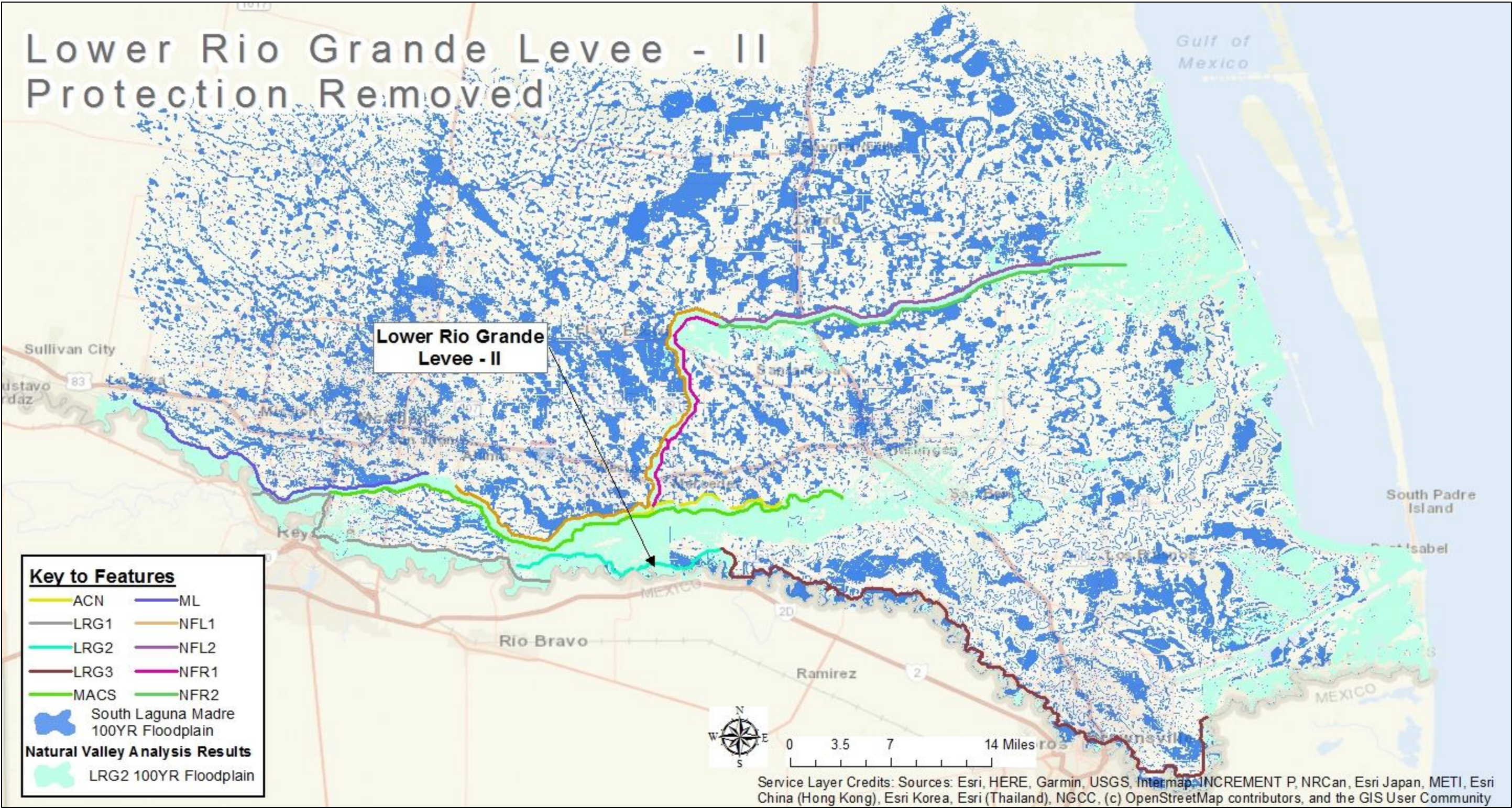
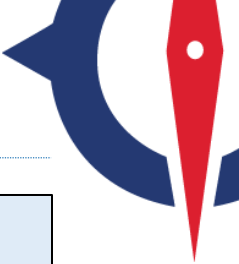


Exhibit 22: Lower Rio Grande Levees - II Protection Removed 100-year Depth

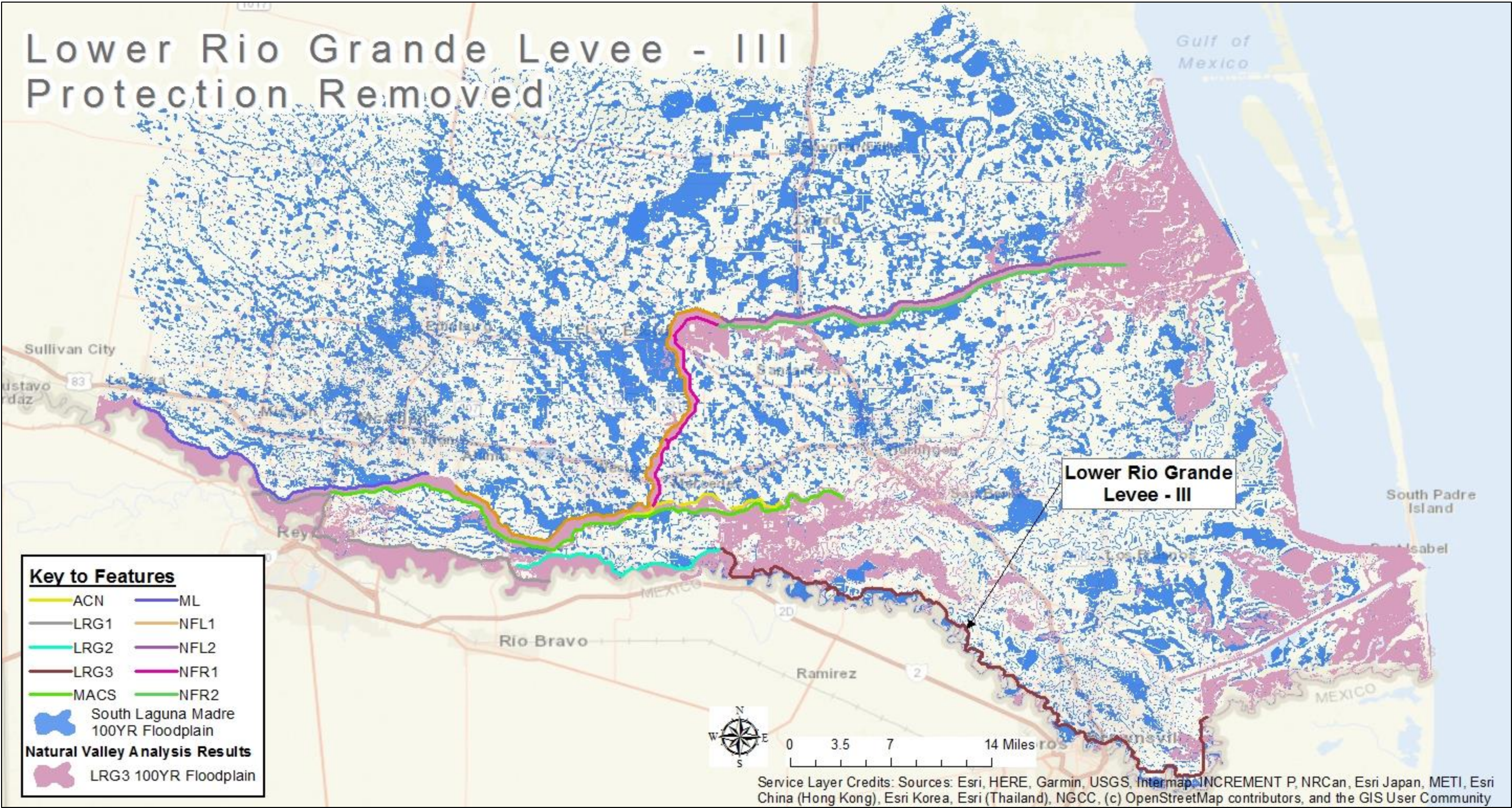
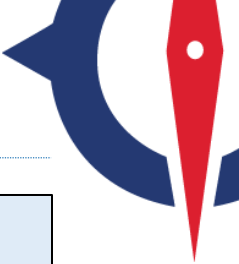


Exhibit 23: Lower Rio Grande Levees - III Protection Removed 100-year Depth

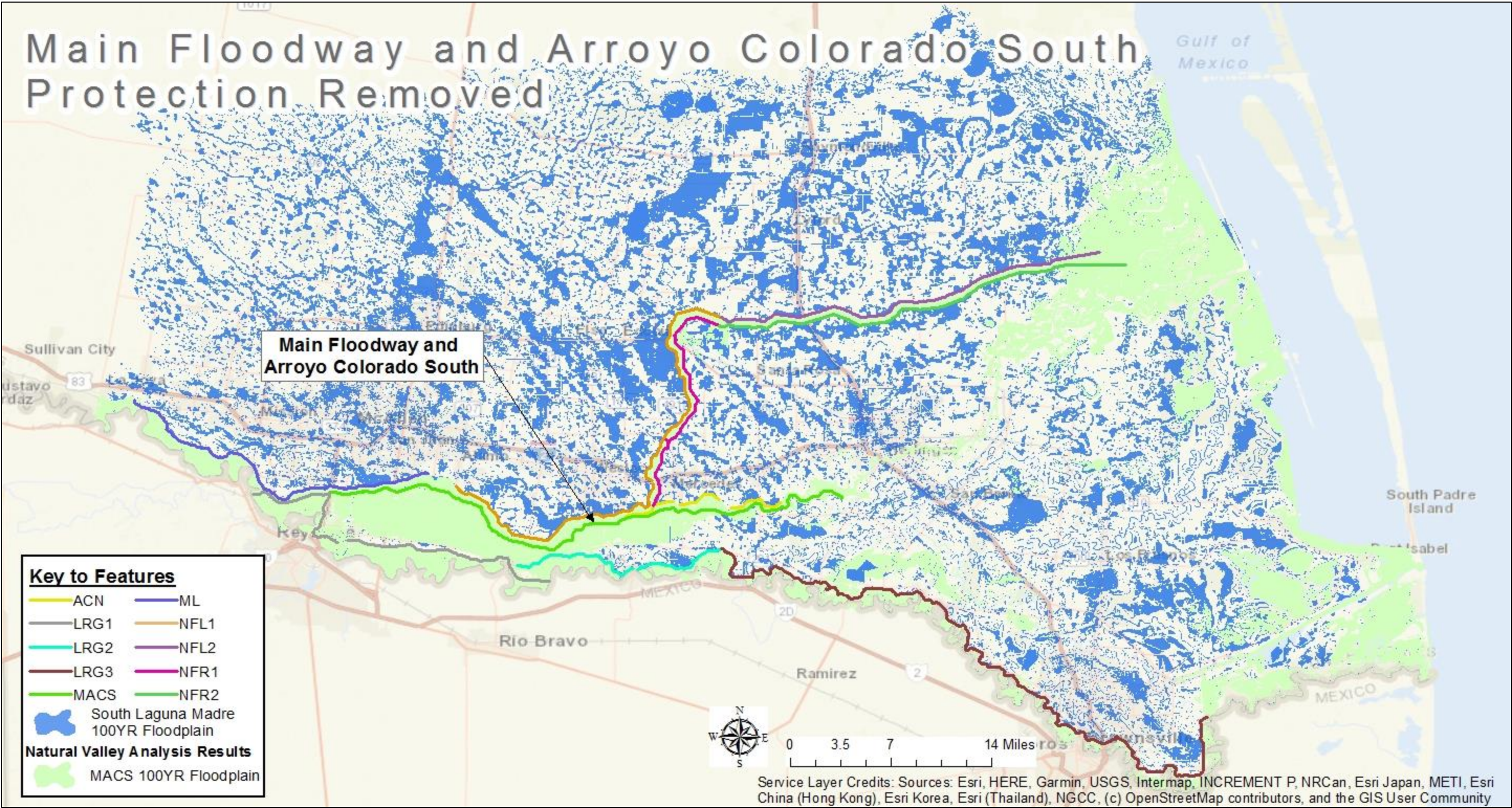
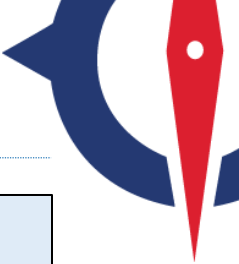


Exhibit 24: Main Floodway and Arroyo Colorado South Protection Removed 100-year Depth

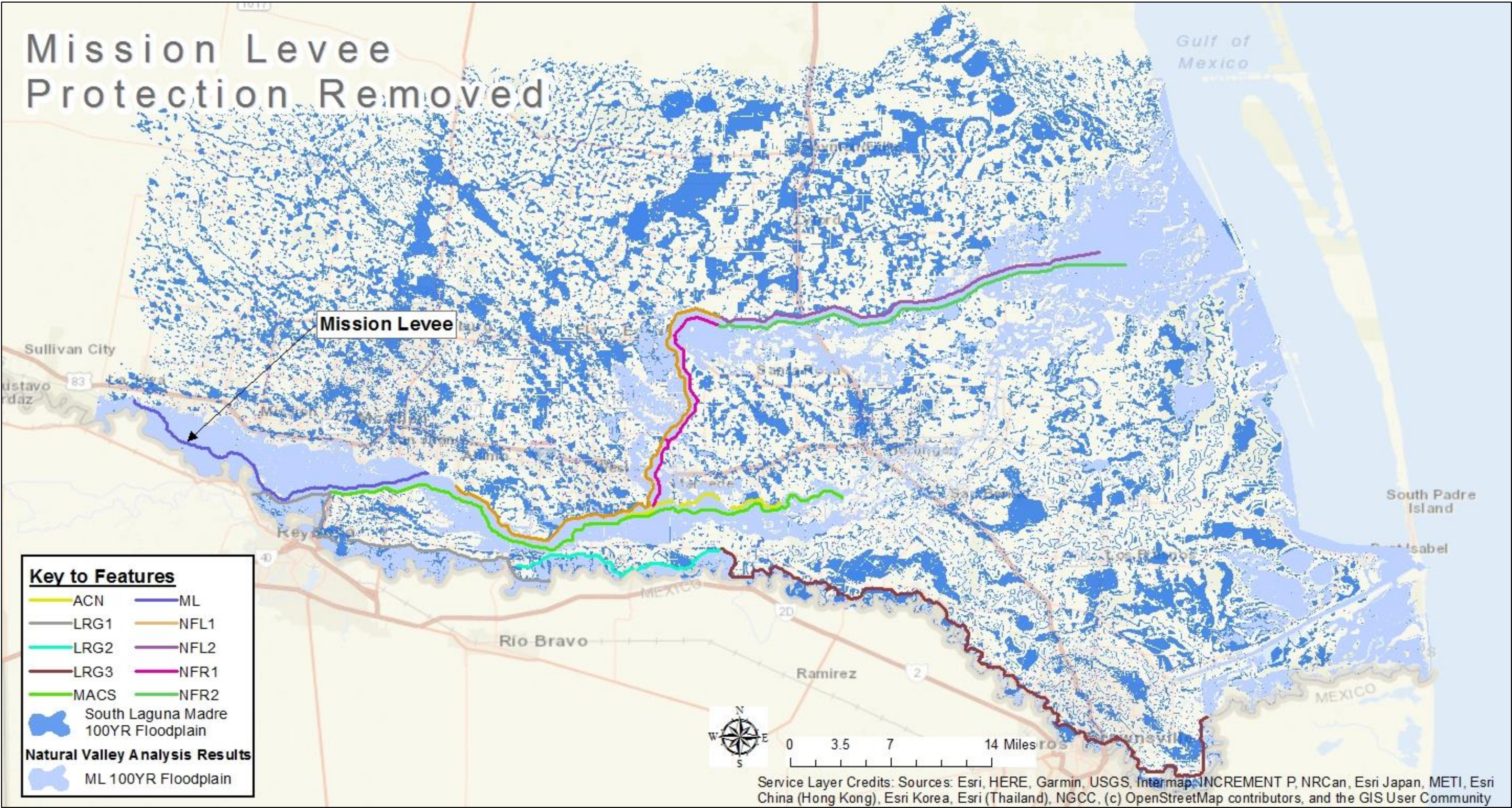
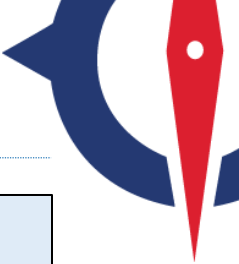


Exhibit 25: Mission Levee Protection Removed 100-year Depth

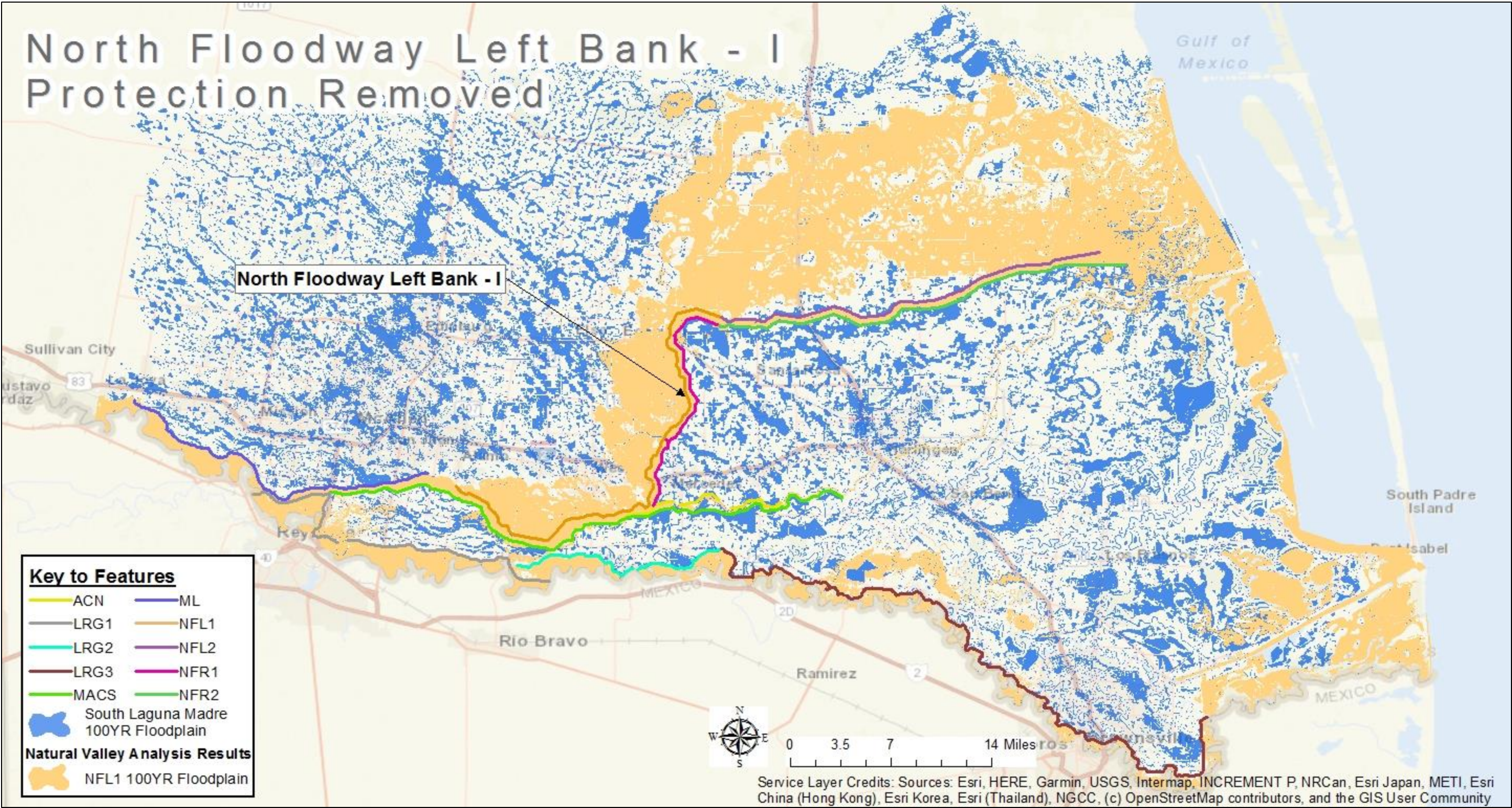
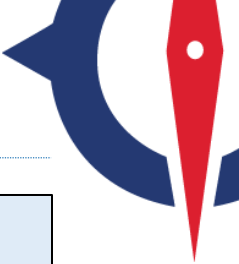


Exhibit 26: North Floodway Left Bank - I Protection Removed 100-year Depth

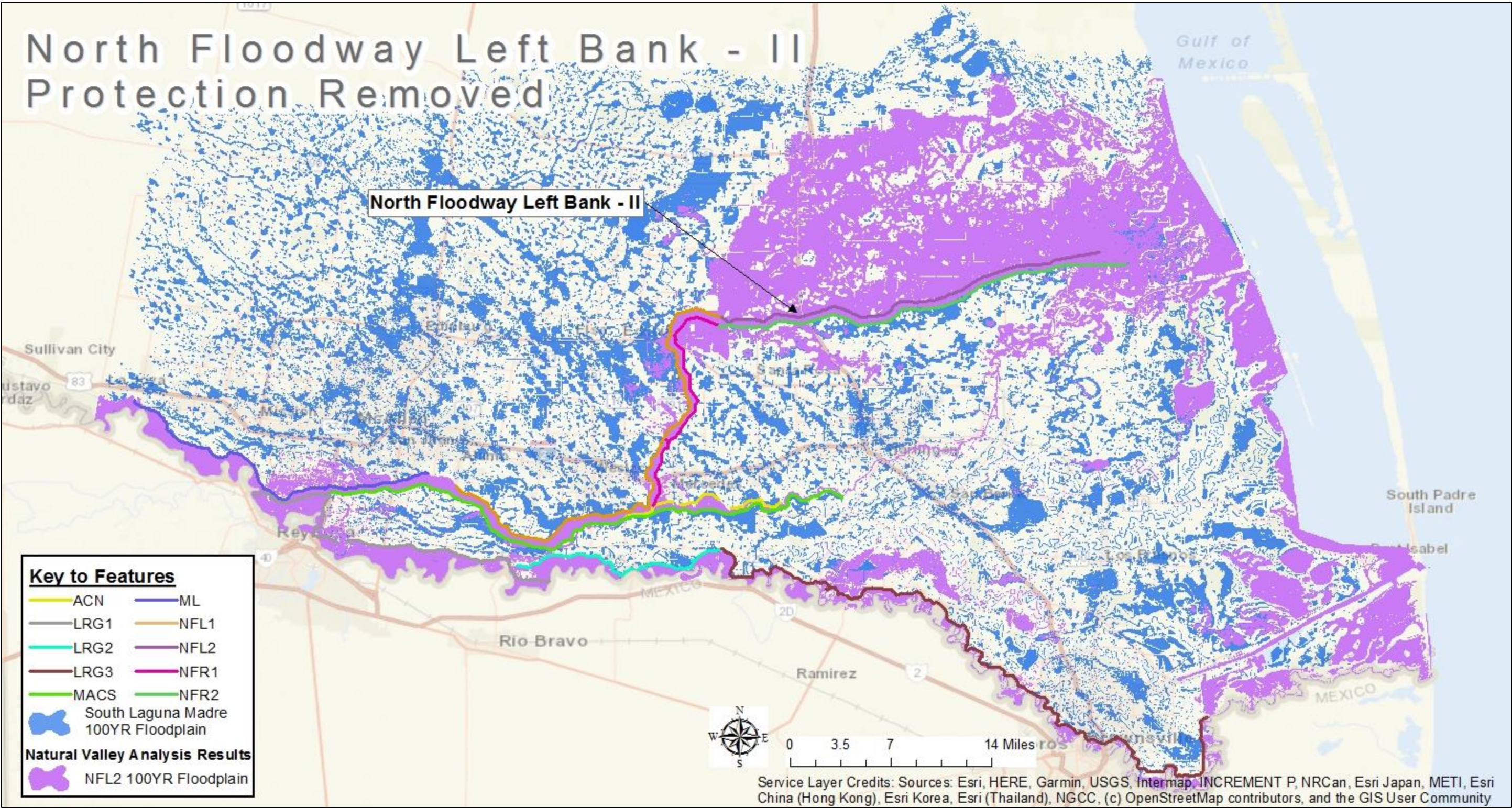
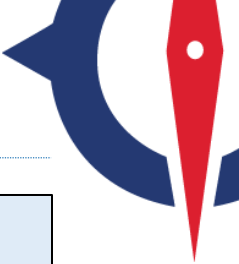


Exhibit 27: North Floodway Left Bank - II Protection Removed 100-year Depth

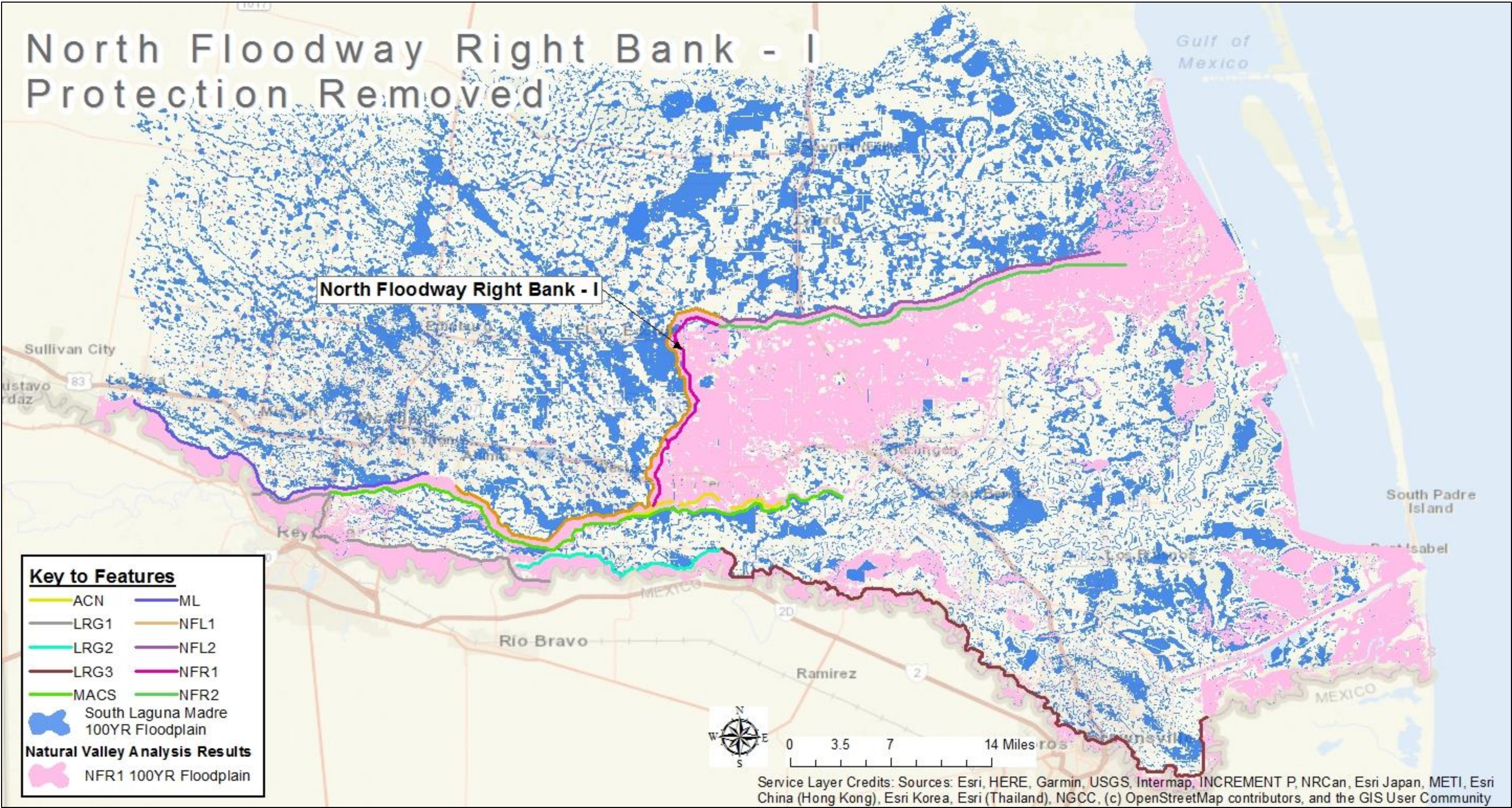
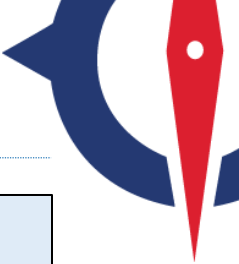


Exhibit 28: North Floodway Right Bank - I Protection Removed 100-year Depth

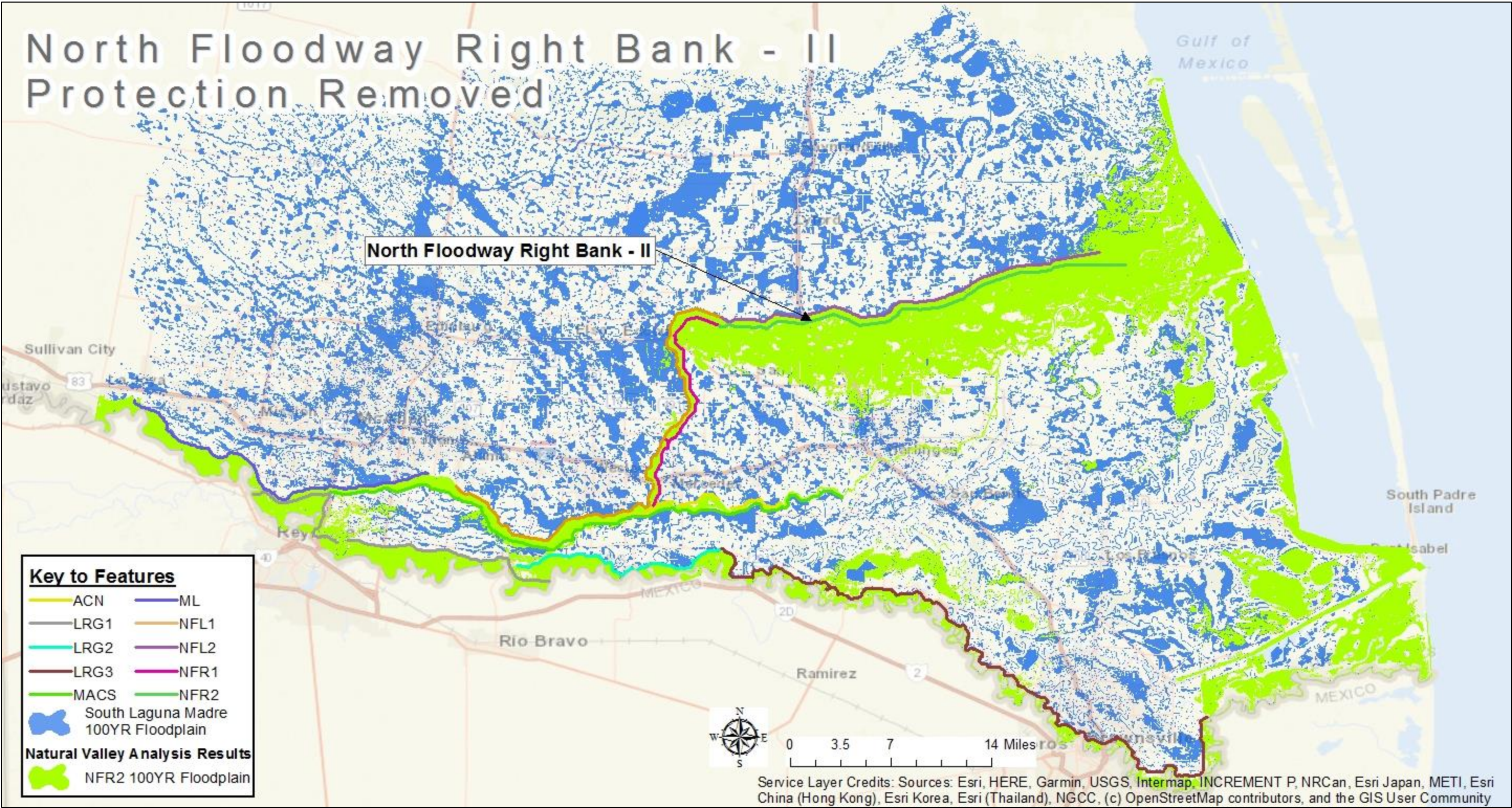
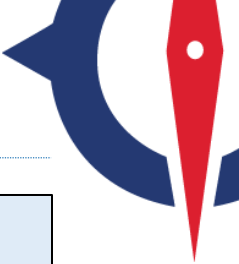


Exhibit 29: North Floodway Right Bank - II Protection Removed 100-year Depth

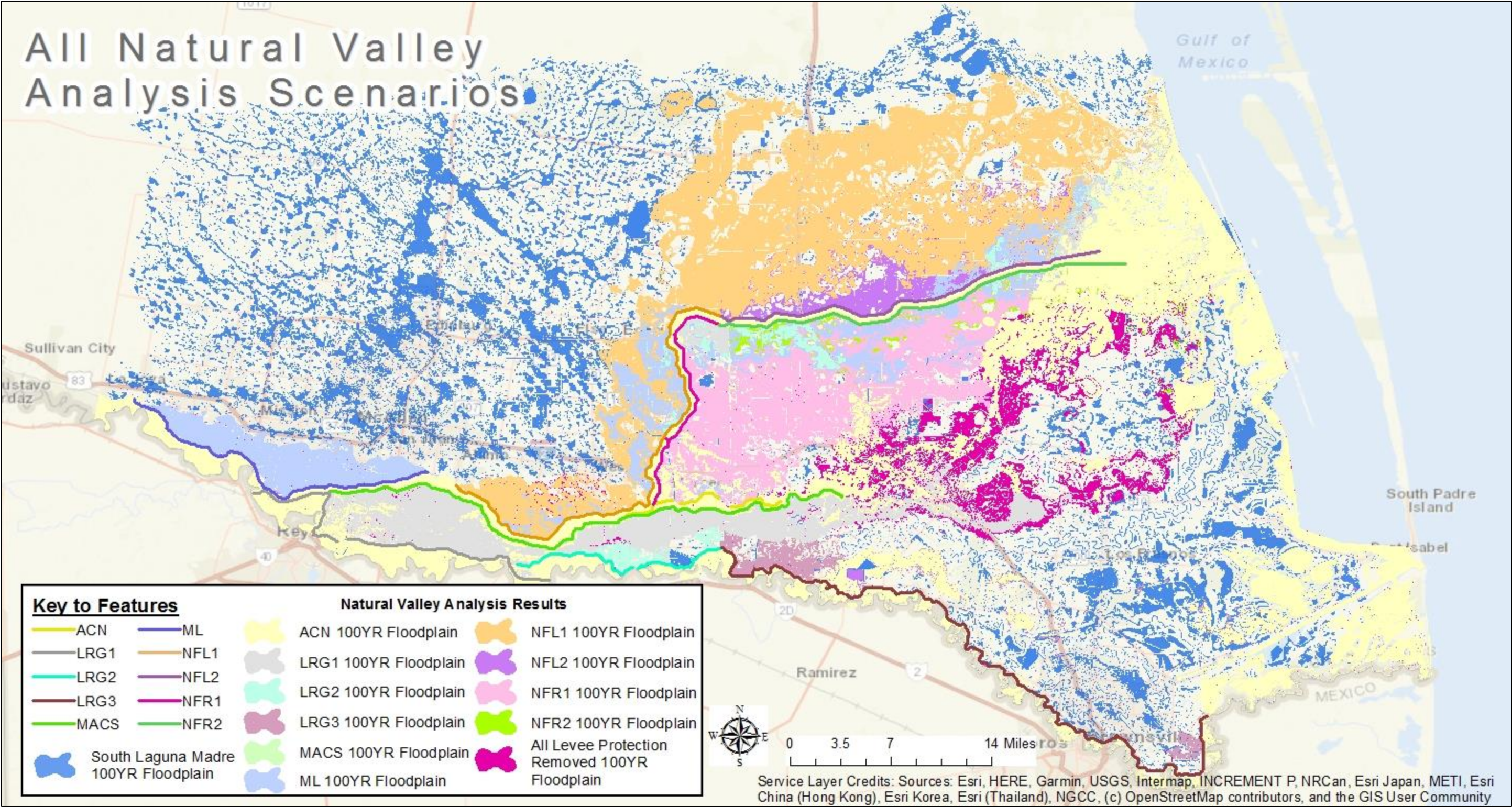
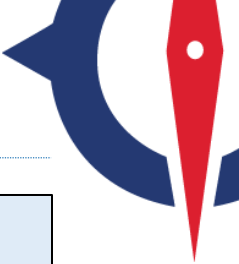


Exhibit 30: All Natural Valley Procedure Scenarios 100-year Depth

