Long-term Flood Recovery Plan

Prepared for:

CITY OF JERSEY VILLAGE
A TEXAS STAR COMMUNITY

Prepared by:

DANNENBAUM

In association with

CROUCH ENVIRONMENTAL SERVICES, INC.

Kuo & Associates, Inc.
CONSULTING ENGINEERS - SURVEYORS

August 15, 2017

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08/15/2017

STATE OF TEXAS
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For: City of Jersey Village
By: Dannenbaum Engineering Corporation

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ASCE	American Society of Civil Engineers
BFE	Base Flood Elevation
CESI	Crouch Environmental Services, Incorporated
CRS	Community Rating System
DEC	Dannenbaum Engineering Corporation
DSS	Data Storage System
ESA	Environmental Site Assessment
ETJ	Extra-territorial Jurisdiction
EWP	Emergency Watershed Protection
FFE	Finished Floor Elevation
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FMA	Flood Mitigation Assistance
GIS	Geographic Information System
GRR	General Reevaluation Report
HCAD	Harris County Appraisal District
H&H	Hydrologic and Hydraulic
HCFCD	Harris County Flood Control District
HEC-HMS	Hydrologic Engineering Center – Hydrologic Modeling System
HEC-RAS	Hydrologic Engineering Center – River Analysis System
HGL	Hydraulic Grade Line
HMA	Hazard Mitigation Assistance
HMGP	Hazard Mitigation Grant Program
HWM	High Water Mark
JV	Jersey Village
LOMR	Letter of Map Revision
NFIP	National Flood Insurance Program
NRCS	Natural Resources Conservation Service
PDM	Pre-Disaster Mitigation
POI	Point of Interest
REC	Recognized Environmental Condition
RL	Repetitive Loss
RPW	Relatively Permanent Waterway
RS	River Station
SFHA	Special Flood Hazard Area
SIA	Structural Inventory Analysis
SRL	Severe Repetitive Loss
SVSQ	Storage Volume-Storage Flow
TDEM	Texas Department of Emergency Management
TOD	Transit Oriented Development
TSARP	Tropical Storm Allison Recovery Project
TWDB	Texas Water Development Board
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
WOB	White Oak Bayou
WOUS	Waters of the United States
WRDA	Water Resources Development Act
WSE	Water Surface Elevation
XS	Cross-section

Executive Summary

Flooding has plagued the City of Jersey Village along White Oak Bayou for at least the past two decades. HCFCD constructed several stormwater improvement projects in the White Oak Bayou Watershed including numerous stormwater detention basins, channel improvements, and redesigning the Jersey Village Channel to divert a substantial amount of flow around Jersey Village. Despite these efforts, major flooding issues have persisted and the most recent Tax Day Flood (April 18, 2016) caused significant damage in the City. The City of Jersey Village contracted with Dannenbaum Engineering Corporation (DEC) to develop a Long-term Flood Recovery Plan to identify a recommended solution to help mitigate the chronic flooding issues.

The primary purpose of the recovery plan was to provide the City with several flood control solutions that were hydraulically, economically, environmentally, and socially feasible. The main objectives included:

1. Assessing existing conditions to identify the extent of flooding during different storm events.
2. Analyzing individual solutions with the use of hydrologic and hydraulic modeling.
3. Finalizing a long-term plan including a combined recommended solution, a benefit-cost analysis and possible funding sources.

The study accomplished the project objectives in three phases: Phase 1 included data collection and public involvement, Phase 2 was the technical analysis and development of alternatives, and Phase 3 involved development of the recommended solution and a benefit-cost analysis.

In Phase 1, DEC reviewed previous studies and construction plans to assist with the study. The study team also conducted a field visit along the channels in Jersey Village. The field visit focused on points of interest along the bayous such as bridges, stream confluences, inline structures, storm sewer outfalls, and other drainage features. Kuo and Associates, Inc. performed a topographic survey to acquire Finished Floor Elevations (FFE) and limited roadway cross-sections. The survey focused on homes and streets within the Federal Emergency Management Agency (FEMA) Effective 100-yr Floodplain and the floodplain fringe. The study team distributed a questionnaire to the residents of Jersey Village as another form of data collection. The purpose of the questionnaire was to gain insight from the public to identify types of flooding and prioritize alternatives for the study. In addition to the questionnaire, the study team conducted a public scoping meeting for public involvement.

During Phase 2, DEC performed a Rapid Assessment of homes in Jersey Village to calculate the magnitude of damages to homes that frequently flood. The Rapid Assessment aimed to identify homes that were likely to continue to flood after infrastructure improvements. The Structural Inventory Analysis (SIA) Tool compared the FFE to the flood stages in the nearby streams for the 2-, 5-, 10-, 25-, 50-, 100- and 500-

year storm events. DEC used the 2014 FEMA Effective models and the 2017 Revised Existing models derived from Existing Conditions models received from HCFCD for the analysis. The Revised Existing results yielded a 10-year level of protection in Jersey Village.

After the Revised Existing models were completed, DEC calibrated the models to the Tax Day Flood using rainfall data obtained from rain gauges in and around Jersey Village. DEC compared the calibrated water surface elevations (WSE) to the surveyed high water marks (HWM). The WSE calibration tolerance was ± one foot and the average difference in WSE compared to the HWM was 0.65 ft. DEC validated the models by comparing calibrated SIA results to the affected homes data provided by the City of Jersey Village for the Tax Day Flood. The SIA Tool identified 208 homes flooded by the bayous, while the City identified 238 flooded homes.

After calibrating the Revised Existing models, DEC began the analysis of individual alternatives and divided them into two categories: structural and non-structural alternatives. The structural alternatives included:

- Converting the Jersey Meadows Golf Course to a multi-use detention facility
- Removal of the Elwood Weir
- Increasing the E127-00-00 channel capacity
- Increasing the E100-00-00 (White Oak Bayou) channel capacity
- Reducing or modifying existing bridges along the main channel
- Diverting more flow into the Bypass channel
- Redesigning the storm sewer system in the Wall Street Neighborhood

The non-structural alternatives involved home buyouts, structure elevations, mitigation reconstruction, and modifications to the current City ordinances. DEC also performed a drainage impact study to assess the drainage requirements for the proposed Transit Oriented Development (TOD) in Jersey Village. Table I includes a summary of each individual alternative, its outcome, and DEC's recommendation for that alternative.

Table I. Alternatives Summary

Alternative	Hydraulic Impact	Flood Risk Impact	Benefit Type	Cost Effective?	DEC Recommendation
Jersey Meadows Golf Course	Reduction in WSE	Decreased	Reduction in Damages	Yes	Recommended
Elwood Weir Removal	Negligible	None	None	No	Not Recommended
E127-00-00 Channel Improvements	Negligible	None	None	No	Not Recommended
E100-00-00 Channel Improvements	Reduction in WSE	Decreased	Reduction in Damages	Yes	Recommended
Main Channel Bridges*	Negligible	None	None	No	Not Recommended
Jersey Village Bypass	Increase in WSE (adverse)	Increased	Increase in Damages	N/A	Not Recommended

Alternative	Hydraulic Impact	Flood Risk Impact	Benefit Type	Cost Effective?	DEC Recommendation
Wall Street Neighborhood Improvements	Reduction in WSE	Decreased	Increase in Mobility	Yes	Recommended
Buyouts	N/A	Removed	Removal of Flood Risk	Yes	Recommended
Structure Elevation	N/A	Decreased	Reduction in Damages	Yes	Recommended
Mitigation Reconstruction	N/A	Decreased	Reduction in Damages	No	Not Recommended
Community Rating System	N/A	N/A	Flood Insurance Discounts	Yes	Recommended

*The City can convert the Equador Pedestrian Bridge to a roadway bridge for mobility purposes with no adverse impact.

During Phase 3, DEC reviewed the results of the models and developed “Recommended Solution with a combination of structural and non-structural alternatives. The recommended structural components comprised adding detention storage to the Jersey Meadows Golf Course, the Federal Project White Oak Bayou Channel Improvements from the confluence with the E135-00-00 tributary to Beltway 8, and drainage improvements to the Wall Street Storm Sewer System. The recommended non-structural alternatives included property acquisition, structure elevation, and implementation of the CRS. DEC re-ran the SIA Tool with the Golf Course storage and channel improvements in the models and the results yielded the following:

- All homes were removed from the 25-year floodplain
- There was an 84.5 percent reduction in the number of homes inundated during a 50-year event
- 62 homes were removed from the 100-year floodplain with a reduction in damages of $5,379,655

The structural solutions did not eliminate flood risk and the SIA tool showed inundation of several homes during 50-year, 100-year, and 500-year events. Homes selected for non-structural alternatives were among those still inundated by the 50-year and 100-year floods.

DEC performed a benefit-cost analysis used the SIA Tool on the Jersey Meadows Golf Course Detention alternative as part of Phase 3 of the Long-term Flood Recovery Plan. The Golf Course provided over $1.2M in present value benefits and had a benefit-cost ratio (BCR) of 1.65. DEC did not calculate benefit-cost ratios for the Federal White Oak Bayou channel improvements and the Wall Street Neighborhood Storm Sewer Improvements. HCFCD and USACE completed the benefit-cost analysis for the entire White Oak Bayou Federal Project with a worst-case watershed BCR of 4.2. DEC could not calculate a BCR for the Wall Street Neighborhood Storm Sewer Improvements because the type of model used for analysis was not compatible with the SIA Tool.

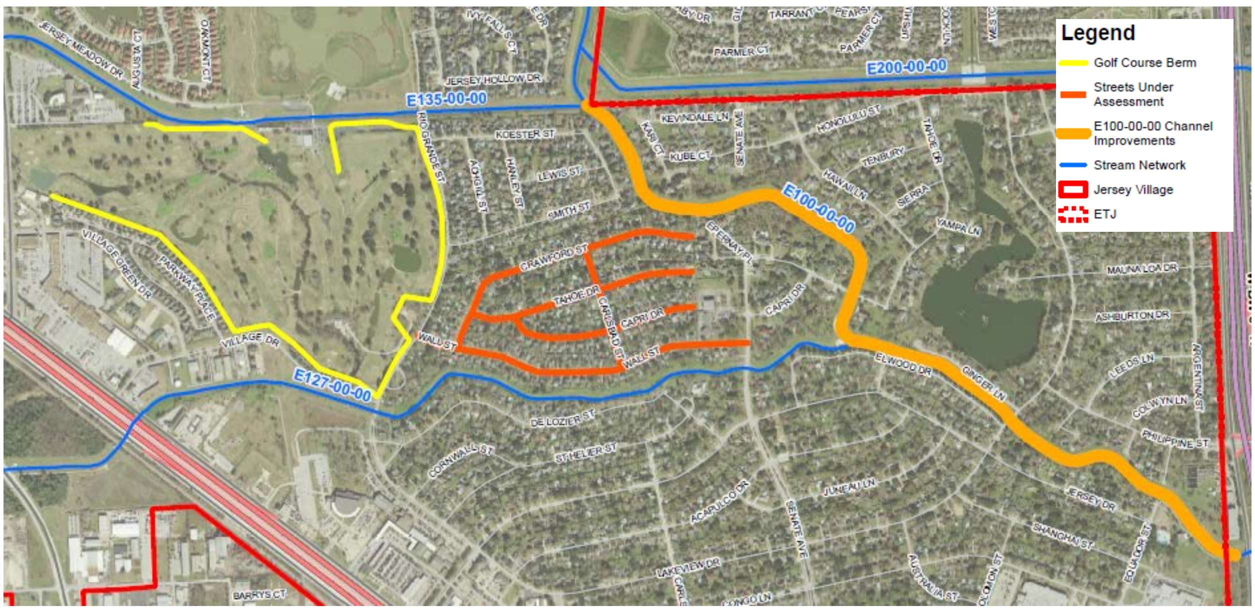
The study team researched potential funding sources for the recommended solution and determined that funding can obtained at the local, State, and federal level. Local funding can include the City of Jersey Village’s Capital Improvement Plan (CIP). The Texas Water Development Board (TWDB) provides funding and loans at the State level. Federal funding includes grant programs from three federal agencies: the Natural Resources Conservation Service (NRCS), USACE, and FEMA.

After the final analysis was complete, DEC categorized the recommended projects as short-term or long-term and developed a phasing plan. The short-term recommendations included improvements to the Jersey Meadows Golf Course, the Wall Street Storm Sewer System and non-structural grant applications. The only long-term recommendation was the Federal Project White Oak Bayou Channel Improvements. Table II includes a summary of the recommended phases and estimated costs and Figure I shows a map of the proposed structural solutions.

Table II. Phasing and Cost Summary

Phase Number	Project Name	Estimated Cost
1	Jersey Meadows Golf Course	$733,425
2	Wall Street Neighborhood Improvements	$5,705451
3	Non-structural Alternatives	Varies
4	White Oak Bayou Federal Plan Channel Improvements	$4,578,588

Figure I. Recommended Structural Solutions Overview



Project Overview

1. Introduction

1.1. Background

The City of Jersey Village has been repetitively flooded along White Oak Bayou for the past three decades. The City of Jersey Village is located in northwest central Harris County (see Exhibit 1.1). Residential properties within the City have sustained damages due to flooding four times over the past twenty years: 1998 (Tropical Storm Frances), 2001 (Tropical Storm Allison), September 2002, and 2016 (Tax Day Flood). After over 230 homes were damaged in the last substantial storm event on April 18, 2016 (the Tax Day Flood; see Exhibit 1.2), the City decided to find a solution to ameliorate flooding. The City initiated the Jersey Village Long-term Flood Recovery Plan as a response to the reoccurring flooding.

The City of Jersey Village and the Harris County Flood Control District (HCFCD) have implemented several stormwater improvement efforts in the last twenty years. Some of these improvements include the redesign of the Bypass channel around Jersey Village and the construction of several regional detention ponds within and upstream of the City for a total cost of $95 million. Additionally, the City has constructed $25 million of street drainage improvements aimed at reducing neighborhood flooding over the same period of time (see Exhibit 1.3). Despite these efforts, major flooding issues have persisted and the community requested immediate action after the Tax Day Flood. Many of the residents' homes were flooded for the third or fourth time within the last twenty years. The City contracted with DEC to prepare the Long-term Flood Recovery Plan and present several alternative solutions to help mitigate the chronic flooding occurring in Jersey Village.

1.2. Project Purpose

The overall purpose of the recovery plan was to provide the City of Jersey Village with a number of viable flood control solutions that are hydraulically, economically, environmentally, and socially feasible. The three main objectives were:

- Assessing the existing conditions to determine the extent of flooding during different storm events, including an analysis of the storm that occurred on April 18, 2016.
- Analyzing potential improvement solutions with the use of hydrologic and hydraulic (H&H) modeling, including the solutions presented in the HCFCD Federal Plan updated in 2014.
- Finalizing a long-term improvement plan, which includes a benefit-cost analysis, possible funding sources and the detailed analysis for each alternative.

The study team accomplished these goals in three phases. Phase 1 consisted of data collection and public involvement. Data collection included topographic survey of homes and streets, distributing a questionnaire to all the residents of Jersey Village, obtaining H&H models available from HCFCD, review of previous studies in the area, completing a preliminary environmental review, and performing a field visit. Phase 2 was the technical analysis and development of alternatives. Phase 2 included a Rapid Assessment of the existing conditions, calibration of H&H models to the Tax Day Flood, and extensive H&H modeling of existing conditions and proposed alternatives. Phase 2 also included a drainage impact study of the Transit-Oriented Development (TOD), within the Jersey Village City Limits and the extraterritorial jurisdiction (ETJ). Finally, Phase 3 involved a benefit-cost analysis, developing a recommended solution and combination of alternatives, detailed analysis of the Wall Street Storm Sewer System, and finalizing the long-term plan.

Throughout each of these phases, public outreach was a priority for the study team. The study team involved the community by distributing questionnaires for data collection to the residents, providing project updates, and conducting three public meetings to receive feedback and suggestions from the community.

1.3. Project Area Description

The City of Jersey Village is located in the Houston metropolitan area within west-central Harris County, Texas. Jersey Village (JV) is in the White Oak Bayou (WOB) Watershed. The main WOB channel, E100-00-00, and two tributaries, E127-00-00 and E135-00-00, run through the City. The City has a total area of 3.4 mi^2, not including the area of the ETJ, and approximately 5.9 miles of open channels. The total drainage area for White Oak Bayou upstream of Jersey Village and including the City is 20.8 mi^2 (see Exhibit 1.4). The land use in Jersey Village is primarily residential with areas of commercial, industrial, and institutional land use near Beltway 8 and US 290. The TOD area southwest of US 290 currently consists of primarily commercial and industrial land use. However, the redevelopment plan for the TOD includes multifamily and single family residential as well. Approximately 55 ac of the proposed plan is located within the JV City limits and the other 245 ac is in the ETJ (see Exhibit 1.1). All models, LiDAR, and topographic survey are in the North American Vertical Datum (NAVD) of 1988, 2001 adjustment.

1.4. Scope of Work Summary

A. Kuo and Associates

DEC contracted with Kuo and Associates for the topographic survey portion of the project. Kuo surveyed the finished floor elevations of 975 homes within the 100-year floodplain and the floodplain fringe and cross-sections of the streets in the floodplain. Kuo also surveyed high water marks (HWM) at several homes as indicated by the homeowner. Additionally, Kuo collected topographic survey of the storm sewer system in the Wall Street neighborhood to aid in the detailed storm sewer analysis of the neighborhood. Kuo did not survey any of the streams – including the Bypass – because stream survey was not in the scope of the project.

B. Crouch Environmental Services, Inc.

DEC contracted with Crouch Environmental Services, Inc. (CESI) for the public outreach and environmental portions of the study. Crouch Communications – a division of CESI – facilitated the three public meetings for the project, developed meeting content such as displays and videos, collected public comments, and helped to develop, deliver, and analyze data from the citizen questionnaires from Phase 1 of the study. Crouch Communications prepared a Public Meeting Summary Report for each public meeting that included the public records and comments for each meeting as well as all meeting content. Additionally, Crouch Communications developed a website for the project where they posted public meeting content and study materials for public review. The project web address was jvfloodrecovery.com. CESI's environmental scope included a desktop environmental review during Phase 1 and a full Phase I Environmental Site Assessment (ESA) in Phase 3 for the recommended alternatives.

C. Dannenbaum Engineering Corporation

DEC's project scope included data collection, public outreach, rapid assessment, technical analysis, and meetings. DEC conducted a field visit and stakeholder meeting and developed a citizen questionnaire in conjunction with Crouch Communications as part of the data collection scope. The public outreach scope included attending and facilitating three public meetings along with Crouch Communications. The City held one public meeting for each of the three project phases. Public involvement was a large portion of the project scope. DEC's scope also included attending meetings with City staff every three weeks and attending City Council meetings as needed. Other meetings included two stakeholder meetings.

The Rapid Assessment scope included an analysis of homes in Jersey Village at risk for flooding. The Rapid Assessment used hydraulic models and the Structural Inventory Analysis (SIA) Tool developed by DEC for HCFCD. The SIA Tool calculated the depth of flooding in each home and the corresponding amount of damage. The Tool also indicated the smallest flood event to inundate each home in the analysis. The Rapid Assessment identified homes most at risk for flooding and continued flooding after implementation of the Long-term Flood Recovery Plan.

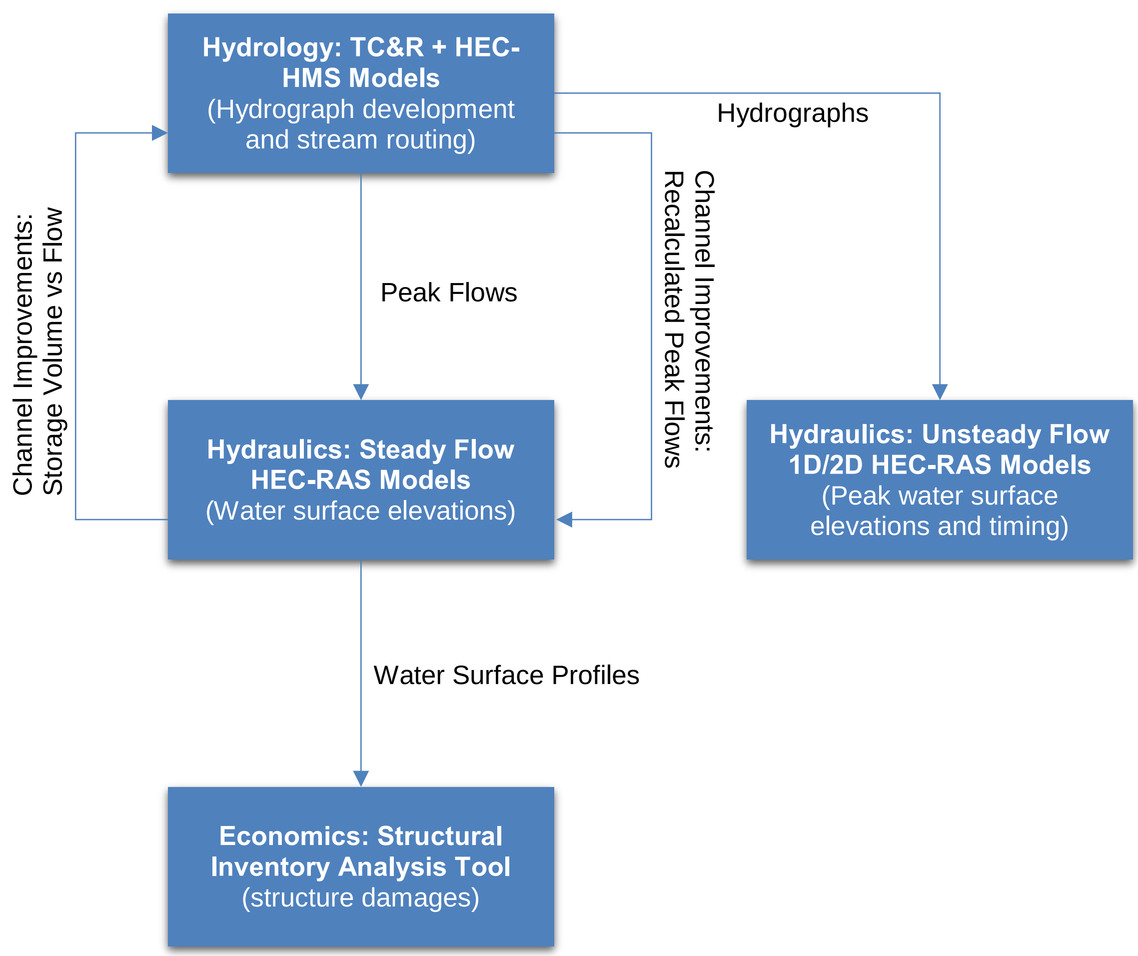
The technical analysis scope of the project included H&H modeling and continued Structural Inventory Tool analysis. DEC obtained the most recent H&H models for the White Oak Bayou Watershed and calibrating those models to the Tax Day Flood to verify their accuracy. Additionally, the technical analysis scope included the development and analysis of alternatives. The scope did not specifically require any alternatives and no alternatives were specifically out of scope. However, the scope limited the number of alternatives analyzed in detail to the six most feasible solutions. Therefore, DEC was required to evaluate all of the potential alternatives from a high level and disregard infeasible alternatives. DEC actually analyzed six structural alternatives and four non-structural alternatives and categorized them into short-term and long-term solutions. The scope also included developing a phasing plan for the recommended solutions and a cost-benefit analysis to determine the economic feasibility of each individual alternative. Additionally, the technical analysis scope involved a drainage impact study of the proposed Transit Oriented Development (TOD) District. The TOD analysis was separate from the other alternatives of the study.

1.5. Project Analysis Methodology

The project included three different types of models and calculations: hydrologic, hydraulic, and damages to homes for economics. The hydrologic methodology included TC&R calculations following HCFCD guidelines in conjunction with HEC-HMS modeling. DEC used HEC-RAS for the open channel hydraulic modeling for all alternatives except for the Wall Street Storm Sewer Analysis. DEC performed the economic analysis using the SIA Tool for the alternatives analyzed with HEC-RAS. The base conditions (Revised Existing) and alternatives analysis included seven standard storms: 2-year, 5-year, 10-year, 25-year, 50-year, 100-year, and 500-year. Figure 1.4A illustrates the relationship between hydrology, hydraulics, and economics for the study.

The individual reports discussed the analysis methodology for the Transit Oriented Development District and the Wall Street Neighborhood Storm Sewer System alternative (see Appendices 8A and 7J respectively).

Figure 1.4A – Model and Calculations Relationships



Phase 1

2. Data Collection

To examine the hydraulic conditions in Jersey Village, DEC collected several different types of data. The study team completed a field visit, distributed a questionnaire to residents, conducted a public scoping meeting, and reviewed previous studies and construction plans for projects in the area. The previous studies and plans included the drainage impact study for US 290, the Jersey Meadows Golf Course Drainage Study, the Jersey Village Comprehensive plan, the TOD Master Plan, and construction plans for the Bypass Channel, Jersey Meadows Stormwater Detention Basin, and the Elwood Weir. Kuo and Associates collected topographic survey of streets, finished floor elevations (FFE) of homes in the floodplain, and HWM at residences. HCFCD provided the report and H&H models for the most recent General Reevaluation Report (GRR) for White Oak Bayou. HCFCD also provided the most recent Letter of Map Revision (LOMR) models submitted to the Federal Emergency Management Agency (FEMA) to revise the Flood Insurance Rate Maps (FIRM) for the WOB Watershed. DEC downloaded the latest FEMA Effective HEC-HMS and HEC-RAS models from HCFCD's website. Harris County's Flood Warning System was used to obtain the real-time rainfall data for several large storm events occurring over the past twenty years, including Tropical Storm Allison (June 2001) and the Tax Day Flood (April 2016) rainfall data. See Appendix 2A for the studies and plans reviewed for the Long-term Flood Recovery Plan.

2.1. Summary of Previous Studies and Construction Efforts

The study team reviewed several reports and plan sets for information pertaining to the current drainage infrastructure in and around Jersey Village. The documents reviewed included the US 290 Drainage Impact and Mitigation Study, the Jersey Meadows Golf Course Drainage Study, TOD Master Plan, Jersey Village Comprehensive Plan, and the most recent GRR for White Oak Bayou. The study team also reviewed the construction plans for the Jersey Meadows Stormwater Detention Basin, the White Oak Bayou Bypass Channel, and the Elwood Weir. These studies and plan sets aided in the development of alternatives and addressed public concern about mitigation efforts surrounding construction.

A. US 290 Drainage Impact and Mitigation Study

DEC reviewed the US 290 drainage impact study to address public concern regarding the construction of the portion of US 290 through Jersey Village. The purpose of this study was to provide a preliminary drainage mitigation plan for Phase II of the US 290/Hempstead Program. The study identified existing drainage conditions, recommended drainage improvements for proposed conditions, and analyzed the potential impacts on the surrounding area and adjacent tributaries. The final recommendations of the study concluded that the construction of 19 detention ponds will provide enough mitigation to prevent adverse impacts along the entire project corridor. There were 22 outfalls included in the study with two of them directly affecting Jersey Village: Outfalls 6 and 7 at E135-00-00 and E127-00-00 respectively. The required detention for Outfall 6 was 115.4 acre-feet provided in two detention ponds. The mitigation for Outfall 7 was provided by routing some flow to Outfalls 6 and 8 and providing detention within the storm sewer system. The outfall sizes remained the same as the existing conditions. Overall, the report concluded that the proposed drainage system will provide enough mitigation and no adverse impacts will occur to any adjoining streams or properties for the 10-year and 100-year storm events. See Appendix 2A for the full report.

B. Jersey Meadows Golf Course Drainage Study

One of the alternatives in this study was converting the Jersey Meadows Golf Course into a dual-purpose stormwater storage facility. Brooks & Sparks performed a drainage analysis study in October 2003 exploring the possibility of providing detention storage on the Golf Course. The drainage study evaluated the existing conditions and infrastructure of the Golf Course, provided recommendations, and estimated costs for the proposed solution. Several notable existing conditions discovered included runoff flowing onto Rio Grande Street from the Golf Course, runoff flowing onto the Golf Course from the north side of the property and the presence of ponding behind several homes along the Golf Course and on the driving range.

The study recommended a berm along the northern, eastern, and southern perimeter of the Golf Course with a top elevation of 111.5 ft. The berm was designed to provide approximately 115 ac-ft of storage volume. The design for the berm not only provided storage, it regulated the amount of runoff entering and exiting the Golf Course. The study also recommended a system of storm sewer pipes, inlets, swales, and trench drains along the portion of the Golf Course adjacent to homes at The Park at Jersey Village. The Brooks & Sparks study also recommended a subsequent drainage study to evaluate the drainage systems along Rio Grande, Wall, Smith, and Koester Street. During field investigations, the drainage systems on these streets lacked inlets and storm sewer pipes to convey the existing runoff. The estimated construction cost of the recommended solutions was $683,400 in 2003.

C. General Reevaluation Report on White Oak Bayou

HCFCD completed the GRR as part of the White Oak Bayou Federal Flood Damage Reduction Project in conjunction with the U.S. Army Corps of Engineers (USACE). The WOB Flood Damage Reduction Project is under the umbrella of Section 211 of the Federal Water Resources Development Act of 1996 (WRDA 1996), which allows a non-Federal sponsor to design and construct a federally authorized project and be eligible for reimbursement of an amount equal to the estimate of the federal share. The GRR study followed the procedures and guidance of the USACE. HCFCD estimated $61.2 million in average annual flood damages without any implemented projects along WOB. The study considered over 90 configurations of structural and non-structural alternatives and over 300 different combinations of alternatives.

The final Recommended Plan for the entire watershed included 15.4 miles of earthen channel modifications from Cole Creek to FM 1960 and four detention basins along White Oak Bayou providing around 2,940 ac-ft of storage volume. Figure 2.1A displays the proposed GRR channel improvements.

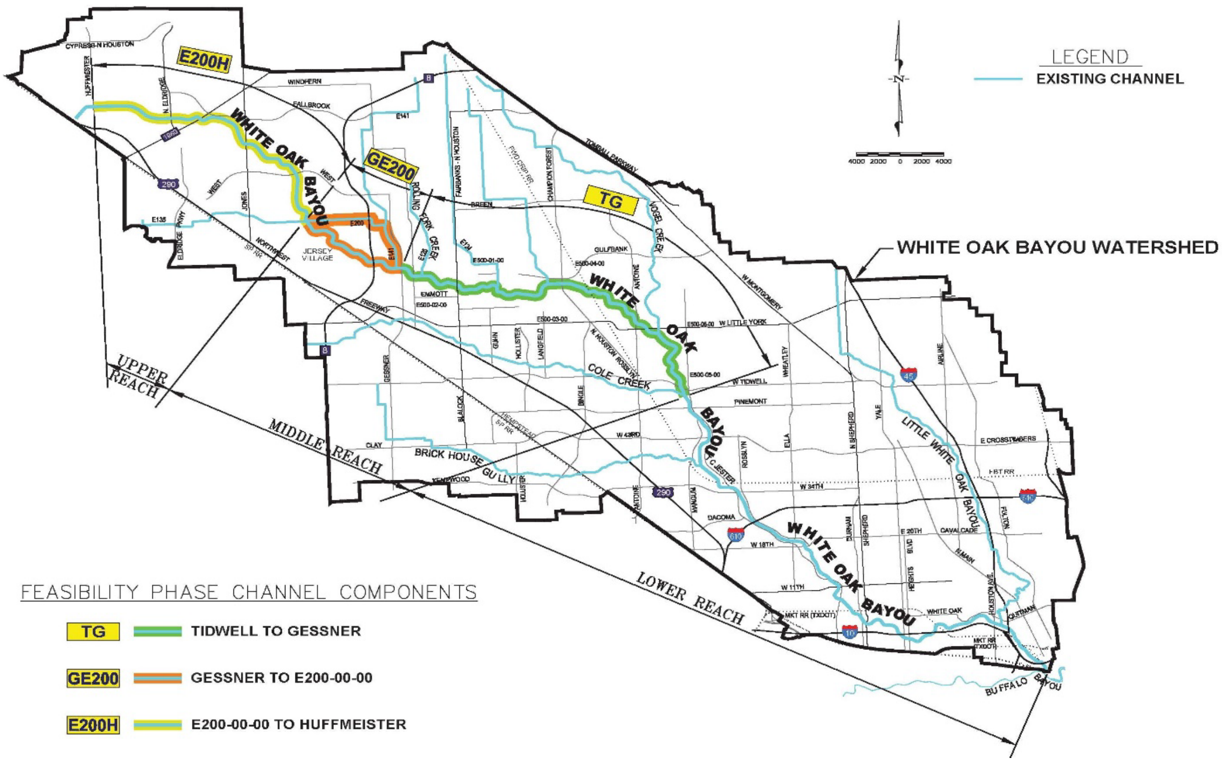


Figure 2.1A. GRR Channelization Components

In Jersey Village, the plan focused on rerouting E200-00-00 to convey flow around the City, modifications on the WOB main channel through Jersey Village and the addition of several detention basins upstream and downstream of the City. The Recommended Plan showed a reduction of approximately 58% to the average annual flood damages for the entire watershed, providing an estimated annual benefit of $35.6 million. The fully funded cost estimate was $110.3 million and the benefit-cost ratio for annual damages was approximately 4.2 with an interest rate of 7%. After careful consideration, the study concluded that the Recommended Plan would provide substantial benefits. Many of the improvements have been constructed to date (see Exhibit 1.3), however, the channel improvements from Gessner to FM 1960 have not yet been constructed due to a lack of funding. Additionally, HCFCD partially constructed the channel improvements from Cole Creek to Gessner due to a lack of federal reimbursement. Some sections were widened, but not deepened, while others were deepened, but not widened.

D. Construction Plans

Dannenbaum also reviewed the construction plans for the Jersey Meadows Stormwater Detention Facility (E535-01-00), the Federal Plan White Oak Bayou Bypass Channel (E200-00-00), and the Elwood Weir near the confluence of South Fork Tributary (E127-00-00) and White Oak Bayou (E100-00-00). A review of the plans for the Jersey Meadows Stormwater Detention Basin concluded that increasing the volume for the regional detention facility would not be feasible due to the presence of mitigation wetlands and the high groundwater that serves as the permanent water surface elevation (WSE). DEC reviewed the plans for the Bypass and determined that the Bypass functions as designed, despite the widespread perception that it does not function correctly. The study team also reviewed the construction plans for the Elwood Weir and concluded that the Elwood Weir was designed as a drop structure to reduce erosion. DEC updated the hydraulic models using the Elwood Weir record drawings.

2.2. Field Visit

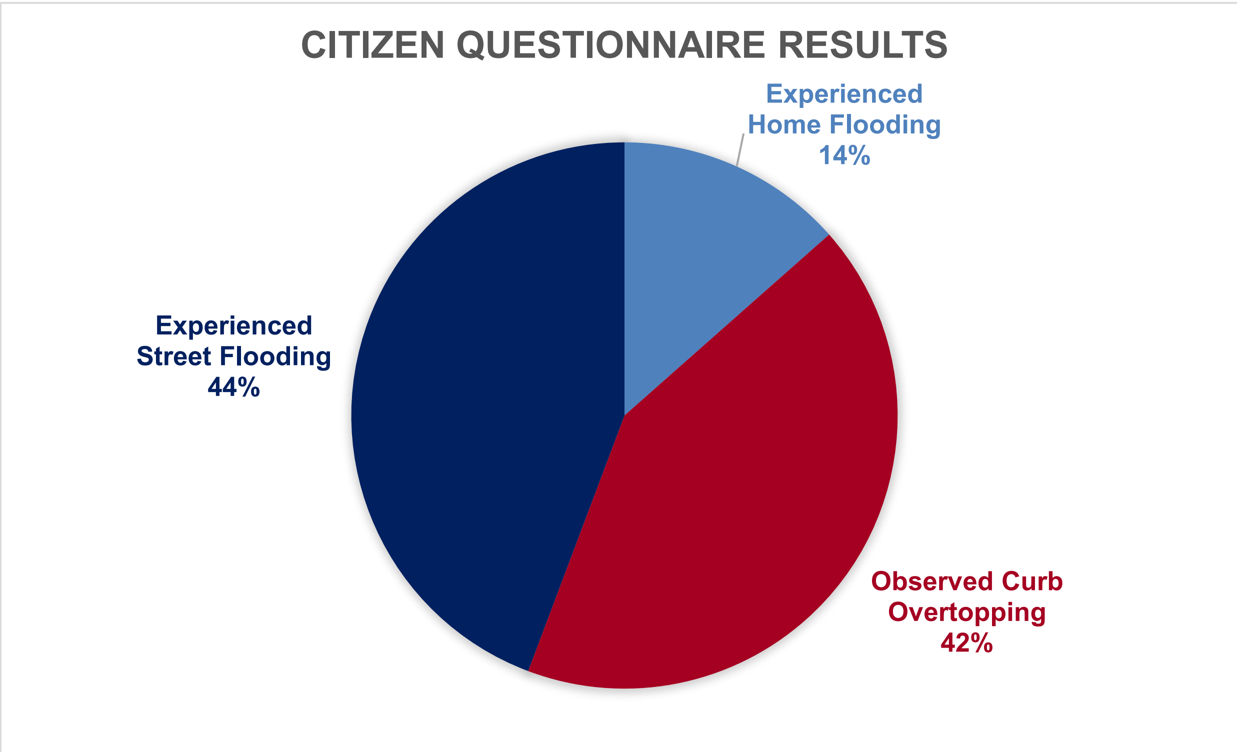
On September 28, 2016, DEC and the City of Jersey Village conducted a field visit along the channels in Jersey Village. Exhibit 2.1 displays the proposed route map for the field visit. DEC and the City visited approximately 16 points of interest (POI). The POIs were located throughout the City of Jersey Village along White Oak Bayou and its tributaries, E127-00-00 and E135-00-00. Examples of POIs included bridges, stream confluences, inline structures, and other drainage features. Appendix 2B includes a summary report and photos from the field visit. DEC was particularly interested in the Elwood Weir and the stream confluence between E127-00-00 and E100-00-00. DEC documented areas of slope failure and sloughing along White Oak Bayou. Other key POI were the Jersey Meadows Golf Course and the Jersey Meadows Stormwater Detention Basin. The study team investigated the water features and the natural overland drainage patterns of the Golf Course. Dannenbaum also observed the outlet structure and permanent water elevation in the Jersey Meadows Detention Basin.

2.3. Questionnaire

An open line of communication with the residents of Jersey Village was a high priority during the development of the Long-term Flood Recovery plan. One of the main sources of input from the public was through the questionnaire provided to the residents. The purpose of the questionnaire was to collect public commentary to help identify problem areas and prioritize alternatives for the study. CESI distributed the questionnaire through two sources: on paper and through the website. The questionnaire focused on the level of flooding the resident has observed throughout their time in Jersey Village. Overall, there were 334 responses to the questionnaire.

Of the 334 responses, 74 residents specified flooding in their home, 243 residents indicated that the street had flooded in the past and 232 residents said the curb was overtopped. The survey asked detailed questions about the specific areas of the home that were flooded and the maximum depth the resident observed. Some residents reported home flooding up to 36 inches. For any homes that did flood, the questionnaire inquired about the source of the flooding: flooding from White Oak Bayou and/or the tributaries, poor street drainage or both (see Exhibits 2.2-2.4). The survey contained questions that involved non-structural alternatives and the residents' willingness to participate in possible FEMA programs. These survey questions helped gain residential insight through personal experiences within the community that could provide important guidance later in the analysis. Appendix 2C contains the full catalog of responses.

Figure 2.3A. Citizen Questionnaire Results



2.4. Topographic Survey

DEC contracted with Kuo and Associates, Inc. to perform a topographic survey including FFE, HWM, and limited roadway cross-sections. Kuo surveyed the streets and homes located within the FEMA effective 100-year floodplain and the floodplain fringes. Overall, there were approximately 225 homes surveyed in the floodplain fringe and an additional 750 homes within the 100-year floodplain. The surveyed roadway cross-sections included at least the elevations at the curb, the gutter and the centerline of the road. Kuo provided a plan drawing in AutoCAD with all the survey data information and pictures of each house surveyed. The plan drawing contained all the parcels surveyed, each finished floor elevation, the street cross-section elevations, the street names and the address for each home surveyed. Kuo provided a separate excel spreadsheet that correlated the home address to the finished floor elevation and corresponding image name. DEC compared the street elevations to the base flood elevations of the bayou to locate areas of concern for street flooding (see Exhibit 2.5). The AutoCAD file, elevation point file, and photos can be found in Appendix 2D.

2.5. Phase 1 Public Meeting

In addition to the questionnaire distributed to the residents, the public had the opportunity to voice any comments or concerns they had through the first public scoping meeting, held on October 18, 2016. Crouch Communications facilitated the public meeting and residents were given the chance to either give verbal comments to the study team directly during the meeting or fill out comment cards. The comment cards included more residents in the comment process, without requiring them to speak in front of the crowd.

Several residents came forward to speak during the public meeting. A court reporter recorded the verbal comments for the public record. Many of the public comments reiterated the need for channel improvements and improved street drainage systems, particularly along Wall Street and Capri Drive. Multiple people submitted pictures demonstrating the level of flooding their home has experienced in the past. All of the comments helped to identify potential alternatives and reiterate the narrative of repetitive flooding in Jersey Village. For more detail, the Public Meeting No. 1 Summary Report – including the comment cards and transcript of verbal comments – is provided in Appendix 2E.

PHASE 2

3. Rapid Assessment

3.1. Purpose

The Rapid Assessment portion of the Jersey Village Long-term Recovery Plan was completed in order to expedite the assessment of damages to homes that frequently flood. One of the main goals of the rapid assessment was to evaluate how many homes are currently deep in the floodplain and how many of those homes may remain at risk after improvements are completed in the future due to the magnitude of flooding experienced by those homes. Another goal of the assessment was to include the most recent data available, such as home appraisal values and FFE, to screen homes for possible future alternatives. DEC performed the preliminary assessment utilizing the Structural Inventory Tool developed by DEC for use by HCFCD.

3.2. Structural Inventory Analysis Tool

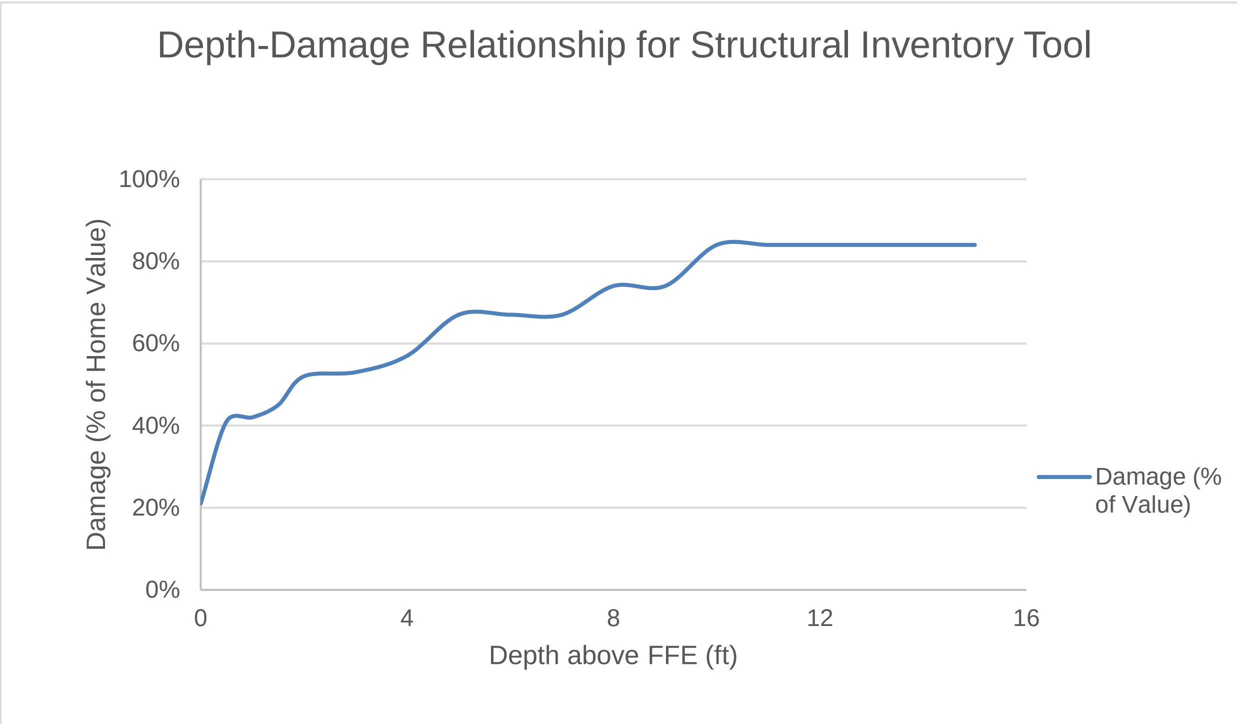
The Structural Inventory Analysis (SIA) Tool compares an estimated or surveyed finished floor elevation to the flood stage in the nearby stream for multiple storm frequencies. This comparison approximates the amount of damage done based on the depth of inundation of the structure. The SIA Tool offers several advanced calculation options, which include the ability to identify multiple structure and contents types, apply a unique depth-damage curve to each type, calculate expected annualized damages for the structure and include or exclude buyout properties from the analysis. The software includes a structural inventory database for each studied stream in Harris County. All the structures within a watershed are identified in a GIS-based shapefile, which is used as an input database for the SIA Tool. HEC-RAS models provide the flood stage data.

For the preliminary assessment, DEC ran the SIA Tool using data from the 2014 FEMA Effective models and the 2017 Revised Existing models. The Revised Existing model was adapted from the Existing model completed by HCFCD, which is currently under review with FEMA. Only the streams within Jersey Village were analyzed for the Rapid Assessment, which include E100-00-00, E127-00-00, and E135-00-00 of the White Oak Bayou watershed.

A. Structural Inventory Analysis Tool Input

The SIA Tool requires two sets of input data. The required input includes the hydraulic data in data storage system (DSS) format, which defines the flooding condition, and the structure inventory database containing all of the important information needed to evaluate each structure. Other data necessary for the calculations to be completed includes the backwater elevations and the reach designations for each stream. As mentioned earlier, specific structure types are noted in the structure inventory database and these structure types correspond to an individual depth-damage curve. The depth-damage curves provided with the software or the user can manually input a new curve for any structural, contents or vehicle type. Depth inundation equals the WSE minus the FFE of the home. The damage e as a percentage of home's value dependent on the depth of inundation. Figure 3.2A displays an example depth-damage curve used in the Structural Inventory Tool.

Figure 3.2A – Depth-Damage Relationship



The SIA Tool has additional economic capabilities in the economics tab. The user can choose to calculate annualized damages over a certain analysis period (default 50 years) and a certain discount rate (default 7%). The results include annualized damages and present value of damages for the given analysis period and discount rate. The HEC-RAS input data must include the seven standard storm events (2-, 5-, 10-, 25-, 50-, 100-, and 500-year) for the SIA Tool to calculate annualized damages and present value of damages. The user can also choose to exclude buyout properties (assume no damages), include buyout properties (assume damages), or evaluate the buyout program (damages for those properties only). Another economic function is the generic value option, which applies user entered improvement, property, and vehicle values to the analysis.

B. Structural Inventory Analysis Tool Output

The SIA Tool generates two files of output data from each analysis. The first of these files is an Excel spreadsheet with a summary of the analysis. This spreadsheet includes four separate tabs: a raw summary of the calculations, a stylized summary of the calculations that is ready to print, a duplication of the Event Monitor from the Results tab of the tool, and an overview of the configuration files used in the analysis.

The second output file is an ArcGIS shapefile with the calculated values for each structure. There are fields for the depth of inundation and the water surface elevation on the structure for each of the storm event frequencies. The shapefile also contains the value amount for the damage on the structure, contents and vehicle for each storm event. A field of particular interest in the shapefile is the "LOW_FLOOD" field, which denotes the lowest storm event where the structure is flooded by comparing the FFE to the flood stages for various frequencies. This field helps to illustrate which homes are at the greatest risk of inundation within the floodplain.

C. Rapid Assessment Results

DEC ran the SIA Tool for two HEC-RAS models: the 2014 FEMA Effective model and the 2017 Revised Existing model. Although the Effective model was recent, it did not include construction projects completed by HCFCD within the watershed, but did include LOMRs approved by FEMA for private development. The FEMA Effective floodplain is shown on Exhibit 3.1. The Revised Existing model was a better representation for current conditions due to the inclusion of the Bypass channel (E200-00-00), the channel improvements east of Beltway 8 along E100-00-00, several regional detention facilities, and the Elwood Weir on the E127-00-00 tributary. The level of protection for the Revised Existing HEC-RAS model is shown in Exhibit 3.2. By comparing the damages results for the two models, DEC was able to quantify the benefits to Jersey Village of infrastructure improvements (see Table 3.3A).

The backwater elevations and reach designations were provided for each stream and were crosschecked with the HEC-RAS models to ensure accurate data. The structure inventory database used was an ArcGIS shapefile containing all the structures present in Jersey Village. DEC updated the shapefile prior to running the SIA Tool to incorporate new development in the area, surveyed FFE, and 2015 Harris County Appraisal District (HCAD) appraisal values for each property. DEC analyzed the 2-year, 5-year, 10-year, 25-year, 50-year, 100-year and 500-year storms. The following tables show the summarized results for the Revised Existing model analysis:

Table 3.2A – Revised Existing Number of Flooded Homes

Tributary River	No. of Flooded Structures				
	10-yr	25-yr	50-yr	100-yr	500-yr
E100-00-00	0	26	98	149	326
E127-00-00	0	0	5	14	91
E135-00-00	0	0	0	0	12
Total	0	26	103	163	429

Table 3.2B – Revised Existing Single Event Damages

Tributary River	Total Single Event Damages				
	10-yr	25-yr	50-yr	100-yr	500-yr
E100-00-00	$0	$1,186,953	$5,888,840	$10,461,308	$32,386,281
E127-00-00	$0	$9,626*	$97,761	$523,747	$7,433,181
E135-00-00	$0	$16,104*	$135,629*	$422,017*	$4,057,298
Total	$0	$1,212,683	$6,122,230	$11,407,072	$43,876,760

*NOTE: The Structural Inventory tool reported minor damages due to allowances within the program for garage and vehicle flooding even when no homes were flooded.

3.3. Preliminary Conclusions

The SIA Tool identified the homes most likely to receive damage during different storm events (See Exhibit 3.3). The SIA Tool showed no damages occurring during a 10-year storm event for the Revised Existing conditions, but there were still homes affected by 25-year, 50-year and 100-year storms. The SIA tool verified that Jersey Village has a 10-year level of protection. The depth of inundation for the homes flooded during the 25-year, 50-year, 100-year and 500-year events is in Exhibits 3.3-3.7. Homes inundated by at least one foot during a 100-year storm were identified as potential candidates for non-structural alternatives if they remain at high risk after the implementation of structural solutions.

DEC also analyzed the FEMA Effective model in the SIA Tool to show the difference the improvements in the watershed have made to the extent of the floodplain. The Revised Existing conditions showed a dramatic improvement from the FEMA Effective Floodplain. The full results of the structural inventory analysis are in Appendices 3A and 3B. The following tables demonstrate the reduction in water surface elevation and damages between the FEMA Effective model and Revised Existing model.

Table 3.3A – WSE Comparison: Effective vs Revised Existing

Location	River Station	2014 FEMA Effective	2017 Revised Existing	Difference
		100-yr WSE	100-yr WSE	(Revised - Effective)
	ft	ft	ft	ft
Upstream of Bypass	105640	107.13	105.31	-1.82
Downstream of Bypass	104527	106.02	104.42	-1.6
Tahoe Drive Bridge	101325	104.68	102.73	-1.95
Downstream of Confluence with E127-00-00	100723	103.9	101.93	-1.97
Lakeview Bridge	99202	102.86	101.01	-1.85
Upstream of Beltway 8	97054	101.19	98.74	-2.45

Table 3.3B – Structural Inventory Output Comparison

Storm Event	Single Event Damages			Single Event Flooded Homes		
	Effective	Revised Existing	Reduction in Damages	Effective	Revised Existing	Difference in Number of Homes Inundated
10-yr	$12,903,477	$0	$12,903,477	158	0	158
50-yr	$43,228,048	$6,122,230	$37,105,818	459	103	356
100-yr	$70,174,570	$11,407,072	$58,767,498	611	163	448
500-yr	$150,759,510	$43,876,760	$106,882,750	1091	429	662

Statistically, there is a 1% chance of a 100-year storm happening in any given year. Compounded over a 30-year time period, there is a 26% probability that a 100-year event will occur. For a 50-year (2% annual chance) storm to occur during a 30-year time period, the probability of flooding increases to 45%. Therefore, the homes identified by the SIA Tool as flooded are likely to flood again within the next 30 years.

4. Environmental Desktop Review

Crouch Environmental Services, Inc. performed a preliminary environmental desktop review in Jersey Village. The report included a Regulatory Database Report, Sanborn Fire Insurance Maps, a City Directory Report, Historical Aerial Photographs, United States Geological Survey (USGS) Topographic Maps, a Waters of the U.S. (WOUS) Overview, and a Threatened and Endangered Species Overview. CESI also reviewed the wetlands database from the US Fish and Wildlife Service. Sites for potential structural alternatives were investigated for archaeological significance. The Regulatory Database Report identified sites that have existing or potential Recognized Environmental Conditions (RECs). To simplify the report, the total area was divided into four quadrants: western, northern, southern, and eastern. The purpose of the review was to study and summarize publicly available information as part of a preliminary environmental investigation. Recommendations were beyond the scope of the investigation. The entire desktop review report and all of its attachments and exhibits is in Appendix 4A.

5. Base Conditions Models

5.1. Existing Conditions

DEC received the existing conditions HEC-HMS and HEC-RAS models from HCFCD for all streams within the White Oak Bayou Watershed. The HEC-HMS model was in version 4.0 and the HEC-RAS models were in version 4.1. The streams were in individual HEC-RAS models. The streams pertinent to the Long-term Flood Recovery Plan were E100-00-00 (White Oak Bayou), E127-00-00, E135-00-00, E141-00-00, and E200-00-00 (Bypass). However, two regional detention ponds (E500-12-00 and E535-01-00) were not included in the existing conditions models as they were built to mitigate for channel improvements that have not yet been constructed. The Existing Conditions models included the following standard storm return intervals: 2-, 5-, 10-, 25-, 50-, 100-, and 500-year. DEC created the Revised Existing Conditions by adapting these models to suit the needs of the Long-term Flood Recovery Plan.

5.2. Revised Existing Conditions

A. HEC-RAS Geometric Modifications

The Existing Conditions models received from HCFCD were not interconnected. Analyzing the effects of the main channel on the tributaries in Jersey Village was critical to the study; therefore, DEC connected the tributaries and the Bypass to the main channel using stream junctions. The streams in the combined HEC-RAS model included:

- E100-00-00
- E127-00-00
- E135-00-00
- E141-00-00
- E200-00-00

The stream junctions accounted for the backwater effects to the tributaries from the White Oak Bayou main channel. Other updates included converting the model to HEC-RAS version 5.0.3, adding the “Elwood” weir near the mouth of E127-00-00, and editing overlapping cross-sections (see Exhibit 5.1). Study engineers converted the combined model to HEC-RAS 5.0.3 in order to utilize the newest HEC-RAS capability: 2D modeling. DEC did not update the Manning’s n values because the models represented current conditions. The updated and combined HEC-RAS geometry provided a more accurate hydraulic analysis and allowed the streams to interact with one another. Additionally, cross-sections downstream of Windfern Road were removed from the model to simplify the analysis.

B. HEC-HMS and Flow Modifications

The Existing Conditions HEC-HMS calculated the discharges produced by drainage area E127A as a single sub-basin and joined the E127A sub-basin directly to the nearest junction along the White Oak Bayou main channel. Additionally, the existing condition model did not account for any flow routing for Tributary E127-00-00. In order to evaluate the proposed alternatives discussed in this report, including detention in the Jersey Meadows Golf Course and channel improvements to tributary E127-00-00, DEC created a Revised Existing HEC-HMS model by dividing sub-basin E127A into three smaller sub-basin areas:

- E127A1: Sub-drainage area west of US 290.
- E127A2: Sub-drainage area east of US 290 (excluding the Jersey Meadows Golf Course area)
- E127A3: Sub-drainage area for the Jersey Meadows Golf Course only

Study engineers used the HCFCD TC&R method for developing Clark Unit Hydrographs for the subdivided drainage areas. The TC&R method and the Clark Unit Hydrograph method were consistent with the methodology for the White Oak Bayou Watershed. Exhibit 5.2 presents a map of the new sub-basins for E127-00-00.

In addition to subdividing drainage area E127A, DEC added two routing reaches – E127A_R1 and E127A_R2 – to the Revised Existing HEC-HMS model. Reach E127A_R1 included the area between the location of the proposed Golf Course detention pond outfall (cross-section 4702) and US 290 (cross-section 6863). Reach E127A_R2 stretched from the confluence with channel E100-00-00 (cross-section 146.9) to cross-section 4702. DEC did not connect sub-basin E127A2 to a routing reach to avoid unrealistic flow losses. Routing computations were executed using the HCFCD Hydrology and Hydraulics Guidance Manual. DEC used the storage volume-storage flow (SVSQ) relationship from the Revised Existing HEC-RAS model in the HEC-HMS routing reaches. The flows were routed using 20%, 40%, 60%, 80%, 100%, 120%, 140%, 160%, and 180% of the 1% (100-year) Existing peak flows. The revisions to the HEC-HMS model resulted in an increase in flow downstream of E127-00-00. See Table 5.2A for the comparison of discharges for the Revised Existing versus Existing.

Table 5.2A – Existing vs Revised Existing Flows

Location along E100-00-00	10-yr Flow (cfs)		50-yr Flow (cfs)		100-yr Flow (cfs)		500-yr Flow (cfs)	
	Existing	Rev. Existing	Existing	Rev. Existing	Existing	Rev. Existing	Existing	Rev. Existing
Confluence with E135-00-00	4,720	4,720	7,303	7,303	8,438	8,438	11,058	11,058
Confluence with E127-00-00	4,051	4,310	5,782	5,975	6,821	6,985	10,158	10,435
Junction DS of Beltway 8	4,855	5,109	6,901	7,184	7,806	8,162	10,784	11,095
Confluence with E141-00-00	7,937	8,125	12,375	12,654	14,037	14,398	18,340	18,585
Junction DS of Windfern Road	7,899	8,061	12,266	12,544	13,963	14,312	18,227	18,467

C. Revised Existing HEC-RAS Model

DEC added the peak flows from the Revised Existing HEC-HMS model to the Revised Existing HEC-RAS model. Together, the revised geometry and flows formed the final Revised Existing HEC-RAS model. DEC used the flow distribution spreadsheets (QT Cards) from HCFCD for interpolating flows for HEC-RAS cross-sections in between HEC-HMS nodes. DEC maintained flow change locations between the Existing and Revised Existing Conditions. The completed Revised Existing HEC-HMS and HEC-RAS models were the foundation for the development of alternatives and all results from alternatives were compared to the Revised Existing models. Table 5.2B presents a comparison of WSE at key locations, while the full HEC-HMS and HEC-RAS results are in Appendix 5B.

Table 5.2B – Existing vs Revised Existing WSE Comparison

Location	10-yr WSE (ft)		50-yr WSE (ft)		100-yr WSE (ft)		500-yr WSE (ft)	
	Existing	Rev. Existing	Existing	Rev. Existing	Existing	Rev. Existing	Existing	Rev. Existing
Confluence with E135-00-00	102.12	101.38	104.06	104.14	104.60	104.66	105.64	105.74
Confluence with E127-00-00	99.35	98.70	101.63	101.77	102.10	102.22	103.27	103.35
DS of Beltway 8	94.60	94.76	97.47	97.68	98.20	98.23	99.41	99.38
Confluence with E141-00-00	94.17	94.30	97.02	97.22	97.70	97.84	99.22	99.18
DS of Windfern Road	92.34	92.46	94.86	94.94	95.35	95.43	96.21	96.23
Near Mouth of E127-00-00	96.41	100.27	97.86	102.30	98.47	102.77	99.97	103.82

NOTE: The large difference in WSE near the mouth of E127-00-00 is due to a different tailwater assumption (normal depth vs backwater from junction).

6. Model Calibration

6.1. Introduction

DEC was tasked with calibrating the Revised Existing models to the Tax Day Flood (April 18, 2016) as part of the Jersey Village Long-term Flood Recovery Plan. On April 18, 2016, rainfall and flood levels reached record heights in the Jersey Village area. More than 230 homes flooded within the Jersey Village City Limits. According to the HCFCD, the storm was larger than a 100-year storm (1% annual chance storm), but less than a 500-year storm (0.2% annual chance storm) in the Jersey Village area. The DEC scope included calculating a more precise return interval for the Tax Day Flood and compared it to other record storms such as the Memorial Day 2015 Flood and Tropical Storm Allison (2001). Appendix 6A includes the HCFCD rain gauge rainfall data around Jersey Village during the Tax Day Flood. Table 6.1A displays a comparison of HWM for the recent major storms. Table 6.1B displays a comparison of cumulative rainfall at various intervals for a four-day period.

Table 6.1A – Major Storm High Water Marks

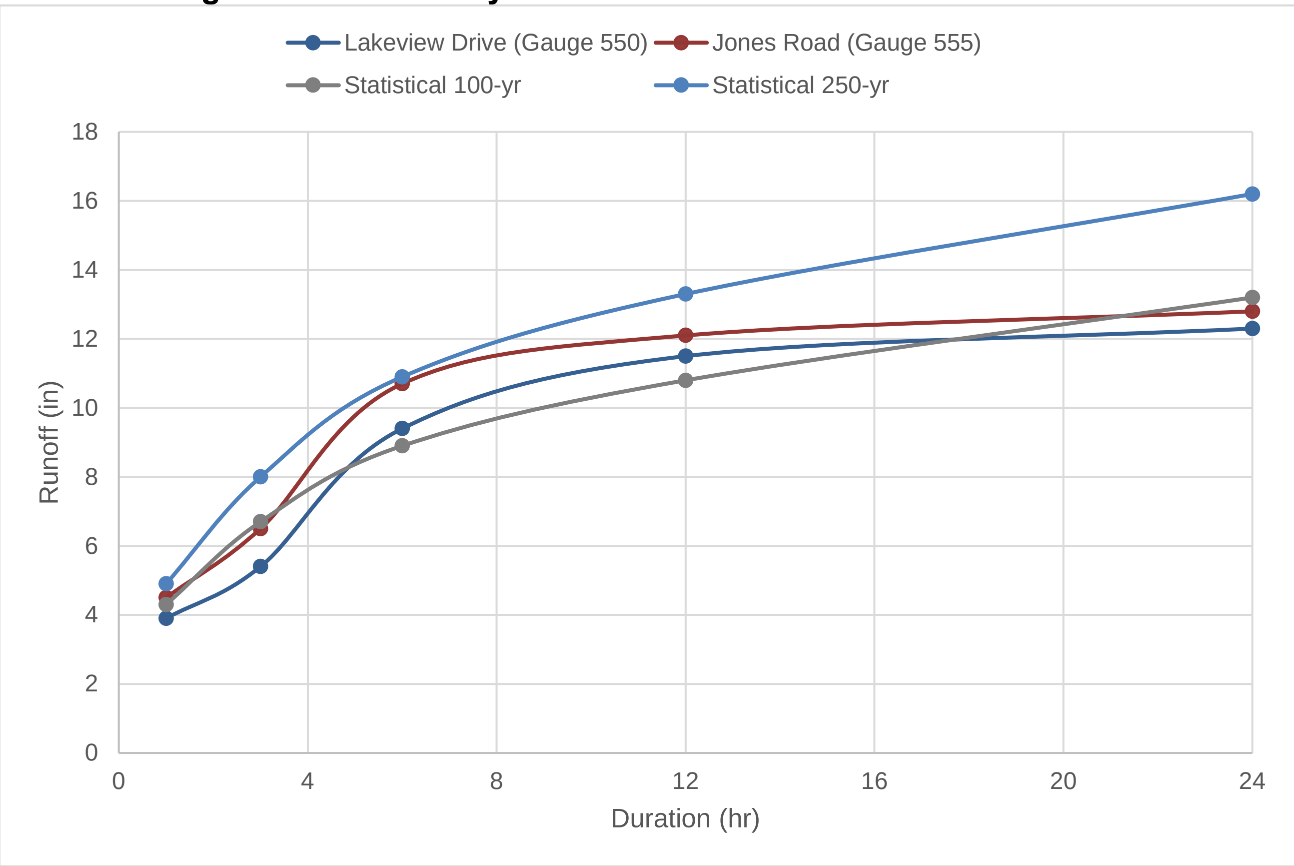
Road Name	Location Relative to Jersey Village	HCFCD High Water Marks (Surveyed)			Difference High Water Marks	
		T.S. Allison 6/9/01	Memorial Day 5/26/15	Tax Day 4/18/16	Tax Day vs T.S. Allison	Tax Day vs Memorial Day
		(2)	(3)	(4)	(4) - (2)	(4) - (3)
		ft	ft	ft	ft	ft
Windfern Rd	Downstream	96.6	86.5	94.8	-1.8	8.3
Gessner Rd	Downstream	96.1	88.4	96.5	0.4	8.1
Lakeview Dr	In Jersey Village	99.9	93.1	101.3	1.4	8.2
West Rd	Upstream	107.8	104.6	110.6	2.8	6.0
Jones Rd	Upstream	111.5	110.2	115.3	3.8	5.1

Table 6.1B – Major Storm Rainfall Data (4-day)

Sensor ID	Location	Event	15-min	30-min	1-hr	2-hr	3-hr	6-hr	12-hr	1-day	2-day	4-day
			in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
545	Fairbanks North Houston; Downstream of Jersey Village	T.S. Allison	0.28	0.32	0.96	1.63	2.58	4.74	10.74	10.78	10.94	10.94
		Memorial Day 2015	0.04	0.48	2.04	4.56	5.32	6.24	6.24	6.32	8.32	8.56
		Tax Day	**0.90**	**1.70**	**2.80**	**3.60**	**4.20**	**7.00**	**9.10**	**9.90**	**10.00**	**10.50**
550	Lakeview Dr; in Jersey Village	T.S. Allison	0.28	0.92	1.20	1.44	2.28	4.04	8.78	8.78	8.78	8.78
		Memorial Day 2015	0.16	0.72	2.16	4.36	4.96	5.76	5.84	5.84	7.44	7.72
		Tax Day	**1.30**	**2.40**	**3.90**	**4.80**	**5.40**	**9.40**	**11.50**	**12.30**	**12.30**	**13.00**
555	Jones Rd; Upstream of Jersey Village	T.S. Allison	0.44	0.56	0.60	0.84	2.15	4.14	10.89	10.89	10.93	10.93
		Memorial Day 2015	0.04	0.32	1.76	3.08	3.52	4.28	4.28	4.28	6.32	6.32
		Tax Day	**1.60**	**2.80**	**4.50**	**6.10**	**6.50**	**10.70**	**12.10**	**12.80**	**12.80**	**13.90**
HCFCD White Oak Bayou Watershed		100-yr Storm	2.1	3.0	4.3	5.7	6.7	8.9	10.8	13.2	14.5	15.9
HCFCD White Oak Bayou Watershed		250-yr Storm	2.4	3.4	4.9	6.7	8.0	10.9	13.3	16.2	17.4	18.8

As shown in Tables 6.1A and 6.1B, the Tax Day Flood had higher WSE than Tropical Storm Allison and the Memorial Day 2015 Flood in the Jersey Village area. The Tax Day Flood had higher rainfall amounts than Tropical Storm Allison and the Memorial Day 2015 Flood at Jones Road and Lakeview Drive, and higher rainfall for the critical 12-hour period than the statistical 100-year flood. HCFCD had not constructed any of White Oak Bayou Federal plan components (channel improvements, regional detention, the WOB Bypass) when Tropical Storms Frances and Allison occurred; therefore, more homes flooded during those storms than did on Tax Day 2016. The Memorial Day Flood was more severe in other areas of the greater Houston Area than in the Jersey Village area. The following figure shows the rainfall runoff from the Tax Day Flood compared to the statistical flood data for White Oak Bayou according to HCFCD.

Figure 6.1A – Tax Day Rainfall-Runoff vs Statistical Flood Data



6.2. Hydrology Calibration

For the hydrologic calibration, DEC downloaded rain gauge data from the Harris County Flood Warning System website for five rain gauges in or near Jersey Village (see Exhibit 6.1). The timestamped data began around 2:00PM on Sunday, April 17, 2016, ended at 2:00PM on Monday, April 18, 2016, and was collected in 30-minute increments. The time increment from 11:00PM to 11:30PM on April 17 recorded the highest incremental rainfall ranging from 2.32” to 2.84” for the gauges nearest Jersey Village. The total rainfall ranged from 11.56” to 14.64” for the selected gauges over the selected 24-hour time period. The average return interval for the 12-hr rainfall data was approximately 238 years (0.42% annual chance of occurrence). The majority of the rainfall occurred between 7:30PM on April 17 and 10:30AM on April 18. Discharge (flow) data was not available for HEC-HMS model validation (See Appendix 6A).

DEC reviewed previous storm calibrations within the FEMA Effective HEC-HMS model to determine the appropriate calibration methodology. The Effective model contained specific storm models for the March 1992 Flood, Tropical Storm Frances (September

1998), and Tropical Storm Allison (June 2001). For each storm, actual rainfall data for those storms was imported to the model as time-series data. The rainfall data for each gauge was assigned to the nearest drainage areas (see Exhibit 6.2). DEC applied the same methodology to the Revised Existing HEC-HMS model for calibration to the Tax Day Flood. DEC did not edit other parameters like infiltration to the soil and travel times.

DEC ran the HEC-HMS model with the rainfall data from the Tax Day Flood and reviewed the results. The flows generated by the model were larger than the 100-year storm flows, but smaller than 500-year flows, and were consistent with the HCFCD report on the Tax Day Flood (see Appendix 6A). Due to soil losses and head losses from routing, the average return interval for the volumetric flow from the storm was approximately 171 years, or a 0.59% annual chance of occurrence. Exhibit 6.3 displays the stream network for the White Oak Bayou Watershed.

6.3. Hydraulics Calibration

A. Calibration Criteria

DEC calibrated the HEC-HMS and HEC-RAS models for the Clear Creek Watershed among others after Tropical Storm Allison in 2001 as part of the Tropical Storm Allison Recovery Project (TSARP). The allowable WSE tolerance was two feet (2 ft) for the TSARP calibration reports. The 2 ft tolerance was due to model accuracy in HEC-HMS, allowable accuracy in the LiDAR data, and accuracy in the HEC-RAS model. The quality of topographic data, model data, and model performance has improved since 2001. Therefore, DEC chose a WSE calibration tolerance of plus or minus one foot (±1 ft) compared to the surveyed HWM.

B. Calibrated HEC-RAS Model

The final step in the calibration process was to import the discharges calculated in HEC-HMS to the Revised Existing HEC-RAS model. DEC used the QT Cards spreadsheets received from HCFCD to develop the flow distribution for HEC-RAS, added the flows to the HEC-RAS model, and computed the Tax Day WSE.

The results from the calibration efforts focused on WSE. Study engineers compared the WSE for the Revised Existing model to surveyed HWM at bridges and a few homes within Jersey Village (see Table 6.4a). The detailed results from the HEC-RAS and HEC-HMS models for the Tax Day Flood are in Appendix 6B. The HWM at the bridges were surveyed by HCFCD shortly after the Tax Day Flood, and Kuo and Associates surveyed the HWM at homes in September-October of 2016 (see Exhibit 6.4). The depth of flooding in homes from the citizen questionnaires was also used for comparison to the calibrated model results. However, the depth listed in the citizen questionnaires was not surveyed and was inconsistent with other surveyed HWM and therefore was used for reference only. The minimum increase in WSE was 0.22 ft at Gessner and the maximum increase in WSE was 1.09 ft at West Road. The sample standard deviation for the increase in WSE compared to the HWM was 0.32 ft for the Revised Existing model. The average increase in WSE compared to the HWM was 0.66 ft for the Revised Existing Conditions. The average WSE return interval was approximately 145 years (0.7% annual chance of occurrence). DEC mapped the 100-year and Tax Day floodplains with the calibrated Revised Existing model for comparison of inundation areas (see Exhibit 6.5).

Table 6.3A – Calibration Results

Source	**Location**	**River Station** (ft)	**High Water Mark** (ft) (1)	**Revised Existing WSE** (ft) (2)	**Difference** (ft) (2) – (1)
White Oak Bayou Main Channel (E100-00-00)					
HCFCD	Jones Road	116680	115.3	115.82	0.52
HCFCD	West Road	110454	110.6	111.69	1.09
HCFCD	Lakeview Drive	99202	101.3	101.63	0.33
HCFCD	Gessner Road	93534	96.5	96.72	0.22
HCFCD	Windfern Road	91972	94.8	95.71	0.91
Survey	Property on Hawaii Ln	102317	103.08	103.99	0.91
Survey	Property on Hawaii Ln	102317	103.28	103.99	0.71
Survey	Property on Jersey Dr	99044	100.78	103.61	0.87
South Fork Tributary (E127-00-00)					
Survey	Property on St. John Ct	1977	102.74	103.61	0.87
Survey	Property on Wall St	1977	102.90	103.63	0.73

6.4. Model Validation

For model validation, DEC ran the SIA Tool with the hydraulic data from the calibrated HEC-RAS model. The City of Jersey Village reported that 238 homes flooded on Tax Day 2016. However, several homes were flooded due to local street flooding instead of riverine flooding. The SIA results identified 208 homes flooded due to riverine flooding using the calibrated HEC-RAS model (see Exhibit 6.6) The SIA Tool did not include homes that were inundated by local street flooding. The percent difference between the number of homes inundated by the calibrated HEC-RAS model and the reported number of homes was 12.6%. The approximate damages output by the SIA Tool for the Tax Day Flood was $15,141,963. Table 6.4B compares SIA results for the 100-year event and the Tax Day Flood. The full results for the Tax Day structural inventory analysis are in Appendix 6C.

Table 6.4B – Structural Inventory Results Comparison

	100-yr Event	**Tax Day Event**
No. of Flooded Structures	163	208
Damages to Flooded Structures	$11,407,072	$15,141,963
Avg. Damages Per Structure	$69,982	$72,798

NOTE: The Structural Inventory tool reported minor damages to some homes that were not identified as flooded. Therefore, the average damages per structure was calculated using the total damages for homes that were identified as flooded and excluded minor damages to homes that were not identified as flooded.

6.5. 2D Model Development

DEC developed a 2D HEC-RAS model for the Revised Existing Conditions to assess problem areas within Jersey Village. The 2D model analyzed flow in two directions: downstream and lateral flow. The Revised Existing 1D steady flow model only analyzed flow in the downstream direction. The majority of the analysis for the Long-term Flood Recovery Plan was completed using the 1D analysis method as it is the most conservative and is standard engineering practice.

DEC developed the 2D Revised Existing model by first converting the 1D HEC-RAS model from steady flow (no change with time) to unsteady flow (flow changing with time). Flow versus time hydrographs from the Revised Existing HEC-HMS model were added directly to cross-sections within the HEC-RAS model. The unsteady flow version of the model accounted for the varying travel time for the tributaries and drainage areas within the watershed. After the unsteady model was complete, study engineers converted the model to 2D using LiDAR. The final analysis was a hybrid 1D/2D model: 1D within the channel banks and 2D in the overbanks through Jersey Village. The overflow from the 1D channel to the 2D overbanks was simulated as a lateral weir. The lateral weir consisted of actual terrain data from the banks and provided a realistic transition between the channel and the overbanks.

The Revised Existing 2D model identified overflow points between the channels and the overbanks. The locations of overflow were consistent with citizen observations. DEC observed overflow locations along the main channel near Elwood Street and Jersey Drive and near the Jersey Meadows Golf Course on Tributary E127-00-00. Tributary E135-00-00 also experienced a small amount of overflow into Jersey Meadow Golf Course. The Tax Day floodplain generated by the 2D model was smaller than the 1D steady floodplain. The 2D floodplain was smaller because the 2D model accounts for flow travel time through the watershed, whereas the 1D steady flow model does not account for timing and only uses the peak flow for each drainage area. Additionally, DEC calibrated the 2D Tax Day model to the surveyed HWM with a calibration tolerance of one foot. DEC ran the Revised Existing 2D model two storms: 100-year and the Tax Day Flood (April 2016). See Appendix 6D for detailed results. Exhibit 6.7 displays a map of the 2D Tax Day simulation and Table 6.5A – 2D Calibration Results includes a comparison of the maximum WSE from the 2D model with the HWM.

Table 6.5A – 2D Calibration Results

Source	**Location**	**River Station** (ft)	**High Water Mark** (ft) (1)	**Revised Existing 2D WSE** (ft) (2)	**Difference** (ft) (2) – (1)
White Oak Bayou Main Channel (E100-00-00)					
HCFCD	Jones Road	116680	115.3	114.32	-0.98
HCFCD	West Road	110454	110.6	110.33	-0.27
HCFCD	Lakeview Drive	99202	101.3	100.64	-0.66
HCFCD	Gessner Road	93534	96.5	96.18	-0.32
HCFCD	Windfern Road	91972	94.8	95.36	0.56
Survey	Property on Hawaii Ln	102317	103.08	102.09	-0.99
Survey	Property on Jersey Dr	99044	100.78	100.09	-0.69
South Fork Tributary (E127-00-00)					
Survey	Property on St. John Ct	1977	102.74	102.17	-0.57
Survey	Property on Wall St	1977	102.90	102.23	-0.67

7. Development of Alternatives

7.1. Structural Alternatives

A. Jersey Meadow Golf Course

The Jersey Meadow Golf Course is a 131-acre Golf Course owned by the City of Jersey Village. Currently, the Golf Course is not self-contained and water sheet flows across Rio Grande Street and down Wall Street during large storm events. During smaller storm events, the Golf Course drains into the E127-00-00 Tributary. The Golf Course is an important area of concern for the citizens and the City of Jersey Village (see Exhibit 7.1).

The alternative for the Golf Course was to add a berm around the Golf Course to retain the water and release it into the E127-00-00 Tributary later to reduce the flow through the channel and prevent sheet flow from reaching Wall Street. After determining the discharge from the Golf Course in existing conditions, the DEC modeled the Golf Course in HEC-HMS and the output flows were used in the Revised Existing HEC-RAS models. As stated in section 5.2.B., study engineers revised the HEC-HMS model to sub-divide the E127A drainage area into three sub-basins, one of which was the Jersey Meadow Golf Course (see Appendices 5A and 5B). DEC also developed a stage vs time tailwater curve for the outflow conditions. The tailwater curve was created by using the rating curve (stage vs flow) from cross-section (XS) 4656.5 on E127-00-00 in the Revised Existing HEC-RAS model, and the flow hydrograph from the Revised Existing HEC-HMS model at the junction node of Reach E127A_R1 and sub-basin E127A3 (Jersey Meadow Golf Course) and interpolating to create a stage vs time curve.

DEC modeled the Golf Course in HEC-HMS using two different methods: (1) complete removal of the Golf Course sub-basin simulating self-containment and (2) modeling the Golf Course as a reservoir to simulate detention pond conditions. DEC developed the elevation-storage relationship for the reservoir simulation using ArcGIS and LiDAR to determine the storage volume available at different elevations. According to existing topography, the minimum elevation in the Golf Course was 101.1 ft at a location along Rio Grande Street near Wall Street. The maximum elevation along Rio Grande Street north of Wall Street was 107.3 ft. The average elevation in the area was around 103.8 ft. The top of the berm was set to the maximum elevation on Rio Grande of 107.3 ft in the HEC-HMS model, which set the average berm height around 3.5 ft. The total storage volume available under elevation 107.3 ft was approximately 152.5 ac-ft, however this did not account for a loss of volume due to the construction of the berm itself. The preliminary 100-year WSE in the Golf Course was 106.8 ft. The preliminary berm design for future planning and design featured a top elevation of 108 ft to ensure freeboard (see Exhibit 7.3). The final design of the berm will ensure enough freeboard to protect nearby homes and may differ from the recommendations within this report. Table 7.1A shows the total storage volume at each elevation. DEC included the existing 36" outfall pipe in the model with the addition of a 10 ft weir simulating an emergency spillway for extreme events. Exhibit 7.2 displays the recommended Golf Course berm design.

Table 7.1A – Golf Course Stage-Storage Table (modeled in HEC-HMS)

	Elevation	Total Volume	
	(ft)	(ft^3)	(ac-ft)
Minimum Elev.	101.1	12	0.00
Average Elev.	103.8	180,780	4.2
Maximum Elev.	107.3	6,641,390	152.5

The model simulating a berm around the Golf Course yielded results with no discernable difference to the model that excluded the Golf Course altogether. Therefore, this report presents only the reservoir simulation results. The results from the HEC-HMS models showed that every storm frequency except for the 500-year event was contained within the Golf Course by the berm. DEC created a new HEC-RAS model containing the reduced flows from the Golf Course simulation and the Revised Existing geometry. DEC compared the output from the Golf Course HEC-RAS model to the WSE for the Revised Existing Conditions model. Table 7.1B shows the peak flows at different areas downstream of the detention pond. Table 7.1C and Exhibit 7.4 illustrate the reduction in water surface elevation at select river stations along the Tributary and main channel. The detailed results for each model are in Appendix 7A.

Table 7.1B – Revised Existing vs Golf Course Detention Flow Summary

Location	10-yr		50-yr		100-yr		500-yr	
	Rev. Existing	Golf Course w/Berm	Rev. Existing	Golf Course w/Berm	Rev. Existing	Golf Course w/Berm	Rev. Existing	Golf Course w/Berm
Golf Course Sub-basin	172	172	243	243	279	279	378	378
DS of Golf Course	812	654	1,115	922	1,277	1,062	1,799	1,492
Mouth of E127-00-00	1,191	1,026	1,654	1,464	1,904	1,689	2,660	2,365
Confluence with E100-00-00	4,310	4,176	5,975	5,840	6,985	6,865	10,435	10,300

Table 7.1C – Revised Existing vs Golf Course with Berm WSE Comparison

Location	10-yr WSE (ft)		50-yr WSE (ft)		100-yr WSE (ft)		500-yr WSE (ft)	
	Rev. Existing	Golf Course Detention	Rev. Existing	Golf Course Detention	Rev. Existing	Golf Course Detention	Rev. Existing	Golf Course Detention
Golf Course Outfall	104.43	103.72	105.44	105.10	105.65	105.40	106.04	105.91
Mouth of E127-00-00	100.07	99.88	102.16	102.10	102.62	102.56	103.69	103.66
Confluence with E127-00-00	99.65	99.46	101.77	101.70	102.22	102.15	103.35	103.30
US of Lakeview Drive	98.54	98.34	100.96	100.89	101.33	101.28	102.41	102.37
US of Beltway 8	95.13	94.98	98.05	97.98	98.66	98.65	100.12	100.06
DS of Windern Road	92.46	92.36	94.94	94.90	95.43	95.39	96.23	96.22

DEC ran the Gold Course HEC-RAS results through the SIA Tool to assess the benefits of the Golf Course alternative. Exhibit 7.5 shows a map of the SIA Tool results and more detailed structural inventory results can be found in Appendix 7B. A summary of the results from the Structural Inventory Tool are included in Table 7.1D.

Table 7.1D – Golf Course Alternative Structural Inventory Damages Summary

		Single Event Damages by Stream			
		25-yr	50-yr	100-yr	500-yr
Revised Existing Conditions	E100-00-00	$1,186,953	$5,888,840	$10,461,308	$32,386,281
	E127-00-00	$9,626	$97,761	$523,747	$7,433,181
	Total Damages	$1,196,579	$5,986,601	$10,985,055	$39,819,462
Golf Course w/Berm	E100-00-00	$759,004	$5,054,685	$9,717,495	$30,947,861
	E127-00-00	$12,702	$81,335	$509,980	$6,468,659
	Total Damages	$771,706	$5,136,020	$10,227,475	$37,416,228
Reduction in Damages (Revise Ex – GC w/Berm)		$424,873	$850,581	$757,580	$2,403,633

Table 7.1E – Golf Course Alternative Structural Inventory: Flooded Homes

	Number of Homes Flooded During Each Storm Event		Difference in Number of Homes Inundated
	Revised Existing Conditions	Golf Course With Berm	
10-yr	0	0	0
25-yr	26	18	8
50-yr	103	88	15
100-yr	163	156	7
500-yr	429	391	38

Overall, the results from the HEC-HMS and HEC-RAS analysis and the SIA showed a reduction in flooded homes along the E100-00-00 channel, downstream of the E127-00-00 Tributary. The total reduction in damages for the 100-year storm was $757,580 for a single event. Additionally, constructing a berm around the Golf Course for detention purposes prevented sheet flow from reaching Wall Street and the surrounding neighborhood, thereby reducing localized flooding.

B. E127-00-00 Tributary Channel

DEC considered two structural alternatives for tributary E127-00-00:

1. Elwood Weir impact analysis
2. Channel improvements from the confluence with channel E100-00-00 (XS 146.9) to US 290 (XS 6863.3).

i. Elwood Weir Removal

DEC reviewed the construction plans for the Elwood Weir prior to completing any modeling and determined that the weir was constructed as a drop structure to provide a transition between the higher flowline of E127-00-00 to the much lower flowline of E100-00-00. Additionally, the construction plans revealed that the weir helps to prevent erosion at the confluence of E127-00-00 and E100-00-00.

DEC analyzed the Elwood Weir using two boundary condition methods in order accurately assess its impact on E127-00-00. The first method was to analyze E127-00-00 as though it was not connected to any other streams and was not affected by backwater from E100-00-00, or the normal depth method. The second method was to analyze the Weir in the combined model accounting for backwater from E100-00-00. For both scenarios, the weir was removed completely and the resulting WSE were compared to the WSE in the Revised Existing models. For the normal depth scenario and 1% flow frequency, the results comparison indicated that the removal of the weir reduced the WSE at cross-section 196.3 (just upstream of the weir) by approximately 3.5 ft. However, by cross-section 1024 (approximately 900 ft upstream of the weir) there was no significant effect on the WSE. In fact, the “no weir” scenario produced slightly higher WSE than the Revised Existing scenario upstream of cross-section 1024. Since the 100-year WSE was contained within banks in the Revised Existing conditions, there were no tangible benefits to the homes near the stream. Exhibits 7.6 and 7.7 provide comparisons of a HEC-RAS cross-section with and without the Elwood Weir. Table 7.1F presents the comparison of WSE for several locations on E127-00-00.

Table 7.1F – Revised Existing vs No Weir (Normal Depth) WSE Comparison

Location along E127-00-00	10-yr WSE (ft)		50-yr WSE (ft)		100-yr WSE (ft)		500-yr WSE (ft)	
	Rev. Existing	No Weir	Rev. Existing	No Weir	Rev. Existing	No Weir	Rev. Existing	No Weir
DS of US 290	105.57	105.57	106.62	106.62	106.99	106.99	107.73	107.72
DS of Rio Grande St	102.70	102.70	103.78	103.78	104.27	104.28	105.18	105.18
DS of Senate Ave	97.49	97.49	98.34	98.34	98.87	98.72	100.32	99.93
US of Weir	95.18	91.90	96.15	92.72	96.60	93.11	97.78	94.14
DS of Weir	87.64	87.50	88.55	88.35	89.00	88.75	90.24	89.81

In the backwater scenario, the reduction in WSE for the 100-year storm was minimal (≤ 0.01 ft). The backwater scenario was the more realistic scenario as backwater from the receiving stream always affects tributaries, especially during extreme events. Therefore, DEC engineers concluded that there was no significant reduction in WSE on E127-00-00 because of removing the Elwood Weir. Therefore, DEC did not recommend removal of the weir due to the lack of hydraulic benefits. See Appendix 7C for the detailed results comparison.

The study team also compared the FFE for homes located near the Elwood Weir to the Revised Existing WSE in the nearest HEC-RAS cross-sections of the Tributary. The results showed no flooded homes along the E127-00-00 Tributary due to the Elwood Weir during a 100-year storm event. Table 7.1G illustrates the comparison results.

Table 7.1G – Elwood Weir Finished Floor Elevation Comparison Table

Slab #	Slab Elevation (ft) (1)	River Station	No Weir WSE (ft) (2)	Weir WSE (ft) (3)	No Weir vs Slab (ft) (2) - (1)	Weir vs Slab (ft) (3) - (1)
1	102.06	632.7	97.08	98.02	-4.98	-4.04
2	104.49	527.7	96.34	97.59	-8.15	-6.90
3	105.21	711.5	97.64	98.34	-7.57	-6.87
4	103.56	476.7	95.84	97.44	-7.72	-6.13
5	102.12	207.6	93.22	96.63	-8.90	-5.49
6	103.82	945.5	98.47	98.75	-5.35	-5.07
7	103.12	773.3	97.92	98.48	-5.20	-4.64
8	103.87	945.5	98.47	98.75	-5.40	-5.12
9	103.32	794.2	97.98	98.52	-5.34	-4.80
10	103.89	953.0	98.49	98.76	-5.40	-5.13
11	103.13	819.4	98.06	98.56	-5.07	-4.57
12	103.33	968.5	98.54	98.78	-4.79	-4.55
13	103.93	902.1	98.33	98.68	-5.60	-5.25
14	102.44	861.2	98.20	98.62	-4.24	-3.82
15	102.39	665.3	97.31	98.15	-5.08	-4.24
16	102.47	501.7	96.09	97.51	-6.38	-4.96

Slab #	Slab Elevation (ft) (1)	River Station	No Weir WSE (ft) (2)	Weir WSE (ft) (3)	No Weir vs Slab (ft) (2) - (1)	Weir vs Slab (ft) (3) - (1)
17	102.78	407.4	95.17	97.23	-7.61	-5.55
18	102.13	285.9	93.98	96.87	-8.14	-5.26
19	102.31	196.3	93.11	96.60	-9.20	-5.71
20	103.02	146.9	88.75	89.00	-14.27	-14.02
21	102.10	743.8	97.82	98.44	-4.28	-3.66
22	101.41	668.7	97.34	98.17	-4.07	-3.24
23	101.46	574.8	96.67	97.78	-4.78	-3.68

ii. Channel Improvements on E127-00-00

The proposed channel improvements for tributary E127-00-00 (see Exhibit 7.8) included a uniform flow line slope with a minimum bottom width of 6 ft and side slopes of 3:1 (H:V). DEC did not change the channel bank stations due to limited easement widths and minimum maintenance berm widths of 20 ft. The existing easement varied in width from 150 ft from the mouth to 600 ft upstream of XS 1977. Upstream of this location, the easement was approximately 100 ft wide. No additional ROW acquisition was necessary to perform the proposed channel improvements. The flow line of the channel was lowered to elevation 84.58 ft from elevation 87.58 ft between cross-sections 160 (location of the Elwood Weir) and 196.3, reducing the height of the Elwood Weir drop structure from 5 ft to 2 ft. From XS 196.3 to 6863, the channel was improved according to the summary in Table 7.1H. Refer to Exhibit 7.10 for a typical section of the channel improvements.

Table 7.1H – E127-00-00 Tributary Channel Improvements

From	To	Exist. Flow Line El.		Prop. Flow Line El.		Diff. FL Elev. DS	Prop FL Slope	Bottom Width	Side Slope	Top Width	Min. Berm Width
Sta.	Sta.	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
5487.0	6863.3	95.63	98.14	95.47	97.56	0.58	0.15%	6.0	3.0	61.3	20.0
1977.0	5487.0	91.09	95.63	89.23	95.47	0.16	0.18%	6.0	3.0	63.9	20.0
1024.0	1977.0	90.82	91.09	87.84	89.23	1.86	0.18%	6.0	3.0	77.57	30.0
196.3	1024.0	87.58	90.82	86.96	87.84	3.32	0.35%	6.0	3.0	83.5	30.0
160.0*	196.3	87.58	87.58	84.58	86.96	3.00	0.00%	6.0	3.0	106.2	20.0
146.9	160.0*	87.58	87.58	82.58	84.58	3.00	15.27%	6.0	3.0	106.2	20.0

*Station 160 is location of Elwood Weir drop structure.

Due to the proposed channel improvements, it was necessary to revise the flow routing for Tributary E127-00-00. The flows in the HEC-HMS for the channel improvements were determined after using the SVSQ cards obtained from the E127-00-00 Channel Improvements HEC-RAS model for 20%, 40%, 60%, 80%, 100%, 120%, 140%, 160%, and 180% of the 1% (100-year) flow frequency. The comparison of discharges for the Revised Existing versus Proposed Channel Improvements is in Table 7.1I.

Table 7.1I – Revised Existing vs Proposed Channel Improvement Flows

Location	10-yr Flow (cfs)		50-yr Flow (cfs)		100-yr Flow (cfs)		500-yr Flow (cfs)	
	Rev. Existing	Chan. Imp.	Rev. Existing	Chan. Imp.	Rev. Existing	Chan. Imp.	Rev. Existing	Chan. Imp.
Confluence with E135-00-00	4,720	4,720	7,303	7,303	8,438	8,438	11,058	11,058
Confluence with E127-00-00	4,310	4,299	5,975	5,943	6,985	6,911	10,435	10,423
Junction DS of Beltway 8	5,109	5,105	7,184	7,202	8,162	8,179	11,095	11,072
Confluence with E141-00-00	8,125	8,123	12,654	12,665	14,398	14,417	18,585	18,615
Junction DS of Windfern Road	8,061	8,059	12,544	12,536	14,312	14,319	18,467	18,488
DS of US 290	661	661	958	958	1,110	1,110	1,539	1,539
DS of Golf Course	812	828	1,115	1,150	1,277	1,325	1,799	1,834
Mouth of E127-00-00	1,191	1,205	1,654	1,689	1,904	1,953	2,660	2,713

The channel improvements to E127-00-00 were only modeled using the normal depth boundary condition. For normal depth boundary conditions and the 100-year storm, the results comparison indicated that the proposed channel improvements produced a reduction in WSE of 0.5 ft to 1 ft. The reduction in WSE was 0.04 ft at cross-section 6832 – the limits of the channel improvements. Since E127-00-00 is contained within banks for the 100-year storm for most of its length in the normal depth condition, the channel improvements did not provide any tangible hydraulic benefits. See Appendix 7D for the full HEC-HMS and HEC-RAS results for the E127-00-00 Tributary channel improvements. Exhibit 7.9 and Table 7.1J present the comparison of WSE for several locations on tributary E127-00-00.

Table 7.1J – Revised Existing vs Channel Improvements (Normal Depth) WSE

Location along E127-00-00	10-yr WSE (ft)		50-yr WSE (ft)		100-yr WSE (ft)		500-yr WSE (ft)	
	Rev. Existing	Chan. Imp.	Rev. Existing	Chan. Imp.	Rev. Existing	Chan. Imp.	Rev. Existing	Chan. Imp.
DS of US 290	105.57	105.30	106.62	106.51	106.99	106.95	107.73	107.64
DS of Rio Grande St	102.70	101.64	103.78	102.85	104.27	103.43	105.18	104.69
DS of Senate Ave	97.49	96.64	98.34	97.83	98.87	98.39	100.32	99.74
US of Weir	95.18	95.33	96.15	96.33	96.60	96.80	97.78	97.92
DS of Weir	87.64	87.74	88.55	88.71	89.00	89.19	90.24	90.44

To determine the economic benefits along the E127-00-00 Tributary, DEC exported the HEC-RAS data to a DSS file and ran the Structural Inventory Tool. The SIA indicated no decrease in the number flooded homes along the E127-00-00 Tributary, except for the 500-year event. Most of the homes inundated during various storm events were flooded due to backwater from the main channel rather than overflow from the Tributary (see Section 3. Rapid Assessment). The results are in Exhibit 7.11 and Appendix 7E. Table 7.1K summarizes the SIA results.

Table 7.1K - E127-00-00 Channel Improvements Structural Inventory Summary

Single Event Damages			Reduction in Damages	Number of Homes Flooded During Each Storm Event		Difference in Number of Homes Inundated
Storm Event	Revised Existing	E127-00-00 Channel Improvements		Revised Existing	E127-00-00 Channel Improvements	
10-yr	$0	$2,066	-$2,066	0	0	0
25-yr	$9,626	$13,274	-$3,648	0	0	0
50-yr	$97,761	$108,384	-$10,623	5	5	0
100-yr	$523,747	$607,485	-$83,738	14	14	0
500-yr	$7,433,181	$7,026,505	$406,676	91	75	16

NOTE: The increase in damages for the E127-00-00 channel improvements alternative is due to the increase in flows resulting from the channel improvements at the downstream end of E127-00-00. There was no mitigation analysis for this alternative.

As shown in Table 7.1K, there was no reduction in the number of flooded homes for all storms except the 500-year storm. Both the hydraulic benefits and the economic benefits indicated that channel improvements to Tributary E127-00-00 were not feasible; therefore, DEC did not recommend the alternative for continued analysis as part of the Recommended Solution for the Long-term Flood Recovery Plan.

C. White Oak Bayou (E100-00-00) Channel Improvements

DEC considered one structural alternative along the White Oak Bayou main channel: channel improvements. The capacity of White Oak Bayou through Jersey Village was a major topic of discussion during the first public meeting for the Long-term Flood Recovery Plan. Therefore, channel improvements along the White Oak Bayou main channel were an important part of the Phase 2 alternatives analyses.

USACE and HCFCD studied channel improvements along White Oak Bayou in detail as part of the GRR for the White Oak Bayou Watershed. DEC used the GRR recommended plan channel XS within the Jersey Village City Limits for the analysis (see Exhibits 7.12-13). The channel improvements were included in the HEC-RAS model from just downstream of the confluence with Tributary E135-00-00 to just upstream of Beltway 8 (cross-sections 104527 through 97546), a length of 1.5 miles. The improvements altered the channel cross-section to have 3:1 (H:V) side slopes with a shelf approximately three feet above the bottom of the channel and a rectangular channel bottom lined with gabions (see Exhibit 7.14).

The channel improvements reduced the WSE through Jersey Village significantly. However, since the channel improvements caused an increase in conveyance, DEC performed flow routing computations to calculate the increase in flows and observed impacts beginning upstream of Beltway 8. Additionally, the channel improvements to E100-00-00 resulted in a WSE reduction along Tributary E127-00-00 in the combined HEC-RAS model. The maximum reduction in WSE was 1.12 ft, 0.46 ft, 0.24ft, and 0.19 ft for the 10-year, 50-year, 100-year, and 500-year respectively (see Appendix 7F for results). Tables 7.1L and 7.1M include the flow and WSE comparison between the channel improvements alternative and the Revised Existing condition at key locations in Jersey Village. See section 10.1 for a discussion of mitigation for channel improvements.

Table 7.1L – Revised Existing vs E100-00-00 Channel Improvements Flows

Location	10-yr Flow (cfs)		50-yr Flow (cfs)		100-yr Flow (cfs)		500-yr Flow (cfs)	
	Rev. Existing	Chan. Imp.	Rev. Existing	Chan. Imp.	Rev. Existing	Chan. Imp.	Rev. Existing	Chan. Imp.
Confluence with E135-00-00	4,720	4,720	7,303	7,303	8,438	8,438	11,058	11,058
Confluence with E127-00-00	4,310	4,334	5,975	6,024	6,985	7,203	10,435	10,748
Junction DS of Beltway 8	5,109	5,291	7,184	7,560	8,162	8,666	11,095	12,261
Confluence with E141-00-00	8,125	8,435	12,654	12,986	14,398	14,881	18,585	20,000
Junction DS of Windfern Road	8,061	8,409	12,544	12,958	14,312	14,851	18,467	19,984

Table 7.1M – Revised Existing vs E100-00-00 Channel Improvements WSE

Location	10-yr WSE (ft)		50-yr WSE (ft)		100-yr WSE (ft)		500-yr WSE (ft)	
	Rev. Existing	Chan. Imp.	Rev. Existing	Chan. Imp.	Rev. Existing	Chan. Imp.	Rev. Existing	Chan. Imp.
DS of Bypass	101.29	100.07	104.28	103.90	104.84	104.60	106.20	106.01
Confluence with E135-00-00	102.45	101.43	104.15	103.83	104.66	104.49	105.73	105.67
Confluence with E127-00-00	99.69	98.86	101.78	101.44	102.22	102.08	103.35	103.3
DS of Lakeview Drive	98.42	97.59	100.71	100.25	101.14	100.9	102.18	102.24
DS of Beltway 8	94.76	95.06	97.68	97.85	98.23	98.2	99.38	99.79
Confluence with E141-00-00	94.30	94.6	97.22	97.38	97.84	98.03	99.18	99.58
DS of Windfern Road	92.46	92.71	94.94	95.06	95.43	95.55	96.23	96.37
Near Mouth of E127-00-00	100.15	99.32	102.23	101.88	102.69	102.52	103.76	103.7

To quantify the individual benefits from the E100-00-00 channel improvements, DEC exported a DSS file from the HEC-RAS model and ran the SIA Tool. The Structural Inventory indicated a substantial decrease in flooded homes for the 25-year and 50-year frequencies. The results can be seen on Exhibit 7.15 and in Appendix 7G. The following tables show the SIA results for the E100-00-00 channel improvements.

Table 7.1N – E100-00-00 Channel Improvements Structural Inventory Results

Single Event Damages			Reduction in Damages	Number of Homes Flooded During Each Storm Event		Difference in Number of Homes Inundated
Storm Event	Revised Existing	E100-00-00 Channel Improvements		Revised Existing	E100-00-00 Channel Improvements	
10-yr	$0	$0	$0	0	0	0
25-yr	$1,212,683	$304,552	$908,131	26	8	18
50-yr	$6,122,230	$3,918,731	$2,203,499	103	70	33
100-yr	$11,407,071	$9,439,528	$1,967,543	163	145	18
500-yr	$43,879,072	$49,692,107	-$5,813,035	429	427	2

NOTE: An increase in damages was observed for the 500-year storm because of the increased flows due to channel improvements. See section 10.1 for a discussion on mitigation.

D. Bridges

Another alternative evaluated for the Long-term Flood Recovery Plan was the modification of the bridges along the WOB channel located within Jersey Village City limits (see Exhibit 7.16). DEC studied the following bridges: Tahoe Drive, Lakeview Drive, and Equador Pedestrian Bridge. Study engineers investigated several iterations of the bridge modifications to determine which bridges provided the largest hydraulic benefit to the surrounding area.

To determine the maximum WSE reduction possible, DEC removed all three bridges from the model. With no bridges in the model, the maximum drop in WSE compared to Revised Existing Conditions was 0.18 ft for a 100-year event. This small drop in WSE was evidence that the bridges were not a major cause of flooding in Jersey Village. However, 0.18 ft of WSE reduction still provided some hydraulic and economic benefits. Several other iterations were completed to study the individual effects of each of the existing bridges and numerous bridge modification combinations were explored. Each of these combinations showed very little improvement to the water surface elevation for different storm frequencies. The removal of the Equador Pedestrian Bridge showed the greatest WSE decrease, but the benefits were not substantial enough to justify the loss of pedestrian mobility. The benefits of modifying Tahoe Bridge and Lakeview Bridge were negligible. The final solution included leaving the Tahoe and Lakeview Bridges intact and the complete removal and replacement of the Equador Pedestrian Bridge with a roadway bridge connecting Equador Street across White Oak Bayou.

DEC modeled the roadway bridge on Equador Street with a preliminary design similar to the bridges on Tahoe Drive and Lakeview Drive. DEC added an interpolated cross-section upstream of the new bridge to the base conditions model accommodate the larger width of the bridge. The 100-year water surface elevation from the “No Bridge” model was determined to be 101.02 ft. The bottom chord of the bridge had a minimum elevation of 101.03 ft where the span was directly over the existing channel. The span of the bridge was less than 135 ft, so no piers were necessary in the preliminary bridge design from a structural standpoint. The WSE results along E100-00-00 are on Exhibit 7.17. The cross-section of the Equador Pedestrian Bridge in existing conditions and of the new Equador Street Bridge are shown in Exhibits 7.18 and 7.19, respectfully. Table 7.1O shows a comparison of the freeboard in the existing model and the proposed solution. The HEC-RAS Summary Tables are in Appendix 7H.

Table 7.1O – Freeboard Summary Table

		Revised Existing Conditions			New Equador Bridge		
		Tahoe Bridge	Lakeview Bridge	Equador Bridge	Tahoe Bridge	Lakeview Bridge	Equador Bridge
Top of Deck Elevation (ft)		104.66	102.64	99.04	104.66	102.64	105.90
Low Chord Elevation (ft)		99.97	98.24	96.95	99.97	98.24	101.03
2-yr	WSE (ft)	97.25	95.67	91.5	97.24	95.65	91.41
	Freeboard (ft)	2.72	2.57	5.45	2.73	2.59	9.62
5-yr	WSE (ft)	99.19	97.7	93.92	99.16	97.65	93.8
	Freeboard (ft)	0.78	0.54	3.03	0.81	0.59	7.23
10-yr	WSE (ft)	100.39	98.45	95.82	100.34	98.36	95.66
	Freeboard (ft)	-0.42	-0.21	1.13	-0.37	-0.17	5.37
25-yr	WSE (ft)	101.88	100.21	97.97	101.84	100.12	97.69
	Freeboard (ft)	-1.91	-1.97	-1.02	-1.87	-1.88	3.34
50-yr	WSE (ft)	102.46	100.92	99.2	102.42	100.83	98.63
	Freeboard (ft)	-2.49	-2.68	-2.25	-2.45	-2.59	2.4
100-yr	WSE (ft)	102.95	101.3	99.77	102.94	101.28	99.36
	Freeboard (ft)	-2.98	-3.06	-2.82	-2.97	-3.04	1.67
500-yr	WSE (ft)	104.05	102.38	101.18	104.06	102.42	101.13
	Freeboard (ft)	-4.08	-4.14	-4.23	-4.09	-4.18	-0.1

NOTE: Freeboard = Low Chord Elevation – WSE

The results showed a drop in water surface elevation around the Equador Bridge area, which was expected. There was also a small increase in the available freeboard on the bridge. DEC exported the HEC-RAS results to a DSS file and ran the SIA Tool. The SIA output for the new Equador Street Bridge is shown in Exhibit 7.20. The following table shows a comparison of the SIA results for the existing conditions and the proposed bridge conditions. For detailed results, see Appendix 7I.

Table 7.1P - Bridge Alternative Structural Inventory Summary Table

Single Event Damages			**Reduction in Damages**	**Number of Homes Flooded During Each Storm Event**		**Difference in Number of Homes Inundated**
Storm Event	Existing Conditions	New Equador Bridge		Revised Existing	New Equador Bridge	
10-yr	$0	$0	$0	0	0	0
50-yr	$6,052,516	$5,178,132	$874,384	101	84	17
100-yr	$10,959,495	$10,815,674	$143,821	159	157	2
500-yr	$33,194,932	$34,650,722	-$1,455,790	328	333	-5

Overall, the results from the HEC-RAS analysis and the SIA output showed a slight improvement to the existing floodplain, but not enough to justify the cost of modifying the existing infrastructure in place. However, if the City of Jersey Village was to consider constructing a roadway bridge on Equador Street for mobility purposes, the results show no adverse impacts on the surrounding area.

E. Street Drainage Improvements

As a separate analysis, DEC analyzed the storm sewer system along and connecting to Wall Street (see Exhibit 7.21). The storm sewer system was analyzed using XP-STORM – a detailed storm sewer modeling program. The analysis of the Wall Street storm sewer system included all of the connecting streets: Carlsbad, Crawford, Capri, and Tahoe. DEC conducted a field visit to the neighborhood and observed a lack of inlets and cascading low points in the roadways. Additionally, Kuo and Associates collected topographic survey and record drawings of the streets within the study scope.

A review of the Revised Existing HEC-RAS models for Tributary E127-00-00 and the WOB main channel indicated that the streets were unaffected by bayou flooding for the 2-, 5-, and 10-year storms. Therefore, addressing the storm sewer conveyance issues for storms up to and including the 10-year storm would reduce localized street flooding and increase mobility during those storm events.

DEC developed an existing conditions XP-STORM model using the topographic survey and analyzed the existing storm sewer pipes and inlets. The capacity of the storm sewer system was determined by analyzing the smaller storms and comparing the hydraulic grade line (HGL) to the gutter elevations of the streets. After the existing system capacity was determined, the study team developed proposed models that increased the number of inlets and the storm sewer pipe sizes and reduced the HGL to acceptable levels for the smaller storms. DEC performed a mitigation analysis that utilized the proposed storage in the Jersey Meadow Golf Course to ensure no adverse impacts to E127-00-00. The street study also included a phasing plan for construction of the improved storm sewer system. The full analysis and report for the Wall Street System Drainage Improvements is in Appendix 7J.

F. Bypass Channel Modifications

One of the alternatives identified during the Phase 1 Public Meeting was improvements to the Jersey Village Bypass Channel, or E200-00-00 (see Exhibit 7.22). Many citizens believed that the Bypass could accept more flow and that the connection between the Bypass and the main channel could improve. Therefore, DEC analyzed increases in flow to the Bypass.

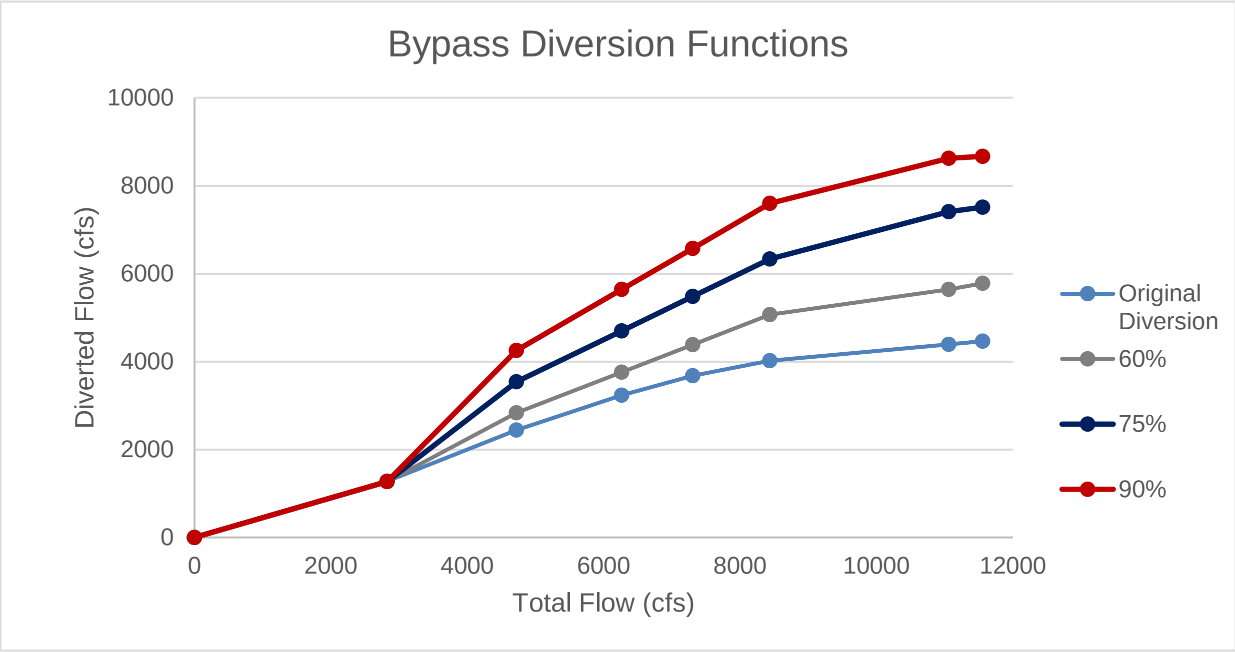
DEC did not alter the flow diversion function in the Revised Existing Conditions – it remained the same as received from HCFCD. The percentage of flow entering the Bypass in Revised Existing Conditions was approximately 48% of the total flow for the 100-year storm. The remaining 52% of the flow continued down the White Oak Bayou main channel. Table 7.1P includes a table of diversion percentages and the flows attributed to each channel.

Table 7.1Q – Bypass Flows and Diversion Percentage

Storm Event	Inflow at XS 105640	Diversion to Bypass	Main Channel Flow	% Diversion
	(cfs)	(cfs)	(cfs)	
10-yr	4720	2440	2280	51.7%
50-yr	7303	3680	3622	50.4%
100-yr	8438	4019	4419	47.6%
500-yr	11058	4393	6665	39.7%

DEC analyzed three new diversion percentages: 60% to the Bypass, 75% to the Bypass, and 90% to the Bypass for the 10-year, 50-year, and 100-year storms. The percent diversion for the 500-year storm was 51%, 67%, and 78% respectively to preserve the original diversion function as shown in Figure 7.1 below.

Figure 7.1A – Bypass Diversion Pattern



Increasing the flows in the Bypass caused significant adverse impacts in several locations:

- Along the Bypass, primarily on the Jersey Village side (south bank)
- The area immediately upstream of Jersey Village
- Tributary E141-00-00 downstream of the Bypass
- Upstream of the confluence of E100-00-00 and E141-00-00
- Downstream of the confluence of E141-00-00 and E100-00-00

The impacts ranged in severity depending on the diversion percentage; however, the 90% diversion percentage resulted in the largest adverse impacts (see Appendix 7K). The impacts were so large in some locations that mitigation would be virtually impossible (see Exhibits 7.23-7.25). Exhibits 7.26-7.28 compare the Bypass WSE to revised existing conditions in a HEC-RAS cross-section along E200-00-00. Due to these large impacts, DEC did not recommend increasing the flow to the Bypass by adjusting the connection between the Bypass and the main channel (see Table 7.1S).

Table 7.1S – Revised Existing vs Bypass Diversion Increases WSE Comparison

Location	100-yr WSE			
	Rev. Existing	60% Diversion	75% Diversion	90% Diversion
US of Bypass	105.53	105.23	107.54	109.12
Confluence with E135-00-00	104.66	104.29	103.68	102.82
Confluence with E127-00-00	102.22	101.98	101.60	101.05
US of Beltway 8	98.62	98.64	98.61	98.52
DS of Beltway 8	98.26	98.33	98.36	98.33
Confluence with E141-00-00	97.84	97.93	97.97	97.98
DS of Windfern Road	95.65	95.70	95.73	95.74
Headwaters of Bypass	105.24	106.29	107.51	108.97
Bypass Confluence with E141-00-00	102.13	102.80	103.66	105.02

Additionally, DEC checked the FFE of the homes near the Bypass with the increased WSE. The homes along the Bypass channel inside the Jersey Village city limits were more likely to be flooded by the E100-00-00 channel. For this reason, the homes along the Bypass correspond to the E100-00-00 channel and not the E200-00-00 Bypass channel in the SIA Tool. Therefore, DEC analyzed the flooding of homes along the Bypass channel by manually comparing the FFE to the water surface elevation of the nearest HEC-RAS cross-section. The team compared the FFE to the WSE for the Revised Existing Conditions and all three Bypass diversion scenarios: 60%, 75% and 90%. The Bypass did not inundate any homes during a 100-year storm event for the Revised Existing Conditions. As more flow was diverted through the Bypass channel, the WSE came out of banks for the 100-year event. All three diversion scenarios inundated homes not previously flooded by the Bypass in the Revised Existing Conditions. The Table 7.1Q compares the WSE for each scenario and quantifies the depth of inundation for several homes along the Bypass channel.

Table 7.1T – Bypass Alternative Finished Floor Elevation Comparison Table

Slab #	River Station	Slab Elevation	Rev. Exist. WSE	60% Bypass WSE	75% Bypass WSE	90% Bypass WSE	Rev. Exist - FFE	60% WSE - FFE	75% WSE - FFE	90% WSE - FFE
		(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
		(1)	(2)	(3)	(4)	(5)	(2) - (1)	(3) - (1)	(4) - (1)	(5) - (1)
1	7478	106.91	105.21	106.30	107.58	109.09	-1.70	-0.60	0.67	2.18
2	7315	105.66	105.17	106.27	107.56	109.08	-0.49	0.61	1.91	3.42
3	7211	105.57	105.14	106.24	107.55	109.07	-0.43	0.67	1.98	3.50
4	7091	105.43	105.10	106.21	107.53	109.06	-0.33	0.78	2.10	3.63
5	7360	106.45	105.18	106.28	107.57	109.08	-1.27	-0.17	1.12	2.63
6	6511	105.57	104.92	106.04	107.38	108.99	-0.65	0.47	1.81	3.42
7	6556	105.42	104.93	106.05	107.39	108.99	-0.49	0.63	1.97	3.57
8	6241	106.76	104.83	105.95	107.30	108.95	-1.93	-0.81	0.54	2.18
9	6241	107.63	104.83	105.95	107.30	108.95	-2.80	-1.68	-0.33	1.32
10	6241	108.52	104.83	105.95	107.30	108.95	-3.69	-2.57	-1.22	0.42

Slab #	River Station	Slab Elevation	Rev. Exist. WSE	60% Bypass WSE	75% Bypass WSE	90% Bypass WSE	Rev. Exist - FFE	60% WSE - FFE	75% WSE - FFE	90% WSE - FFE
		(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
		(1)	(2)	(3)	(4)	(5)	(2) - (1)	(3) - (1)	(4) - (1)	(5) - (1)
11	6021	104.82	104.76	105.88	107.25	108.92	-0.06	1.06	2.42	4.10
12	6075	105.02	104.78	105.90	107.26	108.93	-0.24	0.88	2.24	3.90
13	5996	105.27	104.75	105.87	107.24	108.91	-0.52	0.60	1.97	3.65
14	5851	105.20	104.71	105.83	107.20	108.89	-0.50	0.62	2.00	3.69
15	5823	104.65	104.70	105.82	107.19	108.89	0.04	1.16	2.54	4.24
16	5631	106.52	104.63	105.75	107.14	108.86	-1.89	-0.77	0.61	2.34
17	5466	104.66	104.58	105.70	107.09	108.84	-0.08	1.04	2.43	4.18
18	5486	104.86	104.59	105.71	107.10	108.84	-0.27	0.85	2.24	3.98
19	5371	105.23	104.55	105.67	107.07	108.82	-0.68	0.44	1.84	3.59
20	5290	105.05	104.53	105.65	107.05	108.81	-0.52	0.60	2.00	3.76
21	5210	104.62	104.51	105.63	107.03	108.81	-0.11	1.01	2.41	4.19
22	5121	104.63	104.49	105.61	107.01	108.80	-0.14	0.98	2.38	4.17
23	4946	105.75	104.44	105.57	106.98	108.78	-1.31	-0.18	1.23	3.03
24	4656	105.95	104.37	105.51	106.95	108.76	-1.58	-0.44	1.00	2.81
25	4531	106.23	104.34	105.49	106.94	108.76	-1.89	-0.74	0.71	2.53
26	4411	106.46	104.31	105.47	106.93	108.75	-2.15	-0.99	0.47	2.29
27	4266	105.29	104.28	105.44	106.91	108.74	-1.01	0.15	1.62	3.45
28	4110	106.11	104.26	105.42	106.89	108.73	-1.85	-0.69	0.78	2.63
29	4135	105.26	104.26	105.42	106.89	108.74	-1.00	0.16	1.63	3.48
30	3901	105.58	104.22	105.38	106.86	108.71	-1.36	-0.20	1.28	3.14
31	3893	105.49	104.22	105.37	106.86	108.71	-1.27	-0.12	1.37	3.22
32	2871	106.26	104.00	105.14	106.65	108.55	-2.26	-1.12	0.39	2.29
33	2891	105.77	104.00	105.15	106.65	108.55	-1.77	-0.62	0.88	2.78
34	2801	105.60	103.98	105.13	106.63	108.54	-1.62	-0.47	1.03	2.94
35	2709	106.03	103.96	105.11	106.61	108.52	-2.07	-0.92	0.58	2.49
36	2619	105.45	103.94	105.09	106.59	108.50	-1.51	-0.36	1.14	3.05
37	2531	106.25	103.92	105.07	106.57	108.49	-2.33	-1.18	0.32	2.24
38	2436	106.13	103.90	105.05	106.55	108.47	-2.23	-1.08	0.42	2.34
39	2246	106.07	103.87	105.03	106.52	108.45	-2.20	-1.04	0.45	2.38
40	2246	106.14	103.87	105.03	106.52	108.45	-2.27	-1.11	0.38	2.31

In addition to studying the flow diversion through the Bypass channel, DEC also studied the final design of E200-00-00 with the record drawings and final survey contours provided by HCFCD. The record drawings DEC compared the record drawings of the Bypass to the HEC-RAS models also provided by HCFCD. The study team checked several cross-sections and the overall slope of the channel. DEC was able to confirm the data from the record drawings matched the HEC-RAS models used in the analysis.

G. Other Structural Alternatives

DEC considered other structural alternatives during the study such as levees, floodwalls, channel intersection modifications, and improvements to existing regional detention ponds. However, after reviewing the easement widths along the Bayous in Jersey Village, it was determined that there was not enough physical space along the Bayou for levees or channel intersection modifications.

New levees must be FEMA certified, which requires that the top of the levee is three feet above the 100-year WSE with levees in place. Levees also require costly maintenance to prevent levee breaches during large storm events. Levee construction is generally extremely expensive and would most likely have a very low benefit-cost ratio. Levees block the natural runoff toward the Bayou and detention storage, pumping, slope drains, etc. must intercept and mitigate the flow. DEC did not recommend levees due to their expense and risk toward human life.

DEC also considered floodwalls, but did not recommend them. The function of a floodwall is essentially the same as a levee, but would block off the Bayou from view completely from ground level. Floodwalls also require extensive maintenance, are expensive to construct and would not be feasible from a benefit-cost perspective.

DEC reviewed the record drawings for the Jersey Meadows Stormwater Detention Basin and concluded that increasing the volume for the regional detention facility would not be feasible due to the presence of mitigation wetlands and the high groundwater that serves as the permanent WSE.

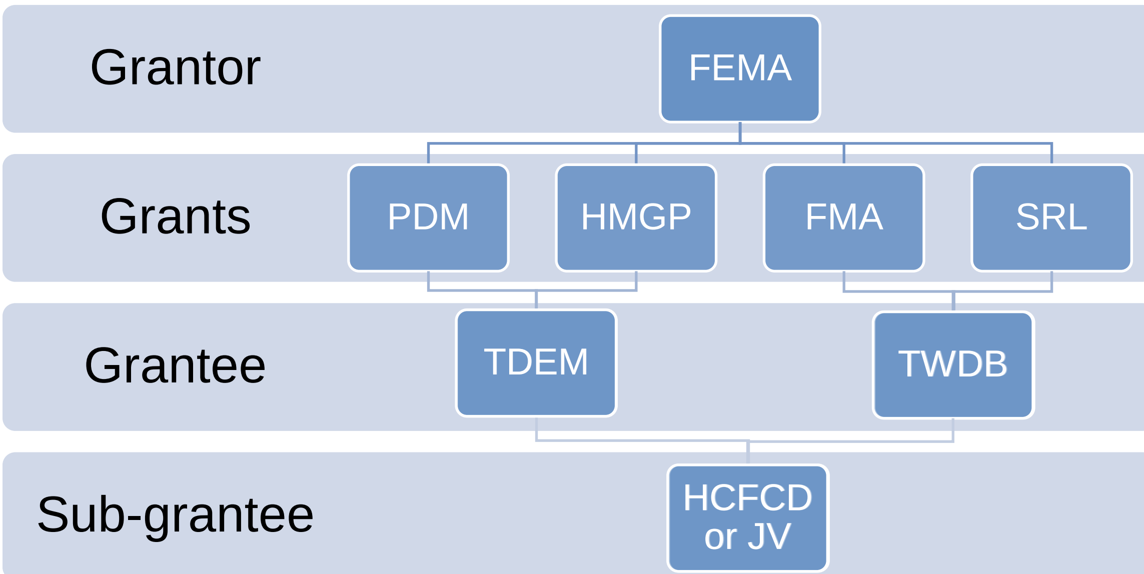
7.2. Non-Structural Alternatives

A. FEMA Hazard Mitigation Assistance Programs

FEMA has several programs featuring non-structural solutions offered under the umbrella of the Hazard Mitigation Assistance (HMA) Grant Program. The non-structural solutions include property acquisition, structure elevation, and mitigation reconstruction. All of these solutions are partially funded through any one of three available grants: Flood Mitigation Assistance (FMA) Grant Program, Pre-Disaster Mitigation (PDM) Grant Program, or Hazard Mitigation Grant Program (HMGP). The FMA, PDM, and HMGP each provide different funding amounts and the application criteria differ for each. The FMA grant is an annual application that requires all structures included to possess flood insurance. The PDM grant is an annual application as well but does not require insurance to qualify. The HMGP funds are only available if there is a presidential disaster declaration following a significant storm event. Reference documents for these programs are included in Appendix 7L.

A FMA, PDM, or HMGP application includes a sub-application for each structure participating and is compiled and submitted through a local sponsor. The local sponsor can be the City of Jersey Village or HCFCD. If the application is accepted and approved, the Texas Water Development Board (TWDB) distributes to funds all approved applications in Texas. The following figure breaks down the application hierarchy for each grant program.

Figure 7.2A – FEMA Mitigation Grants



Application approval is an all or nothing process, where all of the structures receive funding or none of them does. FEMA is more likely to approve an application if most of the structures are classified as Repetitive Loss (RL) or Severe Repetitive Loss (SRL). A home qualifies as RL if the National Flood Insurance Program (NFIP) paid two or more claims of over $1,000 over a ten-year period. A SRL property must meet one of the following criteria to qualify: (1) the NFIP paid four or more claims of more than $5,000 or (2) the NFIP paid two or more claims where the total surpassed the current value of the property. In either case, at least two of the claims must have been within ten years of each other. The following table is a brief summary of the different FEMA grant programs.

Table 7.2A – Grant Program Summary Table

Grant Program	Application	Flood Insurance Needed?	SRL/RL Eligible?
Flood Mitigation Assistance (FMA)	Annual Grant	Yes	Yes
Pre-Disaster Mitigation (PDM)	Annual Grant	No	No
Hazard Mitigation Grant Program (HMGP)	Federal Disaster	No	No

Depending on the grant program and the activity type, different cost-share amounts are available. Non-federal funds for any of the programs can come from several sources including the property owner, local government, or State government. Typically, the local sponsor provides the additional funds required. Section 11.3B of the report includes a more detailed discussion of funding sources.

i. Property Acquisition and Structure Demolition or Relocation Program

FEMA offers financial assistance to local sponsors for property acquisition and structure demolition (also called a buyout) to create open space in frequently flooded areas. The purpose of the program is to alleviate flood-prone property owners from frequent flooding by purchasing the property and either demolishing or relocating the structure. Although relocating the structure to another site is an option, simply acquiring the land and demolishing the existing structure requires minimal environmental review and is considerably less expensive. Additionally, for a structure to be eligible for a buyout, the property cannot be part of any future planned development project and the owner must be selling the property voluntarily. Any incompatible easements must be extinguished before acquisition.

If FEMA funds are used for demolition or relocation projects, the law requires the property to be maintained as open space by the local sponsor submitting the application. Once the structure is demolished or relocated, the property must be dedicated to uses compatible with open space, recreation or wetlands management practices. No new structures may be built on the property with the exception of a few: public buildings open on all sides, public restrooms or structures compatible with open space, recreation or wetlands management use and applicable floodplain management policies and practices. All of these structures must be elevated or flood proofed to the Base Flood Elevation (BFE) plus one foot of freeboard.

When submitting a buyout application package, the application must include the scope of work, project schedule, and a preliminary cost estimate for each property. The scope of work section must include the value of each property and documentation for how the market value was determined and an appeal process for any property owners who dispute the purchase offer. Additional application requirements include a Statement of Assurances, a sample of the deed restriction, property owner documentation, voluntary interest documentation, and a certification of owner status for the pre-event value. While developing the scope of work for the application package, the application must account for several allowable and non-allowable property-related costs. Table 7.2B includes the general allowable costs.

Table 7.2B – Property Acquisition and Structure Demo/Relocation Allowable Cost

Both Structure Demolition and Relocation	Structure Demolition Only	Structure Relocation Only
Remove demolition debris and hazardous wastes to an approved landfill Abatement of asbestos and/or lead-based paint Removal of septic tanks Permitted disposal of fuel tanks that support residential use only Removal of all structure foundation and basement walls to at least 1 ft below the finish grade of the site Removal of trees that restriction demo work Termination of abandoned utilities at least 2 feet below finish grade of the site Capping of all wells and/or removal of associated parts Grading, leveling and site stabilization of all demo sites	Market value of the real property at the time of sale or immediately prior to most recent disaster or flood event For land already owned by eligible entity, compensation is for the structure and for development rights only, not for the land Fees for necessary appraisals, title searches, title insurance, property inspections and surveys Property tax liens or obligations can be extinguished with proceeds from property sale with transfer of title Fees associated with title transfer, contract review and other costs for real estate settlement, including recordation of deed and deed restrictions Demo, site restoration and stabilization of acquired site	Market value of the real property (land only) For land already owned by eligible entity, compensation is for development rights Fees for necessary appraisals, title searches, title insurance, property inspections, plan reviews, permit fees, surveys Property tax liens or obligations can be extinguished with proceeds from property sale with transfer of title Fees associated with title transfer, contract review and other costs for real estate settlement, including recordation of deed and deed restrictions Jacking and moving the structure to a different site The reason cost of disassembling, moving and reassembling any attached appurtenances Necessary site preparation: foundation, water, sewer, utility hookups Site restoration and site stabilization of acquired site

A shortfall is when the amount the owner is paid for a damaged residence is less than the cost of a comparable replacement home and has an allowable cost of up to $31,000 per property. Non-allowable costs specifically listed in the HMA Guidance Addendum include the following:

- Compensation for land that is already held by an eligible entity, even if the entity is not the sub-applicant for the project; compensation for development right may be allowable

- Property acquisition and structural demolition projects where State or local laws or ordinances requires structure demolition and prohibits future development of the property
- Remediation, remediation plans and environmental cleanup and certification of contaminated properties
- Aesthetic improvements and landscaping, new site property acquisition and public infrastructure and utility development

After demolition is completed, the local sponsor must provide proof that all required activities were completed according to FEMA regulations. The recipient is required to provide the following for verification: a photograph of the post-property site, a copy of the recorded deed and deed restrictions, latitude and longitude coordinates of the property, a signed statement of voluntary participation from the owner of the property and a completed FEMA Form AW-501 for any property identified in the FEMA RL database. Every three years, FEMA requires documentation that the recipient has properly maintained the property.

ii. Structure Elevation

Structure elevation is another FEMA program provided through the HMA program. The purpose of the structure elevation program is to raise an existing structure to an elevation that is equivalent or higher than the Base Flood Elevation (BFE). All structures being elevated must be structurally sound and able to be elevated safely. FEMA requires that structure elevation projects be designed in accordance with NFIP standards in 44 CFR Part 60 and with ASCE 24-14. Distribution of funds for approved projects falls under the same cost share process as the buyout program.

The home elevation program application must include the scope of work, the schedule of the project, and a cost estimate for construction. The scope of work requires specific data such as the physical address and property owner’s name, the name and location of the flooding source, the existing and proposed finished floor elevation, the BFE, the existing foundation type, the proposed elevation method, and a statement that the project will be designed according to NFIP standards in 44 CFR Part 60. FEMA has completed a Sample Engineering Case Study for Elevation to demonstrate all the information typically required in a structure elevation application.

If FEMA approves the application, federal funds can be applied to eligible costs. The following costs are generally allowable for a structure elevation project:

- engineering services for design, structural feasibility analysis, and cost estimate preparation
- surveying, soil sampling, Elevation Certificate, title search, deed registration fees, legal and/or permitting fees, project administration, and construction management
- disconnection of all utilities
- building an adequate foundation
- elevation of the structure and attachment onto the new foundation
- construction of a floor system that meets minimum building code requirements

- reconnecting utilities and extending pipes and lines and elevating utilities as necessary
- debris disposal and erosion control
- costs for repair of lawns, landscaping, etc. if damaged by structure elevation
- elevation of existing decks, porches or stairs
- construction of new stairs, landings and railing to access the elevated living space
- construction of ADA-compliant access facilities or ramps when an owner or family member has a permanent disability and a physician's written certification
- documented reasonable living expenses of owner incurred during elevation construction
- abatement of asbestos and lead-based paint
- filling basements with compacted clean fill

FEMA also provides a list of ineligible structure elevation costs. The ineligible costs include elevating structures not in compliance with current NFIP standards, building additional structures, construction of new decks or porches, aesthetic improvements, and exterior finish on the exposed foundation of the elevated building. For more details on elevation project implementation, consult the Hazard Mitigation Assistance Guidance Addendum.

The closeout process for a structural elevation project extends beyond the typical HMA grant closeout processes. The additional requirements include:

- updating the property information in the HMA system
- a Certificate of Occupancy
- a Final Elevation Certificate
- a copy of the recorded deed amendment for each property, a front, rear and side photograph of the final structure
- verification that each structure has flood insurance
- certification by an engineer or local official that the structure is in compliance with local ordinances and NFIP regulations

iii. Mitigation Reconstruction

Mitigation reconstruction is another option available through the HMA program and can be funded through HMGP, PDM or FMA. Mitigation reconstruction provides funding for the total or partial demolition of an existing structure and then rebuilding the structure to be code-compliant and hazard-resistant with elevated foundation systems. Properties located within the regulatory floodway or coastal high hazard areas are ineligible for the program. Each new structure must be designed using the most current data available, including advisory base flood elevations (ABFE).

When submitting an application for mitigation reconstruction, the applicant must provide justification for choosing mitigation reconstruction over buyouts or home elevation. Mitigation reconstruction applications cannot be combined with buyout or home elevation applications. The Mitigation Reconstruction Project Application Package requires the overall scope of work for each structure submitted. The scope of work must include the six following sections:

1. pre-construction
2. site preparation
3. foundation construction
4. structural shell construction
5. interior finishes
6. construction completion

If FEMA approves the application, eligible costs are limited to a $150,000 federal share per property. The $150,000 federal share is separate from the cost share process used for the buyout and the home elevation programs. Appendix 7L contains a list of eligible and ineligible activities and additional guidance for the mitigation reconstruction program.

Once FEMA approves the project, the implementation stage can begin. Project implementation is everything in the scope of work, including the pre-construction activities (plan review and inspection, site preparation) and the construction activities (building the foundation and structural shell, interior finishes, obtaining all builder certifications). The closeout process for a mitigation reconstruction project involves extra steps beyond the typical HMA grant closeout processes. The additional requirements include the Certificate of Occupancy and Final Elevation Certificate for each structure, a certification from a licensed professional engineer verifying the structure was designed according to the 2009 International Codes, verification that the final square footage is within 10% of the original and that the structure has flood insurance.

iv. Dry Floodproofing

Another approach to reduce flood damage risk is to floodproof a structure. Floodproofing uses techniques to keep a structure watertight like sealing the structure below the Base BFE to prevent floodwaters from seeping in. FEMA provides funding for this activity through the HMGP, PDM, and FMA programs. The funding is only available for historic residential homes or non-residential structures. For all dry floodproofing activities, FEMA requires the design be in accordance with ASCE 24-14.

B. Non-structural Alternatives Grant Program Recommendations

The key non-structural alternatives considered included Property Acquisition and Structure Demolition, Structure Elevation, and Mitigation Reconstruction. Each program is voluntary for the homeowner. DEC determined that Mitigation Reconstruction was not an economically feasible option for the local sponsor or homeowner. The maximum FEMA reimbursement does not adequately cover costs for the typical home in Jersey Village. The majority of the financial burden falls on the homeowner. Additionally, there are no homes in Jersey Village that could not be bought or elevated.

One general criteria for non-structural alternatives selection was the home's FEMA classification status: RL or SRL (see Exhibit 7.29). DEC prioritized RL and SRL homes due the larger cost share available from the FEMA FMA grant program. Another factor included the 100-year flooding depth indicated by the SIA Tool. The study team automatically considered homes inundated by a storm frequency less than a 100-year storm event or inundated by more than 0.5 ft during a 100-year storm event. Additionally, DEC considered all homes in the Effective FEMA Floodway for non-structural alternatives. However, not every home selected fit all criteria and some homes were not selected even if they met one or more criteria. Neighborhood continuity was an important factor in home selection. The final factor contributing to home selection was whether the home was substantially damaged during the Tax Day Flood Event. To qualify as substantially damaged, the estimated necessary repairs must be over 50% of the value of the home. The three homes in Jersey Village that are currently being elevated due to substantial damage were not included.

DEC considered two scenarios when selecting potential properties for non-structural solutions:

1. No structural alternatives were constructed
2. Constructed recommended structural alternatives

For the scenario with no structural alternatives in place, 129 homes of the 163 identified by the SIA Tool in the Revised Existing Conditions (100-year) were included as potential buyout and structure elevations. DEC selected buyout locations by looking at homes that fit the above criteria and were located in adjacent groups. The groups were required to total more than five acres of property or contain ten or more homes. DEC considered homes for structure elevation if they fit buyout criteria, but were not adjacent to other potential buyout homes. DEC selected 60 homes for property acquisition and 69 homes for structure elevation (see Exhibit 7.30). A detailed breakdown for each scenario is available in Appendix 7M. The following tables summarize the potential locations for the no structural alternatives scenario.

Table 7.2E – Potential Buyout Groups with No Structural Alternatives

Buyout Group	Number of Homes	Number of RL/SRL Homes	Total Area (ac)	Avoided Damages (100-year)	Total HCAD Value	Total JV Tax Revenue Lost	Approx. Local Sponsor Cost*
1	5	4	7.15	$688,523	$2,256,130	$16,752	$483,798
2	15	11	4.96	$1,215,371	$3,222,656	$23,928	$920,552
3	16	13	4.55	$1,303,519	$3,635,232	$26,992	$980,016
4	10	8	5.13	$859,429	$2,455,759	$18,234	$697,190
5	14	13	4.85	$1,534,703	$3,290,522	$24,432	$799,362
Grand Total	60	49	26.65	$5,601,546	$14,860,299	$110,338	$3,880,918

*Local sponsor cost does not include additional items that HCFCD traditionally includes in their costs.

Table 7.2F – Structure Elevation Summary with No Structural Alternatives

Total # of Homes Being Elevated	69
Total # of RL/SRL Homes	51
Total Damages (100-yr Event)	$3,941,888
Total Home Value (2016 HCAD)	$16,543,435
	Average Home
Building Area (ft^2)	2,463
Height Raised (ft^2)	3.75
Structure Elevation Cost	$160,000
Local Sponsor Share	$2,836,000

When choosing properties for the second scenario, two options were explored: Option 1 included both potential buyouts and structure elevations and Option 2 only considered structure elevations. The recommended structural alternatives removed 62 homes from the 100-year floodplain, leaving 101 homes in the floodplain. This reduced the number of homes from 129 homes in the first scenario to 58-82 homes suggested for non-structural alternatives.

For Option 1, there were 26 potential buyout locations and 32 possible home elevations (see Exhibit 7.31). DEC did not select the remaining 43 homes because the future structural improvements removed most of the potential flood damage. Loss of tax revenue was not included in the cost for buyouts. Additionally, the City of Jersey Village has historically preferred not to participate in the buyout program due to loss of revenue. For Option 2, DEC selected 82 homes for structure elevation. The study team selected an additional 24 homes based on public feedback and emphasis on neighborhood continuity (see Exhibit 7.32). The following tables summarize the potential locations for both options within the recommended solution scenario. The total avoided damages for the non-structural alternatives is equal to the value of the number of homes removed from the floodplain: $4,783,785 for Option 1 and $6,378,730 for Option 2.

The benefits of non-structural alternatives were the total avoided damages for a 100-year event calculated with the SIA Tool. For the potential buyout properties, DEC calculated the cost by assuming every property possessed flood insurance and accounting for the increased federal cost share for RL and SRL properties. The calculated cost included the HCAD value of the home plus an additional 20% and the cost of demolition. Estimating cost for the structural elevation properties was slightly more difficult due to variations in cost that need to be judged on a case-to-case basis. The total cost of structural elevation ranges from $120,000 to $200,000. The cost depends on the square footage of the footprint, how many stories the home is, etc.

Table 7.2G – Potential Buyout Groups with Structural Alternatives (Option 1)

Buyout Group	Number of Homes	Number of RL/SRL Homes	Total Area (ac)	Avoided Damages (100-year)	Total HCAD Value	Total Tax Revenue Lost (Jersey Village)	Approx. Local Sponsor Cost*
1	15	13	4.52	$1,290,590	$3,183,250	$23,636	$807,892
2	11	11	3.59	$1,265,538	$2,590,937	$19,238	$581,217
Grand Total	26	24	8.11	$2,556,127	$5,774,187	$42,873	$1,389,109

*Local sponsor cost does not include additional items that HCFCD traditionally includes in their costs.

Table 7.2H – Structure Elevation Summary with Structural Alternatives

	Option 1	**Option 2**
	Average Home	**Average Home**
Building Area (ft^2)	2,439	2,419
Height Raised (ft^2)	3.88	4.07
Structure Elevation Cost	$160,000	$160,000
Local Sponsor Share	$1,484,000	$3,344,000
Total # of Homes Being Elevated	32	82
Total # of RL/SRL Homes	20	61
Total Avoided Damages (100-yr Event)	$2,227,658	$6,378,730
Total Home Value (2016 HCAD)	$7,921,882	$19,002,164

For structure elevation, several factors can influence the cost: the square footage of the footprint, number of stories, number of feet the foundation is elevated, and type of foundation. The amount of engineering required, the type of piles the company chooses, or the methodology used to raise the home fluctuate the cost as well. For these reasons, it is difficult to obtain a general cost estimate for multiple houses due to the fluctuation in price dependent on the structure being elevated. The price for structure elevation can range anywhere from $80,000 to $200,000. Due to these deviations in price, DEC developed an example house for an estimated cost. The example home was a two-story, 2,500-ft^2 home with a slab-on-grade foundation. The company would perform engineering calculations in-house and have their own equipment to raise the foundation and insert the pilings, making the cost $50-$60 per square foot. This method would involve tearing up the existing flooring and results in several extra repair costs.

Another method is to hire a home moving company and lift the home around eight feet in the air while the foundation is built underneath it. This method generally costs $75-$80 per square foot. Although this method is more expensive up front, it is safer for the home and results in less repair costs. For this reason, DEC chose the second methodology for the example case.

Table 7.2J – Structure Elevation Example Case

Structure Area	2,500 ft^2
Footprint Area	1,500 ft^2
# of Stories	2
Foundation	Slab-on-grade
Cost per ft^2	$80
CMU around base*	$20,000
Demolition	-
Total Cost	$140,000
FEMA Cost Share	$90,000
Non-federal Cost	$50,000

*Cost not included in FEMA cost-share

The non-federal portion of the cost for structure elevation is traditionally paid by the individual homeowners to prevent public tax dollars from being spent on improving private property. Homeowners do assume some risk when pursuing a structure elevation grant; however, when done properly, structure elevations have proven to be effective for reducing flood risk. Overall, the cost of elevating a home is more economically feasible to implement due to lower construction costs and larger federal funding shares available through the FMA grant program.

C. City Ordinances

An alternative the City can implement to possibly lower flood insurance in Jersey Village is to participate in the Community Rating System (CRS) program. The CRS is an effort by the NFIP to encourage higher standards by rewarding participating communities with lowered insurance premiums. These discounts serve as incentive instituting policies that protect against loss of life or property in the event of a flood. To participate in CRS, the community can choose any one of the 19 public information and floodplain management activities listed in the CRS Coordinator's Manual. If the community has already implemented some of these policies, community officials need to fill out an application detailing these efforts.

Each activity the community participates in earns them a certain number of points and based on the credits earned, the community is assigned to one of ten classes, with one being the best. The rate class determines the flood insurance discount percentage. The following table shows the discount property owners can receive based on the number of points earned through CRS.

Table 7.2J – Total Discount in a SFHA in Each CRS Class

Rate Class	Credits Earned	Discount
10	0 - 499	0%
9	500 - 999	5%
8	1,000 - 1,499	10%
7	1,500 - 1,999	15%
6	2,000 - 2,499	20%
5	2,500 - 2,999	25%
4	3,000 - 3,499	30%
3	3,500 - 3,999	35%
2	4,000 - 4,499	40%
1	4,500 +	45%

To be eligible for a CRS discount, every community needs to participate in the elevation certificates activity. This mandates that a FEMA Elevation Certificate must be completed and maintained for all buildings constructed, substantially improved or placed in the Special Flood Hazard Area (SFHA) after the initial date on the CRS application. If the community is a repetitive loss community, a comprehensive flood hazard mitigation plan must be completed. The 19 approved activities to earn credit are split into four different categories: (1) public information, (2) mapping and regulations, (3) flood damage reduction, and (4) flood preparedness. In addition to the 19 approved credits, communities can earn extra credit as well. A couple of ways a community can do this is by implementing the same regulation standards for developing inside the SFHA as developing outside of the SFHA. Table 7.2J shows all the activities for which a community can earn credits. For more detailed information on each activity, see the CRS Coordinator's Manual in Appendix 7L.

Table 7.2K – Approved Activities to Accumulate CRS Credits

Series 300: Public Information		Maximum Points	Average Points
310	Elevation Certificates	116	46
320	Map Information Service	90	63
330	Outreach projects	350	63
340	Hazard Disclosure	80	14
350	Flood Protection Information	125	33
360	Flood Protection Assistance	110	49
370	Flood Insurance Promotion	110	0
	Total	981	268
Series 400: Mapping and Regulations		Maximum Points	Average Points
410	Floodplain Mapping	802	65
420	Open Space Preservation	2,020	474
430	Higher Regulatory Standards	2,042	214
440	Flood Data Maintenance	222	54
450	Stormwater Management	755	119
	Total	5,841	926
Series 500: Flood Damage Reduction		Maximum Points	Average Points
510	Floodplain Management Planning	622	123
520	Acquisition and Relocation	1,900	136
530	Flood Protection	1,600	136
540	Drainage System Maintenance	570	214
	Total	4,692	609
Series 600: Flood Preparedness		Maximum Points	Average Points
610	Flood Warning and Response	395	144
620	Levee Safety	235	0
630	Dam Safety	160	0
	Total	790	144
	Grand Total	**12,304**	**1,947**

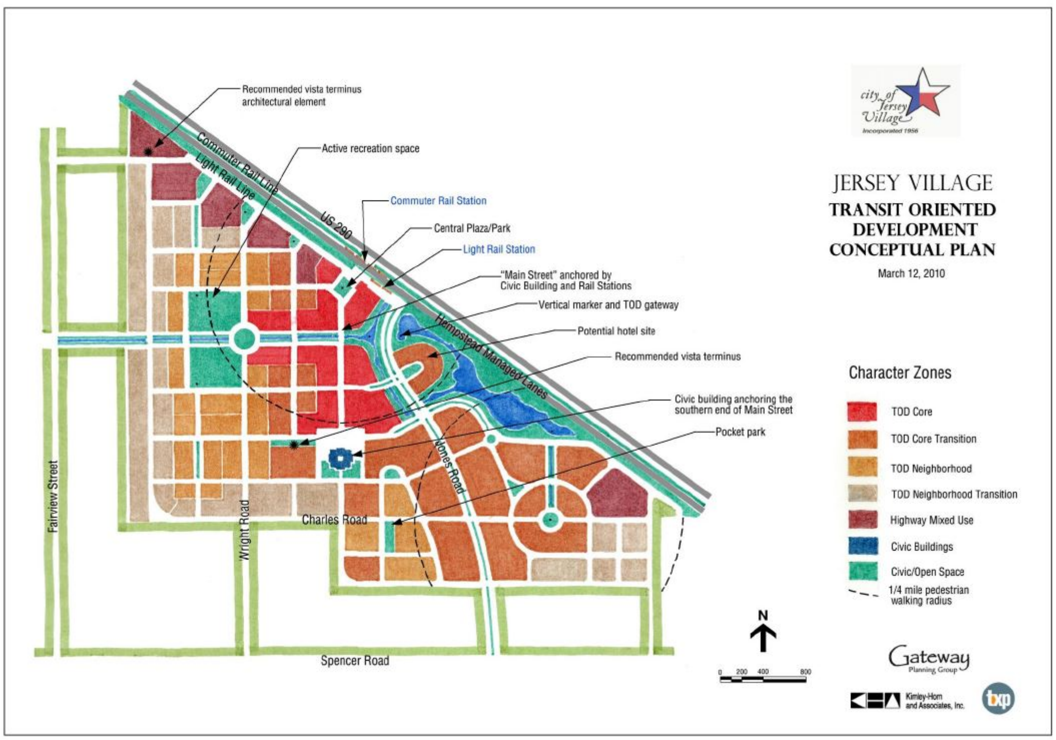
A community can implement higher regulatory standards to earn up to 2,042 total points. Some of the suggested regulations include limiting development by prohibiting fill, buildings and/or storage of materials in the SFHA, enforcing a freeboard requirement, mandating engineered foundations and lowering the substantial improvement threshold below 50%. Other examples include guaranteeing that new buildings are protected from shallow flooding, protecting critical community facilities, counting improvements cumulatively for a total substantial improvement, and a community can earn bonus points if a regulatory standard is required by the state. Other higher standard regulations outside of the activities listed in the CRS Coordinator's Manual can earn bonus points as well.

8. Transit Oriented Development (TOD) District Drainage Impact Study

DEC completed a drainage impact study for the proposed Transit-Oriented Development (TOD) District on the east side of Jersey Village. The purpose of the TOD is to re-develop the existing area south of US 290 and create an opportunity for quality growth and economic development. The TOD has a total of 300 acres, with an estimated 55 acres within Jersey Village City Limits and the other 245 acres within Jersey Village's ETJ. The analysis for the TOD included performing hydrologic calculations and determining the minimum mitigation that will be required for the future re-development.

An evaluation of the existing conditions concluded that the current land use includes industrial, commercial, residential and some undeveloped areas. After re-development, the land use will include mostly commercial and residential land use, with some developed green areas. Figure 8A shows the proposed JV TOD Conceptual Plan.

Figure 8A – JV TOD Conceptual Plan



The entire proposed project area drained to the E127-00-00 tributary. This increased the total runoff draining into the channel. DEC accounted for the excess drainage in the mitigation design. In addition to the mitigation required from re-development of the area, DEC added mitigation volume to the design to account for development in the Effective FEMA Floodplain. Study engineers calculated 166.2 ac-ft as the total required storage volume. The depth of the pond was restricted by the bottom elevation of the E127-00-00 channel and the area of the pond was limited to the area indicated in the JV TOD Conceptual Plan. Due to these restrictions, DEC converted two additional green areas on the land plan to multi-purpose areas. These areas serve as recreational space and as extra detention for the 100-year storm event. The total provided storage volume was 167.4 ac-ft. The detailed TOD Drainage Impact Study report is in Appendix 8A.

9. Phase 2 Public Meeting

The City, DEC, and Crouch Communications conducted the Phase 2 Public Meeting on March 23, 2017. It was an open-house style meeting facilitated by Crouch Communications. The purpose of the second public meeting was to provide an update to the citizens of Jersey Village on the progress of the study, the remaining timeline of the study, and to solicit public comment. Crouch Communications developed a video presentation with showings approximately every 25 minutes. The video contents included information on the study background, a summary of Phase 1, and the Phase 2 alternatives. The study team did not present results and recommendations at the meeting. After citizens viewed the video, meeting facilitators guided them back to the main auditorium to view informational displays, provide comments, and visit with the study team. The study team, including members of City Staff and City Council, Crouch Communications, and DEC were available for the entire meeting to answer questions and discuss the study with citizens. The open-house style meeting made the study team accessible to a larger number of people and citizens were able to come and go as their schedule allowed, while still receiving all meeting information. Comment cards were available during the meeting just as they were during the Phase 1 Public Meeting and were included in the public record for the meeting. The Phase 2 Public Meeting Summary Report is in Appendix 9A.

Phase 3

10. Recommended Solution

10.1. Plan Components

The final “Recommended Solution” included a combination of several structural and non-structural alternatives. The recommended structural alternatives were detention storage in the Jersey Meadow Golf Course, White Oak Bayou Channel Improvements from the confluence with Tributary E135-00-00 to Beltway 8, and drainage improvements to the Wall Street Storm Sewer System (see Exhibit 10.1). The recommended non-structural alternatives included home buyouts, structure elevations, and implementation of the CRS.

DEC analyzed each structural alternative independently of the other structural alternatives to determine the merit of each individual alternative. DEC recommended the alternatives that yielded significant hydraulic benefits and economic benefits for analysis in the Recommended Solution. The detention storage in the Jersey Meadows Golf Course and the channel improvements along White Oak Bayou were both recommended for analysis in the recommended solution. Both alternatives were included in the same HEC-HMS and HEC-RAS models to assess the combined benefits. Study engineers analyzed mitigation for the channel improvements in the Recommended Solution by including regional detention ponds E500-12-00 (Fallbrook Stormwater Detention Basin) and E535-01-00 (Jersey Meadows Stormwater Detention Basin) in the HEC-HMS and HEC-RAS models (see Appendix 10B). The Recommended Solution resulted in much larger benefits than each individual alternative. The drainage improvements to the Wall Street Storm Sewer System could not be included in the HEC-HMS and HEC-RAS models because the analysis was performed using XP-STORM. Exhibit 10.2 displays the 100-year floodplain generated from the Recommended Solution models. Exhibit 10.4 compares the 100-year floodplain for the Recommended Solution to the 100-year floodplain from the Revised Existing models. Tables 10.1A and 10.1B include the flow and WSE results for the Recommended Solution compared with the Revised Existing models.

Table 10.1A – Revised Existing vs Recommended Solution Flows

Location	10-yr Flow (cfs)		50-yr Flow (cfs)		100-yr Flow (cfs)		500-yr Flow (cfs)	
	Rev. Existing	Pref. Solution	Rev. Existing	Pref. Solution	Rev. Existing	Pref. Solution	Rev. Existing	Pref. Solution
Confluence with E135-00-00	4720	4632	7303	7211	8438	8371	11058	11020
Confluence with E127-00-00	4310	3948	5975	5416	6985	6747	10435	10430
Junction DS of Beltway 8	5109	4897	7184	6715	8162	7679	11095	11730
Confluence with E141-00-00	8125	7896	12654	11999	14398	13723	18585	19109
Junction DS of Windfern Road	8061	7894	12544	11964	14312	13706	18467	19102
DS of US 290	661	661	958	958	1110	1110	1539	1539
DS of Golf Course	812	654	1115	922	1277	1062	1799	1492
Mouth of E127-00-00	1191	1025	1654	1464	1904	1689	2660	2365

Table 10.1B – Revised Existing vs Recommended Solution WSE

Location	10-yr WSE (ft)		50-yr WSE (ft)		100-yr WSE (ft)		500-yr WSE (ft)	
	Rev. Existing	Pref. Solution	Rev. Existing	Pref. Solution	Rev. Existing	Pref. Solution	Rev. Existing	Pref. Solution
Confluence with E135-00-00	102.45	100.86	104.14	103.28	104.66	104.23	105.74	105.59
Confluence with E127-00-00	99.69	98.32	101.77	100.78	102.22	101.66	103.35	103.13
DS of Beltway 8	94.76	94.59	97.68	97.33	98.23	98.09	99.38	99.61
Confluence with E141-00-00	94.30	94.16	97.22	96.90	97.84	97.60	99.18	99.40
DS of Windfern Road	92.46	92.34	94.94	94.75	95.43	95.28	96.23	96.29
Near Mouth of E127-00-00	100.31	98.92	102.30	101.34	102.77	102.19	103.82	103.61

DEC used the SIA to calculate the benefits achieved with implementation of the Recommended Plan. Exhibit 10.6 and Appendix 10C include the results of the SIA analysis. The SIA Tool computed a large reduction in damages for all storm frequencies. For the 25-year storm event, all homes previously predicted to flood were protected from damage. For the 100-year storm event, the number of homes probable to flood reduced from 163 homes to 101 homes. DEC also analyzed the effect of the Recommended Plan on the Tax Day Flood. The following tables show a summary of the reduction in damages.

Table 10.1C – Recommended Plan vs Revised Existing Damages

		Single Event Damages by Stream			
		25-yr	50-yr	100-yr	500-yr
Revised Existing	E100-00-00	$1,186,953	$5,888,840	$10,461,308	$32,386,281
	E127-00-00	$9,626	$97,761	$523,747	$7,433,181
	E135-00-00	$16,104	$135,629	$422,017	$4,059,610
	Total Damages	$1,212,683	$6,122,230	$11,407,071	$43,879,072
Recommended Solution	E100-00-00	$1,717	$618,825	$5,370,942	$32,091,550
	E127-00-00	$12,702	$36,124	$234,458	$5,728,839
	E135-00-00	$16,104	$135,629	$422,017	$4,059,610
	Total Damages	$30,523	$790,578	$6,027,416	$41,879,999
Reduction in Damages		**$1,182,160**	**$5,331,652**	**$5,379,655**	**$1,999,073**

Table 10.1D – Structural Inventory Recommended Plan (Homes Removed)

	Number of Homes Flooded During Each Storm Event		Number of Homes Removed For Each Storm Event	% Difference Between Existing and Recommended Plan
	Revised Existing	Recommended Solution		
10-yr	0	0	0	0.0%
25-yr	26	0	26	100.0%
50-yr	103	16	87	84.5%
100-yr	163	101	62	38.0%
500-yr	429	397	32	7.5%

Table 10.1E – Structural Inventory Recommended Plan (100-yr vs Tax Day Event)

	100-yr Event		Tax Day Event	
	Revised Existing	Recommended Solution	Revised Existing	Recommended Solution
No. of Flooded Structures	163	101	208	182
Total Damages	$11,407,071	$6,027,416	$15,141,963	$11,443,479
Avg. Damages Per Structure	$69,982	$59,677	$72,798	$62,876

Additionally, DEC mapped the Recommended Solution Tax Day floodplain and compared it to the 100-year floodplain in Exhibit 10.3. Exhibit 10.5 compares the Revised Existing floodplain to the Recommended Solution floodplain for the Tax Day storm event.

In addition to the structural alternatives, non-structural alternatives were included in the Recommended Solution. After completion of the Jersey Meadows Detention Basin and the White Oak Bayou Channel Improvements, 101 homes remained at risk for future flooding during a 100-year storm. Of those 101 homes, 58 were identified as potential candidates for buyouts or home elevations. The number of homes identified as buyout candidates was 26 and the remaining 32 homes were identified as home elevation candidates. However, all 58 homes were candidates for buyouts. Mitigation reconstruction was not recommended because FEMA will not fund more than $150,000 per home, leaving the local share as more than 50% in most cases (based on a 2,500 ft^2) home. The 43 homes that were not identified as potential candidates for non-structural alternatives did not meet the criteria described in section 7.2.A.

10.2. Recommended Solution Benefit-Cost Analysis

A. Jersey Meadows Golf Course

DEC performed a benefit/cost analysis in Phase 3 of the Long-term Flood Recovery Plan (see Appendix 10A) for the Jersey Meadows Golf Course. The benefits were defined as the reduction in damages due to the construction and implementation of the selected alternatives. DEC used the SIA Tool was used to quantify the reduction in damages for the Golf Course alternative. Study engineers calculated benefits for a few individual storm events as well as present value of benefits. DEC calculated the present value for a period of 50 years with the current federal interest rate of 2.875%. The lowest benefit-cost ratio was 1.03 for the 100-year single event and the highest benefit-cost ratio was 1.65 for the present value of avoided damages. Therefore, DEC recommended improvements to the Jersey Meadows Golf Course from an economic view as well as a hydraulic view. Table 10.2A summarizes the results of the benefit/cost analysis.

Table 10.2A – Jersey Meadows Golf Course Benefit-Cost Analysis Results

Total Cost (Present Value)		**$733,425**	
	50-year Avoided Damages	**100-year Avoided Damages**	**Present Value of Avoided Damages**
	$850,581	$757,580	$1,211,501
Benefit-Cost Ratio	1.16	1.03	1.65

B. White Oak Bayou Channel Improvements

A benefit-cost analysis was prepared for the White Oak Bayou Federal Flood Damage Reduction Plan as part of the justification for the Federal Project (see Appendix 2A). The Federal Plan included the channel improvements to White Oak Bayou recommended for the Jersey Village Long-term Flood Recovery Plan. The General Reevaluation Report for the Federal Project included a detailed economic analysis. The base conditions for the GRR economic analysis included 10,495 structures in the White Oak Bayou Watershed at a total value of $1.44 billion (2011 dollars) with 91% of structures being single or multi-family residential. The total damages for the 100-year storm were $423 million. The economic analysis was completed for a 50-year planning period using the 2014 federal interest rate of 3.75% and an arbitrary interest rate of 7% to ensure the project's viability in the future if interest rates should rise again. The average annual damages for the watershed in a "do nothing" scenario were $61.2 million. The average annual damages for the watershed with the Federal Recommended Plan were $25.1 million with a net annual benefit of $30.5 million, which included the reduction in flood insurance rates to the residents in the 100-year floodplain. The analysis was broken up into economic reaches and the reach including Jersey Village had expected annual damages of $6.64 million for the "do nothing" scenario and expected annual damages of $2.46 million for the Recommended Plan scenario. The reduction in damages for the Jersey Village economic reach was 63%. The overall benefit-cost ratio for the White Oak Bayou Watershed was 6.9 with a 3.75% interest rate and 4.2 with a 7% interest rate. The benefit-cost ratios for the project confirmed its economic feasibility now and in the future.

C. Other Alternatives

The improvements to the Wall Street storm sewer system could not be included in the benefit-cost analysis because XP-STORM is not compatible with the SIA Tool. The benefits for the street and storm sewer improvements were qualitative, such as improved mobility in the neighborhood. The City was already planning improvements to the streets themselves due to the aging infrastructure in the Wall Street neighborhood. Additionally, the non-structural alternatives were not included in the benefit-cost analysis for the overall plan. A detailed benefit-cost analysis must be performed on each individual home included on a grant application, which was beyond the scope of this study.

10.3. Partnerships

The City of Jersey Village can collaborate with several different stakeholders and entities to implement the Long-term Flood Recovery Plan. A partnership with HCFCD and USACE for the construction of the White Oak Bayou Channel Improvements may expedite a project that would otherwise take years to complete. A separate partnership with HCFCD regarding home buyouts will greatly benefit the City, HCFCD, and FEMA. Collaborating with the citizens of Jersey Village for home elevations will benefit both the citizens and the City of Jersey Village. Other partnerships may include working with TWDB and other State agencies for funding and grants.

10.4. Phase I Environmental Site Assessment

CESI performed a Phase 1 Environmental Site Assessment (ESA) for the Long-term Flood Recovery Plan Recommended Solution. The proposed project area included the Jersey Meadows Golf Course and the 7,960 ft long portion of the White Oak Bayou main channel within Jersey Village. The overall purpose of the assessment was to evaluate the proposed project area and determine if further testing is needed before construction and to identify REC. The ESA identified two pipelines that intersect the property: Kinder Morgan Tejas Natural Gas Pipeline and Enterprise Crude Oil Pipeline. In addition to these two pipelines, the study observed small structures on the Jersey Meadows Golf Course property and White Oak Bayou is a Relatively Permanent Waterway (RPW). Based on the data collected, CESI recommended that the client did not have to perform any additional environmental investigations and that if potential contaminants were discovered during construction, work should be suspended and testing performed. The complete Phase 1 ESA is located in Appendix 10E.

10.5. Phase 3 Public Meeting

The study team conducted the Phase 3 Public Meeting on June 27, 2017 at City Hall in a formal manner, beginning with a video presentation and a PowerPoint presentation. The video and PowerPoint presentation contained information on the final recommended plan for the City of Jersey Village. Citizens were encouraged to ask questions and provide verbal and written comments. Verbal questions and comments were directed to a panel of experts with members of the study team and the City of Jersey Village. The panel of experts answered questions as time allowed for each individual making verbal comments. Many citizens asked questions related to the structural alternatives recommended by DEC at the public meeting. A full summary report, including a transcript of the meeting and a record of all public comments, is in Appendix 10D.

11. Funding Sources

Potential funding sources for the selected alternatives exist at the local, State, and federal level. Grants are available for both structural and non-structural solutions. Some examples of these funding sources include applying for grants from the USACE, FEMA, TWDB, and the Natural Resources Conservation Service (NRCS). The most effective method of utilizing the funding sources available would be to combine several of these options to help diversify the cost. Appendix 11A includes reference documents relating to potential funding sources.

11.1. Local

Funding from local sources would include incorporating the proposed projects into the City of Jersey Village's Capital Improvement Plan (CIP) or creating a City Bond Program. The City updates their CIP every year for a five-year period. Cities and counties often implement bond programs to fund infrastructure when there is not enough funding to meet infrastructure needs. Examples of the types of projects often funded by bonds include transportation, drainage infrastructures, and new public buildings. However, the citizens of the municipality must approve the bond program through a vote.

Cities and counties can also use general revenue funds for the local sponsor portion of FEMA grant programs for non-structural alternatives such buyouts and home elevations. HCFCD acts as the local sponsor for homeowners wishing to participate in FEMA buyouts. HCFCD also conducts their own buyout program without FEMA funds. HCFCD does not participate in the home elevation FEMA program, but other municipalities in the Greater Houston Metropolitan Area have.

11.2. State

One source of funding available at the State level is the Texas Water Development Fund (DFund), which is available through TWDB. The DFund is a State loan program that provides financial support for numerous infrastructure projects. Eligible entities for the loan include any political subdivision or a nonprofit water supply corporation. The DFund provides funds for the planning, design, acquisition, and construction of projects for water supply, water conservation, water quality enhancement, flood control, wastewater, and municipal solid waste. More specifically, the flood control projects include both structural and non-structural projects. Structural projects consist of construction of stormwater retention basins, channel modifications, bridge modifications, and more. Non-structural solutions include acquisition of floodplain land for use as public open space, relocation of residents in the floodplain, improvements to flood warning systems, and the development of flood management plans.

The terms of the loan include a long-term fixed interest rate based on TWDB's cost of funds sold with the State's General Obligation AAA rating. Typically, the loan has a repayment plan that lasts anywhere from 20 to 30 years, and up to 50 years in some cases. The DFund has a few benefits, including having no maximum funding limit and year-round access to loan funding. Before submitting the financial assistance application package, the applicant must attend a pre-application conference with the Regional Project Implementation Team. After submitting the application, TWDB will provide a notice of complete application and review the application. The TWDB staff will provide a recommendation to the Board and the Board will consider the application for approval.

Another grant available through TWDB is the Flood Protection Planning (FPP) Grant. The grant provides assistance for the evaluation of structural and non-structural solutions to alleviate flooding hazards that cause loss of life or property. The grant program encourages local entities to implement a flood warning system, create local strategies to improve alert and response time for floods and develop a flood protection plan. The funding for these planning studies includes assessing existing flooding issues, conducting hydrologic studies, determining the needs of the public, and recommending solutions that are environmentally, socially, and economically feasible. TWDB provides up to 50% of the cost for the planning study.

11.3. Federal

FEMA has funding available for local flood damage reduction projects as part of their HMA Program. These funds are only accessible through the HMGP and PDM grant programs. The projects must lessen the severity of flooding and decrease the predicted amount of flood damage. Examples of a localized flood damage reduction projects include new or repaired culverts, storm sewer pipes, pump stations, floodgates, and detention/ retention basins. Other examples include slope stabilization or grading to direct water away from structures, vegetation management for stabilization and flood protection, and stabilization measures for roads and bridges. In addition to FEMA funding, USACE provides funding for federally approved flood damage reduction projects. Many projects include a cost share between USACE and HCFCD in Harris County.

After a natural disaster has occurred, NRCS has emergency programs in place to help with disaster relief. HCFCD utilizes the Emergency Watershed Protection (EWP)

Program. All projects done through the EWP program must have a local sponsor who is responsible for obtaining all the land rights for repair work, procuring necessary permits, providing the local cost share, installation of the work and performing continual maintenance. The NRCS may pay up to 75% of the construction costs for the emergency repairs. The remaining 25% is provided by HCFCD for open channels in Harris County and can be made in cash or in-kind services. The purpose of an EWP project must be to lower risk to local lives and property. The solutions must be economically, environmentally and socially feasible and conserve natural resources. The type of work authorized by the EWP program focuses on watershed impairments. Repair activities can include removing debris from a clogged channel, stabilizing streambanks, repairing damaged water control structures and public infrastructures and removing wind-borne debris. If a sponsor wants to increase the level of protection during a project, they are responsible for paying up to 100% of the upgraded portion of the project.

As discussed in section 7.2, FEMA has several programs available as an avenue to fund modifications to individual structures. These programs include the HMGP, PDM, and FMA programs. All of these programs fall under the umbrella of the FEMA Hazard Mitigation Assistance Program. Each of these programs possess separate requirements and provide different federal awards. Federal awards can be granted for use in several different activities listed by FEMA, including the Property Acquisition and Structure Demolition or Relocation program, the Structure Elevation program or the Mitigation Reconstruction program. The following table gives a brief summary for the funding available for each grant program.

Table 11.3A – Summary of FEMA Funding for Non-structural Alternatives

Grant Program	FEMA Funding Available		
	Property Acquisition and Structure Demolition	Structure Elevation	Mitigation Reconstruction
Flood Mitigation Assistance (FMA)	SRL: 100% Federally Funded RL: 90% Federally Funded Other: 75% Federally Funded	SRL: 100% Federally Funded RL: 90% Federally Funded Other: 75% Federally Funded	Maximum $150,000 Federal Share
Pre-Disaster Mitigation (PDM)	75% Federally Funded	75% Federally Funded	Maximum $150,000 Federal Share
Hazard Mitigation Grant Program (HMGP)	75% Federally Funded	75% Federally Funded	Maximum $150,000 Federal Share

HMGP funds are only available after a presidential disaster declaration. Applications are submitted to the Texas Division of Emergency Management (TDEM) within six months of the declared disaster. PDM funds are awarded annually and the property owners applying are not required to possess flood insurance. The special case for PDM funds applies to impoverished areas where, instead of federal funds accounting for 75% of the project, they account for 90%. The remaining 10% of funding is provided through other sources. FEMA awards FMA funds annually as well, but they can only be distributed to property owners that have flood insurance at the time of application. This program works on a cost-share basis for both property acquisition and structure elevation projects. However, there are multiple amounts of federal awards available depending on the condition of the property. If a property qualifies as SRL, FEMA provides 100% of the project cost. If a property qualifies as RL, the federal award is 90% of the project cost. Finally, if the property is neither SRL nor RL, the federal award will only account for 75% of the funds.

For property acquisition, FEMA does not cover the closing or moving costs for the resident. These funds may be provided through other sources, although it is not required of the local sponsor submitting the application. Furthermore, the local sponsor providing the non-federal portion of the cost-share is responsible for maintaining the property and keeping it as an open space according to FEMA criteria.

There are several options available for funding the non-federal cost share. The local sponsor, the homeowner, or a third party can provide the matching funds . Although this is the simplest method of matching funds, it can be a financial burden to the property owner or local government. One possibility for matching funds includes using Increased Cost of Compliance (ICC) Funds. ICC coverage can provide up to $30,000 to help flood insurance policyholders cover the cost of implementing mitigation measures to help lower their flood risk. In order to be eligible for ICC coverage, the homeowner must meet one of two criteria: the structure must be substantially damaged after the flood event or be a RL/SRL property. For a home to qualify as substantially damaged, the damage to the home must be at least over 50% of the home's market value. ICC coverage can be used for four different types of individual mitigation activities: structure elevation, floodproofing for non-residential buildings, structure relocation, or structure demolition in more extreme cases. In some cases, policyholders can share their ICC benefits with their community and enable the community to file a single claim on behalf of a community mitigation project. The community may then use FEMA mitigation grant funds to help pay for the local portion of the mitigation activities that is more than the ICC claim payment. Table 11.3B contains a summary of the approved activities for FEMA funding.

Table 11.3B – HMA Grant Program Funding

Funding Source	FMA	PDM	HMGP
Potential Cost Share (% Grant /% Local)			
Standard	75/25	75/25	75/25
Special Conditions (e.g. impoverished, RL, SRL)	90/10 RL 100/0 SRL	90/10	N/A
Eligible Planning Projects			
Hazard Mitigation Planning	✔	✔	✔
Planning (H&H studies, solution analysis)			✔
Engineering Design	✔	✔	
Eligible Mitigation Projects			
Property Acquisition/Demolition/Relocation	✔	✔	✔
Structure Elevation	✔	✔	✔
Dry Floodproofing of Historic Residential Structures	✔	✔	✔
Dry Floodproofing of Non-Residential Structures	✔	✔	✔
Generators		✔	✔
Localized Flood Risk Reduction Projects	✔	✔	✔
Non-Localized Flood Risk Reduction Projects	✔	✔	✔
Structural Retrofitting of Existing Buildings	✔	✔	✔
Non-Structural Retrofitting of Existing Buildings	✔	✔	✔
Safe Room Construction	✔	✔	✔
Retrofit for One- and Two-Family Residences		✔	✔
Infrastructure Retrofit	✔	✔	✔
Soil Stabilization	✔	✔	✔
Wildfire Mitigation		✔	✔
Post Disaster Code Enforcement			✔
Initiative Projects (flood warning, public awareness)			✔
Water Quality and Green Infrastructure			✔

12. Recommendations and Phasing

The study team reviewed the results of the many analyses that were part of the Long-term Flood Recovery Plan and identified alternatives as either short-term or long-term. Short-term alternatives were those that the City of Jersey Village can fund and implement on their own or through a partnership within the next few years. The long-term alternatives were those that depended on funding from other agencies that the City could not fund themselves.

The study team recommends completing improvements to the Jersey Meadows Golf Course and the Wall Street Storm Sewer System in the short-term using CIP funds. DEC recommended completing the improvements to the Wall Street Storm Sewer according to the phasing plan found Appendix 7J. Improvements to the Jersey Meadows Golf

Course are a high priority and provide benefits for other alternatives, including the Wall Street Storm Sewer System and the White Oak Bayou Channel Improvements.

Additionally, applying for funding for the homes identified as candidates for non-structural alternatives can be completed in the short-term. The FMA grant program receives funding annually and the amount of funding available from FEMA varies from year to year. Due to limited funding, not all homes should be included on the same application. DEC recommends splitting the FMA grant applications into phases due to the sheer volume of homes in need. Grants awarded under the FMA program put the vast majority of the cost burden on FEMA instead of the local sponsor. In conclusion, the recommended short-term alternatives are Jersey Meadows Golf Course Detention, Wall Street Storm Sewer System improvements, and non-structural alternatives. The cost burden on the City of Jersey Village is a minimum of approximately $6.5 million, not including the local share of non-structural alternatives.

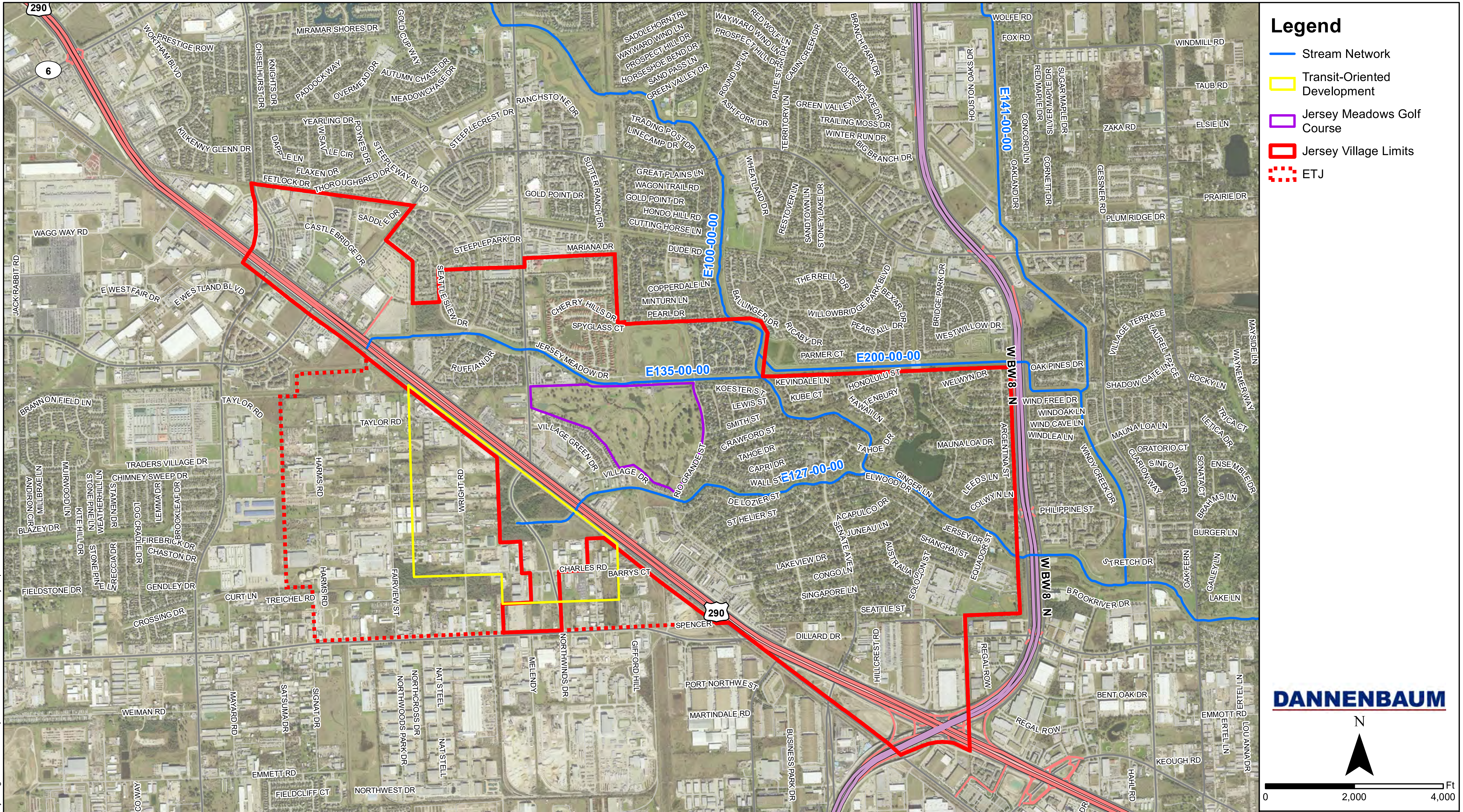
The White Oak Bayou Channel Improvements are the only recommended long-term solution. The channel improvements are part of the White Oak Bayou Federal Flood Damage Reduction Plan, revised in August of 2014. The channel improvements through Jersey Village combined with the already constructed improvements provide the greatest benefit to the City of Jersey Village. HCFCD has already completed $95 million in improvements to the White Oak Bayou Watershed, but USACE has not reimbursed HCFCD for the federal Share. Therefore, HCFCD has not completed any work in the White Oak Bayou Watershed for the last few years. Potential cost sharing between the City and HCFCD may expedite the improvements in Jersey Village, but does guarantee a change in timeline. See Table 12A for a summary of costs and phasing.

Table 12A. Phasing and Cost Summary

Phase Number	Project Name	Estimated Cost
1	Jersey Meadows Golf Course	$733,425
2	Wall Street Neighborhood Improvements	$5,705,451
3	Non-structural Alternatives	$9.84M - $16.4M*
4	White Oak Bayou Federal Plan Channel Improvements	$4,578,588

*The cost of non-structural alternatives is the potential range of total costs and does not subtract the federal share.

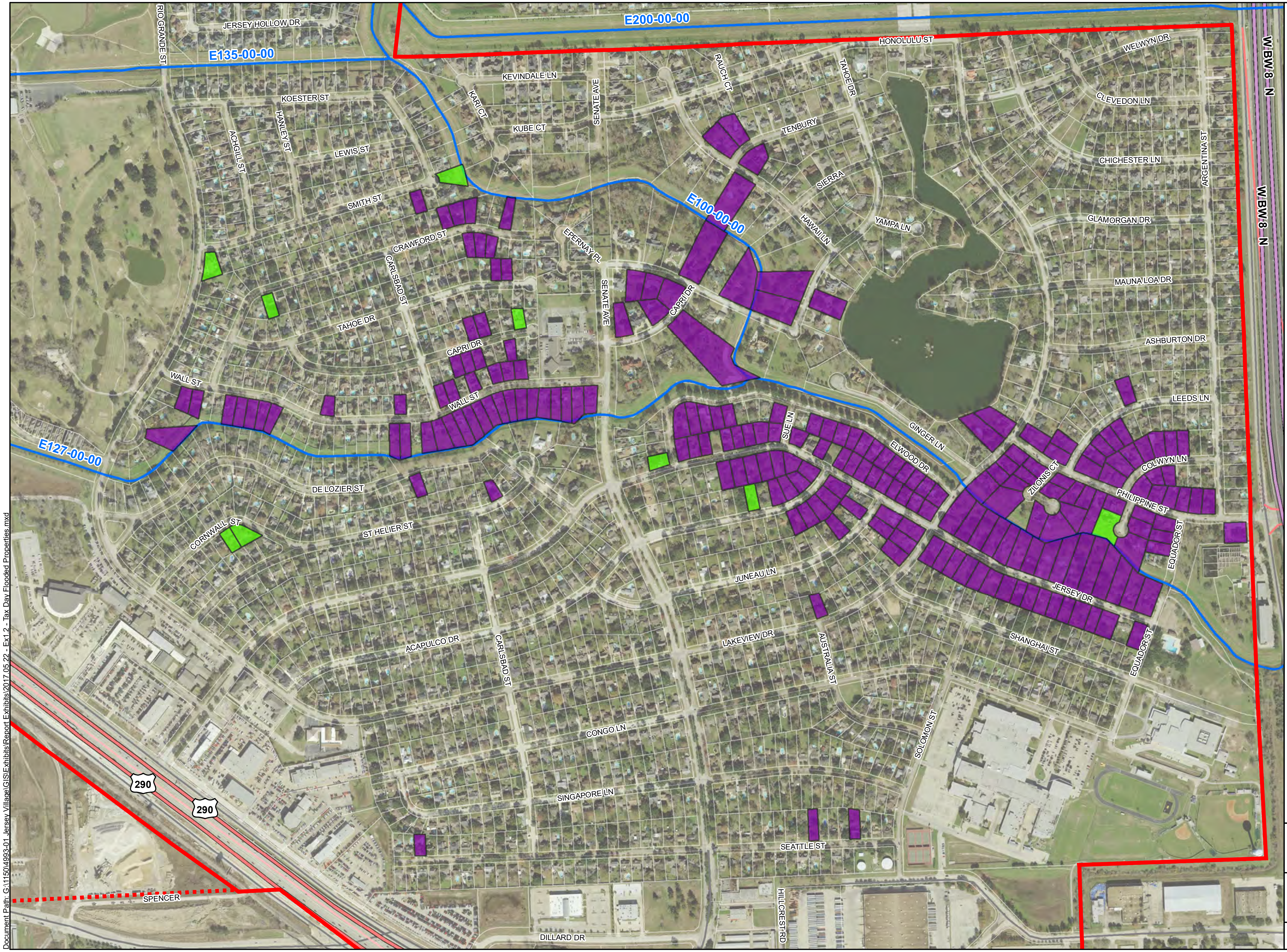
Exhibits



City of Jersey Village
Long-term Flood Recovery Plan

Exhibit 1.1
Vicinity Map

1 in. = 2,000 ft	June 2017



Legend

Stream Network
Jersey Village
ETJ

Affected Parcels

April 18, 2016

Entire Home
Garage Only

DANNENBAUM

N

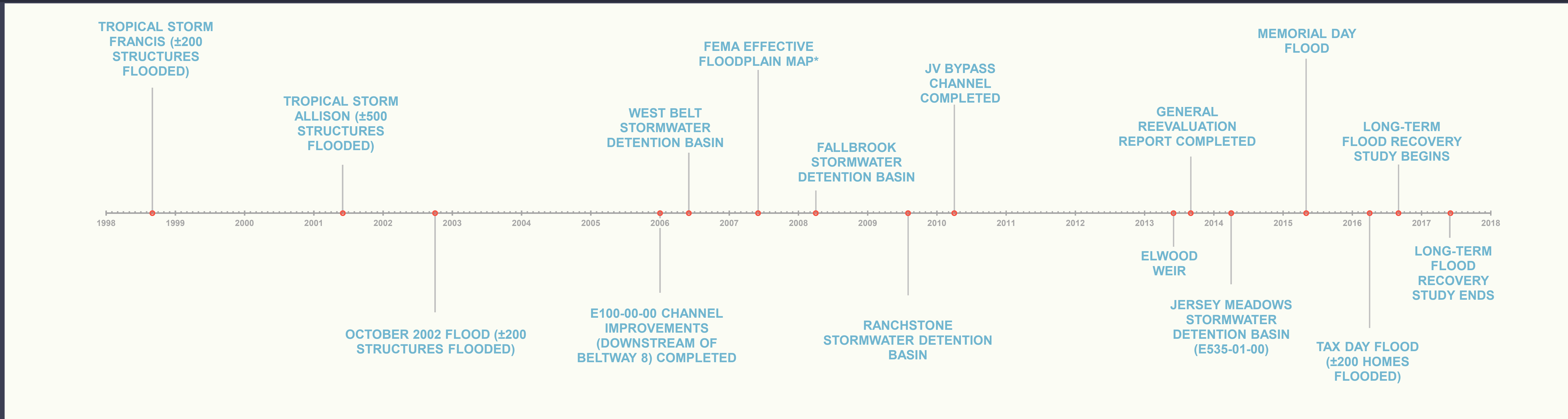
0 600 1,200 Ft

City of Jersey Village
Long-term Flood Recovery Plan

Exhibit 1.2
Affected Homes (April 18, 2016)

1 in. = 600 ft | June 2017

TIMELINE



*FEMA Effective Maps updated in 2014 but not reflective of HCFCD improvements completed

EVENT DETAILS

DATE	MILESTONE
9/11/1998	Tropical Storm Francis (±200 structures flooded)
6/9/2001	Tropical Storm Allison (±500 structures flooded)
10/1/2002	October 2002 Flood (±200 structures flooded)
1/1/2006	E100-00-00 Channel Improvements (Downstream of Beltway 8) Completed
6/20/2006	West Belt Stormwater Detention Basin (E500-10-00)
6/18/2007	FEMA Effective Floodplain Map*
4/18/2008	Fallbrook Stormwater Detention Basin (E500-12-00)
8/13/2009	Ranchstone Stormwater Detention Basin (E500-11-00)
4/1/2010	JV Bypass Channel Completed
6/1/2013	Elwood Weir
9/1/2013	General Reevaluation Report Completed
4/1/2014	Jersey Meadows Stormwater Detention Basin (E535-01-00)
5/26/2015	Memorial Day Flood
4/16/2016	Tax Day Flood (±200 homes flooded)
9/1/2016	Long-term Flood Recovery Study Begins
6/27/2017	Long-term Flood Recovery Study Ends

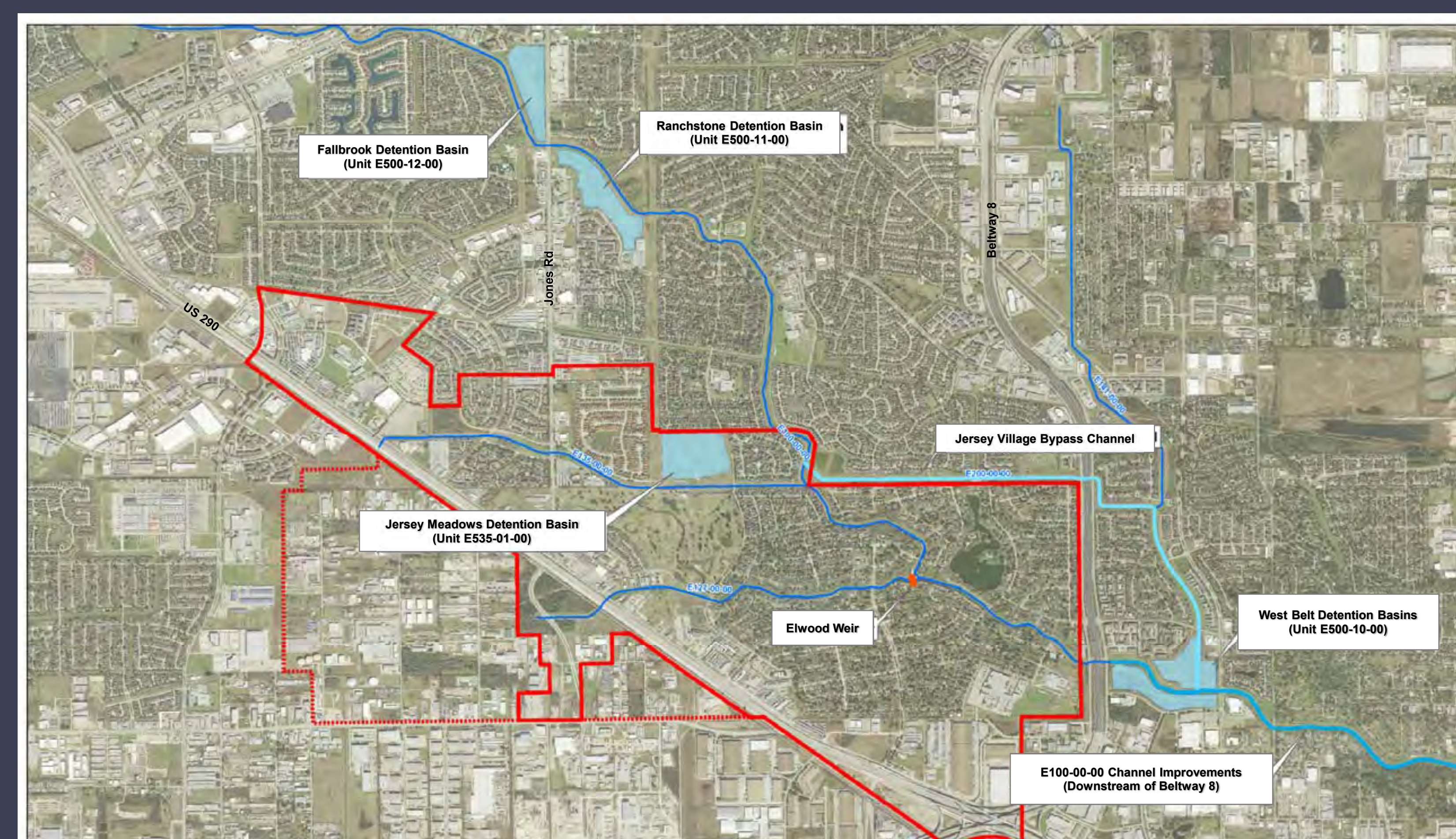
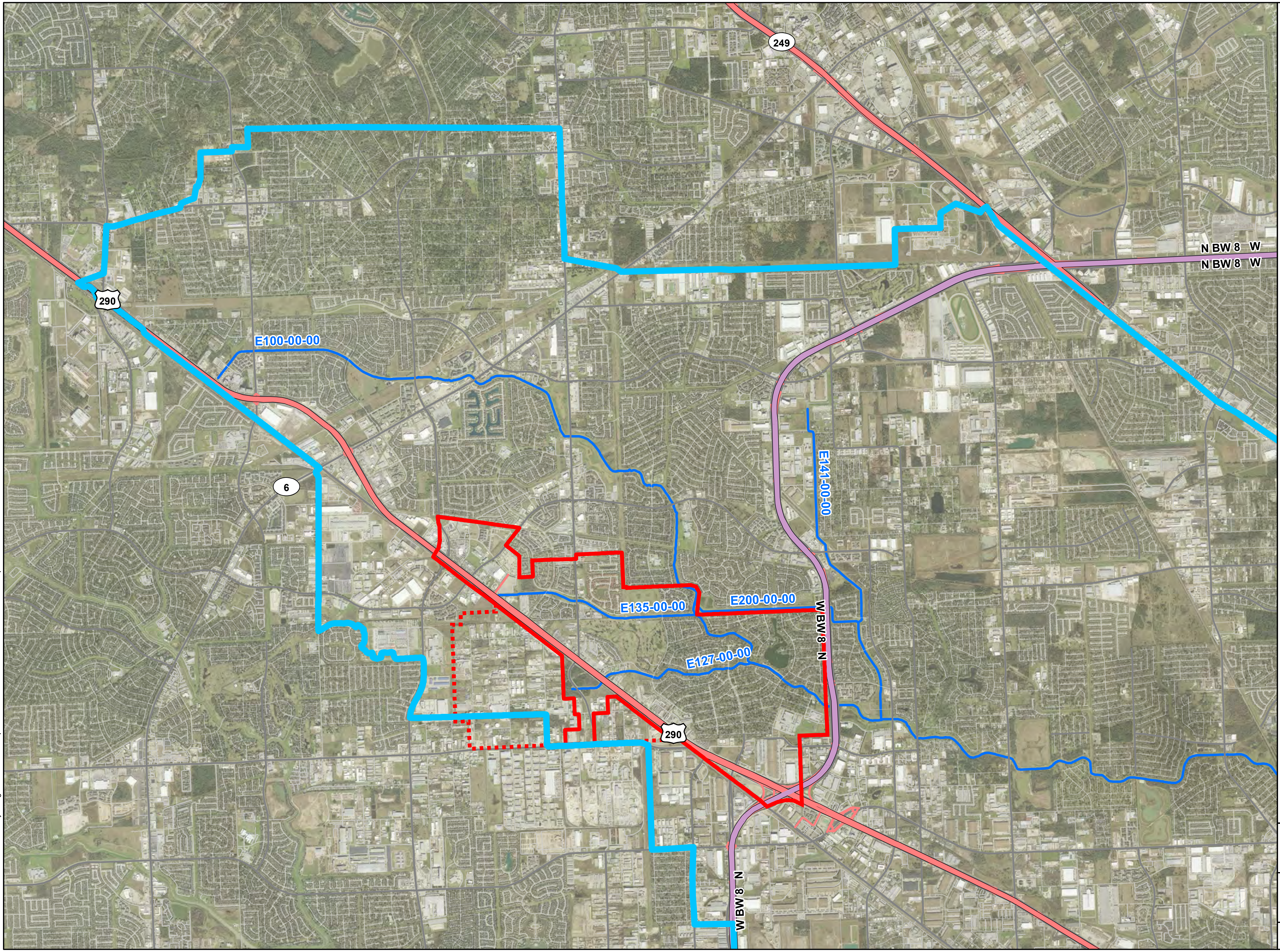


Exhibit 1.3
Jersey Village Timeline



Legend

- Stream Network
- White Oak Bayou
- Jersey Village
- ETJ

DANNENBAUM

N

0 4,000 8,000 Ft

City of Jersey Village
Long-term Flood Recovery Plan

Exhibit 1.4
White Oak Bayou Upper Watershed

1 in. = 4,000 ft | June 2017

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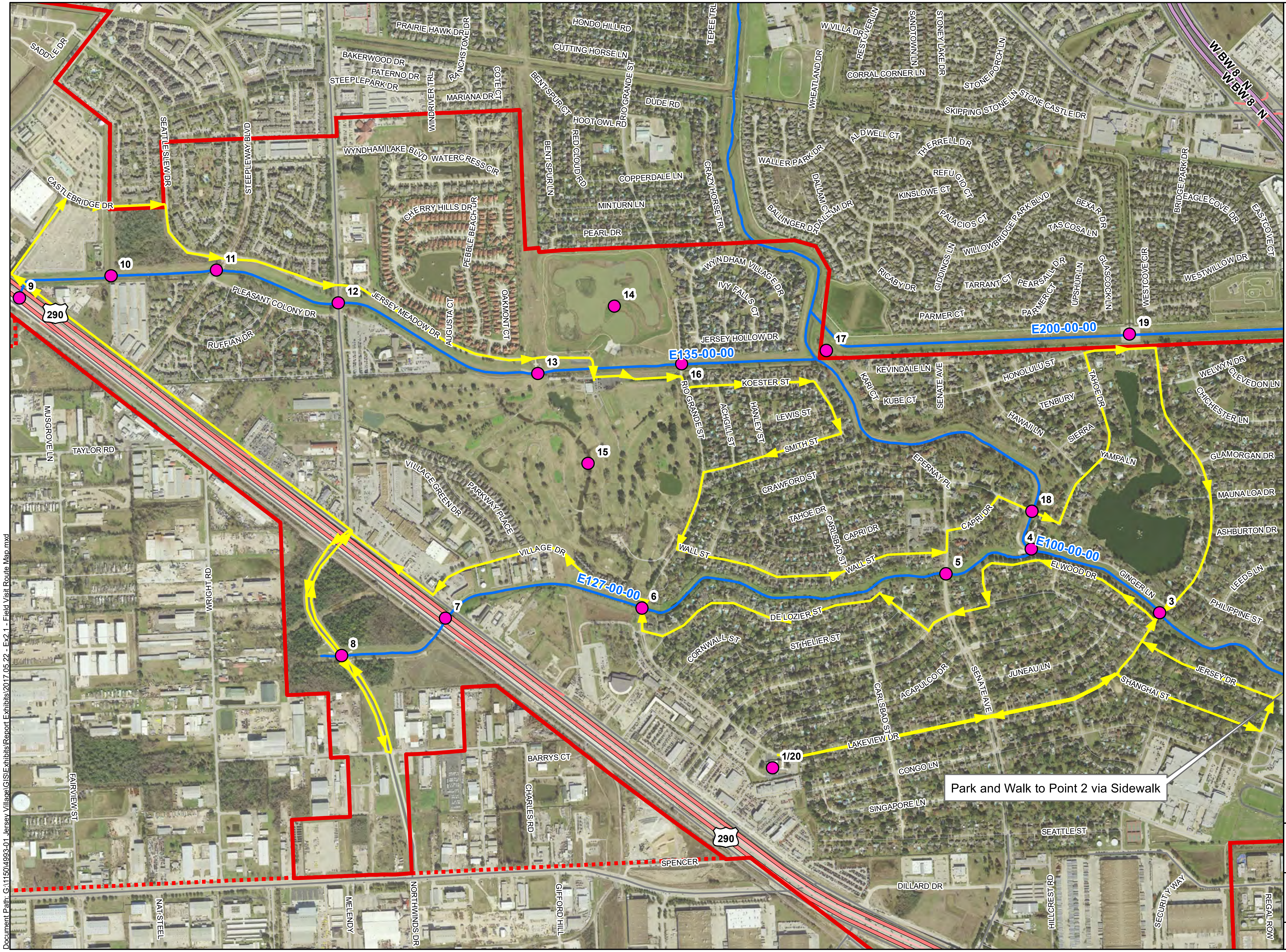

Legend

- Points of Interest
- Driving Route
- Stream Network
- Jersey Village
- ETJ

DANNENBAUM

N

0 1,000 2,000 Ft

City of Jersey Village
Long-term Flood Recovery Plan

Exhibit 2.1
Field Visit Route Map

1 in. = 1,000 ft	June 2017

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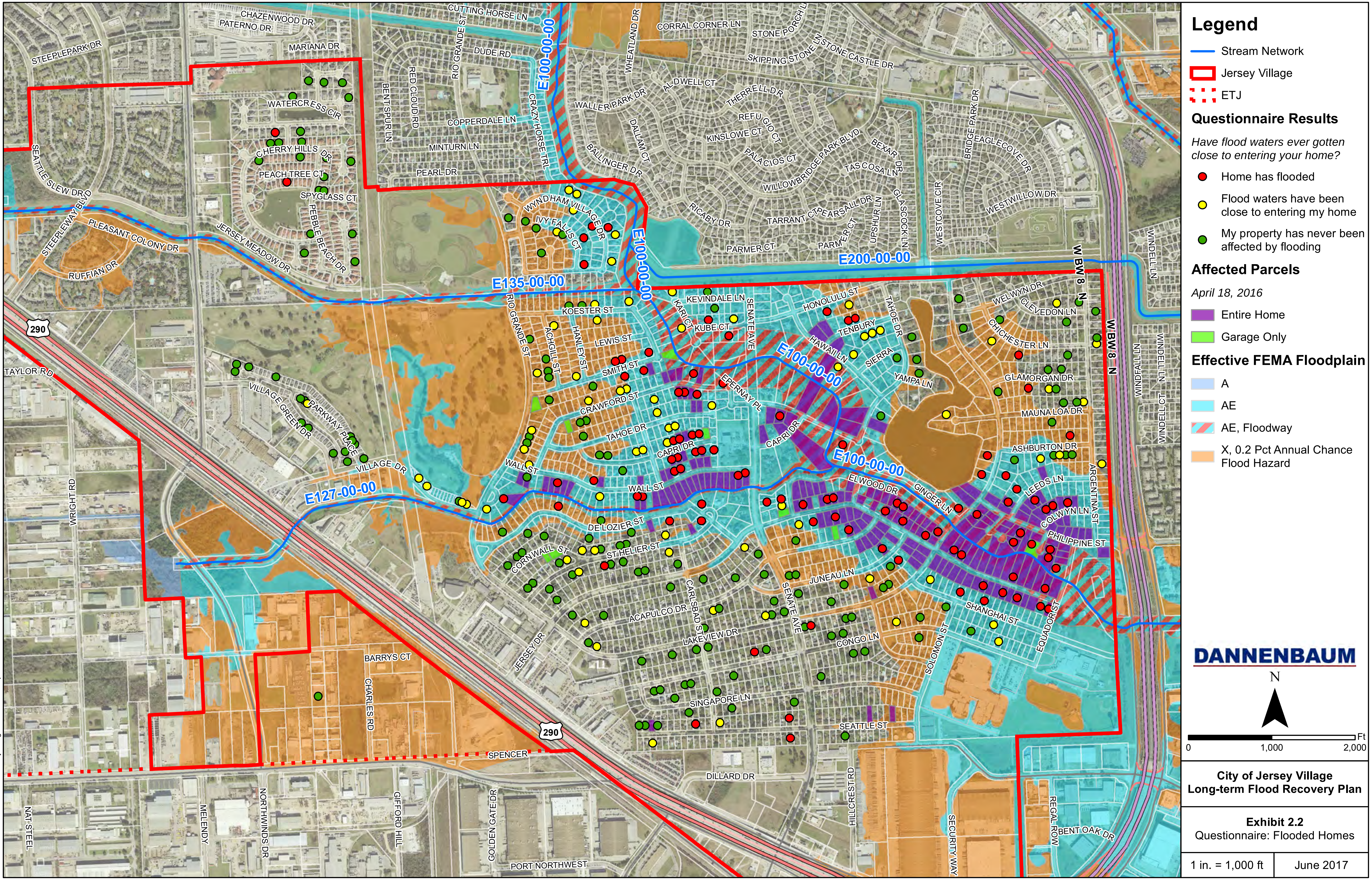

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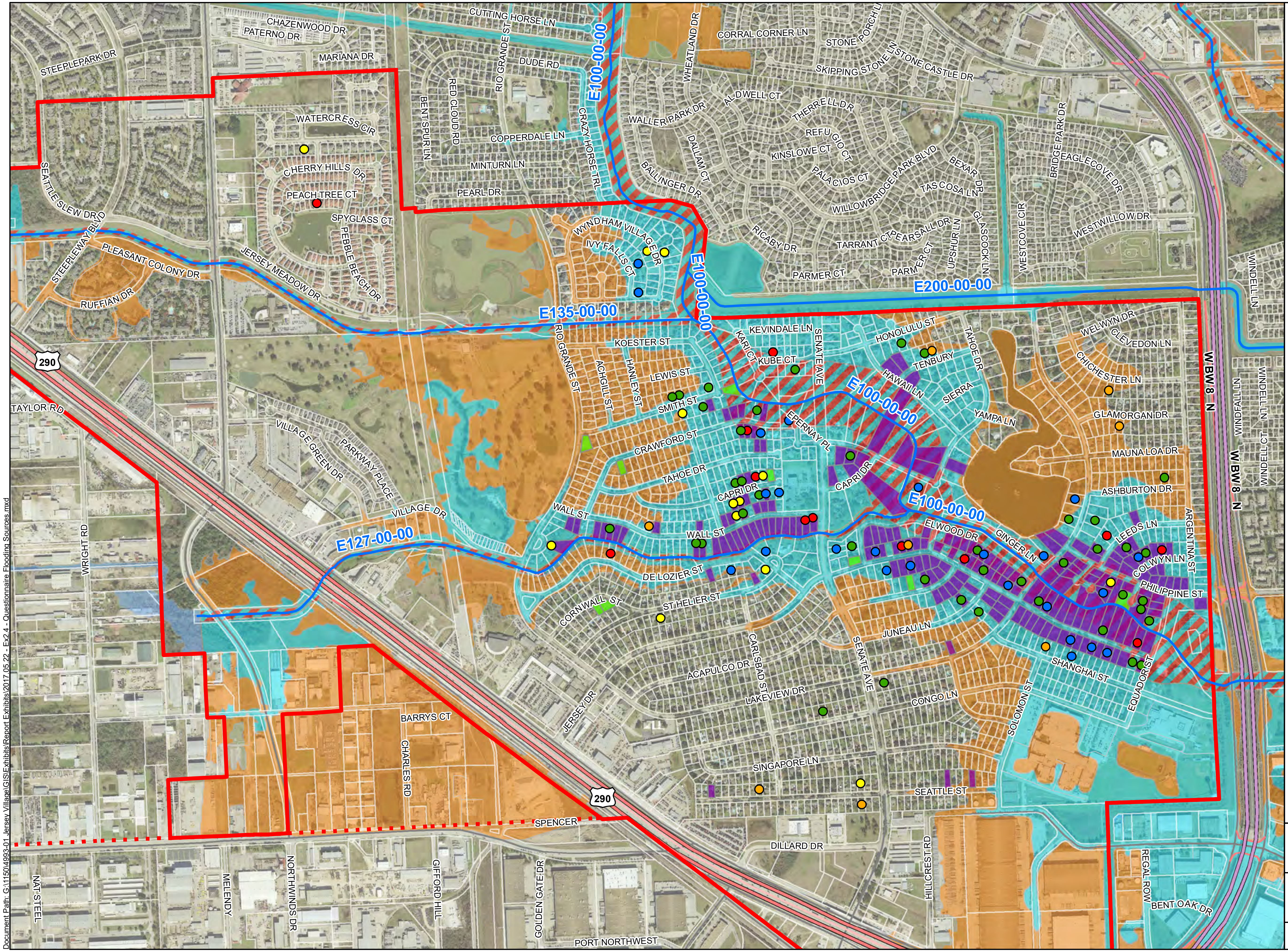

Legend

- Stream Network
- Jersey Village
- ETJ

Affected Parcels

April 18, 2016

- Entire Home
- Garage Only

Questionnaire Results

Source of Flooding

- Street
- White Oak Bayou and/or tributaries
- Both (Street and WOB)
- Backyard
- All

Effective FEMA Floodplain

- A
- AE
- AE, Floodway
- X, 0.2 Pct Annual Chance Flood Hazard

DANNENBAUM

N

0 1,000 2,000 Ft

City of Jersey Village
Long-term Flood Recovery Plan

Exhibit 2.4
Questionnaire: Flooding Sources

1 in. = 1,000 ft | June 2017


Legend
Revised Existing BFE
Stream Network
City of Jersey Village
ETJ
Questionnaire Data
Has the street flooded?
No
Yes, curb was not overtopped
Yes, curb was overtopped
Road Flood Depth (ft)
0
0 - 0.50
0.51 - 1.0
1.01 - 1.5
1.51 - 2.0
2.01 - 2.5
2.51 - 3.0
3.01 - 3.5
3.51 - 4.0
4.01+
DANNENBAUM
N
0 1,000 2,000 Ft
City of Jersey Village
Long-term Flood Recovery Plan
Exhibit 2.5
Flooding at Street Centerline
1 in. = 1,000 ft
June 2017
E135-00-00
E200-00-00
E100-00-00
E127-00-00
E141-00-00
290
529
WEST RD
W GULF BANK RD
JONES RD
SENATE AVE
HEMPSTEAD RD
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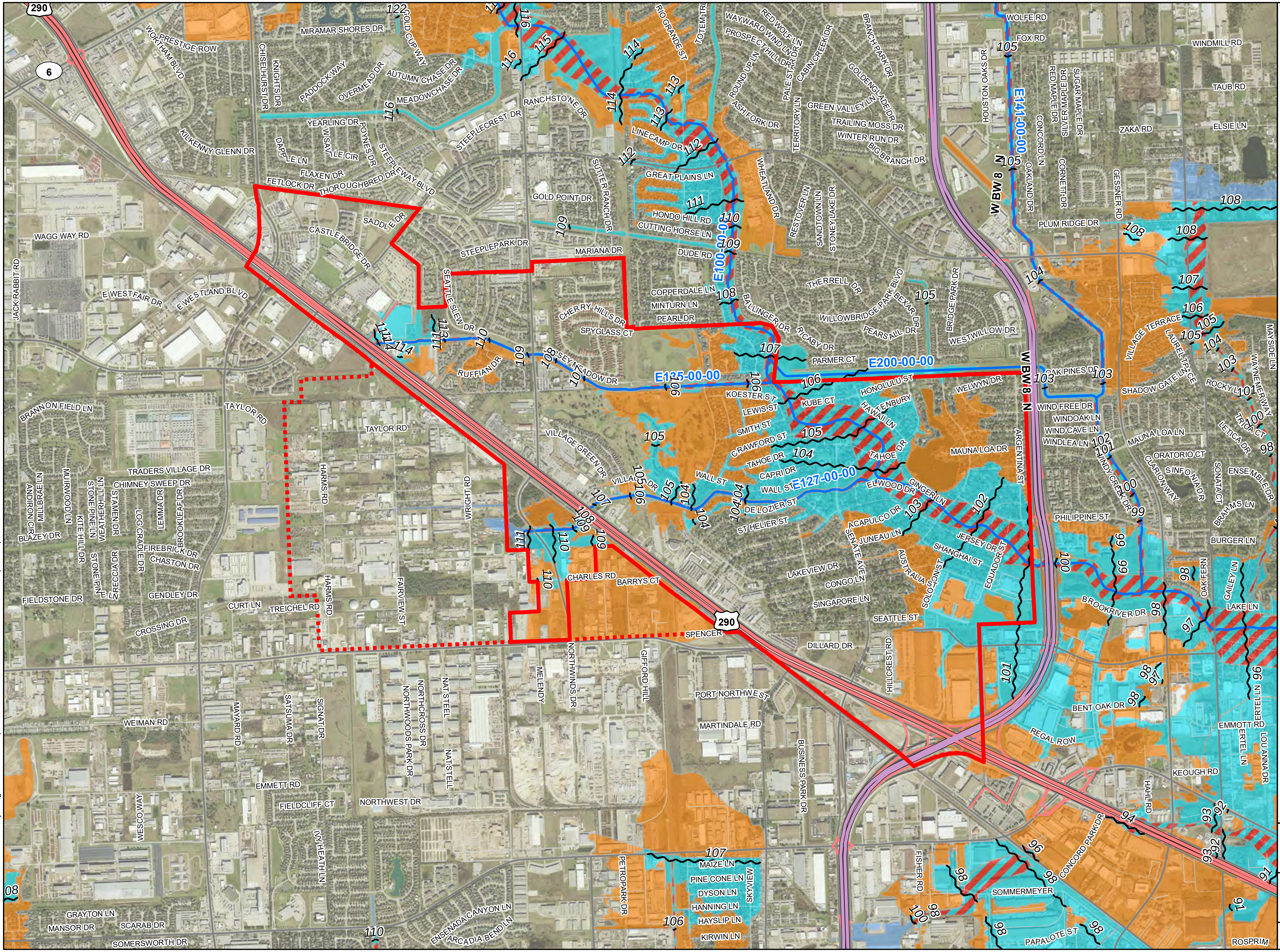


Legend

- Base Flood Elevation
- Stream Network
- Jersey Village
- ETJ

Effective FEMA Floodplain

- A
- AE
- AE, Floodway
- AO
- X, 0.2 Pct Annual Chance Flood Hazard

DANNENBAUM

N

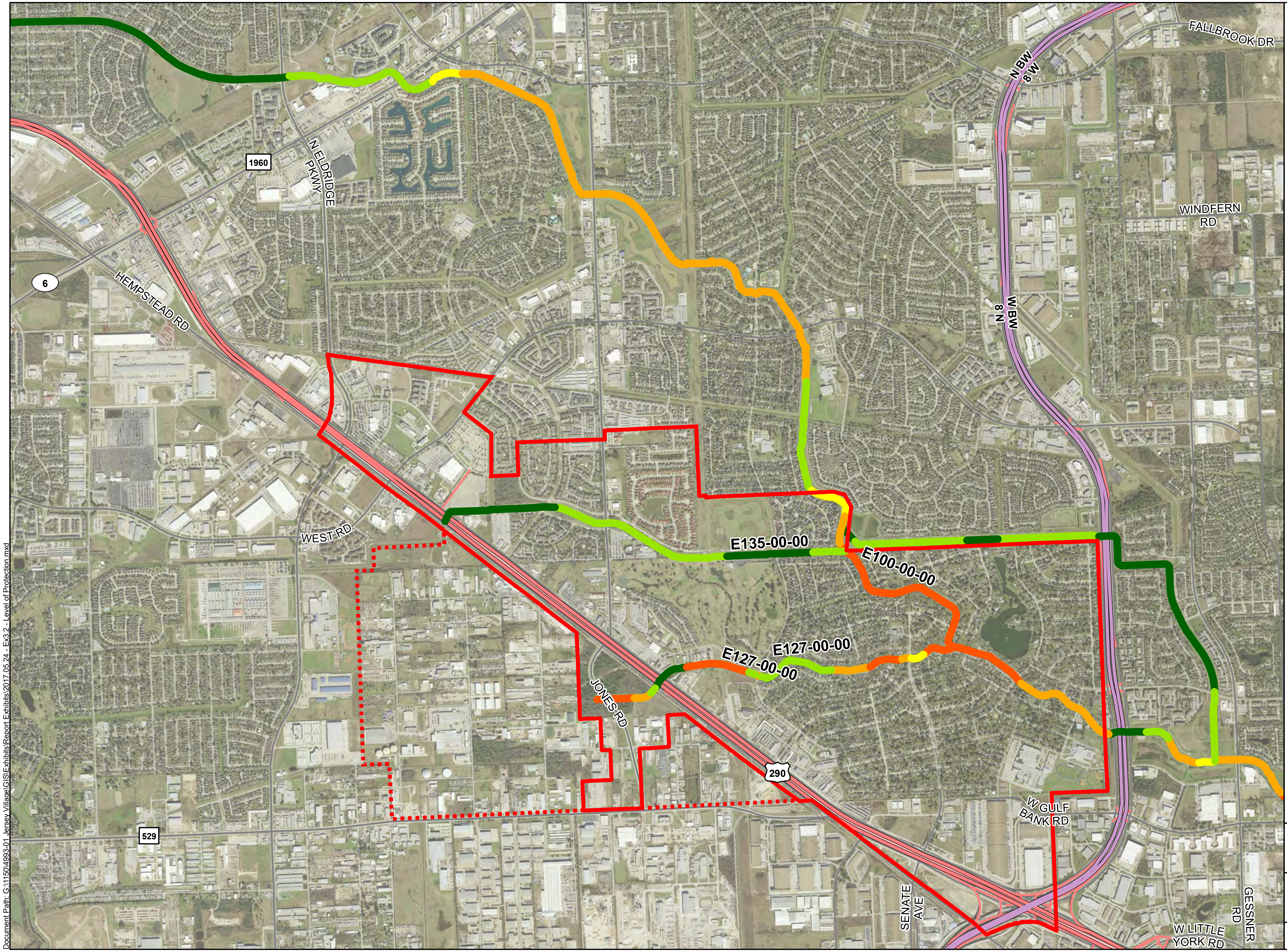
0 2,000 4,000 Ft

City of Jersey Village
Long-term Flood Recovery Plan

Exhibit 3.1
Effective Floodplain Map

1 in. = 2,000 ft	June 2017

Document Path: G:\1150\4993-01 Jersey Village\GIS\Exhibits\Report Exhibits\2017.05.22 - Ex3.1 - Effective Floodplain Map.mxd



Legend

City of Jersey Village

ETJ

Level of Protection

Revised Existing

10-yr Event

25-yr Event

50-yr Event

100-yr Event

500-yr Event

DANNENBAUM

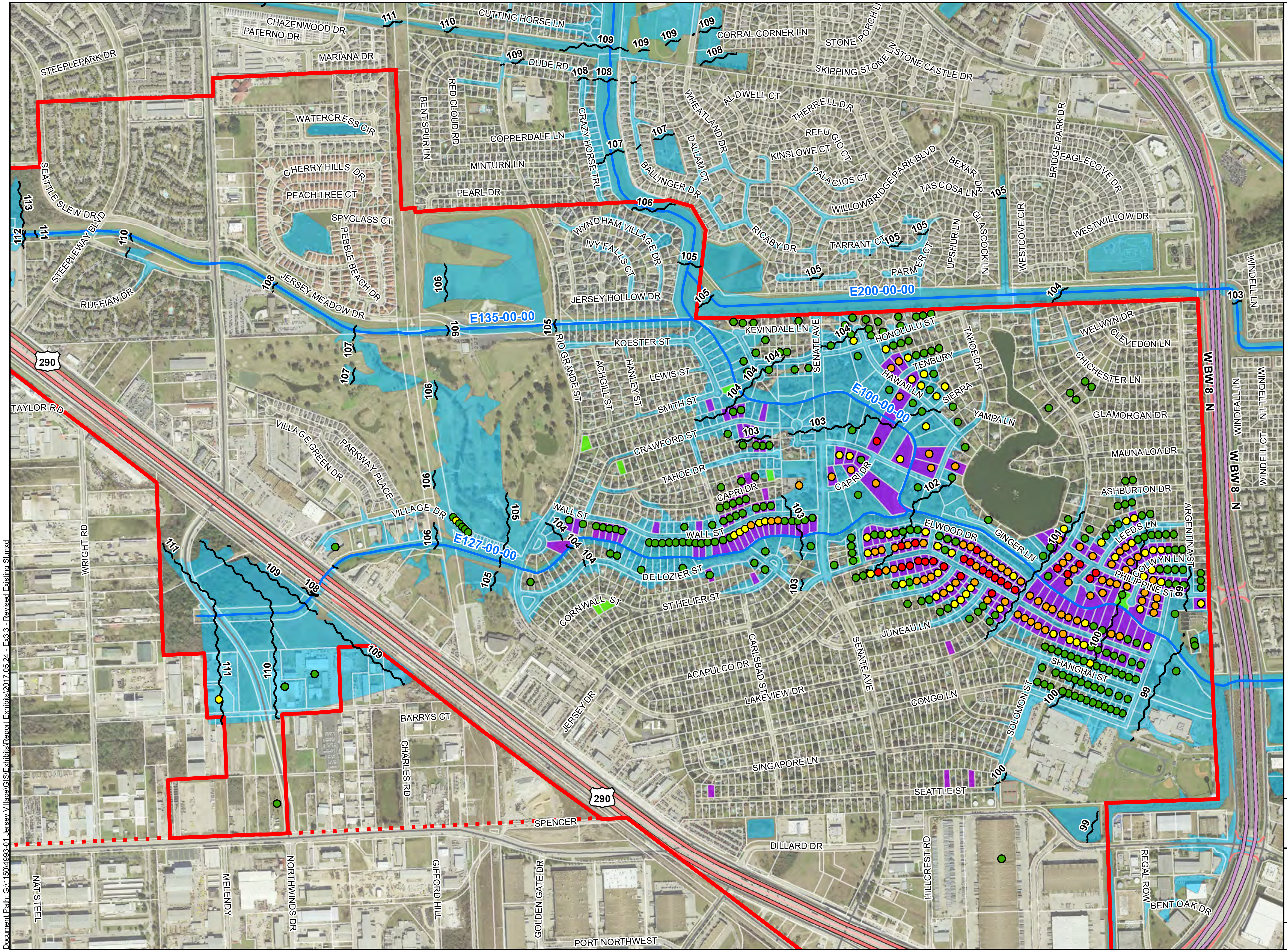
N

0 2,000 4,000 Ft

City of Jersey Village
Long-term Flood Recovery Plan

Exhibit 3.2
Revised Existing
Channel Level of Protection

1 in. = 2,000 ft	June 2017



Legend

- Revised Existing BFE
- Stream Network
- Revised Existing Floodplain (100-yr)
- Jersey Village
- ETJ

Revised Existing Structural Inventory

- 4% (25-yr Event)
- 2% (50-yr Event)
- 1% (100-yr Event)
- 0.2% (500-yr Event)

Affected Parcels

April 18, 2016

- Entire Home
- Garage Only

DANNENBAUM

N

0 1,000 2,000 Ft

City of Jersey Village
Long-term Flood Recovery Plan

Exhibit 3.3
Structural Inventory
2016 Revised Existing Conditions

1 in. = 1,000 ft	June 2017

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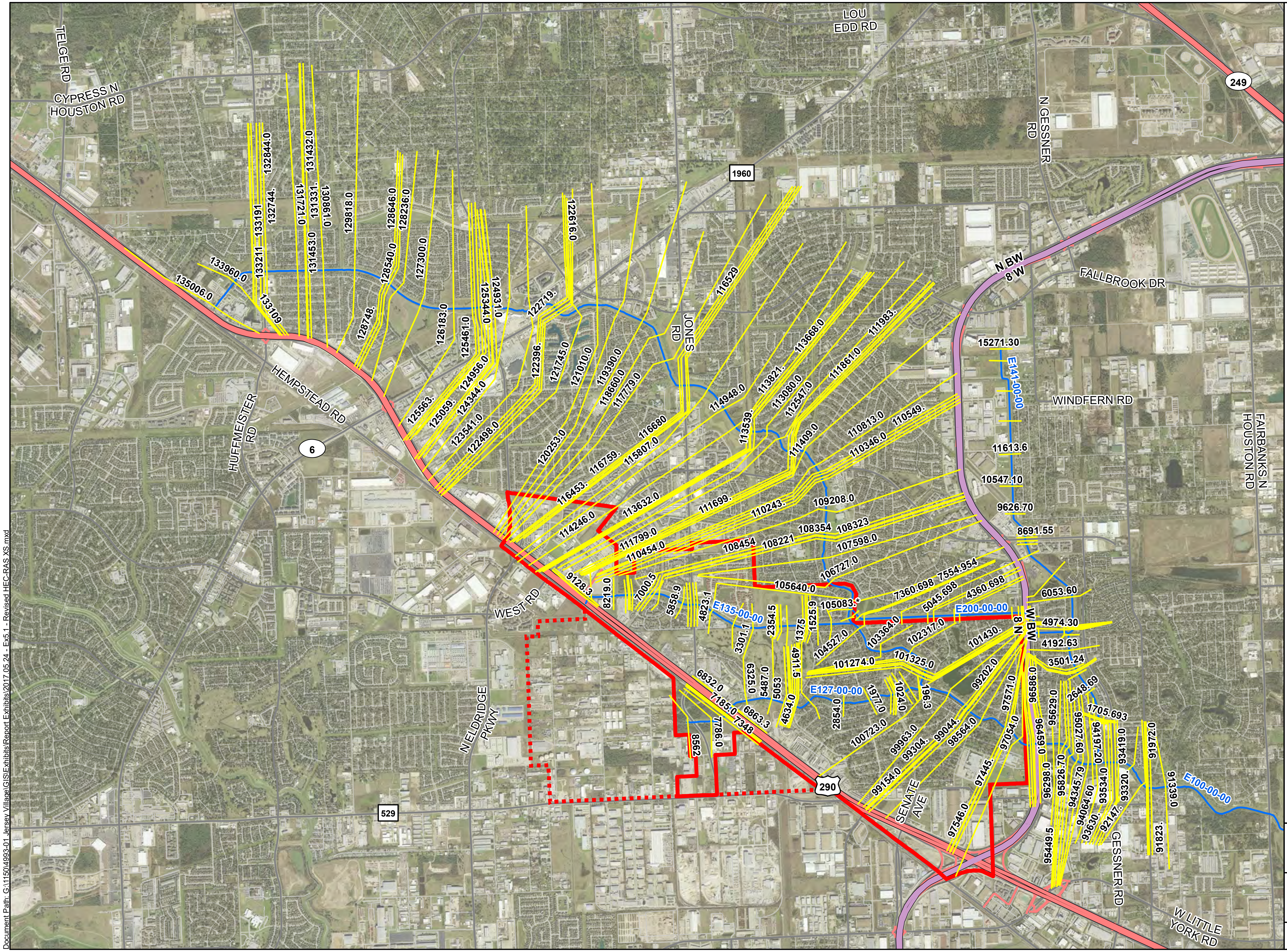


Legend

- 2017 HEC-RAS XS
- Stream Network
- City of Jersey Village
- ETJ

DANNENBAUM

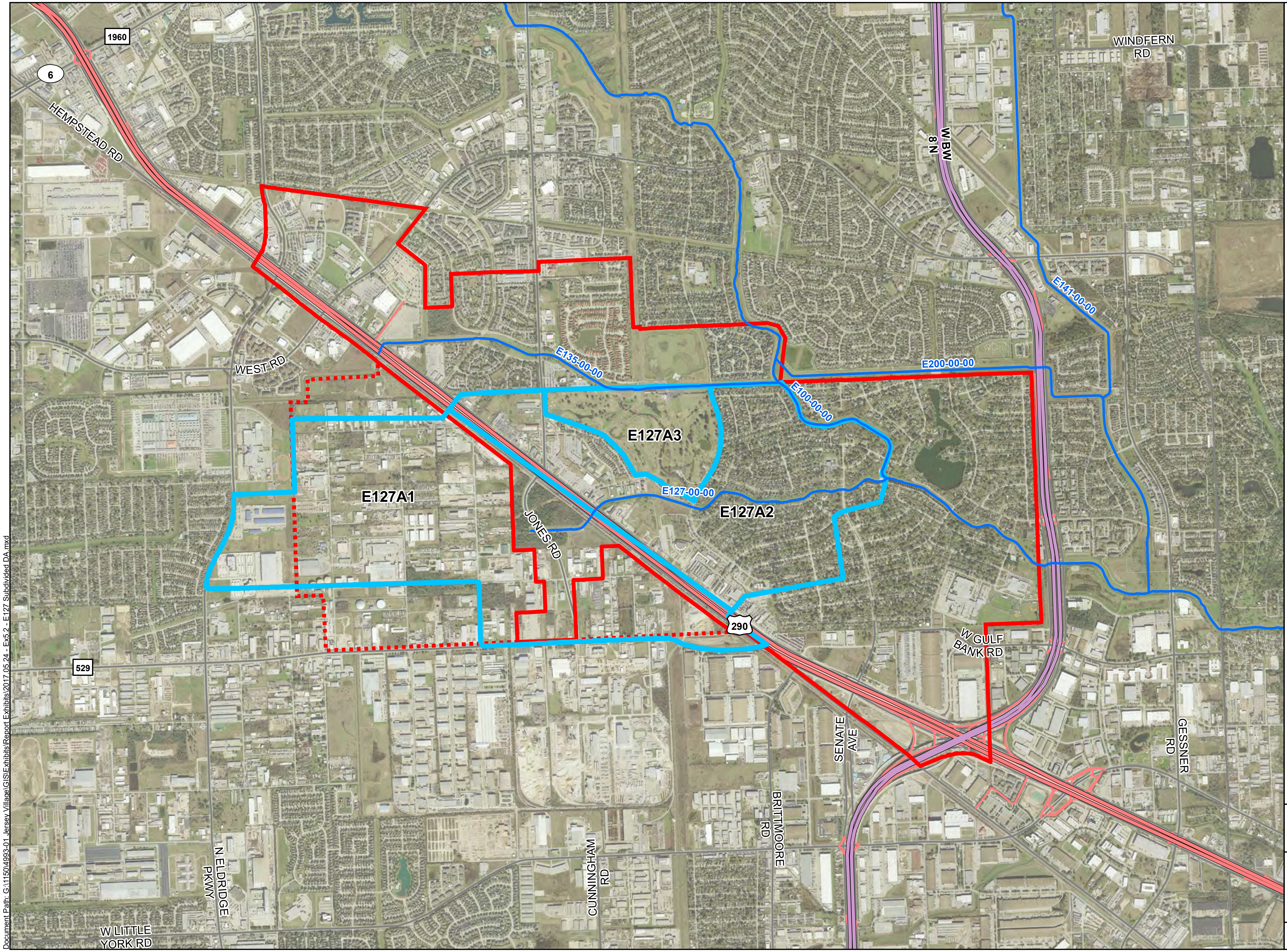
N

0 3,000 6,000 Ft

City of Jersey Village
Long-term Flood Recovery Plan

Exhibit 5.1
Revised HEC-RAS Cross-sections

1 in. = 3,000 ft	June 2017



Legend

- E127-00-00 Subareas
- Stream Network
- City of Jersey Village
- ETJ

DANNENBAUM

N

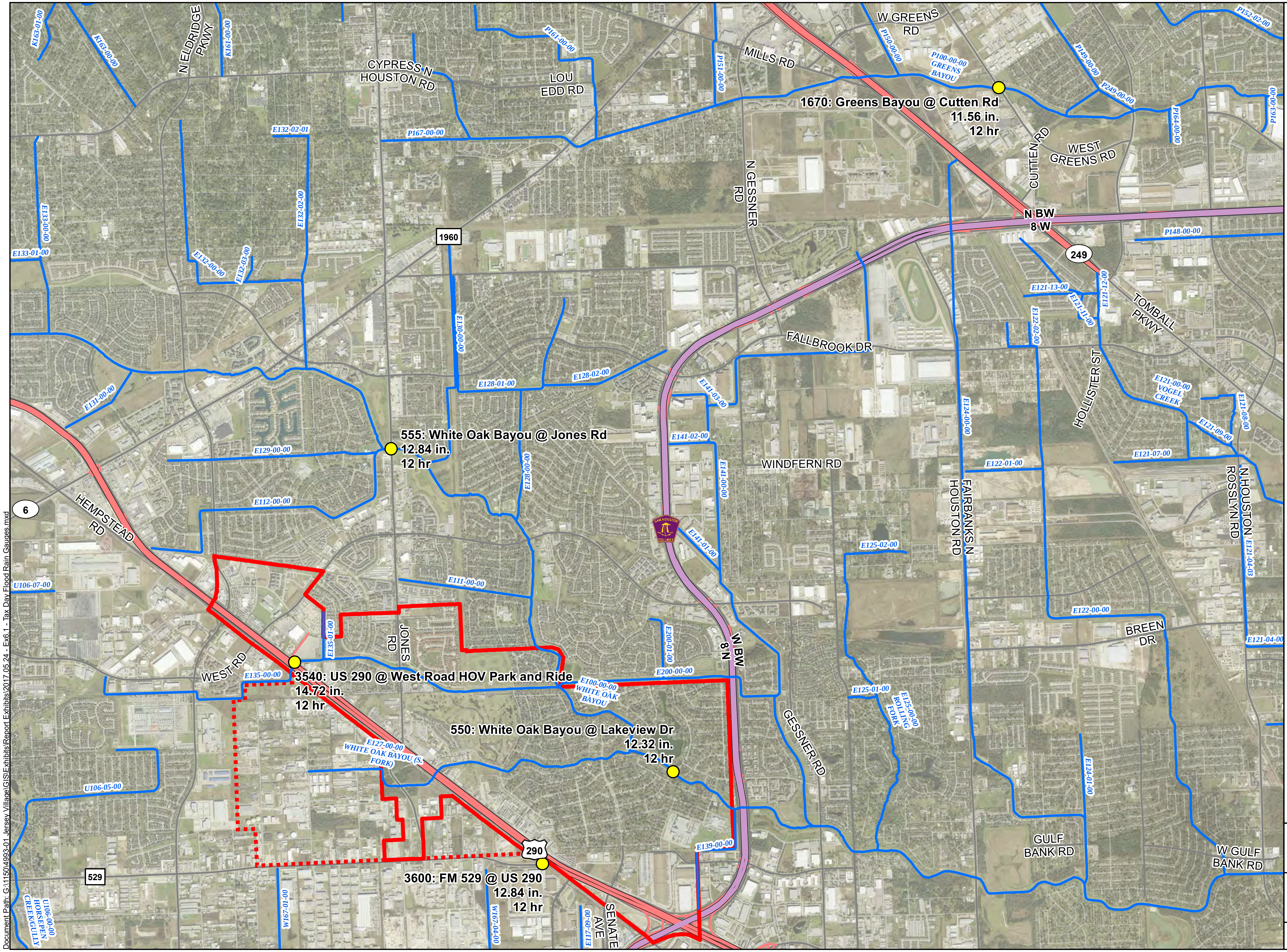
0 2,000 4,000 Ft

City of Jersey Village
Long-term Flood Recovery Plan

Exhibit 5.2
E127-00-00 Subdivided Drainage Areas

1 in. = 2,000 ft	June 2017

Document Path: G:\1150\4993-01 Jersey Village\GIS\Exhibits\Report Exhibits\2017.05.24 - Ex5.2 - E127 Subdivided DA.mxd



Legend

- Rain Gauges (in/12 hr)
- Streams
- City of Jersey Village
- ETJ

DANNENBAUM

N

0 3,000 6,000 Ft

City of Jersey Village
Long-term Flood Recovery Plan

Exhibit 6.1
Tax Day Flood Rain Gauges

1 in. = 3,000 ft	June 2017

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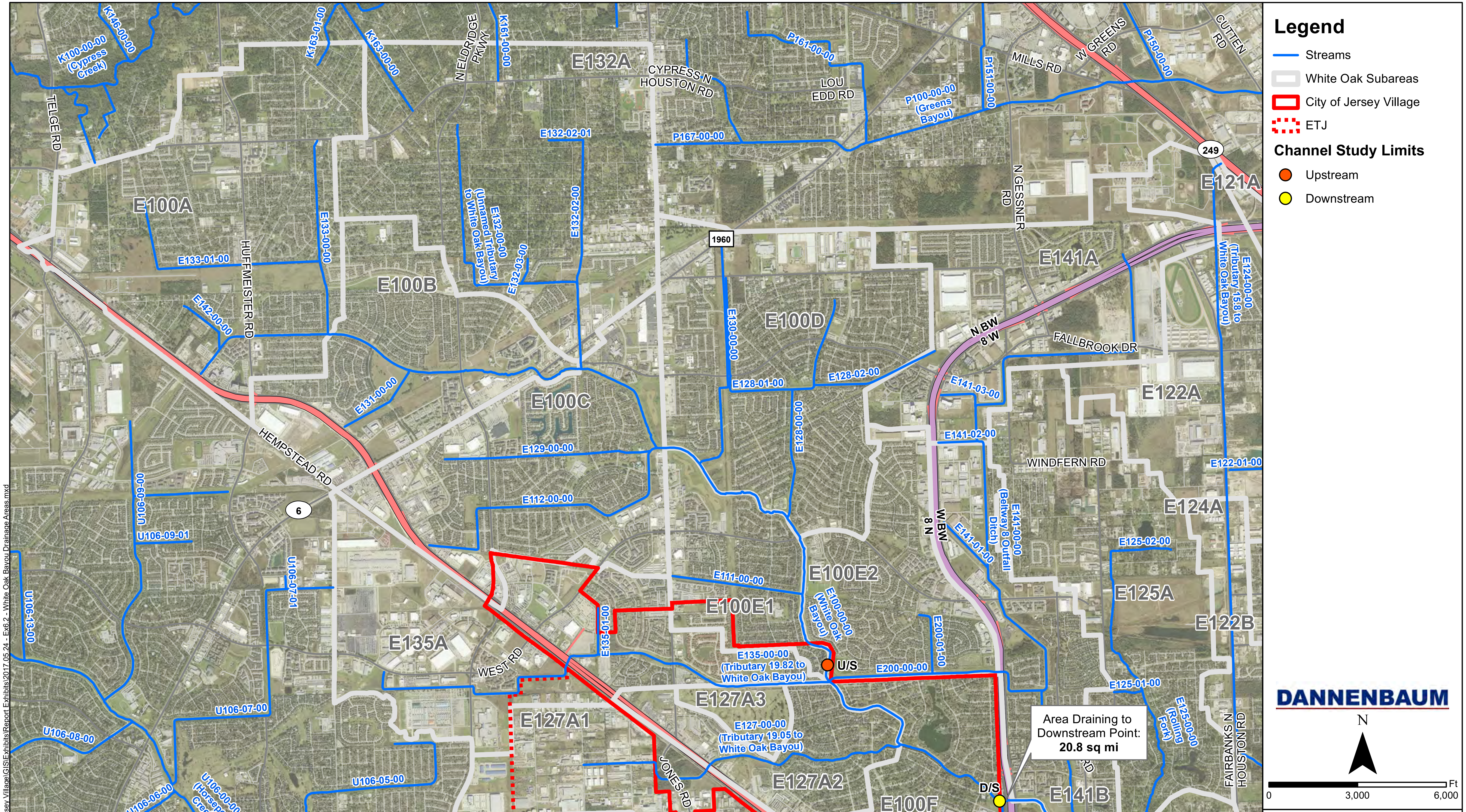
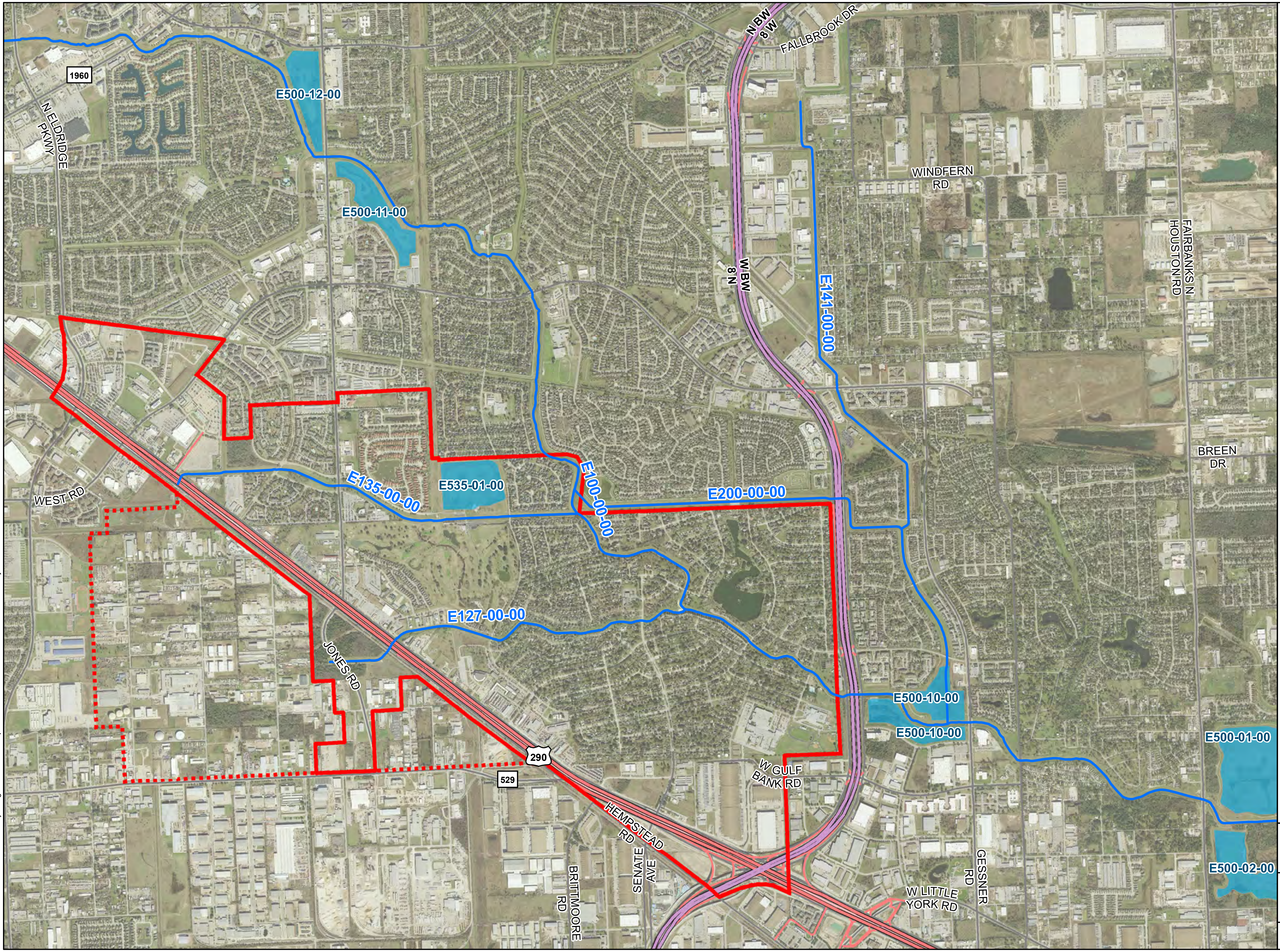


City of Jersey Village
Long-term Flood Recovery Plan

Exhibit 6.2
White Oak Bayou Drainage Areas

1 in. = 3,000 ft	June 2017



Legend

- Stream Network
- Regional Detention Ponds
- City of Jersey Village
- ETJ

DANNENBAUM

N

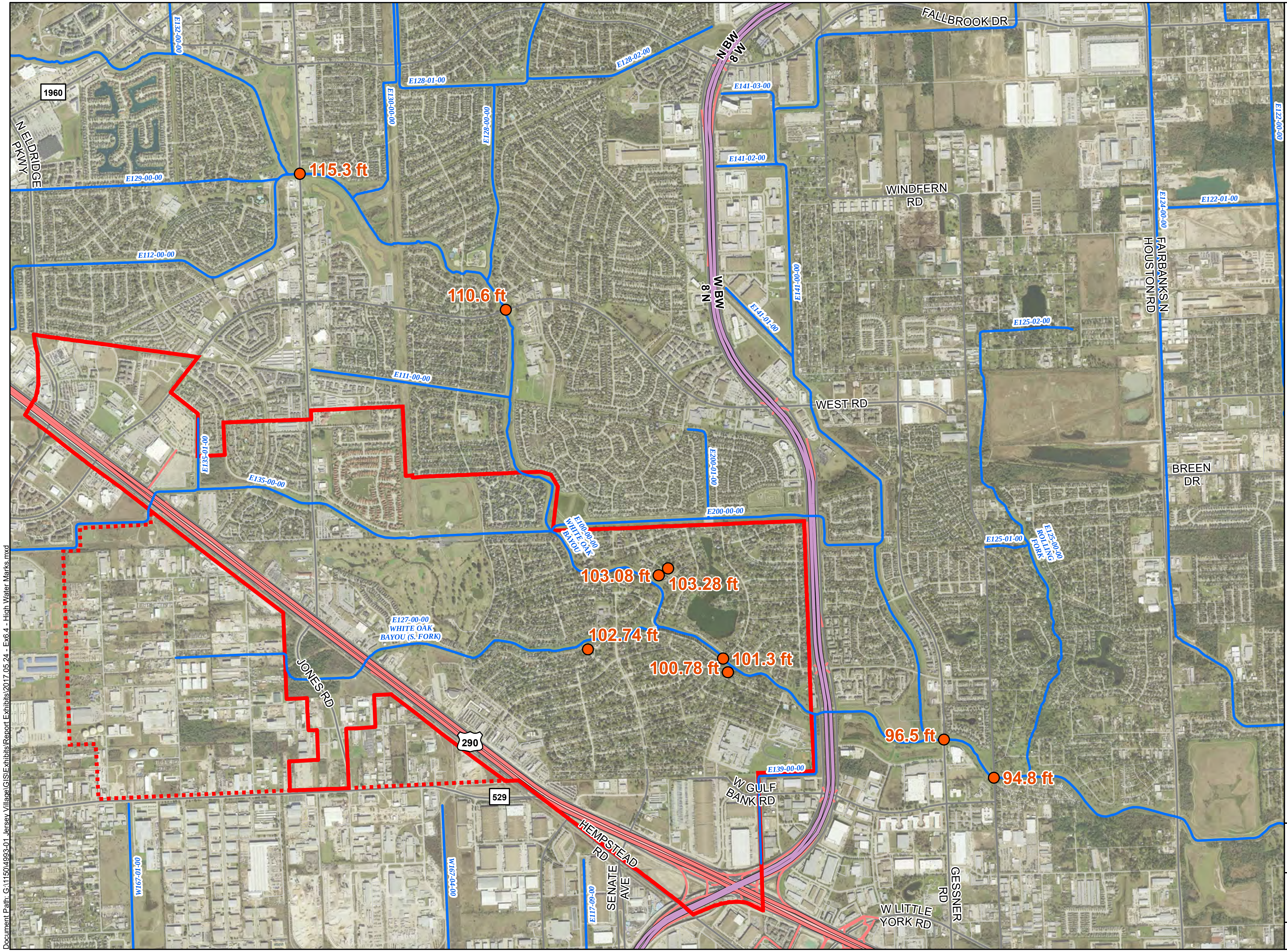
0 2,000 4,000 Ft

City of Jersey Village
Long-term Flood Recovery Plan

Exhibit 6.3
White Oak Bayou Stream Network

1 in. = 2,000 ft	June 2017

Document Path: G:\11504993-01 Jersey Village\GIS\Exhibits\Report Exhibits\2017.05.24 - Ex6.3 - White Oak Bayou Stream Network.mxd



Document Path: G:\1150\4993-01 Jersey Village\GIS\Exhibits\Report Exhibits\2017.05.24 - Ex6.4 - High Water Marks.mxd

Legend

- High Water Marks
- Streams
- City of Jersey Village
- ETJ

DANNENBAUM

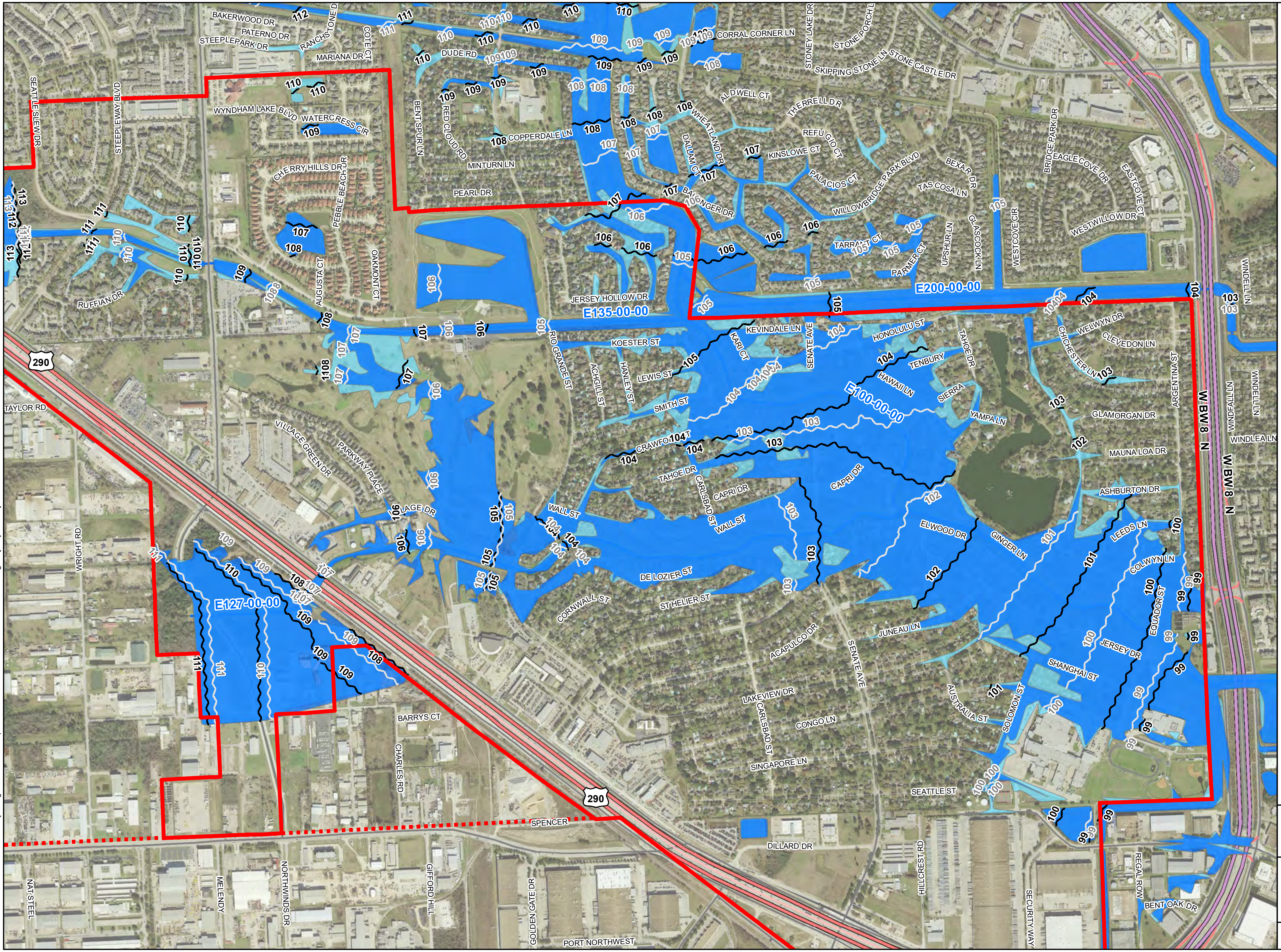
N

0 2,000 4,000 Ft

City of Jersey Village
Long-term Flood Recovery Plan

Exhibit 6.4
Tax Day High Water Mark Locations

1 in. = 2,000 ft | June 2017



Legend

- Revised Existing Floodplain (100-yr)
- Revised Existing Floodplain (Tax Day)
- Revised Existing BFE (100-yr)
- Revised Existing BFE (Tax Day)
- Stream Network
- Jersey Village
- ETJ

DANNENBAUM

N

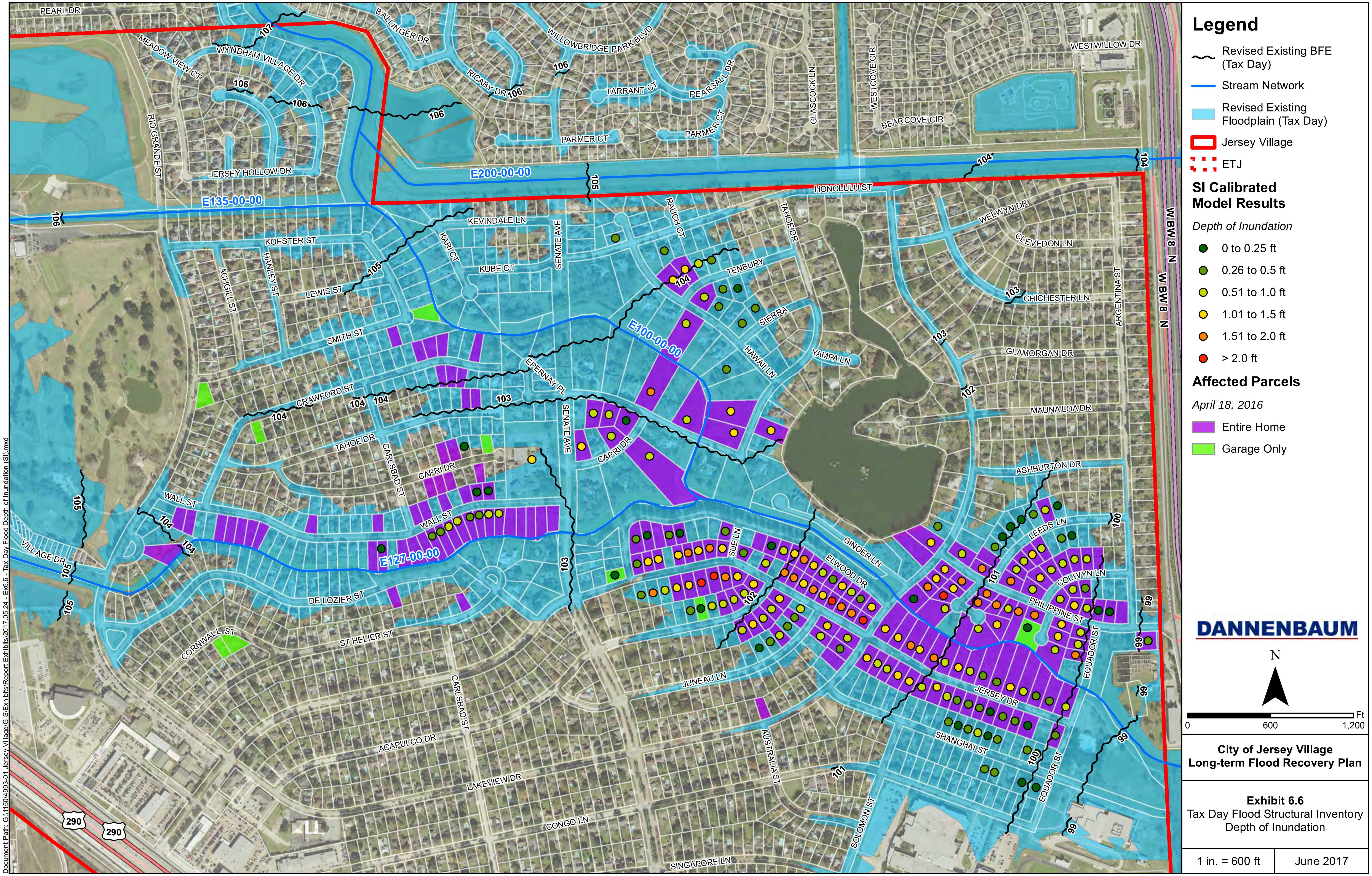
0 1,000 2,000 Ft

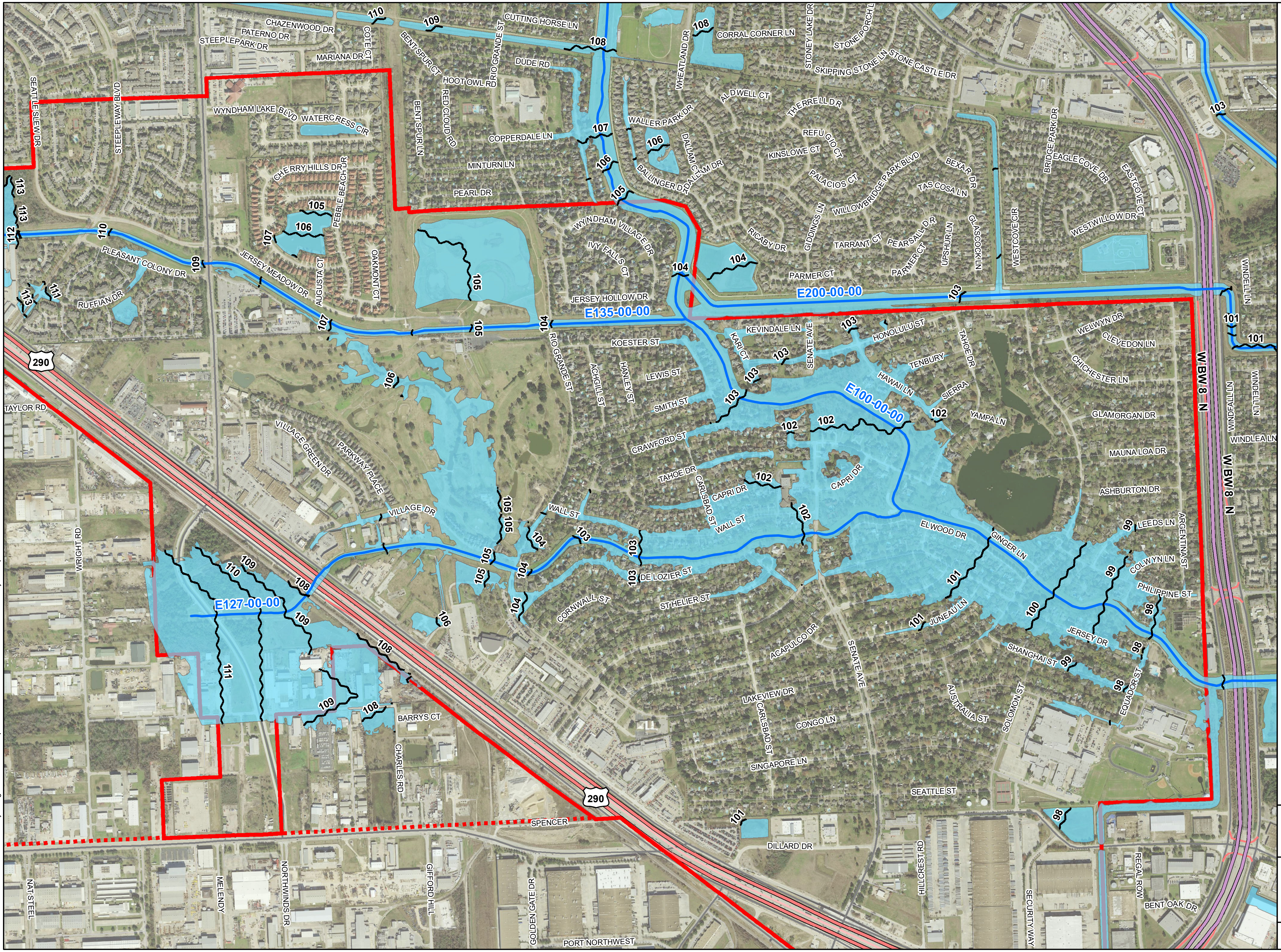
City of Jersey Village
Long-term Flood Recovery Plan

Exhibit 6.5
Revised Existing Floodplains
[100-yr vs Tax Day]

1 in. = 1,000 ft	June 2017

Document Path: G:\1150\4993-01 Jersey Village\GIS\Exhibits\Report Exhibits\2017.05.24 - Ex6.5 - Revised Existing FP [100yr vs Tax].mxd


Legend
Revised Existing BFE (Tax Day)
Stream Network
Revised Existing Floodplain (Tax Day)
Jersey Village
ETJ
SI Calibrated Model Results
Depth of Inundation
0 to 0.25 ft
0.26 to 0.5 ft
0.51 to 1.0 ft
1.01 to 1.5 ft
1.51 to 2.0 ft
> 2.0 ft
Affected Parcels
April 18, 2016
Entire Home
Garage Only
DANNENBAUM
N
0
600
1,200
Ft
City of Jersey Village
Long-term Flood Recovery Plan
Exhibit 6.6
Tax Day Flood Structural Inventory
Depth of Inundation
1 in. = 600 ft
June 2017
E200-00-00
E135-00-00
E100-00-00
E127-00-00
PEARL DR
BALLINGER DR
WILLOWBRIDGE PARK BLVD
WESTWILLOW DR
MEADOW VIEW CT
WYNDHAM VILLAGE DR
RICABY DR
TARRANT CT
PEARSALL DR
GLASCOCK LN
WESTCOVE CIR
BEARCOVE CIR
PARMER CT
RIO GRANDE ST
JERSEY HOLLOW DR
HONOLULU ST
KEVINDALE LN
KOESTER ST
KARI CT
SENATE AVE
RAUCH CT
TAHOE DR
WELWYN DR
CLEVEDON LN
KUBE CT
TENBURY
LEWIS ST
ACHGILL ST
HANLEY ST
CHICHESTER LN
SMITH ST
SIERRA
HAWAII LN
YAMPA LN
GLAMORGAN DR
EPERNAY PL
CRAWFORD ST
MAUNA LOA DR
CAPRI DR
CARLSBAD ST
ASHBURTON DR
WALL ST
LEEDS LN
GINGER LN
ELWOOD DR
SUE LN
COLWYN LN
PHILIPPINE ST
VILLAGE DR
DE LOZIER ST
ST HELIER ST
CORNWALL ST
JUNEAU LN
JERSEY DR
EQUADOR ST
SHANGHAI ST
ACAPULCO DR
AUSTRALIA ST
LAKEVIEW DR
CONGO LN
SOLOMON ST
SINGAPORE LN
ARGENTINA ST
W BW 8 N
290
Document Path: G:\11504993-01 Jersey Village\GIS\Exhibits\Report Exhibits\2017.05.24 - Ex6.6 - Tax Day Flood Depth of Inundation (SI).mxd



Legend

- Stream Network
- 2D Tax Day BFE
- 2D Tax Day Floodplain
- Jersey Village
- ETJ

DANNENBAUM

N

0 1,000 2,000 Ft

City of Jersey Village
Long-term Flood Recovery Plan

Exhibit 6.7
Revised Existing
2D Tax Day Floodplain

1 in. = 1,000 ft | August 2017

Document Path: G:\11504993-01 Jersey Village\GIS\Exhibits\Report Exhibits\2017.05.26 - Ex7.1 - Golf Course Alternative.mxd

Legend

- DrainagePaths
- Contours (1 ft)
- Stream Network
- Golf Course Boundary
- Revised Existing Floodplain (100-yr)

DANNENBAUM

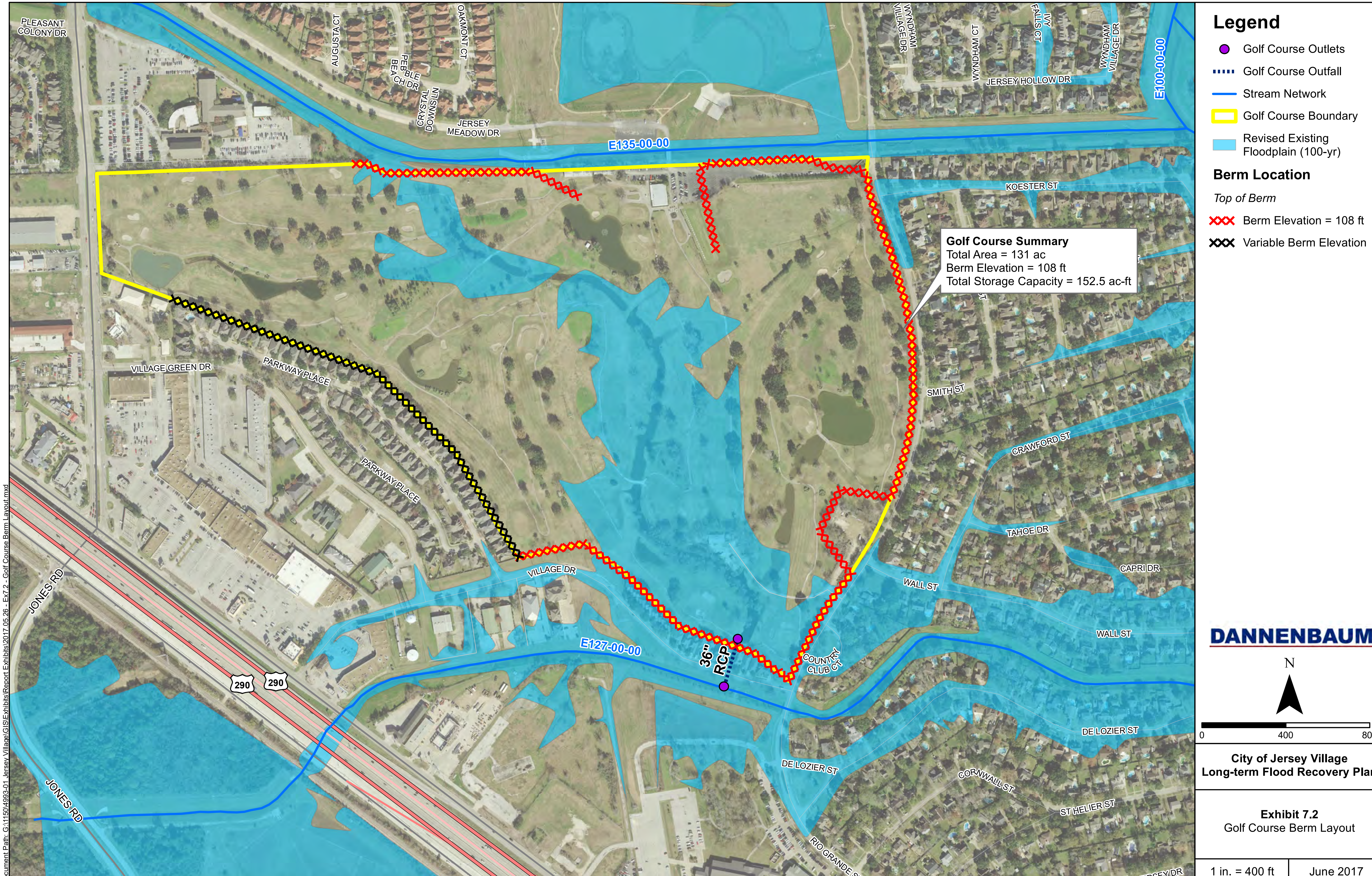
N

0 400 800 Ft

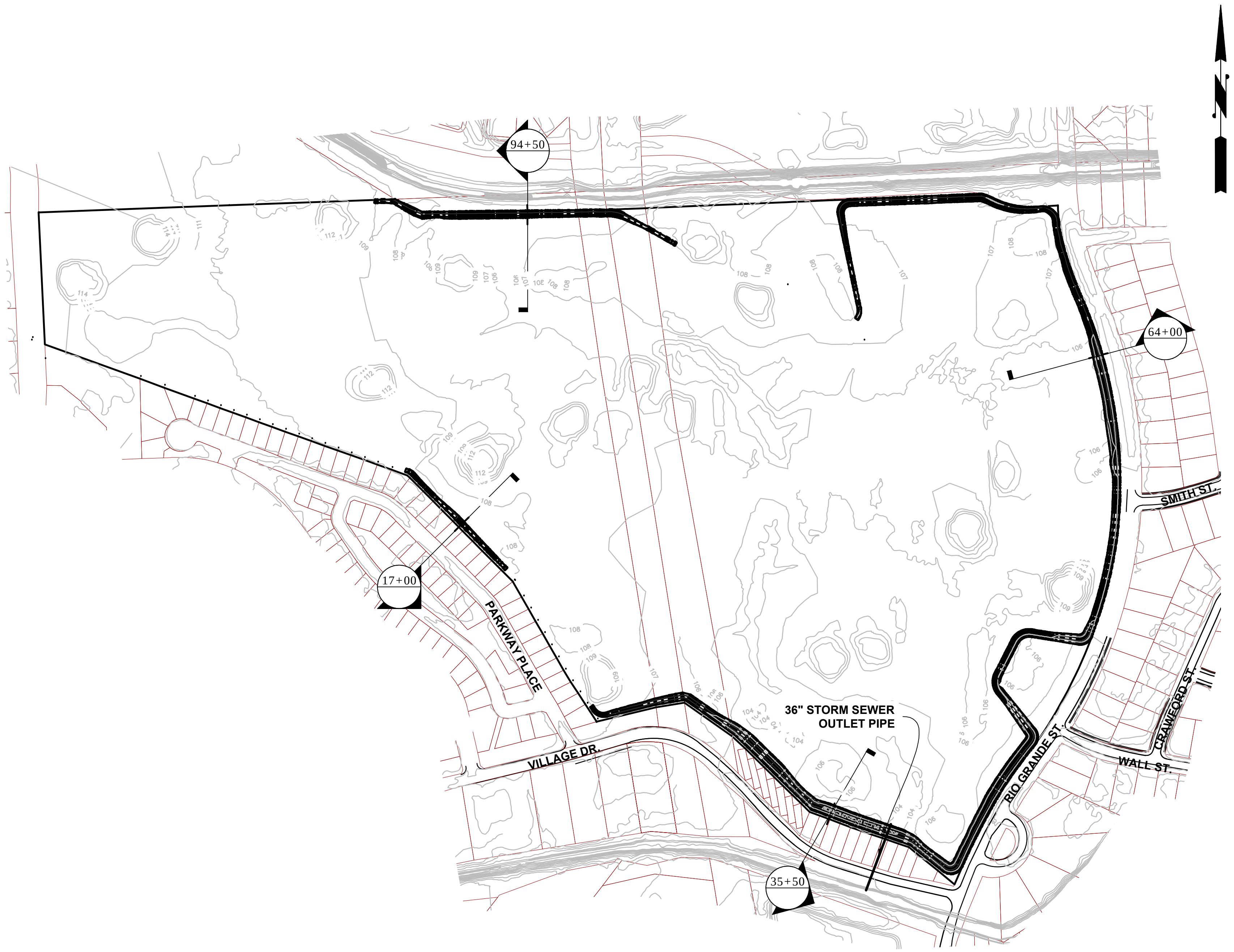
City of Jersey Village
Long-term Flood Recovery Plan

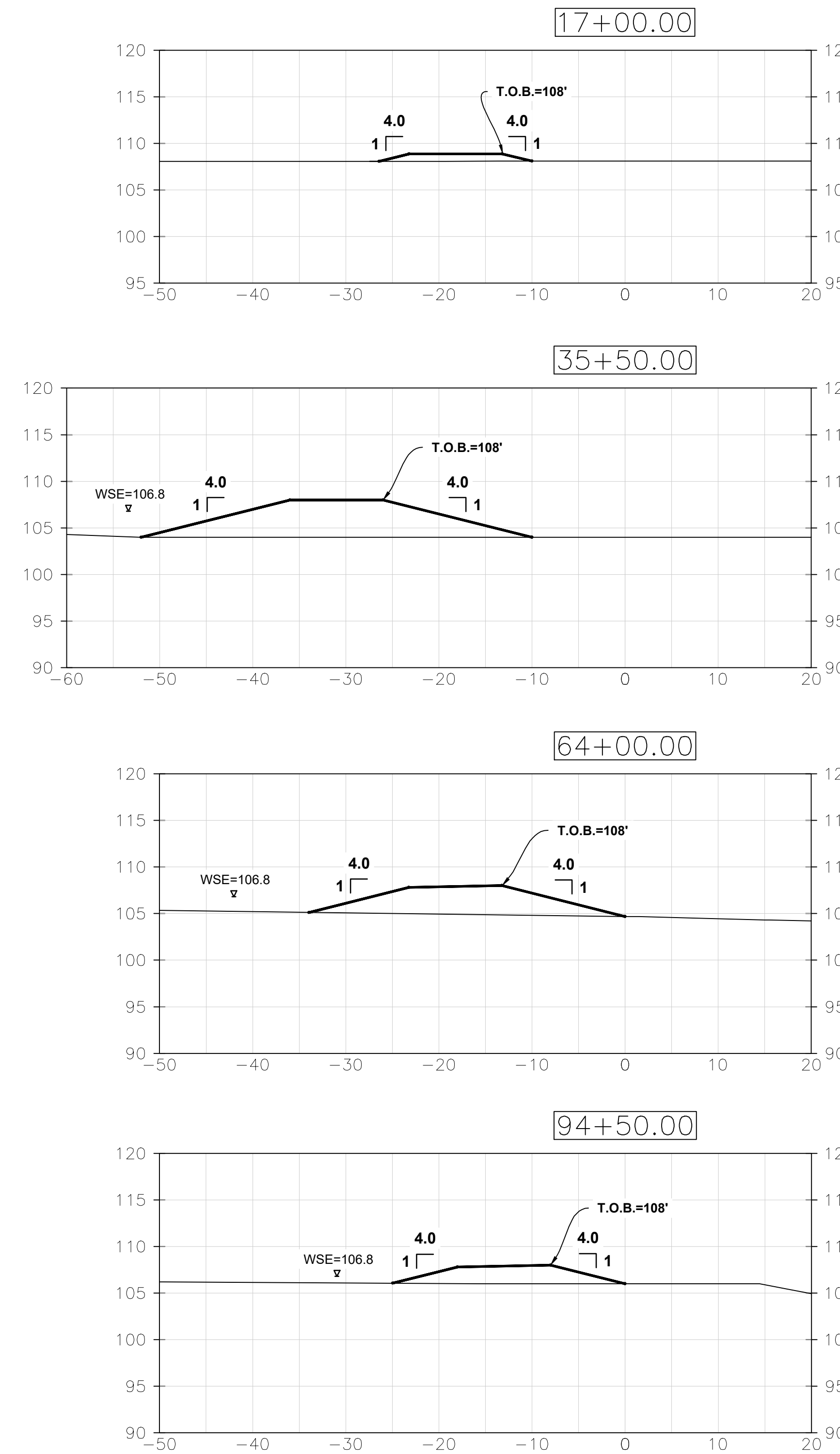
Exhibit 7.1
Golf Course Berm Alternative

1 in. = 400 ft	June 2017



Document Path: G:\1150\4993-01 Jersey Village\GIS\Exhibits\Report Exhibits\2017 05 26 - Ex7.2 - Golf Course Berm Layout.mxd





PRELIMINARY FILL VOLUME = 10,737 CY

BENCHMARK

FLOODPLAIN REFERENCE MARK NUMBER 050105 IS AN HCFCD BRASS DISK STAMPED E100 BM20 LOCATED ON THE SOUTHERLY SIDEWALK ON THE BRIDGE ON TAHOE DRIVE APPROXIMATELY 1000 FEET FROM THE INTERSECTION OF SENATE AVENUE IN KEYMAP 409M IN THE WHITE OAK WATERSHED NEAR STREAM E100-00-00.

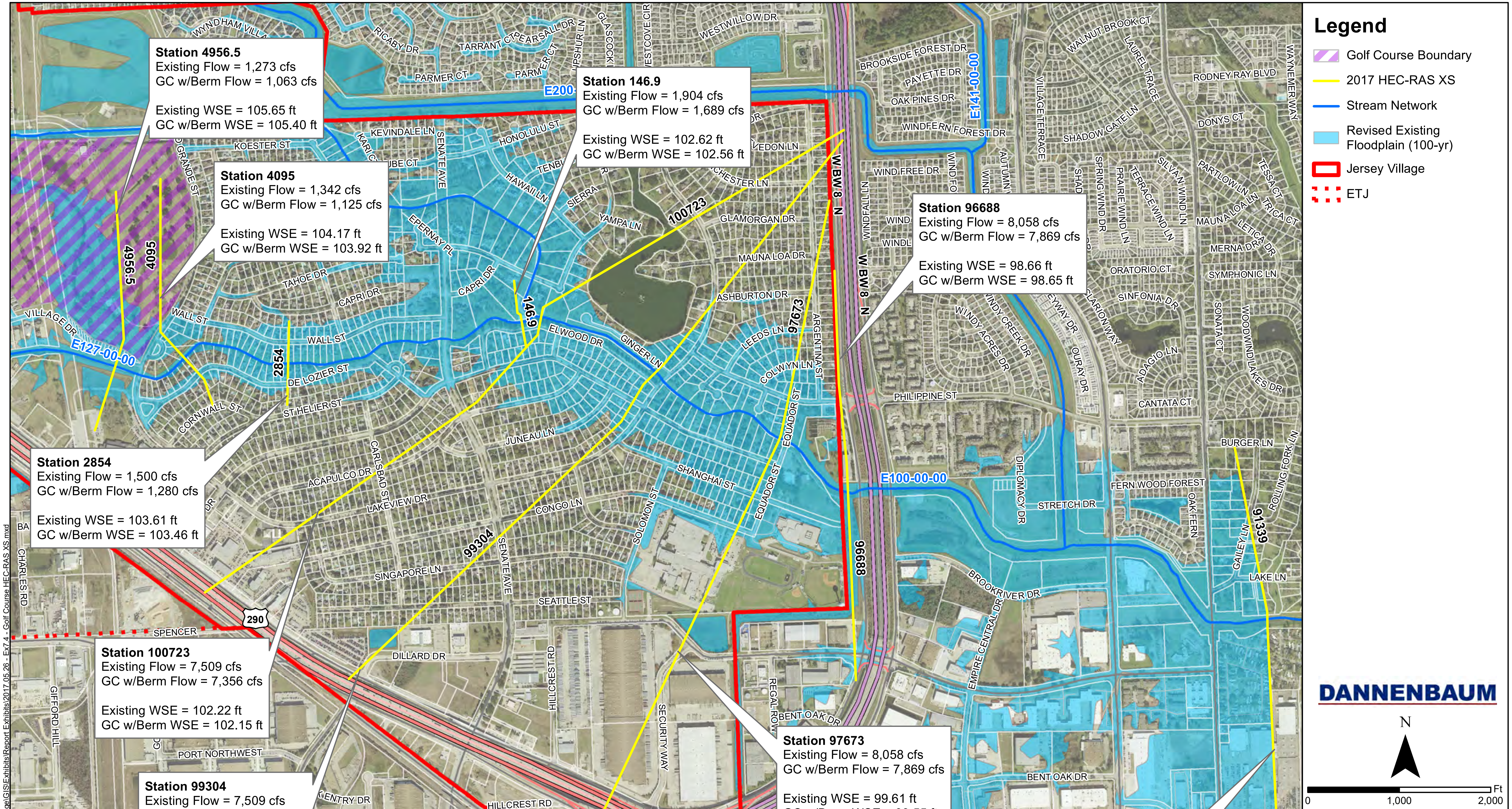
ELEV. 101.43 FEET NAVD 1988, 2001 ADJUSTMENT

DANNENBAUM
ENGINEERING COMPANY - HOUSTON, LLC
T.B.P.E. FIRM REGISTRATION #8998
3100 WEST ALABAMA HOUSTON, TEXAS 77098 (713) 520-9570

EXHIBIT 7.3
Typical Berm Cross-sections

Jersey Village Long-term Recovery Plan

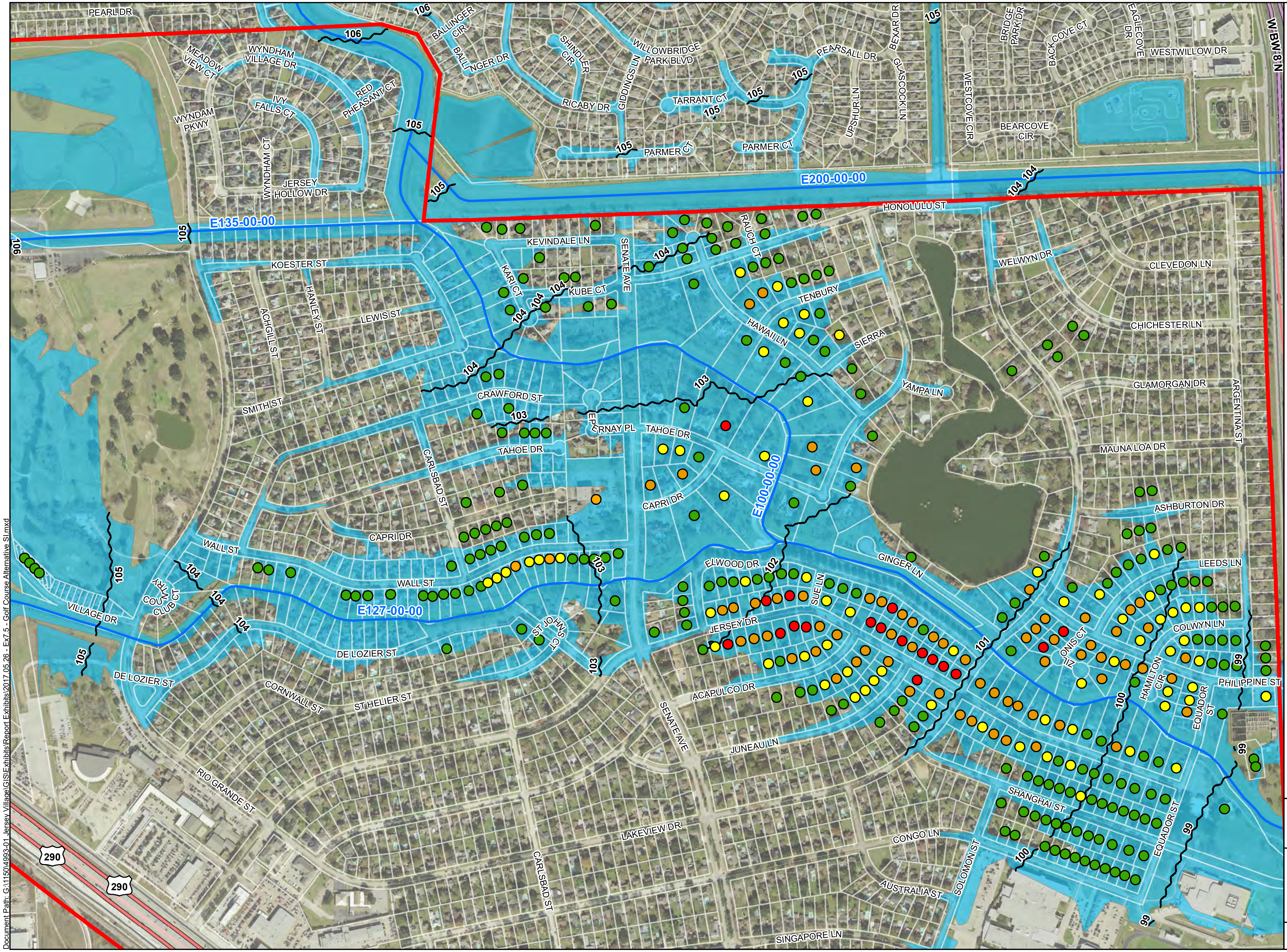
SCALE: N.T.S. | JUNE 2017



City of Jersey Village
Long-term Flood Recovery Plan

Exhibit 7.4
Golf Course Berm
Channel Impacts (100-yr Event)

1 in. = 1,000 ft	June 2017



Legend

- Revised Existing BFE
- Stream Network
- Revised Existing Floodplain (100-yr)
- Jersey Village
- ETJ

SI Golf Course Alternative Results

- 4% Event (25-yr)
- 2% Event (50-yr)
- 1% Event (100-yr)
- 0.2% Event (500-yr)

DANNENBAUM

N

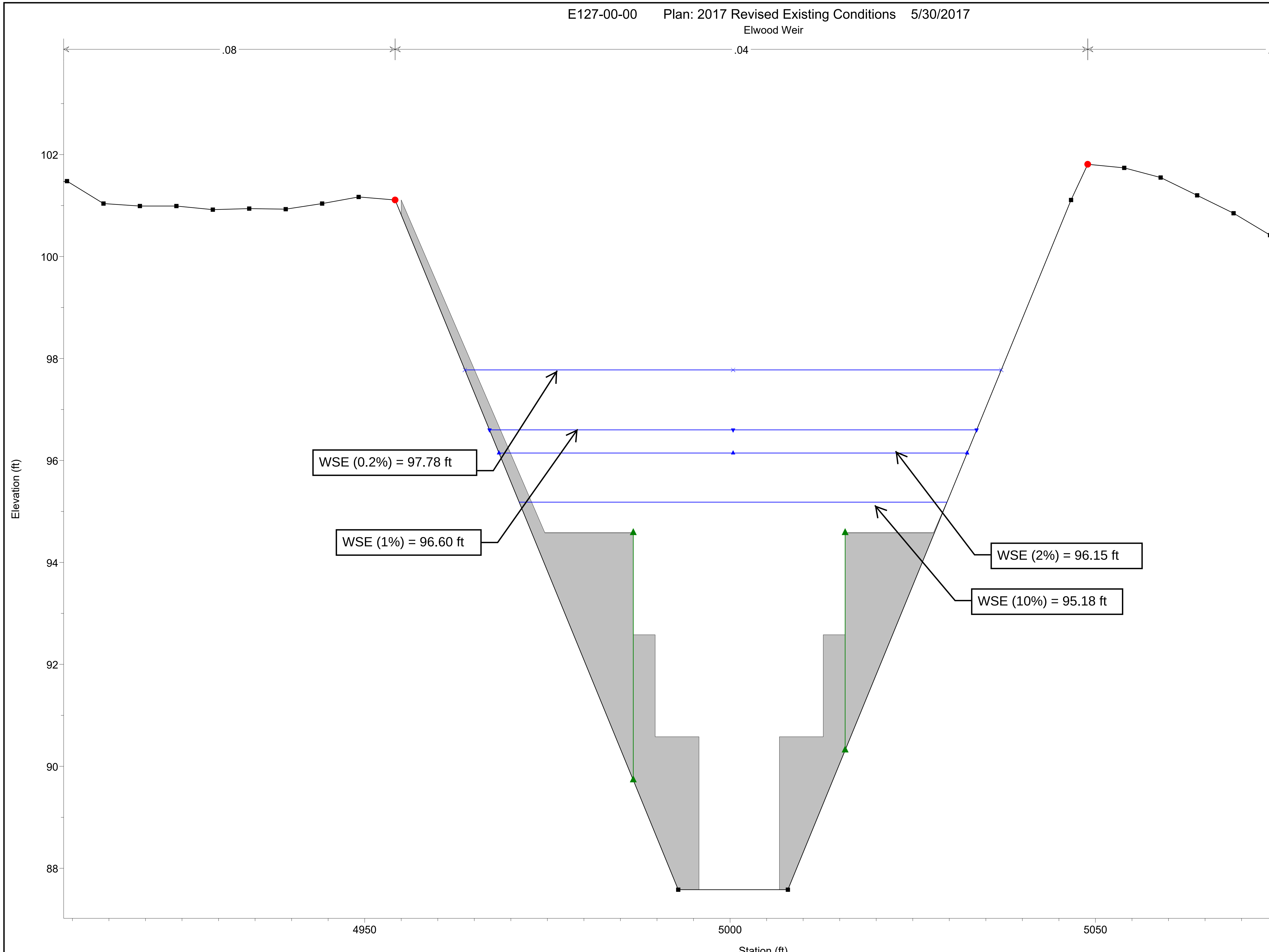
0 600 1,200 Ft

City of Jersey Village
Long-term Flood Recovery Plan

Exhibit 7.5
Golf Course Berm
Structural Inventory Results

1 in. = 600 ft	June 2017

Document Path: G:\115043993-01 Jersey Village\GIS\Exhibits\Report Exhibits\2017.05.26 - Ex7.5 - Golf Course Alternative SI.mxd



DANNENBAUM
Exhibit 7.6
Elwood Weir Existing Cross-section

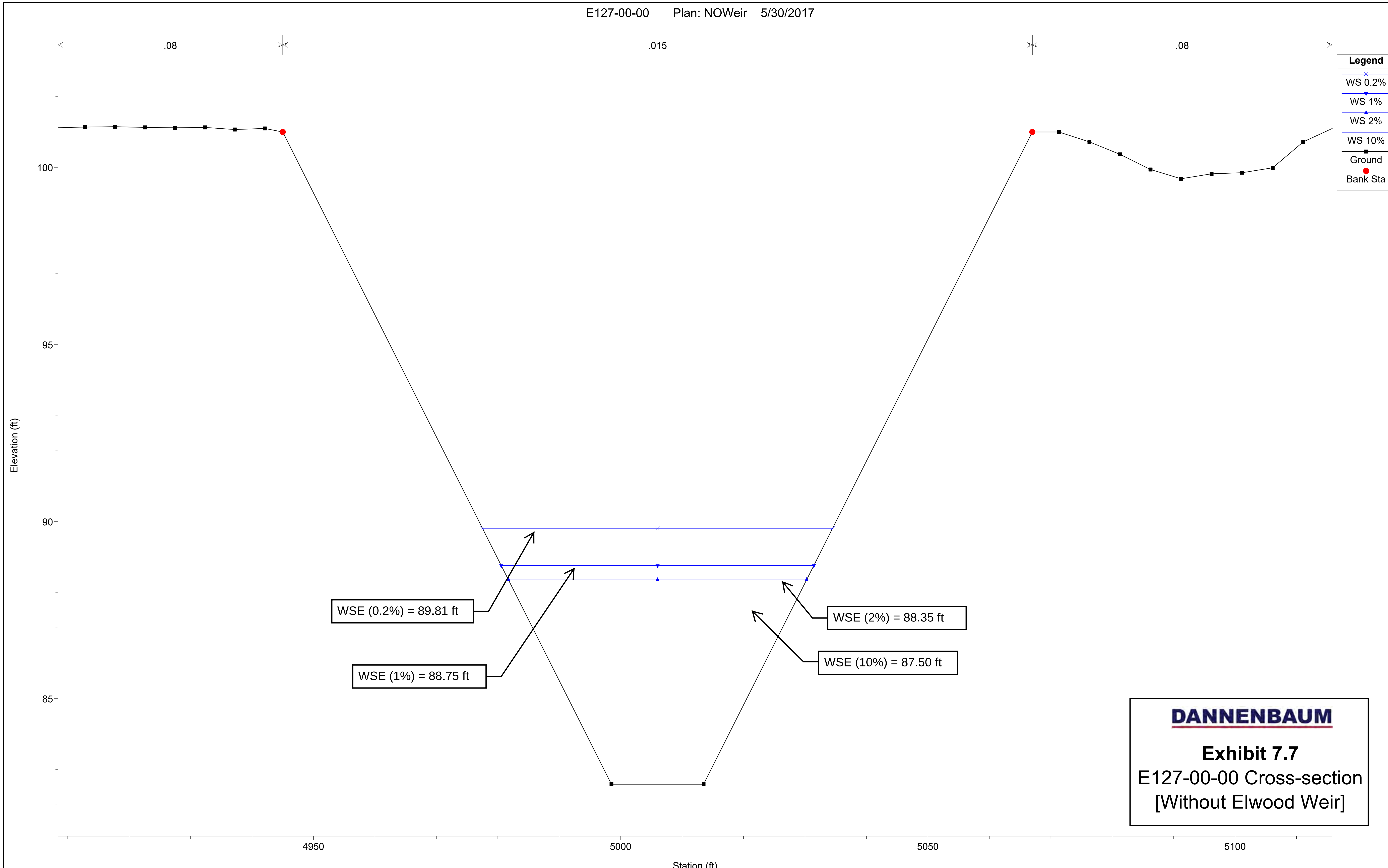
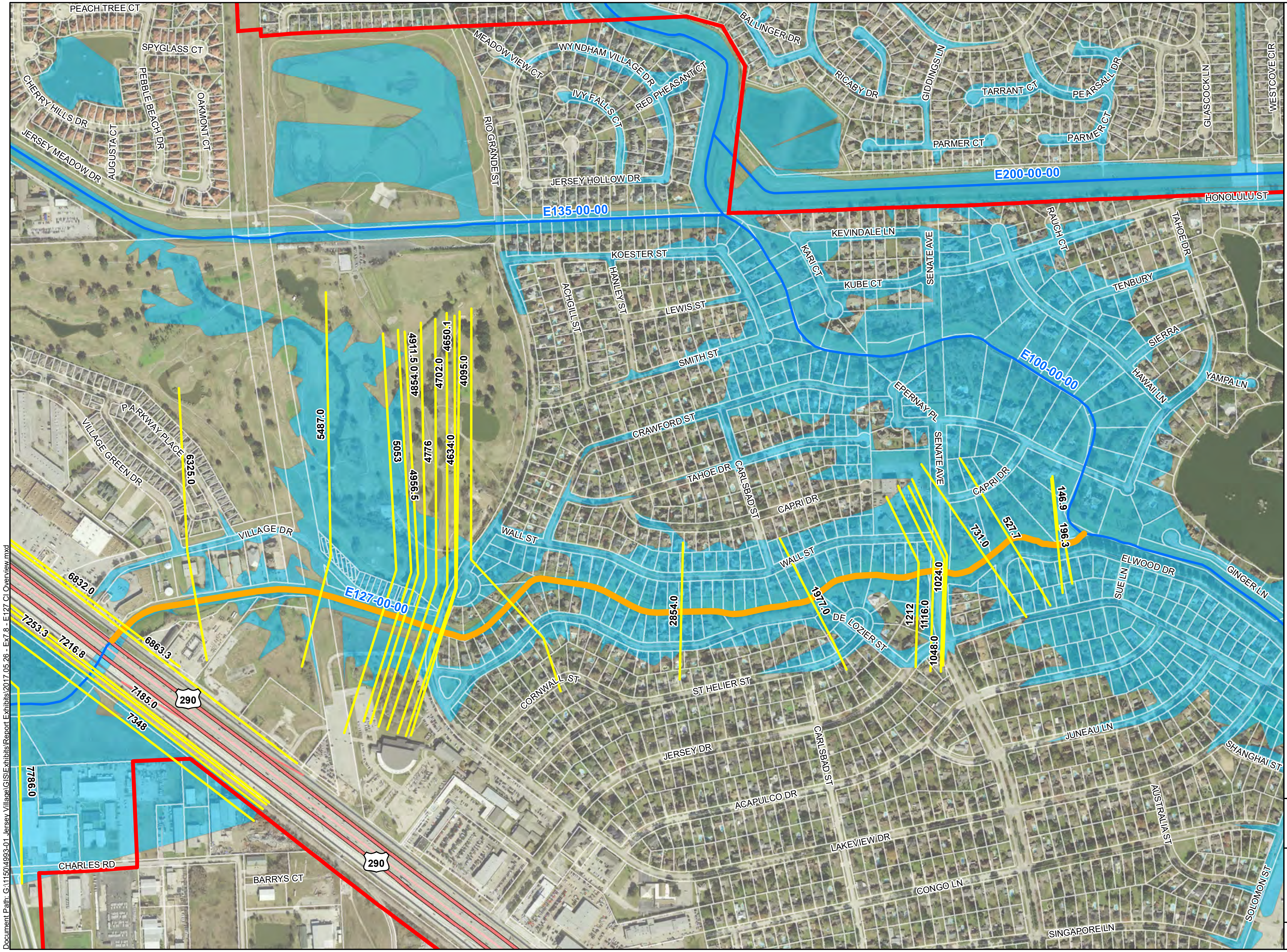


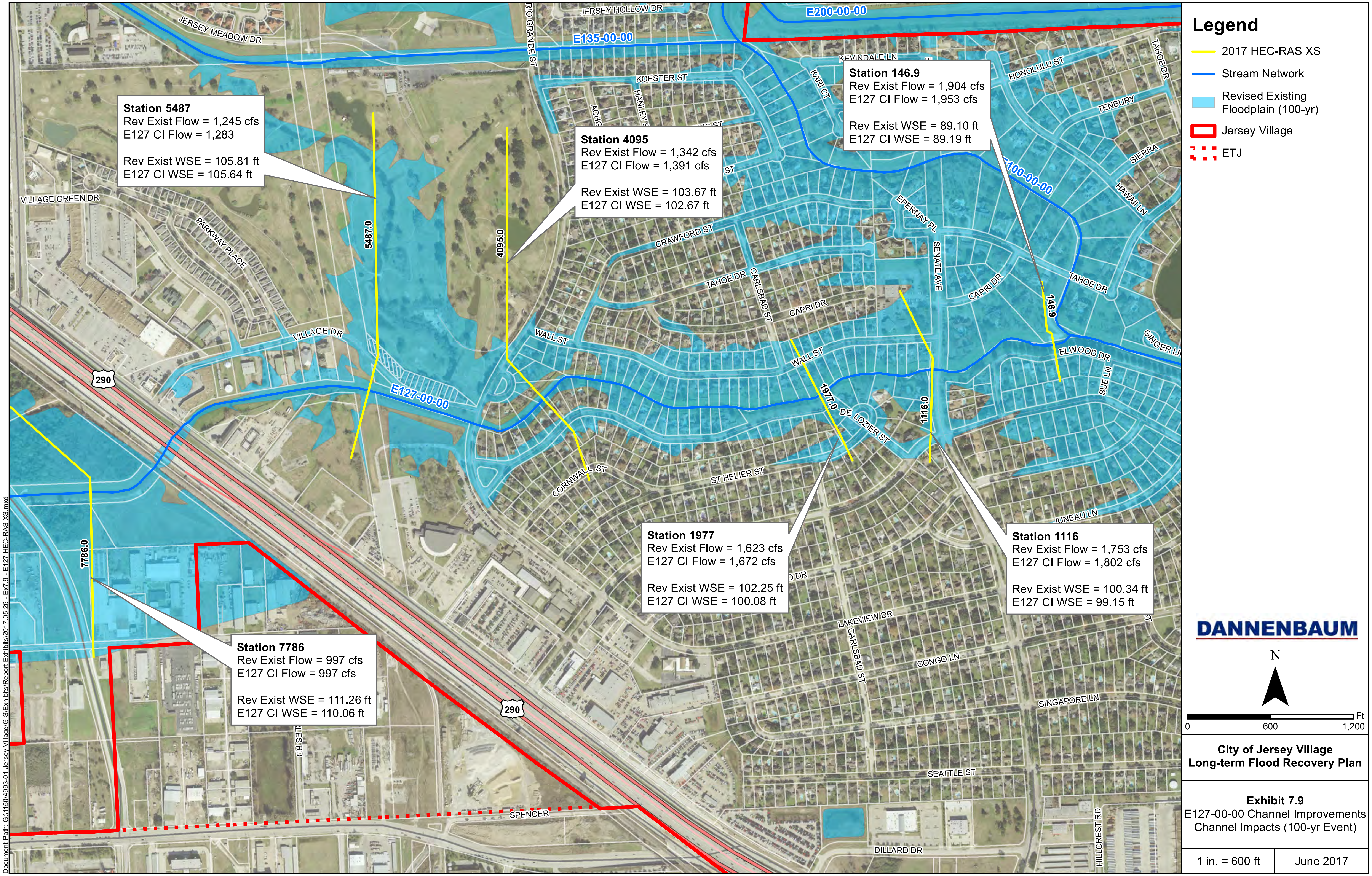
Exhibit 7.7
E127-00-00 Cross-section
[Without Elwood Weir]

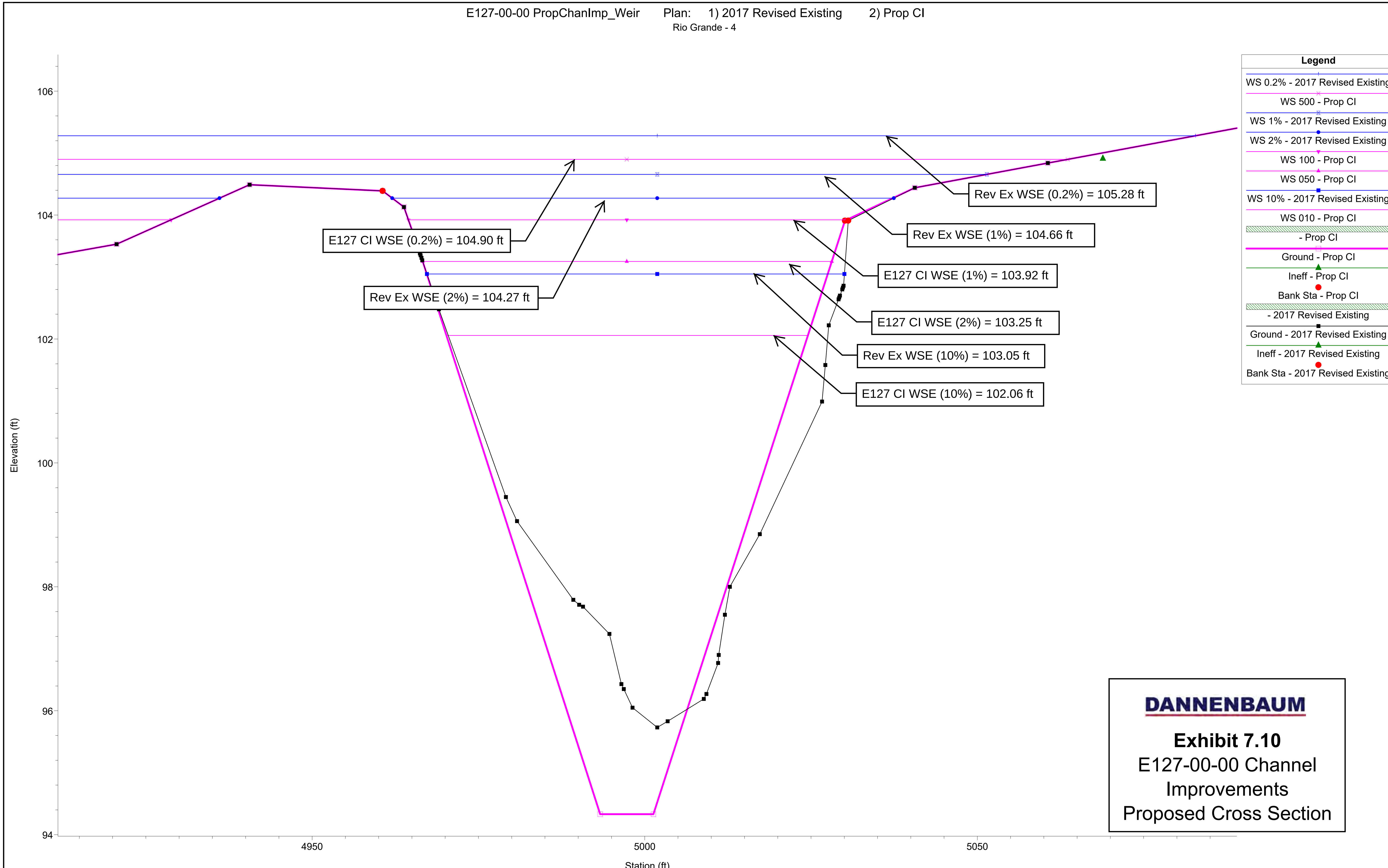


City of Jersey Village
Long-term Flood Recovery Plan

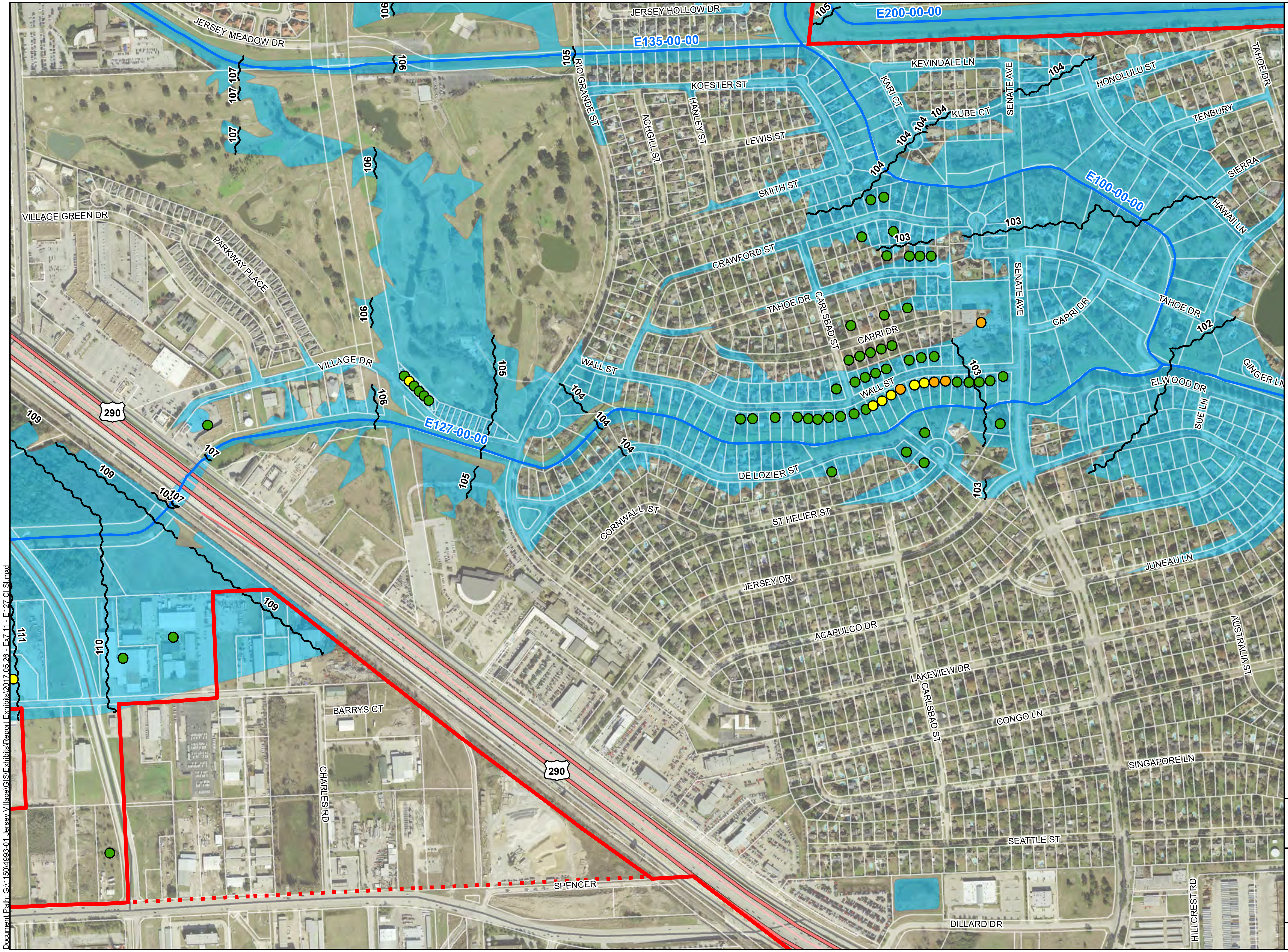
Exhibit 7.8
E127-00-00 Channel Improvements Alternative

1 in. = 600 ft	June 2017


Legend
2017 HEC-RAS XS
Stream Network
Revised Existing Floodplain (100-yr)
Jersey Village
ETJ
Station 5487
Rev Exist Flow = 1,245 cfs
E127 CI Flow = 1,283
Rev Exist WSE = 105.81 ft
E127 CI WSE = 105.64 ft
Station 4095
Rev Exist Flow = 1,342 cfs
E127 CI Flow = 1,391 cfs
Rev Exist WSE = 103.67 ft
E127 CI WSE = 102.67 ft
Station 146.9
Rev Exist Flow = 1,904 cfs
E127 CI Flow = 1,953 cfs
Rev Exist WSE = 89.10 ft
E127 CI WSE = 89.19 ft
Station 1977
Rev Exist Flow = 1,623 cfs
E127 CI Flow = 1,672 cfs
Rev Exist WSE = 102.25 ft
E127 CI WSE = 100.08 ft
Station 1116
Rev Exist Flow = 1,753 cfs
E127 CI Flow = 1,802 cfs
Rev Exist WSE = 100.34 ft
E127 CI WSE = 99.15 ft
Station 7786
Rev Exist Flow = 997 cfs
E127 CI Flow = 997 cfs
Rev Exist WSE = 111.26 ft
E127 CI WSE = 110.06 ft
5487.0
4095.0
1977.0
1116.0
146.9
7786.0
E200-00-00
E135-00-00
E100-00-00
E127-00-00
290
JERSEY HOLLOW DR
JERSEY MEADOW DR
RIO GRANDE ST
KOESTER ST
KEVINDALE LN
KARI CT
HONOLULU ST
TAHOE DR
TENBURY
SIERRA
HAWAII LN
VILLAGE GREEN DR
PARKWAY PLACE
CRAWFORD ST
EPERNAY PL
SENATE AVE
CAPRI DR
CARLSBAD ST
VILLAGE DR
WALL ST
ELWOOD DR
GINGER LN
SUE LN
DE LOZIER ST
CORNWALL ST
ST HELIER ST
JUNEAU LN
LAKEVIEW DR
CONGO LN
SINGAPORE LN
SEATTLE ST
SPENCER
DILLARD DR
HILLCREST RD
DANNENBAUM
N
0
600
1,200
Ft
City of Jersey Village
Long-term Flood Recovery Plan
Exhibit 7.9
E127-00-00 Channel Improvements
Channel Impacts (100-yr Event)
1 in. = 600 ft
June 2017
Document Path: G:\1150\4993-01 Jersey Village\GIS\Exhibits\Report Exhibits\2017.05.26 - Ex7.9 - E127 HEC-RAS XS.mxd



E127-00-00 PropChanImp_Weir Plan: 1) 2017 Revised Existing 2) Prop CI
Rio Grande - 4
Legend
WS 0.2% - 2017 Revised Existing
WS 500 - Prop CI
WS 1% - 2017 Revised Existing
WS 2% - 2017 Revised Existing
WS 100 - Prop CI
WS 050 - Prop CI
WS 10% - 2017 Revised Existing
WS 010 - Prop CI
- Prop CI
Ground - Prop CI
Ineff - Prop CI
Bank Sta - Prop CI
- 2017 Revised Existing
Ground - 2017 Revised Existing
Ineff - 2017 Revised Existing
Bank Sta - 2017 Revised Existing
Rev Ex WSE (0.2%) = 105.28 ft
Rev Ex WSE (1%) = 104.66 ft
E127 CI WSE (0.2%) = 104.90 ft
E127 CI WSE (1%) = 103.92 ft
Rev Ex WSE (2%) = 104.27 ft
E127 CI WSE (2%) = 103.25 ft
Rev Ex WSE (10%) = 103.05 ft
E127 CI WSE (10%) = 102.06 ft
Elevation (ft)
106
104
102
100
98
96
94
4950
5000
5050
Station (ft)
DANNENBAUM
Exhibit 7.10
E127-00-00 Channel Improvements Proposed Cross Section



Legend

- Revised Existing BFE
- Stream Network
- Revised Existing Floodplain (100-yr)
- Jersey Village
- ETJ

E127 CI Structural Inventory Results

- 2% (50-yr Event)
- 1% (100-yr Event)
- 0.2% (500-yr Event)

DANNENBAUM

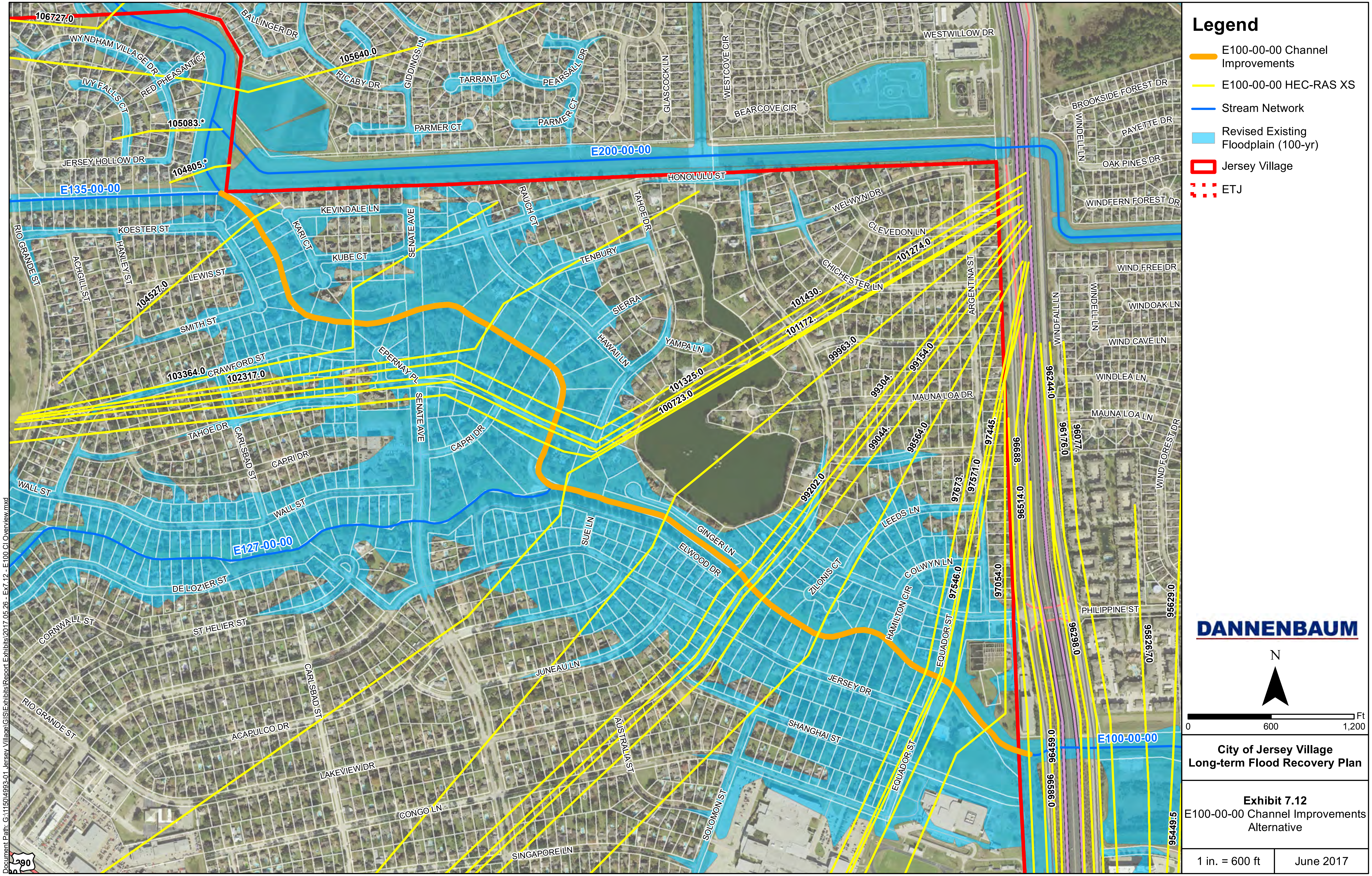
N

0 600 1,200 Ft

City of Jersey Village
Long-term Flood Recovery Plan

Exhibit 7.11
E127-00-00 Channel Improvements
Structural Inventory Results

1 in. = 600 ft	June 2017

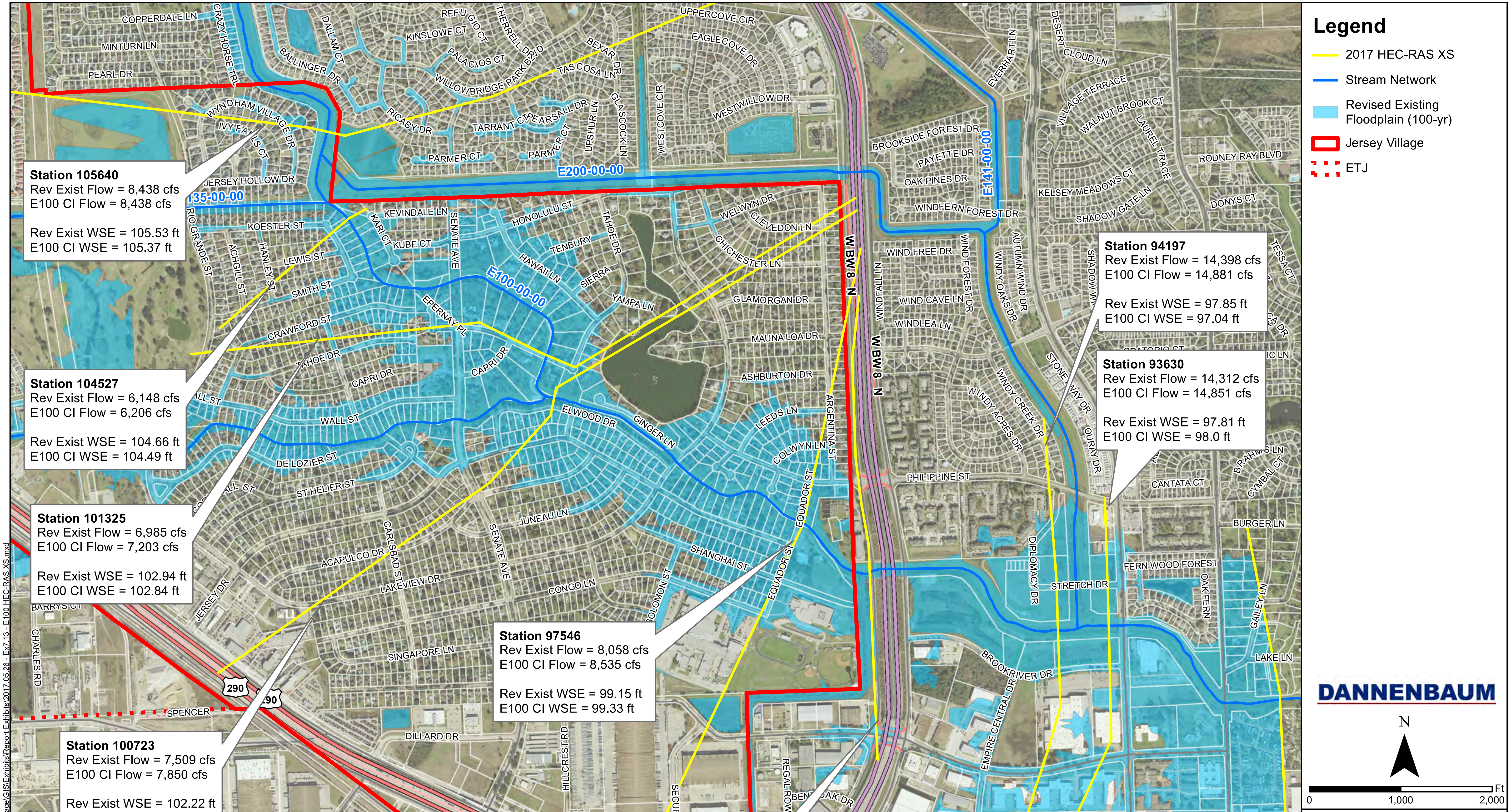


Document Path: G:\1150\4993-01 Jersey Village\GIS\Exhibits\Report Exhibits\2017.05.26 - Ex7.12 - E100 CI Overview.mxd

City of Jersey Village
Long-term Flood Recovery Plan

Exhibit 7.12
E100-00-00 Channel Improvements Alternative

1 in. = 600 ft	June 2017



Document Path: G:\11150\4993-01 Jersey Village\GIS\Exhibits\Report Exhibits\2017 05 26 - Ex7.13 - E100 HEC-RAS XS.mxd

City of Jersey Village
Long-term Flood Recovery Plan

Exhibit 7.13
E100-00-00 Channel Improvements
Channel Impacts (100-yr Event)

1 in. = 1,000 ft | June 2017

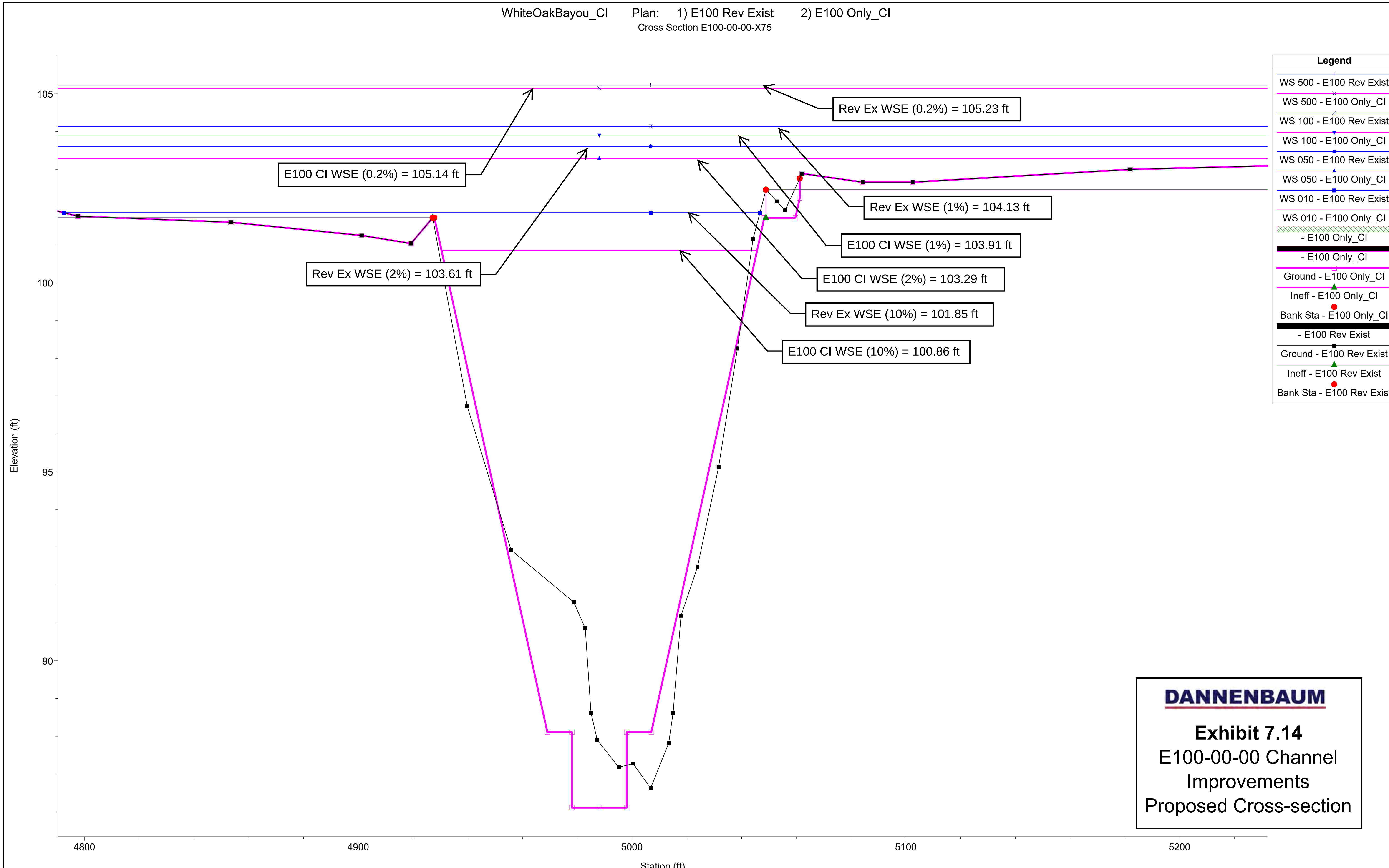
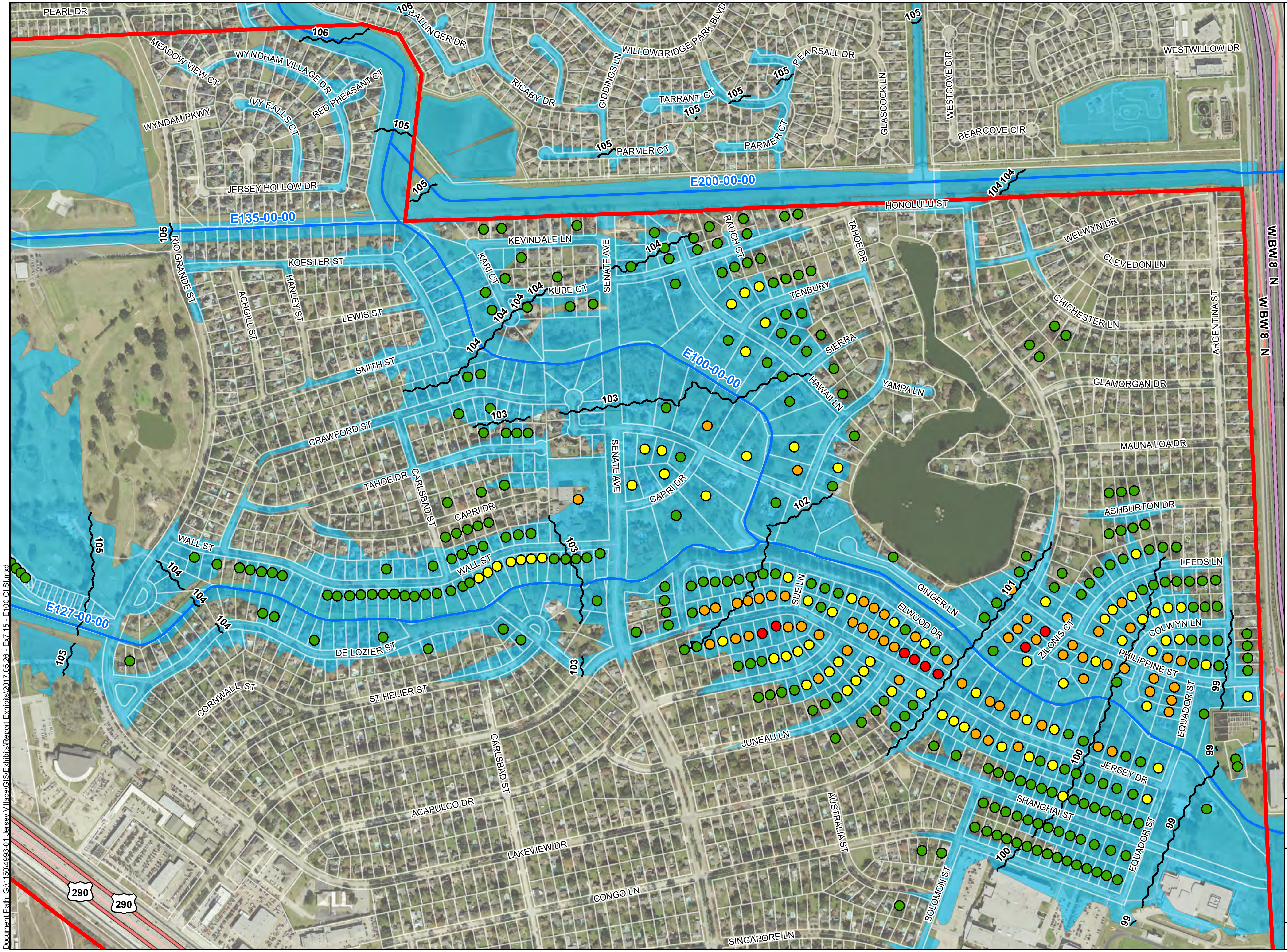


Exhibit 7.14
E100-00-00 Channel Improvements Proposed Cross-section



Document Path: G:\11504893-01 Jersey Village\GIS\Exhibits\Report Exhibits\2017.05.26 - Ex7.15 - E100 CI Str.mxd

Legend

- Revised Existing BFE
- Stream Network
- Revised Existing Floodplain (100-yr)
- Jersey Village
- ETJ

E100 CI Structural Inventory Results

- 4% (25-yr Event)
- 2% (50-yr Event)
- 1% (100-yr Event)
- 0.2% (500-yr Event)

DANNENBAUM

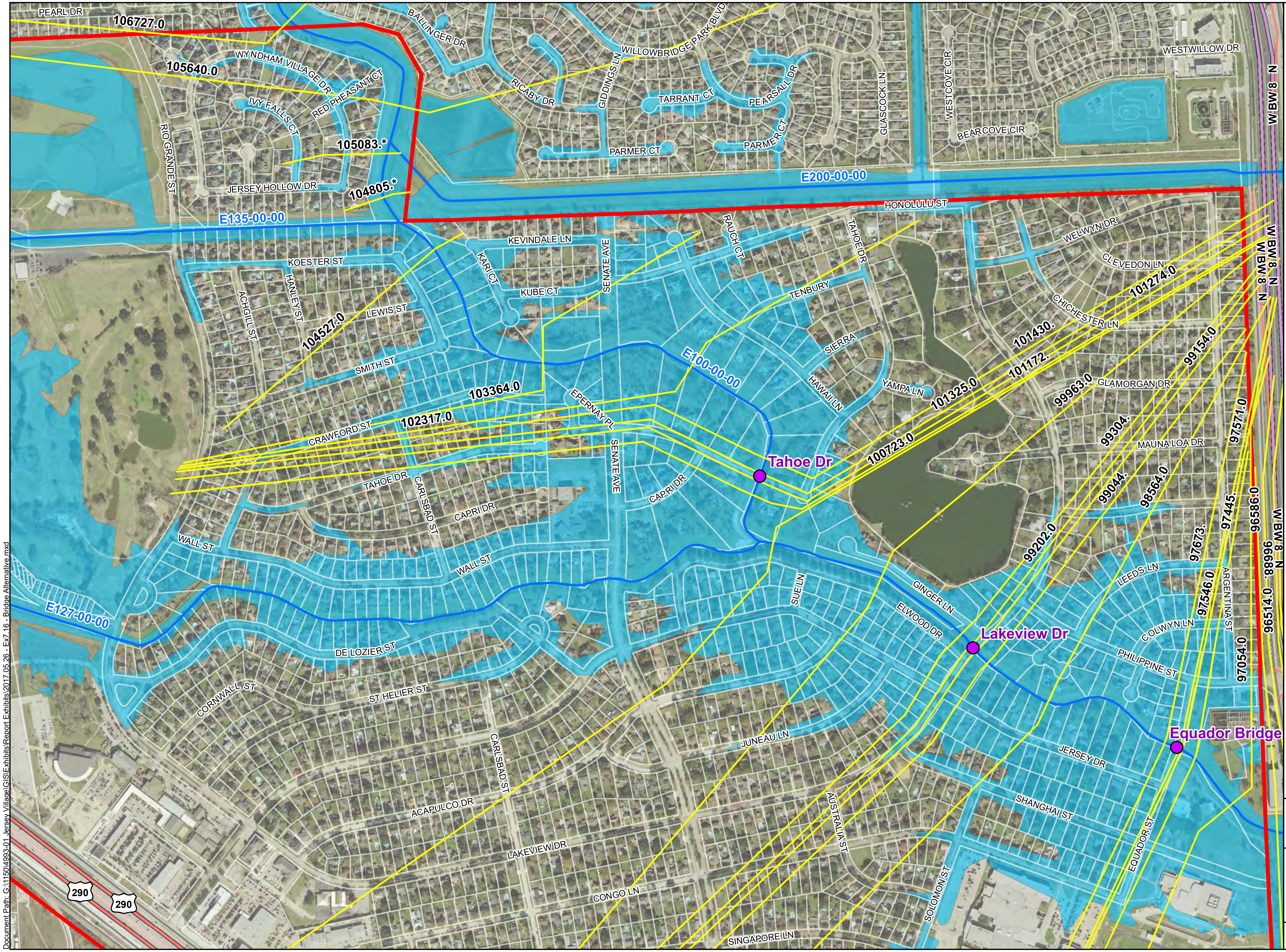
N

0 600 1,200 Ft

City of Jersey Village
Long-term Flood Recovery Plan

Exhibit 7.15
E100-00-00 Channel Improvements Structural Inventory Results

1 in. = 600 ft	June 2017



Legend

- JV Bridges
- E100-00-00 HEC-RAS XS
- Stream Network
- Revised Existing Floodplain (100-yr)
- Jersey Village
- ETJ

DANNENBAUM

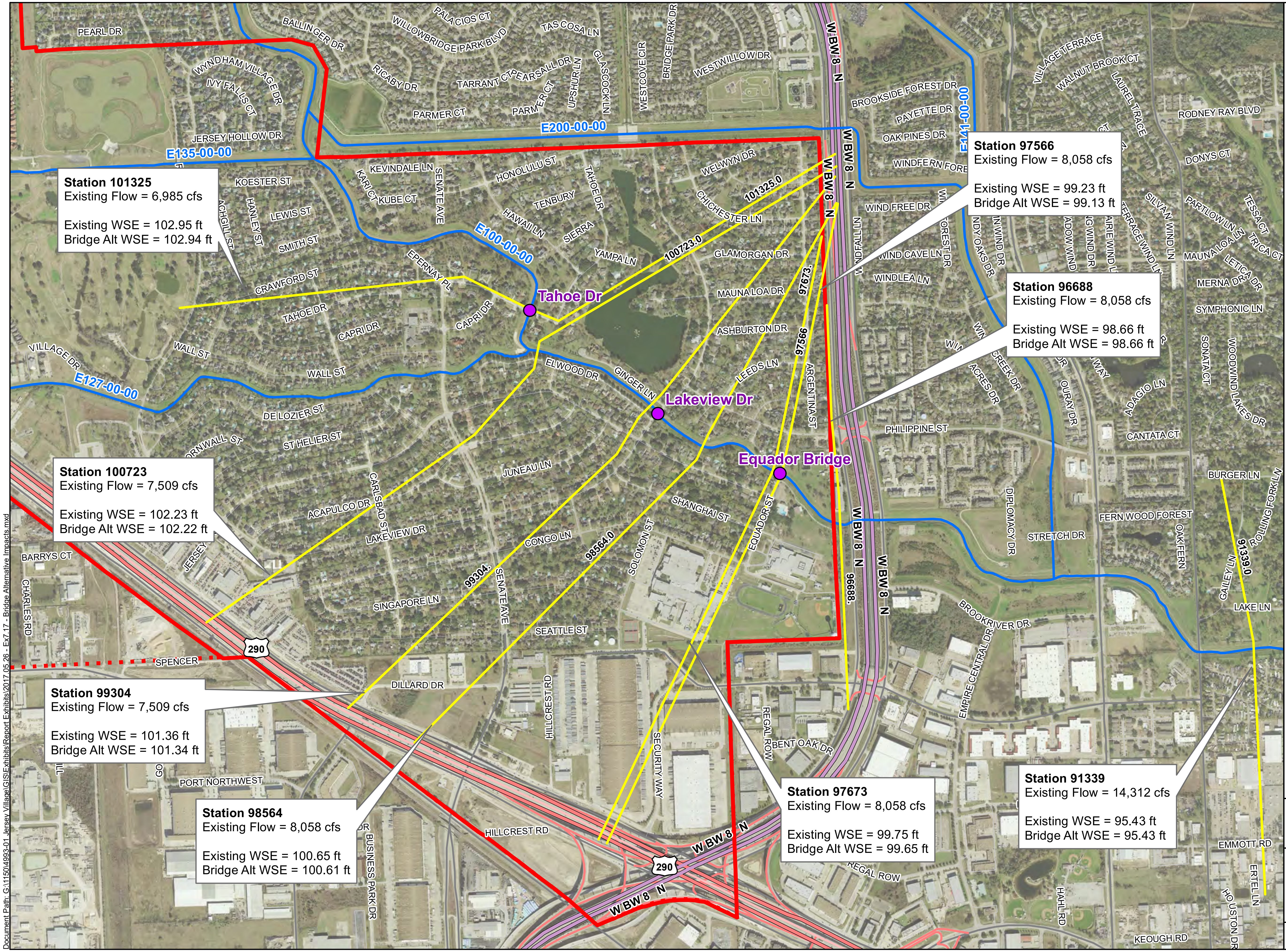
N

0 | 600 | 1,200 Ft

City of Jersey Village
Long-term Flood Recovery Plan

Exhibit 7.16
Bridge Removal Alternative

1 in. = 600 ft	June 2017



Legend

- JV Bridges
- 2017 HEC-RAS XS
- Stream Network
- Revised Existing Floodplain (100-yr)
- Jersey Village
- ETJ

DANNENBAUM

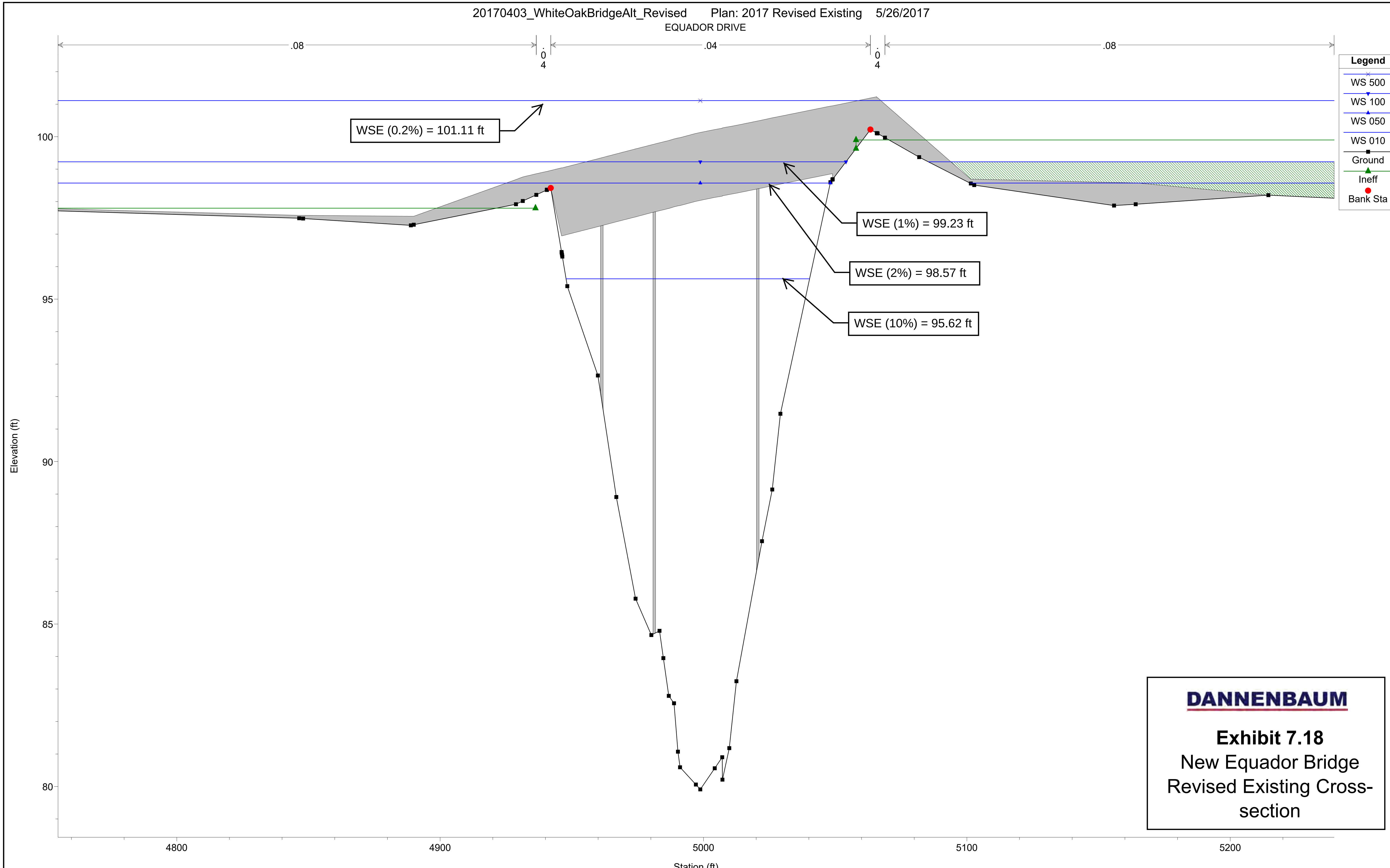
N

0 1,000 2,000 Ft

City of Jersey Village
Long-term Flood Recovery Plan

Exhibit 7.17
New Equador Bridge
Channel Impacts (100-yr Event)

1 in. = 1,000 ft | June 2017



DANNENBAUM

Exhibit 7.18

New Equador Bridge Revised Existing Cross-section

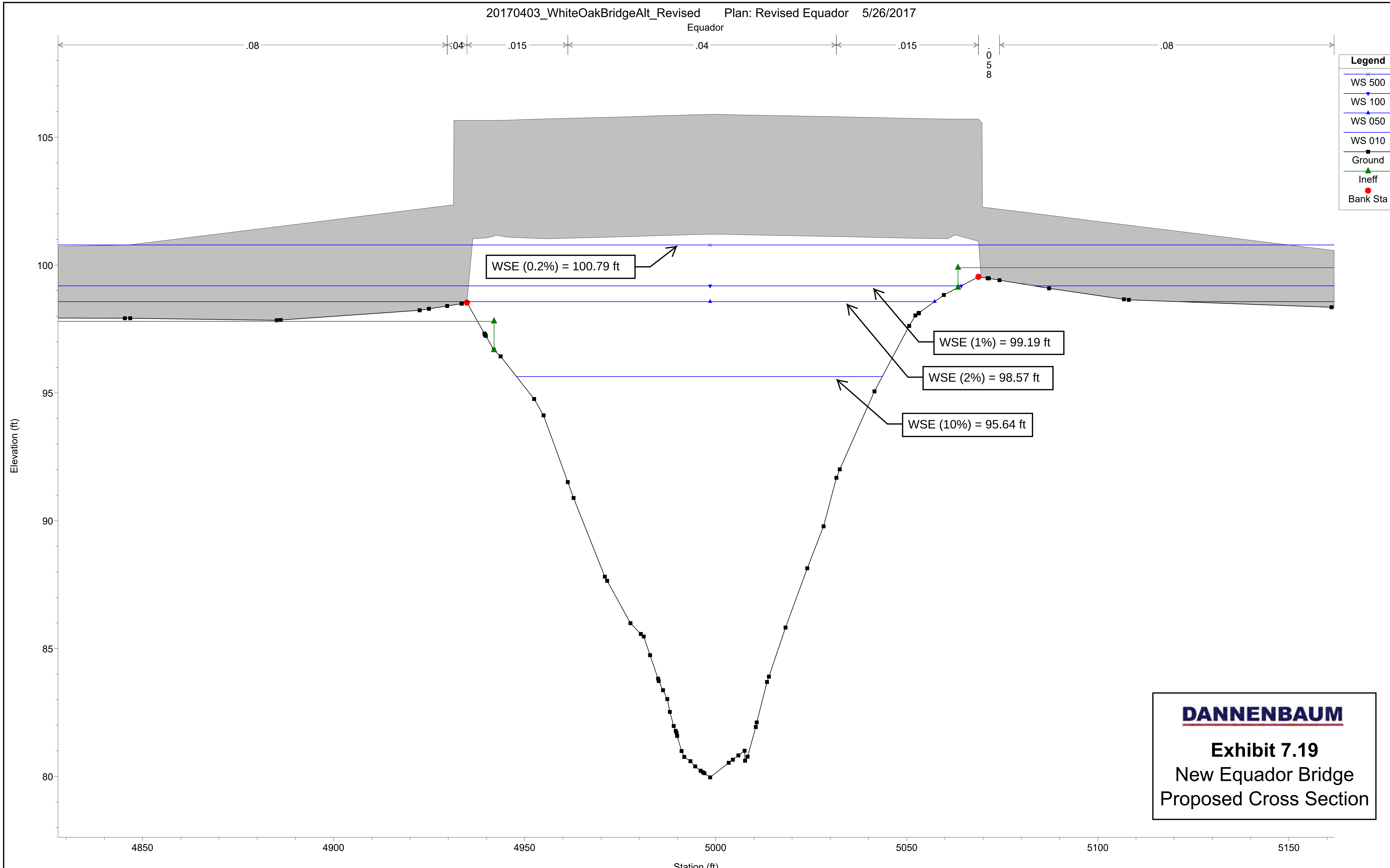
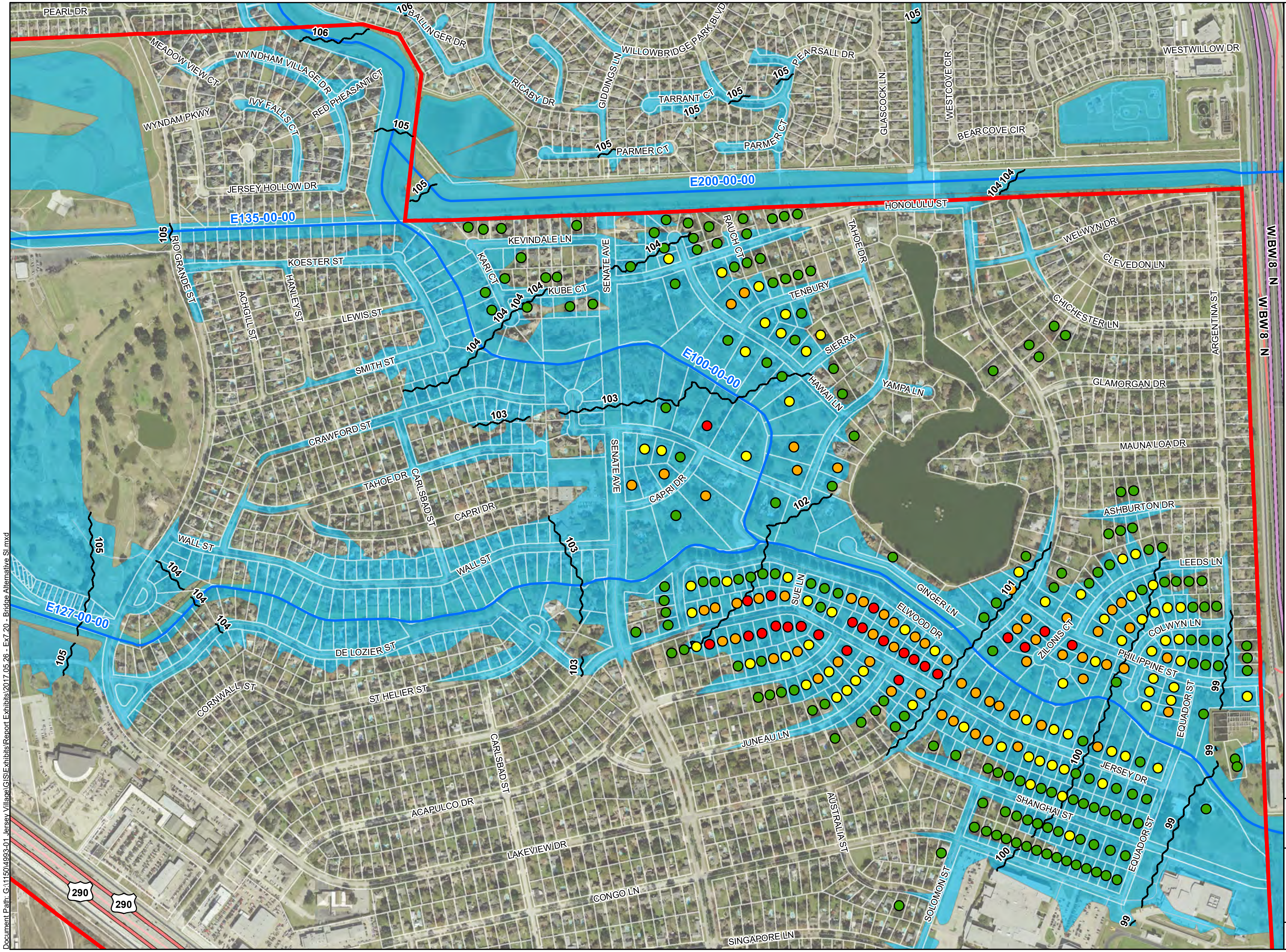


Exhibit 7.19
New Equador Bridge
Proposed Cross Section



Legend

- Revised Existing BFE
- Stream Network
- Revised Existing Floodplain (100-yr)
- Jersey Village
- ETJ

SI Bridge Alternative Results

- 4% Event (25-yr)
- 2% Event (50-yr)
- 1% Event (100-yr)
- 0.2% Event (500-yr)

Note
No homes have been impacted or removed by the Structural Inventory Tool after the addition of a bridge at Equador St.

DANNENBAUM

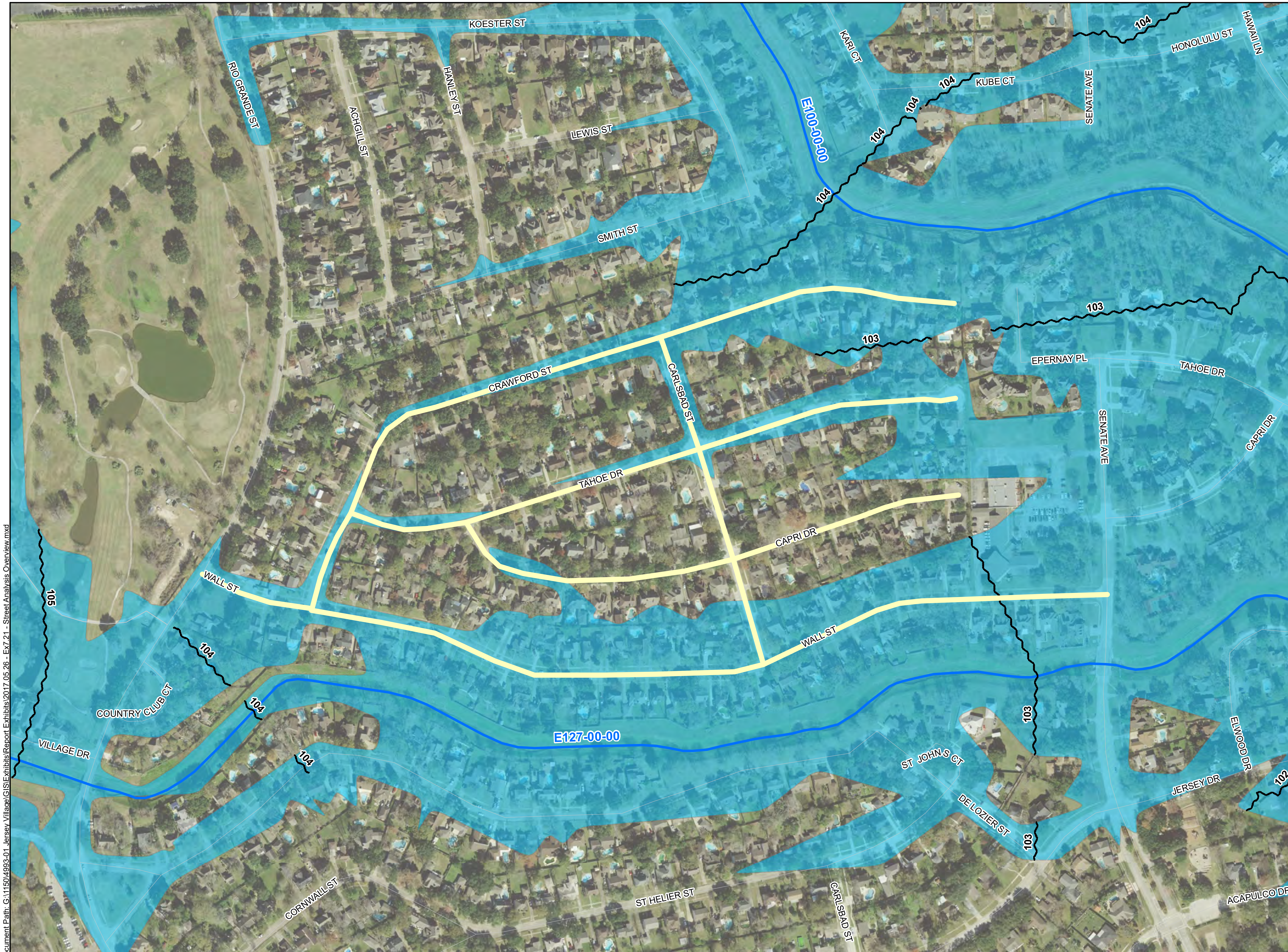
N

0 600 1,200 Ft

City of Jersey Village
Long-term Flood Recovery Plan

Exhibit 7.20
New Equador Bridge
Structural Inventory Results

1 in. = 600 ft | June 2017



Legend

- Streets Under Assessment
- Revised Existing BFE
- Stream Network
- Revised Existing Floodplain (100-yr)
- Jersey Village
- ETJ

DANNENBAUM

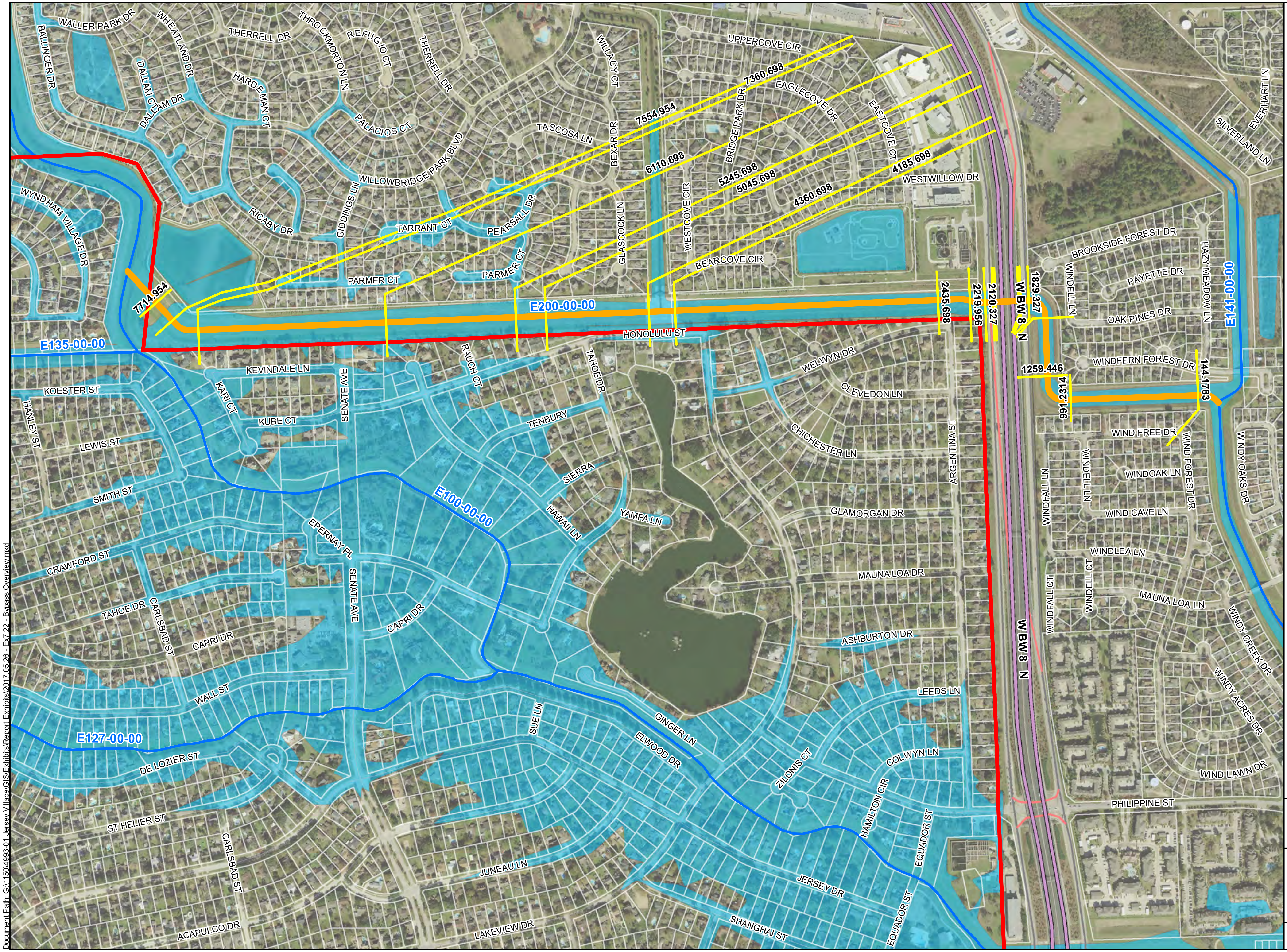
N

0 300 600 Ft

City of Jersey Village
Long-term Flood Recovery Plan

Exhibit 7.21
Overall Street Assessment

1 in. = 300 ft	June 2017



Legend

- E200-00-00 Bypass Channel
- E200-00-00 HEC-RAS XS
- Stream Network
- Revised Existing Floodplain (100-yr)
- Jersey Village
- ETJ

DANNENBAUM

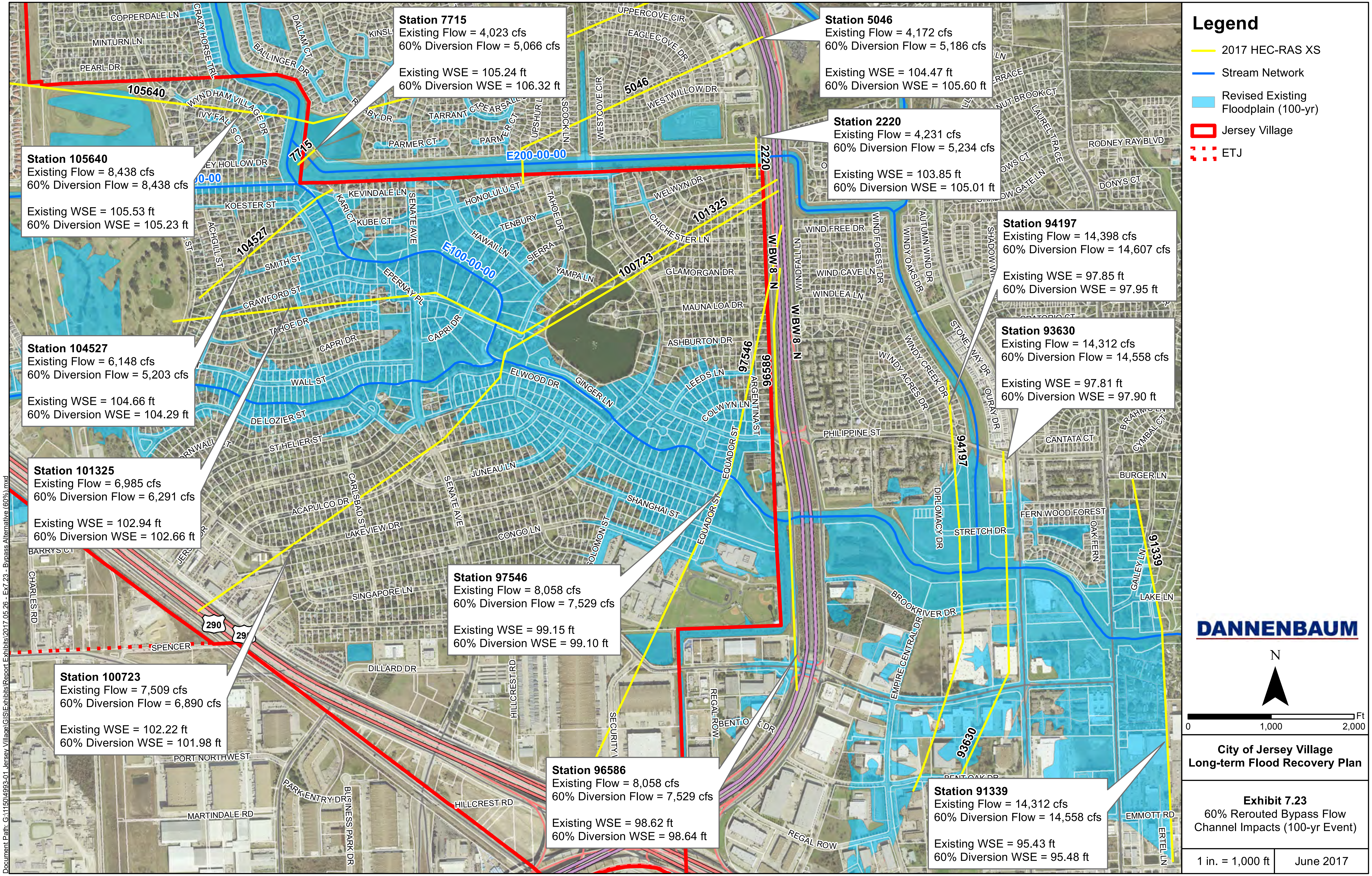
N

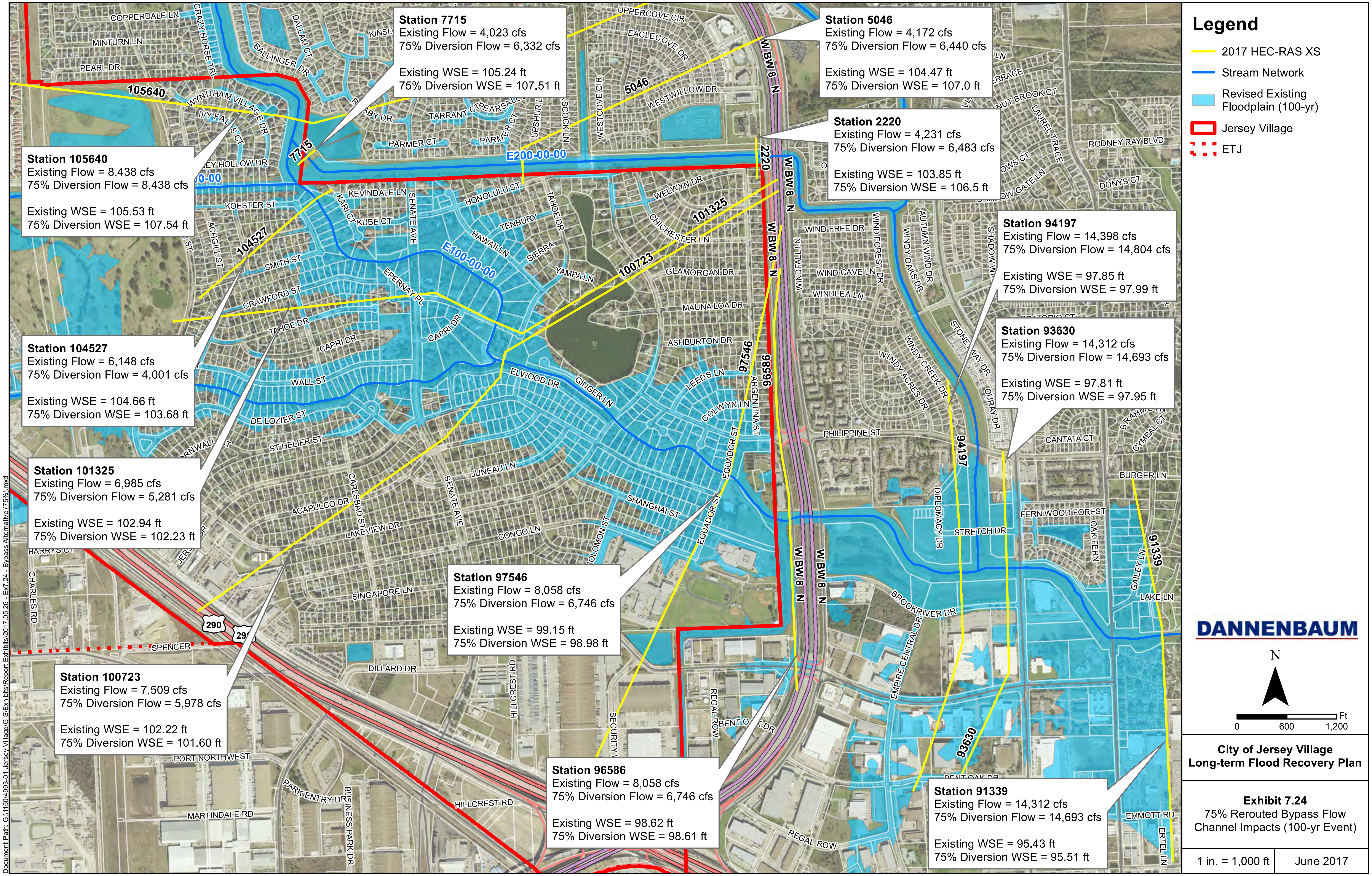
0 600 1,200 Ft

City of Jersey Village
Long-term Flood Recovery Plan

Exhibit 7.22
Rerouted Bypass Flow Alternative

1 in. = 600 ft	June 2017

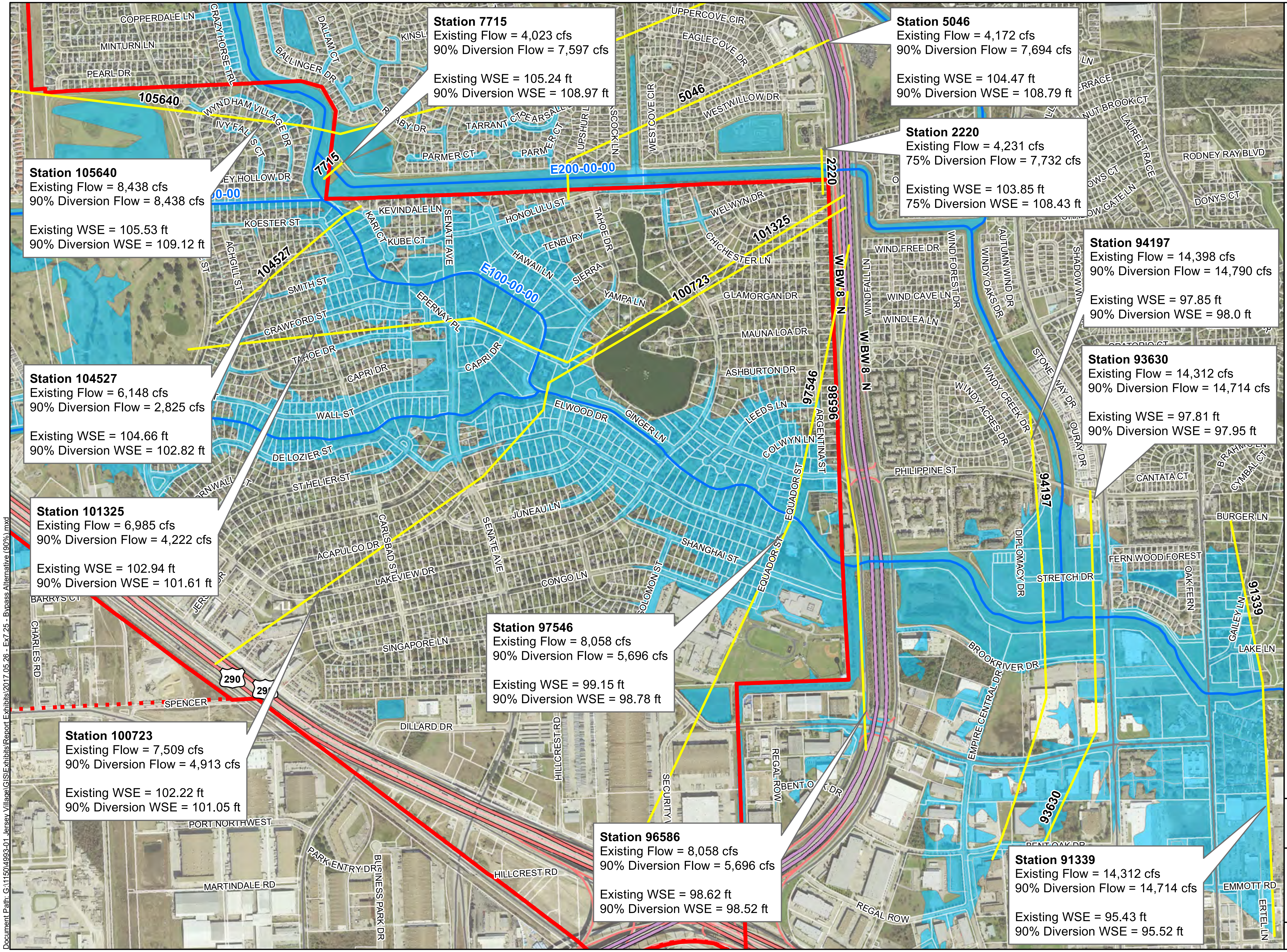

Station 7715
Existing Flow = 4,023 cfs
60% Diversion Flow = 5,066 cfs
Existing WSE = 105.24 ft
60% Diversion WSE = 106.32 ft
Station 5046
Existing Flow = 4,172 cfs
60% Diversion Flow = 5,186 cfs
Existing WSE = 104.47 ft
60% Diversion WSE = 105.60 ft
Station 2220
Existing Flow = 4,231 cfs
60% Diversion Flow = 5,234 cfs
Existing WSE = 103.85 ft
60% Diversion WSE = 105.01 ft
Station 105640
Existing Flow = 8,438 cfs
60% Diversion Flow = 8,438 cfs
Existing WSE = 105.53 ft
60% Diversion WSE = 105.23 ft
Station 94197
Existing Flow = 14,398 cfs
60% Diversion Flow = 14,607 cfs
Existing WSE = 97.85 ft
60% Diversion WSE = 97.95 ft
Station 93630
Existing Flow = 14,312 cfs
60% Diversion Flow = 14,558 cfs
Existing WSE = 97.81 ft
60% Diversion WSE = 97.90 ft
Station 104527
Existing Flow = 6,148 cfs
60% Diversion Flow = 5,203 cfs
Existing WSE = 104.66 ft
60% Diversion WSE = 104.29 ft
Station 101325
Existing Flow = 6,985 cfs
60% Diversion Flow = 6,291 cfs
Existing WSE = 102.94 ft
60% Diversion WSE = 102.66 ft
Station 97546
Existing Flow = 8,058 cfs
60% Diversion Flow = 7,529 cfs
Existing WSE = 99.15 ft
60% Diversion WSE = 99.10 ft
Station 100723
Existing Flow = 7,509 cfs
60% Diversion Flow = 6,890 cfs
Existing WSE = 102.22 ft
60% Diversion WSE = 101.98 ft
Station 96586
Existing Flow = 8,058 cfs
60% Diversion Flow = 7,529 cfs
Existing WSE = 98.62 ft
60% Diversion WSE = 98.64 ft
Station 91339
Existing Flow = 14,312 cfs
60% Diversion Flow = 14,558 cfs
Existing WSE = 95.43 ft
60% Diversion WSE = 95.48 ft
E200-00-00
E100-00-00
Legend
2017 HEC-RAS XS
Stream Network
Revised Existing Floodplain (100-yr)
Jersey Village
ETJ
DANNENBAUM
N
0 1,000 2,000 Ft
City of Jersey Village
Long-term Flood Recovery Plan
Exhibit 7.23
60% Rerouted Bypass Flow Channel Impacts (100-yr Event)
1 in. = 1,000 ft
June 2017
Document Path: G:\1150\4993-01 Jersey Village\GIS\Exhibits\Report Exhibits\2017.05.26 - Ex7.23 - Bypass Alternative (60%).mxd



City of Jersey Village
Long-term Flood Recovery Plan

Exhibit 7.24
75% Rerouted Bypass Flow Channel Impacts (100-yr Event)

1 in. = 1,000 ft | June 2017



Legend

- 2017 HEC-RAS XS
- Stream Network
- Revised Existing Floodplain (100-yr)
- Jersey Village
- ETJ

DANNENBAUM

N

0 600 1,200 Ft

City of Jersey Village
Long-term Flood Recovery Plan

Exhibit 7.25
90% Rerouted Bypass Flow Channel Impacts (100-yr Event)

1 in. = 1,000 ft	June 2017

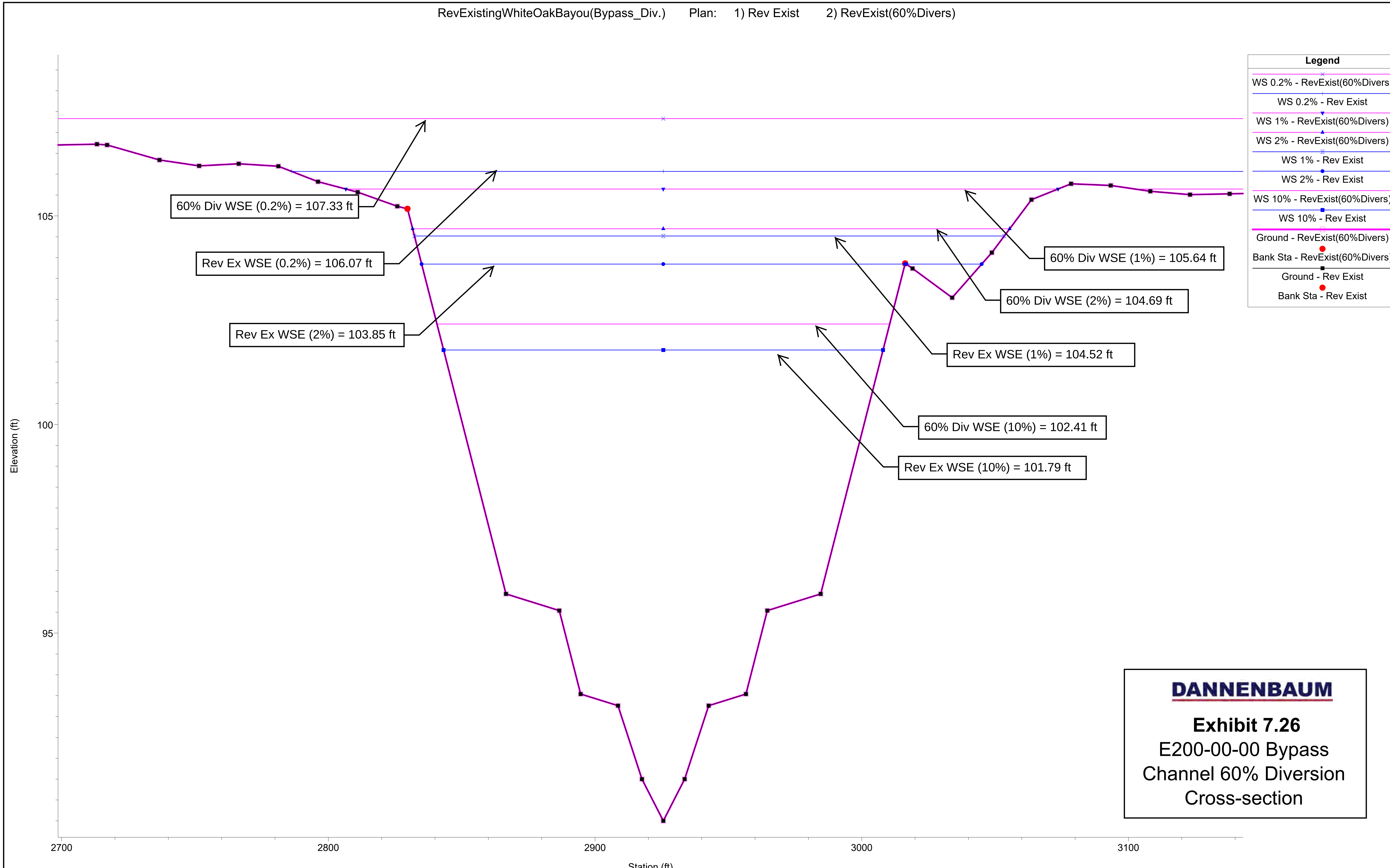
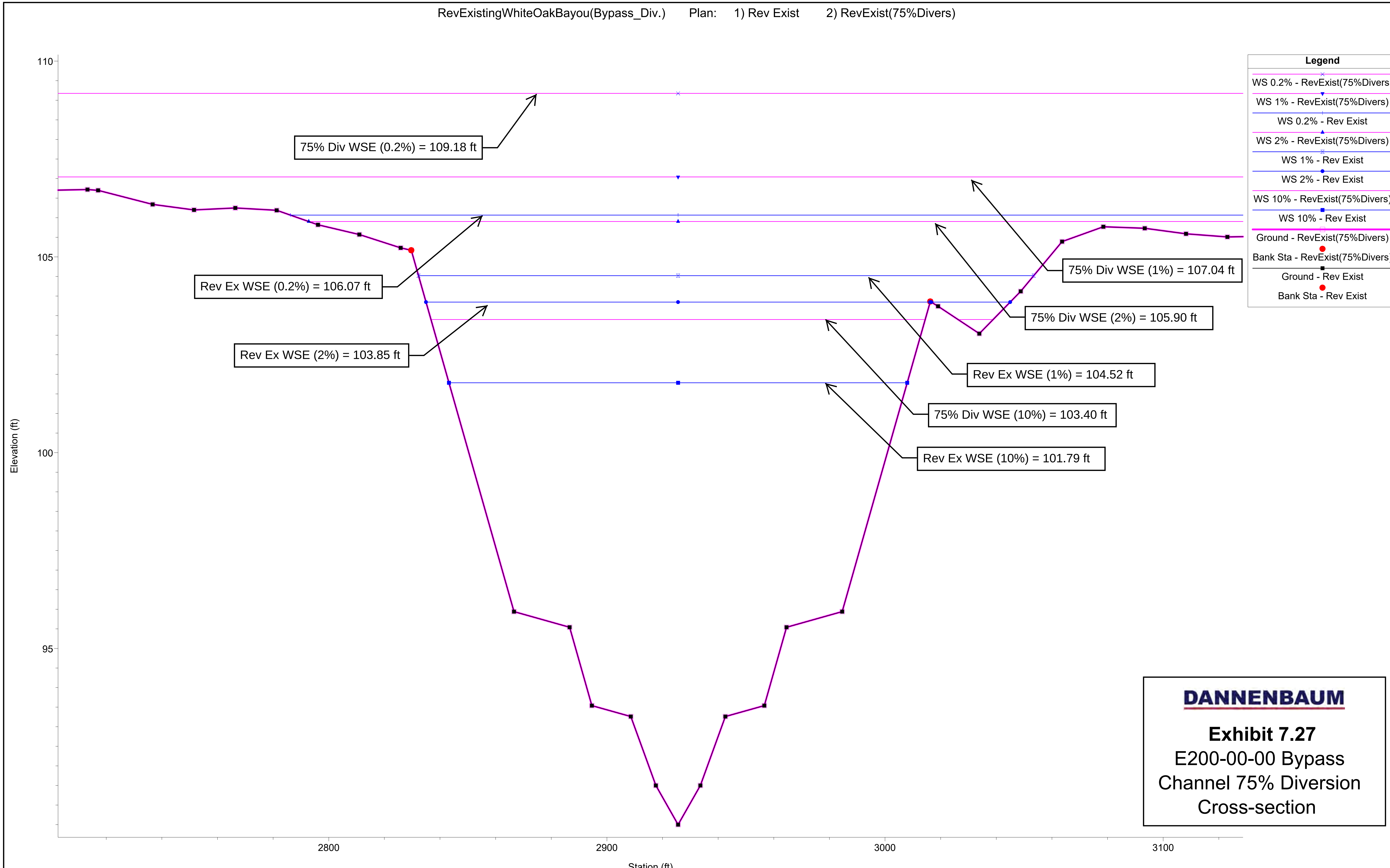
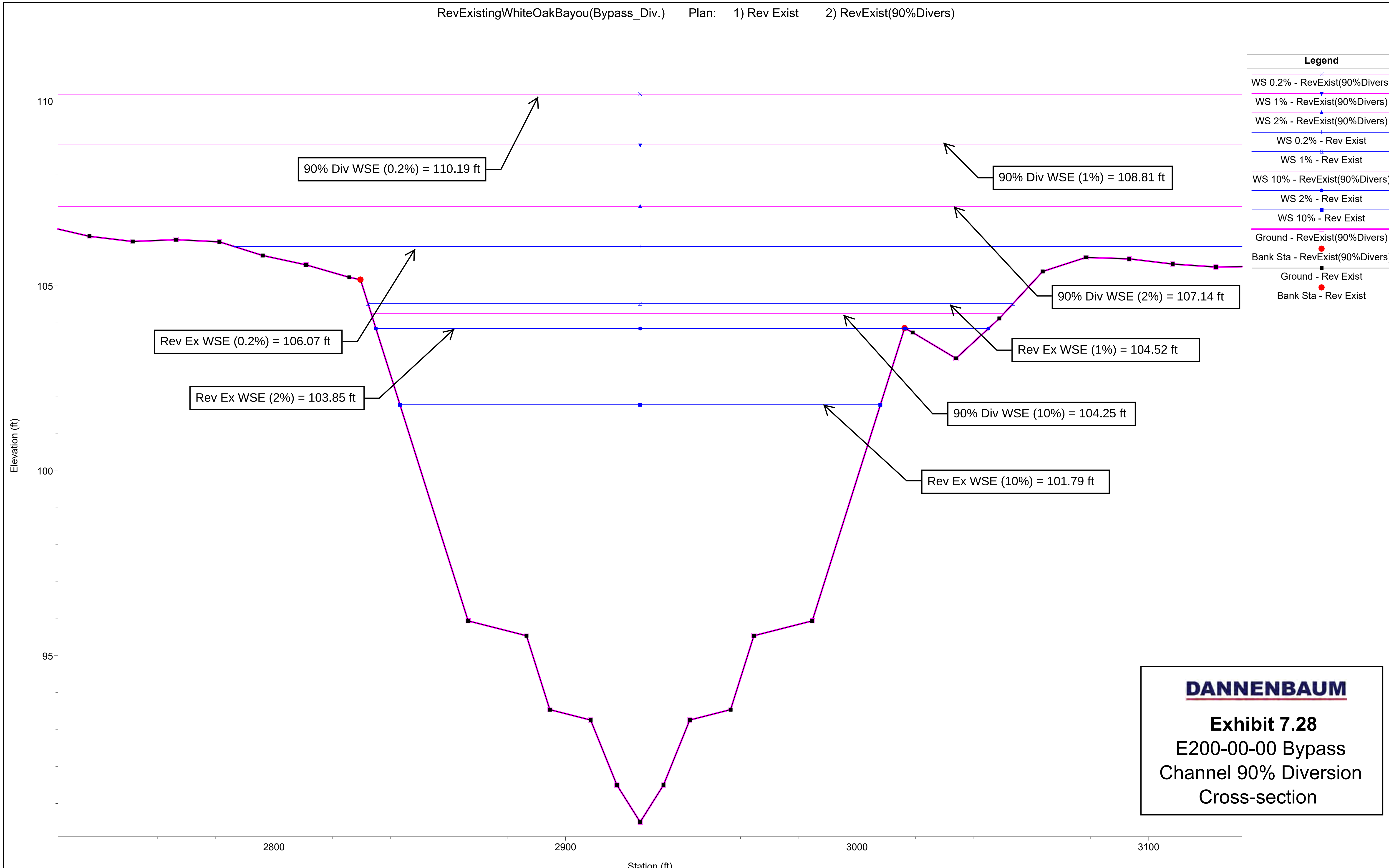


Exhibit 7.26

E200-00-00 Bypass Channel 60% Diversion Cross-section



RevExistingWhiteOakBayou(Bypass_Div.) Plan: 1) Rev Exist 2) RevExist(75%Divers)
75% Div WSE (0.2%) = 109.18 ft
Rev Ex WSE (0.2%) = 106.07 ft
Rev Ex WSE (2%) = 103.85 ft
75% Div WSE (1%) = 107.04 ft
75% Div WSE (2%) = 105.90 ft
Rev Ex WSE (1%) = 104.52 ft
75% Div WSE (10%) = 103.40 ft
Rev Ex WSE (10%) = 101.79 ft
Legend
WS 0.2% - RevExist(75%Divers)
WS 1% - RevExist(75%Divers)
WS 0.2% - Rev Exist
WS 2% - RevExist(75%Divers)
WS 1% - Rev Exist
WS 2% - Rev Exist
WS 10% - RevExist(75%Divers)
WS 10% - Rev Exist
Ground - RevExist(75%Divers)
Bank Sta - RevExist(75%Divers)
Ground - Rev Exist
Bank Sta - Rev Exist
Elevation (ft)
Station (ft)
110
105
100
95
2800
2900
3000
3100
DANNENBAUM
Exhibit 7.27
E200-00-00 Bypass Channel 75% Diversion Cross-section



RevExistingWhiteOakBayou(Bypass_Div.) Plan: 1) Rev Exist 2) RevExist(90%Divers)
Legend
WS 0.2% - RevExist(90%Divers)
WS 1% - RevExist(90%Divers)
WS 2% - RevExist(90%Divers)
WS 0.2% - Rev Exist
WS 1% - Rev Exist
WS 10% - RevExist(90%Divers)
WS 2% - Rev Exist
WS 10% - Rev Exist
Ground - RevExist(90%Divers)
Bank Sta - RevExist(90%Divers)
Ground - Rev Exist
Bank Sta - Rev Exist
90% Div WSE (0.2%) = 110.19 ft
90% Div WSE (1%) = 108.81 ft
90% Div WSE (2%) = 107.14 ft
Rev Ex WSE (0.2%) = 106.07 ft
Rev Ex WSE (1%) = 104.52 ft
Rev Ex WSE (2%) = 103.85 ft
90% Div WSE (10%) = 104.25 ft
Rev Ex WSE (10%) = 101.79 ft
Elevation (ft)
110
105
100
95
Station (ft)
2800
2900
3000
3100
DANNENBAUM
Exhibit 7.28
E200-00-00 Bypass Channel 90% Diversion Cross-section

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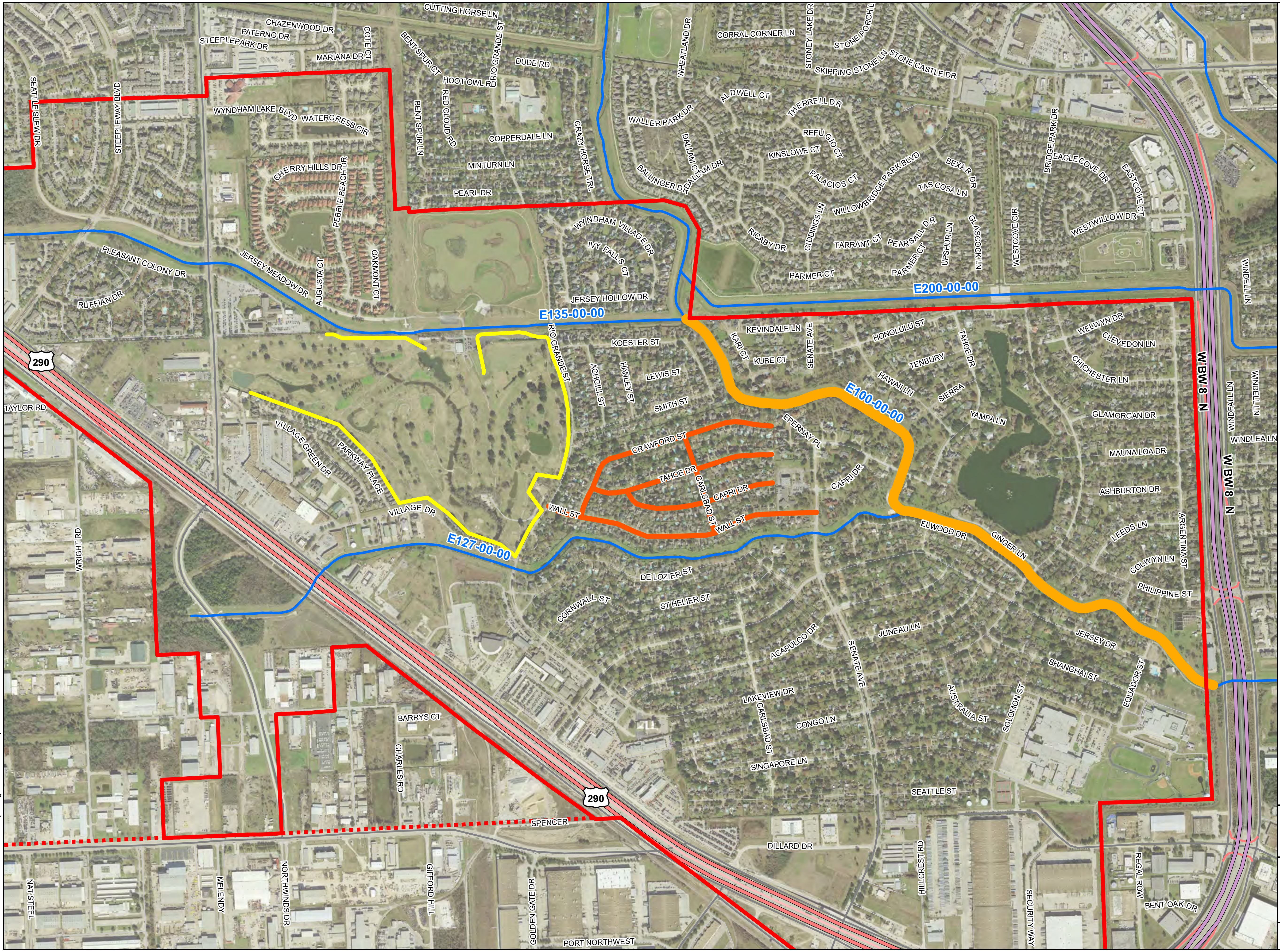


Legend

- Golf Course Berm
- Streets Under Assessment
- E100-00-00 Channel Improvements
- Stream Network
- Jersey Village
- ETJ

DANNENBAUM

N

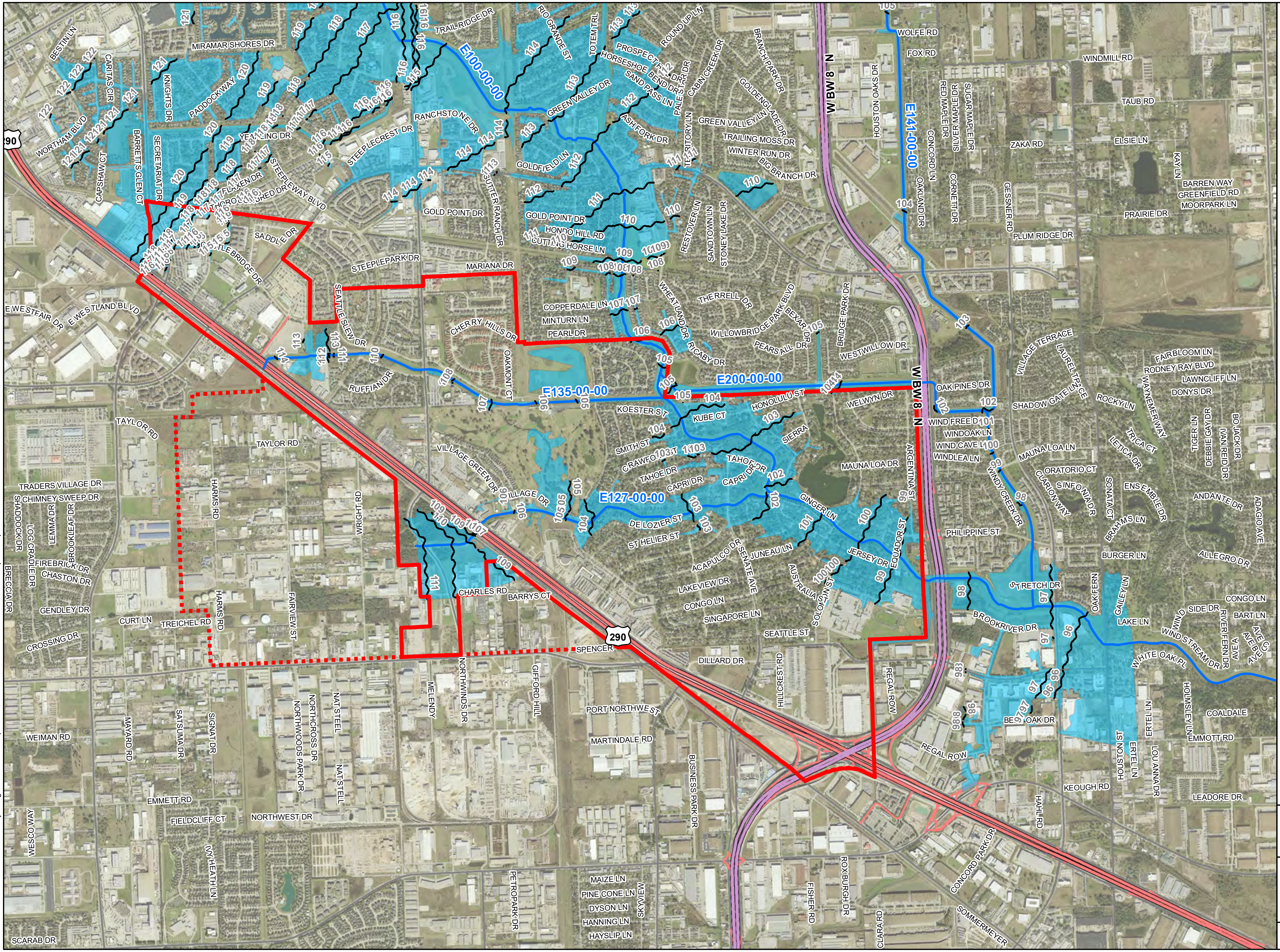
0 | 1,000 | 2,000 Ft

City of Jersey Village
Long-term Flood Recovery Plan

Exhibit 10.1
Recommended Solution Overview

1 in. = 1,000 ft | June 2017

Document Path: G:\1150\4993-01 Jersey Village\GIS\Exhibits\Report Exhibits\2017.05.26 - Ex10.1 - Preferred Solution Overview.mxd



Document Path: G:\1150\4993-01 Jersey Village\GIS\Exhibits\Report Exhibits\2017.05.26 - Ex10.2 - Preferred Floodplain map.mxd

Legend

- Recommended Solution BFE
- Stream Network
- Recommended Solution Floodplain (100-yr)
- Jersey Village
- ETJ

DANNENBAUM

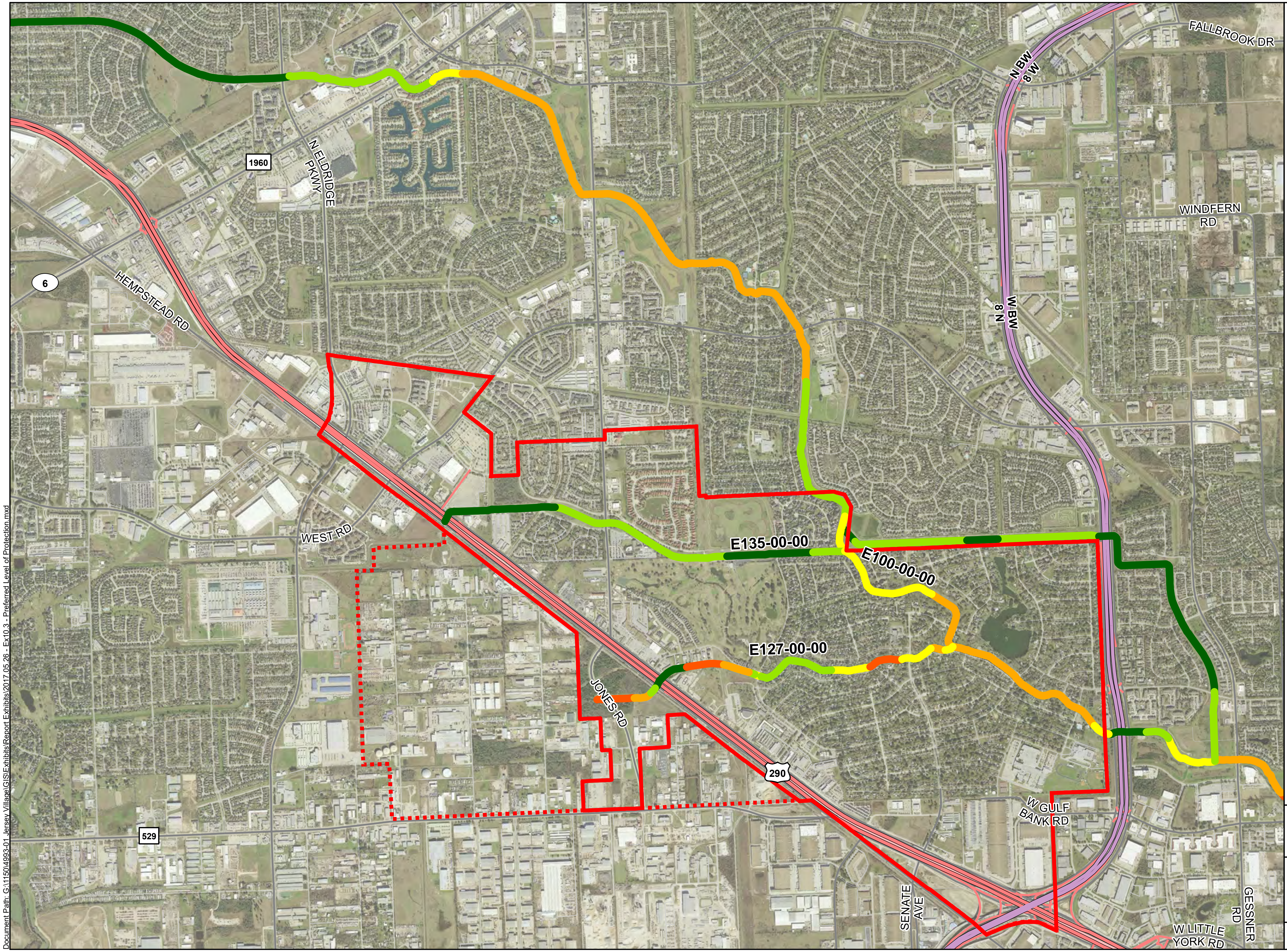
N

0 2,000 4,000 Ft

City of Jersey Village
Long-term Flood Recovery Plan

Exhibit 10.2
Recommended Solution
Floodplain [100-yr Map]

1 in. = 2,000 ft	June 2017



Legend

- City of Jersey Village
- ETJ

Level of Protection

Recommended Solution

- 10-yr Event
- 25-yr Event
- 50-yr Event
- 100-yr Event
- 500-yr Event

DANNENBAUM

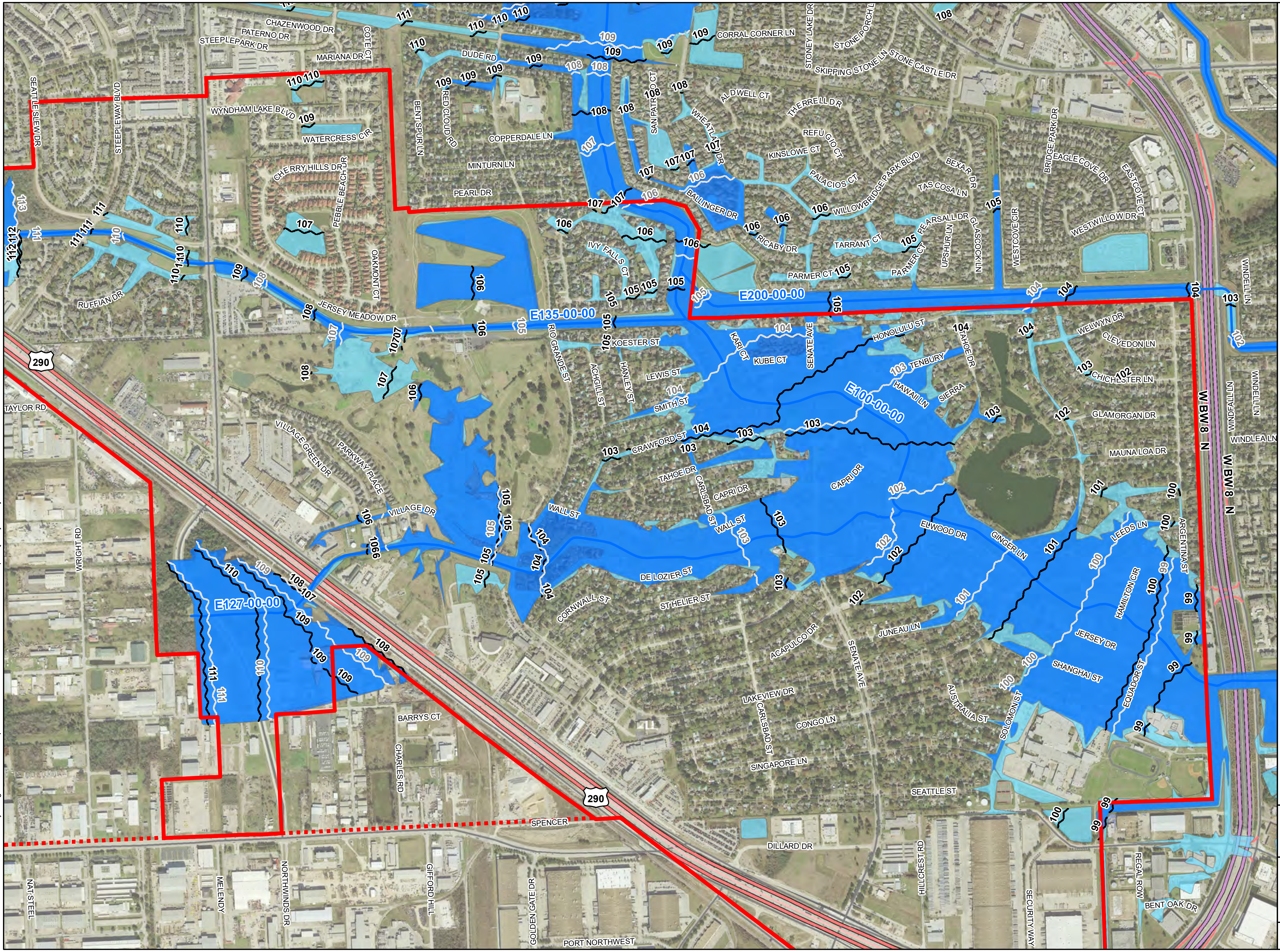
N

0 2,000 4,000 Ft

City of Jersey Village Long-term Flood Recovery Plan

Exhibit 10.3
Recommended Solution
Channel Level of Protection

1 in. = 2,000 ft	June 2017



Legend

- Recommended Solution BFE (100-yr)
- Recommended Solution BFE (Tax Day)
- Recommended Solution Floodplain (100-yr)
- Recommended Solution Floodplain (Tax Day)
- Stream Network
- Jersey Village
- ETJ

DANNENBAUM

N

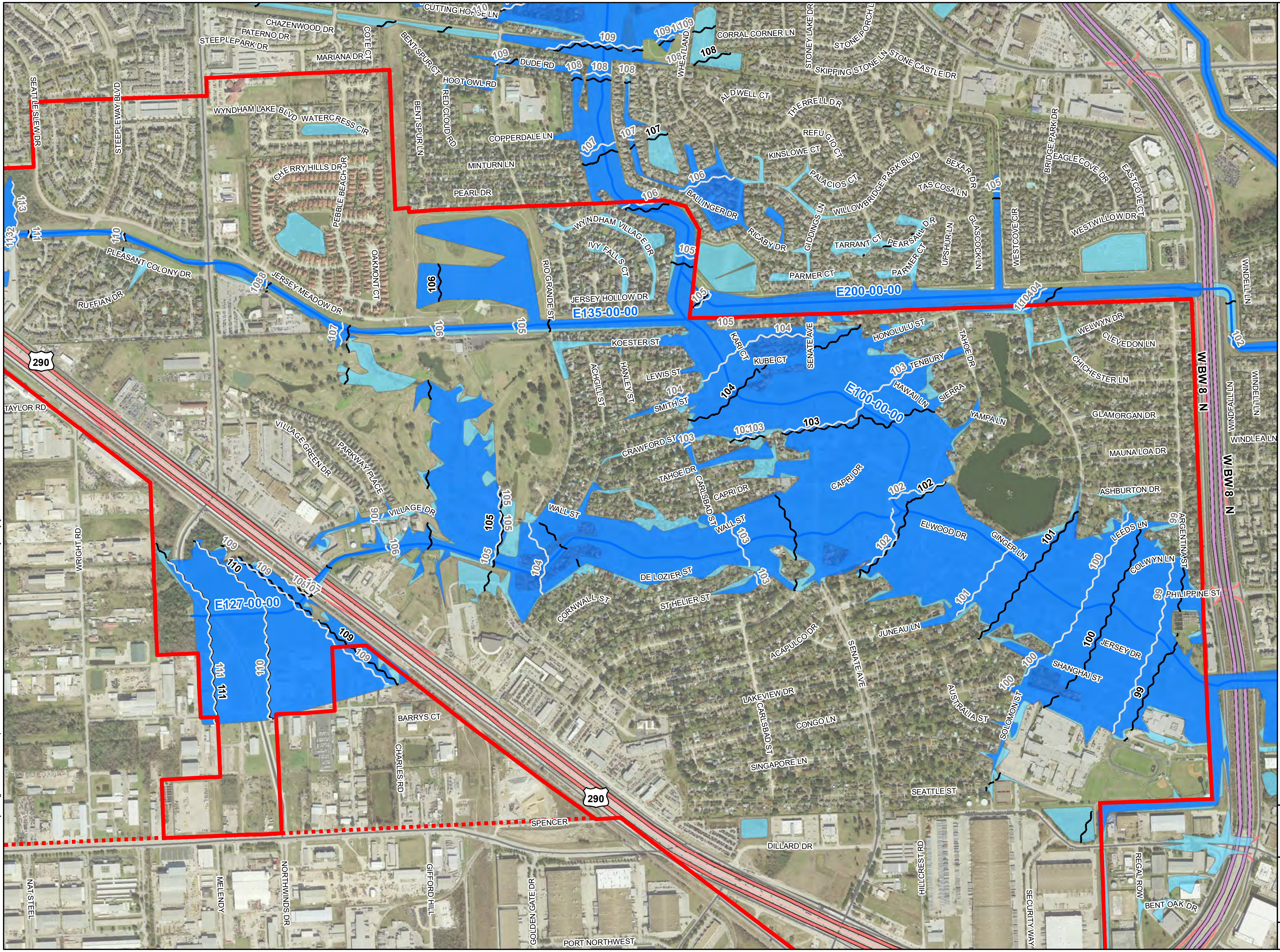
0 | 1,000 | 2,000 Ft

City of Jersey Village
Long-term Flood Recovery Plan

Exhibit 10.4
Recommended Solution Floodplain [100-yr vs Tax Day]

1 in. = 1,000 ft	June 2017

Document Path: G:\1150\4993-01 Jersey Village\GIS\Exhibits\Report Exhibits\2017.05.26 - Ex10.4 - Preferred Floodplain (100-yr v Tax).mxd



Legend

- Recommended Solution BFE (100-yr)
- Revised Existing BFE (100-yr)
- Recommended Solution Floodplain (100-yr)
- Revised Existing Floodplain (100-yr)
- Stream Network
- Jersey Village
- ETJ

DANNENBAUM

N

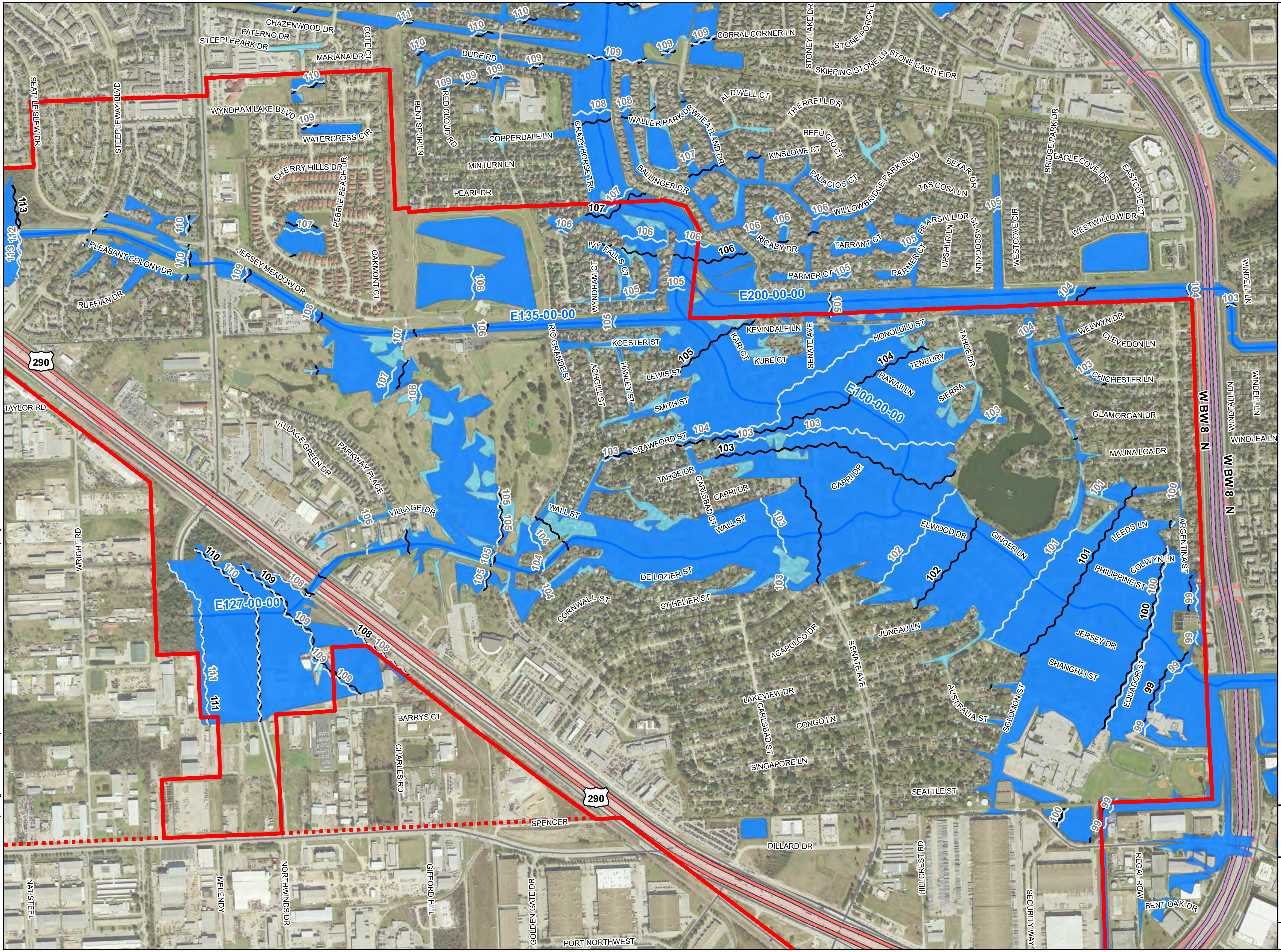
0 1,000 2,000 Ft

City of Jersey Village
Long-term Flood Recovery Plan

Exhibit 10.5
Revised Existing vs
Recommended Solution
Floodplains [100-yr]

1 in. = 1,000 ft	June 2017

Document Path: G:\1150\4993-01 Jersey Village\GIS\Exhibits\Report Exhibits\2017.05.26 - Ex10.5 - Revised vs Preferred [100-yr].mxd



Legend

- Recommended Solution Floodplain (Tax Day)
- Revised Existing BFE (Tax Day)
- Recommended Solution Floodplain (Tax Day)
- Revised Existing Floodplain (Tax Day)
- Stream Network
- Jersey Village
- ETJ

DANNENBAUM

N

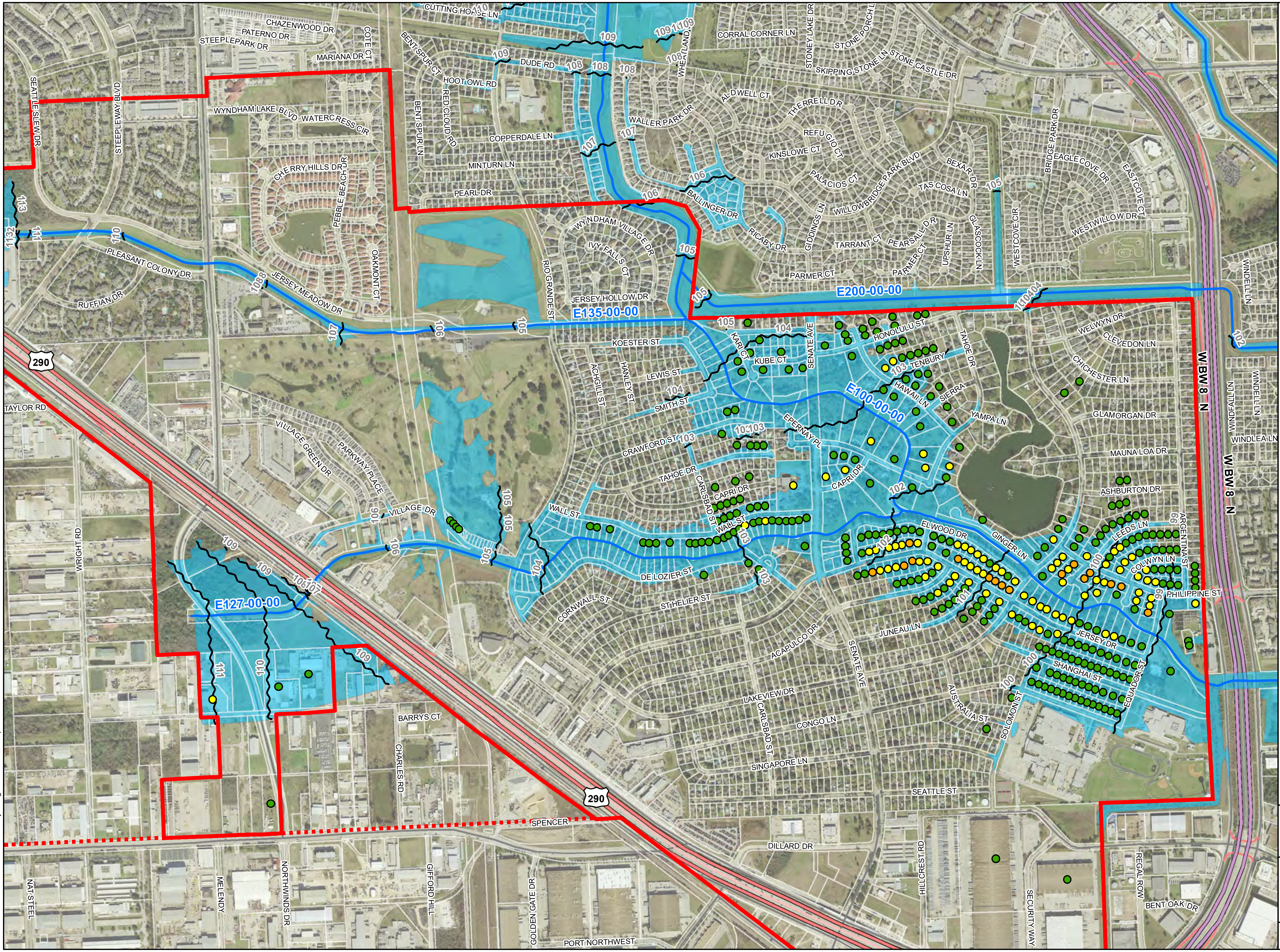
0 1,000 2,000 Ft

City of Jersey Village
Long-term Flood Recovery Plan

Exhibit 10.6
Revised Existing vs Recommended Solution Floodplains [Tax Day]

1 in. = 1,000 ft	June 2017

Document Path: G:\1150\4993-01 Jersey Village\GIS\Exhibits\Report Exhibits\2017.05.26 - Ex10.6 - Revised vs Preferred [Tax].mxd



Legend

- Recommended Solution BFE
- Stream Network
- Recommended Solution Floodplain (100-yr)
- Jersey Village
- ETJ

Recommended Solution Structural Inventory

- 2% (50-yr Event)
- 1% (100-yr Event)
- 0.2% (500-yr Event)

DANNENBAUM

N

0 — 1,000 — 2,000 Ft

City of Jersey Village
Long-term Flood Recovery Plan

Exhibit 10.7
Recommended Solution
Structural Inventory Results

1 in. = 1,000 ft	June 2017