Drainage Impact Study

January 31

2017

Drainage Impact Study Report for the Jersey Village Transit-Oriented Development, a 300-acre development in the City of Jersey Village, south of US-290.

JV TOD

For: City of Jersey Village

By: Dannenbaum Engineering Corporation

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EXECUTIVE SUMMARY

The following report presents Dannenbaum Engineering Corporation's (DEC) drainage impact study for the Transit-Oriented Development (TOD) in Jersey Village, Texas. The purpose of the proposed TOD re-development plan is to revitalize the area located on the south side of US 290 creating an opportunity for quality growth and economic development. DEC's analysis includes hydrologic calculations and determination of mitigation required for the future re-development of the area.

The project area has a total of 300 acres and is located to the south of US 290 in Jersey Village. Approximately 55 acres of the proposed plan is located within the city limits, while the other 245 acres is within Jersey Village's Extra-Territorial Jurisdiction (ETJ).

The primary objectives of the drainage study include the following:

- Hydrology of existing and proposed drainage areas.
- The minimum required storage volume using a comparison of the existing and proposed conditions and Harris County Flood Control District (HCFCD) methods and regulations.
- Preliminary detention pond sizing to meet the minimum required volume.

The existing land use for the TOD includes industrial, commercial, residential and some undeveloped areas. There are four drainage areas present in existing conditions. The largest of these drainage areas outfalls into the E127-00-00 tributary. Offsite drainage areas drain through two of the existing drainage areas of the TOD toward E127-00-00.

After re-development, the entire project area will be routed to outfall into the E127-00-00 channel. The increase in drainage area being discharged into the channel will require a detention pond to mitigate for adverse impacts to the area. The required storage volume will be determined through the comparison of existing and proposed hydrographs. This volume will be used to design the detention ponds.

The size and location of the ponds is restricted by the JV TOD Conceptual Layout Plan (see Figure 1) and the bottom elevation of the outfall channel. Two multi-use detention areas are added to provide the extra mitigation for higher frequency events. The detention ponds are designed for a 10-year and 100-year storm frequency and as gravity flow systems.

The following detention summary table details the key results of this drainage study:

Detention Summary Table

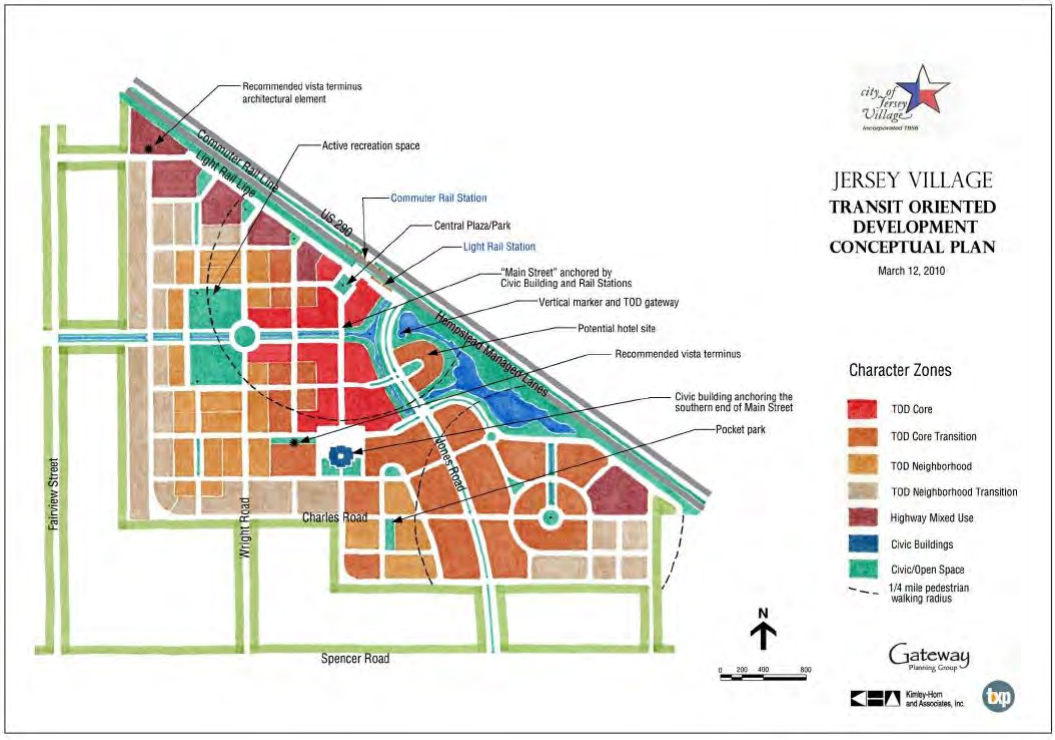
Transit-Oriented Development		
Detention Basin Drainage Area	300 acres	
Detention Storage Rate	0.48 acre-feet/acre	
Floodplain Storage Rate	1.0 acre-feet/acre	
Combined Storage Rate	0.55 acre-feet/acre	
Detention Storage Required	145.0 acre-feet	
Floodplain Storage Required	21.2 acre-feet	
Total Storage Provided	167.4 acre-feet	
	10% (10-Year)	**100% (100-Year)**
Maximum Allowable Outflow (cfs)	810	1237

1. INTRODUCTION

1.1. BACKGROUND

The Transit-Oriented Development (TOD) is a proposed 300-acre conceptual re-development plan located in the City of Jersey Village (JV) in Harris County, Texas. The TOD conceptual plan exists in response to the future roadway improvements and the proposed commuter rail service adjacent to the area. The purpose of this plan is to revitalize the area located on the south side of US 290 creating an opportunity for quality growth and economic development. Figure 1 shows the conceptual plan for the TOD from the Jersey Village TOD Phase 1 Report.

Figure 1: JV TOD Conceptual Plan



1.2. TOD PROJECT LIMITS

The project area is located to the south of US 290 in Jersey Village, with the western boundary between Wright Rd and Fairview St and the southern boundary between Charles Rd and Spencer Rd. Approximately 55 acres of the proposed plan is located within the Jersey Village city limits, while the other 245 acres is within the Extra Territorial Jurisdiction (ETJ).

1.3. TOD OBJECTIVES

The primary objectives of the drainage study include the following:

- Hydrology of existing and proposed drainage areas.
- The minimum required storage volume using a comparison of the existing and proposed conditions and Harris County Flood Control District (HCFCD) methods and regulations.
- Preliminary detention pond sizing including length, width and elevations to meet the minimum required volume.

1.4. ASSUMPTIONS AND CONSTRAINTS

Several assumptions and constraints were applied while performing this drainage study. For existing drainage areas, LiDAR was used to determine existing run-off patterns. For proposed conditions, the entire project area was routed to outfall into the existing E127-00-00 tributary. Alternative solutions based on existing drainage areas were considered. However, these alternatives were disregarded since some of the existing drainage areas did not have a defined outfall location. The land use for the existing drainage areas were determined using the Jersey Village TOD Phase 1 Report current land use exhibit, aerial photos and HCAD parcel data. Land use for the proposed drainage area was determined utilizing the JV TOD conceptual plan from the same feasibility study (see Section 1.5).

The ultimate pond design and location was based on the JV TOD conceptual re-development plan. It was assumed that the main detention pond would outfall into the E127-00-00 tributary by US 290. It was determined that offsite drainage was present. The offsite areas were treated as if they were only passing through the TOD area. A more in depth analysis of this offsite drainage will be required in the future detailed study. It was assumed that future drainage will use storm sewers but those were not designed during this study. Only a hydrological analysis was performed during the course of this study.

Some constraints for the project included the presented conceptual land plan and the depth of the channel. For proposed conditions, all of the land use data and drainage areas were based off of the conceptual land plan for the JV TOD. The land use plan designated a specific area for a detention pond so all mitigation was restricted to that area. Also, the depth of the channel restricted the design depth for the detention pond.

1.5. PRIOR STUDIES

The only prior study used during the TOD drainage analysis was the Jersey Village TOD Phase 1 Report conducted by Kimley-Horn in October 2009 for the development of the JV TOD. Kimley Horn & Associates, along with Gateway Planning Group and TXP, Inc. (Project Team), worked to find a sustainable solution to encourage quality and economic growth in the area. The feasibility study was completed to determine the viability of transforming the current development into a new environment. Currently, the proposed TOD area is mostly commercial and industrial buildings, but the study explored the possibility of turning the area into a more commercial and residential area. Pending roadway improvements to Jones Road and a future commuter rail service adjacent to the study area encouraged the necessity of the study. The feasibility study considered several different areas of concern, including land use, zoning, transportation, environmental and the current market, and presented several recommendations for each. Overall, the Project Team concluded that current conditions would help facilitate re-development in the TOD with the adjacent land use and recommended that the next stage of planning and fiscal analysis should begin.

2. EXISTING CONDITIONS

2.1. LOCATION AND TOPOGRAPHY

The Jersey Village TOD is located in the northwestern region of Harris County, adjacent to the south side of US 290. According to LiDAR data, the overall topography of the area has a relatively flat slope, with an average elevation around 111 ft, an approximate high elevation of 116 ft and a low of 106 ft. These elevations exclude those of the channel running through the property and the floodplain is not contained to the channel according to effective FEMA flood maps, as illustrated in Exhibit 6.

2.2. LAND USE

Currently, the TOD contains numerous land uses including undeveloped, commercial, industrial and residential. According to LiDAR, some area outside of the TOD was drains through the TOD area. The land use types in this area mirror those in the existing TOD, with the addition of a school. The land use map found in the JV TOD Phase 1 Report is used to determine the areas of each land use type, which are used in the existing hydrologic calculations.

In proposed conditions, the JV TOD consist of the following land uses: commercial, residential, industrial and developed green areas. These are specified in the finalized JV TOD Conceptual Plan in the JV TOD Phase 1 Report.

2.3. HCFCD FACILITIES AND UNIT NUMBERS

The outlets for the proposed detention ponds are connected to the E127-00-00 tributary located in the White Oak Bayou Watershed.

3. HYDROLOGY

3.1. ANALYSIS OBJECTIVE

The primary analysis objective was to define the hydrologic impacts that will be caused by the re-development of the JV TOD. An analysis was performed to calculate the increase in volume of run-off, which was used to determine the minimum required detention volume needed to mitigate impacts from development.

3.2. HYDROLOGIC METHODOLOGY

The hydrologic methodology used in this analysis was the Method 2 for moderate project drainage areas (Small Watershed method), which can be found in Section 6 of the HCFCD Policy Criteria and Procedure (PCP) Manual. The same methodology was used for calculating existing and proposed conditions. Method 2 was chosen due to the size of the JV TOD tract being between 50 and 640 acres. An ArcHydro analysis was performed in ArcGIS to delineate the four drainage areas for the existing conditions. It was assumed that all flow would be routed to outfall into the E127-00-00 channel so there was only one drainage area in proposed conditions.

The current land use map from the JV TOD Overall Phase 1 Report was utilized to calculate the percent impervious for each drainage area. For proposed conditions, the final conceptual plan was used for the future land use.

The peak flow, Q_p, for each drainage area, A, was calculated with the formula for the HCFCD Site Run-off Curves:

$$Q_p = b * A^m$$

The values of *b* and *m* were taken from Section 3.3 of the HCFCD PCP Manual. Calculated peak flows were compared to the peak flows determined from the Site Run-off Curves and were found to be similar. Due to this similarity, the calculated values were used for more precise calculations. The Small Watershed method was used to develop hydrographs, which includes calculating the total run-off volume, the time to peak and the incremental flow values. The total run-off volume was determined by multiplying the total drainage area by the direct run-off value for White Oak Bayou found in the HCFCD PCP Manual.

Once the total run-off volume, V, for each drainage area was determined, the time to peak, T_p, was calculated using the subsequent equation:

$$T_p = \frac{V}{1.39 * Q_p}$$

The peak flow and time to peak values for existing conditions are listed in Table 1 and for proposed conditions in Table 2. A time increment, t_i, of five minutes, over a 24-hour time period, was chosen and the incremental flows, q_i, were found using the following formula:

$$q_i = \left(\frac{Q_p}{2}\right)\left[1 - \cos\left(\frac{\pi * t_i}{T_p}\right)\right]$$

After completing the Small Watershed process for each drainage area in existing and proposed conditions, two hydrographs were produced for each area with a 10% and 1% design frequency. These hydrographs were used to determine the required storage volume in the proposed drainage area. The required volume was calculated by taking the difference between the existing and proposed conditions hydrographs. After the required volume was determined, the minimum required storage rate was calculated by dividing the required volume by the total TOD area, or 300 acres. The calculated storage rate was increased by 15% to incorporate a factor of safety for tailwater impacts in drainage efficiency.

3.3. PRE-PROJECT CONDITIONS

The total area of the project area was determined to be approximately 300 acres. Using existing 2008 LiDAR data, an ArcHydro model was run in ArcGIS. The ArcHydro analysis showed the project area draining to four separate outfalls. The largest of the existing drainage areas discharged to the E127-00-00 tributary. Offsite drainage areas were determined to be draining through two of the existing drainage areas of the TOD. The existing and offsite drainage areas are shown in Exhibit 2.

For the existing flows, the percent of impervious land was calculated using the current land use map from the previous JV TOD feasibility study. The Small Watershed Method was used to develop hydrographs according to the HCFCD PCP Manual. The peak flows were calculated for both the 10-year and 100-year frequencies. The peak flow values for each drainage area are shown in Table 1.

Table 1: Site Run-off Curve Peak Existing Discharge

Drainage Area	Area (ac)	Total Area (ac)	Peak Flow (cfs)		Peak Time (hr)	
			10-year	100-year	10-year	100-year
1	221.9	460.2	810	1237	2.79	3.34
1 (offsite)	238.3					
2	23.7	23.7	68	105	1.68	2.00
3	29.2	74.8	181	276	2.03	2.43
3 (offsite)	45.6					
4	24.8	24.8	83	122	1.58	1.90
Total TOD Area		**300 ac**				
Total Area (w/offsite)		**583.5 ac**				

4. PROPOSED DRAINAGE PLAN

4.1. DESCRIPTION

The proposed drainage plan for the JV TOD included three detention ponds, each with an outfall into the E127-00-00 tributary. Two of these detention ponds were multi-use areas designed to flood during higher return interval storms. For the analysis of the proposed conditions, it was assumed the entire TOD area would be routed to drain into the E127-00-00 channel. The future land use for the project was based off the finalized conceptual plan for the Jersey Village TOD.

4.2. HYDROLOGICAL ANALYSIS

The entire project area was routed to outfall into the E127-00-00 tributary for the proposed drainage plan. Alternative plans were considered where the drainage areas mirrored those in the existing conditions. After examination, it was determined that three of the existing drainage areas did not outfall into any channel or pond, so the alternative plans were not analyzed any further. Another constraint for the drainage analysis was the JV TOD conceptual plan, where only one large area had been designated for a detention pond. The mitigation limitations reinforced the practicality of routing the entire system into one outfall location.

Along with the proposed drainage area, offsite drainage areas were accounted for in the drainage area calculations. These drainage areas are shown in Exhibit 3. The entire TOD area is 300 acres, so the Site Run-Off Curve Equation and the Small Watershed method were used to calculate peak flows and develop hydrographs for proposed conditions. Table 2 shows the peak discharge and time to peak of the proposed drainage area.

Table 2: Site Run-off Curve Peak Proposed Discharge

Drainage Area	Area (ac)	Total Area (ac)	Peak Flow (cfs)		Peak Time (hr)	
			10-year	100-year	10-year	100-year
1	300	584	978	1237	2.92	3.49
1 (offsite)	284					

The peak time was calculated using the Small Watershed method as well, and then used to find the incremental flow values to create a proposed flow hydrograph for the 10-year and 100-year storm frequencies. The hydrographs were calculated with a five-minute time interval over a 24-hour period.

A comparison of the existing and proposed hydrographs for each drainage area was performed to determine the amount of mitigation required. As stated previously, existing conditions showed four separate drainage areas, but only one of these drainage areas outfalls into the E127-00-00 channel. In proposed conditions, the entire project area was routed to discharge into that tributary. For the hydrograph comparison, only the drainage areas discharging into the E127-00-00 channel were used. Due to the increase in the drainage area discharging into the channel, higher levels of mitigation were required. Table 3 demonstrates the hydrograph comparison calculations for the 100-year storm frequency.

Table 3: Required Detention Volume from Hydrograph Comparison (100-yr)

	Pre-Dev	Post-Dev
Area	460 ac	584 ac
Direct Run-off	12.37 in	12.34 in
Volume	475 ac-ft	600 ac-ft
Q_p	1237 cfs	1497 cfs
T_p	3.3 hr	3.5 hr
Required Volume	126 ac-ft	
Req'd Vol with 15% F.S.	145 ac-ft	

After the required volume was calculated, it was increased by 15% to incorporate a factor of safety. The following graphs are the existing and proposed 10-year and 100-year hydrographs for the proposed drainage plan.

Figure 1: Proposed Conditions Small Watershed Hydrograph (10-year)

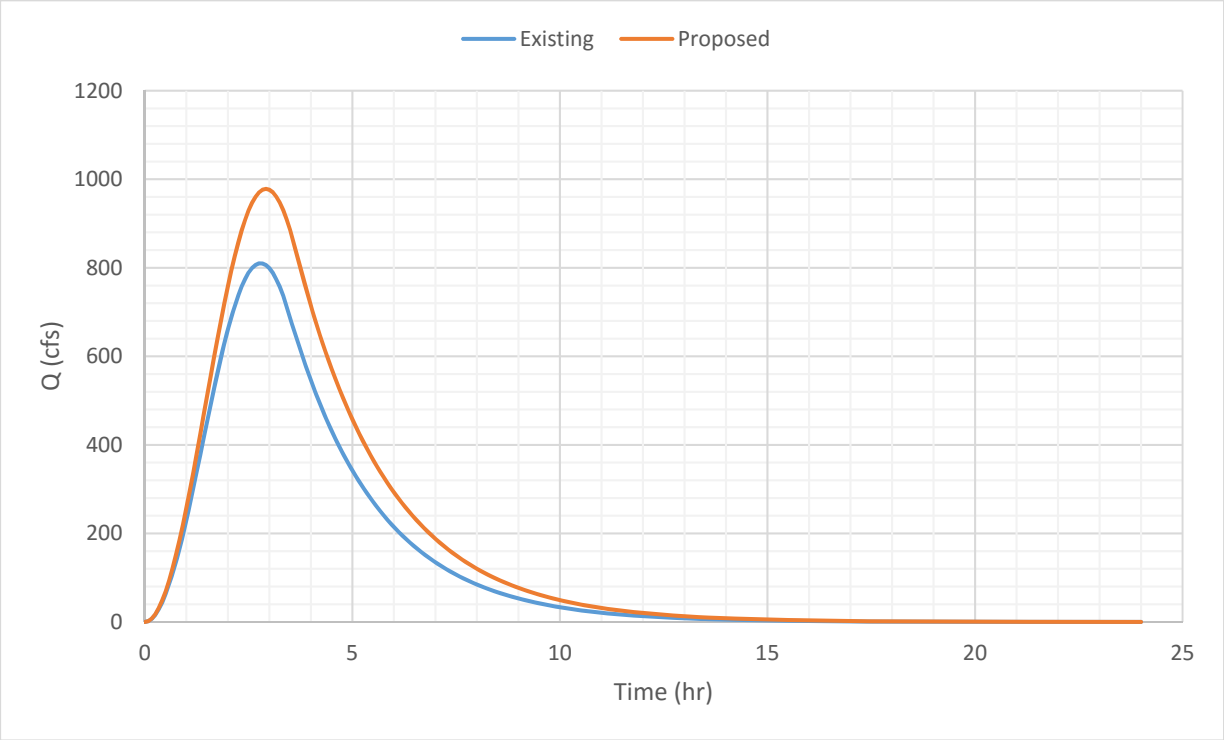
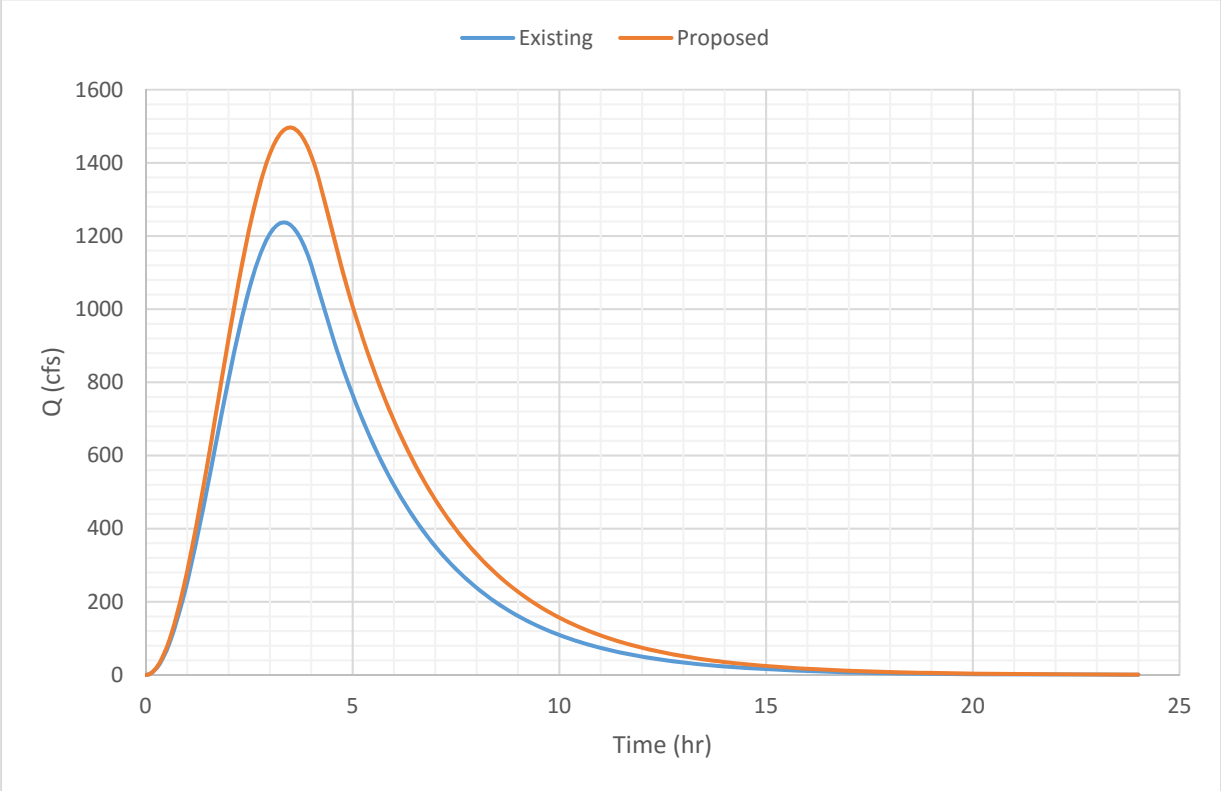


Figure 2: Proposed Conditions Small Watershed Hydrograph (100-year)



For the proposed conditions, the minimum detention storage rate calculated was 0.42 ac-ft/ac through hydrograph comparison. The minimum detention storage rate was increased by 15% to include a factor of safety, which resulted in a required storage rate of 0.48 ac-ft/ac.

According to FEMA regulations, any area being developed inside of the floodplain needs to be filled in order to match the base flood elevations. The required storage rate for developing in the floodplain is 1.0 ac-ft/ac. Preliminary calculations concluded at least 21.2 ac-ft of fill is needed to match base flood elevations, which means an additional 21.2 ac-ft of storage needs to be mitigated. The combined total storage volume is 166 ac-ft, or a required storage rate of 0.55 ac-ft/ac.

4.3. DETENTION LAYOUT

The size and location of the detention pond was determined and set in the conceptual land plan for the Jersey Village TOD. The detention layout was designed to meet the required detention criteria of 166 ac-ft (0.55 ac-ft/ac) for the proposed conditions. Using the conceptual land plan, the channel was assumed to be rerouted into the proposed detention pond and discharge through the existing outfall to E127-00-00 by US-290. The pond flowline was set to 101 ft, approximately one foot above the bottom elevation of the existing channel at the outfall. The top of the pond was set to the average ground elevation in the pond area, 108 ft. The shape of the pond was determined by the proposed surrounding development. The final design layout had a total detention volume of 141.4 ac-ft, which is lower than the required detention volume of 166 ac-ft.

After revisiting the conceptual plan, two other developed green areas located upstream next to the E127-00-00 tributary were designated as multi-use detention areas. It was assumed that the area could remain as active recreation space and only flood during higher return interval storm events. The multi-use areas were given a shallow depth to accommodate their original purpose. The green space added 24.9 ac-ft of storage, making the total detention volume 166.3 ac-ft. Table 3 displays the land area, volumes and depths for each basin.

Table 3: Detention Pond Design Summary

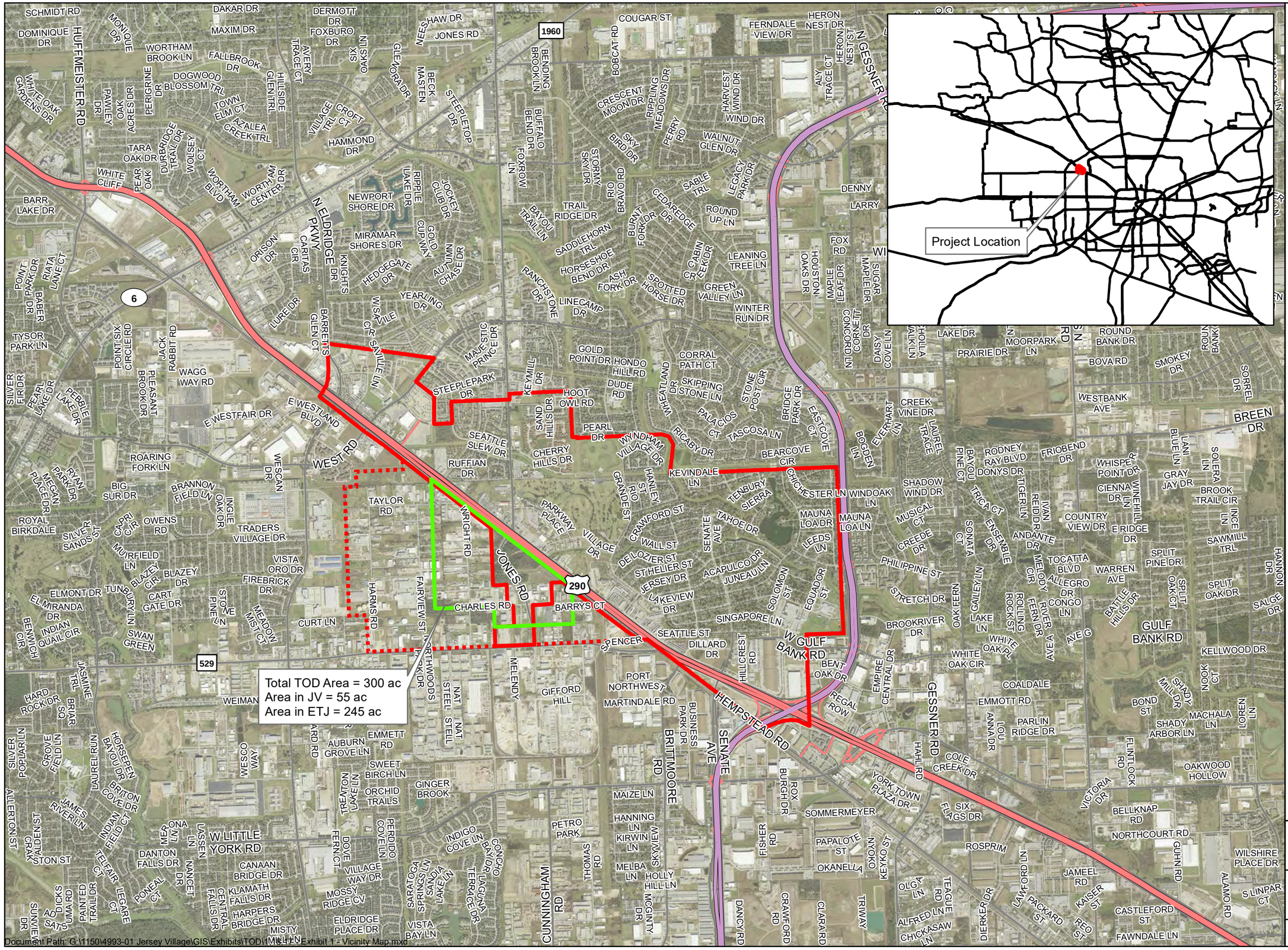
	Pond 1	**Pond 2**	**Pond 3**
Area of Top of Pond	24.8 ac	5.0 ac	4.4 ac
Average Natural Ground Elevation	108 ft	111 ft	111 ft
Side Slopes	4:1	4:1	4:1
Berm Width	20	20	20
Depth	7 ft	3.5 ft	3.5 ft
Bottom of Pond Elevation	101 ft	107.5 ft	107.5 ft
Storage Volume	141.4 ac-ft	13.1 ac-ft	11.8 ac-ft

The detention pond layout can be seen in further detail in Exhibit 7. The final detention pond layout does not include storage for any offsite drainage present. This will need to be accounted for in a more detailed study.

5. CONCLUSIONS

After the analysis was completed, it was determined that an adequate drainage system could be provided in the area, regardless of the final development plan. The recommended detention plan layout has the entire project area discharging into the E127-00-00 tributary. The detention ponds were designed to meet HCFCD storage volume requirements for a 100-year storm, including the required storage volume for developing in the floodplain. It was assumed that the channel would be rerouted through the proposed detention pond to accommodate the conceptual land plan for the Jersey Village TOD.

The conveyance system for the TOD and off-site areas to reach the basins are not included in this analysis. Additional analysis will be required for storm sewers, sanitary sewers and other utilities. A detailed study will be needed to design the final drainage system layout.



Legend

- TOD Area Outline
- City of Jersey Village
- ETJ

DRAFT
Not to be used for analyses, design or construction. For reference only.

DANNENBAUM

N

0 3,000 6,000 Ft

City of Jersey Village
Long-term Flood Recovery Plan

Exhibit 1
TOD Vicinity Map

1 in. = 3,000 ft | January, 2017

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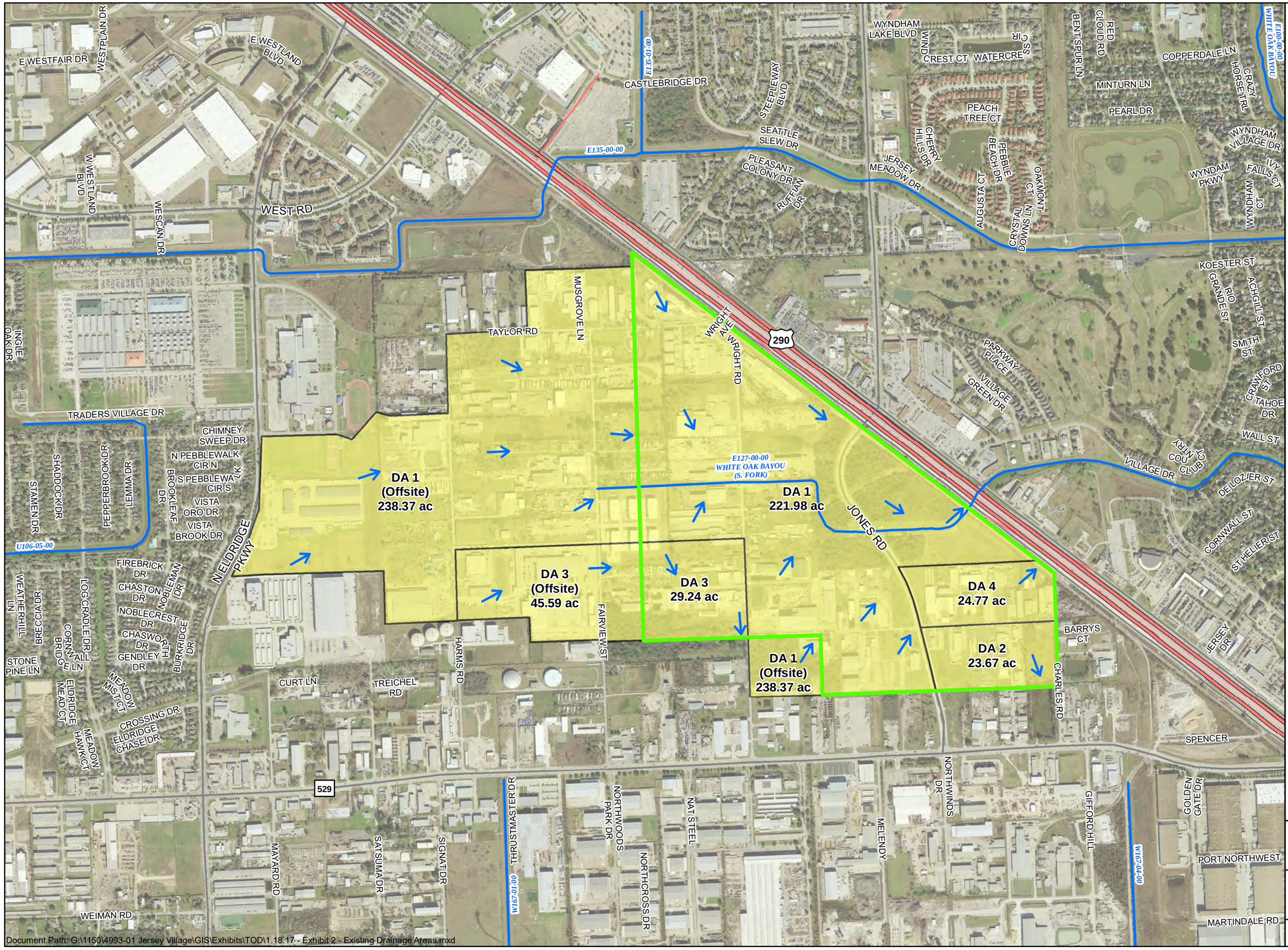

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Legend

- Streams
- TOD
- TOD Existing DA

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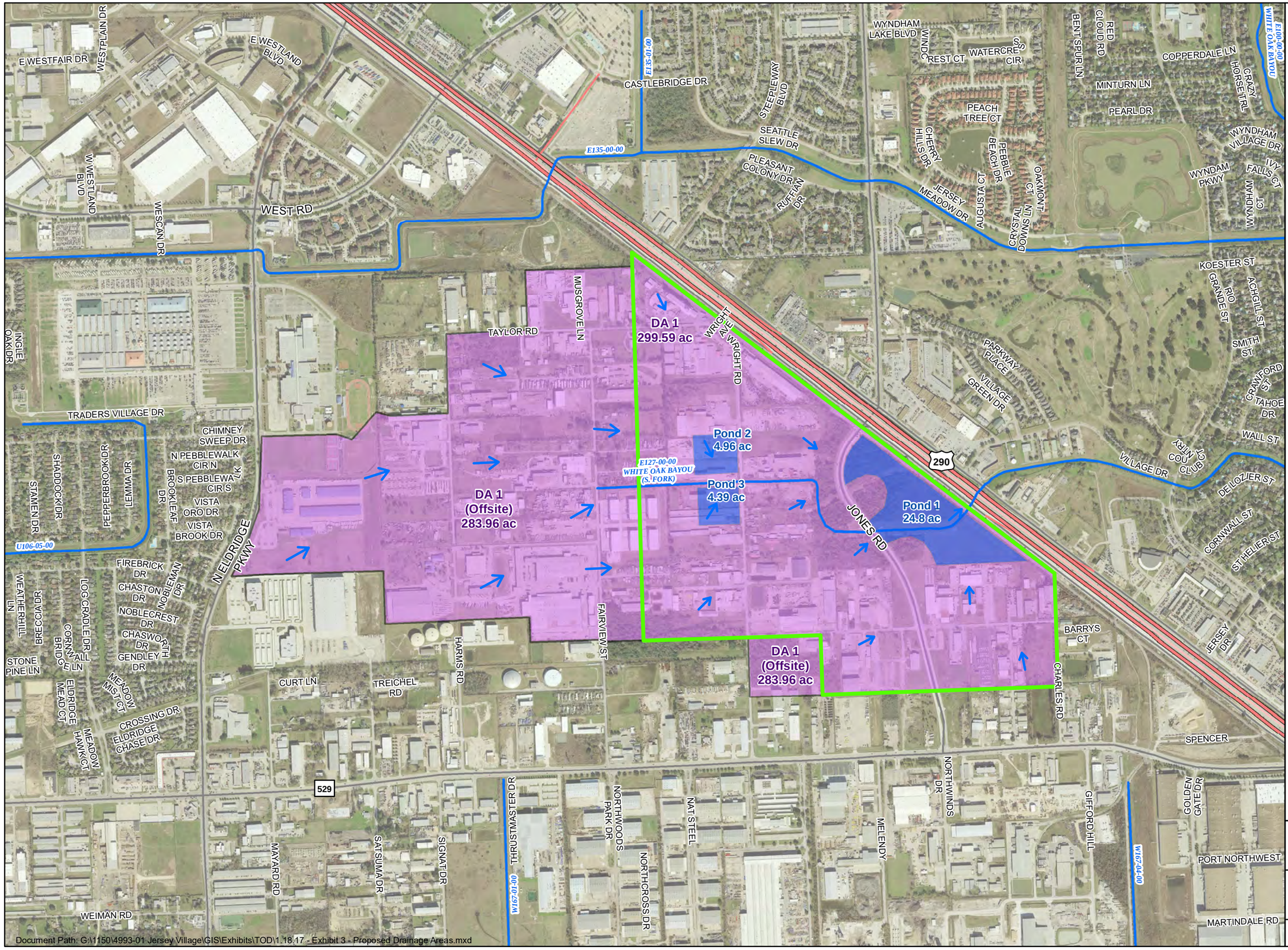
City of Jersey Village
Long-term Flood Recovery Plan

Exhibit 2
TOD Existing Drainage Area Map

1 in. = 1,000 ft | January, 2017



Legend

- Streams
- TOD
- Pond Area
- TOD Proposed DA

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City of Jersey Village
Long-term Flood Recovery Plan

Exhibit 3
TOD Proposed Drainage Area Map

1 in. = 1,000 ft	January, 2017

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Offsite Drainage Areas (Not Shown)	
Land Use	Area (ac)
Commercial	*115.8*
Governmental	*1.4*
Industrial	*58*
Residential	*34.9*
Schools	*49.6*
Undeveloped	*12.6*

DA 1 (Offsite) 238.37 ac

DA 1 221.98 ac

DA 3 29.24 ac

DA 3 (Offsite) 45.59 ac

DA 1 (Offsite) 238.37 ac

DA 4 24.77 ac

DA 2 23.67 ac

CHARLES RD

E127-00-00 WHITE OAK BAYOU (S. FORK)

VILLAGE DR

290

Legend

- Streams
- Contour (1 ft)
- TOD
- TOD Existing DA

TOD Existing Land Use

Channel	*(4.2 ac)*
Commercial	*(192.4 ac)*
Industrial	*(6.5 ac)*
Residential	*(14.7 ac)*
Road	*(7.4 ac)*
Undeveloped	*(65.8 ac)*

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0 500 1,000 Ft

City of Jersey Village
Long-term Flood Recovery Plan

Exhibit 4
TOD Existing Project Area Map

1 in. = 500 ft | January, 2017

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Offsite Drainage Areas (Not Shown)	
Land Use	Area (ac)
Commercial	*115.8*
Governmental	*1.4*
Industrial	*58*
Residential	*34.9*
Schools	*49.6*
Undeveloped	*12.6*

DA 1 (Offsite) 283.96 ac

Pond 2 4.96 ac

Pond 3 4.39 ac

DA 1 299.59 ac

Pond 1 24.8 ac

DA 1 (Offsite) 283.96 ac

E127:00:00 WHITE OAK BAYOU (S FORK)

Legend

- Streams
- Contour (1 ft)
- TOD
- Proposed DA

Pond Layout

- Berm
- Toe of Pond
- Top of Pond

TOD Proposed Land Use

- Green Area *(37.9 ac)*
- Water *(30.1 ac)*
- Commercial *(101.8 ac)*
- Industrial *(21.9 ac)*
- Residential *(108.0 ac)*

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City of Jersey Village
Long-term Flood Recovery Plan

Exhibit 5
TOD Proposed Project Area Map

1 in. = 500 ft | January, 2017

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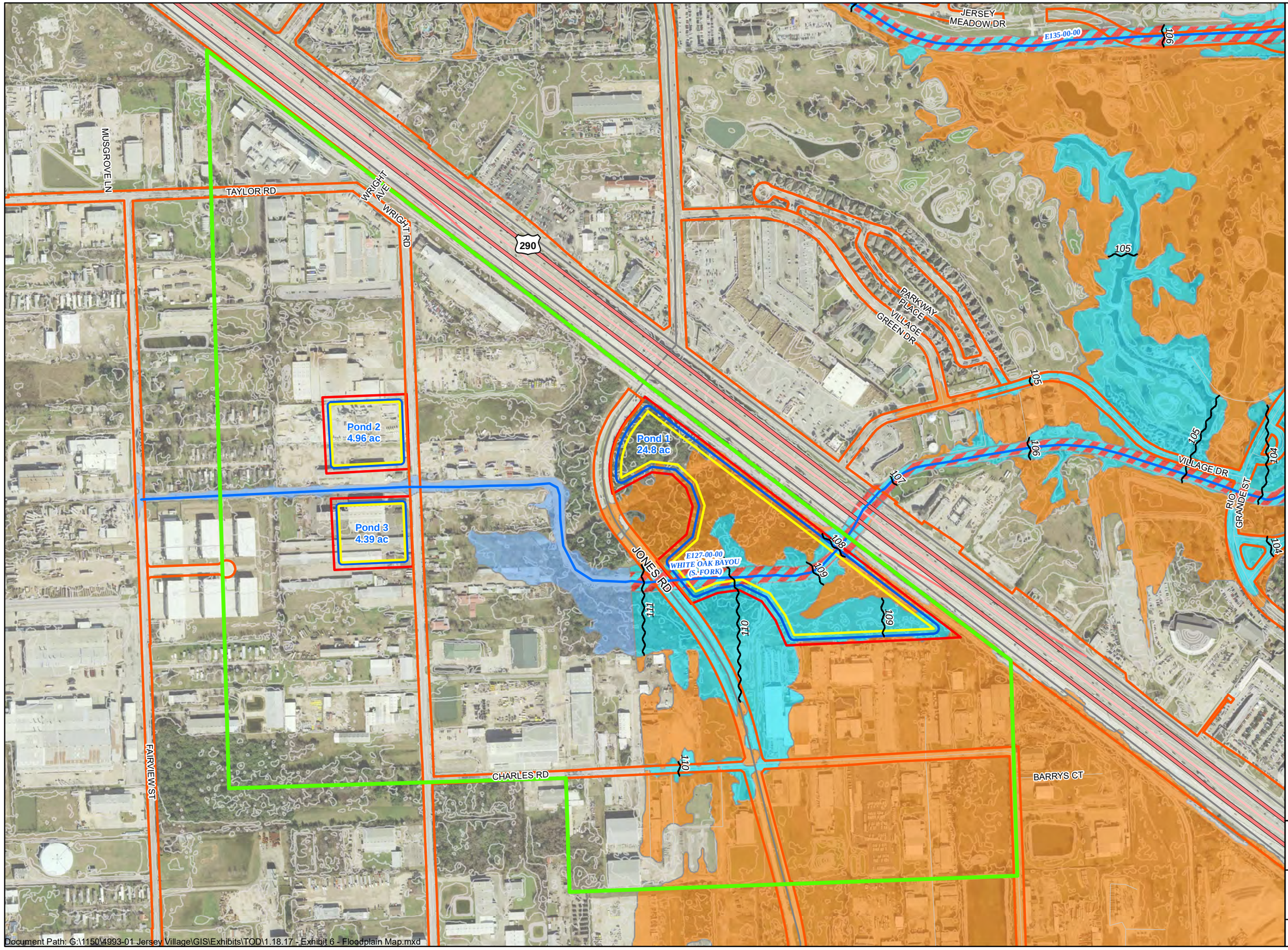

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Legend

- Base Flood Elevation
- Streams
- Right-of-Way
- Contour (1 ft)
- TOD

Pond Layout

- Berm
- Toe of Pond
- Top of Pond

FEMA Effective Floodplain

- A
- AE
- AE, Floodway
- X, 0.2% Flood Event

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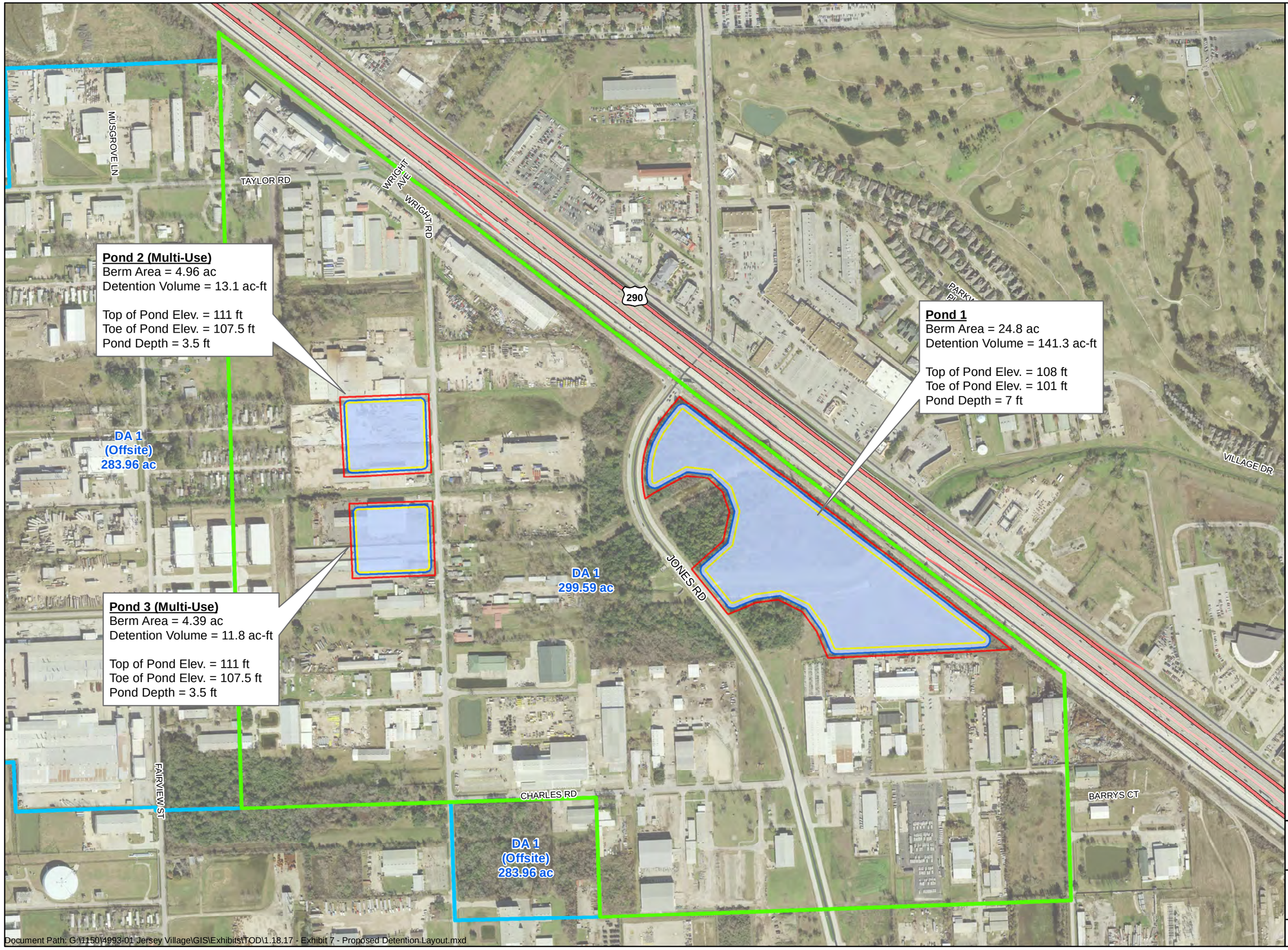
City of Jersey Village
Long-term Flood Recovery Plan

Exhibit 6
FEMA Effective Floodplain Map

1 in. = 526 ft | January, 2017



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Legend

- TOD
- TOD Proposed DA

Pond Layout

- Berm
- Toe of Pond
- Top of Pond

DANNENBAUM

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0 500 1,000 Ft

City of Jersey Village
Long-term Flood Recovery Plan

Exhibit 7
TOD Proposed Detention Layout

1 in. = 500 ft | January, 2017

Exhibit 8

TOD Existing Peak Flow Calculations

	Drainage Area	Area *ac*	% Impervious Cover	b	m	Q_P (formula) *cfs*	Total Rainfall *in*	Direct Run-Off *in*	Total Run-off Volume ft^3	Total Run-off Volume *ac-ft*	T_P *s*	T_P *min*
10% Event (10-year)	1	460.25	61.2%	5.21	0.823	810	7.6	6.77	11,312,397	260	10,043	167.4
	2	23.67	54.4%	5.02	0.823	68	7.6	6.62	568,744	13	6,035	100.6
	3	74.83	60.1%	5.18	0.823	181	7.6	6.75	1,832,731	42	7,299	121.7
	4	24.77	85.0%	5.90	0.823	83	7.6	7.30	656,380	15	5,703	95.0
1% Event (100-year)	1	460.25	61.2%	7.96	0.823	1237	13.2	12.37	20,668,359	474	12,016	200.3
	2	23.67	54.4%	7.75	0.823	105	13.2	12.22	1,049,908	24	7,212	120.2
	3	74.83	60.1%	7.93	0.823	276	13.2	12.35	3,353,875	77	8,732	145.5
	4	24.77	85.0%	8.70	0.823	122	13.2	12.90	1,159,905	27	6,834	113.9

Exhibit 9

TOD Proposed Peak Flow Calculations

	Drainage Area	Area *ac*	% Impervious Cover	b	m	Q_P (formula) *cfs*	Total Rainfall *in*	Direct Run-Off *in*	Total Run-off Volume ft^3	Total Run-off Volume *ac-ft*	T_P *s*	T_P *min*
10% Event (10-year)	1	583.55	59.9%	5.18	0.823	978	7.6	6.74	14,283,620	328	10,504	175.1
1% Event (100-year)	1	583.55	59.9%	7.92	0.823	1497	13.2	12.34	26,146,025	600	12,565	209.4