MARE ISLAND
DRAINAGE REPORT
Charlie, Delta and Foxtrot Outfalls

Vallejo, CA

Date:
August 21, 2019

Prepared by:
BKF Engineers

Prepared For:
Lennar Mare Island, LLC

This report has been prepared by or under the supervision of the following Registered Civil Engineer(s):

Brian Scott, P.E.

Ramon Alvarez-Muro, P.E.

REGISTERED PROFESSIONAL ENGINEER
BRIAN SCOTT
PE 61034
CIVIL
STATE OF CALIFORNIA

MARE ISLAND
DRAINAGE REPORT

INTRODUCTION

The following presents BKF Engineers (BKF) analyses of the existing storm drainage system to three main outfalls on Mare Island in Vallejo, California (City). The hydrology and hydraulics study includes Charlie, Delta, and Foxtrot outfalls on the eastern side of Mare Island. The portion of the Mare Island evaluated is approximately 156 acres. The site consists primarily of industrial areas along the Napa River. See Figure 1A for the outfall delineations.

SCOPE OF THE REPORT

This report addresses the hydrology and hydraulics of the existing storm drainage facilities and the recommended improvements for the drainage basin trunk lines only. This report does not evaluate future smaller storm laterals within the three drainage basins. The design of these laterals is dependent on the future improvements that will be designed at a later date. Subsequent drainage reports will be prepared to document the hydrology and hydraulics for the future storm drain laterals.

For this report, contributing drainage areas for the smaller outfalls have been redirected to the main trunk lines and outfalls. The main outfalls have been sized with these areas to provide flexibility moving forward. Depending on the final development plans, some of the smaller existing outfalls may remain.

PROJECT DESCRIPTION

Land Use

The project site is parcels and roadways within a special zoning for Mare Island. The project site is fully developed and consists mostly of industrial use occupancy. For this reason a runoff coefficient of 0.90 is used for all drainage areas. On the southwestern edge of the study area, Foxtrot Basin includes some residential land use areas.

Existing Drainage Watersheds

Site drainage flows to three main outfalls along the Napa River, which discharges into the San Francisco Bay at the southern edge of Mare Island. Within Charlie Basin and Delta Basin, there are eleven smaller outfalls that collect local drainage and discharge directly to the Napa River. Existing site hydrology is shown in Figure 1B, 1D and 1F.

Existing drainage delineations are based on aerial topographic survey (conducted in March of 2018) and extensive field investigation of the existing storm drain structures in the study area. Within the three basins, site investigation and verification of the drainage system was conducted on approximately 350 structures. The findings of the field investigation have been incorporated in the hydraulic analysis of the site.

The regional drainage pattern is generally from the south to the north towards the Napa River while the southwestern portion of the site drains to the west. Overland release directions within Charlie Basin are towards the Napa River on the south side of G Street. On the Napa River side of Railroad Avenue, overland release directions for both Delta and Foxtrot Basin follow a similar path towards the Napa River. On the southern side of Railroad Avenue, overland release directions for Delta and Foxtrot Basin are towards the undeveloped parcels to the west.

Proposed Drainage Watersheds

Changes to the three watersheds are proposed to more efficiently make use of the current outfall sizes. Proposed changes to the storm drainage watersheds are shown on Figure 5A. Runoff is conveyed to the three main outfalls which discharge to the Napa River.

ANALYSIS APPROACH

The drainage systems are evaluated for the 15-year peak storm event. Peak flow rates through the Project area are computed using the Rational Method. Water levels throughout the projects storm drain systems are analyzed using the Stormcad computer program, which evaluates for both surcharge and non-surcharge flow conditions.

DESIGN PARAMETERS/STANDARDS

Calculations included in this report are based on the following design parameters/standards:

- All elevations presented are based on the NAVD 88 vertical datum.
- A minimum time of concentration of 10 minutes is used where runoff from parcels will enter the storm drain system.
- For proposed conditions, the travel time in the pipe is computed based on a free outfall to avoid artificially high pipe travel times associated with low flow velocities determined under surcharged pipe conditions.
- The Stormcad computer program by Bentley is used to evaluate Rational Method flow rates, travel time in pipes and depth of flow in pipes. The HEC-22 Energy junction loss method is used. Manholes are considered half benched for lines larger than 30 inches. Manholes are considered flat for all other lines.

Additionally this report has been prepared in accordance with the Vallejo Flood and Wastewater District's (VFWD) standards as described below in Table 1:

Table 1: Storm Drain Design Criteria

Parameter	District Standard	Value used in modeling
Elevations		North American Datum 1988
Runoff Coefficient	Varies based on land use	C = 0.90 (Basin wide)

Pipe material for pipes up to 36-inch diameter		HDPE
Pipe material for pipes larger than 36-inch diameter		RCP
Manhole spacing	350-feet maximum for lines less than or equal to 24 inches 500 feet for lines greater than 24 inches	350-feet maximum for lines less than or equal to 24 inches 500 feet for lines greater than 24 inches
Structure Energy Loss Method		HEC-22 Energy (second edition)
Structure Energy Loss Benching		30-inch lines & smaller - Flat Lines larger than 30 inches - Half
Minimum flow velocity	2.5 fps when flowing half full	2.0 fps when flowing half full
Maximum flow velocity	10 fps when flowing half full	10 fps when flowing half full
Starting hydraulic grade line at Napa River outfalls	6.20 Mean Sea Level (NAVD 88)	6.20 Mean Sea Level (NAVD 88)
15-year Design Storm - Rainfall intensity use will be based on a minimum time of concentration Tc = 10 min	2.76 in/hr (Solano County Water Agency Hydrology Manual)	2.76 in/hr (Solano County Water Agency Hydrology Manual)
Mean Annual Precipitation	20 inches per year	20 inches per year
Minimum pipe slope	12-inch = 0.003 ft/ft 15-inch = 0.0023 ft/ft 18-inch = 0.0018 ft/ft 24-inch = 0.0012 ft/ft 36-inch = 0.0007 ft/ft	0.0010 ft/ft or higher

Variances to VFWD Standards

Table 2 below is a list of variances to the District's standards that were used in the design and modeling of the proposed storm drain system. Due to the flat topography of the island, the new pipes need to be as shallow as possible in order to drain the entire basins. These variances help improve the efficiency of the new storm drain system by reducing the depth of the storm drain pipes.

Table 2: Storm Drain Design Criteria Variances

Parameter	District Standard	Value used in modeling
Minimum pipe size	12-inch diameter from catch basins, otherwise 15-inch diameter	15-inch diameter (smaller for a few already constructed lines)
Manning's n (roughness coefficient) for proposed pipes	All pipe: 0.013	HDPE: 0.011 RCP: 0.013
Minimum depth of cover for mains	5-feet minimum	3-feet minimum[(1)]

Minimum Freeboard for 15-year design storm	Energy Grade Line to Ground 2-feet	Hydraulic Grade Line to Ground 0.75-feet

Notes:
1. Pipes installed with less than 5 feet of cover must have a load capacity of at least 2,000 lbs/square foot (includes Class IV RCP, Class V RCP, and HDPE pipe), must be backfilled with controlled low strength material (CLSM), or installed with concrete caps. Load calculations for minimum cover are provided in Appendix B.

EXISTING LEVEL OF SERVICE

Existing storm drainage areas are shown on Figures 1B, 1D and 1F. Based on observations, the existing storm drain systems function during normal rainfall events. However, in terms of the design storm, the existing storm system is undersized and hydraulically deficient. There are also large onsite areas that are subject to long-term ponding following storm events because of either clogged inlets or no inlets serving localized low points.

Most of the existing system mains do not have adequate capacity for the design storm in all of the three basins. In addition, the existing 30-inch HDPE outfall at Charlie Basin and the 1-foot by 6-foot outfall at Foxtrot Basin collect storm drainage that far exceeds their respective capacities. A summary of the existing results are shown on Figures 1C, 1E and 1G.

Figure 6 shows the existing overland release path for the three drainage basins. Most of the areas within the basins have a positive overland release path. There are three locations that do not have an overland release path due to low site elevations.

1. Area 1 – This area is located in the Foxtrot Basin. A new 30-inch truck storm drain line through the coal sheds was recently installed in this area that has capacity in excess of the 100-year event. The oversized main trunk line will provide capacity to prevent ponding during the 100-year event.
2. Area 2 – This area is located in the Delta Basin. There is a low lying area to the south of Building 489 on 3rd Street. The ponding depth is approximately 2-inches before runoff will overland flow to the west towards Azuar Dr.
3. Area 3 – This area is located in the Charlie Basin. There is a low lying area around Building 559. The ponding depth is approximately 7-inches before runoff will overland flow to the west towards Azuar Dr.

PROPOSED IMPROVEMENTS

Proposed storm drainage facilities are shown on Figures 5B, 5C and 5D. The proposed storm system uses the three main existing outfalls. Schematics of the drainage systems modeled in Stormcad are shown on Figure 5BB, 5CC and 5DD.

The existing 72-inch RCP outfall at Delta Basin has the greatest capacity, but currently receives less runoff than the hydraulically deficient 30-inch HDPE outfall at Charlie Basin. Similarly, the 1-foot by 6-foot outfall at Foxtrot Basin collects approximately 70% of the area directed to the Delta Basin outfall. As a result, the proposed system diverts flow from both Charlie and Foxtrot through the public streets to the Delta Basin mainline.

All existing storm drain lines through existing buildings will be re-routed around the buildings (with one exception in Foxtrot Basin). Wherever possible, the proposed trunk lines are located within existing alignments in order to reduce the possibility of utility conflicts at the site.

For Charlie Basin, trunk line improvements are from existing 12-inch through 24-inch lines to proposed 30-inch through 42-inch lines. For Delta Basin, trunk line improvements are from existing 24-inch through 48-inch lines to proposed 36-inch through 72-inch lines. The trunk line improvements for Foxtrot Basin are from existing 15-inch through 21-inch lines to proposed 15-inch through 36-inch lines.

New streets and site improvements shall be designed to provide positive overland release for the 100-year storm event. Building elevations shall be set to be above the anticipated 100-year overland flow depths. Existing site elevations around buildings 489 and 559 will need to be raised to eliminate localized ponding.

CONCLUSIONS

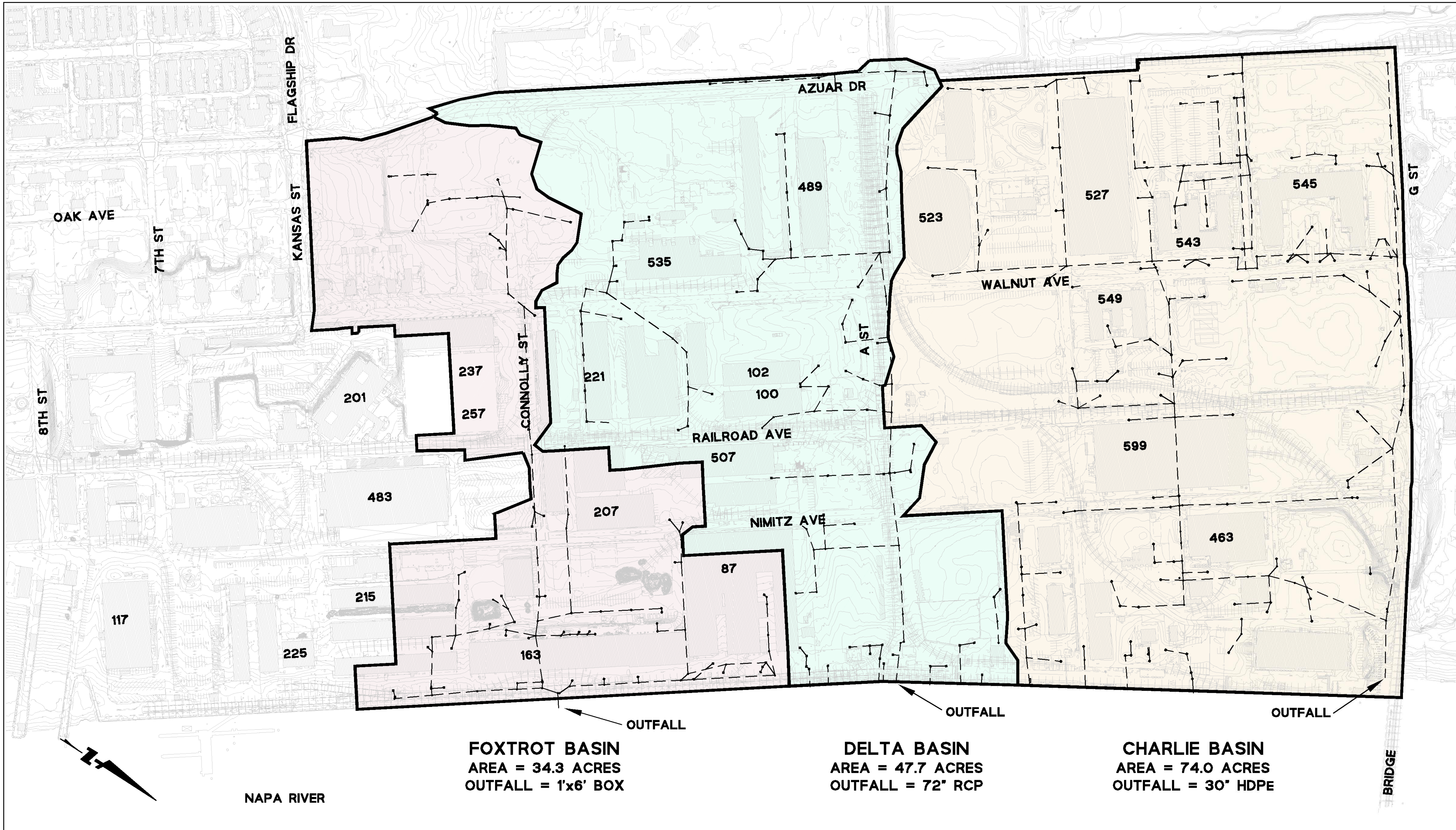
- Based on the field verified data existing storm drain systems in Charlie, Delta and Foxtrot watersheds do not provide a 15-year storm event level of service.

- When variances of Table 2 are taken into account the proposed storm drain systems for Charlie, Delta and Foxtrot meet the 15-year storm design storm at all minus one location. The one location is the first upstream manhole above the Charlie Outfall which is located on what was previously a boat launch area. This location should it flood would not cause any property damage and flood waters would simply overland release to the Mare Island Straight down the boat launch. For this node, a bolt-down, open grate is recommended.

LIST OF FIGURES

LIST OF TABLES

APPENEDICES



DRAWING NAME: J:\2017\170420_Mare_Island\ENG\EXHIBITS\Hydrology-Hydraulics\Figure-1A-OVERALL.dwg
PLOT DATE: 08-28-18 PLOTTED BY: TAYL

JOB No:	20170420
DATE:	AUG 2019
BY:	J.T.
REV:	R.A.M.

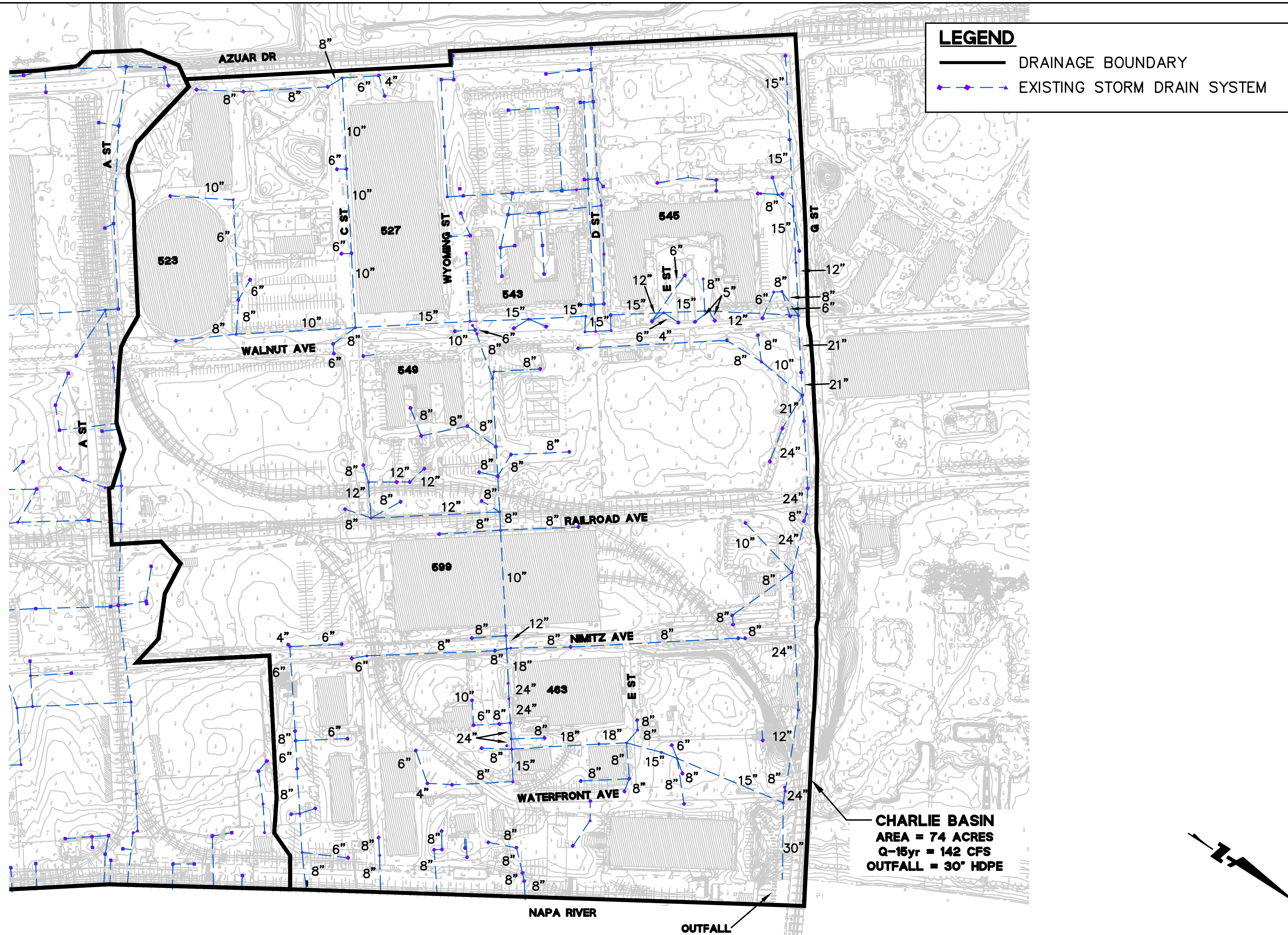
GRAPHIC SCALE

300 0 300 600

FIGURE 1A

MARE ISLAND
HYDROLOGY AND HYDRAULIC ANALYSIS
CHARLIE, DELTA, FOXTROT WATERSHED KEYMAP

BKF 100+ YEARS
ENGINEERS SURVEYORS PLANNERS



GRAPHIC SCALE

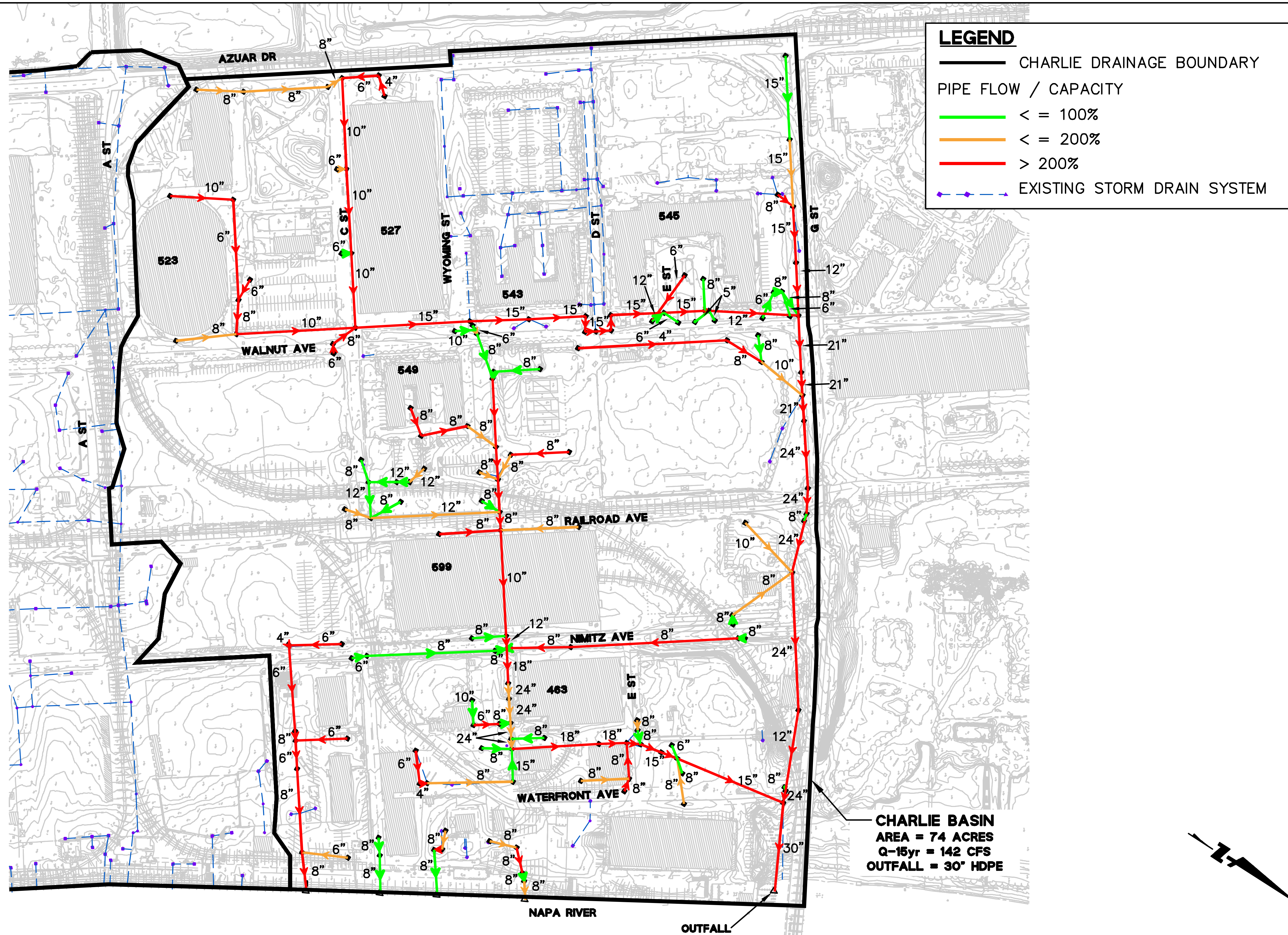
250 0 250 500

JOB No: 20170420
DATE: AUG 2019
BY: J.T.
REV: R.A.M.

FIGURE 1B
MARE ISLAND
HYDROLOGY AND HYDRAULIC ANALYSIS
CHARLIE BASIN WATERSHED

BKF 100+ YEARS ENGINEERS SURVEYORS PLANNERS

DRAWING NAME: J:\2017\170420_Mare_Island\ENG\EXHIBITS\Hydrology-Hydraulics\FIG_Char_Drainage_Areas.dwg
PLOT DATE: 08-29-19 PLOTTED BY: tayl



DRAWING NAME: J:\2017\170420_Mare_Island\ENG\EXHIBITS\Hydrology-Hydraulics\FIG_Char_Drainage_Areas.dwg
PLOT DATE: 08-28-19 PLOTTED BY: tayl

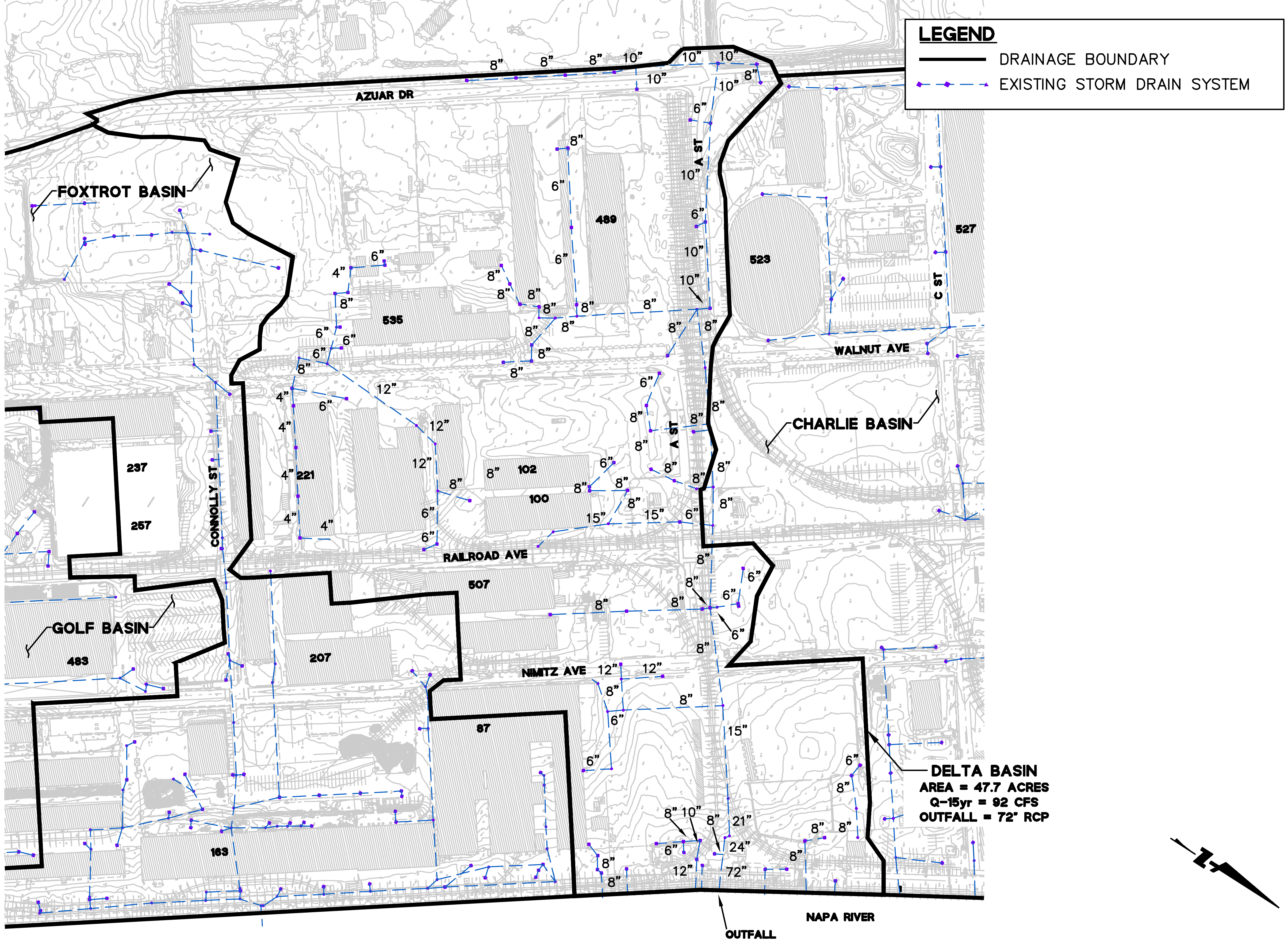
JOB No: 20170420
DATE: AUG 2019
BY: J.T.
REV: R.A.M.

GRAPHIC SCALE
250 0 250 500

FIGURE 1C
MARE ISLAND
HYDROLOGY AND HYDRAULIC ANALYSIS
CHARLIE BASIN WATERSHED - PIPE FLOW / CAPACITY FOR 15-YEAR STORM

BKF 100+ YEARS ENGINEERS SURVEYORS PLANNERS

©BKF Engineers



GRAPHIC SCALE

250 0 250 500

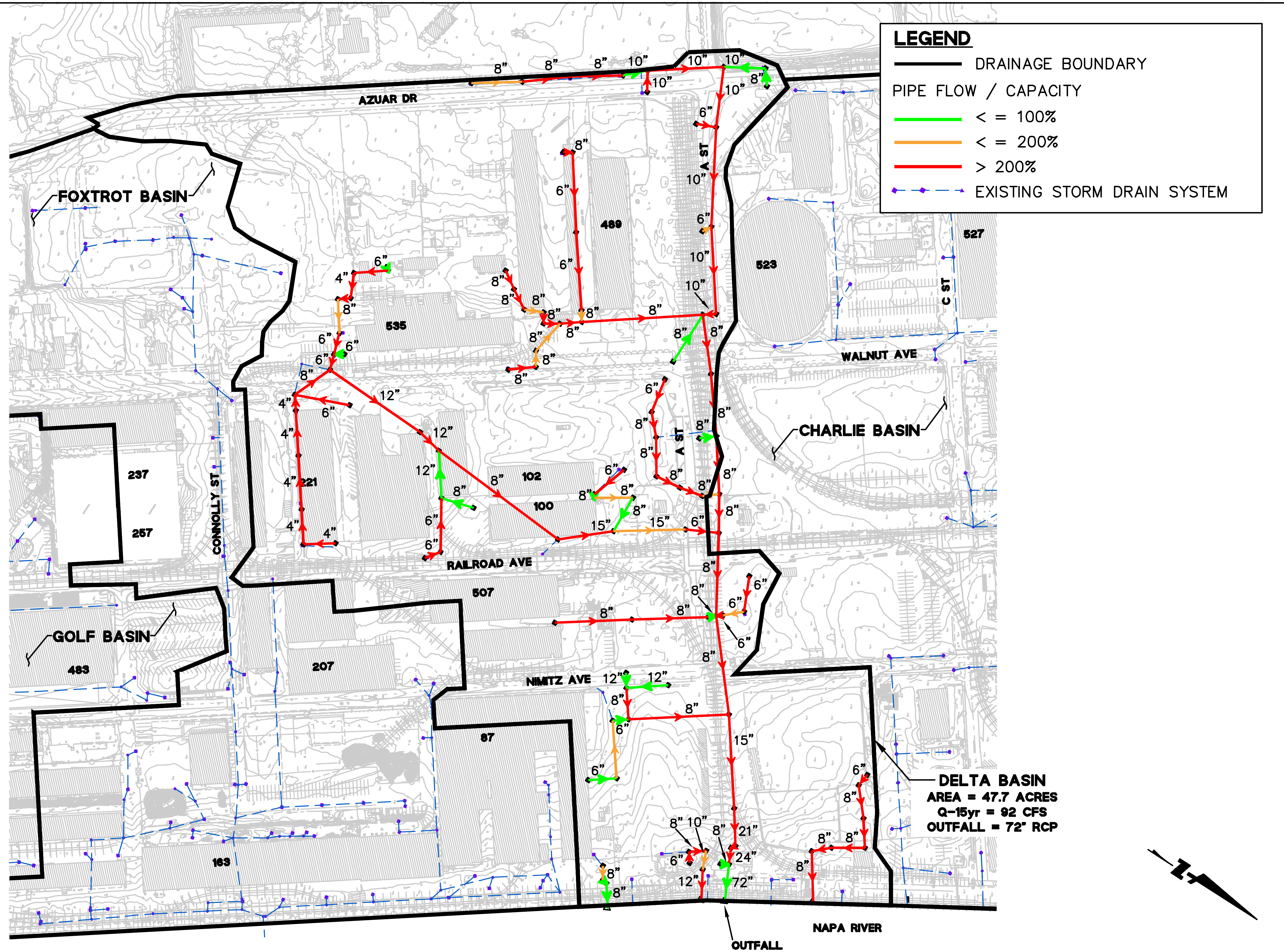
JOB No: 20170420
DATE: AUG 2019
BY: J.T.
REV: R.A.M.

FIGURE 1D
MARE ISLAND
HYDROLOGY AND HYDRAULIC ANALYSIS
DELTA BASIN WATERSHED

BKF
100+ YEARS
ENGINEERS
SURVEYORS
PLANNERS

DRAWING NAME: J:\2017\170420_Mare_Island\ENG\EXHIBITS\Hydrology-Hydraulics\FIG_Delt_Drainage_Areas.dwg
PLOT DATE: 08-28-19 PLOTTED BY: tayl

©BKF Engineers



JOB No:	20170420
DATE:	AUG 2019
BY:	J.T.
REV:	R.A.M.

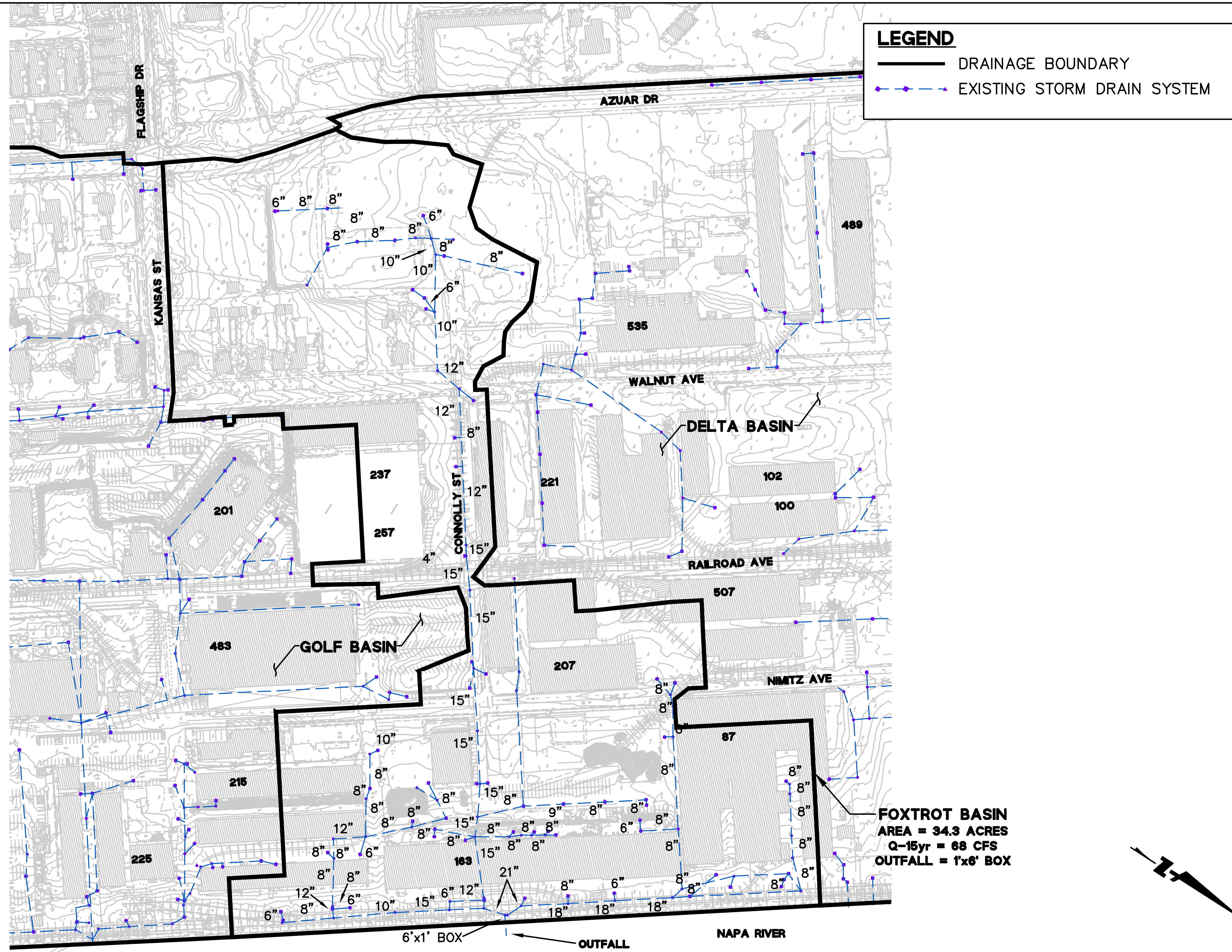
GRAPHIC SCALE

250 0 250 500

FIGURE 1E
MARE ISLAND
HYDROLOGY AND HYDRAULIC ANALYSIS
DELTA BASIN WATERSHED - PIPE FLOW / CAPACITY FOR 15-YEAR STORM

BKF
100+ YEARS
ENGINEERS
SURVEYORS
PLANNERS

DRAWING NAME: J:\2017\170420_Mare_Island\ENG\EXHIBITS\Hydrology-Hydraulics\FIG_Delt_Drainage_Areas.dwg
PLOT DATE: 08-28-19 PLOTTED BY: tayl



GRAPHIC SCALE

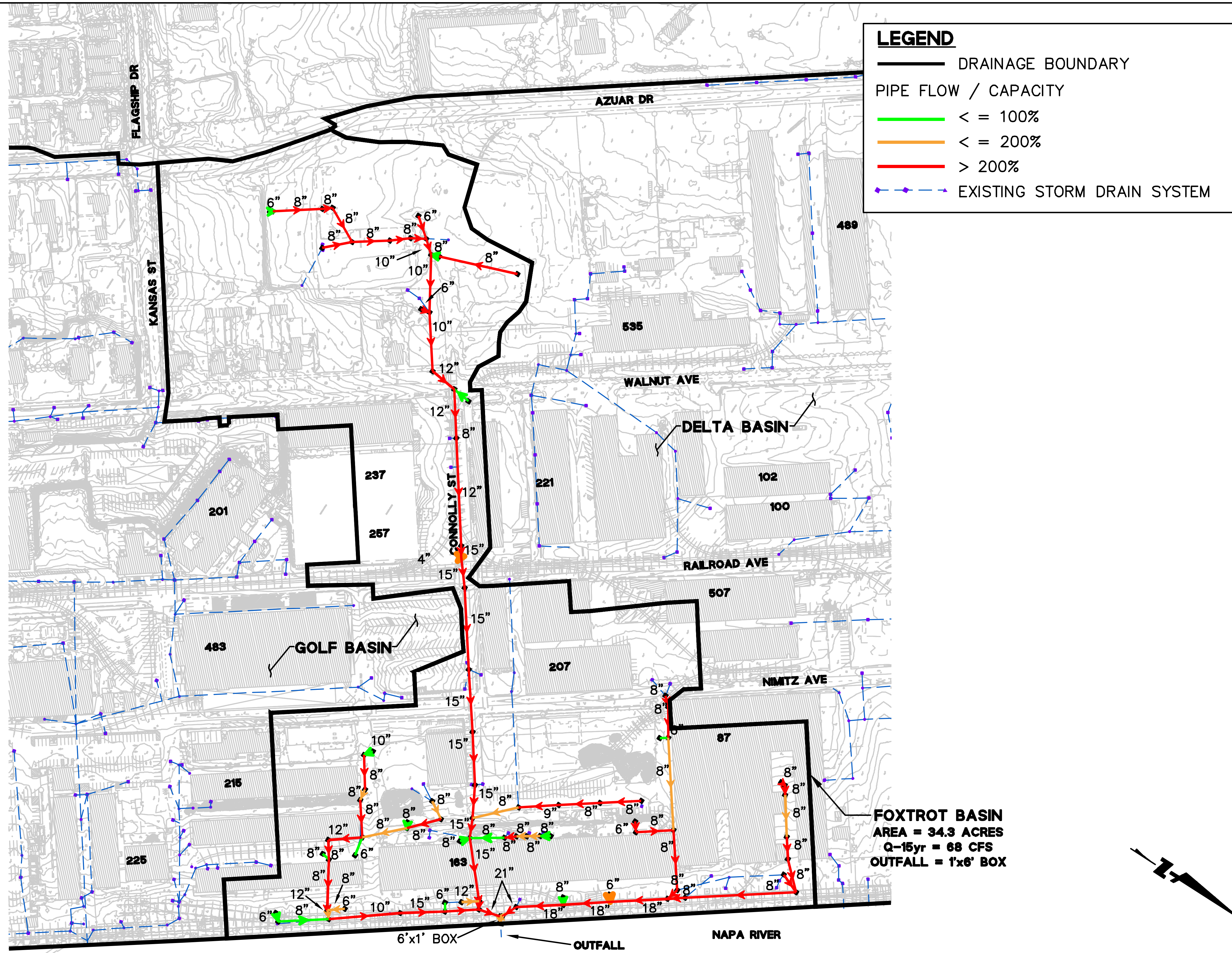
250 0 250 500

JOB No: 20170420
DATE: AUG 2019
BY: J.T.
REV: R.A.M.

FIGURE 1F
MARE ISLAND
HYDROLOGY AND HYDRAULIC ANALYSIS
FOXTROT BASIN WATERSHED

BKF
100+ YEARS
ENGINEERS
SURVEYORS
PLANNERS

DRAWING NAME: J:\2017\170420_Mare_Island\ENG\EXHIBITS\Hydrology-Hydraulics\FIG_Fox_Drainage_Areas.dwg
PLOT DATE: 08-29-19 PLOTTED BY: tayl



GRAPHIC SCALE

250 0 250 500

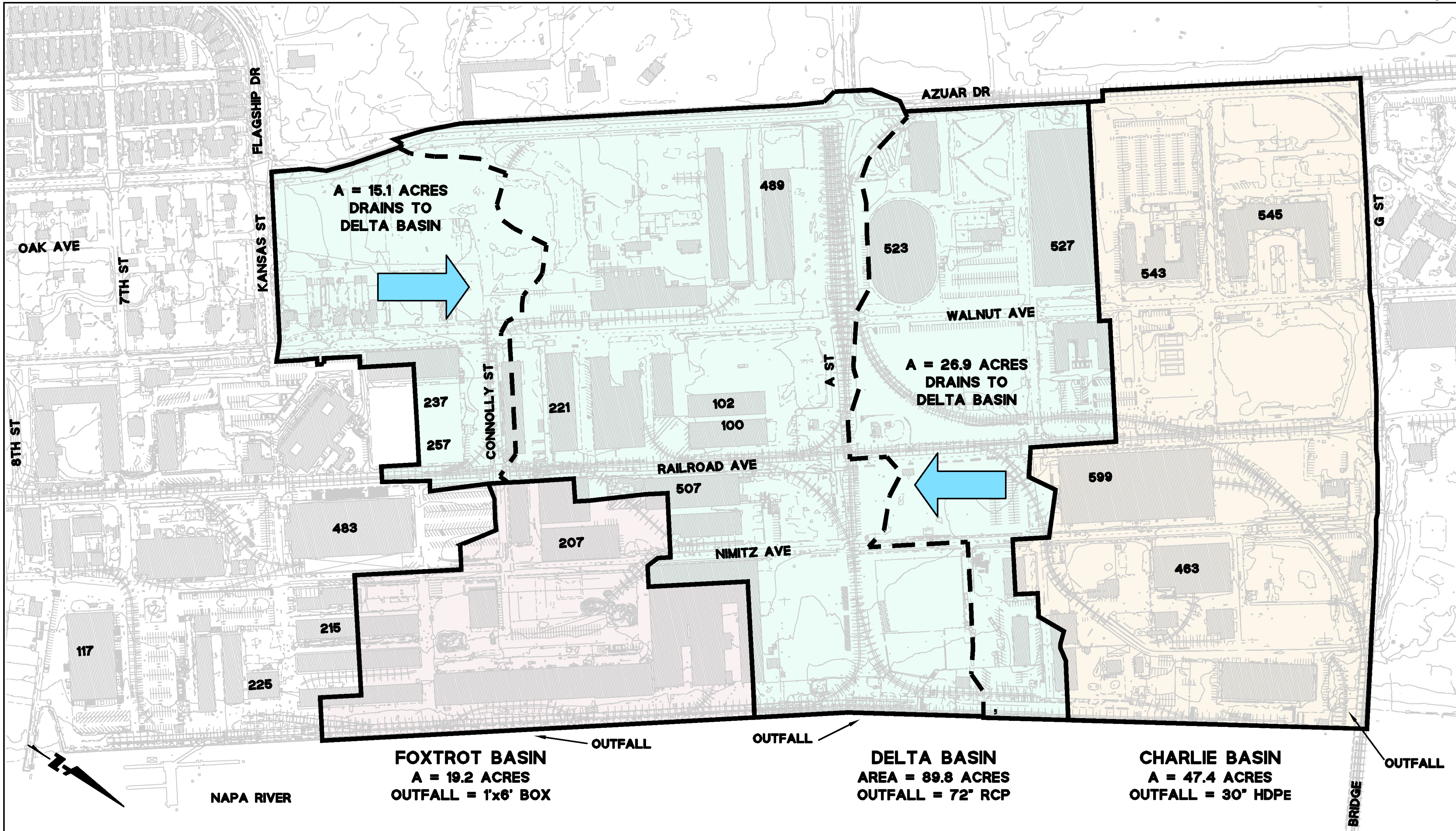
JOB No: 20170420
DATE: AUG 2019
BY: J.T.
REV: R.A.M.

FIGURE 1G
MARE ISLAND
HYDROLOGY AND HYDRAULIC ANALYSIS
FOXTROT BASIN WATERSHED - PIPE FLOW / CAPACITY FOR 15-YEAR STORM

BKF
100+ YEARS
ENGINEERS
SURVEYORS
PLANNERS

DRAWING NAME: J:\2017\170420_Mare_Island\ENG\EXHIBITS\Hydrology-Hydraulics\FIG_Fox_Drainage_Areas.dwg
PLOT DATE: 08-29-19 PLOTTED BY: tayl

©BKF Engineers



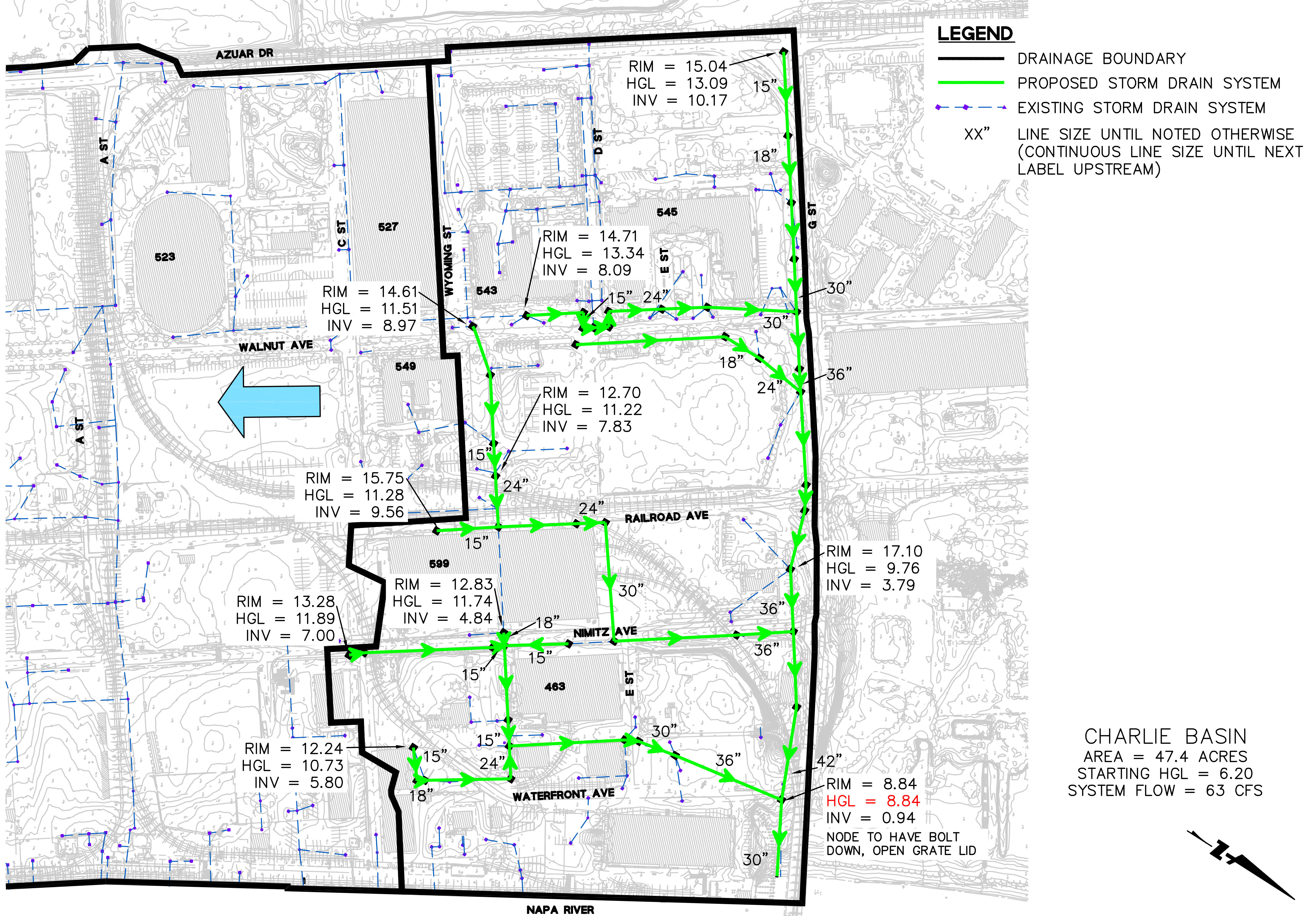
DRAWING NAME: J:\2017\170420_Mare_Island\ENG\EXHIBITS\Hydrology-Hydraulics\Figures-ALT4.dwg
PLOT DATE: 08-20-19 PLOTTED BY: TATL

JOB No: 20170420
DATE: AUG 2019
BY: J.T.
REV: R.A.M.

GRAPHIC SCALE
300 0 300 600

FIGURE 5A
MARE ISLAND
HYDROLOGY AND HYDRAULIC ANALYSIS
ALTERNATIVE 4 PROPOSED WATERSHEDS

BKF 100+ YEARS
ENGINEERS SURVEYORS PLANNERS



DRAWING NAME: \\Bk1-rc\vol4\2017\170420_Mare_Island\ENG\EXHIBITS\Hydrology-Hydraulics\Figures-ALT4.dwg
PLOT DATE: 07-01-19 PLOTTED BY: tayl

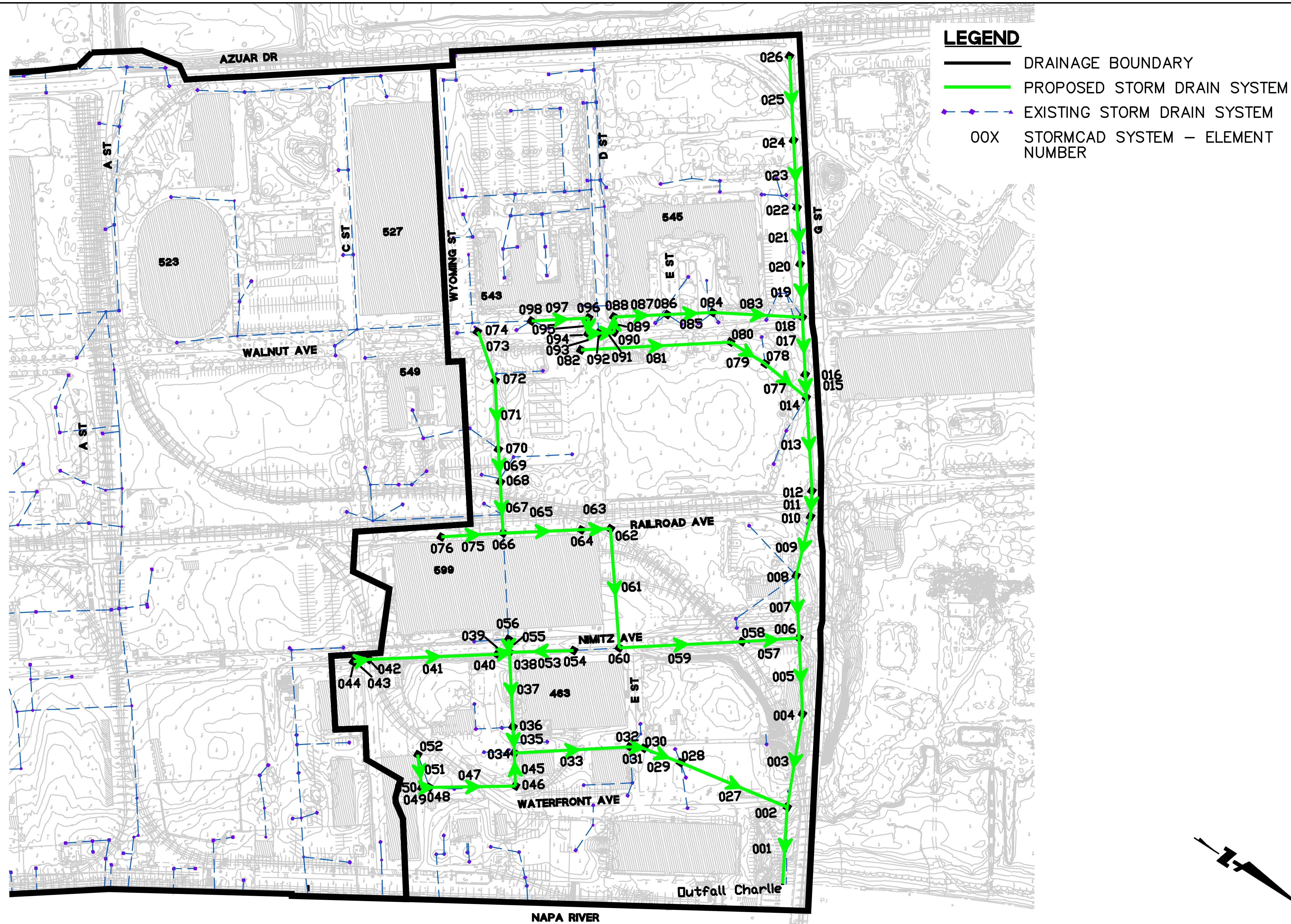
JOB No: 20170420
DATE: AUG 2019
BY: J.T.
REV: R.A.M.

GRAPHIC SCALE

250 0 250 500

FIGURE 5B
MARE ISLAND
HYDROLOGY AND HYDRAULIC ANALYSIS
PROPOSED CHARLIE BASIN WATERSHED - 15-YEAR STORM RESULTS

BKF 100+ YEARS
ENGINEERS
SURVEYORS
PLANNERS



GRAPHIC SCALE

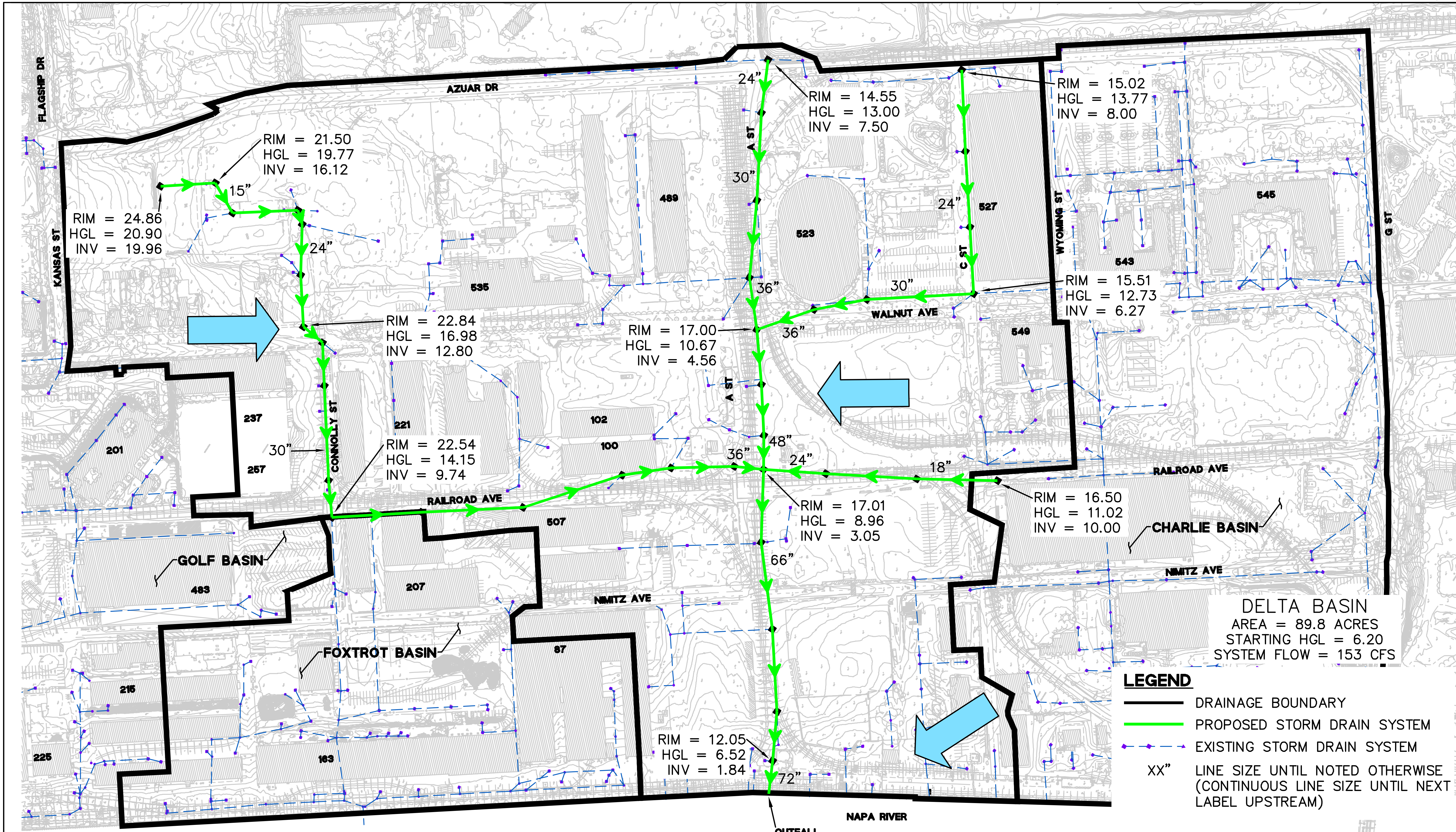
250 0 250 500

JOB No: 20170420
DATE: AUG 2019
BY: J.T.
REV: R.A.M.

FIGURE 5BB
MARE ISLAND
HYDROLOGY AND HYDRAULIC ANALYSIS
CHARLIE BASIN STORMCAD SCHEMATIC

BKF 100+ YEARS ENGINEERS SURVEYORS PLANNERS

DRAWING NAME: \\Bkf-rc\vol4\2017\170420_Mare_Island\ENG\EXHIBITS\Hydrology-Hydraulics\StormCad_Schematics.dwg
PLOT DATE: 10-29-18 PLOTTED BY: laut



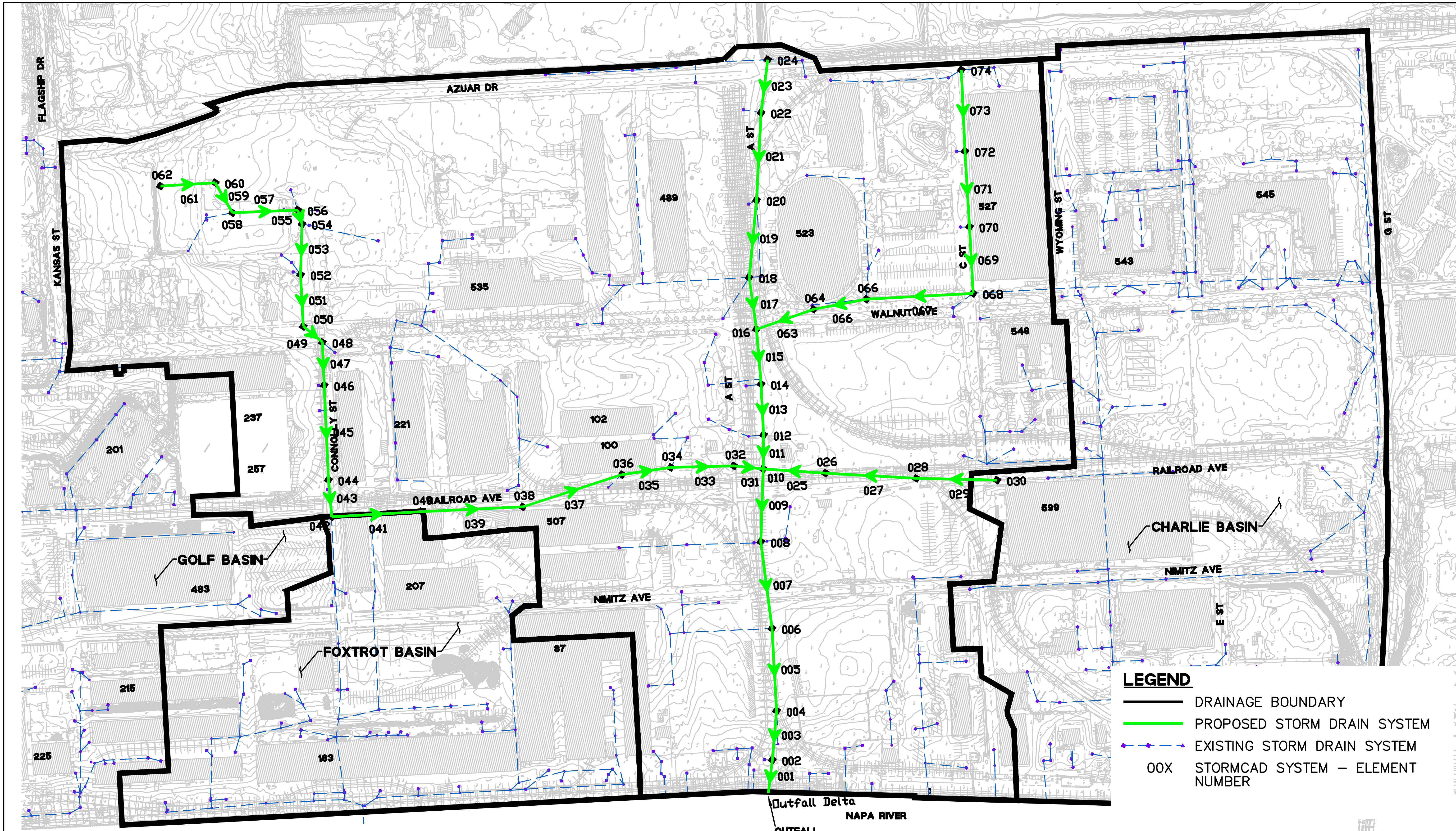
DRAWING NAME: J:\2017\170420_Mare_Island\ENG\EXHIBITS\Hydrology-Hydraulics\Figures-ALT4.dwg
PLOT DATE: 08-20-19 PLOTTED BY: TAYL

JOB No: 20170420
DATE: AUG 2019
BY: J.T.
REV: R.A.M.

GRAPHIC SCALE
250 0 250 500

FIGURE 5C
MARE ISLAND
HYDROLOGY AND HYDRAULIC ANALYSIS
PROPOSED DELTA BASIN WATERSHED - 15-YEAR STORM RESULTS

BKF 100+ YEARS ENGINEERS SURVEYORS PLANNERS



DRAWING NAME: \\Bkf-rc\vol4\2017\170420_Mare_Island\ENG\EXHIBITS\Hydrology-Hydraulics\StormCad_Schematics.dwg
PLOT DATE: 10-29-18 PLOTTED BY: laut

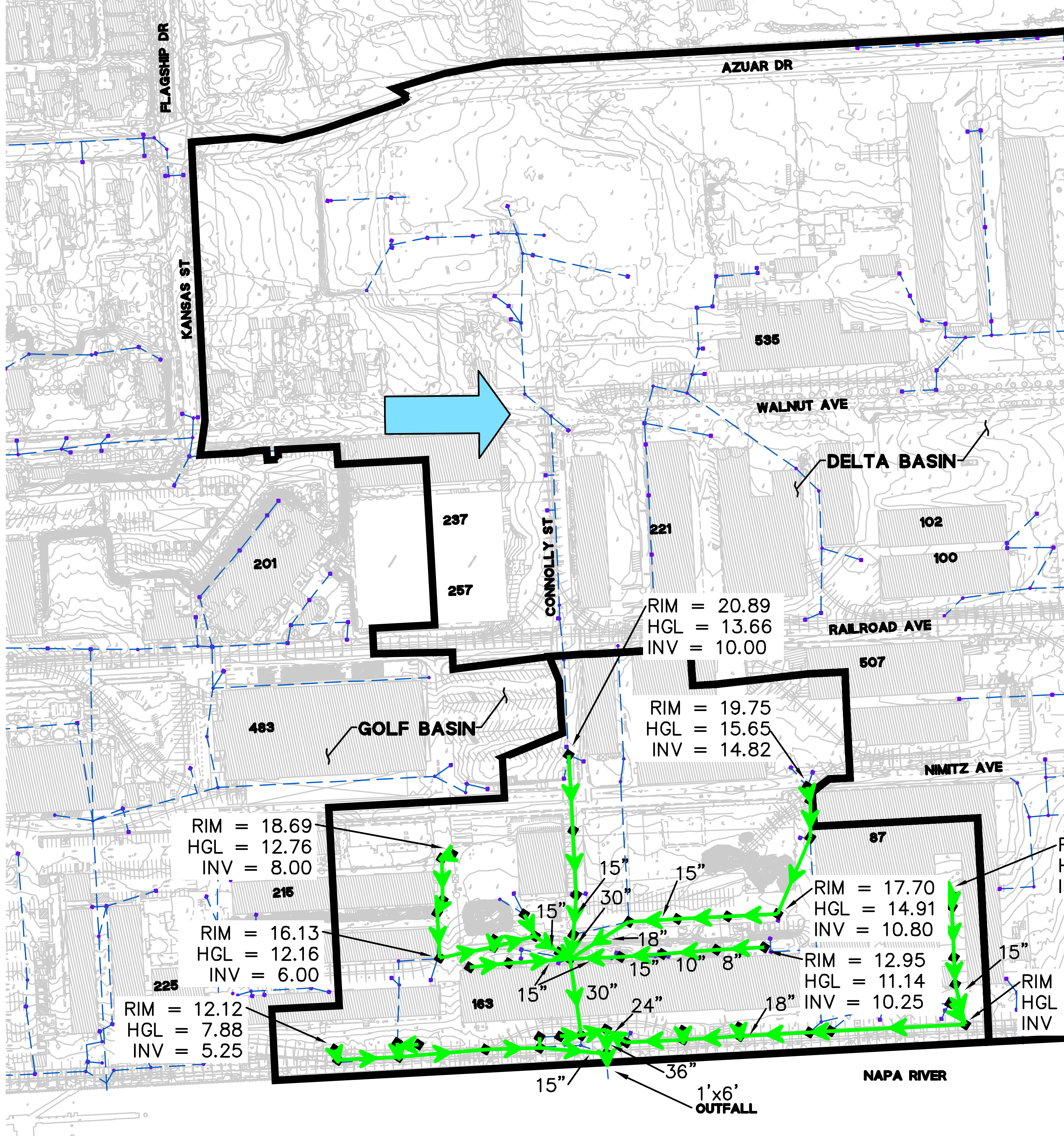
JOB No: 20170420
DATE: AUG 2019
BY: J.T.
REV: R.A.M.

GRAPHIC SCALE
250 0 250 500

FIGURE 5CC
MARE ISLAND
HYDROLOGY AND HYDRAULIC ANALYSIS
DELTA BASIN STORMCAD SCHEMATIC

BKF 100+ YEARS
ENGINEERS
SURVEYORS
PLANNERS

©BKF Engineers



LEGEND

- DRAINAGE BOUNDARY
- PROPOSED STORM DRAIN SYSTEM
- EXISTING STORM DRAIN SYSTEM
- XX" LINE SIZE UNTIL NOTED OTHERWISE (CONTINUOUS LINE SIZE UNTIL NEXT LABEL UPSTREAM)

FOXTROT BASIN
AREA = 19.2 ACRES
STARTING HGL = 6.20
SYSTEM FLOW = 38 CFS

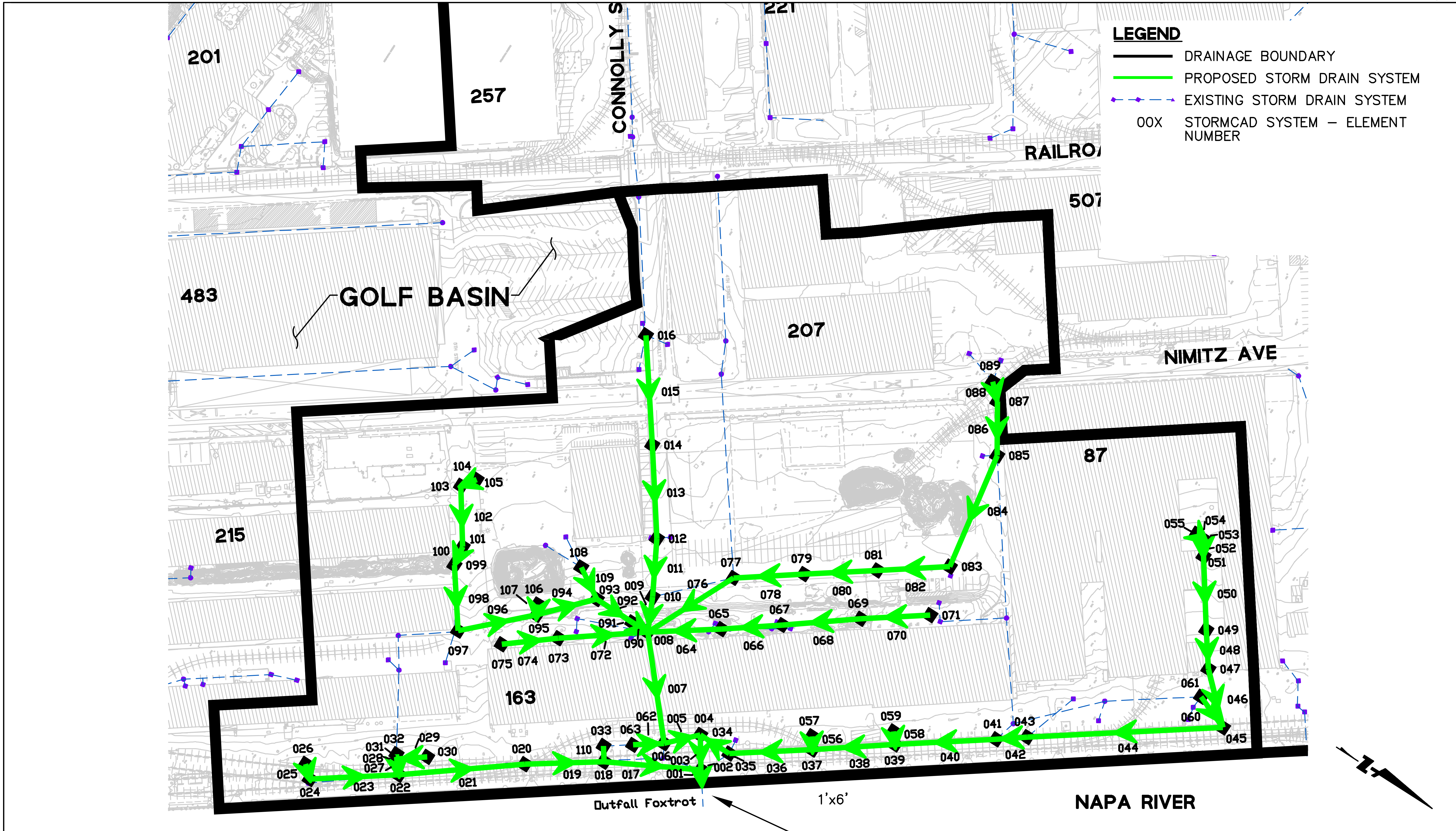
GRAPHIC SCALE
250 0 250 500

JOB No: 20170420
DATE: AUG 2019
BY: J.T.
REV: R.A.M.

DRAWING NAME: J:\2017\170420_Mare_Island\ENG\EXHIBITS\Hydrology-Hydraulics\Figures-ALT4.dwg
PLOT DATE: 08-20-19 PLOTTED BY: TAYL

FIGURE 5D
MARE ISLAND
HYDROLOGY AND HYDRAULIC ANALYSIS
PROPOSED FOXTROT BASIN WATERSHED - 15-YEAR STORM RESULTS

BKF 100+ YEARS
ENGINEERS
SURVEYORS
PLANNERS



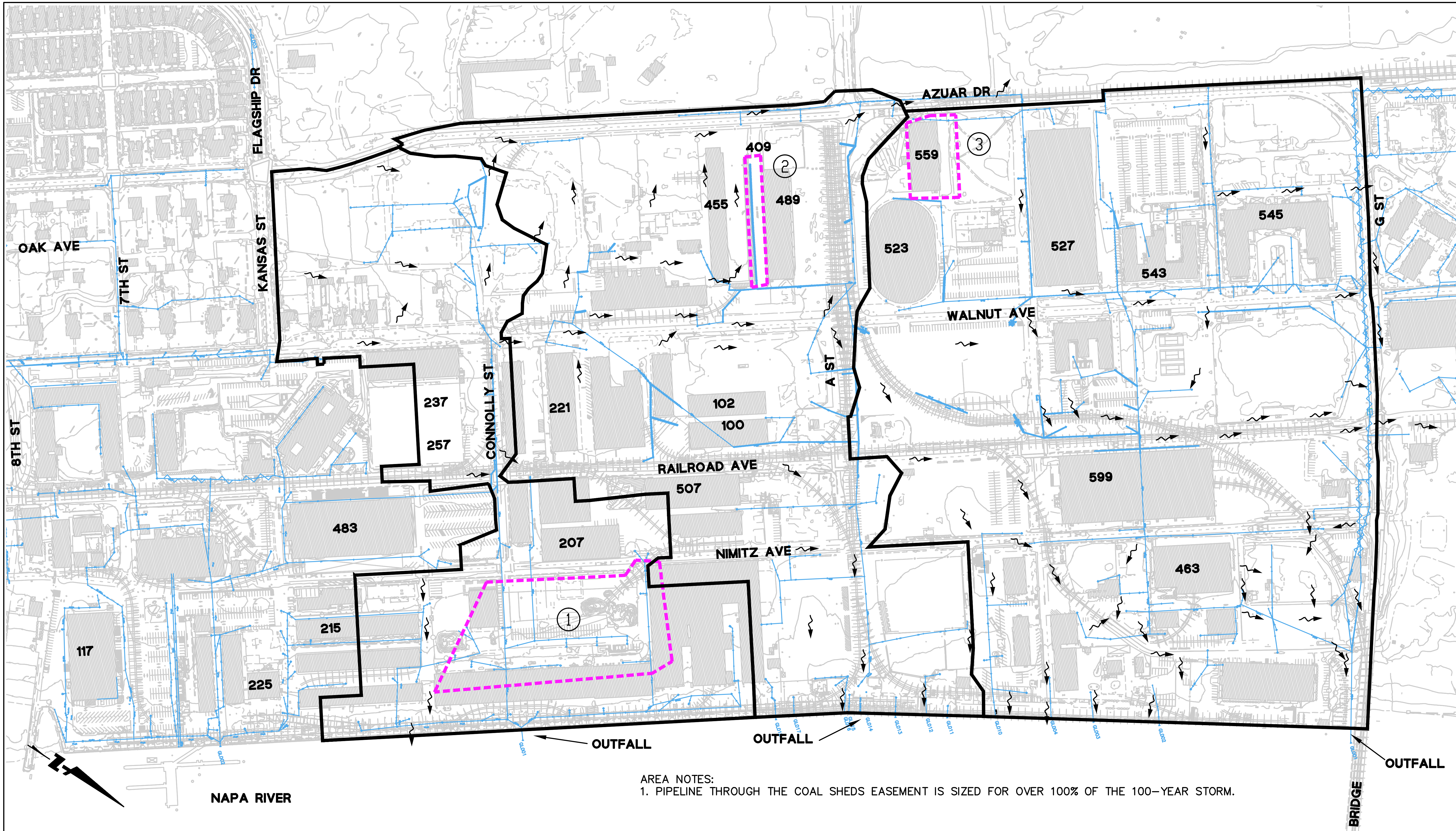
JOB No: 20170420
DATE: AUG 2019
BY: J.T.
REV: R.A.M.

GRAPHIC SCALE

125 0 125 250

FIGURE5DD
MARE ISLAND
HYDROLOGY AND HYDRAULIC ANALYSIS
FOXTROT BASIN STORMCAD SCHEMATIC

BKF 100+ YEARS ENGINEERS SURVEYORS PLANNERS



DRAWING NAME: \\Bkf-rc\vol4\2017\170420_Mare_Island\ENG\EXHIBITS\Hydrology-Hydraulics\Overland_Release.dwg
PLOT DATE: 08-04-19 PLOTTED BY: tayl

JOB No: 20170420
DATE: AUG 2019
BY: J.T.
REV: R.A.M.

GRAPHIC SCALE

300 0 300 600

LEGEND

- AREAS WITHOUT OVERLAND RELEASE OR RAISED ENTRYWAYS
- (#) AREA NUMBER (SEE NOTES)
- OVERLAND RELEASE PATH
- EXISTING DRAINAGE BOUNDARY

FIGURE 6
MARE ISLAND
HYDROLOGY AND HYDRAULIC ANALYSIS
OVERLAND RELEASE

BKF
100+ YEARS
ENGINEERS
SURVEYORS
PLANNERS

Mare Island Drainage Report
Table 3 - Charlie Basin
15-Year Hydrology - Proposed Condition

StormCAD Node ID	Inlet Area (acres)	Lateral Area (acres)	Inlet C	Inlet C*A (acres)	Cumulative Area (acres)	Cumulative C*A (acres)	Inlet Tc (minutes)	System Tc (minutes)	Intensity (in/hr)	Discharge (cfs)
98	0.35		0.90	0.31	0.35	0.31	10	10.0	2.76	**0.9**
96	0.11		0.90	0.10	0.45	0.41	10	13.3	2.39	**1.0**
94					0.45	0.41		14.1	2.30	**0.9**
92	5.51		0.90	4.96	5.96	5.37	15	15.0	2.20	**11.9**
90					5.96	5.37		15.2	2.19	**11.9**
88	0.05		0.90	0.04	6.01	5.41	10	15.3	2.18	**11.9**
86	1.01		0.90	0.91	7.02	6.32	10	15.9	2.16	**13.7**
84	0.34		0.90	0.31	7.36	6.62	10	16.3	2.14	**14.3**
82	2.21		0.90	1.99	2.21	1.99	10	10.0	2.76	**5.5**
80					2.21	1.99		12.0	2.54	**5.1**
78	0.21		0.90	0.19	2.42	2.18	10	12.5	2.48	**5.4**
76	1.22		0.90	1.10	1.22	1.10	10	10.0	2.76	**3.1**
74	0.00		(N/A)	0.00	0.00	0.00	10	10.0	2.76	**0.0**
72	0.58		0.90	0.52	0.58	0.52	10	10.0	2.76	**1.5**
70	0.67		0.90	0.61	1.25	1.13	10	12.4	2.49	**2.8**
68	2.09		0.90	1.88	3.34	3.01	10	13.0	2.43	**7.4**
66		1.22			4.56	4.11		13.9	2.33	**9.6**
64	0.81		0.90	0.73	5.37	4.83	10	14.9	2.21	**10.8**
62	0.44		0.90	0.40	5.81	5.23	10	15.2	2.19	**11.5**
60					5.81	5.23		17.3	2.09	**11.0**
58	1.19		0.90	1.07	7.00	6.30	10	20.5	1.94	**12.3**
56	2.88		0.90	2.60	2.88	2.60	10	10.0	2.76	**7.2**
54	0.48		0.90	0.43	0.48	0.43	10	10.0	2.76	**1.2**
52	0.96		0.90	0.87	0.96	0.87	10	10.0	2.76	**2.4**
50	1.14		0.90	1.02	2.10	1.89	10	10.7	2.68	**5.1**
48	1.09		0.90	0.98	3.19	2.87	10	10.8	2.67	**7.7**
46	1.04		0.90	0.94	4.23	3.80	10	12.2	2.51	**9.6**
44	0.21		0.90	0.19	0.21	0.19	10	10.0	2.76	**0.5**
42					0.21	0.19		11.5	2.59	**0.5**
40					0.21	0.19		24.7	1.73	**0.3**
38		3.36			3.57	3.21		26.6	1.65	**5.3**
36	2.25		0.90	2.02	5.82	5.23	10	27.3	1.61	**8.5**
34	0.41	4.23	0.90	0.37	10.46	9.41	10	27.5	1.60	**15.2**
32	2.62		0.90	2.35	13.07	11.76	10	29.0	1.53	**18.1**
30	0.78		0.90	0.70	13.85	12.47	10	29.2	1.52	**19.1**
28	3.13		0.90	2.82	16.99	15.29	10	29.6	1.50	**23.1**
26	1.64		0.90	1.47	1.64	1.47	10	10.0	2.76	**4.1**
24	1.78		0.90	1.60	3.42	3.08	10	11.5	2.59	**8.1**
22	3.26		0.90	2.93	6.68	6.01	10	12.1	2.53	**15.3**
20					6.68	6.01		12.8	2.44	**14.8**
18	0.41	7.36	0.90	0.37	14.45	13.01	10	17.6	2.08	**27.2**
16	0.53		0.90	0.48	14.98	13.48	10	18.2	2.05	**27.8**
14	0.82	2.42	0.90	0.74	18.22	16.40	10	18.4	2.04	**33.6**
12	0.73		0.90	0.66	18.95	17.06	10	19.2	2.00	**34.3**
10					18.95	17.06		19.5	1.99	**34.1**
8	3.06		0.90	2.76	22.01	19.81	10	20.0	1.96	**39.2**
6		7.00			29.01	26.11		21.9	1.87	**49.2**
4					29.01	26.11		22.5	1.84	**48.5**
2	1.41	16.99	0.90	1.27	47.41	42.67	10	30.6	1.47	**63.2**

Notes
(1) See Figure 5BB for StormCAD schematic

Mare Island Drainage Report
Table 4 - Charlie Basin
15-Year Hydraulics - Proposed Condition

Pipe [6] #	Upstream Node	Downstream Node	**Total Discharge [3] (cfs) [1]**	Capacity @ Constructed Slope (cfs)	Pipe Size (inches)	Length (feet)	Constructed Slope (ft/ft)	Pipe Roughness (Mannings n) [5]	Invert Elevation Upstream	Invert Elevation Downstream	Ground/Rim Elevation Upstream	Ground/Rim Elevation Downstream	HGL Elevation [4] Upstream	HGL Elevation [4] Downstream	**Freeboard [2] (feet)**	Upstream Cover (feet)	Velocity (ft/s)	**Velocity @ Half Full (ft/s)**
97	98	96	**0.9**	3.0	15	140	0.002	0.011	8.09	7.88	14.71	14.44	13.34	13.32	**1.4**	5.4	0.7	**2.4**
95	96	94	**1.0**	3.0	15	39	0.002	0.011	7.88	7.82	14.44	14.24	13.30	13.30	**1.1**	5.3	0.8	**2.4**
93	94	92	**0.9**	3.0	15	27	0.001	0.011	7.82	7.78	14.24	14.24	13.28	13.28	**1.0**	5.2	0.8	**2.4**
91	92	90	**11.9**	10.7	24	38	0.002	0.011	7.78	7.72	14.24	14.04	13.03	12.95	**1.2**	4.5	3.8	**3.4**
89	90	88	**11.9**	10.6	24	38	0.002	0.011	7.72	7.66	14.04	14.00	12.67	12.59	**1.4**	4.3	3.8	**3.4**
87	88	86	**11.9**	10.2	24	131	0.001	0.011	7.66	7.47	14.00	14.14	12.31	12.05	**1.7**	4.3	3.8	**3.2**
85	86	84	**13.7**	18.9	30	112	0.002	0.011	7.47	7.30	14.14	14.78	12.14	12.05	**2.0**	4.2	2.8	**3.9**
83	84	18	**14.2**	18.8	30	220	0.002	0.011	7.30	6.97	14.78	15.24	12.01	11.83	**2.8**	5.0	2.9	**3.8**
81	82	80	**5.5**	9.2	18	367	0.005	0.011	9.50	7.50	14.36	14.34	12.66	11.94	**1.7**	3.4	3.1	**5.2**
79	80	78	**5.1**	8.8	18	100	0.005	0.011	7.50	7.00	14.34	14.84	11.84	11.67	**2.5**	5.3	2.9	**5.0**
77	78	14	**5.4**	23.6	24	130	0.008	0.011	7.00	5.99	14.84	15.16	11.74	11.68	**3.1**	5.8	1.7	**7.5**
75	76	66	**3.1**	9.9	15	152	0.017	0.011	9.56	7.01	15.75	16.50	11.28	11.04	**4.5**	4.9	2.5	**8.1**
73	74	72	**0.0**	4.6	15	127	0.004	0.011	8.97	8.51	14.61	15.82	11.51	11.51	**3.1**	4.4	0.0	**3.7**
71	72	70	**1.5**	4.9	15	169	0.004	0.011	8.51	7.83	15.82	12.70	11.48	11.42	**4.3**	6.1	1.2	**3.9**
69	70	68	**2.8**	4.8	15	80	0.004	0.011	7.83	7.51	12.70	14.06	11.33	11.22	**1.4**	3.6	2.3	**3.9**
67	68	66	**7.4**	16.9	24	125	0.004	0.011	7.51	7.01	14.06	16.50	11.21	11.11	**2.9**	4.6	2.3	**5.4**
65	66	64	**9.6**	16.8	24	192	0.004	0.011	7.01	6.25	16.50	15.86	10.95	10.70	**5.6**	7.5	3.1	**5.4**
63	64	62	**10.8**	17.1	24	71	0.004	0.011	6.25	5.96	15.86	16.00	10.64	10.52	**5.2**	7.6	3.4	**5.4**
61	62	60	**11.5**	30.7	30	292	0.004	0.011	5.96	4.79	16.00	14.48	10.53	10.36	**5.5**	7.5	2.4	**6.3**
59	60	58	**11.0**	49.8	36	301	0.004	0.011	4.79	3.59	14.48	17.32	10.37	10.31	**4.1**	6.7	1.6	**7.0**
57	58	6	**12.3**	50.0	36	140	0.004	0.011	3.59	3.03	17.32	18.60	10.30	10.26	**7.0**	10.7	1.7	**7.1**
55	56	38	**7.2**	7.6	18	32	0.004	0.011	4.84	4.72	12.83	12.83	11.74	11.63	**1.1**	6.5	4.1	**4.3**
53	54	38	**1.2**	5.4	15	158	0.005	0.011	5.51	4.72	13.53	12.83	11.95	11.91	**1.6**	6.8	1.0	**4.4**
51	52	50	**2.4**	3.8	15	82	0.002	0.011	5.80	5.60	12.24	12.04	10.73	10.64	**1.5**	5.2	2.0	**3.1**
49	50	48	**5.1**	9.0	18	19	0.005	0.011	5.60	5.50	12.04	11.44	10.37	10.34	**1.7**	4.9	2.9	**5.1**
47	48	46	**7.7**	18.4	24	211	0.005	0.011	5.50	4.50	11.44	12.00	10.35	10.18	**1.1**	3.9	2.5	**5.9**
45	46	34	**9.6**	26.2	24	80	0.010	0.011	4.50	3.73	12.00	11.73	9.92	9.82	**2.1**	5.5	3.1	**8.3**
43	44	42	**0.5**	9.3	15	38	0.015	0.011	7.00	6.45	13.28	13.75	11.89	11.89	**1.4**	5.0	0.4	**7.5**
41	42	40	**0.5**	5.2	15	316	0.005	0.011	6.45	5.00	13.75	13.04	11.89	11.87	**1.9**	6.1	0.4	**4.2**
39	40	38	**0.3**	7.5	15	29	0.010	0.011	5.00	4.72	13.04	12.83	11.87	11.87	**1.2**	6.8	0.3	**6.1**
37	38	36	**5.3**	4.8	15	182	0.004	0.011	4.72	3.99	12.83	12.00	11.55	10.67	**1.3**	6.9	4.3	**3.9**
35	36	34	**8.5**	4.8	15	65	0.004	0.011	3.99	3.73	12.00	11.73	10.01	9.21	**2.0**	6.8	6.9	**3.9**
33	34	32	**15.2**	30.6	30	283	0.004	0.011	3.73	2.60	11.73	12.28	9.72	9.44	**2.0**	5.5	3.1	**6.2**
31	32	30	**18.2**	30.8	30	35	0.004	0.011	2.60	2.46	12.28	11.66	9.33	9.28	**3.0**	7.2	3.7	**6.3**
29	30	28	**19.1**	30.8	30	97	0.004	0.011	2.46	2.07	11.66	10.51	9.18	9.02	**2.5**	6.7	3.9	**6.3**
27	28	2	**23.2**	49.8	36	283	0.004	0.011	2.07	.94	10.51	8.84	9.08	8.84	**1.4**	5.4	3.3	**7.0**
25	26	24	**4.1**	8.8	18	206	0.005	0.011	10.17	9.14	15.04	14.50	13.12	12.89	**1.9**	3.4	2.3	**5.0**
23	24	22	**8.1**	8.8	18	165	0.005	0.011	9.14	8.32	14.50	15.02	12.59	11.90	**1.9**	3.9	4.6	**5.0**
21	22	20	**15.3**	34.5	30	139	0.005	0.011	8.32	7.62	15.02	14.69	12.06	11.92	**3.0**	4.2	3.1	**7.0**
19	20	18	**14.8**	34.3	30	130	0.005	0.011	7.62	6.97	14.69	15.24	11.91	11.79	**2.8**	4.6	3.0	**7.0**
17	18	16	**27.1**	55.7	36	140	0.005	0.011	6.97	6.27	15.24	15.49	11.70	11.53	**3.5**	5.3	3.8	**7.9**
15	16	14	**27.7**	55.6	36	56	0.005	0.011	6.27	5.99	15.49	15.16	11.51	11.44	**4.0**	6.2	3.9	**7.9**
13	14	12	**33.4**	55.6	36	229	0.005	0.011	5.99	4.85	15.16	14.52	11.31	10.90	**3.9**	6.2	4.7	**7.9**
11	12	10	**34.1**	56.1	36	63	0.005	0.011	4.85	4.53	14.52	14.98	10.85	10.73	**3.7**	6.7	4.8	**7.9**
9	10	8	**33.9**	55.7	36	149	0.005	0.011	4.53	3.79	14.98	17.10	10.68	10.41	**4.3**	7.5	4.8	**7.9**
7	8	6	**38.9**	55.7	36	153	0.005	0.011	3.79	3.03	17.10	18.60	10.19	9.82	**6.9**	10.3	5.5	**7.9**
5	6	4	**49.2**	71.1	42	186	0.005	0.013	3.03	2.10	18.60	20.42	9.86	9.42	**8.7**	12.1	5.1	**7.4**
3	4	2	**48.5**	71.3	42	231	0.005	0.013	2.10	.94	20.42	8.84	9.37	8.84	**11.1**	14.8	5.0	**7.4**
1	2 [7]	Outfall Charlie	**63.0**	34.3	30	188	0.005	0.011	.94	**.00**	8.84	10.00	9.37	6.20	**ABOVE RIM**	5.4	12.8	**7.0**

Notes
(1) ft = feet, cfs = cubic feet per second, ft/s = feet per second
(2) Freeboard is HGL (Hydraulic Grade Line) below Rim of Inlet
(3) Discharge is from the Rational Method, Q = CIA
(4) Tailwater set to mean sea level (6.20 feet NAVD 88)
(5) Pipe roughness is 0.011 for HDPE and 0.013 for RCP
(6) See Figure 5BB for StormCAD schematic and Figure 5B for corresponding results
(7) Node to have bolt down, open grate lid. Stormwater that reaches the structure rim will dlow down the boat ramp to the Napa River.

Mare Island Drainage Report
Table 5 - Delta Basin
15-Year Hydrology - Proposed Condition

StormCAD Node ID	Inlet Area (acres)	Lateral Area (acres)	Inlet C	Inlet C*A (acres)	Cumulative Area (acres)	Cumulative C*A (acres)	Inlet Tc (minutes)	System Tc (minutes)	Intensity (in/hr)	Discharge (cfs)
74	2.37		0.90	2.14	2.37	2.14	10	10.0	2.76	**6.0**
72	1.59		0.90	1.43	3.96	3.57	10	12.0	2.54	**9.1**
70	2.64		0.90	2.38	6.60	5.94	10	13.2	2.41	**14.4**
68	5.21		0.90	4.69	11.81	10.63	10	14.2	2.29	**24.5**
66	4.18		0.90	3.76	15.99	14.39	10	15.2	2.19	**31.8**
64					15.99	14.39		15.7	2.17	**31.4**
62	1.62		0.90	1.46	1.62	1.46	10	10.0	2.76	**4.1**
60					1.62	1.46		10.3	2.73	**4.0**
58	2.37		0.90	2.13	3.99	3.59	10	10.8	2.67	**9.7**
56	1.53		0.90	1.38	5.52	4.97	10	11.7	2.57	**12.9**
54	1.47		0.90	1.32	6.99	6.29	10	11.9	2.55	**16.1**
52	4.09		0.90	3.68	11.08	9.97	10	12.4	2.50	**25.1**
50					11.08	9.97		12.8	2.44	**24.6**
48	1.16		0.90	1.05	12.24	11.02	10	13.0	2.42	**26.9**
46	1.10		0.90	0.99	13.34	12.01	10	13.4	2.38	**28.8**
44	1.69		0.90	1.52	15.03	13.52	10	14.1	2.30	**31.3**
42					15.03	13.52		14.5	2.25	**30.7**
40	4.55		0.90	4.10	19.58	17.62	10	15.5	2.18	**38.7**
38	1.87		0.90	1.68	21.45	19.30	10	16.3	2.14	**41.6**
36					21.45	19.30		17.1	2.10	**40.8**
34	0.74		0.90	0.67	22.19	19.97	10	17.5	2.08	**41.9**
32	3.72		0.90	3.35	25.91	23.32	10	18.0	2.06	**48.3**
30	2.19		0.90	1.97	2.19	1.97	10	10.0	2.76	**5.5**
28	2.95		0.90	2.65	5.14	4.63	10	10.5	2.70	**12.6**
26					5.14	4.63		11.6	2.59	**12.1**
24	9.14		0.90	8.23	9.14	8.23	15	15.0	2.20	**18.2**
22	3.66		0.90	3.29	12.80	11.52	10	15.7	2.17	**25.2**
20	0.53		0.90	0.48	13.33	12.00	10	16.4	2.13	**25.8**
18	5.29		0.90	4.76	18.62	16.75	10	17.4	2.08	**35.2**
16		15.99			34.60	31.14		17.9	2.06	**64.7**
14	0.49		0.90	0.44	35.09	31.58	10	18.4	2.04	**64.9**
12	4.01		0.90	3.61	39.10	35.19	10	18.8	2.02	**71.5**
10		31.05			70.15	63.14		19.1	2.00	**127.5**
8	2.78		0.90	2.51	72.94	65.64	10	19.7	1.97	**130.5**
6	4.73		0.90	4.26	77.67	69.90	10	20.4	1.94	**136.8**
4	5.67		0.90	5.11	83.34	75.01	10	21.0	1.91	**144.7**
2	5.72		0.90	5.15	89.06	80.16	10	21.3	1.90	**153.3**

Notes
(1) See Figure 5CC for StormCAD schematic

Mare Island Drainage Report
Table 6 - Delta Basin
15-Year Hydraulics - Proposed Condition

Pipe [6] #	Upstream Node	Downstream Node	**Total Discharge [3] (cfs) [1]**	Capacity @ Constructed Slope (cfs)	Pipe Size (inches)	Length (feet)	Constructed Slope (ft/ft)	Pipe Roughness (Mannings n) [5]	Invert Elevation		Ground/Rim Elevation		HGL Elevation [4]		**Freeboard [2] (feet)**	Upstream Cover (feet)	Velocity (ft/s)	**Velocity @ Half Full (ft/s)**
									Upstream	Downstream	Upstream	Downstream	Upstream	Downstream				
73	74	72	**6.0**	14.2	24	224	0.003	0.011	8.00	7.37	15.02	16.06	13.75	13.64	**1.3**	5.0	1.9	**4.5**
71	72	70	**9.1**	14.1	24	208	0.003	0.011	7.37	6.79	16.06	15.00	13.52	13.28	**2.5**	6.7	2.9	**4.5**
69	70	68	**14.4**	25.8	30	183	0.003	0.011	6.79	6.27	15.00	15.51	13.20	13.03	**1.8**	5.7	2.9	**5.3**
67	68	66	**24.5**	25.6	30	294	0.003	0.011	6.27	5.45	15.51	15.75	12.51	11.76	**3.0**	6.7	5.0	**5.2**
66	66	64	**31.8**	42.0	36	148	0.003	0.011	5.45	5.03	15.75	15.50	11.60	11.36	**4.2**	7.3	4.5	**5.9**
63	64	16	**31.4**	42.0	36	166	0.003	0.011	5.03	4.56	15.50	17.00	11.16	10.90	**4.3**	7.5	4.4	**5.9**
61	62	60	**4.1**	12.2	15	151	0.026	0.011	19.96	16.12	24.86	21.50	20.77	19.83	**4.1**	3.7	8.9	**9.9**
59	60	58	**4.0**	5.7	15	95	0.006	0.011	16.12	15.59	21.50	21.01	19.66	19.40	**1.8**	4.1	3.3	**4.6**
57	58	56	**9.7**	20.0	24	179	0.006	0.011	15.59	14.59	21.01	20.49	19.29	19.06	**1.7**	3.4	3.1	**6.4**
55	56	54	**12.9**	19.8	24	40	0.006	0.011	14.59	14.37	20.49	20.52	18.73	18.64	**1.8**	3.9	4.1	**6.3**
53	54	52	**16.1**	20.0	24	139	0.006	0.011	14.37	13.59	20.52	21.29	18.26	17.75	**2.3**	4.2	5.1	**6.4**
51	52	50	**25.1**	36.1	30	142	0.006	0.011	13.59	12.80	21.29	22.84	17.50	17.12	**3.8**	5.2	5.1	**7.4**
49	50	48	**24.6**	36.1	30	68	0.006	0.011	12.80	12.42	22.84	23.20	16.76	16.58	**6.1**	7.5	5.0	**7.4**
47	48	46	**26.9**	36.3	30	118	0.006	0.011	12.42	11.76	23.20	23.39	16.11	15.75	**7.1**	8.3	5.5	**7.4**
45	46	44	**28.8**	36.2	30	260	0.006	0.011	11.76	10.31	23.39	23.81	15.39	14.47	**8.0**	9.1	5.9	**7.4**
43	44	42	**31.3**	58.9	36	102	0.006	0.011	10.31	9.74	23.81	22.54	14.42	14.26	**9.4**	10.5	4.4	**8.3**
41	42	40	**30.7**	58.7	36	247	0.006	0.011	9.74	8.37	22.54	22.00	13.91	13.53	**8.6**	9.8	4.3	**8.3**
39	40	38	**38.7**	58.8	36	279	0.006	0.011	8.37	6.82	22.00	21.00	13.15	12.48	**8.9**	10.6	5.5	**8.3**
37	38	36	**41.6**	59.0	36	286	0.006	0.011	6.82	5.22	21.00	19.48	12.11	11.32	**8.9**	11.2	5.9	**8.3**
35	36	34	**40.8**	58.6	36	136	0.006	0.011	5.22	4.47	19.48	17.72	11.02	10.66	**8.5**	11.3	5.8	**8.3**
33	34	32	**41.9**	58.9	36	174	0.006	0.011	4.47	3.50	17.72	17.25	10.31	9.82	**7.4**	10.3	5.9	**8.3**
31	32	10	**48.3**	58.8	36	81	0.006	0.011	3.50	3.05	17.25	17.01	9.28	8.97	**8.0**	10.8	6.8	**8.3**
29	30	28	**5.5**	12.9	18	222	0.011	0.011	10.00	7.60	16.50	16.00	10.90	10.51	**5.6**	5.0	7.0	**7.3**
27	28	26	**12.6**	27.8	24	250	0.011	0.011	7.60	4.90	16.00	16.50	10.30	9.75	**5.7**	6.4	4.0	**8.8**
25	26	10	**12.1**	27.8	24	171	0.011	0.011	4.90	3.05	16.50	17.01	9.62	9.27	**6.9**	9.6	3.8	**8.8**
23	24	22	**18.2**	30.5	30	147	0.004	0.011	7.50	6.92	14.55	14.74	12.96	12.75	**1.6**	4.6	3.7	**6.2**
21	22	20	**25.2**	30.5	30	241	0.004	0.011	6.92	5.97	14.74	15.48	12.38	11.74	**2.4**	5.3	5.1	**6.2**
19	20	18	**25.8**	49.5	36	213	0.004	0.011	5.97	5.13	15.48	16.49	11.73	11.50	**3.8**	6.5	3.6	**7.0**
17	18	16	**35.2**	49.6	36	144	0.004	0.011	5.13	4.56	16.49	17.00	11.14	10.85	**5.4**	8.4	5.0	**7.0**
15	16	14	**64.7**	89.7	48	151	0.004	0.013	4.56	3.97	17.00	17.00	10.54	10.23	**6.5**	8.4	5.2	**7.1**
13	14	12	**64.9**	90.2	48	140	0.004	0.013	3.97	3.42	17.00	17.23	9.98	9.70	**7.0**	9.0	5.2	**7.2**
11	12	10	**71.5**	90.3	48	94	0.004	0.013	3.42	3.05	17.23	17.01	9.34	9.11	**7.9**	9.8	5.7	**7.2**
9	10	8	**127.5**	129.9	66	200	0.002	0.013	3.05	2.75	17.01	16.55	8.80	8.52	**8.2**	8.5	5.4	**5.5**
7	8	6	**130.5**	130.0	66	240	0.002	0.013	2.75	2.39	16.55	16.51	8.22	7.88	**8.3**	8.3	6.2	**5.5**
5	6	4	**136.8**	164.1	72	226	0.002	0.013	2.39	2.05	16.51	14.49	7.65	7.46	**8.9**	8.1	6.5	**5.8**
3	4	2	**144.7**	166.5	72	136	0.002	0.013	2.05	1.84	14.49	12.05	7.08	6.94	**7.4**	6.4	6.6	**5.9**
1	2	Outfall Delta	**153.3**	166.3	72	91	0.002	0.013	1.84	1.70	12.05	11.00	6.38	6.24	**5.7**	4.2	6.7	**5.9**

Notes
(1) ft = feet, cfs = cubic feet per second, ft/s = feet per second
(2) Freeboard is HGL (Hydraulic Grade Line) below Rim of Inlet
(3) Discharge is from the Rational Method, Q = CIA
(4) Tailwater set to mean sea level (6.20 feet NAVD 88)
(5) Pipe roughness is 0.011 for HDPE and 0.013 for RCP
(6) See Figure 5CC for StormCAD schematic and Figure 5C for corresponding results

Mare Island Drainage Report
Table 7 - Foxtrot Basin
15-Year Hydrology - Proposed Condition

StormCAD Node ID	Inlet Area (acres)	Lateral Area (acres)	Inlet C	Inlet C*A (acres)	Cumulative Area (acres)	Cumulative C*A (acres)	Inlet Tc (minutes)	System Tc (minutes)	Intensity (in/hr)	Discharge (cfs)
108	0.73		0.90	0.66	0.73	0.66	10	10.0	2.76	**1.8**
106	0.43		0.90	0.38	0.43	0.38	10	10.0	2.76	**1.1**
105	0.96		0.90	0.87	0.96	0.87	10	10.0	2.76	**2.4**
103					0.96	0.87		10.2	2.74	**2.4**
101					0.96	0.87		10.9	2.66	**2.3**
99					0.96	0.87		11.2	2.63	**2.3**
97	1.23		0.90	1.11	2.19	1.97	10	12.0	2.54	**5.1**
95		0.43			2.62	2.36		12.4	2.49	**5.9**
93		0.73			3.34	3.01		12.7	2.46	**7.5**
91	0.37		0.90	0.33	3.72	3.34	10	12.9	2.44	**8.2**
89	1.35		0.90	1.21	1.35	1.21	10	10.0	2.76	**3.4**
87					1.35	1.21		10.1	2.75	**3.4**
85					1.35	1.21		10.2	2.73	**3.3**
83	0.39		0.90	0.35	1.73	1.56	10	11.3	2.62	**4.1**
81	0.63		0.90	0.57	2.36	2.13	10	11.8	2.56	**5.5**
79	1.87		0.90	1.69	4.24	3.81	10	12.1	2.52	**9.7**
77					4.24	3.81		12.3	2.50	**9.6**
75	0.18		0.90	0.16	0.18	0.16	10	10.0	2.76	**0.4**
73	0.37		0.90	0.34	0.55	0.50	10	10.4	2.72	**1.4**
71	0.48		0.90	0.43	0.48	0.43	10	10.0	2.76	**1.2**
69	0.27		0.90	0.24	0.75	0.67	10	10.5	2.71	**1.8**
67	0.16		0.90	0.14	0.90	0.81	10	10.9	2.66	**2.2**
65					0.90	0.81		11.2	2.63	**2.2**
63	1.01		0.90		1.01	0.91				
61	1.53		0.90	1.38	1.53	1.38	10	10.0	2.76	**3.8**
59	0.63		0.90	0.56	0.63	0.56	10	10.0	2.76	**1.6**
57	0.72		0.90	0.65	0.72	0.65	10	10.0	2.76	**1.8**
55	1.52		0.90		1.52	1.37				
53					1.52	1.37		10.1	2.75	**3.8**
51					1.52	1.37		10.2	2.74	**3.8**
49					1.52	1.37		10.7	2.68	**3.7**
47					1.52	1.37		11.0	2.65	**3.7**
45		1.53			3.06	2.75		11.5	2.59	**7.2**
43					3.06	2.75		12.6	2.47	**6.9**
41					3.06	2.75		12.8	2.45	**6.8**
39		0.63			3.68	3.31		13.4	2.38	**8.0**
37		0.72			4.40	3.96		14.1	2.30	**9.2**
35					4.40	3.96		14.8	2.23	**8.9**
33					0.00	0.00		0.0	4.08	**0.0**
32					0.00	0.00		0.0	4.08	**0.0**
30	0.82		0.90	0.74	0.82	0.74	10	10.0	2.76	**2.1**
28		0.00			0.82	0.74		10.4	2.71	**2.0**
26	0.44		0.90	0.39	0.44	0.39	10	10.0	2.76	**1.1**
24					0.44	0.39		10.4	2.72	**1.1**
22		0.82			1.26	1.13		12.7	2.45	**2.8**
20					1.26	1.13		14.0	2.31	**2.6**
18		0.00			1.26	1.13		14.8	2.22	**2.5**
16	2.30		0.90	2.07	2.30	2.07	10	10.0	2.76	**5.8**
14	1.02		0.90	0.91	3.31	2.98	10	10.5	2.70	**8.1**
12					3.31	2.98		10.9	2.66	**8.0**
10					3.31	2.98		11.1	2.64	**7.9**
8		9.40			12.72	11.44		12.9	2.43	**28.1**
6		1.01			13.73	12.36		13.4	2.38	**29.6**
4		4.40			18.13	16.32		15.1	2.20	**36.1**
2		1.26			19.39	17.45		15.9	2.16	**37.9**

Notes
(1) See Figure 5DD for StormCAD schematic

Mare Island Drainage Report
Table 8 - Foxtrot Basin
15-Year Hydraulics - Proposed Condition

Pipe [6] #	Upstream Node	Downstream Node	**Total Discharge [3] (cfs) [1]**	Capacity @ Constructed Slope (cfs)	Pipe Size (inches)	Length (feet)	Constructed Slope (ft/ft)	Pipe Roughness (Mannings n) [5]	Invert Elevation Upstream	Invert Elevation Downstream	Ground/Rim Elevation Upstream	Ground/Rim Elevation Downstream	HGL Elevation [4] Upstream	HGL Elevation [4] Downstream	**Freeboard [2] (feet)**	Upstream Cover (feet)	Velocity (ft/s)	**Velocity @ Half Full (ft/s)**
110	33	18	**0.0**	8.5	15	22	0.012	0.011	3.00	2.73	12.52	12.23	7.35	7.35	**5.2**	8.3	0.0	**6.9**
109	108	93	**1.8**	2.9	15	49	0.001	0.011	5.25	5.18	20.49	16.58	10.92	10.89	**9.6**	14.0	1.5	**2.4**
107	106	95	**1.1**	6.4	15	14	0.007	0.011	5.60	5.50	17.31	17.31	11.70	11.70	**5.6**	10.5	0.9	**5.2**
104	105	103	**2.4**	7.9	15	23	0.011	0.011	8.00	7.75	18.69	18.19	12.75	12.73	**5.9**	9.4	2.0	**6.5**
102	103	101	**2.4**	5.9	15	84	0.006	0.011	7.75	7.25	18.19	18.20	12.66	12.58	**5.5**	9.2	2.0	**4.8**
100	101	99	**2.3**	7.2	15	28	0.009	0.011	7.25	7.00	18.20	18.00	12.54	12.51	**5.7**	9.7	1.9	**5.9**
98	99	97	**2.3**	8.0	15	90	0.011	0.011	7.00	6.00	18.00	16.13	12.47	12.39	**5.5**	9.8	1.9	**6.6**
96	97	95	**5.1**	5.2	15	110	0.005	0.011	6.00	5.50	16.13	17.31	12.03	11.54	**4.1**	8.9	4.1	**4.2**
94	95	93	**5.9**	4.7	15	85	0.004	0.011	5.50	5.18	17.31	16.58	11.21	10.70	**6.1**	10.6	4.8	**3.8**
92	93	91	**7.5**	5.3	15	58	0.005	0.011	5.18	4.90	16.58	12.92	10.03	9.47	**6.6**	10.2	6.1	**4.3**
90	91	8	**8.2**	8.3	15	25	0.012	0.011	4.90	4.60	12.92	12.92	8.98	8.69	**3.9**	6.8	6.7	**6.8**
88	89	87	**3.4**	9.4	15	28	0.015	0.011	14.82	14.40	19.75	19.78	15.56	15.64	**4.2**	3.7	7.0	**7.6**
86	87	85	**3.4**	9.3	15	74	0.015	0.011	14.40	13.29	19.78	19.00	15.55	15.42	**4.2**	4.1	7.0	**7.6**
84	85	83	**3.3**	9.4	15	166	0.015	0.011	13.29	10.80	19.00	17.70	15.33	15.02	**3.7**	4.5	2.7	**7.6**
82	83	81	**4.1**	9.4	15	100	0.015	0.011	10.80	9.30	17.70	16.93	14.81	14.52	**2.9**	5.7	3.4	**7.6**
80	81	79	**5.5**	9.3	15	101	0.015	0.011	9.30	7.80	16.93	17.38	14.25	13.73	**2.7**	6.4	4.5	**7.6**
78	79	77	**9.7**	6.9	15	97	0.008	0.011	7.80	7.00	17.38	15.51	12.75	11.19	**4.6**	8.3	7.9	**5.7**
76	77	8	**9.6**	7.0	15	119	0.008	0.011	7.00	6.00	15.51	12.92	10.42	8.54	**5.1**	7.3	7.8	**5.7**
74	75	73	**0.4**	7.7	15	78	0.010	0.011	10.15	9.35	12.65	11.75	10.41	10.01	**2.2**	1.3 [7]	3.4	**6.3**
72	73	8	**1.4**	9.0	15	123	0.014	0.011	9.35	7.65	11.75	12.92	9.81	9.10	**1.9**	1.2 [7]	5.3	**7.3**
70	71	69	**1.2**	1.2	8	96	0.007	0.011	10.25	9.55	12.95	12.85	11.11	10.44	**1.8**	2.0 [7]	3.4	**3.5**
68	69	67	**1.8**	2.1	10	108	0.006	0.011	9.55	8.85	12.85	12.45	10.16	9.61	**2.7**	2.5 [7]	4.3	**3.8**
66	67	65	**2.2**	6.5	15	84	0.007	0.011	8.85	8.25	12.45	12.95	9.44	9.19	**3.0**	2.4 [7]	4.8	**5.3**
64	65	8	**2.2**	5.9	15	101	0.006	0.011	8.25	7.65	12.95	12.92	9.13	9.08	**3.8**	3.5	4.4	**4.8**
62	6	63	**2.5**	3.5	15	43	-0.002	0.011	3.51	3.60	12.75	12.50	8.06	8.01	**4.7**	8.0	2.1	**2.9**
60	61	45	**3.8**	5.3	15	52	0.005	0.011	6.00	5.75	12.56	12.45	10.50	10.37	**2.1**	5.3	3.1	**4.3**
58	59	39	**1.6**	5.7	15	18	0.006	0.011	4.10	4.00	12.50	12.36	8.38	8.37	**4.1**	7.2	1.3	**4.6**
56	57	37	**1.8**	5.6	15	18	0.005	0.011	3.60	3.50	12.50	12.50	8.20	8.19	**4.3**	7.7	1.5	**4.6**
54	55	53	**3.8**	5.2	15	11	0.005	0.011	7.11	7.06	16.44	16.44	11.44	11.41	**5.0**	8.1	3.1	**4.2**
52	53	51	**3.8**	5.4	15	24	0.005	0.011	7.06	6.94	16.44	16.44	11.27	11.21	**5.2**	8.1	3.1	**4.4**
50	51	49	**3.8**	5.4	15	101	0.005	0.011	6.94	6.43	16.44	13.39	11.12	10.87	**5.3**	8.3	3.1	**4.4**
48	49	47	**3.7**	5.4	15	54	0.005	0.011	6.43	6.16	13.39	12.68	10.79	10.66	**2.6**	5.7	3.0	**4.4**
46	47	45	**3.7**	5.4	15	83	0.005	0.011	6.16	5.75	12.68	12.45	10.57	10.38	**2.1**	5.3	3.0	**4.4**
44	45	43	**7.2**	8.8	18	269	0.005	0.011	5.75	4.41	12.45	12.50	9.96	9.06	**2.5**	5.2	4.1	**5.0**
42	43	41	**6.9**	6.3	18	43	0.003	0.011	4.41	4.30	12.50	12.52	8.93	8.80	**3.6**	6.6	3.9	**3.6**
40	41	39	**6.8**	5.8	18	139	0.002	0.011	4.30	4.00	12.52	12.36	8.67	8.25	**3.9**	6.7	3.8	**3.3**
38	39	37	**8.0**	17.8	24	114	0.004	0.011	4.00	3.50	12.36	12.50	8.26	8.15	**4.1**	6.4	2.5	**5.6**
36	37	35	**9.2**	13.7	24	114	0.003	0.011	3.50	3.20	12.50	12.30	8.04	7.90	**4.5**	7.0	2.9	**4.4**
34	35	4	**8.9**	17.4	24	47	0.004	0.011	3.20	3.00	12.30	12.30	7.80	7.75	**4.5**	7.1	2.8	**5.5**
31	32	28	**0.0**	9.4	15	7	0.015	0.011	5.10	5.00	12.20	12.20	7.91	7.91	**4.3**	5.9	0.0	**7.6**
29	30	28	**2.1**	4.6	15	42	0.004	0.011	5.15	5.00	12.44	12.20	7.92	7.89	**4.5**	6.0	1.7	**3.7**
27	28	22	**2.0**	8.9	15	22	0.014	0.011	5.00	4.70	12.20	12.20	7.83	7.82	**4.4**	6.0	1.7	**7.3**
25	26	24	**1.1**	8.2	15	22	0.012	0.011	5.25	5.00	12.12	11.99	7.88	7.87	**4.2**	5.6	0.9	**6.7**
23	24	22	**1.1**	3.8	15	122	0.002	0.011	5.00	4.70	11.99	12.20	7.86	7.84	**4.1**	5.7	0.9	**3.1**
21	22	20	**2.8**	4.9	15	174	0.004	0.011	4.70	3.99	12.20	12.49	7.71	7.47	**4.5**	6.3	2.3	**4.0**
19	20	18	**2.6**	8.2	15	109	0.012	0.011	3.99	2.73	12.49	12.23	7.43	7.30	**5.1**	7.3	2.2	**6.7**
17	18	2	**2.5**	4.8	15	133	0.004	0.011	2.73	2.20	12.23	12.41	7.26	7.12	**5.0**	8.3	2.1	**3.9**
15	16	14	**5.8**	4.4	15	151	0.003	0.011	10.00	9.50	20.89	18.80	13.59	12.73	**7.3**	9.6	4.7	**3.6**
13	14	12	**8.1**	4.8	15	129	0.004	0.011	9.50	9.00	18.80	17.58	12.12	10.67	**6.7**	8.1	6.6	**3.9**
11	12	10	**8.0**	8.2	15	80	0.011	0.011	9.00	8.08	17.58	14.17	10.12	9.08	**7.5**	7.3	7.6	**6.7**
9	10	8	**7.9**	43.3	30	49	0.008	0.011	8.08	7.69	14.17	12.92	9.02	9.04	**5.2**	3.6	6.7	**8.8**
7	8	6	**28.1**	14.6	30	166	0.001	0.011	3.66	3.51	12.92	12.75	8.30	7.74	**4.6**	6.8	5.7	**3.0**
5	6	4	**29.6**	60.6	36	44	0.006	0.011	3.51	3.25	12.75	12.30	7.72	7.66	**5.0**	6.2	4.2	**8.6**
3	4	2	**36.1**	34.2	36	53	0.002	0.011	3.00	2.90	12.30	12.41	7.03	6.91	**5.3**	6.3	5.1	**4.8**
1	2	Outfall Foxtrot	**37.9**	40.2	1' x 6' box	19	0.011	0.013	2.20	2.00	12.41	12.00	6.38	6.20	**6.0**	9.2	6.3	

Notes
(1) ft = feet, cfs = cubic feet per second, ft/s = feet per second
(2) Freeboard is HGL (Hydraulic Grade Line) below Rim of Inlet
(3) Discharge is from the Rational Method, Q = CIA
(4) Tailwater set to mean sea level (6.20 feet NAVD 88)
(5) Pipe roughness is 0.011 for HDPE and 0.013 for RCP
(6) See Figure 5DD for StormCAD schematic and Figure 5D for corresponding results
(7) Pipe is installed along pedestrian walkway where there is no vehicle access. No adjustment in pipe cover is proposed.

APPENDIX A

WEST YOST ASSOCIATES
Consulting Engineers

December 4, 2006

Mr. Rolf Ohlemutz
Vallejo Sanitation & Flood Control District
450 Ryder Street
Vallejo CA 94590

Project No.: 078-00-06-04.02

SUBJECT: Mare Island Straight Tail Water Elevation

Dear Mr. Ohlemutz:

West Yost Associates (WYA) has recommended several improvements along the Lemon Street Channel and downstream of the Solano Avenue Pump Station in the *Draft – Lemon Street Channel Flood Reduction Study*; dated November, 2006. The Recommended Project included the addition of two ditches that would alleviate a 0.2 foot rise in floodwater elevation at two locations (near Sonoma Boulevard). At your request, further analysis was undertaken to estimate the probability that the extreme tide used in the modeling and the 100-year storm peak would coincide (which contribute to the need for these two ditches). Phrased another way, this question is what tail water elevation in the Mare Island Straight is appropriate for planning and design of storm drainage systems in the *Lemon Street Channel Flood Reduction Study*.

Several different tail water conditions have been used in the past by the District and other agencies, including:

- The District's design criteria state that the design tide elevation shall be 3.5 feet MSL (assumed to be NGVD), which corresponds to a tide elevation of about 6.2 feet NAVD.
- The Vallejo Flood Insurance Study indicates that the 100-year Napa River water surface elevation at White Slough and Chabot Creek is just under 6 feet NGVD (about 8.5 feet NAVD).
- The County of Solano Hydrology and Drainage Design Procedures Manual (October 1977) indicates that a high tide of 6.5 feet MSL is appropriate. This elevation is probably based on NGVD and corresponds to an elevation of 9.0 feet NAVD.
- The US Army Corps of Engineers study, San Francisco Bay Tidal Stage Versus Frequency Study (October 1984) states that the 100-year tide at the mouth of the Napa River is 6.5 feet NGVD, or 9.0 feet NAVD.
- The US Army Corps of Engineers study, White Slough Section 205 Flood Control Study (December 2001) states that the 100-year tide for the Napa River around White Slough is 8.2 feet NGVD, or 10.7 feet NAVD.

Thus, the potential design tide elevation ranges from 6.2 feet to 10.7 feet NAVD.

METHODOLOGY

San Francisco Bay historical water surface elevations were downloaded from the California Data Exchange Center (CEDEC) website, which is operated by the California Department of Water Resources (DWR). Data was taken for the Martinez (MRZ) Station. Hourly stage data were available for the period from July 1, 1994 to the present. All elevations, except for those after October 1, 2006, were based on the National Geodetic Vertical Datum (NGVD). After October 1, 2006, the elevations were based on the North American Vertical Datum (NAVD). NGVD elevations were converted to NAVD elevations by adding 2.68 feet. For the remainder of this letter, all elevations are given in NAVD.

The hourly tidal elevations for 2005 and 2006 are shown in Figures 1 and 2, respectively (as samples of the 12 years worth of data analyzed). The tide appears to fluctuate primarily between the elevations of -1 and 10 feet NAVD. The hourly data from July 1, 1994 to November 16, 2006, were analyzed to determine the probability of the water surface elevation within each 0.1 foot increment between -1 and 10.0 feet NAVD. Obviously erroneous data was discarded and not included in this analysis.

RESULTS

The results of the probability analysis are shown in Figure 3. For example, the probability of the tide being at elevation 5.0 feet (within 0.1 foot increments) is 2.12 percent. Similarly, the probability of the tide being at elevation 6.0 feet is 1.28 percent, and the probability of the tide being at elevation 7.0 is 0.24 percent.

Using this probability distribution, it is possible to determine the probability of a tide exceeding any particular elevation. For example, there is a 50 percent probability that the tide will exceed elevation 3.9 feet. There is a 10 percent chance that the tide will exceed elevation 5.9 feet. Similarly, there is a 1.03 percent chance that the tide will exceed elevation 7.0 feet, and there is a 0.047 percent probability of the tide exceeding elevation 8.0 feet. There is a 0.002 percent probability that the tide will exceed elevation 9.5 feet.

Also shown on Figure 3 are the 10-year, 50-year, 100-year, and 500-year maximum tide elevations as summarized in the US Army Corps of Engineers White Slough Section 205 Flood Control Study (converted to NAVD). The probability analysis was based on a 12-year period of data. Thus, it would be expected that the data would have exceeded the 10-year tide very rarely. In fact, there were only two hours in the 12-year period in which the data exceeded 10-year tide elevation. During this 12-year period, there were no data that exceeded the 50-year tide elevation; again, as expected.

This analysis was undertaken to determine what tide elevation is appropriate for use as a downstream boundary condition in the modeling of the District's storm drain systems. The District's design criteria state that the design tide elevation shall be 3.5 feet MSL, which would correspond to a tide of about 6.2 feet NAVD. The probability of the tide exceeding elevation 6.2 feet is about 5.12 percent.

Figure 1. Hourly River Elevations at Martinez Station
January 1, 2005 - December 31, 2005

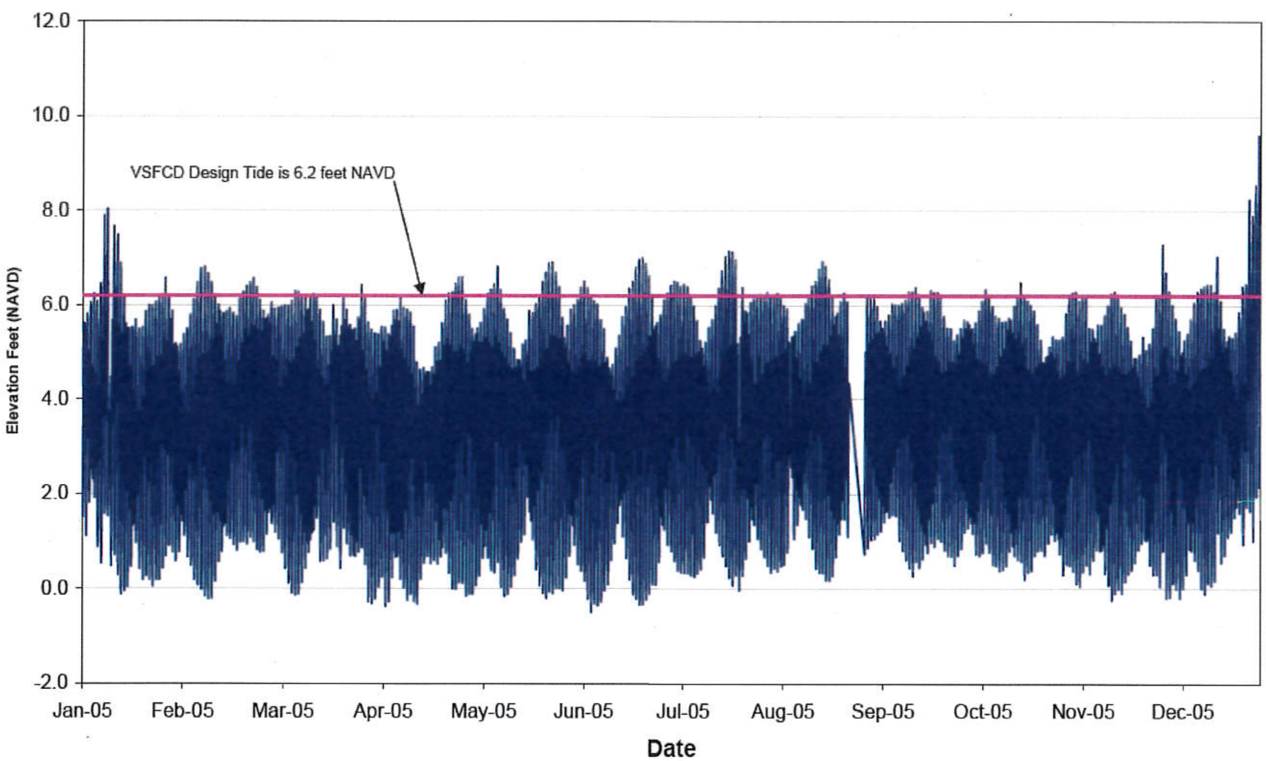


Figure 2. Hourly River Elevations at Martinez Station
January 1, 2006 - November 1, 2006

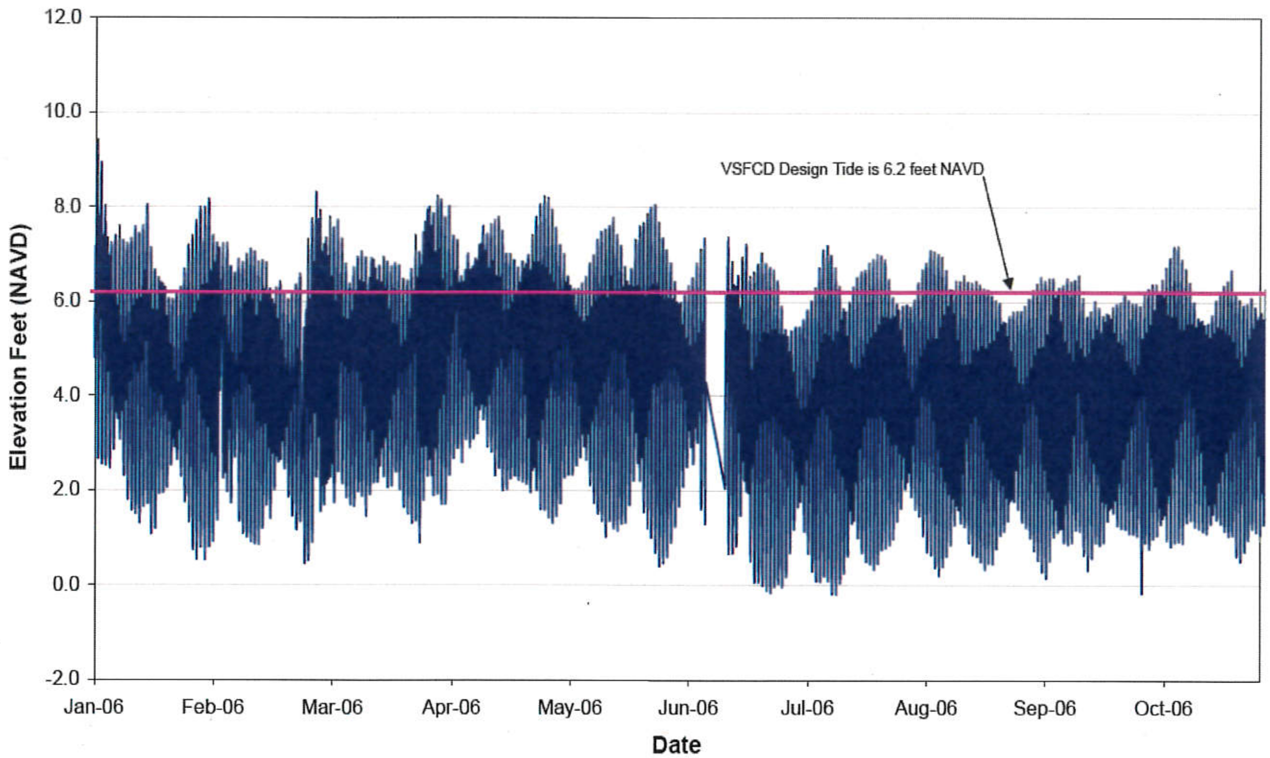
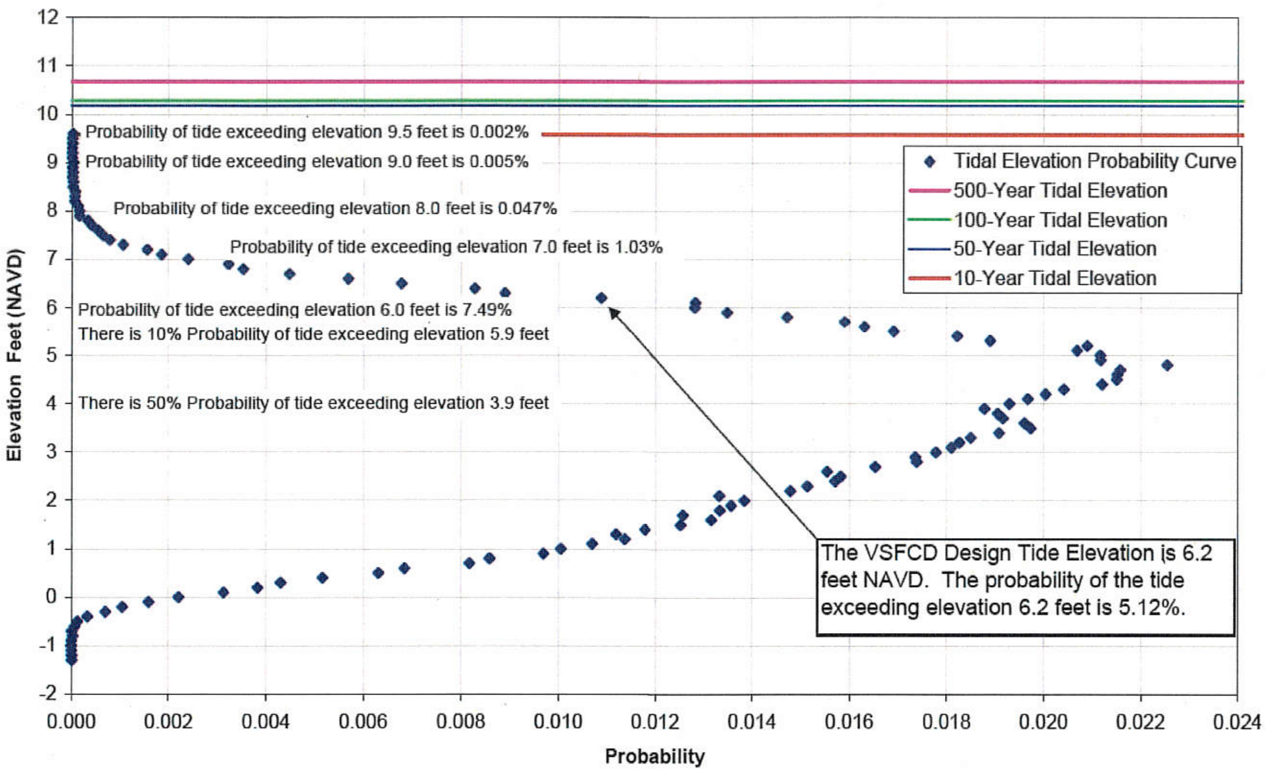


Figure 3. Probablity of Tide at 0.1 ft Increments Based on Data From the Martinez Gage for the Period of January 1994 - November 2006



The District's design tide is also shown on Figures 1 and 2. As shown on Figure 1, there are periods of several months when the design tide is not exceeded by the lower-high tide and is rarely exceeded by the higher-high tide. Alternatively, as shown on Figure 2, there are also periods when the design tide is exceeded by both the lower-high tide and the higher-high tide. Although tide levels are cyclical, for the durations of 1 to 4 hours critical to this analysis (see below) the occurrence of tides above the design tide are assumed to occur randomly.

For storm drains serving areas of less than 640 acres, the design storm is a 15-year event. In any given year, this storm (or a larger storm) has a 6.7 percent chance of occurring. For the Lemon Street/Solano Avenue System, for the 15-year design storm, the critical duration storm related high flow/stages is less than one hour. Given that the 15-year storm is occurring, there is also a 5.12 percent chance that the actual tide would exceed the design tide. Or phrased another way, in any given year, there is a 0.42 percent chance (probability of 0.0042) that there would be a 15-year storm with the peak flow being coincident with a tide above the design tide. Phrased yet another way, the combination of a 15-year design storm peak flow occurring at the same time the tide exceeds the design tide is expected to occur, on the average, once every 238 years.

For storm drains serving areas of greater than 640 acres (like the Solano Avenue Drain), the design storm is a 100-year event. In any given year, this storm (or a larger storm) has a 1 percent chance of occurring. For the Lemon Street/Solano Avenue system, for the 100-year design storm, the critical duration of storm related high flows/stages is about four hours. Given that the 100-year storm is occurring, there is also a 5.12 percent chance that the actual tide would exceed the design tide for any single hour. For the critical four hour period, there is a 19 percent chance that the tide will exceed the design tide for one or more of the four hours. Or phrased another way, in any given year, there is a 0.19 percent chance (probability of 0.0019) that there would be a 100-year storm with one or more of the critical hours of peak flow being coincident with a tide above the design tide. Phrased yet another way, the combination of a 100-year design storm peak flow occurring at the same time the tide exceeds the design tide is expected to occur, on the average, once every 526 years.

WIND, WAVE RUN-UP, AND RIVER FLOWS

High winds that occur during large storms can cause waves that increase design water levels above the design tide. In the USACE White Slough Study, the 100-year design tide was increased by 0.5 feet to account for wave run-up. Also, large storms can cause increased flows and increased water levels in rivers. However, the Martinez tide data presented in Figure 3 includes wave run-up and peak storm flow effects (from the Sacramento River). Thus, these adjustments are already accounted for in this analysis.

CONCLUSION

Based on this analysis, it appears that the VSFCD design tide elevation of 6.2 feet NAVD is appropriate for the planning and design of facilities in the *Lemon Street Channel Flood Reduction Study*. When the MOUSE hardware lock is available, we will revise the design storm model runs to include this design tide elevation.

Please call if you have any questions or comments.

Sincerely,

WEST YOST ASSOCIATES

Douglas T. Moore
Principal Engineer

DTM:nmp

APPENDIX B

Mare Island

C-76 Pipe, D-Load Calculation

American Concrete Pipe Association
Highway Live Loads on Concrete Circular Pipe
Dated: 2001 (revised)

Cover:

Rim	4.44	
Invert	0	
Diameter	1.25	
Crown	1.25	
Thickness	0.2	
Top	1.4	
H (Cover)	3.0	
Table 1, LRFD Wheel Surface Contact Area		
a (width)	1.67	feet
b (length)	0.83	feet
Impact Factor, Equation 1		
IM = (33 * (1 - 0.125H)) / 100		
IM =	0.206	
Table 2		
Use Default		
Load Reduction Factor	1	

Table 4, LRFD

H>3.17		
P =	50000	pounds
Spread a	a+4+1H	
Spread a =	8.7	feet
Spread b	b+4+1H	
Spread b =	7.8	feet

Average Pressure Intensity, Equation 2

w = P * (1 + IM) / A

w =	888	pounds per square foot

Live Load is equation 3:
Wt = (w + Ll) * L * Sl

For H < 8 feet, Ll = 64 pounds per square foot
L use greater of a and b

l =	8.7	feet
Sl outside span of pipe	2.5	feet (Wall B)
Wt =	20644	pounds/lf

Live Load is equation 4:
Wl = Wt/Le

Le from Figure 7

Le = L + 1.75(3/4Bc)	12	feet
Wl =	**1727**	**psf**
Class IV D Load 0.01 inch crack =	2000	psf

Class IV pipe is recommended.