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Introduction

The purpose of this report is to document the stormwater hydraulic modeling completed to design the systems and produce construction drawings for the Doyle Drive Replacement Project (Project) Contract 3. The purpose of the Drainage Report is to describe the following:

1. The drainage objectives of the project
2. The methodology for attaining objectives
3. The existing system baseline
4. The proposed design

This report builds on the findings of the 35% schematic design *Stormwater Drainage Report* dated February 2009 (35% Report) and uses the information to progress and refine the analysis of the storm drainage system to understand the interaction between the Doyle Drive roadway (Roadway) drainage system, Presidio Trust (Offsite) drainage areas, any potential detention spaces throughout the Presidio, roadway Best Management Practices (BMP's), stormwater pump stations, and the discharge outfalls.

Hydraflow, static modeling software, has been used to analyze the proposed Roadway drainage system and help determine size of inlets, diameter of pipes, and pipe profiles.

Infoworks CS, dynamic modeling software developed by Wallingford software, has been used to assess the existing condition of the Offsite drainage, and model the Roadway and Offsite drainage systems together Contract 3 of the Project. The Infoworks modeling process is described within the context of the dynamic hydraulic model for the project and it incorporates the agreed parameters of the 35% Report.

The overall approach for carrying out and documenting the work done on each contract will be as follows:

1. Identify the drainage objectives as follows:
    - General project objectives (background and project contracts)
    - Existing site conditions including location (maps, latitude/longitude, etc), basin characteristics (topography, water bodies, NRCS soil types, land use, etc), existing drainage systems and their watersheds, existing outfalls, tides, floodplain studies, etc. Base maps showing existing drainage should be attached
    - Existing drainage, maintenance, water quality, operational and other issues affecting proposed design
    - Proposed drainage objectives including location (maps, latitude/longitude, etc), basin characteristics (topography, water bodies, NRCS soil types, land use, etc)
2. The methodology section will discuss:
    - Design standards and Standard references
    - Hydrology (design storms, hydrographs, routing methods, software used, etc)
    - Key equations (Rational method + IDF equations + time of concentration + runoff coefficients, Manning's equation + roughness coefficients for pipes and open channels, modified Manning's equation for spread calculations + clogging factors, etc)
    - Soil conditions, special conditions, and requirements by other agencies. This discussion will include the following (pipe materials, joints, subexcavation, need for

culvert end protection and erosion control, bicycle traffic, ADA compliance, Presidio requirements, San Francisco, etc)

3. The existing system baseline will include the following:
   - Establish the existing conditions for the Offsite Presidio Trust storm drainage network using a dynamic hydraulic model.
   - Set the baseline for evaluating outfall design for the Project
4. The proposed design will include the following:
   - Use static hydraulic modeling to design the Roadway drainage for each of the proposed contracts of the Project. The appendix of the report will contain, proposed drainage system layout (pipes and channels), profiles, Results of calculations (include sample calculations, output hydrographs, hydraulic grade lines, channel sections, riprap layering and dimensions, basin calculations, etc)
   - Simulate the impact of the Roadway Drainage system by incorporating the systems and the results of the roadway static model into the dynamic model. This will include routing the Roadway drainage to the existing outfalls, and rerouting the transverse crossings of the Presidio storm drainage network to avoid the obstructions defined by the Project
   - Assess the hydraulic impacts of proposed Presidio Trust detention devices/BMP's, Roadway detention devices/BMP's and stormwater pump station
   - Determine the peak flow at each outfall and compare it to the capacity of each outfall and the existing condition to determine whether the outfall capacity needs to be increased. If the outfalls need to be replaced, the dynamic model will be re-evaluated to verify the design
   - Discussion of information presented in the Construction Drawings. This will include the Alternative Pip Culvert (APC) table, supporting calculations/design for items shown in the Quantities Table and any other pertinent information to the drawing set

Not all steps in the overall approach are relevant to the Contract 3 design. This approach represents the studies and analysis that will be considered for each contract in the Project. The Drainage Construction Drawings (plans, profiles, details and quantity sheets) have been provided within Appendix E and should be reviewed along with this report.

1 Drainage Objectives

1.1 Project Goals

The goals of the stormwater drainage system for the project are as follows:

- Design a system for the Roadway for the 25 Year Storm Event
- Treat all stormwater from the proposed Roadway in the ultimate condition of the Project
- Verify that the Presidio Trust outfalls to San Francisco Bay can convey the 25 Year Storm Event, and upgrade them as necessary
- Do not increase flooding or cause flooding as a result of the Project storm drainage system in the ultimate condition
- Work with the Presidio Trust to satisfy their goals to maximum extent practical

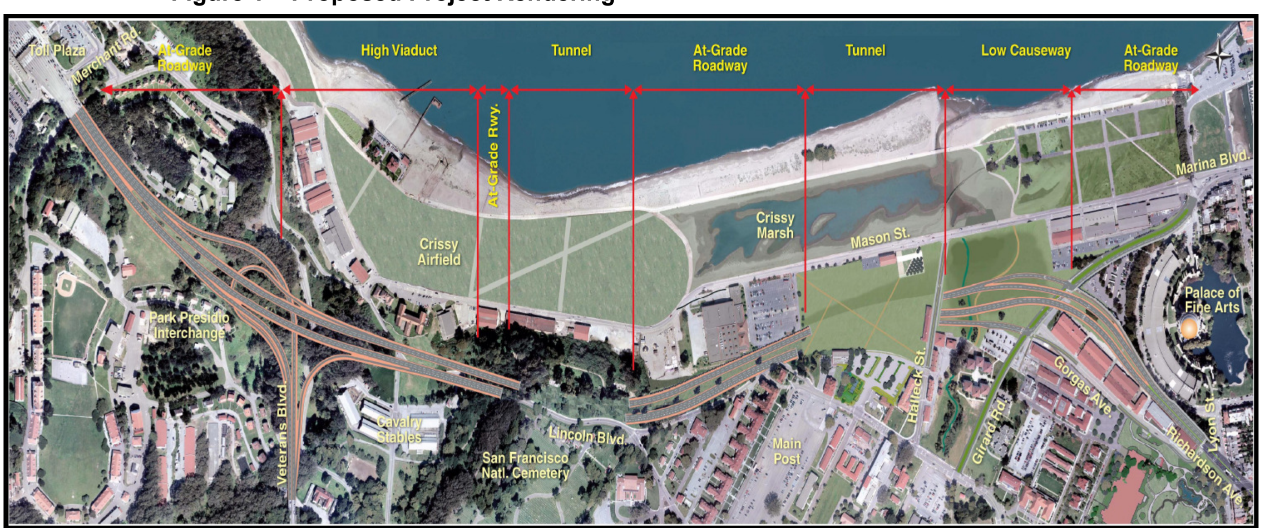
1.2 Background

Doyle Drive is an approximately 1.5 miles long freeway and forms the southern approach of Route 101 to the Golden Gate Bridge. It is a critical link for traveling between the San Francisco Peninsula and the North Bay.

Currently, over 91,000 vehicles use Doyle Drive every weekday. The freeway, built in 1936 has reached the end of its useful life. Short-term improvements to keep the existing highway structures safe are no longer cost effective and the existing structures have structural sufficiency ratings below recommended levels, and so need to be replaced.

The Doyle Drive Replacement Project extends from the Golden Gate Bridge Toll Plaza on the west to Broderick Street on the east, and includes Richardson Avenue, Gorgas Avenue and Marina Boulevard. On the eastern end of the project area, access to Doyle Drive is provided via two approaches: one beginning at the intersection of Marina Boulevard and Lyon Street and the other at the intersection of Richardson Avenue and Lyon Street. Access is also provided where Veterans Boulevard (Route 1) connects to Doyle Drive approximately one mile west of the Marina Boulevard approach.

Figure 1 – Proposed Project Rendering



1.3 Project Contracts

The Project will be constructed in several contracts, and storm drainage improvements will be part of Contract 3 to Contract 7. Arup PB JV (Design Team) has evaluated the stormwater systems of the entire project at a design development level. As roadway construction drawings are produced for each contract, the associated stormwater modeling and analysis will also be completed. This report focuses on documenting the modeling and analyses for the storm drainage systems associated with Contract 3. Figure 2 shows the breakdown of the contracts for the project.

Figure 2 – Contracts 3 through 7 for the Doyle Drive Replacement Project

Contract 3 shown in Figure 2 above, includes constructing the new southbound high viaduct structure from Route 101/1 interchange to the Western Portal of the Battery Tunnel, reconfiguring the Route 101/1 interchange, reconstructing Veterans Boulevard (Route 1) from Ruckman Undercrossing to the interchange, and a realigned segment of Lincoln Boulevard. For a more complete description of the limits of Contract 3 work refer to the Construction Documents and Specifications.

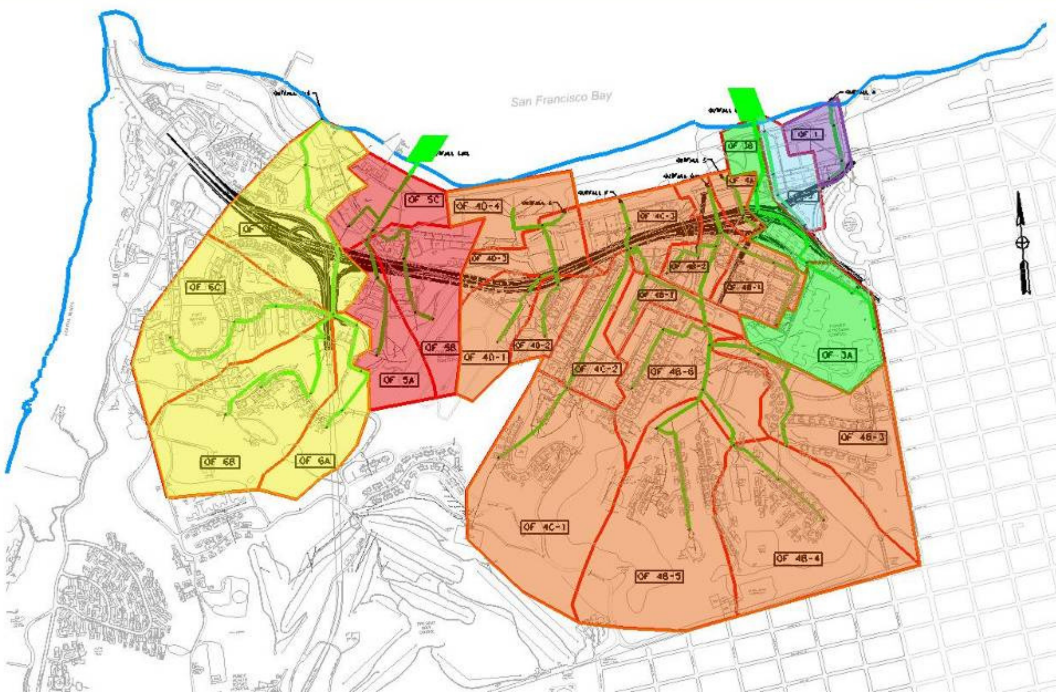
1.4 Existing Site Conditions

The 35% Report establishes the baseline input parameters for the analysis of the existing condition. The sub-catchment areas, sub-catchment runoff SCS curve numbers, and time of concentration inputs were used for the analysis of the existing condition.

1.4.1 Input Parameters

The tributary area of the Presidio site has been divided into 6 watersheds based on topography and which outfalls they historically have discharged to. These watersheds include portions of the existing Doyle Drive Alignment. They are shown in Figure 3 below, and more detailed information can be found in Appendix A1.

Figure 3 - Presidio Watersheds with Proposed Doyle Drive Alignment



Additional site survey was requested at key locations throughout the Presidio Trust network. These areas include the outfalls and the areas where the existing network will be impacted by the proposed Doyle Drive Replacement Project (for example, at the proposed Main Post Tunnel). Survey at the outfalls allowed for a greater understanding of the existing capacity of the system. The modeling is reflective of the information provided by the Presidio Trust and selective survey investigations on site.

The input parameters from the 35% design report were incorporated into the dynamic model. The input parameters include subcatchment areas, runoff generation SCS curve numbers, and time of concentration inputs. The only change in modeling the existing conditions is the storm drainage pipes sizes and inverts were defined, instead of assuming channel flow with uniform slopes. Pipe sizes and invert levels were provided from as-built information provided by the Presidio Trust.

1.4.2 Time of Concentration

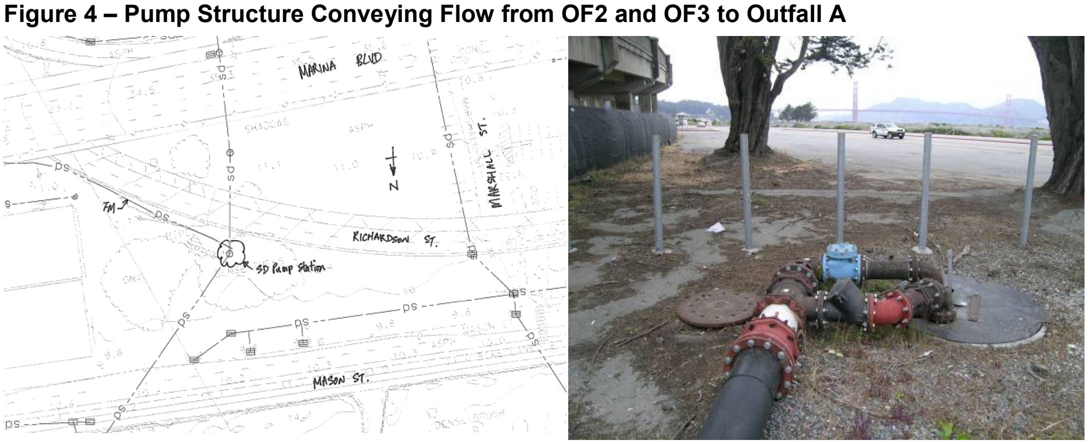
In the 35% Report, the time of concentration was calculated by inputting the watershed parameters into NRCS's WinTR-55 computer program. Each watershed's time of concentration was determined by flow path characteristics (sheet flow, shallow flow, and channel flow) and using Manning's equation. The time of concentration contributions from the 35% Report shows the shallow concentrated flow and in-channel flow small in comparison to sheet flow. It is assumed that the change in the time of concentration contribution due to the modeling of storm drainage pipes in lieu of shallows and channels would be negligible, and so the previous time of concentration has been incorporated into the new model.

1.4.3 Changes to Existing Site Conditions

The Presidio Trust has informed the Design Team that Outfall B discharging to San Francisco Bay located between the eastern edge of Crissy Marsh and the Marina Gate is completely blocked. A plan showing the location of Outfall B is located in Appendix A 3.1. The runoff from the OF 2 and OF3 watersheds (colored blue and green respectively in Figure 3) that have historically drained to outfall B, as assumed in the 35% Report, are now being conveyed to Outfall A via a pump facility. This is located between Richardson Avenue and Mason Street near Marshall Street, as shown in Figure 4.

The Presidio Trust has stated that this blockage and pumping scenario has been ongoing since 2004, and that during larger storm events there is flooding throughout the OF 2 and OF 3 watersheds. This information invalidates the fundamental approach in the 35% Report, and will be incorporated into the current existing conditions hydraulic model when the capacity of the pumps, any storage associated with the system, and other specifications clarifying how the pump should be modeled are provided from the Presidio Trust.

Figure 4 – Pump Structure Conveying Flow from OF2 and OF3 to Outfall A



1.5 Existing Offsite Drainage System

As per the 35% Report, there are no creeks, streams, open culverts or bridges that cross the current Doyle Drive alignment. Most of the drainage in the urban areas occurs through the Presidio storm drain system in underground pipes and open channels along roads. There are several parts of the storm drainage network that cross or run alongside the proposed Doyle Drive that may have potential conflict with the proposed Doyle Drive Replacement Project.

There are no water quality treatment devices or BMP's within the Project area or the neighboring offsite drainage systems.

1.6 Proposed Drainage Objectives

The following section describes the proposed drainage objectives for the roadway drainage system, offsite systems, and outfalls.

1.6.1 Roadway Drainage System

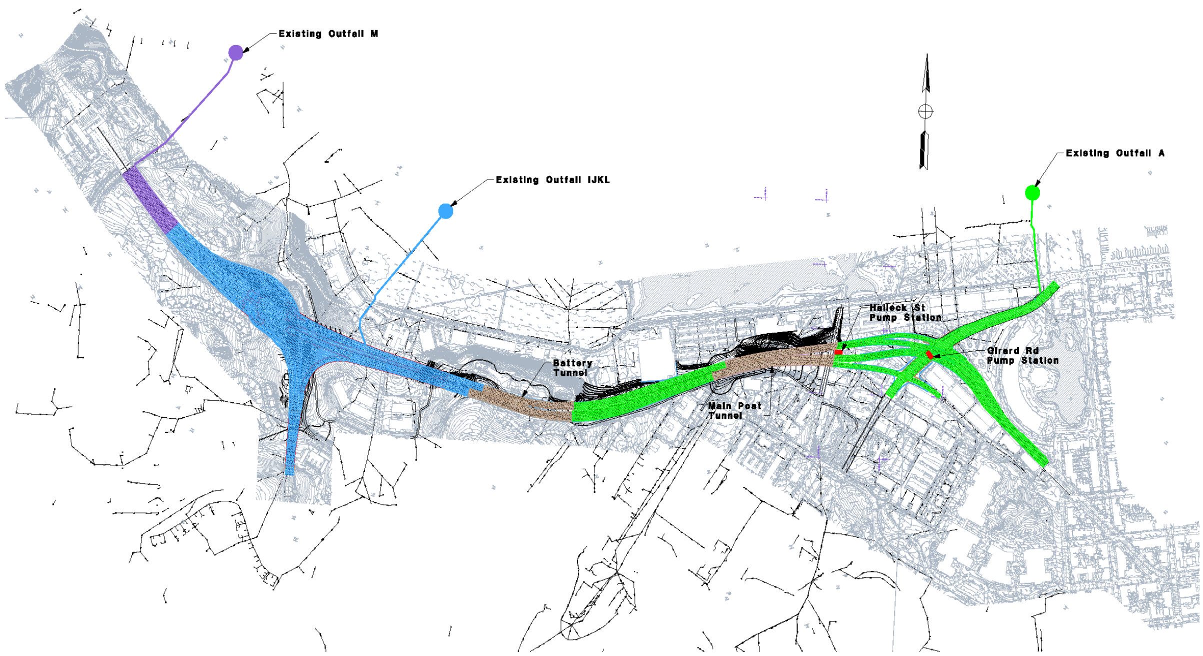
The stormwater from the roadway will need to be managed. In its current condition most of the runoff from the highway is collected and conveyed to the Presidio storm drain network via overland flow. A condition for the Project is that roadway runoff must be treated before it is discharged to the Presidio Trust System, and ultimately to the outfalls. Treatment will only occur in the ultimate condition of the Project, and not at interim conditions such is the case of Contract 3.

The drainage areas for the roadway section have been divided into four major discharge points, each corresponding to a large catchment area that are described as follows:

- The first discharge point will pick up the roadway runoff on the eastern side of the project, which will be sent to a point near Girard Road and ultimately pumped to Outfall A or a new Outfall structure in proximity to Outfall A.
- The second discharge point will collect runoff from the at grade roadway between the Battery Tunnel and Main Post Tunnel and portions of the new freeway just east of the Main Post Tunnel. This runoff will be collected in a pump structure near Halleck Street and conveyed to Mason Street where it will ultimately be discharged to Outfall A or a new outfall structure in proximity to Outfall A.
- The third discharge point will be underneath the High Viaduct where the majority of runoff from the western portion of the alignment will be picked up and ultimately be conveyed to Outfall IJKL or a new outfall structure in proximity to Outfall IJKL. Outfall IJKL is highly susceptible to filling up by the tidal sands and a headwall structure and extension out to the Bay must be constructed.
- The fourth and last discharge point is the drainage to Outfall M. This is a small amount of runoff from the western end of the Doyle Drive Roadway in the Golden Gate Toll Plaza and is very similar to the existing condition (highway with drainage inlets) and thus has not been modeled.

Figure 5 shows the entire alignment and the four separate points of discharge and their associated subcatchment areas.

Figure 5 – Proposed Roadway Drainage Discharge Points and Associated Subcatchments



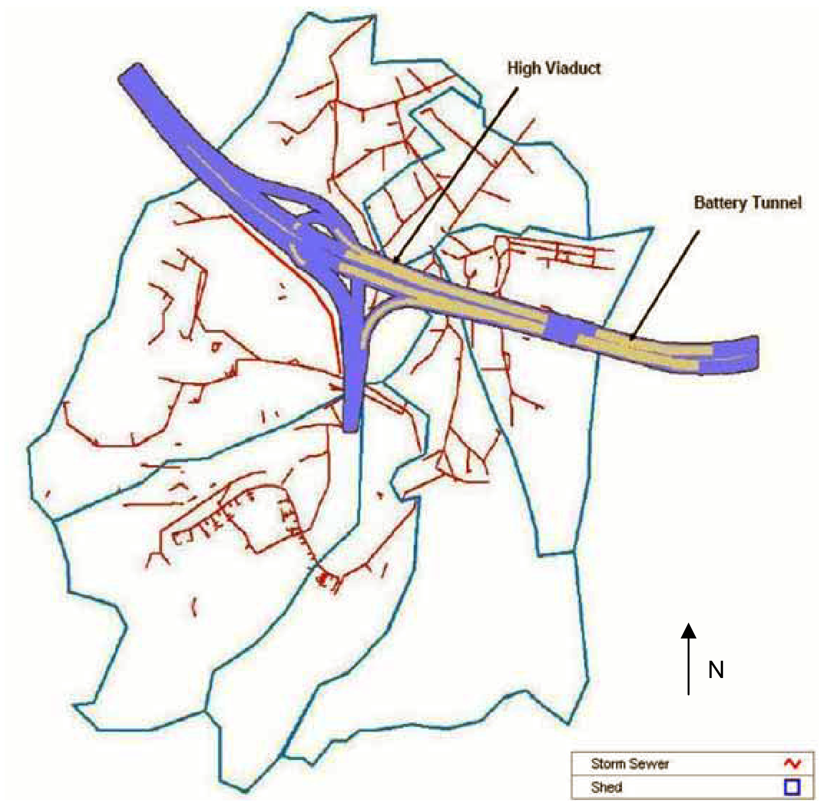
1.6.2 Offsite Drainage

The area of impact for Contract 3 – End of the Project to San Francisco National Cemetery can be summarized as follows:

Existing offsite runoff south of Doyle Drive and west of Veterans Boulevard is intercepted by storm drains and conveyed east pass under Veterans Boulevard (Highway 1), which has an elevated section, and then north along Lincoln Boulevard, under Doyle Drive High Viaduct to San Francisco Bay (see Figure 6). Between Lincoln Boulevard and San Francisco National Cemetery, storm drains intercept runoff south of Doyle Drive and convey flows north under the Doyle Drive to the San Francisco Bay. Flows in excess of the storm drain capacity are intercepted by local streets or just sheet flow under the high viaduct to the San Francisco Bay.

Future offsite runoff for this area will continue to follow a similar path. Some of existing storm drainage pipes and structures may need to be relocated as a result of new roadway improvement, but generally this area will not be greatly affected. Due to the existing topography of the site, offsite runoff will have minimum impact to Doyle Drive between Veterans Boulevard and San Francisco National Cemetery. The proposed relocations have been shown in the construction drawings.

Figure 6 – Existing Storm Drainage at High Viaduct Crossing Proposed Alignment



1.6.3 Outfalls

The aim of the Project is to use the existing storm drainage system to the maximum extent practical. As presented in the Outfalls Report dated April 2009 it is the design team's objective to either reuse the existing outfalls or if necessary upsize the necessary outfalls within the same alignment.

2 Methodology

The proposed stormwater drainage analysis for the Doyle Drive project has been approached holistically to analyze the ultimate and integrated stormwater strategy as opposed to analysis of the roadway drainage isolated from the Presidio Network's outfalls. The approach of designing the roadway drainage in a separate static model and then incorporating the design parameters into the dynamic model allows the Design Team to evaluate design scenarios for the outfalls easily while understanding the interactions between the different components of the system (such as roadway drainage, changes in transverse/offsite crossings, detention devices, BMP's, stormwater pump stations, outfalls, etc).

2.1 Roadway Computations

Hydraflow has been used for the static modeling exercise and Infoworks has been used for the dynamic modeling exercise. The static model will analyze the proposed drainage systems to size the system for the 25-YR event while conforming to the design criteria for the project. The proposed dynamic hydraulic model has incorporated the Roadway drainage and Offsite drainage for Contract 3.

2.1.1 Approach

Hydraflow software has been used to design the roadway drainage system. The inlet sizes, spacing, and pipe sizes for the roadway drainage were designed using Hydraflow software. Hydraflow is a static modeling software that is the preferred method of Caltrans to analyze the roadway drainage system. The complete of the drainage system for the Project (southbound, northbound, and interchange) is analyzed in order to size the inlets, pipes, and other structures. The total watershed area of the Hydraflow includes both Contracts 3 and 7.

The static model has not been used to model the offsite Presidio Trust system because static models interpret results based on a calculated peak flow, rather than calculating results continuously throughout the duration of the storm.

2.1.2 Design Criteria

The following are the design criteria used for the roadway hydraulic modeling.

1) Design Criteria & Reference

   a. Caltrans Highway Design Manual

   b. FHWA Urban Drainage Design Manual (HEC 22)

   c. Rainfall Depth-Duration-Frequency data from California Department of Water Resources Website (San Francisco Sunset Station) (http://www.water.ca.gov/floodmgmt/hafoo/hb/csm/engineering/index.cfm), refer to Table 1 for intensity values

Table 1 - IDF Intermediate Intensity Values (in/hr)

Storm Event	5-Minute	15-Minute	30-Minute	60-Minute
2-Yr	1.87	1.11	0.77	0.49
5-Yr	2.63	1.55	1.08	0.68

10-Yr	3.14	1.86	1.29	0.81
25-Yr	3.77	2.23	1.55	0.98
50-Yr	4.24	2.51	1.74	1.10
100-Yr	4.70	2.78	1.93	1.22

2) Design Storm: 25 yrs (4%) (HDM Table 831.8)
3) Design Water Spread: Shoulder or parking lane (HDM Table 831.8)
4) Computer Software: "Hydraflow - Storm Sewers 2000"

2.1.3 Hydrology Analysis

The following is a description of the design calculations and parameters used.

1) Using Rational Method (Q=CiA) to estimate peak discharge
2) Coefficient of runoff
    a. Paved Area = 0.95
    b. Unpaved Area = 0.44
3) Frequency Adjustment (HDM Chapter 818.2 (1))
    a. For 25 yrs storm, C(f) = 1.1
    b. $C(f)*C \leq 1.0$

2.1.4 Hydraulic Analysis and Modeling

The following is a description of the process followed using Hydraflow, the analysis and modeling software used.

1) Use energy-based Standard Step method (Bernoulli's energy equation) to determine the Hydraulic Profile
2) Use Manning's equation to estimate the friction loss in pipe
3) Tailwater Level/Design Constraint is assumed to be equal to the Mean High High Water Level of Tidal = 5.80' (NAVD 88)
    a. Information is obtained from National Oceanic and Atmospheric Administration Website (www.noaa.gov) – San Francisco Bay Station
4) Inlet Capacity Calculation
    a. Using Computer Software, "Hydraflow" to assist calculation
    b. Calculation is based on FHWA HEC 22 for inlet interception capacity calculation
    c. Any bypass flow will carryover to the next inlet downstream
    d. Inlet in Sag will capture 100% of the flow
    e. The interception efficiency for a grate inlet is assumed to be 50% (partially clogged conditions)
5) Inlet Type and Location
    a. Within freeway area = Grate Inlet (Caltrans Std Type G2 Inlet)

   b. Outside of freeway area = Combination Inlet (Caltrans Std Type GO)

6) Water Spread Width Calculation

   a. Hydraflow using modified Manning equation (similar to equation in HEC 22) to calculate the water depth and water spread

   b. Standard Gutter Depression is assumed at all inlet locations

   c. At points where the super elevation changes direction and the cross slope is 0% provide an extra drainage inlet 20' upstream to prevent ponding

7) Self Cleaning Velocity

   a. To the maximum extent practical the self cleaning velocity of the pipe network should be 3 ft/s and at a minimum 2 ft/s. It should be noted that the velocity is highly dependent on the pipe material, so engineering judgment should be used when conducting this self cleaning velocity check

2.2 Dynamic Modeling Software

Infoworks CS has been used to create the dynamic hydraulic model for the existing project conditions. Static modeling has not been used to model the offsite Presidio Trust system and outfalls because static models interpret results based on a calculated peak flow, rather than calculating results continuously throughout the duration of a storm event. The Infoworks CS software can also help refine the drainage design by incorporating additional appropriate parameters into the model:

- Modeling of the systems using pipes instead of channel flow, to allow for a more accurate set of results with regard to flow routing to the outfalls.
- Modeling attenuation, storage, and pump structures on one software platform will alleviate the need to integrate different software results to obtain results for the entire system.
- The same storm data, rainfall distribution, runoff curves, and volume runoff generation methods will be used from the 35% Report. The 35% Report used a Natural Resource Conservation Service (NRCS) unit hydrograph distribution routing model, while the analysis described herein uses the simplified unit hydrograph approach. The difference between these two methods is minimal and thus is not considered to be significant in the analysis.
- Continuous modeling of tailwater conditions of varying sea level conditions. Within the analysis a constant tailwater condition has been assumed, however if in-depth flood modeling is required the capability of modeling tidal activity is possible.
- Contour grading models (.tin) can be input into the dynamic model to understand areas at risk of flooding, and the extent of the flood boundary.

As storm intensity changes, runoff is routed through the system based on intensity, runoff generated, pipe capacity, flow in the system, and time of concentration for runoff to reach the pipe network. Continuous dynamic modeling offers the ability to analyze any part of the system at any specific point in time in order to get a greater understanding of the entire network. Infoworks also offers the ability to model details of the system such as invert and ground elevations so that pipe flows are modeled accurately to obtain an understanding of areas of potential flooding.

2.2.1 Rainfall Data

The rainfall depth has been obtained from the rainfall gauge for the City of San Francisco with over 116 years of data, from the California Department of Water Resources website. This rainfall depth was distributed over a 24-hr period per the NRCS Type 1 distribution method to obtain rainfall intensity over the storm duration.

2.2.2 Pipe Network Modeling

To simplify the modeling process only one length of pipe was assumed to capture all of the runoff from each subcatchment, and the pipe size was selected as the largest pipe in the subcatchment. Figure 7 and Figure 8 illustrate how the actual pipe network information relates to the information within the hydraulic model. When conducting a flood risk analysis within an area this approach would be considered conservative, however, the main objective of this analysis is to determine outfall capacity. This approach will ensure that the maximum amount of flow reaches the downstream ends of the system and ultimately the outfall, regardless of potential flow restrictions within the system caused by smaller pipe sizes. This modeling technique will ensure that the overall analysis of the peak flow at the outfalls remains conservative. If it is determined that certain areas may be risk to flooding, a more detailed analysis may be considered to accurately assess the impacts on the upstream reaches of the system.

Figure 7 – Example of Actual Pipe Network

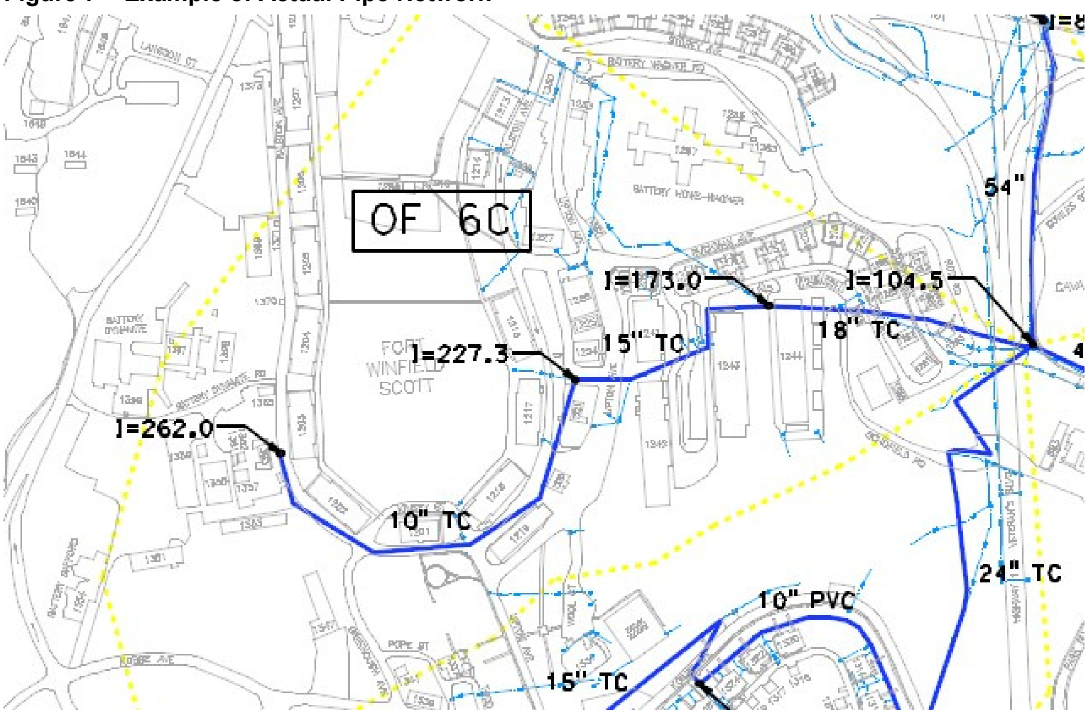
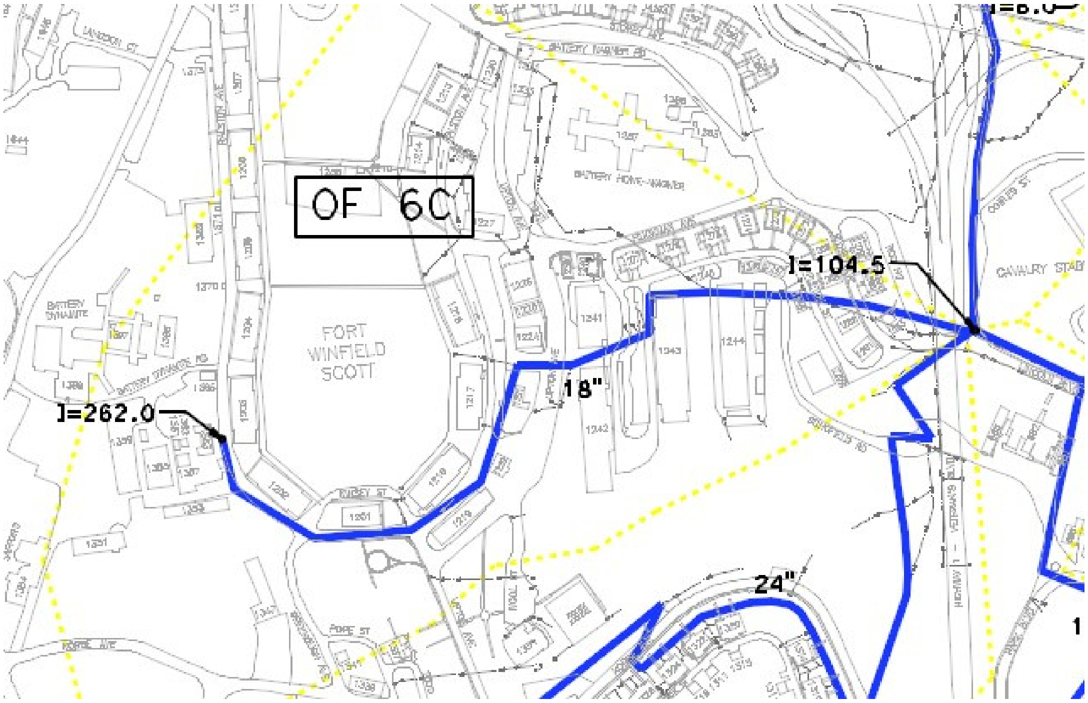


Figure 8 – Example of Modeled Pipe Network



A manning's n value of 0.013 (concrete pipe) was used to model all of the pipes in the network. When evaluating the peak discharge at the outfalls it is conservative to use a lower n value because it will result in the greatest flow.

2.3 Outfalls Design Criteria

The following section describes the outfalls criteria for the temporary and permanent condition.

2.3.1 Temporary Condition

The discharge rate to the outfalls of the Roadway Drainage in Contract 3 represents an interim condition of the project. Caltrans hydraulics officials have advised that the drainage criteria for temporary drainage should be no less than twice the expected life of the temporary facility. The Design Team has decided that using the criteria of the 5-yr event for the evaluation of the outfalls in the temporary condition of Contract 3 would be appropriate. The Roadway system represents a permanent condition and was sized to the 25-year event per Caltrans standards.

2.3.2 Permanent Condition

The analysis for the roadway systems is based on a 25-year design storm event, however the permanent design of the outfalls may be considered to be designed to the 10-year event. While the 25-yr event is typical for Caltrans facilities, the outfalls are part of the Presidio Trust drainage system, which is comprised of local streets that only need to be designed per the 10-year event.

Index 801.3 Drainage Standards of the Caltrans Highway Design Manual, which states, in part:

> "…State-of-the-art methods and procedures associated with the necessary hydrologic analysis required to determine the severity and probability of

occurrence of possible rare storms and flood events are inherently ambiguous. Therefore, the suggested drainage design criteria relating to frequency of occurrence references in this manual are provided for guidance only and are not intended to establish either legal or design standards which must be strictly adhered to. Rather, they are intended as a starting point of reference for designing the most cost effective drainage structures and facilities considering the importance of the highway, safety, legal obligations, ease of maintenance, and aesthetics...."

Index 801.5 Economics of Design states that,

"an economic analysis of alternate drainage designs, where a choice is available, should always be made."

Index 831.3 Design Storm and Water Spread, the section that most directly deals with "the selection of appropriate design storm frequency", furthermore:

"In order for a design frequency to be meaningful criteria for roadway drainage design, it must be tied to an acceptable tolerance of flooding."

Caltrans guidelines state:

"Drainage design criteria relating to the frequency of occurrence of rare storms and flood events were considered, based on guidance provided in the Caltrans Highway Design Manual. The decision to use the 25-year event only for permanent drainage for both Caltrans facilities and local streets was agreed upon by both Caltrans Hydraulics and the Consultant."

The above text illustrates that the use of the 10-year event for design of the Outfalls may be justifiable if the cost of construction and upgrade is too high, from a financial and environmental point of view. Contract 3 represents a temporary case, in which the Roadway runoff will be routed through to the existing Presidio Trust's drainage system and subsequently discharge to the San Francisco Bay via Outfall IJKL and Outfall 15 with the 5-year design storm in mind. In the permanent case all Roadway runoff within the area of Contracts 3 and 7 will be discharged via Outfall IJKL only.

The capacity and design of Outfall IJKL will be re-evaluated during Contract 7 when the northbound section of the freeway is constructed and the storm drainage system in this area will be complete and will be subject to the requirements of the permanent case. The merits and consequences for using the 10 and 25-year design event will be studied in greater with respect to economic feasibility, environmental stewardship and the safety concerns to the travelling public and adjacent property within the Presidio Lands.

2.4 Special Conditions

The National Park Services (NPS) has previously stated that no Doyle Drive roadway runoff can be conveyed to Crissy Marsh, and their stance on this issue has not changed.

3 Existing Site Base Conditions

To simplify the modeling process two separate models were created. The first model incorporates the subcatchments associated with OF1, OF2, OF3, OF5, and OF6. These areas were included within one model because they all discharge to San Francisco Bay. Within this report, and subsequent reports this model will be referred to the San Francisco Bay Model. Subcatchments associated with OF 4 all discharge to Crissy Marsh, and were modeled separately. Within the report, and subsequent reports this model will be referred to as the Crissy Marsh Model.

These results supersede the preliminary analysis conducted in the Outfalls Report Dated April 2009.

3.1 San Francisco Bay Model

There are four outfalls associated with the San Francisco Bay Model, as shown in Appendix A 3.1. Outfall A drains OF 1, OF 2 and OF 3, Outfall B is blocked, Outfall IJKL drains OF 5, and Outfall 15 drains OF 6. Figure 9 and Figure 10 shows excerpts of the San Francisco Bay Model from Appendix A 3.1.

Figure 9 – San Francisco Bay Model – Outfall A and Outfall B (Excerpts from Appendix A 3.1)

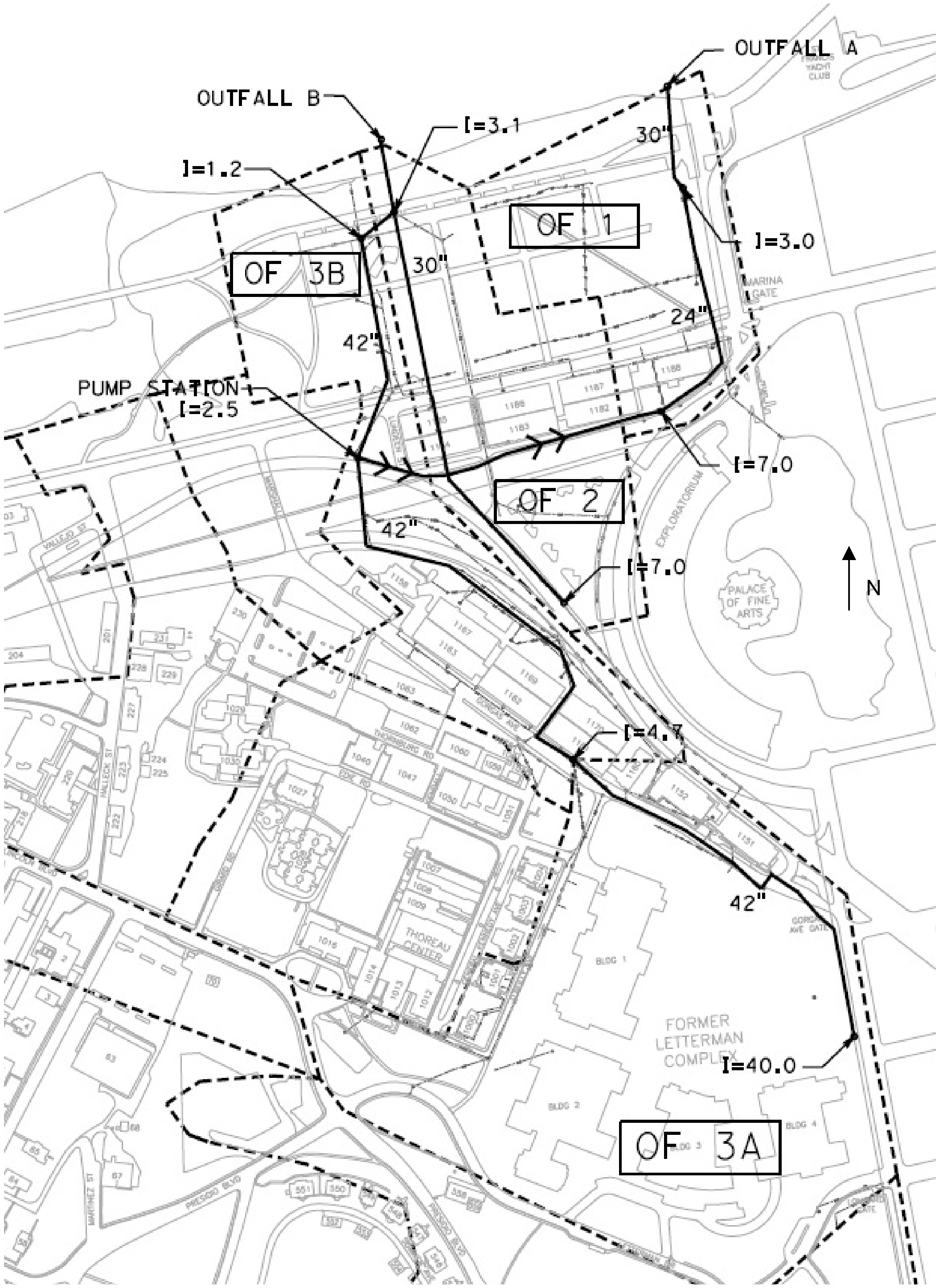
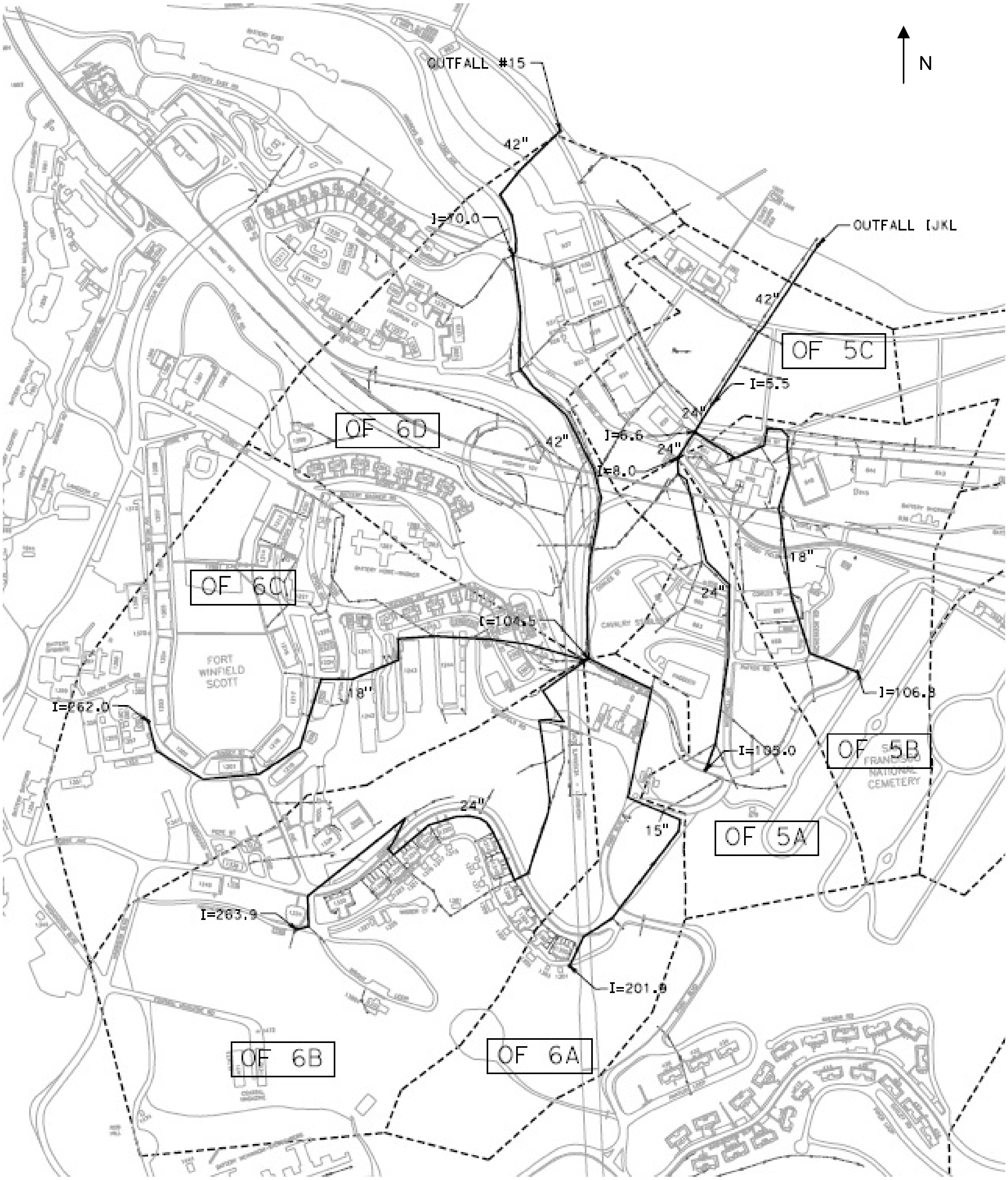


Figure 10 – San Francisco Bay Model – Outfall IJKL and Outfall 15 (Excerpts from Appendix A 3.1)



The western portion of the Doyle Drive Roadway in the Golden Gate Toll Plaza drains to Outfall M. The contribution from the roadway in the existing and proposed condition is a very small watershed and it has not been captured in the dynamic model.

Table 2 summarizes the existing capacity and peak flows to the outfalls. As mentioned earlier the information for the current pump configuration of the Presidio Trust has not been provided to the design team. Thus, the baseline analysis for Outfall A cannot be determined at this time and will be provided in a future report. The modeling parameters and sketches are contained in Appendix A.

Table 2 - San Francisco Bay Model Outfall Existing Results

	Outfall A (30”)	Outfall B (42”)	Outfall IJKL (42”)	Outfall 15 (42”)
Subcatchment Area (ac)	10.57	58.46	74.36	189.87
SCS Curve Number	87	88	73	80
Time of Concentration (min)	Unknown	Blocked	70.74	71.76
Design Tailwater Elevation (+ft)	5.8		5.8	5.8
Flow Line Elevation at Outfall (+ft)	0		0	0
Slope	1%		0.6%	10%
Capacity	Information not provided in this report		75	329
5-YR (cfs)			37	97
10-YR (cfs)			46	121
25-YR (cfs)			58	150
100-YR (cfs)			76	164

The results show that Outfall IJKL has existing capacity for all storm events below the 100-YR event.

Preliminary survey of Outfall IJKL was unable to definitively determine the size of the outfall. This uncertainty is most likely attributed to the Outfall being partially blocked with sands due to tidal activity. At Mason Street the survey has indicated that the Outfall is 42” and thus this assumption has been made for the entire run of the outfall. It is possible that the outfall pipe is actually reduced to 36” and even potentially 30” as it approaches San Francisco Bay. Follow up survey will be conducted in the future to verify these preliminary results.

3.2 Crissy Marsh Model

There are four outfalls associated with the Crissy Marsh Model, as shown in Appendix A 3.2. Outfall C drains OF 4A, Outfall D drains OF 4B, Outfall F drains OF 4C, and Outfall G drains OF 4D. Figure 11 shows an excerpt of San Francisco Bay Model from Appendix A 3.2.

Figure 11 – Crissy Marsh Model (Excerpt from Appendix A 3.2)

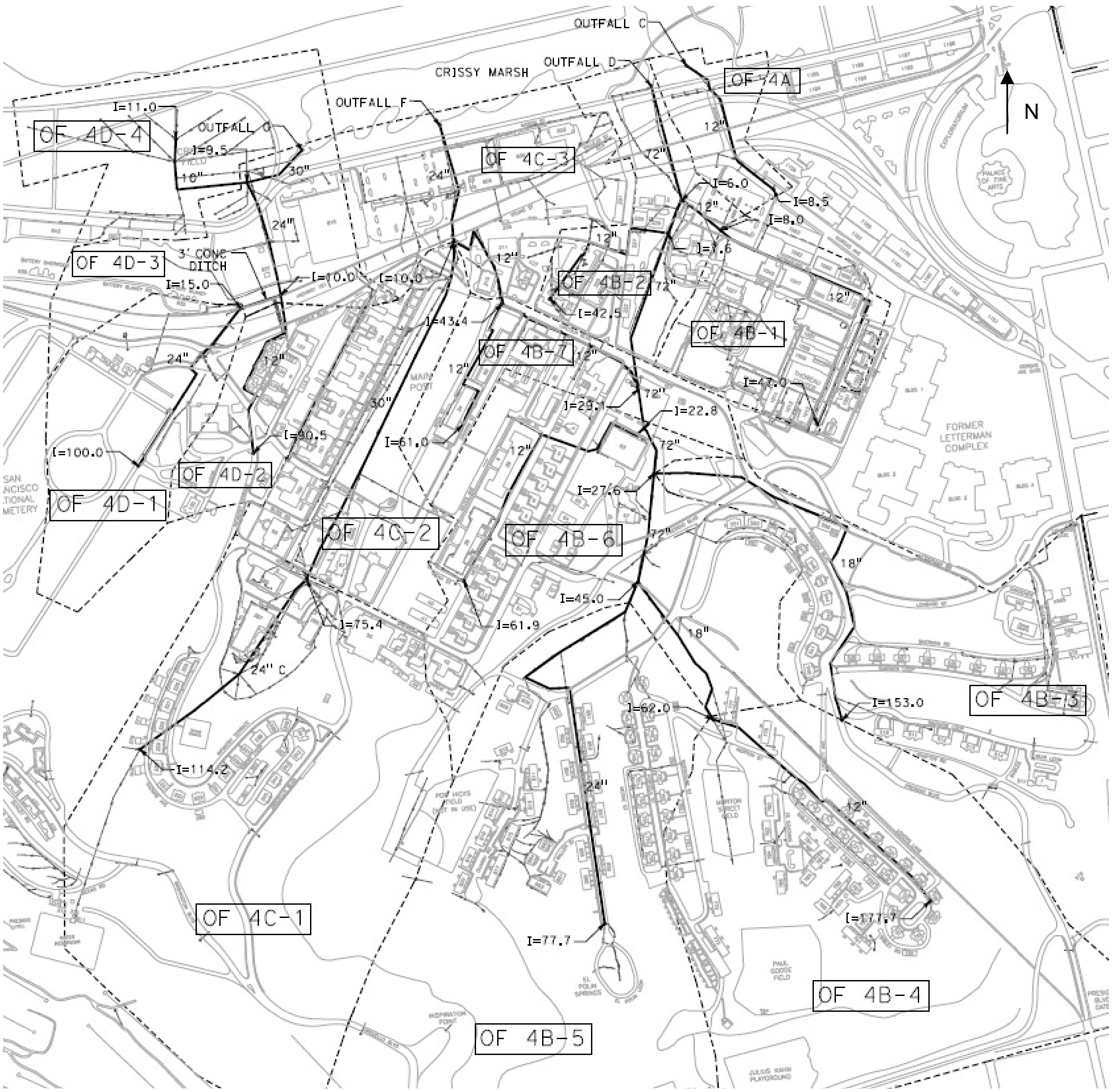


Table 3 summarizes the existing capacity and peak flows to the outfalls. The modeling parameters and sketches are contained in Appendix A.

Table 3 - Crissy Marsh Model Bay Model Existing Outfall Results

	Outfall C (12")	Outfall D (72")	Outfall F (24")	Outfall G (30")
Subcatchment Area (ac)	6.48	280.00	121.31	114.73
SCS Curve Number	94	86	96	86
Time of Concentration (min)	31.86	90.18	64.02	70.32
Design Tailwater Elevation (+ft)	5.8	5.8	5.8	5.8
Flow Line Elevation at Outfall (+ft)	0	0	0	0
Slope	3%	1.8%	1.1%	1.1%
Capacity	2	439	30	71
5-YR (cfs)	4	144	69	66
10-YR (cfs)	4	166	72	76
25-YR (cfs)	5	187	74	86
100-YR (cfs)	5	213	77	90

3.3 Results Discussion

The results documented within this report are different from those previously submitted in the 35% Report due to the differences in modeling capabilities. The variations in the capacity and peak flow numbers between this and the previous model in the 35% Report can be directly attributed to the fact that the outfalls have been modeled as pipes instead of channels. As a result, flow is restricted from going through the outfalls and the peak flow results are reduced.

These outfall maximum flow results will be used to establish the baseline hydraulic condition of the Project. The goal for the Project is to either maintain or lower the maximum flow to the outfalls for the 25-YR event, or increase outfall capacity such that the maximum flow can be conveyed. The existing dynamic model will be updated at each stage of the contract to reflect collected information via survey, the Presidio Trust, and other credible sources.

4 Proposed Design

4.1 Roadway Results Discussion

The design parameters presented within section 2 have been used with the Hydraflow model to size the storm drainage pipes and determine inlet spacing. The designed system meets the criteria and the hydraulic profile (HGL) show that for the 25-year event the highway will be safe for travel. The design of the system has been shown in the construction documents. The analysis associated with how the drainage from the roadway drainage system will be conveyed to the outfalls, and impact this drainage will have on the Offsite Drainage systems will be discussed in Section 6. The associated computations and profiles with HGL's are available in Appendix B.

4.2 Offsite Drainage System

The changes in pipe alignment and flow routing of the offsite system do not change the way the existing system conveys flow and consequently will not affect the results of the Proposed System Dynamic Model. In subsequent contracts the offsite drainage system may have to be significantly changed by the Project and these changes will be included in the analysis.

4.3 Presidio Trust Detention Devices/BMP's

At this time there are no areas within Contract 3 work area that the Presidio Trust have identified as potential locations for detention devices to attenuate flow before discharge to the outfalls or stormwater BMP's for treatment purposes. Detention devices and BMP's throughout the Presidio lands are currently under investigation by the Presidio Trust and if applicable to the Roadway or Offsite Drainage Systems, they may be incorporated in future hydraulic studies.

4.4 Roadway Stormwater Detention Devices/BMP's

At this time there are no plans to implement detention devices in Contract 3. Permanent stormwater BMP's for the Contract 3 area will be constructed as part of Contract 7 as they are likely to be damaged due to future construction disturbance. The potential detention advantage of stormwater BMP's to attenuate flow prior to discharge to the outfalls is currently under evaluation and will be discussed in subsequent submissions.

4.5 Stormwater Pump Stations

There is no stormwater pump station proposed for Contracts 3 area.

4.6 Dynamic Modeling

During the modeling process it is important to evaluate the results of the system after each contract so the impacts on the outfall can be measured. The end of Contract 3 represents a temporary condition of the project and dictates that a separate stormwater drainage system be implemented to collect drainage from the roadway and then ultimately discharge it to the Presidio Trust network out to San Francisco Bay. The roadway drainage must be treated via BMP's in the permanent condition, but not in the temporary case as such with Contract 3. The design of the stormwater BMP's associated with the Roadway systems in Contract 3 will be completed as part of Contract 7.

The discharge rate to the outfalls of the Roadway Drainage in Contract 3 represents an interim condition of the project. Caltrans hydraulics officials have advised that the drainage criteria for temporary drainage should be no less than twice the expected life of the temporary facility. The Design Team has decided that using the criteria of the 5-yr event for the evaluation of the outfalls in the temporary condition of Contract 3 would be appropriate. The Roadway system represents a permanent condition and was sized to the 25-year event per Caltrans standards. The roadway drainage design and transverse drainage crossings design discussed above represent the items that will be implemented in Contract 3. Items such as offsite detention devices/BMP's, Roadway detention devices/BMP's, stormwater pump station are not part of Contract 3 and thus will not be incorporated into the model.

In future contracts the dynamic model will be used to analyze the variability in flow while it is routed to stormwater detention devices, BMP's, storage devices, and pumping configurations. The model's analytic capability will aid in understanding the impact on the outfall hydrographs with different detention devices, BMP, storage tanks and pumping configurations. This will be discussed in further detail in later contract report submittals.

4.6.1 Incorporation of Roadway Drainage Static Modeling Results

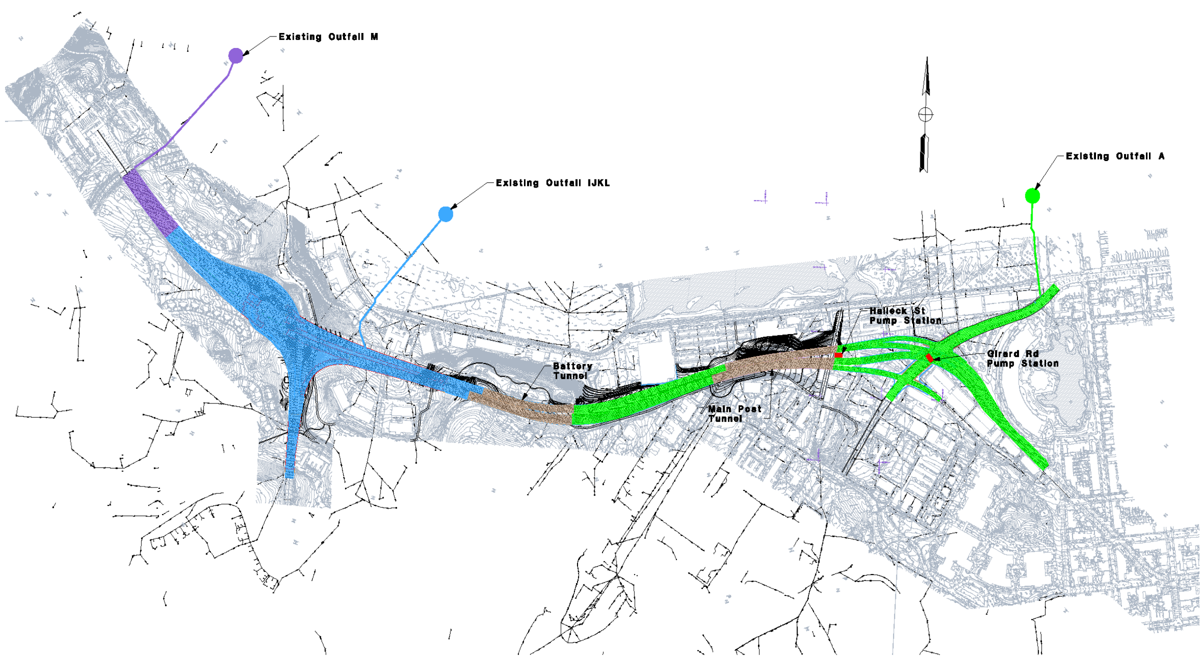
The output parameters from the Static model using Hydraflow have been incorporated into the Infoworks dynamic model to perform the routing exercise of discharge to the outfalls. These output parameters include subcatchment area, time of concentration, curve numbers, pipe inverts, pipe sizes, etc. Appendix C contains detailed information and a sketch that demonstrates the modeling parameters used.

4.6.2 Land Use Changes

The existing subcatchment areas and volume runoff SCS curve number definition included areas of the current Doyle Drive Roadway. The proposed model takes these areas into account separately as described in Section 4, thus the existing subcatchment information has been modified to reflect this change. Figure 12 shows those areas of the entire alignment that have been modeled in relation to the existing watersheds in blue and green. The blue of Contract 3 have been subtracted from the existing subcatchments and the calculations can be shown in further detail in Appendix C.

Where a watershed in the Presidio has not been modified or where the fundamental function of the watershed will not be affected or changed, analysis of these areas has not been undertaken.

Figure 12 – Existing Watersheds with the Proposed Doyle Drive Highway Watersheds



4.6.3 San Francisco Bay Model

Contract 3 only has impacts on Outfall IJKL and Outfall 15 within the San Francisco Bay Model. Table 4 summarizes the peak flows to the outfalls as a result of this Contract. The modeling parameters and sketches are contained in Appendix C

Table 4 - San Francisco Bay Model Outfall Interim Results

<table>
<tr><th></th><th>Outfall A (30")</th><th>Outfall B (42")</th><th>Outfall IJKL (42")</th><th>Outfall 15 (42")</th></tr>
<tr><td>Subcatchment Area (ac)</td><td>10.57</td><td>58.46</td><td>70.96</td><td>178.21</td></tr>
<tr><td>Doyle Drive Roadway Area (ac)</td><td>0</td><td>0</td><td>7.85</td><td>7.22</td></tr>
<tr><td>SCS Curve Number</td><td>87</td><td>88</td><td>75</td><td>79</td></tr>
<tr><td>Time of Concentration (min)</td><td>Unknown</td><td rowspan="9">Blocked</td><td>70.74</td><td>71.76</td></tr>
<tr><td>Design Tailwater Elevation (+ft)</td><td>5.8</td><td>5.8</td><td>5.8</td></tr>
<tr><td>Flow Line Elevation at Outfall (+ft)</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Slope</td><td>1%</td><td>0.6%</td><td>10%</td></tr>
<tr><td>Capacity</td><td rowspan="5">Information not provided in this report</td><td>75</td><td>329</td></tr>
<tr><td>5-YR (cfs)</td><td>40</td><td>95</td></tr>
<tr><td>10-YR (cfs)</td><td>50</td><td>118</td></tr>
<tr><td>25-YR (cfs)</td><td>62</td><td>147</td></tr>
<tr><td>100-YR (cfs)</td><td>82</td><td>188</td></tr>
</table>

As shown in the Table, the capacities of Outfall IJKL and Outfall 15 are much greater than the expected flows of the temporary 5-year event.

4.6.4 Crissy Marsh Model

Contract 3 does not affect those onsite or offsite areas associated with the Crissy Marsh Model.

4.7 Outfall Results

In the temporary condition of Contract 3 there is sufficient outfall capacity to discharge the Roadway Drainage to Outfall IJKL and Outfall 15.

4.8 Construction Drawings Supporting Information

The supporting information and calculations to the items presented in the Quantities Table in the Construction Drawings are as follows:

The APC table shown and the CSP pipe types have been used based on the recommendations by Caltrans in a letter dated, April 25th, 2009. Please see Appendix D 1.1.

Appendix D 2.1 contains methodology and calculations for the design of the channel and rock slope protection (RSP) as part of Drainage System 24, unit b and unit c respectively.