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TECHNICAL MEMORANDUM

Date: January 9, 2020 **BKF Job No.:** C20160367-11

Deliver To: Craig Freeman, SFPUC

From: Erik Moreno, BKF Engineers
Lindsey Carmona, BKF Engineers

Subject: **Balboa Reservoir**
Hydrologic and Hydraulic Modeling

Balboa Reservoir is a 17-acre site in San Francisco bounded by City College campus to the east, multi-family housing and retail on Ocean Avenue to the south, Westwood Park neighborhood to the west, and Riordan High School to the north. Balboa Reservoir is proposed to be developed (the Project).

The Project is subject to the Stormwater Management Requirements (SMR) and shall provide stormwater best management practices (BMPs) to reduce the 2-year, 24-hour peak runoff rate and total runoff volume from the Project (i.e. runoff from on-site areas only) by 25%. Herein, this is referred to as the 2-year storm requirement.

There are capacity limitations in the Ocean Avenue combined sewer system. Therefore, the Project may not increase the peak discharge to the Ocean Avenue sewer system in the 5-year, 3-hour and 100-year, 3-hour storm events. Herein, this is referred to as the 5-year and 100-year storm requirement.

This memorandum has been prepared to document the hydrologic and hydraulic modeling, and to present two alternatives for the project that will meet these requirements. Alternative 1 uses only green infrastructure, and alternative 2 uses a combination of green infrastructure and traditional stormwater detention.

Assumptions

The following assumptions were made to develop the existing and proposed conditions model:

- Sewer System geometry developed using:
  - Ocean Avenue Combined Sewer System (CSS) provided by SFPUC;
  - As-built drawings;
  - Estimated pipe slopes (1% assumed).
- Green infrastructure assumed to be a single, vertical wall bioretention planter:
  - 6" ponding depth;
  - 1 in/hr infiltration rate
- Detention system assumed to be off-line vaults separated from the main with a side weir and with orifice controls to throttle discharge to the sewer main.
- Existing 6' x 6' storm drain structure at Node C-010, downstream of 72" pipe in East system is shown on survey and may contain orifice controls. Due to insufficient information, 6' x 6' structure not modeled.
- NAVD88 vertical datum.
- All impervious area is assumed to be directly connecting (no composite curve number).

Drainage Systems

In existing conditions, the Project site may be split into two drainage systems (West and East), each with a separate connection to the combined sewer under Ocean Avenue. The East system captures runoff from off-site areas (areas not impacted by the Project). The West system does not include runoff from any off-site areas. Refer to Exhibit 1.

Table 1. Existing Drainage System Areas

Drainage System	On-site Area *Acres*	Off-site Area *Acres*	Total Area *Acres*
West System	14.5	0.0	14.5
East System	2.4	7.2	9.6

In the proposed conditions, additional area is added to the West system, and a portion of the West system is diverted to the East system. Refer to Exhibit 2.

Table 2. Proposed Drainage System Areas

Drainage System	On-site Area *Acres*	Off-site Area *Acres*	Total Area *Acres*
West System	14.3	0.0	14.3
East System	4.3	7.0	11.3

Existing Runoff

Runoff from the West system in existing conditions is significantly attenuated by two undersized pipes. The pipes are both 12-inch diameter, relatively flat and are the only outlets for the existing parking lot. The limited capacity of these pipes results in significant volume stored in the parking lot, and low discharge rates to Ocean Avenue. Runoff rates from the East system are not attenuated in existing conditions.

Table 3. Existing Conditions Flow Results

Drainage System	2-year Storm (On-site Only)		5-year Storm (On-site and Offsite)		100-year Storm (On-site and Offsite)	
	cfs	*AF*	*cfs*	*AF*	*cfs*	*AF*
West System	8.4	2.3	8.5	0.9	9.4	1.7
East System	3.4	0.5	17.2	0.8	28.8	1.5

Proposed Runoff

Two alternatives were studied to meet the Project requirements the proposed conditions.

Alternative 1 – Green Infrastructure:

The required flow rate and volume reductions are achieved using only green infrastructure (GI), assumed to be unlined bioretention planters. For the 2-year on-site analysis, the amount of green infrastructure provided in the West system is based on preliminary site plans; the amount provided in the East system is the minimum required based on modeling. For the 5-year and 100-year requirement, additional green infrastructure area was added to reduce peak discharge to Ocean Avenue down to existing conditions. Modeling results are shown in the following tables.

Table 4. Alternative 1 – Required GI for 2-year Requirement (On-site Only)

Drainage System	Provided GI Area	2-year Peak Runoff Rate	2-year Rate Reduction	2-year Total Runoff Volume	2-year Volume Reduction
	Acres	*cfs*	*Percent*	*cf*	*Percent*
West System	1.1	5.9	30%	1.1	54%
East System	0.4	1.3	61%	0.3	28%

Table 5. Alternative 1 – Required GI for 5-year and 100-year Requirement (On-site and Off-site)

Drainage System	Provided GI Area	5-year Storm		100-year Storm	
		Existing Discharge Rate	Proposed Discharge Rate	Existing Discharge Rate	Proposed Discharge Rate
	Acres	*cfs*	*cfs*	*cfs*	*cfs*
West System	1.9	8.5	0.0	9.4	9.0
East System	0.5	17.2	17.0	28.8	28.4

Alternative 2 – Combination Green Infrastructure and Detention:

For this alternative, the 2-year requirement volume reduction is achieved using GI, and an off-line detention system is used to reduce the 2-year peak rate down to existing conditions. The benefit of this approach is less green infrastructure is required in the western system. For the 5-year and 100-year requirement, additional detention volume was added to reduce the peak discharge to Ocean Avenue down to existing conditions. Modeling results are shown in the following tables.

Table 6. Alternative 2 – Required GI and Detention for 2-year Requirement (On-site)

Drainage System	Provided GI Area	Provided Detention Volume	2-year Peak Runoff Rate	2-year Rate Reduction	2-year Total Runoff Volume	2-year Volume Reduction
	Acres	*AF*	*cfs*	*Percent*	*cf*	*Percent*
West System	0.4	0.3	6.2	26%	1.7	25%
East System	0.4	0.0	1.3	61%	0.3	28%

Table 7. Alternative 2 – Required GI and Detention for 5-year and 100-year Requirement (On-site and Off-site)

Drainage System	Provided GI Area	Provided Detention Volume	5-year Storm		100-year Storm	
			Existing Discharge Rate	Proposed Discharge Rate	Existing Discharge Rate	Proposed Discharge Rate
	Acres	*AF*	*cfs*	*cfs*	*cfs*	*cfs*
West System	0.4	0.9	8.5	4.5	9.4	9.2
East System	0.4	0.1	17.2	17.1	28.8	26.5

Storm Drain System Model

The XPSWMM 2017 dynamic hydrologic and hydraulic modeling program developed by XP Solutions was used to analyze the performance of the existing and proposed storm drain system. Santa Barbara Urban Hydrograph (SBUH) methodology is used to compute the runoff and the USEPA SWMM hydraulic computational engine to compute the one-dimensional flow through the proposed storm drain system.

The existing conditions XPSWMM model consists of two storm sewer lines that drain the east and west side of the site. The storm sewer line that drains the west side of the site connects to the existing combined sewer main in Ocean Avenue near Plymouth Avenue. The storm sewer line that drains the east side of the site connects to the same combined sewer main in Ocean Avenue near Lee Avenue.

The proposed conditions model consists of two sewer systems that serve the east and west side of the site. The model includes green infrastructure and detention facilities that are required for the project to comply with the SFPUC's Stormwater Management Requirements (per discussion above). The two proposed storm sewer lines connect to the combined sewer main in Ocean Avenue at the same location as the existing storm sewer lines.

Santa Barbara Unit Hydrograph Hydrologic Parameters

Rainfall

The green infrastructure is modeled using the SFPUC's 2-year, 24-hour hyetograph. For the 5-year and 100-year requirements, the SFPUC's 5-year, 3-hour "Level of Service" storm and the 100-year, 3-hour storm hyetograph are used.

Runoff Curve Number

The curve number (CN) of a drainage area is based on the soil type and surface cover. SBUH automatically assigns a Curve Number of 98 to all impervious areas. Per the geotechnical report dated January 22, 2018 from Rockridge Geotechnical, the top layer of soil encountered in the borings taken on site were silty sand, sand with silt, and clayey sand with gravel. These soil types behave similar to type B soils. Therefore, a Curve Number of 61 was assigned to all pervious areas. This number is based on type B soils with "Open Space" land use (lawns, parks, etc.) with "Good Condition" (grass cover > 75%).

Percent Impervious

The total impervious area for each DMA was estimated based on a combination of the proposed roadway and preliminary site layout. Roof and pavement covers (i.e. asphalt, concrete, etc.) are assumed to be 100% impervious. Note that impervious area is modeled as directly connecting impervious area (i.e. a composite curve number is not computed for our analysis).

Time of Concentration

The time of concentration was calculated using the velocity methodology developed by the Natural Resources Conservation Service (NRCS). A time of concentration of 5 minutes was used for DMAs that had a calculated time of concentration less than 5 minutes, per the Santa Barbara Urban Hydrograph Methodology.

Computational Time Step

For the hydrologic analyses, a computational time step of 60 seconds was used.

SWMM Hydraulic Parameters

Manning's n

Manning's n, or the roughness coefficient, is dependent on the storm drain pipe material. The existing storm drain is assumed to be vitrified clay pipe. Manning's n is 0.014 for vitrified clay. The same Manning's n was used in proposed conditions because the pipe type has not yet been determined.

Computational Time Step

For the hydraulic analyses, a computational time step of 10 seconds was used.

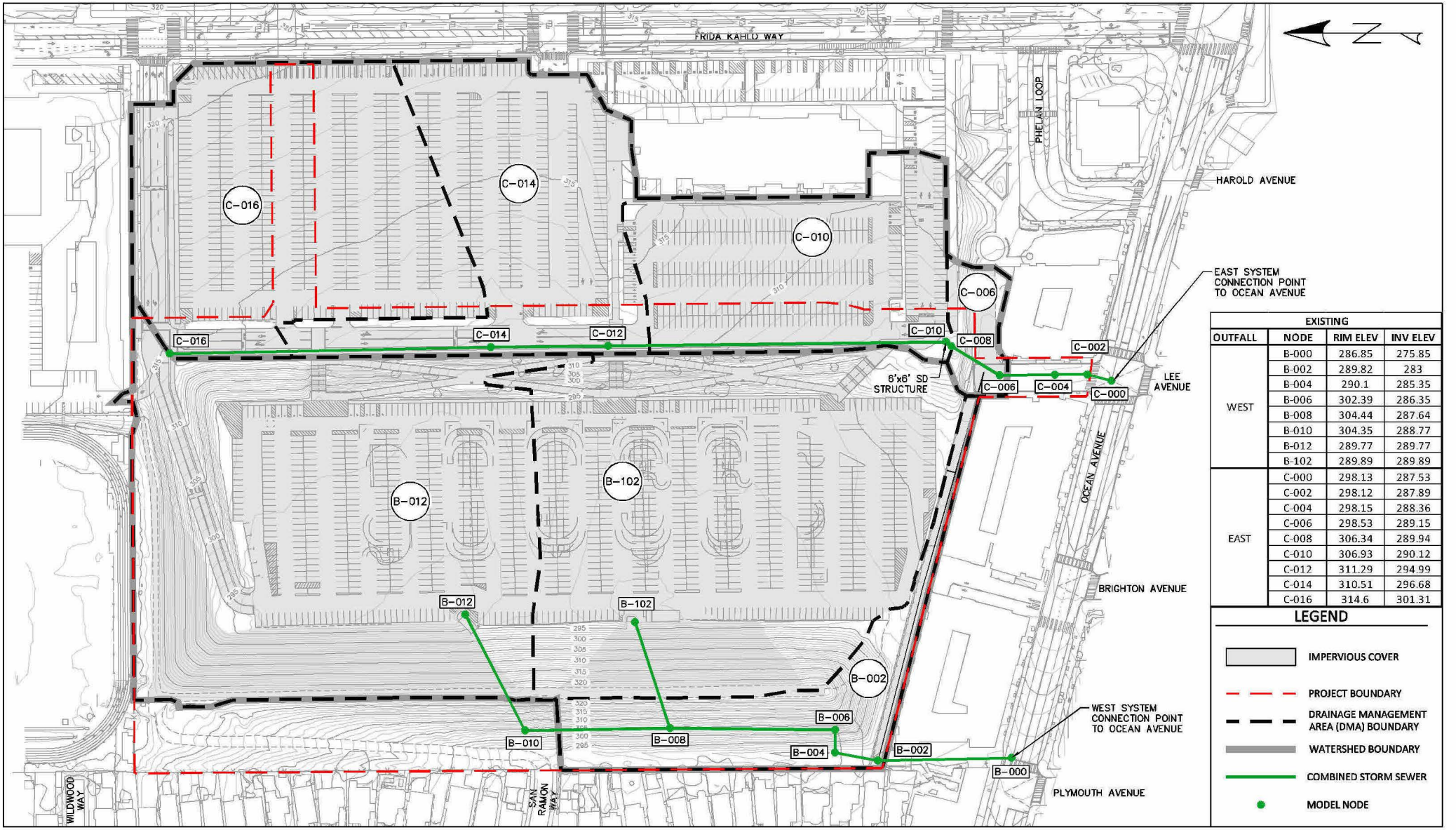
Green Infrastructure

A storage node representing bioretention areas was added to both the west and east systems. Both bioretention nodes have infiltration rates of 1.0 inch/hour[1], and 6-inches of ponding depth before flows bypass downstream.

Detention Systems

An off-line detention node is added to the model, downstream of the Green Infrastructure. Flow is diverted to the detention node using a side weir. The crest of the side weir is set to divert the peak of the hydrograph to optimize detention volume. An orifice meters flow from the detention vault back to the storm drain main. No infiltration is modeled for the detention node.

[1] Estimated based on recommendations provided by Rockridge Geotechnical through email.



EXISTING			
OUTFALL	NODE	RIM ELEV	INV ELEV
WEST	B-000	286.85	275.85
	B-002	289.82	283
	B-004	290.1	285.35
	B-006	302.39	286.35
	B-008	304.44	287.64
	B-010	304.35	288.77
	B-012	289.77	289.77
	B-102	289.89	289.89
EAST	C-000	298.13	287.53
	C-002	298.12	287.89
	C-004	298.15	288.36
	C-006	298.53	289.15
	C-008	306.34	289.94
	C-010	306.93	290.12
	C-012	311.29	294.99
	C-014	310.51	296.68
	C-016	314.6	301.31

LEGEND

- IMPERVIOUS COVER
- PROJECT BOUNDARY
- DRAINAGE MANAGEMENT AREA (DMA) BOUNDARY
- WATERSHED BOUNDARY
- COMBINED STORM SEWER
- MODEL NODE

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255 SHORELINE DR., SUITE 200
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www.bkf.com
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BALBOA RESERVOIR

EXISTING SYSTEM

SAN FRANCISCO, CALIFORNIA

JANUARY 9, 2020

EXHIBIT 1

PROPOSED			
OUTFALL	NODE	RIM ELEV	INV ELEV
WEST	B-000	286.85	275.85
	B-002	288.64	283
	B-004	289.18	283.54
	B-006	288.77	283.94
	B-008	288.11	284.61
	B-010	293.38	286.95
	B-012	294.24	287.58
	B-014	295.58	288.01
	B-016	300.77	289.5
	B-018	305.8	290.73
	B-020	309.79	291.73
	B-022	312	292.27
	B-024	312.21	292.68
	B-026	312.49	293.03
	B-028	313.49	294.34
	B-102	299.35	289.07
	B-104	302.51	289.99
EAST	C-000	298.13	287.53
	C-002	297	287.89
	C-004	297.21	288.36
	C-006	297.56	289.15
	C-008	297.66	289.37
	C-010	299.92	290.07
	C-012	302.99	290.73
	C-014	305.24	291.54
	C-016	307.82	293.29
	C-018	312.12	295.33
	C-020	312.81	297.35
	C-022	313.5	299.49
	C-024	313.68	299.95
	C-026	315.73	300.95
	C-102	313.47	300.01
	C-104	313.76	300.95
	C-202	313.52	299.89
	C-204	316.07	301.49

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BALBOA RESERVOIR

PROPOSED SYSTEM

SAN FRANCISCO, CALIFORNIA

JANUARY 9, 2020

EXHIBIT 2

Balboa Reservoir Project Review Comment Form

Submittal: Balboa Res H&H Modeling
File Dates: version 10/25/19; received 10/29/19

Response Date:	12/18/2019
Agency / Dept:	SFPUC WWE
Primary Contact:	Craig Freeman

Comment Type Category:
G - General
T - Technical
E - Editorial
C - Coordination

Response Code:
1 - Accepted - Will comply
2 - Accepted - Action completed
3 - Discussion or clarification required
4 - Unacceptable for reasons given

REVIEW						RESPONSE			
Comment No.	Reviewer	Comment Type	Reference (Page / Section / Dwg. / Fig. #)		Review Comment	Respondent	Response Date	Response Code	Response Comment
1	CF		page 1, 3rd paragraph, first sentence		Delete "known".	Lindsey Carmona	1/9/2020	2	Deleted.
2	CF		Assumptions Section, third bullet.		Existing text, "Detention system assumed to be off-line vaults separated from the main with a side weir and with orifice controls to throttle discharge back to the sewer main." Is it "back to"? If discharging downstream, suggest deleting "back".	Lindsey Carmona	1/9/2020	2	Text has been revised.
3	CF		Assumptions Section, fourth bullet.		Comment regarding existing text, "Existing 6' x 6' storm drain structure downstream of 72" pipe in East system is shown on survey and may contain orifice controls." SFPUC webGIS does not identify either structure, though our webGIS does contain information on what appear to be 2009-installed pipes by City College. Please advise and clarify in memo. (No pipe size info in memo, so hard to locate where this text is pointing to.)	Lindsey Carmona	1/9/2020	2	The location of the 6'x6' storm drain structure was added to Exhibit 1. The bullet point in the "Assumptions" list was revised to say "Existing 6' x 6' storm drain structure at Node C-010, downstream of 72" pipe in East system is shown on survey and may contain orifice controls."
4	KK		Conceptual Analysis		Consistent with conceptual level analysis in memo, conceptual stormwater management approaches and modeling assumptions are not reviewed in detail regarding SMO requirements. SFPUC to review proposed stormwater management and modeling assumptions during the Preliminary SCP and Final SCP approvals process. Stormwater management controls sizing and approach understood to likely to change.	Lindsey Carmona	1/9/2020	1	Understood.
5	KK		Eastern DMA - Scale and Scope		Regarding Alternative 1: Clarify why GI is assumed within the East System calculations, and clarify 'the minimum required GI Area based on modeling of the east system'. This memo identifies a large offsite drainage management area east of the Balboa Redevelopment Project boundary limits. A portion of this out-of-project-limits area contributing to the East System includes future roadway improvements (i.e. Lee Ave, etc.). (Separately, as previously understood, Lee Avenue is not currently proposed with stormwater GI due to project constraints.)	Lindsey Carmona	1/9/2020	1	GI is only assumed to manage runoff from on-site areas. We do not account for GI managing runoff from off-site areas. Even though the latest site plan does not show planters within Lee Avenue, we believe accounting for GI management for all on-site areas in the East System is reasonable given the following: 1. New buildings within the East System boundary can have on-site stormwater management BMPs; 2. North Street (east and west of Lee Avenue) can have small planters to manage runoff, as shown in the latest site plan; 3. The remaining on-site area in the East system (i.e. Lee Avenue) could be managed using permeable pavement in the parking lanes and/or a BMP in the open space to the east of Node C-010.
6	KK		Alternative 2		Regarding Alternative 2: While GI has been proposed in combination with detention. Detention facilities, where working in concert with GI, must be designed and sized using 'multi-stage' detention requirements.	Lindsey Carmona	1/9/2020	1	Understood. During the design phase, the detention systems will be designed to comply with the 'multi-stage' detention requirements.

7	CF		Purpose of Memo and Revisions		It appears (from some distance) that the intent of this concept analysis is to assess the feasibility within the project team of onsite management of flows from the 5yr and 100yr storm, including initial examination of two primary alternatives. Please feel free to coordinate with Molly Petrick on the end point of this memo and if revisions to it are even required.	Lindsey Carmona	1/9/2020	1	We will share this report with Molly Petrick.