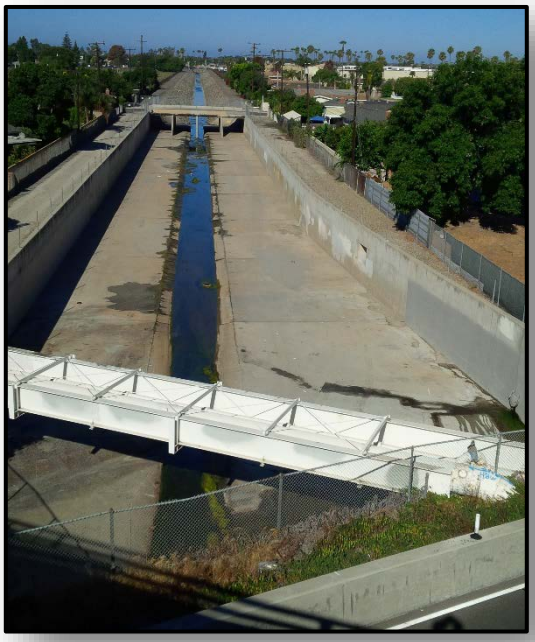
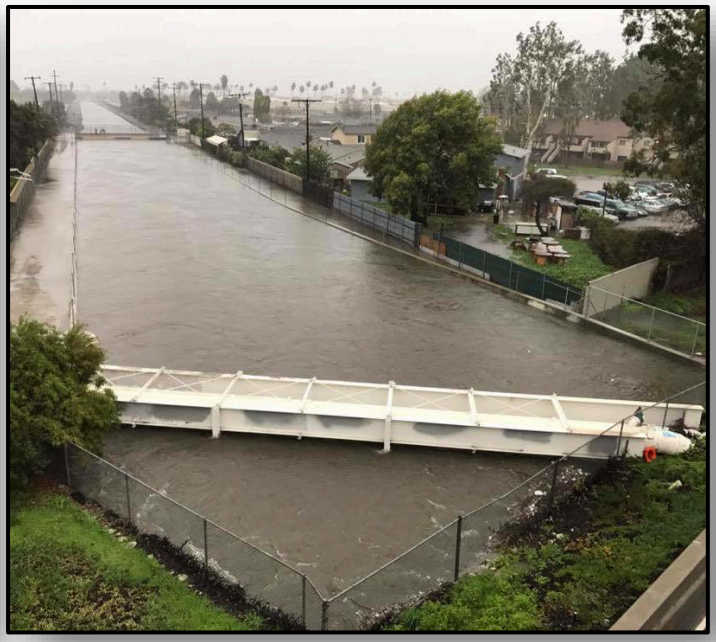
Appendix H – Plan Formulation

For

WESTMINSTER, EAST GARDEN GROVE

FLOOD RISK MANAGEMENT STUDY





October 2018

US Army Corps of Engineers®
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1. 2018 TSP Milestone Briefing Placemat (revised)

Appendix H

Plan Formulation

For

WESTMINSTER, EAST GARDEN GROVE

FLOOD RISK MANAGEMENT STUDY

1.0 Purpose

The purpose of the Plan Formulation Appendix is to provide additional details on the plan formulation process that were not included in the body of the main report.

2.0 Preliminary Alternative Development

2.1 Plan Formulation Strategies

The initial screening of measures demonstrated that the urban nature of the project area (high land values and a lack of available real estate) tended to self-select for measures that limit property acquisition, such as nonstructural measures and measures that are implemented within existing rights of way. Based on these considerations, the following strategies were used for developing study alternatives

- Maximize Nonstructural and Flood Proofing – This strategy aims to reduce the impacts of flooding by retrofitting existing buildings and infrastructure to be more flood resistant.
- Focus on Improving Channel Conveyance – This strategy aims to reduce the risk and impacts of flooding by more efficiently transporting flood waters, especially in upstream channel reaches where the watershed has more slope.
- Focus on Increasing Channel Capacity – This strategy aims to reduce the risk and impacts of flooding by increasing flood water storage within the existing drainage channels.
- Focus on Improving Downstream Conveyance – This strategy aims to reduce the risk and impacts of flooding by more efficiently transporting flood waters received from the channels. While downstream conveyance improvements are unlikely to provide significant flood damage risk reduction alone, it is recognized that any improvements to conveyance and capacity upstream would exacerbate existing flow restrictions downstream.

2.2 Initial Array of Alternatives

Based on the remaining measures and the VT alignment that came out of the August 2017 In-Progress Review (IPR), six alternative plans were identified to be carried forward in the initial array of alternatives.

1. No action alternative
2. Nonstructural alternative
3. In-channel modification alternative (Minimum Channel Modifications)

4. In-channel modification alternative (Maximum Channel Modifications)
5. In-channel modification alternative (Moderate Channel Modifications) (hybrid) plan
6. Diversion tunnel alternative

Table 1: Forming preliminary study alternatives from retained measures.

		Initial Array of Alternatives					
		No Action	Nonstructural	Minimum Channel Improvements (slickening)	Maximum Channel Improvements (contains 100yr consistent with NFIP)	Diversion Tunnel	Moderate Channel Improvements (Hybrid)
Nonstructural Measures	Floodplain regulation	Screened Out					
	Emergency response	Screened Out					
	Evacuation planning	Screened Out					
	Flood proofing	Screened Out					
	Flood warning system		X	X	X	X	X
	Razing/Removing structures	Screened Out					
	Removal of impediments to flow		X	X	X	X	X
In-Channel Modifications	All trapezoidal channels converted to concrete lining			X			Reach-by-reach assessment
	Trapezoidal channels converted to concrete rectangular channels				X		Reach-by-reach assessment
	Rectangular channels and additional flood wall				X		Reach-by-reach assessment
	Pump station improvements	Screened Out					
Upstream Improvements	Diversion/Bypass channels	Screened Out					
	Storage/Retention basins						
	Dams						
	Levees						
	Santa Ana River (SAR) diversion						
Downstream Improvements	Raising Pacific Coast Highway	Screened Out					
	Floodwall north side of Pacific Coast Highway (PCH)			X	X		X
	Remove tide gates on CO5	Screened Out					
	Replace/relocate tide gates on CO5			X	X	X	X
	Warner Ave widening (and associated BCER)			X	X		X
	Dredging in Outer Bolsa Bay	Screened Out					
	Breach levee on N/W side of CO5 into muted tidal pocket	Screened Out					
	Construct new ocean outlet (approx 30' diam tunnel)					X	

Table 1 was not included in the Draft Integrated Feasibility Report (IFR), but it is included here to demonstrate the earliest steps in the process of screening and combining management measures into preliminary alternatives.

3.0 Siting Channel Modification Measures

Following the decisions to screen out the standalone nonstructural and diversion tunnel alternatives described in section 2.2, the remaining alternatives (except for the No Action Alternative) all focused specifically on the study drainage channels and key downstream infrastructure.

- No Action Plan
- Minimum Channel Modifications Plan
- Maximum Channel Modifications Plan
- Moderate Channel Modifications (Hybrid) Plan

In order to begin siting the potential channel modifications included in these alternatives, it is important to clearly define the extent of the study channels. Then, the channels needed to be subdivided into discrete reaches based on size, geometry, and material in order to indicate where specific measures would be sited and, ultimately, develop cost estimates.

Once cost information was developed for each measure and channel reach, an incremental analysis could be carried out to determine whether the Minimum Channel Modifications and Maximum Channel Modifications plans could be hybridized to optimize net benefits. Once this examination was complete, the PDT identified an apparent Tentatively Selected Plan (TSP). For this study, the TSP is the plan that maximizes net benefits, also referred to as the National Economic Development (NED) plan.

While the process described here is used to define and justify the federal interest and investment in a study alternative, it does not inherently represent the goals of the project's NFS. In instances where the NFS has identified goals that are not addressed by the tentatively selected plan, development and consideration of a Locally Preferred Plan (LPP) may be warranted. In the case of this study, the Federal Government's goal is to maximize net benefits, while OCPW's goal is to contain the 1% ACE storm event within the study channels. If the TSP does not meet the NFS's objectives but additional project features would, an LPP may be justified. Therefore the decision about whether or not to pursue an LPP in this study cannot be made until after the TSP/NED plan is identified. See Section 4.2 for more information on a potential LPP.

3.1 Study Channels

The channels within the Westminster Watershed collect local storm water runoff and vary in size, geometry, and material. Typical channel configurations are described below and vary throughout the channel systems.

- Concrete rectangular channels: vertical channel walls with concrete lined sides and bottom.
- Riprap-lined trapezoidal channels: sloped channels that are lined with riprap; soft or unpaved bottom.
- Concrete-lined trapezoidal channels: sloped channels with concrete lined sides and bottoms.
- Enclosed culverts: rectangular or box conduits that are not expressed at the surface.
- Levees: earthen berms are located along channels in the flattest downstream extents of the watershed.
- Steel Sheet Pile: rectangular channels comprised of vertical sheet pile walls with soft channel bottom in between.

The original study scope included all of the drainage channels within the watershed. In consultation with OCPW and a review of existing conditions in the watershed, it was determined that the study would instead focus only on channel reaches C02, C04, C05, and C06 (Figure 1).

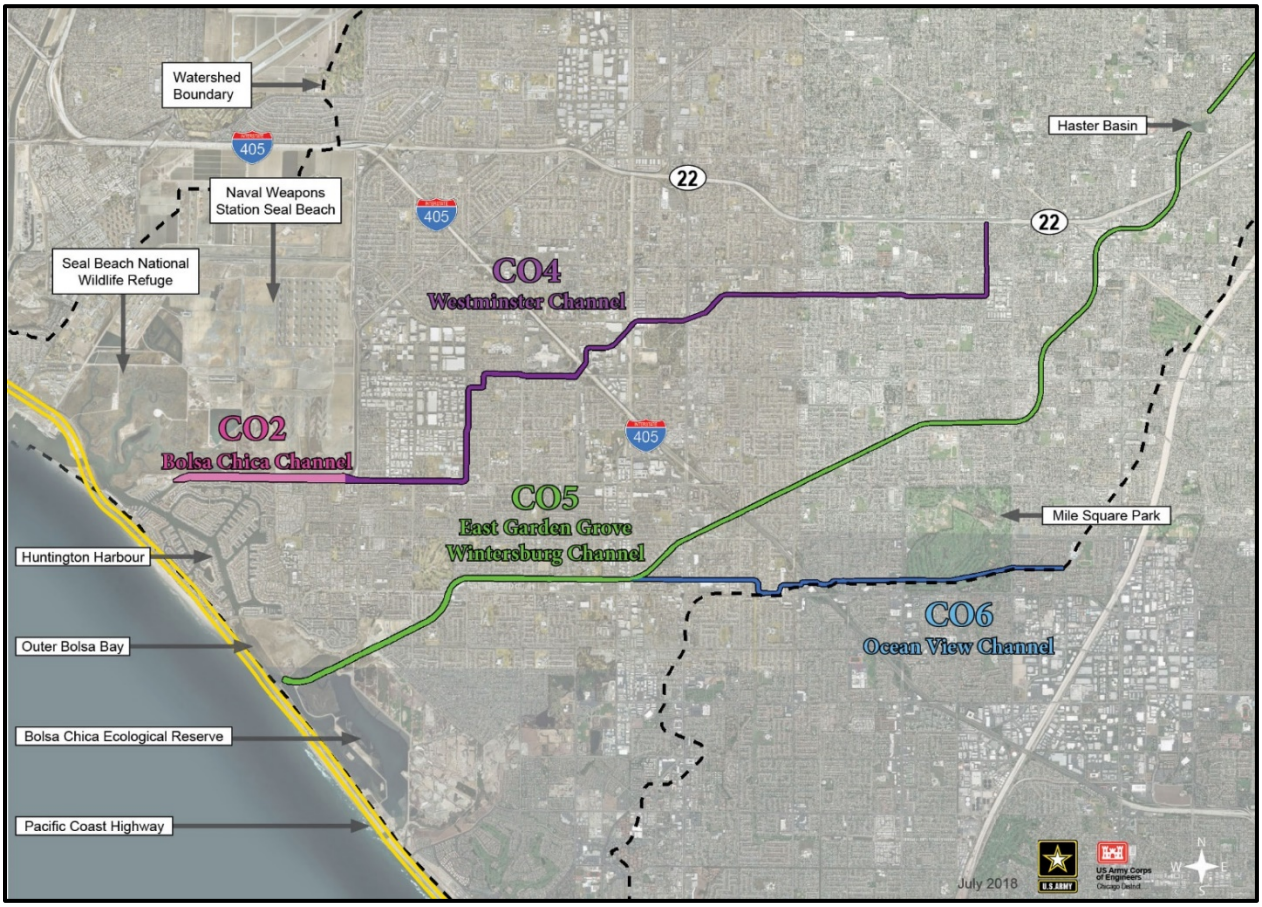

Figure 1: Drainage channels within the study area.

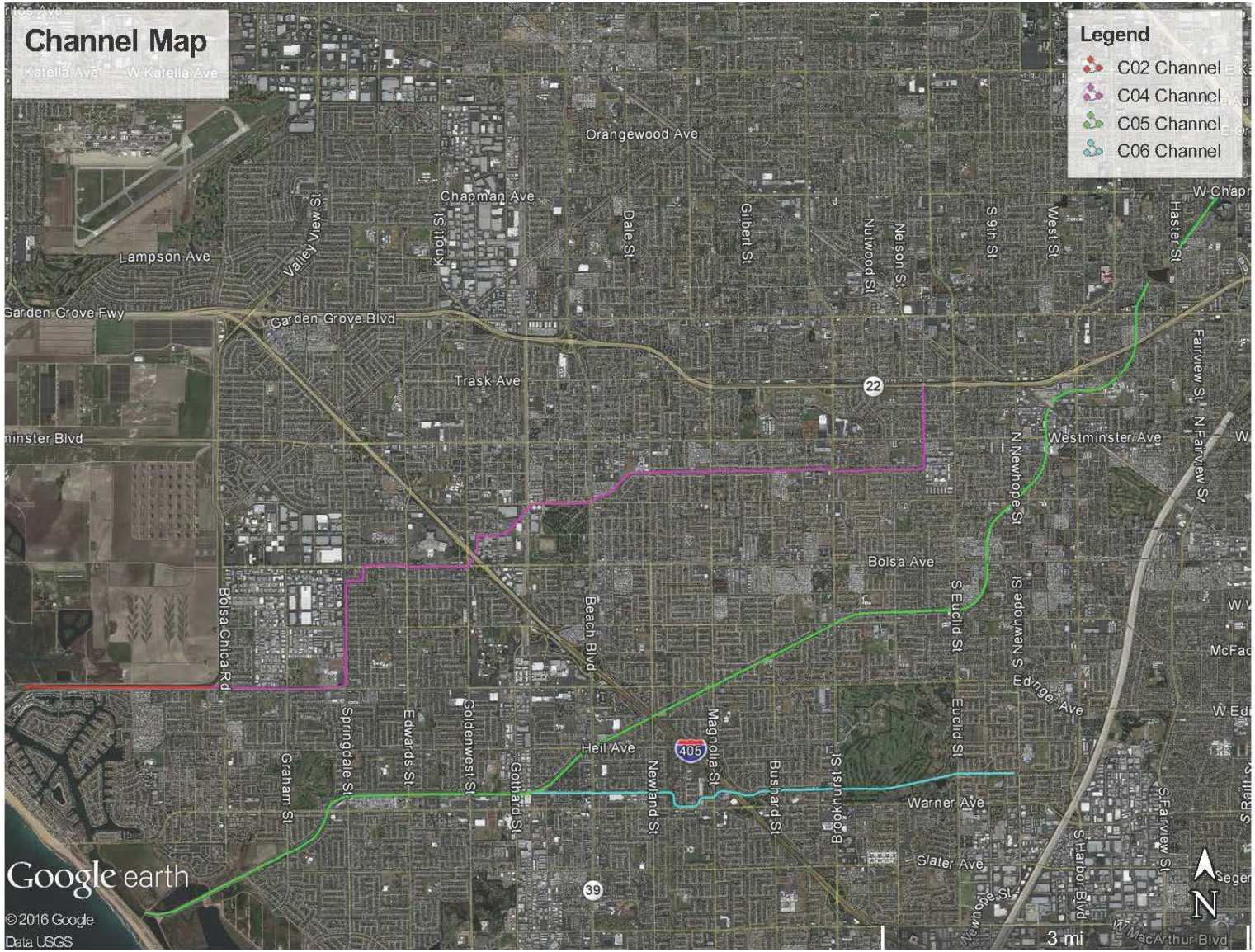

Figure 2: The study area is considers the CO2, CO4, CO5, and CO6 drainage channels.

3.2 Channel Reaches

The drainage channels that this study considers are broken up into discrete smaller segments, or reaches, to facilitate the siting of channel modification measures throughout the study area. Once all of the individual reaches were inventoried and classified, the PDT was then able to determine where along their length modifications could be implemented to improve conveyance efficiency and/or provide additional storage capacity within the channels. The reaches were originally delineated by dividing the drainage channels according to characteristics such as cross-sectional geometry, bottom material, and side-slope material.

Table 2: Existing channel descriptions in the study area are defined predominantly by cross-sectional geometry and materials.

Channel	Reach	Description
CO5	1	From the tidal gate to approximately 1,300 ft past Edwards St the channel is trapezoidal earthen channel with a riprap right bank between Warner Ave and Springdale St.
CO5	2	Golden West St to the confluence with CO6 the section is rectangular concrete channel.
CO5	3	From the confluence with CO6 to Beach Blvd, the section is trapezoidal riprap. Beach Blvd to I-405 FWY the section is rectangular concrete channel
CO5	4	I-405 FWY to Magnolia St the section is rectangular concrete channel. Magnolia St to Bushard St the section is trapezoidal riprap.
CO5	5	Trapezoidal riprap from Bushard St to Brookhurst St. Trapezoidal concrete channel for approximately 1,300 ft upstream, then trapezoidal riprap until 3rd St.
CO5	6	3rd St to Roosevelt Ave the section is trapezoidal concrete channel.
CO5	7	Roosevelt Ave to Hazard Ave the section is covered concrete conduit.
CO5	8	Hazard Ave to Woodbury Rd the section is trapezoidal concrete channel.
CO5	9	Woodbury Rd to Garden Grove Blvd the section is trapezoidal concrete channel.
CO5	10	Garden Grove Blvd to Haster Basin the section is covered concrete conduit.
CO5	11	Haster Basin to Twintree Cir the section is covered concrete conduit.
CO5	12	Twintree Cir to Chapman Ave the section is trapezoidal concrete channel for approx. 1,400 ft transitioning to covered concrete conduit for approx. 1,000 ft.
CO6	13	At the confluence with CO5 the section is rectangular concrete channel. Above the confluence with CO5 to Beach Blvd the section is earthen trapezoidal riprap. From Newland St to Ross Ln the section is earthen trapezoidal riprap.
CO6	14	From Ross Ln to Riverbend Dr the section is rectangular concrete channel.
CO6	15	From Riverbend Dr to I-405 FWY the section is covered concrete conduit.
CO6	16	From the I-405 FWY to Bushard St the section is rectangular concrete channel.
CO6	17	From Bushard St to Tahoma St the section is earthen trapezoidal riprap, transitioning to earthen trapezoidal until Brookhurst St.
CO6	18	Trapezoidal earthen channel from Brookhurst St to Euclid St (Mile Square Regional Park).
CO6	19	From Euclid St to Newhope Ave, the section is earthen trapezoidal riprap.
CO4	20	Trapezoidal concrete from the confluence with Bolsa Chica Channel CO2 to Bolsa Chica St. Trapezoidal earthen channel with a riprap right bank from Bolsa Chica St to Graham St. Earthen trapezoidal riprap from Graham St to Springdale St. Earthen trapezoidal riprap from Springdale St to McFadden Ave. Trapezoidal earthen channel with a riprap left bank to Edwards St. Covered concrete conduit from Edwards St to approx. 100 ft before Goldenwest St, then rectangular concrete channel to Goldenwest St, then covered concrete conduit to the I-405 FWY.
CO4	21	From the I-405 FWY to Cedarwood Ave the section is trapezoidal concrete channel. Cedarwood Ave to Beach Blvd the section is rectangular concrete channel.
CO4	22	Beach Blvd to Brookhurst St the section is rectangular concrete channel. Brookhurst St to Westminster Ave the section is trapezoidal earthen channel with a riprap right bank. Westminster Ave to the 22 Garden Grove FWY the section is trapezoidal concrete.
CO2	23	Reach 23 stretches from the confluence of Bolsa Chica St and Edinger Ave westward to the Edinger Ave/Sunset Bay East bridge. The entire Reach is earthen trapezoidal channel.

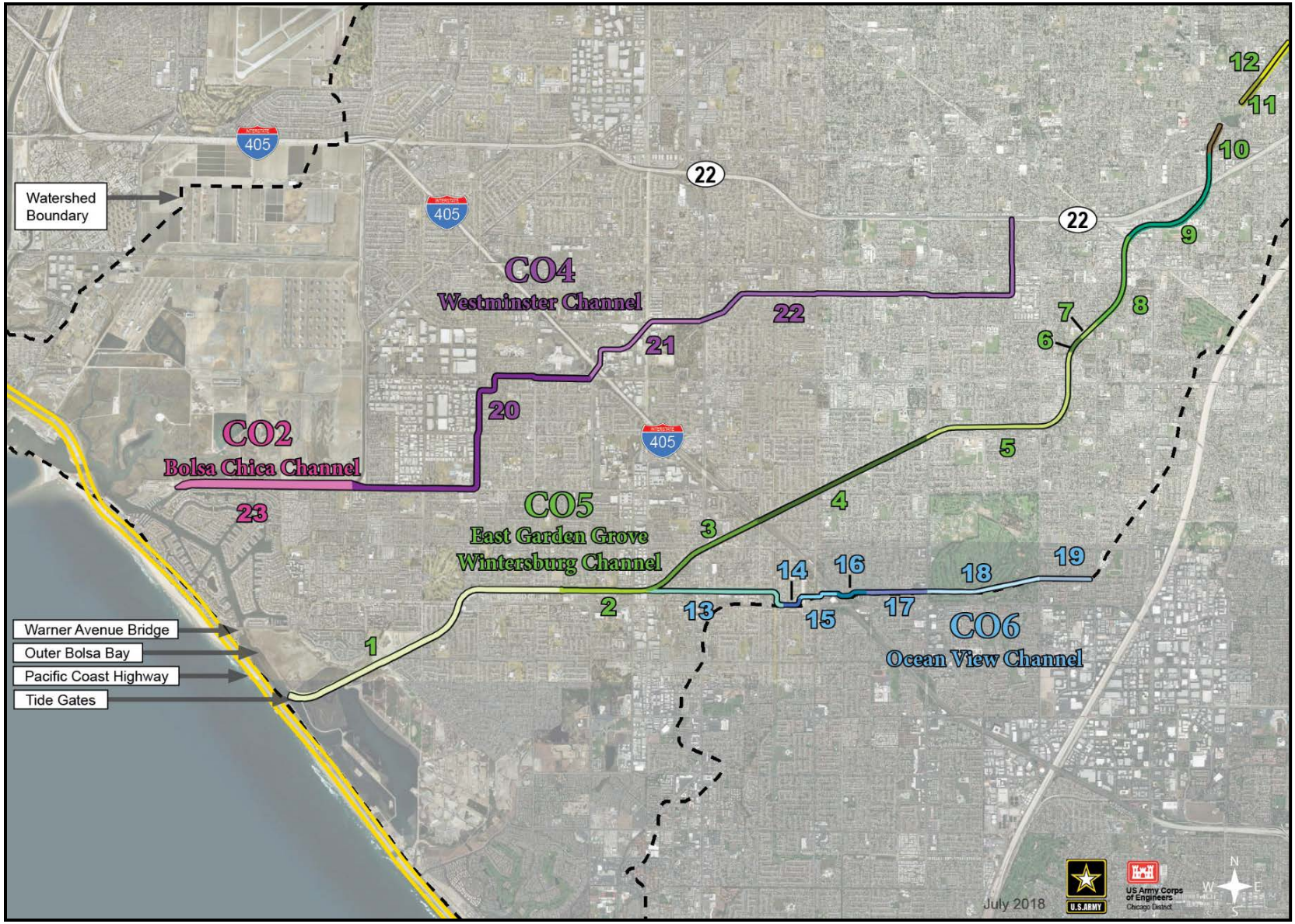

Figure 3: Study channels divided into 23 discrete reaches for siting in-channel modifications.

Reach 1 – C05

Figure 4: Reach 1 is a soft-bottom leveed reach. Recent and ongoing work has started the process of replacing earthen levees (left) with steel sheet pile walls (right).

Reach 2 – C05

Figure 5: Reach 2 is concrete lined rectangular channel.

Reach 3 – C05

Figure 6: Reach 3 transitions from riprap lined trapezoidal (left) to concrete lined rectangular (right).

Reach 4 – C05


Figure 7: Concrete rectangular channel downstream (left) and riprap trapezoidal channel upstream (right) on Reach 4.

Reach 5 – C05

Figure 8: Reach 5 is predominantly riprap lined trapezoidal channel.

Reach 6 – C05


Figure 9: Reach 6 is concrete lined trapezoidal channel.

Reach 7 – C05

Figure 10: Reach 7 is concrete rectangular conduit that passes under Rosita Park.

Reach 8 – C05

Figure 11: Reach 8 is concrete lined trapezoidal channel.

Reach 9 – C05

Figure 12: Reach 9 is concrete lined trapezoidal channel.

Reach 10 – C05

Figure 13: Reach 10 is concrete rectangular conduit that daylights just downstream of the Haster Basin outlet.

Reach 11 – C05

Figure 14: Reach 11 is concrete rectangular conduit that daylights at the inlet to Haster Basin.

Reach 12 – C05

Figure 15: Reach 12 is predominantly concrete lined trapezoidal channel.

Reach 13 – C06

Figure 16: Earthen trapezoidal near the confluence of C05/C06 (left), transitions to riprap trapezoidal upstream (right).

Reach 14 – C06

Figure 17: Reach 14 is concrete rectangular channel.

Reach 15 – C06

Figure 18: Reach 15 is concrete rectangular conduit from Riverbend Drive (left) to I-405 (right).

Reach 16 – C06

Figure 19: Reach 16 is concrete rectangular channel.

Reach 17 – C06

Figure 20: Reach 17 transitions from riprap lining downstream (left) to earthen channel further upstream (right).

Reach 18 – C06

Figure 21: Drainage channel through Mile Square Park.

Reach 19 – C06

Figure 22: Reach 19 is riprap lined trapezoidal channel.

Reach 23 – C02

Figure 23: Outlet of C02 at Edinger Bridge (left) and downstream view from C02/C04 confluence (right)

Reach 20 – C04

Figure 24: Reach 20 is earthen and tidally influenced downstream (left), with increased riprap applied upstream (right)

Reach 21 – C04

Figure 25: Reach 21 goes under the Westminster Mall, downstream outlet and upstream inlet of conduit (respectively)

Figure 26: Reach 21 is concrete rectangular from I-405 (left) to Hazard Ave (right)

Figure 27: Cedarwood Ave to Beach Blvd. is concrete rectangular

Reach 22 – C04


Figure 28: Beach Blvd. to Brookhurst Ave is concrete rectangular

Figure 29: Reach 22 becomes riprap lined trapezoidal from Brookhurst St to Westminster Blvd.

Figure 30: Reach 22 becomes concrete lined trapezoidal from Westminster Blvd. to Route 22

Figure 31: CO2, the confluence of CO2/CO4 near Bolsa Chica St., and the downstream reach of CO4.

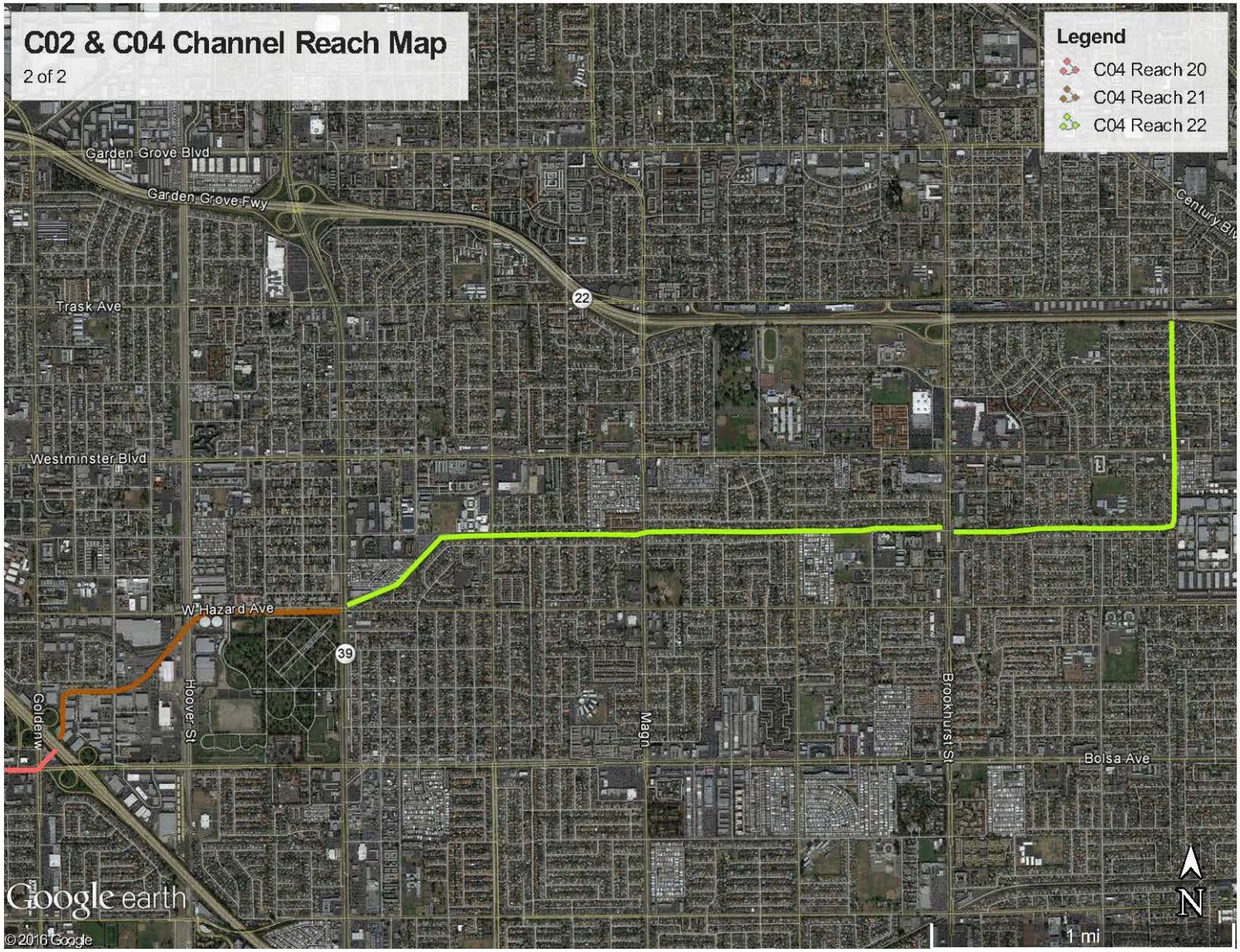

Figure 32: CO4 is divided into 3 reaches.

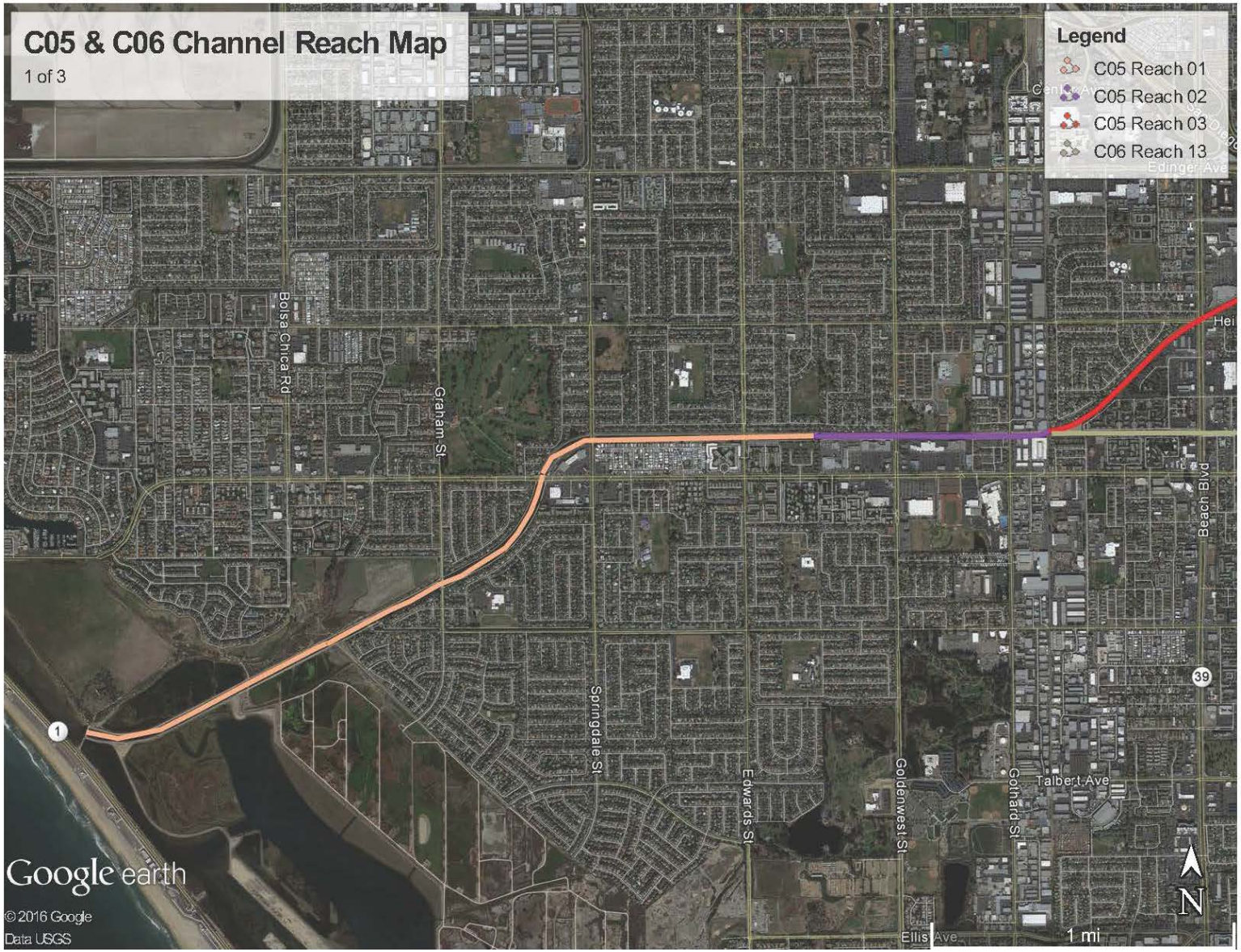

Figure 33: CO5 outlets into Outer Bolsa Bay near the Bolsa Chica ecological Reserve. The confluence of CO5/CO6 is located just east of Gothard Street.

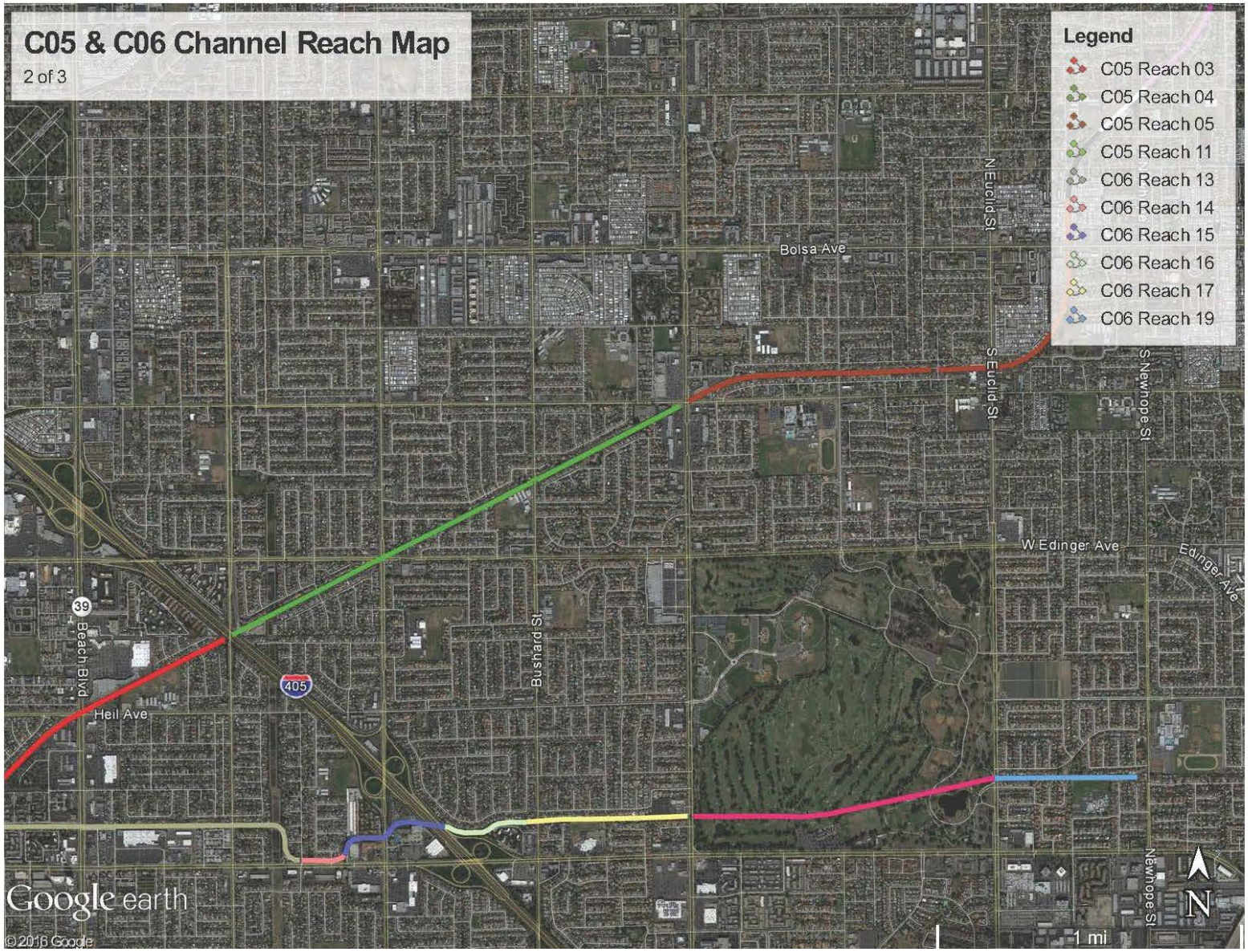

Figure 34: CO5 and CO6 run from west to east through a densely populated urban project area.

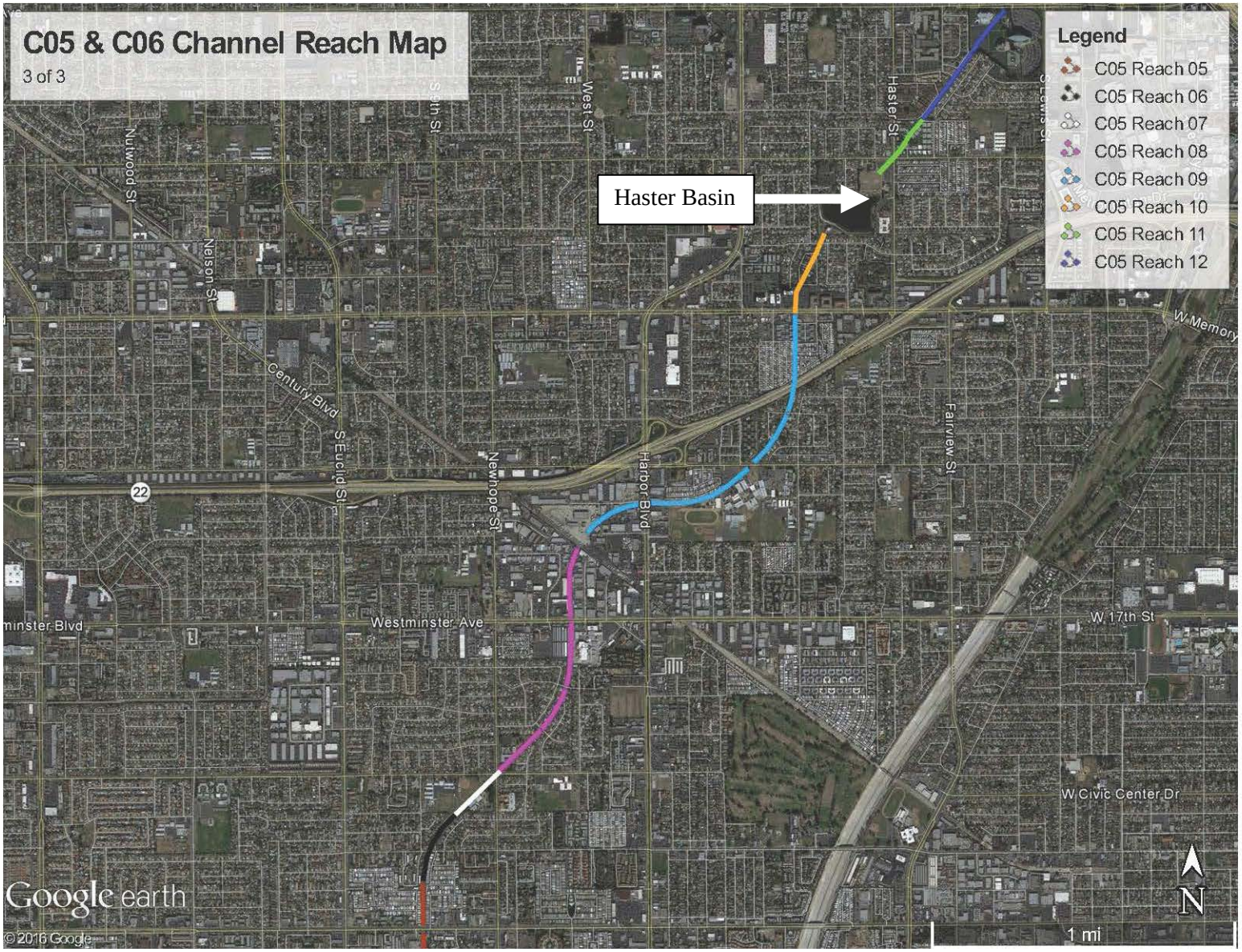

Figure 35: The upstream reaches of the CO5 channel flow from north to south, crossing the Haster Basin reservoir and State Route 22

3.3 No Action Alternative

Under the No Action Alternative, no management measures would be implemented to reduce the current risk of flood damage in the project area. Flooding will continue throughout the Westminster watershed due to the insufficient capacity of the existing channel systems. This will continue to cause damages to structures and road closures in the project area as a result of channel overtopping.

Outer Bolsa Bay will continue to flood during frequent storm events, impacting traffic on Pacific Coast Highway. The oil wells in the BCER will remain at risk of inundation by flows that overtop the CO5 channel upstream of the reserve and travel overland into the Muted Tidal Basin and Seasonal Pond area.

Under the No Action Alternative, these channel conditions would remain unchanged, as described in Table 3 and Table 4. Overtopping of the levees on CO2 and CO5 would continue to occur during 2% and 20% ACE storm events, respectively.

Table 3: Existing channel conditions in CO2/CO4 on a reach-by-reach basis.

Channel	Reach	EXISTING CONDITIONS / NO ACTION
		CO2/CO4
CO2	23	Earthen trapezoidal
CO4	20	Riprap lined trapezoidal from CO2 to Bolsa Chica Street; Earthen & riprap trapezoidal from Bolsa Chica Street to Graham Street; Earthen trapezoidal from Graham Street to McFadden Avenue; Riprap trapezoidal from McFadden Avenue to Bolsa Avenue; Earthen & riprap trapezoidal from Bolsa Avenue to Edwards Street Concrete lined rectangular from Edwards Street to I-405
CO4	21	Concrete lined rectangular
CO4	22	Concrete lined compound from Beach Blvd to Magnolia Street; Concrete rectangular with soft bottom from Magnolia Street to Brookhurst; Riprap trapezoidal from Brookhurst Street to Westminster Avenue; Concrete lined trapezoidal from Westminster Avenue to SR-22

Table 4: Existing channel conditions in CO5/CO6 system on a reach-by-reach basis.

Channel	Reach	EXISTING CONDITIONS / NO ACTION
		CO5/CO6
CO5	1	Earthen levee from tide gates to Warner Avenue w/ some SSP on south bank near Graham Street; SSP rectangular from Graham Street to Warner Avenue; Earthen levees from Warner Avenue to 1,300 ft upstream of Edwards Avenue
CO5	2	Concrete lined rectangular
CO5	3	Riprap lined trapezoidal from CO5/CO6 confluence to Woodruff Street; Concrete rectangular from Woodruff Street to I-405
CO5	4	Concrete lined rectangular from I-405 to Quartz Street; Riprap lined trapezoidal from Quartz Street to Bushard Street
CO5	5	Riprap lined trapezoidal from Bushard Street to Brookhurst Street; 1,300 ft of concrete lined trapezoidal upstream of Brookhurst Street; Riprap lined trapezoidal to 3rd St
CO5	6	Concrete lined trapezoidal

CO5	7	Covered concrete conduit
CO5	8	Concrete lined trapezoidal
CO5	9	Concrete lined trapezoidal
CO5	10	Covered concrete conduit
CO5	11	Covered concrete conduit
CO5	12	Concrete lined trapezoidal (first 1400') and covered concrete conduit (next 1000')
CO6	13	Earthen trapezoidal from CO5/CO6 confluence to Bolsa Avenue/RT-39; Riprap lined trapezoidal from Bolsa Avenue/RT-39 to Ross Lane
CO6	14	Concrete lined rectangular
CO6	15	Covered concrete conduit
CO6	16	Concrete lined rectangular
CO6	17	Earthen and riprap lined trapezoidal
CO6	18	Mile Square Park - concrete low flow v-channel
CO6	19	Riprap lined trapezoidal

3.4 Minimum Channel Modifications Plan

Under the Minimum Channel Modifications Alternative, earthen or riprap lined channels would be paved with concrete to increase conveyance efficiency. H&H modeling determined that widening Warner Avenue Bridge, replacing the tide gates, and building a floodwall along PCH at Outer Bolsa Bay were all necessary measures to implement in the Minimum Channel Modifications plan and that leveed sections of CO2 and CO5 (reaches 23 and 1, respectively) should be modified to the maximum condition.

Table 5: Minimum channel modifications in CO2/CO4 on a reach-by-reach basis compared to existing conditions.

CO2/CO4			
Channel	**Reach**	**EXISTING CONDITIONS**	**MINIMUM CHANNEL MODIFICATIONS**
CO2	23	Earthen trapezoidal	Widened to 230' soft bottom with double sheet piles on both sides
CO4	20	Riprap lined trapezoidal from CO2 to Bolsa Chica Street; Earthen & riprap trapezoidal from Bolsa Chica Street to Graham Street; Earthen trapezoidal from Graham Street to McFadden Avenue; Riprap trapezoidal from McFadden Avenue to Bolsa Avenue; Earthen & riprap trapezoidal from Bolsa Avenue to Edwards Street Concrete lined rectangular from Edwards Street to I-405	Concrete lined trapezoidal from CO2 to Edwards Street; Concrete lined rectangular from Edwards Street to I-405 (existing);
CO4	21	Concrete lined rectangular	Concrete lined rectangular;
CO4	22	Concrete lined compound from Beach Blvd to Magnolia Street; Concrete rectangular with soft bottom from Magnolia Street to Brookhurst; Riprap trapezoidal from Brookhurst Street to Westminster Avenue; Concrete lined trapezoidal from Westminster Avenue to SR-22	Concrete lined compound from Beach Blvd to Magnolia Street; Concrete rectangular from Magnolia Street to Brookhurst; Concrete lined trapezoidal from Brookhurst Street to SR-22;

Table 6: Minimum channel modifications in CO5/CO6 on a reach-by-reach basis compared to existing conditions.

CO5/CO6			
Channel	**Reach**	**EXISTING CONDITIONS**	**MINIMUM CHANNEL MODIFICATIONS**
CO5	1	Earthen levee from tide gates to Warner Avenue w/ some SSP on south bank near Graham Street; SSP rectangular from Graham Street to Warner Avenue; Earthen levees from Warner Avenue to 1,300 ft upstream of Edwards Avenue	Sheet pile/soft bottom/splash walls (various heights) from tide gates to existing rectangular channel west of Golden West Street
CO5	2	Concrete lined rectangular	Concrete lined rectangular
CO5	3	Riprap lined trapezoidal from CO5/CO6 confluence to Woodruff Street; Concrete rectangular from Woodruff Street to I-405	Concrete lined trapezoidal from confluence with CO6 to Beach Blvd; Concrete lined rectangular from Beach Blvd. to I-405
CO5	4	Concrete lined rectangular from I-405 to Quartz Street; Riprap lined trapezoidal from Quartz Street to Bushard Street	Concrete lined rectangular from I-405 to Magnolia Street; Concrete lined trapezoidal from Magnolia Street to Bushard Street
CO5	5	Riprap lined trapezoidal from Bushard Street to Brookhurst Street; 1,300 ft of concrete lined trapezoidal upstream of Brookhurst Street; Riprap lined trapezoidal to 3rd St	Concrete lined trapezoidal
CO5	6	Concrete lined trapezoidal	Concrete lined trapezoidal
CO5	7	Covered concrete conduit	Covered concrete conduit
CO5	8	Concrete lined trapezoidal	Concrete lined trapezoidal
CO5	9	Concrete lined trapezoidal	Concrete lined trapezoidal
CO5	10	Covered concrete conduit	Covered concrete conduit
CO5	11	Covered concrete conduit	Covered concrete conduit
CO5	12	Concrete lined trapezoidal (first 1400') and covered concrete conduit (next 1000')	Concrete lined trapezoidal (first 1400') and covered concrete conduit (next 1000')
CO6	13	Earthen trapezoidal from CO5/CO6 confluence to Bolsa Avenue/RT-39; Riprap lined trapezoidal from Bolsa Avenue/RT-39 to Ross Lane	Concrete lined trapezoidal
CO6	14	Concrete lined rectangular	Concrete lined rectangular
CO6	15	Covered concrete conduit	Covered concrete conduit
CO6	16	Concrete lined rectangular	Concrete lined rectangular
CO6	17	Earthen and riprap lined trapezoidal	Concrete lined trapezoidal
CO6	18	Mile Square Park - concrete low flow v-channel	Mile Square Park - concrete low flow v-channel
CO6	19	Riprap lined trapezoidal	Concrete lined trapezoidal

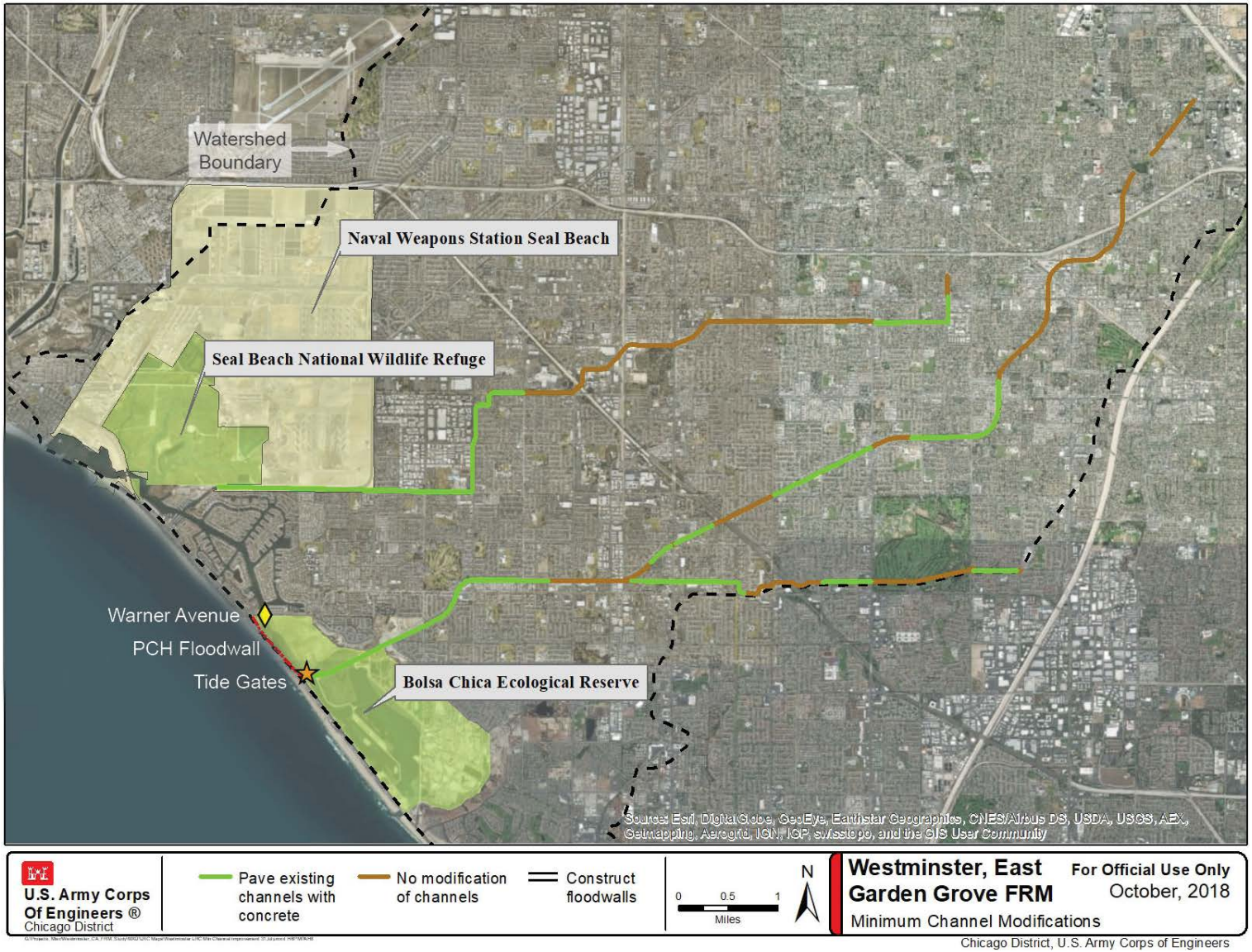

Figure 36: Minimum Channel Modifications Plan

3.5 Maximum Channel Modifications Plan

Under the Maximum Channel Modifications Alternative, trapezoidal channels would be reconfigured to have a rectangular cross sectional geometry. This would increase both conveyance and capacity. This alternative is designed to contain the 1% ACE storm event. For reaches that do not contain the 1% ACE event after conversion to a concrete rectangular channel, floodwalls are added.

H&H modeling determined that widening Warner Avenue Bridge, replacing the tide gates, and building a floodwall along PCH at Outer Bolsa Bay were all necessary measures to implement in the Maximum Channel Modifications plan.

Table 7: Maximum channel modifications in CO2/CO4 on a reach-by-reach basis compared to existing conditions.

CO2/CO4			
Channel	**Reach**	**EXISTING CONDITIONS**	**MAXIMUM CHANNEL MODIFICATIONS**
CO2	23	Earthen trapezoidal	Widened to 230' soft bottom with double sheet piles on both sides
CO4	20	Riprap lined trapezoidal from CO2 to Bolsa Chica Street; Earthen & riprap trapezoidal from Bolsa Chica Street to Graham Street; Earthen trapezoidal from Graham Street to McFadden Avenue; Riprap trapezoidal from McFadden Avenue to Bolsa Avenue; Earthen & riprap trapezoidal from Bolsa Avenue to Edwards Street Concrete lined rectangular from Edwards Street to I-405	80' Concrete rectangular with middle 48' left earthen from CO2 to McFadden Avenue; 68' Concrete rectangular with middle 40' left earthen from McFadden Avenue to Bolsa Avenue; 55' Concrete rectangular from Bolsa Avenue to Edwards Street; 3 crossings replaced of different dimensions
CO4	21	Concrete lined rectangular	Navy railroad reroute pending
CO4	22	Concrete lined compound from Beach Blvd to Magnolia Street; Concrete rectangular with soft bottom from Magnolia Street to Brookhurst; Riprap trapezoidal from Brookhurst Street to Westminster Avenue; Concrete lined trapezoidal from Westminster Avenue to SR-22	Base of concrete lined channel increased to 35' from Beach Blvd to Magnolia Street; Soft bottom channel from Magnolia Street to Brookhurst Street concrete lined; Concrete lined trapezoidal from Brookhurst Street to Westminster Avenue; 18' Concrete rectangular from Westminster Avenue to SR-22; 12 crossings replaced of different dimensions

Table 8: Maximum channel modifications in CO5/CO6 on a reach-by-reach basis compared to existing conditions.

CO5/CO6			
Channel	**Reach**	**EXISTING CONDITIONS**	**MAXIMUM CHANNEL MODIFICATIONS**
CO5	1	Earthen levee from tide gates to Warner Avenue w/ some SSP on south bank; SSP rectangular from Graham Street to Warner Avenue; Earthen levees from Warner Avenue to 1,300 ft upstream of Edwards Avenue	Sheet pile/soft bottom/splash walls (various heights) from tide gates to existing rectangular channel west of Golden West Street
CO5	2	Concrete lined rectangular	Concrete lined rectangular with 1' splash walls from Golden West St to Gothard St; Concrete lined rectangular from Gothard Street to CO5/CO6 confluence
CO5	3	Riprap lined trapezoidal from CO5/CO6 confluence to Woodruff Street; Concrete rectangular from Woodruff to 405	Concrete lined rectangular; Some section of 1' splash wall between Beach Blvd and Woodruff Road; 2 crossings replaced of different sizes
CO5	4	Concrete lined rectangular from 405 to Quartz; Riprap trapezoidal from Quartz Street to Bushard Street	Concrete lined rectangular with splash walls (various heights); 3 crossings replaced of different sizes
CO5	5	Riprap lined trapezoidal from Bushard Street to Brookhurst Street; 1,300 ft of concrete lined trapezoidal upstream of Brookhurst Street; Riprap lined trapezoidal to 3rd St	Concrete lined rectangular with splash walls (various heights); 5 crossings replaced of different dimensions
CO5	6	Concrete lined trapezoidal	Concrete lined rectangular; 1 crossing replaced
CO5	7	Covered concrete conduit	Covered concrete conduit
CO5	8	Concrete lined trapezoidal	Concrete lined rectangular; 3 crossings replaced of different sizes
CO5	9	Concrete lined trapezoidal	Concrete lined rectangular; 2 crossings replaced of different sizes
CO5	10	Covered concrete conduit	Concrete lined rectangular
CO5	11	Covered concrete conduit	Covered concrete conduit
CO5	12	Concrete lined trapezoidal (first 1400') and covered concrete conduit (next 1000')	Concrete lined rectangular with splash walls (various heights); Haster Basin inlet culverts modified
CO6	13	Earthen trapezoidal from CO5/CO6 confluence to Bolsa Avenue/RT-39; Riprap lined trapezoidal from Bolsa Avenue/RT-39 to Ross Lane	Concrete lined rectangular at confluence; Concrete lined trapezoidal from confluence to Ross Street; 2 crossings replaced of different sizes
CO6	14	Concrete lined rectangular	Concrete lined rectangular from Ross Street to Asari Lane; Concrete lined rectangular with splash walls (1.5-2') from Asari Lane to Riverbend Drive
CO6	15	Covered concrete conduit	Covered concrete conduit; 1 crossing replaced
CO6	16	Concrete lined rectangular	Concrete lined rectangular
CO6	17	Earthen and riprap lined trapezoidal	Concrete lined trapezoidal
CO6	18	Mile Square Park-concrete low flow v-channel	Mile Square Park-concrete low flow v-channel
CO6	19	Riprap lined trapezoidal	Concrete lined trapezoidal

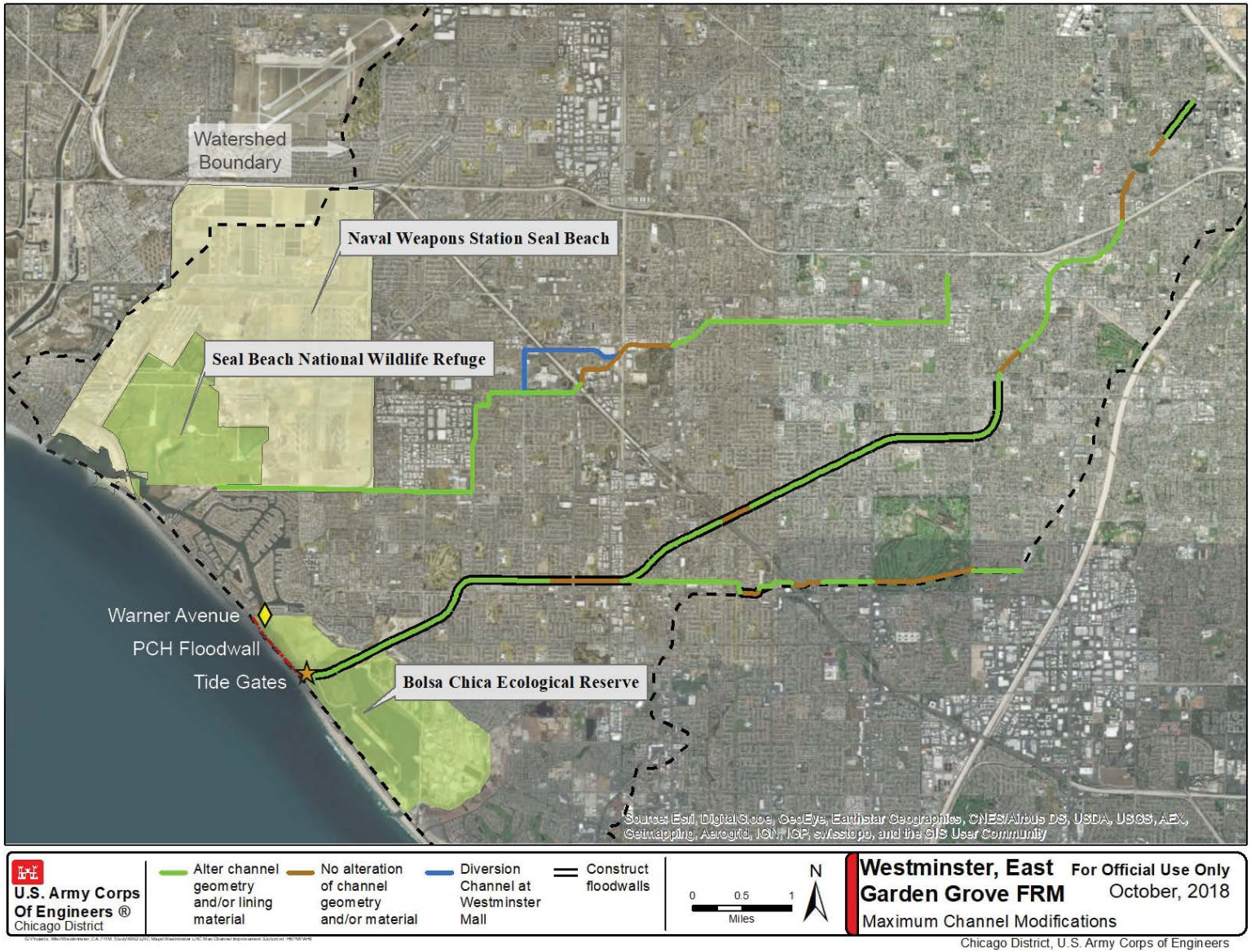

Figure 37: Maximum Channel Modifications Plan

Diversion Channel at Westminster Mall

To address flooding caused by a restriction where flows in C04 are directed into a long reach of covered conduit that runs under I-405 and the Westminster Mall, a bypass channel would be constructed to direct flows around this existing bottleneck (Figure 38).

This diversion would span 2 reaches in C04 (reaches 20 and 21) and be a combination of open channel and reinforced concrete box (RCB). It would split off of reach 21 at the intersection of Hoover and Hazard streets, run west along an abandoned Navy railroad line to the north of Westminster Mall, and then turn south underneath Edwards Street until it reconnects with reach 20 (where reach 20 goes underground) near the intersection of Edwards Street and Bolsa Avenue (Figure 38).

A more detailed description of this diversion that includes channel and RCB dimensions, preliminary drawings, and cost estimates in is included as an attachment to *Appendix B – Civil Engineering*.

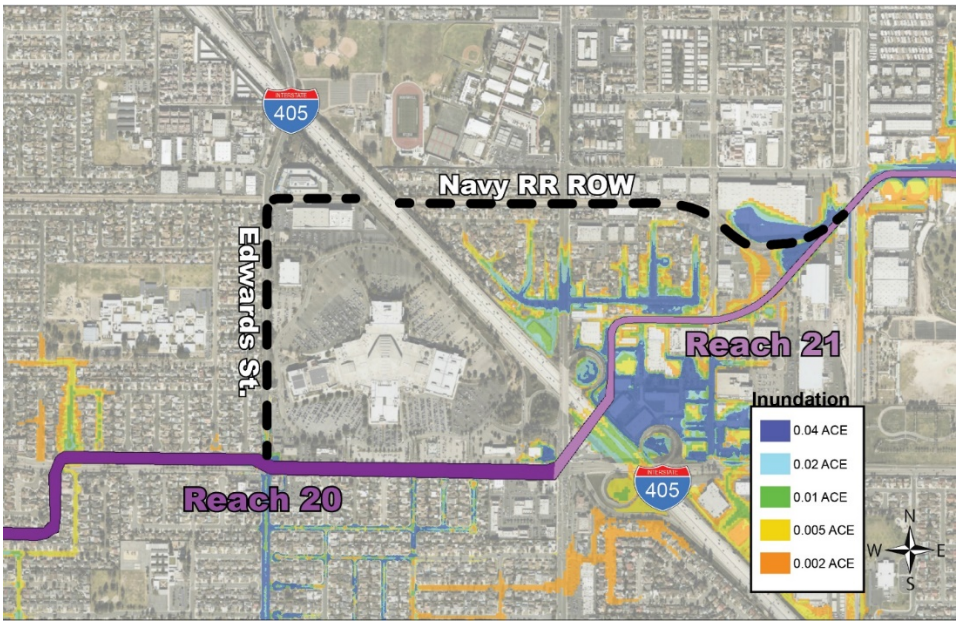

Figure 38: Proposed alignment of diversion channel at Westminster Mall (Black Dashed Line) would reduce flooding on C04 Reach 21 where it crosses I-405.

3.6 Cost Estimates for Minimum and Maximum Alternatives

The current cost estimate for C05 includes reaches 1-12. C06 includes reaches 13-19. C02 includes reach 23 and C04 includes reaches 20-22. The real estate cost includes estimates for staging areas, while the relocation costs are tied to the bridge replacement estimates.

To obtain a rough estimate of potential mitigation costs, an article regarding the cost of marine coastal restoration was reviewed. The study evaluated costs and feasibility of 235 studies with restoration or rehabilitation projects of coral reefs, seagrass, mangroves, saltmarshes, and oyster reefs worldwide (Bayraktarov et al. 2016). The average cost of saltmarsh restoration calculated from the study was used as the baseline cost for the mitigation that may be required. Average cost per hectare was $1,042,116 in the study (2010 dollars). Approximately 1 acre is being impacted by the removal of the constriction upstream of Warner Avenue Bridge. It was assumed that at least 10 acres of mitigation would be needed to offset this impact, costing an estimated $4.2M. Additional costs associated with construction of the mitigation

site (e.g., grading and handling of material, adaptive management, contingency) give a total estimated mitigation cost of $9.375M. A pedestrian bridge would also be impacted by widening of the Warner Avenue Bridge and would require replacement. Based on costs of the current pedestrian bridge it was estimated that the potential in-kind replacement of the bridge would be $1-1.5 M.

Table 9: Current cost estimates for the Minimum and Maximum Channel Modifications alternatives.

Reach	**Min Total Cost ($000)**	*Min Construction Cost ($000)*	*Min Bridge Cost ($000)*	*Min OMRR&R ($000)*	**Max Total Cost ($000)**	*Max Construction Cost ($000)*	*Max Bridge Cost ($000)*	*Max OMRR&R ($000)*
1	$259,083	*$242,104*	*$16,979*	*$90*	$259,083	*$242,104*	*$16,979*	*$90*
2	$48,682	*$36,702*	*$11,979*	*$31*	$48,682	*$36,702*	*$11,979*	*$31*
3	$13,896	*$13,896*	*$0*	*$42*	$57,010	*$39,329*	*$17,680*	*$46*
4	$14,623	*$14,623*	*$0*	*$58*	$54,344	*$38,126*	*$16,218*	*$59*
5	$14,720	*$14,720*	*$0*	*$67*	$73,589	*$43,044*	*$30,545*	*$73*
6	$0	*$0*	*$0*	*$2*	$9,318	*$7,235*	*$2,083*	*$8*
7	$0	*$0*	*$0*	*$66*	$73,426	*$0*	*$73,426*	*$66*
8	$0	*$0*	*$0*	*$9*	$28,980	*$18,566*	*$10,415*	*$31*
9	$0	*$0*	*$0*	*$31*	$46,799	*$12,478*	*$34,321*	*$62*
10	$0	*$0*	*$0*	*$0*	$0	*$0*	*$0*	*$0*
11	$0	*$0*	*$0*	*$0*	$0	*$0*	*$0*	*$0*
12	$0	*$0*	*$0*	*$0*	$0	*$0*	*$0*	*$0*
13	$13,740	*$13,740*	*$0*	*$30*	$34,117	*$22,727*	*$11,390*	*$30*
14	$0	*$0*	*$0*	*$0*	$709	*$709*	*$0*	*$2*
15	$0	*$0*	*$0*	*$0*	$9,351	*$9,351*	*$0*	*$6*
16	$0	*$0*	*$0*	*$0*	$352	*$352*	*$0*	*$5*
17	$4,996	*$4,996*	*$0*	*$13*	$14,804	*$9,596*	*$5,207*	*$13*
18	$0	*$0*	*$0*	*$0*	$0	*$0*	*$0*	*$0*
19	$4,065	*$4,065*	*$0*	*$7*	$5,654	*$5,654*	*$0*	*$7*
23	$281,160	*$277,167*	*$3,993*	*$4*	$281,160	*$277,167*	*$3,993*	*$38*
20	$42,817	*$42,817*	*$0*	*$93*	$142,041	*$88,792*	*$53,249*	*$93*
21	$0	*$0*	*$0*	*$10*	$104,739	*$93,891*	*$10,848*	*$88*
22	$9,299	*$9,299*	*$0*	*$69*	$115,314	*$58,742*	*$56,571*	*$100*
Floodwall (PCH)	$19,380	*$19,380*	-	*$18*	$19,380	*$19,380*	*$0*	*$18*
Widen Warner Ave	$59,191	*$0*	-	*$57*	$59,191	*$0*	*$59,191*	*$57*
Tide Gates	$8,512	*$8,512*	-	*$8*	$8,512	*$8,512*	*$0*	*$8*
Real Estate	$20,000	*$20,000*	-	-	$20,000	*$20,000*	*$0*	*$0*
Mitigation	$9,375	*$9,375*	-	*$30*	$9,375	*$9,375*	*$0*	*$30*
Total	**$823,541**	*$731,398*	*$92,143*	*$732*	**$1,475,931**	*$1,061,834*	*$414,097*	*$959*

2019 Price Levels

3.7 Annualized Costs and Benefits for Minimum and Maximum Alternatives

A comparison of EAD benefits for the without project condition to both the Minimum Channel Modifications and Maximum Channel Modifications plans are contained in Table 10 and Table 11. The tables includes the impacts as currently modeled for the Without Project Condition, the Minimum Alternative, and the Maximum Alternative. The Moderate Alternative has not been run separately yet, specific estimates for this alternative are not yet included.

The net benefits in Table 12 provided the basis for the incremental analyses in the development of the TSP.

Table 10: Structures impacted and EAD for Without Project Condition on C02/C04. Additionally, the EAD for the Minimum and Maximum Alternatives are displayed.

Stream	Damage Reach	Number of Structures Impacted	EAD for the Without Project Condition ($1000)	EAD for the Minimum Alternative ($1000)	EAD for the Maximum Alternative ($1000)
C04	C04_4a	21	$43	$0	$0
	C04_4b	244	$2,510	$4	$0
	C04_3	108	$0	$0	$8
	C04_2	384	$25	$0	$1
	C04_1	310	$21	$0	$1
C02	C02_1	584	$6,115	$45	$24
Total Damages/ Impacts		1651	$8,714	$50	$33
Total Damages Reduced			$ 0	$ 8,664	$ 8,681

**2019 Price Levels; Without Uncertainty; Without Levee Fragility; Direct Damages to Structures and Contents Only*
**Number of Structures Impacted is estimated at the mean 0.2% ACE with HEC-FDA*

Table 11: Structures impacted and EAD for Without Project Condition on C05/C06. Additionally, the EAD for the Minimum and Maximum Alternatives are displayed.

Stream	Damage Reach	Number of Structures Impacted	EAD for the Without Project Condition ($1000)	EAD for the Minimum Alternative ($1000)	EAD for the Maximum Alternative ($1000)
C06	C06_1A	31	$157	$29	$0
	C06_1B	98	$28	$1	$0
	C06_2	751	$719	$0	$0
C05	C05_1A	168	$173	$2	$9
	C05_2A	10	$88	$43	$0
	C05_2B	86	$248	$252	$0
	C05_2C	13	$40	$15	$0
	C05_2D	271	$927	$321	$13
	C05_3A	43	$267	$20	$0
	C05_3B	35	$97	$95	$0
	C05_3C	85	$0	$0	$1
	C05_3D	512	$1,105	$8	$2
	C05_4A	1812	$15,714	$28	$4
	C05_4B	96	$215	$0	$4
	C05_5	134	$6,591	$1	$2
	C05_6	2598	$62,098	$1	$1
Total Damages/ Impacts		6743	$88,467	$818	$36
Total Damages Reduced			$0	$87,649	$88,431

**2019 Price Levels; Without Uncertainty; Without Levee Fragility; Direct Damages to Structures and Contents Only*
**Number of Structures Impacted is estimated at the mean 0.2% ACE with HEC-FDA*

3.8 Incremental Analysis to Develop a Moderate Channel Modifications (Hybrid) Plan

The details of the Moderate Channel Modifications (Hybrid) Plan were developed by comparing the reach-by-reach benefits and costs provided for each of the reaches in the Minimum and Maximum Channel Modification plans. This was done to explore the potential for increasing net benefits by identifying a plan that is between these alternatives in terms of economic outputs. Considerations made for developing the combined alternative included (1) if the combination was hydraulically complete and (2) if the next increment would result in increased net benefits.

A hydraulically complete plan accounted for the interaction and linkages of modifications from the Minimum and Maximum Channel Modifications plans across the various channels and reaches. For example, maximum channel modifications could not be made upstream of minimum channel modifications. This would potentially result in conveyance issues and induced damages downstream.

The incremental analysis was carried out on a reach-by-reach basis starting at the downstream channel limits (Huntington Harbour for C02/C04 and Outer Bolsa Bay for C05/C06). The analysis moved upstream in each channel, to identify the reach where the maximum channel modification measure no longer created the greatest net benefits. Upstream of this point all reaches would have the minimum channel modification measure applied. No reaches were skipped or 'stranded' during the incremental analysis in order to avoid causing induced damages from overly increased conveyance upstream.

This process was repeated for each reach to create a complete alternative. The combination of minimum and maximum reach modifications included in the Moderate Channel Modifications (Hybrid) Plan is shown in Table 12.

In total, the Moderate Channel Modifications (Hybrid) Plan that is generated through this incremental analysis is identical in composition to the Minimum Channel Modifications Plan. This indicates that hybridizing the Minimum and Maximum Modification plans does optimize net benefits. Stated otherwise, the incremental analysis, which was utilized to optimize net benefits, indicates that the Minimum Channel Modifications Plan is the study alternative that appears to provide the greatest net benefits.

3.9 Moderate Channel Modifications (Hybrid Plan)

Based on the results of the incremental analysis described in Section 3.6, the Moderate Channel Modifications (Hybrid) Plan is identical to the Minimum Channel Modifications Plan. This indicates that there is not a combination of minimum and maximum modifications that provides greater net benefits than either of the previously formulated Minimum or Maximum Channel Modifications plans.

Table 12: The Moderate Channel Modifications (Hybrid) Plan that results from the incremental analysis(see column "Option Optimizing Net Benefits") is identical in composition to the Minimum Channel Modifications Plan.

Channel	Economic Impact Areas		Channel Reaches			Minimum Channel Modifications Plan 2.875%				Maximum Channel Modifications Plan 2.875%				Incremental Justification					
						Total First Cost ($000)	Average Annual Cost ($000)	Average Annual Benefits ($000)	Average Annual Net Benefits ($000)	Total First Cost ($000)	Average Annual Cost ($000)	Average Annual Benefits ($000)	Average Annual Net Benefits ($000)	Alt. With Highest Net Benefits	Cum. Net Benefits for Min Alt.	Cum Net Benefits for Max Alt.	Option Maximizing Net Benefits	Cum. Net Benefits for Hybrid Alt.	Increment is "Justified"
C05	C05_5	C05_6	1	2		$307,764	$11,801	$75,789	$63,989	$307,764	$11,801	$75,789	$63,989	Max	$63,989	$63,989	**Max**	$63,989	Yes
	C05_4B		3			$13,896	$554	$258	($296)	$57,010	$2,210	$929	($1,281)	Min	$63,692	$62,708	**Min**	$63,692	No
	C05_4A		4			$14,623	$598	$17,492	$16,894	$54,344	$2,121	$18,128	$16,008	Min	$80,586	$78,716	**Min**	$80,586	No
	C05_2D	C05_3D	5			$14,720	$598	$2,045	$1,447	$73,589	$2,866	$3,684	$818	Min	$82,033	$79,534	**Min**	$82,033	No
	C05_2C	C05_3C	6	7		$0	$0	$276	$276	$82,744	$3,214	$3,359	$145	Min	$82,309	$79,679	**Min**	$82,309	No
	C05_2B	C05_3B	8			$0	$0	$75	$75	$28,980	$1,131	$1,094	($36)	Min	$82,384	$79,642	**Min**	$82,384	No
	C05_2A	C05_3A	9			$0	$0	$526	$526	$46,799	$1,838	$1,585	($253)	Min	$82,910	$79,389	**Min**	$82,910	No
	C05_1A		10	11	12	$0	$0	$230	$230	$0	$209	$209	$209	Min	$83,140	$79,598	**Min**	$83,140	No
C06	C06_2		13	14	15	$13,740	$541	$884	$343	$44,177	$1,715	$1,320	($395)	Min	$343	($395)	**Min**	$343	No
	C06_1B		16	17		$4,996	$198	$43	($155)	$15,156	$592	$124	($469)	Min	$189	($863)	**Min**	$189	No
	C06_1A		18	19		$4,065	$161	$689	$528	$5,654	$221	$728	$507	Min	$717	($357)	**Min**	$717	No
C02	C02_1		23			$281,160	$10,707	$6,713	($3,994)	$281,160	$10,707	$6,713	($3,994)	Max	($3,994)	($3,994)	**Max**	($3,994)	Yes
C04	C04_4b	C04_4a	20			$42,817	$1,670	$3,186	$1,516	$142,041	$5,483	$5,124	($360)	Min	($2,477)	($4,353)	**Min**	($2,477)	No
	C04_3		21			$0	$0	$2	$2	$104,739	$4,063	$492	($3,571)	Min	($2,475)	($7,924)	**Min**	($2,475)	No
	C04_1	C04_2	22			$9,299	$371	$80	($291)	$115,314	$4,476	$2,581	($1,895)	Min	($2,766)	($9,819)	**Min**	($2,766)	No
Channel Construction Subtotal						**$707,081**	**$27,198**	**$108,290**	**$81,091**	**$1,359,472**	**$52,436**	**$121,859**	**$69,422**						
Downstream Measures Costs			Floodwall (PCH)			$19,380	$735	-	-	$19,380	$735	-	-						
			Widen Warner Ave			$59,191	$2,246	-	-	$59,191	$2,246	-	-						
			Tide Gates			$8,512	$323	-	-	$8,512	$323	-	-						
			Real Estate			$20,000	$759	-	-	$20,000	$759	-	-						
			Mitigation			$9,375	$356	-	-	$9,375	$356	-	-						
Total by Alternative						**$823,541**	**$31,618**	**$108,290**	**$76,672**	**$1,475,931**	**$56,856**	**$121,859**	**$65,003**						
						BCR	**3.3**			**BCR**	**2.2**								

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4.0 Comparison of Final Array of Alternatives

Per USACE Guidance, the PDT tentatively selects the alternative that maximizes net benefits, or the NED Plan, as the recommendation for this Flood Risk Management Study. In order to determine which alternative is the NED Plan, the costs and benefits for the Final Array of Alternatives were compared. The alternative with the greatest net benefits is the apparent NED Plan, and thus the TSP.

4.1 Tentatively Selected Plan

Based on the cost and benefit analysis of the final array of alternatives NED Plan, the Minimum Channel Modifications Plan. This plan is estimated to produce $101,771,000 in average annual benefits at an average annual cost of $43,524,000 (total project cost of $823,541,000), for a BCR of 3.3 at the current Federal Discount Rate (FDR) of 2.875%.

Table 13: The apparent NED is the TSP. The LPP will also be carried forward to the ADM.

Name	Total First Cost ($1,000)	Equivalent Average Annual Values ($1,000s)		
		Benefits	Costs	Net Benefits
No Action	-	-	-	-
Minimum Channel Modifications	**$823,541**	**$145,295**	**$43,524**	**$101,771**
Maximum Channel Modifications	**$1,475,931**	**$160,511**	**$74,409**	**$86,102**
Moderate Channel Modifications	*No moderate plan was identified that would optimize net benefits based on most up-to-date costs and benefits*			

The Moderate Channel Modifications Plan in Table 13 shows the same costs and benefits as the Minimum Channel Modifications Plan. This indicates that, based on a reach-by-reach incremental justification using current cost and benefit estimates, the Minimum Channel Modifications Plan maximizes net benefits. As the study progresses into detailed design, cost and benefit calculations will continue to be refined. It is possible, therefore, that the configuration of Moderate Channel Modifications Plan could change slightly to include additional reaches that are justified to receive the maximum modifications (altering channel geometry). The PDT will continue to update the incremental analysis as cost and benefit estimates are refined.

Earlier iterations of the incremental justification process yielded multiple preliminary Moderate Channel Modifications plans as the PDT continued to refine cost and benefit estimates. These plans included additional reaches in which maximum channel modifications (altering channel geometry) were justified. Intermediate iterations of the Moderate Channel Modifications Plan were all identified as the apparent NED plan at the time of their creation; this is inherent to the incremental justification process that was utilized to optimize net benefits.

4.2 Identification of a Locally Preferred Plan

The non-federal sponsor has expressed an interest in pursuing a LPP from one of the final array of alternative plans that was not identified as having the highest average annual net benefits. The LPP is the Maximum Channel Modifications Plan based on the NFS's goal of containing the 1% ACE event in the

study channels. The Maximum Channel Modifications Plan is estimated to produce $86,102,000 in average annual benefits at an average annual cost of $74,409,000 (total project cost of 1,475,931,000), for a BCR of 2.2 at the current FDR of 2.875%. LPPs may be selected pending approval from HQUSACE and the Assistant Secretary of the Army (Civil Works), and have a BCR greater than 1.

Table 14: The apparent NED is the TSP. The LPP will also be carried forward to the ADM.

Plan	Name	Total First Cost ($1,000)	Equivalent Average Annual Values ($1,000s)		
			Benefits	Costs	Net Benefits
NED	Minimum Channel Modifications	$823,541	$145,295	$43,524	$101,771
LPP	Maximum Channel Modifications	$1,475,931	$160,511	$74,409	$86,102

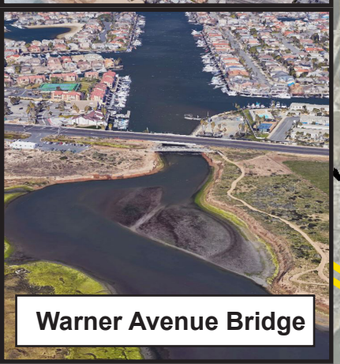
Attachments

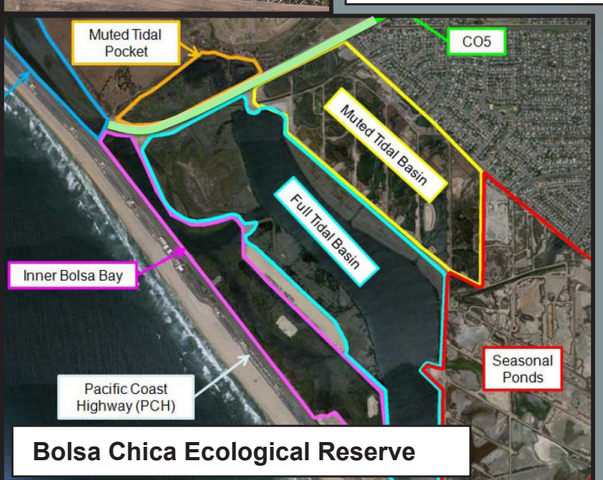
A number of intermediate and supplemental documents related to the plan formulation process are presented in the following pages. These documents were created to increase clarity of communication with the PDT, the NFS, and the VT. Descriptions of the documents are included below:

1. 2018 TSP Milestone Briefing Placemat (revised)

- This double sided "placemat" was created and distributed prior to the 25 July 2018 TSP Milestone Briefing to serve as a quick reference for attendees form the VT and the NFS. The placemat provides general information about the project, calls out important features and place names in the project area, and presents summary information regarding the NED/TSP and LPP Plans.

WESTMINSTER, EAST GARDEN GROVE, FLOOD RISK MANAGEMENT STUDY





Watershed Boundary

Seal Beach Naval Weapons Station

Seal Beach National Wildlife Refuge

Anaheim Bay

Huntington Harbour

Warner Avenue Bridge

Outer Bolsa Bay

Tide Gates

Bolsa Chica Ecological Reserve

Pacific Coast Highway

CO2 Bolsa Chica Channel

CO4 Westminster Channel

CO5 East Garden Grove Wintersburg Channel

CO6 Ocean View Channel

Inundation

- 0.04 ACE
- 0.02 ACE
- 0.01 ACE
- 0.005 ACE
- 0.002 ACE

Oct. 2018

WESTMINSTER, EAST GARDEN GROVE, FLOOD RISK MANAGEMENT STUDY

Study Channels

CO2
- ~ 1.5 miles
- No slope / at sea level

CO4
- ~ 8 miles
- Sloping from +75 ft. to sea level

CO5
- ~ 11 miles
- Sloping from +130 ft. to sea level

CO6
- ~ 4 miles
- Sloping from +130 ft. to +5 ft. at confluence with CO5

Without Project Damages

Expected Annual Damages

CO2/CO4 = $ 8,714,000

CO5/CO6 = $88,467,000

Total = $97,181,000

Event Based Impacts Watershed		
ACE*	Structures*	Mean Damages*
0.1	2995	$71,677,000
0.04	3767	$88,375,000
0.02	4398	$101,166,000
0.01	5504	$117,805,000
0.005	6601	$139,853,000
0.002	8394	$177,923,000

**Only structure and content damages are provided above*
**Estimates do not include uncertainty*
**C05/06 accounts for approximately 78% of the total damage at the 0.002 ACE*

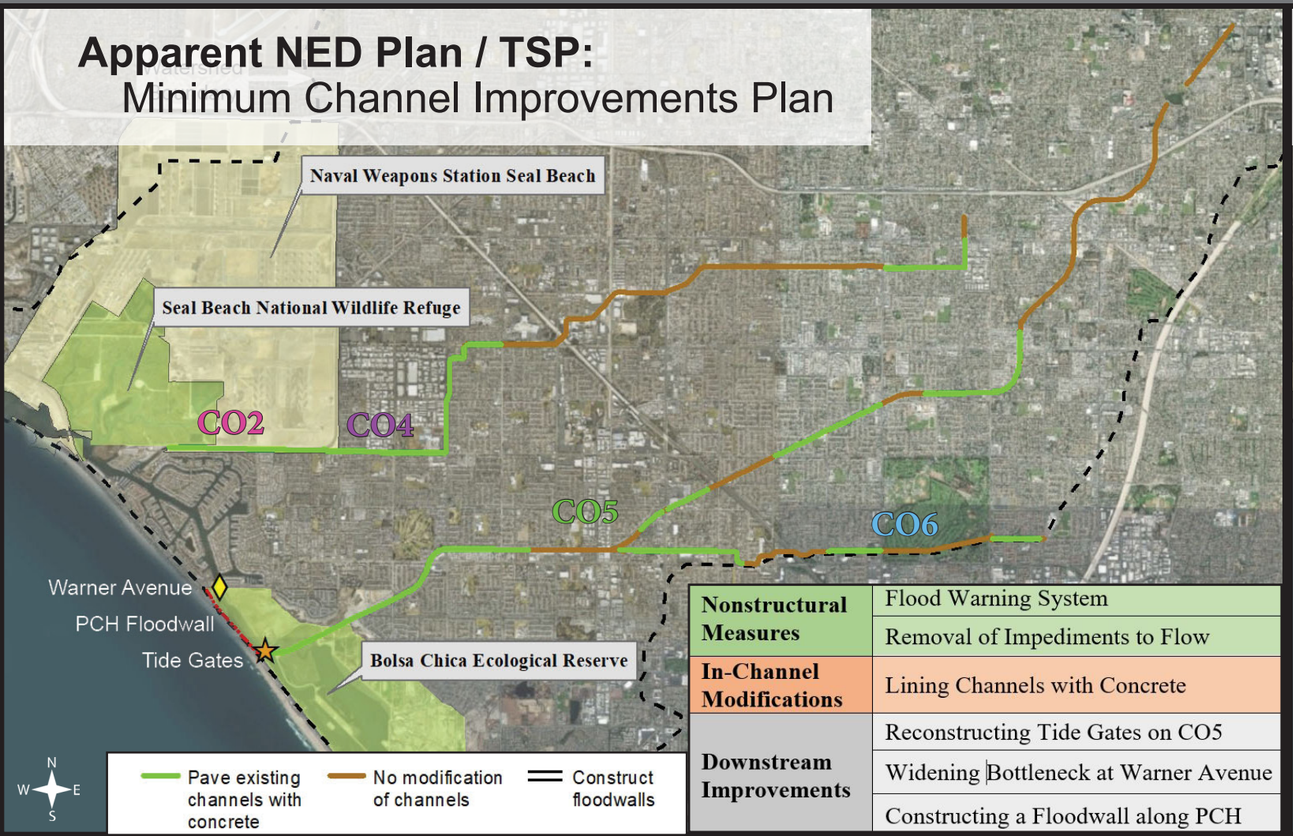
Existing Channel Conditions

Improved Channel Conditions

Study Schedule

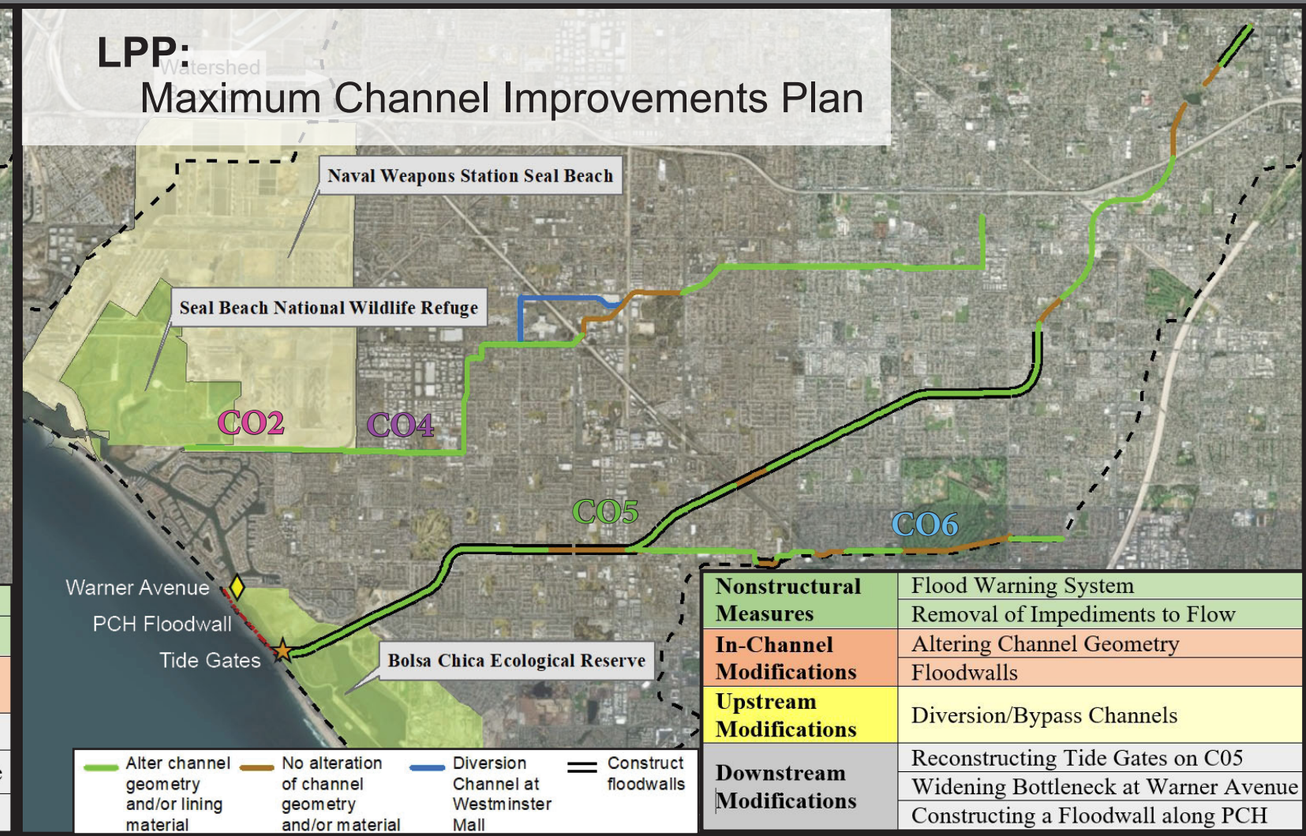
Activity	Timing
Public review of Draft Feasibility Report begins	19 October 2018
Public review of Draft Feasibility Report ends	03 December 2018
Agency Decision Milestone (ADM) for selected study alternative	31 January 2019
Feasibility Study Chief's Report to Congress	31 January 2020

Apparent NED Plan / TSP: Minimum Channel Improvements Plan



Nonstructural Measures	Flood Warning System
	Removal of Impediments to Flow
In-Channel Modifications	Lining Channels with Concrete
Downstream Improvements	Reconstructing Tide Gates on CO5
	Widening Bottleneck at Warner Avenue
	Constructing a Floodwall along PCH

LPP: Maximum Channel Improvements Plan



Nonstructural Measures	Flood Warning System
	Removal of Impediments to Flow
In-Channel Modifications	Altering Channel Geometry
	Floodwalls
Upstream Modifications	Diversion/Bypass Channels
Downstream Modifications	Reconstructing Tide Gates on C05
	Widening Bottleneck at Warner Avenue
	Constructing a Floodwall along PCH