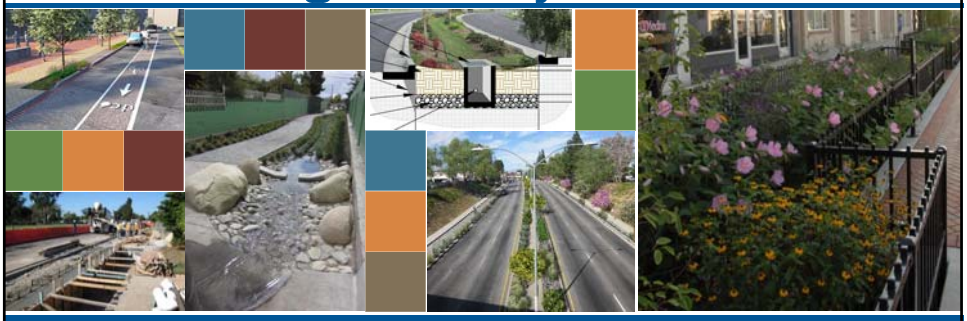
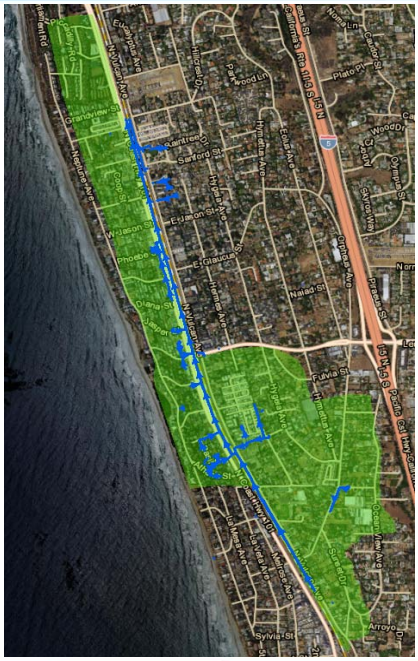
An Evaluation of Gray and Green Infrastructure to Address Water Quality and Flooding in the City of Encinitas



March 15, 2017

Study Area

- 320 acres in Leucadia
- Limited and undersized stormwater infrastructure
- Events exceeding a 1-year storm cause flooding



Existing Flooding Problems

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Existing Flooding Problems

- Along Vulcan Ave

- Intersection of Orpheus Ave and Hymettus Ave

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Data Collection and Site Evaluation

- Hydrologic and Hydraulic Study (2003)
- Leucadia Drainage Improvement Alternatives Study (2005)
- GIS layers: 2-ft Contours, Storm Drains
- Field Visit

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Gray Infrastructure Evaluation

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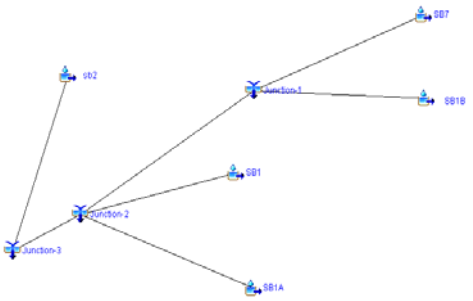
Gray Infrastructure Evaluation

- U.S. Army Corps of Engineers HEC-HMS
- Determine peak flowrates for 5-year, 10-year, and 50/100-year, 24-hour storm events

Drainage Analysis			
	50/100-YR	10-Yr	5-Yr
SB1	40.2	15.8	7.8
SB7	28.2	13.2	8.2
SB1B	24.7	11.5	7
Junction-1	52.8	24.7	15.2
SB1A	7.4	2.9	1.4
Junction-2	94.4	40.4	22.3
SB2	49.4	24.2	15.8
Junction-3	142.5	63.9	37.5



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Gray Infrastructure Evaluation

- Federal Highway Administration (FHWA) Hydraulic Toolbox

Pipe Location	Design Storm Event		
	5-Year	10-Year	50/100-Year
	Pipe Size, inch		
Orpheus Avenue (from Puebla St. to the intersection of Union St. and Orpheus Ave.)	18	24	30
Orpheus Avenue (from Union St. to Vulcan Ave.)	24	30	36
Vulcan Avenue (from Cereus St. to Encinitas Blvd.)	36	42	54
Cost	$1,961,592	$2,087,301	$2,328,126

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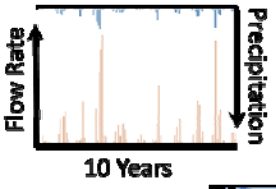
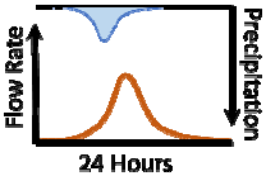
Green Infrastructure Design and Evaluation

- Model: USEPA SUSTAIN
- 10 years of rainfall/runoff data
- Simulated flow exceedance and bacteria removal
- Storm Scenarios: 85th percentile, 5-year, 10-year, and 50/100-yr, 24-hour design storm

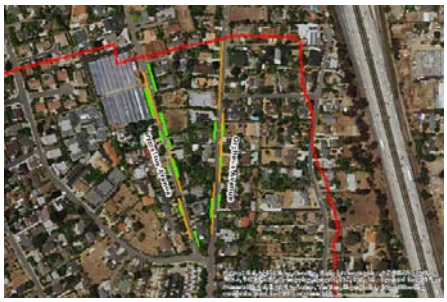


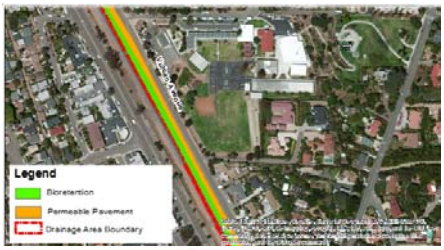


Goal	Model Scenario	Target	Threshold Value
Reduce Flooding	Long-Term Simulation (2000-2010)	Attenuate Flow to Thresholds	1 cfs (regulated flow rate that drains the study area)
	Design Storm Simulation	Attenuate Flow to Thresholds	1 cfs (regulated flow rate that drains the study area)
		Capture the Runoff Volume	100% removal

Green Infrastructure Design and Evaluation

- Permeable Pavement:
  - Area= 7,350 ft^2
  - Retention Volume= 2,940 ft^3
- Bioretention:
  - Area= 45,000 ft^2,
  - Retention Volume= 76,500 ft^3





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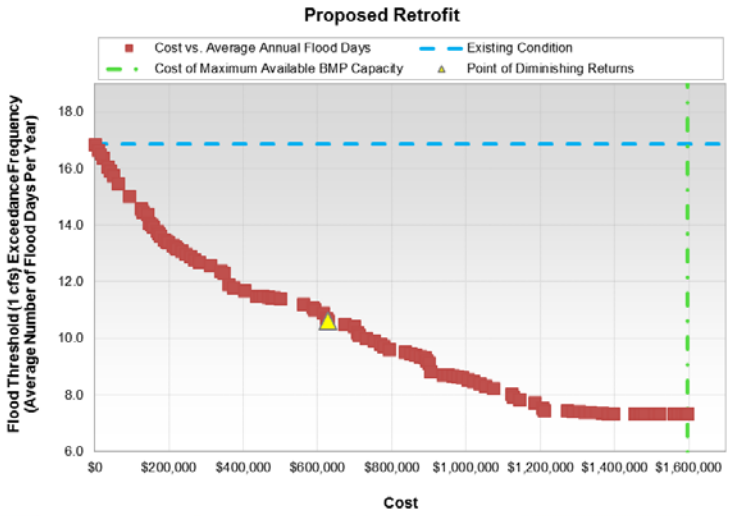
Green Infrastructure Design and Evaluation



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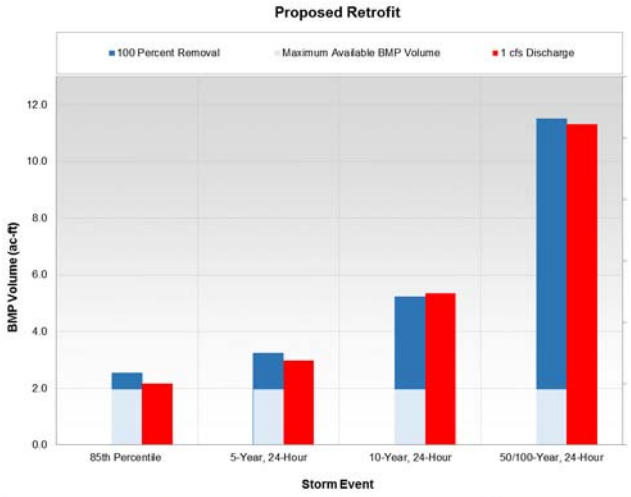
Green Infrastructure Design and Evaluation



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Green Infrastructure Design and Evaluation

Design Storm Event	Threshold: 100 percent Volume Removal		Threshold: 1 cfs bypass	
	Green Infrastructure Capacity (ac-ft)	Cost	Green Infrastructure Capacity (ac-ft)	Cost
85th Percentile	2.4	$3,790,320	2.0	$1,553,080
5-Year, 24-Hour	3.2	$4,951,640	2.8	$3,997,730
10-Year, 24-Hour	5.1	$7,221,500	4.9	$7,744,470
50/100-Year, 24-Hour	11.5	$16,683,660	10.5	$15,751,030

Proposed Retrofit	Design Storm Event			
	85th Percentile	5-Year, 24-Hour	10-Year, 24-Hour	50/100-Year, 24-Hour
Maximum Available Green Infrastructure Capacity	1.82	1.82	1.82	1.82
Percent Runoff Volume Removal	77%	60%	36%	17%
Approximate Total Cost	$1,595,600			

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Green Infrastructure Design and Evaluation

Proposed Retrofit	Existing Conditions		Gray Infrastructure		Green Infrastructure	
	Cost	Annual Flooding Frequency (day)	Cost	Annual Flooding Frequency (day)	Cost	Annual Flooding Frequency (day)
Recommended Size for Long Term Simulation	$0	17	$1,874,939	8	$1,595,600	8
Recommended Size for 5-Year, 24 Hour	$0	17	$1,961,592	1	$4,951,640	1
Recommended Size for 10-Year, 24 Hour	$0	17	$2,087,301	1	$7,221,500	1
Recommended Size for 50/100-Year, 24 Hour	$0	17	$2,328,126	0	$16,683,660	0

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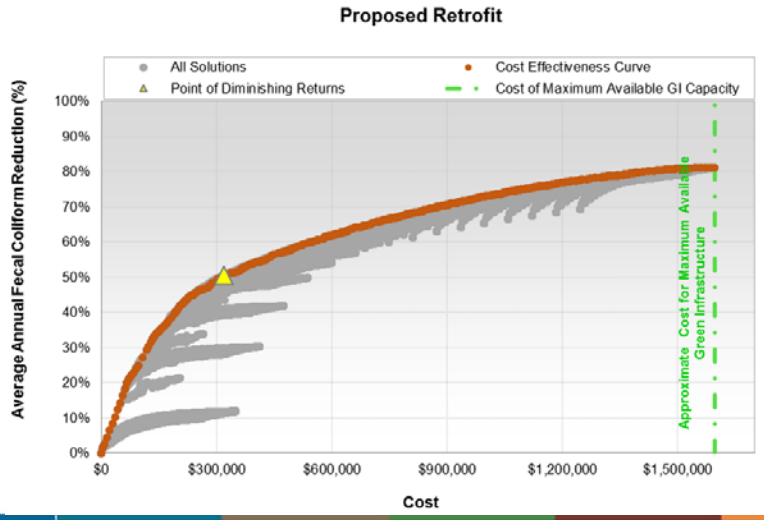
Green Infrastructure Design and Evaluation



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Summary of Findings

BMP Type	Area (ft^2)	Retention Volume (ft^3)
Permeable Pavement	7,350	2,940
Bioretention	45,000	76,500

- Provide the capacity to treat 77%, 60%, 36%, and 17% of the flow volume produced by 85th percentile, 5-year, 10-year, 50/100-year, 24-hour design storm event respectively

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Summary of Findings

Model Results	Green Solution	Gray Solution
Flooding	Decreased by 56%	Decreased by 100%
Bacteria Loads	Decreased by 80%	No improvement
Cost	$1.6M	$1.9M

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Summary of Findings

Cost for grey solution

Item No.	Description	Long Term Simulation	5-Year	10-Year	50/100-Year
1	18-inch RCP (D-2000)				
	Quantity	-	880	--	--
	Unit Price	-	$195.00	--	--
	Total	-	$171,600	--	--
2	24-inch RCP (D-2000)				
	Quantity	$6920	1,490	880	--
	Unit Price	$203.33	$203.33	$203.33	--
	Total	$1,407,066.67	$302,967	$178,933	--
3	30-inch RCP (D-2000)				
	Quantity	--	--	1,490	880
	Unit Price	--	--	$211.67	$211.67
	Total	--	--	$315,383	$186,267
4	36-inch RCP (D-2000)				
	Quantity	--	4,550	--	1,490
	Unit Price	--	$220.00	--	$220.00
	Total	--	$1,001,000	--	$327,800
5	42-inch RCP (D-2000)				
	Quantity	--	--	4,550	--
	Unit Price	--	--	$237.50	--
	Total	--	--	$1,080,625	--
6	54-inch RCP (D-2000)				
	Quantity	--	--	--	4,550
	Unit Price	--	--	--	$275.00
	Total	--	--	--	$1,251,250
Subtotal Cost		$1,407,066.67	$1,475,567	$1,574,942	$1,765,317
7	Construction Contingency	$211,060.00	$211,335	$236,241	$264,798
8	Design	$161,812.67	$169,690	$181,118	$203,011
9	Construction Staking	$40,000.00	$40,000	$40,000	$40,000
10	Construction Inspection	$45,000.00	$45,000	$45,000	$45,000
11	Soil/Materials Testing	$10,000.00	$10,000	$10,000	$10,000
Total Cost		$1,874,939	$1,961,592	$2,087,301	$2,328,126

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Summary of Findings

Cost for green solution

Item No.	Description	Estimated Qty	Unit	Unit Cost	Total
	Preparation				
1	Traffic Control	20	Day	$1,000.00	$20,000.00
2	Temporary Construction Fence	10,544	LF	$2.50	$26,360.00
3	Silt Fence	10,544	LF	$3.00	$31,632.00
	Site Preparation				
4	Saw Cut Existing Asphalt	1,050	LF	$5.12	$5,376.00
5	Asphalt Removal	7,350	SF	$3.36	$24,696.00
6	Sidewalk Removal	42,000	SF	$2.01	$84,420.00
7	Excavation and Removal	5,272	CY	$45.00	$237,250.00
	Structures				
8	Permeable Pavement	7,350	SF	$12.00	$88,200.00
9	Structural Layer (washed no. 57 or no. 2 stone)	45	CY	$50.00	$2,268.52
10	Concrete Transition Strip	1,050	LF	$4.00	$4,200.00
	Bioretention				
11	Fine Grading	45,000	SF	$0.72	$32,400.00
12	Hydraulic Restriction Layer (30 mil liner)	7,140	SY	$0.60	$4,284.00
13	Soil Media Barrier (washed sand)	277.78	CY	$40.00	$11,111.00
14	Soil Media Barrier (choking stone, washed no. 8)	277.78	CY	$45.00	$12,500.00
15	Mortared Cobble Energy Dissipater	277	SF	$2.25	$623.00
16	Curb Opening with Grate	7	LS	$350.00	$2,585.00
	Landscaping				
17	Soil Media	3,333	CY	$45.00	$150,000.00
18	Vegetation	45,000	SF	$4.00	$180,000.00
19	Mulch	417	CY	$55.00	$22,917.00
	Construction Subtotal				$940,820
20	Planning (20% of subtotal)				$188,160
21	Mobilization (10% of subtotal)				$94,080
22	Construction Contingency (15% of subtotal)				$141,120
	Construction Total				$1,364,180
23	Design (10% of Construction Total)				$136,420
24	Construction Staking				$40,000
25	Construction Inspection				$45,000
26	Soil/Material Testing				$10,000
	Total Cost				$1,595,600

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