Holistic Approach to Los Angeles River Water Quality Management

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ENE 510 – Water Quality Management and Practice (class project)

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USC Viterbi School of Engineering

University of Southern California

Swan

SAFE WATER FOR ALL NATIONS

S.W.A.N is an initiative started by Dr. Massoud Pirbazari of the University of Southern California focusing on the improvement of drinking water quality for citizens of developing countries. SWAN's goal is to provide comprehensive and visually based information so that people, at the household level, can treat their water, and in turn, improve their health and well-being.

https://cee.usc.edu/research/water-quality-research-group/swan/

THIS SITE IS UNDER CONSTRUCTION.
All material included in this presentation have been adapted from sources* outlined on the final slide.

* *We would like to thank those whose work has been pivotal in the creation of this site.*

(See Reference Page for Sources)

Agenda

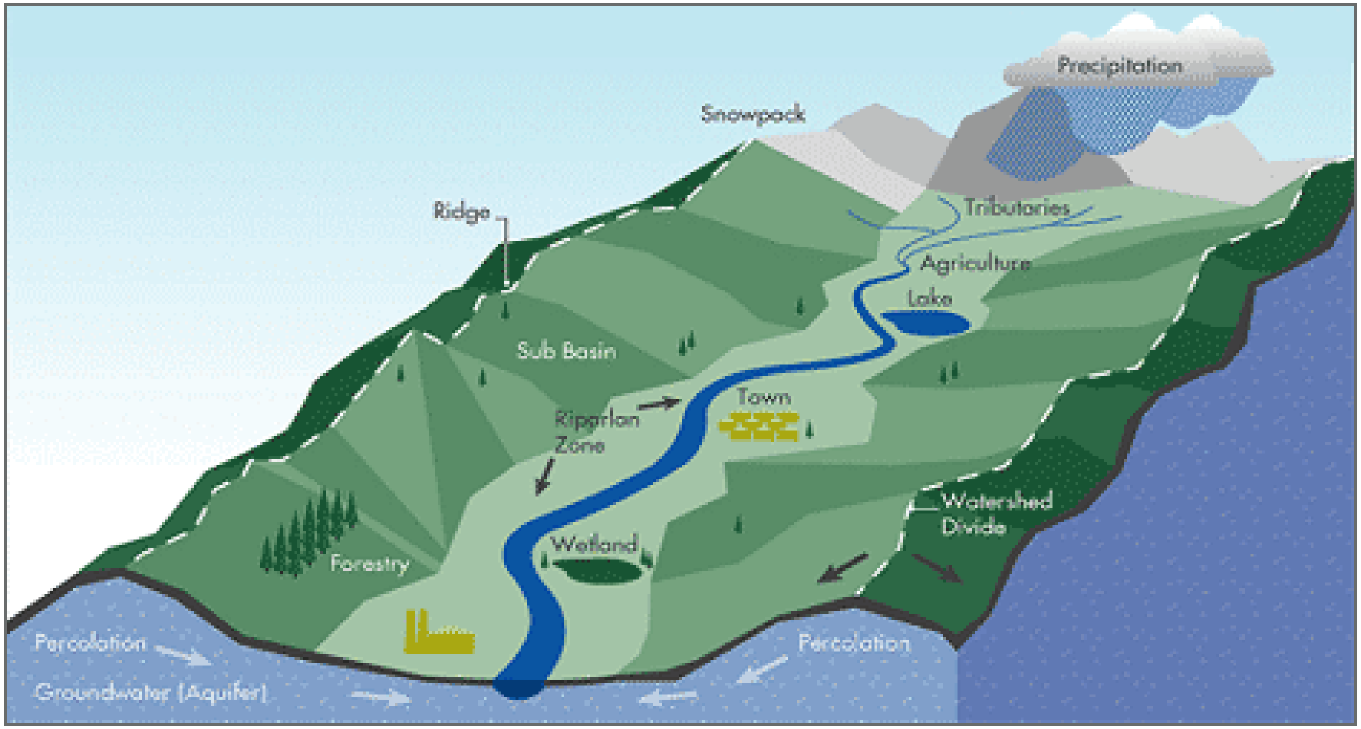
1. Introduction to LA River
2. Regulations
3. Discharges & Treatment
4. LID & BMP's
5. Sustainability/Feasibility

Part 1

Introduction to LA River

What is a Watershed?

An area of land that drains all the streams and rainfall to a common outlet such as the outflow of a reservoir, mouth of a bay, or any point along a stream channel. The word watershed is sometimes used interchangeably with drainage basin or catchment.



Los Angeles River Watershed

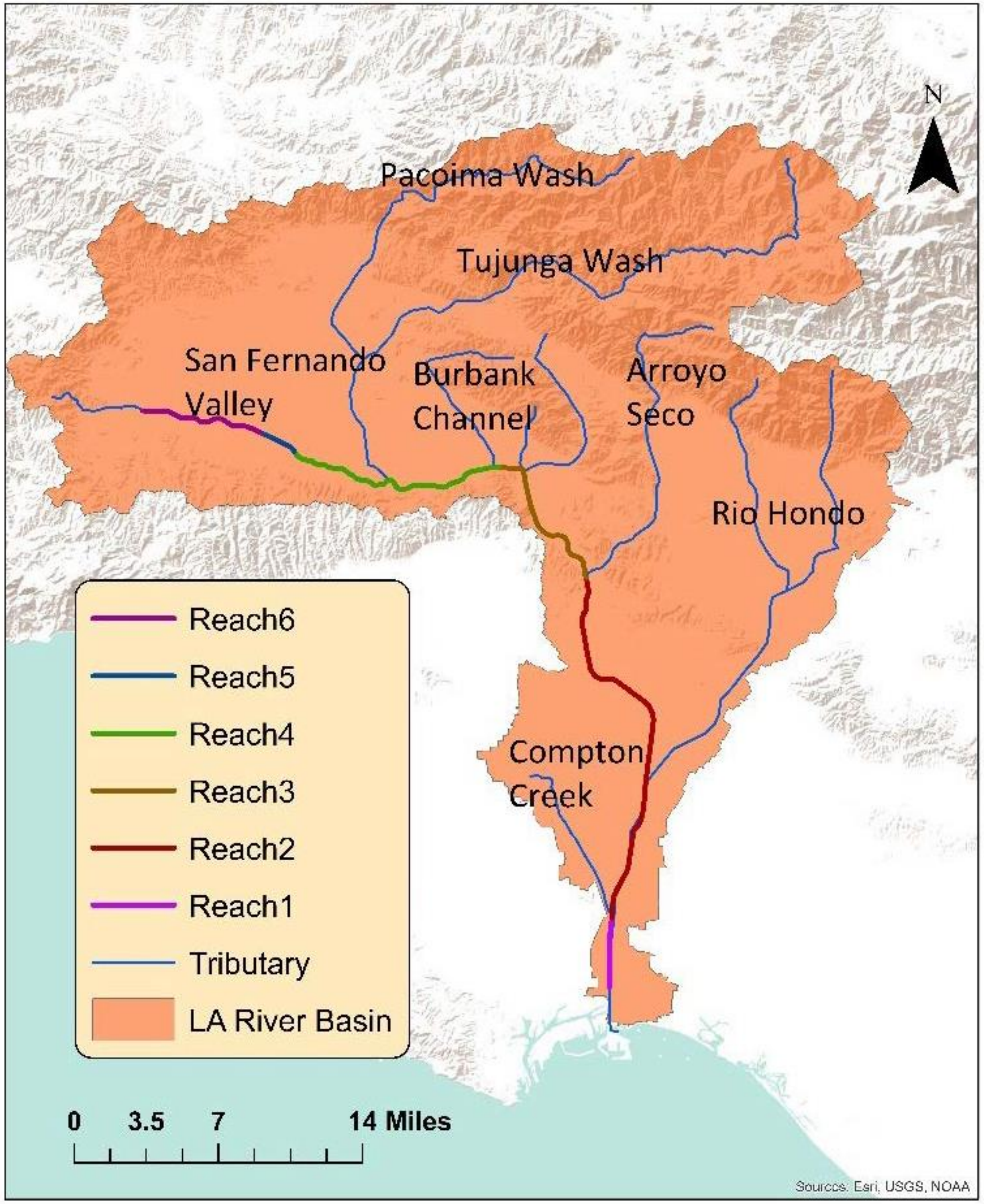
Length - 51 miles
Area - 834 mi^2

Tributaries

- Arroyo Calabasas
- Bell Creek
- Aliso Creek
- Pacoima Wash
- Big Tujunga Creek
- Tujunga Wash
- Verdugo Wash
- Arroyo Seco
- Santa Anita Creek
- Rio Hondo
- Compton Creek

Source #2

LA River Reaches



- Reach 6 – Tujunga Wash
- Reach 5 (2.5 mi) – San Fernando Valley
- Reach 4 (11 mi) – Glendale Narrows
- Reach 3 (8 mi) – Downtown LA
- Reach 2 (19 mi) – Compton Creek
- Reach 1 (2.6 mi) – Long Beach

Source #3

Metals in the LA River

Sampling Location	Dist km (miles)	Dry Season Ni	Zn	As	Pb	Se	Wet Season Ni	Zn	As	Pb	Se
1	71 (44.1)	6.89	62.41	3.03	1.05	3.03	0.01	0.04	0.01	0.00	0.00
2	63 (39.2)	0.94	1.05	2.88	0.02	0.70	na	na	na	na	na
3	58 (36.5)	1.10	2.06	3.88	0.05	0.25	na	na	na	na	na
4	58 (35.9)	1.25	0.85	2.91	0.01	0.22	0.00	0.00	0.01	0.00	0.01
5	56 (35.2)	1.10	6.10	1.44	0.23	0.20	0.00	0.00	0.02	0.01	0.01
6	47 (29.4)	4.85	30.33	2.24	0.28	2.58	0.01	0.02	0.01	0.00	0.00
7	40 (25.1)	5.32	25.03	2.50	0.27	2.52	0.00	0.00	0.00	0.00	0.00
8	40 (25.1)	2.86	3.31	1.38	0.04	1.30	0.00	0.02	0.01	0.00	0.00
9	40 (25.0)	3.15	4.85	1.63	0.08	1.46	0.00	0.02	0.01	0.00	0.01
10	35 (21.8)	4.88	21.85	2.85	0.25	2.30	0.00	0.01	0.00	0.00	0.00
11	26 (16.1)	6.19	40.95	2.70	0.51	2.31	0.00	0.02	0.02	0.00	0.00
12	6 (4.0)	6.01	39.21	2.55	0.48	2.21	0.01	0.01	0.00	0.00	0.00
13	5 (3.0)	6.48	27.80	16.88	0.47	28.15	0.00	0.01	0.00	0.00	0.00
14	1 (0.9)	10.25	21.31	75.60	0.27	170.43	0.00	0.00	0.00	0.00	0.00
MCL (ppb)*		100	5000	10	15	50	100	5000	10	15	50
Minimum (ppb)		0.94	0.850	1.377	0.009	0.198	0.002	0.000	0.002	0.001	0.000
Maximum (ppb)		10.25	62.414	3.880	1.054	3.027	0.009	0.039	0.017	0.006	0.009
STD. Dev.		2.77	18.710	0.730	0.281	1.036	0.002	0.011	0.005	0.002	0.003
Average (ppb)		4.38	20.508	2.499	0.287	1.589	0.005	0.013	0.008	0.003	0.003

*The table also shows a comparison of average, standard deviation (SD), minimum, and the maximum of the various parameter in different locations in LA River. Sampling location1and 14 were furthest and closest to the ocean. These locations including the Sepulveda Basin (1), La Crescenta (2), Eaton Canyon Falls (3), JPL Area (4), Eaton Canyon Wash (5), Glendale Narrows (6), Under the bridge near Confluence (7), Lower Arroyo Seco (8), Arroyo Seco Confluence (9), First and Seventh Street (10), City Bell (11), Willow Street in Long Beach (12), Pacific Coast Highway Bridge (13) and Queensway in Long Beach (14) (The Mouth of the LA River). MCL=Maximum Contamination Limit, na = not available. *(all after [23]USEPA, 2012 except nickel, which is after Title 22 of the California Code of Regulations). N (dry)=14 and N (wet)=14*

Source #4

Other Pollutants in the LA river

- **Chloride**
  - High chloride concentrations were recorded near the ocean
  - Chloride concentrations ranged (5.5 mg/L to 16,027 mg/L) in dry period (Avg.1,589 mg/L)
  - During the wet period, concentrations of chloride ranged from 3.4 to 5,860 mg/L (Avg. 444 mg/L)
- **Fluoride**
  - Concentrations ranged from 0 to 0.66 mg/L for the wet period and 0 to 1.032 mg/L for the dry period with an average concentration of 0.37 mg/L during the wet period and 0.56 mg/L during the dry period
- **Nitrate**
  - Concentration during the dry period of 0 to 21.5 mg/L (avg.10 mg/L)
  - 0 to 17 mg/L (avg. 6 mg/L) during the wet period
- **Phosphate**
  - Range of 0 to 1.65 mg/L during the dry period (avg. 0.33 mg/L)
  - 0 to 0.67 mg/L and an average concentration of 0.14 mg/L for the wet season
  - Highest concentrations recorded for the dry period (1.65 ppm) around Glendale Wastewater Treatment Plant where its effluent discharges to the LA River
- **Sulfate**
  - Concentrations 13 to 2,313 mg/L (avg. 308 mg/L)in dry period
  - 7.9 to 746 mg/L (avg. 121 mg/L) during wet period
  - higher concentrations recorded in Sepulveda Basin and PCH Bridge

Table 2. Spatial and seasonal changes of various water parameter (anions) [ppm] for LA river

Sampling locations	Dist. km (mile)	Dry Season					Wet Season				
		Cl	F	NO_3	PO_4	SO_4	Cl	F	NO_3	PO_4	SO_4
1	71 (44.1)	101.7	0.6	16.8	0.0	151.9	122.4	0.7	17.1	0.0	361.4
2	63 (39.2)	5.7	0.2	1.2	0.0	35.6	5.9	0.1	1.6	0.0	30.1
3	58 (36.5)	9.2	0.9	1.0	0.0	13.3	4.7	0.6	0.7	0.0	8.9
4	58 (35.9)	12.6	1.0	1.8	0.0	24.4	3.4	0.4	5.7	0.0	12.1
5	56 (35.2)	5.5	1.0	0.0	0.0	14.9	4.2	0.5	1.6	0.0	8.0
6	47 (29.4)	97.4	0.6	21.5	1.7	118.0	30.6	0.4	7.2	0.4	70.8
7	40 (25.1)	106.7	0.6	16.7	0.7	123.3	22.7	0.3	6.0	0.3	69.1
8	40 (25.1)	82.5	0.3	18.9	0.0	119.0	14.4	0.3	5.9	0.0	21.9
9	40 (25.0)	93.9	0.5	18.4	0.4	120.5	66.1	0.5	11.2	0.0	125.0
10	35 (21.8)	103.4	0.6	16.5	0.6	124.0	16.7	0.4	5.9	0.0	34.7
11	26 (16.1)	101.7	0.6	16.8	0.0	151.9	25.1	0.3	6.6	0.3	72.3
12	6 (4.0)	108.2	0.6	6.5	0.6	146.6	20.0	0.3	6.6	0.2	67.8
13	5 (3.0)	5395.2	0.6	5.7	0.7	859.0	21.2	0.3	6.6	0.7	72.1
14	1 (0.9)	16027.4	0.0	0.0	0.0	2312.9	5860.4	0.0	0.0	0.0	746.0
MCL* (ppm)		250	4	10	na	250	250	4	10	na	250
Minimum (ppm)		5.51	0.00	0.00	0.00	13.31	3.39	0.00	0.00	0.00	7.98
Maximum (ppm)		16027.41	1.03	21.49	1.65	2312.94	5860.43	0.66	17.12	0.67	745.98
STD. Dev.		4391.44	0.29	8.40	0.48	613.97	1559.24	0.17	4.44	0.21	200.76
Average (ppm)		1589.36	0.56	10.12	0.33	308.24	444.14	0.37	5.91	0.14	121.43

*The table also shows a comparison of average, standard deviation (SD), minimum, and the maximum of the various parameter in various locations in LA River Sampling locations 1and 14 were furthest and closest to the ocean. These locations including the Sepulveda Basin (1), La Crescenta (2), Eaton Canyon Falls (3), JPL Area (4), Eaton Canyon Wash (5), Glendale Narrows (6), Under the bridge near Confluence (7), Lower Arroyo Seco (8), Arroyo Seco Confluence (9), First and Seventh Street (10), City of Bell (11), Willow Street in Long Beach (12), Pacific Coast Highway Bridge (13) and Queensway in Long Beach (14) (The Mouth of the LA River). MCL=Maximum Contamination Limit, na = not available. . *(after [23]). N (dry)=14 and N (wet)=14*

Source:Water Quality Assessment of the Los Angeles River Watershed, California, USA in Wet and Dry Periods. M.H.R. Boroon et al.

Chemicals of Emerging Concern(CEC) in the LA River

- Not widely regulated or routinely monitored
- Can be pharmaceuticals, personal care products (PPCPs), commercial, industrial chemicals, natural hormones, food additives, and some pesticides from industrial and municipal waste streams
- Result from treated effluent discharge from water treatment plants (ranging from <1 ng/L to several μg/L), depending on the chemical
- Chlorinated phosphate flame-retardants were detected at the highest concentrations, with a mean total aggregate concentration of TCEP, TCPP,and TDCPP of 3400 and 2400 ng/L

Table.5:

Table 2. The number and percentage of target analytes (aggregated for LAR and SGR) detected in sampling Event #1 (Ev#1; July 2011) and Event #2 (EV#2; October 2011). PPCPs = pharmaceuticals and personal care products; REF = reference station.

	PPCPs		Commercial		Pesticides		Hormones		TOTAL	
	Ev#1	Ev#2	Ev#1	Ev#2	Ev#1	Ev#2	Ev#1	Ev#2	Ev#1	Ev#2
No. Target CECs	22	24	21	25	14	15	5	10	62	74
No. CECs Detected	20	19	7	8	5	10	0	1	32	38
% CECs Detected	91	79	33	32	36	67	0	10	52	51
No. CECs Detected -- SGR REF	3	1	3	0	0	0	0	0	6	1
No. CECs Detected -- LAR REF	10	4	5	6	4	7	0	0	19	17

Table.6:

Table 3. Monitoring trigger quotients (MTQs) for individual CECs detected in the Los Angeles and San Gabriel rivers during low flow conditions for Event #1 (Ev#1; July 2011) and Event #2 (EV#2; October 2011). C_{max} = maximum observed aqueous concentration in ng/L; MTL = monitoring trigger level, based on observed or predicted no effect concentrations and uncertainty factors of 1 to 100 (Anderson *et al.* 2012); MTQ = C_{max} / MTL; and NA = data not available. Permethrin values are the sum of *cis-* and *trans-*isomers.

Analyte	MTL (ng/L)	C_{max} (ng/L)		MTQ	
		Ev#1	Ev#2	Ev#1	Ev#2
17β-estradiol	2	<1.25	<1.25	<0.62	<0.62
Acetaminophen	920000	25.8	16.0	<0.01	<0.01
Atrazine	200	13.7	17.1	0.07	0.09
BDE 47	100	1.0	2.2	0.01	0.02
BDE 99	100	0.4	0.9	<0.01	0.01
Bifenthrin	0.4	<1.5	3.6	<3.80	9.00
Bisphenol A	60	<12.5	<25.0	<0.21	<0.42
Carbamazepine	2500	330.0	318.0	0.13	0.13
Chlorpyrifos	5	0.9	4.9	0.18	0.99
DEET	58400	860.0	380.0	0.01	0.01
Diazepam	12700	4.3	6.1	<0.01	<0.01
Diclofenac	100	77.0	124.0	0.77	1.24
Dilantin	33500	291.0	239.0	0.01	0.01
Estrone	6	<2.5	<2.5	<0.42	<0.42
Fipronil	51	13.6	7.4	0.27	0.14
Fipronil desulfinyl	59	13.8	13.3	0.23	0.23
Fipronil sulfide	59	2.0	1.7	0.03	0.03
Fipronil sulfone	59	5.7	10.6	0.10	0.18
Galaxolide	700	n/a	2750.0	NA	3.90
Gemfibrozil	7800	193.0	324.0	0.02	0.04
Ibuprofen	100	40.5	<25.0	0.41	<0.25
Permethrin	1	<18.0	1.7	<18.00	1.70
Sulfamethoxazole	5900	790.0	932.0	0.14	0.16
TCEP	51000	785.0	581.0	0.02	0.01
TCPP	74900	2150.0	2900.0	0.03	0.04
TDCPP	51000	1345 .0	923.0	0.03	0.02
Tonalide	1000	188.0	NA	0.19	NA
Triclocarban	360	102.0	92.0	0.28	0.26
Triclosan	250	18.2	26.3	0.07	0.11
Trimethoprim	4000	78.5	180.0	0.02	0.04

The occurrence and fate of chemicals of emerging concern (CECs) in coastal urban rivers receiving discharge of treated municipal wastewater effluent. A.Sengupta et al.

CEC (continued)

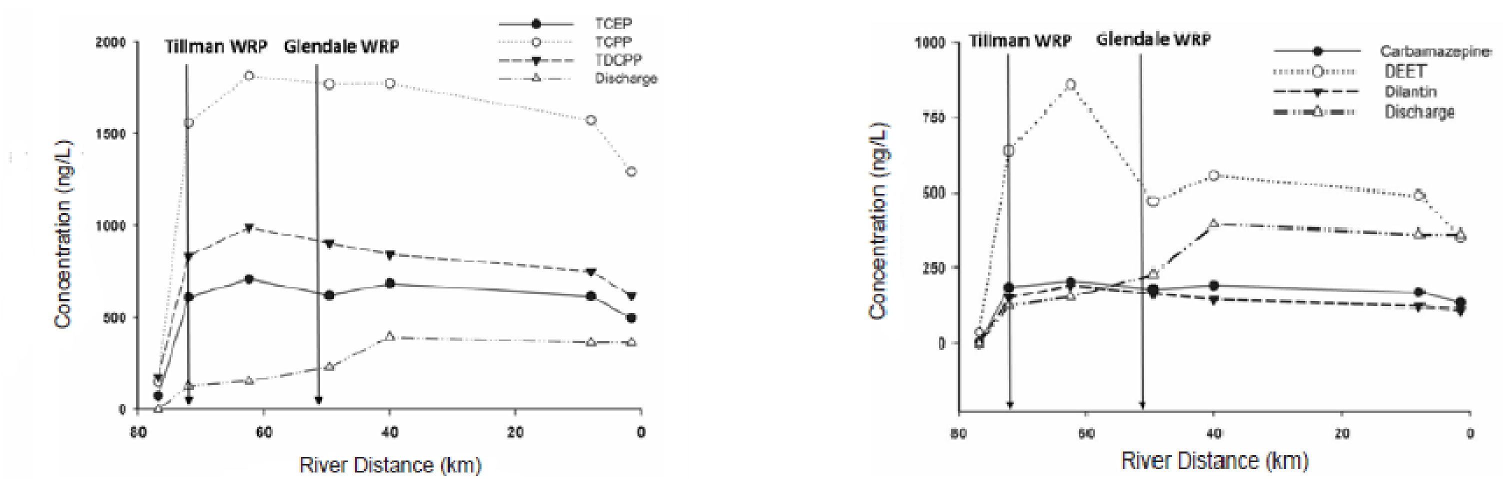


Figure . In-stream concentration profiles of chlorinated phosphate flame retardants (TCPP, TDCPP, and TCEP; top) and selected pharmaceuticals and personal care products (PPCPs; bottom) for the Los Angeles River (.3: y 2011). The confluence point of the river and the ocean is considered as river kilometer = 0. The units plotted for discharge are (100 m³/s). WRP = water reclamation plant

The occurrence and fate of chemicals of emerging concern (CECs) in coastal urban rivers receiving disch
of treated municipal wastewater effluent. A Sengupta et al.

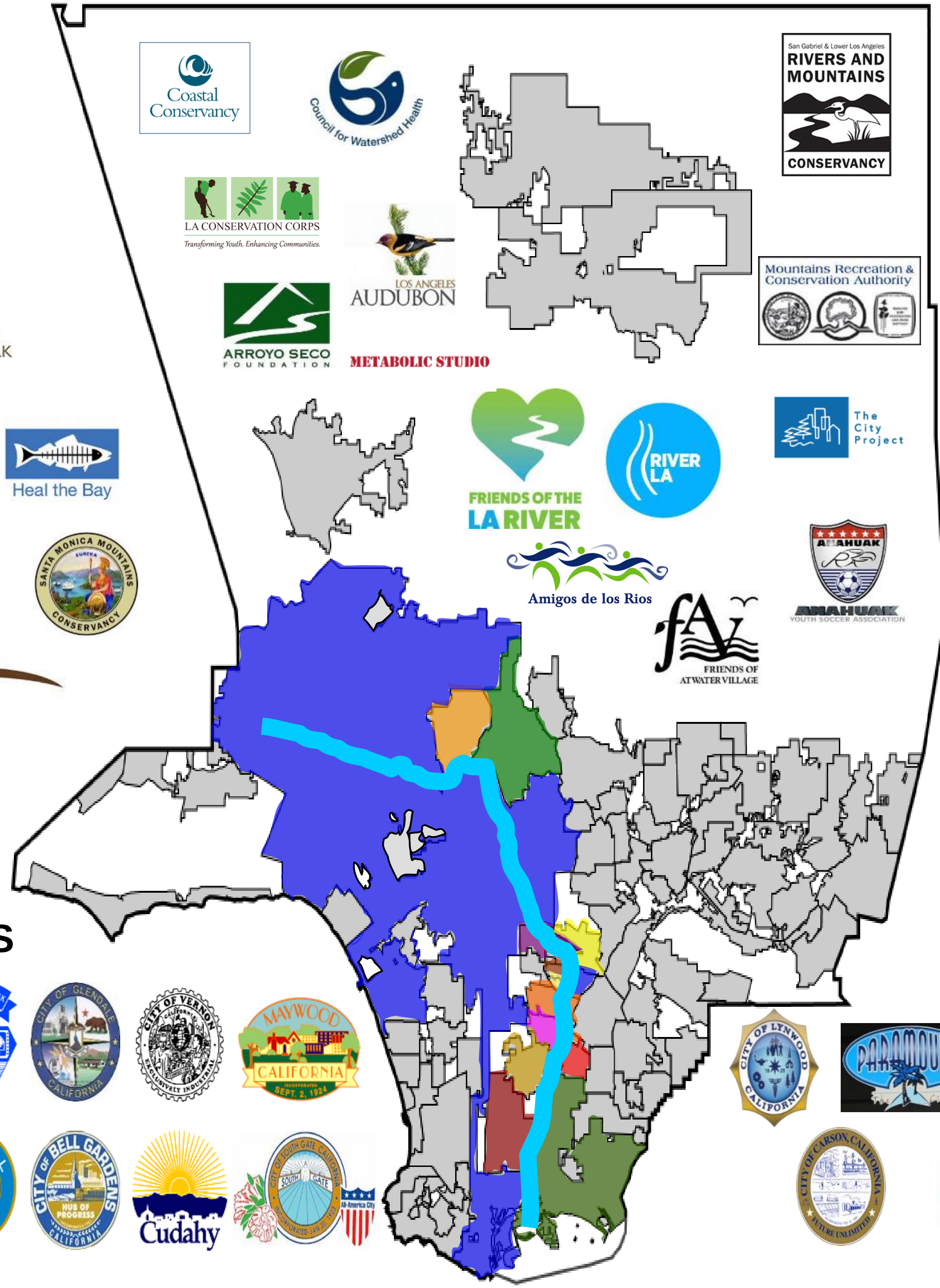
Part 2

Regulations that Impact LA River Water Quality

Agencies involved in LA River

US Army Corps of Engineers
United States Environmental Protection Agency
California Water Boards
California State Parks
Department of Water Resources, State of California
California Natural Resources Agency
Los Angeles County Flood Control District
County of Los Angeles Public Works
Eric Garcetti #lamayor
Engineering, City of Los Angeles
Los Angeles River Revitalization
LA Sanitation, environment, City of Los Angeles
LA DWP Los Angeles Department of Water & Power

NGOs



51 MILES

15 CITIES

City of Los Angeles
City of Burbank
City of Glendale
City of Vernon
Maywood California
City of Lynwood
Paramount
Compton
City of Commerce
City of Bell
City of Bell Gardens
Cudahy
City of South Gate
City of Carson
City of Long Beach

Clean Water Act

In 2010, the EPA designated the LA River as a “navigable waterway.”

Navigable Waterway = “waters that are subject to the ebb and flow of the tide and/or are presently used, or have been used in the past, or may be susceptible for use to transport interstate or foreign commerce.”

→ tributaries are protected from pollutants under the *Clean Water Act*

The reason why the LA River water quality is protected!!!

TMDL

"States are required to evaluate all available water quality-related data and information to develop a list of waters that do not meet established WQS (impaired) and those that currently meet WQS, but may exceed it in the next reporting cycle (threatened). States then must develop a TMDL for every pollutant/waterbody combination on the list. An essential component of a **TMDL** is the calculation of the maximum amount of a pollutant that can occur in waterbody and still meet WQS. Within the TMDL, the state allocates this loading capacity among the various point sources and non-point sources. Permits for point sources are issued through EPA's or NPDES program."

– Clean Water Act Section 303(d)

Source #6

TMDL

<u>Purpose</u>: Protection of surface and groundwater. For all those who use water and/or discharge wastewater in the Los Angeles Region.

TMDL = Wasteload Allocation from point sources (WRP's) + Load Allocations from nonpoint sources (urban runoff) + Natural Background + Margin of Safety

Los Angeles Water Resources Control Board (LAWRCB) is responsible for establishing water quality standards in the Los Angeles area and these standards are described in the Los Angeles Water Quality Control "Basin Plan."

LA River: metals, nutrients, solids, BOD, bacteria from WRP's and runoff

CALIFORNIA
Water Boards
STATE WATER RESOURCES CONTROL BOARD
REGIONAL WATER QUALITY CONTROL BOARDS

Source #7

Reach-Specific TMDLs for Wet and Dry Weather (kg/day)

		Critical Flow (cfs)	Cadmium	Copper	Lead	Zinc
Dry Weather	LAR Reach 5[7]	8.74	-	0.65 x WER[1]	3.6 x WER[1]	-
	LAR Reach 4	129.13	-	8.1 x WER[2]	26 x WER[1]	-
	LAR Reach 3	39.14	-	2.5 x WER[2]	9.6 x WER[1]	-
	Tujunga Wash	0.15	-	0.007 x WER[3]	0.029 x WER[1]	
	Burbank Channel	17.3	-	0.80 x WER[4]	3.2 x WER[1]	-
	LAR Reach 2	4.44	-	0.24 x WER[2]	1.02 x WER[1]	-
	LAR Reach 1	2.58	-	0.14 x WER[2]	0.64 x WER[1]	-
	Compton Creek	0.90	-	0.041 x WER[6]	0.16 x WER[1]	-
	Rio Hondo Reach 1	0.50	-	0.015 x WER[5]	0.045 x WER[1]	0.16 x WER[1]
Wet Weather	Conversion factor (µg/L)[8]		3.1 x WER[1]	17 x WER[2]	62 x WER[1]	159 x WER[1]

Source #8

MS4 Permit for LA County

- **MS4** = Municipal Separate Storm Sewer Systems

- Permit No. R4-2012-0175 was adopted by the LARWQCB in 2012. It regulates storm & non-stormwater discharges from the MS4s in LA County (Flood Control District + 84 municipalities).

- The permit allows permittees to create Watershed Management Programs (WMPs) or EWMPs to meet Water Quality Based Effluent Limits (WQBELs) individually or as a group. This MS4 permit offers an alternate compliance pathway to WQBELs, which is to develop and implement WMPs/EWMPs (which require adaptive modeling and Best Management Practices implementation to achieve retention of the 85th percentile storm across the watershed) as the functional equivalence of complying with the receiving water limitations.

Source #9

NPDES Permit

Purpose: Addresses water pollution by regulating point sources that discharge pollutants to waters of the United States. Created by the Clean Water Act, the EPA authorizes States to perform permitting, administrative, and enforcement aspects of the program.

Tillman operates under a Los Angeles Municipal Storm Water permit (NPDES Permit No: CAS004001) for its discharge of tertiary treated wastewater into the LA River.

Limit metals, nutrients, TSS, BOD, and bacteria.

Effluent limitations are Technology-based and Water Quality-based.

Source #10

ORDER R4-2017-xxx
NPDES NO. CA0056227

WASTE DISCHARGE REQUIREMENTS FOR THE CITY OF LOS ANGELES, DONALD C. TILLMAN WATER RECLAMATION PLANT DISCHARGE TO THE LOS ANGELES RIVER VIA DISCHARGE OUTFALLS AND PONDS

The following Discharger is subject to waste discharge requirements (WDRs) set forth in this Order:

Table 1. Permittee Information

Discharger/Permittee	City of Los Angeles
Name of Facility	Donald C. Tillman Water Reclamation Plant
Facility Address	6100 Woodley Avenue
	Van Nuys, CA 91406
	Los Angeles County

Table 2. Discharge Location

Discharge Point Nos.	Description	Discharge Point Latitude (North)	Discharge Point Longitude (West)	Receiving Water
001	Tertiary Treated Effluent	34.18028	-118.4794	Los Angeles River, directly and via Lake Balboa, Wildlife Lake, Hayvenhurst Channel, Haskell Channel and Bull Creek

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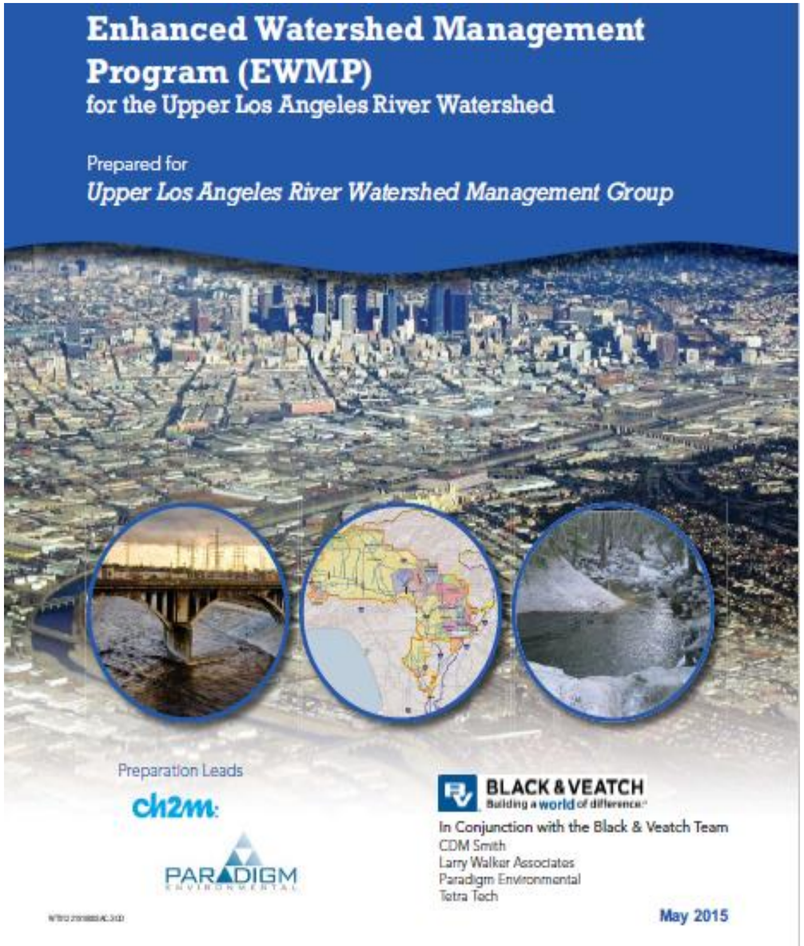
- Many more…

Enhance Watershed Management Plan

- Mandated by LARWCB.
- Provides a framework for meeting stormwater regulations through implementation of LID and control measures.
- Serves as a reference document for the schedule of TMDL compliance for each reach of ULAR as well as proposed site-specific projects to meet stormwater compliance regulations.
- Outlines the TMDL compliance schedule for the watershed: 100% compliance by 2028 for copper, zinc, and lead in dry weather, and 100% compliance for fecal bacteria by 2037.



Source #12

CA Code of Regulations – Title 22

What defines "**Recycled Water**" ?

§60301.230. Disinfected tertiary recycled water.

"Disinfected tertiary recycled water" means a filtered and subsequently disinfected wastewater that meets the following criteria:

(a) The filtered wastewater has been disinfected by either:

(1) A chlorine disinfection process following filtration that provides a CT (the product of total chlorine residual and modal contact time measured at the same point) value of not less than 450 milligram-minutes per liter at all times with a modal contact time of at least 90 minutes, based on peak dry weather design flow; or

(2) A disinfection process that, when combined with the filtration process, has been demonstrated to inactivate and/or remove 99.999 percent of the plaque forming units of F-specific bacteriophage MS2, or polio virus in the wastewater. A virus that is at least as resistant to disinfection as polio virus may be used for purposes of the demonstration.

Wastewater Treatment Plants that provide disinfected, tertiary-treated recycled water, with filtration and disinfection to meet Title 22 requirements are referred to as WRP's.

CA Code of Regulations – Title 22

Regulations for the production and use of recycled water:

- **Non-Potable Reuse** = Purposes such as irrigation, street sweeping, industrial cooling, in-plant use at the WRPs, dust control, and environmental benefits (LA River revitalization plans)

- **Indirect Potable Reuse** = Groundwater recharge (future plans to do this)

- **Direct Potable Reuse** = Highly treated recycled water directly into potable raw water supplies. (Regulation in California does not currently permit DPR.)

Source #13

Part 3

Discharges to LA River

Pollutants Sources

Table 7: The sources of pollutants and remedial actions

Types	Sources	The effect	Action
Trash, debris and other floatables	Careless disposal of packaging, street litter, and plant debris	Negative aesthetic impacts Affect aquatic life Harbor bacteria Inhibit dissolved oxygen levels	Best Management Practices are used to target the highest trash areas
Bacteria and viruses	Trash, sanitary sewer leaks and spills, malfunctioning septic systems, fecal matter from humans, pets, and wildlife	Affect aquatic life	TMDLs have not yet been imposed
Nutrients, particularly nitrogen and phosphorus	Lawn fertilizers, human and animal waste, wastewater plants effluent	Cause algae growth and reduce of dissolved oxygen	TMDLs became effective and number of targets for nitrogen compounds in the Los Angeles River were established
Metals (zinc, cadmium, copper, chromium, nickel)	Industries	Toxic to all forms of wildlife in high levels	Metal TMDLs were imposed in 2005
Chemicals of emerging concerns	Industries Pharmaceuticals Pesticides	Interfere with endocrine(hormone) system, cause cancerous tumors, birth defects, development disorders	Different treatment can be used but ozone, carbon, and reverse osmosis are the most effective processes

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Pollutants Sources (cont'd)

- **Wildfire:**
  - According to fire statistics by State of California, annually the average of 3,720 Acres are burned.
  - Study done by Paulina Pinedo-Gonzalez and others from University of Southern California shows that in runoff from recently burned areas, 58% and 24% of the total dissolved (<0.2 mm) Pb and Fe, respectively, was present in the soluble pool. In contrast, runoff from urban and natural unburned areas carried less than 17% and 8% of the total dissolved Pb and Fe, respectively, in the soluble pool.
  - Therefore, wildfire should be taken in consideration as source of pollutants to LA river.

- **Vehicle Emission**
  - Acoording DMV, about 7.8 millions vehicles, including auto, trucks and motorcycle, yearly are registerd in Los Angeles.
  - A study done by Air Resources Board on Lake Tahoe confirms the atmospheric deposition for nitrogen (N), phosphorus (P), and particulate matter (P) from the traffic on the lake.
  - Thus, the vehicle emission in LA also should be taken in consideration as source of pollutants to the river but more studies should be done to quantify these pollutants.

Dry Weather - Urban Runoff

Dry weather TMDL applies when the majority of water present in the stream originates from WRPs and the stormdrain network. (<500 cfs)

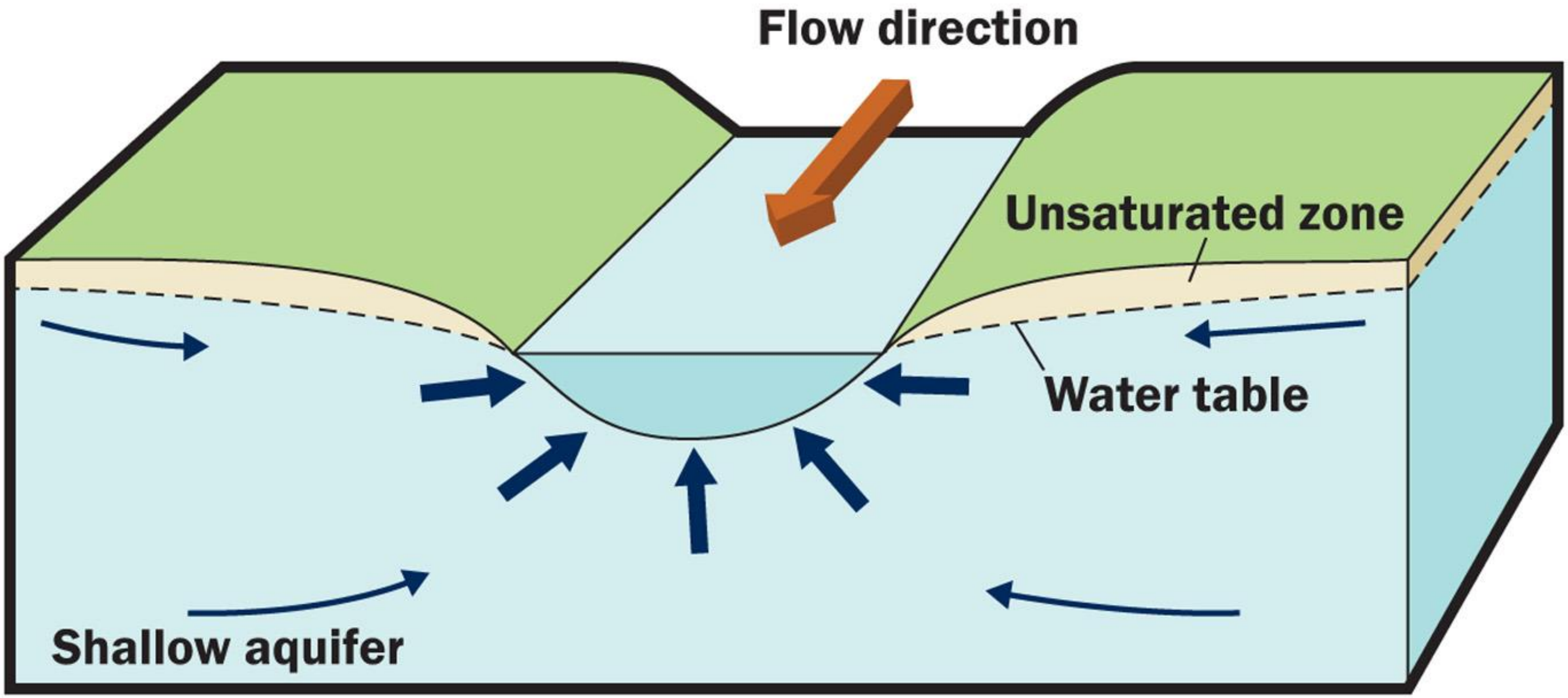
Dry Weather - Urban Runoff

Trash on Alvarado Street in LA

Wet Weather - Stormwater Runoff

Wet weather TMDL is defined for days when a rain event adds large volume of water (>500 cfs) and carries pollutant load to the river or its tributaries.

Groundwater Upwelling



Small contribution due to lining, but may affect water quality.

Discharges to the LA River

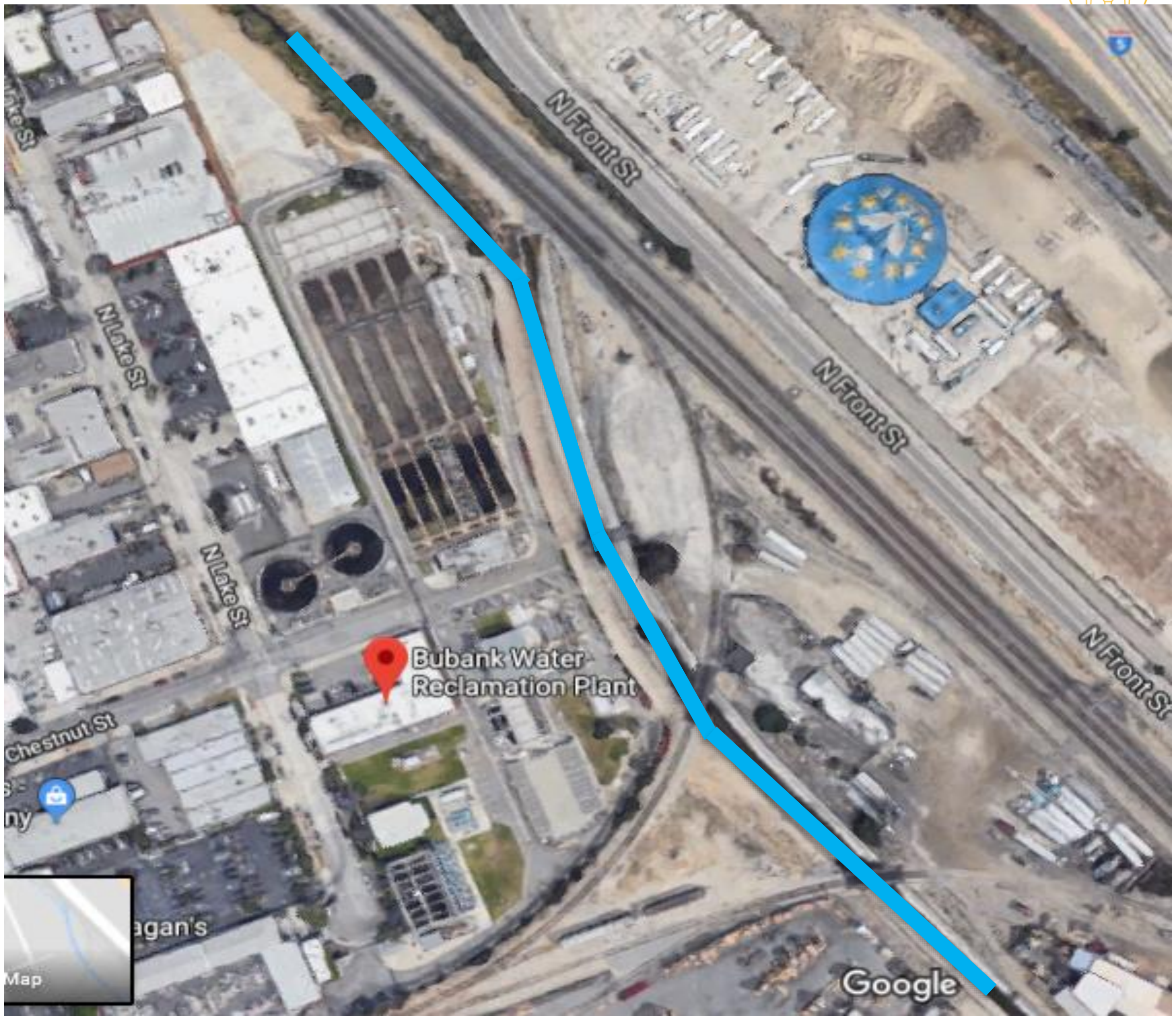
70-100% of flow comes from WRP's in dry weather

Water Reclamation Plant (WRP)	Design Flow (MGD)	Average Daily Flow (2004-2013)	Discharges to River
Burbank	15	7	5.75 MGD (6,438 AF)
LA-Glendale	20	18.2	9.82 MGD (11,000 AF)
Donald C. Tillman	80	31.9	5.71 MGD (6,400 AF)

Source #19

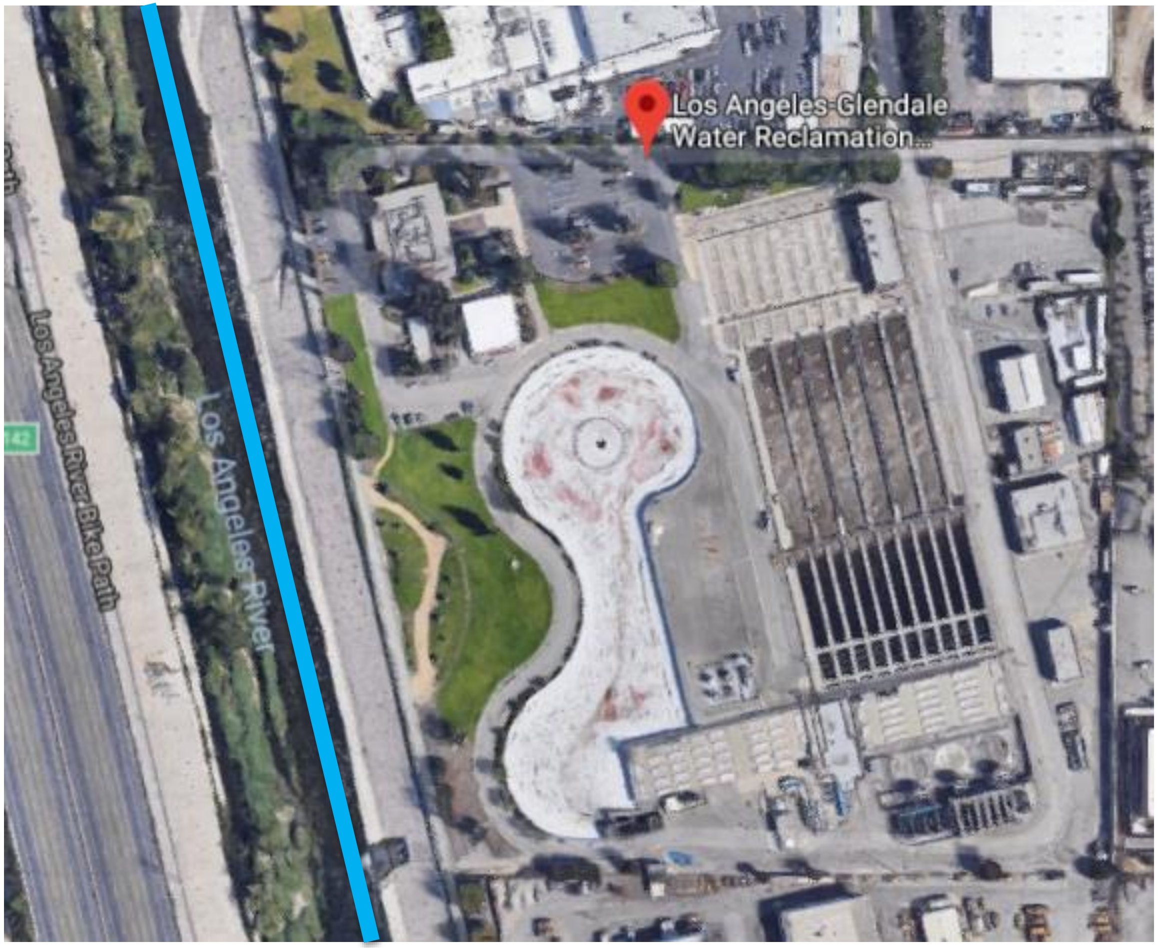
Burbank WRP

1. Barscreens
2. Primary Settling
3. Secondary Biological
4. Secondary Settling
5. Deep-bed Sand Filters
6. Chlorine Contact Tanks
7. Dechlorination
8. Reclaimed Water Pump Station



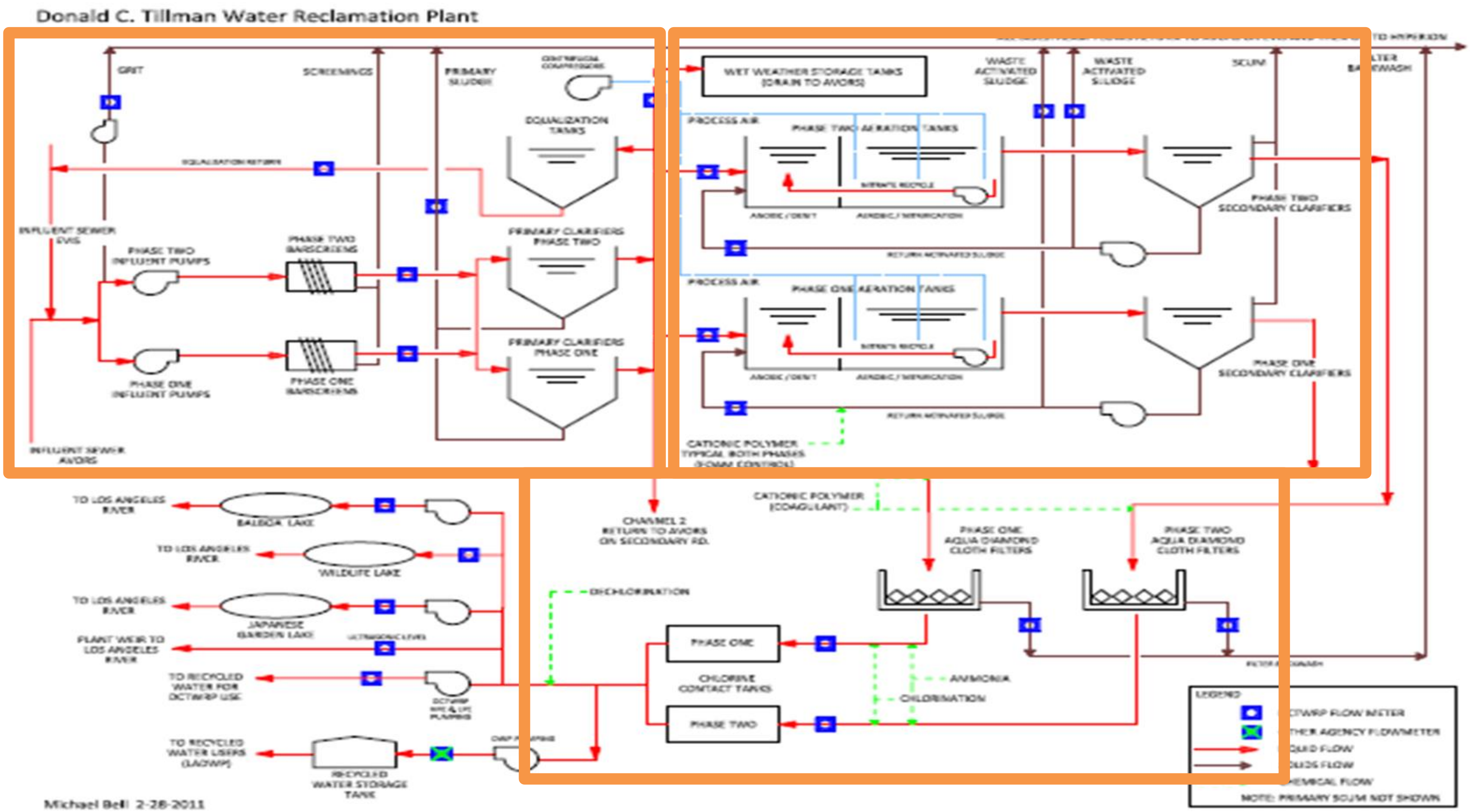
LA-Glendale WRP

1. Barscreens
2. Primary Settling
3. Secondary Biological (Nit/Denit)
4. Secondary Settling
5. Alum addition, Tetra Denite Sand Filters
6. Bleach Addition, Chlorine Contact Tanks
7. Dechlorination (Sodium Bisulfite)
8. Reclaimed Uses or Discharged to LA River

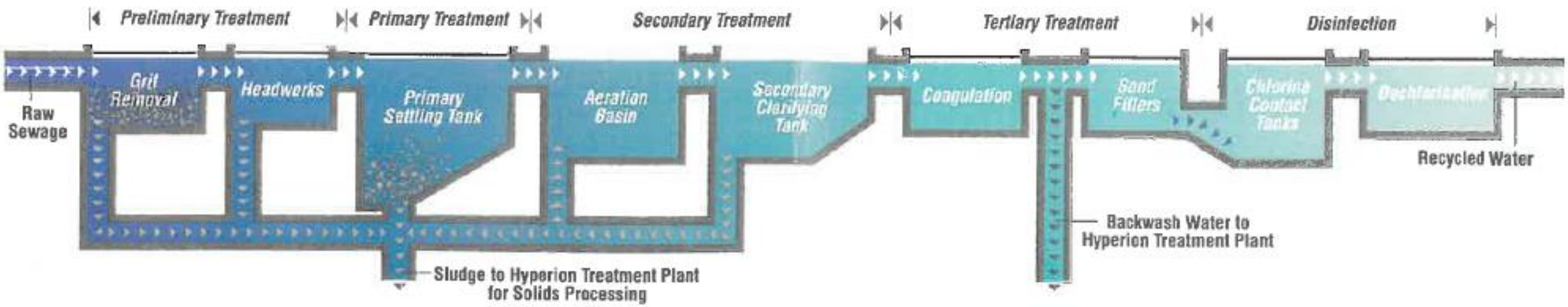


Donald C. Tillman Water Reclamation Plant

Tillman Process Diagram



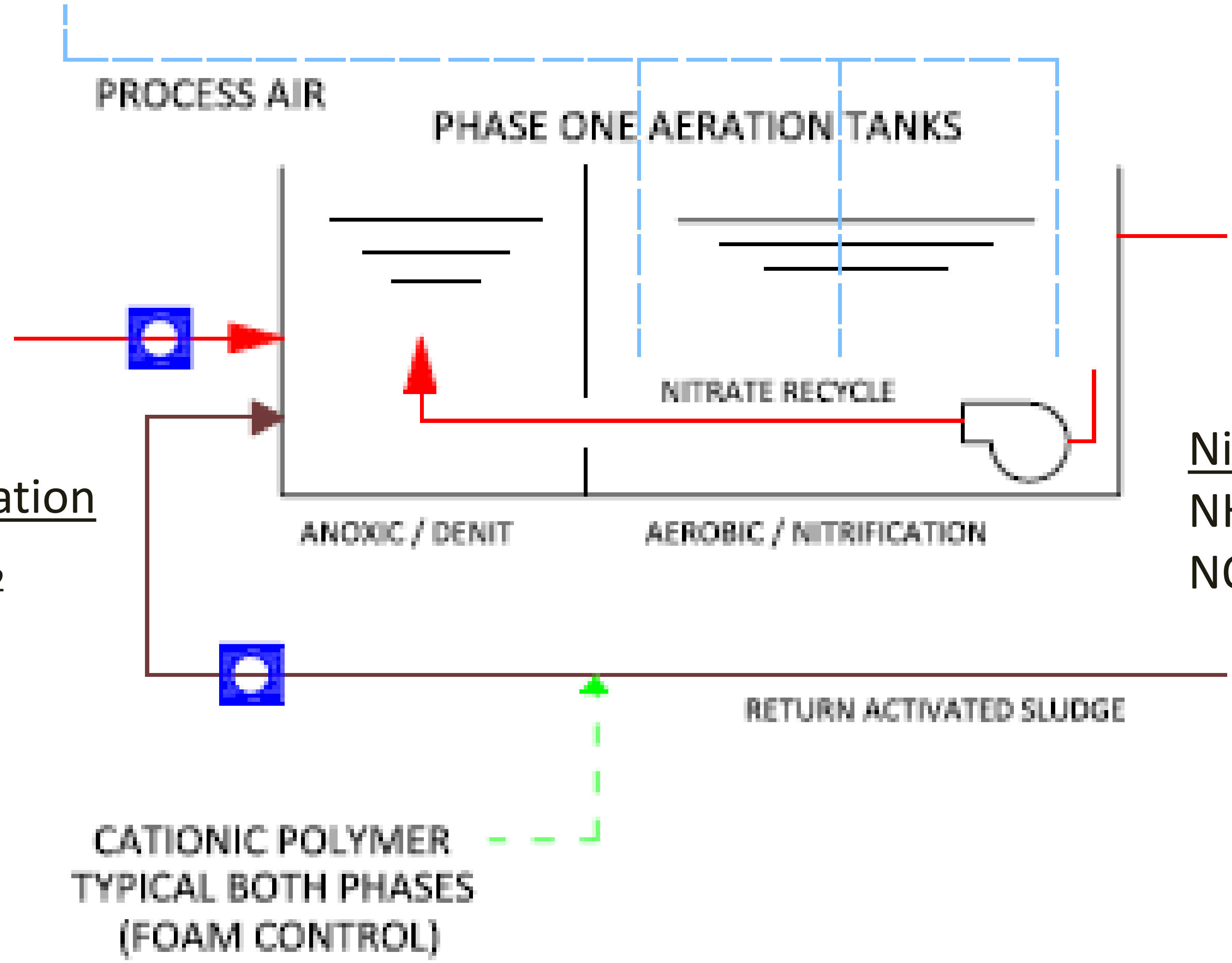
Tillman Process Diagram



Headworks

Primary Sedimentation Tanks

Biological Treatment - Aeration Tanks



Denitrification

$NO_3 \rightarrow N_2$

Nitrification

$NH_4 + O_3 \rightarrow NO_2$

$NO_2 + O_2 \rightarrow NO_3$

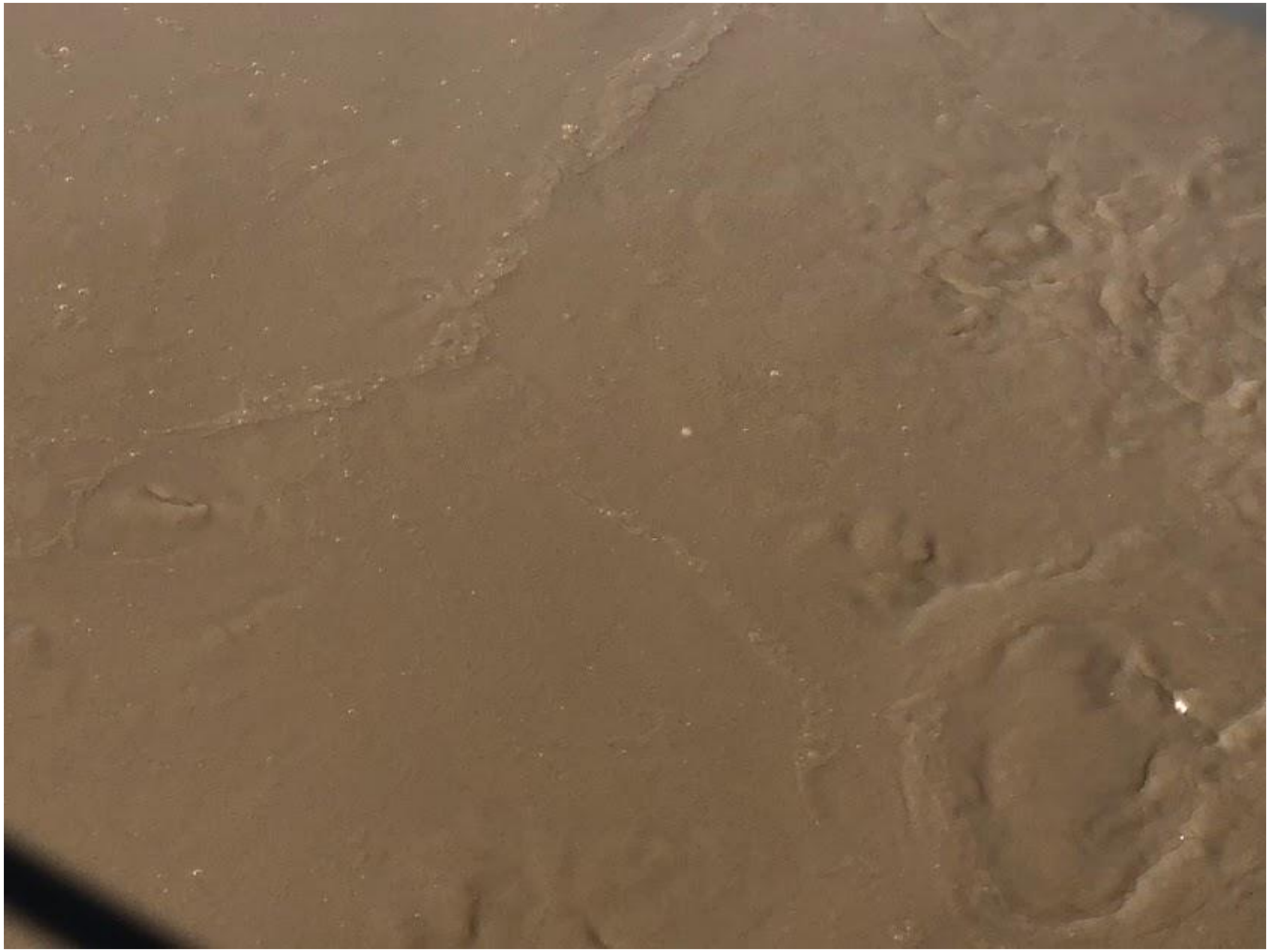
Source #20

Aeration Supply

Aeration Tanks

Denitrification

N2

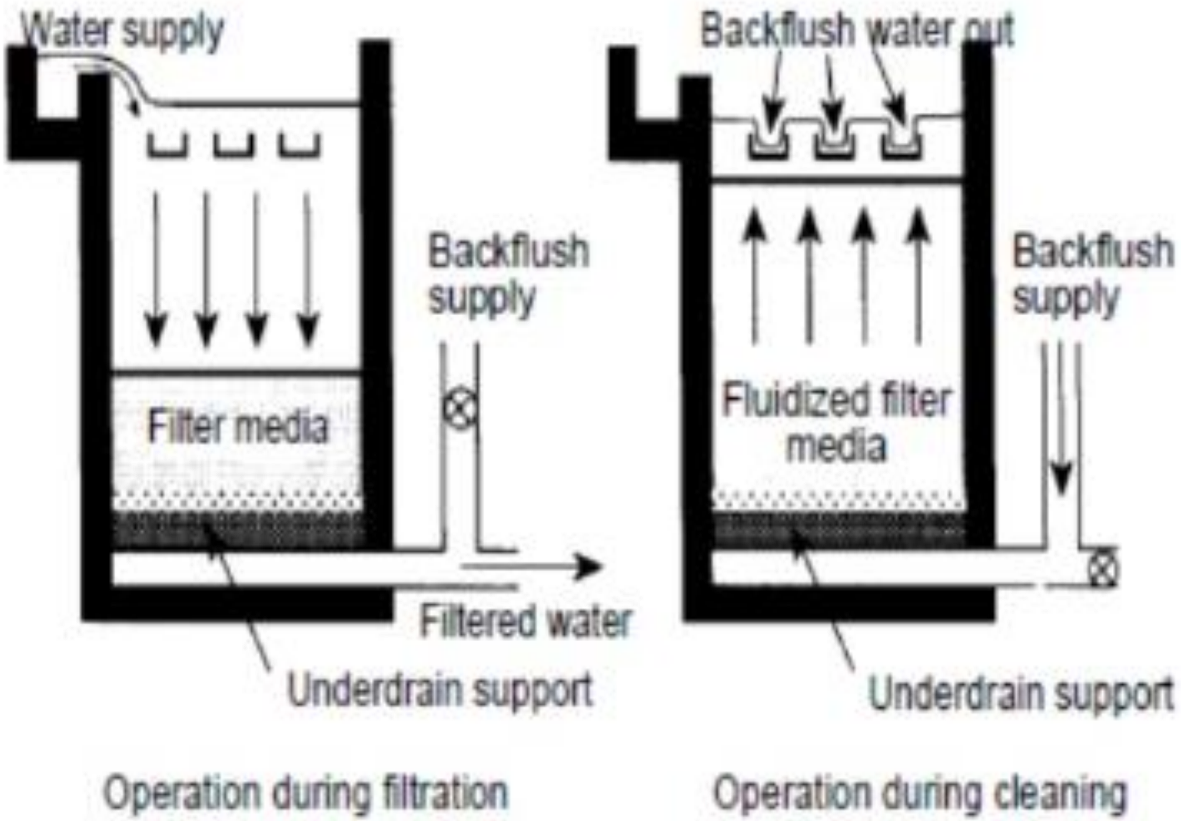


Sludge Handling

RAS is recycled internally, all other solids are sent to Hyperion.

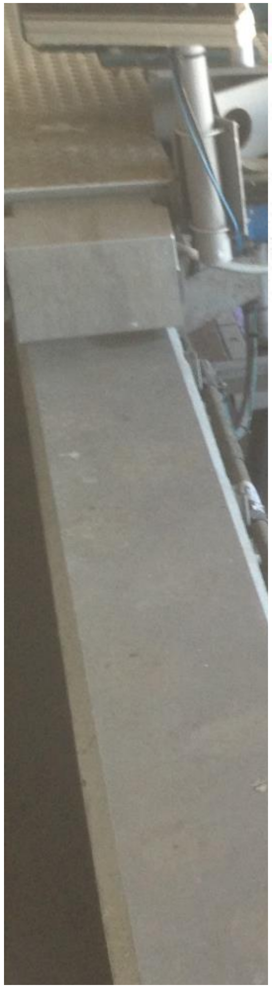
Secondary Sedimentation Tanks

Sand Filter



Source #21

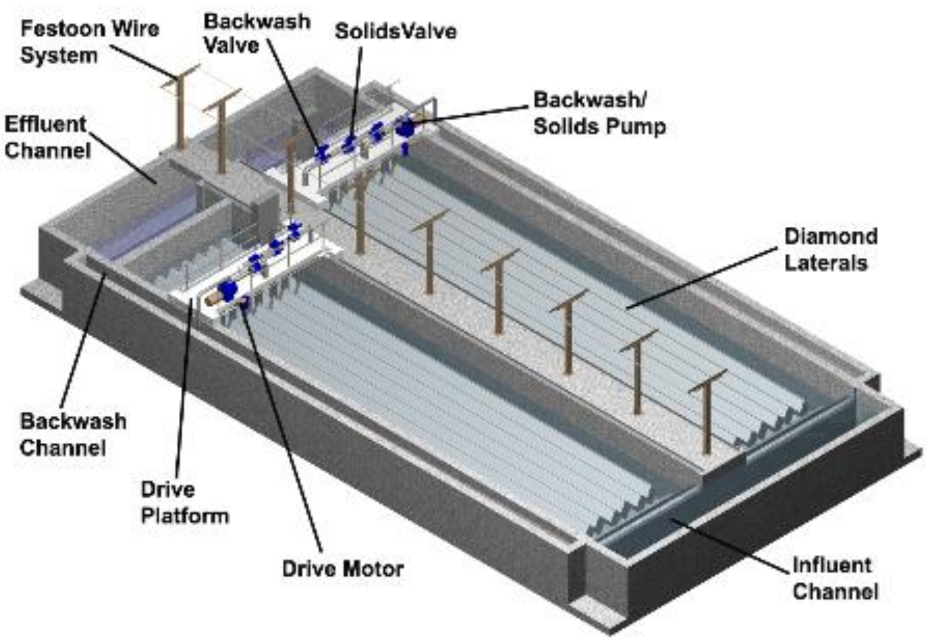
Aqua Diamond Cloth Filtration



AquaDiamond®

Cloth Media Filter with OptiFiber®

The AquaDiamond® cloth media filter is a unique combination of two proven technologies; traveling bridge and cloth media filters. The result is two to three times the flow capacity of a traveling bridge filter within an equivalent footprint, making it ideal for sand filter retrofits.



Source #22

Chlorine Contact Basin

Dechlorination Before Discharge

Recycling/Reuse/Discharge

Options

- Japanese Garden Lake
- Balboa Lake
- Wildlife Lake
- on site uses at plant
- LADWP Valley Power Generating Station
- **108" pipe to LA River**

Regulatory Testing

Emergency Flow Diversion

Detected* Primary Drinking Water Standards Constituents				
Constituent	units	MCL or MRDL[a]	LADWP DW 2014 Range[b]	DCT RW 2014 Range[c]
aluminum	µg/L	1000	<50 - 230	ND - 13.2
arsenic	µg/L	10	<2 - 4	1.03 - 2.73
barium	µg/L	1000	<100 - 112	21.6 - 26.1
bromate	µg/L	10	<1 - 13	
chromium (VI)	µg/L	10	<1 - 3	DNQ
flouride	mg/L	2	0.2 - 1	.56 - 1.02
gross alpha	pCi/L	15	<3 - 5	.356 - 2.49
gross beta	pCi/L	50	<4 - 10	3.3-4.8
nitrate	mg/L	45	<2 -27	23.92 - 34.6
Total N	mg/L	10	<0.4 - 4	0 - 7.81
selenium	µg/L	50	<5 - 6	DNQ - 1.8
tetrachloroethylene	µg/L	5	<0.5 - 1.2	ND
trichloroethylene	µg/L	5	<0.5 - 3.8	ND
turbidity	NTU	0.3	0 - .47	.6 - 3.1
uranium	pCi/L	20	<1 - 5	
chlorine residual	mg/L	4	1.7 - 2.1	
copper	µg/L	TT	90th percentile value= 383	8.45 - 13.1
haa5	µg/L	60	3 - 46	20.4 - 23.0
lead	µg/L	TT	90th percentile value = 9.2	DNQ
total coliform	% pos	5% positive/month	0 - 1.6%	29% in Dec 2013[d]
tthm	µg/L	80	10 - 82	15.5 - 28.6

MRDL - Maximum Residual Disinfectant Level
MCL - Maximum Contaminant Level
TT - treatment technique requirement

ND - Not Detectable
DNQ- Detectable, not quantifiable
* - Detected in drinking water

Source #23

Pilot Study

Advanced Purification and Soil Aquifer Treatment for Groundwater Recharge

LA Groundwater Replenishment Project

Purpose: Reduce the City's dependence on imported water sources by increasing beneficial reuse of the available water supply from DCTWRP and increasing the local groundwater supply available for potable use.

1. Construction of a new advanced water purification facility to provide additional levels of treatment of recycled water generated by the existing DCTWRP facility.

2. Conveyance by existing and new pipelines to transport the purified water from the AWPF to existing spreading grounds.

3. Replenishment by spreading of the purified water to percolate into the San Fernando Basin.

Soil Aquifer Treatment

Advanced Purification Process

<u>Pilot Testing Options</u>

O_3 + SAT

O_3 + BAC + SAT

O_3 + BAC + AOP

MF + RO/CCD + AOP

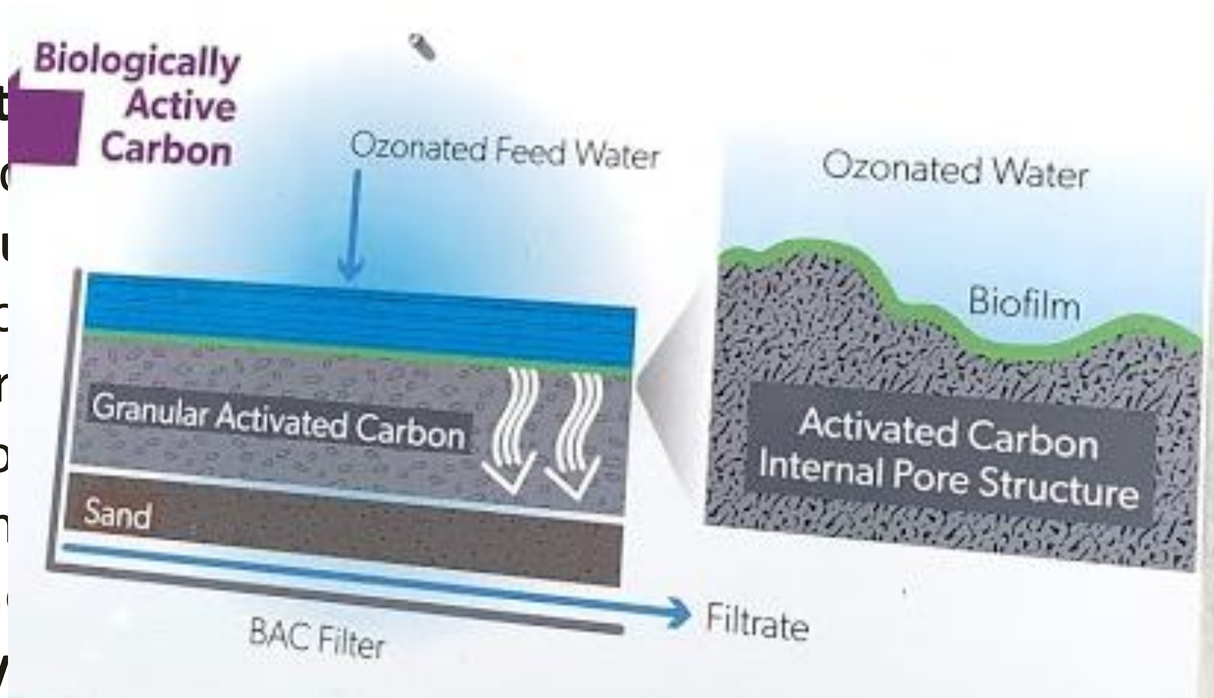
O_3 + MF + RO/CCD + AOP

O_3 + BAC + MF + RO/CCD + AOP

Select the most economical combination which meets WQ goals.

Methods

- **Reverse Osmosis**: Salts, Pharmaceuticals, Viruses, Pesticides, Organics
- **Microfiltrat** … al are being testec
- **Closed Circ** … ni- batch appro … produced (r
- **Ozone**: Stro … contaminan … ore readily rem
- **Biologically** … nant removal. Uses GAC as the filter media and allows indigenous bacteria to grow on the surface. The biofilm consumes OM while the media filters out solids and PM.



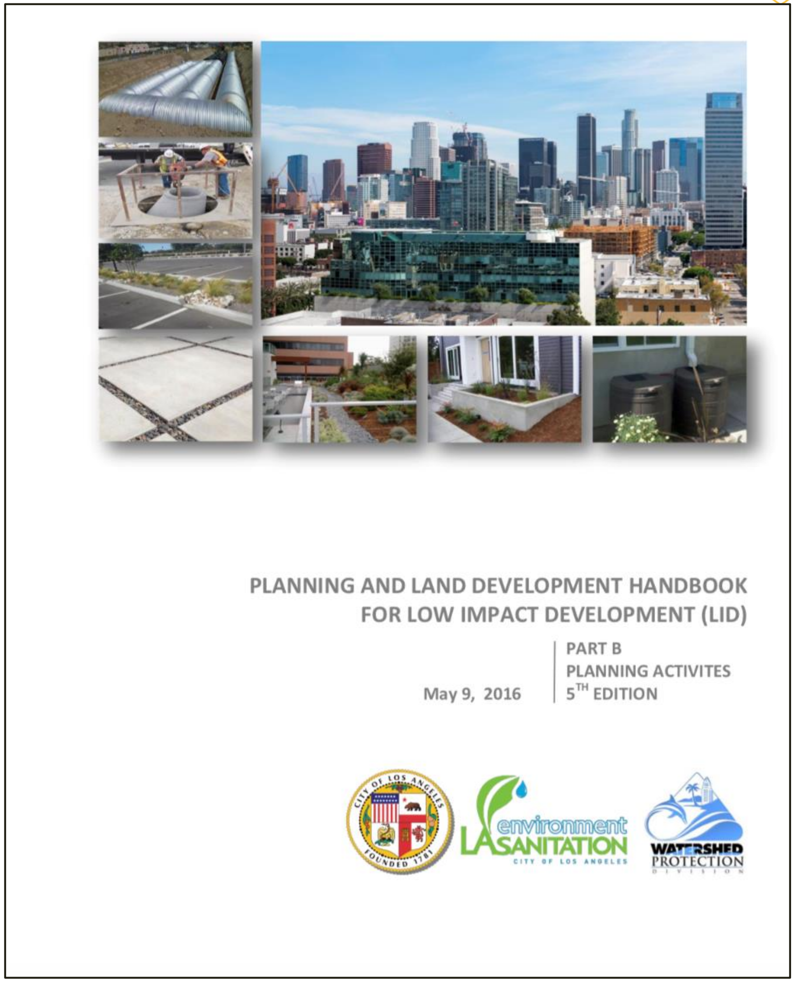
Part 4

Low Impact Development
&
Best Management Practices

LID Ordinance

<u>Adopted</u>: November 14, 2011

<u>Definition</u>: Requires **<u>all</u>** development and redevelopment projects that create, add, or replace **500-sq ft** or more of impervious area to **capture** the **¾-inch rain event** (85th percentile storm) for infiltration or on-site reuse.



Source #3, 23, 24, 25, 26

LID Ordinance – Purpose

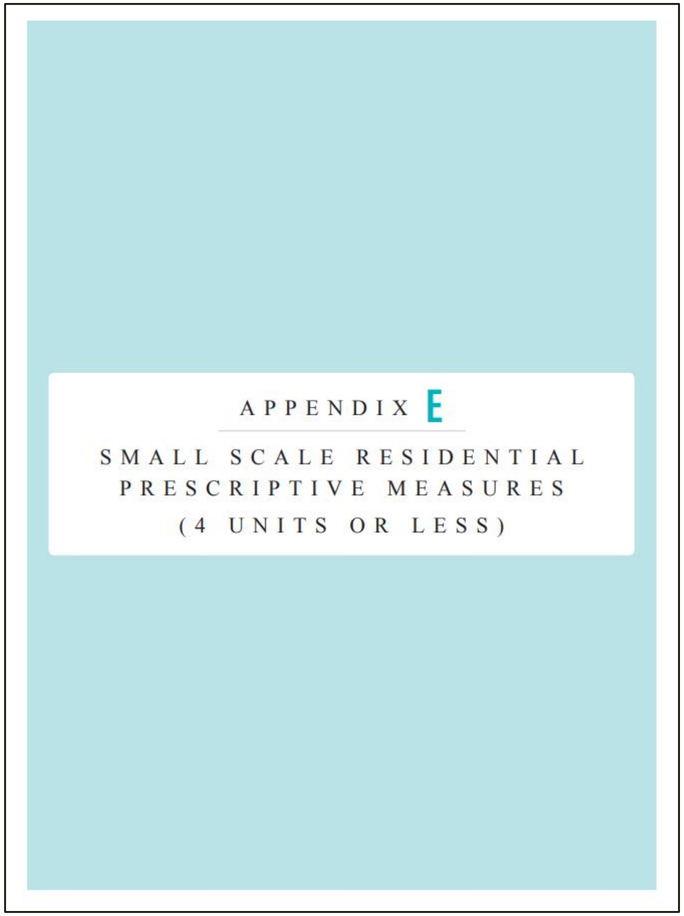
- Encourage the beneficial use of rainwater and urban runoff.
- Reduce stormwater/urban runoff while improving water quality.
- Promote rainwater harvesting.
- Reduce offsite runoff and provide increased groundwater recharge.
- Reduce erosion and hydrologic impacts downstream.
- Enhance the recreational and aesthetic values in our communities.

Source #26, 27

LID Ordinance – Compliance (Residential)

Prescriptive Measures - Appendix E

- Rain Barrels (Small Cisterns)
- Rain Tanks (Cisterns > 130 gal)
- Permeable Pavements (or Porous Pavement Systems)
- Planter Boxes
- Rain Gardens
- Dry Wells


APPENDIX E

SMALL SCALE RESIDENTIAL PRESCRIPTIVE MEASURES (4 UNITS OR LESS)

Source #26, 27, 28

LID Ordinance – Compliance (All Other Developments)

Capture & Manage 100% of Stormwater Quality Design Storm

¾-in, 24-hr rain event **OR** 85th percentile, 24-hr runoff

Infiltration

- Infiltration Trenches
- Infiltration Basins
- Dry Well
- Permeable Pavement
- Underground Detention Chambers

Capture and Use

- Cisterns
- Rain Barrels

City Approved Bio-Filtration/Retention System

Combination

Source #29

Water Quality Benefits

BMPs

- Bioretention
- Detention Basin
- LID
- Media Filter
- Porous Pavement
- Retention Pond
- Wetland Basin

Pollutants

- Solids
  - Total Suspended Solids (TSS)
- Bacteria
  - E. Coli
  - Fecal Coliform
- Metals
  - Arsenic
  - Lead
- Nutrients
  - Total Phosphorus
  - Total Nitrogen

Source #30

Efficiency of LID infrastructure

Efficiency Ratio (ER) is defined in terms of the average Event Mean Concentration (EMC) of pollutants over some time period.

$$ER = \frac{\text{Avg. Inlet EMC} - \text{Avg. Outlet EMC}}{\text{Avg. Inlet EMC}}$$

Efficiency of various BMP's

BMP Type	Solids	Bacteria		Metals		Nutrients	
	TSS	E. Coli	Fecal Coliform	Arsenic	Lead	Phosphorus	Nitrogen
Bioretention	11%	1%			8%	13%	18%
Detention Basin	-6%		-14%	37%	4%	-4%	1%
LID	**53%**						
Media Filter	6%		8%	4%	5%	6%	6%
Porous Pavement	39%			**53%**	**48%**	**41%**	
Retention Pond	-1%	6%	-33%	8%	-3%	2%	-4%
Wetland Basin	1%	1%	7%		3%	4%	-1%

Source #30

Porous Pavement used to capture stormwater on USC campus at The Village

Retention Ponds – Wet Ponds

Advantages

- Benefit human recreation activities, wildlife habitat, open space
- Provide water quality improvements
- Serve tributary area of any size
- Provide change in runoff and in sediment transport

Disadvantages

- Public safety concerns
- Standing waters can promote insect breeding
- Must have base flow to maintain water level
- Potential algae growth issues
- Large footprint is required
- Temperature gradient issues with receiving waters

Open earthen basins in which a permanent pool of water is displaced by stormwater runoff and it designed to temporarily retain runoff and release it slowly over a designed retention period and its primary treatment mechanisms is sedimentation

Maintenance

- Annual inspections
- Inspections after major storm events
- Trash and debris removal
- Prune/remove vegetation that limits water access to the pond
- Re-vegetate the slope as needed
- Remove invasive vegetation
- Remove dead vegetation
- Do not use vegetation control chemicals
- Remove excessive sediment

Removal Efficiency

- TSS - 70%
- TN - 35%
- TP - 45%
- Treats - Cadmium, Chromium, Copper, Zinc
- Does not treat - Total Nitrogen, Lead
- Runoff reduction - 0%

https://webpages.uidaho.edu/larc380/new380/assets/images/StormwaterFiles/images/WetPond.jpg

Retention Pont - Wet Extended Detention Ponds

Advantages

- Simple design
- Inexpensive to build
- Easy to operate
- Could be a part of existing storm drain system
- With appropriate vegetation selection can mitigate adverse effects

Disadvantages

- Temperature gradient issues for the receiving waters
- Adverse effect on the value of nearby properties

https://dpw.lacounty.gov/ldd/lib/fp/Hydrology/Low%20Impact%20Development%20Standards%20Manual.pdf

Permanent basins formed by construction of embankments or excavation to detain runoff and promote settling of sediment particles and its primary treatment mechanism is sedimentation

Maintenance

- Annual inspections
- Inspections after major storm events
- Trash and debris removal
- Prune/remove vegetation that limits water access to the pond
- Re-vegetate the slope as needed
- Remove invasive vegetation
- Remove dead vegetation
- Do not use vegetation control chemicals
- Remove excessive sediment

Removal Efficiency

- TSS - 80%
- TN - 55%
- TP - 68%
- Treats - Copper,
- Does not treat - Total Nitrogen, Lead ,Cadmium, Chromium, Lead, Zinc
- Runoff reduction - 0%

Stormwater Wetland

Advantages

- Treat runoff from large tributary areas
- Provide significant water quality improvements including elimination of nutrients
- Provide substantial wildlife habitat
- Provide passive recreation
- Improves site aesthetics

Disadvantages

- Must have base flow
- Depends upon geomorphology of the tributary area
- “Swampy looking” site concerns
- Public safety concerns
- Insect breeding due to standing waters
- Large footprint required
- High initial cost

Single-stage treatment system requires longer release period than ponds

Maintenance

- Annual inspections
- Inspections after major storm events
- Trash and debris removal (before the wet season)
- Maintain site vegetation for aesthetic appearance
- Prune/remove vegetation that limits water access to the pond
- Re-vegetate the slope as needed
- Remove invasive vegetation
- Remove dead vegetation
- Do not use vegetation control chemicals
- Remove excessive sediment

Removal Efficiency

- TSS - 80%
- TN - 55%
- TP - 45%
- Treats Total Kjeldahl Nitrogen, Cadmium, Chromium, Copper, Lead, Zinc
- Does not treat - Total Nitrogen, Lead ,Cadmium, Chromium, Lead, Zinc
- Runoff reduction - 0%
- Runoff reduction for constructed gravel wetlands - 90%

https://dpw.lacounty.gov/ldd/lib/fp/Hydrology/Low%20Impact%20Development%20Standards%20Manual.pdf

Infiltration Practices – Infiltration Trench

Advantages

- Retains runoff and eliminates pollutants
- Reduces peak runoff flows
- Provides erosion control
- Provides groundwater recharge

Disadvantages

- Not suitable for soils with too low permeability
- Not suitable for soils with too high permeability
- Not suitable for industrial sites
- Not suitable for locations with contaminated soil
- Not suitable for high sediment loads
- May result in insect breeding
- Large footprint required
- Not suitable for sites with high slopes

Single-stage Shallow earthen basin which is designed to retain and infiltrate stormwater runoff and its primary treatment mechanisms are filtration, adsorption, biodegr.adation.

Maintenance

- Trim overgrown vegetation
- Remove invasive, poisonous vegetation
- Remove trash and debris
- Remove any evidence of contamination
- Repair/regrade eroded areas
- Remove sediment, oil, grease when accumulated
- Remove the top layer of the basin bottom if water drainage rate is low

Removal Efficiency

- TSS - 80%
- TN - 60%
- TP - 60%
- Metals – 90%
- Pathogens – 90%
- Runoff reduction - 90%

https://c1.staticflickr.com/5/4084/4949432301_d057faf6bf_b.jpg

Infiltration Practices - Bioswale

Advantages

- Reduces/eliminates stormwater runoff
- Reduces peak discharge of runoff
- Controls soil erosion
- Provides groundwater recharge
- Provides stormwater treatment
- Requires small footprint
- Fits in narrow areas
- Compatible with developed sites
- Does not require base flow

Disadvantages

- Not suitable for soils with too low permeability
- Not suitable for soils with too high permeability
- Not suitable for industrial sites
- Not suitable for locations with contaminated soil
- Not suitable for high sediment loads
- May result in insect breeding
- Large footprint required
- Not suitable for sites with high slopes

Narrow trench which is designed to retain and infiltrate stormwater runoff filled with gravel and sand and its primary treatment mechanisms are filtration, adsorption, biodegradation. It is used for small drainage areas and can store stormwater underground within the void spaces of rocks or stones or percolation tank modules.

Maintenance

- Regular inspection and routine maintenance
- Check for debris/remove and dispose as needed
- Check for sediment buildup and crusting
- Eliminate standing waters
- Inspect overflow devices
- Remove evidences of contamination
- Repair eroded areas

Removal Efficiency

- TSS - 50 - 80%
- TN - 50% (10% if situated less than 75 feet from surface waters)
- TP - 15 - 45%
- Runoff reduction - 90%
- Metals - 65 - 100% (Lead, Zinc)
- Pathogens - 50 - 80%

http://www.asla-sandiego.org/aslasdwp/wp-content/uploads/2014/11/Lid-Manual-_-Infiltration-Trench.jpg

Infiltration Practices – Dry Well

Advantages

- Minimal space to install
- Low installation cost
- Reduces peak discharge during small storm events
- Provide groundwater recharge

Disadvantages

- Not suitable for low permeability soils
- Not suitable for high groundwater levels
- Not suitable for contaminated sites
- Cannot receive untreated runoff (only from rooftops)
- Require complete reconstruction if failes
- Not suitable for steep slope sites

Bored, drilled, or driven shaft with depth greater than the width which is designed to temporarily store and infiltrate stormwater runoff. Its primary treatment mechanisms are filtration, adsorption, biodegradation.

Maintenance

- Regular inspections and routine maintenance
- Remove and dispose trash and debris
- Eliminate standing waters
- Check for sediment buildup and crusting
- Remove any evidence of contamination
- Remove oil and grease

Removal Efficiency

- TSS - 90%
- TN - 55%
- TP - 60%
- Runoff reduction - 90%
- Metals - 65 - 100% (Lead, Zinc)
- Pathogens - 50 - 80%

http://hbteam.org/wp-content/uploads/2013/07/completed-4ft-bs.jpg

Infiltration Practices – Bioretention System

Advantages

- Retains runoff
- Eliminates pollutants
- Conserves water
- Enhances aesthetics
- Provides shades and windbreaks

Disadvantages

- Not suitable for industrial sites with contaminated soils
- Not suitable for sites with sites with high groundwater levels
- Not suitable for unstable underground stratification
- May promote insect breeding

Vegetated shallow depression designed to receive, retain, and infiltrate runoff. Its primary treatment mechanisms: sedimentation, filtration, adsorption, biodegradation.

Maintenance

- Irrigate plants during prolonged dry periods
- Inspect regularly
- Replace soil/ plant material as needed
- Remove weeds
- Select proper soil mix/ optimal plants
- Replace mulch regularly in areas exposed to heavy metals deposition
- Eliminate standing water
- Inspect for debris/ remove regularly
- Repair/replace damaged pipes
- Remove any visual contaminants
- Remove oil and grease

Removal Efficiency

- TSS - 99%
- TN - 65%
- TP - 65%
- Runoff reduction - 80%
- Treats - Chromium, Copper, Zinc, pathogens
- Does not treat - soluble phosphorus, nitrate

http://bluegreenbldg.org/wp-content/uploads/2009/01/oakleycityhall2small.jpg

Infiltration Practices – Tree Box Filter

Advantages

- Enhances aesthetics
- Adapts to street landscapes
- Small footprint
- Ideal for highly-developed sites
- Adapts to site conditions
- Reduces runoff
- Eliminates pollutants

Disadvantages

- Not suitable for industrial sites with contaminated soils
- Require individual owners to perform maintenance
- Require irrigation
- May conflict with water conservation

Pre-cast concrete box with a small tree or shrub planted installed along the edge of parking lot, roadway. Its primary treatment mechanisms: sedimentation, filtration, adsorption, biodegradation.
.

Maintenance

- Irrigate as needed
- Inspect and replace soil as needed
- Inspect for erosion
- Prune tree as needed
- Remove weeds
- Select proper soil mixture
- Analyse soil for fertility and pollutant level
- Excavate and clean if does not drain for more than 96 hours
- Eliminate standing water/ implement Pest Management Practices
- Inspect/ clean underdrain
- Inspect/replace damaged pipes
- Repair structural deficiencies

Removal Efficiency

- TSS - 8%
- TN - 32%
- TP - -25%(negative)
- Nitrates - -100%(negative)
- Treats - total Nitrogen, total Kjeldahl Nitrogen, Chromium, Lead
- Does not treat - Suspended Solids, total Phosphorus, Cadmium, Copper, Zinc, Nitrates
- Runoff reduction - 15%

https://s-media-cache-ak0.pinimg.com/736x/a3/1e/e7/a31ee7f60460c202fe8334097f6b6051.jpg

Infiltration Practices – Sand FIlter

Advantages

- Effective treatment
- Relatively small footprint
- Can be placed underground
- Suitable for almost any soil condition
- Permeable soil not required
- Reduces peak runoff for small storm events

Disadvantages

- Flat surface required
- Does not reduce volume of runoff
- Expensive to construct

Constructed sand bed with underdrain system where water percolates through the sand and then collected by underdrain. Its primary treatment mechanisms: settling filtration, adsorption.

Maintenance

- Regular inspections and routine maintenance
- Remove/dispose trash and debris
- Remove any evidence of contamination
- Trim overgrown vegetation/remove invasive vegetation
- Remove accumulated sediment, oil, grease
- Restore sand bed if drops below 18 inches
- Repair eroded areas
- Add fill material

Removal Efficiency

- TSS - 90% (10% with underdrain)
- TN - 60% (10% if less than 75 feet from surface waters or with underdrain)
- TP - 65% (33% with underdrain)
- Runoff reduction - 0%
- Treats - Cadmium, Chromium, Copper, Lead, Zinc

http://www.richmondregional.org/Planning/images/P1010033.JPG

Infiltration Practices – Permeable Pavement

Advantages

- Reduces runoff during small storm events
- Serves aesthetic and functional purposes
- Reduces heat island effect if light color concrete is used
- Provides dual use for limited spaces
- Reduces need and space for stormwater management

Disadvantages

- Not suitable for contaminated sites
- Not suitable for high transit areas
- Not suitable where heavy trucks or equipment are used
- Development of sacrificial non-infiltrating areas in the transition areas
- Results in uneven driving surfaces
- Could trap high-heeled shoes
- Could be clogged if not situated properly
- High cost of restoration
- Can no longer function properly if clogged

Permeable interlocking concrete pavers - Layer of durable concrete pavers or blocks separated by joints filled with small stones. Its primary treatment mechanisms are filtration and adsorption.

Maintenance

- Inspect for proper infiltration
- Dispose/replace old aggregate as needed
- Sweep regularly
- Do not overlay with impermeable surface
- Prune vegetation
- Remove poisonous, dead, nuisance vegetation
- Prevent spills
- Eliminate standing water
- Fill and compact holes
- Inspect for erosion

Removal Efficiency

- TSS - 90%
- TN - 60% (10% when less than 75 feet from surface water)
- TP - 65%
- Runoff reduction - 75%

http://nacto.org/wp-content/themes/sink_nacto/views/design-guides/retrofit/urban-street-design-guide/images/pervious-pavement/carousel//pervious-pavement-9.jpg

Filtering Practices – Green Roof

Advantages

- Reduces downstream runoff
- No additional space required
- Provide thermal insulation/reduces energy costs
- Protects roof from climatic extremes, UV damage
- Reduces airborne pollutants
- Reduces peak runoff and volume
- Adsorbs air pollution, negates acid rain effects
- Provides habitat for wildlife
- Provides sound insulation
- Reduces urban heat effect

Disadvantages

- Hard to incorporate into existing buildings
- Increases building cost
- Increases retrofit cost
- Requires maintenance, irrigation

Multilayered system of lightweight growth media and special mix of vegetation underlain by root barrier, drainage layer, waterproof membrane designed to retain precipitations within pore space and slowly release via evaporation from soil and transpiration by plants

.

Maintenance

- Inspect waterproof membrane 2-3 times per year
- Inspect soil for erosion
- Keep drain inlets unrestricted
- Remove debris
- Maintain vegetation
- Provide shade during dry season
- Irrigate regularly during dry season
- Prevent spills
- Provide all tenants with operation manuals
- Provide safe access to the roof
- Eliminate standing water

Removal Efficiency

- TSS - 81%
- TN - 32%
- TP - 45%
- Runoff reduction - 50 - 75%

https://www.asla.org/greenroofeducation/img/sidebar_photo1.jpg

Filtering Practices – Stormwater Planter

Advantages

- Low cost when integrated into site landscaping
- Can disconnect downspouts
- Small footprint
- Suitable for parking lots and sites with limited spacing
- Reduces peak flow for small storm events
- Contributes to site aesthetics
- Provide water conservation
- Little maintenance

Disadvantages

- Not suitable for contaminated sites
- Not suitable for steep slopes
- May require irrigation
- May increase building cost due to wall waterproofing

Situated completely within impermeable structure consists of ponding area, mulch layer, planting soil, vegetation, underdrain. Its primarily treatment mechanisms: sedimentation, filtration, adsorption, biodegradation.

Maintenance

- Irrigate plants as needed
- Inspect/ provide unobstructed flow entrance
- Prune vegetation
- Remove debris
- Eliminate standing water
- Inspect /clean underdrain
- Implement Pest Management practices to prevent insect breeding
- Excavate and clean if not drained in 96 hours

Removal Efficiency

- TSS - 81%
- TN - 32%
- TP - 45%
- Runoff reduction - 50 - 75%
- Treats - Chromium, Lead
- Does not treat - Cadmium, Copper, Zinc

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https://s-media-cache-ak0.pinimg.com/originals/f8/de/2c/f8de2c542e23ac7d1265d77b3446ff04.jpg

Filtering Practices – Vegetated Filter

Advantages

- Easy to install
- Reduces peak flow for small storm events
- Contributes to site aesthetics
- Little maintenance

Maintenance

- Inspect for erosion/ damage of vegetation
- Remove sediment as needed
- Remove debris
- Eliminate standing water
- Inspect vegetation for health and density
- Replenish, prune, remove fallen, mow grass
- Remove invasive vegetation and weeds
- Remove trash and visual contamination

Disadvantages

- Not suitable for industrial sites with contaminated soils
- Not suitable for steep slopes
- May erode/ not effective for high flow velocities if vegetation is not properly maintained
- Channelization may occur
- Requires irrigation

Vegetated areas designed to collect and direct sheet flow from adjacent impervious areas. Its Primariy treatment mechanisms: biological and chemical processes, sedimentation, filtration, biodegradation, adsorption.

Removal Efficiency

- TSS - 73%
- TN - 40%
- TP - 45%
- Runoff reduction - 50%
- Treats - Cadmium, Chromium, Lead
- Does not treat - Copper, Zinc, total Kjeldahl Nitrogen

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http://www.balticdeal.eu/wp-content/uploads/2011/08/filter_strip.jpg

Filtering Practices – Vegetated Swale

Advantages

- Low installation cost
- Suitable for parking lots and limited space areas
- Reduces peak flow during small storm events
- Contributes to site aesthetics
- Little maintenance

Disadvantages

- Not suitable for contaminated sites
- Not suitable for steep sloped sites
- Not suitable if curb-and-gutter system is required
- Not effective / may erode at high flow velocities
- Channelization may occur
- Requires irrigation

Open, shallow channels with low-lying vegetation. Its Primary treatments mechanisms: settling, filtration, adsorption, biodegradation.

Maintenance

- Inspect for erosion/ damage of vegetation
- Remove sediment as needed
- Remove debris
- Eliminate standing water
- Inspect vegetation for health and density
- Replenish, prune, remove fallen, mow grass
- Remove invasive vegetation and weeds
- Remove trash and visual contamination

Removal Efficiency

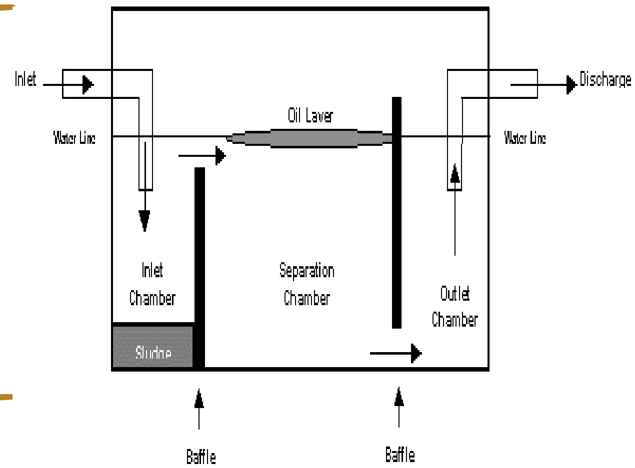
- TSS - 65%
- TN - 20%
- TP - 25%
- Runoff reduction - 60%

http://www.missionengineersinc.com/mediac/400_0/media/DIR_123/DIR_20601/groceryoutlet2.jpg

Pre-Treatment Practices – Oil and Grit Separator

Advantages

- Underground location
- Size of a lot is not deterrent
- Soil type is not deterrent
- Slope of the terrain is not deterrent
- Low risks to public safety



Maintenance

- Inspect unit after every major storm event and at least monthly
- Clean unit twice a year

Disadvantages

- Low removal efficiency
- Does not effectively removes soluble pollutant
- Does not effectively remove fine particles
- Does not effectively remove bacteria
- Susceptible to flushing during large storm events
- Construction and maintenance cost

Removal Efficiency

- TSS - 25%
- O & G - 61%

Multi-chambered structures designed to remove coarse sediment and oils from stormwater, screens trash and debris detains stormwater for short period of time.

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http://infohouse.p2ric.org/ref/07/images/page2.gif

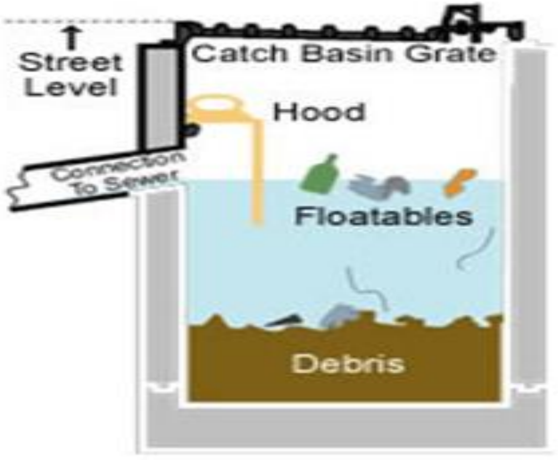
Pre-Treatment Practices – Catch Basin

Advantages

- Improves aesthetics and quality of receiving water body

Disadvantages

- Poor pollutants removal
- Requires maintenance



Maintenance

- Inspect unit annually
- Clean unit periodically
- Collect and dispose debris

Removal Efficiency

- TSS - 15%
- TN - 5%
- TP - 5%

Chambers or sumps built at the curb to traps sediment, trash and debris.

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https://www.epa.gov/sites/production/files/2016-03/catch-basin-hood.png

City of Los Angeles Projects

CLEAN STREETS LA

LA DWP Los Angeles Department of Water & Power

City of Los Angeles Founded 1781

LA Sanitation environment CITY OF LOS ANGELES

Source #31

Broadway Neighborhood Greenway Project

Pilot project in South Los Angeles

Various types of stormwater infiltration BMPs

Broadway Neighborhood Greenway Project

4 BMP Types

- Residential Rain Gardens/Infiltration Trenches
- Residential Street End Infiltration – Drywells
- Commercial Green Streets
- Sub-regional Infiltration Galley

Source #33

Green Streets – Avalon Green Alley

Avalon Alley (Before)

Green Streets works to develop and implement new and sustainable solutions for managing storm water.

- Utilizes permeable materials and drought tolerant plants
- Captures, cleans and/or infiltrates rain water

Green Streets - Avalon Green Alley

Avalon Alley (After)

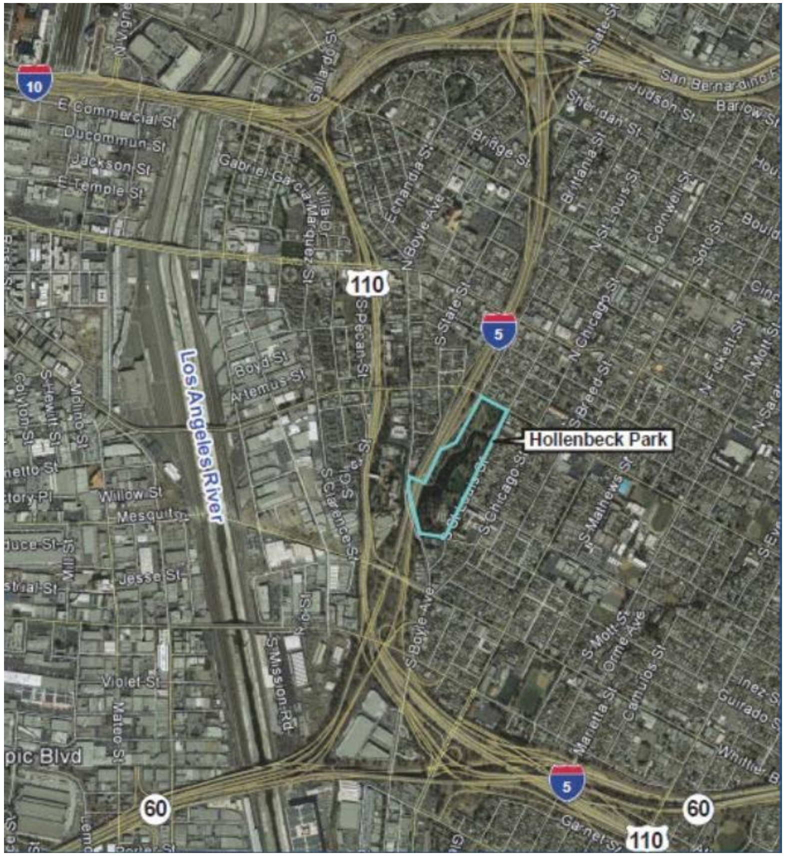
- Improve City alleys with **permeable pavers** to infiltrate storm water runoff.
- Light colored paving to reduce heat island effect.
- Cross walk striping, lights, and signage to **encourage pedestrian use** and **increase workability**.
- Native and drought tolerant planting to help green and **beautify the neighborhood**.

Source #34, 35

Hollenbeck Park Lake Rehabilitation and Stormwater Management Project

<u>Objectives</u>:

- Improve water quality and control algae.
- Contribute to water quality improvement and TMDL compliance in the LA River watershed.
- Replace potable water use with LA River dry/wet weather flow diversion and recycled water.
- Provide a long-term solution to erosion.
- Restore the park's appearance and function for aesthetic and recreational public uses for the community.



Source #36, 37

Shoreline Wetland Treatment System

Process: Shoreline wetlands planted with emergent species along the lake's littoral edge receiving water treated through an anaerobic subsurface gravel filled chamber below the sidewalk.

Benefits:

- Nitrogen and phosphorus removal
- Passive algal control
- Improves shoreline by preventing erosion and bank subsidence

Source #38, 39

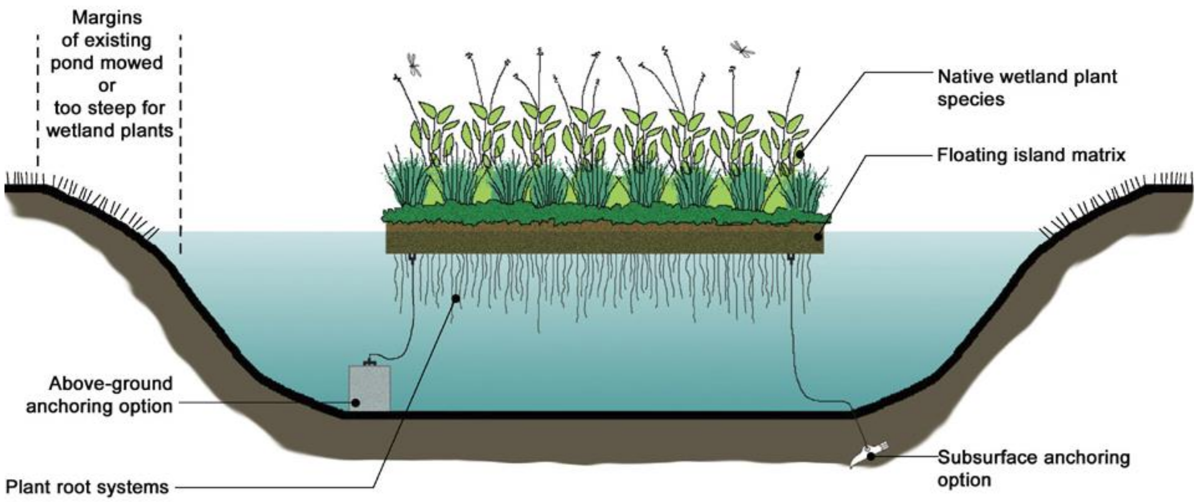
Innovative BMPs

- Floating Wetlands
- Stream Buffer
- Water Hyacinth

Floating Wetlands

New natural treatment technology used for improvement of water quality in lakes within an urban setting.

- Planted with wetland species, which ultimately grow up and through buoyant media.
- The plants produce large root mats that hang suspended in the water.
- Water taken up by the plants is treated as it passes through the root zone.



Source #40

Case Study - Australia

Remove pollutants from stormwater discharged into a storage basin. The plant roots provide large surface areas for biofilm growth, which serves to trap suspended particles and enable the biological uptake of nutrients.

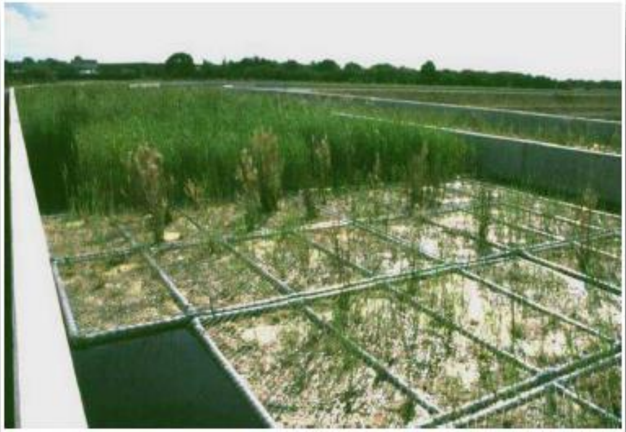
Result: Sampling location and influent pollutant loads are extremely important and can significantly influence the results of performance and efficacy measurements of FW systems.

Source #41, 42, 43

Case Study – Heathrow Airport

Floating wetlands have been tried at Heathrow Airport since 1994 for the treatment of stormwater runoff containing glycol derived from de-icing compounds. The main purpose of this system was for the removal of glycol and associated BOD.

Full-scale floating treatment wetland system for removal of glycol from de-icing water at Heathrow Airport, UK.



Application of Floating Wetlands for Enhanced Stormwater Treatment: A Review by Auckland Regional Council November 2006

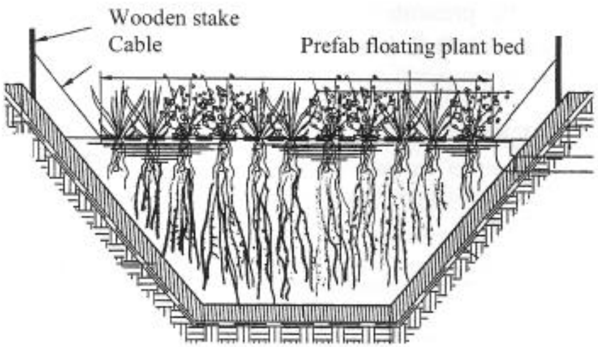
Case Study - Belgium

Treatment of Combined Sewer Overflows

Van Acker et al. (2005) describe systems employed in Belgium by Aquafin for treatment of combined sewer overflows (Figure 10). This system is designed to deal with the variable, event-driven nature of combined sewer overflows and therefore has some structural and design elements that are of interest.

Floating wetland rafts treating for combined sewer overflows at Bornem in Belgium (Photo C.C. Tanner October 2005).

Cross section of a floating wetland treatment system for treatment of periodic wastewater discharges from combined sewer overflows in Belgium.

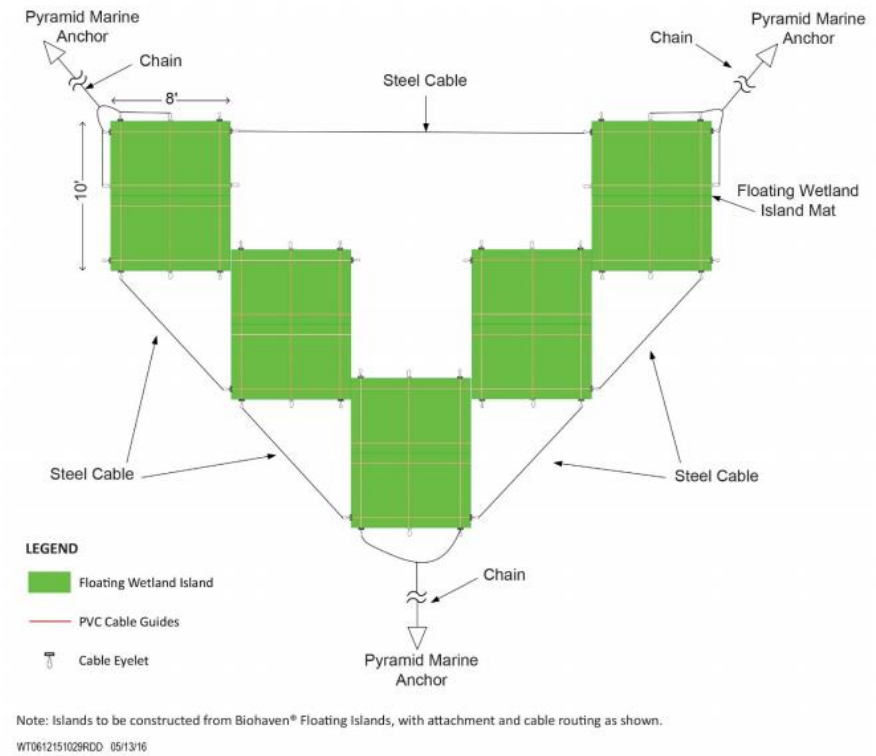


Case Study – River in India

Professor Billore of Vikram University in Ujjain, India is currently conducting a research project into the use of floating wetlands to restore water quality to the holy River Kshipra. To date, a 200 m2 of floating wetlands have been installed in the least turbulent part of the River Kshipra as a demonstration model in the following figures. The floating rafts are constructed locally using low-cost materials such as bamboo. This project is the first innovation of this kind in India. No data has been published to date on the treatment performance of this system.

Demonstration floating wetland installed on the River Kshipra in India.

Case Study in LA - Hollenbeck Park Lake



<u>Process</u>: Floating islands made of recycled plastic foam and soil media planted with wetland species to assimilate nutrients and provide structure for microbial communities.

Benefits

- 20% Nitrogen and 10% Phosphorus removal
- Passive algal control
- Enhanced solids settling

Application of Floating Wetlands in LA River

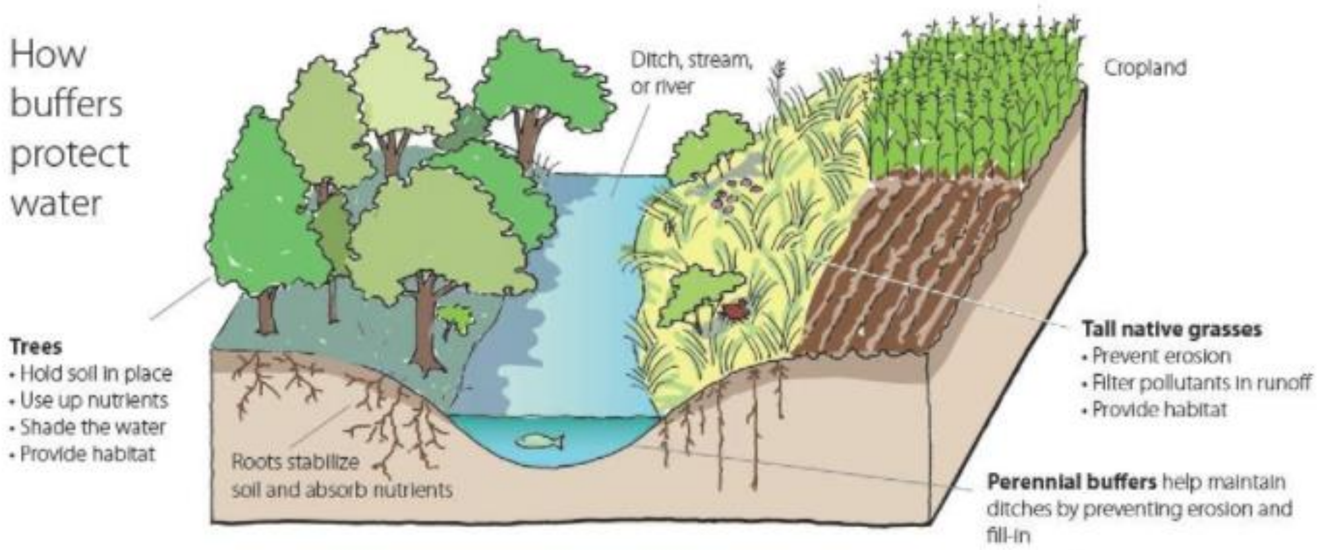
- Using native plants typically require less water and manpower to maintain
  - 5% of original LA River wetlands and river landscapes remain
- Plant Alternatives
  - One-Sided Blue Grass (Native Grass)
  - Typical Wetland Plants and Wildflowers
  - Vetiver Grass (Australia)

Source #51, 52

Stream Buffer Ordinance

Riparian Stream Buffer = an area running parallel alongside both sides of a stream, river, pond, or lake in which disturbance of land or vegetation is restricted in order to protect the health of the stream and enhance water quality.

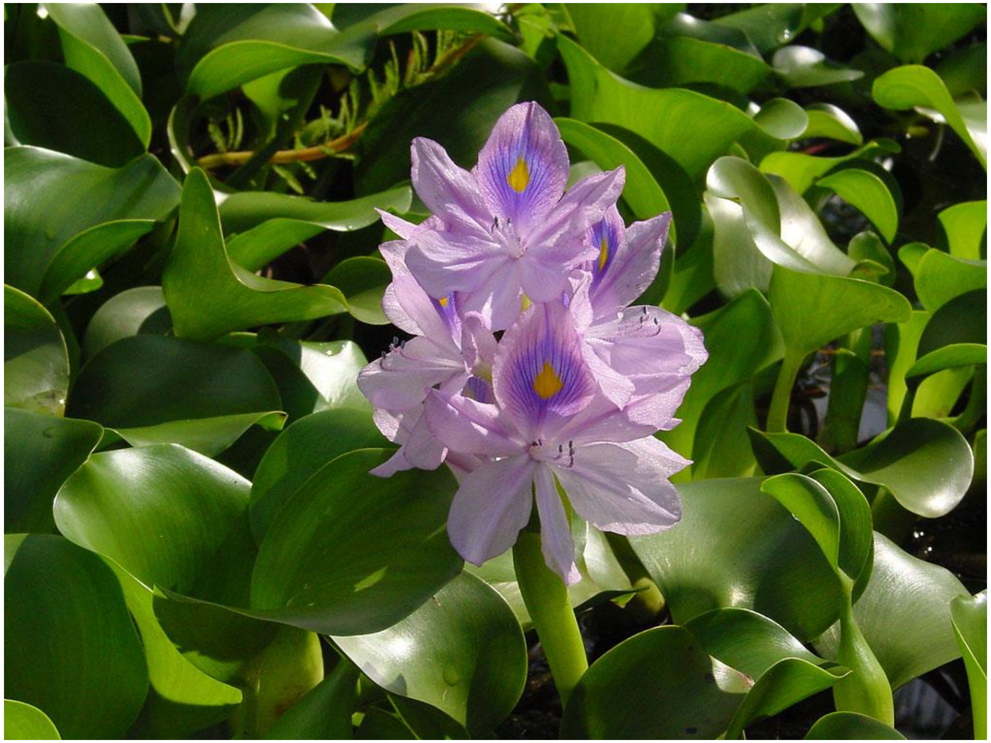
- Stream buffers help to filter pollution out of runoff as it enters the stream.



Source #51, 52

Water Hyacinth

- Researchers discovered that water hyacinths **thrive on sewage** by absorbing and digesting nutrients and minerals from wastewater.
- The optimum growth rate of water hyacinth has great effect on waste water purification efficiency in continuous system and nutrient removal has been successfully achieved.



Water Hyacinth
San Pasqual Aquatic Reclamation Facility

- San Diego built a 1 MGD plant for service in 1984 using water hyacinths in a hybrid aquatic plant/microbial filter.
- Treat wastewater high in sulfate without the development of odors of insect nuisances.

Criteria of Plant Species Selection

- Tolerant of varied moisture conditions (wet and dry)
- Tolerant varied soil types and growing conditions
- Availability in plant nurseries
- Low maintenance requirements
- Not invasive weeds
- Not aggressive/invasive root systems
- Exhibit an attractive appearance

Leymus condensatus 'Canyon Prince': This selection grows to 3' and is tolerant of a wide range of conditions, including drought, seasonal wet conditions, poor soils and some shade.

Achillea millefolium: A native perennial that attracts polinators and is tolerant of poor soils, seasonal flooding and deer. Available in many flower colors.

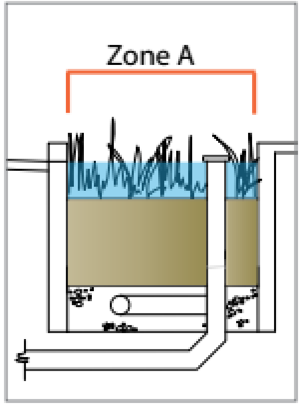
Juncus patens: An easy to grow native rush. It tolerates poor drainage, flooding, drought and shade. A strong performer in bioretention areas, more drought tolerant than J. effusus.

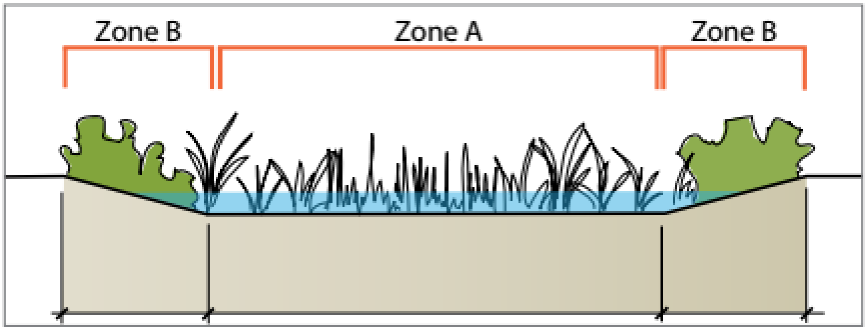
Muhlenbergia rigens: A native grass with dense bright, grey-green, evergreen foliage. It tolerates a range of soils, sun to part-shade, seasonal flooding and drought.

https://www.casqa.org/sites/default/files/downloads/central_coast_bioretention_plant_guidance_print.pdf

LID Plant Guidance for Bioretention

- Factors to consider:
  - → Surface grade
  - → Ponding area
- All plants have the same conditions (Zone A)
- Sloped Soil Surface, resulting in differing planting conditions across the structure (Zones A and B)
- If not A and B, can be treated as a traditional landscape area





https://www.casqa.org/sites/default/files/downloads/central_coast_bioretention_plant_guidance_print.pdf

Plants for Bioretention Areas

Local drought-tolerant plants for bioretention

Common Name	Scientific Name	Zone(s)	Height/ Width	Light	Notes:	Climate Zones[2]
Trees						
Western Redbud	*Cercis occidentalis*	B	20'/20'	sun	small tree or large shrub, tolerates clay, winter wet, drought, flowers stronger with frost	all but coastal
Desert Willow	*Chilopsis linearis*	B	25'/30'	sun	tolerates alkaline soil, sand, clay, seasonal flooding and drought, not coastal condition	all, but 1A-3A
Western Sycamore	*Platanus racemosa*	B	40'-80'/40'-70'	sun	tolerates sand and clay soils, seasonal flooding, needs space to grow, avoid underground water/sewer pipes	all, but 1A-3A
Coast Live Oak	*Quercus agrifolia*	B	25'-60'/40'-70'	sun - shade	tolerates drought and winter wet conditions, mature trees produce significant litter limiting understory plantings, need space to grow	all, but 1A-3A
Large Shrubs						
Toyon, Christmas Berry	*Heteromeles arbutifolia*	B	8'-20'/8'-20'	sun-pt shade	tolerates sand, clay and serpentine soils, seasonal water with good drainage	all, but 1A-3A
Pacific Wax Myrtle	*Myrica californica*	B	10'-30'/10'-30'	sun-pt shade	large shrub or small tree, tolerates coastal conditions, sand, clay and seasonal inundation	all, but 1A-3A
Western Elderberry	*Sambucus mexicana*	B	10'-30'/8'-20'	sun-pt shade	large shrub to tree, tolerates clay, seasonal flooding and drought, good wildlife food source	all, but 1A-3A
Shrubs and Subshrubs						
Coyote Brush	*Baccharis pilularis*	B	wide variation	sun	adaptable evergreen shrub, provides quick cover and bank stabilization, tolerant of coastal conditions, alkaline soil, sand, clay and seasonal wet	all, but 1A-3A
California Wild Rose	*Rosa californica*	A,B	3'-6'/spreads	sun-pt shade	tolerates a wide variety of soils, seasonal flooding and some drought, spreads aggresively, avoid edges of walkways because of thorns	all
Perennials						
Yarrow	*Achillea millefolium*	B	1'-3'/2'	sun-pt shade	tolerates alkaline soil, sand, clay, seasonal wet conditions, foot traffic and deer, will self sow	all
Beach Strawberry	*Fragaria chiloensis*	B	2-4"/spreads	sun-pt shade	vigorous spreading groundcover, tolerates sand, clay, wet conditions, prefers good drainage	all, but 1A-3A
Douglas Iris	*Iris douglasiana*	B	1.5'-3'/spreads	sun - shade	tolerates sand, clay and serpentine soils, seasonal wet (but not soggy) soils and drought	all, but 1A-3A
Hummingbird Sage	*Salvia spathacea*	B	1'-3'/4'-5'	pt sun-pt shade	low growing perennial, tolerates clay, winter wet, summer drought, prefers light shade, provides nectar for birds and insects, does well under oaks	all, but 1A-3A
Bog Sage	*Salvia uliginosa**	B	3'-6'/spreads	sun	quick growing, spreading perennial, tolerates wet to dry, cut back winter, divide rhizomes	all, but 1A-3A
Blue-eyed Grass	*Sisyrinchium bellum*	B	6"-1'/6"-1'	sun	a semi-evergreen perennial, tolerates sand, clay, seasonal wet soils and deer, dormant in summer, but can be delayed with supplemental irrigation	all, but 1A-3A
California Goldenrod	*Solidago californica*	B	1'-4'/1'-4'	sun-pt shade	tolerates poor soils, seasonal wet and drought, can spread aggressively if over irrigated	all, but 24
Grasses and Grass-like Plants						
Berkeley Sedge, Grey Sedge	*Carex divulsa**	A,B	12"-18"/12"-18"	sun-pt shade	tolerates foot traffic, some drought and boggy soils	all, but 1A-3A
California Meadow Sedge	*Carex pansa*	A,B	6"-12"/spreads	sun - shade	good lawn substitute, tolerates wide range of growing conditions, seasonal inundation, drought, foot traffic and mowing	all, but 1A-3A
Clustered Field Sedge	*Carex praegracilis*	A	1'/spreads	sun-pt shade	useful lawn substitute and bank stabilizer, good planted in masses, tolerates wide range of growing conditions, foot traffic and mowing, may look weedy when mixed with other plants	all, but 1A-3A
San Diego Sedge	*Carex spissa*	A	3'-6'/2'-5'	pt sun-shade	a large grass, tolerates alkaline soil, clay, serpentine, seasonal inundation, and deer	all, but 1A-3A
Small Cape Rush	*Chondropetalum tectorum**	A,B	2'-3'/3'-4'	sun-pt shade	A tough, attractive reed-like plant, tolerates boggy or clay soils and drought once established, Chondropetalum elephantinum is a much larger species	all, but 1A, 2A, 3A, 7
Molate Red Fescue	*Festuca rubra 'Molate'*	A,B	8"-12" /spreads	pt sun-shade	a tufted, spreading bunchgrass, good lawn substitute, provides erosion control, tolerates wet conditions, but looks best with regular water, tolerates drought once established	all
Soft Rush	*Juncus effusus*	A	2'-3'/2'-3'	sun-pt shade	tolerates poor drainage, heavy soils, needs more supplemental water than Juncus patens	all
Wire Grass, Blue Rush	*Juncus patens*	A	1'-2'/1'-2'	sun - shade	strong performance in bioretention ares, tolerates poor drainage, seasonal inundation, drought, shade	all, but 1A-3A
Canyon Prince Wild Rye	*Leymus condensatus 'Canyon Prince'*	B	2'-3'/spreads	sun-pt shade	tolerates drought, wet, but not soggy soils, looks best with supplemental irrigation, spreads by rhizomes	all, but 1A-3A
Deer Grass	*Muhlenbergia rigens*	B	4'-5'/4'-6'	sun-pt shade	a large grass, tolerates sandy and clay soils, seasonal inundation, best when cut back annually to remove old thatch	all, but 1A-3A

[1] See: **www.centralcoastlidi.org** for a photo gallery of the plants in this list.
[2] Refers to Sunset Western Garden Book Climate Zones. The Central Coast includes Zones 1A, 2A, 3A, 7, 9, and 14-24. www.sunset.com/garden/climate-zones
* Indicates non native species. Non natives are only recommended for use in urbanized settings and should not be used on sites in proximity to natura areas.

Note: Fertilizer, Synthetic herbicides and pesticides should not be used in bioretention areas because of their potential toxicity risk to aquatic organisms

https://www.casqa.org/sites/default/files/downloads/central_coast_bioretention_plant_guidance_print.pdf

Constraints

Footprint

- Water Hyacinths requires a large surface area
- Floating Wetlands requires a good depth of water (which the LA River doesn't always have)

Maintenance

- Water Hyacinths (if not properly maintained) has odors and insect nuisances

Costs

- Water Hyacinths have required additional equipment costs, which could lead to rising treatment costs than what was initially intended

Lifecycle Benefits

- At the Broadway Neighborhood Greenway Project, the infiltrated water counts as withdrawal credit for the City (may be costly/need by the City)
- Conservation reduces flows to river

Source #60

Assumptions

Most studies/articles, such as the UCLA Study, assume LID as a widespread component in their planning models.

- Only 1% of the City of LA has incorporated LID
- Models are limited to their assumptions that may or may not be true in the future
- Unable to draw the conclusion that LID would help us meet all water quality regulations in the future

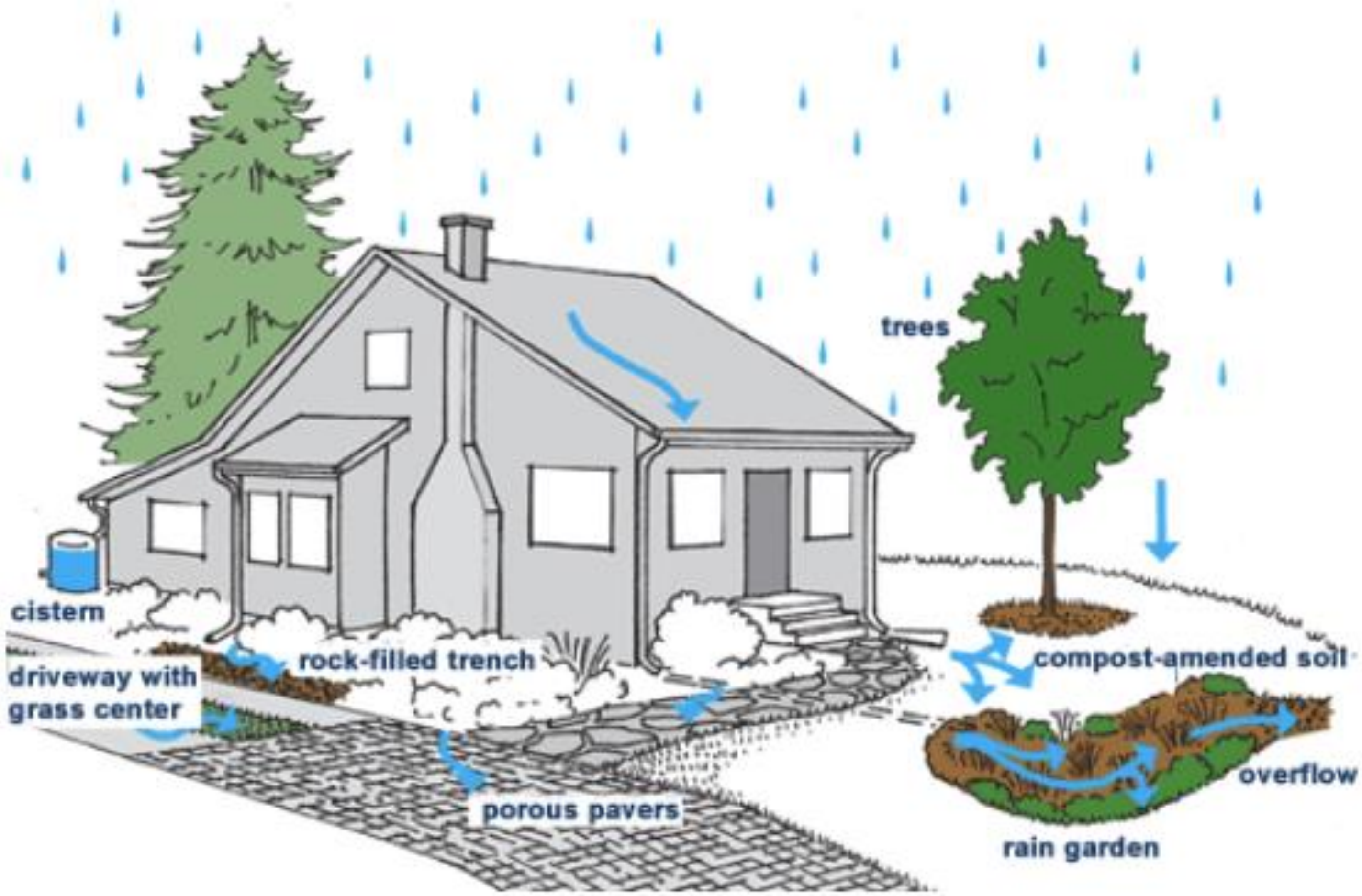
Source #3

Is LID Good or Bad?

In summary, we have found that:

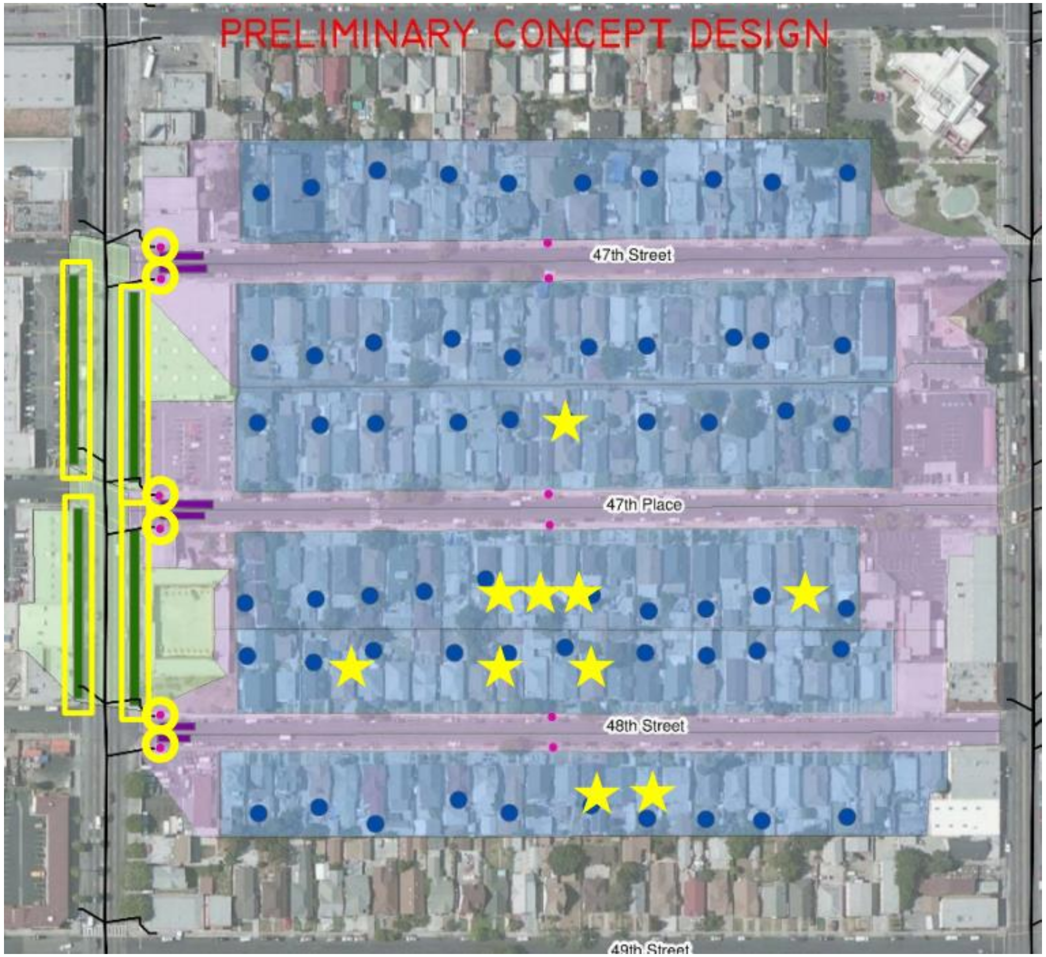
- LID is a great step towards efforts to improve LA River water quality
  - However, it is an effort that must be implemented ALL OVER Los Angeles in order to be successful
- We recommend City-Wide regulations requiring LID implementation
  - However, it will take several years to implement

How Can LID Be Effective?



Source #61

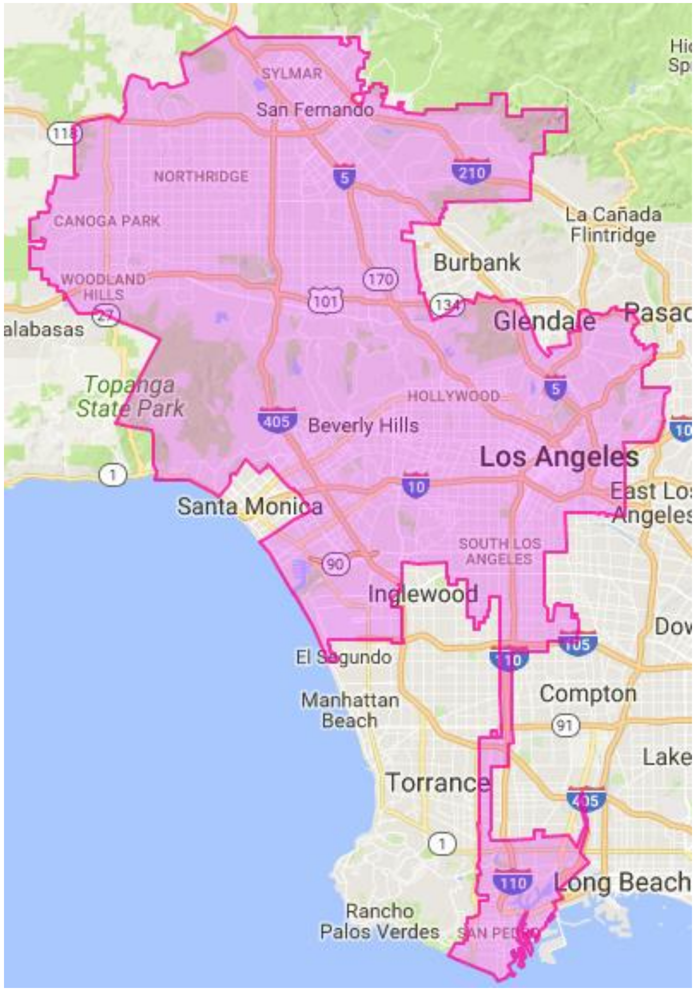
How Can LID Be Effective?



Broadway Neighborhood Greenway Project

How Can LID Be Effective?

Must be widespread



City of LA

Part 4

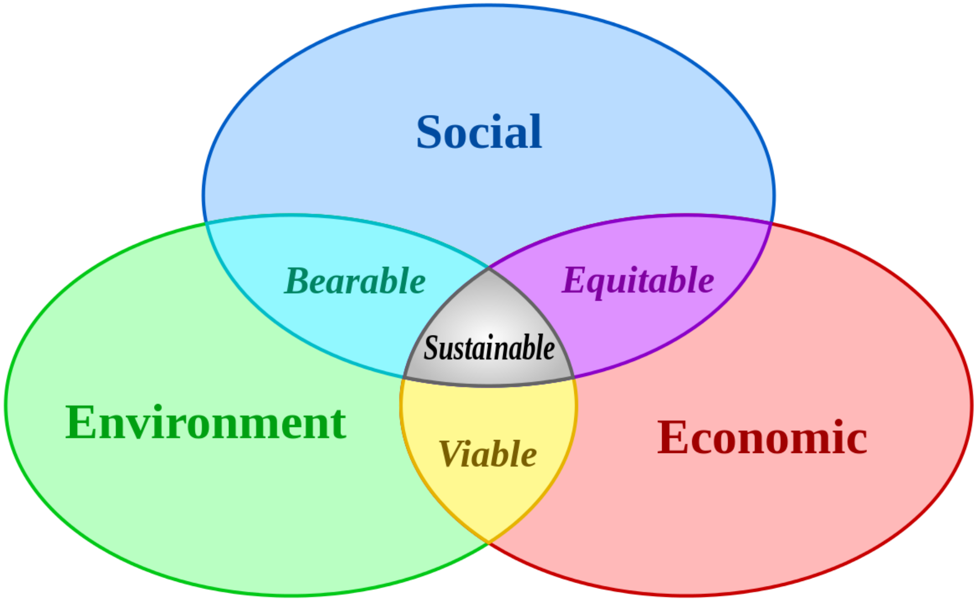
Sustainability

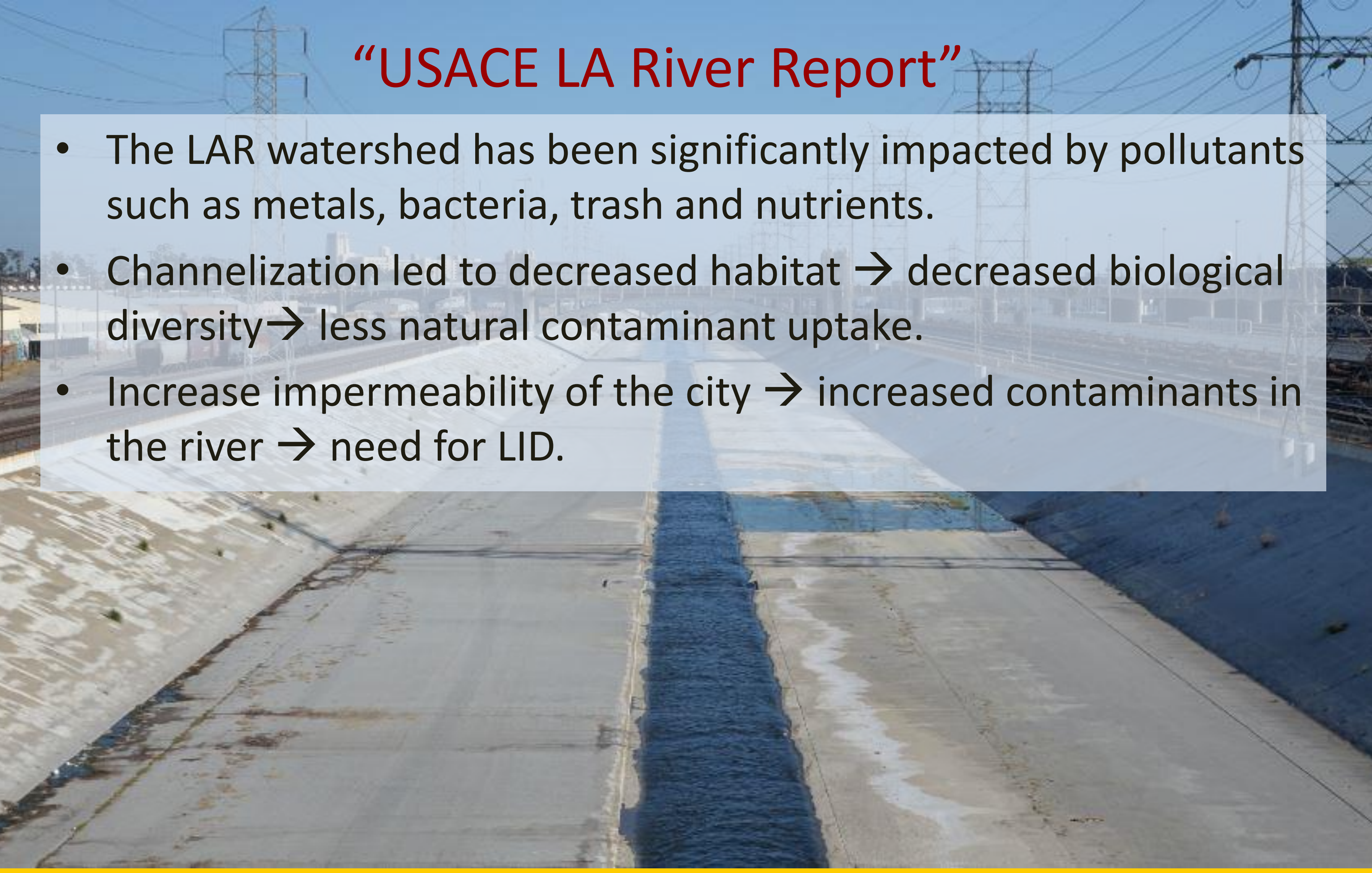
Sustainability

Source #63,64

Economics

- High cost of implementing LID throughout the whole city is far more expensive than traditional storm water management.
- Wastewater tertiary treatment is expensive (to produce an influent that is suitable for tertiary treatment is expensive); choose the most cost effective treatment.
- Incentivizing residential and private land owners to build with LID due to cost.





"USACE LA River Report"

- The LAR watershed has been significantly impacted by pollutants such as metals, bacteria, trash and nutrients.
- Channelization led to decreased habitat → decreased biological diversity→ less natural contaminant uptake.
- Increase impermeability of the city → increased contaminants in the river → need for LID.

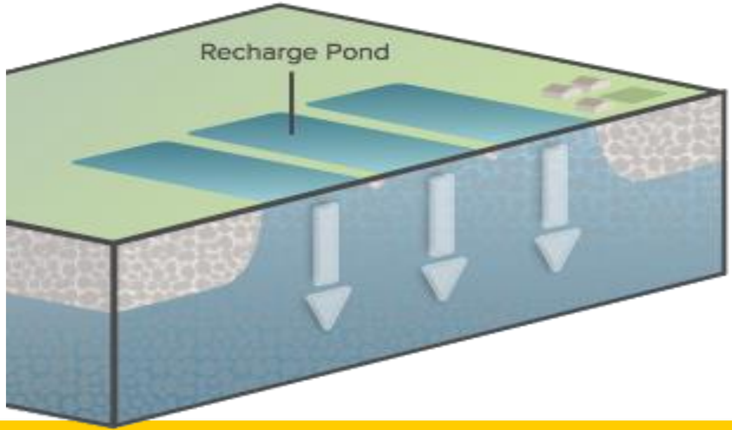
Source #66

Recharge Ponds

Building 7 new recharge ponds along the LAR could potentially result in conserved water.

Retrofitting debris basins to store stormwater and then release it down-stream later for infiltration through constructing a controlled outflow could result in 48 AFY.

Converting some portions of the LAR stormwater conveyance system could result in stormwater conservation as well.

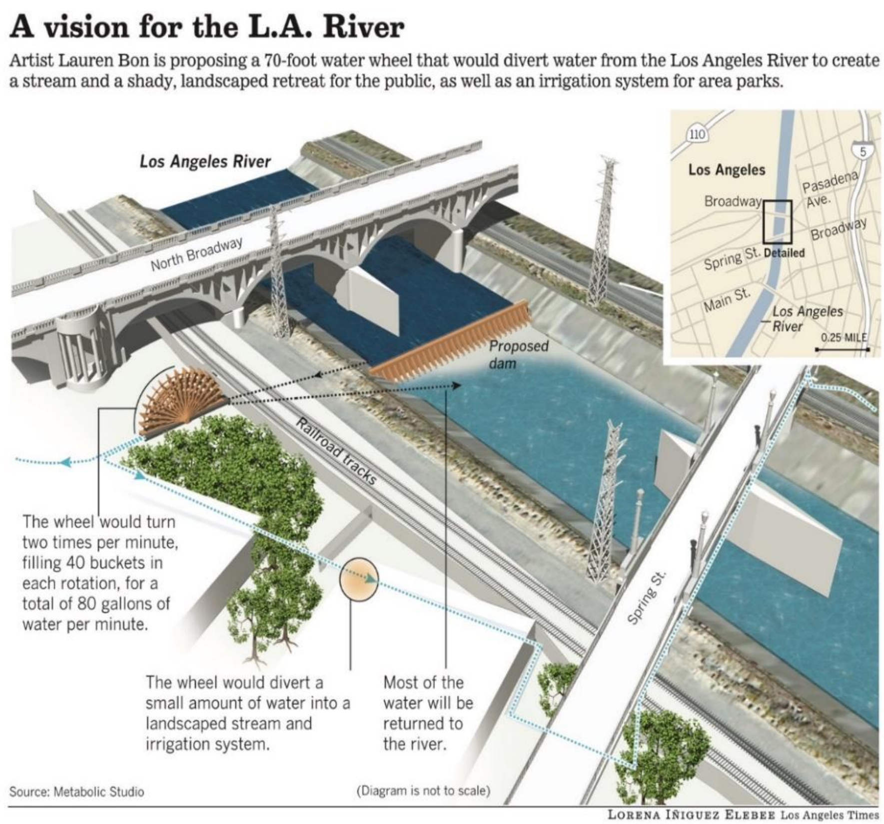


Source #67,68

Rubber Dams

Benefits

- Creates stable flow.
- Allow biological and habitat growth as they can uptake the contaminates.
- Floating Wetlands
- Recreational Opportunities
- Not a concrete structure so when it's a dry weather event, it's very beneficial and when it's wet weather they can take out it and return it later.



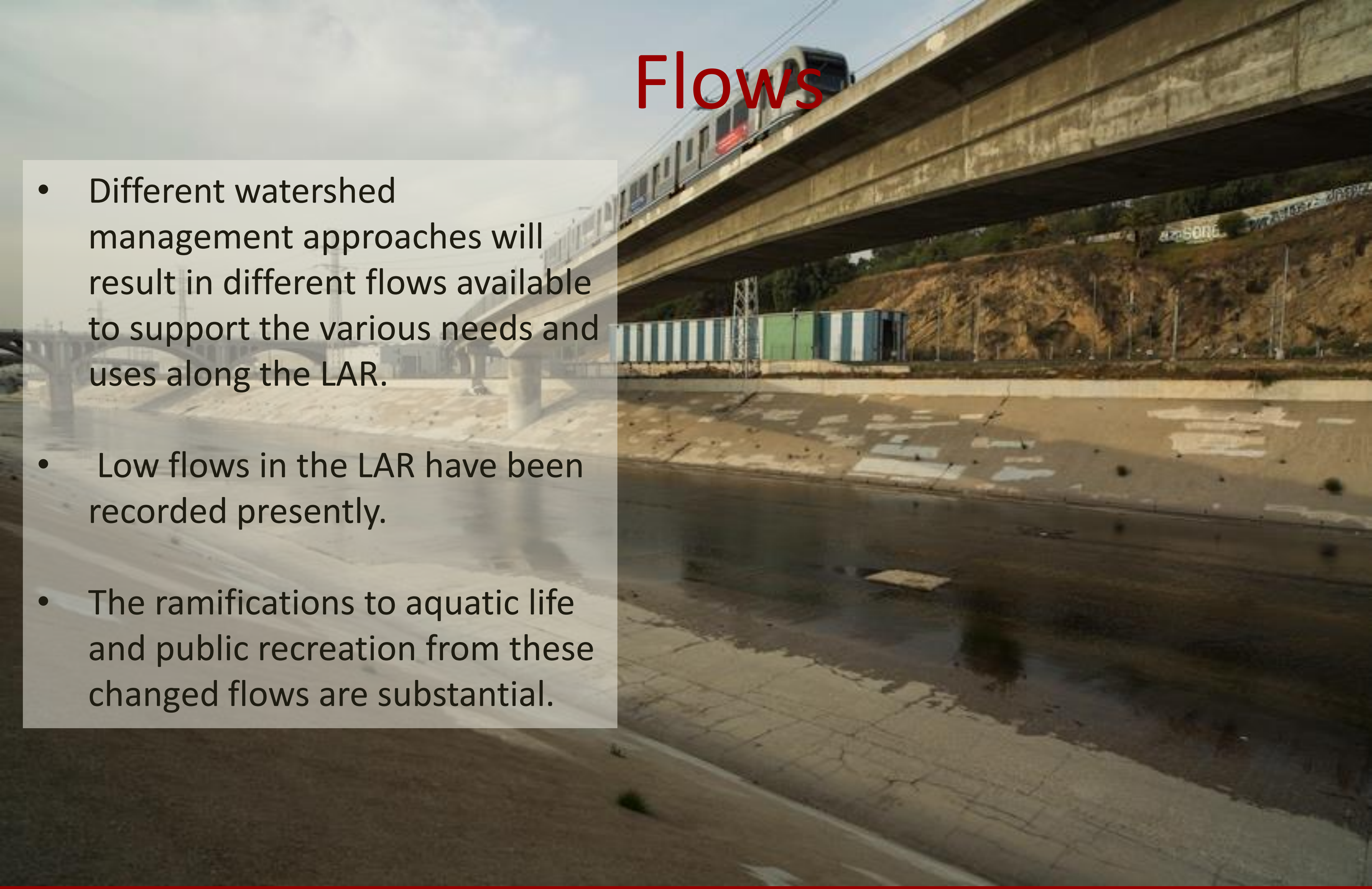
“A Climate Stress Test of Los Angeles” Water Quality Plan

The study has important limitations, such as:

- Unaddressed uncertainties that might prove relevant to TMDL implementation plans, which include the efficacy of various BMPs, in particular those involving green infrastructure.
- Uncertainties in hydrologic flows that might be represented by alternative rainfall-runoff models.
- Uncertainty in the spatial distribution of extreme precipitation events.

The results shows a reduction in annual average loads of Zinc and Copper by 10% and 7%, respectively.

Flows



- Different watershed management approaches will result in different flows available to support the various needs and uses along the LAR.
- Low flows in the LAR have been recorded presently.
- The ramifications to aquatic life and public recreation from these changed flows are substantial.

Wastewater Change Petition

- Water Code Section 1211
  "Prior to making any change in the point of discharge, place of use, or purpose of use of treated wastewater, the owner of the wastewater treatment plant shall obtain approval of the board for that change."
- If the water reuse project will decrease the amount of water in a stream or other waterway, the owner of the wastewater treatment plant needs to file a wastewater change petition. To approve a petition, the Board must find that the proposed change will not injure other legal users of water, will not unreasonably harm instream uses, and is not contrary to the public interest.

– State Water Resources Control Board

Source #72

"A Climate Stress Test of LA WQ plans"

Results

- Climate change and temperature differences could significantly affect the nature's aquatic species.
- Climate projections affect the water by changing the frequency and size of extreme precipitation events in the basin.
- Land use affects total impervious cover .
- The impervious cover changes the amount of runoff from any given precipitation event.
- Models must incorporate accurate land use in order for results to be accurate.

Source #70

"Water Quality assessment of the LA River Watershed"

- Water quality in a stream depends on precipitation and effects of the earth's surface.
- Water changes chemically, physically, and biologically.
- Trends show that dry period samples have higher concentrations compared to wet period concentrations.
- The concentration values of most metals were lower than MCL, which also suggests the City should enforce regulation for urban runoff, street and industrial runoff, point and nonpoint source pollutants, and dumping of waste along the river.
- It would be helpful to know what contaminants have leached into the ground and how this could affect the watershed and water chemistry.

Source #71

Factors affecting the quality of LA River

- **Temperature**
  - The maximum temperature is also recorded in months other than formal June-August summer.
  - This occurs maybe because of the water discharged by water reclamation plants into the river or climate change.

Table 3. Maximum water temperatures (max), minimum water temperatures (min), and range between maximum and minimum water temperatures each month (range). Highest maximum water temperatures for each month shown in bold; highest maximum water temperature for each site underlined.

	June			July			Aug.			Sept.			Oct.		
Site	Max	Min	Rng	Max	Min	Rng	Max	Min	Rng	Max	Min	Rng	Max	Min	Rng
A1*	23.7	17.2	6.5	**26.3**	16.7	9.6	25.8	15.8	10.0	23.5	13.7	9.8	19.9	13.8	6.1
A2*	**20.6**	13.7	7.0	19.9	14.0	5.8	19.9	13.8	6.1	18.5	13.8	4.8	17.7	13.5	4.2
B1*	28.4	21.2	7.1	28.7	25.1	3.6	**29.3**	23.8	5.5	26.7	21.7	5.0	24.8	18.4	6.3
B2*	29.9	22.8	7.0	30.5	25.9	4.6	**30.8**	25.5	5.4	29.3	23.3	6.0	26.3	19.9	6.4
C1*	20.9	15.2	5.7	22.1	17.8	4.4	**36.7**	16.0	20.7	25.4	14.4	11.0	33.3	13.4	20.0
C2*	**31.5**	14.4	17.1	31.3	17.8	13.5	26.2	19.7	6.5	21.6	17.2	4.4	31.0	15.1	15.9
D1*	**36.8**	17.1	19.7	**36.5**	19.8	16.8	35.5	19.1	16.5	-	-	-	-	-	-
D2	**33.2**	20.0	13.2	31.5	23.5	8.0	-	-	-	-	-	-	-	-	-
D3	35.7	17.2	18.6	**36.4**	20.6	15.7	35.6	19.8	15.8	**33.8**	17.4	16.4	31.3	17.0	14.3
D4	35.6	16.7	18.9	**35.7**	20.4	15.3	34.9	19.5	15.4	33.3	17.0	16.3	**33.4**	13.2	20.1
E1*	26.4	16.5	9.9	25.0	19.7	5.4	26.8	19.6	7.2	**29.5**	17.7	11.8	-	-	-
F1	33.3	20.9	12.4	34.9	20.3	14.6	**36.1**	19.6	16.5	32.1	17.5	14.6	28.0	17.5	10.5
F2*	34.4	21.3	13.1	34.0	20.2	13.8	**37.0**	18.6	18.4	30.6	17.5	13.1	28.6	15.4	13.1

* indicates natural bottom location

Fig. 6. Los Angeles River seasonal average maximum temperatures from estuary to headwaters.

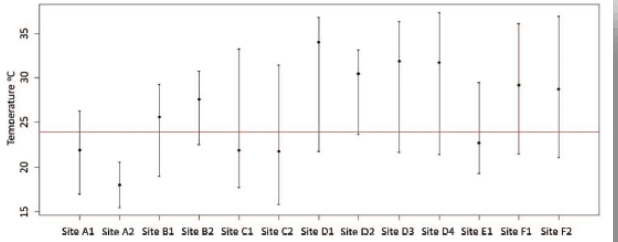


Fig. 7. Temperature ranges for sites in the Los Angeles River June–October with thermal limit of 24°C for target native fish species.

Factors affecting the quality of LA River(cont'd)

- **Temperature**
  - Higher water temperature for the LA River during the dry period
  - Average of 20.6°C in dry weather and 14.9° in wet period
- **pH**
  - pH range from 4.88 to 8.6
  - An average pH of 7.27 for the dry period and 7.96 during the wet period
- **Dissolved Oxygen (DO)**
  - Range from 5.8 to 12.2 mg/L for the dry period (avg. 8.9 mg/L) and 6.9 to 17.9 mg/L during the wet period(avg.10.3 mg/L)
- **Salinity**
  - Very low salinities were recorded

Table 1. Spatial and seasonal changes of various water parameters for LA river

Sampli Locatic	Table.2	Dry Season				Wet Season			
		DO (ppm)	pH	Temp (℃)	Salinity (‰)	DO (ppm)	pH	Temp (℃)	Salinity (‰)
1	71 (44.1)	8.3	7.94	26.2	3	17.9	8.14	17.7	5
2	63 (39.2)	9.8	8.08	15.8	0	8.3	8.08	15.8	0
3	58 (36.5)	9.7	7.6	17	0	10.1	7.5	13.9	0
4	58 (35.9)	9.6	7.29	17.7	0	12.6	7.9	9.5	0
5	56 (35.2)	9.3	7.29	17.1	0	12.7	7.9	9.1	0
6	47 (29.4)	7.24	6.8	21.8	0	11.7	7.8	14.2	0
7	40 (25.1)	8.1	6.27	22.3	0	14.4	8	12.8	0
8	40 (25.1)	9.9	6.98	18.9	0	11.1	7.8	15.3	0
9	40 (25.0)	9.3	7.15	19.7	0	13.7	8.5	16.5	2
10	35 (21.8)	9.2	7.03	22.5	0	14.4	8	16.5	0
11	26 (16.1)	11.7	7.94	26.2	3	16.5	8	17.3	0
12	6 (4.0)	12.2	8.63	21.5	0	14.5	8	17.7	0
13	5 (3.0)	8.4	4.88	20.7	10	9.5	8	16.8	1
14	1 (0.9)	5.8	7.97	21	33	14.9	7.8	15.6	16
Minimum		5.8	4.88	15.8	0	8.3	7.5	9.1	0
Maximum		12.2	8.63	26.2	33	17.9	8.5	17.7	16
STD. Dev.		1.63	0.92	3.18	8.92	2.70	0.22	2.77	4.33
Average		9.18	7.27	20.60	3.50	13.02	7.95	14.90	1.71

The table also shows a comparison of average, standard deviation (SD), minimum, and the maximum of various parameter in the various locations in LA River. Sampling location1and 14 were furthest and closest to the ocean. These locations including the Sepulveda Basin (1), La Crescenta (2), Eaton Canyon Falls (3), JPL Area (4), Eaton Canyon Wash (5), Glendale Narrows (6), Under the bridge near Confluence (7), Lower Arroyo Seco (8), Arroyo Seco Confluence (9), First and Seventh Street (10), City of Bell (11), Willow Street in Long Beach (12), Pacific Coast Highway Bridge (13) and Queensway in Long Beach (14) (The Mouth of the LA River). MCL=Maximum Contamination Limit, na = Not Available. N (dry)=14 and N (wet)=14

Water Quality Assessment of the Los Angeles River Watershed, California, USA in Wet and Dry Periods. M.H.R. Boroon et al.

"Contamination of Soil and Groundwater Due to Stormwater Infiltration Practices"

- Many priority pollutants in urban storm water runoff have some potential to compromise groundwater supplies.
- Concentration of the pollutant in the receiving soil may become elevated above the acceptable level.

Source #72

Questions?

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