Water Quality Improvement by Implementation of Proposition O in the Los Angeles River Watershed, CA

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Abstract

Proposition O was created to help the City of Los Angeles comply with the Total Maximum Daily Load (TMDL) requirements under the Clean Water Act. In this study, the effectiveness of the Proposition O projects in Los Angeles River watershed was examined to show whether it achieves the goal of meeting water quality standards. Our analysis shows the most effective single project will remove at most 2% of pollutant loads from Los Angeles River Watershed and will not achieve TMDL compliance, although several projects can make important contributions to achieve compliance. The ranking results show that the projects that treat the runoff from the largest drainage area have the greatest impact on the water quality of Los Angeles river.

Keywords: Proposition O, Clean Water Act, TMDL BMPs, stormwater management, water quality improvement

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Introduction

Stormwater and urban runoff are the major problems to rivers, lakes, beaches and coastal waters because of rapid urbanization and population growth. Many studies have shown that stormwater pollution from urban watersheds significantly impacts surface water quality (Stenstrom and Strecker,1993) because the runoff contains many pollutants such as pathogens, toxic substances, heavy metals, and sediments (Corbett et al.,1997). In Los Angeles region, the amount of stormwater flow can be up to 380 million L/day on dry-weather days and 38 billion L/day into Santa Monica Bay on wet-weather days (Bureau of Sanitation). Dry-weather flows are diverted to wastewater treatment plant during dry seasons and stormwater runoff discharges straight into the rivers and the ocean without treatment, and the mass emission of bacteria and heavy metals often exceeds water quality standards for both dry and wet-weather conditions (LADPW, 2006).

In California, the discharge of dry- and wet weather runoff and nonpoint source pollution are regulated under the Federal Clean Water Act (CWA) and the California Porter-Cologne Water Quality Control Act (Swamikannu, 2003). Under the Porter-Cologne Water Quality Act, the California Water Quality Control Plan, Los Angeles Region, also known as the Basin Plan, sets water standards and implementation programs to protect all water bodies within the State. The CWA requires identifying impaired water bodies known as 303(d) list, establishing TMDLs and implementing Best Manage Practices (BMPs) to comply with the TMDLs. In Los Angeles region, over 700 water body-pollutant combinations have been identified (LARWQCB, 1996;RWQCB, 1998) and a total of nine TMDLs were adopted for trash, bacteria, nutrients, metal and sediment. In response, local governments such as the City of Los Angeles must comply with the TMDL requirements.

In response, Proposition O, the Clean Water, Ocean, River, Beach, Bay Storm Water Cleanup Measure, was proposed and approved by 2/3 of Los Angeles voters in November 2004. It authorized the City of Los Angeles to issue $500 million in general bonds for projects that

- protect rivers, lakes, beaches, and the ocean,
- conserve and protect drinking water and other water sources,
- reduce flooding and use neighborhood parks to decrease polluted runoff, and
- capture, clean up, and reuse stormwater.

After screening 52 submitted proposals by city agencies and community and non-profit organizations, 16 projects have been approved so far in addition to a previously approved project that installs catch basin inserts and covers in high trash generating areas to comply with the Trash TMDLs. As of August, 2007, $ 462,432,715 has been allocated for those projects that were approved by the City Council.

Our previous study focused on the analysis on policy implementation of the Proposition O process to address the issues of public perception of the community solicitation process (Park, 2007). This study evaluated the effectiveness of projects considered for Proposition O implementation to improve water quality. The objectives are to investigate how each project impacts stormwater water quality and helps to meet TMDL requirements especially in Los Angeles River watershed. In addition, the cost-effectiveness of each project was evaluated and all projects in the watershed were ranked based on water quality improvement and cost comparisons.

Methods

Study Area

This study focused on Los Angeles River watershed for both dry and wet weather runoff. The Los Angeles River watershed is one of the largest watersheds in the region with an area of approximately 2161 km^2. More than 40% of the watershed is open space as shown in Figure 1 (SCAG, 2005).

The Los Angeles River flows 82 km from San Fernando Valley to Long Beach and the majority of the river is lined with concrete for flood control. The river and other water bodies are listed as 2006 303(d) impaired water bodies for trash, ammonia, metals, coliform, as well as other pollutants that are associated with urban runoff. In this watershed, trash, nutrients and metal TMDLs were adopted for the river.

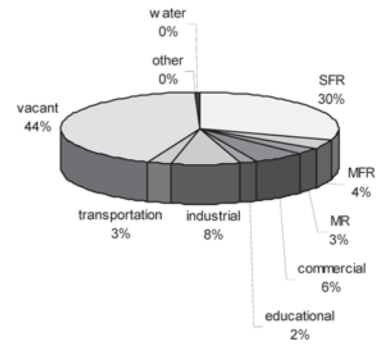

Figure 1. Land use composition in Los Angeles River Watershed

Table 1. Runoff coefficients and event mean concentrations by land use in the County of Los Angeles (LADPW)

	Unit	SFR	MFR	MxdR	C	E	I	T	V
RC		0.29	0.33	0.72	0.72	0.72	0.69	0.75	0.23
Total Coliform	MPN/100mL	1395691	n/d	n/d	1733009	n/d	508710	806940	21288
Fecal Coliform	MPN/100mL	1085354	n/d	n/d	1071657	n/d	653070	1340167	2175
SS	mg/L	105	46	69	67	103	229	75	164.68
Oil & Grease	mg/L	1.36	n/d	n/d	3.65	n/d	1.87	3.19	0
Total Copper	g/L	15	12	17	35	21	31	52	9
Total Lead	g/L	10	5	9	12	5	15	9	0
Total Zinc	g/L	80	135	185	239	124	566	279	39
Kjeldahl-N	mg/L	2.80	1.86	2.7	3.37	1.62	3.07	1.81	0.81
NH3-N	mg/L	0.36	0.38	0.58	0.91	0.26	0.48	0.23	0.08
Nitrate-N	mg/L	1.04	1.73	0.71	0.58	0.63	0.86	0.75	1.11
Nitrite-N	mg/L	0.09	0.08	0.1	0.14	0.08	0.09	0.09	0.05
Total P	mg/L	0.39	0.19	0.26	0.41	0.31	0.44	0.44	0.11

Note that SFR is high density single-family residential, MFR is multiple-family residential, MxdR is mixed residential, C is retail/commercial, E is educational, I is light industrial, T is transportation and V is vacant land uses. SS is suspended solids, N is nitrogen, and P is Phosphorus. Note that n/d represents no data were collected.

Project Evaluation Methods

Stormwater pollutant loads from proposed project sites were estimated using the volume-concentration method, which is the product of rainfall runoff volume and pollutant concentrations from each land use in the drainage areas. Runoff coefficients (RCs) and event mean concentrations (EMCs) for each land use in Los Angeles region are shown in Table 1. Annual wet-weather runoff from the watershed was estimated assuming annual average rainfall of 251 mm.

Dry-weather pollutant concentrations were derived from the monitoring data collected by LADPW during the 1998 and 2006 dry-weather seasons (LADPW). Annual dry-weather flow for the watershed is assumed to be 4 m^3/sec.

The performance of BMPs was evaluated using their removal efficiencies from existing literature (DOT;EPA, 1993; USEPA, 1999). It was assumed that all runoff from the drainage area passes through the series of proposed BMPs in a sequential way.

The pollution reduction and the effect of each project on TMDL compliance were estimated at watershed scale using previous stormwater monitoring measurement (LADPW).

Results

Annual wet-weather runoff from the watershed was estimated to be approximately 236 million m^3/year and the average runoff coefficient of the entire watershed was 0.36. Figure 2 shows the annual runoff volume from each project site. The greatest runoff volume from a project site was 5.4 million m^3/year, corresponding to 2% of total runoff volume from the entire watershed whereas the smallest runoff volume from a site was less than 0.005% of total runoff from the entire watershed.

Table 2 shows the estimated annual dry- and wet-weather loads from the watershed. The wet-weather loads were much greater than dry-weather loads except nutrients. For example, dry-weather bacteria loads were approximately 0.3-5% of wet-weather loads; dry-weather TSS load was 15% of wet-weather loads; and dry-weather metal load were 18-35% of wet-weather loads. On the other hand, dry-weather nutrient loads were 1.3 to 11 times the wet-weather loads.

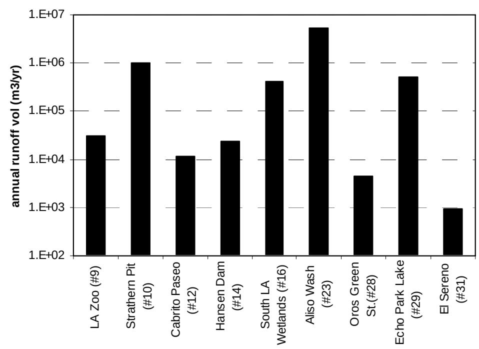

Figure 2. Estimated stromwater runoff volume from project sites in Los Angeles River Watershed

Table 2. Estimated annual dry- and wet-weather loads

Pollutants	Unit	Wet-weather loads	Dry-weather loads
Total Coliform	colonies/year	2.12×10^{18}	9.85×10^{16}
Fecal Coliform	colonies/year	1.73×10^{18}	8.18×10^{15}
SS	Kg/year	30,647,717	2.28×10^{15}
Oil & Grease	Kg/year	363,868	4,583,101
Total Copper	kg/year	4,916	1,706
Total Lead	kg/year	1,776	463
Total Zinc	kg/year	43,841	7,927
Kjeldahl-N	kg/year	522,045	1,589,253
NH^3-N	kg/year	87,513	246,820
Nitrate-N	kg/year	223,441	297,667
Nitrite-N	kg/year	19,790	211,037
TP	kg/year	72,097	222,064

All proposed BMPs in the watershed will have high removal efficiencies for TSS and metals, with maximum removal efficiency of 80% or more. It was expected that most of the BMPs would be appropriate to remove TSS and metal loads discharged to Los Angeles River. However, the removal efficiencies for nutrients and bacteria varied.

Table 3 shows the estimated annual dry- and wet-weather mass loads generated from the project sites and the loads after treatment by the proposed BMPs with maximum removal efficiencies. The greatest mass loads from a project site for both dry- and wet-weather conditions were 2-3% of total loads from the entire watershed whereas the least mass loads were less than 0.01% of the loads from the entire watershed.

Figure 3 compares the daily mass loads and the TMDLs in wet-weather days. The project with the greatest percentage reduction in the watershed was taken as the example project. The results showed that ammonia-nitrogen TMDLs would be violated five times whereas nitrate- and nitrite-nitrogen TMDLs would rarely be violated. Ammonia-nitrogen TMDLs would be exceeded by approximately 2-140% when violated. A comparison to past events suggests that only one violation would have been prevented. Metal TMDLs would frequently be violated with lead being the closest to compliance. Total copper TMDL would often be exceeded by approximately 14-2,200%. All events would still exceed the TMDL by approximately 11-2,150% even after the installation of the project. Total lead TMDL would be exceeded only once by approximately 17 times. This event would still exceed the TMDL by 16 times with the installation of the project. Total zinc TMDLs would be exceeded 5 times by approximately 6-750%. All these events still exceed the TMDL by 3-720% with the installation of the project.

Figure 4 compares the daily mass loads and the TMDLs in dry weather days. The results showed that metal TMDLs would always be violated such that copper TMDLs would be exceeded by as much as 29 times and lead by as much as 4 times. However, the installation of the project alone would not be sufficient to reduce the number of exceedances. The copper TMDL would be exceeded by 28 times and lead TMDL by 4 times. Even the application of all proposed projects would not reduce the number of exceedances. For nutrients, the ammonia- and nitrite-nitrogen TMDLs would be exceeded twice and four times, respectively, and no exceedance would occur for nitrate-nitrogen TMDL. The ammonia- and nitrite-nitrogen TMDLs would be exceeded by approximately 60-110% and 9-60%, respectively. These events would still exceed TMDLs even with the application of the project

The results show that the projects that treat the largest drainage area had the greatest impact on the water quality of Los Angeles River. The project would also achieve the greatest percentage reduction in the watershed even though the single project would not achieve TMDL compliance. Even the installation of all proposed BMPs would not be sufficient to meet the TMDL requirements. Additional projects will be required to reliably meet the TMDLs.

Table 3. Estimated annual dry- and wet-weather loads before and after BMPs (with maximum removal efficiency) of each project in Los Angeles River Watershed

		LA Zoo Parking Lot (#9)		Strathern Pit (#10)		Cabrito Paseo (#12)		Hansen Dam (#14)		South LA Wetlands (#16)		Aliso Wash (#23)		Oros Green St. (#28)		Echo Park Lake (#29)		Parking lot El Sereno (#31)	
		inf.	eff.	inf.	eff.	inf.	eff.	inf.	eff.	inf.	eff.	inf.	Eff.	inf.	eff.	inf.	eff.	inf.	eff.
Wet-weather	Total Coli..	2.4E+14	7.7E+13	5.9E+15	4.2E+15	1.5E+14	1.1E+14	3.9E+13	1.9E+13	5.7E+15	4.0E+15	5.3E+16	5.3E+15	4.0E+13	1.4E+12	7.3E+15	5.1E+14	2.0E+11	0
	Fecal Coli.	4.1E+14	6.8E+13	7.1E+15	5.0E+15	1.1E+14	7.8E+13	3.0E+13	1.5E+13	4.3E+15	3.0E+15	4.3E+16	4.3E+15	3.8E+13	1.3E+12	5.5E+15	3.8E+14	2.1E+10	0
	Enterococcus	1.1E+13	3.3E+12	1.7E+15	1.2E+15	4.3E+13	3.0E+13	4.6E+12	2.3E+12	2.6E+15	1.8E+15	2.2E+16	2.2E+15	2.1E+13	7.3E+11	3.7E+15	2.6E+14	9.9E+09	0
	TSS	2308	0	220659	44132	1352	27	3891	16	34019	6804	732153	73215	767	32	39289	0	156	0
	O&G	98	75	1944	1944	28	7	9	2	811	811	8969	2960	7	6	916	9	0	0
	Cu	2	0.01	31	6	0.31	0.03	0.3	0.01	9	1.8	116	1	0.11	0	10	0.04	0.01	0
	Pb	0	0	14	2	0.13	0.01	0.05	0	3.7	0.63	48	0.48	0.06	0	5	0.02	0	0
	Zn	9	0.04	532	106	3	0.3	2	0.05	85	17	1146	11	1.54	0.02	93	0.37	0.04	0
	Kjeldahl-N	55	10	3059	2142	35	18	28	10	1103	772	13265	2653	13	3	1399	441	0.77	0
	NH3-N	7	1.2	475	266	7	4	4	1	237	133	2133	448	2	0.38	297	75	0.08	0
	Nitte-N	23	6	894	626	9	2	25	3	296	207	5120	2560	4	1.27	395	152	1.05	0
	Nitrite-N	3	0.46	91	64	1	0.63	1	0.45	43	30	473	237	0.4	0.12	54	17	0.04	0
	TP	14	0.32	441	185	5	0.73	4	0.24	124	52	1848	185	2	0.36	153	7	0.1	0.01
Dry-weather	Total Coli.	6.08E+12	1.90E+12	2.53E+14	1.77E+14	3.55E+12	2.48E+12	1.37E+13	6.72E+12	9.22E+13	6.64E+13	2.18E+15	2.18E+14	1.55E+12	0.00E+00	1.35E+14	9.45E+12	6.17E+11	0
	Fecal Coli.	5.05E+11	8.39E+10	2.10E+13	1.47E+13	2.95E+11	2.06E+11	1.14E+12	5.58E+11	7.66E+12	5.51E+12	1.81E+14	1.81E+13	1.29E+11	0.00E+00	1.12E+13	7.85E+11	5.12E+10	0
	Enterococcus	1.41E+11	4.40E+10	5.85E+12	4.10E+12	8.20E+10	5.74E+10	3.17E+11	1.56E+11	2.13E+12	1.54E+12	5.05E+13	5.05E+12	3.58E+10	0.00E+00	3.12E+12	2.19E+11	1.43E+10	0
	TSS	283	0.03	11779	2356	165	3	639	3	4293	1085	101547	10155	72	1	6287	0	29	0
	Cu	0.11	0.001	4	1	0.06	0.006	0.24	0.005	1.6	0.4	38	0.38	0.03	0	2.34	0.05	0.01	0
	Pb	0.03	0	1	0.2	0.02	0.001	0.06	0.001	0.43	0.1	10	0.1	0.01	0	0.63	0.01	0	0
	Zn	0.49	0.003	20	4	0.29	0.03	1.1	0.02	7	2	176	2	0.12	0.001	11	0.22	0.05	0
	Kjeldahl-N	98	17	4084	2859	57	29	221	77	1489	1071	35213	7043	25	5	2180	687	10	0
	NH3-N	15	3	634	355	9	4	34	10	231	136	5469	1148	3.88	1	339	85	2	0
	Nitrate-N	18	5	765	536	11	2	41	6	279	201	6595	3298	4.68	1	408	157	2	0
	Nitrite-N	13	2	542	380	8	4	29	10	198	142	4676	2338	3.32	1	290	91	1	0
	TP	14	0.34	571	240	8	7	31	2	208	95	4920	492	3.49	1	305	65	1	0

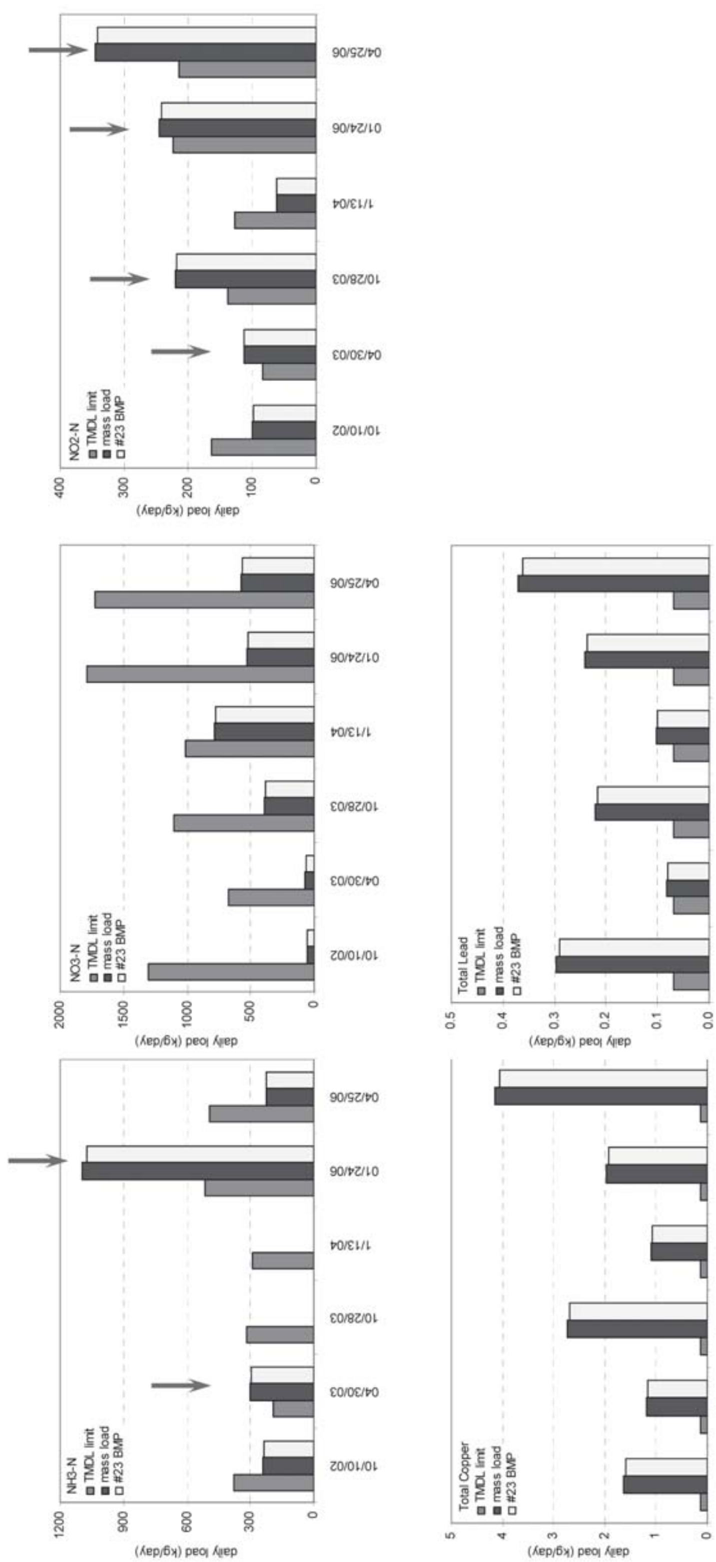

Figure 3. Wet-weather TMDL exceedance in Los Angeles River Watershed

Note that blue bars are TMDLs for each water quality parameter for each monitoring event; red bars are the mass loads from entire watershed; and yellow bars are the mass loads reduced by proposed BMPs of an example project. Solid arrows indicate that both mass load generated from the watershed and after the selected BMPs exceed the TMDL. The dotted arrow indicates the BMP reduces the load not to exceed the TMDL.

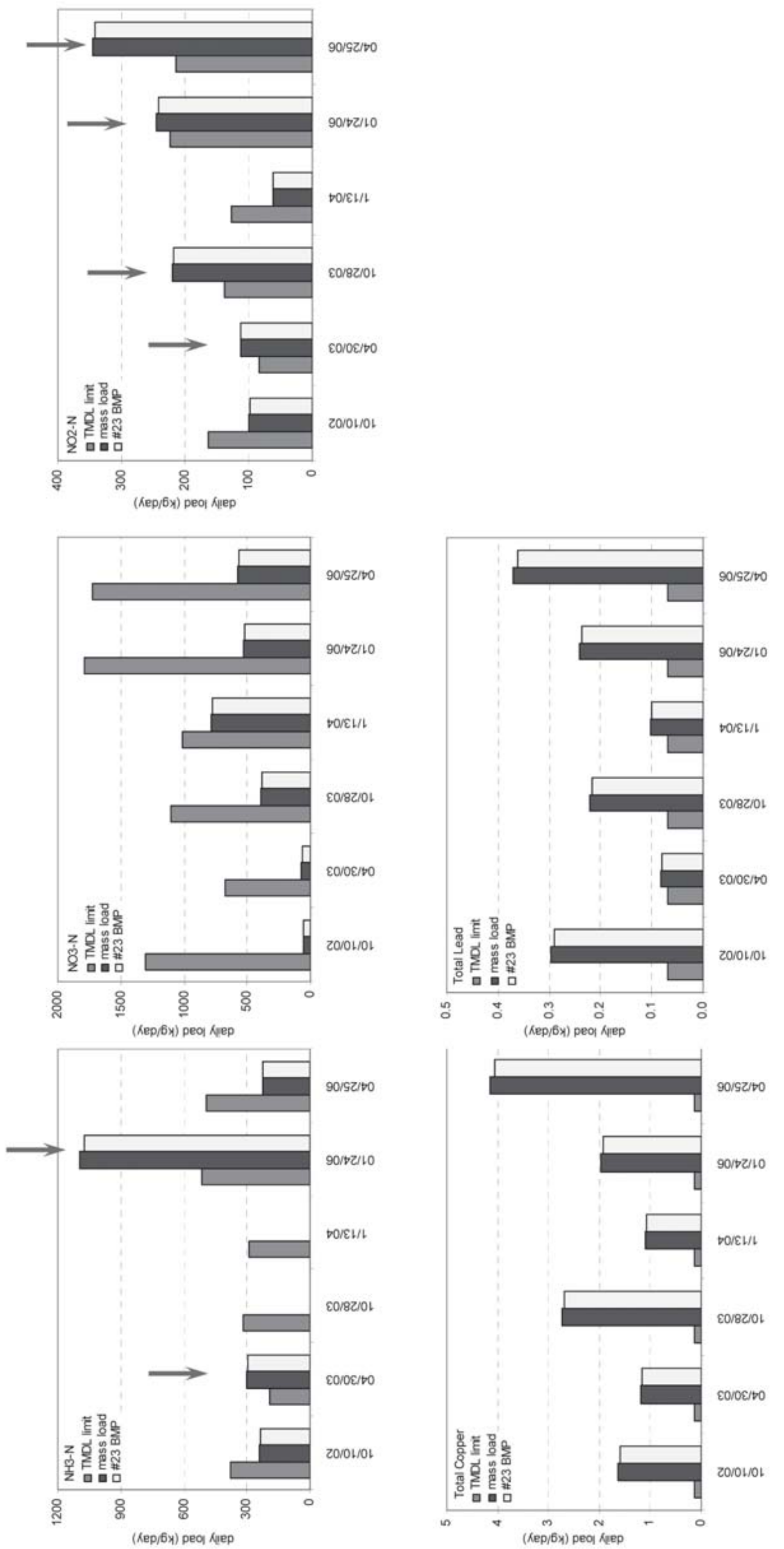

Figure 4. Dry–weather TMDL exceedance in Los Angeles River Watershed

Note that blue bars are TMDLs for each water quality parameter for each monitoring event; red bars are the mass loads from entire watershed; and yellow bars are the mass loads reduced by proposed BMPs of an example project. Solid arrows for nutrients indicate that both mass load and the load after the selected BMPs exceed the TMDL. All metal TMDLs are exceeded.

Figure 5 shows the cost-effectiveness of projects. The cost ranges from $1600-$3 million per ha of drainage area and $90-$1.3 million per g of Cupper, for example. The most cost-effective project per drainage area was also the most cost-effective project per mass load reduction for all pollutants considered.

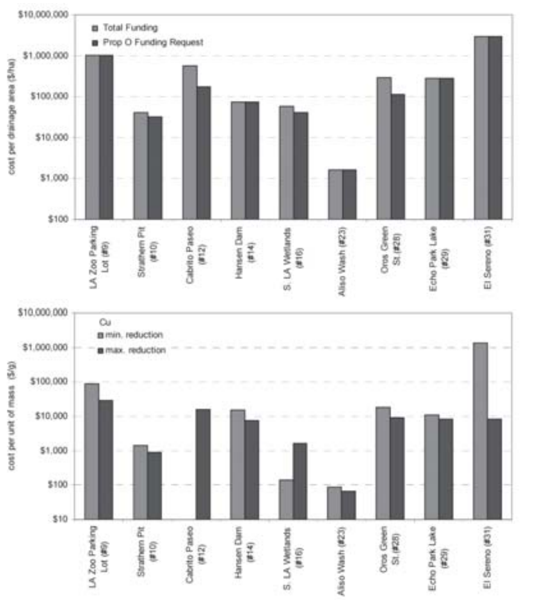

Figure 5. Cost-effectiveness of proposed projects in Los Angeles River Watershed

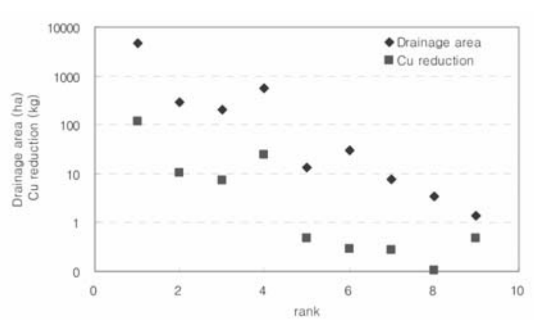

Figure 6. Rank of proposed projects in Los Angeles River Watershed

The ranking results from mass load reduction and cost effectiveness are shown in Figure 6. The results show that projects treating a large drainage area reduced greater mass pollution while the projects addressing small sites reduced smaller amount of pollutants. Therefore, the (semi-) regional projects with larger drainage area tended to be ranked high.

Conclusions

Our analysis shows the most effective single projects will remove at most 2% of pollutant loads from the entire Los Angeles River Watershed and no single project will achieve TMDL compliance, although several projects can make important contributions to eventually comply with the TMDLs. The results show that current projects would not be sufficient to retrofit all the problems in the watersheds to meet TMDL regulations. However, the short fall in the required pollutant reductions to meet the TMDLs should not be counted as a failure of Proposition O, since it was not intended to remedy all polluted runoff. In addition, Proposition O can fund only those projects within the jurisdiction of the City of Los Angeles. Therefore, it is required to develop regional projects to meet the TMDL requirements. However, proposed projects in the watershed will contribute to protect the rivers and oceans, and to clean up stormwater by reducing stormwater runoff and pollution.

Our analysis is specific to the Los Angeles area in the sense that the various loads and BMPs are applied to specific areas. The results of the analysis are more general, and suggest that large urban areas that need to comply with TMDLs can best be managed by large projects, treating large areas within watersheds. Furthermore, watershed-wide approaches that transcend jurisdictions are required. Perhaps the first part of any large compliance effort should be the development of ways for diverse agencies to cooperate in implementing a single, watershed-wide approach.

The Oros Green Street project, which uses small-scale BMPs did not score high with traditional ranking methods, but it is the potential exception to the broader conclusions of this work. If the small scale BMPs demonstrated in this project can be made economic and easy to implement through scaling up with multiple applications, their score could become competitive with the large-scale projects. The small scale projects have the advantage of not needing large land parcels, which are generally unavailable.

Acknowledgments

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