Analysis Methodology for Stormwater Treatment Costs

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ABSTRACT

Most if not all cities within the United States will be affected by proposed stringent Federal stormwater treatment plans and standards that require three levels of treatment of all stormwater before it is discharged into a public body of water. This work presents a methodology for conceptual cost budgeting for these new required treatments. The work is case study based and presents nine different cost analyses scenarios based on different strategies for determination of rainfall, locations of plants, and size of plants. The paper also describes methodologies and cost modeling tools needed for assessment of community/city economic impacts associated with construction and operation of the new required treatment plants. Practicing engineers and cost managers will learn what these new standards require and one methodology for how best to calculate and present the budget for their significant upfront capital expenditures as well as long-term operating and maintenance costs.

BACKGROUND

Most if not all cities within the United States will be affected by proposed stringent Federal stormwater treatment plans and standards that require three levels of treatment of all stormwater before it is discharged into a public body of water. In 2000, the US Environmental Protection Agency (USEPA) established numerical criteria for priority toxic pollutants in the State of California in the form of the California Toxics Rule (CTR), filling a policy gap in water quality standards that was created in 1994 when a State court overturned California's water quality control plans. California policy makers have used the stringent CTR discharge limits to create a variety of State water quality standards, and will presumably refer to the numerical criteria in the CTR as new State and regional rules are promulgated in efforts "to preserve and enhance water quality and protect the beneficial uses of all regional waters." The joint implications of the recent California Toxics Rule, the steadily increasing demands associated with National Pollutant Discharge Elimination System (NPDES) Permit requirements (driven in part by a recent US Environmental Protection Agency consent decree), and the growing number of major Los Angeles waterbodies appearing on the Clean Water Act 303(d) list are that municipalities in the Los Angeles region may well be required to provide tertiary (Level III) treatment of storm water and urban runoff [1, 2, 3].

Tertiary water treatment involves elimination of all contaminants from the stormwater. Like most communities in the United States, the Los Angeles region does not have the plants and other facilities that can divert intermittent storm flows and provide the tertiary treatment to needed to assure compliance with applicable water quality standards and objectives. This paper measures the costs of treating this stormwater under different scenarios, including 1) varied rainfall amounts and 2) alternative combinations of treatment plants in the watershed basins and the cities of Los Angeles County. It will also make some attempt to evaluate the benefits from comprehensive stormwater treatment, although this is much more difficult because of the difficulty of attaching dollar values to intangibles.

ESTIMATING COSTS FOR CASES AND SCENARIOS

Several studies have estimated the costs of building these facilities, including a widely cited 1998 study for the California Department of Transportation, conducted by the water treatment and environmental engineering firm of Brown & Caldwell. This study found that construction of approximately 480 facilities to divert and treat flows from about 90% of the annual expected storm events would cost approximately $53.6 billion. The Los Angeles County Sanitation District, which operates most of the region’s water treatment plants, subsequently reviewed the Brown & Caldwell study and concluded that the costs were more likely to be in the range of $65 billion. Based on these initial studies, the authors studied nine combinations of cases and scenarios. There are three alternative prototypical levels of rainfall accumulation combined with three scales of treatment plants. Each scale of treatment plant also has associated siting options around Los Angeles county. Advanced treatment capacity is assumed in all cases [4, 5].

Rainfall Scenarios

The Brown and Caldwell (1998) study assumed a 1.25" 24-hour storm. The researchers have retained this default assumption as Scenario I. The other rainfall scenarios are based on our study of county rainfall data. The researchers analyzed daily precipitation data at seventy-six representative stations throughout the entire monitoring area.

These data were kept by the Los Angeles County Department of Public Works. Many of these stations have records of precipitation for over seventy years. Out of the total 1,484,090 station-days the researchers found that only 132,299 station days had any trace of rainfall. Thus, 91.1 percent of the time there was no precipitation at all. Figure 1 shows average annual Los Angeles region rainfall over the last 70 years and shows how infrequently rain did occur. The Figure shows that on average, the Los Angeles area experiences about 32 days of rainfall per annum. Typically, 22 (70%) of these wet days result in 0-0.5 inches of rain, 0.5-1.5 inches fall on about 7 (20%) wet days, from 1.5 to 2.25 inches are recorded on an average of only 2 (7%) days each year, and more than 2.25" falls about 1 day (3%) per year. Rain-driven stormwater treatment facilities are basically idle for approximately 333 of 365 days, or over 91% of the average year. Figure 2 summarizes the distribution of rainfall during the 24-hr period from the132,299 station-day data.

Based these figures, in the interests of being conservative and because the great majority of the 24-hr rainfall data were below 0.5", the researchers chose the 0.5" rainfall as Scenario II. The researchers also calculated the average rainfall that occurred during continuous three-day periods in which precipitation occurred. The observed average *total* for these three-day storms was 2.25". This 2.25" value is also the 97th percentile for observed 24-hr rainfall. Thus, 2.25" with a three-day runoff period was chosen as the design rainfall for Scenario III.

Construction Cases

The researchers studied three treatment plant siting and sizing cases for each rainfall scenario. The 45.2 (average) million-gallon plants assumed in the Brown and Caldwell study constitute Case I. Because plant sizes are fixed for this case, the number of Case I plants varies with the rainfall scenario. This produces a relatively large number of treatment facilities, which the researchers sited relatively uniformly throughout the region. Case II places one large treatment plant in each of the county's sub-basins for a total of 65 plants regardless of rainfall scenario. Case II plant sizes vary with rainfall. Case III is based on political "equity" with one treatment plant in each of the county's cities. There are 87 cities but many straddle more than one sub-basin. Drainage requirements dictate that such cities accommodate one plant per-sub basin. Census Designated Places (CDPs) include both incorporated and unincorporated communities. Unincorporated CDPs in Los Angeles County were added to adjacent cities for the purposes of this study. This produced a total of 123 sub-basin-CDP combinations in Los Angeles County. There are also seven residual basin areas that are neither incorporated nor designated as a CDP but which certainly experience rainfall. Case III then places a treatment plant in each one of these 130 areas with the plant sized to treat the runoff from each area.

Real estate costs

The Brown and Caldwell and LACSD review study both used a real estate cost of $914,760 per acre. This figure significantly underestimates real estate costs for most basin areas in this study. The researchers have constructed weighted costs based on the distribution of residential, non-residential, and vacant land values. These improved estimates of land costs used were derived from a record of all 2001Los Angeles county real property transactions as reported by DataQuick Information Systems. These data were for various land uses, by city, including transactions labeled "vacant land." Because there is no way to tell exactly where plants will be sited, The researchers computed a composite land cost index by weighting the DataQuick transactions data by the amount of land by general land use type in each city. Land use data were provided by the Southern California Association of Governments. Note that these values are specific to each basin, sub-basin, or City/CDP depending on the particular facility case. The various siting assumptions have implications for Collection System costs. Plant size is function of the design flow for the plant with 0.2455 acres of plant land needed per MG of flow. Acres per plant is defined to mean how much land is needed to construct each individual treatment plant. The land requirements therefore vary with plant capacity (millions of gallons treated). In Case II and Case III, the plant sizes are determined based on required flow treatments (and hence drainage areas) of each individual sub-basin or individual City/CDP, and the plant sizes vary across rainfall scenarios. In the Case I scenarios, the plant size is fixed and the number of plants varies based on required flow treatments of each basin (because of different rainfall assumptions). Hence, given the nine different combinations of cases scenarios, there is a blending of costs across hundreds of different size plants.

In some combinations, the required individual plant capacities may be quite small for a small city, e.g., Case III, Scenario II. Consequently, the required plant size can be very small, perhaps less than one acre. Consistent with the 9-combinations approach, the plant construction cost for such small (and arguably 33 unlikely) projects is included in the total cost for each combination. In some combinations, the required individual plant capacities may be quite large, e.g., a large basin in Case II, Scenario III. In these cases, the required plant size is very large, perhaps over one thousand acres. Again, in keeping with the 9-combination approach, the plant construction cost for even such large (and arguably unlikely) project is included in the total combination cost. Given the large number of plants and the large variety of sizes, the total cost difference across the combinations is not large. In the interests of conservatism, the study assumed that vacant land parcels would be available in Case III (the City/CDP option), and used the "vacant land" real estate costs as opposed to the weighted costs for unincorporated areas added to each basin. The weighted cost estimates were used in all other cases.

Construction costs

Treatment plant cost will vary with size of the plant, but not as significantly as one would expect. For Case I, all plants are assumed to be the same size (45.2 MG) and the Brown and Caldwell cost capacity equation was used to compute the plant costs. The Brown and Caldwell typical plant size of 45.2 MG was then used to treat the different flow amounts for Case I

Two corrections were applied to the Brown and Caldwell estimates. First, this study assumes an Engineering News Record (ENR) Construction Cost Index (CCI; 1913 = 100) of 7420.88 for Los Angeles as of July 5, 2002. The Brown and Caldwell and LACSD review study both used a twenty city average ENR CCI of 6710. Using the Los Angeles index provides a correction that brings the project to the current time and correct location. Second, the Brown and Caldwell and LACSD studies both assumed a 20 percent "Engineering/Legal/Administrative" soft cost to account for additional project costs other than the land and physical construction costs. Most projects experience a much higher soft cost share of 25 percent to 50 percent, but normally do not include land in the value from which the percentage is taken. To correct this, The researchers have applied an "Engineering/Legal/Administrative" soft cost of 25 percent instead of 20 percent to the base construction value, and applied a 10 percent soft cost to the corrected land values.

The Case II and the Case III options of our study require construction of treatment plants of a wide variety of capacities. For plants under 100 MG, The researchers used the cost capacity equation, for plants from 100 to 150 The researchers used $2.2 M per MG of runoff to be treated, for plants from 150 to 250, the researchers used $2.4 M per MG of runoff to be treated, and for plants of more than 250, the researchers used $2.5 M per MG of runoff to be treated. These costs are consistent with both the Brown and Caldwell and with the LACSD studies.

The cost capacity equation is as below

$$C = K \times [Q^{0.6}] \quad \text{(eq. 1)}$$

Where C = cost of collection system in million of dollars

K = cost capacity constant of 11.2372

Q = design flow in millions of gallons

Hence the construction cost for typical plants (of the hundreds of the study) would be as follows (based on three levels of treatment):

- 1 MG plant $ 11,237,200
- 25MG plant) $ 77,521,491
- 45.2 MG plant (B&C Model) $ 110,596,446
- 100 MG plant $ 178,097,618
- 200 MG plant $ 480,000,000

- 500 MG plant $1,250,000,000
- 1,000MG plant $2,500,000,000
- 2,500 MG plant $6,250,000,000

Corrections for real estate costs based on specific plant location and would then be applied to each of these values for each plant in every scenario. Note that plant real estate costs constitute a large portion of the total cost of all scenarios.

The costs of this study are based upon the following assumptions of processes:

- Level I treatment includes: sewage pumping, screening and grinding, grit removal, influent chemical systems, and primary sedimentation
- Level II treatment includes: chlorination, scrubbers, de-chlorination, effluent filtration, effluent screening, effluent pumping/disposal, and defoament
- Level II treatment includes: reverse osmosis

These processes are typical use in the industry today and are consistent with other stormwater treatment studies.

Collection system costs

Collection system costs are a function of the area of land to be treated by a plant and the amount of flow (a function of runoff). For example two basins of the same size (a fixed amount of land) with varying flows would have collection system costs. Similarly for two basins of the same flow but with different land areas would also have different collection system costs. This method is consistent with the methods used by Brown and Caldwell and by LACSD.

The equation to calculate the collection system cost is as below

$$C = K \times [(A \times Q)^{0.5}] \quad \text{(eq. 2)}$$

Where C = cost of collection system in million of dollars

K = 0.0001318 × Q + 0.0594214 where Q is size of plant in MG

A = drainage area in acres

Q = design flow of in millions of gallons (size of plant)

Operations and maintenance costs

Annual operations and maintenance (O&M) costs were calculated on a percentage basis with a different percentage for each level of treatment. This method is consistent with the methods used by Brown and Caldwell and by LACSD.

The O& M cost equation is as below

$$C = M \div F \quad \text{(eq. 3)}$$

Where C = cost of O&M in million of dollars

M = capital cost for each element of the plant (collection system, level 1 treatment, level 2 treatment, and level 3 treatment in million of dollars)

F = factor based on function with

$F_{collection} = 1220.30$

$F_{level\ 1} = 484.66$

$F_{level\ 2} = 333.19$

$F_{level\ 3} = 269.56$

Summary of Cost Estimates

Tables 1 to 3 summarize runoff and cost information for the nine combinations of rainfall scenarios and plant siting cases. Data are presented for the county's seven watersheds as well as county totals. The volume of storm water runoff was computed using modified coefficients of runoff with consideration of antecedent conditions. The runoff coefficients for the seven watersheds in each of the three rainfall scenarios are represented in Column 2 of Tables 1 to 3. In computing the total runoff volume it was also assumed that the first 0.06" of the design rainfall was assumed to fill the local depression areas and, therefore, did not contribute to runoff. The computed total runoff values for the seven drainage basins under each of the scenarios are shown in Column 4 of Tables 1 to 3. Economic impact analysis requires particular attention to the columns headed "Collection System" and "Level III plus Levels I and II." These entries include land costs. As noted above, Level I (physical) treatment consists of equalization and sedimentation. Level II (disinfection) treatment consists of disinfection and de-chlorination. Level III (advanced) treatment is the most ambitious and conventionally consists of reverse osmosis to remove heavy metals.

ECONOMIC IMPACTS

Expenditures of this magnitude will substantially affect the regional economy. An extension of this research has examined the compliance costs and impacts associated with treatment of storm flows produced by 0-0.5" of rain (22 of 32 wet days, or 70% of the average rain events per year), 1.25" of rain (the Brown & Caldwell assumption that corresponds to about 29 of 32 wet days or about 90% of the average rain events per year) and a 2.25" one day storm (statistically about 97% of the average annual storm events).

The net employment impacts associated with the construction and operation of the new treatment plants will be strongly negative despite many with stimulative secondary economic effects. Any short-term positive employment stimulus will be more than offset by the long-term household income reductions necessary to pay for the new facilities. Building and operating a system of treatment plants of the scales described in Tables 1 to 3 involves large expenditures. Paying for these expenditures requires levels of taxation that often have opposite (and usually greater) depressive economic effects. Because construction staging information is not known at this point of the discussion, the authors assume that capital costs are evenly spread over fifteen years of construction activity. Operations and maintenance costs start small and reach full scale in year 16. This is a twenty-year analysis that combines a Year 1-Year 15 construction and operations period, a Year 16-Year 20 full operations period and a Year 1-Year 20 financing period.

The authors assume households throughout Los Angeles county are taxed for twenty years to repay four-percent twenty-year bonds (including 10 percent of underwriting costs). The depressive economic effects of this financing scheme are calculated by reducing households' expenditures by the amount of the annual tax needed to service this debt. Two economic models were used to study the full impacts of all of these activities. The first is IMPLAN (http://www.implan.com/products/products.htm), a 528-sector input-output model describing the economy of the five-county Southern California region. The other model used in this study is a proprietary model developed at the University of Southern California, the Southern California Planning Model (SCPM) which has the unique capability to allocate all of the IMPLAN outputs to the various cities and communities throughout the five-county southern California metropolitan areas.

During the two decades of analysis, job losses will be larger in years 16-20, after the capital spending for new facilities in years 1-15 is completed. For the 65 plant scenario (Case I), on average the annual full-time equivalent ("person year") job losses will range from approximately 31,400 in the event that 70% of the annual storm flow is treated to 199,750 to achieve 97% coverage. The study also estimates that the present value of the 20-year economic impacts associated with the 65-plant base case is strongly negative, again due primarily to higher taxes and lower household income and spending. The magnitude of these losses is predicted to range from a present value of –$24.8 billion to build facilities that can treat 70% of the expected annual storm flows to –$155.6 billion for 97% storm event coverage. About 80% of the predicted economic impacts associated with stormwater treatment facilities will be focused in Los Angeles County. According to the 2000 census, the County was home to approximately 3 million households. This study estimates that each County household will "pay" (experience a negative economic impact) of about $6,670 over 20 years to build facilities that can treat 70% of the expected storms and about $42,000 to achieve 97% storm coverage.

CONCLUSIONS

This work has presented a methodology for conceptual cost budgeting for proposed stringent stormwater treatment plans and standards that require three levels of treatment of all stormwater before it is discharged into a public body of water. The work is case study based and presented nine different cost analyses scenarios based on different strategies for determination of rainfall, locations of plants, and size of plants. To meet these new mandates, communities in the greater Los Angeles and surrounding areas must construct, maintain and operate a very large network of collection and treatment plants and facilities that presently does not exist. Most of these new facilities will remain idle for more than 90% of the time each year. The cost and size of the new collection and treatment facilities increase substantially as they are designed to accommodate a larger number of expected annual rain events. Based on a cost-capacity estimating model, it will cost about six times more to build a system that can handle 97% versus 70% of the region's annual average storm days, or to achieve about 9 additional days of storm flow coverage. Over the twenty year period analyzed in the report, most communities in the greater Los Angeles area will experience very significant employment and net economic losses caused by the new stormwater regulations

Future research should begin to examine benefits of the construction of these plants. At the top-end of these costs (the 2.25" rainfall design storm), the costs will almost certainly be so high that they may seem too difficult to justify remedying events that occur less than two days per year. There is obvious value in policies promoting "beneficial uses" such as swimming, surfing and other forms of water recreation, the maintenance of ocean water quality, and the protection of drinking water sources against contaminants. However, are these valuable benefits worth billions rather than millions? Costs are easier to evaluate in this context than are intangible benefits. Future research should seek to develop a more complete measure of storm water treatment costs to bench mark the benefits that must be achieved for various investments in treatment facilities.

REFERENCES

1. Environmental Protection Agency (May 18, 2000) "Water Quality Standards; Establishment of Numerical Criteria for Priority Toxic Pollutants for the State of California," *Federal Register*, **65** (97), 40 CFR Part 131.

2. State of California, California Regional Water Quality Control Board, Los Angeles Region (December 13, 2001) Order No. 01-182, NPDES Permit No. CAS004001, "Waste Discharge Requirements for Municipal Storm Water and Urban Runoff Discharges within the County of Los Angeles, and the Incorporated Cities Therein, Except the City of Long Beach."

3. State of California, California Regional Water Quality Control Board, Los Angeles Region (February 23, 1995) "Water Quality Control Plan: Los Angeles Region," State Water Resources Control Board and the State Office of Administrative Law: Sacramento.

4. Brown and Caldwell (1998) *Costs of Storm Water Treatment for Los Angeles NPDES Permit Area*. Prepared for the California Department of Transportation

5. County Sanitation Districts of Los Angeles County (2002) memo "Review of the Report 'Caltrans Cost of Storm Water Treatment for the Los Angeles County NPDES Permit Area'", April 29.

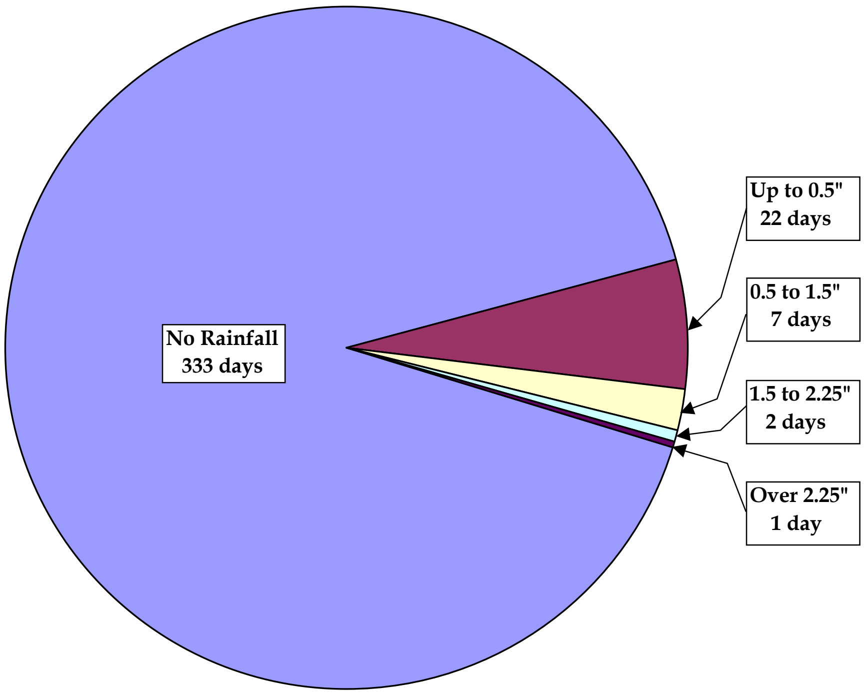

Figure 1. Average Annual Los Angeles Region Rainfall Over the Last 70 Years
24 Hours of Rainfall Distribution

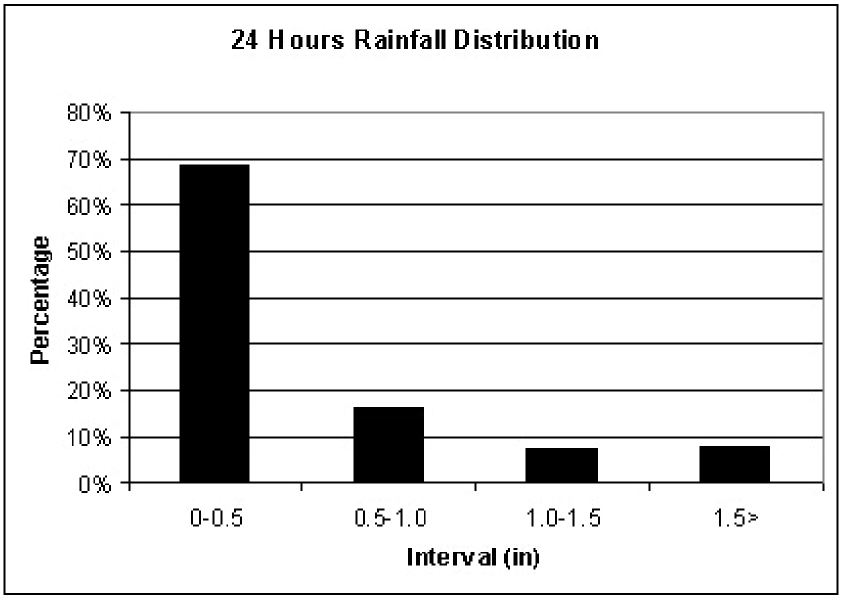

Figure 2: Condition Distribution of Rainfall in Watersheds Affecting Los Angeles County for Those Days on Which Measurable Precipitation Occurs.

Table 1. Cost Data for Multiple 45.2 MG Plants (Numbers Vary by Sub-Basin Flow) – CASE 1

Scenario 1 - 24-hour, 1.25 inch storm
Acres per plant are 11.1 acres

Drainage Basin	Runoff Information			Number of Treatment Plants Required	Treatment Costs, Millions of Dollars									
					Capital Costs						O & M Costs			
	Runoff Coefficient	Drainage Area, Acres	Total Runoff, Million Gallons		Collection System	Level 1	Level 2 plus Level 1	Level 3 plus Levels 1 & 2	Land Costs (Levels 1 & 2)	Level 3 without Land	Collection System	Level 1	Level 2 plus Level 1	Level 3 plus Levels 1 & 2
Dominguez	0.599	69,091	1,337	27	628	1,954	2,887	6,231	2,022	4,209	0.5	2.4	5.2	14.0
Upper Los Angeles Rive	0.452	522,061	7,572	173	4,111	10,379	15,335	33,097	9,916	23,181	3.4	13.8	29.7	79.2
Malibu	0.299	98,729	956	20	635	1,535	2,269	4,896	1,754	3,142	0.5	1.7	3.7	10.0
San Gabriel	0.403	370,468	4,774	107	2,749	6,345	9,375	20,233	5,809	14,425	2.3	8.7	18.7	49.9
Santa Ana	0.423	15,680	214	5	120	249	368	794	182	613	0.1	0.4	0.8	2.2
Santa Clara	0.294	491,947	4,641	104	3,124	4,244	6,270	13,532	1,355	12,177	2.6	8.5	18.2	48.5
Santa Monica Bay	0.504	134,429	2,190	44	1,122	3,479	5,140	11,094	3,932	7,162	0.9	4.0	8.6	22.9
Total		1,702,404	21,684	480	12,489	28,185	41,645	89,877	24,968	64,909	10	40	85	227

Scenario 2 - 24-hour, 0.50 inch storm
Acres per plant are 11.1 acres

Drainage Basin	Runoff Information			Number of Treatment Plants Required	Treatment Costs, Millions of Dollars									
					Capital Costs						O & M Costs			
	Runoff Coefficient	Drainage Area, Acres	Total Runoff, Million Gallons		Collection System	Level 1	Level 2 plus Level 1	Level 3 plus Levels 1 & 2	Land Costs (Levels 1 & 2)	Level 3 without Land	Collection System	Level 1	Level 2 plus Level 1	Level 3 plus Levels 1 & 2
Dominguez	0.539	69,091	445	10	363	650	961	2,074	673	1,401	0.3	0.8	1.7	4.7
Upper Los Angeles Rive	0.407	522,061	2,538	56	2,380	3,479	5,140	11,093	3,324	7,770	2.0	4.6	10.0	26.5
Malibu	0.269	98,729	317	7	366	509	752	1,624	582	1,042	0.3	0.6	1.2	3.3
San Gabriel	0.363	370,468	1,606	36	1,595	2,134	3,154	6,807	1,954	4,853	1.3	2.9	6.3	16.8
Santa Ana	0.381	15,680	71	2	69	83	122	263	60	203	0.1	0.1	0.3	0.7
Santa Clara	0.265	491,947	1,557	34	1,809	1,424	2,104	4,540	455	4,085	1.5	2.8	6.1	16.3
Santa Monica Bay	0.454	134,429	729	16	647	1,158	1,711	3,693	1,309	2,384	0.5	1.3	2.9	7.6
Total		1,702,404	7,263	161	7,228	9,437	13,944	30,094	8,356	21,738	6	13	28	76

Scenario 3 - 24-hour, 2.25 inch storm
Acres per plant are 11.1 acres

Drainage Basin	Runoff Information			Number of Treatment Plants Required	Treatment Costs, Millions of Dollars									
					Capital Costs						O & M Costs			
	Runoff Coefficient	Drainage Area, Acres	Total Runoff, Million Gallons		Collection System	Level 1	Level 2 plus Level 1	Level 3 plus Levels 1 & 2	Land Costs (Levels 1 & 2)	Level 3 without Land	Collection System	Level 1	Level 2 plus Level 1	Level 3 plus Levels 1 & 2
Dominguez	0.629	69,091	2,584	57	874	3,776	5,580	12,043	3,907	8,136	0.7	4.7	10.1	27.0
Upper Los Angeles Rive	0.475	522,061	14,750	326	5,737	20,218	29,873	64,471	19,316	45,155	4.7	26.9	57.8	154.3
Malibu	0.314	98,729	1,843	41	882	2,960	4,374	9,439	3,381	6,058	0.7	3.4	7.2	19.3
San Gabriel	0.423	370,468	9,318	206	3,841	12,384	18,299	39,492	11,338	28,154	3.1	17.0	36.5	97.5
Santa Ana	0.444	15,680	414	9	167	482	712	1,536	351	1,185	0.1	0.8	1.6	4.3
Santa Clara	0.309	491,947	9,039	200	4,360	8,265	12,212	26,356	2,639	23,717	3.6	16.5	35.4	94.5
Santa Monica Bay	0.529	134,429	4,228	94	1,559	6,716	9,924	21,417	7,591	13,827	1.3	7.7	16.6	44.2
Total		1,702,404	42,176	933	17,419	54,802	80,973	174,754	48,522	126,232	14	77	165	441

Table 2. Cost Data for One Plant per Sub-Basin (65 Plants) – CASE 2

Scenario 1 - 24-hour, 1.25 inch storm
Acres per plant range from 665.1 to 1.438 acres

	Runoff Information				Treatment Costs, Millions of Dollars									
					Capital Costs						O & M Costs			
Drainage Basin	Runoff Coefficient	Drainage Area, Acres	Total Runoff, Million Gallons	Number of Treatment Plants Required	Collection System	Level 1	Level 2 plus Level 1	Level 3 plus Levels 1 & 2	Land Costs (Levels 1 & 2)	Level 3 without Land	Collection System	Level 1	Level 2 plus Level 1	Level 3 plus Levels 1 & 2
Dominguez	0.599	73,925	1,337	2	1,547	1,980	2,925	6,314	2,023	4,291	1.3	6.0	18.9	24.0
Upper Los A	0.452	527,446	7,572	9	17,147	10,390	15,352	33,132	9,700	23,432	14.1	31.7	99.4	125.7
Malibu	0.299	99,662	956	24	668	1,625	2,401	5,182	1,896	3,287	0.5	5.0	15.6	19.7
San Gabriel	0.403	377,505	4,774	10	9,655	6,233	9,210	19,876	5,498	14,378	7.9	19.0	59.7	75.4
Santa Ana	0.423	16,634	214	5	133	263	389	839	197	642	0.1	0.8	2.5	3.2
Santa Clara	0.294	498,500	4,641	9	14,208	4,246	6,274	13,541	1,313	12,228	11.6	12.9	40.6	51.4
Santa Monic	0.504	136,878	2,190	6	2,049	3,527	5,211	11,246	3,931	7,315	1.7	10.8	33.8	42.7
Total		1,730,549	21,684	65	45,407	28,264	41,762	90,129	24,556	65,573	37	86	271	342

Scenario 2 - 24-hour, 0.50 inch storm
Acres per plant range from 223.1 to 0.477 acres

	Runoff Information				Treatment Costs, Millions of Dollars									
					Capital Costs						O & M Costs			
Drainage Basin	Runoff Coefficient	Drainage Area, Acres	Total Runoff, Million Gallons	Number of Treatment Plants Required	Collection System	Level 1	Level 2 plus Level 1	Level 3 plus Levels 1 & 2	Land Costs (Levels 1 & 2)	Level 3 without Land	Collection System	Level 1	Level 2 plus Level 1	Level 3 plus Levels 1 & 2
Dominguez	0.539	73,925	445	2	524	653	965	2,084	673	1,410	0.4	2.0	6.3	7.9
Upper Los A	0.407	527,446	2,538	9	4,773	3,455	5,105	11,017	3,251	7,765	3.9	10.5	33.1	41.8
Malibu	0.269	99,662	317	24	351	673	994	2,145	629	1,517	0.3	2.1	6.4	8.1
San Gabriel	0.363	377,505	1,606	10	2,855	2,133	3,152	6,802	1,849	4,952	2.3	6.5	20.4	25.8
Santa Ana	0.381	16,634	71	5	68	112	165	356	65	290	0.1	0.3	1.1	1.3
Santa Clara	0.265	498,500	1,557	9	3,861	1,433	2,117	4,569	441	4,128	3.2	4.4	13.7	17.3
Santa Monic	0.454	136,878	729	6	790	1,111	1,642	3,543	1,309	2,235	0.6	3.4	10.6	13.4
Total		1,730,549	7,263	65	13,222	9,569	14,139	30,515	8,217	22,298	11	29	92	116

Scenario 3 - 24-hour, 2.25 inch storm
Acres per plant range from 1,295.4 to 2.772 acres

	Runoff Information				Treatment Costs, Millions of Dollars									
					Capital Costs						O & M Costs			
Drainage Basin	Runoff Coefficient	Drainage Area, Acres	Total Runoff, Million Gallons	Number of Treatment Plants Required	Collection System	Level 1	Level 2 plus Level 1	Level 3 plus Levels 1 & 2	Land Costs (Levels 1 & 2)	Level 3 without Land	Collection System	Level 1	Level 2 plus Level 1	Level 3 plus Levels 1 & 2
Dominguez	0.629	73,925	2,584	2	3,390	3,827	5,654	12,202	3,909	8,293	2.8	11.7	36.6	46.3
Upper Los A	0.475	527,446	14,750	9	41,651	20,291	29,982	64,706	18,894	45,812	34.1	61.9	194.2	245.5
Malibu	0.314	99,662	1,843	24	1,042	3,013	4,452	9,608	3,654	5,954	0.9	9.2	28.8	36.5
San Gabriel	0.423	377,505	9,318	10	22,972	12,263	18,120	39,106	10,731	28,376	18.8	37.4	117.4	148.4
Santa Ana	0.444	16,634	414	5	211	495	731	1,578	381	1,198	0.2	1.5	4.7	6.0
Santa Clara	0.309	498,500	9,039	9	34,840	8,379	12,381	26,720	2,558	24,163	28.6	25.5	80.2	101.4
Santa Monic	0.529	136,878	4,228	6	4,167	6,803	10,052	21,694	7,589	14,105	3.4	20.7	65.1	82.3
Total		1,730,549	42,176	65	108,272	55,072	81,372	175,616	47,716	127,900	89	168	527	666

Table 3. Cost Data for One Plant Per City/CDP (130 Plants) – CASE 3

Scenario 1 - 24-hour, 1.25 inch storm
Acres per plant range from 1057 to 0.005 acres

Drainage Basin	Runoff Information			Number of Treatment Plants Required	Treatment Costs, Millions of Dollars									
					Capital Costs						O & M Costs			
	Runoff Coefficient	Drainage Area, Acres	Total Runoff, Million Gallons		Collection System	Level 1	Level 2 plus Level 1	Level 3 plus Levels 1 & 2	Land Costs (Levels 1 & 2)	Level 3 without Land	Collection System	Level 1	Level 2 plus Level 1	Level 3 plus Levels 1 & 2
Dominguez	0.599	72,036	1,337	18	803	1,916	2,832	6,111	1,975	4,136	1	2	5	14
Upper Los Angeles Rive	0.452	519,639	7,572	44	18,025	10,267	15,170	32,739	9,650	23,089	15	14	29	78
Malibu	0.299	98,026	956	7	1,227	1,486	2,195	4,737	1,636	3,102	1	2	4	10
San Gabriel	0.403	371,403	4,774	37	8,487	6,116	9,037	19,505	5,610	13,895	7	8	18	47
Santa Ana	0.423	16,365	214	4	129	218	322	694	176	518	0	0	1	2
Santa Clara	0.294	490,288	4,641	4	27,880	4,018	5,937	12,812	789	12,023	23	9	18	49
Santa Monica Bay	0.504	134,647	2,190	16	3,611	3,439	5,081	10,965	3,855	7,110	3	4	9	23
Total		1,702,404	21,684	130	60,162	27,459	40,573	87,563	23,690	63,873	49	39	83	222

Scenario 2 - 24-hour, 0.50 inch storm
Acres per plant range from 355 to 0.002 acres

Drainage Basin	Runoff Information			Number of Treatment Plants Required	Treatment Costs, Millions of Dollars									
					Capital Costs						O & M Costs			
	Runoff Coefficient	Drainage Area, Acres	Total Runoff, Million Gallons		Collection System	Level 1	Level 2 plus Level 1	Level 3 plus Levels 1 & 2	Land Costs (Levels 1 & 2)	Level 3 without Land	Collection System	Level 1	Level 2 plus Level 1	Level 3 plus Levels 1 & 2
Dominguez	0.539	72,036	445	18	377	737	1,089	2,349	657	1,692	0	1	2	5
Upper Los Angeles Rive	0.407	519,639	2,538	44	4,921	3,790	5,600	12,086	3,234	8,852	4	5	10	28
Malibu	0.269	98,026	317	7	454	545	805	1,738	542	1,195	0	1	1	3
San Gabriel	0.363	371,403	1,606	37	2,611	2,314	3,419	7,379	1,887	5,492	2	3	6	16
Santa Ana	0.381	16,365	71	4	67	104	154	333	58	274	0	0	0	1
Santa Clara	0.265	490,288	1,557	4	6,500	1,327	1,960	4,231	265	3,966	5	3	6	16
Santa Monica Bay	0.454	134,647	729	16	1,083	1,309	1,934	4,175	1,283	2,892	1	2	3	9
Total		1,702,404	7,263	130	16,013	10,126	14,962	32,290	7,928	24,363	13	14	29	78

Scenario 3 - 24-hour, 2.25 inch storm
Acres per plant range from 2061 to 0.010 acres

Drainage Basin	Runoff Information			Number of Treatment Plants Required	Treatment Costs, Millions of Dollars									
					Capital Costs						O & M Costs			
	Runoff Coefficient	Drainage Area, Acres	Total Runoff, Million Gallons		Collection System	Level 1	Level 2 plus Level 1	Level 3 plus Levels 1 & 2	Land Costs (Levels 1 & 2)	Level 3 without Land	Collection System	Level 1	Level 2 plus Level 1	Level 3 plus Levels 1 & 2
Dominguez	0.629	72,036	2,584	18	1,408	3,864	5,709	12,320	3,818	8,502	1	5	10	26
Upper Los Angeles Rive	0.475	519,639	14,750	44	44,114	20,826	30,771	66,410	18,797	47,613	36	27	57	152
Malibu	0.314	98,026	1,843	7	2,549	2,985	4,411	9,519	3,153	6,366	2	3	7	19
San Gabriel	0.423	371,403	9,318	37	19,841	12,573	18,578	40,095	10,949	29,145	16	17	36	97
Santa Ana	0.444	16,365	414	4	205	481	711	1,534	341	1,193	0	1	2	4
Santa Clara	0.309	490,288	9,039	4	72,062	7,779	11,494	24,806	1,536	23,270	59	17	36	95
Santa Monica Bay	0.529	134,647	4,228	16	8,379	6,993	10,333	22,301	7,442	14,859	7	8	16	43
Total		1,702,404	42,176	130	148,558	55,501	82,007	176,985	46,037	130,949	122	76	164	438

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