Evaluation of CalTrans' Benefit-Cost Assessment of Alternatives to Control Pollution in Surface Water Run-off

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Chapter I Introduction

In Natural Resources Defense Council et al. v. James W. Van Loben Sels, the United States District Court [Order No. Cv 93-6073 ER (Jrx), 1995] ordered the California Department of Transportation (CalTrans) to evaluate the costs and benefits of alternative means to reduce pollution run-off from CalTrans District 7 roadways into surface waters. CalTrans relies primarily on a report for this evaluation, prepared for CalTrans by Brown and Caldwell (1996). The report by Brown and Caldwell in turn relies upon a method for estimating benefits proposed by Wilchfort, Lund, and Lew (1996) in a separate report prepared for CalTrans.

The goals of the U.S. Clean Water Act are to make surface waterways drinkable, swimmable, and fishable. Sources of emissions are required to obtain permits. CalTrans holds a permit from the Los Angeles Region Water Resources Control Board to discharge pollutants. Under the Clean Water Act, section 402(p), permittees are required in part to control pollution under a maximum extent practicable standard. This standard, as interpreted by the federal court, requires pollution control measures unless the costs greatly outweigh the benefits. Brown and Caldwell (1996) conclude that the costs are substantially greater than the benefits for controlling surface water run-off in CalTrans District 7.

This evaluation of Brown and Caldwell (1996) and Wilchfort, Lund, and Lew (1996) is divided into six chapters. Each chapter evaluates the extent of bias in six inter-related, key facets of the estimation of benefits and costs of treating surface water run-off. Chapter 2 evaluates how the selection of the geographical region under consideration and the time frame for analysis biases the estimates of benefits and costs. Chapter 3 evaluates the extent to which establishing the baseline of pollution without treatment biases the estimates of benefits and costs. Chapter 4 evaluates how the selection of treatment options biasis the benefit-cost calculation. The treatment options determine the cost of treatment, and the amount of pollution reduction. But in addition, the options are considered in the context of the geographical region, time frame, and scope of pollutants included in the analysis. Chapter 5 identifies benefits that are adversely affected by surface water run-off, and compares these with the benefits considered by the CalTrans studies. Chapter 6 evaluates how biases in the analysis are caused by the method used to link changes in pollution to changes in benefits. Chapter 7 evaluates bias in the assignment of dollar values to changes in benefits.

Chapter 8 summarizes the bases for the conclusions of this report. A central conclusion is that the approach to circumscribe benefit-cost analysis in Brown and Caldwell's (1996) study and the method for benefit estimation proposed by Wilchfort, Lund, and Lew (1996) should be rejected. The method proposed by Wilchfort, Lund, and Lew is not from the peer-reviewed literature, and is not based upon any presently known or acceptable theory of economics or econometrics. The method is inconsistent with fundamental economic principles, systematically disregards and eliminates essential data and benefits from the evaluation, and therefore arrives at biased benefit estimates. The approach to benefit-cost analysis by these two interwoven studies biases the benefits down, the costs up, and focuses on the options for pollution control that control only some of the pollution in surface water run-off. The benefit estimates presented by Brown and Caldwell (1996) and Wilchfort, Lund, and Lew (1996) should be rejected as biased.

If the court were to accept the benefit-cost analysis by Brown and Caldwell and the method for benefit estimation by Wilchfort, Lund, and Lew, it would be legitimizing a method for estimating economic benefits that has not passed the rigorous tests imposed on accepted methods, and legitimizing an approach to benefit-cost analysis that is biased.

Chapter 1 References

Brown and Caldwell, 1996, CalTrans Storm Water Facilities Retrofit Evaluation, Draft Volume I, Executive Summary, Chapters 1-10, Appendixes 1-6, prepared for the California Department of Transportation, September, Irvine, California.

Natural Resources Defense Council et al. v. James W. Van Loben Sels, the United States District Court [Order No. Cv 93-6073 ER (Jrx), 1995]

Wilchfort, Orit, Jay R. Lund, and Dan Lew, 1996, Preliminary Economic Valuation of Stormwater Quality Improvement for Ballona Creek, Draft Final, September, Department of Civil and Environmental Engineering and Department of Agricultural and Resource Economics, University of California, Davis.

Chapter II   Geographical and Temporal Scope

Estimates of benefits and costs can be biased by incorrectly specifying the geographical and temporal scope of analysis, the main two subsections of this chapter. Bias can be introduced in several ways to both benefit and cost estimates.

There are five ways the geographical scope of the analysis can bias benefit and cost estimates: (1) Selecting the Watershed for Analysis; (2) Omitting Areas that Receive Waters in the Watershed; (3) Economies of Scale in Cost Estimates from Omitting Pollution Sources within a Watershed; (4) Benefit Transfer: Omitting Classes of Benefits; and (5) Benefit Transfer: Incorrectly Estimating the Value of Benefits.

Geographical Scope

(1) Selecting the Watershed for Analysis: Even if the benefit-cost analysis by Brown and Caldwell (1996) were reliable for the Santa Monica Bay region, the results would be inapplicable to the watersheds in CalTrans District 7 and their reaches. Pollution levels and categories of economic benefits are significantly different between Santa Monica Bay watersheds and the rest of District 7.

Brown and Caldwell (1996) and Wilchfort, Lund, and Lew (1996) omit benefits because of the geographic scope of their analyses. Neither study considered benefits of pollution control in the major watersheds of District 7: the Los Angeles River, the San Gabriel River, the Dominguez Channel, nor the Los Cerritos Channel.

The Los Angeles River plus the San Gabriel River have a factor of 10 times the mass emissions as Ballona Creek. If their conclusion were correct for Santa Monica Bay, it would not be transferable to the broader region encompassed by CalTrans District 7 watersheds and their reaches.

The Los Angeles and Long Beach harbors are critical centers of economic activity for Southern California. The Brown and Caldwell (1996) study is unable to include any comparable harbor in the geographical region they consider. Consequently, any conclusion they reach regarding the benefits and costs of pollution control is inapplicable to the majority of the land area and watersheds affected by pollution in CalTrans District 7. Similarly, the conclusions are inapplicable to regions outside District 7.

(2) Omitting Areas that Receive Waters in the Watershed: Both studies (Brown and Caldwell, 1996, and Wilchfort, Lund, and Lew, 1996) omit geographical areas and receiving waters *within their own watershed study areas* where benefits occur from the pollution reduction, biasing downward the benefit estimates for those watersheds. Wilchfort, Lund, and Lew (1996) omit from their benefit calculations the adjacent Ballona Wetlands, Ballona Lagoon, Venice canals, Dockweiler Beach, and the adjacent beaches along the Santa Monica Bay. Wilchfort, Lund, and Lew (1996) exclude the inland reaches of Ballona Creek. Brown and Caldwell (1996) only consider a small portion of the Ballona Wetlands in their computations of

the benefits of controlling CalTrans-only pollution within the Santa Monica Bay watershed. Brown and Caldwell also omit the Malibu Lagoon in their benefit analysis of the Santa Monica Bay watershed. *These last two omissions alone would almost double the benefit estimation by Brown and Caldwell, had they been included.*

(3) Economies of Scale in Cost Estimates from Omitting Pollution Sources within a Watershed: The third type of bias occurs when cost estimates are based upon more expensive, selective treatment of just some pollution sources. There are economies of scale if a facility can be designed to treat pollution from several sources rather than just one source. Efficient engineering requires consideration of design options that account for geographical connections in a watershed which typically result in surface water pollution run-off from many sources.

Brown and Caldwell acknowledge that there are economies of scale to jointly treat all water in a watershed. Yet they do not present a benefit-cost analysis for joint treatment of all water that reaches the Santa Monica Bay; their benefit-cost analysis is for water from CalTrans sources only. They do not compare benefits and costs of detention ponds with groundwater recharge, water reclamation projects jointly built and operated with water districts, water agencies, cities, and other agencies, or diverting water run-off to Publicly Owned Treatment Works (POTWs) by way of existing sanitary sewers, and seasonally shut off the diversion during heavy rains to avoid overflow to the sewage treatment facilities. Wilchfort Lund and Lew (1996) dismiss a water reclamation option without correctly analyzing the benefits.

(4) Benefit Transfer -- Omitting Classes of Benefits: Bias can occur when benefit estimates from a study of one geographical region are transferred to another region without sufficient care; this can occur in two ways. The fourth type of bias is when pollution reduction can affect beneficial uses, some of which may be present in one geographical region but not in another. Wilchfort, Lund and Lew (1996) bias their benefit estimate downward by confining the study area, thereby omitting classes of benefits in the method they propose. Brown and Caldwell (1996) use Wilchfort, Lund, and Lew's (1996) method, omitting a class of benefits in their analysis of a larger geographical area.

Wilchfort, Lund, and Lew (1996) omit the benefits from preserving and enhancing ecosystems such as the Ballona Wetlands. They also omit health benefits to swimmers at Dockweiler Beach (Haile et al., 1996). Wilchfort, Lund, and Lew (Appendix C, p.5) categorize "preservation value, intrinsic value, bequest value, option value, and existence value" as "nonuse values … not included in the analysis of Ballona Creek." Wilchfort, Lund, and Lew (1996) do not extend the method they propose to ecosystem or health benefits and so omit these important classes of benefits. Brown and Caldwell (1996) apply the method of Wilchfort, Lund, and Lew to the entire Santa Monica Bay. Because the method they use does not consider ecosystem or health benefits, they omit these classes of benefits.

(5) Benefit Transfer -- Incorrectly Estimating the Value of Benefits: If the dollar value of a beneficial use is lower in one geographical region than another, transferring the value from the former geographical region to the latter region biases downward the benefit estimate of pollution reduction; this is what Wilchfort, Lund, and Lew (1996) do, and Brown and Caldwell (1996) follow their example. Wilchfort, Lund, and Lew (1996), use forest service studies from the

1980s to establish a value for outdoor recreation at Southern California beaches. Brown and Caldwell (1996) then apply those estimates to the Santa Monica Bay watershed.

Temporal Scope

Both the analyses by Brown and Caldwell (1996) and by Wilchfort, Lund, and Lew (1996) confine the temporal scope of analysis, biasing downward the benefit estimates. Benefit estimates are biased downward because they only calculate benefits of pollution control for 40 days out of the year. Both studies ignore the economic and population growth in the region, both of which will result in increases in pollution and increases in benefits from pollution reduction over the relevant period. Both of these biases result in benefit estimates that are lower than they would be.

The method proposed by Wilchfort, Lund, and Lew (1996) assumes that pollution emissions are do not have random fluctuations. Brown and Caldwell (1996) use the method proposed by Wilchfort, Lund, and Lew. In fact, "a uniform storm water quality has been assumed for all CalTrans runoff" (Brown and Caldwell, p.iv). To the contrary, between wet years and dry years pollution emissions vary considerably.

A. Geographical Scope of Analysis

For benefit estimation, Brown and Caldwell (1996) follow the approach that Wilchfort, Lund, and Lew (1996) developed and applied for CalTrans. In fact, both reports cite and heavily rely on one, another for key assumptions, data, and estimates. The Wilchfort, Lund, and Lew (1996) report is reviewed as a subcomponent of the report by Brown and Caldwell (1996). But both reports use terminology in confusing ways, such as "basin treatment," "regional treatment" and so on, without clarifying whether they are referring to CalTrans Region 7, the watershed they are analyzing, or whether the treatment is for CalTrans only roads rather than joint treatment by all agencies responsible for all surface water run-off within a watershed. What follows will clarify what these two reports purport to accomplish.

Wilchfort, Lund, and Lew (1996) develop a method for benefit estimation and apply it to retrofitting CalTrans freeways, highways, and other CalTrans facilities within the Ballona Creek watershed. Wilchfort, Lund, and Lew (1996) then extend their benefit estimates to treatment of all roads within the Ballona Creek watershed. Wilchfort, Lund, and Lew (1996) use cost estimates from Brown and Caldwell (1996) to compare benefits and costs of treating only CalTrans pollution emissions for the Ballona Creek watershed. Wilchfort, Lund, and Lew (1996) then use cost estimates from Brown and Caldwell (1996) to compare benefits and costs of treating all surface water run-off from roads within the Ballona Creek watershed.

Brown and Caldwell (1996) follow the method proposed by Wilchfort, Lund, and Lew (1996) to estimate the benefits of treating only CalTrans pollution emissions for all watersheds that reach the Santa Monica Bay. For one study area, Brown and Caldwell (1996) estimate the costs of retrofitting only CalTrans freeways in the Van Nuys quadrangle of freeways. For another study area, Brown and Caldwell (1996) estimate the costs of retrofitting sections of

Pacific Coast Highway along Santa Monica Bay. They use a combination of estimates from the two study areas to derive cost estimates for treating only CalTrans highways and freeways in the Ballona Creek watershed and in the Santa Monica Bay watershed. Brown and Caldwell (1996) also estimate the costs of treating jointly with other agencies all the surface water run-off from all roads in the Ballona Creek watershed. Table 2-1 summarizes which benefit-cost comparisons the two reports purport to make, and the reports within which the benefit-cost comparisons can be found.

Brown and Caldwell (1996) and Wilchfort, Lund, and Lew (1996) omit benefits because of the geographic scope of their analyses. Neither study considered benefits of pollution control in the major watersheds of District 7: the Los Angeles River, the San Gabriel River, the Santa Clara River, and the Dominguez Channel.

Table 2-1: Benefit-Cost Comparisons in Brown and Caldwell and Wilchfort, Lund, and Lew

Watershed\Treatment Option	Retrofit Only CalTrans Roads	Joint Treatment of All Roads
Ballona Creek	Wilchfort, Lund, and Lew	Wilchfort, Lund, and Lew
Santa Monica Bay	Brown and Caldwell	No Analysis
Los Angeles River	No Analysis	No Analysis
San Gabriel River	No Analysis	No Analysis
Santa Clara River	No Analysis	No Analysis
Other Watersheds	No Analysis	No Analysis

1. Selecting the Watershed for Analysis

Brown and Caldwell (1996, pp.8-12) state that the first step in assessing benefits is to define the receiving water reaches. They identify the following: Santa Monica Bay Watershed draining into Santa Monica Bay, Dominguez Channel draining into San Pedro Bay, Los Angeles River and San Gabriel River Watersheds draining into the Pacific Ocean, Santa Clara River Watershed draining into Santa Barbara Channel (Brown and Caldwell 1996: pg., 8-13, Table 8.1). Brown and Caldwell (1996) are misleading when they indicate that the Los Angeles and San Gabriel Rivers drain into the Pacific Ocean; both waterways discharge into San Pedro Bay.

No areas affected by pollution in District 7 are considered for benefit calculations by Brown and Caldwell (1996), except Ballona Creek by reference to and incorporation of the Wilchfort, Lund, and Lew (1996) study, and the Santa Monica Bay watershed as calculated in Chapter 8 of Brown and Caldwell. The majority of the land area in District 7 is in the watersheds of the Los Angeles River plus the San Gabriel River plus the Dominguez Channel, all of which empty into San Pedro Bay, plus the Santa Clara River which empties into Ventura County. No benefits are considered for these watersheds.

The Los Angeles and Long Beach harbors are critical centers of economic activity for Southern California. The Brown and Caldwell (1996) study is unable to include any comparable harbor in the geographical region they consider. Consequently, any conclusion they reach regarding the benefits and costs of pollution control is inapplicable to the majority of the land area and watersheds affected by pollution in CalTrans District 7.

In CalTrans District 7, the relevant areas for consideration are the areas affected by pollutants flowing across and from CalTrans roads and other CalTrans facilities. Presumably this includes all areas within watersheds that would receive surface water run-off from CalTrans highways and roads, including inland waterways, receiving inland water bodies, receiving coastal waters of inland waterways, and habitat and beaches nearby receiving coastal waters. Tables 2-2 and 2-3 list some of these areas.

The Brown and Caldwell (1996) study failures to recognize that runoff from District 7 flows not only into the northern half of Santa Monica Bay, but also into Ventura County, the Pacific Ocean off of Palos Verdes Peninsula, and San Pedro Bay. Excluding the canyons in the northern half of Santa Monica Bay, the Ballona Creek drainage basin, and the Santa Clara River, the remaining watersheds of District 7 drain into the Dominguez and Los Cerritos channels, and the Los Angeles and San Gabriel rivers, all of which discharge into San Pedro Bay. (A Map of Los Angeles County Permitted Area, prepared by the Los Angeles County Department of Public Works, is inserted as the next page of this report without a page number, showiing the watersheds.) The pollution remains constrained by the breakwater, and is channeled into the northern coastal area of Orange County. Yet in Table 8.2 of Brown and Caldwell (1996, p.8-13), they list the LA River as flowing into Santa Monica Bay, and in Table 8.1 they list both the LA River and the San Gabriel River as flowing into the Pacific Ocean.

Nowhere do Brown and Caldwell mention the Los Angeles and Long Beach Harbors which are in San Pedro Bay. These harbors are integral to the regional economy.

Further, the San Pedro, Middle, and Long Beach Breakwaters span about 75% of San Pedro Bay and prevent ocean mixing and dilution of pollutants. Instead, the flow of pollutants is directed by the breakwaters onto the beaches at Long Beach, Seal Beach, Sunset Beach and Bolsa Chica State Beach “with the predominant southward direction of littoral drift along the southern California beaches” (Pan and Schroeder, 1996). Pollution from the Dominguez and Los Cerritos channels and Los Angeles and San Gabriel rivers could have detrimental effects on the interconnected Seal Beach National Wildlife Refuge and the Bolsa Chica Ecological Reserve, which has recently been approved for re-opening to tidal influences (U.S. Department of the Interior, 1997). Brown and Caldwell (1996) do not consider benefits to these geographical areas from controlling surface water run-off in CalTrans District 7. From Table 2-4 it appears that

Table 2-2: Inland Areas Subject to CalTrans Pollutants but Omitted from Analysis

Watershed or Waterbody	Presumably Affected Area
Ventura County	
Santa Clara River	Santa Clara River Channel, Ventura County
Santa Clara River	Filmore State Fish Hatchery
Santa Clara River	Santa Clara River Channel, LA County
Westlake Lake	
Malibu Creek	Malibu Creek State Park
Las Virgenes Creek	Malibu Creek State Park
Chatsworth Reservoir	
Lees Lake	
Topanga Canyon Creek	Topanga State Park
The only inland waterway considered by Brown and Caldwell: Las Virgenes Canyon	Las Virgenes Canyon
LA Reservoir	
Lake Palmdale	
Hansen Flood Control Basin	Hansen Dam Recreation Area
LA River: Sepulveda Flood Control Basin	Victory Sepulveda Dam and Recreation Area
LA River	Toluca Lake
LA River	Hollywood Reservoir
LA River	Silver Lake
LA River	Elysian Park
San Gabriel River	Santa Fe Flood Control Basin
Dalton Creek	Dalton Wash
Dalton Creek	San Dimas Wash
Thompson Creek	Paddington Reservoir
Thompson Creek	Frank G. Bolelli Regional Park
Brea Canyon Creek	Brea Canyon Creek Channel
Legg Lake	Rio Hondo Recreation Area
Rio Hondo River	Rio Hondo River Channel
San Gabriel River	Upper San Gabriel River Channel

Source: Automobile Club of Southern California, 1995 map of Los Angeles County and Vicinity

Table 2-3: Coastal Areas Subject to CalTrans Pollutants

Watershed and/or Highway	Presumably Affected Area
Not considered by B&C	
Ventura County	
Santa Clara River	Ventura Harbor Channel Islands National Park
Santa Clara River	McGrath State Beach
Santa Clara River	Mandalay State Beach
Considered by B&C	
Ventura County to Ballona Creek in Santa Monica Bay	
Arroyo Sequit	Leo Carrillo State Beach
Nicholas Canyon	Nicholas County Beach
Los Alisos Canyon	R.H. Meyer Memorial State Beach
Decker Canyon	R.H. Meyer Memorial State Beach
Lachusa Canyon	R.H. Meyer Memorial State Beach
Encinal Canyon	Trancas Beach
Trancas Canyon	Zuma County Beach
Zuma Canyon	Pt. Dume State Beach
Ramirez Canyon	Paradise Cove
Escondido Canyon	Latigo Pt.
Latigo Canyon	Dan Block State Beach
Sostice Canyon	Dan Block State Beach
Puerco Canyon	Puerco Beach
Malibu Canyon	Puerco Beach
Winter Canyon	Amarillo Beach
Malibu Creek	Malibu Beach
Malibu Creek	Malibu Lagoon
Jerry's (Sweetwater) Canyon	Keller's Shelter
Carbon Canyon	Carbon Beach
Las Flores Canyon	La Costa Beach, Las Flores Beach
Piedro Gorda Canyon	Big Rock Beach
Pena Canyon	Las Tunas State Beach
Tuna Canyon	Topanga Beach
Topanga Canyon	Topanga State Beach
San Ynez Canyon	Topanga State Beach
Pulga Canyon	Will Rogers State Beach
Temescal Canyon	Will Rogers State Beach
Ballona Creek	Santa Monica State Beach
Ballona Creek	Venice Municipal Beach
Ballona Creek	Ballona Wetlands
Ballona Creek	Marina Del Rey
Not considered by B&C	
Ballona Creek	del Rey Lagoon
Ballona Creek	Ballona Lagoon
Ballona Creek	Venice Canals

Table 2-3 Continued: Coastal Areas Presumably Affected by CalTrans Pollutants

Southern Santa Monica Bay	
Ballona Creek	Dockweiler State Beach
Ballona Creek	El Segundo Beach
Ballona Creek	Manhattan State Beach
Ballona Creek	City of Manhattan Beach
Ballona Creek	City of Hermosa Beach
Ballona Creek	City of Redondo Beach
Ballona Creek	King Harbor
Ballona Creek	Redondo City Beach
Ballona Creek	Redondo State Beach
Ballona Creek	Torrance Beach
Ballona Creek	Rat Beach
Not considered by B&C	
Palos Verdes Peninsula	
Hwy 107	Bluff Cove
Hwy 107	Palos Verdes Pt.
Hwy 107	Lunada Bay
Hwy 107	Resort Pt.
Hwy 107	Rancho Palos Verdes
Hwy 107	Pt. Vicente
Hwy 107	Long Pt.
Hwy 107	Abalone Cove
Hwy 107	Portugese Bay
Hwy 107	Inspiration Pt.
Hwy 213	White Pt.
Hwy 213	Pt. Fermin
Not considered by B&C	
San Pedro Bay	
Dominguez Channel	Los Angeles Harbor, Long Beach Harbor, San Pedro Bay
Los Angeles River	San Pedro Bay
Los Cerritos Channel	Bahia Marina, Long Beach Marina, San Pedro Bay
Los Cerritos Channel	San Pedro Bay and Orange County Pacific Ocean
San Gabriel River	San Pedro Bay and Orange County Pacific Ocean
Waterways to San Pedro Bay	Bellmont Shore, San Pedro Bay
Northern Coastal Orange County	
Waterways to San Pedro Bay	Seal Beach
Waterways to San Pedro Bay	Anaheim Bay
Waterways to San Pedro Bay	Seal Beach National Wildlife Refuge
Waterways to San Pedro Bay	Sunset Aquatic Regional Park
Waterways to San Pedro Bay	Surfside Beach
Waterways to San Pedro Bay	Sunset County Beach
Waterways to San Pedro Bay	Huntington Harbor
Waterways to San Pedro Bay	Bolsa Chica State Beach
Waterways to San Pedro Bay	Bolsa Chica Ecological Reserve

Sources: Automobile Club of Southern California, 1995 map of Los Angeles County and Vicinity; and Automobile Club of Southern California, 1995 map of Metropolitan Los Angeles: Central and Western Area; Automobile Club of Southern California, 1995 map of Metropolitan Los Angeles: Southern Area Automobile Club of Southern California, 1995 map of Central Orange County Area

Brown and Caldwell omitted the watersheds in District 7 from their analyses that have the greatest amount of annual pollution, those that empty into San Pedro Bay. The Los Angeles River plus the San Gabriel River have a factor of 10 times the mass emissions as Ballona Creek. If their conclusion were correct for Santa Monica Bay, it would not be transferable to the broader region encompassed by CalTrans District 7 watersheds and their reaches.

The method proposed by Wilchfort, Lund, and Lew (1996) assumes that pollution emissions are constant across geographical regions. Brown and Caldwell (1996) use the method proposed by Wilchfort, Lund, and Lew. In fact, "a uniform storm water quality has been assumed for all CalTrans runoff" (Brown and Caldwell, p.iv). To the contrary, pollution emissions vary considerably across geographical regions, as shown by the Santa Monica Bay Restoration Project (1994, pp. 7-6 and 7-7) with extensive data for 44 individual pollutants for Malibu Creek, Santa Monica Canyon, Pico-Kenter Stormdrain, Ballona Creek, and Centinela Creek. In a study prepared for CalTrans, regional variation is considerable, as shown in Table 2-4 duplicated from Pan and Schroeder (1996).

Table 2-4: Estimated mass emissions from Rivers in CalTrans District 7 of Selected Contaminants from Six Streams in 1988 Water Year (Source SCCWRP, 1992)

Stream	Susp. Sol. 10^3 kg	Cd kg	Cr kg	Cu kg	Ni kg	Pb kg	Zn kg	ΣPCB kg
Santa Clara River	28,236	40	1,702	1,560	965	2,554	7,490	1.4
Calleguas Creek	20,893	94	3,408	2,508	1,944	878	6,113	5.9
Ballona Creek	18,276	152	1,694	6,147	1,849	12,579	34,296	7.7
Los Angeles River	154,639	801	6,357	18,694	7,287	32,145	84,169	40.1
San Gabriel River	113,671	499	7,486	12,060	4,990	17,189	56,558	18.4
Santa Ana River	85,294	67	2,559	3,644	2,352	2,662	18,584	2.0

Source: Table 3 of Pan and Schroeder (1996). The title of the table given by the authors, Pan and Schroeder, erroneously assigns Santa Monica Bay as the receiving water of all these rivers.

2. Omitting Areas ***Within CalTrans Watershed Study Areas*** *Affected by Pollution Control*

In a benefit-cost comparison of pollution control in a watershed, omitting benefits to areas that could or would receive cleaner water tends to bias the results against pollution control.

a. Areas Included by Brown and Caldwell and by Wilchfort, Lund, and Lew

For benefit analysis, Brown and Caldwell (1996) use the study by Wilchfort, Lund, and Lew (1996) as a "representative study area". Wilchfort, Lund, and Lew (1996) represent that they found the value of improved storm water runoff quality in Ballona Creek. Their areas of analysis consist of the last 2-3 miles of the creek and Marina del Rey. Brown and Caldwell (1996) apply the approach of Wilchfort, Lund, and Lew (1996) to the Ballona Creek and other urban watersheds that empty into Santa Monica Bay, from the Ventura County border to Palos Verdes Peninsula, including Ballona Creek (and thus omiting the LA River watershed).

b. Areas Omitted by Brown and Caldwell and by Wilchfort, Lund, and Lew

Wilchfort, Lund, and Lew (1996) omit from their benefit calculations the adjacent Ballona Wetlands, Ballona Lagoon, Venice canals, Dockweiler Beach, and the adjacent beaches along the Santa Monica Bay. Brown and Caldwell (1996) only consider a small portion of the Ballona Wetlands in their computations of the benefits of controlling CalTrans-only pollution within the Santa Monica Bay watershed.

Brown and Caldwell (1996, p.1-5) state that for benefit analysis "[t]he representative study area selected was the Ballona Creek drainage basin, an area of about 130 square miles that collects storm water from the area south of the Santa Monica Mountains and between Interstates 405 and 110". However, it is clear in their study that the only areas actually considered were those at the end of the creek toward the outlet; they ignored any inland benefits that might accrue to the remaining expanse of the Ballona Creek drainage basin, through the city and into the mountains.

Wilchfort, Lund, and Lew (1996) omit benefits to the Ballona Wetlands and the beaches at the outlet of Ballona Creek. To justify these omissions, they report (p.6) that on a visit 20 June 1996, they did not detect physical "connections between Ballona Creek and the Ballona Lagoon, Venice Canals, and del Rey Lagoon; these reaches appear to be unaffected by flows and storm water quality in Ballona Creek." They are demonstrably wrong for four reasons. One, this error is one page after a diagram that reveals extraordinary variation in flow rates from Ballona Creek between dry periods, such as their June 20 visit, and during storms. Second, the California Regional Water Quality Control Board, Los Angeles Region (LARWQCB, 1997) lists Marina del Rey, the Ballona Wetlands, Ballona Lagoon, and the Del Rey Lagoon as an interconnected complex of habitat. Third, on a visit 22 November 1997, first-hand observations include birds foraging and moving among Ballona Creek, Ballona Wetlands, Ballona Lagoon, and Venice Canals, so that pollution in any of these waters affects wildlife that inhabit the area. Table 2-5 lists birds observed during that visit. Fourth, the Santa Monica Bay Watershed (1993, p.55-60) states, "Ballona Lagoon is a tidally influenced marine habitat. It receives tidal flows through a set of culverts which connect to the Marina Del Rey ocean channel. … Del Rey Lagoon is a non-tidal lagoon which receives saline water via a controlled culvert from Ballona Creek. … The main sources of water to Del Rey Lagoon include 1) storm water runoff, and 2) tidal inflow from Ballona Creek."

The Santa Monica Bay Restoration Project (1994, p8-13) details plans to restore the Ballona Wetlands. Restoration of the Wetlands is a potential use for water reclaimed from Ballona Creek, a potential benefit not considered by Wilchfort, Lund, and Lew (1996), nor by Brown and Caldwell (1996).

Wilchfort, Lund, and Lew (1996) ignore the Ballona Creek Wetlands, and Brown and Caldwell (1996) only consider a small portion of the wetlands, 35.15 acres (Brown and Caldwell, Table 8.9, p. 8-22). The LARWQCB (1997) states, "the 260-acre Ballona Wetland is the largest remaining wetland within this complex" (p.102). Brown and Caldwell also omit the 40-acre Malibu Lagoon in their benefit analysis of the Santa Monica Bay watershed (see Brown and Caldwell, Table 8.9, p. 8-22). *These two omissions alone would almost double the benefit estimation by Brown and Caldwell, had they been included.* This points to the lack of geographical scope inherent in the method proposed by Wilchfort, Lund, and Lew (1996) and adopted by Brown and Caldwell (1996).

Table 2-5 22 Nov 97 Ballona Wetlands Visit

Shore birds using the estuary Mud and rocky shore	Other birds present
	Caved Grebe
Killdeer	Double-crested Cormorant
Willet (common)	Green-Winged Teal
Whimbrel	Great Egret
Least Sandpiper	Snowy Egret
Ruddy Turnstone	Great Blue Heron*
Black Turnstone	Northern Harrier
	Savannah Sparrow
	Surf Scoter
	Red-Breasted Merganser

*Approximately 20 Great Blue Heron all in one small location.

Wilchfort, Lund, and Lew (1996, p.24) simply assert that swimming at Dockweiler beach "is unaffected by Ballona Creek" so they omit the beach from their analysis. To the contrary, the LARWQCB (1997, p.101-104) lists the adjacent beaches, including Dockweiler State Beach and Venice Beach, as well as Santa Monica Bay and the ocean, as part of the Ballona Creek watershed where beneficial uses are impacted by pollution runoff. The Santa Monica Bay Restoration Project (1994, Chapter 6) states that Ballona Creek sediment builds up at the breakwater at Marina del Rey Harbor, and sediment is dredged and moved "downcoast of the entrance, where long shore currents transported the material downcoast" (p.6-9). Moreover, "Advection is the transport of material by ocean currents, … (dispersing) contaminants which are discharged into the Bay" (p.6-12).

Wilchfort, Lund, and Lew (1996) exclude the inland reaches of Ballona Creek. Much of the inland exclusion is justified by claiming that as a channeled storm drain, Ballona Creek has only a limited potential to accrue benefits beyond those at the creek outlet. In failing to envision the flow from the upper reaches of the basin as potential water reclamation sites or as progress toward the "California goal that all fresh water be a potential drinking water source" (Brown and Caldwell, 1996, Executive Summary: iv), Wilchfort, Lund, and Lew (1996) circumscribe the potential for beneficial use.

3. Economies of Scale in Cost Estimates -- Omitting Pollution Control of Pollution from Other Sources within a Watershed

Brown and Caldwell (1996) "scale up" the results from the Ballona Creek study by Wilchfort, Lund, and Lew (1996) to the area circumscribed by the Santa Monica Bay up to the county line between Los Angeles County and Ventura County. They also "scale up" the cost estimates for treatment that would only reduce pollution from CalTrans facilities within the Santa Monica Bay watershed. They omit analysis of joint treatment with other agencies within the Santa Monica Bay watershed.

Brown and Caldwell (1996, p. 1-5) used a scale-up of the cost estimates from the Van Nuys Quadrangle and from a portion of Pacific Coast Highway to estimate retrofit costs for CalTrans facilities in the Ballona Creek watershed, for all roads and run-off in the Ballona Creek watershed with joint treatment, for CalTrans facilities only within the Santa Monica Bay watershed, and for CalTrans facilities only within the entire area of District 7. Brown and Caldwell (1996, Chapter 8) present cost estimates for CalTrans facilities within the portion of District 7 that drains into the Santa Monica Bay. While it is likely that cost estimates can be transferred from one geographical region to another more easily than benefit estimates, such methodology suffers from the exclusion of scale economies that Brown and Caldwell use in their comparison of benefits and costs in Chapter 8. Limiting the feasible set of treatment options inflates cost estimates, biasing the results of the benefit-cost comparison.

The geographic extent of a project may be suggestive of the degree to which scale economies may be present. Economies of scale means that over a particular range of output, average cost will be decreasing as the scale of the project increases. If the geographic scope of a project is too narrowly defined, the analyst may exclude from the feasible set the very options that reduce the cost. The failure to minimize costs will result in biased conclusions. Brown and Caldwell (1996) were aware of this problem:

> *"An additional preliminary analysis was performed to determine if an economy of scale could be realized by treating flows from an entire drainage area, including County and City areas. It was concluded from this analysis that, on a unit cost basis (dollar per gallon of storm water treated), it would be more cost-effective to build a regional treatment facility because the existing collection system would be in place and the larger treatment facilities are more cost effective considering both construction cost and annual operating costs" (Brown and Caldwell 1996: Executive Summary viii).*

Why this more efficient scale of operation was not chosen for their benefit-cost analysis is unclear. In Chapter 6, Brown and Caldwell (1996) present cost calculations for joint (with other government agencies) treatment projects in the Ballona Creek watershed (Brown and Caldwell add confusion by referring to this as "regional treatment"), but they do not extend the cost calculations to the Santa Monica Bay watershed. Brown and Caldwell also do not follow through with an analysis of benefits from joint treatment, nor a benefit-cost comparison for joint treatment projects in the Santa Monica Bay watershed. They only consider benefits of treating

CalTrans pollution alone, which they acknowledge is a much more costly treatment, thereby diminishing the objectivity of their conclusions.

A study prepared by UC Davis for CalTrans (Schroeder and Smith, 1996, p.5) states: "Multiple use facilities, such as detention ponds and groundwater recharge facilities may be relatively inexpensive" with "local geography… an important factor." Brown and Caldwell (1996) do not compare benefits and costs of detention ponds with groundwater recharge. CalTrans' own consultants have identified these options as potentially inexpensive, yet CalTrans seemingly did not instruct Brown and Caldwell to analyze these options.

Brown and Caldwell (1996) regularly cite and rely on the study by Wilchfort, Lund, and Lew (1996). That study identifies water reclamation as an option, but does not analyze the benefits or costs. Wilchfort, Lund, and Lew (1996, p.20) cite a study (City of Los Angeles, 1995) that estimates that reclaimed water at Ballona Creek would cost $1,300 per acre-ft at 2cfs, 20% of average daily dry weather flow. But Wilchfort, Lund, and Lew (1996) fail to consider the benefits, merely claiming that the project is not economic. Because they do not consider the marginal cost of water that this reclamation project would displace, plus the benefit of reduced pollution, plus the potential benefit of reclaiming the Ballona Creek Wetlands, their claim is not supported by adequate analysis.

Given all of the drainage canals within District 7, there may be water reclamation projects that are economic without even considering the pollution control benefits. But the maximum extent practicable test requires consideration of the benefits of reduced pollution, which could reveal additional water reclamation projects that are economic after considering the benefits of pollution reduction. Water reclamation projects jointly built and operated with water districts, water agencies, cities, and other agencies may have joint benefits that exceed joint costs, but this potential is unexplored by Brown and Caldwell (1996).

An option omitted by Brown and Caldwell (1996) is to divert water runoff to Publicly Owned Treatment Works (POTWs) by way of existing sanitary sewers, and seasonally shut off the diversion during heavy rains to avoid overflow to the sewage treatment facilities. The County Sanitation Districts of Los Angeles County, the City of Los Angeles, and Las Virgenes Municipal Water District/Triunfo County Sanitation District (TWRC) own existing transmission facilities that parallel the coastline, and own sewage treatment facilities that could be used to treat runoff without the construction and land acquisition expense of treatment level 2 (and treatment level 3 in the case of TWRC).

Another option, mentioned by Brown and Caldwell, (1996, p.8-9), is to use trapping catch basins at drainage inlets, but Brown and Caldwell do not consider this option. Instead, they mention a study by Woodward-Clyde and Uribe & Associates, September 1996, without including the study in the references, nor presenting any information from it.

Only Wilchfort, Lund, and Lew (1996) consider the benefits and costs from joint control by CalTrans and other authorities for pollution control of all surface water run-off from all roads, and that study is both flawed and confined to the Ballona Creek watershed.

4. Benefit Transfer: Omitting Classes of Benefits

By confining their analysis to the last portion of Ballona Creek and the marina, Wilchfort, Lund, and Lew (1996) omit the benefits from preserving and enhancing ecosystems such as the Ballona Wetlands. They also omit health benefits to swimmers at Dockweiler Beach (Haile et al., 1996). Wilchfort, Lund, and Lew (Appendix C, p.5) categorize "preservation value, intrinsic value, bequest value, option value, and existence value" as "nonuse values … not included in the analysis of Ballona Creek." They give two reasons. "First, nonuse values are generally thought to be associated with unique resources that have no readily available substitutes for providing the amenities people value. Ballona Creek, a channeled storm drain, does not fall into this category of resource amenity. … The second reason that nonuse values are not included is the question of measurement. There are no credible empirical measurements of nonuse value for ordinary streams such as Ballona Creek because they are believed *a priori* to be small" (Appendix C, p.5-6). Wilchfort, Lund, and Lew (1996) do not extend the method they propose to ecosystem or health benefits and so omit these important classes of benefits.

Brown and Caldwell (1996) apply the method of Wilchfort, Lund, and Lew to the entire Santa Monica Bay. Because the geographical region is not confined in the Brown and Caldwell study, one would expect that these important classes of benefits – ecosystem and health benefits – would be included in their benefit calculations. Because the method of Wilchfort, Lund, and Lew does not consider nonuse, ecosystem, or health benefits, Brown and Caldwell also omit these classes of benefits.

5. Benefit Transfer: Incorrectly Estimating the Value of Benefits

Downing and Ozuna (1996, p.322) describe benefit accrual as a "function of non-linear random variables" such that a benefit function estimated in one geographical area could result in biased and inaccurate measures of economic welfare when applied to other areas. Wilchfort, Lund, and Lew (1996), use forest service studies from the 1980s to establish a value for outdoor recreation at Southern California beaches. Brown and Caldwell (1996) then apply those estimates to the Santa Monica Bay watershed. Benefit transfer should be approached with some care, but it has not been in the study. This issue is systematically developed in Chapter 7.

B. Temporal Scope

Investment projects, such as projects to improve runoff quality, accrue both benefits and costs not only in the current period, but often for many years into the future. In order to determine the feasibility of a project, it is necessary to estimate the benefits and costs over the lifetime of the project. There are a few basic guidelines to select the time frame for study: 1) the time period should be long enough to evaluate the importance of long term trends that affect benefits and costs, 2) the time period should account for periodic and temporally related random fluctuations of factors that influence benefits and costs, and 3) the length of time chosen should correspond to the majority of foreseeable benefits that accrue.

1. Economic and Population Growth will Increase Pollution Over Time unless There is Additional Pollution Control

Brown and Caldwell (1996) use a twenty year time frame for their analysis, which should adequately reflect the relevant time frame. But Brown and Caldwell ignore the economic and population growth in the region, both of which will result in increases in pollution and increases in benefits from pollution reduction over the relevant period. Increasing pollution makes it increasingly necessary to reduce pollution. A higher population means that the benefits from pollution reduction will accrue to more people, so the net benefits from pollution reduction will increase. An increase in pollution means that the per capita benefits of pollution control will increase. An increase in economic growth means that those who live in the area will be willing to pay more for pollution reduction. Neither study (Brown and Caldwell, 1996, and Wilchfort, Lund, and Lew, 1996) considers these impacts on the benefits of controlling surface water run-off.

2. Temporal Fluctuations in the Levels of Pollution

The method proposed by Wilchfort, Lund, and Lew (1996) assumes that pollution emissions do not have random fluctuations. Brown and Caldwell (1996) use the method proposed by Wilchfort, Lund, and Lew. In fact, "a uniform storm water quality has been assumed for all CalTrans runoff" (Brown and Caldwell, p.iv). To the contrary, between wet years and dry years pollution emissions vary considerably, as shown by the Santa Monica Bay Restoration Project (1994, p 7-8) with extensive data for 33 individual pollutants for Ballona Creek and Malibu Creek. The assumption of uniformity is grossly inconsistent with the facts.

3. Year-Round Benefits of Pollution Control

Neither study (Brown and Caldwell, 1996, and Wilchfort, Lund, and Lew, 1996) considered year round benefits of pollution control, instead calculating benefits based on 40 days out of the year, in essence presenting a fraction of the benefits.

The benefits of improved water quality are year-round benefits, not just benefits during the 40 storm days of the year. For any of the levels of treatment defined by Brown and Caldwell (1996), and for regional water reclamation and treatment options, and for other possible regional best management practices, treatment that reduces pollution during storms also reduces pollution at other times. The only benefits considered by these two studies are recreation benefits during and immediately after storms. Yet the Santa Monica Bay Restoration Project (1996) demonstrated year-round discharge of urgan runoff. This confines the analysis to 40 days out of the year, rather than 365 days, which biases the benefit estimates downward.

The benefits of pollution control are enjoyed year-round. Storm water treatment facilities are designed to manage the large volume of water during storms, but run-off treatment occurs all 365 days of the year. Run-off treatment all year will generate benefits all year. The appropriate time frame of analysis during any given year is all 365 days during which both benefits and costs are accrued.

The Los Angeles Regional Water Quality Control Board (1997) specifically refers to dry period runoff from storm water channels that pollutes the inland waterways, the marshes, wetlands, lagoons, beaches, and the ocean off Santa Monica Bay. Moreover, many pollutants are deposited in the rivers, harbors, wetlands, beaches, and the ocean. These pollutants remain a potential threat, and are periodically released over time. Some bioaccumulate, such as PAH and organic pollutants, while other pollutants mix with sediment and are later released when currents, tides, storms, dredging, or other forces mix sediments with the water. The concerns expressed by the LARWQCB (1997) for exposure to pathogens by swimmers, divers, surfers, and other water contact activities expressly include the dry weather periods.

Brown and Caldwell (1996) select for benefits only the 40 days out of the year including and immediately following storms, yet the entire year is utilized for cost evaluation. This – and the other limitations – biases the calculations by Brown and Caldwell (1996) and by Wilchfort, Lund, and Lew (1996) that skew relative comparisons of benefits and costs.

Chapter 2 References

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Chapter III The Baseline Level of Pollution Concentration in Surface Water Run-Off Without Treatment

The baseline level of pollution run-off has two parts: (i) the current pollution concentration in surface water run-off – without treatment, and (ii) the future pollution concentration in run-off without treatment during the period relevant to the proposed treatment options. In order to estimate the benefits of pollution control, it is necessary to establish the baseline of pollution prior to control, and the level of benefits corresponding to that amount of pollution. The treatment options determine how much reduction in pollution is possible and at what cost. The level of pollution after treatment is integral to the new level of benefits. The benefit-cost test compares the increase in benefits to the treatment cost.

In order to accurately assess the benefits, it is necessary to accurately measure the baseline. This chapter establishes that the baseline used by CalTrans in their conclusions about the benefits and costs of pollution control in District 7 only contains the first part – the current condition – and omits the expected increase in future pollution in the absence of treatment.

Irrespective of the original source of pollution, all reductions in pollution that are provided by treatment affect the benefit calculus. If pollutants that would be controlled are omitted from the analysis because they are not considered when establishing the baseline, then the benefits of treatment are biased downward. This chapter demonstrates that Brown and Caldwell (1996) omit numerous pollutants that typically are found in CalTrans run-off, and they omit pollutants from sources other than CalTrans that would be controlled by regional pollution control measures. Wilchfort, Lund, and Lew (1996) establish their baseline for analysis from information obtained from Brown and Caldwell, so both analyses have this bias.

Wilchfort, Lund, and Lew (1996) propose a method to estimate benefits of treatment, a method upon which Brown and Caldwell (1996) rely. In their method, as detailed in Chapter 5 below, they propose a range given by an upper bound and a lower bound for surface water run-off of each pollutant. For the treatment measures that they consider, if the baseline is outside the range they propose and if the pollution reduction does not include the range, then they propose omitting the pollutant from the analysis and setting any derivative benefits equal to zero. In this way, their method eliminates benefits of pollution control from the benefit estimate. Specific to their method, if the baseline they use in their analysis places a pollutant below the range they propose, then they omit any benefits from controlling that pollutant. For many pollutants Brown and Caldwell (1996) analyze, their baseline is a constant value below the range they propose. This chapter shows that, to the contrary, the actual level of pollution randomly varies geographically and over time, so that the method proposed by Wilchfort, Lund, and Lew (1996) arbitrarily omits benefits of pollution control. This chapter also shows that variation in pollution run-off from CalTrans roads and highways is typically higher than the baseline established by Brown and Caldwell (1996) for most pollutants.

A. Common CalTrans Pollutants

The CalTrans – UC Davis Storm Water Quality Project has compiled from the "Storm Water Monitoring Site Inventory" a summary of the pollutants of storm water runoff from CalTrans highways and freeways (Dammel 1997). The various pollutants are divided into five general categories: Physical and Aggregate Properties, Metals, Inorganic Non-metallics, Aggregate Organics, Microbiological. Ranges of typical and observed values are supplied for each pollutant as well as the relative frequency of detection. Table 3-1 summarizes the key information.

The CalTrans – UCD project also identified less common CalTrans storm water pollutants. These are significant here because all, with the exception of cyanide, appeared in District 7 samples. Table 3-2 lists the less common pollutants.

The Los Angeles Regional Water Quality Control Board (RWQCB, 1997) lists 19 pollutants/categories of pollutants: DDT, PCBs, polycyclic aromatic hydrocarbons (PAHs), chlordane, tributyltin (TBT), cadmium, chromium, copper, lead, nickel, silver, zinc, bacteria/viruses, total suspended solids, nutrients, trash, chlorine, oxygen demand, and oil & grease. The pollutants relevant for this study are not just the pollutants that emanate from CalTrans sources, but also all pollutants that would be reduced with any joint pollution control projects, since those projects generate benefits by reducing all pollutants, not just pollutants from CalTrans.

Having defined the current condition, the next consideration is the change in the current condition over the relevant time frame, assuming that no treatments beyond those extant would be implemented. As pointed out in Chapter 2 above, factors that would likely increase pollution emissions over the next 20 years are increases in population and economic activity. Some of the literature reviewed in Appendix 3.1 of Brown and Caldwell (1996) could be helpful in estimating the increase in pollution. The first flush effect is the higher levels of pollution that occur when storms follow a dry period. First flush is logically a function of ADT (average daily traffic) and the time for buildup of pollutants since the last storm. One author reviewed by Brown and Caldwell, Barrett et al. (p.1-2), relates mean pollution to VDS (vehicles during storm), which would increase with population and economic activity. Fecal coliform is logically a function of the area of the roads, so as highways and the number of lanes and miles are added with population and economic growth, more fecal coliform would be added to storm water run-off.

Table 3-1. Commonly Observed Highway and Freeway Runoff Parameters (from Dammel 1997)

Parameter	Frequency (Detection / #Samples)	Typical Range	Units
Physical & Aggregate Properties			
Turbidity	100.0%	0-200	NTU
Alkalinity	94.1%	0-50	mg/L
Hardness	100.0%	0-100	mg/L
Conductivity	100.0%	0-300	umhos/cm
Salinity	100.0%	0-0.5	Alone
Total Dissolved Solids	88.5%	0-1000	mg/L
Total Suspended Solids	92.3%	0-1000	mg/L
Volatile Suspended Solids	100.0%	0-200	mg/L
Settleable Solids	40.0%	0-1	mg/L
Metals			
Barium	96.3%	0-0.5	mg/L
Calcium	100.0%	0-50	mg/L
Copper	72.0%	0-0.2	mg/L
Iron	100.0%	0-30	mg/L
Lead	78.8%	0-0.2	mg/L
Magnesium	100.0%	0-10	mg/L
Manganese	100.0%	0-0.2	mg/L
Potassium	100.0%	0-10	mg/L
Sodium	100.0%	0-20	mg/L
Zinc	90.6%	0-1	mg/L
Inorganic Nonmetallics			
Chloride	95.2%	0-20	mg/L
Fluoride	93.8%	0-2	mg/L
pH	100.0%	5-9.	pH Units
Ammonia (Nitrogen)	100.0%	0-5	mg/L
Nitrite	50.0%	0-2	mg/L
Nitrate	100.0%	0-10	mg/L
Organic Nitrogen (inc. Kjeldahl)	97.9%	0-10	mg/L
Dissolved Oxygen	100.0%	0-10	mg/L
Ortho-phosphate Phosphorus	100.0%	0-1	mg/L
Dissolved Phosphorus	100.0%	0-1	mg/L
Total Phosphorus	100.0%	0-2	mg/L
Sulfate	95.2%	0-20	mg/L
Aggregate Organics			
Biochemical Oxygen Demand	88.6%	0-100	mg/L
Chemical Oxygen Demand	100.0%	0-500	mg/L
Total Organic Carbon	100.0%	0-100	mg/L
Oil and Grease	73.5%	0-50	mg/L
Total Phenols	64.3%	0-200	mg/L
Petroleum Hydrocarbons	95.5%	0-50	mg/L
Microbiological			
Total Coliform Bacteria	100.0%	0-500,000	MPN/100mL
Total Fecal Coliform	100.0%	0-500,000	MPN/100mL
Fecal Streptococcus Bacteria	75.0%	0-500,000	MPN/100mL
Fecal Enterococcus Bacteria	50.0%	0-500,000	MPN/100mL

Source: Dammel 1997

Table 3-2. Less Commonly Observed Highway and Freeway Runoff Parameters

Parameter	Frequency (Detection / #Samples)	Typical Range	Units
Metals			
Antimony	13.8%	-	ug/L
Arsenic	11.8%	-	ug/L
Cadmium	8.6%	-	ug/L
Chromium	45.1%	0-100	ug/L
Mercury	20.7%	0-100	ug/L
Nickel	39.0%	0-50	ug/L
Selenium	8.7%	-	ug/L
Inorganic Nonmetallics			
Boron	31.3%	0-200	ug/L
Cyanide	9.5%	-	ug/L
Individual Organics			
4-Methylphenol	?	-	ug/L
Toluene	8.3%	-	ug/L
Total Xylenes	6.4%	-	ug/L

Source: Dammel 1997

Official forecasts of annual population and economic growth for the next 20 years are as follows: 1.4% population growth from 1994-2020 (Southern California Association of Governments, 1996), and 2% economic growth (South Coast Air Quality Management District, 1996). While these forecasts may be dated, the most recent should be used. At the least, these growth rates could be used to consider increasing pollution concentrations as a result of increasing population and economic activity. Brown and Caldwell could have considered how ADT and VDS vary with population and the regional level of economic activity. Brown and Caldwell (1996) do not do so.

B. Pollutants Brown and Caldwell Considered

Compared to the 53 measures of pollution by Dammel (1997) and the additional pollutants given by the LARWCQB (1997), Brown and Caldwell (1996) present only 15 measures of pollution to define the current condition, shown in Table 3-3. By restricting the number of pollutants, Brown and Caldwell (1996) ignore benefits of pollution control.

CalTrans has a permit to spray pesticides, and the data from that should be included in the study they commissioned by Brown and Caldwell (1996). Yet, no mention of the pesticide applications nor data that show the trend over time are included in the study by Brown and Caldwell.

Table 3-3. Brown and Caldwell Design Storm Water Quality Values

Constituent	Composite Value (mg/L)
Total Suspended Solids (TSS)	200
Volatile Suspended Solids (VSS)	75
Total Dissolved Solids (TDS)	100
Total Organic Carbon (TOC)	50
Chemical Oxidation Demand (COD)	150
Nitrate (NO_3)	5
Total Kjeldahl Nitrogen (TKN)	2
Phosphate (PO_4)	0.5
Cadmium (Cd)	0.005
Copper (Cu)	0.08
Lead (Pb)	0.05
Zinc (An)	0.4
Oil and Grease (O&G)	15
Fecal Coliform (MPN/100mL)	1600
Total Coliform (MPN/100mL)	5000

Source: Brown and Caldwell 1996, pg. 3-9

Brown and Caldwell (1996) decide upon a constant pollution emission rate for each measure of pollution on their list by basing their estimates on a hypothetical "design storm." In theory, the design storm embodies the characteristics of a typical storm within a region. The problem, however, is that their design storm underestimates or ignores the effects of less common pollutants as well as the "first flush" effect observed early in a rainy season or after long periods of dryness. Their "design storm" also ignores run-off during the dry season. Table 3-3 lists the constant pollution concentration in surface water run-off that Brown and Caldwell (1996) assume for their analysis. They use these assumptions of constant pollution concentration for the purposes of developing treatment options (Brown and Caldwell 1996: pg. 3-9), and for estimating the change in concentrations from treatment.

Brown and Caldwell's (1996) assumption of a constant rate is inconsistent with the data they review, and other data. Table 3-4 shows how studies of different geographical areas in different times give variation in the pollution concentration. These are studies that Brown and Caldwell (1996) reviewed. Table 3-5 shows variation of measures of pollution in District 7 during a single year, also reviewed by Brown and Caldwell. A comparison of Table 3-3 with Tables 3-4 and 3-5 also shows some unexplained inconsistencies between the "Preliminary Values" and the "Composite Value" ultimately selected by Brown and Caldwell for use in their analysis.

The pollution emission rates from CalTrans roads and facilities in Table 3-3 are not reliable numbers in any sense. For example, during the storm event on February 19, 1996, samples of CalTrans runoff taken in District 7 revealed that fecal and total coliform varied between 100 and 10,000 MPN/ml (Loge and Darby, 1996), as shown in Table 3-6, and averaged about 4,500 and 7,500 respectively. This range of numbers is inconsistent with the results from four storms reported in Brown and Caldwell and shown in Table 3-5. As shown in the Table 3-5, Brown and Caldwell (1996) present values of fecal coliform observed at between 80 to 5,000 MPN/ml. Woodward-Clyde (1996) list the three Storm monitoring sites reported in Table 3-6 and the local receiving waters in District 7: site 1 on Interstate 405 at Santa Monica Boulevard (Ballona Creek), site 2 on Highway 101 at Canoga Avenue (Los Angeles River), and site 3 on Interstate 405 at Yukon Avenue (Dominguez Channel). According to Woodward-Clyde, all three sites are representative of District 7.

Clearly, different storms, monitoring stations, the first flush effect, and the different times for sampling lead to different results. Brown and Caldwell (1996) do not account for the variation in pollution. Nor do they justify with data and statistical analysis their basis for arriving at their “composite values” shown in Table 3-3. Yet the number for fecal coliform, 1600 MPN/100mL, takes on special significance in the benefit computations by both Brown and Caldwell (1996) and Wilchfort, Lund, and Lew (1996). This is just one example of a more detailed analysis given in Chapter 4 below that shows how the misspecification of the baseline biases the results of Brown and Caldwell (1996) and the results of Wilchfort, Lund, and Lew(1996).

In general, Tables 3-1 and 3-2 reveal that typical results from sampling vary significantly from the numbers shown in Table 3-3 for all the pollutants shown, and the range of values reported by Dammel (1997) is not consistent with the range of values from the samples specially selected by Brown and Caldwell (1996) as shown in Table 3-5. In fact, the range of values presented by Dammel *greatly exceeds* the observations from the four storms reported by Brown and Caldwell (1996) for *almost all the pollutants*.

The present condition is highly variable. The method used to value the benefit from pollution abatement should reflect the current conditions. Brown and Caldwell (1996) rely on the method presented by Wilchfort, Lund, and Lew (1996) to assess the benefits of treatment, a method that is predicated on a constant, rather than variable, level of pollution. Wilchfort, Lund, and Lew’s (1996) method omits benefits for pollutants that are omitted in the analysis because the assumed constant level of pollutant falls below a specified range. Consequently, Brown and Caldwell’s (1996) assumed current condition causes benefits to be omitted, while the actual level of pollution falls within the range that should count towards a benefit in Wilchfort, Lund, and Lew’s (1996) method. Consequently, Brown and Caldwell’s (1996) analysis of the Santa Monica Bay watershed has biased benefit estimates. In turn, Wilchfort, Lund, and Lew (1996) rely on Brown and Caldwell’s assessment of the current condition for their analysis of Ballona Creek Watershed, resulting in biased benefit estimates.

Table 3-4. Pollution Concentrations Reported by Studies Selected by Brown and Caldwell

Pollutant	Preliminary Value	Reported Concentrations (mg/L), Specific References Given in Appendix 3.1 of Brown and Caldwell									
		Driscoll	Bordanic	CDOT	CDOT	Driscoll	Driscoll	Driscoll	FHWA	FHWA	FHWA
TSS	200	142		1419	469	345	113	267	108	191	94
VSS	30	39									20
TDS	100								87	63	97
TOC	25	25									21
COD	115	114							112	116	49
NO_3	0.75	0.76							1.00	0.46	0.26
TKN	2	1.83							2.3	1.7	2
PO_4	0.1	0.4							0.04	0.05	0.11
Cd	0.02								0.01	nd*	0.02
Cu	0.08	0.54		0.049	0.145		0.085				0.06
Pb	0.5	0.4		0.128	0.81	1.233	0.378	1.291	0.53	0.48	0.4
Zn	0.4	0.329		0.47	0.748	0.935	0.300	0.375	0.525	0.25	0.27
O&G	10		5								10

*nd not detected

Table 3-5. Brown and Caldwell's Four Selected Storm Sampling Results in mg/L, 1995-96 District 7 (from Brown and Caldwell, Table 3.5, p. 3-8)

Pollutant	Acronym	Preliminary Value	Storm 1		Storm 2		Storm 3		Storm 4	
			Min	Max	Min	Max				
Total Suspended Solids	TSS	200	63	159	82	94	131	218	41	142
Volatile Suspended Solids	VSS	30	30	154	31	43	40	80	18	101
Total Dissolved Solids	TDS	100	50	170	70	100	73	90	20	110
Total Organic Carbon	TOC	25	13	122	48	84	16	22	15	75
Chemical Oxidation Demand	COD	115	180	650	30	190	6	13	27	295
Nitrate	NO_3	3.4	4.5	42.5	5.4	6.4	0.48	0.5	0.65	8.2
Total Kjeldahl Nitrogen	TKN	2	2.4	7	2.6	5.3	1.3	1.9	1.9	6.5
Phosphate	PO_4	0.1	0.24	0.95	0.69	0.75	2.3	5.2	0.15	0.75
Cadmium	Cd	0.02	ND**	ND**	0.005	0.005	ND**	ND**	0.004	0.004
Copper	Cu	0.08	0.051	0.132	0.053	0.073	0.068	0.118	0.05	0.161
Lead	Pb	0.05	0.021	0.055	0.041	0.054	0.119	0.119	0.037	0.104
Zinc	Zn	0.4	0.269	0.789	0.207	0.533	0.218	0.634	0.148	0.743
Oil & Grease	O&G	10	9.6	28.9	10.6	23.6			10.3	15
Fecal Coliform, *MPN/100 ml			1600	1600	50	130			3000	5000
Total Coliform, *MPN/100 ml			5000	5000	80	300			5000	5000

(*most probable number)

Table 3-6: Fecal coliform and Total Coliform at Three Sites

Bacteria and Sample Location	Fecal Coliform Density (MPN/ml)	Total Coliform Density (MPN/ml)	Type of Coliform
Site 1: 405 Fwy at Santa Monica Blvd.			
Klebsiella pneumoniae	100		Fecal
Kluyvera ascorbata	1000		Fecal
Morganella morganii	1000		Fecal
Site 2: 101 Fwy at Canoga Ave			
Morganella morganii	100		Fecal
Escherichia coli	100		Fecal
Citrobacter freundii, Kluyvera cryocrescens		1000	Total
Providencia stuartii	1000		Fecal
Citrobacter freundii		1000	Total
Site 3: 405 Fwy at 182 St.			
Escherichia coli	100		Fecal
Proteus vulgaris		1000	Total
Kluyvera oxytoca	10,000		Fecal
Klebsiella oxytoca		10,000	Total
Pantoea agglomerans		10,000	Total
Total	13,400	23,000	
Average	4,466.67	7,666.67	

Source: Loge and Darby, 1996

C. Baseline Levels of Pollutants Over Time

Brown and Caldwell fail to state how their design storm is applied to future periods. Since no projections or rates of change are mentioned at any point in the study, it appears that Brown and Caldwell implicitly assume that no changes occur in the design storm for the twenty year span of the analysis, and that the values in Table 3-3 are repeated for each time period. At the least, the values should be adjusted to account for population and economic growth.

Finally, Brown and Caldwell only use pollution concentrations during storms. Pollution reductions during storms, however, also reduce pollution during the rest of the year. Hence, in order to adequately assess the benefits it is necessary to establish pollution levels during the rest of the year.

Chapter 3 References

Brown and Caldwell, 1996, CalTrans Storm Water Facilities Retrofit Evaluation, Draft Volume I, Executive Summary, Chapters 1-10, Appendixes 1-6, prepared for the California Department of Transportation, September, Irvine, California.

Dammel, Ed, 1997, Further Clarification of the Summaries of Water Quality Data Associated with Runoff from Caltrans Highways and Freeways, January 31, 1997, Caltrans – UC Davis Storm Water Quality Project, Sacramento.

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Chapter IV Treatment Options, Treatment Costs, and Expected Pollution Concentration in Surface Water Run-Off After Treatment

The goal of a benefit-cost test is to measure the economic value of a change in environmental quality. Having established the reference or baseline condition, it is then necessary to determine the expected concentrations of the pollutants after the implementation of the appropriate treatments. Those estimates are then projected over the relevant time period such that the expected and baseline conditions could be compared in each year. Although there are numerous treatment options, the pollution reduction potential of the various treatment options should be well understood, and estimates should therefore be made with a considerable degree of certainty.

The importance of selecting the most efficient treatment option for a given situation cannot be overstated. The efficient option is that which achieves the desired result at the minimum cost. This definition is not theoretical: successful firms continually strive to improve the quality of their output while reducing production costs. Failure to do so would compromise the long term performance of the firm by eliminating the profits that would have been earned as a result of cost reductions. The same logic applies to the problem of pollution control: the analysis must make every effort to include the most efficient treatment options so that estimates will reflect the optimal results of treatment.

Selecting the treatment option may determine whether the benefits of treatment are greater than the cost. The treatment option determines treatment costs and the reduction in pollution concentrations in surface water run-off. The reduction in pollution can be subtracted from the baseline to estimate the expected level of pollution concentration in surface water run-off after treatment, and so affect the benefits from treatment.

Economies of scale occur when the average cost of treatment falls with the amount of treatment. This chapter establishes that Brown and Caldwell (1996) are aware of economies of scale in treatment options for surface water run-off. Yet, for the benefit-cost test by Brown and Caldwell (1996), the three levels of treatment they consider are for only one treatment option, the option with the least economies of scale. This chapter identifies watersheds in District 7 with potential for economies of scale, and shows that Brown and Caldwell did not select those watersheds for the study site. Within the Brown and Caldwell study site, this chapter identifies the treatment options with potential for economies of scale, options not selected by Brown and Caldwell for analysis. Finally, for the treatment options common to both studies, this chapter identifies discrepancies in treatment effectiveness between Brown and Caldwell (1996) and Wilchfort, Lund, and Lew (1996).

A. Brown and Caldwell's Treatment Option, Economies of Scale, and Expected Pollution Reduction

1. Treatments Brown and Caldwell Considered

Brown and Caldwell (1996) estimate the cost of building numerous, relatively small, concrete-lined holding tanks along CalTrans roads, pumping stations, maintenance yards, and park-and-ride parking lots. Pipes would be laid to transport run-off from storm drains to the holding tanks. The water in the holding tanks would be treated at one of three levels. Level 1 is detention and screening, which removes about 50% of oil and grease, 25% of fecal coliform, 40% of lead, and 95% of debris. Level 2 is filtration and disinfection, which removes all oil and grease, reduces fecal coliform by a factor of 10^2, and 64% of the lead. Level 3 is reverse osmosis, which reduces fecal coliform by a factor of 10^3 from no treatment, and 98% of the lead from no treatment (calculated from Table 10, Wilchfort, et al., 1996, p.26). There is no clear statement whether Level 1 treatment is a prerequisite for Level 2 treatment, although Levels 1 and 2 treatment are prerequisite for Level 3 treatment (Brown and Caldwell, pp. 5-9 and 5-11).

2. Economies of Scale

Brown and Caldwell (1996) initially estimate costs for three levels of treatment along 24.1 miles of CalTrans freeways in the Van Nuys quadrangle, and for a section of Pacific Coast Highway. The treatment projects are scaled to treat CalTrans runoff from a 1-year 24 hour storm, consisting of 8 treatment plants from 0.35 to 4.67 mgd in the Van Nuys quadrangle, and 5 treatment plants from 0.39 to 0.86 mgd along Pacific Coast Highway.

Brown and Caldwell divide the cost estimates to create average costs per mile, per drainage acreage, and per flow in order to extend the cost estimates to other areas. They refer to the use of average costs per mile as Method 1, average costs per drainage acreage as Method 2, and average cost per flow as Method 3 for the purposes of extending their estimates of numerous, relatively small holding tanks and treatment levels to other areas.

First, they extend their estimates to 42.1 miles of CalTrans highways and freeways within the Ballona Creek watershed using Method 1. They multiply the cost per mile from the Van Nuys quadrangle times the number of freeway miles in the Ballona Creek watershed, and add the cost per mile from the PCH study times the number of highway miles in the Ballona Creek watershed.

Next, Brown and Caldwell extend their treatment cost estimates to all roads, not just CalTrans roads, that pollute the Ballona Creek watershed. It is at this juncture that Brown and Caldwell acknowledge economies of scale from joint treatment projects with other agencies. Joint treatment allows for economies of scale, and they assume 4 treatment plants of equal size at 386.75mgd. This scale is considerably larger than the 8 treatment plants from 0.35 to 4.67 mgd in the Van Nuys quadrangle, and 5 treatment plants from 0.39 to 0.86 mgd along Pacific Coast Highway. In order to scale the costs, they assume the average costs for the Sepulveda quadrangle are estimates relevant for a 2mgd facility, and they use a polynomial fitted to the scale up cost factors presented in Table 4-1.

Table 4-1 Economies of Scale for Regional Treatment in the Ballona Creek Watershed

Flow Rate	2.00 mgd	10.0 mgd	50.0 mgd	500 mgd
Cost Factor	1.00	3.29	11.05	69.275

Source: Computed from Brown and Caldwell, Table 6.8, p.6-22

Brown and Caldwell *do not* consider economies of scale for the Benefit-Cost test they apply to treatment in the Santa Monica Bay Watershed. They extend their cost estimates *only* to CalTrans roads in the Santa Monica Bay watershed and *only* to CalTrans roads within District 7, so the treatment option is the small scale cost estimate applicable to 2mgd facilities.

B. Joint Treatment with Other Agencies

Joint projects are projects undertaken by CalTrans in cooperation with any of the following agencies: the Los Angeles County Department of Public Works, the County Sanitation Districts of Los Angeles County, the City of Los Angeles, the Ports of Los Angeles and Long Beach, and the various cities within District 7. Joint projects can be considered within any watershed, or within the entire District 7. Brown and Caldwell confuse these possibilities by reference to "regional treatment", when in fact the only joint treatment considered by Brown and Caldwell was for the Ballona Creek watershed, and they only considered costs, not benefits.

It is joint treatment options that have the potential for economies of scale. Confining treatment options to CalTrans *only* freeways and roads loses the potential for economies of scale. By selecting the options with the smallest economies, Brown and Caldwell (1996) bias the cost estimates upward and consider the least effective treatment options, options with the smallest reduction in pollution and the smallest benefits.

C. Watersheds with Potential Economies of Scale

A comprehensive survey of the potential for economies of scale is missing in Brown and Caldwell (1996). Mass emissions of pollution is one indicator of the watersheds with potential for economies of scale. Based upon this indicator, Table 4-2 ranks District 7 watersheds in this order for potential economies of scale: Los Angeles River, San Gabriel river, Santa Clara River, followed by rivers that flow into Santa Monica Bay, including Ballona Creek. Based upon this indicator, Brown and Caldwell (1996) should have selected San Pedro Bay and Northern Orange County as the receiving waters with the greatest potential for economies of scale, rather than the study area they chose, namely, Santa Monica Bay. Based upon this indicator, Wilchfort, Lund, and Lew (1996) should have chosen the receiving waters of the Los Angeles River rather than Ballona Creek for their study area. Of course, the costs are not the only consideration. The benefits of pollution control to San Pedro Bay and northern Orange County beaches have to be considered relative to the benefits to Santa Monica Bay.

Table 4-2: Estimated mass emissions from Rivers in CalTrans District 7 of Selected Contaminants from Six Streams in 1988 Water Year (Source SCCWRP, 1992)

Stream	Susp. Sol. 10^3 kg	Cd kg	Cr kg	Cu kg	Ni kg	Pb kg	Zn kg	ΣPCB kg
Santa Clara River	28,236	40	1,702	1,560	965	2,554	7,490	1.4
Calleguas Creek	20,893	94	3,408	2,508	1,944	878	6,113	5.9
Ballona Creek	18,276	152	1,694	6,147	1,849	12,579	34,296	7.7
Los Angeles River	154,639	801	6,357	18,694	7,287	32,145	84,169	40.1
San Gabriel River	113,671	499	7,486	12,060	4,990	17,189	56,558	18.4
Santa Ana River	85,294	67	2,559	3,644	2,352	2,662	18,584	2.0

Source: Table 3 of Pan and Schroeder (1996). The title of the table given by Pan and Schroeder erroneously assigns Santa Monica Bay as the receiving water of all these rivers.

D. Treatment Options with Potential Economies of Scale within the Santa Monica Bay Watershed Not Considered by Brown and Caldwell Nor Wilchfort, Lund, and Lew

There are obvious options with potential economies of scale within the study areas of Brown and Caldwell (1996) and Wilchfort, Lund, and Lew (1996). Below are three options for joint treatment projects just within the Ballona Creek watershed.

1. Joint Water Treatments Not Considered

The lack of geographical scope in Brown and Caldwell's study restricts treatment options. Joint treatment options are more efficient because the greater scale allows the average cost of water treatment to fall. Further, joint treatment options would have a far greater impact on total pollutant concentration and, therefore, on benefits. For example, Brown and Caldwell find that at any level of treatment of CalTrans runoff, the changes in benefits are very small because overall concentrations are only be marginally affected by CalTrans runoff. If, however, the same level of treatment were achieved through joint treatment efforts that include the entire region, far more significant changes in pollution concentrations and benefits could be attained. Brown and Caldwell (1996) neither estimate the cost nor the benefits of jointly treating all surface water run-off into Santa Monica Bay.

2. Joint Water Reclamation Not Considered

As stated previously, Brown and Caldwell (1996) realize that there exist regional treatment alternatives that are more efficient than the methods they propose. Wilchfort, Lund, and Lew (1996) cite a City of Los Angeles (1995) study of the potential for a water reclamation and treatment facility at the mouth of Ballona Creek. Without comparing the benefits and costs, they reject this alternative. One reason given is that the cost of the reclaimed water is higher than the cost of water from other sources. However, the benefit of pollution control should also be considered, but they do not consider it. Another reason they give for ignoring a regional alternative is that a water delivery system does not exist for transporting treated water to customers. Although Brown and Caldwell (1996) consider various sizes and locations for *water treatment facilities* along various channels and drains that feed into Ballona Creek, Wilchfort, Lund, and Lew do not consider locating different sizes and numbers of *water reclamation projects* closer to potential water customers, along any of the various drainage ditches that feed into Ballona Creek (upper Ballona Creek, Benedict Canyon Drain, Sepulveda Channel, Centinela Creek Channel, shown in Figure 1 from Wilchfort, Lund, and Lew, 1996, p.3).

Brown and Caldwell (1996) also fail to thoroughly explore the water reclamation potential of runoff. A brief study of a map of the main expanse of Ballona Creek reveals eight parks, a junior college, a high school, two middle schools and three elementary schools in very close proximity. A more detailed investigation of the channels and waterways of Dominguez Channel and the Los Angeles and San Gabriel Rivers would expose similar opportunities to make use of reclaimed water.

Wilchfort, Lund, and Lew (1996) ignore the possible beneficial use of reclaimed water on the grounds that the cost would equal about $1300/Acre-foot. This ignores the value of additional water. If regional water reclamation and treatment is considered as an option, the value of the reclaimed water is equal to the value of water displaced by the reclaimed water. The marginal cost of procuring drinking water, which would be displaced by the reclaimed water, is $879 and $1,161/Acre-foot in the Winter and Summer, respectively, for the City of Los Angeles (calculated from Hall, 1996, pp. 86-87). Consequently, the cost of water treatment to be balanced by pollution control benefits is only $421/AF in the winter and $139/AF in the summer. And the benefits include level 3 treatment of all dry season flow (325 days), and some portion of the first flush during the 40 storm days.

3. Joint Treatment of Dry Weather Diversions of Storm Water Runoff to POTWs

An option omitted by Brown and Caldwell (1996) is to divert water runoff to Publicly Owned Treatment Works by way of existing sanitary sewers, and seasonally shut off the diversion during heavy rains to avoid overflow to the sewage treatment facilities. The County Sanitation Districts of Los Angeles County and the City of Los Angeles own existing transmission facilities that parallel the coastline, and sewage treatment facilities that could be used to treat runoff without the expense of treatment levels 2 and 3.

The possibility of joint treatment at Level 1, concert with diversion to POTWs, was not considered by Brown and Caldwell (1996).

E. Inconsistencies in Estimates of Expected Pollution Reduction from Treatment

Estimates of the expected condition after treatment are complicated by inconsistencies between Brown and Caldwell (1996) and Wilchfort, Lund, and Lew (1996). In theory, the degree of effectiveness of each Level of treatment should be consistent between the two reports, but this does not appear to be the case. Wilchfort, Lund, and Lew list the effectiveness of each Level of treatment for the pollutants considered (Wilchfort, Lund, and Lew 1996: Appendix D, pg. 2). Notably, Level 1 treatment is most effective in removing debris, but a percentage of the other pollutants is removed as well. Brown and Caldwell, however seem to assume that Level 1 treatment affects only debris (Brown and Caldwell 1996: pg. 8-23, Table 8.10). Similarly, Brown and Caldwell appear to assume that Level 2 treats only fecal coliform and that Level 3 treats only lead and copper (pp. 8-23,24, Tables 8.11 and 8.12). Table 4-3 summarizes the discrepancies.

Table 4-3. Discrepancies in Treatment Effectiveness (from Wilchfort, Lund, and Lew 1996 Appendix D, pg. 2; Brown and Caldwell 1996: pp. 8-23,24)

	Level 1		Level 2		Level 3	
Pollutant	Wilchfort	B&C	Wilchfort	B&C	Wilchfort	B&C
Oil & Grease	50%	--	100%	--	100%	--
Fecal Coliform	25%	0%	99%	99%	99%	99%
Lead	40%	0%	64%	0%	98%	95%
Copper	//	0%	//	0%	//	95%
Debris	95%	95%	95%	95%	95%	95%

-- = Not Considered by Brown and Caldwell
// = Not Considered by Wilchfort, Lund, and Lew

Brown and Caldwell (1996, Table 8.6, pg. 8-19) list untreated trash into Santa Monica Bay equal to trash after Level 1 treatment (Table 8.10, pg. 8-23), although presumably the numbers should differ.

F. Expected Condition After Treatment

Brown and Caldwell (1996) only provide estimates of the reduction for a few pollutants. The elimination and grouping of key data by Brown and Caldwell makes it difficult to understand how the conditions of the resources in question would be affected by surface water run-off treatment.

Chapter 4 References

Brown and Caldwell, 1996, CalTrans Storm Water Facilities Retrofit Evaluation, Draft Volume I, Executive Summary, Chapters 1-10, Appendixes 1-6, prepared for the California Department of Transportation, September, Irvine, California.

City of Los Angeles, Bureau of Engineering, Stormwater Management Division, Bureau of Public Works, 1995, Ballona Creek Treatment Facility Feasibility Study and Preliminary Design, prepared by Camp Dresser & McKee Inc. 10 November 1995.

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Pan, Nancy L. and Edward D. Schroeder, 1996, Beneficial Impacts of storm Water On Santa Monica Bay, prepared under contract number 43Y091 for the California Department of Transportation, September 19, 1996, College of Engineering, Department of Civil and Environmental Engineering, University of California Davis.

Wilchfort, Orit, Jay R. Lund, and Dan Lew, 1996, Preliminary Economic Valuation of Stormwater Quality Improvement for Ballona Creek, Draft Final, September, Department of Civil and Environmental Engineering and Department of Agricultural and Resource Economics, University of California, Davis.

Appendix to Chapter IV. Treatment Cost Estimates

Brown and Caldwell (1996) estimate the cost of building numerous, relatively small, concrete-lined holding tanks along CalTrans roads, pumping stations, maintenance yards, and park-and-ride parking lots. Pipes would be laid to transport run-off from storm drains to the holding tanks. The water in the holding tanks would be treated at one of three levels. Level 1 is detention and screening, which removes about 50% of oil and grease, 25% of fecal coliform, 40% of lead, and 95% of debris. Level 2 is filtration and disinfection, which removes all oil and grease, reduces fecal coliform by a factor of 10^2, and 64% of the lead. Level 3 is reverse osmosis, which reduces fecal coliform by a factor of 103 from no treatment, and 98% of the lead from no treatment (calculated from Table 10, Wilchfort, et al., 1996, p.26). There is no clear statement whether Level 1 treatment is a prerequisite for Level 2 treatment, although Levels 1 and 2 treatment are prerequisite for Level 3 treatment (Brown and Caldwell, pp. 5-9 and 5-11).

Brown and Caldwell (1996) initially estimate costs for three levels of treatment along 24.1 miles of CalTrans freeways in the Van Nuys quadrangle, and for a section of Pacific Coast Highway. The treatment projects are scaled to treat CalTrans runoff from a 1-year 24 hour storm, consisting of 8 treatment plants from 0.35 to 4.67 mgd in the Van Nuys quadrangle, and 5 treatment plants from 0.39 to 0.86 mgd along Pacific Coast Highway. Table 4A-1 presents treatment flow, miles, drainage acres, and the present value costs, in millions of dollars, including land, construction, and operation and maintenance. The present value calculation is based upon a 5% interest rate and a 20 year life of the treatment facilities.

Table 4A-1

Study Area	Miles	Flow in MGD	Drainage Acres	PV Cost @5%, yr=20, in Millions $		
				Level 1	Level 2	Level 3
Van Nuys	24.1	12.45	632.4	$149.164	$167.768	$237.254
PCH	27.2	3.05	201.7	1	$ 39.847	$ 78.798

Source: Brown and Caldwell

Brown and Caldwell divide the cost estimates to create average costs per mile, per drainage acreage, and per flow in order to extend the cost estimates to other areas. They refer to the use of average costs per mile as Method 1, average costs per drainage acreage as Method 2, and average cost per flow as Method 3 for the purposes of extending their estimates of numerous, relatively small holding tanks and treatment levels to other areas. First, they extend their estimates to 42.1 miles of CalTrans highways and freeways within the Ballona Creek watershed (Table 4A-2). They use Method 1, multiplying the cost per mile from the Van Nuys quadrangle times the number of freeway miles shown in Table 4A-2, plus the cost per mile from the PCH study area times the number of highway miles shown in Table 4A-2.

Table 4A-2 CalTrans Roads
in the Ballona Creek Watershed

Hwy or Fwy	Miles
Hwy 2	6.2
Fwy 405	13.2
Fwy 101	6.0
Hwy 170	1.1
Fwy 10	11.9
Hwy 9	2.7
Hwy 1	1.0
Total	42.1

Source: Brown and Caldwell

Next, Brown and Caldwell extend their treatment cost estimates to all roads, not just CalTrans roads, that pollute the Ballona Creek watershed. It is at this juncture that Brown and Caldwell acknowledge economies of scale from joint treatment projects with other agencies. For this calculation, Brown and Caldwell use Method 3, based upon the average cost per flow. They state that the calculation accounts for differing “soil imperviousness” equal to 65% for CalTrans right-of-way versus 48% for the entire Ballona Creek watershed (Brown and Caldwell, p.6-21). They are a bit mysterious about how these numbers enter into the calculation. But the end result is a one year-24 hour storm flow for the Ballona Creek watershed equal to 1547 mgd, and the CalTrans share is 46 mgd (computed from Brown and Caldwell, Table 6.9, p.6-23).

Brown and Caldwell use the average cost per gallon from the Van Nuys quadrangle to calculate the total cost of treatment at Levels 1, 2, and 3 for the Ballona Creek watershed. Without accounting for economies of scale for joint treatment facilities, the procedure would be to multiply the average cost for each treatment level times 1547 million gallons. But joint treatment allows for economies of scale, and they assume 4 treatment plants of equal size (386.75mgd) at these sites: Centinela Creek Channel at the joining with Ballona Creek, Sepulveda Channel where it joins Ballona Creek, Ballona Creek where Benedict Canyon meets Ballona Creek, and the upper reach of Ballona Creek. In order to scale the costs, they assume the average costs for the Sepulveda quadrangle are estimates relevant for a 2mgd facility, and they use a polynomial fitted to the scale up cost factors presented in Table 4A-3.

Table 4A-3 Scale-Up Cost Factors

Flow Rate	2.00 mgd	10.0 mgd	50.0 mgd	500 mgd
Cost Factor	1.00	3.29	11.05	69.275

Source: Computed from Brown and Caldwell, Table 6.8, p.6-22

They further extend their cost estimates to all CalTrans roads in the Santa Monica Bay watershed and to all CalTrans roads within District 7.

For the cost of Level 1 treatment in the Van Nuys Quadrangle, Brown and Caldwell present a breakdown of the costs between operations and maintenance and capital costs, as shown in Table 4A-4.

Table 4A-4

Item	Estimated Total cost
Cluster Construction	$20,944,000
Detention Basin Construction	$59,928,000
Site Work	$92,122,000
Construction Contingency	$19,237,000
Engineering and Administration	$16,672,000
Land Acquisition	$32,194,000
Subtotal Capital Items	**$241,097,000**
Annual Operations and Maintenance	$544,000
Total Present Worth @5%, yr=20	**$254,697,000**

Source: Replication of Brown and Caldwell, Table 6.5, p. 6-18.

Chapter V Identification of Benefit Categories

An economic valuation of the benefits of controlling surface water run-off will produce estimates that are biased downward if the analysis excludes categories of benefits. This chapter compares the categories of benefits identified by the LARWQCD (1997) and the Santa Monica Bay Restoration Project (1994) with the benefit categories identified and included in the studies by Brown and Caldwell (1996) and Wilchfort, Lund, and Lew (1996). This chapter shows that the studies by Brown and Caldwell (1996) and Wilchfort, Lund, and Lew (1996) exclude categories of benefits.

This chapter also identifies contradictions between the studies by Brown and Caldwell (1996) and Wilchfort, Lund, and Lew (1996), showing that each study omits benefit categories contained in the other, even though the two studies both include the Ballona Creek watershed.

A. Lack of Comprehensive Benefits Identification and Contradictions

1. Benefit Categories Actually Counted by Brown and Caldwell and by Wilchfort, Lund, and Lew

In their study of the benefits of the Ballona Creek watershed, Wilchfort, Lund, and Lew (1996) actually count only four benefits for only forty days of the year: 1) UCLA team rowing in the mouth of Ballona Creek, 2) bicycling along the edge of Ballona Creek, 3) 200 sailboats that dock in Marina del Rey, and 4) 12 commercial vessels docked in the marina that engage in shellfishing and dinner cruises. Although they discuss many other benefits, none are part of their benefit estimate that they ultimately compare against costs.

In their study of the benefits of the Santa Monica Bay watershed, Brown and Caldwell (1996) actually only count one benefit for only forty days of the year: habitat. They simply calculate the distance (omitting distances along concrete lined drainage channels) of each creek from a CalTrans freeway or highway to the Santa Monica Bay. They multiply this distance times a 50 foot stretch on each side of the center line of the creek to obtain wildlife habitat [Brown and Caldwell, p. 8-22]. Although they discuss other benefits, none are part of their benefit estimate that they ultimately compare against costs.

2. Contradictions

Ballona Creek is within the Santa Monica Bay watershed. Brown and Caldwell (1996) count wildlife habitat along Ballona Creek in their computations, a benefit ignored by Wilchfort, Lund, and Lew (1996). Wilchfort, Lund, and Lew (1996) count team rowing, bicycling, sailing, and commercial vessels as benefits in their computations, benefits ignored by Brown and Caldwell (1996). These contradictions result in both studies omitting benefit categories that the other includes, biasing downward their benefit estimates.

3. Scope and Scale

Pollution control benefits are underestimated if there is failure to identify the relevant benefits. The scope and scale of analysis are major factors. If only a limited geographical area is considered, only a limited amount of benefits will be counted. If pollution controls provide pollution reduction throughout the year, then benefits are derived throughout the year. If pollution controls reduce not only CalTrans pollutants, but other pollutants at the same time, then benefits are derived from the reductions in all the pollutants that are controlled.

Santa Monica Bay is the only area affected by pollution in District 7 considered for benefit calculations by Brown and Caldwell (1996). The majority of the land area in District 7 is in the watersheds of the Los Angeles River plus the San Gabriel River plus the Dominguez Channel plus the Los Cerritos Channel, all of which empty into San Pedro Bay. Brown and Caldwell identify an incomplete list of benefit categories for the Los Angeles and San Gabriel rivers, but then ignore them. For example, the Los Angeles and Long Beach harbors are critical centers of economic activity for Southern California, yet Brown and Caldwell ignore the economic value to these harbors of controlling surface water run-off. Any study that fails to include the complete range of benefits over the relevant geographical area understates the value of the resource and the degree to which it is affected by pollution.

Table 5-1. LARWQCB Beneficial Use Categories

Benefit Use Categories	**Abbreviation**
Municipal and Domestic Supply	MUN
Industrial Use	IND
Processed	PROC
Agricultural Use	AGR
Groundwater Recharge	GRW
Navigation	NAV
Water Contact Recreation	REC1
Non-Contact Water Recreation	REC2
Commercial and Sport Fishing	COM
Warm Freshwater Habitat	WARM
Cold Freshwater Habitat	COLD
Estuarine Habitat	EST
Marine Habitat	MAR
Wildlife Habitat	WILD
Preservation of Biological Habitat	BIOL
Rare, Threatened, Endangered Species	RARE
Migration of Aquatic Organisms	MIGR
Spawning, Reproduction, Development	SPWN
Shellfish Harvesting	SHEL
Wetland Habitat	WET

Source: LARWQCB (1997)

Within their study area, Wilchfort, Lund, and Lew (1996) do not consider the full range of benefit categories. For example, the recreational benefit categories of the Ballona Creek watershed include, among other recreational uses: bicycling, jogging, swimming, rowing, boating, surfing, sunbathing, bird watching, and recreational fishing. Natural resources yield benefits in addition to those associated with recreational activities. Creation and enhancement of ecosystems is essential to rebuild the Pacific flyway for migrating birds. The quality of a resource can affect property values and the success of local businesses. Habitat areas supporting a wide variety of aquatic plants and animals are greatly impacted by the quality of storm water runoff. If habitats are affected, it is clear that commercial fishing, shellfish harvesting and commercial boating activities will be affected as well. The study by Wilchfort, Lund, and Lew (1996) omits most of these benefit categories.

Table 5-2 LARWQCB Summary of Santa Monica Bay Watershed Beneficial Uses

Benefit \ Sub-region	1	2	3	4	5	6	7	8	9	10	**Total**
Municipal and Domestic Supply	E	E	I	P		P					**E**
Industrial Use		E		E	E	E	E	E	E	E	**E**
Processed		E									**E**
Agricultural Use		E									**E**
Groundwater Recharge	I	E									**E**
Navigation	E	E	E	E	E	E	E	E	E	E	**E**
Water Contact Recreation	E	E	E	E	E	E	E	E	E	E	**E**
Non-Contact Water Recreation	E	E	E	E	E	E	E	E	E	E	**E**
Commercial and Sport Fishing	E		E	E	E	E	E	E	E	E	**E**
Warm Freshwater Habitat	E	E	E	I		P					**E**
Cold Freshwater Habitat	E	E	E								**E**
Estuarine Habitat	E	E	E			E					**E**
Marine Habitat		E		E	E	E	E	E	E	E	**E**
Wildlife Habitat	E	E	E	E	E	E	E	E	E	E	**E**
Preservation of Biological Habitat				E	E	E	E	E	E	E	**E**
Rare, Threatened, Endangered Species	E	E	E	E	E	E	E	E	E	E	**E**
Migration of Aquatic Organisms	P	E	E	E	E	E	E	E	E	E	**E**
Spawning, Reproduction, Development	P	E	E	E	E	E	E	E	E	E	**E**
Shellfish Harvesting				E	E	E		E	E	E	**E**
Wetland Habitat	E	E	E			E					**E**

Source: Los Angeles Regional Water Quality Control Board (1997)

E: Existing Beneficial Use P: Potential Beneficial Use I: Intermittent Beneficial Use

B. Benefit Categories Considered by LARWQCD

1. Beneficial Use Categories for Santa Monica Bay Watershed

The Los Angeles Regional Water Quality Control Board (LARWQCB, 1997) classifies beneficial uses into 20 categories, shown in Table 5-1. LARWQCB (1997) summarizes the beneficial uses in the Santa Monica Bay watershed, as shown in Table 5-2.

2. Geographical Subregions for Santa Monica Bay Watershed

The LARWQCB (1997) divides the Santa Monica Bay watershed into 10 sub-watershed areas. Table 5-3 summarizes each of these 10 areas. There are creeks, beaches, Lagoons, parks, lakes, a recreation areas, reservoirs, and two harbors listed in Table 5-3. This is contrasted with the single benefit calculated by Brown and Caldwell (1996) for wildlife habitat. They calculate the acreage of the habitat for the Santa Monica Bay watershed, given by multiplying the distance of each creek from a CalTrans road to the Bay times a 50 foot stretch on each side of the center line of the creek [Brown and Caldwell, 1996, p. 8-22].

Table 5-3 LARWQCB List of Santa Monica Bay Watershed Areas with Beneficial Uses

Waterbody	Drainage Area (Acres)	Discharge Point	Average Annual Storm Runoff (AFY)
Sub-region 1: Northcoast Total	**55 sq mi**		
Arroyo Sequit	7203	Lagoon/Ocean	985
Nicholas Canyon Creek	1428	Ocean	192
Los Alisos Canyon Creek	1108	Ocean	153
Decker Canyon	not listed		
Lachusa Canyon Creek	1178	Ocean	149
Encinal Canyon Creek	2014	Ocean	272
Trancas Canyon Creek	6862	Lagoon/Ocean	1158
Dume Creek (Zuma Canyon)	6101	Lagoon/Ocean	1129
Ramirez Canyon Creek	3387	Ocean	642
Escondido Canyon Creek	2229	Ocean	321
Latigo Canyon Creek	combined		
Sostice Canyon Creek	3370	Ocean	518
Lagoons			
Arroya Sequit Canyon Lagoon			
Trancas Lagoon			
Zuma Lagoon			
Sub-region 2: Malibu Canyon Total	**109 sq mi**		**13,565**
Malibu Creek			
Malibu Lagoon	40		
Inland Parks, Tributaries, Lakes, and Reservoirs			
Santa Monica Mountains National Recreation Area			
Cold Creek			
Lindero Creek			
Las Virgenes Creek			

Medea Creek			
Triunfo Creek			
Malibou Lake			
Lake Sherwood			
Westlake Lake			
Lake Lindero			
Lake Eleanor			
Las Virgenes Reservoir			
Century Reservoir			
Sub-region 3: Topanga and Adjacent Total	**18 sq mi**		
Puerco Canyon and Corral Canyon Creeks	4288	Ocean	755
Carbon Canyon Creek	2246	Ocean	371
Las Flores Canyon Creek	3157	Ocean	571
Piedro Gorda Canyon Creek	2054	Ocean	253
Pena Canyon Creek	combined		
Tuna Canyon Creek	combined		
Topanga Canyon Creek	12,606	Lagoon/Ocean	2371
San Ynez Canyon	4959	Ocean	1043
Inland Tributaries, Storm Drains, and Parks			
Topanga Creek State Park			
Will Rogers State Park			
Lagoon			
Topanga Canyon Lagoon			
Winter Canyon	not listed		
Jerry's (Sweetwater) Canyon	not listed		
Sub-region 4: Santa Monica Canyon Total	**5600**		
Inland Tributaries, Storm Drains, and Parks			
Mandeville Canyon Storm Drain			
Sullivan Canyon storm Drain			
Sullivan Canyon Park			
Rustic Canyon Storm Drain			
portions of Topanga State Park			
Coastal Parks			
Will Rogers State Beach			
Pulga Canyon	not listed		
Temescal Canyon	not listed		

Sub-region 5: Pico-Kenter and Adjacent Total	**9105**		
Montana Ave.	825	Beach	
Wilshire Blvd.	926	Beach	
Santa Monica Pier	94	Beach	
Pico-Kenter	4147	Surfzone	
Ashland Ave.	264	Beach	
Rose Ave.	2117	to Ashland/Beach	
Thornton Ave.	267	Beach	
Brooks Ave.	304	Beach	
Venice Pavilion	161	Surfzone	
Sub-region 6: Ballona Creek Total	**127 sq mi**		
Ballona Creek Upstream (above tidal prisms)			
Ballona Creek Estuary (tidal prisms)			
Ballona Wetlands			
Ballona Lagoon/Venice Canals			
Del Rey Lagoon			
Marina del Rey			
Adjacent Beaches			
Nearshore Zone			
Offshore Zone			
Inland Tributaries, Storm Drains, and Parks			
Centinela Creek Channel Drain			
Sepulveda Canyon Channel Drain			
Benedict Canyon Channel Drain			
Sub-region 7: El Segundo/LAX Area Total	**6680**		
Playa del Rey	403	Beach	
North Westchester	2416	Beach	
Imperial Highway	1958	Beach	
El Segundo Blvd.	539	Beach	
Chevron Refinery	1129	3,500 feet offshore	
Hyperion Treatment Plant	144	5-mile offshore	
Scattergood Power Plant	96	storm drain	
Sub-region 8: South Bay Total	**7054**		
Coastal Parks, Beaches, Harbor			
Manhattan Beach			
Redondo Beach			
Hermosa Beach			
Torrance Beach			

King Harbor			
Sub-region 9: Palos Verdes Peninsula Total	**10,977**		
Coastal Beaches and Coves			
Point Vicente Beach			
Royal Palm Beach			
White Point Beach			
Malaga Cove			
Bluff Cove			
Lunada Bay			
Abalone Cove			
Pt. Vicente			
Abalone Cove County Beach			
Portuguese Pt.			
Inspiration Pt.			
Portuguese Bend			
Royal Palms Beach			
Whites Point County Beach			
Sub-region 10: Ocean Nearshore and Offshore			

Source: Los Angeles Regional Water Quality Control Board (1997)

C. Benefit Categories Considered by Brown and Caldwell and by Wilchfort, Lund, and Lew

For benefits assessment of the Santa Monica Bay watershed, Brown and Caldwell (1996) rely on the method outlined in Wilchfort, Lund, and Lew (1996).

1. Identifying Benefit Categories

Brown and Caldwell state that the first step in assessing benefits is to locate the receiving water reaches (Brown and Caldwell 1996: pg. 8-12). These are located as follows: Santa Monica Bay Watershed draining into Santa Monica Bay, Dominguez Channel draining into San Pedro Bay, Los Angeles River and San Gabriel River Watersheds draining into the Pacific Ocean, Santa Clara River Watershed draining into Santa Barbara Channel (Brown and Caldwell 1996: pg., 8-13, Table 8.1). It is imprecise to state that the Los Angeles and San Gabriel Rivers drain into the Pacific Ocean; both waterways discharge into San Pedro Bay, where Long Beach and Los Angeles harbors are located.

The second step Brown and Caldwell (1996) follow is to identify benefit categories at each location. Table 5-4 lists the benefits Brown and Caldwell considered.

Table 5-4. Benefit Categories Brown and Caldwell Initially Considered

Benefit	Malibu Creek	Ballona Creek	L.A. County Coastal Nearshore	L.A. River to Estuary
Municipal and Domestic Supply	P	P		P
Navigation			E	
Water Contact Recreation	E	P	E	E
Non-Contact Water Recreation	E	E	E	E
Commercial and Sport Fishing			E	
Warm Freshwater Habitat	E	P		E
Cold Freshwater Habitat	E			
Estuarine Habitat				
Marine Habitat			E	E
Wildlife Habitat	E	E	E	E
Preservation of Biological Habitat			E	
Rare, Threatened, Endangered Species				
Migration of Aquatic Organisms	E		E	P
Spawning, Reproduction, Development	E		E	P
Shellfish Harvesting			E	P
Wetland Habitat	E			

Source: Brown and Caldwell 1996: Table 8.2
E = Existing, P = Potential, Blank = Not Considered

Table 5-5 lists benefit categories ascribed to Ballona Creek by Wilchfort, Lund, and Lew (1996). There are two columns for each water reach. The first column is marked WRCB to reflect the claim by Wilchfort, Lund, and Lew that they listed beneficial uses described by the Water Resources Control Board (Wilchfort, Lund, and Lew, 1996, Table 1, p.7). In the second column, from Wilchfort, Lund, and Lew (Table 2), they circumscribe benefit categories

Table 5-5. Benefit Categories Wilchfort, Lund, and Lew Considered Relevant

Benefit	Beach and Marina		Ballona Creek Estuary		Ballona Lagoon Venice Canals		Ballona Wetlands		del Rey Lagoon		Ballona Creek to Estuary		Ballona Creek		Total	
	WRCB	Site Visit	WRCB	Site Visit	WRCB	Site Visit	WRCB	Site Visit	WRCB	Site Visit	WRCB	Site Visit	WRCB	Site Visit	WRCB	Site Visit
Municipal and Domestic Supply											P		P		P	
Navigation		E	E		E				E						E	E
Water Contact Recreation		E	E	E	E		E		E		P		P		E	E
Non-Contact Water Recreation		E	E	E	E		E		E		E	E	E	E	E	E
Commercial and Sport Fishing		E	E		E				E						E	E
Warm Freshwater Habitat											P				P	
Cold Freshwater Habitat																
Estuarine Habitat			E	E	E		E		E			E			E	E
Marine Habitat			E		E							E			E	E
Wildlife Habitat			E	E	E		E		E		P		E		E	E
Preservation of Biological Habitat																
Rare, Threatened, Endangered Species			E		E		E		E						E	
Migration of Aquatic Organisms			E		E		E		E						E	
Spawning, Reproduction, Development			E		E		E		E						E	
Shellfish Harvesting		E	E		E										E	E
Wetland Habitat					E		E		E						E	

Source: Wilchfort, Lund, and Lew 1996: Tables 1&2, p.7&10

E = Existing, P = Potential, Blank = Not Considered presented in their first table, after a site visit. During a summer site visit, Wilchfort, Lund, and Lew evaluate storm conditions and seemingly arbitrarily eliminate some areas that receive water during storms, and add others. Based upon their summer site visit Wilchfort, Lund, and Lew decide that storm water does not reach the Ballona Lagoon, Venice Canals, nor the del Rey Lagoon, all inconsistent with the LARWQCB (1997), but they decide that storm water does reach the Marina and the beach.

2. Inconsistencies

Several problems are immediately evident in Brown and Caldwell's (1996) assessment of benefits. First is the discrepancy between the identification of receiving waters and the water bodies listed in Table 5-4. Dominguez Channel, the San Gabriel and Santa Clara River Watersheds are identified as part of District 7, but not included in the listing of benefit categories in Table 5-4. Second, they list the L.A. River but they really only consider Santa Monica Bay.

Table 5-6 reveals a list of benefit categories that Brown and Caldwell (1996) consider as existing and potential, inconsistent with the benefits ascribed by the LARWQCB (1997). Brown and Caldwell decide not to calculate any benefit for the use of Dockweiler Beach, although the 75,000 – 600,000 people who engage in Water Contact Recreation there on a daily basis (Wilchfort, Lund, and Lew 1996: pg. 24) are much more than "potential," the status given by Brown and Caldwell and which is inconsistent with the LARWQCB (see Table 5-6 below). Brown and Caldwell (1996) exclude Commercial and Sport Fishing and Shellfish Harvesting from any of the receiving waters of Ballona Creek or Malibu Creek, shown in Table 5-4 above, but these are common and valuable activities all along the Southern California coast, and this exclusion is inconsistent with the LARWQCB (1997, pp. 75, 103). Also shown in Table 5-4, Brown and Caldwell assume that the receiving waters from either Malibu Creek or Ballona Creek exclude Marine Habitat, or Rare-Threatened-Endangered Species, contrary to the LARWQCB (1997, pp.75, 103). The LARWQCB (1997, p.103) lists the nearshore and the offshore zones as receiving reaches of Ballona Creek. Table 5-6 shows that for Ballona Creek the LARWQCB lists Estuarine Habitat, Preservation of Biological Habitat, Migration of Aquatic Organisms, Spawning-Reproduction-Development, and Wetland Habitat as benefits, all omitted by Brown and Caldwell.

Table 5-6 compares the benefits of Ballona Creek pollution control among Brown and Caldwell (1996), Wilchfort, Lund, and Lew (1996), and the LARWQCB (1997). One of the lists of benefits by Wilchfort, Lund, and Lew appears to be relatively complete in comparison with the LARWQCB, although the second list of Wilchfort, Lund, and Lew is circumscribed by their determinations during their site visit; and it is their second list that they use when calculating benefits. Brown and Caldwell ignore navigation, inconsistent with both the LARWQCB and with Wilchfort, Lund, and Lew, especially since Brown and Caldwell incorporate the latter report by reference.

Most of the drainage area in CalTrans District 7 drains from the Los Angeles River and the San Gabriel River, both of which empty inside the breakwaters of San Pedro Bay, the location of the Los Angeles Harbor and the Long Beach Harbor. Brown and Caldwell confine their analysis to Santa Monica Bay. Both the Marina del Rey and King harbor are within Santa

Monica Bay, the study area for Brown and Caldwell, and these harbors include Navigation as a benefit. Brown and Caldwell incorporate the analysis of Wilchfort, Lund, and Lew, but on this point – the benefit of navigation from the Marina – they differ. Brown and Caldwell (p. 8-20) decide to ignore the commercial boating harmed by trash and debris that were identified by Wilchfort, Lund, and Lew, and only consider private pleasure boats. Because “there is insufficient data at present to estimate the value of shellfishing in Santa Monica Bay” (Brown and Caldwell, p.21), that aspect of commercial boats moored in the Marina at Ballona Creek is ignored. Since Brown and Caldwell determine that treatment of CalTrans facilities alone would not substantially reduce trash and debris, they decide that the value of control to private pleasure boats is not worth calculating; this decision is inconsistent with Wilchfort, Lund, and Lew, and this decision ignores the the pollution released by dredging the sediment that collects in the harbor.

Table 5-6: Comparison of Ballona Creek Benefit Categories Ascribed by Wilchfort, Lund, and Lew (1996, Tables 1&2), Brown and Caldwell (1996, Table 8.2), and the Los Angeles Regional Water Quality Control Board (1997, Table 22)

Benefit	Brown and Caldwell	Wilchfort, Lund, and Lew		LARWQCB
		From WQCB	From Site Visit	
Municipal and Domestic Supply	P	P		P
Industrial Use				E
Processed				
Agricultural Use				
Groundwater Recharge				
Navigation		E	E	E
Water Contact Recreation	P	E	E	E
Non-Contact Water Recreation	E	E	E	E
Commercial and Sport Fishing		E	E	E
Warm Freshwater Habitat	P	P		P
Cold Freshwater Habitat				
Estuarine Habitat		E	E	E
Marine Habitat		E	E	E
Wildlife Habitat	E	E	E	E
Preservation of Biological Habitat				E
Rare, Threatened, Endangered Species		E		E
Migration of Aquatic Organisms		E		E
Spawning, Reproduction, Development		E		E
Shellfish Harvesting		E	E	E
Wetland Habitat		E		E

E = Existing, P = Potential, Blank = Not Considered

Table 5-7 compares benefit categories of pollution control for Santa Monica Bay between Brown and Caldwell (1996) and the LARWQCB (1997). Six categories of benefits given by the LARWQCB are omitted by Brown and Caldwell from even an initial consideration.

Table 5-7: Comparison of Santa Monica Bay Watershed Benefit Categories Ascribed by Brown and Caldwell (1996, columns 1, 2, &3 of Table 8.2), and the Los Angeles Regional Water Quality Control Board (1997)

Benefit	Brown and Caldwell	LARWQCB
Municipal and Domestic Supply	P	E
Industrial Use		E
Processed		E
Agricultural Use		E
Groundwater Recharge		E
Navigation	E	E
Water Contact Recreation	E	E
Non-Contact Water Recreation	E	E
Commercial and Sport Fishing	E	E
Warm Freshwater Habitat	E	E
Cold Freshwater Habitat	E	E
Estuarine Habitat		E
Marine Habitat	E	E
Wildlife Habitat	E	E
Preservation of Biological Habitat	E	E
Rare, Threatened, Endangered Species		E
Migration of Aquatic Organisms	E	E
Spawning, Reproduction, Development	E	E
Shellfish Harvesting	E	E
Wetland Habitat	E	E

E = Existing, P = Potential, Blank = Not Considered

D. Benefit Categories Ignored by Brown and Caldwell and by Wilchfort, Lund, and Lew

Of the 20 benefit categories listed by the LARWQCB, in their final analysis comparing benefits to costs for the Santa Monica Bay watershed, Brown and Caldwell (p.8-21) only count Freshwater Habitat in their actual benefit calculation. Through similar logic that is critiqued in the next chapter, Wilchfort, Lund, and Lew (1996) eliminate all but four benefit categories for computation of benefits for the Ballona Creek watershed: 1) UCLA team rowing in the mouth of Ballona Creek, 2) bicycling along the edge of Ballona Creek, 3) 200 sailboats that dock in Marina del Rey, and 4) 12 commercial vessels docked in the marina that engage in shellfishing and dinner cruises. The rest of the benefit categories are missing in the numerical comparison with cost.

The pattern of omitting benefit categories is extensive, permeating both analyses. These omissions range across the spectrum, geographically, temporally, and categorically. Here are some major benefit categories that are omitted from both studies (Brown and Caldwell, 1996, and Wilchfort, Lund, and Lew, 1996).

1. Geographic Benefit Categories

a. The Majority of CalTrans District 7

Neither study considered benefits of pollution control in the major watersheds of the Los Angeles River, the San Gabriel River, the Dominguez Channel, nor the Los Cerritos Channel. Interior portions of District 7 alone the Los Angeles and San Gabriel Rivers and their tributaries have benefits from pollution control. The relevant locations of inland parks, lakes, and other recreation areas were not identified. The benefits of pollution control were not catalogued.

b. Controlling Pollution in the Entire Watershed, not Just CalTrans Pollution: Joint Agency Projects

Only Wilchfort, Lund, and Lew (1996) consider the benefits from joint control by CalTrans and other authorities for pollution control from all roads; that study is confined to Ballona Creek and it omits categories of benefits. Although they calculate the cost of joint control of all pollution in the Ballona Creek watershed, Brown and Caldwell (1996) fail to consider the benefits or costs of controlling all pollutants in surface water run-off to Santa Monica Bay.

2. Temporal Benefit Categories

a. Year-Round Benefits: Controlling Surface Water Run-Off, not Just Storm Water Run-off

Neither study considered year round benefits of pollution control, instead confining benefits to 40 days out of the year. The benefits of improved water quality are year-round benefits, not just benefits during the 40 storm days of the year. For any of the three levels of treatment considered by Brown and Caldwell (1996), and Wilchfort, Lund, and Lew (1996), treatment that reduces pollution during storms also reduces pollution at other times. The only benefits considered by these two studies are benefits during and immediately after storms. This confines their analyses to 40 days out of the year, rather than 365 days, which biases the benefit estimates downward.

b. Future Benefits

Neither study considered benefits from controlling pollution in the context of population and economic growth, both of which may be expected to add pressure for and benefit to additional pollution control. There are two avenues for this to occur. More people and economic activity will likely result in more pollution contained in surface-water run-off. More people and higher income per capita will likely add greater benefits to more people and a higher willingness to pay for pollution control.

3. Water Reclamation

Neither study considers the value of reclaimed water. Wilchfort, Lund, and Lew (1996, p.20) specifically rule out water reclamation. Their reasoning is that "the cost of using Ballona Creek flows as a local reclaimed water source was calculated to be over $1,300 per acre-ft., significantly higher than retail water costs and other more feasible reclaimed water projects" (p.19-20). This reasoning is false for two reasons. First, the Los Angeles Department of Water and Power sets their retail water rates based upon the marginal cost of the next best water reclamation project (Mayor's Blue Ribbon Committee, 1992, 1994), and their marginal cost used in their rate design equals $879 and $1,161/Acre-foot in the Winter and Summer, respectively, (converted to acre-feet from Hall, 1996, pp. 86-87). Second, water reclamation removes pollution which is an additional benefit that could make up more than the difference between $1300/Acre-foot and the $879 to $1,161/Acre-foot value of the water. Wilchfort, Lund, and Lew ignore the benefit of removing pollution when they dismiss water reclamation. Brown and Caldwell (1996) ignore water reclamation as an option for the Santa Monica Bay watershed.

4. Primary and Secondary Income

a. LA and Long Beach Harbors

Los Angeles and Long Beach Harbors connect the Southland to the Pacific Rim. The harbors face problems from dredging sediment borne by stormwater, dredging that releases heavy metals and other contaminants, mixing contaminants with the water in San Pedro Bay. No analysis was undertaken to catalogue benefits to these harbors.

b. Polluted Silt Closing Channels

Marina del Rey "channels are periodically shut down … (from) polluted silt washing down Ballona Creek" (Cone, 1997, p.16). This potential benefit from pollution reduction was omitted by both Wilchfort, Lund, and Lew (1996) and Brown and Caldwell (1996), as well as potential joint solutions. "Fed up with the recurring hunt for disposal sites, county supervisors and the Corps of Engineers last month launched a $2.7 million search for new solutions" (Cone 1997: p. 16). Storm water runoff treatment would greatly reduce the amount of polluted silt flowing into the waterways. This is true for King Harbor, as well as Marina del Rey. Having the harbors and waterways available for use is a benefit which is omitted from the analyses.

c. Regional Economic Impacts

All the activities provided by the yacht clubs (yacht race spectators, various services near the water such as food service, membership parties, docking, living on docked boats) have higher values from reduced pollution in the water. The aesthetic value includes reduced odor, more wildlife, cleaner water, and the knowledge of a healthier ecosystem and a healthier environment. The increase in aesthetic value is likely to increase monthly attendance at yacht clubs and beaches from, for example, "monthly attendance at Dockweiler Beach … between 75,000 in the winter months to 600,000 in the summer months" (Wilchfort, Lund, and Lew 1996: pg. 24). The increase in attendance adds to the direct economic benefits to businesses that serve beach visitors.

There are benefits to the regional economy of an improvement to the water quality. If pollution generally makes an area less desirable, it is very likely that there will be primary income effects on local businesses whose success is closely tied to the quality of the area and the level of availability of beneficial uses, and therefore, the level of pollution. Neither Wilchfort, Lund, and Lew nor Brown and Caldwell included any estimate of the primary income effects.

The Santa Monica Bay Restoration Project (1994, p.1-9) estimates $3.6 million for 1989 in direct expenditures by fishers alone, and $232 million and more than 3,000 jobs from tourists in 1986, stating "aesthetic resources make and intangible but important contribution to the local economy" (p.1-8). They find, "secondary economic impacts from the Bay area's commercial and industrial activities emanate to the rest of the Los Angeles region" (p.1-11).

5. Property Values

Property values in the surrounding areas are adversely affected by water pollution. d'Arge and Shogren (1989) estimate the effect of water quality on property values for houses near lakes in Iowa. Doss and Taff (1996) review published research to estimate the value to residential property of proximity to differing types of wetlands in Ramsey County, Minnesota.

6. Health Effects

The Santa Monica Bay Restoration Project (1994) devotes Chapter 12 to "Health Hazards of Seafood Consumption." There, they list the highest hazards as including PCBs (p.12-17), which are among the pollutants measured in surface water run-off (p.7-13) from Ballona Creek into Santa Monica Bay. There are other hazards. Brown and Caldwell (1996) ignore PCBs and other pollutants in fish and shellfish. Wilchfort, Lund, and Lew (1996) note pollution in shellfish, but they also ignore pollutants in fish, obtaining their data on pollution from Brown and Caldwell.

The Santa Monica Bay Restoration Project (1994) devotes Chapter 11 to "Swimming-Related Health Hazards." These include hazardous chemicals and biological pathogens. The latter include fecal coliform and enterococcus bacteria, but there are enteric viruses and other biological hazards. Of grave concern is dry weather run-off. Haile et al. (1996) estimate the ill health effects from water pollution in Santa Monica Bay. Brown and Caldwell (1996) and Wilchfort, Lund, and Lew (1996) only consider fecal coliform. After considering it, they ignore it in the benefit calculation, partially on the basis of wet-weather only analyses.

The method proposed by Wilchfort, Lund, and Lew (1996), relied upon by Brown and Caldwell (1996), only considers lost days of recreation due to health-related beach closings that prohibit all water related recreation in the upper reaches of Ballona Creek, including team rowing. Their method has no calculation of the economic loss from morbidity or mortality, and omits Dockweiler Beach. This category of benefit is not permitted by their method.

7. Recreation Benefits

a. Contact Recreation

In their analysis, Wilchfort, Lund, and Lew (1996) ignore the beach. They decide that no pollutant harms those who use the beach, except fecal coliform. They speculate (Wilchfort, Lund, and Lew , p.20) that fecal coliform does not originate from any CalTrans sources, contrary to the analysis on behalf of CalTrans by Pan and Schroeder (1996, p.6) who conclude that fecal coliform is from storm water run-off, not sewage overflow or leakage. Wilchfort, Lund, and Lew further decide, contrary to the report by the City of Los Angeles, Division of Public Works, Bureau of Engineering (1995), that there is no benefit if pollution control by CalTrans reduces fecal coliform; for example, in their calculation of the benefits of a joint agency water treatment facility at the mouth of Ballona Creek, they implicitly assume that there is no benefit from reducing fecal coliform.

A regional water treatment facility, or several facilities, would not just reduce fecal coliform from CalTrans roads and facilities, but a joint product is also obtained if there is a reduction the frequency of closing Dockweiler Beach and other nearby beaches. More generally, an important omitted benefit of cleaner water is to those who swim at the beaches along Santa Monica Bay. In particular, the study by Wilchfort, Lund, and Lew (1996) omits benefits to those who swim, bellyboard, surf, windsurf, skimboard, wade, tiptoe in, or loll about in the water at Dockweiler Beach, which extends on both sides of the outlet of Ballona Creek to the Bay. Swimmers are better off if all year long, including the peak summer months, they do not swallow as much arsenic, antimony, barium, lead, cadmium, mercury, chromium, nickel, and thallium. Swimmers are better off if they do not swallow as much nitrate, sulfate, oil and grease, and ammonia. Swimmers are better off if they do not accidentally ingest selenium and zinc. Swimmers are better off if they are exposed to less fecal coliform. To measure the benefits, it would be necessary to determine the value to swimmers of reduced exposure to these pollutants, all year long and including the summer. The value is not zero – that is the number used by Wilchfort, Lund, and Lew (1996) and Brown and Caldwell (1996). This is a serious omission from these two reports. Brown and Caldwell (1996) not only omit the benefit of water contact recreation at Dockweiler Beach, but for all the beaches along the entire coast, given in Table 5-3. They not only omit the benefit to water contact recreators of having a cleaner beach, they also omit the cost of ill-health to those who get sick.

b. Non-Contact Recreation

Non-contact recreators at the beaches, the lagoons, and the yacht clubs have higher values from reduced pollution in the water. The aesthetic value includes reduced odor, more wildlife, cleaner water, and the knowledge of a healthier ecosystem and a healthier environment. This benefit of reduced pollution could be substantial, given that annual attendance at the beaches in Santa Monica Bay is between 40 and 50 million people per year (Santa Monica Bay Restoration Project, 1994, Figure 1-3, p 1-7). Wilchfort, Lund, and Lew include for Non-Contact Recreation benefits only the 100 members of the LMU and UCLA crew rowing teams. These benefits are entirely omitted by Brown and Caldwell for all the beaches listed in Table 5-3.

c. Fishing

Fisheries off the coast of California depend on the ecosystem along the coast, not just in the estuaries, for food and spawning. Heavy metals and other pollutants bioaccumulate. Wilchfort, Lund, and Lew (1996) consider the benefits to fisheries only in a most oblique way, through a reduction in benefits from shellfishing by those who hire 12 commercial boats that dock in Marina del Rey. Brown and Caldwell (1996) and Wilchfort, Lund, and Lew (1996) exclude from consideration the potential benefits to the Ballona wetlands, the Del Rey Lagoon, and the Ballona Lagoon, all adjacent to the mouth of Ballona Creek, as habitat. A joint product of reducing pollution from transportation related activities is an improvement in the coastal ecosystem. Commercial fishing vessels from the Los Angeles Long Beach, and Newport harbors catch fish that depend on the ecosystem of the Santa Monica Bay. Sport fishing includes all fish, not just shellfish, and should be included as another joint product that benefits from reduced pollution outflow from Ballona Creek.

The Santa Monica Bay Restoration Project (1994, p.1-8) identifies "gillnetting for California Halibut .., and Purse seining for northern anchovy in the outer portions of the Bay, … and 5.5 million sport fishing trips in 1989."

d. Boating

Marina del Rey "channels are periodically shut down … (from) polluted silt washing down Ballona Creek" (Cone, 1997, p.16). This potential benefit from pollution reduction was omitted by both Wilchfort, Lund, and Lew (1996) and Brown and Caldwell (1996), as well as potential joint solutions. "Fed up with the recurring hunt for disposal sites, county supervisors and the Corps of Engineers last month launched a $2.7 million search for new solutions" (Cone 1997: p. 16). Storm water runoff treatment would greatly reduce the amount of polluted silt flowing into the waterways. This is true for King Harbor, as well as Marina del Rey. Having the harbors and waterways available for use more days during the year is a valuable benefit which is omitted from the analyses.

8. Nonuse Benefits

a. Non-Use Values

The method proposed by Wilchfort, Lund, and Lew (1996), and relied upon by Brown and Caldwell (1996), does not permit the calculation of benefits from non-use values. Consequently, both studies omit all benefits related to non-use values, causing the benefit estimates to be biased downward.

Wilchfort, Lund, and Lew (1996) omit all nonuse values from the benefit estimation of reducing pollution from Ballona Creek. They state,

> "*There are two primary reasons that nonuse values are not included in the analysis of Ballona Creek. First, nonuse values are generally thought to be associated with unique resources that have no readily available substitutes for providing the amenities people value. Ballona Creek, a channeled storm drain, does not fall into this category of resource amenity*." (Appendix C, p.5).

This first argument is wrong for two reasons. First, the pollution is degrading unique resources. The pollution from Ballona Creek reaches the Marina del Rey, the Ballona Lagoon, the Venice Canals, the Del Rey Lagoon, and the Ballona Wetlands (LARWQCB, 1997, p.100). The pollution is degrading the wetlands (LARWQCB, 1997, p.104). The pollution from Ballona Creek empties into the Santa Monica Bay. The Ballona Wetlands are a unique resource:

> *"The Ballona Wetlands are a complex of estuary, lagoon, salt marsh, freshwater marsh and dune habitats. … A dynamic, vital place, the Ballona Wetlands are a highly valuable resource for the Los Angeles region. They have critical habitat value for many species of organisms, serve as an invaluable educational resource, and are unique in being situated in a large metropolitan area. … The wetlands have been reduced to a little over 180 acres (from 1800-2000acres). Even after these staggering losses, the Ballona Wetlands constitute the last large area of this habitat type in Los Angeles County."* (Friends of Ballona Wetlands, 1997, p.1).

The Santa Monica Bay is also a unique resource. "In 1988, California Governor Deukmejian nominated Santa Monica Bay to be included in the National Estuary Program and in July 1988 the Bay became one of 21 bodies of water nationwide to be granted this status" (Santa Monica Bay Restoration Project, 1994, p.1-2).

Second, even if there are many close substitutes, that does not mean that the substitutes have little value; the availability of close substitutes does not mean the resource has zero, or close to zero, nonuse value. Substitutes may be plentiful but at high cost, in which case the nonuse value may be high.

Wilchfort, Lund, and Lew (1996) state their second argument for not including nonuse values. It is that they, Wilchfort, Lund, and Lew, don't value Ballona Creek: "There are no credible empirical measurements of nonuse value for ordinary streams such as Ballona Creek because they are believed a priori to be small" (Appendix C, p.6). They go on to describe Ballona Creek as a polluted concrete channel, as opposed to "high quality resources" for which the nonuse value is "not related to any quality change." For sure, pollution reduces the value. But changes in quality can be valuable. The Ballona Wetlands and the Santa Monica Bay are high quality resources that cannot be described as concrete pollution-drainage ditches. Moreover, Brown and Caldwell (1996) ignore nonuse values without consideration for any unique resources in their study area – the Santa Monica Bay watershed.

A panel of experts convened by NOAA (1994), including two Nobel Laureates, Kenneth Arrow and Robert Solow (Arrow, et al., 1993), designed protocols for Contingent Valuation (CV) studies that are strict enough to be able to replicate results, "estimates reliable enough to be the starting point of a judicial process of damage assessment, including lost passive use values" (Arrow et al., 1993). Another argument Wilchfort, Lund, and Lew use to justify setting the nonuse value to zero is because the protocols for CV are restrictive, requiring "extensive preparation of survey material, time-consuming pretesting and data collection, and a period for analysis and reporting" (Wilchfort et al, Appendix C, p.4). Yet, "several CV practitioners believe the panel's guidelines and protocols for CV studies are overly prescriptive. These individuals argue that reliability can be obtained under less restrictive protocols" (Kopp, 1995); Harrison and Lesley (1996) agree.

A final reason for setting the nonuse value to zero given by Wilchfort, Lund, and Lew (Appendix C. pp. 6-7) is that the only estimates they could find in the literature are higher than a number they are willing to use. They argue that it is wrong to compare literature estimates of wild rivers in Colorado with the concrete drainage ditches that make up Ballona Creek, thereby ignoring the values of the Ballona Wetlands and Santa Monica Bay. Brown and Caldwell follow their example, ignoring nonuse values.

9. Ecosystems

There are benefits to the economy of an improvement to the water quality, restoration of aquatic ecosystems and habitat (Costanza, et al., 1997; Whitelaw and Niemi, 1997). Wetlands, such as the Ballona Wetlands and Bolsa Chica Wetlands, are within the reaches of watersheds in CalTrans District 7. These wetlands contain delicate ecosystems whose susceptibility to damage from pollution is well documented. Both Brown and Caldwell (1996) and Wilchfort, Lund, and Lew n(1996) ignore wetlands.

Brown and Caldwell (1996) calculate a value for wildlife habitat along Ballona Creek. Their estimate, however, is limited to 35 acres -- compared to the 180 acres of the wetland plus additional acreage for the lagoons and the upper reach of the creek. Brown and Caldwell (1996) also omit all the lagoons given in Table 5-3 above.

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Chapter VI Linking Pollutant Changes to Benefit Changes

This chapter reveals how the report by Brown and Caldwell (1996) displays a number of pollutants and a list of beneficial uses in their analysis of Santa Monica Bay, and yet in their actual computations count only one beneficial use – wildlife habitat. This chapter also reveals how, in Brown and Caldwell's analysis, only one pollutant – copper – is included in the actual benefit computation for pollution control (Brown and Caldwell, Table 8.13, p.8-25).

This chapter explains how Wilchfort, Lund, and Lew (1996) are able to consider a list of beneficial uses in their analysis of Ballona Creek, and yet in their actual computations count only five beneficial uses – UCLA's team rowing in the mouth of Ballona Creek, bicycling along Ballona creek, pleasure boating from the Marina, and commercial vessels for dinner cruises and commercial vessels for shellfishing. Since Wilchfort, Lund, and Lew only consider five pollutants at the outset of their analysis, it is less surprising that only four pollutants – oil and grease, fecal coliform, lead, and debris – are included in the actual benefit computation for pollution control (Wilchfort, Lund, and Lew Tables 11 and 12, pp. 26-27).

There are six concepts key to the elimination of benefits and pollutants by Wilchfort, Lund, and Lew (1996) and Brown and Caldwell (1996). Two concepts are general and four are specific to the method proposed by Wilchfort, Lund, and Lew and applied by Brown and Caldwell; details of two general concepts are presented in the next section and details of four specific concepts are presented in later sections.

One general concept is the selection of the pollutants and the increment of pollution reduction for the benefit computation. Normally, this is determined by the context in which particular pollution control options are considered; for examples, (i) pollution control by CalTrans alone of just CalTrans facilities, (ii) pollution control by CalTrans of CalTrans facilities simultaneously with pollution control by other permit holders, or (iii) joint agency pollution control. A second general concept is diminishing marginal utility.

Four concepts are specific to the method by Wilchfort, Lund, and Lew, which was adopted by Brown and Caldwell: pollution thresholds, linearity of changes in benefits to changes in pollution, legal standards (unrelated to economic benefits) that confine links among specific pollutants to specific benefits, and the assumption that the current condition describing the pollution concentration is the same constant everywhere and every time, rather than randomly varying over time and geographically across water reaches.

A. Identifying Pollutants, and the Incremental Benefits for Increments of Pollution Reduction

In this section we present two aspects of a generally accepted approach for identifying pollutants and pollution reduction, in contrast to the unusual approach by Wilchfort, Lund, and Lew which was applied by Brown and Caldwell.

1. Identifying Pollutants and Incremental Pollution Reduction

Brown and Caldwell present three levels of pollution reduction based on three treatment levels. These levels of treatment can be applied to all storm water, or to some minuscule fraction. In this section, we argue that the appropriate analysis is to consider the benefits and costs of application to all storm water, not to some minuscule fraction. We also present some reasonable means of applying the pollution reduction from the three treatment levels to all pollutants in storm water, rather than to a few select pollutants as do Wilchfort, Lund, and Lew and Brown and Caldwell. There may be better ways to apply the treatments to each pollutant in storm water; we merely indicate that the information at hand presents a way to consider most of the pollutants, rather than ignoring most of the pollutants as do Brown and Caldwell and Wilchfort, Lund, and Lew

Dammel (1997) classifies pollutants into five categories and presents a range of values for pollution concentration and the frequency of detection (see Tables 3-1 and 3-2 above). Each aggregate category includes either numerous pollutants, or sub-categories of pollutants, or both: (i) Physical and Aggregate Properties (5 properties and 4 subcategories of pollutants), (ii) Metals (10 pollutants), (iii) Inorganic Nonmetallics (11 pollutants and 1 property), (iv) Aggregate Organics (6 subcategories), (v) Microbiological (4 pollutants). From Wilchfort et al, (1996,

Table 10, p.26) we have samples from four of these five categories of pollutants, with corresponding reductions in pollution for three treatment levels, shown in Table 6-1.

Table 6-1. Pollutants and Percentage Reductions in Pollution

Dammel's (1997) Pollution Categories	Physical and Aggregate Properties	Inorganic Nonmetallics	Metals	Aggregate Organics	Microbiological
Representative Pollutants given in Wilchfort, Lund, and Lew*	Total Suspended Solids*	1.	Lead*	Oil and Grease*	Fecal Coliform*
Level 1*	95%*	1.	40%*	50%*	25%*
Level 2*	95%*	1.	64%*	100%*	99%*
Level 3*	95%*	1.	98%*	100%*	99.9%*
Pollutant Categories or Representative Pollutants in Dunn et al. (1995)**	Suspended Sediments **	Total Nitrogen / Total Phosphorus**	Trace Metals* *	Biochemical Oxygen Demand**	Bacteria**
Design 6: Infiltration Basin	80-100% **	60-80% **	80-100% **	80-100% **	80-100% **
Design 13: Sand Filter	90% **	70% / 50% **	80% **	90% **	90% **

*Source: From Wilchfort, Lund, and Lew (1996, Table 10, p.26)
**Source: From Dunn et al. (1995), referenced in Brown and Caldwell (Appendix 3.1, Table 1.3, p.1-7).

1. No representative pollutants considered by Wilchfort, Lund, and Lew

Table 6-1 also shows pollutant removal for 2 of the 13 urban Best Management Practice designs considered by Dunn et al. (1995), as summarized in Brown and Caldwell (Appendix 3.1, Table 1.3, p.1-7). It appears to be standard practice to group some pollutants into categories and assume that treatment reduces all pollutants within a category by the same amount. For total phosphorus and total nitrogen, the only single pollutants within the same category, 10 of the 13 BMPs have identical pollutant removal efficiency, and the remaining 3 have similar pollutant removal efficiency. In order to calculate the expected condition after applying treatment, in the absence of additional information that an engineering firm such as Brown and Caldwell should have, one could assume that each treatment level reduces all pollutants in each category by the same percentage. In this fashion, one could include in the benefit calculations all pollutants considered by Dammel.

2. The Increment of Pollution Reduction

In order to ascertain the pollution reduction afforded by the control measure, one multiplies the percentage reduction times the current condition (the level of pollution concentration without control). The current condition is given in the data given by Dammel, as shown above in Tables 3-1 and 3-2. See Table 6-2 for descriptions of the data values from Dammel for the pollutants considered by Wilchfort, Lund, and Lew; these data are consistent with the assumptions of a one-tailed probability distribution of pollution, truncated at zero with a 95% probability of occurring within the "typical range", and a given frequency with which the pollution concentration is zero (100% minus the Table values). From these data and this assumption about the probability distribution of the current condition, the reductions in pollutant categories could be computed. In this fashion, that range of values likely to occur could be considered without eliminating pollutants from benefit calculations, and a broader range of actual results from sampling data could be incorporated into analyses of benefits of pollution control, rather than constraining the analyses to a few pollutants as do Brown and Caldwell and Wilchfort, Lund, and Lew

Table 6-2. Pollution Concentration and Frequency of Occurrence

Dammel's Pollution Categories*	Physical and Aggregate Properties*	Inorganic Nonmetallics*	Metals *	Aggregate Organics*	Microbiological *
Representative Pollutants**	Total Suspended Solids**	Total Nitrogen / Total Phosphorus	Lead**	Oil and Grease**	Fecal Coliform**
Typical Range*	0-1000 mg/L*	0-10 mg/L* 0-2 mg/L*	0-0.2 mg/L*	0-50 mg/L*	0-500,000 MPN/100mL*
Frequency*	92.3%*	97.9%* / 100%*	78.8%*	73.5%*	100%*

*Source: Dammel (1997)

**Source: Wilchfort, Lund, and Lew

The size of pollution reduction is another basic consideration. The context in which particular pollution control options are considered includes the "water quality goals … derived from the Clean Water Act of fishable, swimmable waters and a California goal that all fresh water be a potential drinking water source" (Brown and Caldwell, p.iv). Brown and Caldwell acknowledge that the language of the permit explicitly states that water quality control efforts are "… to be evaluated by the total efforts of all the permittees, not on an individual basis" (pg. 8-5). Hence, actions by CalTrans must not be considered in isolation from other efforts to reduce pollution. Consequently, the appropriate levels of pollution reduction should be considered in the context of simultaneous or joint actions with other agencies, whichever of these two is the most cost effective.

Even if CalTrans just reduces pollutants from CalTrans facilities, the increment of pollution reduction for benefit calculation must consider reductions as though other agencies are also engaged in pollution reduction. The incremental benefit from simultaneous or joint reductions can then be compared with the incremental costs of all the agencies to determine whether or not the incremental benefits exceed the incremental costs. In their analysis of the benefits of pollution control for Santa Monica Bay, Brown and Caldwell (1996) evaluate the benefits on an individual basis rather than the total efforts of all the permittees.

There are economies of scale and scope of building larger pollution control facilities that limit all pollutants, not just CalTrans pollutants. Brown and Caldwell omit these economies in their cost estimates for Santa Monica Bay. In their analysis of the costs of pollution control for Santa Monica Bay, Brown and Caldwell (1996) evaluate the costs on an individual basis rather than the total efforts of all the permittees.

In their comparison of the benefits and costs of pollution control for Santa Monica Bay, Brown and Caldwell (1996) evaluate the benefits and costs on an individual basis rather than the total efforts of all the permittees. Thus, their analysis violates the language of their permit as they have described it.

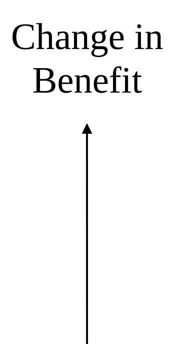
3. *Diminishing Marginal Utility*

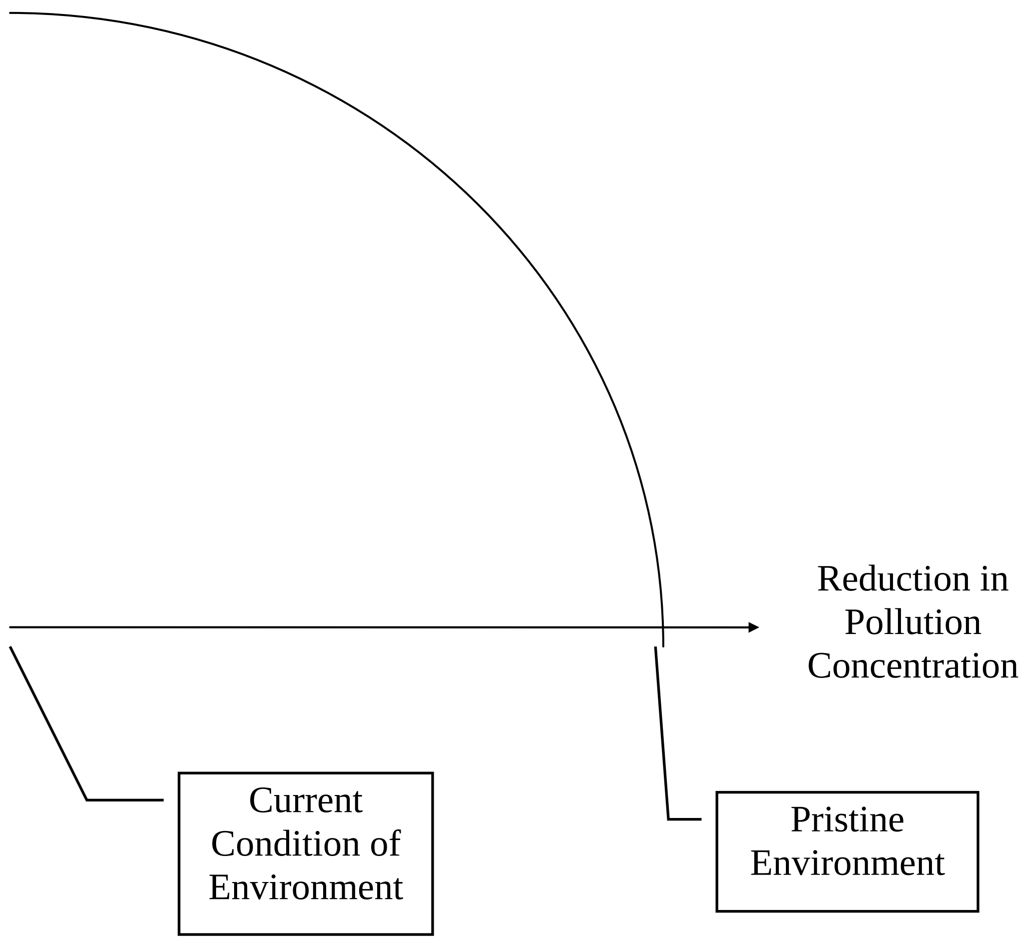
Figure 6-1 illustrates the concept of diminishing marginal utility. It is standard economic analysis to apply the concept of diminishing marginal utility to the relationship between pollution reduction and increase in benefits. Diminishing marginal utility is among the most fundamental notions in economic analysis, which states that in any endeavor the largest increase in benefits is derived from the initial amounts, and incrementally less benefit is received from subsequent equal amounts.

The application of diminishing marginal utility to the study in question is threefold. First, the initial pollution control reaps the greatest increase in benefit. Second, as the resource becomes progressively cleaner, equal changes in pollutant concentration yield progressively smaller increases in benefits. Third, the increase in benefits from a reduction in pollutant concentration is never zero. Until the resource is pristine, any quality improvement makes the resource more valuable.

Failure to incorporate diminishing marginal utility will either underestimate or overestimate the change in the value of a benefit depending on the current level of pollutant concentration. In order to compare diminishing marginal utility to the method by Wilchfort, Lund, and Lew, the reader needs to know about the two types of pollution thresholds they assume, a topic developed in the next section. For Wilchfort, Lund, and Lew, the initial reduction in pollution may reap no benefit if the current level of pollution is so putrid that no benefit can be obtained. For pollution reduction in between their putrid threshold and the noisome threshold, as the resource becomes progressively cleaner, equal changes in pollutant concentration yield the same change in benefits, in opposition to the fundamental principle of marginal utility. For pollution reduction below the noisome threshold, Wilchfort, Lund, and Lew assume equivalency between this threshold and a "pristine" environment. We now turn to a discussion to clarify the threshold concept introduced by Wilchfort, Lund, and Lew and adopted by Brown and Caldwell.

Figure 6-1. Diminishing Marginal Utility Between Pollution and Benefits.





B. Wilchfort, Lund, and Lew Method

Brown and Caldwell's study proceeds with a method proposed by Wilchfort, Lund, and Lew. The method proposed by Wilchfort, Lund, and Lew eliminates from the benefit computation most pollutants, and thereby eliminates beneficial use values due to pollution control. For the pollutants actually considered, the method further eliminates from the benefit computation some beneficial uses affected by the few pollutants actually considered.

1. General Approach

Wilchfort, Lund, and Lew (1996) eliminate pollutants and benefits of pollution reduction by combining the concepts of pollution thresholds, their assumption that the current condition describing the pollution concentration is a constant (rather than varying) equal to an arbitrary number, legal standards (unrelated to economic benefits) that confine specific beneficial uses to specific pollutants, and linearity of changes in benefits to changes in pollution.

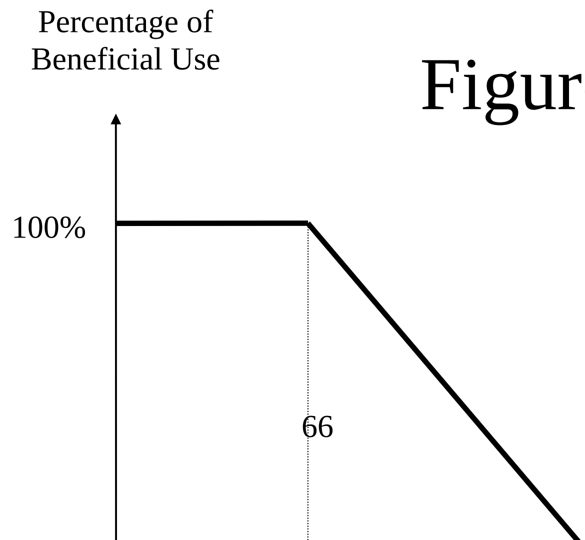
First, Wilchfort, Lund, and Lew (1996) assume that there are upper and lower pollution concentration thresholds above and below which there are no benefits to improved water quality – which are referred to here as the putrid and noisome thresholds, respectively (see Figure 6-2 below). The putrid threshold delineates the level of pollution beyond which no benefits can be derived from the resource. Their rationale for establishing this limit is as follows: if a resource is so polluted that no benefits can currently be derived from it, the marginal improvement from CalTrans runoff treatment would not render the resource useful; therefore, the benefit of pollution control is zero, so the pollutant can be ignored.

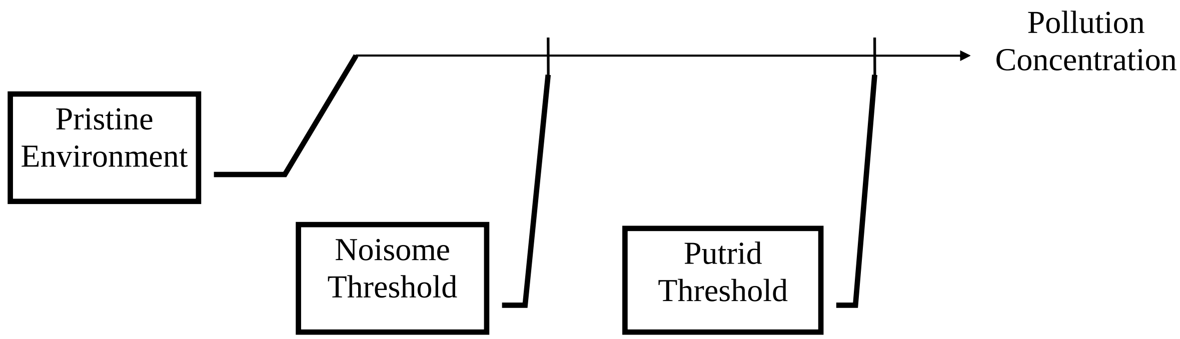
The noisome threshold defines the pollutant concentration below which the resource is "unimpaired," and above which there is some loss of value to beneficial uses. Wilchfort, Lund, and Lew (1996) assume that all benefits of the resource are available if the pollution concentration is at or below the lower threshold; therefore, further improvements in water quality would yield no benefits and the pollutant can be ignored. This assumption is tantamount to assuming that the environment is pristine for pollution concentration below the noisome level, an error. Simply put, there is an economic value people place on a pristine environment.

Wilchfort, Lund, and Lew (1996) also eliminate pollutants from the analysis in three more cases. One is if they cannot establish the pollution concentration. Two is if they cannot find a legal standard to artifically establish an economic threshold. Three is if more than one pollutant in a category of pollutants falls in between the two thresholds, and the analysis can be simplified by just focusing on one pollutant, ignoring the other pollutants in that category.

In their application of the Wilchfort, Lund, and Lew method, Brown and Caldwell eliminated most pollutants from the analysis after inappropriately and arbitrarily selecting among alternative legal standards to establish an economically noisome threshold, and arbitrarily picking constant values for the current condition that fall below the noisome thresholds. Next, Brown and Caldwell ignored pollutants for which they found no legal standard, irrespective of the economic value, the impact on human health, or the the impact on the ecosystem. They additionally ignored pollutants for which they were not able to determine the current condition.

Figure 6-2





While Brown and Caldwell rely on the method by Wilchfort, Lund, and Lew, in their benefit analyses of Ballona Creek, Wilchfort, Lund, and Lew rely on Brown and Caldwell's arbitrary specification of a constant current condition, on Brown and Caldwell's arbitrary and inappropriate use of legal standards (unrelated to economic benefits) for thresholds, on Brown and Caldwell's elimination of pollutants for which there was no legal standard to establish thresholds, on Brown and Caldwell's elimination of pollutants for which they were not able to identify the current condition, and on elimination of pollutants within a category of pollutants. Consequently, Wilchfort, Lund, and Lew only consider five pollutants at the outset of their analysis, which they pare to four.

Having winnowed the list of pollutants to a handful, Wilchfort, Lund, and Lew confine the types of beneficial uses to pollutants for which a water quality standard is specified to protect a particular beneficial use.

For the few beneficial uses remaining in the analysis, Wilchfort, Lund, and Lew assume that the relationship between pollution concentrations and benefits is linear such that the same change in pollutant concentration will always yield the same change in benefits. This linear relationship is shown in Figure 6-2. They term the change in the percentage of total benefits available a "benefit multiplier". For each of the handful of pollutants they consider, in combination with specific beneficial uses they calculate a benefit multiplier for each of the three treatment levels given by Brown and Caldwell. The multipliers are based upon both the thresholds and the amount of the water that is treated. In the analyses by Wilchfort, Lund, and Lew and Brown and Caldwell of, respectively, Ballona Creek and the Santa Monica Bay, for Winter-time only treatment of only CalTrans facilities, the proportion of water treated is minuscule, and so are the multipliers, rendering the calculation of benefits de minimus.

Finally, for beneficial uses that several pollutants affect, Wilchfort, Lund, and Lew use two alternative methods when deciding upon the selection of the benefit multiplier. They name these the “Limiting Pollutant Method” (LPM) and the “Averaging Method” (AM). The LPM selects the smallest from among the benefit multipliers. The AM calculates a simple average of the benefit multipliers to determine the benefit fraction for a reduction in pollution.

2. Eliminating Pollutants: Inappropriate Use of Legal Standards to Establish Economic Benefit Thresholds, and Arbitrarily Selected Constant Values for the Current Condition

In general, Brown and Caldwell establish thresholds on the basis of Regional Water Quality Control Board, Los Angeles County Health Department, and EPA standards. The pollutants for which Brown and Caldwell choose to present standards for acute toxicity and human health are shown in Table 6-3.

Brown and Caldwell’s arbitrarily selected constant values for the current condition are listed by them in a table that juxtaposes values reported by others (Brown and Caldwell, Table 3.4, p. 3-8) and also values from four storms sampled by CalTrans District 7 (Brown and Caldwell, Table 3.5, p. 3-8). Brown and Caldwell’s tables are replicated here for convenience in Tables 6-4 and 6-5.

Table 6-3. Dammel's Typical Range, Brown and Caldwell's Current Condition, and Thresholds Based on Brown and Caldwell's Selection of Water Quality Standards

POLLUTANT	Dammel's Typical Range	Brown & Caldwell's Current Condition	B&C's Water Quality Standards (mg/L or MPN/100mL): 1-Hour Toxicity: (Aquatic Life) **Acute Toxicity** – Inland	Estuarine	Oceanic[a]	Municipal Supply[b]	Other Use
Physical & Aggregate Properties							
Total Suspended Solids	0-**1000?**	**200?**			75%[c]		
Volatile Suspended Solids	0-200	75					
Total Dissolved Solids	0-**1000?**	100				500	250
Turbidity	0-200	**?**			225		
Hardness (200 mg/L $CaCO_3$)			d				
Inorganic Nonmetallics							
Chloride	0-**20**	**?**				250	10
Nitrate	0-10	5.0				45	
Total Kjeldahl Nitrogen	0-10	2					
Phosphate	0-2	0.5					
Sulfate	0-20	**?**				500	30
Ammonia	0-5	**?**	25		6		
Aggregate Organics							
Oil & Grease	0-**50?**	**15?**			75		No Film
Total Organic Carbon	0-100	50					
Chemical Oxygen Demand	0-500	150					
Microbiological							
Fecal Coliform	0-**500,000**	**1600**	e	e	e		200[e]
Total Coliform	0-**500,000**	**5000**	f	f	f		70[f]
Metals							
Antimony (Sb)	******13.8%	**0.018***				0.006	
Arsenic (As)	**?**	**?**	0.360	0.069	0.080	0.05	
Barium (Ba)	0-0.5	**?**				1.0	
Cadmium (Cd)	-	0.005	0.009	0.043	0.010	0.005	
Chromium III (Cr III)	0-**100**	**?**	3.064		33		
Chromium VI (Cr IV)	0-**100**	**?**	0.016	1.100	0.020	0.05	
Copper (Cu)	0-**0.2**	**0.08**	0.034	0.003	0.03.	1.3[g]	
Lead (Pb)	0-**0.2**	**0.05**	0.197	0.140	0.020	0.015[g]	
Mercury (Hg)	0-**100**	**?**	0.002	0.002	0.0004	0.002	
Nickel (Ni)	0-**50**	**?**	2.549	0.075	0.050	0.1	
Selenium (Se)	******8.7%	**?**	0.005	0.300	0.150	0.05	
Thallium (Tl)	**?**	**?**				0.002	
Zinc (Zn)	0-**1**	**0.4**	0.211	0.095	0.200	5[h]	

a. Oceanic limits are instantaneous maximum allowed (SWRCB 1990).
b. Based on Los Angeles Basin Plan, Table 3-5 (RWQCB 1994), unless otherwise noted.
c. Infers a required minimum of 75% solids removal from waste stream.
d. Calculated metals values are based on 200 mg/L hardness (SWRCB 1993).
e. Based on recreational use for whole-body water contact (REC1).
f. Based on food consumption limitations (SHELL).
g. Based on primary drinking water standards (22 CAC 64672.3a-b).
h. Based on secondary drinking water standards (22 CAC 64449.1; Table 64449-A).
* Antimony is omitted in Brown and Caldwell's Chapter 3, but listed in the Executive Summary, Table 3, p. v.
** Frequency of Detection given by Dammel (1997), see Table 3-2 above

Source: Brown and Caldwell (1996, Table 3, p.v)

Brown and Caldwell arbitrarily specify the current condition as follows. First they select four samples of District 7 storm water quality, shown in Table 6-4, and then select "Preliminary Values" from those samples, also shown in Table 6-4. They also select for review some pollution concentrations reported by others, shown in Table 6-5, and then select "Preliminary Values" from those reports, also shown in Table 6-5. They state, "each of these preliminary values was then combined to obtain a probable constituent concentration expected in District 7 runoff. These water quality values were considered in developing GMPs" ("Good Management Practices", Brown and Caldwell, p. 3-9). Table 6-6 shows the two sets of preliminary values, and the "probable constituent concentration expected in District 7 runoff" expected by Brown and Caldwell, compared to the range of values reported by Dammel (1997) which are presented in an earlier chapter in Table 3-1.

Brown and Caldwell's constant values for the pollution concentration are arbitrary because they bear no meaningful statistical relationship to the sampled data: they consider only four observations (four storms), their numbers are not estimates of averages, nor do their numbers reflect the variation of the reported actual sampled values.

Here are seven ways in which the benefit calculations are de minimus, all of which are critiqued in a following section. First, Brown and Caldwell consider the 29 pollutants given in Table 6-3, and ignore the other 24 pollutants given in Tables 3-1 and 3-2 above. Second, Wilchfort, Lund, and Lew name the lower threshold the "Unimpaired Use Concentration," implying that the environment is pristine for pollution concentrations below this level. If it is pristine below the standards and the current condition can be found to fall in that category, then they assign zero benefit for further pollution reduction. Third, Brown and Caldwell select from among myriad alternative legal standards (pollution criteria and standards) arbitrarily choosing the ones that are high rather than low (Table 6-3, acute toxicity instead of chronic toxicity). Fourth, Brown and Caldwell choose the current pollution concentration levels from selected samples and reports of water quality for which the concentrations are in the low end of the typical range reported by Dammel (Table 6-3: compare the columns "Brown and Caldwell's Current Condition" to "Dammel's Typical Range"). Fifth, Brown and Caldwell eliminate pollutants for which the assumed current condition is lower than the selected standards (Table 6-3: Nitrate, Cadmium). Sixth, Brown and Caldwell eliminate from the analysis pollutants for which there are standards but for which no value is presented for the current condition, even though there are procedures for sampling and even though samples and studies exists with values for those pollutants (Table 6-3: pollutants marked with a question mark --Turbidity, Chloride, Sulfate, Ammonia, Arsenic, Barium, Chromium III, Chromium IV, Mercury, Nickel, Thallium). Seventh, Brown and Caldwell eliminate from the analysis pollutants for which no standard is presented (Table 6-3: Volatile Suspended Solids, Total Kjeldahl Nitrogen, Total Organic Carbon, Chemical Oxygen Demand), even though there may be easily estimated economic benefits from pollution control. Then most pollutants are ignored in the calculation of the benefits of pollution control. In fact, at this stage of their analysis, the only candidates are Total Suspended Solids, Oil & Grease, Total Coliform, Fecal Coliform, Antimony, Copper, Lead, and Zinc.

Table 6-4. Brown and Caldwell's Four Selected Storm Sampling Results in mg/L, 1995-96 District 7
(from Brown and Caldwell, Table 3.5, p. 3-8)

		Preliminary	Storm 1		Storm 2		Storm 3		Storm 4	
Pollutant	Acronym	Value	Min	Max	Min	Max				
Total Suspended Solids	TSS	200	63	159	82	94	131	218	41	142
Volatile Suspended Solids	VSS	30	30	154	31	43	40	80	18	101
Total Dissolved Solids	TDS	100	50	170	70	100	73	90	20	110
Total Organic Carbon	TOC	25	13	122	48	84	16	22	15	75
Chemical Oxidation Demand	COD	115	180	650	30	190	6	13	27	295
Nitrate	NO_3	3.4	4.5	42.5	5.4	6.4	0.48	0.5	0.65	8.2
Total Kjeldahl Nitrogen	TKN	2	2.4	7	2.6	5.3	1.3	1.9	1.9	6.5
Phosphate	PO_4	0.1	0.24	0.95	0.69	0.75	2.3	5.2	0.15	0.75
Cadmium	Cd	0.02	ND**	ND**	0.005	0.005	ND**	ND**	0.004	0.004
Copper	Cu	0.08	0.051	0.132	0.053	0.073	0.068	0.118	0.05	0.161
Lead	Pb	0.05	0.021	0.055	0.041	0.054	0.119	0.119	0.037	0.104
Zinc	Zn	0.4	0.269	0.789	0.207	0.533	0.218	0.634	0.148	0.743
Oil & Grease	O&G	10	9.6	28.9	10.6	23.6			10.3	15
Fecal Coliform, *MPN/100 Ml			1600	1600	50	130			3000	5000
Total Coliform, *MPN/100 Ml			5000	5000	80	300			5000	5000

(*most probable number)

Table 6-5. Pollution Concentrations Reported by Studies Selected by Brown and Caldwell

Pollutant	Preliminary Value	Reported Concentrations (mg/L), Specific References Given in Appendix 3.1 of Brown and Caldwell									
		Driscoll	Bordanic	CDOT	CDOT	Driscoll	Driscoll	Driscoll	FHWA	FHWA	FHWA
TSS	200	142		1419	469	345	113	267	108	191	94
VSS	30	39									20
TDS	100								87	63	97
TOC	25	25									21
COD	115	114							112	116	49
NO_3	0.75	0.76							1.00	0.46	0.26
TKN	2	1.83							2.3	1.7	2
PO_4	0.1	0.4							0.04	0.05	0.11
Cd	0.02								0.01	nd*	0.02
Cu	0.08	0.54		0.049	0.145		0.085				0.06
Pb	0.5	0.4		0.128	0.81	1.233	0.378	1.291	0.53	0.48	0.4
Zn	0.4	0.329		0.47	0.748	0.935	0.300	0.375	0.525	0.25	0.27
O&G	10		5								10

*nd not detected

Table 6-6. Brown and Caldwell's Current Condition Compared to Commonly Observed Pollution Concentration Reported by Dammel (1997) in mg/L except for Coliform Bacteria

	Brown and Caldwell			Dammel	
Pollutant	Preliminary Value Selected Studies[1]	Preliminary Value Selected Storm Samples[2]	Composite Value[3]	Typical Range	Frequency (Detection per Number of Samples)
TSS	200	200	200	0-1000	92.3%
VSS	30	30	75	0-200	100.0%
TDS	100	100	100	0-1000	88.5%
TOC	25	25	50	0-100	100.0%
COD	115	115	150	0-500	100.0%
NO_3	0.75	3.4	5.0	0-10	100.0%
TKN	2	2	2	0-10	97.9%
PO_4	0.1	0.1	0.5	0-2	100.0%
Cd	0.02	0.02	0.005	-	8.6%
Cu	0.08	0.08	0.08	0-0.2	72.0%
Pb	0.5	0.05	0.05	0-0.2	78.8%
Zn	0.4	0.4	0.4	0-1	90.6%
O&G	10	10	10	0-50	73.5%
Fecal Coliform, *MPN/100 Ml		1600	1600	0-500,000	100.0%
Total Coliform, *MPN/100 Ml		5000	5000	0-500,000	100.0%

(*most probable number)

Brown and Caldwell next eliminate antimony and zinc from their analysis. Presumably they eliminate these two metals since they include lead and copper which are considered "indicator pollutants," (see Brown and Caldwell, p.8-15, Table 8.4) for the metals pollution category. Brown and Caldwell do not explicitly explain why they eliminate antimony and zinc from the analysis. They also eliminate Total Suspended Solids, but add tons of debris. Brown and Caldwell (p.8-15, Table 8.4) thereby pare the analysis down to only consider Debris, Oil and Grease, Total Coliform, Fecal Coliform, Copper, and Lead.

At this point, the analyses of Wilchfort, Lund, and Lew and Brown and Caldwell slightly diverge. Wilchfort, Lund, and Lew only specify upper and lower thresholds for Debris, Oil & Grease, Fecal Coliform, and Lead; they do not explain why they ignore total coliform or copper. Presumably they eliminate copper from the analysis since lead is an indicator pollutant for metals, and presumably they eliminate total coliform since fecal coliform is an indicator for biological pollutants; they do not bother to justify eliminating copper and total coliform. Brown and Caldwell only specify upper and lower thresholds for Debris, Oil & Grease, Fecal Coliform, Copper and Lead; they do not explain why they ignore total coliform. Presumably, fecal coliform is an indicator for biological pollutants, so they eliminate total coliform from the analysis.

Tables 6-7 and 6-8 present thresholds from Brown and Caldwell and thresholds from Wilchfort, Lund, and Lew, respectively. Comparing the lower bounds of these tables with Table 6-3, we see that the lower threshold for fecal coliform has been doubled from the legal standard in Table 6-3, and that the lower thresholds for lead and copper in Tables 6-7 and 6-8 do not match the legal standards given in Table 6-3. Moreover, comparing Table 6-7 with Table 6-8, we see that the upper thresholds for the effect of oil and grease on Navigation do not match, and that Brown and Caldwell simply ignore the impacts of debris, oil and grease, and lead on recreation, while Wilchfort, Lund, and Lew do not.

Table 6-7. Brown and Caldwell's Pollutant Thresholds (from Brown and Caldwell 1996: pg. 8-18, Table 8.5)

	Fecal Coliform (MPN/100mL)		Debris (Tons)		Oil & Grease (mg/L)		Lead (mg/L)		Copper (mg/L)	
Benefit	Full Use	No Use	Full Use	No Use	Full Use	No Use	Full Use	No Use	Full Use	No Use
Contact and Non-Contact Rec.	400	5000	--	--	--	--	--	--	--	--
Navigation	--	--	0	8	0	75	--	--	--	--
Habitat	--	--	--	--	--	--	0.008	0.05	0.008	0.05

Table 6-8. Wilchfort, Lund, and Lew's Pollutant Thresholds (from Wilchfort, Lund, and Lew, 1996: pg. 18, Table 3)

	Fecal Coliform (MPN/100mL)		Debris (Tons)		Oil & Grease (mg/L)		Lead (mg/G or mg/L)	
Benefit	Full Use	No Use	Full Use	No Use	Full Use	No Use	Full Use	No Use
Contact Recreation	400	5000	--	--	0	75	.015 mg/G	.015 mg/G
Non-Contact Recreation	--	--	0	100	0	150	--	--
Navigation	--	--	0	8	0	150	--	--
Shellfish	70	70	0	8	--	--	0.008 mg/L	0.05 mg/L
Habitat	--	--	--	--	--	--	0.008	0.05

3. Eliminating Benefits by Confining Benefits to Water Pollution Standards

Tables 6-7 and 6-8 also highlight another assumption. For both studies, if thresholds are not formed explicitly for particular beneficial uses, then the method assumes that there is no benefit to pollution control. For example, neither study considers the impact of fecal coliform, debris, or oil and grease on habitat, nor the impact of debris on contact recreation. Wilchfort, Lund, and Lew do not consider the impact of oil and grease on shellfish.

More generally, consider the last five columns of Table 6-3. Each blank cell in the table is equivalent to the assumption that the pollutant does no harm to the beneficial use. In particular, note that there are 20 beneficial uses given in Table 5-6, but Table 6-3 presents legal standards that relate pollutants to only five columns that represent beneficial use impacts. The fifth column is labeled “other” but this column only has six entries. Most beneficial uses are omitted because there is no legal standard to create a threshold. Thus, the method by Wilchfort, Lund, and Lew assumes that most pollutants do not harm most beneficial uses.

4. Brown and Caldwell’s Changes in Benefits from Changes in Pollution Concentration for Treating CalTrans-Only Facilities in the Santa Monica Bay Watershed

Wilchfort, Lund, and Lew propose a method to calculate the increase in benefits due to a decrease in pollution. They propose to multiply the dollar value of the beneficial use that would exist if the environment were pristine times a benefit fraction. The numerator of the benefit fraction is the reduction of pollution concentration from water treatment that occurs between the thresholds. The denominator is the difference between the upper and lower thresholds. Therefore, the fraction is smaller if only a small amount of the storm water runoff is treated, or if the treatment reduces the pollution concentration outside the thresholds. The fraction is also smaller if the thresholds are chosen so that the difference between the thresholds is large.

Therefore, if only CalTrans sources are treated, without considering treatment of other sources of storm water run-off, then the analytical method pre-determines that the benefits will be smaller. If the existing pollution concentration is selected such that it falls near the selected upper or lower bound, then it is more likely that treatment reduces pollution concentration outside the thresholds, and the benefits are small. Finally, if treatment reduces the pollution concentration within the thresholds, then both increasing the upper threshold or lowering the lower threshold will lower the benefits. Again, the analytical method pre-determines that the benefits will be smaller.

In order to calculate the reduction in pollution from treating CalTrans facilities alone, Brown and Caldwell distinguish between the pollution concentration from CalTrans facilities and the pollution concentration in storm water run-off to calculate the current condition. They do this in low density urban watersheds and in high density urban watersheds for four pollutants: debris, fecal coliform, lead, and copper. This is summarized in Table 6-9.

Table 6-9. Brown and Caldwell's Current Condition and CalTrans Runoff (From Brown and Caldwell, Tables 8.6, 8.7, and 8.8, p.8-19)

	Debris		Fecal Coliform	Lead	Copper
	lbs/sq.mi.	lbs/storm	MPN/100mL	ug/L	ug/L
Low Density Watershed	43	9954	34,000	33	30
High Density Watershed	156	28,555	222,308	46	37
Watershed Total		38,510			
Low Density CalTrans	21	7	1,600	50	80
High Density CalTrans	78	308	1,600	50	80
CalTrans Total		315			

Low Density Watershed identified in Table 8.6 of Brown and Caldwell as SMBRP#1-21.
High Density Watershed identified in Table 8.6 of Brown and Caldwell as SMBRP#20-28.

Some key parameters that Brown and Caldwell omit, but which can be calculated from a comparison of their tables (Brown and Caldwell, Tables 8.7 and 8.11), as well as a comparison between two other tables (Brown and Caldwell, Tables 8.8 and 8.12) are given here: According to their numbers, runoff from CalTrans as a percentage of total storm water runoff equals 0.63% in low population density watersheds, and 4.3% in high population density watersheds. Given these parameters and the percentage reduction of pollution concentration from CalTrans facilities after treatment, the expected condition after treatment can be calculated. The change in pollution is then found by subtracting the expected condition from the current condition, which Brown and Caldwell present (Brown and Caldwell, Tables 8.10, 8.11, and 8.12, pages 8-23 and 8-24).

Based on the thresholds, and current and expected pollutant concentrations, Brown and Caldwell estimate the changes in benefits as a result of CalTrans storm water treatment. Brown and Caldwell find that the removal of CalTrans debris from runoff does not render the creeks and harbors useful during storm events, and the value of treatment to Navigation is therefore also zero (p.8-24). Similarly, they find that CalTrans storm water treatment would not reduce fecal coliform levels below the 5000 MPN/100mL threshold, so the value of improved water quality to Contact and Non-Contact Recreation is zero (p.8-24). According to Brown and Caldwell, only Habitat will enjoy a 4% increase in benefit value as a result of CalTrans storm water treatment since current concentrations of copper and lead are below the upper thresholds. They calculate the benefit from copper reduction and omit the calculation for lead.

5. Wilchfort, Lund, and Lew's Changes in Benefits from Changes in Pollution Concentration for the Ballona Creek Watershed

Wilchfort, Lund, and Lew present two benefit calculations for the Ballona Creek Watershed. One is the benefit of only treating CalTrans facilities. The second is the benefit of jointly treating the watershed at the mouth of the creek.

For both benefit calculations, Wilchfort, Lund, and Lew eliminate categories of effects of pollutants on beneficial uses. They eliminate the impact of lead on water contact recreation by establishing a threshold for lead in sediment that is higher than the selected value describing the current concentration (prior to treatment). Since lead is the "representative pollutant" in the metals category, they assume that no other metal affects water contact recreation. They eliminate the impact of fecal coliform on shell fishing by establishing a threshold that is lower than the treated water condition. Since fecal coliform is the "representative pollutant" in the biological pollutant category, they assume that no other biological pollutant affects shell fishing.

For the CalTrans only benefit calculation, Wilchfort, Lund, and Lew eliminate the impact of fecal coliform on water contact recreation and the impact of debris on navigation. Elimination of these beneficial uses are on the grounds that the pollution levels are above the putrid thresholds after treatment. (Even with their method of analysis, this result should not hold for their benefit calculation of joint treatment, because joint treatment would reduce the pollution by a much greater amount to a level below their putrid threshold; but as noted below, Wilchfort, Lund, and Lew do not consider any benefits in their joint treatment analysis that they eliminate by their CalTrans only analysis.) As representative pollutants, they assume that no other pollutants in those categories affect those beneficial uses.

After this winnowing process, for the analysis of CalTrans only treatment, only three pollutants actually enter the benefit calculation: oil and grease, lead, and debris. Oil and grease affects pleasure sailboats, the UCLA rowing team, and bicycling. Lead affects commercial vessels that take passengers shell fishing. Debris affects bicycling. The "benefit fractions" for these beneficial uses are very small, because the pollution reduction from confining treatment to CalTrans only is smaller.

They confine benefits to the wet season. They only count the Winter months when the number of visitors are small, and only for 40 days out of the year for visits, so the benefit estimate is small.

For the joint pollution control benefit calculation, Wilchfort, Lund, and Lew make three critical assumptions. First, they assume that pollution control at the mouth of Ballona Creek will not control any pollutants except those that would be controlled in the CalTrans only analysis. Second, they assume that the only beneficial uses that will benefit from pollution control are those that were considered in the CalTrans only analysis. Third, they assume that joint control will not reduce pollution during the dry seasons. The first two assumptions confine the analysis to the same pollutants and beneficial uses as the CalTrans only analysis. The third assumption restricts the increase in benefits to 40 days in the year and reduces the number of people to smaller Wintertime use numbers.

Even though treatment level 3 eliminates between 95% and 100% of all pollutants, the benefit fractions for level 3 treatment are only 4% for oil and grease, 5% for lead that affects shellfish, and 10% for debris that affects non-contact water recreation. For oil and grease, and for debris, the reason is that the putrid thresholds are extremely high relative to the single numbers representing pollution concentrations prior to treatment; hence the denominator of the fraction is large. For lead, the reason is that the single number representing pollution concentration prior to treatment is just slightly above the legal standard that established the noisome threshold for shellfish.

While level 3 treatment removes almost all pollutants, the only pollutants that have significant "benefit multipliers" are for the effect of fecal coliform on water contact recreation, and the effect of debris on navigation. But the only water contact recreation considered by Wilchfort, Lund, and Lew is the UCLA rowing team, so the increase in benefit is confined to a small number of beneficial users.

Moreover, eliminating debris only provides small changes in benefits to those who sail pleasure boats and to navigation by commercial vessels. The reason for these results is that Wilchfort, Lund, and Lew's method proposes two alternative means for calculating benefits when more than one pollutant affects a beneficial use. One method is to select the smallest "benefit multiplier" from among the pollutants and use it. Since oil and grease also affects pleasure boating, and the benefit multiplier for oil and grease is 4%, that small percentage – rather than the 94% multiplier for debris on navigation – is the one they propose to use. Since fecal coliform and lead also affect shellfish, and their benefit multipliers are 0% and 5% respectively, then the smallest benefit multiplier is zero, so the benefit to shell fishing is zero. The second method uses an average of the "benefit multipliers". For this method, when two out of three of the multipliers are close to zero, the average cannot be very large.

C. Critique of Method

The method proposed by Wilchfort, Lund, and Lew, adopted by Brown and Caldwell, and applied by both groups, is not appropriate for analyzing the increase in economic benefits from controlling water pollution. The method is baseless in both economic theory and econometric theory. It requires arbitrary assumptions for thresholds. It leads to the omission of harmful pollutants from the analysis. It requires the omission of beneficial uses from the analysis. It ignores the variation in pollution concentration over time and watershed. It requires arbitrary choices for computation of benefits – the selection of the benefit multiplier for a beneficial use affected by multiple pollutants.

1. Thresholds

One artifice upon which the Wilchfort, Lund, and Lew method depends is the thresholds, both upper and lower, for circumscribing the benefits of pollution control. It is the thresholds that determine the benefit multiplier, a fraction used by the method to calculate the benefit of pollution control. It is the thresholds, or lack thereof, that cause omission of harmful pollutants from the analysis. It is the threshold artifice that causes omission of valuable beneficial uses. It is the threshold artifice that results in a procedure requiring arbitrary choices for benefit computation; this latter topic is explored in another section below.

Harmful Pollutants and Beneficial Uses Omitted from the Benefit Calculation

Comparing Table 6-3 with Tables 3-1 and 3-2, Brown and Caldwell only consider the 29 pollutants for which they establish thresholds, ignoring the other 24 pollutants given by Dammel.

Beneficial uses and harmful pollutants are omitted from the benefit calculation. For example, "Some water bodies are designated for shellfish harvesting, which must not exceed a total coliform bacteria count of 70 per 100 ml. There is no standard for fish" (Brown and Caldwell, p. vi). Excepting for shellfish, fishing is a beneficial use omitted from the analysis because there is no threshold. The implication is that it is safe to eat fish contaminated with fecal coliform bacteria, an indicator of other microbiological pollutants, or PCBs, a pollutant listed by the Santa Monica Bay Restoration Project (1994, p.12-17), as among the highest hazards, or high levels of lead, pesticides, or other known reproductive toxins or carcinogens, simply because there is no legal standard.

There is a fundamental error in the method proposed by Wilchfort, Lund, and Lew (1996). Their method assumes that there is no economic benefit from reducing the amount of pollution below a legal standard. Proper economic analysis sets out to find out what the economic benefits of pollution reduction are rather than simply assuming the benefits equal zero.

Table 6-3 (which replicates a table in Brown and Caldwell that they used repeatedly in their report) shows the beneficial uses for which Brown and Caldwell established thresholds. Of the 20 beneficial uses listed by the LARWQCB (see Table 5-7 above) for Santa Monica Bay, Brown and Caldwell omit 12 beneficial uses because they have no threshold. Table 6-3 has columns for 5 beneficial uses: Municipal water supply, Inland (Warm and Cold Freshwater) Habitat, Estuarine Habitat, and Oceanic (Marine) Habitat. In the "other" column of Table 6-3, the footnote for fecal and total coliform relate these two pollutants to Water Contact Recreation and Shellfish Harvesting, respectively. Wilchfort, Lund, and Lew add a pollutant and establish thresholds for the effect of "debris" on Navigation.

All of the blanks in Table 6-3 refer to missing thresholds for the impacts of the pollutants on beneficial uses. Values of those beneficial uses from reducing those pollutants are omitted. For example, while it defies common sense, Brown and Caldwell infer that trash floating in the water will not deter people from going to the beach, or that a surfer's recreational experience will not be harmed by garbage floating about. Yet, they do not establish thresholds for the impact of debris on water contact recreation at the beach. None of the heavy metals have thresholds for Water Contact Recreation, even though there are primary and secondary drinking water standards listed in Table 6-3. Consequently, Brown and Caldwell omit the value of beach recreation from their analysis. Also, it is unreasonable to claim that Habitats are not affected by fecal coliform, or debris, or that only Marine Habitats are affected by oil and grease in the water.

The only pollutant in Table 6-3 linked to Water Contact Recreation is Fecal Coliform. Wilchfort, Lund, and Lew state that beach closures are caused by sewage spills and not by storm water runoff (Wilchfort, Lund, and Lew 1996: pg. 20). Their reasoning leads them to believe that “since beach closure has been associated with sewage spills and not stormwater quality, swimming apparently is not affected by the stormwater quality in Ballona Creek and improving the water quality will not increase the value of swimming” (Wilchfort, Lund, and Lew 1996: pg. 20). By this line of reasoning, Wilchfort, Lund, and Lew (1996) and Brown and Caldwell (1996) eliminate from the analysis the changes in benefits for beach recreation. Wilchfort, Lund, and Lew carry this omission on to their analysis of joint treatment at the mouth of Ballona Creek, treatment that would virtually eliminate Fecal Coliform.

Arbitrary Thresholds

Some of the thresholds are simply made up. Wilchfort, Lund, and Lew admit as much, “Concentration thresholds at which beneficial uses are eliminated typically have not been determined, but are estimated for purposes of this study..."”(Wilchfort, Lund, and Lew, p.16).

Other thresholds are inappropriate because they are nonsense for calculating economic benefits. Brown and Caldwell set the unimpaired use value for fecal coliform at 400 MPN/100mL based on a study by Haile et al. (1996) which found that swimmers begin to experience adverse health effects at that concentration. To assume that individuals do not reduce the number of beach visits until they begin to get sick is nonsensical. If any lower threshold is to be established, it should be based on the pollutant concentration at which individuals begin to substitute other activities for beach recreation, or substitute other locations. The upper threshold for fecal coliform is set at 5000 MPN/100mL based on the Health Department standard for beach closure (Wilchfort, Lund, and Lew 1996: pg. 14). Brown and Caldwell imply that people will continue to use the beach right until the point where it is so polluted that it must be closed. The arbitrariness of this threshold is obvious: the beach is closed at 5000 MPN/100mL because people cannot necessarily tell that the water is unsafe; however, this standard does not in any way reflect an individual’s choice to go to the beach. The upper threshold for fecal coliform does not necessarily bear any relevance to the way in which benefits change as a result of a cleaner environment.

It is arbitrary and inappropriate to set econmic benefit thresholds on the basis of legal or quasi-legal mandates. Some standards may be based on outdated health literature not relevant to current conditions. Some standards do not exist for economic benefits from cleaner water. Consider the example of fish which has no legal standard for total coliform. The fish are affected, those who eat the fish are affected, recreational fishers are affected, and the value we place on the ecosystem is affected. Similarly, those who visit beaches receive value from waters with lower levels of heavy metals, even though Brown and Caldwell do not identify a legal standard for heavy metals for water contact recreation.

There is no basis in economics, public health, law, or common sense to accept the fiction that economic benefits depend on legal standards. Even though tap water meets legal standards, people have water delivered to their homes. This proves that the legal threshold is not an “unimpaired use concentration” for economic analysis, and it is economic analysis that determines the economic benefits. Legal standards designed to meet certain health objectives, such as acute toxicity, do not avoid harm if met. Brown and Caldwell do not consider standards for chronic toxicity. Even chronic toxicity standards that protect life up to some number such as one in a million over a lifetime of exposure do not avoid all harm. Allergies, discomfort, displeasure, distaste, and disgust are not avoided, although we are willing to pay in order to improve our circumstances.

For the category of metals, Table 6-10 displays EPA protocols for measurement and ambient water quality criteria for acute and chronic toxicity an for human health for the following: antimony (Sb), arsenic (As), cadmium (Cd), trivalent chromium (Cr III), hexavalent chromium (Cr IV), copper (Cu), lead (Pb), mercury (lig), nickel (Ni), selenium (Se), silver (Ag), thallium (Tl), and zinc (Zn) (Grovhoug, 1996). The standards for acute toxicity are not the same as those for chronic toxicity. In fact, there is a plethora of alternatives from which an arbitrary specification of a threshold could be chosen for a pollutant. The method by Wilchfort, Lund, and Lew gives no guidance to relate these standards to economic value, and so there is no basis for selecting among all the alternatives.

2. Linear Assumption

The assumption of a linear relationship between benefits and pollutant concentrations is inappropriate. Brown and Caldwell state that “[t]he linear relationship is a simplifying assumption that enables preliminary development of benefit-cost analysis. It is likely that the relationship between pollutant concentrations and beneficial use value is more complicated, but not necessary to define precisely for the purposes of a preliminary assessment” (Brown and Caldwell 1996: pg. 8-15).

A fundamental concept in economic theory is that of “diminishing marginal utility”. This concept leaves no doubt that the relationship between benefits and pollutant concentrations is indeed more complicated than the strictly linear approach proposed by Wilchfort, Lund, and Lew. This “simplifying assumption” compromises the theoretical validity of the method.

Table 6-10. EPA Ambient Water Quality Criteria for Total Recoverable and Total Dissolved Priority Pollutant Metals and Metal Species Calculated at a Hardness of 100 mg/L and 25 mg/L $CaCO_3$

Metal	Ambient Water Quality Criteria[1] (mg/L)													
	Freshwater Criteria								Marine Criteria				Human Health Criteria	
	Acute[2] Tot. Rec. 100 mg/L $CaCO_3$	Acute[3] Tot. Diss. 100 mg/L $CaCO_3$	Acute[4] Tot. Rec. 25 mg/L $CaCO_3$	Acute[3,4] Tot. Diss. 25 mg/L $CaCO_3$	Chronic[2] Tot. Rec. 100 mg/L $CaCO_3$	Chronic[3] Tot. Diss. 100 mg/L $CaCO_3$	Chronic[4] Tot. Rec. 25 mg/L $CaCO_3$	Chronic[3,4] Tot. Diss. 25 mg/L $CaCO_3$	Acute[2] Tot. Rec.	Acute[3] Tot. Diss.	Chronic[2] Tot. Rec.	Chronic[3] Tot. Diss.	H_2O / organism[2] Tot. Rec.	organism[2] Tot. Rec.
Sb	---	---	---	---	---	---	---	---	---	---	---	---	14[5]	4300[5]
As	360	342	360	342	190	181	190	181	69	65.6	36	34.2	0.018[5]	0.14[5]
Cd[6]	3.9	3.3	0.82	0.70	1.1	0.94	0.38	0.33	43	36.6	9.3	7.9	---	---
Cr III[6]	1700	1450	560	476	210	179	67	57	---	---	---	---	---	---
Cr IV	16	15.2	16	15.2	11	10.5	11	10.5	1100	1050	50	47.5	---	---
Cu[6]	18	15.3	4.8	4.1	12	10.2	3.6	3.1	2.9	1.5	2.9	2.5	---	---
Pb[6]	82	41	14	7	3.2	0.8	0.54	0.14	220	110	8.5	2.1	---	---
Hg	2.4	2.0	2.4	2.0	0.012	---[7]	0.012	---[7]	2.1	1.8	0.025	---[7]	0.14	0.15
Ni[6]	1400	1190	440	374	160	136	49	42	75	64	8.3	7.1	610[5]	4600[5]
Se	20	---[7]	20	---[7]	5	---[7]	5	---[7]	300	---[7]	71	---[7]	---	---
Ag[6]	4.1	3.5	0.37	0.91	---	---	---	---	2.3	2.0	---	---	---	---
Tl	---	---	---	---	---	---	---	---	---	---	---	---	1.7[5]	6.3[5]
Zn[6]	120	102	36	31	110	94	33	18	95	81	86	73	---	---

1. WQC promulgated in the National Toxics Rule (NTR) for 14 states at 40 CFR Part 131 (57FR 60848). Criteria for metals listed at 40 CFR Part 131 are expressed as total recoverable at a hardness of 100 mg/L $CaCO_3$ and a water effect ration (WER) of 1.0. The lowest WQC for each analytic method is shaded.
2. As listed in the NTR at 40 CFR Part 131 for total recoverable metals. Hardness dependent freshwater acute and chronic criteria expressed at a hardness of 100 mg/L $CaCO_3$ at a WER of 1.0.
3. For Cd, Cr III, Cu, Ni, and Zn, acute and chronic criteria for dissolved metals and metal species were calculated by taking 85% of the corresponding total recoverable criteria level. For As and Cr VI, acute and chronic criteria for dissolved metals and metals species were calculated by taking 95% of the corresponding total recoverable criteria level. For lead, acute dissolved criteria were calculated by taking 50% of the corresponding total recoverable level; for lead chronic criteria, dissolved criteria were calculated by taking 25% of the total recoverable levels. Dissolved values for mercury chronic criteria and selenium acute and chronic criteria were not calculated because these metals bioaccumulate, and dissolved criteria would not be appropriate. (*Guidance Document on Dissolved Criteria: Expression of Aquatic Life Criteria*, October 1993. Attachment 2 to memorandum from Martha Prothro to Water Management Division Directors, October 1, 1993.)
4. Hardness dependent freshwater acute and chronic criteria recalculated at a hardness of 25 mg/L $CaCO_3$ and a WER of 1.0 as specified at 40 CFR Part 131.36(b)(2). For dissolved metals, hardness calculations were performed prior to adjusting for dissolved levels.
5. Criterion reflects recalculated value using IRIS
6. Freshwater criteria are hardness dependent for this metal.
7. Metal is bioaccumulative and, therefore, it is not appropriate to calculate WQC for dissolved levels. (*Guidance Document on Dissolved Criteria: Expression of Aquatic Life Criteria*, October 1993. Attachment 2 to memorandum from Martha Prothro to Water Management Division Directors, October 1, 1993.)

Source: Thomas R. Grovhoug,1996, *Analysis of Trace Metals in Stormwater Runoff and Receiving Waters*, Larry Walker Associates, Davis California, 19 September 1996

3. Changes in Benefits

For beneficial uses that several pollutants affect, Wilchfort, Lund, and Lew use two alternative methods to select the benefit multiplier: the “Limiting Pollutant Method” (LPM) and the “Averaging Method” (AM). Neither the LPM nor the AM account for synergistic effects of multiple pollutants, nor the cumulative impact of multiple toxins, each of which may be below some threshold.

When discussing their relative merits, at first Wilchfort, Lund, and Lew state, the LPM “assumes that the benefit value of management measure is limited by the pollutant that has the most adverse impact on the beneficial use” (Wilchfort, Lund, and Lew Appendix B, p.8). One might assume that this means to use the multiplier of the pollutant that does the most damage. For example, toxins are a threat to health for water contact recreation, while turbidity affects the visual ascetics. Yet in just this type of example, Wilchfort, Lund, and Lew select the multiplier for turbidity rather than the multiplier for toxins in an example to illustrate their method (Example A.4, p.8, Appendix B, Wilchfort, Lund, and Lew). The LPM actually means: *use the smallest from among all the pollutant multipliers that apply to a beneficial use.*

Example 6.1

An example highlights this aspect of the method proposed by Wilchfort, Lund, and Lew. Suppose that two pollutants, A and B, both affect a beneficial use but in unrelated ways. Further suppose that the pollution concentration of A is so high that, by itself, it would eliminate 100% of the value of the beneficial use. Further suppose that the pollution concentration of B is so low that, by itself, it would only eliminate 5% of the value of the beneficial use. Given both pollutants, the value of the beneficial use is zero. Given complete control of both pollutants, the value of the beneficial use is restored 100%.

Suppose that there are three alternative pollution control options, each of which are 100 % effective for the specific pollutant they control. Treatment Option 1 only removes pollutant A, Option 2 only removes B, while Option 3 removes both. Hence, the benefit multipliers for the three options are given in Table 6-11:

Table 6-11: Benefit Multipliers for Example 6.1

OPTION	Pollutant A	Pollutant B	LPM Multiplier	AM Multiplier
1	1	0	0	.5
2	0	.05	0	.025
3	1	.05	.05	.525

Under the LPM procedure, Option 1 has no benefit because the benefit multiplier is the smallest from (1,0), and the smallest multiplier is zero. Even though Option 1 eliminates most of the damage to the beneficial use, there is no benefit value to compare against the cost of the option. Option 2 also has no value because the benefit multiplier is the smallest from (0, 0.05), which is zero. Option 3 makes the environment pristine, eliminating all the pollutants. But because pollutant B only causes 5% damage, the LPM method only allows 5% of the benefit value to count. That is, the benefit multiplier equals the smallest from among (1, 0.05), which is 5%. So, under Treatment Option 3, the value of the beneficial use is restored 100% from no value at all, but the LPM procedure only admits 5% of the value of the beneficial use in the benefit calculation.

The reader may say, “perhaps this example 6.1 is not relevant in the computations performed by Brown and Caldwell or Wilchfort, Lund, and Lew” Actually, this example almost exactly describes the application of the LPM method by Wilchfort, Lund, and Lew to the calculation of benefit values from sailboats due to reduction of oil and grease, and debris, for the joint treatment of water at the mouth of Ballona Creek. For treatment Level 3 almost all the pollution is controlled, the multiplier for oil and grease is 4%, and that for debris is 94%, but only a 4% increase in benefit is calculated by the LPM method.

In their fairness, Wilchfort, Lund, and Lew do not use the LPM method for the “bottom line” calculation for comparing benefits and costs (Wilchfort, Lund, and Lew, Tables 15 and 16, pp.28, 30). Instead, they use the “Averaging Method” (AM). The AM, however, is nearly as erroneous. Consider an example.

Example 6.2

Suppose that three pollutants, A, B, and C all affect a beneficial use but in unrelated ways. Further suppose that the pollution concentration of A is so high that, by itself, it would eliminate 100% of the value of the beneficial use. Further suppose that the pollution concentration of B is so low that, by itself, it would only eliminate 5% of the value of the beneficial use. Finally, suppose the analyst can identify a pollutant C that is defined as doing no damage because the noisome threshold is selected to be higher than the constant value selected to represent the pollution concentration prior to treatment. Suppose that treatment is 100% effective for all three pollutants, resulting in restoration of 100% of the value of the beneficial use.

The separate benefit fractions for pollutants A, B, and C are 100%, 5%, and 0%. The AM procedure calculates a simple average (100+5+0)/3 = 35%. Even though treatment changes the benefit from 0% to 100%, only 35% of the value of the beneficial use is permitted in the Wilchfort, Lund, and Lew AM procedure.

The reader may say, surely no analyst would simply add pollutants to the analysis and average zeros into a benefit multiplier, lowering the number. Perhaps it just an honest mistake in the Wilchfort, Lund, and Lew calculation of the beneficial use of commercial vessels for joint treatment of water at the mouth of Ballona Creek. In that calculation by Wilchfort, Lund, and Lew, the separate benefit fractions for fecal coliform, lead and debris are 0%, 5%, and 94%, and the average is 33%, the benefit multiplier they used for commercial vessels.

The use of an average multiplier is simply wrong. If one pollutant has little effect on a beneficial use, while the other pollutant has a large effect, then treatment Level 3, which effectively eliminates almost all pollutants, should result in a benefit calculation that reflects the increase in benefit values to the beneficial use. The average multiplier does not do so.

4. The Size of the Decrement Under Consideration: CalTrans Only Treatment vs. Simultaneous or Joint Treatment as the Basis for Selecting the Decrement of Pollution Concentration

Wilchfort, Lund, and Lew recognize that the benefit-cost comparison should include a joint treatment option. They perform a benefit cost calculation for joint control of pollution at the mouth of Ballona Creek. Brown and Caldwell only analyze the benefit-cost trade-off for CalTrans-Only Treatment in the Santa Monica Bay watershed.

The Maximum Extent Practicable (MEP) standard places on the storm water discharge permit applicant the responsibility to prove that any best management practices (BMPs) eliminated or not considered were indeed less effective and less efficient than the option selected. The definition of MEP requires that the selection of BMPs be a thorough and comparative effort. This view is supported and expanded upon by the language of the Los Angeles County 1996 NPDES Permit (8.1.4, pg. 8-5). It states that "… permittees are required to implement a comprehensive pollution prevention and management program [which]… consist[s] of a combination of best management practices, control techniques, system design and engineering methods" (LA Storm Water Permit 1996b, quoted in Brown and Caldwell 1996, pg. 8-5).

The marginal analysis by Brown and Caldwell is surprising since they acknowledge that they are legally obligated to consider "best management practices" (BMPs) that treat all sources of pollution, not just pollution from CalTrans sources. They also acknowledge that they are legally obligated to consider regional solutions, such as water reclamation and treatment. Brown and Caldwell acknowledge that the language of the permit explicitly states that water quality control efforts are "… to be evaluated by the total efforts of all the permittees, not on an individual basis" (pg. 8-5). It is then clear that proper usage of a maximum extent practicable standard goes well beyond the isolated efforts of a single entity and must instead be a function of the collaborative efforts of all polluters discharging in a given region. This again refers to the MEP definition and the responsibility to explore all available combinations of options on widely applied basis.

Wilchfort, Lund, and Lew use marginal analysis to estimate the benefit of pollution control from CalTrans roads and facilities only. They also marginalize the analysis by considering the incremental reduction in pollution from Level 1 treatment, then the additional incremental reduction in pollution by going from Level 1 to Level 2 treatment, then the additional incremental reduction in pollution by going from Level 2 to Level 3 treatment. Brown and Caldwell estimate that the pollution flowing into Ballona Creek from CalTrans roads and facilities is a small portion of the total pollution concentration flowing from Ballona Creek into Santa Monica Bay. This small reduction in pollution is made smaller by increments from one treatment Level to another.

Consequently, by marginally decreasing pollution only from CalTrans roads and facilities, one level at a time, most benefit from pollution control is zero: either the pollution concentration exceeds the "fully impaired threshold" or falls below the "unimpaired threshold". These thresholds result in what is technically called non-convexity.

In his undergraduate textbook, Goodstein (1995, pp.529-538) explains that "when nonconvexities are present, … marginal analysis will no longer provide a reliable guide to the efficient level of pollution control" (p.531). This is a well-known result. The non-convexity in the Wilchfort, Lund, and Lew methodology is caused by their establishment of unimpaired and fully impaired use thresholds. In essence, they assume that small amounts of pollution, below the "unimpaired threshold", are harmless, and that there is no benefit from reducing excessive pollution beyond the "fully impaired threshold" because the environment has no use value if polluted that much. The non-convexity assumption is shown in Figure 6-2. Figure 6-2 corresponds with Figure T1.1C of Goodstein (1995).

The method proposed by Wilchfort, Lund, and Lew cannot be used to correctly estimate small changes in pollution unless it drops the assumptions of thresholds, or the incremental analysis of benefits and costs. As Goodstein (1995) wrote, "when nonconvexities are present, …

marginal analysis will no longer provide a reliable guide to the efficient level of pollution control" (p.531).

The criticism of this section also applies to Brown and Caldwell (1996). They apply incremental analysis of treating only CalTrans runoff to Santa Monica Bay, at increments of Level 1 treatment, the incremental difference between Level 1 and Level 2 treatment, and the incremental difference between Level 2 and Level 3 treatment. They use the non-convexity approach of Wilchfort, Lund, and Lew (1996), based upon "unimpaired thresholds" and "fully impaired thresholds". They also fail to consider a regional treatment option, a source of non-convexity in costs with a level of benefits that they do not estimate. Because their analysis combines non-convexity in benefits with incremental analysis of CalTrans pollution control only, and incremental treatment levels, their analysis "will no longer provide a reliable guide to the efficient level of pollution control" (Goodstein, 1995).

Chapter 6 References

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Chapter VII Valuing Benefits

This chapter establishes that the method for estimating the benefit of reducing pollution in surface water run-off proposed by Wilchfort, Lund, and Lew (1996) and adopted by Brown and Caldwell (1996) is not an established method that is accepted in the peer review literature. It also establishes that existing literature includes methods to estimate benefit categories omitted by these two studies (Brown and Caldwell, 1996, and Wilchfort, Lund, and Lew, 1996). This chapter reviews estimates of benefits that could be transferred and applied to the study areas of these two studies. Finally, this chapter reviews methods and complementary data applicable to the study areas that could be used to estimate benefits omitted by the two studies.

A review of the literature establishes:

- The method proposed by Wilchfort, Lund, and Lew (1996), relied upon by Brown and Caldwell (1996), does not exist in the peer-reviewed literature.
- Established methods do exist to value recreational use benefits of improving water quality.
- A recently developed method and its variants (contingent valuation and contingent ranking) can be used to value ecosystems and non-use benefits of improved water quality.
- The contingent valuation method took several decades to develop and mature in the peer-review literature, culminating in acceptance by a panel of eminent economists, including Nobel Laureates, and continues to be refined in the literature today.
- Use of contingent valuation in legal proceedings has passed legal tests, including formal acceptance by the courts and acceptance by several government agencies in adopted regulations.

In subsection A, this chapter begins with a brief review of the literature by economists of methods for estimating the benefits of environmental quality. In subsections B through I estimates are presented from the literature of values of beneficial uses that could be the basis for more acceptable estimates of the benefits of reducing storm drain pollution in CalTrans District 7. Subsections J and K present some problems of the benefit estimation by Wilchfort, Lund, and Lew (1996) and Brown and Caldwell (1996), in addition to those presented in earlier chapters (particularly Chapter 6) including benefits they omit and suggestions for estimating these benefits.

This chapter does not endorse a particular method in the literature but rather demonstrates the significant divergence of the "CalTrans method" from recognized methods for valuating the benefits of water quality.

A. Methods for Benefit Estimation

1. Survey of the Literature by Cropper and Oates

In their 65 page survey of environmental economics, Cropper and Oates (1992) review the literature. Their review is divided into two parts, a summary of the profession's approach to environmental policy and an overview and categorization of approaches to valuing the benefits from changes in environmental quality. This section summarizes the latter part of their review.

The four approaches for valuing environmental quality are the use of averting behavior, weak complements, hedonic market methods, and contingent valuation. The first three methods are indirect market methods (sometimes called revealed preference methods) in that they use information about market decisions to avoid damage from pollution (weak substitutes), or market decisions to buy complements to environmental quality (trips for recreation, for example).

a. Averting Behavior

For averting behavior, economists use information about decisions by firms and consumers to avoid damages from pollution. The value of an improvement in environmental quality is calculated as the cost of averting behavior to maintain the same economic value in the face of a change in environmental quality. Cropper and Oates provide the example of using the cost of additional fishing gear and labor to catch unpolluted fish as the value of improved water quality.

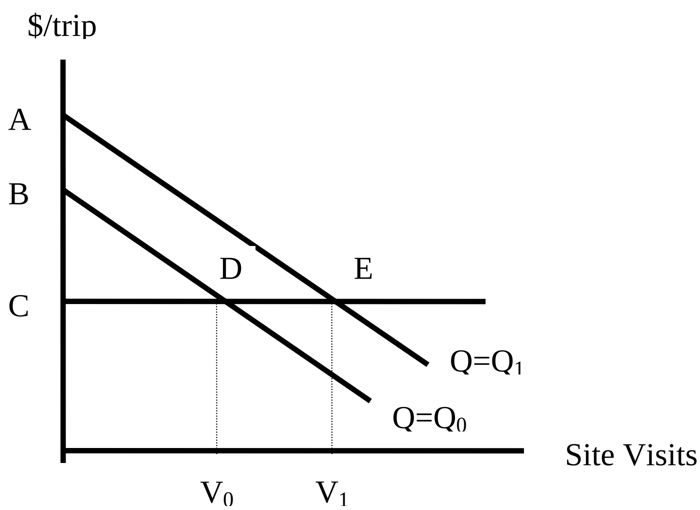
b. Weak Complements

For weak complements, Cropper and Oates summarize the traditional travel-demand approach with a diagram, their Figure 2 (p.705), reproduced here in Figure 7.1.

Demand for recreation increases with the quality of the resource from Q_0 to Q_1 as shown in the figure. The value of the increase in quality, given a travel cost of C, equals the area ABDE. The number of site visits increases from V_0 to V_1 as a result of the improvement in environmental quality.

The modern approach is to use discrete continuous choice models for weak complements (Hanemann, 1984) to calculate the compensating variation, as the product of the change in utility conditional on visiting the site times the probability of a site visit, plus the product of the change in the probability due to the change in environmental quality times the utility of a visit. Cropper and Oates (1992) point out that these approaches have been used to value the recreational benefits of improved water quality since 1978 (Binkeley and Hanemann, 1978; and Feenberg, and Mills, 1980).

Figure 7.1



c. Hedonic Market Methods

Hedonic market methods decompose the prices into attributes that make up the good. Cropper and Oates (1992) provide the example of decomposing the price of a house into attributes of houses such as square footage, and environmental quality.

d. Contingent Valuation (CV)

Cropper and Oates (1992) point out that when water quality does not vary appreciably within a region, contingent valuation methods are necessary. They also note that CV methods are necessary to estimate all the benefits of improved environmental quality, "There is, in addition, an entire category of benefits — nonuse values — which cannot even in principle be measured by indirect market methods. Nonuse values refer to the benefits received from knowing that a good exists, even though the individual may never experience the good directly. Examples include preserving an endangered species or … improvements in water quality to the point where the water is fishable or swimmable" (p.709).

Cropper and Oates describe the elements of a CV questionnaire, and briefly critique the method. The elements of the questionnaire are a description of the good (the improvement in environmental quality and how it will be achieved), a payment mechanism (increase taxes, utility bill), and a method for eliciting values. They omit the requirement that alternative commodities be included in the survey instrument. The method for eliciting values is either open ended (how much are you willing to pay?) or closed ended with a simple yes/no response (are you willing to pay X $?). Since the closed-ended method is similar to shopping with posted prices and similar to referendum voting, it is the preferred method, but requires powerful econometric techniques. Finally, the Willingness to Pay (WTP) versus the Willingness to Accept (WTA) depends on the property rights.

Cropper and Oates (1992) review the critiques of CV. The critiques include the criticism that the response is hypothetical, and that for private goods CV compares well with actual WTP, but not with WTA, possibly because consumers are not used to selling commodities, and that in some cases of public goods, WTP differs from actual results. The criticism that CV respondents may behave with strategic bias has been tested and repeatedly rejected (Mitchell and Carson, 1989). Another criticism is that WTP values may be unreliable if the commodity is not well understood, but this criticism can be defended against by varying the amount of information in the survey to examine for systematic changes in the answers. Finally, Cropper and Oates (1992) review the issue that for theoretical reasons WTA may be much greater than WTP for public goods, but that some evidence suggests that this result also holds for private goods, which would be inconsistent with theory. Cropper and Oates's review was written prior to further work (Shogren et al., 1994) that resolved this last issue.

2. Freeman's Summary of the Value of Marine Recreation

For swimming and related beach activities, fishing, and boating on tidal estuaries and the ocean, Freeman's (1993) report summarizes estimates of economic values for recreation and visits, the attributes of sites that matter, values attributable to changes in attributes, and transferability of values of visits and attributes across sites. Freeman reviews the travel cost model, the random utility model, the CV method, and participation models.

a. Travel Cost Model

The travel cost model assumes that travel cost to the recreation site is the implicit price. Travel cost equals the explicit cost of travel plus the cost of time. The empirical method is to regress the number of trips against travel cost and other explanatory variables. The area under the demand curve is value of site for an individual. A change in environmental quality shifts the demand curve, and the difference in the area between the curves is the value of improved quality, which is summed over individuals. The total area divided by total number of trips equals the average per trip value, but is not equal to the value of an additional trip due to a change in quality: "consumer surplus per visit for a given level of quality cannot be used to value a change in quality that shifts the demand" (Freeman, 1993, p.4).

b. Random Utility Model

The random utility model (RUM) explains the recreation site choice as a function of characteristics of all available sites in the choice set. The characteristics include travel cost. Estimation of RUM gives the indirect utility function: v(M - t, Q, S) where M = income, t =

travel cost, Q = environmental quality, and S = characteristics. The change in consumer surplus for a change in quality can be calculated. If one alternative is no site visit, the value of a visit can be calculated. The value of adding or deleting a site can also be calculated.

The RUM gives values for a single choice occasion. The number of visits is needed, which is obtained in one of two ways. One way is to consider the number of trips a separate problem. The second method is a discrete choice model with no activity as an option for each choice occasion, with two variants. One variant is a single equation method with no activity as an option. The second variant is a nested RUM with two equations. One equation determines whether to undertake any activity on a given choice occasion, and the other equation predicts where to visit, given that the first choice is to undertake an activity.

c. CV Method

Freeman notes that the CV method can value one visit to a site, access to a site for a season, or changes in the qualitative characteristics of a site.

d. Participation Models

Participation models proceed with two steps. The first step estimates the probability of any individual participating in the recreation activity during a year as a function of socio-economic characteristics, availability and or quality of recreation opportunities. The second step predicts the number of days of recreation conditional upon being a participant. With these models we can estimate the average consumer surplus per visit, changes in participation for changes in availability and changes in participation for changes in quality. But using average consumer surplus per visit to calculate the value of predicted increased participation is incorrect: "First, it uses an average value when the marginal value for an increase in the level of the activity is relevant. Also, if the average quality of the recreation resource influences activity rates, applying a unit value only to the change in activity levels does not capture the value of a change in quality to the existing users" (Freeman, 1993, p.7).

3. Hanemann's Testimony of the American Trader Oil Spill off Huntington Beach

Hanemann (1997) presents written testimony as the expert witness called by the State of California in the case of the *American Trader* oil spill. The case is based upon an spill of 397,000 gallons of oil, on February 7, 1990, 1.3 miles offshore of Huntington Beach caused when the *American Trader* grounded on its own anchor. Hanemann (1997) estimates losses of $12.18 million (p.1) resulting from closing the beaches and harbors during the period from February 8 to March 13 along a 14 mile stretch of shoreline from San Pedro Bay, Long Beach, to Crystal Cove, just north of Laguna Beach, and additional losses resulting from visits under polluted conditions during February through April.

Hanemann's (1997) approach is to estimate the number of trips if there had been no oil spill minus the number of trips that did occur following the oil spill. He multiplies the value per trip times the number of lost trips, and adds this to the number of actual trips times the lost value per trip. He identifies three forms of losses to recreators: (i) losses from trips not taken, (ii) losses from trips taken to other, less desirable sites, and (iii) losses from trips taken to the site, but with diminished value because of the pollution. He notes that his estimates are low because they omit non-use values (p.8).

Hanemann (1997) explains that the value per trip is called the consumer's surplus, either the willingness to pay (WTP) to take a trip or the willingness to accept (WTA) to forego a trip. This concept is applied by economists to private goods as well as public goods, such as outdoor recreation. The value is estimated for specific activity and for specific sites, or extrapolated from studies of similar activities at similar sites (the benefits transfer approach). Hanemann states that the benefits transfer approach is sanctioned under federal laws (CERCLA and the Oil Pollution Act of 1990) and used by the State of California (p.5).

Hanemann (1997) estimates losses to the following categories of recreation: general beach recreation, surfing, private boating, and party/charter boat fishing. He notes that he has omitted "relatively highly valued activities, such as bird watching and wildlife viewing, … because of data limitations" (Hanemann, 1997, p.8). Hanemann (1997) summarizes other studies and presents his own conservative estimate of the value for recreation categories.

4. Benefit transfer

Downing and Ozuna (1996) define benefit transfer to mean taking known benefit data from a "study site" and applying it to a "policy site". There are two possible approaches: (i) transfer benefit estimates directly from study site to policy site, or (ii) transfer the benefit function and use study site coefficients to estimate policy site benefits. The problem is that even if it can be found that the coefficients of the study and policy sites are statistically equivalent, welfare estimates may be statistically different due to the non-linearity of benefit accrual. Non-linearities cause asymmetries which in turn results in divergences between benefit functions and estimates. Downing and Ozuna suggest that similar results could be obtained using the travel cost models since benefits in those models are also functions of non-linear random variables.

Downing and Ozuna (1996) use Texas coastal bay angler data from 8 contiguous bay regions over three distinct time periods to evaluate benefit function transfer. They conclude that benefit function transfer results in an over-estimate of WTP. The data are from boat-launch intercepts, and based on the question, "Based on your current income, if the total cost of all your saltwater fishing last year was ___ dollars more, would you have quit fishing completely?" Values of $50, $100, $200, $400, $600, $800, $1000, $1500, $5000, $10000 and $20,000 were rotated among respondents. Excluding non-Texans, the annual mean offer amounts vary in the $2000-$3000 range across the 8 sites and across the three years 1987, 1988, 1989. Over time, the amounts increased so that over half of the mean values in the last year were greater than $3000. The percentage of times the CV valuation function was transferable across time within and across bays is given in Table 7.1.

Table 7.1. Percent of Benefit Function Transferability Determined by Statistical Significance

	From 1987 to 1988		From 1987 to 1989	
	Within bay	Across bay	Within bay	Across bay
Transferable	63	50	50	41
Questionable	25	36	38	39

Nontransferable	12	14	12	20

Next the authors determine the extent to which the per person per trip median WTP estimates are transferable, and of the transferable functions whether the benefit estimates are transferable. Because the confidence intervals are small, in general the estimates of WTP are not transferable if statistical tests are the basis for the decision, even when the values are close.

Loomis, Roach, Ward, and Ready (1995) test the hypothesis that estimates of recreation benefits from the travel cost demand model can be transferred among reservoirs in Arkansas, California, and Tennessee/Kentucky. The hypothesis is not rejected for transferability between Arkansas and Tennessee, but is rejected between Arkansas and California. They report estimates of the average consumer surplus per day in 1980 dollars for 10 Northern California lakes, the closest of which to Southern California is Lake Isabella. For two different estimation procedures, the amount for Lake Isabella is $5.70/day and $4.14/day (tables 3a and 3b).

Kirchhoff, Colby, and LaFrance (1997) use data collected in 1992 by mail survey from visitors to two New Mexico canyons well known for bird watching, and two white water rafting canyons in Arizona, to evaluate benefit transfers. The data are non-dichotomous CVM, and the authors use tobit to account for non-negative valuation, with a constraint to account for total WTP greater than or equal to travel costs. They reject the hypotheses that the valuation functions are equivalent. They also reject the hypotheses that the predicted WTP from the transfer functions are equal to the estimated WTP with a few exceptions in one direction for the bird watchers, but not in the other direction. The compensating variation (CV) estimates of WTP are presented in Table 7.2.

Table 7.2. Kirchhoff, Colby, and LaFrance (1997) estimates of compensating variation CV and average expenses per visit

Location	Activity	CV	Expenses
Taos Box, New Mexico	White Water Rafting	$33.50	$92.97
Lower Gorge, New Mexico	White Water Rafting	$21.40	$41.66
Ramsey Canyon, Arizona	All visitors	$139.97	not available
San Pedro, Arizona	All Visitors	$83.03	not available
San Pedro, Arizona	Bird Watchers	$90.58	not available

Note that although the functions are not transferable if statistical significance is the basis for the decision, the values are similar.

As pointed out by Hanemann (1997), benefit transfer is an accepted approach to reduce the expense of determining the benefits of environmental quality, but it is important to use care when using this approach. Hanemann emphasizes using similar types of recreation at similar sites.

5. Use Values, Nonuse Values, Indirect Market Methods and CV

"Use value" refers to benefits from active recreation (boating, swimming, hiking, bicycling) and passive recreation (viewing, sitting, sunbathing). "Nonuse value" includes existence value, bequest value, and option value. As explained by Cropper and Oates (1992) in their literature review, use values can be estimated by indirect market methods. The CV method can estimate use values as well as nonuse values.

In 1989 the District of Columbia Court of Appeal (Ohio v. The United States Department of Interior) accepted the inclusion of nonuse value as part of the benefits to be measured under *CERCLA* (*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, 42 U.S.C. 9601-9675). Under the Oil Pollution Act of 1990, NOAA (1994) issued regulations accepting CV as a method to measure the benefits from environmental amenities. The contingent valuation (CV) method is used to estimate nonuse values.

Carson, Flores, Martin, and Wright (1996) review 83 studies that provide 616 estimates of the value of public goods using both CV and Indirect Market Methods (travel demand or hedonic prices). The goods include recreation, health risks, and changes in environmental quality. Results from Indirect Market Methods (IMM) techniques depend on commodity definition, functional form, number of sites, value of time, and technique-specific assumptions, and CV results depend on payment mechanisms, the elicitation question(s), information in the survey about alternative uses of money, survey design, and instrument variation. The mean and median CV/IMM ratios are 0.89 and 0.75 with a 95% interval [0.81 to 0.96]. For trimmed datasets, 0.77 and 0.75 [0.74 to 0.81]. For weighted datasets (weights given to each study rather than each estimate) 0.92 and 0.94 [0.81 to 1.03]

6. Willingness-to-Pay Versus Willingness-to-Accept

Bromley (1995) reminds us that the correct measure, WTA or WTP depends on the property rights to a clean environment. He points out that some economists may desire WTP simply because it is easier to obtain estimates of the average WTP of a population that are similar from sample to sample than it is to obtain estimates of the average WTA. He also reminds us that Hanemann (1991) proved that WTA can be much larger than WTP if there are no close substitutes for the public good (cleaner environment). Bromley also notes that empirical research confirms that WTA is greater than WTP by more than 5 times for some environmental amenities. The legal circumstances hinge on whether environmental law gives the recreational user a right to swimmable and fishable waters. If so, then WTA is the appropriate measure. Wilchfort, Lund, and Lew (1996) use WTP.

B. Water Reclamation

Wilchfort, Lund, and Lew (1996) ignore the possible beneficial use of reclaimed water on the specious grounds that the cost would equal about $1300/Acre-foot. They ignore the value of additional water. If regional water reclamation and treatment is considered as an option, the value of the reclaimed water is equal to the value of water displaced by the reclaimed water. According the Los Angeles Mayor’s Blue Ribbon Committee on Water Rates (1992, 1994) the marginal cost to the Los Angeles Department of Water and Power of procuring drinking water, which would be displaced by the reclaimed water, equals $879 and $1,161/Acre-foot in the Winter and Summer, respectively, (converted to acre-feet from Hall, 1996, pp. 86-87). The difference between the cost of reclaiming the water and the value of the additional water is the cost of reducing pollution after netting out the value of the reclaimed water. That difference is what remains to be balanced by all the other benefits.

Wilchfort, Lund, and Lew (1996) also claim that there may not be sufficient demand for the reclaimed water, yet the reclamation of the Ballona Wetlands could benefit from any unused reclaimed water, a valuation they ignore.

C. Secondary Income

Regional forecasts of economic activity are commonly used to estimate employment and secondary income effects that could result from, for example, increases in tourism. Models of the local economic region already exist and are available (Office of Economic Analysis, California State University Long Beach, 1998). Models of regional economic activity are used to estimate the impact of recreation demand on a regional economy (Harris and Seung, 1997).

D. Property Values: The case of improved water quality of wetlands

The Ballona Wetlands are bordered by residential and commercial property. Lagoons in the Santa Monica Bay are listed in Table 5-3. Improved water quality to these wetlands and lagoons and other coastal areas impacted by surface water run-off will increase property values, a benefit that should be included in the calculation by CalTrans. Some examples of similar calculations in the literature could provide the basis for benefit transfer calculations by CalTrans in this case.

d'Arge and Shogren (1989) compare hedonic and CV estimates of the effect of water quality on property values for houses near lakes in Iowa. The value of water quality ranges from 13% to 23% of the total value of the total residence value per square foot.

Doss and Taff (1996) review published research on the value of wetlands. They use an hedonic approach to estimate the value to residential property of proximity to differing types of wetlands in Ramsey County, Minnesota. They control for other characteristics of houses that affect value. As long as the houses are not located too close to the wetlands, housing value increases with how close it is to open-water wetlands that support waterfowl. An additional 200 meters (one city block) closer increases the value of a house by $1,980 for houses with a mean value of $104,956, or a 2% increase in value per block distance.

E. Health Effects

There are several approaches to estimate the benefits of avoiding ill-health effects from pollution. One approach is to use contingent valuation to estimate directly the willingness to pay for pollution reduction. A second approach is to combine estimates of the value of avoiding ill effects with estimates of the frequency of occurrence (Hall and Hall, 1997).

Based upon contingent valuation, Creel and Loomis (1997) use nonparametric techniques to estimate the WTP by Californians for a series of programs to reduce exposure to heavy metals. In this article the authors present estimates pooled across all levels of risk reduction from all the programs. Comparing the unconditional expected WTP across three alternative estimation procedures (nonparametric and parametric) results in similar estimates of $401 to $414. The authors note that for transferability to other states, conditional WTP estimates are necessary, and the three estimation procedures provide substantially different conditional expected WTP amounts.

Using the second approach, Hall et al. (1992) estimate the value of improving air quality in the South Coast air basin. To apply this approach, one would need estimates of ill health effects from water pollution in Santa Monica Bay. Fortunately, such estimates exist (Haile, et al., 1996).

F. Recreation Values

1. Beach Visits

As noted by Hanemann (1997), there are three components to lost value that should be taken into account: the value of beach visits lost because of pollution: (i) losses from trips not taken, (ii) losses from trips taken to other, less desirable sites, and (iii) losses from trips taken to the site, but with diminished value because of the pollution. The number of visits in these three categories needs to be estimated. For the first two categories, the Santa Monica Bay Restoration Project (1994, p.1-7) estimates that attendance at beaches in the Santa Monica Bay fell by 56% from the 79 million visits per year in 1983 in part because of "public fear of water pollution."

Table 7.3 Freeman (1993) summary of four studies of values for beach trips and swimming, values are converted to 1991$.

Author	Location	Activity	Value per trip
Bell and Leeworthy[1] (1990)	Florida	tourists	$50.40
Leeworthy[2] (1991)	Florida	travel cost to a special reef and state park	$223 to $3,448
Leeworthy and Wiley[3] (1991)	New Jersey	day trip visits	$24.74 to $88.17
Silberman and Klock[4] (1988)	New Jersey	poor quality New Jersey beach	$4.57

1. Problem: study treated all beaches in Florida as one site, and travel cost (from hotel) was endogenous since the tourist picked the hotel.
2. Substantial variation in number of days results in per day variation.
3. Variation depending on functional form and regression estimation procedures.
4. CV study, mean bid of for question: how much more would you pay. Anchoring bias due to entry fee.

The benefit transfer approach could be used to infer values per trip for the first and second components. Table 7.3 presents Freeman's summary of four studies, three of which are not really comparable to most day visits to beaches in Santa Monica Bay, but are of interest for general comparison. Tables 7.4 and 7.5 include some duplication, but are presented for completeness of the information found in Hanemann (1996, 1997).

Hanemann (1996) examines serious flaws of a study of beach recreation by Dunford et al. (1995). Hanemann (1996) reviews three studies that estimate the value of beach recreation, with results shown below in Table 7.4. Table 7.5 presents Hanemann's (1997) summary of consumer's surplus for lost beach trips and consumer's surplus for trips with pollution.

Table 7.4. Summary Table from Hanemann (1996), Consumer Surplus from Beach Recreation in 1990$

Authors	Location	Activity	Value per day trip
Dornbusch et al.[1] (1987)	Northern Orange County	water-dependent activities (including Swimming/surfing)	$9.94
Dornbusch et al.[1] (1987)	Northern Orange County	water-enhanced activities (incl sunning, beach activity)	$10.58
Bell and Leeworthy[2] (1986)	Florida residents in 1984	general beach recreation	$13.19
Leeworthy and Wiley[3] (1993)	1989 NOAA survey, Cabrillo-Long Beach	general beach recreation	$8.16
Leeworthy and Wiley[3] (1993)	1989 NOAA survey, Santa Monica beaches	general beach recreation	$18.36
Leeworthy and Wiley[3] (1993)	1989 NOAA survey, Leo Carillo State Beach	general beach recreation	$51.94
Leeworthy[4]	1990 NOAA survey, San Diego County beaches	general beach recreation	$60.79
Leeworthy[4]	1990 NOAA survey, San Onofre State Beach	general beach recreation	$57.31
Leeworthy[4]	1990 NOAA survey, Pismo Beach State Beach	general beach recreation	$26.20
Leeworthy[4]	1990 NOAA survey, Half Moon Bay State Beach	general beach recreation	$20.70
Leeworthy[4]	1990 NOAA survey, Patrick's Point State Park	general beach recreation	$17.78
Leeworthy[4] truncated model	1989 and 1990 NOAA survey, Southern California Region	general beach recreation	$23.58
Leeworthy[4] untruncated model	1989 and 1990 NOAA survey, Southern California Region	general beach recreation	$44.52

1. David M. Dornbusch & Company, Impacts of Outer Continental Shelf Development on Recreation and Tourism. Volume 3: Detailed Methodology, prepared for Minerals Management Service, San Francisco, April 1987.
2. Frederick W. Bell and Vernon R. Leeworthy, An Economic Analysis of the Importance of Saltwater Beaches in Florida, Sea Grant Report SGR-82, February 1986.
3. Vernon R. Leeworthy and Peter C. Wiley, Recreational Use Value for Three Southern California Beaches, NOAA Strategic Environmental Assessments Division, Office of Ocean Resources and Conservation, Rockville MD, March 1993.
4. Vernon R. Leeworthy personal communication to Hanemann.

Table 7.5. Hanemann 's (1997) summary of Consumer's Surplus for lost Beach Recreation trips and Consumer's Surplus for trips with pollution, in 1990$

Author	Location	Activity	Value per trip
Curtis & Shows (1982)	Delray Beach, Florida	Beach Recreation	$3.00
Curtis & Shows (1984)	Northeast Florida	Beach Recreation	$5.73
Dornbusch et al. (1987)	Northern Orange County	Beach Recreation	$9.94 - 10.58
Tyrrell (1982)	Rhode Island	Beach Recreation	$12.82
Bell & Leeworthy (1986)	Florida	Beach Recreation	$13.19
Meta Systems (1985)	Boston area	Beach Recreation	$13.60
Leeworthy[1] et al. (most conservative judgments)	Island Beach State Park, New Jersey	Beach Recreation	$21.05
Leeworthy[1] et al. (most conservative judgments)	Cabrillo - Long Beach	Beach Recreation	$8.16
Leeworthy[1] et al. (most conservative judgments)	Santa Monica Beaches	Beach Recreation	$18.36
Leeworthy[1] et al. (most conservative judgments)	Pismo State Beach	Beach Recreation	$26.20
Leeworthy[1] et al. (most conservative judgments)	Leo Carillo State Beach	Beach Recreation	$51.94
Leeworthy[1] et al. (most conservative judgments)	San Onofre State Beach	Beach Recreation	$57.31
Leeworthy[1] et al. (most conservative judgments)	San Diego County Beaches	Beach Recreation	$60.79
Department of Interior (p.7 of Hanemann, 1997)	average for U.S. beaches	Beach Recreation	$11.00
Hanemann (1997) conservative estimate	Northern Orange County beaches	Beach Recreation	$15.00 $11-$23
Hanemann (1997) conservative estimate	Northern Orange County beaches	Surfing (25% higher)	$18.75
Spectrum Economics (1991)	Southern California Reservoirs	Private Boating	$34.00
Mannesto (1989)	San Joaquin / Sacramento Delta	Private Boating	$32.00
Walsh, Johnson & McKeon (1988)	literature review	Private Motorized boating	$36.13
Walsh, Johnson & McKeon (1988)	literature review	Private Nonmotorized boating	$55.73
Hanemann (1997) conservative estimate	Northern Orange County	Private Boating	$40.00 $32-$50
Center for Natural Areas (1980)	Southern California	Party/Charter Boat Fishing	$131.54
Huppert & Thompson (1984)	Newport Harbor	Party/Charter Boat Fishing	$49.44 - $67.52
Rowe et al. (1985)	Orange County	Party/Charter Boat Fishing	$38.00
Jones & Stokes (1989)	Southern California	Party/Charter Boat Fishing	$87.12
Jones & Stokes (1989)	Southern California	Private / rental boat fishing	$$29.60
Walsh, Johnson, & McKeon (1988)	literature review	All saltwater fishing combined	$83.00
Hanemann (1997) conservative estimate	Northern Orange County	Party/Charter Boat Fishing	$83.00

1. The PARVS study is a NOAA study of beach recreation on the east and west coasts, directed by NOAA economist Dr. Robert Leeworthy, whose reports include beaches in Southern California (Hanemann, 1997, p.6).

Freeman (1993, p. 26) states, "For beaches, the available evidence suggest that perceptible pollutants such as oil and potential threats to health such as fecal coliform bacteria and PCB (polychlorinated biphenyl) contamination are important attributes. The values per person per day for changes in these attributes may be relatively small, but given high participation in beach activities, aggregate values can be large." He reviews five studies of beach recreation that relate WTP to measures of beach quality. Freeman's (1993) summary of results from 4 studies of beach recreation and water quality are shown in Table 7.6.

Table 7.6. The Value of a Reduction in Pollution for a Beach Visit

Author	Location/Study	Method	Pollution	1991$ Value
Feenberg and Mills (1980)	day trips by Boston Beach Users, 1974 household survey	Random Utility Model	10% reduction in oil, total bacteria, and color	$3.23 per person-year
Bockstael, Hanemann, and Kling (1987)	day trips by Boston Beach Users, 1974 household survey	Random Utility Model	10% reduction in oil, fecal coliform, and chemical oxygen demand	$10.48 per person-year
McConnell (1986)	day trips by New Bedford beach users	Travel Demand for hypothetical trip visits	removal of PCBs in bottom sediments	$3-$4 per person-year
Bockstael, McConnell and Strand (1989)	All Chesapeake Bay Visitors	Travel Cost Model	20% improvement in water quality	$45million per year
Bockstael, McConnell and Strand (1989)	Washington DC and Baltimore SMSA	Contingent Valuation	Improving water quality in areas unacceptable for swimming to acceptable	$89million per year

Hanemann (1997) presents what he terms a conservative estimate of the lost benefit due to trip diversions from polluted beaches, and the losses from visits to polluted beaches in Orange County, shown in Table 7.7.

Table 7.7. Hanemann's (1997) Values for Diverted Trips and Visits to Polluted Beaches

Hanemann (1997) conservative estimate	Northern Orange County	Surfing Trips Diverted	$12.00
Hanemann (1997) conservative estimate	Northern Orange County	Whale Watching trips Diverted	$12.00
Hanemann (1997) conservative estimate	Northern Orange County	Catalina Excursion trips Diverted	$12.00
Hanemann (1997) conservative estimate	Northern Orange County	Polluted Beach Recreation	$3.00
Hanemann (1997) conservative estimate	Northern Orange County	Polluted Surfing Conditions	$3.00

2. Surfing

Hanemann (1994) presents his estimate of the lower bound of consumer surplus of surfing, equal to $16.95, "the entrance fee charged by Raging Waters, an inland water park in San Dimas, CA which provides surfable waves. … It is a lower bound because it excludes the travel cost, and the amenity value of surfing in the ocean under natural conditions" (p.26). Hanemann (1997) notes that the value of specialized recreation is higher than for general recreation, concluding "the consumer's surplus for surfing in Orange County is likely to be at least 25% higher than the consumer's surplus for general beach recreation" (p.8), which would be $18.75/trip.

3. Bird watching; viewing, photographing, and feeding wildlife

All the studies of anglers by men are complemented by this study of "nonconsumptive" wildlife recreation: birding; viewing, photographing, and feeding wildlife. Rockel and Kealy (1991) use a data set from 1980, and estimate the average annual WTP of participants in the U.S. to equal $3,731/observation, and based on the number of participants, 28.2 million, "a total value of the resource of $164.5 billion in 1980 dollars" (p.429), for the linear model; for the semi-log model, $198/observation and $8.7 billion; and for the semi-log model, $515/observation and $22.7 billion.

For comparison, recall that Table 7.2 presents the estimate of the value of bird watching by Kirchhoff, Colby, and LaFrance (1997) at $90.58/visit.

4. Shoreline Fishing Trips

Englin, Lambert, and Shaw (1997) specify joint estimation of the demand for recreation and fishery population growth and catch. They estimate the consumer surplus of $47/trip and $210/angler-year using National Acid Precipitation Assessment Program survey data from 1989 in New England.

McKean, Walsh, and Johnson (1996) estimate consumer surplus for the anglers in a previous study (McKean, Johnson, and Walsh, 1995) at $69.20/trip and $528/year.

Kling and Thompson (1996) compare results for alternative estimation procedures, and use statistical tests to discriminate among models. They estimate (Model C, p.110) the value of recreational fishing in Southern California equal to $23.56 for shore fishing trips, and $61.79 for boat fishing trips.

Freeman (1993) reviews 26 Fisheries studies that use increases in the catch rate as a measure of quality to explain a portion of the WTP. None of the studies are for Southern California. The relationship between pollutants and catch rate is needed to translate the values into the benefit of pollution reduction. Freeman also reviews three studies that correlate WTP directly with levels of nutrients and pollutants in water, but omitted is how the fishers know the water quality of these particular nutrients or pollutants.

Cameron, Shaw, Ragland, Callaway, and Keefe (1996) model both recreational value and frequency of recreation trips as a function of water levels for reservoirs and rivers in Columbia River Basin. Nonresponse bias is important. They use a recreation demand model bifurcated by season, panel data, control for heteroscedasticity and estimate parameters with Limdep. They find per month willingness to pay for improved quality $13/month to $99/month, depending on the lake, which translates into $20 to $60/trip

5. Boating

Table 7.8 is compiled from Tables 2 and 4 of Freeman (1993), where he summarizes the study by Wegge, Hanemann, and Strand (1986).

Table 7.8. Freeman's (1993) summary Wegge, Hanemann, and Strand (1986): Per Person Values (1991$) for the Southern California Pacific Coast

Activity	Estimation Method	Value per Trip	Trips/yr**	Annual Value
1 Day Charter (owner)	TC CV*	$30-125 $79 mean	3.7-15.4	$463
1 Day Charter (rent)	TC CV*	$67-253 $24 mean	3.7-14	$936
Day+ Charter (owner)	TC	$70-501	3.7-26.5	$1,855
Day+ Charter (rent)	TC	$86-799	3.7-34.3	$2,954
Private Boat	TC CV*	$84-373 $73 mean	11.4-50.7	$4,261
Shore Boat	TC CV*	$47-237 $16 mean	7.2-36	$1,697

*Note: CV method had upper bounds for bidding that were exceeded; in those cases, it was arbitrarily assumed that the value was 20% higher than the maximum in the questionnaire (footnote 9, page 12).
**Calculated here by dividing annual value by the range of values per trip

Hanemann (1994) reviews studies of the benefit of boating, and he presents his own estimate, as shown in Table 7.9. The data from these studies identifies boat visits to Santa Monica Bay from harbors outside the Bay.

Table 7.9. Hanemann (1994) review of the literature estimating the value of boating by anglers

Authors	Data/Method	Location	Activity	per person-trip Value in 1990$
Spectrum Economics[1], Inc. (1991)		7 Lake / Reservoirs in Southern California	Freshwater boating by private owners	$34.00
Center for Natural Areas[2] (1980)	1978-79 survey of 4,238 fishers on 367 boats. 4 fishing regions and 13 origin zones. Log-log OLS estimation	San Diego to Newport	Party/Charter boating	$184.74
Center for Natural Areas[2] (1980)	1978-79 survey of 4,238 fishers on 367 boats. 4 fishing regions and 13 origin zones. Semi-log OLS estimation	Seal Beach to Paradise Cove (north Santa Monica Bay)	Party/Charter boating	$96.07
Huppert and Thompson[3] (1984)	1978-79 survey of 4,238 fishers on 367 boats; dropped 1100 observations. 7 fishing regions and 96 origin zones. Semi-log Weighted LS estimation; price = 1/3rd wage rate	Newport	Party/Charter boating	$49.44
Huppert and Thompson[3] (1984)	1978-79 survey of 4,238 fishers on 367 boats; dropped 1100 observations. 7 fishing regions and 96 origin zones. Semi-log Weighted LS estimation; price = 2/3rd wage rate	Newport	Party/Charter boating	$67.52
Wegge, Hanemann, and Strand (1985), reanalyzed by Jones and Stokes[4] (1989)	1983 mail survey of subscribers to South Coast Sportfishing magazine; Tobit estimation	Southern California	Party/Charter boating	$87.12
Wegge, Hanemann, and Strand (1985), reanalyzed by Jones and Stokes[4] (1989)	1983 mail survey of subscribers to South Coast Sportfishing magazine; Tobit estimation	Southern California	private/rental boating	$29.60
Hanemann[5]	1981 and 1989 National Marine Fisheries Service telephone, mail and intercept surveys	Orange County	combined party/charter & private/rental boating	$38.00

1. Spectrum Economics Inc., Recreation Forecasts and Benefit Estimates for California Reservoirs: Recalibrating the California Travel Cost Model, Report to Joint Agency Recreation Committee, July 1991.
2. Center for Natural Areas, Survey of Partyboat Passengers to Summarize and Analyze Recreational Demand for Partyboat Fishing in California, Administrative Report LJ-80-14C, National Marine Fisheries Service, Southwest Fisheries Center, La Jolla, November 1980.
3. Daniel D. Huppert and Cynthia J. Thompson, Demand Analysis of Partyboat Angling in Calfirnia Using the Travel Cost Method, Administrative Report LJ-84-06, National Marine Fisheries Service, Southwest Fisheries Center, La Jolla, revised September 1984.
4. Thomas Wegge, Michael Hanemann, and Ivar Strand, An Economic Assessment of Marine Recreational Fishing in Southern California, Jones and Stokes Associates, 1985. Also, Jones & Stokes, Inc. Final Report – Development and Application of a Predictive Model to Analyze the Economic Effects of Species Availability (JSA 85-099) Sacramento, CA. Prepared for National Coalition for Marine Conservation, San Diego, CA and National Marine Fisheries Service, Southwest Region, Terminal Island, CA. Administrative Report SWR. June 1989.
5. Calculated by Hanemann (1994) from Robert D. Rowe, Edward R. Morey, Arthur D. Ross, and W. Douglass Shaw, Valuing Marine Recreation Fishing on the Pacific Coast, Prepared by Energy & Resource Consultants, Inc., Boulder, CO for National Marine Fisheries Service, Southwest Region, March 1985, and from Cynthia J. Thompson and Stephen J. Crooke, Results of the Southern California Sportfish Economic Survey, NOAA Technical Memorandum NMFS-SWFSC-164, August 1991.

Freeman (1993) reviewed two studies relating boating to water quality. Vaughan, et al. (1985) did not find significant benefits; the authors note they had poor data on water quality. Bockstael, McConnell, and Strand (1989) found that excessive nutrients adversely affect the amenity values from boating activities. Those who trailer their boat to an access point can be used to estimate the value of improved water quality, estimated at $78 per boater-year for a 20% improvement in water quality.

Kaoru, Smith, and Liu (1995) use a Random Utility Model to estimate consumer surplus to an average boat fishing party for reductions in nutrient loadings and their impact on fish stocks. The data (1,012 interviews) were collected in 1981 and 1982 from fishers launching from 35 sites in Pamlico Sound and Albemarle Sound on the Atlantic coast. For two alternative measures of the cost of time, they estimate benefits from reducing nitrogen loadings (BOD) by 36% at all 35 sites. The benefits equal $6.52 and $3.95, respectively.

Montgomery and Needelman (1997) summarize other studies by Kaoru and Smith as including these indirect proxy measures of water pollution in the sounds: phosphorous and nitrogen estimated from loadings in local counties, BOD and total suspended solids based on local municipal water treatment plants.

G. Nonuse Values

Silberman, Gerlowski, and Williams (1992) estimate the existence value of a project to restore a 12 mile stretch of New Jersey beach damaged by erosion. Nonusers within 85 miles have an estimate of $9.26 one time willingness to pay, and represent 138/(138+83) percent of the population.

1. Rare and Threatened / Endangered Species

Ozuna, Jang, and Stoll (1993) identify statistical bias from using logit and probit estimation of referendum CV data when there are omitted variables, heteroscedasticity, or asymmetrical distributions. They compare such estimates with nonparametric estimates for duck hunting and for WTP for preserving whooping cranes. Mean and median estimated WTP for preserving cranes equal $33.26 and $12.50.

Loomis and White (1996) summarize study results on the annual household values of rare and threatened/endangered species, shown in Table 7.10.

Table 7.10. Annual Values/Household of Preserving Rare and Threatened/Endangered Species

	Low Value	High Value	Average of Studies
	Studies Reporting Annual WTP		
Northern Spotted Owl	$44	$95	$70
Pacific Salmon/Steelhead	$31	$88	$63
Grizzly Bears			$46
Whooping Cranes			$35
Red-cockaded Woodpecker	$10	$15	$13
Sea Otter			$29
Gray Whales	$17	$33	$26
Bald Eagles	$15	$33	$24
Bighorn sheep	$12	$30	$21
Sea Turtle			$13
Atlantic Salmon	$7	$8	$8
Squawfish			$8
Striped Shiner			$6
	Studies Reporting Lump Sum WTP		
Bald Eagles	$178		$216
Humpback Whale			$173
Monk Seal			$120
Gray Wolf	$16		$67
Arctic Grayling/Cutthroat Trout	$13		$15

Stevens, Echeverria, Glass, Hager, and More (1991) estimate the annual willingness to pay for wildlife, shown in Table 7.12.

Table 7.12. Annual Value for wildlife (salmon estimates from Massachusetts respondents; all others from New England):

Model	Bald Eagle	Wild Turkey	Coyote Control	Coyote Preservation	Salmon
Logit	28.25	7.11	2.08	3.65	6.25
Tobit	19.90	9.60	3.40		6.95
Average	19.28	11.86	4.20	5.35	7.93

H. Valuing Ecosystems: The Case of Wetlands

Alberini, Kanninen, and Carson (1997) test alternative model specifications on three well-known Contingent Valuation data sets, one of which is the San Joaquin Valley (SJV) Wetlands Improvement CV Survey, and the second data set is the Alaska Oil Spill CV Survey. They estimate annual household willingness to pay shown in Table 7.13. For the SJV Wetlands improvement program, households in California are willing to pay an annual increase in California household taxes of between $175 to $250. For the Alaska Oil Spill, the estimate for a program of tanker escort and emergency response to spills, the national average of a one time charge, U.S. taxpayers are willing to pay between $3.08 and $3.75. This latter program is virtually all a nonuse value since very few U.S. residents visit Alaska.

Table 7.13. Estimates of WTP for SJV Wetlands Improvement and Alaska Oil Spill Protection

Model	SJ Valley	Alaska
Double-Bounded	$175	$3.36
Random Effects	$232	$3.08
Random Effects with Shift	$250	$3.75

Allen, Cunningham, Greenwood, and Rosenthal (1992) estimate the value of California wetlands as shown in Table 7.14.

Table 7.14. Summary Table of per acre Annual Values of California Wetlands in 1990$

Wetland Function	Low	Medium	High
Flood Control	$260	$4,650	$4,650
Water Supply	$6,800	$6,800	$20,360
Water Quality	$3,360	$6,600	$10,400
Recreation	$67	$347	$6,060
Commercial Fisheries	$38	$199	$877
Habitat	$3,337	$3,337	$8,128
Total per acre Benefit	$13,862	$21,933	$50,475
Wetland Acreage	454,000	454,000	454,000
Total Benefit (billions)	$6.29	$9.96	$22.92

Source: Allen, Cunningham, Greenwood, and Rosenthal (1992)

Costanza et al. (1997) group renewable ecosystem services into 17 categories that represent joint products which support human welfare. They divide ecosystems into two primary categories, Marine and Terrestrial. Major subdivisions of the Marine ecosystem are the Open Ocean and Coastal biomes. The major subdivisions of the Terrestrial ecosystem are Forest, Grass/rangelands, Wetlands, Lakes/rivers, Desert, Tundra, Ice/rock, Cropland and Urban biomes. Three of the major subdivisions are further divided into minor subdivisions. The authors summarize the literature that estimates the 17 ecosystem services for each of the biomes. Most of the cells in the table are blank, meaning that there is no information about the values of the services provided by the biomes. Table 2 from their article is duplicated below in Table 7.15.

From Table 7.15, we can calculate the average annual value per hectare estimated by Costanza et al. (1997) at 33,268,000/51,625 = $644.42/hectare or $260.79/acre (a hectare equals 2.471 acres).

Table 7.15. Summary of average global value of annual ecosystem services

	million hectare	Ecosystem Services in 1994 US$ per hectare-year																	$/ha-yr	Billion $/year
Biome	Area	1 Gas regula-tion	2 Climate regula-tion	3 Distur-bance regula-tion	4 Water regula-tion	5 Water supply	6 Erosion control	7 Soil forma-tion	8 Nu-trient cycling	9 Waste treat-ment	10 Pollina-tion	11 Biologi-cal control	12 Habitat refugia	13 Food produc-tion	14 raw mater-ials	15 Genetic resour-ces	16 Recrea-tion	17 Cul-tural	Value per hectare	Total Global Flow Value
Marine	36,302																		577	20,949
Open ocean	33,200	38							118			5		15	0			76	252	8,381
Coastal	3,102			88					3,677			38	8	93	4		82	62	4,052	12,568
Estuaries	180			567					21,100			78	131	521	26		381	29	22,832	4,110
Seagrass/algae beds	200								19,002						2				19,004	3,801
Coral reefs	62			2,760						58		5	7	220	27		3,008	1	6,075	375
Shelf	2,660								1,431			39		68	2			70	1,610	4,283
Terrestrial	15,323																		804	12,319
Forest	4,856		141	2	2	3	96	10	361	87		2		43	138	16	66	2	969	4,706
Tropical	1,900		223	5	6	8	245	10	922	87				32	315	41	112	2	2,007	3,813
Temperate/boreal	2,955		88		0			10		87		4		50	25		36	2	302	894
Grass/rangelands	3,898	7	0		3		29	1		87	25	23		67		0	2		232	906
Wetlands	330	133		4,539	15	3,800				4,177			304	256	106		574	881	14,785	4,879
Tidalmarsh/mangrove	165			1,839						6,696			169	466	162		658		9,990	1,648
Swamps/floodplains	165	265		7,240	30	7,600				1,659			439	47	49		491	1,761	19,580	3,231
Lakes/rivers	200				5,445	2,117				665				41			230		8,498	1,700
Desert	1,926																			
Tundra	743																			
Ice/rock	1,640																			
Cropland	1,400										14	24		54					92	128
Urban	332																			
Total	51,625	1,341	684	1,779	1,115	1,692	576	53	17,075	2,277	117	417	124	1,386	721	79	815	3,015		33,268

Blank (open) cells indicate lack of information. Shaded cells indicate services that do not occur or are known to be negligible

Source: Reproduced from Costanza et al., *Nature*, 15 May 1997, 387:253-260.

Costanza et al. (1989) estimate the present value of wetlands in Louisiana to equal between $2429 and $6400/acre (8% discount rate) or $8977-17000/acre (3% = i).

Bell (1997) considers the value of saltwater marsh as a nursery for fish and as a contributor to the value of the fishery. He estimates the asset value of an additional acre of wetlands, based on an 8.125% discount rate, equal to $6,471 and $981 in 1984$ on the East and West Coast of Florida, respectively.

I. Valuing Programs to Improve Water Quality

Whitehead, Bloomquist, Hoban, and Clifford (1995) estimate the annual household value of maintaining water quality, fish, and wildlife habitat in the Albemarle-Pamlico Estuarine System in North Carolina. The survey includes households in North Carolina and counties in Virginia within the watershed, a 1990 population of 7,442,684 and assuming 2.54 persons / household, 2,930,190 households. For 262 on-site users, 454 off-site users, and 192 non-users in the sample, the WTP is estimated at $71.13, $55.76, and $49.46.

Wang (1997) proposes a model that posits random utility, with clear answers to dichotomous CV questions, and "Don't Know" as a response when the amount is close to the mean of the respondent's value. He applies the model to the Galveston Bay Texas improvement program, which consists of "(1) tighter water quality standards, (2) increasing monitoring and enforcement activities, (3) creating new wetland reserves, (4) establishing a program to test all types of seafood for possible contamination, and (5) establishing a rapid response capability to minimize the effects of oil and chemical spills" (p.227). Respondents are asked whether they would vote for the program if a surcharge were added to their water utility bills. Wang estimates the mean WTP equal to $11.86/month The data from respondents are summarized:

Table 7.16. Monthly Willingness to Pay for Galveston Bay Water Improvement Program

Amount / month	Referendum Vote (percentage)			
for 5 years	For the program	Against the program	Not sure	Sample Size
$5	47.3	25.8	26.9	93
$10	38.1	30.9	30.9	97
$15	31.0	35.6	33.3	87
$30	12.0	60.0	28.0	100
Total	31.8	38.5	29.7	377

Montgomery and Needelman (1997) estimate that removing toxics from New York state water bodies would provide an annual benefit of $63/person (both anglers and nonanglers) in 1989$. The author uses a random sample from the general population, a random utility model of travel demand, nested logit, to estimate the value to anglers. The site choice is a function of water quality defined as suitable for drinking, swimming, or fishing, pH (acidity), and fish contamination warnings.

J. Critique of Approach by Wilchfort, Lund, and Lew Relied upon by Brown and Caldwell

Because Brown and Caldwell (1996) rely on the benefit valuation method proposed by Wilchfort, Lund, and Lew (1996), this critique has its focus on the approach proposed by Wilchfort, Lund, and Lew. General categories of benefits include secondary income, property values, recreation, nonuse values, and values of ecosystems. First, some comments apply to all the categories of benefits.

1. Year-Round Benefits

Pollution from storm drains affects benefits year round, and is not confined to stormy weather. This is so for many reasons, and is so obvious that reiteration seems to belabor the point. However, the approach by Wilchfort, Lund, and Lew, followed by Brown and Caldwell, is to assume that harm is confined to stormy periods, 40 days during the year.

There is a distinction between pollution emissions and pollution concentrations. Pollution emissions occur primarily during storms, but also occur during the remainder of the year. Pollution concentrations are increased by pollution emissions, and cause continuing problems. Wildlife in Ballona Wetlands consume organisms that live along the channel; those organisms biomagnify pollution.

The demand for recreation is not a simple function of pollution emissions, but a function of pollution concentration. There is a lagged effect. The tourism industry is affected by the level of pollution in Santa Monica Bay. The number of beach visits is also affected by past pollution emissions. The pollution level in Santa Monica Bay depends on the accumulation of pollution emissions over time from the concrete drainage system, as well as streams and adjacent roads. For example, Fernandez (1997) states, "The BOD (biochemical oxygen demand) has a cumulative effect over time since the level at each point in time depends on previous periods in a linear manner" (p.295). For example, the epidemiological study of swimmers in Santa Monica Bay includes exposure to fecal coliform throughout the year, not just during storm days (Haile, et al., 1996).

Wilchfort, Lund, and Lew (1996) and Brown and Caldwell (1996) assume that benefits from pollution control occur in 40 out of 365 days, and assign zero benefits to the other 325 days. In this review of the literature, no other study has done so.

2. Water Reclamation

Wilchfort, Lund, and Lew discard water reclamation as an option. Brown and Caldwell ignore it. Wilchfort, Lund, and Lew ignore the possible beneficial use of reclaimed water on the specious grounds that the cost would equal about $1300/Acre-foot. They omit the value of additional water. If regional water reclamation and treatment is considered as an option, the value of the reclaimed water is equal to the value of water displaced by the reclaimed water. According the Los Angeles Mayor's Blue Ribbon Committee on Water Rates (1992, 1994) the marginal cost to the Los Angeles Department of Water and Power of procuring drinking water, which would be displaced by the reclaimed water, equals $879 and $1,161/Acre-foot in the Winter and Summer, respectively, (converted to acre-feet from Hall, 1996, pp. 86-87). The difference between the cost of reclaiming the water and the value of the additional water is the cost of reducing pollution after netting out the value of the reclaimed water. That difference is what remains to be balanced by all the other benefits.

3. Secondary Economic Effects

Pollution generally makes an area less desirable. There will be secondary economic effects on local businesses whose success is closely tied to the quality of the area. The demand for recreation is a function of the environmental quality. Visits to the beach, harbor, and wetlands, are a function of the level of pollution. These visits bring business to the local economy, and the reduction of visits from pollution is harmful to the local economy. Wilchfort, Lund, and Lew (1996) and Brown and Caldwell (1996) excluded an estimate of the secondary economic effects.

4. Property Values

Beneficial uses such as cycling, fishing and boating are adversely affected by pollution, and so too are property values in the surrounding areas. The number of homes and commercial establishments near the Ballona Wetlands, the distance to the wetlands, and the present property values could be ascertained. The increase in property values from improving the wetlands could be inferred from the literature if site specific estimates are deemed too expensive. Wilchfort, Lund, and Lew (1996) and Brown and Caldwell (1996) exclude the impact of changes in property values.

5. Health Effects

Ill-health effects avoided are additional benefits of pollution control. The level of pollution affects the value per hour of recreational experiences, and the frequency and duration of visits, all of which affect the benefit of recreational use. In addition, if we have ill effects from exposure to pollution, ill effects that can be avoided or reduced by pollution reduction, those are additional benefits. Haile, et al.(1996) estimate the frequency of illnesses that occur to swimmers. The amount that we are willing to pay to avoid the symptoms of ill-health is a topic covered in the literature (Hall et al., 1992 and references therein). Wilchfort, Lund, and Lew (1996) and Brown and Caldwell (1996) omit the economic value of ill-health effects avoided by pollution reduction.

6. Recreation Demand

This section presents errors in the method proposed by Wilchfort, Lund, and Lew (1996) for estimating benefits of recreation. One error is the assumption by Wilchfort, Lund, and Lew that the demand for recreation visits does not depend on the level of pollution. A second error is their assumption that the marginal utility of benefits is linear. A third error is their transfer of benefit estimates between dissimilar recreation activities and dissimilar locations. A fourth error is the omission of categories of recreation benefits.

a. Approach of Wilchfort, Lund, and Lew

Wilchfort, Lund, and Lew (1996) derive the marginal benefit of improvements in water quality and compare them with the marginal costs. Their first step was to list recreation activities and define the pollutants which affect those activities. For each benefit, they select pollution thresholds at which beneficial uses would be "unimpaired" and "fully impaired". For small reductions in pollution, they calculate a "benefit multiplier" that is a fraction less than one. For a pollution control program, pollution falls from the present level to a marginally cleaner level. The fraction used as a benefit multiplier equals the portion of pollution reduction that falls within the "unimpaired and "fully impaired" thresholds. They multiply this fraction times their estimate of "unimpaired" recreation benefits. Thus, they assume a linear relationship between pollution emissions and the percentage of unimpaired beneficial value available (benefit multiplier).

Wilchfort, Lund, and Lew (1996) derive multipliers for each pollutant. When, in their judgment, a form of recreation is affected by more than one pollutant, they propose an average to derive a composite multiplier for the type of recreation.

Wilchfort, Lund, and Lew (1996) refer to some literature to justify an hourly benefit of recreation. They multiply their hourly benefit times their estimate of the number of hours of recreation in a visit to obtain the benefit of a visit, and multiply this times the number of visits during the 40 rainy days in the year:

Benefit/Hour x Hours/Visit x #Visits/40 storm days = Total "Unimpaired" Benefits

Wilchfort, Lund, and Lew (1996) multiply their estimate of the unimpaired beneficial use value times the fractional benefit multiplier to estimate the marginal benefit from the incremental changes in water quality:

Marginal Benefit = "Unimpaired Benefit x fractional benefit multiplier

This multiplication is where Wilchfort, Lund, and Lew implicitly assume constant marginal utility of recreation.

As pointed out in the previous chapter, for most recreation categories neither Brown and Caldwell (1996) nor Wilchfort, Lund, and Lew (1996) have a benefit multiplier (for example, if they assume no effect from pollutants); in those cases they set the multiplier equal to zero and ignore the benefit. For those categories of recreation where the reduction in pollutants falls outside the thresholds, the fractional benefit multiplier is set to zero and those benefits are ignored. For any remaining categories of recreation, the size of the fractional multiplier reduces their estimate of 40 storm days of beneficial losses to a fraction of their estimated "unimpaired" benefits.

Compare the approach by Wilchfort, Lund, and Lew (1996) to the calculations by Hanemann (1997). Hanemann identifies three forms of losses to recreators due to pollution: (i) losses from trips not taken, (ii) losses from trips taken to other, less desirable sites, and (iii) losses from trips taken to the site, but with diminished value because of the pollution. Wilchfort, Lund, and Lew's method at best incorrectly accounts only for the third item in Hanemann's list of benefits.

b. Number of Visits Depends on the Amount of Pollution

One of the assumptions by Wilchfort, Lund, and Lew (1996) is that the number of visits to a recreation site is independent of the amount of pollution. This assumption is inconsistent with the literature.

Cameron, Shaw, Ragland, Callaway, and Keefe (1996) model both recreational value and frequency of recreation trips as a function of water quality for reservoirs and rivers in Columbia River Basin. They use a recreation demand model bifurcated by season, panel data, control for heteroscedasticity and estimate parameters with Limdep. They find per month willingness to pay for improved quality $13/month to $99/month, depending on the lake, which translates into $20 to $60/trip

Ribaudo, Young, and Shortle (1986) study of the frequency of visit to a site dependent on water quality. The site is St. Albans Bay in Lake Champlain, Vermont. The number of visits dropped because of eutrophication, and by 1980 the state ceased active management of the site.

Parsons and Kealy (1995) based their work on an earlier model by Bockstael, Hanemann and Kling (1987). The model estimates the demand for and benefits of swimming at a beach, and is premised on the idea that individuals select a particular beach for swimming based on the characteristics of the beach and the costs of reaching the beach. The model estimates the number of trips an individual takes to the beach. The authors conclude that improvements in the quality of a resource improve economic welfare in two ways: 1) by increasing the value of recreation at the site, and 2) by increasing the number of trips taken to the site. It is clear that a less polluted resource is more valuable because it can provide any individual with more benefits. The second point is omitted by the method of Wilchfort, Lund, and Lew (1996). A cleaner resource provides more benefits by attracting more people to enjoy it.

In calculating the unimpaired benefit value, it is essential to understand that the quantity demanded of beneficial uses is a function of the level of pollution. A cleaner area will attract more people, thereby increasing the number of visits, and therefore the total benefit value. This point is illustrated in Figure 2 above, a basic point in the literature review by Cropper and Oates (1992).

Since the quantity demanded for recreation depends on the pollution concentration, pollution emissions can affect the use. For their method, Wilchfort, Lund, and Lew (1996) state in Appendix B that incorrectly using the impaired benefit instead of the unimpaired benefit will bias their benefit estimates downward. But that is precisely what they do since they assume that the number of visits and hours per visit are invariant with the level of pollution.

c. Diminishing Marginal Utility of Recreation Benefits

An implicit assumption of the method by Wilchfort, Lund, and Lew (1996) is constant marginal utility, an assumption inconsistent with economic analysis. For example, Parsons and Kealy's (1995) model assumes diminishing marginal utility: net utility and the marginal utility of the recreation dollar (a) diminish as the number of trips taken (T) increases.

d. Benefit Transfer

Wilchfort, Lund, and Lew (1996) value four beneficial uses of Ballona Creek and its reaches. Their terminology and the actual use are presented in Table 7.15, as well as the value per unit of recreation which they state is from a literature review, and a value per unit of recreation they call the "Upper Bound" which they state is a "conservative" number.

In Appendix B, however, Wilchfort, Lund, and Lew (1996) provide a reason for using the "upper bound," to avoid an error that their approach may cause. On page 3 of Appendix B, they acknowledge that their estimates could be 75% lower than the those that are internally consistent with their method, unless the use value is adjusted upward to account for the "unimpaired value". If that is so, the upward adjustment may not be "conservative".

Table 7.15: Beneficial Uses in Wilchfort, Lund, and Lew from Table 8 of their study, p.22

Beneficial Use Category	Actual Use Valued in Wilchfort, Lund, and Lew	Literature $/Unit 1996 $	Upper Bound $/Unit 1996 $
Navigation	Pleasure boating: sailboats and motorboats	$1.90/Hr	$10/Hr
Contact Recreation (Rec-1)	UCLA Crew Rowing Team	$1.90/Hr	$10/Hr
Non-Contact Recreation (Rec-2)	Bicycling around upper reach of Ballona Creek	$2.20/Hr	$10/Hr
Shellfish / Commercial Harvest	12 Commercial Vessels in Marina del Rey: Dinner Cruises and Day Sport Fishing	$300-$500/Day	$1000/Day

In Appendix C, Wilchfort, Lund, and Lew (1996) distinguish between the willingness-to-pay (WTP) and consumer surplus (CS). They refer to the WTP as the total value under the demand curve, while the CS is the WTP minus the cost of recreation, typically parking and other user fees but omitting travel cost. They call the cost of recreation "the market clearing price (MCP)", which they arbitrarily set equal to 55% or 45% of the *average* WTP, depending on the recreational activity. The *average* WTP is the WTP divided by a the number of recreation visitors. The *average* CS is simply the *average* WTP times .55 (or .45). They use benefit numbers from the Forest Service Handbook, and divide by 12 hours to get an hourly value. They could get lower values if they divided by, say, 16 hours, or higher hourly values by dividing by 8 hours/day. Their report states, "A RVD is defined as 12 hours of a recreational activity" (Appendix C, p.2). They do not state who defined a RVD. They state that they use the *average* WTP rather than the lower *average* CS because they want to be conservative, and because the Forest Service percentages of 45% or 55% may not be accurate (Appendix C, p.3).

In order to consider whether the values transferred from forest service studies to marine recreation by Wilchfort, Lund, and Lew are reasonable, note that the WTP must be larger than the cost of recreation, since the difference must be positive or the consumer would not engage in the recreation. That is, the consumer surplus can not be negative. Consider the value of pleasure boating which Wilchfort, Lund, and Lew believe equals $1.90/hour. One telephone call provided an estimate of the cost of a dock from one of the yacht clubs at Marina del Rey. Guest docks cost $0.50/foot-day, and the median boat is 33 feet, for a total of $16.50/day. Assuming the vessel costs $100,000, lasts for 20 years, and the interest rate is 7%, then the daily capital cost is $25.86. Add a maintenance and repair cost, plus a travel demand cost, equal to 50% of the capital cost, and sum to get $55.29/day. The weekly cost is $387, a cost that must be lower than the weekly WTP. At $1.90/hour, 6 people per vessel, 8 hours of recreation per trip, and three trips per week, the weekly WTP equals $274, a clearly inconsistent result. From this comparison, the value for boating presented by Wilchfort, Lund, and Lew, from forest service studies of boating in mountain lakes, is not representative of the value of ocean marina recreation in Southern California.

For further comparison, Wilchfort, Lund, and Lew base their value of boating on old forest service numbers which they report in their Table 2, Appendix C, p. 4, giving the WTP for a day of recreation in 1989 $ equal to $18 for non-motorized boating and $13 per person-day for motorized boating. Compared to the values in Tables 7.8 and 7.9, Wilchfort, Lund, and Lew have underestimated the value of pleasure boating. Consider the estimate by Hanemann (1997) of $87/person-day, Wilchfort, Lund, and Lew (1996) have under-estimated the value of boating by five hundred percent.

<u>e. Omitted Categories of Impacted Recreation Demand</u>

The analysis by Wilchfort, Lund, and Lew (1996) limits benefits to four recreational activities, with benefits adversely affected by only five pollutants. Motor boats and sail boats in Marina del Rey are adversely affected by debris, and oil and grease. Team rowing at the mouth of Ballona Creek is affected by oil and grease, fecal coliform, and lead. Bicycling along Ballona Creek is affected visually by debris, and oil and grease floating in the creek. Twelve commercial boats docked in the Marina that take visitors on dinner cruises, and sport fishers on day trips, are adversely affected by debris that closes the Marina and by shell fish with lead and fecal coliform.

For any method of pollution control, all the benefits of pollution control need to be considered when comparing benefits to costs, not just a subset of benefits. Omitted recreation benefits include year-round benefits, beach visits without water contact, water contact beach visits such as surfing, bird and wildlife viewing, shoreline fishing, and boating (including avoiding closure of Marina del Rey due to polluted silt). Other benefits include higher property values for property adjacent to creeks and wetlands, secondary economic effects, reduced ill-health effects from water contact recreation in the Santa Monica Bay, and cleaner ecosystems with benefits to fisheries, aquatic and wildlife habitat, nonuse values, and the value of reclaimed water.

7. Nonuse Values

The method proposed by Wilchfort, Lund, and Lew (1996), and relied upon by Brown and Caldwell (1996), does not permit the calculation of benefits from non-use values. Consequently, both studies omit all benefits related to non-use values, causing the benefit estimates to be biased downward.

Wilchfort, Lund, and Lew (1996) omit all nonuse values from the benefit estimation of reducing pollution from Ballona Creek. They state,

> "*There are two primary reasons that nonuse values are not included in the analysis of Ballona Creek. First, nonuse values are generally thought to be associated with unique resources that have no readily available substitutes for providing the amenities people value. Ballona Creek, a channeled storm drain, does not fall into this category of resource amenity*." (Appendix C, p.5).

This first argument is wrong for two reasons. First, the pollution is degrading unique resources. The pollution from Ballona Creek reaches the Marina del Rey, the Ballona Lagoon, the Venice Canals, the Del Rey Lagoon, and the Ballona Wetlands (LARWQCB, 1997, p.100). The pollution is degrading the wetlands (LARWQCB, 1997, p.104). The pollution from Ballona Creek empties into the Santa Monica Bay. The Ballona Wetlands are a unique resource:

> *"The Ballona Wetlands are a complex of estuary, lagoon, salt marsh, freshwater marsh and dune habitats. … A dynamic, vital place, the Ballona Wetlands are a highly valuable resource for the Los Angeles region. They have critical habitat value for many species of organisms, serve as an invaluable educational resource, and are unique in being situated in a large metropolitan area. … The wetlands have been reduced to a little over 180 acres (from 1800-2000acres). Even after these staggering losses, the Ballona Wetlands constitute the last large area of this habitat type in Los Angeles County."* (Friends of Ballona Wetlands, 1997, p.1).

The Santa Monica Bay is also a unique resource. "In 1988, California Governor Deukmejian nominated Santa Monica Bay to be included in the National Estuary Program and in July 1988 the Bay became one of 21 bodies of water nationwide to be granted this status" (Santa Monica Bay Restoration Project, 1994, p.1-2).

Second, even if there are many close substitutes, that does not mean that the substitutes have little value; the availability of close substitutes does not mean the resource has zero, or close to zero, nonuse value. Substitutes may be plentiful but at high cost, in which case the nonuse value may be high.

Wilchfort, Lund, and Lew (1996) state their second argument for not including nonuse values. It is that they, Wilchfort, Lund, and Lew, don't value Ballona Creek: "There are no credible empirical measurements of nonuse value for ordinary streams such as Ballona Creek because they are believed a priori to be small" (Appendix C, p.6). They go on to describe Ballona Creek as a polluted concrete channel, as opposed to "high quality resources" for which the nonuse value is "not related to any quality change." For sure, pollution reduces the value. But changes in quality can be valuable. The Ballona Wetlands and the Santa Monica Bay are high quality resources that cannot be described as concrete pollution-drainage ditches. Moreover, Brown and Caldwell (1996) ignore nonuse values without consideration for any unique resources in their study area – the Santa Monica Bay watershed.

A panel of experts convened by NOAA (1994), including two Nobel Laureates, Kenneth Arrow and Robert Solow (Arrow, et al., 1993), designed protocols for Contingent Valuation (CV) studies that are strict enough to be able to replicate results, "estimates reliable enough to be the starting point of a judicial process of damage assessment, including lost passive use values" (Arrow et al., 1993). Another argument Wilchfort, Lund, and Lew use to justify setting the nonuse value to zero is because the protocols for CV are restrictive, requiring "extensive preparation of survey material, time-consuming pretesting and data collection, and a period for analysis and reporting" (Wilchfort et al, Appendix C, p.4). Yet, "several CV practitioners believe the panel's guidelines and protocols for CV studies are overly prescriptive. These individuals argue that reliability can be obtained under less restrictive protocols" (Kopp, 1995); Harrison and Lesley (1996) agree. Harrison and Lesley (1996) empirically show that estimated WTP using population weights of explanatory variables in a valuation function estimated from a convenience survey of college students is close to the Exxon Valdez oil spill study results that were estimated from a $3 million dollar CV study of a random sample of over 1000 completed interviews.

A final reason for setting the nonuse value to zero given by Wilchfort, Lund, and Lew (Appendix C. pp. 6-7) is that the only estimates they could find in the literature are higher than a number they are willing to use. They argue that it is wrong to compare literature estimates of wild rivers in Colorado with the concrete drainage ditches that make up Ballona Creek, thereby ignoring the values of the Ballona Wetlands and Santa Monica Bay. Brown and Caldwell follow their example, ignoring nonuse values.

K. Brown and Caldwell's Valuation of Changes in Benefits

Having eliminated from their analysis the vast majority of all available or potential benefits, the change in benefit value is easy to calculate. Based upon the method of Wilchfort, Lund, and Lew (1996), Brown and Caldwell (1996) determined that of all potential benefits, the only benefit category that would benefit from pollution control is riparian habitat because the concentrations of lead and copper were in between the "unimpaired" and "fully impaired" thresholds. Brown and Caldwell assume that the benefit of pollution reduction to all other categories zero.

Brown and Caldwell value freshwater habitats at $395,000 per acre based on wetland creation projects that CalTrans has funded in the past (Brown and Caldwell 1996: pg. 8-21). Brown and Caldwell (1996) further estimate that the total acreage of riparian habitats in the Santa Monica Bay is 361.7 acres, and that the total value is therefore $143,000,000. Brown and Caldwell use a 4% discount rate for 20 years to calculate the annual benefit of freshwater habitats at $10,500,000.

Brown and Caldwell further estimated that Level 3 treatment of CalTrans runoff would improve benefits by a total of 4%. They therefore estimated that to total annual change in benefits due to improved storm water runoff quality is $420,000 (Brown and Caldwell 1996: pg. 8-25). They compare that figure to their $44,000,000 annual cost estimate for Level 3 treatment to determine that costs outweigh benefits by a factor of 105 (pg. 8-25,26).

The $395,000 per acre value of freshwater habitat used by Brown and Caldwell, which they convert at 4% for 20 years, gives an annual value equal to $29,065 per acre. This compares with the medium annual value for California wetlands of $21,933 per acre in Table 7.14 from Allen, Cunningham, Greenwood, and Rosenthal (1992). However, land does not have to be replaced every 20 years. On an annual basis at 4% with an infinite time horizon, Brown and Caldwell's estimate equals $15,800 per year. This is somewhat low compared to the medium value for California wetlands of $21,933 given by Allen, Cunningham, Greenwood, and Rosenthal (1992), and it is rather low if the higher value in Table 7.14 ($50,475) is applicable for Southern California. In magnitude, a more serious error is the acreage used by Brown and Caldwell, omitting the Ballona wetlands, lagoons, and marshes in Santa Monica Bay.

The benefit estimate by Brown and Caldwell is unreliable for these reasons. They use the method by Wilchfort, Lund, and Lew which omits nonuse values, all benefit values unrelated to recreation, and most categories of recreation.

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Chapter VIII Summary and Conclusions

Brown and Caldwell (1996) and Wilchfort, Lund, and Lew (1996) are two interwoven studies that jointly define the scope of benefit-cost assessment and the method of estimating benefits of controlling pollution in surface water run-off in CalTrans District 7. Brown and Caldwell confine the analyses by selecting the pollution control options and the initial pollutants to be considered. The former affects the effectiveness and cost of pollution control, and the latter eliminates benefits under consideration. Wilchfort, Lund, and Lew propose a method to estimate benefits that is used to justify the elimination of pollutants under consideration and to restrict the benefits that count. Both studies confine the geographical and temporal scope of analyses such that only a fraction of benefits are included in the calculations.

The main option developed by Brown and Caldwell is pollution control of CalTrans roads, while allowing uncontrolled pollution from all other sources, so the effect is small relative to the magnitude of the problem. They estimate the change in pollution from "CalTrans-only" pollution control, applied to all the watersheds that reach the Santa Monica Bay. They also estimate the effect of CalTrans-only pollution control within the Ballona Creek watershed. They extend the analysis to "joint" pollution control of all roads within the Ballona Creek watershed.

Brown and Caldwell (1996) present estimates of the cost of CalTrans-only pollution control for Santa Monica Bay. They estimate the cost of CalTrans-only pollution control and the cost of joint pollution control in the Ballona Creek watershed. They also estimate benefits of CalTrans-only pollution control for Santa Monica Bay. They conclude that the costs greatly outweigh the benefits for CalTrans-only pollution control for Santa Monica Bay.

Wilchfort, Lund, and Lew (1996) estimate benefits of CalTrans-only pollution control for the mouth of Ballona Creek, and compare their benefit estimate with Brown and Caldwell's cost estimate. They conclude that the costs greatly outweigh the benefits for CalTrans-only pollution control in the Ballona Creek watershed.

In the Ballona Creek watershed analysis, when Wilchfort, Lund, and Lew apply their method for benefit estimation to CalTrans-only pollution control, their method leads them to eliminate from their analysis all but a handful of pollutants and benefits. They then apply their method to estimate the benefit of joint pollution control in the watershed, but they restrict this analysis to the same handful of pollutants and benefits in their CalTrans-only pollution control benefit estimate. They compare their benefit estimate with Brown and Caldwell's cost estimate. Wilchfort, Lund, and Lew conclude that the costs of joint pollution greatly outweigh the benefits for the Ballona Creek watershed.

A. The Titles of the Studies Divert and Narrow Focus

The objective of benefit-cost analysis is to quantify all the benefits and costs of alternatives in a circumstance and to calculate the net benefits (benefits minus costs) of the alternatives in a single unit of measure – dollars. The purpose is to assist good decision-making in a circumstance. CalTrans is relying on two studies for the circumstance of surface water run-off to waterways (including storm drains, rivers, and streams) and their receiving reaches (including Santa Monica Bay, San Pedro Bay, and the Pacific Ocean). Analysis of the titles alone reveals much about these studies. The titles of these two studies are verisimilitudes that divert and narrow focus from the circumstance, from the objective, and from the purpose of benefit-cost analysis.

The title of the study by Brown and Caldwell (CalTrans Storm Water Facilities Retrofit Evaluation) diverts and narrows focus from surface water run-off to storm water run-off, excluding all benefits except benefits that accrue during 40 storm days of the 365 day year. The title also narrows alternatives to CalTrans-only storm drain retrofit options that fail to take advantage of economies of scale of treating all surface water run-off jointly with other agencies, affecting the cost calculations and the effectiveness, and thereby the benefits.

The title of the study by Wilchfort, Lund, and Lew (Preliminary Economic Valuation of Stormwater Quality Improvement for Ballona Creek) diverts and narrows focus from surface water run-off to storm-water run-off, similarly omitting benefits except those that accrue during 40 storm days of the 365 day year. Their title also diverts and narrows the focus to Ballona Creek, omitting benefits to the receiving waters (Santa Monica Bay). Their title further diverts focus from quantifying benefits and costs to presenting a method for "preliminary economic valuation". There is nothing preliminary about their conclusions that would excuse CalTrans from an analysis of all the benefits and costs of promising alternatives with economies of scale.

Both reports shift focus from the purpose of benefit-cost analysis. By shifting and narrowing focus to partial benefit calculations, and to alternatives that fail to take advantage of economies of scale, these studies do not assist good decision making.

B. Evaluation of the Content of the Studies

This report evaluates the adequacy of the benefit-cost analyses by Brown and Caldwell (1996) and Wilchfort, Lund, and Lew (1996) for the purpose of concluding whether there are control options to reduce pollution in surface water run-off in CalTrans District 7 that have benefits high enough to justify the cost. This report also evaluates the precedent that would be set if the Court were to accept the results of these two benefit-cost analyses -- legitimizing the approach to benefit-cost analysis and the method for benefit estimation contained in these two interwoven reports.

1. Chapter 1: Overview of Approach

Chapter 1 presents an overview of key components for a benefit-cost analysis of treating surface water run-off. First is the selection of the geographical region under consideration and the time frame for analysis. Second is establishing the baseline of pollution without treatment. Third is the selection of treatment options that determine the cost of treatment and the amount of pollution reduction. Fourth is identification of the benefits that are adversely affected by pollution in the surface water run-off. Fifth is the method used to link changes in pollution to changes in benefits. Sixth is the assignment of dollar values to changes in benefits. Each of these components of benefit-cost analysis is the basis for evaluation of the studies by Brown and Caldwell (1996) and Wilchfort, Lund, and Lew (1996).

2. Chapter 2: Temporal and Geographical Scope of Analysis

Brown and Caldwell (1996) and Wilchfort, Lund, and Lew (1996) bias there analyses by geographically and temporally circumscribing the benefits and costs of pollution control.

a. Geographical Scope

There are five ways the geographical scope of the analysis can bias benefit and cost estimates: (1) Selecting the Watershed for Analysis; (2) Omitting Areas that Receive Waters in the Watershed; (3) Economies of Scale in Cost Estimates from Omitting Pollution Sources within a Watershed; (4) Benefit Transfer: Omitting Classes of Benefits; and (5) Benefit Transfer: Incorrectly Estimating the Value of Benefits.

(1) Selecting the Watershed for Analysis

Even if the benefit-cost analysis by Brown and Caldwell (1996) were reliable for the Santa Monica Bay region, the results would be inapplicable to the watersheds in CalTrans District 7 and their reaches. Pollution levels and categories of economic benefits are significantly different between Santa Monica Bay watersheds and the rest of District 7where pollution levels are significantly higher.

Brown and Caldwell (1996) and Wilchfort, Lund, and Lew (1996) omit benefits because of the geographic scope of their analyses. Neither study considered benefits of pollution control in the major watersheds of District 7: the Los Angeles River, the San Gabriel River, the Dominguez Channel, nor the Los Cerritos Channel.

The Los Angeles River plus the San Gabriel River have a factor of 10 times the mass emissions as Ballona Creek. If their economic conclusion were correct for Santa Monica Bay, they would not be transferable to the broader region encompassed by CalTrans District 7 watersheds and their reaches.

The Los Angeles and Long Beach international harbors are critical centers of economic activity for Southern California. The Brown and Caldwell (1996) study is unable to include any comparable harbor in the geographical region they consider. Consequently, any conclusion they reach regarding the benefits and costs of pollution control is inapplicable to the majority of the land area and watersheds affected by pollution in CalTrans District 7.

(2) Omitting Areas that Receive Waters in the Watershed:

Both studies (Brown and Caldwell, 1996, and Wilchfort, Lund, and Lew, 1996) omit geographical areas and receiving waters *within their own watershed study areas* where benefits occur from the pollution reduction, biasing downward the benefit estimates for those watersheds. Wilchfort, Lund, and Lew (1996) omit from their benefit calculations the adjacent Ballona Wetlands, Ballona Lagoon, Venice canals, Dockweiler Beach, and the adjacent beaches along the Santa Monica Bay. Wilchfort, Lund, and Lew (1996) exclude the inland reaches of Ballona Creek. Brown and Caldwell (1996) only consider a small portion of the Ballona Wetlands in their computations of the benefits of controlling CalTrans-only pollution within the Santa Monica Bay watershed. Brown and Caldwell also omit the Malibu Lagoon in their benefit analysis of the Santa Monica Bay watershed. *These two omissions alone would almost double the benefit estimation by Brown and Caldwell, had they been included*.

(3) Economies of Scale in Cost Estimates from Omitting Pollution Sources within a Watershed:

The third type of bias occurs when cost estimates are based upon more expensive, selective treatment of just some pollution sources. There are economies of scale if a facility can be designed to treat pollution from several sources rather than just one source. Efficient engineering requires consideration of design options that account for geographical connections in a watershed which typically result in surface water pollution run-off from many sources. Treatment designs that just treat CalTrans-only pollution may not be efficient because economies of scale are lost.

Brown and Caldwell acknowledge that there are economies of scale for joint treatment of all water in a watershed. Yet they do not present a benefit-cost analysis for joint treatment of all water that reaches the Santa Monica Bay; their benefit-cost analysis is for water from CalTrans-only. They do not compare benefits and costs of detention ponds with groundwater recharge, water reclamation projects jointly built and operated with water districts, water agencies, cities, and other agencies, or diverting water run-off to Publicly Owned Treatment Works (POTWs) by way of existing sanitary sewers, and seasonally shut off the diversion during heavy rains to avoid overflow to the sewage treatment facilities. Wilchfort Lund and Lew (1996) dismiss a water reclamation option without correctly analyzing the benefits.

(4) Benefit Transfer -- Omitting Classes of Benefits

Bias can occur when benefit estimates from a study of one geographical region are transferred to another region without sufficient care; this can occur in two ways. The fourth type of bias is when pollution reduction can affect beneficial uses, some of which may be present in one geographical region but not in another. Wilchfort, Lund and Lew (1996) bias their benefit estimate downward by confining the study area, thereby omitting classes of benefits in the method they propose. Brown and Caldwell (1996) use Wilchfort, Lund, and Lew’s (1996) method, omitting a class of benefits in their analysis of a larger geographical area.

Wilchfort, Lund, and Lew (1996) omit the benefits from preserving and enhancing ecosystems such as the Ballona Wetlands. They also omit health benefits to swimmers at Dockweiler Beach. Wilchfort, Lund, and Lew (Appendix C, p.5) categorize “preservation value, intrinsic value, bequest value, option value, and existence value” as “nonuse values … not included in the analysis of Ballona Creek.” Wilchfort, Lund, and Lew (1996) do not extend the method they propose to ecosystem or health benefits and so omit these important classes of benefits. Brown and Caldwell (1996) apply the method of Wilchfort, Lund, and Lew to the entire Santa Monica Bay. Because the method they use does not consider ecosystem or health benefits, they omit these classes of benefits.

(5) Benefit Transfer -- Incorrectly Estimating the Value of Benefits

If the dollar value of a beneficial use is lower in one geographical region than another, transferring the value from the former geographical region to the latter region biases downward the benefit estimate of pollution reduction; this is what Wilchfort, Lund, and Lew (1996) do, and Brown and Caldwell (1996) follow their example. Wilchfort, Lund, and Lew (1996), use forest service studies from the 1980s to establish a value for outdoor recreation at Southern California beaches. Brown and Caldwell (1996) then apply those estimates to the Santa Monica Bay watershed.

b. Temporal Scope

Both the analyses by Brown and Caldwell (1996) and by Wilchfort, Lund, and Lew (1996) confine the temporal scope of analysis, biasing downward the benefit estimates. Benefit estimates are biased downward because they only calculate benefits of pollution control for 40 days out of the year. Both studies ignore the economic and population growth in the region, both of which will result in increases in pollution and increases in benefits from pollution reduction over the relevant period. Both of these biases result in benefit estimates that are lower than they should be.

The method proposed by Wilchfort, Lund, and Lew (1996) assumes that pollution emissions are do not have random fluctuations. Brown and Caldwell (1996) use the method proposed by Wilchfort, Lund, and Lew. In fact, “a uniform storm water quality has been assumed for all CalTrans runoff” (Brown and Caldwell, p.iv). To the contrary, between wet years and dry years pollution emissions vary considerably.

3. Chapter 3: The Baseline Level of Pollution

The baseline level of pollution run-off has two parts: (i) the current amount of surface water run-off – without treatment, and (ii) the future level of pollution run-off without treatment during the period relevant to the proposed treatment options. In order to estimate the benefits of pollution control, it is necessary to establish the baseline of pollution prior to control, and the level of benefits corresponding to that amount of pollution. The treatment options determine how much reduction in pollution is possible and at what cost. The level of pollution after treatment is integral to the new level of benefits. The benefit-cost test compares the increase in benefits to the treatment cost.

In order to accurately assess the benefits, it is necessary to accurately measure the baseline. This chapter establishes that the baseline used by CalTrans in their conclusions about the benefits and costs of pollution control in District 7 only contains the first part – the current condition – and omits the expected increase of pollution in the future. In the absence of treatment, increases in population and economic activity will likely increase pollution emissions over the next 20 years. Some of the literature reviewed in Appendix 3.1 of Brown and Caldwell (1996) could be helpful in estimating the increase in pollution. Brown and Caldwell (1996) do not do so.

Irrespective of the original source of pollution, all reductions in pollution that are provided by treatment affect the benefit calculus. If pollutants that would be controlled are omitted from the analysis because they are not considered when establishing the baseline, then the benefits of treatment are biased downward. This chapter demonstrates that Brown and Caldwell (1996) omit numerous pollutants that typically are found in CalTrans run-off, and they omit pollutants from sources other than CalTrans that would be controlled by joint pollution control measures. Wilchfort, Lund, and Lew (1996) establish their baseline for analysis from information obtained from Brown and Caldwell, so both analyses have this bias.

Compared to the 53 types or measures of pollutants identified in a study for CalTrans by Dammel (1997) and the additional pollutants given by the LARWCQB (1997), the treatment options considered by Brown and Caldwell (1996) include only 15 pollutants on the list that defines the current condition. By restricting the number of pollutants, Brown and Caldwell (1996) ignore benefits of pollution control.

Wilchfort, Lund, and Lew (1996) propose a method to estimate benefits of treatment, a method upon which Brown and Caldwell (1996) rely. In their method, as detailed in Chapter 5 of this report, they propose a range given by an upper bound and a lower bound for concentration of each pollutant. For the treatment measures that they consider, if the baseline is outside the range they propose and if the pollution reduction does not result in a concentration within the range, then they propose omitting the pollutant from the analysis and setting any derivative benefits equal to zero. In this way, their method eliminates benefits of pollution control from the benefit estimate. Also in their method, if the baseline they use in their analysis places a pollutant below the range they propose, then they omit any benefits from controlling that pollutant. For many pollutants Brown and Caldwell (1996) analyze, their baseline is a constant value below the range they propose. This chapter shows that, to the contrary, the actual level of pollution randomly varies geographically and over time, so that the method proposed by Wilchfort, Lund, and Lew (1996) arbitrarily omits benefits of pollution control. This chapter also shows that variation in pollution run-off from CalTrans roads and highways is typically higher than the baseline established by Brown and Caldwell (1996) for most pollutants.

4. Chapter 4: Treatment Options and Pollution Reduction

The goal of a benefit-cost test is to measure the economic value of a change in environmental quality. Having established the reference or baseline condition, it is then necessary to determine the expected concentrations of the pollutants after the implementation of the appropriate treatments. Those estimates are then projected over the relevant time period such that the expected and baseline conditions could be compared in each year. Although there are numerous treatment options, the pollution reduction potential of the various treatment options should be well understood, and estimates should therefore be made with a considerable degree of certainty.

The importance of selecting the most efficient treatment option for a given situation cannot be overstated. The efficient option is that which achieves the desired result at the minimum cost. This definition is not theoretical: successful firms continually strive to improve the quality of their output while reducing production costs. Failure to do so would compromise the long term performance of the firm by eliminating the profits that would have been earned as a result of cost reductions. The same logic applies to the problem of pollution control: the analysis must make every effort to include the most efficient treatment options so that estimates will reflect the optimal results of treatment.

Selecting the treatment option may determine whether the benefits of treatment are greater than the cost. The treatment option determines treatment costs and the reduction in pollution concentrations in surface water run-off. The reduction in pollution can be subtracted from the baseline to estimate the expected level of pollution concentration in surface water run-off after treatment, and so affect the benefits from treatment.

Economies of scale occur when the average cost of treatment falls with the amount of treatment. This chapter establishes that Brown and Caldwell (1996) are aware of economies of scale in treatment options for surface water run-off. Yet, for the benefit-cost test by Brown and Caldwell (1996), the three levels of treatment they consider are for only one treatment option, the option with the least economies of scale. This chapter identifies watersheds in District 7 with potential for economies of scale, and shows that Brown and Caldwell did not select those watersheds for the study site. Within the Brown and Caldwell study site, this chapter identifies the treatment options with potential for economies of scale, options not selected by Brown and Caldwell for analysis. Finally, for the treatment options common to both studies, this chapter identifies discrepancies in treatment effectiveness between Brown and Caldwell (1996) and Wilchfort, Lund, and Lew (1996).

The treatment option Brown and Caldwell analyze for the Santa Monica Bay region is CalTrans-only roads. For the Ballona Creek watershed, Brown and Caldwell analyze CalTrans-only treatment and joint treatment of all roads. Appendix 4A reveals that Brown and Caldwell's calculation of CalTrans-only treatment results in controlling only a small fraction of total pollution. In the Ballona Creek watershed, the fraction is 46/1547 which equals less than 3% of the pollution in the surface water run-off. Since the analysis is confined to 40 out of 365 days in the year, this amount is further reduced to a small fraction of the 3%.

5. Chapter 5: Identification of Benefits

An economic valuation of the benefits of controlling surface water run-off will produce estimates that are biased downward if the analysis excludes categories of benefits. This chapter identifies contradictions between the study by Brown and Caldwell (1996) and the study by Wilchfort, Lund, and Lew (1996), showing that each study omits benefit categories contained in the other, even though the two studies both include the Ballona Creek watershed. This chapter compares the categories of benefits identified by the LARWQCD (1997) and the Santa Monica Bay Restoration Project (1994) with the benefit categories identified and included in the studies by Brown and Caldwell (1996) and Wilchfort, Lund, and Lew (1996). This chapter shows that the latter studies exclude categories of benefits.

In their study of the benefits of the Ballona Creek watershed, Wilchfort, Lund, and Lew (1996) actually count only four benefits for only forty days of the year: 1) UCLA team rowing in the mouth of Ballona Creek, 2) bicycling along the edge of Ballona Creek, 3) 200 sailboats that dock in Marina del Rey, and 4) 12 commercial vessels docked in the marina that engage in shellfishing and dinner cruises. Although they discuss many other benefits, none are part of their benefit estimate that they ultimately compare against costs. This contrasts with 14 existing and 2 potential beneficial use categories for the Ballona Creek watershed, according to the Los Angeles Regional Water Quality Control Board (LARWQCB, 1997).

In their study of the benefits of the Santa Monica Bay watershed, Brown and Caldwell (1996) actually only count one benefit for only forty days of the year: habitat. They simply calculate the distance (omitting distances along concrete lined drainage channels) of each creek from a CalTrans freeway or highway to the Santa Monica Bay. They multiply this distance times a 50 foot stretch on each side of the center line of the creek to obtain wildlife habitat [Brown and Caldwell, p. 8-22]. Although they discuss other benefits, none are part of their benefit estimate that they ultimately compare against costs. This contrasts with 20 beneficial use categories that exist for the Santa Monica Bay, according to the Los Angeles Regional Water Quality Control Board (LARWQCB, 1997).

Ballona Creek is within the Santa Monica Bay watershed. Brown and Caldwell (1996) count wildlife habitat along Ballona Creek in their computations, a benefit ignored by Wilchfort, Lund, and Lew (1996). Wilchfort, Lund, and Lew (1996) count team rowing, bicycling, sailing, and commercial vessels as benefits in their computations, benefits ignored by Brown and Caldwell (1996). These contradictions result in both studies omitting benefit categories that the other includes, biasing downward their benefit estimates.

Table 5-6 reveals a list of benefit categories that Brown and Caldwell (1996) consider as existing and potential, inconsistent with the benefits ascribed by the LARWQCB (1997). Brown and Caldwell decide not to calculate any benefit for the use of Dockweiler Beach, although the 75,000 – 600,000 people who engage in Water Contact Recreation there on a daily basis (Wilchfort, Lund, and Lew 1996: pg. 24) are much more than “potential,” the status given by Brown and Caldwell and which is inconsistent with the LARWQCB (see Table 5-6). Brown and Caldwell (1996) exclude Commercial and Sport Fishing and Shellfish Harvesting from any of the receiving waters of Ballona Creek or Malibu Creek, shown in Table 5-4, but these are common and valuable activities all along the Southern California coast, and this exclusion is inconsistent with the LARWQCB (1997, pp. 75, 103). Also shown in Table 5-4, Brown and Caldwell assume that the receiving waters from either Malibu Creek or Ballona Creek exclude Marine Habitat, or Rare-Threatened-Endangered Species, contrary to the LARWQCB (1997, pp.75, 103). The LARWQCB (1997, p.103) lists the nearshore and the offshore zones as receiving reaches of Ballona Creek. Table 5-6 shows that for Ballona Creek the LARWQCB lists Estuarine Habitat, Preservation of Biological Habitat, Migration of Aquatic Organisms, Spawning-Reproduction-Development, and Wetland Habitat as benefits, all omitted by Brown and Caldwell.

Brown and Caldwell ignore navigation, inconsistent with both the LARWQCB and with Wilchfort, Lund, and Lew, especially since Brown and Caldwell incorporate the latter report by reference.

For Ballona Creek, Brown and Caldwell ascribe only two existing beneficial uses compared to 14 existing uses identified by the LARWQCB, and compared to 12 initially identified by Wilchfort, Lund, and Lew. The latter study pares their initial list to 8 existing beneficial uses after a site visit (see Table 5-6), inconsistent with Brown and Caldwell.

Of the 20 benefit categories listed by the LARWQCB, in their final analysis comparing benefits to costs for the Santa Monica Bay watershed, Brown and Caldwell (p.8-21) only count Freshwater Habitat in their actual benefit calculation. Through similar logic that is critiqued in the chapter 6, Wilchfort, Lund, and Lew (1996) eliminate all but four benefit categories for computation of benefits for the Ballona Creek watershed: 1) UCLA team rowing in the mouth of Ballona Creek, 2) bicycling along the edge of Ballona Creek, 3) 200 sailboats that dock in Marina del Rey, and 4) 12 commercial vessels docked in the marina that engage in shellfishing and dinner cruises. The rest of the benefit categories are missing in the numerical comparison with cost.

Brown and Caldwell (p. 8-20) decide to ignore the commercial boating harmed by trash and debris that were identified by Wilchfort, Lund, and Lew, and only consider private pleasure boats. Because “there is insufficient data at present to estimate the value of shellfishing in Santa Monica Bay” (Brown and Caldwell, p.21), that aspect of commercial boats moored in the Marina at Ballona Creek is ignored. Since Brown and Caldwell determine that treatment of CalTrans facilities alone would not substantially reduce trash and debris, they decide that the value of control to private pleasure boats is not worth calculating.

The pattern of omitting benefit categories is extensive, permeating both analyses. These omissions range across the spectrum, geographically, temporally, and categorically. Here are some major benefit categories that are either omitted wholesale from both studies (Brown and Caldwell, 1996, and Wilchfort, Lund, and Lew, 1996) or major portions of the categories are omitted:

1. Geographic Categories
    a. The majority of CalTrans District 7
    b. Benefits from controlling all pollutants in the watersheds
2. Temporal Categories
    a. Year round benefits
    b. Future increases of benefits
3. Water reclamation
4. Primary and Secondary Income
    a. Dredging in LA and Long Beach Harbors, releasing heavy metals
    b. Dredging in Marina del Rey and King Harbor
    c. Regional economic impacts
5. Property values
6. Health effects
7. Recreation
    a. Contact recreation, particularly at the beach year round
    b. Non-contact recreation
    c. Fishing
    d. Boating
8. Nonuse Benefits
9. Ecosystems

6. Chapter 6: Method for Relating Changes in Pollution to Changes in Benefits

This chapter reveals how the report by Brown and Caldwell (1996) displays a number of pollutants and a list of beneficial uses in their analysis of Santa Monica Bay, and yet in their actual computations count only one beneficial use – wildlife habitat. This chapter also reveals how, in Brown and Caldwell's analysis, only one pollutant – copper – is included in the actual benefit computation for pollution control (Brown and Caldwell, Table 8.13, p.8-25).

This chapter explains how Wilchfort, Lund, and Lew (1996) are able to consider a list of beneficial uses in their analysis of Ballona Creek, and yet in their actual computations count only five beneficial uses – UCLA's team rowing in the mouth of Ballona Creek, bicycling along Ballona creek, pleasure boating from the Marina, and commercial vessels for dinner cruises and commercial vessels for shellfishing. Since Wilchfort, Lund, and Lew only consider five pollutants at the outset of their analysis, it is less surprising that only four pollutants – oil and grease, fecal coliform, lead, and debris – are included in the actual benefit computation for pollution control (Wilchfort, Lund, and Lew Tables 11 and 12, pp. 26-27).

There are six concepts key to the elimination of benefits and pollutants in the method for estimating benefits proposed and applied by Wilchfort, Lund, and Lew (1996) and applied by Brown and Caldwell (1996). Two concepts are general and four are specific.

One general concept is the selection of the pollutants and the increment of pollution reduction for the benefit computation. Normally, this is determined by the context in which particular pollution control options are considered; for examples, (i) pollution control by

CalTrans alone of just CalTrans facilities, (ii) pollution control by CalTrans of CalTrans facilities simultaneously with pollution control by other permit holders, or (iii) joint agency pollution control. A second general concept is diminishing marginal utility.

Four concepts are specific to the method by Wilchfort, Lund, and Lew, which was adopted by Brown and Caldwell: pollution thresholds, linearity of changes in benefits to changes in pollution, legal standards (unrelated to economic benefits) that determine economic benefits and confine links among specific pollutants to specific benefits, and the assumption that the current condition describing the pollution concentration is the same constant everywhere and every time, rather than randomly varying over time and geographically across water reaches.

a. The Increment of Pollution Reduction Determined by the Treatment Option

The size of pollution reduction is a basic consideration. The context in which particular pollution control options are considered includes the "water quality goals … derived from the Clean Water Act of fishable, swimmable waters and a California goal that all fresh water be a potential drinking water source" (Brown and Caldwell, p.iv). Brown and Caldwell acknowledge that the language of the permit explicitly states that water quality control efforts are "… to be evaluated by the total efforts of all the permittees, not on an individual basis" (pg. 8-5). Hence, actions by CalTrans must not be considered in isolation from other efforts to reduce pollution. Consequently, the appropriate levels of pollution reduction should be considered in the context of simultaneous or joint actions with other agencies, whichever of these two is the most cost effective.

In their comparison of the benefits and costs of pollution control for Santa Monica Bay, Brown and Caldwell (1996) evaluate the benefits and costs on an individual basis rather than the total efforts of all the permittees. Thus, their analysis violates the language of their permit, but it minimizes the reduction in pollution and so minimizes the benefit.

b. Diminishing Marginal Utility

It is standard economic analysis to apply the concept of diminishing marginal utility to the relationship between pollution reduction and increase in benefits. Diminishing marginal utility is among the most fundamental notions in economic analysis, which states that in any endeavor the largest increase in benefits is derived from the initial amounts, and incrementally less benefit is received from subsequent equal amounts.

The method proposed by Wilchfort, Lund, and Lew is inconsistent with diminishing marginal utility. Wilchfort, Lund, and Lew assume two types of pollution thresholds: the putrid threshold and the noisome threshold. Their reasoning is as follows: the initial reduction in pollution may reap no benefit if the current level of pollution is so putrid that no benefit can be obtained. For pollution reduction in between their putrid threshold and the noisome threshold, their assumption is as follows: as the resource becomes progressively cleaner, equal changes in pollutant concentration yield the same change in benefits. For pollution reduction below the noisome threshold, Wilchfort, Lund, and Lew assume that there is no benefit. Their assumption is that there is equivalency between the noisome threshold and a "pristine" environment. All three levels of pollution – above the putrid threshold, between the thresholds, and below the noisome threshold, are in opposition to the fundamental principle of diminishing marginal utility.

c. Eliminating Pollutants: Inappropriate Use of Legal Standards to Establish Economic Benefit Thresholds, and Arbitrarily Selected Constant Values for the Current Condition

Wilchfort, Lund, and Lew's method eliminates pollutants from the analysis. First, pollutants are eliminated for which the existing level is at or below the noisome threshold. Second, pollutants are eliminated if the existing level is above the putrid threshold and if the reduction in pollution is so small that the expected pollution concentration remains above the putrid threshold.

Brown and Caldwell (1996) and Wilchfort, Lund, and Lew (1996) also eliminate pollutants from the analysis in three more cases. One is if they cannot establish the pollution concentration. Two is if they cannot find an existing legal standard to establish an economic threshold. Three is if more than one pollutant in a category of pollutants falls in between the two thresholds, and the analysis can be simplified by just focusing on one pollutant, ignoring the other pollutants in that category.

Brown and Caldwell begin their analysis by considering only 29 out of 53 pollutants in CalTrans run-off. In their application of the Wilchfort, Lund, and Lew method, Brown and Caldwell next eliminated most of their 27 pollutants from the analysis after selecting among alternative legal standards that are unrelated to economic benefits for the noisome threshold, and arbitrarily picking constant values for the current condition that fall below the noisome thresholds. Next, Brown and Caldwell ignored pollutants for which they found no legal standard, irrespective of the impact on human health or the ecosystem. They additionally ignored pollutants for which they were not able to determine the current condition.

In their benefit analyses of Ballona Creek, Wilchfort, Lund, and Lew rely on Brown and Caldwell's arbitrary specification of a constant current condition, on Brown and Caldwell's selection of legal standards for economic benefit thresholds, on Brown and Caldwell's elimination of pollutants for which there was no legal standard to establish economic thresholds, on Brown and Caldwell's elimination of pollutants for which they were not able to identify the current condition, and on elimination of pollutants within a category of pollutants. Consequently, Wilchfort, Lund, and Lew only consider five pollutants at the outset of their analysis, which they pare to four.

Brown and Caldwell's constant values for the pollution concentration are arbitrary because they bear no meaningful statistical relationship to the sampled data: they consider only four observations (four storms), their numbers are not estimates of averages, nor do their numbers reflect the variation of the reported actual sampled values.

Here are seven ways in which the benefit calculations are minimized. First, Brown and Caldwell consider the 29 pollutants, and ignore the other 24 pollutants identified in CalTrans reports. Second, Wilchfort, Lund, and Lew name the lower threshold the "Unimpaired Use

Concentration," implying that the environment is pristine for pollution concentrations below this level. If it is pristine below the standards and the current condition can be found to fall in that category, then they assign zero benefit for further pollution reduction. Third, Brown and Caldwell select from among myriad alternative pollution criteria and standards, choosing the ones that are high rather than low (for example, acute toxicity instead of chronic toxicity). Fourth, Brown and Caldwell choose the current pollution concentration levels from selected samples and reports of water quality for which the concentrations are in the low end of the typical range reported in CalTrans studies. Fifth, Brown and Caldwell eliminate pollutants for which the assumed current condition is lower than the selected standards. Sixth, Brown and Caldwell eliminate from the analysis pollutants for which there are standards but for which no value is presented for the current condition, even though there are procedures for sampling and even though samples and studies exists with values for those pollutants. Seventh, Brown and Caldwell eliminate from the analysis pollutants for which no standard is presented. Then most pollutants are ignored in the calculation of the benefits of pollution control. In fact, at this stage of their analysis, the only candidates are Total Suspended Solids, Oil & Grease, Total Coliform, Fecal Coliform, Antimony, Copper, Lead, and Zinc.

Brown and Caldwell next eliminate antimony and zinc from their analysis. Brown and Caldwell do not explicitly explain why they eliminate antimony and zinc from the analysis. They also eliminate Total Suspended Solids, but add tons of debris. Brown and Caldwell (p.8-15, Table 8.4) thereby pare the analysis down to only consider Debris, Oil and Grease, Total Coliform, Fecal Coliform, Copper, and Lead.

At this point, the analyses of Wilchfort, Lund, and Lew and Brown and Caldwell slightly diverge. Wilchfort, Lund, and Lew only specify upper and lower thresholds for Debris, Oil & Grease, Fecal Coliform, and Lead; they do not explain why they ignore total coliform or copper. Brown and Caldwell only specify upper and lower thresholds for Debris, Oil & Grease, Fecal Coliform, Copper and Lead; they do not explain why they ignore total coliform.

Thresholds selected by Brown and Caldwell are not consistent with legal standards nor consistent with thresholds selected by Wilchfort, Lund, and Lew. The lower threshold for fecal coliform has been doubled from the legal standard, and that the lower thresholds for lead and copper do not match the legal standards. The upper thresholds for the effect of oil and grease on Navigation do not match when comparing the study by Brown and Caldwell to the study by Wilchfort, Lund, and Lew. Brown and Caldwell simply ignore the impacts of debris, oil and grease, and lead on recreation, while Wilchfort, Lund, and Lew do not.

Setting thresholds for economic benefits on the basis of legal or quasi-legal mandates is arbitrary and inappropriate. There is no basis in economics, public health, law, or common sense to accept the fiction that economic benefits of pollution control are zero when pollution is reduced below legal standards. Some standards are mandated strictly by health risks, while others pass a benefit-cost test. A standard that passes a benefit-cost test does not give the pollution level where benefits are zero; it may give the level where the additional benefits equal the additional costs. For the category of metals, Table 6-10 displays EPA protocols for measurement and ambient water quality criteria for acute and chronic toxicity an for human health for the following: antimony (Sb), arsenic (As), cadmium (Cd), trivalent chromium (Cr

III), hexavalent chromium (Cr IV), copper (Cu), lead (Pb), mercury (lig), nickel (Ni), selenium (Se), silver (Ag), thallium (Tl), and zinc (Zn). The standards for acute toxicity are not the same as those for chronic toxicity. In these cases there are a plethora of alternatives from which a threshold could be chosen for these pollutant, using the method by Wilchfort, Lund, and Lew. The method by Wilchfort, Lund, and Lew gives no guidance to relate these standards to economic value, and so there is no basis for selecting among the alternatives.

Some of the thresholds are simply made up. Wilchfort, Lund, and Lew admit as much.

d. Eliminating Benefits by Confining Benefits to Water Pollution Standards

Having winnowed the list of pollutants to a handful, Wilchfort, Lund, and Lew's method for benefit estimation confines the types of beneficial uses to pollutants for which a water quality standard is specified to protect a particular beneficial use. There is no basis in economic theory for this elimination of benefits. Tables 6-7 and 6-8 also highlight this assumption in the method. For example, neither study considers the impact of fecal coliform, debris, or oil and grease on habitat, nor the impact of debris on contact recreation. Wilchfort, Lund, and Lew do not consider the impact of oil and grease on shellfish.

There are 20 beneficial uses given in Table 5-6, but Table 6-3 presents legal standards that relate pollutants to only five columns that represent beneficial use impacts. The fifth column is labeled "other" but this column only has six entries. Most beneficial uses are omitted because there is no legal standard to artificially create an economic threshold. Thus, the method by Wilchfort, Lund, and Lew simply assumes that reducing most pollutants has zero economic benefit.

Of the 20 beneficial uses listed by the LARWQCB (see Table 5-7 above) for Santa Monica Bay, Brown and Caldwell omit 12 beneficial uses because they have no threshold.

e. Brown and Caldwell's Changes in Benefits from Changes in Pollution Concentration for Treating CalTrans-Only Facilities in the Santa Monica Bay Watershed

Wilchfort, Lund, and Lew's method calculates the increase in benefits due to a decrease in pollution. They propose to multiply the dollar value of the beneficial use that would exist if the environment were pristine times a benefit fraction. The numerator of the benefit fraction is the reduction of pollution concentration between the thresholds that occurs from water treatment. The denominator is the difference between the upper and lower thresholds. Therefore, the fraction is smaller if only a small amount of the storm water runoff is treated, or if the treatment reduces the pollution concentration outside the thresholds. The fraction is also smaller if the thresholds are chosen so that the difference between the thresholds is large.

Therefore, if only CalTrans sources are treated, without considering treatment of other sources of storm water run-off, then the analytical method pre-determines that the benefits will be relatively smaller. If the existing pollution concentration is selected such that it falls near the selected upper or lower bound, then it is more likely that treatment reduces pollution concentration outside the thresholds, and the benefits are smaller. Finally, if treatment reduces the pollution concentration within the thresholds, then both increasing the upper threshold or lowering the lower threshold will lower the benefits. Again, the analytical method pre-determines that the benefits will be smaller.

In order to calculate the reduction in pollution from treating CalTrans facilities alone, Brown and Caldwell distinguish between the pollution concentration from CalTrans facilities and the pollution concentration in storm water run-off to calculate the current condition. They do this in low density urban watersheds and in high density urban watersheds for four pollutants: debris, fecal coliform, lead, and copper. This is summarized in Table 6-9.

Based on the thresholds, and current and expected pollutant concentrations, Brown and Caldwell estimate the changes in benefits as a result of CalTrans storm water treatment. Brown and Caldwell find that the removal of CalTrans debris from runoff does not render the creeks and harbors useful during storm events, and the value of treatment to Navigation is therefore also zero (B&C, 1996, p.8-24). Similarly, they find that CalTrans storm water treatment would not reduce fecal coliform levels below the 5000 MPN/100mL threshold, so the value of improved water quality to Contact and Non-Contact Recreation is zero (B&C, 1996, p.8-24). According to Brown and Caldwell, only Habitat will enjoy a 4% increase in benefit value as a result of CalTrans storm water treatment since current concentrations of copper and lead are below the upper thresholds. They calculate the benefit from copper reduction and omit the calculation for lead.

f. Wilchfort, Lund, and Lew's Changes in Benefits from Changes in Pollution Concentration for the Ballona Creek Watershed

Wilchfort, Lund, and Lew present two benefit calculations for the Ballona Creek Watershed. One is the benefit of CalTrans-only treatment facilities. The second is the benefit of jointly treating the watershed at the mouth of the creek.

For both benefit calculations, Wilchfort, Lund, and Lew eliminate categories of effects of pollutants on beneficial uses. They eliminate the impact of lead on water contact recreation by establishing a threshold for lead in sediment that is higher than the selected value describing the current concentration (prior to treatment). Since lead is the "representative pollutant" in the metals category, they assume that no other metal affects water contact recreation. They eliminate the impact of fecal coliform on shell fishing by establishing a threshold that is lower than the treated water condition. Since fecal coliform is the "representative pollutant" in the biological pollutant category, they assume that no other biological pollutant affects shell fishing.

For the CalTrans only benefit calculation, Wilchfort, Lund, and Lew eliminate the impact of fecal coliform on water contact recreation and the impact of debris on navigation. Elimination of these beneficial uses are on the grounds that the pollution levels are above the putrid thresholds after treatment. Even with their method of analysis, this result should not hold for their benefit calculation of joint treatment, because joint treatment would reduce the pollution by a much greater amount to a level below their putrid threshold; but Wilchfort, Lund, and Lew do not consider any benefits in their joint treatment analysis that they eliminate by their CalTrans only analysis. As representative pollutants, they assume that no other pollutants in those categories affect those beneficial uses.

After this winnowing process, for the analysis of CalTrans only treatment, only three pollutants actually enter the benefit calculation: oil and grease, lead, and debris. Oil and grease affects pleasure sailboats, the UCLA rowing team, and bicycling. Lead affects commercial vessels that take passengers shell fishing. Debris affects bicycling. The "benefit fractions" for these beneficial uses are very small, because the pollution reduction from confining treatment to CalTrans-only is very small.

They confine benefits to the wet season. They only count the Winter months when the number of visitors are small, and only for 40 days out of the year for visits, so the benefit estimate is small.

For the joint pollution control benefit calculation, Wilchfort, Lund, and Lew's approach to benefit estimation contains three critical assumptions. First, they assume that pollution control at the mouth of Ballona Creek will not control any pollutants except those that would be controlled in the CalTrans-only analysis. Second, they assume that the only beneficial uses that will benefit from pollution control are those that were considered in the CalTrans-only analysis. Third, they assume that joint control will not reduce pollution during the dry seasons. The first two assumptions confine the analysis to the same pollutants and beneficial uses as the CalTrans-only analysis. The third assumption restricts the increase in benefits to 40 days in the year and reduces the number of people to smaller Wintertime use numbers.

Even though treatment level 3 eliminates between 95% and 100% of all pollutants, the benefit fractions for level 3 treatment are only 4% for oil and grease, 5% for lead that affects shellfish, and 10% for debris that affects non-contact water recreation. For oil and grease, and for debris, the reason is that the putrid thresholds are extremely high relative to the single numbers representing pollution concentrations prior to treatment; hence the denominator of the fraction is large. For lead, the reason is that the single number representing pollution concentration prior to treatment is just slightly above the legal standard that artifically established the noisome threshold for shellfish.

While level 3 treatment removes almost all pollutants, the only pollutants that have significant "benefit multipliers" are for the effect of fecal coliform on water contact recreation, and the effect of debris on navigation. But the only water contact recreation considered by Wilchfort, Lund, and Lew is the UCLA rowing team, so the increase in benefit is confined to a small number of beneficial users.

Moreover, eliminating debris only provides small changes in benefits to those who sail pleasure boats and to navigation by commercial vessels. The reason for these results is that Wilchfort, Lund, and Lew's method proposes two alternative means for calculating benefits when more than one pollutant affects a beneficial use. One method is to select the smallest "benefit multiplier" from among the pollutants and use it. Since oil and grease also affects pleasure boating, and the benefit multiplier for oil and grease is 4%, that small percentage – rather than the 94% multiplier for debris on navigation – is the one they propose to use. Since fecal coliform and lead also affect shellfish, and their benefit multipliers are 0% and 5% respectively, then the smallest benefit multiplier is zero, so the benefit to shell fishing is zero. The second method uses an average of the "benefit multipliers". For this method, when two out of three of the multipliers are close to zero, the average cannot be very large.

g. Multiple Pollutants Affecting One Beneficial Use

For beneficial uses that several pollutants affect, Wilchfort, Lund, and Lew use two alternative methods to select the benefit multiplier: the "Limiting Pollutant Method" (LPM) and the "Averaging Method" (AM). Neither the LPM nor the AM account for synergistic effects of multiple pollutants, nor the cumulative impact of multiple toxins, each of which may be below some threshold.

When discussing their relative merits, at first Wilchfort, Lund, and Lew state: the LPM "assumes that the benefit value of management measure is limited by the pollutant that has the most adverse impact on the beneficial use" (Wilchfort, Lund, and Lew Appendix B, p.8). One might assume that this means to use the multiplier of the pollutant that does the most damage. For example, toxins are a threat to health for water contact recreation, while turbidity affects the visual ascetics. Yet in just this type of example, Wilchfort, Lund, and Lew select the multiplier for turbidity rather than the multiplier for toxins in an example to illustrate their method

(Example A.4, p.8, Appendix B, Wilchfort, Lund, and Lew). The LPM actually means: *use the smallest from among all the pollutant multipliers that apply to a beneficial use.*

Wilchfort, Lund, and Lew do not use the LPM method for the "bottom line" calculation for comparing benefits and costs (Wilchfort, Lund, and Lew, Tables 15 and 16, pp.28, 30). Instead, they use the "Averaging Method" (AM). The AM, however, is nearly as erroneous. Chapter 6 presents Example 6.2.

Suppose that three pollutants, A, B, and C all affect a beneficial use but in unrelated ways. Further suppose that the pollution concentration of A is so high that, by itself, it would eliminate 100% of the value of the beneficial use. Further suppose that the pollution concentration of B is so low that, by itself, it would only eliminate 5% of the value of the beneficial use. Finally, suppose the analyst can identify a pollutant C that is defined as doing no damage because the noisome threshold is selected to be higher than the constant value selected to represent the pollution concentration prior to treatment. Suppose that treatment is 100% effective for all three pollutants, resulting in restoration of 100% of the value of the beneficial use.

In this example, the separate benefit fractions for pollutants A, B, and C are 100%, 5%, and 0%. The AM procedure calculates a simple average (100+5+0)/3 = 35%. Even though treatment changes the benefit from 0% to 100%, only 35% of the value of the beneficial use is permitted in the Wilchfort, Lund, and Lew AM procedure.

The reader may say, surely no method for calculating benefits would simply add pollutants to the analysis and average zeros into a benefit multiplier, lowering the number. In the Wilchfort, Lund, and Lew method, the calculation of the beneficial use of commercial vessels for joint treatment of water at the mouth of Ballona Creek does just that. In that calculation by Wilchfort, Lund, and Lew, the separate benefit fractions for fecal coliform, lead and debris are 0%, 5%, and 94%, and the average is 33%, the benefit multiplier they used for commercial vessels.

h. The Size of the Decrement Under Consideration: CalTrans Only Treatment vs. Simultaneous or Joint Treatment as the Basis for Selecting the Decrement of Pollution Concentration

Wilchfort, Lund, and Lew recognize that the benefit-cost comparison should include a joint treatment option. They perform a benefit cost calculation for joint control of pollution at the mouth of Ballona Creek. Brown and Caldwell only analyze the benefit-cost trade-off for CalTrans-Only Treatment in the Santa Monica Bay watershed.

The Maximum Extent Practicable (MEP) standard places on the storm water discharge permit applicant the responsibility to prove that any best management practices (BMPs) eliminated or not considered were indeed less effective and less efficient than the option selected. The definition of MEP requires that the selection of BMPs be a thorough and comparative effort. This view is supported and expanded upon by the language of the Los Angeles County 1996 NPDES Permit (8.1.4, pg. 8-5). It states that "… permittees are required to implement a comprehensive pollution prevention and management program [which]… consist[s] of a combination of best management practices, control techniques, system design and engineering methods" (LA Storm Water Permit 1996b, quoted in Brown and Caldwell 1996, pg. 8-5).

The marginal analysis by Brown and Caldwell is surprising since they acknowledge that they are legally obligated to consider best management practices that treat all sources of pollution, not just pollution from CalTrans sources. They also acknowledge that they are legally obligated to consider regional solutions, such as water reclamation and treatment. Brown and Caldwell acknowledge that the language of the permit explicitly states that water quality control efforts are "… to be evaluated by the total efforts of all the permittees, not on an individual basis" (pg. 8-5). It is then clear that proper usage of a maximum extent practicable standard goes well beyond the isolated efforts of a single entity and must instead be a function of the collaborative efforts of all polluters discharging in a given region. This again refers to the MEP definition and the responsibility to explore all available combinations of options on widely applied basis.

Wilchfort, Lund, and Lew use marginal analysis to estimate the benefit of pollution control from CalTrans roads and facilities only. They also marginalize the analysis by considering the incremental reduction in pollution from Level 1 treatment, then the additional incremental reduction in pollution by going from Level 1 to Level 2 treatment, then the additional incremental reduction in pollution by going from Level 2 to Level 3 treatment. Brown and Caldwell estimate that the pollution flowing into Ballona Creek from CalTrans roads and facilities is a small portion of the total pollution concentration flowing from Ballona Creek into Santa Monica Bay. This small reduction in pollution is made smaller by increments from one treatment Level to another.

Consequently, by marginally decreasing pollution only from CalTrans roads and facilities, one level at a time, most benefit from pollution control is zero: either the pollution concentration exceeds the "fully impaired threshold" or falls below the "unimpaired threshold". These thresholds result in what is technically called non-convexity.

In his undergraduate textbook, Goodstein (1995, pp.529-538) explains that "when nonconvexities are present, … marginal analysis will no longer provide a reliable guide to the efficient level of pollution control" (p.531). This is a well-known result. The non-convexity in the Wilchfort, Lund, and Lew methodology is caused by their establishment of unimpaired and fully impaired use thresholds. In essence, they assume that small amounts of pollution, below the "unimpaired threshold", are harmless, and that there is no benefit from reducing excessive pollution beyond the "fully impaired threshold" because the environment has no use value if polluted that much. The non-convexity assumption is shown in Figure 6-2. Figure 6-2 corresponds with Figure T1.1C of Goodstein (1995).

The method proposed by Wilchfort, Lund, and Lew cannot be used to correctly estimate small changes in pollution unless it drops the assumptions of thresholds, or the incremental analysis of benefits and costs. As Goodstein (1995) wrote, "when nonconvexities are present, … marginal analysis will no longer provide a reliable guide to the efficient level of pollution control" (p.531).

The criticism of this section also applies to Brown and Caldwell (1996). They apply incremental analysis of treating only CalTrans runoff to Santa Monica Bay, at increments of Level 1 treatment, the incremental difference between Level 1 and Level 2 treatment, and the incremental difference between Level 2 and Level 3 treatment. They use the non-convexity approach of Wilchfort, Lund, and Lew (1996), based upon "unimpaired thresholds" and "fully impaired thresholds". They also fail to consider a regional treatment option, a source of non-convexity in costs with a level of benefits that they do not estimate. Because their analysis combines non-convexity in benefits with incremental analysis of CalTrans pollution control only, and incremental treatment levels, their analysis "will no longer provide a reliable guide to the efficient level of pollution control" (Goodstein, 1995).

7. Chapter 7: Assigning of Dollar Values to Benefits and Literature Review

This chapter establishes that the method for estimating the benefit of reducing pollution in surface water run-off proposed by Wilchfort, Lund, and Lew (1996) and adopted by Brown and Caldwell (1996) is not an established method that is accepted in the peer review literature. It also establishes that existing literature includes methods to estimate benefit categories omitted by these two studies (Brown and Caldwell, 1996, and Wilchfort, Lund, and Lew, 1996). This chapter reviews estimates of benefits that could be transferred and applied to the study areas of these two studies. Finally, this chapter reviews methods and complementary data applicable to the study areas that could be used to estimate benefits omitted by the two studies.

A review of the literature establishes:

- The method proposed by Wilchfort, Lund, and Lew (1996), relied upon by Brown and Caldwell (1996), does not exist in the peer-reviewed literature.
- Established methods do exist to value recreational use benefits of improving water quality.
- A recently developed method and its variants (contingent valuation and contingent ranking) can be used to value ecosystems and non-use benefits of improved water quality.
- The contingent valuation method took several decades to develop and mature in the peer-review literature, culminating in acceptance by a panel of eminent economists, including Nobel Laureates, and continues to be refined in the literature today.
- Use of contingent valuation in legal proceedings has passed legal tests, including formal acceptance by the courts and acceptance by several government agencies in adopted regulations.
- The method proposed by Wilchfort, Lund, and Lew should not be relied upon. The method is not accepted by economists as a valid method of estimating benefits.

In subsection A, this chapter begins with a brief review of the literature by economists of methods for estimating the benefits of environmental quality. In subsections B through I estimates are presented from the literature of values of beneficial uses that could be the basis for acceptable estimates of the benefits of reducing storm drain pollution in CalTrans District 7. Subsections J and K present some problems of the benefit estimation by Wilchfort, Lund, and Lew (1996) and Brown and Caldwell (1996), in addition to those presented in earlier chapters (particularly Chapter 6) including benefits they omit and suggestions for estimating these benefits.

Literature Review

In Chapter 7, this report summarizes three literature surveys and over 50 more peer reviewed publications, many of which summarize numerous published results. One literature survey is a 65 page article published in the *Survey of Economic Literature* that surveys the literature on environmental economics. Another survey is an 85 page report to the U.S. Environmental Protection Agency that reviews the empirical evidence of the value of marine recreation. The third survey is the testimony presented on behalf of the State of California on the economic benefits of water quality in the case of the American Trader oil spill off Huntington Beach.

A literature review identifies four approaches for valuing environmental quality: the use of averting behavior, weak complements, hedonic market methods, and contingent valuation. The first three methods are indirect market methods (sometimes called revealed preference methods) in that they use information about market decisions to avoid damage from pollution (weak substitutes), or market decisions to buy complements to environmental quality (trips for recreation, for example). The earliest of these approaches was developed in the 1950's, and these approaches have been used to value the recreational benefits of improved water quality since 1978, with literally hundreds of peer review articles and books. The method proposed by Wilchfort, Lund, and Lew is not among these four approaches.

The most recently developed method has been refined for over two decades in the peer review literature, reviewed and accepted by government agencies, reviewed by a panel of distinguished economists, and accepted by the courts. The method proposed by Wilchfort, Lund, and Lew has only been reviewed once, and this is that review.

In 1989 the District of Columbia Court of Appeal (Ohio v. The United States Department of Interior) accepted the inclusion of nonuse value as part of the benefits to be measured under *CERCLA* (*Comprehensive Environmental Response, Compensation, and Liability Act of 1980,* 42 U.S.C. 9601-9675). Under the Oil Pollution Act of 1990, NOAA (1994) issued regulations accepting CV as a method to measure the benefits from environmental amenities. The contingent valuation (CV) method is used to estimate nonuse values.

A panel of experts convened by NOAA (1994), including two Nobel Laureates, Kenneth Arrow and Robert Solow (Arrow, et al., 1993), designed protocols for Contingent Valuation (CV) studies that are strict enough to be able to replicate results, "estimates reliable enough to be the starting point of a judicial process of damage assessment, including lost passive use values" (Arrow et al., 1993).

The literature review establishes categories of benefits that are omitted by Brown and Caldwell (1996) and Wilchfort, Lund, and Lew (1996). General categories of benefits include secondary income, property values, recreation, nonuse values, and values of ecosystems. First, some comments apply to all the categories of benefits.

a. Year-Round Benefits

Wilchfort, Lund, and Lew (1996) and Brown and Caldwell (1996) assume that benefits from pollution control occur in 40 out of 365 days, and assign zero benefits to the other 325 days. In this review of the literature, no other study has done so.

b. Water Reclamation

Wilchfort, Lund, and Lew discard water reclamation as an option. Brown and Caldwell ignore it. Wilchfort, Lund, and Lew ignore the possible beneficial use of reclaimed water on specious grounds. They omit the value of additional water.

c. Secondary Economic Effects

Pollution generally makes an area less desirable. There will be secondary economic effects on local businesses whose success is closely tied to the quality of the area. The demand for recreation is a function of the environmental quality. Visits to the beach, harbor, and wetlands, are a function of the level of pollution. These visits bring business to the local economy, and the reduction of visits from pollution is harmful to the local economy. Wilchfort, Lund, and Lew (1996) and Brown and Caldwell (1996) excluded an estimate of the secondary economic effects.

d. Property Values

Beneficial uses such as cycling, fishing and boating are adversely affected by pollution, and so too are property values in the surrounding areas. The number of homes and commercial establishments near the Ballona Wetlands (and other areas impacted by pollution), the distance to the wetlands, and the present property values could be ascertained. The increase in property values from improving the wetlands and other impacted areas could be inferred from the literature if site specific estimates are deemed too expensive. Wilchfort, Lund, and Lew (1996) and Brown and Caldwell (1996) exclude the impact of changes in property values.

e. Health Effects

Ill-health effects avoided are additional benefits of pollution control. The level of pollution affects the value per hour of recreational experiences, and the frequency and duration of visits, all of which affect the benefit of recreational use. In addition, if we have ill effects from exposure to pollution, ill effects that can be avoided or reduced by pollution reduction, those are additional benefits. Haile, et al.(1996) estimate the frequency of illnesses that occur to swimmers. The amount that we are willing to pay to avoid the symptoms of ill-health is a topic covered in the literature (Hall et al., 1992 and references therein). Wilchfort, Lund, and Lew (1996) and Brown and Caldwell (1996) omit the economic value of ill-health effects avoided by pollution reduction.

f. Recreation Demand

One error in the method proposed for benefit estimation by Wilchfort, Lund, and Lew is that the demand for recreation visits does not depend on the level of pollution. A second error is their assumption that the marginal utility of benefits is linear. A third error is their transfer of benefit estimates between dissimilar recreation activities and dissimilar locations. A fourth error is the omission of categories of recreation benefits. The methods in the literature do not make these errors.

(1) Approach of Wilchfort, Lund, and Lew

Wilchfort, Lund, and Lew (1996) derive the marginal benefit of improvements in water quality and compare them with the marginal costs. Their first step was to list recreation activities and define the pollutants which affect those activities. For each benefit, they select pollution thresholds at which beneficial uses would be “unimpaired” and “fully impaired”. For small reductions in pollution, they calculate a “benefit multiplier” that is a fraction less than one. For a pollution treatment option, pollution falls from the present level to a marginally cleaner level. The fraction used as a benefit multiplier equals the portion of pollution reduction that falls within the “unimpaired and “fully impaired” thresholds. They multiply this fraction times their estimate of “unimpaired” recreation benefits. Thus, they assume a linear relationship between pollution emissions and the percentage of unimpaired beneficial value available (benefit multiplier).

Wilchfort, Lund, and Lew (1996) derive multipliers for each pollutant. When, in their judgment, a form of recreation is affected by more than one pollutant, they propose an average to derive a composite multiplier for the type of recreation.

Wilchfort, Lund, and Lew (1996) refer to some literature to justify an hourly benefit of recreation. They multiply their hourly benefit times their estimate of the number of hours of recreation in a visit to obtain the benefit of a visit, and multiply this times the number of visits during the 40 rainy days in the year:

Benefit/Hour x Hours/Visit x #Visits/40 storm days = Total “Unimpaired” Benefits

Wilchfort, Lund, and Lew (1996) multiply their estimate of the unimpaired beneficial use value times the fractional benefit multiplier to estimate the marginal benefit from the incremental changes in water quality:

Marginal Benefit = “Unimpaired Benefit x fractional benefit multiplier

This multiplication is where Wilchfort, Lund, and Lew implicitly assume constant marginal utility of recreation.

As pointed out in the previous chapter, for most recreation categories neither Brown and Caldwell (1996) nor Wilchfort, Lund, and Lew (1996) have a benefit multiplier (for example, if they assume no effect from pollutants); in those cases they set the multiplier equal to zero and ignore the benefit. For those categories of recreation where the reduction in pollutants falls outside the thresholds, the fractional benefit multiplier is set to zero and those benefits are ignored. For any remaining categories of recreation, the size of the fractional multiplier reduces their estimate of 40 storm days of beneficial losses to a fraction of their estimated "unimpaired" benefits.

Compare the approach by Wilchfort, Lund, and Lew (1996) to the calculations by Hanemann (1997). Hanemann identifies three forms of losses to recreators due to pollution: (i) losses from trips not taken, (ii) losses from trips taken to other, less desirable sites, and (iii) losses from trips taken to the site, but with diminished value because of the pollution. Wilchfort, Lund, and Lew's method at best incorrectly accounts only for the third item in Hanemann's list of benefits.

(2) Number of Visits Depends on the Amount of Pollution

One of the assumptions by Wilchfort, Lund, and Lew (1996) is that the number of visits to a recreation site is independent of the amount of pollution. This assumption is inconsistent with the literature.

In calculating the unimpaired benefit value, it is essential to understand that the quantity demanded of beneficial uses is a function of the level of pollution. A cleaner area will attract more people, thereby increasing the number of visits, and therefore the total benefit value. This point is illustrated in Figure 2 above, a basic point in the literature survey by Cropper and Oates (1992).

Since the quantity demanded for recreation depends on the pollution concentration, pollution emissions can affect the use. For their method, Wilchfort, Lund, and Lew (1996) state in Appendix B that incorrectly using the impaired benefit instead of the unimpaired benefit will bias their benefit estimates downward. But that is precisely what they do since they assume that the number of visits and hours per visit are invariant with the level of pollution.

(3) Diminishing Marginal Utility of Recreation Benefits

An implicit assumption of the method by Wilchfort, Lund, and Lew (1996) is constant marginal utility, an assumption inconsistent with economic analysis. For example, Parsons and Kealy's (1995) model assumes diminishing marginal utility: net utility and the marginal utility of the recreation dollar (a) diminish as the number of trips taken (T) increases.

(4) Benefit Transfer

Wilchfort, Lund, and Lew (1996) value four beneficial uses of Ballona Creek and its reaches. Their terminology and the actual use are presented in Table 7.15, as well as the value per unit of recreation which they state is from a literature review, and a value per unit of recreation they call the "Upper Bound" which they state is a "conservative" number.

In Appendix B, however, Wilchfort, Lund, and Lew (1996) provide a reason for using the "upper bound," to avoid an error that their approach may cause. On page 3 of Appendix B, they acknowledge that their estimates could be 75% lower than the those that are internally consistent with their method, unless the use value is adjusted upward to account for the "unimpaired value". If that is so, the upward adjustment may not be "conservative".

In Appendix C, Wilchfort, Lund, and Lew (1996) distinguish between the willingness-to-pay (WTP) and consumer surplus (CS). They refer to the WTP as the total value under the demand curve, while the CS is the WTP minus the cost of recreation, typically parking and other user fees but omitting travel cost. They call the cost of recreation "the market clearing price (MCP)", which they arbitrarily set equal to 55% or 45% of the *average* WTP, depending on the recreational activity. The *average* WTP is the WTP divided by a the number of recreation visitors. The *average* CS is simply the *average* WTP times .55 (or .45). They use benefit numbers from the Forest Service Handbook, and divide by 12 hours to get an hourly value. They could get lower values if they divided by, say, 16 hours, or higher hourly values by dividing by 8 hours/day. Their report states, "A RVD is defined as 12 hours of a recreational activity" (Appendix C, p.2). They do not state who defined a RVD. They state that they use the *average* WTP rather than the lower *average* CS because they want to be conservative, and because the Forest Service percentages of 45% or 55% may not be accurate (Appendix C, p.3).

In order to consider whether the values transferred from forest service studies to marine recreation by Wilchfort, Lund, and Lew are reasonable, note that the WTP must be larger than the cost of recreation, since the difference must be positive or the consumer would not engage in the recreation. That is, the consumer surplus can not be negative. Consider the value of pleasure boating which Wilchfort, Lund, and Lew believe equals $1.90/hour. One telephone call provided an estimate of the cost of a dock from one of the yacht clubs at Marina del Rey. Guest docks cost $0.50/foot-day, and the median boat is 33 feet, for a total of $16.50/day. Assuming the vessel costs $100,000, lasts for 20 years, and the interest rate is 7%, then the daily capital cost is $25.86. Add a maintenance and repair cost, plus a travel demand cost, equal to 50% of the capital cost, and sum to get $55.29/day. The weekly cost is $387, a cost that must be lower than the weekly WTP. At $1.90/hour, 6 people per vessel, 8 hours of recreation per trip, and three trips per week, the weekly WTP equals $274, a clearly inconsistent result. From this comparison, the value for boating presented by Wilchfort, Lund, and Lew, from forest service studies of boating in mountain lakes, is not representative of the value of ocean marina recreation in Southern California.

For further comparison, Wilchfort, Lund, and Lew base their value of boating on old forest service numbers which they report in their Table 2, Appendix C, p. 4, giving the WTP for a day of recreation in 1989 $ equal to $18 for non-motorized boating and $13 per person-day for motorized boating. Compared to the values in Tables 7.8 and 7.9, Wilchfort, Lund, and Lew have underestimated the value of pleasure boating. Based upon the estimate by Hanemann (1997) of $87/person-day, Wilchfort, Lund, and Lew (1996) have under-estimated the value by five hundred percent. Hanemann's (1994, 1996, 1997) estimates were presented on behalf of the State of California in the *American Trader* Oil Spill case.

(5) Omitted Categories of Impacted Recreation Demand

The analysis by Wilchfort, Lund, and Lew (1996) limits benefits to four recreational activities, with benefits adversely affected by only five pollutants. Motor boats and sail boats in Marina del Rey are adversely affected by debris, and oil and grease. Team rowing at the mouth of Ballona Creek is affected by oil and grease, fecal coliform, and lead. Bicycling along Ballona Creek is affected visually by debris, and oil and grease floating in the creek. Twelve commercial boats docked in the Marina that take visitors on dinner cruises, and sport fishers on day trips, are adversely affected by debris that closes the Marina and by shell fish with lead and fecal coliform.

For any method of pollution control, all the benefits of pollution control need to be considered when comparing benefits to costs, not just a subset of benefits. Omitted recreation benefits include year-round benefits, beach visits without water contact, water contact beach visits such as surfing, bird and wildlife viewing, shoreline fishing, and boating (including avoiding closure of Marina del Rey due to polluted silt). Other benefits include higher property values for property adjacent to creeks and wetlands, secondary economic effects, reduced ill-health effects from water contact recreation in the Santa Monica Bay, and cleaner ecosystems with benefits to fisheries, aquatic and wildlife habitat, nonuse values, and the value of reclaimed water.

g. Nonuse Values

The method proposed by Wilchfort, Lund, and Lew (1996), and relied upon by Brown and Caldwell (1996), does not permit the calculation of benefits from non-use values. Consequently, both studies omit all benefits related to non-use values, causing the benefit estimates to be biased downward.

h. Brown and Caldwell's Valuation of Changes in Benefits

Having eliminated from their analysis the vast majority of all available or potential benefits, the change in benefit value is easy to calculate. Based upon the method of Wilchfort, Lund, and Lew (1996), Brown and Caldwell (1996) determined that of all potential benefits, the only benefit category that would benefit from pollution control is riparian habitat because the concentrations of lead and copper were in between the "unimpaired" and "fully impaired" thresholds. Brown and Caldwell assume that the benefit of pollution reduction to all other categories zero.

Brown and Caldwell value freshwater habitats at $395,000 per acre based on wetland creation projects that CalTrans has funded in the past (Brown and Caldwell 1996: pg. 8-21). Brown and Caldwell (1996) further estimate that the total acreage of riparian habitats in the

Santa Monica Bay is 361.7 acres, and that the total value is therefore $143,000,000. Brown and Caldwell use a 4% discount rate for 20 years to calculate the annual benefit of freshwater habitats at $10,500,000.

Brown and Caldwell further estimated that Level 3 treatment of CalTrans runoff would improve benefits by a total of 4%. They therefore estimated that to total annual change in benefits due to improved storm water runoff quality is $420,000 (Brown and Caldwell 1996: pg. 8-25). They compare that figure to their $44,000,000 annual cost estimate for Level 3 treatment to determine that costs outweigh benefits by a factor of 105 (pg. 8-25,26).

The $395,000 per acre value of freshwater habitat used by Brown and Caldwell, which they convert at 4% for 20 years, gives an annual value equal to $29,065 per acre. This compares with the medium annual value for California wetlands of $21,933 per acre in Table 7.14 from Allen, Cunningham, Greenwood, and Rosenthal (1992). However, land does not have to be replaced every 20 years. On an annual basis at 4% with an infinite time horizon, Brown and Caldwell's estimate equals $15,800 per year. This is somewhat low compared to the medium value for California wetlands of $21,933 given by Allen, Cunningham, Greenwood, and Rosenthal (1992), and it is rather low if the higher value in Table 7.14 ($50,475) is applicable for Southern California. In magnitude, a more serious error is the acreage used by Brown and Caldwell, omitting the Ballona wetlands, lagoons, and marshes in Santa Monica Bay.

C. Concluding Remarks

A pattern emerges for the studies by Brown and Caldwell (1996) and Wilchfort, Lund, and Lew (1996) of omitting benefit categories. These omissions permeate their approach to benefit-cost analysis and are the object of their proposed method for estimating benefits.

The geographic and temporal scope the their analyses omits benefits, and inflates costs per unit of treatment. They leave out receiving reaches of the watersheds in their study areas, omitting benefits. They only account for benefits in 40 out of the 365 day year. They fail to account for changes in benefits over time as population and the economy grow.

The CalTrans-only treatment option ensures that only minimal improvement will result for pollution concentration. In their comparison of the benefits and costs of pollution control for Santa Monica Bay, Brown and Caldwell (1996) evaluate the benefits and costs of CalTrans-only treatment rather than joint treatment by all the permittees. Thus, their analysis violates the language of their permit.

The benefit estimate by Brown and Caldwell is unreliable. They use the method by Wilchfort, Lund, and Lew which omits nonuse values and most benefit values unrelated to recreation. Their method eliminates most categories of recreation.

The method proposed by Wilchfort, Lund, and Lew, adopted by Brown and Caldwell, and applied by both groups, is not appropriate for analyzing the increase in economic benefits from controlling water pollution. The method is baseless in both economic theory and econometric theory. It requires arbitrary assumptions for thresholds. It leads to the omission of harmful pollutants from the analysis. It requires the omission of beneficial uses from the analysis. It ignores the variation in pollution concentration over time and watershed. It requires arbitrary choices for computation of benefits – the selection of the benefit multiplier for a beneficial use affected by multiple pollutants.

One artifice upon which the Wilchfort, Lund, and Lew method depends is the thresholds, both upper and lower, for circumscribing the benefits of pollution control. It is the thresholds that determine the benefit multiplier, a fraction used by the method to calculate the benefit of pollution control. It is the thresholds, or lack thereof, that cause omission of harmful pollutants from the analysis. It is the threshold artifice that causes omission of valuable beneficial uses. It is the threshold artifice that results in a procedure requiring arbitrary choices for benefit computation. It is the threshold artifice that is incompatible with the economic concept of diminishing marginal utility. It is the threshold in combination with incrementally small, CalTrans-only treatment that results in non-convexity, and so their “marginal analysis will no longer provide a reliable guide to the efficient level of pollution control” (Goodstein, 1995 p.531).   The thresholds determine economic benefit in the Wilchfort, Lund, and Lew method, but they are arbitrary and have no basis in economic valuation.

Their conclusion is that the costs outweigh the benefits of pollution control. Their conclusion hinges on having a low benefit estimate (by ignoring benefits), a high cost estimate (by only considering the most expensive control measures with no economies of scale or scope) and by confining their analysis to an insignificant reduction in pollution that is ineffective in providing benefits. Their conclusion relies on a method for benefit-cost analysis that does not exist in the peer-reviewed literature.

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