8.0 COST TO BENEFIT ANALYSIS

A cost-to-benefit analysis (CBA) is often used to evaluate the desirability of a given action or intervention. CBAs use a monetary valuation of costs and benefits, which are then expressed as a ratio. This allows the many impacts of an invasive species, such as *Arundo*, to be synthesized into a common measure, namely dollars. The results can then be used to show how much benefit is obtained by removing the species and where the most substantial benefits accrue. This in turn could help focus control efforts on watersheds or sites with the greatest potential benefit.

Multiple CBAs have examined the potential net economic benefit of programs to control *Arundo*. A detailed examination of benefits related to water savings on the Rio Grande River in Texas found a net benefit four to eight times greater than the cost (Seawright 2009). Broader CBAs covering multiple factors on watersheds within California have found benefit to cost ratios of 3.9:1 for the Santa Clara (Swezey 2008) and 1.1:1 for the Santa Margarita (Hastings et al. 1998). These CBAs were far less intensive analyses compared to the Seawright study. All CBAs for *Arundo* that could be found showed a positive benefit to cost ratio.

Completing a CBA for *Arundo* control is more straightforward than many that are completed for other types of environmental programs. This is due to reasonably well-defined impacts (potential benefits when *Arundo* is controlled) and applicable cost valuations. Impacts from *Arundo* within the study area have been quantified in this report using the mapped spatial distribution of *Arundo*. This information is used in this CBA, which applies to the entire study area. Cost and benefits are generated for both the peak *Arundo* distribution and current infestation level (which reflects control work over the past 15 years). A ten-year evaluation period was selected as many impacts are periodic in nature and control programs typically take many years to implement. This CBA is a rudimentary analysis and was not completed by an economist. Many complexities were excluded from the analysis including discounting and depreciation over time. As both the benefits and the costs are accrued on a similar timeline, this simplification is not likely to adversely affect the analysis. Also, unlike other CBA studies (such as Seawright 2009), this CBA did not project future increases in acreage of *Arundo* (increases the valuation of benefits in the future).

For this CBA, the costs of controlling *Arundo* will be evaluated, and then the benefits will be presented. This includes an analysis for each benefit (impact) class to clearly outline what approach was used in determining valuations. Results are then presented as a Benefit to Cost ratio to determine the net benefit or cost of controlling *Arundo* within the study area. The higher the benefit is in relation to the cost, the better the economic justification for the action.

8.1 Cost

Generating the cost of controlling *Arundo* for watersheds within the study area is straightforward. The spatial data set gives acreage for *Arundo* within each watershed, and therefore a good estimate of cost per acre for control is all that is needed. Over $70 million have already been spent controlling *Arundo* within the study area over the past 15 years. The approximate amount of money spent treating *Arundo* on each watershed is known as most programs share this information in news updates, proposals and other outreach material. For each watershed treated, acreage and cost of work completed is given in Table 8-1. This data is based on the author's knowledge of federal, state, and local funding of implementation programs, as well as information published by watershed programs. The average cost is $25,000 per acre of *Arundo* controlled. This is a strongly supported valuation based on over fifty projects within nine watersheds that have large implementation programs. This cost is subdivided into $5,000 for management and $20,000 for implementation, based on the author's knowledge of typical cost subdivisions in proposals and reports. Program management costs are high (management of

contractors, right of entry agreements, permitting, etc.) as are implementation costs (treatment, biomass reduction, re-vegetation, etc.). It is not surprising that *Arundo* control is an expensive undertaking given that *Arundo* stands have high biomass per acre, are difficult to control, and exist in sensitive habitat that is highly regulated. *Arundo* is also distributed across the landscape making program implementation complex and management intensive.

It should be noted that control costs vary substantially between watersheds and projects. This can be attributed to different treatment approaches, how biomass is dealt with, efficiency, and if re-vegetation is included in the project. The $25,000 average cost per acre for control is a well-supported cost estimate for watersheds taken as a whole, or for larger implementation projects. This estimate should not necessarily be used for site-specific projects, particularly if they are small.

The total cost of controlling all *Arundo* at the peak of its acreage would have been $196 million for 7,859 net acres (Table 8-2). A significant amount of control has already occurred, and the current cost of controlling *Arundo* at current distribution levels is $124 million for 4,997 net acres.

Table 8-1. Existing program costs used to generate cost basis for *Arundo* control by watershed within the study area.

Watershed	Treated net acres	Expenditure	Cost per acre
Calleguas	1.4	-	-
Carlsbad	98.7	1,500,000	15,201
Estero Bay	1.2	-	-
Los Angeles River	16.3	250,000	15,379
Otay	-	-	-
Pajaro River	-	-	-
Penasquitos	2.2	-	-
Pueblo San Diego	0.0	-	-
Salinas	106.4	500,000	4,700
San Diego	56.2	1,000,000	17,798
San Dieguito	89.8	1,500,000	16,701
San Gabriel River	0.0	-	-
San Juan	13.1	250,000	19,025
San Luis Rey	612.4	7,500,000	12,246
Santa Ana	1006.9	40,000,000	39,724
Santa Clara	0.3	-	-
Santa Margarita	684.7	10,000,000	14,605
Santa Monica Bay	0.3	-	-
Santa Ynez	-	-	-
South Coast	7.8	-	-
Sweetwater	5.7	-	-
Tijuana	41.1	1,500,000	36,496
Ventura River	117.4	7,500,000	63,909
TOTALS:	**2861.9**	**$71,500,000**	**$24,983**

Table 8-2. Estimated control costs by watershed within the study area for peak *Arundo* levels and current *Arundo* levels.

Watershed	PEAK Net Acres	Cost peak distribution			CURRENT Net Acres	Cost current infestation		
		Management: 5k	Implementation: 20k	Total		Management: 5k	Implementation: 20k	Total
Calleguas	229	1,145,750	4,583,000	5,728,750	228	1,138,539	4,554,155	5,692,693
Carlsbad	148	739,472	2,957,889	3,697,362	49	246,088	984,352	1,230,440
Estero Bay	10	48,828	195,310	244,138	9	42,953	171,811	214,764
Los Angeles	131	656,886	2,627,543	3,284,429	115	575,608	2,302,431	2,878,039
Otay	19	92,945	371,781	464,726	19	92,945	371,781	464,726
Pajaro River	8	40,681	162,723	203,404	8	40,681	162,723	203,404
Penasquitos	24	117,737	470,947	588,683	21	106,860	427,440	534,300
Pueblo S.Diego	15	75,009	300,035	375,043	15	74,834	299,336	374,170
Salinas	1,332	6,658,544	26,634,177	33,292,721	1,225	6,126,663	24,506,651	30,633,314
San Diego	149	747,328	2,989,310	3,736,638	93	466,390	1,865,559	2,331,949
San Dieguito	175	874,894	3,499,577	4,374,471	85	425,825	1,703,299	2,129,124
San Gabriel	44	221,535	886,141	1,107,677	44	221,465	885,858	1,107,323
San Juan	173	867,083	3,468,333	4,335,416	160	801,380	3,205,519	4,006,899
San Luis Rey	684	3,419,392	13,677,570	17,096,962	71	357,237	1,428,946	1,786,183
Santa Ana	2,534	12,668,913	50,675,651	63,344,563	1,527	7,634,222	30,536,887	38,171,109
Santa Clara	1,019	5,093,858	20,375,431	25,469,289	1,018	5,092,328	20,369,313	25,461,641
Santa Margarita	689	3,444,463	13,777,850	17,222,313	4	20,972	83,890	104,862
Santa Monica	18	92,430	369,722	462,152	18	90,964	363,857	454,821
Santa Ynez	6	30,104	120,414	150,518	6	30,104	120,414	150,518
South Coast	30	149,075	596,300	745,375	22	110,003	440,014	550,017
Sweetwater	42	208,866	835,464	1,044,330	36	180,474	721,897	902,371
Tijuana	131	653,115	2,612,459	3,265,574	90	447,615	1,790,459	2,238,074
Ventura River	250	1,249,462	4,997,848	6,247,311	133	662,691	2,650,762	3,313,453
TOTALS:	**7,859**	**$39,296,369**	**$157,185,475**	**$196,481,844**	**$4,997**	**$24,986,839**	**$99,947,355**	**$124,934,194**

8.2 Benefit

The CBA included six *Arundo* impact classes. Each of these impacts is a 'benefit' when the agent causing the impact (*Arundo*) is removed. The six classes are: fire, water use, sediment trapping, flood damage, habitat enhancement, and beach debris.

8.2.1 Reduced Fire Impacts (Benefit)

Benefits related to reduced fire impacts resulting from *Arundo* control are presented in Table 8-3. This information is generated from data presented in Chapter 6 on fires that were initiated in *Arundo* stands, as well as wildfire events that burned *Arundo*. *Arundo*-initiated fires have costs associated with fire suppression (Table 8-3). A conservative fire response and suppression cost of $50,000 per event was used in generating cost estimates. The number of events over a ten-year period was based on data for the San Luis Rey watershed. This was then extrapolated to all watersheds based on their acreage of *Arundo*. Fire suppression costs are related to the number of units responding, work hours spent suppressing the fire, equipment costs, and other support. Fires usually involve multiple units that frequently use air suppression and often have fire lines cut by crews and/or mechanized equipment. The impacts from the fire suppression activities indicate the level of effort exerted during the action (suppression disturbance impacts are outlined in Chapter 6). *Arundo*-initiated fire impacts to habitat are also included in the cost estimate. The value of burned *Arundo* riparian habitat is priced lower ($20,000 per acre) then the valuation of un-invaded riparian habitat that burns ($80,000 per acre). These per acre cost valuations are based on mitigation costs associated with restoring riparian habitat, excluding easements and land purchase. Both the actual fire acreage and fire suppression acreage are aggregated in the cost estimate.

Arundo-initiated fires were estimated to generate $74.6 million of impacts over 10 years at peak *Arundo* distribution, and $38.8 million over 10 years at current *Arundo* levels (Table 8-3).

Wildfires represent a potentially open-ended impact class in terms of cost. As discussed in Chapter 6, *Arundo* stands may be conveying fires across the landscape, linking upland areas and spreading fire into urbanized areas. This seems to have occurred in Santa Clara, where a smaller 8,474-acre fire spread across the river via *Arundo* stands to the southern mountain range where it burned 107,560 acres. Other fires such as the Freeway Complex fire in Orange/Riverside County and western portions of the Witch Fire in San Diego County may also have had increased fire conveyance as the fires burned through riparian zones containing *Arundo* surrounded by urbanized areas. Impact costs were hundreds of millions of dollars with large losses to both habitat and developed areas. These landscape-level wildfire costs are too complicated to include in this CBA, but they clearly constitute a significant unmeasured cost that should be partially applied to *Arundo*. Further documentation needs to occur to more clearly define the role *Arundo* is having in wildland fires.

Wildfires can burn riparian habitat, particularly in firestorm/Santa Ana type events. *Arundo*-invaded habitat burns during these events along with un-invaded habitat. The *Arundo*-invaded areas burn much hotter than native vegetation due to the large amount of biomass per acre and the high levels of fuel per unit of biomass (Chapter 6). This results in more intense and complete fires that have a greater impact on the habitat. Post-fire recovery of *Arundo* stands is rapid, typically resulting in further domination of *Arundo* in areas that have burned (Ambrose 2007). A valuation of *Arundo's* degradation of habitat during wildfire events was valued at $2,500 per acre of burned *Arundo*-invaded habitat. This is an

extremely conservative valuation of the impacts to habitat, and it specifically excludes valuation of the fire conveyance impacts that *Arundo* has during wildfire events.

Wildfires that burn *Arundo* stands were estimated to generate $17.6 million of impacts over 10 years at peak *Arundo* distribution and $10.4 million over 10 years at current *Arundo* levels (Table 8-3).

8.2.2 Reduced Water Use (Benefit)

Water use of *Arundo*-invaded habitat was estimated in Section 4.2. Specific adjustments were made for replacement vegetation. Water use and net water savings are exceedingly difficult to validate in field studies, but it seems clear from the high productivity of *Arundo* (i.e. the very high stand biomass, the high leaf area recorded in studies, and the high water use of C_3 plants in general) that it does indeed have substantially higher water use than native vegetation and/or open areas that would exist in post-control riverine sites. The calculated water savings generated are significant (Section 4.2). It is important to note that most of the areas where *Arundo* is present within the study area have water available throughout the year. Many watersheds have significant amounts of imported water that generate these year-round flows or, at a minimum, make water tables high enough to support *Arundo* throughout the growing season.

Putting a valuation on water 'saved' after *Arundo* removal is complicated. In a more comprehensive study, this value would vary by watershed and be based on the specific benefit that the saved water is generating. One key benefit may be the potential for an increase in groundwater recharge. This may benefit domestic use (Santa Ana, Santa Margarita) or heavy agricultural use (Salinas, Santa Clara) of groundwater in a system. For those watersheds (San Luis Rey, San Diego) that have only moderate use of groundwater, the focus may turn to other potential benefits. An increase of water in the riverine system can also benefit habitat and recreation. Longer baseline flows can be critical to several endangered species, particularly on systems with high levels of water management (dams and reservoirs). All of these benefits could be priced out at different rates. For this analysis, a single low value of $50 per acre-foot (ac-ft) of water was used in calculating benefit of water savings. This is a conservative valuation, particularly for southern California. A valuation of $50 per ac-ft of water was the lower end value in the Rio Grande *Arundo* water use CBA study, with the higher end coming in at $200 per ac-ft (Seawright 2009). Valuations for domestic water use are $527 per ac-ft (Metropolitan Water District) and for agricultural water range from $70 (Coachilla) to $482 per ac-ft (MWD). Much of the water is priced at highly subsidized rates. Nearly all watersheds in the study area import water at a high absolute cost. Additionally, water transfer and pumping costs range from $70–$200 ac-ft (MWD). Water recycling and conservation measures typically cost $70–$150 per ac-ft and are usually considered to be a net benefit.

The estimated valuation of water saved over 10 years by controlling *Arundo* is $78.2 million at its peak distribution and $49.6 million at current distribution level (Table 8-4).

Table 8-3. Estimated reduction of fire impacts (benefit).

Watershed	PEAK *ARUNDO* LEVELS					CURRENT *ARUNDO* LEVELS				
	Fire Started by *Arundo*				Wildfires	Fire started by *Arundo*				Wildfire
	50k per event	Habitat damage: *Arundo* $20K ac	Habitat damage: rip $80K ac	*Arundo* fires 10 yr total	Wildfire: 500K per 200 ac	50k per event	Habitat damage: *Arundo* $20K ac	Habitat damage: rip $80K ac	*Arundo* fires 10 yr total	Wildfire: 500K per 200 ac
Calleguas	115,742	401,857	2,129,655	2,647,254	578,711	115,000	395,814	2,149,120	2,659,934	575,000
Carlsbad	73,947	256,745	1,360,629	1,691,321	369,736	24,609	98,862	459,889	583,360	123,044
Los Angeles	66,394	230,518	1,221,641	1,518,553	331,968	57,561	202,254	1,075,696	1,335,510	287,804
Otay	9,322	32,365	171,519	213,205	46,608	9,295	32,278	173,696	215,268	46,473
Penasquitos	11,810	41,004	217,300	270,114	59,049	10,686	37,407	199,700	247,793	53,430
Salinas	1,003,061	348,263	1,845,632	3,196,956	501,000	100,000	223,336	1,744,000	2,067,336	501,000
San Diego	75,111	260,787	1,382,050	1,717,948	375,557	47,000	169,675	878,336	1,095,011	235,000
San Dieguito	87,491	303,768	1,609,833	2,001,092	437,455	42,582	160,061	795,781	998,425	212,912
San Gabriel	22,281	77,359	409,967	509,607	111,404	22,146	76,929	413,873	512,948	110,732
San Juan	87,575	304,061	1,611,385	2,003,022	437,876	80,138	280,262	1,497,619	1,858,019	400,690
San Luis Rey	341,939	1,187,213	6,291,682	7,820,834	1,709,696	35,724	207,323	667,604	910,651	178,618
Santa Ana	1,361,931	4,728,624	25,059,526	31,150,080	6,809,654	820,000	2,813,396	15,324,160	18,957,556	4,100,000
Santa Clara	540,629	1,877,065	9,947,580	12,365,274	2,703,147	540,500	1,776,596	10,100,864	12,417,960	2,702,500
S. Margarita	344,446	119,592	633,781	1,097,819	1,722,231	-	-	-	0	0
Santa Monica	9,314	32,340	171,385	213,038	46,572	9,096	31,642	169,994	210,732	45,482
South Coast	14,908	51,759	274,298	340,965	74,538	11,000	39,256	205,575	255,831	55,002
Sweetwater	21,172	73,510	389,567	484,249	105,861	18,047	63,511	337,270	418,828	90,237
Tijuana	67,785	235,350	1,247,246	1,550,381	338,926	47,250	161,674	883,008	1,091,932	236,250
Ventura	165,997	576,341	3,054,344	3,796,682	829,985	94,000	257,212	1,756,672	2,107,884	470,000
TOTALS:	**$4,420,856**	**$11,138,520**	**$59,029,021**	**$74,588,396**	**$17,589,972**	**$2,084,635**	**$7,027,490**	**$38,832,856**	**$47,944,981**	**$10,424,174**

Table 8-4. Estimated reduction of water use by *Arundo* (benefit).

Watershed	10 Year Water Use	
	Peak *Arundo* levels	Current *Arundo* levels
Calleguas	2,290,974	2,290,974
Carlsbad	1,478,605	492,060
Los Angeles River	1,313,470	1,150,950
Otay	185,848	185,848
Penasquitos	235,419	213,650
Salinas	13,314,032	12,250,510
San Diego	1,494,312	932,570
San Dieguito	1,749,387	851,450
San Gabriel River	442,969	442,969
San Juan	1,733,768	1,602,390
San Luis Rey	6,837,215	714,310
Santa Ana	25,332,010	15,264,940
Santa Clara	10,185,377	10,185,377
Santa Margarita	6,887,344	41,940
Santa Monica Bay	184,819	184,819
South Coast	298,082	219,960
Sweetwater	417,636	360,870
Tijuana	1,305,930	895,020
Ventura River	2,498,351	1,325,080
TOTALS:	**$78,185,547**	**$49,605,686**

8.2.3 Reduced Sediment Trapping (Benefit)

As outlined in Section 5.1, it is likely that *Arundo* has impacts to sediment transport, particularly in low gradient areas where *Arundo* cover is high (>40%). Many of these areas are highly urbanized, have large-scale agricultural operations, or have significant infrastructure present. Localized sediment trapping is likely occurring in portions of these highly invaded reaches, resulting in loss of flow conveyance. *Arundo* stands on their own, not even considering sediment trapping, were demonstrated to reduce flow conveyance by five feet where they occurred (Section 5.1). This is a significant loss of conveyance, likely larger than the sediment trapping effect. If these areas are managed for flood risk, agencies (particularly ACOE, municipalities, and counties) may be forced to undertake vegetation reduction or sediment removal to maintain flow conveyance. For example, levees on the San Luis Rey River were designed to contain flows up to a 120–year event. Vegetation and *Arundo* growth reduced this to a 90–year event capacity (ACOE pers. comm. 2009). This can result in areas being designated as 'high flood risk' (i.e. raising insurance costs) or being designated as uninsurable. Both of these scenarios result in lower property values. When sediment removal and vegetation clearing are not permitted or are considered too costly, the alternative is building new levees or increasing existing levee heights. Both

Santa Margarita and San Luis Rey have required either modification or installation of levee structures and/or vegetation reduction programs to maintain flow conveyance. The Salinas River has had channel maintenance activities to reduce flood risk and bank/bridge failure. Other riverine systems in the study area are likely to have had actions in the past and/or will require actions in the future. Cost of implementing vegetation reduction and or sediment removal is also very high. While costs include the removal work itself, this is often a small proportion of the total project cost. Projects typically require complicated regulatory clearance that can take years to obtain, as well as significant mitigation for habitat disturbance/impacts. No specific cost valuation data exist other than the authors' familiarity with actions carried out on various rivers and the high costs associated with programs undertaking these types of activities. Therefore, valuations assigned in the benefit analysis are again highly conservative. Alternative activities, such as increasing levee heights or constructing new levees are not included here, but these actions do occur and the costs associated with them are high, both in terms of construction cost, permitting and mitigation for permanent wetland loss. True costs of *Arundo* impacts could be one or two orders of magnitude greater than presented here.

The valuation of avoided sediment removal or vegetation reduction costs over 10 years by controlling *Arundo* was estimated to be $2,500,000 (Table 8-5).

Table 8-5. Estimated reduction of sediment trapping (benefit).

Watershed	Sediment Removal
Calleguas	$250,000
Carlsbad	
Los Angeles River	$250,000
Otay	
Penasquitos	
Salinas	$1,000,000
San Diego	
San Dieguito	
San Gabriel River	$250,000
San Juan	
San Luis Rey	$500,000
Santa Ana	$250,000
Santa Clara	
Santa Margarita	
Santa Monica Bay	
South Coast	
Sweetwater	
Tijuana	
Ventura River	
TOTALS:	**$2,500,000**

8.2.4 Reduced Flood Damage: Bridges (Benefit)

Arundo biomass mobilizes during high flow events. This material can contribute or cause loss of structures that cross or are located within (power poles, sewer, gas, and water lines) the river channel. The exact proportion of damage costs associated with the presence of *Arundo* is difficult to determine. The most easily verified flood damage events involving *Arundo* are related to massive amounts of *Arundo* debris that form dams against bridges (Section 5.2.5.1). Loss of bridges has occurred on numerous watersheds that have high levels of *Arundo* invasion. Not all bridges were observed at the time of failure, but observations of bridges that have been damaged and operations to clear bridges of *Arundo* during flow events demonstrate that *Arundo* is a factor. High flow events that mobilize *Arundo* biomass also move large woody material such as trees. This combination of material collects and backs up against bridge pylons, or if flows are high enough, against the bridge itself. Older bridges with narrow spans are at greater risk of failing. Smaller bridges are also at higher risk as they typically have low clearance and narrow spans. Each watershed was reviewed for bridges (road and rail) that cross over river habitat with significant levels of *Arundo* around or upstream of them. These bridges were classified into three groups and conservative replacement costs were applied: large ($5 million), medium ($1.5 million), and small ($500,000). These valuations are extremely conservative, as bridge construction often requires costly environmental review and mitigation. Results were multiplied by 20% to estimate the likelihood of bridge loss within the 10-year period and to account for a portion of cost that is due to large flood events taking out bridges regardless of whether *Arundo* material is in the system or not.

The valuation of avoided bridge losses at peak *Arundo* distribution was estimated to be $24.2 million over 10 years. Control programs have cleared *Arundo* around and above several bridges, reducing estimated projected impacts to $17.3 million over 10 years (Table 8-6).

8.2.5 Habitat Enhancement (Benefit)

As explored in multiple chapters within this report, *Arundo* has many abiotic and biotic impacts. Some of the most severe impacts to riparian systems are to abiotic processes that are nearly impossible to quantify monetarily in terms of their environmental consequences. Changes to geomorphic form and function, hydrology, water use, and other abiotic functions affect the entire system. Most of the valuations for these types of impacts in previous sections were limited to anthropogenic costs including infrastructure, water for urban and agriculture use, or flood damage. Environmental costs were not included. This CBA will limit valuation of environmental impacts to the degradation of habitat *Arundo* has invaded. The cost of controlling *Arundo* is used as a valuation of the habitat benefit (habitat restoration as well and threatened and endangered species' benefits). A valuation of $25,000 per acre is used to represent the benefit of habitat enhancement/restoration that occurs when *Arundo* is controlled. This is the same as the cost of the work as outlined in Section 8.1. The total cost is lower, however, reflecting the subtraction of *Arundo* acreage that was counted under the fire benefits evaluation. This avoids double counting benefits. The use of this valuation is corroborated by the common use of *Arundo* control as a form of mitigation for impacts to riparian habitat. This is still a slightly conservative valuation as many other forms of riparian 'mitigation' have higher costs per acre ($50,000 to $100,000) for restoration activities, even when land use restrictions (easements or land costs) are excluded from project costs.

The total 10 year benefit calculated for habitat restoration/enhancement was estimated to be $181 million at peak *Arundo* distribution and $110 million for current distribution levels (Table 8-7).

Table 8-6. Estimated reduction of bridge losses (benefit) by watershed at peak and current *Arundo* levels.

Watershed	Number of Bridges: Large, Medium, & Small	PEAK *ARUNDO* LEVELS		CURRENT *ARUNDO* LEVELS	
		Bridge loss or damage	Flood damage: Bridge 20%	Bridge loss or damage	Flood damage: Bridge 20%
Calleguas	Med: 8, Sm: 1	12,500,000	2,500,000	12,500,000	2,500,000
Carlsbad		0	0	0	0
Los Angeles River	Lg: 1	5,000,000	1,000,000	5,000,000	1,000,000
Otay		0	0	0	0
Penasquitos		0	0	0	0
Salinas	Lg: 4, Med: 2, Sm: 1	22,000,000	4,400,000	22,000,000	4,400,000
San Diego	Med: 1, Sm: 2	2,500,000	500,000	500,000	100,000
San Dieguito		0	0	0	0
San Gabriel River	Lg: 1	5,000,000	1,000,000	5,000,000	1,000,000
San Juan	Med: 1, Sm: 1	2,000,000	400,000	2,000,000	400,000
San Luis Rey	Med: 4	6,000,000	1,200,000	0	0
Santa Ana	Lg: 5	25,000,000	5,000,000	10,000,000	2,000,000
Santa Clara	Lg: 2, Med: 3	14,500,000	2,900,000	14,500,000	2,900,000
Santa Margarita	Lg: 2, Med: 1	11,500,000	2,300,000	0	0
Santa Monica Bay		0	0	0	0
South Coast		0	0	0	0
Sweetwater		0	0	0	0
Tijuana	Sm: 1	500,000	100,000	500,000	100,000
Ventura River	Lg: 2, Med: 2, Sm: 3	14,500,000	2,900,000	14,500,000	2,900,000
	TOTALS:	**$121,000,000**	**$24,200,000**	**$86,500,000**	**$17,300,000**

Table 8-7. Estimated habitat enhancement (benefit) by watershed at peak and current *Arundo* levels.

Watershed	Habitat benefit: 25K per ac	
	PEAK *ARUNDO* LEVELS	**CURRENT *ARUNDO* LEVELS**
Calleguas	5,226,429	5,190,372
Carlsbad	3,376,431	909,509
Los Angeles River	2,996,281	2,589,891
Otay	424,270	424,270
Penasquitos	537,429	483,046
Salinas	32,857,393	30,197,986
San Diego	3,410,654	2,005,966
San Dieguito	3,994,761	1,749,414
San Gabriel River	1,010,978	1,010,624
San Juan	3,955,339	3,626,822
San Luis Rey	15,612,946	302,166
Santa Ana	57,433,784	32,260,330
Santa Clara	23,122,958	23,115,310
Santa Margarita	17,222,313	104,862
Santa Monica Bay	421,728	414,396
South Coast	680,677	485,319
Sweetwater	952,443	810,484
Tijuana	2,971,387	1,943,887
Ventura River	5,526,884	2,593,026
TOTALS:	**$181,735,081**	**$110,217,679**

8.2.6 Reduced Beach Debris

Impacts from clearing *Arundo* debris from beaches in southern California was reviewed in Section 5.2.5.2. These costs are based on information collected from municipalities that remove biomass from beaches. Only watersheds that are near beaches and actively remove biomass were given benefit valuations. The estimated 10–year benefit of reduced *Arundo* biomass on beaches is $1.97 million (Tables 8-8&9).

8.2.7 Total Benefit

The total benefit of controlling *Arundo* at its peak distribution was estimated at $380 million (Table 8-8), and the benefit at its current distribution at $239 million (Table 8-9). This is a conservative

valuation because several types of impacts could not be estimated or quantified, and all evaluated impacts were conservatively valued.

8.3 Benefit to Cost Ratio

The benefit to cost ratio for peak *Arundo* distribution was 1.94 to 1 ($380,767,747 to $196,481,844). Current *Arundo* distribution generates a similar benefit to cost ratio of 1.91 to 1 ($239,461,270 to $124,934,194). A 2:1 return ratio on funds invested is a significant benefit, particularly considering the additional impacts that were not assessed (due to complex valuation), as well as the conservative valuation of factors that were included.

A more rigorous CBA carried out for either specific watersheds or the entire project area would likely generate higher benefit to cost ratios. Higher cost valuations of impacts could be documented and defended, and some of the more complicated impacts, which were not included in this CBA, could be explored and included.

Table 8-8. Estimated benefits at the peak level of *Arundo* distribution.

Watershed	Water use 10 yr	Sediment removal	Flood damage: bridge & levee	*Arundo* fires 10 yr total	Wildfire: 500K per 200 ac	Habitat rest 25K	Beach debris	10 year benefit
Calleguas	2,290,974	250,000	2,500,000	2,647,254	578,711	5,226,429	-	13,493,368
Carlsbad	1,478,605	-	0	1,691,321	369,736	3,376,431	-	6,916,093
Los Angeles	1,313,470	250,000	1,000,000	1,518,553	331,968	2,996,281	328,125	7,738,397
Otay	185,848	-	0	213,205	46,608	424,270	-	869,931
Penasquitos	235,419	-	0	270,114	59,049	537,429	-	1,102,011
Salinas	13,314,032	1,000,000	4,400,000	3,196,956	501,000	32,857,393	-	55,269,381
San Diego	1,494,312	-	500,000	1,717,948	375,557	3,410,654	-	7,498,471
San Dieguito	1,749,387	-	0	2,001,092	437,455	3,994,761	-	8,182,694
San Gabriel	442,969	250,000	1,000,000	509,607	111,404	1,010,978	328,125	3,653,083
San Juan	1,733,768	-	400,000	2,003,022	437,876	3,955,339	-	8,530,006
San Luis Rey	6,837,215	500,000	1,200,000	7,820,834	1,709,696	15,612,946	328,125	34,008,816
Santa Ana	25,332,010	250,000	5,000,000	31,150,080	6,809,654	57,433,784	-	125,975,527
Santa Clara	10,185,377	-	2,900,000	12,365,274	2,703,147	23,122,958	328,125	51,604,881
Santa Margarita	6,887,344	-	2,300,000	1,097,819	1,722,231	17,222,313	328,125	29,557,833
Santa Monica	184,819	-	0	213,038	46,572	421,728	-	866,157
South Coast	298,082	-	0	340,965	74,538	680,677	-	1,394,261
Sweetwater	417,636	-	0	484,249	105,861	952,443	-	1,960,188
Tijuana	1,305,930	-	100,000	1,550,381	338,926	2,971,387	-	6,266,624
Ventura River	2,498,351		2,900,000	3,796,682	829,985	5,526,884	328,125	15,880,026
TOTALS:	**$78,185,547**	**$2,500,000**	**$24,200,000**	**$74,588,396**	**$17,589,972**	**$181,735,081**	**$1,968,750**	**$380,767,747**

Table 8-9. Estimated benefits at current levels of *Arundo*.

Watershed	Water use 10 yr	Sediment removal	Flood damage: bridge & levee	*Arundo* fires 10 yr total	Wildfire: 500K per 200 ac	Habitat rest 25K	Beach debris	10 year benefit
Calleguas	2,290,974	250,000	2,500,000	2,659,934	575,000	5,190,372		13,466,280
Carlsbad	492,060		0	583,360	123,044	909,509		2,107,972
Los Angeles	1,150,950	250,000	1,000,000	1,335,510	287,804	2,589,891	328,125	6,942,280
Otay	185,848		0	215,268	46,473	424,270		871,858
Penasquitos	213,650		0	247,793	53,430	483,046		997,919
Salinas	12,250,510	1,000,000	4,400,000	2,067,336	501,000	30,197,986		50,416,832
San Diego	932,570		100,000	1,095,011	235,000	2,005,966		4,368,547
San Dieguito	851,450		0	998,425	212,912	1,749,414		3,812,201
San Gabriel	442,969	250,000	1,000,000	512,948	110,732	1,010,624	328,125	3,655,399
San Juan	1,602,390		400,000	1,858,019	400,690	3,626,822		7,887,921
San Luis Rey	714,310		0	910,651	178,618	302,166	328,125	2,433,870
Santa Ana	15,264,940	250,000	2,000,000	18,957,556	4,100,000	32,260,330		72,832,826
Santa Clara	10,185,377		2,900,000	12,417,960	2,702,500	23,115,310	328,125	51,649,272
Santa Margarita	41,940		0	0	0	104,862	328,125	474,927
Santa Monica	184,819		0	210,732	45,482	414,396		855,429
South Coast	219,960		0	255,831	55,002	485,319		1,016,111
Sweetwater	360,870		0	418,828	90,237	810,484		1,680,419
Tijuana	895,020		100,000	1,091,932	236,250	1,943,887		4,267,089
Ventura River	1,325,080		2,900,000	2,107,884	470,000	2,593,026	328,125	9,724,115
TOTALS:	**$49,605,686**	**$2,000,000**	**$17,300,000**	**$47,944,981**	**$10,424,174**	**$110,217,679**	**$1,968,750**	**$239,461,270**