7. ECONOMIC FEASIBILITY OF BEACH NOURISHMENT

7.1 POTENTIAL BEACH NOURISHMENT ALTERNATIVES

This Coastal RSM Plan describes two potential alternatives for nourishment of the southern Monterey Bay beaches (Table 14):

- Alternative 1: small-scale nourishment of the southern bight
- Alternative 2: large-scale nourishment of the southern bight

Alternative 1 considers the use of opportunistic sand sources from Monterey Harbor to nourish the southern three miles of the bay. Approximately 75,000 yd^3 of sand may become available from dredging of the harbor for placement on to the beach. Sand would be placed at a location away from the rocky reef, kelp forest and eelgrass meadow (if still present) and be allowed to spread along the three miles of shoreline through sediment transport processes (this Coastal RSM Plan recommends a receiver site between Monterey Beach Resort and Ocean Harbor House condominiums, Figure 29). Using an estimate of 1.7 yd^3 of sediment to nourish one square foot of beach, the estimated increase in width of the nourished three-mile stretch of shoreline, after the sand has spread and equilibrium is reached, would be three feet.

Alternative 2 is a scenario in which large-scale extraction of sand from offshore sources (offshore Sand City and Monterey Submarine Canyon head) is placed in the southern bight, either as a nearshore or beach placement. Sand would be extracted and transported using a hopper dredge, and be placed at one or more locations in the southern bight away from sensitive habitat. To increase the width of the three-mile equilibrium beach by 75 feet would require approximately two million yd^3 of sand. However, this volume would not be placed all at one time, as the materials would be placed in strips along the three-mile stretch to minimize environmental disturbances.

For Alternative 2, two methods of placement are considered for the beach nourishment material: subaerial placement (directly onto the beach); and nearshore placement (in the surf zone). Placement onto the beach creates a wider beach more quickly but is more expensive as additional equipment and time is required to place the material, whereas nearshore placement simply involves depositing the material, which then takes longer to be worked onto the beach (by wave action) and hence produces less beach width increase. The relative merits of these approaches are further described in Section 5.1.

Table 14. Potential Beach Nourishment Alternatives for Southern Monterey Bay

	Alternative	Receiver Site	Shore Length (miles)	Equilibrium Width (feet)	Required Volume (yd^3)	Source Site	Excavation / Dredge Method	Transport Method	Placement Method
1	**Southern Bight Small**	South Sub-cell	3	3	75,000	Monterey Harbor			
a						Opportunistic/stockpile	Hopper Dredge	Hopper	Hydraulic Discharge to Beach
b						Opportunistic/stockpile	Hopper Dredge	Hopper	Place in nearshore
2	**Southern Bight Large**	South Sub-cell	3	75	2,000,000				
a						Offshore Sand City	Hopper Dredge	Hopper	Hydraulic Discharge to Beach
b						Offshore Sand City	Hopper Dredge	Hopper	Place in nearshore
c						Canyon Head	Hopper Dredge	Hopper	Hydraulic Discharge to Beach
d						Canyon Head	Hopper Dredge	Hopper	Place in nearshore

7.2 APPROACH TO ECONOMIC ANALYSIS

This section provides a review of the relative costs and benefits of each of the beach nourishment alternatives. At this regional scale of analysis the intention is not to determine exact costs and benefits for funding and approval purposes, but to determine the likely economic viability of proposed alternatives. For regional planning purposes, if it can be determined that an alternative is likely to have a benefit to cost ratio robustly greater than 1 (i.e. benefits are greater than costs) then it can be considered viable and appropriate for further investigation and development.

Costs for the beach nourishment options and recreational benefits of the nourishment have been calculated using a decision support tool developed for CSMW. Benefits associated with prevention of erosion, and hence protection of coastal assets, have been calculated using property values provided by the Monterey County Property Assessor and the Monterey Regional Water Pollution Control Agency (MRWPCA).

7.2.1 Application of the Coastal Sediment Benefits Analysis Tool

The benefit-cost analysis for beach nourishment in this Coastal RSM Plan uses the Coastal Sediment Benefits Analysis Tool (CSBAT) developed by CSMW (Corps, 2008), populated with data from southern Monterey Bay to investigate the economics of the small-scale and large-scale alternatives summarized Table 14.

CSBAT was originally developed for application in San Diego County, and the southern Monterey Bay application represents the first use outside San Diego. The tool focuses principally on the value of recreational benefits arising from beach nourishment works. Consequently, it utilizes a range of data on both the physical attributes of the source and receiver sites and the economic value of beach visitors.

Where possible data specific to southern Monterey Bay has been obtained and used in the analysis; however there has been very little study of the economics of beach use in this area, so average and pro-rated values from the San Diego application have been used for many of the attributes. This application of analogous data (from another site within the state) in the absence of locally specific data is considered valid for a regional planning assessment such as this, where it is necessary to determine the likely viability of beach nourishment alternatives.

The CSBAT tool allows the user to appraise various beach nourishment alternatives through different combinations of:

- sediment source site
- receiver site
- volume of dredged material
- mode/s of transportation.

Utilizing background attribute data such as unit costs, beach visitor numbers, and other parameters, the tool produces reports containing information such as:

- baseline data on the sites
- results from the model including estimated beach nourishment costs
- change in recreational benefits
- projected increases in spending and tax value
- potential environmental impacts
- estimated change in beach width
- cumulative cost/benefits using various transportation routes and scenarios.

The calculation of economic benefits within CSBAT is based on potential changes in the amenity/recreation value of the beach. These benefits are derived from increased visitor numbers due to increased capacity on the larger (post-nourishment) beach, the associated increased visitor spend, increased taxation on that spend, and increased recreational 'value' (economic equivalent of the recreational benefit) derived by visitors to a wider beach. The increase in visitor numbers and their corresponding increase in economic benefit are calculated based on King (2001), where visitor surveys at a number of southern California beaches showed that in general respondents preferred wider beaches and would attend wider beaches more often. From the work of King (2001) and the analyses for the San Diego application of CSBAT, it was concluded that a doubling in beach width would increase attendance by 2.5% and recreational value (per visitor) by 18%. This is an underlying assumption in the CSBAT analysis.

The tool makes calculations of the changes in beach width and hence visitor numbers and recreational benefits for up to a 20 year period from the original beach nourishment. Over time the beach fill spreads laterally along the shoreline, and this process together with ongoing erosion gradually reduces the width of the beach and hence the additional recreational benefits provided by the nourishment. A 20-year period is assessed as this is considered a reasonable maximum duration of the positive affect of the nourishment on beach widths.

One of the most important inputs for the analysis is beach visitor numbers. Table 15 presents observed visitor numbers from 1995 to 2007 for Monterey State Beach in the southern bight. The visitor numbers show a large degree of fluctuation from year to year, with low values in the early part of the record rising to peaks in excess of one million visitors then settling to a more consistent level in recent years. CSBAT uses an 'average' annual attendance figure for benefit estimates, so in order to define a value relevant to current beach usage, an average from the last five years has been used. Using the last five years avoids the large fluctuations in the earlier years, and is more representative of the present day beach use. Based on this approach the visitor numbers used in the CSBAT analysis are 644,677 for Monterey State Beach.

Table 15. Annual Visitor Numbers for Monterey State Beach

1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Mean Last 5 years
107,946	131,340	251,994	258,771	919,104	457,161	493,170	1,259,688	841,461	834,850	598,204	534,322	414,548	**644,677**

On the costs side of the analysis, generic cost rates defined for the San Diego application of CSBAT (the tool was originally developed for that application) have been used. It is recognized that the actual cost rates in southern Monterey Bay may be different from those in southern California; however it is considered appropriate to use these rates for a regional plan such as this, as they are adequate to assess the overall economic viability of the nourishment alternatives.

7.2.2 Estimation of Protection Benefits

The CSBAT tool does not calculate the economic benefits arising from the protection of infrastructure and built assets. However, beach nourishment projects not only provide larger amenity beaches, but also slow the rate of beach/dune erosion. As such, nourishment projects prevent the loss of assets located within areas vulnerable to erosion (Section 3). Depending on the nature and location of coastal development and infrastructure, this can be a major contributor to the overall benefits arising from the nourishment.

Values for the majority of assets at risk of erosion (Section 3) were obtained from the records of the Monterey County Property Assessor. However, one of the most important built assets located along this coast is the Monterey Interceptor pipeline and the pump stations associated with the pipeline. Estimates of the replacement value of this infrastructure were obtained from MRWPCA. MRWPCA undertook an analysis of the replacement cost for the Salinas Interceptor approximately five years ago, which concluded a replacement cost of $600-$700 per linear foot would be appropriate for that 36 inch-diameter pipeline. The Monterey Interceptor is 24 inches and larger in sections, and it was recommended that $600/foot be used for replacement taking account of local ground conditions, access and property issues (Jennifer Gonzales, MRWPCA, personal communication). In addition, an estimated replacement cost of £75 million was recommended for Seaside Pump Station.

Beach nourishment generally has a finite life and only acts to delay the erosion process. Consequently, the true value of the protection benefit from beach nourishment is the value of the delay in loss of an asset. The process of evaluating this delay requires the definition of likely time scales for erosion loss with and without the nourishment project, then application of a discount rate to determine the present value of that benefit.

The potential timescale until loss of facilities without any beach nourishment are provided in Section 3.3. It was then assumed that the nourishment of 2,000,000 yd^3 of sand would delay the onset of erosion by 20 years (to be consistent with the time period considered in the recreation benefits analysis). Discounted values for the loss of the asset (using a 5% discount rate) with and without project were then calculated and the difference between those values is the benefit of the delay. A three-year delay was also considered for the 75,000 yd^3 nourishment alternative. It was assumed that the delay in erosion would be the same regardless of whether sand was placed on the beach or in the nearshore, as the overall impact on erosion rates would be the same for both (even though the dry beach area is less for nearshore placement).

Another aspect of the protection benefits of beach nourishment that is not taken into account by CSBAT is the benefit of maintaining the current recreational amenity of the beach by preventing the loss of beach width. While no attempt has been made to estimate the number of visitors that would not visit the beach if it were allowed to erode, it is reasonable to assume that a smaller beach would attract/accommodate less people. However, this benefit is difficult to quantify and has not been included in these analyses. This means that the results of the economics are conservative as any positive outcomes would be enhanced through the addition of these recreational benefits.

7.3 COSTS AND BENEFITS

This section outlines the costs and benefits for each of the two beach nourishment alternatives using CSBAT, plus the additional benefits from protection of properties.

7.3.1 Costs

The costs associated with each of the potential beach nourishment alternatives all using the hopper dredge technology are presented in the Tables 16 and 17.

Table 16. Small-Scale Nourishment of the Southern Bight sourced from Monterey Harbor (Alternative 1)

Cost component	1a. Beach	1b. Nearshore
Sand volume (yd^3)	75,000	75,000
Transport Distance (miles)	2.53	2.53
Total Trips	28	28
Construction Period (days)	6	5
Total Transport Cost ($)	431,560	193,503
Mob/Demob. ($)	600,000	500,000
Cost per Yard ($)	14	9
Total Beach Nourishment Cost ($)	**1,030,000**	**694,000**

Table 17. Large-Scale Nourishment of the Southern Bight (Alternative 2)

Cost component	2a. Sand City Beach	2b. Sand City Nearshore	2c. Canyon Head Beach	2d. Canyon Head Nearshore
Sand volume (yd^3)	2,000,000	2,000,000	2,000,000	2,000,000
Transport Distance (miles)	1.81	1.81	15.33	15.33
Total Trips	741	741	741	741
Construction Period (days)	151	118	309	265
Total Transport Cost ($)	11,044,907	4,832,451	19,747,047	10,873,016
Mob/Demob. ($)	600,000	500,000	600,000	500,000
Cost per Yard ($)	6	3	10	6
Total Beach Nourishment Cost ($)	**11,650,000**	**5,330,000**	**20,350,000**	**11,400,000**

The results show that placing sand directly on to the beach is substantially more expensive than placing sand in the nearshore. This is to be expected due to the significant increase in effort and equipment required to undertake the beach placement. However, Section 7.3.2 demonstrates the differences in the benefits resulting from the two approaches.

7.3.2 Recreational Benefits

The benefits generated by the application of CSBAT provide an estimate of the economic value of the improved recreational amenity of southern Monterey Bay beaches. Tables 18 to 21 present the details of the benefits calculated for the two alternatives. For each alternative, the value of the increase in recreational benefit is calculated in three parts, based on the increased beach width providing for increased visitor numbers and an increased recreational benefit value for all visitors. The parameters presented are:

- beach width increase: this varies dependant on the method of sand delivery (subaerial beach or nearshore) and is used to determine the increase in beach visitors
- increase in state and local spending: the increased spend resultant from more visitors
- increase in state and local taxes: income based on spending
- increase in recreational value: reflects the increased value derived by visitors from a wider beach, plus the increased visitor numbers
- total increase in recreational benefit: the discounted total of the above three benefits increases over a full 20 years (note only the first ten years are presented individually in Tables 18 to 21).

Table 18. Recreational Benefits of Small-Scale Nourishment of the Southern Bight with Beach Placement (Alternative 1a)

	Increases in:			
	Beach Width (ft)	State & Local Spending ($)	State & Local Taxes ($)	Recreational Value ($)
Year-1	3.75	11,243	1,293	38,329
Year-2	0.3	899	103	2,940
Year-3	0.0	0.0	0.0	0.0
Year-4	0.0	0.0	0.0	0.0
Year-5	0.0	0.0	0.0	0.0
Year-6	0.0	0.0	0.0	0.0
Year-7	0.0	0.0	0.0	0.0
Year-8	0.0	0.0	0.0	0.0
Year-9	0.0	0.0	0.0	0.0
Year-10	0.0	0.0	0.0	0.0
Total Increase in Recreational Benefit ($)		**54,995**		

Table 19. Recreational Benefits of Small-Scale Nourishment of the Southern Bight with Nearshore Placement (Alternative 1b)

	Increases in:			
	Beach Width (ft)	State & Local Spending ($)	State & Local Taxes ($)	Recreational Value ($)
Year-1	0.0	0.0	0.0	0.0
Year-2	0.6	1,799	207	5,877
Year-3	0.98	2,923	336	9,088
Year-4	1.09	3,261	375	9,652
Year-5	0.0	0.0	0.0	0.0
Year-6	0.0	0.0	0.0	0.0
Year-7	0.0	0.0	0.0	0.0
Year-8	0.0	0.0	0.0	0.0
Year-9	0.0	0.0	0.0	0.0
Year-10	0.0	0.0	0.0	0.0
Total Increase in Recreational Benefit ($)		**36,264**		

Table 20. Recreational Benefits of Large-Scale Nourishment of the Southern Bight with Beach Placement (Alternatives 2a and 2c)

	Increase in:			
	Beach Width (ft)	State & Local Spending ($)	State & Local Taxes ($)	Recreational Value ($)
Year-0	100.0	299,818	34,479	880,495
Year-1	77.76	233,136	26,811	671,330
Year-2	69.15	207,325	23,842	575,432
Year-3	62.84	188,413	21,668	502,571
Year-4	57.94	173,728	19,979	444,523
Year-5	54.01	161,928	18,622	396,936
Year-6	50.56	151,585	17,432	355,752
Year-7	47.11	141,241	16,243	317,382
Year-8	43.66	130,897	15,053	281,655
Year-9	40.21	120,553	13,864	248,411
Year-10	36.76	110,210	12,674	217,498
Total Increase in Recreational Benefit ($)		**8,067,127**		

Table 21. Recreational Benefits of Large-Scale Nourishment of the Southern Bight with Nearshore Placement (Alternatives 2b and 2d)

	Increase in:			
	Beach Width (ft)	State & Local Spending ($)	State & Local Taxes ($)	Recreational Value ($)
Year-0	0.0	0.0	0.0	0.0
Year-1	16.0	47,971	5,517	152,212
Year-2	26.0	77,953	8,965	231,435
Year-3	29.0	86,947	9,999	244,587
Year-4	15.0	44,973	5,172	123,493
Year-5	11.55	34,629	3,982	91,138
Year-6	8.1	24,285	2,793	61,267
Year-7	4.65	13,942	1,603	33,718
Year-8	1.2	3,599	414	8,343
Year-9	0.0	0.0	0.0	0.0
Year-10	0.0	0.0	0.0	0.0
Total Increase in Recreational Benefit ($)		**1,479,160**		

It is notable that the increased recreational benefits provided where the sand is placed directly on to the beach are significantly greater than those for nearshore placement. This is because the maximum beach width increase is realized in the first year, and, more importantly, because the overall beach width increase is much greater and lasts longer (as erosion and dispersion gradually reduce the beach width over time).

7.3.3 Property Protection Benefits

The protection of built assets from long-term erosion is a tangible benefit of the beach nourishment proposals. Using the risk analysis in Section 3.3, Table 22 estimates the economic value of these assets vulnerable to erosion (Figure 19) together with an estimate of when they would be lost to erosion without beach nourishment, when the delayed loss would occur if nourishment was undertaken, and the 'present value' of that delay in loss.

Table 22. Assets Protected by Beach Nourishment

Asset	Land Value	Buildings/Facility value	Total Value	Approx. year of loss		Value of delay in erosion
				No project	With 2m cy fill	
Monterey Interceptor (8,600 foot from Wharf II to Monterey Pump Station)	$5,160,000			20	40	$1,211,794
Monterey Interceptor (1,750 foot section south from Seaside Pump Station)	$76,050,000			40	60	$6,731,198
Monterey Beach Resort	$5,061,190	$12,977,895	$18,039,085	20	20	$4,236,367
Ocean Harbor House Condominiums	$15,933,694	$19,389,305	$35,322,999	50	70	$1,919,366
La Playa Street Town Homes	$4,777,434	$6,325,399	$11,102,833	20 (ongoing)	40 (ongoing)	$1,448,546
Total erosion prevention benefits in the southern bight						**$15,550,000**

Table 22 demonstrates the high value of the beach front facilities and properties along this coast, and in particular in the southern reach. In addition to the simple value of the assets, their loss would have significant secondary impacts such as disruption to wastewater facilities for the cities of Pacific Grove and Monterey, as well as major environmental consequences, if the Monterey Interceptor was breached; and impacts on the local tourist economy if oceanfront resorts were lost.

In order to appropriately represent the likely nature of erosion losses at the facilities identified in Table 22, assumptions were made regarding the progression of loss:

- Given it's proximity to the shoreline, a 8,600 foot section of the Monterey Interceptor pipeline is considered to be at risk between Monterey Harbor and Monterey Pump Station. Elsewhere the pipeline is set back from the coast, except near Seaside Pumping

Station, where the Station itself and a 1,750 foot section of the pipeline are considered at long-term risk.

- For the Monterey Beach Resort it is assumed that the seawall constructed in 1968 has a design life of 50 years and hence is likely to remain effective for no more than 20 years, after which erosion of the property would begin.
- For Ocean Harbor House condominiums it is assumed that the seawall that is due to be constructed will have a 50-year life, after which erosion of the property would be immediate as the fronting beach would be lost and the property outflanked by erosion.
- Twenty six property parcels are identified as being at risk in the Monterey La Playa town homes development. It is assumed that the first losses occur in year 20, with 25% of the at-risk parcels lost every 10 years thereafter.

This analysis demonstrates that the erosion delay benefits of the proposed beach nourishment projects could be significant.

7.3.4 Ecologic Protection Benefits

Recent analyses indicate that reduction of beach widths associated with seawall construction results in severe ecologic degradation (Dugan et al., 2008). If no beach nourishment occurs it is possible that armouring would be installed to protect development. Therefore, beach nourishment would maintain ecology closer to existing conditions. This benefit has not been quantified.

7.4 ECONOMIC VIABILITY OF ALTERNATIVES

Sections 7.1 to 7.3 present the various aspects of the costs and benefits of beach nourishment in the southern bight of southern Monterey Bay. This section amalgamates these aspects to review the economic viability of the alternatives.

7.4.1 Alternative 1: Small-Scale Nourishment of the Southern Bight

Table 23 presents a summary of the costs and benefits for Alternative 1, the placement of 75,000yd^3 of sand from Monterey Harbor directly on to the southern bight beaches.

Table 23. Economic Summary of Alternative 1

Scenario	Total Cost	Increase in Recreational Benefits	Property Protection Benefits	Total Benefits	Net Benefits	Cost/Benefit Ratio
1a. Beach Placement	$1,031,560	$54,955	$3,397,397	$3,452,352	$2,420,792	3.35
1b. Nearshore Placement	$693,503	$36,264	$3,397,397	$3,433,661	$2,740,158	4.95

The data demonstrates that there is a clear economic justification to placing sand from Monterey Harbor on to the adjacent shoreline. Indeed, the additional cost of placing the sand from the harbor onto the adjacent beaches could be minimized if coordinated with maintenance dredging of the harbor, potentially reducing the cost side of the equation. It is notable that placing this relatively small volume of sand onto this frontage has little benefit in terms of increasing the beach for amenity purposes, but it is the benefits in delaying erosion that provide the clear justification.

7.4.2 Alternative 2: Large-Scale Nourishment of the Southern Bight

Table 24 presents a summary of the costs and benefits for Alternative 2, the nourishment of the three mile frontage of the southern bight with 2,000,000 yd^3 of sand from three potential offshore sources. Both subaerial beach and nearshore placement are considered.

Table 24. Economic Summary of Alternative 2

Scenario	Total Cost	Increase in Recreational Benefits	Property Protection Benefits	Total Benefits	Net Benefits	Cost/Benefit Ratio
2a. Offshore Sand City source to beach	$11,644,907	$8,067,127	$15,547,271	$23,614,398	$11,969,491	2.03
2b. Offshore Sand City source to nearshore	$5,332,452	$1,479,160	$15,547,271	$17,026,431	$11,693,979	3.19
2c. Canyon head source to beach	$20,347,048	$8,067,127	$15,547,271	$23,614,398	$3,267,350	1.16
2d. Canyon head source to nearshore	$11,373,016	$1,479,160	$15,547,271	$17,026,431	$5,653,415	1.50

The economic summary for Alternative 2 demonstrates clearly that these beach nourishment alternatives are economically viable. All alternatives have a positive benefit-cost ratio, with the Sand City borrow area proving most cost-effective due to it's proximity to the southern bight frontage.

Section 7.3.1 showed that the costs of placing sand on to the beach are substantially greater than placing in the nearshore; however it also delivers a greater recreational benefit. Considering the benefit-cost ratio, the nearshore placement option (from offshore Sand City) looks most attractive (ratio of 3.19). However, the incremental benefit of placing the sand directly on the beach is greater than one (i.e. the additional cost to place the sand on the beach is $6.3 million and the additional recreational benefits are $6.6 million), suggesting the additional investment is economically worthwhile. This is supported by this alternative having the highest net benefit at $12.59 million.

The results indicate that there is a clear economic justification for undertaking beach nourishment in the southern bight of southern Monterey Bay. Although the analysis does not guarantee funding for these alternatives (Section 9), it has shown that beach nourishment in southern Monterey Bay would deliver net economic benefits to the area and region.