



Oceanside Receiver Site in November 2001



**2001 REGIONAL BEACH
MONITORING PROGRAM**

ANNUAL REPORT

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CFC-495-01

**SANDAG
2001 REGIONAL BEACH
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ANNUAL REPORT

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SANDAG

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October 2002

EXECUTIVE SUMMARY

This report presents the findings of the SANDAG 2001 Regional Beach Monitoring Program. As in past years, the general objective was to document changes in the condition of the shorezone, thereby providing a basis for evaluating the impacts of natural events and human intervention. The program was substantially expanded in 2001, however, to monitor the fate of nourishment material introduced at twelve receiver sites under SANDAG's Regional Beach Sand Project (RBSP). The RBSP provided 2.1 million cubic yards of sand to the receiver sites between April 6 and September 23, 2001.

The 2001 Monitoring Program included a beach component and a lagoon entrance component. The beach component consisted of semi-annual profiling on 58 shore-perpendicular transects, semi-annual oblique aerial photography at the twelve RBSP receiver sites, and monthly beach width measurements at four of the RBSP receiver sites. The lagoon entrance component encompassed five sites in the Oceanside Littoral Cell: the jetty-stabilized entrances at Agua Hedionda and Batiquitos, and the unstabilized entrances at San Elijo, San Dieguito, and Los Peñasquitos. Topographic data and oblique aerial photographs were obtained at each entrance on a semi-annual basis, along with monthly observations and ground photographs at the three unstabilized entrances.

To provide continuity with SANDAG's previous monitoring work, the 2001 monitoring year was defined as November 2000 through October 2001. The principal study findings for this period are as follows:

1. Precipitation and streamflow were well below average, while the wave conditions were relatively mild. The primary implications are threefold: (1) the absence of large wave events during the Summer and Fall seasons helped to prolong the life of the RBSP beach fills; (2) the scant precipitation and low stream flows failed to deliver significant quantities of beach-quality sediment to the coast in the winter months that preceded the RBSP; and (3) the low streamflows failed to flush coastal sediment from the lagoon entrances in the Oceanside Cell.
2. The only non-RBSP nourishment project undertaken during the 2001 monitoring year was a miniscule 1,000 cy fill at Moonlight Beach. As a result, 467,000 cy of the RBSP fill material (about 22%) served to compensate for the average annual nourishment provided from other sources in prior years. The remaining RBSP material, 1,637,000 cy, represented incremental nourishment. The incremental

volume was relatively small in the Silver Strand Cell (47,000 cy), moderate in the Mission Beach Cell (149,000 cy) and large in the Oceanside Cell (1,441,000 cy).

3. The 2001 sand bypass volumes at Batiquitos and Agua Hedionda Lagoons (45,000 and 429,000 cy, respectively) were substantially higher than the average annual values in recent years (2,000 and 143,000 cy). These large volumes were not caused by the RBSP, because the bypass work was conducted prior to or concurrent with the start of the nourishment activities. Conversely, the sand bypass volume at Oceanside Harbor was well below average: 80,000 cy in 2001 vs. 237,000 cy in the past. The implications are twofold: (1) the beaches adjacent to the two lagoon entrances benefited from the increased bypass volumes at these sites; and (2) the beaches at Oceanside and North Carlsbad were negatively impacted by the decreased bypass volume at the harbor.
4. The combination of RBSP beach fills and mild wave conditions during the 2001 monitoring year proved to be extremely favorable for the San Diego County coast. Wider beaches resulted in all three littoral cells, with the greatest increases occurring in the Oceanside Cell (where more than 85% of the RBSP nourishment material was placed). At 58% of the transects with measurements dating back to 1997, the beach width in Fall 2001 was greater than that noted in any of the prior four years.
5. Gains in shorezone sediment volume outnumbered losses by a wide margin. The gains were concentrated in the Oceanside Cell, whereas gains and losses were mixed in the Silver Strand and Mission Beach Cells. In the absence of other nourishment programs and of significant riverine input, the increase in shorezone volume may be attributed primarily to the RBSP. Although the greatest gains occurred at the receiver beaches, significant volume increases also occurred at a number of flanking locations.
6. The initial performance of the individual RBSP fills varied considerably. Based on the use of a single indicator profile to represent each site, the retention of nourishment material on the subaerial beach at the time of the Fall 2001 Survey ranged from about 65% at Fletcher Cove, Leucadia, and Batiquitos to greater than 90% at Imperial Beach, Mission Beach, Torrey Pines, North Carlsbad, and Oceanside. Although it is premature to draw conclusions about long-term performance, the high fill retention, shoreline advance, and shorezone volume gain that occurred at Oceanside suggest that coarse sediment sizes and large fill volumes will produce superior results.

7. With the exception of a brief closure at San Elijo that occurred in early December, 2000, all five lagoon entrances in the Oceanside Cell remained open to tidal exchange during the 2001 monitoring year. At Agua Hedionda and Batiquitos, where the entrances are stabilized by jetties, the channels provided the full range of tidal exchange while exhibiting only small variations in water depth. At San Elijo, San Dieguito, and Los Peñasquitos, where the entrances are unstabilized, tidal exchange was limited to the higher stages of the tide.
8. In late November, 2001, shortly after the end of the 2001 monitoring year, the entrance channels at San Dieguito and Los Peñasquitos closed in apparent response to an early-Winter wave event of unusually long duration. Although the RBSP beach fills at Del Mar and Torrey Pines appear to have contributed to these closures, the post-RBSP closure frequencies at the three unstabilized entrance channels remained less than or equal to those that preceded the nourishment program.

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SANDAG
2001 REGIONAL BEACH
MONITORING PROGRAM

ANNUAL REPORT

1. INTRODUCTION

This report presents the findings of the SANDAG 2001 Regional Beach Monitoring Program. As in the case of five prior annual monitoring programs conducted between 1996 and 2000, the 2001 effort was performed on behalf of the San Diego Association of Governments (SANDAG) by Coastal Frontiers Corporation.

The study area extends 59 miles from the U.S.-Mexican Border to Oceanside Harbor, and contains the Silver Strand Littoral Cell, the Mission Bay Littoral Cell, and the southern half of the Oceanside Littoral Cell (Figure 1). As in past years, the general objective of the 2001 Monitoring Program was to document changes in the condition of the shorezone, thereby providing a basis for evaluating the impacts of natural events and human intervention. The program was substantially expanded in 2001, however, to monitor the fate of nourishment material introduced at twelve receiver beaches under SANDAG's Regional Beach Sand Project (RBSP). The RBSP, to be discussed in Section 2.2, provided a total of 2.1 million cubic yards of sand to the receiver beaches between April 6 and September 23, 2001.

The 2001 Monitoring Program included a beach component and a lagoon entrance component. The beach component consisted of semi-annual profiling on 58 shore-perpendicular transects, semi-annual oblique aerial photography at the twelve RBSP receiver sites, and monthly beach width measurements at four of the RBSP receiver sites. The lagoon entrance component addressed five sites in the Oceanside Littoral Cell: the jetty-stabilized entrances at Agua Hedionda and Batiquitos, and the unstabilized entrances at San Elijo, San Dieguito, and Los Peñasquitos (Figure 1). Topographic data and oblique aerial photographs were obtained at each entrance on a semi-annual basis, along with monthly observations and ground photographs at the three unstabilized entrances.

To provide continuity with the previous monitoring work (Coastal Frontiers, 2001), the one-year period covered by this report extends from the Fall 2000 Survey through the

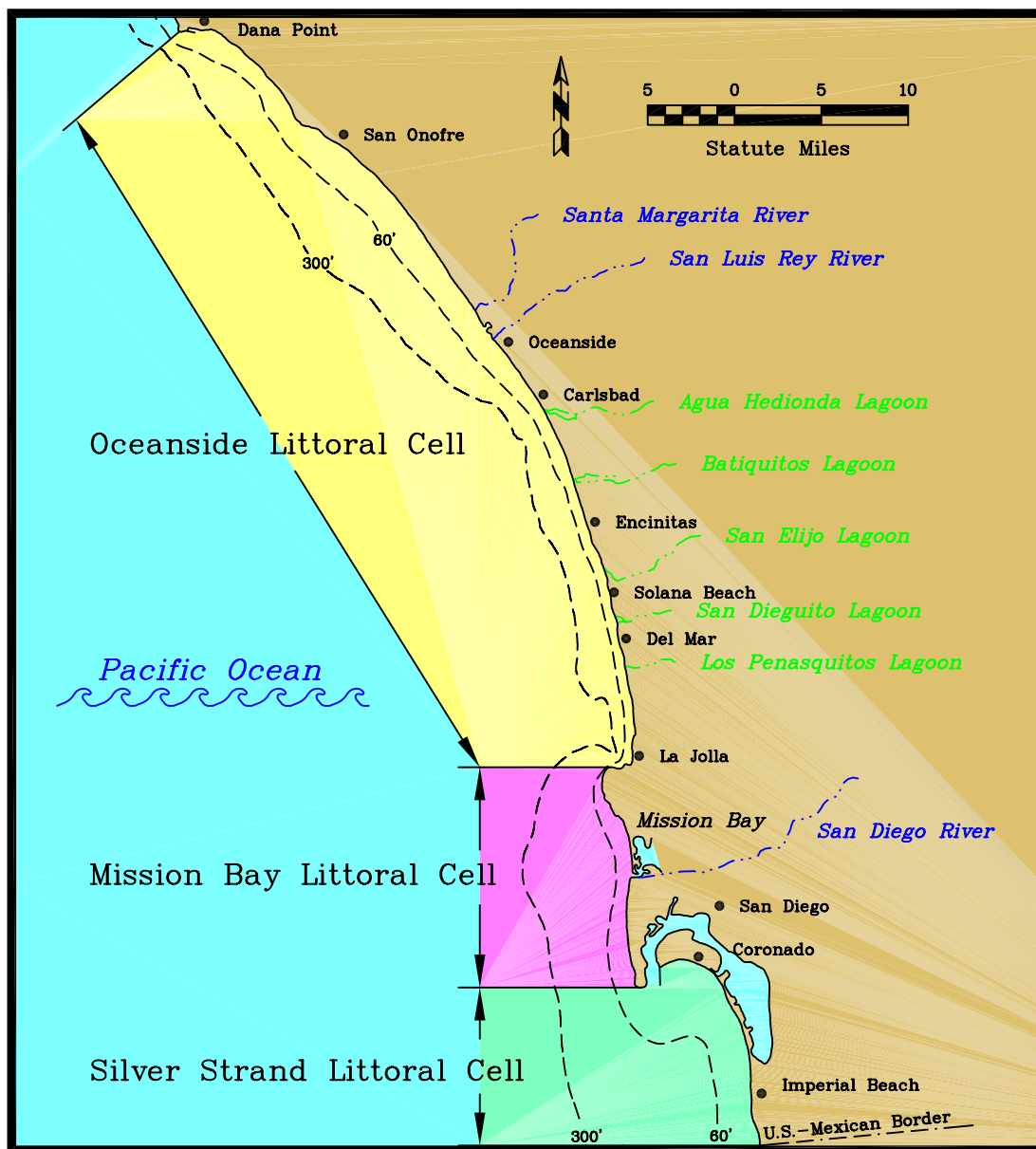


Figure 1. The Coast of San Diego County

Fall 2001 Survey (approximately November 2000 through October 2001). The Spring 2001 Survey was conducted immediately prior to the start of the RBSP, and therefore represents the pre-project condition of the shorezone. The Fall 2001 Survey was conducted about six months after completion of the first RBSP fill, and one month after completion of the last RBSP fill.

This report provides a detailed account of the 2001 Regional Beach Monitoring Program. Pertinent background information is presented in Section 2, which summarizes the environmental conditions and human intervention that occurred during the study period. Section 3 describes the monitoring methods, while Section 4 presents the results. The condition of San Diego County's beaches is analyzed in Section 5, with particular emphasis on the RBSP receiver sites. Section 6 discusses the condition of the five lagoon entrances in the Oceanside Cell. Conclusions are presented in Section 7. Selected tables, figures, and plates are interspersed with the text, while the remaining tables, plots and plates are provided in a separate volume of appendices. All elevations are referenced to Mean Lower Low Water (MLLW), which lies 2.75 ft below Mean Sea Level (MSL).

2. BACKGROUND INFORMATION

This section presents background information on the natural and human factors that exert a significant influence on the state of the San Diego County coast. It is intended not only to provide a general context for the monitoring data, but also to aid in evaluating the performance of the twelve RBSP beach fills. Environmental conditions are discussed in Section 2.1, followed by human intervention (including the RBSP) in Section 2.2. In Section 2.3, the conditions that prevailed during the 2001 monitoring period are compared with those in the recent past. All data are presented in terms of “monitoring years” that commence on November 1 and end on October 31. Hence, the 1999 monitoring year extends from November 1, 1998 through October 31, 1999.

2.1. Environmental Conditions

Environmental conditions of importance to the shorezone include precipitation, streamflow, and waves. During periods of heavy precipitation, rivers and streams transport substantial quantities of beach-quality sediment to the coast. Conversely, riverine sediment input becomes negligible during dry periods (Inman and Masters, 1989). The nature and severity of the wave climate control the rate of coastal sediment transport, with particular importance attached to storm events.

2.1.1. Precipitation

Although the amount of precipitation varies with location in San Diego County, rainfall patterns tend to be similar throughout the region. In other words, periods of above- or below-average rainfall at one site can be used to infer similar conditions at other sites (Elwany, *et al.*, 1998). The data acquired at San Diego’s Lindberg Field were selected to represent precipitation in the entire study area, based on this station’s extended period of record (1914-present).

Figure 2 shows the annual precipitation measured at Lindberg Field from 1915 through 2001. The average value prior to 2001 was 10.3 inches, with a maximum of 26.4 inches in 1941 and a minimum of 3.6 inches in 1961. During the SANDAG monitoring period that preceded the RBSP (1996-2000), above-average precipitation was recorded only in 1998 (corresponding to the El Niño winter of 1997-98). The precipitation during the 2001 monitoring year was about 30% below average, at 7.3 inches

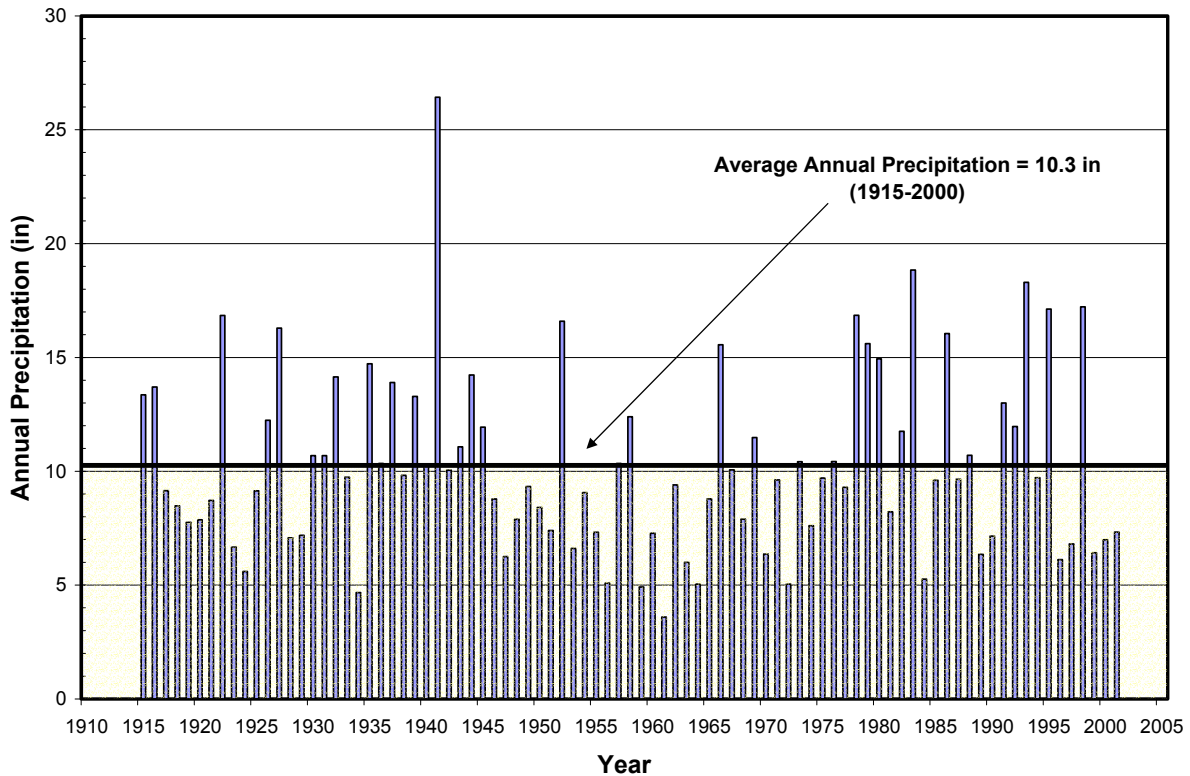


Figure 2. Annual Precipitation at Lindberg Field, 1915-2001

The cumulative residual rainfall at Lindberg Field is shown in Figure 3. Residual rainfall represents the difference between the rainfall observed in a particular year and the average annual rainfall. When the residual values are summed over extended periods of time, the resulting cumulative values provide an indication of long-term climatic trends (Inman and Jenkins, 1999). A positive slope to the graph denotes a “wet” period of above-average precipitation, while a negative slope denotes a “dry” period of below-average precipitation.

Notwithstanding several short-term exceptions, the period from 1945 through 1977 can be characterized as dry, while the period from 1978 through the mid-1990’s can be characterized as wet. More recently, the three consecutive years of below-average rainfall that have followed the 1997-98 El Niño event suggest the onset of another dry period.

2.1.2. Streamflow

Daily streamflow measurements for the San Luis Rey and San Diego Rivers were obtained from the U.S. Geological Survey (USGS). The mouth of the San Luis Rey River is

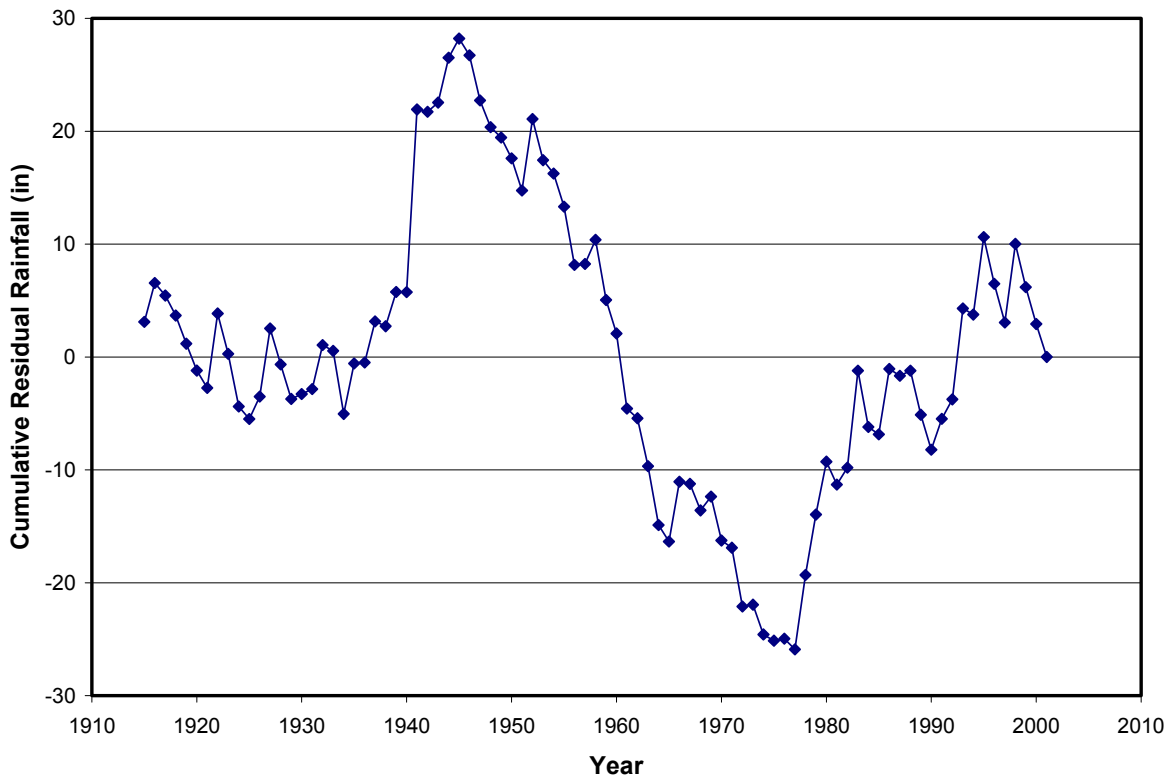


Figure 3. Cumulative Residual Rainfall at Lindberg Field, 1915-2001

located approximately 0.5 miles southeast of Oceanside Harbor, while that of the San Diego River adjoins the entrance to Mission Bay (Figure 1). These rivers were selected for analysis because they are among the largest in the study area, and because streamflow data are available for an extended period of record that includes the 2001 monitoring year.

Figure 4 presents the annual mean streamflow measured in each river between 1983 and 2001. In keeping with the rainfall data discussed in Section 2.1.1, the flow was well below average in 1999, 2000, and 2001. It should be noted that two substantial gaps exist in the data for the San Luis Rey: (1) October 1992-August 1993, and (2) November 1997-May 1998. Both of these periods were characterized by high flow rates in the San Diego River, suggesting that the true long-term average for the San Luis Rey is higher than that shown in Figure 4.

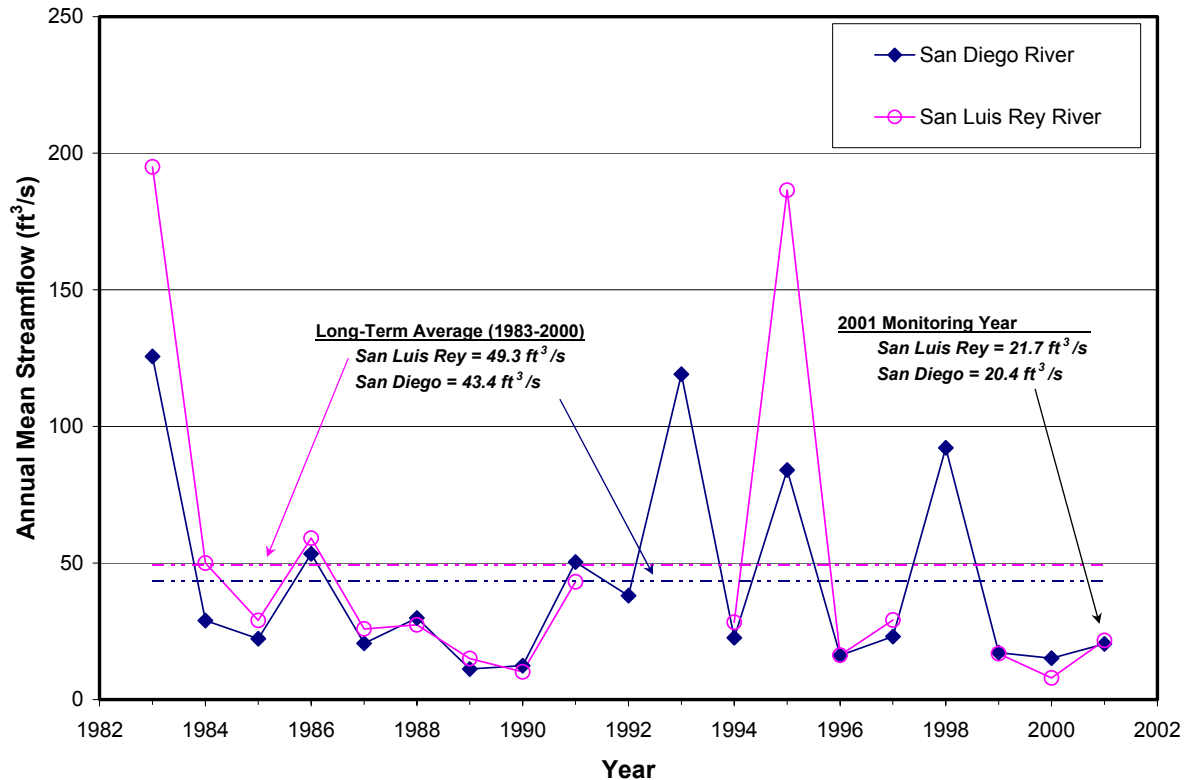


Figure 4. Annual Mean Streamflow in the San Luis Rey and San Diego Rivers, 1983-2001

Figures 5 and 6 compare the monthly mean streamflow in each river during the 2001 monitoring year with the long-term monthly mean values for the period 1983-2000. As in the case of the annual data presented in Figure 4, the monthly data indicate that 2001 was characterized by below-average flow rates. The long-term monthly values for the San Luis Rey would be higher than those shown in Figure 5 were it not for the two data gaps identified above.

2.1.3. Wave Climate

Two measures of the wave climate were used to compare the potential for sediment transport in 2001 with that in previous years: (1) total wave energy, and (2) the number of storm events. Although both measures are imperfect, they nevertheless provide a first-order basis for the desired inter-annual comparison.

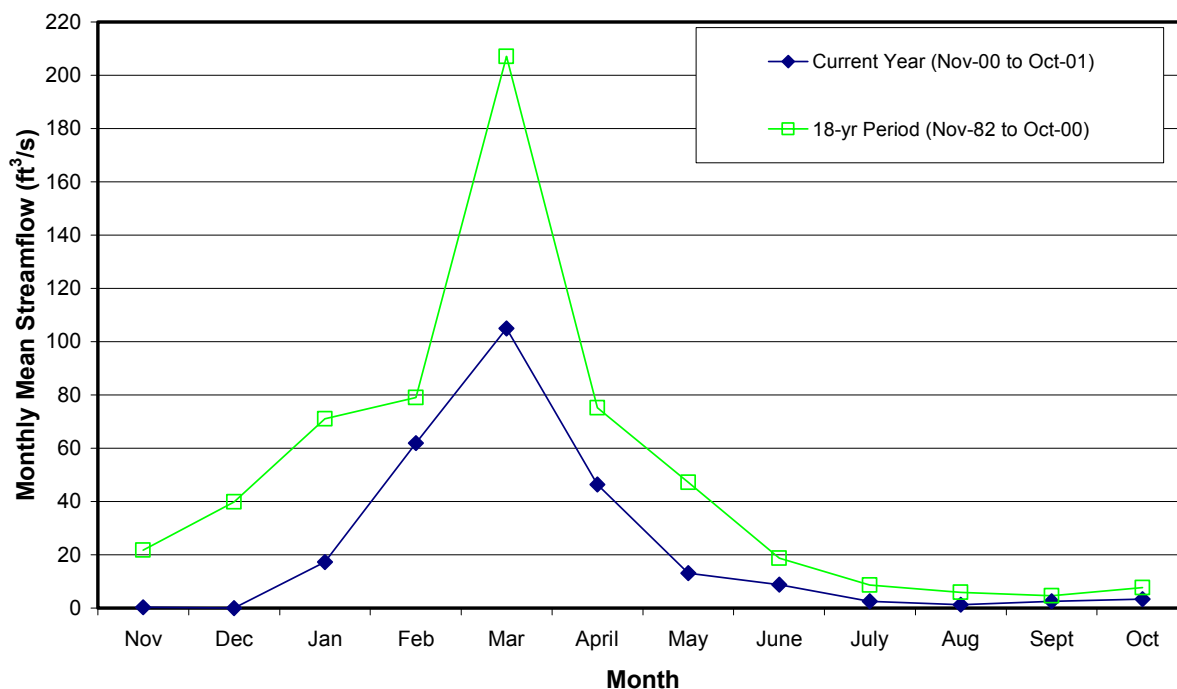


Figure 5. Monthly Mean Streamflow in the San Luis Rey River

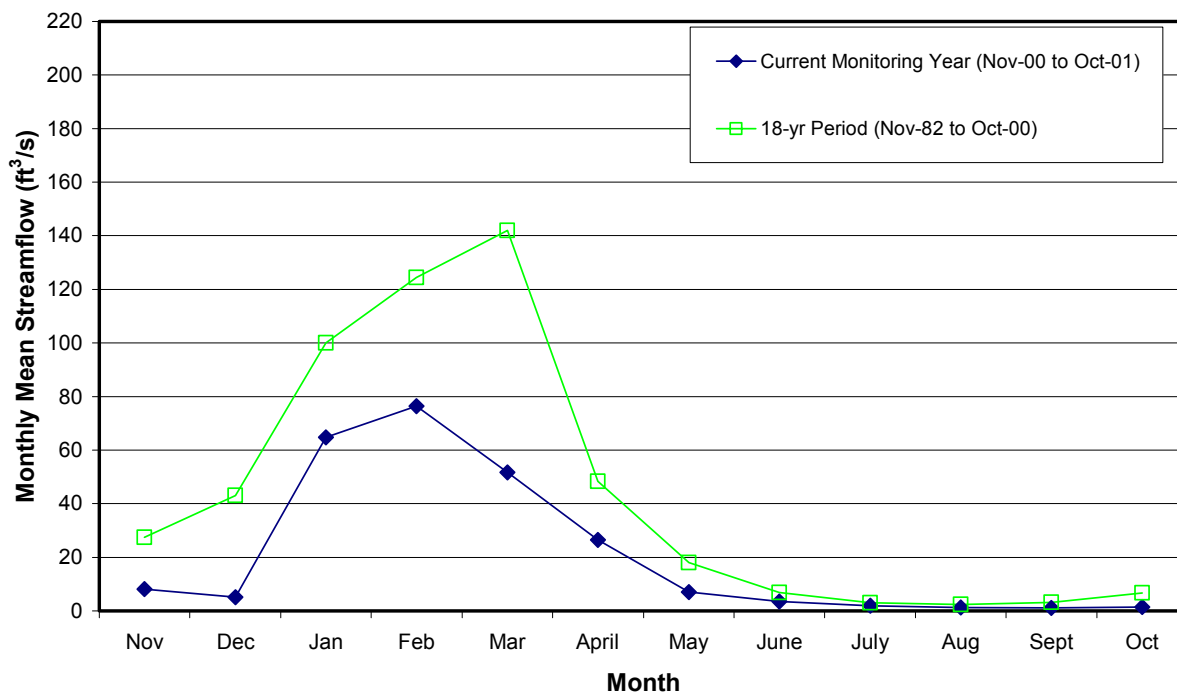


Figure 6. Monthly Mean Streamflow in the San Diego River

The analysis was undertaken with wave measurements acquired under the auspices of the Coastal Data Information Program (CDIP), which is operated by Scripps Institution of Oceanography (2002). The CDIP Oceanside Buoy was selected as the data source, primarily because the period of record (May 1997-present) exceeds that of the other offshore measurement stations in the area (Point La Jolla, Torrey Pines, and Dana Point).

The significant wave height (H_s), peak wave period (T_p), and wave direction recorded at the Oceanside Buoy during the 2001 monitoring year are presented as time series in Figure 7. Consistent with the seasonal wave climate in Southern California, northerly swell predominated from mid-November through February, and southerly swell from April through mid-October. March and mid-October through mid-November were transition periods. The most severe storms occurred during the winter months of January through March.

The total wave energy in 1998, 1999, 2000, and 2001 was compared using the Relative Incident Energy Index (E_r) introduced by Seymour (1998). This index is based on the following proportionality between the wave power per unit crest length (P) in deep water, the significant wave height (H_s) and the peak wave period (T_p):

$$P \sim H_s^2 T_p \quad (1)$$

The total energy per unit crest length (E) delivered in a year is found by integrating the wave power (P) over the time (t):

$$E = \int P \, dt \quad (2)$$

Using Equations (1) and (2) with the wave height expressed in meters, the wave period in seconds, and the duration in hours, Seymour defined E_r as follows:

$$E_r = E/1000 \quad (3)$$

The computed values of E_r are shown in Figure 8. Gaps in the Oceanside Buoy data, such as the May 2001 gap evident in Figure 7, were accounted for by assuming that the average wave power during the remainder of the year prevailed during the period lacking measurements. The highest Energy Index, with a value of 149, occurred during the 1998 El Niño year. The index then decreased with each successive year, dropping to 100 in 2001.

Figure 9 displays the number of storms per year with significant wave heights exceeding threshold values of 7 ft (2.1 m) and 10 ft (3.0 m). Once again, the most severe wave conditions occurred in 1998, when H_s exceeded 7 ft on sixteen occasions and 10 ft on six occasions. The 2001 monitoring year ranked third among the four years considered,

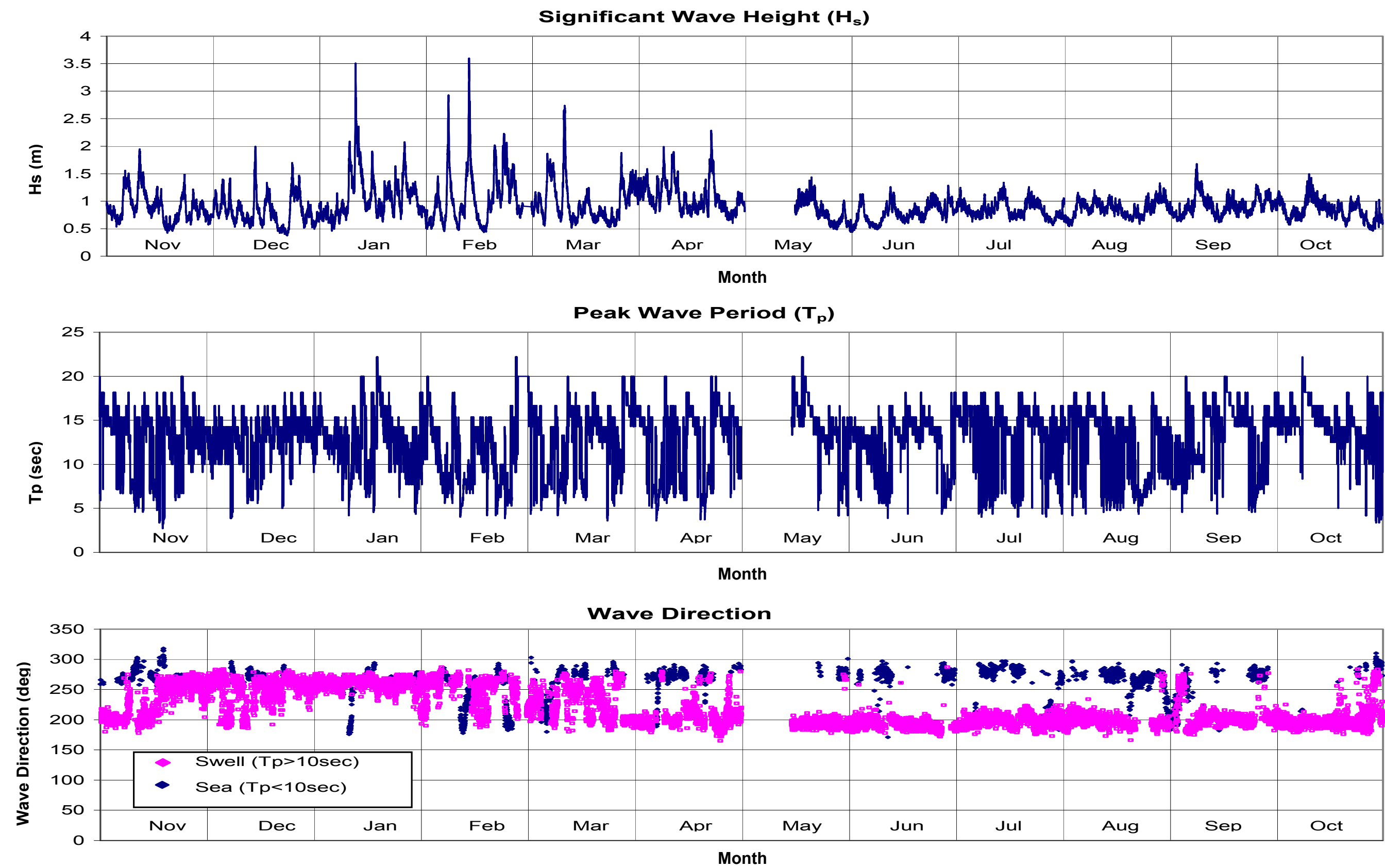


Figure 7. Wave Characteristics at the Oceanside Buoy, 2001 Monitoring Year

with H_s exceeding 7 ft on six occasions and 10 ft on only two occasions. The maximum significant wave height in 2001, 11.8 ft (3.60 m), occurred on February 13. Subsequent to the April 6 initiation of the RBSP nourishment operations, the maximum significant wave height was a modest 5.5 ft (1.68 m) that occurred on September 9 (Figure 7).

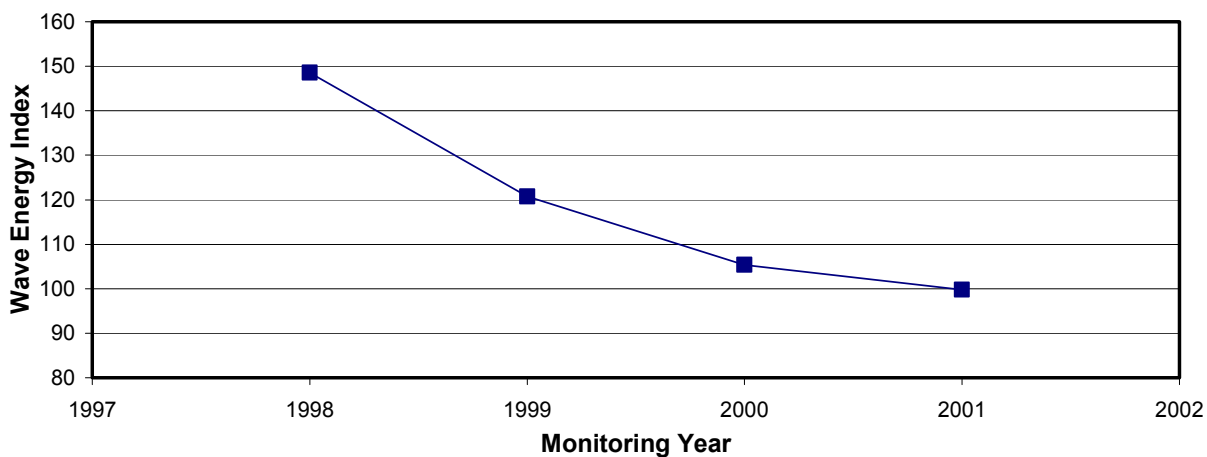


Figure 8. Relative Incident Energy Index at the CDIP Oceanside Buoy, 1998-2001

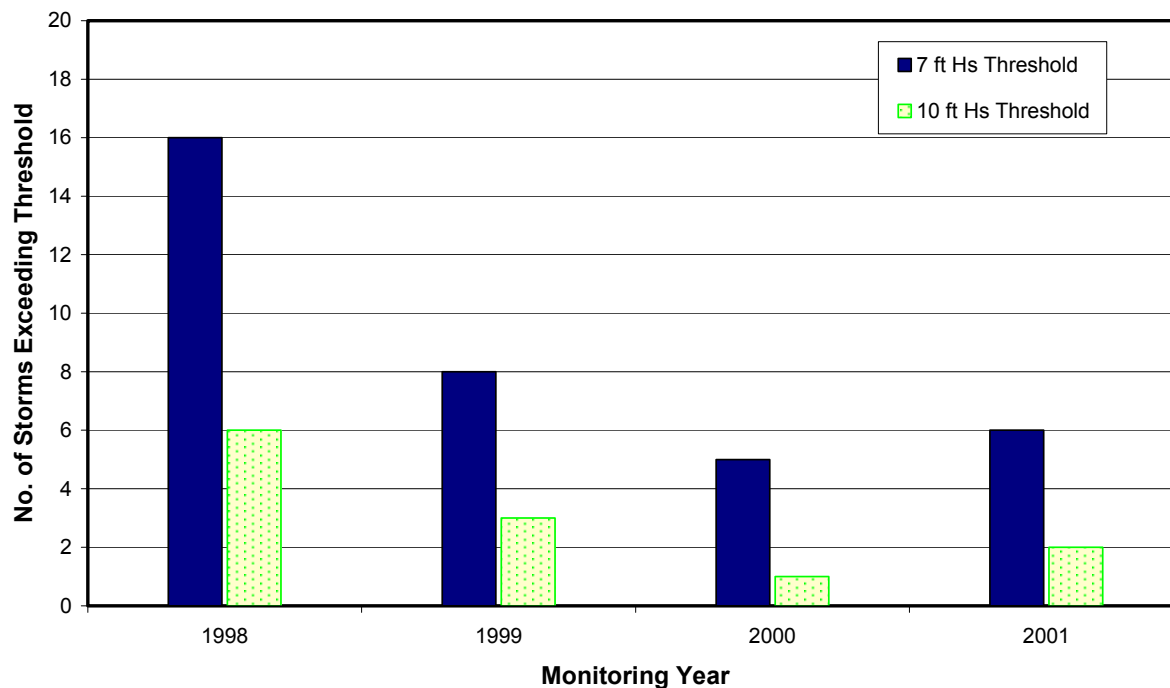


Figure 9. Storm Events per Year with Significant Wave Heights Exceeding 7 ft and 10 ft, 1998-2001

2.2. Human Intervention

Human activities that exert a significant influence on the San Diego County coast include beach nourishment projects such as the RBSP, and sand bypassing at littoral barriers such as Oceanside Harbor. The RBSP is discussed in Section 2.2.1, other nourishment projects in Section 2.2.2, and sand bypassing in Section 2.2.3.

2.2.1. Regional Beach Sand Project

In 1993, SANDAG adopted a comprehensive plan for erosion mitigation known as the “Shoreline Preservation Strategy for the San Diego Region.” The Strategy proposed an extensive beach building and maintenance program to provide for environmental quality, recreation, and storm protection in the coastal zone. Following a number of modest beach nourishment projects that were undertaken primarily on an opportunistic basis (i.e., when sand became available from other sources), the Regional Beach Sand Project (RBSP) was conceived as a more comprehensive approach to restoring the County’s sand-starved beaches.

Between April 6 and September 23, 2001, the RBSP provided 2.1 million cubic yards (cy) of beach-quality sand to twelve receiver beaches located between Imperial Beach and Oceanside. The material was excavated from six offshore borrow areas using a trailing suction hopper dredge, and pumped onto the subaerial portion of each receiver beach (Noble, 2002). Once on the beach, the sand was shaped to the design configuration using conventional earth-moving equipment. The median grain size (d_{50}) varied considerably among the borrow areas, ranging from 0.14 mm (fine sand) to 0.62 mm (coarse sand) (Noble Consultants, 2001).

Table 1 provides the volume, dimensions, and median grain size of each beach fill, along with the construction period. The majority of the sand, 1.8 million cy, was used to nourish ten receiver beaches in the Oceanside Littoral Cell. The nourishment quantities at these sites ranged from 421,000 cy at Oceanside to 101,000 cy at Cardiff. In the Mission Beach Cell, 151,000 cy were placed at Mission Beach; in the Silver Strand Cell, 120,000 cy were placed at Imperial Beach.

2.2.2. Other Nourishment Projects

A number of beach nourishment projects were undertaken in San Diego County prior to the RBSP. Nearly all of these depended on “sand of opportunity” that was derived

Table 1. RBSP Beach Fills

Littoral Cell	Receiver Beach	Fill Characteristics				Construction
		Volume (cy)	Length (ft)	Width (ft)	d ₅₀ (mm) ⁽¹⁾	Period
Silver Strand	Imperial Bch	120,000	2300	120	0.24-0.52	5/22 - 6/04
	Total Nourishment in Silver Strand Cell = 120,000 cy					
Mission Beach	Mission Bch	151,000	2300	200	0.52	5/10 – 5/21
	Total Nourishment in Mission Beach Cell = 151,000 cy					
Oceanside	Torrey Pines	245,000	1600	160	0.14	4/06 – 4/27
	Del Mar	183,000	3200	120	0.14	4/27 – 5/10
	Fletcher Cove	146,000	1900	70	0.14	6/15 – 6/24
	Cardiff	101,000	900	150	0.34	8/02 – 8/10
	Moonlight Bch	105,000	1100	180	0.34-0.62	8/10 – 8/16
	Leucadia	132,000	2700	120	0.62	6/04 – 6/15
	Batiquitos	117,000	1500	180	0.62	8/16 – 8/23
	S. Carlsbad	158,000	2000	180	0.62	6/25 – 7/06
	N. Carlsbad	225,000	3100	100	0.14-0.62	7/06 – 8/02
	Oceanside	421,000	4400	185	0.62	8/24 – 9/23
	Total Nourishment in Oceanside Cell = 1,833,000 cy					
Total RBSP Nourishment = 2,104,000 cy						

Note: ⁽¹⁾ d₅₀ represents median grain size of fill material.

Source: Noble Consultants, 2001

from projects whose primary motive was not beach replenishment. The primary sources of opportunistic nourishment were the dredge spoils associated with lagoon restoration and harbor maintenance.

Nourishment projects conducted in the seven-year period from November 1993 through October 2000 are summarized below by littoral cell. This time period was selected because it commences with the adoption of SANDAG's Shoreline Preservation Strategy and concludes just prior to the inception of the RBSP. With the exception of the RBSP and a 1,000-cy fill at Moonlight Beach, no nourishment projects were undertaken during the 2001 monitoring year.

Silver Strand Littoral Cell

Five opportunistic beach nourishment projects were undertaken in the Silver Strand Littoral Cell during the seven-year period that preceded the RBSP. One was associated with lagoon enhancement at the Tijuana Estuary, while the other four originated with construction and maintenance activities in San Diego Harbor. As shown in Table 2, these projects resulted in an average annual nourishment rate of 73,000 cubic yards/year (cy/yr) for the littoral cell.

**Table 2. Beach Nourishment in the Silver Strand Littoral Cell,
November 1993 through October 2000**

Project	Date	Sediment Source	Placement Location	Nourishment Quantity (cy)
U.S. Navy Pier 2 Dredging	1995	San Diego Harbor	Imperial Beach (nearshore)	233,000
U.S. Coast Guard Ballast Point Dredging	1995	San Diego Harbor	Imperial Beach (nearshore)	41,000
SIO Nimitz Marine Facility Dredging	1996	San Diego Harbor	Imperial Beach (nearshore)	47,000
San Diego Harbor Maintenance Dredging	1996	San Diego Harbor	Silver Strand State Beach (nearshore)	175,000
Tijuana Estuary Tidal Restoration Project	1997	Tijuana Estuary	South of River Mouth	18,000
<i>Average Annual Nourishment Rate in the Silver Strand Cell = 73,000 cy/yr</i>				

Source: SANDAG, 1996 and 1999; Sachs, 2002

Mission Beach Littoral Cell

Nourishment activity in the Mission Beach Cell preceding the RBSP was limited to the placement of approximately 12,000 cubic yards of sand off of Mission Beach as part of the aborted U.S. Navy Homeporting Project. This small amount equates to an average annual nourishment rate of about 2,000 cy/yr for the 1993-2000 period of interest.

Oceanside Littoral Cell

Eight nourishment projects, seven of which were opportunistic, were undertaken in the Oceanside Cell between 1993 and 2000. As enumerated in Table 3, the total volume of 2.75 million cubic yards was equivalent to an average annual nourishment rate of

**Table 3. Beach Nourishment in the Oceanside Littoral Cell
November 1993 through October 2000**

Project	Date	Sediment Source	Placement Location	Nourishment Quantity (cy)
Batiquitos Lagoon Enhancement	1994-97	Batiquitos Lagoon	Carlsbad	1,800,000
Descanso/Carlsbad Blvd. Lot Division	1994	Inland	Carlsbad	20,000
Santa Margarita River Desiltation	1995	River Mouth	Oceanside	40,000
Moonlight Beach Nourishment	1996-2000	Inland (non-opportunistic)	Encinitas	5,000
U.S. Navy Homeporting	1997	North Island	Oceanside	102,000
			Del Mar (nearshore)	170,000
Sand-for-Trash Pilot Program	1997	Inland	Oceanside	1,000
Agua Hedionda Facilities Modification	1998	Agua Hedionda Lagoon	Carlsbad	560,000
North County Commuter Rail Project	1999	Inland	Solana Beach	54,000
<i>Average Annual Nourishment Rate in the Oceanside Cell (Nov 93 – Oct 00) = 393,000 cy/yr</i>				

Source: SANDAG, 1996, 1999; Sachs, 2002

393,000 cy/yr. Nearly two thirds of the material was derived from the Batiquitos Lagoon restoration project, which provided 1.8 million cubic yards for beach replenishment in Carlsbad. The only non-opportunistic beach fill activity occurred at Moonlight Beach, where approximately 1,000 cy of purchased sand was placed each year from 1996 through 2000.

2.2.3. Sand Bypassing

Sand bypassing is used to return sediment to the littoral system that has been trapped by coastal features such as harbors, lagoon entrances, and jetties. Although bypassing does not increase the quantity of sediment in the littoral system, it plays a crucial role in maintaining the distribution of sediment within that system. Because sediment trapping is an ongoing process, bypassing operations typically are conducted at periodic intervals.

Bypassing is not undertaken in the Silver Strand and Mission Beach Cells, but occurs at Batiquitos Lagoon, Agua Hedionda Lagoon, and Oceanside Harbor in the Oceanside Cell. The bypassing operations at Batiquitos were initiated in 1997 following lagoon restoration, while the bypassing operations at Agua Hedionda and Oceanside Harbor have been performed on a regular basis for decades. The sediment quantities bypassed at each site between November 1993 and October 2000 are presented in Table 4. Relatively high bypass rates, averaging 237,000 and 143,000 cy/yr, were maintained at Oceanside and Agua Hedionda, respectively. The rate at Batiquitos was far lower, at 2,000 cy/yr.

**Table 4. Sand Bypassing in the Oceanside Littoral Cell
November 1993 through October 2000**

Bypass Project	Date	Placement Location	Bypass Quantity (cy)
Batiquitos Lagoon	1999	South of Entrance	11,000
	2000	South of Entrance	4,000
	<i>Average Annual Bypass Rate at Batiquitos Lagoon = 2,000 cy/yr</i>		
Agua Hedionda Lagoon	1994	Carlsbad	159,000
	1996	Carlsbad	443,000
	1997	Carlsbad	197,000
	1999	Carlsbad	203,000
	<i>Average Annual Bypass Rate at Agua Hedionda Lagoon = 143,000 cy/yr</i>		
Oceanside Harbor	1994	Oceanside	483,000
	1995	Oceanside	177,000
	1996	Oceanside	162,000
	1997	Oceanside	129,000
	1998	Oceanside	254,000
	1999	Oceanside	172,000
	2000	Oceanside	285,000
	<i>Average Annual Bypass Rate at Oceanside Harbor = 237,000 cy/yr</i>		

Source: Dillingham, 2002; Tucker, 2002

During the 2001 monitoring year, the bypass volumes were 45,000 cy at Batiquitos, 429,000 cy at Agua Hedionda, and 80,000 cy at Oceanside Harbor. All of the bypass work was completed prior to or concurrent with the start of the RBSP nourishment activities.

2.3. The Year in Perspective

Table 5 compares the environmental conditions that prevailed during the 2001 monitoring year with those in the past. Both precipitation and streamflow were well below average, while the wave conditions were relatively mild. The implications of these circumstances are threefold:

- The absence of large wave events during the Summer and Fall seasons helped to prolong the life of the RBSP beach fills.
- The scant precipitation and low streamflows failed to deliver significant quantities of beach-quality sediment to the coast in the winter months that preceded the RBSP nourishment activities.
- The low streamflows failed to flush coastal sediment from the lagoon entrances in the Oceanside Cell.

Table 5. 2001 Environmental Conditions vs. Historical Averages

Parameter	Historical Average	2001 Monitoring Year	Percent of Average ⁽⁴⁾
Precipitation ⁽¹⁾ (in.)	10.3	7.3	71%
Streamflow ⁽²⁾ (cfs)			
<i>San Diego River</i>	43.4	20.4	47%
<i>San Luis Rey River</i>	49.3	21.7	44%
Wave Climate ⁽³⁾			
<i>Energy Index</i>	125	100	80%
<i>Storms w/ $H_s > 7$ ft</i>	9.7	6	62%
<i>Storms w/ $H_s > 10$ ft</i>	3.3	2	60%

Notes: ⁽¹⁾ Historical Average Precipitation based on the period 1915-2000.

⁽²⁾ Historical Average Streamflow based on the period 1983-2000.

⁽³⁾ Historical Average Energy Index and Storms based on the period 1998-2000.

⁽⁴⁾ Percent of Average derived by dividing the 2001 Monitoring Year value by the Historical Average value.

In Table 6, the beach nourishment volume provided to each littoral cell in 2001 is compared with the average annual volume provided during the seven prior monitoring years. To aid in assessing the significance of the RBSP, comparisons are made both with and without the RBSP fill quantities.

As indicated above, the only non-RBSP nourishment project undertaken during the 2001 monitoring year was a 1,000 cy fill at Moonlight Beach. As a result, 467,000 cy of the RBSP fill material (about 22%) served to compensate for the average annual nourishment

Table 6. 2001 Beach Nourishment Volumes vs. Historical Averages

Littoral Cell	Historical Average ⁽¹⁾ (cy/yr)	2001 Monitoring Year (cy)		Difference ⁽²⁾ (cy)	
		Without RBSP	With RBSP	Without RBSP	With RBSP
Silver Strand	73,000	0	120,000	(73,000)	+47,000
Mission Beach	2,000	0	151,000	(2,000)	+149,000
Oceanside	393,000	1,000	1,834,000	(392,000)	+1,441,000
Total	468,000	1,000	2,105,000	(467,000)	+1,637,000

Notes: ⁽¹⁾ Historical Average based on the period 1993-2000.

⁽²⁾ Difference derived by subtracting the Historical Average value from the 2001 Monitoring Year value.

provided from other sources in prior years. The remaining RBSP material, 1,637,000 cy, represented incremental nourishment. The incremental volume was relatively small in the Silver Strand Cell (47,000 cy), moderate in the Mission Beach Cell (149,000 cy) and large in the Oceanside Cell (1.4 million cy).

The 2001 sand bypass volumes at Batiquitos, Agua Hedionda, and Oceanside Harbor are compared with the average values from the seven prior monitoring years in Table 7. The 2001 volumes were well above average at the two lagoon entrances, and well below average at the harbor. The unusually large volumes at the lagoon entrances cannot be attributed to the RBSP, because the bypass work was conducted prior to or concurrent with the start of the nourishment activities.

Table 7. 2001 Sand Bypassing Volumes vs. Historical Averages

Location	Historical Average ⁽¹⁾ (cy/yr)	2001 Monitoring Year (cy)	Difference ⁽²⁾ (cy)
Batiquitos	2,000	45,000	43,000
Agua Hedionda	143,000	429,000	286,000
Oceanside Harbor	237,000	80,000	(157,000)

Notes: ⁽¹⁾ Historical Average based on the period 1993-2000.

⁽²⁾ Difference derived by subtracting the Historical Average value from the 2001 Monitoring Year value.

The implications of the bypass data in Table 7 are as follows:

- The beaches adjacent to the Batiquitos and Agua Hedionda Lagoon entrances benefited from the increased bypass volumes at these sites.
- The beaches at Oceanside and North Carlsbad were negatively impacted by the decreased bypass volume at Oceanside Harbor.

3. MONITORING METHODS

As indicated in Section 1, the general objective of the 2001 Regional Beach Monitoring Program was to detect changes in the condition of the shorezone between the U.S.-Mexican Border and Oceanside Harbor. The specific focus was to track the performance of the twelve RBSP beach fills, including their positive impacts on beach condition and their potentially negative impacts on lagoon entrances.

Although the two program components, beach monitoring and lagoon entrance monitoring, resembled those in prior years, both were expanded to develop more detailed information about the outcome of the RBSP. The underlying rationale was to provide coverage of each of the twelve receiver beaches, enhanced coverage of four of these fill sites (North Carlsbad, Leucadia, Mission Beach, and Imperial Beach), and enhanced coverage of the three unstabilized lagoon entrances in the Oceanside Cell (San Elijo, San Dieguito, and Los Peñasquitos).

Data acquisition and reduction under each program component are described in the subsections that follow.

3.1. Beach Monitoring

The beach monitoring component consisted of semi-annual beach profile surveys, semi-annual oblique aerial photography, and monthly beach width measurements. The beach profiling and aerial photography were performed by Coastal Frontiers personnel, while the beach width measurements were made by representatives of the cities in whose jurisdictions the beaches were located.

3.1.1. Beach Profile Surveys

Beach profile data were obtained in the Spring and Fall of 2001, corresponding to the transitions between the summer and winter wave seasons. To address the expanded monitoring requirements associated with the RBSP, the number of survey transects was increased from 33 in prior years to 58 in 2001. Of the 25 sites added to the program, thirteen were newly-established for the express purpose of documenting changes at the RBSP receiver beaches, and twelve represented pre-existing transects monitored by the cities of Carlsbad (seven transects) and Encinitas (five transects). The cities' contribution of data at these sites is gratefully acknowledged by SANDAG. The locations of all 58 transects are listed in Table 8 and illustrated in Figures 10a and 10b.

Table 8. Beach Profile Transect Locations

	TRANSECT ⁽⁴⁾	LOCATION	SPONSOR	TRANSECT ⁽⁴⁾	LOCATION	SPONSOR
Silver Strand Littoral Cell	SS-0003	Tijuana Estuary	SANDAG	SS-0035 ⁽³⁾	Imperial Beach	SANDAG
	SS-0007	Tijuana Estuary	SANDAG	SS-0050 ^(2,3)	Imperial Beach	SANDAG
	SS-0015 ⁽³⁾	Imperial Beach	SANDAG	SS-0077	Silver Strand	SANDAG
	SS-0020 ^(1,2,3)	Imperial Beach	SANDAG	SS-0090	Silver Strand	SANDAG
	SS-0025 ^(1,2,3)	Imperial Beach	SANDAG	SS-0160	Coronado	SANDAG
Mission Beach Littoral Cell	OB-0230	Ocean Beach	SANDAG	MB-0384 ⁽³⁾	Mission Beach	SANDAG
	MB-0310 ⁽³⁾	Mission Beach	SANDAG	PB-0408	Pacific Beach	SANDAG
	MB-0320 ^(2,3)	Mission Beach	SANDAG			
	MB-0335 ^(1,2,3)	Mission Beach	SANDAG			
	MB-0340 ^(1,3)	Mission Beach	SANDAG			
Oceanside Littoral Cell	LJ-0443	La Jolla	SANDAG	SD-0700 ⁽³⁾	Grandview	SANDAG
	LJ-0450	La Jolla	SANDAG	SD-0710 ^(1,2)	Batiquitos	Encinitas
	LJ-0445	La Jolla	SANDAG	CB-0720	Batiquitos	SANDAG
	LJ-0460	Scripps Pier	SANDAG	CB-0740	South Carlsbad	Carlsbad
	TP-0470	Blacks Beach	SANDAG	CB-0760	Ponto Beach	SANDAG
	TP-0520 ⁽¹⁾	Torrey Pines	SANDAG	CB-0775 ^(1,2)	South Carlsbad	SANDAG
	TP-0530 ⁽¹⁾	Torrey Pines	SANDAG	CB-0780	Carlsbad	Carlsbad
	DM-0565 ⁽²⁾	South Del Mar	SANDAG	CB-0800	Carlsbad	Carlsbad
	DM-0580 ⁽¹⁾	Del Mar	SANDAG	CB-0820	Aqua Hedionda	Carlsbad
	DM-0590	Del Mar	SANDAG	CB-0830	Carlsbad	SANDAG
	SD-0600 ⁽¹⁾	Fletcher Cove	SANDAG	CB-0840 ⁽³⁾	Carlsbad	Carlsbad
	SD-0620	Seaside Park	Encinitas	CB-0850 ⁽³⁾	Carlsbad	Carlsbad
	SD-0625	San Elijo	Encinitas	CB-0865 ^(1,2,3)	Carlsbad	SANDAG
	SD-0630 ⁽¹⁾	Cardiff	SANDAG	CB-0880 ^(1,3)	Buena Vista	SANDAG
	SD-0650	San Elijo Park	Encinitas	OS-0900 ⁽³⁾	Oceanside	Carlsbad
	SD-0660	Swami's	Encinitas	OS-0915 ^(1,2)	Oceanside	SANDAG
	SD-0670 ^(1,3)	Moonlight Beach	SANDAG	OS-0930 ⁽¹⁾	Buccaneer Bch	SANDAG
	SD-0675 ^(2,3)	Stone Steps	SANDAG	OS-1000	Oceanside	SANDAG
	SD-0680 ⁽³⁾	Beacons	SANDAG	OS-1030	Oceanside	SANDAG
	SD-0690 ^(1,2,3)	Leucadia	SANDAG	OS-1070	Oceanside	SANDAG
	SD-0695 ^(2,3)	Leucadia	SANDAG			

Notes: ⁽¹⁾ Transect crosses RBSP nourishment site (shown in red type).

⁽²⁾ New transect established to support RBSP in Spring 2001.

⁽³⁾ Transect used for monthly beach width measurements.

⁽⁴⁾ Transect locations shown in Figures 10a and 10b.

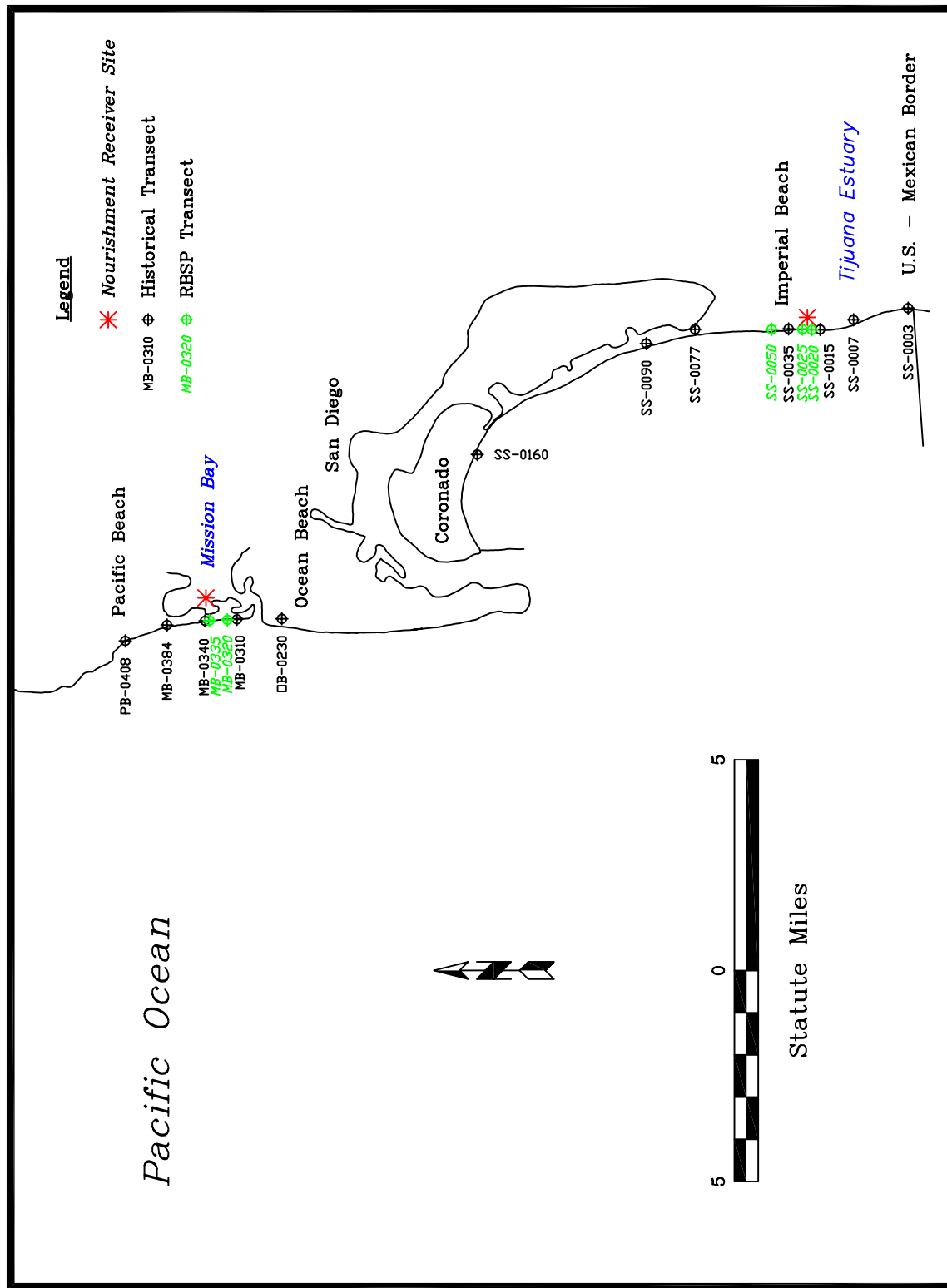


Figure 10a. Beach Profile Transects in the Silver Strand and Mission Beach Littoral Cells

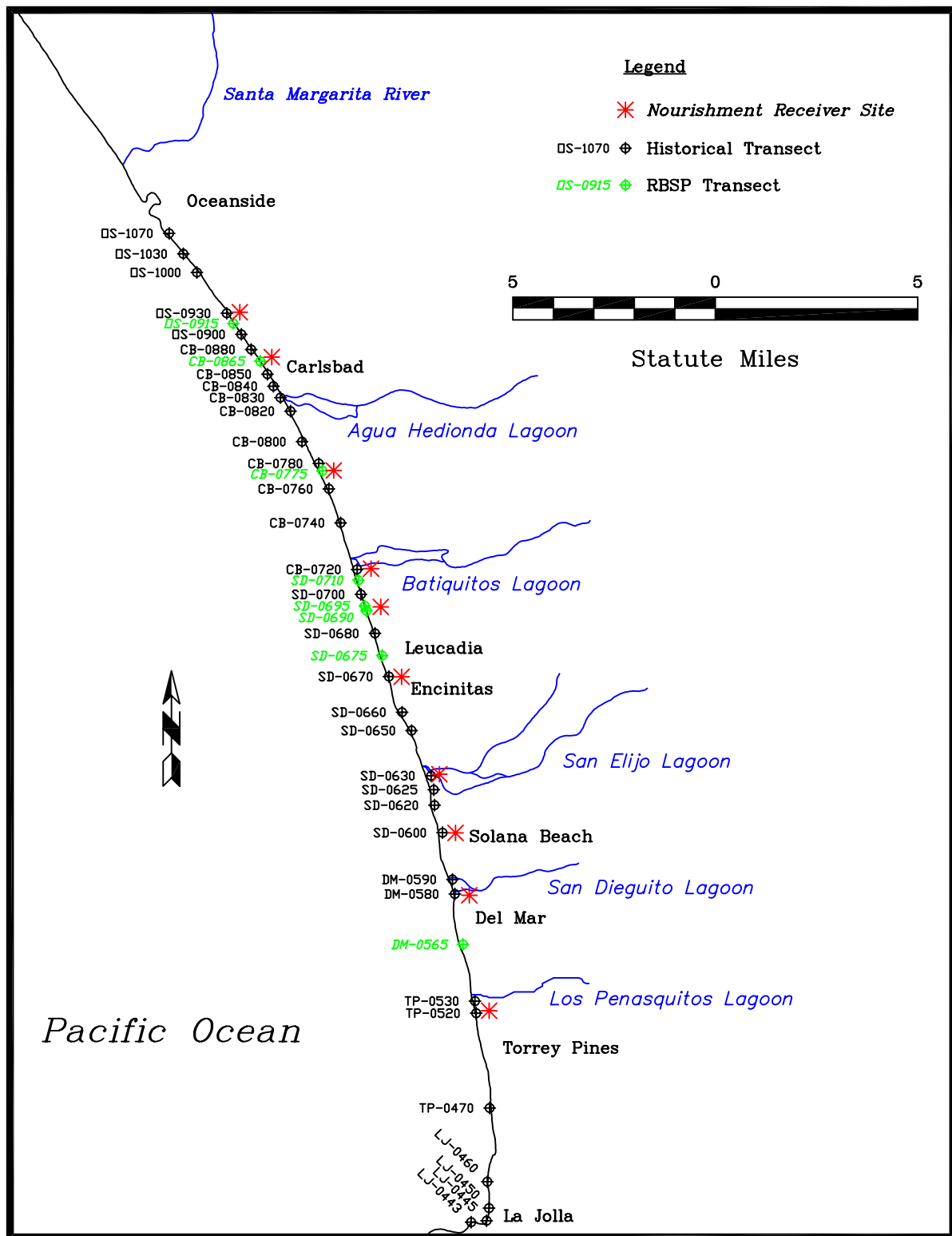


Figure 10b. Beach Profile Transects and Lagoons Entrances in the Oceanside Littoral Cell

The Spring beach profiling activities typically are conducted in late April or early May, after the end of the Winter storm season. In 2001, however, the start date was advanced to March 26 to document the pre-nourishment condition of the beaches. Unfortunately, the heavy surf conditions that prevailed at the time precluded all field activities. To insure that pre-RBSP profiles would be available for the first two sites scheduled to receive nourishment, data were acquired under marginal wave conditions on April 5 and 6 at Torrey Pines (Transects TP-0520 and TP-0530) and Mission Beach (MB-0335 and MB-0340).

Following a return to stable weather conditions, beach profiles were obtained at all 58 transects (including those surveyed on April 5-6) between April 23 and April 27. This time period followed the completion of sand placement at Torrey Pines, but preceded the nourishment activities at the other eleven receiver beaches. In consequence, the April 23-27 data depict the beach condition prior to nourishment at all transects except TP-0520 and TP-0530, and the April 5-6 data represent the pre-nourishment condition at these two sites.

The Fall 2001 profile work was conducted between October 16 and 22 under ideal conditions. The winds were light, while the waves typically were less than 3 ft. The data obtained during this survey followed the completion of the first RBSP fill at Torrey Pines by six months, and the completion of the last fill at Oceanside by one month.

The data acquisition and processing methods used for the 2001 profile surveys are described below. Because these methods are identical to those employed in previous SANDAG and city monitoring programs (Leidersdorf, *et al.*, 1999), the results are directly comparable.

Data Acquisition

The wading and bathymetric portions of the survey were performed concurrently by two crews. Data were acquired along each transect from the survey monument to an offshore limit that ranged from the 35-ft isobath in the Silver Strand Cell to the 50-ft isobath in the northern portion of the Oceanside Cell. Each survey monument was located at the back beach, while each offshore limit was located seaward of the "depth of closure" indicated by prior survey data. (The depth of closure is the depth at which sediment transport is not substantially affected by littoral processes.)

The beach and surf zone were surveyed using an electronic total station and a survey rodman. The total station was used to determine the position and elevation of the beach at each location occupied by the rodman. Each transect was surveyed from the back beach seaward through the surf zone until the survey rod no longer protruded above the water

surface when held erect. This location, typically in a water depth of 10 to 12 ft below MLLW, provided substantial overlap with the landward portion of the bathymetric survey.

Bathymetric data were acquired with a digital acoustic echo sounder operated from a shallow-draft inflatable survey vessel. The boat transited each transect from the offshore limit to the surf zone guided by GPS navigation. Soundings were acquired continuously and correlated with the vessel position at 10-second intervals, or approximately every 60 ft. The positions were obtained with a GPS receiver, which utilizes a network of navigational satellites maintained by the U.S. Government. To improve the accuracy of each position fix, differential corrections transmitted in real-time by U.S. Coast Guard base stations were utilized. The calibration of the echo sounder was checked at the beginning and end of each survey session, and at periodic intervals during each session, using a standard “bar check” procedure.

Data Processing

The data from the wading portion of the survey were processed using software developed by Spectra Precision Software. The raw total station data were read by the software, and the coordinates and elevation of each data point were calculated and inserted into a CAD drawing.

To minimize the influence of wave contamination on the bathymetric portion of the survey, a smooth line was faired through the echo sounder record. The record then was digitized at each position fix. An additive correction was computed and applied to the digitized soundings based on the results of the bar check calibration procedure. Finally, the corrected soundings were adjusted to MLLW datum using the water levels recorded at the National Ocean Service tide gauge on Scripps Pier in La Jolla.

The adjusted soundings were merged with the corresponding differentially-corrected position data. The resulting x, y, z triplets (northing, easting, and elevation) were inserted into the CAD drawing containing the wading data. As indicated above, the field work was conducted in such a manner as to provide substantial overlap between the wading and bathymetric portions of the survey. The processed data were examined in this region to insure that the two data sets were compatible. Once this confirmatory inspection had been completed, the data were merged and the bathymetric data were deleted from the region of overlap in favor of the more accurate wading data. The soundings then were projected onto the transect alignment, and the resulting range and elevation data were used to create continuous beach profile plots.

Based on past experience, the accuracy of the processed soundings is approximately ± 0.5 ft. According to the GPS equipment specifications, the root mean square (RMS) accuracy of horizontal positions obtained in the manner described above is 3.1 ft. As indicated earlier, the wading data are inherently more accurate than the bathymetric data. The electronic total station used to conduct the survey is capable of measuring ranges to within ± 0.5 ft and elevation differences to within ± 0.1 ft. However, because the swimmer was required to negotiate waves and currents in the surf zone, the horizontal accuracy perpendicular to each transect (parallel to the shoreline) varied from minimal at short ranges to approximately ± 15 ft at the seaward end of the wading data.

3.1.2. Aerial Photography

To augment the beach profile data, oblique aerial photographs of the twelve RBSP receiver sites were obtained at approximately the same time as the Spring and Fall Surveys. The photographs were taken from a fixed-wing aircraft circling each site at altitudes of 500 to 1,000 ft.

The Spring 2001 photo mission was flown on April 4, two days prior to the commencement of the beach nourishment activities at Torrey Pines. Although the Fall Survey was undertaken during the third week in October, the corresponding photo mission was delayed until November 13 in deference to the security measures instituted after the terrorist attacks of September 11.

3.1.3. Beach Width Measurements

Monthly beach width measurements were initiated by the cities of Carlsbad, Encinitas, San Diego, and Imperial Beach in 2001 to provide secondary information on the performance of the RBSP fill material at the North Carlsbad, Leucadia, Mission Beach, and Imperial Beach receiver sites. The measurements were made by city personnel at five beach profile transects associated with each of the North Carlsbad, Mission Beach, and Imperial Beach fills, and at six transects associated with the Leucadia fill (a total of 21 transects, each of which is identified in Table 1). Data acquisition commenced on May 31 at Imperial Beach, June 1 at Mission Beach and North Carlsbad, and July 13 at Leucadia.

Prior to the start of the measurement program, the individuals involved were provided with equipment, training, written instructions, and forms for data acquisition. The instructions specified that data were to be obtained monthly, at a time when the predicted tide height was 1 to 3 ft above MLLW. The beach width was to be measured from a permanent marker on the back beach to the estimated intersection of the still water level and

the beach face. In addition, the foreshore slope was to be measured just above the still water level and recorded along with the date and time of the observation.

After the end of the 2001 monitoring period, the data were transmitted to Coastal Frontiers for processing. Each measurement was adjusted to approximate the MSL beach width using the corresponding foreshore slope and the still water level recorded at the NOS tide gauge on Scripps Pier. Measurements obtained when the still water level was less than +1 ft (MLLW) were removed from the data set, because the mild beach slopes that typically prevail below that elevation produce inaccurate estimates of the MSL beach width.

3.2. Lagoon Entrance Monitoring

The 2001 lagoon monitoring effort included semi-annual surveys and oblique aerial photography at the entrances to Agua Hedionda, Batiquitos, San Elijo, San Dieguito, and Los Peñasquitos Lagoons. In addition, the unstabilized entrance channels at San Elijo, San Dieguito, and Los Peñasquitos were inspected and photographed on a monthly basis. The surveys and aerial photography were performed by Coastal Frontiers; the monthly channel inspections were undertaken by SANDAG. Each of the three components is described in a separate subsection below

3.2.1. Topographic Surveys

The lagoon entrance surveys were conducted in the Spring and Fall in conjunction with the beach profile data collection activities. The Spring work was performed on April 18 and 19, while the Fall work was performed between October 12 and 22.

In the case of Agua Hedionda and Batiquitos Lagoons, where the entrances are stabilized by jetties, an electronic total station and conventional wading techniques were used to obtain two profiles across each channel. One profile was located at the jetty tips, while the other was located at the seaward edge of the coast road bridge.

At San Elijo, San Dieguito, and Los Peñasquitos Lagoons, which lack stabilizing jetties, the condition of each entrance channel was documented by obtaining topographic data from wading depth in the ocean to wading depth in the lagoon. Particular emphasis was placed on areas perceived either to control tidal access (“sills”) or to contain shoals. As in the case of the jetty-protected entrance channels, the data were obtained using an electronic total station and conventional wading techniques.

All of the lagoon entrance data were processed in the manner described above for the wading portion of the beach profile surveys.

3.2.2. *Aerial Photography*

Oblique aerial photographs of the five lagoon entrances were obtained in the Spring and Fall, during the same missions used to photograph the RBSP receiver sites (April 4 and November 13). As described in Section 3.1.2, the work was performed from a fixed-wing aircraft that circled each site at altitudes of 500 to 1000 ft.

To facilitate the discovery of shoals in the entrance channels, each photo mission was undertaken during a period of low tidal elevations. The water levels ranged from -0.4 to +0.3 ft (MLLW) during the Spring overflight, and -0.4 to +0.9 ft during the Fall overflight.

3.2.3. *Monthly Inspections*

Monthly inspections of the entrances to San Elijo, San Dieguito, and Los Peñasquitos Lagoons were added to the SANDAG Monitoring Program in 2001 to provide a greater understanding of the condition of each channel after placement of the RBSP fill material. In addition to photographs from repeatable locations, the inspections included notes on whether the channels were open to tidal exchange.

4. MONITORING DATA

This section presents the results of the 2001 Regional Beach Monitoring Program, consisting of direct measurements and computed values. Many of the data products represent updated versions of those appearing in prior annual reports (Coastal Frontiers, 1997; 1998; 1999; 2000; 2001), while others have been introduced for the first time in 2001. The data derived from the beach component of the monitoring work are described in Section 4.1, while those derived from the lagoon entrance component are described in Section 4.2.

4.1. Beach Data

As described in Section 3.1, beach data acquisition consisted of semi-annual profile surveys, semi-annual oblique aerial photography, and monthly beach width measurements. The results of these activities are provided in Sections 4.1.1 through 4.1.3.

4.1.1. Beach Profile Data (*Appendices A-F*)

The 2001 beach profile data were used in conjunction with data from past SANDAG, City of Carlsbad, and City of Encinitas surveys to create profile plots, and to compute changes in shoreline position, beach width, and sediment volume. Of the 58 transects profiled in 2001, 45 had been profiled in Fall 2000; 40 in Spring 2000, Fall 1999, and Spring 1999; 39 in Fall 1998, Spring 1998, and Fall 1997; 38 in Spring 1997; and 24 in Fall and Spring 1996. Selected historical data acquired prior to the initiation of the SANDAG Monitoring Program in 1996 also were utilized. A summary of the historical beach profile data for the San Diego region known to exist in the public domain is provided in **Appendix A**, while a summary of the recent profile data acquired by SANDAG, Carlsbad, and Encinitas is provided in **Appendix B**. To facilitate the identification of changes in beach condition attributable to the RBSP, those transects that cross the RBSP fill sites are identified by red type in Appendix B.

Beach profile plots for the nearshore portion of each transect are provided in **Appendix C**, while plots for the entire length of each transect are provided in **Appendix D**. In addition to the Spring and Fall 2001 data, the plots display the profiles from Fall 2000 and Fall 1984 (when available), and the envelope of all profiles obtained during the SANDAG monitoring period that preceded the RBSP (Spring 1996-Spring 2001, or Spring 1997-Spring 2002, to the extent that data are available). Post-Nourishment (as-built) profiles also are included for the transects that cross or adjoin the RBSP fill sites. These

data, which are limited to the subaerial portion of the beach, were provided by Noble Consultants based on aerial photography (2002).

Comparing the Spring 2001 profile with those from Fall 2000 and Fall 2001 provides an indication of seasonal changes, while comparing the three Fall profiles illustrates the nature of inter-annual and long-term changes. A significant difference between the pre-RBSP envelope and the Fall 2001 profile indicates that a material change in beach condition may have resulted from the RBSP nourishment activities.

Tables and plots of shoreline position and beach width derived from the profile data are provided in **Appendix E**. Data from the following 15 surveys were utilized to the extent that they were available:

Pre-1984:	date varies
1984:	Fall
1989:	Fall
1996:	Spring and Fall
1997:	Spring and Fall
1998:	Spring and Fall
1999:	Spring and Fall
2000:	Spring and Fall
2001:	Spring and Fall

Because the survey data acquired prior to 1984 are relatively sparse in both time and space, it was not possible to select a single survey from this period that encompassed more than a small percentage of the 58 transects included in the analysis. Therefore, pre-1984 data for each transect were selected on an individual basis, with preference given to data collected during the Fall. The Fall 1984 and Fall 1989 data were selected for analysis because many of the historical transects were profiled at these times.

The following shoreline and beach width tabulations were prepared:

- MSL Shoreline Positions: The shoreline position was computed as the horizontal distance, in feet, between the transect origin (typically a permanent marker located near the back beach) and the point at which the beach profile intersected the plane of MSL Datum. Notwithstanding the use of MLLW as the elevation reference for the profile data, MSL was adopted as the shoreline reference in the belief that it provides a more accurate indicator of changes in beach configuration.

- Seasonal Changes in MSL Shoreline Position: Seasonal changes in MSL shoreline position were determined for the six most recent summers (1996 through 2001), and five most recent winters (1996-97, 1997-98, 1998-99, 1999-2000, and 2000-2001). The changes are expressed in feet, with positive values denoting shoreline advance and negative values denoting shoreline retreat.
- Long-Term Changes, Long-Term Change Rates, and Annual Changes: Long-term shoreline changes were calculated for three intervals that preceded the RBSP: pre-1984 to Fall 1984; Fall 1984 to Fall 1989 (5 years); and Fall 1989 to Fall 2000 (11 years). Long-term change rates were calculated by dividing the change in MSL shoreline position by the corresponding time interval. To reflect the seasonal nature of changes in beach configuration, the time interval was computed in one-quarter year increments (Winter, Spring, Summer, and Fall). For example, the time interval between surveys conducted in September 1984 (Fall 1984) and November 1989 (Fall 1989) was taken as 5 years rather than 5.17 years. The change rates are expressed in feet/year, with positive values denoting shoreline advance and negative values denoting retreat. To facilitate comparisons between long- and short-term changes, the long-term changes and change rates are tabulated with the annual changes in shoreline position recorded between Fall 1996 and Fall 2001. The final year, Fall 2000-Fall 2001, encompasses the RBSP nourishment activities.
- MSL Beach Widths: Beach width provides an indication of both recreational area and the protection afforded to upland facilities. The width was computed as the distance between the landward edge of the beach sand and the MSL shoreline position. Beach width data derived from surveys conducted prior to the inception of the SANDAG Monitoring Program in 1996 should be considered approximate.

Sediment volume changes are tabulated in **Appendix F**. The volume changes were computed along each transect for the entire width of the shorezone, and for that portion of the profile located above MSL. In the case of the shorezone, the onshore boundary of the control volume was placed at the transect origin, while the offshore boundary was placed at the “statistical range of closure”. This parameter represents the distance seaward of the transect origin beyond which profile variations are smaller than the accuracy of the survey technique. As implied by its definition, the statistical range of closure was adopted as the offshore boundary to separate the “signal” of true profile change from the “noise” of survey inaccuracy. The sea bottom elevation at the range of closure corresponds to the “depth of closure” described in Section 3.1.1.

The statistical range of closure was derived for each transect in the following manner:

- The successive survey profiles were interpolated to obtain sea bottom elevations at a common set of ranges spaced 15 ft apart.
- The sample standard deviation (σ) of the sea bottom elevations was computed at each 15-ft range increment.
- Statistical closure was assumed to occur at the smallest range at which σ decreased below the survey accuracy of 0.5 ft, provided that the average value of σ remained less than or equal to 0.5 ft seaward of that point. If this condition was not satisfied by the first downcrossing of σ below 0.5 ft, the next downcrossing seaward of that location was checked.
- In determining statistical closure, attention was restricted to depths greater than 12 ft (MLLW) to insure that the berm-bar portion of the profile would be included in the control volume.

To the extent that data were available, the determination of statistical closure was based on the ten semi-annual surveys that commenced in Fall 1997 and ended in Spring 2002. Surveys prior to Fall 1997 were not utilized, because they tended either to omit a significant number of the current transects, or to terminate landward of the depth of profile closure. The final survey, Spring 2002, would appear to be incompatible with the Fall 2000-Fall 2001 monitoring period addressed in this report. It was included, however, in an attempt to define a control volume that would encompass the seaward dispersion of the RBSP fill material. For those transects that lacked profile data encompassing the relatively severe El Niño winter of 1997-98, the range of closure was estimated from the adjoining transect or transects with similar exposure and beach characteristics. The results of the range-of-closure analysis are presented in Table 9.

For each survey at each transect, the shorezone volume per linear foot of shoreline (cy/ft) was calculated as the area under the profile to an arbitrary basement elevation of -60 ft. Volume changes then were computed for the following thirteen periods:

Winter:	Fall 1997 to Spring 1998
	Fall 1998 to Spring 1999
	Fall 1999 to Spring 2000
	Fall 2000 to Spring 2001

Table 9. Range and Depth of Closure at Each Profile Location

	Transect ⁽²⁾	Location	Range of Closure ⁽³⁾	Depth of Closure
Silver Strand Littoral Cell	SS-0003	Tijuana Estuary	1501	-32
	SS-0007	Tijuana Estuary	1132	-17
	SS-0015	Imperial Beach	1448	-19
	SS-0020 ⁽¹⁾	Imperial Beach	1463	-22
	SS-0025 ⁽¹⁾	Imperial Beach	2064	-27
	SS-0035	Imperial Beach	2260	-29
	SS-0050 ⁽⁴⁾	Imperial Beach	2445	-30
	SS-0077	Silver Strand	1893	-30
	SS-0090	Silver Strand	1499	-29
	SS-0160	Coronado	2109	-25
Mission Beach Littoral Cell	OB-0230	Ocean Beach	2249	-23
	MB-0310	Mission Beach	1460	-24
	MB-0320 ⁽⁴⁾	Mission Beach	1785	-29
	MB-0335 ^(1,4)	Mission Beach	1740	-29
	MB-0340 ⁽¹⁾	Mission Beach	1687	-29
	MB-0384	Mission Beach	1764	-27
	PB-0408	Pacific Beach	1074	-14
Oceanside Littoral Cell	LJ-0443	La Jolla Shores	1038	-13
	LJ-0445	La Jolla	802	-13
	LJ-0450	La Jolla	1195	-17
	LJ-0460	Scripps	1047	-19
	TP-0470	Blacks Beach	1573	-29
	TP-0520 ⁽¹⁾	Torrey Pines	1398	-26
	TP-0530 ⁽¹⁾	Torrey Pines	1464	-25
	DM-0565 ⁽⁴⁾	Del Mar	1770	-25
	DM-0580 ⁽¹⁾	Del Mar	1899	-29
	DM-0590	San Dieguito	1146	-16
	SD-0595 ⁽⁴⁾	Seascape Surf	1072	-13
	SD-0600 ⁽¹⁾	Solana Beach	910	-13
	SD-0610 ⁽⁴⁾	Tide Park	838	-13
	SD-0620 ⁽⁴⁾	Seaside Park	1935	-30

(continued)

Table 9. Range and Depth of Closure at Each Profile Location (continued)

	Transect ⁽²⁾	Location	Range of Closure ⁽³⁾	Depth of Closure
Oceanside Littoral Cell (continued)	SD-0625 ^(1,4)	San Elijo Lagoon	1800	-30
	SD-0630 ⁽¹⁾	Cardiff	1808	-30
	SD-0650 ⁽⁴⁾	San Elijo St. Bch	1590	-30
	SD-0660 ⁽⁴⁾	Swami's	1650	-30
	SD-0670 ⁽¹⁾	Moonlight Bch.	1639	-29
	SD-0675 ⁽⁴⁾	Stone Steps	1230	-21
	SD-0680	Leucadia	1357	-21
	SD-0690 ^(1,4)	Leucadia	1470	-27
	SD-0695 ⁽⁴⁾	Leucadia	1500	-27
	SD-0700 ⁽⁴⁾	Grandview	1515	-27
	SD-0710 ^(1,4)	Leucadia	1485	-27
	CB-0720	Batiquitos	1556	-27
	CB-0740	S. Carlsbad	1264	-18
	CB-0760	Ponto Beach	1322	-24
	CB-0775 ^(1,4)	South Carlsbad	1500	-25
	CB-0780	Carlsbad	1527	-25
	CB-0800	Carlsbad	1026	-13
	CB-0820	Agua Hedionda	1270	-22
	CB-0830	Carlsbad	1134	-21
	CB-0840	Carlsbad	984	-17
	CB-0850	Carlsbad	947	-14
	CB-0865 ^(1,4)	Carlsbad	1105	-16
	CB-0880 ⁽¹⁾	Buena Vista	1031	-16
	OS-0900	S. Oceanside	1317	-26
	OS-0915 ^(1,4)	Oceanside	1230	-26
	OS-0930 ⁽¹⁾	Buccaneer	1313	-24
	OS-1000	Oceanside	1082	-19
	OS-1030	Oceanside	1247	-21
	OS-1070	Oceanside	1455	-17

Notes: ⁽¹⁾ Transect crosses RBSP nourishment site (shown in red type).

⁽²⁾ Transect locations are indicated in Figures 10a and 10b.

⁽³⁾ Range of closure measured from transect origin, and based on Fall 1997 through Spring 2002 Survey data unless otherwise noted.

⁽⁴⁾ Range of closure estimated from nearby transects due to insufficient data.

Summer:	Spring 1998 to Fall 1998 Spring 1999 to Fall 1999 Spring 2000 to Fall 2000 Spring 2001 to Fall 2001
Annual:	Fall 1997 to Fall 1998 Fall 1998 to Fall 1999 Fall 1999 to Fall 2000 Fall 2000 to Fall 2001
Long-Term:	Fall 1997 to Fall 2000

Beach volume above MSL, like beach width, provides an indication of the recreational area and the protection afforded to upland facilities. Changes in beach volume above MSL were developed for the same thirteen periods as changes in shorezone volume above the depth of closure.

4.1.2. Aerial Photographs (Section 5)

Oblique aerial photographs obtained at the twelve RBSP receiver sites in Spring and Fall, 2001, are provided in **Section 5**.

4.1.3. Beach Width Measurements (Appendix G)

The monthly beach width data obtained by the Cities of Carlsbad, Encinitas, San Diego, and Imperial Beach are presented as time-series plots in **Appendix G**. As indicated in Section 3.1.3, the measurements were adjusted to approximate the MSL beach width using the corresponding water levels and beach slopes. The MSL beach widths obtained from the Spring and Fall 2001 profile data, which are inherently more accurate than the monthly measurements, also are shown on the plots in Appendix G.

4.2. Lagoon Entrance Data

Lagoon entrance data acquisition consisted of semi-annual surveys and oblique aerial photography at all five entrances, and monthly inspections and photographs at the unstabilized entrances to San Elijo, San Dieguito, and Los Peñasquitos.

4.2.1. Topographic Data (Appendix H)

The 2001 lagoon entrance monitoring data are presented in graphical form in **Appendix H**. For Agua Hedionda and Batiquitos, the channel cross-sections obtained in

Spring 2001 and Fall 2001 were plotted with those from Fall 2000 to illustrate the changes in channel configuration.

For each of the three unstabilized entrances (San Elijo, San Dieguito, and Los Peñasquitos), the following six contour maps were prepared to illustrate changes in the condition of the channel:

- A contour map depicting the topographic data obtained in Fall 2000;
- A contour map depicting the topographic data obtained in Spring 2001;
- A contour map depicting the topographic data obtained in Fall 2001;
- A contour map illustrating the elevation changes that occurred between Fall 2000 and Spring 2001, as well as the net change in volume within the survey area;
- A contour map illustrating the elevation changes that occurred between Spring 2001 and Fall 2001, as well as the net change in volume within the survey area;
- A contour map illustrating the elevation changes that occurred between Fall 2000 and Fall 2001, as well as the net change in volume within the survey area.

4.2.2. Aerial Photographs (Section 6)

Oblique aerial photographs obtained at the five lagoon entrances in Spring and Fall, 2001, are provided in **Section 6**.

4.2.3. Inspection Results (Appendix I)

Selected ground photographs obtained by SANDAG on a monthly basis at the entrances to San Elijo, San Dieguito, and Los Peñasquitos Lagoons are provided in **Appendix I**.

5. BEACH CONDITION

Based on the data presented in Sections 2 and 4, this chapter assesses the condition of San Diego County's beaches during the 2001 monitoring year. Section 5.1 provides a regional overview, while Section 5.2 describes the performance of the twelve RBSP beach fills.

5.1. Regional Overview

The combination of RBSP beach fills and mild wave conditions during the 2001 monitoring year proved to be extremely favorable for the San Diego County coast. As detailed below, the monitoring data pertaining to shoreline movement, beach width, and sediment volume all attest to a significant improvement in the state of the coast.

During the one-year period between the Fall 2000 and Fall 2001 surveys, the following changes in the position of the MSL shoreline were noted at the 44 transects for which data are available:

- 26 transects (59%) exhibited shoreline advance in excess of 10 ft;
- 12 transects (27%) exhibited essentially no shoreline change (10 ft or less);
- 6 transects (14%) exhibited shoreline retreat in excess of 10 ft.

Because the shoreline position at Transect SS-0007 is influenced more by the migration of the Tijuana River mouth than by coastal processes, it was excluded from the foregoing compilation. In addition, eight of the seventeen transects that traverse RBSP fill sites were established in Spring 2001, and hence were not available for the Fall 2000-Fall 2001 comparison. Had these transects pre-dated the Fall 2000 Survey, the percentage of sites experiencing shoreline advance undoubtedly would have been higher.

Notwithstanding the absence of data from the eight new transects through the RBSP fills, the percentage of transects exhibiting shoreline advance was higher in 2001 than in any of the prior four monitoring years. As summarized in Figure 11, the past values ranged from 17% in 1997 to 50% in 1999. Detailed data are provided in Appendix E.

The changes in MSL beach width that occurred during the 2001 monitoring year are presented graphically in Figures 12a and b. Although the beaches tended to widen in all three littoral cells, the most substantial gains were recorded in the Oceanside Cell, where

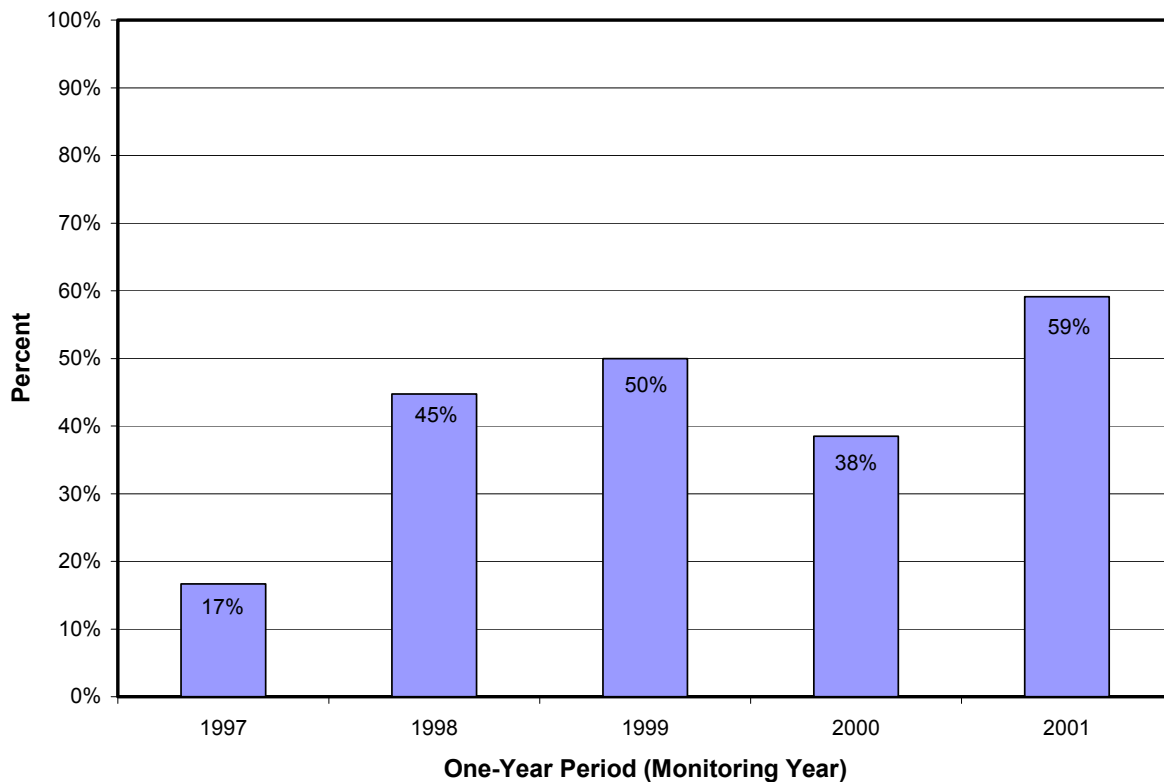


Figure 11. Percentage of Transects Exhibiting MSL Shoreline Advance

more than 85% of the RBSP nourishment material was placed. The largest increase in width, 107 ft, occurred at the Oceanside receiver site (Transect OS-0930). The largest decrease, 46 ft, occurred in Del Mar just south of the entrance to San Dieguito Lagoon (Transect DM-0590). As in the case of the shoreline data, detailed beach width data are provided in Appendix E.

In Figures 13a and b, the MSL beach widths measured in Spring and Fall 2001 are compared with the envelope of widths measured prior to the RBSP (Spring 1996-Spring 2001 or Spring 1997-Spring 2001, to the extent that data are available). At 22 of the 38 transects (58%) with measurements dating back to 1997, the beach width in Fall 2001 was greater than that noted in any of the prior four years. The largest increase relative to the pre-RBSP envelope, 97 ft, was found at Oceanside on Transect OS-0930.

Figures 14a and b present the volume changes that occurred in the subaerial beach (above MSL) and the entire shorezone (inside the range of closure) between Fall 2001 and Fall 2002. The supporting data appear in Appendix F. In the Silver Strand and Mission

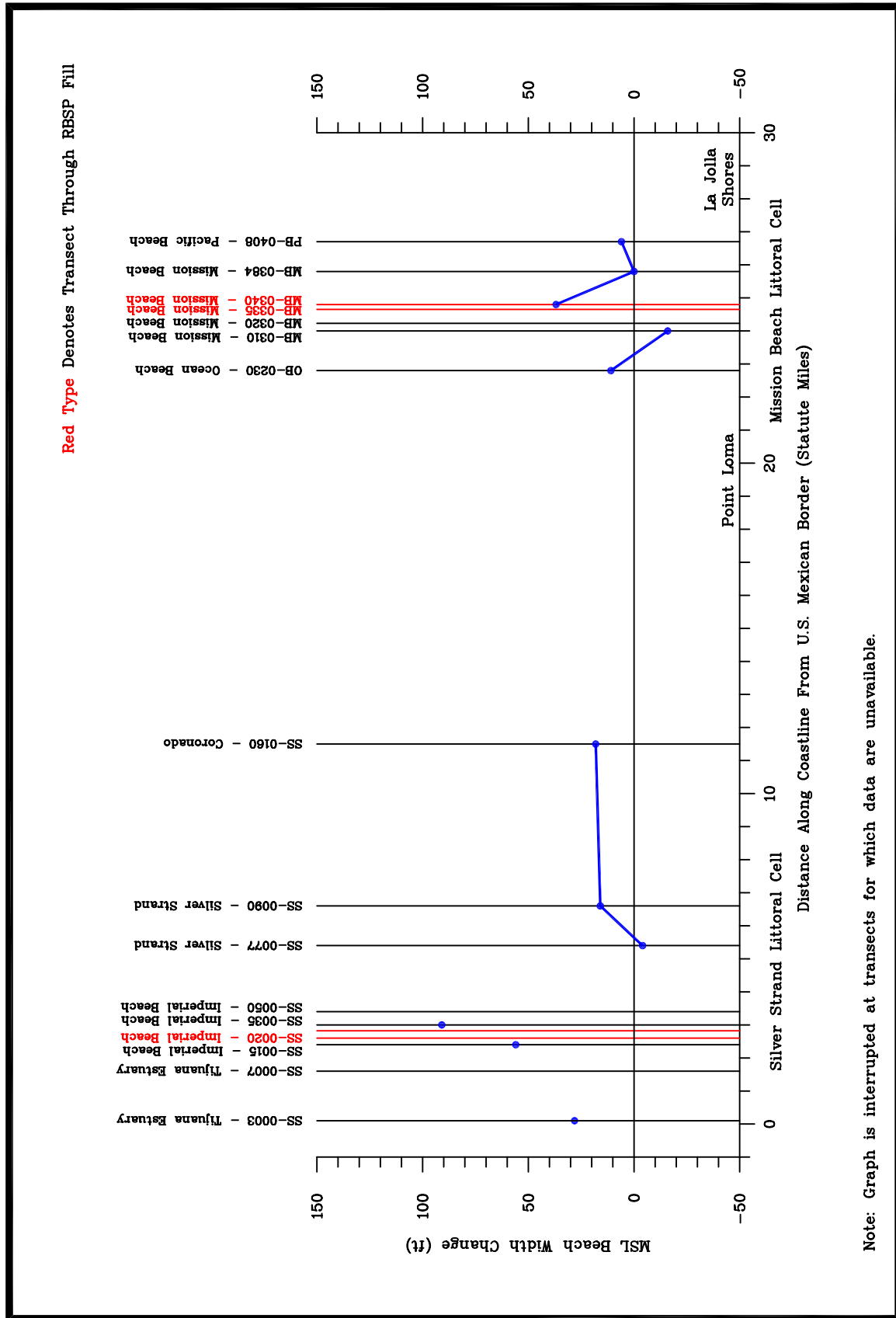


Figure 12a. MSL Beach Width Changes in the Silver Strand and Mission Beach Littoral Cells, Fall 2000 to Fall 2001

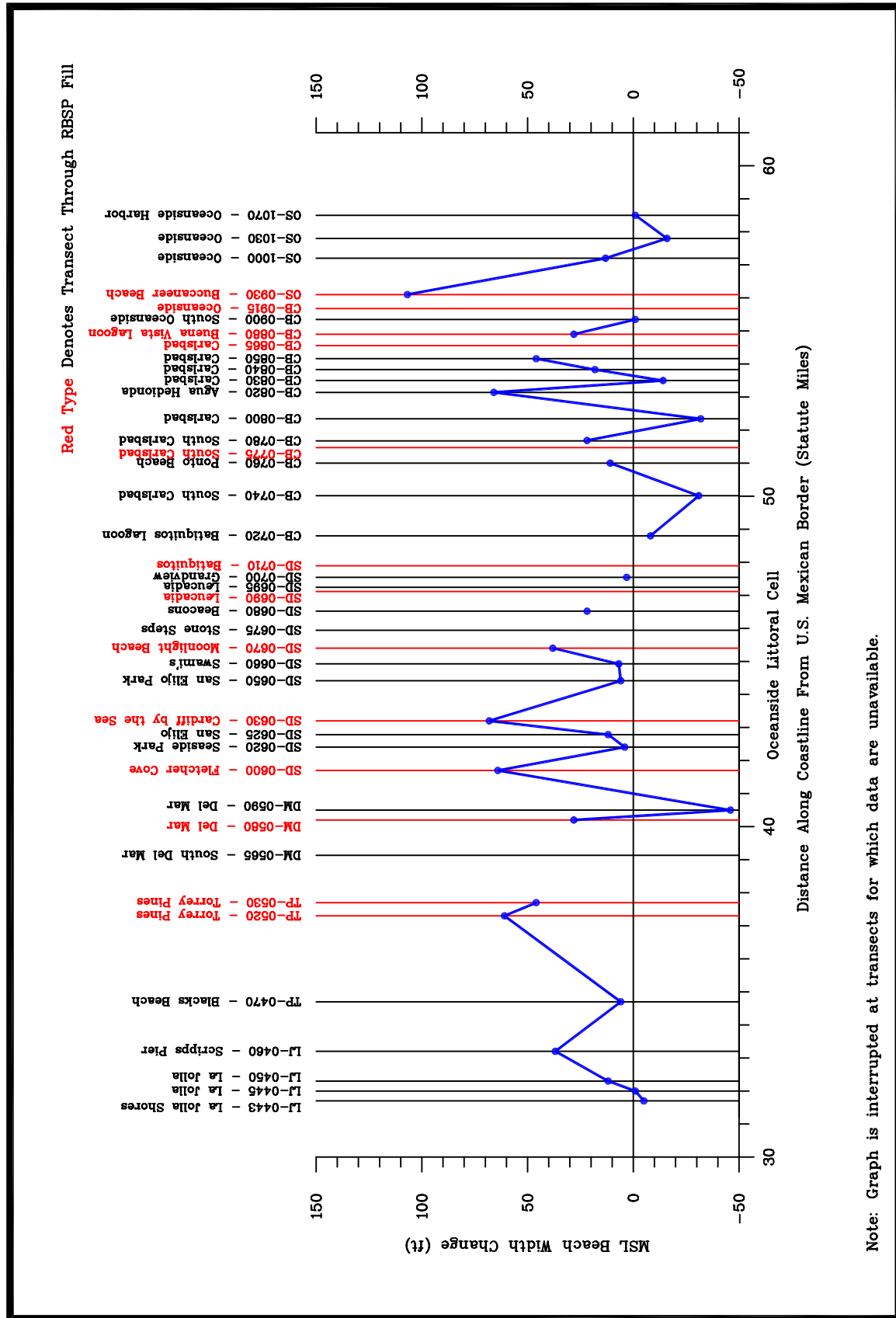


Figure 12b. MSL Beach Width Changes in the Oceanside Littoral Cell, Fall 2000 to Fall 2001

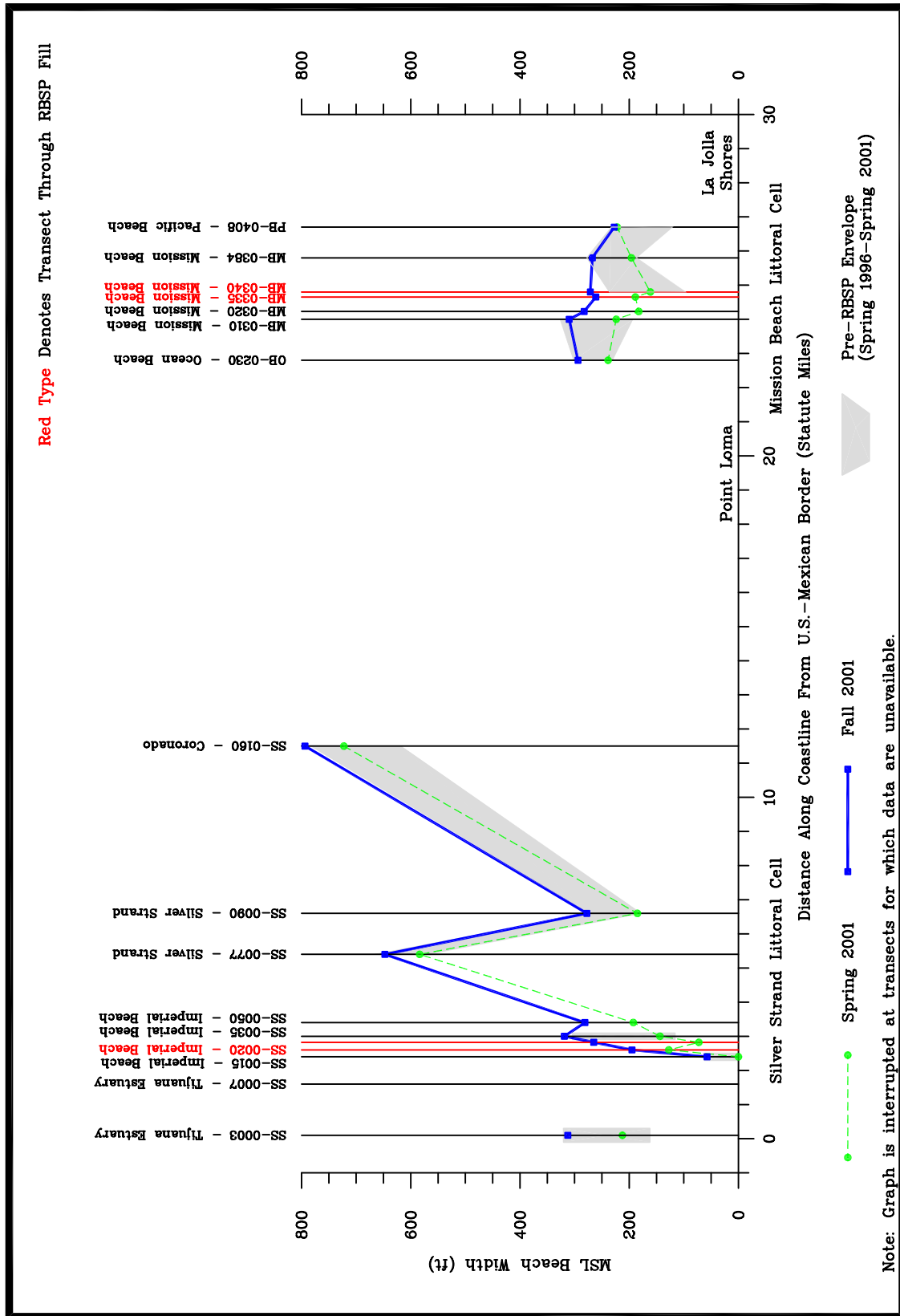
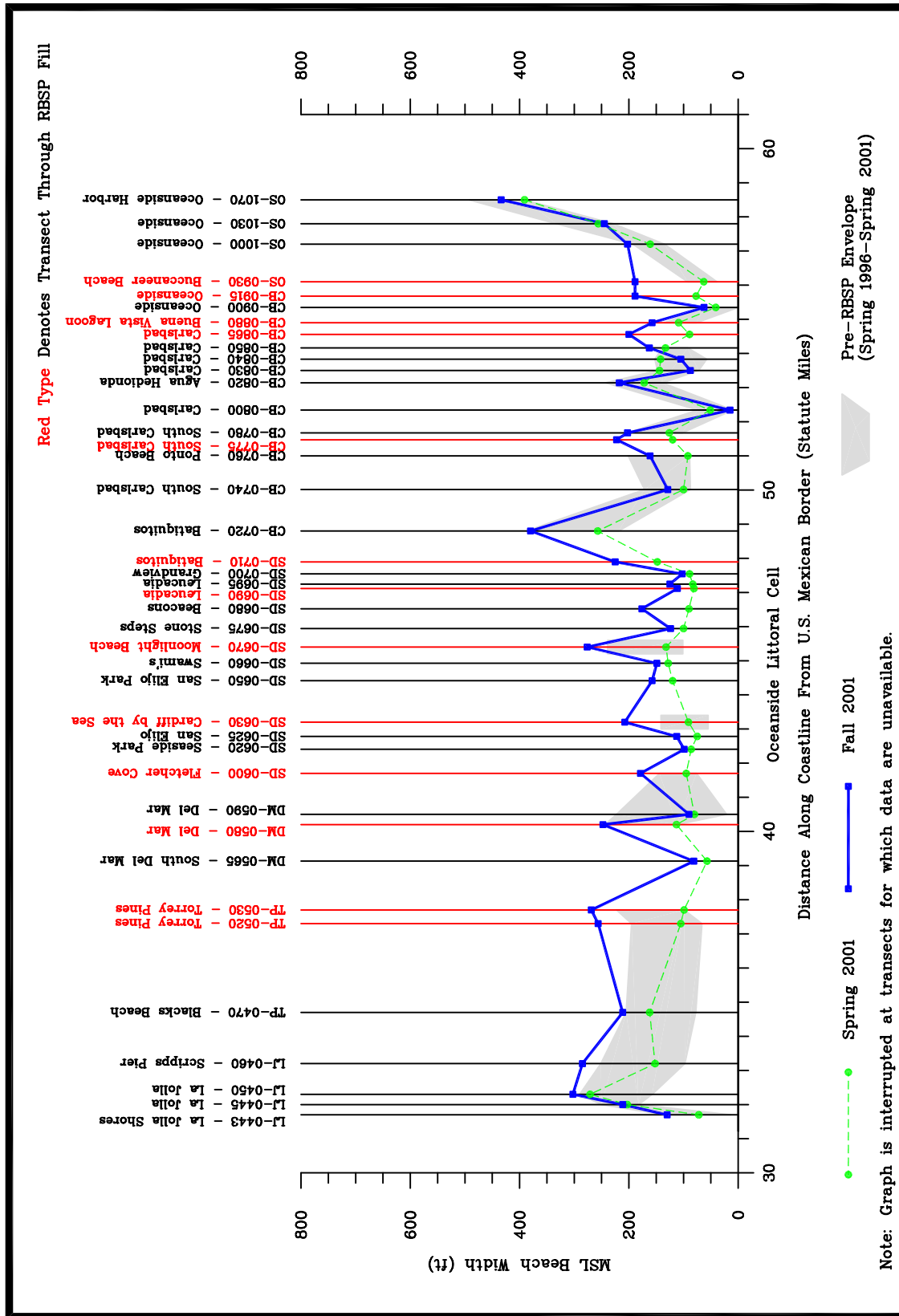


Figure 13a. Comparison of 2001 MSL Beach Widths with Historical Envelope in the Silver Strand and Mission Beach Littoral Cells



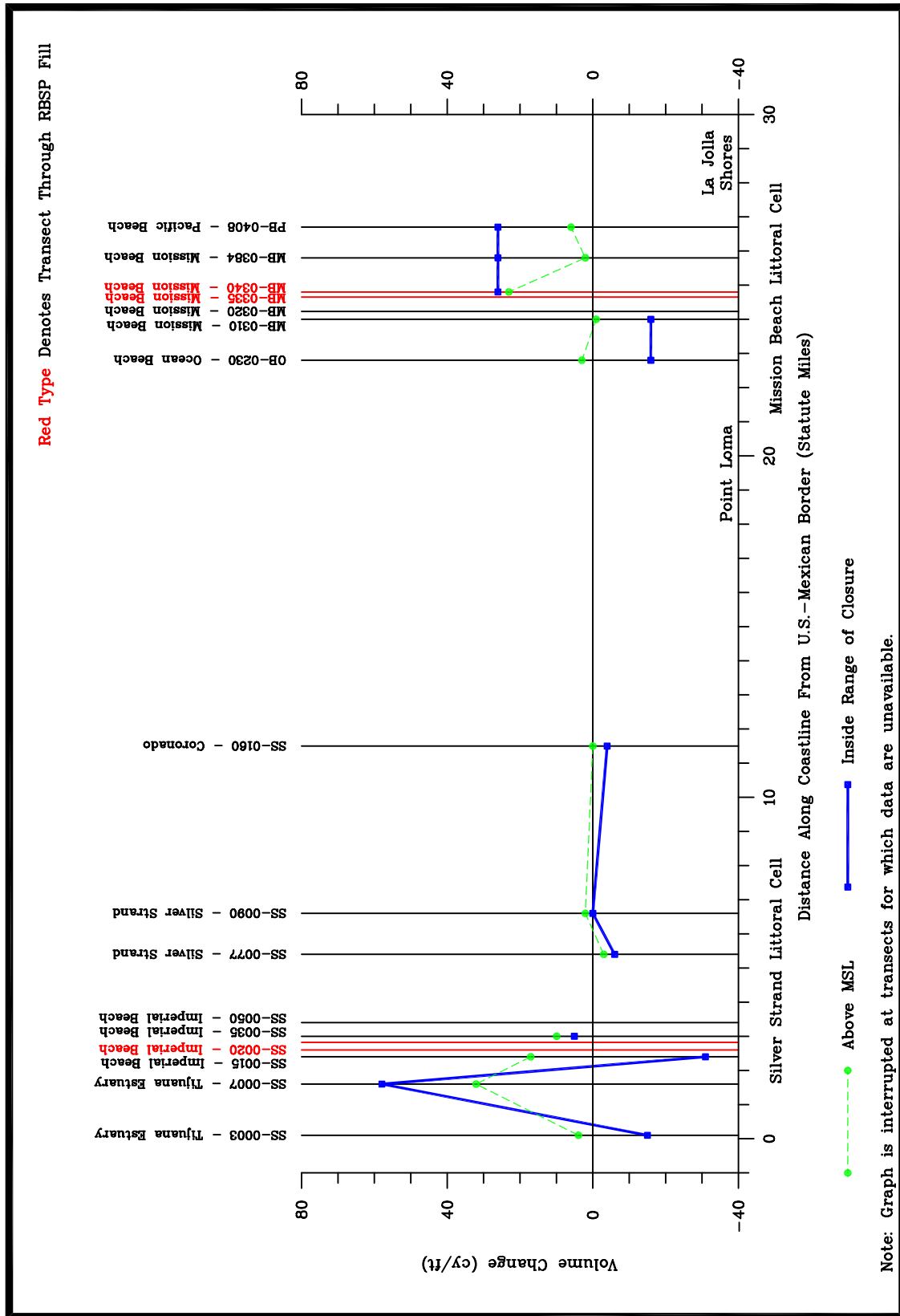


Figure 14a. Sediment Volume Changes in the Silver Strand and Mission Beach Littoral Cells, Fall 2000 to Fall 2001

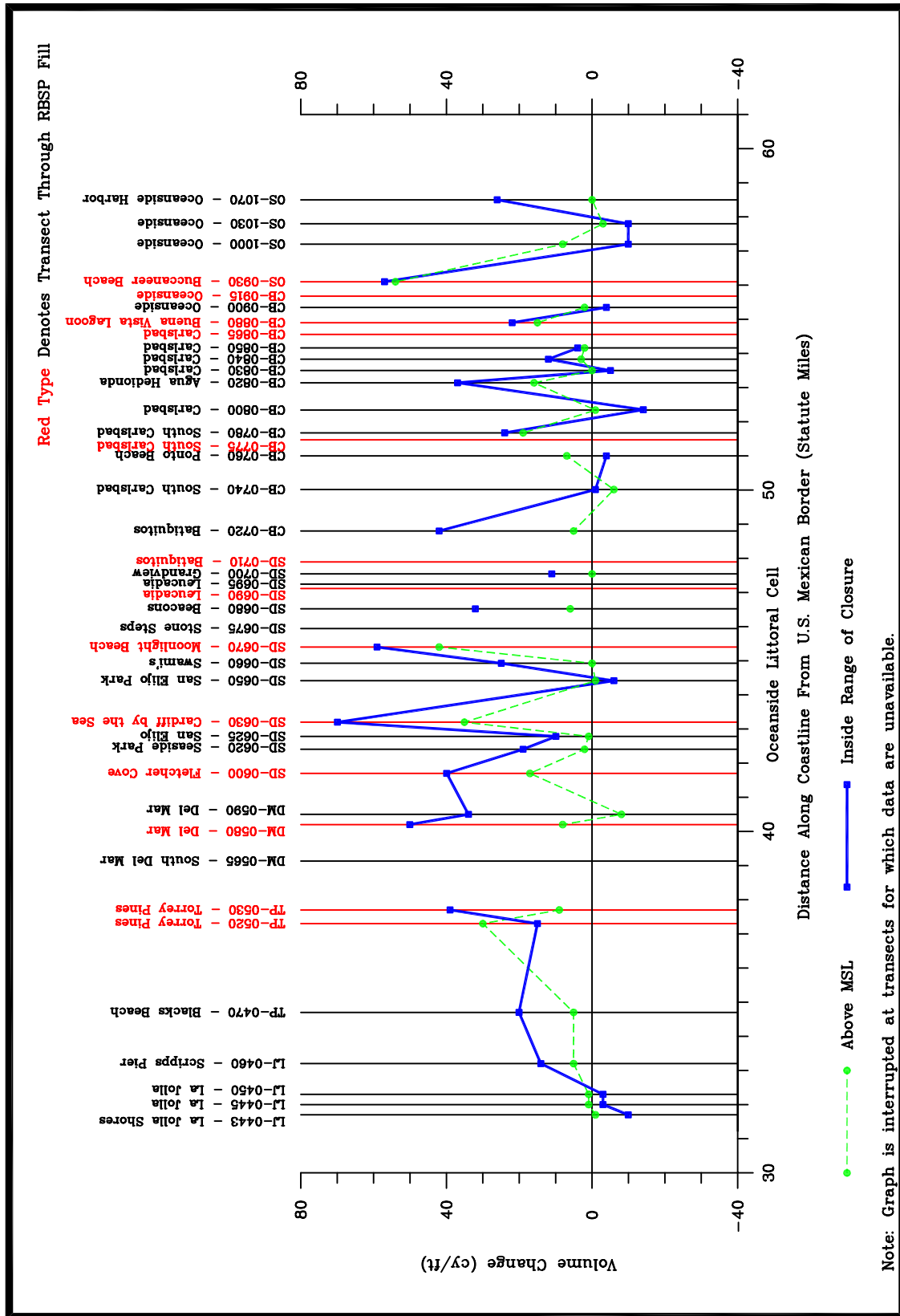


Figure 14b. Sediment Volume Changes in the Oceanside Littoral Cell, Fall 2000 to Fall 2001

Beach Cells, where the RBSP nourishment quantities were modest (Section 2.3.), the subaerial sediment volumes tended to increase while the shorezone volumes reflected a mixture of gains and losses (Figure 14a). In the Oceanside Cell, gains predominated in both the subaerial and shorezone sediment volumes (Figure 14b).

When all 45 transects for which data are available are considered together, the gains outnumber the losses by a wide margin. The breakdown is as follows:

Subaerial Beach Volumes

- 11 transects (24%) exhibited gains in excess of 10 cy/ft;
- 34 transects (76%) exhibited no significant change (10 cy/ft or less);
- no transect (0%) exhibited a loss in excess of 10 cy/ft.

Shorezone Beach Volumes

- 24 transects (53%) exhibited gains in excess of 10 cy/ft;
- 16 transects (36%) exhibited no significant change (10 cy/ft or less);
- 5 transects (11%) exhibited losses in excess of 10 cy/ft.

As in the case of shoreline advance (Figure 11), the percentage of transects exhibiting shorezone volume gains (53%) was higher in 2001 than in any of the previous SANDAG monitoring years. The prior values, displayed in Figure 15, ranged from 18% in 2000 to 46% in 1998. The relatively high percentage in 1998 was caused, at least in part, by the delivery of riverine sediment to the coast during the wet El Niño winter of 1997-98 (Coastal Frontiers, 1999).

In the absence of other nourishment programs and of significant riverine sediment input analogous to that which occurred in 1997-98, the volume gains recorded during the 2001 monitoring year may be attributed primarily to the RBSP. Although the greatest gains occurred at the receiver beaches, Figures 14a and b indicate that significant volume increases also occurred at a number of flanking locations.

5.2. RBSP Beach Fill Performance

The subsections that follow assess the initial performance of each of the twelve RBSP beach fills. The locations of the fills, along with those of all beach profile transects in the vicinity, are shown in Figures 16 through 21.

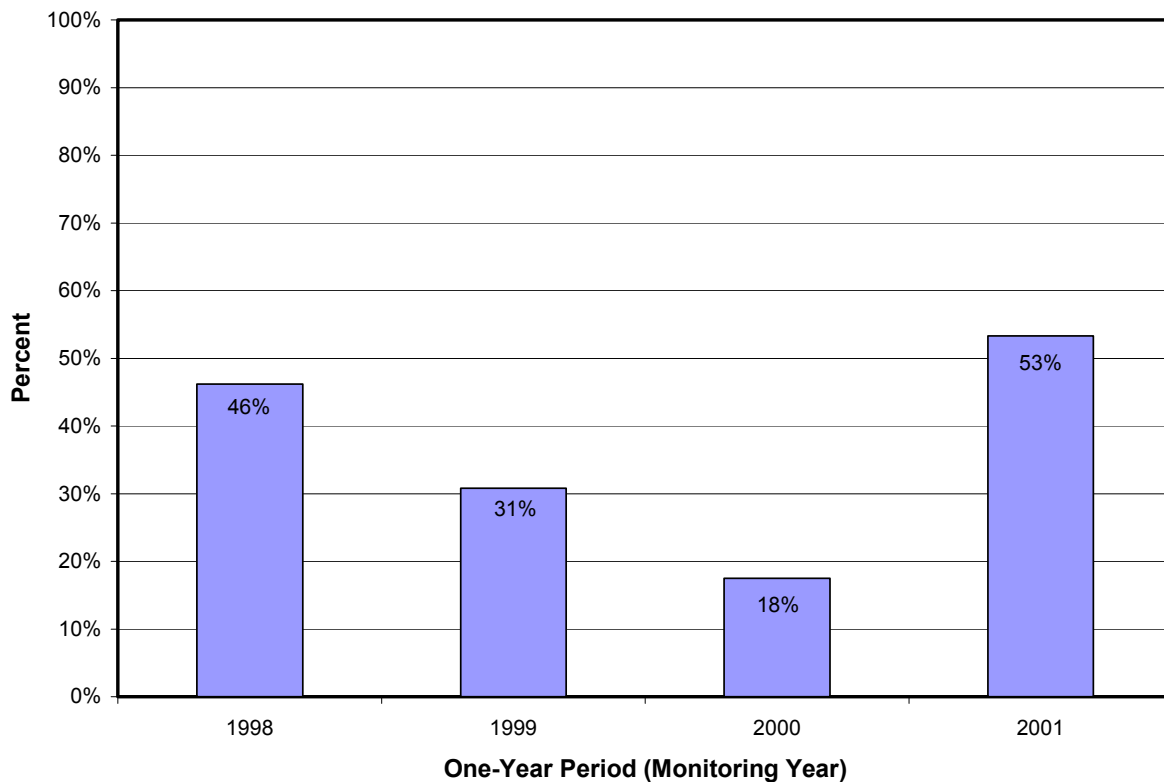


Figure 15. Percentage of Transects Exhibiting Shorezone Volume Gains

The approximate fill retention at each placement site is shown in Figure 22, based on the use of single indicator transect to characterize that site. In those instances where more than one transect crossed the fill, the transect that received the greatest nourishment (as indicated by the Post-Nourishment profile) was adopted as the indicator. The percent fill retention was derived by comparing the subaerial volume gain in Fall 2001 (relative to Spring 2001) with that reflected in the Post-Nourishment profile. Hence, if all of the subaerial volume gain in the Post-Nourishment profile was still present at the time of the Fall Survey, the fill retention was computed to be 100%. It should be noted that the Post-Nourishment profiles, having been derived from aerial photogrammetry (Noble Consultants, 2002), are inherently less accurate than the survey data and seldom extend sufficiently far offshore to reach the MSL shoreline. It therefore was necessary to extrapolate the data to the elevation of MSL. Despite these limitations, as well as those associated with the use of a single indicator transect to represent each site, the fill retention shown in Figure 22 appears to provide a reasonable approximation of the extent to which the nourishment material remained at the placement site.

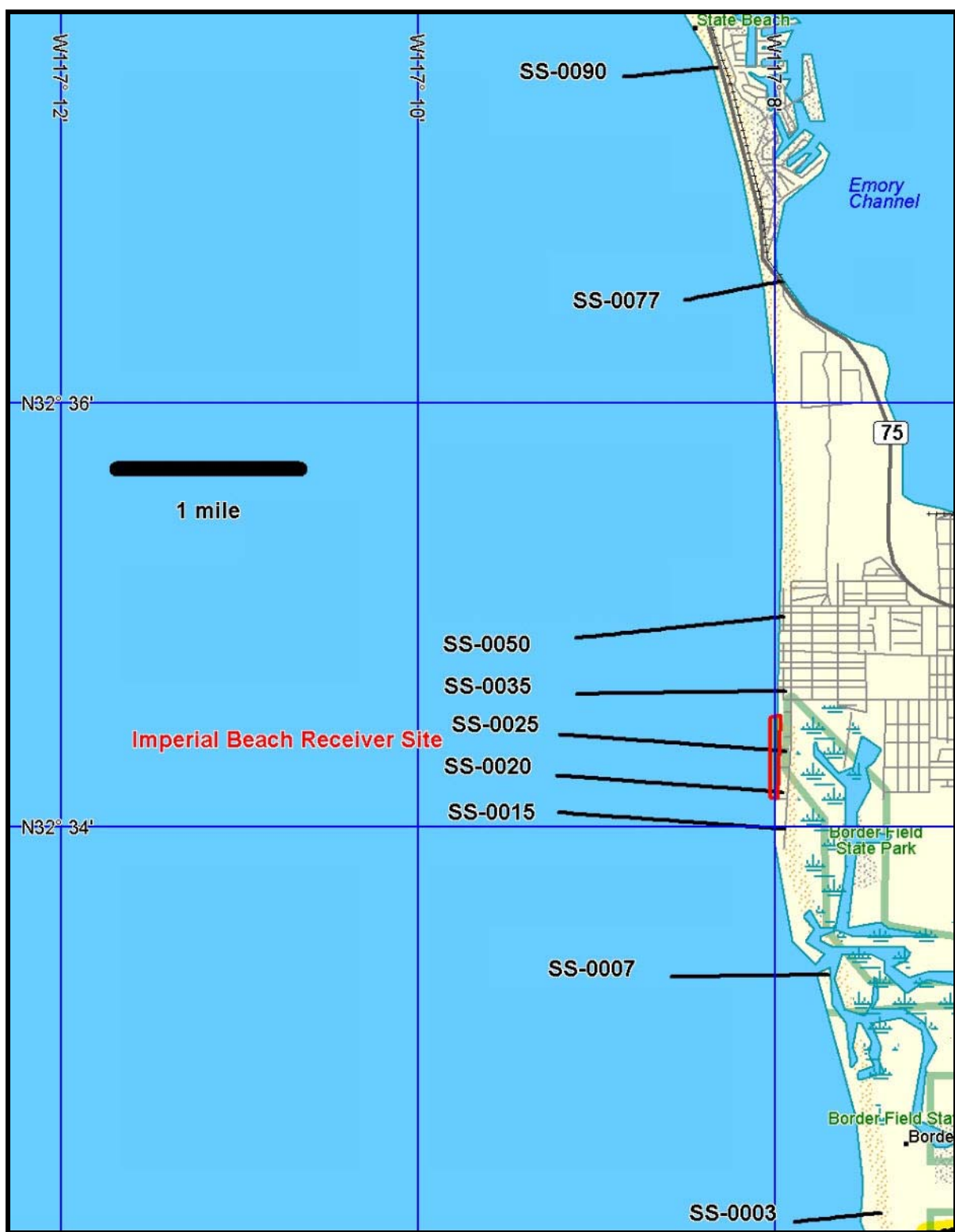


Figure 16. Location Map for Imperial Beach Receiver Site



Figure 17. Location Map for Mission Beach Receiver Site

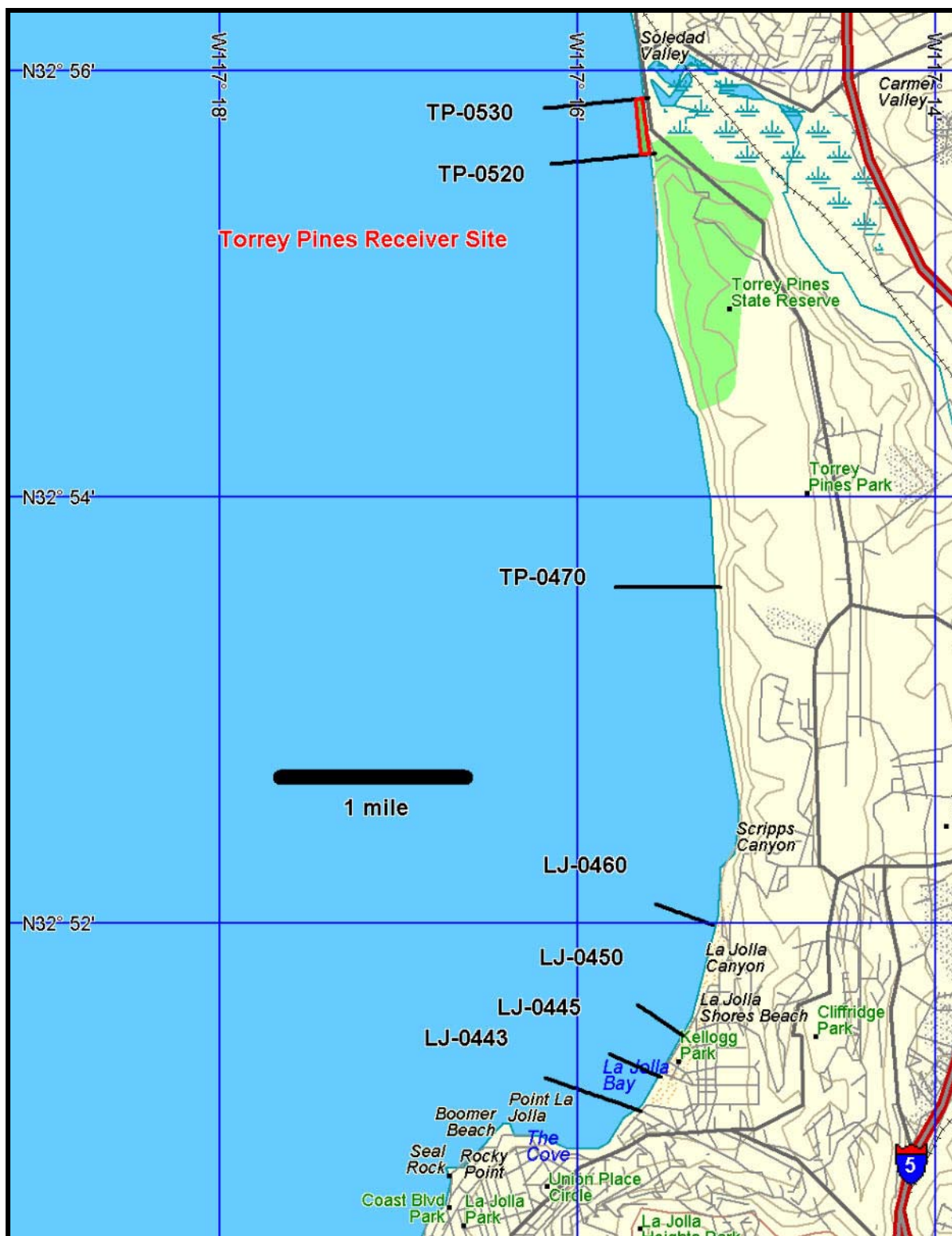


Figure 18. Location Map for Torrey Pines Receiver Site

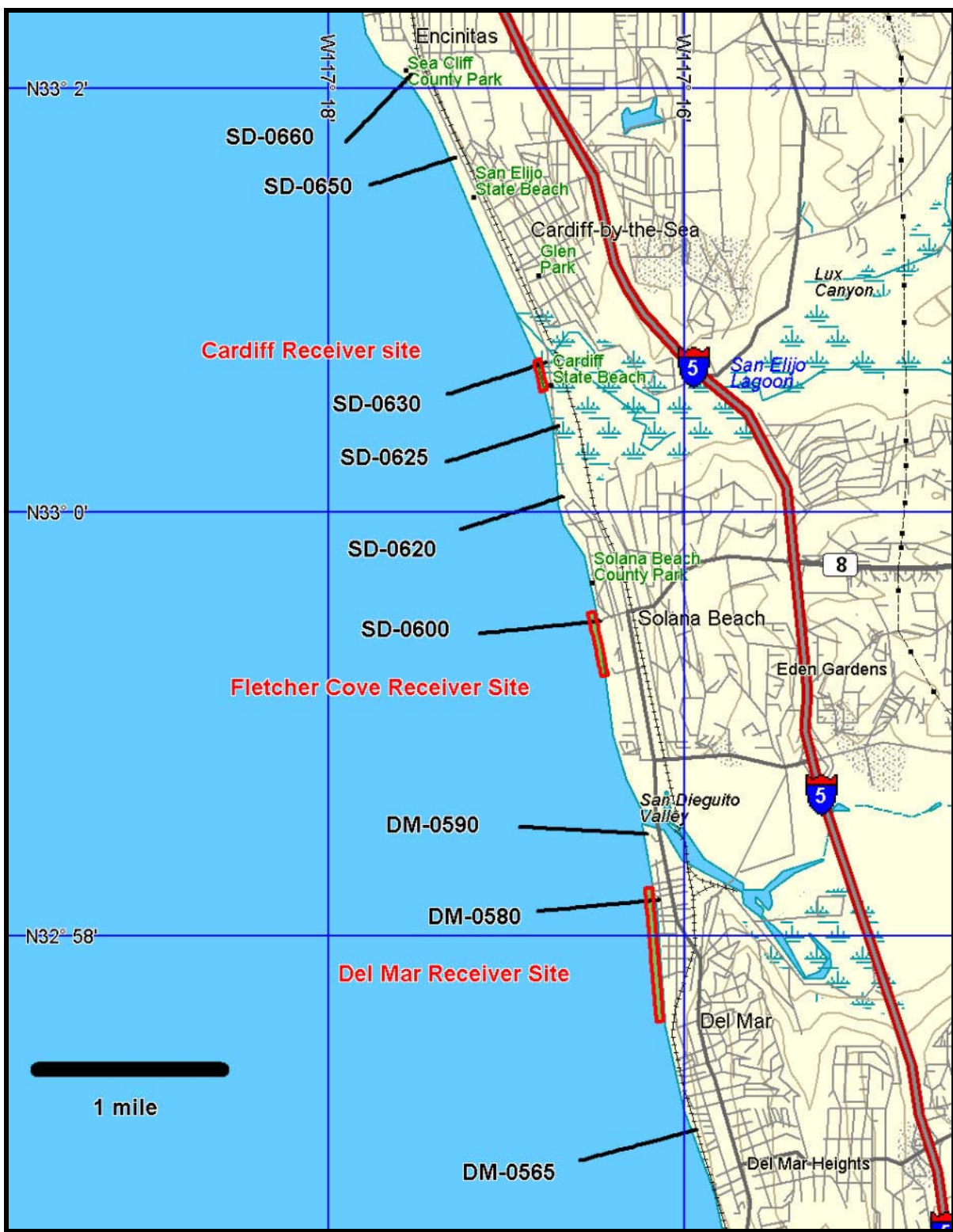


Figure 19. Location Map for Del Mar, Fletcher Cove, and Cardiff Receiver Sites

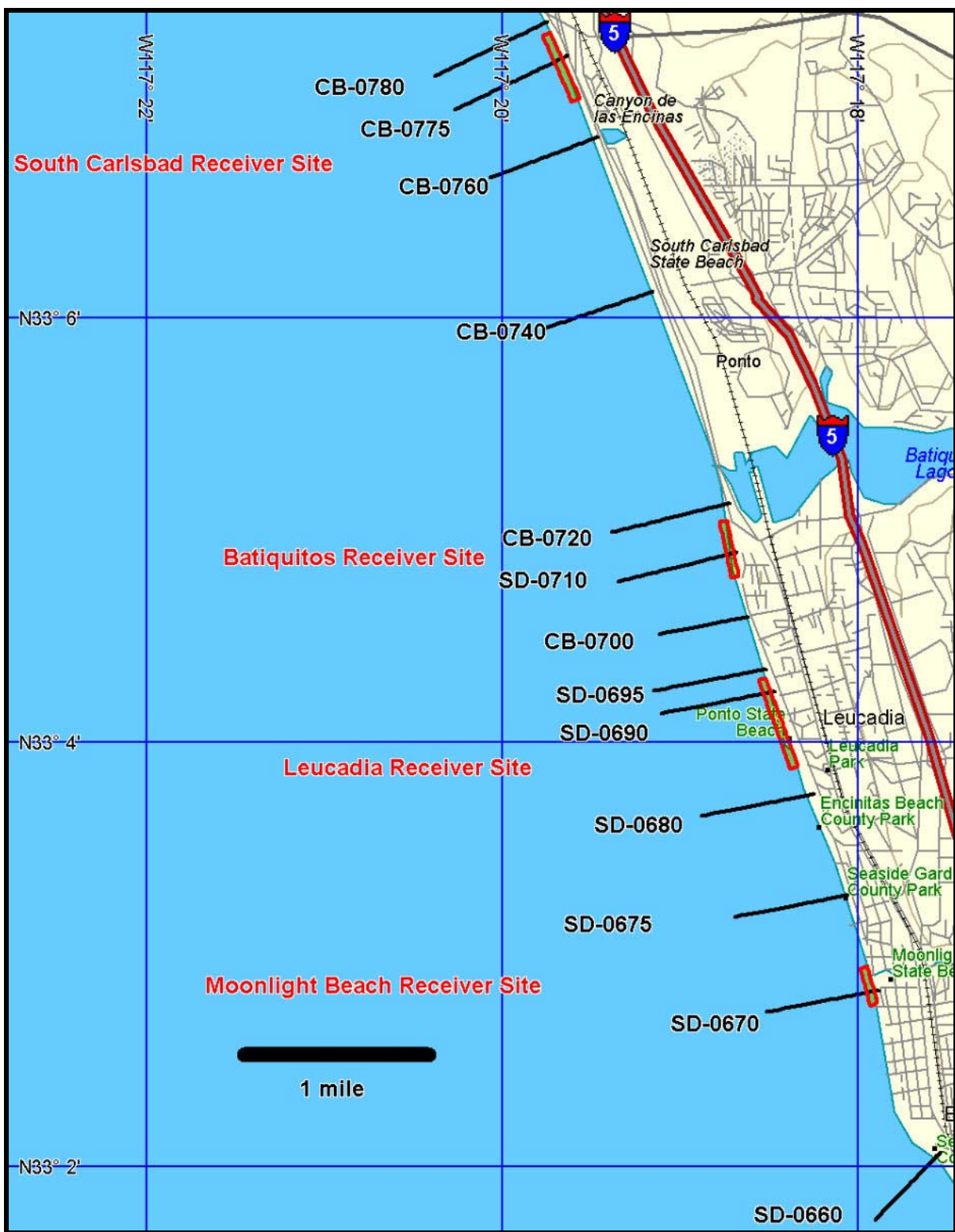


Figure 20. Location Map for Moonlight Beach, Leucadia, Batiquitos, and South Carlsbad Receiver Sites



Figure 21. Location Map for North Carlsbad and Oceanside Receiver Sites

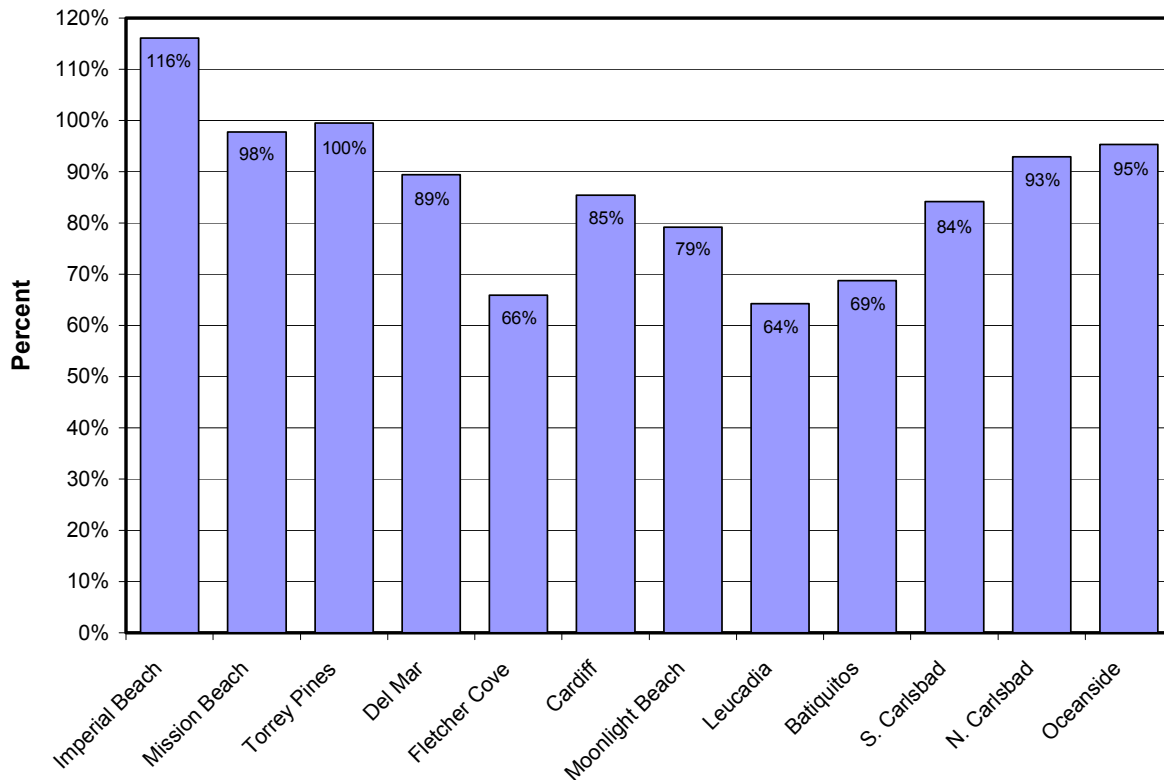


Figure 22. Fill Retention at RBSP Receiver Sites, Fall 2001

Table 10 provides the MSL shoreline change and shorezone volume change at each indicator transect between Spring 2001 and Fall 2001, along with the percent fill retention. To provide a reference against which individual fill performance can be measured, the table includes the average, maximum, and minimum values for each parameter.

5.2.1. Imperial Beach (Figure 16)

The Imperial Beach fill, consisting primarily of coarse sand, was constructed from May 22 to June 5, 2001 (Table 1). At 120,000 cy, it was among the smallest fills in the RBSP. Pre-and post-nourishment views of the receiver beach are provided in Plate 1.

Figure 23 displays the Spring 2001, Post-Nourishment, and Fall 2001 profiles on Transect SS-0025. The profiles indicate that considerable accretion occurred above the waterline following fill placement. As a result, the shoreline advance of 193 ft and fill retention of 116% were the largest recorded at the twelve receiver sites (Table 10). Factors that may have contributed to the subaerial accretion include the onshore transport of sediment that routinely occurs during the summer months, and the alongshore transport of

Table 10. RBSP Beach Fill Performance

Receiver Beach	Indicator Transect	MSL Shoreline Change, Spring–Fall, 2001 (ft)	Shorezone Volume Change, Spring–Fall, 2001 (cy/ft)	Fill Retention ⁽¹⁾ (Percent)
Imperial Beach	SS-0025	193	34	116
Mission Beach	MB-0340	110	7	98
Torrey Pines	TP-0520	151	24	100
Del Mar	DM-0580	134	46	89
Fletcher Cove	SD-0600	84	32	66
Cardiff	SD-0630	117	65	85
Moonlight Beach	SD-0670	144	30	79
Leucadia	SD-0690	30	14	64
Batiquitos	SD-0710	77	-3	69
S. Carlsbad	CB-0775	103	68	84
N. Carlsbad	CB-0865	111	54	93
Oceanside	OS-0930	126	65	95
<i>Average</i>		<i>115</i>	<i>36</i>	<i>87</i>
<i>Maximum</i>		<i>193</i>	<i>68</i>	<i>116</i>
<i>Minimum</i>		<i>30</i>	<i>-3</i>	<i>64</i>

Note: ⁽¹⁾ Fill retention computed as the volume gain between the Spring 2001 and Fall 2001 profiles divided by the volume gain between Spring 2001 and Post-Nourishment profiles.



April 2001 (Pre-RBSP)



November 2001 (5.5 months after nourishment)

Plate 1. Imperial Beach Receiver Site in April and November 2001

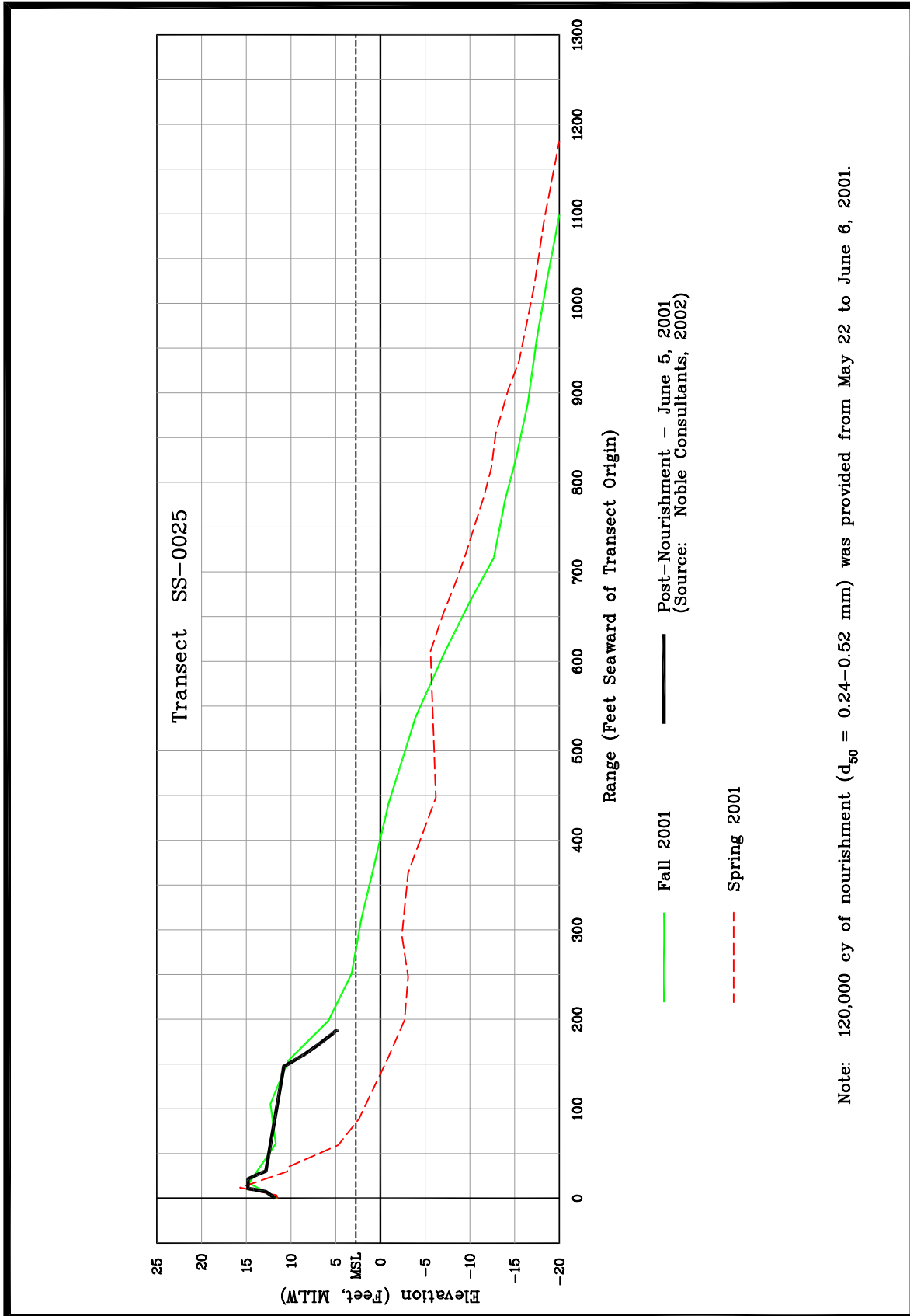


Figure 23. Transect SS-0025 at Imperial Beach Receiver Site

sediment from south to north (as suggested by a loss of subaerial volume at Transect SS-0020; Appendix A). The shorezone volume increase of 34 cy/ft between Spring and Fall, 2001, approximated the average value for the RBSP receiver beaches.

5.2.2. Mission Beach (Figure 17)

The Mission Beach fill consisted of 151,000 cy of coarse sand. It was constructed from May 10 to 21. Pre-and post nourishment photographs are shown in Plate 2, while the Spring 2001, Post-Nourishment, and Fall 2001, profiles appear in Figure 24.



April 2001 (Pre-RBSP)



November 2001 (6 months after nourishment)

Plate 2. Mission Beach Receiver Site in April and November 2001

Although the slope of the beach face on Transect MB-0340 decreased between the Post-Nourishment profile and the Fall Survey, the fill retention remained high at 98%. The shorezone volume increased by only 7 cy/ft, however, because the increase in volume that occurred above MSL was largely offset by a decrease below. (Figure 24).

5.2.3. Torrey Pines (Figure 18)

At Torrey Pines, the beach fill consisted of 245,000 cy of fine sand placed from April 6 to 27. Among the twelve RBSP fills, this quantity was exceeded only by the 421,000 cy supplied at Oceanside. Pre- and post-nourishment photographs are provided in Plate 3; successive profiles are shown in Figure 25.

As in the case of Mission Beach, fill retention remained high (100%) at Torrey Pines Transect TP-0520 despite flattening of the nourished beach face. The MSL shoreline advanced 151 ft between Spring and Fall, well above the RBSP average of 115 ft, but the shorezone volume increase of 24 cy/ft was below average. At the north end of the fill, (Transect TP-0530), the beach continued to accrete after placement of the nourishment.

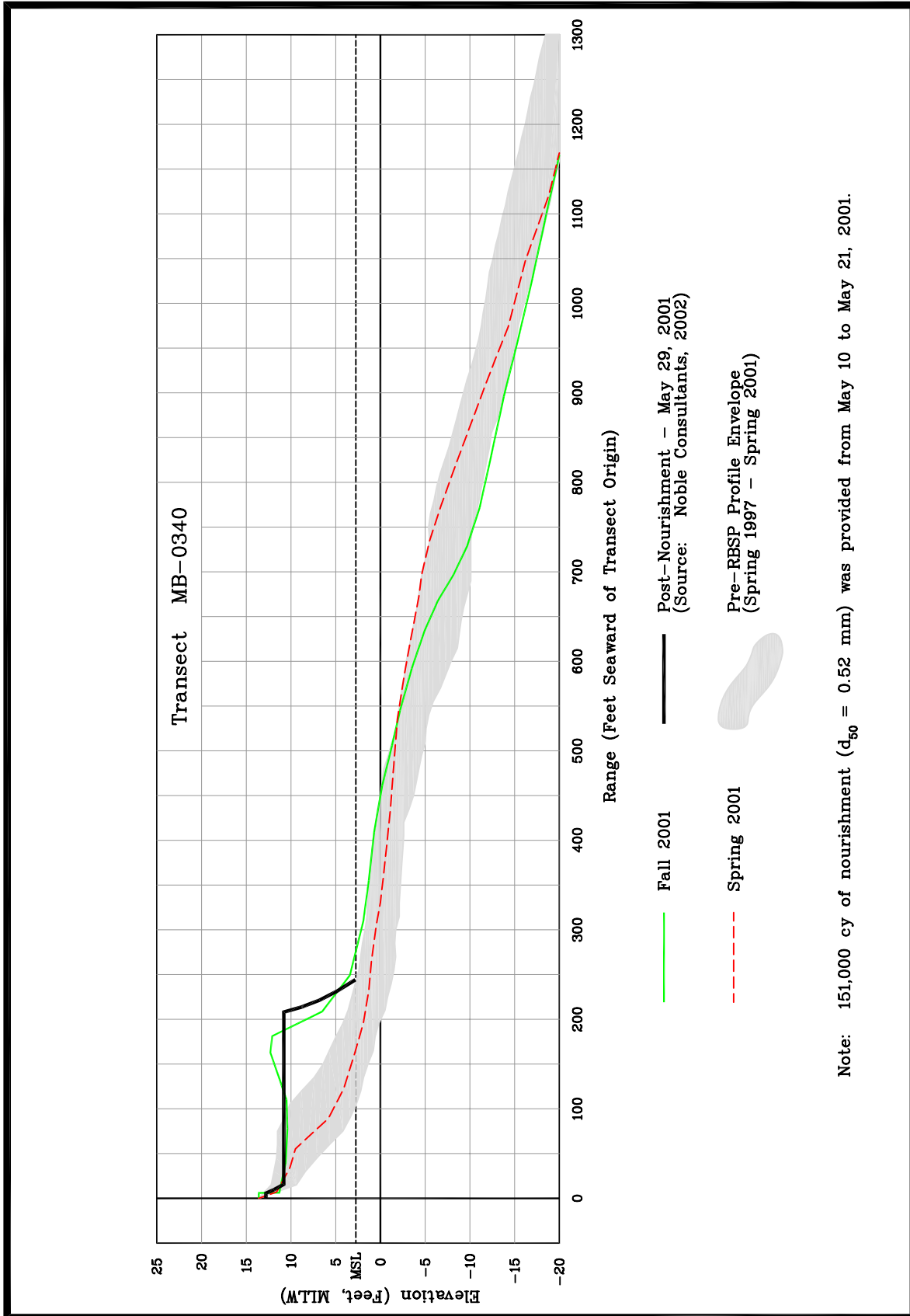


Figure 24. Transect MB-0340 at Mission Beach Receiver Site

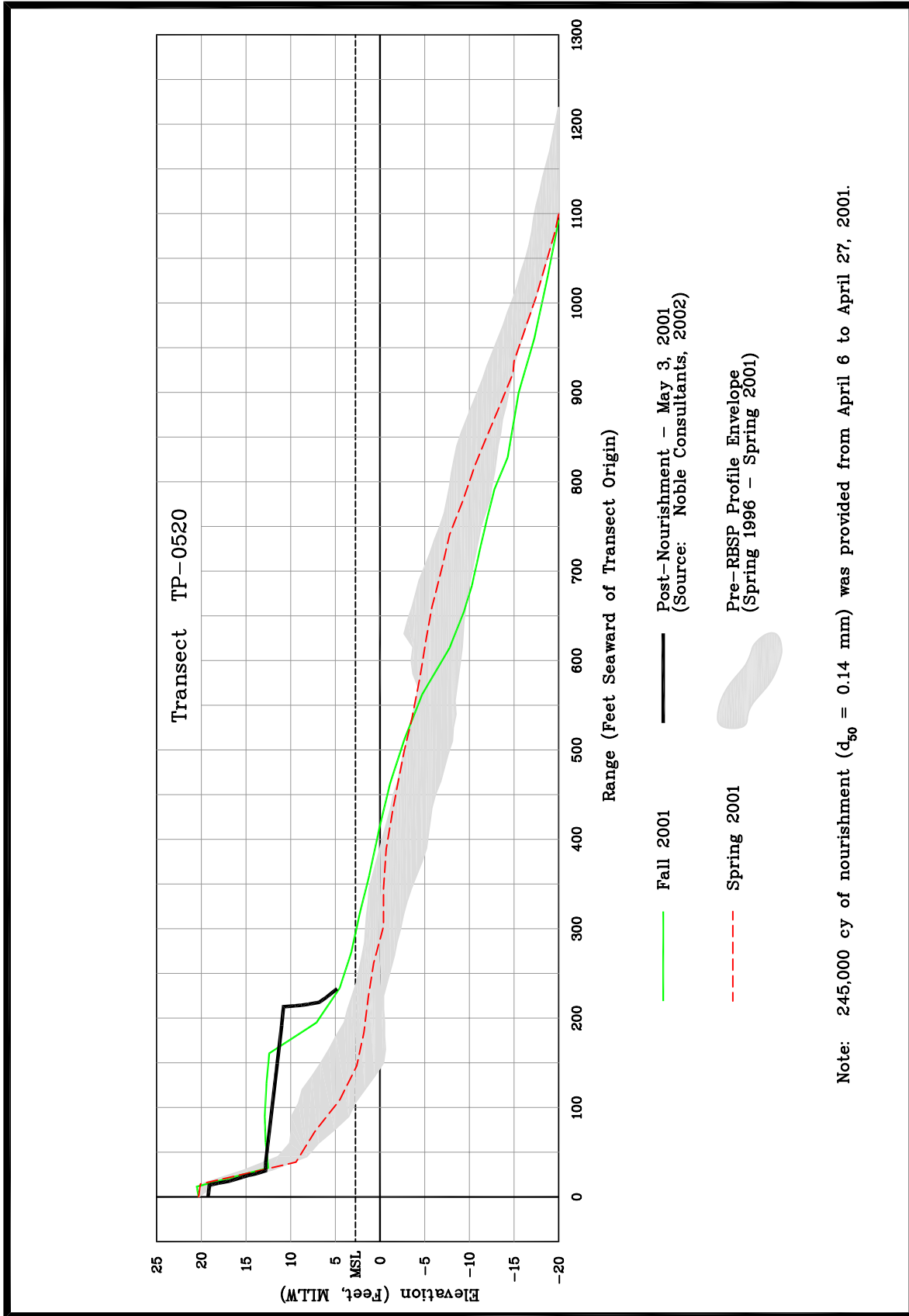


Figure 25. Transect TP-0520 at Torrey Pines Receiver Site



April 2001 (Pre-RBSP)

November 2001 (6.5 months after nourishment)

Plate 3. Torrey Pines Receiver Site in April and November 2001

The fact that the Fall 2001 profile at TP-0530 exceeded the pre-nourishment envelope by a substantial margin on the beach face (from -2 to +10 ft; Appendix C) suggests that the accretion resulted from northerly transport of the Torrey Pines fill during the summer wave season.

Additional information regarding the performance of the Torrey Pines fill can be obtained from the Southern California Beach Processes Study. The study findings, which include detailed wave data and bi-weekly surveys, are presented in a series of quarterly reports available at <http://cdip.ucsd.edu> (e.g., Guza, *et al.*, 2001).

5.2.4. Del Mar (Figure 19)

The Del Mar fill (Plate 4) consisted of 183,000 cy of fine sand placed from April 27 to May 10. The Post-Nourishment and Fall 2001 profiles on Transect DM-0580 (Figure 26) are quite similar, indicating that changes in the subaerial beach were modest during the intervening five and a half months. Table 10 indicates that the shoreline advance of 134 ft, shorezone volume increase of 46 cy/ft, and fill retention of 89% were all slightly above average for the RBSP fills.

At Transect DM-0590, which lies about 1,500 ft north of the Del Mar fill, the Fall 2001 profile exceeded the pre-RBSP envelope in the waterline area from -2 ft to +3 ft (Appendix C). As in the case of Torrey Pines Transect TP-0530, the probable cause is northerly transport of the nourishment material.

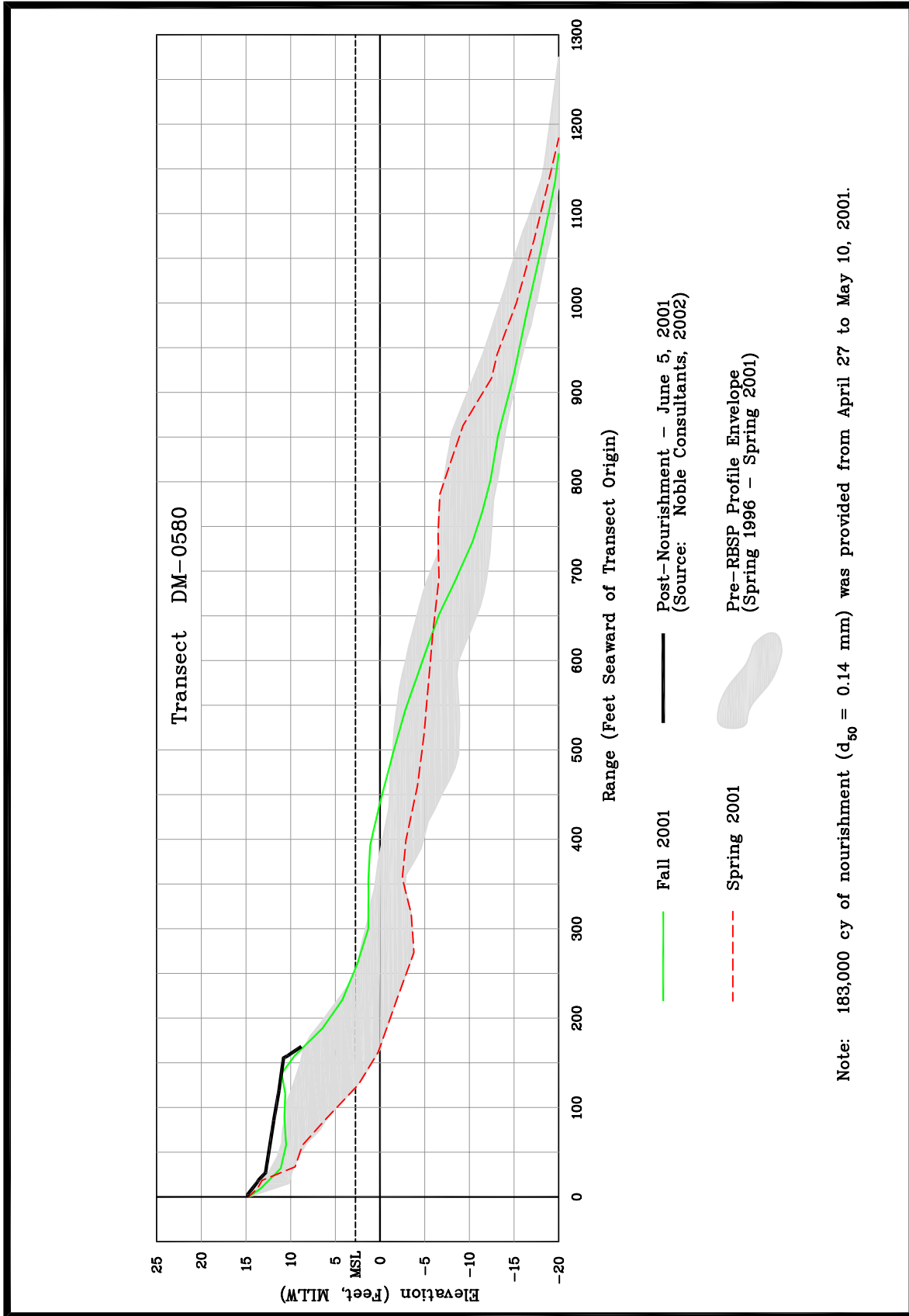
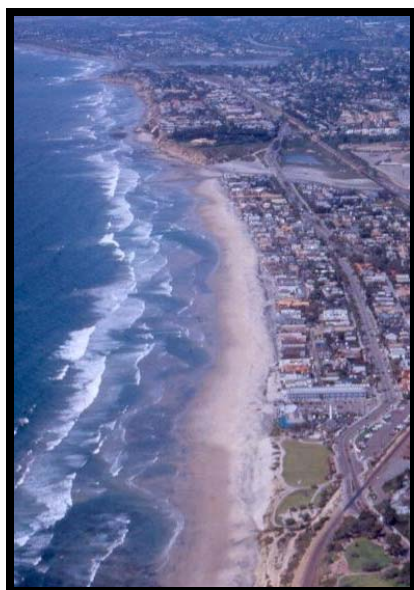
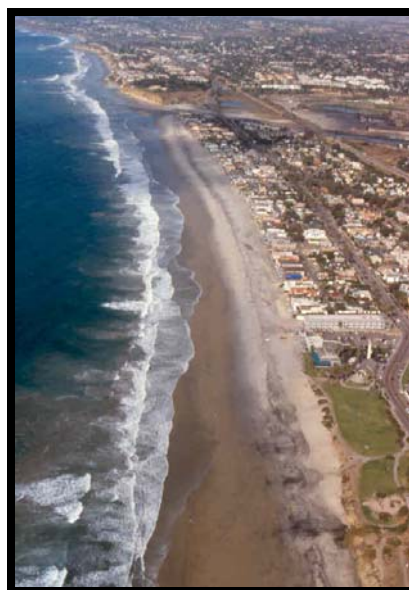


Figure 26. Transect DM-0580 at Del Mar Receiver Site



April 2001 (Pre-RBSP)



November 2001 (6 months after nourishment)

Plate 4. Del Mar Receiver Site in April and November 2001

5.2.5. Fletcher Cove (Figure 19)

The Fletcher Cove fill (Plate 5), placed from June 15 to 24, consisted of 146,000 cy of fine sand. In contrast to the four sites discussed previously, the fill retention at Fletcher Cove (Transect SD-0600) was relatively low at 66%. Nevertheless, the shorezone volume increase of 32 cy/ft was about average for the RBSP fills. This increase in volume, along with the profile data shown in Figure 27, indicate that much of the sediment lost from the subaerial beach moved offshore but remained within the shorezone.



April 2001 (Pre-RBSP)



November 2001 (4.5 months after nourishment)

Plate 5. Fletcher Cove Receiver Site in April and November 2001

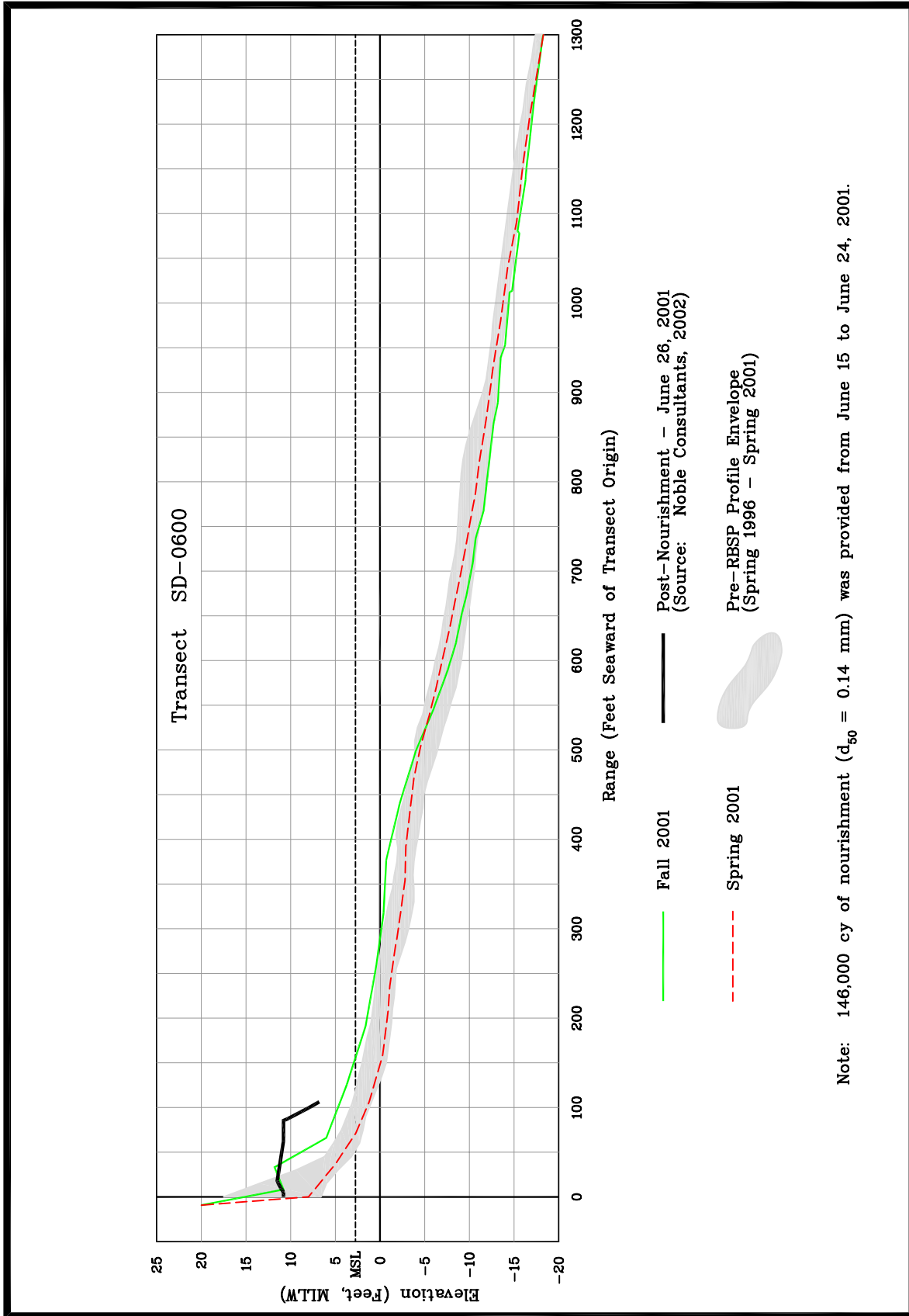


Figure 27. Transect SD-0600 at Fletcher Cove Receiver Site

5.2.6. Cardiff (Figure 19)

Cardiff received the smallest nourishment quantity among the RBSP receiver sites, 101,000 cy of medium sand (Plate 6). The fill was placed from August 2 to 10.



April 2001 (Pre-RBSP)

November 2001 (3 months after nourishment)

Plate 6. Cardiff Receiver Site in April and November 2001

As shown in Table 10, the fill retention (85%) and shoreline advance (117 ft) at Cardiff closely approximated the average values for the RBSP beach fills. The shorezone volume gain of 65 cy/ft was nearly double the RBSP average, however. The Fall 2001 profile in Figure 28 includes a substantial bulge between -10 ft and -2 ft, apparently caused by the offshore transport of nourishment material from the beach face.

5.2.7. Moonlight Beach (Figure 20)

Moonlight Beach (Plate 7), like Cardiff, received a relatively small quantity of nourishment: 105,000 cy of primarily coarse sand. The fill was placed from August 10 to 16.

Successive profiles through the fill on Transect SD-0670 are provided in Figure 29. The shorezone volume gain of 30 cy/ft and fill retention of 79% were slightly below average, but the shorezone advance of 144 ft was among the largest recorded. The magnitude of the advance is partly explained by the 180-ft design fill width, which exceeded the design dimension at most of the other receiver sites (Table 1).

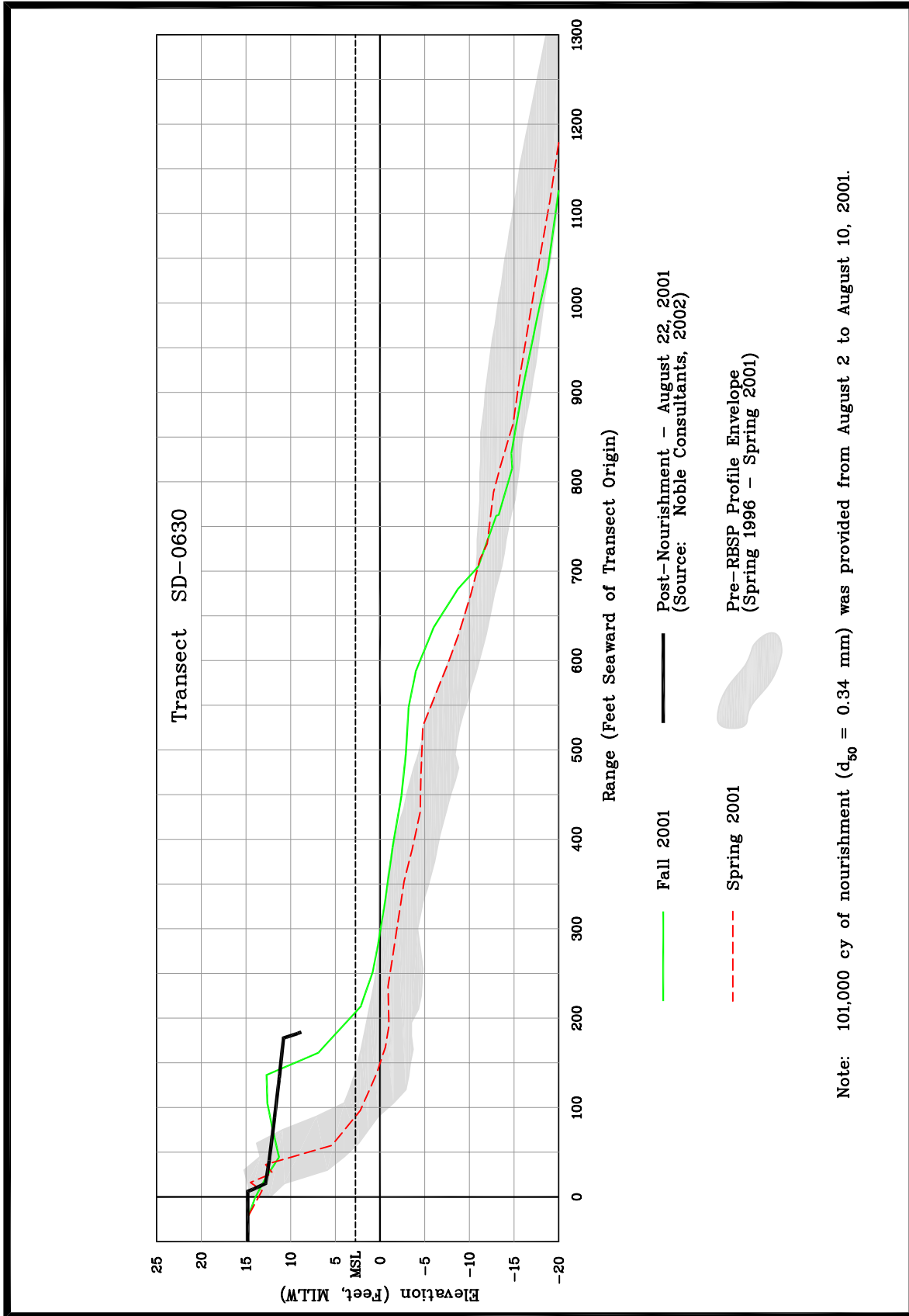


Figure 28. Transect SD-0630 at Cardiff Receiver Site

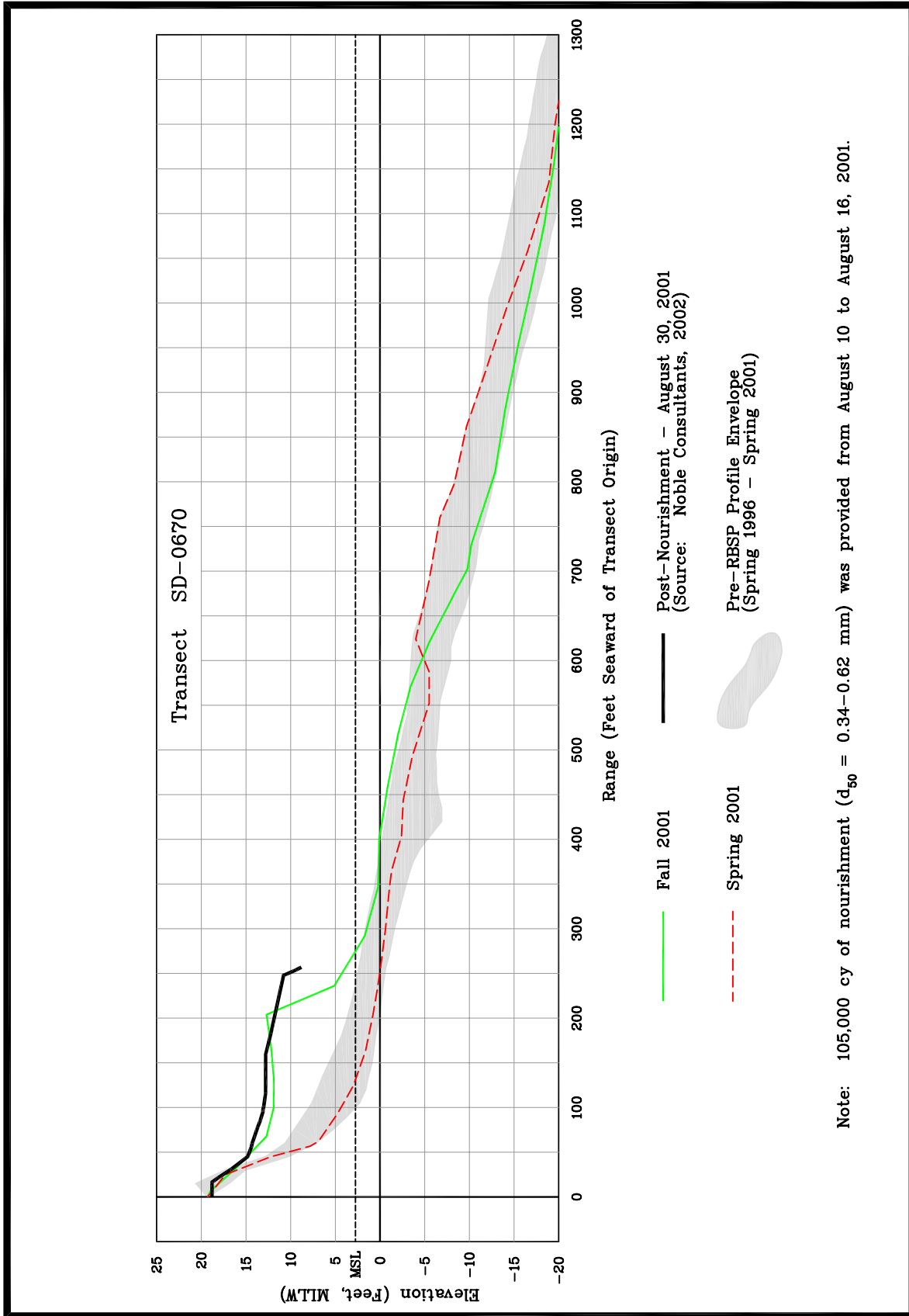


Figure 29. Transect SD-0670 at Moonlight Beach Receiver Site



April 2001 (Pre-RBSP)



November 2001 (3 months after nourishment)

Plate 7. Moonlight Beach Receiver Site in April and November 2001

5.2.8. Leucadia (Figure 20)

The Leucadia fill (Plate 8) consisted of 132,000 cy of coarse sand. A relatively long, narrow fill with a nominal width of 120 ft, it was placed from June 4 to 15.



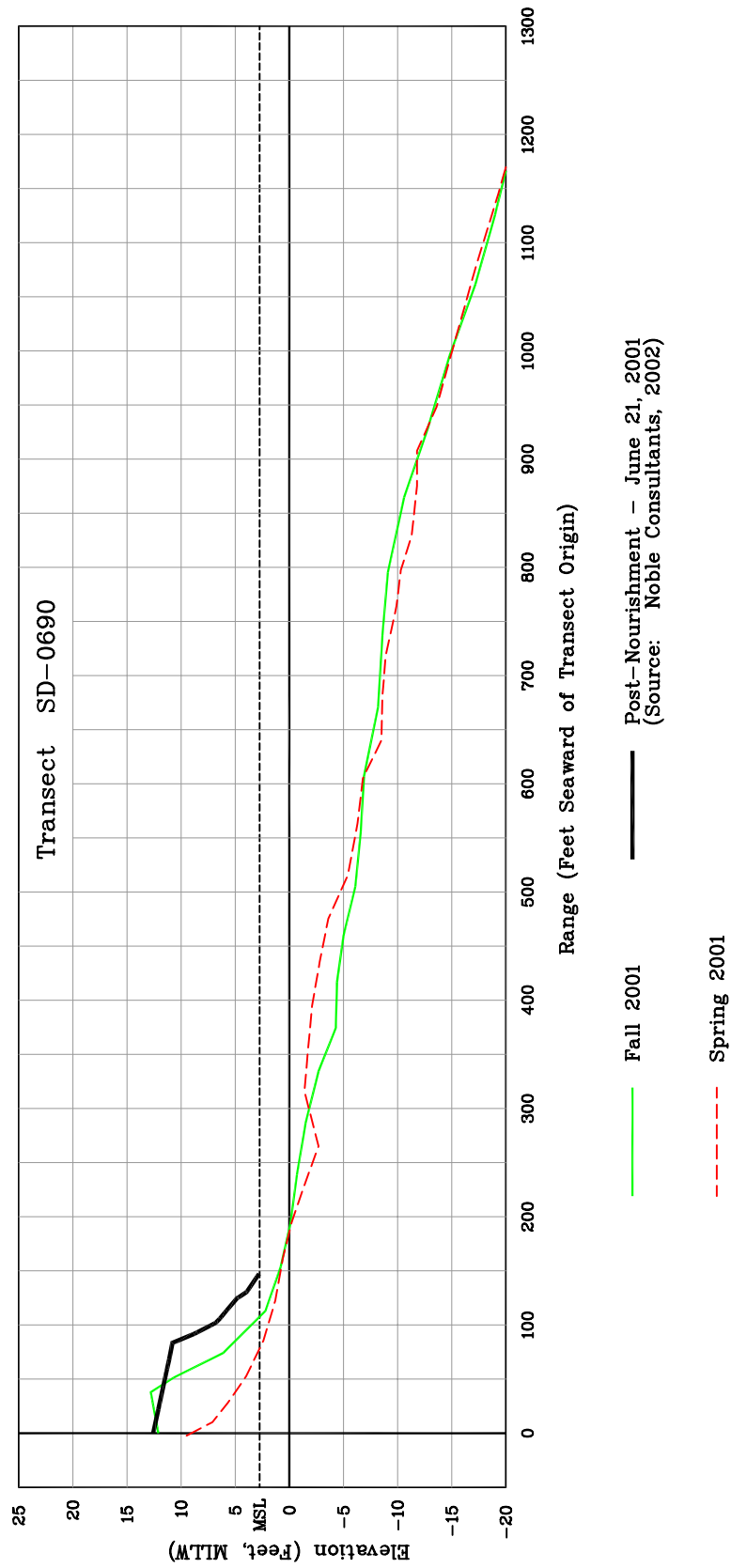
April 2001 (Pre-RBSP)



November 2001 (5 months after nourishment)

Plate 8. Leucadia Receiver Site in April and November 2001

Survey profiles on Transect SD-0690 are provided in Figure 30. Although the nourishment material on the subaerial beach experienced significant erosion, a corresponding area of accretion on the submerged slope analogous to that seen at Fletcher Cove (Figure 27) and Cardiff (Figure 28) was absent at Leucadia. In consequence, the shoreline advance (30 ft) and shorezone volume gain (14 cy/ft) were well below average,



Note: 132,000 cy of nourishment ($d_{50} = 0.62$ mm) was provided from June 4 to June 15, 2001.

Figure 30. Transect SD-0690 at Leucadia Receiver Site

while the fill retention (64%) was the lowest recorded at any of the receiver sites. The profile data from the adjacent transects to the north (SD-0695) and south (SD-0680) suggest that the eroded material was dispersed laterally. In both cases, the subaerial volume increased during the period between the Post-Nourishment and Fall Surveys (Appendix C).

5.2.9. Batiquitos (Figure 20)

At the Batiquitos receiver site, 117,000 cy of coarse sand were provided from August 16 to 23 (Plate 9). Profile data for Transect SD-0710 are shown in Figure 31.



April 2001 (Pre-RBSP)

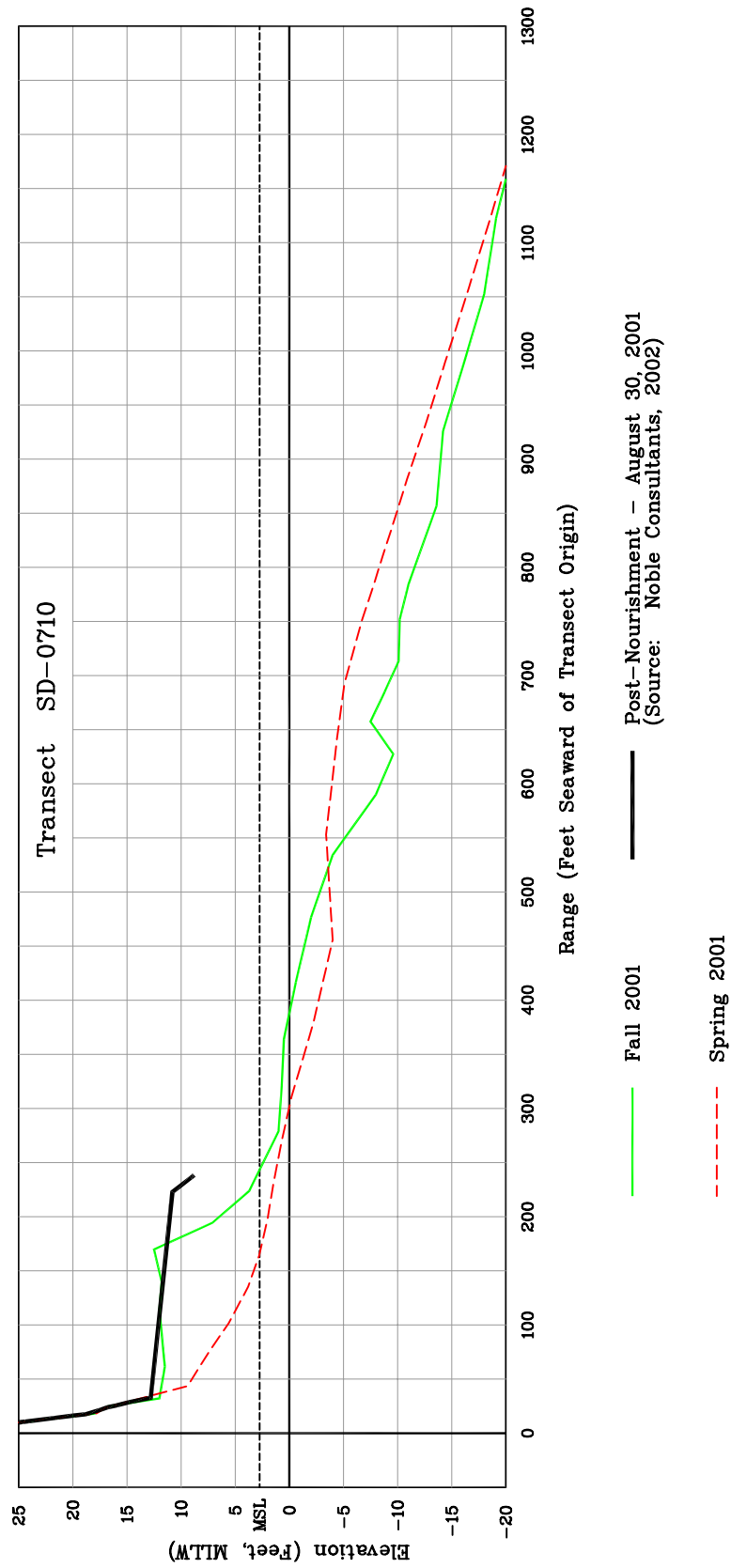


November 2001 (2.5 months after nourishment)

Plate 9. Batiquitos Receiver Site in April 2001 and November 2001

The performance of the Batiquitos fill resembled that of the Leucadia fill, with substantial erosion of the nourishment material on the subaerial portion of the profile, and no appreciable accretion on the submerged portion. The shoreline advance (77 ft) and fill retention (69%) were well below average; the shorezone volume change of -3 cy/ft represented the only net loss among the twelve receiver beaches.

Approximately 500 ft north of the Batiquitos fill, at Transect CB-0720, the Fall 2001 profile registered accretion from MSL to +10 ft relative to a Post-Nourishment profile obtained on August 30 (Appendix C). This finding suggests that a portion of the nourishment material was transported to the north by the late-summer wave conditions.



Note: 117,000 cy of nourishment ($d_{50} = 0.62$ mm) was provided from August 16 to August 23, 2001.

Figure 31. Transect SD-0710 at Batiquitos Receiver Site

5.2.10. South Carlsbad (Figure 20)

South Carlsbad received 158,000 cy of coarse sand from June 25 to July 6 (Plate 10). The Spring 2001, Post-Nourishment, and Fall 2001 profiles obtained on Transect CB-0775 are shown in Figure 32.



April 2001 (Pre-RBSP)

November 2001 (4.5 months after nourishment)

Plate 10. South Carlsbad Receiver Site in April and November 2001

The shoreline advance of 103 ft and fill retention of 84% at South Carlsbad were slightly below average, but the shorezone volume gain of 86 cy/ft was the highest among all twelve receiver sites. As is evident in Figure 32, the volume increase was concentrated in the upper portion of the profile between -5 and +13 ft. Immediately north of the South Carlsbad fill, at Transect CB-0780, accretion of the subaerial beach was evident in the Fall 2001 profile. The implication is that some of the South Carlsbad material was transported to the north, in analogous fashion to the Batiquitos fill.

5.2.11. North Carlsbad (Figure 21)

The 225,000 cy North Carlsbad fill (Plate 11) was the third largest constructed under the RBSP. Placed from July 6 to August 2, it consisted of a mixture of coarse (21%), medium (2%) and fine (77%) sand. Beach profiles obtained on Transect CB-0865 are shown in Figure 33.

The 93% fill retention and 54 cy/ft shorezone volume gain at North Carlsbad ranked high among the RBSP fills. Although the shoreline advance of 111 ft was about average in absolute terms, it was substantial relative to the design fill width of only 100 ft.

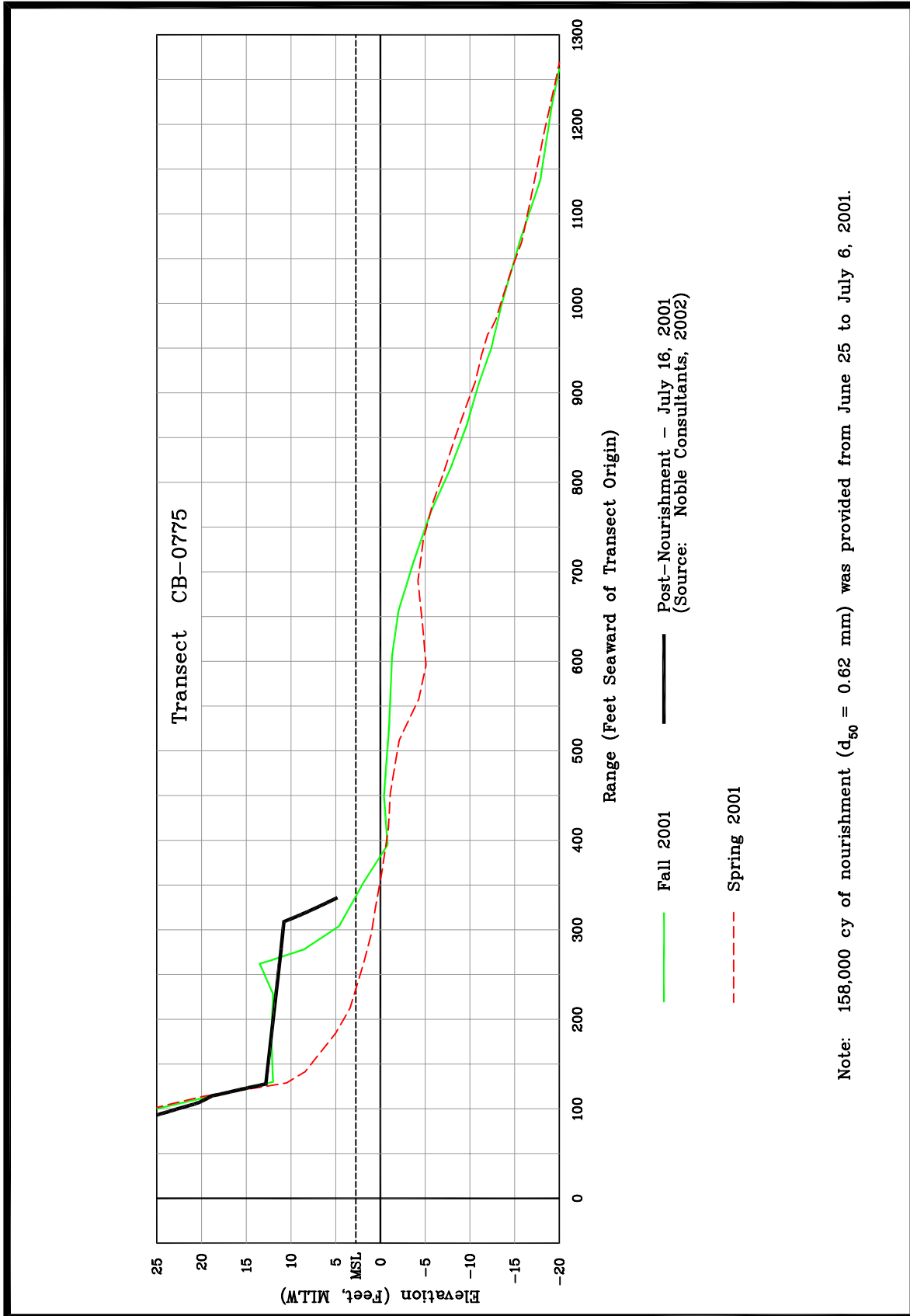
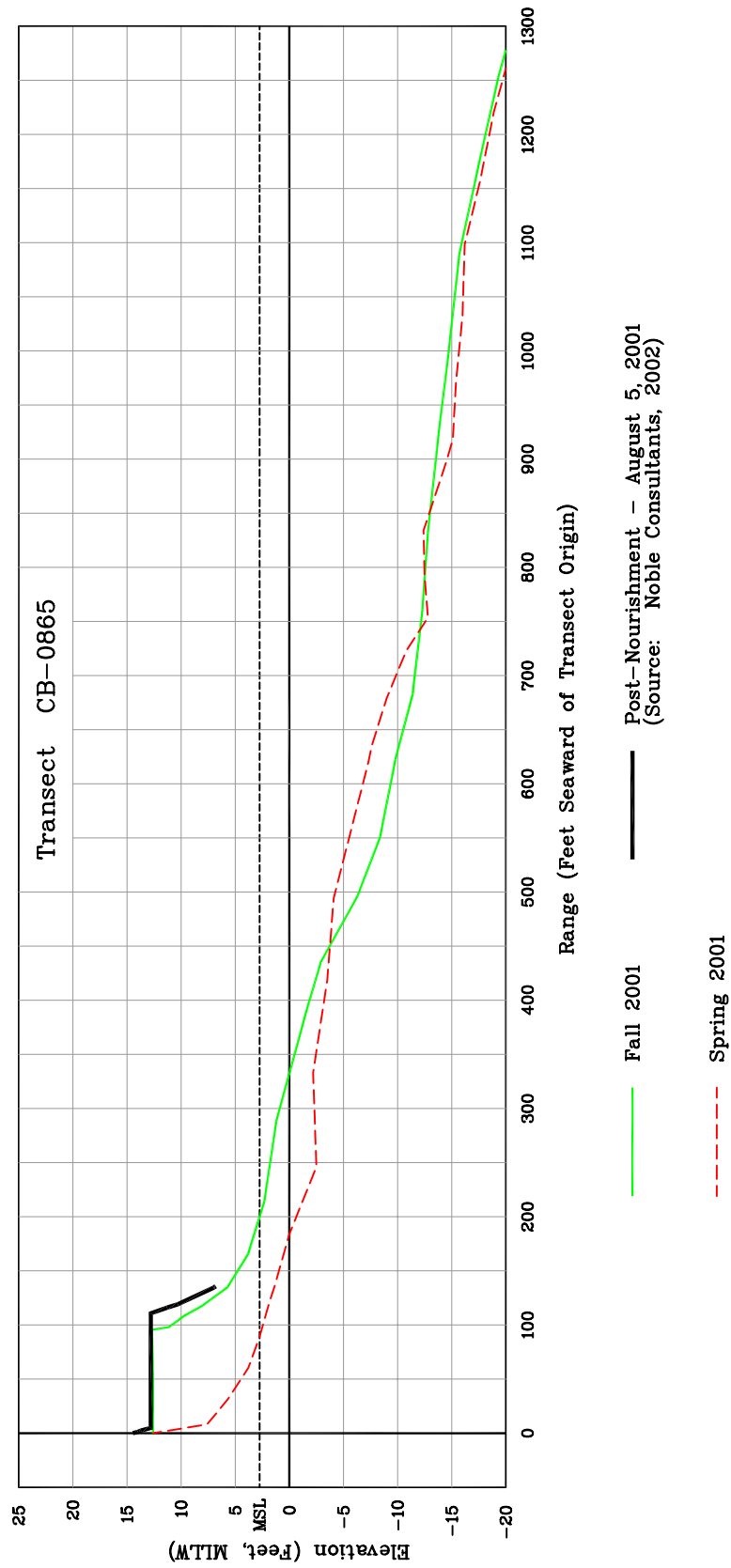


Figure 32. Transect CB-0775 at South Carlsbad Receiver Site



Note: 225,000 cy of nourishment ($d_{50} = 0.14\text{--}0.62\text{ mm}$) was provided from July 6 to August 2, 2001.

Figure 33. Transect CB-0865 at North Carlsbad Receiver Site



April 2001 (Pre-RBSP)



November 2001 (3.5 months after nourishment)

Plate 11. North Carlsbad Receiver Site in April and November 2001

5.2.12. Oceanside (Figure 21)

The Oceanside fill (Plate 12) was the largest (421,000 cy) and longest (4,400 ft) of the RBSP fills. Comprised entirely of coarse sand, it also was the last to be constructed (August 24-September 23). Profile data obtained on Transect OS-0930 are presented in Figure 34.



April 2001 (Pre-RBSP)



November 2001 (1.5 months after nourishment)

Plate 12. Oceanside Receiver Site in April and November 2001

The initial performance of the Oceanside fill was exemplary, with all three parameters in Table 10 exceeding their respective RBSP averages. The shoreline advanced 126 ft, the shorezone volume increased by 65 cy/ft, and fill retention was 95%. It should be noted that these numbers might have been less favorable had the fill been completed earlier in the summer. Nevertheless, the positive findings at Oceanside suggest that superior results will accrue to the fills with coarser sediment sizes and larger nourishment volumes.

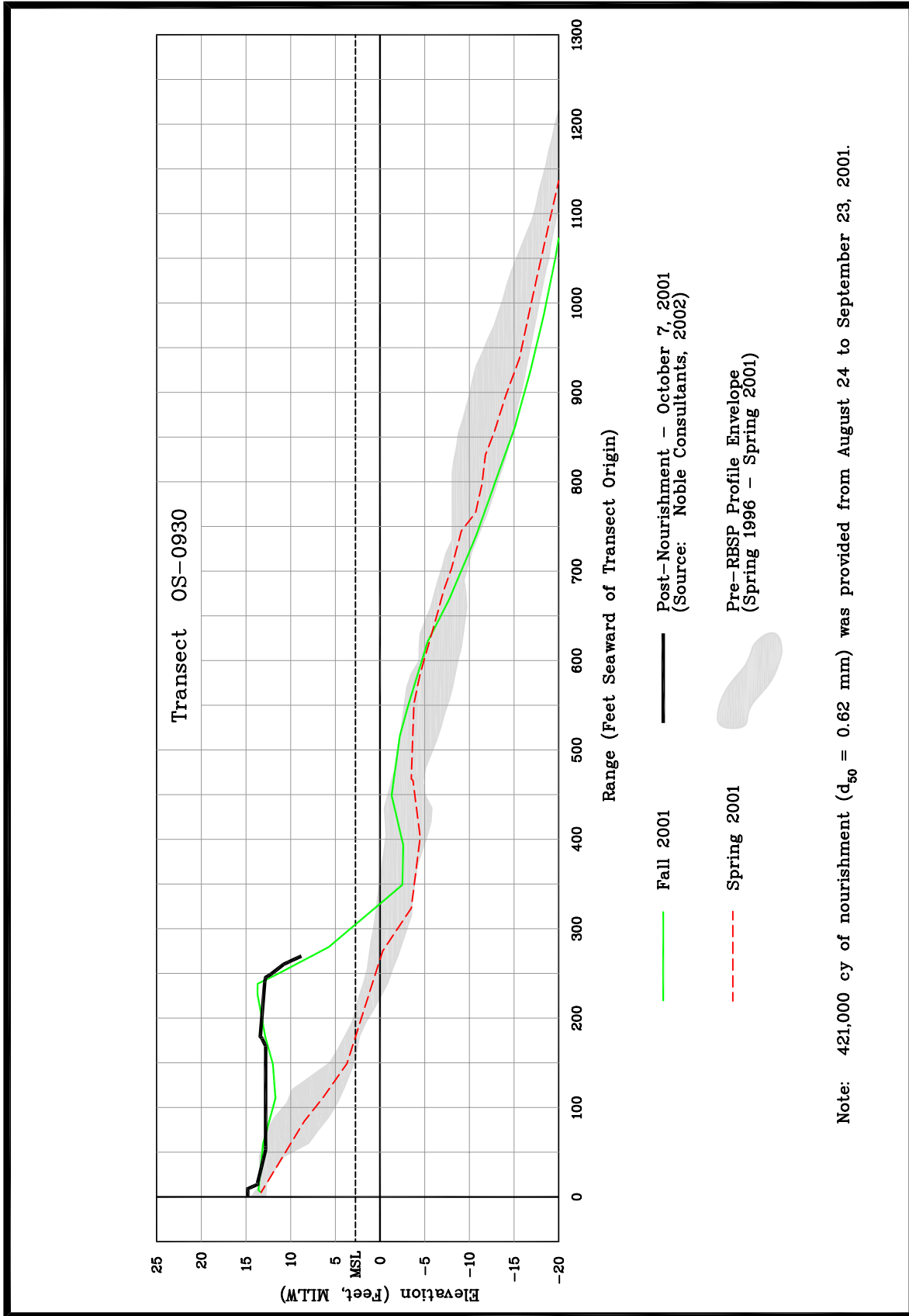


Figure 34. Transect OS-0930 at South Oceanside Receiver Site

6. LAGOON ENTRANCE CONDITION

Section 6 evaluates the condition of the five lagoon entrances in the Oceanside Littoral Cell during the 2001 monitoring year. An overview is provided in Section 6.1, followed by a discussion of each entrance in Section 6.2. The location of each entrance is indicated in Figure 1.

6.1. Overview

With the exception of a brief closure at San Elijo that occurred in early December, 2000, all five lagoon entrances in the Oceanside Littoral Cell remained open to tidal exchange during the 2001 monitoring year (approximately November 2000 through October 2001). At Agua Hedionda and Batiquitos, where the entrances are stabilized by jetties, the channels provided the full range of tidal exchange while exhibiting only small variations in water depth. At San Elijo, San Dieguito, and Los Peñasquitos, tidal exchange through the unstabilized entrance channels was limited to the higher stages of the tide. The status of these three channels, each of which closed on one or more occasions during the four-year monitoring period that preceded the RBSP (Spring 1997-Spring 2001; Coastal Frontiers, 2001), is summarized in Figure 35.

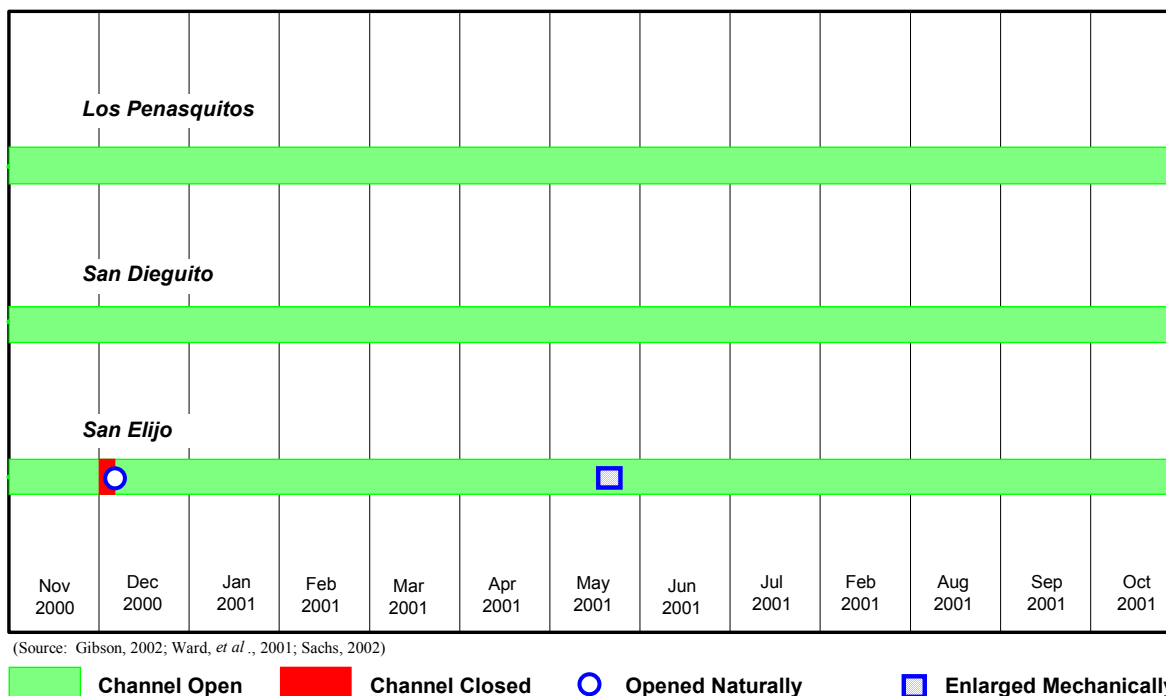


Figure 35. Condition of Unstabilized Lagoon Entrances, Fall 2000 to Fall 2001

In late November 2001, shortly after the end of the 2001 monitoring year, the entrance channels at San Dieguito and Los Peñasquitos closed in apparent response to an early-Winter wave event. The maximum significant wave height of 7.3 ft (2.22 meters) measured at the Oceanside Buoy was unexceptional, but the storm persisted for more than three days (November 21-24). Even if these closures are taken into consideration, the post-RBSP closure frequencies at the three unstabilized entrance channels remained less than or equal to those that preceded the nourishment program.

6.2. Lagoon Entrance Performance

The performance of each lagoon entrance is evaluated below. Supporting topographic data are provided in Appendix H, while ground photographs of the three unstabilized channels appear in Appendix I.

6.2.1. Agua Hedionda

Plate 13 displays the condition of the north entrance to Agua Hedionda Lagoon in April and November, 2001. In the April photo, a dredge is evident removing a flood tide shoal from the region landward of the jetties. When the November photo was taken, the shoal had returned.



April 2001

November 2001

Plate 13. Agua Hedionda Lagoon North Entrance in April and November 2001.

Figure 36 presents the controlling elevations that were measured in the north entrance channel on a semi-annual basis from Spring 1997 through Fall 2001. (“Controlling elevation” refers to the lowest elevation at which water can pass unobstructed between the ocean and the lagoon.) During the period that preceded the RBSP (Spring 1997-Spring 2001), the controlling elevations ranged from -4.0 to -5.9 ft (MLLW). In Fall 2001, a controlling elevation of -4.9 ft was detected at the coast road bridge.

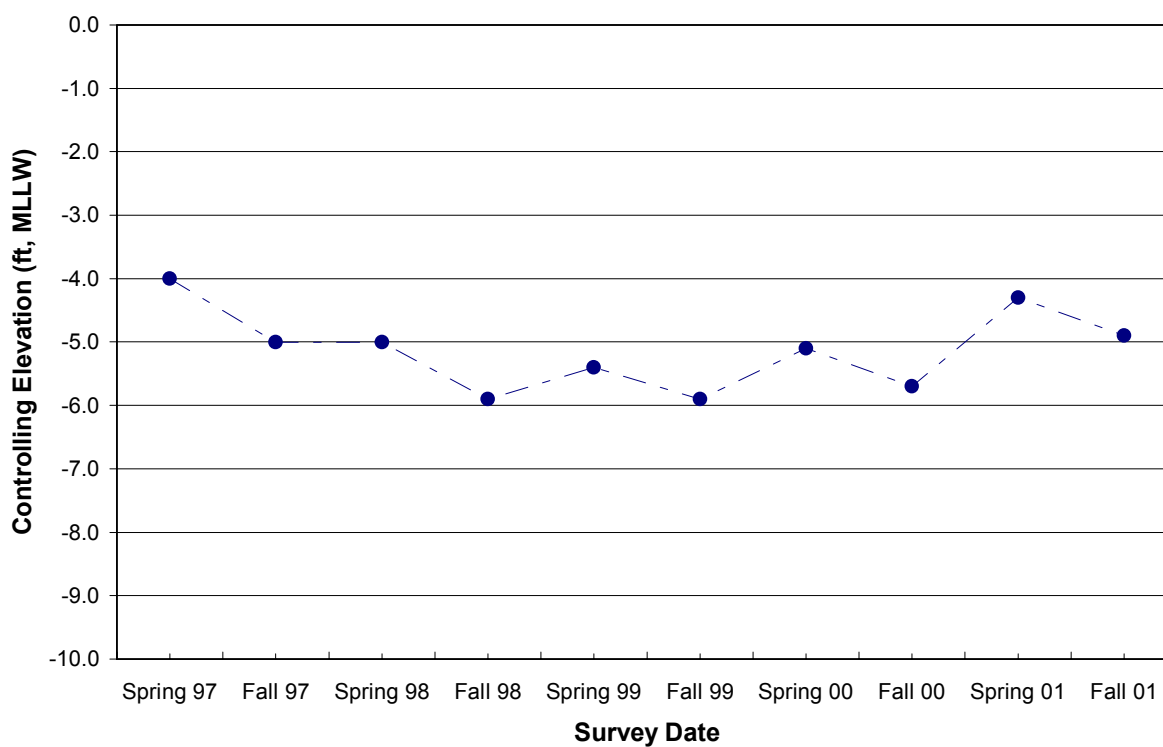


Figure 36. Controlling Elevation for Tidal Exchange in Agua Hedionda Lagoon

6.2.2. Batiquitos

The condition of the Batiquitos Lagoon entrance channel in April and November, 2001, is shown in Plate 14. Substantial shoals were evident in the outer and middle basins on both occasions.



April 2001



November 2001

Plate 14. Batiquitos Lagoon Entrance in April and November 2001.

Between Spring 1997 and Fall 2001, the controlling elevations measured in the entrance channel varied between -5.0 and -6.3 ft (Figure 37). The elevation of -5.9 ft found at the coast road bridge in Fall 2001 was within this narrow range that preceded the RBSP.

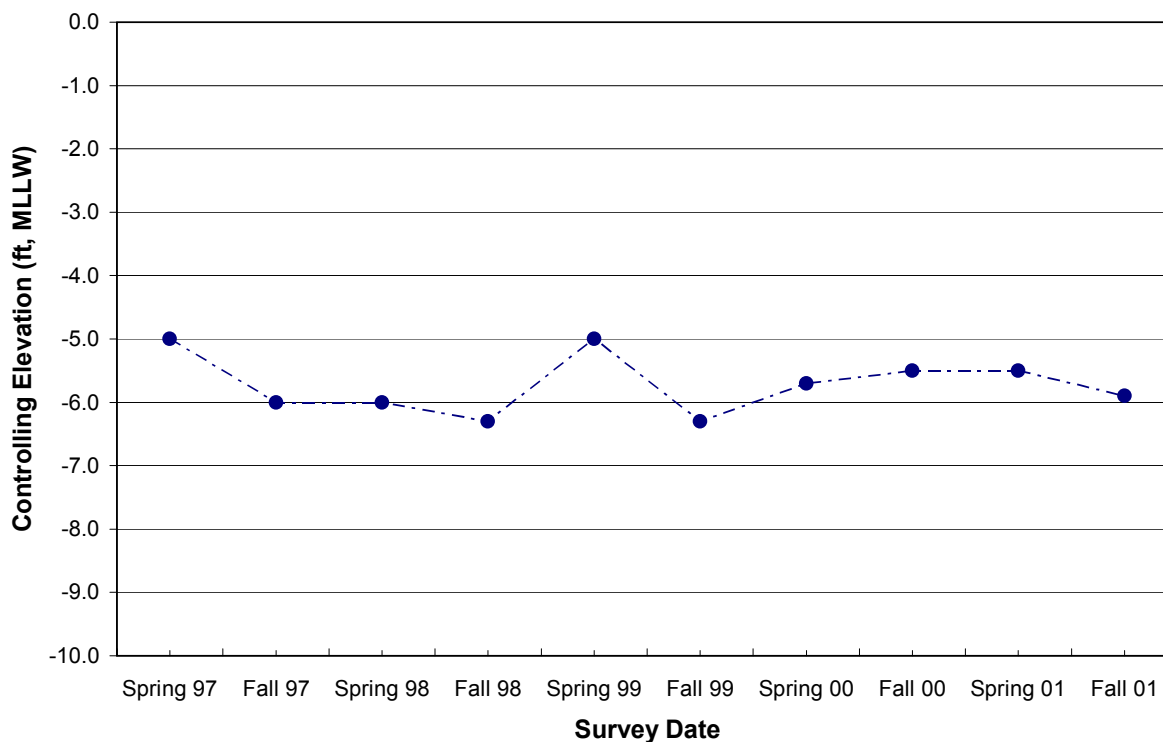


Figure 37. Controlling Elevation for Tidal Exchange in Batiquitos Lagoon

6.2.3. San Elijo

Other than the brief closure that occurred from December 1 to 5, 2000, the San Elijo Lagoon entrance channel remained open to tidal exchange for the entire 2001 monitoring year (Figure 35). The December closure and re-opening resulted from natural causes rather than human intervention. Although mechanical enlargement of the channel was undertaken in May, 2001, to increase the flow, tidal exchange never completely ceased at that time. The occurrence of only one closure during the one-year monitoring period contrasts sharply with the channel's past history. Based on the records maintained by the San Elijo Lagoon Conservancy, the average closure frequency between 1987 and 1999 was 4.9 times per year (Gibson, 2002).

Plate 15 shows the channel condition in April and November, 2001. The controlling elevation noted in Fall 2001, +1.4 ft, was near the bottom of the range that prevailed prior to the RBSP (+0.9 to +7.0 ft; Figure 38).



April 2001



November 2001

Plate 15. San Elijo Lagoon Entrance in April and November 2001.

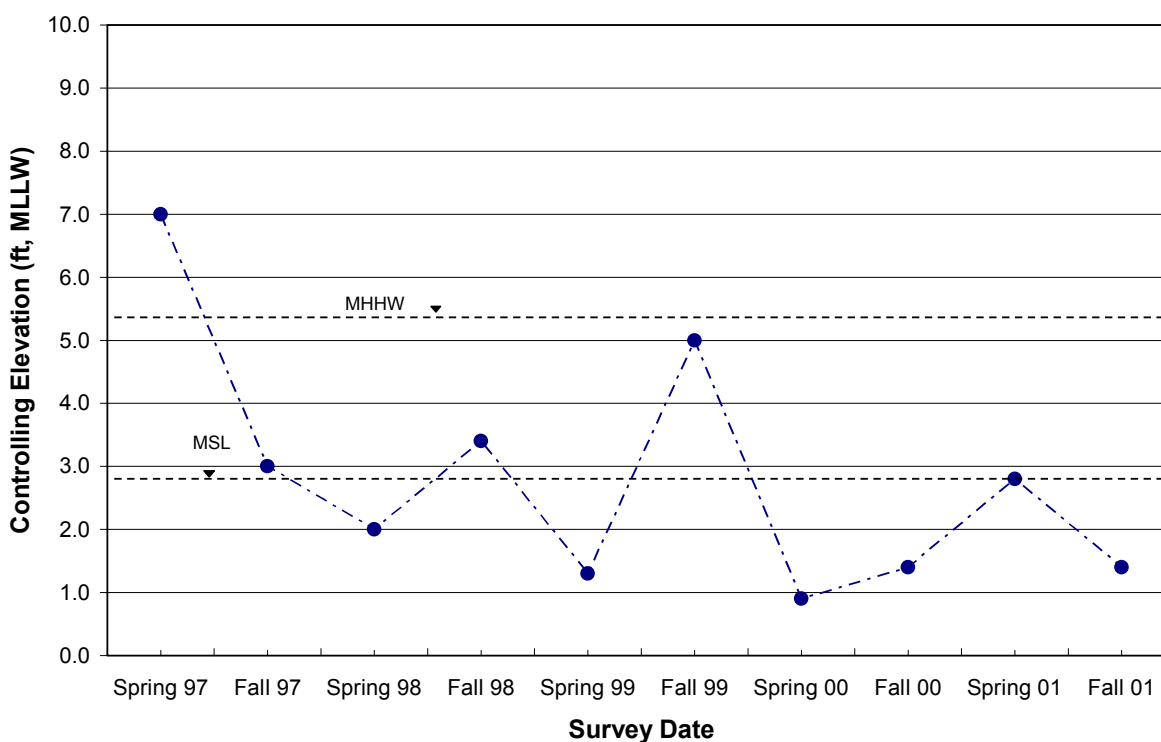


Figure 38. Controlling Elevation for Tidal Exchange in San Elijo Lagoon

Based on the elevation change data presented in Appendix H, the sediment volume in the entrance channel survey area decreased by 2,500 cy between Fall 2000 and Spring 2001 and increased by 400 cy between Spring and Fall 2001. The net change during the 2001 monitoring year was a modest decrease of 2,100 cy.

6.2.4. San Dieguito

The San Dieguito Lagoon entrance channel (Plate 16) provided restricted tidal exchange during the entire 2001 monitoring year (Figure 35). Per Figure 39, the controlling elevation in Fall 2001 was +3.1 ft, which was slightly above MSL (+2.8 ft), and within the exceptionally wide pre-RBSP range of +1.0 to +9.4 ft.



April 2001



November 2001

Plate 16. San Dieguito Lagoon Entrance in April and November 2001.

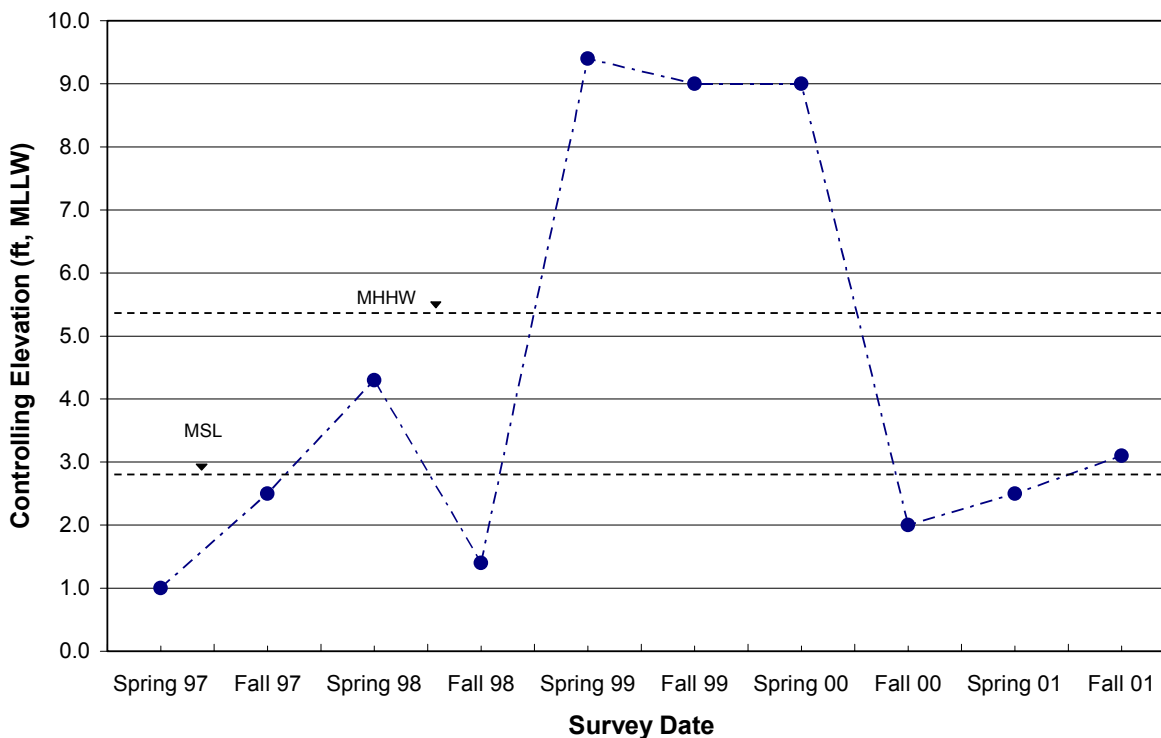


Figure 39. Controlling Elevation for Tidal Exchange in San Dieguito Lagoon

Between Fall 2000 and Spring 2001, seasonal offshore transport driven by the winter wave climate caused a net loss of 28,000 cy in the entrance channel survey area (Appendix H). This loss was followed by a seasonal gain of 19,500 cy between Spring and Fall, 2001, producing a net loss of 8,500 cy for the Fall 2000-Fall 2001 monitoring period.

As indicated in Section 6.1, the San Dieguito Lagoon entrance channel closed in late November, shortly after the end of the 2001 monitoring year. Although the channel has closed repeatedly in the past, remaining open only about one-third of the time (Elwany, *et al.*, 1998), the monitoring data suggest that the November 2001 closure was caused, at least in part, by the northerly transport of sediment from the nearby Del Mar fill. Of particular relevance is an accumulation of sediment noted at the waterline of Transect DM-0590 at the time of the Fall 2001 Survey (Section 5.2.4). This transect lies to the north of the Del Mar fill, and immediately south of the lagoon entrance channel (Figure 19).

6.2.5. Los Peñasquitos

As in the case of San Dieguito, the Los Peñasquitos Lagoon entrance channel provided restricted tidal exchange during the entire 2001 monitoring year before closing in late November (Figure 35). Partial blockage of the channel occurred from early December, 2000, through early January, 2001, but mechanical intervention was not required at that time (Ward, *et al.*, 2001).

The channel condition in April and November, 2001, is shown in Plate 17. Extensive shoaling is evident landward of the coast road bridge in both photographs. A controlling elevation of +3.4 ft was found at the time of the Fall 2001 Survey. Prior to the RBSP, the values ranged from +1.8 to +7.4 ft (Figure 40).



April 2001



November 2001

Plate 17. Los Peñasquitos Lagoon Entrance in April and November 2001.

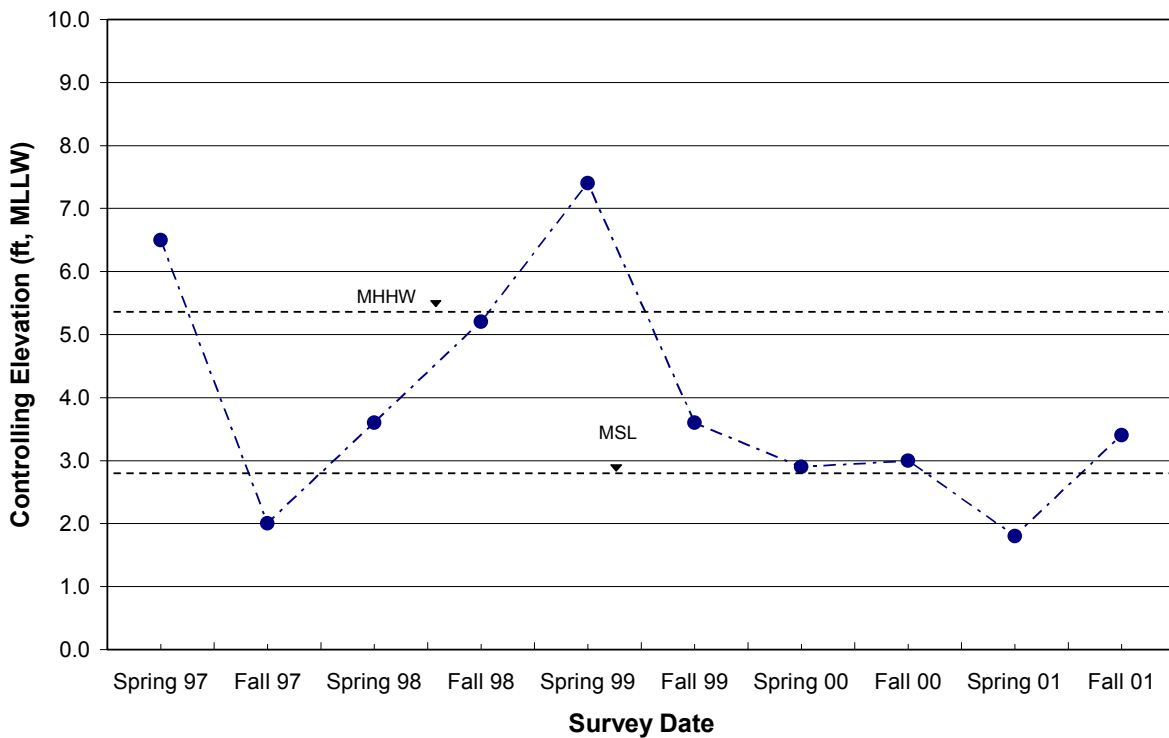


Figure 40. Controlling Elevation for Tidal Exchange in Los Peñasquitos Lagoon

The elevation change data in Appendix H indicate that the entrance channel survey area gained 100 cy between Fall 2000 and Spring 2001, and an additional 8,400 cy between Spring and Fall 2001. The total gain of 8,500 cy for the year was concentrated in the region seaward of the coast road bridge, rather than inside the lagoon.

In Section 5.2.3, post-nourishment accretion at the waterline of Transect TP-0530 was attributed to the northerly transport of sediment from the Torrey Pines fill. As this transect is located just south of Los Peñasquitos Lagoon (Figure 18), it is likely that the RBSP fill material contributed to the channel closure that occurred in late November 2001. Nevertheless, this single event in a thirteen month period of yields a far lower closure frequency than the eight closures that occurred between September 1998 and September 2000 (Williams, *et al.*, 1999; Ward, *et al.*, 2000).

7. CONCLUSIONS

Conclusions pertaining to the 2001 monitoring year in general (November 2000 through October 2001), and to the initial outcome of the RBSP in particular, are summarized below.

1. Precipitation and streamflow were well below average, while the wave conditions were relatively mild. The primary implications are threefold: (1) the absence of large wave events during the Summer and Fall seasons helped to prolong the life of the RBSP beach fills; (2) the scant precipitation and low stream flows failed to deliver significant quantities of beach-quality sediment to the coast in the winter months that preceded the RBSP; and (3) the low streamflows failed to flush coastal sediment from the lagoon entrances in the Oceanside Cell.
2. The only non-RBSP nourishment project undertaken during the 2001 monitoring year was a miniscule 1,000 cy fill at Moonlight Beach. As a result, 467,000 cy of the RBSP fill material (about 22%) served to compensate for the average annual nourishment provided from other sources in prior years. The remaining RBSP material, 1,637,000 cy, represented incremental nourishment. The incremental volume was relatively small in the Silver Strand Cell (47,000 cy), moderate in the Mission Beach Cell (149,000 cy) and large in the Oceanside Cell (1,441,000 cy).
3. The 2001 sand bypass volumes at Batiquitos and Agua Hedionda Lagoons (45,000 and 429,000 cy, respectively) were substantially higher than the average annual values in recent years (2,000 and 143,000 cy). These large volumes were not caused by the RBSP, because the bypass work was conducted prior to or concurrent with the start of the nourishment activities. Conversely, the sand bypass volume at Oceanside Harbor was well below average: 80,000 cy in 2001 vs. 237,000 cy in the past. The implications are twofold: (1) the beaches adjacent to the two lagoon entrances benefited from the increased bypass volumes at these sites; and (2) the beaches at Oceanside and North Carlsbad were negatively impacted by the decreased bypass volume at the harbor.
4. The combination of RBSP beach fills and mild wave conditions during the 2001 monitoring year proved to be extremely favorable for the San Diego County coast. Wider beaches resulted in all three littoral cells, with the greatest increases occurring in the Oceanside Cell (where more than 85% of the RBSP nourishment

material was placed). At 58% of the transects with measurements dating back to 1997, the beach width in Fall 2001 was greater than that noted in any of the prior four years.

5. Gains in shorezone sediment volume outnumbered losses by a wide margin. The gains were concentrated in the Oceanside Cell, whereas gains and losses were mixed in the Silver Strand and Mission Beach Cells. In the absence of other nourishment programs and of significant riverine input, the increase in shorezone volume may be attributed primarily to the RBSP. Although the greatest gains occurred at the receiver beaches, significant volume increases also occurred at a number of flanking locations.
6. The initial performance of the individual RBSP fills varied considerably. Based on the use of a single indicator profile to represent each site, the retention of nourishment material on the subaerial beach at the time of the Fall 2001 Survey ranged from about 65% at Fletcher Cove, Leucadia, and Batiquitos to greater than 90% at Imperial Beach, Mission Beach, Torrey Pines, North Carlsbad, and Oceanside. Although it is premature to draw conclusions about long-term performance, the high fill retention, shoreline advance, and shorezone volume gain that occurred at Oceanside suggest that coarse sediment sizes and large fill volumes will produce superior results.
7. With the exception of a brief closure at San Elijo that occurred in early December, 2000, all five lagoon entrances in the Oceanside Cell remained open to tidal exchange during the 2001 monitoring year. At Agua Hedionda and Batiquitos, where the entrances are stabilized by jetties, the channels provided the full range of tidal exchange while exhibiting only small variations in water depth. At San Elijo, San Dieguito, and Los Peñasquitos, where the entrances are unstabilized, tidal exchange was limited to the higher stages of the tide.
8. In late November 2001, shortly after the end of the 2001 monitoring year, the entrance channels at San Dieguito and Los Peñasquitos closed in apparent response to an early-Winter wave event of unusually long duration. Although the RBSP beach fills at Del Mar and Torrey Pines appear to have contributed to these closures, the post-RBSP closure frequencies at the three unstabilized entrance channels remained less than or equal to those that preceded the nourishment program.

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