FINAL CONSTRUCTION REPORT
FOR WHEELER NORTH REEF AT SAN CLEMENTE, CALIFORNIA

(FORMERLY THE SONGS ARTIFICIAL REEF MITIGATION PROJECT, PHASE 2 MITIGATION REEF)

Volume I: Technical Report

for

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TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

Documented within this report are the construction methods employed in building Phase 2 of the Wheeler North Reef (WNR) (formerly the SONGS Artificial Reef Mitigation Project). Approximately 126,000 tons of boulder-size quarry material were deposited over 152 acres. The reef was constructed in two phases: Phase 1, the Experimental Reef (22.4 acres), completed in September 1999, and Phase 2 (152 acres), completed on September 11, 2008.

The Phase 2 reef design was constructed of 17 polygons, varying spatially from 1.35 to 38.88 acres. Polygon siting relied primarily on the historical locations of kelp communities (maps) and multibeam and sub-bottom profiling sonar surveys conducted at the offshore lease site. The acoustical surveys were verified (ground-truthed) by dive surveys. Additionally, the dive surveys evaluated the biological diversity of the lease area. The design also considered the historical, physical, and biological data collected during previous studies in the area and the results of experimental reef monitoring between 1999 and 2004.

The Phase 2 reef construction achieved the following: 1) all polygons were built in close proximity to the San Mateo Kelp Bed; 2) all polygons avoided hard substrate areas; 3) the integrity of the Phase 1 Experimental Reef modules was maintained; 4) navigation channels were provided; and 5) all constructed reef polygons avoided areas of historical kelp growth as well as areas of special interest to local fisheries.

Phase 2 reef construction material consisted exclusively of quarry rock cast upon the appropriate benthic substrate in a single-layer deposition at a density of approximately 829 tons per acre. Reef construction was initiated on June 9, 2008 and concluded on September 11, 2008, consisting of a 73 day work cycle.

California Coastal Commission (CCC) permit (CDP #E-07-010) requires the Phase 2 Mitigation Reef be constructed of single layer quarry rock distributed on the seafloor at a percent coverage varying between 42 to 86 percent. The Phase 2 reef is required to cover 127.6 acres, which combined with the 22.4-acre Phase 1 (Experimental Artificial Reef), creates a 150-acre reef, as stipulated in the CCC permit.

Approximately 152 acres of reef were built during the construction activities of Phase 2. Of this total area, approximately 130.6 acres have a measured coverage of 42.31 percent which demonstrates compliance with the Coastal Development Permit specification for seafloor boulder density and reef size. The 130.6-acre parcel is a summation of all of the polygons except Polygon 5 and the western part of Polygon 7.

Section 4.5 (Table 4-1) gives the hard substrate coverage estimates based on the method recommended by the CCC consulting scientists (Schroeter et al., 2008). This method weights the percent coverage estimates of the individual polygons by dividing the polygons' individual areas by the area of the entire reef. In summary, the reef was constructed in compliance with all engineering specifications.

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1.0 INTRODUCTION

Contained within is a detailed report of the construction of the recently completed Phase 2 Mitigation Reef. The area of the Phase 2 reef is 152 acres as determined by high-resolution sonar (multibeam system). The reef is located offshore of San Clemente, California, in water depths of approximately 11.5 to 15 meters (38 to 49 ft) (Figure 1-1). The project area is an 862-acre leased parcel located 0.6 miles offshore of the San Clemente beach between the City Pier to the north and San Mateo Point, approximately 2.5 miles to the south (Figure 1-1).

Southern California Edison (SCE) retained Coastal Environments (CE) to provide engineering and design services, construction management, and construction verification. SCE also retained the services of Connolly Pacific Company (CP) as the reef construction contractor.

The reef was built in two phases: 1) the Phase 1 Experimental Artificial Kelp Reef, completed in September 1999, which consisted of 56 modules (40 m x 40 m) and totaled 22.4 acres (CE, 1999a,b), and served as a scientific platform for experimental study to determine the optimal materials and design specifications for subsequent reef construction; and 2) Phase 2, the final build-out of the reef to meet the conditions of the Coastal Development Permit.

Construction of the WNR commenced on June 9, 2008 and concluded on September 11, 2008, a construction period that lasted 73 days. The decision to commit to this construction period was influenced by the characteristic meteorological and oceanographic conditions of mild weather and low wave energy of the summer season.

The construction contractor (CP) built the Phase I Experimental Artificial Reef in 1999 and thus was able to capitalize on their previous experience to build the Phase 2 reef. For both reef projects, CP transported quarry boulders to the San Clemente construction site by utilizing tugboats towing either 1 or 2 flat deck (supply) barges. Boulders were mined from quarries at Santa Catalina Island and Ensenada, Mexico.

Figure 1-1 shows the general location of San Clemente with respect to Long Beach Harbor, Catalina Island, and the construction site. The polygons are defined by the identification number (ID) used during construction, as well as by being sequentially numbered from 1 to 17. Figure 1-1 shows the constructed polygons with their ID numbers, and Figure 1-2 shows the polygons sequentially numbered from 1 to 17.

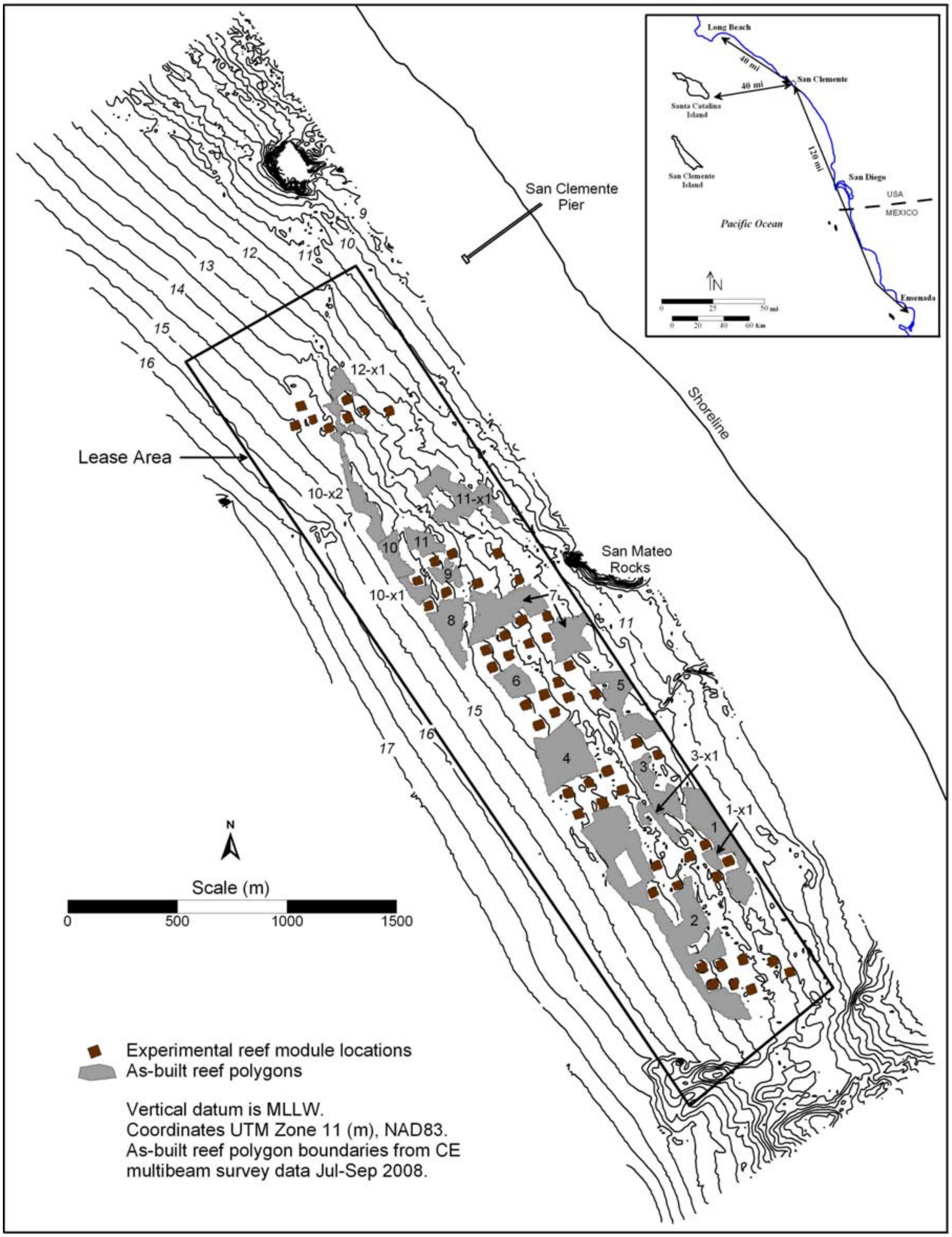

Figure 1-1. Southern California Edison WNR polygons.

Construction began on June 9, 2008 with boulder deposition starting in Polygon 6. Upon completion of this polygon, the operation moved to the south end of the project site, where construction began on Polygon 2 (Figure 1-1). Polygon 6 and the southern portion of Polygon 2 were immediately surveyed by CE and the California Coastal Commission consulting scientists (CCC-CS) to verify that the construction specifications had been attained. The surveys proved that the finished polygons had been constructed as specified. A report was prepared by CE (2008c) and approved by the CCC. The polygons were generally constructed from south to north in the following order: 6, 2, 1, 12(1-x1), 13(3-x1), 3, 5, 4, 7, 8, 9, 10, 11, 14(10-x1), 16(11-x1), 15 (10-x2), and 17(12-x1). Table 1-1 presents the polygon IDs, sequential numbering system, design acreage for each polygon, constructed acreage of each polygon, total rock tonnage placed within each polygon, and tons/acre for each polygon.

Phase 2 construction concluded on September 11, 2008, by which time approximately 126,000 tons of boulders had been deposited over 152 acres of suitable reef substrate (Table 1-1). The average tonnage per acre was 828.6, calculated by dividing the total deposited rock tonnage by the total Phase 2 as-built acreage as determined by high-resolution sonar (multibeam). The variation of boulder deposition per polygon ranged from 743.3 to 986.8.

The results of this project are presented in two volumes. Volume I is a technical report, and Volume II is a data report that contains all of the data collected and analyzed for this study, including daily constructed reef areas, on-site monitoring (DGPS boundary surveys), multibeam surveys, CCC-CS diving survey results, and selected photographs.

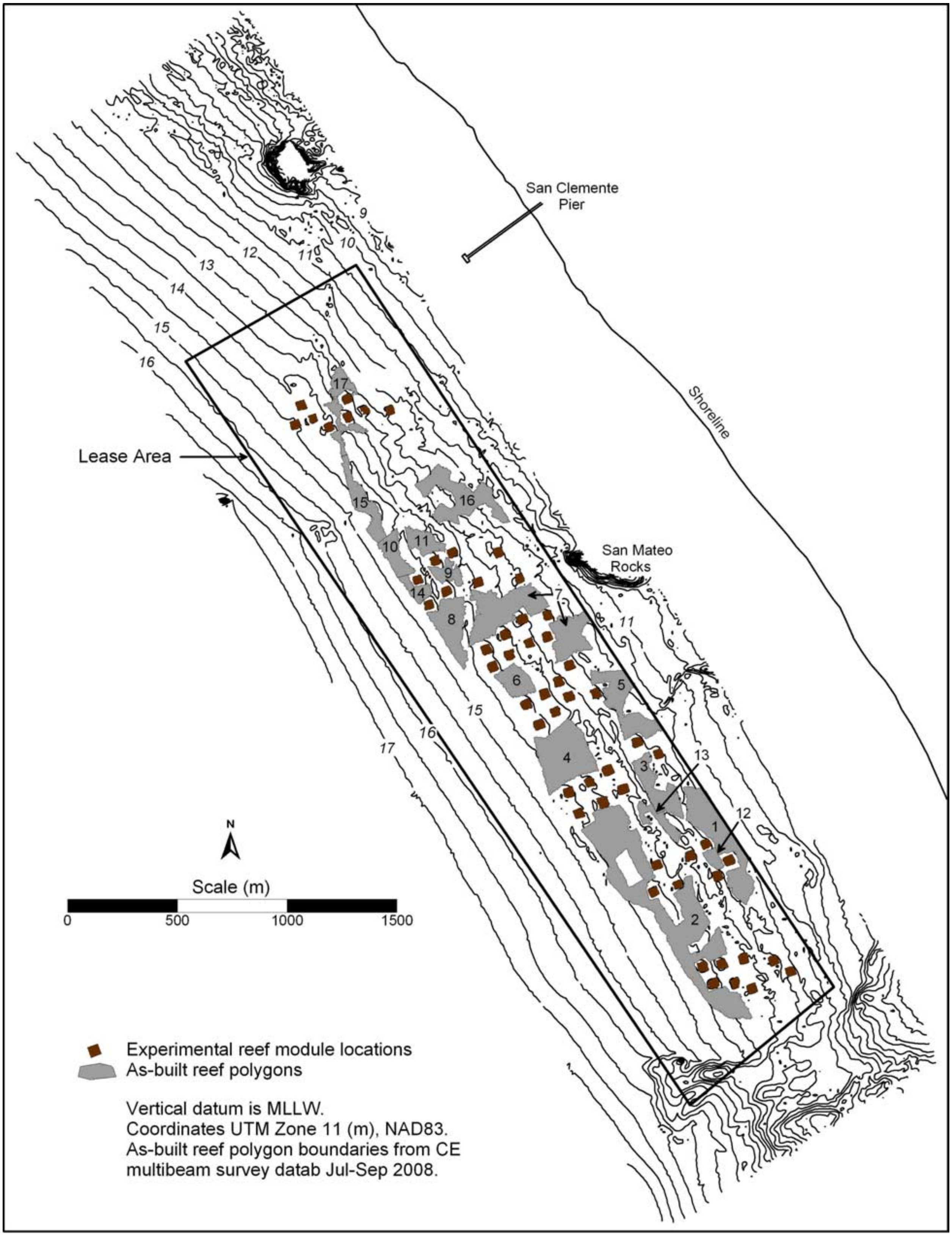

Figure 1-2. Polygon numbering system.

Table 1-1. Polygon areas as designed and as-built, placed tonnage, and tons/acre.

Polygon Number	Polygon ID	Polygon Area (Design)	Polygon Area[a] (As-built, acres)	Placed Rock[b] (Tons)	Tons/Acre[c] (As-built / Polygon)
1	1	13.3	13.83	11,444.8	827.5
2	2	37.5	38.88	31,872.0	819.8
3	3	6.5	6.61	5,093.0	770.5
4	4	14.1	14.05	10,996.9	782.7
5	5	9.2	9.48	7,046.1	743.3
6	6	4.1	4.24	3,208.8	756.8
7	7	25.8	19.03	15,541.9	816.7
8	8	7.5	7.64	6,087.4	796.8
9	9	2.4	2.52	1,967.2	780.6
10	10	3.8	3.89	3,838.6	986.8
11	11	3.5	3.48	3,094.2	889.1
12	1-x1	1.3	1.35	1,258.7	932.4
13	3-x1	2.8	2.85	2,600.3	912.4
14	10-x1	2.0	2.12	2,008.1	947.2
15	10-x2	5.3	5.54	4,642.4	838.0
16	11-x1	10.9	11.19	10,440.7	933.0
17	12-x1	7.0	5.32	4,816.4	905.3
Totals		**157.0**	**152.02**	**125,957.5**	N/A[d]

[a] Area of polygons as determined by the multibeam sonar system.
[b] Total tonnage placed on the polygon.
[c] Tonnage divided by areas as determined by multibeam sonar system.
[d] Not applicable.

2.0 MATERIALS

2.1 TYPE

Quarry boulders were the exclusive construction material used to build the Phase 2 reef, specifically quarter-ton rock obtained from the Pebbly Beach and Empire quarries on Catalina Island and the La Piedra quarry in Ensenada, Mexico. Explosives were employed to reduce quarry faces to "rubble" piles, from which boulders of suitable specifications were produced, sorted, and stockpiled. The Pebbly Beach and Empire quarries stockpiled approximately 70,000 tons of boulder stock prior to commencement of reef construction activities. Quarry production continued virtually until the end of reef construction. The total boulder tonnage used to construct the Phase 2 reef was 125,957.5 tons. The subtotals from each source are as follows: a) Pebbly Beach quarry, 86,904 tons; b) Empire quarry, 12,157 tons; and c) La Piedra quarry, 26,896.5 tons.

Each quarry provided a different type of rock. The Pebbly Beach quarry rock is predominantly a dense, iron-rich breccia (San Onofre Breccia), a sedimentary rock composed of multiple clasts from a few different rock types, and secondarily, a volcanic andesite/dacite. The Empire quarry rock is a less dense, silica-rich rhyolite tuff that has been slightly metamorphosed. The La Piedra (Ensenada) quarry rock is dense granite. Table 2-1 gives the rock source(s) for each polygon.

2.2 DIMENSIONS

Daily measurements of boulder dimensions (length, width, and height) were taken of a random selection of 20 boulders collected from the quarry material stockpile on the supply barge. The following were the numbers of collected boulders used to certify dimensions; a) Pebbly Beach quarry, 960 boulders; b) Empire quarry, 180 boulders; and c) Ensenada quarry, 280 boulders.

The dimensions and statistical analysis of the randomly selected boulders are presented in Table 2-2. Boulder length varied from 1 to 4 ft, with an average length of 2.3 ft; width varied from 0.5 to 3 ft, with an average width of 1.8 ft; and height varied from 0.5 to 2.5 ft, with an average of 1.4 ft. The maximum measured boulder height was 2.5 ft. Table 2-3 gives the mean and standard deviation (STD) for each measurement by polygon.

2.3 ATTAINMENT OF MATERIAL SPECIFICATIONS

Routine material inspection conducted by CP and CE insured conformance with specifications and permit requirements. Twining Laboratories, Inc., performed independent material tests. The Phase 2 reef boulders were required to conform to specifications, including size (Section 2.2), specific gravity, durability, and purity. In all cases, the observed quarry boulders were satisfactory and of good quality. The boulders were also tested for specific gravity, water absorption, and abrasion resistance (Twining Laboratories, 2008a,b,c), and the

Table 2-1. Rock sources for Phase 2 WNR polygons.

Polygon #	Polygon ID	Rock Source	Placed Rock (Tons)
1	1	Pebbly and Empire	11,445
2	2	Pebbly and Empire	31,872
3	3	Pebbly Beach	5,093
4	4	Ensenada and Pebbly	10,997
5	5	Ensenada and Pebbly	7,046
6	6	Pebbly and Empire	3,209
7	7	Ensenada and Pebbly	15,542
8	8	Ensenada and Pebbly	6,087
9	9	Ensenada and Pebbly	1,967
10	10	Ensenada and Pebbly	3,839
11	11	Pebbly Beach	3,094
12	1-x1	Pebbly Beach	1,259
13	3-x1	Pebbly Beach	2,600
14	10-x1	Pebbly Beach	2,008
15	10-x2	Ensenada and Pebbly	4,642
16	11-x1	Ensenada and Pebbly	10,441
17	12-x1	Pebbly Beach	4,816
Total			**125,957**

Table 2-2. Mean and standard deviation (STD) of rock dimensions.

Rock Quarry Location	Sample # N	Length (ft)		Width (ft)		Height (ft)	
		Mean	STD	Mean	STD	Mean	STD
Empire	180	2.4	0.8	1.8	0.6	1.3	0.5
Ensenada	280	2.4	0.8	1.8	0.6	1.4	0.5
Pebbly Beach	960	2.3	0.7	1.8	0.6	1.4	0.5

Table 2-3. Statistics on rock dimensions by polygon, WNR.

Polygon No.	Sample # N	Length (ft)		Width (ft)		Height (ft)	
		Mean	STD	Mean	STD	Mean	STD
1	150	2.3	0.7	1.8	0.6	1.4	0.5
2	410	2.2	0.8	1.7	0.6	1.3	0.5
3	40	2.4	0.9	2.0	0.7	1.6	0.6
4	110	2.3	0.8	1.8	0.6	1.4	0.5
5	90	2.2	0.7	1.8	0.6	1.5	0.5
6	80	2.3	0.7	1.9	0.6	1.4	0.4
7	170	2.4	0.7	1.9	0.5	1.4	0.4
8	40	2.5	0.8	1.9	0.6	1.6	0.5
9	30	2.4	0.8	1.8	0.6	1.5	0.5
10	40	2.3	0.8	1.8	0.6	1.4	0.4
11	20	2.6	0.6	1.9	0.4	1.4	0.4
12	30	2.3	0.8	1.9	0.6	1.6	0.6
13	20	2.2	0.7	1.6	0.5	1.4	0.5
14	20	2.3	0.6	1.7	0.5	1.3	0.4
15	40	2.3	0.9	1.7	0.6	1.5	0.6
16	90	2.3	0.8	1.8	0.6	1.5	0.5
17	40	2.3	0.7	1.8	0.5	1.5	0.4

Results met the American Society of Civil Engineers (ASCE) specifications for quarter-ton rock riprap. The tests also indicated that the boulders' durability met the California Department of Fish and Game's (CDFG's) guidelines (Bedford, 1997) regarding the capacity to remain unchanged while being submerged in seawater for 30 years. The purity of the rocks (absence of debris, stains, and foreign materials) was confirmed by CE representatives, both at the quarry and on the barge during placement.

In addition to the rock specification tests (specific gravity, absorption, etc.), Twining Laboratories performed six random rock size tests to ensure that the boulders stockpiled at the quarries met the CE and CCC-CS specifications for size and quantity of each size. The results of these tests are included in Volume II, Appendix A.

Table 2-4 summarizes the results of the rock specification tests and the design specifications are presented in Table 2-5. These design specifications are from the Final Design Plan (CE, 2008a).

2.4 MATERIAL TRANSPORTATION

Material transportation to San Clemente was accomplished using barges supplied from Catalina and Long Beach. The supply barges were pulled by tugboat to the construction site. A tugboat pulled either one barge or two barges in tandem. CP has two different sizes of supply barges, the smaller barges can hold 2,500 tons of rock, and the larger barges can hold 4,000 tons.

Table 2-4. Rock specifications for Phase 2 WNR from Twining Laboratories (2008a,b,c).

Parameter	Test	Quarry		
		Pebbly Beach	Empire	La Piedra
Apparent Specific Gravity	ASTM[a] C127	2.72	2.45	2.73
Absorption (%)	ASTM C127	2.0	5.5	0.5
Abrasion[b] (%)	ASTM 535	28.9	32.2	11.0

[a] ASTM = American Society of Testing and Materials.
[b] Percent wear at 1,000 revolutions.

Table 2-5. Material test requirements.

Test	California / ASTM Test	Requirement
Apparent Specific Gravity	206 / ASTM C127	2.3 minimum
Absorption	206 / ASTM C127	4.2% maximum
Abrasion (%)	ASTM C535	maximum 38% at 500 revolutions / maximum 50% at 1000 revolutions

ASTM = American Society of Testing and Materials

3.0 CONSTRUCTION TECHNIQUES

Described within are the construction methods utilized by CP to build the Phase 2 reef. Initially, the derrick barge *DB Long Beach* was positioned by tugboat above the designated polygon. Six motorized winch anchor lines moored the *DB Long Beach* within the boundary of a given polygon (Figure 3-1). During boulder deposition, the *DB Long Beach* was guided into the designated position by winching “in” or “out” on six anchor cables connected to their respective anchors. The anchors were designed to minimize possible drag on the ocean floor; each anchor was connected by braided steel cable to a 15-ton concrete anchor block, which was connected to a surge-can (foam-filled) and then cabled to the *DB Long Beach* (Refer Figure 3-1). The locations of the anchors were routinely monitored by an attending tugboat and by the derrick barge winch operator.

After securely tethering the supply barge to the *DB Long Beach,* the derrick barge winch operator maneuvered the edge of the flat deck barge to the required position (e.g., at the first line) (Figure 3-2). Positioning was accomplished with the aid of CP’s proprietary survey software. CP’s software utilizes coordinate data (horizontal coordinates, northings and eastings) from two differential global positioning satellite systems (DGPS) and a differential correction signal broadcast by the U.S. Coast Guard from Point Loma, CA. The software triangulated the data to show the edge of the supply barge in relation to the polygon boundary. The *DB Long Beach* winch operator used a computer monitor displaying the triangulated data to assist in locating the edge of the supply barge at the exact line of deployment. Positional accuracy of the DGPS system is estimated at 1 to 2 feet, and the software acceptance limits were set at 6 feet, meaning that the winch operator would hold position to within a tolerance of 6 feet. In addition to the winch operator, the deck engineer and CE representative observed the computer monitor displays verifying correct positioning of the supply barge and ensuring that boulder deposition occurred in the correct location.

The polygon boundary points were specified to the construction contractor who in turn computed the coordinates of a set of parallel lines oriented in a direction, which was more or less perpendicular to the shoreline. The number of parallel lines set for each polygon varied depending on the area of the polygon. Polygon line spacing was optimally set at 12 feet, except for Polygons 1-x1, 2, and 6, which were spaced at 14 feet.

Prior to construction startup, CP retained an independent survey company, Bill Carr Surveys, Inc., to perform a quality assurance check of the accuracy of CP’s navigational system. Using a standard land survey system consisting of a total station, prism, and data collection unit, the accuracy of the navigation system was verified. In addition, CP conducted daily calibration checks of the navigation system. The navigation system was in complete performance throughout the construction process assuring both CE and CP that accurate deposition/placement of boulders in the designated areas had occurred.

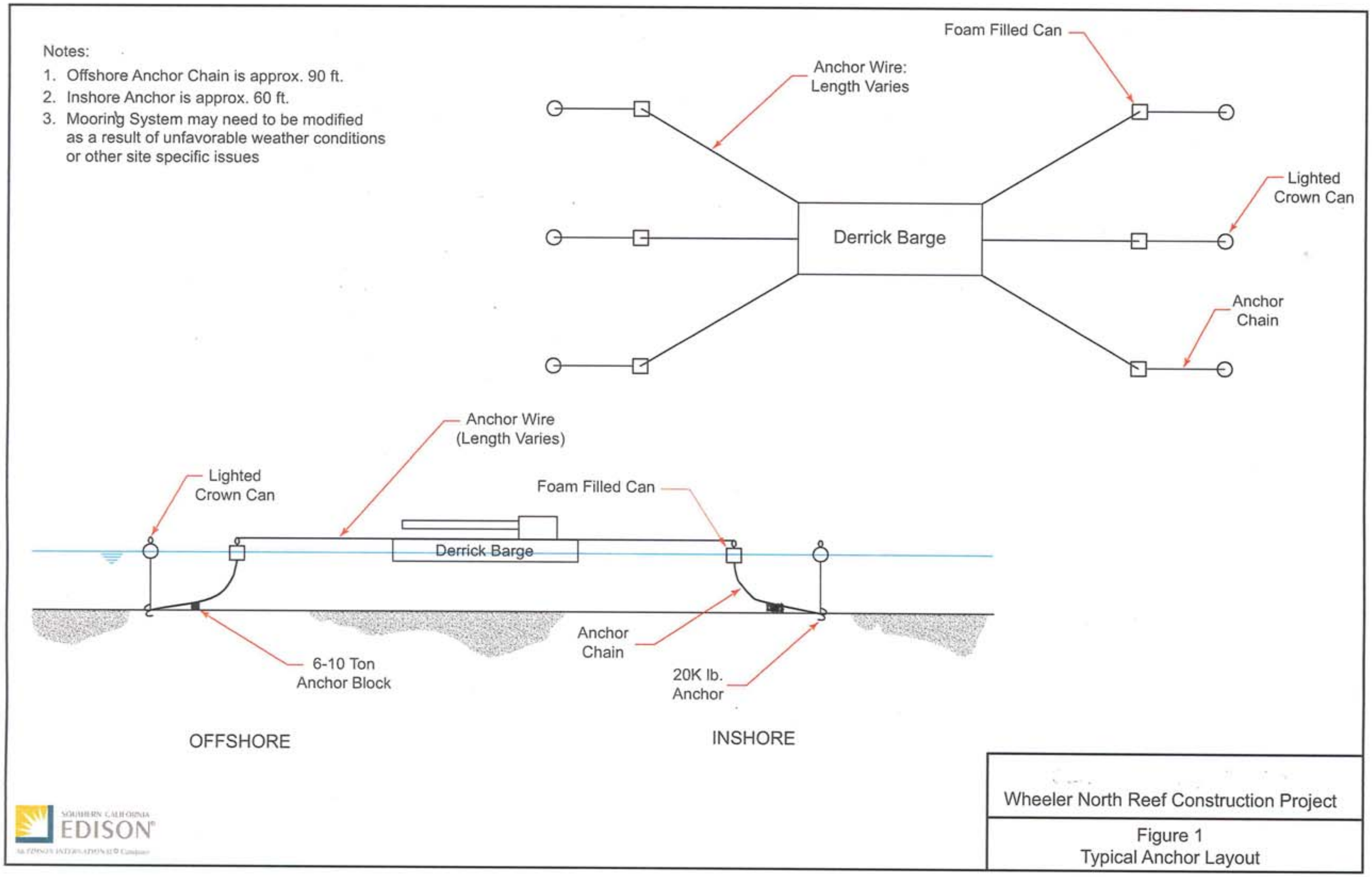

Figure 3-1. Derrick barge anchor schematic from CP.

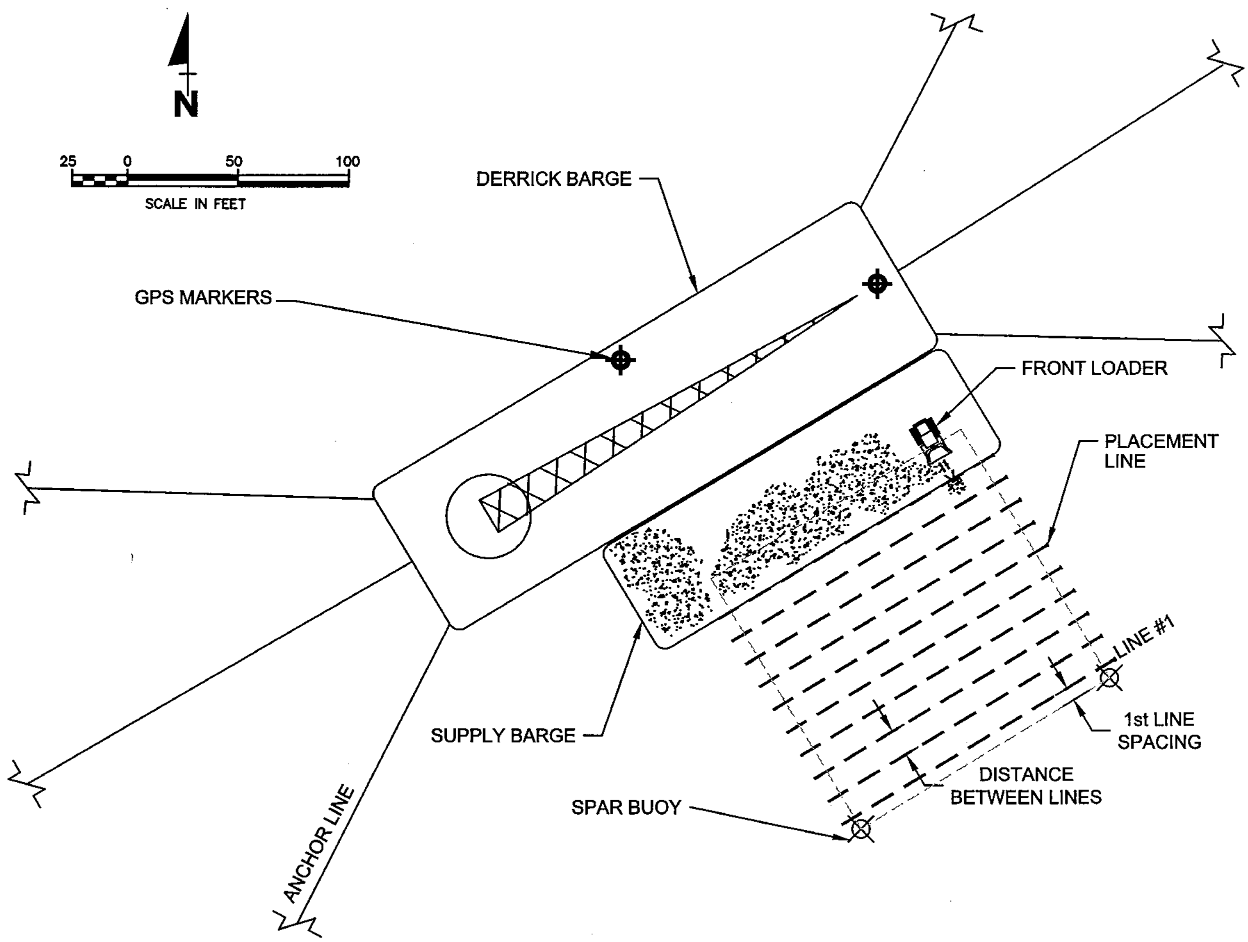

Figure 3-2. Construction method schematic showing derrick barge, supply barge, front-loader, rock placement lines, and six-anchor positioning.

CE further documented the accuracy of CP's survey system by taking DGPS survey measurements of the ends of certain rock placement lines as the rocks were placed in the water at these locations. The survey measurements were taken using a handheld Magellan Mobile Mapper CX accurate to within 3 feet (manufacturer's specs). The survey data were plotted on a figure for each polygon to confirm that the location where the rock was being placed was in fact the correct location. These survey data figures are included in Volume II (CE, 2008e) and show that all of the surveyed points are within 10 feet of the polygon boundaries as specified in the Final Design Plan (CE, 2008a).

The edge of the supply barge was aligned with the first placement line just inside the edge of the polygon. Using a Caterpillar 973C track-loader, the boulders were removed from the stockpile to the edge of the flat deck barge and cast on the bottom of the ocean. The track-loader spread any given boulder load in a small area by swinging in a semicircle to ensure that the materials were spread evenly on the bottom in a single layer. Numerous track-loader bucket loads were necessary to complete a line. After finishing the first line, the entire rig (derrick barge plus supply barge) was moved to the next line by manipulating the anchor winches, and the process continued until the polygon was complete.

Early in July, CP modified the boulder deposition method for completing the placement lines. Instead of completing an entire line before moving, CP completed a 25 to 100 foot segment (depending on the amount of physical space available on the deck of the supply barge) of all the lines in a given polygon and then repeated the process in the opposite direction (either NW or SE) until the polygon was complete. The modified method allowed the winch operator to move the barges 12 to 14 feet at a time instead of 25 to 125 feet, thus saving a significant amount of time.

Upon completion of a polygon, the *DB Long Beach* and the supply barge were positioned at the southern edge of the next module using the anchor/winch control system and DGPS. The designed anchoring locations minimized the number of anchor relocations required during the construction process.

Equipment used during construction at the site consisted of one derrick barge, two tugboats, seven supply barges, two track-loaders (one backup), eight winches, and a DGPS survey system with appropriate software. Specifications for the heavy equipment are given in Table 3-1.

Table 3-1. Specifications for the heavy equipment used at the experimental site.

Vehicle	Dimensions	Capacity
CAT 973C Track Loader	15 x 9 ft	Bucket holds 4 to 6 yd^3
Tugboat	60 x 25 ft	Pulls one or two barges
Rock Barges	200 x 50 ft	2,500-4,000 tons
Derrick Barge	255 x 78 ft	Crane capacity up to 275 tons

4.0 PHASE 2 REEF CONSTRUCTION

4.1 CONSTRUCTION SCHEDULE

A timeline of Phase 2 reef construction is presented in Figure 4-1. The construction contractor averaged approximately 1,725 tons/day of quarry boulder deposition which exceeded the original work plan of 1,200 tons per day. Non-significant delays were experienced twice due to equipment failure on June 24 and June 30, 2008. Three other partial-day delays occurred in June due to unscheduled equipment maintenance. On July 5, 2008, the project suspended operations (1 partial day) due to the oceanographic conditions associated with a long-period swell. The long-period swell caused a barge line failure, after which normal operations were suspended and repairs were initiated.

4.2 POLYGON BOUNDARIES

Prior to construction start-up, the necessary input data for the navigation system was prepared and checked by CE. As mentioned in Section 3.0, CE personnel made independent measurements of the boundary coordinates of each polygon using a differential GPS unit separate from CP's (Magellan). The accuracy of the portable DGPS system used by CE was comparable to the dual DGPS system used by CP. Coastal Environments' portable DGPS (±1 meter) provided independent verification of the positions reported by CP. CE's survey data was plotted on individual polygon maps containing the designed polygon corner coordinates. The survey data demonstrated that all of the polygons were built in the designed locations. A typical plot showing designed vs. as-built polygon boundaries is shown in Figure 4-2. This plot demonstrates close agreement between design and as-built coordinates. All of the individual polygon maps with the surveyed line endpoints are included in Volume II.

Multibeam surveys delineated the ocean floor boundaries of the as-built polygons. Figure 4-3 shows the multibeam data for Polygon 6. The dotted line designates the designed polygon boundary, and the solid line represents the as-built boundary. The two lines parallel to the design boundary line represent the 10-foot tolerance allowed by the design plan. The as-built boundary line tracks very closely to the design boundary line. All of the polygon multibeam surveys are included in Volume II. The overall as-built polygon acreages determined using the multibeam surveys are presented in Table 1-1 (Chapter 1).

All of the polygons were built as designed with the exception of Polygon 7 and 17 (12-x1). The anchor setup location prevented the construction of the northeastern section of Polygon 7 due to the proximity of the San Mateo Rocks outcrop (Figure 1-1). Anchoring in this location may have caused environmental damage to the San Mateo Rocks or damage to the anchors and anchoring lines. In addition, two areas of Polygon 17 (12-x1) were not completed because the supply of quarry rocks had been depleted. In addition, on certain polygons, the angles (especially on the first and last lines) were too acute to allow access by the rock barge and derrick. These small areas were not constructed.

Polygon No.	Polygon ID	Start / Completion	2008 June	2008 July	2008 Aug	2008 Sep
1	Polygon No. 1	28-Jun-08 / 22-July-08				
2	Polygon No. 2	13-Jun-08 / 17-Jul-08				
3	Polygon No. 3	22-Jul-08 / 24-Jul-08				
4	Polygon No. 4	28-Jul-08 / 4-Aug-08				
5	Polygon No. 5	24-Jul-08 / 7-Aug-08				
6	Polygon No. 6	9-Jun-08 / 12-Jun-08				
7	Polygon No. 7	7-Aug-08 / 18-Aug-08				
8	Polygon No. 8	19-Aug-08 / 21-Aug-08				
9	Polygon No. 9	22-Aug-08 / 25-Aug-08				
10	Polygon No. 10	25-Aug-08 / 27-Aug-08				
11	Polygon No. 11	27-Aug-08 / 29-Aug-08				
12	1-x1	2-Jul-08 / 3-Jul-08				
13	3-x1	18-Jul-08 / 21-Jul-08				
14	10-x1	28-Aug-08 / 28-Aug-08				
15	10-x2	8-Sep-08 / 10-Sep-08				
16	11-x1	29 Aug-08 / 5-Sep-08				
17	12-x1	10-Sep-08 / 11-Sep-08				

Figure 4-1. Timeline of construction activity.

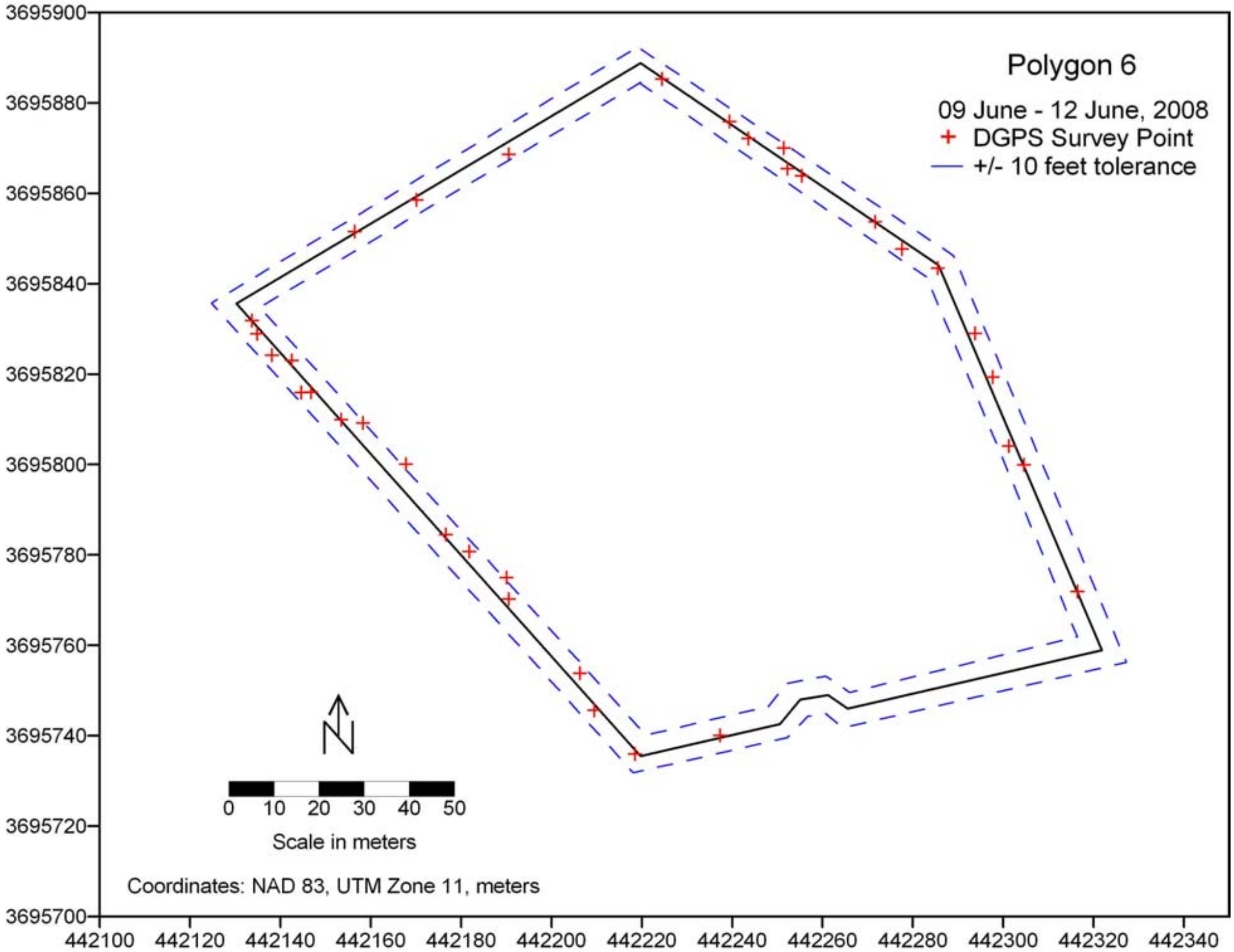

Figure 4-2. Comparison between designed and as-built boundary by DGPS from the rock barge for Polygon 6.

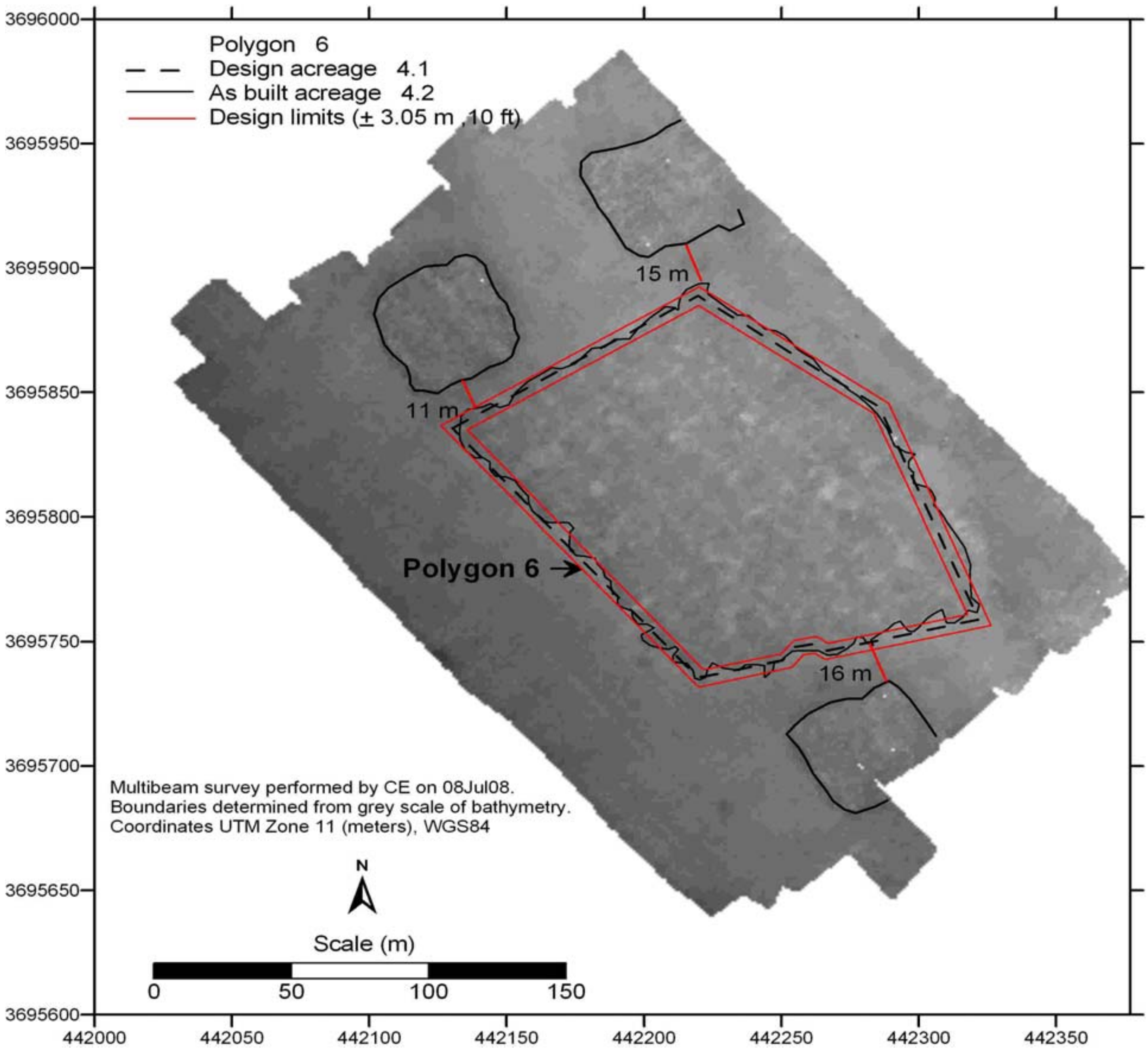

Figure 4-3. As-built Polygon 6 boundary (solid line) overlaid on top of designed Polygon 6 boundary (dashed line). Red lines show allowable tolerance of polygon boundaries. Notice that distances from adjacent hard substrates are shown.

4.3 OVERLAP ESTIMATES

Design specifications (CE, 2008a) required that the reef height would be less than 1 m and that rock overlap (stacking of the rocks) should be less than 15 percent. Rock overlap on the constructed reef was evaluated by calculating the difference in the seafloor bathymetry before and after construction of the reef. Data from the bathymetric survey conducted in 2006 (CE and Fugro, 2006b) was used to establish the baseline bathymetry. Multibeam bathymetric data collected in a survey by CE in 2008 for each polygon was used to represent post-construction bathymetry. No significant differences in seafloor bathymetry greater than 0.5 m were detected (Volume II, Appendix F). This is in agreement with the diver observations made along the CCC-CS transects. The conclusion is that placed rock stacking was minimal.

4.4 MATERIAL QUANTITIES

The technique used to determine the weight of material on the barge is called "gauging." An air-filled PVC pipe, capped at both ends and graduated in 0.1-foot increments, floats inside of a larger open-ended PVC pipe. Seawater is allowed to flood the larger PVC pipe, and the smaller, closed-ended PVC pipe comes to the equilibrium floating point. The larger PVC pipe (the stilling well) has a flat wooden protrusion that rests squarely on the deck of the supply barge when taking a measurement. The four corners of the barge are gauged to determine the height of the barge deck (free-board) in relation to the water surface. All CP barges have a calibration table certified by a naval architect that relates the tonnage onboard to the incremental free board height. These tables were used to estimate the placed rock tonnage based on the incremental free board height. Supply barges were gauged initially upon tethering to the DB *Long Beach* to determine the preliminary total tonnage onboard. The barge was gauged at various times during polygon construction as well as at the conclusion of each day and each polygon. The difference between gauging periods determined the tons of quarry material deposited daily or the boulder deposition in a completed polygon.

CE used an additional technique to estimate material quantities by taking an accurate count of the number of bucket loads placed per line and per polygon. The dimensions of the bucket were measured and combined with the average density of the quarry rocks, and adjusted for the void-to-material volume ratio; an estimate of tonnage per bucket was determined (4.5 tons per load). The total tonnage per polygon was estimated by the bucket tonnage, multiplied by the number of bucket loads placed per polygon.

Figure 4-4 shows the quantity of rock placed in each of the 17 polygons and Figure 4-5 represents the average tonnage per acre for each polygon. Table A-1 (Appendix A) presents the rock quantities placed within each polygon as determined by CP and CE. A comparison between CP and CE rock tonnage estimates are presented graphically in Figure A-1 (Appendix A).

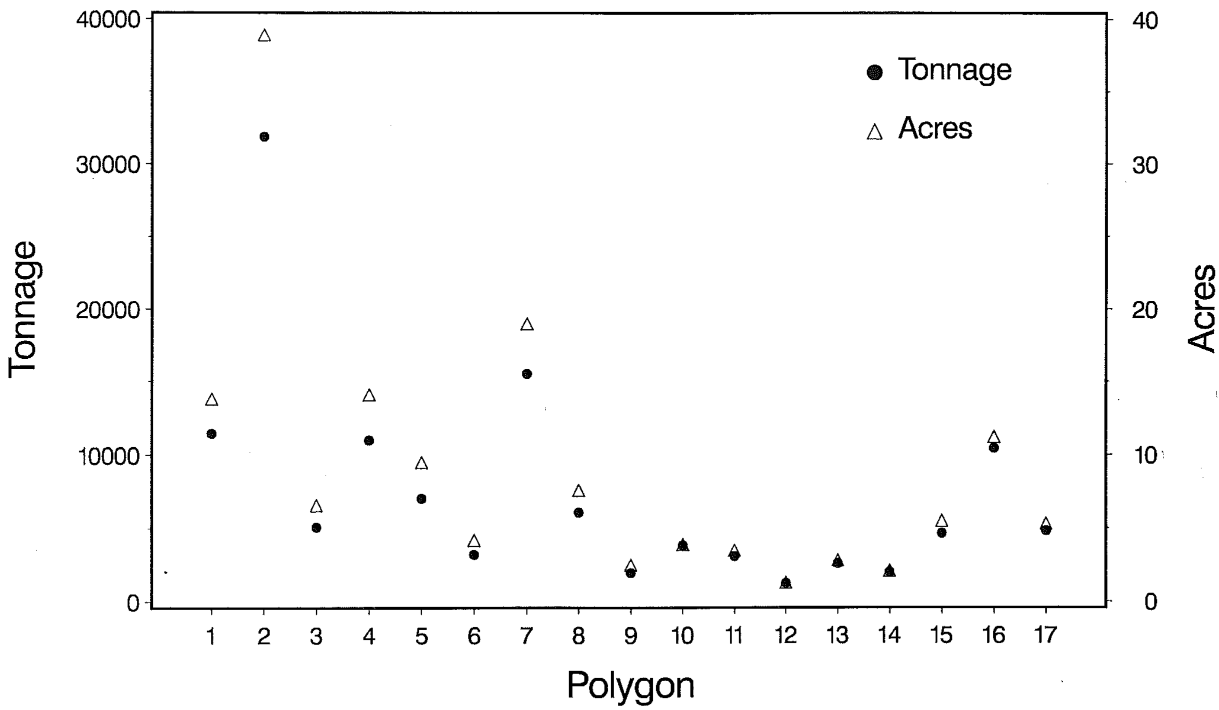

Figure 4-4. Total weight of rock placed on each polygon.

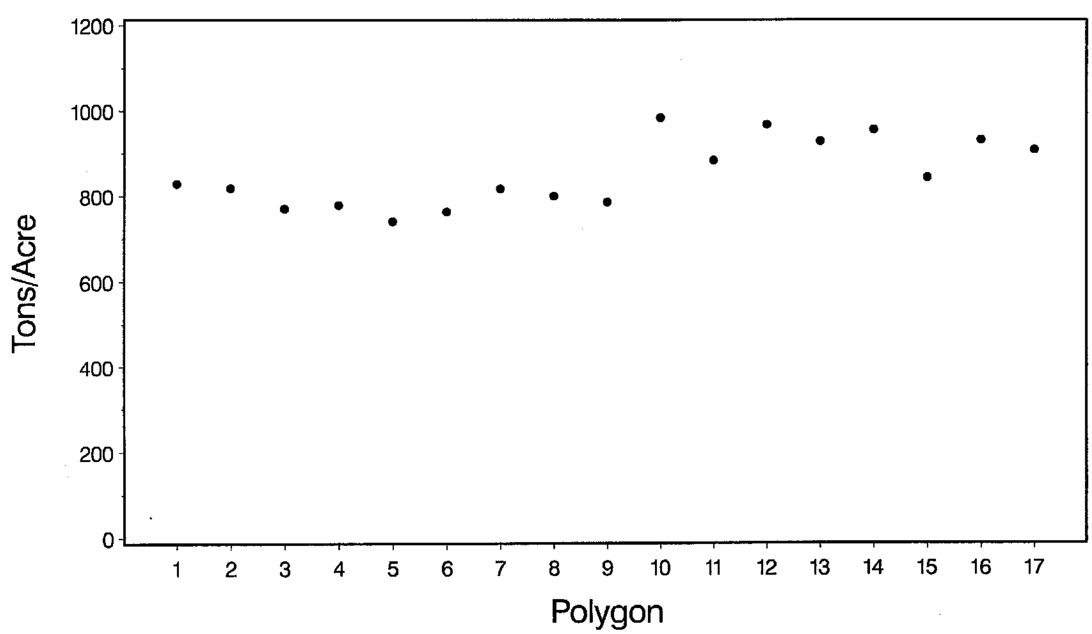

Figure 4-5. Density of rock (tons/acre) placed on each polygon.

4.5 COVERAGE ESTIMATES

Possible variations of material dimensions from polygon to polygon were taken into consideration in calculating pre-construction weights. The construction method was designed to ensure that the material was uniformly distributed within the polygon boundaries (Chapter 3). Therefore, variations in coverage achieved from polygon to polygon are expected to be proportional to the difference between the reported quantity of rock placed.

The CCC-CS has surveyed the 17 polygons of Phase 2 comprising the WNR (Schroeter et al., 2008) using the point contact method. This survey method is described in detail in Section 5.3. The number of transects varied from 2 to 20 depending on the size of the polygon. A total of 80 permanent transects were completed within the 17 polygons. The transects were proportionally distributed over the 152 acres of the Phase 2 reef (Figure 4-6), averaging one transect for every two acres of reef (Table 4-1). For small polygons (< 4 acres), the CCC-CS established two transects in order to have replicates.

For Polygons 2 and 6, the CCC-CS expanded the sampling coverage by adding additional transects (Figure 4-7) to determine the adequacy of sample size and the precision of the estimates of quarry coverage obtained from the permanent transects (Schroeter et al., 2008).

Table 4-1 shows the polygon areas as built, the as-built tons/acre per polygon, and the percent coverage for each polygon. Schroeter et al. (2008) recommended estimating the coverage of the reef by weighting the percent cover estimate of the individual polygons by their fractional area to estimate the coverage of the entire reef area.

This weighted average was calculated by dividing the as-built acreage of each individual polygon by the total Phase 2 acreage, and then multiplying the quotient by the percent coverage estimate of the individual polygons and summing the results.

The CCC permit (CDP #E-07-010) required that the Phase 2 Mitigation Reef be constructed of quarry rock distributed on the seafloor such that the percent coverage would be between 42 and 86 percent. In addition, the Phase 2 WNR is required to be 127.6 acres, which combines with the 22.4-acre Experimental Artificial Reef to create a 150-acre reef as stipulated in the CCC permit.

The weighted average substrate coverage was calculated for four cases: Case 1, which includes the entire Phase 2 as-built reef (152 acres); Case 2, which eliminates Polygon 7 and fifty percent of Polygon 5 (total area is 128.2 acres); Case 3, which eliminates Polygon 7 and forty percent of Polygon 5 (total area is 129.1 acres); and Case 4, which eliminates all of Polygon 5 and the western portion of Polygon 7 (total area is 130.3 acres). Table 4-2 presents the weighted average for the 4 cases. For cases 1, 2, 3, and 4, the substrate coverage was calculated at 40.8, 42.08, 42.02, and 42.3 percent, respectively. Cases 2, 3, and 4 meet the CCC's permit condition. For Cases 2, 3, and 4 the reef is larger than the required 127.6 acres and has substrate coverage equal to or greater than 42%. The CCC-CS hard substrate coverage estimates of the western and eastern portions of Polygon 7 are given in Table 4-3.

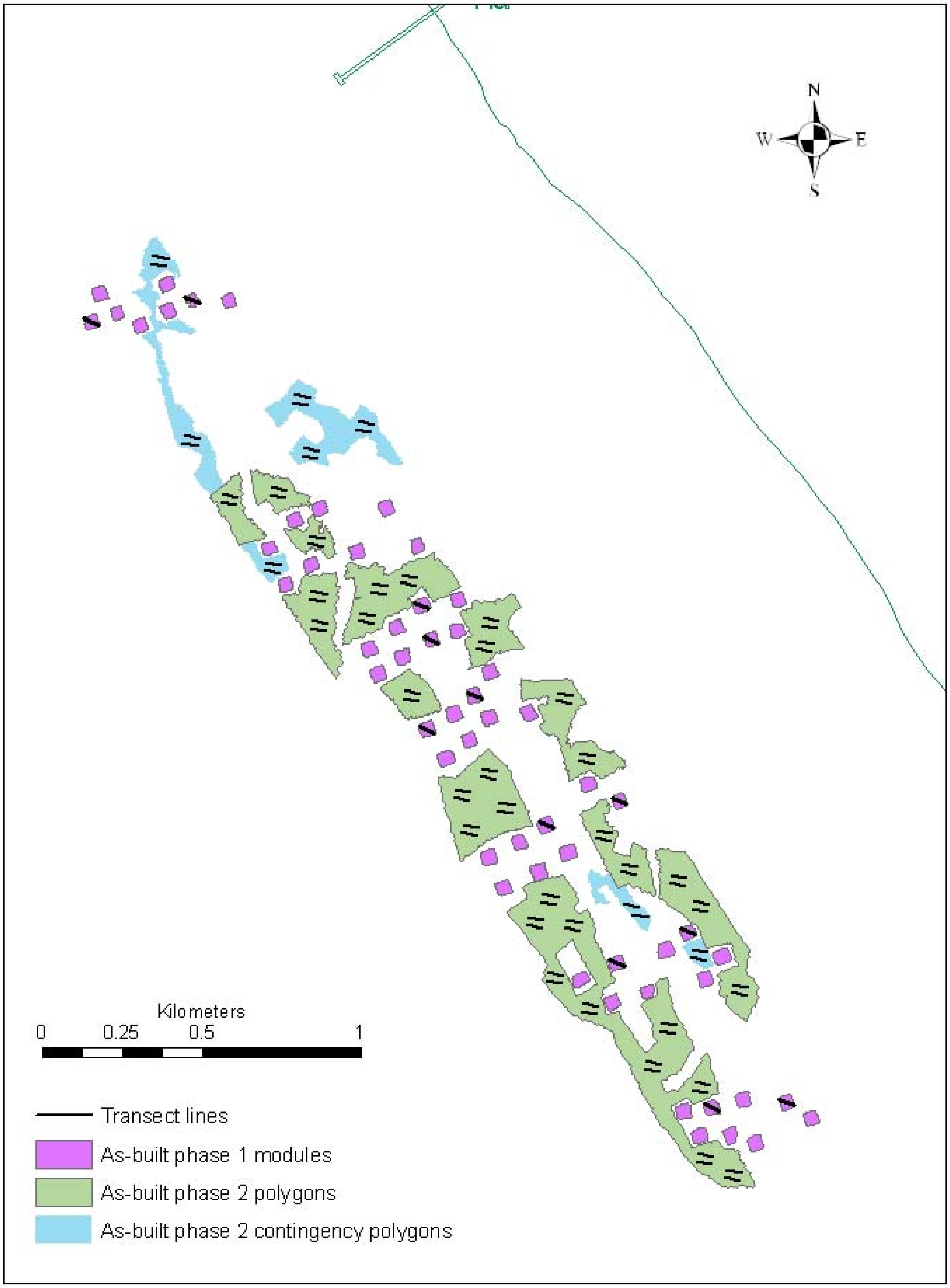

Figure 4-6. Location of permanent transects on the WNR used to estimate percentage cover of hard substrate (cobble + boulder). Phase 1 modules are shown in purple, Phase 2 polygons in light green and light blue.

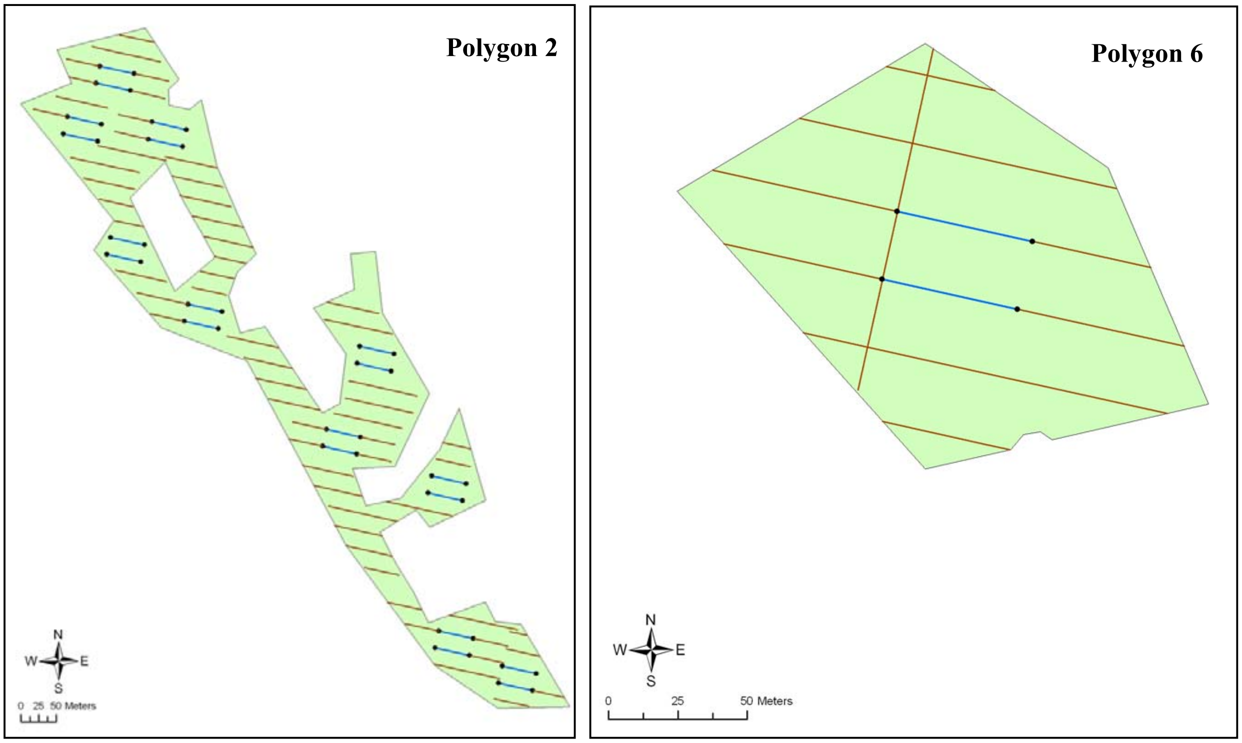

Figure 4-7. Location of permanent and additional transects on Polygons 2 (left) and 6 (right) of the WNR used to estimate the percentage cover of hard substrate (cobble + boulder). Permanent transects are indicated by solid blue lines with black dots at either end; the additional transects are indicated by solid brown lines.

Table 4-1. As-built polygon coverage from Schroeter et al. (2008).

Polygon Number	Polygon ID	Polygon Area[a] (As-built acreage)	Tons/Acre[b] (As-built)	Acres/ Transect	Percent Substrate Coverage[c]
1	1	13.83	827.5	2.3	42.2
2	2	38.88	819.8	1.9	42.3
3	3	6.61	770.5	1.7	37.8
4	4	14.05	782.7	1.8	35.4
5	5	9.48	743.3	2.4	33.8
6	6	4.24	756.8	2.1	42.5
7	7	19.03	816.7	1.9	33.7
8	8	7.64	796.8	1.9	37.3
9	9	2.52	780.6	1.3	53.5
10	10	3.89	986.8	1.9	53.5
11	11	3.48	889.1	1.7	42.0
12	1-x1	1.35	932.4	0.7	59.0
13	3-x1	2.85	912.4	1.4	45.5
14	10-x1	2.12	947.2	1.1	43.0
15	10-x2	5.54	838.0	2.8	39.5
16	11-x1	11.19	933.0	1.9	39.3
17	12-x1	5.32	905.3	2.7	65.5

[a] Area of polygons as determined by multibeam sonar system.
[b] Total tonnage placed on the polygon divided by as-built area.
[c] Hard substrate coverage estimated by Schroeter et al. (2008).

Table 4-2. WNR hard substrate coverage estimated by weighting the percent coverage of individual polygons by total polygon area (Schroeter et al., 2008).

Case #	Description	Total Polygon Area (acres)	Coverage %
1	All Polygons	152	40.8
2	Eliminating Polygon 7 and 50% of Polygon 5	128.2	42.08
3	Eliminating Polygon 7 and 40% of Polygon 5	129.1	42.02
4	Eliminating Polygons 5 & 7 (West Section)	130.3	42.31

Table 4-3. As-built polygon coverage for West and East parts of Polygon 7 (Schroeter et al., 2008).

Sub-Polygon 7	Sub-Polygon Area (As-built, acres)	Percent Substrate Coverage
West	12.2	27.5
East	6.8	43.0

5.0 CONSTRUCTION VERIFICATION

This section describes the efforts made to verify that the Phase 2 reef was constructed according to the design specifications, which included: 1) on-site monitoring, 2) multibeam surveys, and 3) diver surveys.

5.1 ON-SITE MONITORING

The objective of on-site monitoring was to document and ensure that a target rock density was spread in a mono-layer on the bottom of the ocean within each polygon. By placing a certain rock density on a specified area accurately and reducing rock overlap, one could attain the design coverage within an acceptable variation (Coastal Environments, 2008a). On-site monitoring included the following elements:

1. Checking the locations of the polygon boundaries using differential GPS and a total station.
2. Recording the number of lines/polygon, spacing between lines, and number of track-loader bucket loads placed on each line. This information was also used to estimate the weight of rock placed.
3. Gauging the barges frequently during and at the end of the day to estimate the weight of rock used in building each polygon.
4. Taking photographs to document various construction elements and meet water quality permit conditions.
5. Reviewing project plans with the contractor on a regular basis.
6. Writing daily reports to document events during construction of each polygon.
7. Monitoring the survey system's computer monitors to ensure that all rock was placed in its proper location and within the boundaries of each polygon.
8. Measuring the dimensions of 20 randomly selected rocks each day to ensure that the rock dimensions matched the design specifications.

5.2 MULTIBEAM VERIFICATION SURVEYS

5.2.1 Method

Each of the constructed polygons was surveyed between July 8 and October 8, 2008. The ECO-M, a 27-ft Farallon, was used as the survey vessel. The vessel was equipped with the following survey instrumentation:

1. Odom ES3 Multibeam Sonar System
2. Hemisphere GPS Heading and Positioning Receiver (VS110)
3. Hypack and Hysweep Survey and Multibeam Data Acquisition Programs

4. Digibar Pro Speed of Sound Profiler
5. TSS DMS 10 Motion Sensor

Proper calibration of all instrumentation was performed prior to any survey work. A patch test was carried out to determine offsets between the sonar head and motion reference unit and entered into Hypack. After mobilization of the ECO-M, measurements of all offsets between sensors were recorded and entered into Hypack.

The boundary of the polygons was verified using multibeam sonar. The first two polygons surveyed (Polygon 6 and Polygon 2) used the bathymetry from the multibeam to define the polygons. This required an inordinate amount of time for editing and near-flat sea conditions to collect reasonable data. Consequently, the remaining polygons were evaluated using the backscatter intensity data from the multibeam to create a pseudo–side-scan image that provided excellent resolution to delineate the boundaries of the constructed reefs. The principle of the backscatter pseudo–side-scan images is, briefly, that hard substrate has a stronger acoustic return than sand, and so the boundaries of the artificial reef can be delineated. A brief description of the equipment used for the multibeam surveys is presented below.

The Hemisphere GPS Heading and Position Receiver (VS110) provides less than 1 m differential positioning, and with two antenna (DGPS) inputs into the receiver, it can output a heading accuracy of less than 0.1 degree. The GPS data were corrected using the U.S. Coast Guard beacon at Point Loma (station broadcast frequency 302 kHz). The GPS used to determine the coordinates of the surveyed points (position) is mounted directly over the multibeam transducer so there is no offset.

The TSS DMS 10 motion sensor has an array of solid-state sensing elements that measure the instantaneous linear acceleration and angular rates, allowing the sensor to provide its altitude relative to the true vertical. By locating the TSS DMS 10 motion sensor at the transducer, information is provided to the ES3 and Hypack on the heave, pitch, and roll of the transducer. The motion sensor data, in conjunction with the GPS heading and position data, is used to georeference the stream of bathymetric data.

The Digibar Pro is an acoustic means of accurately determining the speed of sound by profiling with this instrument. The sound measurements are used for determining the average speed of sound through the water column in order to determine the depth.

The Odom ES3 is a multibeam echosounder that has a range up to 60 m water depth with a transmit frequency of 240 kHz. The transducer was configured as an over-the-side mounted transducer. The ES3 processing program utilizes the roll from the DMS 10 and outputs the roll corrected bathymetric and backscatter data to Hysweep, where heave, pitch, heading, and position are recorded for processing of the data.

5.2.2 Data Processing

The bathymetric data is stored in Hysweep along with the patch test offsets and transducer draft, and processed in a Hypack module called MBMax, which utilizes all the offsets and allows for input of the speed-of-sound profile and tidal data for correction to MLLW. MBMax also provides various filters and editing tools. The processed data are then output as an XYZ file and imported into Surfer version 8.0 for digitizing the delineated boundaries of the constructed polygons and outlining the nearby experimental artificial reef modules. The digitized boundaries of the reef polygons were imported into Didger for calculation of areas. Final drawings were completed in Surfer. See Figure 5-1 for a flow chart of the data processing.

The backscatter data are output to Hysweep along with the bathymetric data. This file is then converted to a GSF file in MBMax. The GSF file is then imported into Geocoder, which is a side-scan module of Hypack. Each individual line is brought into Geocoder and then mosaiced to create the pseudo–side-scan image, which is a georeferenced tiff file. This file is then imported into Surfer and Didger following the same procedure of digitizing and area calculation described above.

5.2.3 Survey

The polygons were preplotted in Hypack (Figure 5-2), and parallel survey lines were set up with 12-14 m spacing depending on water depth. Because the survey lines were spaced very closely, there was over 200 percent coverage. This overlapping data allowed CE to verify the results. Vessel speed was from 4.0 to 5.5 knots in order to reduce turbulence around the transducer.

5.3 DIVE SURVEYS

The percentage cover of quarry rock per polygon was estimated by Schroeter et al. (2008). Diver surveys were conducted by the CCC-CS dive team on all polygons. In each polygon, 50 m long transects were laid approximately east-west (Figure 5-3). Beginning five meters from the starting point, 1 m^2 quadrats were positioned every 10 meters alternating to either the north or to the south side of the main transect line. In each quadrat, substrate under each of 20 uniformly placed points was categorized as follows: 1) whether it was sand (<0.2 cm), pebble (0.2-6.39 cm), cobble (6.4-25.59 cm), or boulder (>25.6 cm); 2) whether the hard substrate was quarry rock or pre-existing hard substrate; and 3) whether overlap was present or absent. Substrate categories are summarized in Table 5-1. All cobbles and boulders encountered during the surveys were quarried material.

The transects shown in Figure 4-6 (Section 4) are designated as permanent because they will also be monitored in the future. They total 92, and are divided as follows: 12 transects are located on the Phase 1 Experimental Reef and 80 transects are located on the Phase 2 reef.

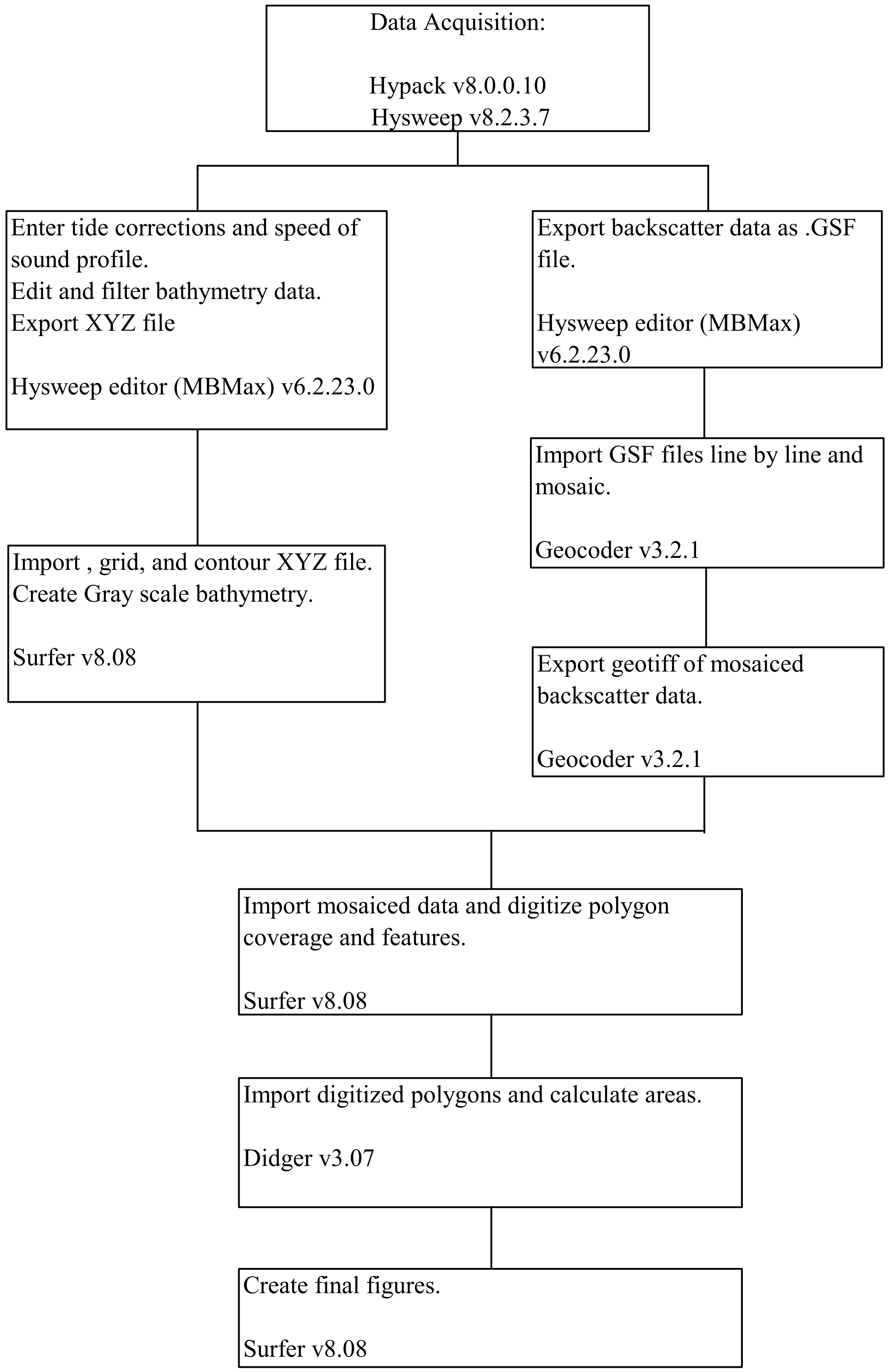

Figure 5-1. Flow chart of data processing for multibeam data.

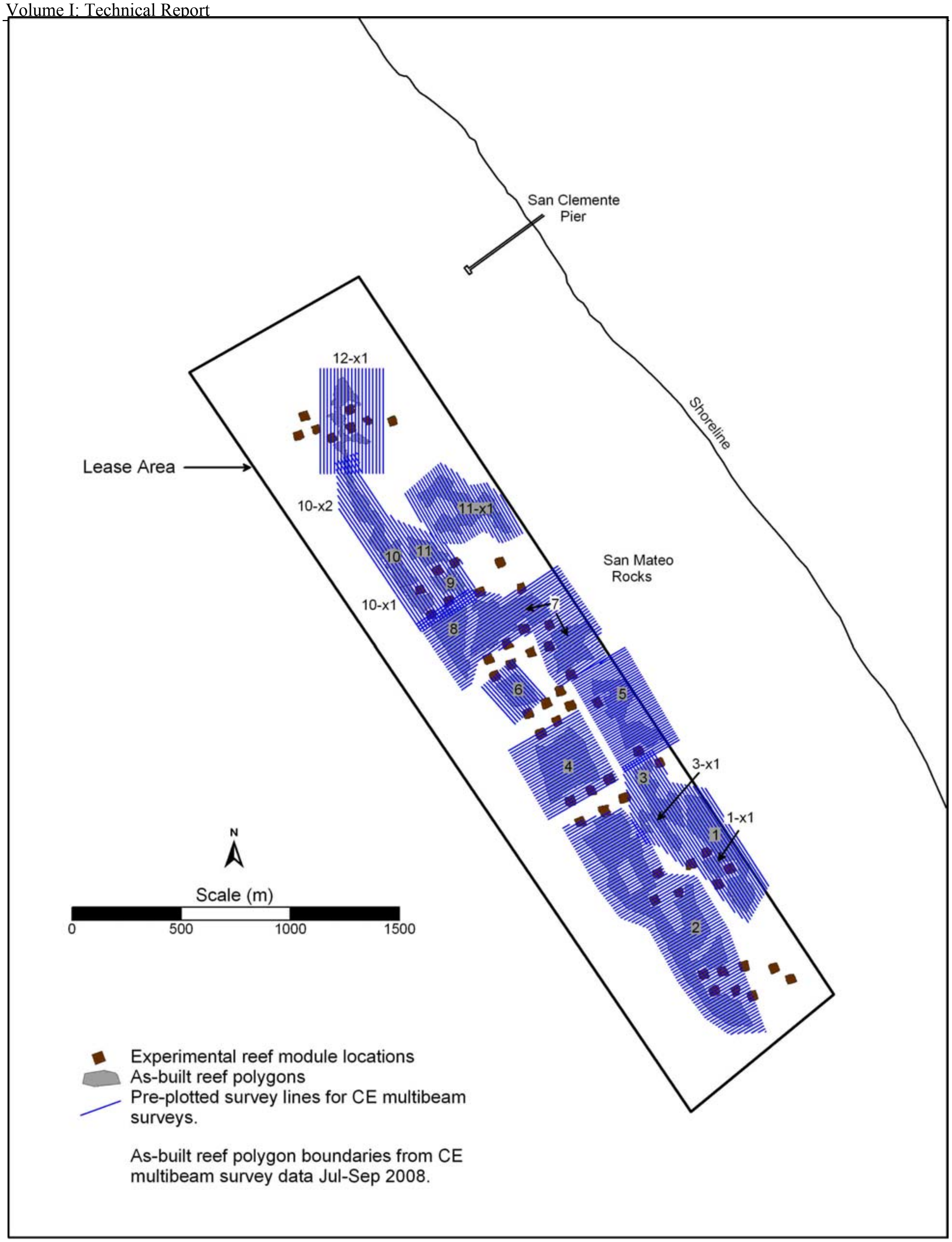

Figure 5-2. Pre-plotted survey lines for multibeam surveys for the 17 polygons.

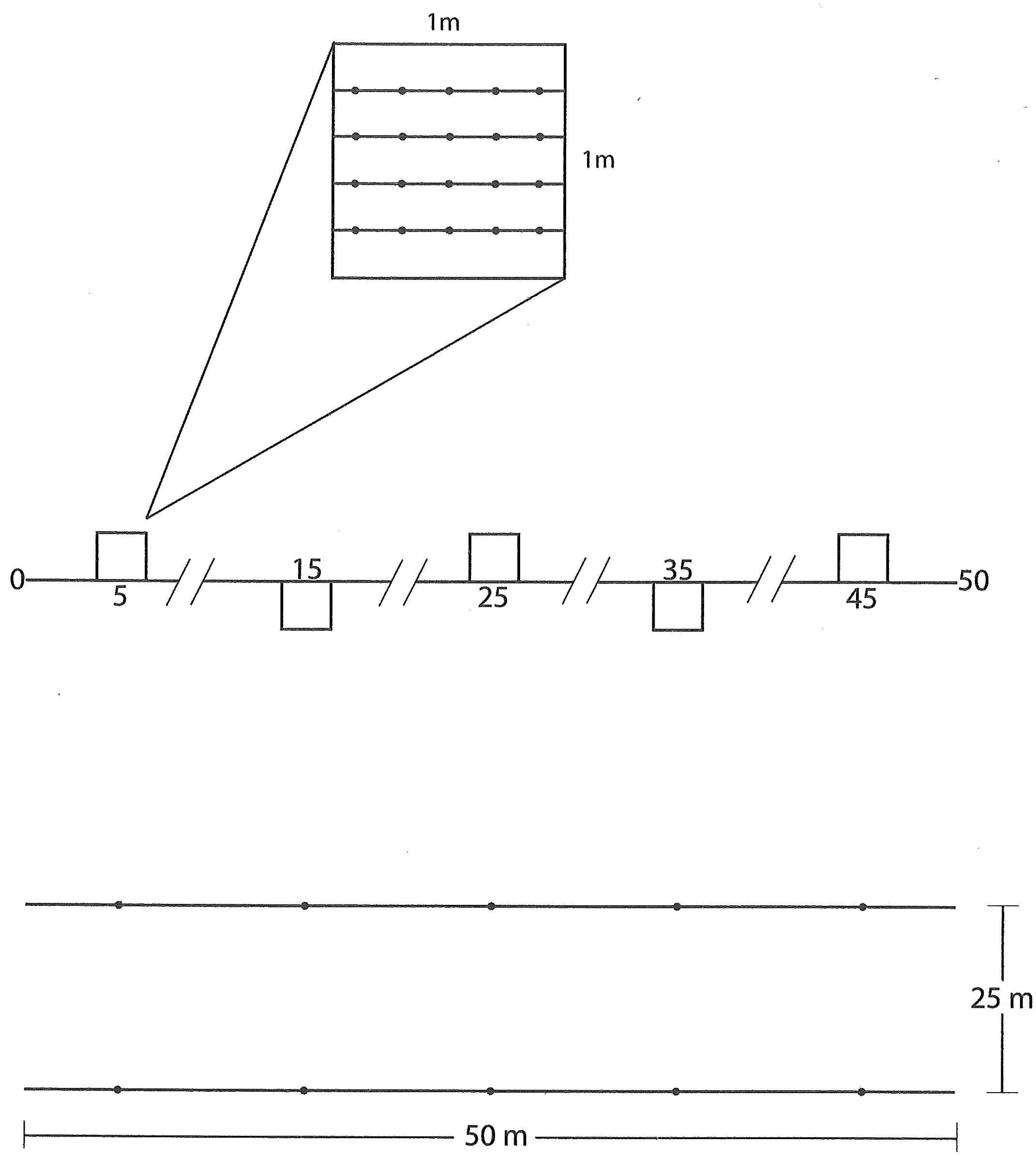

Figure 5-3. Schematic diagram of transects, quadrats, and sample points within quadrats on permanent transects.

Table 5-1. Description of substrate categories. All cobbles and boulders encountered during the surveys were quarried rock. Bedrock represents continuous natural hard substrate.

Code	Size (cm)	Description
S	< 0.2	Sand
MS	n/a	Mudstone
SH	n/a	Shell Hash
P	0.2 - 6.4	Pebble
C	6.5 - 25	Cobble
SB	26 - 50	Small Boulder
MB	51 - 100	Medium Boulder
LB	>100	Large Boulder
BR	n/a	Bedrock

CCC-CS also conducted expanded sampling in two polygons (2 and 6) to assess the adequacy of their sample size and accuracy of their estimates of quarry rock coverage obtained. Percentage cover in the expanded sampling was estimated in the same way as explained above. Transects used in the expanded sampling extended east to west across the width of each polygon. The number of quadrats sampled for Polygons 2 and 6 were 492 and 75, respectively. Figure 4-7 (Section 4) shows the locations of the expanded transects along Polygons 2 and 6. A comparison between the results of percent coverage for the permanent and expanded transacts are presented in Table 3a and Table 3b of the report prepared by Schroeter et al. (2008). For the readers' convenience, we present these results in Tables 5-2 and 5-3. There were differences in the mean coverage between permanent and expanded transects for Polygons 2 and 6 (Table 5-2). However, estimates of average percent coverage of hard substrate from permanent and expanded sampling for Polygon 2 and 6 combined using the weighting average method (Schroeter et al., 2008) resulted in hard substrate coverage estimates within 1%. The area of Polygon 2 is 38.88 acres and the area of Polygon 6 is 4.24 acres.

Table 5-2. Estimates of average percent coverage of hard substrate from permanent and expanded sampling for Polygons 2 and 6, separately (Schroeter et al., 2008).

Polygon	Substrate Type	Permanent			Expanded		
		Mean	Stderr[a]	n[b]	Mean[a]	Stderr	n[b]
2	Cobble	6.0	0.9	100	5.5	0.4	492
2	Boulder	36.3	2.6	100	35.1	1.2	492
2	Cobble + Boulder	42.3	2.7	100	40.6	1.3	492
6	Cobble	7.5	4.1	10	8.1	1.3	75
6	Boulder	35.0	9.1	10	39.1	3.2	75
6	Cobble + Boulder	42.5	10.0	10	47.2	3.5	75

[a] Stderr is the standard error (Standard deviation of the mean).
[b] n is the number of 1 m^2 squares.

Table 5-3. Estimates of average percent coverage of hard substrate from permanent and expanded sampling for Polygons 2 and 6, combined (Schroeter et al., 2008).

Substrate Type	Permanent			Expanded		
	Mean	Stderr[a]	n[b]	Mean[a]	Stderr	n[b]
Cobble	6.1	4.2	110	5.8	1.4	567
Boulder	36.2	9.5	110	35.6	3.4	567
Cobble + Boulder	42.3	10.3	110	41.4	3.7	567

[a] Stderr is the standard error (Standard deviation of the mean).
[b] n is the number of 1 m^2 squares.

6.0 PERMIT COMPLIANCE

The following environmental instruments were required to permit the construction of the Phase 2 WNR. A lease was secured from the California State Lands Commission (CSLC). A 410 Certification was obtained from the California Regional Water Quality Control Board (2008), a 404 permit was secured from the U.S. Army Corps of Engineers (USACOE, 2008), and a Coastal Development Permit was issued by the California Coastal Commission (2008). Several reports were written during this Phase 2 WNR construction. A list of these reports is given in Appendix B.

The following are the measures that were taken to ensure compliance with permits.

1. Quarry boulders were inspected prior to placement. Inspections showed that materials were acceptable according to the technical specifications (Section 2.3). The boulders were free from potentially harmful contaminants and met CDFG requirements for hardness and suitability for remaining in the ocean for 30 years.
2. CP contacted the U.S. Coast Guard more than two weeks prior to moving any quarry material to the construction site to allow issuance of a Notice to Mariners.
3. A multibeam sonar survey and biological survey were conducted by CE (2008b) prior to construction. The surveys showed no significant hard substrate or valuable marine habitat or invasive species including *Caulerpa* at the project site. The results are in agreement with the biological survey conducted by Coastal Resources Associates, Inc. (1999) prior to construction of the experimental kelp reef.
4. An anchoring plan was submitted to CCC staff. Approval of the plan was obtained prior to any construction activity on site.
5. Water spray was used at the CP dock yard and on the *DB Long Beach* to suppress fugitive dust (CE, 2008d).
6. Turbidity during construction was minimized by spraying the quarry material with water prior to deposition. Daily turbidity was monitored visually and photographically to demonstrate compliance with the Regional Water Quality Control Board permit requirement that the turbidity plume should not exceed the distance of one-half mile from the flat deck barge, and the plume shall be dissipated within a few hours after forming.
7. Fuel consumption records were kept on file by CP.

7.0 PHOTOGRAPHIC DOCUMENTATION

The photographs taken during the construction of Phase 2 WNR document the reef building materials and construction processes. Photographs were taken of quarry material, construction processes and utilized equipment. In excess of 1,000 photographs were taken between June 9 and September 11, 2008. Selected photographs are shown in Appendix C.

8.0 PROJECT SUMMARY

Construction of Phase 2 of the WNR was initiated on June 9, 2008 and concluded on September 11, 2008. During Phase 2, a 152-acre, low-profile (<1 m), single-layer kelp reef was constructed approximately one-half mile off the coast of San Clemente, California, extending from approximately one-half mile south of the San Clemente Pier and continuing in a southerly direction to San Mateo Point. The Phase 2 reef utilized similar design specifications for seafloor deposition to those of the lowest substrate density (42% bottom coverage) used for the construction of the 22.4-acre experimental reef, which was constructed in September 1999 (Phase 1).

The Phase 2 mitigation reef consists of 17 polygons varying in area between 1.3 and 38.9 acres. A total of 125,957.5 tons of rock were used in the construction of the Phase 2 reef and the overall average yield was 828.6 tons/acre. The 17 polygons were all constructed of quarry rock procured from the following quarries: 1) the Pebbly Beach quarry on Santa Catalina Island, 2) the Empire quarry on Santa Catalina Island, and 3) the La Piedra quarry in Ensenada, Mexico. CP and CE experienced no reportable safety issues or injuries during construction of the reef.

Several steps were taken in order to complete WNR Phase 2 reef construction: 1) rock selection, testing and inspection, 2) construction of polygons, 3) on-site monitoring during construction, 4) sonar and diver verification of the completed work, and 5) multibeam bathymetry surveys before and after construction. A timeline plot covering the major milestones of the project is shown in Figure 8-1.

The Phase 2 mitigation reef was completed in order to fulfill CCC Permit No. 6-81-330-A (SONGS Units 2 & 3), Condition C, Kelp Reef Mitigation, of April 9, 1997 (CCC, 1997), which mandated the completion of a 150-acre artificial reef subject to compliance monitoring by the CCC. Including the 22.4-acre experimental reef, a total of 174.4 acres of mitigation reef have been constructed. A large scale 11x17-inch as-built bathymetric map for the project area is shown in Appendix D.

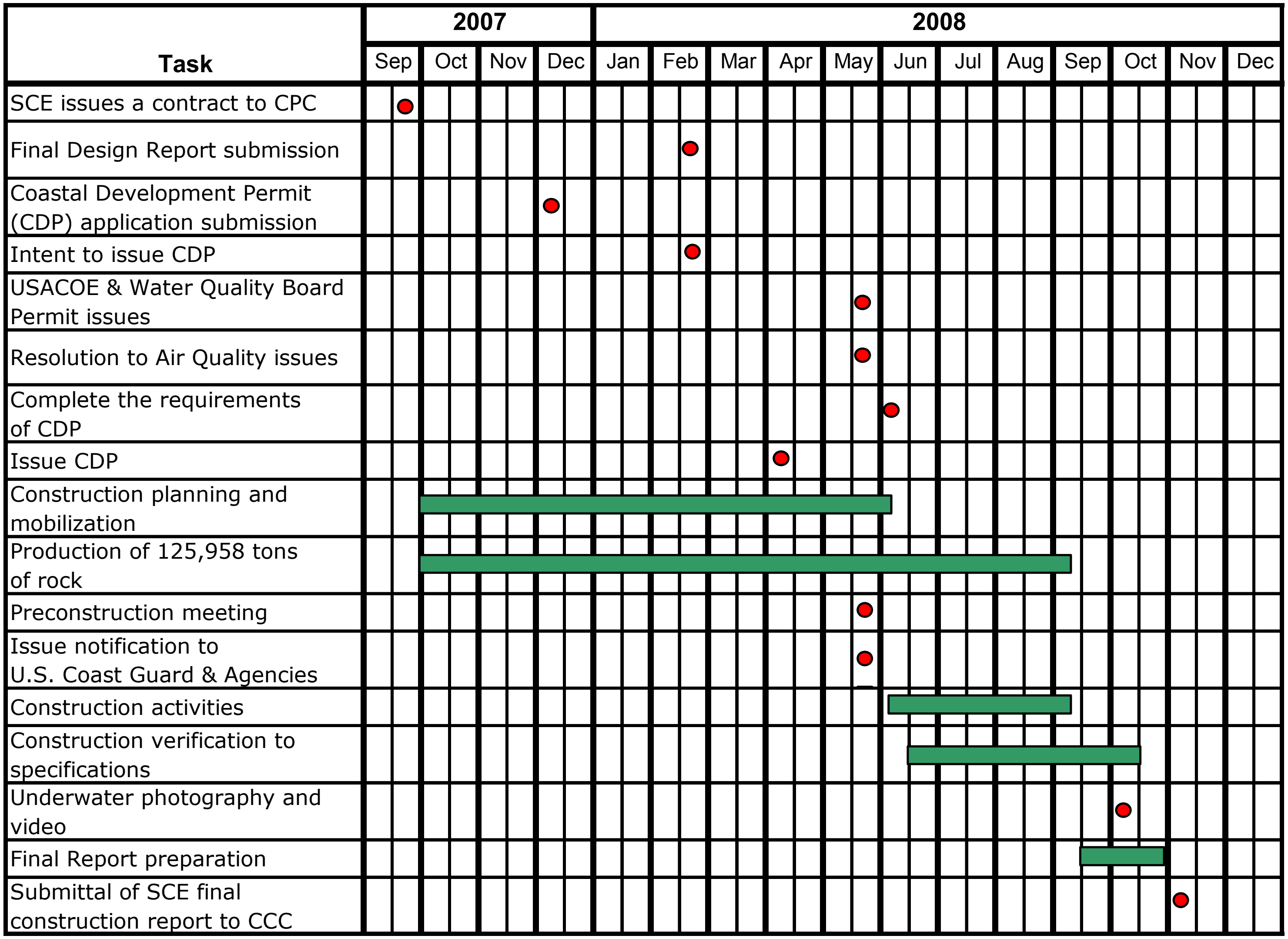

Figure 8-1. Timeline of major project milestones.

9.0 CONCLUSIONS

Phase 2 of the WNR construction project included several critical steps: 1) the siting and design phase, performed by CE and approved by the CCC scientists; 2) the selection of a construction contractor; 3) the selection of material sources; 4) obtaining permits; 5) public meetings; 6) reef construction; 7) compliance with regulations and permit requirements; and 8) verification that the reef was constructed according to specifications.

The construction of the 152-acre portion of the WNR began on June 9, 2008 and ended on September 11, 2008 (73 construction days). Construction time for the polygons varied from 1 day to a couple of weeks based on the area of the polygon. On average, 1,725 tons of rocks were deposited each working day. An anchor plan was prepared before construction, which optimized the moving of the *DB Long Beach* anchors during construction (CE, 2008a). Rocks were placed in a mono-layer as requested by the scientists, such that the average height of the reef was between 1 and 2 feet. The construction techniques minimized rock overlap, and diver surveys confirm minimal overlap.

Owing to the accurate construction techniques employed in the building of the reef (Chapter 3), the percentage coverage and distribution of material within a given polygon is consistent and uniform. Placement location and spacing also appear to be accurate and per the approved siting specifications.

The Phase 2 WNR, as designed and constructed, provides the CCC's Phase 2 reef monitoring program scientists with well-defined and distinctive polygons per the design specifications (CE, 2008a) such that variation of size, orientation, placement, spacing, and hard substrate coverage on the bottom of the ocean met design specifications. The constructed Phase 2 reef creates a nominal 152-acre, low-relief reef constructed of quarry rock. The parameters used are similar to those used in the construction of the lowest substrate coverage modules utilized in the Phase 1 Experimental Reef.

Weighted average percent coverage estimates were calculated for four different scenarios in Section 4.5. SCE recommends that Case 4 be adopted by the CCC. Case 4 eliminates Polygon 5 and the western section of Polygon 7. This leaves 130.3 acres of constructed Phase 2 reef with an average percent coverage of 42.3%. By adding the 130.3 acres to the previously constructed 22.4 acres of the Experimental Reef, completed in September 1999, results in a single layer low relief reef totaling 152.7 acres, which fulfills the requirements of CCC Permit No. 6-81-330-A Condition C (SONGS Units 2 & 3, Kelp Reef Mitigation).

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Coastal Environments, 2008b. Pre-Construction Biological Survey of the Wheeler North Reef. Report submitted to Southern California Edison Company, 2244 Walnut Grove Avenue, Rosemead, 19 May 2008, CE Ref. No. 08-13. 6 pp.

Coastal Environments, 2008c. Wheeler North Reef, Construction Verification for Polygon 6 and Southern Part of Polygon 2 (A & B). Report submitted to Southern California Edison Company, 2244 Walnut Grove Avenue, Rosemead, 14 August 2008, CE Ref. No. 08-21A. 15 pp. + appendix, figures and tables.

Coastal Environments, 2008d. Wheeler North Reef Water Quality Compliance Report (9 June through 26 July 2008). Report submitted to Southern California Edison Company, 2244 Walnut Grove Avenue, Rosemead, 1 August 2008, CE Ref. No. 08-24. 10 pp.

Coastal Environments, 2008e. Final Construction Report for Wheeler North Reef at San Clemente, California (Formerly the Songs Artificial Reef Mitigation Project, Phase 2 Mitigation Reef), Volume II: Data Report. Report submitted to Southern California Edison Company, 2244 Walnut Grove Avenue, Rosemead, 27 October 2008, CE Ref. No. 08-34. 11 pp. + 8 appendices, figures, tables, and photographs.

Coastal Resources Associates, Inc., 1999. Assessment of Sites for the Experimental Reef Modules at San Clemente. Report submitted to SCE, Rosemead, CA 91770, on August 9, 1999, 9 pp. plus 6 figures.

Reed, C. D., S. C. Schroeter, and David Huang. 2005. Final Report on the Findings and Recommendations of the Experimental Phase of the SONGS Artificial Reef Mitigation Project. Prepared for the California Coastal Commission, Marine Science Institute, University of California, Santa Barbara, 1 August 2005. 136 pp.

Schroeter, S., Reed, D., Huang, D., Weisman, D., Welch, G., and Hellmers, E., 2008. Summary of Substrate Sampling of the Wheeler North Artificial Reef. Prepared for the CCC, October 2008, 5 pp. and 4 figures.

Twining Laboratories, 2008a. Sample analysis at Pebbly Beach Quarry, Santa Catalina Island, for SCE Phase 2 WN Reef, San Clemente, CA. Report submitted to Connolly-Pacific Company, Long Beach, CA, 27 February 2008, 3 pp.

Twining Laboratories, 2008b. Sample analysis at Empire Quarry, Santa Catalina Island, for SCE Phase 2 WN Reef at San Clemente, CA. Report submitted to Connolly-Pacific Company, Long Beach, CA, 27 February 2008, 3 pp.

Twining Laboratories, 2008c. Sample analysis at La Piedra Quarry in Ensenada, Mexico, for SCE Phase 2 WN Reef at San Clemente, CA. Report submitted to Connolly-Pacific Company, Long Beach, CA, 27 February 2008, 3 pp.

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APPENDIX A

CP REPORTED POLYGON TONNAGE, ACREAGE AND TONS/ACRE VERSUS CE AS-BUILT VALUES

Table A-1. CP reported polygon tonnage, acreage, and tons/acre versus CE as-built values.

Polygon Number	Polygon ID	Placed Rock (Tons) (CP)[1]	Placed Rock (Tons) (CE)[2]	CP		CE	
				Area (Acres)[3]	Tons/ Acre[4]	Area (Acres)[5]	Tons/ Acre[6]
1	1	11,444.8	11,444.8	13.34	857.9	13.8	829.3
2	2	31,872.0	31,872.0	36.92	863.3	38.9	819.3
3	3	5,093.0	5,093.0	6.44	790.8	6.6	771.7
4	4	10,996.9	10,996.9	13.97	787.2	14.1	779.9
5	5	7,046.1	7,046.1	9.18	767.5	9.5	741.7
6	6	3,208.8	3,208.8	4.04	794.3	4.2	764.0
7	7	15,541.9	15,541.9	18.35	847.0	19.0	818.0
8	8	6,087.4	6,087.4	7.41	821.5	7.6	801.0
9	9	1,967.2	1,967.2	2.4	819.7	2.5	786.9
10	10	3,838.6	3,838.6	3.69	1,040.3	3.9	984.3
11	11	3,094.2	3,094.2	3.43	902.1	3.5	884.1
12	1-x1	1,258.7	1,258.7	1.28	983.4	1.4	899.1
13	3-x1	2,600.3	2,600.3	2.84	915.6	2.9	896.7
14	10-x1	2,008.1	2,008.1	2.03	989.2	2.1	956.2
15	10-x2	4,642.4	4,642.4	5.23	887.6	5.5	844.1
16	11-x1	10,440.7	10,440.7	10.88	959.6	11.2	932.2
17	12-x1	4,816.4	4,816.4	5.37	896.9	5.3	908.8
Totals/Average		125,957.5	119,128.5	146.8	N/A	152.0	N/A

1 Connolly-Pacific reported value determined by barge gauge.
2 CE reported value determined by counting loads and multiplying by 4.5 tons per load.
3 Acreage as determined by Connolly-Pacific during construction of WNR (Numbers are design acreage minus any corner areas that could not be accessed by derrick barge).
4 Connolly-Pacific value (CP tonnage per polygon divided by CP determined acreage), this is the number that was used during construction of WNR.
5 Acreage as determined by Coastal Environments using the multibeam sonar system.
6 Coastal Environments value (CP tonnage per polygon divided by CE determined acreage), this is the number determined after completion of the multibeam surveys.

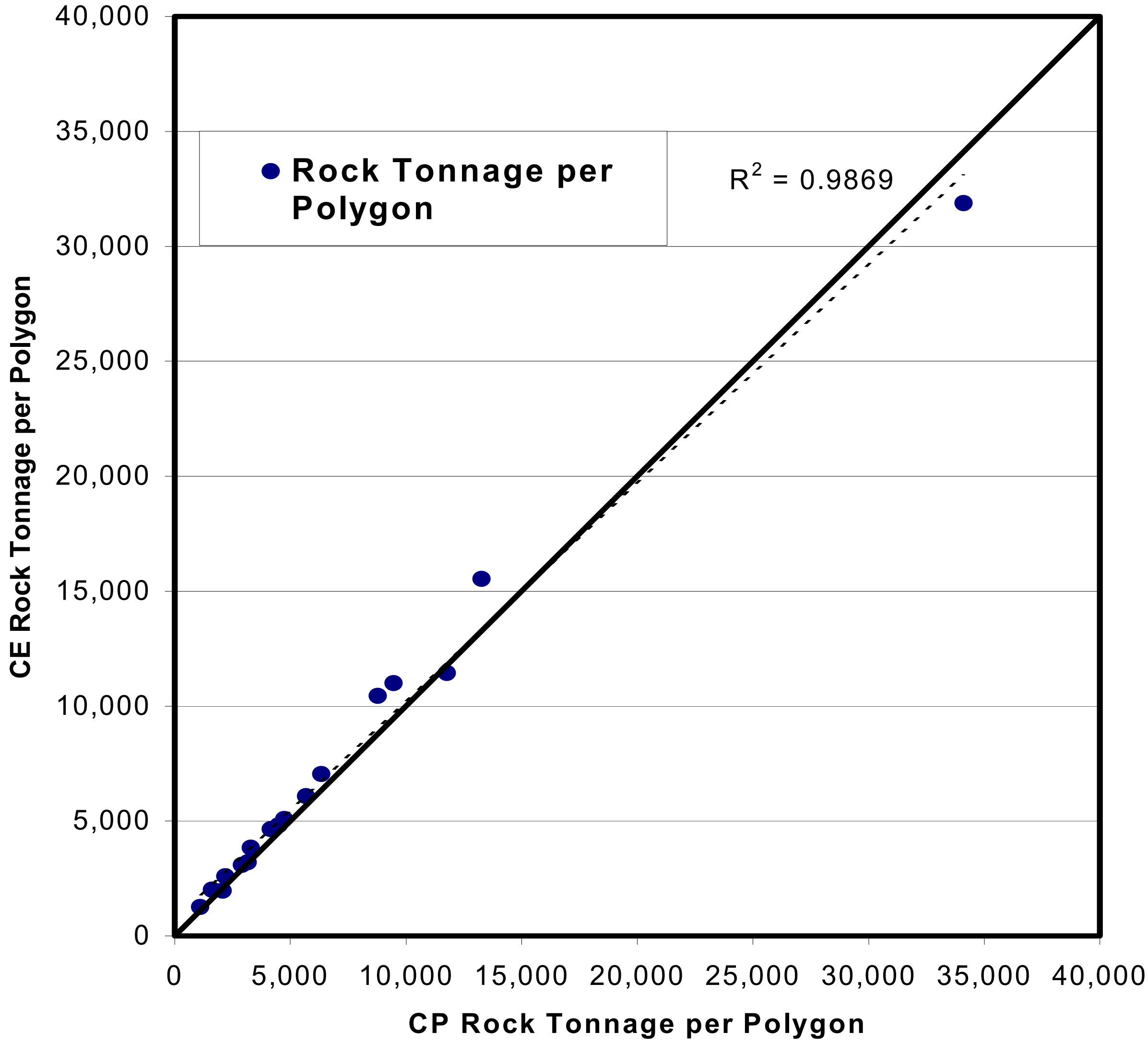

Figure A-1. Comparison between CP and CE values for tonnage placed per polygon.

APPENDIX B

LIST OF TECHNICAL REPORTS PREPARED FOR PHASE 2 WNR BY CE

Table B-1. List of technical reports prepared for Phase 2 WNR by CE.

Report No.	Title	Description	No. of Pages
1	Final Design Plan, Wheeler North Reef at San Clemente, California, (SONGS Artificial Reef Mitigation Project, Phase 2 Mitigation Reef), Coastal Development Permit #E-07-010	Submitted Southern California Edison Company on 11 February 2008 (Revised), CE Reference No. 07-23A	53 pp. + 9 appendices, figures and tables
2	Documentation of GIS Data Transmittal, Wheeler North Reef at San Clemente, California, (SONGS Artificial Reef Mitigation Project, Phase 2 Mitigation Reef), Coastal Development Permit #E-07-010	Submitted Southern California Edison Company on 5 March 2008, CE Reference No. 08-06	17 pp. + figures
3	Southern California Edison, Wheeler North Reef Construction Verification Plan	Submitted Southern California Edison Company on 14 May 2008 (revised), CE Reference No. 08-10A	9 pp. + figures
4	*Caulerpa* Survey For Wheeler North Reef, Construction Project, San Clemente, California	Submitted Southern California Edison Company on 16 May 2008, CE Reference No. 08-12	5 pp. + 1 appendix and figures
5	Pre-construction Biological Survey of the Wheeler North Reef	Submitted Southern California Edison Company on 19 May 2008, CE Reference No. 08-13	6 pp. + figure and table
6	Update and Review of Kelp Canopy GIS Data submitted to the Coastal Commission Staff for the Wheeler North Reef Project	Submitted Southern California Edison Company on 23 June 2008, CE Reference No. 08-16	8 pp. + figures
7	Wheeler North Reef Project, (SONGS Artificial Reef Mitigation Project, Phase 2 Mitigation Reef), Bi-Weekly Construction Progress Report #1 (09 June 2008 Through 21 June 2008)	Submitted Southern California Edison Company on 8 July 2008, CE Reference No. 08-17	6 pp. + figures and photographs
8	Wheeler North Reef Project, (SONGS Artificial Reef Mitigation Project, Phase 2 Mitigation Reef), Bi-Weekly Construction Progress Report #2 (23 June 2008 through	Submitted Southern California Edison Company on 9 July 2008, CE Reference No. 08-19	6 pp. + figures and photographs

Report No.	Title	Description	No. of Pages
	05 July 2008)		
9	Wheeler North Reef, Construction Verification for Polygon 6 and Southern Part of Polygon 2 (A&B)	Submitted Southern California Edison Company on 14 August 2008, CE Reference No. 08-21A	15 pp. + appendix, figures and tables
10	Wheeler North Reef Project, (SONGS Artificial Reef Mitigation Project, Phase 2 Mitigation Reef), Bi-Weekly Construction Progress Report #3 (7 July 2008 through 19 July 2008)	Submitted Southern California Edison Company on 22 July 2008, CE Reference No. 08-22	6 pp. + figures and photographs
11	Wheeler North Reef, Water Quality Compliance Report (9 June through 26 July 2008)	Submitted Southern California Edison Company on 1 August 2008, CE Reference No. 08-24	10 pp. + figure, table and photographs
12	Wheeler North Reef Project, (SONGS Artificial Reef Mitigation Project, Phase 2 Mitigation Reef), Bi-Weekly Construction Progress Report #4 (21 July 2008 through 2 August 2008)	Submitted Southern California Edison Company on 5 August 2008, CE Reference No. 08-25	7 pp. + figures and photographs
13	Wheeler North Reef Project, (SONGS Artificial Reef Mitigation Project, Phase 2 Mitigation Reef), Bi-Weekly Construction Progress Report #5 (4 August 2008 through 16 August 2008)	Submitted Southern California Edison Company on 22 August 2008, CE Reference No. 08-27	7 pp. + figures and photographs
14	Wheeler North Reef Project, (SONGS Artificial Reef Mitigation Project, Phase 2 Mitigation Reef), Bi-Weekly Construction Progress Report #6 (18 August 2008 through 30 August 2008)	Submitted Southern California Edison Company on 4 September 2008, CE Reference No. 08-29	8 pp. + figures and photographs
15	Wheeler North Reef Project, (SONGS Artificial Reef Mitigation Project, Phase 2 Mitigation Reef), Bi-Weekly Construction Progress Report #7 (2 September 2008 through 12 September 2008)	Submitted Southern California Edison Company on 17 September 2008, CE Reference No. 08-30	8 pp. + figures and photographs

APPENDIX C

PHOTOGRAPHS TAKEN DURING CONSTRUCTION

Photo C-1. Pebbly Beach Quarry rock face, Catalina Island.

Photo C-2. Rock production at Pebbly Beach Quarry. Large rocks were broken into smaller rocks by the Breaker (right) and small rocks were separated out by the Grizzly (left).

Photo C-3. Photograph showing derrick barge crane loading rocks from the Empire Quarry onto a rock barge.

Photo C-4. Derrick Barge *Long Beach (DB Long Beach)*.

Photo C-5. Photograph showing anchor system consisting of surge cans connected to 15-ton concrete blocks and anchors. Anchors are beneath surge cans.

Photo C-6. Photograph showing tugboat bringing in a rock barge for tie-up with the *DB Long Beach*.

Photo C-7. Photograph showing typical rock pile from Pebbly Beach Quarry.

Photo C-8. Photograph showing typical rock pile from Empire Quarry.

Photo C-9. Photograph showing typical rock pile from La Piedra (Ensenada) Quarry.

Photo C-10. Photograph showing the control room for the derrick barge winches. The derrick barge position is controlled by pulling on six, 1.5-inch-diameter wires attached to the six anchor buoys. At the right top corner is the navigation system monitor showing the location of the supply barge edge.

Photo C-11. Photograph showing rock placement by the front loader.

Photo C-12. Photograph showing a close-up view of rock placement.

Photo C-13. Photograph showing construction worker measuring the height of the supply barge from the surface water at one of its four edges. Data is used to estimate the weight of the placed rock on the bottom of the ocean.

Photo C-14. Photograph showing average turbidity plume created during reef construction.

APPENDIX D

AS-BUILT BATHYMETRIC MAP FOR PHASE 2 WNR

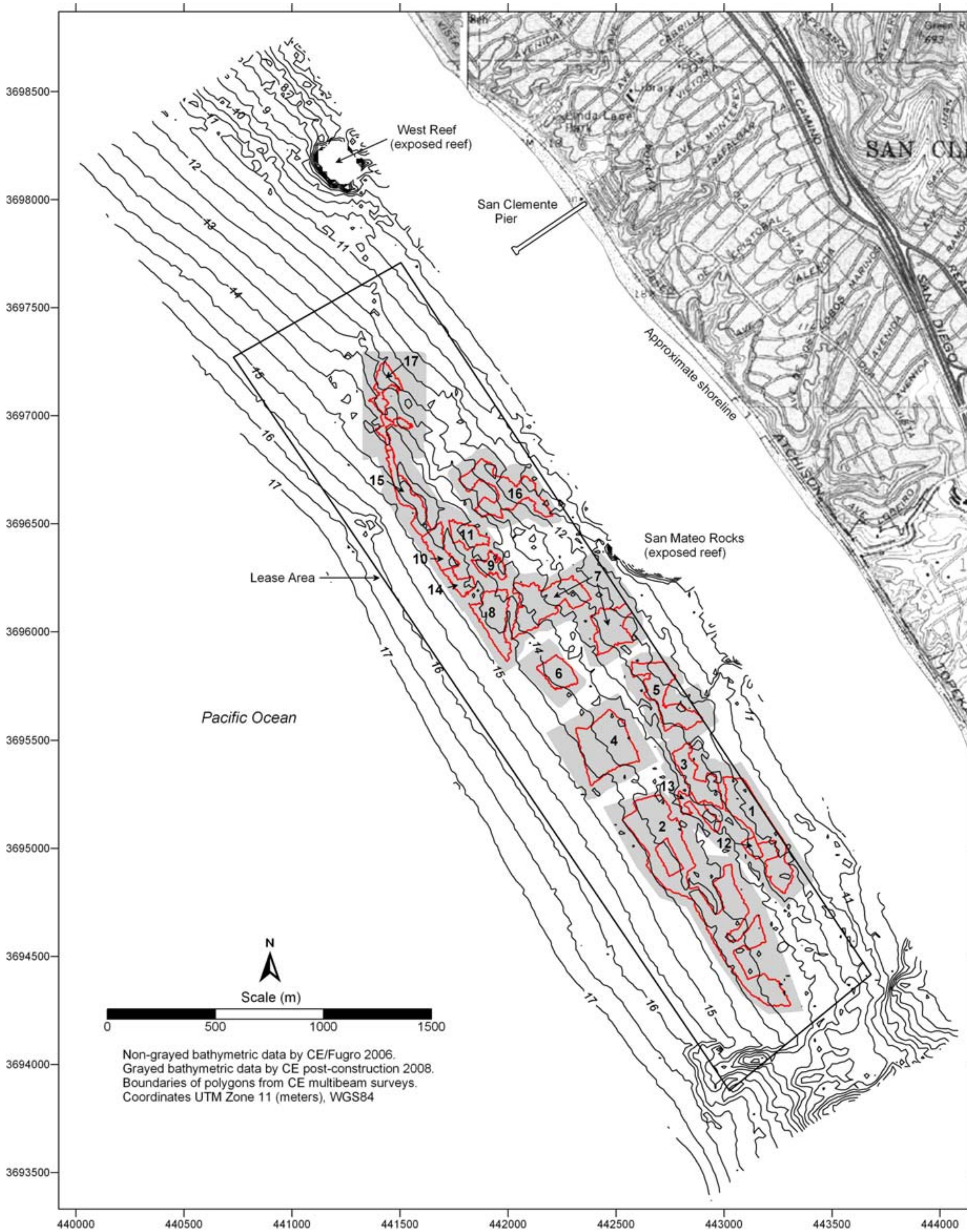

Figure D-1. As-built bathymetric map for WNR at San Clemente, CA.