



## **APPENDIX A**

### **History of Engineering Studies at Coronado Cays**

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### CORONADO CAYS DEVELOPMENT HISTORY OF ENGINEERING STUDIES

Although other consultants have studied the Coronado Cays development, including five separate consultants that studied the bulkhead failure at 37 and 39 Green Turtle Road on December 31, 1986, TerraCosta (and its predecessor firm, Group Delta Consultants) has conducted numerous studies throughout the Coronado Cays since 1985. In the following pages, we summarize TerraCosta's previous studies and believe that they provide a good overview of the stability of the bulkheads at the Coronado Cays development.

### **1986 through 1998**

#### 37 and 39 Green Turtle Road

On December 31, 1986, during the falling limb of one of the year's largest tidal cycles, three of the pre-cast concrete bulkhead panels failed at 37 and 39 Green Turtle Road. The results of various investigations concluded that the failed portion of the bulkhead was caused by a loss of berm support that resulted in the toe of the bulkhead kicking out, with the wall pivoting about the upper anchor. The loss of berm support was attributed to erosion of the supporting materials due to prop wash. The elevation of the bay floor fronting the three failed bulkheads at the time of failure ranged from -4.25 to -6 feet (MLLW). As a result of the bulkhead failure, a series of studies and reviews had been conducted by both the Coronado Cays Homeowners Association (CCHOA) and the City of Coronado. At that time, there was no general concurrence between the CCHOA and the City as to the overall stability of bulkheads.

#### 1980s and Early 1990s Bathymetric Surveys and Bulkhead Inspection Program

TerraCosta and its predecessor firm Group Delta Consultants (GDC) have collectively been involved in various engineering studies and inspection programs in and adjacent to the interior waterways throughout the Coronado Cays development since 1985. GDC's predecessor firm Medall, Worswick & Associates (MWA) was originally contracted in July 1985 by the City of Coronado to perform a hydrographic survey of all of the interior waterways, providing sea-floor bathymetry at a scale of 1 inch equals 40 feet. Subsequent studies by GDC included underwater inspection services along all of the causeway bulkheads, inspection services for bulkhead penetrations, and engineering consultation associated with the bulkhead failure in the vicinity of 37 and 39 Green Turtle Road. In 1990, a second bathymetric survey and report were prepared by GDC, which in part described several locations within the waterways where certain repairs were warranted in order to restore adequate passive resistance to the bulkhead.

## Mardi Gras Bulkhead Stabilization

In addition to the Green Turtle Road bulkhead failures in 1986, distress features were noted in November 1993 in the bulkhead along Tunapuna Lane within the Mardi Gras Village of the Coronado Cays. The CCHOA retained Cotton, Shires & Associates, Inc. (geotechnical engineering consultants) and Nowak-Meulmester and Associates (structural engineering consultants) to provide design input and design of a tieback repair of the wall. The portion of the wall addressed by this repair extended from Unit 85 to Unit 113 of Tunapuna Lane. This work was initiated in 1997 and repairs to the bulkhead were completed by the summer of 1998.

## **2002 through 2003**

### Bathymetric Survey and Bulkhead Inventory

TerraCosta was contracted by the City to update the bathymetric survey data for the entirety of the Coronado Cays development. In April 2002, TerraCosta measured the berm elevations using a series of fathometer transects from a small work boat. The survey consisted of the following:

- A continuous transect around the perimeter of all waterways at a distance of approximately 3 feet out from the bulkhead.
- A continuous transect around the inside dock line of all waterways at a distance of approximately 10 feet out from the bulkhead.
- A continuous transect around the outside dock line (pier head line) of all waterways. Where variable dock lengths exist within a particular waterway, the fathometer transect followed a string line connecting the maximum projection of adjacent bulkheads along a given waterway.
- A continuous transect down the centerline of all waterways.

Comparisons of measured berm elevations from the 1985 and 1990 bathymetric survey data were then made to assess changes in berm elevation. The survey data was presented in a series of figures that included color plots indicating bottom depths by a color-keyed index, in addition to displaying the difference in berm height between the previous 1990 survey and the 2002 survey. Given the importance of the berm elevation directly adjacent the bulkhead, these figures were used in assessing wall stability.

TerraCosta also performed a general inspection of the bulkheads and associated engineering elements to evaluate and document the condition of all bulkhead penetrations (primarily storm drain penetrations) and the integrity of all bulkhead panel joints. TerraCosta also performed an underwater inspection assessing the integrity of the concrete bulkhead panel joints along the public causeways. The results of this survey were provided in TerraCosta's report provided in May 2003

## 2005 through 2007

### Mardi Gras Bulkhead Stabilization

In November 2005, TerraCosta and Blaylock Engineering Group (structural engineers) met with CCHOA Board Members to discuss apparent bulkhead movement at Mardi Gras Village. In June 2006, TerraCosta performed a reconnaissance of the bulkhead wall from Unit 1 to Unit 113 Tunapuna Lane. The site reconnaissance consisted of observing gaps between the pilasters and property line walls, measuring the mudline elevation at each property line intersection of the bulkhead, generally observing backyard drainage, and observing bulkhead wall drains. TerraCosta performed review of available reports, pertinent bulkhead measurements, considered the preliminary assessment of bulkhead conditions, and then provided conclusions and recommendations pertaining to various alternatives that the CCHOA might pursue for added stabilization of the bulkhead. Recommendations consisted of various structural upgrades to the 1998 tieback anchor system and periodic surveying of the elevation of the berm fronting the bulkhead in the area. In summary, the original design for the Mardi Gras bulkhead consisted of a 12-foot-tall, cantilevered sheet-pile with a design exposed wall height of 4 feet, leaving 8 feet of penetration into the underlying beach sands. The original bulkhead distress noted in November 1993 resulted from about 1 foot of scour of the beach sands, resulting in a 5-foot unsupported wall height with 7 feet of embedment. The Cotton Shires/Nowak-Meulmester (CSNM) team designed a tied-back grade beam assuming a minimum mudline elevation of 4 feet MLLW, or 6 feet of unsupported wall height with 6 feet of embedment. By 2003, the beach sands had scoured to below the CSNM design mudline elevation, resulting in yet additional wall yielding and distress. This history is important because several units along Tunapuna Lane from Lot 71 through Lot 81 have upwards of 4.5 feet of exposed wall height with no stabilizing tiebacks, and are currently in need of stabilization.

### Bulkhead and Berm Study

In 2005, bulkhead measurements performed by the CCHOA suggested that the actual lengths of the bulkheads differed from the lengths used by TerraCosta in developing guidelines for berm reconstruction. In response to the CCHOA's concerns, TerraCosta performed a confirmation study of bulkhead lengths in selected areas, and reviewed and reassessed potential berm stabilization needs based on the results of the sheet-pile length confirmation. The confirmation study consisted of the following:

Phase 1: On November 30, 2005, TerraCosta conducted field measurements of the lengths of the existing bulkheads. The bulkheads were measured at ten selected points.

Phase 2: TerraCosta performed additional field measurements on May 16, 2006, and August 7, 2006. A total of 51 measurements were taken.

In December 2006, TerraCosta issued a report providing a reassessment of potential berm stabilization needs based on the results of the sheet-pile length confirmation. An important feature of that December 2006 report was the designation of "cautionary" and "serious" berm elevations as they pertain to bulkhead stability. For locations with the 17.5-foot-long bulkhead, a "cautionary" designation was reported for areas where the top-of-berm elevations were between -6 and -7 feet Mean Sea Level (MSL) (-3.1 and -4.1 feet MLLW, respectively). Areas where the top-of-berm

elevations were below elevation -7 feet MSL (-4.1 feet MLLW) were reported with a “serious” designation. For locations with the 20-foot-long bulkhead, a “cautionary” designation was reported on areas where the top-of-berm elevations were between -7 and -8 feet MSL (-4.1 and -5.1 feet MLLW, respectively). Areas where the top-of-berm elevations were below elevation -8 feet MSL (-5.1 feet MLLW) were reported with a “serious” designation. Figure 3 of our August 2, 2021, Geotechnical Assessment of Bulkheads report includes a table of those berm elevation designations for Areas A, B, and C. It should be noted that Areas A and C have the same bulkhead length of 17.5 feet, and that Area B has a bulkhead length of 20 feet. As such, walls in Areas A and C had shallower cautionary and serious berm elevations than walls in Area B.

The December 2006 report also provided a brief summary of the stability analyses that had been performed by five independent consultants following the 1986 failure at 37 and 39 Green Turtle Road. All five consultants used berm elevation as a proxy for the variation in passive resistance that the soil berm provides for stabilizing the bulkhead. At that time, TerraCosta concluded that given the performance of the bulkheads since the 1986 failure, it could safely be said that the existing factor of safety of the bulkhead was greater than 1.0 and likely less than 1.5 for those areas where the existing berm elevation was less than the design elevation. Technical references listing the various reports containing stability analyses were provided in the 2006 report.

Field data collected in the Phase 1 and Phase 2 studies were then utilized in conjunction with the 2003 bathymetric survey data to determine the elevation of the soil berm fronting the bulkheads within the development. Using the aforementioned bulkhead screening criteria for both the 17.5-foot-long bulkhead and the 20-foot-long bulkhead, no lots were designated as being in a “serious” condition. However, at that time, Lots 277, 278, 279, 280, 282, 288, 289, and 290, and portions of Lots 197 and 276, were classified as being in a “cautionary” condition.

In response to concerns surrounding the lots listed above, identified as being in a “cautionary” condition, the City suggested that TerraCosta proceed with the development of guidelines for berm restoration. In December 2006, TerraCosta completed a four-page plan set titled, “Coronado Cays Berm Reconstruction Guidelines.”

### [2006 Bathymetric Survey](#)

TerraCosta performed an additional bathymetric survey in late 2006 to update, in more detail, the elevation of the soil berms fronting the vertical concrete bulkheads, and to continue evaluating the stability of the bulkheads throughout the Coronado Cays. That survey, the results of which were reported in April 2007, included the following:

- A bathymetric survey was conducted in November 2006 using a Furuno Echo Sounder operating at a frequency of 50 kHz linked to real-time GPS data acquisition.
- Additional sheet-pile length measurements in areas previously classified as “cautionary” in the December 2006 report.
- Manual measurements of the berm elevation in shallow areas adjacent to the bulkhead walls that could not be effectively surveyed using traditional techniques.
- Field verification of the above three phases by means of a detailed level survey.

Data collected from the 2006 survey was also compiled into colored strip-chart figures similar to those prepared for our 2003 study. Based on the results of those surveys, areas reported as “cautionary” in our December 2006, Bulkhead and Berm Study were then considered to be reasonably safe. Note also that after conducting additional bulkhead length measurements along the south side of Green Turtle Road, the bulkheads on these lots were designated as part of Area B, as shown in Figure 3 of our August 2, 2021, Geotechnical Assessment of Bulkheads report.

## 2009 through 2014

### 2009 Bathymetric Survey

In 2009, TerraCosta completed bathymetric surveying utilizing several different methodologies that depended upon access to the specific survey areas. The surveying consisted of the following:

- Bathymetric sounding data collection occurred between July 1 and 3, 2009, during which approximately 18 miles of boat tracks provided the boat survey coverage, covering the entire Coronado Cays development.
- Manual survey data collection occurred during tidal lows on July 23 and 24, 2009.
- Berms having a top-of-berm elevation below -5 feet MSL, whether measured from the 2006 survey or the current survey, were manually resurveyed.

Data collected from the 2009 bathymetric survey was also compiled into colored strip-chart figures similar to those prepared for our 2003 and 2006 studies. At that time, it was determined that there were nine localized areas within the Coronado Cays totaling 227 feet in length that were designated as “cautionary.” Along with presentation of the bathymetric survey data, an additional graphic titled “Cautionary Areas” was produced to display the extent of the areas described above. The individual lots where bulkhead maintenance infill was required were 197, 198/199, and 205 Sandpiper Strand, 272, 277, 278, and 279 Green Turtle Road, and 411 Catspaw Cape.

In our report that accompanied the 2009 survey data, it was recommended that the berms in those areas be stabilized as recommended in the December 2006 “Coronado Cays Berm Reconstruction Guidelines.” Notably, at that time, there were no areas within the interior waterways of the Coronado Cays where there was significant risk of bulkhead failure (classified in our December 2006 report as “serious”) due to an insufficient berm geometry.

### 2012 Survey and Bulkhead Berm Maintenance

In 2012, additional bathymetric surveying was performed within the Coronado Cays development. That survey data was documented in a draft report titled, “Coronado Cays Bulkhead Berm Maintenance,” dated November 5, 2012. In that report, four isolated areas within the Antigua Court Village were identified as having berm elevations below an acceptable level that were considered “cautionary.” Those lots were 59, 69, and 73/75 Antigua Court, in addition to the bulkhead fronting the northwesterly common area.

## 2013 Channel Berm Stabilization and 2014 City Channel Berm Stabilization Plan Sets

In August 2013, TerraCosta completed a plan set titled, “Coronado Cays Channel Berm Stabilization,” which incorporated the 2009 and 2012 bathymetric survey data. The plan set was based upon the 2006 Berm Reconstruction Guidelines, and specifically addressed the six areas identified as “cautionary” in 2009, in addition to the four isolated areas within the Antigua Court Village in 2012. The proposed maintenance infill consisted of the placement of approximately 235 cubic yards of clean sand fill material.

Notably, of the ten discrete sites that required maintenance infill, five were within City jurisdiction, while the remaining areas were within the Unified Port of San Diego (Port) jurisdiction. The total proposed fill length within the Port’s jurisdiction was 95 feet, along which we proposed the placement of 77 yards of clean sand fill material.

In October 2014, a second plan set was produced that specifically addressed the five areas within the City’s jurisdiction, and excluded the areas of proposed maintenance infill within the Port’s jurisdiction.

## **2015 through 2018**

### Completion of Maintenance Infill within City Jurisdiction

In February 2015, work was completed in the Coronado Cays development to place maintenance infill on the berms within the City’s jurisdiction, as indicated in TerraCosta’s October 2014 plan set. Between 2012 and the commencement of work within the City’s jurisdiction, the City worked with the Port for more than a year to obtain approval for berm maintenance in those areas within the Port’s jurisdiction. However, the City was ultimately unsuccessful in obtaining approval from the Port and therefore moved forward with stabilization work only within the areas under their jurisdiction at that time.

### Antigua Court Bulkhead Geotechnical Assessment

In September 2015, TerraCosta performed a geotechnical reconnaissance of the bulkheads, specifically within the Antigua Court Village, to assess the overall condition and extent of any observed yielding or distress that may be related to bulkhead movement. That field work consisted of the following:

- Mapping, and photographic and written documentation of those areas that were observed to exhibit distress or were experiencing evidence of settlement and/or lost ground.
- Surface hand-probing to assess the general condition of fill soils behind the bulkheads to identify areas that would benefit from ground improvement.
- Performing a lead-line survey documenting berm elevations along the toe of the bulkheads.

In the report that accompanied the results of the field work completed within the Antigua Court Village, it was specifically noted that the areas within the Port’s jurisdiction that had been previously identified as requiring maintenance infill had yet to be addressed by the Port. Based



on TerraCosta's review of data collected during the 2012 bathymetric survey and the 2015 data collection, TerraCosta concluded that the two areas within the Port's jurisdiction were still in need of additional berm maintenance. It was also noted that the berms in areas within the City's jurisdiction that had received infill as indicated in TerraCosta's 2014 plan set had been raised significantly, and that the factor of safety of the bulkhead exceeded the original design criteria.

### Inventory and Inspection of Causeway Bulkheads

In December 2015, TerraCosta performed a geotechnical reconnaissance and underwater inspection and inventory of the bulkheads fronting all of the City-owned causeways within the Coronado Cays development to assess the overall condition and extent of any observed yielding or distress that might be related to bulkhead movement. That consisted of the following:

- Mapping, and photographic and written documentation of those areas that were observed to exhibit distress or exhibiting evidence of settlement and/or lost ground.
- An underwater inspection and inventory of the bulkheads was completed. Work included inspection of the bulkhead panels for separations of joints, cracking, and other damage, location of bulkhead penetrations, and evidence of soil piping and lost ground from behind the bulkhead.
- Performing a lead-line survey to document berm elevations along the toe of the bulkheads.
- Southwest Geophysics conducted a geophysical survey for the presence of significant voids and affected underground utilities. The survey was performed using ground penetrating radar (GPR) over readily accessible portions of the nine study areas. A report of the survey findings was included with TerraCosta's report that accompanied the results of the study.

### Coronado Cays Causeway Bulkhead Maintenance

In February 2018, TerraCosta completed a plan set titled, "Coronado Cays Causeway Bulkhead Maintenance," which detailed chemical grouting, crack repair, and spall repair notes and specifications specific to areas identified as problematic during the December 2015 field work.

### Inventory and Inspection of CCHOA-Owned and City-Owned Bulkheads

Between January and March 2016, TerraCosta performed a geotechnical reconnaissance and inventory of bulkheads fronting all CCHOA-owned lots and common areas within the Coronado Cays development, excluding bulkheads within the Antigua Court Village that had been recently surveyed in 2015, bulkheads fronting privately owned lots, and City-owned areas, including the causeways. Field work consisted of the following:

- A visual inspection and inventory of the bulkheads and surrounding areas for signs of settlement causing damage to the bulkheads or improvements supported by the bulkheads.
- Coordination with the CCHOA to help identify areas that had experienced previous sinkholes or settlement.
- Performing a lead-line survey that documented berm elevations along the toe of the bulkheads.



- Southwest Geophysics conducted a geophysical survey for the presence of significant voids and affected underground utilities within areas of interest identified during coordination with the City and the CCHOA. The survey was performed using ground penetrating radar (GPR) over readily accessible portions of the study areas. A report of the survey findings was included with TerraCosta's report that accompanied the results of the study.

After completion of the field work described above, TerraCosta completed five individual reports summarizing our findings, conclusions, and recommendations. Descriptions of voids, observed distress features, bulkhead penetrations, and areas where soil piping had been observed were provided. Reports were completed specific to Bahama Village, Trinidad Village, Kingston Village, Montego Village, and Jamaica Village.

In our reports, TerraCosta recommended that select wall panel joints be grouted with either a chemical or cementitious grout. Recommendations included injecting grout on the back sides of the walls to the full depth of the panels to prevent further ground loss and settlement due to soil piping through the panel joints. Additional recommendations pertained to areas where severe spalling and cracking had occurred and where temporary repairs (i.e., patching or epoxy injection) would prevent further intrusion of sea water and extend the life of the reinforced concrete panels.

At the time of the completion of the reports for the villages listed above, after comparing the 2009 bathymetric survey data to the recently collected 2016 lead-line survey data in selected areas, TerraCosta did not observe any evidence of an imminent bulkhead failure.

