

**ELEVATION CHANGES  
IN THE  
CITY OF LONG BEACH**

**NOVEMBER 2022 THROUGH NOVEMBER 2023**

**PREPARED**

**FOR**

**LONG BEACH CITY COUNCIL**

**BY THE**

**ENERGY RESOURCES DEPARTMENT**

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## **ELEVATION SURVEY ANALYSIS**

The City of Long Beach semi-annual elevation surveys of the Civic Center, Central City, Harbor District, Alamitos Bay, Naples, and offshore drilling islands were conducted during May 2023 and November 2023. Annual and semi-annual changes in elevation that have occurred since the prior survey of November 2022 are discussed in this report. The results in this report reflect elevation changes both within and beyond the influence of oil field operations, as some changes are due to natural geologic factors. All semi-annual and annual elevation changes described in this report are considered minor and are being closely monitored.

### **Elevation Change – November 2022 to May 2023**

**(Figure 1)**

Elevations in the Civic Center, Central City, Alamitos Bay, Naples, and the offshore islands were stable during the first six-month period.

Minor elevation changes were observed within and north of the Wilmington Oil Field in the Harbor District, along the shoreline, and adjacent to Shoreline Village. A minor elevation rise of as much as 0.070 foot (0.84 inch) was observed in the northwest end of the Wilmington Oil Field. A minor elevation rise of 0.083 foot (1.00 inch) was observed along the shoreline. A minor elevation loss of as much as 0.103 foot (1.24 inches) was observed around Shoreline Drive, adjacent to Shoreline Village.

The elevation changes observed in the Wilmington Oil Field in the first six-month survey period were considered minor; however, fluid injection volumes were closely monitored to mitigate further elevation changes into the next second six-month survey period.

Minor elevation changes were observed outside of the Wilmington Oil Field operated area, west of the Los Angeles River and south of the Colorado Lagoon.

### **Elevation Change – May 2023 to November 2023**

**(Figure 2)**

Elevations in the Civic Center, Central City, Alamos Bay, Naples, the offshore islands, and the shoreline were stable during the second six-month period.

Minor elevation changes were observed within the Wilmington Oil Field in the Harbor District and Shoreline Village. An elevation loss of as much as 0.076 foot (0.91 inch) was observed throughout portions of Pier A, Pier A West, Pier B, and Terminal Island. This minor elevation loss was expected due to controlled changes in fluid injection volume. Additionally, an elevation loss of 0.051 foot (0.61 inch) was observed on the Navy Mole. The elevation loss observed in Shoreline Village during the first six-month survey period reversed in the second six-month survey period, resulting in an elevation rise of as much as 0.075 foot (0.90 inch).

A minor elevation rise of 0.064 foot (0.77 inch) was observed outside of the Wilmington Oil Field operated area in the vicinity of the East Willow Street, within the Long Beach Oil Field.

### **Elevation Change – November 2022 to November 2023**

**(Figure 3)**

Elevations in Civic Center, Alamos Bay, Naples, and offshore drilling islands were stable during the twelve-month period.

Minor elevation changes were observed within the Wilmington Oil Field in the Harbor District, the Central City and along the shoreline. An elevation loss of as much as 0.092 foot (1.10 inches) was observed in the Harbor District in Pier A, Pier A West, and Terminal Island. This minor loss occurred during the second six-month survey period as described in the previous section. Elevation losses of as much as 0.060 foot (0.72 inch) were observed in the southeast corner of Pier H, the marina mole, northeast Shoreline Drive, and Central City.

Minor elevation losses of as much as 0.076 (0.91 inch) were observed north of the Wilmington Oil Field operated area. An elevation rise of 0.059 foot (0.71 inch) was observed north of the Seal Beach Oil Field, adjacent to the San Gabriel River.

### **Use of Global Positioning System (GPS)**

This report is based solely upon computer processed data utilizing the City of Long Beach Real Time Network (CLBRTN). The CLBRTN consists of 15 permanent reference GPS base stations, communication equipment, computer server, monitoring software and five mobile GPS receivers. The Long Beach Energy Resources surveyors and contract surveyors use the mobile GPS receivers linked to the reference base stations to measure approximately 250 City and Harbor bench marks.

## **APPENDIX**

### **Brief History of Long Beach Subsidence**

Long Beach and the general vicinity have a history of regional subsidence (loss of elevation) since 1929. Elevation changes were minor, amounting to an average of about -0.036 foot (-0.43 inch) per year until about 1939. Geologic movement, such as the Long Beach Earthquake of March 1933, altered this average rate at times. Contributing causes of the subsidence include: groundwater withdrawal from aquifers in the Long Beach area, regional basin sediment compaction, and tectonic effects of local faulting.

Development of the Wilmington Oil Field began in 1936. Oil operations accelerated subsidence and within twenty years, created a 29-foot deep subsidence bowl centered in the Wilmington-Long Beach Harbor area near Bench Mark 8772, at the Edison power plant. Development of the Ranger zone, west of Pine Avenue and its extension seaward in 1947 started the first definitive subsidence in the Central Business District that could be attributed to oil production.

Repressuring operations began in the 1950s. By 1965, subsidence stopped throughout the Long Beach portion of the Wilmington Oil Field. Several bench marks recovered over one foot in elevation, due to waterflood repressuring. As an example, from 1960 to 1970, Bench Mark 1735, near the corner of Ocean Boulevard and Magnolia Avenue, recovered approximately one foot of elevation. The recovery of bench mark elevations is known as rebound.

The Alamitos Bay and Naples area had losses in elevation prior to development of the adjacent oil operations. These original small losses were most likely due to the regional effects of basin sediment compaction and tectonic movements along the Newport-Inglewood Fault zone. Later, the coastal strip from the Civic Center eastward to the Alamitos Bay Peninsula lost elevation due to oil and gas production from the West Wilmington Oil Field and possibly the adjacent oil fields. The coastal strip rebounded slightly due to water injection from the offshore Oil Islands that began in 1965.

## **Survey Accuracy**

The May 2002 Elevation Leveling Campaign marked the conversion from spirit, first and second order rod leveling, to GPS surveying of bench mark elevations.

Through statistical analysis of satellite, base station, and mobile instrument geometries, a coincident spirit leveling and GPS bench mark elevation survey, City surveyors estimate the relative accuracy of GPS elevations to be 8 to 10 millimeters (0.025 foot or 0.30 inch). Areas are considered to be stable where elevation change is less than 0.050 foot (0.60 inch) over a six-month survey period.

Studies by the City's subsidence control engineers, geologists, and consultants show that the bench marks may, at times, rise and fall somewhat concurrently city wide in such a manner as to make an entire survey either optimistic or pessimistic. These elevation changes are random and can be due to a variety of factors. Repressuring operations and the resulting rebound can mask the rise or fall pattern. Surface elevations in a rebounded area can be expected to fluctuate under changing waterflood conditions. Because of these fluctuations, conclusions based upon short-term survey data should be viewed with caution. Short-term survey data are useful for possible early detection and confirmation of subsidence trends or relative elevation changes but should not be accepted without consideration of the above factors. Annual survey data tend to average these fluctuations and depict a more dependable picture of the relative movements of bench marks.

## **Elevation Change Map Construction**

**(Figures 1, 2 and 3)**

All data are presented as contour lines showing the average change in surface elevation during a particular time period. For example, any point along a line reading 0.050 foot (0.60 inch) on an Elevation Change Map is presumed to have gained an elevation of one-twentieth of a foot or six-tenth of an inch during that period. The small hachures along contour lines point towards a loss in elevation.







