



September 3, 2013

HONORABLE MAYOR AND CITY COUNCIL  
City of Long Beach  
California**RECOMMENDATION:**

Receive and file the attached report, "Elevation Changes in the City of Long Beach, November 2012 through April 2013." (Citywide)

**DISCUSSION**

The City of Long Beach, through the Long Beach Gas and Oil Department (LBGO), supervises oil production and subsidence control operations in the Wilmington Oil Field. LBGO conducts elevation surveys every six months to monitor elevation changes in the oil fields and adjacent city areas. This report focuses on elevation changes that have occurred from November 2012 through April 2013. The LBGO survey includes the following areas: Civic Center, Central City, Alamitos Bay, Naples, Harbor District, and an offshore area encompassing the four oil islands.

The results of the six-month survey show that elevations were stable in the Civic Center, Central City, Alamitos Bay, Naples, and the offshore drilling islands. In the Harbor District, Pier A declined up to 0.08 foot (1.0 inch). A mitigation plan, based on adjustments of oil field operations, has been implemented and the areas will be closely monitored for further action. Piers C, E and H were stable during the past six months, while elevations on Piers D and T rose up to 0.06 foot (0.7 inches). The elevation change is within normal limits and not expected to continue.

The LBGO survey uses a series of benchmarks to determine elevation changes. Studies by the Department's engineers and geologists show that the benchmarks may rise and fall in such a manner as to make a survey either optimistic (slightly up in elevation) or pessimistic (slightly down in elevation). These changes in elevations may be associated with tidal cycles, temperature changes, and/or deep earth tectonic changes or re-pressuring operations. Surface elevations in a rebounded area can be expected to fluctuate under changing water flood conditions.

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September 3, 2013  
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This matter was reviewed by Deputy City Attorney Richard Anthony and by Budget Management Officer Victoria Bell on August 1, 2013.

TIMING CONSIDERATIONS

City Council action on this matter is not time critical.

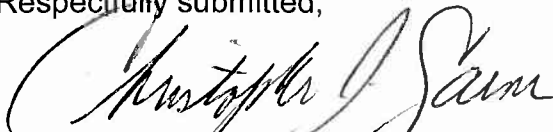
FISCAL IMPACT

There is no fiscal impact or local job impact associated with this action.

SUGGESTED ACTION:

Approve recommendation.

Respectfully submitted,



CHRISTOPHER J. GARNER  
DIRECTOR OF LONG BEACH GAS AND OIL

CJG:JJ

Attachment

APPROVED:

  
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PATRICK H. WEST  
CITY MANAGER

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

**NOVEMBER 2012 THROUGH APRIL 2013**

**PREPARED**

**FOR**

**LONG BEACH CITY COUNCIL**

**BY THE**

**LONG BEACH GAS AND OIL  
DEPARTMENT**

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## ELEVATION SURVEY ANALYSIS

The City of Long Beach semi-annual elevation survey of the Civic Center, Central City, Harbor District, Alamitos Bay, Naples, and offshore drilling islands was conducted during May 2013. Changes in elevation that have occurred since the last two surveys, November 2012 and May 2012, are discussed in this report. The results in this report reflect elevation changes both within and beyond the scope of oilfield operations. Some changes are due to natural geologic factors.

### **Elevation Change – November 2012 through April 2013 (Figure 1)**

Elevations throughout the Alamitos Bay, Naples, the Civic Center and offshore drilling islands were stable during the six-month period.

In the Harbor District, Pier A declined up to 0.08 foot (1.0 inch). Active oilfield development in the area may have contributed to the decline. A mitigation plan, based on adjustments of oil field operations, has been implemented and the area will be closely monitored for further action. The rate of decline is not expected to continue. Piers D and T showed a rise in elevation of up to 0.06 foot (0.7 inches) during the period. The increase is within normal limits for the area. Piers C, E and H were stable during the period. The decline observed during the November 2012 survey did not continue.

Elevations in the City of Long Beach beyond the boundaries of the Wilmington Oil Field were up during the six month period.

## **Elevation Change – May 2012 through April 2013 (Figure 2)**

Elevations in the Alamos Bay, Naples and offshore drilling islands remained stable during the twelve month period. Elevations in the western portion of the Central City decreased by 0.05 foot (0.6 inch). The elevation change was relatively minor.

In the Harbor District, Piers A, S and the northern portion of Pier B experienced an elevation decrease of up to 0.11 foot (1.3 inches) during the twelve month period. A mitigation plan, based on adjustments of oil field operations, has been implemented and the area will be closely monitored for further action. A recent increase in the number of water injection wells is expected to reduce the rate of elevation decline. Piers D and the eastern portion of Pier T rose by as much as 0.16 foot (1.9 inch) during the 12-month period. The elevation increase was believed to have resulted from a realignment of waterflood activities in the area. The area will be closely monitored for continued elevation gain and mitigation measures implemented if the gain continues. Elevations on Piers C and E declined up to 0.07 foot (0.8 inches) during the twelve month period, most of the loss being observed in the previous six months. The abandonment and replacement of numerous wells due to the Gerald Desmond Bridge project is believed to have been a factor. Mitigation measures implemented in the first six months of the period successfully halted continued elevation decline in the second half of the period. The area continues to be closely monitored for elevation changes.

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

This report is based solely upon computer processed data utilizing the Long Beach Deformation Network (LBDN). The LBDN consists of thirteen permanent, reference GPS base stations, communication equipment, computer server, monitoring software and five mobile GPS receivers. The Public Works Department's Bureau of Engineering surveyors utilize the mobile GPS receivers linked to the reference base stations to measure approximately 240 City and Harbor bench marks.

## APPENDIX

### Brief History of Long Beach Subsidence

Long Beach and the general vicinity have a history of regional subsidence (losses 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 were 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 1932. Oil operations accelerated subsidence and 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 affects 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.

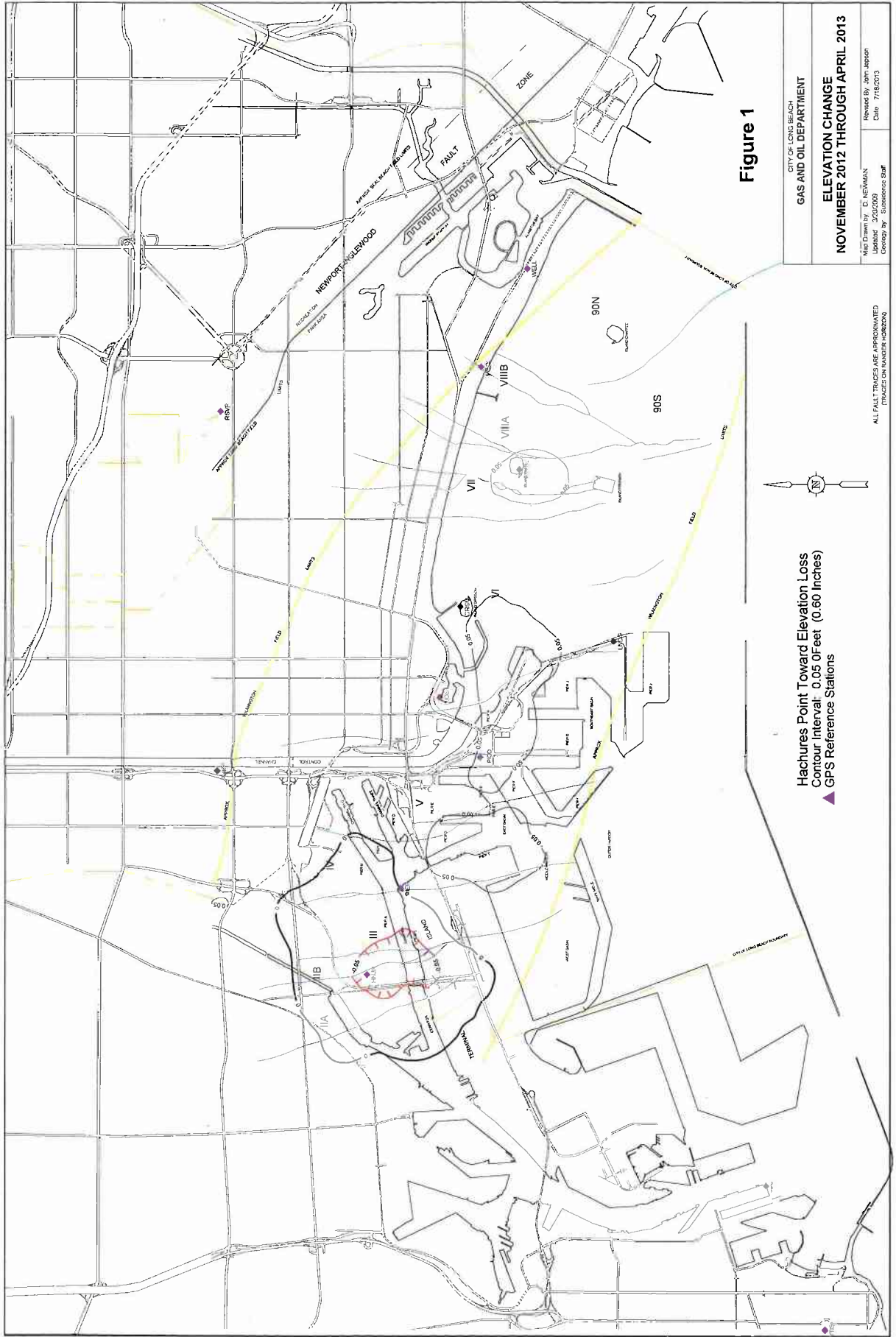
Through statistical analysis of satellite, base station, mobile instrument geometries, a coincident spirit leveling and GPS bench mark elevation survey, City surveyors estimate the accuracy of GPS elevations to be 8 to 10 millimeters (0.025 foot or 0.30 inch). Areas are considered to be stable where 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 not well understood. 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 water flood 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 and 2)**

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 0.05 foot (0.60 inch) on an Elevation Change Map 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.

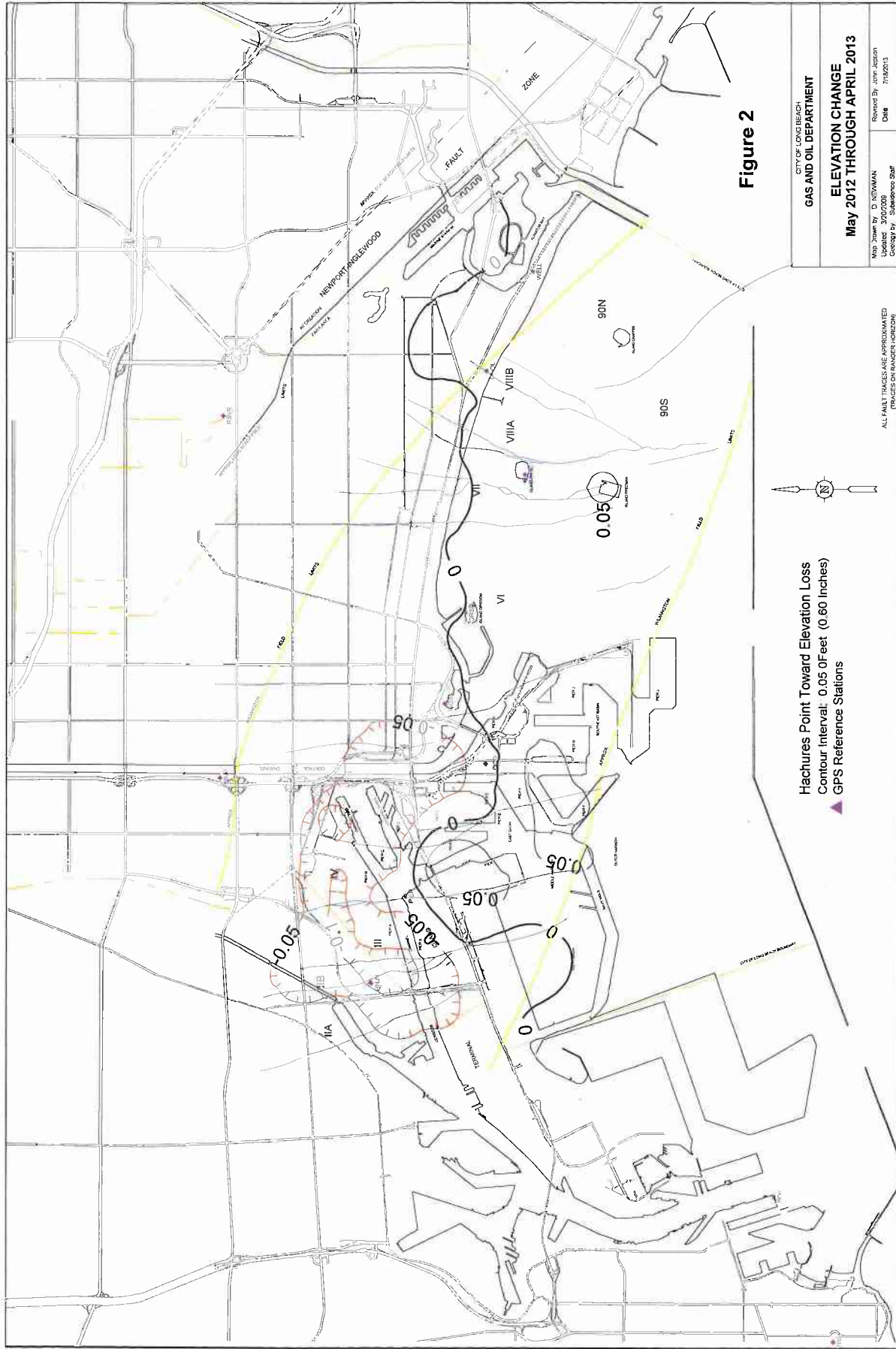


**Figure 1**

CITY OF LONG BEACH  
 GAS AND OIL DEPARTMENT  
**ELEVATION CHANGE**  
**NOVEMBER 2012 THROUGH APRIL 2013**

Map Drawn by: D. NEWMAN  
 Updated: 2/20/2013  
 Checked by: J. J. J. J.  
 Date: 7/18/2013

ALL FAULT TRACES ARE APPROXIMATED  
 FROM STATE ARCHIVE RECORDS



Hachures Point Toward Elevation Loss  
 Contour Interval: 0.05 0feet (0.60 inches)  
 ▲ GPS Reference Stations



ALL FAULT TRACES ARE APPROXIMATED  
 (PROJECTS ON HATCHERS POINT)

Figure 2

CITY OF LONG BEACH GAS AND OIL DEPARTMENT	
ELEVATION CHANGE May 2012 THROUGH APRIL 2013	
Map Drawn By: D. NOVAKIAN	Reviewed By: John Jackson
Updated: 3/20/2009	Date: 7/18/2013
Created by: Subcontract Staff	