



DEPARTMENT

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September 2, 2014

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 2013 through April 2014." (Citywide)

**DISCUSSION**

The City of Long Beach, through the Long Beach Gas and Oil Department (LBGO), oversees 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 2013 through April 2014. The LBGO survey includes the following areas: Civic Center, Central City, Alamitos Bay, Naples, Harbor District, and the 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, Harbor District, and the offshore areas.

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 over the active Wilmington Oil Field can be expected to fluctuate under changing water flood conditions.

This matter was reviewed by Deputy City Attorney Richard Anthony on July 31, 2014 and by Budget Management Officer Victoria Bell on August 1, 2014.

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TIMING CONSIDERATIONS

City Council action on this matter is not time critical.

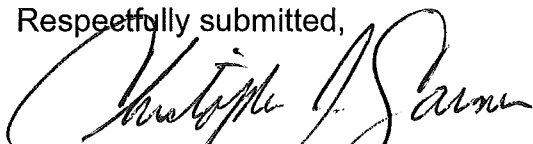
FISCAL IMPACT

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:KT

Attachment

APPROVED:

  
\_\_\_\_\_  
PATRICK H. WEST  
CITY MANAGER

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

**NOVEMBER 2013 THROUGH APRIL 2014**

**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 2014. Changes in elevation that have occurred since the last two surveys, November 2013 and May 2013, 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 2013 through April 2014** (Figure 1)

Elevations throughout the Alamitos Bay, Naples, the Civic Center and offshore drilling islands were stable during the six-month period. The Harbor District was also stable during the period. Elevation decreases observed in 2013 surveys did not continue. The increased number of injection wells in the Harbor District appears to have mitigated the observed downward effects in the previous year's surveys.

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 2013 through April 2014**

**(Figure 2)**

Elevations in the Civic Center, Central City, Alamitos Bay, Naples, and offshore drilling islands remained stable during the twelve month period.

The Harbor District was stable during the period, except for small portions of Piers C, E, F, and S. Elevations on Pier C increased by as much as 0.06 foot (0.7 inch). The increase was believed to have resulted from increased injection volumes in the area. Overall, elevations on Pier E and F declined up to 0.07 foot (0.8 inches) overall in some isolated areas during the twelve month period. However, mitigation measures implemented immediately after the May 2013 survey appeared to have adequately addressed the decline trend.

## **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.

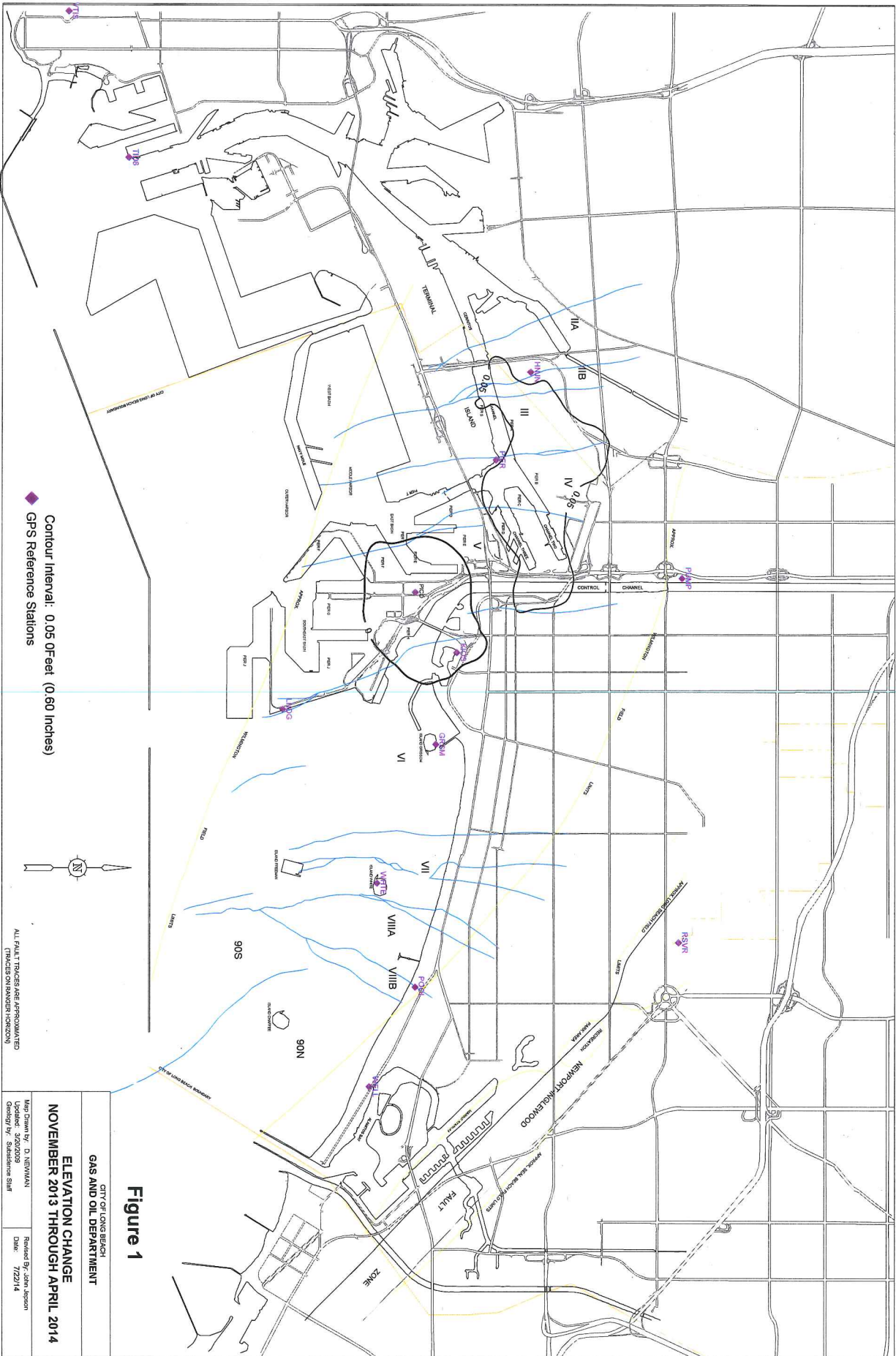
Through statistical analysis of satellite, base station, mobile instrument geometries, a coincident spirit leveling and GPS bench mark elevation survey, City surveyors estimate the relative accuracy of GPS elevations to be 8 to 10 millimeters (0.025 foot or 0.30 inch). Areas are considered to be stable 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 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.



Contour Interval: 0.05 Feet (0.50 inches)  
 ◆ GPS Reference Stations



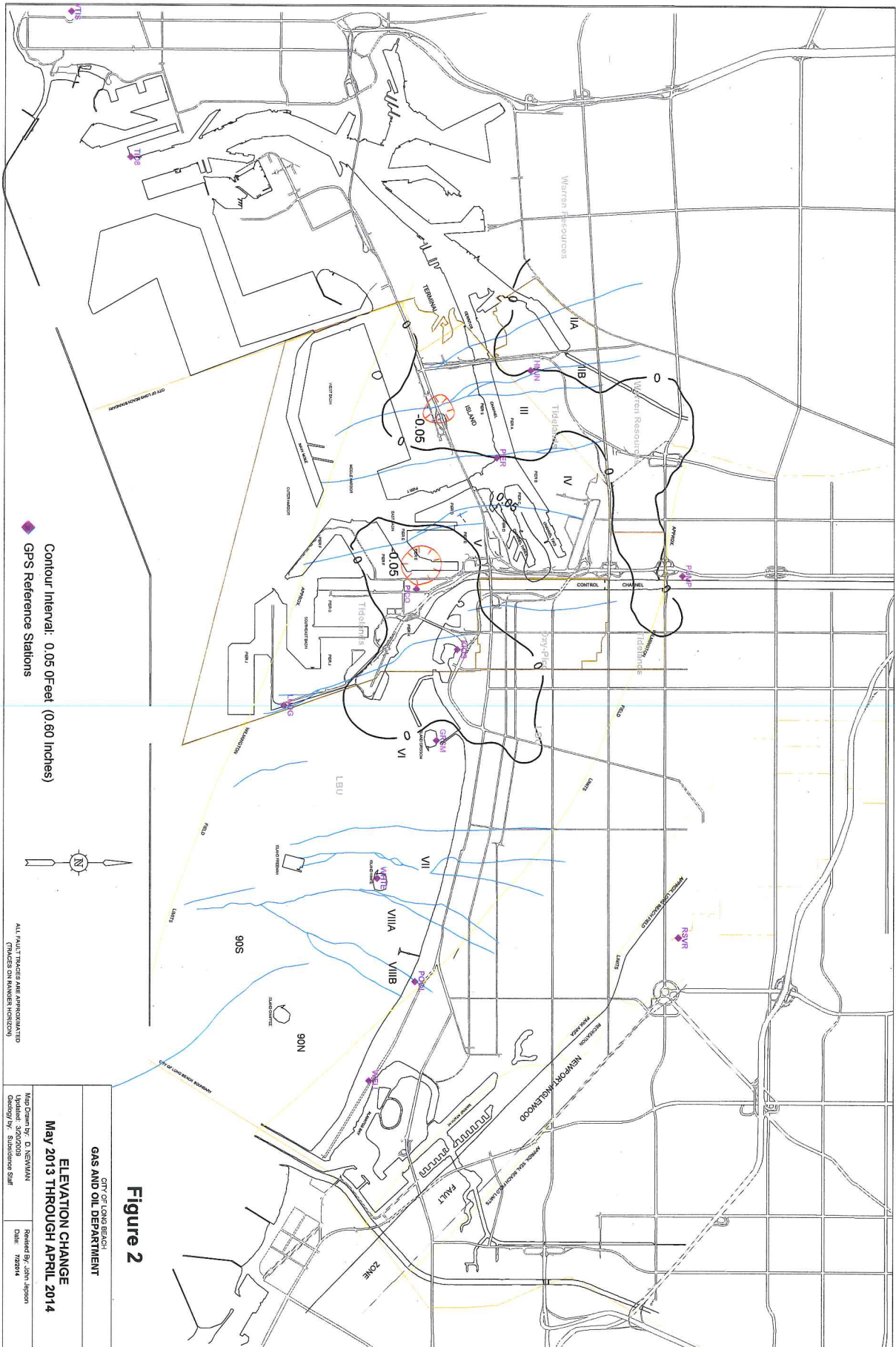
ALL FAULT TRACES ARE APPROXIMATE  
 (TRACES ON VARIOUS HORIZONS)

**Figure 1**

CITY OF LONG BEACH  
 GAS AND OIL DEPARTMENT

**ELEVATION CHANGE  
 NOVEMBER 2013 THROUGH APRIL 2014**

Map Drawn by: D. NEWMAN	Reviewed by: John Jackson
Checked by: Subdivision Staff	Date: 7/22/14



**Figure 2**

CITY OF LONG BEACH  
 GAS AND OIL DEPARTMENT

**ELEVATION CHANGE**  
 May 2013 THROUGH APRIL 2014

Map Drawn by: D. TERMAN  
 Checked by: John Johnson  
 Date: 12/2014

ALL PAVEMENT TRACERS ARE APPROXIMATED  
 (TRACERS ON NUMBER INDICATING)

Contour Interval: 0.05 Of Feet (0.80 Inches)  
 GPS Reference Stations