

# Air Quality in Newport Beach

Field Measurements of Ambient Particulates and  
Associated Trace Elements and Hydrocarbons

Karleen A. Boyle, Ph.D.

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Environmental & Regulatory Specialists, Inc.  
Newport Beach, CA  
949-646-8958  
Mobile: 202-270-6979  
kboylesudol@verizon.net

# Study Objectives

- To measure concentrations of particulate pollutants in the air at several locations in Newport Beach
- To characterize the chemical composition of the airborne particles collected
- To determine whether chemical profiles of particles from different sources are distinct

# Why focus on particulates?

- Resident complaints of “soot” from airport
- Potential to adversely impact human health
- Considered a priority pollutant by EPA
- Regulated under the Clean Air Act

# Properties of atmospheric particles

|  | PM <sub>2.5</sub>                                      |                                   | PM <sub>10</sub>            |
|--|--|-----------------------------------|-----------------------------|
| <b>Particle Name</b>                           | <b>Ultrafine particles (UFP)</b>                       | <b>Fine particles</b>             | <b>Coarse particles</b>     |
| <b>Particle Size (aerodynamic diameter)</b>    | Below 0.1µm  | Between 0.1µm – 2.5 µm            | Between 2.5 µm-10µm         |
| <b>Example</b>                                 | Viral cells  | 1/30 the diameter of a human hair | Dust or soot (black carbon) |
| <b>Example of source</b>                       | Jet engine exhaust                                     | Diesel engine exhaust             | Windblown dust              |
| <b>Atmospheric residence time</b>              | minutes to hours (before growing to fine size class)→→ | days to weeks                     | minutes to days             |
| <b>Potential transport distance</b>            | 10 miles (before converting to fine size class) →→     | thousands of miles                | Around 10 miles             |
| <b>Penetration of human respiratory system</b> | Alveoli of lungs                                       |                                   | Nasal passages              |

# Sources of Urban PM

- Passenger vehicles
- Heavy duty diesel vehicles
- Tire and brake wear
- Construction activities
- Charbroilers/ Wood smoke
- Incinerators
- Boilers
- Stationary power turbines

# Airport-associated PM sources

- Aircraft engines
- Ground support equipment (GSE) – often diesel
- Aircraft auxiliary power units (APUs)
- Aircraft tire and brake wear
- Emergency generators
- Airport ground transport
- Fuel storage tanks

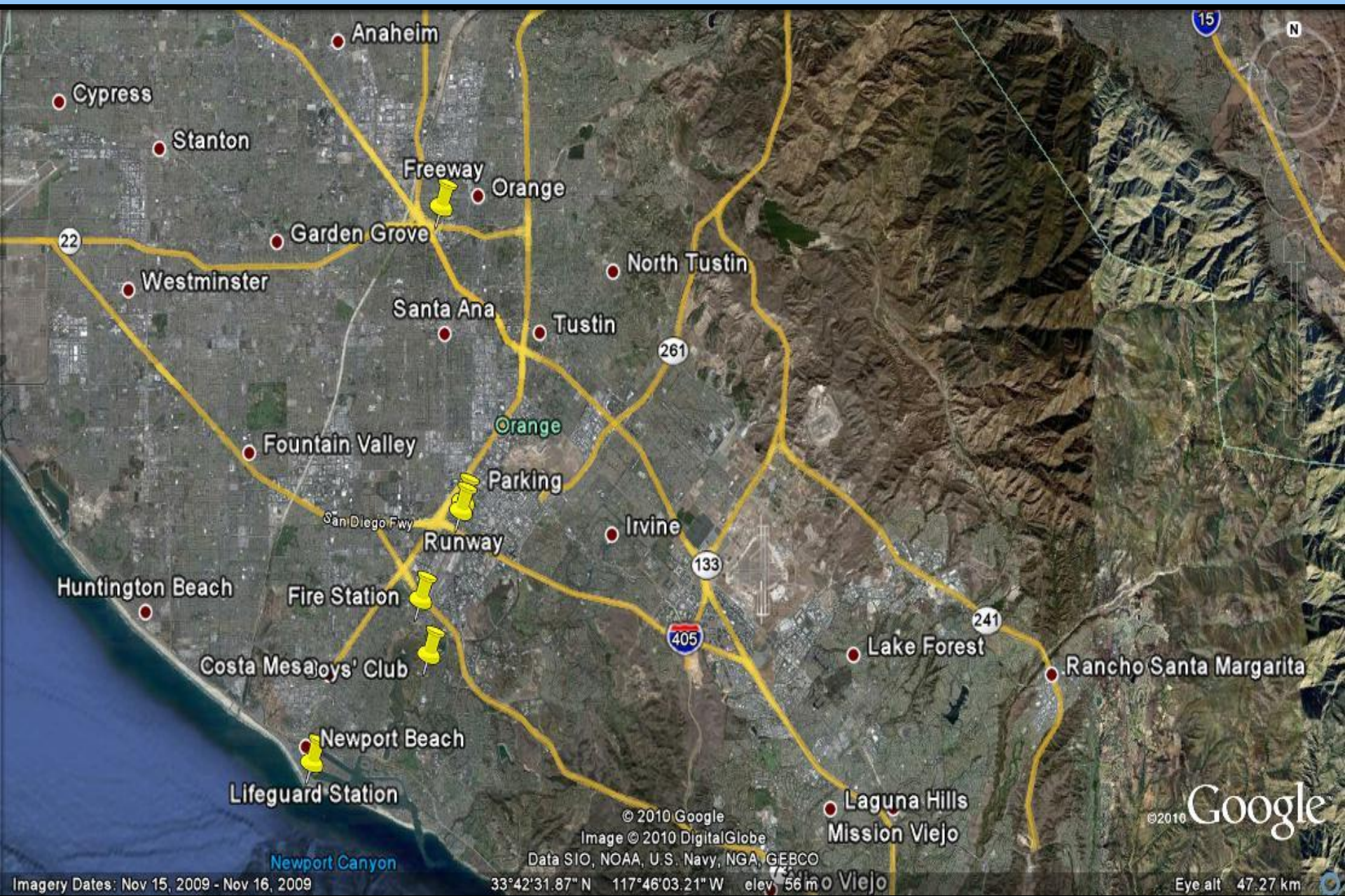
# JWA emission control practices

- Low emission electric vehicles and GSE on commercial ramp
- Ground-based electrical power in place of jet-fueled APUs
- Fleet vehicles and taxi provider required to use cleaner-burning fuel (compressed natural gas)
- Electric charging stations for ground service equipment and airport vehicles

# Study Design

- Field measurements of ambient PM<sub>2.5</sub> at 6 field locations at different proximity to JWA and various freeways
- Concentrations of particle-associated metals, trace elements and hydrocarbons were measured
- Chemical profiles of locations were compared to test whether different emission sources were distinct





Anaheim

Cypress

Stanton

Freeway

Orange

Garden Grove

22

Westminster

North Tustin

Santa Ana

Tustin

261

Fountain Valley

Orange

Parking

Irvine

Runway

San Diego Fwy

133

Huntington Beach

Fire Station

405

241

Costa Mesa Boys' Club

Lake Forest

Rancho Santa Margarita

Newport Beach

Lifeguard Station

Laguna Hills

Mission Viejo

Google

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Image © 2010 DigitalGlobe

Data SIO, NOAA, U.S. Navy, NGA, GEBCO

33°42'31.87" N 117°46'03.21" W elev. 56 m o Viejo

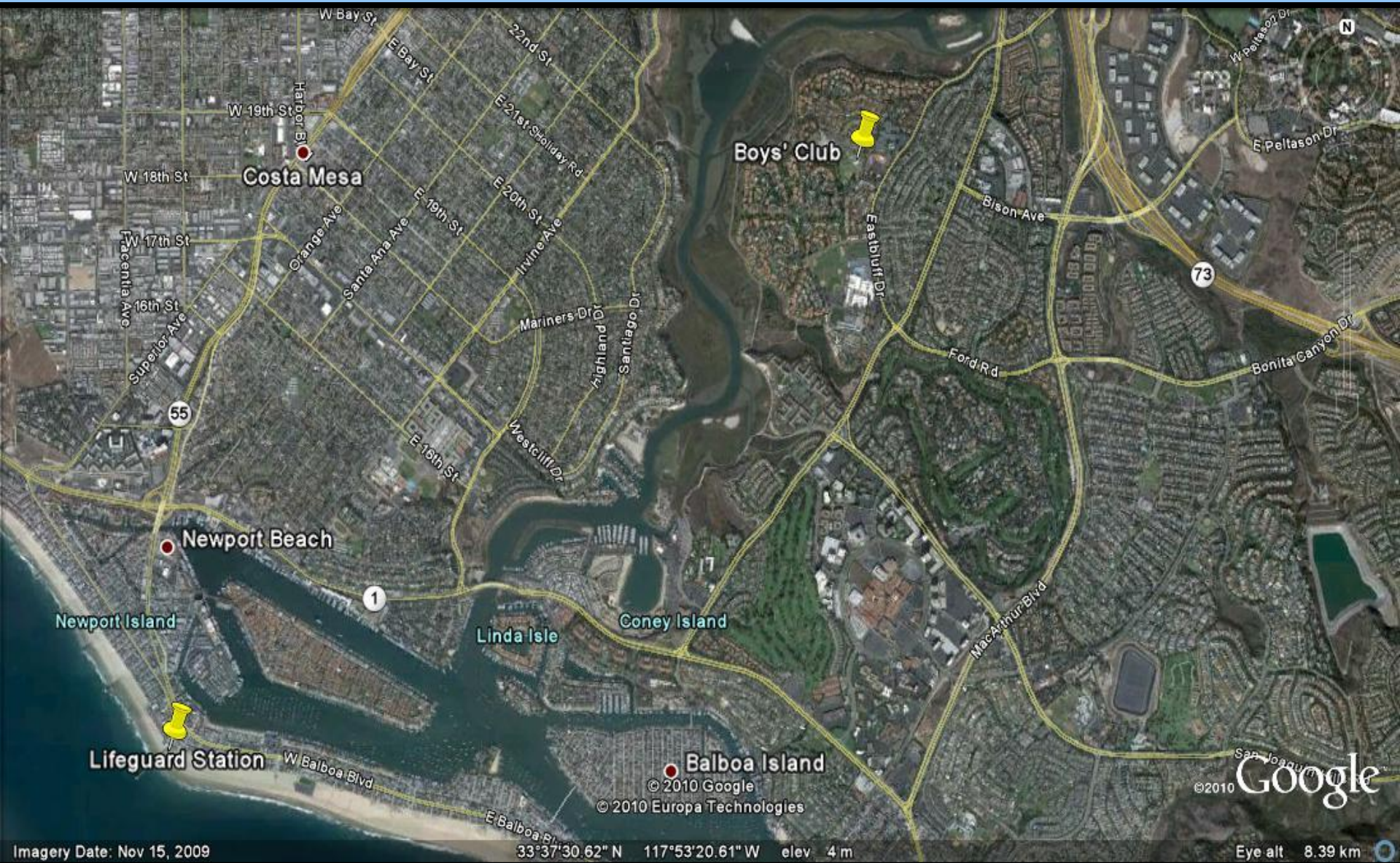
©2010

Eye alt 47.27 km

Imagery Dates: Nov 15, 2009 - Nov 16, 2009

Newport Canyon





Costa Mesa

Boys' Club

Newport Beach

Lifeguard Station

Balboa Island

Google

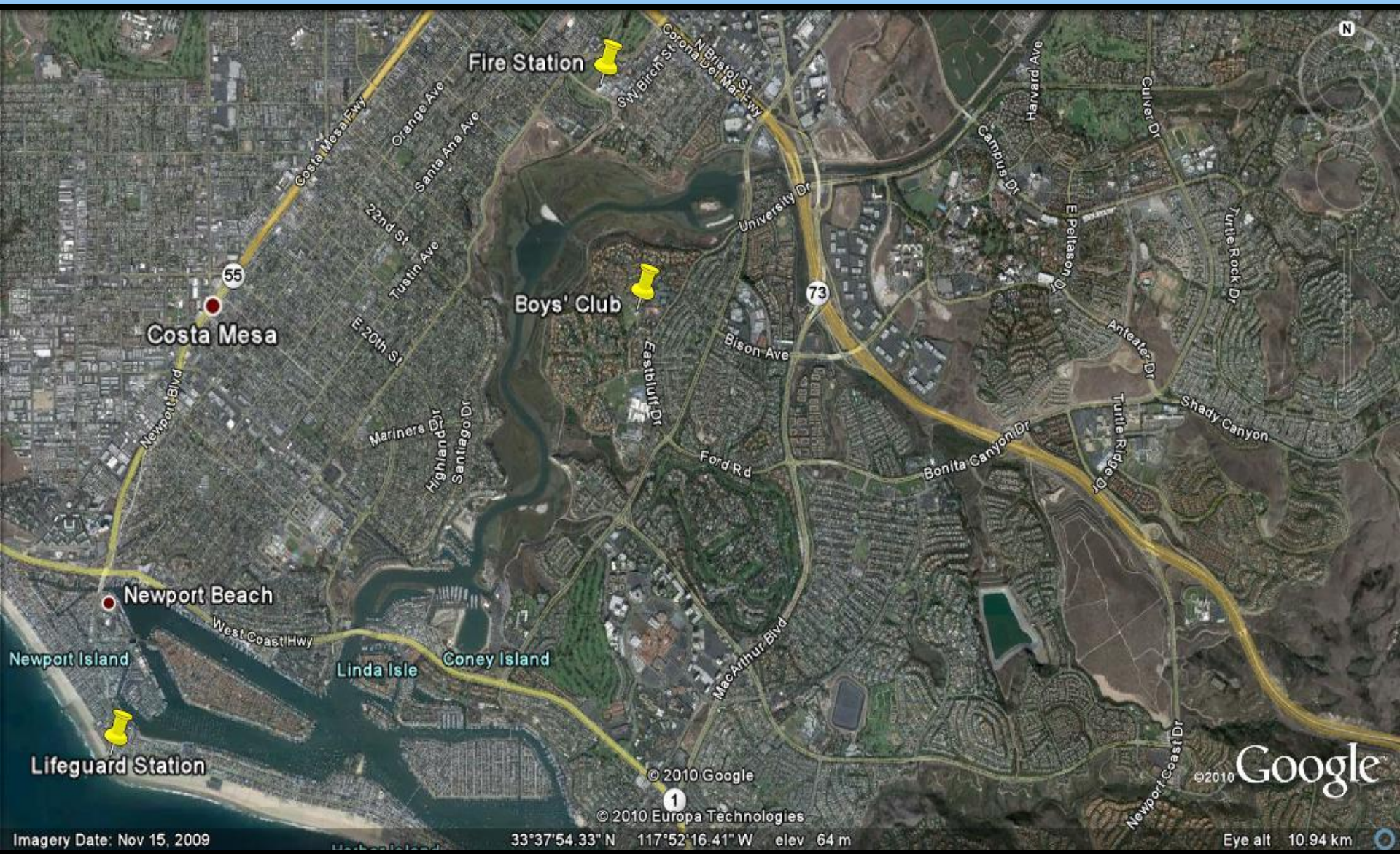
Imagery Date: Nov 15, 2009

33°37'30.62" N 117°53'20.61" W elev 4 m

Eye alt 8.39 km



# Stations upwind of JWA



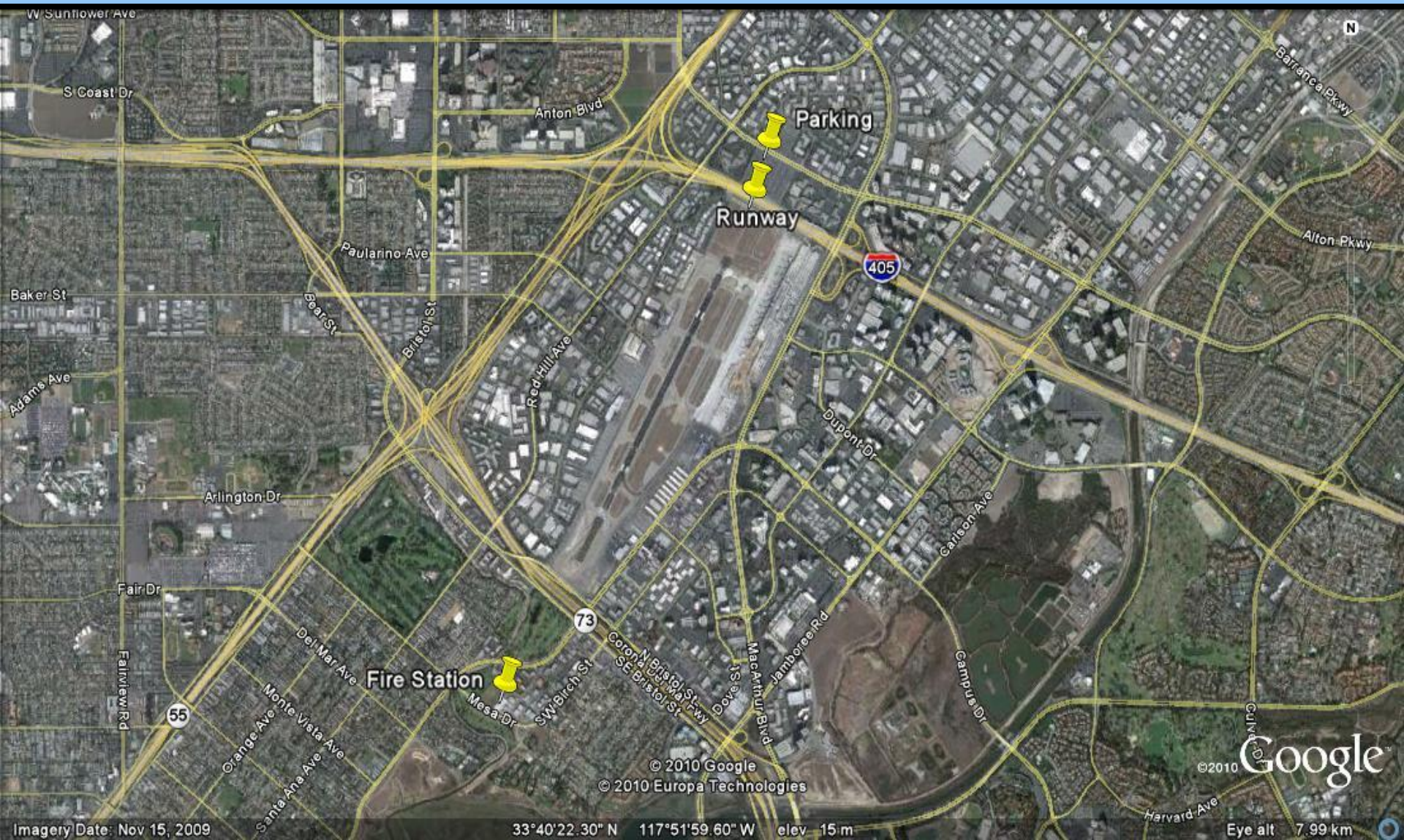
Imagery Date: Nov 15, 2009

© 2010 Google  
© 2010 Europa Technologies  
33°37'54.33" N 117°52'16.41" W elev 64 m

Eye alt 10.94 km

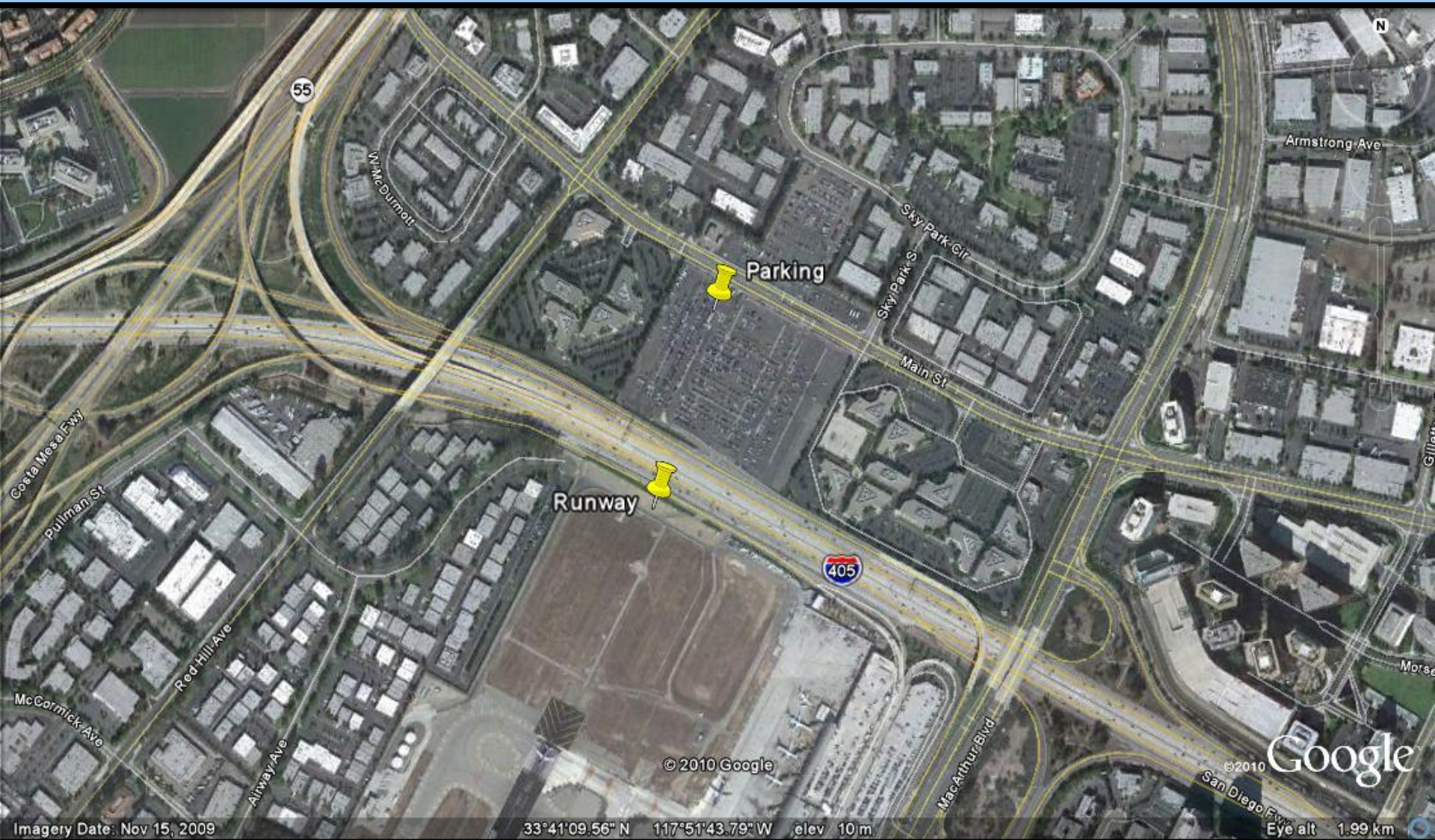


# Runway and adjacent stations



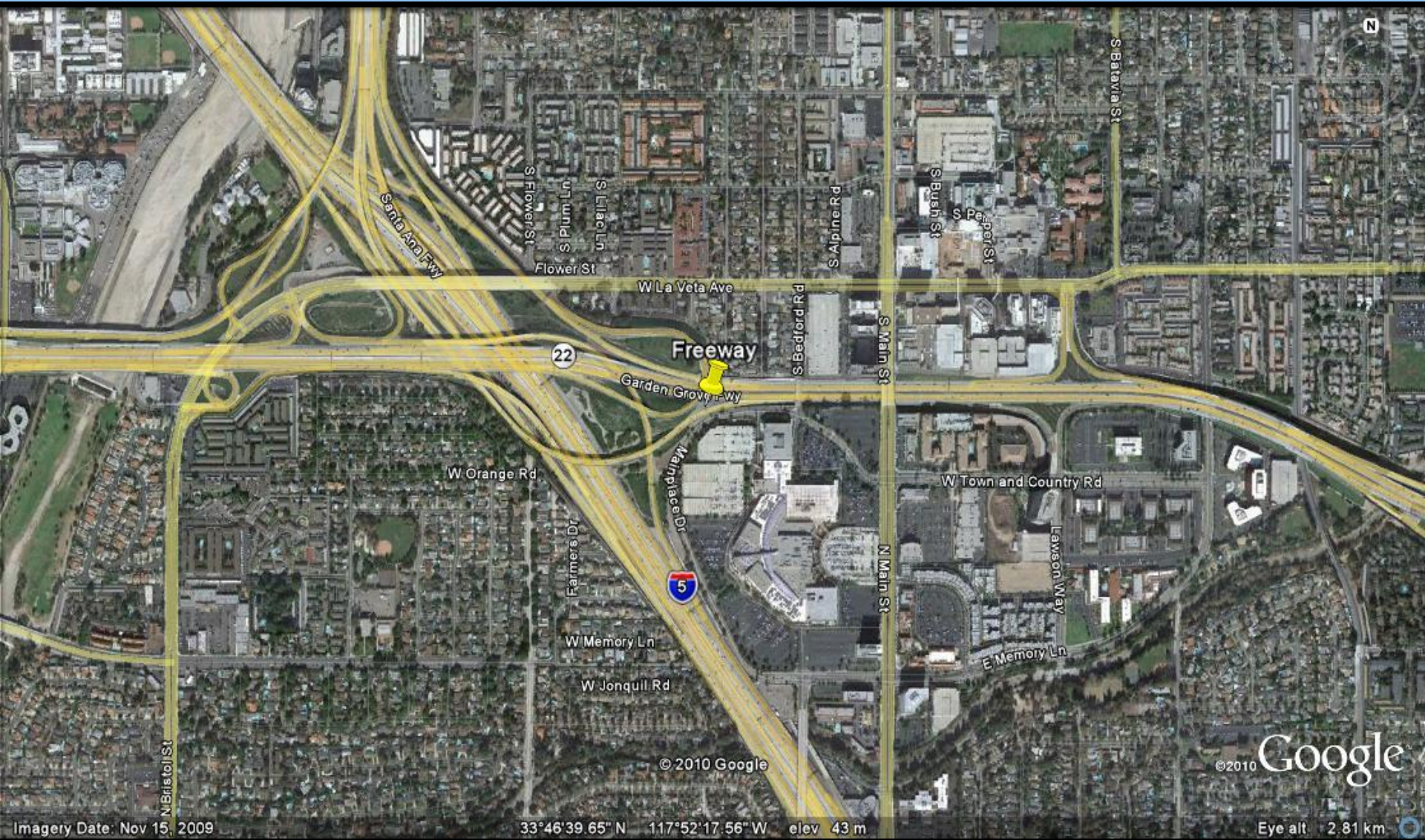


# Runway and parking stations



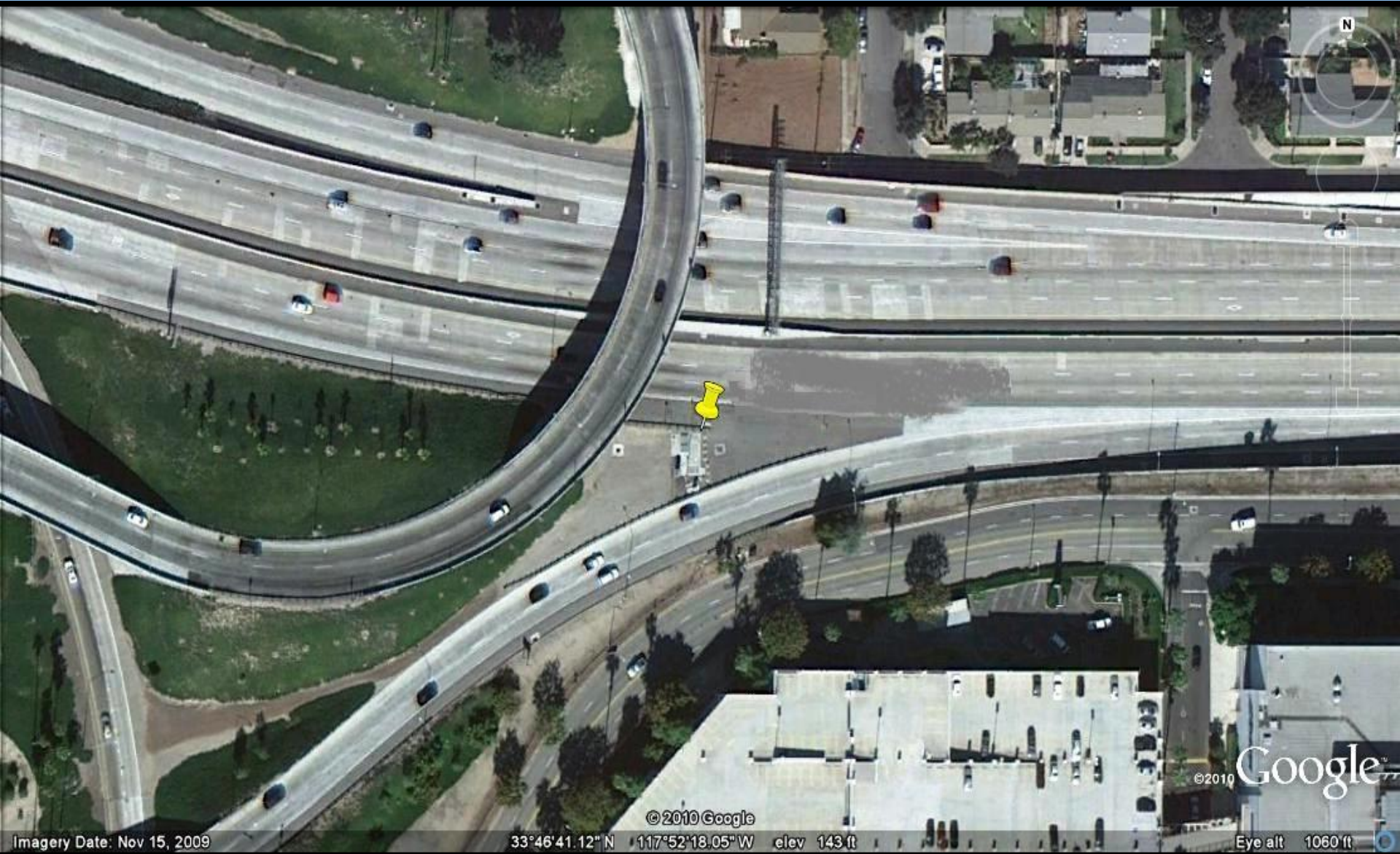


# Freeway comparison station





# Freeway site detail



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Imagery Date: Nov 15, 2009

33°46'41.12" N 117°52'18.05" W elev 143 ft

Eye alt 1060 ft

# Study Methods

- Three samples were taken at each location
- Collected on 5 days between 8/3/09 and 8/19/09
- Sampling periods chosen to capture morning and evening freeway rush hours and periods of active flight operations at JWA
- Sampling hours: 0630-2300
- Total of 16.5 hours per sample
- Sampling periods ended before early morning hours to avoid brief periods of offshore flow



# Data collected

- Concentrations of particles  $2.5\mu\text{m}$  in diameter and smaller ( $\text{PM}_{2.5}$ )
- Concentrations of particle-associated trace elements and metals
- Concentrations of particle-associated polycyclic aromatic hydrocarbons (PAHs)
- Simultaneous  $\text{PM}_{2.5}$  and  $\text{PM}_{10}$  collection at Freeway, Parking and Runway

# Air sampling equipment

- **For inorganics and gravimetric mass:** Paired Airmetrics Minivol air samplers with 1 teflon and 1 quartz filter
- Teflon filter analyzed for inorganics using X-ray Fluorescence
- Quartz filter analyzed for organic and elemental carbon using thermal/optical reflectance and transmittance (TOR/TOT) method
- **For PAHs:** Fine Particulate/Semi-Volatile Organic Compound (FPSVOC) sampling system

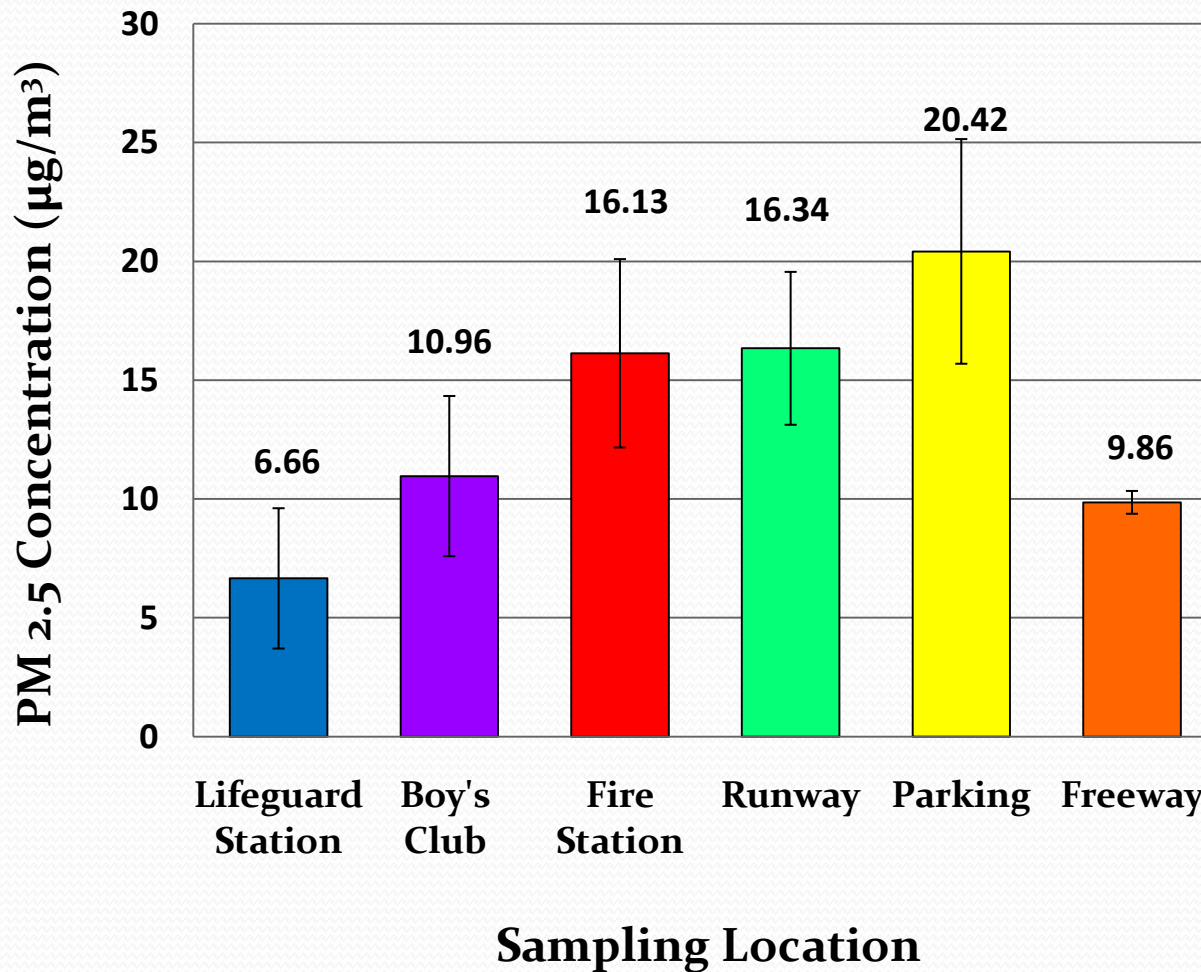
# Air sampling array



# Results

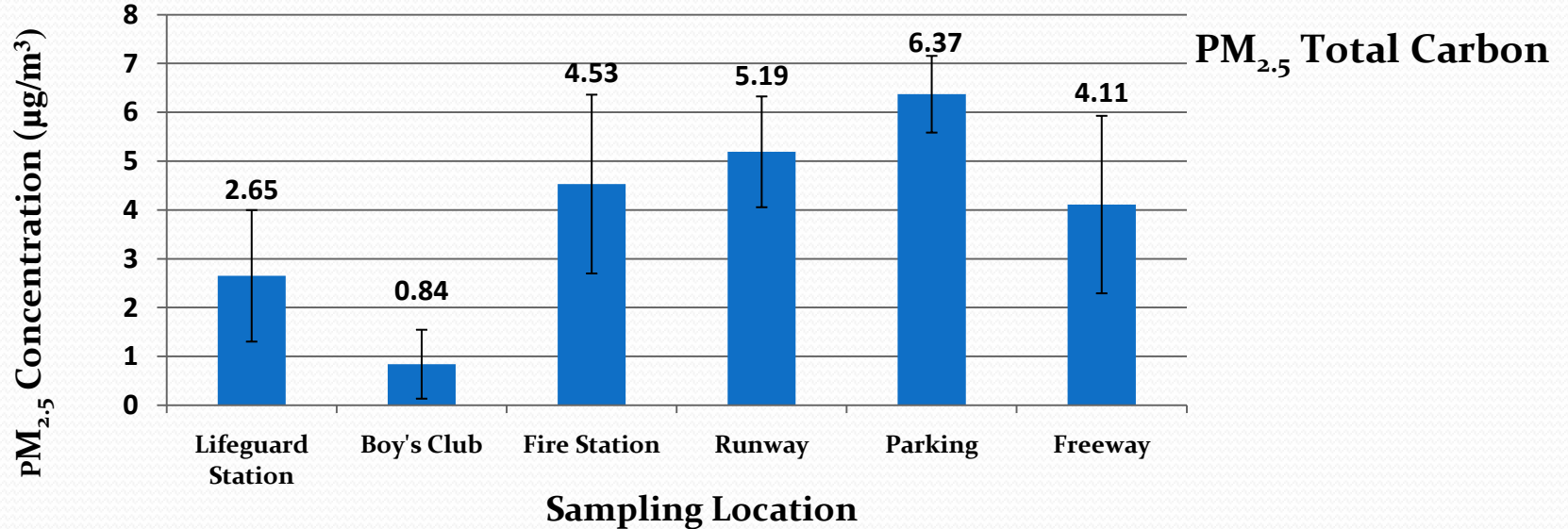
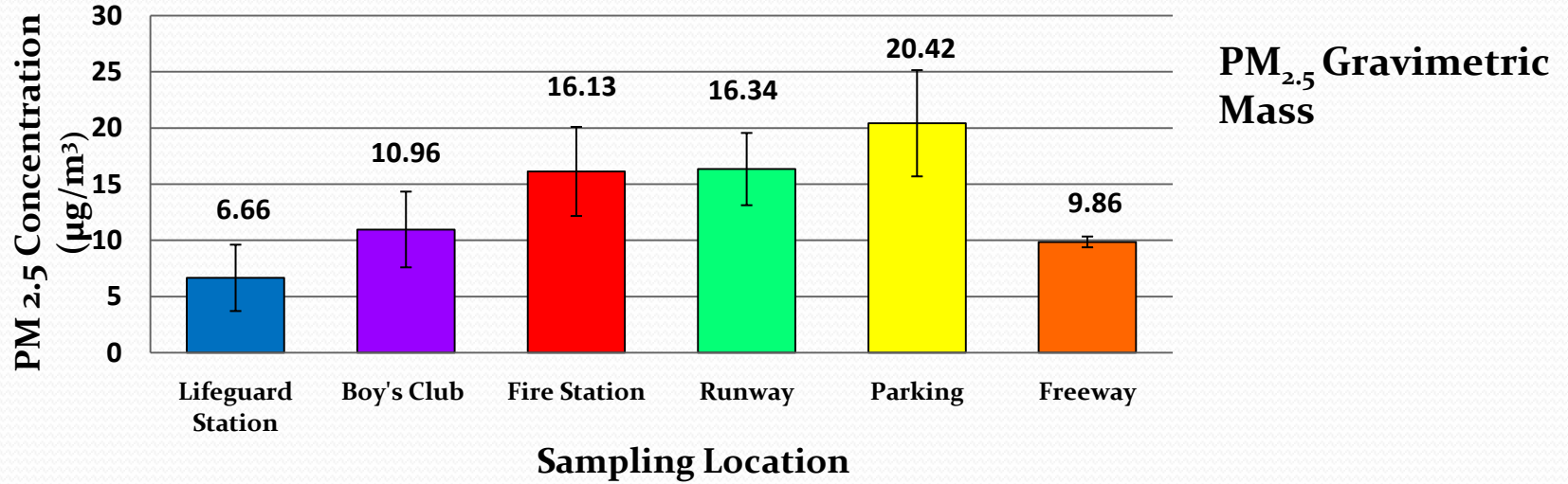
- **Context:**
- Study designed as preliminary assessment
- Minimal sample sizes employed (n=3)
- More data needed for definitive results
- However, several statistically significant trends were detected, even at a very low level of replication
- Suggests that real differences are present in PM<sub>2.5</sub> characteristics between locations

# PM<sub>2.5</sub> Concentrations

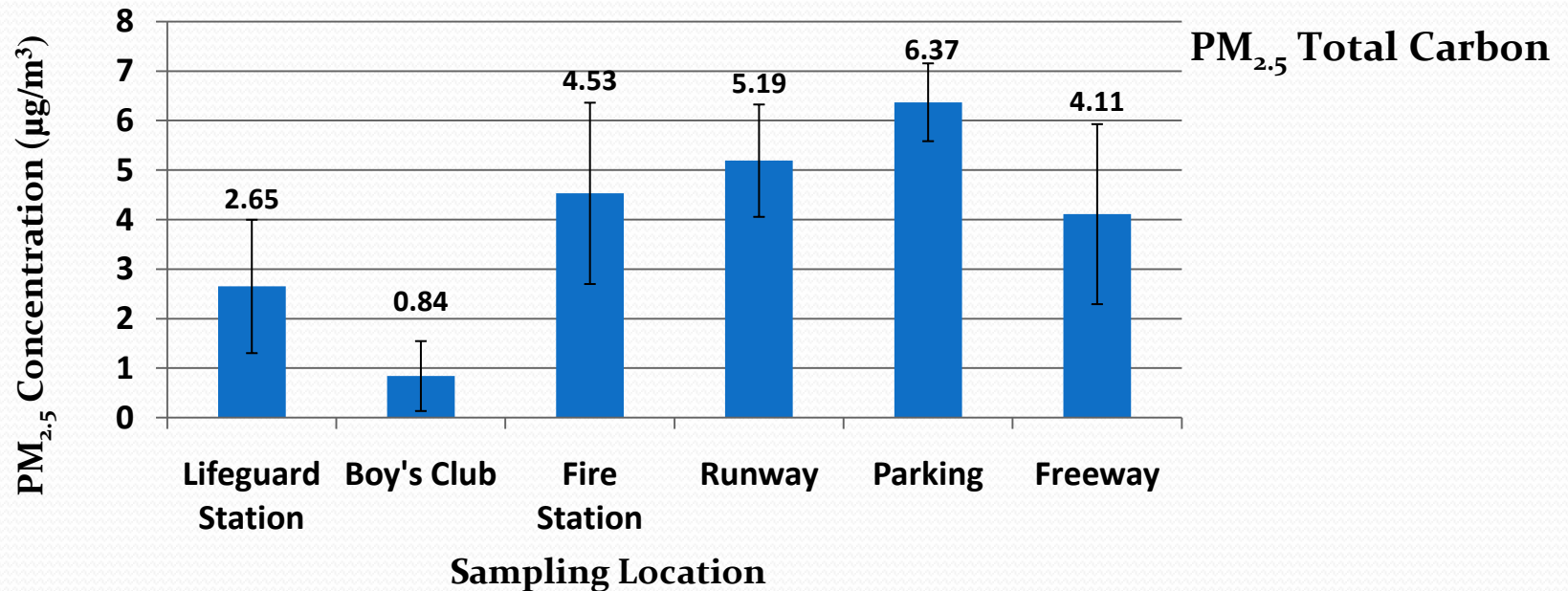
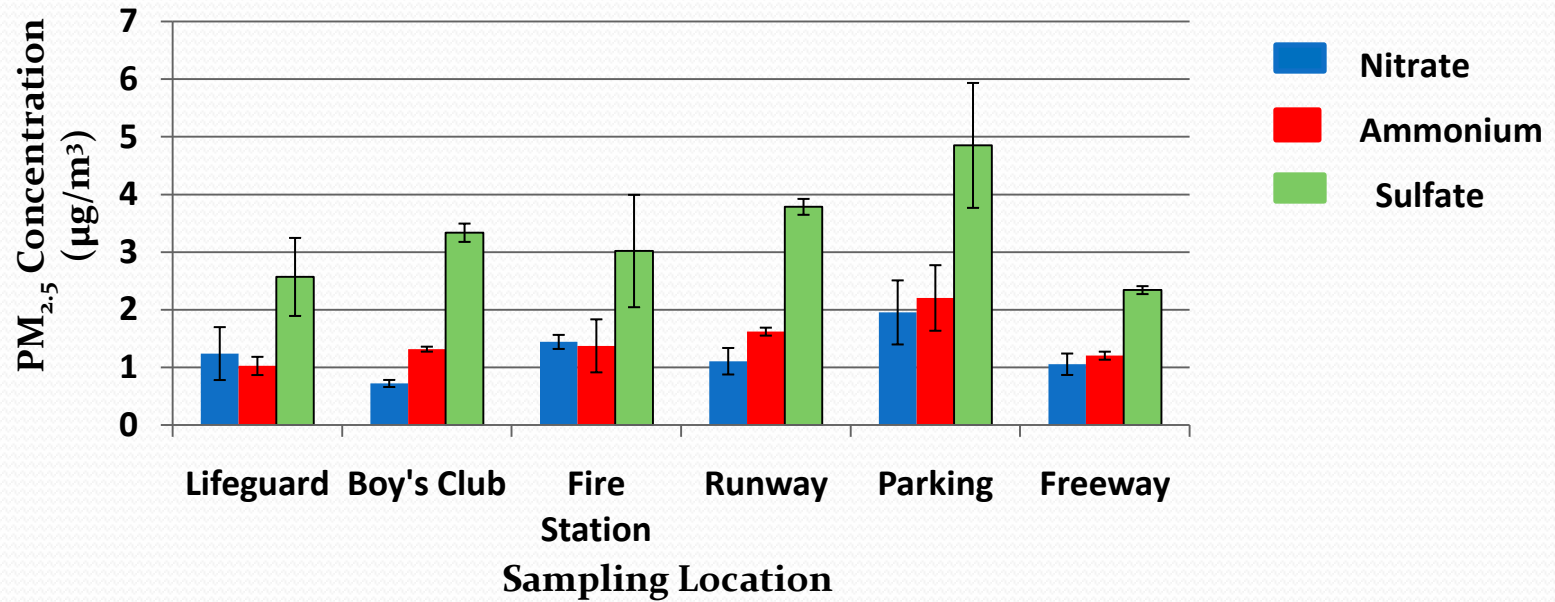


Mean concentrations of total particle mass in PM<sub>2.5</sub> at sampling locations. Error bars denote standard error.

# Carbon concentrations track trends in PM



# Sulfate, nitrate and ammonium





# Generating chemical profiles of sources

- Chemical profiles of all locations were compared to determine if any elements were specific to one location
- Two elements were found only at the Runway location: uranium and yttrium
- No elements were unique to the Freeway or Parking stations
- The only other element found at a single location was iridium, detected at the Boys' Club
- Elements were defined as potentially source-associated if their highest concentrations were measured at, or adjacent to, one of the source locations.



# Statistical analyses

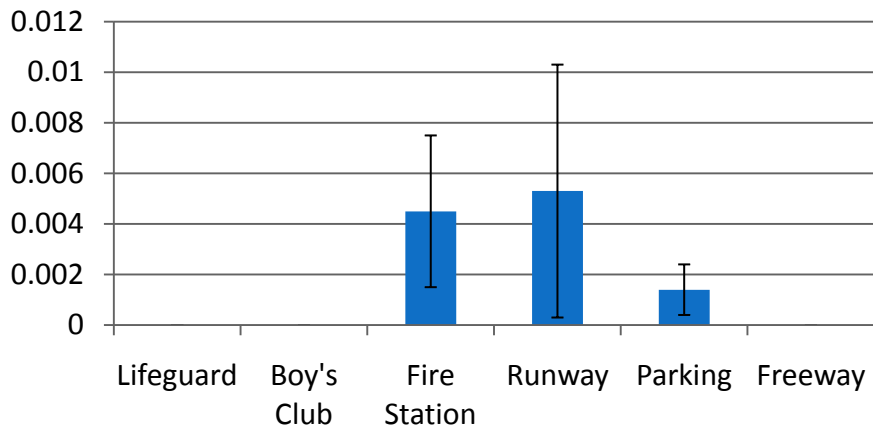
- Concentrations of individual elements were compared between study sites using 1-factor ANOVAs
- Results were considered significant if  $p \leq 0.05$
- If ANOVA results were significant, a posthoc Fisher's protected least significant differences (PLSD) test was used to identify differences among means due to location

# Potential Runway-associated elements

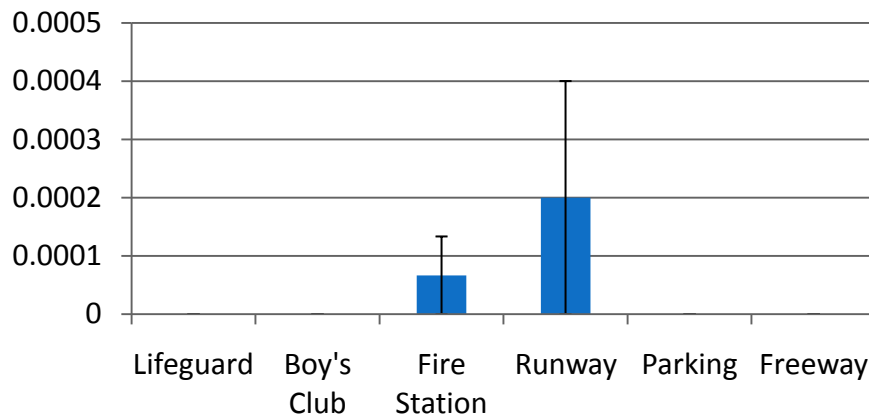
- **Ten elements were identified:**
- Three elements demonstrated statistically significant effects of location: antimony, palladium and potassium
- Seven elements met the criteria, without statistically significant location effects: nickel, vanadium, hafnium, indium, molybdenum, silver and strontium

# Potential Runway-associated elements

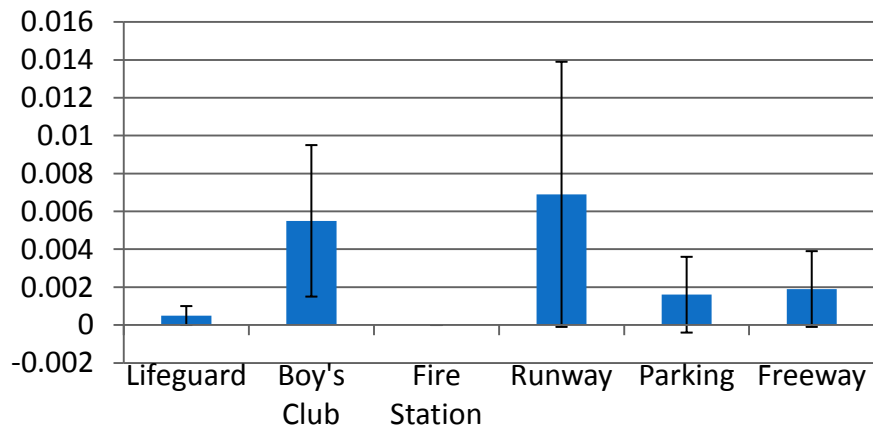
## Hafnium



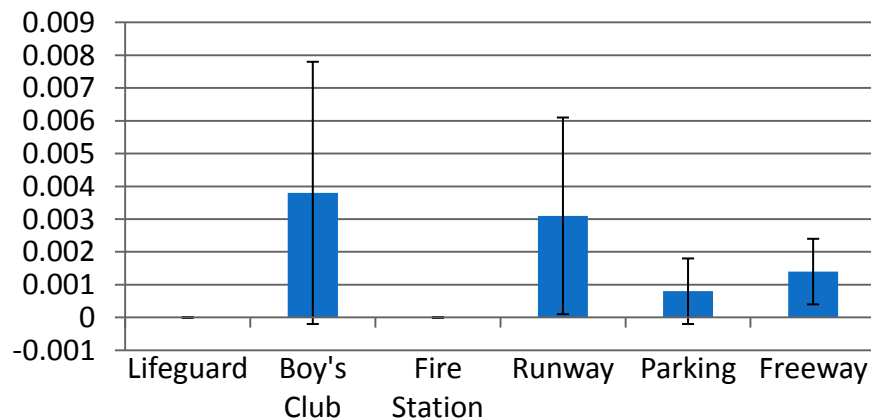
## Molybdenum



## Indium

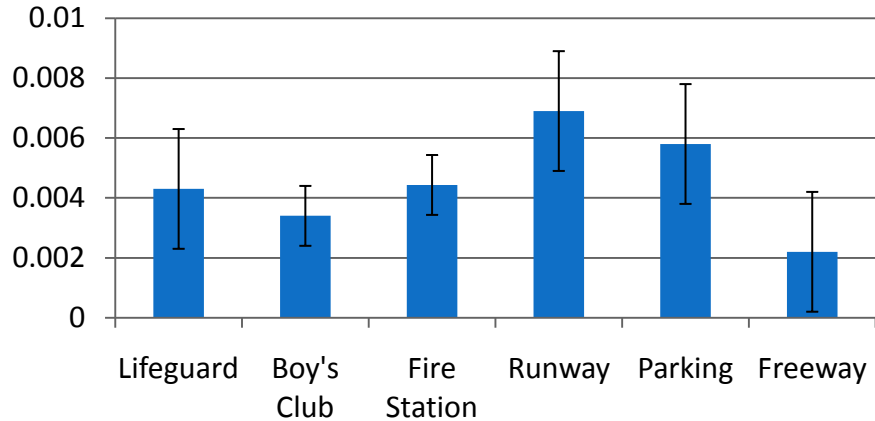


## Silver

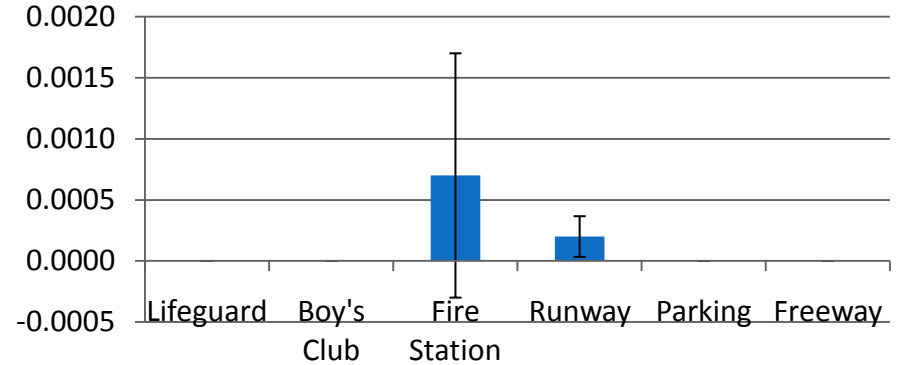


# Potential Runway-associated elements

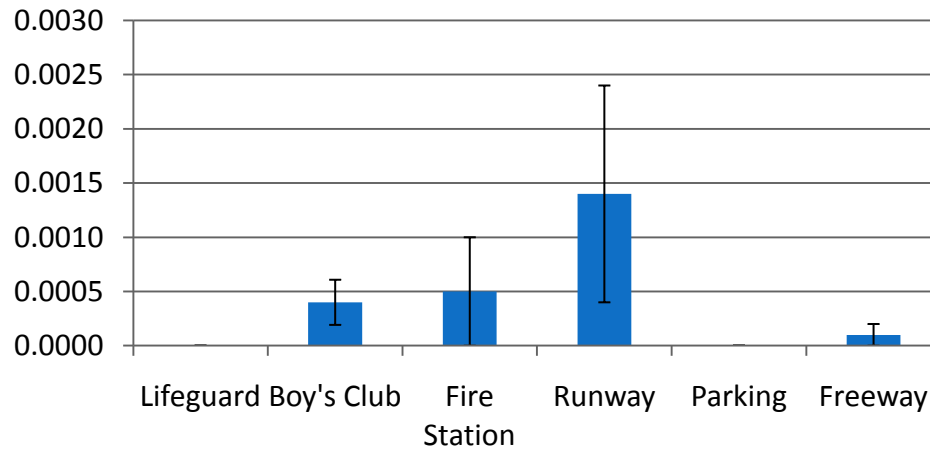
## Strontium



## Nickel



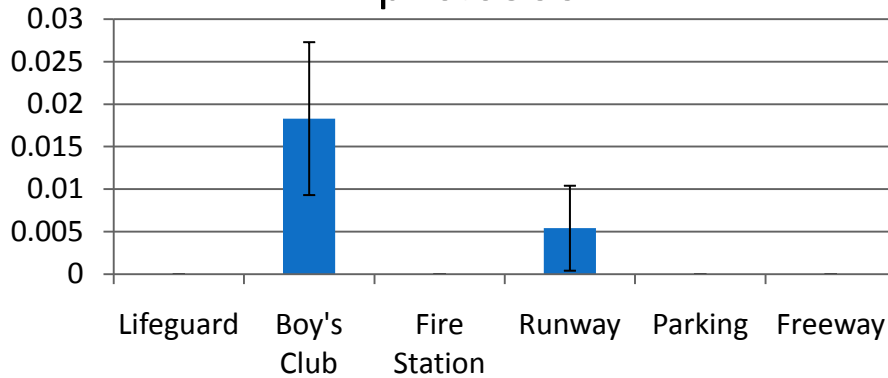
## Vanadium



# Potential Runway-associated elements showing significant effect of location

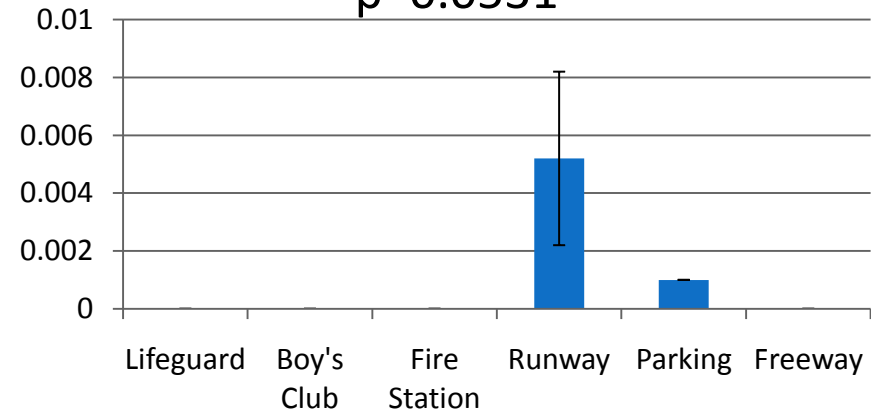
## Antimony

$p=0.0366$



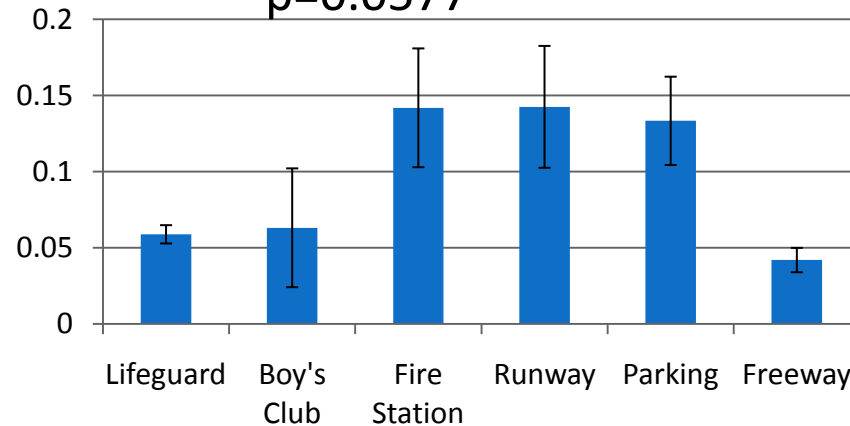
## Palladium

$p=0.0531$



## Potassium

$p=0.0577$

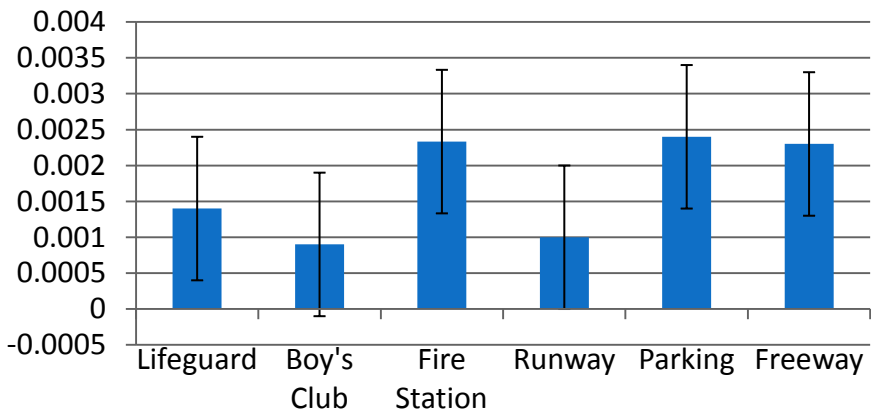


# Potential Freeway-associated elements

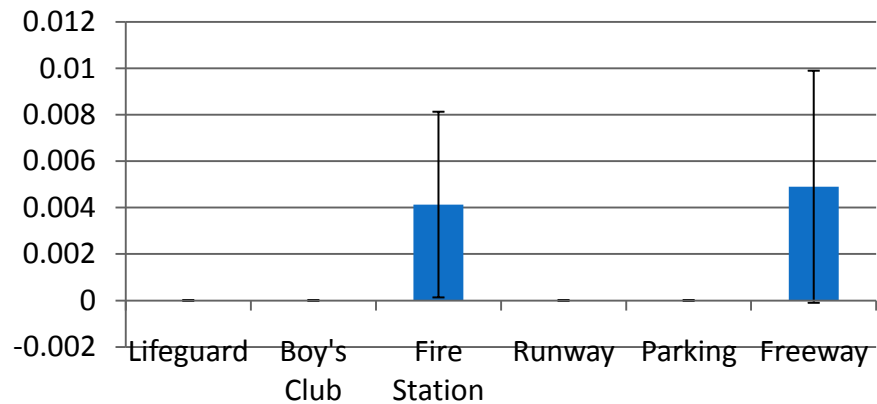
- **Eight elements were identified:**
- Two elements demonstrated statistically significant effects of location: terbium and titanium
- Six elements met the criteria, without statistically significant location effects: bromine, cerium, gold, rubidium, samarium, and zirconium

# Potential Freeway-associated elements

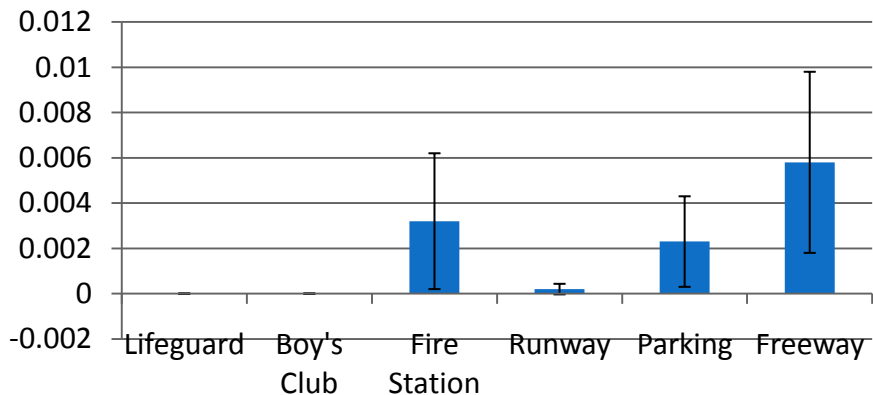
## Bromine



## Cerium

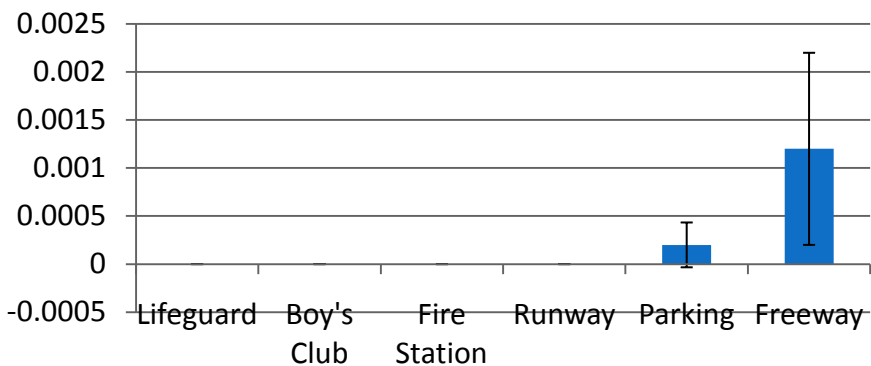


## Gold

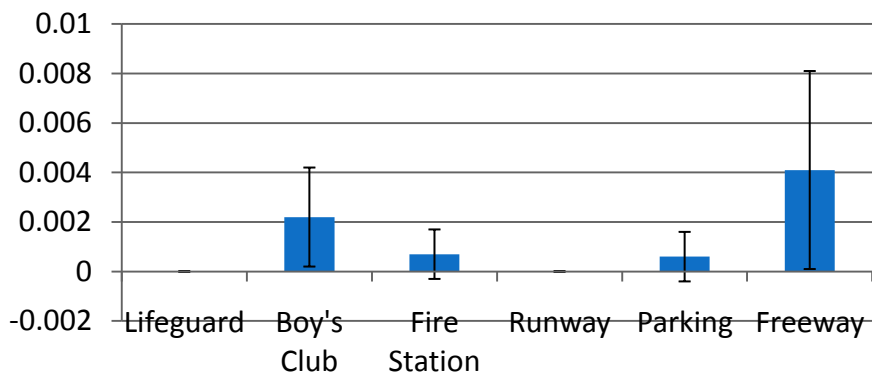


# Potential Freeway-associated elements

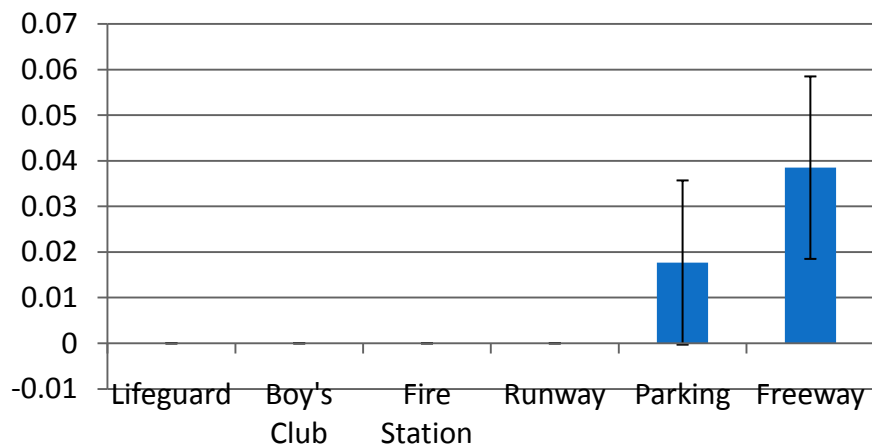
## Rubidium



## Zirconium



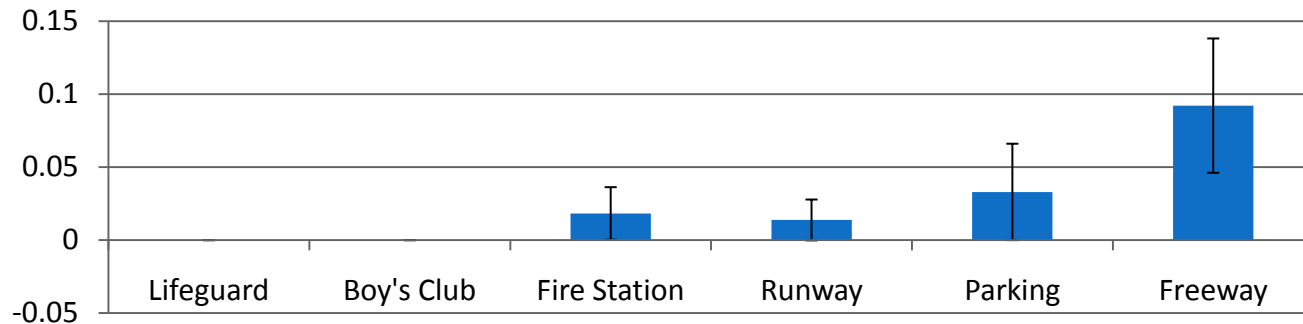
## Samarium



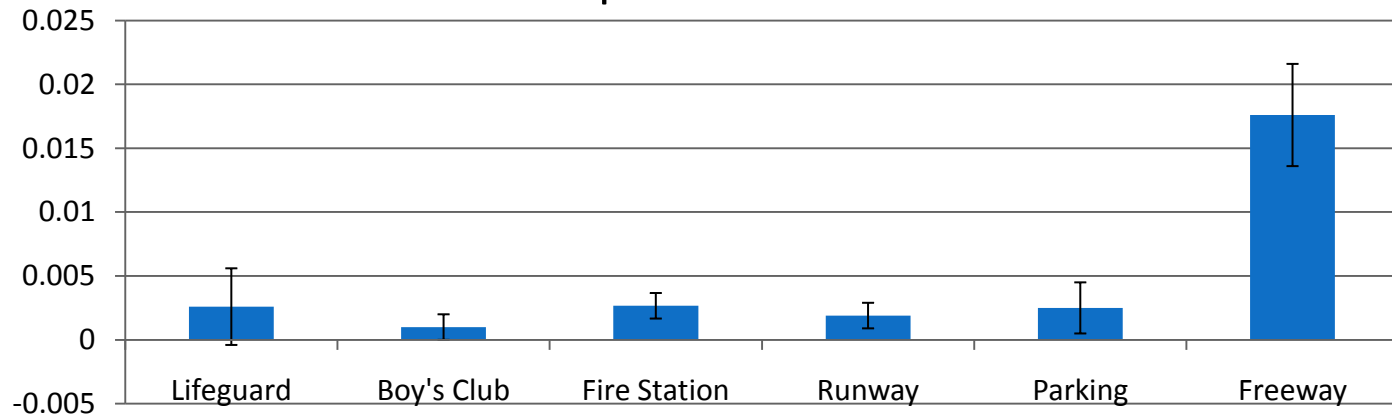


# Potential Freeway-associated elements showing significant effect of location

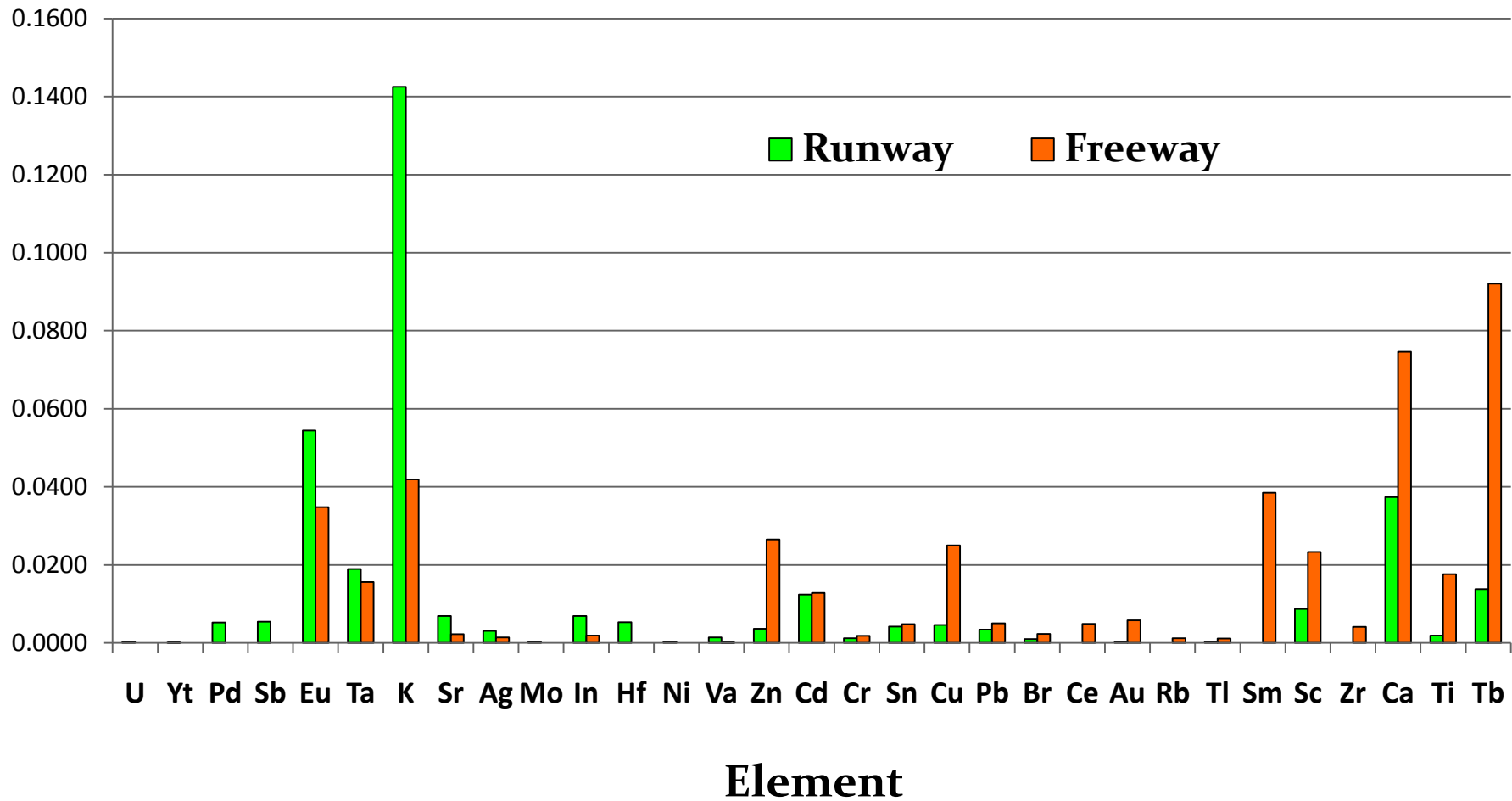
**Terbium**  
 $p=0.0001$



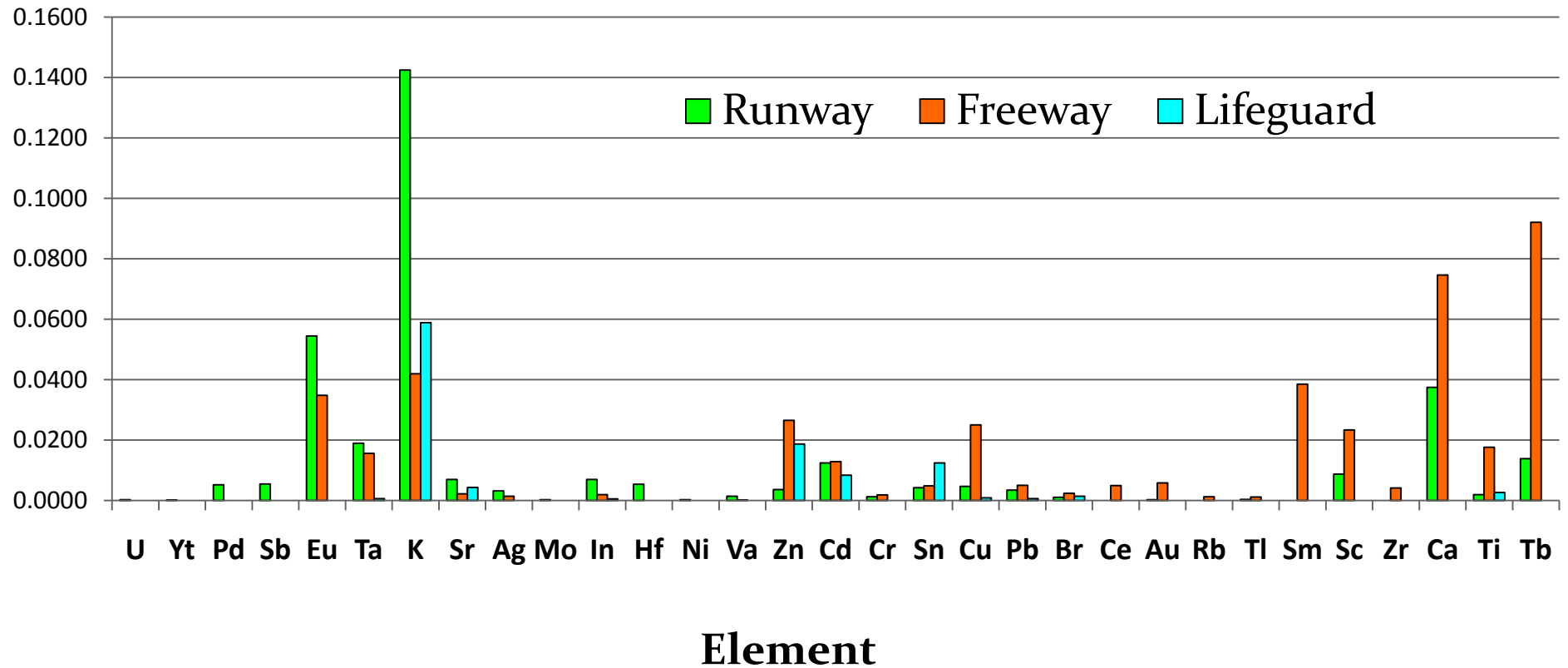
**Titanium**  
 $p=0.0008$



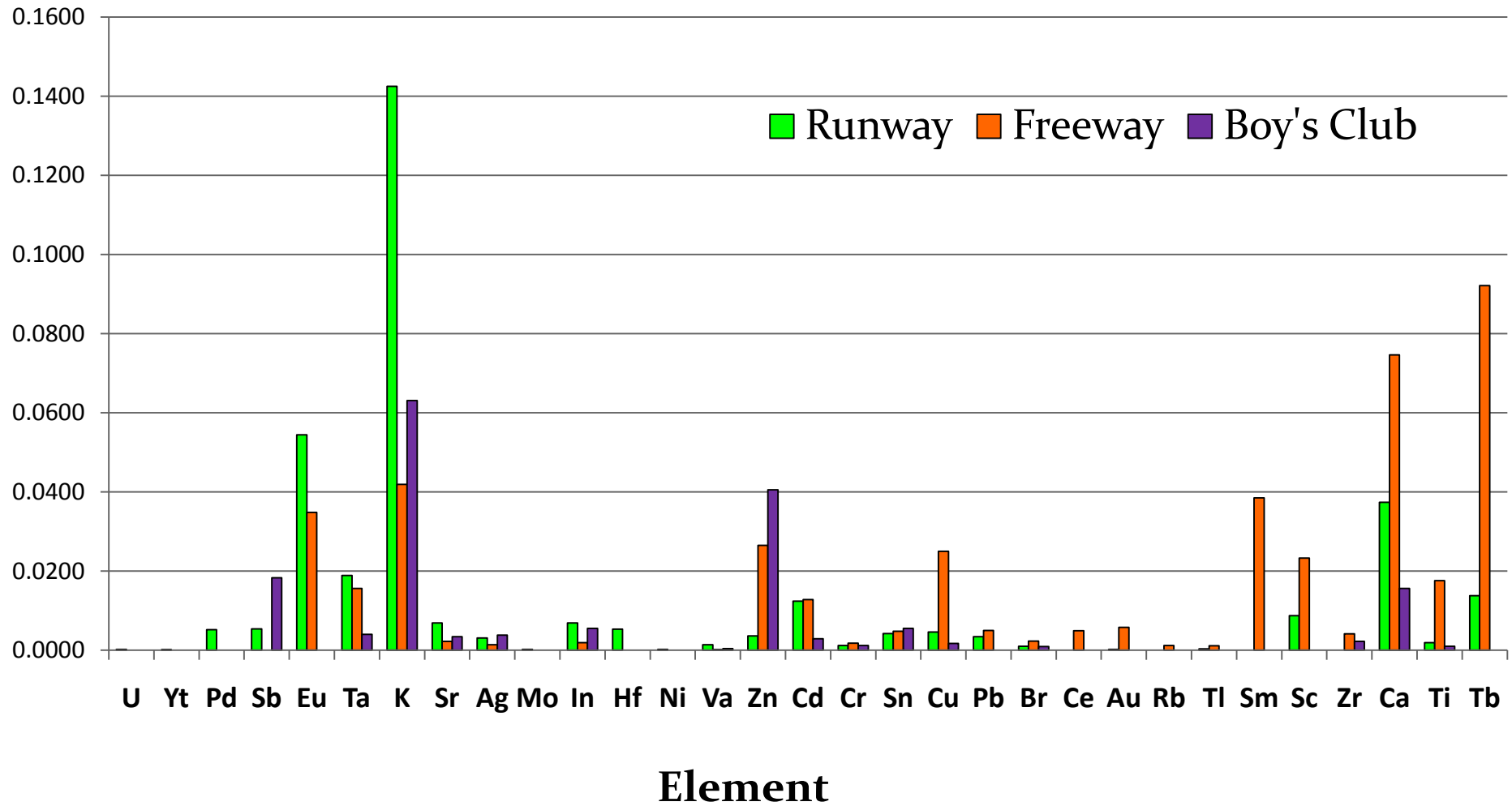
# Comparing source profiles



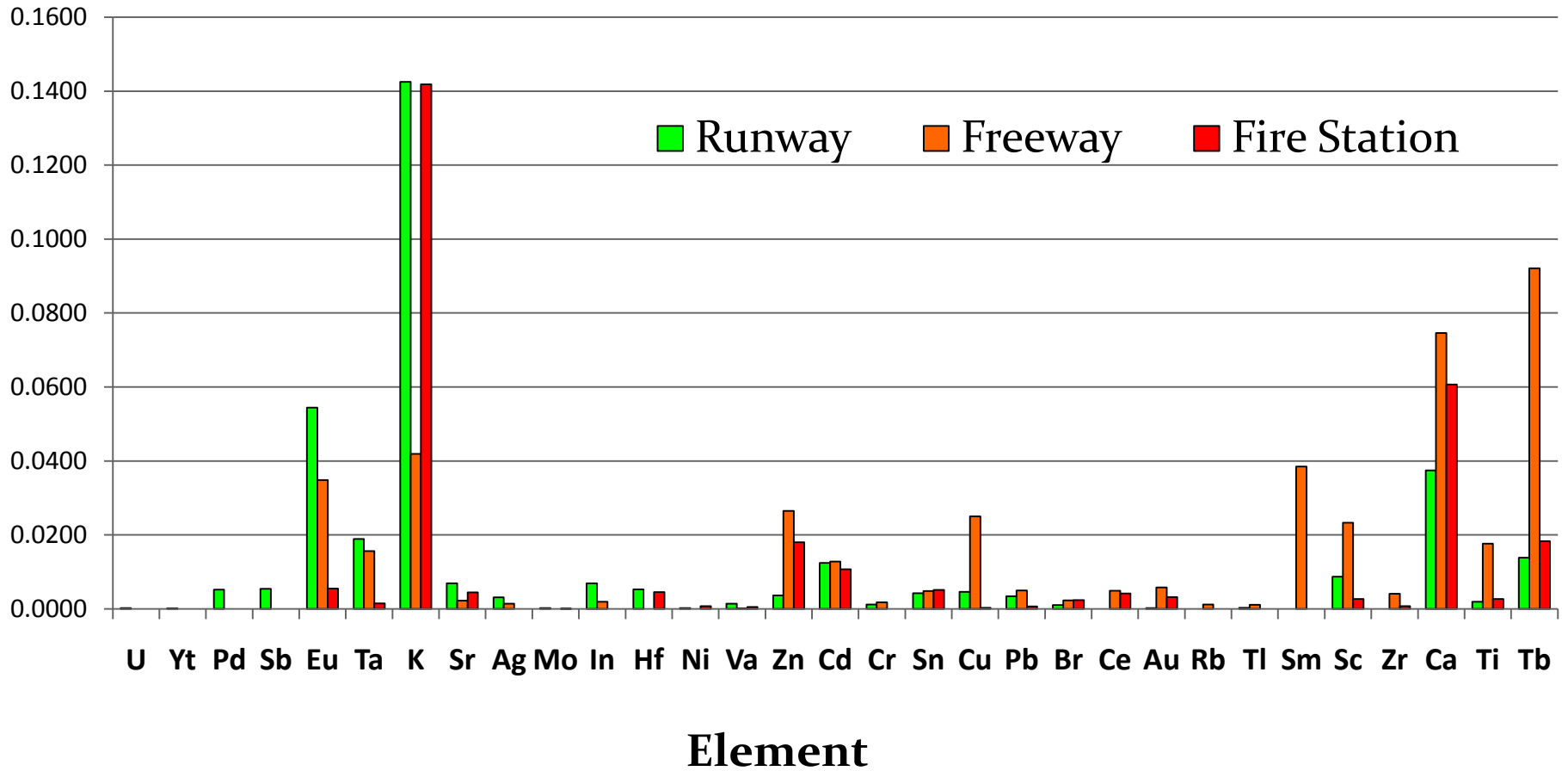
# Source profiles vs. Lifeguard HQ



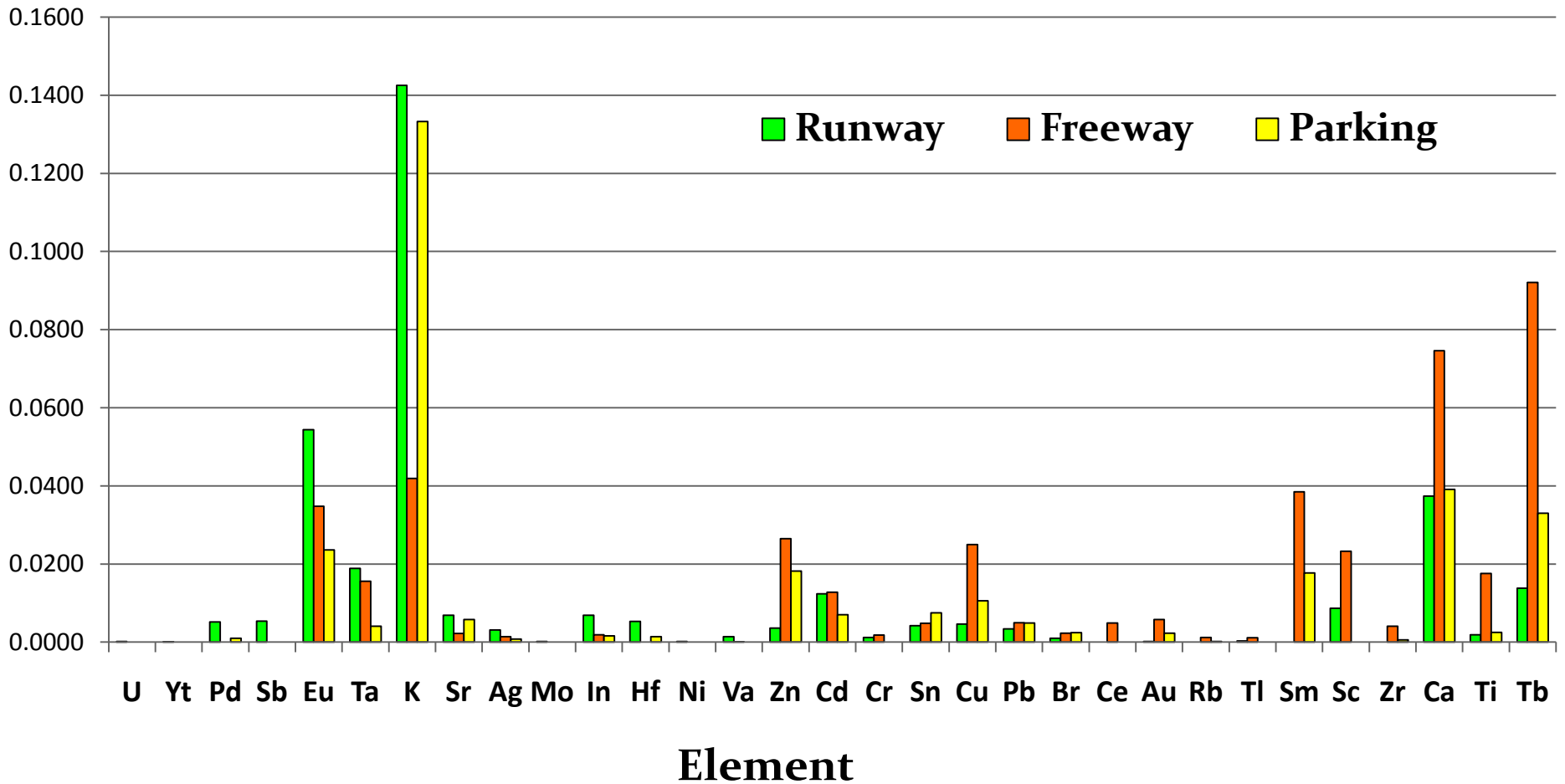
# Source profiles vs. Boys' Club



# Source profiles vs. Fire Station



# Source profiles vs. Parking



# Particle-associated PAHs

- PAHs were divided into two categories: light and heavy
- **Light PAHs:** 38 compounds from 1+2ethylnaphthalene through xanthone
- **Heavy PAHs:** 70 compounds from acenaphthenequinone through dibenzo(b,K)fluoranthene

# Heavy PAHs

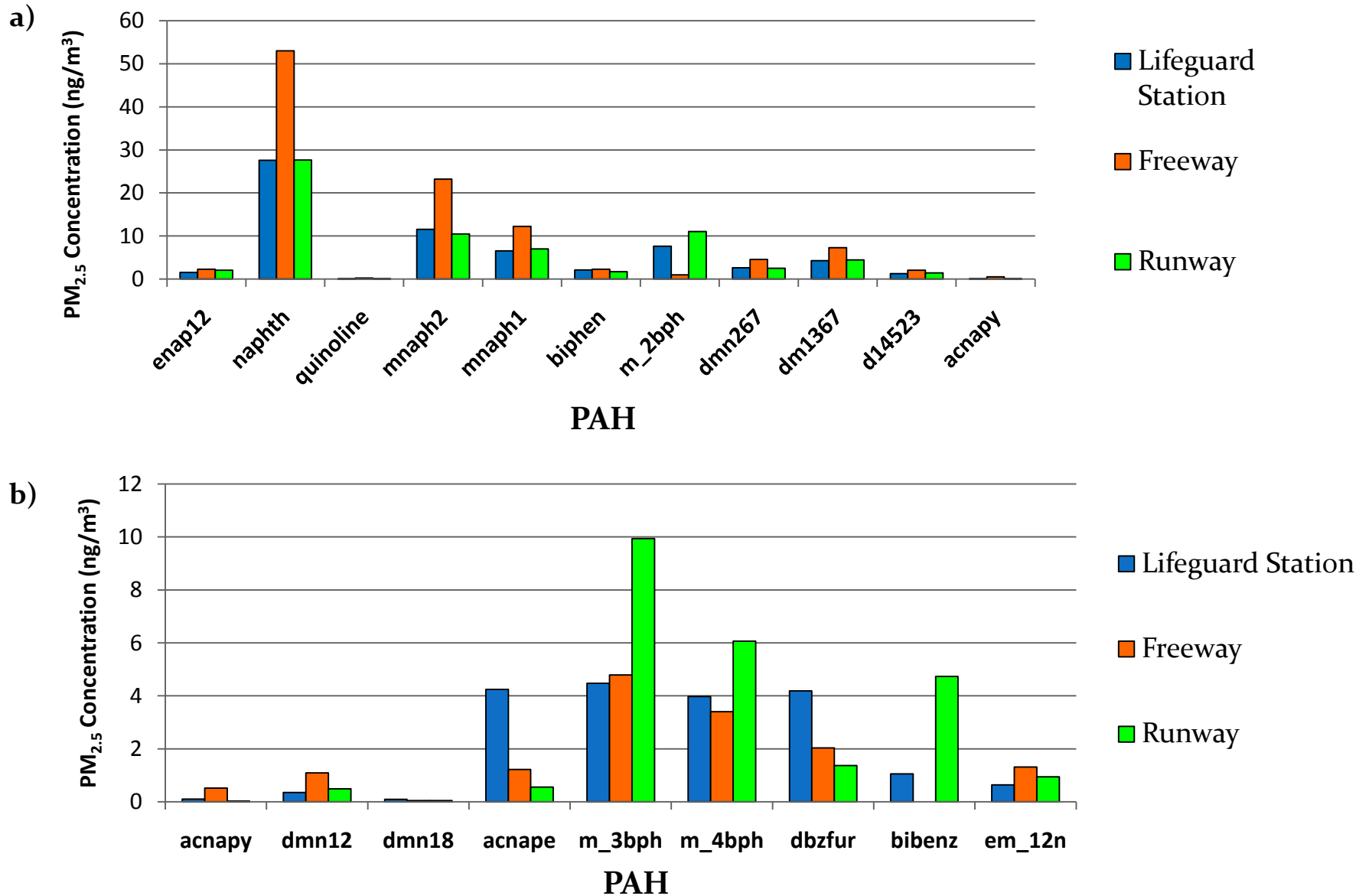
- Concentrations of most heavy PAHs were higher at the Freeway location than at the Runway station
- This is to be expected because jet fuel is more highly refined than automobile and diesel fuels
- Two heavy PAHs were measured at higher concentrations at the Runway than at any other site:  
7,12-dimethylbenz(a)anthracene and  
benzo(b+j+k)fluoranthene



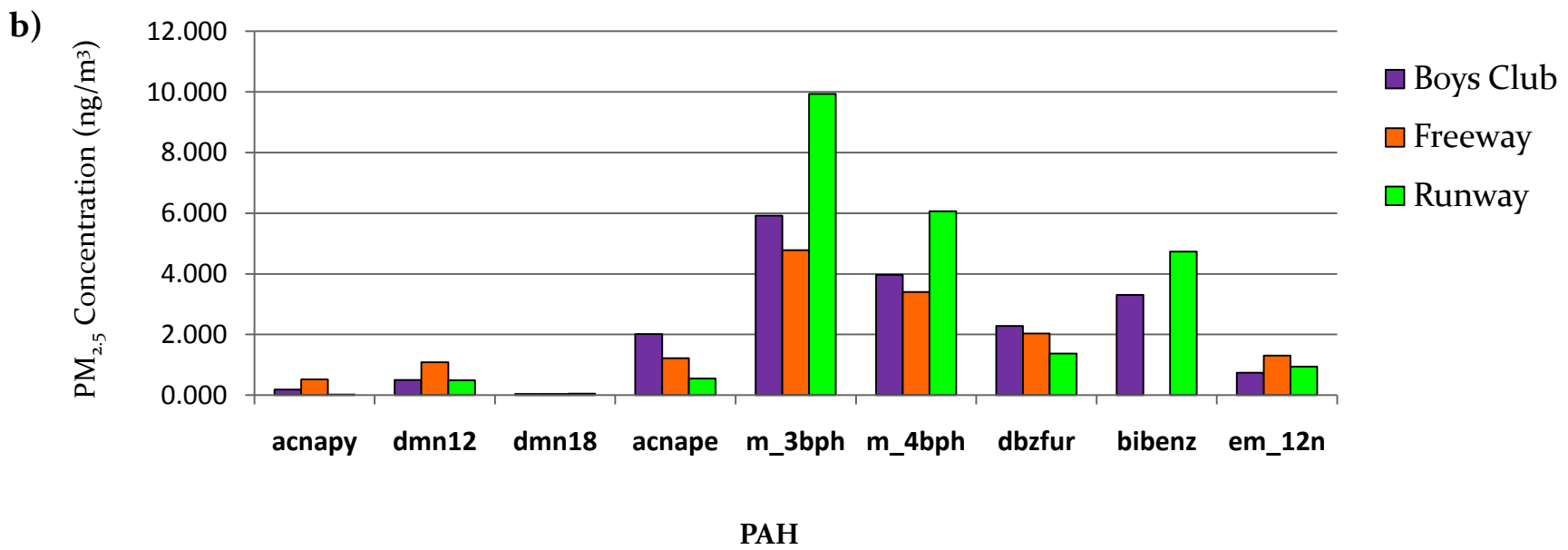
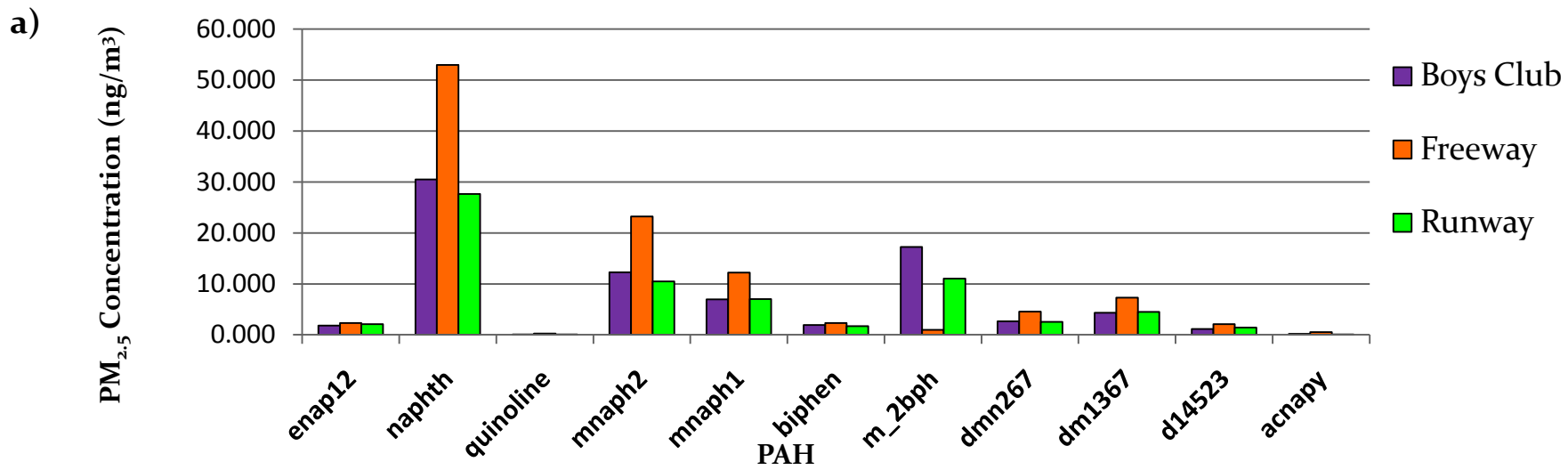
# Light PAHs

- **Seven light PAHs were measured at higher concentrations at the Runway vs. Freeway station:** 2-methylbiphenyl, 3-methylbiphenyl, 4-methylbiphenyl, bibenzene, b-trimethylnaphthalene, c-trimethylnaphthalene and ethyl-1-methylnaphthalene
- As sites moved closer to the Runway, the number of runway-associated PAHs elevated in air samples increased

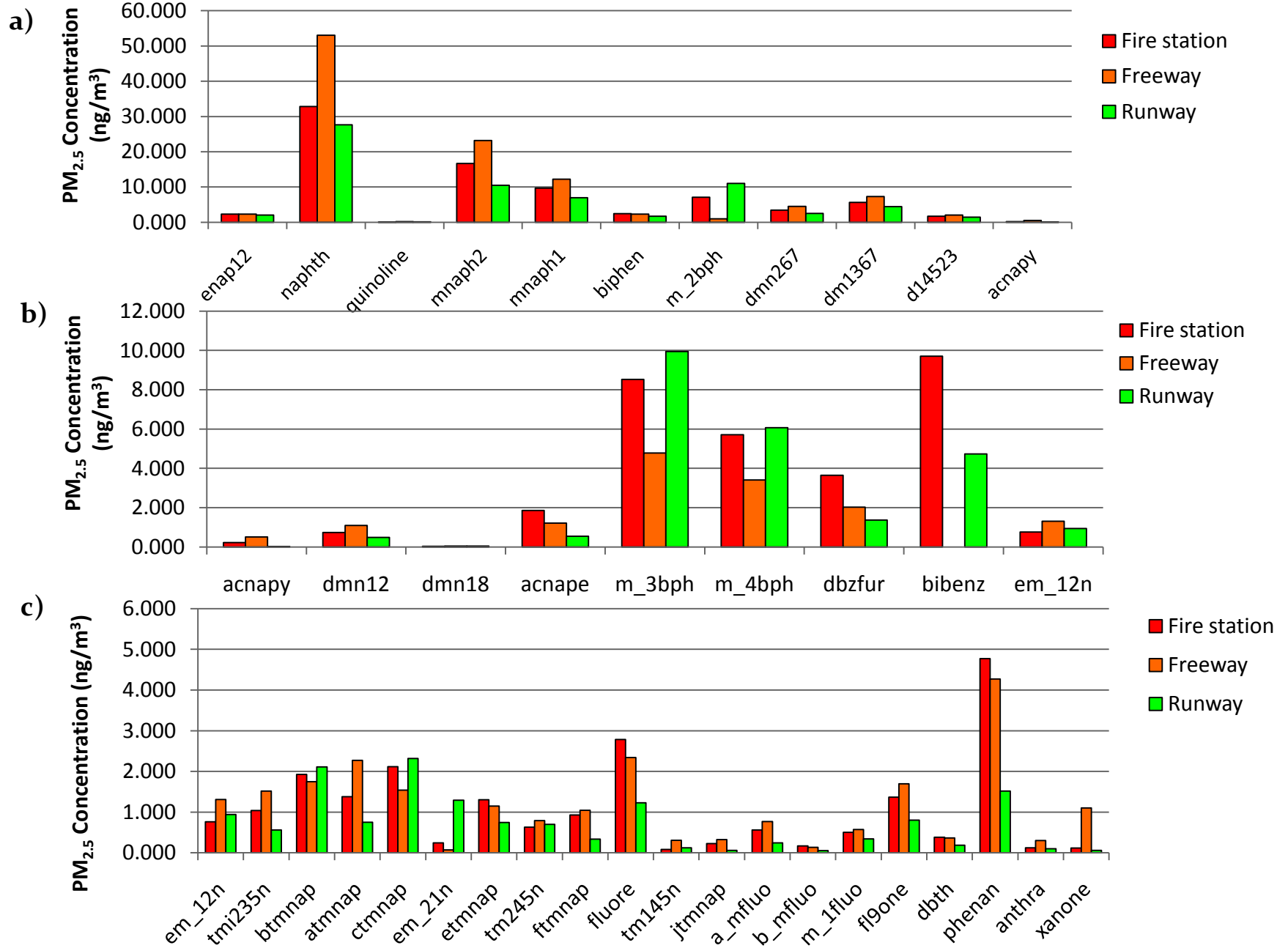
# PAH source profiles vs. Lifeguard HQ



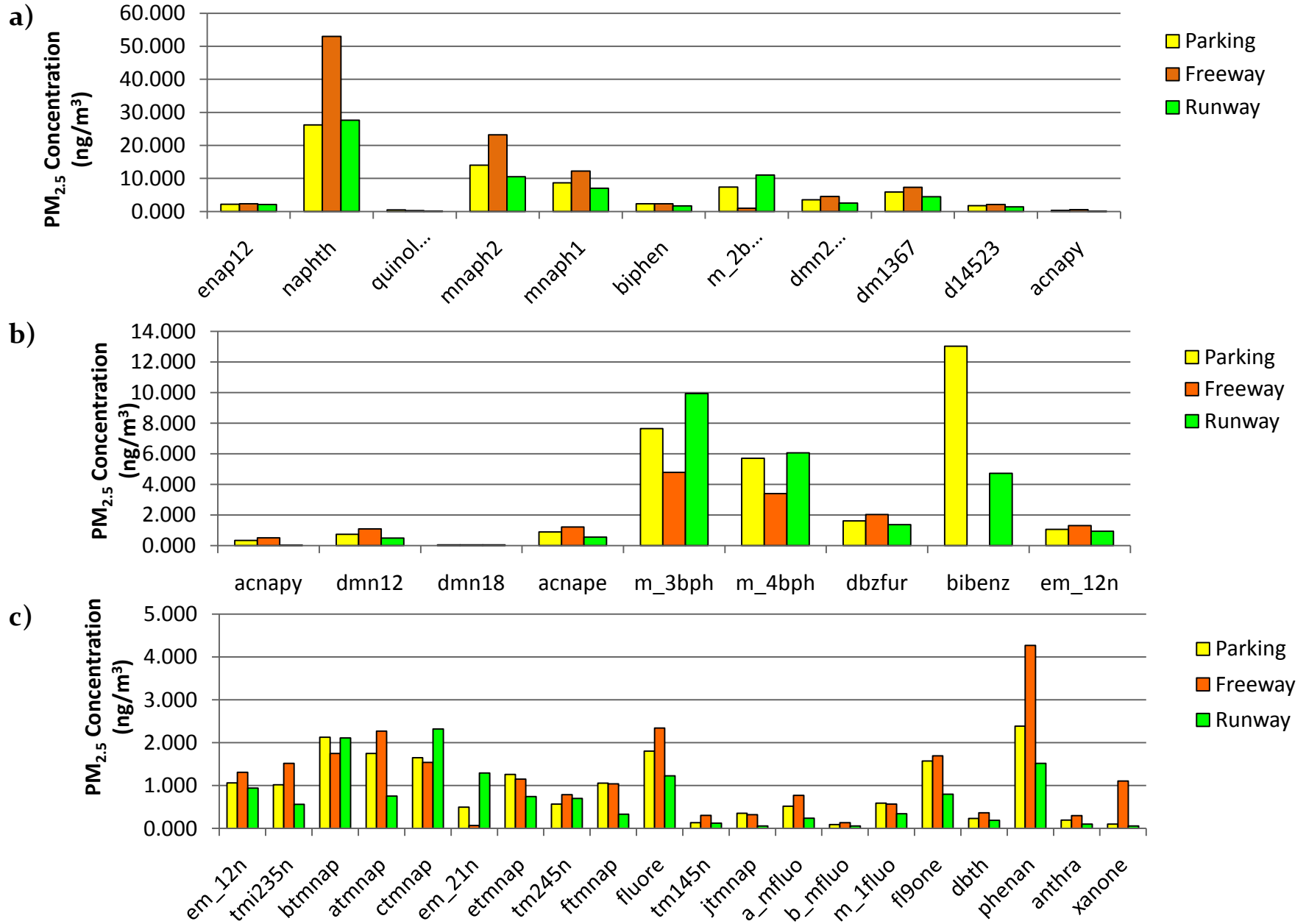
# PAH source profiles vs. Boys' Club



# PAH source profiles vs. Fire Station



# PAH source profiles vs. Parking



# Conclusions

- Ambient PM<sub>2.5</sub> concentrations in Newport Beach are within federal air quality standards
- PM<sub>2.5</sub> collected at runway and freeway locations differs in both chemical composition and relative concentrations of certain elements
- With further study, these profiles may be refined to produce chemical “fingerprints” that would allow particulate emissions to be associated with their source

# Conclusions

- Previous studies (Westerdahl et al., 2008; Hu et al., 2009) have documented real-time peaks in aircraft-related UFP over 900m downwind of airports
- Our results suggest that these peaks documented for individual take-offs and landings translate into measurably increased concentrations of particle-associated metals and PAHs when averaged over hours
- Our data suggest that aircraft particulate emissions may persist a significant distance from the airport – up to 10km for particle-associated sulfate and some light PAHs

# Future Research

- Increase the statistical power of this data set and continue to develop chemical “fingerprints” associated with different emission sources by adding more sampling periods at present locations
- Add sampling stations at crosswind and downwind locations to better define the transport of aircraft-associated PM
- Add sampling stations in locations of concern to the community such as Upper Newport Bay
- Design “before/after” field sampling study to assess the effectiveness of mitigation strategies



# Acknowledgements

- This study would not have been possible without the assistance of many people. Thank you to Mr. Homer Bludau, retired City Manager of Newport Beach, Mr. Dave Kiff, current City Manager and Mr. Thomas Edwards for the opportunity to carry out this study.
- Many thanks to Mr. Alan Murphy, JWA Airport Director, for supporting this work by allowing us to station air samplers on airport property. Thanks to Mr. Jack Jennrich for his assistance with the logistic challenges involved.