Name: ______________________
Period:______________________

AP Environmental Science Lab: Using GPS to monitor tectonic plate motions

Objectives:
Students will be able to
1) graph and analyze the position of a survey benchmark over time (I&E standard 1a)
2) interpret the rate and direction of motion of the underlying tectonic plate (I&E standard 1d)
3) determine the magnitude and velocity of the resultant horizontal velocity vector from its north and east components (I&E standard 1e)
4) analyze the pattern of motion across the San Andreas fault as measured by GPS

Pre-lab Questions: (May be answered during the introductory powerpoint slides)

1. What type of plate boundary exists between the Pacific and North American plates in southern California?

 ____

2. What is the name of the primary fault along this boundary?

 ____

3. What type of motion occurs along this plate boundary? (Horizontal? Vertical?)

 ____

4. In what direction is the Pacific Plate moving relative to North America?

 ____

5. How do we know what direction the Pacific Plate is moving?

 ____

 ____

6. Looking at the attached map, which of the labeled sites are on the Pacific Plate and which are on the North American plate?

 Sites on the North American plate: _______________________________

 Sites on the Pacific plate: _______________________________

7. Which site(s) do you expect to be moving the fastest (relative to North America)? Which do you expect to be moving the slowest?

 Fastest: ____________________ Slowest: ____________________

This material is based upon work supported by the National Science Foundation under Grant Number 0844400. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

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Method:

1. Each pair of students will be given a GPS data set for one particular site, consisting of points representing the north and east position of your site over a time period of several years. You will need to plot one graph showing how the north position has changed over time and another graph showing how the east position has changed over time. One member of your pair may plot the north graph and the other may plot the east graph.
2. After plotting all of your points, use a ruler to draw a straight line that passes through the middle of the set of data points. Your "best-fit" line does not have to touch every single point, but should be a straight line that passes as closely as possible to as many data points as possible.
3. Calculate the velocity of your site (how fast it is moving) in both the north and east directions. To do this, use the first and last entries in the data table to calculate how far your station moved and divide this by how long it took for it to move that far.
4. On the map with a grid overlain on top of it, plot a vector (an arrow) showing how fast your site is moving in the north direction, and plot a second vector showing how fast it is moving in the east direction. Use a ruler to make the length of each arrow equal to the distance that your site moves in one year. Plot the tail of the north vector at the location of your site on the map; plot the tail of the east vector at the head of the north vector.
5. Draw the resultant vector that connects the tail of the north vector to the head of the east vector. Measure the length of this vector with a ruler, and write this number on the map next to your vector.
6. A transparency copy of this map will be circulated between the groups. Place this transparency map over your map, aligning all of the sites and faults, and then trace your resultant vector (just the overall horizontal velocity vector, not the north and east components) onto the transparency using a transparency pen. Make sure the tail of your vector is at the location of your site on the map. Also write the overall velocity of your site (in cm/year) on the map next to your vector. (Alternatively, students can call out their north and east velocities and the teacher can plot each group's vectors on the transparency).

Discussion Questions:

1. What do the slopes of your north and east graphs represent?

2. What does the length and orientation of your resultant vector represent?

3. Which station is moving the fastest? Which is moving the slowest?

4. Does this agree with what you expected to find?

5. Describe the pattern of site velocities as you travel from site PT65 on the North American Plate to site NORCO on the Pacific Plate. Is there a sudden and dramatic change in site velocities when you cross the San Andreas fault? Or do the velocities change more gradually? Is this the pattern that you expected to find, or does it surprise you?

6. Explain why the site velocities might have this pattern.

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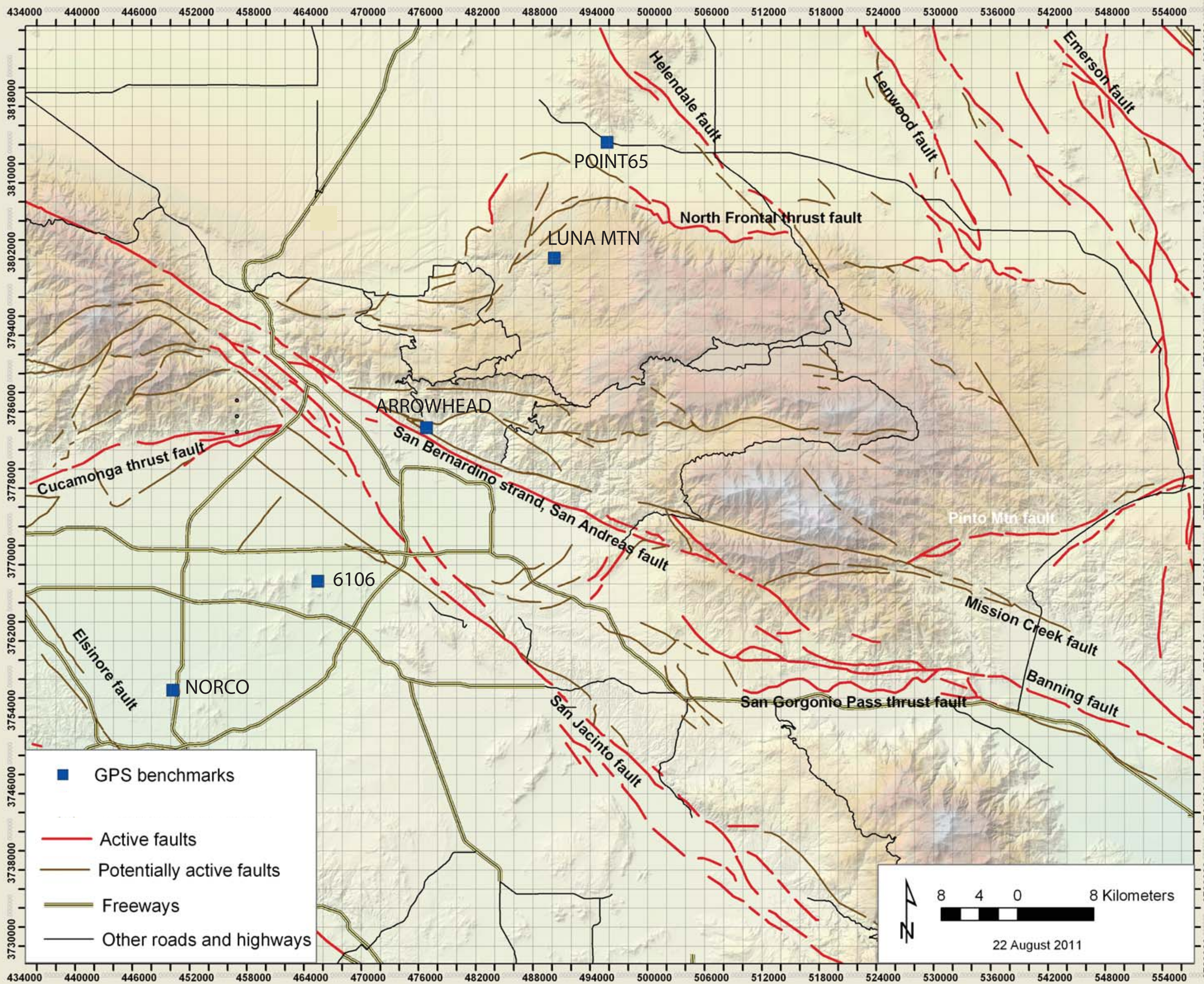
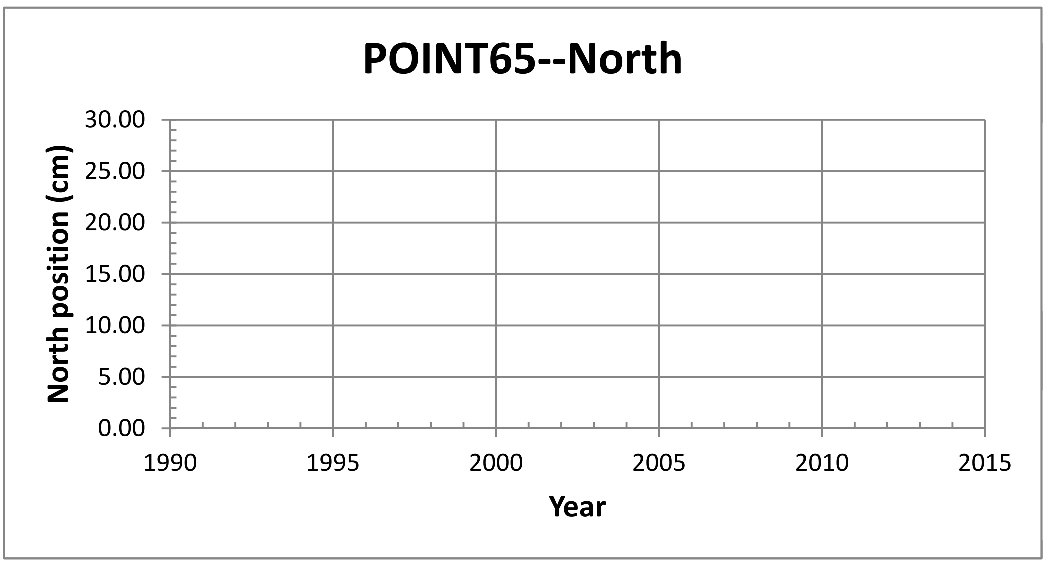
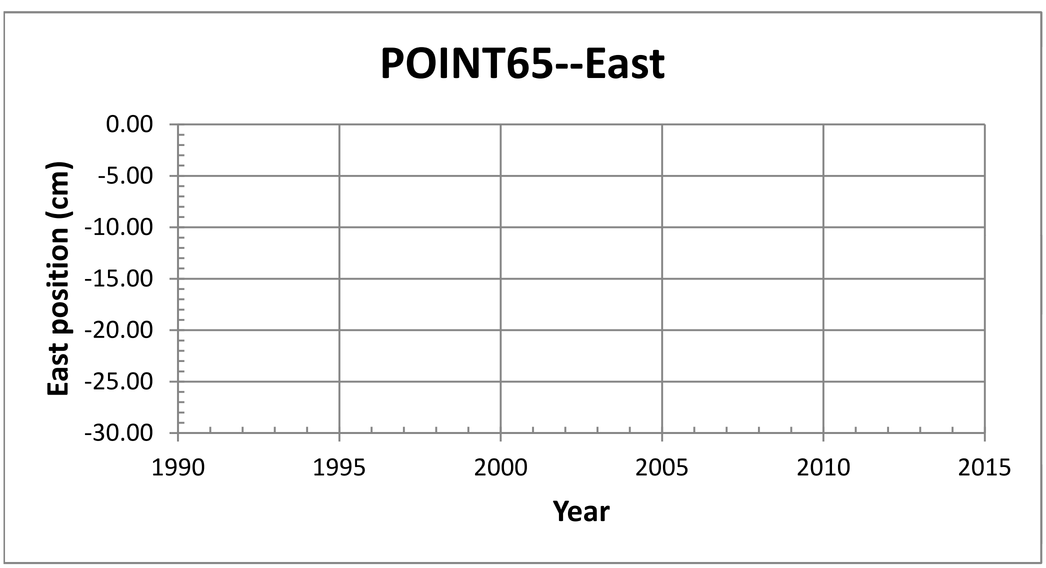


Helendale fault
Lenwood fault
Emerson fault
POINT65
North Frontal thrust fault
LUNA MTN
ARROWHEAD
Cucamonga thrust fault
San Bernardino strand, San Andreas fault
Pinto Mtn fault
6106
Mission Creek fault
Elsinore fault
NORCO
Banning fault
San Gorgonio Pass thrust fault
San Jacinto fault
GPS benchmarks
Active faults
Potentially active faults
Freeways
Other roads and highways
8 4 0 8 Kilometers
22 August 2011

Site--POINT65

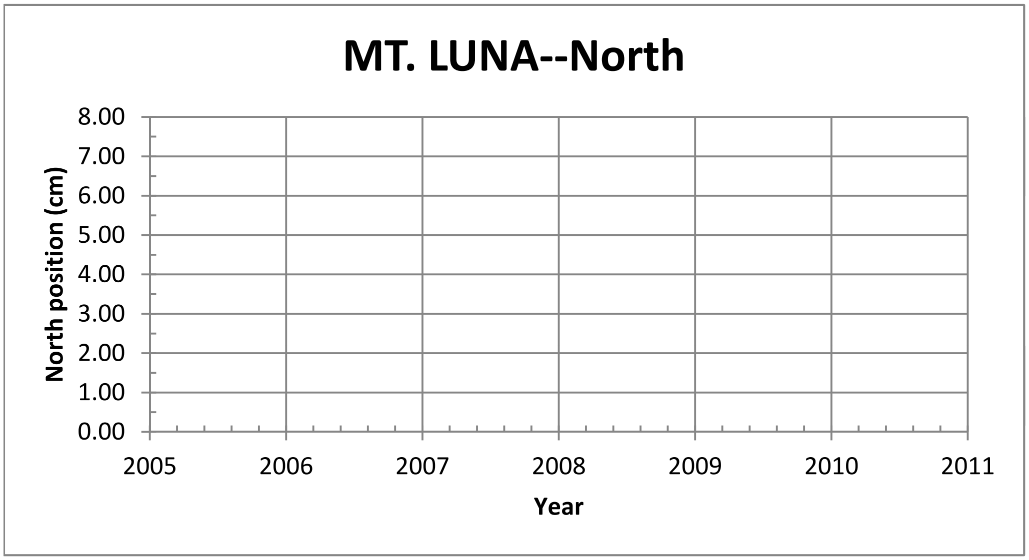
Date	North position (cm)	East position (cm)
1993.6	0.00	0.00
1995.6	3.40	-5.92
1999.8	9.01	-10.44
2002.5	13.80	-16.62
2002.9	14.39	-16.73
2003.5	14.92	-16.76
2004.5	16.72	-18.88
2005.5	17.36	-20.30
2007.8	20.51	-22.64
2008.5	21.35	-23.79
2009.6	22.89	-24.66
2010.5	23.83	-25.97

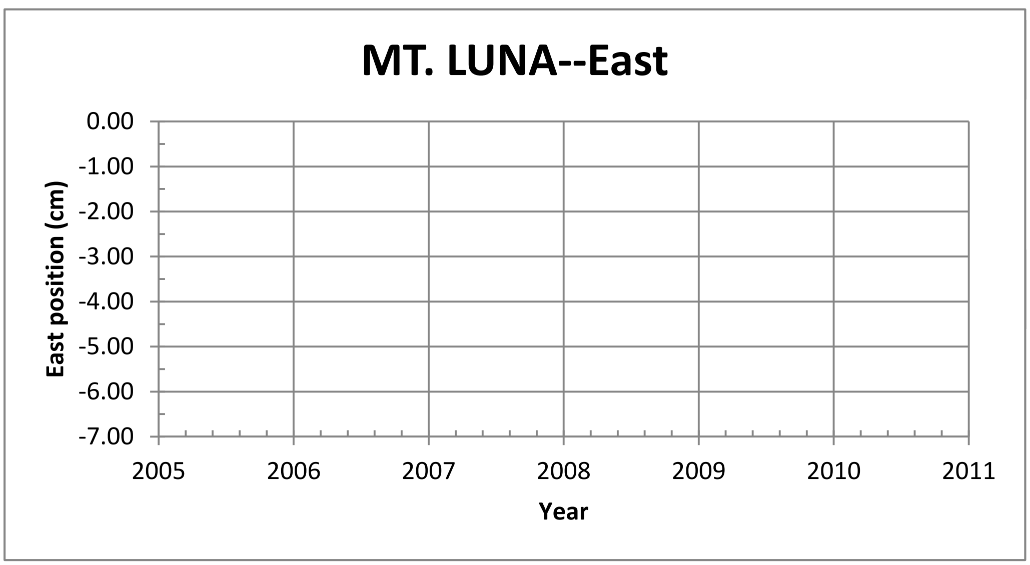




Site--MT. LUNA

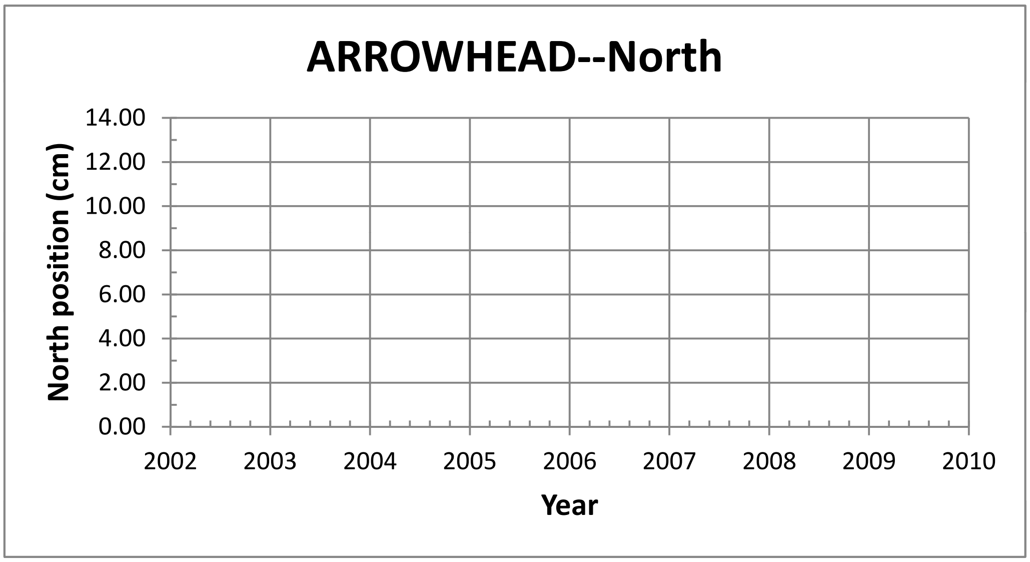
Date	North position (cm)	East position (cm)
2005.5	0.00	0.00
2008.6	4.62	-3.57
2009.5	5.56	-4.90
2010.5	6.96	-5.96

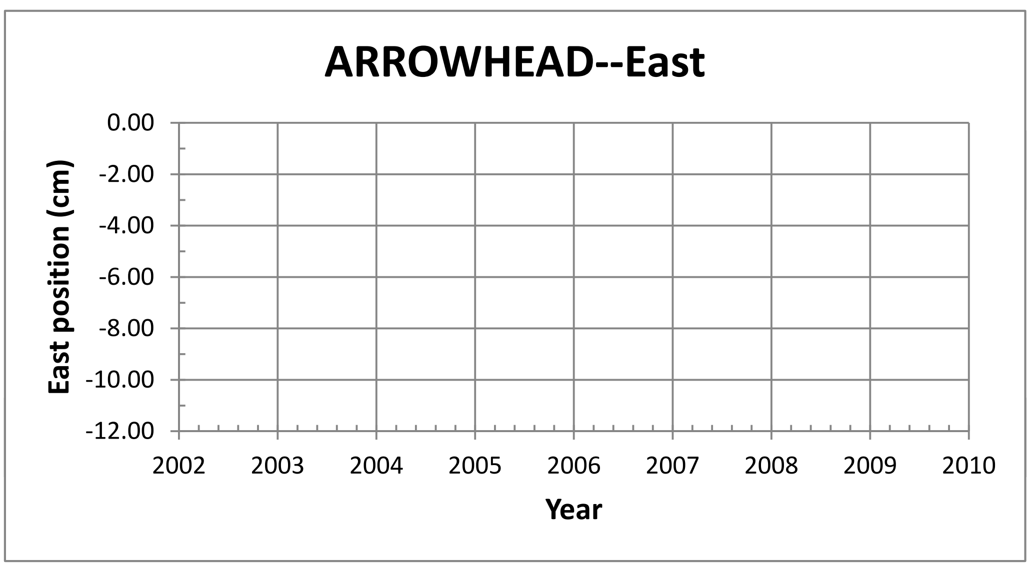




Site-- ARROWHEAD

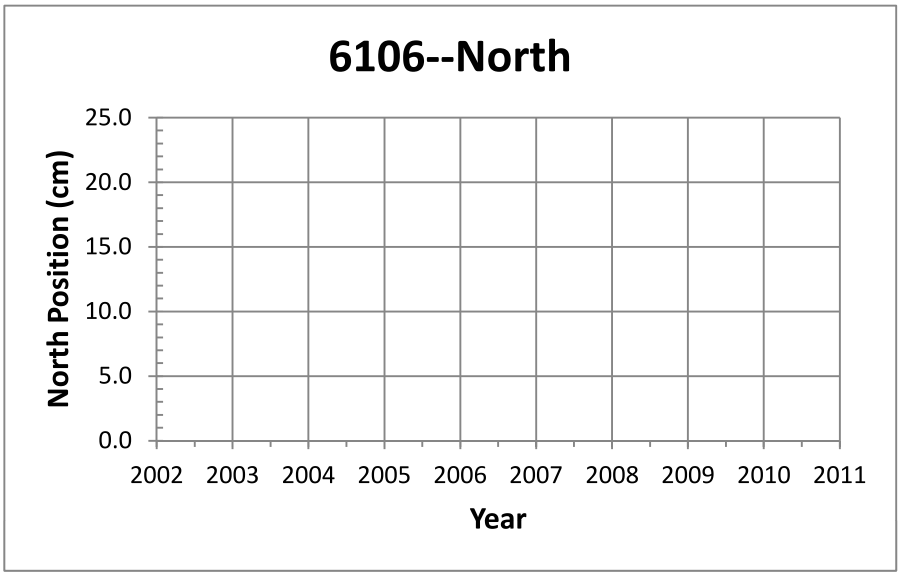
DATE	north position (cm)	east position (cm)
2002.9	0.00	0.00
2003.5	0.52	-1.23
2004	2.19	-1.21
2004.5	3.21	-2.32
2005.5	4.60	-5.40
2008.6	9.41	-9.45
2009.5	11.50	-10.61

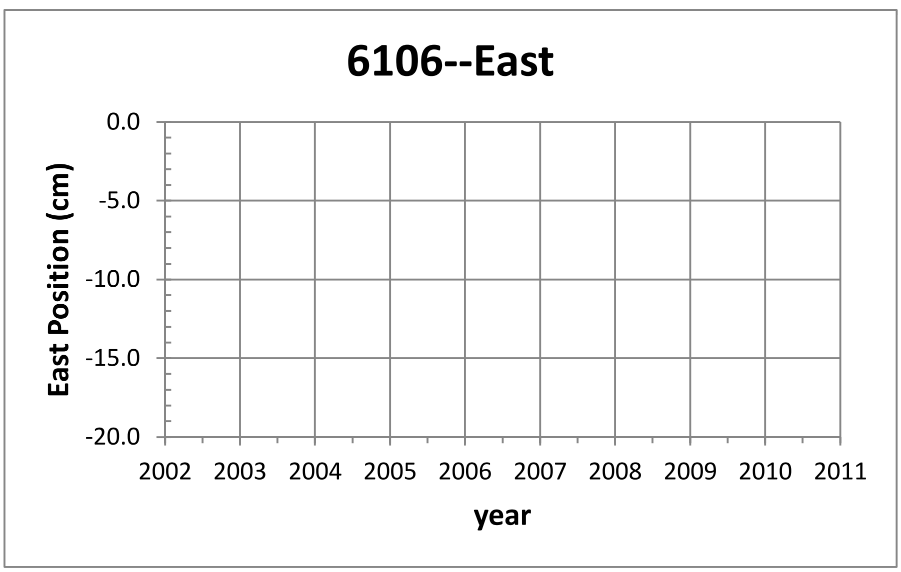




Site 6106

Year	North position (cm)	East position (cm)
2002.5	0.0	0.0
2003.5	1.5	-2.5
2004	4.0	-2.8
2004.5	5.1	-3.8
2005.5	6.1	-6.1
2009.5	15.9	-14.6
2010.5	19.2	-17.2





Site: NORCO

Year	North (cm)	East (cm)
2002.5	0.0	0.0
2002.9	1.1	-0.9
2003.5	2.6	-2.2
2004	3.7	-3.0
2004.5	4.8	-4.7
2005.5	7.2	-6.9