In [1]:

```
# Import packages
import pandas as pd # Reading csv file
from shapely.geometry import Point # Shapely for converting latitude/longtitude to ge
import geopandas as gpd # To create GeodataFrame
import matplotlib.pyplot as plt # for plotting
from pyproj import CRS
```

In [2]:

```
# import housing data
df_all = pd.read_csv('data/kc_house_data.csv')
df_all.head(10)
```

Out[2]:

| | id | date | price | bedrooms | bathrooms | sqft_living | sqft_lot | floors |
|---|---|---|---|---|---|---|---|---|
| **0** | 7129300520 | 10/13/2014 | 221900 | 3 | 1.00 | 1180 | 5650 | 1.0 |
| **1** | 6414100192 | 12/9/2014 | 538000 | 3 | 2.25 | 2570 | 7242 | 2.0 |
| **2** | 5631500400 | 2/25/2015 | 180000 | 2 | 1.00 | 770 | 10000 | 1.0 |
| **3** | 2487200875 | 12/9/2014 | 604000 | 4 | 3.00 | 1960 | 5000 | 1.0 |
| **4** | 1954400510 | 2/18/2015 | 510000 | 3 | 2.00 | 1680 | 8080 | 1.0 |
| **5** | 7237550310 | 5/12/2014 | 1230000 | 4 | 4.50 | 5420 | 101930 | 1.0 |
| **6** | 1321400060 | 6/27/2014 | 257500 | 3 | 2.25 | 1715 | 6819 | 2.0 |
| **7** | 2008000270 | 1/15/2015 | 291850 | 3 | 1.50 | 1060 | 9711 | 1.0 |
| **8** | 2414600126 | 4/15/2015 | 229500 | 3 | 1.00 | 1780 | 7470 | 1.0 |
| **9** | 3793500160 | 3/12/2015 | 323000 | 3 | 2.50 | 1890 | 6560 | 2.0 |

10 rows × 21 columns

In [3]:

```
# clean data--convert "NaN" to 0 and replace "?" with 0
df_all = df_all.fillna(0).replace('?',0)
df_all.head(10)
```

Out[3]:

| | id | date | price | bedrooms | bathrooms | sqft_living | sqft_lot | floors |
|---|---|---|---|---|---|---|---|---|
| **0** | 7129300520 | 10/13/2014 | 221900 | 3 | 1.00 | 1180 | 5650 | 1.0 |
| **1** | 6414100192 | 12/9/2014 | 538000 | 3 | 2.25 | 2570 | 7242 | 2.0 |
| **2** | 5631500400 | 2/25/2015 | 180000 | 2 | 1.00 | 770 | 10000 | 1.0 |
| **3** | 2487200875 | 12/9/2014 | 604000 | 4 | 3.00 | 1960 | 5000 | 1.0 |
| **4** | 1954400510 | 2/18/2015 | 510000 | 3 | 2.00 | 1680 | 8080 | 1.0 |
| **5** | 7237550310 | 5/12/2014 | 1230000 | 4 | 4.50 | 5420 | 101930 | 1.0 |
| **6** | 1321400060 | 6/27/2014 | 257500 | 3 | 2.25 | 1715 | 6819 | 2.0 |
| **7** | 2008000270 | 1/15/2015 | 291850 | 3 | 1.50 | 1060 | 9711 | 1.0 |
| **8** | 2414600126 | 4/15/2015 | 229500 | 3 | 1.00 | 1780 | 7470 | 1.0 |
| **9** | 3793500160 | 3/12/2015 | 323000 | 3 | 2.50 | 1890 | 6560 | 2.0 |

10 rows × 21 columns

In [4]:

```
# want to look at houses with two bedrooms or less
df = df_all[(df_all['bedrooms'] <= 2)]
df.info
```

Out[4]:

```
<bound method DataFrame.info of                  id        date   price  
bedrooms  bathrooms  sqft_living  \
2      5631500400   2/25/2015  180000         2       1.00          770
11     9212900260   5/27/2014  468000         2       1.00         1160
18       16000397   12/5/2014  189000         2       1.00         1200
23     8091400200   5/16/2014  252700         2       1.50         1070
31     2426039314   12/1/2014  280000         2       1.50         1190
...           ...         ...     ...       ...        ...          ...
21570  2767604724  10/15/2014  505000         2       2.50         1430
21572  2767600688  11/13/2014  414500         2       1.50         1210
21579  1972201967  10/31/2014  520000         2       2.25         1530
21594  1523300141   6/23/2014  402101         2       0.75         1020
21596  1523300157  10/15/2014  325000         2       0.75         1020

       sqft_lot  floors  waterfront  view  ...  grade  sqft_above  \
2         10000     1.0         0.0   0.0  ...      6         770
11         6000     1.0         0.0   0.0  ...      7         860
18         9850     1.0         0.0   0.0  ...      7        1200
23         9643     1.0         0.0   0.0  ...      7        1070
31         1265     3.0         0.0   0.0  ...      7        1190
...         ...     ...         ...   ...  ...    ...         ...
21570      1201     3.0         0.0   0.0  ...      8        1430
21572      1278     2.0         0.0   0.0  ...      8        1020
21579       981     3.0         0.0   0.0  ...      8        1480
21594      1350     2.0         0.0   0.0  ...      7        1020
21596      1076     2.0         0.0   0.0  ...      7        1020

      sqft_basement yr_built  yr_renovated  zipcode      lat     long  
\
2                 0     1933           0.0    98028  47.7379 -122.233
11              300     1942           0.0    98115  47.6900 -122.292
18                0     1921           0.0    98002  47.3089 -122.210
23                0     1985           0.0    98030  47.3533 -122.166
31                0     2005           0.0    98133  47.7274 -122.357
...             ...      ...           ...      ...      ...      ...
21570             0     2009           0.0    98107  47.6707 -122.381
21572           190     2007           0.0    98117  47.6756 -122.375
21579            50     2006           0.0    98103  47.6533 -122.346
21594             0     2009           0.0    98144  47.5944 -122.299
21596             0     2008           0.0    98144  47.5941 -122.299

       sqft_living15  sqft_lot15
2               2720        8062
```

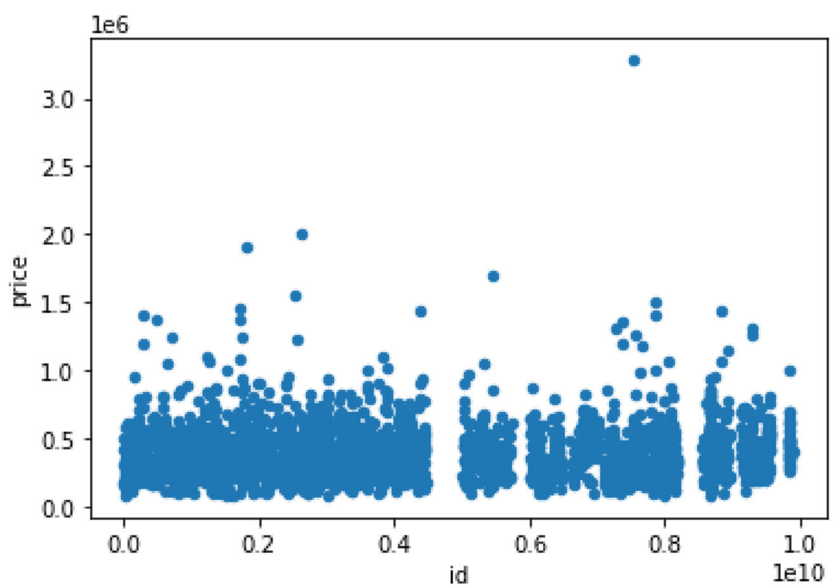
```
11              1330        6000
18              1060        5095
23              1220        8386
31              1390        1756
...              ...         ...
21570           1430        1249
21572           1210        1118
21579           1530        1282
21594           1020        2007
21596           1020        1357

[2956 rows x 21 columns]>
```

In [5]:

```
# want to look at price range
df.plot(kind='scatter', x='id', y='price')
```

Out[5]:

<AxesSubplot:xlabel='id', ylabel='price'>



In [6]:

```
# limit price range to less than $2 mill to remove obvious outlier
df = df[(df['price'] <= 2000000)]
df.info
```

Out[6]:

```
<bound method DataFrame.info of                 id        date   price
bedrooms  bathrooms  sqft_living  \
2      5631500400   2/25/2015  180000         2       1.00          770
11     9212900260   5/27/2014  468000         2       1.00         1160
18       16000397   12/5/2014  189000         2       1.00         1200
23     8091400200   5/16/2014  252700         2       1.50         1070
31     2426039314   12/1/2014  280000         2       1.50         1190
...           ...         ...     ...       ...        ...          ...
21570  2767604724  10/15/2014  505000         2       2.50         1430
21572  2767600688  11/13/2014  414500         2       1.50         1210
21579  1972201967  10/31/2014  520000         2       2.25         1530
21594  1523300141   6/23/2014  402101         2       0.75         1020
21596  1523300157  10/15/2014  325000         2       0.75         1020

       sqft_lot  floors  waterfront  view  ...  grade  sqft_above  \
2         10000     1.0         0.0   0.0  ...      6         770
11         6000     1.0         0.0   0.0  ...      7         860
18         9850     1.0         0.0   0.0  ...      7        1200
23         9643     1.0         0.0   0.0  ...      7        1070
31         1265     3.0         0.0   0.0  ...      7        1190
...         ...     ...         ...   ...  ...    ...         ...
21570      1201     3.0         0.0   0.0  ...      8        1430
21572      1278     2.0         0.0   0.0  ...      8        1020
21579       981     3.0         0.0   0.0  ...      8        1480
21594      1350     2.0         0.0   0.0  ...      7        1020
21596      1076     2.0         0.0   0.0  ...      7        1020

      sqft_basement yr_built  yr_renovated  zipcode      lat     long
\
2                 0     1933           0.0    98028  47.7379 -122.233
11              300     1942           0.0    98115  47.6900 -122.292
18                0     1921           0.0    98002  47.3089 -122.210
23                0     1985           0.0    98030  47.3533 -122.166
31                0     2005           0.0    98133  47.7274 -122.357
...             ...      ...           ...      ...      ...      ...
21570             0     2009           0.0    98107  47.6707 -122.381
21572           190     2007           0.0    98117  47.6756 -122.375
21579            50     2006           0.0    98103  47.6533 -122.346
21594             0     2009           0.0    98144  47.5944 -122.299
21596             0     2008           0.0    98144  47.5941 -122.299

       sqft_living15  sqft_lot15
2               2720        8062
```

```
11              1330        6000
18              1060        5095
23              1220        8386
31              1390        1756
...              ...         ...
21570           1430        1249
21572           1210        1118
21579           1530        1282
21594           1020        2007
21596           1020        1357

[2955 rows x 21 columns]>
```

In [7]:

```
# function to create GeoDataFrame
def add_geo_col(df):
    # create a geometry column
    geometry = [Point(xy) for xy in zip(df['long'], df['lat'])]

    # Coordinate reference system : WGS84 (the GPS model for conversion)
    crs = CRS('epsg:4326')

    # Creating a Geographic data frame
    gdf = gpd.GeoDataFrame(df, crs=crs, geometry=geometry).reset_index()
    return gdf
```

In [8]:

```
gdf = add_geo_col(df)
gdf.head()
```

Out[8]:

| | index | id | date | price | bedrooms | bathrooms | sqft_living | sqft_lot | flo |
|---|---|---|---|---|---|---|---|---|---|
| **0** | 2 | 5631500400 | 2/25/2015 | 180000 | 2 | 1.0 | 770 | 10000 | |
| **1** | 11 | 9212900260 | 5/27/2014 | 468000 | 2 | 1.0 | 1160 | 6000 | |
| **2** | 18 | 16000397 | 12/5/2014 | 189000 | 2 | 1.0 | 1200 | 9850 | |
| **3** | 23 | 8091400200 | 5/16/2014 | 252700 | 2 | 1.5 | 1070 | 9643 | |
| **4** | 31 | 2426039314 | 12/1/2014 | 280000 | 2 | 1.5 | 1190 | 1265 | |

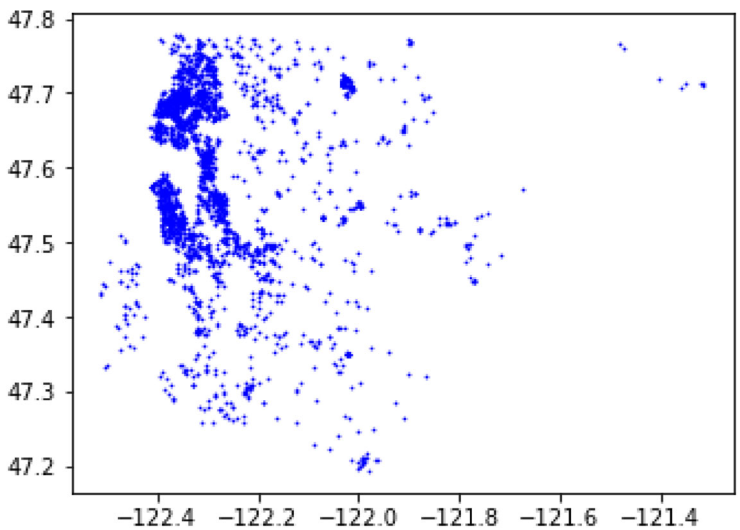
5 rows × 23 columns

In [9]:

```
# Plot all points
gdf.plot(marker='o', color='b', markersize=0.5)
```

Out[9]:

<AxesSubplot:>



In [10]:

```
# check what projection is used
gdf.crs
```

Out[10]:

```
<Geographic 2D CRS: EPSG:4326>
Name: WGS 84
Axis Info [ellipsoidal]:
- Lat[north]: Geodetic latitude (degree)
- Lon[east]: Geodetic longitude (degree)
Area of Use:
- name: World
- bounds: (-180.0, -90.0, 180.0, 90.0)
Datum: World Geodetic System 1984
- Ellipsoid: WGS 84
- Prime Meridian: Greenwich
```

In [11]:

```
# function to convert meters to miles
def m_2_mi(meters):
    return meters * 0.00062137
```

In [12]:

```
# function to find distance between two Points
def dist_to_point(point1, point2):
    pt1_gdf = gpd.GeoSeries([point1], crs=4326)
    pt2_gdf = gpd.GeoSeries([point2], crs=4326)
    pt1_gdf = pt1_gdf.to_crs(3857)
    pt2_gdf = pt2_gdf.to_crs(3857)
    distance = m_2_mi(pt1_gdf.distance(pt2_gdf))
    return round(distance.at[0], 3)
```

In [13]:

```
# Want to compile list of top 5 employers in Seattle area with a centralized campus
# Source is https://www.huduser.gov/portal/publications/pdf/SeattleWA-CHMA-19.pdf
df_top10_employers = pd.read_csv('data/top_employers.csv')
df_central5 = df_top10_employers[df_top10_employers['centralized_campus']=='y'].reset_
df_central5 = add_geo_col(df_central5)
df_central5
```

Out[13]:

| | level_0 | index | rank | employer | no_employees | long | lat | centralized |
|---|---|---|---|---|---|---|---|---|
| **0** | 0 | 0 | 1 | The Boeing Company | 64,300 | -122.312023 | 47.532685 | |
| **1** | 1 | 1 | 2 | Amazon.com, Inc. | 45,000 | -122.339688 | 47.615875 | |
| **2** | 2 | 2 | 3 | Microsoft Corporation | 43,031 | -122.339688 | 47.645744 | |
| **3** | 3 | 3 | 4 | University of Washington | 30,200 | -122.303644 | 47.655544 | |
| **4** | 4 | 7 | 8 | Starbucks Corporation | 11,239 | -122.336000 | 47.580700 | |

In [14]:

```
# function to find the average distance of a house to the top 5 employers
def avg_dists(point1, gdf):
    dists = [dist_to_point(point1, point2) for point2 in gdf['geometry']]
    avg = sum(dists)/len(dists)
    return avg
```

In [15]:

```
downtown = Point(-122.3344, 47.6050) # coordinates for center of downtown Seattle

# Calculate average distance of each property to central downtown
gdf['dist_2_downtown'] = [dist_to_point(point, downtown) for point in gdf['geometry']]
```

In [16]:

```
# Calculate average distance of each property to the top 5 employers
gdf['avg_dists'] = [avg_dists(point, df_central5) for point in gdf['geometry']]
```

In [17]:

```
gdf.head()
```

Out[17]:

| | index | id | date | price | bedrooms | bathrooms | sqft_living | sqft_lot | flo |
|---|---|---|---|---|---|---|---|---|---|
| **0** | 2 | 5631500400 | 2/25/2015 | 180000 | 2 | 1.0 | 770 | 10000 | |
| **1** | 11 | 9212900260 | 5/27/2014 | 468000 | 2 | 1.0 | 1160 | 6000 | |
| **2** | 18 | 16000397 | 12/5/2014 | 189000 | 2 | 1.0 | 1200 | 9850 | |
| **3** | 23 | 8091400200 | 5/16/2014 | 252700 | 2 | 1.5 | 1070 | 9643 | |
| **4** | 31 | 2426039314 | 12/1/2014 | 280000 | 2 | 1.5 | 1190 | 1265 | |

5 rows × 25 columns

In [18]:

```
gdf.to_pickle('data/geodata.pkl')
```