CSCI 5901 - Process of Data Science - Assignment 3

Team Members

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In [1]:
```
from rtree import index
from rtree.index import Rtree
p = index.Property()
idx = index.Index(properties=p)
idx
```

Out[1]:
```
<rtree.index.Index at 0x1a890a48f98>
```

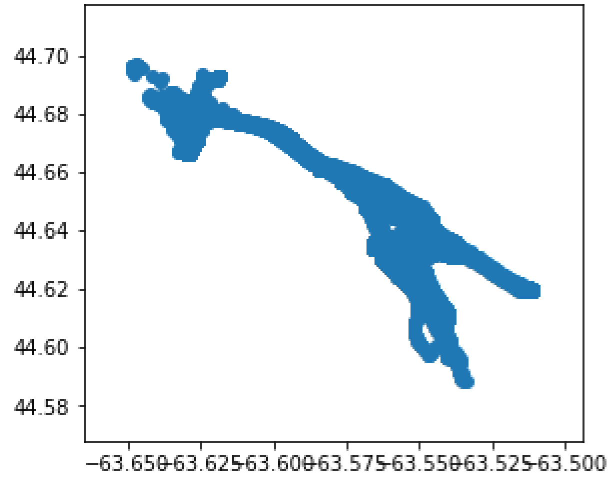
In [2]:
```
import geopandas as gpd
import numpy as np
import pandas as pd
from shapely.geometry import Point
import shapely
import missingno as msn
import seaborn as sns
import matplotlib.pyplot as plt

% matplotlib inline
```

1. Find all the vessels that visited ports in the provided shapefile (Nima_Ports.Zip). For this part, you are going to create a buffer with an appropriate radius around the shape of each all polygons in the shapefile. Second, you are going to find all the AIS messages (from AIS data) that intersect with these ports. (20 points)

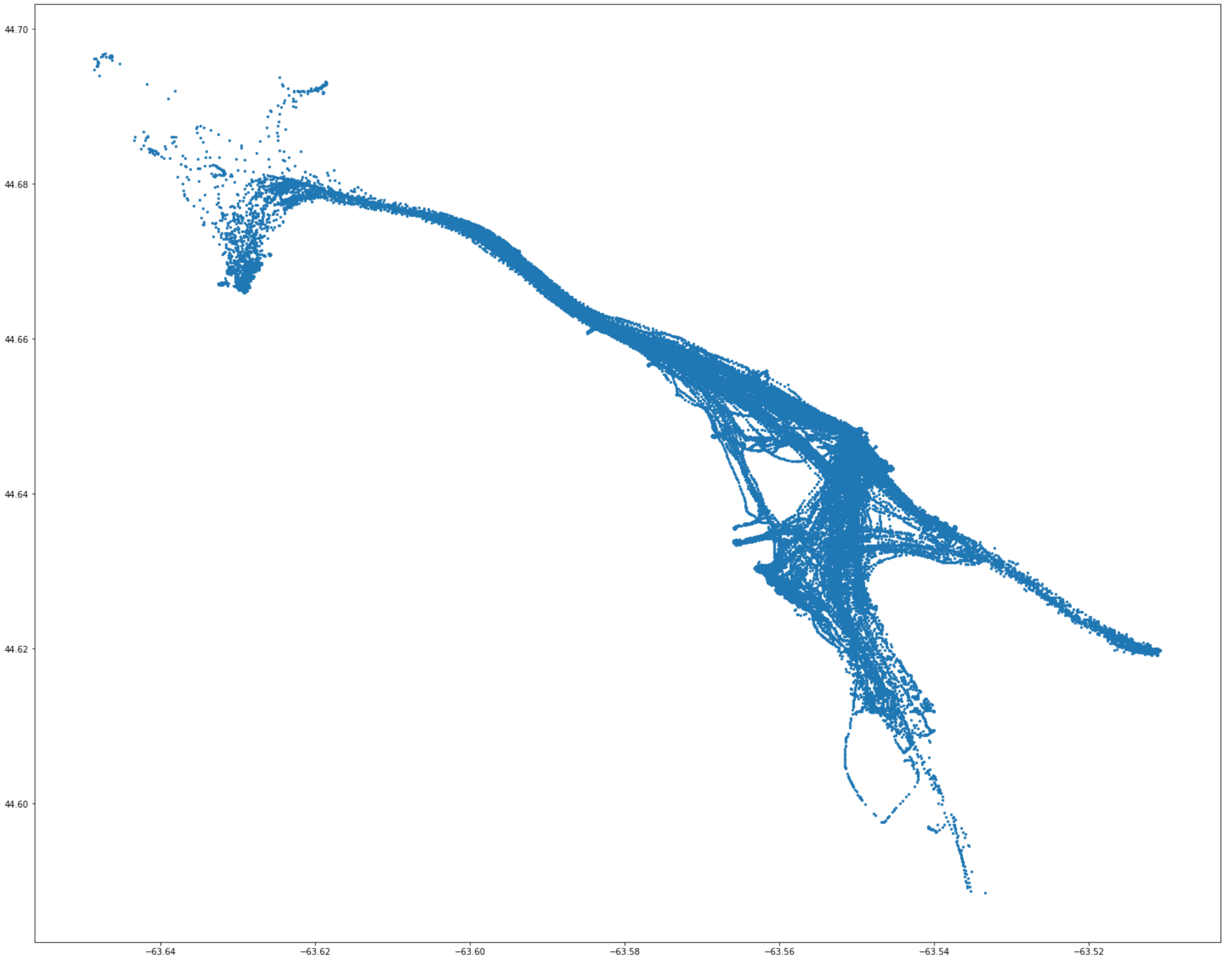
In [3]:
```
#In this cell we are reading the AISData file and Converting them into GeoDataFra
df=pd.read_csv('AISData.csv')
gdf = gpd.GeoDataFrame(df.drop(['location.coordinates.0', 'location.coordinates.1
crs={'init': 'epsg:4326'},
geometry=[shapely.geometry.Point(xy) for xy in zip(df['location.coordinates.0'],
```

In [4]:
```
# Here we are plotting from csv data with location coordinates

gdf.plot()
```

Out[4]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1a890a48e80>
```



In [5]:
```
ax=gdf.plot(figsize=(25,25),markersize=5)
```



In [6]:

```
# Here we are reading the shape file to get the ports

halifax=gpd.read_file('assignment3shapefile.shp')
halifax.head()
```

Out[6]:

	field_1	port_name	size	geometry
0	0	pointpolygon	0.0000	POLYGON ((-63.59160304069519 44.6649292254607,...
1	1	port1	0.0018	POLYGON ((-63.569431 44.649993, -63.5694396674...
2	2	port2	0.0018	POLYGON ((-63.60949000000001 44.675853, -63.60...
3	3	ind	0.0000	POLYGON ((-63.54742169380188 44.64697911403847...
4	4	port5	0.0018	POLYGON ((-63.568048 44.663875, -63.5680566674...

In [8]:

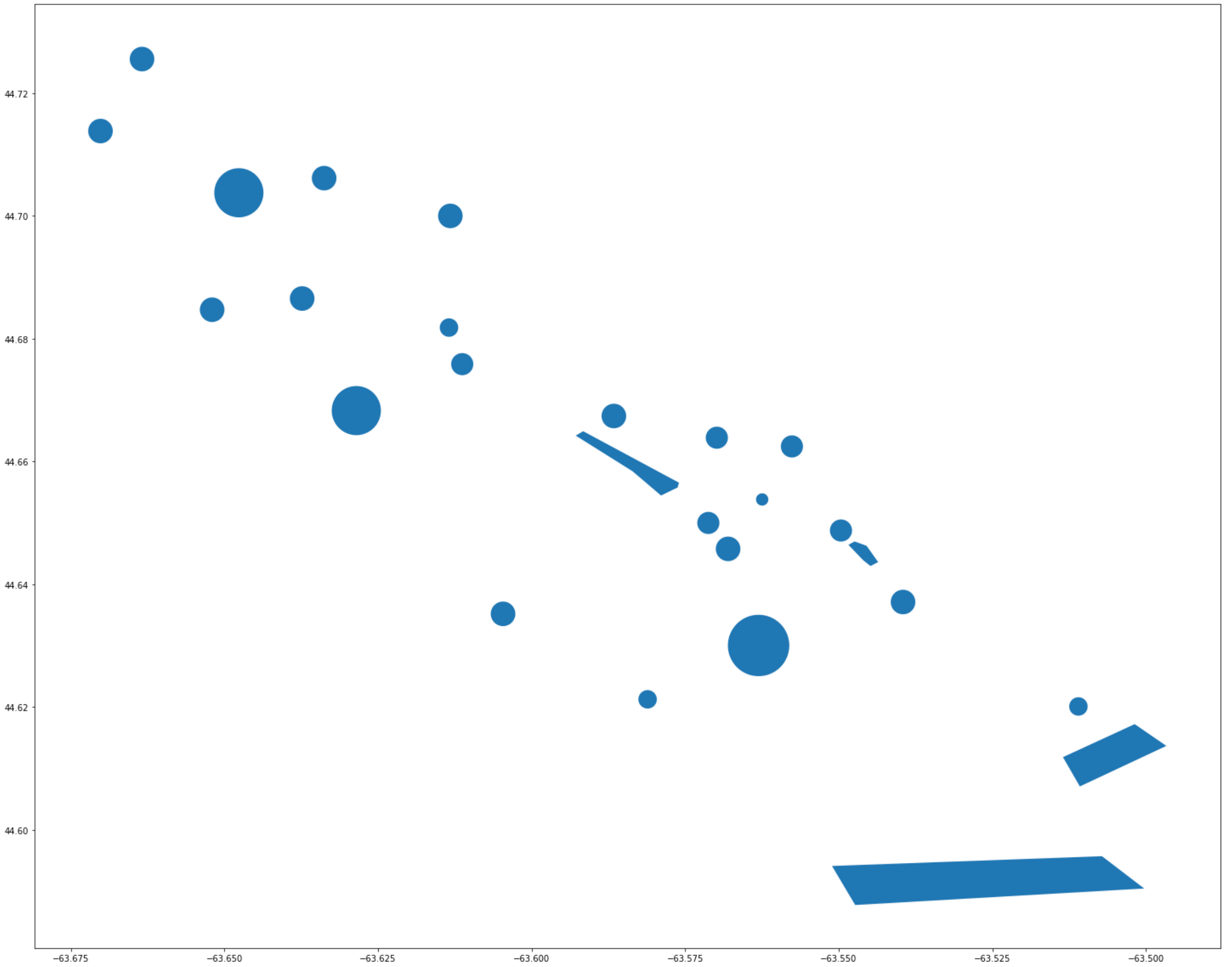
```
bylaw=halifax.set_index(['port_name']) # Here we are assigning the port names to
```

In [9]:

```
bylaw.plot(figsize=(25,25))
```

Out[9]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1a8c6268630>
```

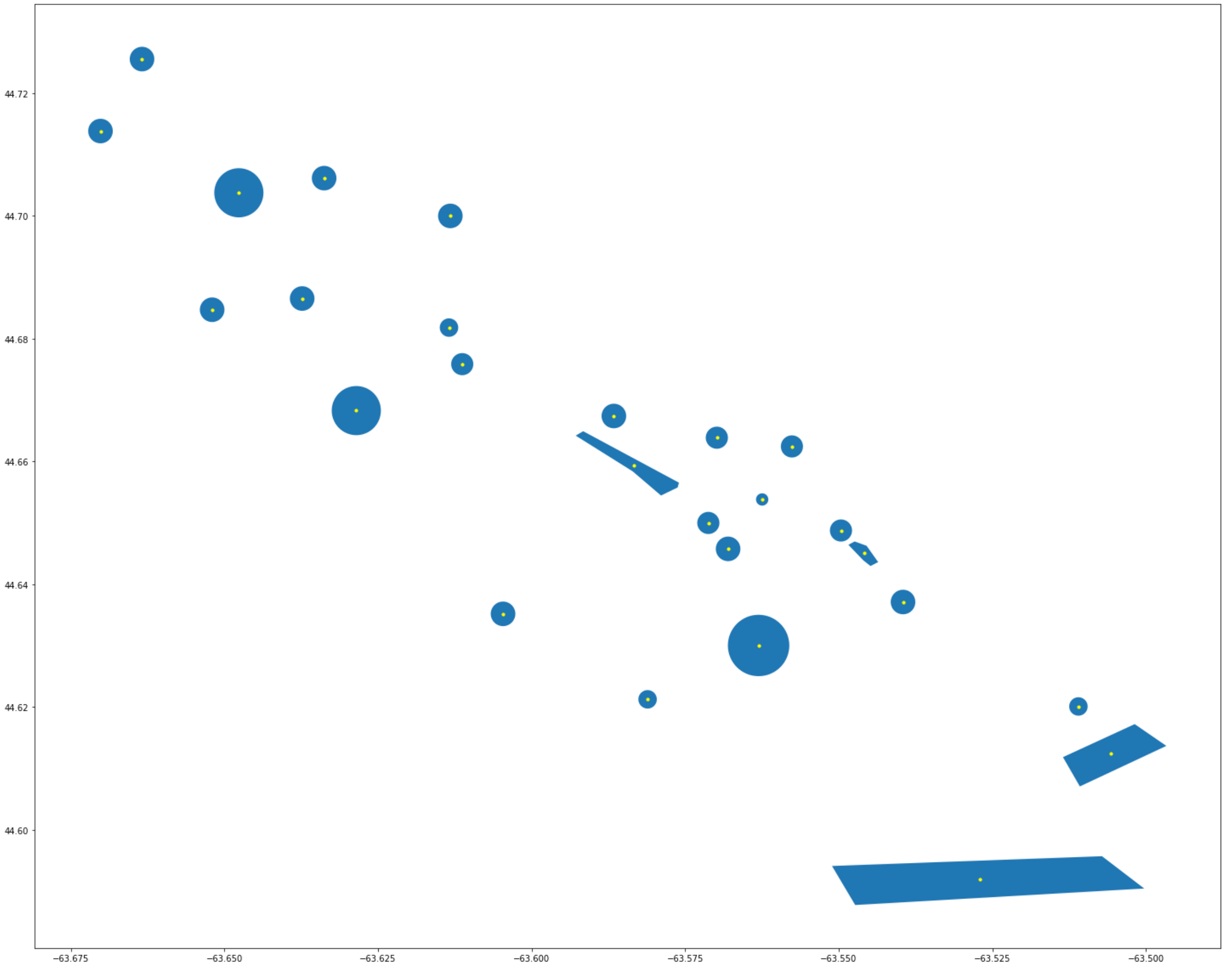


In [10]:

```
# Getting the centroid for all ports

d1=bylaw.loc[['pointpolygon'],:].centroid #centroid for the first port
d2=bylaw.loc[['port1'],:].centroid
d3=bylaw.loc[['port2'],:].centroid
d4=bylaw.loc[['ind'],:].centroid
d5=bylaw.loc[['port5'],:].centroid
d6=bylaw.loc[['port6'],:].centroid
d7=bylaw.loc[['port7'],:].centroid
d8=bylaw.loc[['south_enterance'],:].centroid
d9=bylaw.loc[['auto_port'],:].centroid
d10=bylaw.loc[['southend container terminal'],:].centroid
d11=bylaw.loc[['NN Jetty'],:].centroid
d12=bylaw.loc[['Bills island'],:].centroid
d13=bylaw.loc[['mid bedford'],:].centroid
d14=bylaw.loc[['Fairview cove'],:].centroid
d15=bylaw.loc[['armament'],:].centroid
d16=bylaw.loc[['waterfront h'],:].centroid
d17=bylaw.loc[['northarm'],:].centroid
d18=bylaw.loc[['p111'],:].centroid
d19=bylaw.loc[['pp'],:].centroid
d20=bylaw.loc[['po001'],:].centroid
d21=bylaw.loc[['po002'],:].centroid
d22=bylaw.loc[['oulier_maybecday'],:].centroid
d23=bylaw.loc[['p003'],:].centroid
d24=bylaw.loc[['enter2'],:].centroid
d25=bylaw.loc[['p009'],:].centroid
d26=bylaw.loc[['p010'],:].centroid

# plotting the ports
ax=bylaw.loc[['pointpolygon', 'port1', 'port2', 'ind', 'port5', 'port6', 'port7',
       'NN Jetty', 'Bills island', 'mid bedford', 'Fairview cove','armament', 'wa
       'po002', 'oulier_maybecday', 'p003', 'enter2', 'p009', 'p010'],:].plot(fig

#plptting the yellow center points
gpd.GeoSeries([d1[0],d2[0],d3[0],d4[0],d5[0],d6[0],d7[0],d8[0],d9[0],d10[0],d11[0
              ,d19[0],d20[0],d21[0],d22[0],d23[0],d24[0],d25[0],d26[0]]).plot(ax=
```

Out[10]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1a8bc1ef940>
```

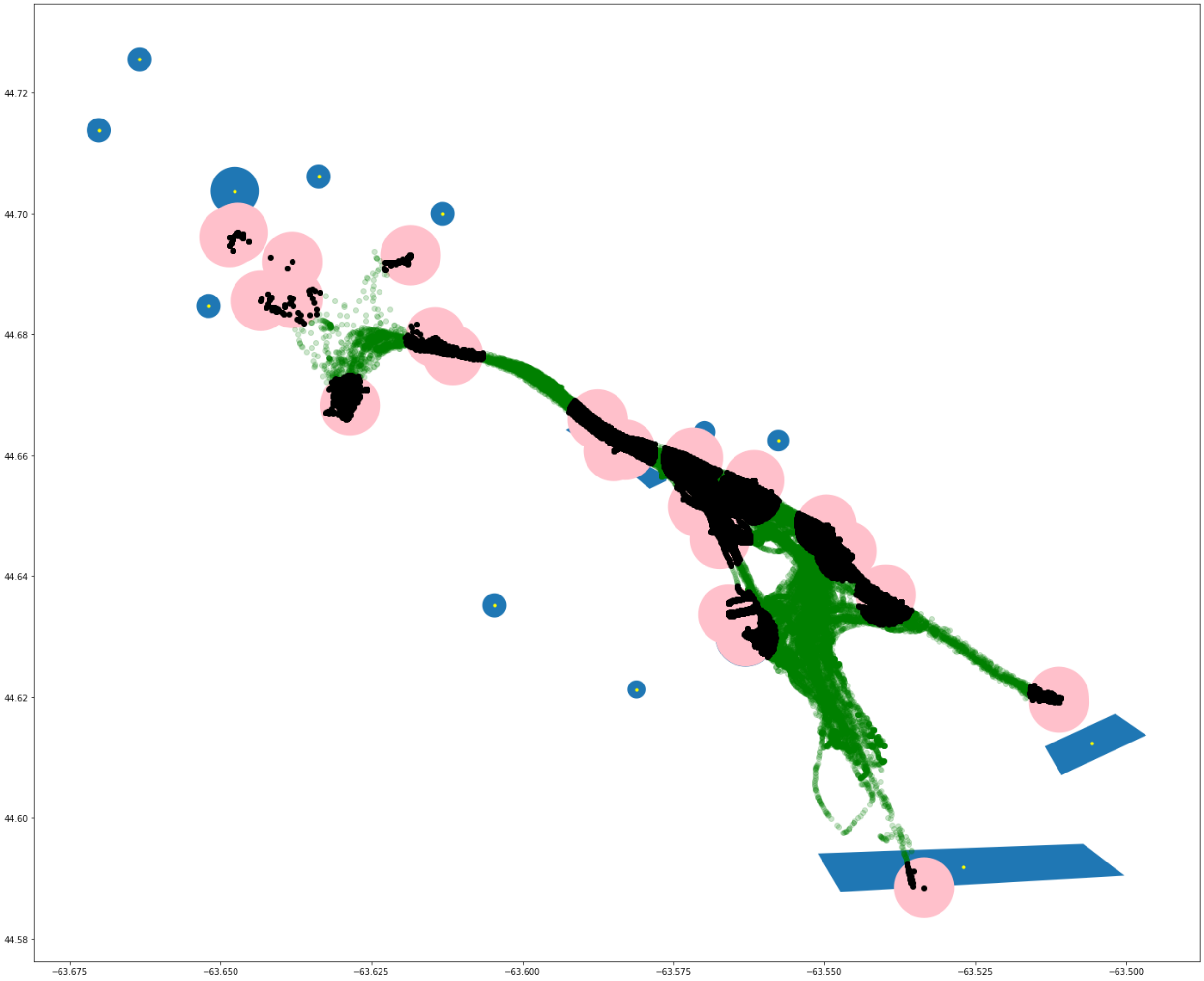

44.72
44.70
44.68
44.66
44.64
44.62
44.60
−63.675
−63.650
−63.625
−63.600
−63.575
−63.550
−63.525
−63.500

In [11]:

```
p1=gdf.loc[gdf.distance(d1[0])==gdf.distance(d1[0]).min(),:]
p2=gdf.loc[gdf.distance(d2[0])==gdf.distance(d2[0]).min(),:]
p3=gdf.loc[gdf.distance(d3[0])==gdf.distance(d3[0]).min(),:]
p4=gdf.loc[gdf.distance(d4[0])==gdf.distance(d4[0]).min(),:]
p5=gdf.loc[gdf.distance(d5[0])==gdf.distance(d5[0]).min(),:]
p6=gdf.loc[gdf.distance(d6[0])==gdf.distance(d6[0]).min(),:]
p7=gdf.loc[gdf.distance(d7[0])==gdf.distance(d7[0]).min(),:]
p8=gdf.loc[gdf.distance(d8[0])==gdf.distance(d8[0]).min(),:]
p9=gdf.loc[gdf.distance(d9[0])==gdf.distance(d9[0]).min(),:]
p10=gdf.loc[gdf.distance(d10[0])==gdf.distance(d10[0]).min(),:]
p11=gdf.loc[gdf.distance(d11[0])==gdf.distance(d11[0]).min(),:]
p12=gdf.loc[gdf.distance(d12[0])==gdf.distance(d12[0]).min(),:]
p13=gdf.loc[gdf.distance(d13[0])==gdf.distance(d13[0]).min(),:]
p14=gdf.loc[gdf.distance(d14[0])==gdf.distance(d14[0]).min(),:]
p15=gdf.loc[gdf.distance(d15[0])==gdf.distance(d15[0]).min(),:]
p16=gdf.loc[gdf.distance(d16[0])==gdf.distance(d16[0]).min(),:]
p17=gdf.loc[gdf.distance(d17[0])==gdf.distance(d17[0]).min(),:]
p18=gdf.loc[gdf.distance(d18[0])==gdf.distance(d18[0]).min(),:]
p19=gdf.loc[gdf.distance(d19[0])==gdf.distance(d19[0]).min(),:]
p20=gdf.loc[gdf.distance(d20[0])==gdf.distance(d20[0]).min(),:]
p21=gdf.loc[gdf.distance(d21[0])==gdf.distance(d21[0]).min(),:]
p22=gdf.loc[gdf.distance(d22[0])==gdf.distance(d22[0]).min(),:]
p23=gdf.loc[gdf.distance(d23[0])==gdf.distance(d23[0]).min(),:]
p24=gdf.loc[gdf.distance(d24[0])==gdf.distance(d24[0]).min(),:]
p25=gdf.loc[gdf.distance(d25[0])==gdf.distance(d25[0]).min(),:]
p26=gdf.loc[gdf.distance(d26[0])==gdf.distance(d26[0]).min(),:]



# creating buffer on the buffer with 5km radius
ax=bylaw.loc[['pointpolygon', 'port1', 'port2', 'ind', 'port5', 'port6', 'port7',
              'southend container terminal','NN Jetty', 'Bills island', 'mid bedf
              'waterfront h', 'northarm', 'plll', 'pp', 'po001','po002', 'oulier_
              'p009', 'p010'],:].plot(figsize=(25,25))
gpd.GeoSeries([d1[0],d2[0],d3[0],d4[0],d5[0],d6[0],d7[0],d8[0],d9[0],d10[0],d11[0
               d16[0],d17[0],d18[0],d19[0],d20[0],d21[0],d22[0],d23[0],d24[0],d25
               d26[0]]).plot(ax=ax,color='yellow',markersize=10)

p1=p1.iloc[0,:].geometry.buffer(0.005)
p2=p2.iloc[0,:].geometry.buffer(0.005)
p3=p3.iloc[0,:].geometry.buffer(0.005)
p4=p4.iloc[0,:].geometry.buffer(0.005)
p5=p5.iloc[0,:].geometry.buffer(0.005) # getting the buffer with 5km radius for t
p6=p6.iloc[0,:].geometry.buffer(0.005)
p7=p7.iloc[0,:].geometry.buffer(0.005)
p8=p8.iloc[0,:].geometry.buffer(0.005)
p9=p9.iloc[0,:].geometry.buffer(0.005)
p10=p10.iloc[0,:].geometry.buffer(0.005)
p11=p11.iloc[0,:].geometry.buffer(0.005)
p12=p12.iloc[0,:].geometry.buffer(0.005)
p13=p13.iloc[0,:].geometry.buffer(0.005)
p14=p14.iloc[0,:].geometry.buffer(0.005)
p15=p15.iloc[0,:].geometry.buffer(0.005)
p16=p16.iloc[0,:].geometry.buffer(0.005)
p17=p17.iloc[0,:].geometry.buffer(0.005)
p18=p18.iloc[0,:].geometry.buffer(0.005)
p19=p19.iloc[0,:].geometry.buffer(0.005)
```

```
p20=p20.iloc[0,:].geometry.buffer(0.005)
p21=p21.iloc[0,:].geometry.buffer(0.005)
p22=p22.iloc[0,:].geometry.buffer(0.005)
p23=p23.iloc[0,:].geometry.buffer(0.005)
p24=p24.iloc[0,:].geometry.buffer(0.005)
p25=p25.iloc[0,:].geometry.buffer(0.005)
p26=p26.iloc[0,:].geometry.buffer(0.005)

# plotting the buffer radius near ports

gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,p19
gdf.plot(ax=ax,color='g',alpha=0.2)
gdf.loc[gdf.within(p1),:].plot(ax=ax,color='k')
gdf.loc[gdf.within(p2),:].plot(ax=ax,color='k')
gdf.loc[gdf.within(p3),:].plot(ax=ax,color='k')
gdf.loc[gdf.within(p4),:].plot(ax=ax,color='k')
gdf.loc[gdf.within(p5),:].plot(ax=ax,color='k')
gdf.loc[gdf.within(p6),:].plot(ax=ax,color='k')
gdf.loc[gdf.within(p7),:].plot(ax=ax,color='k')
gdf.loc[gdf.within(p8),:].plot(ax=ax,color='k')
gdf.loc[gdf.within(p9),:].plot(ax=ax,color='k')
gdf.loc[gdf.within(p10),:].plot(ax=ax,color='k')
gdf.loc[gdf.within(p11),:].plot(ax=ax,color='k')
gdf.loc[gdf.within(p12),:].plot(ax=ax,color='k')
gdf.loc[gdf.within(p13),:].plot(ax=ax,color='k')
gdf.loc[gdf.within(p14),:].plot(ax=ax,color='k')
gdf.loc[gdf.within(p15),:].plot(ax=ax,color='k')
gdf.loc[gdf.within(p16),:].plot(ax=ax,color='k')
gdf.loc[gdf.within(p17),:].plot(ax=ax,color='k')
gdf.loc[gdf.within(p18),:].plot(ax=ax,color='k')
gdf.loc[gdf.within(p19),:].plot(ax=ax,color='k')
gdf.loc[gdf.within(p20),:].plot(ax=ax,color='k')
gdf.loc[gdf.within(p21),:].plot(ax=ax,color='k')
gdf.loc[gdf.within(p22),:].plot(ax=ax,color='k')
gdf.loc[gdf.within(p23),:].plot(ax=ax,color='k')
gdf.loc[gdf.within(p24),:].plot(ax=ax,color='k')
gdf.loc[gdf.within(p25),:].plot(ax=ax,color='k')
gdf.loc[gdf.within(p26),:].plot(ax=ax,color='k')
```

```
Out[11]: <matplotlib.axes._subplots.AxesSubplot at 0x1a8bc2b9a90>
```

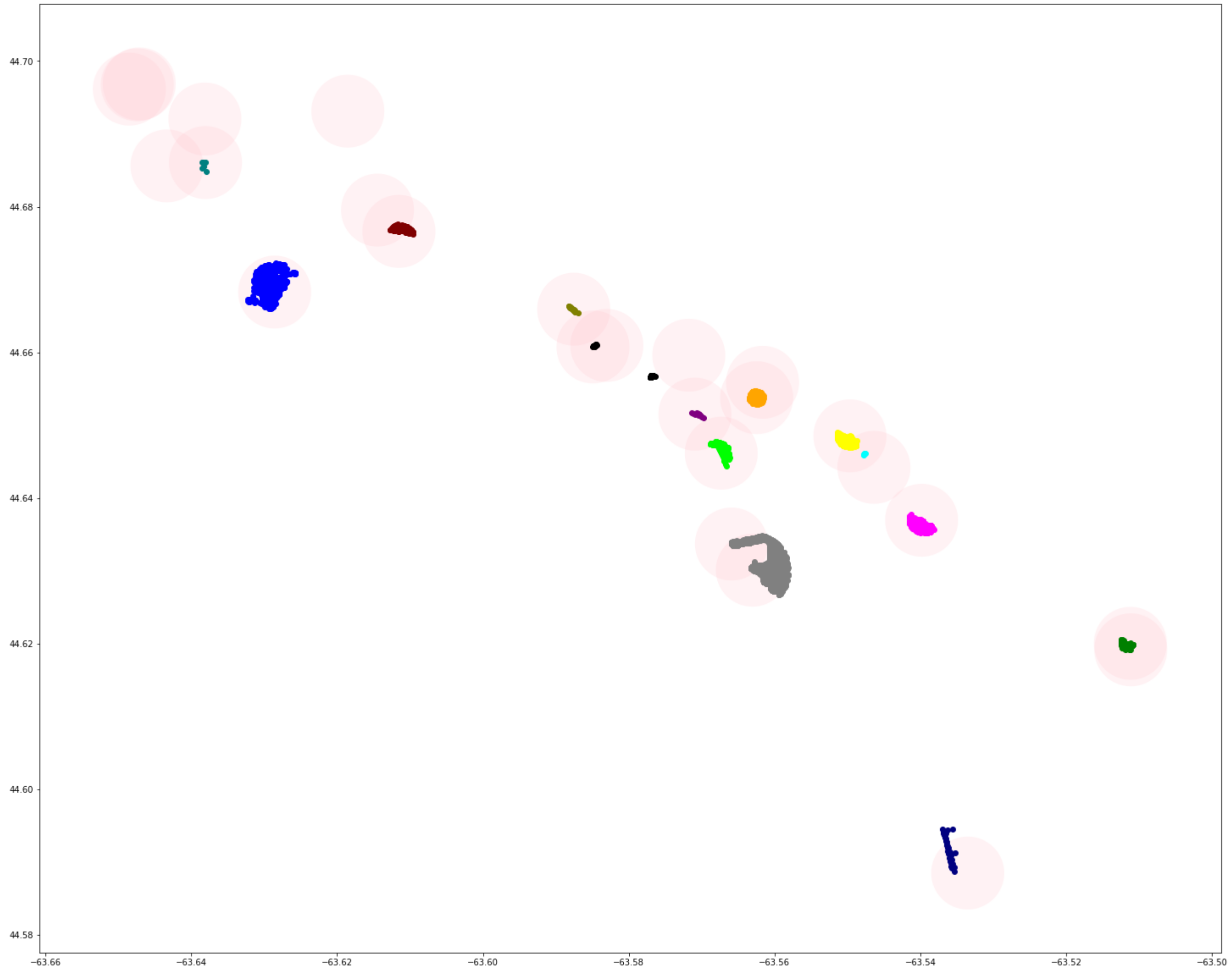


2. Show the density (i.e., density is the number of AIS messages in a port), of each port on a map by using a colour-coded map. (20 points)

In [12]:

```
# In this cell we are finding the intersection of vessels with the ports
#in the 5km radius

joinres=gpd.sjoin(gdf,bylaw,op='within',how='left')
col=['r','b','g','k','yellow','orange','Olive','Maroon','Purple','Fuchsia','Lime'
i=0
ax=gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,


for g in set(joinres['index_right']):
  tmp=joinres.loc[joinres['index_right']==g,:]
  if tmp.shape[0]>0:
    tmp.plot(ax=ax,color=col[i])
  i=i+1
```

```
C:\Users\lanch\Anaconda3\lib\site-packages\geopandas\tools\sjoin.py:44: UserWar
ning: CRS of frames being joined does not match!
  warn('CRS of frames being joined does not match!')
```



3. Now divide the AIS data into data frames with a one-hour interval. Repeat steps 1 and 2 for all of the sub-dataframes. Here each data frame has only information of one hour. Note that if step 1 and 2 you are using the whole AIS data as a one-time interval. In step 3, you are repeating steps 1 and 2 for all of the one-hour intervals. This can generate many

plots that you are going to visualize them. You can save all the plots with proper name and title in a folder or generate a matplotlib animation to visualize it. (20 points)

In [14]:
```
# Loading the csv file

df=pd.read_csv('AISData.csv')
gdf0 = gpd.GeoDataFrame(df.drop(['location.coordinates.0', 'location.coordinates.
crs={'init': 'epsg:4326'},
geometry=[shapely.geometry.Point(xy) for xy in zip(df['location.coordinates.0'],
```

In [15]:
```
df['event_time']=pd.to_datetime(df['event_time'])  # converting the event_time st
df.drop(['Unnamed: 0'],axis=1,inplace=True)  # droping the Unnamed column
df['hour'] = df['event_time'].dt.hour   # creating a new column with values of ho
df.head()
```

Out[15]:

	event_time	location.coordinates.0	location.coordinates.1	position_accuracy	mms
0	2019-04-11 09:47:30.153000+00:00	-63.556082	44.624835	0.0	31601380
1	2019-04-11 09:47:27.273000+00:00	-63.556053	44.624817	0.0	31601380
2	2019-04-11 09:47:34.340000+00:00	-63.556138	44.624868	0.0	31601380
3	2019-04-11 09:47:37.087000+00:00	-63.556187	44.624898	0.0	31601380
4	2019-04-19 09:52:19.358000+00:00	-63.555998	44.624883	0.0	31601380

In [16]:
```
ho = []
for i in range(24):
  ho.append('df_h'+str(i))  # creating a dataframe names
d = {}
for i,name in enumerate(ho):
  d[name] = pd.DataFrame()  # creating a dataframe for each hour
  d[name] = df[df['hour']==i]  # assingning the dataframe for each time interval
```

In [17]:

```
# displaying the number of rows for each hour in each dataframe.

for i,name in enumerate(ho):
  print(i,'hour dataframe', name, 'has',len(d[name]),'rows')
```

```
0 hour dataframe df_h0 has 31899 rows
1 hour dataframe df_h1 has 32367 rows
2 hour dataframe df_h2 has 33209 rows
3 hour dataframe df_h3 has 32699 rows
4 hour dataframe df_h4 has 32541 rows
5 hour dataframe df_h5 has 32312 rows
6 hour dataframe df_h6 has 31873 rows
7 hour dataframe df_h7 has 31246 rows
8 hour dataframe df_h8 has 31729 rows
9 hour dataframe df_h9 has 27980 rows
10 hour dataframe df_h10 has 29939 rows
11 hour dataframe df_h11 has 32681 rows
12 hour dataframe df_h12 has 32808 rows
13 hour dataframe df_h13 has 33073 rows
14 hour dataframe df_h14 has 33250 rows
15 hour dataframe df_h15 has 32120 rows
16 hour dataframe df_h16 has 32281 rows
17 hour dataframe df_h17 has 31733 rows
18 hour dataframe df_h18 has 32393 rows
19 hour dataframe df_h19 has 30319 rows
20 hour dataframe df_h20 has 29485 rows
21 hour dataframe df_h21 has 31261 rows
22 hour dataframe df_h22 has 34368 rows
23 hour dataframe df_h23 has 33105 rows
```

In [18]:

```
d['df_h1'].tail() # displaying dataframe with time interval at 1 O'clock
```

Out[18]:

	event_time	location.coordinates.0	location.coordinates.1	position_accuracy	
766641	2019-06-11 01:19:45.339000+00:00	-63.549448	44.648083	0.0	316(
766642	2019-06-11 01:19:54.725000+00:00	-63.549452	44.648085	0.0	316(
766655	2019-05-29 01:52:33.904000+00:00	-63.549472	44.648048	0.0	316(
766657	2019-05-29 01:52:21.984000+00:00	-63.549428	44.648043	0.0	316(
766662	2019-05-29 01:59:33.302000+00:00	-63.549478	44.648003	0.0	316(

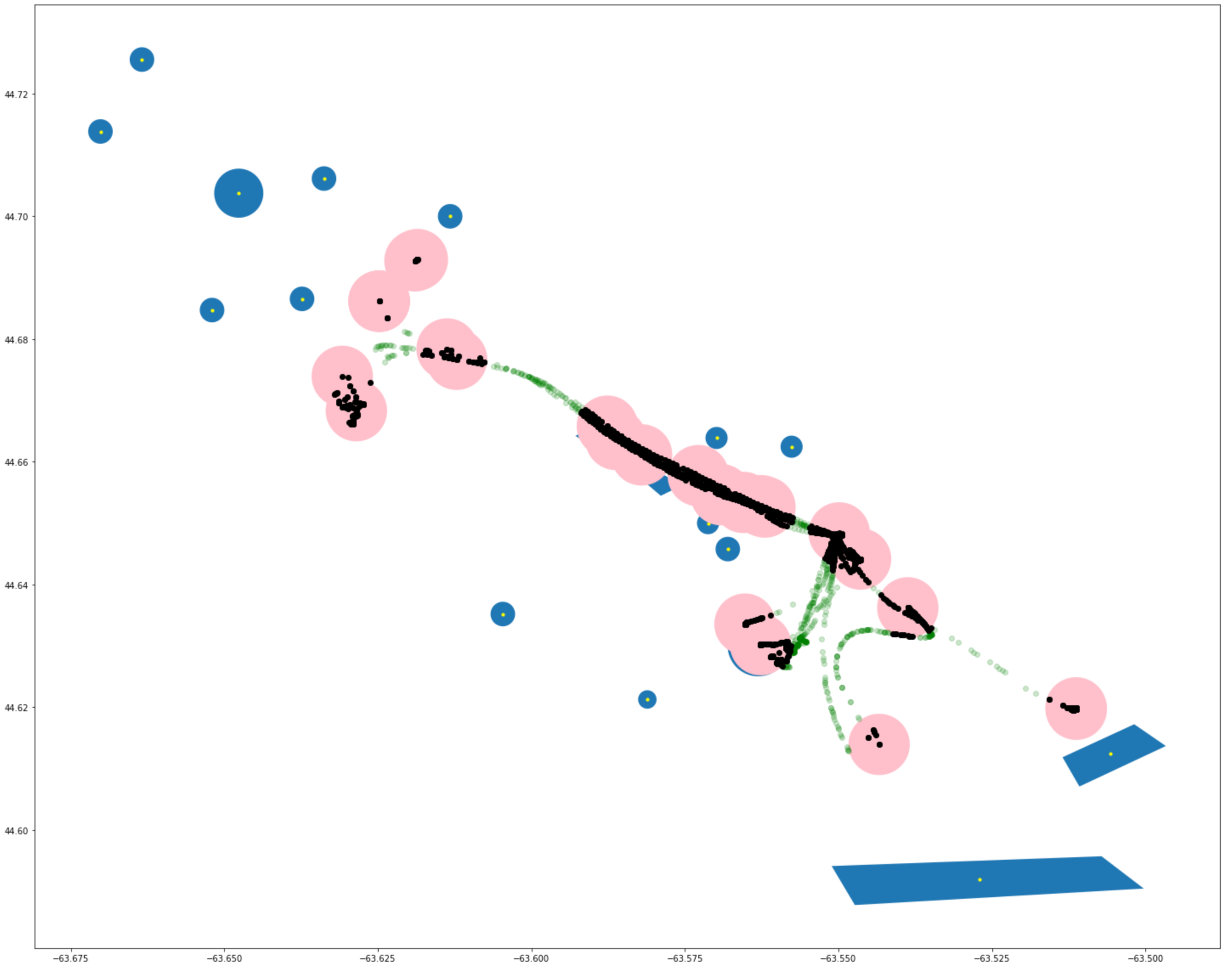
0th interval

In [19]:
```
gdf0 = gpd.GeoDataFrame(d['df_h0'].drop(['location.coordinates.0', 'location.coor
crs={'init': 'epsg:4326'},
geometry=[shapely.geometry.Point(xy) for xy in zip(d['df_h0']['location.coordinat
```

In [26]:

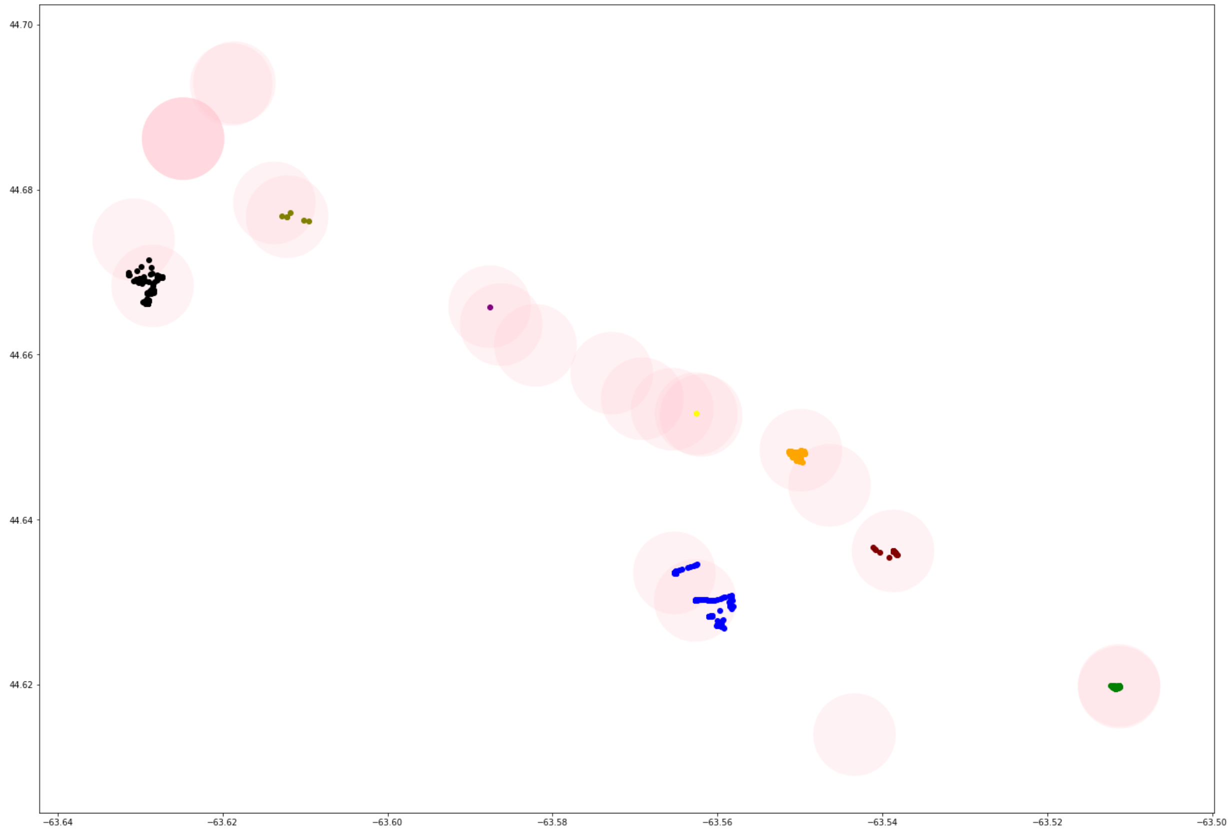
```
p1=gdf0.loc[gdf0.distance(d1[0])==gdf0.distance(d1[0]).min(),:]
p2=gdf0.loc[gdf0.distance(d2[0])==gdf0.distance(d2[0]).min(),:]
p3=gdf0.loc[gdf0.distance(d3[0])==gdf0.distance(d3[0]).min(),:]
p4=gdf0.loc[gdf0.distance(d4[0])==gdf0.distance(d4[0]).min(),:]
p5=gdf0.loc[gdf0.distance(d5[0])==gdf0.distance(d5[0]).min(),:]
p6=gdf0.loc[gdf0.distance(d6[0])==gdf0.distance(d6[0]).min(),:]
p7=gdf0.loc[gdf0.distance(d7[0])==gdf0.distance(d7[0]).min(),:]
p8=gdf0.loc[gdf0.distance(d8[0])==gdf0.distance(d8[0]).min(),:]
p9=gdf0.loc[gdf0.distance(d9[0])==gdf0.distance(d9[0]).min(),:]
p10=gdf0.loc[gdf0.distance(d10[0])==gdf0.distance(d10[0]).min(),:]
p11=gdf0.loc[gdf0.distance(d11[0])==gdf0.distance(d11[0]).min(),:]
p12=gdf0.loc[gdf0.distance(d12[0])==gdf0.distance(d12[0]).min(),:]
p13=gdf0.loc[gdf0.distance(d13[0])==gdf0.distance(d13[0]).min(),:]
p14=gdf0.loc[gdf0.distance(d14[0])==gdf0.distance(d14[0]).min(),:]
p15=gdf0.loc[gdf0.distance(d15[0])==gdf0.distance(d15[0]).min(),:]
p16=gdf0.loc[gdf0.distance(d16[0])==gdf0.distance(d16[0]).min(),:]
p17=gdf0.loc[gdf0.distance(d17[0])==gdf0.distance(d17[0]).min(),:]
p18=gdf0.loc[gdf0.distance(d18[0])==gdf0.distance(d18[0]).min(),:]
p19=gdf0.loc[gdf0.distance(d19[0])==gdf0.distance(d19[0]).min(),:]
p20=gdf0.loc[gdf0.distance(d20[0])==gdf0.distance(d20[0]).min(),:]
p21=gdf0.loc[gdf0.distance(d21[0])==gdf0.distance(d21[0]).min(),:]
p22=gdf0.loc[gdf0.distance(d22[0])==gdf0.distance(d22[0]).min(),:]
p23=gdf0.loc[gdf0.distance(d23[0])==gdf0.distance(d23[0]).min(),:]
p24=gdf0.loc[gdf0.distance(d24[0])==gdf0.distance(d24[0]).min(),:]
p25=gdf0.loc[gdf0.distance(d25[0])==gdf0.distance(d25[0]).min(),:]
p26=gdf0.loc[gdf0.distance(d26[0])==gdf0.distance(d26[0]).min(),:]



# creating buffer on the buffer with 5km radius
ax=bylaw.loc[['pointpolygon', 'port1', 'port2', 'ind', 'port5', 'port6', 'port7',
              'southend container terminal','NN Jetty', 'Bills island', 'mid bedf
              'waterfront h', 'northarm', 'plll', 'pp', 'po001','po002', 'oulier_
              'p009', 'p010'],:].plot(figsize=(25,25))
gpd.GeoSeries([d1[0],d2[0],d3[0],d4[0],d5[0],d6[0],d7[0],d8[0],d9[0],d10[0],d11[0
               d16[0],d17[0],d18[0],d19[0],d20[0],d21[0],d22[0],d23[0],d24[0],d25
               d26[0]]).plot(ax=ax,color='yellow',markersize=10)

p1=p1.iloc[0,:].geometry.buffer(0.005)
p2=p2.iloc[0,:].geometry.buffer(0.005)
p3=p3.iloc[0,:].geometry.buffer(0.005)
p4=p4.iloc[0,:].geometry.buffer(0.005)
p5=p5.iloc[0,:].geometry.buffer(0.005) # getting the buffer with 5km radius for t
p6=p6.iloc[0,:].geometry.buffer(0.005)
p7=p7.iloc[0,:].geometry.buffer(0.005)
p8=p8.iloc[0,:].geometry.buffer(0.005)
p9=p9.iloc[0,:].geometry.buffer(0.005)
p10=p10.iloc[0,:].geometry.buffer(0.005)
p11=p11.iloc[0,:].geometry.buffer(0.005)
p12=p12.iloc[0,:].geometry.buffer(0.005)
p13=p13.iloc[0,:].geometry.buffer(0.005)
p14=p14.iloc[0,:].geometry.buffer(0.005)
p15=p15.iloc[0,:].geometry.buffer(0.005)
p16=p16.iloc[0,:].geometry.buffer(0.005)
p17=p17.iloc[0,:].geometry.buffer(0.005)
p18=p18.iloc[0,:].geometry.buffer(0.005)
p19=p19.iloc[0,:].geometry.buffer(0.005)
```

```
p20=p20.iloc[0,:].geometry.buffer(0.005)
p21=p21.iloc[0,:].geometry.buffer(0.005)
p22=p22.iloc[0,:].geometry.buffer(0.005)
p23=p23.iloc[0,:].geometry.buffer(0.005)
p24=p24.iloc[0,:].geometry.buffer(0.005)
p25=p25.iloc[0,:].geometry.buffer(0.005)
p26=p26.iloc[0,:].geometry.buffer(0.005)

# plotting the buffer radius near ports

gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,p19
gdf0.plot(ax=ax,color='g',alpha=0.2)
gdf0.loc[gdf0.within(p1),:].plot(ax=ax,color='k')
gdf0.loc[gdf0.within(p2),:].plot(ax=ax,color='k')
gdf0.loc[gdf0.within(p3),:].plot(ax=ax,color='k')
gdf0.loc[gdf0.within(p4),:].plot(ax=ax,color='k')
gdf0.loc[gdf0.within(p5),:].plot(ax=ax,color='k')
gdf0.loc[gdf0.within(p6),:].plot(ax=ax,color='k')
gdf0.loc[gdf0.within(p7),:].plot(ax=ax,color='k')
gdf0.loc[gdf0.within(p8),:].plot(ax=ax,color='k')
gdf0.loc[gdf0.within(p9),:].plot(ax=ax,color='k')
gdf0.loc[gdf0.within(p10),:].plot(ax=ax,color='k')
gdf0.loc[gdf0.within(p11),:].plot(ax=ax,color='k')
gdf0.loc[gdf0.within(p12),:].plot(ax=ax,color='k')
gdf0.loc[gdf0.within(p13),:].plot(ax=ax,color='k')
gdf0.loc[gdf0.within(p14),:].plot(ax=ax,color='k')
gdf0.loc[gdf0.within(p15),:].plot(ax=ax,color='k')
gdf0.loc[gdf0.within(p16),:].plot(ax=ax,color='k')
gdf0.loc[gdf0.within(p17),:].plot(ax=ax,color='k')
gdf0.loc[gdf0.within(p18),:].plot(ax=ax,color='k')
gdf0.loc[gdf0.within(p19),:].plot(ax=ax,color='k')
gdf0.loc[gdf0.within(p20),:].plot(ax=ax,color='k')
gdf0.loc[gdf0.within(p21),:].plot(ax=ax,color='k')
gdf0.loc[gdf0.within(p22),:].plot(ax=ax,color='k')
gdf0.loc[gdf0.within(p23),:].plot(ax=ax,color='k')
gdf0.loc[gdf0.within(p24),:].plot(ax=ax,color='k')
gdf0.loc[gdf0.within(p25),:].plot(ax=ax,color='k')
gdf0.loc[gdf0.within(p26),:].plot(ax=ax,color='k')
plt.savefig('Q3 images/interval_00_q1.png')
```


44.72
44.70
44.68
44.66
44.64
44.62
44.60
−63.675
−63.650
−63.625
−63.600
−63.575
−63.550
−63.525
−63.500

In [25]:
```
joinres=gpd.sjoin(gdf0,bylaw,op='within',how='left')
col=['r','b','g','k','yellow','orange','Olive','Maroon','Purple','Fuchsia','Lime'
i=0
ax=gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,


for g in set(joinres['index_right']):
  tmp=joinres.loc[joinres['index_right']==g,:]
  if tmp.shape[0]>0:
    tmp.plot(ax=ax,color=col[i])
  i=i+1
plt.savefig('Q3 images/interval_00_q2.png')
```

```
C:\Users\lanch\Anaconda3\lib\site-packages\geopandas\tools\sjoin.py:44: UserWar
ning: CRS of frames being joined does not match!
  warn('CRS of frames being joined does not match!')
```



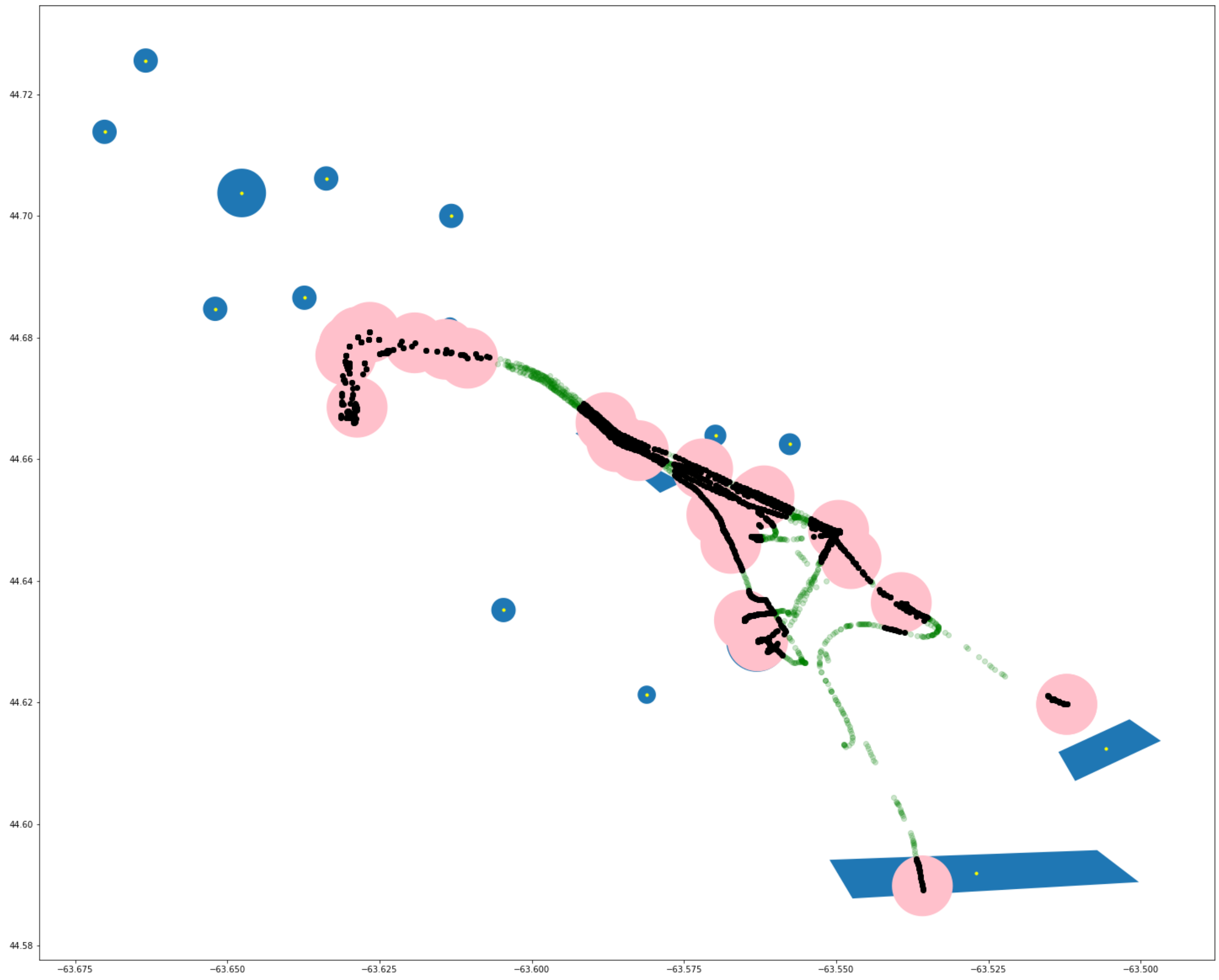
```
1st interval
```

In [27]:
```
gdf1 = gpd.GeoDataFrame(d['df_h1'].drop(['location.coordinates.0', 'location.coor
crs={'init': 'epsg:4326'},
geometry=[shapely.geometry.Point(xy) for xy in zip(d['df_h1']['location.coordinat
```

In [29]:

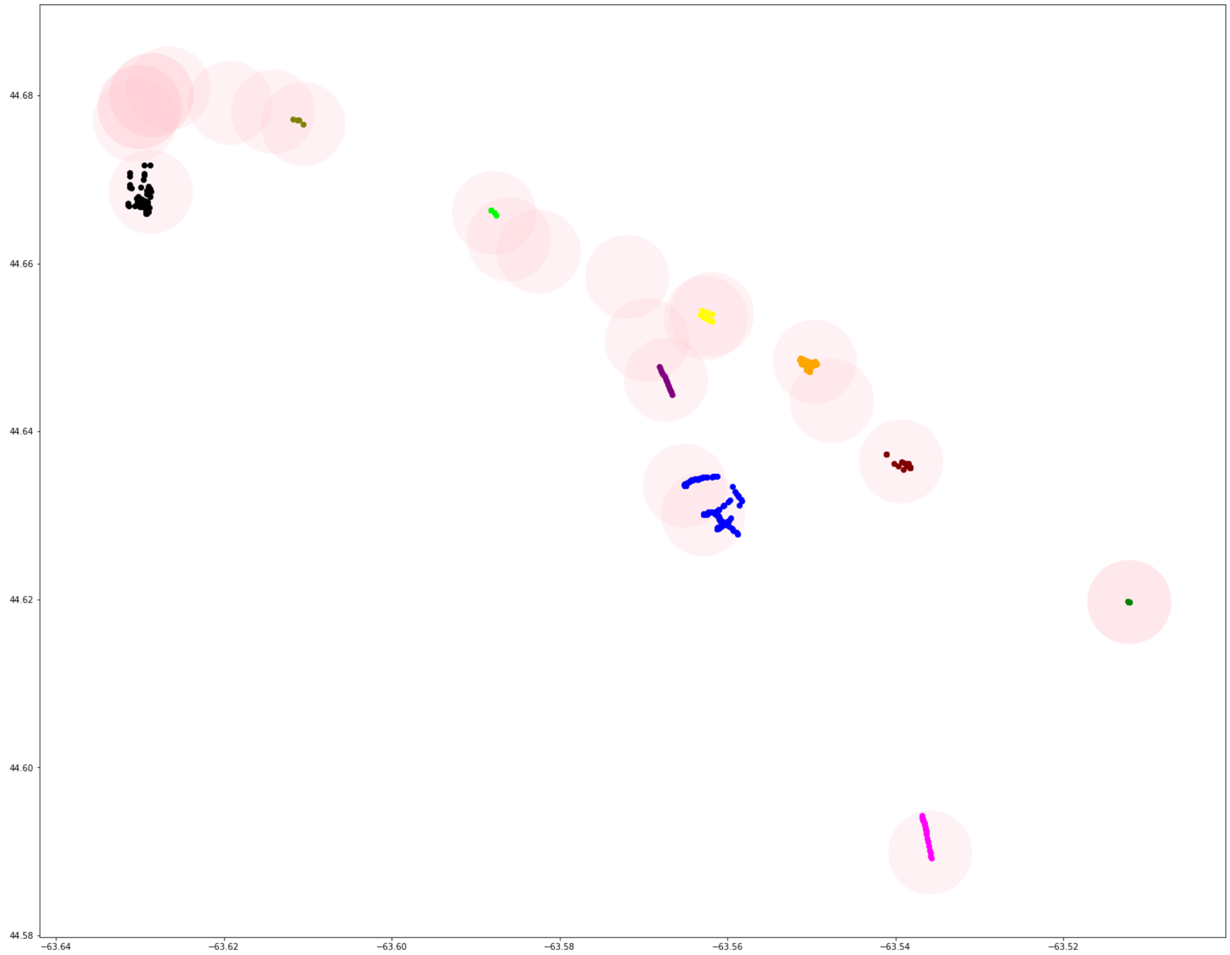
```
p1=gdf1.loc[gdf1.distance(d1[0])==gdf1.distance(d1[0]).min(),:]
p2=gdf1.loc[gdf1.distance(d2[0])==gdf1.distance(d2[0]).min(),:]
p3=gdf1.loc[gdf1.distance(d3[0])==gdf1.distance(d3[0]).min(),:]
p4=gdf1.loc[gdf1.distance(d4[0])==gdf1.distance(d4[0]).min(),:]
p5=gdf1.loc[gdf1.distance(d5[0])==gdf1.distance(d5[0]).min(),:]
p6=gdf1.loc[gdf1.distance(d6[0])==gdf1.distance(d6[0]).min(),:]
p7=gdf1.loc[gdf1.distance(d7[0])==gdf1.distance(d7[0]).min(),:]
p8=gdf1.loc[gdf1.distance(d8[0])==gdf1.distance(d8[0]).min(),:]
p9=gdf1.loc[gdf1.distance(d9[0])==gdf1.distance(d9[0]).min(),:]
p10=gdf1.loc[gdf1.distance(d10[0])==gdf1.distance(d10[0]).min(),:]
p11=gdf1.loc[gdf1.distance(d11[0])==gdf1.distance(d11[0]).min(),:]
p12=gdf1.loc[gdf1.distance(d12[0])==gdf1.distance(d12[0]).min(),:]
p13=gdf1.loc[gdf1.distance(d13[0])==gdf1.distance(d13[0]).min(),:]
p14=gdf1.loc[gdf1.distance(d14[0])==gdf1.distance(d14[0]).min(),:]
p15=gdf1.loc[gdf1.distance(d15[0])==gdf1.distance(d15[0]).min(),:]
p16=gdf1.loc[gdf1.distance(d16[0])==gdf1.distance(d16[0]).min(),:]
p17=gdf1.loc[gdf1.distance(d17[0])==gdf1.distance(d17[0]).min(),:]
p18=gdf1.loc[gdf1.distance(d18[0])==gdf1.distance(d18[0]).min(),:]
p19=gdf1.loc[gdf1.distance(d19[0])==gdf1.distance(d19[0]).min(),:]
p20=gdf1.loc[gdf1.distance(d20[0])==gdf1.distance(d20[0]).min(),:]
p21=gdf1.loc[gdf1.distance(d21[0])==gdf1.distance(d21[0]).min(),:]
p22=gdf1.loc[gdf1.distance(d22[0])==gdf1.distance(d22[0]).min(),:]
p23=gdf1.loc[gdf1.distance(d23[0])==gdf1.distance(d23[0]).min(),:]
p24=gdf1.loc[gdf1.distance(d24[0])==gdf1.distance(d24[0]).min(),:]
p25=gdf1.loc[gdf1.distance(d25[0])==gdf1.distance(d25[0]).min(),:]
p26=gdf1.loc[gdf1.distance(d26[0])==gdf1.distance(d26[0]).min(),:]



# creating buffer on the buffer with 5km radius
ax=bylaw.loc[['pointpolygon', 'port1', 'port2', 'ind', 'port5', 'port6', 'port7',
              'southend container terminal','NN Jetty', 'Bills island', 'mid bedf
              'waterfront h', 'northarm', 'plll', 'pp', 'po001','po002', 'oulier_
              'p009', 'p010'],:].plot(figsize=(25,25))
gpd.GeoSeries([d1[0],d2[0],d3[0],d4[0],d5[0],d6[0],d7[0],d8[0],d9[0],d10[0],d11[0
               d16[0],d17[0],d18[0],d19[0],d20[0],d21[0],d22[0],d23[0],d24[0],d25
               d26[0]]).plot(ax=ax,color='yellow',markersize=10)

p1=p1.iloc[0,:].geometry.buffer(0.005)
p2=p2.iloc[0,:].geometry.buffer(0.005)
p3=p3.iloc[0,:].geometry.buffer(0.005)
p4=p4.iloc[0,:].geometry.buffer(0.005)
p5=p5.iloc[0,:].geometry.buffer(0.005) # getting the buffer with 5km radius for t
p6=p6.iloc[0,:].geometry.buffer(0.005)
p7=p7.iloc[0,:].geometry.buffer(0.005)
p8=p8.iloc[0,:].geometry.buffer(0.005)
p9=p9.iloc[0,:].geometry.buffer(0.005)
p10=p10.iloc[0,:].geometry.buffer(0.005)
p11=p11.iloc[0,:].geometry.buffer(0.005)
p12=p12.iloc[0,:].geometry.buffer(0.005)
p13=p13.iloc[0,:].geometry.buffer(0.005)
p14=p14.iloc[0,:].geometry.buffer(0.005)
p15=p15.iloc[0,:].geometry.buffer(0.005)
p16=p16.iloc[0,:].geometry.buffer(0.005)
p17=p17.iloc[0,:].geometry.buffer(0.005)
p18=p18.iloc[0,:].geometry.buffer(0.005)
p19=p19.iloc[0,:].geometry.buffer(0.005)
```

```
p20=p20.iloc[0,:].geometry.buffer(0.005)
p21=p21.iloc[0,:].geometry.buffer(0.005)
p22=p22.iloc[0,:].geometry.buffer(0.005)
p23=p23.iloc[0,:].geometry.buffer(0.005)
p24=p24.iloc[0,:].geometry.buffer(0.005)
p25=p25.iloc[0,:].geometry.buffer(0.005)
p26=p26.iloc[0,:].geometry.buffer(0.005)

# plotting the buffer radius near ports

gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,p19
gdf1.plot(ax=ax,color='g',alpha=0.2)
gdf1.loc[gdf1.within(p1),:].plot(ax=ax,color='k')
gdf1.loc[gdf1.within(p2),:].plot(ax=ax,color='k')
gdf1.loc[gdf1.within(p3),:].plot(ax=ax,color='k')
gdf1.loc[gdf1.within(p4),:].plot(ax=ax,color='k')
gdf1.loc[gdf1.within(p5),:].plot(ax=ax,color='k')
gdf1.loc[gdf1.within(p6),:].plot(ax=ax,color='k')
gdf1.loc[gdf1.within(p7),:].plot(ax=ax,color='k')
gdf1.loc[gdf1.within(p8),:].plot(ax=ax,color='k')
gdf1.loc[gdf1.within(p9),:].plot(ax=ax,color='k')
gdf1.loc[gdf1.within(p10),:].plot(ax=ax,color='k')
gdf1.loc[gdf1.within(p11),:].plot(ax=ax,color='k')
gdf1.loc[gdf1.within(p12),:].plot(ax=ax,color='k')
gdf1.loc[gdf1.within(p13),:].plot(ax=ax,color='k')
gdf1.loc[gdf1.within(p14),:].plot(ax=ax,color='k')
gdf1.loc[gdf1.within(p15),:].plot(ax=ax,color='k')
gdf1.loc[gdf1.within(p16),:].plot(ax=ax,color='k')
gdf1.loc[gdf1.within(p17),:].plot(ax=ax,color='k')
gdf1.loc[gdf1.within(p18),:].plot(ax=ax,color='k')
gdf1.loc[gdf1.within(p19),:].plot(ax=ax,color='k')
gdf1.loc[gdf1.within(p20),:].plot(ax=ax,color='k')
gdf1.loc[gdf1.within(p21),:].plot(ax=ax,color='k')
gdf1.loc[gdf1.within(p22),:].plot(ax=ax,color='k')
gdf1.loc[gdf1.within(p23),:].plot(ax=ax,color='k')
gdf1.loc[gdf1.within(p24),:].plot(ax=ax,color='k')
gdf1.loc[gdf1.within(p25),:].plot(ax=ax,color='k')
gdf1.loc[gdf1.within(p26),:].plot(ax=ax,color='k')
plt.savefig('Q3 images/interval_01_q1.png')
```


44.72
44.70
44.68
44.66
44.64
44.62
44.60
44.58
−63.675
−63.650
−63.625
−63.600
−63.575
−63.550
−63.525
−63.500

In [30]:
```
joinres=gpd.sjoin(gdf1,bylaw,op='within',how='left')
col=['r','b','g','k','yellow','orange','Olive','Maroon','Purple','Fuchsia','Lime'
i=0
ax=gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,


for g in set(joinres['index_right']):
  tmp=joinres.loc[joinres['index_right']==g,:]
  if tmp.shape[0]>0:
    tmp.plot(ax=ax,color=col[i])
  i=i+1
plt.savefig('Q3 images/interval_01_q2.png')
```

```
C:\Users\lanch\Anaconda3\lib\site-packages\geopandas\tools\sjoin.py:44: UserWar
ning: CRS of frames being joined does not match!
  warn('CRS of frames being joined does not match!')
```

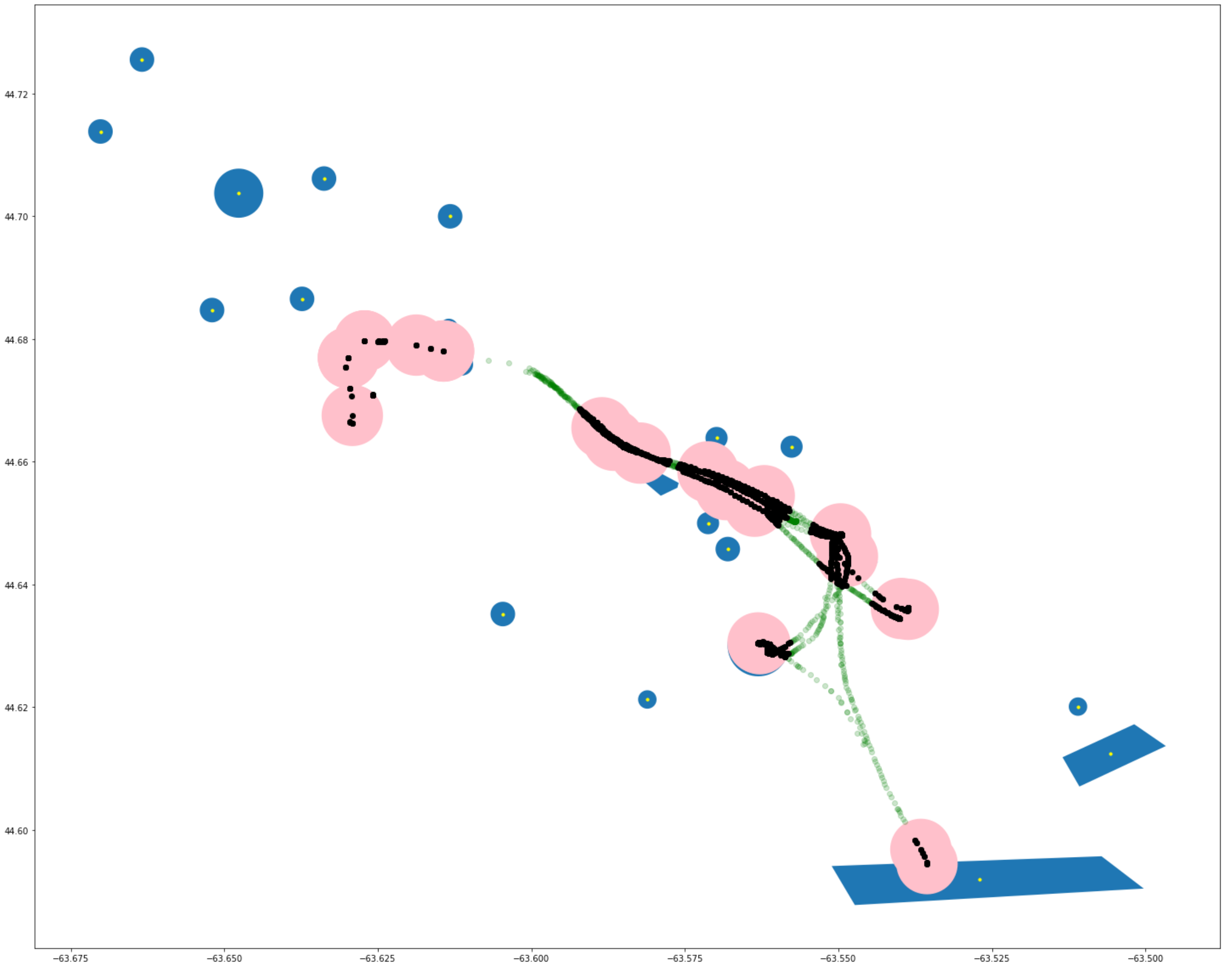


```
2nd interval
```

In [32]:

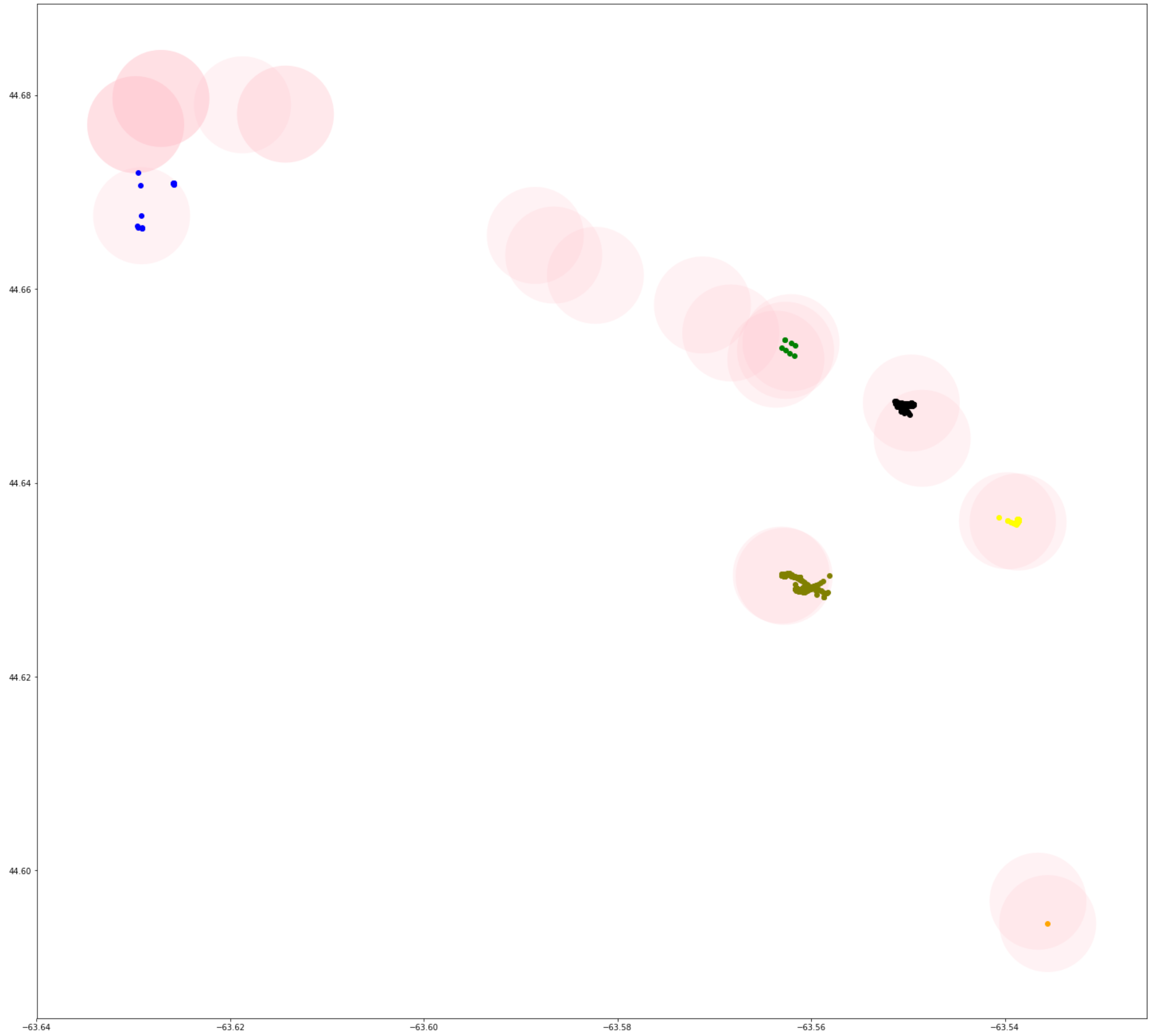
```
gdf2 = gpd.GeoDataFrame(d['df_h2'].drop(['location.coordinates.0', 'location.coor
crs={'init': 'epsg:4326'},
geometry=[shapely.geometry.Point(xy) for xy in zip(d['df_h2']['location.coordinat

p1=gdf2.loc[gdf2.distance(d1[0])==gdf2.distance(d1[0]).min(),:]
p2=gdf2.loc[gdf2.distance(d2[0])==gdf2.distance(d2[0]).min(),:]
p3=gdf2.loc[gdf2.distance(d3[0])==gdf2.distance(d3[0]).min(),:]
p4=gdf2.loc[gdf2.distance(d4[0])==gdf2.distance(d4[0]).min(),:]
p5=gdf2.loc[gdf2.distance(d5[0])==gdf2.distance(d5[0]).min(),:]
p6=gdf2.loc[gdf2.distance(d6[0])==gdf2.distance(d6[0]).min(),:]
p7=gdf2.loc[gdf2.distance(d7[0])==gdf2.distance(d7[0]).min(),:]
p8=gdf2.loc[gdf2.distance(d8[0])==gdf2.distance(d8[0]).min(),:]
p9=gdf2.loc[gdf2.distance(d9[0])==gdf2.distance(d9[0]).min(),:]
p10=gdf2.loc[gdf2.distance(d10[0])==gdf2.distance(d10[0]).min(),:]
p11=gdf2.loc[gdf2.distance(d11[0])==gdf2.distance(d11[0]).min(),:]
p12=gdf2.loc[gdf2.distance(d12[0])==gdf2.distance(d12[0]).min(),:]
p13=gdf2.loc[gdf2.distance(d13[0])==gdf2.distance(d13[0]).min(),:]
p14=gdf2.loc[gdf2.distance(d14[0])==gdf2.distance(d14[0]).min(),:]
p15=gdf2.loc[gdf2.distance(d15[0])==gdf2.distance(d15[0]).min(),:]
p16=gdf2.loc[gdf2.distance(d16[0])==gdf2.distance(d16[0]).min(),:]
p17=gdf2.loc[gdf2.distance(d17[0])==gdf2.distance(d17[0]).min(),:]
p18=gdf2.loc[gdf2.distance(d18[0])==gdf2.distance(d18[0]).min(),:]
p19=gdf2.loc[gdf2.distance(d19[0])==gdf2.distance(d19[0]).min(),:]
p20=gdf2.loc[gdf2.distance(d20[0])==gdf2.distance(d20[0]).min(),:]
p21=gdf2.loc[gdf2.distance(d21[0])==gdf2.distance(d21[0]).min(),:]
p22=gdf2.loc[gdf2.distance(d22[0])==gdf2.distance(d22[0]).min(),:]
p23=gdf2.loc[gdf2.distance(d23[0])==gdf2.distance(d23[0]).min(),:]
p24=gdf2.loc[gdf2.distance(d24[0])==gdf2.distance(d24[0]).min(),:]
p25=gdf2.loc[gdf2.distance(d25[0])==gdf2.distance(d25[0]).min(),:]
p26=gdf2.loc[gdf2.distance(d26[0])==gdf2.distance(d26[0]).min(),:]



# creating buffer on the buffer with 5km radius
ax=bylaw.loc[['pointpolygon', 'port1', 'port2', 'ind', 'port5', 'port6', 'port7',
              'southend container terminal','NN Jetty', 'Bills island', 'mid bedf
              'waterfront h', 'northarm', 'plll', 'pp', 'po001','po002', 'oulier_
              'p009', 'p010'],:].plot(figsize=(25,25))
gpd.GeoSeries([d1[0],d2[0],d3[0],d4[0],d5[0],d6[0],d7[0],d8[0],d9[0],d10[0],d11[0
               d16[0],d17[0],d18[0],d19[0],d20[0],d21[0],d22[0],d23[0],d24[0],d25
               d26[0]]).plot(ax=ax,color='yellow',markersize=10)

p1=p1.iloc[0,:].geometry.buffer(0.005)
p2=p2.iloc[0,:].geometry.buffer(0.005)
p3=p3.iloc[0,:].geometry.buffer(0.005)
p4=p4.iloc[0,:].geometry.buffer(0.005)
p5=p5.iloc[0,:].geometry.buffer(0.005) # getting the buffer with 5km radius for t
p6=p6.iloc[0,:].geometry.buffer(0.005)
p7=p7.iloc[0,:].geometry.buffer(0.005)
p8=p8.iloc[0,:].geometry.buffer(0.005)
p9=p9.iloc[0,:].geometry.buffer(0.005)
p10=p10.iloc[0,:].geometry.buffer(0.005)
p11=p11.iloc[0,:].geometry.buffer(0.005)
p12=p12.iloc[0,:].geometry.buffer(0.005)
p13=p13.iloc[0,:].geometry.buffer(0.005)
p14=p14.iloc[0,:].geometry.buffer(0.005)
p15=p15.iloc[0,:].geometry.buffer(0.005)
```

```
p16=p16.iloc[0,:].geometry.buffer(0.005)
p17=p17.iloc[0,:].geometry.buffer(0.005)
p18=p18.iloc[0,:].geometry.buffer(0.005)
p19=p19.iloc[0,:].geometry.buffer(0.005)
p20=p20.iloc[0,:].geometry.buffer(0.005)
p21=p21.iloc[0,:].geometry.buffer(0.005)
p22=p22.iloc[0,:].geometry.buffer(0.005)
p23=p23.iloc[0,:].geometry.buffer(0.005)
p24=p24.iloc[0,:].geometry.buffer(0.005)
p25=p25.iloc[0,:].geometry.buffer(0.005)
p26=p26.iloc[0,:].geometry.buffer(0.005)

# plotting the buffer radius near ports

gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,p19
gdf2.plot(ax=ax,color='g',alpha=0.2)
gdf2.loc[gdf2.within(p1),:].plot(ax=ax,color='k')
gdf2.loc[gdf2.within(p2),:].plot(ax=ax,color='k')
gdf2.loc[gdf2.within(p3),:].plot(ax=ax,color='k')
gdf2.loc[gdf2.within(p4),:].plot(ax=ax,color='k')
gdf2.loc[gdf2.within(p5),:].plot(ax=ax,color='k')
gdf2.loc[gdf2.within(p6),:].plot(ax=ax,color='k')
gdf2.loc[gdf2.within(p7),:].plot(ax=ax,color='k')
gdf2.loc[gdf2.within(p8),:].plot(ax=ax,color='k')
gdf2.loc[gdf2.within(p9),:].plot(ax=ax,color='k')
gdf2.loc[gdf2.within(p10),:].plot(ax=ax,color='k')
gdf2.loc[gdf2.within(p11),:].plot(ax=ax,color='k')
gdf2.loc[gdf2.within(p12),:].plot(ax=ax,color='k')
gdf2.loc[gdf2.within(p13),:].plot(ax=ax,color='k')
gdf2.loc[gdf2.within(p14),:].plot(ax=ax,color='k')
gdf2.loc[gdf2.within(p15),:].plot(ax=ax,color='k')
gdf2.loc[gdf2.within(p16),:].plot(ax=ax,color='k')
gdf2.loc[gdf2.within(p17),:].plot(ax=ax,color='k')
gdf2.loc[gdf2.within(p18),:].plot(ax=ax,color='k')
gdf2.loc[gdf2.within(p19),:].plot(ax=ax,color='k')
gdf2.loc[gdf2.within(p20),:].plot(ax=ax,color='k')
gdf2.loc[gdf2.within(p21),:].plot(ax=ax,color='k')
gdf2.loc[gdf2.within(p22),:].plot(ax=ax,color='k')
gdf2.loc[gdf2.within(p23),:].plot(ax=ax,color='k')
gdf2.loc[gdf2.within(p24),:].plot(ax=ax,color='k')
gdf2.loc[gdf2.within(p25),:].plot(ax=ax,color='k')
gdf2.loc[gdf2.within(p26),:].plot(ax=ax,color='k')
plt.savefig('Q3 images/interval_02_q1.png')
```


44.72
44.70
44.68
44.66
44.64
44.62
44.60
−63.675
−63.650
−63.625
−63.600
−63.575
−63.550
−63.525
−63.500

```
In [33]: joinres=gpd.sjoin(gdf2,bylaw,op='within',how='left')
         col=['r','b','g','k','yellow','orange','Olive','Maroon','Purple','Fuchsia','Lime'
         i=0
         ax=gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,


         for g in set(joinres['index_right']):
           tmp=joinres.loc[joinres['index_right']==g,:]
           if tmp.shape[0]>0:
             tmp.plot(ax=ax,color=col[i])
           i=i+1
         plt.savefig('Q3 images/interval_02_q2.png')
```

```
C:\Users\lanch\Anaconda3\lib\site-packages\geopandas\tools\sjoin.py:44: UserWar
ning: CRS of frames being joined does not match!
  warn('CRS of frames being joined does not match!')
```

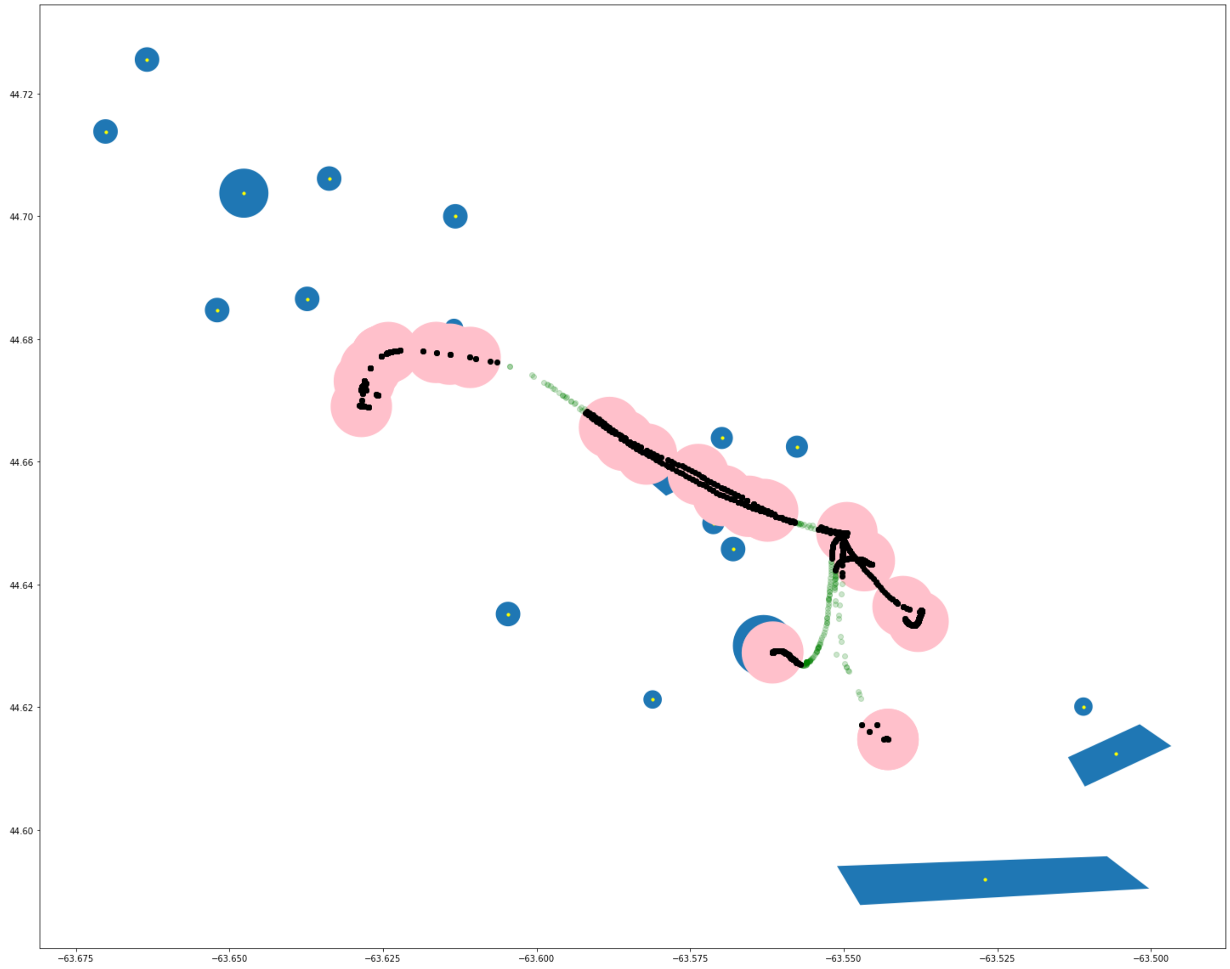


```
3rd interval
```

In [34]:

```
gdf3 = gpd.GeoDataFrame(d['df_h3'].drop(['location.coordinates.0', 'location.coor
crs={'init': 'epsg:4326'},
geometry=[shapely.geometry.Point(xy) for xy in zip(d['df_h3']['location.coordinat

p1=gdf3.loc[gdf3.distance(d1[0])==gdf3.distance(d1[0]).min(),:]
p2=gdf3.loc[gdf3.distance(d2[0])==gdf3.distance(d2[0]).min(),:]
p3=gdf3.loc[gdf3.distance(d3[0])==gdf3.distance(d3[0]).min(),:]
p4=gdf3.loc[gdf3.distance(d4[0])==gdf3.distance(d4[0]).min(),:]
p5=gdf3.loc[gdf3.distance(d5[0])==gdf3.distance(d5[0]).min(),:]
p6=gdf3.loc[gdf3.distance(d6[0])==gdf3.distance(d6[0]).min(),:]
p7=gdf3.loc[gdf3.distance(d7[0])==gdf3.distance(d7[0]).min(),:]
p8=gdf3.loc[gdf3.distance(d8[0])==gdf3.distance(d8[0]).min(),:]
p9=gdf3.loc[gdf3.distance(d9[0])==gdf3.distance(d9[0]).min(),:]
p10=gdf3.loc[gdf3.distance(d10[0])==gdf3.distance(d10[0]).min(),:]
p11=gdf3.loc[gdf3.distance(d11[0])==gdf3.distance(d11[0]).min(),:]
p12=gdf3.loc[gdf3.distance(d12[0])==gdf3.distance(d12[0]).min(),:]
p13=gdf3.loc[gdf3.distance(d13[0])==gdf3.distance(d13[0]).min(),:]
p14=gdf3.loc[gdf3.distance(d14[0])==gdf3.distance(d14[0]).min(),:]
p15=gdf3.loc[gdf3.distance(d15[0])==gdf3.distance(d15[0]).min(),:]
p16=gdf3.loc[gdf3.distance(d16[0])==gdf3.distance(d16[0]).min(),:]
p17=gdf3.loc[gdf3.distance(d17[0])==gdf3.distance(d17[0]).min(),:]
p18=gdf3.loc[gdf3.distance(d18[0])==gdf3.distance(d18[0]).min(),:]
p19=gdf3.loc[gdf3.distance(d19[0])==gdf3.distance(d19[0]).min(),:]
p20=gdf3.loc[gdf3.distance(d20[0])==gdf3.distance(d20[0]).min(),:]
p21=gdf3.loc[gdf3.distance(d21[0])==gdf3.distance(d21[0]).min(),:]
p22=gdf3.loc[gdf3.distance(d22[0])==gdf3.distance(d22[0]).min(),:]
p23=gdf3.loc[gdf3.distance(d23[0])==gdf3.distance(d23[0]).min(),:]
p24=gdf3.loc[gdf3.distance(d24[0])==gdf3.distance(d24[0]).min(),:]
p25=gdf3.loc[gdf3.distance(d25[0])==gdf3.distance(d25[0]).min(),:]
p26=gdf3.loc[gdf3.distance(d26[0])==gdf3.distance(d26[0]).min(),:]



# creating buffer on the buffer with 5km radius
ax=bylaw.loc[['pointpolygon', 'port1', 'port2', 'ind', 'port5', 'port6', 'port7',
              'southend container terminal','NN Jetty', 'Bills island', 'mid bedf
              'waterfront h', 'northarm', 'plll', 'pp', 'po001','po002', 'oulier_
              'p009', 'p010'],:].plot(figsize=(25,25))
gpd.GeoSeries([d1[0],d2[0],d3[0],d4[0],d5[0],d6[0],d7[0],d8[0],d9[0],d10[0],d11[0
               d16[0],d17[0],d18[0],d19[0],d20[0],d21[0],d22[0],d23[0],d24[0],d25
               d26[0]]).plot(ax=ax,color='yellow',markersize=10)

p1=p1.iloc[0,:].geometry.buffer(0.005)
p2=p2.iloc[0,:].geometry.buffer(0.005)
p3=p3.iloc[0,:].geometry.buffer(0.005)
p4=p4.iloc[0,:].geometry.buffer(0.005)
p5=p5.iloc[0,:].geometry.buffer(0.005) # getting the buffer with 5km radius for t
p6=p6.iloc[0,:].geometry.buffer(0.005)
p7=p7.iloc[0,:].geometry.buffer(0.005)
p8=p8.iloc[0,:].geometry.buffer(0.005)
p9=p9.iloc[0,:].geometry.buffer(0.005)
p10=p10.iloc[0,:].geometry.buffer(0.005)
p11=p11.iloc[0,:].geometry.buffer(0.005)
p12=p12.iloc[0,:].geometry.buffer(0.005)
p13=p13.iloc[0,:].geometry.buffer(0.005)
p14=p14.iloc[0,:].geometry.buffer(0.005)
p15=p15.iloc[0,:].geometry.buffer(0.005)
```

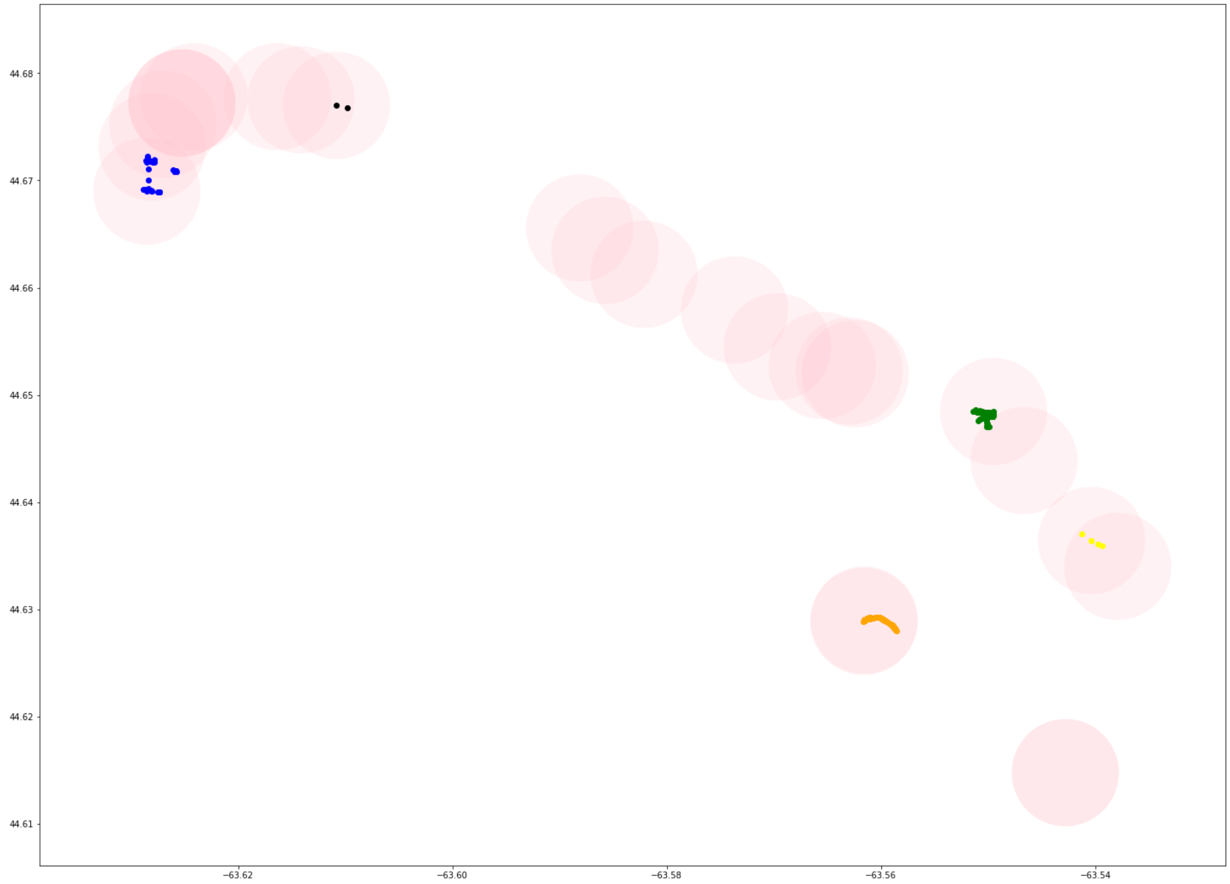
```
p16=p16.iloc[0,:].geometry.buffer(0.005)
p17=p17.iloc[0,:].geometry.buffer(0.005)
p18=p18.iloc[0,:].geometry.buffer(0.005)
p19=p19.iloc[0,:].geometry.buffer(0.005)
p20=p20.iloc[0,:].geometry.buffer(0.005)
p21=p21.iloc[0,:].geometry.buffer(0.005)
p22=p22.iloc[0,:].geometry.buffer(0.005)
p23=p23.iloc[0,:].geometry.buffer(0.005)
p24=p24.iloc[0,:].geometry.buffer(0.005)
p25=p25.iloc[0,:].geometry.buffer(0.005)
p26=p26.iloc[0,:].geometry.buffer(0.005)

# plotting the buffer radius near ports

gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,p19
gdf3.plot(ax=ax,color='g',alpha=0.2)
gdf3.loc[gdf3.within(p1),:].plot(ax=ax,color='k')
gdf3.loc[gdf3.within(p2),:].plot(ax=ax,color='k')
gdf3.loc[gdf3.within(p3),:].plot(ax=ax,color='k')
gdf3.loc[gdf3.within(p4),:].plot(ax=ax,color='k')
gdf3.loc[gdf3.within(p5),:].plot(ax=ax,color='k')
gdf3.loc[gdf3.within(p6),:].plot(ax=ax,color='k')
gdf3.loc[gdf3.within(p7),:].plot(ax=ax,color='k')
gdf3.loc[gdf3.within(p8),:].plot(ax=ax,color='k')
gdf3.loc[gdf3.within(p9),:].plot(ax=ax,color='k')
gdf3.loc[gdf3.within(p10),:].plot(ax=ax,color='k')
gdf3.loc[gdf3.within(p11),:].plot(ax=ax,color='k')
gdf3.loc[gdf3.within(p12),:].plot(ax=ax,color='k')
gdf3.loc[gdf3.within(p13),:].plot(ax=ax,color='k')
gdf3.loc[gdf3.within(p14),:].plot(ax=ax,color='k')
gdf3.loc[gdf3.within(p15),:].plot(ax=ax,color='k')
gdf3.loc[gdf3.within(p16),:].plot(ax=ax,color='k')
gdf3.loc[gdf3.within(p17),:].plot(ax=ax,color='k')
gdf3.loc[gdf3.within(p18),:].plot(ax=ax,color='k')
gdf3.loc[gdf3.within(p19),:].plot(ax=ax,color='k')
gdf3.loc[gdf3.within(p20),:].plot(ax=ax,color='k')
gdf3.loc[gdf3.within(p21),:].plot(ax=ax,color='k')
gdf3.loc[gdf3.within(p22),:].plot(ax=ax,color='k')
gdf3.loc[gdf3.within(p23),:].plot(ax=ax,color='k')
gdf3.loc[gdf3.within(p24),:].plot(ax=ax,color='k')
gdf3.loc[gdf3.within(p25),:].plot(ax=ax,color='k')
gdf3.loc[gdf3.within(p26),:].plot(ax=ax,color='k')
plt.savefig('Q3 images/interval_03_q1.png')
```


44.72
44.70
44.68
44.66
44.64
44.62
44.60
−63.675
−63.650
−63.625
−63.600
−63.575
−63.550
−63.525
−63.500

In [35]:

```
joinres=gpd.sjoin(gdf3,bylaw,op='within',how='left')
col=['r','b','g','k','yellow','orange','Olive','Maroon','Purple','Fuchsia','Lime'
i=0
ax=gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,


for g in set(joinres['index_right']):
  tmp=joinres.loc[joinres['index_right']==g,:]
  if tmp.shape[0]>0:
    tmp.plot(ax=ax,color=col[i])
  i=i+1
plt.savefig('Q3 images/interval_03_q2.png')
```

```
C:\Users\lanch\Anaconda3\lib\site-packages\geopandas\tools\sjoin.py:44: UserWar
ning: CRS of frames being joined does not match!
  warn('CRS of frames being joined does not match!')
```

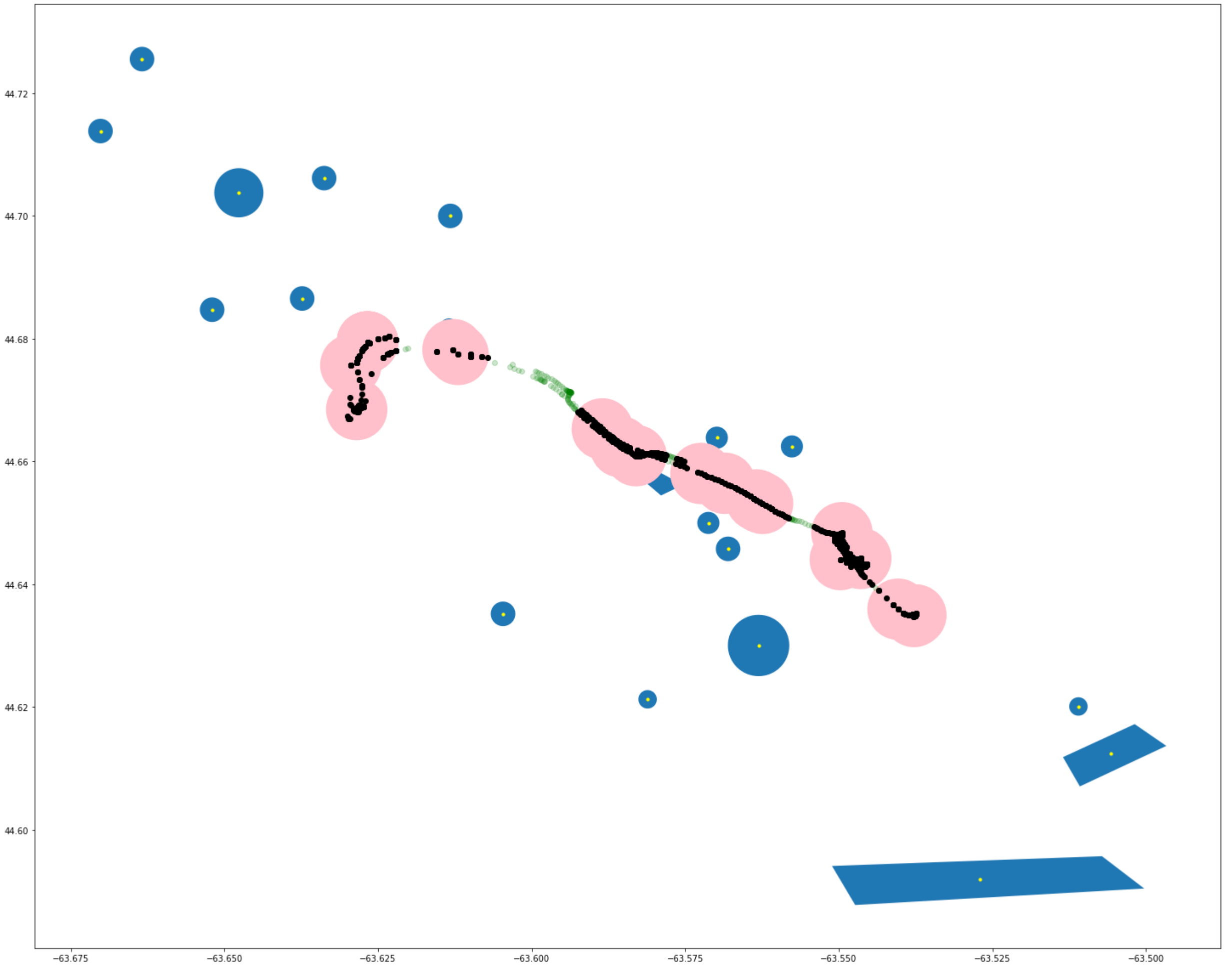


4th interval

In [36]:

```
gdf4 = gpd.GeoDataFrame(d['df_h4'].drop(['location.coordinates.0', 'location.coor
crs={'init': 'epsg:4326'},
geometry=[shapely.geometry.Point(xy) for xy in zip(d['df_h4']['location.coordinat

p1=gdf4.loc[gdf4.distance(d1[0])==gdf4.distance(d1[0]).min(),:]
p2=gdf4.loc[gdf4.distance(d2[0])==gdf4.distance(d2[0]).min(),:]
p3=gdf4.loc[gdf4.distance(d3[0])==gdf4.distance(d3[0]).min(),:]
p4=gdf4.loc[gdf4.distance(d4[0])==gdf4.distance(d4[0]).min(),:]
p5=gdf4.loc[gdf4.distance(d5[0])==gdf4.distance(d5[0]).min(),:]
p6=gdf4.loc[gdf4.distance(d6[0])==gdf4.distance(d6[0]).min(),:]
p7=gdf4.loc[gdf4.distance(d7[0])==gdf4.distance(d7[0]).min(),:]
p8=gdf4.loc[gdf4.distance(d8[0])==gdf4.distance(d8[0]).min(),:]
p9=gdf4.loc[gdf4.distance(d9[0])==gdf4.distance(d9[0]).min(),:]
p10=gdf4.loc[gdf4.distance(d10[0])==gdf4.distance(d10[0]).min(),:]
p11=gdf4.loc[gdf4.distance(d11[0])==gdf4.distance(d11[0]).min(),:]
p12=gdf4.loc[gdf4.distance(d12[0])==gdf4.distance(d12[0]).min(),:]
p13=gdf4.loc[gdf4.distance(d13[0])==gdf4.distance(d13[0]).min(),:]
p14=gdf4.loc[gdf4.distance(d14[0])==gdf4.distance(d14[0]).min(),:]
p15=gdf4.loc[gdf4.distance(d15[0])==gdf4.distance(d15[0]).min(),:]
p16=gdf4.loc[gdf4.distance(d16[0])==gdf4.distance(d16[0]).min(),:]
p17=gdf4.loc[gdf4.distance(d17[0])==gdf4.distance(d17[0]).min(),:]
p18=gdf4.loc[gdf4.distance(d18[0])==gdf4.distance(d18[0]).min(),:]
p19=gdf4.loc[gdf4.distance(d19[0])==gdf4.distance(d19[0]).min(),:]
p20=gdf4.loc[gdf4.distance(d20[0])==gdf4.distance(d20[0]).min(),:]
p21=gdf4.loc[gdf4.distance(d21[0])==gdf4.distance(d21[0]).min(),:]
p22=gdf4.loc[gdf4.distance(d22[0])==gdf4.distance(d22[0]).min(),:]
p23=gdf4.loc[gdf4.distance(d23[0])==gdf4.distance(d23[0]).min(),:]
p24=gdf4.loc[gdf4.distance(d24[0])==gdf4.distance(d24[0]).min(),:]
p25=gdf4.loc[gdf4.distance(d25[0])==gdf4.distance(d25[0]).min(),:]
p26=gdf4.loc[gdf4.distance(d26[0])==gdf4.distance(d26[0]).min(),:]



# creating buffer on the buffer with 5km radius
ax=bylaw.loc[['pointpolygon', 'port1', 'port2', 'ind', 'port5', 'port6', 'port7',
              'southend container terminal','NN Jetty', 'Bills island', 'mid bedf
              'waterfront h', 'northarm', 'plll', 'pp', 'po001','po002', 'oulier_
              'p009', 'p010'],:].plot(figsize=(25,25))
gpd.GeoSeries([d1[0],d2[0],d3[0],d4[0],d5[0],d6[0],d7[0],d8[0],d9[0],d10[0],d11[0
               d16[0],d17[0],d18[0],d19[0],d20[0],d21[0],d22[0],d23[0],d24[0],d25
               d26[0]]).plot(ax=ax,color='yellow',markersize=10)

p1=p1.iloc[0,:].geometry.buffer(0.005)
p2=p2.iloc[0,:].geometry.buffer(0.005)
p3=p3.iloc[0,:].geometry.buffer(0.005)
p4=p4.iloc[0,:].geometry.buffer(0.005)
p5=p5.iloc[0,:].geometry.buffer(0.005) # getting the buffer with 5km radius for t
p6=p6.iloc[0,:].geometry.buffer(0.005)
p7=p7.iloc[0,:].geometry.buffer(0.005)
p8=p8.iloc[0,:].geometry.buffer(0.005)
p9=p9.iloc[0,:].geometry.buffer(0.005)
p10=p10.iloc[0,:].geometry.buffer(0.005)
p11=p11.iloc[0,:].geometry.buffer(0.005)
p12=p12.iloc[0,:].geometry.buffer(0.005)
p13=p13.iloc[0,:].geometry.buffer(0.005)
p14=p14.iloc[0,:].geometry.buffer(0.005)
p15=p15.iloc[0,:].geometry.buffer(0.005)
```

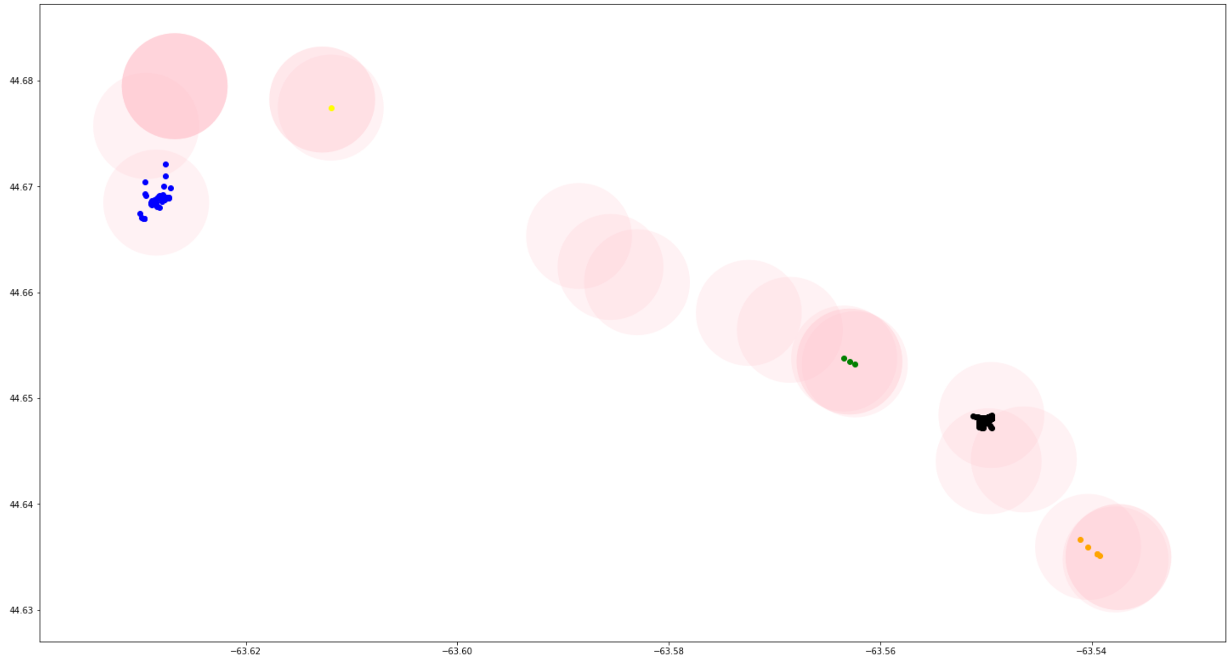
```
p16=p16.iloc[0,:].geometry.buffer(0.005)
p17=p17.iloc[0,:].geometry.buffer(0.005)
p18=p18.iloc[0,:].geometry.buffer(0.005)
p19=p19.iloc[0,:].geometry.buffer(0.005)
p20=p20.iloc[0,:].geometry.buffer(0.005)
p21=p21.iloc[0,:].geometry.buffer(0.005)
p22=p22.iloc[0,:].geometry.buffer(0.005)
p23=p23.iloc[0,:].geometry.buffer(0.005)
p24=p24.iloc[0,:].geometry.buffer(0.005)
p25=p25.iloc[0,:].geometry.buffer(0.005)
p26=p26.iloc[0,:].geometry.buffer(0.005)

# plotting the buffer radius near ports

gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,p19
gdf4.plot(ax=ax,color='g',alpha=0.2)
gdf4.loc[gdf4.within(p1),:].plot(ax=ax,color='k')
gdf4.loc[gdf4.within(p2),:].plot(ax=ax,color='k')
gdf4.loc[gdf4.within(p3),:].plot(ax=ax,color='k')
gdf4.loc[gdf4.within(p4),:].plot(ax=ax,color='k')
gdf4.loc[gdf4.within(p5),:].plot(ax=ax,color='k')
gdf4.loc[gdf4.within(p6),:].plot(ax=ax,color='k')
gdf4.loc[gdf4.within(p7),:].plot(ax=ax,color='k')
gdf4.loc[gdf4.within(p8),:].plot(ax=ax,color='k')
gdf4.loc[gdf4.within(p9),:].plot(ax=ax,color='k')
gdf4.loc[gdf4.within(p10),:].plot(ax=ax,color='k')
gdf4.loc[gdf4.within(p11),:].plot(ax=ax,color='k')
gdf4.loc[gdf4.within(p12),:].plot(ax=ax,color='k')
gdf4.loc[gdf4.within(p13),:].plot(ax=ax,color='k')
gdf4.loc[gdf4.within(p14),:].plot(ax=ax,color='k')
gdf4.loc[gdf4.within(p15),:].plot(ax=ax,color='k')
gdf4.loc[gdf4.within(p16),:].plot(ax=ax,color='k')
gdf4.loc[gdf4.within(p17),:].plot(ax=ax,color='k')
gdf4.loc[gdf4.within(p18),:].plot(ax=ax,color='k')
gdf4.loc[gdf4.within(p19),:].plot(ax=ax,color='k')
gdf4.loc[gdf4.within(p20),:].plot(ax=ax,color='k')
gdf4.loc[gdf4.within(p21),:].plot(ax=ax,color='k')
gdf4.loc[gdf4.within(p22),:].plot(ax=ax,color='k')
gdf4.loc[gdf4.within(p23),:].plot(ax=ax,color='k')
gdf4.loc[gdf4.within(p24),:].plot(ax=ax,color='k')
gdf4.loc[gdf4.within(p25),:].plot(ax=ax,color='k')
gdf4.loc[gdf4.within(p26),:].plot(ax=ax,color='k')
plt.savefig('Q3 images/interval_04_q1.png')
```


44.72
44.70
44.68
44.66
44.64
44.62
44.60
−63.675
−63.650
−63.625
−63.600
−63.575
−63.550
−63.525
−63.500

In [37]:

```
joinres=gpd.sjoin(gdf4,bylaw,op='within',how='left')
col=['r','b','g','k','yellow','orange','Olive','Maroon','Purple','Fuchsia','Lime'
i=0
ax=gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,


for g in set(joinres['index_right']):
  tmp=joinres.loc[joinres['index_right']==g,:]
  if tmp.shape[0]>0:
    tmp.plot(ax=ax,color=col[i])
  i=i+1
plt.savefig('Q3 images/interval_04_q2.png')
```

```
C:\Users\lanch\Anaconda3\lib\site-packages\geopandas\tools\sjoin.py:44: UserWar
ning: CRS of frames being joined does not match!
  warn('CRS of frames being joined does not match!')
```

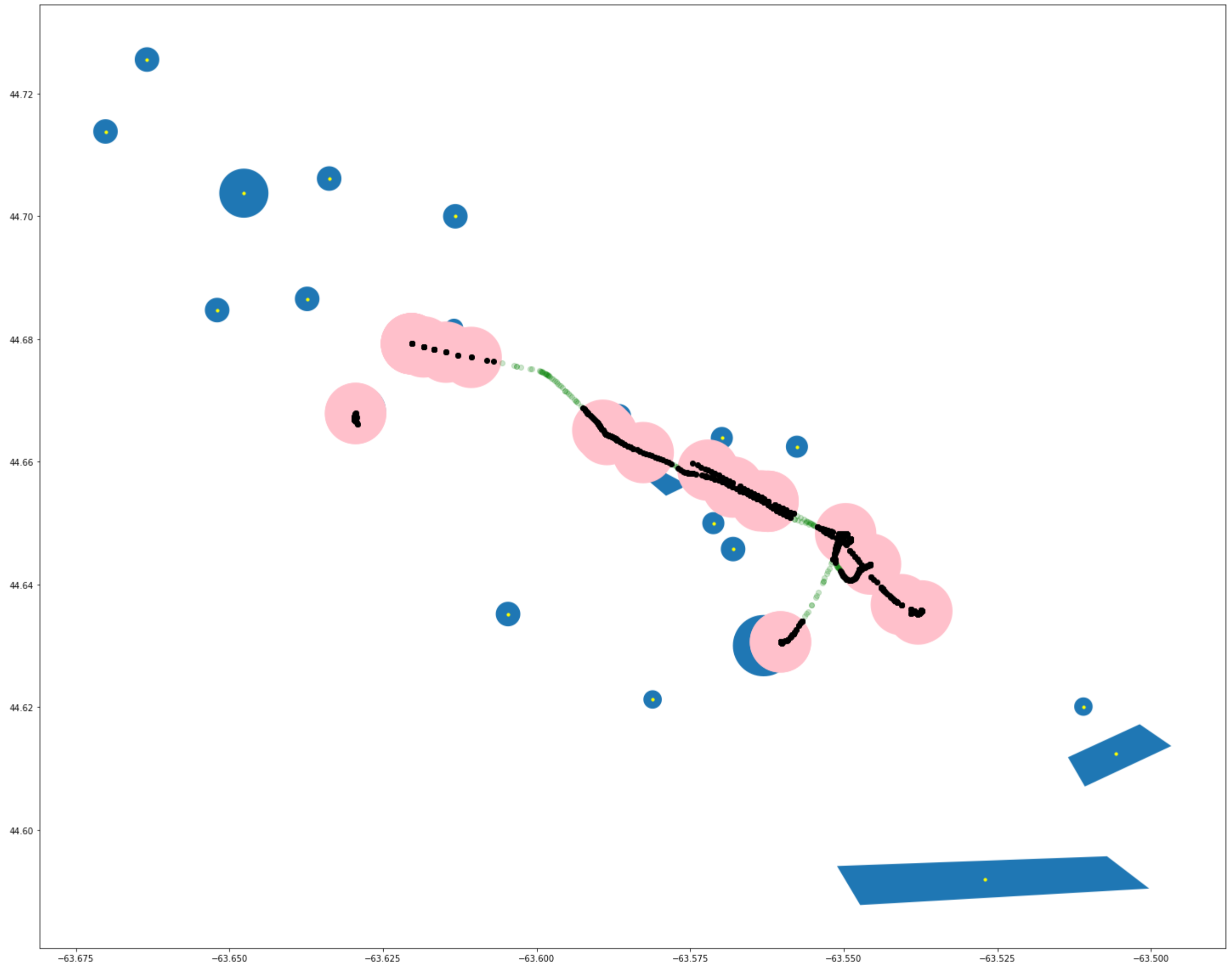


5th interval

In [38]:

```
gdf5 = gpd.GeoDataFrame(d['df_h5'].drop(['location.coordinates.0', 'location.coor
crs={'init': 'epsg:4326'},
geometry=[shapely.geometry.Point(xy) for xy in zip(d['df_h5']['location.coordinat

p1=gdf5.loc[gdf5.distance(d1[0])==gdf5.distance(d1[0]).min(),:]
p2=gdf5.loc[gdf5.distance(d2[0])==gdf5.distance(d2[0]).min(),:]
p3=gdf5.loc[gdf5.distance(d3[0])==gdf5.distance(d3[0]).min(),:]
p4=gdf5.loc[gdf5.distance(d4[0])==gdf5.distance(d4[0]).min(),:]
p5=gdf5.loc[gdf5.distance(d5[0])==gdf5.distance(d5[0]).min(),:]
p6=gdf5.loc[gdf5.distance(d6[0])==gdf5.distance(d6[0]).min(),:]
p7=gdf5.loc[gdf5.distance(d7[0])==gdf5.distance(d7[0]).min(),:]
p8=gdf5.loc[gdf5.distance(d8[0])==gdf5.distance(d8[0]).min(),:]
p9=gdf5.loc[gdf5.distance(d9[0])==gdf5.distance(d9[0]).min(),:]
p10=gdf5.loc[gdf5.distance(d10[0])==gdf5.distance(d10[0]).min(),:]
p11=gdf5.loc[gdf5.distance(d11[0])==gdf5.distance(d11[0]).min(),:]
p12=gdf5.loc[gdf5.distance(d12[0])==gdf5.distance(d12[0]).min(),:]
p13=gdf5.loc[gdf5.distance(d13[0])==gdf5.distance(d13[0]).min(),:]
p14=gdf5.loc[gdf5.distance(d14[0])==gdf5.distance(d14[0]).min(),:]
p15=gdf5.loc[gdf5.distance(d15[0])==gdf5.distance(d15[0]).min(),:]
p16=gdf5.loc[gdf5.distance(d16[0])==gdf5.distance(d16[0]).min(),:]
p17=gdf5.loc[gdf5.distance(d17[0])==gdf5.distance(d17[0]).min(),:]
p18=gdf5.loc[gdf5.distance(d18[0])==gdf5.distance(d18[0]).min(),:]
p19=gdf5.loc[gdf5.distance(d19[0])==gdf5.distance(d19[0]).min(),:]
p20=gdf5.loc[gdf5.distance(d20[0])==gdf5.distance(d20[0]).min(),:]
p21=gdf5.loc[gdf5.distance(d21[0])==gdf5.distance(d21[0]).min(),:]
p22=gdf5.loc[gdf5.distance(d22[0])==gdf5.distance(d22[0]).min(),:]
p23=gdf5.loc[gdf5.distance(d23[0])==gdf5.distance(d23[0]).min(),:]
p24=gdf5.loc[gdf5.distance(d24[0])==gdf5.distance(d24[0]).min(),:]
p25=gdf5.loc[gdf5.distance(d25[0])==gdf5.distance(d25[0]).min(),:]
p26=gdf5.loc[gdf5.distance(d26[0])==gdf5.distance(d26[0]).min(),:]



# creating buffer on the buffer with 5km radius
ax=bylaw.loc[['pointpolygon', 'port1', 'port2', 'ind', 'port5', 'port6', 'port7',
              'southend container terminal','NN Jetty', 'Bills island', 'mid bedf
              'waterfront h', 'northarm', 'plll', 'pp', 'po001','po002', 'oulier_
              'p009', 'p010'],:].plot(figsize=(25,25))
gpd.GeoSeries([d1[0],d2[0],d3[0],d4[0],d5[0],d6[0],d7[0],d8[0],d9[0],d10[0],d11[0
               d16[0],d17[0],d18[0],d19[0],d20[0],d21[0],d22[0],d23[0],d24[0],d25
               d26[0]]).plot(ax=ax,color='yellow',markersize=10)

p1=p1.iloc[0,:].geometry.buffer(0.005)
p2=p2.iloc[0,:].geometry.buffer(0.005)
p3=p3.iloc[0,:].geometry.buffer(0.005)
p4=p4.iloc[0,:].geometry.buffer(0.005)
p5=p5.iloc[0,:].geometry.buffer(0.005) # getting the buffer with 5km radius for t
p6=p6.iloc[0,:].geometry.buffer(0.005)
p7=p7.iloc[0,:].geometry.buffer(0.005)
p8=p8.iloc[0,:].geometry.buffer(0.005)
p9=p9.iloc[0,:].geometry.buffer(0.005)
p10=p10.iloc[0,:].geometry.buffer(0.005)
p11=p11.iloc[0,:].geometry.buffer(0.005)
p12=p12.iloc[0,:].geometry.buffer(0.005)
p13=p13.iloc[0,:].geometry.buffer(0.005)
p14=p14.iloc[0,:].geometry.buffer(0.005)
p15=p15.iloc[0,:].geometry.buffer(0.005)
```

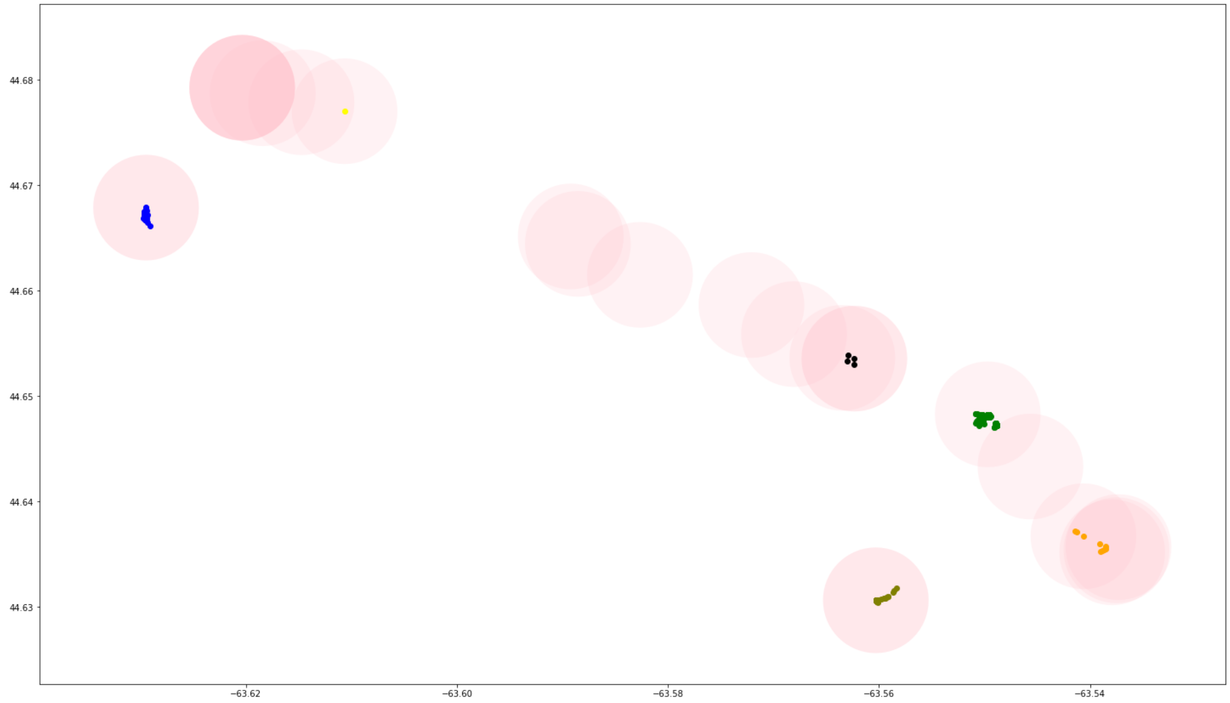
```
p16=p16.iloc[0,:].geometry.buffer(0.005)
p17=p17.iloc[0,:].geometry.buffer(0.005)
p18=p18.iloc[0,:].geometry.buffer(0.005)
p19=p19.iloc[0,:].geometry.buffer(0.005)
p20=p20.iloc[0,:].geometry.buffer(0.005)
p21=p21.iloc[0,:].geometry.buffer(0.005)
p22=p22.iloc[0,:].geometry.buffer(0.005)
p23=p23.iloc[0,:].geometry.buffer(0.005)
p24=p24.iloc[0,:].geometry.buffer(0.005)
p25=p25.iloc[0,:].geometry.buffer(0.005)
p26=p26.iloc[0,:].geometry.buffer(0.005)

# plotting the buffer radius near ports

gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,p19
gdf5.plot(ax=ax,color='g',alpha=0.2)
gdf5.loc[gdf5.within(p1),:].plot(ax=ax,color='k')
gdf5.loc[gdf5.within(p2),:].plot(ax=ax,color='k')
gdf5.loc[gdf5.within(p3),:].plot(ax=ax,color='k')
gdf5.loc[gdf5.within(p4),:].plot(ax=ax,color='k')
gdf5.loc[gdf5.within(p5),:].plot(ax=ax,color='k')
gdf5.loc[gdf5.within(p6),:].plot(ax=ax,color='k')
gdf5.loc[gdf5.within(p7),:].plot(ax=ax,color='k')
gdf5.loc[gdf5.within(p8),:].plot(ax=ax,color='k')
gdf5.loc[gdf5.within(p9),:].plot(ax=ax,color='k')
gdf5.loc[gdf5.within(p10),:].plot(ax=ax,color='k')
gdf5.loc[gdf5.within(p11),:].plot(ax=ax,color='k')
gdf5.loc[gdf5.within(p12),:].plot(ax=ax,color='k')
gdf5.loc[gdf5.within(p13),:].plot(ax=ax,color='k')
gdf5.loc[gdf5.within(p14),:].plot(ax=ax,color='k')
gdf5.loc[gdf5.within(p15),:].plot(ax=ax,color='k')
gdf5.loc[gdf5.within(p16),:].plot(ax=ax,color='k')
gdf5.loc[gdf5.within(p17),:].plot(ax=ax,color='k')
gdf5.loc[gdf5.within(p18),:].plot(ax=ax,color='k')
gdf5.loc[gdf5.within(p19),:].plot(ax=ax,color='k')
gdf5.loc[gdf5.within(p20),:].plot(ax=ax,color='k')
gdf5.loc[gdf5.within(p21),:].plot(ax=ax,color='k')
gdf5.loc[gdf5.within(p22),:].plot(ax=ax,color='k')
gdf5.loc[gdf5.within(p23),:].plot(ax=ax,color='k')
gdf5.loc[gdf5.within(p24),:].plot(ax=ax,color='k')
gdf5.loc[gdf5.within(p25),:].plot(ax=ax,color='k')
gdf5.loc[gdf5.within(p26),:].plot(ax=ax,color='k')
plt.savefig('Q3 images/interval_05_q1.png')
```


44.72
44.70
44.68
44.66
44.64
44.62
44.60
−63.675
−63.650
−63.625
−63.600
−63.575
−63.550
−63.525
−63.500

In [39]:

```
joinres=gpd.sjoin(gdf5,bylaw,op='within',how='left')
col=['r','b','g','k','yellow','orange','Olive','Maroon','Purple','Fuchsia','Lime'
i=0
ax=gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,


for g in set(joinres['index_right']):
  tmp=joinres.loc[joinres['index_right']==g,:]
  if tmp.shape[0]>0:
    tmp.plot(ax=ax,color=col[i])
  i=i+1
plt.savefig('Q3 images/interval_05_q2.png')
```

```
C:\Users\lanch\Anaconda3\lib\site-packages\geopandas\tools\sjoin.py:44: UserWar
ning: CRS of frames being joined does not match!
  warn('CRS of frames being joined does not match!')
```

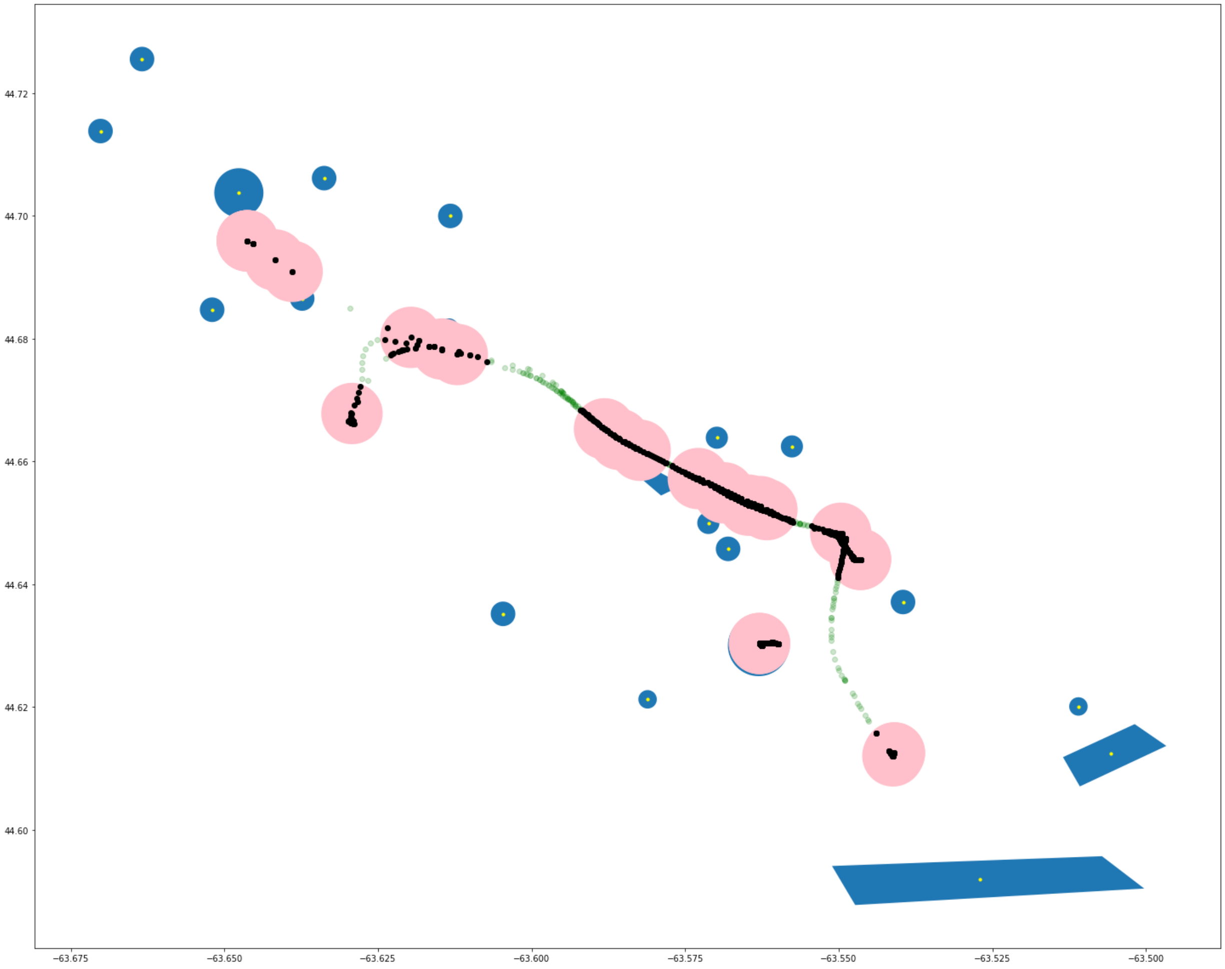


```
6th interval
```

In [40]:

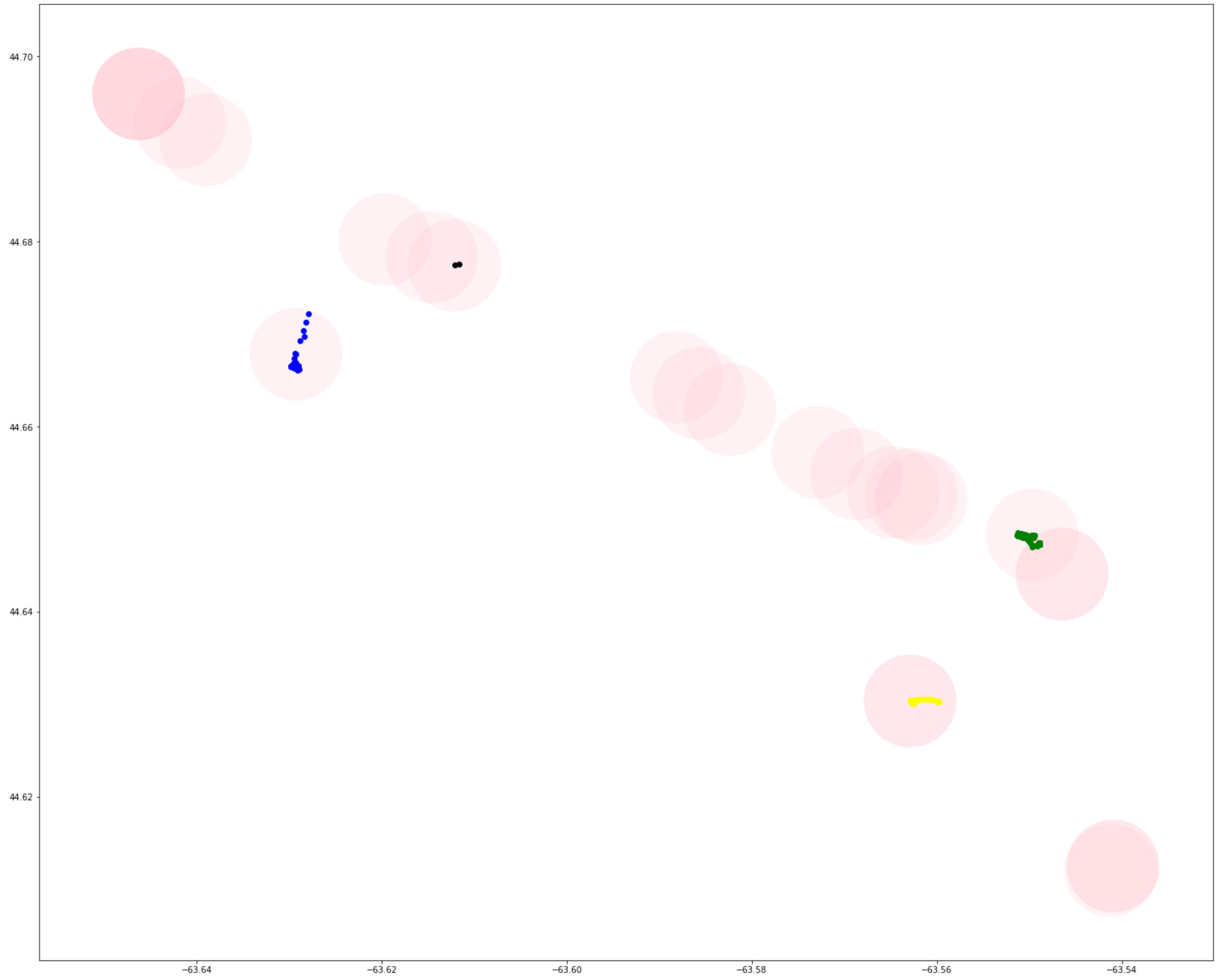
```
gdf6 = gpd.GeoDataFrame(d['df_h6'].drop(['location.coordinates.0', 'location.coor
crs={'init': 'epsg:4326'},
geometry=[shapely.geometry.Point(xy) for xy in zip(d['df_h6']['location.coordinat

p1=gdf6.loc[gdf6.distance(d1[0])==gdf6.distance(d1[0]).min(),:]
p2=gdf6.loc[gdf6.distance(d2[0])==gdf6.distance(d2[0]).min(),:]
p3=gdf6.loc[gdf6.distance(d3[0])==gdf6.distance(d3[0]).min(),:]
p4=gdf6.loc[gdf6.distance(d4[0])==gdf6.distance(d4[0]).min(),:]
p5=gdf6.loc[gdf6.distance(d5[0])==gdf6.distance(d5[0]).min(),:]
p6=gdf6.loc[gdf6.distance(d6[0])==gdf6.distance(d6[0]).min(),:]
p7=gdf6.loc[gdf6.distance(d7[0])==gdf6.distance(d7[0]).min(),:]
p8=gdf6.loc[gdf6.distance(d8[0])==gdf6.distance(d8[0]).min(),:]
p9=gdf6.loc[gdf6.distance(d9[0])==gdf6.distance(d9[0]).min(),:]
p10=gdf6.loc[gdf6.distance(d10[0])==gdf6.distance(d10[0]).min(),:]
p11=gdf6.loc[gdf6.distance(d11[0])==gdf6.distance(d11[0]).min(),:]
p12=gdf6.loc[gdf6.distance(d12[0])==gdf6.distance(d12[0]).min(),:]
p13=gdf6.loc[gdf6.distance(d13[0])==gdf6.distance(d13[0]).min(),:]
p14=gdf6.loc[gdf6.distance(d14[0])==gdf6.distance(d14[0]).min(),:]
p15=gdf6.loc[gdf6.distance(d15[0])==gdf6.distance(d15[0]).min(),:]
p16=gdf6.loc[gdf6.distance(d16[0])==gdf6.distance(d16[0]).min(),:]
p17=gdf6.loc[gdf6.distance(d17[0])==gdf6.distance(d17[0]).min(),:]
p18=gdf6.loc[gdf6.distance(d18[0])==gdf6.distance(d18[0]).min(),:]
p19=gdf6.loc[gdf6.distance(d19[0])==gdf6.distance(d19[0]).min(),:]
p20=gdf6.loc[gdf6.distance(d20[0])==gdf6.distance(d20[0]).min(),:]
p21=gdf6.loc[gdf6.distance(d21[0])==gdf6.distance(d21[0]).min(),:]
p22=gdf6.loc[gdf6.distance(d22[0])==gdf6.distance(d22[0]).min(),:]
p23=gdf6.loc[gdf6.distance(d23[0])==gdf6.distance(d23[0]).min(),:]
p24=gdf6.loc[gdf6.distance(d24[0])==gdf6.distance(d24[0]).min(),:]
p25=gdf6.loc[gdf6.distance(d25[0])==gdf6.distance(d25[0]).min(),:]
p26=gdf6.loc[gdf6.distance(d26[0])==gdf6.distance(d26[0]).min(),:]



# creating buffer on the buffer with 5km radius
ax=bylaw.loc[['pointpolygon', 'port1', 'port2', 'ind', 'port5', 'port6', 'port7',
              'southend container terminal','NN Jetty', 'Bills island', 'mid bedf
              'waterfront h', 'northarm', 'plll', 'pp', 'po001','po002', 'oulier_
              'p009', 'p010'],:].plot(figsize=(25,25))
gpd.GeoSeries([d1[0],d2[0],d3[0],d4[0],d5[0],d6[0],d7[0],d8[0],d9[0],d10[0],d11[0
               d16[0],d17[0],d18[0],d19[0],d20[0],d21[0],d22[0],d23[0],d24[0],d25
               d26[0]]).plot(ax=ax,color='yellow',markersize=10)

p1=p1.iloc[0,:].geometry.buffer(0.005)
p2=p2.iloc[0,:].geometry.buffer(0.005)
p3=p3.iloc[0,:].geometry.buffer(0.005)
p4=p4.iloc[0,:].geometry.buffer(0.005)
p5=p5.iloc[0,:].geometry.buffer(0.005) # getting the buffer with 5km radius for t
p6=p6.iloc[0,:].geometry.buffer(0.005)
p7=p7.iloc[0,:].geometry.buffer(0.005)
p8=p8.iloc[0,:].geometry.buffer(0.005)
p9=p9.iloc[0,:].geometry.buffer(0.005)
p10=p10.iloc[0,:].geometry.buffer(0.005)
p11=p11.iloc[0,:].geometry.buffer(0.005)
p12=p12.iloc[0,:].geometry.buffer(0.005)
p13=p13.iloc[0,:].geometry.buffer(0.005)
p14=p14.iloc[0,:].geometry.buffer(0.005)
p15=p15.iloc[0,:].geometry.buffer(0.005)
```

```
p16=p16.iloc[0,:].geometry.buffer(0.005)
p17=p17.iloc[0,:].geometry.buffer(0.005)
p18=p18.iloc[0,:].geometry.buffer(0.005)
p19=p19.iloc[0,:].geometry.buffer(0.005)
p20=p20.iloc[0,:].geometry.buffer(0.005)
p21=p21.iloc[0,:].geometry.buffer(0.005)
p22=p22.iloc[0,:].geometry.buffer(0.005)
p23=p23.iloc[0,:].geometry.buffer(0.005)
p24=p24.iloc[0,:].geometry.buffer(0.005)
p25=p25.iloc[0,:].geometry.buffer(0.005)
p26=p26.iloc[0,:].geometry.buffer(0.005)

# plotting the buffer radius near ports

gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,p19
gdf6.plot(ax=ax,color='g',alpha=0.2)
gdf6.loc[gdf6.within(p1),:].plot(ax=ax,color='k')
gdf6.loc[gdf6.within(p2),:].plot(ax=ax,color='k')
gdf6.loc[gdf6.within(p3),:].plot(ax=ax,color='k')
gdf6.loc[gdf6.within(p4),:].plot(ax=ax,color='k')
gdf6.loc[gdf6.within(p5),:].plot(ax=ax,color='k')
gdf6.loc[gdf6.within(p6),:].plot(ax=ax,color='k')
gdf6.loc[gdf6.within(p7),:].plot(ax=ax,color='k')
gdf6.loc[gdf6.within(p8),:].plot(ax=ax,color='k')
gdf6.loc[gdf6.within(p9),:].plot(ax=ax,color='k')
gdf6.loc[gdf6.within(p10),:].plot(ax=ax,color='k')
gdf6.loc[gdf6.within(p11),:].plot(ax=ax,color='k')
gdf6.loc[gdf6.within(p12),:].plot(ax=ax,color='k')
gdf6.loc[gdf6.within(p13),:].plot(ax=ax,color='k')
gdf6.loc[gdf6.within(p14),:].plot(ax=ax,color='k')
gdf6.loc[gdf6.within(p15),:].plot(ax=ax,color='k')
gdf6.loc[gdf6.within(p16),:].plot(ax=ax,color='k')
gdf6.loc[gdf6.within(p17),:].plot(ax=ax,color='k')
gdf6.loc[gdf6.within(p18),:].plot(ax=ax,color='k')
gdf6.loc[gdf6.within(p19),:].plot(ax=ax,color='k')
gdf6.loc[gdf6.within(p20),:].plot(ax=ax,color='k')
gdf6.loc[gdf6.within(p21),:].plot(ax=ax,color='k')
gdf6.loc[gdf6.within(p22),:].plot(ax=ax,color='k')
gdf6.loc[gdf6.within(p23),:].plot(ax=ax,color='k')
gdf6.loc[gdf6.within(p24),:].plot(ax=ax,color='k')
gdf6.loc[gdf6.within(p25),:].plot(ax=ax,color='k')
gdf6.loc[gdf6.within(p26),:].plot(ax=ax,color='k')
plt.savefig('Q3 images/interval_06_q1.png')
```


44.72
44.70
44.68
44.66
44.64
44.62
44.60
−63.675
−63.650
−63.625
−63.600
−63.575
−63.550
−63.525
−63.500

In [41]:
```
joinres=gpd.sjoin(gdf6,bylaw,op='within',how='left')
col=['r','b','g','k','yellow','orange','Olive','Maroon','Purple','Fuchsia','Lime'
i=0
ax=gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,


for g in set(joinres['index_right']):
  tmp=joinres.loc[joinres['index_right']==g,:]
  if tmp.shape[0]>0:
    tmp.plot(ax=ax,color=col[i])
  i=i+1
plt.savefig('Q3 images/interval_06_q2.png')
```

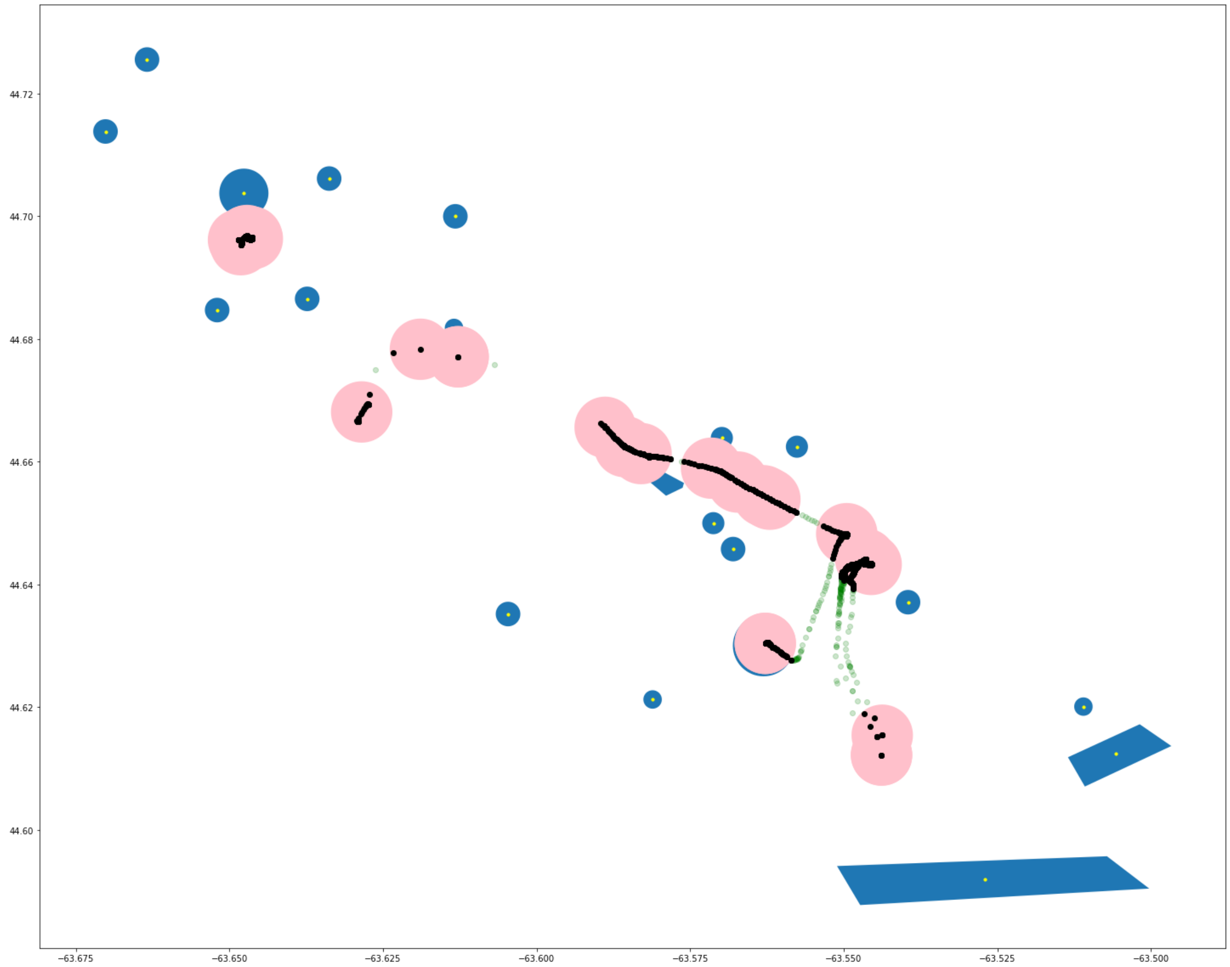
```
C:\Users\lanch\Anaconda3\lib\site-packages\geopandas\tools\sjoin.py:44: UserWar
ning: CRS of frames being joined does not match!
  warn('CRS of frames being joined does not match!')
```



```
7th interval
```

In [42]:
```
gdf7 = gpd.GeoDataFrame(d['df_h7'].drop(['location.coordinates.0', 'location.coor
crs={'init': 'epsg:4326'},
geometry=[shapely.geometry.Point(xy) for xy in zip(d['df_h7']['location.coordinat

p1=gdf7.loc[gdf7.distance(d1[0])==gdf7.distance(d1[0]).min(),:]
p2=gdf7.loc[gdf7.distance(d2[0])==gdf7.distance(d2[0]).min(),:]
p3=gdf7.loc[gdf7.distance(d3[0])==gdf7.distance(d3[0]).min(),:]
p4=gdf7.loc[gdf7.distance(d4[0])==gdf7.distance(d4[0]).min(),:]
p5=gdf7.loc[gdf7.distance(d5[0])==gdf7.distance(d5[0]).min(),:]
p6=gdf7.loc[gdf7.distance(d6[0])==gdf7.distance(d6[0]).min(),:]
p7=gdf7.loc[gdf7.distance(d7[0])==gdf7.distance(d7[0]).min(),:]
p8=gdf7.loc[gdf7.distance(d8[0])==gdf7.distance(d8[0]).min(),:]
p9=gdf7.loc[gdf7.distance(d9[0])==gdf7.distance(d9[0]).min(),:]
p10=gdf7.loc[gdf7.distance(d10[0])==gdf7.distance(d10[0]).min(),:]
p11=gdf7.loc[gdf7.distance(d11[0])==gdf7.distance(d11[0]).min(),:]
p12=gdf7.loc[gdf7.distance(d12[0])==gdf7.distance(d12[0]).min(),:]
p13=gdf7.loc[gdf7.distance(d13[0])==gdf7.distance(d13[0]).min(),:]
p14=gdf7.loc[gdf7.distance(d14[0])==gdf7.distance(d14[0]).min(),:]
p15=gdf7.loc[gdf7.distance(d15[0])==gdf7.distance(d15[0]).min(),:]
p16=gdf7.loc[gdf7.distance(d16[0])==gdf7.distance(d16[0]).min(),:]
p17=gdf7.loc[gdf7.distance(d17[0])==gdf7.distance(d17[0]).min(),:]
p18=gdf7.loc[gdf7.distance(d18[0])==gdf7.distance(d18[0]).min(),:]
p19=gdf7.loc[gdf7.distance(d19[0])==gdf7.distance(d19[0]).min(),:]
p20=gdf7.loc[gdf7.distance(d20[0])==gdf7.distance(d20[0]).min(),:]
p21=gdf7.loc[gdf7.distance(d21[0])==gdf7.distance(d21[0]).min(),:]
p22=gdf7.loc[gdf7.distance(d22[0])==gdf7.distance(d22[0]).min(),:]
p23=gdf7.loc[gdf7.distance(d23[0])==gdf7.distance(d23[0]).min(),:]
p24=gdf7.loc[gdf7.distance(d24[0])==gdf7.distance(d24[0]).min(),:]
p25=gdf7.loc[gdf7.distance(d25[0])==gdf7.distance(d25[0]).min(),:]
p26=gdf7.loc[gdf7.distance(d26[0])==gdf7.distance(d26[0]).min(),:]



# creating buffer on the buffer with 5km radius
ax=bylaw.loc[['pointpolygon', 'port1', 'port2', 'ind', 'port5', 'port6', 'port7',
              'southend container terminal','NN Jetty', 'Bills island', 'mid bedf
              'waterfront h', 'northarm', 'plll', 'pp', 'po001','po002', 'oulier_
              'p009', 'p010'],:].plot(figsize=(25,25))
gpd.GeoSeries([d1[0],d2[0],d3[0],d4[0],d5[0],d6[0],d7[0],d8[0],d9[0],d10[0],d11[0
               d16[0],d17[0],d18[0],d19[0],d20[0],d21[0],d22[0],d23[0],d24[0],d25
               d26[0]]).plot(ax=ax,color='yellow',markersize=10)

p1=p1.iloc[0,:].geometry.buffer(0.005)
p2=p2.iloc[0,:].geometry.buffer(0.005)
p3=p3.iloc[0,:].geometry.buffer(0.005)
p4=p4.iloc[0,:].geometry.buffer(0.005)
p5=p5.iloc[0,:].geometry.buffer(0.005) # getting the buffer with 5km radius for t
p6=p6.iloc[0,:].geometry.buffer(0.005)
p7=p7.iloc[0,:].geometry.buffer(0.005)
p8=p8.iloc[0,:].geometry.buffer(0.005)
p9=p9.iloc[0,:].geometry.buffer(0.005)
p10=p10.iloc[0,:].geometry.buffer(0.005)
p11=p11.iloc[0,:].geometry.buffer(0.005)
p12=p12.iloc[0,:].geometry.buffer(0.005)
p13=p13.iloc[0,:].geometry.buffer(0.005)
p14=p14.iloc[0,:].geometry.buffer(0.005)
p15=p15.iloc[0,:].geometry.buffer(0.005)
```

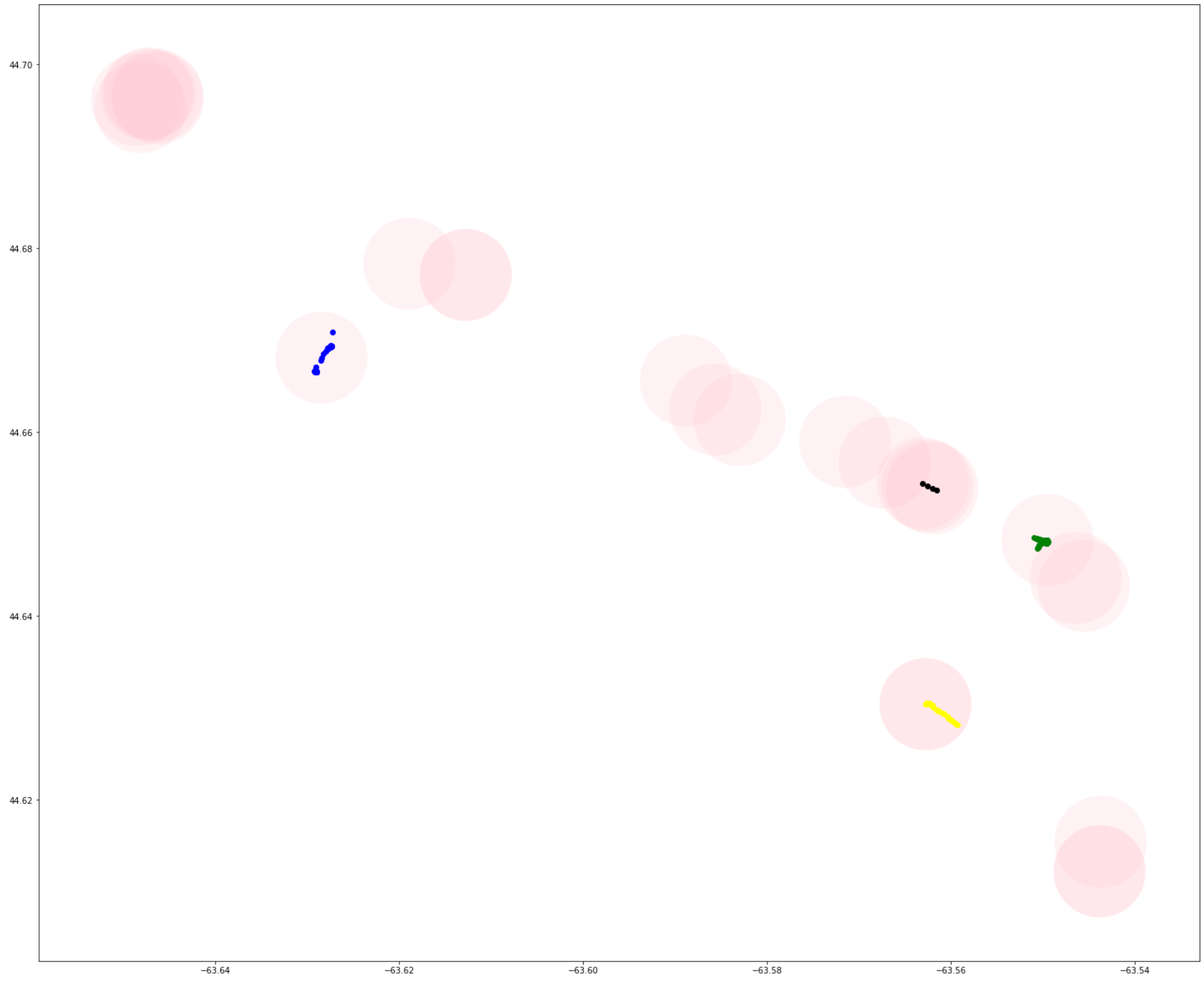
```
p16=p16.iloc[0,:].geometry.buffer(0.005)
p17=p17.iloc[0,:].geometry.buffer(0.005)
p18=p18.iloc[0,:].geometry.buffer(0.005)
p19=p19.iloc[0,:].geometry.buffer(0.005)
p20=p20.iloc[0,:].geometry.buffer(0.005)
p21=p21.iloc[0,:].geometry.buffer(0.005)
p22=p22.iloc[0,:].geometry.buffer(0.005)
p23=p23.iloc[0,:].geometry.buffer(0.005)
p24=p24.iloc[0,:].geometry.buffer(0.005)
p25=p25.iloc[0,:].geometry.buffer(0.005)
p26=p26.iloc[0,:].geometry.buffer(0.005)

# plotting the buffer radius near ports

gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,p19
gdf7.plot(ax=ax,color='g',alpha=0.2)
gdf7.loc[gdf7.within(p1),:].plot(ax=ax,color='k')
gdf7.loc[gdf7.within(p2),:].plot(ax=ax,color='k')
gdf7.loc[gdf7.within(p3),:].plot(ax=ax,color='k')
gdf7.loc[gdf7.within(p4),:].plot(ax=ax,color='k')
gdf7.loc[gdf7.within(p5),:].plot(ax=ax,color='k')
gdf7.loc[gdf7.within(p6),:].plot(ax=ax,color='k')
gdf7.loc[gdf7.within(p7),:].plot(ax=ax,color='k')
gdf7.loc[gdf7.within(p8),:].plot(ax=ax,color='k')
gdf7.loc[gdf7.within(p9),:].plot(ax=ax,color='k')
gdf7.loc[gdf7.within(p10),:].plot(ax=ax,color='k')
gdf7.loc[gdf7.within(p11),:].plot(ax=ax,color='k')
gdf7.loc[gdf7.within(p12),:].plot(ax=ax,color='k')
gdf7.loc[gdf7.within(p13),:].plot(ax=ax,color='k')
gdf7.loc[gdf7.within(p14),:].plot(ax=ax,color='k')
gdf7.loc[gdf7.within(p15),:].plot(ax=ax,color='k')
gdf7.loc[gdf7.within(p16),:].plot(ax=ax,color='k')
gdf7.loc[gdf7.within(p17),:].plot(ax=ax,color='k')
gdf7.loc[gdf7.within(p18),:].plot(ax=ax,color='k')
gdf7.loc[gdf7.within(p19),:].plot(ax=ax,color='k')
gdf7.loc[gdf7.within(p20),:].plot(ax=ax,color='k')
gdf7.loc[gdf7.within(p21),:].plot(ax=ax,color='k')
gdf7.loc[gdf7.within(p22),:].plot(ax=ax,color='k')
gdf7.loc[gdf7.within(p23),:].plot(ax=ax,color='k')
gdf7.loc[gdf7.within(p24),:].plot(ax=ax,color='k')
gdf7.loc[gdf7.within(p25),:].plot(ax=ax,color='k')
gdf7.loc[gdf7.within(p26),:].plot(ax=ax,color='k')
plt.savefig('Q3 images/interval_07_q1.png')
```


44.72
44.70
44.68
44.66
44.64
44.62
44.60
−63.675
−63.650
−63.625
−63.600
−63.575
−63.550
−63.525
−63.500

In [43]:

```
joinres=gpd.sjoin(gdf7,bylaw,op='within',how='left')
col=['r','b','g','k','yellow','orange','Olive','Maroon','Purple','Fuchsia','Lime'
i=0
ax=gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,


for g in set(joinres['index_right']):
  tmp=joinres.loc[joinres['index_right']==g,:]
  if tmp.shape[0]>0:
    tmp.plot(ax=ax,color=col[i])
  i=i+1
plt.savefig('Q3 images/interval_07_q2.png')
```

```
C:\Users\lanch\Anaconda3\lib\site-packages\geopandas\tools\sjoin.py:44: UserWar
ning: CRS of frames being joined does not match!
  warn('CRS of frames being joined does not match!')
```

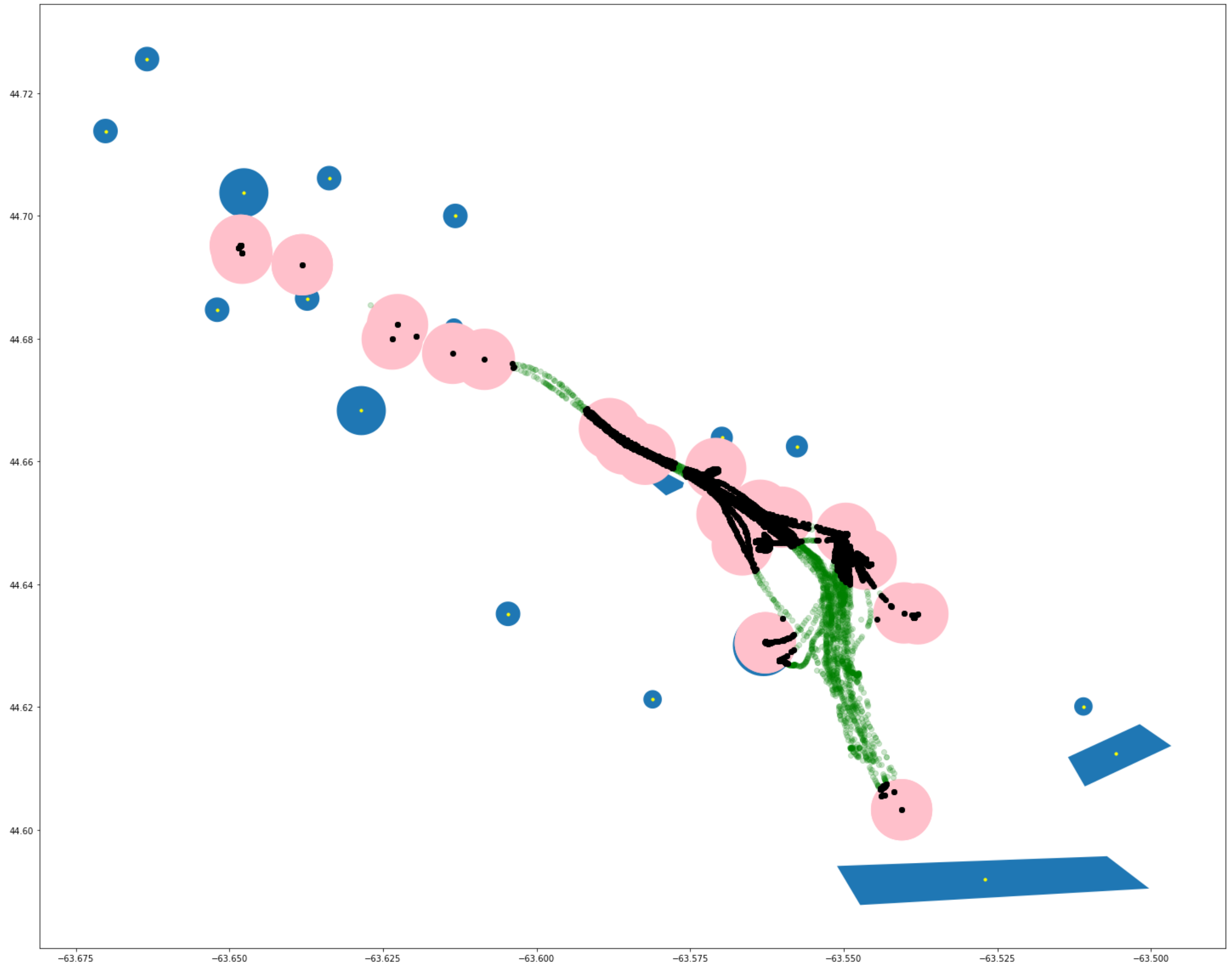


8th interval

In [44]:

```
gdf8 = gpd.GeoDataFrame(d['df_h8'].drop(['location.coordinates.0', 'location.coor
crs={'init': 'epsg:4326'},
geometry=[shapely.geometry.Point(xy) for xy in zip(d['df_h8']['location.coordinat

p1=gdf8.loc[gdf8.distance(d1[0])==gdf8.distance(d1[0]).min(),:]
p2=gdf8.loc[gdf8.distance(d2[0])==gdf8.distance(d2[0]).min(),:]
p3=gdf8.loc[gdf8.distance(d3[0])==gdf8.distance(d3[0]).min(),:]
p4=gdf8.loc[gdf8.distance(d4[0])==gdf8.distance(d4[0]).min(),:]
p5=gdf8.loc[gdf8.distance(d5[0])==gdf8.distance(d5[0]).min(),:]
p6=gdf8.loc[gdf8.distance(d6[0])==gdf8.distance(d6[0]).min(),:]
p7=gdf8.loc[gdf8.distance(d7[0])==gdf8.distance(d7[0]).min(),:]
p8=gdf8.loc[gdf8.distance(d8[0])==gdf8.distance(d8[0]).min(),:]
p9=gdf8.loc[gdf8.distance(d9[0])==gdf8.distance(d9[0]).min(),:]
p10=gdf8.loc[gdf8.distance(d10[0])==gdf8.distance(d10[0]).min(),:]
p11=gdf8.loc[gdf8.distance(d11[0])==gdf8.distance(d11[0]).min(),:]
p12=gdf8.loc[gdf8.distance(d12[0])==gdf8.distance(d12[0]).min(),:]
p13=gdf8.loc[gdf8.distance(d13[0])==gdf8.distance(d13[0]).min(),:]
p14=gdf8.loc[gdf8.distance(d14[0])==gdf8.distance(d14[0]).min(),:]
p15=gdf8.loc[gdf8.distance(d15[0])==gdf8.distance(d15[0]).min(),:]
p16=gdf8.loc[gdf8.distance(d16[0])==gdf8.distance(d16[0]).min(),:]
p17=gdf8.loc[gdf8.distance(d17[0])==gdf8.distance(d17[0]).min(),:]
p18=gdf8.loc[gdf8.distance(d18[0])==gdf8.distance(d18[0]).min(),:]
p19=gdf8.loc[gdf8.distance(d19[0])==gdf8.distance(d19[0]).min(),:]
p20=gdf8.loc[gdf8.distance(d20[0])==gdf8.distance(d20[0]).min(),:]
p21=gdf8.loc[gdf8.distance(d21[0])==gdf8.distance(d21[0]).min(),:]
p22=gdf8.loc[gdf8.distance(d22[0])==gdf8.distance(d22[0]).min(),:]
p23=gdf8.loc[gdf8.distance(d23[0])==gdf8.distance(d23[0]).min(),:]
p24=gdf8.loc[gdf8.distance(d24[0])==gdf8.distance(d24[0]).min(),:]
p25=gdf8.loc[gdf8.distance(d25[0])==gdf8.distance(d25[0]).min(),:]
p26=gdf8.loc[gdf8.distance(d26[0])==gdf8.distance(d26[0]).min(),:]



# creating buffer on the buffer with 5km radius
ax=bylaw.loc[['pointpolygon', 'port1', 'port2', 'ind', 'port5', 'port6', 'port7',
              'southend container terminal','NN Jetty', 'Bills island', 'mid bedf
              'waterfront h', 'northarm', 'plll', 'pp', 'po001','po002', 'oulier_
              'p009', 'p010'],:].plot(figsize=(25,25))
gpd.GeoSeries([d1[0],d2[0],d3[0],d4[0],d5[0],d6[0],d7[0],d8[0],d9[0],d10[0],d11[0
               d16[0],d17[0],d18[0],d19[0],d20[0],d21[0],d22[0],d23[0],d24[0],d25
               d26[0]]).plot(ax=ax,color='yellow',markersize=10)

p1=p1.iloc[0,:].geometry.buffer(0.005)
p2=p2.iloc[0,:].geometry.buffer(0.005)
p3=p3.iloc[0,:].geometry.buffer(0.005)
p4=p4.iloc[0,:].geometry.buffer(0.005)
p5=p5.iloc[0,:].geometry.buffer(0.005) # getting the buffer with 5km radius for t
p6=p6.iloc[0,:].geometry.buffer(0.005)
p7=p7.iloc[0,:].geometry.buffer(0.005)
p8=p8.iloc[0,:].geometry.buffer(0.005)
p9=p9.iloc[0,:].geometry.buffer(0.005)
p10=p10.iloc[0,:].geometry.buffer(0.005)
p11=p11.iloc[0,:].geometry.buffer(0.005)
p12=p12.iloc[0,:].geometry.buffer(0.005)
p13=p13.iloc[0,:].geometry.buffer(0.005)
p14=p14.iloc[0,:].geometry.buffer(0.005)
p15=p15.iloc[0,:].geometry.buffer(0.005)
```

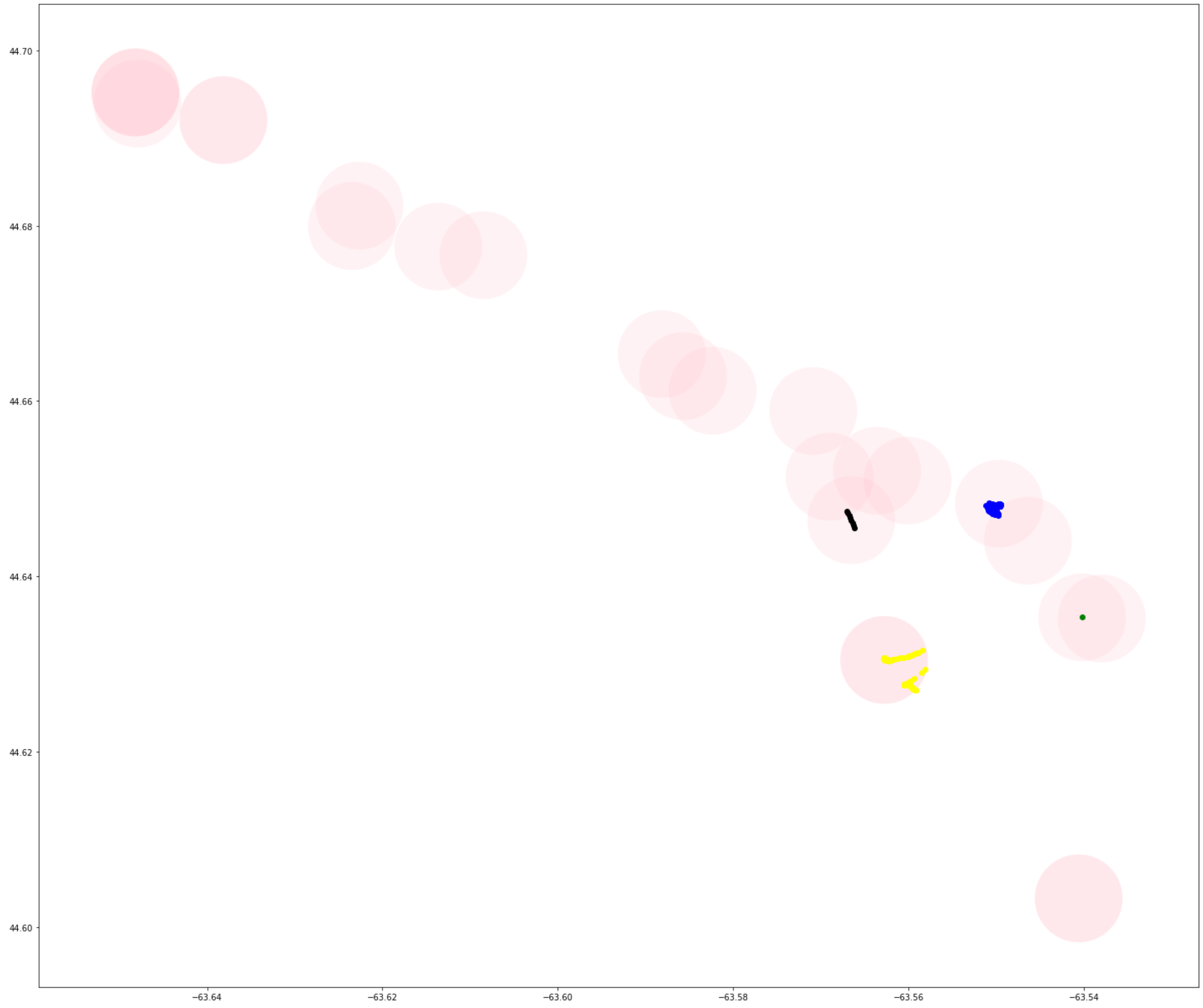
```
p16=p16.iloc[0,:].geometry.buffer(0.005)
p17=p17.iloc[0,:].geometry.buffer(0.005)
p18=p18.iloc[0,:].geometry.buffer(0.005)
p19=p19.iloc[0,:].geometry.buffer(0.005)
p20=p20.iloc[0,:].geometry.buffer(0.005)
p21=p21.iloc[0,:].geometry.buffer(0.005)
p22=p22.iloc[0,:].geometry.buffer(0.005)
p23=p23.iloc[0,:].geometry.buffer(0.005)
p24=p24.iloc[0,:].geometry.buffer(0.005)
p25=p25.iloc[0,:].geometry.buffer(0.005)
p26=p26.iloc[0,:].geometry.buffer(0.005)

# plotting the buffer radius near ports

gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,p19
gdf8.plot(ax=ax,color='g',alpha=0.2)
gdf8.loc[gdf8.within(p1),:].plot(ax=ax,color='k')
gdf8.loc[gdf8.within(p2),:].plot(ax=ax,color='k')
gdf8.loc[gdf8.within(p3),:].plot(ax=ax,color='k')
gdf8.loc[gdf8.within(p4),:].plot(ax=ax,color='k')
gdf8.loc[gdf8.within(p5),:].plot(ax=ax,color='k')
gdf8.loc[gdf8.within(p6),:].plot(ax=ax,color='k')
gdf8.loc[gdf8.within(p7),:].plot(ax=ax,color='k')
gdf8.loc[gdf8.within(p8),:].plot(ax=ax,color='k')
gdf8.loc[gdf8.within(p9),:].plot(ax=ax,color='k')
gdf8.loc[gdf8.within(p10),:].plot(ax=ax,color='k')
gdf8.loc[gdf8.within(p11),:].plot(ax=ax,color='k')
gdf8.loc[gdf8.within(p12),:].plot(ax=ax,color='k')
gdf8.loc[gdf8.within(p13),:].plot(ax=ax,color='k')
gdf8.loc[gdf8.within(p14),:].plot(ax=ax,color='k')
gdf8.loc[gdf8.within(p15),:].plot(ax=ax,color='k')
gdf8.loc[gdf8.within(p16),:].plot(ax=ax,color='k')
gdf8.loc[gdf8.within(p17),:].plot(ax=ax,color='k')
gdf8.loc[gdf8.within(p18),:].plot(ax=ax,color='k')
gdf8.loc[gdf8.within(p19),:].plot(ax=ax,color='k')
gdf8.loc[gdf8.within(p20),:].plot(ax=ax,color='k')
gdf8.loc[gdf8.within(p21),:].plot(ax=ax,color='k')
gdf8.loc[gdf8.within(p22),:].plot(ax=ax,color='k')
gdf8.loc[gdf8.within(p23),:].plot(ax=ax,color='k')
gdf8.loc[gdf8.within(p24),:].plot(ax=ax,color='k')
gdf8.loc[gdf8.within(p25),:].plot(ax=ax,color='k')
gdf8.loc[gdf8.within(p26),:].plot(ax=ax,color='k')
plt.savefig('Q3 images/interval_08_q1.png')
```


44.72
44.70
44.68
44.66
44.64
44.62
44.60
−63.675
−63.650
−63.625
−63.600
−63.575
−63.550
−63.525
−63.500

In [45]:

```
joinres=gpd.sjoin(gdf8,bylaw,op='within',how='left')
col=['r','b','g','k','yellow','orange','Olive','Maroon','Purple','Fuchsia','Lime'
i=0
ax=gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,


for g in set(joinres['index_right']):
  tmp=joinres.loc[joinres['index_right']==g,:]
  if tmp.shape[0]>0:
    tmp.plot(ax=ax,color=col[i])
  i=i+1
plt.savefig('Q3 images/interval_08_q2.png')
```

```
C:\Users\lanch\Anaconda3\lib\site-packages\geopandas\tools\sjoin.py:44: UserWar
ning: CRS of frames being joined does not match!
  warn('CRS of frames being joined does not match!')
```

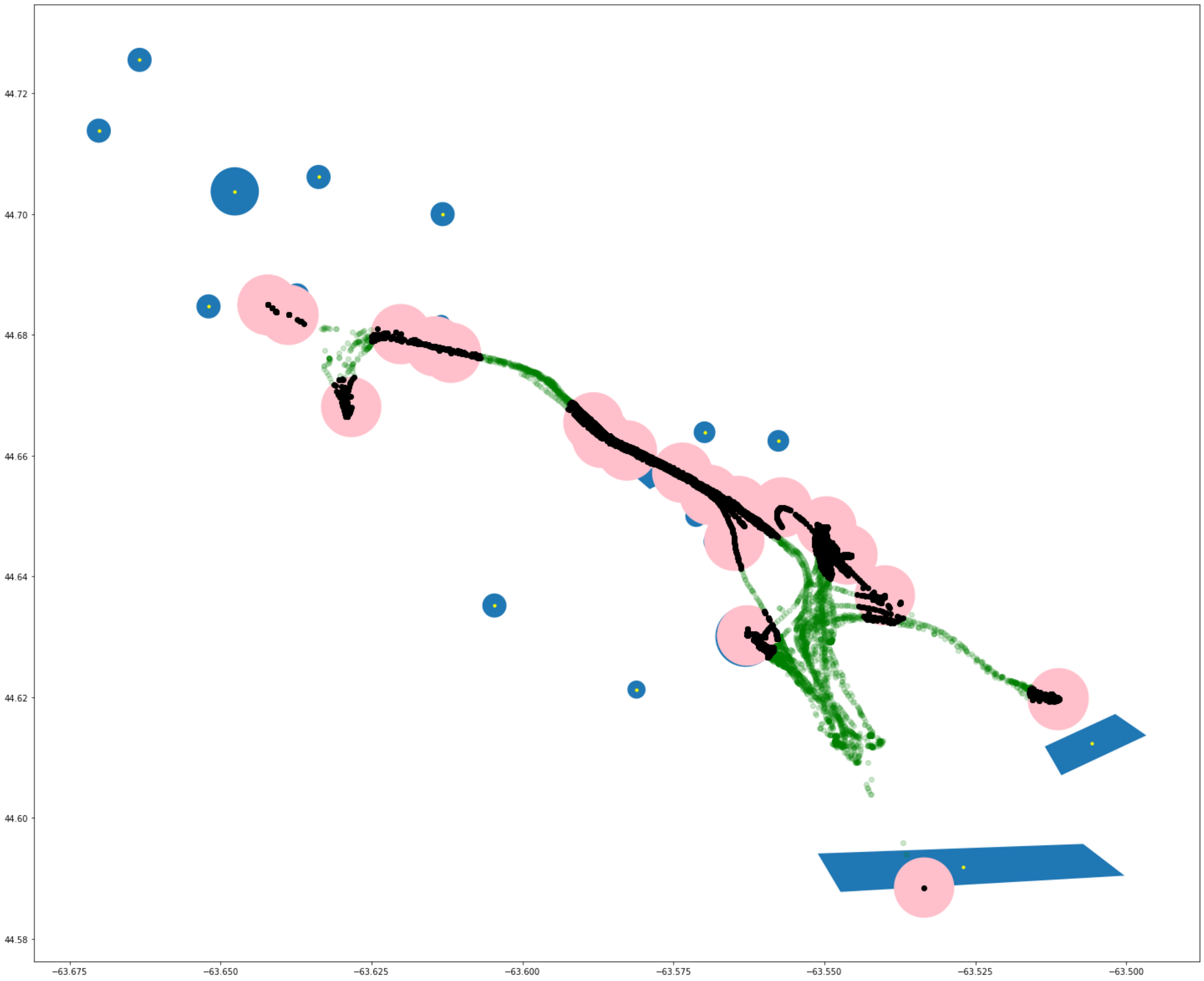


9th interval

In [46]:

```
gdf9 = gpd.GeoDataFrame(d['df_h9'].drop(['location.coordinates.0', 'location.coor
crs={'init': 'epsg:4326'},
geometry=[shapely.geometry.Point(xy) for xy in zip(d['df_h9']['location.coordinat

p1=gdf9.loc[gdf9.distance(d1[0])==gdf9.distance(d1[0]).min(),:]
p2=gdf9.loc[gdf9.distance(d2[0])==gdf9.distance(d2[0]).min(),:]
p3=gdf9.loc[gdf9.distance(d3[0])==gdf9.distance(d3[0]).min(),:]
p4=gdf9.loc[gdf9.distance(d4[0])==gdf9.distance(d4[0]).min(),:]
p5=gdf9.loc[gdf9.distance(d5[0])==gdf9.distance(d5[0]).min(),:]
p6=gdf9.loc[gdf9.distance(d6[0])==gdf9.distance(d6[0]).min(),:]
p7=gdf9.loc[gdf9.distance(d7[0])==gdf9.distance(d7[0]).min(),:]
p8=gdf9.loc[gdf9.distance(d8[0])==gdf9.distance(d8[0]).min(),:]
p9=gdf9.loc[gdf9.distance(d9[0])==gdf9.distance(d9[0]).min(),:]
p10=gdf9.loc[gdf9.distance(d10[0])==gdf9.distance(d10[0]).min(),:]
p11=gdf9.loc[gdf9.distance(d11[0])==gdf9.distance(d11[0]).min(),:]
p12=gdf9.loc[gdf9.distance(d12[0])==gdf9.distance(d12[0]).min(),:]
p13=gdf9.loc[gdf9.distance(d13[0])==gdf9.distance(d13[0]).min(),:]
p14=gdf9.loc[gdf9.distance(d14[0])==gdf9.distance(d14[0]).min(),:]
p15=gdf9.loc[gdf9.distance(d15[0])==gdf9.distance(d15[0]).min(),:]
p16=gdf9.loc[gdf9.distance(d16[0])==gdf9.distance(d16[0]).min(),:]
p17=gdf9.loc[gdf9.distance(d17[0])==gdf9.distance(d17[0]).min(),:]
p18=gdf9.loc[gdf9.distance(d18[0])==gdf9.distance(d18[0]).min(),:]
p19=gdf9.loc[gdf9.distance(d19[0])==gdf9.distance(d19[0]).min(),:]
p20=gdf9.loc[gdf9.distance(d20[0])==gdf9.distance(d20[0]).min(),:]
p21=gdf9.loc[gdf9.distance(d21[0])==gdf9.distance(d21[0]).min(),:]
p22=gdf9.loc[gdf9.distance(d22[0])==gdf9.distance(d22[0]).min(),:]
p23=gdf9.loc[gdf9.distance(d23[0])==gdf9.distance(d23[0]).min(),:]
p24=gdf9.loc[gdf9.distance(d24[0])==gdf9.distance(d24[0]).min(),:]
p25=gdf9.loc[gdf9.distance(d25[0])==gdf9.distance(d25[0]).min(),:]
p26=gdf9.loc[gdf9.distance(d26[0])==gdf9.distance(d26[0]).min(),:]



# creating buffer on the buffer with 5km radius
ax=bylaw.loc[['pointpolygon', 'port1', 'port2', 'ind', 'port5', 'port6', 'port7',
              'southend container terminal','NN Jetty', 'Bills island', 'mid bedf
              'waterfront h', 'northarm', 'plll', 'pp', 'po001','po002', 'oulier_
              'p009', 'p010'],:].plot(figsize=(25,25))
gpd.GeoSeries([d1[0],d2[0],d3[0],d4[0],d5[0],d6[0],d7[0],d8[0],d9[0],d10[0],d11[0
               d16[0],d17[0],d18[0],d19[0],d20[0],d21[0],d22[0],d23[0],d24[0],d25
               d26[0]]).plot(ax=ax,color='yellow',markersize=10)

p1=p1.iloc[0,:].geometry.buffer(0.005)
p2=p2.iloc[0,:].geometry.buffer(0.005)
p3=p3.iloc[0,:].geometry.buffer(0.005)
p4=p4.iloc[0,:].geometry.buffer(0.005)
p5=p5.iloc[0,:].geometry.buffer(0.005) # getting the buffer with 5km radius for t
p6=p6.iloc[0,:].geometry.buffer(0.005)
p7=p7.iloc[0,:].geometry.buffer(0.005)
p8=p8.iloc[0,:].geometry.buffer(0.005)
p9=p9.iloc[0,:].geometry.buffer(0.005)
p10=p10.iloc[0,:].geometry.buffer(0.005)
p11=p11.iloc[0,:].geometry.buffer(0.005)
p12=p12.iloc[0,:].geometry.buffer(0.005)
p13=p13.iloc[0,:].geometry.buffer(0.005)
p14=p14.iloc[0,:].geometry.buffer(0.005)
p15=p15.iloc[0,:].geometry.buffer(0.005)
```

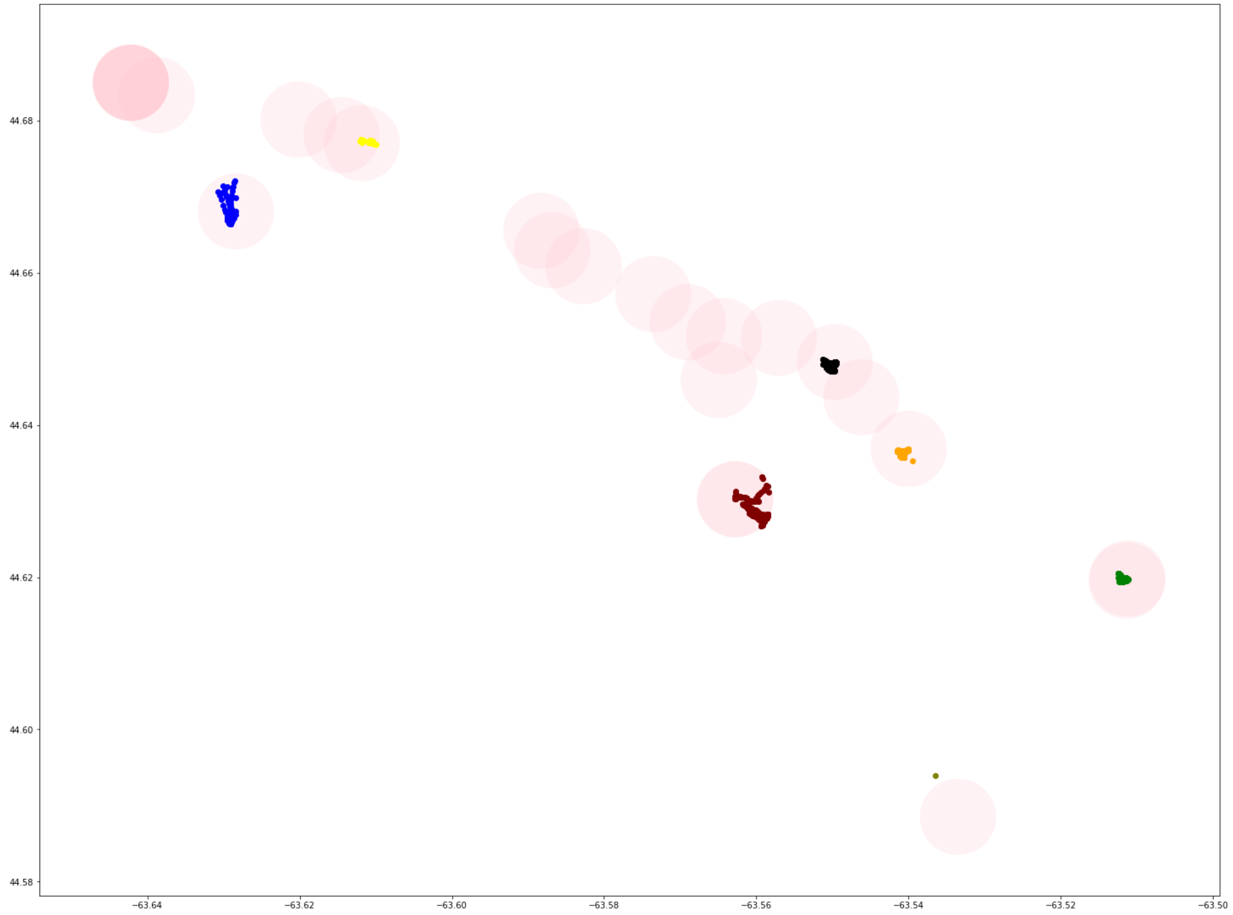
```
p16=p16.iloc[0,:].geometry.buffer(0.005)
p17=p17.iloc[0,:].geometry.buffer(0.005)
p18=p18.iloc[0,:].geometry.buffer(0.005)
p19=p19.iloc[0,:].geometry.buffer(0.005)
p20=p20.iloc[0,:].geometry.buffer(0.005)
p21=p21.iloc[0,:].geometry.buffer(0.005)
p22=p22.iloc[0,:].geometry.buffer(0.005)
p23=p23.iloc[0,:].geometry.buffer(0.005)
p24=p24.iloc[0,:].geometry.buffer(0.005)
p25=p25.iloc[0,:].geometry.buffer(0.005)
p26=p26.iloc[0,:].geometry.buffer(0.005)

# plotting the buffer radius near ports

gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,p19
gdf9.plot(ax=ax,color='g',alpha=0.2)
gdf9.loc[gdf9.within(p1),:].plot(ax=ax,color='k')
gdf9.loc[gdf9.within(p2),:].plot(ax=ax,color='k')
gdf9.loc[gdf9.within(p3),:].plot(ax=ax,color='k')
gdf9.loc[gdf9.within(p4),:].plot(ax=ax,color='k')
gdf9.loc[gdf9.within(p5),:].plot(ax=ax,color='k')
gdf9.loc[gdf9.within(p6),:].plot(ax=ax,color='k')
gdf9.loc[gdf9.within(p7),:].plot(ax=ax,color='k')
gdf9.loc[gdf9.within(p8),:].plot(ax=ax,color='k')
gdf9.loc[gdf9.within(p9),:].plot(ax=ax,color='k')
gdf9.loc[gdf9.within(p10),:].plot(ax=ax,color='k')
gdf9.loc[gdf9.within(p11),:].plot(ax=ax,color='k')
gdf9.loc[gdf9.within(p12),:].plot(ax=ax,color='k')
gdf9.loc[gdf9.within(p13),:].plot(ax=ax,color='k')
gdf9.loc[gdf9.within(p14),:].plot(ax=ax,color='k')
gdf9.loc[gdf9.within(p15),:].plot(ax=ax,color='k')
gdf9.loc[gdf9.within(p16),:].plot(ax=ax,color='k')
gdf9.loc[gdf9.within(p17),:].plot(ax=ax,color='k')
gdf9.loc[gdf9.within(p18),:].plot(ax=ax,color='k')
gdf9.loc[gdf9.within(p19),:].plot(ax=ax,color='k')
gdf9.loc[gdf9.within(p20),:].plot(ax=ax,color='k')
gdf9.loc[gdf9.within(p21),:].plot(ax=ax,color='k')
gdf9.loc[gdf9.within(p22),:].plot(ax=ax,color='k')
gdf9.loc[gdf9.within(p23),:].plot(ax=ax,color='k')
gdf9.loc[gdf9.within(p24),:].plot(ax=ax,color='k')
gdf9.loc[gdf9.within(p25),:].plot(ax=ax,color='k')
gdf9.loc[gdf9.within(p26),:].plot(ax=ax,color='k')
plt.savefig('Q3 images/interval_09_q1.png')
```


44.72
44.70
44.68
44.66
44.64
44.62
44.60
44.58
−63.675
−63.650
−63.625
−63.600
−63.575
−63.550
−63.525
−63.500

In [47]:

```
joinres=gpd.sjoin(gdf9,bylaw,op='within',how='left')
col=['r','b','g','k','yellow','orange','Olive','Maroon','Purple','Fuchsia','Lime'
i=0
ax=gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,


for g in set(joinres['index_right']):
  tmp=joinres.loc[joinres['index_right']==g,:]
  if tmp.shape[0]>0:
    tmp.plot(ax=ax,color=col[i])
  i=i+1
plt.savefig('Q3 images/interval_09_q2.png')
```

```
C:\Users\lanch\Anaconda3\lib\site-packages\geopandas\tools\sjoin.py:44: UserWar
ning: CRS of frames being joined does not match!
  warn('CRS of frames being joined does not match!')
```

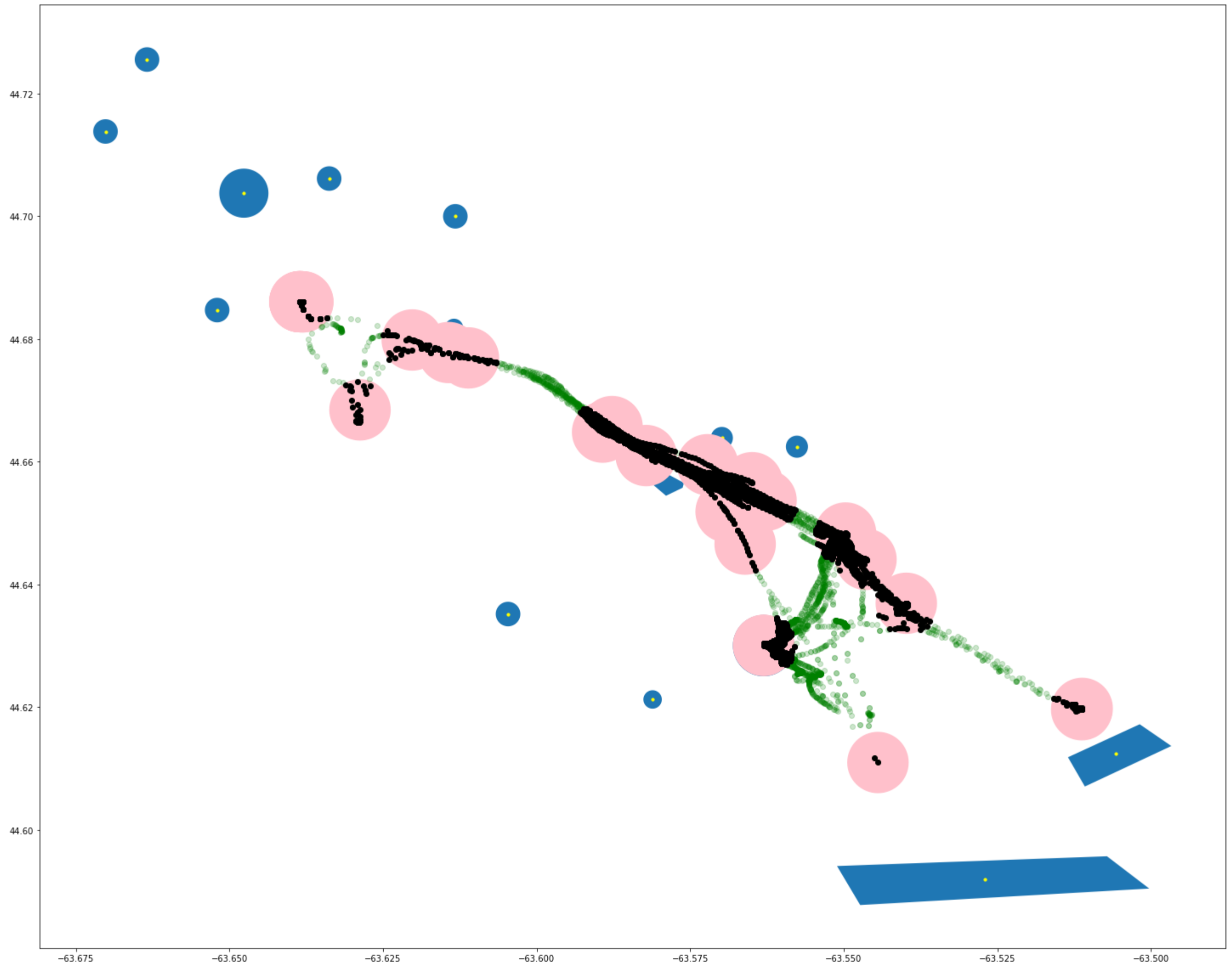


```
10th interval
```

In [48]:

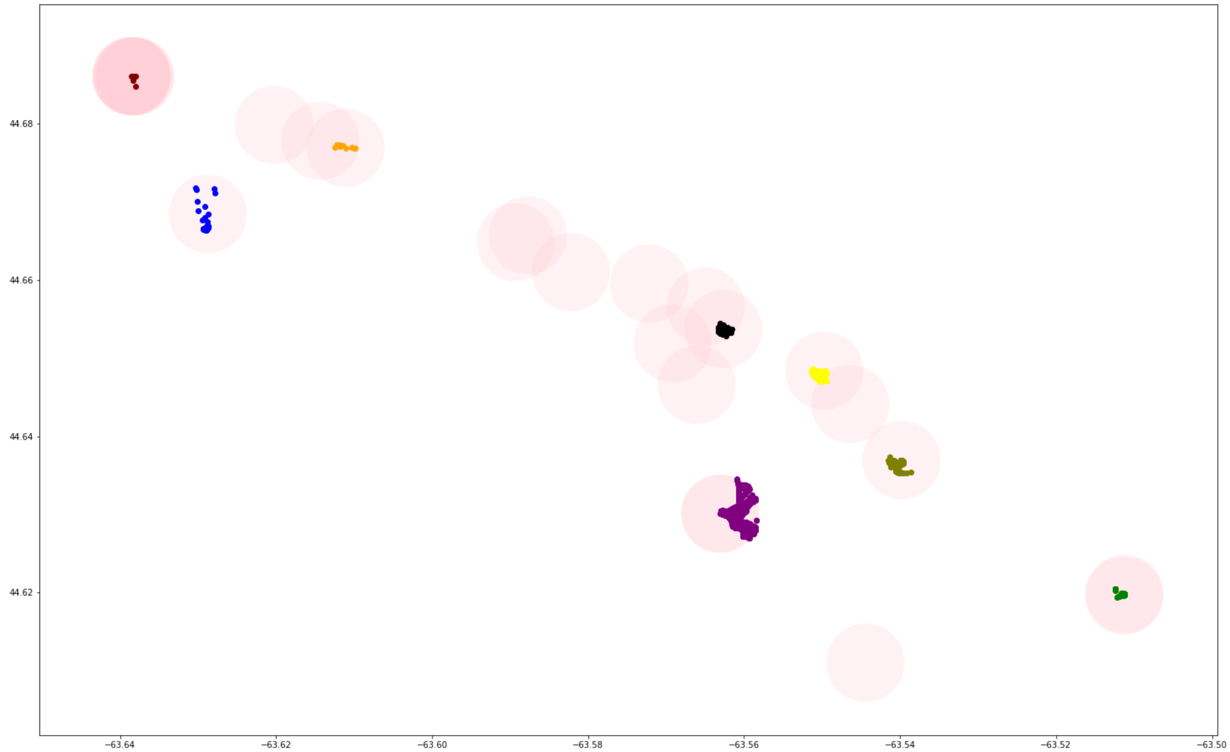
```
gdf10 = gpd.GeoDataFrame(d['df_h10'].drop(['location.coordinates.0', 'location.coo
crs={'init': 'epsg:4326'},
geometry=[shapely.geometry.Point(xy) for xy in zip(d['df_h10']['location.coordinat

p1=gdf10.loc[gdf10.distance(d1[0])==gdf10.distance(d1[0]).min(),:]
p2=gdf10.loc[gdf10.distance(d2[0])==gdf10.distance(d2[0]).min(),:]
p3=gdf10.loc[gdf10.distance(d3[0])==gdf10.distance(d3[0]).min(),:]
p4=gdf10.loc[gdf10.distance(d4[0])==gdf10.distance(d4[0]).min(),:]
p5=gdf10.loc[gdf10.distance(d5[0])==gdf10.distance(d5[0]).min(),:]
p6=gdf10.loc[gdf10.distance(d6[0])==gdf10.distance(d6[0]).min(),:]
p7=gdf10.loc[gdf10.distance(d7[0])==gdf10.distance(d7[0]).min(),:]
p8=gdf10.loc[gdf10.distance(d8[0])==gdf10.distance(d8[0]).min(),:]
p9=gdf10.loc[gdf10.distance(d9[0])==gdf10.distance(d9[0]).min(),:]
p10=gdf10.loc[gdf10.distance(d10[0])==gdf10.distance(d10[0]).min(),:]
p11=gdf10.loc[gdf10.distance(d11[0])==gdf10.distance(d11[0]).min(),:]
p12=gdf10.loc[gdf10.distance(d12[0])==gdf10.distance(d12[0]).min(),:]
p13=gdf10.loc[gdf10.distance(d13[0])==gdf10.distance(d13[0]).min(),:]
p14=gdf10.loc[gdf10.distance(d14[0])==gdf10.distance(d14[0]).min(),:]
p15=gdf10.loc[gdf10.distance(d15[0])==gdf10.distance(d15[0]).min(),:]
p16=gdf10.loc[gdf10.distance(d16[0])==gdf10.distance(d16[0]).min(),:]
p17=gdf10.loc[gdf10.distance(d17[0])==gdf10.distance(d17[0]).min(),:]
p18=gdf10.loc[gdf10.distance(d18[0])==gdf10.distance(d18[0]).min(),:]
p19=gdf10.loc[gdf10.distance(d19[0])==gdf10.distance(d19[0]).min(),:]
p20=gdf10.loc[gdf10.distance(d20[0])==gdf10.distance(d20[0]).min(),:]
p21=gdf10.loc[gdf10.distance(d21[0])==gdf10.distance(d21[0]).min(),:]
p22=gdf10.loc[gdf10.distance(d22[0])==gdf10.distance(d22[0]).min(),:]
p23=gdf10.loc[gdf10.distance(d23[0])==gdf10.distance(d23[0]).min(),:]
p24=gdf10.loc[gdf10.distance(d24[0])==gdf10.distance(d24[0]).min(),:]
p25=gdf10.loc[gdf10.distance(d25[0])==gdf10.distance(d25[0]).min(),:]
p26=gdf10.loc[gdf10.distance(d26[0])==gdf10.distance(d26[0]).min(),:]



# creating buffer on the buffer with 5km radius
ax=bylaw.loc[['pointpolygon', 'port1', 'port2', 'ind', 'port5', 'port6', 'port7',
              'southend container terminal','NN Jetty', 'Bills island', 'mid bedf
              'waterfront h', 'northarm', 'plll', 'pp', 'po001','po002', 'oulier_
              'p009', 'p010'],:].plot(figsize=(25,25))
gpd.GeoSeries([d1[0],d2[0],d3[0],d4[0],d5[0],d6[0],d7[0],d8[0],d9[0],d10[0],d11[0
               d16[0],d17[0],d18[0],d19[0],d20[0],d21[0],d22[0],d23[0],d24[0],d25
               d26[0]]).plot(ax=ax,color='yellow',markersize=10)

p1=p1.iloc[0,:].geometry.buffer(0.005)
p2=p2.iloc[0,:].geometry.buffer(0.005)
p3=p3.iloc[0,:].geometry.buffer(0.005)
p4=p4.iloc[0,:].geometry.buffer(0.005)
p5=p5.iloc[0,:].geometry.buffer(0.005) # getting the buffer with 5km radius for t
p6=p6.iloc[0,:].geometry.buffer(0.005)
p7=p7.iloc[0,:].geometry.buffer(0.005)
p8=p8.iloc[0,:].geometry.buffer(0.005)
p9=p9.iloc[0,:].geometry.buffer(0.005)
p10=p10.iloc[0,:].geometry.buffer(0.005)
p11=p11.iloc[0,:].geometry.buffer(0.005)
p12=p12.iloc[0,:].geometry.buffer(0.005)
p13=p13.iloc[0,:].geometry.buffer(0.005)
p14=p14.iloc[0,:].geometry.buffer(0.005)
p15=p15.iloc[0,:].geometry.buffer(0.005)
```

```
p16=p16.iloc[0,:].geometry.buffer(0.005)
p17=p17.iloc[0,:].geometry.buffer(0.005)
p18=p18.iloc[0,:].geometry.buffer(0.005)
p19=p19.iloc[0,:].geometry.buffer(0.005)
p20=p20.iloc[0,:].geometry.buffer(0.005)
p21=p21.iloc[0,:].geometry.buffer(0.005)
p22=p22.iloc[0,:].geometry.buffer(0.005)
p23=p23.iloc[0,:].geometry.buffer(0.005)
p24=p24.iloc[0,:].geometry.buffer(0.005)
p25=p25.iloc[0,:].geometry.buffer(0.005)
p26=p26.iloc[0,:].geometry.buffer(0.005)

# plotting the buffer radius near ports

gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,p19
gdf10.plot(ax=ax,color='g',alpha=0.2)
gdf10.loc[gdf10.within(p1),:].plot(ax=ax,color='k')
gdf10.loc[gdf10.within(p2),:].plot(ax=ax,color='k')
gdf10.loc[gdf10.within(p3),:].plot(ax=ax,color='k')
gdf10.loc[gdf10.within(p4),:].plot(ax=ax,color='k')
gdf10.loc[gdf10.within(p5),:].plot(ax=ax,color='k')
gdf10.loc[gdf10.within(p6),:].plot(ax=ax,color='k')
gdf10.loc[gdf10.within(p7),:].plot(ax=ax,color='k')
gdf10.loc[gdf10.within(p8),:].plot(ax=ax,color='k')
gdf10.loc[gdf10.within(p9),:].plot(ax=ax,color='k')
gdf10.loc[gdf10.within(p10),:].plot(ax=ax,color='k')
gdf10.loc[gdf10.within(p11),:].plot(ax=ax,color='k')
gdf10.loc[gdf10.within(p12),:].plot(ax=ax,color='k')
gdf10.loc[gdf10.within(p13),:].plot(ax=ax,color='k')
gdf10.loc[gdf10.within(p14),:].plot(ax=ax,color='k')
gdf10.loc[gdf10.within(p15),:].plot(ax=ax,color='k')
gdf10.loc[gdf10.within(p16),:].plot(ax=ax,color='k')
gdf10.loc[gdf10.within(p17),:].plot(ax=ax,color='k')
gdf10.loc[gdf10.within(p18),:].plot(ax=ax,color='k')
gdf10.loc[gdf10.within(p19),:].plot(ax=ax,color='k')
gdf10.loc[gdf10.within(p20),:].plot(ax=ax,color='k')
gdf10.loc[gdf10.within(p21),:].plot(ax=ax,color='k')
gdf10.loc[gdf10.within(p22),:].plot(ax=ax,color='k')
gdf10.loc[gdf10.within(p23),:].plot(ax=ax,color='k')
gdf10.loc[gdf10.within(p24),:].plot(ax=ax,color='k')
gdf10.loc[gdf10.within(p25),:].plot(ax=ax,color='k')
gdf10.loc[gdf10.within(p26),:].plot(ax=ax,color='k')
plt.savefig('Q3 images/interval_10_q1.png')
```


44.72
44.70
44.68
44.66
44.64
44.62
44.60
−63.675
−63.650
−63.625
−63.600
−63.575
−63.550
−63.525
−63.500

In [49]:
```
joinres=gpd.sjoin(gdf10,bylaw,op='within',how='left')
col=['r','b','g','k','yellow','orange','Olive','Maroon','Purple','Fuchsia','Lime'
i=0
ax=gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,


for g in set(joinres['index_right']):
  tmp=joinres.loc[joinres['index_right']==g,:]
  if tmp.shape[0]>0:
    tmp.plot(ax=ax,color=col[i])
  i=i+1
plt.savefig('Q3 images/interval_10_q2.png')
```

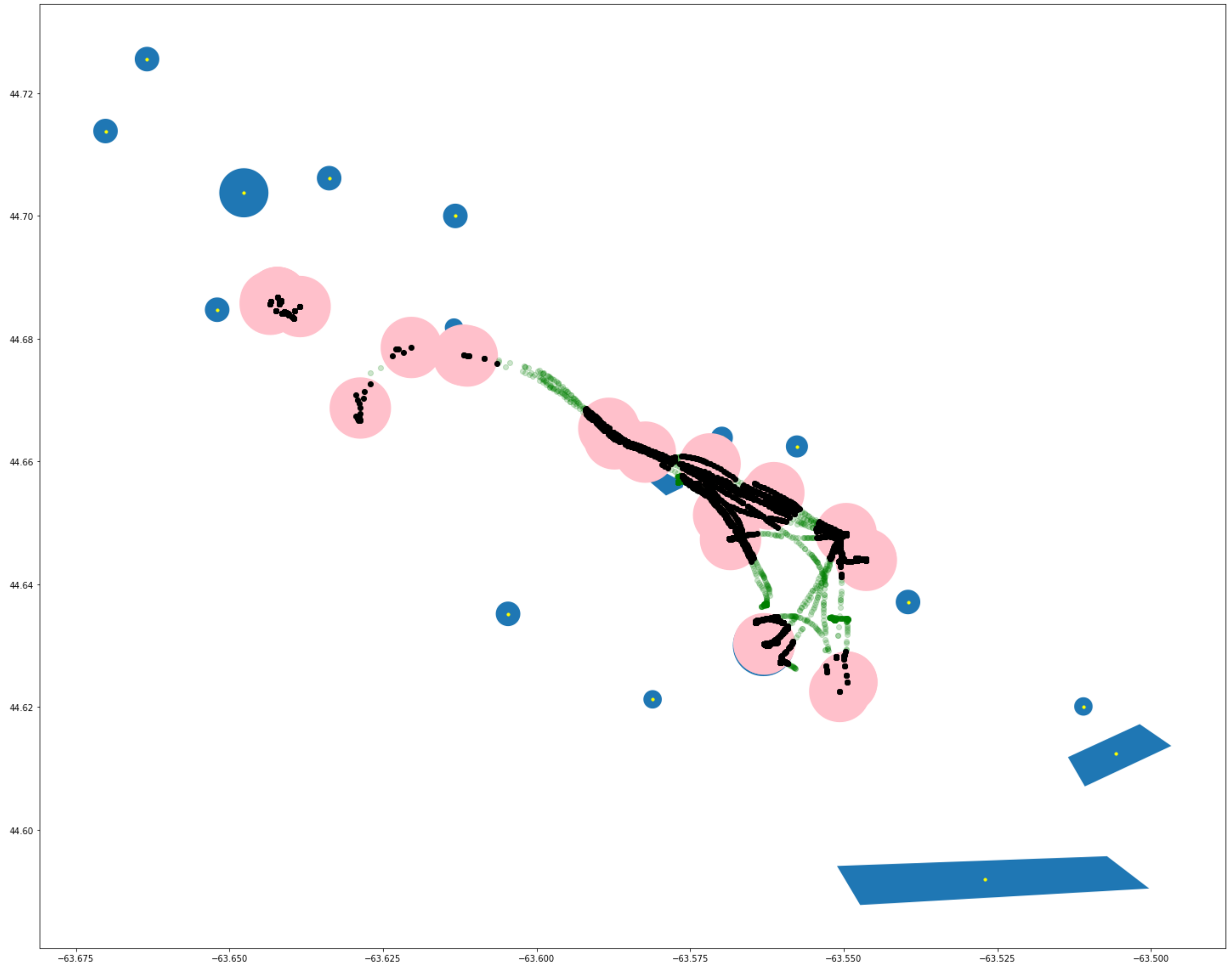
```
C:\Users\lanch\Anaconda3\lib\site-packages\geopandas\tools\sjoin.py:44: UserWar
ning: CRS of frames being joined does not match!
  warn('CRS of frames being joined does not match!')
```



11th interval

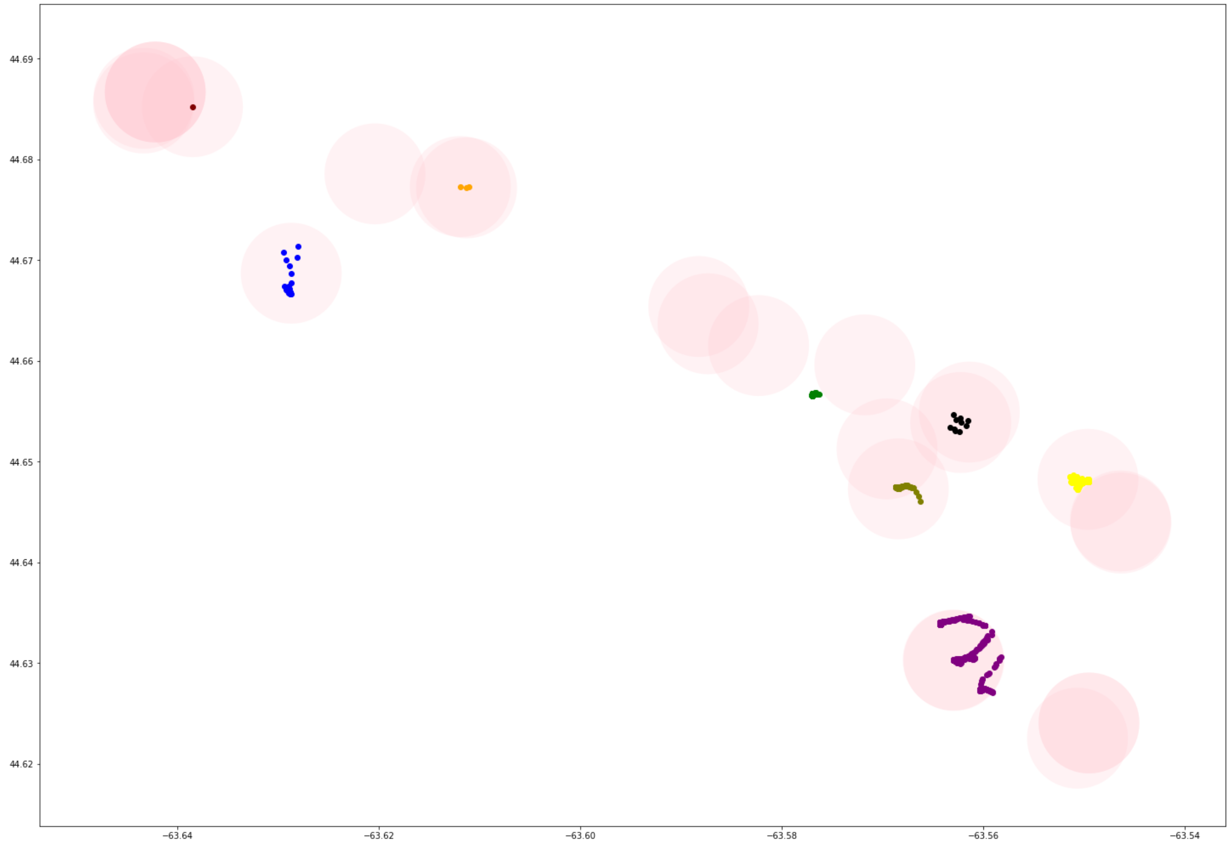
In [50]:
```
gdf11 = gpd.GeoDataFrame(d['df_h11'].drop(['location.coordinates.0', 'location.co
crs={'init': 'epsg:4326'},
geometry=[shapely.geometry.Point(xy) for xy in zip(d['df_h11']['location.coordina

p1=gdf11.loc[gdf11.distance(d1[0])==gdf11.distance(d1[0]).min(),:]
p2=gdf11.loc[gdf11.distance(d2[0])==gdf11.distance(d2[0]).min(),:]
p3=gdf11.loc[gdf11.distance(d3[0])==gdf11.distance(d3[0]).min(),:]
p4=gdf11.loc[gdf11.distance(d4[0])==gdf11.distance(d4[0]).min(),:]
p5=gdf11.loc[gdf11.distance(d5[0])==gdf11.distance(d5[0]).min(),:]
p6=gdf11.loc[gdf11.distance(d6[0])==gdf11.distance(d6[0]).min(),:]
p7=gdf11.loc[gdf11.distance(d7[0])==gdf11.distance(d7[0]).min(),:]
p8=gdf11.loc[gdf11.distance(d8[0])==gdf11.distance(d8[0]).min(),:]
p9=gdf11.loc[gdf11.distance(d9[0])==gdf11.distance(d9[0]).min(),:]
p10=gdf11.loc[gdf11.distance(d10[0])==gdf11.distance(d10[0]).min(),:]
p11=gdf11.loc[gdf11.distance(d11[0])==gdf11.distance(d11[0]).min(),:]
p12=gdf11.loc[gdf11.distance(d12[0])==gdf11.distance(d12[0]).min(),:]
p13=gdf11.loc[gdf11.distance(d13[0])==gdf11.distance(d13[0]).min(),:]
p14=gdf11.loc[gdf11.distance(d14[0])==gdf11.distance(d14[0]).min(),:]
p15=gdf11.loc[gdf11.distance(d15[0])==gdf11.distance(d15[0]).min(),:]
p16=gdf11.loc[gdf11.distance(d16[0])==gdf11.distance(d16[0]).min(),:]
p17=gdf11.loc[gdf11.distance(d17[0])==gdf11.distance(d17[0]).min(),:]
p18=gdf11.loc[gdf11.distance(d18[0])==gdf11.distance(d18[0]).min(),:]
p19=gdf11.loc[gdf11.distance(d19[0])==gdf11.distance(d19[0]).min(),:]
p20=gdf11.loc[gdf11.distance(d20[0])==gdf11.distance(d20[0]).min(),:]
p21=gdf11.loc[gdf11.distance(d21[0])==gdf11.distance(d21[0]).min(),:]
p22=gdf11.loc[gdf11.distance(d22[0])==gdf11.distance(d22[0]).min(),:]
p23=gdf11.loc[gdf11.distance(d23[0])==gdf11.distance(d23[0]).min(),:]
p24=gdf11.loc[gdf11.distance(d24[0])==gdf11.distance(d24[0]).min(),:]
p25=gdf11.loc[gdf11.distance(d25[0])==gdf11.distance(d25[0]).min(),:]
p26=gdf11.loc[gdf11.distance(d26[0])==gdf11.distance(d26[0]).min(),:]


# creating buffer on the buffer with 5km radius
ax=bylaw.loc[['pointpolygon', 'port1', 'port2', 'ind', 'port5', 'port6', 'port7',
              'southend container terminal','NN Jetty', 'Bills island', 'mid bedf
              'waterfront h', 'northarm', 'plll', 'pp', 'po001','po002', 'oulier_
              'p009', 'p010'],:].plot(figsize=(25,25))
gpd.GeoSeries([d1[0],d2[0],d3[0],d4[0],d5[0],d6[0],d7[0],d8[0],d9[0],d10[0],d11[0
               d16[0],d17[0],d18[0],d19[0],d20[0],d21[0],d22[0],d23[0],d24[0],d25
               d26[0]]).plot(ax=ax,color='yellow',markersize=10)

p1=p1.iloc[0,:].geometry.buffer(0.005)
p2=p2.iloc[0,:].geometry.buffer(0.005)
p3=p3.iloc[0,:].geometry.buffer(0.005)
p4=p4.iloc[0,:].geometry.buffer(0.005)
p5=p5.iloc[0,:].geometry.buffer(0.005) # getting the buffer with 5km radius for t
p6=p6.iloc[0,:].geometry.buffer(0.005)
p7=p7.iloc[0,:].geometry.buffer(0.005)
p8=p8.iloc[0,:].geometry.buffer(0.005)
p9=p9.iloc[0,:].geometry.buffer(0.005)
p10=p10.iloc[0,:].geometry.buffer(0.005)
p11=p11.iloc[0,:].geometry.buffer(0.005)
p12=p12.iloc[0,:].geometry.buffer(0.005)
p13=p13.iloc[0,:].geometry.buffer(0.005)
p14=p14.iloc[0,:].geometry.buffer(0.005)
p15=p15.iloc[0,:].geometry.buffer(0.005)
```

```
p16=p16.iloc[0,:].geometry.buffer(0.005)
p17=p17.iloc[0,:].geometry.buffer(0.005)
p18=p18.iloc[0,:].geometry.buffer(0.005)
p19=p19.iloc[0,:].geometry.buffer(0.005)
p20=p20.iloc[0,:].geometry.buffer(0.005)
p21=p21.iloc[0,:].geometry.buffer(0.005)
p22=p22.iloc[0,:].geometry.buffer(0.005)
p23=p23.iloc[0,:].geometry.buffer(0.005)
p24=p24.iloc[0,:].geometry.buffer(0.005)
p25=p25.iloc[0,:].geometry.buffer(0.005)
p26=p26.iloc[0,:].geometry.buffer(0.005)

# plotting the buffer radius near ports

gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,p19
gdf11.plot(ax=ax,color='g',alpha=0.2)
gdf11.loc[gdf11.within(p1),:].plot(ax=ax,color='k')
gdf11.loc[gdf11.within(p2),:].plot(ax=ax,color='k')
gdf11.loc[gdf11.within(p3),:].plot(ax=ax,color='k')
gdf11.loc[gdf11.within(p4),:].plot(ax=ax,color='k')
gdf11.loc[gdf11.within(p5),:].plot(ax=ax,color='k')
gdf11.loc[gdf11.within(p6),:].plot(ax=ax,color='k')
gdf11.loc[gdf11.within(p7),:].plot(ax=ax,color='k')
gdf11.loc[gdf11.within(p8),:].plot(ax=ax,color='k')
gdf11.loc[gdf11.within(p9),:].plot(ax=ax,color='k')
gdf11.loc[gdf11.within(p10),:].plot(ax=ax,color='k')
gdf11.loc[gdf11.within(p11),:].plot(ax=ax,color='k')
gdf11.loc[gdf11.within(p12),:].plot(ax=ax,color='k')
gdf11.loc[gdf11.within(p13),:].plot(ax=ax,color='k')
gdf11.loc[gdf11.within(p14),:].plot(ax=ax,color='k')
gdf11.loc[gdf11.within(p15),:].plot(ax=ax,color='k')
gdf11.loc[gdf11.within(p16),:].plot(ax=ax,color='k')
gdf11.loc[gdf11.within(p17),:].plot(ax=ax,color='k')
gdf11.loc[gdf11.within(p18),:].plot(ax=ax,color='k')
gdf11.loc[gdf11.within(p19),:].plot(ax=ax,color='k')
gdf11.loc[gdf11.within(p20),:].plot(ax=ax,color='k')
gdf11.loc[gdf11.within(p21),:].plot(ax=ax,color='k')
gdf11.loc[gdf11.within(p22),:].plot(ax=ax,color='k')
gdf11.loc[gdf11.within(p23),:].plot(ax=ax,color='k')
gdf11.loc[gdf11.within(p24),:].plot(ax=ax,color='k')
gdf11.loc[gdf11.within(p25),:].plot(ax=ax,color='k')
gdf11.loc[gdf11.within(p26),:].plot(ax=ax,color='k')
plt.savefig('Q3 images/interval_11_q1.png')
```


44.72
44.70
44.68
44.66
44.64
44.62
44.60
−63.675
−63.650
−63.625
−63.600
−63.575
−63.550
−63.525
−63.500

In [51]:
```
joinres=gpd.sjoin(gdf11,bylaw,op='within',how='left')
col=['r','b','g','k','yellow','orange','Olive','Maroon','Purple','Fuchsia','Lime'
i=0
ax=gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,


for g in set(joinres['index_right']):
  tmp=joinres.loc[joinres['index_right']==g,:]
  if tmp.shape[0]>0:
    tmp.plot(ax=ax,color=col[i])
  i=i+1
plt.savefig('Q3 images/interval_11_q2.png')
```

```
C:\Users\lanch\Anaconda3\lib\site-packages\geopandas\tools\sjoin.py:44: UserWar
ning: CRS of frames being joined does not match!
  warn('CRS of frames being joined does not match!')
```

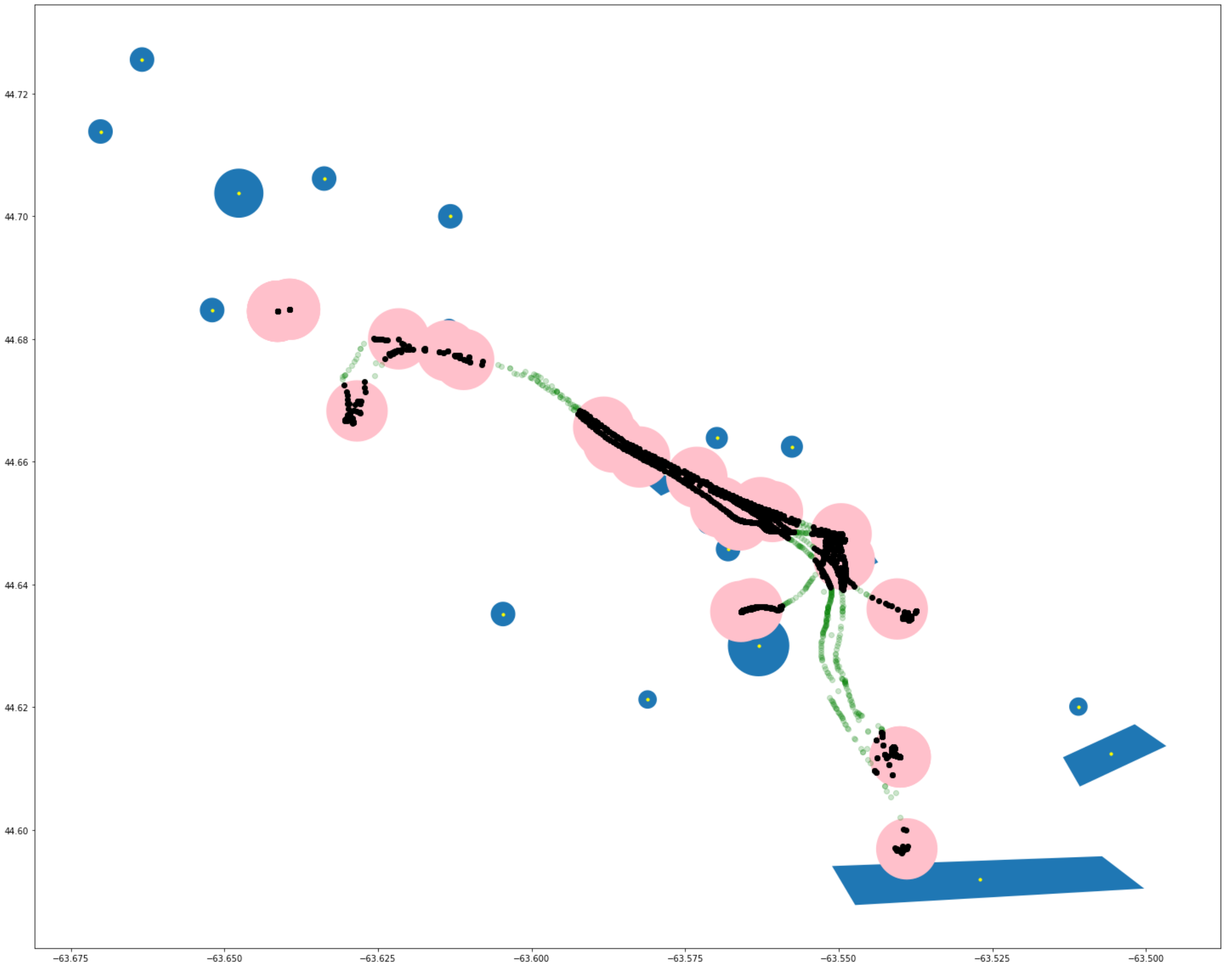


12th interval

In [52]:

```
gdf12 = gpd.GeoDataFrame(d['df_h12'].drop(['location.coordinates.0', 'location.co
crs={'init': 'epsg:4326'},
geometry=[shapely.geometry.Point(xy) for xy in zip(d['df_h12']['location.coordina

p1=gdf12.loc[gdf12.distance(d1[0])==gdf12.distance(d1[0]).min(),:]
p2=gdf12.loc[gdf12.distance(d2[0])==gdf12.distance(d2[0]).min(),:]
p3=gdf12.loc[gdf12.distance(d3[0])==gdf12.distance(d3[0]).min(),:]
p4=gdf12.loc[gdf12.distance(d4[0])==gdf12.distance(d4[0]).min(),:]
p5=gdf12.loc[gdf12.distance(d5[0])==gdf12.distance(d5[0]).min(),:]
p6=gdf12.loc[gdf12.distance(d6[0])==gdf12.distance(d6[0]).min(),:]
p7=gdf12.loc[gdf12.distance(d7[0])==gdf12.distance(d7[0]).min(),:]
p8=gdf12.loc[gdf12.distance(d8[0])==gdf12.distance(d8[0]).min(),:]
p9=gdf12.loc[gdf12.distance(d9[0])==gdf12.distance(d9[0]).min(),:]
p10=gdf12.loc[gdf12.distance(d10[0])==gdf12.distance(d10[0]).min(),:]
p11=gdf12.loc[gdf12.distance(d11[0])==gdf12.distance(d11[0]).min(),:]
p12=gdf12.loc[gdf12.distance(d12[0])==gdf12.distance(d12[0]).min(),:]
p13=gdf12.loc[gdf12.distance(d13[0])==gdf12.distance(d13[0]).min(),:]
p14=gdf12.loc[gdf12.distance(d14[0])==gdf12.distance(d14[0]).min(),:]
p15=gdf12.loc[gdf12.distance(d15[0])==gdf12.distance(d15[0]).min(),:]
p16=gdf12.loc[gdf12.distance(d16[0])==gdf12.distance(d16[0]).min(),:]
p17=gdf12.loc[gdf12.distance(d17[0])==gdf12.distance(d17[0]).min(),:]
p18=gdf12.loc[gdf12.distance(d18[0])==gdf12.distance(d18[0]).min(),:]
p19=gdf12.loc[gdf12.distance(d19[0])==gdf12.distance(d19[0]).min(),:]
p20=gdf12.loc[gdf12.distance(d20[0])==gdf12.distance(d20[0]).min(),:]
p21=gdf12.loc[gdf12.distance(d21[0])==gdf12.distance(d21[0]).min(),:]
p22=gdf12.loc[gdf12.distance(d22[0])==gdf12.distance(d22[0]).min(),:]
p23=gdf12.loc[gdf12.distance(d23[0])==gdf12.distance(d23[0]).min(),:]
p24=gdf12.loc[gdf12.distance(d24[0])==gdf12.distance(d24[0]).min(),:]
p25=gdf12.loc[gdf12.distance(d25[0])==gdf12.distance(d25[0]).min(),:]
p26=gdf12.loc[gdf12.distance(d26[0])==gdf12.distance(d26[0]).min(),:]



# creating buffer on the buffer with 5km radius
ax=bylaw.loc[['pointpolygon', 'port1', 'port2', 'ind', 'port5', 'port6', 'port7',
              'southend container terminal','NN Jetty', 'Bills island', 'mid bedf
              'waterfront h', 'northarm', 'plll', 'pp', 'po001','po002', 'oulier_
              'p009', 'p010'],:].plot(figsize=(25,25))
gpd.GeoSeries([d1[0],d2[0],d3[0],d4[0],d5[0],d6[0],d7[0],d8[0],d9[0],d10[0],d11[0
               d16[0],d17[0],d18[0],d19[0],d20[0],d21[0],d22[0],d23[0],d24[0],d25
               d26[0]]).plot(ax=ax,color='yellow',markersize=10)

p1=p1.iloc[0,:].geometry.buffer(0.005)
p2=p2.iloc[0,:].geometry.buffer(0.005)
p3=p3.iloc[0,:].geometry.buffer(0.005)
p4=p4.iloc[0,:].geometry.buffer(0.005)
p5=p5.iloc[0,:].geometry.buffer(0.005) # getting the buffer with 5km radius for t
p6=p6.iloc[0,:].geometry.buffer(0.005)
p7=p7.iloc[0,:].geometry.buffer(0.005)
p8=p8.iloc[0,:].geometry.buffer(0.005)
p9=p9.iloc[0,:].geometry.buffer(0.005)
p10=p10.iloc[0,:].geometry.buffer(0.005)
p11=p11.iloc[0,:].geometry.buffer(0.005)
p12=p12.iloc[0,:].geometry.buffer(0.005)
p13=p13.iloc[0,:].geometry.buffer(0.005)
p14=p14.iloc[0,:].geometry.buffer(0.005)
p15=p15.iloc[0,:].geometry.buffer(0.005)
```

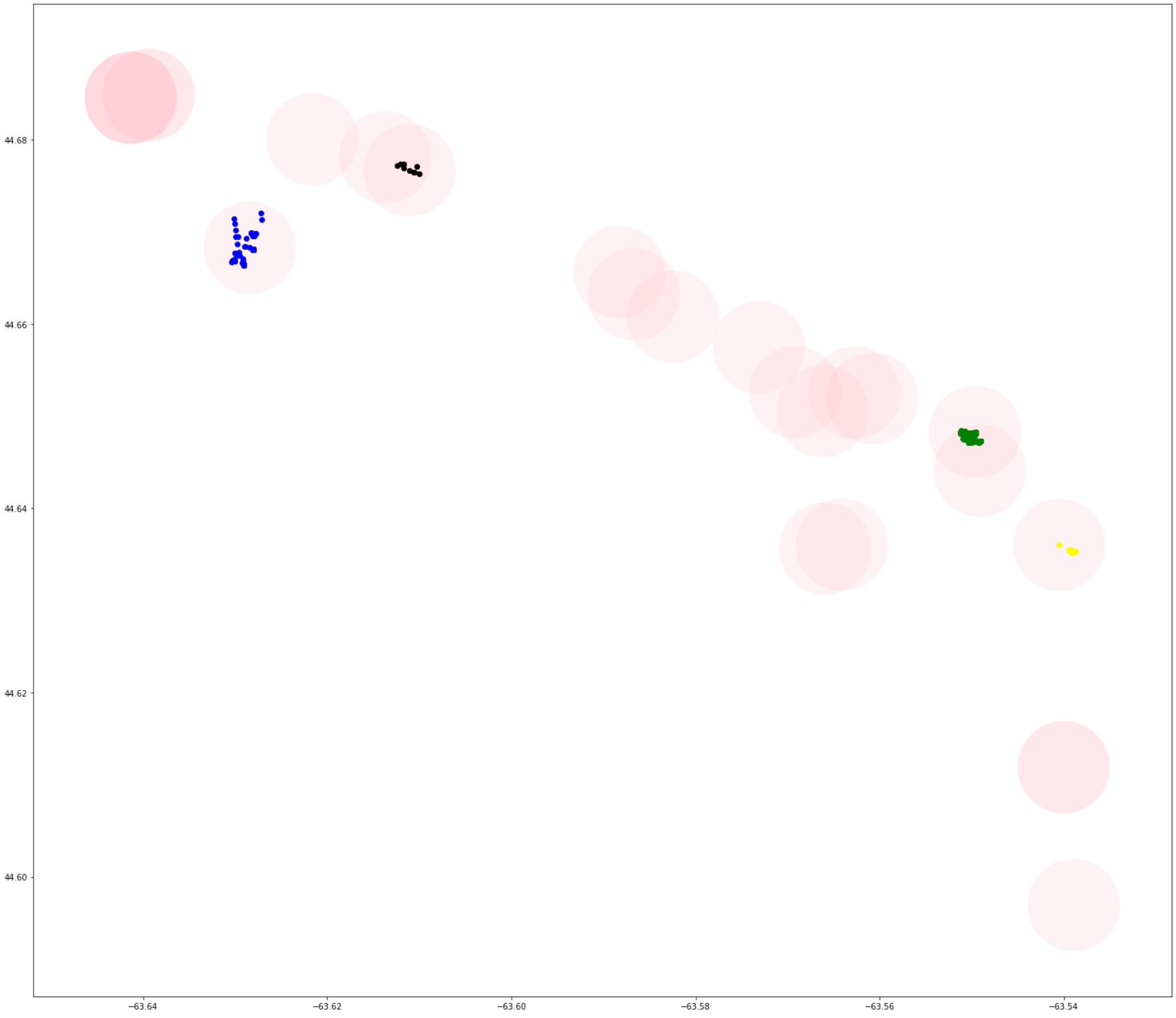
```
p16=p16.iloc[0,:].geometry.buffer(0.005)
p17=p17.iloc[0,:].geometry.buffer(0.005)
p18=p18.iloc[0,:].geometry.buffer(0.005)
p19=p19.iloc[0,:].geometry.buffer(0.005)
p20=p20.iloc[0,:].geometry.buffer(0.005)
p21=p21.iloc[0,:].geometry.buffer(0.005)
p22=p22.iloc[0,:].geometry.buffer(0.005)
p23=p23.iloc[0,:].geometry.buffer(0.005)
p24=p24.iloc[0,:].geometry.buffer(0.005)
p25=p25.iloc[0,:].geometry.buffer(0.005)
p26=p26.iloc[0,:].geometry.buffer(0.005)

# plotting the buffer radius near ports

gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,p19
gdf12.plot(ax=ax,color='g',alpha=0.2)
gdf12.loc[gdf12.within(p1),:].plot(ax=ax,color='k')
gdf12.loc[gdf12.within(p2),:].plot(ax=ax,color='k')
gdf12.loc[gdf12.within(p3),:].plot(ax=ax,color='k')
gdf12.loc[gdf12.within(p4),:].plot(ax=ax,color='k')
gdf12.loc[gdf12.within(p5),:].plot(ax=ax,color='k')
gdf12.loc[gdf12.within(p6),:].plot(ax=ax,color='k')
gdf12.loc[gdf12.within(p7),:].plot(ax=ax,color='k')
gdf12.loc[gdf12.within(p8),:].plot(ax=ax,color='k')
gdf12.loc[gdf12.within(p9),:].plot(ax=ax,color='k')
gdf12.loc[gdf12.within(p10),:].plot(ax=ax,color='k')
gdf12.loc[gdf12.within(p11),:].plot(ax=ax,color='k')
gdf12.loc[gdf12.within(p12),:].plot(ax=ax,color='k')
gdf12.loc[gdf12.within(p13),:].plot(ax=ax,color='k')
gdf12.loc[gdf12.within(p14),:].plot(ax=ax,color='k')
gdf12.loc[gdf12.within(p15),:].plot(ax=ax,color='k')
gdf12.loc[gdf12.within(p16),:].plot(ax=ax,color='k')
gdf12.loc[gdf12.within(p17),:].plot(ax=ax,color='k')
gdf12.loc[gdf12.within(p18),:].plot(ax=ax,color='k')
gdf12.loc[gdf12.within(p19),:].plot(ax=ax,color='k')
gdf12.loc[gdf12.within(p20),:].plot(ax=ax,color='k')
gdf12.loc[gdf12.within(p21),:].plot(ax=ax,color='k')
gdf12.loc[gdf12.within(p22),:].plot(ax=ax,color='k')
gdf12.loc[gdf12.within(p23),:].plot(ax=ax,color='k')
gdf12.loc[gdf12.within(p24),:].plot(ax=ax,color='k')
gdf12.loc[gdf12.within(p25),:].plot(ax=ax,color='k')
gdf12.loc[gdf12.within(p26),:].plot(ax=ax,color='k')
plt.savefig('Q3 images/interval_12_q1.png')
```


44.72
44.70
44.68
44.66
44.64
44.62
44.60
−63.675
−63.650
−63.625
−63.600
−63.575
−63.550
−63.525
−63.500

In [53]:

```
joinres=gpd.sjoin(gdf12,bylaw,op='within',how='left')
col=['r','b','g','k','yellow','orange','Olive','Maroon','Purple','Fuchsia','Lime'
i=0
ax=gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,


for g in set(joinres['index_right']):
  tmp=joinres.loc[joinres['index_right']==g,:]
  if tmp.shape[0]>0:
    tmp.plot(ax=ax,color=col[i])
  i=i+1
plt.savefig('Q3 images/interval_12_q2.png')
```

```
C:\Users\lanch\Anaconda3\lib\site-packages\geopandas\tools\sjoin.py:44: UserWar
ning: CRS of frames being joined does not match!
  warn('CRS of frames being joined does not match!')
```

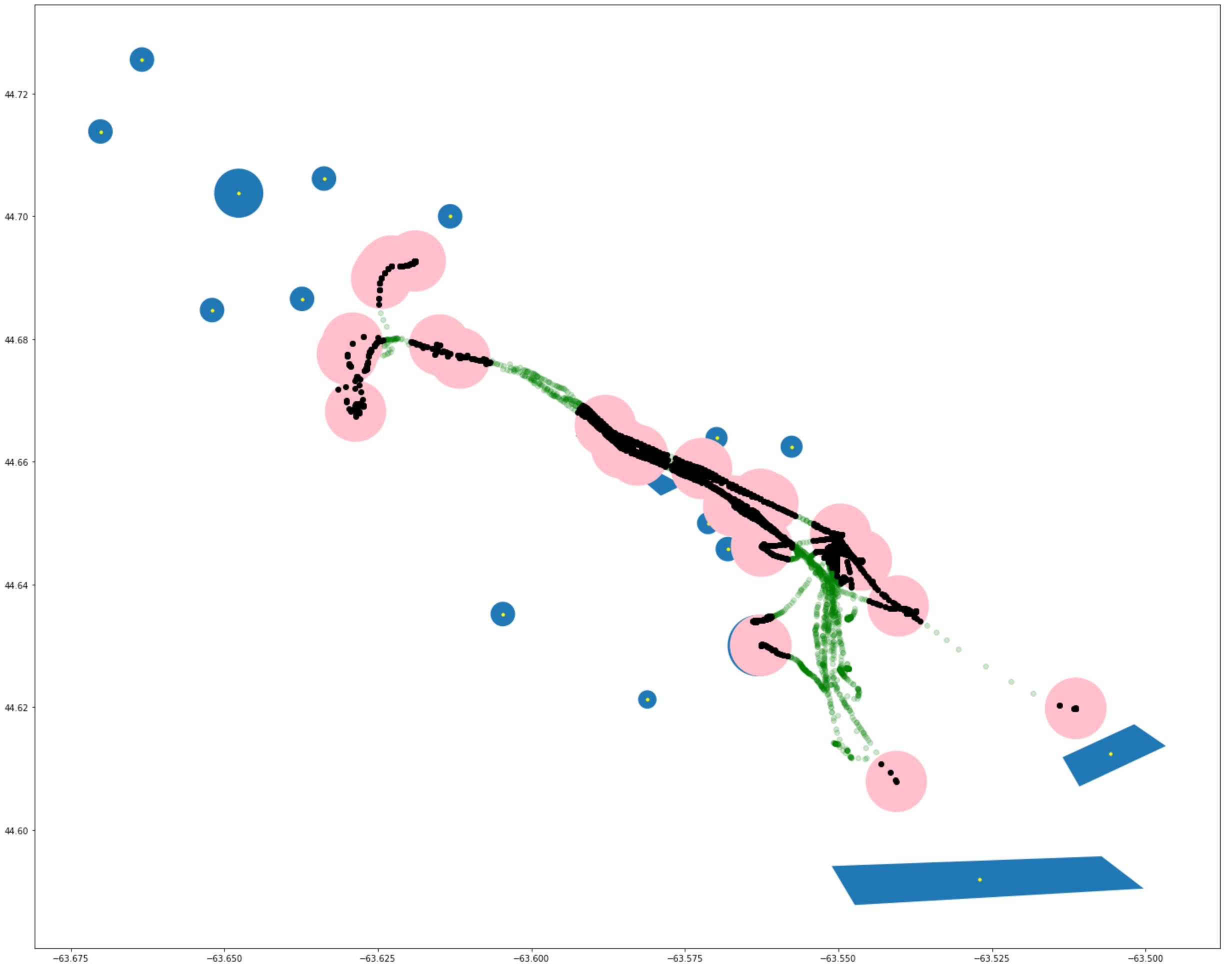


13th interval

In [54]:

```
gdf13 = gpd.GeoDataFrame(d['df_h13'].drop(['location.coordinates.0', 'location.co
crs={'init': 'epsg:4326'},
geometry=[shapely.geometry.Point(xy) for xy in zip(d['df_h13']['location.coordina

p1=gdf13.loc[gdf13.distance(d1[0])==gdf13.distance(d1[0]).min(),:]
p2=gdf13.loc[gdf13.distance(d2[0])==gdf13.distance(d2[0]).min(),:]
p3=gdf13.loc[gdf13.distance(d3[0])==gdf13.distance(d3[0]).min(),:]
p4=gdf13.loc[gdf13.distance(d4[0])==gdf13.distance(d4[0]).min(),:]
p5=gdf13.loc[gdf13.distance(d5[0])==gdf13.distance(d5[0]).min(),:]
p6=gdf13.loc[gdf13.distance(d6[0])==gdf13.distance(d6[0]).min(),:]
p7=gdf13.loc[gdf13.distance(d7[0])==gdf13.distance(d7[0]).min(),:]
p8=gdf13.loc[gdf13.distance(d8[0])==gdf13.distance(d8[0]).min(),:]
p9=gdf13.loc[gdf13.distance(d9[0])==gdf13.distance(d9[0]).min(),:]
p10=gdf13.loc[gdf13.distance(d10[0])==gdf13.distance(d10[0]).min(),:]
p11=gdf13.loc[gdf13.distance(d11[0])==gdf13.distance(d11[0]).min(),:]
p12=gdf13.loc[gdf13.distance(d12[0])==gdf13.distance(d12[0]).min(),:]
p13=gdf13.loc[gdf13.distance(d13[0])==gdf13.distance(d13[0]).min(),:]
p14=gdf13.loc[gdf13.distance(d14[0])==gdf13.distance(d14[0]).min(),:]
p15=gdf13.loc[gdf13.distance(d15[0])==gdf13.distance(d15[0]).min(),:]
p16=gdf13.loc[gdf13.distance(d16[0])==gdf13.distance(d16[0]).min(),:]
p17=gdf13.loc[gdf13.distance(d17[0])==gdf13.distance(d17[0]).min(),:]
p18=gdf13.loc[gdf13.distance(d18[0])==gdf13.distance(d18[0]).min(),:]
p19=gdf13.loc[gdf13.distance(d19[0])==gdf13.distance(d19[0]).min(),:]
p20=gdf13.loc[gdf13.distance(d20[0])==gdf13.distance(d20[0]).min(),:]
p21=gdf13.loc[gdf13.distance(d21[0])==gdf13.distance(d21[0]).min(),:]
p22=gdf13.loc[gdf13.distance(d22[0])==gdf13.distance(d22[0]).min(),:]
p23=gdf13.loc[gdf13.distance(d23[0])==gdf13.distance(d23[0]).min(),:]
p24=gdf13.loc[gdf13.distance(d24[0])==gdf13.distance(d24[0]).min(),:]
p25=gdf13.loc[gdf13.distance(d25[0])==gdf13.distance(d25[0]).min(),:]
p26=gdf13.loc[gdf13.distance(d26[0])==gdf13.distance(d26[0]).min(),:]



# creating buffer on the buffer with 5km radius
ax=bylaw.loc[['pointpolygon', 'port1', 'port2', 'ind', 'port5', 'port6', 'port7',
              'southend container terminal','NN Jetty', 'Bills island', 'mid bedf
              'waterfront h', 'northarm', 'plll', 'pp', 'po001','po002', 'oulier_
              'p009', 'p010'],:].plot(figsize=(25,25))
gpd.GeoSeries([d1[0],d2[0],d3[0],d4[0],d5[0],d6[0],d7[0],d8[0],d9[0],d10[0],d11[0
               d16[0],d17[0],d18[0],d19[0],d20[0],d21[0],d22[0],d23[0],d24[0],d25
               d26[0]]).plot(ax=ax,color='yellow',markersize=10)

p1=p1.iloc[0,:].geometry.buffer(0.005)
p2=p2.iloc[0,:].geometry.buffer(0.005)
p3=p3.iloc[0,:].geometry.buffer(0.005)
p4=p4.iloc[0,:].geometry.buffer(0.005)
p5=p5.iloc[0,:].geometry.buffer(0.005) # getting the buffer with 5km radius for t
p6=p6.iloc[0,:].geometry.buffer(0.005)
p7=p7.iloc[0,:].geometry.buffer(0.005)
p8=p8.iloc[0,:].geometry.buffer(0.005)
p9=p9.iloc[0,:].geometry.buffer(0.005)
p10=p10.iloc[0,:].geometry.buffer(0.005)
p11=p11.iloc[0,:].geometry.buffer(0.005)
p12=p12.iloc[0,:].geometry.buffer(0.005)
p13=p13.iloc[0,:].geometry.buffer(0.005)
p14=p14.iloc[0,:].geometry.buffer(0.005)
p15=p15.iloc[0,:].geometry.buffer(0.005)
```

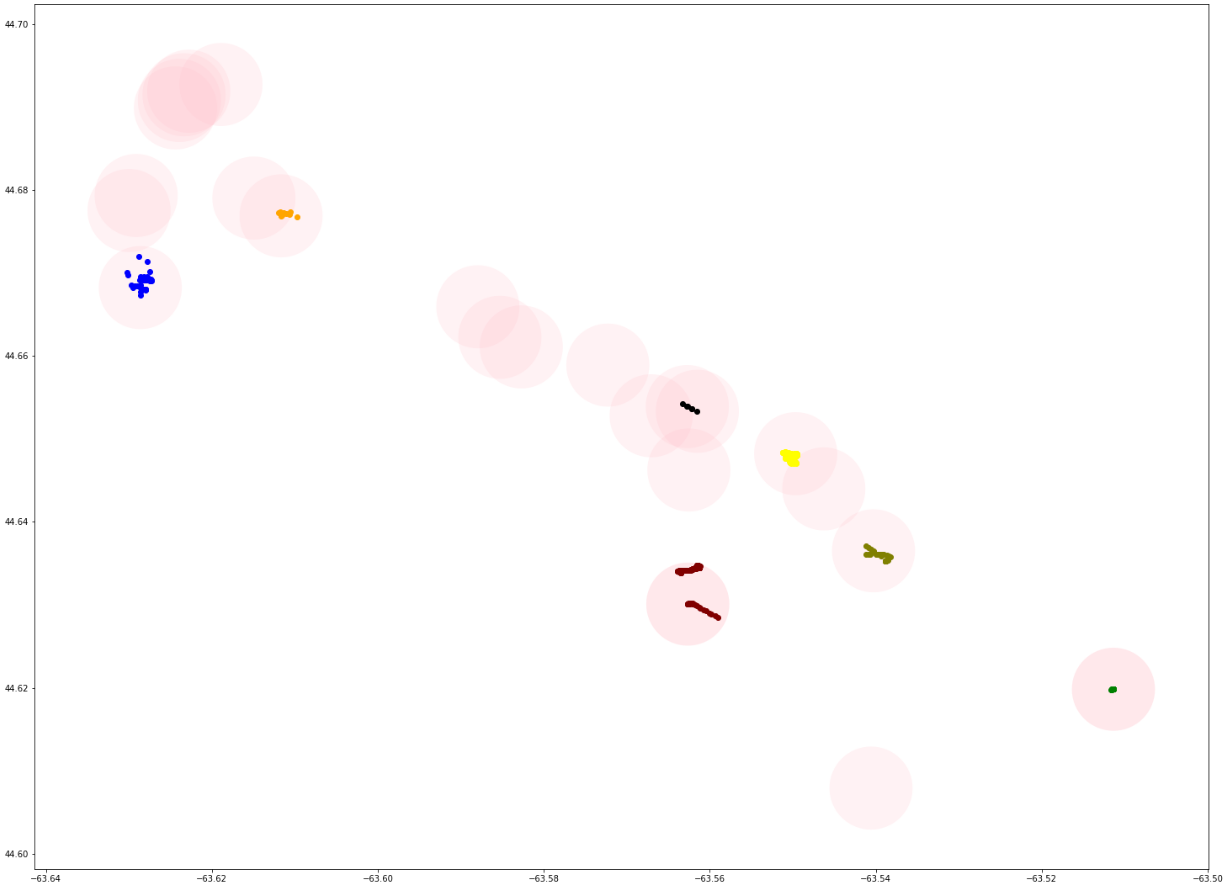
```
p16=p16.iloc[0,:].geometry.buffer(0.005)
p17=p17.iloc[0,:].geometry.buffer(0.005)
p18=p18.iloc[0,:].geometry.buffer(0.005)
p19=p19.iloc[0,:].geometry.buffer(0.005)
p20=p20.iloc[0,:].geometry.buffer(0.005)
p21=p21.iloc[0,:].geometry.buffer(0.005)
p22=p22.iloc[0,:].geometry.buffer(0.005)
p23=p23.iloc[0,:].geometry.buffer(0.005)
p24=p24.iloc[0,:].geometry.buffer(0.005)
p25=p25.iloc[0,:].geometry.buffer(0.005)
p26=p26.iloc[0,:].geometry.buffer(0.005)

# plotting the buffer radius near ports

gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,p19
gdf13.plot(ax=ax,color='g',alpha=0.2)
gdf13.loc[gdf13.within(p1),:].plot(ax=ax,color='k')
gdf13.loc[gdf13.within(p2),:].plot(ax=ax,color='k')
gdf13.loc[gdf13.within(p3),:].plot(ax=ax,color='k')
gdf13.loc[gdf13.within(p4),:].plot(ax=ax,color='k')
gdf13.loc[gdf13.within(p5),:].plot(ax=ax,color='k')
gdf13.loc[gdf13.within(p6),:].plot(ax=ax,color='k')
gdf13.loc[gdf13.within(p7),:].plot(ax=ax,color='k')
gdf13.loc[gdf13.within(p8),:].plot(ax=ax,color='k')
gdf13.loc[gdf13.within(p9),:].plot(ax=ax,color='k')
gdf13.loc[gdf13.within(p10),:].plot(ax=ax,color='k')
gdf13.loc[gdf13.within(p11),:].plot(ax=ax,color='k')
gdf13.loc[gdf13.within(p12),:].plot(ax=ax,color='k')
gdf13.loc[gdf13.within(p13),:].plot(ax=ax,color='k')
gdf13.loc[gdf13.within(p14),:].plot(ax=ax,color='k')
gdf13.loc[gdf13.within(p15),:].plot(ax=ax,color='k')
gdf13.loc[gdf13.within(p16),:].plot(ax=ax,color='k')
gdf13.loc[gdf13.within(p17),:].plot(ax=ax,color='k')
gdf13.loc[gdf13.within(p18),:].plot(ax=ax,color='k')
gdf13.loc[gdf13.within(p19),:].plot(ax=ax,color='k')
gdf13.loc[gdf13.within(p20),:].plot(ax=ax,color='k')
gdf13.loc[gdf13.within(p21),:].plot(ax=ax,color='k')
gdf13.loc[gdf13.within(p22),:].plot(ax=ax,color='k')
gdf13.loc[gdf13.within(p23),:].plot(ax=ax,color='k')
gdf13.loc[gdf13.within(p24),:].plot(ax=ax,color='k')
gdf13.loc[gdf13.within(p25),:].plot(ax=ax,color='k')
gdf13.loc[gdf13.within(p26),:].plot(ax=ax,color='k')
plt.savefig('Q3 images/interval_13_q1.png')
```


44.72
44.70
44.68
44.66
44.64
44.62
44.60
−63.675
−63.650
−63.625
−63.600
−63.575
−63.550
−63.525
−63.500

In [55]:

```
joinres=gpd.sjoin(gdf13,bylaw,op='within',how='left')
col=['r','b','g','k','yellow','orange','Olive','Maroon','Purple','Fuchsia','Lime'
i=0
ax=gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,


for g in set(joinres['index_right']):
  tmp=joinres.loc[joinres['index_right']==g,:]
  if tmp.shape[0]>0:
    tmp.plot(ax=ax,color=col[i])
  i=i+1
plt.savefig('Q3 images/interval_13_q2.png')
```

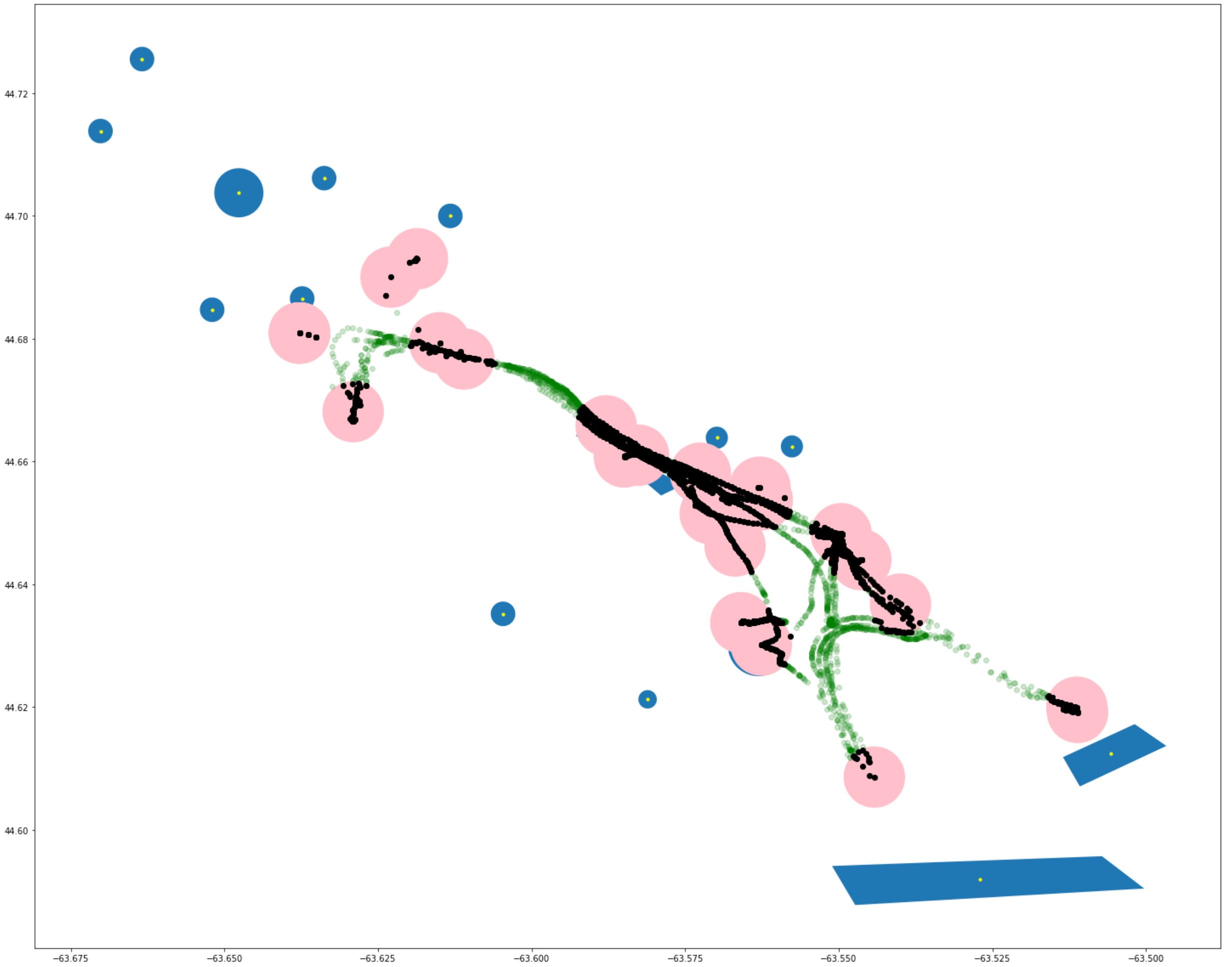
```
C:\Users\lanch\Anaconda3\lib\site-packages\geopandas\tools\sjoin.py:44: UserWar
ning: CRS of frames being joined does not match!
  warn('CRS of frames being joined does not match!')
```



14th interval

In [56]:
```
gdf14 = gpd.GeoDataFrame(d['df_h14'].drop(['location.coordinates.0', 'location.co
crs={'init': 'epsg:4326'},
geometry=[shapely.geometry.Point(xy) for xy in zip(d['df_h14']['location.coordina

p1=gdf14.loc[gdf14.distance(d1[0])==gdf14.distance(d1[0]).min(),:]
p2=gdf14.loc[gdf14.distance(d2[0])==gdf14.distance(d2[0]).min(),:]
p3=gdf14.loc[gdf14.distance(d3[0])==gdf14.distance(d3[0]).min(),:]
p4=gdf14.loc[gdf14.distance(d4[0])==gdf14.distance(d4[0]).min(),:]
p5=gdf14.loc[gdf14.distance(d5[0])==gdf14.distance(d5[0]).min(),:]
p6=gdf14.loc[gdf14.distance(d6[0])==gdf14.distance(d6[0]).min(),:]
p7=gdf14.loc[gdf14.distance(d7[0])==gdf14.distance(d7[0]).min(),:]
p8=gdf14.loc[gdf14.distance(d8[0])==gdf14.distance(d8[0]).min(),:]
p9=gdf14.loc[gdf14.distance(d9[0])==gdf14.distance(d9[0]).min(),:]
p10=gdf14.loc[gdf14.distance(d10[0])==gdf14.distance(d10[0]).min(),:]
p11=gdf14.loc[gdf14.distance(d11[0])==gdf14.distance(d11[0]).min(),:]
p12=gdf14.loc[gdf14.distance(d12[0])==gdf14.distance(d12[0]).min(),:]
p13=gdf14.loc[gdf14.distance(d13[0])==gdf14.distance(d13[0]).min(),:]
p14=gdf14.loc[gdf14.distance(d14[0])==gdf14.distance(d14[0]).min(),:]
p15=gdf14.loc[gdf14.distance(d15[0])==gdf14.distance(d15[0]).min(),:]
p16=gdf14.loc[gdf14.distance(d16[0])==gdf14.distance(d16[0]).min(),:]
p17=gdf14.loc[gdf14.distance(d17[0])==gdf14.distance(d17[0]).min(),:]
p18=gdf14.loc[gdf14.distance(d18[0])==gdf14.distance(d18[0]).min(),:]
p19=gdf14.loc[gdf14.distance(d19[0])==gdf14.distance(d19[0]).min(),:]
p20=gdf14.loc[gdf14.distance(d20[0])==gdf14.distance(d20[0]).min(),:]
p21=gdf14.loc[gdf14.distance(d21[0])==gdf14.distance(d21[0]).min(),:]
p22=gdf14.loc[gdf14.distance(d22[0])==gdf14.distance(d22[0]).min(),:]
p23=gdf14.loc[gdf14.distance(d23[0])==gdf14.distance(d23[0]).min(),:]
p24=gdf14.loc[gdf14.distance(d24[0])==gdf14.distance(d24[0]).min(),:]
p25=gdf14.loc[gdf14.distance(d25[0])==gdf14.distance(d25[0]).min(),:]
p26=gdf14.loc[gdf14.distance(d26[0])==gdf14.distance(d26[0]).min(),:]



# creating buffer on the buffer with 5km radius
ax=bylaw.loc[['pointpolygon', 'port1', 'port2', 'ind', 'port5', 'port6', 'port7',
              'southend container terminal','NN Jetty', 'Bills island', 'mid bedf
              'waterfront h', 'northarm', 'plll', 'pp', 'po001','po002', 'oulier_
              'p009', 'p010'],:].plot(figsize=(25,25))
gpd.GeoSeries([d1[0],d2[0],d3[0],d4[0],d5[0],d6[0],d7[0],d8[0],d9[0],d10[0],d11[0
               d16[0],d17[0],d18[0],d19[0],d20[0],d21[0],d22[0],d23[0],d24[0],d25
               d26[0]]).plot(ax=ax,color='yellow',markersize=10)

p1=p1.iloc[0,:].geometry.buffer(0.005)
p2=p2.iloc[0,:].geometry.buffer(0.005)
p3=p3.iloc[0,:].geometry.buffer(0.005)
p4=p4.iloc[0,:].geometry.buffer(0.005)
p5=p5.iloc[0,:].geometry.buffer(0.005) # getting the buffer with 5km radius for t
p6=p6.iloc[0,:].geometry.buffer(0.005)
p7=p7.iloc[0,:].geometry.buffer(0.005)
p8=p8.iloc[0,:].geometry.buffer(0.005)
p9=p9.iloc[0,:].geometry.buffer(0.005)
p10=p10.iloc[0,:].geometry.buffer(0.005)
p11=p11.iloc[0,:].geometry.buffer(0.005)
p12=p12.iloc[0,:].geometry.buffer(0.005)
p13=p13.iloc[0,:].geometry.buffer(0.005)
p14=p14.iloc[0,:].geometry.buffer(0.005)
p15=p15.iloc[0,:].geometry.buffer(0.005)
```

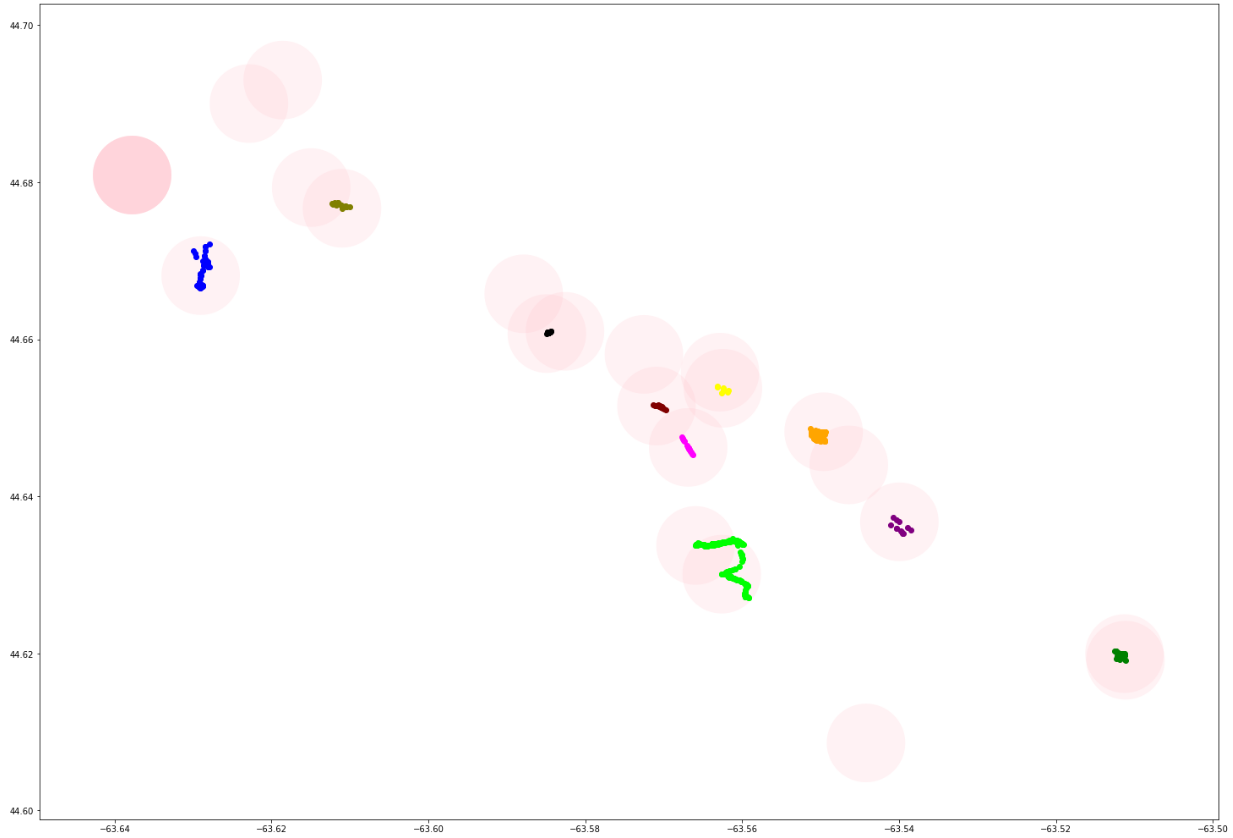
```
p16=p16.iloc[0,:].geometry.buffer(0.005)
p17=p17.iloc[0,:].geometry.buffer(0.005)
p18=p18.iloc[0,:].geometry.buffer(0.005)
p19=p19.iloc[0,:].geometry.buffer(0.005)
p20=p20.iloc[0,:].geometry.buffer(0.005)
p21=p21.iloc[0,:].geometry.buffer(0.005)
p22=p22.iloc[0,:].geometry.buffer(0.005)
p23=p23.iloc[0,:].geometry.buffer(0.005)
p24=p24.iloc[0,:].geometry.buffer(0.005)
p25=p25.iloc[0,:].geometry.buffer(0.005)
p26=p26.iloc[0,:].geometry.buffer(0.005)

# plotting the buffer radius near ports

gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,p19
gdf14.plot(ax=ax,color='g',alpha=0.2)
gdf14.loc[gdf14.within(p1),:].plot(ax=ax,color='k')
gdf14.loc[gdf14.within(p2),:].plot(ax=ax,color='k')
gdf14.loc[gdf14.within(p3),:].plot(ax=ax,color='k')
gdf14.loc[gdf14.within(p4),:].plot(ax=ax,color='k')
gdf14.loc[gdf14.within(p5),:].plot(ax=ax,color='k')
gdf14.loc[gdf14.within(p6),:].plot(ax=ax,color='k')
gdf14.loc[gdf14.within(p7),:].plot(ax=ax,color='k')
gdf14.loc[gdf14.within(p8),:].plot(ax=ax,color='k')
gdf14.loc[gdf14.within(p9),:].plot(ax=ax,color='k')
gdf14.loc[gdf14.within(p10),:].plot(ax=ax,color='k')
gdf14.loc[gdf14.within(p11),:].plot(ax=ax,color='k')
gdf14.loc[gdf14.within(p12),:].plot(ax=ax,color='k')
gdf14.loc[gdf14.within(p13),:].plot(ax=ax,color='k')
gdf14.loc[gdf14.within(p14),:].plot(ax=ax,color='k')
gdf14.loc[gdf14.within(p15),:].plot(ax=ax,color='k')
gdf14.loc[gdf14.within(p16),:].plot(ax=ax,color='k')
gdf14.loc[gdf14.within(p17),:].plot(ax=ax,color='k')
gdf14.loc[gdf14.within(p18),:].plot(ax=ax,color='k')
gdf14.loc[gdf14.within(p19),:].plot(ax=ax,color='k')
gdf14.loc[gdf14.within(p20),:].plot(ax=ax,color='k')
gdf14.loc[gdf14.within(p21),:].plot(ax=ax,color='k')
gdf14.loc[gdf14.within(p22),:].plot(ax=ax,color='k')
gdf14.loc[gdf14.within(p23),:].plot(ax=ax,color='k')
gdf14.loc[gdf14.within(p24),:].plot(ax=ax,color='k')
gdf14.loc[gdf14.within(p25),:].plot(ax=ax,color='k')
gdf14.loc[gdf14.within(p26),:].plot(ax=ax,color='k')
plt.savefig('Q3 images/interval_14_q1.png')
```


44.72
44.70
44.68
44.66
44.64
44.62
44.60
−63.675
−63.650
−63.625
−63.600
−63.575
−63.550
−63.525
−63.500

In [57]:

```
joinres=gpd.sjoin(gdf14,bylaw,op='within',how='left')
col=['r','b','g','k','yellow','orange','Olive','Maroon','Purple','Fuchsia','Lime'
i=0
ax=gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,


for g in set(joinres['index_right']):
  tmp=joinres.loc[joinres['index_right']==g,:]
  if tmp.shape[0]>0:
    tmp.plot(ax=ax,color=col[i])
  i=i+1
plt.savefig('Q3 images/interval_14_q2.png')
```

```
C:\Users\lanch\Anaconda3\lib\site-packages\geopandas\tools\sjoin.py:44: UserWar
ning: CRS of frames being joined does not match!
  warn('CRS of frames being joined does not match!')
```

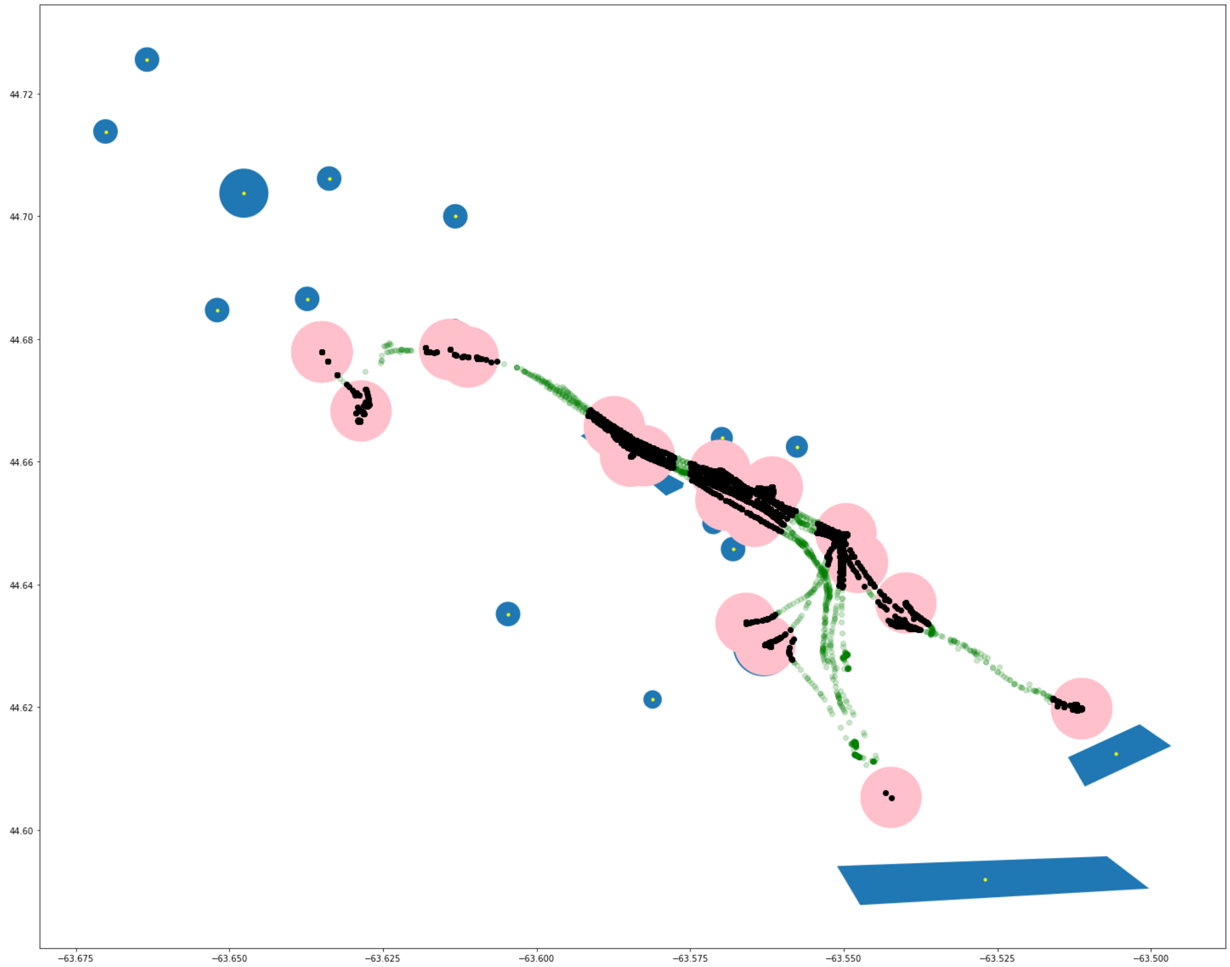


15th interval

In [59]:

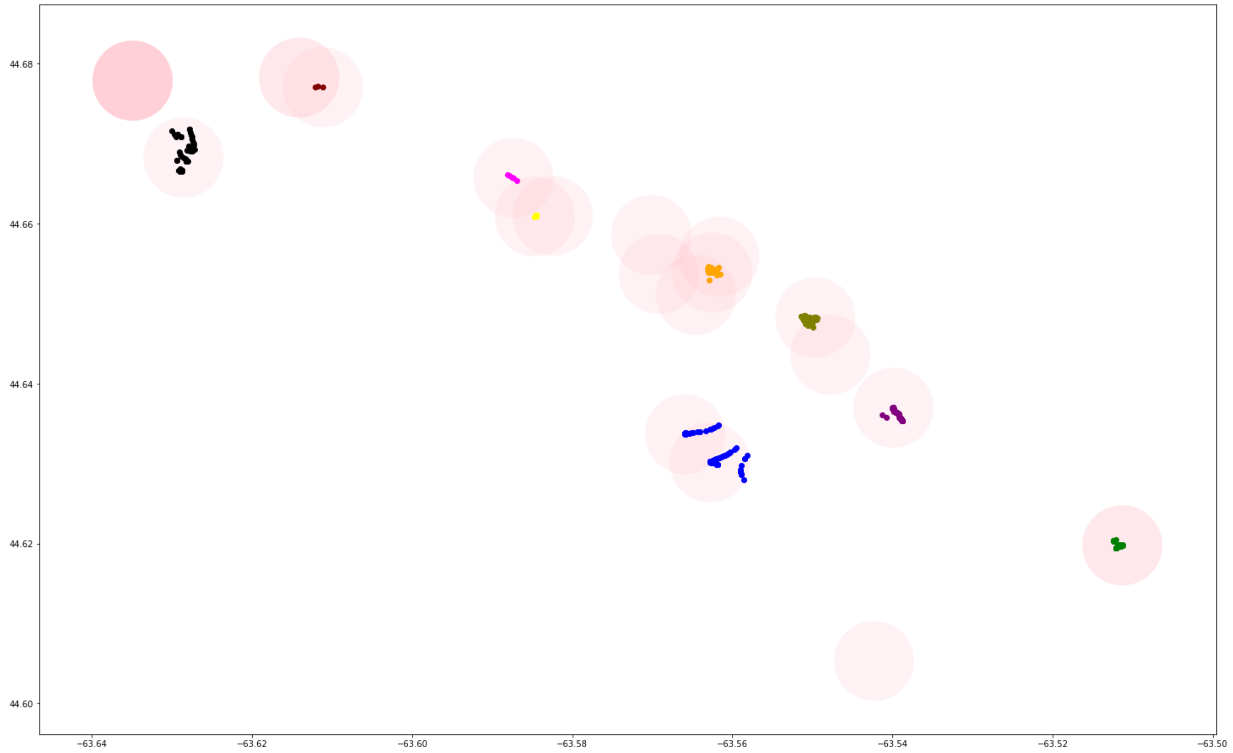
```
gdf15 = gpd.GeoDataFrame(d['df_h15'].drop(['location.coordinates.0', 'location.co
crs={'init': 'epsg:4326'},
geometry=[shapely.geometry.Point(xy) for xy in zip(d['df_h15']['location.coordina

p1=gdf15.loc[gdf15.distance(d1[0])==gdf15.distance(d1[0]).min(),:]
p2=gdf15.loc[gdf15.distance(d2[0])==gdf15.distance(d2[0]).min(),:]
p3=gdf15.loc[gdf15.distance(d3[0])==gdf15.distance(d3[0]).min(),:]
p4=gdf15.loc[gdf15.distance(d4[0])==gdf15.distance(d4[0]).min(),:]
p5=gdf15.loc[gdf15.distance(d5[0])==gdf15.distance(d5[0]).min(),:]
p6=gdf15.loc[gdf15.distance(d6[0])==gdf15.distance(d6[0]).min(),:]
p7=gdf15.loc[gdf15.distance(d7[0])==gdf15.distance(d7[0]).min(),:]
p8=gdf15.loc[gdf15.distance(d8[0])==gdf15.distance(d8[0]).min(),:]
p9=gdf15.loc[gdf15.distance(d9[0])==gdf15.distance(d9[0]).min(),:]
p10=gdf15.loc[gdf15.distance(d10[0])==gdf15.distance(d10[0]).min(),:]
p11=gdf15.loc[gdf15.distance(d11[0])==gdf15.distance(d11[0]).min(),:]
p12=gdf15.loc[gdf15.distance(d12[0])==gdf15.distance(d12[0]).min(),:]
p13=gdf15.loc[gdf15.distance(d13[0])==gdf15.distance(d13[0]).min(),:]
p14=gdf15.loc[gdf15.distance(d14[0])==gdf15.distance(d14[0]).min(),:]
p15=gdf15.loc[gdf15.distance(d15[0])==gdf15.distance(d15[0]).min(),:]
p16=gdf15.loc[gdf15.distance(d16[0])==gdf15.distance(d16[0]).min(),:]
p17=gdf15.loc[gdf15.distance(d17[0])==gdf15.distance(d17[0]).min(),:]
p18=gdf15.loc[gdf15.distance(d18[0])==gdf15.distance(d18[0]).min(),:]
p19=gdf15.loc[gdf15.distance(d19[0])==gdf15.distance(d19[0]).min(),:]
p20=gdf15.loc[gdf15.distance(d20[0])==gdf15.distance(d20[0]).min(),:]
p21=gdf15.loc[gdf15.distance(d21[0])==gdf15.distance(d21[0]).min(),:]
p22=gdf15.loc[gdf15.distance(d22[0])==gdf15.distance(d22[0]).min(),:]
p23=gdf15.loc[gdf15.distance(d23[0])==gdf15.distance(d23[0]).min(),:]
p24=gdf15.loc[gdf15.distance(d24[0])==gdf15.distance(d24[0]).min(),:]
p25=gdf15.loc[gdf15.distance(d25[0])==gdf15.distance(d25[0]).min(),:]
p26=gdf15.loc[gdf15.distance(d26[0])==gdf15.distance(d26[0]).min(),:]



# creating buffer on the buffer with 5km radius
ax=bylaw.loc[['pointpolygon', 'port1', 'port2', 'ind', 'port5', 'port6', 'port7',
              'southend container terminal','NN Jetty', 'Bills island', 'mid bedf
              'waterfront h', 'northarm', 'plll', 'pp', 'po001','po002', 'oulier_
              'p009', 'p010'],:].plot(figsize=(25,25))
gpd.GeoSeries([d1[0],d2[0],d3[0],d4[0],d5[0],d6[0],d7[0],d8[0],d9[0],d10[0],d11[0
               d16[0],d17[0],d18[0],d19[0],d20[0],d21[0],d22[0],d23[0],d24[0],d25
               d26[0]]).plot(ax=ax,color='yellow',markersize=10)

p1=p1.iloc[0,:].geometry.buffer(0.005)
p2=p2.iloc[0,:].geometry.buffer(0.005)
p3=p3.iloc[0,:].geometry.buffer(0.005)
p4=p4.iloc[0,:].geometry.buffer(0.005)
p5=p5.iloc[0,:].geometry.buffer(0.005) # getting the buffer with 5km radius for th
p6=p6.iloc[0,:].geometry.buffer(0.005)
p7=p7.iloc[0,:].geometry.buffer(0.005)
p8=p8.iloc[0,:].geometry.buffer(0.005)
p9=p9.iloc[0,:].geometry.buffer(0.005)
p10=p10.iloc[0,:].geometry.buffer(0.005)
p11=p11.iloc[0,:].geometry.buffer(0.005)
p12=p12.iloc[0,:].geometry.buffer(0.005)
p13=p13.iloc[0,:].geometry.buffer(0.005)
p14=p14.iloc[0,:].geometry.buffer(0.005)
p15=p15.iloc[0,:].geometry.buffer(0.005)
```

```
p16=p16.iloc[0,:].geometry.buffer(0.005)
p17=p17.iloc[0,:].geometry.buffer(0.005)
p18=p18.iloc[0,:].geometry.buffer(0.005)
p19=p19.iloc[0,:].geometry.buffer(0.005)
p20=p20.iloc[0,:].geometry.buffer(0.005)
p21=p21.iloc[0,:].geometry.buffer(0.005)
p22=p22.iloc[0,:].geometry.buffer(0.005)
p23=p23.iloc[0,:].geometry.buffer(0.005)
p24=p24.iloc[0,:].geometry.buffer(0.005)
p25=p25.iloc[0,:].geometry.buffer(0.005)
p26=p26.iloc[0,:].geometry.buffer(0.005)

# plotting the buffer radius near ports

gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,p19
gdf15.plot(ax=ax,color='g',alpha=0.2)
gdf15.loc[gdf15.within(p1),:].plot(ax=ax,color='k')
gdf15.loc[gdf15.within(p2),:].plot(ax=ax,color='k')
gdf15.loc[gdf15.within(p3),:].plot(ax=ax,color='k')
gdf15.loc[gdf15.within(p4),:].plot(ax=ax,color='k')
gdf15.loc[gdf15.within(p5),:].plot(ax=ax,color='k')
gdf15.loc[gdf15.within(p6),:].plot(ax=ax,color='k')
gdf15.loc[gdf15.within(p7),:].plot(ax=ax,color='k')
gdf15.loc[gdf15.within(p8),:].plot(ax=ax,color='k')
gdf15.loc[gdf15.within(p9),:].plot(ax=ax,color='k')
gdf15.loc[gdf15.within(p10),:].plot(ax=ax,color='k')
gdf15.loc[gdf15.within(p11),:].plot(ax=ax,color='k')
gdf15.loc[gdf15.within(p12),:].plot(ax=ax,color='k')
gdf15.loc[gdf15.within(p13),:].plot(ax=ax,color='k')
gdf15.loc[gdf15.within(p14),:].plot(ax=ax,color='k')
gdf15.loc[gdf15.within(p15),:].plot(ax=ax,color='k')
gdf15.loc[gdf15.within(p16),:].plot(ax=ax,color='k')
gdf15.loc[gdf15.within(p17),:].plot(ax=ax,color='k')
gdf15.loc[gdf15.within(p18),:].plot(ax=ax,color='k')
gdf15.loc[gdf15.within(p19),:].plot(ax=ax,color='k')
gdf15.loc[gdf15.within(p20),:].plot(ax=ax,color='k')
gdf15.loc[gdf15.within(p21),:].plot(ax=ax,color='k')
gdf15.loc[gdf15.within(p22),:].plot(ax=ax,color='k')
gdf15.loc[gdf15.within(p23),:].plot(ax=ax,color='k')
gdf15.loc[gdf15.within(p24),:].plot(ax=ax,color='k')
gdf15.loc[gdf15.within(p25),:].plot(ax=ax,color='k')
gdf15.loc[gdf15.within(p26),:].plot(ax=ax,color='k')
plt.savefig('Q3 images/interval_15_q1.png')
```


44.72
44.70
44.68
44.66
44.64
44.62
44.60
−63.675
−63.650
−63.625
−63.600
−63.575
−63.550
−63.525
−63.500

In [60]:
```
joinres=gpd.sjoin(gdf15,bylaw,op='within',how='left')
col=['r','b','g','k','yellow','orange','Olive','Maroon','Purple','Fuchsia','Lime'
i=0
ax=gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,


for g in set(joinres['index_right']):
  tmp=joinres.loc[joinres['index_right']==g,:]
  if tmp.shape[0]>0:
    tmp.plot(ax=ax,color=col[i])
  i=i+1
plt.savefig('Q3 images/interval_15_q2.png')
```

```
C:\Users\lanch\Anaconda3\lib\site-packages\geopandas\tools\sjoin.py:44: UserWar
ning: CRS of frames being joined does not match!
  warn('CRS of frames being joined does not match!')
```

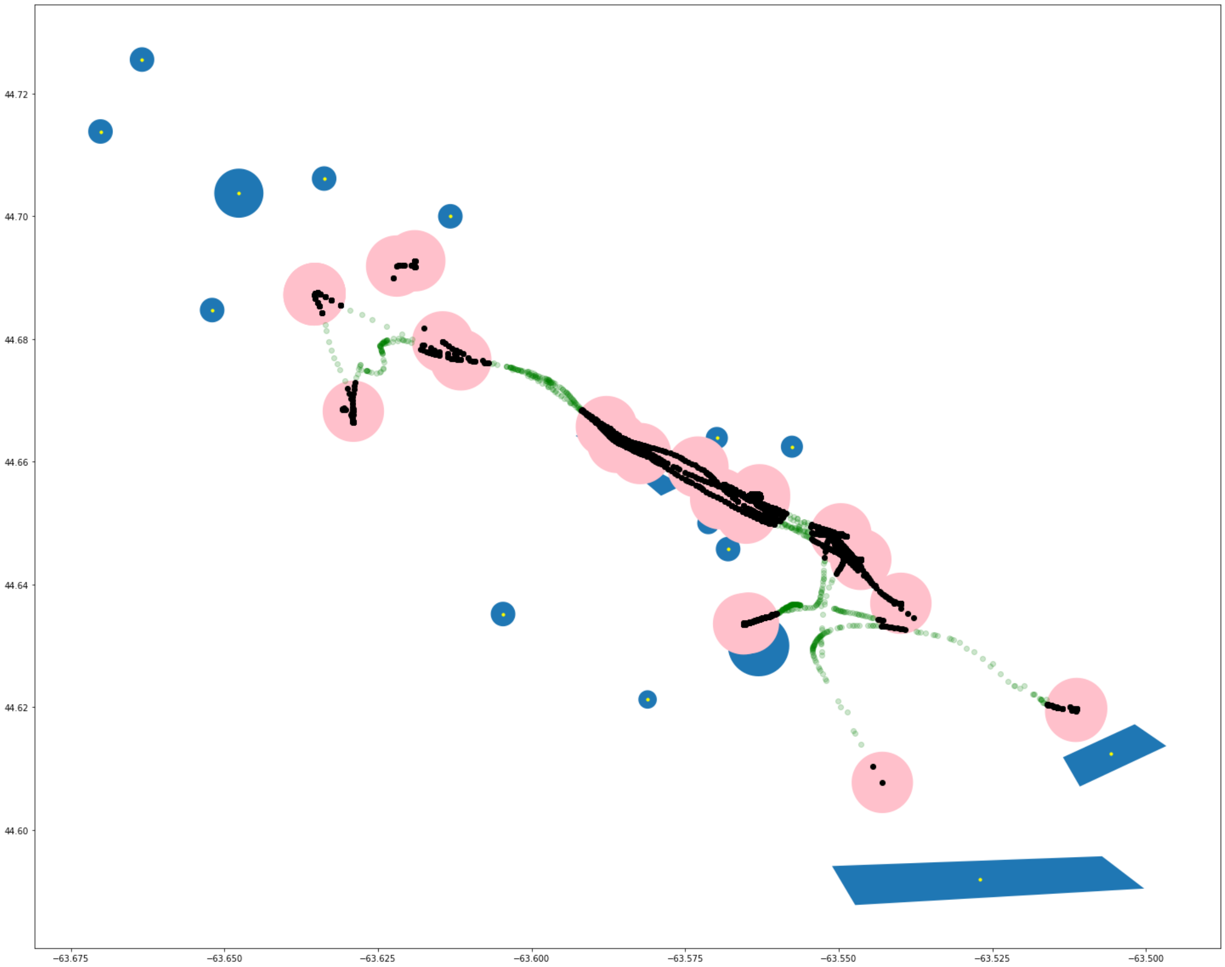


```
16th interval
```

In [61]:

```
gdf16 = gpd.GeoDataFrame(d['df_h16'].drop(['location.coordinates.0', 'location.co
crs={'init': 'epsg:4326'},
geometry=[shapely.geometry.Point(xy) for xy in zip(d['df_h16']['location.coordina

p1=gdf16.loc[gdf16.distance(d1[0])==gdf16.distance(d1[0]).min(),:]
p2=gdf16.loc[gdf16.distance(d2[0])==gdf16.distance(d2[0]).min(),:]
p3=gdf16.loc[gdf16.distance(d3[0])==gdf16.distance(d3[0]).min(),:]
p4=gdf16.loc[gdf16.distance(d4[0])==gdf16.distance(d4[0]).min(),:]
p5=gdf16.loc[gdf16.distance(d5[0])==gdf16.distance(d5[0]).min(),:]
p6=gdf16.loc[gdf16.distance(d6[0])==gdf16.distance(d6[0]).min(),:]
p7=gdf16.loc[gdf16.distance(d7[0])==gdf16.distance(d7[0]).min(),:]
p8=gdf16.loc[gdf16.distance(d8[0])==gdf16.distance(d8[0]).min(),:]
p9=gdf16.loc[gdf16.distance(d9[0])==gdf16.distance(d9[0]).min(),:]
p10=gdf16.loc[gdf16.distance(d10[0])==gdf16.distance(d10[0]).min(),:]
p11=gdf16.loc[gdf16.distance(d11[0])==gdf16.distance(d11[0]).min(),:]
p12=gdf16.loc[gdf16.distance(d12[0])==gdf16.distance(d12[0]).min(),:]
p13=gdf16.loc[gdf16.distance(d13[0])==gdf16.distance(d13[0]).min(),:]
p14=gdf16.loc[gdf16.distance(d14[0])==gdf16.distance(d14[0]).min(),:]
p15=gdf16.loc[gdf16.distance(d15[0])==gdf16.distance(d15[0]).min(),:]
p16=gdf16.loc[gdf16.distance(d16[0])==gdf16.distance(d16[0]).min(),:]
p17=gdf16.loc[gdf16.distance(d17[0])==gdf16.distance(d17[0]).min(),:]
p18=gdf16.loc[gdf16.distance(d18[0])==gdf16.distance(d18[0]).min(),:]
p19=gdf16.loc[gdf16.distance(d19[0])==gdf16.distance(d19[0]).min(),:]
p20=gdf16.loc[gdf16.distance(d20[0])==gdf16.distance(d20[0]).min(),:]
p21=gdf16.loc[gdf16.distance(d21[0])==gdf16.distance(d21[0]).min(),:]
p22=gdf16.loc[gdf16.distance(d22[0])==gdf16.distance(d22[0]).min(),:]
p23=gdf16.loc[gdf16.distance(d23[0])==gdf16.distance(d23[0]).min(),:]
p24=gdf16.loc[gdf16.distance(d24[0])==gdf16.distance(d24[0]).min(),:]
p25=gdf16.loc[gdf16.distance(d25[0])==gdf16.distance(d25[0]).min(),:]
p26=gdf16.loc[gdf16.distance(d26[0])==gdf16.distance(d26[0]).min(),:]



# creating buffer on the buffer with 5km radius
ax=bylaw.loc[['pointpolygon', 'port1', 'port2', 'ind', 'port5', 'port6', 'port7',
              'southend container terminal','NN Jetty', 'Bills island', 'mid bedf
              'waterfront h', 'northarm', 'plll', 'pp', 'po001','po002', 'oulier_
              'p009', 'p010'],:].plot(figsize=(25,25))
gpd.GeoSeries([d1[0],d2[0],d3[0],d4[0],d5[0],d6[0],d7[0],d8[0],d9[0],d10[0],d11[0
               d16[0],d17[0],d18[0],d19[0],d20[0],d21[0],d22[0],d23[0],d24[0],d25
               d26[0]]).plot(ax=ax,color='yellow',markersize=10)

p1=p1.iloc[0,:].geometry.buffer(0.005)
p2=p2.iloc[0,:].geometry.buffer(0.005)
p3=p3.iloc[0,:].geometry.buffer(0.005)
p4=p4.iloc[0,:].geometry.buffer(0.005)
p5=p5.iloc[0,:].geometry.buffer(0.005) # getting the buffer with 5km radius for t
p6=p6.iloc[0,:].geometry.buffer(0.005)
p7=p7.iloc[0,:].geometry.buffer(0.005)
p8=p8.iloc[0,:].geometry.buffer(0.005)
p9=p9.iloc[0,:].geometry.buffer(0.005)
p10=p10.iloc[0,:].geometry.buffer(0.005)
p11=p11.iloc[0,:].geometry.buffer(0.005)
p12=p12.iloc[0,:].geometry.buffer(0.005)
p13=p13.iloc[0,:].geometry.buffer(0.005)
p14=p14.iloc[0,:].geometry.buffer(0.005)
p15=p15.iloc[0,:].geometry.buffer(0.005)
```

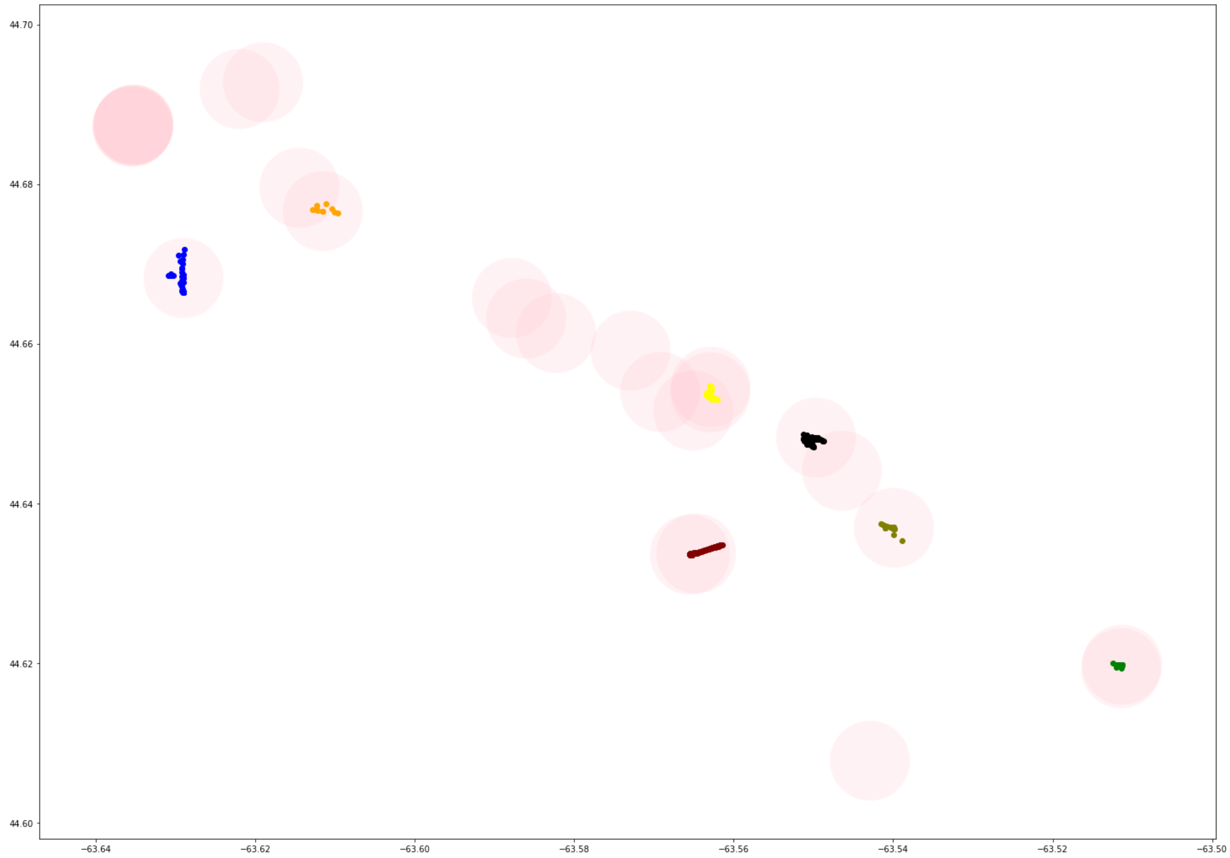
```
p16=p16.iloc[0,:].geometry.buffer(0.005)
p17=p17.iloc[0,:].geometry.buffer(0.005)
p18=p18.iloc[0,:].geometry.buffer(0.005)
p19=p19.iloc[0,:].geometry.buffer(0.005)
p20=p20.iloc[0,:].geometry.buffer(0.005)
p21=p21.iloc[0,:].geometry.buffer(0.005)
p22=p22.iloc[0,:].geometry.buffer(0.005)
p23=p23.iloc[0,:].geometry.buffer(0.005)
p24=p24.iloc[0,:].geometry.buffer(0.005)
p25=p25.iloc[0,:].geometry.buffer(0.005)
p26=p26.iloc[0,:].geometry.buffer(0.005)

# plotting the buffer radius near ports

gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,p19
gdf16.plot(ax=ax,color='g',alpha=0.2)
gdf16.loc[gdf16.within(p1),:].plot(ax=ax,color='k')
gdf16.loc[gdf16.within(p2),:].plot(ax=ax,color='k')
gdf16.loc[gdf16.within(p3),:].plot(ax=ax,color='k')
gdf16.loc[gdf16.within(p4),:].plot(ax=ax,color='k')
gdf16.loc[gdf16.within(p5),:].plot(ax=ax,color='k')
gdf16.loc[gdf16.within(p6),:].plot(ax=ax,color='k')
gdf16.loc[gdf16.within(p7),:].plot(ax=ax,color='k')
gdf16.loc[gdf16.within(p8),:].plot(ax=ax,color='k')
gdf16.loc[gdf16.within(p9),:].plot(ax=ax,color='k')
gdf16.loc[gdf16.within(p10),:].plot(ax=ax,color='k')
gdf16.loc[gdf16.within(p11),:].plot(ax=ax,color='k')
gdf16.loc[gdf16.within(p12),:].plot(ax=ax,color='k')
gdf16.loc[gdf16.within(p13),:].plot(ax=ax,color='k')
gdf16.loc[gdf16.within(p14),:].plot(ax=ax,color='k')
gdf16.loc[gdf16.within(p15),:].plot(ax=ax,color='k')
gdf16.loc[gdf16.within(p16),:].plot(ax=ax,color='k')
gdf16.loc[gdf16.within(p17),:].plot(ax=ax,color='k')
gdf16.loc[gdf16.within(p18),:].plot(ax=ax,color='k')
gdf16.loc[gdf16.within(p19),:].plot(ax=ax,color='k')
gdf16.loc[gdf16.within(p20),:].plot(ax=ax,color='k')
gdf16.loc[gdf16.within(p21),:].plot(ax=ax,color='k')
gdf16.loc[gdf16.within(p22),:].plot(ax=ax,color='k')
gdf16.loc[gdf16.within(p23),:].plot(ax=ax,color='k')
gdf16.loc[gdf16.within(p24),:].plot(ax=ax,color='k')
gdf16.loc[gdf16.within(p25),:].plot(ax=ax,color='k')
gdf16.loc[gdf16.within(p26),:].plot(ax=ax,color='k')
plt.savefig('Q3 images/interval_16_q1.png')
```


44.72
44.70
44.68
44.66
44.64
44.62
44.60
−63.675
−63.650
−63.625
−63.600
−63.575
−63.550
−63.525
−63.500

In [62]:

```
joinres=gpd.sjoin(gdf16,bylaw,op='within',how='left')
col=['r','b','g','k','yellow','orange','Olive','Maroon','Purple','Fuchsia','Lime'
i=0
ax=gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,


for g in set(joinres['index_right']):
  tmp=joinres.loc[joinres['index_right']==g,:]
  if tmp.shape[0]>0:
    tmp.plot(ax=ax,color=col[i])
  i=i+1
plt.savefig('Q3 images/interval_16_q2.png')
```

```
C:\Users\lanch\Anaconda3\lib\site-packages\geopandas\tools\sjoin.py:44: UserWar
ning: CRS of frames being joined does not match!
  warn('CRS of frames being joined does not match!')
```

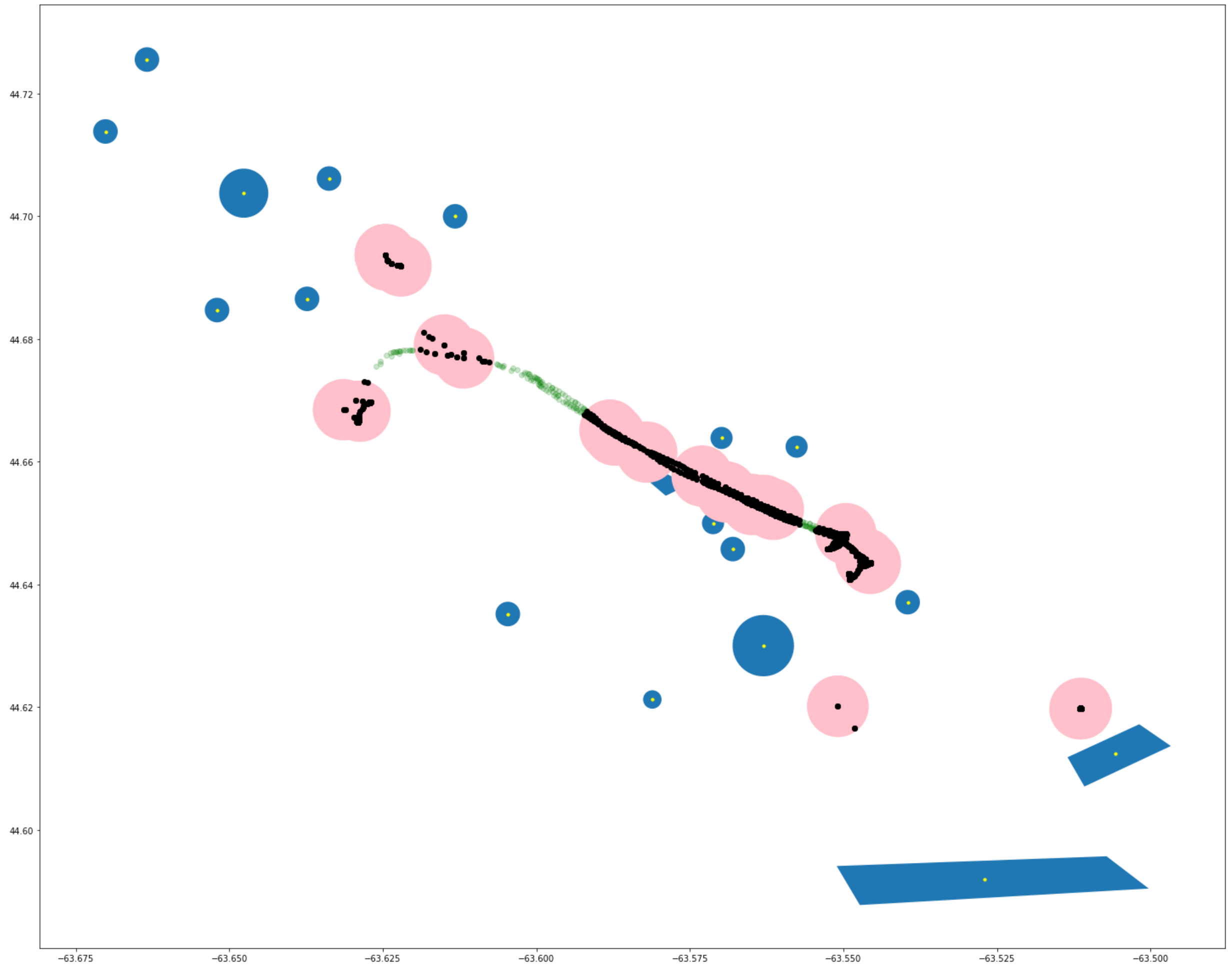


```
17th interval
```

In [63]:

```
gdf17 = gpd.GeoDataFrame(d['df_h17'].drop(['location.coordinates.0', 'location.co
crs={'init': 'epsg:4326'},
geometry=[shapely.geometry.Point(xy) for xy in zip(d['df_h17']['location.coordina

p1=gdf17.loc[gdf17.distance(d1[0])==gdf17.distance(d1[0]).min(),:]
p2=gdf17.loc[gdf17.distance(d2[0])==gdf17.distance(d2[0]).min(),:]
p3=gdf17.loc[gdf17.distance(d3[0])==gdf17.distance(d3[0]).min(),:]
p4=gdf17.loc[gdf17.distance(d4[0])==gdf17.distance(d4[0]).min(),:]
p5=gdf17.loc[gdf17.distance(d5[0])==gdf17.distance(d5[0]).min(),:]
p6=gdf17.loc[gdf17.distance(d6[0])==gdf17.distance(d6[0]).min(),:]
p7=gdf17.loc[gdf17.distance(d7[0])==gdf17.distance(d7[0]).min(),:]
p8=gdf17.loc[gdf17.distance(d8[0])==gdf17.distance(d8[0]).min(),:]
p9=gdf17.loc[gdf17.distance(d9[0])==gdf17.distance(d9[0]).min(),:]
p10=gdf17.loc[gdf17.distance(d10[0])==gdf17.distance(d10[0]).min(),:]
p11=gdf17.loc[gdf17.distance(d11[0])==gdf17.distance(d11[0]).min(),:]
p12=gdf17.loc[gdf17.distance(d12[0])==gdf17.distance(d12[0]).min(),:]
p13=gdf17.loc[gdf17.distance(d13[0])==gdf17.distance(d13[0]).min(),:]
p14=gdf17.loc[gdf17.distance(d14[0])==gdf17.distance(d14[0]).min(),:]
p15=gdf17.loc[gdf17.distance(d15[0])==gdf17.distance(d15[0]).min(),:]
p16=gdf17.loc[gdf17.distance(d16[0])==gdf17.distance(d16[0]).min(),:]
p17=gdf17.loc[gdf17.distance(d17[0])==gdf17.distance(d17[0]).min(),:]
p18=gdf17.loc[gdf17.distance(d18[0])==gdf17.distance(d18[0]).min(),:]
p19=gdf17.loc[gdf17.distance(d19[0])==gdf17.distance(d19[0]).min(),:]
p20=gdf17.loc[gdf17.distance(d20[0])==gdf17.distance(d20[0]).min(),:]
p21=gdf17.loc[gdf17.distance(d21[0])==gdf17.distance(d21[0]).min(),:]
p22=gdf17.loc[gdf17.distance(d22[0])==gdf17.distance(d22[0]).min(),:]
p23=gdf17.loc[gdf17.distance(d23[0])==gdf17.distance(d23[0]).min(),:]
p24=gdf17.loc[gdf17.distance(d24[0])==gdf17.distance(d24[0]).min(),:]
p25=gdf17.loc[gdf17.distance(d25[0])==gdf17.distance(d25[0]).min(),:]
p26=gdf17.loc[gdf17.distance(d26[0])==gdf17.distance(d26[0]).min(),:]



# creating buffer on the buffer with 5km radius
ax=bylaw.loc[['pointpolygon', 'port1', 'port2', 'ind', 'port5', 'port6', 'port7',
              'southend container terminal','NN Jetty', 'Bills island', 'mid bedf
              'waterfront h', 'northarm', 'plll', 'pp', 'po001','po002', 'oulier_
              'p009', 'p010'],:].plot(figsize=(25,25))
gpd.GeoSeries([d1[0],d2[0],d3[0],d4[0],d5[0],d6[0],d7[0],d8[0],d9[0],d10[0],d11[0
               d16[0],d17[0],d18[0],d19[0],d20[0],d21[0],d22[0],d23[0],d24[0],d25
               d26[0]]).plot(ax=ax,color='yellow',markersize=10)

p1=p1.iloc[0,:].geometry.buffer(0.005)
p2=p2.iloc[0,:].geometry.buffer(0.005)
p3=p3.iloc[0,:].geometry.buffer(0.005)
p4=p4.iloc[0,:].geometry.buffer(0.005)
p5=p5.iloc[0,:].geometry.buffer(0.005) # getting the buffer with 5km radius for t
p6=p6.iloc[0,:].geometry.buffer(0.005)
p7=p7.iloc[0,:].geometry.buffer(0.005)
p8=p8.iloc[0,:].geometry.buffer(0.005)
p9=p9.iloc[0,:].geometry.buffer(0.005)
p10=p10.iloc[0,:].geometry.buffer(0.005)
p11=p11.iloc[0,:].geometry.buffer(0.005)
p12=p12.iloc[0,:].geometry.buffer(0.005)
p13=p13.iloc[0,:].geometry.buffer(0.005)
p14=p14.iloc[0,:].geometry.buffer(0.005)
p15=p15.iloc[0,:].geometry.buffer(0.005)
```

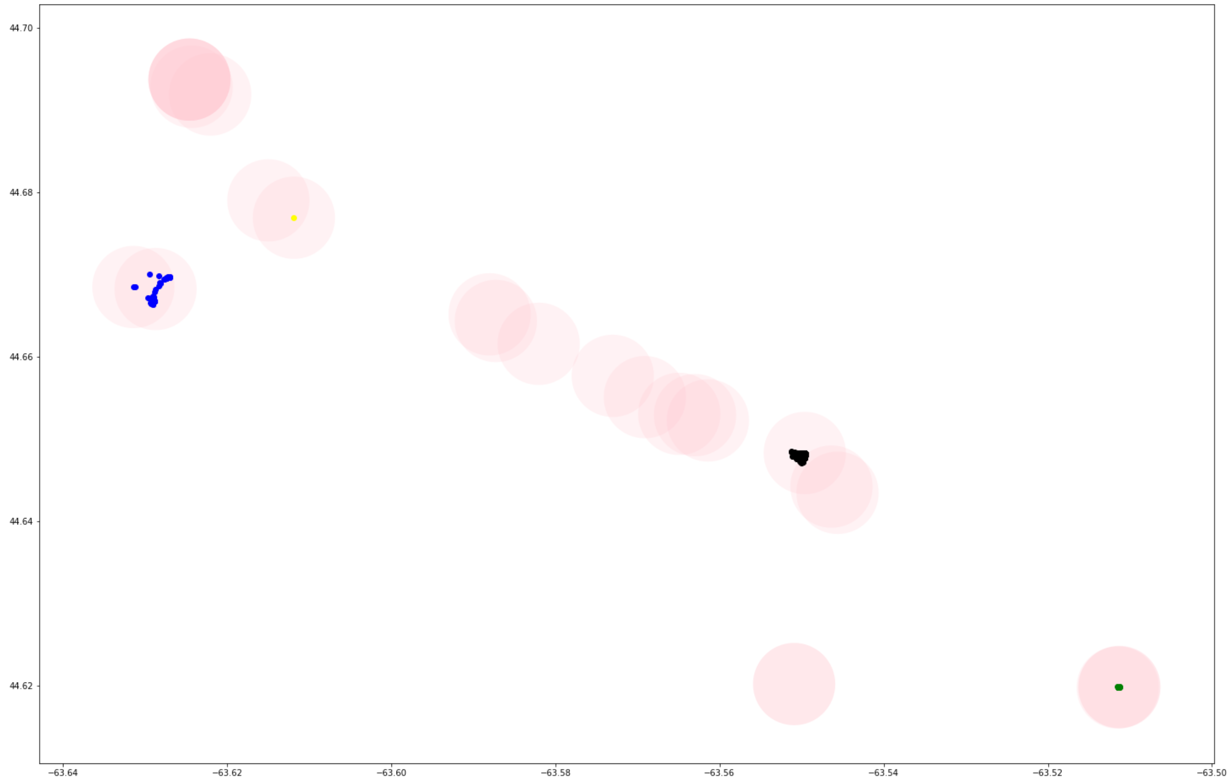
```
p16=p16.iloc[0,:].geometry.buffer(0.005)
p17=p17.iloc[0,:].geometry.buffer(0.005)
p18=p18.iloc[0,:].geometry.buffer(0.005)
p19=p19.iloc[0,:].geometry.buffer(0.005)
p20=p20.iloc[0,:].geometry.buffer(0.005)
p21=p21.iloc[0,:].geometry.buffer(0.005)
p22=p22.iloc[0,:].geometry.buffer(0.005)
p23=p23.iloc[0,:].geometry.buffer(0.005)
p24=p24.iloc[0,:].geometry.buffer(0.005)
p25=p25.iloc[0,:].geometry.buffer(0.005)
p26=p26.iloc[0,:].geometry.buffer(0.005)

# plotting the buffer radius near ports

gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,p19
gdf17.plot(ax=ax,color='g',alpha=0.2)
gdf17.loc[gdf17.within(p1),:].plot(ax=ax,color='k')
gdf17.loc[gdf17.within(p2),:].plot(ax=ax,color='k')
gdf17.loc[gdf17.within(p3),:].plot(ax=ax,color='k')
gdf17.loc[gdf17.within(p4),:].plot(ax=ax,color='k')
gdf17.loc[gdf17.within(p5),:].plot(ax=ax,color='k')
gdf17.loc[gdf17.within(p6),:].plot(ax=ax,color='k')
gdf17.loc[gdf17.within(p7),:].plot(ax=ax,color='k')
gdf17.loc[gdf17.within(p8),:].plot(ax=ax,color='k')
gdf17.loc[gdf17.within(p9),:].plot(ax=ax,color='k')
gdf17.loc[gdf17.within(p10),:].plot(ax=ax,color='k')
gdf17.loc[gdf17.within(p11),:].plot(ax=ax,color='k')
gdf17.loc[gdf17.within(p12),:].plot(ax=ax,color='k')
gdf17.loc[gdf17.within(p13),:].plot(ax=ax,color='k')
gdf17.loc[gdf17.within(p14),:].plot(ax=ax,color='k')
gdf17.loc[gdf17.within(p15),:].plot(ax=ax,color='k')
gdf17.loc[gdf17.within(p16),:].plot(ax=ax,color='k')
gdf17.loc[gdf17.within(p17),:].plot(ax=ax,color='k')
gdf17.loc[gdf17.within(p18),:].plot(ax=ax,color='k')
gdf17.loc[gdf17.within(p19),:].plot(ax=ax,color='k')
gdf17.loc[gdf17.within(p20),:].plot(ax=ax,color='k')
gdf17.loc[gdf17.within(p21),:].plot(ax=ax,color='k')
gdf17.loc[gdf17.within(p22),:].plot(ax=ax,color='k')
gdf17.loc[gdf17.within(p23),:].plot(ax=ax,color='k')
gdf17.loc[gdf17.within(p24),:].plot(ax=ax,color='k')
gdf17.loc[gdf17.within(p25),:].plot(ax=ax,color='k')
gdf17.loc[gdf17.within(p26),:].plot(ax=ax,color='k')
plt.savefig('Q3 images/interval_17_q1.png')
```


44.72
44.70
44.68
44.66
44.64
44.62
44.60
−63.675
−63.650
−63.625
−63.600
−63.575
−63.550
−63.525
−63.500

In [64]:

```
joinres=gpd.sjoin(gdf17,bylaw,op='within',how='left')
col=['r','b','g','k','yellow','orange','Olive','Maroon','Purple','Fuchsia','Lime'
i=0
ax=gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,


for g in set(joinres['index_right']):
  tmp=joinres.loc[joinres['index_right']==g,:]
  if tmp.shape[0]>0:
    tmp.plot(ax=ax,color=col[i])
  i=i+1
plt.savefig('Q3 images/interval_17_q2.png')
```

```
C:\Users\lanch\Anaconda3\lib\site-packages\geopandas\tools\sjoin.py:44: UserWar
ning: CRS of frames being joined does not match!
  warn('CRS of frames being joined does not match!')
```

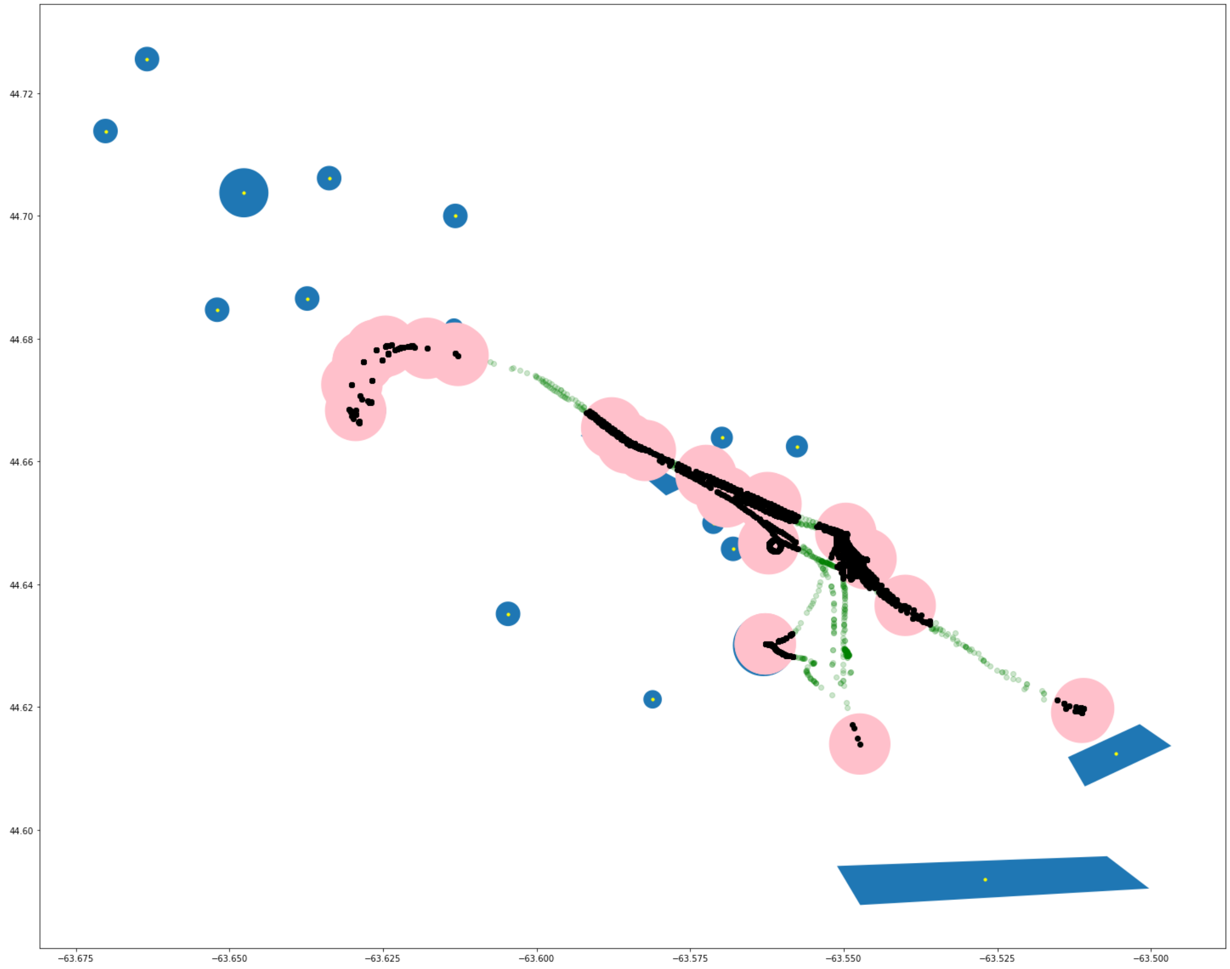


```
18th interval
```

In [65]:

```
gdf18 = gpd.GeoDataFrame(d['df_h18'].drop(['location.coordinates.0', 'location.coo
crs={'init': 'epsg:4326'},
geometry=[shapely.geometry.Point(xy) for xy in zip(d['df_h18']['location.coordina

p1=gdf18.loc[gdf18.distance(d1[0])==gdf18.distance(d1[0]).min(),:]
p2=gdf18.loc[gdf18.distance(d2[0])==gdf18.distance(d2[0]).min(),:]
p3=gdf18.loc[gdf18.distance(d3[0])==gdf18.distance(d3[0]).min(),:]
p4=gdf18.loc[gdf18.distance(d4[0])==gdf18.distance(d4[0]).min(),:]
p5=gdf18.loc[gdf18.distance(d5[0])==gdf18.distance(d5[0]).min(),:]
p6=gdf18.loc[gdf18.distance(d6[0])==gdf18.distance(d6[0]).min(),:]
p7=gdf18.loc[gdf18.distance(d7[0])==gdf18.distance(d7[0]).min(),:]
p8=gdf18.loc[gdf18.distance(d8[0])==gdf18.distance(d8[0]).min(),:]
p9=gdf18.loc[gdf18.distance(d9[0])==gdf18.distance(d9[0]).min(),:]
p10=gdf18.loc[gdf18.distance(d10[0])==gdf18.distance(d10[0]).min(),:]
p11=gdf18.loc[gdf18.distance(d11[0])==gdf18.distance(d11[0]).min(),:]
p12=gdf18.loc[gdf18.distance(d12[0])==gdf18.distance(d12[0]).min(),:]
p13=gdf18.loc[gdf18.distance(d13[0])==gdf18.distance(d13[0]).min(),:]
p14=gdf18.loc[gdf18.distance(d14[0])==gdf18.distance(d14[0]).min(),:]
p15=gdf18.loc[gdf18.distance(d15[0])==gdf18.distance(d15[0]).min(),:]
p16=gdf18.loc[gdf18.distance(d16[0])==gdf18.distance(d16[0]).min(),:]
p17=gdf18.loc[gdf18.distance(d17[0])==gdf18.distance(d17[0]).min(),:]
p18=gdf18.loc[gdf18.distance(d18[0])==gdf18.distance(d18[0]).min(),:]
p19=gdf18.loc[gdf18.distance(d19[0])==gdf18.distance(d19[0]).min(),:]
p20=gdf18.loc[gdf18.distance(d20[0])==gdf18.distance(d20[0]).min(),:]
p21=gdf18.loc[gdf18.distance(d21[0])==gdf18.distance(d21[0]).min(),:]
p22=gdf18.loc[gdf18.distance(d22[0])==gdf18.distance(d22[0]).min(),:]
p23=gdf18.loc[gdf18.distance(d23[0])==gdf18.distance(d23[0]).min(),:]
p24=gdf18.loc[gdf18.distance(d24[0])==gdf18.distance(d24[0]).min(),:]
p25=gdf18.loc[gdf18.distance(d25[0])==gdf18.distance(d25[0]).min(),:]
p26=gdf18.loc[gdf18.distance(d26[0])==gdf18.distance(d26[0]).min(),:]



# creating buffer on the buffer with 5km radius
ax=bylaw.loc[['pointpolygon', 'port1', 'port2', 'ind', 'port5', 'port6', 'port7',
              'southend container terminal','NN Jetty', 'Bills island', 'mid bedfo
              'waterfront h', 'northarm', 'plll', 'pp', 'po001','po002', 'oulier_
              'p009', 'p010'],:].plot(figsize=(25,25))
gpd.GeoSeries([d1[0],d2[0],d3[0],d4[0],d5[0],d6[0],d7[0],d8[0],d9[0],d10[0],d11[0
               d16[0],d17[0],d18[0],d19[0],d20[0],d21[0],d22[0],d23[0],d24[0],d25
               d26[0]]).plot(ax=ax,color='yellow',markersize=10)

p1=p1.iloc[0,:].geometry.buffer(0.005)
p2=p2.iloc[0,:].geometry.buffer(0.005)
p3=p3.iloc[0,:].geometry.buffer(0.005)
p4=p4.iloc[0,:].geometry.buffer(0.005)
p5=p5.iloc[0,:].geometry.buffer(0.005) # getting the buffer with 5km radius for th
p6=p6.iloc[0,:].geometry.buffer(0.005)
p7=p7.iloc[0,:].geometry.buffer(0.005)
p8=p8.iloc[0,:].geometry.buffer(0.005)
p9=p9.iloc[0,:].geometry.buffer(0.005)
p10=p10.iloc[0,:].geometry.buffer(0.005)
p11=p11.iloc[0,:].geometry.buffer(0.005)
p12=p12.iloc[0,:].geometry.buffer(0.005)
p13=p13.iloc[0,:].geometry.buffer(0.005)
p14=p14.iloc[0,:].geometry.buffer(0.005)
p15=p15.iloc[0,:].geometry.buffer(0.005)
```

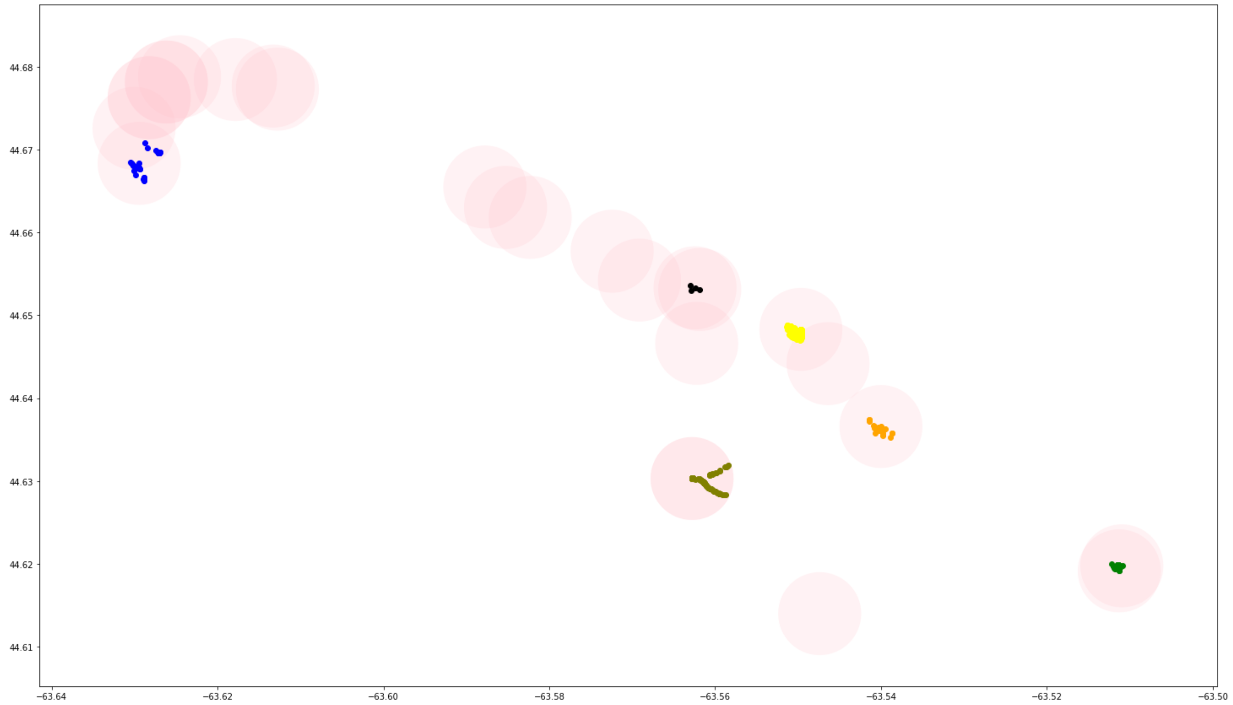
```
p16=p16.iloc[0,:].geometry.buffer(0.005)
p17=p17.iloc[0,:].geometry.buffer(0.005)
p18=p18.iloc[0,:].geometry.buffer(0.005)
p19=p19.iloc[0,:].geometry.buffer(0.005)
p20=p20.iloc[0,:].geometry.buffer(0.005)
p21=p21.iloc[0,:].geometry.buffer(0.005)
p22=p22.iloc[0,:].geometry.buffer(0.005)
p23=p23.iloc[0,:].geometry.buffer(0.005)
p24=p24.iloc[0,:].geometry.buffer(0.005)
p25=p25.iloc[0,:].geometry.buffer(0.005)
p26=p26.iloc[0,:].geometry.buffer(0.005)

# plotting the buffer radius near ports

gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,p19
gdf18.plot(ax=ax,color='g',alpha=0.2)
gdf18.loc[gdf18.within(p1),:].plot(ax=ax,color='k')
gdf18.loc[gdf18.within(p2),:].plot(ax=ax,color='k')
gdf18.loc[gdf18.within(p3),:].plot(ax=ax,color='k')
gdf18.loc[gdf18.within(p4),:].plot(ax=ax,color='k')
gdf18.loc[gdf18.within(p5),:].plot(ax=ax,color='k')
gdf18.loc[gdf18.within(p6),:].plot(ax=ax,color='k')
gdf18.loc[gdf18.within(p7),:].plot(ax=ax,color='k')
gdf18.loc[gdf18.within(p8),:].plot(ax=ax,color='k')
gdf18.loc[gdf18.within(p9),:].plot(ax=ax,color='k')
gdf18.loc[gdf18.within(p10),:].plot(ax=ax,color='k')
gdf18.loc[gdf18.within(p11),:].plot(ax=ax,color='k')
gdf18.loc[gdf18.within(p12),:].plot(ax=ax,color='k')
gdf18.loc[gdf18.within(p13),:].plot(ax=ax,color='k')
gdf18.loc[gdf18.within(p14),:].plot(ax=ax,color='k')
gdf18.loc[gdf18.within(p15),:].plot(ax=ax,color='k')
gdf18.loc[gdf18.within(p16),:].plot(ax=ax,color='k')
gdf18.loc[gdf18.within(p17),:].plot(ax=ax,color='k')
gdf18.loc[gdf18.within(p18),:].plot(ax=ax,color='k')
gdf18.loc[gdf18.within(p19),:].plot(ax=ax,color='k')
gdf18.loc[gdf18.within(p20),:].plot(ax=ax,color='k')
gdf18.loc[gdf18.within(p21),:].plot(ax=ax,color='k')
gdf18.loc[gdf18.within(p22),:].plot(ax=ax,color='k')
gdf18.loc[gdf18.within(p23),:].plot(ax=ax,color='k')
gdf18.loc[gdf18.within(p24),:].plot(ax=ax,color='k')
gdf18.loc[gdf18.within(p25),:].plot(ax=ax,color='k')
gdf18.loc[gdf18.within(p26),:].plot(ax=ax,color='k')
plt.savefig('Q3 images/interval_18_q1.png')
```


44.72
44.70
44.68
44.66
44.64
44.62
44.60
−63.675
−63.650
−63.625
−63.600
−63.575
−63.550
−63.525
−63.500

In [66]:

```
joinres=gpd.sjoin(gdf18,bylaw,op='within',how='left')
col=['r','b','g','k','yellow','orange','Olive','Maroon','Purple','Fuchsia','Lime'
i=0
ax=gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,


for g in set(joinres['index_right']):
  tmp=joinres.loc[joinres['index_right']==g,:]
  if tmp.shape[0]>0:
    tmp.plot(ax=ax,color=col[i])
  i=i+1
plt.savefig('Q3 images/interval_18_q2.png')
```

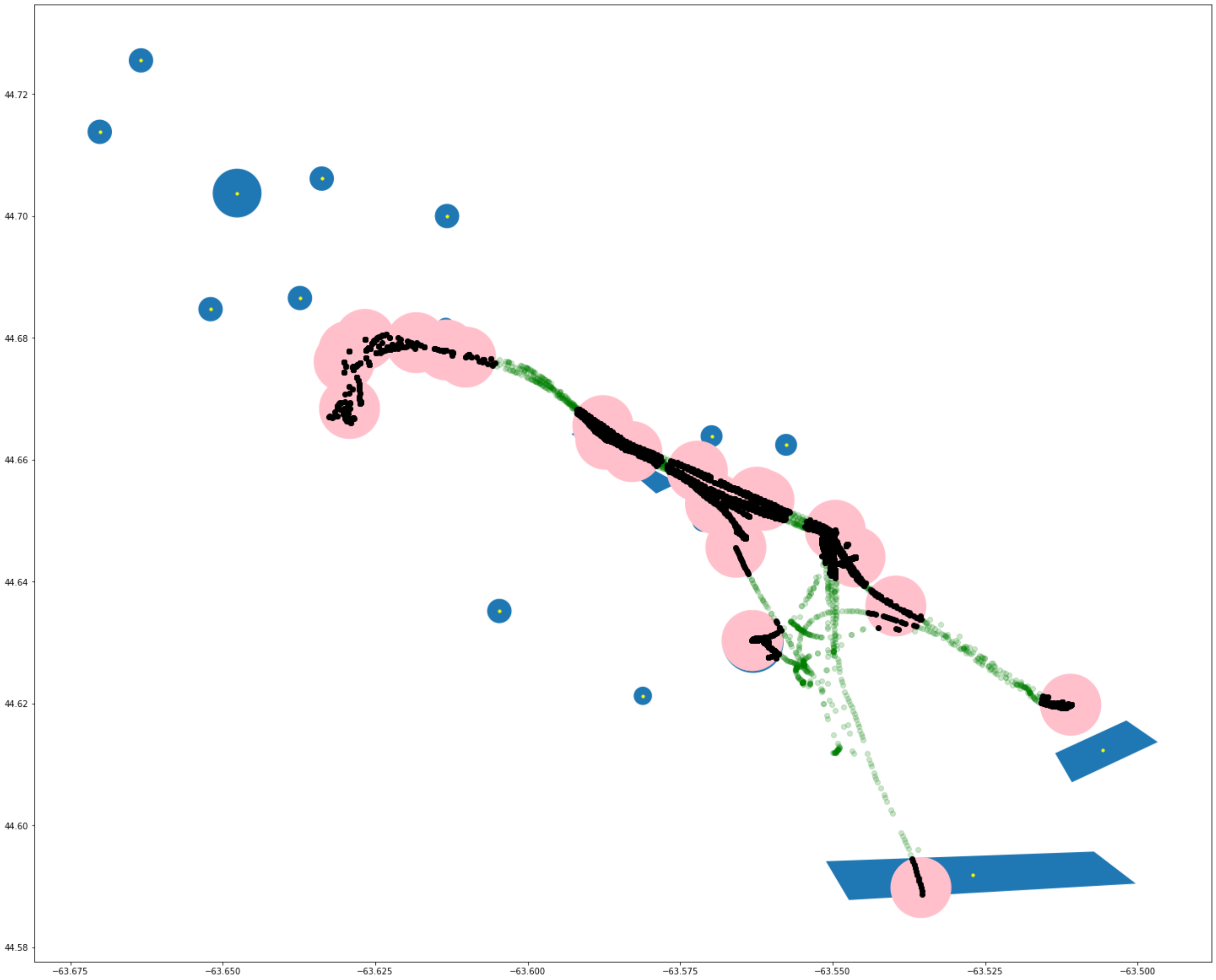
```
C:\Users\lanch\Anaconda3\lib\site-packages\geopandas\tools\sjoin.py:44: UserWar
ning: CRS of frames being joined does not match!
  warn('CRS of frames being joined does not match!')
```



```
19th interval
```

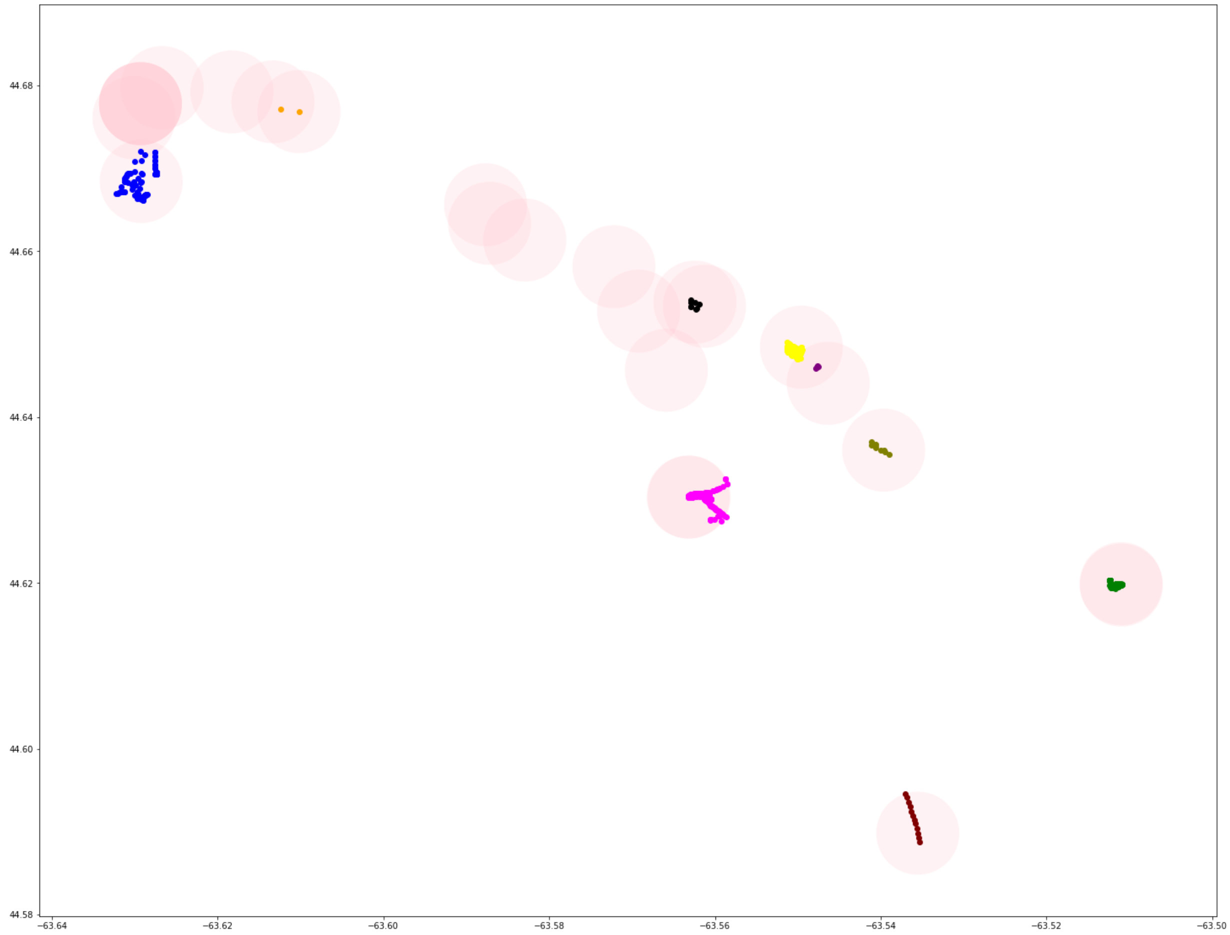
In [67]:
```
gdf19 = gpd.GeoDataFrame(d['df_h19'].drop(['location.coordinates.0', 'location.co
crs={'init': 'epsg:4326'},
geometry=[shapely.geometry.Point(xy) for xy in zip(d['df_h19']['location.coordina

p1=gdf19.loc[gdf19.distance(d1[0])==gdf19.distance(d1[0]).min(),:]
p2=gdf19.loc[gdf19.distance(d2[0])==gdf19.distance(d2[0]).min(),:]
p3=gdf19.loc[gdf19.distance(d3[0])==gdf19.distance(d3[0]).min(),:]
p4=gdf19.loc[gdf19.distance(d4[0])==gdf19.distance(d4[0]).min(),:]
p5=gdf19.loc[gdf19.distance(d5[0])==gdf19.distance(d5[0]).min(),:]
p6=gdf19.loc[gdf19.distance(d6[0])==gdf19.distance(d6[0]).min(),:]
p7=gdf19.loc[gdf19.distance(d7[0])==gdf19.distance(d7[0]).min(),:]
p8=gdf19.loc[gdf19.distance(d8[0])==gdf19.distance(d8[0]).min(),:]
p9=gdf19.loc[gdf19.distance(d9[0])==gdf19.distance(d9[0]).min(),:]
p10=gdf19.loc[gdf19.distance(d10[0])==gdf19.distance(d10[0]).min(),:]
p11=gdf19.loc[gdf19.distance(d11[0])==gdf19.distance(d11[0]).min(),:]
p12=gdf19.loc[gdf19.distance(d12[0])==gdf19.distance(d12[0]).min(),:]
p13=gdf19.loc[gdf19.distance(d13[0])==gdf19.distance(d13[0]).min(),:]
p14=gdf19.loc[gdf19.distance(d14[0])==gdf19.distance(d14[0]).min(),:]
p15=gdf19.loc[gdf19.distance(d15[0])==gdf19.distance(d15[0]).min(),:]
p16=gdf19.loc[gdf19.distance(d16[0])==gdf19.distance(d16[0]).min(),:]
p17=gdf19.loc[gdf19.distance(d17[0])==gdf19.distance(d17[0]).min(),:]
p18=gdf19.loc[gdf19.distance(d18[0])==gdf19.distance(d18[0]).min(),:]
p19=gdf19.loc[gdf19.distance(d19[0])==gdf19.distance(d19[0]).min(),:]
p20=gdf19.loc[gdf19.distance(d20[0])==gdf19.distance(d20[0]).min(),:]
p21=gdf19.loc[gdf19.distance(d21[0])==gdf19.distance(d21[0]).min(),:]
p22=gdf19.loc[gdf19.distance(d22[0])==gdf19.distance(d22[0]).min(),:]
p23=gdf19.loc[gdf19.distance(d23[0])==gdf19.distance(d23[0]).min(),:]
p24=gdf19.loc[gdf19.distance(d24[0])==gdf19.distance(d24[0]).min(),:]
p25=gdf19.loc[gdf19.distance(d25[0])==gdf19.distance(d25[0]).min(),:]
p26=gdf19.loc[gdf19.distance(d26[0])==gdf19.distance(d26[0]).min(),:]


# creating buffer on the buffer with 5km radius
ax=bylaw.loc[['pointpolygon', 'port1', 'port2', 'ind', 'port5', 'port6', 'port7',
              'southend container terminal','NN Jetty', 'Bills island', 'mid bedf
              'waterfront h', 'northarm', 'plll', 'pp', 'po001','po002', 'oulier_
              'p009', 'p010'],:].plot(figsize=(25,25))
gpd.GeoSeries([d1[0],d2[0],d3[0],d4[0],d5[0],d6[0],d7[0],d8[0],d9[0],d10[0],d11[0
               d16[0],d17[0],d18[0],d19[0],d20[0],d21[0],d22[0],d23[0],d24[0],d25
               d26[0]]).plot(ax=ax,color='yellow',markersize=10)

p1=p1.iloc[0,:].geometry.buffer(0.005)
p2=p2.iloc[0,:].geometry.buffer(0.005)
p3=p3.iloc[0,:].geometry.buffer(0.005)
p4=p4.iloc[0,:].geometry.buffer(0.005)
p5=p5.iloc[0,:].geometry.buffer(0.005) # getting the buffer with 5km radius for th
p6=p6.iloc[0,:].geometry.buffer(0.005)
p7=p7.iloc[0,:].geometry.buffer(0.005)
p8=p8.iloc[0,:].geometry.buffer(0.005)
p9=p9.iloc[0,:].geometry.buffer(0.005)
p10=p10.iloc[0,:].geometry.buffer(0.005)
p11=p11.iloc[0,:].geometry.buffer(0.005)
p12=p12.iloc[0,:].geometry.buffer(0.005)
p13=p13.iloc[0,:].geometry.buffer(0.005)
p14=p14.iloc[0,:].geometry.buffer(0.005)
p15=p15.iloc[0,:].geometry.buffer(0.005)
```

```
p16=p16.iloc[0,:].geometry.buffer(0.005)
p17=p17.iloc[0,:].geometry.buffer(0.005)
p18=p18.iloc[0,:].geometry.buffer(0.005)
p19=p19.iloc[0,:].geometry.buffer(0.005)
p20=p20.iloc[0,:].geometry.buffer(0.005)
p21=p21.iloc[0,:].geometry.buffer(0.005)
p22=p22.iloc[0,:].geometry.buffer(0.005)
p23=p23.iloc[0,:].geometry.buffer(0.005)
p24=p24.iloc[0,:].geometry.buffer(0.005)
p25=p25.iloc[0,:].geometry.buffer(0.005)
p26=p26.iloc[0,:].geometry.buffer(0.005)

# plotting the buffer radius near ports

gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,p19
gdf19.plot(ax=ax,color='g',alpha=0.2)
gdf19.loc[gdf19.within(p1),:].plot(ax=ax,color='k')
gdf19.loc[gdf19.within(p2),:].plot(ax=ax,color='k')
gdf19.loc[gdf19.within(p3),:].plot(ax=ax,color='k')
gdf19.loc[gdf19.within(p4),:].plot(ax=ax,color='k')
gdf19.loc[gdf19.within(p5),:].plot(ax=ax,color='k')
gdf19.loc[gdf19.within(p6),:].plot(ax=ax,color='k')
gdf19.loc[gdf19.within(p7),:].plot(ax=ax,color='k')
gdf19.loc[gdf19.within(p8),:].plot(ax=ax,color='k')
gdf19.loc[gdf19.within(p9),:].plot(ax=ax,color='k')
gdf19.loc[gdf19.within(p10),:].plot(ax=ax,color='k')
gdf19.loc[gdf19.within(p11),:].plot(ax=ax,color='k')
gdf19.loc[gdf19.within(p12),:].plot(ax=ax,color='k')
gdf19.loc[gdf19.within(p13),:].plot(ax=ax,color='k')
gdf19.loc[gdf19.within(p14),:].plot(ax=ax,color='k')
gdf19.loc[gdf19.within(p15),:].plot(ax=ax,color='k')
gdf19.loc[gdf19.within(p16),:].plot(ax=ax,color='k')
gdf19.loc[gdf19.within(p17),:].plot(ax=ax,color='k')
gdf19.loc[gdf19.within(p18),:].plot(ax=ax,color='k')
gdf19.loc[gdf19.within(p19),:].plot(ax=ax,color='k')
gdf19.loc[gdf19.within(p20),:].plot(ax=ax,color='k')
gdf19.loc[gdf19.within(p21),:].plot(ax=ax,color='k')
gdf19.loc[gdf19.within(p22),:].plot(ax=ax,color='k')
gdf19.loc[gdf19.within(p23),:].plot(ax=ax,color='k')
gdf19.loc[gdf19.within(p24),:].plot(ax=ax,color='k')
gdf19.loc[gdf19.within(p25),:].plot(ax=ax,color='k')
gdf19.loc[gdf19.within(p26),:].plot(ax=ax,color='k')
plt.savefig('Q3 images/interval_19_q1.png')
```


44.72
44.70
44.68
44.66
44.64
44.62
44.60
44.58
−63.675
−63.650
−63.625
−63.600
−63.575
−63.550
−63.525
−63.500

In [68]:
```
joinres=gpd.sjoin(gdf19,bylaw,op='within',how='left')
col=['r','b','g','k','yellow','orange','Olive','Maroon','Purple','Fuchsia','Lime'
i=0
ax=gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,


for g in set(joinres['index_right']):
  tmp=joinres.loc[joinres['index_right']==g,:]
  if tmp.shape[0]>0:
    tmp.plot(ax=ax,color=col[i])
  i=i+1
plt.savefig('Q3 images/interval_19_q2.png')
```

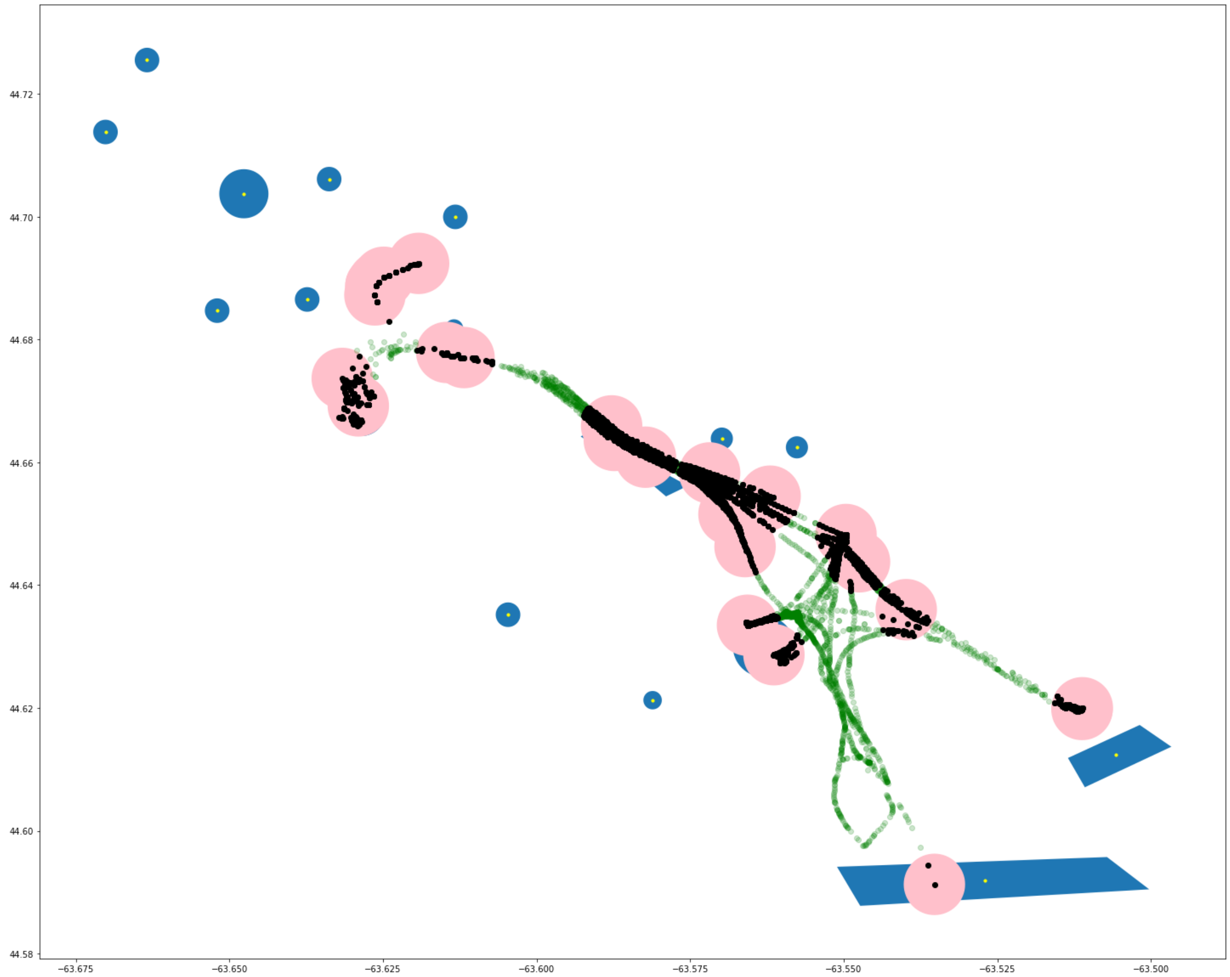
```
C:\Users\lanch\Anaconda3\lib\site-packages\geopandas\tools\sjoin.py:44: UserWar
ning: CRS of frames being joined does not match!
  warn('CRS of frames being joined does not match!')
```



```
20th interval
```

In [69]:
```
gdf20 = gpd.GeoDataFrame(d['df_h20'].drop(['location.coordinates.0', 'location.co
crs={'init': 'epsg:4326'},
geometry=[shapely.geometry.Point(xy) for xy in zip(d['df_h20']['location.coordina

p1=gdf20.loc[gdf20.distance(d1[0])==gdf20.distance(d1[0]).min(),:]
p2=gdf20.loc[gdf20.distance(d2[0])==gdf20.distance(d2[0]).min(),:]
p3=gdf20.loc[gdf20.distance(d3[0])==gdf20.distance(d3[0]).min(),:]
p4=gdf20.loc[gdf20.distance(d4[0])==gdf20.distance(d4[0]).min(),:]
p5=gdf20.loc[gdf20.distance(d5[0])==gdf20.distance(d5[0]).min(),:]
p6=gdf20.loc[gdf20.distance(d6[0])==gdf20.distance(d6[0]).min(),:]
p7=gdf20.loc[gdf20.distance(d7[0])==gdf20.distance(d7[0]).min(),:]
p8=gdf20.loc[gdf20.distance(d8[0])==gdf20.distance(d8[0]).min(),:]
p9=gdf20.loc[gdf20.distance(d9[0])==gdf20.distance(d9[0]).min(),:]
p10=gdf20.loc[gdf20.distance(d10[0])==gdf20.distance(d10[0]).min(),:]
p11=gdf20.loc[gdf20.distance(d11[0])==gdf20.distance(d11[0]).min(),:]
p12=gdf20.loc[gdf20.distance(d12[0])==gdf20.distance(d12[0]).min(),:]
p13=gdf20.loc[gdf20.distance(d13[0])==gdf20.distance(d13[0]).min(),:]
p14=gdf20.loc[gdf20.distance(d14[0])==gdf20.distance(d14[0]).min(),:]
p15=gdf20.loc[gdf20.distance(d15[0])==gdf20.distance(d15[0]).min(),:]
p16=gdf20.loc[gdf20.distance(d16[0])==gdf20.distance(d16[0]).min(),:]
p17=gdf20.loc[gdf20.distance(d17[0])==gdf20.distance(d17[0]).min(),:]
p18=gdf20.loc[gdf20.distance(d18[0])==gdf20.distance(d18[0]).min(),:]
p19=gdf20.loc[gdf20.distance(d19[0])==gdf20.distance(d19[0]).min(),:]
p20=gdf20.loc[gdf20.distance(d20[0])==gdf20.distance(d20[0]).min(),:]
p21=gdf20.loc[gdf20.distance(d21[0])==gdf20.distance(d21[0]).min(),:]
p22=gdf20.loc[gdf20.distance(d22[0])==gdf20.distance(d22[0]).min(),:]
p23=gdf20.loc[gdf20.distance(d23[0])==gdf20.distance(d23[0]).min(),:]
p24=gdf20.loc[gdf20.distance(d24[0])==gdf20.distance(d24[0]).min(),:]
p25=gdf20.loc[gdf20.distance(d25[0])==gdf20.distance(d25[0]).min(),:]
p26=gdf20.loc[gdf20.distance(d26[0])==gdf20.distance(d26[0]).min(),:]



# creating buffer on the buffer with 5km radius
ax=bylaw.loc[['pointpolygon', 'port1', 'port2', 'ind', 'port5', 'port6', 'port7',
              'southend container terminal','NN Jetty', 'Bills island', 'mid bedf
              'waterfront h', 'northarm', 'plll', 'pp', 'po001','po002', 'oulier_
              'p009', 'p010'],:].plot(figsize=(25,25))
gpd.GeoSeries([d1[0],d2[0],d3[0],d4[0],d5[0],d6[0],d7[0],d8[0],d9[0],d10[0],d11[0
               d16[0],d17[0],d18[0],d19[0],d20[0],d21[0],d22[0],d23[0],d24[0],d25
               d26[0]]).plot(ax=ax,color='yellow',markersize=10)

p1=p1.iloc[0,:].geometry.buffer(0.005)
p2=p2.iloc[0,:].geometry.buffer(0.005)
p3=p3.iloc[0,:].geometry.buffer(0.005)
p4=p4.iloc[0,:].geometry.buffer(0.005)
p5=p5.iloc[0,:].geometry.buffer(0.005) # getting the buffer with 5km radius for t
p6=p6.iloc[0,:].geometry.buffer(0.005)
p7=p7.iloc[0,:].geometry.buffer(0.005)
p8=p8.iloc[0,:].geometry.buffer(0.005)
p9=p9.iloc[0,:].geometry.buffer(0.005)
p10=p10.iloc[0,:].geometry.buffer(0.005)
p11=p11.iloc[0,:].geometry.buffer(0.005)
p12=p12.iloc[0,:].geometry.buffer(0.005)
p13=p13.iloc[0,:].geometry.buffer(0.005)
p14=p14.iloc[0,:].geometry.buffer(0.005)
p15=p15.iloc[0,:].geometry.buffer(0.005)
```

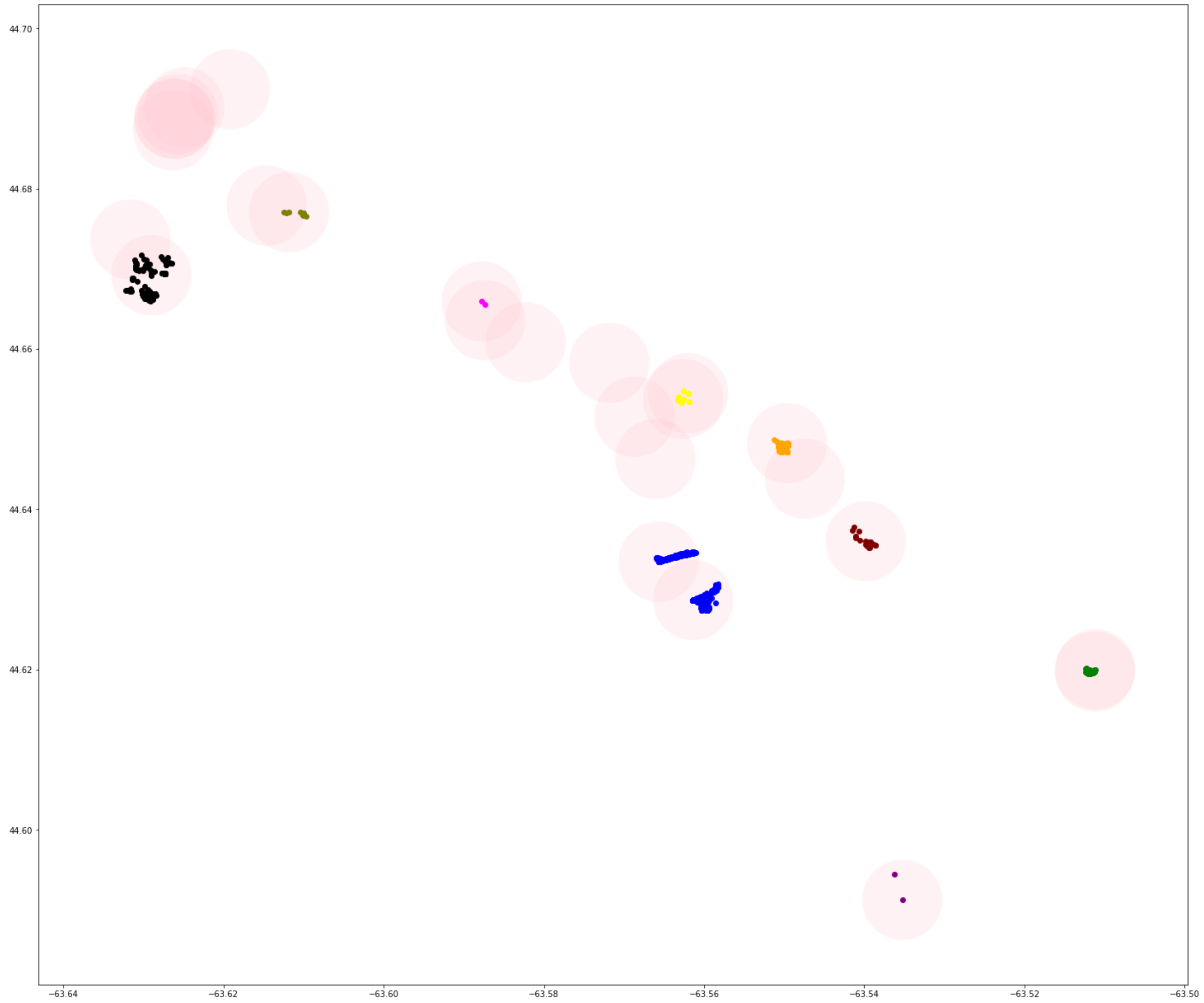
```
p16=p16.iloc[0,:].geometry.buffer(0.005)
p17=p17.iloc[0,:].geometry.buffer(0.005)
p18=p18.iloc[0,:].geometry.buffer(0.005)
p19=p19.iloc[0,:].geometry.buffer(0.005)
p20=p20.iloc[0,:].geometry.buffer(0.005)
p21=p21.iloc[0,:].geometry.buffer(0.005)
p22=p22.iloc[0,:].geometry.buffer(0.005)
p23=p23.iloc[0,:].geometry.buffer(0.005)
p24=p24.iloc[0,:].geometry.buffer(0.005)
p25=p25.iloc[0,:].geometry.buffer(0.005)
p26=p26.iloc[0,:].geometry.buffer(0.005)

# plotting the buffer radius near ports

gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,p19
gdf20.plot(ax=ax,color='g',alpha=0.2)
gdf20.loc[gdf20.within(p1),:].plot(ax=ax,color='k')
gdf20.loc[gdf20.within(p2),:].plot(ax=ax,color='k')
gdf20.loc[gdf20.within(p3),:].plot(ax=ax,color='k')
gdf20.loc[gdf20.within(p4),:].plot(ax=ax,color='k')
gdf20.loc[gdf20.within(p5),:].plot(ax=ax,color='k')
gdf20.loc[gdf20.within(p6),:].plot(ax=ax,color='k')
gdf20.loc[gdf20.within(p7),:].plot(ax=ax,color='k')
gdf20.loc[gdf20.within(p8),:].plot(ax=ax,color='k')
gdf20.loc[gdf20.within(p9),:].plot(ax=ax,color='k')
gdf20.loc[gdf20.within(p10),:].plot(ax=ax,color='k')
gdf20.loc[gdf20.within(p11),:].plot(ax=ax,color='k')
gdf20.loc[gdf20.within(p12),:].plot(ax=ax,color='k')
gdf20.loc[gdf20.within(p13),:].plot(ax=ax,color='k')
gdf20.loc[gdf20.within(p14),:].plot(ax=ax,color='k')
gdf20.loc[gdf20.within(p15),:].plot(ax=ax,color='k')
gdf20.loc[gdf20.within(p16),:].plot(ax=ax,color='k')
gdf20.loc[gdf20.within(p17),:].plot(ax=ax,color='k')
gdf20.loc[gdf20.within(p18),:].plot(ax=ax,color='k')
gdf20.loc[gdf20.within(p19),:].plot(ax=ax,color='k')
gdf20.loc[gdf20.within(p20),:].plot(ax=ax,color='k')
gdf20.loc[gdf20.within(p21),:].plot(ax=ax,color='k')
gdf20.loc[gdf20.within(p22),:].plot(ax=ax,color='k')
gdf20.loc[gdf20.within(p23),:].plot(ax=ax,color='k')
gdf20.loc[gdf20.within(p24),:].plot(ax=ax,color='k')
gdf20.loc[gdf20.within(p25),:].plot(ax=ax,color='k')
gdf20.loc[gdf20.within(p26),:].plot(ax=ax,color='k')
plt.savefig('Q3 images/interval_20_q1.png')
```


44.72
44.70
44.68
44.66
44.64
44.62
44.60
44.58
−63.675
−63.650
−63.625
−63.600
−63.575
−63.550
−63.525
−63.500

In [70]:

```
joinres=gpd.sjoin(gdf20,bylaw,op='within',how='left')
col=['r','b','g','k','yellow','orange','Olive','Maroon','Purple','Fuchsia','Lime'
i=0
ax=gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,


for g in set(joinres['index_right']):
  tmp=joinres.loc[joinres['index_right']==g,:]
  if tmp.shape[0]>0:
    tmp.plot(ax=ax,color=col[i])
  i=i+1
plt.savefig('Q3 images/interval_20_q2.png')
```

```
C:\Users\lanch\Anaconda3\lib\site-packages\geopandas\tools\sjoin.py:44: UserWar
ning: CRS of frames being joined does not match!
  warn('CRS of frames being joined does not match!')
```

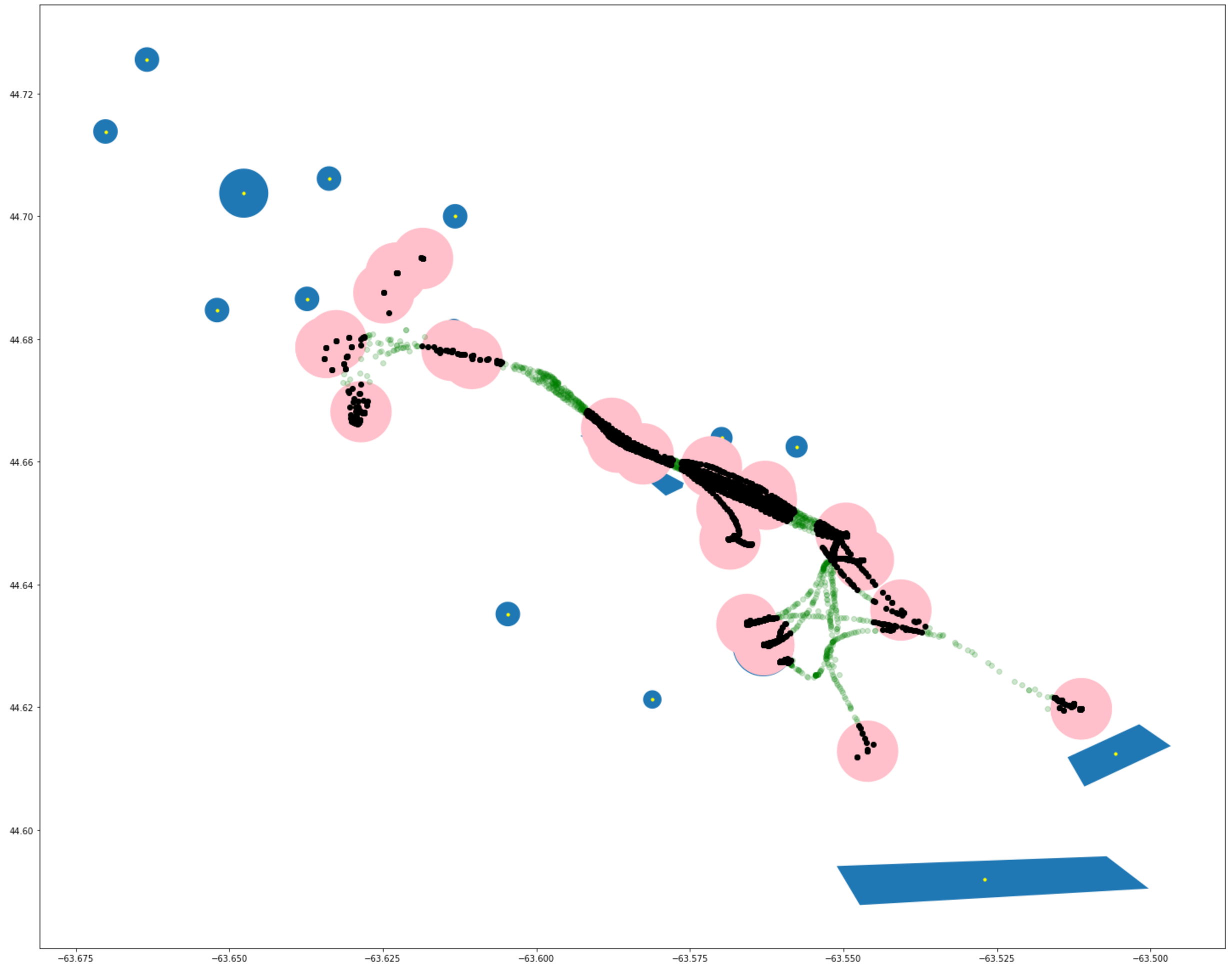


21st interval

In [71]:

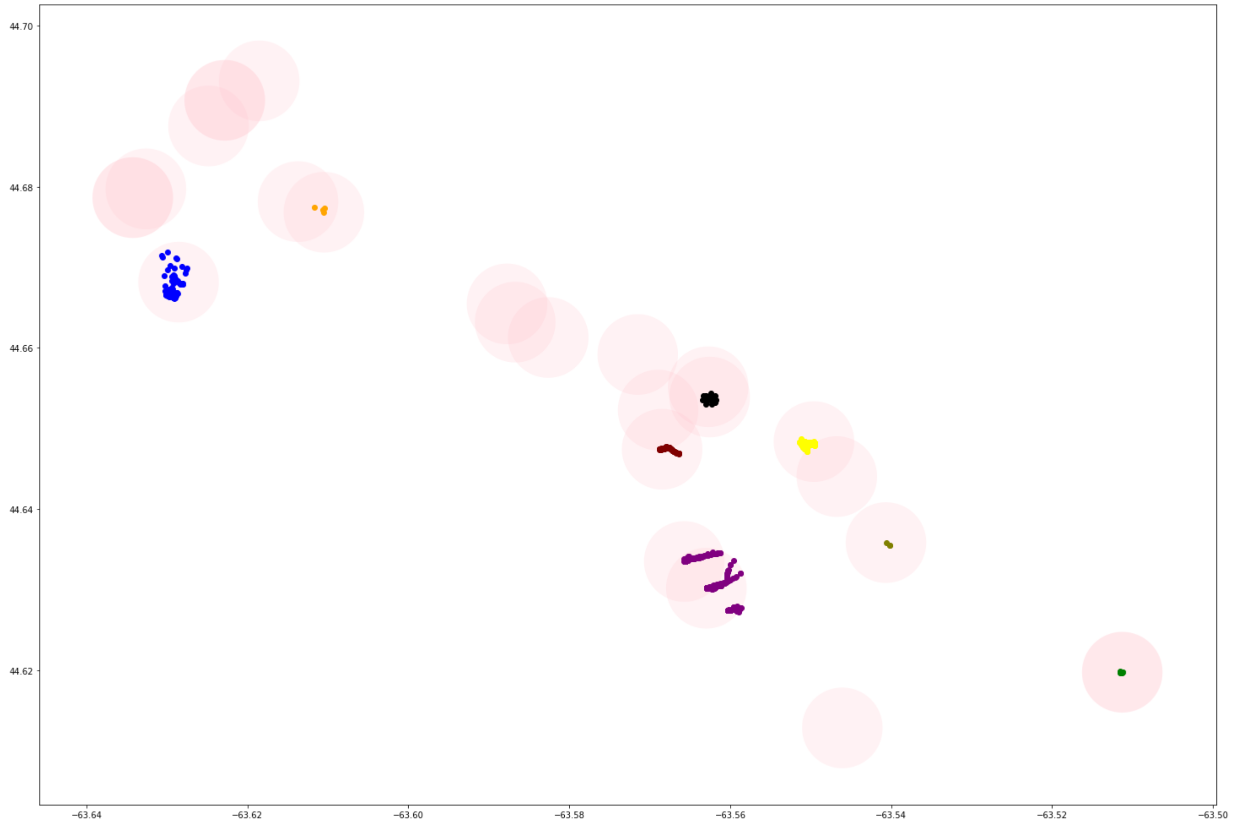
```
gdf21 = gpd.GeoDataFrame(d['df_h21'].drop(['location.coordinates.0', 'location.co
crs={'init': 'epsg:4326'},
geometry=[shapely.geometry.Point(xy) for xy in zip(d['df_h21']['location.coordina

p1=gdf21.loc[gdf21.distance(d1[0])==gdf21.distance(d1[0]).min(),:]
p2=gdf21.loc[gdf21.distance(d2[0])==gdf21.distance(d2[0]).min(),:]
p3=gdf21.loc[gdf21.distance(d3[0])==gdf21.distance(d3[0]).min(),:]
p4=gdf21.loc[gdf21.distance(d4[0])==gdf21.distance(d4[0]).min(),:]
p5=gdf21.loc[gdf21.distance(d5[0])==gdf21.distance(d5[0]).min(),:]
p6=gdf21.loc[gdf21.distance(d6[0])==gdf21.distance(d6[0]).min(),:]
p7=gdf21.loc[gdf21.distance(d7[0])==gdf21.distance(d7[0]).min(),:]
p8=gdf21.loc[gdf21.distance(d8[0])==gdf21.distance(d8[0]).min(),:]
p9=gdf21.loc[gdf21.distance(d9[0])==gdf21.distance(d9[0]).min(),:]
p10=gdf21.loc[gdf21.distance(d10[0])==gdf21.distance(d10[0]).min(),:]
p11=gdf21.loc[gdf21.distance(d11[0])==gdf21.distance(d11[0]).min(),:]
p12=gdf21.loc[gdf21.distance(d12[0])==gdf21.distance(d12[0]).min(),:]
p13=gdf21.loc[gdf21.distance(d13[0])==gdf21.distance(d13[0]).min(),:]
p14=gdf21.loc[gdf21.distance(d14[0])==gdf21.distance(d14[0]).min(),:]
p15=gdf21.loc[gdf21.distance(d15[0])==gdf21.distance(d15[0]).min(),:]
p16=gdf21.loc[gdf21.distance(d16[0])==gdf21.distance(d16[0]).min(),:]
p17=gdf21.loc[gdf21.distance(d17[0])==gdf21.distance(d17[0]).min(),:]
p18=gdf21.loc[gdf21.distance(d18[0])==gdf21.distance(d18[0]).min(),:]
p19=gdf21.loc[gdf21.distance(d19[0])==gdf21.distance(d19[0]).min(),:]
p20=gdf21.loc[gdf21.distance(d20[0])==gdf21.distance(d20[0]).min(),:]
p21=gdf21.loc[gdf21.distance(d21[0])==gdf21.distance(d21[0]).min(),:]
p22=gdf21.loc[gdf21.distance(d22[0])==gdf21.distance(d22[0]).min(),:]
p23=gdf21.loc[gdf21.distance(d23[0])==gdf21.distance(d23[0]).min(),:]
p24=gdf21.loc[gdf21.distance(d24[0])==gdf21.distance(d24[0]).min(),:]
p25=gdf21.loc[gdf21.distance(d25[0])==gdf21.distance(d25[0]).min(),:]
p26=gdf21.loc[gdf21.distance(d26[0])==gdf21.distance(d26[0]).min(),:]



# creating buffer on the buffer with 5km radius
ax=bylaw.loc[['pointpolygon', 'port1', 'port2', 'ind', 'port5', 'port6', 'port7',
              'southend container terminal','NN Jetty', 'Bills island', 'mid bedf
              'waterfront h', 'northarm', 'plll', 'pp', 'po001','po002', 'oulier_
              'p009', 'p010'],:].plot(figsize=(25,25))
gpd.GeoSeries([d1[0],d2[0],d3[0],d4[0],d5[0],d6[0],d7[0],d8[0],d9[0],d10[0],d11[0
               d16[0],d17[0],d18[0],d19[0],d20[0],d21[0],d22[0],d23[0],d24[0],d25
               d26[0]]).plot(ax=ax,color='yellow',markersize=10)

p1=p1.iloc[0,:].geometry.buffer(0.005)
p2=p2.iloc[0,:].geometry.buffer(0.005)
p3=p3.iloc[0,:].geometry.buffer(0.005)
p4=p4.iloc[0,:].geometry.buffer(0.005)
p5=p5.iloc[0,:].geometry.buffer(0.005) # getting the buffer with 5km radius for t
p6=p6.iloc[0,:].geometry.buffer(0.005)
p7=p7.iloc[0,:].geometry.buffer(0.005)
p8=p8.iloc[0,:].geometry.buffer(0.005)
p9=p9.iloc[0,:].geometry.buffer(0.005)
p10=p10.iloc[0,:].geometry.buffer(0.005)
p11=p11.iloc[0,:].geometry.buffer(0.005)
p12=p12.iloc[0,:].geometry.buffer(0.005)
p13=p13.iloc[0,:].geometry.buffer(0.005)
p14=p14.iloc[0,:].geometry.buffer(0.005)
p15=p15.iloc[0,:].geometry.buffer(0.005)
```

```
p16=p16.iloc[0,:].geometry.buffer(0.005)
p17=p17.iloc[0,:].geometry.buffer(0.005)
p18=p18.iloc[0,:].geometry.buffer(0.005)
p19=p19.iloc[0,:].geometry.buffer(0.005)
p20=p20.iloc[0,:].geometry.buffer(0.005)
p21=p21.iloc[0,:].geometry.buffer(0.005)
p22=p22.iloc[0,:].geometry.buffer(0.005)
p23=p23.iloc[0,:].geometry.buffer(0.005)
p24=p24.iloc[0,:].geometry.buffer(0.005)
p25=p25.iloc[0,:].geometry.buffer(0.005)
p26=p26.iloc[0,:].geometry.buffer(0.005)

# plotting the buffer radius near ports

gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,p19
gdf21.plot(ax=ax,color='g',alpha=0.2)
gdf21.loc[gdf21.within(p1),:].plot(ax=ax,color='k')
gdf21.loc[gdf21.within(p2),:].plot(ax=ax,color='k')
gdf21.loc[gdf21.within(p3),:].plot(ax=ax,color='k')
gdf21.loc[gdf21.within(p4),:].plot(ax=ax,color='k')
gdf21.loc[gdf21.within(p5),:].plot(ax=ax,color='k')
gdf21.loc[gdf21.within(p6),:].plot(ax=ax,color='k')
gdf21.loc[gdf21.within(p7),:].plot(ax=ax,color='k')
gdf21.loc[gdf21.within(p8),:].plot(ax=ax,color='k')
gdf21.loc[gdf21.within(p9),:].plot(ax=ax,color='k')
gdf21.loc[gdf21.within(p10),:].plot(ax=ax,color='k')
gdf21.loc[gdf21.within(p11),:].plot(ax=ax,color='k')
gdf21.loc[gdf21.within(p12),:].plot(ax=ax,color='k')
gdf21.loc[gdf21.within(p13),:].plot(ax=ax,color='k')
gdf21.loc[gdf21.within(p14),:].plot(ax=ax,color='k')
gdf21.loc[gdf21.within(p15),:].plot(ax=ax,color='k')
gdf21.loc[gdf21.within(p16),:].plot(ax=ax,color='k')
gdf21.loc[gdf21.within(p17),:].plot(ax=ax,color='k')
gdf21.loc[gdf21.within(p18),:].plot(ax=ax,color='k')
gdf21.loc[gdf21.within(p19),:].plot(ax=ax,color='k')
gdf21.loc[gdf21.within(p20),:].plot(ax=ax,color='k')
gdf21.loc[gdf21.within(p21),:].plot(ax=ax,color='k')
gdf21.loc[gdf21.within(p22),:].plot(ax=ax,color='k')
gdf21.loc[gdf21.within(p23),:].plot(ax=ax,color='k')
gdf21.loc[gdf21.within(p24),:].plot(ax=ax,color='k')
gdf21.loc[gdf21.within(p25),:].plot(ax=ax,color='k')
gdf21.loc[gdf21.within(p26),:].plot(ax=ax,color='k')
plt.savefig('Q3 images/interval_21_q1.png')
```


44.72
44.70
44.68
44.66
44.64
44.62
44.60
−63.675
−63.650
−63.625
−63.600
−63.575
−63.550
−63.525
−63.500

In [72]:
```
joinres=gpd.sjoin(gdf21,bylaw,op='within',how='left')
col=['r','b','g','k','yellow','orange','Olive','Maroon','Purple','Fuchsia','Lime'
i=0
ax=gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,


for g in set(joinres['index_right']):
  tmp=joinres.loc[joinres['index_right']==g,:]
  if tmp.shape[0]>0:
    tmp.plot(ax=ax,color=col[i])
  i=i+1
plt.savefig('Q3 images/interval_21_q2.png')
```

```
C:\Users\lanch\Anaconda3\lib\site-packages\geopandas\tools\sjoin.py:44: UserWar
ning: CRS of frames being joined does not match!
  warn('CRS of frames being joined does not match!')
```

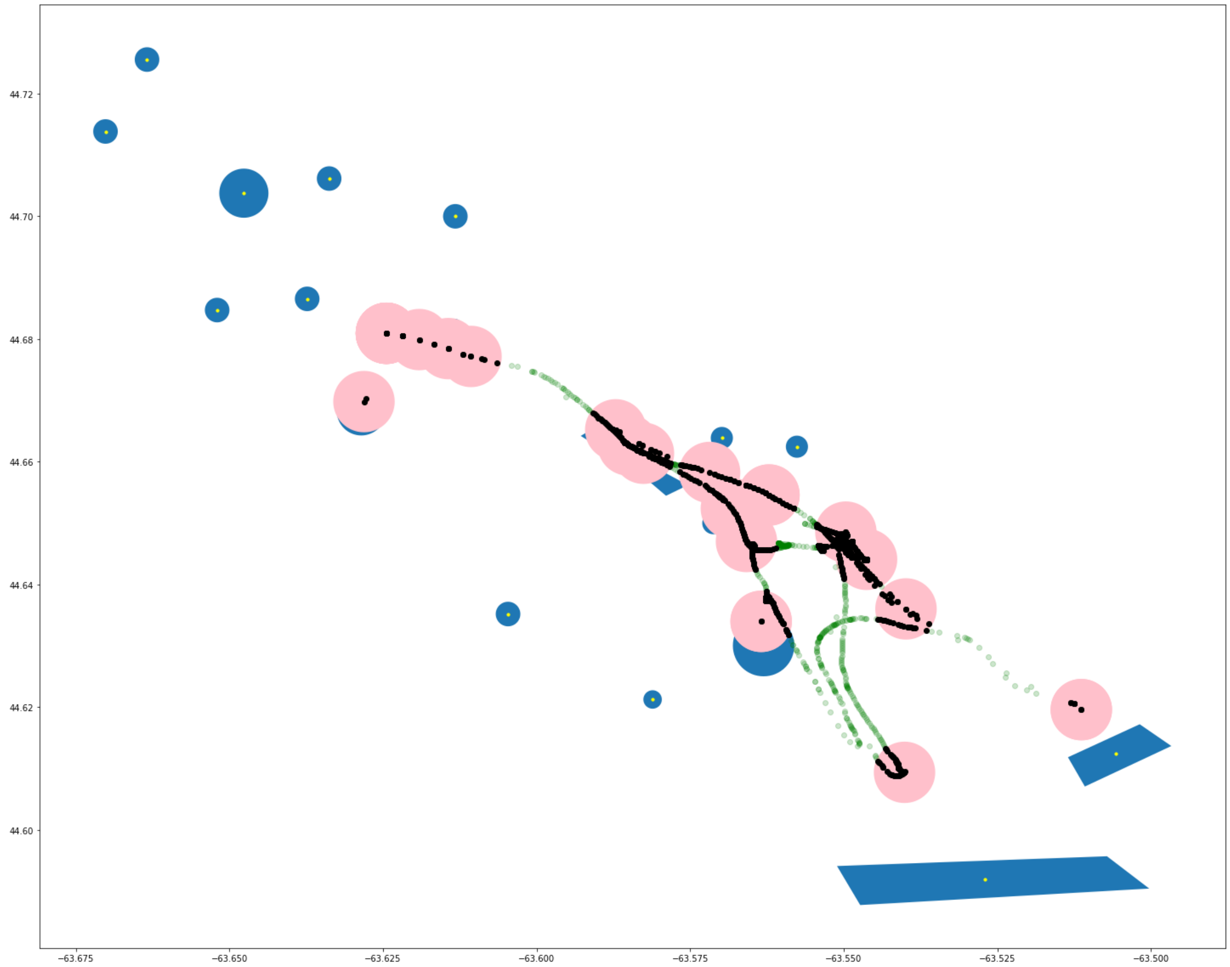


```
22nd interval
```

In [73]:

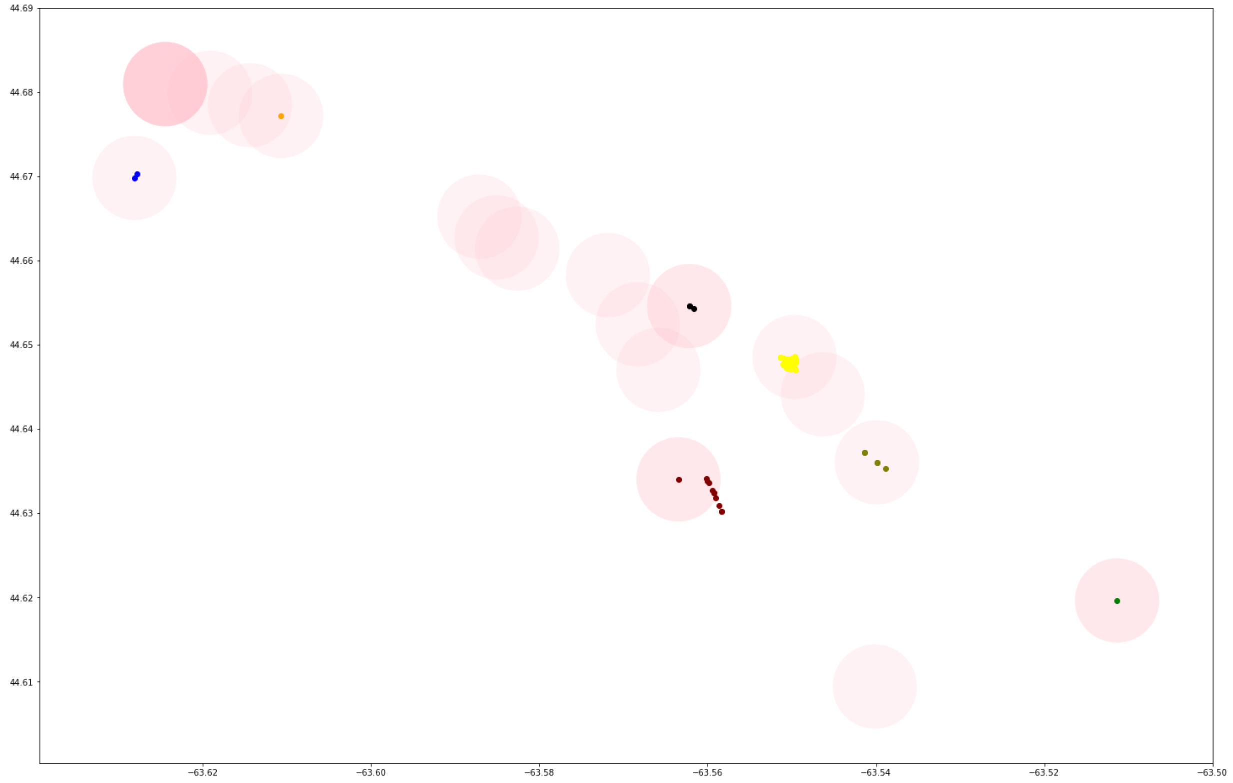
```
gdf22 = gpd.GeoDataFrame(d['df_h22'].drop(['location.coordinates.0', 'location.co
crs={'init': 'epsg:4326'},
geometry=[shapely.geometry.Point(xy) for xy in zip(d['df_h22']['location.coordina

p1=gdf22.loc[gdf22.distance(d1[0])==gdf22.distance(d1[0]).min(),:]
p2=gdf22.loc[gdf22.distance(d2[0])==gdf22.distance(d2[0]).min(),:]
p3=gdf22.loc[gdf22.distance(d3[0])==gdf22.distance(d3[0]).min(),:]
p4=gdf22.loc[gdf22.distance(d4[0])==gdf22.distance(d4[0]).min(),:]
p5=gdf22.loc[gdf22.distance(d5[0])==gdf22.distance(d5[0]).min(),:]
p6=gdf22.loc[gdf22.distance(d6[0])==gdf22.distance(d6[0]).min(),:]
p7=gdf22.loc[gdf22.distance(d7[0])==gdf22.distance(d7[0]).min(),:]
p8=gdf22.loc[gdf22.distance(d8[0])==gdf22.distance(d8[0]).min(),:]
p9=gdf22.loc[gdf22.distance(d9[0])==gdf22.distance(d9[0]).min(),:]
p10=gdf22.loc[gdf22.distance(d10[0])==gdf22.distance(d10[0]).min(),:]
p11=gdf22.loc[gdf22.distance(d11[0])==gdf22.distance(d11[0]).min(),:]
p12=gdf22.loc[gdf22.distance(d12[0])==gdf22.distance(d12[0]).min(),:]
p13=gdf22.loc[gdf22.distance(d13[0])==gdf22.distance(d13[0]).min(),:]
p14=gdf22.loc[gdf22.distance(d14[0])==gdf22.distance(d14[0]).min(),:]
p15=gdf22.loc[gdf22.distance(d15[0])==gdf22.distance(d15[0]).min(),:]
p16=gdf22.loc[gdf22.distance(d16[0])==gdf22.distance(d16[0]).min(),:]
p17=gdf22.loc[gdf22.distance(d17[0])==gdf22.distance(d17[0]).min(),:]
p18=gdf22.loc[gdf22.distance(d18[0])==gdf22.distance(d18[0]).min(),:]
p19=gdf22.loc[gdf22.distance(d19[0])==gdf22.distance(d19[0]).min(),:]
p20=gdf22.loc[gdf22.distance(d20[0])==gdf22.distance(d20[0]).min(),:]
p21=gdf22.loc[gdf22.distance(d21[0])==gdf22.distance(d21[0]).min(),:]
p22=gdf22.loc[gdf22.distance(d22[0])==gdf22.distance(d22[0]).min(),:]
p23=gdf22.loc[gdf22.distance(d23[0])==gdf22.distance(d23[0]).min(),:]
p24=gdf22.loc[gdf22.distance(d24[0])==gdf22.distance(d24[0]).min(),:]
p25=gdf22.loc[gdf22.distance(d25[0])==gdf22.distance(d25[0]).min(),:]
p26=gdf22.loc[gdf22.distance(d26[0])==gdf22.distance(d26[0]).min(),:]



# creating buffer on the buffer with 5km radius
ax=bylaw.loc[['pointpolygon', 'port1', 'port2', 'ind', 'port5', 'port6', 'port7',
              'southend container terminal','NN Jetty', 'Bills island', 'mid bedf
              'waterfront h', 'northarm', 'plll', 'pp', 'po001','po002', 'oulier_
              'p009', 'p010'],:].plot(figsize=(25,25))
gpd.GeoSeries([d1[0],d2[0],d3[0],d4[0],d5[0],d6[0],d7[0],d8[0],d9[0],d10[0],d11[0
               d16[0],d17[0],d18[0],d19[0],d20[0],d21[0],d22[0],d23[0],d24[0],d25
               d26[0]]).plot(ax=ax,color='yellow',markersize=10)

p1=p1.iloc[0,:].geometry.buffer(0.005)
p2=p2.iloc[0,:].geometry.buffer(0.005)
p3=p3.iloc[0,:].geometry.buffer(0.005)
p4=p4.iloc[0,:].geometry.buffer(0.005)
p5=p5.iloc[0,:].geometry.buffer(0.005) # getting the buffer with 5km radius for t
p6=p6.iloc[0,:].geometry.buffer(0.005)
p7=p7.iloc[0,:].geometry.buffer(0.005)
p8=p8.iloc[0,:].geometry.buffer(0.005)
p9=p9.iloc[0,:].geometry.buffer(0.005)
p10=p10.iloc[0,:].geometry.buffer(0.005)
p11=p11.iloc[0,:].geometry.buffer(0.005)
p12=p12.iloc[0,:].geometry.buffer(0.005)
p13=p13.iloc[0,:].geometry.buffer(0.005)
p14=p14.iloc[0,:].geometry.buffer(0.005)
p15=p15.iloc[0,:].geometry.buffer(0.005)
```

```
p16=p16.iloc[0,:].geometry.buffer(0.005)
p17=p17.iloc[0,:].geometry.buffer(0.005)
p18=p18.iloc[0,:].geometry.buffer(0.005)
p19=p19.iloc[0,:].geometry.buffer(0.005)
p20=p20.iloc[0,:].geometry.buffer(0.005)
p21=p21.iloc[0,:].geometry.buffer(0.005)
p22=p22.iloc[0,:].geometry.buffer(0.005)
p23=p23.iloc[0,:].geometry.buffer(0.005)
p24=p24.iloc[0,:].geometry.buffer(0.005)
p25=p25.iloc[0,:].geometry.buffer(0.005)
p26=p26.iloc[0,:].geometry.buffer(0.005)

# plotting the buffer radius near ports

gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,p19
gdf22.plot(ax=ax,color='g',alpha=0.2)
gdf22.loc[gdf22.within(p1),:].plot(ax=ax,color='k')
gdf22.loc[gdf22.within(p2),:].plot(ax=ax,color='k')
gdf22.loc[gdf22.within(p3),:].plot(ax=ax,color='k')
gdf22.loc[gdf22.within(p4),:].plot(ax=ax,color='k')
gdf22.loc[gdf22.within(p5),:].plot(ax=ax,color='k')
gdf22.loc[gdf22.within(p6),:].plot(ax=ax,color='k')
gdf22.loc[gdf22.within(p7),:].plot(ax=ax,color='k')
gdf22.loc[gdf22.within(p8),:].plot(ax=ax,color='k')
gdf22.loc[gdf22.within(p9),:].plot(ax=ax,color='k')
gdf22.loc[gdf22.within(p10),:].plot(ax=ax,color='k')
gdf22.loc[gdf22.within(p11),:].plot(ax=ax,color='k')
gdf22.loc[gdf22.within(p12),:].plot(ax=ax,color='k')
gdf22.loc[gdf22.within(p13),:].plot(ax=ax,color='k')
gdf22.loc[gdf22.within(p14),:].plot(ax=ax,color='k')
gdf22.loc[gdf22.within(p15),:].plot(ax=ax,color='k')
gdf22.loc[gdf22.within(p16),:].plot(ax=ax,color='k')
gdf22.loc[gdf22.within(p17),:].plot(ax=ax,color='k')
gdf22.loc[gdf22.within(p18),:].plot(ax=ax,color='k')
gdf22.loc[gdf22.within(p19),:].plot(ax=ax,color='k')
gdf22.loc[gdf22.within(p20),:].plot(ax=ax,color='k')
gdf22.loc[gdf22.within(p21),:].plot(ax=ax,color='k')
gdf22.loc[gdf22.within(p22),:].plot(ax=ax,color='k')
gdf22.loc[gdf22.within(p23),:].plot(ax=ax,color='k')
gdf22.loc[gdf22.within(p24),:].plot(ax=ax,color='k')
gdf22.loc[gdf22.within(p25),:].plot(ax=ax,color='k')
gdf22.loc[gdf22.within(p26),:].plot(ax=ax,color='k')
plt.savefig('Q3 images/interval_22_q1.png')
```


44.72
44.70
44.68
44.66
44.64
44.62
44.60
−63.675
−63.650
−63.625
−63.600
−63.575
−63.550
−63.525
−63.500

In [74]:
```
joinres=gpd.sjoin(gdf22,bylaw,op='within',how='left')
col=['r','b','g','k','yellow','orange','Olive','Maroon','Purple','Fuchsia','Lime'
i=0
ax=gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,


for g in set(joinres['index_right']):
  tmp=joinres.loc[joinres['index_right']==g,:]
  if tmp.shape[0]>0:
    tmp.plot(ax=ax,color=col[i])
  i=i+1
plt.savefig('Q3 images/interval_22_q2.png')
```

```
C:\Users\lanch\Anaconda3\lib\site-packages\geopandas\tools\sjoin.py:44: UserWar
ning: CRS of frames being joined does not match!
  warn('CRS of frames being joined does not match!')
```

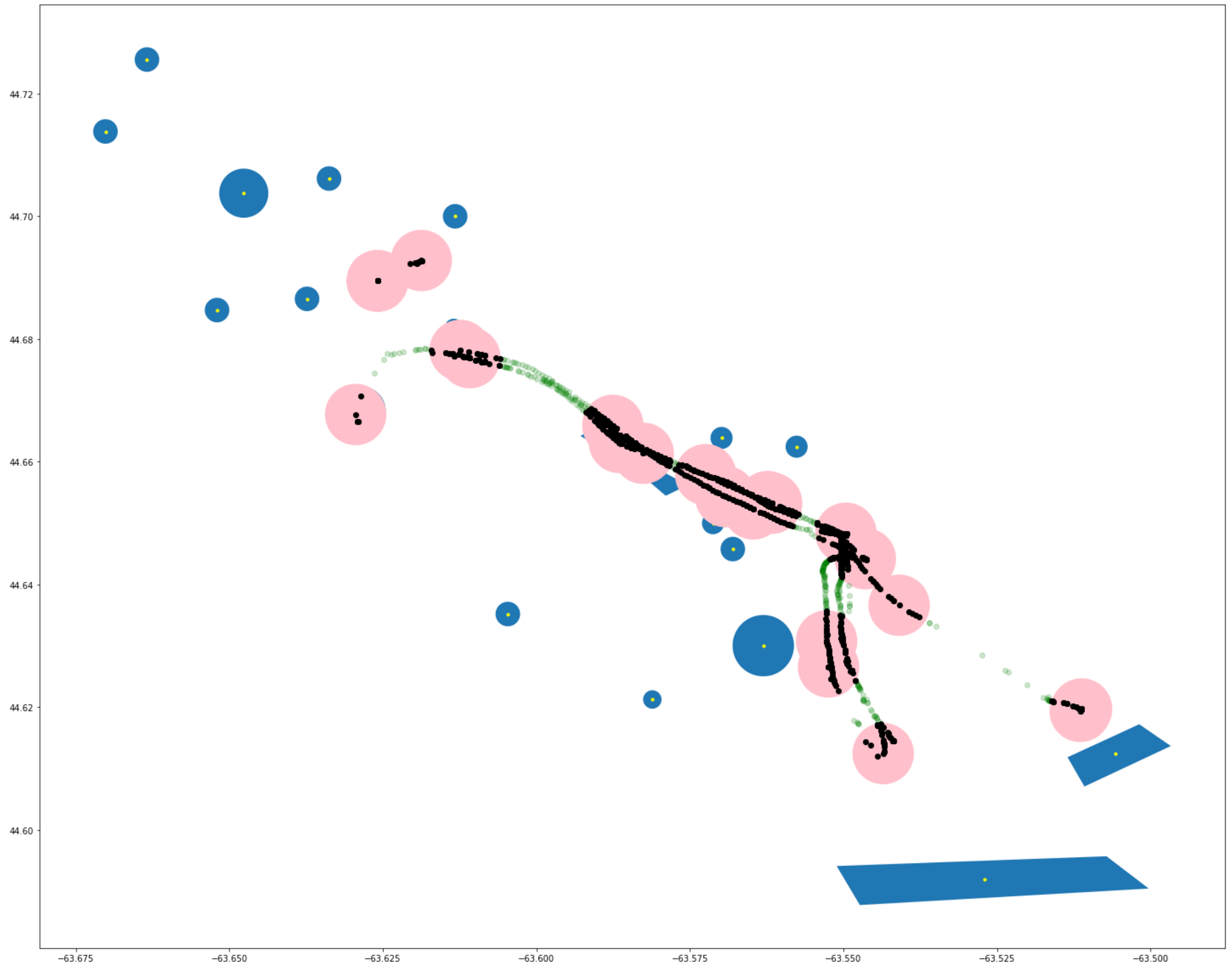


```
23rd interval
```

In [75]:

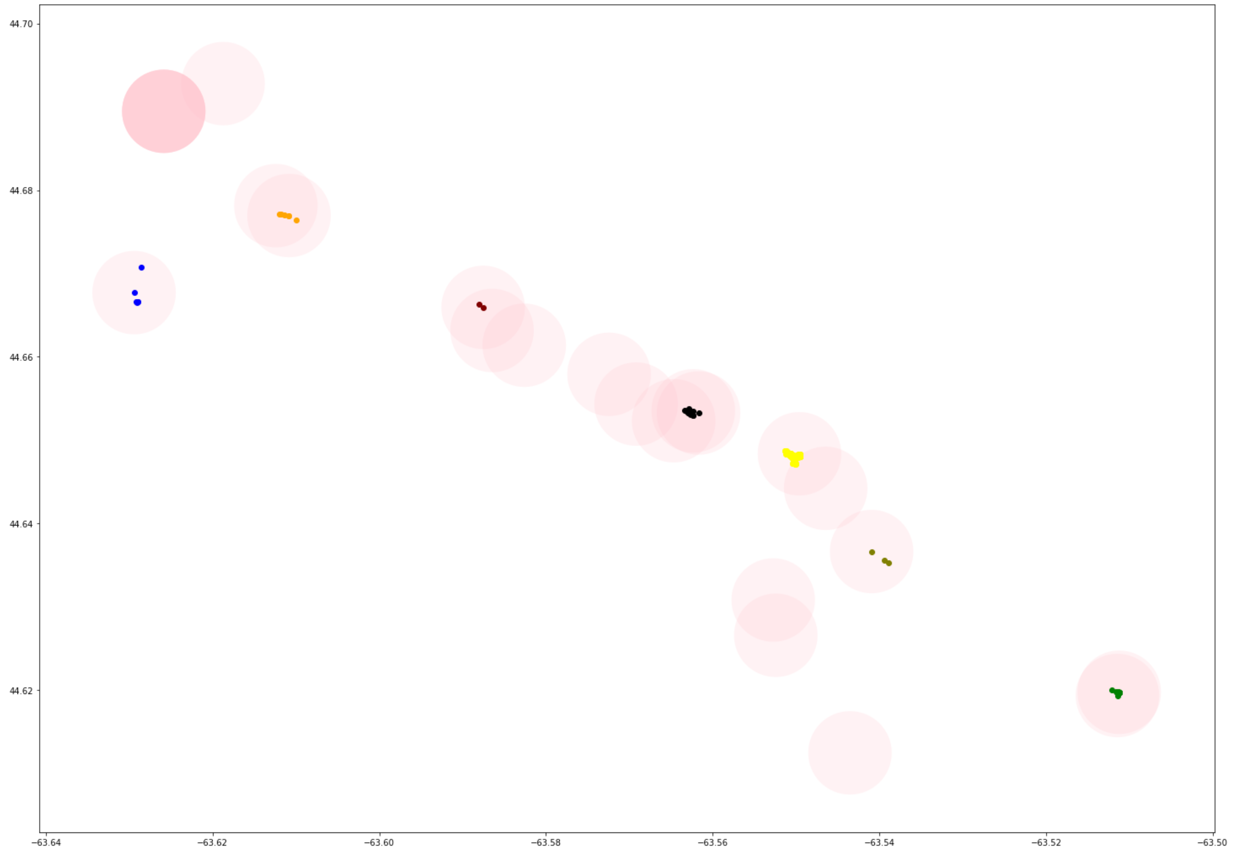
```
gdf23 = gpd.GeoDataFrame(d['df_h23'].drop(['location.coordinates.0', 'location.co
crs={'init': 'epsg:4326'},
geometry=[shapely.geometry.Point(xy) for xy in zip(d['df_h23']['location.coordina

p1=gdf23.loc[gdf23.distance(d1[0])==gdf23.distance(d1[0]).min(),:]
p2=gdf23.loc[gdf23.distance(d2[0])==gdf23.distance(d2[0]).min(),:]
p3=gdf23.loc[gdf23.distance(d3[0])==gdf23.distance(d3[0]).min(),:]
p4=gdf23.loc[gdf23.distance(d4[0])==gdf23.distance(d4[0]).min(),:]
p5=gdf23.loc[gdf23.distance(d5[0])==gdf23.distance(d5[0]).min(),:]
p6=gdf23.loc[gdf23.distance(d6[0])==gdf23.distance(d6[0]).min(),:]
p7=gdf23.loc[gdf23.distance(d7[0])==gdf23.distance(d7[0]).min(),:]
p8=gdf23.loc[gdf23.distance(d8[0])==gdf23.distance(d8[0]).min(),:]
p9=gdf23.loc[gdf23.distance(d9[0])==gdf23.distance(d9[0]).min(),:]
p10=gdf23.loc[gdf23.distance(d10[0])==gdf23.distance(d10[0]).min(),:]
p11=gdf23.loc[gdf23.distance(d11[0])==gdf23.distance(d11[0]).min(),:]
p12=gdf23.loc[gdf23.distance(d12[0])==gdf23.distance(d12[0]).min(),:]
p13=gdf23.loc[gdf23.distance(d13[0])==gdf23.distance(d13[0]).min(),:]
p14=gdf23.loc[gdf23.distance(d14[0])==gdf23.distance(d14[0]).min(),:]
p15=gdf23.loc[gdf23.distance(d15[0])==gdf23.distance(d15[0]).min(),:]
p16=gdf23.loc[gdf23.distance(d16[0])==gdf23.distance(d16[0]).min(),:]
p17=gdf23.loc[gdf23.distance(d17[0])==gdf23.distance(d17[0]).min(),:]
p18=gdf23.loc[gdf23.distance(d18[0])==gdf23.distance(d18[0]).min(),:]
p19=gdf23.loc[gdf23.distance(d19[0])==gdf23.distance(d19[0]).min(),:]
p20=gdf23.loc[gdf23.distance(d20[0])==gdf23.distance(d20[0]).min(),:]
p21=gdf23.loc[gdf23.distance(d21[0])==gdf23.distance(d21[0]).min(),:]
p22=gdf23.loc[gdf23.distance(d22[0])==gdf23.distance(d22[0]).min(),:]
p23=gdf23.loc[gdf23.distance(d23[0])==gdf23.distance(d23[0]).min(),:]
p24=gdf23.loc[gdf23.distance(d24[0])==gdf23.distance(d24[0]).min(),:]
p25=gdf23.loc[gdf23.distance(d25[0])==gdf23.distance(d25[0]).min(),:]
p26=gdf23.loc[gdf23.distance(d26[0])==gdf23.distance(d26[0]).min(),:]



# creating buffer on the buffer with 5km radius
ax=bylaw.loc[['pointpolygon', 'port1', 'port2', 'ind', 'port5', 'port6', 'port7',
              'southend container terminal','NN Jetty', 'Bills island', 'mid bedf
              'waterfront h', 'northarm', 'plll', 'pp', 'po001','po002', 'oulier_
              'p009', 'p010'],:].plot(figsize=(25,25))
gpd.GeoSeries([d1[0],d2[0],d3[0],d4[0],d5[0],d6[0],d7[0],d8[0],d9[0],d10[0],d11[0
               d16[0],d17[0],d18[0],d19[0],d20[0],d21[0],d22[0],d23[0],d24[0],d25
               d26[0]]).plot(ax=ax,color='yellow',markersize=10)

p1=p1.iloc[0,:].geometry.buffer(0.005)
p2=p2.iloc[0,:].geometry.buffer(0.005)
p3=p3.iloc[0,:].geometry.buffer(0.005)
p4=p4.iloc[0,:].geometry.buffer(0.005)
p5=p5.iloc[0,:].geometry.buffer(0.005) # getting the buffer with 5km radius for t
p6=p6.iloc[0,:].geometry.buffer(0.005)
p7=p7.iloc[0,:].geometry.buffer(0.005)
p8=p8.iloc[0,:].geometry.buffer(0.005)
p9=p9.iloc[0,:].geometry.buffer(0.005)
p10=p10.iloc[0,:].geometry.buffer(0.005)
p11=p11.iloc[0,:].geometry.buffer(0.005)
p12=p12.iloc[0,:].geometry.buffer(0.005)
p13=p13.iloc[0,:].geometry.buffer(0.005)
p14=p14.iloc[0,:].geometry.buffer(0.005)
p15=p15.iloc[0,:].geometry.buffer(0.005)
```

```
p16=p16.iloc[0,:].geometry.buffer(0.005)
p17=p17.iloc[0,:].geometry.buffer(0.005)
p18=p18.iloc[0,:].geometry.buffer(0.005)
p19=p19.iloc[0,:].geometry.buffer(0.005)
p20=p20.iloc[0,:].geometry.buffer(0.005)
p21=p21.iloc[0,:].geometry.buffer(0.005)
p22=p22.iloc[0,:].geometry.buffer(0.005)
p23=p23.iloc[0,:].geometry.buffer(0.005)
p24=p24.iloc[0,:].geometry.buffer(0.005)
p25=p25.iloc[0,:].geometry.buffer(0.005)
p26=p26.iloc[0,:].geometry.buffer(0.005)

# plotting the buffer radius near ports

gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,p19
gdf23.plot(ax=ax,color='g',alpha=0.2)
gdf23.loc[gdf23.within(p1),:].plot(ax=ax,color='k')
gdf23.loc[gdf23.within(p2),:].plot(ax=ax,color='k')
gdf23.loc[gdf23.within(p3),:].plot(ax=ax,color='k')
gdf23.loc[gdf23.within(p4),:].plot(ax=ax,color='k')
gdf23.loc[gdf23.within(p5),:].plot(ax=ax,color='k')
gdf23.loc[gdf23.within(p6),:].plot(ax=ax,color='k')
gdf23.loc[gdf23.within(p7),:].plot(ax=ax,color='k')
gdf23.loc[gdf23.within(p8),:].plot(ax=ax,color='k')
gdf23.loc[gdf23.within(p9),:].plot(ax=ax,color='k')
gdf23.loc[gdf23.within(p10),:].plot(ax=ax,color='k')
gdf23.loc[gdf23.within(p11),:].plot(ax=ax,color='k')
gdf23.loc[gdf23.within(p12),:].plot(ax=ax,color='k')
gdf23.loc[gdf23.within(p13),:].plot(ax=ax,color='k')
gdf23.loc[gdf23.within(p14),:].plot(ax=ax,color='k')
gdf23.loc[gdf23.within(p15),:].plot(ax=ax,color='k')
gdf23.loc[gdf23.within(p16),:].plot(ax=ax,color='k')
gdf23.loc[gdf23.within(p17),:].plot(ax=ax,color='k')
gdf23.loc[gdf23.within(p18),:].plot(ax=ax,color='k')
gdf23.loc[gdf23.within(p19),:].plot(ax=ax,color='k')
gdf23.loc[gdf23.within(p20),:].plot(ax=ax,color='k')
gdf23.loc[gdf23.within(p21),:].plot(ax=ax,color='k')
gdf23.loc[gdf23.within(p22),:].plot(ax=ax,color='k')
gdf23.loc[gdf23.within(p23),:].plot(ax=ax,color='k')
gdf23.loc[gdf23.within(p24),:].plot(ax=ax,color='k')
gdf23.loc[gdf23.within(p25),:].plot(ax=ax,color='k')
gdf23.loc[gdf23.within(p26),:].plot(ax=ax,color='k')
plt.savefig('Q3 images/interval_23_q1.png')
```


44.72
44.70
44.68
44.66
44.64
44.62
44.60
−63.675
−63.650
−63.625
−63.600
−63.575
−63.550
−63.525
−63.500

```
In [76]:  joinres=gpd.sjoin(gdf23,bylaw,op='within',how='left')
          col=['r','b','g','k','yellow','orange','Olive','Maroon','Purple','Fuchsia','Lime'
          i=0
          ax=gpd.GeoSeries([p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,p13,p14,p15,p16,p17,p18,


          for g in set(joinres['index_right']):
            tmp=joinres.loc[joinres['index_right']==g,:]
            if tmp.shape[0]>0:
              tmp.plot(ax=ax,color=col[i])
            i=i+1
          plt.savefig('Q3 images/interval_23_q2.png')
```

```
C:\Users\lanch\Anaconda3\lib\site-packages\geopandas\tools\sjoin.py:44: UserWar
ning: CRS of frames being joined does not match!
  warn('CRS of frames being joined does not match!')
```



4. Select any port you like. Create a temporal chart for the density of messages in that port. Your x is the time and each snapshot of the time has the density of port at a specific hour. (20 points)

In [78]:

```
df=pd.read_csv('AISData.csv')
df = df.rename(columns={"location.coordinates.0": "x", "location.coordinates.1":
# change the crs of geodataframe for join
gdf_test = gpd.GeoDataFrame(df.drop(['x', 'y'], axis=1),
crs={'proj': 'longlat', 'a': 255000, 'b': 255000, 'no_defs': True},
geometry=[shapely.geometry.Point(xy) for xy in zip(df.x, df.y)])
location=gpd.read_file('assignment3shapefile.shp')
byname=location.set_index(['port_name'])
joinres=gpd.sjoin(gdf_test,byname,op='within',how='left')
```

In [105]:

```
port_name = location['port_name'].unique()
```

In [79]:

```
joinres.head()
```

Out[79]:

_time	position_accuracy	mmsi	sog	cog	geometry	index_right	field_1	size
9-04- .153Z	0.0	316013808	3.0	319.500000	POINT (-63.55608166666666 44.624835)	NaN	NaN	NaN
9-04- .273Z	0.0	316013808	3.0	320.700012	POINT (-63.55605333333333 44.62481666666667)	NaN	NaN	NaN
9-04- .340Z	0.0	316013808	2.9	319.500000	POINT (-63.55613833333334 44.62486833333333)	NaN	NaN	NaN
9-04- .087Z	0.0	316013808	3.0	319.799988	POINT (-63.55618666666667 44.62489833333333)	NaN	NaN	NaN
9-04- .358Z	0.0	316013808	3.2	337.200012	POINT (-63.55599833333334 44.62488333333334)	NaN	NaN	NaN

In [80]:

```
tmp=joinres.loc[joinres['index_right']=='auto_port',:]
```

In [83]:

```
from datetime import datetime
```

In [84]:

```
# change time string to datetime data type
joinres['event_time']=joinres['event_time'].apply(pd.to_datetime)
```

In [85]:

```
selected_ports = joinres.loc[joinres['index_right']=='auto_port',:]
```

In [86]:
```
selected_ports.head(3)
```

Out[86]:

	Unnamed: 0	event_time	position_accuracy	mmsi	sog	cog	g
3124	3124	2019-06-28 09:54:52.526000+00:00	0.0	316013808	0.1	59.700001	(-63.5124266 44.6205416
3125	3125	2019-06-28 09:54:52.526000+00:00	0.0	316013808	0.1	59.700001	(-63.5124266 44.6205416
3126	3126	2019-05-18 10:18:55.155000+00:00	0.0	316013808	0.0	24.299999	(-63.5123616 44.6205016

In [87]:
```
min_time=np.min(selected_ports['event_time'])
```

In [88]:
```
max_time = np.max(selected_ports['event_time'])
```

In [89]:
```
selected_ports.sort_values(['event_time'])
```

4862	4862	2019-07-08 20:26:16.411000+00:00	0.0	316013808	0.1	245.600006	(-63.511 44.6198
4863	4863	2019-07-08 20:26:32.302000+00:00	0.0	316013808	0.1	245.600006	POI
4914	4914	2019-07-08 20:26:36.544000+00:00	0.0	316013808	0.1	245.600006	(-63.511
4858	4858	2019-07-08 20:27:05.878000+00:00	0.0	316013808	0.8	241.100006	(-63.511 44.6198
4996	4996	2019-07-08 20:27:32.234000+00:00	0.0	316013808	0.2	222.899994	POIN 44.6197
5012	5012	2019-07-08 20:28:33.706000+00:00	0.0	316013808	0.4	217.199997	(-63.511 44.6197

In [90]:
```
selected_ports['hour'] = selected_ports['event_time'].dt.hour
```

```
C:\Users\lanch\Anaconda3\lib\site-packages\ipykernel_launcher.py:1: SettingWith
CopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/stab
le/indexing.html#indexing-view-versus-copy (http://pandas.pydata.org/pandas-doc
s/stable/indexing.html#indexing-view-versus-copy)
  """Entry point for launching an IPython kernel.
```

In [91]:
```
selected_ports.head(3)
```

Out[91]:

position_accuracy	mmsi	sog	cog	geometry	index_right	field_1	size	hour
0.0	316013808	0.1	59.700001	POINT (-63.5124266666667 44.62054166666667)	auto_port	8.0	0.0015	9
0.0	316013808	0.1	59.700001	POINT (-63.5124266666667 44.62054166666667)	auto_port	8.0	0.0015	9
0.0	316013808	0.0	24.299999	POINT (-63.5123616666666 44.62050166666667)	auto_port	8.0	0.0015	10

In [92]:
```
hour=selected_ports.groupby('hour').count()
```

In [93]:

```
hour
```

Out[93]:

	Unnamed: 0	event_time	position_accuracy	mmsi	sog	cog	geometry	index_right	field_1	s
hour										
0	192	192	0	192	0	0	192	192	192	
1	5	5	0	5	0	0	5	5	5	
9	209	209	75	209	75	75	209	209	209	
10	226	226	138	226	138	138	226	226	226	
13	18	18	18	18	18	18	18	18	18	
14	142	142	142	142	142	142	142	142	142	
15	80	80	80	80	80	80	80	80	80	
16	28	28	28	28	28	28	28	28	28	
17	120	120	120	120	120	120	120	120	120	
18	125	125	125	125	125	125	125	125	125	
19	569	569	367	569	367	367	569	569	569	
20	295	295	295	295	295	295	295	295	295	
21	36	36	36	36	36	36	36	36	36	
22	1	1	0	1	0	0	1	1	1	
23	22	22	22	22	22	22	22	22	22	

In [94]:

```
hour_density=hour['event_time']
```

In [95]:

```
hour_index=hour_density.index
```

In [96]:

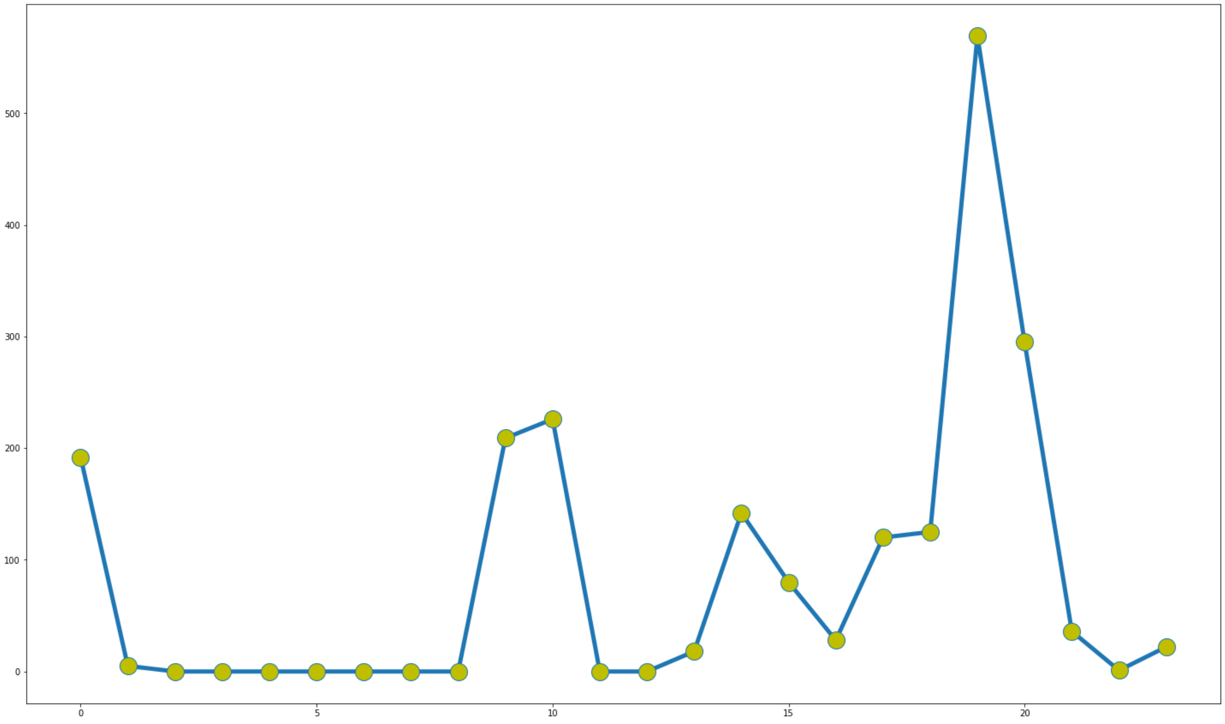
```
hour_density_24 = []
for i in np.arange(24):
    d = 0
    if i in hour_index:
        d= hour_density[i]
    hour_density_24.append(d)
```

```
In [97]: hour_density_24
```

```
Out[97]: [192,
          5,
          0,
          0,
          0,
          0,
          0,
          0,
          0,
          209,
          226,
          0,
          0,
          18,
          142,
          80,
          28,
          120,
          125,
          569,
          295,
          36,
          1,
          22]
```

```
In [98]: fig,axes = plt.subplots(figsize=(25,15))
         axes.plot(hour_density_24,marker='o',markersize=20,lw=5,markerfacecolor='y')
```

```
Out[98]: [<matplotlib.lines.Line2D at 0x1a8bf3df320>]
```



5. Use concept drift methods on step 4 and find out if there is any drift in the data that can be detected. Try to play with the input parameters and justify the one you chose. Explain why the drift was detected, what characteristics changed? (25 points)

In [99]:

```
#https://scikit-multiflow.github.io/scikit-multiflow/skmultiflow.drift_detection.
from skmultiflow.drift_detection import PageHinkley
ph = PageHinkley(min_instances=6, delta=0.0005, threshold=5, alpha=0.9999)
j=0
for i in hour_density_24:
    ph.add_element(i)
    if ph.detected_change():
        print('Change has been detected in data: ' + str(i) + ' - of index: ' + s

        j=j+1
```

```
Change has been detected in data: 209 - of index: 9
Change has been detected in data: 142 - of index: 14
Change has been detected in data: 569 - of index: 19
```

Explanation:

- The drift was detected at 9,14,19 o'clock.
  1. The drift detected at 9 o'clock, because the port is opening at 9, so the density will increase.
  2. The drift detected at 14 o'clock, it might because it's the beginning of the second half of a day, people take the vessel to the destination.
  3. The drift detected at 19 o'clock, it might because it's the end of the work, school, people take the vessel to go home or somewhere else.

6. Cluster the ports based on their message density using DBSCAN and categorize the ports based on traffic (message density). (25 points)

In [100]:
```
joinres.head(3)
```

Out[100]:

	Unnamed: 0	event_time	position_accuracy	mmsi	sog	cog	geo
0	0	2019-04-11 09:47:30.153000+00:00	0.0	316013808	3.0	319.500000	(-63.55608166 44.6
1	1	2019-04-11 09:47:27.273000+00:00	0.0	316013808	3.0	320.700012	(-63.55605333 44.6248166666
2	2	2019-04-11 09:47:34.340000+00:00	0.0	316013808	2.9	319.500000	(-63.55613833 44.624868333

In [101]:
```
m_desity=joinres.groupby('index_right').count()['event_time']
```

In [103]:
```
m_desity.index
```

Out[103]:
```
Index(['Fairview cove', 'armament', 'auto_port', 'ind', 'oulier_maybecday',
       'p010', 'po001', 'pointpolygon', 'port1', 'port2', 'port7',
       'south_enterance', 'southend container terminal', 'waterfront h'],
      dtype='object', name='index_right')
```

In [106]:
```
message_density = pd.DataFrame(np.zeros(len(port_name)),columns=['density'],index
```

In [107]:

```
message_density
```

Out[107]:

	density
pointpolygon	0.0
port1	0.0
port2	0.0
ind	0.0
port5	0.0
port6	0.0
port7	0.0
south_enterance	0.0
auto_port	0.0
southend container terminal	0.0
NN Jetty	0.0
Bills island	0.0
mid bedford	0.0
Fairview cove	0.0
armament	0.0
waterfront h	0.0
northarm	0.0
plll	0.0
pp	0.0
po001	0.0
po002	0.0
oulier_maybecday	0.0
p003	0.0
enter2	0.0
p009	0.0
p010	0.0

In [108]:

```
for port in port_name:
    if port in m_desity.index:
        message_density['density'][port] = m_desity[port]
```

In [109]:
```
message_density
```

Out[109]:

	density
pointpolygon	153.0
port1	13.0
port2	119.0
ind	5.0
port5	0.0
port6	0.0
port7	703250.0
south_enterance	39.0
auto_port	2068.0
southend container terminal	7544.0
NN Jetty	0.0
Bills island	0.0
mid bedford	0.0
Fairview cove	1481.0
armament	14.0
waterfront h	229.0
northarm	0.0
plll	0.0
pp	0.0
po001	1445.0
po002	0.0
oulier_maybecday	255.0
p003	0.0
enter2	0.0
p009	0.0
p010	6.0

In [110]:
```
message_density['density']=message_density['density'].apply(int)
```

In [111]:
```
X = []
for i in message_density['density']:
    a = np.array([i])
    X.append(a)
```

In [112]:
```
X
```

Out[112]:
```
[array([153]),
 array([13]),
 array([119]),
 array([5]),
 array([0]),
 array([0]),
 array([703250]),
 array([39]),
 array([2068]),
 array([7544]),
 array([0]),
 array([0]),
 array([0]),
 array([1481]),
 array([14]),
 array([229]),
 array([0]),
 array([0]),
 array([0]),
 array([1445]),
 array([0]),
 array([255]),
 array([0]),
 array([0]),
 array([0]),
 array([6])]
```

In [114]:
```
# applying DBSCAN in the message density data
# refer to https://scikit-learn.org/stable/modules/generated/sklearn.cluster.DBSC
from sklearn.cluster import DBSCAN
clustering = DBSCAN(eps=3, min_samples=2).fit(X)
```

In [115]:
```
clustering.labels_
```

Out[115]:
```
array([-1,  0, -1,  1,  2,  2, -1, -1, -1, -1,  2,  2,  2, -1,  0, -1,  2,
        2,  2, -1,  2, -1,  2,  2,  2,  1], dtype=int64)
```

In [116]:
```
message_density['class']=clustering.labels_
```

In [117]:
```
message_density.sort_values('class')
```

Out[117]:

	density	class
pointpolygon	153	-1
port2	119	-1
oulier_maybecday	255	-1
po001	1445	-1
waterfront h	229	-1
port7	703250	-1
south_enterance	39	-1
auto_port	2068	-1
southend container terminal	7544	-1
Fairview cove	1481	-1
port1	13	0
armament	14	0
p010	6	1
ind	5	1
Bills island	0	2
NN Jetty	0	2
port6	0	2
northarm	0	2
plll	0	2
pp	0	2
port5	0	2
po002	0	2
p003	0	2
enter2	0	2
p009	0	2
mid bedford	0	2

In [132]:

```
for index, row in message_density.iterrows():
    if row['class']==-1:
        message_density.loc[index]['class'] = 'High'
    if row['class']==0:
        message_density.loc[index]['class'] = 'Medium'
    if row['class']==1:
        message_density.loc[index]['class'] = 'Low'
    if row['class']==2:
        message_density.loc[index]['class'] = 'None'
```

In [124]:

```
message_density
```

Out[124]:

	density	class
pointpolygon	153	-1
port1	13	0
port2	119	-1
ind	5	1
port5	0	2
port6	0	2
port7	703250	-1
south_enterance	39	-1
auto_port	2068	-1
southend container terminal	7544	-1
NN Jetty	0	2
Bills island	0	2
mid bedford	0	2
Fairview cove	1481	-1
armament	14	0
waterfront h	229	-1
northarm	0	2
plll	0	2
pp	0	2
po001	1445	-1
po002	0	2
oulier_maybecday	255	-1
p003	0	2
enter2	0	2
p009	0	2
p010	6	1

In [126]:
```
def replace_class(className):
    if className == -1:
        return 'High'
    if className == 0:
        return 'Medium'
    if className == 1:
        return 'Low'
    if className == 2:
        return 'None'
```

In [128]:
```
message_density['class']=message_density['class'].apply(replace_class)
```

In [131]:
```
message_density.sort_values('class')
```

Out[131]:
```
                              density   class
                pointpolygon      153    High
              oulier_maybecday    255    High
                         port2    119    High
                         po001   1445    High
                   waterfront h    229    High
                  Fairview cove   1481    High
                         port7 703250    High
               south_enterance     39    High
                     auto_port   2068    High
   southend container terminal   7544    High
                          p010      6     Low
```

- After clustering, we categorized the ports into 4 classes, they represent different levels of travelling density.
  1. High travelling density: pointpolygon, oulier_maybecday, port2, po001, waterfront h, Fairview cove, port7, south_enterance, auto_port, southend container terminal
  2. Medium travelling density: armament, port1
  3. Low travelling density: p010, ind
  4. None travelling density: Bills island, p009, port6, port5, northarm, plll, pp, po002, p003, enter2, NN Jetty, mid bedford

References
1. Medium. (2019). GeoPandas 101: Plot any data with a latitude and longitude on a map. [online] Available at: https://towardsdatascience.com/geopandas-101-plot-any-data-with-a-latitude-and-longitude-on-a-map-98e01944b972 [Accessed 5 Aug. 2019].

2. GeoPandas?, C. (2019). Changing colours in GeoPandas?. [online] Geographic Information Systems Stack Exchange. Available at: https://gis.stackexchange.com/questions/152920/changing-colours-in-geopandas [Accessed 5 Aug. 2019].
3. Darribas.org. (2019). lab_03. [online] Available at: http://darribas.org/gds15/content/labs/lab_03.html [Accessed 5 Aug. 2019].
4. Referred the lab tutorials of the Data Science course
5. Scikit-multiflow.github.io. (2019). skmultiflow.drift_detection package — scikit-multiflow 0.1.4 documentation. [online] Available at: https://scikit-multiflow.github.io/scikit-multiflow/skmultiflow.drift_detection.html [Accessed 5 Aug. 2019].

In [ ]: