Geostatistical Analysis of Street Sweeping as a Water Management Tool for the County of San Diego

Darren Chen

GIS 112

Professor David Palomino

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INTRODUCTION

On the 23rd of February, 2015 The San Diego County Department of Environmental health issued a general advisory for coastal users (surfers, swimmers, and other ocean recreationists) that the levels of bacteria can significantly rise along the coast, creeks, and rivers of San Diego. Cautionary beach advisories are commonly issued when rainfall reaches 0.20 inches or greater.

Coastal recreationists across Southern California are advised to avoid contact with ocean and bay waters for 72 hours as a rule of thumb.[1] A surfer who did not heed the 72 hour caution died from a staph infection that authorities believe was caused by storm water runoff. The Department of Environmental health posts warnings within 150 feet of urban runoff drains along the beaches, and people are advised to stay at a minimum of 75 feet from where the runoff water enters the water on dry days[2]. The disease causing bacteria, viruses and protozoa come from four major sources:

- **Environment** - soils, decaying vegetation, etc.
- **Storm Water/ Urban Runoff** - storm drains, road ways

[1] County of San Diego County Beach Water Quality - Historical Reports and Summaries: http://www.sdbeachinfo.com/#

[2] Land and Water Quality Division Beach and Bay Monitoring Program http://www.sandiegocounty.gov/content/dam/sdc/deh/lwqd/Beach&Bay/bb_beach_water_quality_info.pdf

- **Animal Wastes** - dogs, cats, seals
- **Humans** - sewage, cigarette butts, trash

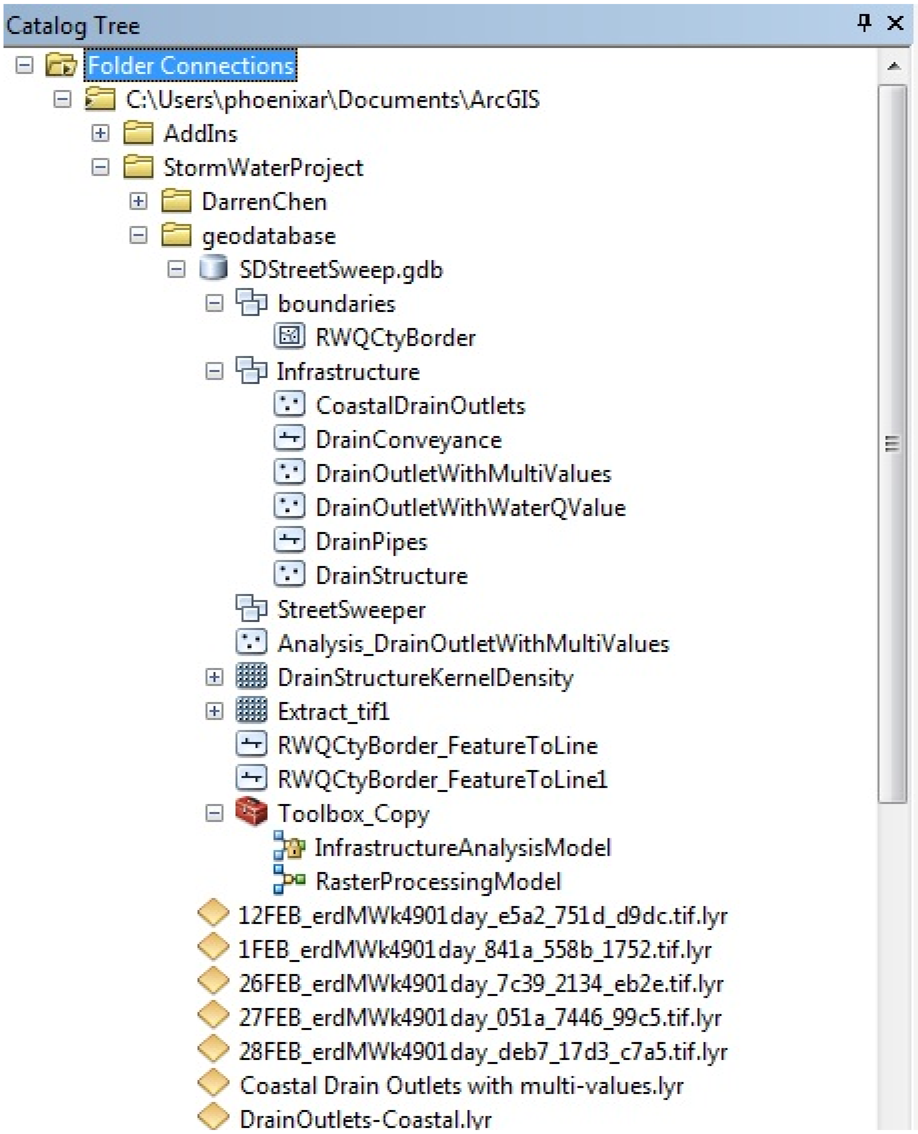
An environmental study found that an average of 20.25 tons of street pollution are collected per street-mile[3]. *The purpose of this project is to analyze the utility of street sweeping as a water quality management tool for the County of San Diego.*

The variables that will be compared in this project are: **coastal water quality** and **street sweeping schedule** for the County of San Diego. Satellite imagery of the San Diego coast is the data source to represent the coastal water quality. The street sweeping schedule is available in tabular files from SANGIS. Each of these datasets will be processed, and analyzed with geostatistical tools in the ARCGIS software suite.

The null hypothesis for the statistical analysis is as follows: *historically, the quality of water surrounding any given storm drain outlet is not affected by sweeping the streets around the respective drain inlets*. The question to be answered is: **Did street sweeping decrease the turbidity of water down the storm drain especially before a precipitous event?**

[3] McCarthy, G. 2005. Connecticut Department of Environmental Protection.*Guidelines for Municipal Management Practices for Street Sweepings and Catch Basin Cleanings*.

DATA



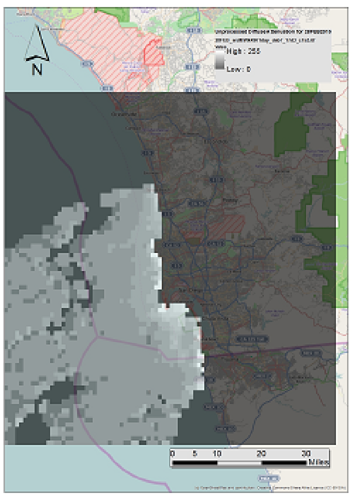
The project data was organized in a File Geodatabase with ARC Catalog. Data collection sources are summarized below:

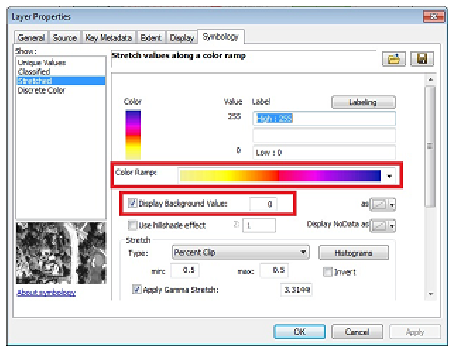
Data:	**Source:**
Water quality	NOAA - ERDDAP site
Precipitous Events	Weather Underground
San Diego Drain Infrastructure	SanGIS
Street Sweeping Schedule and Locations	SanGIS

Data: How bad is the water?

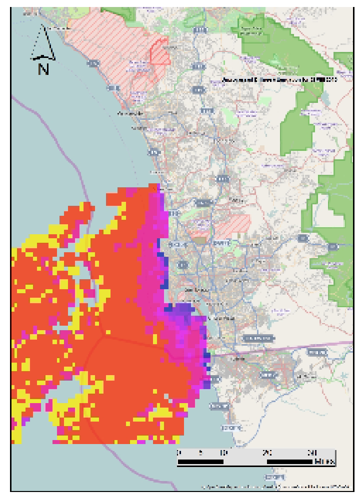
The NOAA ERDDAP website[4] contains raster data that's collected a variety of satellite platforms, such as sea surface salinity/temperature/currents/winds, chlorophyll-a, coral reef watch, fluorescence. Among these satellite platforms, I chose to focus on Diffuse Attenuation data for this project because at a 480 nm wavelength, it is indicative of the turbidity of a water column. This means it is not only limited to a study of algal plumes (as represented by satellite platforms for chlorophyll-a), but is applicable for modeling other particulate matter at greater range of water depths[5].

San Diego Coastal Water Satellite Image 28FEB





San Diego Coastal Water Satellite Image 28FEB PROCESSED



The unprocessed raster on the left was misleadingly symbolized. Pixels containing zero values were represented as black, so the color ramp was applied, the Background value was set to zero and left totally transparent. The result is the map on the right, where turbid waters with are represented according to the selected color ramp.

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[4] http://coastwatch.pfeg.noaa.gov/erddap/griddap/index.html

[5] http://www.dhi-gras.com/products/nearrealtime/diffuseattenuationcoefficient

Data: When did it rain?

Archived data concerning average precipitation in San Diego was collected from WeatherUnderground.

Rainy Days (2015)	Precipitation (Inches)
January 11	.2
January 12	.17
January 26	.04
January 29	T (too much to measure)
January 30	T (too much to measure)
February 22	T (too much to measure)
February 28	T (too much to measure)

Data: What is the connection between beach water quality and the street? (Answer: Infrastructure)

The storm drain infrastructure is an important part of the model that connects the water quality data together with the street sweeping data. Locations with water quality will be traced back up the drain outlet, through the drainage pipes, to the respective drain inlets on the streets. The drain infrastructure data was collected from SanGIS. The drain structures shapefile had 55’186 point features representing inlets, outlets, cleanouts, caps, headwalls, and lugs. The drainage pipe shapefile segments were represented by 48’463 line features.

Data: What days were the streets swept?

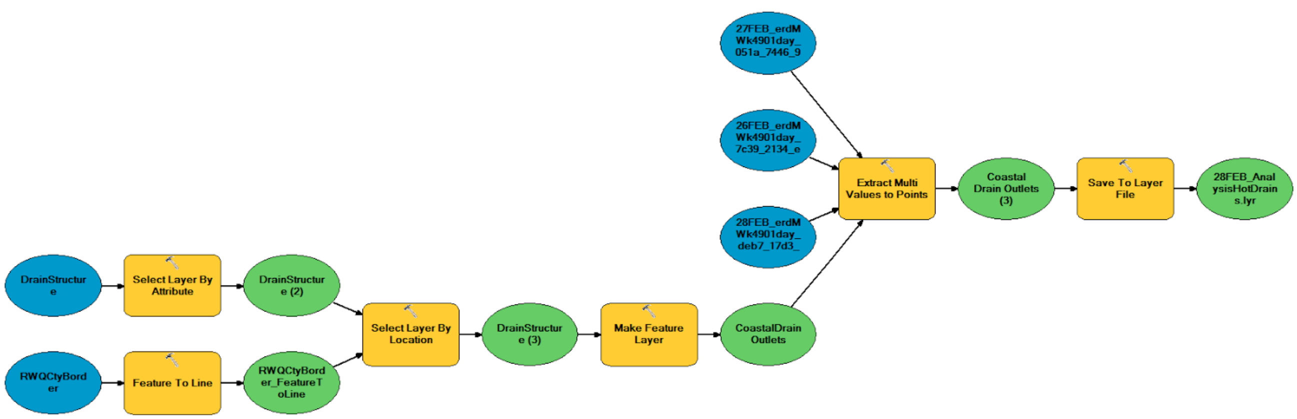
The street sweeping data was also collected from SanGIS, in the form of a spreadsheet for each of the 8 street sweeping districts. Each spreadsheet contained about 3’000 to 5’000 block segments. Each block segment was represented with a written description of the sweeping schedule as posted on

61	54TH ST	4900	4999	4900 - 4999	BAJA DR	FABER WY	BAJA DR - FABER WY	Not Posted, Both Sides Even Month 3rd Thu
62	54TH ST	5000	5079	5000 - 5079	FABER WY	FABER WY	FABER WY - FABER WY	Not Posted, Both Sides Even Month 3rd Thu
63	54TH ST	5080	5099	5080 - 5099	FABER WY	MONTEZUMA RD	FABER WY - MONTEZUMA RD	Not Posted, Both Sides Even Month 3rd Thu
64	54TH ST SB ON RA	0	0	0 - 0	ORANGE AV	54TH PL	ORANGE AV - 54TH PL	Not Posted, Both Sides 2nd Mon
65	55TH PL	5000	5099	5000 - 5099	DOROTHY DR	MARY LANE DR	DOROTHY DR - MARY LANE DR	Not Posted, Both Sides Even Month 3rd Thu
66	55TH ST	3400	3418	3400 - 3418	STREAMVIEW DF	MICHAEL ST	STREAMVIEW DR - MICHAEL ST	Not Posted, Both Sides Odd Month 4th Thu
67	55TH ST	3419	3499	3419 - 3499	MICHAEL ST	DWIGHT ST	MICHAEL ST - DWIGHT ST	Not Posted, Both Sides Odd Month 4th Thu
68	55TH ST	4500	4509	4500 - 4509	EL CAJON BL	GILBERT DR	EL CAJON BL - GILBERT DR	Not Posted, Both Sides Even Month 3rd Thu
69	55TH ST	4510	4599	4510 - 4599	GILBERT DR	MADISON AV	GILBERT DR - MADISON AV	Not Posted, Both Sides Even Month 3rd Thu
70	55TH ST	4600	4639	4600 - 4639	MADISON AV	SIESTA DR	MADISON AV - SIESTA DR	Not Posted, Both Sides Even Month 3rd Thu
71	55TH ST	4640	4699	4640 - 4699	SIESTA DR	ADAMS AV	SIESTA DR - ADAMS AV	Not Posted, Both Sides Even Month 3rd Thu
72	55TH ST	4700	4749	4700 - 4749	ADAMS AV	COLLIER AV	ADAMS AV - COLLIER AV	Not Posted, Both Sides Even Month 3rd Thu
73	55TH ST	4750	4799	4750 - 4799	COLLIER AV	REDLAND DR	COLLIER AV - REDLAND DR	Not Posted, Both Sides Even Month 3rd Thu
74	55TH ST	4800	4859	4800 - 4859	REDLAND DR	REDLAND DR	REDLAND DR - REDLAND DR	Not Posted, Both Sides Even Month 3rd Thu
75	55TH ST	5000	5069	5000 - 5069	DOROTHY DR	MARY LANE DR	DOROTHY DR - MARY LANE DR	Not Posted, Both Sides Even Month 3rd Thu
76	55TH ST	5070	5079	5070 - 5079	MARY LANE DR	MARY LANE DR	MARY LANE DR - MARY LANE DR	Not Posted, Both Sides Even Month 3rd Thu

the street. For example, "Not Posted, Both Sides Even Month 3rd Tue", or "Not Posted, Both Sides 3rd Mon". This field would need to be parsed in order to yield a functional feature layer in ARCMap. (The use of python scripting would be needed).

ANALYSIS

The data processing tools used to connect the water quality data with the storm drain outlets is outlined by the model builder below:

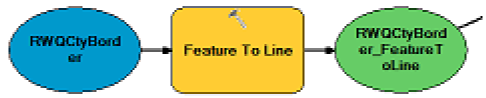


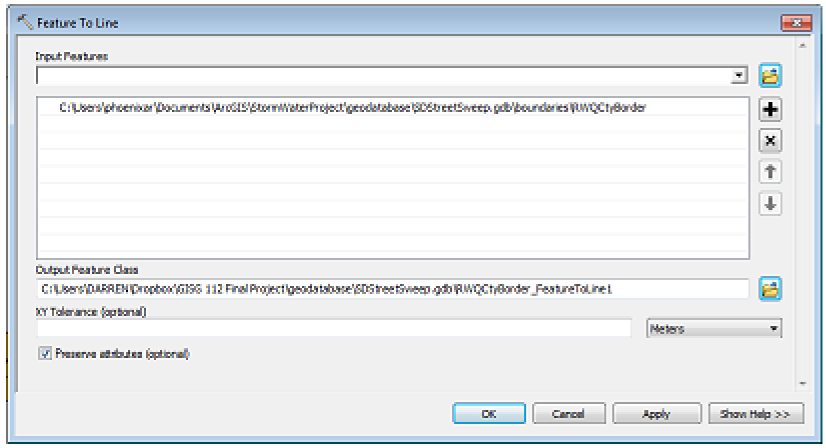
Select Layer By Attribute

Only the storm drain outlets along the San Diego coastline was desired for the project analysis. To select only the drain outlets, selected the only the point features that were coded as outputs. There are drain outlets dispersed throughout the county. Only a fraction of them are located along the coast.

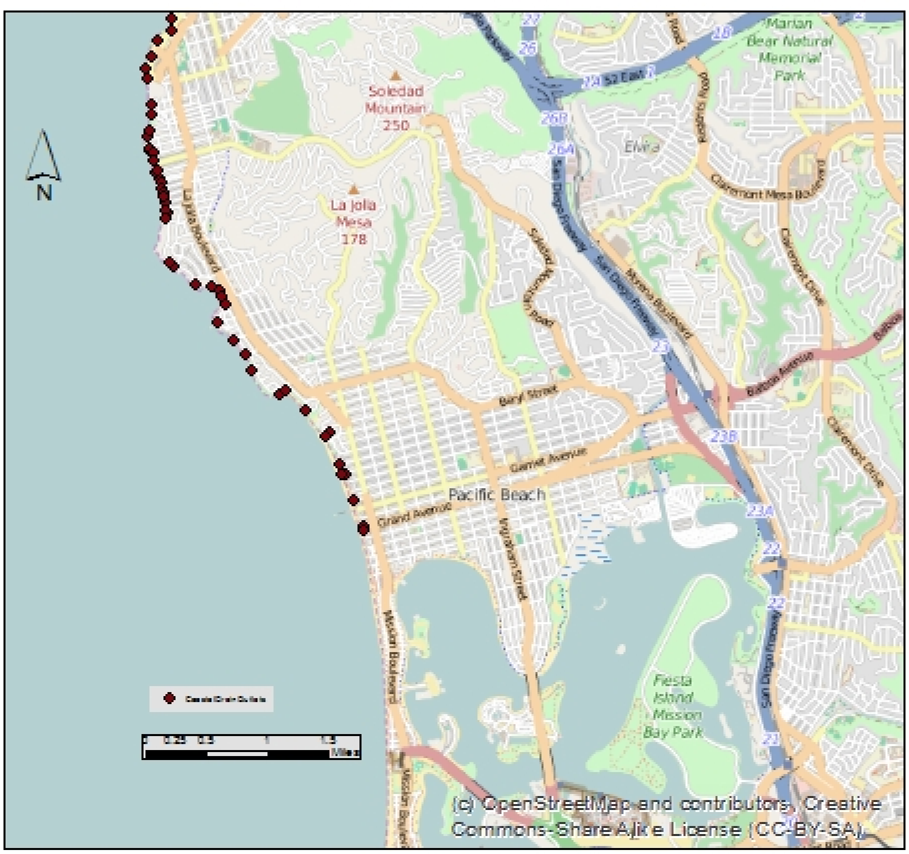
Feature to Line

The San Diego County Water Authority's jurisdictional shapefile served as a clipping feature because it outlines the coastline. The border shapefile was a polygon, so if used without processing all of the storm drains underneath the polygon would have been selected. The "FEATURE TO LINE" tool was used to convert the border of the polygon into a line that would serve to as a clipping feature.





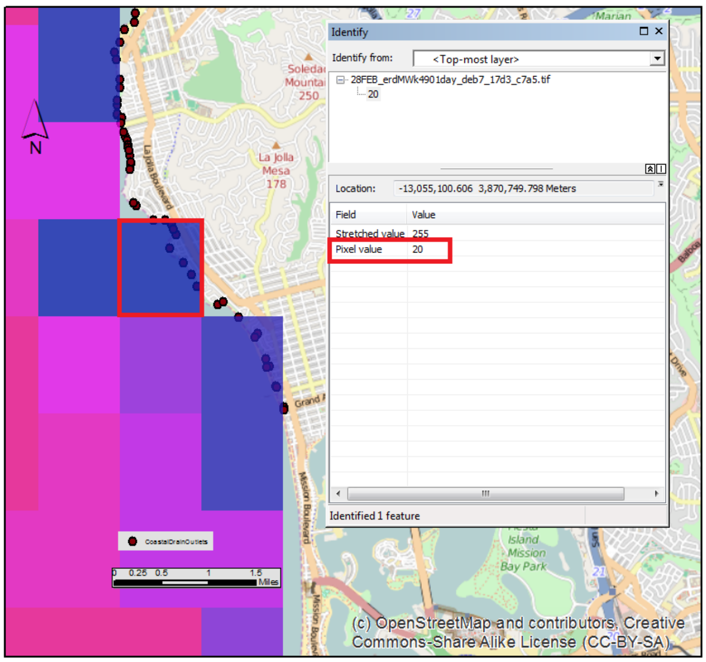
Coastal Street Drain Pipes



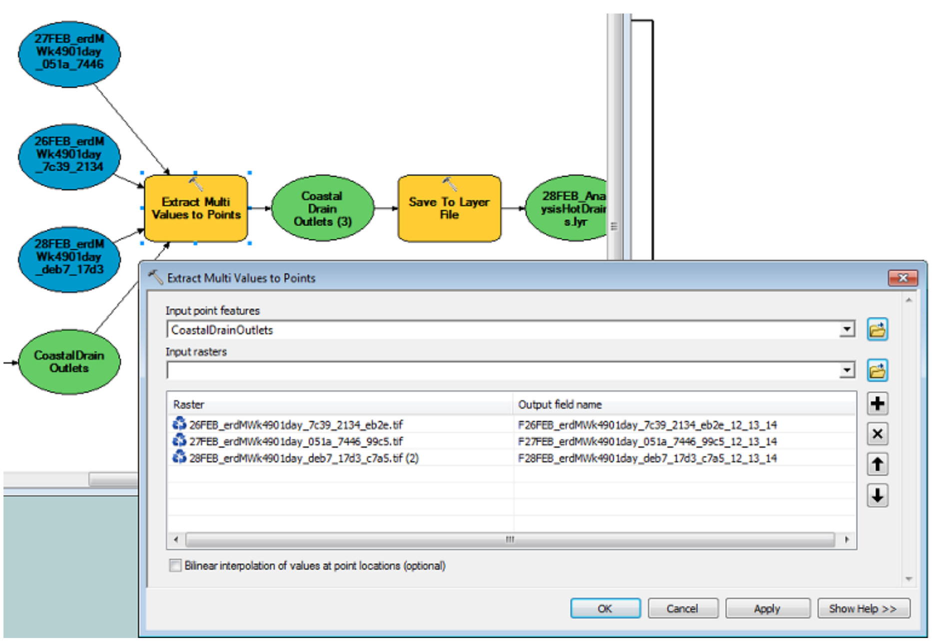
The result is a selection of the drain outlets along the San Diego coastline.

Each pixel of the satellite raster had a value which represented the amount of turbid sediments in milligrams per cubic meter.

Coastal Street Drain Pipes



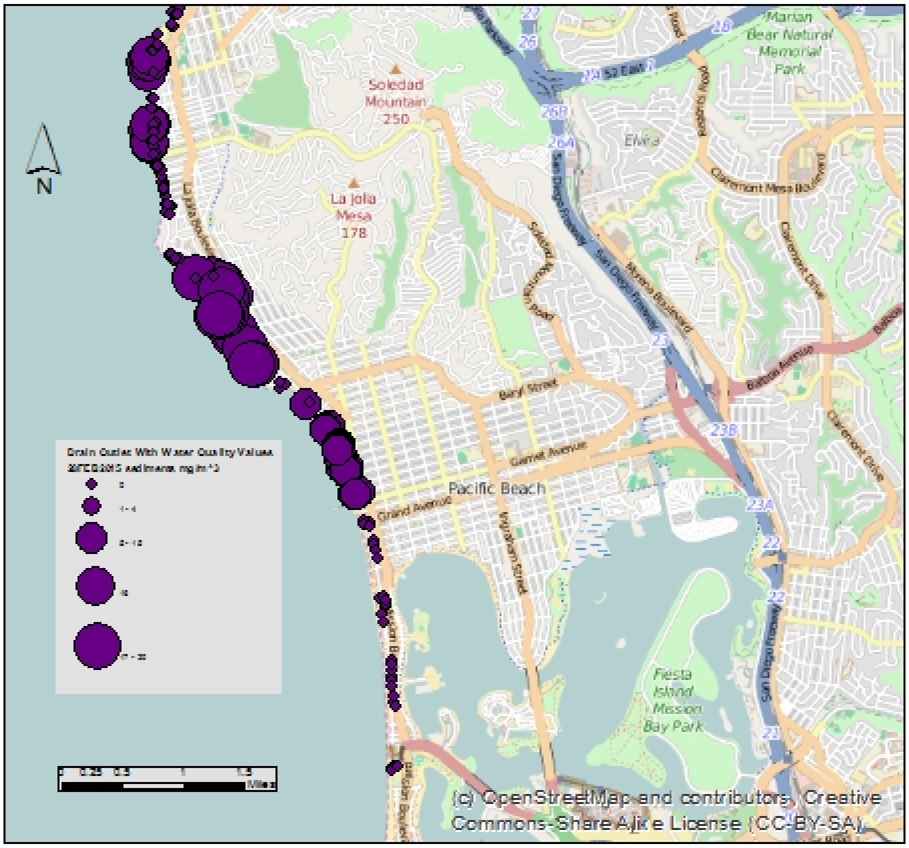
Extract Values to Points



The "Extract Multi Values to Points" tool was used to add the water quality data to the storm drain outlet data table. Data from multiple rasters can be added to this tool and each additional raster would create it's own field in the input point feature's data table.

FINDINGS AND OUTPUT

Coastal Drain Pipes with Water Quality Data for 28 February 2015



The result of the analysis is point feature class of the storm drains with the respective water quality for a particular day of the year.

CONCLUSION and CLOSING THOUGHTS

So far, I am only able to draw conclusions from analyzing one day of the year. During the heaviest storm of the month on the 28th of February, 2015, the water (at 20 mg of sediments per cubic meter) was it's poorest quality at the beaches of La Jolla Cove and at a segment of the Sunset Cliffs area (see final map on next page) when compared to the rest of San Diego. This conclusion was drawn just from the symbology of the storm drains on the previous map. A geostatistical analysis would be possible upon the geocoding of the street sweeping data. However, the complexity of such data processing would require the use of scripted programming to create.

To outline of the expected processing for the next phase of this project:

1. Run the model created in the current stage of the project over multiple days in order to expand the n value for statistical analysis. In other words, run the model for all of the satellites images for an entire 12 month period.

2. Create a relationship class in the geodatabase between the drain structures (points) and the drain conveyance (lines).
3. Use a database management tool to import the coastal water quality data from the drain outlets (created) to the drain inlets.
4. Geocode the street sweeping data with consideration to the schedule in order to create a buffer over the drain inlets. (this will require python scripting due to the high volume of segmented data in each spreadsheet file
5. Perform a Spatial Join of the drain inlets with the street sweeping polygons. Each polygon represents an area that is swept for a particular date.
6. Run a Getis-Ord analysis examining the correlation between the water quality data and the street sweeping data.

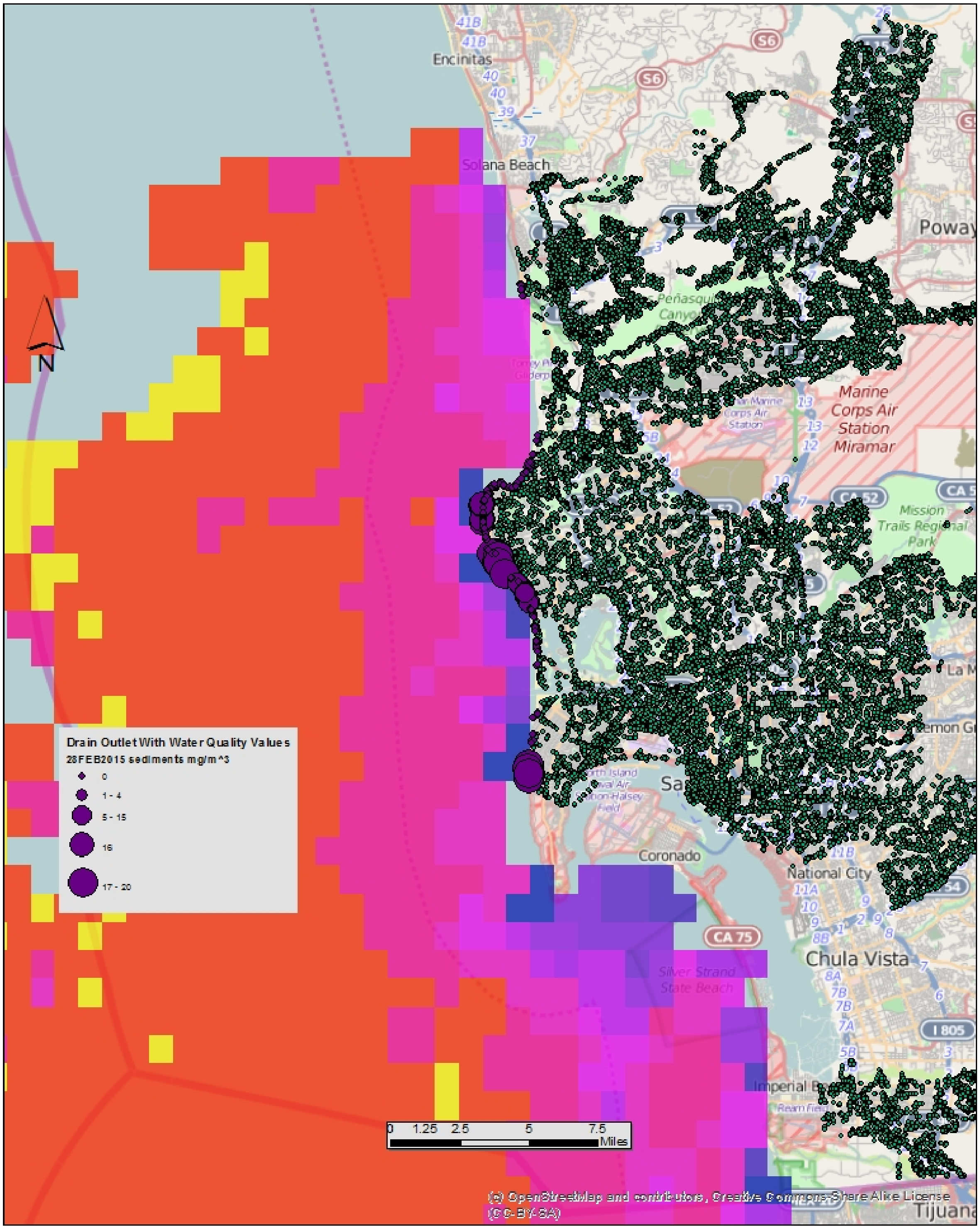
Other considerations for future research on this topic

The extraction of the satellite raster values onto the storm drain outlets was imperfect due to the low spatial resolution of the raster. Each raster pixel was 1600 meters by 1600 meters, so one can assume that there is very a wide margin of error when examining the geostatistical correlation between street sweeping across a few blocks and the respective water quality. For a visual example, there is a large gap in data over La Jolla Cove, Mission Bay, and the San Diego Bay (see final map).

On site water quality data would be especially helpful in determining the relevance of the satellite imagery and the actual quality of the water.

The precipitation data was insufficient to describe the amount of rainwater that fell on the heaviest thunderstorms. The data source weather underground only acknowledged that there was precipitation on the dates where there was more than one inch of rain.

Coastal Drain Pipes with Water Quality Data for 28 February 2015



Works Cited

"County of San Diego Beach Water Quality." *County of San Diego Beach Water Quality*. Web. 19 Mar. 2015. <http://www.sdbeachinfo.com/#>.

"Diffuse Attenuation Coefficient." *Diffuse Attenuation Coefficient*. Web. 19 Mar. 2015. <http://www.dhi-gras.com/products/nearrealtime/diffuseattenuationcoefficient>.

Land and Water Quality Division Beach and Bay Monitoring Program http://www.sandiegocounty.gov/content/dam/sdc/deh/lwqd/Beach&Bay/bb_beach_water_quality_info.pdf

McCarthy, G. 2005. Connecticut Department of Environmental Protection.*Guidelines for Municipal Management Practices for Street Sweepings and Catch Basin Cleanings*.