Lab 3 – GEO 465/565
Storm Water Pollution
The Nation's Most Significant Water Quality Problem

Based on the Mapping an Ocean Sanctuary series of the Center for Image Processing in Education (www.evisual.org)

Introduction

Over the past twenty-five years the United States has made considerable progress in cleaning up our rivers, lakes and coastal waters by controlling pollution from industry and sewage treatment plants. Why then does so much of our water remain too dirty for swimming, fishing or drinking? And why are many species of plants and animals disappearing from our waters? The problem, it now appears, is that we have not done enough to stop *storm water pollution,* or *non-point source pollution*, that runs off the land every time it rains.

Imagine the path that a drop of rain takes from its arrival on the ground to the time it reaches a river, lake or the ocean. Any pollutant that it picks up along the way may get deposited in nearby bodies of water unless the raindrop soaks into the ground before it reaches its destination. Even then, runoff can create a problem for ground water that, in many areas, is used for drinking.

1. What kinds of pollutants may be carried to our rivers and storm water run-off? List at least 3 different pollutants.

   A. Copy and Paste the **Lab_3** folder from the 565 data folder into your student directory (or distance ed students, download **lab3_data.zip** from Blackboard).

   B. Start *ArcMap*. Open the **StormH2O.mxd** project in the lab3_data folder.

   C. The project will open with the California **coast** view open, showing the California coastline, sanctuary boundary, the major islands within the sanctuary, and the topography and bathymetry of the area. *You may need to set your data source!*

   D. **Zoom in** on the coastline surrounding Santa Barbara and the sanctuary.

   E. Investigate the change in elevation. Activate the **Topography** layer by clicking on it. You can tell if it is activated by the blue bar in the background. Expand the Topography legend by clicking on the "+" symbol to the left of the layer name.

   F. Click on the Info tool ⓘ. Click on the highest spots (see legend for color) around Santa Barbara. Each time you click on a location, the elevation will be displayed in the Identify results window.

2. How high are the mountains surrounding Santa Barbara? Record the highest elevation you found.

G. Turn on the **Rivers** layer.

3. How do the mountains surrounding Santa Barbara effect run-off following storm events? Where does the storm water end up?

H. Turn off the **Topography** and **Rivers** layers, and close the Identify Window.

I. **Zoom-out** so you can see the California coast and sanctuary boundaries.

Each year winter storms wash excess nutrients, microorganisms, hazardous chemicals, sediments and debris into our coastal waters. This discharge enters the ocean as buoyant freshwater plumes which spread out over the ocean's surface. In February 1998, storms generated by El Niño resulted in two-thirds of the Santa Barbara Channel being inundated with freshwater run-off, which spreads across the ocean surface forming a large sediment **plume** (A sediment plume is a visible pattern of nutrient rich, brown sediment that forms a kind of cloud in the water spreading out from the coastline.) This plume affects both biological and chemical processes in the channel. Large amounts of mud and terrestrial sediments in the plume reflected the sunlight, reducing the amount of light available to algae on the sea floor.

J. Turn on and activate the **Turbidity_02/09/98** theme. Turbidity is a measure of water clarity.

High amounts of suspended soil, plankton, and small fragments of dead plant material increase the turbidity and change the color of the water. The turbidity data was collected by a satellite with SeaWiF (**Sea**-viewing **W**ide **F**ield-of-View) sensors as it passed over the California coast. The SeaWiF sensors measure the amount of light reflectance. Deeper shades of orange indicate higher levels of suspended sediments.

K. Outline the areas of the sediment plume with values higher than **10**, shown in orange.
- Drop down the **Turbidity_02/09/98** legend.

- Make sure the DRAW tool bar is turned on. (See your lab note book, or previous lab to see how to turn on the different tool bars)

- Activate the New FreeHand Tool

-
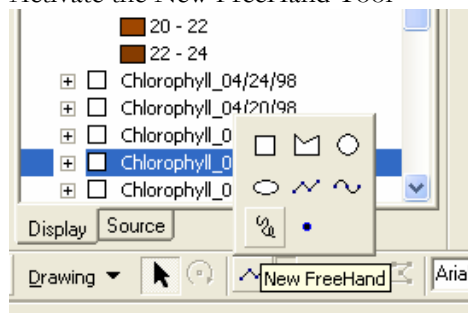
- **Click and hold** – and trace around the areas with a plum value higher than 10, when your done, release the mouse button. The line will be a graphic overlaid your map. *If you make a mistake you can select the drawing you made with the "Select Elements" arrow on the main tool bar and hit the "Delete" button on the keyboard.*

- There are other drawing tools that would work to outline the plume, experiment with a few of them on the Drawing tool bar.

4. Which tool works best for outlining the Plume? Why?

- *Note: Your line doesn't have to be perfect. We are trying to identify areas with higher concentrations of sediments in order to see how long it takes the sediments to settle out. In reality, the sediment plume stretches virtually across the Santa Barbara Channel where it meets up with smaller plumes originating from the islands themselves.*

L. Measure the width of the plume at its widest point (running east to west) *from Santa Barbara towards Santa Cruz.* For our purposes, use the line you just drew, showing the areas with sediment values higher than **10**.
- Click on the **Measure** Tool from the Basic Tool Bar.
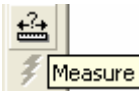
5. Measuring just the areas with sediment values higher than 10, how wide was the sediment plume on February 9, 1998? Which islands were most affected by the run-off?

M. Follow the growth and decline of the sediment plume. One by one, turn on the remaining turbidity themes. *Note: only one turbidity theme is visible at a time. The top-most turbidity theme that is turned on will cover the other themes.*

6. What happens to the sediment plume in April, after the winter storms subside?

7. Imagine you are a mussel, living attached to the bottom of the sea floor. What effect might the sediment from the plume have on you?

N. Turn off all of the **Turbidity** themes, and minimize all their legends (click on the "-" symbol.)

In April 1998, after the sediments had settled out of the water column and the water temperature began to rise; excess nutrients left behind by the sediment plume triggered a rapid growth of single-celled algae, called a *phytoplankton bloom.*

O. One by one, turn on the **Chlorophyll** themes. These images were also captured by the SeaWiF sensors. Oranges and reds indicate high concentrations of chlorophyll, a photosynthetic pigment used by plants and algae. Yellows and greens indicate low concentrations of chlorophyll.

8. Did the phytoplankton bloom grow or shrink between February and April? How do you know?

9. What effect would a large phytoplankton bloom have on the ecosystem? Consider food, dissolved nutrients and oxygen availability initially and after a few weeks.

Urban Pollution

Much of the sediment seen in the SeaWiF images resulted from agricultural, forestry and land development practices in the regions surrounding Santa Barbara. Clear cutting forests, grading land for development projects, and plowing under agricultural fields, all remove natural vegetation and increase erosion. Without plants to anchor the topsoil, it can wash or blow away during storm events and increase sedimentation in our rivers and oceans. Excess sediments are also problematic because they provide a substrate to which pollutants may adhere.

In the city, storm water run-off is likely to encounter and pick up a pollutant, such as motor oil, household chemicals, pet wastes, etc. Excess sediments and nutrients (from lawn fertilizers) are also pollutants. If the water encounters a patch of lawn to soak into, the pollutant might not reach a nearby creek. But if the run-off doesn't flow across any soil or grass along the way, because it keeps encountering hard, *impervious* surfaces, it may well make its way into a storm drain and then all the way from the creeks into the ocean. When all the drops of polluted water from our urban areas are added up, the problem becomes immense. Urban storm water runoff in the United States carries the equivalent of ten supertankers full of oil into our oceans every year, a drop at a time!

Urban areas contribute greatly to water pollution problems because of the higher concentration of hazardous chemicals and other contaminants (more people, cars, factories, etc.) and the greater proportion of impervious surfaces. (In rural areas, the majority of the pollutants are from agricultural sources such as fertilizers or manure.) In urban areas, impervious surfaces first collect pollutants and then allow the pollutants to wash off and to enter our waterways during rainstorms.

10. In a city, common surfaces include **asphalt streets**, **concrete sidewalks**, **landscaped medians**, **bricked walkways**, **dirt patches**, **grass filled parks**, **tarred roof tops**, and **marble walkways**. Decide if each represents a pervious (water can penetrate and soak through to the ground) or an impervious surface, and note it in your write up.

In the remainder of this lesson we will show how GIS technology can be used to identify areas that are contributing the most to the problem and look at one way we might reduce storm water pollution in urban areas.

Santa Barbara: A Case Study

Santa Barbara is a small city along the California coast. Santa Barbara's economy depends on the health of the ocean along its beaches and piers to support outdoor recreation and a very large tourist industry. Most of the time when it rains in Santa Barbara, the beaches have to be closed because of high levels of bacteria in the water, a strong indication that the ocean is being seriously affected by pollution coming off the land.

Rainstorms in Santa Barbara are intense, and rainfall can be too high for the impervious surfaces to handle. Storm water pools on the sidewalk before it flows down the streets and into a storm drain along the curb. From there the water enters a network of pipes that deliver it directly to the creeks which empty into the ocean. Unless it soaks into the ground along the way, storm water in Santa Barbara is not filtered. We have to watch polluted storm water flow by and put up with the damage it causes. Or do we?

11. Suggest 3 things city officials could do to keep polluted storm water from reaching the ocean.

One easy thing to do would be if we could sweep all the streets in town just before a heavy rain. While we might not remove all the pollutants, at least we could remove some of the surface contaminants that would otherwise flow into the storm drains. But there is generally not enough money or time to sweep all the streets before every storm. In this exercise we will use GIS and satellite imagery to focus our efforts and decide which streets should be swept to remove the most contaminants.

Looking at Santa Barbara from Space

Landsat, a satellite with a large array of sensors on board, passes over every part of the earth every few days. Its sensors can detect the color of the earth's surface, heat and infrared radiation. An image analyst can use combinations of these sensors to pick out features in the land cover such as types of crops, wetlands and even the intensity of development.

A. In the **Stormh2o.mxd** project activate the Santa Barbra Data Frame. The view opens showing the city limits of Santa Barbara, California.

- Right click on **Santa Barbara** in the Table of Contents, and select "**Activate**" from the data frame menu.

B. Expand the Santa Barbara Table of Contents by clicking on the "+" symbol next to "**Santa Barbara**".

Shown in the table of contents for the **Santa Barbara** data frame are several layers showing various land cover types, they represent various components of the Landsat image and are not the true colors of the original features. An image analyst examined the satellite data and painstakingly classified every *pixel* in the image.

C. Display each layer to reveal the composite image of Santa Barbara, classified according to land cover.

- *Remember, to display a layer click on the Check Box to the Left of the Layer in the Table of Contents. To turn off a layer, un-check the box.*

12. How much of the ground cover in Santa Barbara is vegetation or natural surfaces? Where are these areas generally found? *A rough estimate is sufficient.*

D. Turn off all of the colored themes **except** for the following: **Santa Barbara Streets**, **Santa Barbara City Limits** and **Highly Developed areas**.

The red areas shown on the screen are areas that Landsat "sees" as made up almost entirely of concrete, asphalt and rooftops, almost all man-made hard surfaces. Each pixel in the image represents an area 30 meters x 30 meters, an area about the size of a small house. These are the areas of greatest concern for sources of urban storm water pollution.

13. Which parts of Santa Barbara are the most highly developed?

If we are only able to sweep some streets before it rains, we want to concentrate on the highly developed areas and their surroundings first. Using GIS, we can figure out which streets to sweep and create maps for the street sweepers to follow. First, let's expand the red areas a little bit to account for the fact that storm water is going to runoff these areas and flow down the street before it runs into a storm drain. Polluted water from the red, "highly developed areas" may flow into a neighboring area before entering a storm drain. We can create a 100 foot buffer around each red area to make sure we sweep all the streets around the areas where the pollution is going to be the greatest.

    E. Create a **100 foot buffer** around the highly developed areas.

- Select the Highly Developed layer

- On the main ArcMap menu bar, select the **"Window"** menu, then select ArcToolbox…

- Expand the Analysis Tools -> Proximity -> and select Buffer

- For Input Features, select the Highly Developed layer. For Output Feature Class, navigate to your student\lab3\data folder and for name use **100ft_HD_buf**

- For linear unit, select 100. For Units select Feet.

- For Dissolve Type, select All
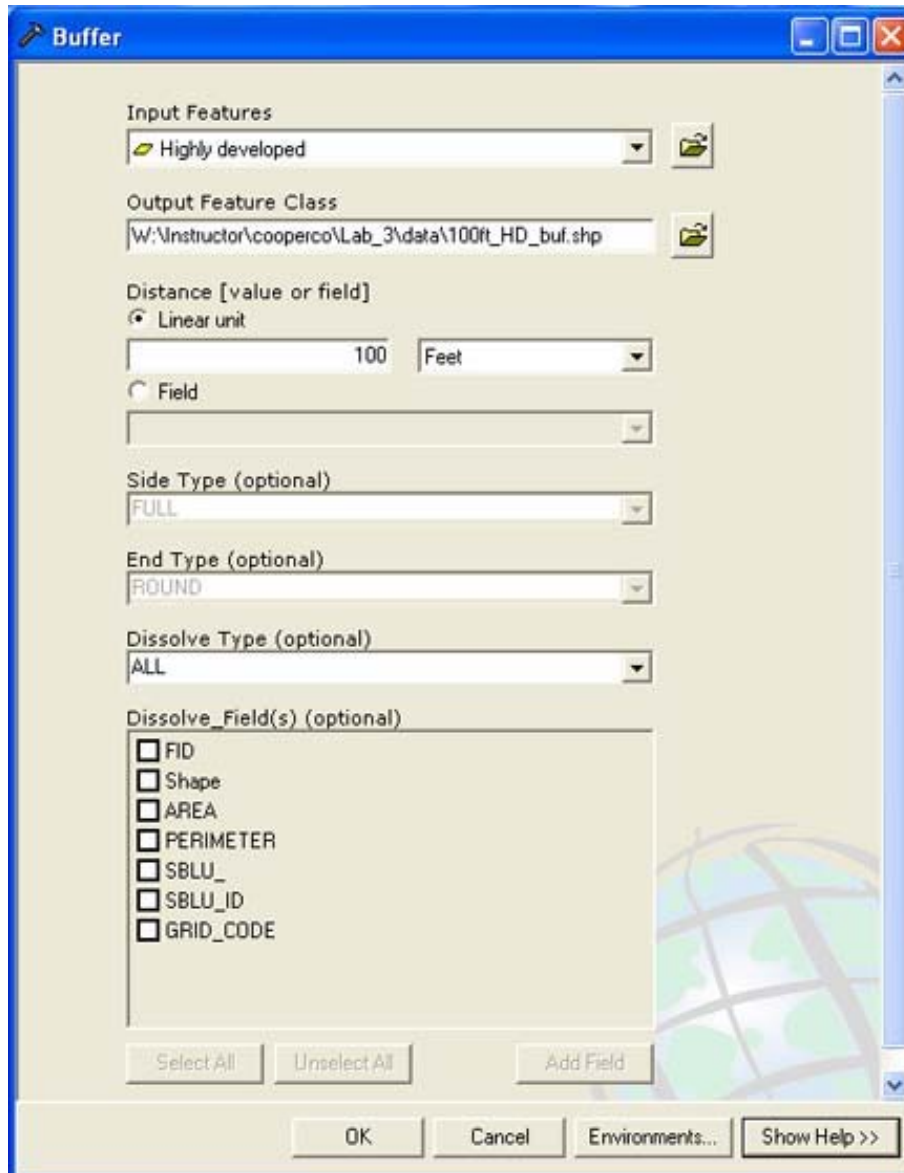
- Click **OK** – *be patient, the program has to calculate the buffers then dissolve them together.*

- The new buffer layer will be added to the top of your table of contents when it is done computing.

F. **Zoom-in** and pan around on the 100ft_HD_buf layer.

14. How do the areas shown in the buffered theme compare with the original highly developed theme?

15. Why did we want to "buffer" the highly developed areas?

Let's see how the streets lay out with respect to this new theme.

G. Zoom-out so that you see all of Santa Barbara.

H. Move the Santa Barbara Streets layer to the top of the list so that it is drawn on top of the 100ft_HD_buf layer and turn it on.

- Make sure that the Table of Contents is set to the Display Tab. If it is set to the Source tab you won't be able to move the order of the layers.

Now we're ready to make a map for the street sweepers. We want them to know where the most important areas are to be cleaned before the rains come.

I. Clip the Streets layer based on the 100ft_HD_buf layer.

- On the main ArcMap menu bar, select the **"Window"** menu, then select ArcToolbox…

- In the ArcToolbox window, expand "Analysis Tools"-> Extract-> and select Clip.

- Select **Streets** as the layer for Input Features and **100ft_HD_buf** as the layer for Clip Features.

- Click on the folder next to "Output Feature Class" to save the clip as a new shapefile

- Name the new shape file **street_HD_buf**, and save it in your *Student/Lab3_data* folder, Click on **Save**.
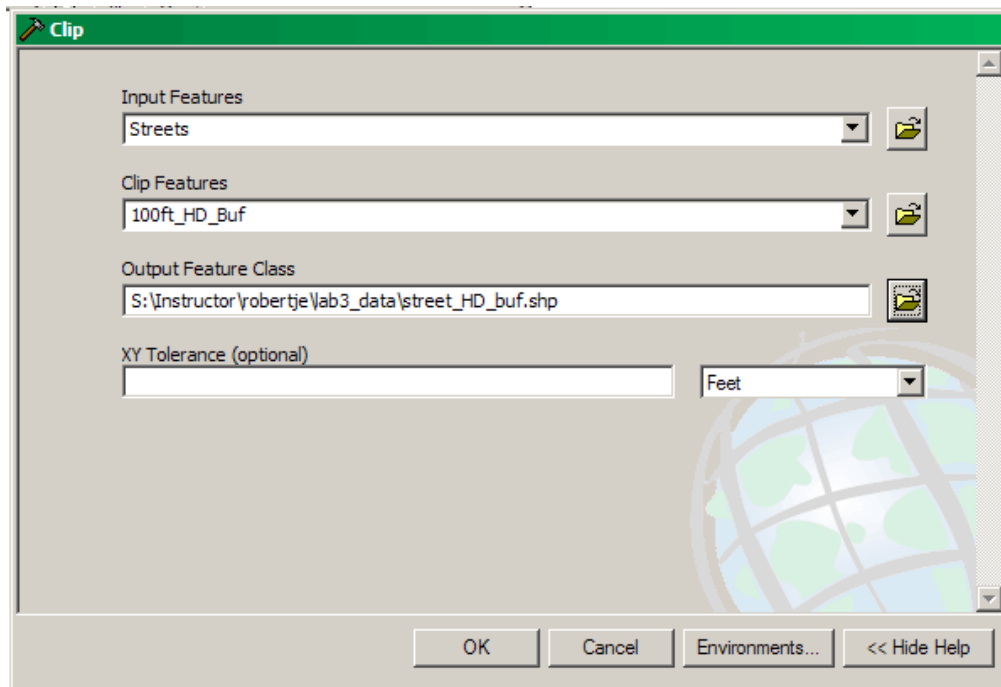
- Click **OK** on Clip Window
- *Again, Be patient*

J. The clipped layer should appear at the top of your table of contents. If so, jump to step L. If not, go to step K.

K. Add the **clip_st_buf** layer from the data folder in the Lab_3 folder in your student drive.

L. Change the symbology of the **street_HD_buf (or clip_st_buf)** layer to be a thick red.

You have just created a map showing the city street network and the areas that we would like swept before a storm (shown in red). The street sweepers would also like a list of the streets and specific blocks that they need to sweep.

M. Right Click on the **street_HD_buf (or clip_st_buf)** layer and select "**open attribute table**".

16. How many separate street sections will need to be cleaned to capture all the areas within 100 feet of the Highly Developed areas?

N. Close the "**Attribute Table**". *If you selected any attributes make sure you clear the selections before closing the attribute table.*

17. What is the advantage of providing a prioritized list of critical streets to the City Council?

18. What other things might the City Council consider doing to minimize the effects of storm water pollution?

19. Write a paragraph describing what you learned about storm pollution. Where is it the greatest problem? How does the ground cover affect runoff? What can we do to minimize the effect of storm water runoff? *Just a paragraph – not a whole page!*

O. On the main ArcMap menu bar, select the **"View"** menu, then select **Layout View.** This is what your map will look like if you print it. *Notice how Santa Barbra is outlined with a dashed blue line. This means that this is the active **Data Frame.***

P. On the main ArcMap menu bar, select the **"Insert"** menu, then select **North Arrow.** Also insert a Title, and Legend. *When you add your legend, only add the necessary layers to tell the story that your map is trying to display. This is where the artistic aspect of cartography really comes in.*

Q. On the main ArcMap menu bar, select the **"File"** menu, then select **Export Map.**

R. Save it in your lab_3 data folder and export as a **.JPG.**
S. **Insert** your exported map into your Word write up and paste it in the drop folder. *Make sure your name is on the write up as well as in the file name.*

See the screen shot below for a sample of what your layout should look like