COASTAL GIS APPLICATION

Coastal Erosion and Shoreland Development Regulation

Town of Mosel, Wisconsin

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The Lake Michigan shore in northern Sheboygan County consists of steep bluffs approximately 50 feet in height. Long term recession rates of approximately two feet per year have been recorded along this segment of the shore. Storms and high water levels in the Great Lakes accelerate shoreline erosion and bluff erosion and increase flooding and property damages. During 1985-86, Lake Michigan set new record marks for high water levels in the 20th century, leading to unprecedented property damage. Recently, water levels in the Great Lakes have increased to a level that begins to concern the U.S Army Corps of Engineers.

In order to discourage development in erosion hazard areas, preserve shore cover and natural beauty and meet other public objectives, Sheboygan adopted a Shoreland-Floodplain Ordinance on October 27, 1970. The ordinance regulates development within 1000 feet of the ordinary high water mark of navigable lakes, ponds, flowages, and specified wetlands; 300 feet of navigable waterways; and within the 500 year floodplain.

Geographic information systems (GIS) may be utilized to more effectively manage development in the coastal zone. This GIS application assesses coastal erosion impacts and explores management issues related to shoreland development in the Town of Mosel in northern Sheboygan County.

General Instructions

These instructions are divided into seven sections. They are designed to be followed from front to back (i.e. Section One first, then Section Two, etc.). Earlier sections contain descriptions of basic ArcGIS 9.2 operations. They also create layers that will be used in the later sections.

As you move through the application, you may need to refer back to earlier descriptions for performing a particular function. The Table of Contents is designed to help you move back and forth through the document.

1. Inputting and viewing existing databases.

In this section, you will input and view five data sources -- floodplains, parcel boundaries, township zoning, a planimetric map and an orthophoto.

Create a document and a view.

From the ArcMap File menu, choose **New…** Select **Blank Document** and click the **OK** button. An empty map screen will appear untitled.

From the View menu, choose **Data Frame Properties** to display the Data Frame Properties dialog box. Click **General** tab, highlight the name **Layers** and type in "Data Layers" as the new name for this Frame. Click **Coordinate System** tab and set the coordinate system to "**NAD 1983 HARN Adj WI Sheboygan Feet**" under "**Predefined > Projected Coordinate Systems > County Systems > Wisconsin**." (The data are in the Sheboygan County Coordinate System). Click **OK**.

> Throughout this application, names will be provided for data frames, layers, files, etc.. You may choose to use other names. However, references to suggested file names will be made in later sections of the application so it will work best if you use the names provided.

From the File menu, choose **Save As...**. Locate the directory where you wish to save your data. In the file Name input box, type a name for your document. Click **OK**.

> An ArcMap document file is assigned the extension ".mxd". A document can contain multiple data views, attribute tables and a layout. For this Shoreland Zoning Applications model, all our work will be saved under a single document. You may wish to adjust this according to your data storage needs.

*Save your work frequently (select **Save** under the File menu)! If the ArcMap program crashes, you can lose any changes made since your last save. If ArcMap does crash and the document was recently saved, it will be very easy to recreate where you left off by simply opening the document.*

Add data files to view.

Click the **Add Data** button to add data files as layers into your view. Locate and highlight the following files and click **OK**: mosflood.shp, mospar.shp, mosplan.shp and moszone.shp. Click **OK** in the 'Unknown Spatial Reference' warning window that appears. To add the digital orthophoto for the northern section of the township, click the **Add Data**

button again; this time add the file called "moseldoq.tif." Click **Yes** in the 'Build Pyramids' dialog/prompt that appears and the orthophoto will draw.

To rename the layers, click on a layer name to make it active. When a layer is active, the name is highlighted by blue color in the Table of Contents. Right click on the layer name and choose **Properties**. In the layer Properties dialog box, click **General** tab. Highlight the current layer name, type a new name and click **OK**. Rename the layers:

> "mosplan.shp" to "Planimetric Map"
> "mosflood.shp" to "Floodplains"
> "moszone.shp" to "Town Zoning"
> "moseldoq.tif" to "Orthophoto"
> "mospar.shp" to "Mosel Parcels"

Click on the box in front of each layer to make the layers visible on the screen.

> Layers are drawn based on the order they appear in the Table of Contents. In order to view a layer, you may need to move it above another layer. To do this, click on the name of the layer to make it active and drag it to a new site on the Table of Contents.

> The **Zoom to layer** can be used to zoom the view to Mosel Township (right click on the name of any Township layer in the Table of Contents and choose **Zoom to layer**). You can also use the **Zoom In** button to focus on a smaller section of the view. Use the **Full Extent** button to view all the data of all the layers.

 Zoom to layer

 Zoom In

 Full Extent

To display the Town Zoning layer by zoning codes, double click on the layer to bring up the Layer Properties dialog box and click on the **Symbology** tab (*Figure 1*). In **Show** frame, choose **Unique Values** under **Categories** class. For Value Field, choose **Zoning** then click **Add All Values** button. To change how each of these categories are labeled in the view, click each Label field in the symbol list box, then highlight the current Label description and change:

> "A-1" to "Prime Agricultural"
> "A-2" to "General Agricultural"
> "B-1" to "Business"
> "C-1" to "Conservancy"
> "I-1" to "Industrial"
> "R-1" to "Single Family Residence"

"R-2" to "Two Family Residence"
"R-3" to "Multiple Family Residence"

Uncheck the box in front of the symbol of **<All other values>**. Click **Apply** in the dialog box to apply your changes to the view. Close the Layer Properties dialog box.
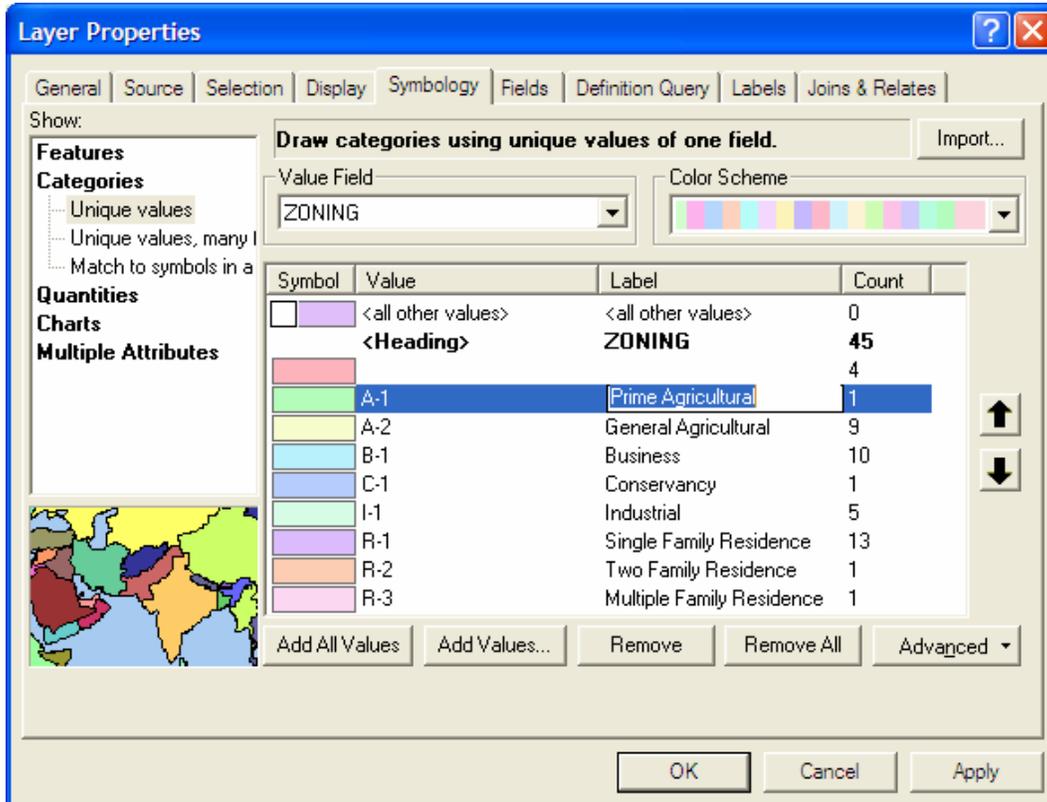
Figure 1. Symbology page in Layer Properties dialog box

Save your document.

2. Modifying existing layers.

In this section, you will create new data layers (parcels, transportation, hydrography, buildings, cemeteries and the bluff edge) by extracting information from existing layers.

Create new layers from the Planimetric Map.

The Planimetric Map layer has a data field called "lgds_level". The codes in this field distinguish line segments in the map according to their feature type. To display these individual features, you will need to query the associated database (attribute table) for specific criteria. This information can be stored in a query format or it can be used to create a new layer in the ArcGIS shapefile format.

A shapefile is an ESRI GIS format for storing geometric and attribute information on a feature. When data in other spatial formats are converted into shapefiles, they maintain the extent and units from the original format. When a new shapefile is created, the extent and units of the new features are determined by existing themes within the view. Although a shapefile has geometric references, it does not have topology. Therefore, there may be limitations when using shapefiles or exporting them into another GIS software program.

To create a layer with information on roads and railroads, make the Planimetric Map layer active. Double click on the name of Planimetric Map layer in the Table of Contents. In Layer Properties dialog box, click **Definition Query** tab and click **Query Builder** button to bring up the Query Builder dialog box (*Figure 2*).

From the Fields list, double-click **lgds_level**; this now appears in the expression box. Next, you want to set this equal to a value (click once on the '=' sign). Click **Get Unique Values** button. From the Values list, double click '**1**'. Click once on the '**or**' button to continue building the query. Return to the Fields list and repeat the procedure for the values '**2**',' **3**',' **4**' and '**20**'. Your finished query should look like this: (**"IGDS_LEVEL" = 1**) **OR** (**"IGDS_LEVEL" = 2**) **OR** (**"IGDS_LEVEL" = 3**) **OR** (**"IGDS_LEVEL" = 4**) **OR** (**"IGDS_LEVEL" = 20**). Click **OK** in the Query Builder and Layer Properties dialog boxes. Your view will now display only the transportation features of the Planimetric Map.
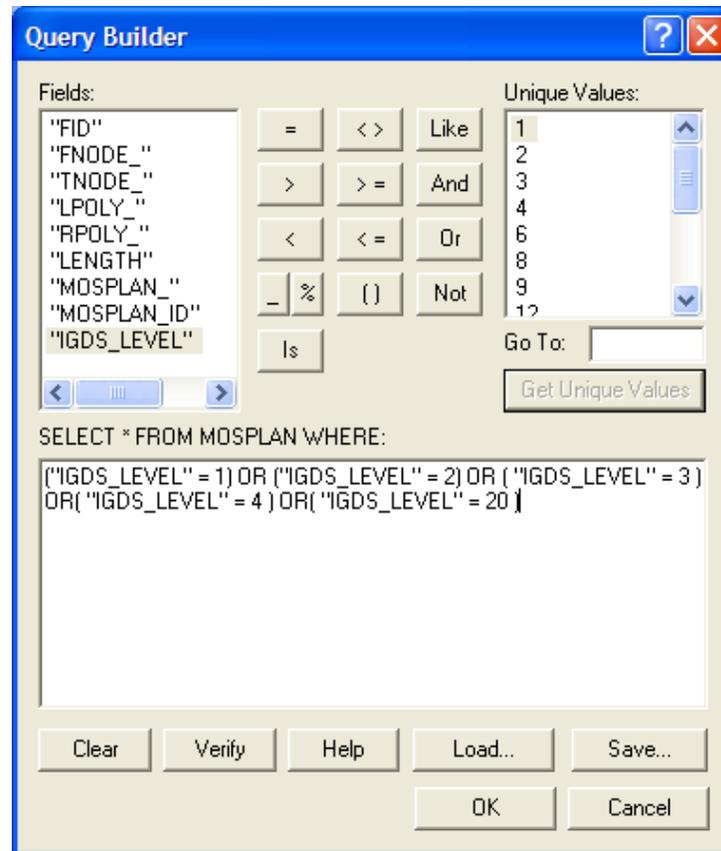
Figure 2. Query Builder

To convert this into a new layer, right-click on the Planimetric Map, point
to **Data** and choose **Export Data…** Choose a directory and name the file
"mostrans.shp." Click **OK**. (*Figure 3*). Answer **Yes** to add this shapefile to
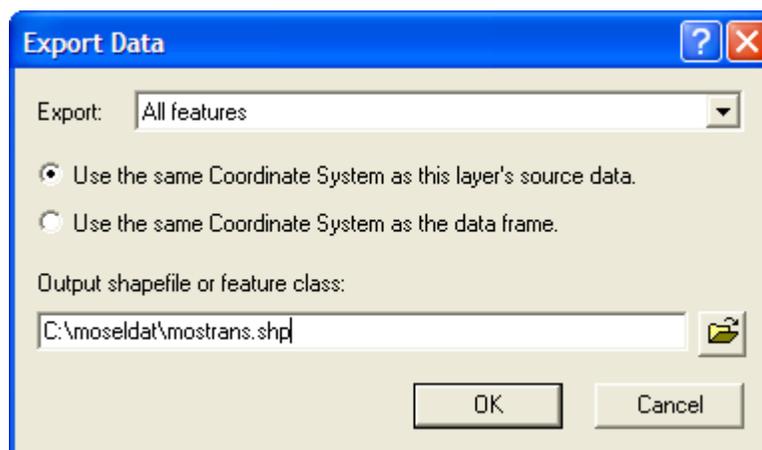the map. Change the layer name to "Transportation Routes."

Figure 3. Export Data

You now have two layers which appear to have the same information. However, the Planimetric Map layer still contains all its original information but, because of the query, is displaying only a portion of these features. To clear this query, delete the query expression in the Definition Query page in the Layer Properties Dialog Box of the Planimetric Map layer, then click **OK**.

To create a layer with information on buildings, build the following query on the Planimetric Map layer: **("IGDS_LEVEL" = 6) OR ("IGDS_LEVEL" = 8) OR ("IGDS_LEVEL" = 60)**. Create a shapefile, save the file as "mosbldg.shp," add it to your view and rename it "Buildings."

To create a layer with information on water bodies, make sure the last query is cleared then build the following query on the Planimetric Map layer: **("IGDS_LEVEL" = 12) OR ("IGDS_LEVEL" = 13)**. Create a shapefile, save it as "moshydro.shp," add it to your view and rename it "Hydrography."

To create a layer with information on cemetery locations, build the following query on the Planimetric Map layer: **("IGDS_LEVEL" = 15) OR ("IGDS_LEVEL" = 27)**. Create a shapefile, save it as "moscult.shp," add it to your view and rename it "Cemeteries."

Remember to clear the Planimetric Map layer's query.

Modify the parcel map to create unique parcel identification numbers.

You will now extract a separate layer for mapping parcel ownership in the Township. The new layer will be used for the rest of this application.

The file "mospar" contains the digital parcel map for the Town of Mosel. If you look at the individual records, you will find that some parcels (i.e. polygons) have identical parcel identification numbers. Using this database will cause problems in subsequent analysis, particularly when you try and link the database to other files. The best remedy for this situation would be to assign unique parcel identification numbers to each parcel. However, this is the job of the county records-keeper and not the GIS analyst. Another solution is to merge parcels with identical parcel IDs and create a separate layer. By doing this, you can now use the spatial attributes of the parcel file in combination with non-spatial attributes (e.g. owner's name) found in other files. The downside of this solution is that some information will be missing in your new file. Specifically, if two identically-numbered parcels are adjacent to each other, the line separating the parcels will disappear. In addition, two parcels that share identification numbers but are not adjacent will combine into one, non-contiguous feature.

Click **Show/Hide ArcToolbox Window** button to open the

ArcToolbox window (*Figure 4*). Click the plus sign in front of **Data management Tools** and **Generalization** to expand the sub-items. Double-click on **Dissolve** to open the Dissolve geoprocessing dialog box (*Figure 5*). In the dialog box, choose **Mosel Parcels** layer from the drop-down list box as the **Input Features**. Save the **Output Feature Class** file name as "Parcels.shp" with full path. Check **Shape (this field is not listed w/9.2)** and **PARCEL_ID** fields in **Dissolve_Field(s)** list box. Choose **AREA** field from the **Statistics Field(s)** drop-down list box. The AREA field is added to the list box by itself. Select **SUM** Statistic Type for AREA field in the list box. Make sure **Multipart** is checked and then click **OK**. The dissolve operation is now processing. Wait for completion and close the dialog box. The new layer is added to the Data Layers frame. Make sure the layer is renamed to "Parcels." Close the ArcToolbox window.
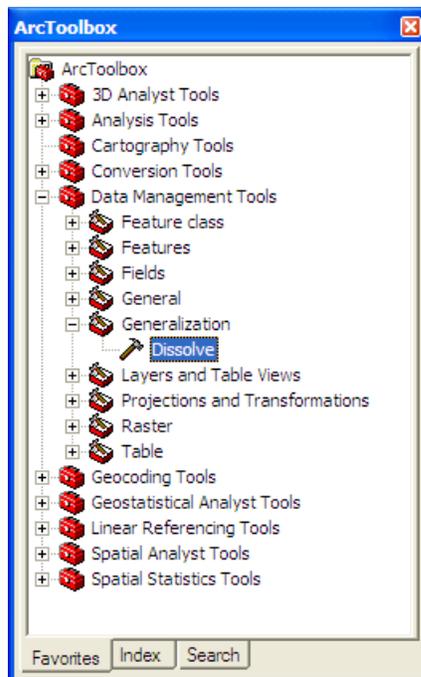

Figure 4. ArcToolbox
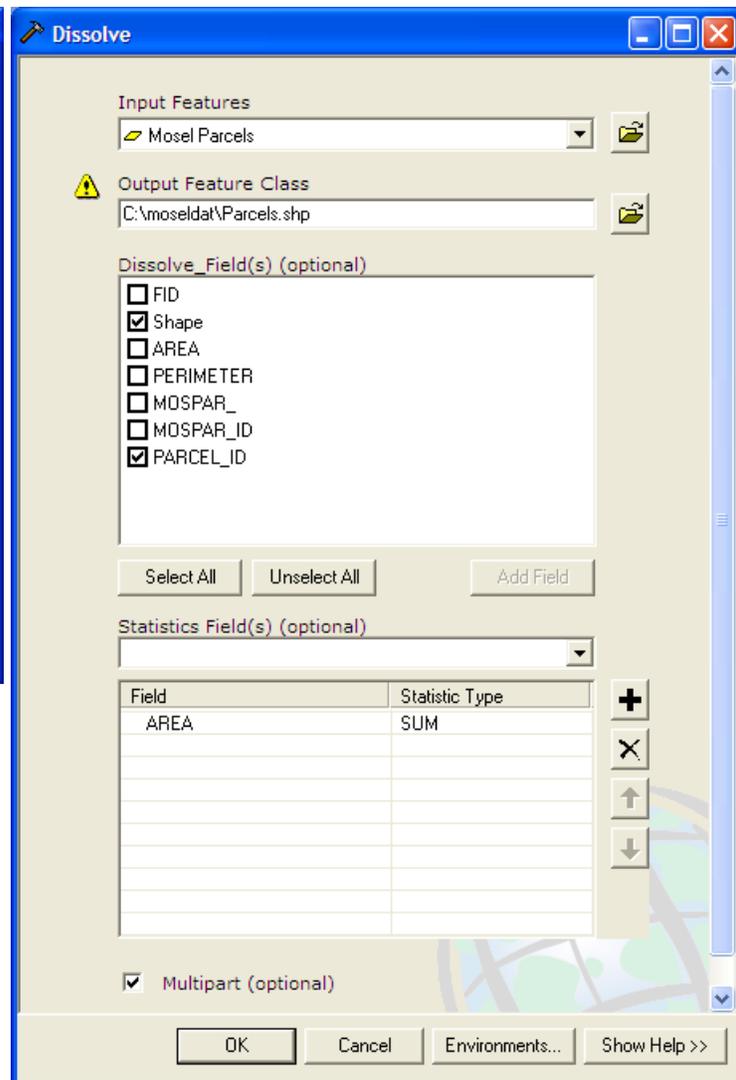
Figure 5. Dissolve dialog box

In other words, you have merged parcels with the same identification number and calculated the area of any new parcels equal to the sum of its component parcel areas.

When a layer is first created, it is displayed in a single color. With the Symbol Selector, you can modify how the layer is displayed. For this view, you will want to display only the outlines of the parcel layer. By making the non-outline portions transparent, you will be able to view other layers under this data layer.

Open the Parcel layer's **Symbol Selector** (*Figure 6*), by clicking on the rectangular symbol under the Parcel layer in the Table of Contents. The Symbol Selector is now displayed. In **Options** frame in the dialog box, click on the **Fill Color** button and choose **No Color**. This indicates a clear foreground. Click on the Outline Color button and click on your preferred choice from the colors displayed. Click **OK** to close the Symbol Selector.

Figure 6. Symbol Selector

You may wish to remove the Mosel Parcels (Mospar.shp) layer from your view. To do this, right click on the Mosel Parcels layer in the Table of Cont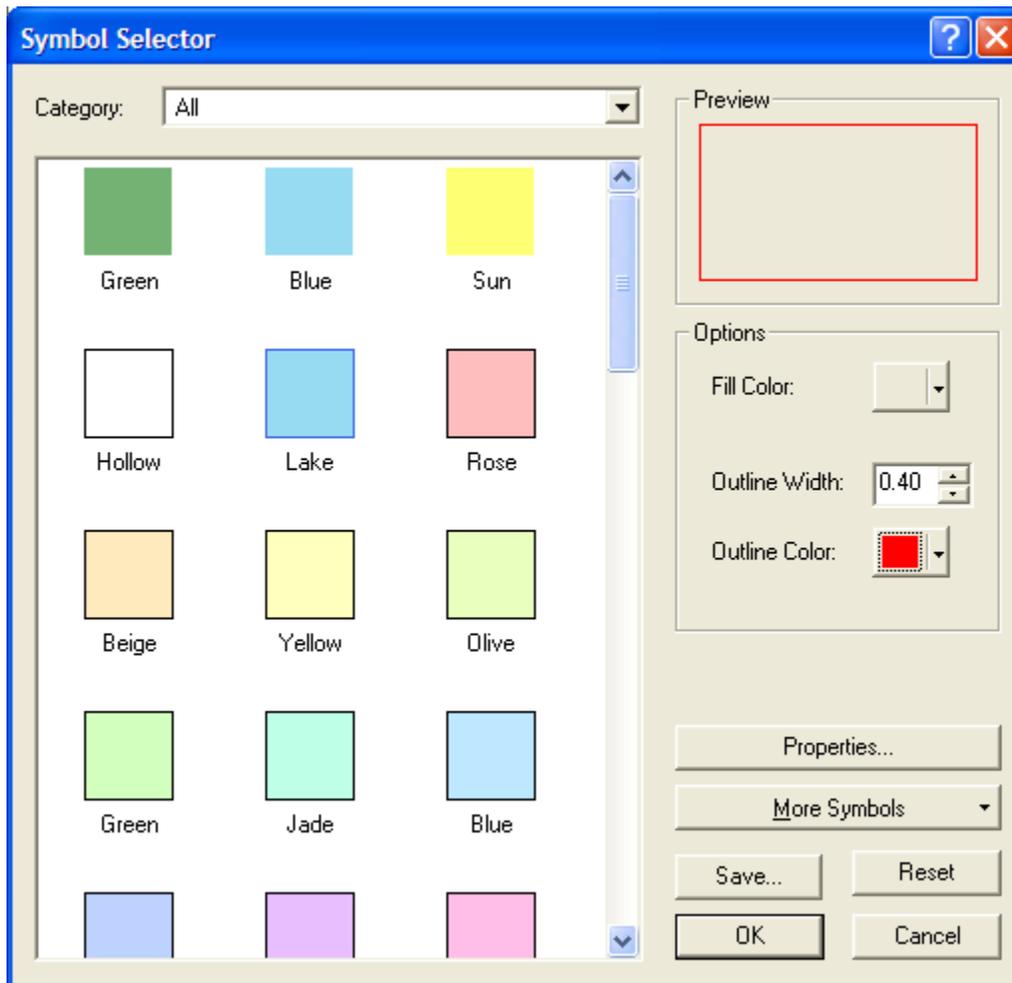ents. Choose Remove from the context menu. This command removes the layers from your data frame and view but does not delete saved files from your directory.

Save your document.

The ArcGIS 9.2 Buffer wizard

The ArcGIS 9.2 Buffer Wizard has been removed from the ArcMap Tools menu, but it is still accessible if you click Tools, click Customize, click Tools in the Commands tab, and select Buffer Wizard. If you want to use this wizard, you can add it to any ArcMap toolbar or pulldown menu from the Customize dialog box. You may want to do this to buffer graphics drawn on a map.

Locating the 9.2 Buffer Wizard operations in the ArcToolbox window

- To buffer at a specified distance or based on distances taken from a field— Analysis toolbox > Proximity toolset > Buffer tool

- To buffer creating multiple rings— Analysis toolbox > Proximity toolset > Multiple Ring Buffer tool

NOTE: In the Buffer tool, the Side Type option is restricted to FULL and the End Type option is restricted to ROUND if you are using an ArcView or ArcEditor license. Setting the Side Type to LEFT or RIGHT and setting the End Type to FLAT, are only possible if you are using ArcInfo.

The ArcGIS 9.2 Geoprocessing wizard

The ArcGIS 9.2 Geoprocessing Wizard has been removed from ArcMap; it is no longer provided in the product.

Locating the 9.2 Geoprocessing Wizard operations in the ArcToolbox window

- Dissolve— Data Management Tools toolbox > Generalization toolset > Dissolve tool

- Merge— Data Management Tools toolbox > General toolset > Append tool

- Clip— Analysis toolbox > Extract toolset > Clip tool

- Intersect— Analysis toolbox > Overlay toolset > Intersect tool

- Union— Analysis toolbox > Overlay toolset > Union tool

NOTE: In the Union and Intersect tools, only two inputs are allowed if you are using an ArcView or ArcEditor license. The ability to union or intersect more than two inputs is only available if you are using an ArcInfo license.

3. Creating a map of the jurisdiction of the Shoreland Zoning Ordinance.

In this section, you will create areas of shoreland zoning jurisdiction along lakes and rivers, along with a map displaying this information. You will also learn how to access a help file containing the text from the Ordinance document.

Create a new data frame.

From the Insert menu of ArcMap, choose Data Frame to create a new data frame. Rename it to "Shoreland Zoning Ordinance." Set the coordinate system to "**NAD 1983 HARN Adj WI Sheboygan Feet**". You can copy a layer between data frames, preserving the colors and other properties from the original layer. Under the Data Layers frame, select the Parcels and the Hydrography layers

.

> In order to select multiple layers, simply hold down the Control key and select each layer. All selected layers should be highlighted by blue color.

Right click on any of the selected layers, choose **Copy** from the context menu. Now, click on the Shoreland Zoning Ordinance frame, then right click on it and choose **Paste Layer(s)** from the context menu. Click on the plus sign in front of the Data Layers frame to collapse all sub items.

Make the Shoreland Zoning Ordinance frame active by right clicking on it and choose **Activate** in the context menu. Make the Hydrography layer the only visible layer. Open the Hydrography's Layer Properties dialog box and click on **Symbology** tab. In **Show** list box, select **Unique values** under **Categories** class. Choose **IDGS_LEVEL** in the Value Field then click **Add All Values** button. Two values will be displayed. Label the value "12" as "Lakes and Ponds." Label the value "13" as "Rivers and Streams." Uncheck the box in front of the symbol of <all other values>. Close the Layer Properties dialog.

Add a field describing shoreland zoning jurisdiction distances.

Based on the Shoreland-Floodplain Ordinance, zoning jurisdiction for navigable waters is determined by the feature type (Lakes and Ponds = 1000 feet, Rivers and Streams = 300 feet).

Right click on the Hydrography layer and choose Open Attribute Table to access the attribute data. Click the **Options** button in the attribute table and choose **Add Field…** Name your field "Distance." This will be a **Short Integer** field; you can adjust the size of the field under **Precision**.

In this case, keep the default settings and click **OK**.

Click the **Options** button and choose Select by Attributes. Construct the query: (**"IGDS_LEVEL" = 12**). Make sure **Create a new selection** method is selected and click apply. Data satisfying this query will now be highlighted in the attribute table. Close the Select by Attributes dialog box. Click the **Selected** button at the bottom of the attributes window to show only selected records.

Right click on the **Distance** field in the attributes table and choose **Field Calculator…** Click **Yes** to confirm the operation. In **Field Calculator** dialog box, type in "1000" in the expression box at the lower window and click **OK** (*Figure 7*).
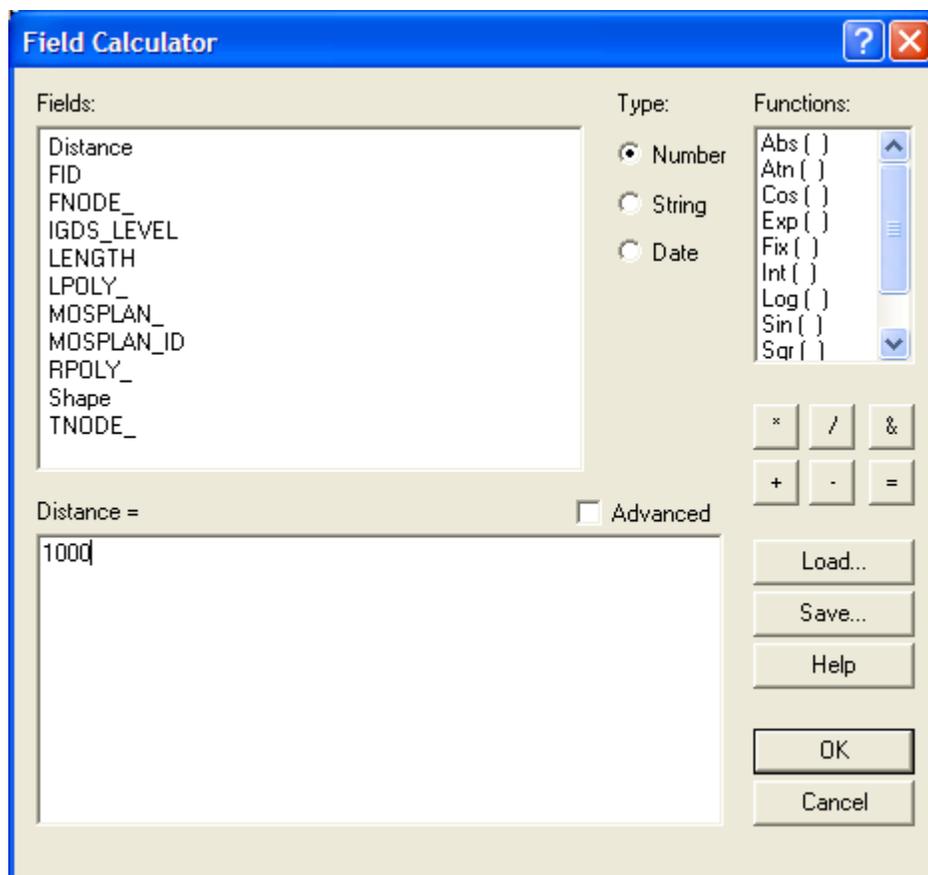

Figure 7. Field Calculator

Click **All** button to show all records. Clear the selection by choosing Clear Selection in the **Options** context menu. Repeat the above procedure to construct the next query: (**"IGDS_LEVEL" = 13**) and give these data the Distance value "300." You can view the result in the attributes table, then close it.

Create shoreline jurisdiction zones using the buffering operation.

Click **Show/Hide ArcToolbox Window** button to open the ArcToolbox window. Click the plus sign in front of **Analysis Tools** and **Proximity** to expand the sub-items. Double-click on **Buffer** to open the Buffer geoprocessing dialog box (*Figure 8*). In the dialog box, choose **Hydrography** layer from the drop-down list box as **Input Features**. Save the Output Feature Class file name as "Buffers.shp" with full path. Click on **Field** radio button and choose **Distance** field. Set **Dissolve Type** to **List** and check **Shape** field in the **Dissolve_Field(s)** list box (the Shape field is not listed w/9.2—didn't check any boxes, thus buffer op will NOT work). Click **OK** to create buffers. After completion, close the dialog box and ArcToolbox. The Buffers layer is already added into the data frame. If not, click **Add Data** button to add it. Rename it to "Shoreland Zones."

If you have trouble creating the buffers, try closing your document, then reopening it and doing the process again.
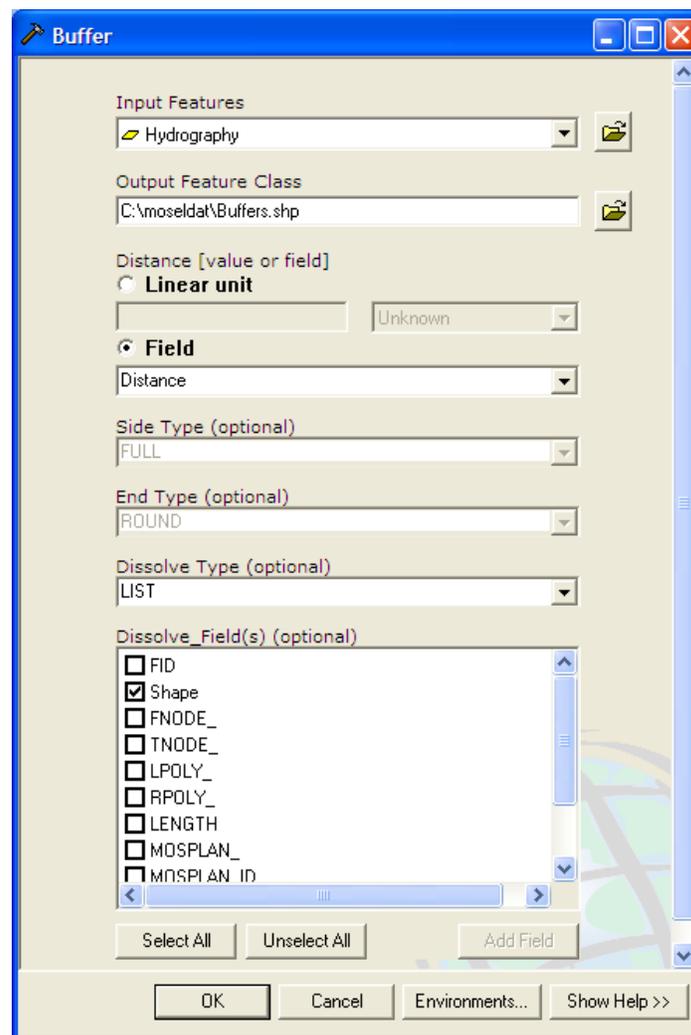

Figure 8. Buffer dialog box

When ArcMap creates a buffer for a line segment, it locates the buffer a specified distance on both sides of the line. On both ends of the line segment, it forms a half circle which connects the two sides of the buffer. This half circle is located the specified distance from the line endpoints. If you create a buffer from a multi-segmented line, you will see a series of circular buffers where the line segments meet.

Create a map of the Shoreland Zoning Ordinance Jurisdiction.

Although you now have a display of this data on your computer screen, you will want to use the Layout capabilities of ArcMap for creating mapping products. These layouts can contain views, tables, charts, scanned pictures and other graphic elements. They also can contain legends, north arrows, scale bars and additional text.

Make the layers Hydrography, Parcels and Shoreland Zones visible. Display them in the colors you wish for your map product. From the View menu, choose **Layout View**. From File Menu, choose **Page and Print Setup…** (*Figure 9*). Set your **Map Page Size** or check **Use Printer Paper Settings**.
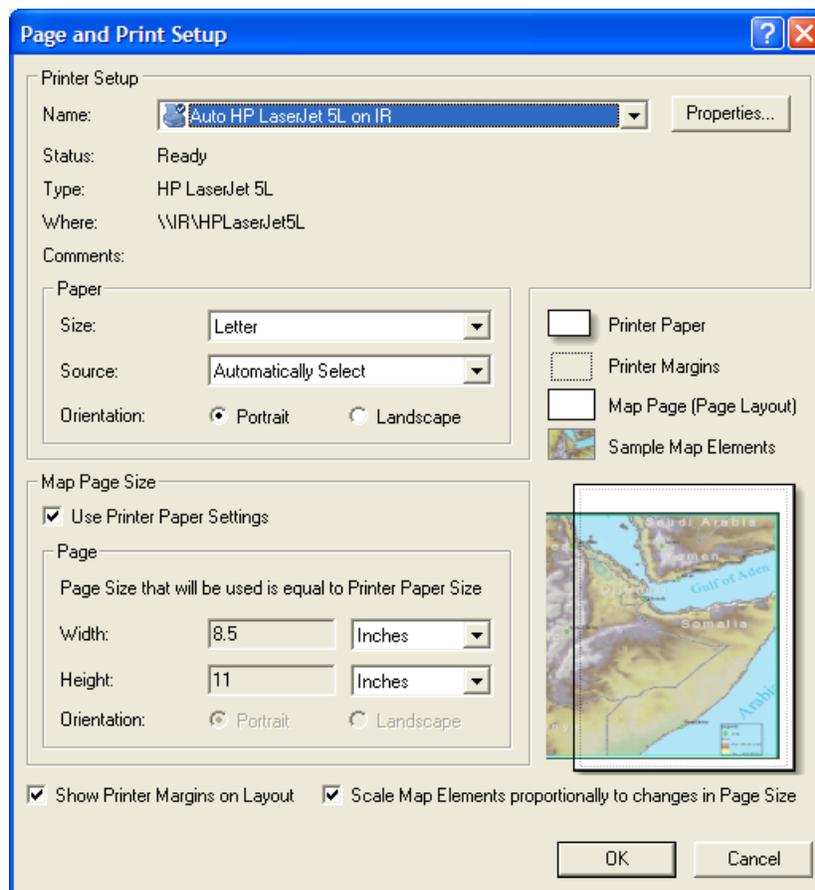

Figure 9. Page and Printer Setup

In this application, we have two data frames in the document. So we see two data frame objects on the page. Select, resize and move them until you like the arrangement on the page. If you just want to print one data frame, move the data frame object, which you don't want to print, out of the page extent and leave there. Remember not to delete it. If you delete the data frame object on the layout page, it will also remove the data frame we had created in the document.

If you are happy with the layout, you are now ready to export or print. Check the page and printer setup settings by selecting **Page and Print Setup…** under the File menu. If you wish to export the map, choose **Export Map…** under the File menu. An Export dialog box prompts you to choose a filename to save the output. If you wish to print the file, choose **Print Preview…** under the File menu. Click Print button to open the print dialog box when you are ready to print.

> ArcMap 9.x does not support multiple layouts in a document. This means you can only create a layout in a ArcMap document. If you want to create two or more layouts, you have to save your document as other files when you create your second layout. Therefore, you can have two different layouts in two separate ArcMap documents.

You may wish to modify the default layout. The following instructions highlight some of the graphic formatting options available.

> To select a feature for editing, click the **Select Element** button on the drawing tools pad, then click the feature. When a graphic is selected, it will be surrounded by an invisible box bordered by four squares. It can now be resized using the two-directional arrows or moved by simply dragging the box to the desired location. You may need to move other graphics around to make room for your selected graphic. To add a feature, click the **A ▾** button for text or **□ ▾** button for graphics. Now, click the mouse on the location where you wish to add the graphic.

▶ Select Element   **□ ▾** Draw Graphics   **A ▾** Add Text

You could also add some basic map elements from the Insert menu (*Figure 10*). They are **Title, Text, Neatline, Legend, North Arrow, Scale Bar, and Scale Text**. Just follow the dialog box, change some settings or choose the element style you like, then click **OK**. The element will be inserted on the page.

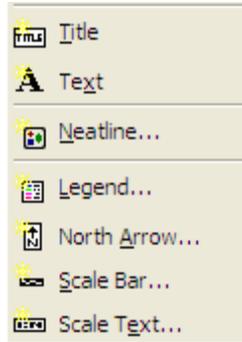From the **View** menu, choose **Data View**. Save your document.

Figure 10. Insert Menu

4. Evaluating potential Lake Michigan erosion impacts.

In this section, you will identify potential impacts from the erosion of the Lake Michigan coastline. Based on parameters outlined in the Shoreland-Floodplain Ordinance, you will estimate the new location of the bluff edge as the current slope stabilizes *(Part I)*. In addition, using a 50-year time frame, you will project the future location of the shoreline and bluff edge. From these projections, land and buildings at risk will be identified *(Part II)*. In addition, economic impacts to land and building values will be estimated *(Part III)*. You will also examine potential impacts to nearby roads. The final analysis will focus on sediment loss from erosion of the 50-foot bluff *(Part IV)*.

Part I: Creating a map of the current stable slope, and projections of future shoreline and bluff edge locations.

Extract a Lake Michigan shoreline layer.

All estimates of recession are based on the current location of the shoreline. This layer will be extracted from the broader hydrography database.

Switch to data view and activate the Shoreland Zoning Ordinance data frame. Make the Hydrography layer visible and other layers invisible. Click the **Select Features** button and then click on a section of the shoreline, highlighting it in cyan. Holding down the shift key, continue clicking on the shoreline until the entire shoreline is selected. Right click on the Hydrography layer, point to **Data** in the context menu and choose **Export Data…** Export selected features to a shape file and save as "lakemich.shp" (*Figure 11*). Click **Yes** to add it to your map as a layer and rename it "Lake Michigan Shoreline." Choose Clear Selected Features from Selection menu.
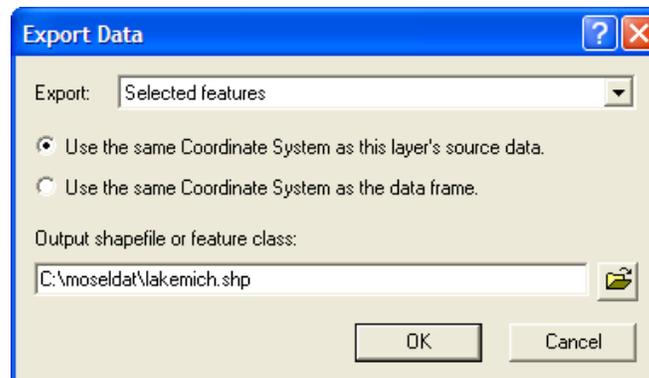
Figure 11. Export Data

Insert a new data frame and copy the following layers from previous data frames: Buildings, Transportation Routes, Orthophoto, Parcels and Lake Michigan Shoreline. Make this data frame active, name it "Shoreline Recession Scenarios" and set the map coordinate system to "**NAD 1983 HARN Adj WI Sheboygan Feet**".

Create a map of the bluff edge as the current bluff erodes to a stable angle.

The Ordinance defines a stable slope angle as 2.5 feet of horizontal distance for every one foot of vertical distance. In this area of the County, the average bluff is 50 feet high. Therefore, the location for the top edge of the bluff, based on a stable slope, will be 125 feet inland from the shoreline. You will use the buffer operation to create a 125-foot buffer from the shoreline. The inland line of the buffer is an estimation of the bluff edge location based on the current shoreline.

Create a buffer around the Lake Michigan Shoreline layer named "buff_125.shp." Click **Show/Hide ArcToolbox** button to open the ArcToolbox. Choose **Buffer** command to open the Buffering dialog box. Select **Lake Michigan Shoreline** layer as **Input Features** and type in "buff_125.shp.shp" with full pathname as **Output Feature Class**. Set Distance **125 feet**, choose **List** for **Dissolve Type** and check **Shape** filed in **Dissolve_field(s)** list box. Click OK to create the buffers (*Figure 12*). Add buff_125.shp to your data frame if it is not added by ArcMap. (Shape not available as Dissolve_Field again?)
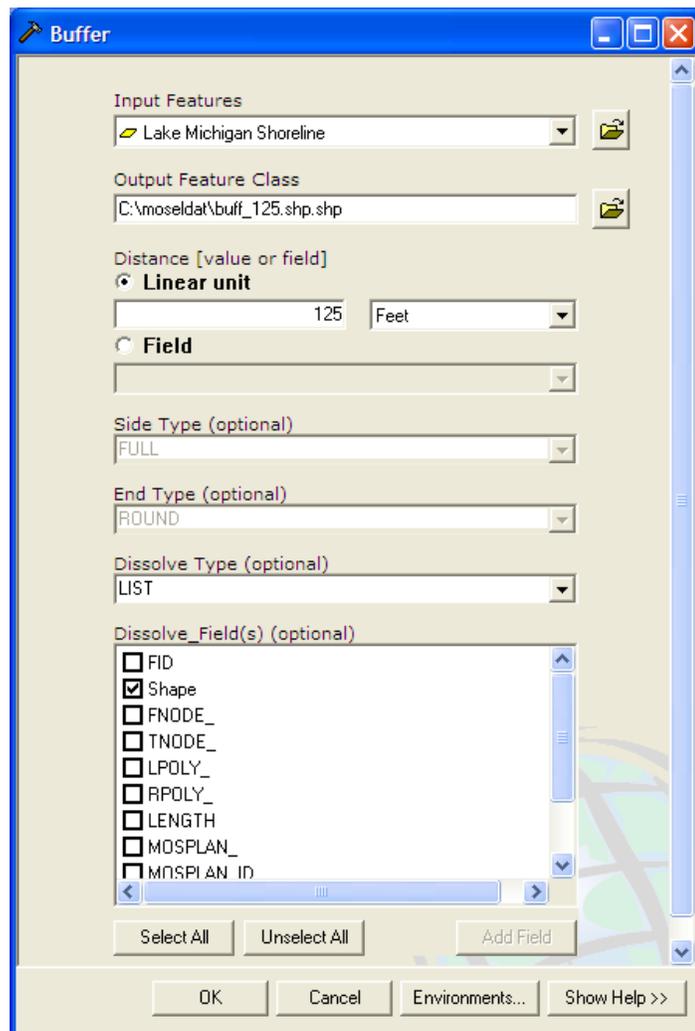

Figure 12. Buffer dialog box

You can improve the look of your buffer is to clip off the portion of the polygon that extends both 125 feet into Lake Michigan and out from the endpoints of the shoreline line segment. You will do this with the help of another geoprocessing function, **Clip**, which will clip a point, line or polygon layer to the size of another polygon layer.

> Double click **Clip** command under Analysis Tools and Extract categories in ArcToolbox window to open the Clip dialog box. In the dialog box, choose the **buff_125** layer as **Input Features** and **Parcels** layer as **Clip Features**. Save the Output Feature Class as "sta_bluf.shp". Click OK to process (*Figure 13*). In other words, the buffer will be clipped to the area where it overlaps with the parcels data (i.e. the land). Add sta_bluff.shp to your data frame if ArcMap doesn't add it. Rename it "Current Stable Bluff," and display only the outline of the buffer. Delete the buff_125.shp from your data frame.
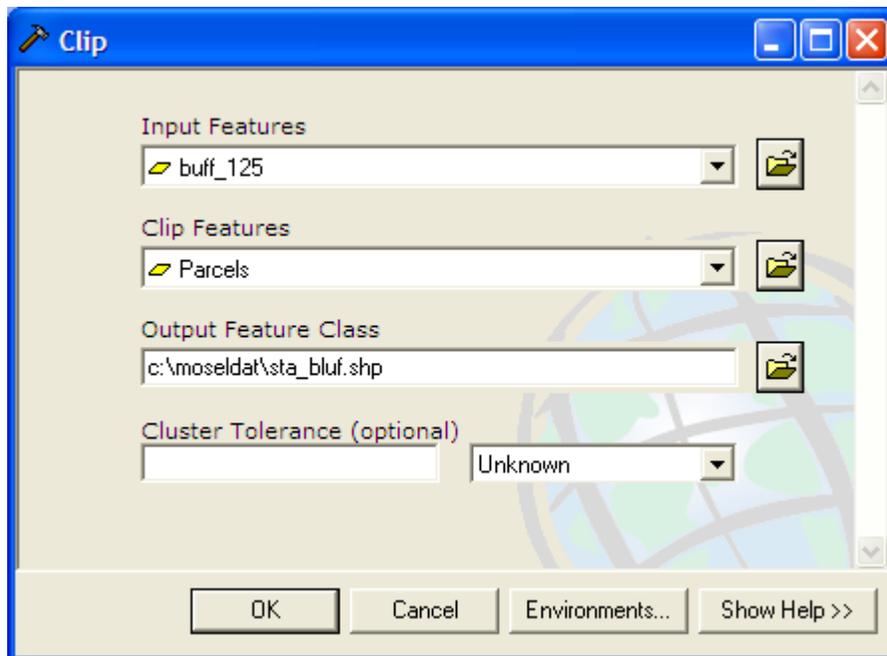

Figure 13. Clip dialog box

> Now, move the Lake Michigan Shoreline layer to the top of the data frame. The inland line of the buffer visually represents the bluff edge estimation.

If you zoom in on the Orthophoto, in certain areas you will be able to discern the current location of the bluff. Compare this with your estimation of the stable bluff location. Because the stable slope angle will actually vary depending on the underlying geological makeup of the slope, it is appropriate to think of the future bluff as falling somewhere within a range of locations around the setback estimation.

Create a map of the projected shoreline location after 50 years of recession.

The setback distance described in the Shoreland-Floodplain Ordinance is based on a longterm shoreline recession rate of two feet per year for the northern half of Sheboygan County. Because the Ordinance considers a 50-year period to be the "useful life of a typical residence," you will use this time interval as a basis for your analysis. In other words, the location of the Lake Michigan shoreline in 50 years is projected to be 100 feet inland from its current location. You will use the buffer operation to create a 100-foot buffer from the shoreline. The inland line of the buffer is an estimation of the future shoreline location.

> Create a buffer around the Lake Michigan Shoreline layer named "buff_100.shp." Set Lake Michigan Shoreline layer as **Input Features** and distance as **100 Feet**. Select dissolve type as **List** and check **Shape** field in the buffer dialog box. After the buffer created, clip this buffer to the Parcels layer, saving the file as "pred_shr.shp." Add the layer to your view and rename it "50-year Shoreline." Delete the buff_100.shp files.

Create a map of the required setback from the Lake Michigan shoreline.

The total setback in northern Sheboygan County is based on both the recession of the shoreline and the stabilization of the slope. This distance totals 225 feet from the Lake Michigan shore. In order to map the setback requirements, you will use the buffer command to create a buffer from the current shoreline. The inland line of this buffer is one way to estimate the location of the bluff edge in 50 years. It will also illustrate the Lake Michigan setback requirements in the Ordinance.

> Double click **Buffer** in the ArcToolbox to open the Buffer dialog box. Set Lake Michigan Shoreline layer as **Input Features** and distance as **225 Feet**. Select dissolve type as **List** and check **Shape** field in the buffer dialog box. Save your file as "buff_225.shp" and click **OK** to create the buffer. Clip this buffer to the Shoreline Parcels layer, saving the file as "LM_setbk.shp" and renaming the layer "Lake Michigan Setback." Remove buff_225.shp layer from the data frame. Visually examine the impact of shoreline recession on nearby buildings and roads.

Part II: Determining land and buildings at risk

Identify high risk land areas and buildings based on stabilization of the slope at its current location.

Add the layer "age.shp" to your view. This layer was created by locating a point on each parcel's primary structure that is closest to the Lake Michigan shoreline. Rename the layer "Shoreline Structures."

There is room for improving the Buildings layer. The data for the Buildings layer is classified into three categories: residential (from an aerial photo), agricultural and buildings (surveyed). However, there are inaccuracies in the classifications for this data set. In addition, the buildings could have been structured as polygons instead of multiple line segments to make their display, coding and analysis more effective. A close look at the features will illustrate the inconsistencies of the digitizing process. Because of these problems, a new simplified layer (age.shp) was created for this application.

All land within this Current Stable Bluff layer is likely to become part of the bluff as it stabilizes. You will now select all buildings within this area as "high risk" of being lost to erosion processes.

Choose **Select By Location** from **Select** menu. In the dialog, **select features from Shoreline Structures** that **Intersect Current Stable Bluff** (*Figure 14*). Click **Apply** and close it.
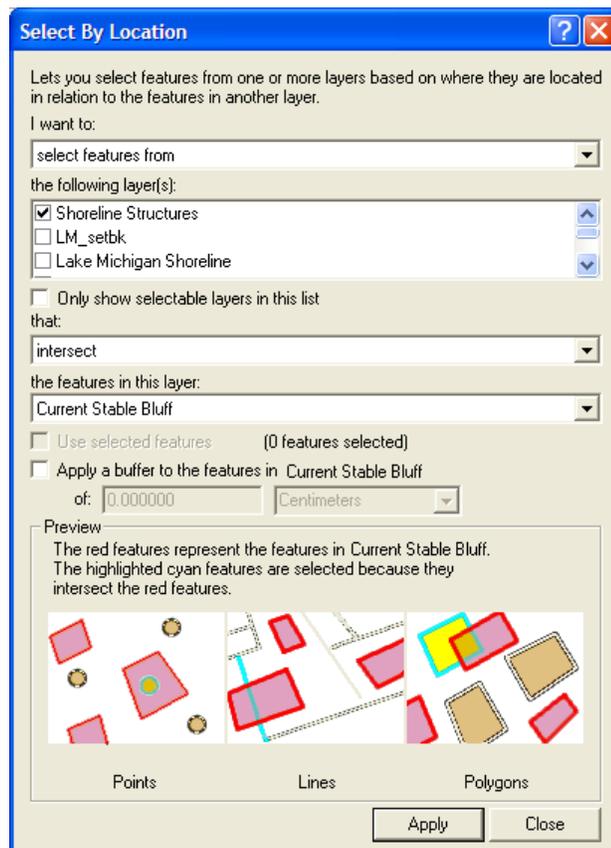

Figure 14. Select By Location dialog box

Right click on the Shoreline Structures layer and open it's attributes table. Click on the Options button at the bottom of the table and add a string field called "Risk." Set **Type** to **Text** and change **Length** to 10 (*Figure 15)*. One record should be highlighted for being at high risk. Right click on the Risk field header and choose **Calculate Values…** in the context menu. Click **Yes** to confirm it. Set this field equal to **"High"** (make sure to include the quotation marks to identify this as a string expression) (*Figure 16)*. Close the attributes table and clear the selection on the Shoreline Structures layer by choosing Clear Selected Features from the Selection menu. Save you document.
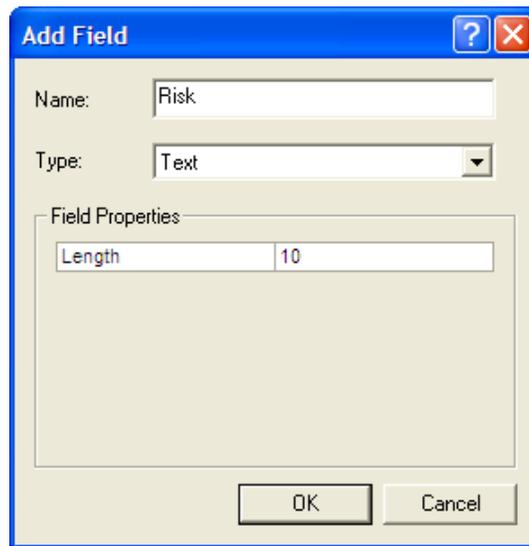
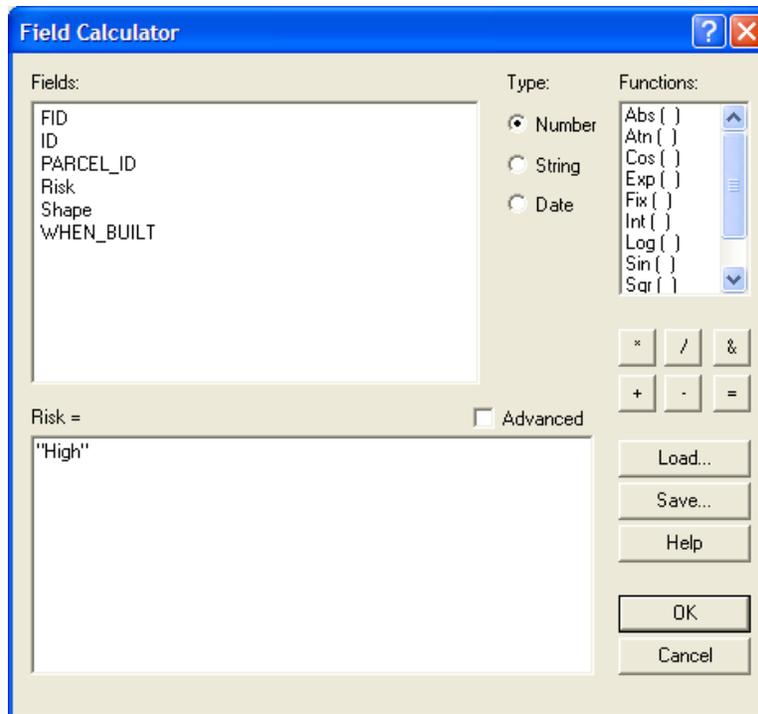

Figure 15. Add Field dialog box

Figure 16. Field Calculator dialog box

You will use the Shoreline Structures layer to determine whether the buildings on a parcel are impacted by bluff recession. You may recall that this point layer was created by locating one point on the major building of each parcel that is closest to the lake. For this analysis, you will assume that damage to this structure will result in the complete loss of improvement values on the property. Obviously, this estimate does not account for the value of other buildings on the property or partial damage to the primary building. The database for this analysis could be improved by associating each building with a separate value and by reformatting the building layer as polygons rather than line segments.

Identify moderate risk land areas and buildings found between the current stable slope location and the Ordinance setback zone.

Over the next 50 years, the Ordinance estimates that all the land within the setback zone will be lost to erosion from shoreline recession and bluff stabilization. Therefore, land areas and buildings between the Current Stable Bluff and the Lake Michigan Setback locations can be considered to be at "moderate risk" from the impacts of recession.

You will make a simple subtraction of the smaller buffer (Current Stable Bluff) from the larger buffer (Lake Michigan Setback) to create a new polygon identifying these areas of moderate risk. And make a selection to identify at-risk buildings.
Note: You will need an ArcGIS 9 ArcInfo license to perform the "Erase" geoprocess. If you are using an ArcView or ArcEditor license, you couldn't perform this operation.

Click **Show/Hide ArcToolbox Window** button to open the ArcToolbox. Double click the **Erase** command under the Analysis Tools and Overlay categories. In the Erase dialog box, choose **Lake Michigan Setback** layer as **Input Features** and choose **Current Stable Bluff** layer as **Erase Features** (*Figure 17*). Save the **Output Feature Class** as "area_modrisk.shp." Click OK to create a new layer. Rename it to "**Areas of moderate risk**."

> Erase command can create a feature class by overlaying the Input Features with the polygons of the Erase Features. Only those portions of the Input Features falling outside the Erase Features outside boundaries are copied to the Output Feature Class.
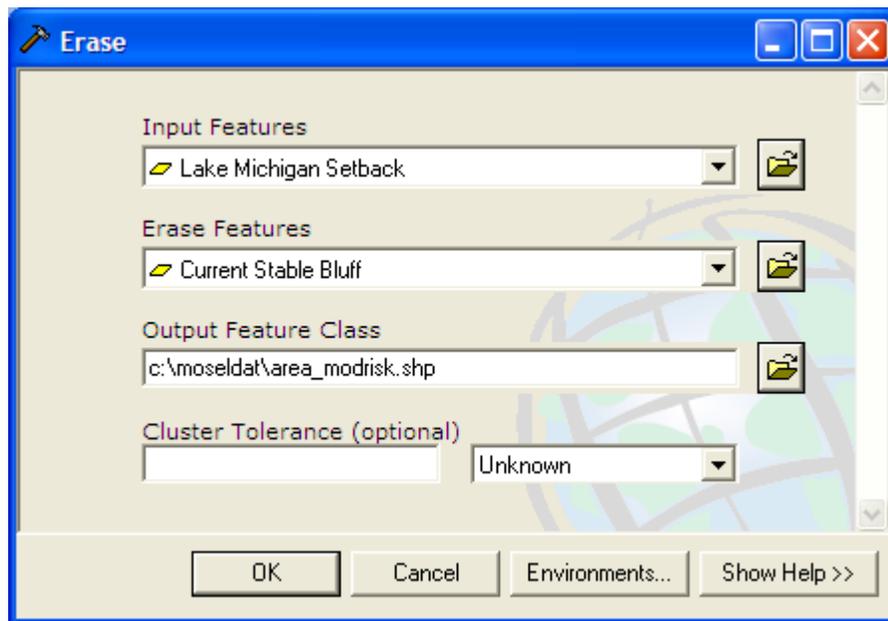

Figure 17. Erase dialog box

Choose **Selection By Location** from **Selection**. Select features from Shoreline Structures that **Intersect Areas of Moderate Risk** (*Figure 18*). Click **Apply** and close it. Open the attribute table of Shoreline Structures, right click on the **Risk** field header, choose **Calculate Values…** to calculate the Risk field equal to "Moderate" (*Figure 19).* Close the attributes table and clear the selection. Save your document.
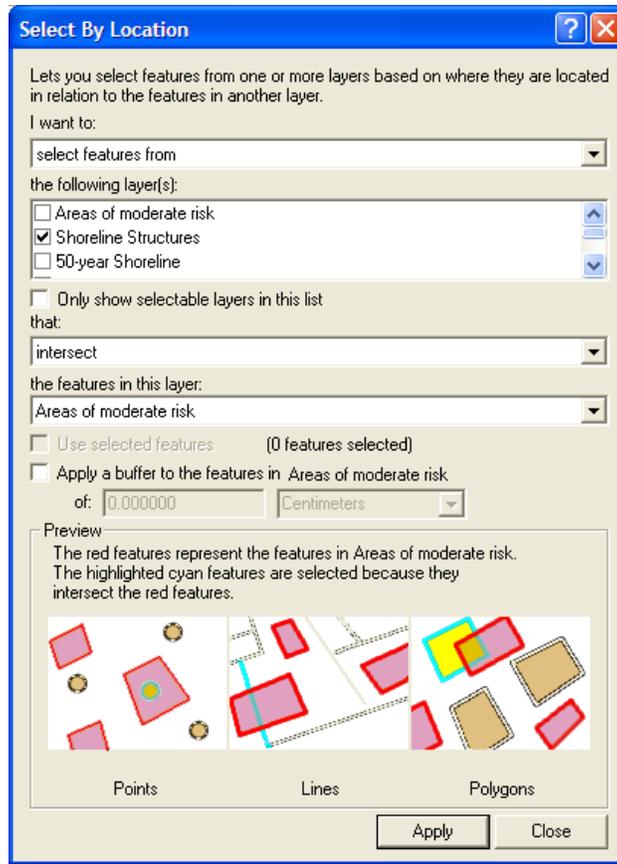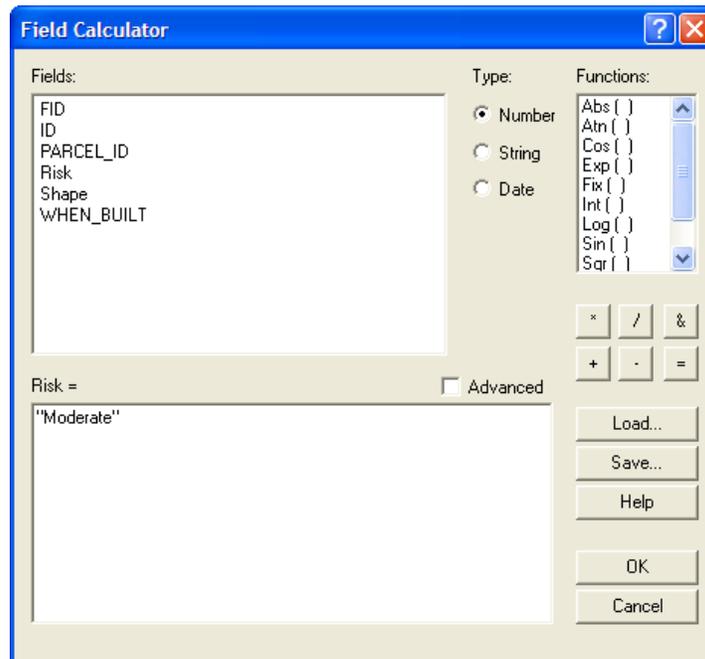
Figure 18. Select By Location dialog box

Figure 19. Field Calculator dialog box

Identify at-risk land areas and buildings within 50 feet of the setback.

One response to the threat of impacts from recession is to move the at-risk structures. In order to move these buildings, land is needed on all sides of the structure for the operation of moving equipment. It is estimated that at least 50 feet is needed on the side of the building facing the lake for this undertaking. This translates to an additional 50 feet of at-risk land inside the setback zone.

Create a 275-foot buffer of the Lake Michigan Shoreline layer, save the buffer layer as "buff_275.shp". Clip this buffer to the Shoreline Parcels layer, saving the file as "at_risk.shp," and renaming the layer "Moving Area." Remove the buff_275.shp file.

Use the **Select by Location** operation to select all Shoreline Structures that intersect with the Moving Area. Then use the **Select by Attributes** operation. In the dialog box, set layer as Shoreline Structures and choose **select from current selection** as method. Build a expression as (**"Risk"** = '') in the expression box (*Figure 20*). Click **Apply** and close it. Now, open the attributes table of Shoreline Structures and calculate the risk field for this new set equal to **"At Risk"**. Clear the selection on the Shoreline Structures layer and save the document.
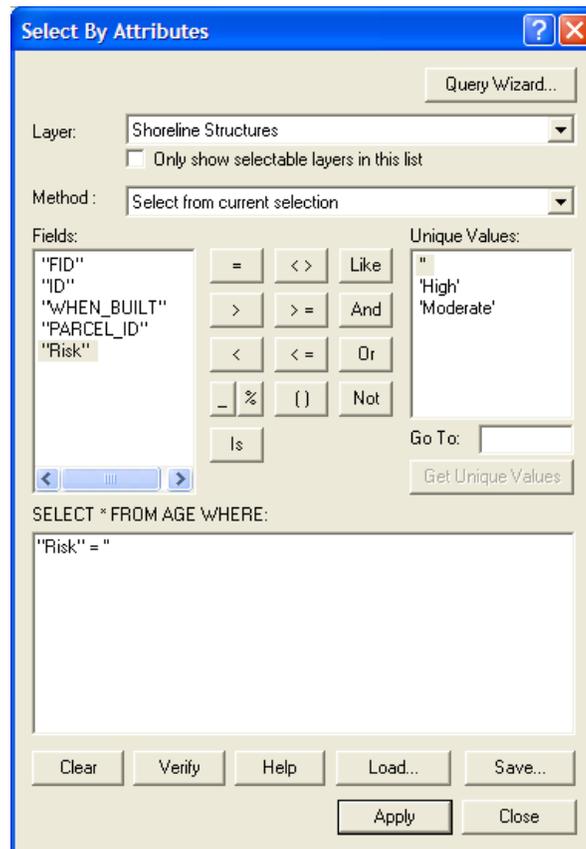

Figure 18. Select by Attributes dialog box

Part III: Estimating the economic impact of recession.

Based on the location of the projected shoreline, you will estimate economic impacts to assessed land values in the area. You will also estimate impacts to buildings and roads from bluff edge recession. All these analyses will be based on the recession rate assumed in the Shoreland-Floodplain Ordinance (i.e. two feet per year over a 50-year time frame).

For this analysis, you will be calculating the impact to lands based on the recession of the shoreline. The actual amount of land lost depends on both the recession of the shoreline cutting away the toe of the bluff, and the stabilization of the bluff causing recession of the bluff edge. Therefore, the total land lost will likely fall somewhere between the future shoreline location and the future bluff location.

Perhaps the best way to estimate this impact is to find the area between the current bluff edge and the future stable bluff location for each parcel. This could be used to estimate loss of land. However, your analysis will focus on a simpler operation – calculating the economic impacts to land lost from only recession of the shoreline.

Estimate the amount of land lost from shoreline recession.

Use the select by location operation to select all parcels that are within 1000 feet of the shoreline (*Figure 21*). Save this layer as a shapefile by choosing **Data>Export Data** under the context menu of Parcels layer (*Figure 22*). Save this layer as par_shor.shp, add it to the view and rename it "Shoreline Parcels." You will be using this parcel layer for the remainder of this section; delete the other Parcels layer from your view.
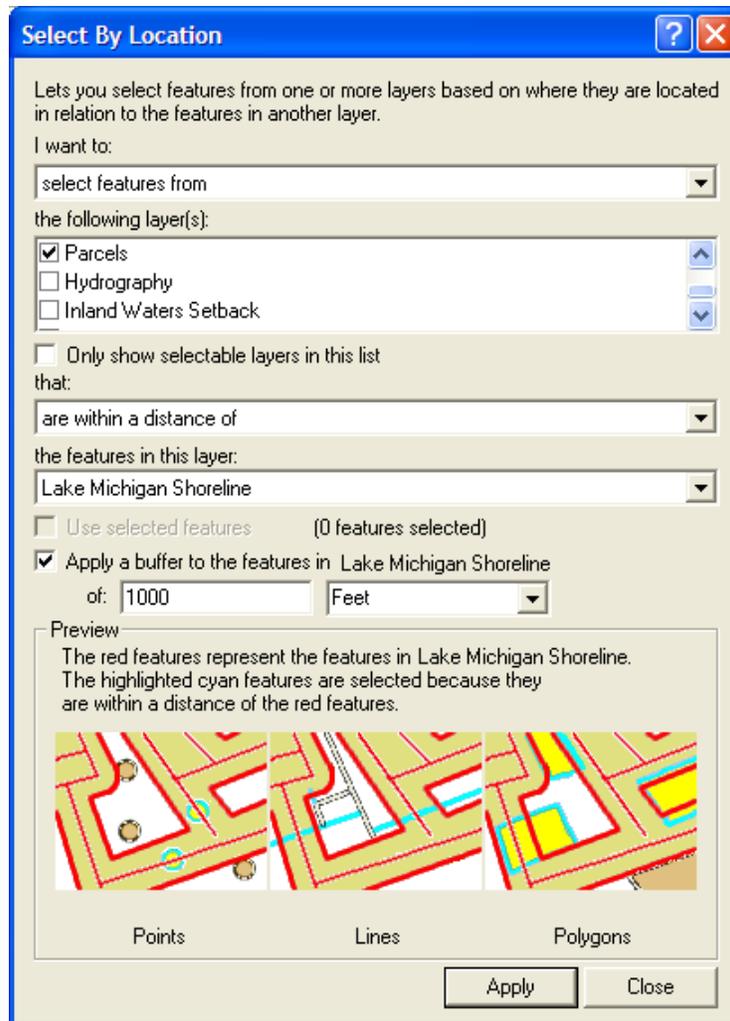
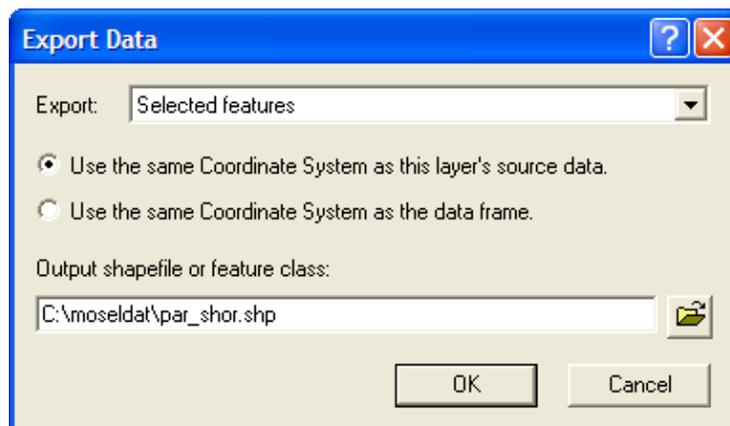**Figure 21. Select By Location dialog box**

Figure 22. Export Data dialog box

Double click **Intersect** command under the **Analysis Tools** and **Overlay** categories in the ArcToolbox window. Add Shoreline Parcels and 50-year Shoreline layers as Input Features and set Output Feature Class as "landlost.shp" with full path. Let other fields default values and create an overlapping layer (*Figure 23)*.

The Intersect command creates a shapefile with polygons formed wherever two or more layers overlap. These polygons contain the attributes of overlapping layers.
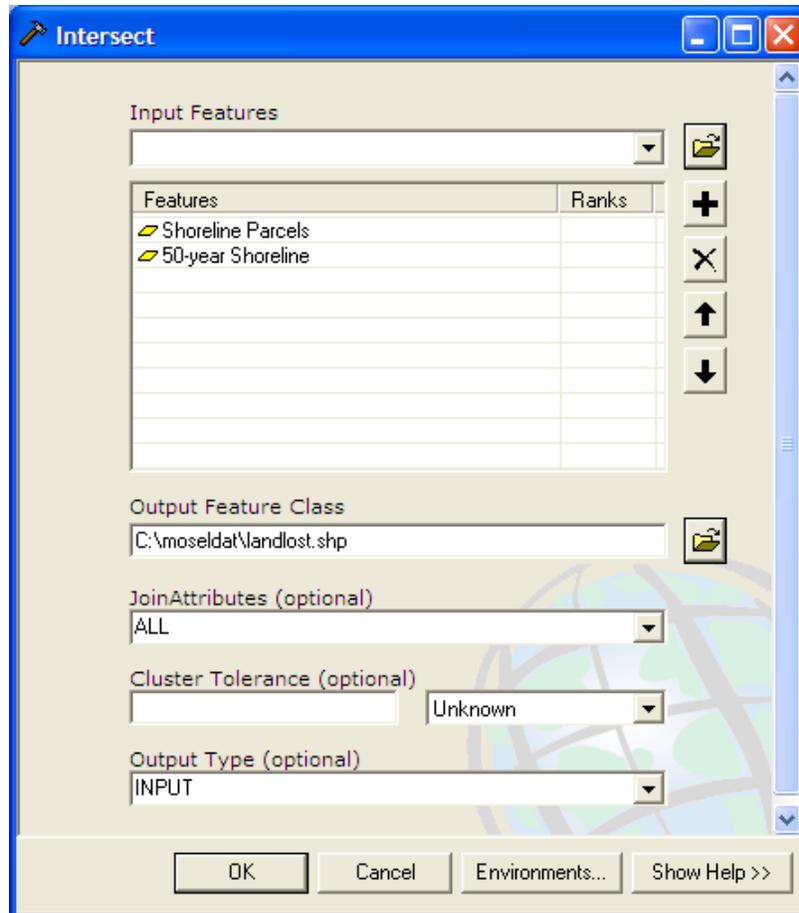

Figure 23. Intersect dialog box

Now, calculate the area of these new intersect polygons by adding a numeric field (type **Double**) to the Attributes of Landlost table (*Figure 24)*. Name this field "Intersect Area." (You may have to abbreviate the field name.) Right click on the header of new field and choose **Calculate Values…** In the Field Calculator, check the box of **Advanced** and type four lines into the **Pre-Logic VBA Script Code** box: (*Figure 25)*

Dim Output as double

> **Dim pArea as Iarea**
> **Set pArea = [shape]**
> **Output = pArea.area**

Type in **Output** in the lower bottom text box and click **OK** to calculate values (*Figure 23*). This intersection area represents the amount of land lost in each parcel to recession over a 50-year interval (based on a recession rate equal to two feet per year).
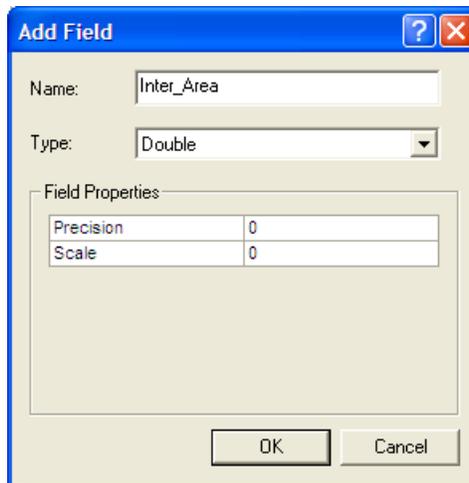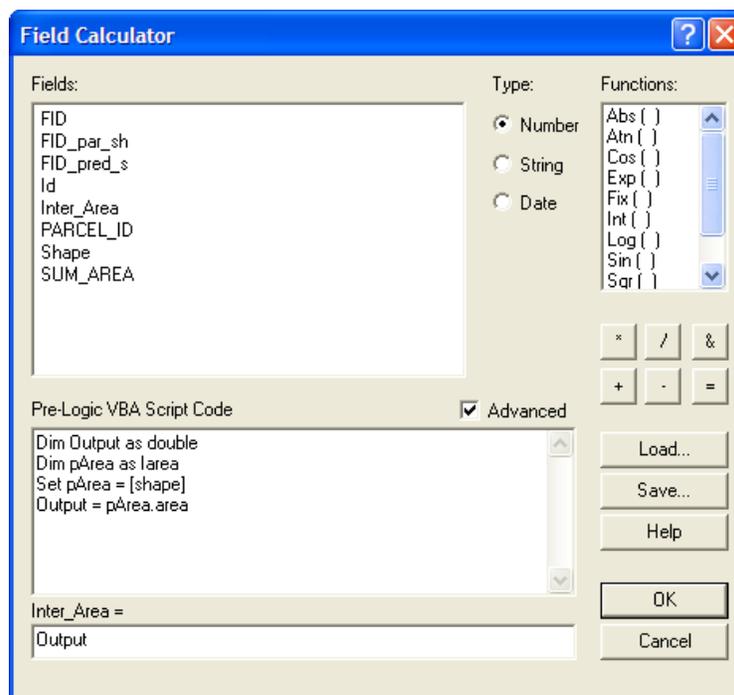
Figure 24. Add Field dialog box

Figure 25. Field Calculator dialog box

Add a **Float** type number field (2 decimal places) named "landlost" to the Attributes of Landlost table. Calculate this field equal to **Intersect Area / Sum_Area**. The landlost field estimates the proportion of land lost from the total area of the parcel.

Estimate the value of the land lost to shoreline recession.

You are now going to match each parcel's spatial information with data on the assessed value of the land. If you examine the data on land values, you will see that several records may share a common parcel identification number. This is because a parcel may be assessed in more than one category and the information is stored as multiple records. For this application, you will need to aggregate all multiple records so each parcel has only one total assessed value.

Both spatial and attribute information on the parcels must be aggregated to perform the analysis described in these GIS applications. In both cases, information is "lost" for analytical purposes when the individual records are combined under one parcel identification number. Clearly there is value in planning for GIS analysis functions when defining and refining database management systems.

Use any text file Editor to open the file "values63.txt" and replace "$" to "_value" in the first line because ArcMap cannot recognize "$" as in the fields. After editing, the first line looks like:
  "Parcel_id","Category","Subcatgry","Acreage","Land_value","Improv_value"
Save the file and close the editor.

Add values63.txt to your data frame and open it.

Right click on the **Parcel_id** field header of the attributes table and choose **Summarize…** in the context menu. Parcel_id field is the field used to aggregate your data. In the dialog box, choose a directory and name for your file (valu_sum.dbf). Check the following three summary fields, then click **OK**: (*Figure 26)*

Field:	Summarize by:
Acreage	Sum
Land_value	Sum
Improv_value	Sum

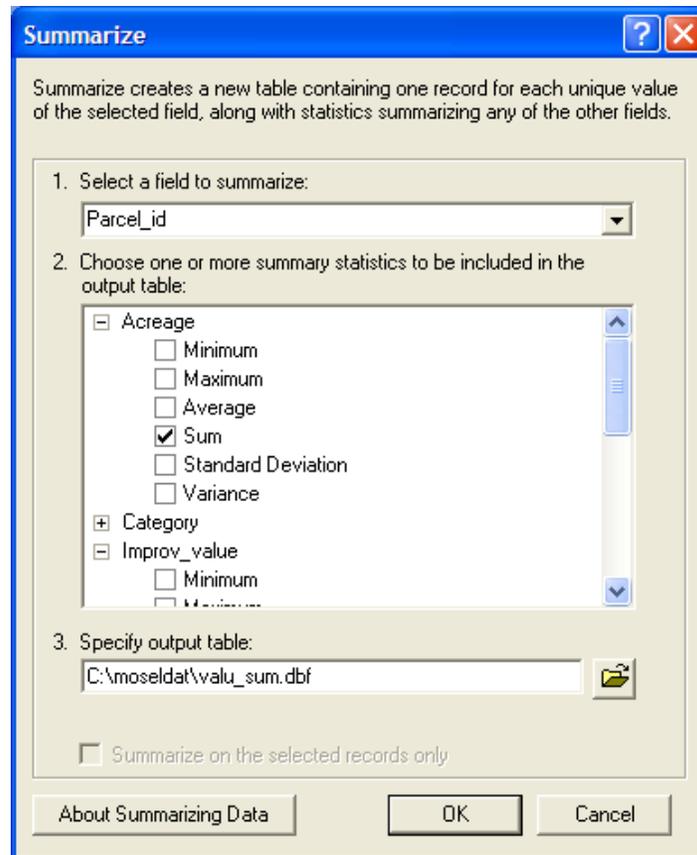Click **Yes** to add the result table in the map.

Figure 26. Summarize dialog box

The new Valu_sum table will also be used to store data on the impact of recession on shoreline parcel assessment value. Both the Landlost and Valu_sum tables share common Parcel_id field values. With the join operation, you will match and append records between tables through this common identifier.

In performing the join operation, the Attributes of Landlost table will be the source table, and Value_sum will be your destination table. Make sure both tables are added in the map. Click **Source** tab at the bottom of the Table of Contents. Right click on the Valu_sum table and choose **Joins and Relates>Join…** Select Parcel_id field of two tables in the two fields drop-down combo boxes. Select Landlost table as the table to join. Click **OK** to join. (*Figure 27)*

When you execute a join, you are not affecting the physical files on the disk. Rather, you are establishing a relationship between two tables. When you save a project, you save the definition of this join in your view. Therefore, next time you open the document, ArcMap will automatically rejoin the tables. When you want to make changes in joined tables, you need to be in the "home" table for the particular fields you wish to edit. Any changes you make will be reflected in the destination table. You can also make a

permanent disk copy of a destination table by exporting this table to a new file.
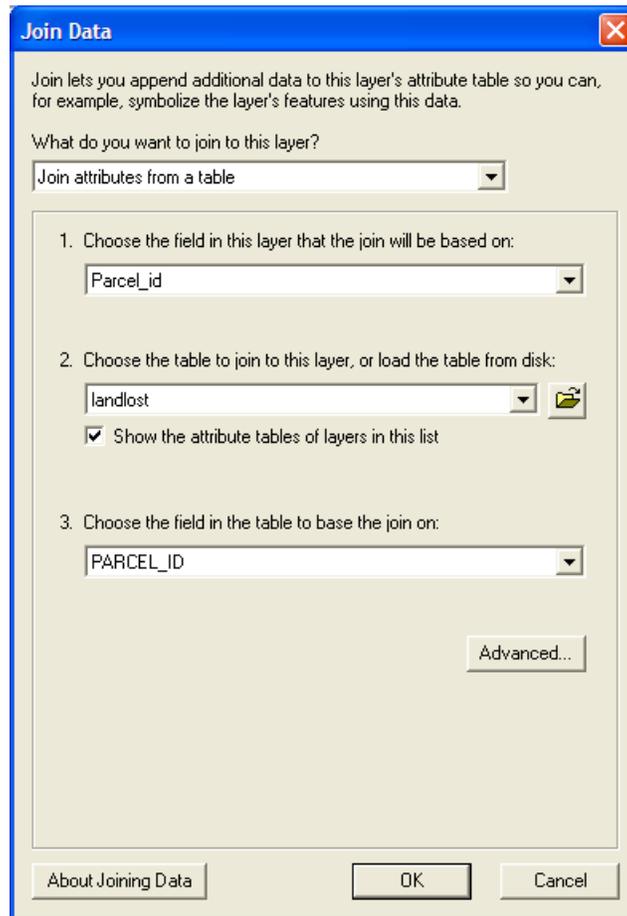

Figure 27. Join Data dialog box

Add a double type number field called "lostvalu" to the Value_sum table and calculate this field equal to **[landlost.landlost] * [valu_sum.Sum_Land_v]** (*Figure 28*). In other words, the lostvalu field contains the loss in assessed value for each shoreline parcel, based on a recession rate of 2 feet per year over a 50-year period. Now, right click on valu_sum layer, choose **Joins and Relates>Remove Join(s)> Remove All Joins**. Save your document.

This time with Valu_sum as the source table and Attributes of Shoreline Parcels as the destination table, join the tables on Parcel_id (*Figure 29*). Examine the data. Some of these parcels were not impacted by shoreline recession and therefore show no loss of land value. In addition, remember that two of the parcels are actually road right-of-way polygons and therefore have no assessed values.
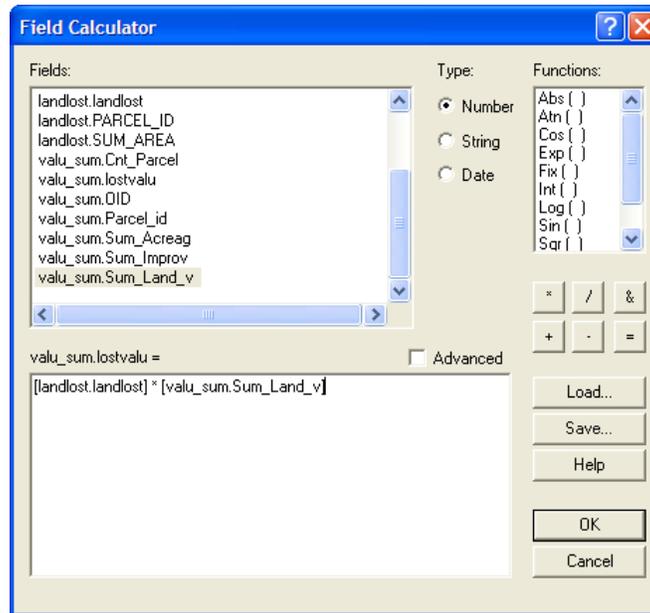
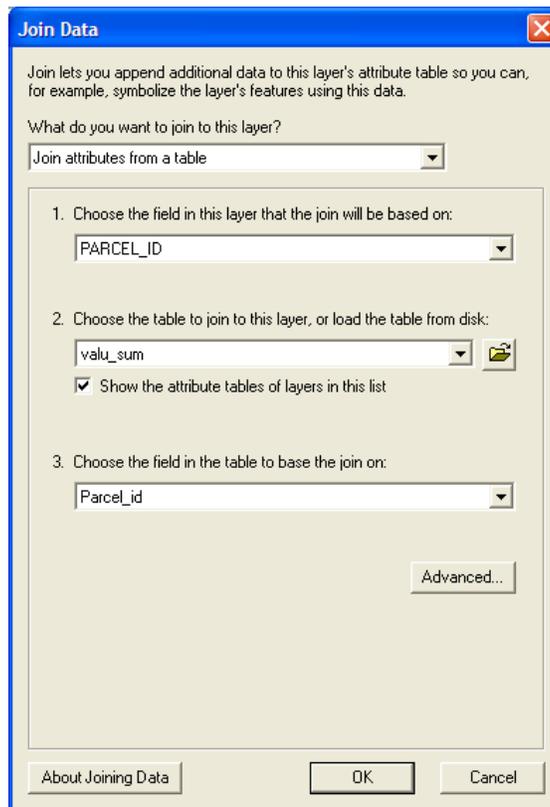**Figure 28. Field Calculator dialog box**

Figure 29. Join data dialog box

To summarize the total economic impacts to land values for the Town of Mosel, narrow down your dataset to examine only those parcels financially impacted by shoreline recession. Build a query on the joined Shoreline Parcels layer to select for all parcels where **"valu_sum.lostvalu" > 0** (*Figure 30*).

Note that two parcels adjacent to the coast are not selected. These parcels have no matches in the tax assessment database and may point out an error in that database.
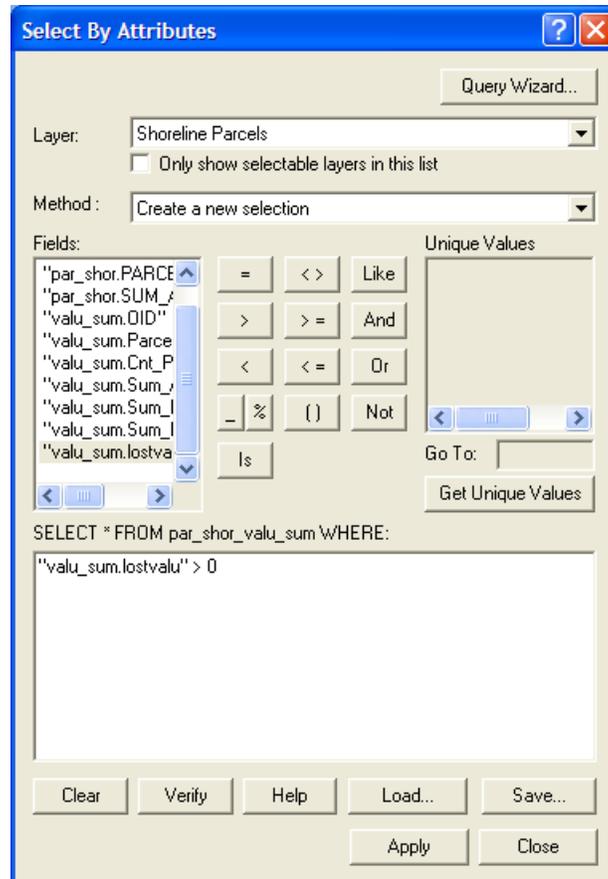

Figure 30. Select By Attributes dialog box

To find the values for the Original Value field, you will need to open the Attributes of Shoreline Parcels table (a subset of this table should be selected). Right click on the header of **Sum_Land_value** field, choose **Statistics…**under the context menu. A box will appear with summary statistics for the **Sum_Land_value** field *(Figure 31)*. You are interested in the total value of the land for the selected set; this is the Sum. Note this value. Now change the field to **valu_sum.lostvalu**, you will find the total value of the land lost.

Clear the selected features from **Selection** menu and save your documents.
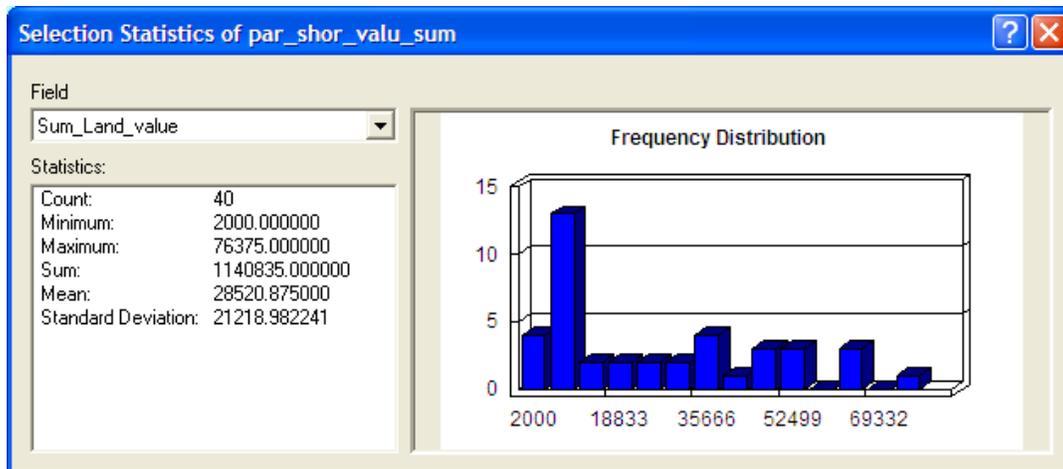
Figure 31. Statistics window

Estimate impacts to buildings from bluff edge recession.

Bluff recession will impact buildings before shoreline recession. Therefore, the estimated 50-year bluff edge location, as projected from the Ordinance setback requirements, will be used for this analysis.

> Make the Shoreline Structures, Buildings, Lake Michigan Setback and Lake Michigan Shoreline layers visible and the others invisible.
>
> In order to obtain totals for improvement values (original and losses), you will need to join the **Valu_sum.dbf** (source table) and the table for the Shoreline Structures layer (destination table) on Parcel_id. For the Original Values, use the statistics operation to calculate the total value (sum) of the **Sum_Improv_value** field for these records.
>
> Now you will determine which buildings are impacted from recession of the bluff. From **Selection** menu, choose **Select By Location** to select all points that intersect with the Lake Michigan Setback layer *(Figure 32)*. Open the attribute table for the Shoreline Structures layer. The selected set will be highlighted; note the sum statistics for **Sum_Improv_value** field.
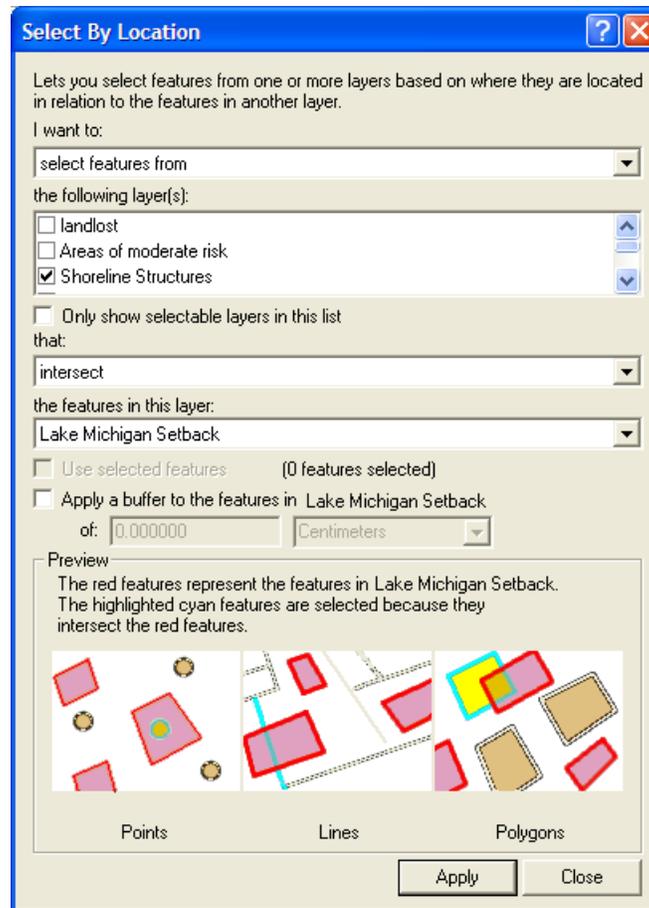
Figure 32. Select by Location dialog box

Estimate the impacts to roads from bluff edge recession.

As with the buildings, recession of the bluff edge is a better predictor of impacts to roads than shoreline recession.

> Make the Transportation Routes, Lake Michigan Shoreline and Lake Michigan Setback visible. Note how close the road (County LS) is to the current bluff edge. You will be using the intersect operation to estimate the length of road impacted by the bluff recession.

> Right click on the Transportation Routes layer and select **Properties…** Change to Definition Query page, build a query, selecting only records with **"LGDS_LEVEL" = 2**. This narrows the layer down to just road centerlines, therefore preventing multiple counting of impacts to the same road section

> Double click the **Intersect** command under the **Analysis Tools** and **Overlay** categories in the ArcToolbox window. Add **Transportation**

Routes and **Lake Michigan Setback** layers for the **Input Features**. Choose a directory and name for your **Output Feature Class** (lostroad.shp) and Click OK to perform the operation *(Figure 33)*. Add the result layer to the Shoreline Recession Scenarios data frame if ArcMap doesn't add it. Rename the layer "Road Impacts".
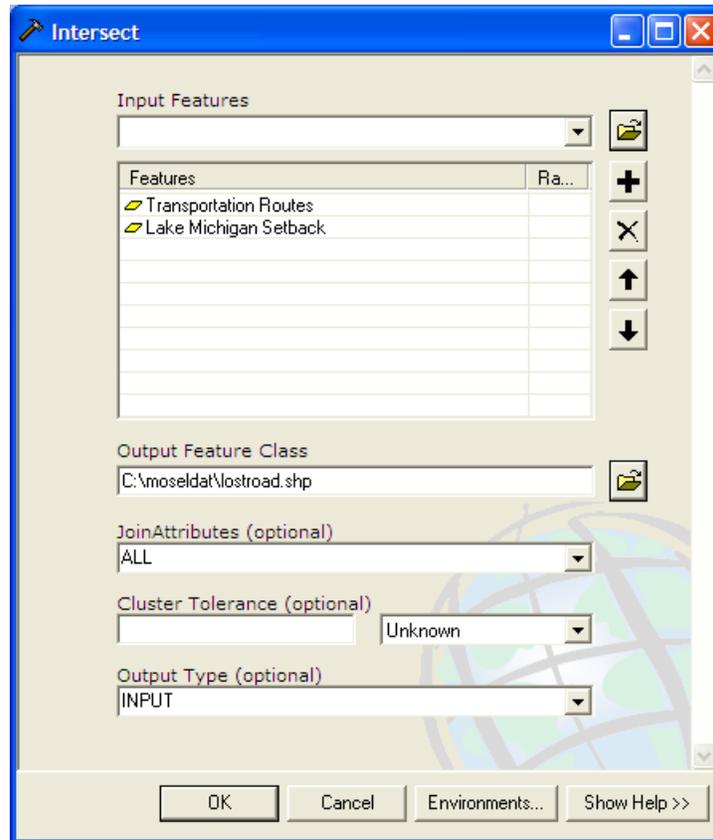

Figure 33. Intersect dialog box

To find the total length of road impacted, open the attribute table for the Road Impacts layer. Add a **Double** type number field called "Impact_Len." Right click on this field header and choose **Calculator Values…** to open **Field Calculator** window. Click **Advanced** checkbox. type the following four lines into the **Pre-Logic VBA Script Code** box and type **Output** in the text box at the bottom of the window *(Figure 34)*.

```
Dim Output as double
Dim pCurve as ICurve
Set pCurve = [shape]
Output = pCurve.Length
```

Click OK to calculate the lengths of the new line segments. To estimate the total length of road impacted by bluff recession, use the statistic function for a sum of the **Impact_Len** field. Save document.
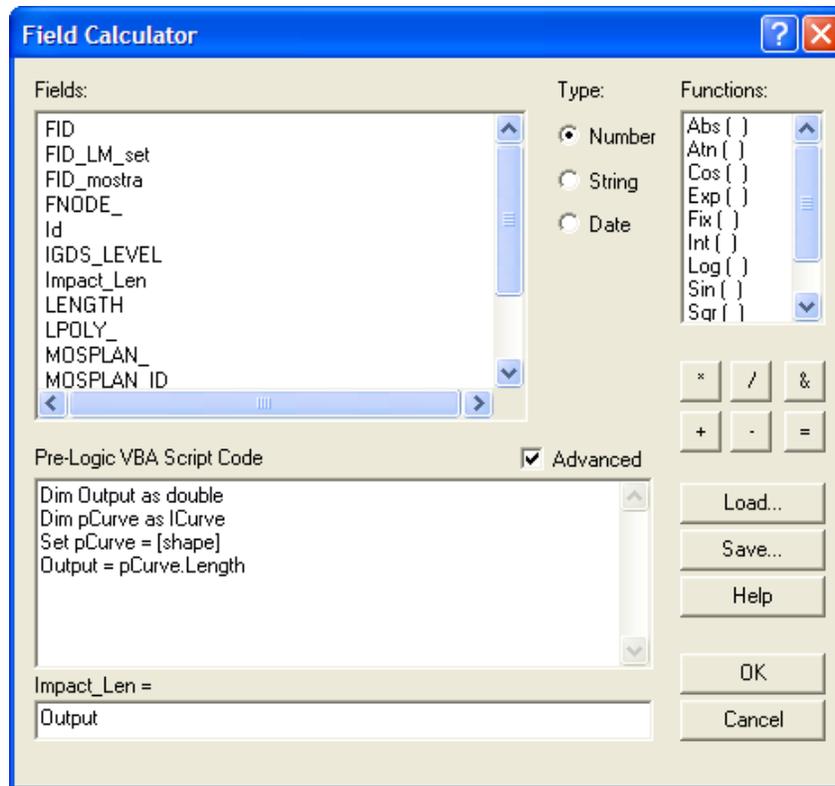
Figure 34. Field Calculator dialog box

Part IV: Estimating the volume of sediment lost to erosion.

Shoreline erosion also impacts water quality in Lake Michigan by adding tons of sediment into the Lake. It is possible to estimate the volume of sediment that will be lost to erosion based on the bluff height, the recession rate, the time frame under consideration and the distance of shoreline under analysis. You will access the formula for calculating sediment volume through ArcMap's hot link tool.

Set up a hot link to the file containing the sediment loss formula.

Hot links provide a tool for linking a layer in your map with an external file. These external files may contain text or images, or they may be used to access a customized script file. You can even use this tool to documents, URLs or a Macro of ArcMap. In this section, you will create a new layer that will act as a link to an image file containing the formula for calculating sediment loss.

Click ArcCatalog button to open ArcCatalog. In the directory tree view, locate a directory you wish to save the new shape file. Right click on the directory and choose **New>Shapefile…** In the dialog box, type in your filename as "sediment.shp" and choose Point Feature Type. Click **Edit** button to select a predefined coordinate system, **NAD 1983**

HARN Adj WI Sheboygan Feet, under **Projected Coordinate Systems>Country System>Wisconsin** subdirectories. Click OK to close the dialog box. Now, the shpefile is created in the directory. Close ArcCatalog and return to ArcMap.

In ArcMap, add sediment.shp to your view. Click **Editor Toolbar** button to open it. On the Editor Toolbar, click **Editor** button and choose **Start Editing**. In Start Editing dialog, choose shapefile type and click OK *(Figure 35)*. Click Start Editing in the next dialog. On the Editor toolbar, set **sediment** in **Target** drop-down combo box and **Create New Feature** in **Task** drop-down combo box *(Figure 36)*.
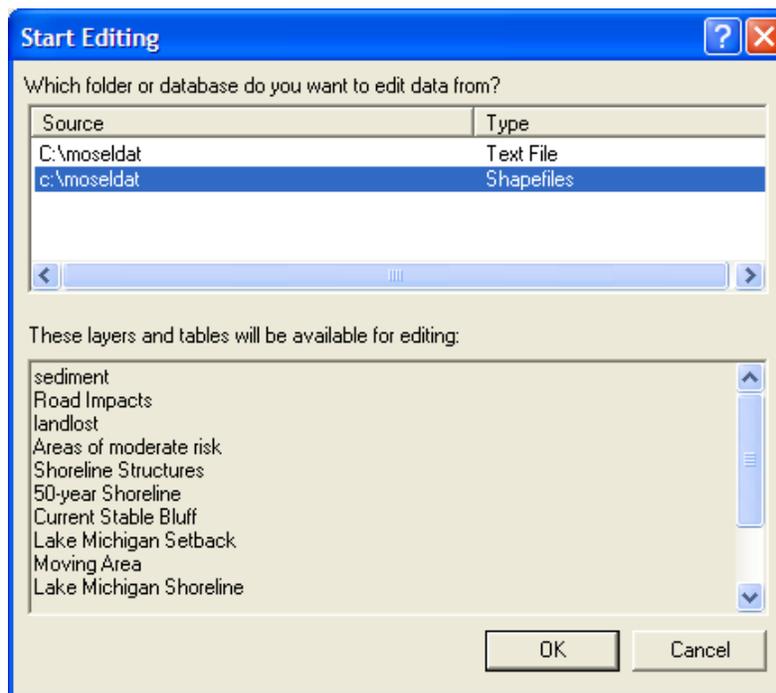
Figure 35. Start Editing dialog box

Figure 36. Editor Toolbar
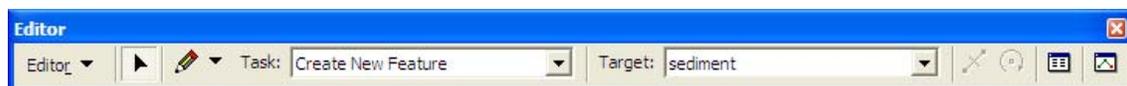
Click Sketch Tool on the Editor toolbar. Place a point somewhere along the Lake Michigan shoreline, just offshore. Save your edits and rename the layer "Sediment Formula." Open the Symbol Selector for this layer by clicking on the legend in the Table of Contents. Choose a new symbol for this layer (e.g. 16-point star). Clicking on this symbol will access your hot link to the sediment formula.

To create the hot link, open the table for the Sediment Formula layer. Add a new Text field named "hotlink," 50 characters in width. Edit the value in this field by typing the pathway name to the file called "formula.gif." For example, this may look like: c:\coastgis\formula.gif. Save your edits and stop editing from the Editor toolbar menu. Close the Editor toolbar window.

Open the **Layer Properties** dialog box for the Sediment Formula layer and change to **Display** page. Check the box in the Hyperlinks frame and choose "hotlink" field in the drop-down combo box. Make sure Document radio button is selected *(Figure 37)*. Click **OK** to close the dialog box.
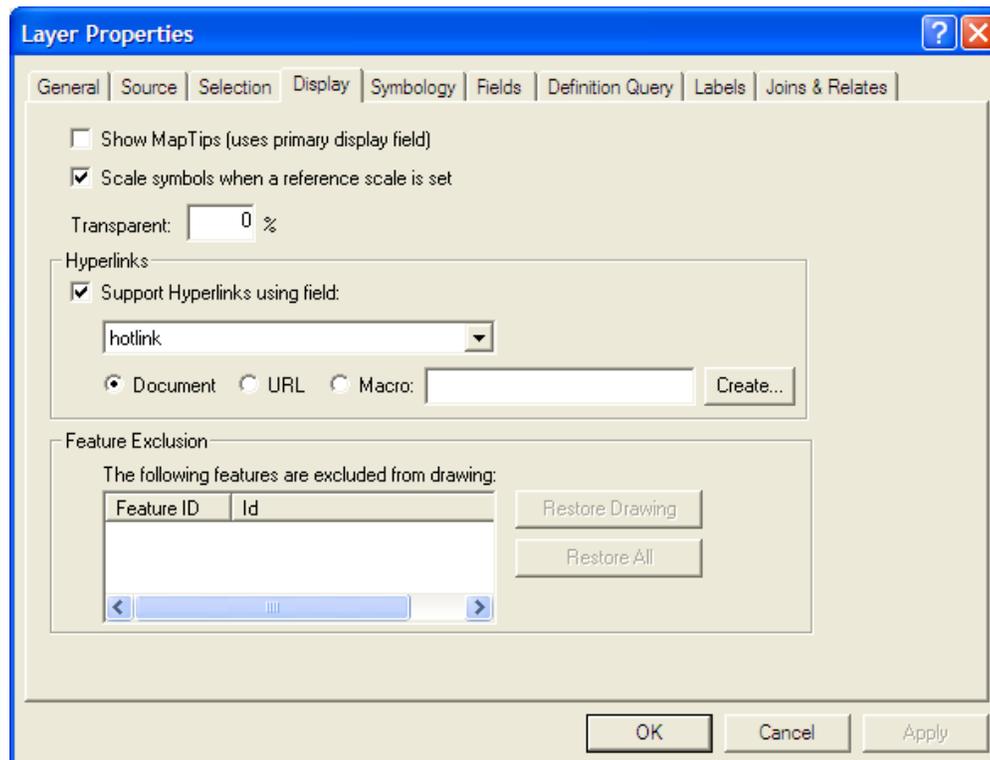
Figure 37. Layer Properties dialog box

Calculate the sediment loss from shoreline recession and bluff stabilization.

With the Sediment Formula layer visible, click the **Hot Link** button. Your cursor will now appear as a lightning bolt. Place the bottom of the lightning bolt in the center of your Sediment Formula point and click the left mouse button. A picture viewer should now appear in your view displaying the sediment formula image file *(Figure 38)*. Examine the formula for computing the sediment loss.

Figure 38. Sediment Loss Formula

Loss = ((r * t * h) - (1.25 * h)) * l

where: h = bluff height
r = recession rate
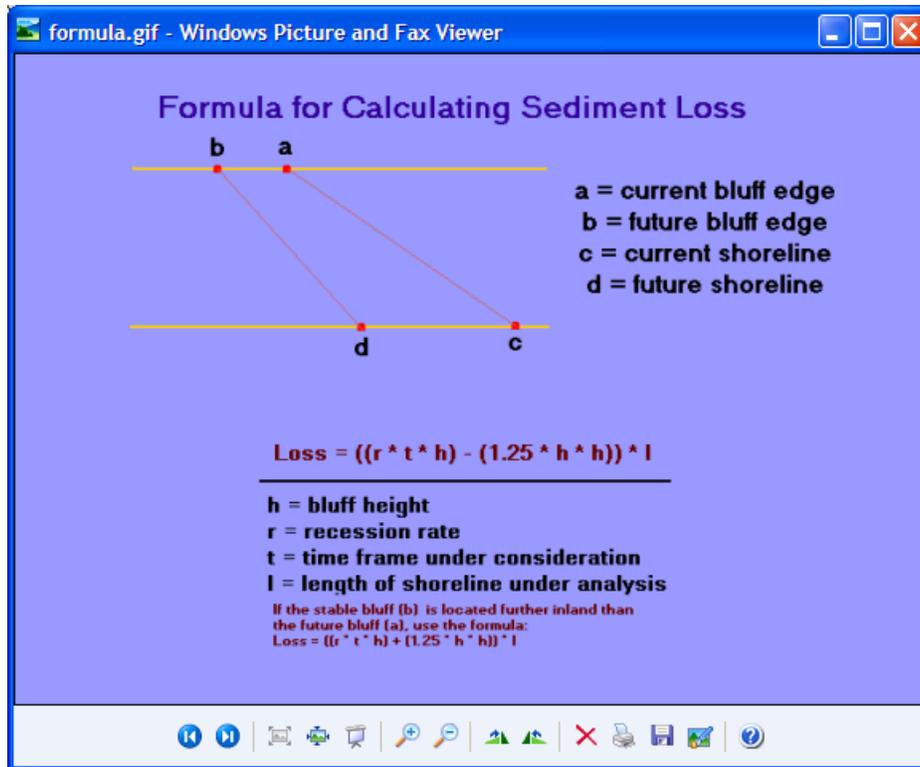t = time frame under consideration
l = length of shoreline under analysis

If the future stable bluff is located further inland than the future bluff, use the formula:

Loss = ((r * t * h) + (1.25*h*h)) * l

Four variables are necessary for calculating this value: height of the bluff (h), recession rate (r), time frame under consideration (t) and length of area under analysis (l). For this application, you will define these variables as: h = 50 feet, r = 2 feet/year and t = 50 years. The length will be equal to the shoreline length for the Township. You may also wish to calculate the sediment loss per mile of shoreline. If you decide to apply this formula to another geographical area, remember to adjust the bluff height and recession rate values accordingly.

Open the table for the Lake Michigan Shoreline layer. Calculate the total length of the shoreline by finding the sum statistics for the length field. Note this value for your sediment loss formula. Calculate the sediment loss value based on the stable slope described by the Ordinance setback distance. You may wish to convert these values from cubic feet into cubic yards (divide by 27). Save your document.

5. Identifying parcels which may be difficult to develop.

In this section, you will identify vacant parcels along the Lake Michigan shoreline which may be difficult to develop under current zoning regulations.

Create buffer layers based on setback distances.

In this area of Sheboygan County, the setback requirements for all "Principle Buildings" (e.g. homes, commercial buildings) along the Lake Michigan Shoreline is 225 feet from the high water mark of Lake Michigan and 75 feet from any navigable inland waters (with certain exceptions). In addition, Town of Mosel zoning requirements include an 80-foot setback from road centerlines.

> Return to your Shoreland Zoning Ordinance data frame and view. For this section, you will focus on the required setbacks within the zones, rather than on the zones themselves. You already have a layer illustrating the required Setback from Lake Michigan. Copy this layer from your Shoreline Recession Scenarios view. Also copy the Transportation Routes and Buildings layers from the Data Layers data frame.
>
> With the Hydrography layer visible, create a buffer which illustrates a setback zone of 75 feet for all inland waters. Save the file as "iw_sb.shp" and Set buffer Distance 75 Feet. Select **List** as **Dissolve_Type** and check **Shpae** field *(Figure 39)*. Perform the operation. When the layer is added to your view, rename it "Inland Waters Setback."
>
> Now, make the Transportation Routes layer visible. You will need to narrow down this layer to show only road centerlines. In the **Definition Query** page of Layer Properties window, build the following query: (**"LGDS_LEVEL" = 2**) and click **OK**. Now, buffer this selected set with an 80-foot buffer distance. Save the file as "rd_sb.shp" *(Figure 40)* and rename the layer "Road Setback."
>
> Finally, you are going to create a layer with all three of these setbacks merged into a single zone representing undevelopable lands. To do this, you will need to use **Union** and **Dissolve** commands to merge the layers. Double click Union command under the Analysis Tools and Overlay categories in the ArcToolbox to open the window. Add **Road Setback**, **Lake Michigan Setback** and **Inland Waters Setback** layers as Input Features. Save your Output Feature Class as "nobd.shp." *(Figure 41)*
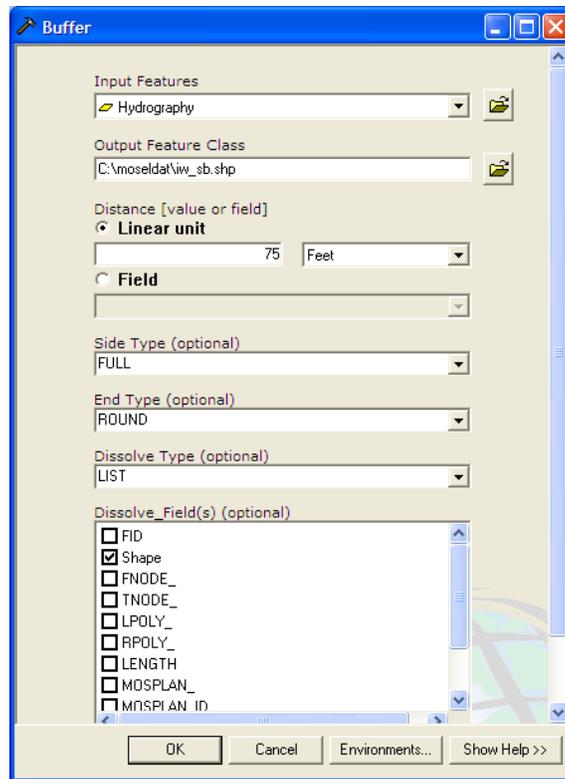
Figure 39. Buffer dialog box

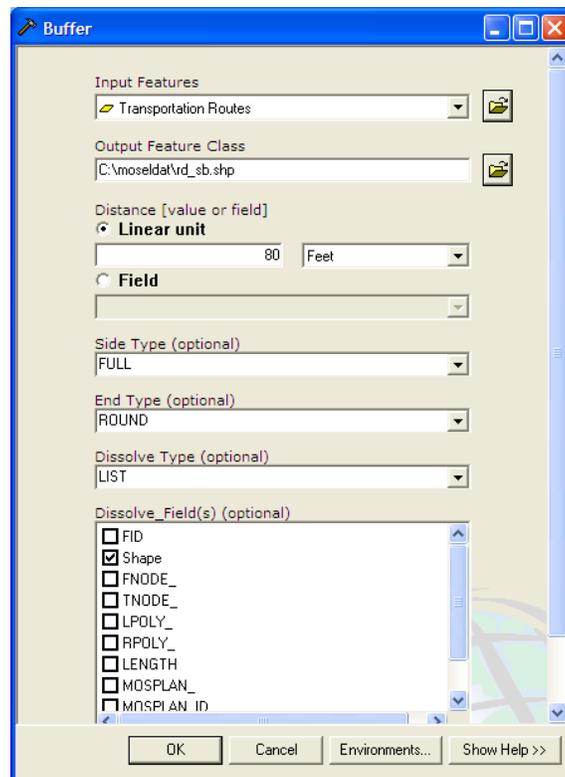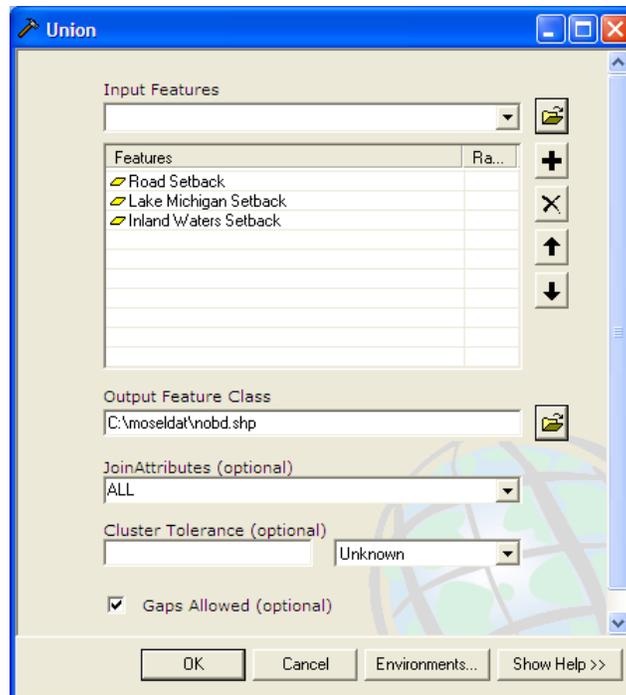**Figure 40. Buffer dialog box**

Figure 41. Union dialog box

Now, double click the **Dissolve** command under Data Management Tools and Generalization categories in the ArcToolbox. Choose nobd as Input Features and save Output Feature Class as "nobuild.shp." Check **Shape** filed in Dissolve_Field(s) list box and click **OK** to dissolve *(Figure 42)*.
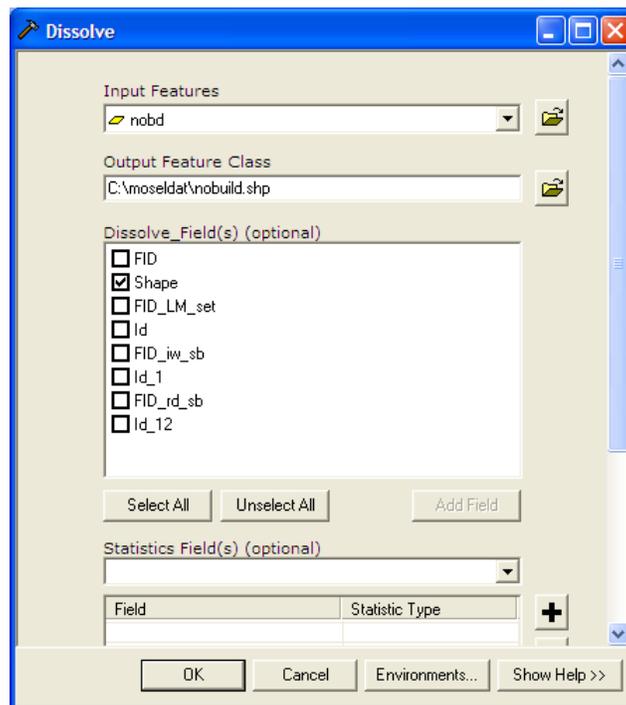

Figure 42. Dissolve dialog box

Bring the new file into the view and rename it "Undevelopable Lands." Remove nobd.shp from the data frame since you will no longer need to access any of the original buffers (all should end in .shp).

Calculate the amount of developable land for each parcel.

In order to narrow down this analysis, you will now select vacant parcels along Lake Michigan. In order to select only vacant parcels, you will first select parcels with buildings and then reverse this selection.

Make the Parcels layer visible and display it with a gray foreground and with colored outlines. Choose **Select By Location...** in the **Selection** menu to create a new set by selecting parcels that intersect with buildings *(Figure 43)*. Now, reverse this set to highlight vacant parcels by opening the parcels layer table and clicking **Switch Selection** in the Options context menu.
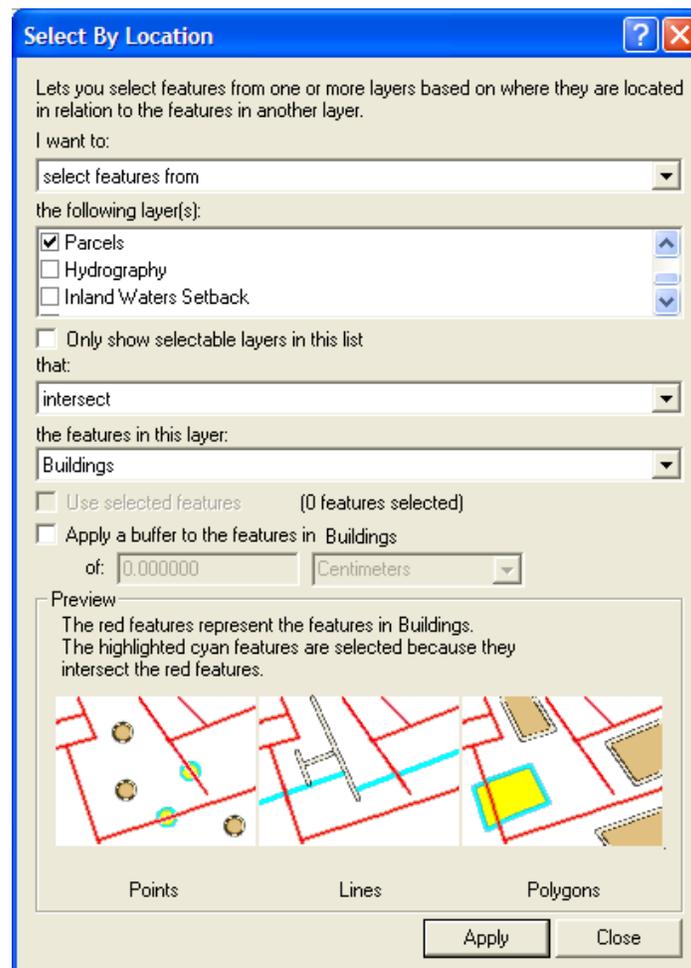

Figure 43. Select By Location dialog box

Close the table and do another **Select By Location...**. **Select from the currently selected features in Parcels layer that are within a distance of Lake Michigan Shoreline.** Type 1000 feet for the selection buffer distance. Click apply button to choose only from the previously selected vacant parcels and close the window *(Figure 44)*.
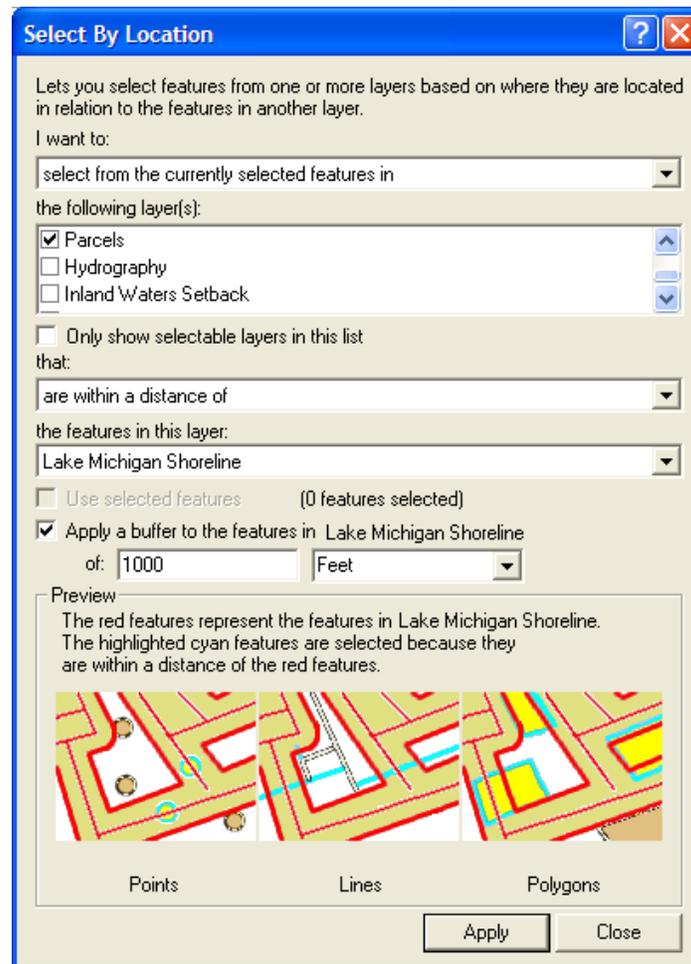
Figure 44. Select By Location dialog box

At this point, you can visually examine the impacts of the various setback zones on vacant property. The **Measure** button is a tool for obtaining measurements from the view screen. However, you may want to obtain more exact measurements of developable land for each parcel.

Clear selected features from Selection menu. Click the Intersect command in the ArcToolbox. Add Parcels and Undevelopable Land as the Input Features. Save the Output Feature Class as "intrsect.shp" and click OK to perform it *(Figure 45)*. Rename the result layer "Intersection" in the Table of Contents window. This file contains polygons representing the undevelopable land for each parcel.
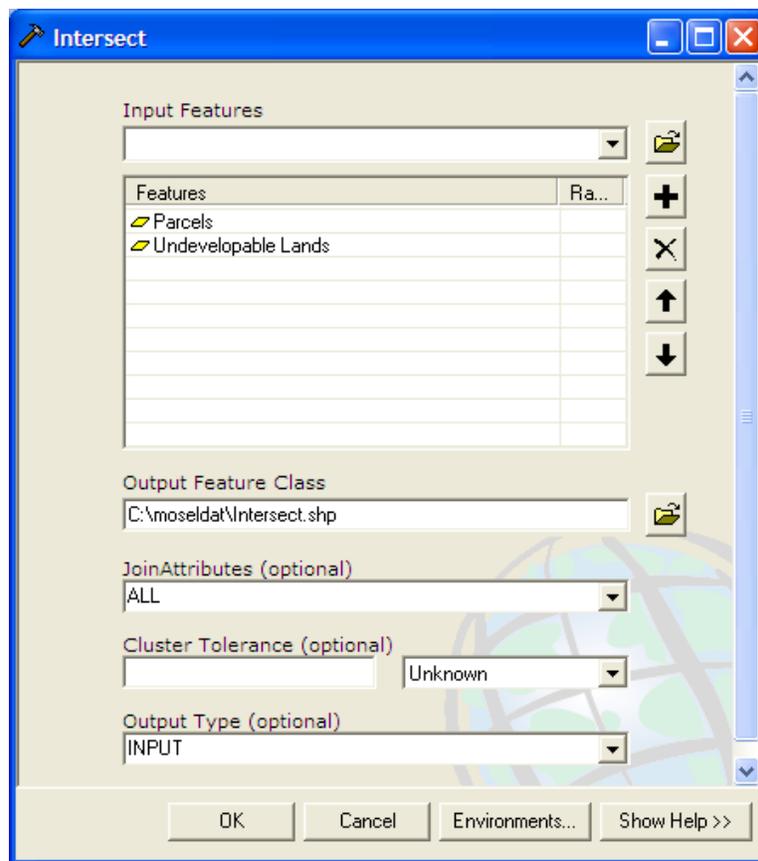
Figure 45. Intersect dialog box

You can use these undevelopable lands to find the total developable area for each parcel. First, add a Double type number field (named "Inter_Area") to the Attribute of **Intersection** table. Right click on header of Inter_Area field and choose **Calculate Values…**. Check Advanced box in the dialog and type the following 4 lines in the **Pre-Login VBA Script Code** box:

```
Dim Output as double
Dim pArea as Iarea
Set pArea = [shape]
Output = pArea.area
```

Type **Output** in the text box at the bottom of the window *(Figure 46).* Click **OK** button. This will calculate the area of the polygons in this shapefile..

Figure 46. Field Calculator dialog box

Now, with Intersect as the source table and the Parcels as the destination table, join the tables on the field "Parcels_id" by right clicking on the Parcels layer and choose **Join…**. Add a Double type number field to the Attributes of Parcels called "Develop" and calculate this field equal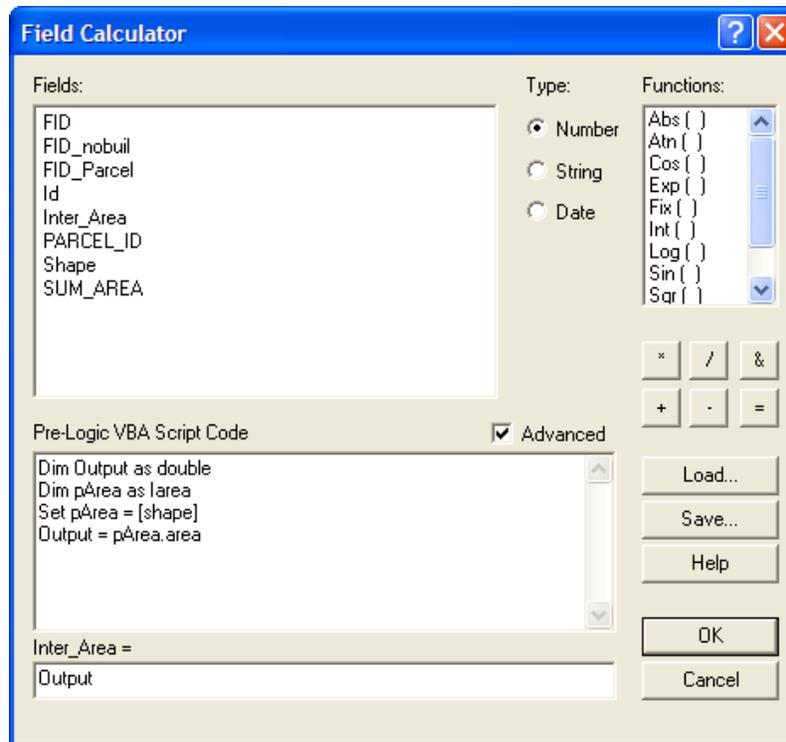 to **[Parcels.SUM_AREA]**. Once again, calculate this field equal to **[Parcels.SUM_AREA] - [Intersect.Inter_Area]**. In other words, you are calculating the amount of land in each parcel that does not fall into one of the setback zones.

We do calculating value two times since some parcels have no overlap with the setbacks layers and therefore, have no Intersection records. If there is no overlap with a setback zone, a parcel's total area is considered developable. So we first fill in **[Parcels.SUM_AREA]** values, then calculate this field equal to **[Parcels.SUM_AREA] - [Intersect.Inter_Area]**. The values of those parcels with no intersection records will have the parcels' area; otherwise, they will be filled in zero.

Chart the amount of developable land on vacant, lakeshore parcels.

Once again, you are going to restrict your analysis to vacant parcels, with no buildings, within 1000 feet of the Lake Michigan Shoreline. With the Parcels layer visible, use the **Select By Location...** operation to select this set.

One way to examine this data is to make a chart illustrating the amount of

developable land for each shoreline parcel. Open the Parcels layer table. Click on the **Options** button and choose **Create Graph**. In the Graph Wizard dialog boxes, first choose the type of your chart. Then, check the field Develop and make graph data series use Fields. Name the title of chart as "Developable Lands." Set label legend with Parcel.id field. Click Finish button. Your chart will now be displayed. A similar chart is like *(Figure 47)*. Now, your can use mouse cursor, clicking on the chart, to query the attributes data.

You can also change formats of the chart by clicking the **Advanced Options…** and **Add Overlay…** buttons in the wizard dialog boxes. You can adjust **Titles**, **Axis**, **Font**, **Markers**, **Background**… and etc.
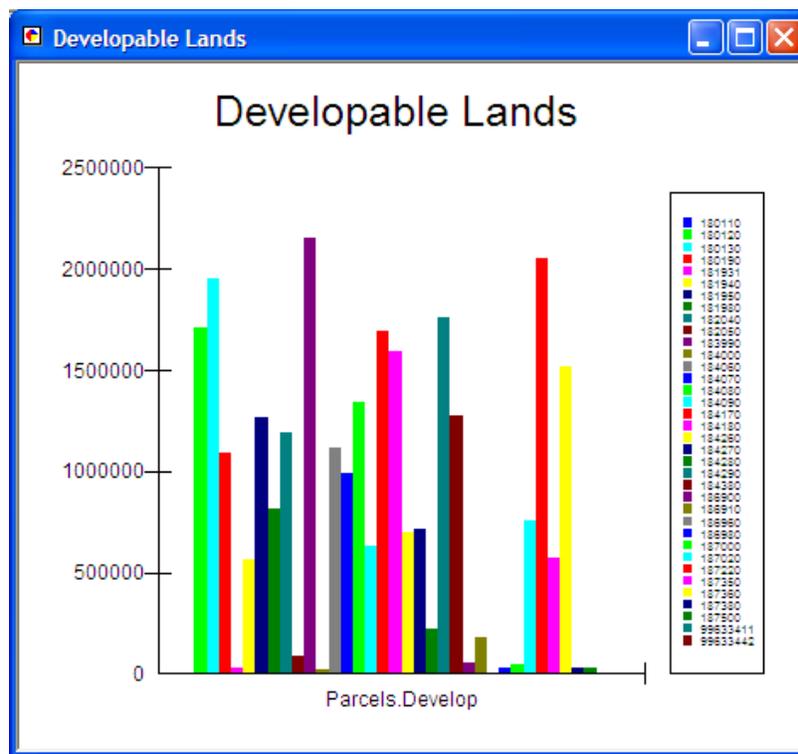
Figure 47. Developable Lands chart

Flag vacant, lakeshore parcels with minimal developable lands.

Although visual interpretation of maps and charts will give you an overall view of this issue, you may want a more qualitative solution to help you with your decisions. In this section, we will flag parcels will less than 25,000 available square feet for development as "parcels for potential concern." The 25,000 square feet value is somewhat arbitrary; it is simply intended to represent a value for which sitting a home may be more difficult. These may be parcels where zoning administrators will pay extra attention when evaluating any submitted permits. However, feel free to change this value if 25,000 does not make sense to you.

The vacant, lakeshore parcels without buildings should be highlighted. Create a query on this layer, selecting from the current selection any parcels with less than 25,000 feet of developable land. Only show these records by clicking the Selected button in the attributes table. Add a Text field to the Parcels layer called "**Flagged**." Calculate values of this filed equal to **"Yes"**. Open the layer properties dialog box and change to Labels page. Check the box in front of **Label features in this layer** and choose Parcels.Flagged in **Label Field** drop-down combo box. Make other values in default values. Click OK. You will find that these parcels are labeled with Yes.

The accuracy of these buffers in determining setback distance is only as good as the accuracy of the lines on which they are based. Any user of these model applications should be aware of the following data limitations and the assumptions made in this analysis:

1. *The Shoreland-Floodplain Ordinance requires a 75-foot setback from the ordinary high water mark for all inland navigable waters. In this analysis, you made two assumptions that could be challenged: (1) all inland waters are navigable, and (2) the rivers and streams can be portrayed by one "centerline" (rather than their two shorelines).*
2. *The Town of Mosel Zoning Ordinance requires a minimum setback of 80 feet from road centerlines, with a 100-foot requirement for state and federal highways. However, the digitized road segments do not differentiate between county, state, federal or "unofficial" (e.g. military base) road segments. Your 80-foot buffer will be inappropriate in some places.*
3. *As you know, the dynamic nature of the Lake Michigan shoreline makes it a difficult feature to digitize accurately. The location of the ordinary high water mark, the basis for this setback, is not static. Therefore, the setback cannot be static.*
4. *Without information describing the creation of this digitized shoreline, we cannot be certain whether the digitized line represents the ordinary high water mark, the location of the water's edge at the time an aerial photograph was taken, or some other feature that was interpreted as the "shoreline." This type of background information about a GIS data feature is called "metadata" and should always be recorded when a GIS layer is created!*

Save your document.

6.   Identifying potential shoreland permit compliance issues.

In this section, you will evaluate aerial photographs and permit information to identify whether structures along the Lake Michigan shoreline are in compliance with the shoreland permit regulations.

Evaluate aerial photographs to determine the age of structures.

Old aerial photographs of Sheboygan County are a good source for tracking the development of this area over the last sixty years. From these photos, it is possible to determine the approximate age of the structures along the shoreline. Of particular importance to this application is the date October 27, 1970. Structures built prior to this date are considered "non-conforming" uses if they do not meet current requirements of the zoning districts. Structures built after the effective date of the ordinance that do not meet the requirements of the ordinance and do not possess a proper variance or permit may not be compliant. In these cases, further investigation may be warranted. Aerial photos from the years 1941, 1961, 1967, 1971, 1978 and 1992 were used to determine the age of major structures within 1000 feet of the Lake Michigan Shoreline. In the Shoreline Structures layer, the field "When_built" contains the range of years when buildings first appeared in the location of the point.

> Copy the Shoreline Structures layer from the Shoreline Recession Scenarios data frame into your Shoreland Zoning Ordinance data frame and make the frame active. Use the **Select By Location...** operation to select all of the shoreline structures that intersect with the Lake Michigan Setback layer. To find out if any of these structures were constructed after the ordinance went into effect, use **Select By Attributes… Select from current selection** and build the following query: **"AGE.WHEN_BUILT" = '1972 - 1978' OR "AGE.WHEN_BUILT" = '1978 - 1992'**. Click **Apply** and close it. Two points should be highlighted.

> Now you will see if these two structures have shoreland permits. Add the table "moselplg.dbf" to your document. Using moselplg.dbf as the source table and Attributes of Shoreline Structures as the destination table, join the tables on the Parcel_id field. You will note that neither of the selected structures have permits. Therefore, further review may be warranted to determine if they are in compliance with the Ordinance. Save your document.

> *This application points out the difficulties in working with a changing feature like the Lake Michigan Shoreline. If the shoreline was a farther distance away when these buildings were constructed, they may have been in compliance with the ordinance at that time. Using photogrammetric techniques, you could determine the distance of these structures from the shoreline at the time the photos were taken.*

7. Informing landowners about septic tank regulations.

In this section, you will generate a form letter, asking landowners for information about their septic systems.

Link attribute files containing information on parcels, sanitary systems and land ownership.

Return to your Data Layers view. Add the dBase file called "moselsan.dbf" and "ownerwww.dbf" to your document. Both these attribute files share the Parcel_id field in common with the Parcels layer. With the ownerwww.dbf file as the source table and the Attributes of Parcels as your destination table, join these tables.

Perform a second join using the moselsan.dbf as the source table and the Attributes of Parcels as the destination table. Once again, use Parcel_id as the common field.

> In order to make the Attributes of Parcels table less complicated, you can hide some of the fields from **Layer Properties**. Open the layer properties dialog box, change to **Fields** page and uncheck any fields which you wish to hide. These fields won't appear if you print the table. In addition, they can't be used to label or query the layer.

Display developed parcels without sanitary permits.

Make the Parcels and Buildings layers visible and other layers invisible. Display the Parcels layer in gray, outlined by another color. Clear any selection you may have on this layer.

You will now find all the parcels that are developed (i.e. overlap with the Buildings layer). Under the Selection menu, choose **Select By Location...**. Select the features from **Parcels** layer that **Intersect Buildings layer.** *(Figure 48)* Click **Apply** and close it. Convert these features to a shapefile by right clicking on the Parcels layer and choosing **Data>Export Data…** Save the file as "developed.shp" and add the file to your view and rename it "Developed Parcels." *(Figure 49)* Click the **Clear Selected Features** for the Selection menu.

Make the Developed Parcels layer visible. In order to select only the parcels without sanitary permits, we will first select those with permits and then reverse the selection. In the attribute table of Developed Parcels layer, under the Options context menu, choose **Select By Attributes.** Build the following query: (**"SANPERMIT" > 0**). Click Apply and close it. Now

click the **Options** button and choose **Switch Selection**. All of the parcels with buildings, but without recorded sanitary permits, will be highlighted. Save your document.
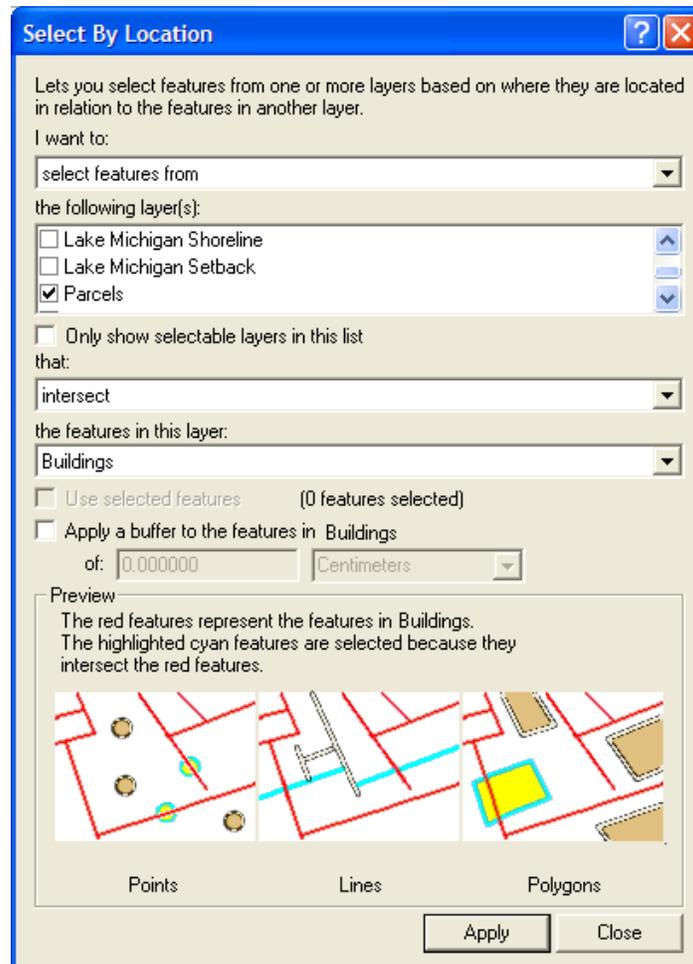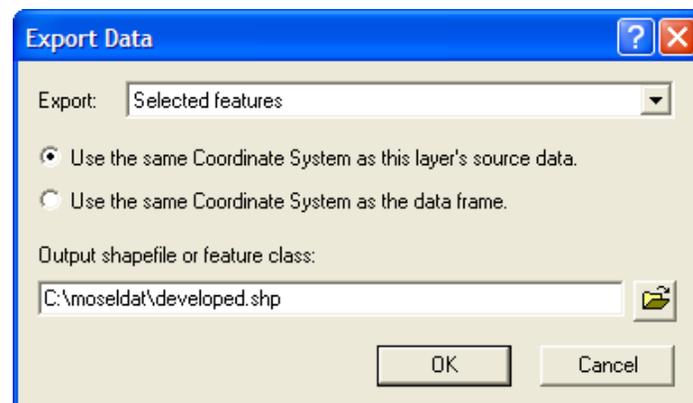

Figure 48. Select By Location dialog box

Figure 49. Export Data dialog box

Mail merge ownership data with a form letter using Microsoft Word.

For this section, a form letter called "notify.doc" has been created. This letter is intended to illustrate the capabilities of coupling the GIS and word processing functions. Feel free to edit the letter and insert additional merge fields to make this exercise more relevant to your applications.

First, you need to save your current selection as a dBase file. Make sure your Attributes of Developed Parcels table is open. To export the database file, click the Options button and choose **Export...** Export your Selected records and save your output file as "notify.dbf." Save your document, minimize the ArcGIS screen and open Microsoft Word.

Open the file "notify.doc." In the Tools menu, select **Mail Merge**. From the Mail Merge Helper box, under Step 1 -- Main Document, choose **form letters** from the Create drop-down menu. A question box will appear; click **Active Window**.

Proceed to Step 2. Select **Open Data Source** under the Get Data dropdown menu. From the List of Files Type, choose the **dBase(*.dbf)** option. Select "notify.dbf" and click **OK**. In the Confirm Data Source dialog box, highlight your appropriate dBase connection and click **OK**. A question box will appear stating that no merge fields have been identified; click the **Edit Main Document** button. Place the cursor below the line "Sheboygan County Property Owner." From the Insert Merge Field scroll list, select **STREET**. Move to the next line and add the merge field **CITY**. Now, type a comma followed by a space and the letters "WI" and two spaces. Add the merge field **ZIP5**.

To proceed with the final step, choose **Mail Merge** from the Tools menu. Under Step 3, click **Merge...**. The Merge Box will appear; simply click the **Merge** button and the program will produce 263 separate form letters for all of the affected properties. Save your letters.