LCC Analysis Tools *for ArcMap 9.3 - Manual*

Version:	Beta 1
Last update:	January 13, 2011
Install Files:	Setup.exe
	Setup_LCCAnalysisTools.msi
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Description: Currently developed for **Mars**, LCC Analysis Tools provides a set of tools for backtracking secondary impact crater chains, e.g. Large Crater Clusters (LCC) to potential parent crater sites by means of a systematic 3-step process:

Step 1. *Cluster Analysis Tool* – Identifies LCC using a nearest neighbor analysis routine and fits elliptical polygons to each identified cluster

Step 2. *Trajectory Analysis Tool* – Generates trajectories for each LCC ellipse identified in Step 1 by extending the ellipse' major axis a specified distance around the planet

Step 3. *Intersection Analysis Tool* – Trajectories are intersected with each other and clusters of intersections identified through the same nearest neighbor analysis routine used in Step 1. Intersection centroids are calculated for each identified intersection cluster pinpointing the potential locations of parent craters

Each analysis routine and its input parameters are presented in a 'Windows' form that allows the user to fill in the desired specifications for modeling ejection-trajectory-impact scenarios.

Requirements: ArcGIS Desktop 9.3

Important: This custom ArcGIS Desktop add-on requires the ArcGIS Desktop ".NET Support" feature to be installed prior to its installation. Please check the PIGWAD website for a document on how to install the support feature before installing this add-on.

ftp://pdsimage2.wr.usgs.gov/pub/pigpen/ArcMap_addons/Installing_ArcGIS_NET_Support.pdf

Manual updated: January 20, 2011
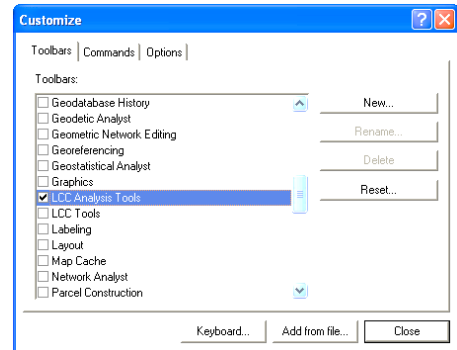
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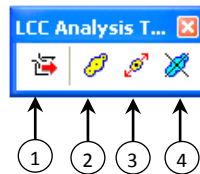
1. Installation instructions

Install the LCC Analysis Tools by double clicking the Setup.exe file and following the installation instructions in the "LCC Analysis Tools Setup Wizard". *NOTE: Make sure both the .msi and .exe files are in the same folder, and at the same level.* The installation routine will register the LCCAnalysisTools.dll with the required ArcMap components. The default install folder is: "C:\Program Files\USGS Astro\LCC Analysis Tools"

2. Adding to ArcMap

1) After install, open ArcMap. On the main menu, click on Tools > Customize…
2) Under the Toolbars tab, look for "LCC Analysis Tools" and click on the check box. The "LCC Analysis Tools" toolbar should appear somewhere on the screen or docked along with the other toolbars.
3) Close the Customize dialog.

3. Toolbar description

	Name	Description	Input	Req. fields	Output
1	Spatial Select/ Export	Select features by drawing a polygon on the map and export them to a new feature class. (See section 4)	Point	N/A	Point
2	Cluster Analysis Tool *(Step 1)*	Identifies clusters of crater points and generates elliptical polygons fitted to each cluster. Optionally, only elliptical polygons are generated provided a 'Cluster ID' field. (See section 5.1)	Point	[ClusterID]*	Polygon
3	Trajectory Analysis Tool *(Step 2)*	Generates ejecta trajectories as polylines by extending the major axes of elliptical polygons across the planet's surface. (See section 5.2)	Polygon	[CenterX] [CenterY] [Rotation] [MAJ_AXIS] [INV_FLAT]	Polyline
4	Intersection Analysis Tool *(Step 3)*	Generates statistically calculated parent crater locations from the intersection of ejecta trajectories. (See section 5.3)	Polyline	N/A	Point

Table 3.1. Name, description, and input requirements for each tool. All tools require the input features to be feature classes within a File Geodatabase and be projected in meters. The Trajectory Analysis tool requires a specific set of fields in order to run. These fields are automatically generated for the output polygon feature class in the previous step. * A 'Cluster ID' field is only necessary when using the Cluster Analysis Tool 'By cluster ID' method.

4. *Spatial Select & Export* window description

The "Spatial Select & Export" window is a 'dockable' window used to prepare crater point data for consumption by the LCC Analysis Tools. The data can be broken down spatially into different feature classes and used as input for subsequent tools. Using the export tool helps in preventing 'crashes' of LCC Analysis tools due to relatively large datasets.
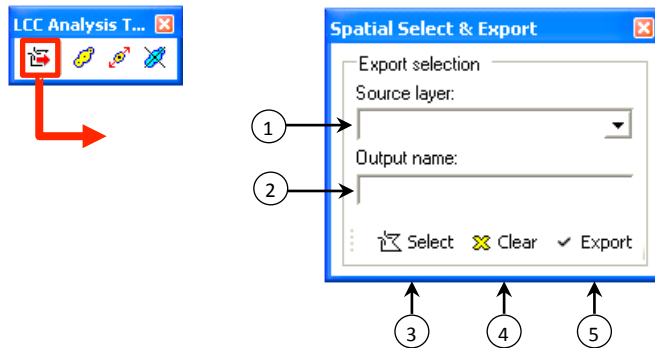
	Name	Description
1	Source Layer	Select the layer to select and export features from
2	Output Name	Type in the new feature class output name. This new feature class will be located in the same data source as the "Source layer" feature class
3	Select	Click on this button and draw a polygon on the map to enclose the features to be exported
4	Clear	Clears the currently selected features on the "Source layer"
5	Export	Exports the selected features from the "Source layer" to a new feature class with the given "Output name" to the same data source location as the "Source layer"

Table 4.1. *Spatial Select & Export* window controls and their description.

5. Tool concepts
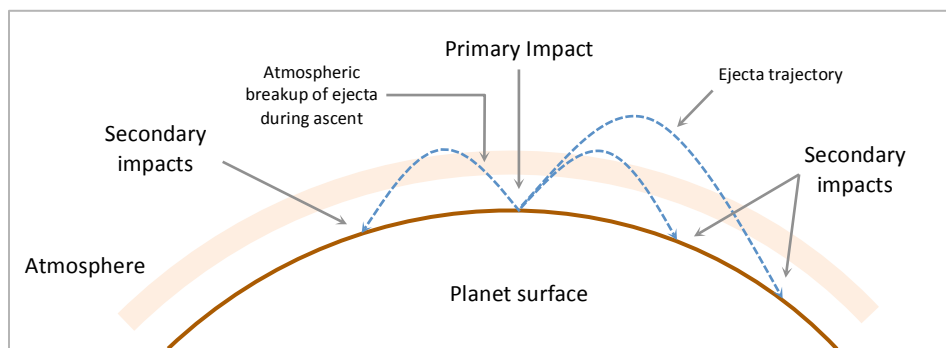
Figure 5.1. Secondary craters are produced by fall-back of high-velocity ejecta blocks from larger primary impacts. The atmosphere may play an important role in the breakup of material during ascent, leading to the characteristic crater distributions of secondary clusters.

The LCC Analysis tools are designed to work sequentially, using the output of each tool as input for the next. The process begins with a crater point feature class. Clusters of craters are identified in the first step. The

second step generates polylines of possible ejection trajectories for each cluster. On the third and final step ejecta trajectories are intersected with each other to generate points of intersections. If intersections are spatially grouped, the tool finds those groups and computes a centroid, or mean center, per group. These centroids are part of the final feature class and indicate the potential locations of primary/source impacts for the input craters used in *Step 1*.

Feature classes used throughout the LCC analysis process are stored in a File Geodatabase and are added to the map as layers during tool execution depending on their relevance. Because each tool can produce feature classes that are only used as temporary output/input, not all layers produced by each tool will be present on the map. The material in Section 6 breaks down the layer groups used by each tool and whether or not they will be shown on the map.

The following sub-sections provide an overview of each tool, a description of the parameters required for them to run, and a diagram explaining the processes that take place behind the scenes to achieve the analyses results.

5.1. Cluster Analysis Tool (Step 1)

The final goal of the Cluster Analysis Tool is to generate elliptical polygons that fit to clustered crater points. These elliptical polygons are used as input to generate possible ejecta trajectories as polylines in *Step 2*.

The Cluster Analysis Tool provides two methods for generating elliptical polygons: (1) *By nearest neighbor* and (2) *By cluster ID*.

Method: *By nearest neighbor* -

Beginning with a raw crater point dataset, this method runs a clustering routine that identifies clusters of crater points based on user-defined parameters. Once clusters are identified, the tool generates elliptical polygons by statistically fitting them to the craters within each cluster. Ellipses hold the spatial distribution characteristics (azimuth, major and minor axis lengths, and derived measurements) for the corresponding cluster they are fitted to.
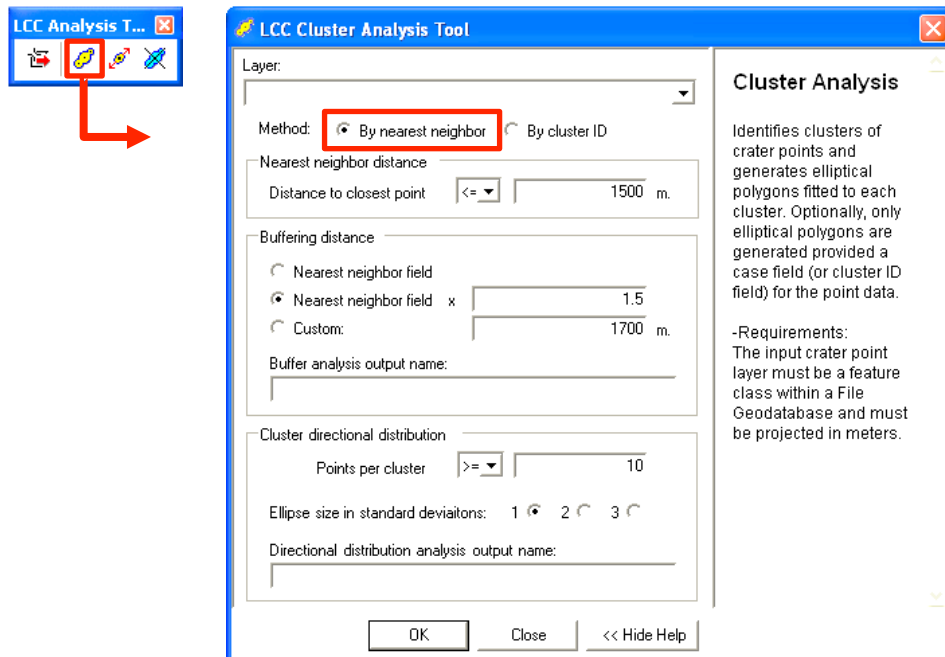
Tool parameters

1. *Layer*:
   The crater point layer to be analyzed; should be a point feature class within a File Geodatabase and must be projected in meters

Figure 5.1.1. Points within a distance threshold are clustered. Others discarded.

2. *Nearest neighbor distance- Distance to closest point*:
   This parameter tells the tool which crater points can be considered as being clustered and which are considered outliers. The tool finds the nearest neighbor of each point in the input layer and stores the distance to that point in the layer attribute table. Only those points whose nearest neighbor distances fall within the specified input are considered for the analysis.

3. *Buffering distance*:
   In order to spatially differentiate between clusters, each point within the nearest neighbor distance threshold (above) is buffered a specific distance:
   a. *Nearest neighbor field-* the distance to each point's closest neighboring point
   b. *Nearest neighbor field times a factor-* the distance to each point's closest neighboring point times a factor, i.e. distance value times 1.5 (to slightly increase the size of the buffer)
   c. *Custom distance-* same distance applied to all points
   Each point ends up having a circular polygon created around it. Circular polygons that overlap each other are merged together to delineate the cluster boundary that spatially encloses the crater points within it, thus identifying the cluster.
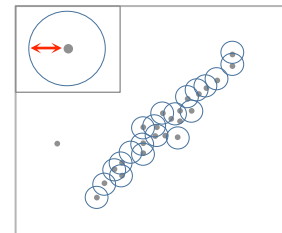

Figure 5.1.2. Clustered points are buffered by a specific distance.

4. *Cluster directional distribution- Points per cluster*:
   Defines the number of crater points that must be present inside the enclosing cluster polygon. Clusters that do not meet this number of craters within their enclosing boundary will not have an elliptical polygon fitted to them.

5. *Cluster directional distribution- Ellipse size in standard deviations*:
   Elliptical polygons are fitted to the clusters that meet the *Points per cluster* criteria. These can have different sizes: 1, 2, or 3 standard deviations. Depending on the size selected, the tool will generate the elliptical polygon covering the desired amount of crater points within the cluster.
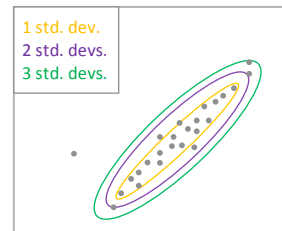

Figure 5.1.3. Ellipse sizes available and how they fit the point data within a cluster.

Background processes

The Cluster Analysis Tool makes use of several ArcGIS core geo-processes. These geo-processes run behind the tool's interface and perform the analysis steps described above.

The cluster analysis begins with a raw point dataset and progresses through several geo-processes. The output layers from each geo-process are then used as input for subsequent geo-processes until reaching the end of the cluster analysis routine with an ellipse polygon layer as main output. This ellipse layer will be used as input for the Trajectory Analysis Tool in *Step 2*.
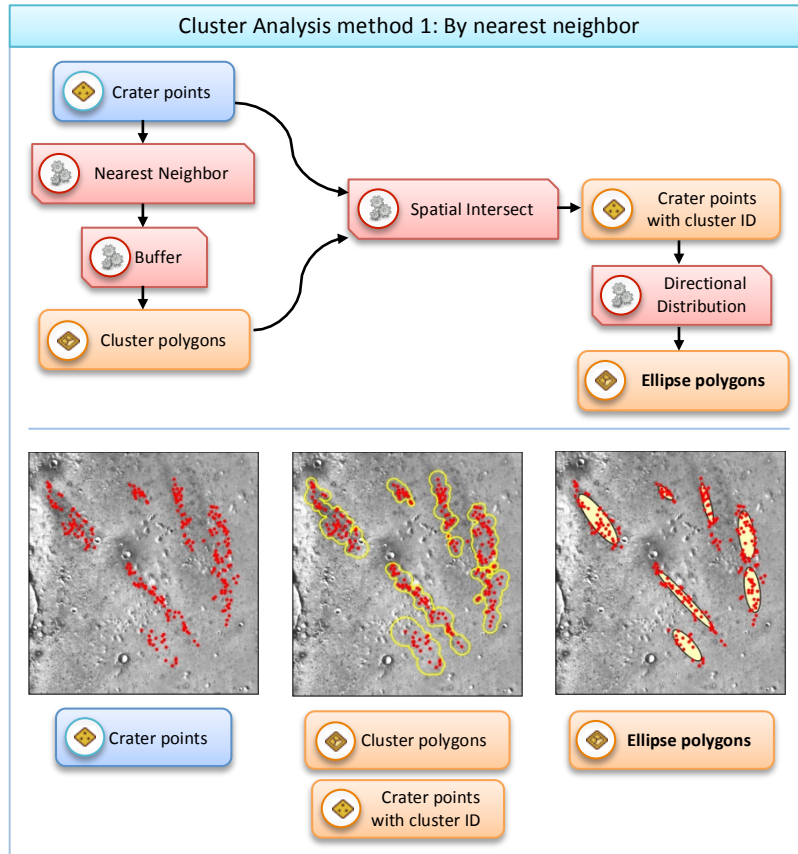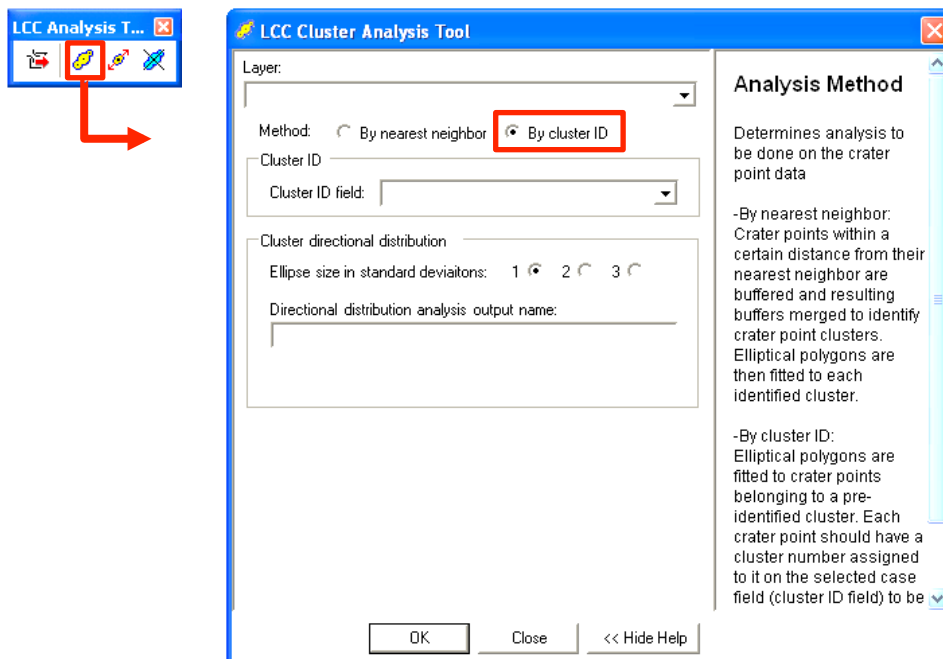
Figure 5.1.4. *Crater Analysis Tool-By nearest neighbor* method background processes and output feature layers. The main input layer is colored in blue, output and intermediate input layers are colored orange, and processes that take these layers and produce an output are in red.

Method: *By cluster ID* -

When selecting this method, the tool will generate the elliptical polygons using pre-identified crater point clusters as input. A field identifying the cluster number each crater belongs to is necessary.

Tool parameters

1. *Layer*:
   The crater point layer to be analyzed; should be a point feature class within a File Geodatabase and must be projected in meters.

2. *Cluster ID- Cluster ID field*:
   Tells the tool which crater points belong to which cluster. The tool reads this field and fits an ellipse to each group of crater points having the same cluster ID.

3. *Cluster directional distribution- Ellipse size in standard deviations:*
   Elliptical polygons are fitted to the clusters that meet the *Points per cluster* criteria. These can have different sizes: 1, 2, or 3 standard deviations (see Fig. 5.1.3). Depending on the size selected, the tool will generate the elliptical polygon covering the desired amount of crater points within the cluster.

Background processes

Similar to *By nearest neighbor*, the geo-processes behind the *By cluster ID* method are core to ArcGIS. The analysis begins with a point feature class. Because this method does no employ a nearest neighbor analysis routine to identify craters, a field with the cluster ID for each point is required for the input feature class. This reduces the number of geo-processes used to produce elliptical features to only the *Directional Distribution*.
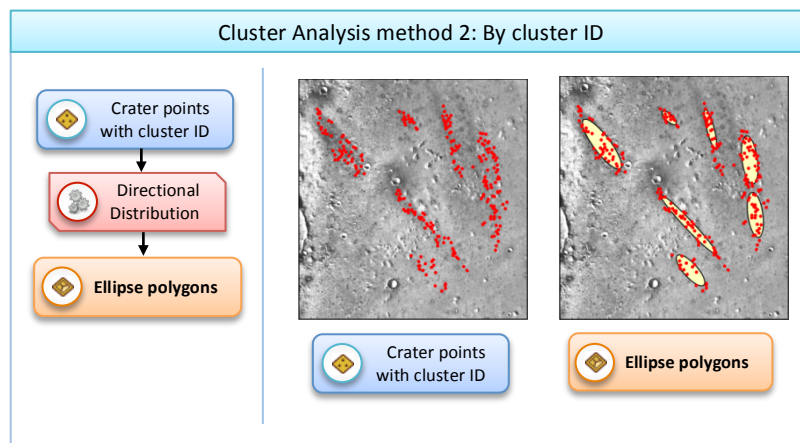
Figure 5.1.5. *Crater Analysis Tool - By cluster* method background process and output feature layer. The main input layer is colored in blue, the output layer is colored orange, and the process producing the output is in red.

5.2. Trajectory Analysis Tool (Step 2)

This tool generates ejecta trajectory polylines that begin at the center of each ellipse in the input layer and are extended along the ellipse major axis until reaching a user-specified distance. The resulting trajectory polylines will be used as input to find potential source crater sites in *Step 3*.
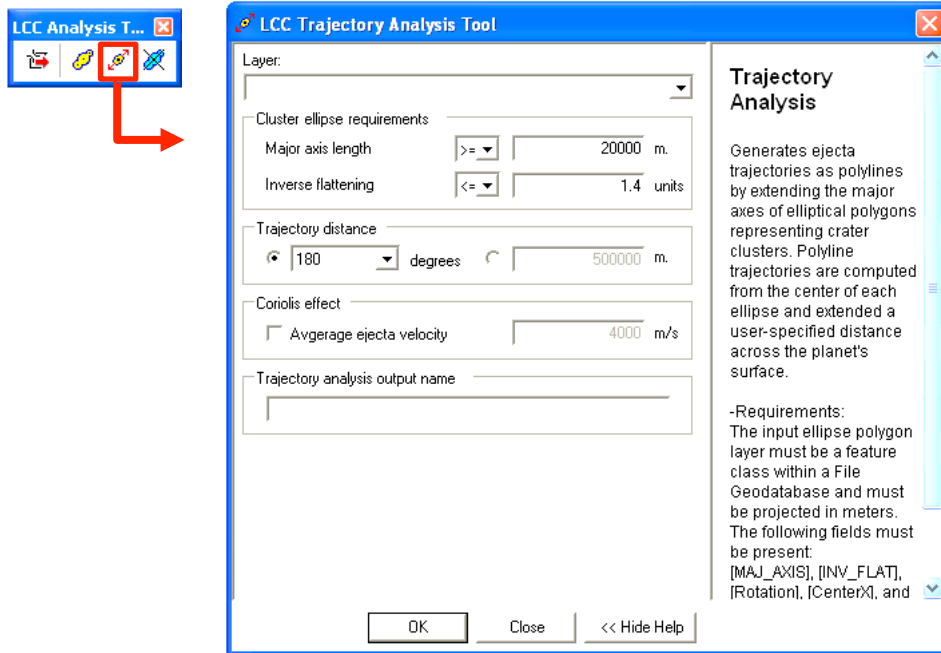
Tool parameters

1. *Layer*:
   The ellipse polygon layer to be analyzed; should be a polygon feature class within a *File Geodatabase* and must be projected in meters. Required fields: [MAJ_AXIS], [INV_FLAT], [Rotation], [CenterX], and [CenterY] (all added by the *Cluster Analysis Tool* to the output ellipse polygon layer in *Step 1*).

2. *Cluster ellipse requirements – Major axis length:*
   This parameter constrains the tool to use only those ellipses whose major axes are within the specified range in this parameter, e.g. LCCs are considered to be ≥20 km in length.

3. *Cluster ellipse requirements – Inverse Flattening:*
   The *inverse flattening* requirement for the ellipses to be used in computing trajectories. Only those ellipses having an *inverse flattening* value that falls inside the threshold specified in this parameter will be used to generate trajectories.

   -More elliptical = *inverse flattening* closer to 1.
   -Less elliptical = *inverse flattening* increasingly greater than 1.

   $$a = major\ axis$$
   $$b = minor\ axis$$

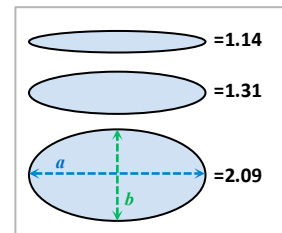 $$inverse\ flattening = 1/f = \frac{a}{(a-b)}$$

Figure 5.2.1. Inverse flattening corresponding to different ellipse sizes.

   The *inverse flattening* of each ellipse is a measure of the spatial distribution of craters inside the cluster. As explained at the beginning of Section 5, Large Crater Clusters (LCCs) are made up of crater chains that were created as secondary impacts of material ejected from a primary, larger impact. Because of the dynamics of material ejection from a primary impact, secondary impacts have characteristic distributions (Fig. 5.1). One of these characteristics is an elongated major-axis. The *inverse flattening* parameter can be used to filter out those crater clusters that may have been caused directly as primary impacts (more circular distributions) from those generated from secondary impacts (more elliptical).

4. *Trajectory distance:*
   This is the total distance, in degrees or meters (used to compute geodesic distance) of the trajectory polylines to be generated for each ellipse (Fig. 5.2.2).
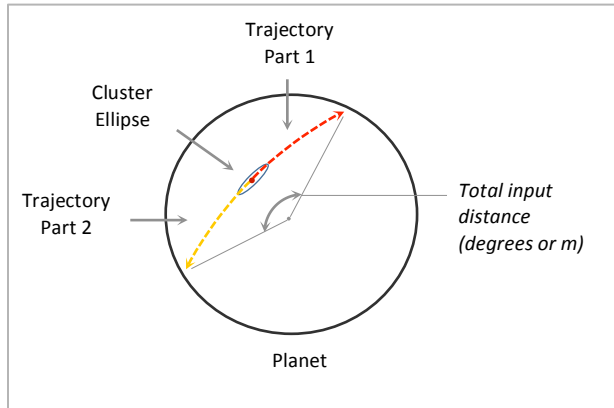

Figure 5.2.2. The *Trajectory distance* input value indicates the total distance each trajectory will be extended. Any trajectory has two parts to it. The distance covered by each part is equal to half the input value.
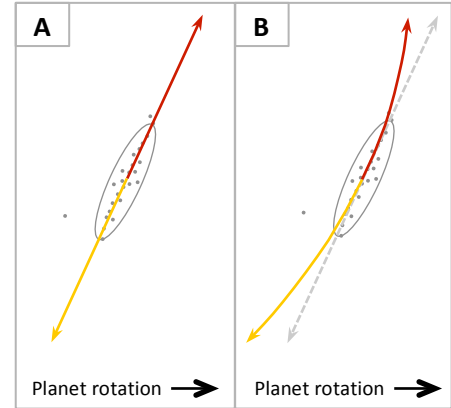
Figure 5.2.3. When the *Coriolis Effect* is applied to the trajectory computations (A), each vertex along the trajectory polyline will be shifted based on the input *Average ejecta velocity* and the rotation of the planet (B).

5. *Coriolis effect – Average ejecta velocity:*
   Because of the planet's rotation during ejecta flight, the Coriolis effect for all trajectories can be computed and applied to the trajectory polylines. If this option is selected, the program will use the input ejecta horizontal velocity (*Average ejecta velocity* parameter) to shift each vertex on the polylines by a distance relative to the rotation of the planet at any latitude location along the trajectory. The resulting polylines will present a continuous shift as they get further away from the center of the ellipse (Fig. 5.2.3).

Background processes

The processes running behind the *Trajectory Analysis Tool* are not core to ArcGIS. A single process runs to generate the trajectories. The output layer is a polyline feature class containing the trajectories for those input ellipse polygons that meet the criteria defined by the user on the *Trajectory Analysis Tool*.
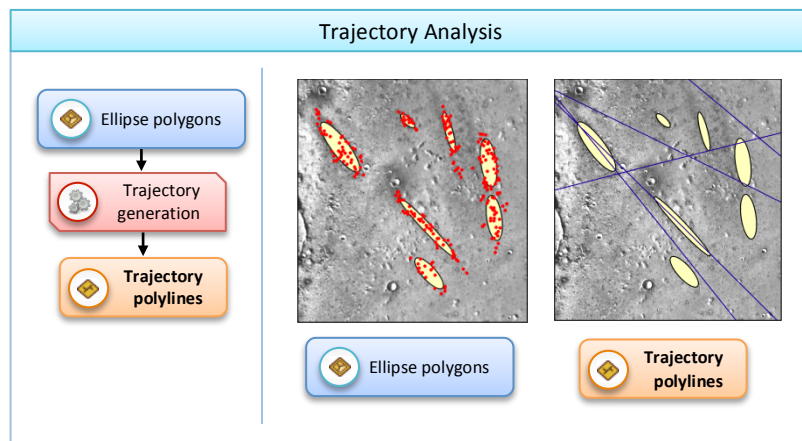

Figure 5.2.4. *Trajectory Analysis Tool* background process and output feature layer. The main input layer is colored in blue, the output layer is colored orange, and the process that takes the input layer to produce the output is in red.

5.3. Intersection Analysis Tool (Step 3)

The final goal of the Intersection analysis tool is to find potential primary impact sites where many trajectories generated in *Step* 2 intersect. This is accomplished by three main steps:

      a.   Find the intersections of all trajectories generated in *Step 2*
      b.   Identify and delineate clusters of intersections
      c.   Compute the mean*,* or centroid*,* of all intersection points within each identified cluster
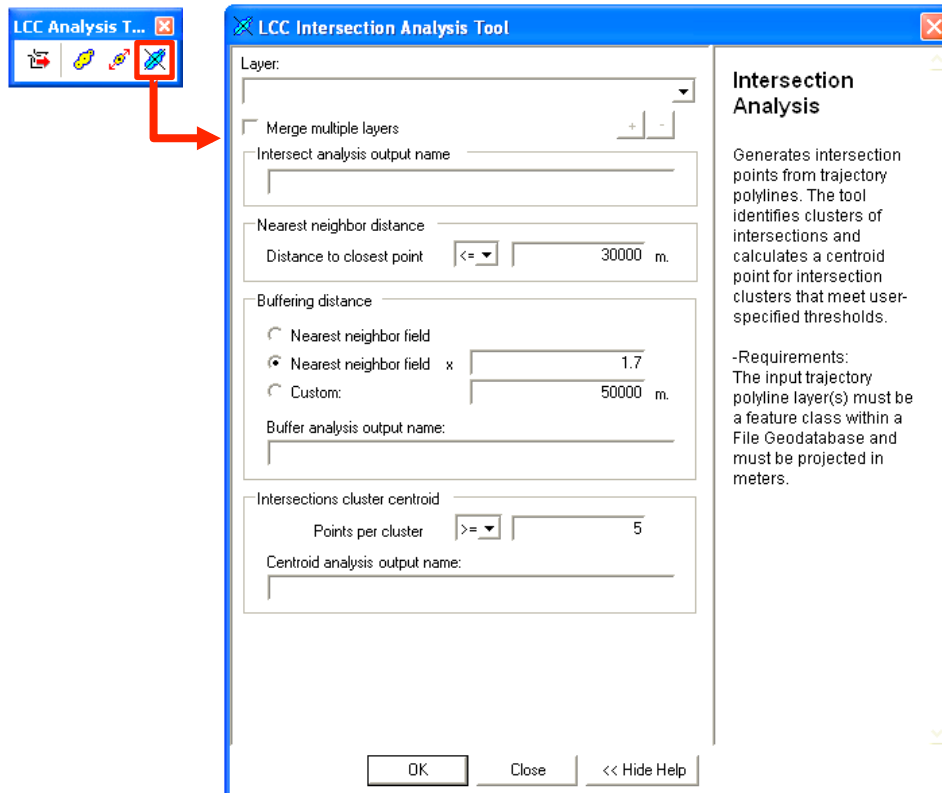
Tool parameters

1.   *Layer*:
The trajectory polyline layer to be analyzed; should be a polyline feature class within a File Geodatabase and must be projected in meters.

Merge multiple layers:
This option allows for a list of layers to be used as input for the analysis. To add a layer to the list, select it from the *Layer* dropdown and press the plus sign (+). To remove a layer, select it on the list and press the minus sign (-).

2.   *Intersect analysis output name:*
The tool begins its analysis process by intersecting all input trajectory polylines and storing the resulting points in a layer. This parameter provides the output name for this layer.
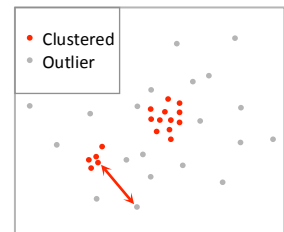

Figure 5.3.1. Points within a distance threshold are clustered. Others discarded.

3. *Nearest neighbor distance- Distance to closest point*:
   This parameter tells the tool which intersections can be considered as being clustered and which are considered outliers. The tool finds the nearest neighbor of each intersection point and stores the distance to that point in the layer attribute table. Only those points whose nearest neighbor distance falls within the specified input distance are considered for the analysis.
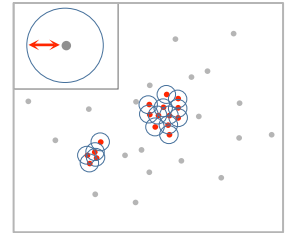
4. *Buffering distance*:
   To spatially delineate clusters, each intersection point within the nearest neighbor distance threshold (above) is buffered a specific distance:
   a. *Nearest neighbor field*- the distance to each point's closest neighboring point
   b. *Nearest neighbor field times a factor*- the distance to each point's closest neighboring point times a factor, i.e. distance value times 1.5 (to slightly increase the size of the buffer)
   c. *Custom distance*- same distance applied to all points
   Each point ends up having a circular polygon created around it. Circular polygons that overlap each other are merged together to delineate the cluster boundary that spatially encloses the intersection points within it, thus identifying the cluster.

5. *Intersections cluster centroid- Points per cluster*:
   Defines the number of intersection points that must be present inside the enclosing cluster polygons. Clusters that meet this number of intersections within them will have a centroid (or mean center) generated from them.

Figure 5.3.2. Clustered points are buffered by a specific distance.
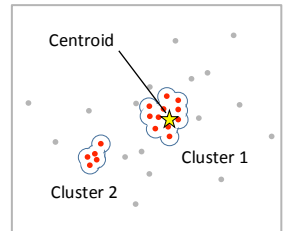
Figure 5.3.3. A centroid is generated for *Cluster 1* only, which meets the "Points per cluster" criteria (e.g. ≥10 intersection points).
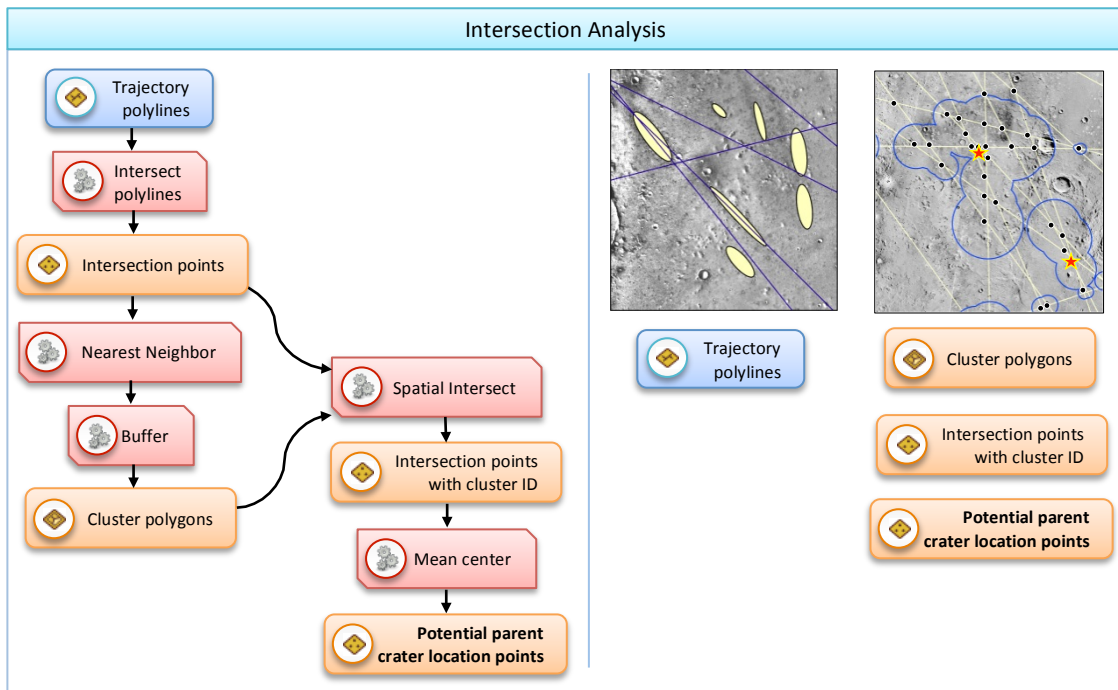
Background processes

Figure 5.3.4. *Intersection Analysis Tool* background processes and output feature layers. The main input layer is colored in blue, output and intermediate input layers are colored orange, and processes that take these layers and produce an output are in red.

6. Layer naming conventions

Due to the large amount of iterations possible in modeling *ejection-trajectory-impact* scenarios, naming conventions have been adopted for output layers that allow the user to easily inspect parameter values used for a specific tool run. When filling in the parameters for each tool, names for the output layers are dynamically constructed with the values entered in each field. The following sub-sections show input parameters, input/output layer names, and layer name descriptions for a complete *LCC Analysis Tools* run. The *Layers used/generated during analysis* tables show layers added to the map. If a layer is not added, a feature class for this layer will still exist on the source geodatabase.

6.1. Cluster Analysis layers (Step 1)

The *Cluster Analysis Tool* produces a total of five layers, some of which are intermediate and are not considered to be part of the final output.

- Sample input parameters:

	Parameter	Value
1	Layer:	Z_CID
2	Nearest neighbor distance- Distance to closest point:	1,500 m
3	Buffering distance:	Nearest neighbor distance field x 1.5
4	Cluster directional distribution- Points per cluster:	10
5	Cluster directional distribution- Ellipse size in standard deviations:	1

- Layers used/generated during analysis:

	Layer	Feature	Type	On Map
1	Z_CID	Crater	Point	Yes
2	B_Z_CID_N1500DFF1o5_MP	Cluster buffer	Polygon	No
3	B_Z_CID_N1500DFF1o5_AD	Cluster buffer	Polygon	No
4	B_Z_CID_N1500DFF1o5	Cluster buffer	Polygon	Yes
5	Z_CID_ B_Z_CID_N1500DFF1o5_JOIN	Crater	Point	No
6	**E_B_Z_CID_N1500DFF1o5_P10S1**	**Ellipse**	**Polygon**	**Yes**

- Output layer name description:

6.2. Trajectory Analysis layers (Step 2)

The *Trajectory Analysis Tool* produces a total of two layers, one of them is produced in an intermediate processes and is not considered to be part of the final output.

- Sample input parameters:

	Parameter	Value
1	Layer:	E_B_Z_CID_N1500DFF1o5_P10S1
2	Cluster ellipse requirements – Major axis length:	7,000 m
3	Cluster ellipse requirements – Inverse Flattening:	1.4
4	Trajectory distance:	180 degrees (of planet)
5	Coriolis effect – Average ejecta velocity:	4,000 m/s

- Layers used/generated during analysis:

	Layer	Feature	Type	On Map
1	E_B_Z_CID_N1500DFF1o5_P10S1	Ellipse	Polygon	Yes
2	G_E_B_Z_CID_N1500DFF1o5_P10S1_EL7000IF1o4_GL180_V4000_UD	Geodesic trajectory	Polyline	No
3	**G_E_B_Z_CID_N1500DFF1o5_P10S1_EL7000IF1o4_GL180_V4000**	**Geodesic trajectory**	**Polyline**	**Yes**

- Output layer name description:

Geodesic trajectory parameters

G_ (Geodesic trajectory) — Cluster Analysis — _EL7000IF1o4_GL180_V4000 (Ellipse length (major axis), Ellipse inverse flattening, Geodesic trajectory length, Average ejecta velocity)

6.3. Intersection Analysis layers (Step 3)

The *Intersection Analysis Tool* produces a total of six layers, some of which are intermediate and are not considered to be part of the final output.
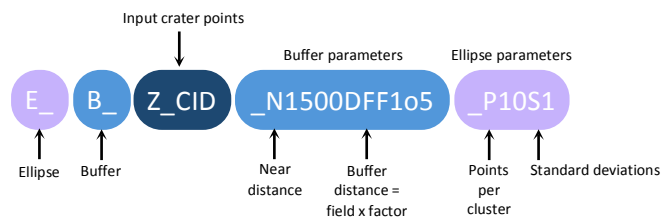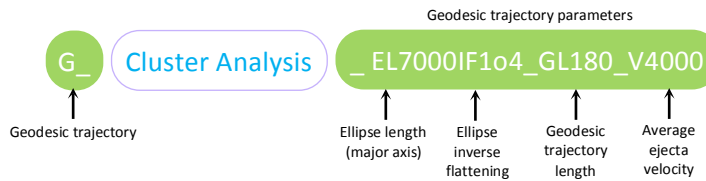
- Sample input parameters:

|	Parameter	Value
1	Layer:	G_E_B_Z_CID_N1500DFF1o5_P10S1_EL7000IF1o4_GL180_V4000
2	Intersect analysis output name:	I_G_E_B_Z_CID_N1500DFF1o5_P10S1_EL7000IF1o4_GL180_V4000
3	Nearest neighbor distance- Distance to closest point:	30,000 m
4	Buffering distance:	Nearest neighbor distance field x 1.7
5	Intersections cluster centroid- Points per cluster:	5

- Layers used/generated during analysis:

	Layer	Feature	Type	On Map
1	G_E_B_Z_CID_N1500DFF1o5_P10S1_EL7000IF1o4_GL180_V4000	Geodesic trajectory	Polyline	Yes
2	I_G_E_B_Z_CID_N1500DFF1o5_P10S1_EL7000IF1o4_GL180_V4000_MP	Intersection	Point	No
3	I_G_E_B_Z_CID_N1500DFF1o5_P10S1_EL7000IF1o4_GL180_V4000_UC	Intersection	Point	No
4	I_G_E_B_Z_CID_N1500DFF1o5_P10S1_EL7000IF1o4_GL180_V4000	Intersection	Point	Yes
5	B_I_G_E_B_Z_CID_N1500DFF1o5_P10S1_EL7000IF1o4_GL180_V4000_N30000DFF1o7	Cluster buffer	Polygon	Yes
6	I_G_E_B_Z_CID_N1500DFF1o5_P10S1_EL7000IF1o4_GL180_V4000_B_I_G_E_…_JOIN	Intersection	Point	No
7	**M_B_I_G_E_B_Z_CID_N1500DFF1o5_P10S1_EL7000IF1o4_GL180_V4000_N30000DFF1o7_P5**	**Mean centroid**	**Point**	**Yes**

- Output layer name description:

7. Tool reporting

Once the parameters in each tool are filled in with the required values and the 'OK' button is clicked, a progress window will appear with information regarding the status of the analysis. When the analysis is done the user is prompted to decide whether or not to save a *Summary File* containing all the information generated during the analysis process. If the file is saved, another window will appear with the option to open the report file in the user's computer default text editor:
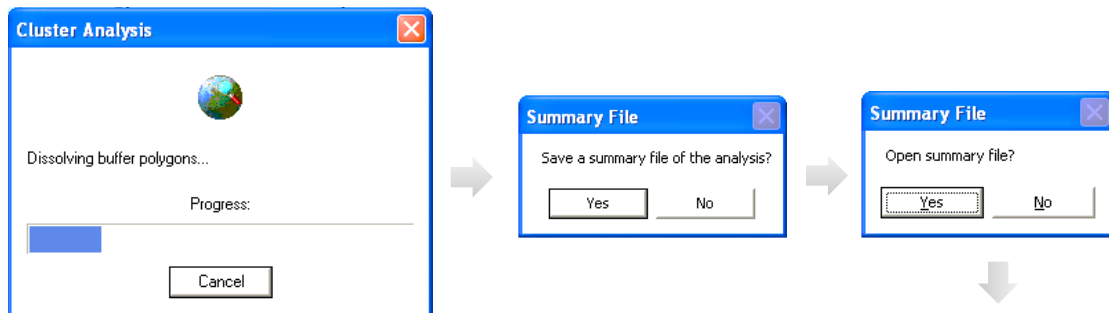
The following are excerpts from reports generated by running all three tools using the parameters discussed in Section 6 as input. Brief descriptions of the main sections and individual items are given and apply to all reports.

-Beginning of summary file:

-End of summary file:

Beginning of input/output section →

```
I/O SUMMARY
****************************************************************************************
INPUT FEATURE LAYER (1)
   Crater points:
    Z_CID

OUTPUT FEATURE LAYERS (5)
-ON MAP:
   Buffer polygons:
    B_Z_CID_N1500DFF1o5
   Ellipse polygons:
    E_B_Z_CID_N1500DFF1o5_P10S1
-NOT ON MAP:
   Crater points:
    (layer1_name_layer2_name)..._JOIN
   Buffer polygons:
    B_Z_CID_N1500DFF1o5_MP
    B_Z_CID_N1500DFF1o5_AD

COMPLETE: Cluster analysis complete.


Program start time and date:  12:14:29.973 on 7/8/2010
Program end time and date:    12:22:10.503 on 7/8/2010
****************************************************************************************
Program run time:  0 d   0 hr   7 min  40.530 sec
      460.530 sec =     7.6755 min =   0.12793 hr = 0.005330 d
```

List of layers input and output layers specifying the name and type of the layer and whether it is added to the map →

Status of analysis →

-The *Intersection Analysis Tool (Step 3)* "TOP BEST RESULTS" report segment:

```
CLUSTER CENTROID ANALYSIS:
****************************************************************************************
[Generating cluster centriods...]
[Performing clear selection...]
[Updating centroid table...]

  STATS: Number of Intersections per Centroid

  |Population total    =         4.0000|
  |------------------------------------|
  |  0% Min            =         7.0000|
  | 25% Lower quartile =        12.5000|
  | 50% Median         =        17.0000|
  | 75% Upper quartile =       121.0000|
  |100% Max            =       225.0000|
  |------------------------------------|
  |Range               =       218.0000|
  |Mean                =        85.6667|
  |St Dev              =       134.8137|
  |Interquartile range =       108.5000|
  |_____|


  STATS: Centroid Intersection Density

  |Population total    =         4.0000|
  |------------------------------------|
  |  0% Min            =         0.0004|
  | 25% Lower quartile =         0.0013|
  | 50% Median         =         0.0021|
  | 75% Upper quartile =         0.0050|
  |100% Max            =         0.0080|
  |------------------------------------|
  |Range               =         0.0076|
  |Mean                =         0.0037|
  |St Dev              =         0.0046|
  |Interquartile range =         0.0038|
  |_____|


  TOP BEST RESULTS: based on intersection count per cluster and cluster area

      Intersection count: descending order
      Cluster area (km2): ascending order


  |OBJECTID|B_JOID|B_PNT_COUNT|B_AREA_KM2|B_PNT_DENS|
  |--------------------------------------------------|
  |       3|    12|        225|  108243.4|    0.0021|
  |--------------------------------------------------|
  |       4|    14|         17|   42737.5|    0.0004|
  |--------------------------------------------------|
  |       2|     9|          8|     997.9|    0.0080|
  |--------------------------------------------------|
  |       1|    16|          7|   14489.3|    0.0005|
  |_____|

[Removing extra layers from map...]
```

This section provides a detailed table of the resulting sites (points) that have the most potential for being sources for the input secondary impacts from *Step 1*. The table lists the top points in the *Mean centroid* layer (see Section 6.3) based on number of intersections and cluster area. The greater the number of intersections used to calculate the centroid, the higher in the list. Also, the less area covered by the cluster of intersections, the higher in the list (see Section 5.3).

8. Methods and specifications for current version

Cluster Analysis Tool:

1. The input dataset must be stored in a File Geodatabase.

2. The Cluster Analysis Tool utilizes two main routines: *distance-based clustering* and *directional distribution analysis*. Distances and angles measured by these routines are computed in Euclidean space (2D Cartesian, i.e. the input data is measured by using a two-dimensional distance formula). For best results, the analysis operations should be performed in a projected coordinate system that minimizes distance and angle distortion for the input dataset.

3. The units of the input dataset' projected coordinate system must be meters.

4. The output feature classes will inherit the input dataset's coordinate system.


Trajectory Analysis Tool:

1. The input dataset must be stored in a File Geodatabase.

2. Actual trajectories and their distances are computed on the surface of the planet (ellipsoid). The Trajectory Analysis Tool calculates trajectory distances by de-projecting coordinate pairs from meters (X, Y) to degrees (Lat, Lon) and applying formulae for the direct and inverse solutions of geodesics on the ellipsoid.

3. The units of the input dataset' projected coordinate system must be meters.

4. Trajectory generation begins at the center of the input ellipse polygon.

5. The *Coriolis effect* for each trajectory is computed based on geophysical parameters from the planet Mars. The tools can still be used on other planetary bodies if this option is omitted.

    - The *Average ejecta velocity* input parameter is the horizontal velocity of the ejecta.

6. The output feature classes will inherit the input dataset's coordinate system.

Intersection Analysis Tool:

1. The input dataset must be stored in a File Geodatabase.

2. The Trajectory Analysis Tool utilizes two main routines: *distance-based clustering* and *mean center* (or *center of concentration*) *analysis*. Distances and angles measured by these routines are computed in Euclidean space (2D Cartesian, i.e. the input data is measured by using a two-dimensional distance formula). For best results, the analysis operations should be performed in a projected coordinate system that minimizes distance and angle distortion for the input dataset.

3. The units of the input dataset' projected coordinate system must be meters.

4. The output feature classes (or layers) will inherit the input dataset's coordinate system.

9. Uninstalling the LCC Analysis Tools

1) Open the Control Panel.
2) Double-click "Add-Remove Programs".
3) Find "LCC Analysis Tools".
4) Click the "Remove" button and follow the directions.
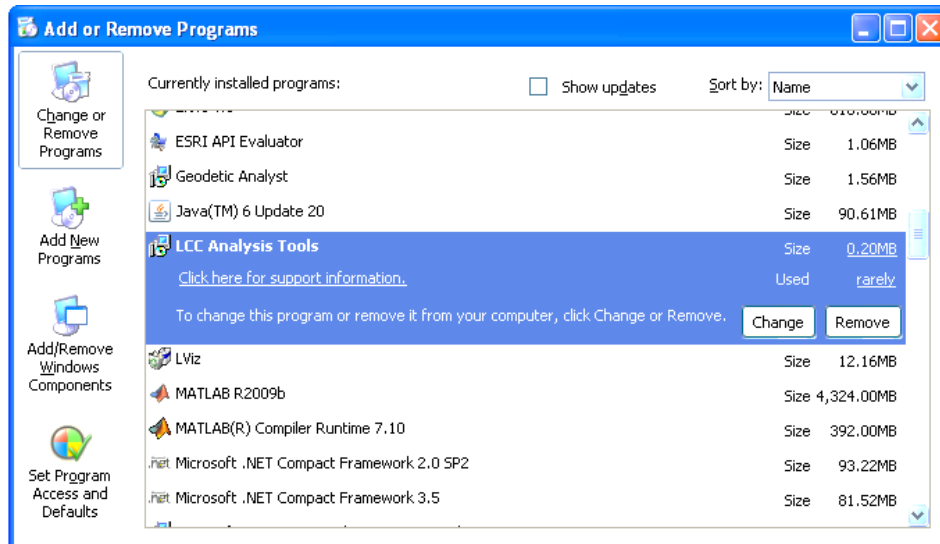
Contact Info:

Please send any bugs, comments, or feedback to:

rnava@usgs.gov