

The following is an example graded mini-project...

Project write-up:

Landfill Suitability (use *Tutor25.rgs*). The *Garbage R' Us* consulting company has approached you about sub-contracting the GIS modeling component of locating the new land fill for Slippery Mountain County. Initial meetings have identified that the best areas for the landfill are those that are gently sloped, near roads, away from water, not too visually exposed to roads, not in areas of high housing density, on appropriate soils, and not in violation of legal constraints. The specific criteria are identified in the following table:

Criteria	Specifications (1= worst ... 9= best)	Overall Weighting
<i>Gently sloped</i>	1 = >20 percent slope 5 = 10-20 9 = <10 percent slope	6 Times
<i>Near roads</i>	1 = >5 cells away 5 = 3-5 9 = <3 cells away	2 Times
<i>Away from water</i>	1 = <3 cells away 5 = 3-5 9 = >5 cells away	4 Times
<i>Not too visually exposed to roads</i>	1 = >20 exposure 5 = 7-20 9 = <7 exposure	1 Times
<i>Not in areas of high housing density (total; within 3)</i>	1 = >12 houses 3 = 6-12 7 = 3-6 9 = <3houses	2 Times
<i>On appropriate soils</i>	0 = 0 open water 1 = 4 upland 3 = 1 floodplain 7 = 3 terrace 9 = 2 lowland	8 Times
<i>Steepness constraint</i>	1 = <50 percent slope (OK) 0 = >50 percent slope (Illegal)	Legal Imperative
<i>Proximity to water constraint</i>	1 = >1 cells away (OK) 0 = <1cells away (Illegal)	Legal Imperative

Your charge is to prepare a prospectus for deriving the Landfill Suitability map that clearly explains how each of criteria are evaluated and then combined into an overall suitability map that respects the legal constraints and reflects the county commissioners' criteria weightings.

In addition, calculate the average landfill suitability rating for each district (*Districts* map). Finally, generate a map that identifies the average rating within 300 meters (3-cell reach) for each of the housing locations (*Housing* map).

Student Report:

Slippery Mountain County Landfill Suitability Study



...nice graphic

**A spatial analysis
using grid-based GIS software
to locate suitable sites for a new landfill,**

A Report By: **Anonymous**

135.0/150 A- ...very good job. *Good organization and generally well-presented ...professional. The flowchart in the text is more appropriate for the appendix ...too detailed to be an overview of the solution. Need to include some of the important graphics (maps) in the text discussion. Additional Considerations section is weak. Also, the Conclusion shouldn't introduce new material (graphics), but summarize and conclude the information in the body of the prospectus. Very well organized Appendix.*

February 23, 2004
GEOG 3110 – GIS Modeling
Professor: Dr. Joseph Berry

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...the page numbers in the T of C work for hardcopy printout, but not for an electronic report (particularly after I have messed with it)

*...would be more 21st century to hyperlink using bookmarks. I made the Appendix item in the T of C hyperlinked to a book mark by highlighting the Title “Appendix” then selecting **Insert → Bookmark →** and naming it “Appendix”; then highlighted the item “Appendix” in the T of C and pressing the **Hyperlink button →** pressing the **Bookmark button →** selecting the item “Appendix”*

INTRODUCTION

The population of Slippery Mountain County has increased over 20% in the past 5 years. Many families have decided to move to the county because of its affordable housing, scenic qualities, excellent outdoor recreation activities, more rural-like lifestyle, and low crime rate. This population increase has also led to an increase in more retail businesses coming to the county.

With the substantial increase in population and new businesses over the past 5 years, this has put a tremendous strain on the counties current landfill space. The county currently has only 1 landfill for all of its residents, and the current landfill is expected to reach capacity within the next 3 to 5 years. Slippery Mountain County recently started an ambitious recycling program which has reduced the amount of waste going into the landfill by 25%, but even with the recycling program, the county will still need another solid waste landfill in the next 3 to 5 years due to the tremendous population growth.

Garbage R' Us consulting company, one of the nations leading companies for developing and locating potential new landfill sites, has recently approached our company, LGIS (Landfill GIS *...trademark the name and get a Internet domain—company name works*) to help them locate a suitable location for building a new landfill. Garbage R' Us traditionally has used field surveys and citizen input as the primary means for locating new landfill sites. Some citizens of Slippery Mountain County have suggested that the company look at using a GIS system (geographic information system) to help them in the decision making process and the company is excited about the potential of GIS. Garbage R' Us has never used a GIS system for locating landfill sites before and this will be a tremendous learning experience for them as well as many of the citizens of Slippery Mountain County. The use of a GIS system will also save Garbage R' Us time and money in locating a suitable landfill site since the budget for this project is very tight. *...good discussion ...might be useful to mention the drawbacks of current manual map analysis procedures that they are using*

APPROACH

Garbage R' Us , LGIS, and the county commissioners had a “kickoff meeting” to discuss what factors they thought were most important in finding a suitable location for a new landfill prior to getting started with the study. The county commissioners over the past several months have received numerous letters from concerned citizens and many citizens have voiced concerns at county commissioner meetings over the new landfill. There were many different factors discussed and it was difficult for the group to come to a consensus on what factors were the most important ones.

The factors that the group agreed were the most important ones are listed in Figure 1 below. These factors do not represent all of the possible factors that could be considered, but are considered the most critical factors and the factors on which information is most readily available from the counties current GIS database, since the county does not have time or money to do field research or to gather additional information.

The 6 criteria used in our analysis are listed in Figure 1 below and 2 constraint criteria (steepness and proximity to water) are also listed in Figure 1.

Criteria	Specifications (1 = worst,9 = best)	Overall Criteria Weighting
Gently Sloped Area	1 = > 20% Slope 5 = 10-20 % Slope 9 = < 10 % Slope	6 Times
Near Roads	1 = > 5 cells away 5 = 3-5 cells away 9 = < 3 cells away	2 Times
Away From Water	1 = 0-3 cells away 5 = 3-5 cells away 9 = 5 cells away	4 Times
Not Too Visually Exposed to Roads	1 = > 20 cell exposure 5 = 7-20 cell exposure 9 = < 7 cell exposure	1 Times
Not in Areas of High Housing Density (total; within 3)	1 = > 12 houses 3 = 6-12 houses 7 = 3-6 houses 9 = < 3 houses	2 Times
On Appropriate Soils	0 = 0 open water 1 = 4 upland 3 = 1 floodplain 7 = 3 terrace 9 = 2 lowland	8 Times
Steepness Constraint	1 = < 50% slope (OK) 0 = > 50% slope (illegal)	Legal Imperative
Proximity to Water Constraint	1 = > 1 cells away (OK) 0 = < 1 cells away (illegal)	Legal Imperative

Figure 1 – Landfill Suitability Criteria and Overall Weighting for Criteria

The LGIS solution uses... present tense is a bit more optimistic LGIS will use the GIS system and the criteria / base data presented in Figure 1 above to do a suitability analysis for the new landfill. LGIS will use the specifications as indicated in the table and will assign a weight value to each of the specified criteria. All of the criteria will be combined (added together) to produce a final suitability map for new potential landfill sites in Slippery Mountain County. Details of the specific spatial analysis operations performed and processing used to generate the final map will be presented in more detail in the “prototype model” section of this paper and in Appendix A.

The criteria represented in Figure 1 are the criteria that the county commissioners and the consultants (LGIS and Garbage R’ Us) agreed upon and these criteria have data readily available for them. The specifications section of the table assigns a rating for each of the 8 criteria. A rating of 1 for the gently sloped areas for instance indicates that a slope greater than 20% is the worst while a 9 value indicates that a slope value of less than 10% is the best. Then each criteria is multiplied by a weighting factor since some criteria are deemed as more important than others. Gently sloped areas have a weighting factor of 6, while the near roads criteria *criterion* has a weighting factor of 2. When the GIS analysis is conducted, the gently sloped areas will contribute more to the overall suitability rating than the near roads factor since it has a greater weight in the analysis.

DATA REQUIREMENTS

The criteria listed in Figure 1 represent the base data files that we will use for conducting our suitability analysis for the new landfill. These criteria were considered the most important criteria and are the criteria for which GIS data is readily available. Slippery Mountain County has over the past 5 years been building a GIS database for the entire county and will in the next year of two have a GIS database for the entire county available and is allowing LGIS to use the data free of charge.

The study area for our *demonstration* analysis is a 25 cell by 25 cell (2,500 meter by 2,500 meter) area in the southwest corner of Slippery Mountain County. The base data files are all in a grid cell format (raster data) with each cell on the map representing a 100 m by 100 m area. The coordinate system and projection of the base data maps is unknown since no metadata has yet to be developed for the county dataset. *...Lat/Lon WGS84 (Properties → Source tab)* The county hopes to compile the metadata information within the next several months. All of the base data files we are using were developed by the Slippery Mountain County GIS Coordinator who has assured us that the information on the maps is accurate and that the information on the different base data maps will line up with one another and that registration problems between maps should not be an issue.

PROTOTYPE MODEL

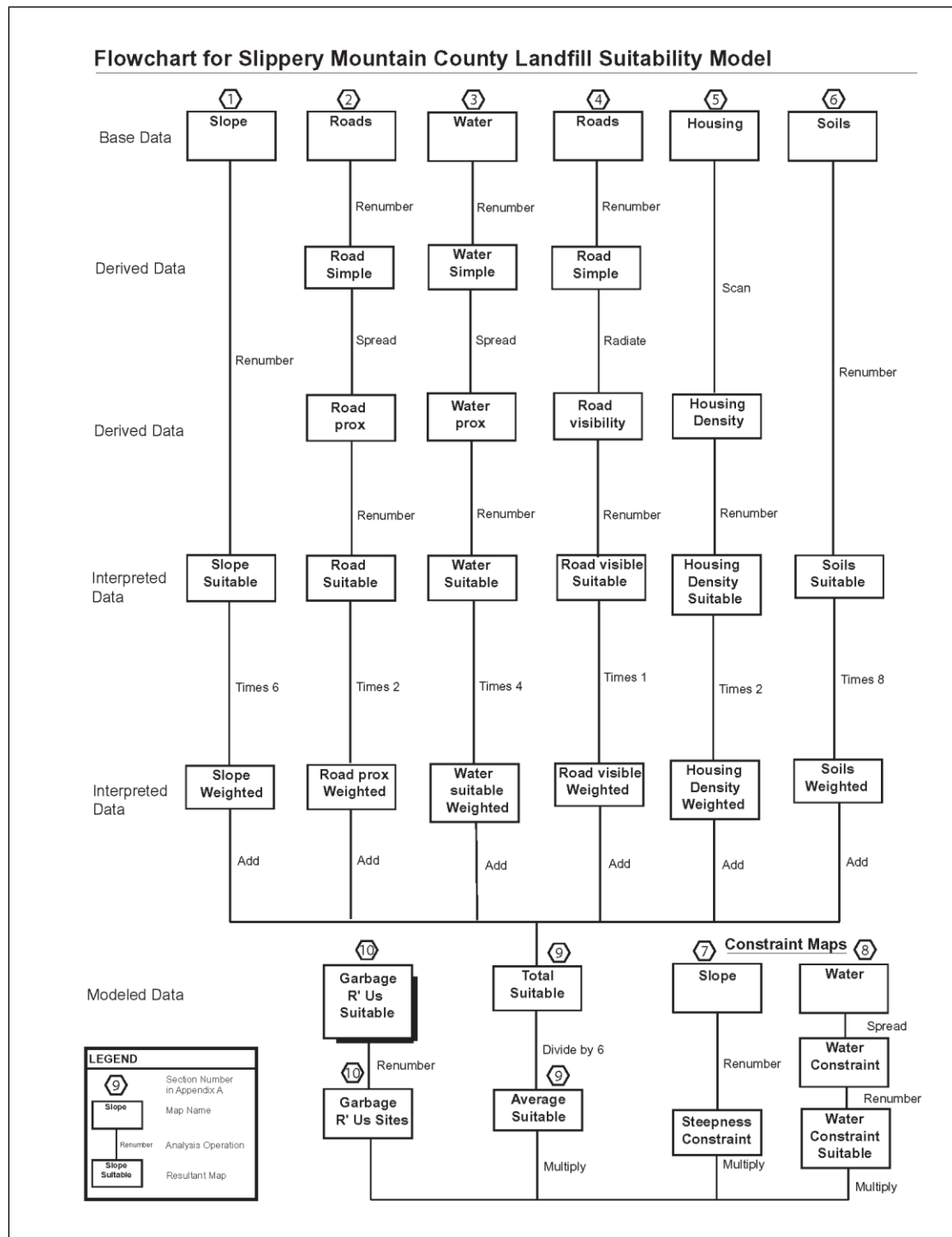
The flowchart in Figure 2 shows the process that LGIS went through to find a suitable location for a new landfill. Our discussion will be more general in nature and will focus more on the process and general discussion of the model that we used. Specific details on processing operations and commands used to implement the model can be found in Appendix A of this report. A more detailed flowchart can also be found in Appendix A on page 12.

1. Base Data Maps

For our suitability analysis, we used 6 different criteria as shown in Figure 1. These 6 criteria represent base data that we obtained from Slippery Mountain County to perform our analysis. The flowchart in Figure 2 shows the processing steps that we went through using each of the 6 criteria base maps to obtain the final suitability map for a new landfill.

2. Derived Data Maps

Since the base data in and by itself is not of much use to us in determining a suitable location to build a new landfill, we will need to manipulate and analyze the data to produce the desired outcomes. The derived data maps as shown in the flowchart in Figure 2 are maps that are generated from the base data maps. We do this to simplify the data on the base maps (such as to aggregate values) and to find areas of interest in our study area (such as locations within 1,000 meters of a road). Note that we are not changing any of the original data on the base maps, we are simply changing the display characteristics of the data.



...too

detailed for the general approach section---more in tune with the Appendix

Figure 2 – Flowchart for the Slippery Mountain County Landfill Suitability Study

Described below are some of the specific details of the derived data maps used in our suitability study and the information that they provide us with.

- *Roads Simple Map* – A zero value means no roads are present, a 1 value means that a road is present
- *Water Simple Map* – A zero value indicates dry land, a 1 value indicates a water feature
- *Road Prox Map* – Shows all locations within 10 cells (1,000 meters) of a road
- *Water Prox Map* – Shows all locations within 10 cells (1,000 meters) of a water feature
- *Road Visibility Map* – Identifies how many times a location is seen from each location (cell) on each of the roads for all of the roads in the study area
- *Housing Density Map* – Identifies how many houses there are for a particular location (grid cell) on the map

Although the derived data maps described above provide us with more useful information than the base data maps, this information still is of little use to us since we really have not defined if a particular location or area is more important than another. We may for instance really want to put a landfill within 3 cells of a road and a distance of 10 cells away from a road would be too far away to put a new landfill.

3. Suitability Maps

In order to remedy our problem described in the previous paragraph, we used a rating suitability model to determine the most suitable area(s) for a new landfill. In this particular type of model, we assign a “goodness scale” to the criteria we specified in Figure 1. The goodness scale in our model has values ranging from 0 to 9. A zero value in this scale represents a constraint, meaning that it is either physically impossible to build a landfill at that location or that the laws of Slippery Mountain County will not allow it. For example a zero value would be assigned to an area that has a lake, since we cannot build a landfill on top of a lake. Slippery Mountain County prohibits building a landfill on slopes greater than 50%, and those areas would receive a value of 0 on the goodness scale.

The 1 thru 9 values on the goodness scale represent how suitable a location is based on our specified criteria. For this model, we use the following numbers and “ratings” in Figure 2 to determine locations suitability for a new landfill.

Value	Rating
1	Poor
3	Fair
5	Good
7	Very Good
9	Excellent

Figure 3 – The Goodness Scale for Suitability ...not sure this warrants a table

The specific suitability values as described in Figure 1 for each of the 6 criteria are listed and described in more detail below. Note that 1 cell is equal to a distance of 100 meters and that the terms “cells” and “locations” are used interchangeably.

- *Suitable Slopes Map* – 1 for slopes over 20%, 5 for slopes 10-20%, and 9 for slopes under 10%
- *Suitable Roads Map* – 1 for locations 5 cells or more away from roads, 5 for locations 3 to 5 cells away, and 9 for locations within 3 cells of a road
- *Suitable Water Map* – 1 for locations within 3 cells of a water feature, 5 for locations within 3 to 5 cells of a water feature, and 9 for locations 5 or more cells away from a water feature
- *Suitable Road Visibility Map* – 1 for locations within 20 or more visually connected cells to the road, 5 for locations with 7 to 20 visually connected cells to a road, and 9 for locations with 7 or fewer visually connected cells to a road
- *Suitable Housing Density Map* – 1 for locations with a density of 12 or more houses, 3 for locations with 6 to 12 houses, 7 for locations with 3 to 6 houses, and 9 for locations with a housing density of less than 3 houses
- *Suitable Soils Map* - 0 for locations with open water (lakes, etc.), 1 for upland type soils, 3 for floodplain type soils, 7 for terrace type soils, and 9 for lowland type soils

All of the maps listed above will display data in a range of values from 0 to 9. A zero value represents a constraint while a 9 value represents the highest suitability (an excellent area).

Keep in mind that these numbers and the ratings assigned to them were chosen by LGIS to conduct the analysis. Limiting the number of values we use for the analysis will make the model easier to run and will make the results more understandable for the county commissioners and the general public. One problem with this approach is that a location may not exactly fall into one of the given values in the chart in Figure 3. A location or locations for instance may have a value of 6, which would fall between the good and very good ratings shown in Figure 3. In this situation, LGIS will need to make a judgment call as to whether the area would receive a “good” or a “very good” rating. This “goodness scale” will then be applied with the weighting criteria factor discussed in the next paragraph of this report to generate a final suitability map.

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4. Weighted Suitability Maps

The saying “all things are not created equal” certainly applies to building a GIS model for doing suitability analysis for a new landfill. The county commissioners and consultants felt that there were some criteria that were more important than others. These criteria that the group felt were more important (or in some instances represented more of a constraint or limitation) were assigned a weight value.

By assigning a weight to each of the 6 criteria in our model (see Figure 1), we put more or less emphasis on a particular criteria in the model. The “soils” criteria for instance are assigned a weight of 8, meaning that it will have the highest level of importance in our final suitability map. Road visibility for instance will be assigned a weight value of 1, meaning that it will have the lowest level of importance in our final map. The higher the weight value for a particular criteria *criterion* in our model, the more a particular criteria will influence the final suitability map in our model. The suitability maps described above are multiplied by the weight factor to determine the weighted value for each map. Provided below is a more detailed description of the weighted maps we generated and the values for each map.

- *Slope Weighted Map* – Multiply the Suitable Slopes Map by 6. Values on this map range from 6 to 54
- *Road prox Weighted Map* – Multiply the Suitable Road Prox Map by 2. Values on this map range from 2 to 18
- *Water Suitable Weighted Map*– Multiply the Water Suitable Map by 4. Values on this map range from 4 to 36
- *Road Visible Weighted Map* – Multiply the Suitable Road Visibility Map by 1. Values on this map range from 1 to 9
- *Housing Density Weighted Map* – Multiply the Suitable Housing Density Map by 2. Values on this map range from 2 to 18.
- *Soils Weighted Map* - Multiply the Suitable Soils Map by 8. Values on this map range from 0 to 72

On the weighted maps, a higher number indicates a higher suitability. The values on the weighted maps range from a zero (constraint area) to a 72 (very high suitability).

...composite graphics might be useful to “show” the groups of maps

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5. Add the Weighted Suitability Maps Together and Find the Average Suitability

The 6 weighted suitability maps listed in the previous section are added together to produce a total suitable map. The total suitable map we generated has a range of values from 55 to 183. The possible range of values on this map could be from 15 (the sum of all the lowest values on each of the 6 weighted maps) to 197 (the sum of all of the highest values on each of the 6 weighted maps). This means that there are no areas that are totally poor or unbuildable (areas with a value of zero or 15) or areas that are totally excellent (with a value of 197) for locating a landfill.

However we need to find the average suitability for each location and to do this we needed to divide the total suitable map by 6 since the total suitable map is the sum of the 6 weighted suitability maps to derive the average suitable map. The average suitable map has values ranging from 9 to 33, with a 9 value representing the poorest suitability and a 33 value representing the highest suitability.

...would be useful to show some of the more/most important solution map (figure 5?)—or hyperlink to the displays in the Appendix

5. Constraint Maps

No matter what type of study or analysis you are doing, there are always those factors that make what you are trying to do impossible or not feasible. In our landfill study model, we determined that very steep slopes and areas that have water features and are in very close proximity to water areas would make it impossible to build there. This is due to either legal constraints (the county won't allow it) or it's physically impossible to do so (like putting a landfill in the middle of a lake or on a very steep slope where all of the trash could slide off). The constraint maps will allow us to mask out those areas where it is impossible or illegal for us to locate a new landfill. The constraint maps in our model are as follows:

- *Steepness Constraint Map* – A zero value represents those areas where the slope is greater than 50%. Slippery Mountain County will not allow us to build in these locations. A 1 value means that the slope is less than 50% and it's OK to build there.
- *Water Proximity Constraint Map* – A zero value represents an area that is less than 1 cell away from a water feature and includes areas that have a water feature, such as a lake. This is a legal requirement of Slippery Mountain County. A 1 value represents an area that is one or more cells away from a water feature.
- ???

6. Garbage R' Us Suitable Sites

The final step in our analysis is to take the average suitable map and to multiply this map with the steepness and water proximity constraint maps. Since the non-buildable or illegal areas on the constraint maps have a value of 0, when we multiply the constraint maps with the average suitable map, we will end up with a value of 0 on the Garbage R' Us Suitable Sites Map (since 0 times any value = 0) for all those areas where it is impossible or illegal to build a new landfill. The 1 values on the constraint maps will have no effect on the average suitable map values since any value on that map multiplied by 1 will result in the same value on the Garbage R' Us Suitable Sites Map.

The Garbage R' Us Suitable Sites Map shows us values ranging from 0 (non-buildable areas) to a 30 (highly suitable). We renumbered these range of values to work with our suitability rating system (1 = poor.....9 = excellent) using the following breakdown of values.

...need a graphic (map) of the result

Value	Rating	Range of Values on Garbage R' Us Suitable Sites Map
0	Non-Buildable / Illegal	0
1	Poor	1 to 9
3	Fair	9 to 15
5	Good	15 to 21
7	Very Good	21 to 27
9	Excellent	27 to 30

Figure 4 – Suitability Rating System for the Garbage R' Us Suitable Sites Map

ADDITIONAL CONSIDERATIONS

The criteria we used to run our suitability model for a new landfill do not represent the only criteria that we could have used for our study. We for instance did not look at **potential rare or endangered plant or animal species** that may be present in the study area. Rare and endangered plant and animal species could potentially kill any potential project depending on how limited of a habitat these species may have. Our model also does not look at potential **noise impacts** from the increased amount of trucks and heavy machinery that would be using the landfill on a daily basis. Perhaps more importantly than anything else is

that the suitability model that we run should be **field verified**. The GIS analyst needs to get into his or her car and drive out to the location to see if what the computer and their analysis tells them makes sense and feels right. *...awkward sentence* In many instances you may see things that the computer and data does not show you. After all, GIS is not science fiction, but involves working with real world locations. *...not sure what you mean*

A model is a **work in progress** and undergoes several changes and levels of refinement before the model is finalized. In fact the model may never be truly finalized since additional information, citizen input, and changing needs or requirements over time may effect how the model is run and would change the desired outcomes. *...true but might scare the client* The model also needs to be flexible and adaptable to changes as they arise over time.

...other extensions might be to incorporate visual exposure to houses; simple proximity (or downwind proximity) to houses (roads); section should

CONCLUSIONS

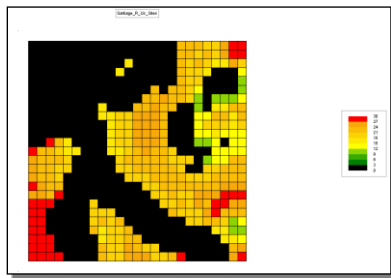
Through our analysis and running of our model, we found a total of 8 sites that would receive an excellent rating in our model (a suitability rating of 27 or higher) as shown in Figure 5a below. 5 of these locations were single cell (100 m x 100 m) locations where it would not be practical to build a new landfill. The largest continuous location is at the bottom left corner of the map in Figure 5a colored in red had an area of 49.4 acres. The tan colored areas directly above this area with a “very good” rating makes up another 46.9 acres. The grey colored areas on the map in Figure 5a represent those areas where there were constraints (steepness and proximity to water) and the red colored areas represent those areas that are excellent. The tan colored areas on the map are areas with a “very good” rating, and many of these areas are directly adjacent to the areas colored in red with an excellent rating. Note that on the final map there are no “poor” areas since the Garbage R’ Us suitability map had no values in the range of 1 to 9.

The map in Figure 5b shows us the suitability when we clump areas together with similar values. We use the criteria specified in Figure 4 to renumber the map to 0 thru 9 values. The black areas on this map represent constraint areas and areas with a suitability rating of less than 7. The large red area on this map for instance has an area of 227 acres. More detail on how the map in Figure 5b is derived is provided in Section 10 of Appendix A on page 24. The important thing to note is how you display the data and group the values together can have a substantial effect on what areas are analyzed as being suitable.

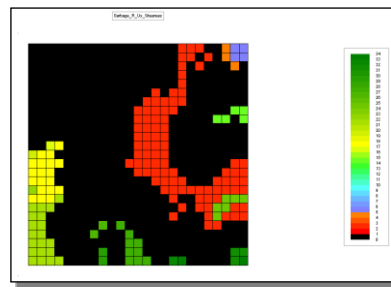
We also discovered that the district with the highest suitability rating was district 6, with an average rating of 4.78 (using the 0 to 9 suitability scale) while district 1 had the lowest rating with a value of zero (not buildable since this district is a lake). See Section 11 in Appendix A on page 27 for the data maps used and the processing operations used. For the average suitability rating within 300 meters (3 cells) of the housing locations, we found that all of the houses happened to lie in fairly suitable areas with the range of values

being from 5.08 to 5.81 on the suitability scale from 0 to 9 with 9 being excellent and 0 being non-buildable. See Section 12 in Appendix A on page 28 for more information on the analysis and processing operations used.

The results of our analysis show that our study area has several “very good” to “excellent” areas for locating a new landfill. This map represents a good starting point and it helps us to narrow down our list of potential sites for a new landfill. Through citizen input, field visits, and additional studies, Slippery Mountain County will be able to find a suitable location for a new landfill. Our GIS analysis is only the first step in a long process, but it helps us to study a very large area in a more timely and cost effective manner and will serve as a solid foundation on which to conduct further studies to locate a suitable location for a new landfill.



A. Garbage_R_Us_Sites Map



B. Garbage_R_Us_Siteareas Map

...better presented in a 2x2 table; use of cryptic map names isn't appropriate for the overview

...useful to have some annotations that “pull” the reader into the points you want to make with these figures

Figure 5 – Garbage R Us Sites Map and Garbage R Us Site-areas Maps (with clumped areas) Showing the Most Suitable Locations for a New Landfill *...these need to be in the body*

APPENDIX A

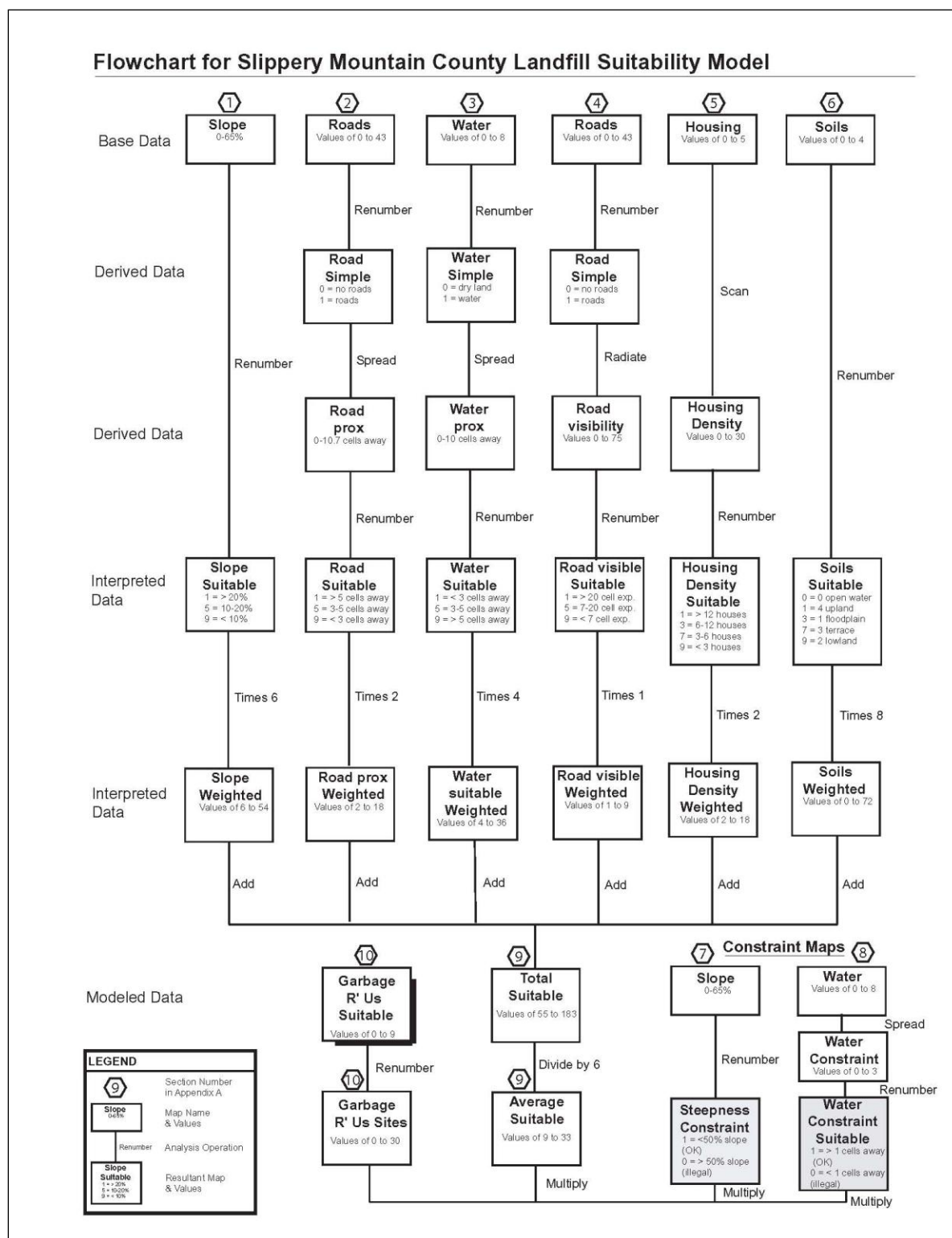


Figure 6 - Detailed Flowchart for the Slippery Mountain County Landfill Suitability Study

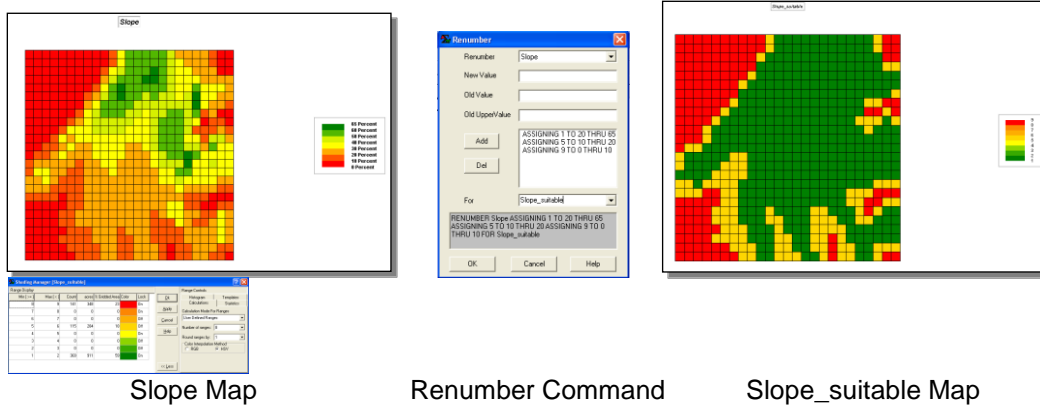
Provided in the following 12 sections of this appendix are detailed descriptions of the map analysis operations used and graphical displays of the intermediary maps and command dialog boxes used to complete the analysis.

Note: All specific commands used are in capital letters and boldface type.

1. Slope Analysis

...Step ??? in the flowchart— could relate to flowchart

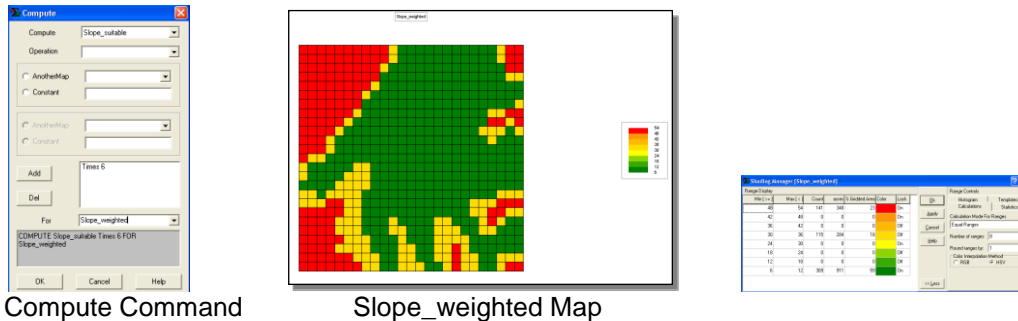
RENUMBER SLOPES ASSIGNING 1 TO 20 THRU 65 ASSIGNING 5 TO 10 THRU 20 ASSIGNING 9 TO 0 THRU 10 FOR SLOPE_SUITABLE



The slope map is an example of a 2D grid map showing us values ranging from 0 to 65%. The slope map is renumbered so that its values fall within the suitability range of 1 (poor suitability) to 9 (excellent suitability). The command used in bold typeface indicates what values are assigned to the existing slope values.

...very well presented and organized

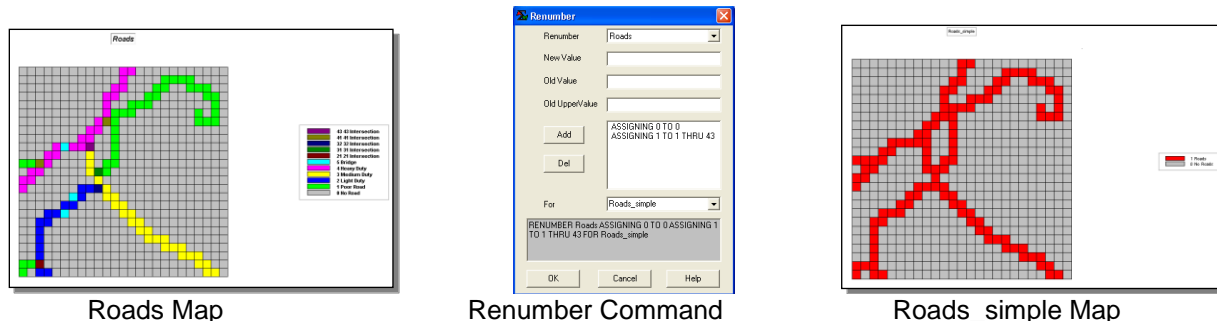
COMPUTE SLOPE_SUITABLE TIMES 6 FOR SLOPE_WEIGHTED *...the weighting step is best reserved for when you average the maps—can be done using the Analyze command (or in the Calculate command sum using parentheses)*



The 2D grid slope weighted map has values ranging from 6 to 54.

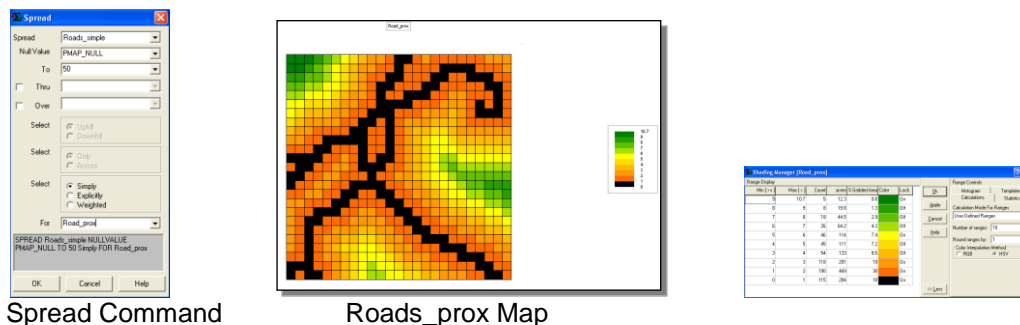
2. Road Proximity Analysis

RENUMBER ROADS ASSIGNING 0 TO 0 ASSIGNING 1 TO 1 THRU 43 FOR ROADS_SIMPLE



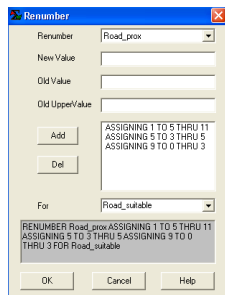
The 2D grid roads map with values of zero to 43 is renumbered to create the 2D grid binary map (values of only zero or 1) of roads_simple. A zero value represents all areas without a road while a 1 value on the roads_simple map represents a road.

SPREAD ROADS_SIMPLE TO 50 SIMPLY FOR ROADS_PROX

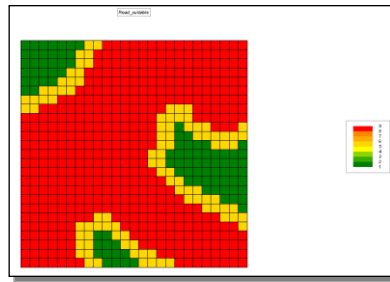


The “spread” command finds the shortest effective distance from all specified cells (the roads on the roads_simple map) to a specified distance which in this case was 50 cells, which allows us to look at the distance of all cells on the map from the roads since the map is 25 x 25 cells. The “simply” option measures the distance from the feature cell, the roads, starting at a value of 1. The values on the roads_prox map range from 0 to 10.7 cells from the road. A 0 value (black color on the map) represents an actual road.

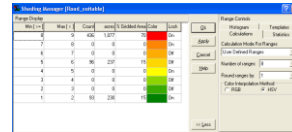
RENUMBER ROAD_PROX ASSIGNING 1 TO 5 THRU 11 ASSIGNING 5 TO 3 THRU 5 ASSIGNING 9 TO 0 THRU 3 FOR ROAD_SUITABLE



Renumber Command

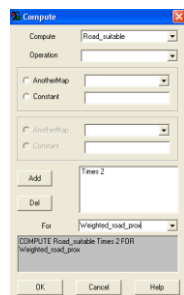


Road_suitable Map

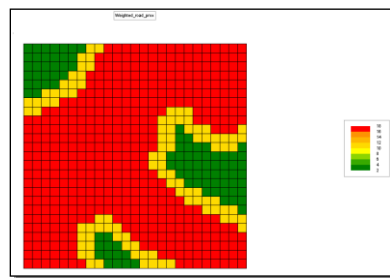


The road_prox map is renumbered to create the 2D grid road_suitable map with values ranging from 1 to 9.

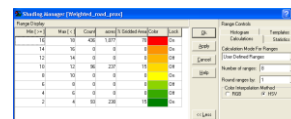
COMPUTE ROAD_SUITABLE TIMES 2 FOR ROAD_PROX_WEIGHTED



Compute Command



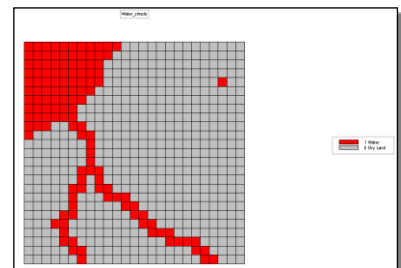
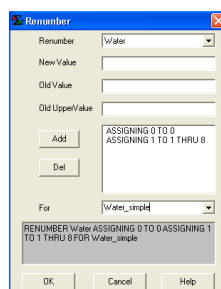
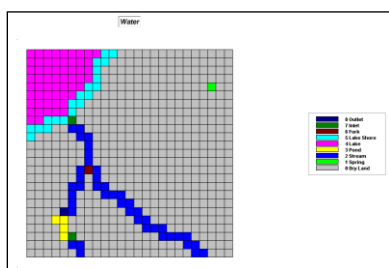
Road_prox_weighted Map



The road_suitable map is multiplied by 2 to create the 2D grid road_prox_weighted map. The values on this map range from 2 to 18. Red colors on the map represent higher values.

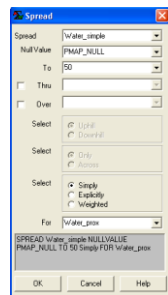
3. Water Proximity Analysis

RENUMBER WATER ASSIGNING 0 TO 0 ASSIGNING 1 TO 1 THRU 8 FOR WATER_SIMPLE

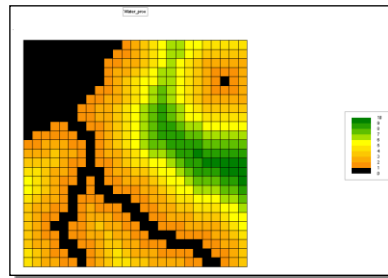


The 2D grid water map, with values ranging from 0 to 8, is renumbered to create the 2D grid binary map of water_simple with values of 0 (dry land areas, grey colors) and 1 (water areas, red colors) on the map.

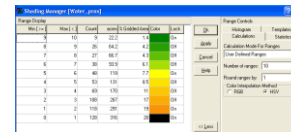
SPREAD WATER_SIMPLE NULLVALUE PMAP_NUL TO 50 SIMPLY FOR WATER_PROX



Spread Command

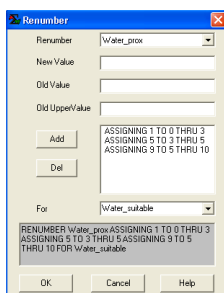


Water_prox Map

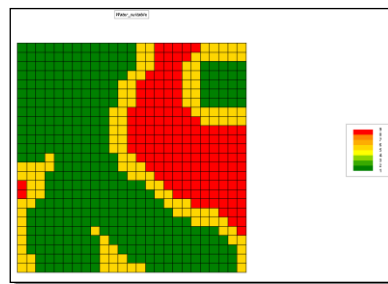


We used the “spread” command to find all of the locations within a 50 cell distance of the water features. By specifying a value of 50 so that we will see the distance for all cells on the map from the water features since the map is 25 x 25 cells in size. The “simply” option will tell us the effective distance from the water features starting with a value of 1 cell. The values on the water_prox map range from 0 to 10. Cells with a zero value (black color on the map) are cells that actually contain a water feature (i.e. stream, lake, etc.).

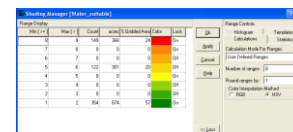
RENUMBER WATER_PROX ASSIGNING 1 TO 0 THRU 3 ASSIGNING 5 TO 3 THRU 5 ASSIGNING 9 TO 5 THRU 10 FOR WATER_SUITABLE



Renumber Command

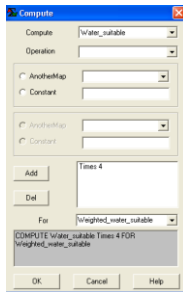


Water_suitable Map

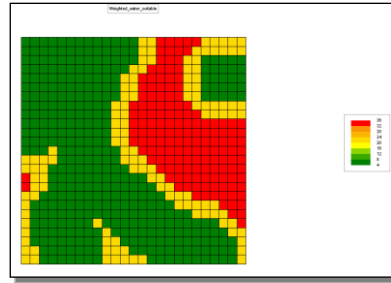


The 2D grid water_suitable map shows us values ranging from 1 to 9. Red colors represent higher values.

COMPUTE WATER_SUITABLE TIMES 4 FOR WEIGHTED_WATER_SUITABLE



Compute Command

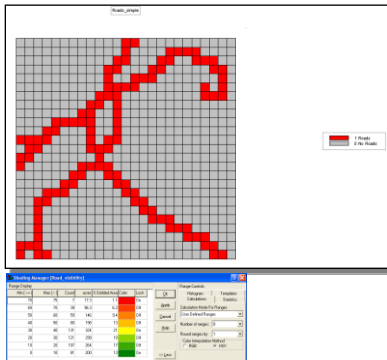


Weighted_water_suitable Map

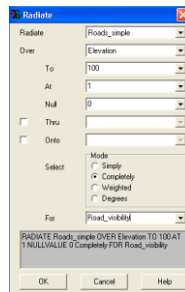
The weighted_water_suitable map shows us values ranging from 4 to 36, with the red colors on the map representing higher values.

4, Road Visibility Analysis

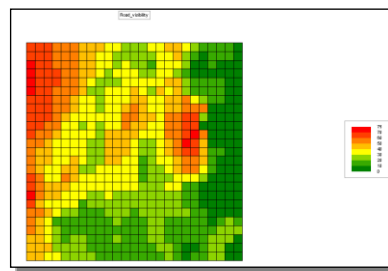
RADIATE ROADS_SIMPLE OVER ELEVATION TO 100 AT 1 NULLVALUE 0 COMPLETELY FOR ROAD_VISIBILITY



Roads_simple Map



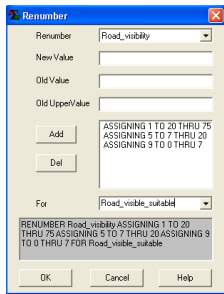
Radiate Command



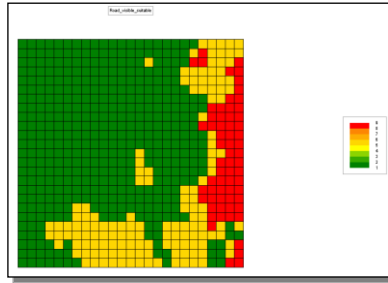
Road_visibility Map

We “radiate” the 2D grid binary roads_simple map to create the road_visibility viewshed map. This map identifies for each cell how many total times that cell is seen from all of the road location cells (the “completely” option). The visibility is determined by using the elevation map. The values on the road_visibility map range from 0 (dark green colors, areas not seen) to 75 (red colors on the map, areas that are highly visible).

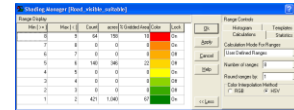
RENUMBER ROAD_VISIBILITY ASSIGNING 1 TO 20 THRU 75 ASSIGNING 5 TO 7 THRU 20 ASSIGNING 9 TO 0 THRU 7 FOR ROAD_VISIBLE_SUITABLE



Renumber Command

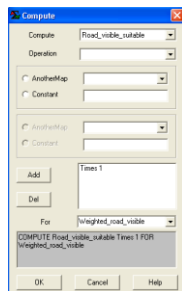


Road_visible_suitable Map

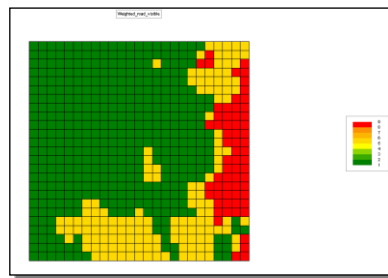


The 2D grid road_visible_suitable map shows us values ranging from 1 (dark green areas, lowest suitability) to 9 (red areas with the highest suitability).

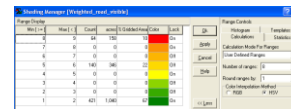
COMPUTE ROAD_VISIBLE_SUITABLE TIMES 1 FOR ROAD_VISIBLE WEIGHTED



Compute Command



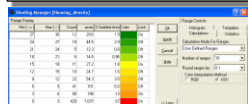
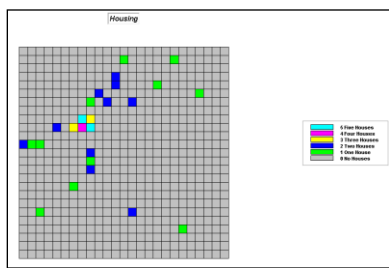
Road_visible_weighted Map



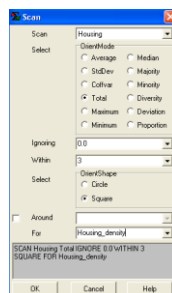
The 2D grid road_visible_weighted map shows us values ranging from 1 to 9, the same values as on the road_visible_suitable map. Since we multiplied the road_visible_suitable map by 1, no additional weight factor is being assigned to this map.

5. Housing Density Analysis

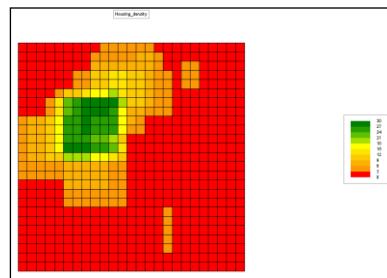
SCAN HOUSING TOTAL IGNORE 0,0 WITHIN 3 SQUARE FOR HOUSING_DENSITY



Housing Map



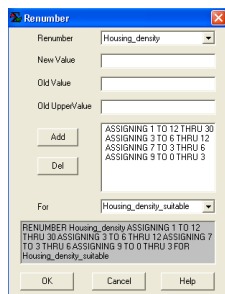
Scan Command



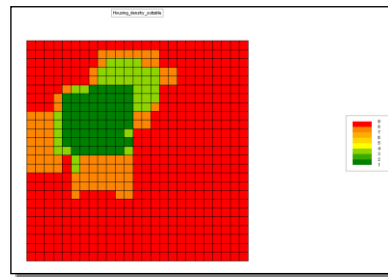
Housing_density Map

The 2D grid housing map with values ranging from 0 (no houses) to 5 (5 houses per cell) is “scanned” to find the housing density. Scan summarizes the values that occur within the vicinity of each cell. We specify a distance of 3 cells since we are interested in how many houses are within 3 cells of each cell on the map. The “total” option replaces the existing cell values with the sum of the cell values included in the scan. The housing density map shows us values of 0 (red colored areas, no houses, low density) to 30 (dark green areas with a high housing density).

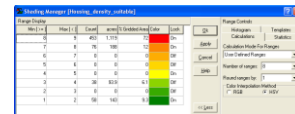
RENUMBER HOUSING_DENSITY ASSIGNING 1 TO 12 THRU 30 ASSIGNING 3 TO 6 THRU 12 ASSIGNING 7 TO 3 THRU 6 ASSIGNING 9 TO 0 THRU 3 FOR HOUSING_DENSITY_SUITABLE



Renumber Command

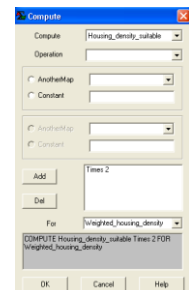


Housing_density_Suitable Map

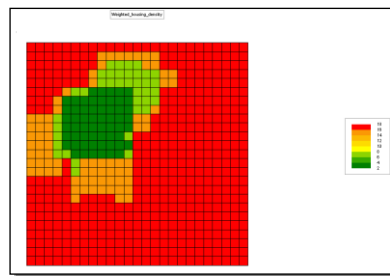


The housing_density_suitable map shows us values ranging from 1 (dark green areas, poor suitability) to 9 (red colored areas, very high suitability).

COMPUTE HOUSING_DENSITY_SUITABLE TIMES 2 FOR HOUSING_DENSITY_WEIGHTED



Compute Command

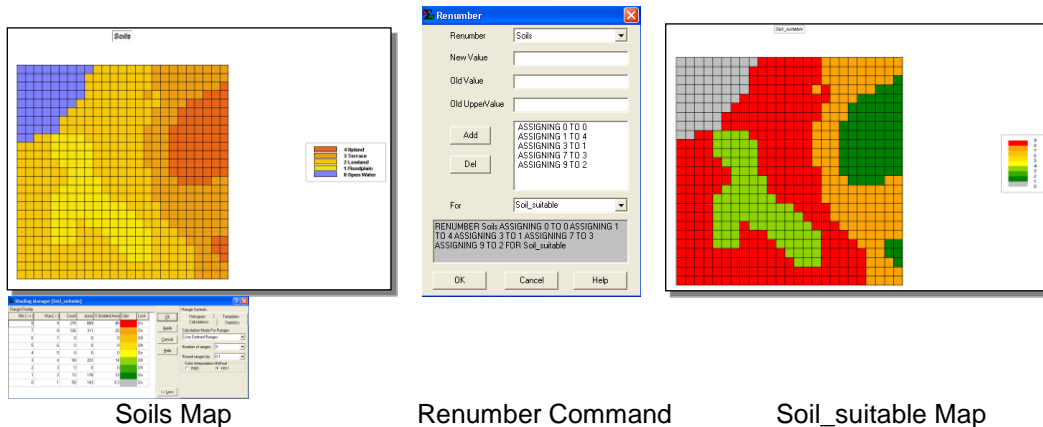


Housing_density_weighted Map

The 2D housing_density_weighted map shows us values ranging from 2 (dark green areas, poor suitability) to 18 (red colored areas, high suitability).

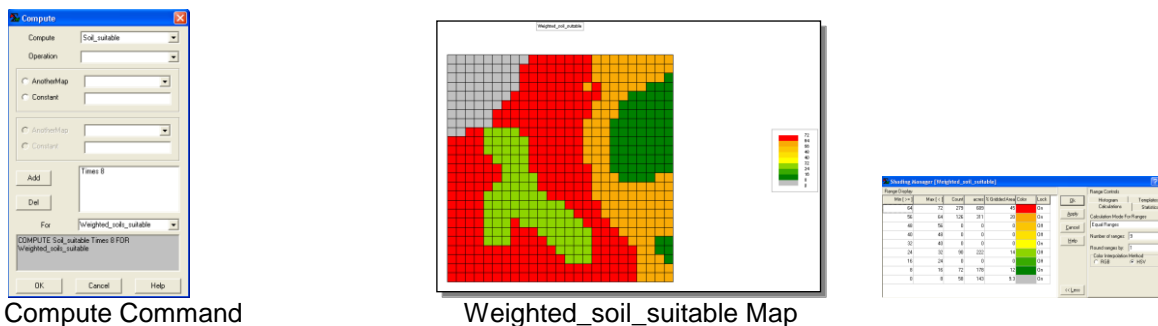
6. Soils Analysis

**RENUMBER SOILS ASSIGNING 0 TO 0 ASSIGNING 1 TO 4 ASSIGNING 3 TO 1 ASSIGNING 7 TO 3
ASSIGNING 9 TO 2 FOR SOIL_SUITABLE**



The 2D grid soils map with values ranging from 0 to 4 is renumbered to produce the soil_suitable map with values ranging from 0 (grey areas on map with no soils) to 9 (red colored areas with highly suitable soils).

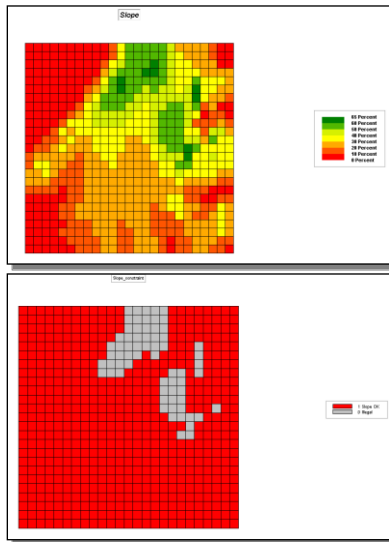
COMPUTE SOIL_SUITABLE TIMES 8 FOR WEIGHTED_SOIL_SUITABLE



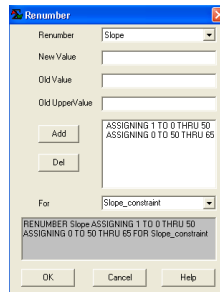
The weighted_soil_suitable map has values ranging from 0 (grey areas with no soils) to 72 (red colored areas with highly suitable soils).

7. Steepness Constraint

**RENUMBER SLOPE ASSIGNING 1 TO 0 THRU 50 ASSIGNING 0 TO 50 THRU 65 FOR
STEEPNESS_CONSTRAINT**



Slope Map



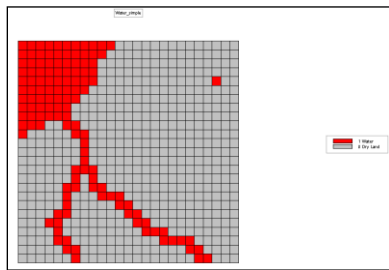
Renumber Command

Steepness_constraint Map

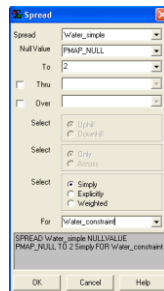
The 2D grid slope map with values of 0 to 65% is renumbered to create a 2D grid binary steepness_constraint map. The grey colored areas with a 0 value represent those areas where the slope is too steep (greater than 50%) due to a county legal constraint. The red colored areas with a value of 1 are areas with a slope less than 50% and it's OK to build a landfill in these areas.

8. Water Constraint

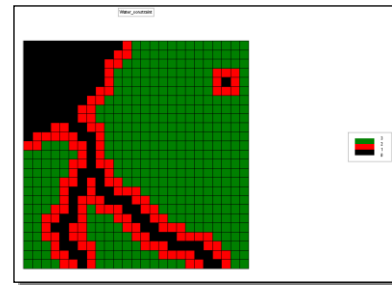
SPREAD WATER_SIMPLE NULLVALUE PMAP_NULL TO 2 SIMPLY FOR WATER_CONSTRAINT



Water_simple Map



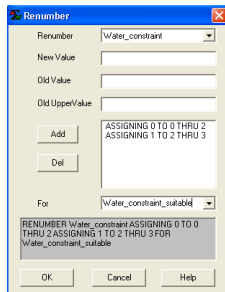
Spread Command



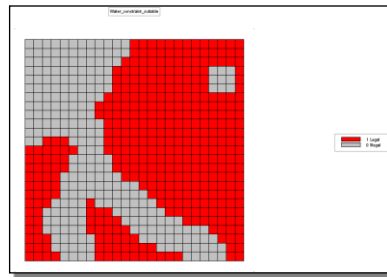
Water_constraint Map

The "spread" command is used to create a 1 cell wide buffer around all of the water features. The water_constraint map shows us values ranging from 0 (black colored areas, actual water features) to 3 (dark green areas that are 2 or more cells away from a water feature). The red colored areas with a value of 1 represent a 1 cell buffer in which a landfill cannot be located due to legal constraints.

RENUMBER WATER_CONSTRAINT ASSIGNING 0 TO 0 THRU 2 ASSIGNING 1 TO 2 THRU 3 FOR WATER_CONSTRAINT_SUITABLE



Renumber Command



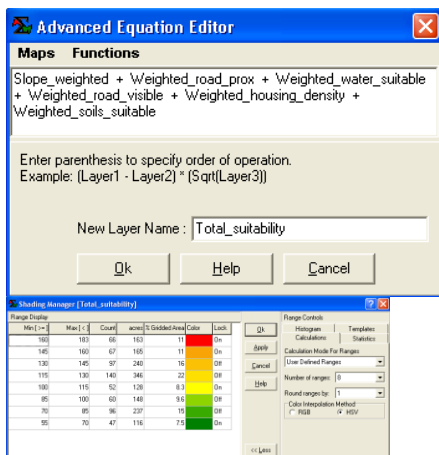
Water_constraint_suitable Map

The water_constraint map is renumbered to create a 2D grid binary map of water_constraint_suitable with values of 0 (grey colored areas where it's illegal to build a landfill) and 1 (red colored areas where it is OK to build a landfill).

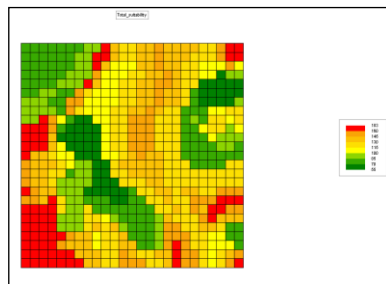
9. Total Suitability Maps

COMPUTE SLOPE_WEIGHTED PLUS WEIGHTED_ROAD_PROX PLUS WEIGHTED_WATER_SUITABLE PLUS WEIGHTED_ROAD_VISIBLE PLUS WEIGHTED_HOUSING_DENSITY PLUS WEIGHTED_SOILS_SUITABLE FOR TOTAL_SUITABILITY

...use parentheses in Calculate for weighting



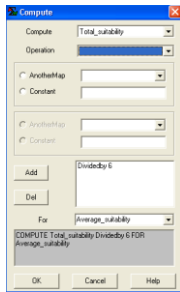
Compute Command



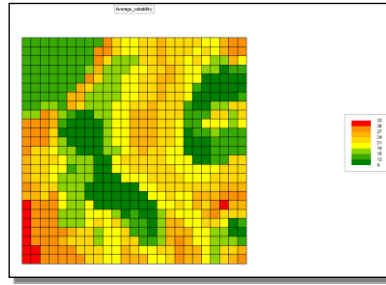
Total_suitability Map

The total_suitability map shows us the suitability values ranging from 55 (dark green areas, low suitability) to 183 (red colored areas on the map with high suitability). This map is the result of adding the 6 weighted suitability maps generated in sections 1 through 6 of the Appendix.

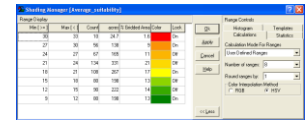
COMPUTE TOTAL_SUITABILITY DIVIDEDBY 6 FOR AVERAGE_SUITABILITY



Compute Command



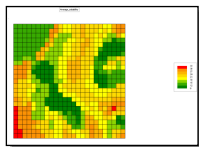
Average_suitability Map



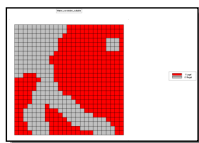
The total_suitability map is divided by 6 to produce the average_suitability map. We divide by 6 since we used a total of 6 different weighted suitability maps to find the total_suitability. The average_suitability map has values ranging from 9 (dark green areas with a low suitability) to a 33 (red colored areas with a high suitability).

10. Final Suitable Landfill Locations

COMPUTE AVERAGE_SUITABILITY TIMES WATER_CONSTRAINT_SUITABLE TIMES
SLOPE_CONSTRAINT FOR GARBAGE_R_US_SITES



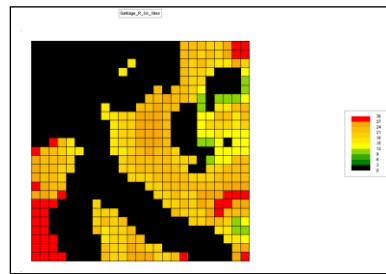
Average_suitability Map



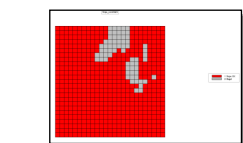
Water_constraint Map



Compute Command



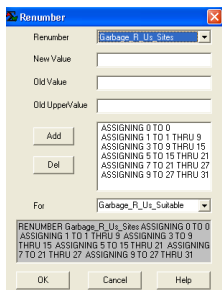
Garbage_R_Us_Sites



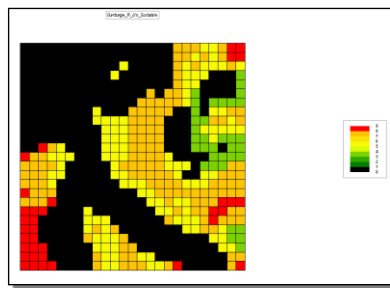
Steepness_constraint Map

When we multiply the 3 maps shown above together, the 0 values on the constraint maps (the grey colored areas) when multiplied with the average_suitability map results in zero values on the final Garbage_R_Us_Sites map (the areas colored in black). The values on the Garbage_R_Us_Sites map range from 0 (black colored areas where it's impossible to build due to legal constraints or is physically impossible) to 30 (red colored areas where it's highly suitable to build a landfill).

RENUMBER GARBAGE_R_US_SITES ASSIGNING 0 TO 0 ASSIGNING 1 TO 1 THRU 9 ASSIGNING 3 TO 9 THRU 15 ASSIGNING 5 TO 15 THRU 21 ASSIGNING 7 TO 21 THRU 27 ASSIGNING 9 TO 27 THRU 30 FOR GARBAGE_R_US_SUITABLE



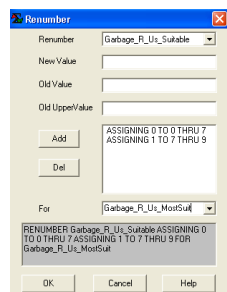
Renumber Command



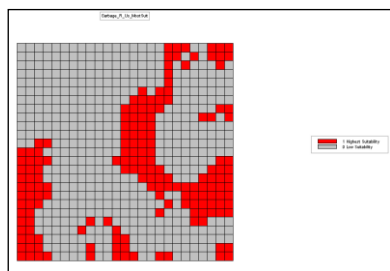
Garbage_R_Us_Suitable Map

We did a renumber on the Garbage_R_Us_Sites map so that the values would fall into our suitability range of 0 (illegal, impossible to build black colored areas on the map) to 9 (red colored areas where it is highly suitable to build a new landfill based on our analysis).

RENUMBER GARBAGE_R_US_SUITABLE ASSIGNING 0 TO 0 THRU 7 ASSIGNING 1 TO 7 THRU 9 FOR GARBAGE_R_US_MOSTSUIT



Renumber Command

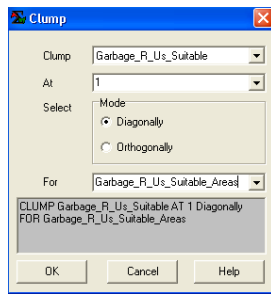


Garbage_R_Us_Mostsuit Map

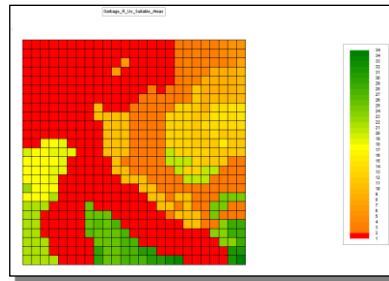
We renumber the Garbage_R_Us_Suitable map to create a binary map that shows us to see the areas with the highest suitabilities of values 7 to 9 being assigned a value of 1 (red colors on the binary map) and areas with a suitability value of 7 or less are assigned a value of 0 (grey colored areas).

The red colored areas on this map represent 422 acres of the site (27% of the total area) which has a high suitability rating (a value of 7 to 9 on the Garbage_R_Us_Suitable Map).

CLUMP GARBAGE_R_US_SUITABLE AT 1 DIAGONALLY FOR GARBAGE_R_US_SUITABLE_AREAS



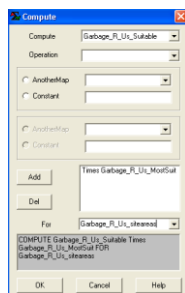
Clump Command



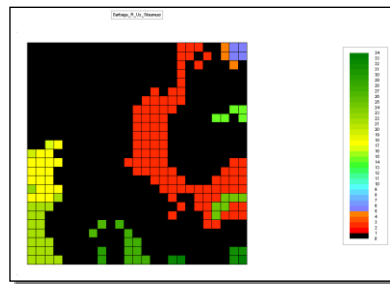
Garbage_R_Us_Suitable_Areas

The “clump” command allows us to uniquely identify groups of cells separately that are geographically separated on the map. This information is useful for us so we can see how much area (acres) each group of connected cells has. The map shows us that there are a total of 34 separate areas on the map. Areas numbered 5, 16, 19, 21, 22, 24 33, and 34 on the map are the ones with the highest suitability rating (these are the red colored areas on the map).

COMPUTE GARBAGE_R_US_SUITABLE_AREAS TIMES GARBAGE_R_US_MOSTSUIT FOR GARBAGE_R_US_SITEAREAS



Compute Command



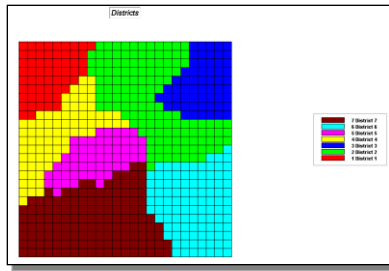
Garbage_R_Us_Siteareas

These 2 maps are multiplied together so we can determine the number of acres for each of the different sites (clumped areas with the same value) on the map. The black areas represent areas where there is a legal constraint, it's impossible to build in that location, or the suitability rating is below a value of 7 on the Garbage_R_Us_Suitable map. We did this to get an idea of how many acres of These black colored areas are a zero value on the Garbage_R_Us_Mostsuit map. Each value on this map represents a different clumped area, so each number represents a different group of connected cells with the same value.

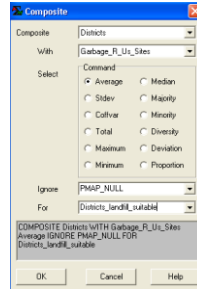
The largest area (red color) has an area of 227 acres while the 2nd largest area is 49.4 acres at the lower left corner of the map in the light green color.

11. Average Suitability Rating for Districts

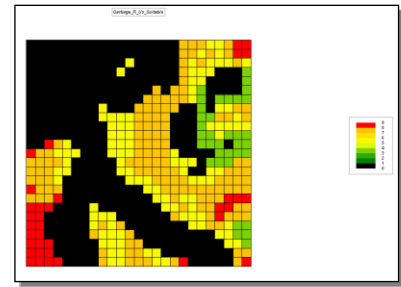
COMPOSITE DISTRICTS WITH GARBAGE_R_US_SUITABLE AVERAGE IGNORE PMAP_NULL FOR DISTRICTS_LANDFILL_SUITABLE



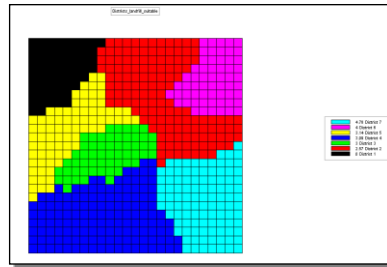
Districts Map



Composite Command



Garbage_R_Us_Suitable



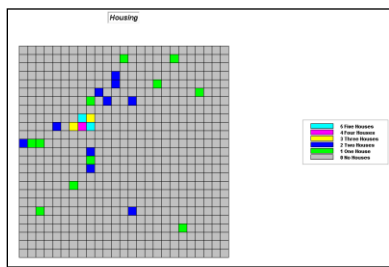
Districts_landfill_suitable Map

Using the “composite” command we are able to summarize the values of one map (the districts map) with values of another map (the Garbage_R_Us_Sites map) for each location on both maps. Composite gives us an average suitability rating for each of the 7 districts. District 1 had the lowest average suitability rating with a value of 0 (upper left corner of the map where there is a water feature) while District 6 in the lower right corner of the map had the highest average suitability with a value of 4.78

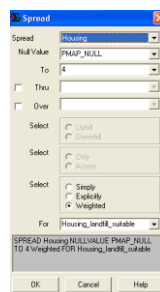
12.Housing Rating Within 300 meters

SPREAD HOUSING NULLVALUE PMAP_NULL TO 4 WEIGHTED FOR HOUSING_LANDFILL_SUITABLE

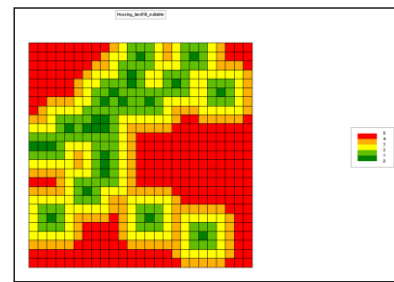
...calculates for more than 300m—works but better if you had used Scan around.



Housing Map



Spread Command

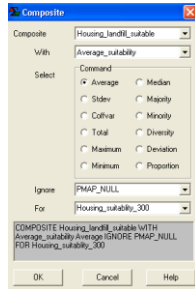


Housing_landfill_suitable Map

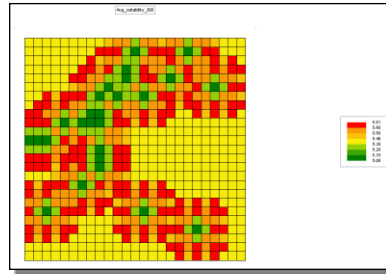
The housing map is “spread” to a distance of 4 cells, one more cell than we are interested in to make sure that we don’t get only a partial value for a cell, to determine the radius (or buffer) of cells around each housing location. The values on the housing_landfill_suitable map range from 0 (dark green color meaning there is a house in that location) to a 5 (red colored areas that indicate that there are no houses present in that

location). The “weighted” option will apply a weight factor so that a cell with more houses will receive a higher value than a cell with fewer houses near it.

COMPOSITE HOUSING_LANDFILL_SUITABLE WITH AVERAGE_SUITABILITY AVERAGE IGNORE PMAP_NULL FOR HOUSING_SUITABILITY_300



Composite Command



Housing_suitability_300 Map

The “composite” command was used to find the average suitability for each of the houses within a 3 cell radius of the houses. The housing_suitability_300 map shows us values ranging from 5.08 to 5.81, meaning that all of the houses are in areas of fairly high suitability (on a scale of 0 being non-suitable to 9 being the most suitable).