



Suitability Analysis for New Austin, TX Landfill Site

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1. Introduction

Austin is a rapidly growing city. Over the past decade Austin's population has increased by 20% from 802,078 to 964,254.¹ However, urban population growth places stress on the infrastructure that already supports the existing population. Because an increase in solid waste is unavoidable with an increase in population, it is likely that Austin's solid waste disposal infrastructure will have to expand.

The goal of my project is to examine where the most ideal location would be for a new solid waste landfill that serves the population of Austin, Texas. This means looking for the location that minimizes pollution risk, cost, and undesirable social impact. In order to do this, large amounts of spatial data that relates to these criteria needs to be managed and analyzed. Thankfully, GIS software is designed to do this. To analyze the data, I will use a system that ranks the data from unsuitable to most suitable in terms of the landfill site location. After compiling these ranks together, I will create a map that shows the degree of suitability ranging from unsuitable to most suitable for the new landfill site for Austin, Texas.

¹ US Census Bureau (2018) QuickFacts Austin, TX. Retrieved from <https://www.census.gov/quickfacts/fact/table/austincitytexas/LND110210>

2. Data Collection

Landfill site selection is a complex process that requires many criteria to consider. For the scope of my project I will consider factors that minimize the cost of construction of the landfill, reduce the negative social impact of the landfill, and minimize the risk that the landfill pollutes the environment around it.

2.1 Surface water

In order to reduce the potential that waste from the landfill is discharged into water bodies without proper treatment, I want to create a zone of unsuitability around surface water bodies.

- Lakes
 - Data from [TWDB](#)
- Rivers
 - Data from [TWDB](#)
- Streams
 - From Garner & Young dataset
- Wetlands
 - Data from [City of Austin](#)
- Zones of flood risk
 - Data from [FEMA](#)

2.2 Ground water

Similarly, I want to reduce the chance that waste leaches underground into the water table. These data describe areas of unsuitability because of their increased risk of pollution from the landfill.

- Aquifer recharge zone
 - Data from [City of Austin](#)
- Karst geology
 - Data from City of Austin

2.3 Land use & infrastructure

The landfill should not be constructed on top of existing infrastructure. In addition, it should not be too close to roads and houses so as to minimize health risks and reduce interference with regular traffic. At the same time, the closer the landfill is to existing roads and highways the less it will cost to construct new roads to the landfill. Similarly, the closer the landfill is to the population that produces its waste the less it will cost to transport waste to the landfill.

- Highways
 - From Garner & Young dataset

- Roads
 - From Garner & Young dataset
- Residential and developed areas
 - Derived from Austin land use and land coverage data from City of Austin
- Airports
 - Birds accumulate near landfills, and we don't want birds to accumulate near airports.
 - Derived from Austin aerial photography
- Parks & protected areas
 - [Data from City of Austin](#)
 - Unsuitable for a landfill
- Railroads
 - From Garner & Young dataset
 - Unsuitable for a landfill
- Power transmission lines.
 - Unsuitable for a landfill

2.4 Slope & precipitation rates

These data factor into erosion. A less erosive location will be less likely to carry pollution into its surrounding environment. In addition, these data factor into the economic feasibility of the site.

- Slope
 - Slopes above 10% grade are unsuitable for a landfill. Below that, the lower the slope the less erosive the location and the easier it is to construct and maintain a solid waste landfill.
 - Data derived from USGS National Elevation Dataset (NED)
- Precipitation
 - Lower precipitation rates mean less erosion and less chance that pollutants are transported away during rainfall.
 - Data from [TWDB](#)

2.5 Other

These data are not a part of my analysis but still are used in my project.

- Texas state boundary
- Texas county boundaries
- Travis county landfill sites
 - Data from TCEQ
- Austin aerial photograph
 - Data from [City of Austin](#)

3. Data Preprocessing

There is a large amount of preprocessing that I need to do in order to prepare my data for my ArcGIS processing scheme.

3.1 Projection & coordinate system

Because the data are from many different sources, they are in different coordinate systems and projections. I want all data to be in NAD_1983 UTM Zone 14. To do this I used the “Project” tool for each file.

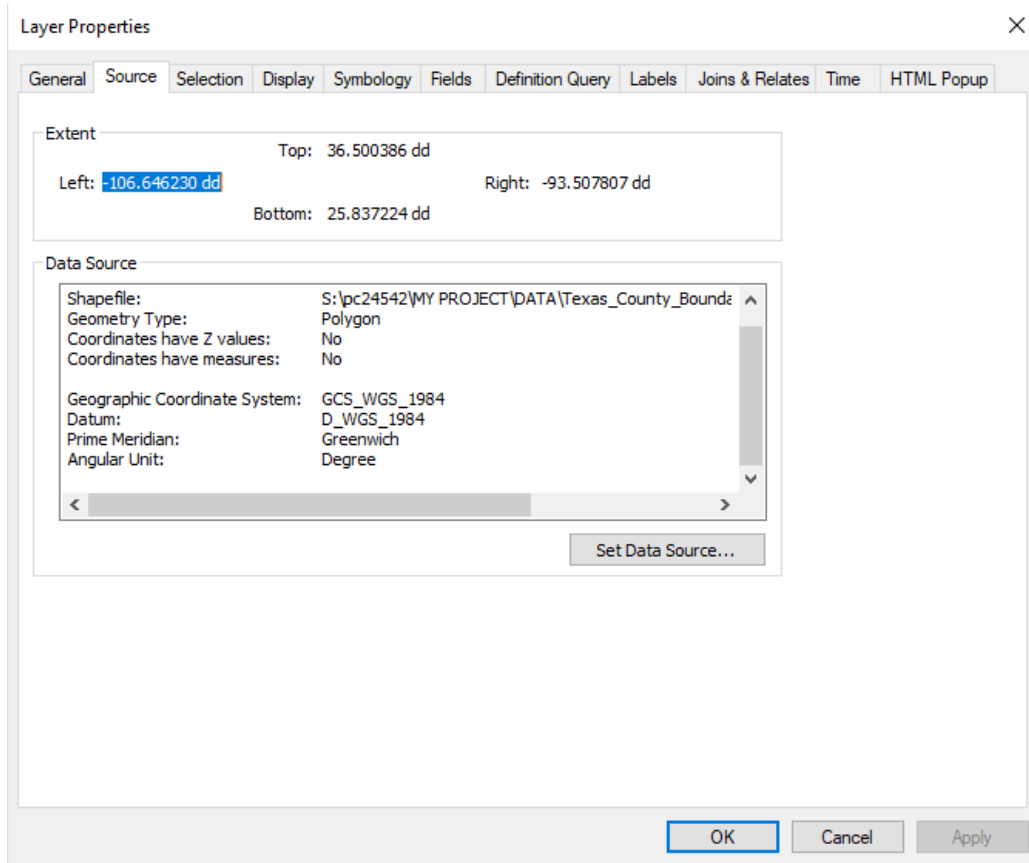


Figure 1 - initial coordinate system of Texas county boundaries data.

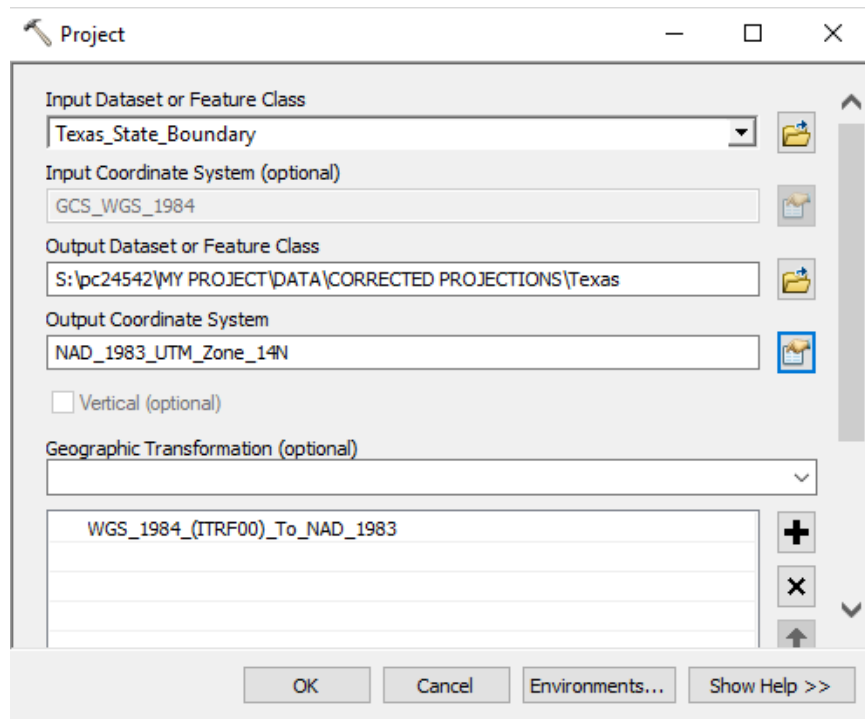


Figure 2 – “Project” tool lets me convert my coordinate system.

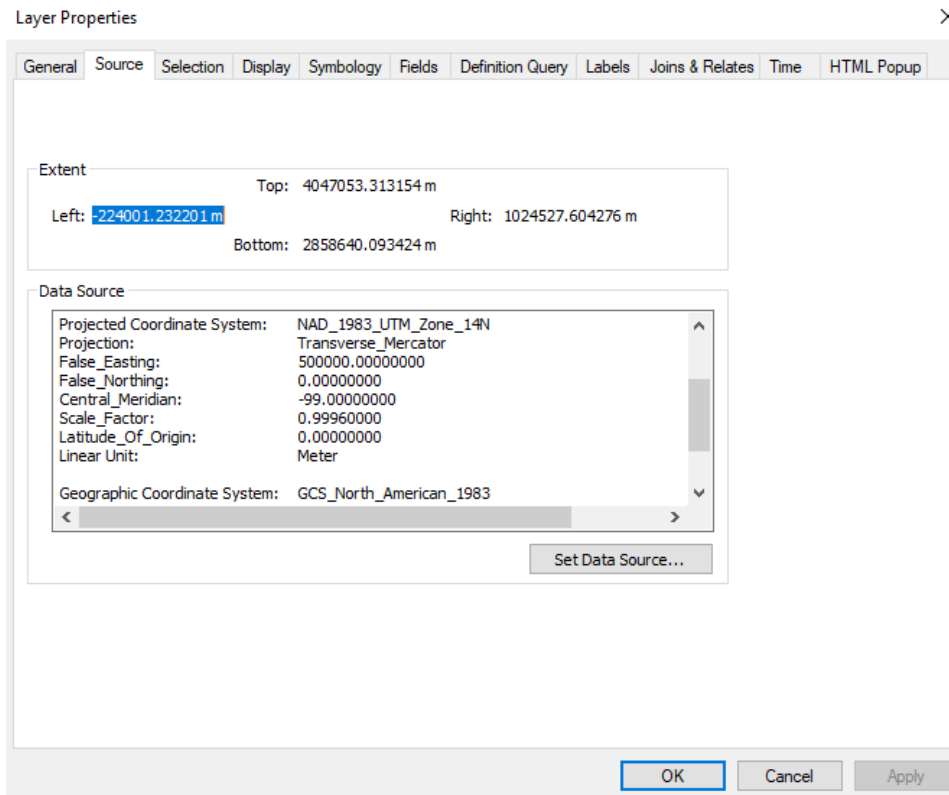


Figure 3 - Texas county boundaries data now in desired coordinate system.

3.2 Combine different files

For each criterion for my analysis, the data is usually spread out over multiple files. To facilitate easier analysis, I condense those multiple files into one file using “Mosaic to New Raster” tool for raster files and “Merge” for vector files. Below I’ll show how I worked with the DEM data as an example.

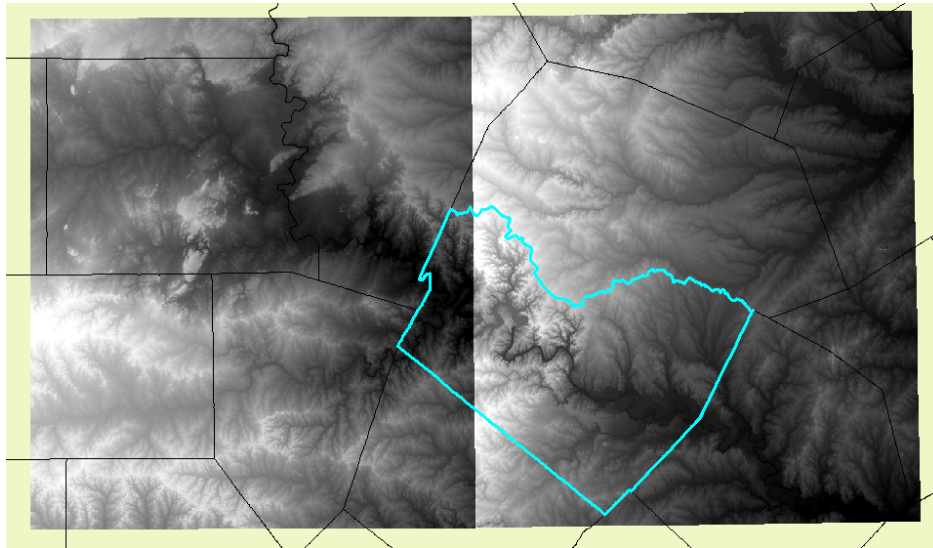


Figure 4 - within Travis county (highlighted) I have two separate DEMs.

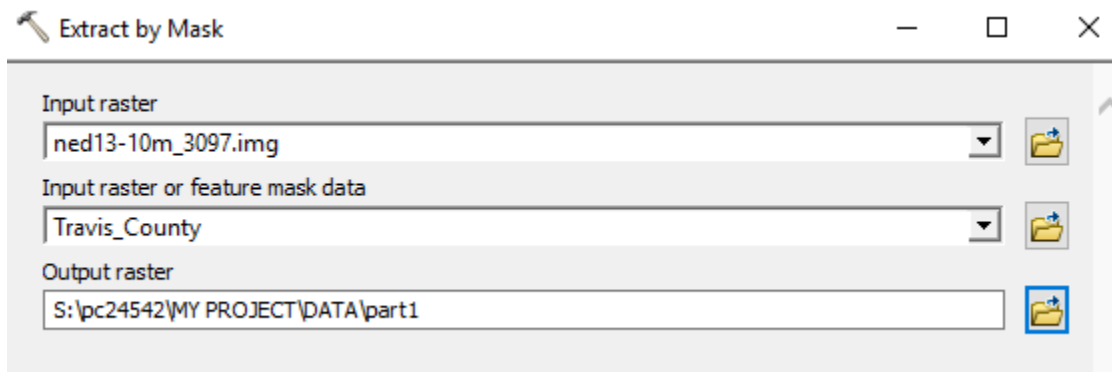


Figure 5 - first I use "Extract by Mask" tool to limit my area to Travis county so that the next step will take computational effort.

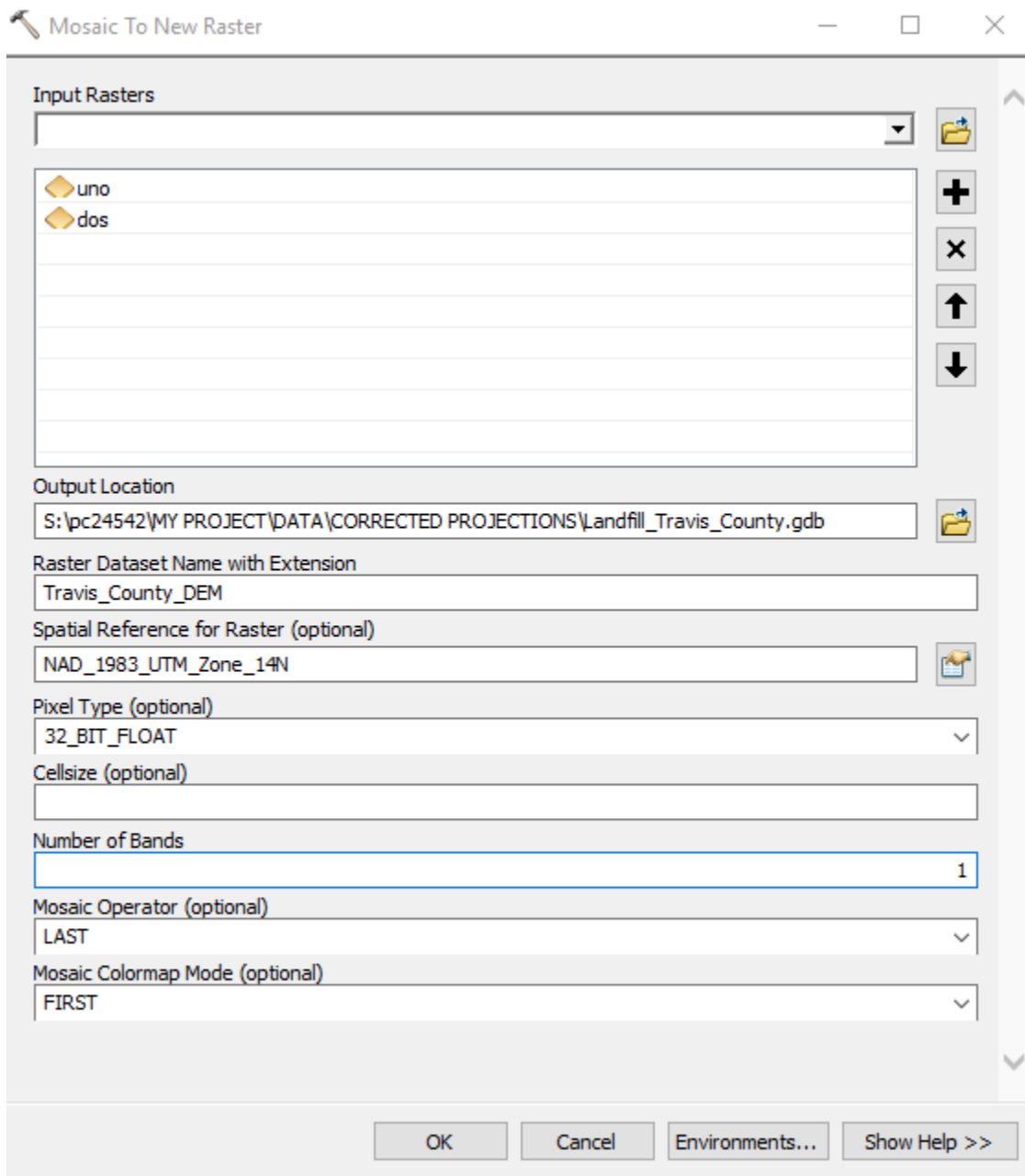


Figure 6 - now I use "Mosaic to New Raster" tool to combine the two DEMs.

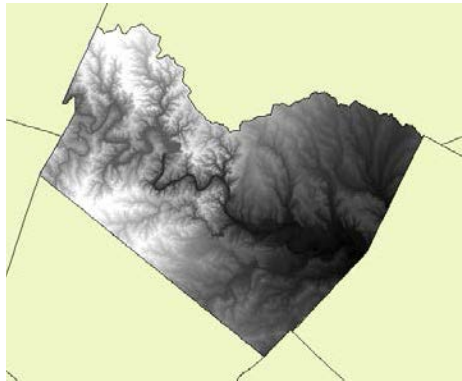


Figure 7 - the resultant DEM

3.3 Clip to reduce file sizes.

Most of the data is statewide or nationwide, but my study area is Travis county. By limiting the spatial aspect using the “Clip” tool, I reduce file sizes and allow the GIS software to run a bit faster.

3.4 Create airport data

Using an aerial photograph as reference, I mapped a polygon of Austin-Bergstrom International Airport. No landfill will be built near this.



Figure 8 - aerial photograph showing Austin-Bergstrom International Airport

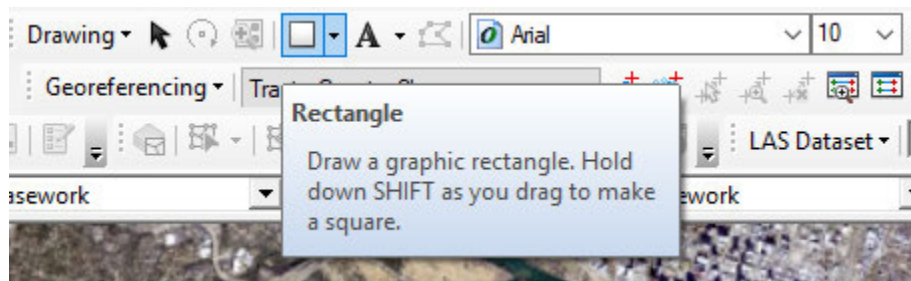


Figure 9 - ArcMap drawing toolbar.



Figure 10 - the airport.

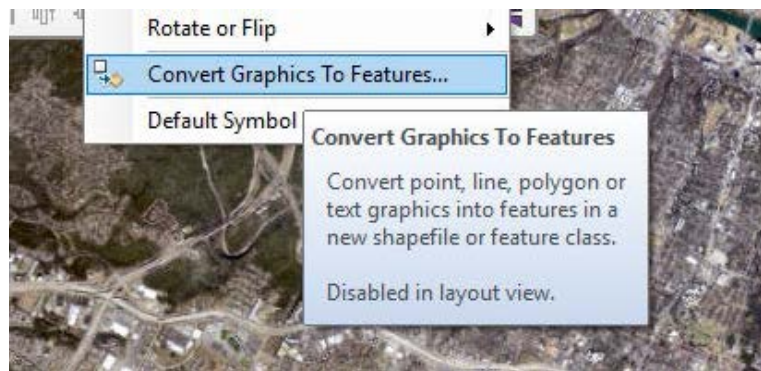


Figure 11 - converting the rectangle into a shapefile

3.5 DEM to Slope

I need slope data for my analysis. The “Slope” tool converts my DEM into a slope field.

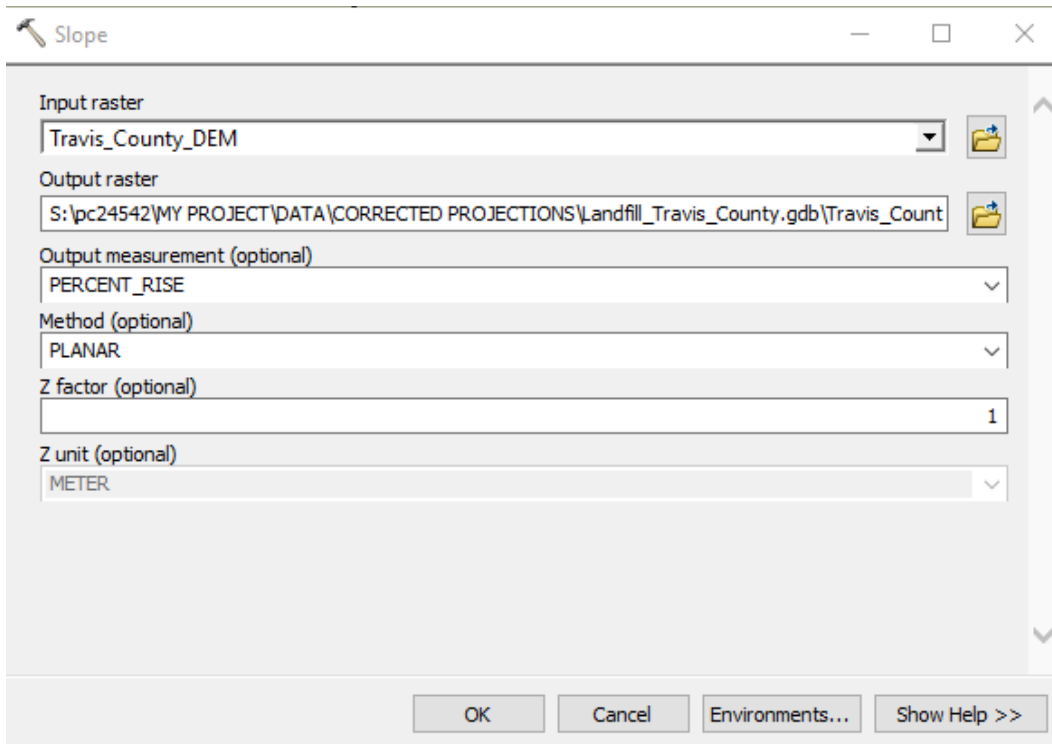


Figure 12 - "Slope" tool

3.6 Buffers

I apply buffers because I don't want a landfill right on the boundary of a zone of unsuitability. Multiple rings buffers are also integral for my analysis because different buffer distances will have different degrees suitability. I used both “Buffer” and “Multiple Ring Buffer” tools. Below is the scheme I used.

Table 1 - buffer scheme

| Criteria | Buffer length(s) (m) |
|---------------|----------------------|
| River | 250m |
| Lake | 250m |
| Stream | 150m |
| Wetlands | 100m |
| Karst Geology | 200m |

| | |
|-------------------------|-------------------------------|
| Recharge Zone | 200m |
| Residential Area | 200m, 500m, 1km, 2km, 5km |
| Park | 200m |
| Airport | 3000m |
| Power Transmission Line | 50m |
| Highway | 200m, 500m, 1km, 2km, 5km |
| Road | 100m, 200m, 300m, 500m, 1000m |
| Railroad | 100m |

Buffer

| | Input Features | Output Feature Class | Distance [value or field] |
|---|---|-------------------------------------|---------------------------|
| 1 | LANDFILL SUITABILITY CRITERIA\Trvs_Cty_Power_Trans | S:\pc24542\MY PROJECT\buffereddata\ | 50 Meters |
| 2 | LANDFILL SUITABILITY CRITERIA\Railroads_Austin_GY | S:\pc24542\MY PROJECT\buffereddata\ | 100 Meters |
| 3 | LANDFILL SUITABILITY CRITERIA\BOUNDARIES_city_of_au | S:\pc24542\MY PROJECT\buffereddata\ | 200 Meters |
| 4 | LANDFILL SUITABILITY CRITERIA\MajorRivers_dd83 | S:\pc24542\MY PROJECT\buffereddata\ | 250 Meters |
| 5 | LANDFILL SUITABILITY CRITERIA\Creeks&Streams_GY | S:\pc24542\MY PROJECT\buffereddata\ | 150 Meters |
| 6 | LANDFILL SUITABILITY CRITERIA\Lakes | S:\pc24542\MY PROJECT\buffereddata\ | 250 Meters |
| 7 | LANDFILL SUITABILITY CRITERIA\Edwards_Recharge_Zon | S:\pc24542\MY PROJECT\buffereddata\ | 200 Meters |
| 8 | LANDFILL SUITABILITY CRITERIA\Wetlands | S:\pc24542\MY PROJECT\buffereddata\ | 100 Meters |
| 9 | LANDFILL SUITABILITY CRITERIA\Karst_Sensitivity | S:\pc24542\MY PROJECT\buffereddata\ | 200 Meters |

Figure 13 - showing buffer scheme in the "Buffer" tool

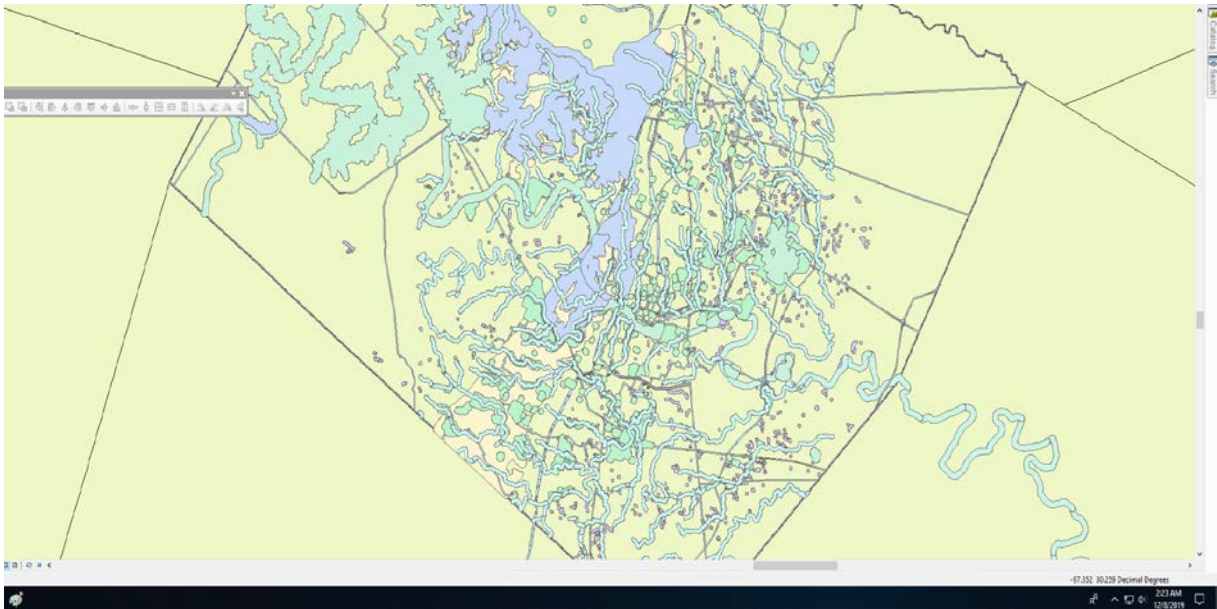


Figure 14 - criteria before buffers are applied

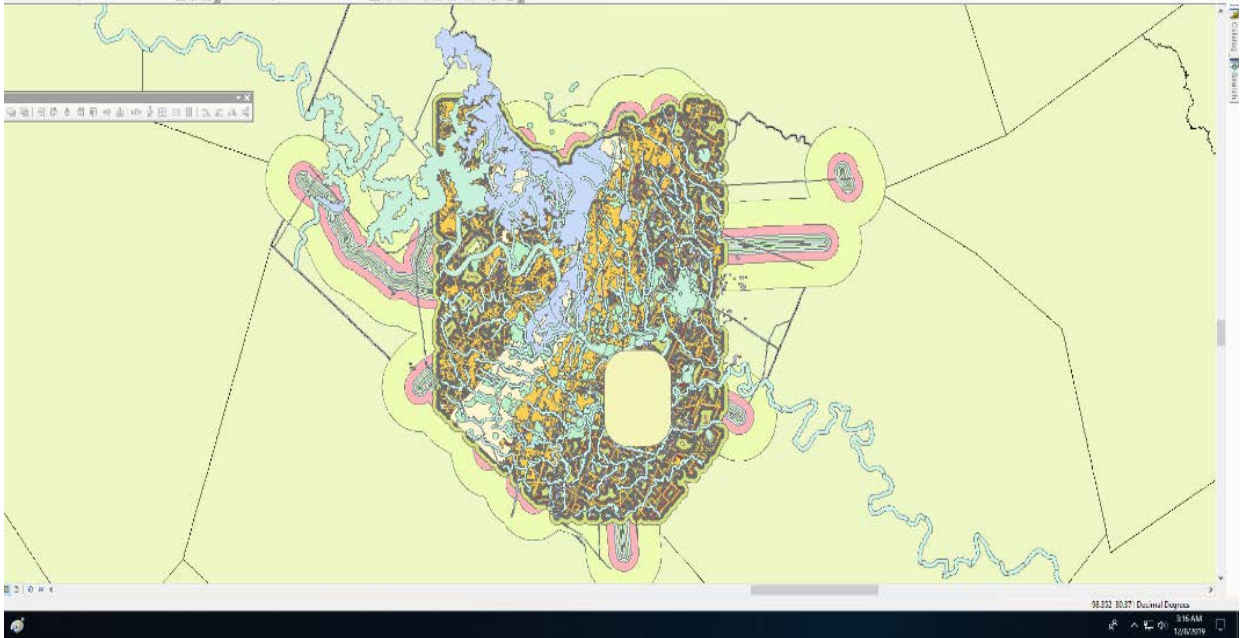


Figure 15 - criteria after buffers are applied

3.7 Converting Vector to Raster

My analysis requires raster calculation, but most of my data are vectors. I use “Polygon to Raster” tool to convert my data.

| | Input Features | Value field | Output Raster Dataset | Cell assign |
|----|------------------------------------|-------------|--------------------------------------|--------------|
| 1 | Buffered Data\Airportbuffered | BUFF_DIST | S:\pc24542\MY PROJECT\rasterfiedata\ | MAXIMUM_AREA |
| 2 | Buffered Data\Creeksbuffered | BUFF_DIST | S:\pc24542\MY PROJECT\rasterfiedata\ | MAXIMUM_AREA |
| 3 | Buffered Data\Karstgeologybuffered | BUFF_DIST | S:\pc24542\MY PROJECT\rasterfiedata\ | MAXIMUM_AREA |
| 4 | Buffered Data\Lakesbuffered | BUFF_DIST | S:\pc24542\MY PROJECT\rasterfiedata\ | MAXIMUM_AREA |
| 5 | Buffered Data\Parksbuffered | BUFF_DIST | S:\pc24542\MY PROJECT\rasterfiedata\ | MAXIMUM_AREA |
| 6 | Buffered Data\Airportbuffered | BUFF_DIST | S:\pc24542\MY PROJECT\rasterfiedata\ | MAXIMUM_AREA |
| 7 | Buffered Data\Powerlinesbuffered | BUFF_DIST | S:\pc24542\MY PROJECT\rasterfiedata\ | MAXIMUM_AREA |
| 8 | Buffered Data\Railroadsbuffered | BUFF_DIST | S:\pc24542\MY PROJECT\rasterfiedata\ | MAXIMUM_AREA |
| 9 | Buffered Data\Rechargezonebuffered | BUFF_DIST | S:\pc24542\MY PROJECT\rasterfiedata\ | MAXIMUM_AREA |
| 10 | Buffered Data\Riversbuffered | BUFF_DIST | S:\pc24542\MY PROJECT\rasterfiedata\ | MAXIMUM_AREA |
| 11 | Buffered Data\Wetlandsbuffered | BUFF_DIST | S:\pc24542\MY PROJECT\rasterfiedata\ | MAXIMUM_AREA |
| 12 | Buffered Data\Roadsbuffered | distance | S:\pc24542\MY PROJECT\rasterfiedata\ | MAXIMUM_AREA |
| 13 | Buffered Data\Highwaysbuffered | distance | S:\pc24542\MY PROJECT\rasterfiedata\ | MAXIMUM_AREA |
| 14 | Nonbuffered Data\Austin_Flood_Risk | ZONE_SUBTY | S:\pc24542\MY PROJECT\rasterfiedata\ | MAXIMUM_AREA |
| 15 | Nonbuffered Data\geo | NAME | S:\pc24542\MY PROJECT\rasterfiedata\ | MAXIMUM_AREA |

Figure 16 - "Polygon to Raster" tool.

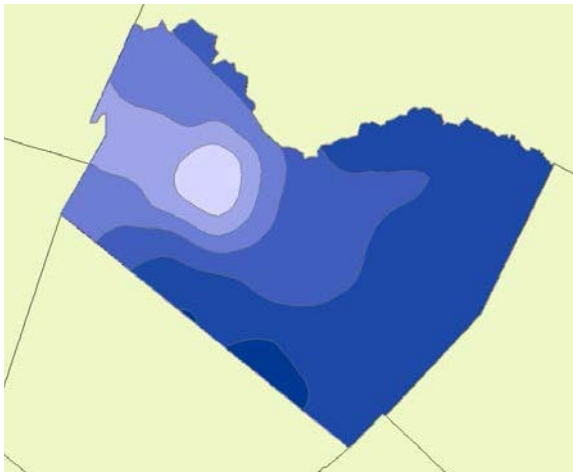


Figure 17 - precipitation data as vectors



Figure 18 - precipitation data as a raster

4. ArcGIS Processing & Analysis

My analysis is centered around the “Raster Calculator” tool. Below is the scheme in which I will use ArcGIS to analyze the data.

1. Use “Reclassify” tool to assign ranks to criteria
2. Use “Raster Calculator” tool to combine all ranks into single raster
3. Result is map showing suitability ranked from unsuitable to most suitable

4.1 Assigning ranks

For each criterion to make sense in analysis, they each need to be classified in terms of suitability for landfill site. Below is the scheme I used to reclassify my data. A higher rank means a higher suitability.

Table 2 - reclassification scheme

| Category | Criterion | Input | Output (rank) |
|---------------------------|------------------------|---------------------------------|---------------|
| Surface water | | | |
| | Lakes* | Entire raster, with 250m buffer | (placeholder) |
| | Rivers* | Entire raster, with 250m buffer | (placeholder) |
| | Streams* | Entire raster, with 150m buffer | (placeholder) |
| | Wetlands* | Entire raster, with 100m buffer | (placeholder) |
| | Zones of flood risk* | Entire raster, with buffer | (placeholder) |
| Ground water | | | |
| | Aquifer recharge zone* | Entire raster, with 200m buffer | (placeholder) |
| | Karst geology* | Entire raster, with 200m buffer | (placeholder) |
| Land use & infrastructure | | | |
| | Highways | 100m buffer | (placeholder) |
| | | 250m buffer | 10 |
| | | 500m buffer | 8 |
| | | 750m buffer | 6 |
| | | 1000m buffer | 4 |
| | | 2000m buffer | 2 |
| | | 5000m buffer | 1 |
| | Roads | 100m buffer | (placeholder) |
| | | 200m buffer | 10 |
| | | 300m buffer | 8 |
| | | 400m buffer | 6 |
| | | 500m buffer | 4 |

| | | | |
|-----------------------|---------------------------------|----------------------------------|---------------|
| | | 1000m buffer | 2 |
| | Residential and developed areas | 250m buffer | (placeholder) |
| | | 500m buffer | 20 |
| | | 750m buffer | 15 |
| | | 1000m buffer | 10 |
| | | 1500m buffer | 5 |
| | Airports* | Entire raster, with 3000m buffer | (placeholder) |
| | Parks and protected areas* | Entire raster, with 200m buffer | (placeholder) |
| | Railroads* | Entire raster, with 100m buffer | (placeholder) |
| | Power transmission lines* | Entire raster, with 50m buffer | (placeholder) |
| Slope & precipitation | | | |
| | Slope | 0-2 % grade | 40 |
| | | 2-4 % grade | 28 |
| | | 4-6 % grade | 12 |
| | | 6-8 % grade | 5 |
| | | 8-10 % grade | 2 |
| | | Above 10% grade | (placeholder) |
| | Precipitation | 30 inches | 12 |
| | | 31 inches | 10 |
| | | 32 inches | 8 |
| | | 33 inches | 6 |
| | | 34 inches | 4 |
| | | 35 inches | 2 |

The reason that I put placeholder values for some of the criteria is that those criteria describe zones of unsuitability. If I assign values of zero to these criteria, then in the raster calculation the locations of those criteria will be overwritten by ranks greater than zero. However, if I assign a placeholder value to these criteria I can extract them prior to raster calculation and then incorporate them into my analysis afterwards. This way zones of unsuitability are not “lost.” Such criteria are marked with an asterisk (*).

Now I use the “Reclassify” tool to apply this scheme.

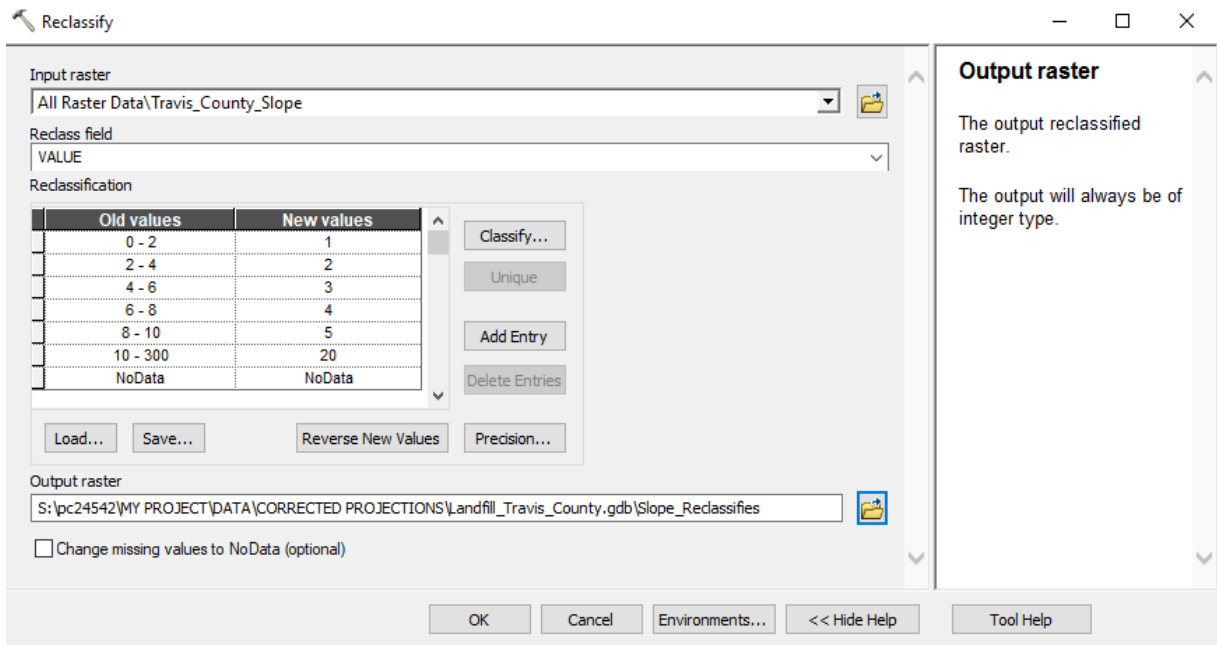


Figure 19 - an example of reclassification using the slope criterion

In reference to Figure 20, the data is now ranked. However, I put in a placeholder value of 20 where the slope is above 10% grade. Locations with this value are unsuitable for a new landfill, so I want to extract these locations from the raster. I use the “Extract by Attribute” tool to separate the raster into one with degrees of suitability and one that is unsuitable.

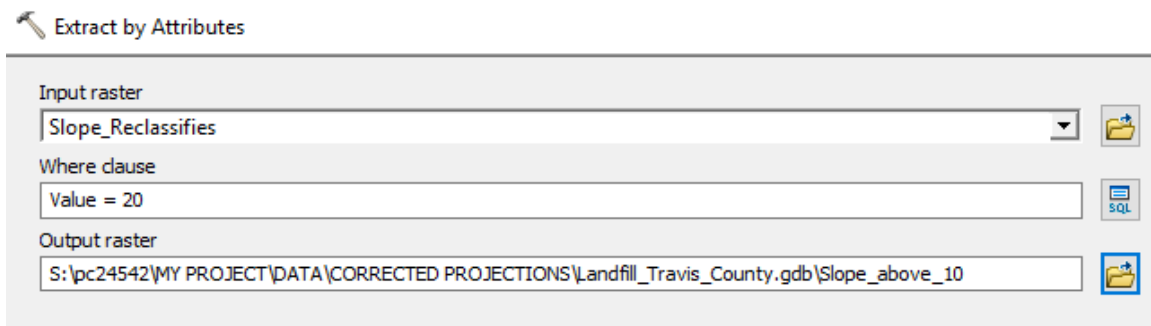


Figure 20 - extracting the raster that shows unsuitability

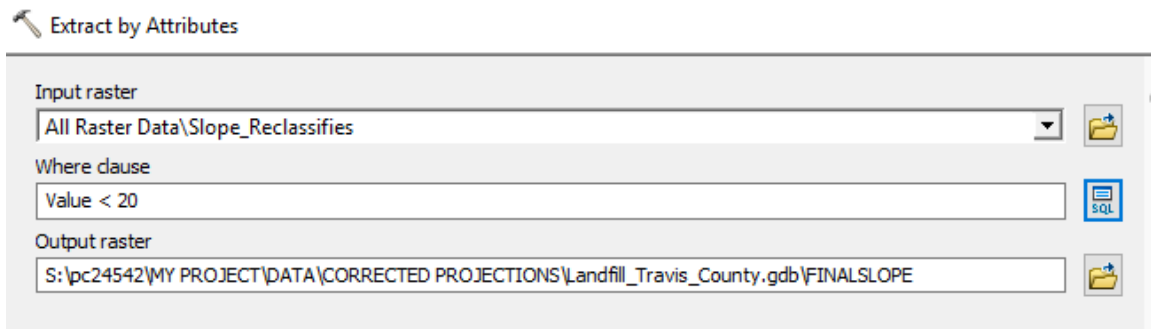


Figure 21 - extracting the raster that has degrees of suitability

4.2 Mosaic to new raster

To facilitate simpler analysis, I combined all of the raster data that tell me where the site is unsuitable. These are the airport, streams, flood risk area, karst geology area, lakes, parks and protected areas, powerlines, railroads, Edwards Aquifer recharge zone, wetlands, and the unsuitable buffers derived from the roads, highways, and residential and urban development raster data.

4.3 Raster calculation/map algebra

I use “Raster Calculator” to add the raster data that conveys degrees of suitability. I add the appropriate layers to each other.

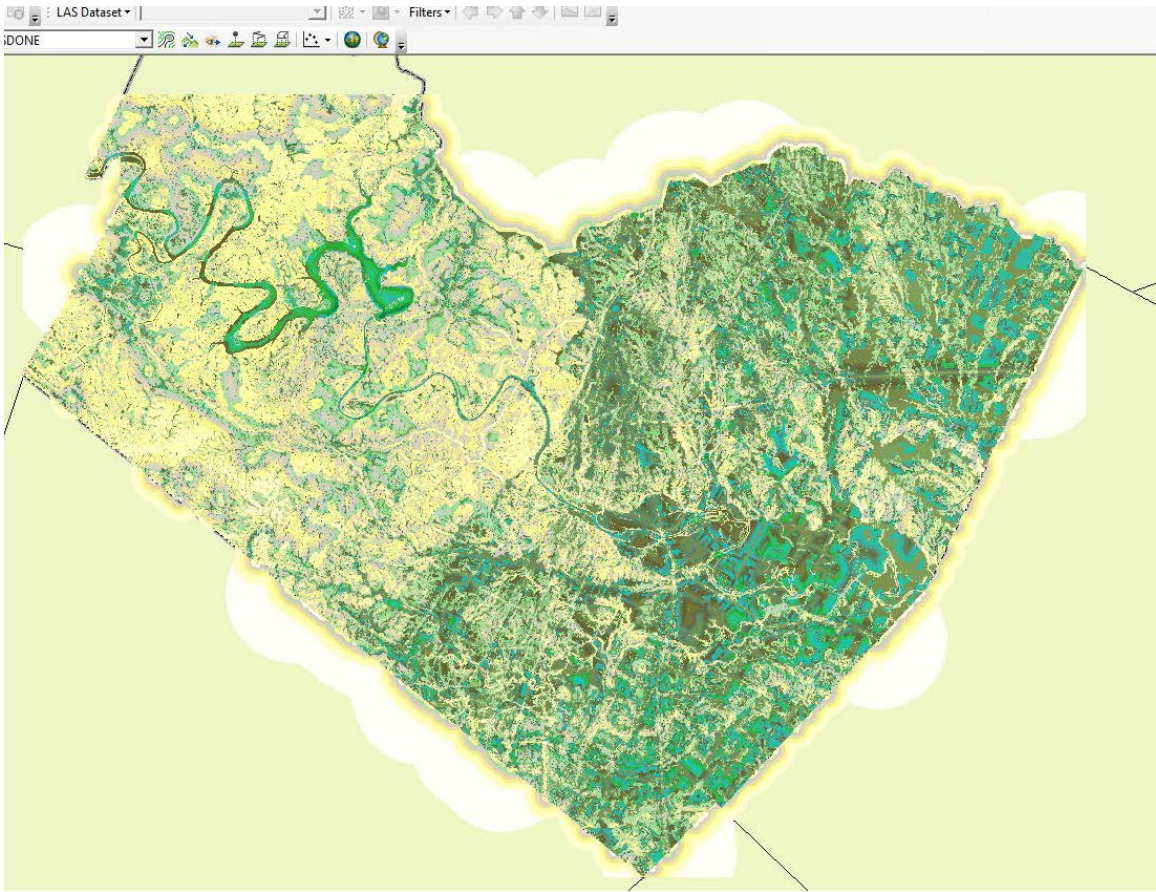


Figure 22 - the result of raster calculation. Values range from 13-90 and represent the added ranks from the scheme described in Table 2.

5. Results

Now I have a raster that describes unsuitability and a raster that describes ranks of suitability. I can throw away where the two intersect to get a raster that describes suitability only where a landfill can be suitable (and not unsuitable.) These are described in the map titled *Site Suitability for New Solid Waste Landfill, Austin, Texas, USA*.

To determine a candidate site, I limited the suitability raster to where suitability had a rank greater than 80 (from a scale of 0-90). To do this I used the tool “Extract by Attributes” I converted this resultant raster to a vector shapefile using “Raster to Polygon.” Then I selected only those sites that were within a 9 miles radius of the center of Austin and did not intersect the unsuitable raster, and exported these sites to a final layer. From there I opened the shapefile’s attribute table and chose the site with the largest area. This site has an area of 24,715 square meters which can be expanded upon field investigation. This site also has no pre-existing landfill. This candidate site is shown in the map titled *Candidate Site for New Solid Waste Landfill, Austin, Texas, USA*.

The final decision of the next landfill site will require further field investigation and acceptance of the public and consideration of who owns the land and the price of the land. However, this study has produced a candidate site that facilitates this investigation.

6. References

These are papers that I used to inform my ArcGIS processing scheme and methodology.

Demesouka, O. E., Vavatsikos, A. P., & Anagnostopoulos, K. P. (2013). Suitability analysis for siting MSW landfills and its multicriteria spatial decision support system: method, implementation and case study. *Waste management*, 33(5), 1190-1206.

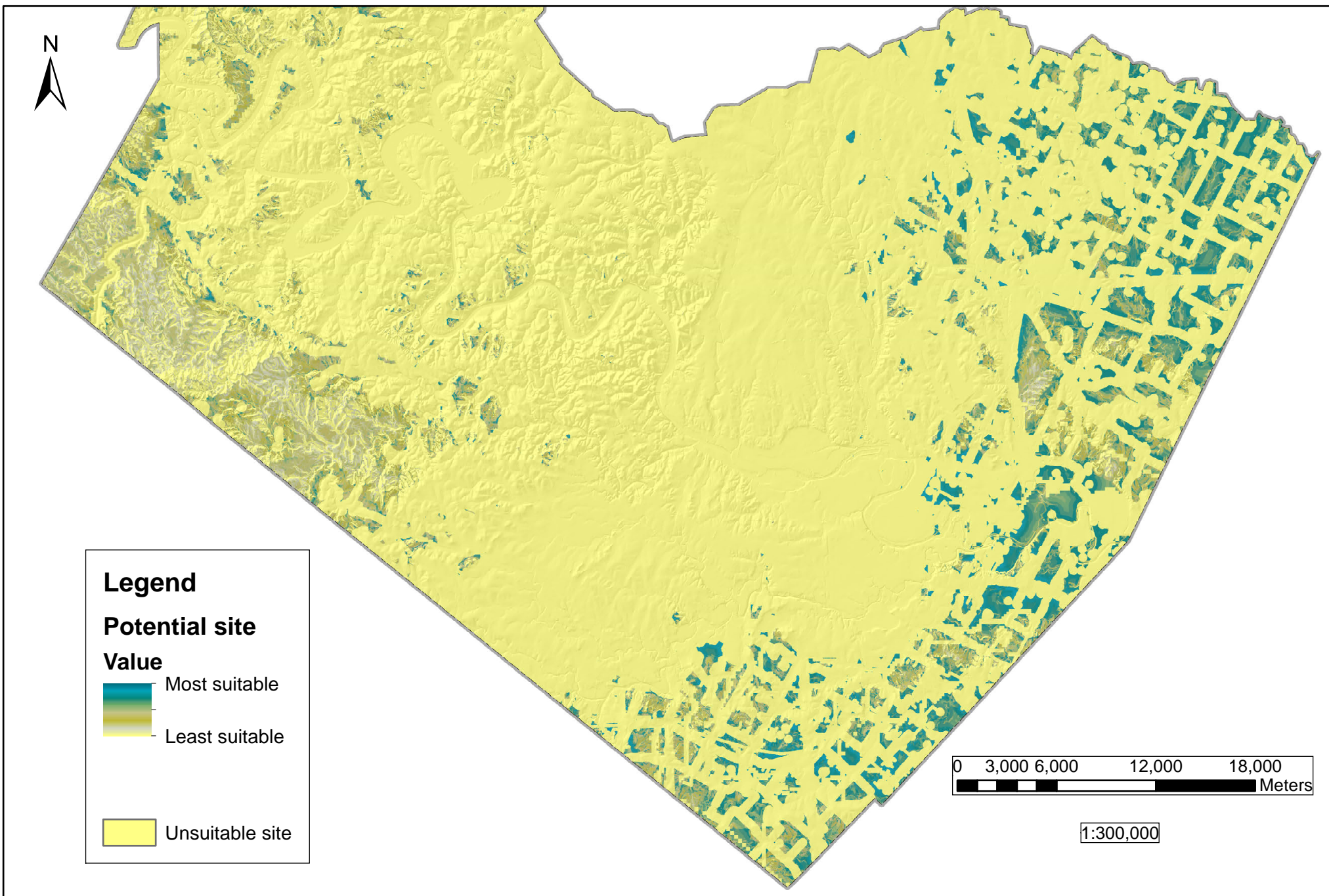
Mat, N. A., Benjamin, A. M., Abdul-Rahman, S., & Wibowo, A. (2016, October). A framework for landfill site selection using geographic information systems and multi criteria decision making technique. In AIP Conference Proceedings (Vol. 1782, No. 1, p. 040011). AIP Publishing.

Vasiljević, T. Z., Srdjević, Z., Bajčetić, R., & Miloradov, M. V. (2012). GIS and the analytic hierarchy process for regional landfill site selection in transitional countries: a case study from Serbia. *Environmental management*, 49(2), 445-458.

Wang, G., Qin, L., Li, G., & Chen, L. (2009). Landfill site selection using spatial information technologies and AHP: a case study in Beijing, China. *Journal of environmental management*, 90(8), 2414-2421.

Title page photo credit: <https://www.austinchronicle.com/news/2019-01-18/austins-least-loved-landfill-may-be-poised-to-grow-again/>

Site Suitability for New Solid Waste Landfill, Travis County, Texas, USA



Candidate Site for New Solid Waste Landfill, Austin, Texas, USA

