Technical Memorandum

Project: Site Analysis of the Town of Gumby's Landfill	
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Subject: GIS Applications – GISC9312	Prepare By: Josh Valenti
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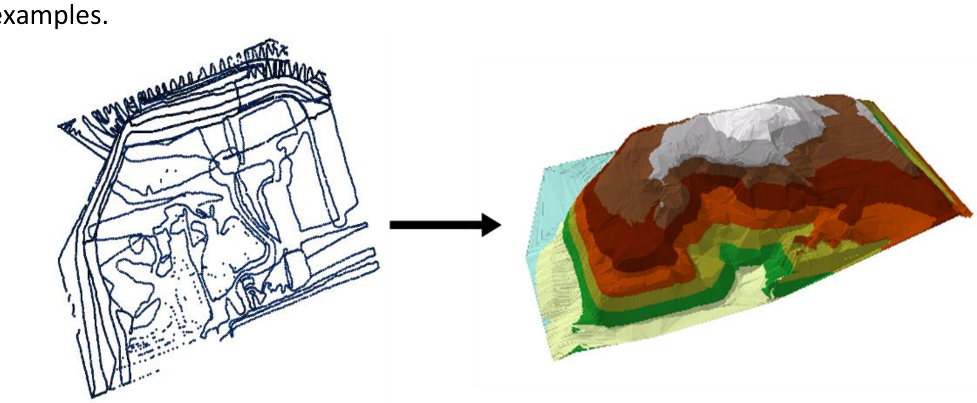
1. Introduction

The Town of Gumby is in need of determining the operational life span of the Gumby Landfill. The Landfill is currently tending to 10,200 homes with an average of 2.5 persons per household (Statistics Canada). The Ontario Ministry of Environment (MOE) has provided the Town of Gumby with a final allowable elevation contour map, which cannot be exceeded. In order to calculate the operational life span of the landfill, it is necessary to undertake a geospatial analysis of the Gumby Landfill. The data set provided by MOE will be analyzed alongside a surveyed dataset, completed by Globomatics Inc. to determine the overall available capacity, along with identifying areas that have exceeded the allowable limit on a $1m^2$ accuracy.

2. Methodology

Surveyed elevation points were collected over 2 days by the Globomatics Inc. surveying team, producing 8,525 points across the Gumby Landfill (Figure 1). These points were then used in production of a Triangulated Irregular Network (TIN) alongside the MOE defined elevation contour data set. A TIN is a vector-based representation of the elevation derived from elevation points or contours, see Figure 1 below for examples.



Elevation points or contours

Triangulated Irregular Network (TIN)

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Figure 1: Elevation data points/contours to TIN

The TINs were then transformed into a raster surface with a cell size of 1m^2. The raster surface drapes a grid over the surface TIN (with a cell size of 1m by 1m), see Figure 2 below for example.

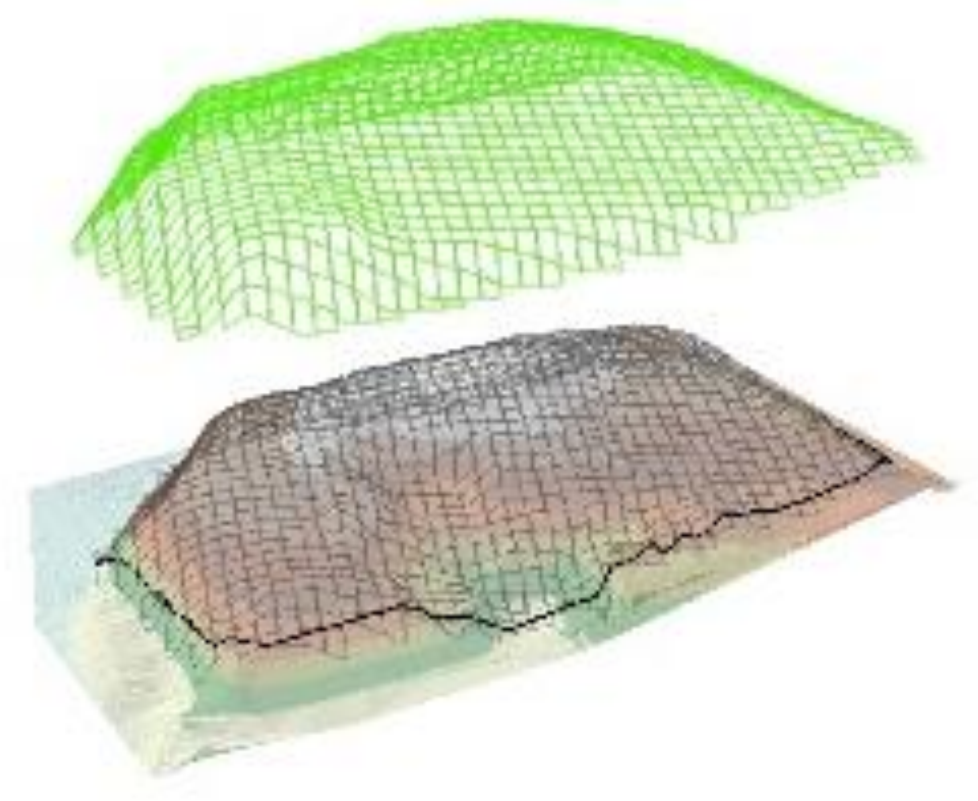

Figure 2: Raster grids overlaid a TIN for visual purposes. These grids are then filled on a cell by cell basis and compared.

These cells are then given a value based on the corresponding elevation calculated by the TIN, creating two raster surfaces. These surfaces were then compared on a cell by cell basis, producing a final raster of Available Volume, see Figure 3 below for an example.

OME Limit

2	3	2	1
2	1	2	2
2	1	1	3
2	2	2	3

-

Existing

2	2	2	1
2	2	1	2
3	1	1	2
3	2	2	2

=

Result

0	0	0	0
0	0	0	0
-1	0	0	1
-1	0	0	1

Figure 3: Simple Raster Calculation example

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The resulting raster layer provides a detailed analysis of the landfill. The positive numbered cells refer to areas that still have available space for further garbage storage. The cells that are negative are areas that have exceeded the MOE limit and proper measures must be done to correct these locations. The cells that have a value of 0 are locations that are equivalent to the MOE limit, and no further storage is available.

The total available volume was then calculated by summarizing the resulting raster layer, subtracting the cells that exceeded the limit (red) from the areas that still contain excess space (blue). Figure 4 below is an example on a 3 cell scale.

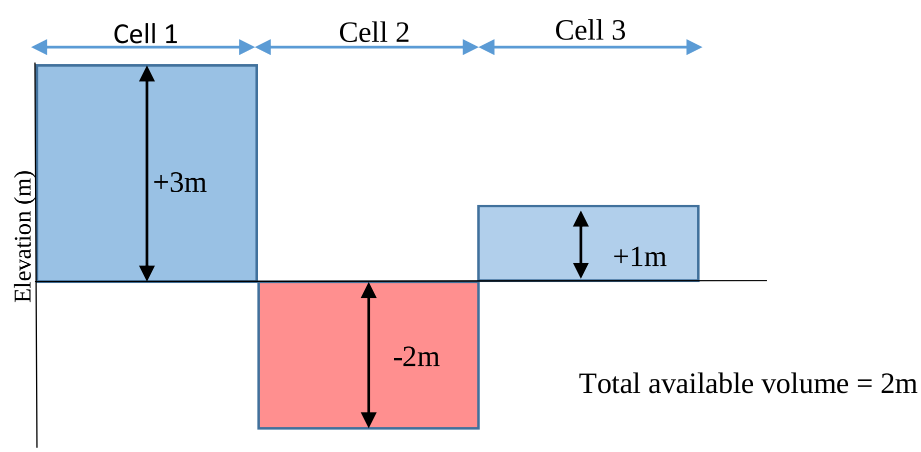

Figure 4 - Cell calculation technique.

3. Results

After processing the two elevation datasets, three maps were produced. Map 1 displays the existing landfill surface, seen below as Figure 5. Map 2 displays the allowed elevation defined by MOE (Figure 6), and the third map (Figure 7) displays the difference in elevation between the two, describing areas that have exceeded and areas that have excess storage space. It was determined that there is 122,423 m^3 of excess space, which can hold up to 73454 tonnes of waste (see Equation 1 below).

Equation 1:

$$Available\ Capacity\ (tonnes) = volume\ (m^3) \times \frac{tonnes}{m^3}$$

$$Available\ Capacity\ (tonnes) = 122{,}423.17\ m^3 \times 0.6 \frac{tonnes}{m^3}$$

$$Available\ Capacity\ (tonnes) = 73453.90\ tonnes$$

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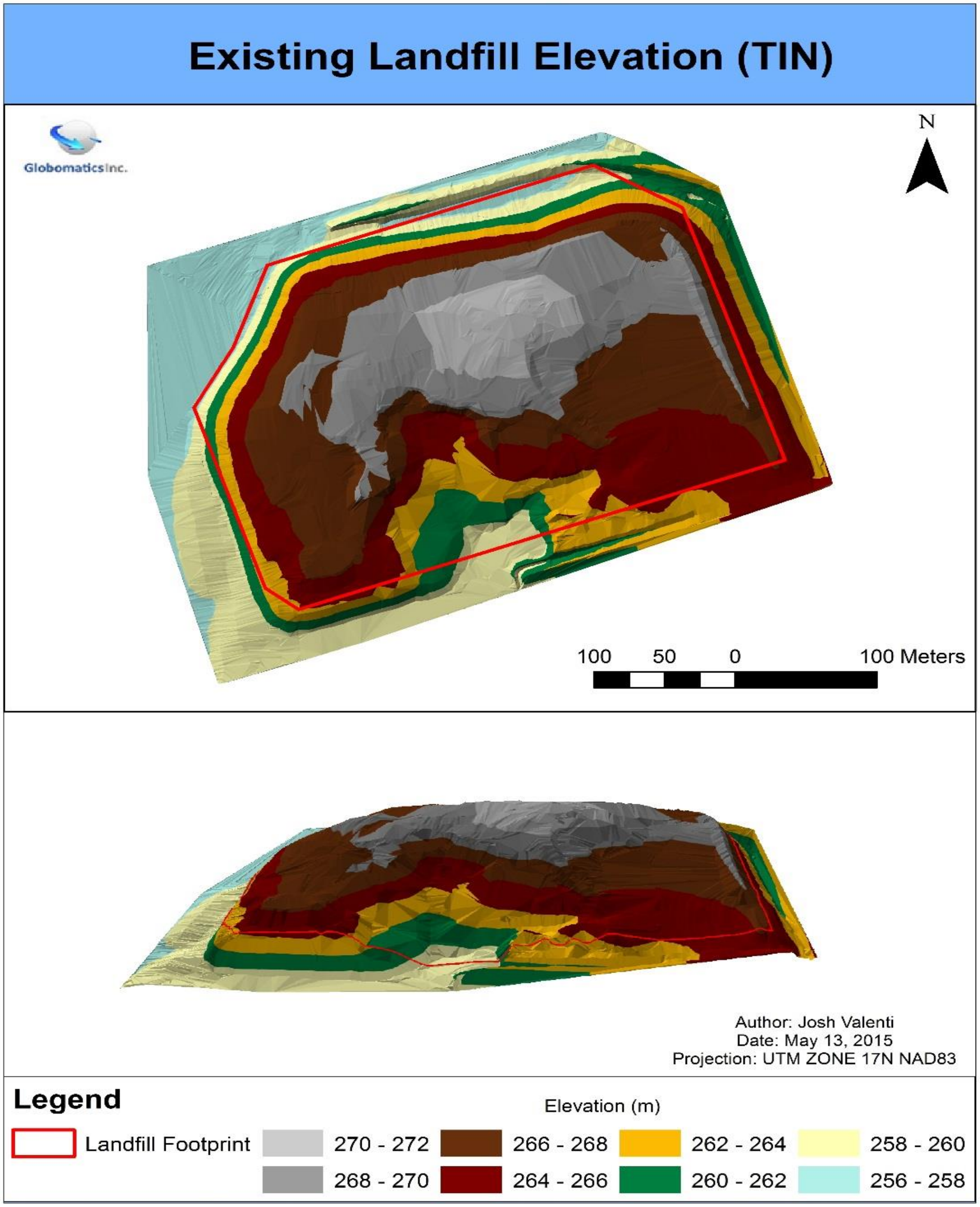

Figure 5 - Existing Landfill Elevation Map

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Map 2 displays the MOE Maximum Landfill Elevation Surface, shown below in Figure 6.

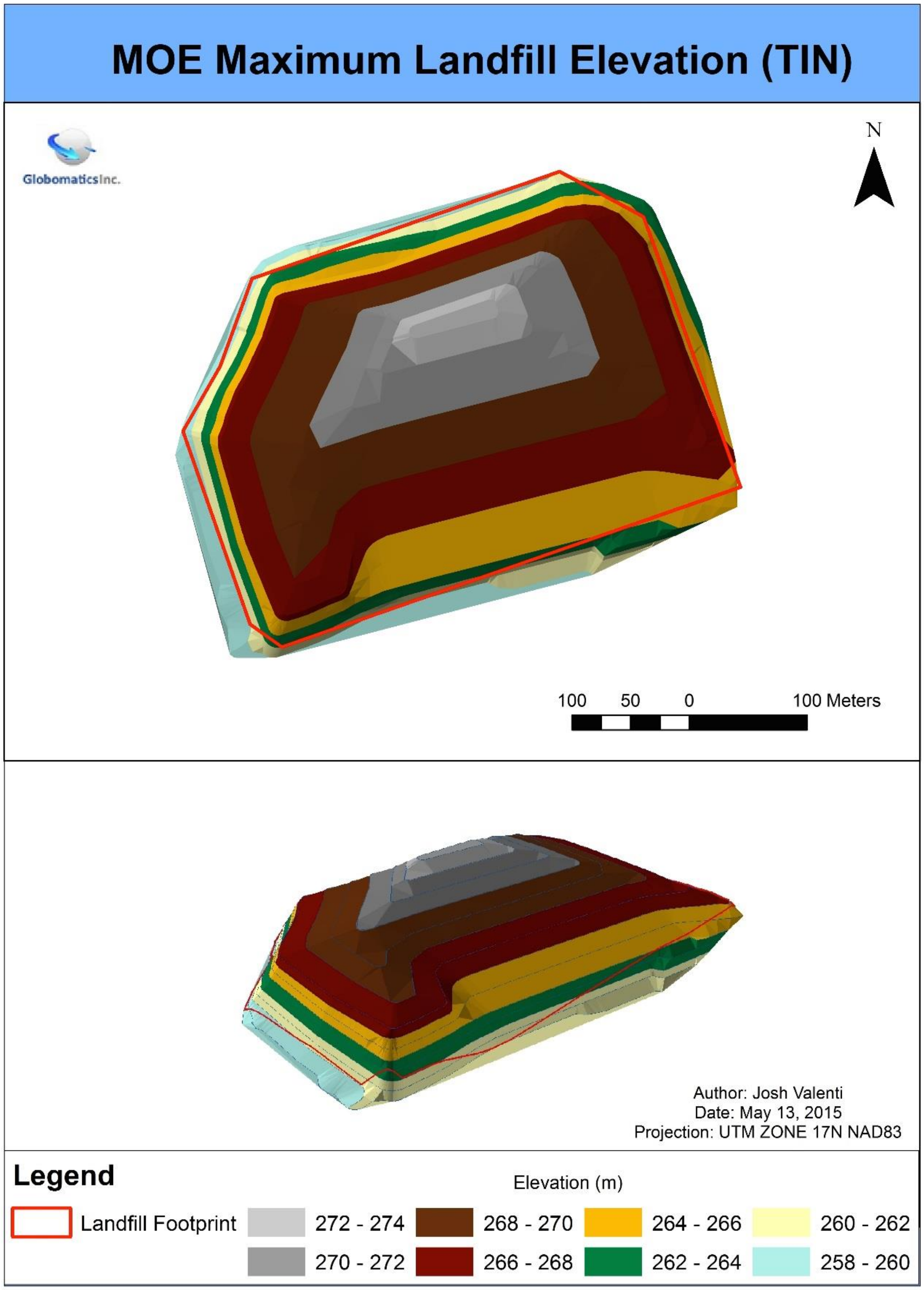

Figure 6 - MOE Maximum Elevation Map

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Map 3 displays the Available Volume left in the Gumby Landfill, see Figure 7 below. The red marks areas that are over capacity and need to be properly attended too. The areas in blue represent areas that have excess volume. The four different views labeled NE, SE, SW, and NW represent the sight line of where the observer is standing (NE = North-east corner, SW = South-west corner, etc.).

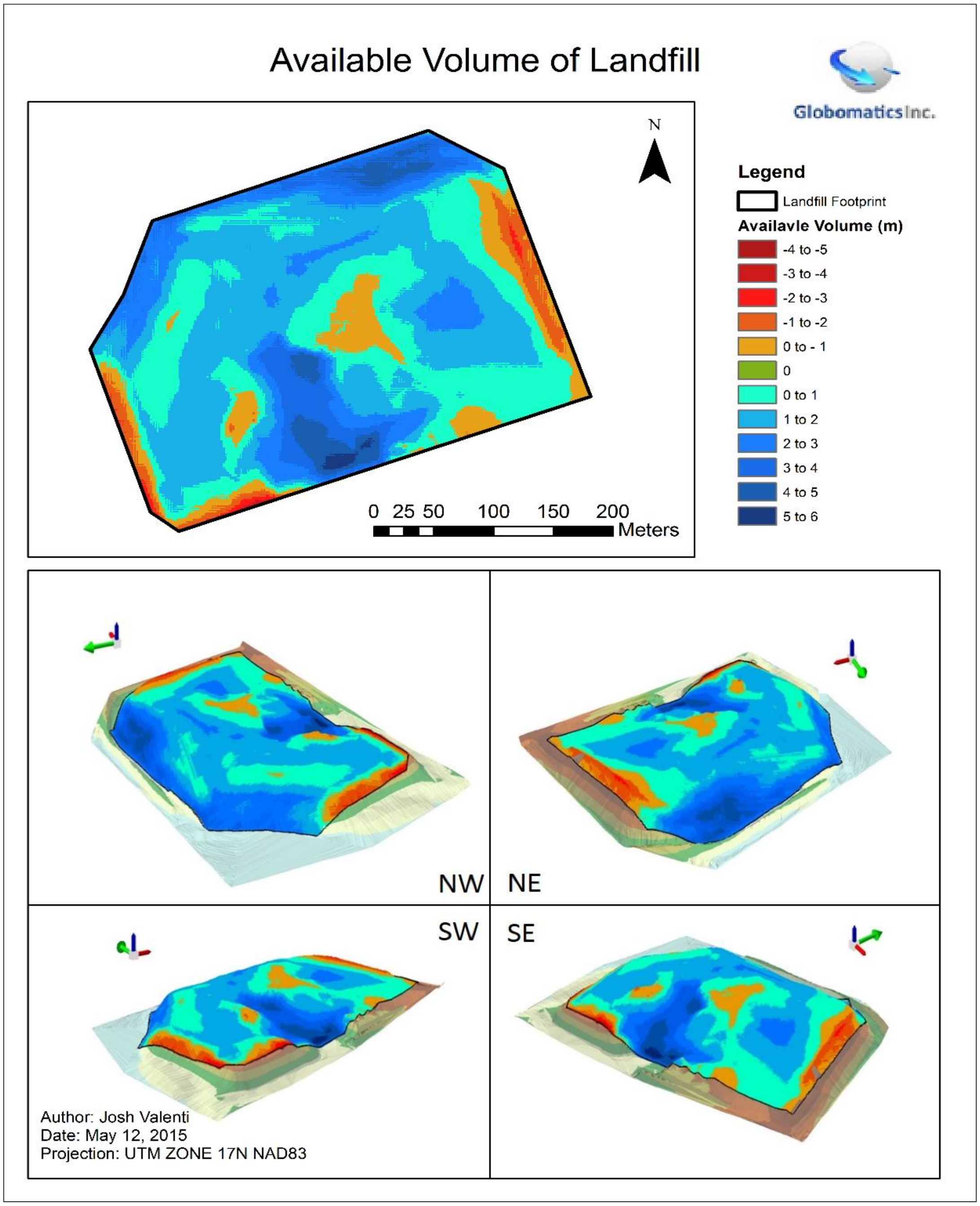

Figure 7 - Available Volume for the Gumby Landfill Map. NW=North-west, NE = North-east, SE = South-east, SW = South-west. Green marker points north.

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4. Discussion

The Town of Gumby consist of 10,200 homes, with an average of 2.5 persons per home. It has been calculated that the waste generation in the Town of Gumby to be 0.31 tonnes/Capita/Year on average for the previous seven years. This is generating an average of 7,905 tonnes per year of waste.

The calculations described above calculated the landfill to have 122,423.1725 m^2 of available space, a capacity for up to 73, 453.90 tonnes of waste. If the Town of Gumby is generating 7,905 tonnes per year, the excess space will be filled by 2022 , as shown below in Figure 8.

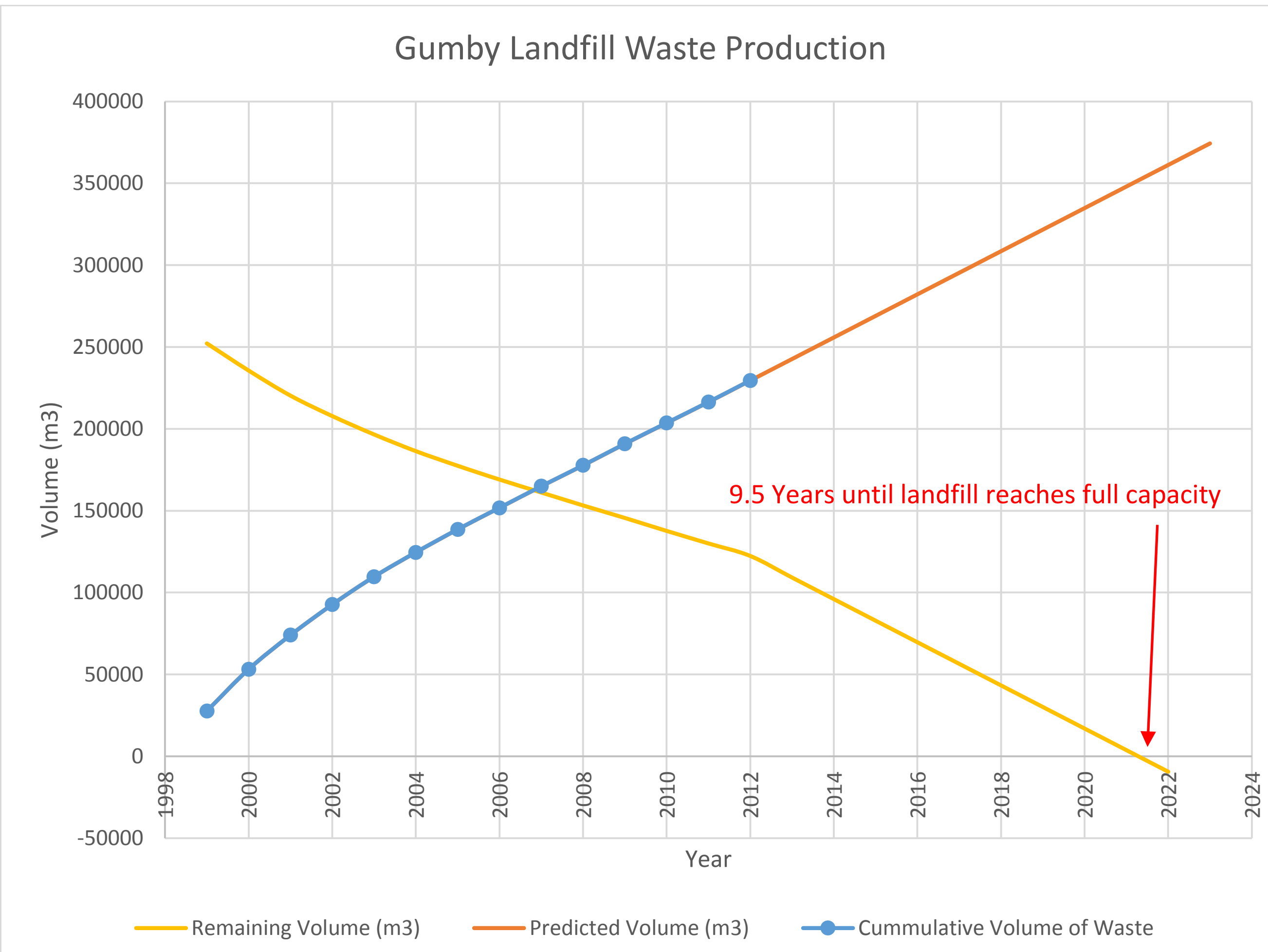

Figure 8 - Change in Waste Generated over Time

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Table 1 below displays the calculated waste generated on a yearly basis using the average generation rate of 0.31 tonnes/Capita/Year. Currently the landfill is at 67% capacity (as of 2015), and the remaining 33% will be filled by 2022 (9.5 years from 2012).

Table 1: Waste Generated by Year, based on 0.31 tonnes/Capita/Year

Year	*Waste Generation Rate (To Landfill) (Tonnes/Capita/Year)*	Waste Generated (Tonnes/Year)	Waste Volume (m3)	Cumulative Volume (m3)	Remaining Volume (m3)
1999	0.65	16575	27625	27625	252218
2000	0.6	15300	25500	53125	235643
2001	0.49	12495	20825	73950	220343
2002	0.44	11220	18700	92650	207848
2003	0.4	10200	17000	109650	196628
2004	0.35	8925	14875	124525	186428
2005	0.33	8415	14025	138550	177503
2006	0.31	7905	13175	151725	169088
2007	0.31	7905	13175	164900	161183
2008	0.3	7650	12750	177650	153278
2009	0.31	7905	13175	190825	145628
2010	0.3	7650	12750	203575	137723
2011	0.3	7650	12750	216325	130073
2012	0.31	7905	13175	229500	122423
2013	0.31	7905	13175	242675	109248
2014	0.31	7905	13175	255850	96073
2015	0.31	7905	13175	269025	82898
2016	0.31	7905	13175	282200	69723
2017	0.31	7905	13175	295375	56548
2018	0.31	7905	13175	308550	43373
2019	0.31	7905	13175	321725	30198

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Year	*Waste Generation Rate (To Landfill) (Tonnes/Capita/Year)*	**Waste Generated (Tonnes/Year)**	**Waste Volume (m3)**	**Cumulative Volume (m3)**	**Remaining Volume (m3)**
2020	0.31	7905	13175	334900	17023
2021	0.31	7905	13175	348075	3848
2022	0.31	7905	13175	361250	-9327

5. Recommendations

The Town of Gumby's landfill is quickly filling to capacity. If the population and compaction rates do not vary, the landfill will reach MOE's maximum allowable elevation in 9.5 years (2022). Globomatics Inc. has determined that a variety of areas (southwest/northeast edges and centre peak) have exceeded these limits and proper mitigation strategies must be done to remove the excess waste down to MOE requirements and relocate to areas that have available capacity (north end of landfill).

Globomatics Inc. recommends continuing tracking of the annual waste production, population growth and waste compaction rates, as all are variables that can alter the operational life span that is calculated to reach capacity and end operations by 2022.

6. Bibliography

Smith, Ian. *Raster Based Analysis of Terrain Surfaces.* Terms of Reference, St. Catharines: Niagara College, 2015.

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