The highground: exploring landfill surface contouring for enhanced aesthetics in Southern California

by

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A REPORT

submitted in partial fulfillment of the requirements for the degree

MASTER OF LANDSCAPE ARCHITECTURE

Department of Landscape Architecture/Regional and Community Planning
College of Architecture, Planning and Design

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Approved by:

Major Professor
Howard Hahn

Abstract

Daily waste production in the United States has steadily increased and follows population growth, especially in metropolitan areas and populated states. Since landfill permitting is typically a long and potentially controversial process, the trend is toward fewer but larger landfills. As a result, landfills near urban areas can be massive and are potentially seen by hundreds of thousands of people daily. Views of refuse being deposited is generally minimal, but as soil cover is incrementally added, the overall emerging landform is often visually incompatible with the surrounding topography. Many landfills tend to be geometrically shaped with angular faces, sharp corners, and mesa-like tops resulting in a flat ridgeline silhouette which can be recognized from great distances. Visual disruptions related to landfill operations can last for decades, and views after closure/restoration are permanent.

This project and report explore to what degree landfills can be aesthetically contoured to more closely replicate contextual topography while maintaining high overall fill capacity. The study site is the Puente Hills landfill located in the urbanized Los Angeles basin. Additionally, 43 other landfills in Los Angeles County were inventoried to analyze geometric form and visual quality. From this group, three candidate landfills were selected for in-depth cross-sectional analysis. Extensive 3D modeling, using both manual and parametric methods, was then performed on the Puente Hills landfill to test various aesthetic “sculpting” scenarios. Corresponding volume capacity gains/losses were compared between enhanced landfill options and a landfill of standard configuration serving as the control. Findings attempt to show that enhanced landfill contouring is possible within acceptable engineering practices which could lead to easier landfill permitting by reducing visual impacts to the viewing public. This project and report also demonstrate how landscape architects can influence the aesthetic integrity of large landscapes that typically fall within the domain of civil engineers.

THE
HIGHGROUND

Exploring Landfill Surface Contouring for Enhanced Aesthetics

2020 SPRING

landfill · CA · contour · terrain · surface

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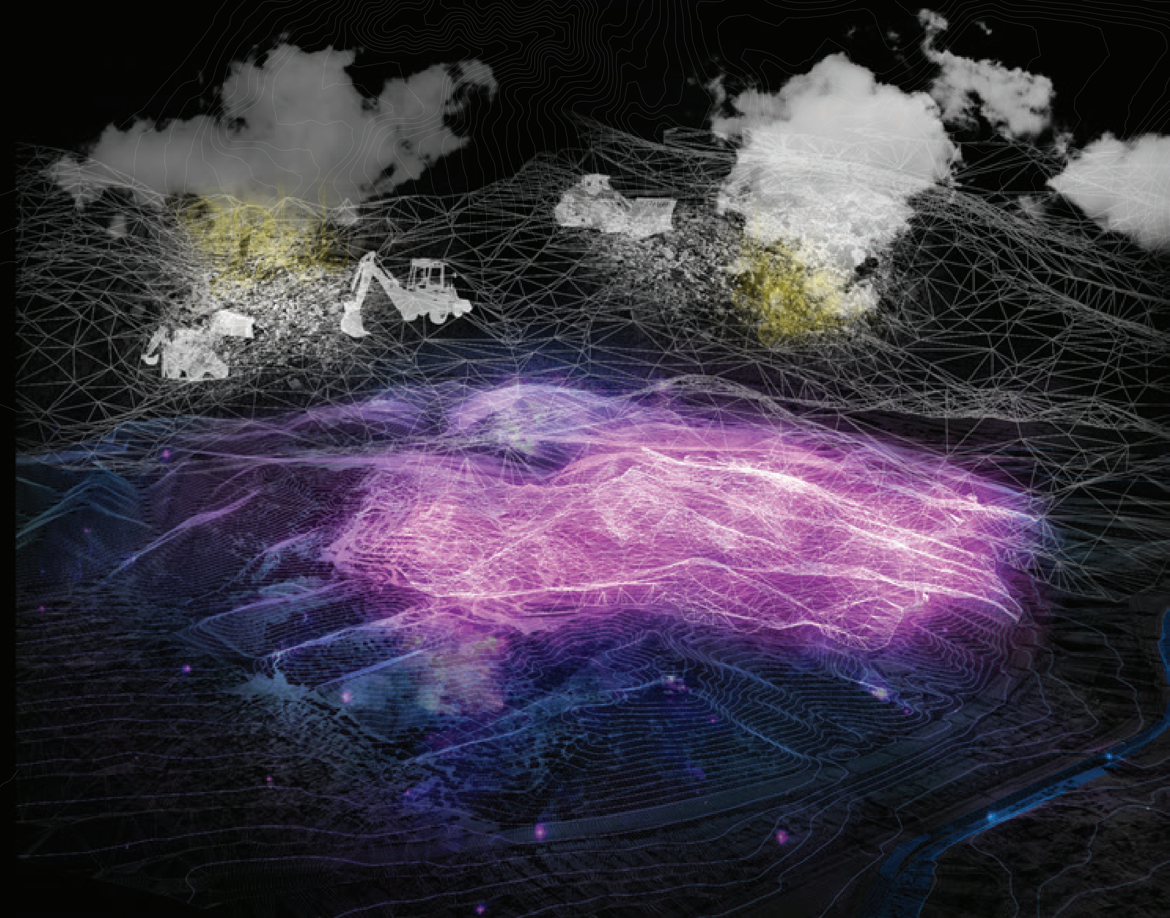

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[311] Zhong, Yingyi. Visibility Analysis of proposed landfill surface 2018 viewing from Community South El Monte. Diagram. 2020.
[312] Zhong, Yingyi. Visibility Analysis of proposed landfill surface G1 viewing from Community South El Monte. Diagram. 2020.
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[317] Zhong, Yingyi. Visibility Analysis of proposed landfill surface P1 viewing from Community South El Monte. Diagram. 2020.
[318] Zhong, Yingyi. Visibility Analysis of proposed landfill surface P4 viewing from Community South El Monte. Diagram. 2020.
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[324] Zhong, Yingyi. Visibility Analysis of proposed landfill surface A2 viewing from Community Avocado Heights. Diagram. 2020.
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[335] Zhong, Yingyi. Visibility Analysis of proposed landfill surface P1 viewing from Community Hacienda Heights. Diagram. 2020.
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[350] Zhong, Yingyi. #2 W-E Cross-section of all analyzed surfaces. Diagram. 2020.
[351] Zhong, Yingyi. #3 W-E Cross-section of all analyzed surfaces. Diagram. 2020.
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[357] Zhong, Yingyi. 2018 Slope Gradient. Diagram. 2020.
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[360] Zhong, Yingyi. A1 Slope Gradient. Diagram. 2020.
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[365] Zhong, Yingyi. P7 Slope Gradient. Diagram. 2020.
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[369] Zhong, Yingyi. A1 Slope Aspect. Diagram. 2020.
[370] Zhong, Yingyi. A2 Slope Aspect. Diagram. 2020.
[371] Zhong, Yingyi. A3 Slope Aspect. Diagram. 2020.
[372] Zhong, Yingyi. P1 Slope Aspect. Diagram. 2020.
[373] Zhong, Yingyi. P4 Slope Aspect. Diagram. 2020.
[374] Zhong, Yingyi. P7 Slope Aspect. Diagram. 2020.

CHAPTER 6

[375] Google Earth Pro. Aerial view of Sunshine Canyon City Landfill, County of Los Angeles, CA. Photograph. 2019.
[376] Zhong, Yingyi. Future Research Diagram. Diagram. 2020.

APPENDICES

[377] Google Earth Pro. Aerial view of Antelope Valley Public Landfill, County of Los Angeles, CA. Photograph. 2019.
[378] Zhong, Yingyi. Inventoried landfill list. Excel Chart. 2020.
[379] Zhong, Yingyi. Grasshopper parametric surface script. Rhino with Grasshopper. 2020.

CHAPTER 1

INTRODUCTION

[0] Aerial view of Puente Hills Landfill, County of Los Angeles, CA (Google Earth Pro 2019).

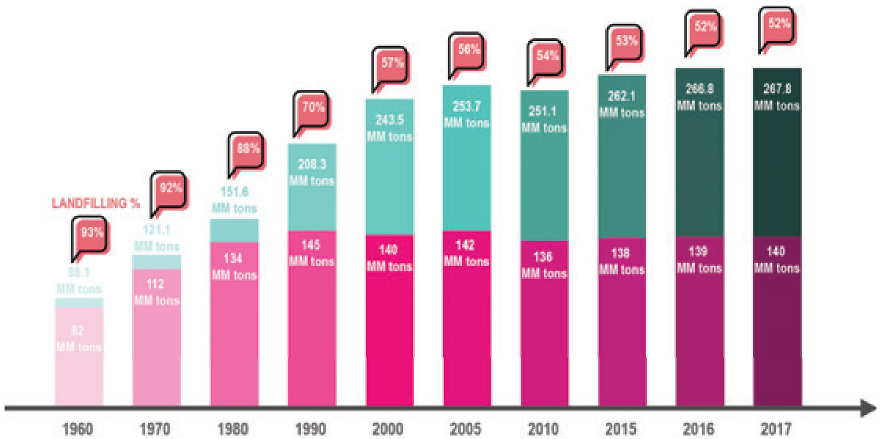
1.1 Background and Research Question

Advanced societies generate enormous industrial, hazardous and municipal waste. Of these three categories, municipal waste is the largest by volume. Disposal sites are typically located close to urban areas to reduce transport and overall costs for consumers. Hence, because of the costly and protracted permitting process, the trend is toward fewer but larger landfill sites (EPA 2015). Also, due to the necessity of covering deposited and compacted refuse with soil on a daily basis, the general public does not see exposed refuse, but over time the emergence of a large landform can be visually dominating and disruptive since the shape often contrasts with the surrounding topographic context. The forms of these large landfills are typically geometric and are defined by simplified angled sides, sharp corners, and a relatively flat top that appears like a mesa. Depending on atmospheric conditions, large landfills can be seen and easily recognized due to the high finished elevation (LASCD 2001).

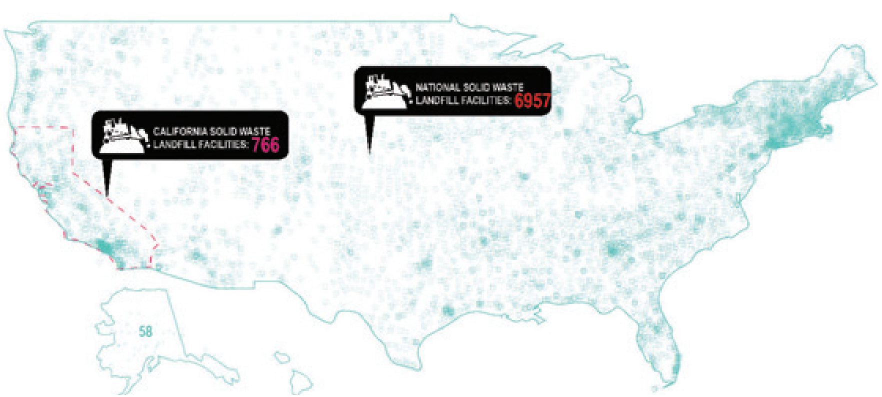
During the permitting process, all aspects of the landfill are evaluated as part of the extensive Environmental Impact Report (EIR) process. Typically, the public is most concerned about potential groundwater contamination by leaching, but a full range of other potential concerns including aesthetics are also studied and addressed through mitigation measures. Landscape architects are sometimes called upon to conduct aesthetic assessments which typically include computerized visibility mapping, impact assessment evaluation using standardized protocols, preparing visual simulations from surrounding sensitive viewpoints, and recommending visual mitigations options which address color and texture impacts associated with revegetation during on-going slope reclamation.

Typically, the footprint and overall shape of the landfill is determined by civil engineers and geotechnical consultants. There are many operational and technical issues to consider: site location, geotechnical stability, soil and geologic factors, excavation and liner systems, methane gas extraction systems, overall landfill shape and capacity projections, borrow fill excavation and cycling for fill cover, compaction requirements, side slope angle/stability, erosion control systems, surface revegetation, surface drainage intercept and routing systems, transverse roads leading up landfill slopes to the upper working deck for use by refuse and earthmoving vehicles, fencing and screening, and providing ancillary facilities. Assuming that groundwater is adequately protected, fencing stops windblown debris, and odors are eliminated, it is the visual appearance of a massive landfill from a range of distances that affects most people.

To improve landfill aesthetics, this research will seek to answer the question: *"How can landfill slopes be better designed to enhance and better blend with surrounding topography and be less visually objectionable?"*



[1] Municipal Solid Waste (MSL) Landfilling Tonnages Percentage: 1960-2017 (Zhong 2019).



[2] Solid Waste Landfill Facilities in the United States: Numbers and Density (Zhong 2019).

1.2 Accumulating Waste

Daily waste production in the United States has increased steadily and follows population growth, especially in metropolitan areas and populated states. According to the Environmental Protection Agency (EPA), approximately 262.4 million tons of municipal solid waste (MSW) was produced in the United States in 2014, and 52.5% of the municipal solid waste was projected to end up in landfills (EPA 2017).

As the oldest form of disposal waste, landfilling has been practiced globally for centuries (Zhang & Klenosky 2016). Considered "out of sight, out of mind", a large amount of MSW can be handled efficiently and cost effectively through landfills. Although the number of existing landfills has decreased due to permitting challenges, the average MSW landfill size has increased (EPA 2014). Also, as many landfills approach closure, it is easier to expand new phases instead of searching for new locations.

[3] Open Landfill in South Tangerang, Indonesia (Fisk 2019)

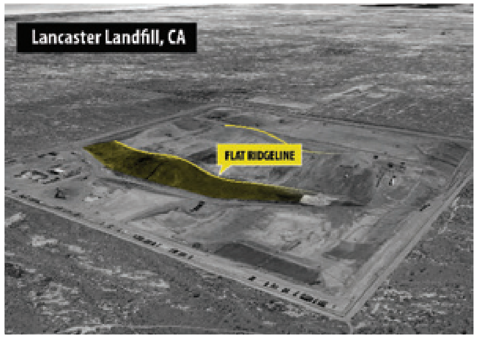
[4] MSL Sanitary Landfill with soil as daily cover material: Salina City Landfill, Salina, KS (Zhong 2019).

“Open Dump” might still be the first image that enters the public’s mindset concerning landfills; however, large open expanses of refuse are considered illegal under the RCRA (Resource Conservation and Recovery Act) and these conditions are rarely seen in the United States today (EPA 2014; Townsend et al. 2015; NWRA 2017). Modern landfills are highly engineered, sustainable and can create significant economic benefits in terms of jobs and tax revenue for the local government and communities (EPA 2014; NWRA 2017). However, as “locally unwanted land uses (LULUs)” persist or remain for a long time, it is hard to change the stigma of landfills in different aspects all at once (Armour and Okeke 1999; Sánchez-Arias et al. 2019).

Thanks to the efforts of environmental engineers, biologists and other professionals, considerable studies have been directed toward the environmental and social issues of landfills. Landscape architects view landfill aesthetics as important as biological and cultural/historic resources (ASLA 2007). Thus, landscape architects should look for opportunities to enhance landfill aesthetics during landfill design stages.

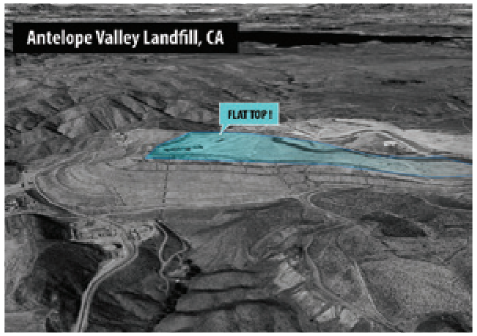
1.3 Landfill Visibility and Appearance

Due to the necessity of daily covering deposited and compacted refuse with soil, the general public mostly sees the emergence of a large landform. Often this landform is fairly geometric with a mesa-like silhouette and can be seen for miles by potentially tens or hundreds of thousands of people, and in some cases, millions of people. Visual disruptions related to landfill operations can last for decades, and views of the landfill after closure/restoration are permanent. A landfill can usually be recognized as an artificial landform that is fairly geometric with a flat top /ridgeline, sharp corners, and angled sides.

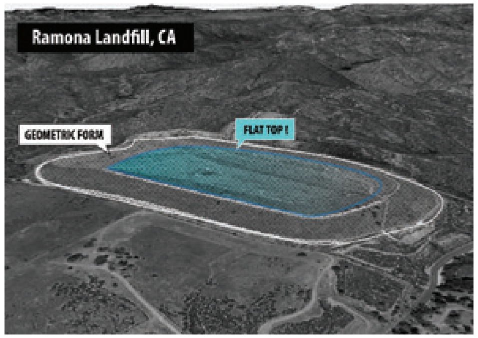


[5] Landfill configuration: Lancaster Landfill, CA (Zhong 2019).

[6] Landfill configuration: El Sobrante Landfill, CA (Zhong 2019).



[7] Landfill configuration: Antelope Valley Landfill, CA (Zhong 2019).



[8] Landfill configuration: Ramona Landfill, CA (Zhong 2019).

1.4 Public Acceptance and Regulation

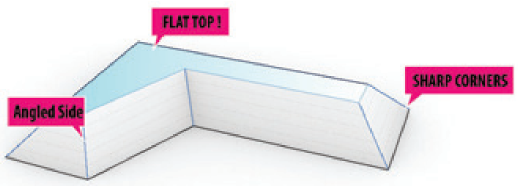
Past news, reports and literature have revealed that local residents do not like having a landfill in their community. Research identifies public opposition as being rooted in the belief that residents think that the cost of having a landfill will exceed the benefits it brings to the community (Simsek et al. 2014; Zhang and Klenosky 2016; Lober and Green 1994). In addition, public opposition to a landfill is always strongest at the siting phase and decreases significantly once the landfill is permitted and operated (Okeke, 2000).

Research has shown that the public is most concerned with the environmental and economic impacts associated with landfills (Okeke 2000; Simsek et al. 2014); yet, not many studies are dedicated to landfill aesthetics. However, aesthetic concerns are to be considered as stipulated by the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA). Furthermore, research conducted by Zhang and Klenosky, and others reveals that having views of a disposal facility will increase residents' stress and anxiety level (Government of California 2016; Simsek et al. 2016, 2; Zhang and Klenosky 2016). Simis and his colleagues observed that the public perceives that having a better living environment with a scenic view and sufficient green space will significantly improve their quality of life (Simis et al. 2016).

1.5 Need for Higher Aesthetics

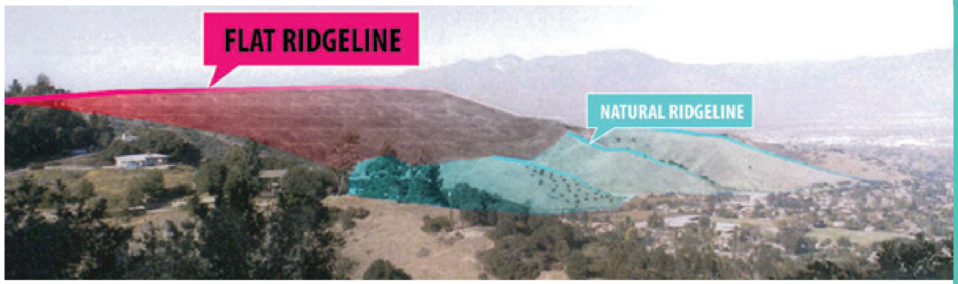
Despite the decrease in the number of MSWLFs, growing municipal solid waste requires the continuous practice of landfilling and the scale of landfills is only getting more massive due to the difficulty of obtaining a landfill permit (EPA 2016). It is easier and less expensive to permit a singular large landfill than multiple smaller ones. Unfortunately, views of massive man-made “mountains” with mesa-like tops become more visible over time as landfilling proceeds. The unnatural landfill appearance continues to be a visual intrusion within the surrounding context, constantly reminding people of the undesirable “landmark” in the community.

Typography/landform is considered an essential part of landscape character. Even more, it is the first thing that people will notice from a wide range of viewing distances, which significantly establishes an overall visual impression of a landscape or place (USDA 1995). Geometric dimensions of a landfill are carefully designed by engineers in order to maximize the landfill volume without increasing the footprint size. In addition, considering the level of difficulty in construction and daily operation, **a simpler and more geometric shape** is preferable from an operational and cost perspective. (Qian and Koerner 2009).



[9] Standard Landfill Configuration (Zhong 2019).

As evidenced through precedent examples, many landfills have **uniformly angled slopes, sharp corners, and a mesa-like ridgeline profile silhouette** that persists through decades of filling operations and concludes with a fairly flat cap at closure. Large landfills can be hundreds of feet high, and the overall form is not compatible with the surrounding context of undisturbed topography.



[10] Visual Stimulation of Puente Hills 2003 Proposed Landfill Plan: View of E. Edgeridge Dr. (Zhong 2019).

Apart from form, color and textures of reclaimed slopes (typically grass) also visually contrast with the contextual landform supporting trees and shrubs. These visual impacts persist throughout decades of landfill operation and exist in perpetuity after the landfill closes. In highly urban areas like Southern California, hundreds of thousands of people may view landfills that contrast with the mountainous background.

Besides being an image problem to surrounding neighborhoods, it has been proved that having views of a landfill can increase nearby residents’ stress and anxiety (Zhang & Klenosky 2016). Even worst, visual disruptions related to landfill operations can last for decades or longer since views of the landfill after closure/restoration are permanent. Thus, visual impacts posed by landfills can be significant and solutions should be pursued to lessen the impacts.

1.6 Project Overview and Objectives

The ultimate goal of this Master's Project and Report is to answer the research question: "*How can landfill slopes be better designed and constructed to blend with surrounding topography and be less visually objectionable*?" The report first provides an overview of how landfills operate according to underlying design principles, followed by typical visual assessment methods. Next, a comprehensive landfill inventory was undertaken to analyze landfill geometrics and select a case study landfill for exploring new landform contouring methods intended to make landfill design appear more natural yet retain fill volume requirements. It is hoped that this project will be of interest to engineers and others involved with landfills to elevate the "state of the art" relative to aesthetics.

The report is broken down into six major chapters. Chapter 1: Introduction, establishes the research need. Chapter 2: Background, provides a general knowledge base about landfill design for uninformed readers in order to support the precedent study and projective design. Chapter 3: Methodology, presents two methodologies used to establish a precedent study and projective design. Chapter 4: The Findings, communicates the results of the precedent study. Chapter 5: The Design, explores enhanced contouring techniques through both manual and automated projective design to improve landform aesthetics. The final chapter, Chapter 6: Conclusion, indicates future research and how results of this project could be applied to "real-world" landfill design.

1.7 Relevance to Contemporary Landscape Architecture

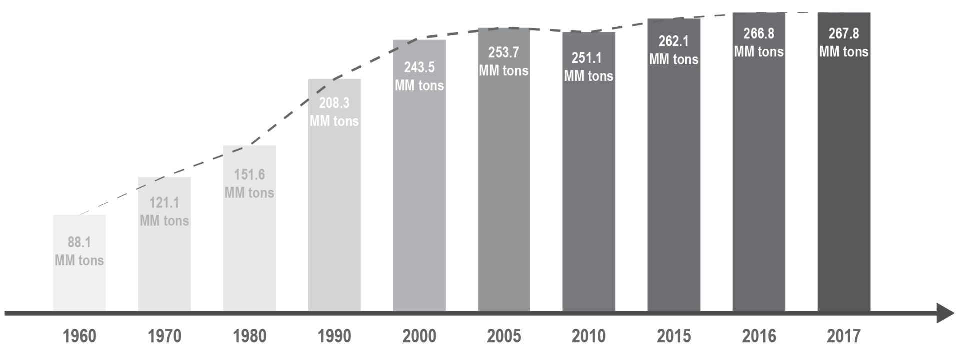
Landfill reclamation has always been a heated topic and landform "sculpting" falls within the practice domain of landscape architecture. Many well-known projects, for example, Fresh Kills Park, have demonstrated the important role of involving landscape architects in the post-closure design of landfills. However, more can be done, not only in the post-closure phase, but in the early stages of landfill design that will truly reduce the negative visual impact of landfills. In this way, we will embrace a future of cross-disciplinary practice that will accumulate knowledge from landscape architects, civil engineers, engineering geologists, historians, hydrologists, biologists and other professionals. Consequently, it would generate a new way of thinking and ensure we provide unique design solutions to modern urban problems.

Landfills as an urban and contemporary issue have been studied by different disciplines. Meanwhile, what landscape architects can do should not be limited to the design of landfills' post-closure use or selecting plant materials for reclamation. The unique part of landscape architecture is that it oversees the whole design and planning process as well as the ability to work across disciplines. This project further recognizes the importance of environmental and geotechnical engineering and planning, while integrating knowledge learned from different disciplines, as well as applying them to new contexts. It also generates knowledge based on the literature. As an explorative study on using landfill contouring to enhance landfill aesthetics, this research will demonstrate how landscape architects working across boundaries might provide valuable ideas on landfill contouring.

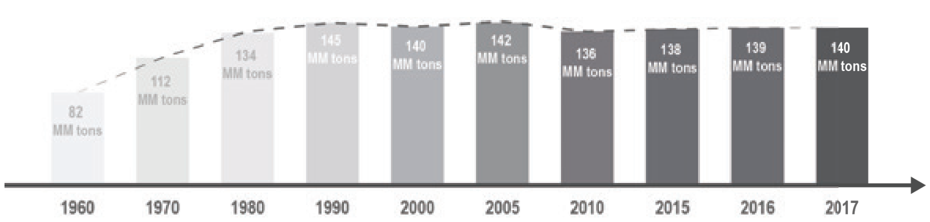
CHAPTER 2
BACKGROUND

[11] Aerial view of Palos Verdes Landfill, County of Los Angeles, CA (Google Earth Pro 2019).

[12] Municipal Solid Waste (MSL) Generation Tonnages: 1960-2017, Data comes from EPA (Zhong 2019).



[13] Municipal Solid Waste (MSL) Landfilling Tonnages: 1960-2017, Data comes from EPA (Zhong 2019).



2.1 Current Trends in Municipal Solid Waste Landfills

There were 262.4 million tons of municipal solid waste (MSW) produced in the United States in 2014, which means each U.S citizen produced 4.48 pounds of MSW per day on average (EPA 2017). The overall amount of trash is increasing every year, among which, 52.5% of the MSW was sent to municipal solid waste landfills (EPA 2017). The EPA defines an MSW landfill as: "An MSW landfill refers to an area of land or an excavation where MSW is placed for permanent disposal (EPA 2014, 2-8)." There are also other types of landfills that are intended to deal with different types of waste, including industrial waste landfills and hazardous waste landfills (EPA 2016; Qian et al. 2001). In this research, I am focusing on municipal waste landfills as they are less toxic and are the most common type of landfill (Qian et al. 2001).

Landfills have been considered "not in my backyard (NIMBY)" and "locally unwanted land uses (LULUs)" for a long period of time (Armour and Okeke 1999; Simsek et al. 2014). Public opposition, restrictive environmental regulations, protracted permitting, and higher operational fees all lead to larger and more remote landfills (EPA 2014; O'Brien 2006). Consequently, there were only 1,900 MSWLFs in 2019, which is a significant decrease from 7,900 MSWLFs in 1988 (EPA 2014). In addition, privately-owned landfills have become another trend as private companies own a significant number of landfills and are able to offer a lower waste disposal fee and generate more profits (EPA 2015; O'Brien 2006).

2.2 Landfill Characteristics

2.2.1 Landfill Types, Permitting, and Location

The EPA defines a Municipal Solid Waste Landfill (MSWLF) as "a discrete area of land or an excavation that receives household waste (EPA 2016)." There are also other types of landfills that are intended to deal with different types of waste, including Industrial Waste landfills and Hazardous Waste landfills (EPA 2016; Qian et al. 2001). The focus of this research is on municipal waste landfills which are less toxic, and represent the most common type of landfill (Qian et al. 2001).

A prospective landfill operator can only construct a landfill after a full solid waste facility permit is obtained (CalRecycle 2020; EPA 2015). In the State of California, a prospective operator must:

1. Comply with all the required federal or equivalent state regulations (EPA 2015; Government of California 2016) consisting of

    Federal Law: Subtitle D of RCRA under Title 40 of the Code of

    State Laws (California): 23 CCR 2908, 27 CCR 20005 to 22278, and 27 CCR 23001 to 23014 (Government of California 2016)

2. In the State of California, permit applicants must comply with all the requirements of the Application Submittal Checklist aka "Laundry List" posted on the CalRecycle Website and provide some examples like completing different maintenance plans, monitoring plans, etc. (CalRecycle 2019; CalRecycle 2020).

During preparation of the landfill permit, the applicant must comply with any location restrictions required by federal regulations related to airports, floodplains, wetlands, fault areas, seismic impact zones and unstable areas (Bagchi 2004; EPA 2015; Qian et al. 2001).

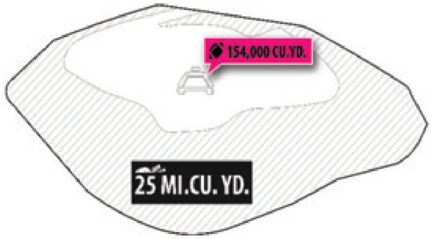
2.2.2 Landfill Scale

The footprint size of modern landfills can be massive. The average landfill size is about 600 acres, which is the equivalent of approximately 452 standard football fields (Save on Energy 2019).

[14] Scale comparison between a standard landfill and a standard football field (Zhong 2019).

2.2.3 Landfill Volume

Landfill volume greatly varies depending on landfill type and local site conditions. Landfill capacities are often expressed in million-tons, or alternatively, cubic cards. For reasons to be discussed later, this report focuses on landfills located in the Los Angeles basin. Reviewing the national website on landfills (https://hifld-geoplatform.opendata.arcgis.com/datasets/solid-waste-landfill-facilities) and the California landfill website (https://www2.calrecycle.ca.gov/swfacilities/Directory/13-AA-0026/Index), "small" landfills typically have a capacity range of 5–25 million cubic yards (cy), while the Puente Hills landfill in Los Angeles, one of the largest in the United States, received up to 476 million cy of waste including approximately 125 million cy waste in place, within a 1,365 acre site including 622 acres devoted to landfilling which rose to approximately 500 feet above ground (CalRecycle 2019; LASCD 2001, 1.0-10; LASCD, 3.0-2). As a comparison, the Reliant Astrodome in Houston has a volume of 1.6 million cy.



[15] Volume comparison between Salina, KS City landfill, and a standard football stadium (Zhong 2019).

2.2.3.1 Calculation of Landfill Volume and Capacity

Definitions

Landfill Capacity can either be expressed in tonnages (tons), or in cubic yards (CYs), which also refers to **Landfill Volume** or **Volume Capacity** (CalRecycle 2018). **Landfill Capacity in tonnages** is equal to in-place waste density multiplied by landfill volume (in cubic yards). In the state of California, "in-place waste densities can range from approximately 1,000 to 1,600 lbs/CY (CalRecycle 2018, 1)."

As landfill capacity in cubic yards is a constant and will not change due to waste density, this report will use landfill capacity in cubic yards to determine landfill capacity.

Calculations

According to the California Integrated Waste Management Board (CIWMB), there are three major methods used to determine the landfill capacity, including **Topographical Survey Methods**, **Weight-Based Methods** and **Trench-Based Methods** (CalRecycle 2018).

Topographical Survey Methods are widely used and provide accurate results. It uses topographical maps (can be retrieved from ground survey or aerial survey, e.g LiDAR) to determine landfill capacity which can be manually calculated (using average-end method) or automatically using CAD (computer-aided design) (CalRecycle 2018).

Weight-Based Methods where landfill capacity is calculated using weight data divided by in-fill density. Related waste-weight data and waste density must be known (CalRecycle 2018).

Trench-Based Methods which use the dimensions of length, width, and depth of trenches to calculate landfill capacity.

In this report, CAD programs will be used to automatically calculate the landfill capacity in cubic yards.

2.2.4 Standard vs “Best Practice” Configurations

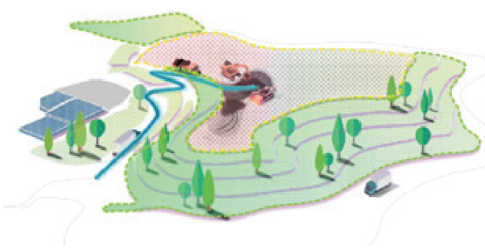
Since the goal of the research is to study how landfill contouring can improve landfill aesthetics, the literature review was directed towards landfill contouring. In California, according to Title 27 CCR 203424 (b), the contour plan must be completed and supervised by a registered civil engineer or certified engineering geologist (27 CA ADC § 20324). Once the potential landfill site is determined, the first step of landfill design is to determine the landfill geometry and configuration (Sharma & Reddy 2004).

There are four major types of landfill configurations, namely: **Above-ground Fill**, **Below-ground Fill**, **Above- and Below- ground Fill**, and **Canyon/Valley Fill** (Sharma & Reddy 2004; Qian et al. 2001).

Because of possible concerns related to design complexity as well as the cost of construction, most landfills are constructed and designed to be fairly geometric and simple in shape. Due to the high visual standards and strict environmental regulations in the State of California, many landfills such as Puente Hills Landfill in City of Industry (Los Angeles County) have a greater degree of contouring and variation (CalCycle 2019; LASCD 2001).

[16] Standard Canyon Fill Configuration in Southern California (Zhong 2019).

versus



[17] Canyon Fill Configuration with better contouring in Southern California (Zhong 2019).

2.3 MSW Landfill Design and Operations

2.3.1 Design Considerations

When considering MSW Landfill design, multiple landfill components must be considered including foundation and liner systems, landfill gas control systems, and closure systems, among others. Landfill configurations can be Trench Fill, Above/below Ground Fill, or Canyon Fill options.

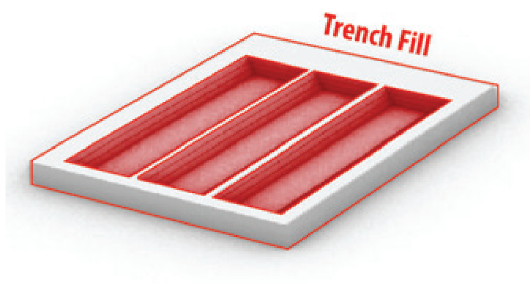
Type selection and footprint configuration

There are four common types of ***landfill configurations*** (Sharma & Reddy 2004; Qian et al. 2001):

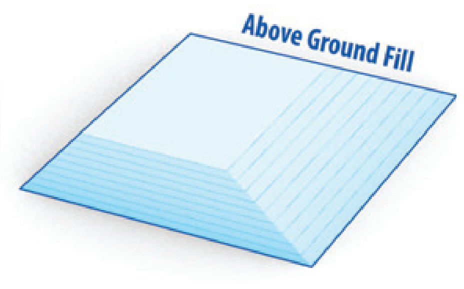
- *Area Fill*: little or no excavation; usually in flat areas;
- *Trench Fill*: deep and narrow trenches are excavated to allow waste filling, usually for a small amount of waste;
- *Above- and below-ground Fill*: the combination of area fill and trench fill, usually in relatively flat areas; and
- *Canyon/Valley Fill*: waste will be contained inside the valley, usually in mountainous topography.

Liners

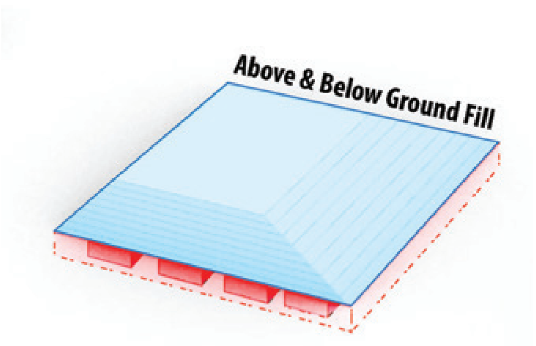
A ***liner*** system is required for landfills to contain the waste in place and prevent potential contamination due to leakage of harmful leachate (Townsend 2015; Qian et al. 2001). The materials used for landfill liners has transitioned from a single layer of clay or geomembrane liner to composite liners that contain "both clay and synthetic geomembranes together with interspersed drainage layers (Qian et al. 2001, 9)."



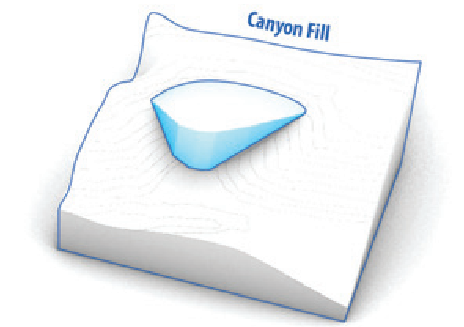
[18] Trench fill: *deep and narrow trenches are excavated to allow waste filling, usually for a small amount of waste* (Zhong 2019).



[19] Area/Above ground fill: *little or no excavation; usually in flat areas* (Zhong 2019).



[20] Above ground and below ground fill: *the combination of area fill and trench fill, usually in relatively flat areas* (Zhong 2019).



[21] Canyon/Valley fil/: *waste will be contained inside the valley, usually in mountainous topography* (Zhong 2019).

Cells and filling sequence

Once landfill configuration is determined, the next step is to **lay out *landfill cells* in the footprint area**. The footprint is considered as "the maximum area available at the site after the area required for other facilities" (Sharma & Reddy 2004, 647).

In many flat areas, cell layout is fairly geometric in order to maximize the available land and volume capacity, which also results in a geometric landform (Sharma and Reddy 2004; Qian and Koerner 2009). After the layout is set, base grading and site topography are carefully considered and designed according to environmental regulations. "The sub-base grading defines the elevations of the deepest level of excavation at different areas of the footprint" (Sharma and Reddy 2004, 648). Moreover, per Title 27 CCR 21090 (a), there is a criterion for maximum slopes for stability requirements and maintenance capability where "slopes cannot be steeper than $1^{3/4}$: 1 with a 15-foot wide bench every 50 feet in elevation. Slopes steeper than 3:1 use synthetic materials in the final cover and must complete a robust slope stability analysis (27 CA ADC § 21090)."

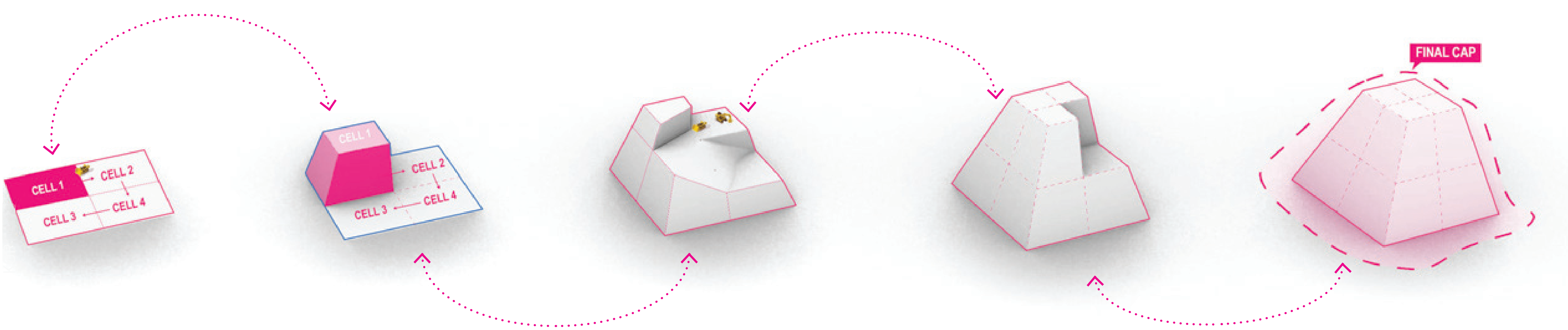
Gas Collection and Control systems

The Gas Collection and Control System of a landfill removes and collects landfill gas primarily consisting of methane and carbon dioxide that is produced over time as refuse decomposes. The collection system prevents landfill gases from escaping into the atmosphere and polluting the air (Townsend 2015; Qian et al. 2001). Collected landfill gas that is collected can either be burned (usually for small amounts of landfill gas production) under controlled conditions or retreated to produce energy for revenue (large amount of landfill gas production) (Townsend 2015; Qian et al. 2001, 332).

Slope stability analysis

Slope stability analysis is rooted in calculating the Factor of Safety (FOS). The slope is said to be stable if the FOS is greater than 1 (Bagchi 2004; Townsend et al. 2015; Qian et al. 2009). The calculation methods include infinite slope method, wedge methods and slice methods; using computer programs like SLOPE/W, XSTABL and others (Bagchi 2004; Qian et al. 2009; Sharma and Reddy 2004; Townsend et al. 2015).

[22] Landfill Formation: How a landfill is built from the landfill cells to a man-made landform (Zhong 2019).



Slope drainage

Unlike the leachate collection and removal system that collects leachate within the landfill, a ***drainage layer*** within the final cover is usually used to prevent water penetrating into the cover soil in order to enhance slope stability, which usually consists of "cohesionless soils or drainage geosynthetics (Qian et al. 2001, 404)". Since water cannot penetrate into the landfill, the uncontaminated surface runoff will be discharged into drainage and sediment control structures per Title 27 CCR 20365 (LACSD 2001, 4.8-2) in the State of California. The ***drainage ways*** of a landfill can include "channels, surface/subsurface pipes, energy dissipating structures and sedimentation basins (LACSD 2001, 4.8-3)," and the ***proposed drainage ways*** of a landfill are determined by the existing surrounding natural basins, proposed landfill grades and drainage benches in order to increase the slope stability and minimize the increase in offsite flow rate (LACSD 2001, 4.8-4).

Engineered berms

Engineered berms might also affect landfill appearance. These are built around the landfill boundary to prevent landfill failures (Bagchi 2004; Qian and Koerner 2009). The engineering berms have multiple benefits such as increasing the landfill volume, lowering construction cost, and function as a visual barrier to reduce public opposition and make permitting easier (Qian and Koerner 2009; Qian et al. 2001). However, stability is the biggest concern when engineering berms (Qian and Koerner 2009). In addition, like base grading, the final cover grading plan should consider slope stability, and it needs to meet the designated height to ensure enough air space or volume for waste disposal and prevent excessive runoff (Sharma and Reddy 2004).

Access and circulation roads

Traffic flow and transportation routing are essential, not only for landfill operations, but also for is landform design due to maintaining safe slope percentages and other safety considerations. According to Noble, the uphill slope of the traffic route should not exceed seven percent and the downhill slope should not exceed 10 percent for loaded vehicles to ensure safety, and the road should be a minimum 24 feet wide to accommodate two lanes (Noble 1976, 21).

2.3.2 Landfill Operations

In this section, landfill operations such as slope vegetation and covering practice that affect the landfill visual quality will be discussed.

Slope vegetation

Types of **vegetation** for reclaiming the slope depends on the thickness of the final cover material. If the final cover material is thin (approximately two feet.), "***only shallow-rooted grass, flowers, and shrubs*** should be planted on the surface (Brunner 1972, 49; Townsend 2015, 400)." If ***trees*** are considered, another layer of impermeable soil together with an additional layer of soil (soil depth varies on the root depth) is needed to be placed atop of the final cover (Brunner 1972,50).

Cover materials

In municipal solid waste landfills, MSW should be covered during each operation by both federal and state regulations (LACSD 2001). In general, cover materials, including ***daily cover material*** – when waste is required to be covered in less than a week – usually requires a minimum of 6'' of cover material; for intermediate cover that is expected to be exposed for more than one week but less than one year- one foot of cover material is recommended; and finally, a cover that is expected to be exposed for more than one year should consist of both **a minimum of 18'' infiltration layer and a minimum of 6'' erosion layers** (Bagchi 2004; Noble 1976; Qian et al. 2001).

[23] Existing Daily Cover Operations Using Foam in Puente Hills Landfill (LASCD 2001).

Post closure uses

In addition, different ***post-closure uses*** will require different thicknesses of final cover, a relatively impermeable soil layer and topsoil layer (Bagchi 2004; Townsend et al. 2015; Noble 1976; Qian et al. 2001). There are two major types of post-closure uses: hard uses and soft uses. Hard uses include residential, commercial and industrial development (parking lots, storage, light industrial buildings) and are not as common as soft uses, due to the concern of landfill stability (Bagchi 2004; Qian et al. 2001; Townsend et al. 2015). Soft landfill uses or recreational uses are the most common post-closure uses, including parks, wildlife and conservation areas, golf courses/driving ranges, sport fields and ski slopes (Bagchi 2004; Townsend et al. 2015; Noble 1976; Qian et al. 2001).

2.3.3 Economics

Ensuring financial viability is important when planning and operating landfills. In the planning and construction phase, landfill permitting, site preparation and the cost of constructing landfill components can all be considered as cost elements (Bagchi 2004, 617; EPA 2015, 2-15; Townsend 2015, 427). In the operational phase, cost elements include equipment purchase and operational costs for moving and compacting refuse; cover material excavation, transport, and spreading; installing and monitoring gas extraction systems, and on-going slope restoration. In the closure and post-closure phase, final cover and post-closure maintenance are two major expenditures (Bagchi 2004, 620; EPA 2015; Townsend 2015; Noble 1976, 46). Concerning revenue sources, a tip fee or gate fee is the major revenue generator (EPA 2015; Townsend 215). Private landfills heavily rely on tip fees and public landfills' revenue comes primarily from tip fees and taxes (EPA 2015). Some landfills which have co-generation facilities running off the extracted methane gas also sell electricity.

LANDFILL OVERALL Visual Quality (OVERALL VR) EVALUATION Criteria (ASLA&FHWA 1981; BLM 1980; CEQA 1970;USFS 1995; Dames& Moore 1994)			
	High	Medium	Low
Visual Attributes			
Ridgeline Silhouette	Dissected and even sharp *ridgeline* with naturally appearing undulation.	Moderate undulating **ridgeline**, undulation sometimes appears low and flat.	No dissection, little or no undulation, *ridgelines* appear to be linear or geometric.
Landform	Over 60% **slope**, relief expressed in dominant geologic features, e.g. cliff, massive rock outcrops.	30-60 % **slope** with few dominant geologic features, e.g. rolling hills, drumlins.	0-30% **slope** with few or no dominant features, e.g. low rolling hills.
Vegetative Pattern	High coverage rate of **vegetation** expressed in different forms, textures and patterns.	Moderate coverage rate of **vegetation** with some diversity (forms, textures, patterns) in plant species.	Low coverage rate of **vegetation** with little or no variety (forms, textures, patterns) in plant species.
	High	Medium	Low
Visual Contrast			
Ridgeline Contrast	Minor or no alteration in **ridgeline**, or re-created with natural undulation that blends with the surrounding ridgeline pattern.	Moderate alteration or major alteration but **ridgelines** are re-created with undulation, dissection.	Major alteration in **ridgeline** leading to a geometric, linear pattern.
Landform Contrast	Minor alteration in existing landform, including **degree of slope, slope angles undulation, shadow relief**, usually blend with surrounding natural landforms.	Moderate alteration in landform, including **degree of slope, undulation, shadow relief**, usually compatible with surrounding landforms but with less variety and details.	Major alteration in landform, including **degree of slope, undulation, shadow relief**, usually appears as geometric shape with no or little variety and details.
Scale / Size Contrast	Similar to surrounding natural landforms, as a subordinate feature.	Exceed **scale** of adjacent landforms, visually dominant.	Grossly exceeds **scale** of adjacent natural landforms, as a dominant

[24] OVERALL VQ Evaluation Criteria (Zhong 2020).

LANDFILL LANDFORM Visual Quality (LANDFORM VR) EVALUATION Criteria (ASLA&FHWA 1981; BLM 1980; CEQA 1970;USFS 1995; Dames& Moore 1994)			
	High	Medium	Low
Visual Attributes			
Ridgeline Silhouette	Dissected and even sharp *ridgeline* with naturally appearing undulation.	Moderate undulating **ridgeline**, undulation sometimes appears low and flat.	No dissection, little or no undulation, *ridgelines* appear to be linear or geometric.
Landform	Over 60% **slope**, relief expressed in dominant geologic features, e.g. cliff, massive rock outcrops.	30-60 % **slope** with few dominant geologic features, e.g. rolling hills, drumlins.	0-30% **slope** with few or no dominant features, e.g. low rolling hills.
Vegetative Pattern (only used when evaluating the overall VQ of a	High coverage rate of vegetation expressed in different forms, textures and patterns.	Moderate coverage rate of vegetation with some diversity (forms, textures, patterns) in plant species.	Low coverage rate of vegetation with little or no variety (forms, textures, patterns) in plant species.
	High	Medium	Low
Visual Contrast			
Ridgeline Contrast	Minor or no alteration in **ridgeline**, or re-created with natural undulation that blends with the surrounding ridgeline pattern.	Moderate alteration or major alteration but **ridgelines** are re-created with undulation, dissection.	Major alteration in **ridgeline** leading to a geometric, linear pattern.
Landform Contrast	Minor alteration in existing landform, including **degree of slope, slope angles undulation, shadow** relief, usually blend with surrounding natural landforms.	Moderate alteration in landform, including **degree of slope, undulation, shadow relief**, usually compatible with surrounding landforms but with less variety and details.	Major alteration in landform, including **degree of slope, undulation, shadow relief**, usually appears as geometric shape with no or little variety and details.
Scale / Size Contrast	Similar to surrounding natural landforms, as a subordinate feature.	Exceed scale of adjacent landforms, visually dominant.	Grossly exceeds scale of adjacent natural landforms, as a dominant

[25] LANDFORM VQ Evaluation Criteria (Zhong 2020).

2.4 Landfill Visual Assessment

2.4.1 Assessing Landfill Visual Impacts

Visual resource analysis is mandated to evaluate potential adverse impacts on the aesthetic environment and must be included when preparing environmental impact reports (EIRs) for NEPA (federal level) or for California's (CEQA) Guideline §15126.2 (b) (Government of California 2016; GEI Consultants, Inc. 2010). Visual assessment protocols slightly vary but are typically a derivative of pioneering methodologies established by three federal agencies: the **Visual Resource Management** (VRM) system used by the Bureau of Land Management (BLM), **Visual Impact Assessment for Highway Projects** used by the Federal Highway Administration FHWA), and the **Scenery Management System** (former Visual Management System --VMS) used by the U.S. Forest Service USFS). All systems assess baseline visual quality, analyze proposed changes/visual contrast, and consider different types of viewers with different visual sensitivity levels. (ASLA 1981; BLM 1980; Dames & Moore 1994). Visual resource analysis is normally documented through narratives, "viewshed" mapping, "before" photographs, and "after" visual simulations formerly based on manual techniques but now done through computer modeling and imaging. (ASLA 1981; BLM 1980; USFS 1995).

Researched visual assessment information was synthesized to produce two visual evaluation charts: one termed "Landfill **Overall** Visual Quality Evaluation Criteria" which included vegetation considerations, and one termed "Landfill **Landform** Visual Quality Evaluation Criteria" that only considered landform properties like slope geometry, side slope contouring, how flat the top deck appeared, and how much the top ridgeline undulated. **Vocabulary** in the charts describe the physical features, and are extracted, illustrated and explained in **Section.2.4.2**, together with important terms in other literature.

2.4.2 Parameters from Landform Classification Scheme

Landform is considered an essential part of landscape character. Most often, it is the first thing a viewer will notice from a far distance to a close-up look, which helps establish an overall visual impression of a landscape or a place (USFS 1995). It is one of the most important factors that affect landfill aesthetics besides **vegetation** and **water** (USFS 1995). Tsouchlaraki's study about demographic effects on the evaluation of landforms has revealed that the public is **fond of landforms that are complex**, such as mountainous landscape (Tsouchlaraki 2006).

Previous studies have contributed to *quantitative* landfill classification methods based on **Digital Elevation Models (DEMs)**. Mokarram and Hojati used the **Topographic Position Index (TPI)** method to classify landform which reveals more landform detail than using **traditional slope, relief and curvature** for landform classification (Mokarram & Hojati 2016). Meanwhile, Iwahashi and Pike (2007) discussed a different type of quantitative landfill classification scheme using **slope gradient, local convexity and surface texture** that is very suitable for landforms with moderate to coarse texture. Saadat (2008) utilized Digital Elevation Models and Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) images to classify landforms and found that this scheme handled low sloped landforms better and was high in accuracy.

In 2006, Tsouchlaraki discussed a modified Hemmings Landform Classification method for visual analysis using "**flat slopes percentage, maximum hypsometric difference and flat slope percentage at the upper or lower half of the hypsometric difference range**" to classify landforms and support visual analysis (Tsouchlaraki 2006, 827).

2.4.3 Landfill Vocabulary

(Landfill) **Visual Vocabulary** is a collection of terms that describe the visual attributes and features of a landfill referenced from literature related to landfills and the fields of geology, visual assessment, landscape planning, and ecology planning. These terms are similar to "**Visual Character**" as defined by the U.S. Bureau of Land Management (BLM) to describe the visible attributes of an object or a scene (form, line, texture, color), while landfill also has exposed pipes, liners, drainage benches, and other visible physical features on its slope surface (BLM 2018).

In addition to the visual vocabulary, there is also (Landfill) **Evaluation Vocabulary** that is a collection of terms used when evaluating landfill visual attributes and features with cross-referencing both the landfill and from literature related to the fields of landscape architecture, geology and mathematics related to visual assessment (Section 2.4.1) and landform classification schemes (Section 2.4.2). In addition, K-State professors were consulted from the departments of landscape architecture, civil engineering and mathematics concerning proper terminology.

[26] Landfill Visual Vocabulary using 2005 Puente Hills Landfill for demonstration (Zhong 2020).

Visual Vocabulary *(Landfill Specific):*

1. (Refuse) Fill Area
   Definition: area within the landfill property that is designated for landfilling(LACSD 2001; Townsend 2015; Qian et al. 2001).

2. (Final/Working) Top Deck
   Definition: the line or edge following along the final/working deck area (LACSD 2001).

3. Liner
   Definition: (Composite) Liner is placed to prevent potential contamination from leakage of leachate and effectively contain the waste in place (Townsend 2015; Qian et al. 2001).

4. Pipeline
   Definition: exposed pipelines on the landfill surface; usually part of the gas collection and control system (Townsend 2015; Qian et al. 2001).

5. Drainage Bench
   Definition: Drainage channels built on landfill slopes that are used to direct water runoff. Benches are usually 15 feet wide located every 40 feet of vertical change (LACSD 2001, 4.8-4).

6. Temporary Access Road
   Definition: transect unsurfaced road that is built to provide a shortcut to the working deck area (Hammond 2019).

7. Permanent Road
   Definition: surfaced access road that is built after the landfill is (partially) closed (Hammond 2019).

[27] Landfill Evaluation Vocabulary using 2005 Puente Hills Landfill for demonstration (Zhong 2020).

Visual Vocabulary *(General terms):*

8. Ridgeline
   Definition: a line consisting of the highest points along the terrain (Hutchison 2018; Marsh 2010, 43).

9. Valley
   Definition: low area in between mountains or hills, usually adjacent to ridge slopes (Hutchison 2018; Marsh 2010, 44).

10. Vegetation
    Definition: vegetation planted on the solid waste fill slopes (LASCD 2001).

11. Side Slope (or called Fill Slope in landfill)
    Definition: the side slope of a cut or fill, which expressed relative to a landfill is usually in a fill location and is called a “fill slope”. (LACSD 2001).

12. Relief
    Definition: difference in elevation of a selected area (Hutchison 2018).

Evaluation Vocabulary

1. Cross Section

Definitions: a vertical plane cutting across an object; in a cross-section drawing, the outline shape defines the intersection of the vertical plane and the object (Ching 2009).

Uses: display the **outline** of the intersected surface of the vertical plane and the landfill, which can help **visualize** the **landfill side slope undulation** along the cut direction.
Comparison: the generated line graph is used to **visualize** and **compare** the **landfill surface undulation** and **context undulation** along the cutline.

2. Slope Gradient

Definitions: rate of change in elevation over change in distance (ESRI 2019; Hutchison 2018).

Uses: describe the **steepness** of the landfill **side slope**.
Comparison: Value in between 1-2, the **higher** the percentage is, the **steeper** the slope is.

3. Slope Aspect

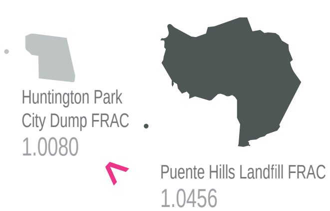
Definitions: the direction or angle that a slope surface faces (ESRI 2019; Hutchison 2018).

Uses: describe the **angle** of the landfill **side slope**.
Comparison: : 8 cardinal directions in a selected area, the **more slope direction variation** it has, which is **evenly disturbed** usually indicates more **slope surface undulation**.

4. Fractal Dimension Index / FRAC

Definitions: "equals 2 times the logarithm of patch perimeter divided by the logarithm of the patch area"; the index reflects the **shape complexity** across a range of spatial scales (McGarigal 2015, 105)."

Uses: evaluate the **(Fill area) shape complexity**.
Comparison: Value in between 1-2, the **higher the FRAC** index number is, the more **complex** the **(Fill area)** shape appears.

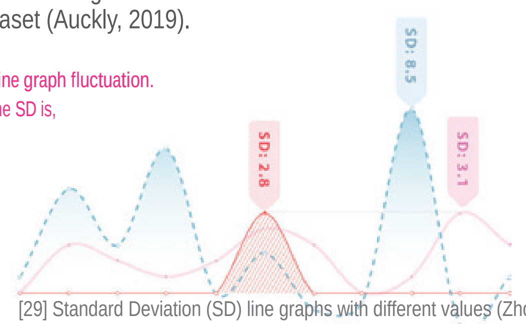


[28] FRAC value of Huntington Park (previous landfill) and Puente Hills Landfill (Zhong 2020).

5. Standard Deviation /SD

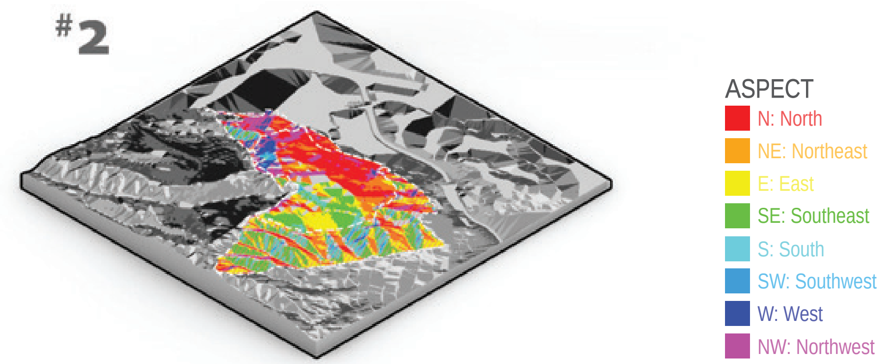
Definitions: Standard deviation is the index showing the **variation** of a set of **linear data**; the bigger the SD, the higher the degree of fluctuation in the linear dataset (Auckly, 2019).

Uses: evaluate the **(cross section) line graph fluctuation**.
Comparison: Value >0, the **higher** the SD is, the **(cross section)** line graph is considered to be more **undulating**.

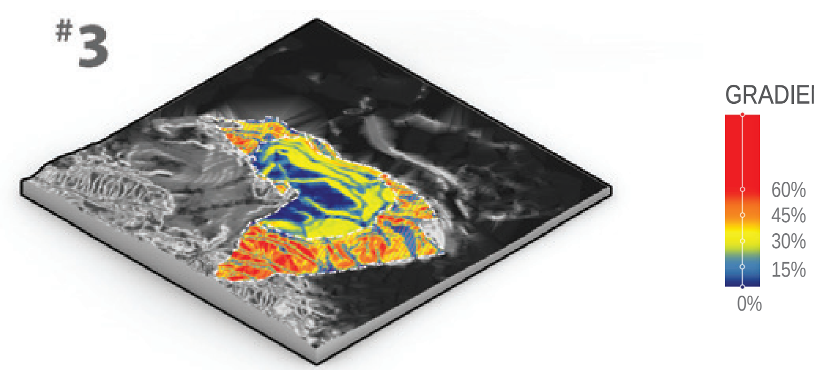


[29] Standard Deviation (SD) line graphs with different values (Zhong 2020).

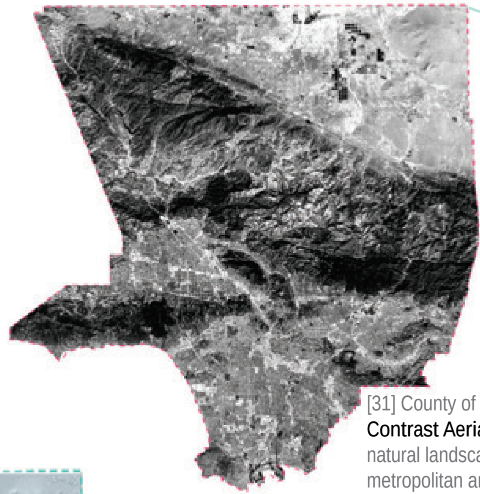
[30] Evaluation Vocabulary: "*Cross-section, FRAC, Longitudinal Profile: landfill and context*" (Zhong 2020).



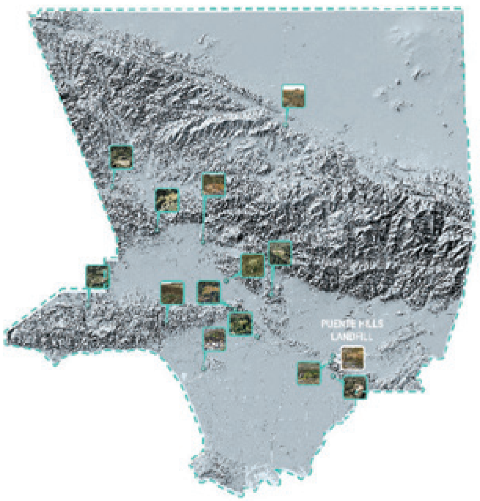
[31] Evaluation Vocabulary: "*Slope Aspect*" (Zhong 2020).



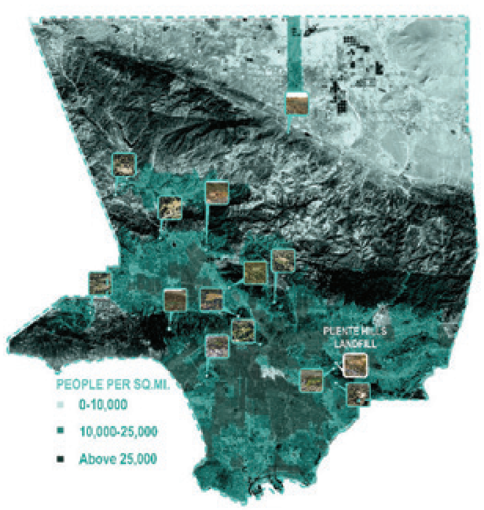
[32] Evaluation Vocabulary: "*Slope Gradient*" (Zhong 2020).



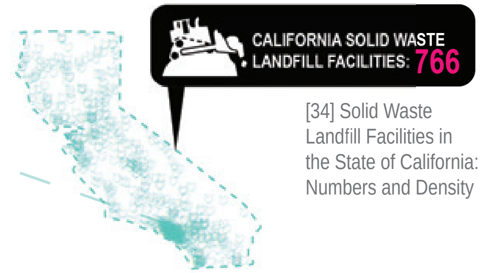
[31] County of Los Angeles: **High Contrast Aerial Map**-showing the natural landscape and populated metropolitan area (Zhong 2019).



[32] County of Los Angeles: **Hillshade Map** with Canyon-Fill Landfills indicating the extremely comparative context (Zhong 2019).



[33] County of Los Angeles: **Population Density Map** with Canyon-Fill Landfills indicating the large amount of potential viewers (Zhong 2019).



[34] Solid Waste Landfill Facilities in the State of California: Numbers and Density

2.5 Study Region: Southern California

In Southern California, low density development patterns (suburban sprawl) and land scarcity contribute to high land prices. Most of the flatter areas have been used for residential development, and landfills are commonly located in canyon areas where the cost of residential development is prohibitive.

The County of Los Angeles, one of the coastal areas in southern California has been chosen as the landfill study location due to the **mountainous background which will serve as the comparative landform context, the high number of potentially sensitive viewers, and the high waste volume generated by a very populated area.**

Due to the surrounding mountain context and available canyons which make development prohibitive, canyon-fill landfills are most economical and are commonly seen in southern California. Compared to landfills that are buried underground (trench-fill landfills) or slightly built above ground (above ground /above and below ground-fill landfills), these landfills are located in canyons. In the early years, waste operations are partially or fully screened from view, but in later phases, landfill heights eventually extend above the containment ridgeline, making them highly visible from surrounding neighborhoods and far distances.

[35] Study Region: The Precedent Study will explore landfills in the County of Los Angeles, CA., while the project site - Puente Hills Landfill for projective design is located in an unincorporated area of the LA County, at the intersection of two major freeways (Zhong 2020).

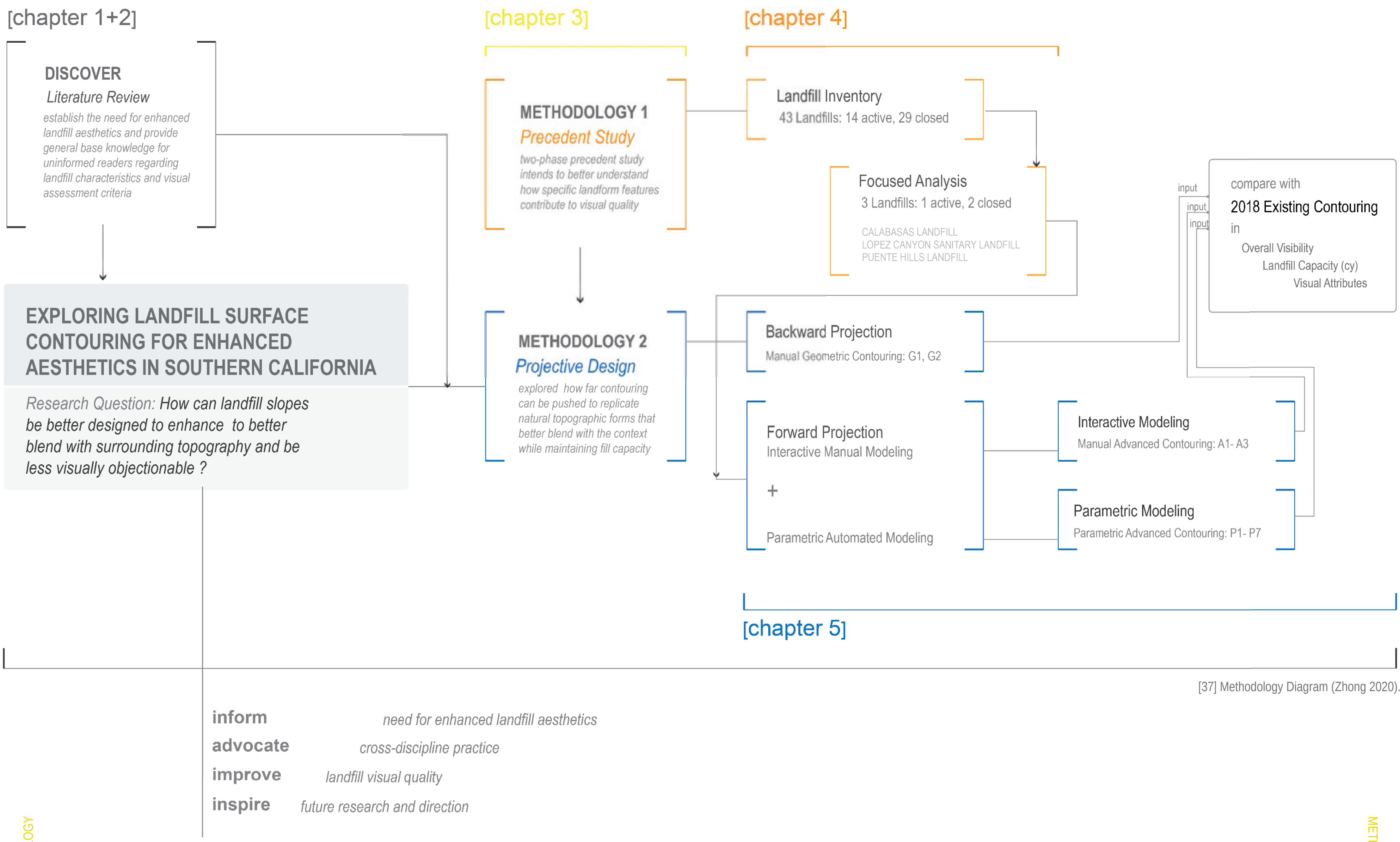
As one of the most nationally prominent landfills due to its location, scale, and design contouring, **Puente Hills Landfill** will be used as the focus of this project and report. The landfill is now closed and reclaimed, but it will serve as the baseline for backward design projection relative to less aesthetic and more common geometric landform types. Although it currently exhibits fairly high aesthetics compared to typical landfill design standards, it will also be used as a baseline for forward projective design. This design exercise is intended to explore how additional landfill contouring and cap reconfigurations might improve aesthetics even more, while still meeting capacity objectives and engineering requirements. A comparison will then be made between "worst case" (backward projection) and "best case" (forward projection) scenarios.

[36] Aerial view of Calabasas Landfill, County of Los Angeles, CA (Google Earth Pro 2019).

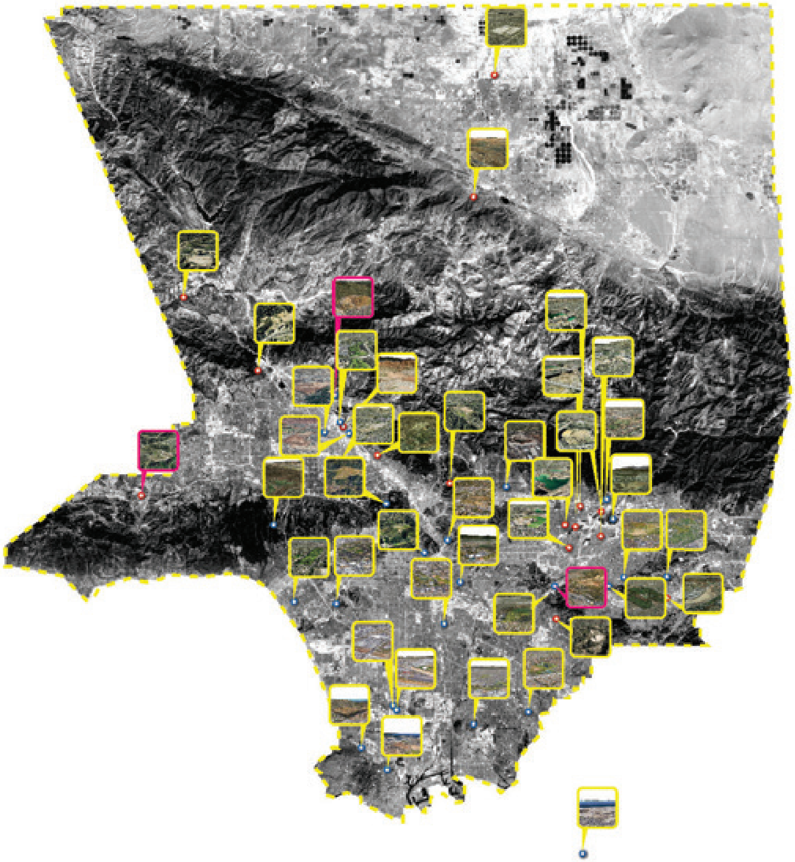
CHAPTER 3
METHODOLOGY

Overview

The first two chapters establish the need for enhanced landfill aesthetics and provide general base knowledge for uninformed readers regarding landfill characteristics and visual assessment criteria. This chapter briefly outlines the methodologies used to guide preparation of the precedent study and projective design. More specifically, it describes how the landfill inventory was compiled, categorized according to visual quality levels, and then how three landfills were selected for more focused analysis. Last this chapter describes the process used to guide the projective design which is the ultimate focus of this project. Results from these methods are reported in Chapter 4: Findings. An overview of the methods is shown in the Methodology Diagram.



[37] Methodology Diagram (Zhong 2020).



■ Selected Landfills for Focused Analysis
■ Selected Landfills for Landfill Inventory

[38] Selected Landfills for Precedent Study: 43 landfills including 14 active landfills (including Calabasas Landfill)and 29 closed landfills(including Lopez Canyon Sanitary Landfill and Puente Hills Landfill) (Zhong 2019).

3.1 Precedent Study

To better understand the current baseline state of visual quality associated with landfills found in **Los Angeles County**, a **two-phase precedent study** was conducted. The **first phase** identified and inventoried the active and closed landfills found in the county to gather basic information and eventually classify them into broad categories of "high", "moderate", and "low" visual quality. In phase two of the precedent study, three landfills (Calabasas Landfill, Lopez Canyon Sanitary Landfill, and Puente Hills Landfill) were selected from the "high visual" group for more focused analysis to better understand how specific landform features contribute to visual quality related to landfill side slope and top deck undulations. Details of these phases are found in Subsections **3.1.1** and **3.1.2**.

3.1.1 Landfill Inventory Process

1. Identification and inventory of landfills

Landfills within Los Angeles County were identified through an online search of California's Solid Waste Information System (SWIS) facility database (https://www2.calrecycle.ca.gov/SWFacilities/Directory/). **Only those landfills sized over 100 acres were considered**. The data for both active and closed landfills were downloaded as an Excel spreadsheet file which contained basic information on each landfill including facility name, enforcement agency, operator, activity type, regulatory status, operational status and latitude/longitude coordinates. A summary of this compiled information is found in Appendix III.

Using either the landfill name or geographic coordinates, the landfill was located on *Google Earth* to evaluate the *facility* and *context* in 3D and capture both **oblique aerial images** and an **ortho imagery documentation and future reference**. All of the site locations were graphically located on a photographic base of Los Angeles County. The landfills were also grouped according to whether they are active or closed. Following each landfill name, the landfill type was designated with a letter abbreviation where "A" = Above-ground landfill, "B" = Below-ground landfill, and "C" = Canyon landfill.

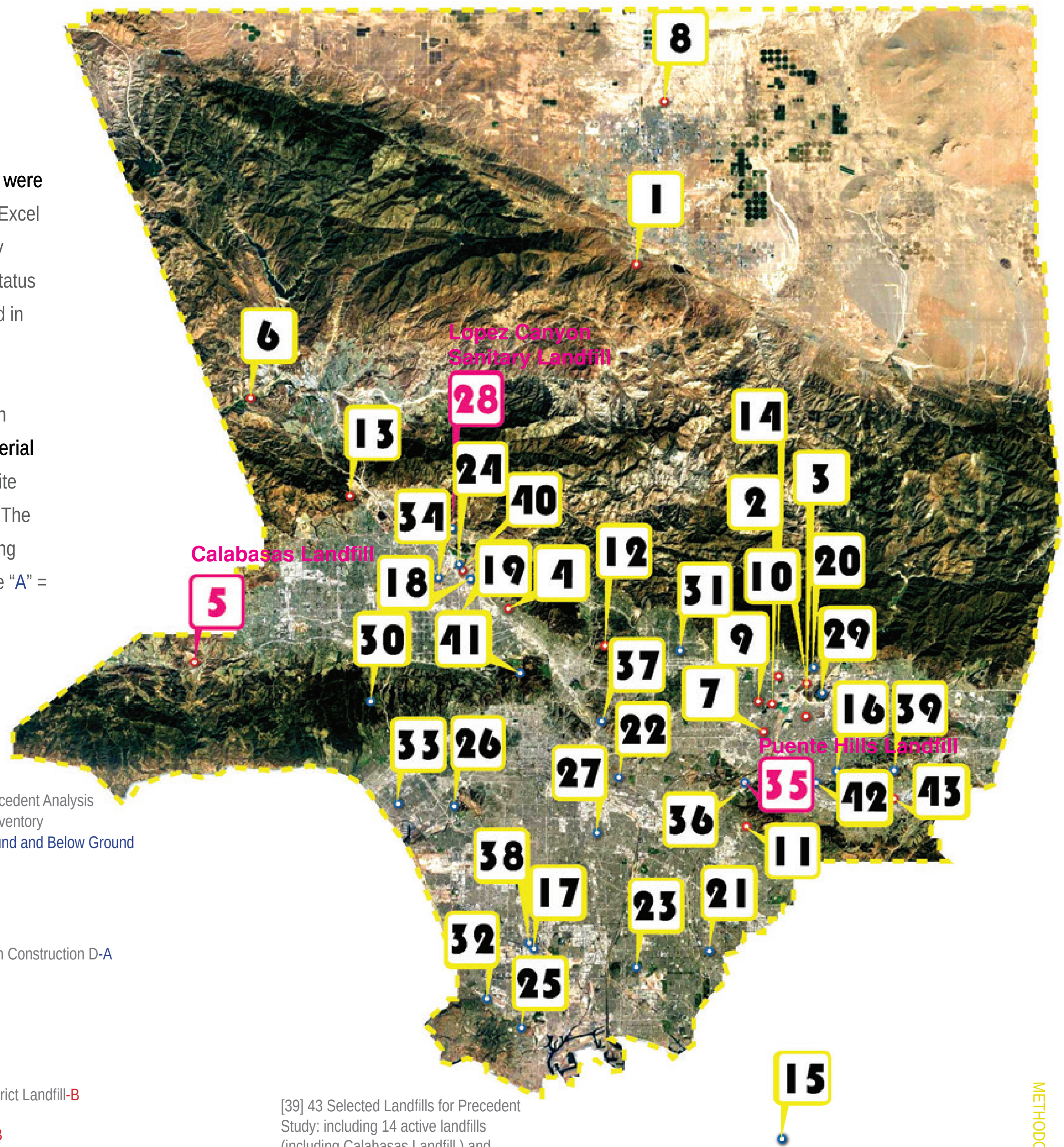
■ Active Landfills: 14

1 Antelope Valley Public Landfill-C
2 Arrow-Live Oak IDEFO-B
3 Azusa Land Reclamation Co. Landfill-B
4 Burbank Landfill Site No. 3-C
5 Calabasas Landfill-C
6 Chiquita Canyon Sanitary Landfill-C
7 Durbin Inert Debris Engineered Fill Site-B
8 Lancaster Landfill and Recycling Center-A
9 Peck Road Gravel Pit-B
10 Reliance Landfill-B
11 Savage Canyon Landfill-C
12 Scholl Canyon Landfill-C
13 Sunshine Canyon City/County Landfill-C
14 United Rock Products Pit #2-B

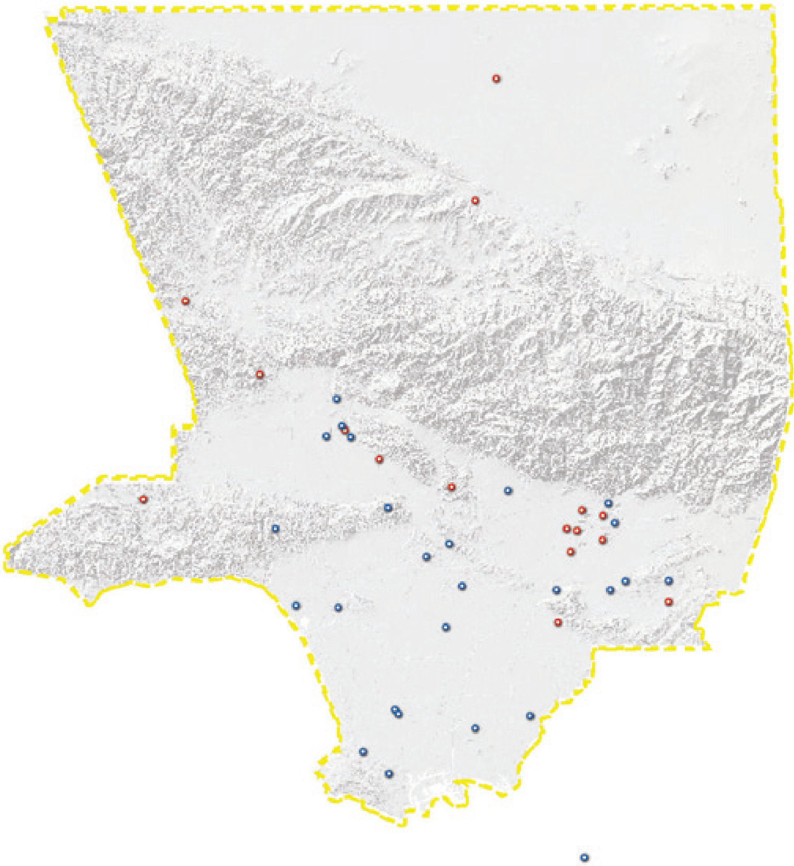
■ Closed Landfills : 29

15 Ascon Construction - Long Beach-A
16 BKK Sanitary Landfill-A
17 BKK Public Dump -Carson-B
18 Bradley Landfill West And West Extension-A
19 Branford LF-A
20 Canyon Park Dump/Rancho Duarte GolfCourse-B
21 City Of Alhambra Landfill
22 Cogen Dump-C
23 Coverstreet Stockpile-A
24 Glenoaks Dump-A
25 Harbor Hills-A
26 Hetzler Landfill-C
27 Huntington Park City Dump-B
28 Lopez Canyon Sanitary Landfill-C
29 Manning Brothers Class III Landfill
30 Mission Canyon #8-C
31 North Avenue Dump / Osborn Construction D-A
32 Palos Verdes Landfill-A
33 Penmar Golf Course-A
34 Penrose Pit-A
35 Puente Hills Landfill-C
36 Rose Hills Landfill-C
37 Rosehills Dwp Landfill-C
38 Southwest Conservation District Landfill-B
39 Spadra Sanitary Landfill-A
40 Spadra Sanitary Landfill #2-B
41 Toyon Canyon Park Reclamation Project-C
42 Valley Land Development Co. Inc-C
43 Valley Land Development Company-C

■ Selected Landfills for In-Depth Precedent Analysis
■ Selected Landfills for Precedent Inventory
-A: Above Ground and Above Ground and Below Ground Landfill;
-B: Below Ground Landfill
-C: Canyon-fill Landfill



[39] 43 Selected Landfills for Precedent Study: including 14 active landfills (including Calabasas Landfill) and 29 closed landfills (including Lopez Canyon Sanitary Landfill and Puente Hills Landfill) (Zhong 2020).



Active Landfills: 14
Closed Landfills : 29

[40] Selected Landfills for Precedent Study: 43 landfills including 14 active landfills and 29 closed landfills (Zhong 2020).

2. Visual quality criteria development

After the **landfill facilities were identified and mapped**, the inventory progressed to a **visual quality (VQ) evaluation**. No such pre-existing evaluation exists, so the *VQ landform terms and criteria associated with standard VQ assessment methodologies described in Section 2.4.* were used.

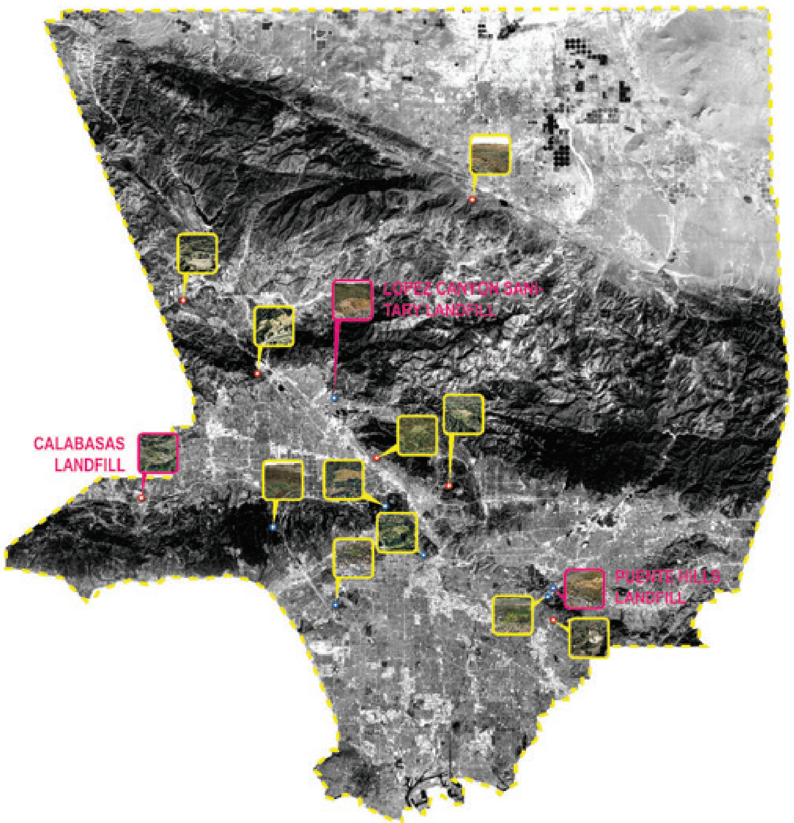
3. Data analysis method

The data analysis process started with a **cursory VQ evaluation based on a review of 3D Google Earth imagery**, after which, ***two visual quality evaluations*** were made: one termed “**Overall**” which included vegetation considerations, and one termed “**Landform**” that only considered landform properties like slope geometry, side slope contouring, how flat the top deck area appeared, and how much the section lines undulated.

4. Landfill VQ ranking groups

The results of the first evaluation- **Overall VQ Evaluation** categorized all 43 landfills into three groups: high Overall VQ group, moderate Overall VQ group, and low Overall VQ group. The results of the second evaluation- **Landform VQ Evaluation** categorized all 43 landfills into three groups: high Landform VQ group, moderate Landform VQ group, and low Landform VQ group.

After both evaluations were made, the author turned the focus to examine the **visual attributes** discussed in Section 2.4.3 and their **relationship** to the **Landform VQ** by comparing each visual attributes across the three landfill Landform VQ ranking groups: high, moderate, and low through once-again the **photo review** discussed previously.



■ Selected Precedents: 3
■ Other Canyon-fill Landfills: 11

[41] Selected Landfills for Focused Analysis: Calabasas Landfill, Lopez Canyon Sanitary Landfill, Puente Hills Landfill in Purplish Red, remaining 11 other canyon fill landfills (Zhong 2020).

3.1.2 Focused Analysis Process

1.“High” visual quality subset (3)

The Focused Analysis selects landfills from the “High” **Overall** and **Landform VQ subsets** for more in-depth and rigorous examination of ***how landfill visual attributes relate to visual quality***. Special attention was directed to how well the landfill visually integrated with the **surrounding contextual landform**.

In addition, due to the time limitation and limited number of landfills with both “High” **Overall** and **Landform** VQ subsets, only **three** landfills including **Calabasas (active) landfill, Lopez Canyon Sanitary landfill (closed), and Puente Hills landfill(closed)** were selected from the subsets.

2. Data analysis method

The **initial examination** concerning the relationship between the visual attributes and visual quality of each landfill was completed in the landfill inventory. The focus analysis first selectively **eliminated** those visual attributes that had less or no significant impact on the **Landform** VQ or were out of the project scope, while the remaining visual attributes then became the major focus of the analysis.

The remaining visual attributes of the three precedents were quantified to set initial design recommendation for the Projective Design phase using the following methods (*see Section 2.4.3. Evaluation Vocabulary for illustration*):

A. **Landfill Planform Analysis** for evaluating visual attribute- "*Landfill Fill Area*."

The **fill area was outlined** on the orthograph documented during the Landfill Inventory Process to study shape complexity of the landfill fill area. In addition, the number of **vertices** of each landfill fill area was recorded through the outlining process. Fill area and perimeter information from each landfill were collected by importing the shape outlines into AutoCAD and extracting the area and perimeter data from the properties dialog. The **FRAC** method was the best choice to evaluate shape complexity since FRAC values do not change at different contour representation scales.

Area and perimeter data were imported into an Excel spreadsheet to calculate **FRAC** values. In the end, **the average of the FRAC value and the vertice count** of each Landform VQ subsets was calculated to evaluate fill area in relation to Landform VQ in a quantitative way.

B. **Landfill Cross-Sectional Analysis** for evaluating visual attributes "*Side Slope*" and "*Final/Working Top Deck*"

b1 **Longitudinal Profile**: *Landfill Profile* and *Context Profile*
For each landfill selected for focused analysis, **two cross-sections** were cut in the north-south and west-east directions that evenly divided and sampled the landfill using the built-in section tool in Google Earth to generate two "**longitudinal profiles**." These profiles **visually represented** the landfill *side slope undulation* and *context slope undulation*, and average slope gradient and elevation gain of each landfill in its context.

In addition, the X,Y data of the section line was imported into Excel to calculate the SD of both the landfill profile and context profile, which reflected the degree of fluctuation for each landfill profile and context profile represented in the line graphs (Auckly 2019). Note that due to limited time, the line graphs were not resized to real world scale, thus, the SD comparison can only be compared within the same landfill but not across the three landfills.

b2 **Top Deck Profile**
For each landfill selected for focused analysis, **two cross sections** were also cut in the north-south west-east directions that evenly divided and sampled the landfill using the built-in section tool in Google Earth for each working deck area to generate a "top deck profile," which **visually represented** top *deck surface undulations*, and the *average slope and elevation* gains of the landfill top deck area.

C. **Landfill Surface Analysis**

Slope gradient and **slope aspect** used as an index reflecting topographical differences were calculated through ArcGIS. In order to compare the topography of the landfill and surrounding context, each attribute slope gradient, slope aspect, and fixed size area was compiled for comparison.

3.2 Projective Design

The "Projective Design" methodology in this report proposes new landfill forms with the design goal of enhancing landfill aesthetics. The Precedent Study informed the visual standard for a canyon-fill landfill landform and what can be done better to enhance landfill aesthetics.

In the projective design phase, different landfill surfaces were generated and explored to arrive at a preferred set of proposed options. Each model presents precise modifications related to ridgelines, flowlines, top deck surface, and was used to calculate capacity volume for comparison to the existing 2018 Puente Hills shape and capacity volume. In addition, visibility analyses were conducted for comparison to the 2018 existing landfill and modified landfills. Supported with illustrations, more methodology details related to this projective process are discussed in **Chapter 5: The Design**.

CHAPTER 4
FINDINGS

[42] Aerial view of Lopez Canyon Sanitary Landfill, County of Los Angeles, CA (Google Earth Pro 2019).

4.1 Precedent Study Findings

This section includes the analysis and findings for both the **Landfill Inventory** and **Focus Analysis**, and further explains how the findings were used to guide projective design.

4.1.1 Precedent Inventory

The inventory compiled from the SWIS facility database (see Section 3.1.1) identified **43 landfills** within the study region of Los Angeles County; **14** landfills are active, and **29** landfills have been closed. The landfills are a mixture of above-ground, below-ground, and canyon-fill types as shown below.

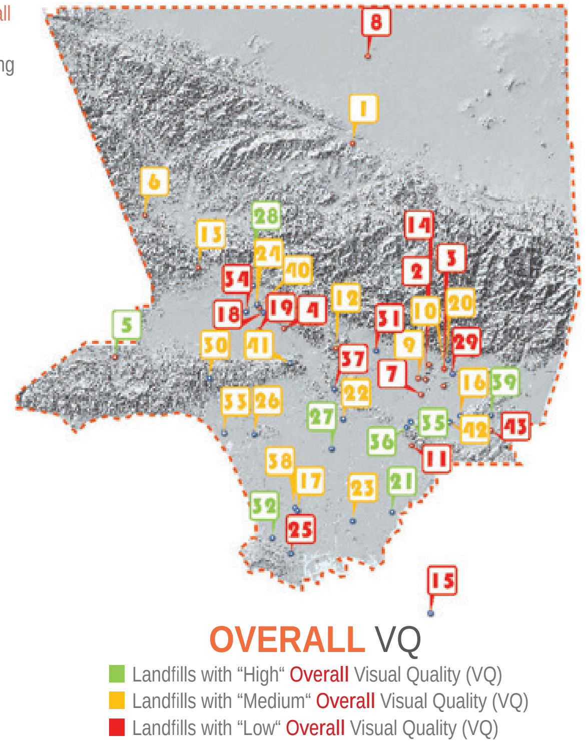
	Landfill Type		
Closure Status	Above-ground (A)	Below-ground (B)	Canyon-fill
Active Landfill (14)	1	6	7
Closed Landfill (29)	12	6	11

[43] Inventory of active and closed landfills (>100 ac) found within the regional study area of Los Angeles County extracted from the SWIS facility database (Zhong 2020).

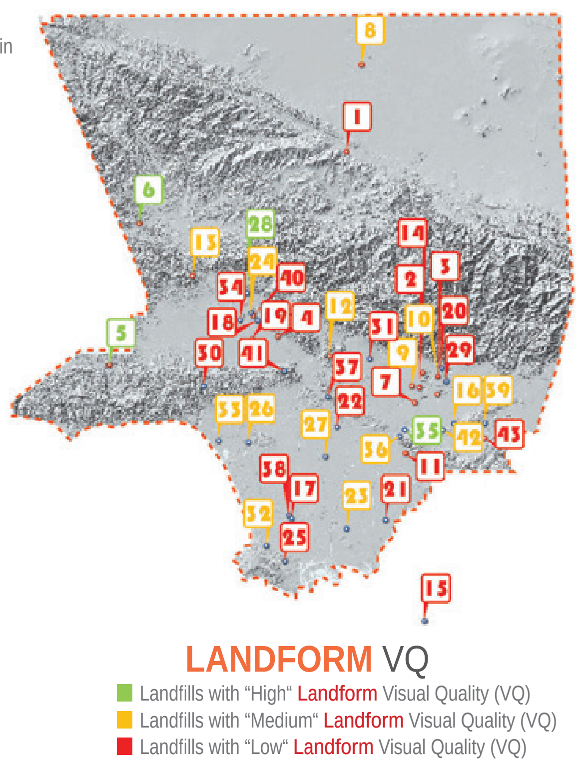
Analyzing the distribution of landfill types, a higher proportion of older landfills that are now closed were above-ground types compared to active landfills which are below-ground or canyon-fill types. Most of the below-ground landfills are found in former/current sand and gravel pits in the San Gabriel Valley that now receive industrial or construction waste, or inert material.

Canyon-fill is a **dominant landfill type** within the active and closed landfills that were inventoried. According to previous research, the canyon-fill type prevails in southern California because nearby mountains offer MSW containment that is partially screened and the steep terrain is prohibitive and costly for other types of development uses. In later fill phases, however, un-natural appearing landfill terrain becomes widely visible when the fill elevation exceeds surrounding natural ridgelines.

[44] Landfills with Overall Visual Quality in High, Medium, and Low (Zhong 2019).



[45] Landfills with Landform Visual Quality in High, Medium, and Low.



Visual Quality Findings for Inventoried Landfills

Based on the visual quality assessment criteria established in Section 2.4.1 (Figure 25) this section assesses overall visual quality relative to the **landform attributes** defined by ridgeline silhouettes, degree of landform undulation, and vegetation patterns, and **visual contrast** based on ridgelines, landform shape, and scale/size. In addition to landform, “overall visual quality” considers slope vegetation which contributes to visual pattern and contrast.

Purpose: Based on the proceeding criteria, the 43 inventoried landfills were classified as exhibiting “High”, “Medium”, and “Low” visual quality for both “overall” and “landform” considerations.

Subjects and Findings: After reviewing the orthophotographs and aerial photographs of the **43** landfills including **14** active landfills and **29** closed landfills,

> there are 8 landfills with “High” **Overall** VQ, 19 landfills with “Medium” **Overall** VQ, 16 landfills with “Low” **Overall** VQ; and
>
> there are 5 landfills with “High” **Landform** VQ, 11 landfills with “Medium” **Landform** VQ, 27 landfills with “Low” **Landform** VQ, and through the visual observation, the author have noted the:
>
> > **Visual attributes** (definitions of landform components are described and illustrated in Section 2.4.3) that affect **Overall VQ** include: side slope undulation, complexity/naturalness of fill slopes, the number and undulation of ridgelines and valleys, form of the final/working top decks, and reclaimed slope vegetation.
> >
> > **Visual attributes** (definitions of landform components are described and illustrated in Section 2.4.3) that affect **Landform VQ** include: side slope undulation, complexity/naturalness of fill slopes, the number and undulation of ridgelines and valleys, and the form of final/working top decks.

Relationships between Visual Attributes and Overall VQ and Landform VQ

1. Landfill Footprint Area (Fill Area)

   Relationship to Overall VQ and Landform VQ: generally, the closer the landfill footprint follows the undulation of natural contours, the higher the Overall VQ and Landform VQ.

   Among the reviewed inventoried landfills, landfill footprints which follow undulating contours also display side fill slopes which have greater undulations replicating natural slopes. Those footprints that are more linear result in geometric slopes which are less naturalistic and have lower visual quality, but offer potentially more fill volume.

2. (Final/Working) Top Deck

   Relationship to Overall VQ and Landform VQ: the more undulation that appears on the top deck surface, the higher the Overall VQ and Landform VQ.

   As observed, most landfills even the ones with high landform VQ, present a flat, geometric top deck area for the reason of stability and working efficiency, with only small-scale undulations (or unevenness) that will not be able to perceived from a distance.

3. Side Slope (or called Fill Slope in landfill)

   Relationship to Overall VQ and Landform VQ: the more undulation appears on the side slope surface, the higher the Overall VQ and Landform VQ.

   Similar to top deck areas, some landfills present only small-scale undulations on side slopes that can be hardly perceived from a distance. For landfills with high landform VQ, more visible undulations appear on the side slopes.

4. Ridgeline (along landfill side slope)

   Relationship to Overall VQ and Landform VQ: the more undulating the landfill ridgelines, the higher the Overall VQ and Landform VQ. Additional finger ridgelines which replicates natural terrain also contributes to higher visual quality.

   When ridgelines on side slopes display both large-scale and small scale undulations, a more natural landform is created that contrasts less with the surrounding context. From landfills with low landform VQ to high landform VQ, the ridgelines appear to be flat and linear, the only difference is that finger ridgelines on side slope surfaces change from very defined to less defined.

5. Valley (along landfill side slope)

   Relationship to Overall VQ and Landform VQ: the more undulating the valleys (flowlines), the higher the Overall VQ and Landform VQ. Drainages and sub-drainages that replicate natural landforms contributes to higher visual quality.

   When valleys on side slope surfaces display both large-scale and small scale undulations, a more natural landform is created that contrasts less with its surrounding context. However, from landfills with low landform VQ to high landform VQ, valleys or visible natural drainageways are rarely found on the landfill surface.

6. Vegetation

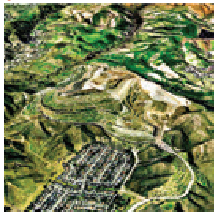
   Relationship to Overall VQ and Landform VQ: vegetation greatly affects Overall VQ, but it does not affect landform VQ. The more diverse slope vegetation is relative to height, color, and texture, the higher the Overall VQ.

7. Relief

   Relationship to Overall VQ and Landform VQ: the higher the landform relief, the lower the Overall VQ and Landform VQ.

   Relief could be simply understood as the final elevation of a landfill, the higher the relief is, the more noticeable a landfill is, and thus the lower VQ. However, relief will not be discussed in the report as the projective design used a closed landfill with designated final elevation.

Landfill Inventory: HIGH OVERALL VQ (VISUAL QUALITY)

5

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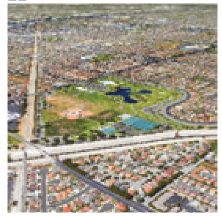
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28

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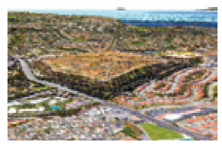
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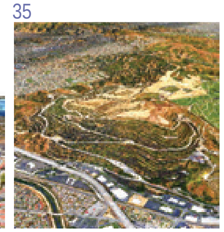
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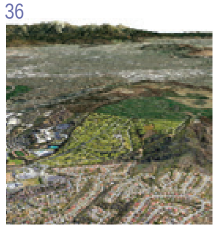
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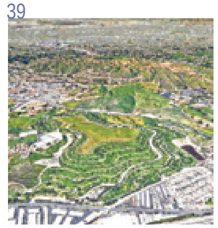


UPPER LEFT TO LOWER RIGHT

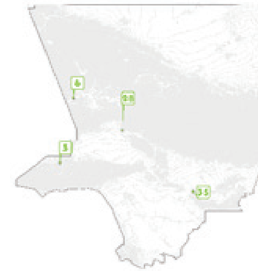
5 Calabasas Landfill
21 City Of Alhambra Landfill
27 Huntington Park City Dump
28 Lopez Canyon Sanitary Landfill
32 Palos Verdes Landfill
35 Puente Hills Landfill
36 Rose Hills Landfill
39 Spadra Sanitary Landfill

[46]-[53] Aerial Photographs of Landfills with High Overall Visual Quality (Google Earth Pro. 2019).

Landfill Visual Characteristic of “High” **Overall** VQ:

- Dense vegetation cover (especially mature trees) on landfill surface.
- Undulating ridgelines
- Visible landfill surface undulation
- Less visual contrast and compatible with surrounding landforms.

Landfill Inventory: HIGH LANDFORM VQ (VISUAL QUALITY)



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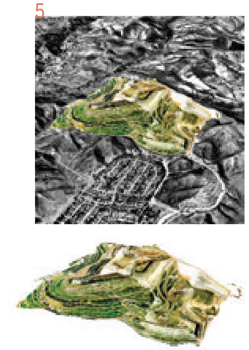
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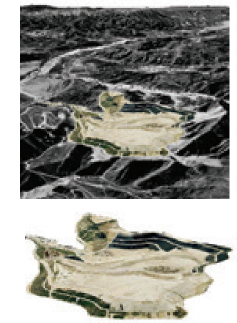
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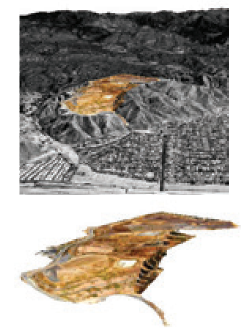
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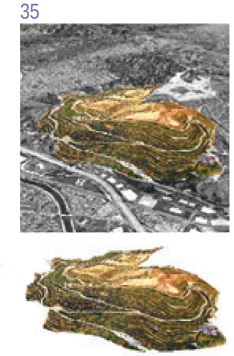


UPPER LEFT TO LOWER RIGHT

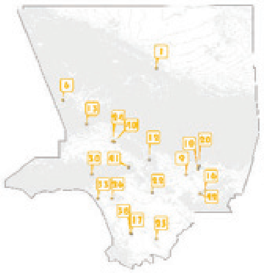
5 Calabasas Landfill
6 Chiquita Canyon Sanitary Landfill
28 Lopez Canyon Sanitary Landfill
35 Puente Hills Landfill

[54]-[57] Aerial Photographs and cutouts of Landfills with High Landform Visual Quality (Google Earth Pro 2019).

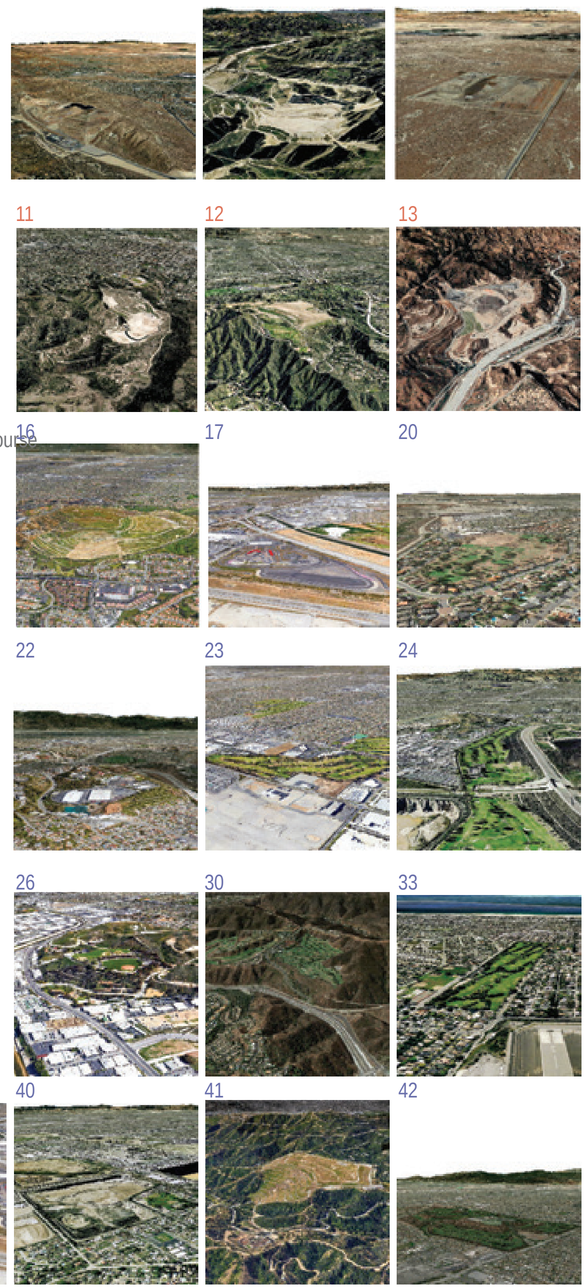
Landfill Visual Characteristic of “High” **Landform** VQ:

- Visible surface undulation
- Moderate slope (usually perceived as rolling hills after reclaimed)
- Undulating ridgelines
- Less visible contrast with surrounding environment
- Size does not exceed adjacent landforms too much

Landfill Inventory: MEDIUM OVERALL VQ (VISUAL QUALITY)



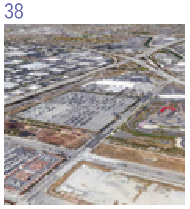
1 Antelope Valley Public Landfill
6 Chiquita Canyon Sanitary Landfill
8 Lancaster Landfill and Recycling Center
11 Savage Canyon Landfill
12 Scholl Canyon Landfill
13 Sunshine Canyon City/County Landfill
16 BKK Sanitary Landfill
17 BKK Public Dump -Carson
20 Canyon Park Dump/Rancho Duarte GolfCourse
22 Cogen Dump
23 Coverstreet Stockpile
24 Glenoaks Dump
26 Hetzler Landfill
30 Mission Canyon #8
33 Penmar Golf Course
38 Southwest Conservation District Landfill
40 Spadra Sanitary Landfill #2
41 Toyon Canyon Park Reclamation Project
42 Valley Land Development Co. Inc



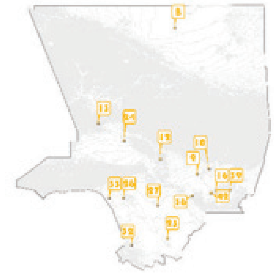
[58]-[76] Aerial Photographs of Landfills with Medium Overall Visual Quality (Google Earth Pro 2019).

Landfill Visual Characteristic of "Medium" **Overall** VQ:

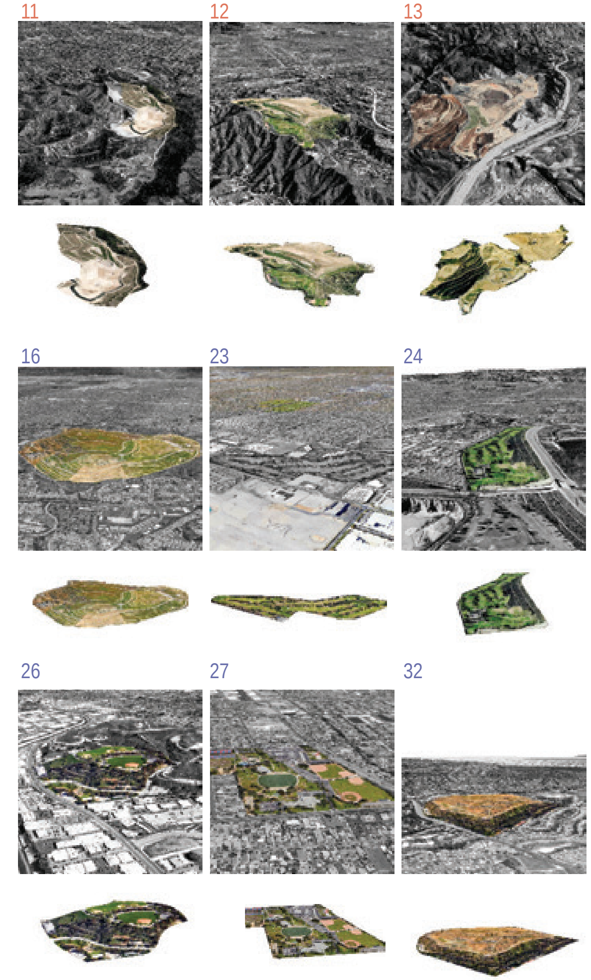
- Moderate vegetation coverage
- Some degree of landfill surface undulation
- Moderate visual contrast and compatible with surrounding landforms.



Landfill Inventory: MEDIUM LANDFORM VQ (VISUAL QUALITY)



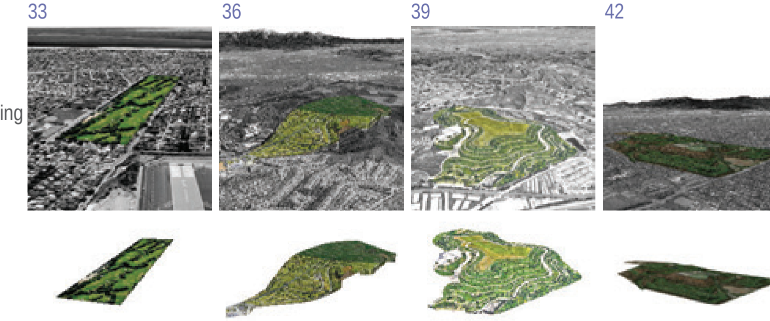
11 Savage Canyon Landfill
12 Scholl Canyon Landfill
13 Sunshine Canyon City/County Landfill
16 BKK Sanitary Landfill
23 Coverstreet Stockpile
24 Glenoaks Dump
26 Hetzler Landfill
27 Huntington Park City Dump
32 Palos Verdes Landfill
33 Penmar Golf Course
36 Rose Hills Landfill
39 Spadra Sanitary Landfill
42 Valley Land Development Co. Inc



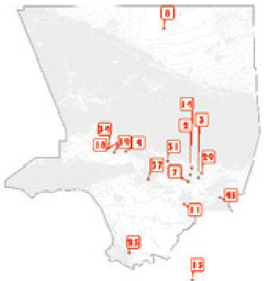
[77]-[89] Aerial Photographs and cutouts of Landfills with Medium Landform Visual Quality (Google Earth Pro 2019).

Landfill Visual Characteristic of "Medium" **Landform** VQ:

- Some surface undulation
- Gentle to flat slope
- Moderate visual contrast with surrounding environment
- Size contrasts with adjacent landforms



Landfill Inventory: LOW OVERALL VQ (VISUAL QUALITY)



2 Arrow-Live Oak IDEFO
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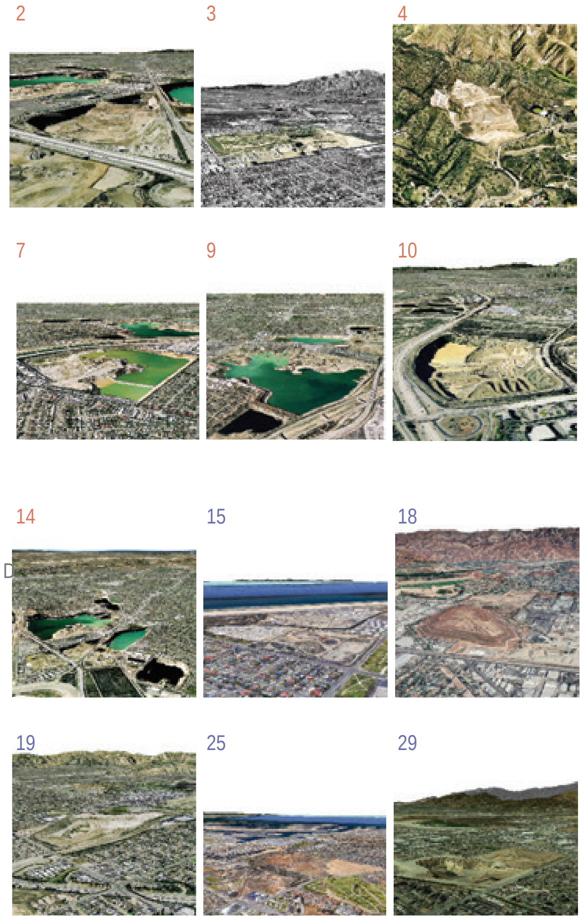
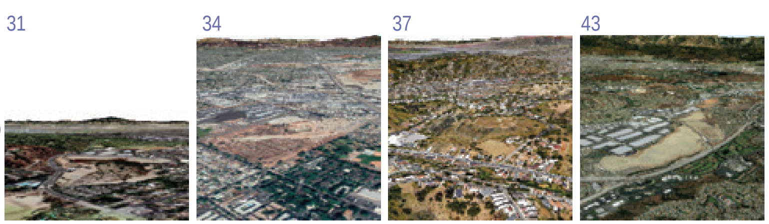
4 Burbank Landfill Site No. 3
7 Durbin Inert Debris Engineered Fill Site
9 Peck Road Gravel Pit
10 Reliance Landfill
14 United Rock Products Pit #2
15 Ascon Construction - Long Beach
18 Bradley Landfill West And West Extension
19 Branford LF
25 Harbor Hills
29 Manning Brothers Class III Landfill
31 North Avenue Dump / Osborn Construction D
34 Penrose Pit
37 Rosehills Dwp Landfill
43 Valley Land Development Company



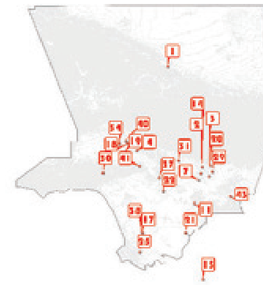


[90]-[105] Aerial Photographs of Landfills with Low Overall Visual Quality (Google Earth Pro 2019).

Landfill Visual Characteristic of "Low" Overall VQ:

- Moderate to low vegetation overage
- Few or no landfill surface undulations
- High visual contrast and compatible with surrounding landforms.

Landfill Inventory: LOW LANDFORM VQ (VISUAL QUALITY)



1 Antelope Valley Public Landfill
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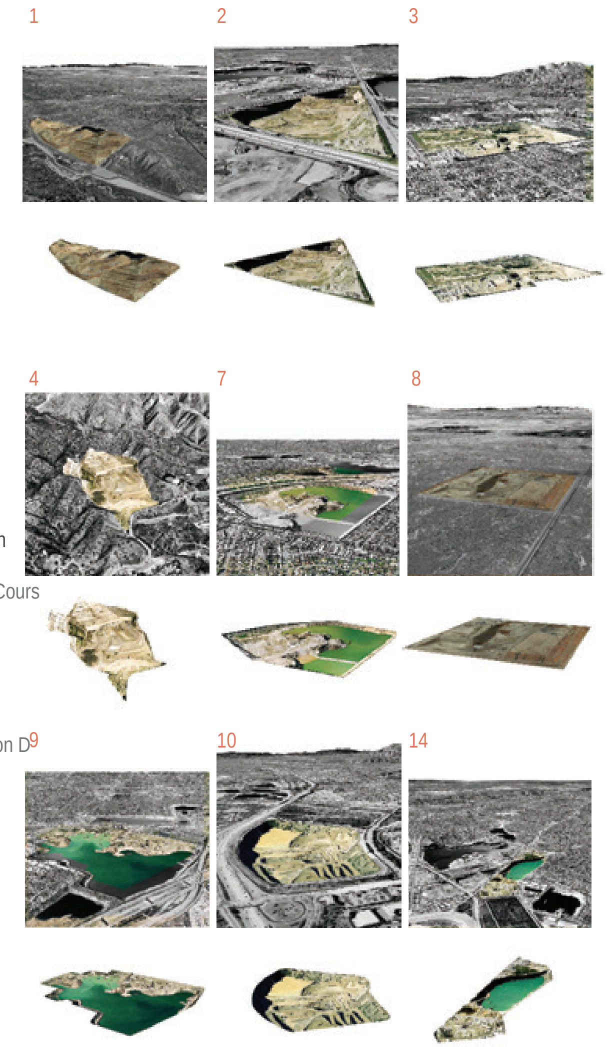
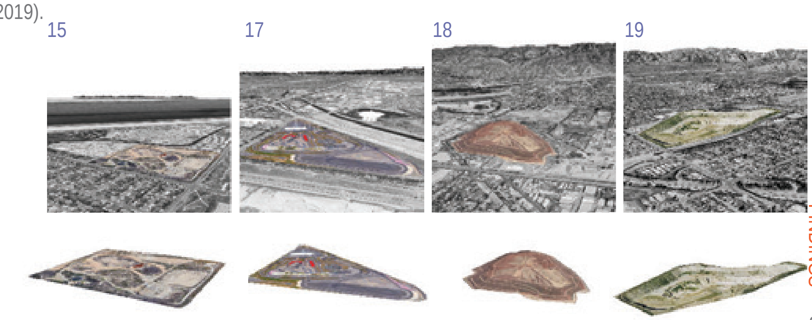
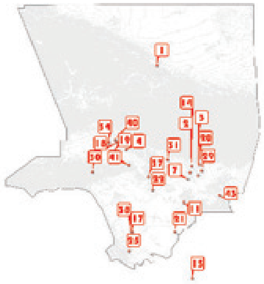
19 Branford LF
20 Canyon Park Dump/Rancho Duarte GolfCours
21 City Of Alhambra Landfill
22 Cogen Dump
25 Harbor Hills
29 Manning Brothers Class III Landfill
30 Mission Canyon #8
31 North Avenue Dump / Osborn Construction D
34 Penrose Pit
37 Rosehills Dwp Landfill
38 Southwest Conservation District Landfill
40 Spadra Sanitary Landfill #2
41 Toyon Canyon Park Reclamation Project
43 Valley Land Development Company



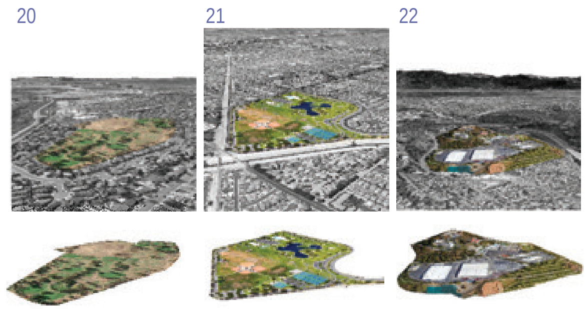
[106]-[118] Aerial Photographs and cutouts of Landfills with Low Landform Visual Quality contd. (Google Earth Pro 2019).

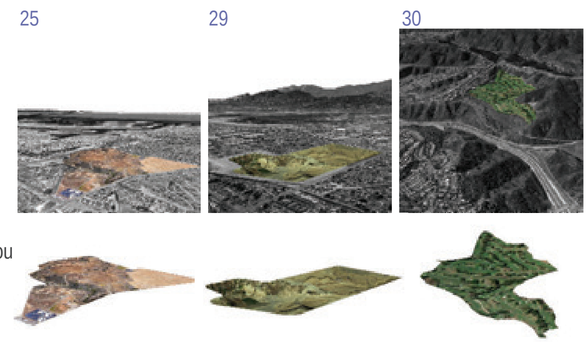


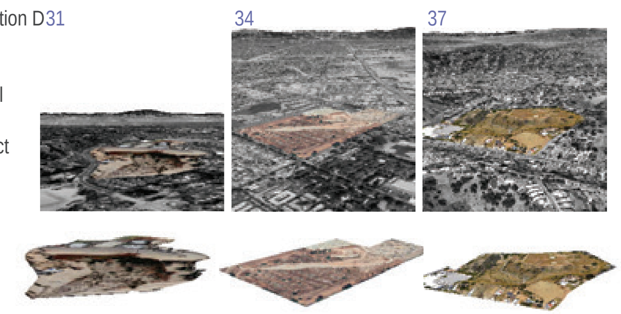
Landfill Inventory: LOW LANDFORM VQ (VISUAL QUALITY)

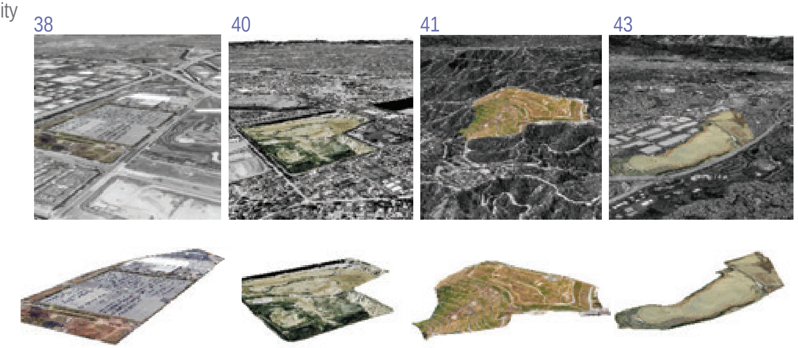


1 Antelope Valley Public Landfill
2 Arrow-Live Oak IDEFO
3 Azusa Land Reclamation Co. Landfill
4 Burbank Landfill Site No. 3
7 Durbin Inert Debris Engineered Fill Site
8 Lancaster Landfill and Recycling Center
9 Peck Road Gravel Pit
10 Reliance Landfill
14 United Rock Products Pit #2
15 Ascon Construction - Long Beach
17 BKK Public Dump -Carson
18 Bradley Landfill West And West Extension
19 Branford LF
20 Canyon Park Dump/Rancho Duarte GolfCou
21 City Of Alhambra Landfill
22 Cogen Dump
25 Harbor Hills
29 Manning Brothers Class III Landfill
30 Mission Canyon #8
31 North Avenue Dump / Osborn Construction D
34 Penrose Pit
37 Rosehills Dwp Landfill
38 Southwest Conservation District Landfill
40 Spadra Sanitary Landfill #2
41 Toyon Canyon Park Reclamation Project
43 Valley Land Development Company









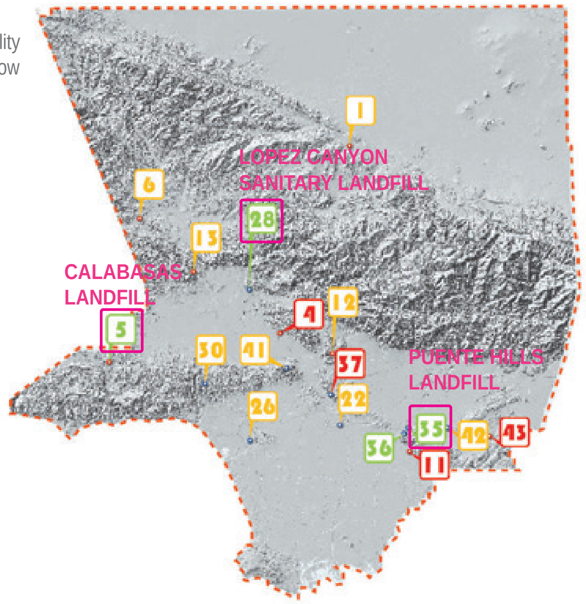
[119]-[132] Aerial Photographs and cutouts of Landfills with Low Landform Visual Quality (Google Earth 2019).

Landfill Inventory: LOW LANDFORM VQ (VISUAL QUALITY)

Landfill Visual Characteristic of "Low" **Landform** VQ:

- Few or no surface undulations on landfill surface
- Linear, flat ridgelines that are very defined and visible on the landfill surface
- Flat top deck
- Gentle to flat slope with no dominant geologic features
- Fairly geometric shape that creates high visual contrast with surrounding environment
- Size contrasts with adjacent landforms

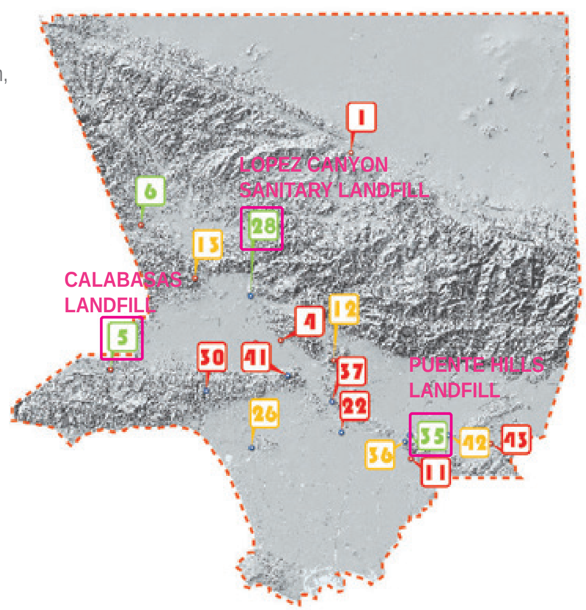
[133] Canyons Landfills with Overall Visual Quality in High, Medium, and Low (Zhong 2019).



OVERALL VQ

- Canyon Landfills with “High“ Overall Visual Quality (VQ)
- Canyon Landfills with “Medium“ Overall Visual Quality (VQ)
- Canyon Landfills with “Low“ Overall Visual Quality (VQ)

[134] Canyon Landfills with Landform Visual Quality in High, Medium, and Low (Zhong 2019).



LANDFORM VQ

- Canyon Landfills with “High“ Landform Visual Quality (VQ)
- Canyon Landfills with “Medium“ Landform Visual Quality (VQ)
- Canyon Landfills with “Low“ Landform Visual Quality (VQ)

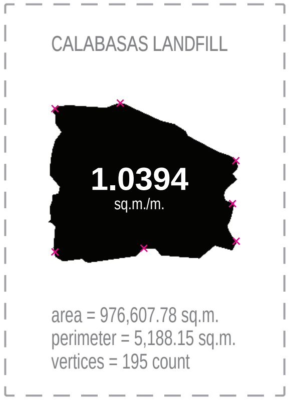
4.1.2 Focused Analysis

Based on the methodology developed in Section 3.1.2, this section reports on the summary of selected precedents’ visual attributes and their relationship to landfill visual quality and to the surrounding contextual landform.

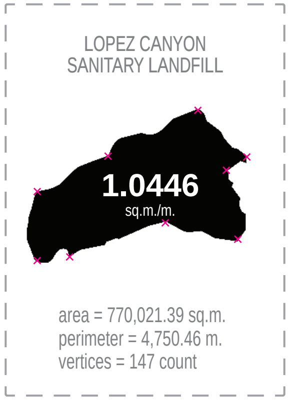
Purpose: This section visually illustrates and evaluates the visual attributes that affect Landform VQ of the selected landfills in order to understand how much aesthetic enhancement on landfill surfaces has been attempted in these “best examples“, and eventually develop the design recommendations on altering these visual attributes to improve landfill visual aesthetics.

Subjects and Findings: In this section, the visual attributes related to Landform VQ are compared across three selected landfills and their corresponding contextual landform in order to understand how these visual attributes affect the Landform VQ and how they can be improved. These visual attributes include: **Fill area, Top deck, and Side Slope**. These visual attributes are evaluated based on the data analysis process described in Section 3.1.2 and visually illustrated in Section 2.4.3. In addition, a special landfill surface analysis is conducted to compare “**Surface Undulation**” appearance of the landfill with undulations of the surrounding context.

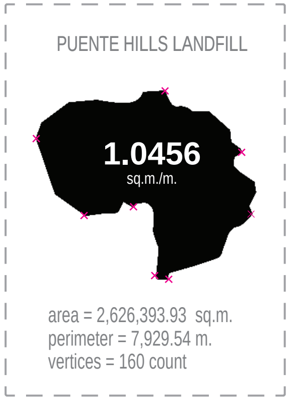
Summary of “FILL AREA” of Selected Landfills



[135] Edge Geometry of Calabasas Landfill (Zhong 2019).



[136] Edge Geometry of Lopez Canyon Sanitary Landfill (Zhong 2019).



[137] Edge Geometry of Puente Hills Landfill (Zhong 2019).

Summary of “FILL AREA” of All 43 Landfills

[138] Silhouettes of landfills with high, medium and low landform VQ (Zhong 2019).

HIGH LANDFORM VQ

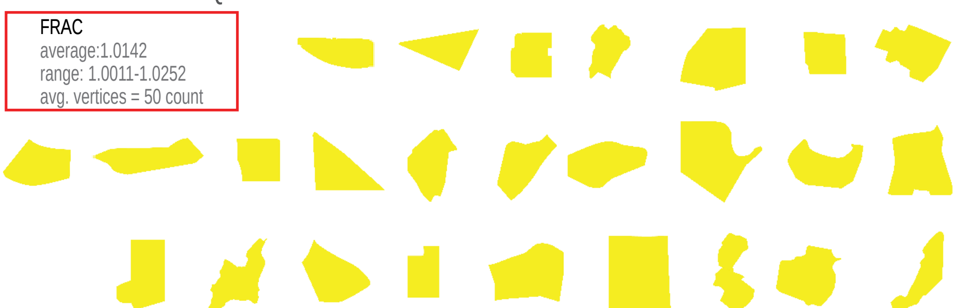
FRAC
average:1.0421
range: 1.0386-1.0456
avg. vertices = 163 count

MEDIUM LANDFORM VQ

FRAC
average:1.0287
range: 1.0026-1.0333
avg. vertices = 92 count

LOW LANDFORM VQ

FRAC
average:1.0142
range: 1.0011-1.0252
avg. vertices = 50 count



4.1.2.1 FILL AREA

FINDINGS

The average FRAC and vertices of landform with High, Medium and Low Landform VQ proved that the **more complex the shape of the (refuse) fill area is, the Higher the Landform VQ**.

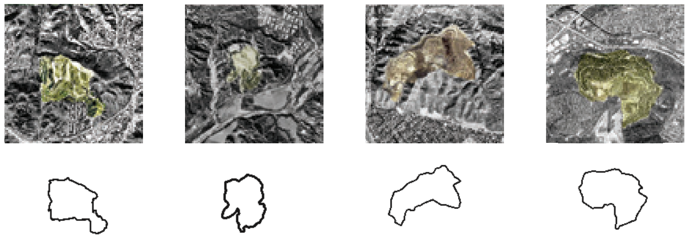
The most complex fill area reached a FRAC value of 1.04 with over 163 vertices counted. Comparing the FRAC value and number of vertices, and visually observing the fill areas of three selected landfills, the author noticed that even though the Calabasas landfill has the highest number of vertices, it has the lowest FRAC value. This is due to a lot minor undulations along the edges, but not major undulations compared to the Puente Hills landfill. From this comparison, the author concludes that similar to side slope undulations, large-scale variation has more impact on visual quality than small-scale variations.

DESIGN RECOMMENDATIONS

The landfill footprint is usually defined at the beginning of the landfill design, however, due to the uncertainty of the filling process and reclamation process, it might vary over time from what was originally designed.

According to the findings, at the design stage, some **large-scale undulations could be introduced to the contour patterns**. During the filling or reclamation process, landfill slopes can be incrementally altered or contoured along the edges of the top working deck with the utilization of GPS-enabled front loaders/ compactors as each fill layer is sequentially placed.

Landfills with HIGH LANDFORM VQ

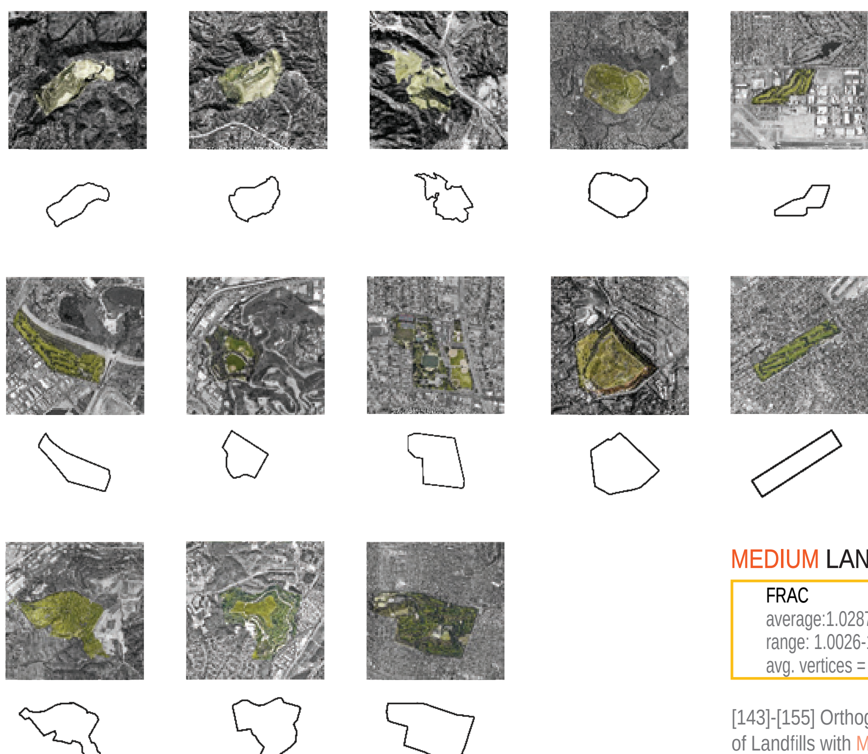


HIGH LANDFORM VQ

FRAC
average:1.0421
range: 1.0386-1.0456
avg. vertices = 163 count

[139]-[142] Orthographs of Landfills with High Landform Visual Quality (Zhong 2019).

Landfills with MEDIUM LANDFORM VQ

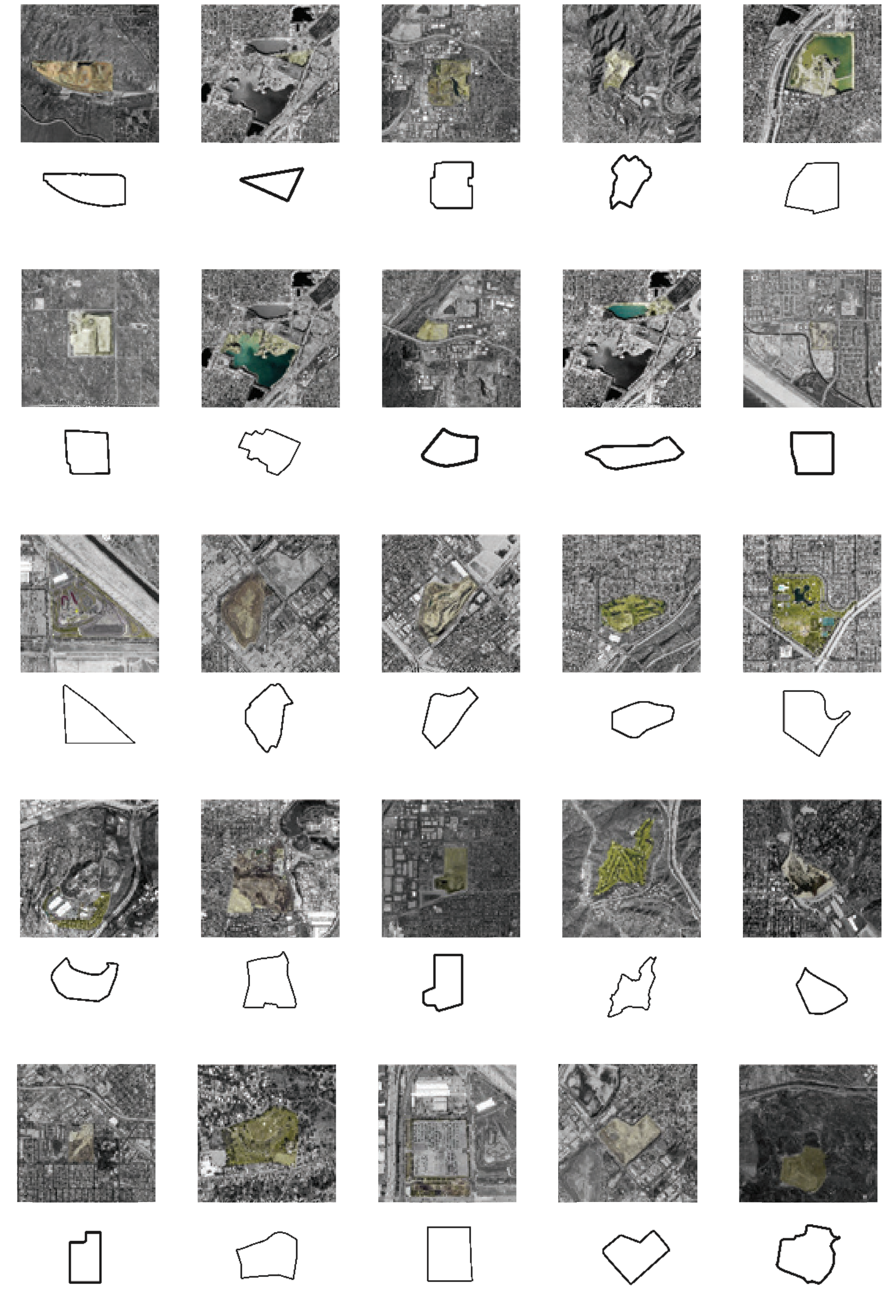


MEDIUM LANDFORM VQ

FRAC
average:1.0287
range: 1.0026-1.0333
avg. vertices = 92 count

[143]-[155] Orthographs of Landfills with Medium Landform Visual Quality (Zhong 2019).

Landfills with LOW LANDFORM VQ



LOW LANDFORM VQ

FRAC
average:1.0142
range: 1.0011-1.0252
avg. vertices = 50 count

[156]-[181] Orthographs of Landfills with Low Landform Visual Quality (Zhong 2019).

Summary of Longitudinal Profile

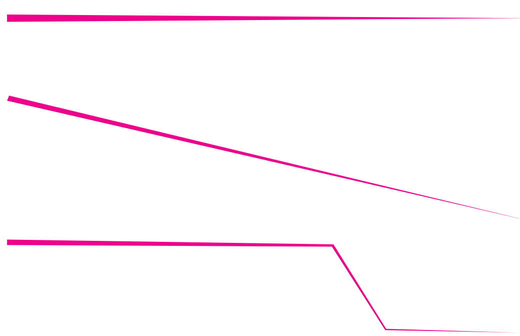
[182] Summary diagram of "longitudinal profile" (Zhong 2019).

TYPICAL LANDFILL PROFILES
LINEAR LINE

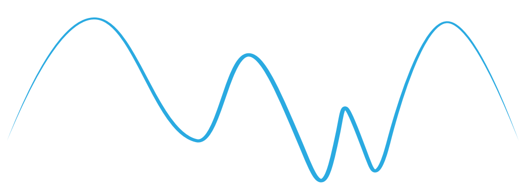
FLAT LINE

OBLIQUE LINE

STEPPED LINE



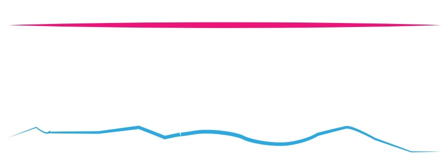
TYPICAL CONTEXT PROFILES
CURVED LINE WITH MULTIPLE UNDULATIONS



DEGREE OF UNEVENNESS

Even, no or few shadow details, appearing in artificial landform surface.

Jagged, rich in shadow details, appearing in natural surface.



4.1.2.2 SIDE SLOPES

FINDINGS:

Comparing the standard deviation (SD) differences in landfill profiles and context profiles of each selected landfill, data revealed that even in these "best examples", the **Context Profiles undulate much more than Landfill Profiles**. **Landfill side slopes also undulate far less than context side slopes** and the selected landfill had moderate or major alteration from natural landform appearance.

However, the landfill profile of Calabasas landfill is slightly higher than its context profile in the west-east direction. Analyzing the line graph of the Calabasas landfill, the natural topography exhibits a gentle undulating profile in the west-east direction, which is similar to the landfill surface undulation, thus, its landfill profile SD and context profile SD are close. While for the same landfill, in the north-south direction, the natural topography has much more undulation compared to the landfill, thus, its context profile SD is a lot higher than the landfill SD. Due to the time limitation, the longitudinal profiles were not scaled up to 1:1, thus, cross landfill comparisons based on SD data was not possible; however, visual observation was used as supplement tool to analyze landfill side slopes.

It was clear from comparing landfill and context profiles that **Landfill Profiles** present in the form of a Linear Line (flat line, oblique line or stepped line) display a linear progression, which indicates the landfill side slope presents a flat, linear surface.

Context Profiles present in the form of a curved line with multiple undulations exhibit a non-linear progression. This shows that the side slopes of the contextual landform present a naturally appearing surface of rugged undulation.

In addition, both Landfill Profiles and Context Profiles tend to **show some degree of unevenness** that will reflect on **more shadow details** on their **side slope surfaces**. However, **Landfill Profiles tend to have a lower degree of unevenness, showing a flat, smooth face with little or no variation.**

DESIGN RECOMMENDATIONS:

According to the findings, **more surface undulation should be introduced to the landfill side slopes** to reduce the visual contrast with the landfill's contextual landform. Supported by findings from the landfill inventory, **undulations on the side slopes could be altered by manipulating the ridgeline and valley network**, which create the "ups and downs" effect on the landfill surface. Increasing the **number** and **degree of undulation** on the landfill ridgelines and valleys can result in more naturally appearing landfill side slopes leading to higher aesthetic quality. In addition, selectively connecting broken ridgelines and valleys can create a smoother landfill surface.

CALABASAS LANDFILL
“LONGITUDINAL PROFILES”

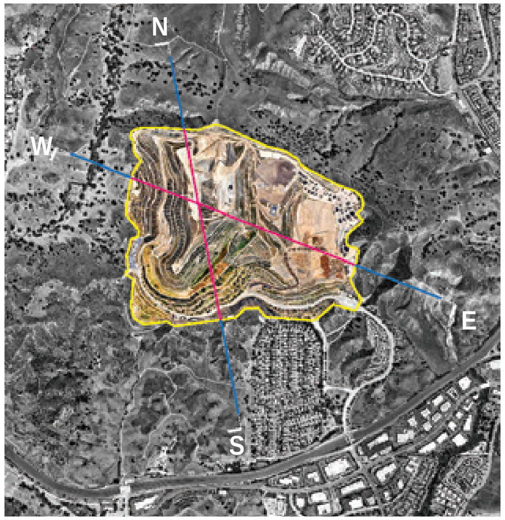
SD SUMMARY CHART

	N-S	W-E	SD DIFFERENCE ACROSS DIRECTIONS
CONTEXT PROFILE SD	2053.51	1777.885	275.625
LANDFILL PROFILE SD	1089.358	1786.415	-697.057
SD DIFFRENCE ACROSS CONTEXT	964.152	-8.53	

[183] SD summary chart of Calabasas landfill “longitudinal profiles“ (Zhong 2020).

SD DATA INTERPRETATION

- landfill profile is more undulating along N-S direction than W-E direction
- along N-S directions, context profile is more undulating than landfill profile
- along N-S directions, context profile is slightly more undulating or has similar degree of undulation with landfill profile



[184] N-S and W-E Cutlines of Calabasas Landfill (Zhong 2019).

N-S LONGITUDINAL PROFILE

[185] N-S Longitudinal Profile of Calabasas Landfill.

W-E LONGITUDINAL PROFILE

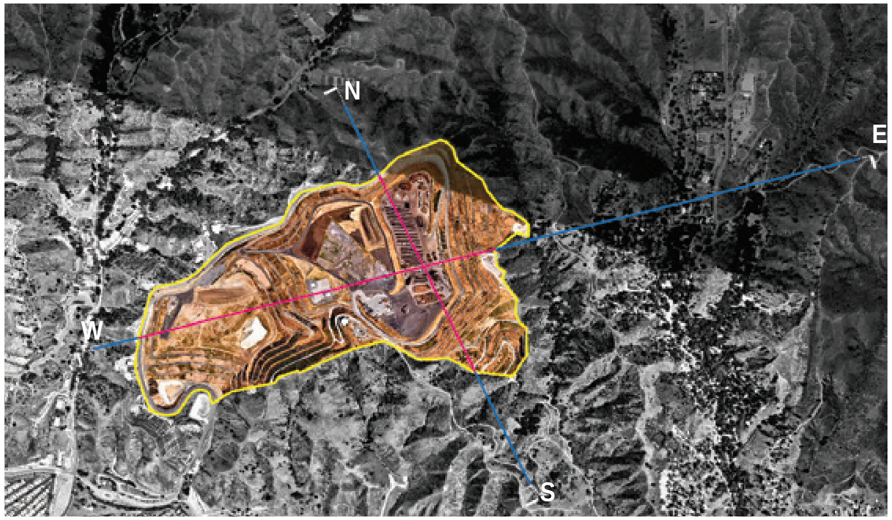
[186] W-E Longitudinal Profile of Calabasas Landfill.

LOPEZ CANYON SANITARY LANDFILL
“LONGITUDINAL PROFILES”

SD SUMMARY CHART

	N-S	W-E	SD DIFFERENCE ACROSS DIRECTIONS
CONTEXT PROFILE SD	1350.956	1782.907	-431.951
LANDFILL PROFILE SD	876.8405	1078.953	-202.1125
SD DIFFRENCE ACROSS CONTEXT	474.1155	703.954	

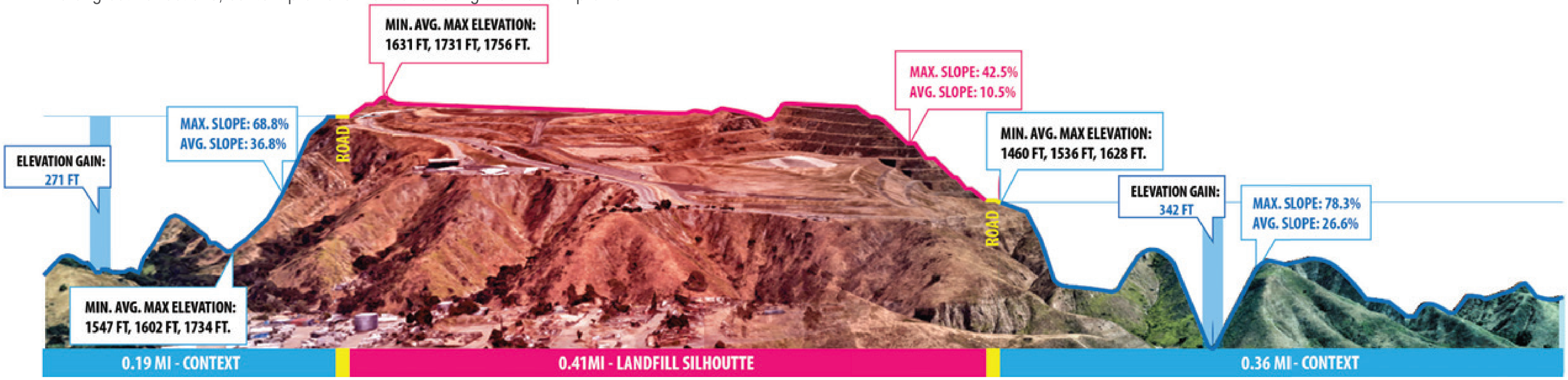
[187] SD summary chart of Lopez Canyon Sanitary landfill “longitudinal profiles“ (Zhong 2020).



[188] N-S and W-E Cutlines of Lopez Canyon Sanitary Landfill (Zhong 2019).

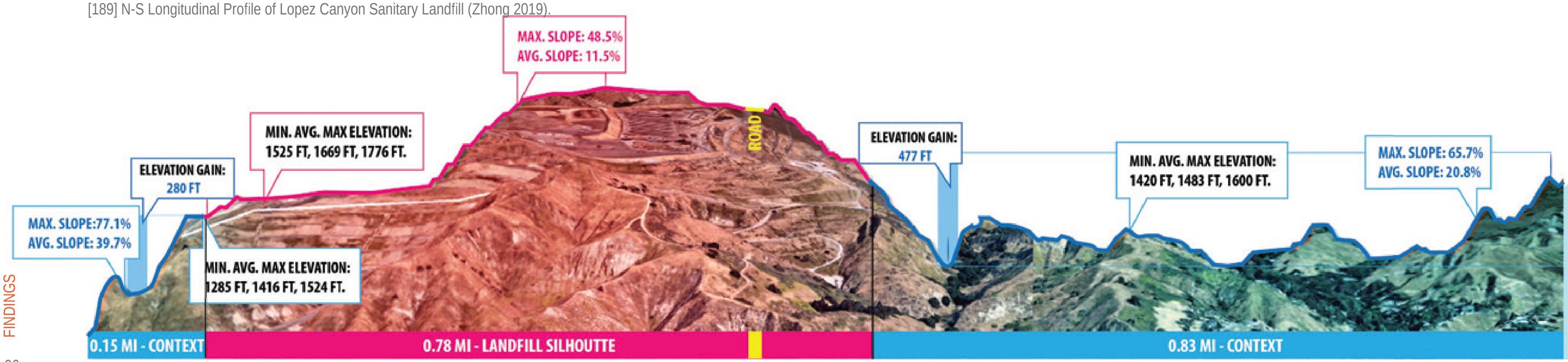
SD DATA INTERPRETATION

- landfill profile is slightly more undulating along N-S direction than W-E direction
- along both directions, context profile is more undulating than landfill profile



N-S LONGITUDINAL PROFILE

[189] N-S Longitudinal Profile of Lopez Canyon Sanitary Landfill (Zhong 2019).



W-E LONGITUDINAL PROFILE

[190] W-E Longitudinal Profile of Lopez Canyon Sanitary Landfill (Zhong 2019).

PUENTE HILLS LANDFILL "LONGITUDINAL PROFILES"

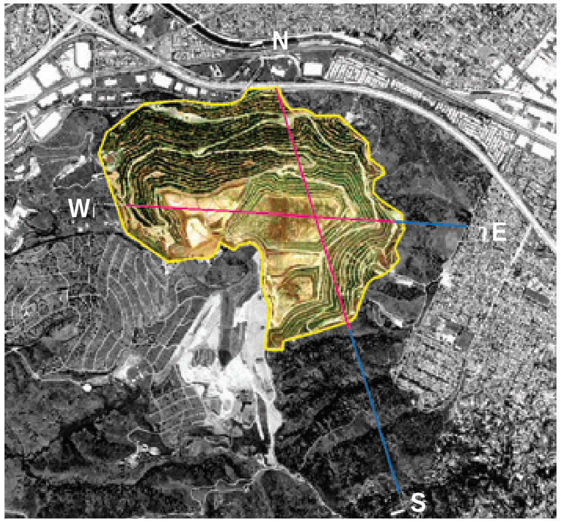
SD SUMMARY CHART

	N-S	W-E	SD DIFFERENCE ACROSS DIRECTIONS
CONTEXT PROFILE SD	1919.619	1350.956	568.663
LANDFILL PROFILE SD	742.6475	876.8405	-134.193
SD DIFFRENCE ACROSS CONTEXT	1176.9715	474.1155	

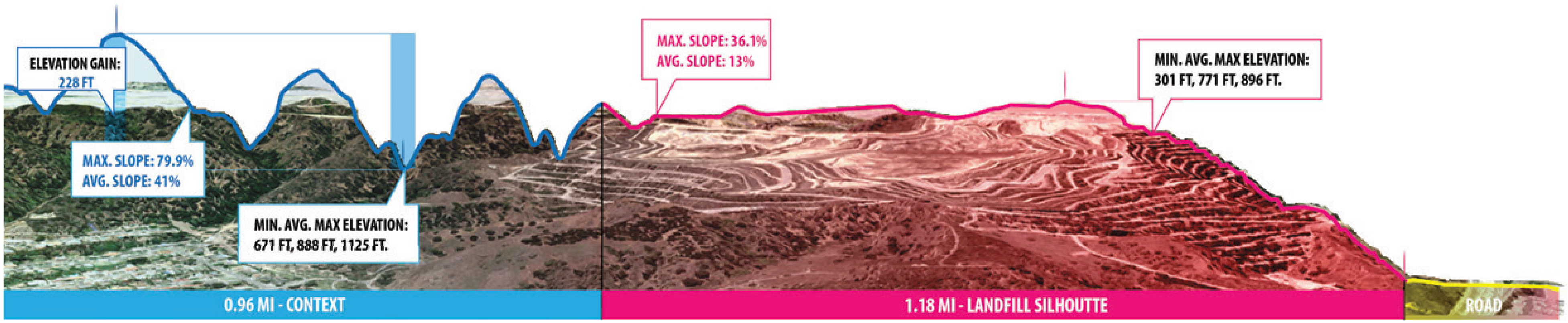
[191] SD summary chart of Puente Hills landfill "longitudinal profiles" (Zhong 2020).

SD DATA INTERPRETATION

- landfill profile is slightly more undulating along N-S direction than W-E direction
- along both directions, context profile is more undulating than landfill profile

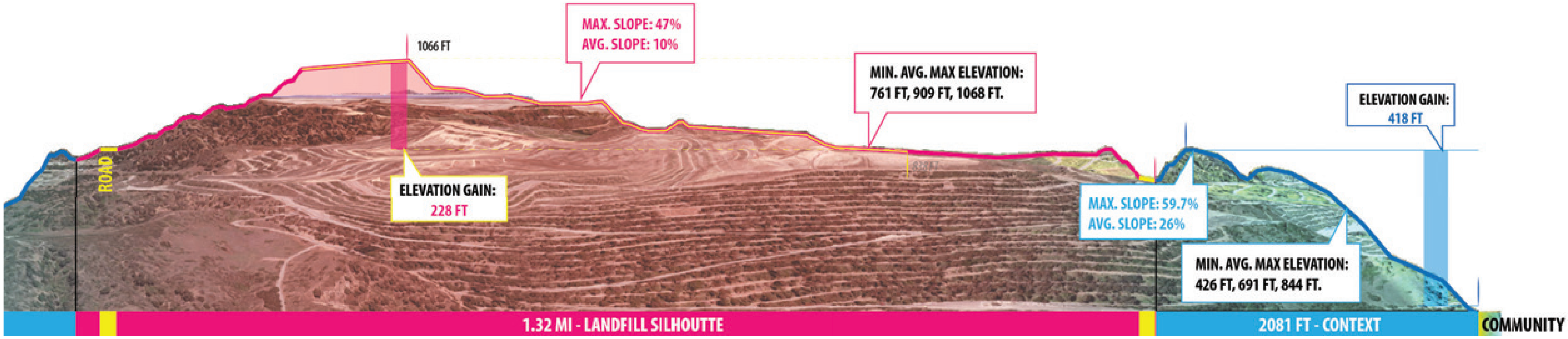


[192] N-S and W-E Cutlines of Puente Hills Landfill (Zhong 2019).



N-S LONGITUDINAL PROFILE

[193] N-S Longitudinal Profile of Puente Hills Landfill (Zhong 2019).



W-E LONGITUDINAL PROFILE

[194] W-E Longitudinal Profile of Puente Hills Landfill (Zhong 2019).

4.1.2.3 TOP DECK

FINDINGS:

Through visual observation and cross-sectional analyses along the top deck areas of the selected landfills, the **Landfill Top Deck Profiles** present a form of linear, stepped, or oblique lines, similar to the landfill profiles. Even though there are significant changes in elevation and slope gradient, these top deck profiles are perceived as **flat, linear, straight lines from far distances**, which also indicates a **flat, geometric top deck area**. In terms of unevenness that is observed along the top deck profiles, the more uneven the top deck surface is, the more details are shown. However, these small-scale undulations are not considered as significant as the large-scale undulations because they are not noticeable from a far distance.

DESIGN RECOMMENDATIONS

Consistent with the findings, **large-scale undulations like rounded caps should be introduced to the top deck area**. In other words, the flat top deck should be modified into **a rounded** (single undulation) form, or multiple rounded forms. In order to achieve this, the **high point elevation** of the final deck might need to be increased to create a better draping effect. In addition, instead of leaving a couple of decks as the landfill closure approaches, the reclamation process should **combine the adjacent decks to create a continuous, smooth surface**.

Summary of "TOP DECK PROFILES"

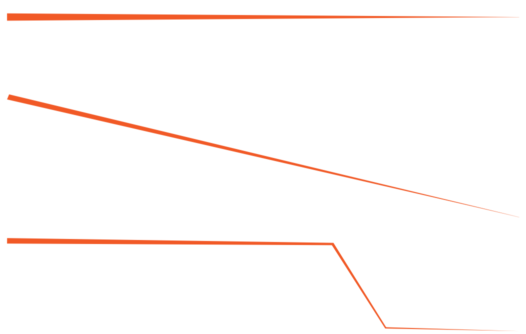
[195] Summary diagram of "top deck profiles" (Zhong 2019).

TYPICAL TOP DECK PROFILES
LINEAR LINE

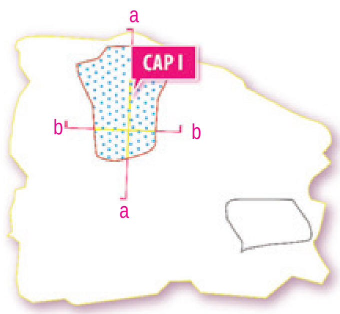
FLAT LINE (from a distance)

OBLIQUE LINE

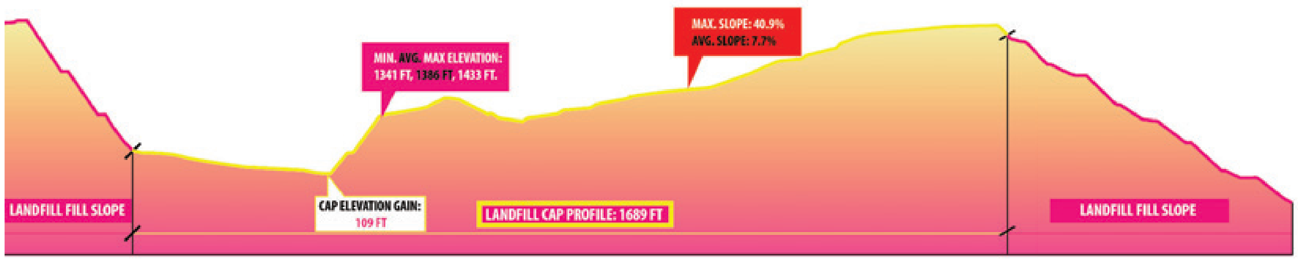
STEPPED LINE



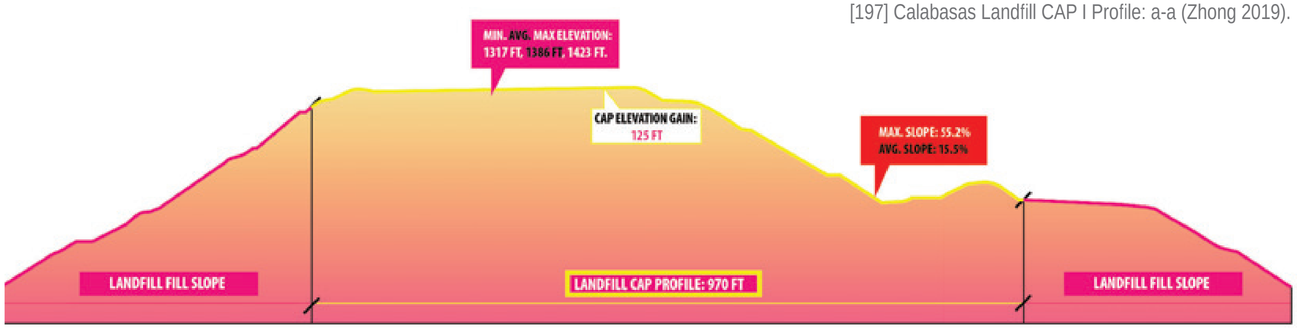
CALABASAS LANDFILL “TOP DECK PROFILES”



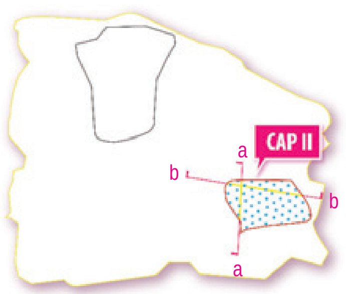
[196] Cutlines of Calabasas Landfill CAP I (Zhong 2019).



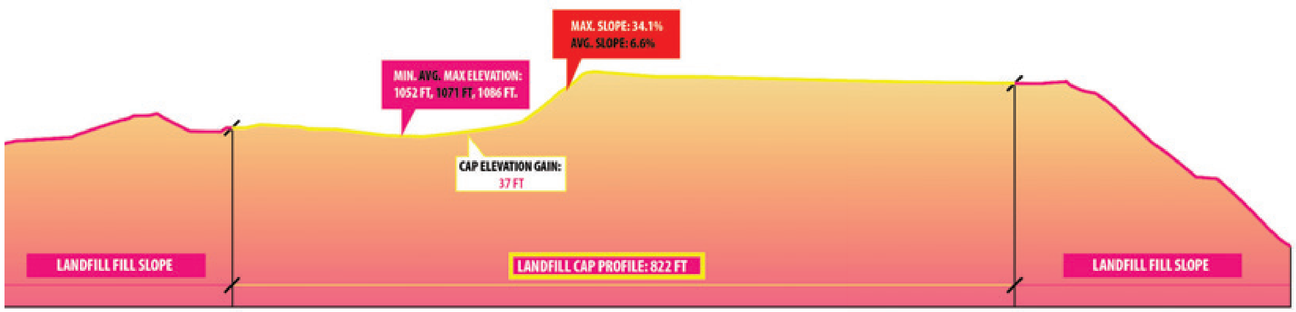
[197] Calabasas Landfill CAP I Profile: a-a (Zhong 2019).



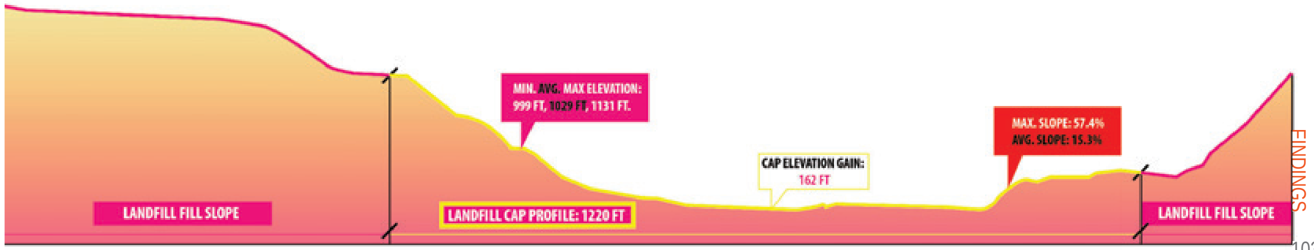
[198] Calabasas Landfill CAP I Profile: b-b (Zhong 2019).



[199] Cutlines of Calabasas Landfill CAP II (Zhong 2019).

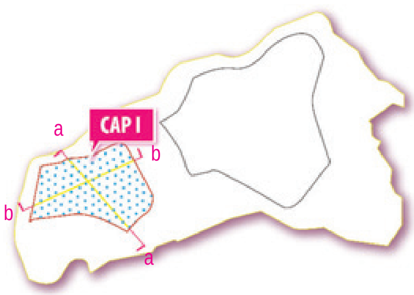


[200] Calabasas Landfill CAP II Profile: a-a (Zhong 2019).

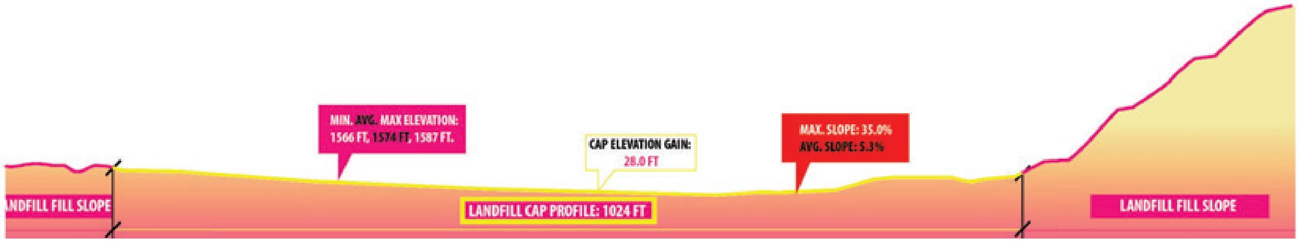


[201] Calabasas Landfill CAP II Profile: b-b (Zhong 2019).

LOPEZ CANYON SANITARY LANDFILL "TOP DECK PROFILES"

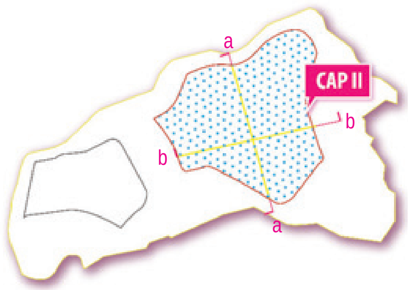


[202] Cutlines of Lopez Canyon Sanitary Landfill CAP I (Zhong 2019).

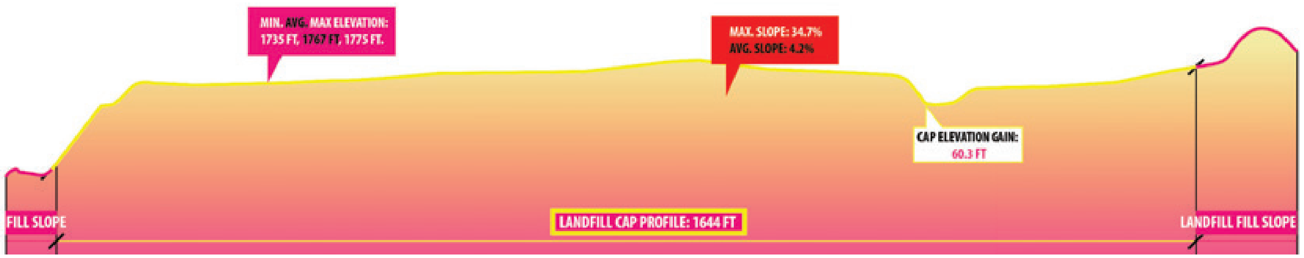


[203] Lopez Canyon Sanitary Landfill CAP I Profile: a-a (Zhong 2019).

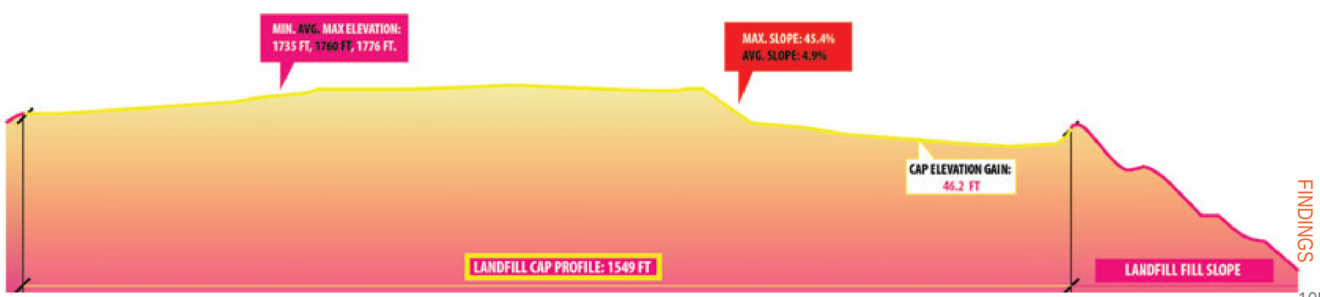
[204] Lopez Canyon Sanitary Landfill CAP I Profile: b-b (Zhong 2019).



[205] Cutlines of Lopez Canyon Sanitary Landfill CAP II (Zhong 2019).

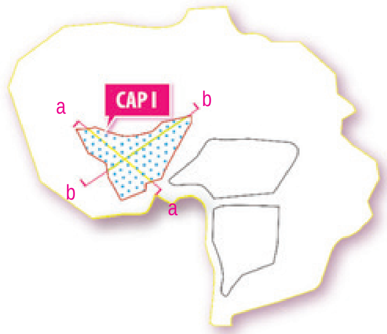


[206] Lopez Canyon Sanitary Landfill CAP II Profile: a-a (Zhong 2019).

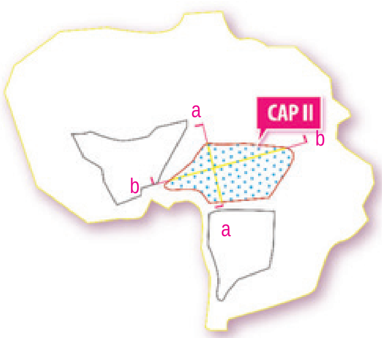


[207] Lopez Canyon Sanitary Landfill CAP II Profile: b-b (Zhong 2019).

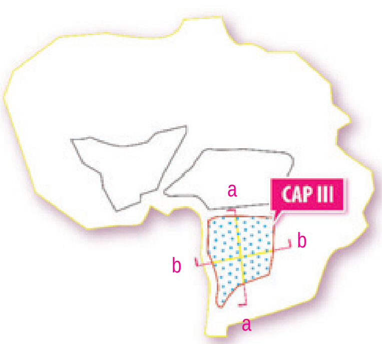
PUENTE HILLS LANDFILL “TOP DECK PROFILES”



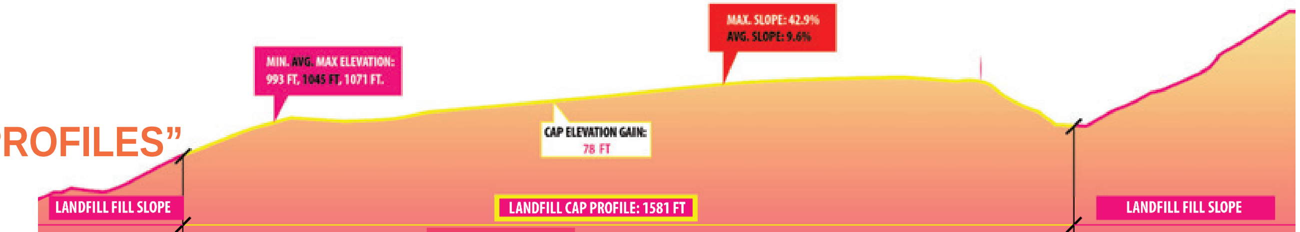
[208] Cutlines of Puente Hills Landfill CAP I (Zhong 2019).



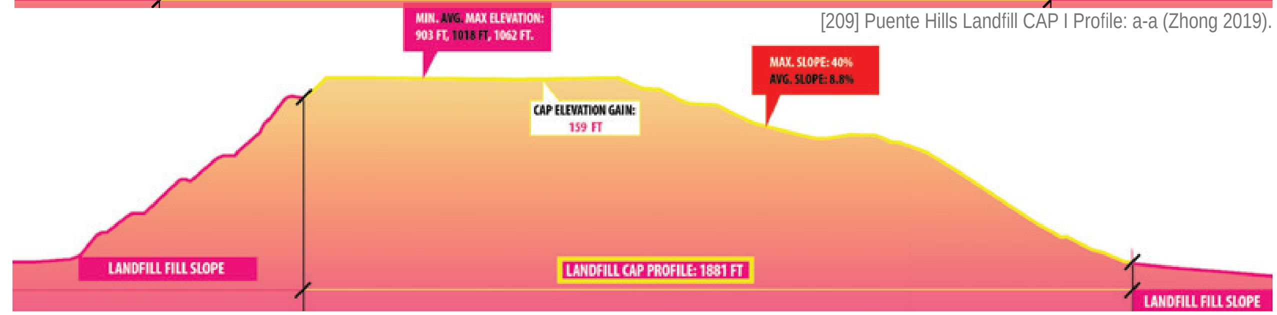
[211] Cutlines of Puente Hills Landfill CAP II (Zhong 2019).



[214] Cutlines of Puente Hills Landfill CAP III (Zhong 2019).



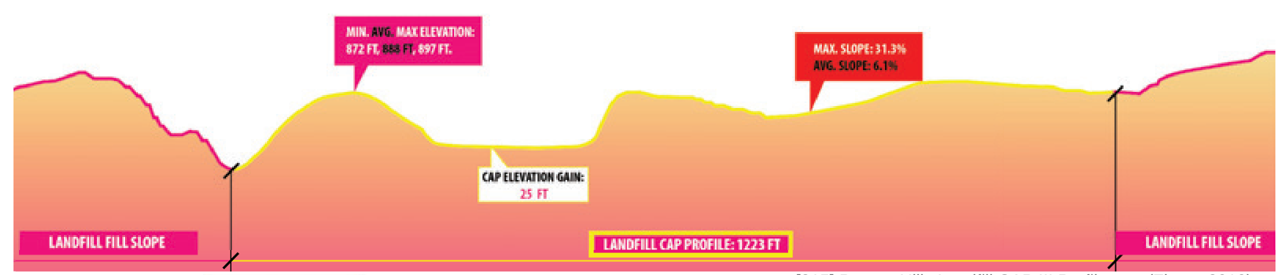
[209] Puente Hills Landfill CAP I Profile: a-a (Zhong 2019).



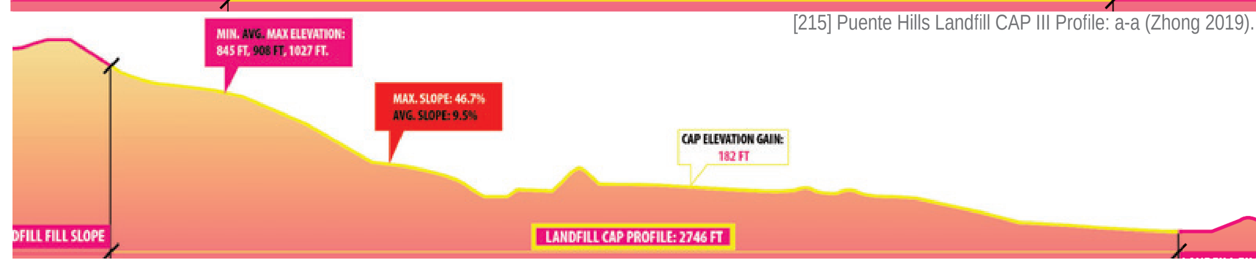
[210] Puente Hills Landfill CAP I Profile: b-b (Zhong 2019).

[212] Puente Hills Landfill CAP II Profile: a-a (Zhong 2019).

[213] Puente Hills Landfill CAP II Profile: b-b (Zhong 2019).



[215] Puente Hills Landfill CAP III Profile: a-a (Zhong 2019).

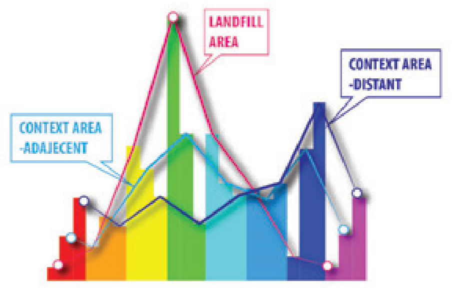


[216] Puente Hills Landfill CAP III Profile: b-b (Zhong 2019).

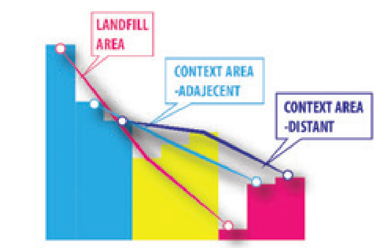
Summary of "SURFACE UNDULATIONS"

• CALABASAS LANDFILL

[217] Data Summary of Calabasas Landfill Slope Aspect: Landfill Area, Context Area-Adjacent, and Context Area-Distant (Zhong 2019).

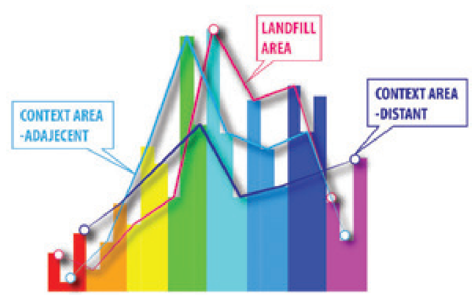


[218] Data Summary of Calabasas Landfill Slope Gradient: Landfill Area, Context Area-Adjacent, and Context Area-Distant (Zhong 2019).

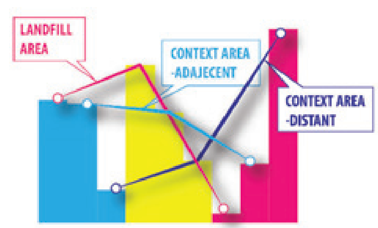


• LOPEZ CANYON SANITARY LANDFILL

[219] Data Summary of Lopez Canyon Sanitary Landfill Slope Aspect: Landfill Area, Context Area-Adjacent, and Context Area-Distant (Zhong 2019).

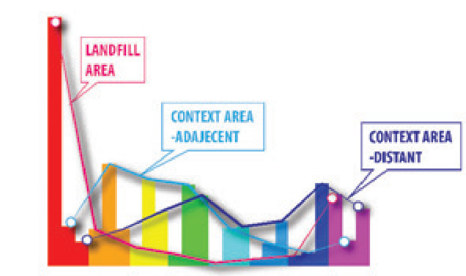


[220] Data Summary of Lopez Canyon Sanitary Landfill Slope Gradient: Landfill Area, Context Area-Adjacent, and Context Area-Distant (Zhong 2019).

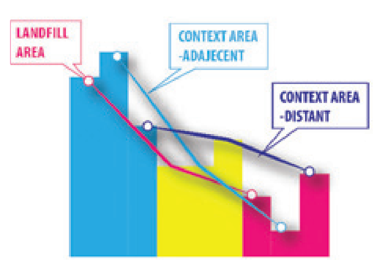


• PUENTE HILLS LANDFILL

[221] Data Summary of Puente Hills Landfill Slope Aspect: Landfill Area, Context Area-Adjacent, and Context Area-Distant (Zhong 2019).



[222] Data Summary of Puente Hills Landfill Slope Gradient: Landfill Area, Context Area-Adjacent, and Context Area-Distant (Zhong 2019).



4.1.2.4 SURFACE UNDULATIONS

FINDINGS

Comparing the landfill slope aspect of each selected landfill, it is obvious that the **spatial distribution of slope aspect within Landfill Area is clustered with one or two dominant and fairly uniform aspects (slope directions), while the spatial distribution of slope aspect within the Context Area is more scattered and varied with very balanced slope aspects**, especially the Distant Context Area. The results indicate that there is big difference in surface undulation between a landfill and its context.

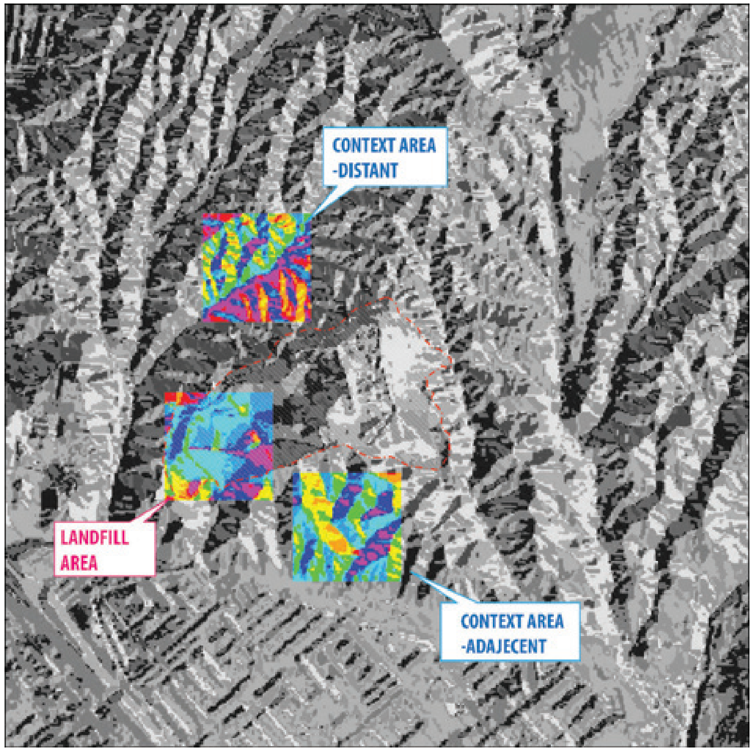
Comparing slope gradients of each selected landfill, it is clear that **Slope gradients are much gentler in the Landfill Area compared to the Context Area**. Around 90% of selected landfill areas have slope gradients located between 0-25%; and 10% of selected landfill areas have slope gradients over 25%. In addition, the **spatial distribution of the same range of slope gradients are similar to slope aspect: it is clustered within landfill areas but are more scattered within context areas**.

.

DESIGN RECOMMENDATIONS

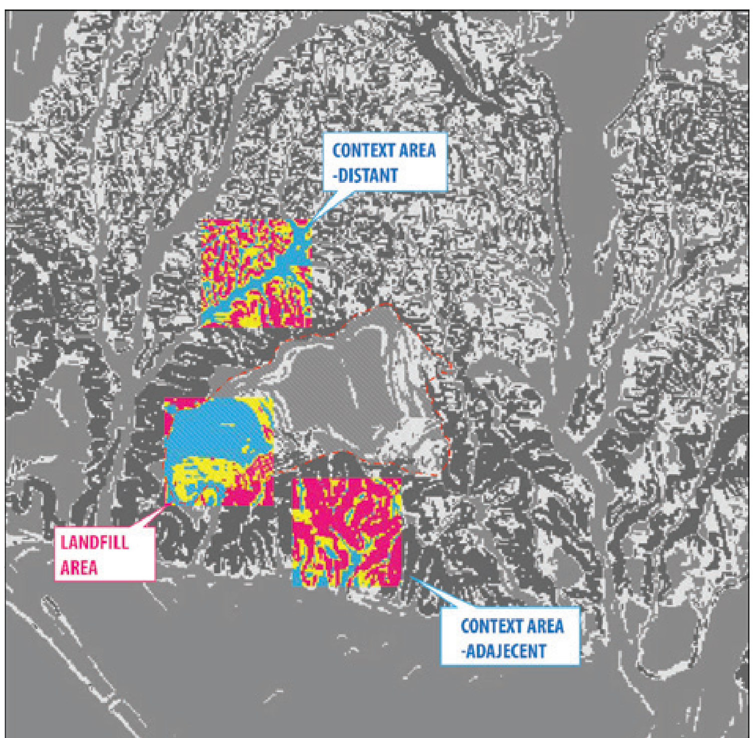
Landfill surface analyses were used as an evaluation tool to assess the degree of undulation across landfill surfaces (including side slope and top deck surfaces), however, the findings indicate that **more surface undulations should be introduced to the landfill surface**. In addition, as the report chose Puente Hills Landfill as the project site, the surface analysis indicates that **special attention should be given to north slopes where heavy surface modification should be implemented** using the breakdown of aspect and gradient percentages to guide modifications to better match the surrounding context.

N: North NE: Northeast E: East SE: Southeast S: South SW: Southwest
W: West NW: Northwest Slope %: 0-15% Slope %: 15-25% Slope %: 25-80%



[223] Calabasas Landfill Slope Aspect: Landfill Area, Context Area-Adjacent, and Context Area-Distant (Zhong 2019).

- N: North
- NE: Northeast
- E: East
- SE: Southeast
- S: South
- SW: Southwest
- W: West
- NW: Northwest

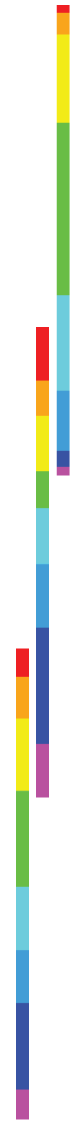


[224] Calabasas Landfill Slope Gradient: Landfill Area, Context Area-Adjacent, and Context Area-Distant (Zhong 2019).

- Slope %: 0-15%
- Slope %: 15-25%
- Slope %: 25-80%

CALABASAS LANDFILL: "SURFACE UNDULATIONS"

SLOPE ASPECT



LANDFILL AREA

- N: 1.80%
- NE: 4.64%
- E: 18.68%
- SE: 36.72%
- S: 20.28%
- SW: 12.76%
- W: 3.36%
- NW: 1.76%

CONTEXT AREA - ADJACENT

- N: 6.16%
- NE: 8.72%
- E: 15.40%
- SE: 20.24%
- S: 13.52%
- SW: 11.24%
- W: 18.32%
- NW: 6.40%

CONTEXT AREA - DISTANT

- N: 11.40%
- NE: 7.52%
- E: 11.56%
- SE: 7.92%
- S: 11.84%
- SW: 13.60%
- W: 24.68%
- NW: 11.48%

SLOPE PERCENTAGE

LANDFILL AREA

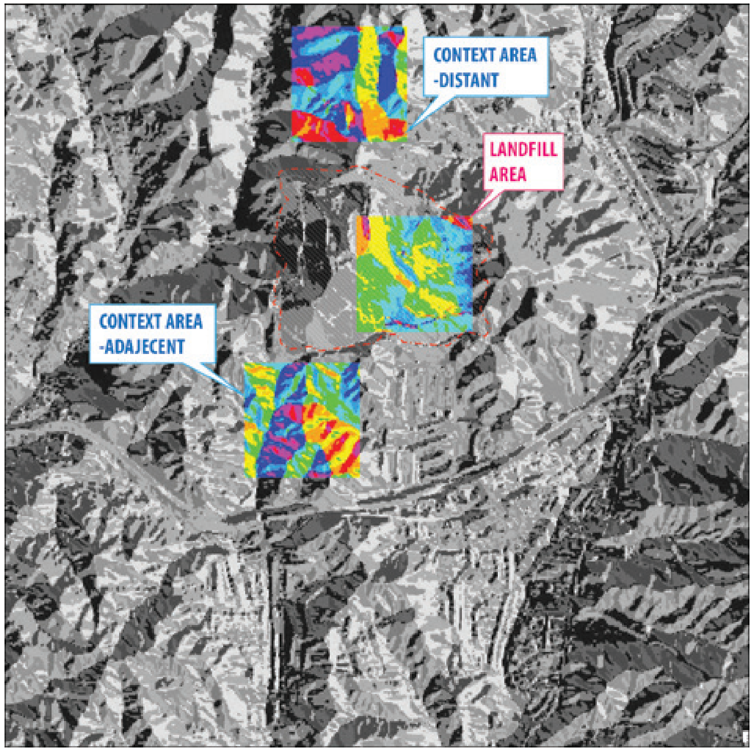
- 0-15% Slope: 67.48%
- 15-25% Slope: 28.48%
- 25-80% Slope: 4.04%

CONTEXT AREA - ADJACENT

- 0-15% Slope: 47.68%
- 15-25% Slope: 33.12%
- 25-80% Slope: 19.20%

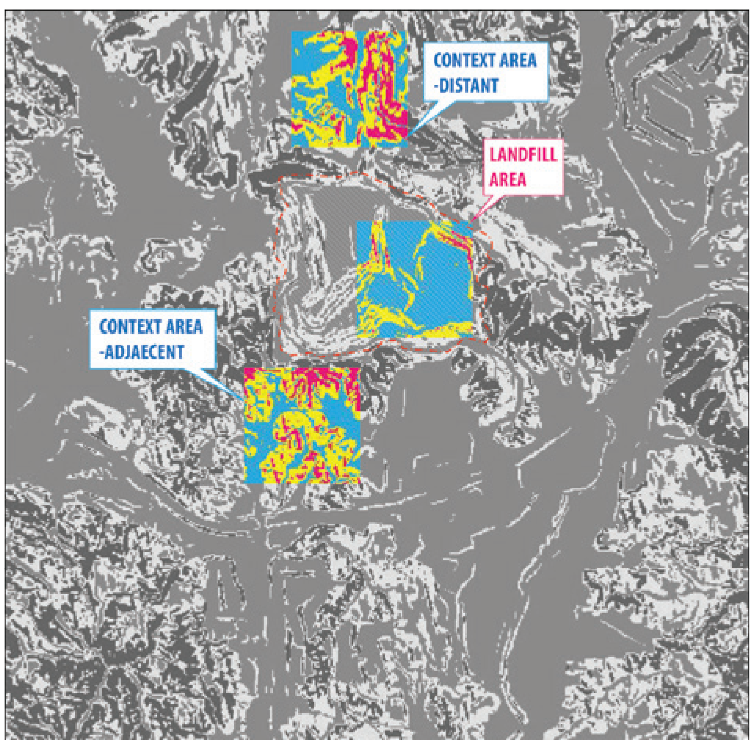
CONTEXT AREA - DISTANT

- 0-15% Slope: 41.28%
- 15-25% Slope: 37.12%
- 25-80% Slope: 21.60%



[225] Lopez Canyon Sanitary Landfill Slope Aspect: Landfill Area, Context Area-Adjacent, and Context Area-Distant (Zhong 2019).

- N: North
- NE: Northeast
- E: East
- SE: Southeast
- S: South
- SW: Southwest
- W: West
- NW: Northwest

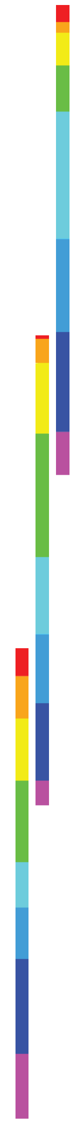


[226] Lopez Canyon Sanitary Landfill Slope Gradient: Landfill Area, Context Area-Adjacent, and Context Area-Distant (Zhong 2019).

- Slope %: 0-15%
- Slope %: 15-25%
- Slope %: 25-80%

LOPEZ CANYON SANITARY LANDFILL: “SURFACE UNDULATIONS”

SLOPE ASPECT



LANDFILL AREA
- N: 3.92%
- NE: 2.20%
- E: 6.84%
- SE: 9.68%
- S: 27.08%
- SW: 19.72%
- W: 21.36%
- NW: 9.20%

CONTEXT AREA - ADJACENT
- N: 0.92%
- NE: 5.00%
- E: 14.92%
- SE: 26.36%
- S: 16.40%
- SW: 14.64%
- W: 16.52%
- NW: 5.24%

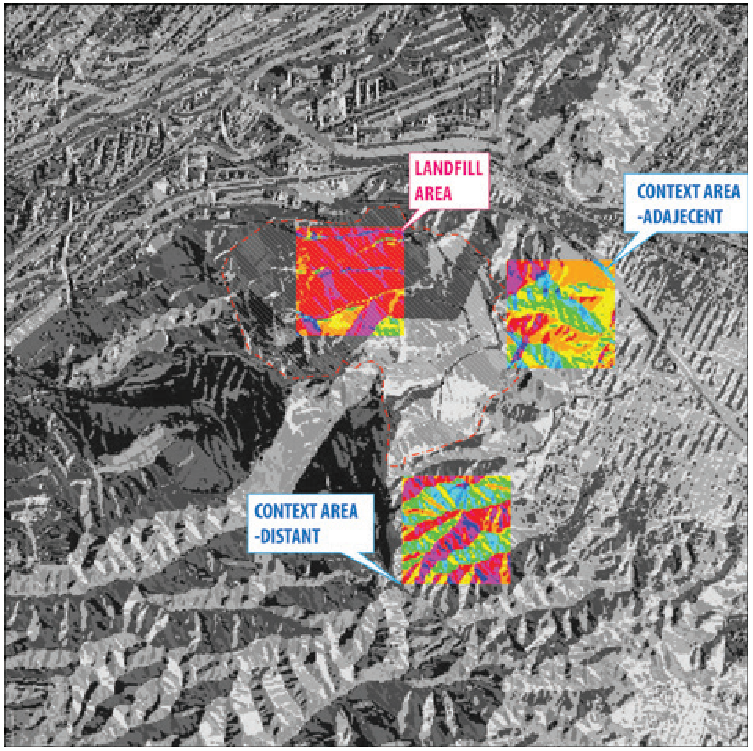
CONTEXT AREA - DISTANT
- N: 5.88%
- NE: 9.00%
- E: 13.20%
- SE: 17.28%
- S: 9.72%
- SW: 10.80%
- W: 20.24%
- NW: 13.88%

SLOPE PERCENTAGE

LANDFILL AREA
- 0-15% Slope: 54.08%
- 15-25% Slope: 27.56%
- 25-80% Slope: 18.36%

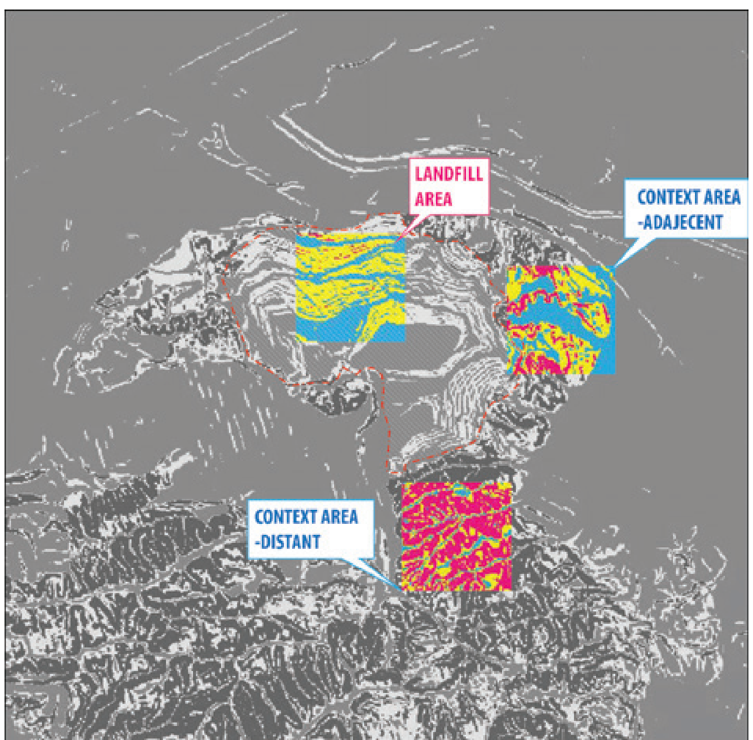
CONTEXT AREA - ADJACENT
- 0-15% Slope: 61.72%
- 15-25% Slope: 27.48%
- 25-80% Slope: 10.80%

CONTEXT AREA - DISTANT
- 0-15% Slope: 39.56%
- 15-25% Slope: 35.40%
- 25-80% Slope: 25.04%



[227] Puente Hills Landfill Slope Aspect: Landfill Area, Context Area-Adjacent, and Context Area-Distant (Zhong 2019).

N: North
NE: Northeast
E: East
SE: Southeast
S: South
SW: Southwest
W: West
NW: Northwest

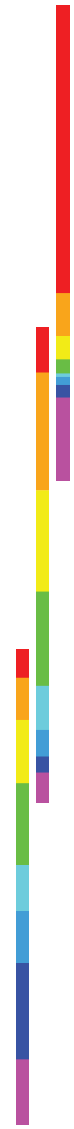


[228] Puente Hills Landfill Slope Gradient: Landfill Area, Context Area-Adjacent, and Context Area-Distant (Zhong 2019).

Slope %: 0-15%
Slope %: 15-25%
Slope %: 25-80%

PUENTE HILLS LANDFILL: "SURFACE UNDULATIONS"

SLOPE ASPECT



LANDFILL AREA

- N: 60.52%
- NE: 8.88%
- E: 5.08%
- SE: 3.00%
- S: 0.81%
- SW: 1.60%
- W: 2.62%
- NW: 17.49%

CONTEXT AREA - ADJACENT

- N: 9.72%
- NE: 24.76%
- E: 21.04%
- SE: 19.80%
- S: 9.28%
- SW: 5.72%
- W: 3.44%
- NW: 6.24%

CONTEXT AREA - DISTANT

- N: 5.88%
- NE: 9.00%
- E: 13.20%
- SE: 17.28%
- S: 9.72%
- SW: 10.80%
- W: 20.24%
- NW: 13.88%

SLOPE PERCENTAGE

LANDFILL AREA

- 0-15% Slope: 42.44%
- 15-25% Slope: 54.28%
- 25-80% Slope: 3.28%

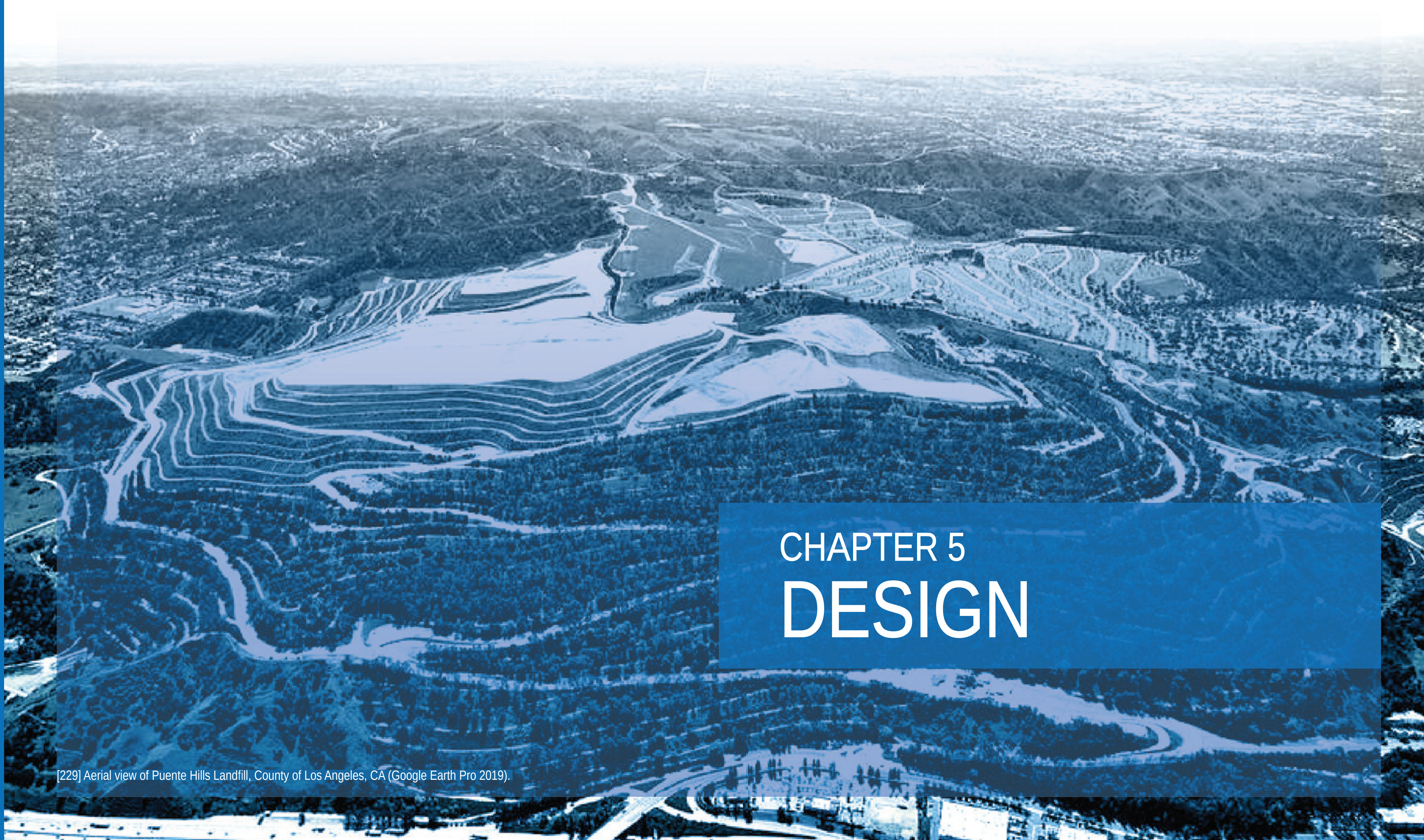
CONTEXT AREA - ADJACENT

- 0-15% Slope: 41.28%
- 15-25% Slope: 38.12%
- 25-80% Slope: 20.60%

CONTEXT AREA - DISTANT

- 0-15% Slope: 11.40%
- 15-25% Slope: 21.72
- 25-80% Slope: 66.88%

CHAPTER 5
DESIGN



[229] Aerial view of Puente Hills Landfill, County of Los Angeles, CA (Google Earth Pro 2019).

Ref. to [35] Study Region in Section 2.5

5.1 The Project Site: Puente Hills Landfill

The Puente Hills landfill was chosen as a project focus for exploring landfill slope contouring and cap options, and rationale for this decision is covered in Section 5.1.1.

Formerly operating as the San Gabriel Valley Dump since 1957, the Puente Hills Landfill was purchased by the County of Los Angeles Sanitation Districts (LACSD), a joint agency of 79 cities back in 1970, and was once considered the largest active landfill in the nation back in 2000 (Kanakri 2007; LACSD 1983; LACSD 2001; Mullen 1993). Puente Hills landfill received roughly one third of the County's daily trash during its operating days (Kanakri 2007; Manaugh & Twilley 2002).

In 2003, after operating for 56 years, the Los Angeles County Board of Supervisors approved a 10-year operating extension and authorized expanding the landfill area by 100 acres (LACSD 2001; Mullen 1993). After reaching its capacity and ultimately reaching a height of 500 feet, Los Angeles County announced in October 2013 that Puente Hills landfill operations would cease. The post-closure plan called for implementation of a 163-acre regional park offering great panoramic views (Waste360 2016).

As once the largest active landfill in the nation, Puente Hills generated a lot of controversy concerning potential environmental issues including aesthetics (LASCD 1982; LASCD 1992; LASCD 2001). Designers of the Puente Hills landfill responded to the public's concern over aesthetics by designing the landfill to higher quality visual standards compared to other surrounding landfills in the Los Angeles vicinity (LACSD 2001).

5.1.1 Rationale for Selecting the Puente Hills Landfill

This project uses the Puente Hills Landfill located in Los Angeles County for exploring landform design beyond current aesthetic standards. The intent of the landfill redesign is to investigate the possibility of re-creating visually enhanced solid waste fill slopes and ridgelines that provide even greater visual compatibility with surrounding natural landforms. Puente Hills Landfill was chosen for the following reasons:

1. Closed Landfill of Higher Aesthetic Quality

As a closed landfill designed to higher visual quality standards than normal and now supporting a successful post-closure park, Puente Hills allowed comparison against a proposed, exploratory design with optimized slope contouring and cap/ridge configuration to see what additional aesthetic benefits might be achievable. Because of the long history of the landfill, many engineering, environmental, and public response documents exist for review.

If a *currently operating landfill* was used, landfill operators might be less inclined to provide base information or cooperate if needed. Operators may have concerns that project results might elevate the public's expectations of visual quality above what was agreed upon in the landfill permit process and cause operational problems. Too much direct contact with landfill staff during research and projective design might also require preparation of a research Internal Review Board (IRB) application required by the university that does not directly align with project goals.

If a *hypothetical site* was used, then the data preparation phase would be longer and require consulting with landfill experts to establish a probable landfill footprint and other technical parameters. Finally, a hypothetical site would not allow the exploratory design efforts to respond to actual site-specific concerns expressed by the public. Whether a closed, currently operational, or hypothetical site was chosen, it was still a project goal to have engineers/landfill experts comment on the feasibility of the exploratory design.

2. Size and Height Prominence

Puente Hills Landfill was once the largest landfill in the nation, with overall operations spread across roughly **1,365-acres** of land, with **622-acre** lands devoted to landfilling. The landfill is located in Puente Hills, in southeastern Los Angeles County near Whittier. The site is east of highly urbanized downtown Los Angeles. Reaching **500** feet above the ground (1,148 feet above mean sea level (msl), this “trash hill” is roughly the height of a forty-story skyscraper. According to Basil Hewitt, a senior engineer from LACSD, “it would be among the twenty tallest skyscrapers in LA, beating our MGM Tower, Fox Plaza and Los Angeles City Hall (LACSD 2001; Manaugh & Twilley 2013, 2; Waste360 2006).”

3. High Visibility and Sensitive Viewers

Puente Hills Landfill is situated at the busy intersection of the **Pomona Freeway (SR 60)** and the **San Gabriel Valley Freeway (I-605)**, where it stretches over 3 miles along the freeways and is very visible by travelers (Mullen 1992; Waste360 2006; LACSD 2001).

From low viewing angles of travelers along the adjacent freeways, they did not see disposal activities on top of the working deck during operational years (particularly in later phases), but continue to have intermittent views of the reclaimed side slopes supporting maturing vegetation (LACSD 2001).

Besides travelers, the landfill is seen at various distances from residential, industrial, and recreational areas found in context of sprawling Los Angeles County development. Residential and recreational viewers are generally considered to be most sensitive to visual changes by most visual assessment methodologies. In terms of total viewers, the former landfill is seen by hundreds of thousands, if not millions of people per day.

4. Adjacent Cultural and Recreational Attractions

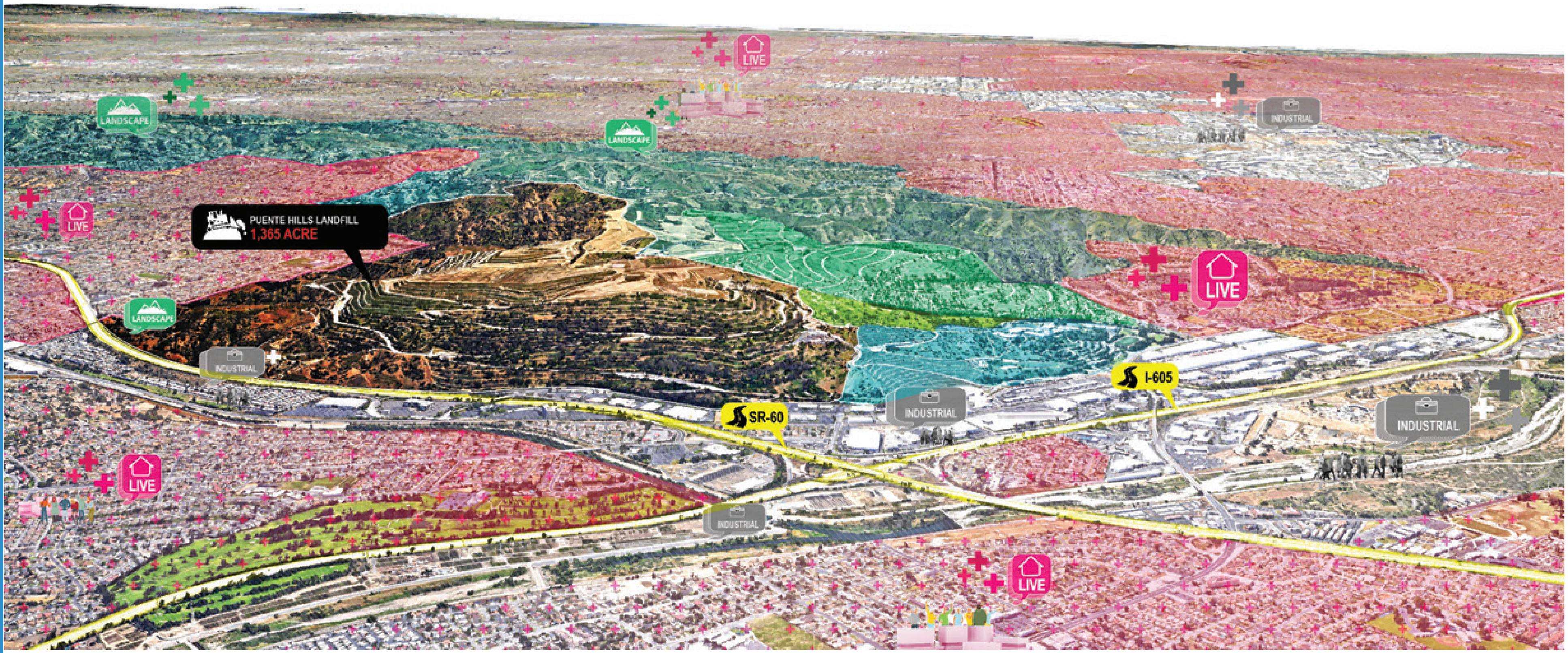
The landfill site is surrounded by several noteworthy cultural and recreational attractions [31]:

Rosehill Memorial Park resides southwest of the landfill. An agreement with the County of Los Angeles Sanitation Districts (LASCD) required that the landfill height not exceed 10-feet above the north-south running ridgeline to prevent landfill activities from being seen (LACSD 2001). Rosehill is a very prominent memorial park in the Los Angeles area and grieving families are considered especially sensitive potential viewers.

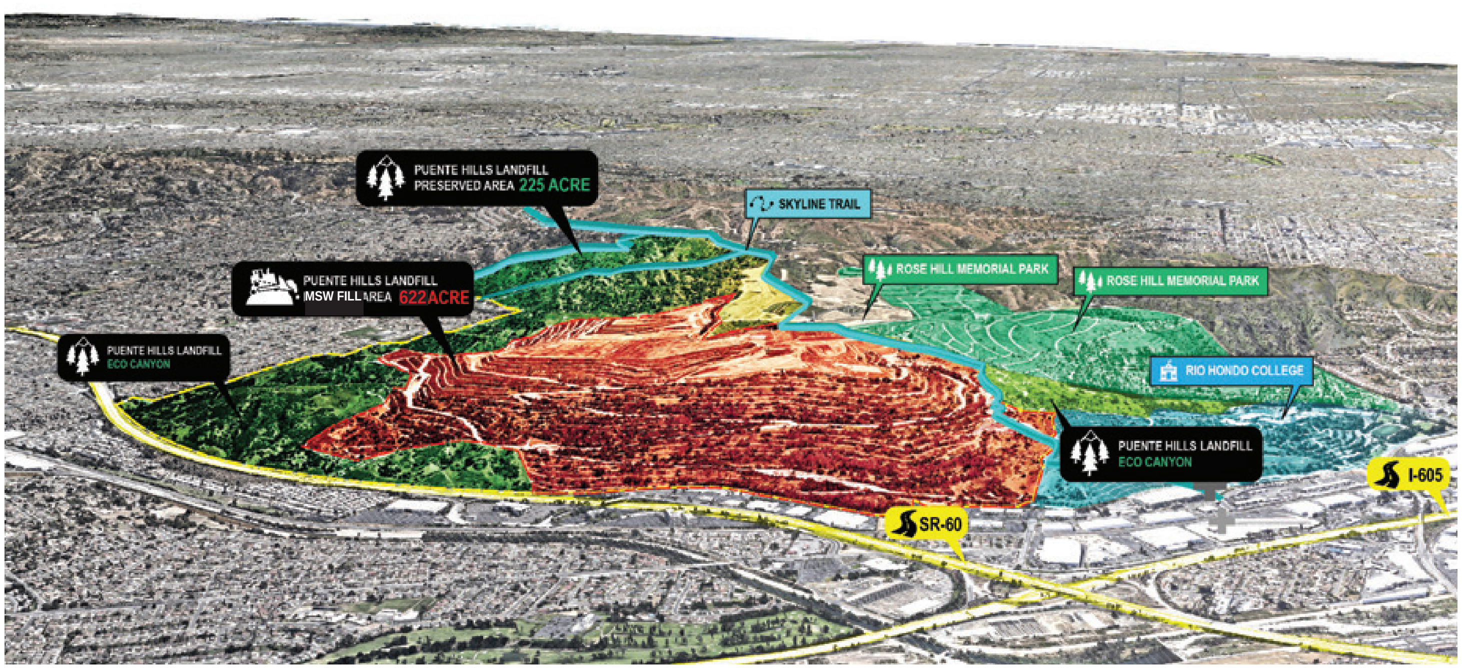
Skyline trail (within the landfill property) follows along Skyline Drive for over four miles within the landfill property, and is used as a popular hiking and equestrian trail.

Rio Hondo College is located in the western foothills area of the Puente Hills Landfill. Ecology Canyon (part of the landfill property) is devoted to study purposes by the college.

Preservation area (within the landfill property) consisting of 225-acres (Canyons 6, 7, and 8) is devoted to protecting wildlife habitat and plant communities and is ecologically significant.



[230] Special Location of Puente Hills: Surrounding landuse and potential sensitive viewers. View is looking southeast (Zhong 2020).



[231] Special Location of Puente Hills: Surrounding important features. View is looking southeast (Zhong 2020).

5. California’s Strict Environmental Policy

California has been the center of the environmental movement after Rachel Carson’s Silent Spring was published in 1962, not to mention the implementation of the California Environmental Quality Act (CEQA) and other environmental restrictions (Fehrenbach 2002). This has created a “pro-environmental political climate and stricter policy over solid waste management in the State of California, whose “waste market is among the world’s largest (Fehrenbach 2002, 1)” Environmental impact assessment documents are required to address aesthetics.

6. Recorded Public Concerns over Landfill Aesthetics

Comments from the Puente Hills Landfill Citizens Advisory Committee (CAC), which was founded in 1981 to provide community input for the Puente Hills Landfill design, advocated for a greater degree of landfill slope contouring to imitate the surrounding mountainous landscape In response to the public’s concern over the landfill appearance, LACSD incorporated increased contour grading in the landfill design proposal as it was stated in the 2003 Environmental Impact Reports for the continued operation of Potential Hills Landfill (LACSD 2001, 3.0-6). The availability of these comments helped identify which visual concerns are most important to the public when considering further grading strategies.

7. Higher Aesthetic Grading Standards than Standard Practice

In addition, comments from the Puente Hills Landfill Citizens Advisory Committee (CAC) was incorporated into the final fill plan for the Puente Hills Landfill design (LACSD 2001). According to senior engineer Basil Hewitt, the final fill plan was designed by the waste engineer from the County of Los Angeles Sanitation District using heavy machinery to create a particular topography, “down to its cell slopes and road pattern, the landfill is an entirely managed and manufactured terrain, a shape calculated in advance and then sculpted, incrementally, with every shift of every machine (Manaugh & Twilley 2013, 3).” As a precedent, **Puente Hills Landfill provides guidance how grading standards can be pushed even further within operational efficiencies**.

5.1.2 Provision of Landfill Grading Standards Useful for Projective Design

Whereas the previous sections established a general knowledge about the project site, this section attempts to collect information that will supplement the projective design which is the subject of this chapter.

Solid Waste Fill Area: The solid waste fill area is approximately 622 acres in which all the landfill operations and material covering processes were happening, as shown on the map created by the Sanitation Districts of Los Angeles County (LACSD 2001, 3.0-2). *Note this fill area served as the design boundary for the projective design and all the surface modifications were maintained within the fill area*.

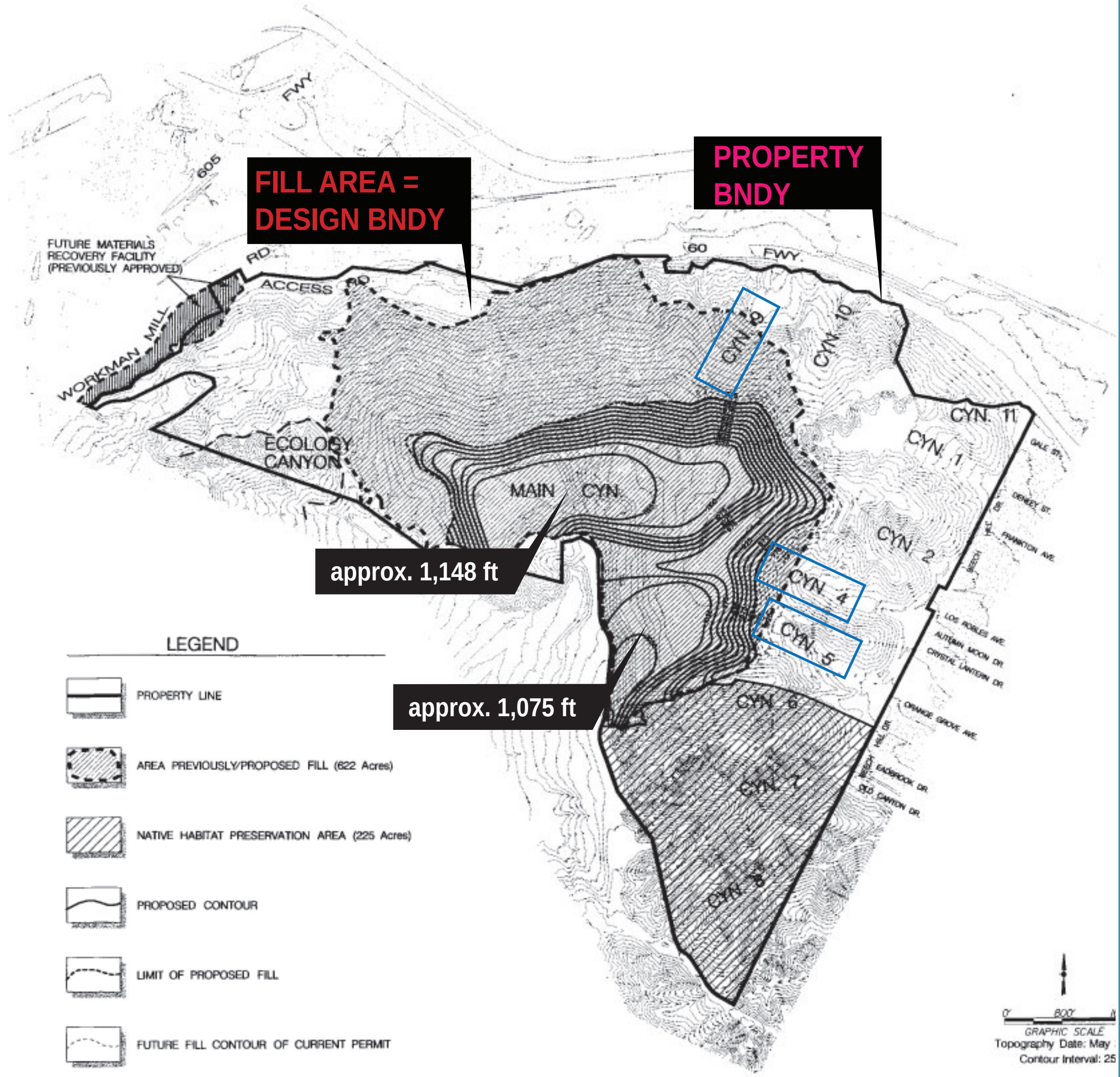
Preserved Areas: Canyons 6,7 and 8 are designated native habitat preservation areas; Ecology Canyon is devoted to Rio Hondo College for educational purpose (LACSD 2001).

Final Elevation: According to documentation, the final height of the main canyon is 1,148 feet above mean sea level (msl), while a portion of the eastern canyon was filled up to the maximum height of 1,075 feet above msl, however, this project used DEM data to determine the heights of different areas.

Final Deck area: The final deck area of Puente Hills Landfill is graded to a “continuous slope to convey rainwater run-off toward storm water collection facilities and to prevent the ponding of water on the deck (LACSD 2001, 3.0-9).” From a distance, however, the final deck area appears “flat”.

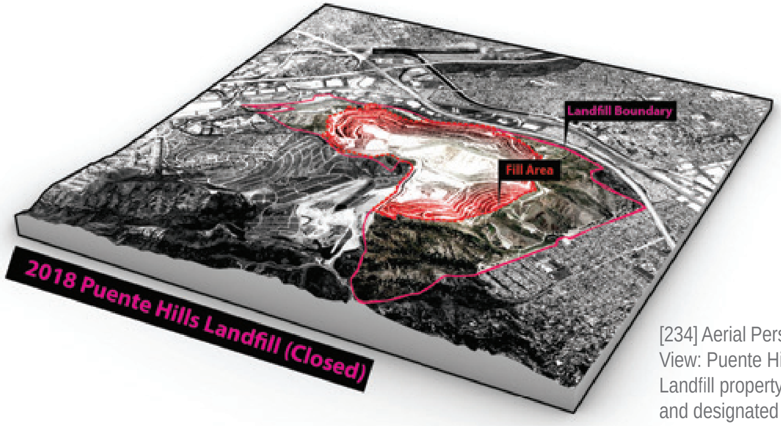
Solid Waste Fill Slopes and Cover Materials: A minimum thickness of 7-foot soils were placed on the final finished front face of the solid waste fill slopes and maintained an overall 2:1 final capped fill slope (LACSD 2001, 3.0-9). In addition, every 40 feet added to the landfill height, required a 15-foot wide bench constructed to improve slope stability and drainage, as well as providing maintenance access.

On-site Drainage: According to LASCD, “Runoff is controlled in permanent storm water/sedimentation basins at the mouths of Canyons 4, 5, 9 and the Main Canyon. As landfilling operations progress and filling advances up the canyons, permanent and temporary drainage facilities were installed to provide adequate control of surface water runoff from unfilled areas around the active area of the landfill (LACSD 2001, 1.0-13).”



[232] Puente Hills Landfill: 2003 Proposed Fill Plan (LACSD 2001).

[233] Aerial View: Puente Hills Landfill property line and designated fill area (Zhong 2020).



[234] Aerial Perspective View: Puente Hills Landfill property line and designated fill area (Zhong 2020).

5.2 Projective Design

Guided by design recommendations from Chapter 4: Findings on how to alter the landform to increase the landfill VQ, this chapter introduces **different modified surfaces** of the existing closed Puente Hills Landfill and estimates the **capacity gain and loss**. The most suitable landfill surface with the enhanced landform VQ and optimized fill volume was selected from many iterations

The Projective design combined with a **two-phase design process**, one termed "*Backward Projection*", proposed **rigorous, geometric landfill surface model** to present how a typical landfill appears and to study the associated capacity gain. The other model termed "*Forward Projection*," proposed a more **natural-like landfill surface** with higher Landform VQ. During the "Forward Projection" design process, the author created multiple iterations using both Manual Modeling (manual modifications) and Parametric Modeling (automated modification).In addition, capacity gains/losses were calculated at the end for comparison. Note that all modifications did not exceed the design boundary/ designated fill area.

After both design processes were completed, the projective design then progressed to the **analysis and comparison phase**, during which, volume capacity, overall visibility and visual attributes of all the proposed surfaces were analyzed and compared to understand the proposed landfills' visual characteristics and the volume capacity. At the end, the author synthesized the results and summarized the pros and cons of each proposed landfill surface, and eventually selected one to recommend as the most suitable landfill that will maximize landfill aesthetics while optimizing volume capacity.

5.2.1 Landfill Modeling Process

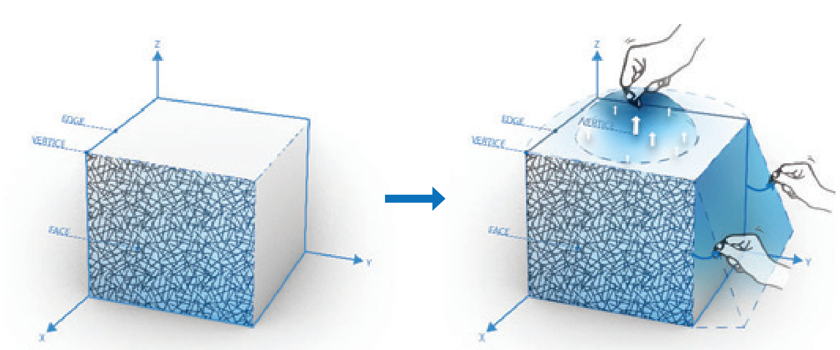
1. Reference landfill surface

The landfill modeling method used a **reference surface approach** where the proposed landfill was modified based upon the existing reference landfill surface.

Two different reference surface were used: one is the **1950 reference surface**, which depicts existing conditions before Puente Hills landfill operations began, and the other is the **2018 reference landfill surface** which depicts the landfill configuration at the time of closure. The author used Autodesk Civil3D software to trace the 1950 landfill contours (25-foot interval) retrieved from the USGS Historical Topographic Maps collection and imported into Rhino3D computer modeling software to create the 1950 landfill surface model. The 2018 landfill contours (20-foot interval) were downloaded through the same USGS website and used to create the 2018 landfill surface model.

2. Visual attribute as control parameters

Three-dimensional geometry consists of three dimensions expressed as "length, width and height", and features composed of "faces, edges, and vertices". Applied to landfills, "face and edge" features correspond to **side slopes, final top deck, and ridgelines or valley flowlines**. Thus, the author manipulated faces, vertices, and edges as **control parameters** to "sculpt" the landform.



[235] Manipulating a three-dimensional geometry by altering its geometry attributes face, vertices, and edge (Zhong 2020).

3. Landfill surface modification method

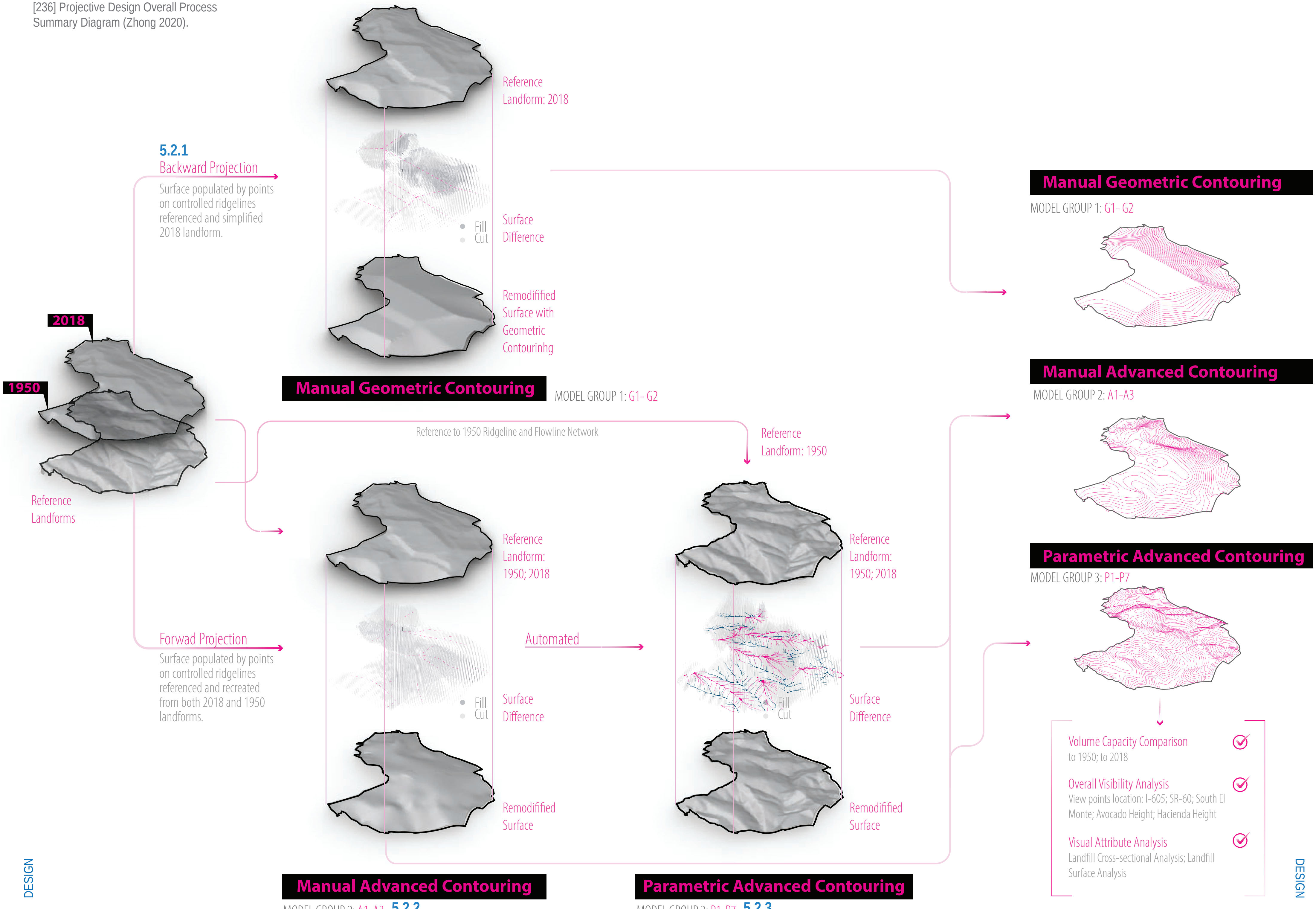
3-1 Interactive Modeling/Free-form Sculpturing

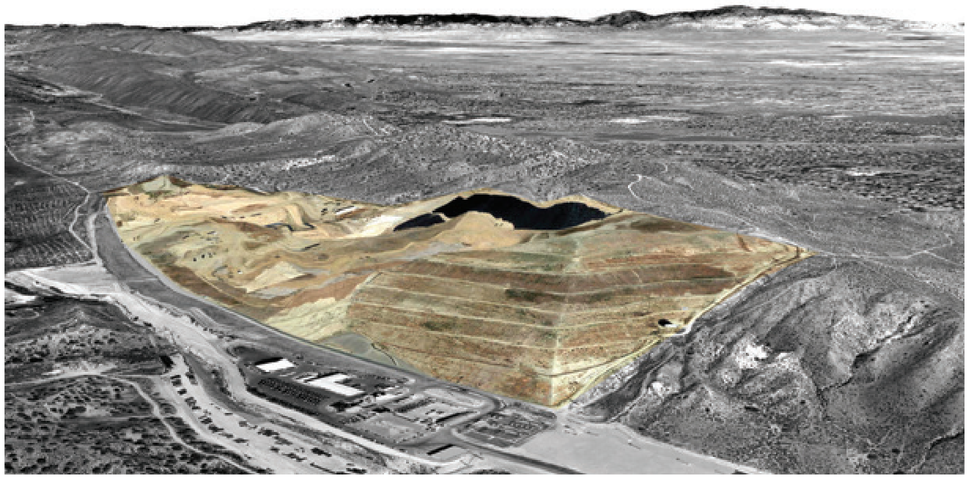
In this approach, reference landfill surfaces were **manually modified** in Rhino3D through control points on the surface to allow modification of **ridgelines, flowlines and the final top deck**. This approach allowed the author to manipulate the landfill surface interactively and instantly see the modified results. However, this approach highly relied on author's aesthetic perception and general understanding of engineering requirements for the landfill design.

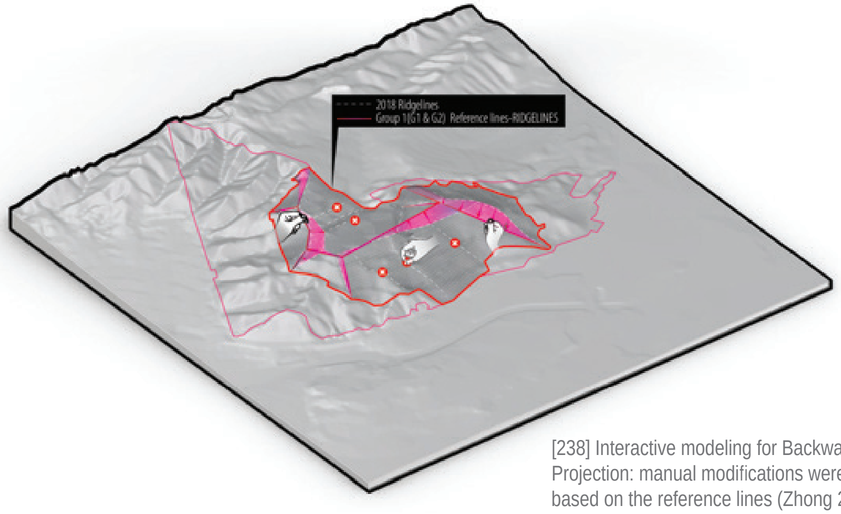
3-2 Parametric Modeling

In this approach, reference landfill surfaces were **automatically modified** in Rhino3D through setting the value of **different parameters** to control the landfill surface in Grasshopper, a built-in plugin in that uses a visual scripting language to support parametric design (Robert McNeel & Associates 2020). This approach required extensive research and testing to first develop the parametric script (Appendix IV). Using a "seed" framework of ridgelines and flowlines patterned after the original 1950 topography, the author manipulated the script parameter sliders to adjust the complexity of the ridgeline/flowline framework to control the resulting surface. This allowed multiple landform surface iterations to be quickly generated, while reducing errors associated with manual techniques. Additionally, this technique allowed rapid automated volume comparisons and visibility mapping. However, this approach relied heavily on the author's understanding of the relationship between the control parameters and landfill aesthetics, and knowledge of Grasshopper.

[236] Projective Design Overall Process Summary Diagram (Zhong 2020).




[237] Angled side of the Antelope Canyon Landfill, CA (Google Earth Pro 2020).



[238] Interactive modeling for Backward Projection: manual modifications were made based on the reference lines (Zhong 2020).

Manual Geometric Contouring

Group 1 Model #: G1, G2 (2 in total)

5.2.2 Backward Projection

Backward projection aims to create a **typical** landfill configuration with low landform VQ (for example, the Antelope Valley Landfill on the left) that tends to be **more geometric** that contrasts with the surrounding canyons in order to achieve a **higher landfill capacity** but **lower landfill aesthetics.** Backward Projection was done to establish a "worst case" baseline of maximum capacity (but low visual quality) to compare against the optimized results to be generated in the Forward Projection sculpting process.

In reference to the Chapter 4: Findings, landfills with low landform VQ tend to present a **flat side slope, flat final top deck, and angled edges (major slope turns and ridgelines)**.Two different sets of reference ridgelines were created based on the existing 2018 reference surface ridgelines, which enforce the angled sides and guided the manual modification on the 2018 reference landfill surface to achieve the visual characteristics mentioned previously. Each set of iterations focus on different visual attributes.
The author first analyzed the ridgeline and valley network of the 2018 reference surface and then manipulated the network (delete, add, reshape) in order to present the visual attributes with a different design intent. During the Backward Projection, two landfill surface were created: one named **Manual Geometric Contouring** (G1), which is more extreme and presents a more geometric shape, and one named **Manual Geometric Contouring** (G2), which is more neutral compared to G1, but is still geometric compared to the 2018 reference surface.

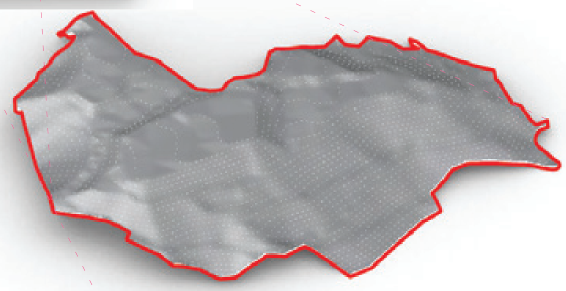
Surface Names: *Manual Geometric Contouring #1 and #2* (G1, G2)
Reference landfill surface*: 2018 surface*
Visual attributes as control parameter*: side slope, top decks, ridgelines*
Landfill surface modification method*: interactive modeling (manual modification)*

2018 Reference Surface

Surface Visual Characteristics:

- 3 relatively flat top decks
- roughly 9 relatively flat side slope (faces)
- countable nearly linear ridgelines (edges)
- no obvious valleys on side slope surface
- some degree of undulation can be observed on the side slope surface

[239] 2018 Contour map and cutout surface of the 1950 and 2018 Puente Hills Landfill surface (Zhong 2020).



1950 Reference Surface

Surface Visual Characteristics:
- natural landform
- steep and naturally appearing undulating side slopes
- considerable dissection and sharp ridgelines
- considerable valleys running parallel to the primary ridgelines

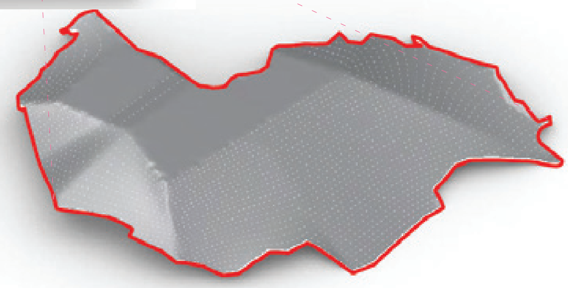
Manual Geometric Contouring #1 (G1)

Surface Visual Characteristics:
- 2 flattened top decks
- 6 flat side slope(faces)
- 5 straight, linear ridgelines (edges)

Comparison to 2018 reference surface:
- Straight, linear ridgelines
- Reduced steepness
- Eliminated side slope undulation
- Eliminated surface drainageways

Comparison to G2: more extreme geometric compared to G2

[240] Contour map and cutout surface of modified landfill surface G1 (Zhong 2020).



Manual Geometric Contouring #2 (G2)

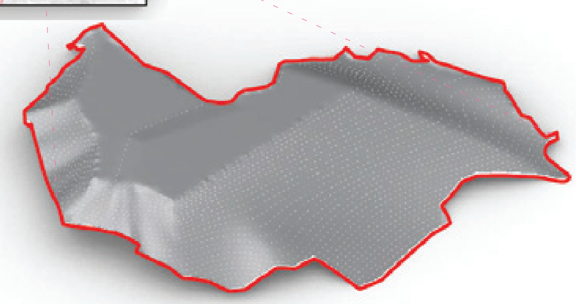
Surface Visual Characteristics:
- 2 flattened top decks
- 8 flat side slope(faces)
- 8 straight, linear ridgelines(edges)

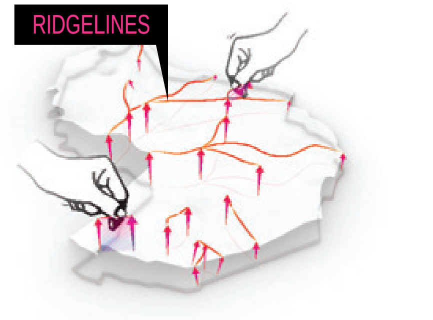
Comparison to 2018 reference surface:
- Straight, linear ridgelines
- Reduced steepness
- Reduced side slope undulation
- Reduced surface drainageways

Comparison to G1

Side slope height of G2 is set lower than G1 and similar to Manual Advanced contouring

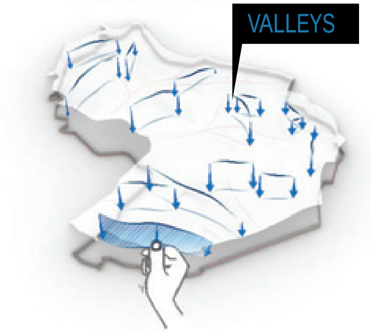
[241] Contour map and cutout surface with of modified landfill surface G2 (Zhong 2020).





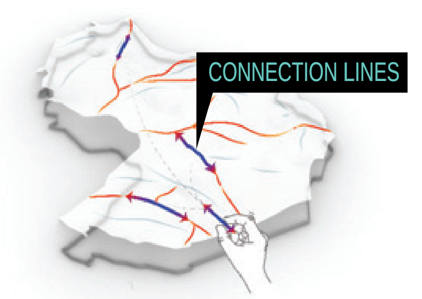
01 RIDGELINES

Surface is manipulated by **ridgelines** with **upward force**.



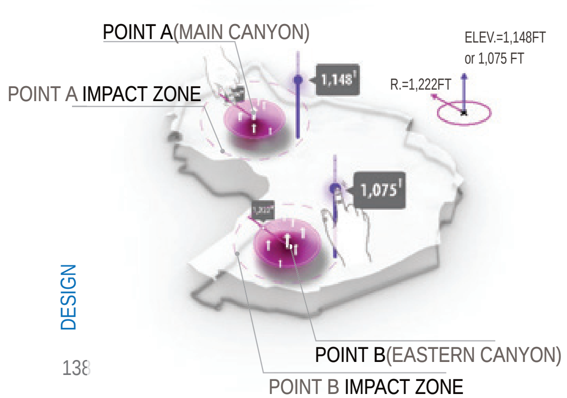
02 VALLEYS

Surface is manipulated by **valleys** with **downward force**.



03 CONNECTION LINES (optional)

Connection lines are added to **connect** the existing **ridgelines** and **valleys** to create a more smooth, natural surface, which can become either ridgelines or valleys.



04 HIGHT POINTS AND IMPACT ZONE

Impact zone is generated center in high point (A or B) with an **adjustable radius**, points within the impact zone affected by the **adjustable elevation of the high points**.

[242] Design Parameters that are used to alter the reference landfill surface in Forward Projection (Zhong 2020).

Manual/ Parametric Advanced Contouring

Group 2 Model #: A1- A3 (3 in total); Group 3 Model #: P1-P7 (7 in total)

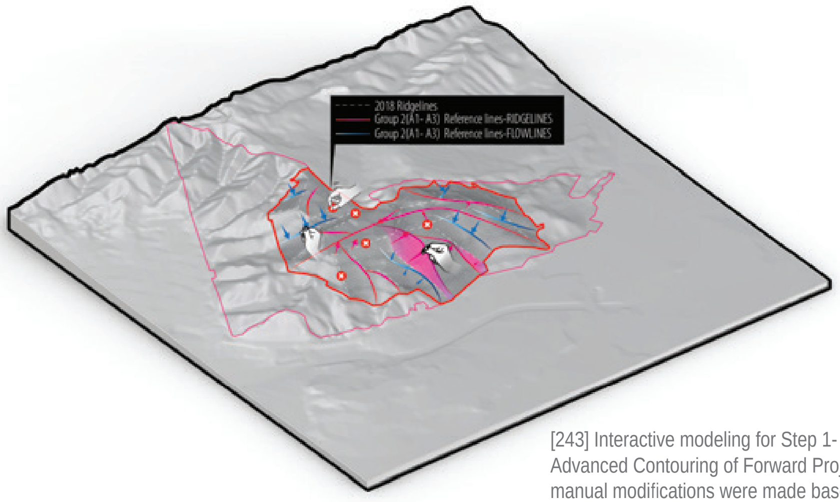
5.2.2 Forward Projection

In reference to the Chapter 4: Findings, landfills with High landform VQ tend to present **undulating side slopes, a rounded top deck, and undulating ridgelines and valleys (drainageways)**. During the *Forward Projection*, the author experimented with two different landfill surface modification methods: interactive modeling and parametric modeling.

Although the surface modification methods are different, the design thinking involved is similar: in order to increase the landfill aesthetics, the control parameters are modified according to the **design recommendations** from Chapter 4: Findings:

Ridgelines and valleys: remove, add, and reshape to manipulate the landform.
Side slopes: manipulate ridgelines and valleys to increase branch numbers and undulations to introduce side slope surface undulation.
Working/Final top deck: reduce flatness, connect with the primary ridgelines to create a more cohesive, natural landform.

From the design recommendations, the author developed some **design parameters** for generating the *enhanced landfill surface* including **ridgelines, valleys, connection lines, high points** and their **impact zones**.



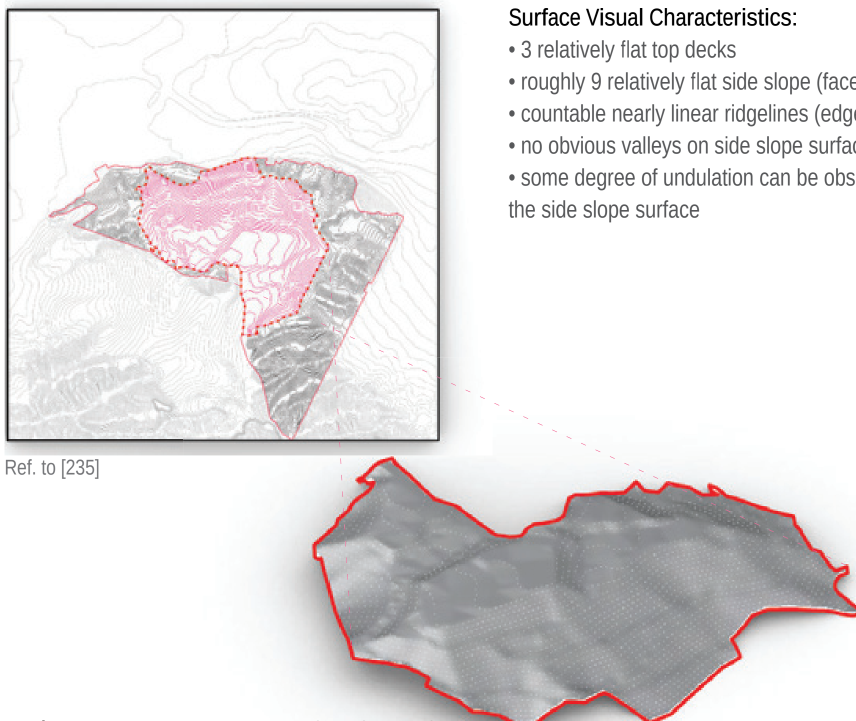
[243] Interactive modeling for Step 1- Manual Advanced Contouring of Forward Projection: manual modifications were made based on the reference lines (Zhong 2020).

5.2.2.1 Manual Advanced Contouring

Interactive modeling is used to create precise modifications on landfill visual attributes that are based on the 2018 reference surface and the results are visually similar while achieving the design requirements. Same as the surface modification method in backward projection, the author first analyzed the ridgelines and valley network of the 2018 reference surface and then manipulated the 2018 ridgeline and valley network (***remove, add, reshape***) to present the visual attributes with a different design intent. The landfill surfaces created using interactive modeling is named Manual Advanced Contouring #1 (A1), a neutral surface that achieved the design intent previously mentioned. Manual Advanced Contouring #2 (A2), is a more extreme surface that achieved all the design intent mentioned above while introducing more surface modifications on landfill visual attributes. Manual Advanced Contouring #3 (A3), is a landfill surface with the design intent of increasing landfill visual aesthetics while increasing landfill volume capacity.

Surface Names: *Manual Advanced Contouring #1, #2 and #3* (A1, A2, A3)
Reference landfill surface*: 2018 surface*
Visual attribute as control parameter*: side slope, top decks, ridgelines, valleys*
Landfill surface modification method*: interactive modeling (manual modification)*

2018 Reference Surface

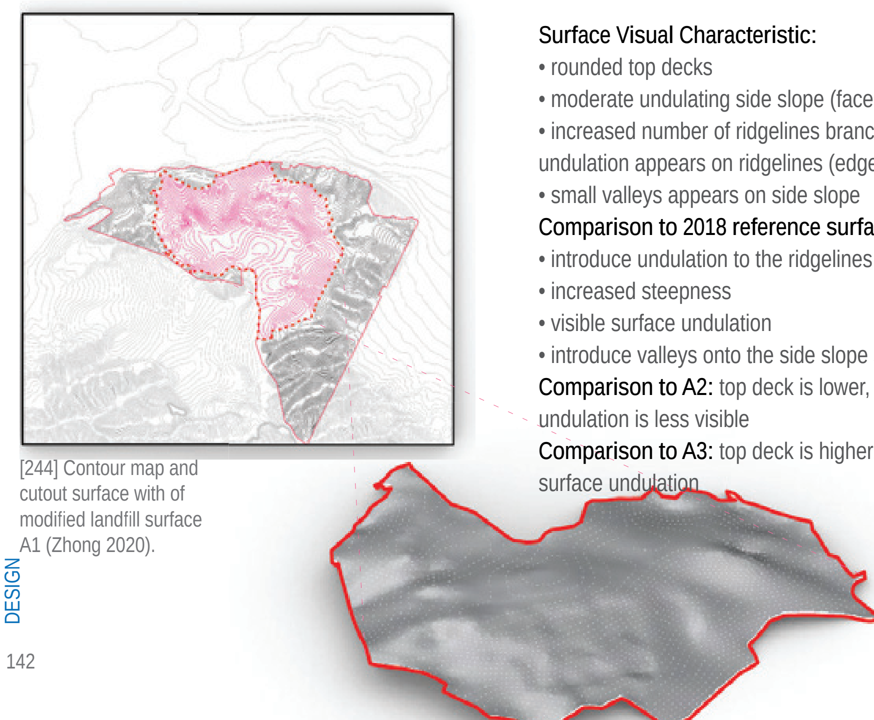


Ref. to [235]

Surface Visual Characteristics:
• 3 relatively flat top decks
• roughly 9 relatively flat side slope (faces)
• countable nearly linear ridgelines (edges)
• no obvious valleys on side slope surface
• some degree of undulation can be observed on the side slope surface

Design Intent: NEUTRAL ENHANCED SURFACE

Manual Advanced Contouring #1 (A1)



[244] Contour map and cutout surface with of modified landfill surface A1 (Zhong 2020).

Surface Visual Characteristic:
• rounded top decks
• moderate undulating side slope (faces)
• increased number of ridgelines branches and increased undulation appears on ridgelines (edges)
• small valleys appears on side slope

Comparison to 2018 reference surface:
• introduce undulation to the ridgelines
• increased steepness
• visible surface undulation
• introduce valleys onto the side slope surface

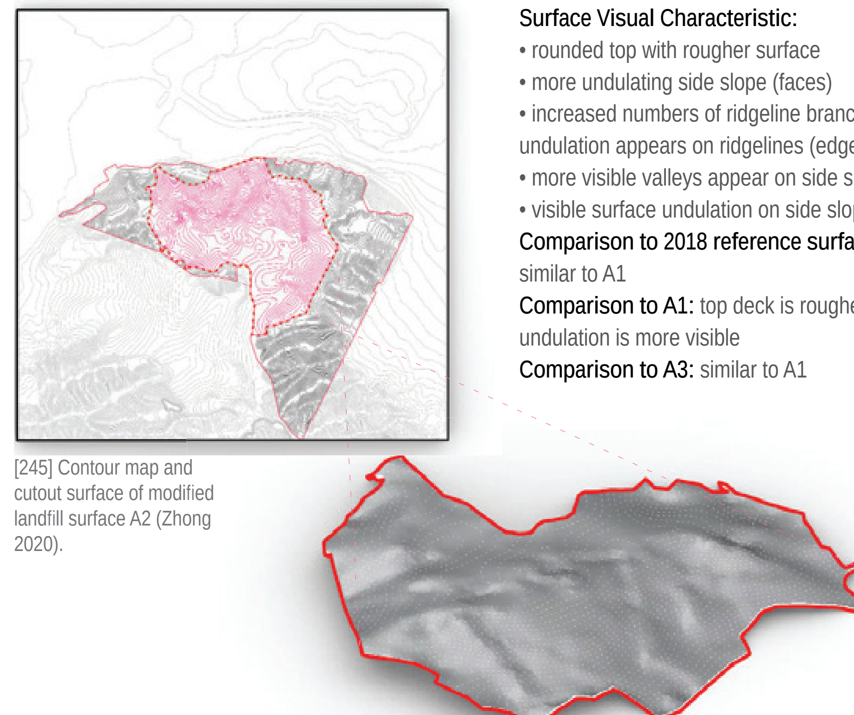
Comparison to A2: top deck is lower, smoother, side slope undulation is less visible

Comparison to A3: top deck is higher, rougher, more visible surface undulation

DESIGN

Design Intent: MOST ENHANCED SURFACE (MOST MODIFIED)

Manual Advanced Contouring #2 (A2)



[245] Contour map and cutout surface of modified landfill surface A2 (Zhong 2020).

Surface Visual Characteristic:
• rounded top with rougher surface
• more undulating side slope (faces)
• increased numbers of ridgeline branches and increased undulation appears on ridgelines (edges)
• more visible valleys appear on side slopes
• visible surface undulation on side slope surfaces

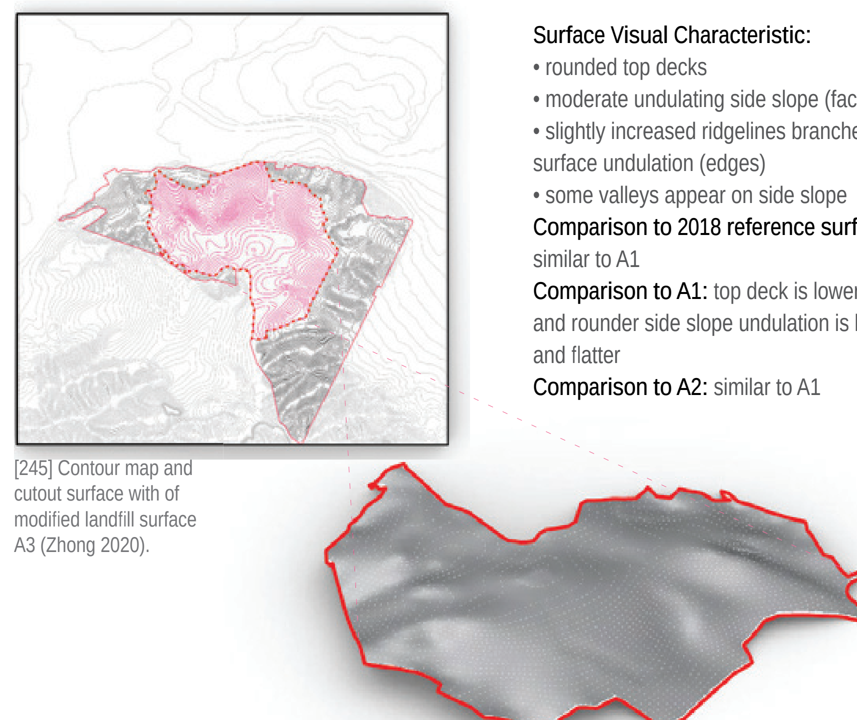
Comparison to 2018 reference surface: similar to A1

Comparison to A1: top deck is rougher, side slope undulation is more visible

Comparison to A3: similar to A1

Design Intent: ENHANCED SURFACE WITH VOLUME CONCERN (LEAST MODIFIED)

Manual Advanced Contouring #3 (A3)



[245] Contour map and cutout surface with of modified landfill surface A3 (Zhong 2020).

Surface Visual Characteristic:
• rounded top decks
• moderate undulating side slope (faces)
• slightly increased ridgelines branches and visible surface undulation (edges)
• some valleys appear on side slope

Comparison to 2018 reference surface: similar to A1

Comparison to A1: top deck is lower, smoother, and rounder side slope undulation is less visible and flatter

Comparison to A2: similar to A1

DESIGN

Parametric Advanced Contouring

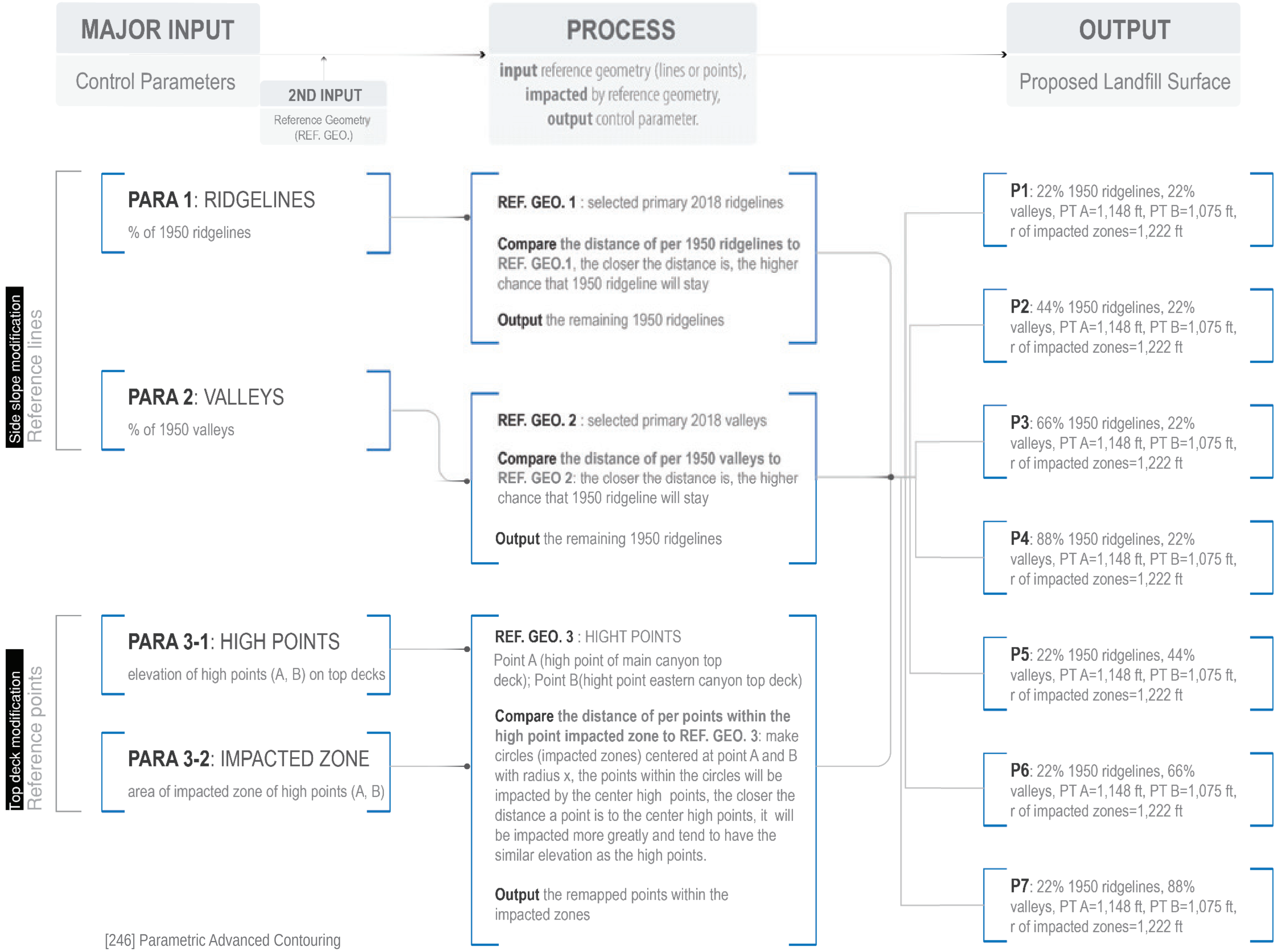
Group 3 Model #: P1- P7 (7 in total)

5.2.2.2. Parametric Advanced Contouring

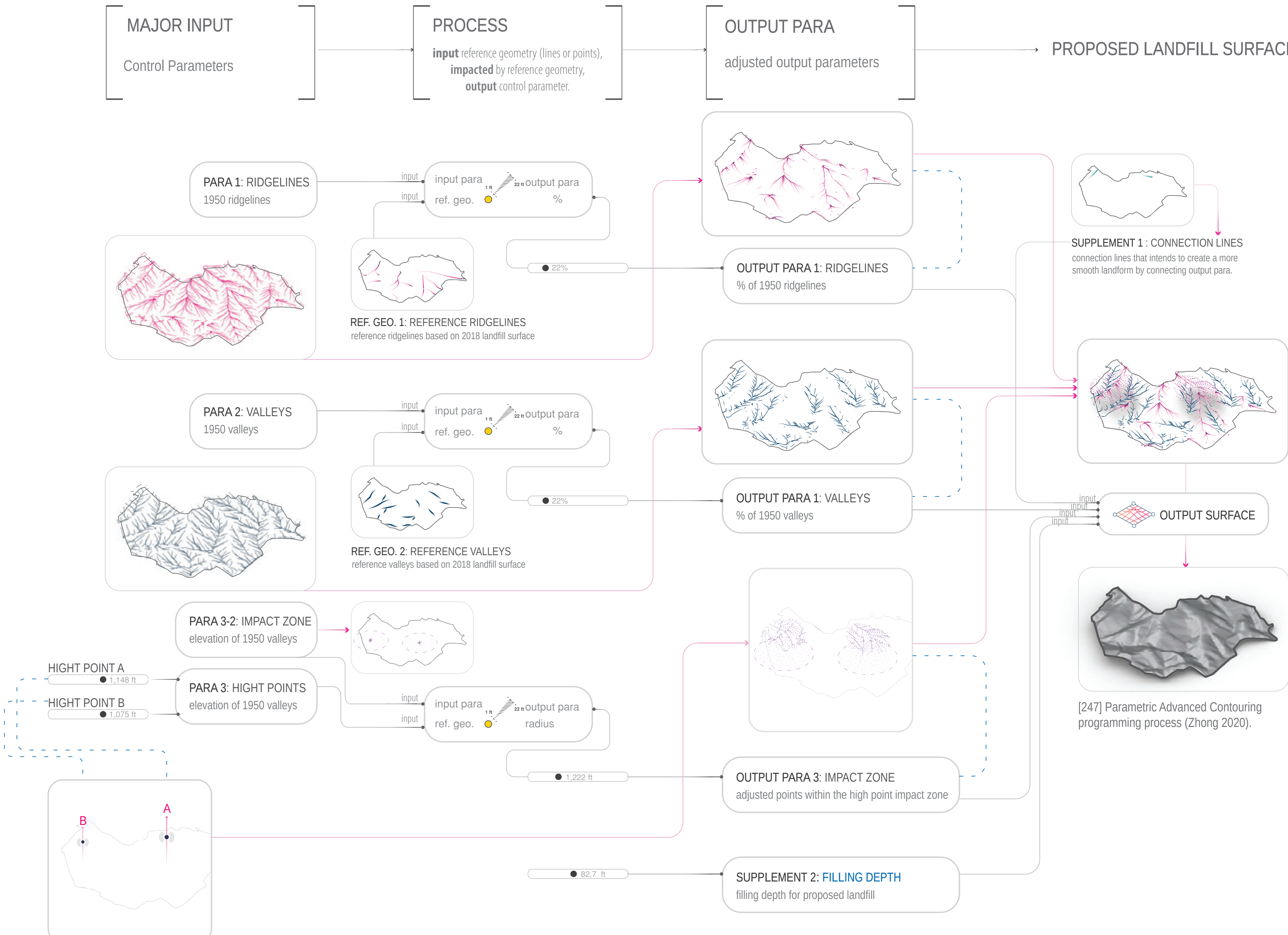
Parametric modeling is used to automate the modification of control parameters (ridgelines, valleys and top deck) that are based on both the 1950 and 2018 reference surfaces.
During the design process, the author wrote a visual script with grasshopper to automatically change the value of control parameters (input) in order to generate the anticipated landfill surface (output) with design intent.

The landfill surfaces created using interactive modeling is named **Parametric Advanced Contouring #1 through #7 (P1 to P7)**, and each automated landfill surface has a different value in the two control parameters -ridgelines and valleys. Even though the top deck can be modified using the script the author created, value of the high points (Point A: 1,148 ft; Point B: 1,075 ft) and the area of impacted zones in P1-P7 remain the same due to the limited time.

Surface Names: *Parametric Advanced Contouring #1, #2, #3, #4, #5, #6, #7* (P1, P2, P3, P4, P5, P6, P7)
Reference landfill surface*: 2018 surface, 1950 surface*
Visual attribute as control parameter*: side slope, top decks, ridgelines, valleys (flowlines)*
Landfill surface modification method*: parametric modeling (manual modification)*



[246] Parametric Advanced Contouring design process (Zhong 2020).

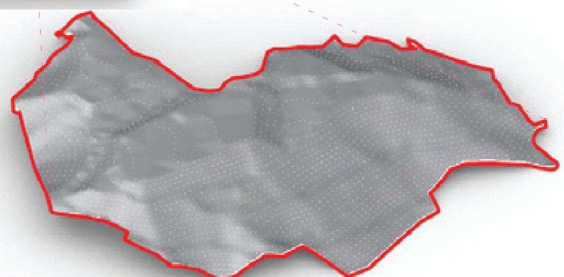


[247] Parametric Advanced Contouring programming process (Zhong 2020).

2018 Reference Surface

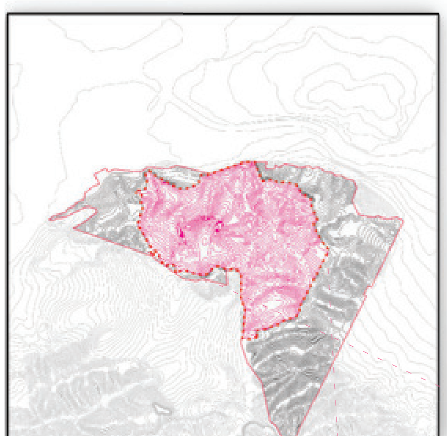
Surface Visual Characteristics:
- 3 relatively flat top deck
- roughly 9 relatively flat side slope (faces)
- countable nearly linear ridgelines (edges)
- no obvious valleys on side slope surfaces

Ref. to [235]



Design Intent: EXPERIMENTAL GROUP TO AUTOMATED THE MODIFICATION PROCESS ON CREATING NATURAL LANDFILL SURFACE

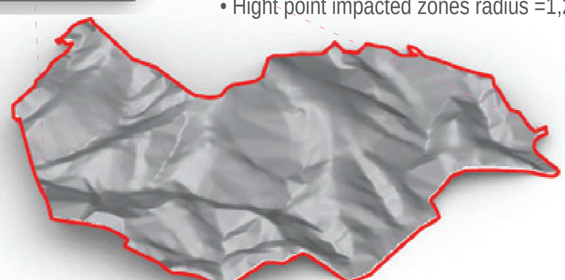
Parametric Advanced Contouring #1 (P1)



Surface Visual Characteristics:
- rounded to tall, pointed top decks, and presenting nearly rocky features
- undulating side slopes and no defined edges that divides the side slopes
- very visible ridgelines and valleys appear on side slopes
- visually similar to 1950 reference surface that presents a rugged terrain

Value of Control Parameters:
- Ridgelines: 22% remained
- Valleys: 22% remained
- High points: Point A =1,148 ft; Point B = 1,075 ft
- Hight point impacted zones radius =1,222ft

[248] Contour map and cutout surface with of modified landfill surface P1 (Zhong 2020).



Parametric Advanced Contouring #2 (P2)

Surface Visual Characteristics:
- rounded to tall, pointed top decks, and presenting nearly rocky features
- undulating side slopes and no defined edges that divides the side slopes
- very visible ridgelines and valleys appears on side slopes
- visually similar to 1950 reference surface that presents a rugged terrain

Value of Control Parameters:
- Ridgelines: 44% remained
- Valleys: 22% remained
- High points: Point A =1,148 ft; Point B = 1,075 ft
- Hight point impacted zones radius =1,222ft

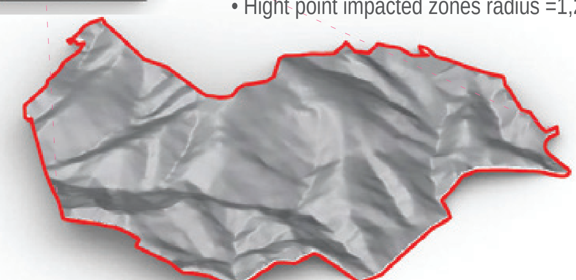
[249] Contour map and cutout surface of modified landfill surface P2 (Zhong 2020).

Parametric Advanced Contouring #3 (P3)

Surface Visual Characteristics:
- rounded to tall, pointed top decks, presenting nearly rocky features
- undulating side slopes and no defined edges that divides the side slopes
- very visible ridgelines and valleys appears on side slopes
- visually similar to 1950 reference surface that presents a rugged terrain

Value of Control Parameters:
- Ridgelines: 66% remained
- Valleys: 22% remained
- High points: Point A =1,148 ft; Point B = 1,075 ft
- Hight point impacted zones radius =1,222ft

[250] Contour map and cutout surface with of modified landfill surface P3 (Zhong 2020).



Parametric Advanced Contouring #4 (P4)

Surface Visual Characteristics:

• rounded to tall, pointed top decks, and presenting nearly rocky features
• undulating side slopes and no defined edges that divides the side slopes
• very visible ridgelines and valleys appears on side slopes
• visually similar to 1950 reference surface that presents a rugged terrain

Value of Control Parameters:

• Ridgelines: 88% remained
• Valleys: 22% remained
• High points: Point A =1,148 ft; Point B = 1,075 ft
• Hight point impacted zones radius =1,222ft

[251] Contour map and cutout surface with of modified landfill surface P4 (Zhong 2020).

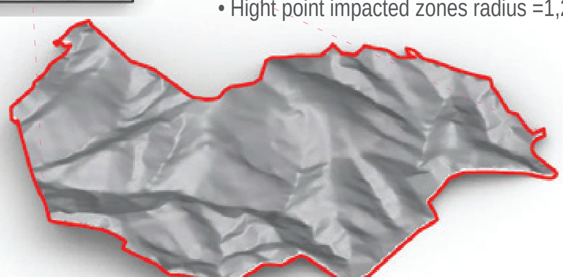
Parametric Advanced Contouring #5 (P5)

Surface Visual Characteristics:

• rounded to tall, pointed top decks, and presenting nearly rocky features
• undulating side slopes and no defined edges that divides the side slopes
• very visible ridgelines and valleys appears on side slopes
• visually similar to 1950 reference surface that presents a rugged terrain

Value of Control Parameters:

• Ridgelines: 22% remained
• Valleys: 66% remained
• High points: Point A =1,148 ft; Point B = 1,075 ft
• Hight point impacted zones radius =1,222ft



[252] Contour map and cutout surface with of modified landfill surface P5 (Zhong 2020).

Parametric Advanced Contouring #6 (P6)

Surface Visual Characteristics:

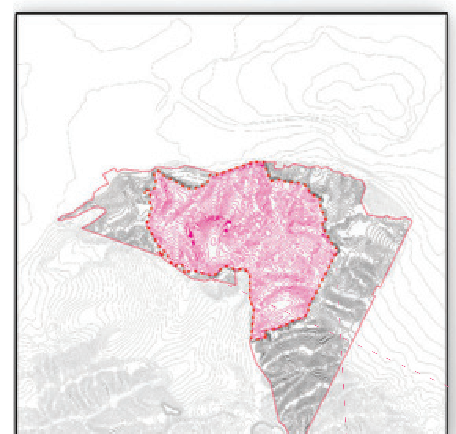
• rounded to tall, pointed top decks, presenting nearly rocky features
• undulating side slopes and no defined edges that divides the side slopes
• very visible ridgelines and valleys appears on side slopes
• visually similar to 1950 reference surface that presents a rugged terrain

Value of Control Parameters:

• Ridgelines: 22% remained
• Valleys: 44% remained
• High points: Point A =1,148 ft; Point B = 1,075 ft
• Hight point impacted zones radius =1,222ft

[253] Contour map and cutout surface of modified landfill surface P6 (Zhong 2020).

Parametric Advanced Contouring #7 (P7)

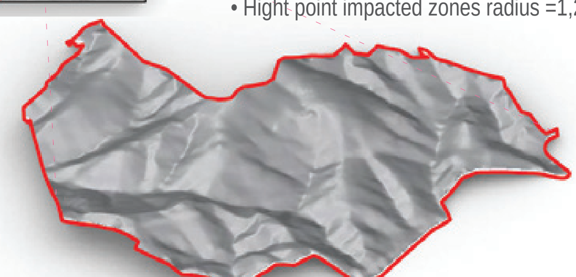


Surface Visual Characteristics:

• rounded to tall, pointed top decks, presenting nearly rocky features
• undulating side slopes and no defined edges that divides the side slopes
• very visible ridgelines and valleys appears on side slopes
• visually similar to 1950 reference surface that presents a rugged terrain

Value of Control Parameters:

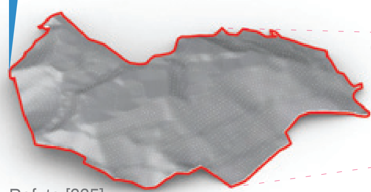
• Ridgelines: 22% remained
• Valleys: 88% remained
• High points: Point A =1,148 ft; Point B = 1,075 ft
• Hight point impacted zones radius =1,222ft



[254] Contour map and cutout surface with of modified landfill surface P7 (Zhong 2020).

2018 Reference Surface

Reference surface



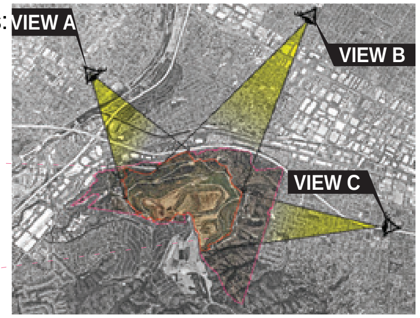
Ref. to [235]

Viewpoint locations:

Viewpoint A: viewing SE direction from Charles T Kranz Intermediate, CA.

Viewpoint B: viewing SW direction from Bassett Senior High School, CA.

Viewpoint C: viewing NW direction from the intersection between Marchmont Ave. and Binney St.



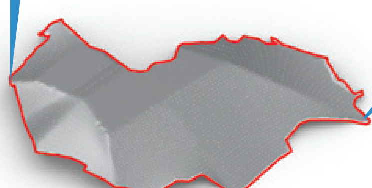
[255] Viewpoints for visual simulation (Zhong 2020).

[256] Existing conditions: view of 2018 Puente Hills Landfill as viewed from A(Zhong 2020).

[257] Existing conditions: view of 2018 Puente Hills Landfill as viewed from B(Zhong 2020).

[258] Existing conditions: view of 2018 Puente Hills Landfill as viewed from C(Zhong 2020).

Manual Geometric Contouring #1 (G1)



Ref. to [240]

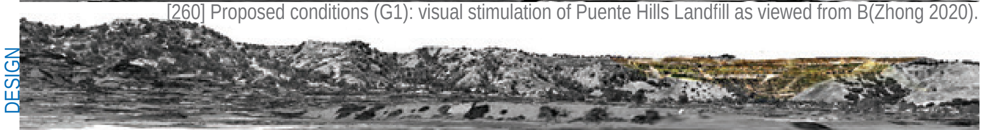
G1: MOST GEOMETRIC SURFACE

Surface Visual Characteristics:

- flattened top decks
- flat side slope
- straight, linear ridgelines

[259] Proposed conditions (G1): visual stimulation of Puente Hills Landfill as viewed from A(Zhong 2020).

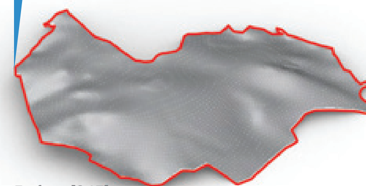
[260] Proposed conditions (G1): visual stimulation of Puente Hills Landfill as viewed from B(Zhong 2020).



[261] Proposed conditions (G1): visual stimulation of Puente Hills Landfill as viewed from C(Zhong 2020).

PROJECTIVE DESIGN SURFACES SUMMARY PAGE

Manual Advanced Contouring #3 (A3)

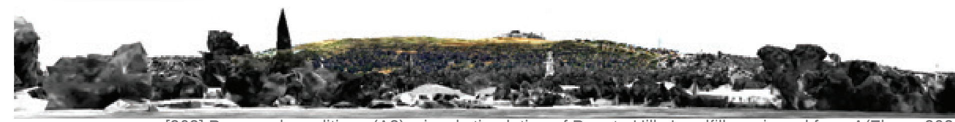


Ref. to [245]

A3: BEST BALANCE OF AESTHETICS AND CAPACITY

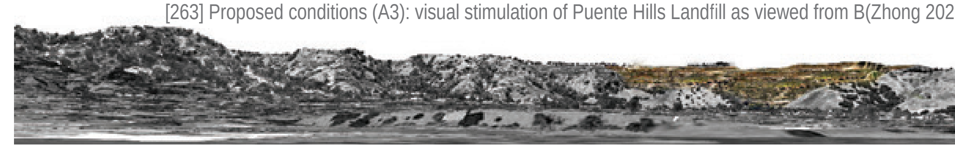
Surface Visual Characteristic:

- rounded top eliminates flat mesa top
- more undulating side slope
- more visible valleys appear on side slopes
- few major ridgelines but finger ridges more pronounced



[262] Proposed conditions (A3): visual stimulation of Puente Hills Landfill as viewed from A(Zhong 2020).

[263] Proposed conditions (A3): visual stimulation of Puente Hills Landfill as viewed from B(Zhong 2020).



[264] Proposed conditions (A3): visual stimulation of Puente Hills Landfill as viewed from C(Zhong 2020).

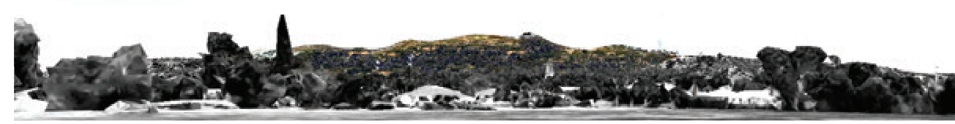
Parametric Advanced Contouring #1 (P1)

Ref. to [248]

P1: EXPERIMENTAL ENHANCED SURFACE

Surface Visual Characteristics:

- rounded to tall, pointed top decks, and presenting nearly rocky features
- undulating side slopes and no defined edges that divides the side slopes
- very visible ridgelines and valleys appear on side slopes
- prove grasshopper script works but too close to 1950 reference surface



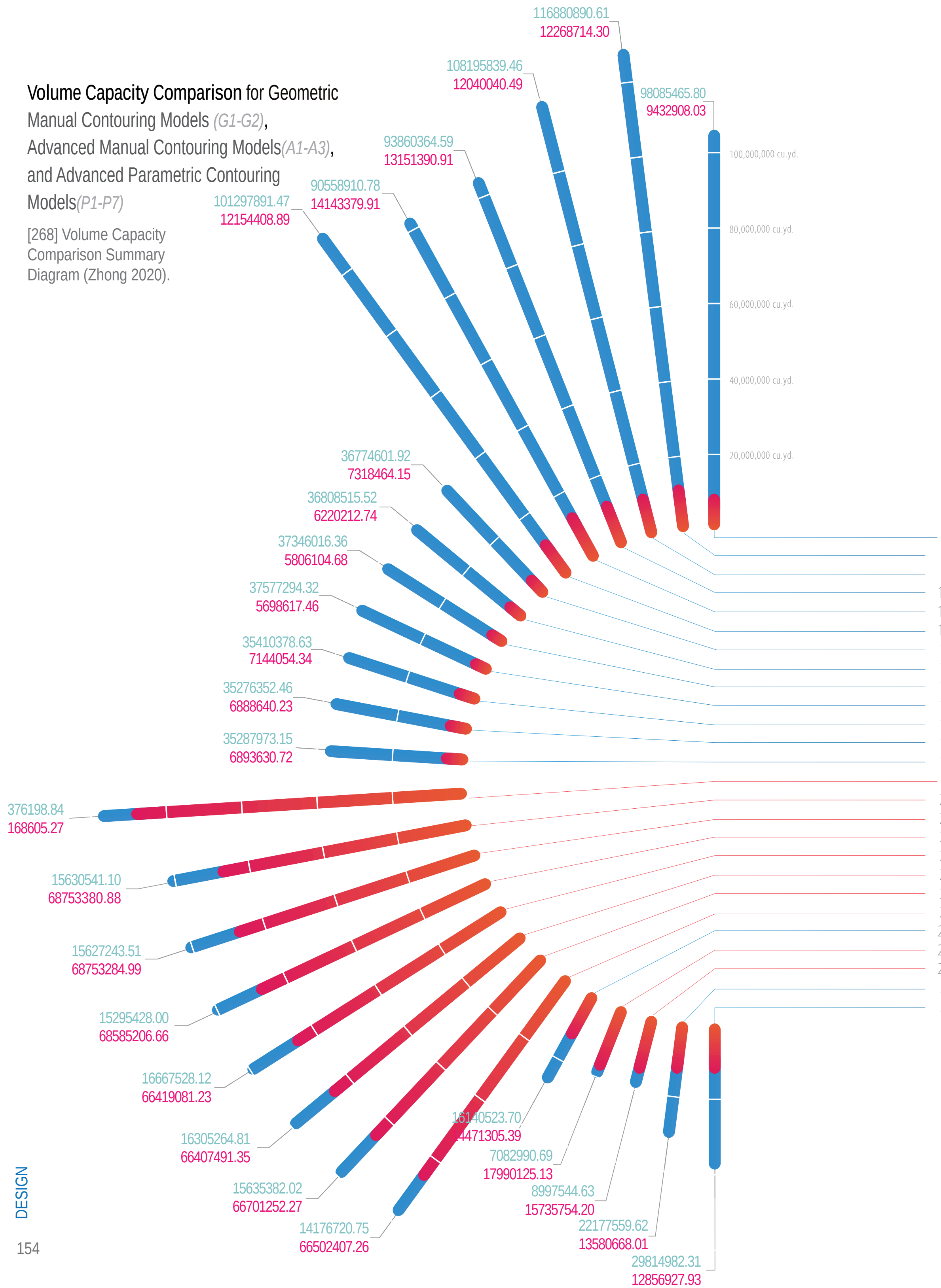
[265] Proposed conditions (P1): visual stimulation of Puente Hills Landfill as viewed from A(Zhong 2020).

[266] Proposed conditions (P1): visual stimulation of Puente Hills Landfill as viewed from B(Zhong 2020).

[267] Proposed conditions (P1): visual stimulation of Puente Hills Landfill as viewed from C(Zhong 2020).

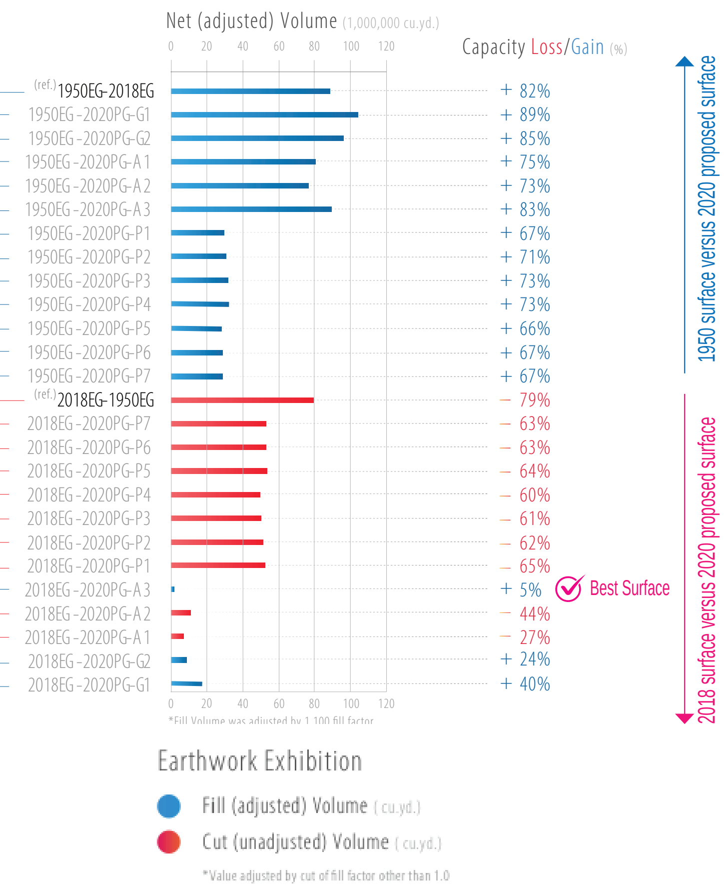
Volume Capacity Comparison for Geometric Manual Contouring Models *(G1-G2)*, Advanced Manual Contouring Models*(A1-A3)*, and Advanced Parametric Contouring Models*(P1-P7)*

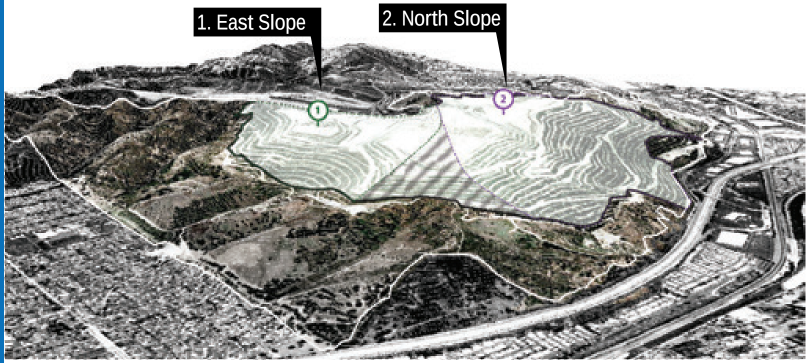
[268] Volume Capacity Comparison Summary Diagram (Zhong 2020).



5.2.3 Volume Capacity Comparison

After all the landfill surfaces were created, contours were imported into Civil3D to calculate **cut and fill volume**. The author created two sets of volumetric surfaces in Civil 3D: one is the 1950 reference landfill surface versus 2020 (proposed surface created year) re-modified landfill surfaces; the other set is 2018 reference landfill surface versus 2020 re-modified landfill surfaces.



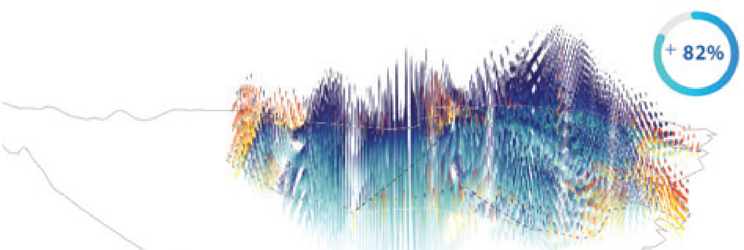


[269] Most seen solid waste fill slopes of Puente Hills Landfill: east-facing slope and north-facing slope (Zhong 2020).

Earthwork Exhibition Diagram

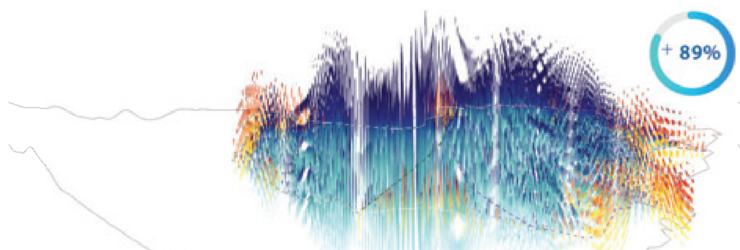
The author chose a northeast angled view to display the **cut and fill volume**, and **volume capacity loss and gain (%)**. This angle allows views of the cut and fill difference on the east and north slopes highlighted as No.1and No. 2 on the top left diagram. These views are widely seen by highway travelers and nearby residents. Also, the perspective view of the earthwork exhibit also visually presents the **degree of surface modification** that had been made to the proposed landfill surface.

Group 1: Manual Geometric Contouring



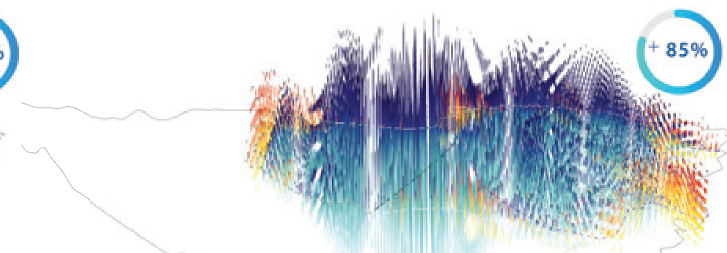
1950-2018

[270] Earthwork Comparison along most seen slopes: 1950-2018 (Zhong 2020).



1950-G1

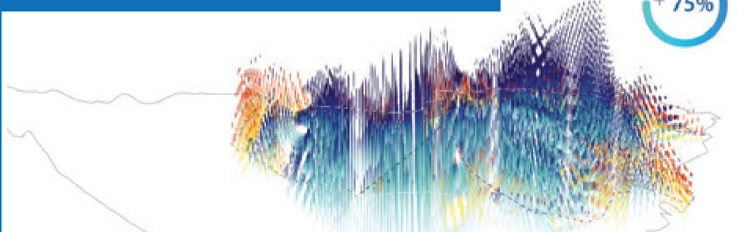
[271] Earthwork Comparison along most seen slopes: 1950-G1 (Zhong 2020).



1950-G2

[272] Earthwork Comparison along most seen slopes: 1950-G2 (Zhong 2020).

Group 2: Manual Advanced Contouring

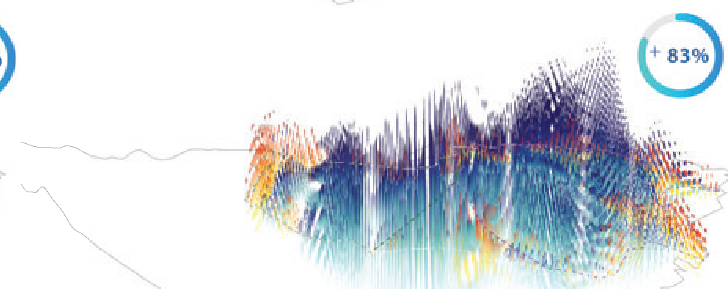


1950-A1

[273] Earthwork Comparison along most seen slopes: 1950-A1 (Zhong 2020).

1950-A2

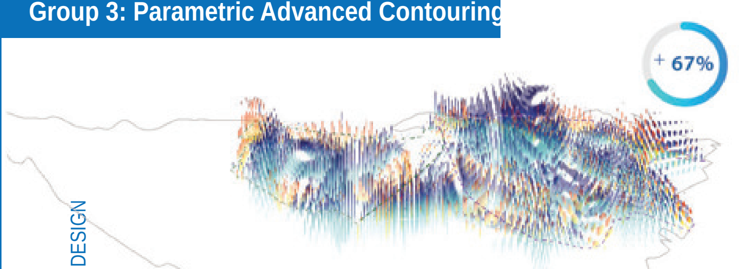
[274] Earthwork Comparison along most seen slopes: 1950-A2 (Zhong 2020).



1950-A3

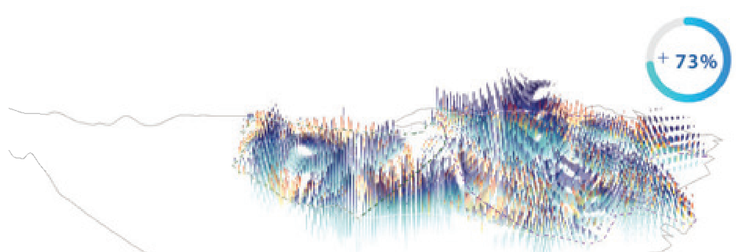
[275] Earthwork Comparison along most seen slopes: 1950-A3 (Zhong 2020).

Group 3: Parametric Advanced Contouring



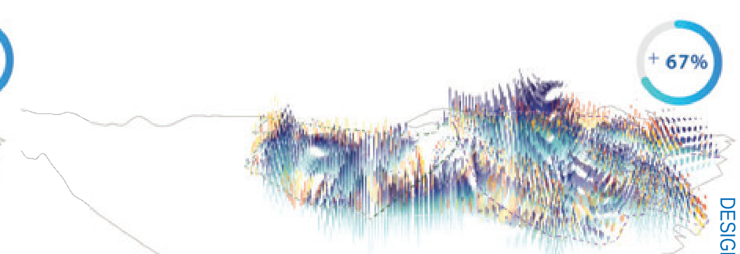
1950-P1

[276] Earthwork Comparison along most seen slopes: 1950-P1 (Zhong 2020).



1950-P4

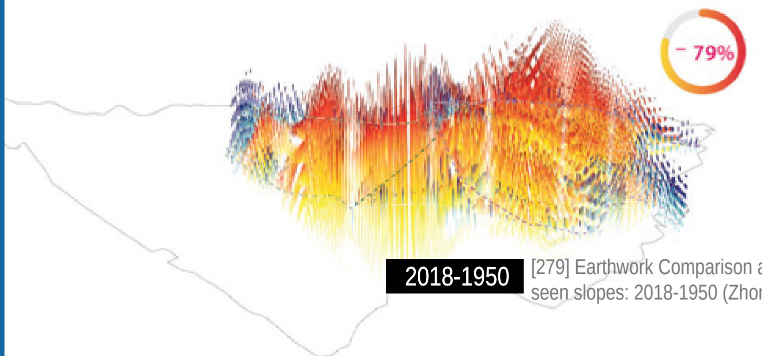
[277] Earthwork Comparison along most seen slopes: 1950-P4 (Zhong 2020).



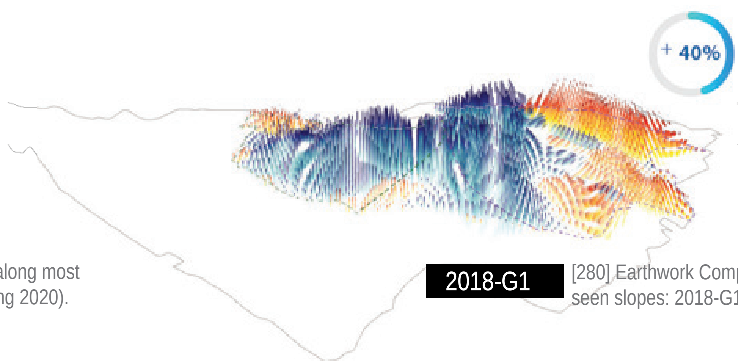
1950-P7

[278] Earthwork Comparison along most seen slopes: 1950-P7 (Zhong 2020).

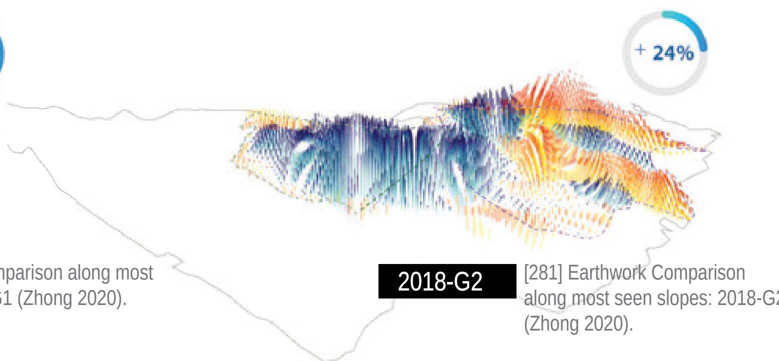
Group 1: Manual Geometric Contouring



2018-1950 [279] Earthwork Comparison along most seen slopes: 2018-1950 (Zhong 2020).

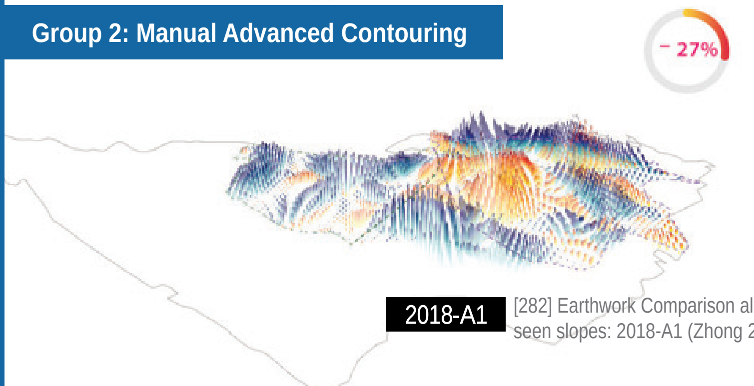


2018-G1 [280] Earthwork Comparison along most seen slopes: 2018-G1 (Zhong 2020).

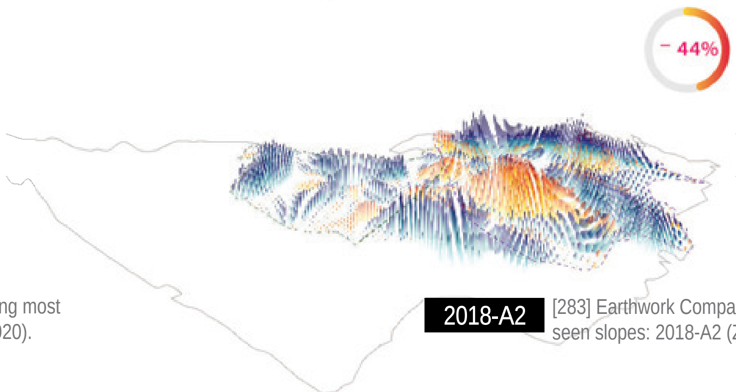


2018-G2 [281] Earthwork Comparison along most seen slopes: 2018-G2 (Zhong 2020).

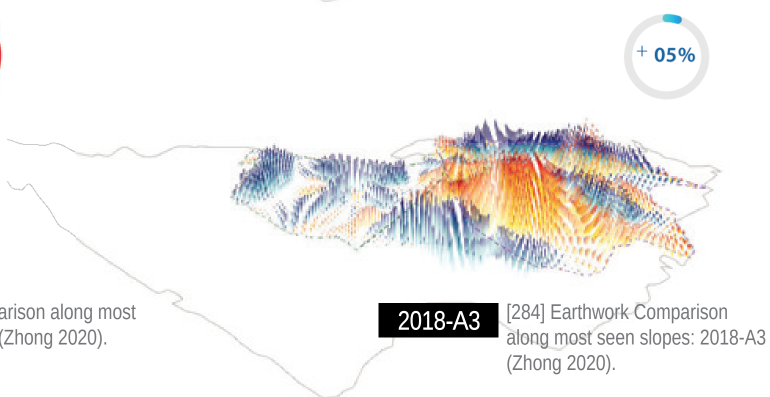
Group 2: Manual Advanced Contouring



2018-A1 [282] Earthwork Comparison along most seen slopes: 2018-A1 (Zhong 2020).

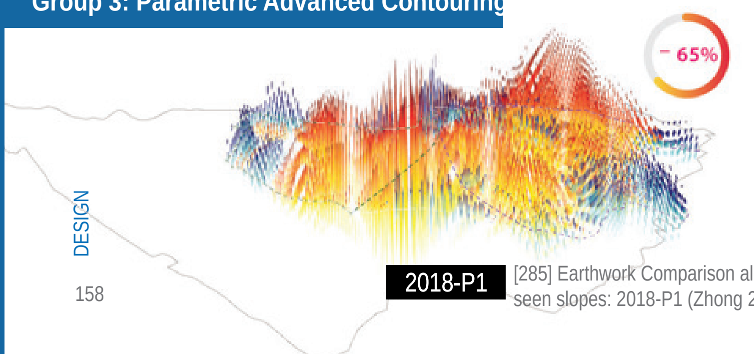


2018-A2 [283] Earthwork Comparison along most seen slopes: 2018-A2 (Zhong 2020).

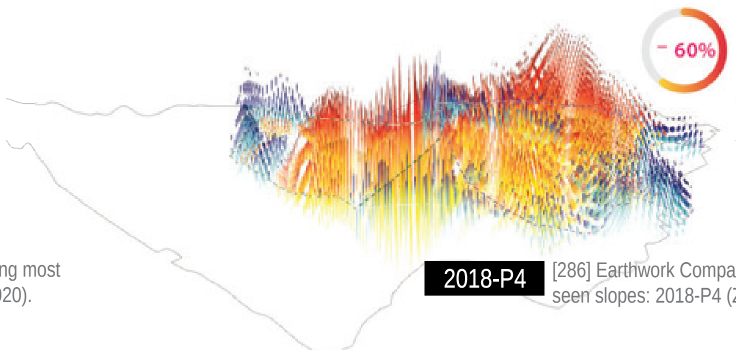


2018-A3 [284] Earthwork Comparison along most seen slopes: 2018-A3 (Zhong 2020).

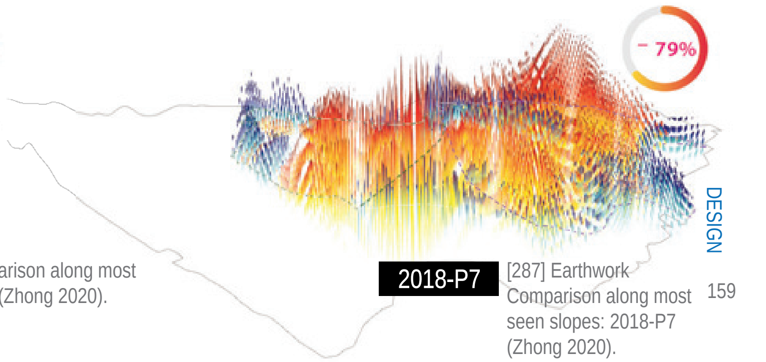
Group 3: Parametric Advanced Contouring



2018-P1 [285] Earthwork Comparison along most seen slopes: 2018-P1 (Zhong 2020).



2018-P4 [286] Earthwork Comparison along most seen slopes: 2018-P4 (Zhong 2020).



2018-P7 [287] Earthwork Comparison along most seen slopes: 2018-P7 (Zhong 2020).

5.2.3 Volume Capacity Comparison

In general, the earthwork exhibit suggests that the **more surface undulations** are introduced onto the landfill surface, the more the cut volume.

Group 1 (Manual Geometric Contouring) has the **least surface undulation** and presents a geometric shape, resulting in a proposed landfill having the **most volume capacity** and exceeding the existing Puente Hills landfill volume capacity by 40%, and 24%.

Within Group 2 (Manual Advanced Contouring), A1 and A2 introduces more surface undulations resulting in capacity loss, while A3 was modified according to the design intent of creating surface undulations similar to A1 and A2, but manages to optimize volume capacity. Thus, the A3 configuration results in product having a **5% volume capacity increase from the 2018 reference surface**, while both A1 and A2 result in 27% and 44 % volume capacity losses.

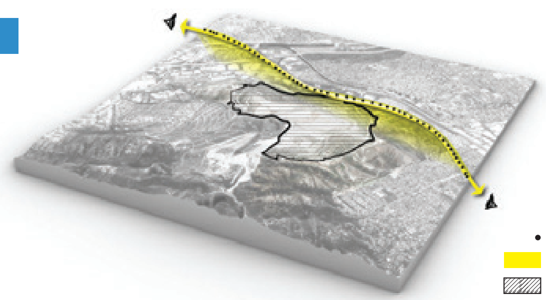
Group 3 (Parametric Advanced Contouring) is an experimental group where a parameterized process was used to alter visual attributes to re-recreate a landfill surface very close to the original 1950 terrain shape. Thus, if the proposed landfill surface has similar visual attributes to its original terrain, it will lose more volume capacity, but present a more natural look. In summary, this group has the **most surface undulation** but **least volume capacity** (unless the overall shape is retained but uniform fill depth is added).

5.2.4 Overall Visibility Analyses

Overall Visibility Analyses (Viewshed analyses) were also calculated using Rhino3D with the Grasshopper plug-in-“Ladybug” to understand the **change in overall visibility** between the 2018 reference landfill surface and proposed landfill surfaces (Group 1: G1,G2; Group 2: A1, A2, A3; and Group 3: P1-P1, P4, P7).

Viewpoints were selected along major **highways** (I-650 and SR-60) and from **nearby communities** (South El Monte; Avocado Heights, and Hacienda Heights). Observer elevations for highway viewpoints were established by taking the topographic elevation at the highway viewpoint location and adding 5 additional feet to represent the viewing height from inside a vehicle. For elevations for community viewpoints, 6 to 15 feet representing a view height from a first or second story building window was added to the corresponding topographic elevation of the viewpoint location.

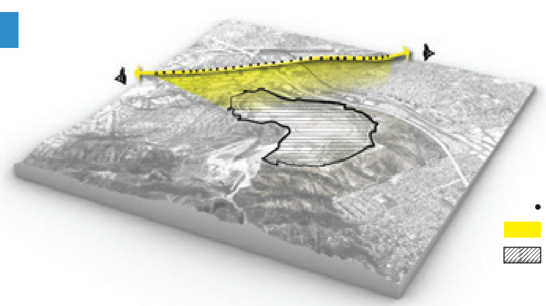
I-605



- Viewpoints (observer points)
- View surface
- Target surface

[288] Viewpoint information viewing from Highway I-605 (Zhong 2020).

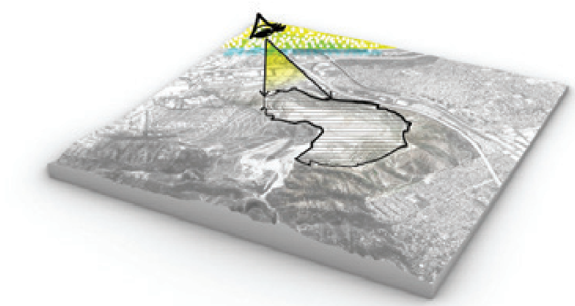
SR-60



- Viewpoints (observer points)
- View surface
- Target surface

[289] Viewpoint information viewing from Highway SR-60 (Zhong 2020).

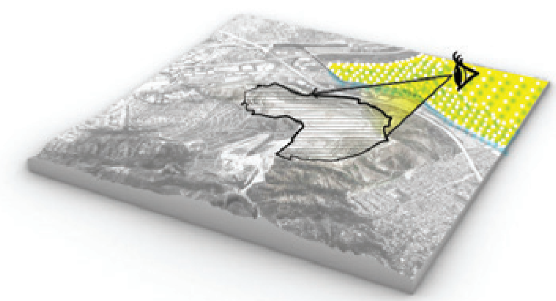
South El Monte



- Viewpoints (observer points)
- View surface
- Target surface

[290] Viewpoint information viewing from Community- South El Monte (Zhong 2020).

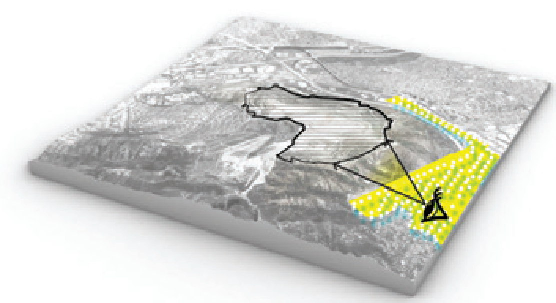
Avocado Heights



- Viewpoints (observer points)
- View surface
- Target surface

[291] Viewpoint information viewing from Community- Avocado Height (Zhong 2020).

Hacienda Heights



- Viewpoints (observer points)
- View surface
- Target surface

[292] Viewpoint information viewing from Community- Hacienda Height (Zhong 2020).

2018 | **G1** | **G2** | **A1** | **A2** | **A3** | **P1** | **P4** | **P7**

Overall Visibility (%)

I-605

[293]-[301] Visibility Analysis of proposed landfill surfaces viewing from Highway I-605 (Zhong 2020).

#View Points=30
#View Points Elevation: point elevation +5-22 ft

SR-60

[302]-[310] Visibility Analysis of proposed landfill surfaces viewing from Highway SR-60 (Zhong 2020).

#View Points=49
#View Points Elevation: point elevation +5-22 ft

South El Monte

[311]-[319] Visibility Analysis of proposed landfill surfaces viewing from Community South El Monte (Zhong 2020).

#View Points=100
#View Points Elevation: point elevation +6-15 ft

Avocado Heights

[320]-[328] Visibility Analysis of proposed landfill surfaces viewing from Community Avocado Heights (Zhong 2020).

#View Points=178
#View Points Elevation: point elevation +6-15 ft

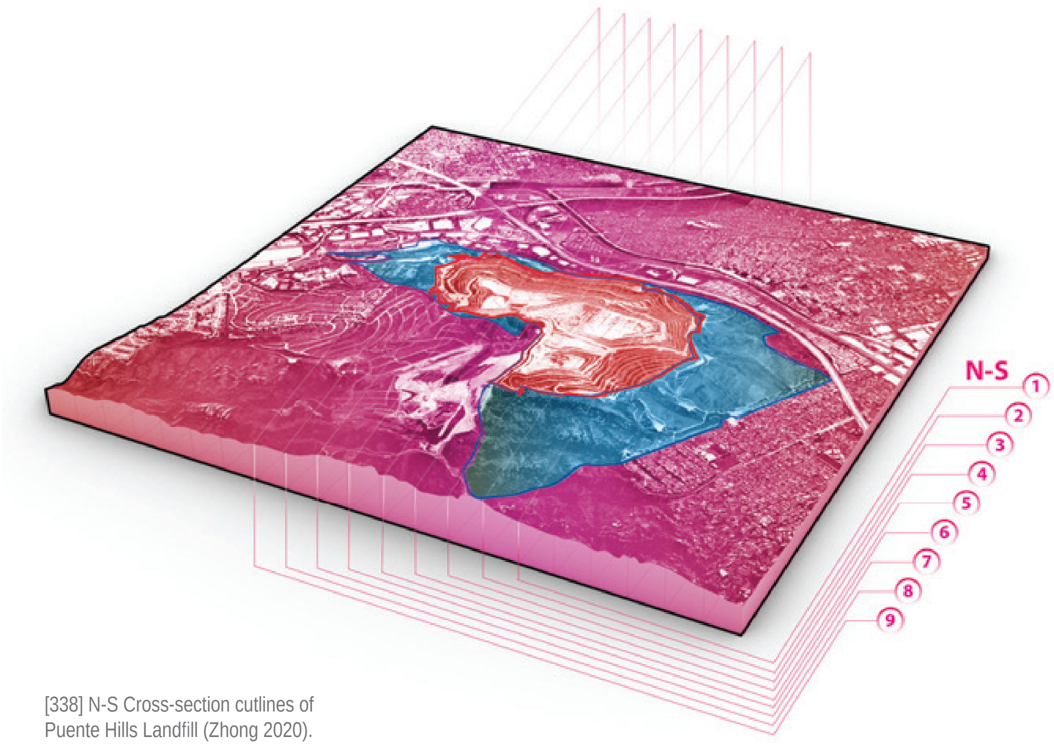
Hacienda Heights

[329]-[337] Visibility Analysis of proposed landfill surfaces viewing from Community Hacienda Heights (Zhong 2020).

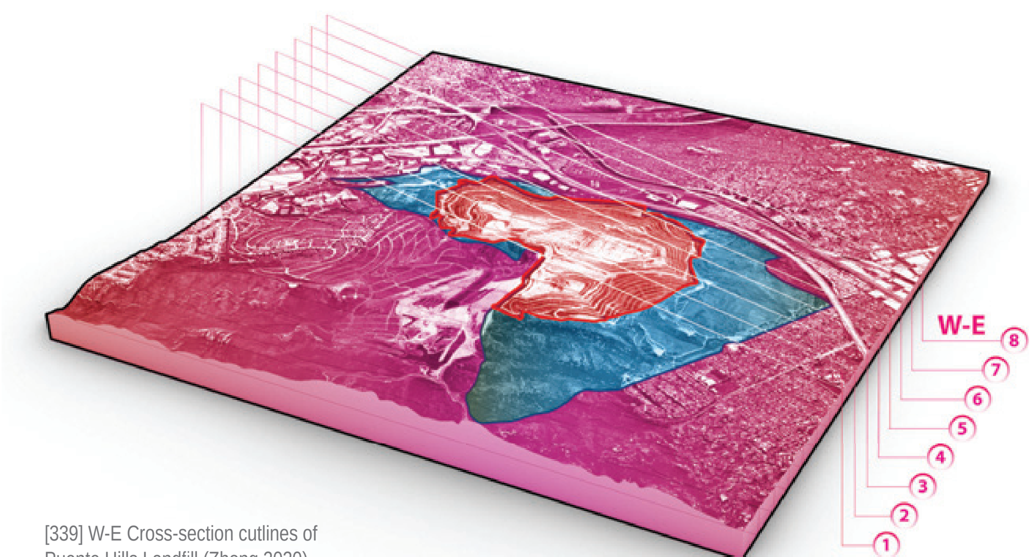
#View Points=131
#View Points Elevation: point elevation +6-15 ft

5.2.4 Overall Visibility Analyses

In general, the discrete visibility maps suggest that **more landfill surface undulations** lead to less visibility **from certain view angles**. However, comparing the 2018 reference surface to G2, the visibility dramatically decreased, and was even lower than A1, A2. This is due to the **landfill surface height of G2** being set lower than G1, but similar to A1 and A2, which is also shown by the following slope gradient analysis.



[338] N-S Cross-section cutlines of Puente Hills Landfill (Zhong 2020).



[339] W-E Cross-section cutlines of Puente Hills Landfill (Zhong 2020).

5.2.5 Visual Attribute Analyses

Although the projective design used visual attributes as control parameters to alter the reference surface in order to change the landform VQ, the findings in Chapter 4 already revealed the relationship between visual attributes and Landform VQ. In summary, the rigid geometric form of the Backward Projection model decreases Landform VQ and landfill aesthetics, whereas the Forward Projection model increases Landform VQ and landfill aesthetics. However, the author saw the necessity of comparing different visual attributes across each proposed landfill surface. This was done by conducting **cross-sectional analyses** and **surface analyses** to not only allow comparison between the 2018 reference surface and proposed landfill surface (**Group 1- Manual Geometric Contouring**: G1, G2, **Group 2 - Manual Advanced Contouring**: A1, A2, A3 and **Group 3 - Parametric Advanced Contouring**: P1, P4, P7), but also between each proposed landfill surface. P1, P4, and P7 were selected to represent the parametric advanced contouring group: P1 has the lowest ridgeline and valley value; P4 has the highest ridgeline value and lowest valley value; and P7 has the lowest ridgeline value and highest valley value. However, due to the time limitation, the author was not able to break down the numbers in the visual attribute analysis; however, the diagram graphically depicts gradient and aspect changes across each landfill surface.

5.2.5.1 Landfill Cross-sectional Analysis

Similar to the landfill cross-sectional analysis conducted in Chapter 4: Findings, **critical sections** were cut along the **N-S** and **W-E** directions of the 2018 reference surface and the proposed landfill surfaces in Rhino with Grasshopper streamlining the process in order to visually present the landfill side slope and top deck undulations.

5.2.5.2 Landfill Surface Analysis

Slope gradient and **slope aspect** were analyzed in Rhino with Grasshopper to understand surface undulations created on landfill side slope and top deck areas of the proposed landfill surfaces.

[340] #1 N-S Cross-section of all analyzed surfaces (Zhong 2020).

[341] #2 N-S Cross-section of all analyzed surfaces (Zhong 2020).

[344] #5 N-S Cross-section of all analyzed surfaces (Zhong 2020).

[345] #6 N-S Cross-section of all analyzed surfaces (Zhong 2020).

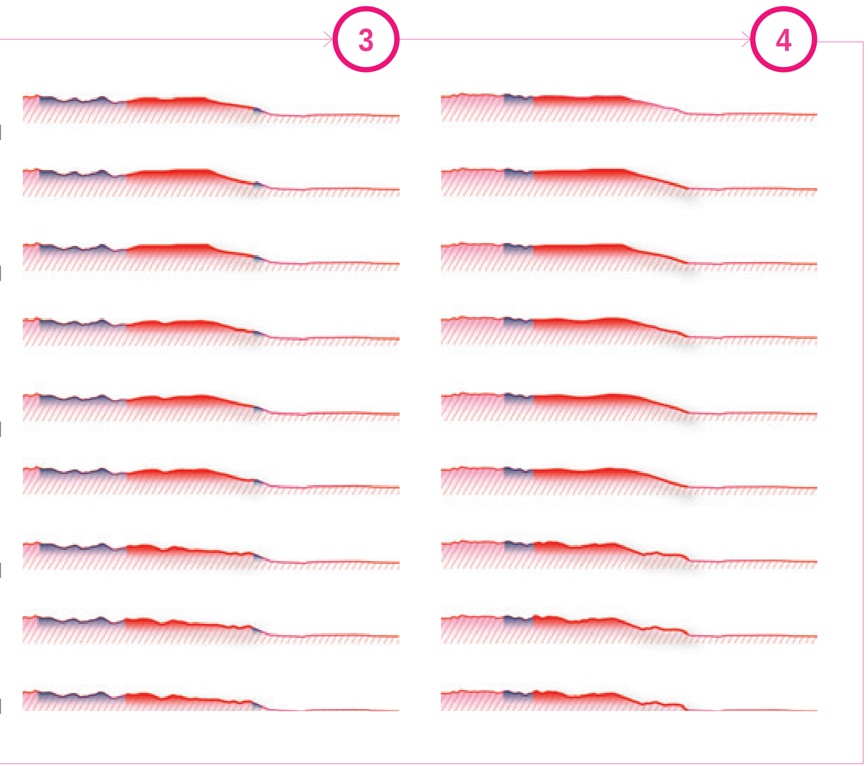
[342] #3 N-S Cross-section of all analyzed surfaces (Zhong 2020).

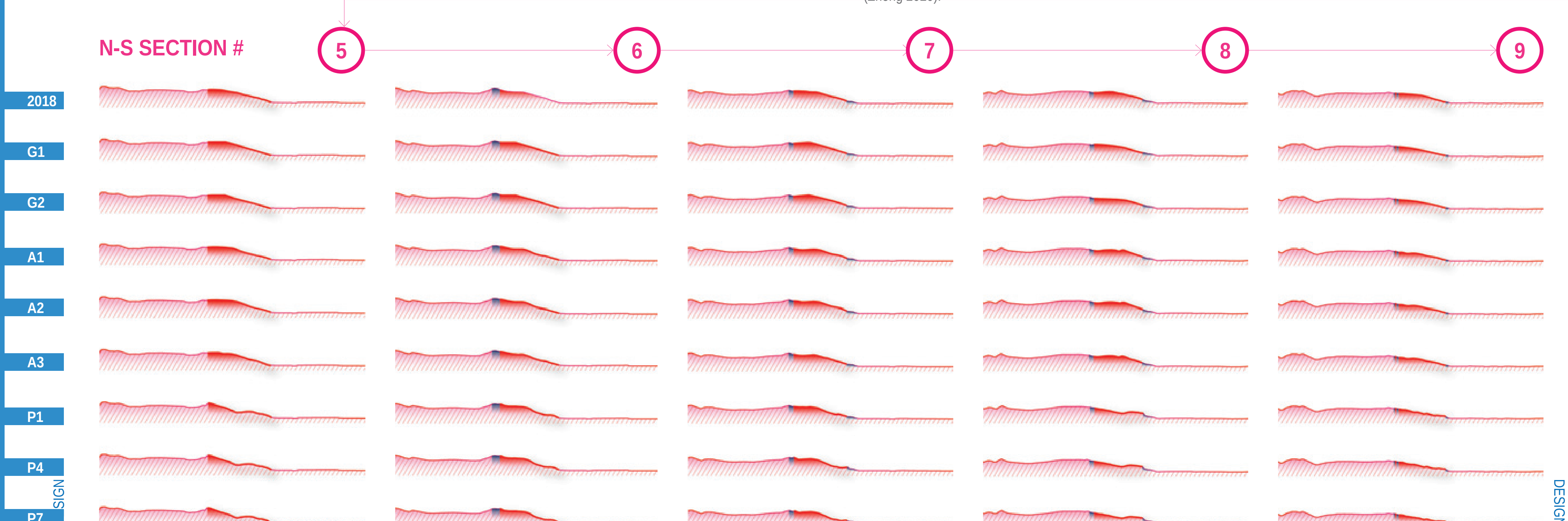
[343] #4 N-S Cross-section of all analyzed surfaces (Zhong 2020).

[346] #7 N-S Cross-section of all analyzed surfaces (Zhong 2020).

[347] #8 N-S Cross-section of all analyzed surfaces (Zhong 2020).

[348] #9 N-S Cross-section of all analyzed surfaces (Zhong 2020).



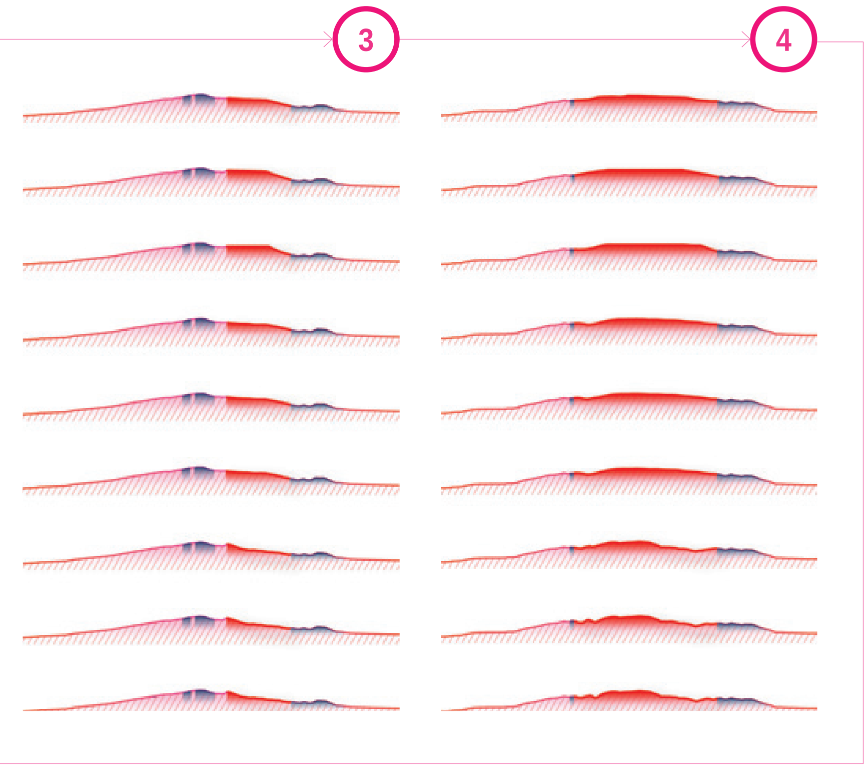


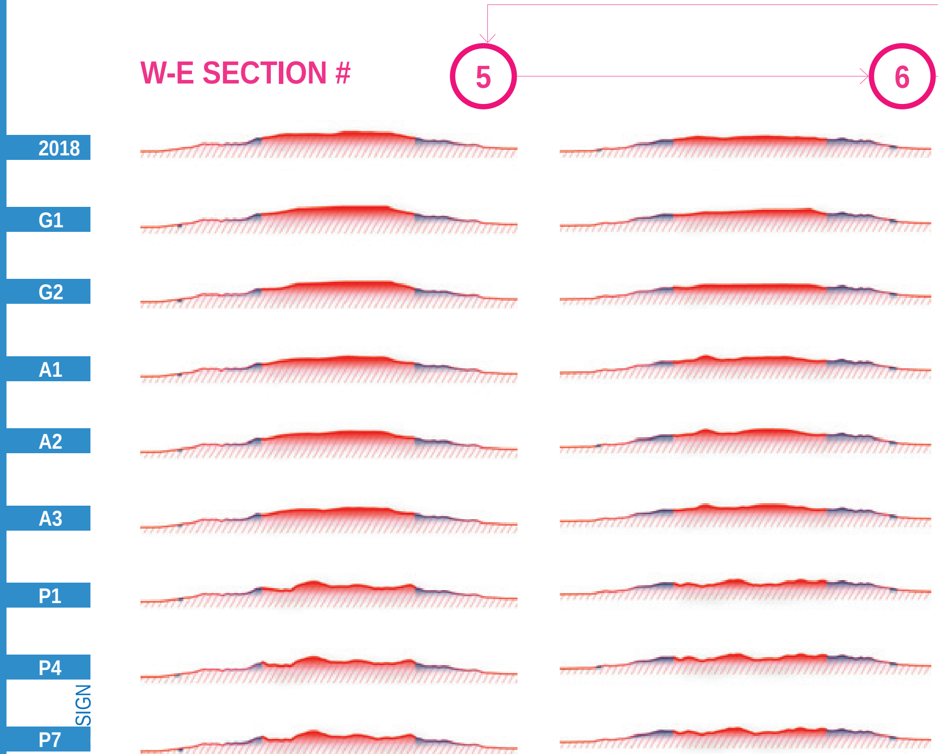
[349] #1 W-E Cross-section of all analyzed surfaces (Zhong 2020).

[350] #2 W-E Cross-section of all analyzed surfaces (Zhong 2020).

[351] #3 W-E Cross-section of all analyzed surfaces (Zhong 2020).

[352] #4 W-E Cross-section of all analyzed surfaces (Zhong 2020).



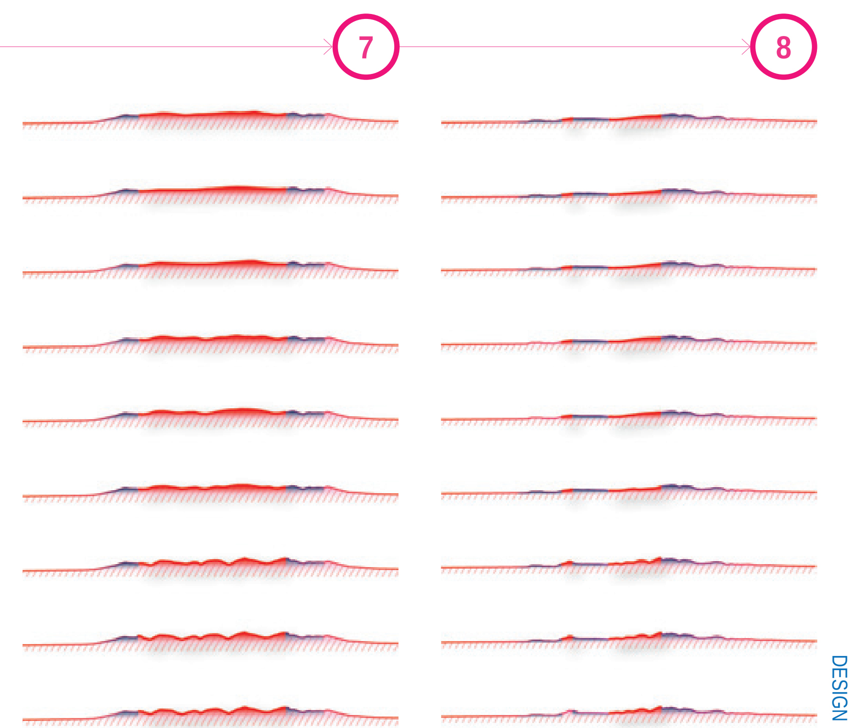


[353] #5 W-E Cross-section of all analyzed surfaces (Zhong 2020).

[354] #6 W-E Cross-section of all analyzed surfaces (Zhong 2020).

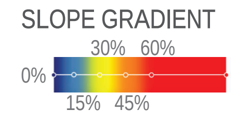
[355] #7 W-E Cross-section of all analyzed surfaces (Zhong 2020).

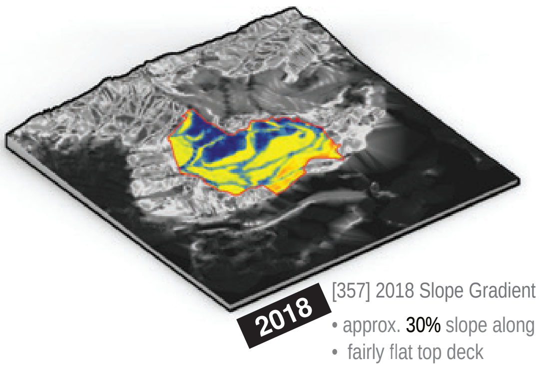
[356] #8 W-E Cross-section of all analyzed surfaces (Zhong 2020).



5.2.5.2 Landfill Surface Analysis

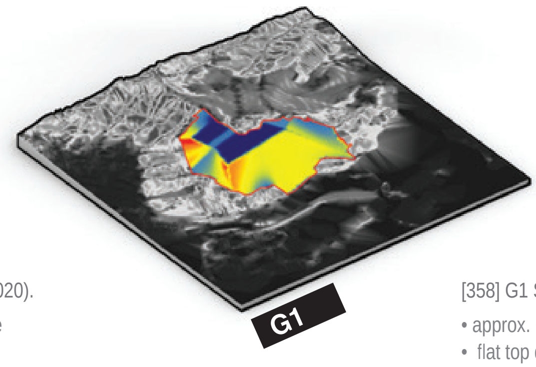
Slope Gradient Analysis





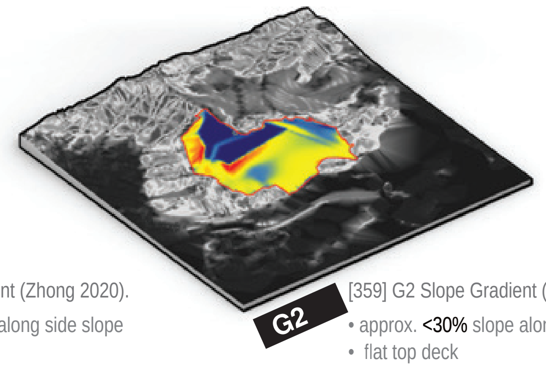
[357] 2018 Slope Gradient (Zhong 2020).

- approx. **30%** slope along side slope
- fairly flat top deck
- spatial distribution of slope is fairly **clustered**
- low side slope undulation and no top deck surface undulation



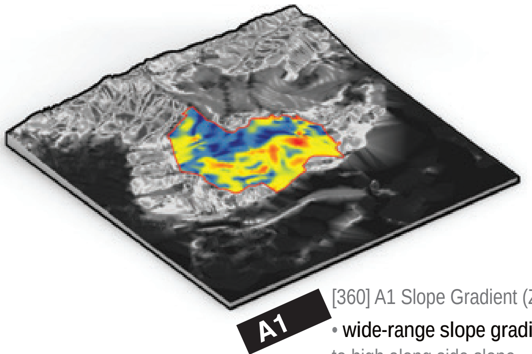
[358] G1 Slope Gradient (Zhong 2020).

- approx. **<30%** slope along side slope
- flat top deck
- spatial distribution of slope is **clustered**
- lowest side slope undulation and no top deck surface undulation



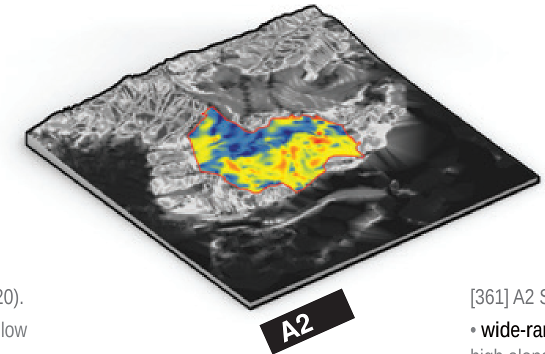
[359] G2 Slope Gradient (Zhong 2020).

- approx. **<30%** slope along side slope
- flat top deck
- spatial distribution of slope is **clustered**
- lowest side slope undulation and no top deck surface undulation
- lower side slope height and slope gradient comparing to G1



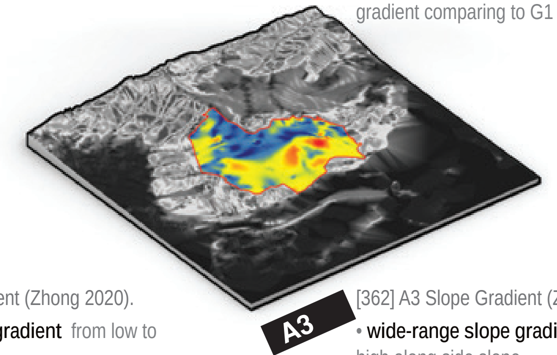
[360] A1 Slope Gradient (Zhong 2020).

- **wide-range slope gradient** from low to high along side slope
- some gradient change on top deck
- spatial distribution of slope **starts to scatter** but still clustered on the facets
- moderate slope undulation and top deck surface undulation



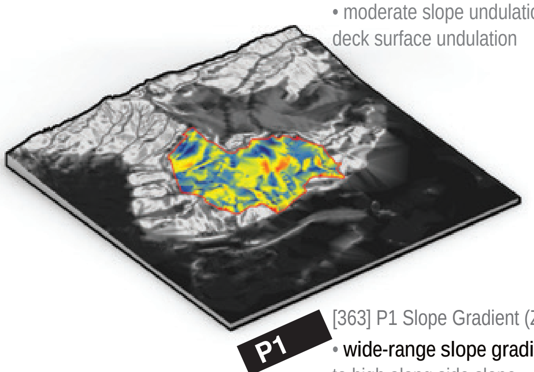
[361] A2 Slope Gradient (Zhong 2020).

- **wide-range slope gradient** from low to high along side slope
- some gradient change on top deck
- spatial distribution of slope s**tarts to scatter** but still clustered on the facets
- moderate slope undulation and top deck surface undulation, but less than A1



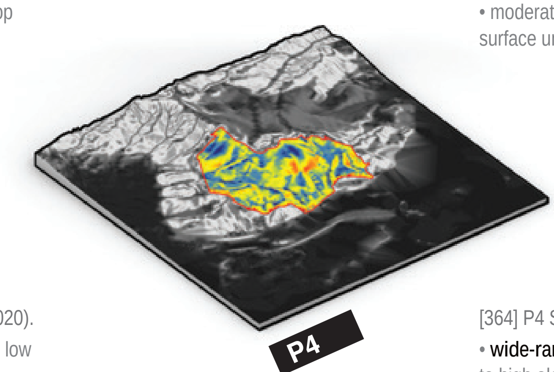
[362] A3 Slope Gradient (Zhong 2020).

- **wide-range slope gradient** from low to high along side slope
- some gradient change on top deck
- spatial distribution of slope **starts to scatter** but still clustered on the facets
- moderate slope undulation and top deck surface undulation, less than A1, A2



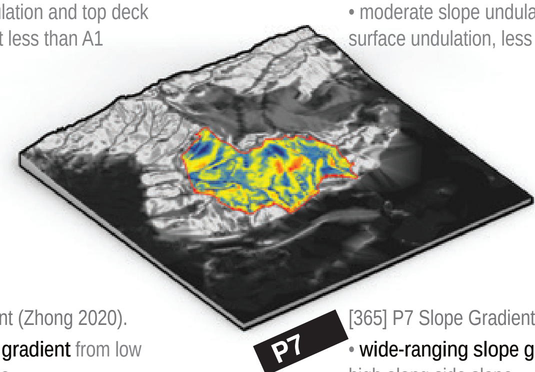
[363] P1 Slope Gradient (Zhong 2020).

- **wide-range slope gradient** from low to high along side slope
- some gradient change on top deck
- **unevenly distributed** gradient, no defined faces
- visible amount of slope undulation and top deck surface undulation



[364] P4 Slope Gradient (Zhong 2020).

- **wide-ranging slope gradient** from low to high along side slope
- some gradient change on top deck
- **unevenly distributed** gradient, no defined faces
- visible amount of slope undulation and top deck surface undulation



[365] P7 Slope Gradient (Zhong 2020).

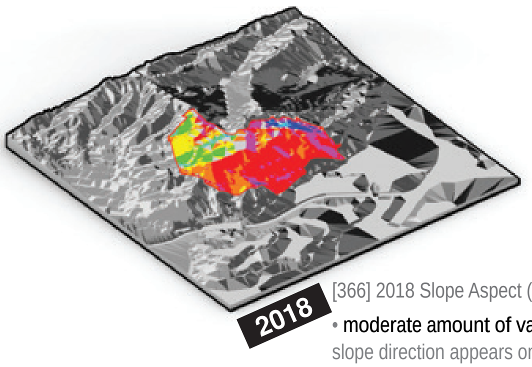
- **wide-ranging slope gradient** from low to high along side slope
- some gradient change on top deck
- **unevenly distributed** gradient, no defined faces
- visible amount of slope undulation and top deck surface undulation

5.2.5.2 Landfill Surface Analysis

Slope Aspect Analysis

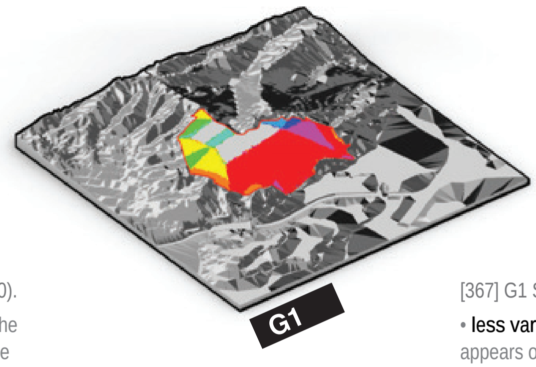
SLOPE ASPECT

- NORTH
- NORTHEAST
- EAST
- SOUTHEAST
- SOUTH
- SOUTHWEST
- WEST
- NORTHWEST



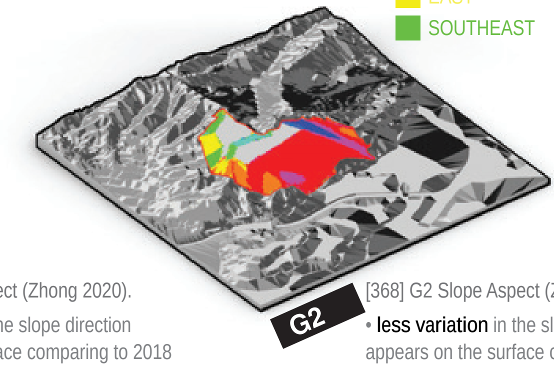
[366] 2018 Slope Aspect (Zhong 2020).

• **moderate amount of variation** in the slope direction appears on the surface
• spatial distribution of aspect is **clustered** that indicates a fairly angular side slope



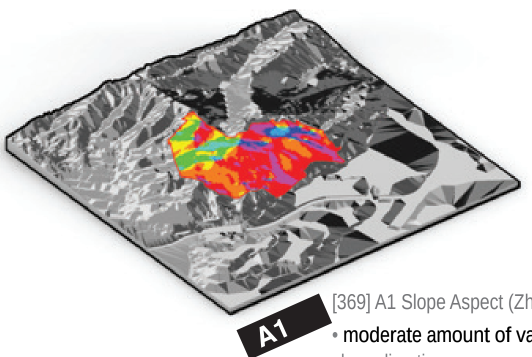
[367] G1 Slope Aspect (Zhong 2020).

• **less variation** in the slope direction appears on the surface comparing to 2018 reference surface
• spatial distribution of aspect is **clustered** that indicates angular slopes



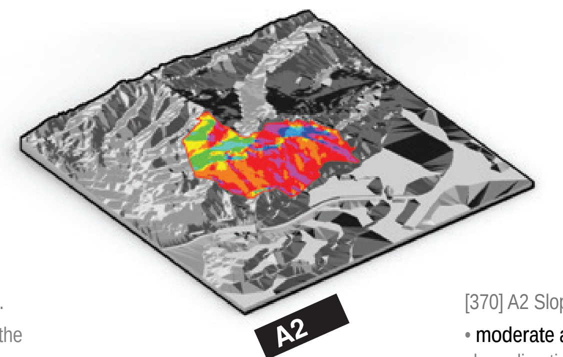
[368] G2 Slope Aspect (Zhong 2020).

• **less variation** in the slope direction appears on the surface comparing to 2018 reference surface
• spatial distribution of aspect is **clustered** that indicates angular slopes



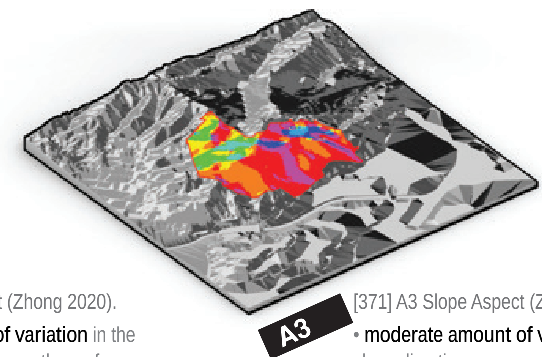
[369] A1 Slope Aspect (Zhong 2020).

• **moderate amount of variation** in the slope direction appears on the surface
• spatial distribution of aspect **starts to scatter** but is still clustered on the facets



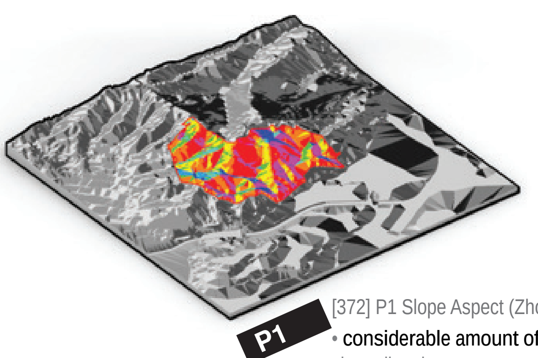
[370] A2 Slope Aspect (Zhong 2020).

• **moderate amount of variation** in the slope direction appears on the surface
• spatial distribution of aspect **starts to scatter** but is still clustered on the facets
• more aspect variation on the north slope than A1 and A3



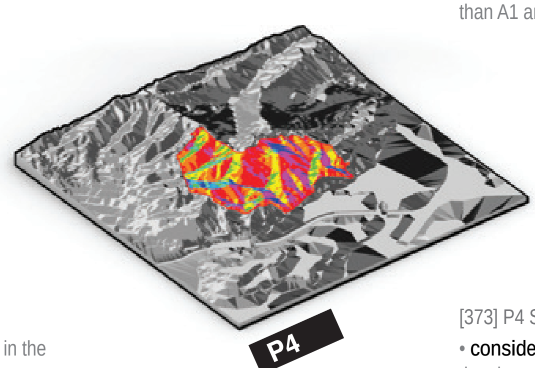
[371] A3 Slope Aspect (Zhong 2020).

• **moderate amount of variation** in the slope direction appears on the surface
• spatial distribution of aspect **starts to scatter** but is still clustered on the facets
• less aspect variation on the north slope than A1 and A2



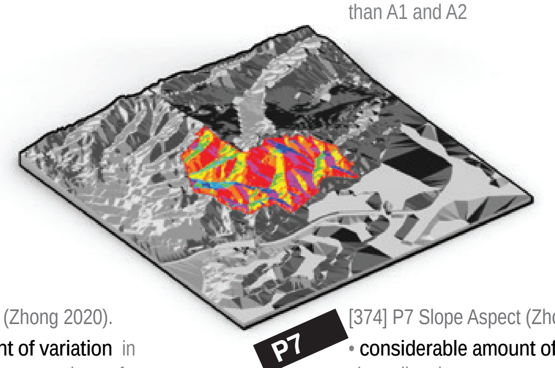
[372] P1 Slope Aspect (Zhong 2020).

• **considerable amount of variation** in the slope direction appears on the surface
• spatial distribution of aspect is **very scattered** indicating no obvious defined edges



[373] P4 Slope Aspect (Zhong 2020).

• **considerable amount of variation** in the slope direction appears on the surface
• spatial distribution of aspect is **very scattered** indicating no obvious defined edges



[374] P7 Slope Aspect (Zhong 2020).

• **considerable amount of variation** in the slope direction appears on the surface
• spatial distribution of aspect is **very scattered** indicating no obvious defined edges

ANALYSIS SUMMARY PAGE

5.2.5.1 Landfill Cross-sectional Analysis

After reviewing all the cross sections running along both the N-S and W-E directions, it was obvious that cross-section lines are flatter and have no or little dissection, while Group 2 has moderate undulation, and Group 3 has the most dissected, naturally-appearing undulation on landfill side slopes. In term of the top deck areas, the shape of the top area for G1 and G2 progressed from flat and linear, to rounded undulation and even presented tall, rocky features like the peaks of the natural landscape.

5.2.5.2 Landfill Surface Analysis

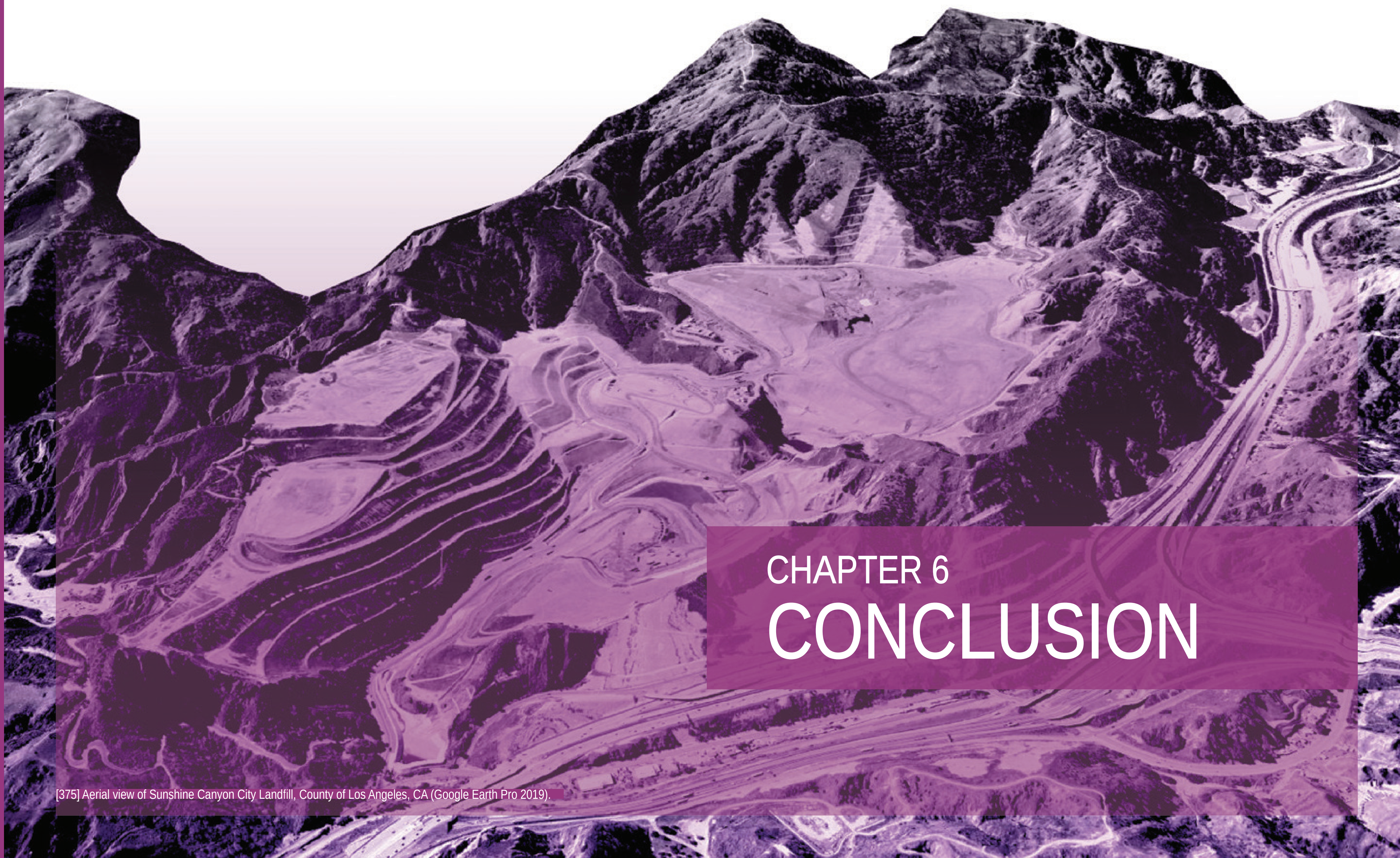
Slope Gradient Analysis

Slope gradient analysis indicated that slope gradients due to surface modifications gradually increased from Group 1 to Group 3, and proposed landfill surfaces in Group 2 and Group 3 presented **more variation of slope gradient** on both side slope surfaces and top deck areas. In addition, **spatial distribution of the slope gradient** progressed from **clustered to scattered** from Group 1 to Group 3 indicating that more undulations appeared on landfill surfaces.

Slope Aspect Analysis

Slope aspect analysis indicated that the from Group 1 to Group 3, the variation on slope aspect gradually increased as surface modification increase from Group 1 to Group 3, and proposed landfill surface in Group 2 and Group 3 presented **more variation on slope aspect** on both side slope surfaces and top deck areas. In addition, **spatial distribution of the slope aspect** progressed from **clustered** to **scattered** from Group 1 to Group 3 indicating that more undulations are appearing on the landfill surface.

CHAPTER 6
CONCLUSION



[375] Aerial view of Sunshine Canyon City Landfill, County of Los Angeles, CA (Google Earth Pro 2019).

6.1 Projective Conclusion

Through this research, the research question "***How can landfill slopes be better designed to enhance and better blend with surrounding topography and be less visually objectionable***?" is answered through both the precedent study and projective design. The precedent study answered the "what" question related to "what degree do existing landfills in southern California, both active and closed, blend into the context of surrounding topography?" This helped identify the best examples which set the current "state of the art" of baseline visual quality. Puente Hills landfill is one of the best existing examples that exemplifies more contouring than older landfills which tend to be more geometric and visually contrasting. The projective design portion of the project explored the "how" question related to improving upon the current best example (Puente Hills landfill) to determine how far contouring can be pushed to replicate more natural topographic forms that better blend with the surroundings while maintaining fill capacity. Of the many iterations attempted, Terrain "A3" represented the best balance of aesthetic contouring and maintaining fill capacity. With more time, contouring for aesthetics could be pushed even further.

The research is fairly new to landscape architects, and even to many civil engineers who may be more focused on fill capacity and other technical requirements rather than aesthetics. Results of this research project are the first steps in showing what might be possible within the realm of landfill design from both an aesthetic and technical perspective. As "shapers and stewards of the land", landscape architects can play a vital role on landfill design teams involving professionals from a diverse range of disciplines. Considering the scale and wide visibility of many landfills which potentially affects hundreds of thousands of people on a daily basis, this can be an important area of practice for the landscape architecture profession.

6.2 Limitation of the Study

Time greatly restricted the depth of this research project and report, especially related to the precedent study and projective design. There are several things that were greatly impacted by the time constraint :

1. Data collection and analysis for precedent study could be more precise and reliable. If time allowed, the filling area of each studied example in the landfill inventory process could be identified and recorded in a 1 :1 real-world scale to ensure the accuracy of the FRAC index calculation. Similarly applied to the SD calculation process, if time permitted, cross-sections could be scaled up to 1:1 scale to calculate their SD so that cross precedent comparison will be feasible.

2. The parametric advanced contouring model could be better improved and designed if more time allowed. The data collection and analysis for the precedent study could be more precise and reliable. In addition, the feasibility study (slope stability analysis) should be conducted to examine all the proposed landfill surfaces.

3.None of the landfill capacity calculations considered the refuse-to-cover ratio.

4.Due to the special period of global pandemic, traveling to the study region was impossible, however, on-site investigation could be very helpful especially since this report is about understanding visual aesthetics.

Secondly, limitations could originate from the methodology itself:

1.The whole group of studied landfills could be broader so the best examples could be better identified. Additionally, very little literature was found specifically related to the aesthetic aspects of landfills. Therefore, the research process proposed in the report might be immature and have more room for improvement.

2. Some of the EIRs of the selected precedents were not available for retrieval unless personally visiting the local library.

3. The accuracy of the USGS topographic maps and reference DEM will greatly affect the model accuracy. In this report, the author used the 20-foot contour interval (2018 reference surface) and 25-feet contour interval (1950 reference surface) considering the availability and author's computing hardware capacity.

6.3 Potential of Future Study

The study is based on the hypothesis that the public values the aesthetic / visual environment that is impacted by the landfill configuration. Due to limited time, it was not possible to deeply analyze the public's attitude towards landfill aesthetics, especially related to the specific landfills studied.

In addition, it is also necessary to test the results by investigating public's reaction to enhanced landfill contouring through visual simulations in a future study. Meanwhile, a more in-depth slope stability analysis should be conducted to understand the feasibility and stability of the proposed landfill surfaces.

In summary, there are some report aspects that have potential for extending future research concerning landfill aesthetics:

- Document observed public reaction to enhanced landfill aesthetics proposed in this project for gauging overall significance of visual concerns.

- Continue studying the operational feasibility and other technical aspects of the proposed design with review and input by civil engineers and other landfill design/operator professionals.

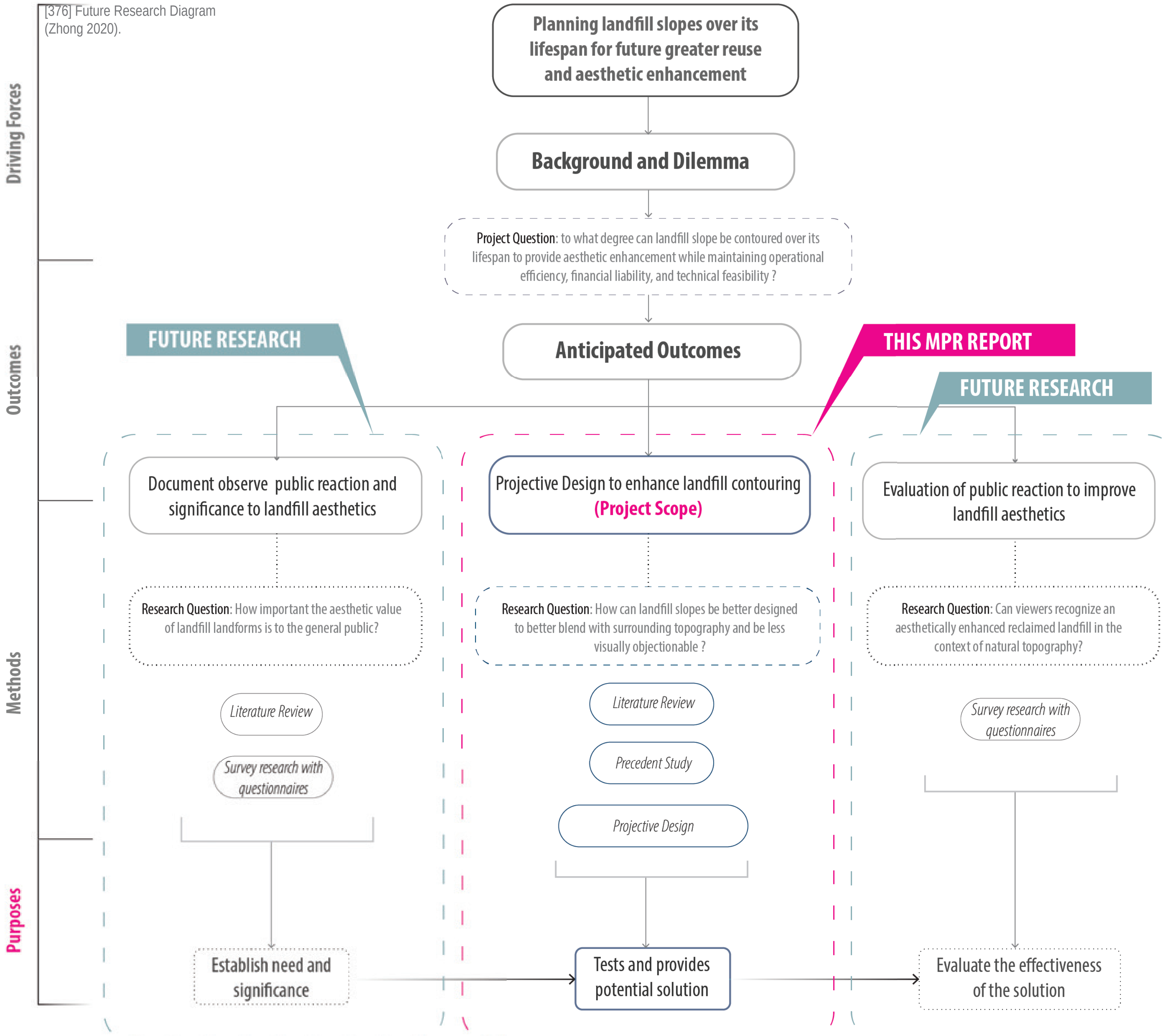
- Investigate, to what degree, can benching and landfill slope drainage structures be effectively integrated into more highly contoured slopes.

From an environmental review and landfill permitting standpoint, the following questions can be pursued in the future:

1) To what degree do aesthetics plays in the range of issues raised by the public in typical opposition to landfill permitting?,

2) To what degree can enhanced landfill slope contouring and ridgeline profile measures be used to offset public opposition to landfill permitting?

[376] Future Research Diagram (Zhong 2020).



6.3 Self-Reflection

The topic of landfill aesthetics has been new to me and I am actually really glad that I chose to work on this project with my major professor, Howard Hahn, whom I cannot thank enough for his guidance and selfless dedication to my project.

Although I know there is still a lot of improvement that can be made to the report, I am still satisfied and proud of what I have accomplished. I hope this project and report will give my audience some insights into landfill design and aesthetics, as well as encourage future research in this area by landscape architects and others concerned with landform aesthetics.

[377] Aerial view of Arrow-Live Oak IDEFO, County of Los Angeles, CA (Google Earth Pro 2019).

APPENDIX I: Glossary

Area Fill (Qian et al. 2001): a common geometrical configuration of landfill that the landfill is constructed above ground with no or little excavation.

Buried/Subsurface Horizontal System (for Liquids Addition) (Townsend 2015): a subsurface trench system that is designed to add liquid to the waste, will affect the slope stability.

California Environmental Quality Act/CEQA (California Government 2019): State environmental law that used to protect the environment and inform the public and decision makers about the potential environmental impacts of proposed projects and engage them.

Canyon Fill (Valley Fill) (Qian et al. 2001): a common geometrical configuration of landfill that the built against or between rolling terrain.

Cost Elements (Townsend 2015, 426): cost of substantial time and resources required by a proposed project, such as a landfill.

Distance Zones (BLM 1980): "a subdivision of the landscape as viewed from an observer position," usually includes foreground, middle ground and background.

Engineering berm (Bagchi 2004; Qian & Koerner 2009): engineered berms that is built around the landfill boundary to prevent landfill failures, sometimes to increase landfill volume as well.

Environmental Impact Report/EIR (Los Angeles Public Library 2019): reports required by laws to be published to inform the public and decision makers about potential environmental impacts that will be caused by the proposed projects. In California, EIRs are mandated by CEQA.

Final Cover System (Townsend et al 2015; Qian et al. 2001): once capacity is reached, landfill will be closed and capped with final cover keep out gas escape and precipitation.

Geographical Information System/GIS (ERSI 2019): "a framework for gathering, managing, and analyzing data." In this research, GIS/ArcGIS is a computerized tool used to analyze geographical information.

Key Observation Points /KOPs (BLM 1980): are selection at different locations where the proposed project is prominently visible.

Landfilling (EPA 2015): the most common way to dispose waste by burying it under the ground.

Leachate Collection and Removal System (LCRS) (Townsend et al 2015; Qian et al. 2001): an engineered system required in a landfill that collects and removes the leachate generated from the waste disposal for treatment.

Landfill Gas Control System (Townsend et al 2015; Qian et al. 2001): an engineered system required in a landfill to prevent landfill gas from escaping to the atmosphere.

Post Closure Use (Townsend et al 2015; Qian et al. 2001): proposed future uses of a closed landfill, usually includes recreational uses, industrial uses and others.

Slope Stability Analysis (Townsend et al 2015; Qian et al. 2001): and overall assessment on waste slope and cover materials to prevent landfill side slope failures, usually conducted in computer application like Slope/w.

Trench Fill (Qian et al. 2001): a common geometrical configuration of a landfill where the original ground surface is excavated into deep trenches.

Municipal Solid Waste/MSL (EPA 2016): non-hazard waste that people dispose daily, usually consisting of paper, bottles, food scraps and other refuse material coming from households, businesses, and schools.

(Topographic) **Aspect** (ESRI 2019): the direction of slope. In ArcGIS, aspect "identifies the downslope direction of the maximum rate of change in value from each pixel to its neighbors."

(Topographic) **Slope** (ESRI 2019): rate of change in elevation over change in distance. In ArcGIS, slope is the "change in elevation for each digital elevation model (DEM) pixel."

Visual Character (ASLA & FHWA 2015; BLM 1980): visible attributes of an object or a scene (form, line, texture, color and etc.)

Visual Resource (BLM 1980): "Any Object (natural and built, moving and stationary) or feature, such as landform or water body, that is visible on a landscape."

Visual Impact Assessment/ VIA (BLM 1980): a comprehensive assessment mandated in an Environmental Report (EIR) that evaluates the visual impacts to landscape character and views caused by proposed projects.

Viewshed Study (ASLA & FHWA 2015; BLM 1980): a spatial analysis that is used analyze different types of viewsheds including static and dynamic to determine the surrounding visible landscape, usually conducted in ArcGIS using digital elevation model (DEM).

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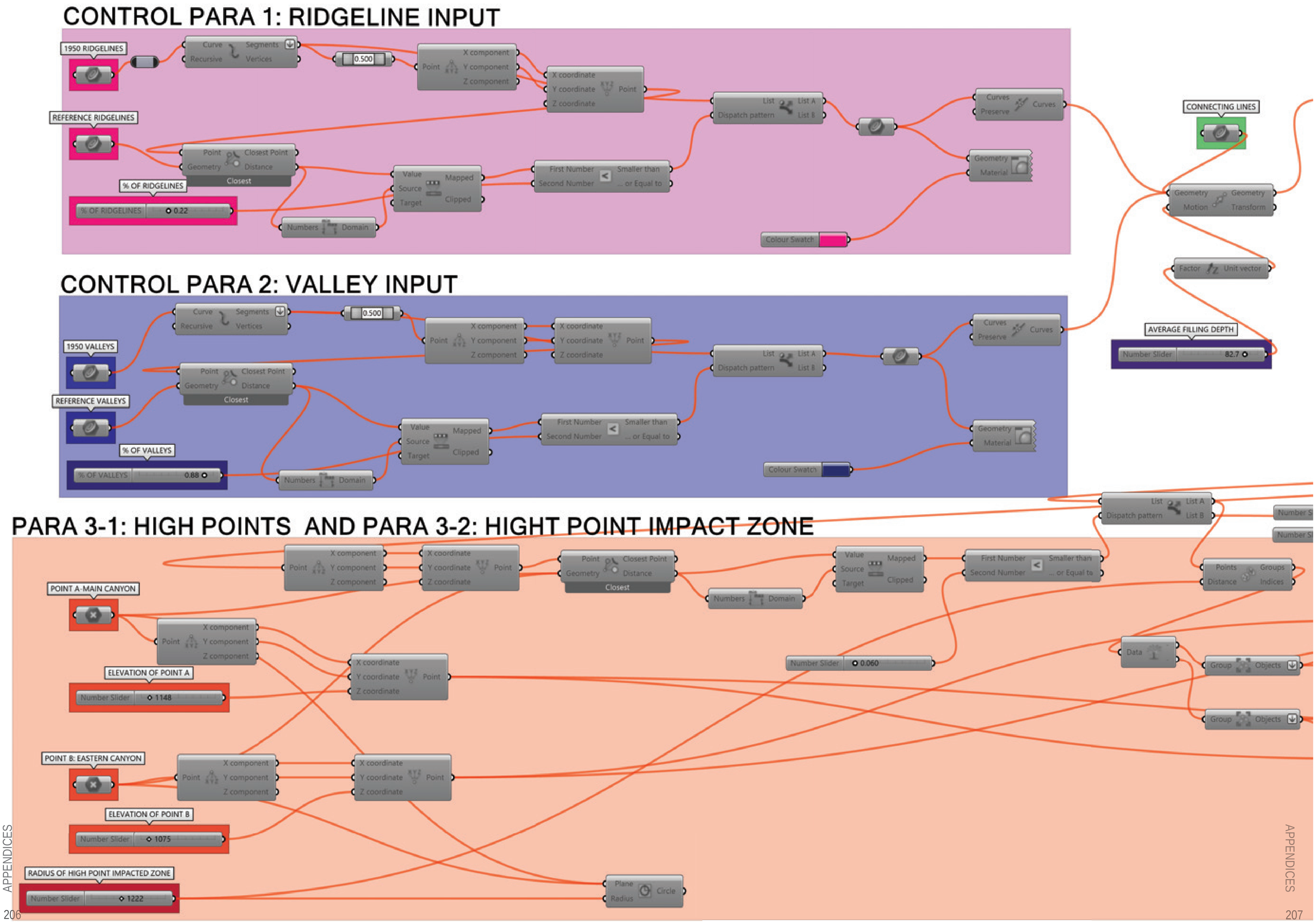
APPENDIX III: Landfill Inventory

LA COUNTY-ACTIVE-14, CLOSED-29										
#	Name	Area (not to scale)	Perimeter (not to scale)	Fractal Dimension Index	Vertices	Overall Visual Qu	Landform visual Quality	Landfill type	Context	Reclaimed Type
1	Antelope Valley Public Landfill	132110.7253	1659.439	1.0224	57	M	L	canyon		n/a
2	Arrow-Live Oak IDEFO	26038.7731	746.5844	1.0286	5	L	L	below ground	urban, industrial,	n/a
3	Azusa Land Reclamation Co. Landfill	125674.4792	1483.3767	1.0077	48	L	L	below ground	industrial	n/a
4	Burbank Landfill Site No. 3	57367.3804	1099.9298	1.0252	90	L	L	canyon	residential, suburban	n/a
5	Calabasas Landfill	976607.78	5188.15	1.0394	195	H	H	canyon	suburban	n/a
6	Chiquita Canyon Sanitary Landfill	74974.4406	1360.3022	1.0386	150	M	H	canyon	suburban	n/a
7	Durbin Inert Debris Engineered Fill Site	241804.9769	1944.1939	0.9981	21	L	L	below ground	urban, residential, industrial	n/a
8	Lancaster Landfill and Recycling Center	118964.1204	1368.3044	0.9986	11	M	L	above ground	no devel	n/a
9	Peck Road Gravel Pit	182994.2838	1919.9193	1.0190	66	L	L	below ground	urban, industrial,	n/a
10	Reliance Landfill	35663.1944	762.1187	1.0017	21	L	L	below ground	urban, industrial,	n/a
11	Savage Canyon Landfill	143794.0779	1767.7884	1.0258	102	M	M	canyon	residential	n/a
12	Scholl Canyon Landfill	154888.4783	1797.9469	1.0222	153	M	M	canyon	residential, suburban	n/a
13	Sunshine Canyon City/County Landfill	153155.5436	2281.0338	1.0631	201	M	M	canyon	residential	n/a
14	United Rock Products Pit #2	65893.9043	1121.29	1.0159	30	L	L	below ground	urban, industrial,	n/a
15	Ascon Construction - Long Beach	51171.4892	899.2481	0.9989	21	L	L	above ground	reidentail	n/a
16	BKK Sanitary Landfill	1763278.93	5214.75	0.9974	65	M	M	canyon		n/a
17	BKK Public Dump -Carson	313103.588	2633.2434	1.0257	15	M	L	below ground	industrial	n/a
18	Bradley Landfill West And West Extension	155773.4375	1668.9788	1.0093	63	L	L	above ground	industrial	n/a
19	Branford LF	149249.6142	1665.2359	1.0125	30	L	L	below ground	industrial, residential	lf mining
20	Canyon Park Dump/Rancho Duarte Golf Cour	117619.0201	1397.1478	1.0031	33	M	L	above ground	low-den resi	golf course
21	City Of Alhambra Landfill	282553.723	2411.54	1.0201	42	H	L	above ground, hill	residential	golf course
22	Cogen Dump	120746.9136	1615.518	1.0257	57	M	L	canyon		industrial
23	Coverstreet Stockpile	76861.304	1404.2966	1.0420	64	M	M	above ground	industrial	park
24	Glenoaks Dump	183674.1898	2097.911	1.0333	30	M	M	above ground	industrial	golf course
25	Harbor Hills	241644.6759	2141.3677	1.0138	54	L	L	above ground, hill		
26	Hetzler Landfill	149003.858	1559.2405	1.0016	33	M	M	canyon		baseball filed
27	Huntington Park City Dump	304607.446	2321.6291	1.0080	42	H	M	below ground		park
28	Lopez Canyon Sanitary Landfill	770021.39	4750.46	1.0447	147	H	H	canyon		
29	Manning Brothers Class III Landfill	73997.4923	1183.813	1.0150	33	L	L	below ground	within residency	park
30	Mission Canyon #8	153466.4932	2189.6367	1.0560	249	M	L	canyon		golf course
31	North Avenue Dump / Osborn Construction D	96823.7847	1261.9965	1.0024	27	L	L	above ground	residential	
32	Palos Verdes Landfill	259163.5802	1961.553	0.9940	27	H	M	above ground		
33	Penmar Golf Course	114979.7454	1426.2536	1.0086	8	M	M	above ground	residential	golf course
34	Penrose Pit	58141.3966	1043.847	1.0144	21	L	L	above ground	industrial, residency	
35	Puente Hills Landfill	2026393.93	7929.54	1.0456	160	H	H	canyon	cayon, residency, highway	
36	Rose Hills Landfill	211040.4128	2325.7886	1.0384	120	H	M	canyon	residential	park
37	Rosehills Dwp Landfill	239193.7581	2007.5329	1.0042	39	L	L	canyon		
38	Southwest Conservation District Landfill	333573.6883	2325.7793	1.0011	6	M	L	below ground		parking lot
39	Spadra Sanitary Landfill	850230.76	4131.01	1.0166	98	H	M	above ground	industrial, residential,	
40	Spadra Sanitary Landfill #2	118318.4799	1440.9217	1.0079	24	M	L	below ground	industrial	open space
41	Toyon Canyon Park Reclamation Project	104694.0586	1340.6803	1.0061	66	M	L	canyon	canyon, low density residency	
42	Valley Land Development Co. Inc	309598.1331	2437.4134	1.0144	45	M	M	canyon	residency, urban	resort

[378] Inventoried landfill list (Zhong 2020).

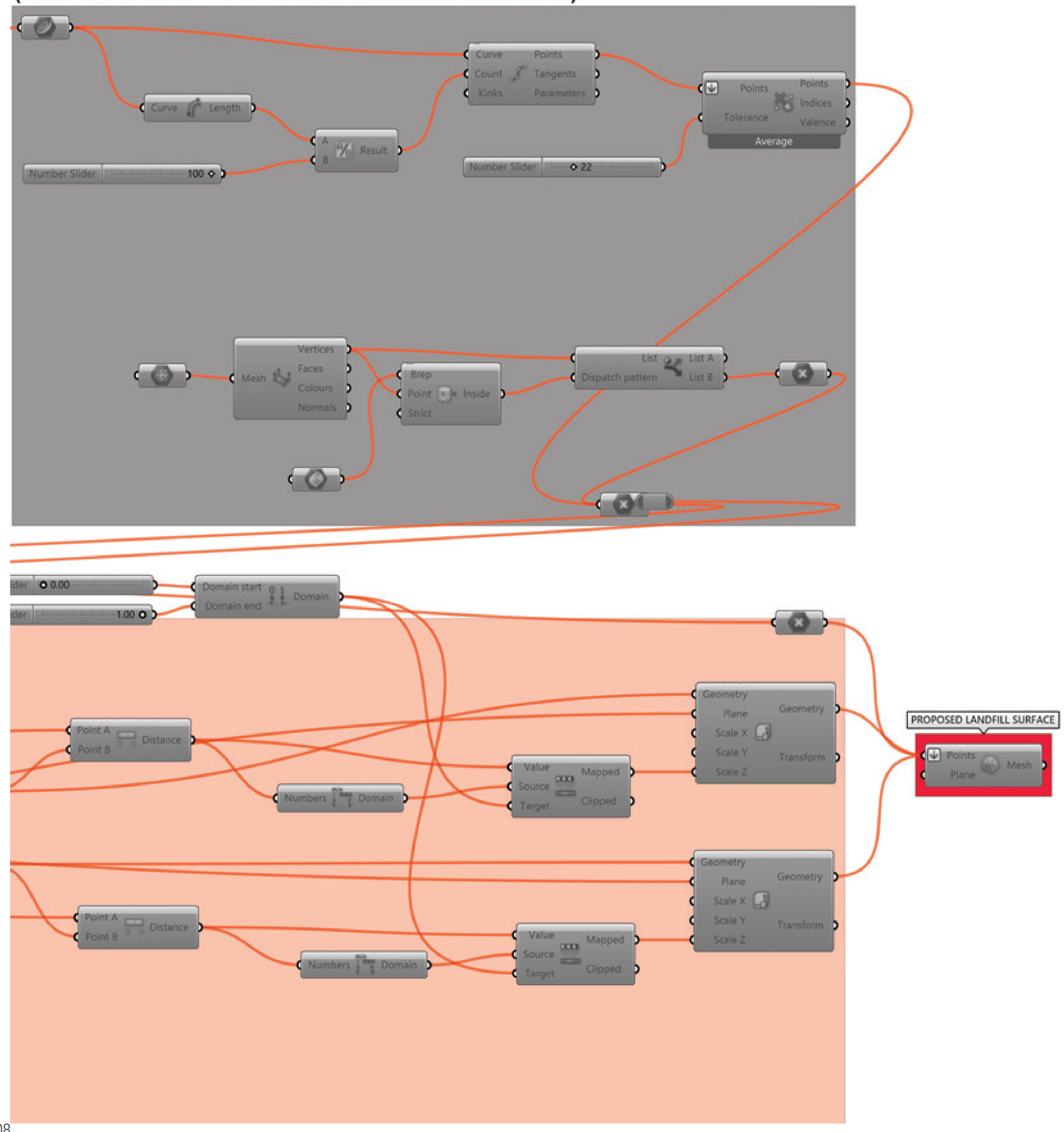
APPENDIX IV: Grasshopper Parametric Surface Script



[379] Grasshopper parametric surface script (Zhong 2020).

APPENDIX IV: Grasshopper Parametric Surface Script

POINTS CLEAN UP REDUCE FILE SIZE
(NOT RELATED TO THE ADJUSTING PROCESS)



ref. [379]