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University of Redlands

Discovering Henry Huntington's Landholdings

A Major Individual Project submitted in partial satisfaction of the requirements
for the degree of Master of Science in Geographic Information Systems

by
Aldous Hin-Che Tsang

Mark Kumler, Ph.D., Committee Chair

Ruijin Ma, Ph.D.

October 2015

Discovering Henry Huntington's Landholdings

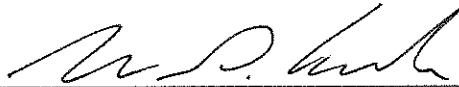
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by
Aldous Hin-Che Tsang

The report of Aldous Hin-Che Tsang is approved.



Ruijin Ma, Ph.D.



Mark Kumler, Ph.D., Committee Chair

October 2015

Acknowledgements

Thank you to everybody of the MS GIS program staff at the University of Redlands for the opportunity to learn more and expand my knowledge of GIS. I'd like to thank Dr. Flewelling, director of the MS GIS program for his insights and approach to teaching. I'd like to take Andrea Barrios for being helpful and encouraging.

I would like to thank my committee head and advisor, Dr. Mark Kumler for the opportunity and journey to work on this project. His guidance and knowledge helped me refine my project. I also would like to thank Dr. Ruijin Ma who was part of my committee. I also would like to thank the technical support of Ruben Ortiz and Nathan Strout. I appreciate their extensive knowledge with virtual machines and programming in the ArcGIS environments.

Thanks to The Huntington Library and Jennifer Goldman for the opportunity to photograph and handle historical maps for this project.

I would like to thank my fellow cohort, Cohort 26, for the experiences and friendship this past year. I am glad to have met everybody and wish everybody the best in their pursuit of GIS.

Lastly, I would like to thank my family and friends, who supported me during this year in the MS GIS Program. I am thankful for the prayers and encouragements that drove me to do my best. I especially want to thank my parents for their support. They have been a driving force in my pursuit of a master's degree.

Abstract

Discovering Henry Huntington's Landholdings

by

Aldous Hin-Che Tsang

In the late 1800s, Henry E. Huntington owned more than 60,000 acres of land in southern California, including thousands of properties in the burgeoning Los Angeles metropolitan area. Detailed maps of these landholdings are in today's Huntington Library, but access is limited to scholarly researchers. A transparentization method was developed to overcome the shortcomings of the swipe and transparency tools. A web application was created to show the landholding of Huntington using tools that assisted the user in exploration and discovery of the past.

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List of Acronyms and Definitions

PNG	Portable Network Graphics
AGOL	ArcGIS Online
GIS	Geographic Information Systems
DSLR	Digital Single Lens Reflex

Chapter 1 – Introduction

Historical maps provide information about places that have been altered by modern development. However, access to historical paper maps is often limited to scholars and researchers. Working with fragile paper maps can be cumbersome and slow. This project created the ability for an institution to expand its research capabilities while extending access to a wider audience by converting historical paper maps into digital online maps. Moreover, the creation of digital historical maps in conjunction with present day aerial basemaps gives researchers and historians the ability to answer questions about land ownership and land use during a specific time in history.

1.1 Client

The initial client and point of contact began with Jennifer Allan Goldman, formerly the Curator and Manuscripts and Institutional Archivist at the Huntington Library, Art Collections, and Botanical Gardens located in San Marino, California. She provided access to the Huntington's vast resource of historical maps. Li Wei Yang took over as point of contact when Ms. Goldman left the Huntington Library. The purpose of this study was to find out how much land Henry E. Huntington owned and where he owned that land, based on the collection of historical maps the Huntington Library possesses.

1.2 Problem Statement

The Huntington Library existed as the repository for all of Huntington's personal and business papers, including hundreds of historical maps, most of which are tract maps used for sales purposes. While Huntington was one of the largest landowners in Los Angeles in 1910, the Library does not have a comprehensive account regarding total acreage or the exact locations of his land ownership. The Huntington Library wanted a web application to display the various maps involving Huntington's landholdings. Having this information compiled would serve both the in-house archivist and researchers, making them more accessible to the public.

1.3 Proposed Solution

The proposed solution was to create a prototype web application capable of displaying Huntington's landholding maps on a current base map. The process started with using photography to capture a small collection of landholding maps and then converting the paper maps to digital images. A web application displayed the georeferenced photos. The prototype web application would have a slider tool with the ability to see the details of the tract map underneath using a transparent background of the original tract map. The user should also have the ability to toggle between a historical topographical base map and a current base map.

1.3.1 Goals and Objectives

Placing the landholding maps of Henry Huntington into context with present day aerial orthographic and historical topographical base maps became the main goal of this project. Presently, researchers and archivists have limited access to the collection of Henry Huntington landholdings stored at the Huntington Library. Showing the collection digitally would give access to more individuals, providing the most benefit to those researchers and archivists at the Library. This would help people to explore and discover the location of Huntington-owned property, and to compare changes over time on these landholdings.

The project developed its primary objectives into the creation of the transparent background images of the original maps in addition to creation of the prototype web application, which uses a slider tool to see the difference between the two images, overlaid on a base map.

1.3.2 Scope

The scope of the project outlines the development a prototype web application to demonstrate how the landholdings of Henry Huntington could be displayed on a base map online. For this development process, seven tract maps covering the surrounding areas of Pasadena and neighboring cities were selected to be georeferenced.

1.3.3 Methods

This project used photographic methods to capture and edit the photos. The selection of the lens to photograph the maps depended on the size of the map, amount of light in the room, and reduction of distortion. A guide to creating a panorama using multiple shots suggests an overlap of 40% to be taken (Adobe, 2015). With this method, it resolved the problem created by several maps that extended beyond what the camera could capture. Adobe Photoshop CC 2014 facilitated the stitching together of the multiple shots. The application of Photoshop techniques also enhanced the photos and removed complex (non-solid) background to obtain the linework of the tract maps.

The georeferencing/rectification process helped to align the edited images properly to the base map. The utilization of Los Angeles County parcel data helped increase the accuracy of the control point links, which worked well with tract maps. First order transformation rectified the majority of the images, whereas second order transformation helped take care of the slight skewing caused by stitching in two of the maps. The prototype web application used Esri's Story Map application as a starting model. Customization and enhancements of the web application used HTML and JavaScript.

1.4 Audience

The audience for this report includes the client, as well as the general public who might have little to no GIS training.

1.5 Overview of the Rest of this Report

This report describes the approach created for the client to digitally display and discover the landholdings of Henry Huntington. Chapter 2 examines the background and related literature for this project. Chapter 3 presents the project system analysis and design. Chapter 4 explains the database design and the conceptual and logical models. Chapter 5 covers the implementation of the project. Chapter 6 shows the results of transparentization for the project. Chapter 7 explores the interface and functions of the web application. Finally, Chapter 8 describes the conclusion of the work performed and suggests possible future work.

Chapter 2 – Background and Literature Review

Maps record the basic geographical information for reconstructing past locations (Rumsey & Williams, 2002). Geographic information can be used to catalog maps digitally, thus allowing historians and researchers to use location to discover all available sources related to a particular location (Gregory, Kemp, & Mostern, 2003). Section 2.1 examines the use of Geographic Information Systems (GIS) in historical research and implementation of GIS by libraries. Section 2.2 looks at the history of the alpha channel and the impact of transparency in GIS. Section 2.3 explains the process of georeferencing. Section 2.4 talks about the growth of web applications and the tools used.

2.1 Historical GIS

According to Gregory et al. (2003), “Historians use GIS generally in three ways: to discover, manage, and integrate historical research resources, to graphically display research results in the form of maps and other visualizations, to perform spatial analysis on historical data” (p. 7). Using GIS can help index and archive historical maps, allowing people to discover information about a particular place. The New York Public Library has used GIS for their The New York City Historical Project (Kuntzen, 2012), where they scanned, georeferenced, and digitized 7,799 maps, mostly historical fire insurance maps dating to 1916. Another example is the David Rumsey Collection (<http://www.davidrumsey.com>) where historical maps are graphically displayed online. The collection has over 61,000 maps, including rare 16th through 20th century maps of North and South America, and historical maps of the world.

2.1.1 Issues of GIS and History

While GIS is great for mapping and analyzing information with geographic units and location, Knowles and Hillier (2008) found “the precision that makes GIS so useful in many kinds of scientific and statistical analysis, however, can make it an awkward instrument for historical research when sources cannot easily be reduced to entries in a tabular database” (p. 2). Historical research often focuses on the interpretation of verbal texts. Doel and Henson (2006) stated, “Historians of science have moved more slowly than colleagues in other fields to incorporate analysis of photographs of the social, technical, and institutional practices of science into their writings” (p. 201). Another impediment to historical GIS has been the epistemological divide between geography and history (Baker, 2003). The two disciplines commonly say that history is the study of when and geography is the study of where (Knowles & Hillier, 2008). Another challenge with historical maps, Gregory et al. (2003) stated is, “Location is a key component of geographical information. Unfortunately, in a historical context, location is often described simply as a place name, an ill-defined region such as ‘the southwest US,’ or descriptively, as in ‘close to the banks of the river’” (p. 13). Additional research and data models on uncertainty can be applied to take into account any ambiguity.

2.1.2 Incorporation of GIS and History

Knowles and Hillier (2008) stated:

Historians are using GIS to study a tremendous variety of subjects, periods, and places, most research and resource creation during the past decade has been concentrated in three areas. One is empirical research on the history of land use and the development of spatial economies. The second is using GIS to visualize past landscapes and the changing morphology of built environments over time. The third consists of infrastructure projects that aim to make historical source materials available to scholars and the general public for mapping and other kinds of analysis. (p. 8)

Historical maps have a lot to offer to GIS, and GIS brings new approaches to the analysis and displaying of historical maps (Rumsey & Williams, 2002).

2.2 Alpha Channel / Transparency

The notion of the alpha channel was invented by Ed Catmull and Alvy Ray Smith in 1970s. Smith (1995) stated:

Alpha (channel) is the transparency (equivalently, opacity) channel. The alpha channel typically contains as many bits as a color channel. So, for example, an 8-bit alpha channel can represent 256 levels of transparency, from 0 (completely transparent) to 255 (completely opaque). (p. 5)

Thus, RGB images (Red, Green, Blue) became RGBA images. GIS has used transparency in many different applications. Rumsey and Williams (2002) explained:

Overlaying georeferenced historical maps allows one to combine maps of differing sizes and scales. With the innovation of partially transparent raster layers in GIS, we were able to produce composite map images that suggest how the passage of time transformed the city. (p.8)

The combination of overlaying rasters and transparency helps with visualization and understanding of maps. Using GIS, one can create maps with dramatic topography using digital elevation models.

2.2.1 PNG Format

Portable Network Graphics (PNG) is a file format for lossless, well-compressed storage of raster images (W3C, 1996). PNG supports alpha channel for truecolor (RGB) and greyscale images (W3C).

2.3 Image Stitching

According to Chen & Klette (1999) defines panoramic image stitching as, “the process performed to generate one panoramic image from a series of smaller, overlapping images” (p. 615). The process required in generating a panoramic images are broken down into three main components: image acquisition, image registration, and image merging (Chen & Klette, 1999). Image stitching is necessary to handle large historical maps that photographic peripherals cannot capture within a single image.

2.4 Georeferencing

Another factor in dealing with historical maps is the conversion process from analog to digital and georeferencing. Balletti (2006) defined georeference as:

Georeference is applied here as the process, which assigns to non-metrical maps (usually the early maps) a ‘metric reference’ from the actual geospace or its mappings. When the metric reference is related to the system of earth coordinates or their map-projection counterparts, it is called georeference. (p. 34)

Georeferencing starts by selection of control points of the scanned historical map. It is important that the scanned image be aligned with its actual geographical location. Rumsey and Williams (2002) wrote, “Once the control points are in place, one applies mathematical algorithms to warp the original map image to fit the selected map projection as close as possible” (p. 5).

2.5 GIS on the Web

In 1993, the Xerox Corporation Palo Alto Research Center developed the first web map viewer. It had simple functions such as zooming capabilities, layer selection, and map projection conversion. Users now were able to use GIS through a browser without any local installation of specialized software on their machines (Fu & Sun, 2011). Today, web services such as Google Maps and ArcGIS Online (AGOL) allow users to create mashups with their own data, or other data found online (Fu & Sun, 2011). Esri released ArcGIS Online (Esri, 2012) in June 2012. AGOL continues to add more functions and tools, such as swipe tool, and editing capabilities that goes beyond the initial development for web applications.

2.6 Summary

Historical research is done using GIS. Many libraries have created digital archival libraries of their collections. In addition, GIS has used transparency to enhance maps. The rising popularity of the online maps has created an influx of web applications. Chapter 3 will discuss the system design and analysis of the project.

Chapter 3 – Systems Analysis and Design

The system analysis and design for this project revolved around displaying the landholdings of Henry Huntington for researchers and the public to view. Section 3.1 looks at the problem that the project attempted to resolve. Section 3.2 reviews the system requirements of the web application — both functional and non-functional. Section 3.3 explains the system design, showing how all the components worked together. Section 3.4 discusses the original project plan findings and the changes throughout the project.

3.1 Problem Statement

The Huntington Library has a collection of documents about Henry Huntington’s landholdings that has not yet been catalogued. Since it was difficult to sort historical maps efficiently, the Huntington did not have an accurate account of the acreage and location of his landholdings. The Huntington needed a web application to display the various historical maps of Huntington’s landholdings around Southern California.

3.2 Requirements Analysis

Table 1 outlines the functional and non-functional requirements for the web application. All data had to be converted to the World Geodetic System 1984 Web Mercator coordinate system to match Esri’s ArcGIS Online standard.

Table 1. System Requirements

Requirement	Functional/Non-Functional
To display maps that can be viewed in a web application	Functional
To displayed a transparent version of georeferenced maps that can be viewed in a web application	Functional
To ensure accuracy of the georeferenced maps to a basemap	Non-Functional
For transparency slider to adjust the opacity of the georeferenced maps	Functional
For swipe tool to wipe georeferenced map on top to reveal transparent version	Functional

Requirement	Functional/Non-Functional
To show the borders for map layouts on basemap	Non-Functional
To use ArcGIS Online to host the web application	Non-Functional
To use ArcGIS for Server to publish map service and feature service	Non-Functional

3.2.1 Functional Requirements

The main functional requirement for the project was to display the georeferenced maps in the web application. This was important for locating Henry Huntington’s landholdings. Another functional requirement was for the transparency slider to control the opacity of the georeferenced map. The transparency slider shows the transparent version of the georeferenced map gradually when the user moves the slider from the left to the right on the slider bar. The ability for the swipe tool to wipe the georeferenced map was a functional requirement that allowed the user to reveal the transparent version of the georeferenced map.

3.2.2 Non-Functional Requirement

The main non-functional requirement was hosting the web application on ArcGIS Online. This allowed the Huntington Library to view the web application through a web browser and no additional resources were necessary to host the web application on their intranet. The use of ArcGIS for Server helped migrate the data from ArcGIS to ArcGIS Online. In order to ensure proper georeferencing, a non-functional requirement checked the accuracy of the georeferenced maps through the alignment with a referenced map.

3.3 System Design

The system design for this project was the creation of the prototype web application to display Henry Huntington’s landholdings in Southern California. The components for the application were the georeferenced maps and the transparent versions of the georeferenced maps. The transparency slider was another component feature for this project. The slider allowed the user to adjust the opacity/transparency of the georeferenced maps to see the underlying linework of the map. The swipe tool was a component for the user to swipe the layer left and right to reveal a second layer below. The top layer was the original georeferenced map while the lower layer was the transparent georeferenced map. Typically, the transparency slider is used to fade layers away or to see objects that may have been obstructed due to overlapping. Similarly, the swipe tool is used to wipe the top layer to show changes on another map. Figure 3-1 shows the front cover of *Cartographica Extraordinaire: The Historical Map*

Transformed by Rumsey and Punt (2004). The cover illustrates the swipe effect between an older map and an aerial photograph. In the case of the swipe tool to compare changes, users have to swipe back and forth to create the illusion of a superimposed image to see change. The web application enhanced both the transparent slider and swipe tools by retaining the georeferenced map's linework and having the background transparent.

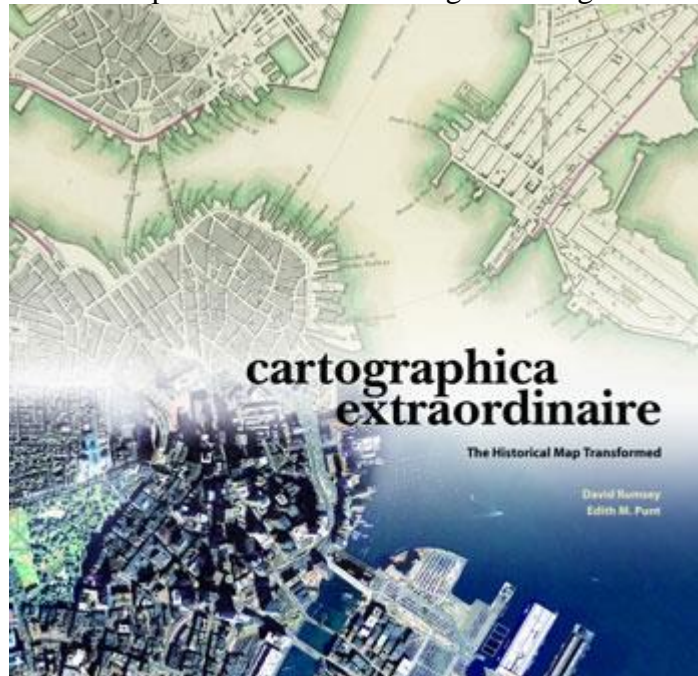


Figure 3-1: Cartographica Extraordinaire: The Historical Map Transformed (Rumsey & Punt, 2004) front cover illustrating swipe effect

3.4 Project Plan

The project plan was to collect and prepare the data and to build the prototype web application. A major task was finding a method to make the background of a map transparent. The method also needed to preserve the linework of the original map. In Adobe Photoshop, identifying the methods to create a transparent background was time consuming. Another task was getting the images georeferenced in ArcGIS. The process was straightforward and did not consume much time. Once the images were georeferenced, they needed to be migrated onto ArcGIS Online. The last major task was the development of the web application. The final phase was building the web application to ensure the data would display and function properly.

Several of the tasks were harder to execute and needed more resources, which pushed the project plan schedule back. The assumption was that the Huntington Library had a few maps digitally scanned. In actuality, none of the maps were scanned. Therefore, using a prosumer grade camera to capture photos of the map was the alternative. The task of removing the background of a map using Photoshop was a learning experience. Once the background of each image was removed, there was an issue of the transparent maps showing a considerable amount of noise when imported into ArcGIS. This issue was unexpected and was dealt with through different iterations of the transparent maps. It was discovered that the high-resolution version of the image

picked up the texture and creases of the map due to the images being in 16 bits per channel. By lowering the image to 8 bits per channel, the images became smoother with less noise as shown in Figure 3-2.

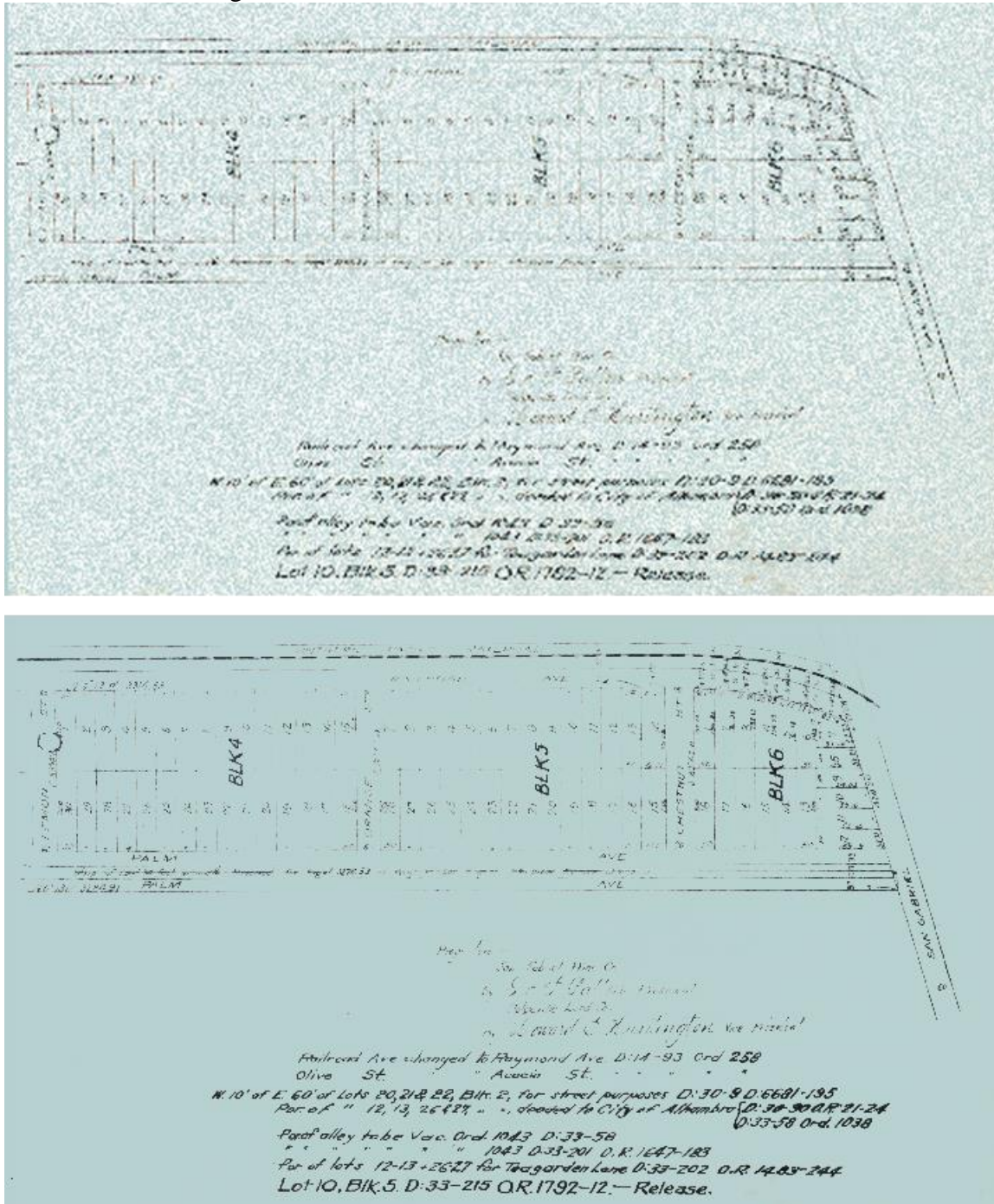


Figure 3-2: 16bits/Channel (top) vs 8bits/Channel comparison (bottom)

The project plan encountered a few other unexpected issues that required additional time and resources to resolve. It was important to allocate additional resources to account for any issues during the phase of project planning and execution.

3.5 Summary

A clear delineation of the problem enables identification of the project requirements - functional and non-functional - needed to provide a desired solution. Next, the system design identified components that were critical to the project's execution. Lastly, the project plan presented the tasks and unexpected issues which were later resolved to meet the goals of the project.

Chapter 4 – Database Design

The development phase of the project formulated the database design. This chapter discusses the conceptual data model and explains how it became the logical data model for the project in the form of a database. It is followed by a discussion of where the data came from and how they were prepared.

4.1 Conceptual Data Model

The conceptual data model is an abstract representation of the client’s problem showing the relationship between essential components. Figure 4-1 shows the conceptual model for this project.

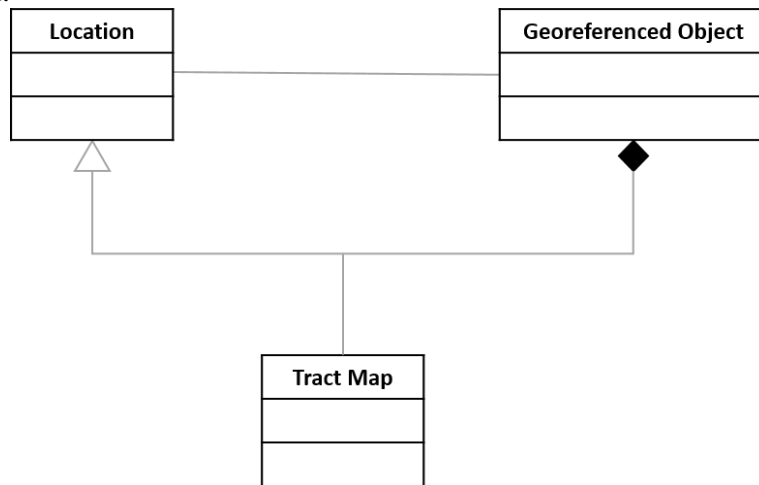


Figure 4-1: Conceptual Data Model

4.2 Logical Data Model

The main dataset for this project was the collection of historical tract maps of Henry E. Huntington. The versions of the maps with opaque linework and transparent backgrounds were derived from the original paper maps. The border corresponds to the boundaries of the tract maps. The logical model is displayed in Figure 4-2.

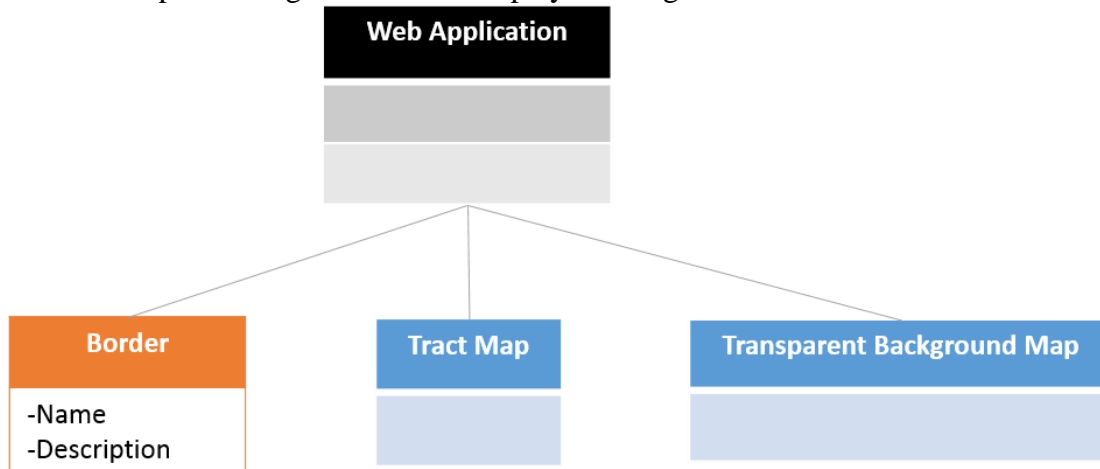


Figure 4-2: Logical Data Model

The historical tract maps and transparent background map versions were put into a geodatabase as raster images. The map border layer was created as a feature class with fields that contained the attributes of the tract maps such as name and description of the tract map.

4.3 Data Sources

The data used for this project originated from the Huntington Library's collection at the Munger Research Center. The data consisted primarily of tract maps, of which seven were selected for this project. Figure 4-3 provides an overview of the selected tract maps. Figure 4-4 shows part of the legal description of one of the tract maps. Figure 4-5 shows a label handwritten by the Huntington Library staff and attached to one of the maps. Figure 4-6 displays a legend. Figure 4-7 shows a map of the electric railway that Huntington owned. Figure 4-8 shows a photograph of an advertisement that includes a tract map.

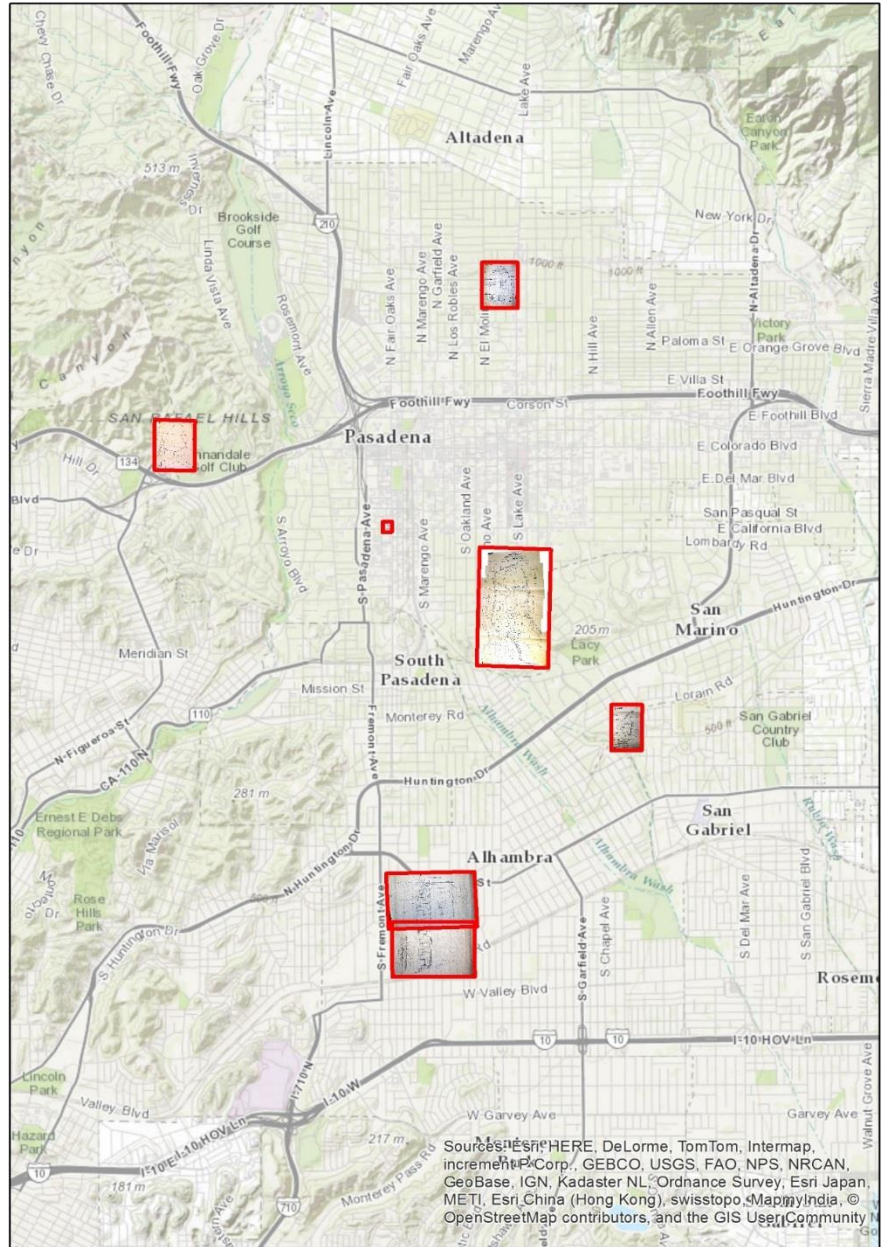


Figure 4-3: Overview of sampled tract maps

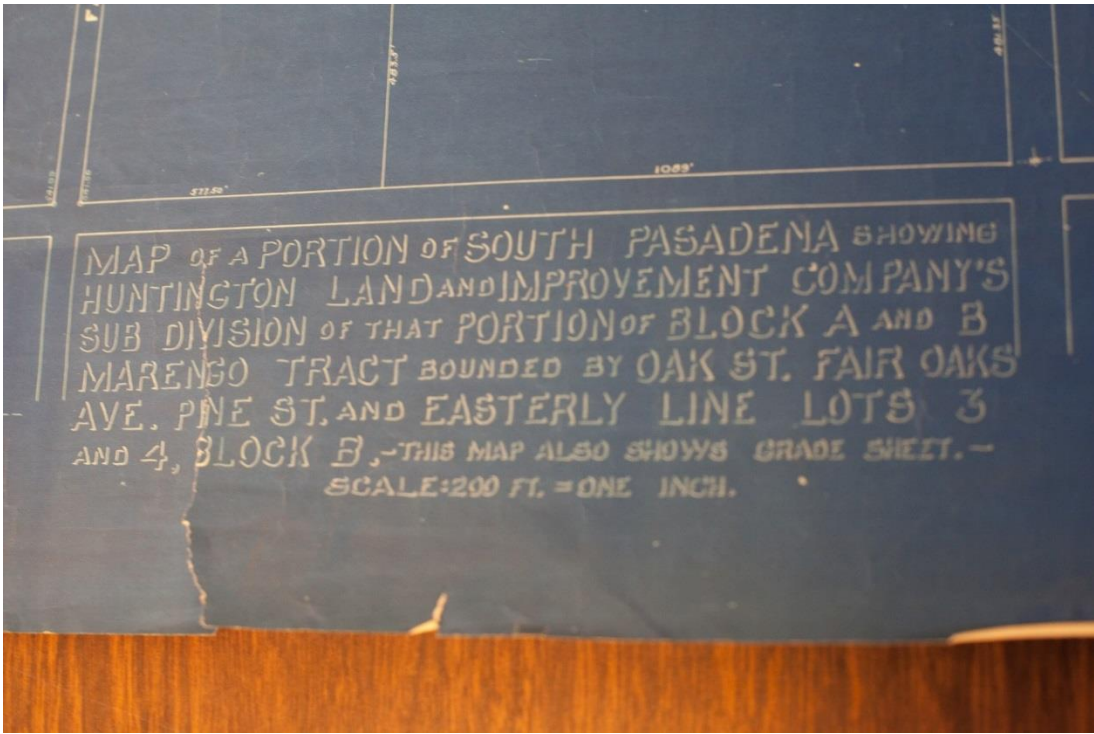


Figure 4-4: Legal description of map in South Pasadena

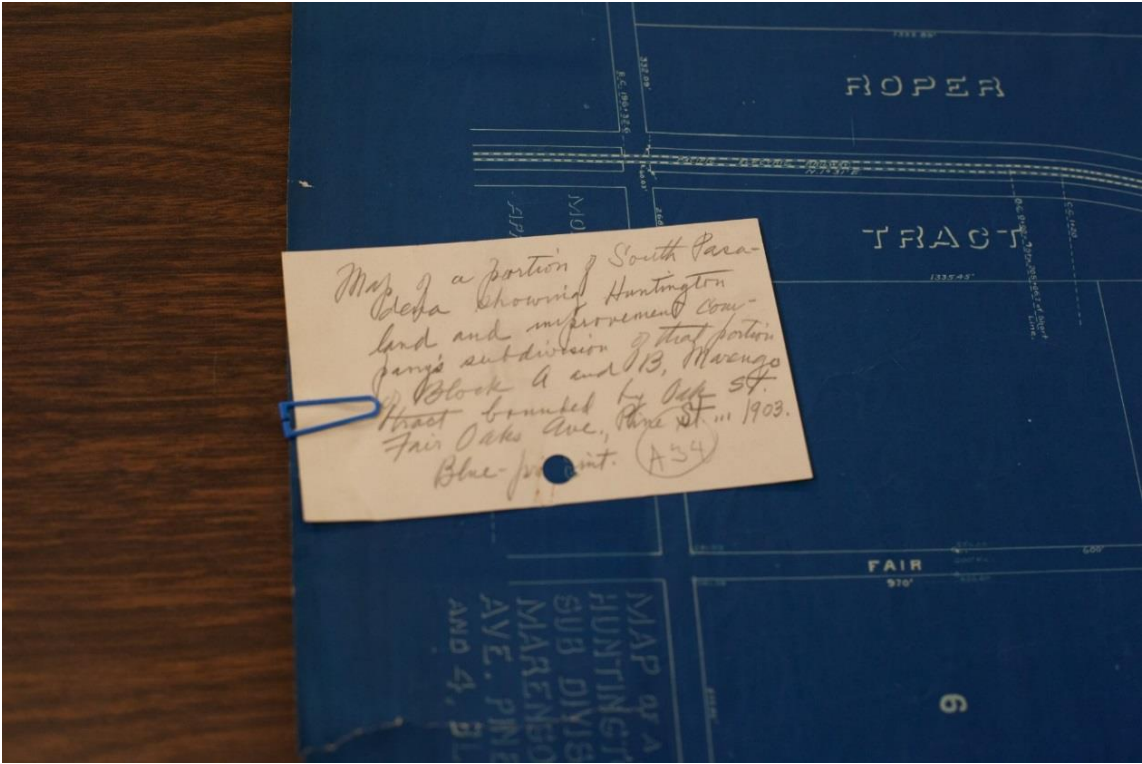


Figure 4-5: Handwritten label of legal description

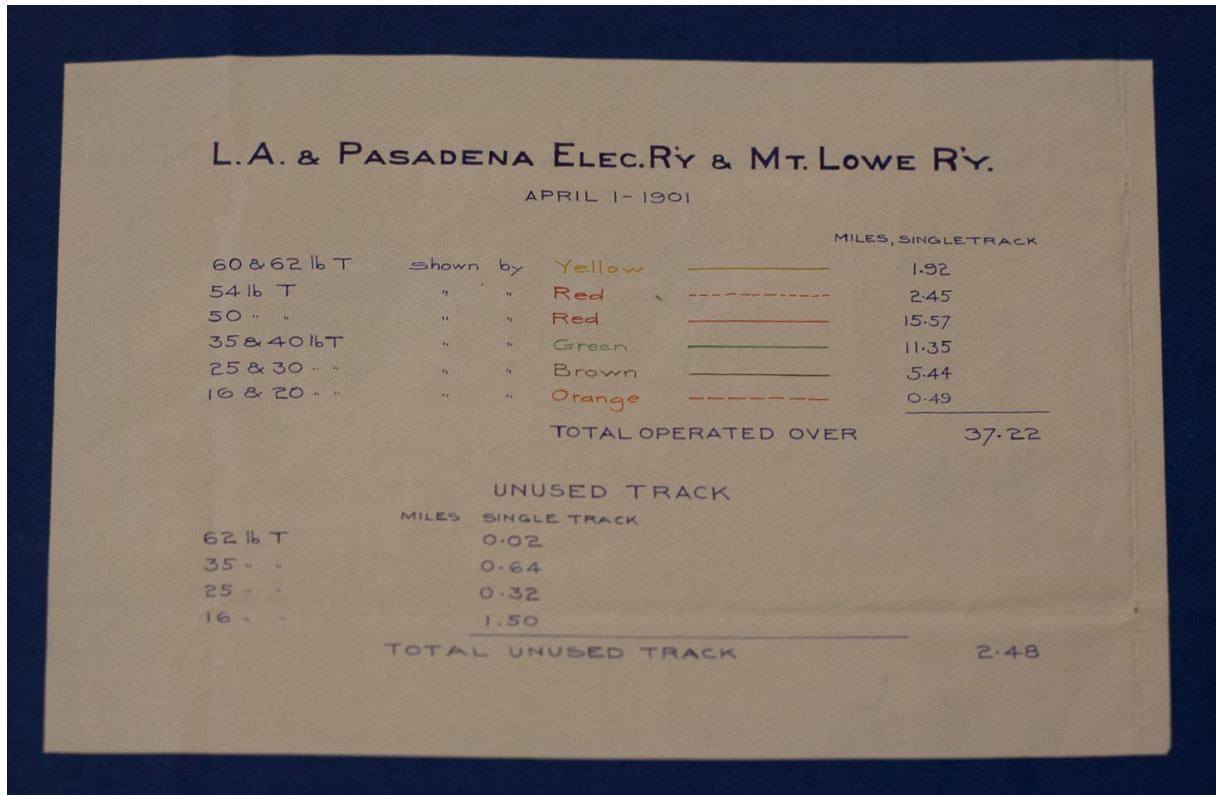
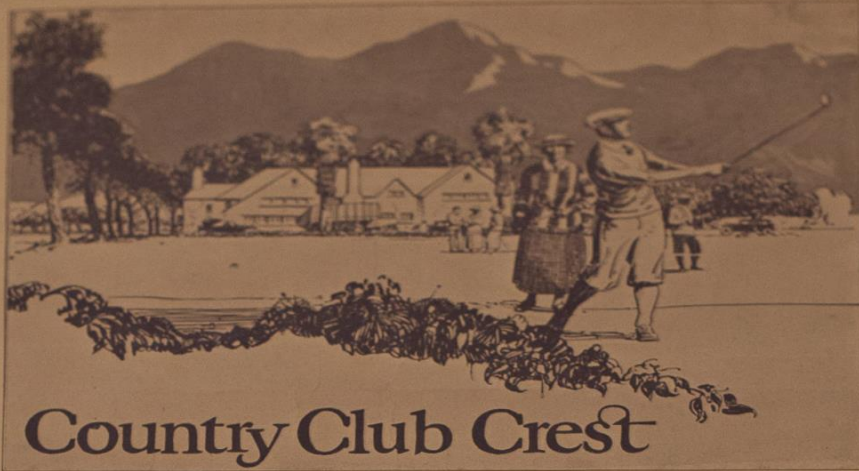


Figure 4-6: Legend accompanying the Los Angeles & Pasadena Electric Railway and Mount Lowe Railway map

OAK KNOLL UNIT *of*



Country Club Crest

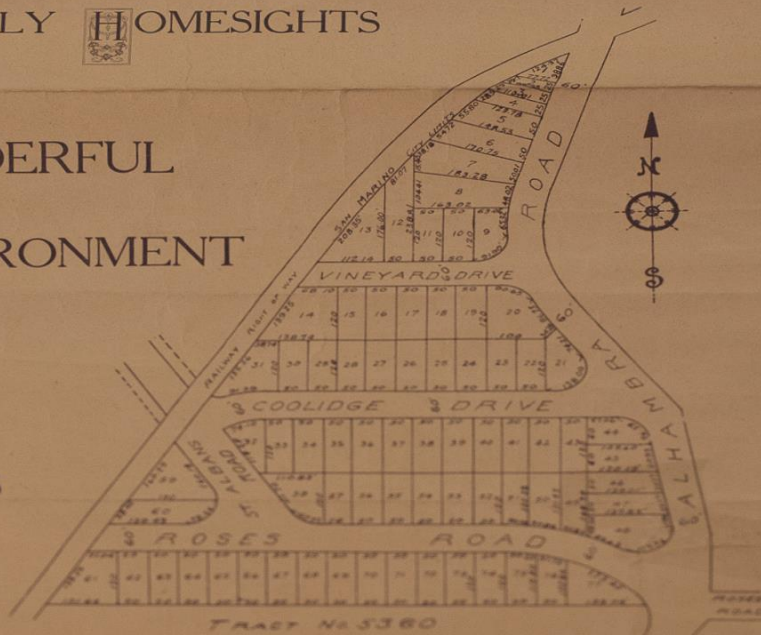
SIGHTLY **H**OMESIGHTS

WONDERFUL

ENVIRONMENT

LOW

PRICES



J. HOMER HOUGH CO.
SUBDIVIDERS

HEAD OFFICE—218 W. Main Street, Alhambra, Phone 1923-A
BRANCH TRACT OFFICE—Oak Knoll Unit, Stone Road and Alhambra Road,
Units 1, 2 and 3, Del Mar Ave. and
Lee James Drive, Phone 1923-W
J. HOMER HOUGH, REALTOR

MAKE RESERVATIONS AT ONCE!

Figure 4-8: An advertisement for the Oak Knoll Unit tract

4.4 Data Collection Methods

The data collection method involved conversion of the paper maps in the Huntington Library's collection into digital form. Due to budgetary constraints, the standard method of using a large format scanner was unavailable. Instead, a Canon 5D Mark II digital single lens reflex (DSLR) camera was used to capture the assortment of maps that Jennifer Goldman, formerly the Curator and Manuscripts and Institutional Archivist at the Huntington Library, had selected. The DSLR camera took shots from above of each map placed on the table. A 50mm lens replicated how the human eye sees. The selection of this focal length was to avoid the distortion that would occur with shorter focal lengths around the edges of the image. The camera settings for the aperture were shot at f/4.5 and 1600 ISO due to the low light in the room. Multiple shots of the maps were taken in portrait and landscape orientations. When the camera was tethered to the laptop, the photos were displayed immediately on the laptop screen. This method helped confirm the focus and sharpness of the image on the laptop instead of relying on the smaller liquid crystal display of the camera. Several of the maps were particularly large, which made it difficult to capture the entirety in one image. A method of capturing multiple shots with a 30% overlap created a panoramic photograph for these larger maps, which Adobe Photoshop helped stitch together.

4.5 Data Scrubbing and Loading (Image Handling)

The image scrubbing process involved using Adobe Lightroom to remove the digital noise from shooting at a higher ISO, to correct the white balance of the images, and to create better contrast and brightness. Adobe Photoshop merged the segmented maps into a single panoramic image.

Following the image clean-up, the next step was to import the images into ArcMap for georeferencing and rectifying to a referenced basemap. Georeferencing uses control points to connect a map to a referenced map. When all the ground control points are inputted, the maps were rectified using affine or second order polynomial transformations.

After the maps were georeferenced and rectified, a map border or polygon feature class was used to create the boundaries of each tract map. All of these map borders were then merged into one and fields were created to apply the necessary attributes such as tract name and legal description.

4.6 Summary

The collection and conversion of the data used digital photography in this project. The resulting images consisted of Henry E. Huntington landholdings in tract maps. The clean-up process prepared the data for the web application.

Chapter 5 – Implementation

This project created a prototype web application for viewing the landholdings of Henry E. Huntington. The swipe and transparency slider tools within the web application enhanced the user experience. These tools helped by showing the transparent versions of the original tract maps that retained the linework as visible, rather than having the tract map disappear. This chapter describes the process of completing this project. Section 5.1 discusses the process of creating a transparent background from the original tract maps. Section 5.2 explains the publishing of the map services to ArcGIS Online. Section 5.3 details the process of developing the web application.

5.1 Creating Transparent Background with Photoshop

After completing the data scrubbing, the next step was to create a version of each map with a transparent background, thus retaining all of the linework of the original maps. The main difficulty was the inconsistent background color of the maps, which made it tedious and complicated to make the background transparent. A workflow helped to minimize the necessary steps to create a transparent background. Inverting the original image (Figure 5-1a), the background turned into a solid color as shown in Figure 5-1b. In most cases, the background would change from partially white to black. Alternatively, the ‘Color Range’ command under the Select menu bar would provide a way to specify a color range for selection. With the ‘Invert Selection’ command, the selected background would select the linework of the tract map. The ‘Layer Via Copy’ command in the context menu would extract the linework to a new layer with the background being transparent. A good method to check the quality of the extraction was to use a solid colored rectangle placed underneath the transparent version of the tract map. Additional clean up with the brush tool eliminated artifacts and noise from the tract map. Finally, the

images were saved in .TIFF format with the “Save Transparency” box checked to preserve the transparency.

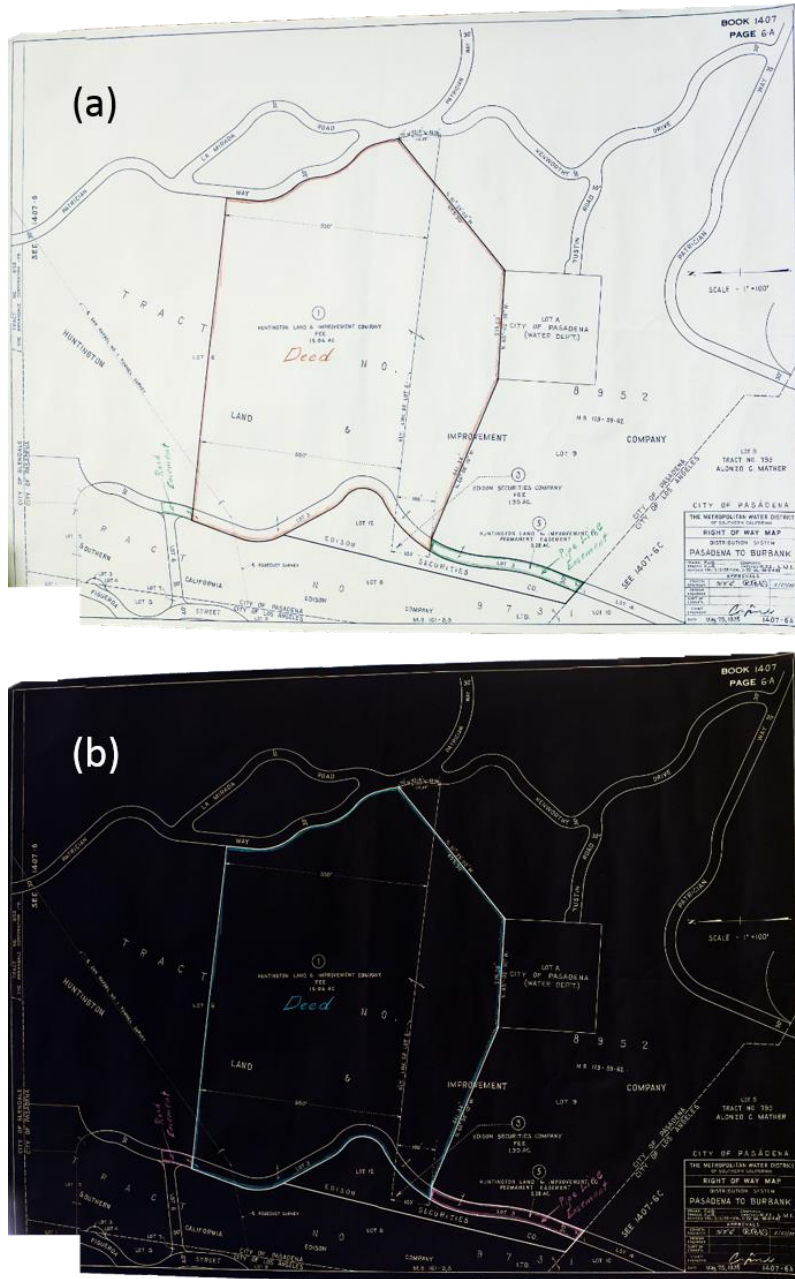


Figure 5-1: Original tract map (a) and inverted tract map (b)

5.2 Creating Transparent Background in ArcGIS

Using model builder in ArcGIS, the linework can be extracted as an alternative to Photoshop. Figure 5-2 showed the model for the combining three bands (R,G,B) into one band. The raster calculator used the expression ‘RasterBand1’ + ‘RasterBand2’ + ‘RasterBand3’ to create the new single band output. Figure 5-3 displayed the dialog box for the CombineBands tool.

Next, the single band was sliced using the 'con' function to extract the features including the linework and text of the tract map. Figure 5-4 showed the model for extracting the features from the single band. The value for the expression was based on the pixel value threshold between the background and the features. The value would be different based on the color depth, number of bits in the band. Figure 5-5 displayed the dialog box for the ExtractFeatures tool. The newly extracted raster would then be exported and saved as a PNG using the 'Export Data' command. This was executed by right clicking the raster in the Table of Contents, Data-> 'Export Data'. Change the format to 'PNG' and save. Photoshop assisted by adding the alpha channel due to ArcMap lacking the specification for the PNG when saving.

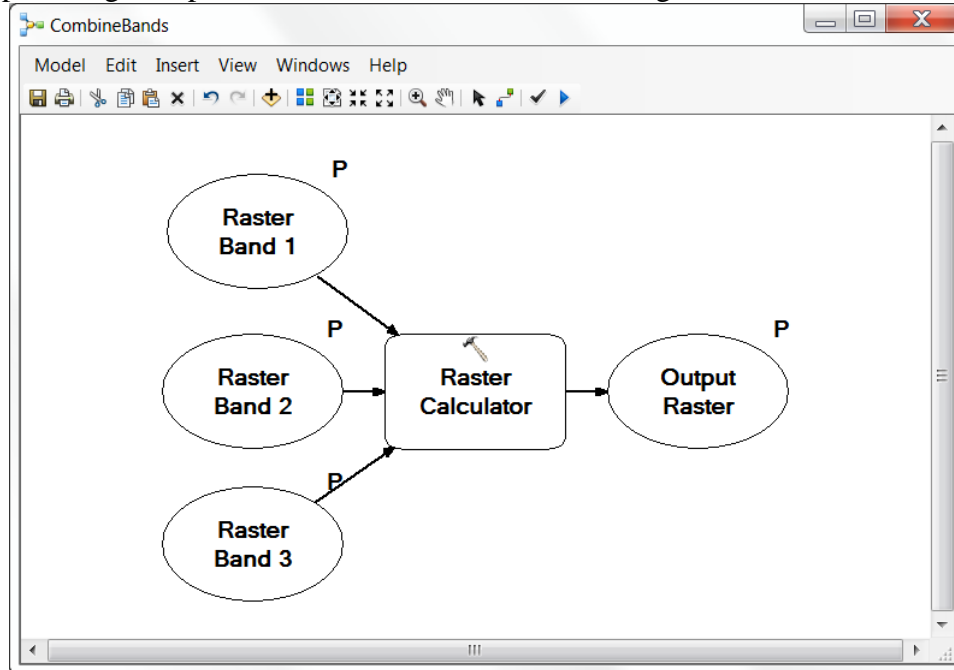


Figure 5-2: Model for combining bands

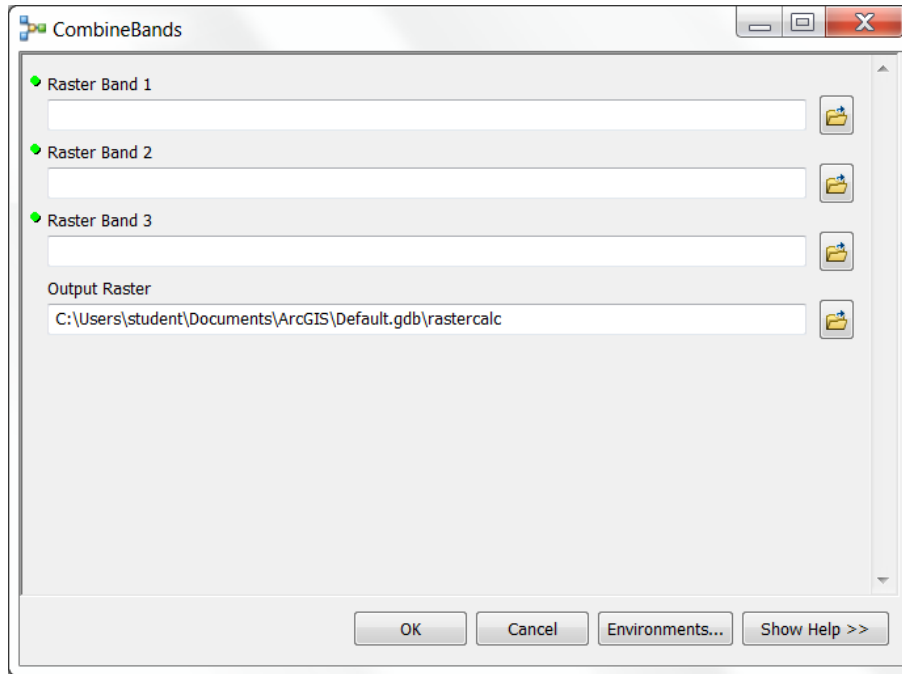


Figure 5-3: Dialog box for CombineBands tool

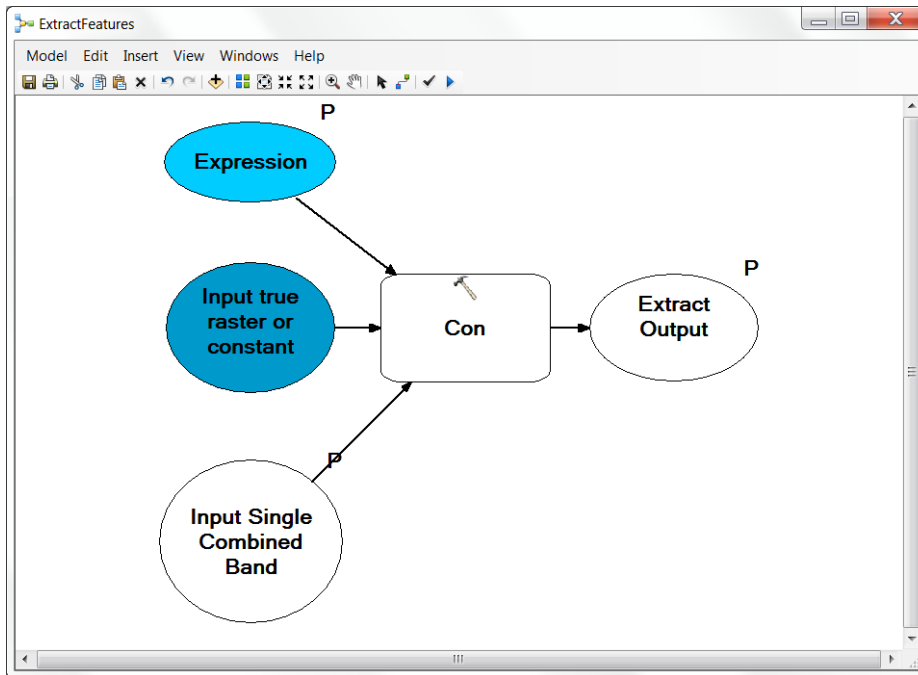


Figure 5-4: Model for extracting features from tract map

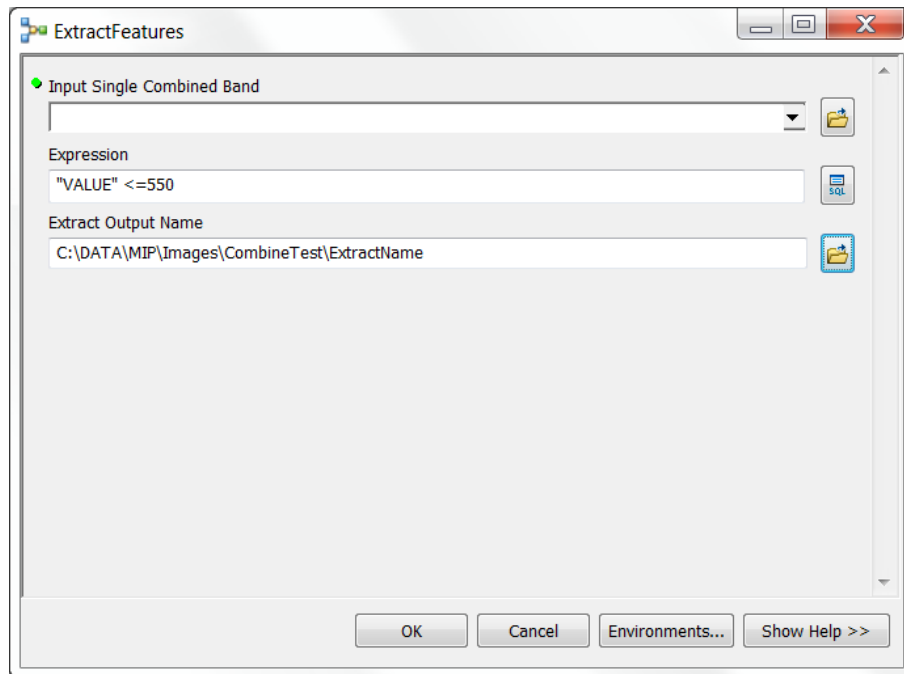


Figure 5-5: Dialog box for ExtractFeatures tool

5.3 Publishing the Map Services

Upon completion of the data processing of the map, these maps were uploaded to ArcGIS Online (AGOL). ArcGIS Desktop accomplished this task by using ArcGIS Server to publish the feature layer and map services. The feature layer contained the description and the boundaries of the tract maps in this project. Two map services created by ArcGIS Server were the referenced maps and the transparent version with the linework. These components were shared to the organization account on AGOL, where the newly uploaded components formed a web map for the web application.

5.4 Developing the Web Application

Initially, the prototype web application began with Esri's Story Map template. It then changed to Esri's *WebApp Builder for ArcGIS* for greater customization and flexibility. The prototype web application used the components of the historical tract maps, transparent versions of the tract maps, and map borders to delineate the tract maps. After the conclusion of these key components, the prototype web application also added several widgets: the bookmarks, basemap gallery, swipe tool, and transparency slider. The bookmark widget allowed the user to select specific tract maps, which in turn would zoom to the selected map. The basemap gallery widget allowed the user to pick a number of basemaps, useful for comparison. The swipe tool widget allowed the user to wipe the top layer map by dragging the selector bar left and right, which showed the linework of the transparent background version of the tract map. The transparency slider, which was embedded inside the layer list widget, allowed the user to change the transparency of the layer from 0% to 100%, with 0% being opaque and 100% being fully transparent. The ArcGIS API for JavaScript helped the implementation of the widget's coding.

Figures 5-6 to 5-9 illustrate the four stages of the tract maps: original map, georeferenced, transparent background with linework, and transparent background version with underlying basemap.



Figure 5-6: Stitched original version of the City of Pasadena Right of Way map

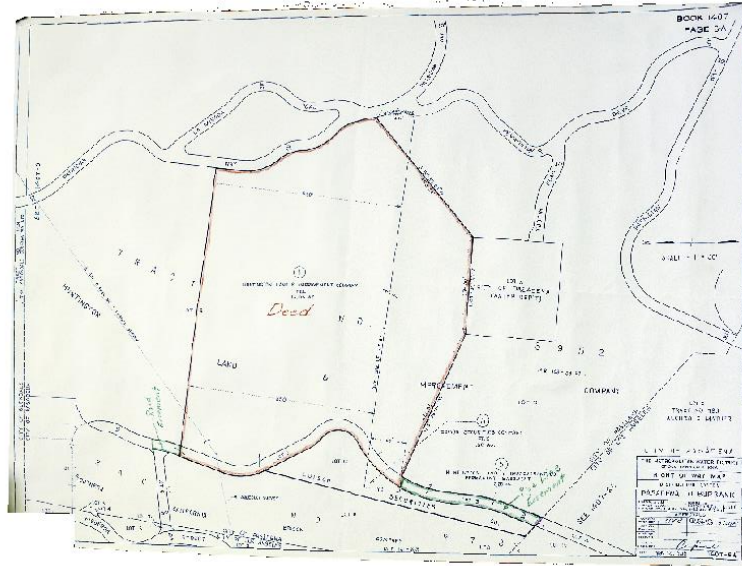


Figure 5-7: Georeferenced version of the City of Pasadena Right of Way map

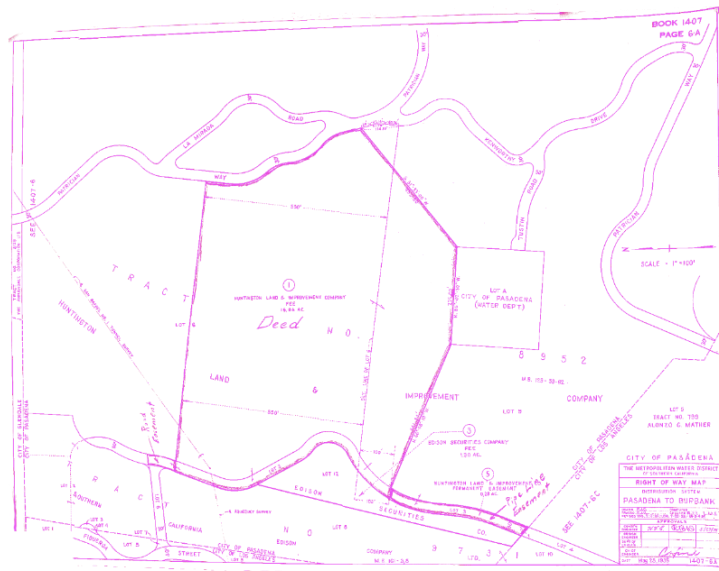


Figure 5-8: Transparent version of the City of Pasadena Right of Way map

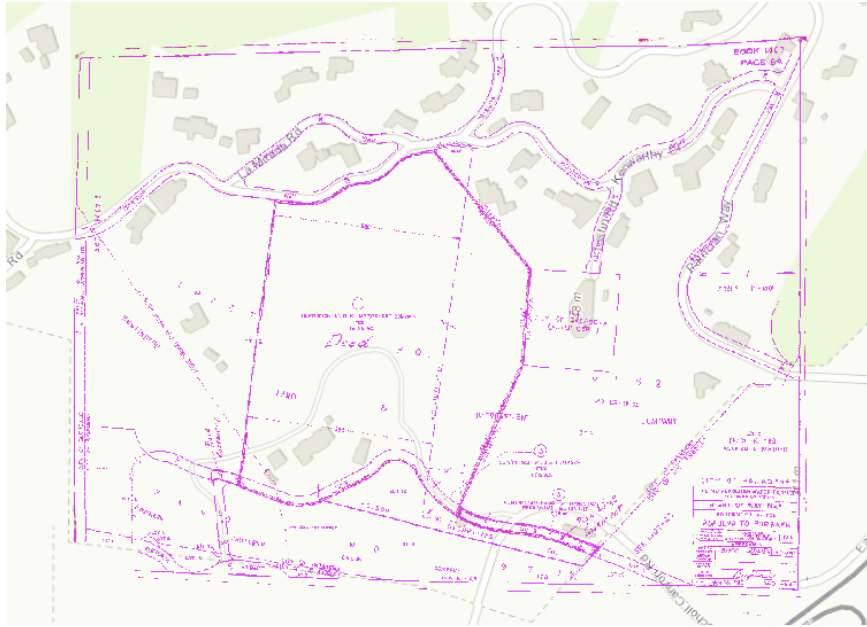


Figure 5-9: Transparent version with basemap of the City of Pasadena Right of Way map

Chapter 6 – Results of Transparentization

In this chapter, Section 6.1 shows the results of transparentization of the remaining maps used for the prototype web application. Section 6.2 looks at how transparentization can be used in Google Earth.

6.1 Additional Maps

Figures 6-1 to 6-4 illustrate the four stages of the maps of the Oak Knoll map: original, georeferenced, transparent background with linework, and transparent background version with basemap. Figures 6-5 to 6-14 show the originals and transparent background versions of Tract Map No. 4726, Tract No. 1313, Dolgeville Subdivision, and Tract No. 5360.

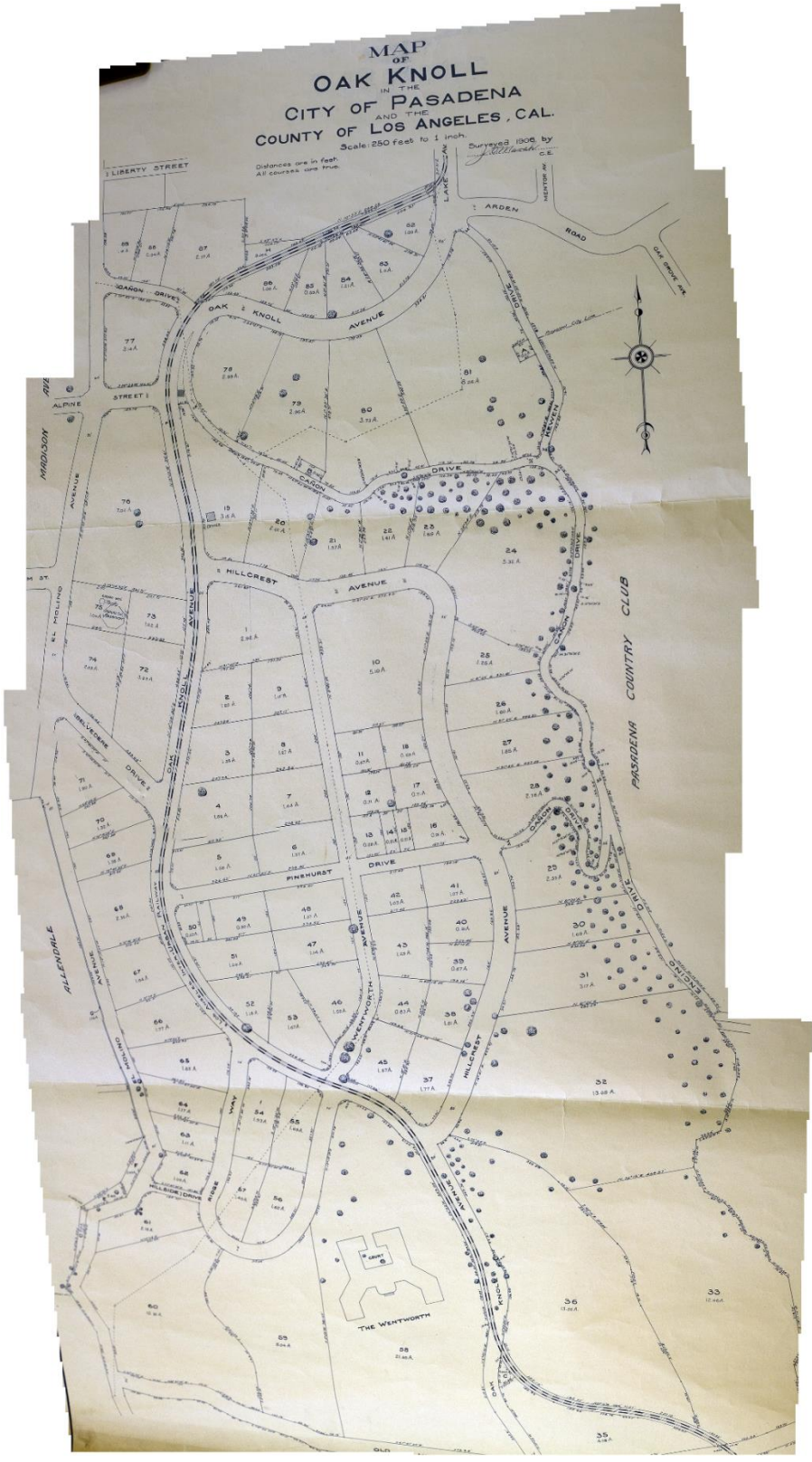


Figure 6-1: Stitched version of the Oak Knoll parcel map



Figure 6-2: Georeferenced version of the Oak Knoll parcel map



Figure 6-3: Transparent version of the Oak Knoll parcel map

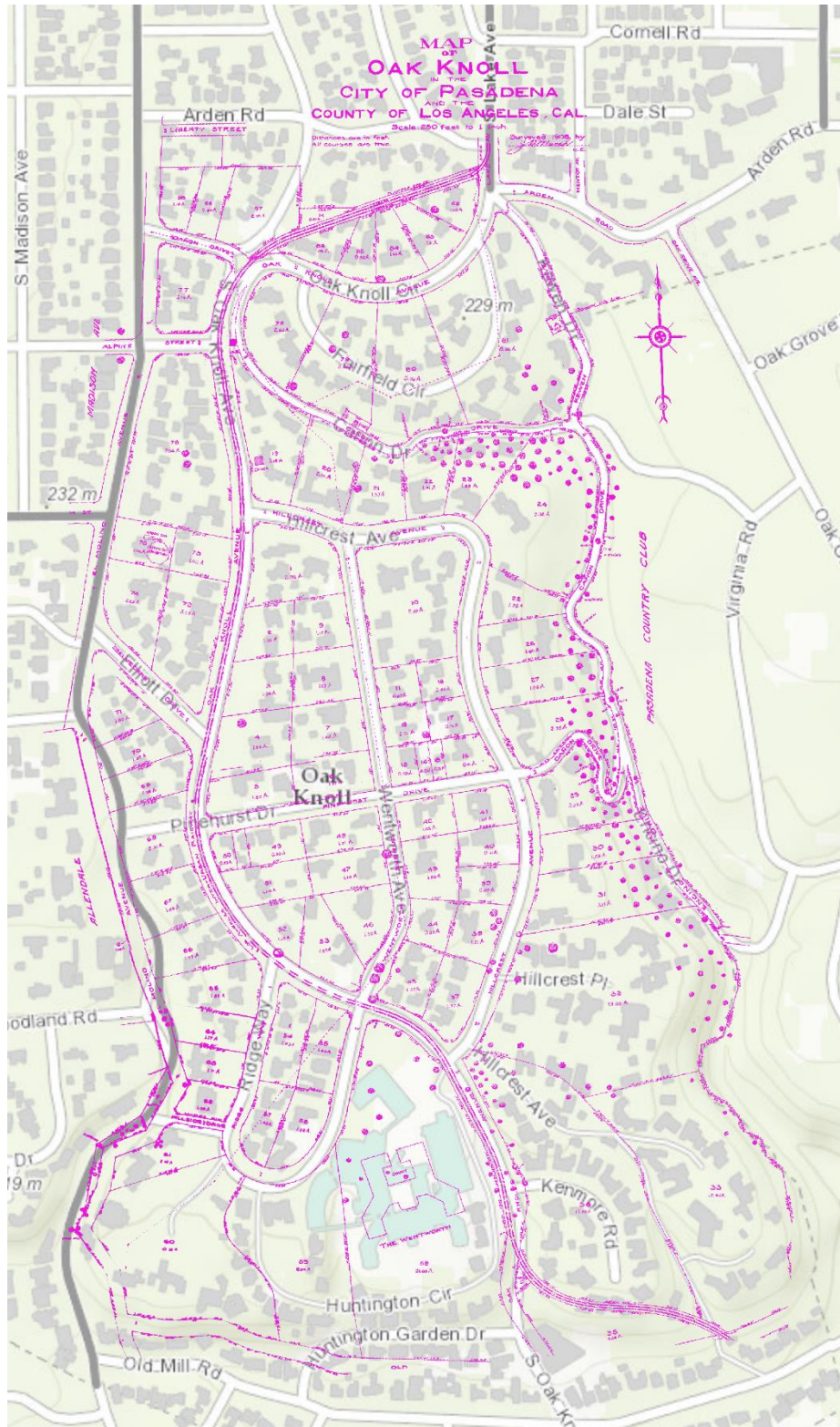


Figure 6-4: Transparent version of the Oak Knoll parcel map with basemap

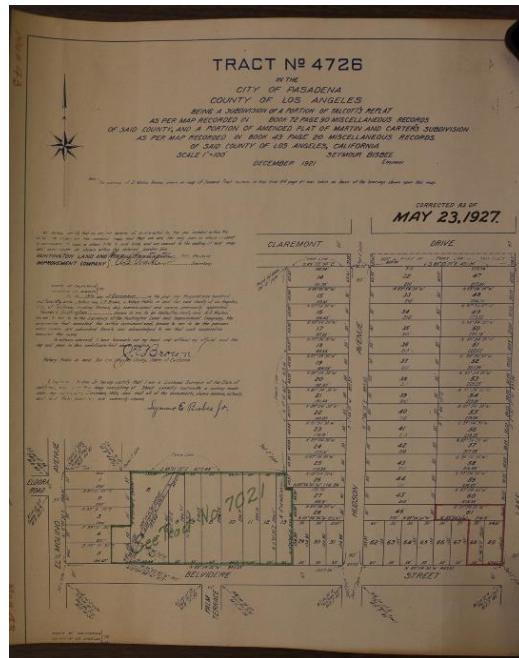


Figure 6-5: Tract No. 4726



Figure 6-6: Transparent version of Tract No. 4726 with basemap

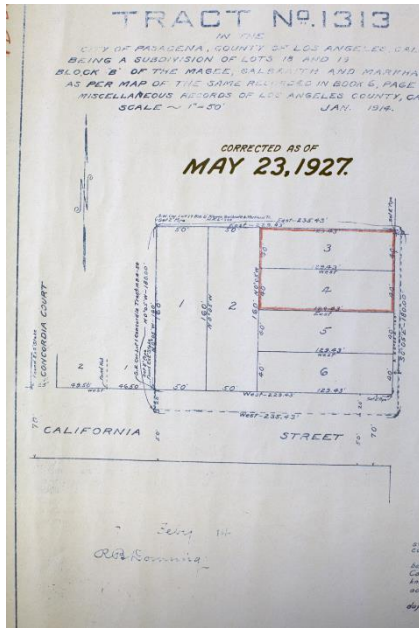


Figure 6-7: Tract No. 1313

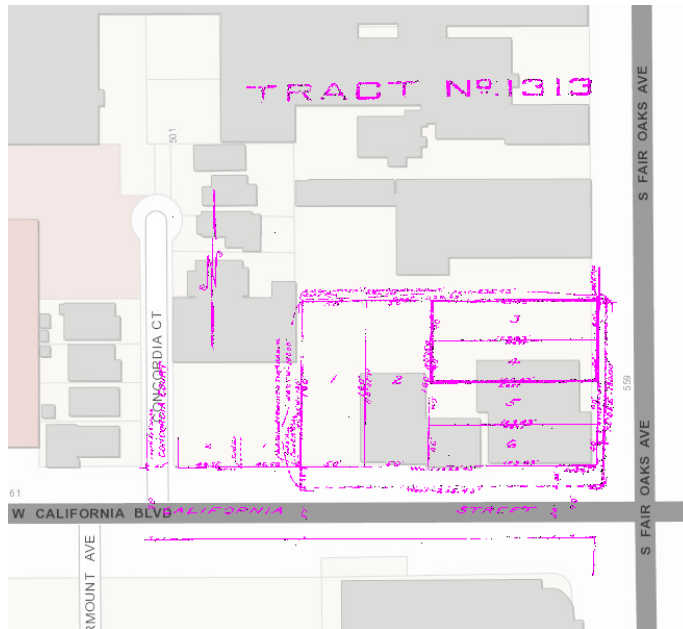


Figure 6-8: Transparent version of Tract No. 1313 with basemap

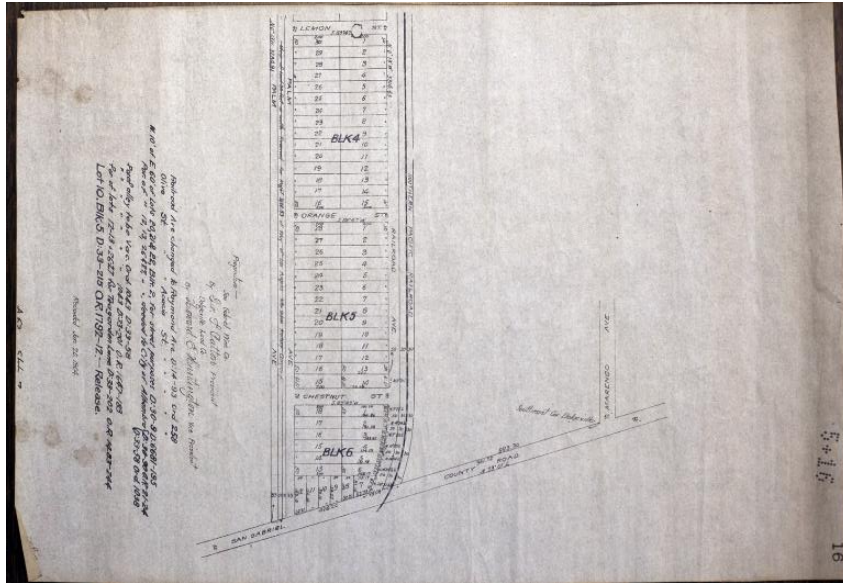


Figure 6-11: Southern portion of the Dolgeville subdivision



Figure 6-12: Transparent version of the Dolgeville subdivision (South) with basemap

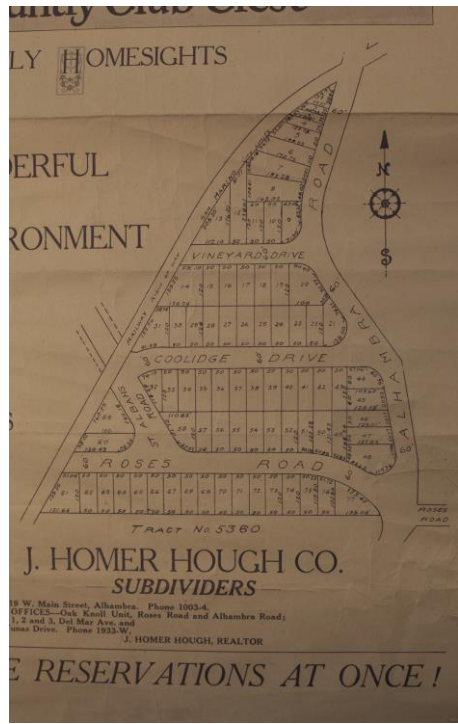


Figure 6-13: Advertisement poster with tract map



Figure 6-14: Transparent version of Tract No. 5360 with basemap

6.2 Google Earth

Other uses for the transparent versions of the maps are possible in Google Earth. The map service was saved as .kml/.kmz format to be used in Google Earth. One application can be used with a time slider of historical aerial maps of an area. Figure 6-15 shows Google Earth using a time slider to display aerial maps from 1994 to 2005.

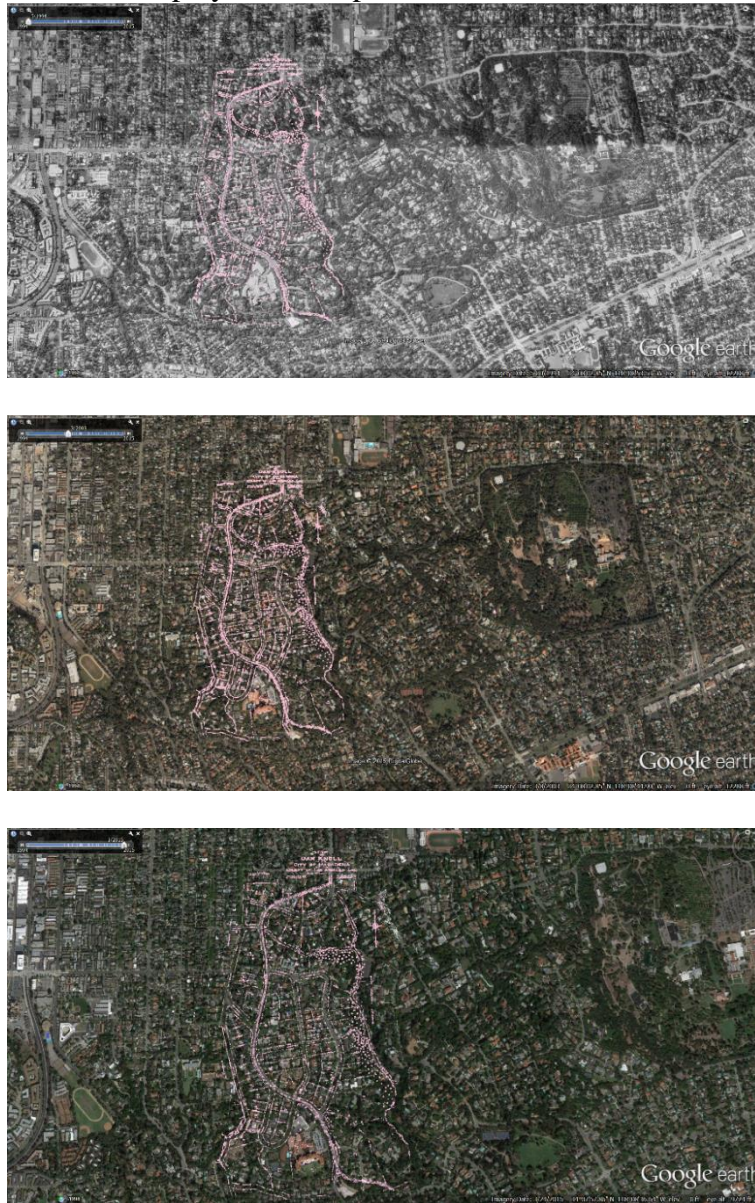


Figure 6-15: Time slider in Google Earth from 1994 (top), 2003 (middle), and 2015 (bottom)

Other visualizations possible in Google Earth include changing the perspective from a two-dimensional to three-dimensional view, so that the user can navigate and rotate view angles. Figures 6-16 to 6-19 show such perspectives in Google Earth.



Figure 6-16: Bird's view of Tract No. 5360

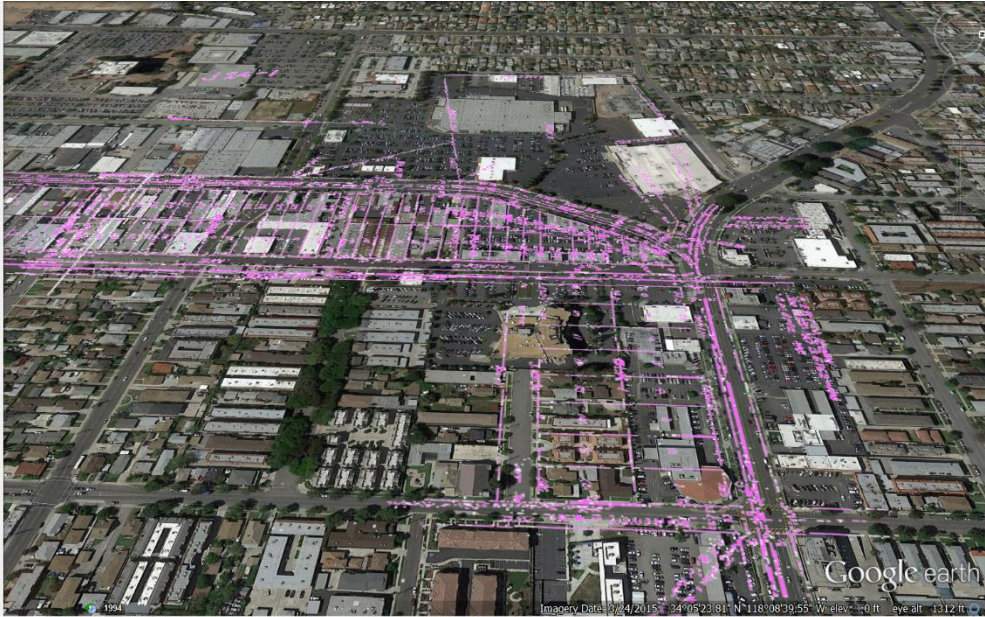


Figure 6-17: Perspective view of Dolgeville tract



Figure 6-18: City of Pasadena Right of Way map with terrain

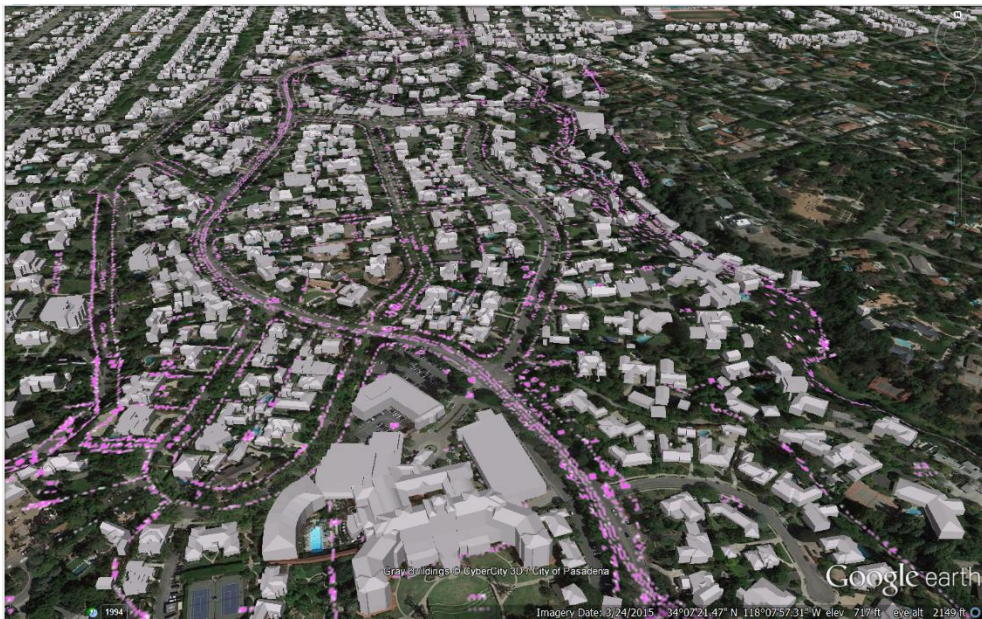


Figure 6-19: Perspective with 3D buildings of Oak Knoll parcel map

Chapter 7 – The Web Application

This chapter discusses the web application developed for the Huntington Library. This application will help users explore and discover the locations of Henry Huntington’s landholdings.

7.1 Prototype Web Application

One of the results of the project was a web application that allowed the user to examine some of Henry Huntington's landholdings using the swipe and transparency tools. The web application is able to display the linework of the original map without the opaque paper background, which helps the user to compare and contrast a historical map to a current map. The web application is useful to the Huntington Library staff for locating some of Henry Huntington's landholdings in southern California. The development of the web application used Esri's ArcGIS API for JavaScript. Figure 7-1 presents the basic interface for this prototype.

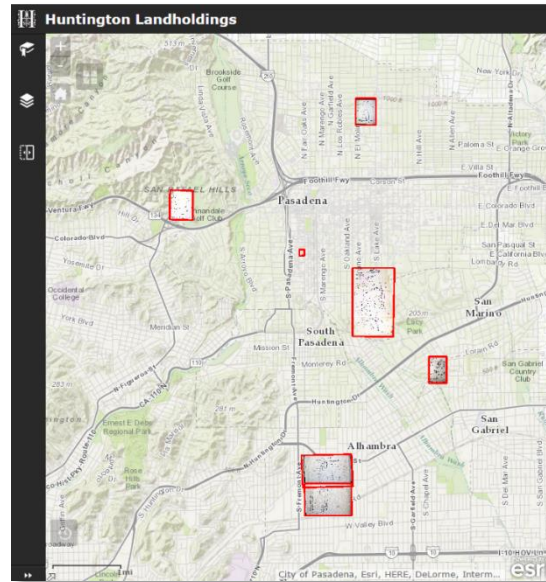


Figure 7-1: Overview of the web application

7.2 Key Functions of Web Application

The bookmarks widget allows the user to select specific tract maps of Huntington's landholdings. The user can zoom to a selected map by clicking on it. The Layer list contains the operational layers consisting of the original tract map and the transparent map version with the linework. Within the Layer list, the user can activate the transparency slider under each operational layer. The slider controls the amount of transparency from 0% to 100%, with 100% being fully transparent, as shown in the Figure 7-2.

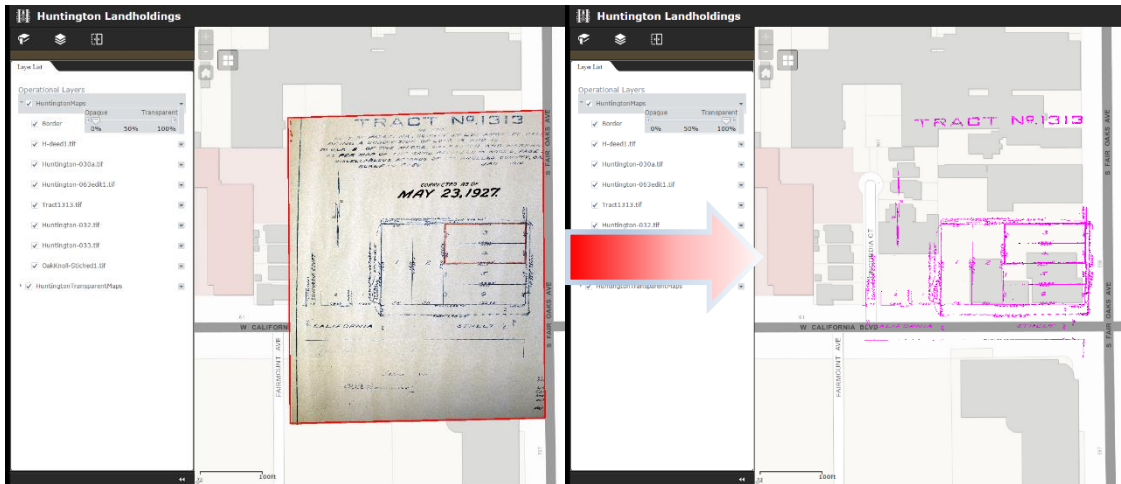


Figure 7-2: 0% Transparency & 100% Transparency (L-R)

The swipe tool demonstrates how the top operational layer is cleared away, revealing the bottom layer of the transparent background with the linework as shown in Figure 7-3. This allows the user to focus on any changes, instead of swiping back and forth multiple times. This is an important enhancement that helps a user quickly understand or recognize differences using the web application.

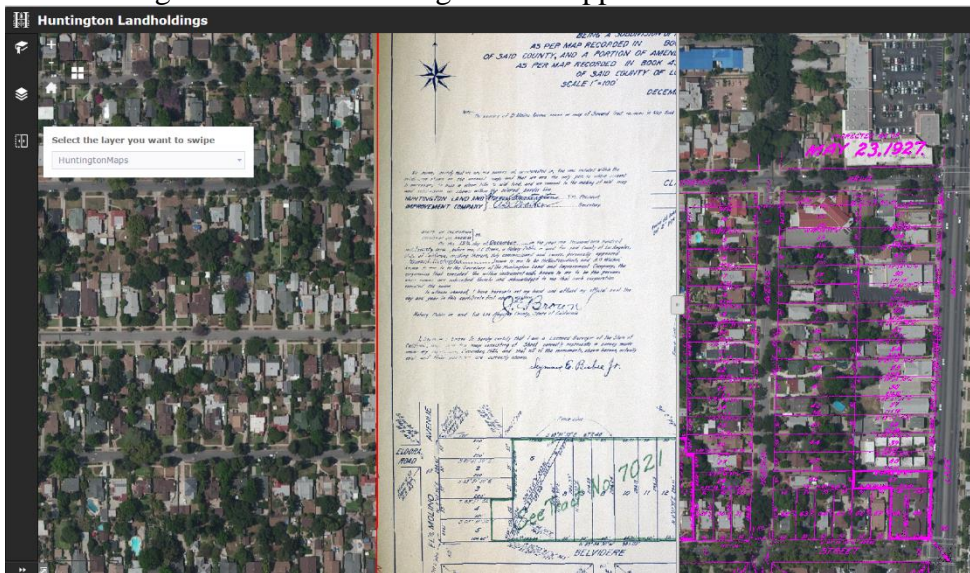


Figure 7-3: Swipe layer tool

Lastly, the basemap gallery allows the user to choose from different basemaps, as shown in Figure 7-4. The different basemaps help the user see changes from different views.

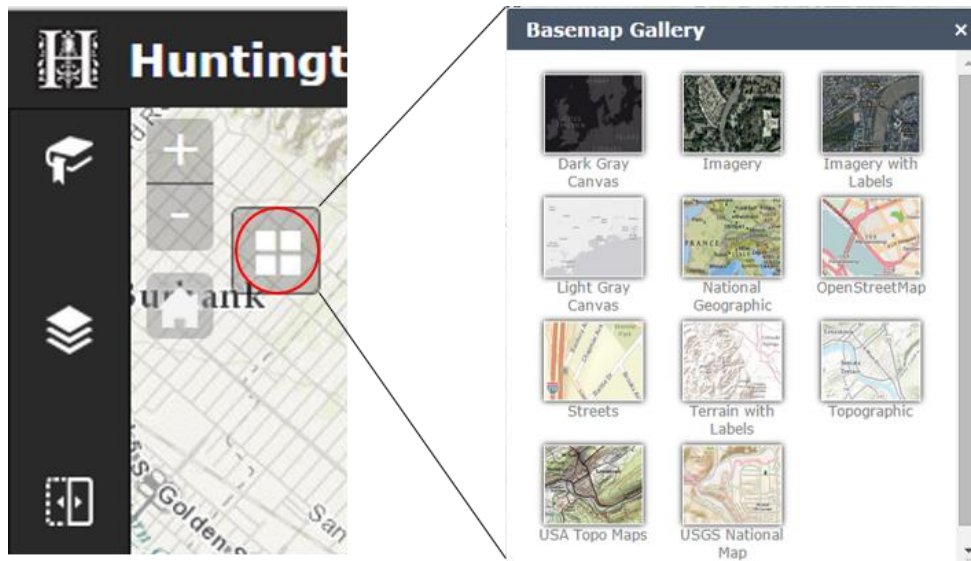


Figure 7-4: Basemap gallery

7.3 Full Implementation

The web application is a prototype. Due to the volume of maps in the Huntington Library, only seven maps were processed to illustrate their possible use. In order to answer the Huntington's initial question of the acreage and location of Henry Huntington's landholdings, the rest of the collection would need to be scanned and georeferenced. At that point, transparent versions of each map would need to be created. The challenges of the full implementation are the necessary resources and time needed to accomplish these tasks. The Huntington Library has an imagery department that can scan these maps. After the scanning of the maps, image adjustments like contrast and brightness are necessary in preparation for the georeferencing and the transparentization of each map. These processes require ArcMap and Photoshop and require a staff member or volunteer with experience using ArcGIS, ArcMap, and Photoshop. Appendix A provides the steps in the workflow.

Chapter 8 – Summary and Future Work

The Huntington Library has a collection of historical maps showing the landholdings of Henry E. Huntington. The Library wanted to view these maps online to see how much land Huntington owned and where exactly it was located. The process of digitization and georeferencing the historical maps onto a basemap assisted in locating these landholdings.

The shortcomings of the existing transparency slider and swipe tools are that the original map fades away or disappears entirely. In addition, the user needs to move the slider back and forth multiple times to visualize where the original image would be on the basemap. A way to overcome these limitations of the transparency slider and swipe tools is to create a transparent version of each map – one that has all of the original linework on a transparent background. This method allows the user to analyze and interpret maps more quickly and efficiently.

This project created a prototype web application that displays the landholdings of Henry E. Huntington. The purpose was to develop a superior method for the Huntington Library staff to view the historical maps. This application fulfills the functional and non-functional requirements of the Huntington Library. Through the combination of the transparent map with linework, transparency slider, swipe tool, and web application, users can explore and discover the landholdings of Henry Huntington throughout southern California.

All the requirements were fulfilled for the project. There are potential extensions that could be applied to the present web application that would further increase usability for the client.

The first improvement would be to create transparent versions of the remaining 200 maps in the collection. Only a handful of tract maps were selected out of the possible 200 maps in the collection. In order for the Huntington to find out exactly how much land Henry Huntington owned, all the maps would have to be scanned and georeferenced. Once completed, they could be analyzed to determine the total number of square miles of land owned by Huntington. Converting the maps from raster to vector format would allow for changes to the symbolization and additional analyses. A tool that automates the process of producing a transparent map would be a valuable follow-on project.

Several improvements could be made to the web application to enhance the user experience. The addition of historical basemaps would allow users for more extensive interpretation of the Huntington tract maps. The option to change basemaps while using the swipe tool in either the left panel or right panel allows for more comparisons. For example, one side could show the street map, while the other side showed an aerial photograph. Figure 8-1 shows how the web application would look like with two different basemaps while using the swipe tool.

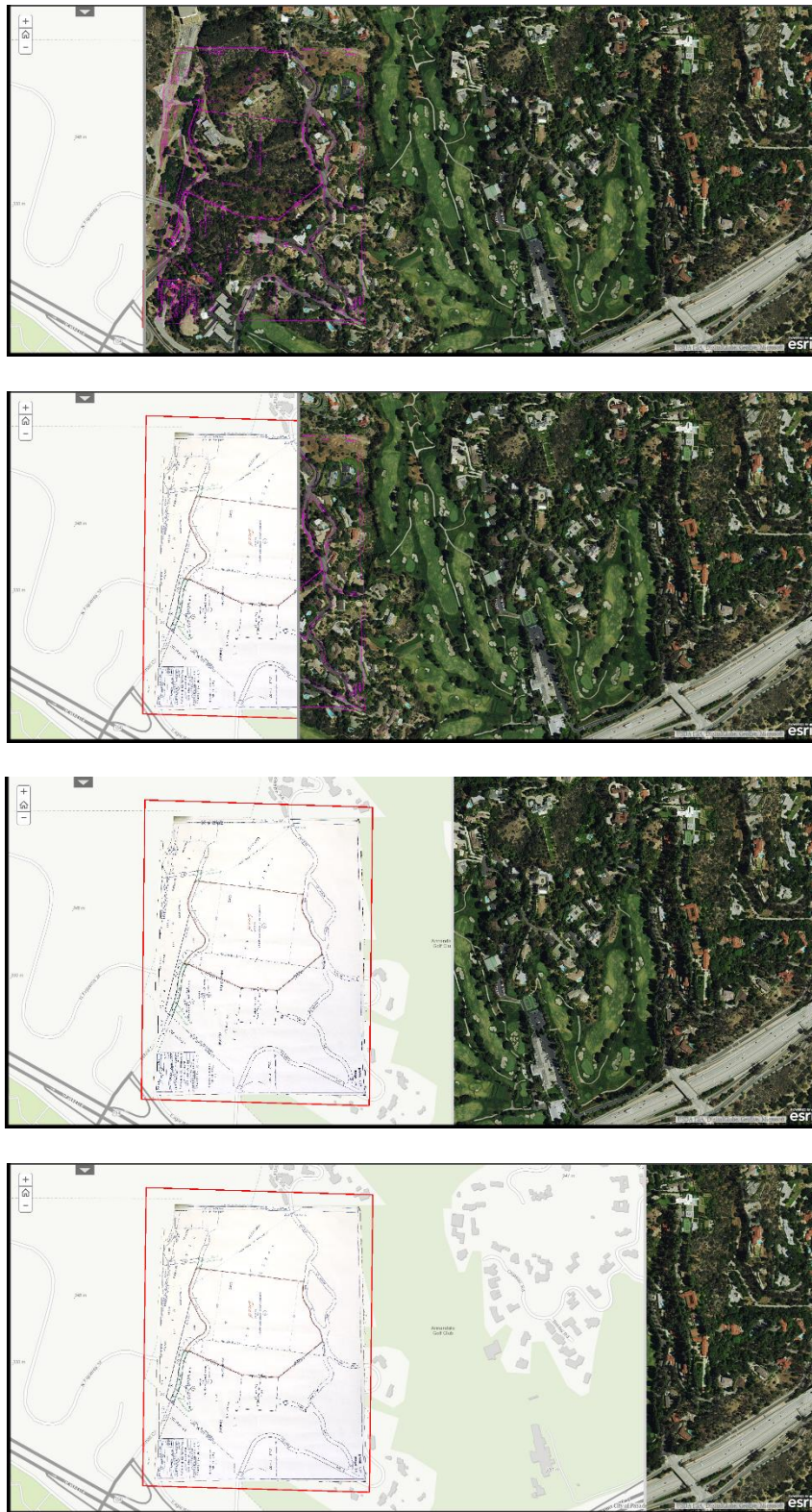


Figure 8-1: Illustration of a swipe with two different base maps

Moving the transparency slider from the Layer list to the main map window would help the user interact more quickly. Adding a time slider of historical basemaps to the web application could illustrate changes over time. The user could view different aerial maps from different years. These changes over time could illustrate the history of an area's development. Examples of the historical time slider can be seen in Google Earth.

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Appendix A. Workflow

These procedures are written so that the Huntington Library staff or volunteer will be able to understand the steps needed to implement the transparentization of their maps.

Procedure:

- 1) Scan maps
- 2) Rotation, Cropping, Color Correction (Brightness/Contrast)
- 3) Import into Photoshop
- 4) Convert map with transparent background
- 5) Import into ArcGIS
- 6) Georeference/Rectify maps
- 7) Share as map service to ArcGIS Online
- 8) Create web application