SPATIAL NARRATIVES OF STRUGGLE AND ACTIVISM IN THE DEL AMO AND MONTROSE SUPERFUND CLEANUPS:

A COMMUNITY-ENGAGED WEB GIS STORY MAP

by

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DEDICATION

I dedicate this document to my loving, supportive husband, Ryan Garfat, to my family for their encouragement throughout this journey, to Cynthia Babich, Florence Gharibian, Cynthia Medina, Savannah Medina, Margaret Manning, and all others who contributed their hearts, time, and wisdom to make this project possible, to the Del Amo/Montrose community, to the Del Amo Action Committee, and to my committee chair Robert Vos, who believed in this project from the beginning and was instrumental in guiding this research.

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ABSTRACT

Long-term remedial action Superfund sites pose steep challenges for the Environmental Protection Agency (EPA) and stakeholders to remain actively engaged in cleanups that could go on essentially in perpetuity. It is essential for communities impacted by Superfund cleanups to actively participate in the cleanups so that they may be part of the decision-making process. Citizens directly affected by Superfund cleanups have unique perspectives, information, and spatial knowledge to contribute, but opportunities for participation in Superfund may be limited to the agendas, meeting spaces, and timelines of the EPA (Laurian 2004). In the City of Los Angeles, the Del Amo and Montrose Superfund sites are located adjacent to each other and directly north of an unincorporated neighborhood of approximately 300 households. Due to the extent of the commingled groundwater contamination originating from both sites, it is understood by the community that the time frame for cleaning up the groundwater will span 3,000 to 5,000 years. The primary goal of this thesis was to understand and portray the cleanup through the perspectives of local community members. Specifically, the objectives of this research were to: (1) use a community-engaged research approach to develop a Web GIS Story Map which incorporated experiential spatial narratives from the perspectives of local citizens affected by the Del Amo and Montrose cleanups; (2) ensure that a critical evaluation of the Story Map was possible on behalf of participants throughout the development of the tool; and (3) promote the Web GIS tool to stakeholder groups and other entities for feedback and evaluation. The Web GIS Story Map combined interactive Web maps and mixed media to communicate the history of the Del Amo and Montrose sites, as well as how the community has been impacted by the cleanups and the contamination over the past two decades. This project demonstrates how a community-engaged Web GIS Story Map can facilitate dialogue among various stakeholder groups invested in the cleanups. In addition, this study recognizes the potential for regulator stakeholders to assist in developing more robust geospatial visualizations of intended remedial objectives.

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ABBREVIATIONS

ATDSR	Agency for Toxic Substances and Disease Registry
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CDC	Centers for Disease Control and Prevention
CIC	Community Involvement Plan
COCs	Contaminants of Concern
DAAC	Del Amo Action Committee
DDT	dichlorodiphenyl-trichloroethane
DNAPL	Dense Non-Aqueous Phase Liquid
Dow	Dow Chemical Corporation
DTSC	California Department of Toxic Substances Control
EPA	Environmental Protection Agency
gpm	gallons per minute
ICs	Institutional Controls
LBF	Lower Bellflower Aquitard
LNAPL	Light Non-Aqueous Phase Liquid
MBFB Sand	Middle Bellflower "B" Sand
MBFC Sand	Middle Bellflower "C" Sand
MCL	Maximum Contaminant Level
Montrose	Montrose Chemical Corporation
µg/L	micrograms per liter
mg/kg/day	milligrams per kilogram per day
mg/L	milligrams per liter
NAPL	Non-Aqueous Phase Liquid
NCP	National Contingency Plan
pCBSA	para-Chlorobenzene sulfonic acid

PCE	Perchloroethylene
ppb	Parts per billion
ppm	Parts per million
PRP	Potential Responsible Parties
RCRA	Resource, Conservation, and Recovery Act
RI	Remedial Investigation
ROD	Record of Decision
RPs	Responsible Parties
RPM	Remedial Project Manager
RWQCB	California Regional Water Quality Control Board
SARA	Superfund Amendments and Reauthorization Act
SCAQMD	South Coast Air Quality Management District
Shell	Shell Oil Company
SVE	Soil Vapor Extraction
SVI	Soil Vapor Intrusion
TCE	Trichloroethylene
TI	Technical Impracticability
UBF	Upper Bellflower
VOCs	Volatile Organic Compounds

CHAPTER 1: INTRODUCTION

The EPA is responsible for handling the cleanups of nation's most hazardous waste sites (Superfund sites) that pose the greatest threat to human health and/or environmental media (soil, soil gas, groundwater, and other water bodies). Once the contamination from a site has been cleaned up to protective standards, the site may be returned to productive reuse. However, the Superfund cleanup process is complex, costly, and may last for many years. In some cases, the nature and extent of the contamination are such that it is not feasible to remediate all or some portions of the site within a reasonable time period. Nonetheless, it is essential that stakeholder groups involved in long-term site cleanups communicate regularly with each other, share data and information, and work collaboratively throughout the process.

A major component of Superfund is to ensure that communities are given adequate information and opportunities for involvement in cleanup activities and decisions. For residents living in close proximity to cleanup sites, it is critical to understand the details of the contamination, what the contaminants are, what media are being affected, and the associated risks (Charnley and Engelbert 2005). Also, communities should know what the EPA and other regulatory agencies are doing and/or have done in the past to address the pollution.

In an effort to facilitate community involvement opportunities in Superfund cleanups, the EPA is encouraged to develop Community Involvement Plans (CIPs) to connect to diverse community groups, listen to their concerns, and consider their input and suggestions regarding cleanup site decisions (US EPA 2012). Traditional channels for communicating information to citizens via the EPA include public meetings, mailers and fliers, site document repositories at local settings such as libraries, as well as online repositories (Charnley and Engelbert 2005). While these examples may be effective in some Superfund cleanups, there are other ways in which communities may acquire information and become involved in the cleanups. Obviously, communities may become highly concerned and thus motivated toward participation when they are directly impacted by potential or immediate exposure to contamination. This is what occurred in the residential community living directly south of the Del Amo and Montrose Superfund sites, when DDT was discovered in backyard soils more than 20 years ago (EPA 2015b).

In 1994, a group of community residents concerned about the contamination from the nearby sites formed the environmental activist organization, the Del Amo Action Committee (DAAC), and they remain instrumental stakeholders in the ongoing cleanups. The perspectives, knowledge, and first-hand experiences of the DAAC and other community members are valuable sources of information within the scientific and engineering contexts of the Del Amo and Montrose Superfund cleanups. Yet these forms of community representation are not accessible like Superfund site documents one would find online or in a local repository. A potential avenue for representing community perspectives, local knowledge of place, and historical events related to the cleanups is a participatory Web GIS tool where contributors provide information in a dedicated online environment. The Web GIS tool could highlight the spatial and experiential components of the Del Amo and Montrose site cleanups from the unique vantage point of the local population.

This study proposed the following as guiding principles in the development of a participatory Web GIS tool to represent community perspectives of the Del Amo and Montrose site cleanups: (1) A value proposition for the development of a Web GIS tool should be established on the basis that community members recognize a need for the tool, or there is a potential positive benefit for the community as a result developing the tool; (2) Participants in the study should define the goals and objectives of the Web GIS tool, including the software platform and functionality of the tool, as well as how it will be used and/or promoted; (3) Participants should be critical evaluators of the tool as it is being developed to ensure their goals and objectives are being reflected accordingly; (4) Ownership of the tool should be transferred to the participants/community members after completion of research if the participants feel that the Web GIS tool will continue to serve a positive purpose and/or be of value in the future. In order to explain these goals further, participatory Web GIS and community-engaged research is introduced, as well as the motivation for pursuing this research.

1.1 Online Public Participation GIS (PPGIS) for Environmental Issues

Environmental problems are inherently spatial, and the data and solutions involved in addressing an environmental issue, whether broad (regional) or at a larger scales (the community), are also geographic in nature (Bailey and Grossardt 2007). The emergence of Web GIS introduced new avenues for communicating and engaging the public in environmental issues. A number of participatory Web GIS tools are designed with the intention of bridging the spatial information gap between lay citizens and GIS experts (Carver et al. 2000; Li, Ru, and Chang 2004; Kingston 2007). Distributed support systems for e-governance, sustainable development, and land use planning have extended the reach of Web GIS towards spatially-informed decision-making via online public participation GIS (Web PPGIS) (McColl and Agget 2006). However, some critics argue that Web PPGIS may not guarantee citizen participation or serve the internal goals of a community due to politically-driven agendas on behalf of the entities who design, implement, and deliver PPGIS tools (Elwood and Leitner 1998; Talen 1999; Sutcliffe and Wilson 2011). This result would defeat the purpose of a community-engaged Web GIS built from the bottom-up, where participants inform the process, goals, and content of the tool.

The field of Critical GIS established a framework for assessing the social impacts and long-term implications of geospatial data and technologies as they were used and evaluated by a small group of GIS professionals in the mid-90s. Scholars of Critical GIS argued that only those individuals capable of using spatial data and technology were qualified to evaluate and assess them, and a new participatory framework emerged as a means of extending spatial data and tools to the public realm. The participatory models (such as Web PPGIS systems) still reflected a separation between lay users and GIS developers, and Critical GIS scholars cautioned against the participatory movement as a truly democratic system. Critical GIS is explored in this study as a mechanism for confronting the notion of power dynamics between a GIS professional (the researcher) and non-GIS user participants, as well as a model for creating the spaces for evaluating the Web GIS on behalf of contributors in situ with its development.

Another focus within Critical GIS is the idea that the analytical power of a GIS may not be adequate in communicating the experiential, subjective complexities associated with citizens’ perspectives of space (Gordon, Schirra, and Hollander 2011). Stoll and Sumn (2005) argue for a new conceptual framework in developing PPGIS that promotes meaningful community interaction and are grounded in the unique local context and motivations of the citizens. Sutcliffe and Wilson (2011) suggest a bottom-up GIS (BUGIS) approach to environmental planning which begins at the neighborhood level, allowing residents rather than technical experts, to characterize their community. The two extensions of Critical GIS used in this study (an evaluation mechanism or system of checks and balances throughout the research process, as well as an awareness of how subjective or experiential spatial information might be communicated in a participatory Web GIS) were situated directly within the research contexts they occurred. Taking into consideration the value of representing local perspectives of space within a participatory Web GIS environment, it is important to establish the principles of community-engaged research most relevant to this study.

1.2 Community-Engaged Research

Community-engaged research is a collaborative process that involves working directly with groups of people connected by way of common interests, spatial proximity, or other factors in order to address one or more problems or issues that they care about (ATSDR and CDC 2011). This research differs from community-*based* studies whereby the researcher initiates the research question and the study is conducted in the community but with little to no direct involvement of the community members in shaping the research (Wallerstein and Duran 2010). It should be noted that community-engaged research methods are common to health-related studies and interventions, but are not confined to this area. Rather, the guiding principles of community-engaged research apply to any study that insists on the direct involvement and guidance of the community.

More specifically, this method ensures that community members and researchers share equally in their contributions and are involved in all phases of the research process. In recognizing that a research agenda may naturally take over if community participation is limited, it is the researcher's obligation to accommodate or encourage new spaces or opportunities for engagement. All aspects of a community-engaged approach should embrace opportunities for trust building. While trust can take a long time to establish, doing so can create lasting partnerships and future opportunities for the community and the researcher and/or affiliated academic institutions (Horowitz, Robinson, and Seifer 2009). Members of an environmental activist group, the Del Amo Action Committee (DAAC), served as the participants and contributors to the Web GIS developed in this study. The relationship necessary to achieve this research was bolstered through direct and regular meetings with the DAAC, through immersion in the local community.

1.3 Motivation

Citizens invested in Superfund cleanups must interact with an array of other stakeholders such as the EPA, local and state agencies, third-party consulting and engineering firms, technical experts, lawyers, as well as the polluters responsible for creating or disposing of the pollution. Conflicting agendas and priorities among groups over a substantial period of time can create perceptions of mistrust and poor handling of critical information and data (Laurian 2004). Further, various obstacles may limit citizen involvement. Culley and Hughey (2007) describe obstacles such as: "Control of resources, barriers to participation, agenda setting, and shaping conceptions about what participation [opportunities are] possible" (99). Community groups or local organizations provide avenues for participation (Laurian 2004), which are more effective than one individual to influence cleanup decisions and activities. This research was initiated by an interest in exploring community involvement in the Del Amo and Montrose Superfund sites in Los Angeles.

The Del Amo and Montrose Superfund sites are adjacent to each other in the City of Los Angeles, and directly north of an unincorporated neighborhood in the County of Los Angeles, located between the larger cities of Torrance and Carson. The EPA's online Superfund site profiles include dozens of documents, reports, fact sheets, and technical records spanning from the mid-1980s to the present, linking the Del Amo and Montrose sites by way of comingled groundwater contamination. The contamination from both sites contributed to three groundwater plumes occurring in different aquifers in the Los

Angeles Groundwater Basin. An EPA (2013c) map of the plumes occurring in water table units reveals an area where all three plumes overlap under a block of residential homes. A brief examination of the site summaries hints at a complex Superfund cleanup in direct proximity to a community and surrounded elsewhere by predominantly light and heavy industrial and commercial land use.

In mid-November of 2014, the Montrose Superfund website featured a document under the heading "Community Involvement" (EPA 2014d). The document contained transcribed minutes from a November 8th public meeting held by the EPA about dense non-aqueous phase liquid (DNAPL) under the Montrose site. During the meeting, community members posed questions and comments about the proposed remedies and other issues. One theme mentioned multiple times was the projected time span of 3,000-5,000 years for cleanup. Due to the extent of the groundwater contamination, the length of time to feasibly return the groundwater to productive use may span thousands of years. A key motivation for this research was to understand the factors that contributed to the cleanup timeline and perhaps more importantly, what this means for the community living near the sites. The Del Amo and Montrose cleanups point to a far more complex narrative, and one that may be understood from the community members who have lived through them.

Based on preliminary research into the history, extent of the contamination, and the various cleanup activities associated with the Montrose and Del Amo Superfund sites, the initial motivation for this project was to design an interactive Web GIS tool for the purpose of educating the public about the history of the Superfund sites and how they have affected the local community. After presenting this idea to the DAAC, the committee contended that an online Web GIS Story Map would benefit the public and the affected community, and expressed an interest in becoming involved in the development of the tool. Representing the Del Amo Action Committee and the residents affected by the long-term Superfund cleanups is the central motivation for this project.

CHAPTER 2: BACKGROUND

This section provides a background and overview of how public participation GIS (PPGIS) and other participatory Web GIS emerged as important vehicles for engaging citizens in spatial problems. Using a Critical GIS framework, this section also investigates how participatory Web tools and spatial technologies in general should be assessed. This section underscores the importance of assessing how spatial information and technologies may exclude non-GIS users, and draws on the work of Critical and Qualitative GIS to support and represent human experiential knowledge and spatial narratives through a Web GIS story map.

2.1 Public Participation GIS (PPGIS)

In the 1990s, GIScience came under scrutiny among social scientists, human geographers, and other critics who recognized that the field was dominated by a small group of individuals with the ability to manipulate and represent space, arguably the most contested (and contentious) scientific medium. Gordon, Schirra, and Hollander (2011) cite the 'rhetorical output' of GIS and its appeal in influencing policy within a wide range of power circles. Obermeyer (1998) suggests that the eye-catching maps and graphics produced by GIS software were so compelling in presentation settings that the soundness of the science was rarely questioned. Pickles (1995) is perhaps the most prolific contributor to the Critical GIS debate, framing the complexities of the issue in his book *Ground Truth: The social implications of geographic information systems*. Pickles (1995) suggests that a critical assessment of GIS is essential in understanding its impact on societies in the midst of their (GIS) rapid development, high demand, and the destabilizing nature of powerful technology in general. Yet, Pickles (1995) argues that these discussions occurred either within the GIS field and concerned issues of method and technique, or among geographers who were natural advocates of GIS. This suggests that the technology was accepted within the internal community of users and supporters and that no formal or unbiased evaluation occurred at all.

If Pickles was correct in this assessment, this brings up important questions about whether (and how) non-GIS users can meaningfully engage in a critical discussion about GIS, particularly if what they are debating may naturally be the tools' output (maps) rather than the tool itself. Nonetheless, the argument for maintaining a critical dialogue about the ways in which spatial problems are represented (and by whom) remains as relevant today as it was 20 years ago. In hazardous waste site cleanups, GIS are authoritative tools for providing predictive modeling (such as how and where a contaminated groundwater plume will migrate in the coming years), assessing levels of exposure associated with location-specific sampling and monitoring of contaminants, and are invariably responsible for establishing spatial boundaries of risk and non-risk. For this project, local knowledge of place among non-GIS users (in this case, the DAAC and other former and current residents of the community) has directly influenced the Del Amo and Montrose cleanups, has done so without EPA oversight, and without the use of GIS. Certainly it is the goal of this project to tell the story of these accomplishments in an online GIS environment, but it is equally important to establish a critical framework that considers the extent to which these stories are honored or obscured in a GIS.

The Critical GIS debate questioned the effects of GIS on the participatory process, reaching its peak in the mid-1990's (Gordon, Schirra, and Hollander 2011). In response, the National Center for Geographic Information Analysis was established in 1996, bringing supporters and critics of GIS together to form the Initiative 19 report: "GIS and society: the social implications of how people, space and environment are represented in GIS." The report outlined a new path for the future of GIS, distinguishing the present state of "GIS1," which focused more on traditional science and cartography from the future visioning of a "GIS2," describing a more participatory GIS (Harris and Weiner 1996). This participatory platform culminated in the concept of public participation GIS (PPGIS) as a means of addressing the challenges associated with extending the technology for effective use among non-GIS users (Harris and Weiner 1996). Additionally, the new vision was supported by GIS experts who recognized that doing so would allow the public to have an influence on how space was represented (Gordon, Schirra, and Hollander 2011).

While the concept of PPGIS was clear in its motivations to extend the reach of GIS to the public and establish a more democratic system of access to spatial data and technology, there was no standard model for how a PPGIS should be designed, implemented, and evaluated. Thus, the resulting Web PPGIS approaches varied significantly in terms of interface design, functionality, and user capabilities, making it difficult to capture the end-user experience of a typical model in early iterations (Carver et al. 2000). However, one common thread of Web PPGIS noted by Gordon, Schirra, and Hollander (2011) included some form of “challenge-based immersion” (511) on behalf of the user such as performing mapping tasks and queries, identifying features, and customizing and exporting their own maps in various user environments.

Many Web PPGIS developed by city and county government departments offered a dedicated Web map with operational layers related to crime, the environment, education, public health, and other information, which the user could display to create a custom map. Along the lines of Web PPGIS for planning, Sani and Rinner (2011), introduced argumentation maps which allowed users to participate in threaded discussions associated with a specific place within a collaborative web map environment, thereby enabling place-based dialog and engagement. Carver et al. (2000) created a more distributed form of planning-based Web PPGIS in which users could suggest areas for woodland expansion in a national park. In this iteration, users were given the contextual data necessary for the planning task, allowing them to weigh and choose which factors were most important in their site selection decision. For each user, a custom decision map was created and then added to a final composite map showing all of the community’s decisions. While each of these examples point to robust extensions of participatory Web GIS, they also introduce a partition between users/contributors and web developers in the conceptualization of the tool and the formalization of results.

Without the constraints of a standardized model, evaluation criteria, or even a formalized definition of Web PPGIS within the GIScience community (Peng 2001), there is not an appropriate framework for assessing these beyond the general goals of Initiative 19, which included a participatory, democratic GIS (1996). Defining these terms within a decision-making framework does not reconcile the concept of Web PPGIS. Gordon, Schirra, and Hollander (2011) point out that access may be a prohibitive factor for users who may not have internet access or high-speed connections, but also suggest that access may be limited due to user permissions set by administrators. In addition, the open-ended nature of many Web PPGIS, or what Gordon, Schirra, and Hollander (2011) refer to as a "geographic sandbox" (513), assumes that users will be able to define the parameters necessary for engaging the spatial data and tools provided in the interface. On a more fundamental level, Sieber (2006) notes that participation in spatial knowledge creation does not necessarily empower those who are involved in or impacted by decision-making. Further, the word "participatory" implies an intercessory role within the broader decision-making process, where top-down practices occur at institutional, academic, technological, or other levels of influence (Sieber 2006).

It seems that in lieu of a standard PPGIS model or definition, the proxy for defining and evaluating them must be context-driven. Also, PPGIS contributors should know how their responses are being used. If a PPGIS is intended to merely showcase participant responses in a final map or report, it should be very clear to the contributors that the information is not directly informing a policy decision, but is rather a representation of the data. As such, a PPGIS that does seek to use citizen data in policy and decision-making should be explicit in how participant information is weighed in decision-making and how this is achieved programmatically via Web. Just as GIS came under scrutiny in the 1990s as an exclusionary, technocratic science, the participatory models that emerged from these critiques have arguably raised more questions about how citizen contributions are encoded and represented in a given PPGIS. If we are to consider the output of a decision-based PPGIS in collecting and disseminating the results of individually "mapped" responses in contrast to a paper ballot in a traditional poll setting, the former method does not lend itself easily to a democratic system where the voter watches their ballot go into a machine. A PPGIS contributor has no way of keeping a watchful eye on their response if it is filtered through the Web, unless they are actively involved and are able to oversee the entire process.

Much like the PPGIS literature, community involvement in Superfund cleanups is heavily stressed by the EPA as an instrumental component in remediation decisions. Yet, the extent to which written public comments (the EPA's formal method of gathering local input on site remediation) influence the final decisions simply cannot be known. This research, in recognizing the limitations of

Superfund and the EPA to provide alternative outlets for citizen participation, is concerned primarily with how community members might engage a participatory Web GIS in situ with the tool's creation and development. As such, the final Web GIS for this project insisted on a participatory process, but it is not considered a "traditional" PPGIS where users are tasked with contributing spatial information in a formal online environment within specific time constraints and/or settings. Rather, this research involved an ongoing participatory process of reviewing and refining the Web GIS tool throughout its development, based on regular feedback from a designated steering committee. Here again, Critical GIS may be a useful lens to consider both the challenge and the potential value in representing spatial experiences and narratives in a hazardous waste environment and the contested spaces it can create.

2.2 Qualitative GIS within a Critical GIS Framework

According to Schuurman (2006), Critical GIS is an approach that evaluates GIS technology and its associated principles, drawing from social theory, science and technology research, and philosophy. As explained in Section 2.1 above, Critical GIS is widely attributed to the participatory GIS movement and later, PPGIS for citizen engagement in geospatial technology and applications, participatory planning, and decision support systems. Yet Critical GIS as a science has since diminished in influence within the GIScience community due to several reasons, and Schuurman (2006) attributes this chiefly to, "The barrier between conceptualization and formalization" (726). This is to say that there is something prohibitive within Critical GIS in its constitution of questioning (and at times, rejecting entirely) the very science it engages. It is important to consider a reconciliation of the two schools of thought via a reframing of how GIS technology can indeed provide a more qualitative, flexible rendering of human spatial experiences and knowledge (Wilson 2009).

More specifically, Critical GIS recognizes considerable gaps in GIS technology to represent multiple epistemologies (ways of knowing and acquiring knowledge) and ontologies (in the domain of Critical GIS, ontologies may be best described as ways of conceptualizing space). The problem can be best described as "lost in translation;" the case for Critical GIS must be communicated in the computational language of code, and the solution must be accomplished within the coding parameters of GIS programming capabilities. As such, the plight of Critical GIS to situate ontologies and epistemologies within GIScience disciplines such as algorithms, spatial analysis, cartography and visualization, and spatial cognition/reasoning (to name a few) has found little success. Only 11 papers on ontologies and epistemologies were featured in GIS journals between 1994 and 2004 (Schuurman 2006).

The importance of these subject areas (and Critical GIS) has a number of implications for how the data models embedded in GIS technology cannot reconcile what Chrisman (1978) states are cartographic data structures within different concepts of space. Schuurman (2006) refers to a later work of Chrisman in 1993, which considers a GIS data model for spatial representations that connect to and are interpreted within the social context of everyday life. Schuurman (2006) uses an example of land-use debates and planning, citing the usefulness of maps "that explicitly represent different connotations of a particular scenario" (730). Such is true for any shared space or geographic place; common geography does not imply common interests or interpretations. Future land use scenarios are particularly relevant in Superfund cleanups, where community members, the EPA, and other agencies and stakeholders may hold very different opinions for how a site is used after cleanup is achieved.

Wilson's (2009) contribution to *Qualitative GIS* in the chapter titled: "Towards a genealogy of Qualitative GIS" speaks to the work surrounding the challenge of capturing and encoding the subjective spatial contexts of human experience in the quantitative medium of GIS. Implicit in Wilson's discussion of a qualitative GIS is a new opportunity for and iteration of Critical GIS for reframing the conceptualization problem posed by Schuurman (2006) within the competing subject areas of GIScience scholarship. Wilson (2009) explains that the practice of qualitative GIS takes on a double critique, one that questions knowledge-making processes and practices, but goes further to alter these in such a way that affects change. The same practice can be translated into a general framework for communities involved in environmental disputes; being critical about a poorly implemented system only goes so far before it becomes necessary to transform the system or create an alternative one. Invariably, this process involves some form of spatial interrogation, particularly since future land use (or site reuse) is factored heavily into Superfund cleanup decisions.

The Del Amo/Montrose community and DAAC actively pursued creative avenues that directly influenced the cleanup process. These examples of community activism are not represented within the official Superfund site narratives provided by the EPA. These "hidden" narratives then, must instead be told by the community members themselves. In recognizing that contested representations and valuations of space exist between the local and scientific communities in the remediation of hazardous waste sites, this research developed a Web GIS Story Map that seeks to engage a critical dialogue about these contested spaces, and the areas of influence that have historically acted upon them. A key aspect of this project involved the regular discussion and critique of the Web GIS tool in situ with its development on behalf of the community. This method of evaluation reflects another aspect of Wilson's (2009) case for a Critical GIS, one that "is bolstered by an *insistence on* and *relevancy through* the technology" (17) rather than a rejection of it.

The next section addresses the use of Web GIS narratives, or story maps, for the purpose of effectively communicating the history of the Del Amo and Montrose Superfund sites from the perspective of the DAAC and other residents from the community.

2.3 Web GIS Story Maps

The online story map concept emerged in the past three years as an innovative and immersive platform for story-telling (Esri 2012). By introducing web maps in a narrative framework, users are oriented geographically throughout the progression of the story, but maps need not be the sole focus. The integration of mixed-media (e.g., photos, videos, documents, audio clips, interactive graphics, and narrative text) addresses two important considerations for the end user and the storyteller. For the storyteller, mixed-media integration makes room for the non-spatial components of a story. For the end user, the mixture of media recognizes that users are more likely to engage in a story that sustains their interest, so variety within a story map via text, maps, graphs, photos, and video or audio clips maximizes its overall impact.

Additionally, the Story Map taps into a person's natural inclination to skip through certain parts as they would in any other story such as a book or a movie that does not grab their interest. Basically, the user can customize their own experience in the choices they make as they use the tool. For instance, they may choose to click on a list of links to read more about unfamiliar terms or ideas, or they may simply skip over these and move to the next panel or section of the story. They may be more interested in the visual arrangement in a Web map, rather than feel compelled to click on individual features in the map. Regardless of how a user progresses through the tool, the components of a story map should be offered in such a way that the user determines the extent to which they will engage in each narrative section.

The decision for using the Story Map platform for this study was based on a number of considerations, primary among these was a recognition on behalf of the steering committee that the community's perspectives were best represented in a narrative framework. Specifically, the steering committee explained that due to the long-term nature of the cleanups over a period of 23 years, a rich community history emerged, and these histories could be illustrated via multi-media sources collected during this time (e.g., photos, documents, videos, and hand-drawn maps). All of these components could be supported within the flexibility of a Story Map platform, along with Web maps and imagery for providing the spatial context for the narratives. Second, the development of the Story Map was conducive to a community-engaged research approach, where the committee could participate in the process of putting the Story Map together. This process also informed the content integration of the Story Map as it developed, and the committee was able to continue contributing to the content and the narrative up to the stage of deployment/publication of the Story Map. On a more fundamental level, the Story Map concept engaged the idea of a qualitative GIS, or human, experiential renderings of space within a geospatial platform, with flexibility to incorporate both (the geospatial as well as experiential) in one integrated platform.

In addition, the decision to develop a Story Map considered the viability of the tool to exist beyond this research, ideally as intellectual property that would be transferred to the DAAC if they wanted to continue maintaining and/or adding to the tool. The development of the Story Map using proprietary software (such as Esri) would require the DAAC to obtain an organizational ArcGIS account to host the Story Map. While this is seen as one potential limitation (in a financial sense), it is also an opportunity to promote and develop the tool beyond the scope of this study, maintain a relationship with the DAAC, and develop a content migration strategy as well as tools (tutorials, how-to guides, etc.) to assist the DAAC in long-term maintenance of the Story Map. This is discussed further in Chapter 6, but overall, the Story Map is well-suited to the process of community-engaged research where a non-profit organization may inherit and support the Web GIS tool beyond the study if it is of value to them.

For the purpose of the Web GIS story map for this project, a few different end user profiles were considered in its creation. First, the DAAC and local community are the subject of the story and the storytellers, so their role as evaluators of and contributors to the tool establish them as the primary audience. Second, regulatory agencies such as the EPA and the Department of Toxic Substances Control (DTSC) are considered as a secondary target audience, since they may naturally be interested in how communities perceive and are affected by Superfund cleanups. Third, this tool considers users who may not have any knowledge of Superfund cleanups or the Del Amo and Montrose sites. For the latter group, the arrangement and presentation of information within the story map attempts to reach a wider audience for the sake of breaking down the complexities of Superfund in general, using the Del Amo and Montrose sites as case studies for learning about the cleanup process and the role of community leadership.

CHAPTER 3: SUPERFUND OVERVIEW AND STUDY SITES

This chapter provides an overview of Superfund legislation and the steps involved in Superfund cleanups, and also introduces the Del Amo and Montrose site histories in more detail. Its purpose is to establish a foundation and background of Superfund and the study site based on information and research materials published by the EPA. This chapter does not include the perspectives of the community, as these are reserved for the Methods and subsequent chapters.

The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980 was enacted by Congress to prioritize and clean up the nation's most polluted sites. The passage of CERCLA, commonly known as Superfund, is closely linked to the Love Canal disaster in the City of Niagara Falls, New York, where toxic materials from numerous manufacturing companies were disposed of in a partially constructed, unlined canal for a period of 25-30 years beginning in the 1920s. The waste materials were buried and the site was covered by dirt in 1953 (Yablonsk, Young, and Morris 1998). Reports of numerous health issues from residents in the 1970s kicked off a series of actions taken by city, county, and state departments, yet environmental investigations of the site were not officially conducted until 1978, when soil, air, and groundwater sampling identified the source and scope of the contamination. In 1978, under the Carter Administration, Love Canal was declared a federal emergency, and funds were appropriated to demolish homes and schools built on top of the site, as well as remediation measures to contain the waste. In 1980, CERCLA statutes formed the baseline provisions for handling the cleanups of what would amount to hundreds of newly discovered Superfund sites around the country.

When CERCLA was first established, it was championed as an aggressive legislative effort to put an end to "careless hazardous waste disposal" (Harris and Wrenn 1988, 36). Originally, the Superfund was a $1.6 billion trust fund covering a five-year period and was set up to finance the investigation of hazardous sites and determine the entities responsible for the pollution. In addition, Superfund financed remedial site costs in cases where responsible parties could not be found or could not pay for the cleanup (Hamilton and Viscusi 1999). In 1985, when CERCLA was about to expire, the Office of Technology

Assessment (OTA) issued a report, *Superfund Strategy*, which concluded that the scope and magnitude of hazardous waste sites was far greater than originally anticipated (Harris and Wrenn 1988). The report states: “The number of dump sites could mushroom to more than 10,000, requiring cleanup efforts over a span of perhaps 50 years” (Harris and Wrenn 1988, 36). In addition, an estimated $100 billion in funds would need to be allocated to cover the costs of the projected number of newly discovered sites. CERCLA was also criticized for its underestimation of the resources necessary to adequately assess environmental and public health risks as well as the number of professionals who were experienced in designing and implementing cleanup remedies (Harris and Wrenn 1988).

In 1986, the Superfund Amendments and Reauthorization Act (SARA) was passed by Congress in an effort to improve upon the apparent weaknesses of CERCLA. Under SARA, stricter requirements for finding permanent remedial solutions and technologies were stressed. New State and Federal environmental laws and regulations were required as well as increased State involvement in cleanup phases. A greater focus was placed on human health impacts of polluted sites, and the trust fund was increased to $8.5 billion (US EPA 2014). While SARA established more rigorous standards for cleanup requirements and put human health as the top priority, exorbitant costs and limitations of available remedial technologies made these difficult to meet the standards at many sites (Harris and Wrenn 1988). This was particularly apparent in SARA’s groundwater quality cleanup goals, intended to reflect the same standards of the Safe Drinking Water Act, which established that water quality should be such that no adverse health effects were present or anticipated (Harris and Wrenn 1988). The implication of SARA for some long-term remedy Superfund sites, such as the Del Amo and Montrose sites where multiple contaminants impact various environmental media, is to add more time and money to an already lengthy cleanup.

3.1 The Superfund Cleanup Process

Under CERCLA, each remedial Superfund cleanup must undergo a series of regulatory steps defined in the National Oil and Hazardous Substances Pollution Contingency Plan, or National Contingency Plan (NCP). Figure 1 depicts the steps of the complex process based on the author's analysis of EPA policy documents. It is important to note that the Superfund cleanup process and the steps involved do not necessarily address the entire site as a "one size fits all" remedy to cleanup. Rather, many sites are broken up into individual operable units (OUs) to reflect the variability of the contamination, the affected media, the geographic scope, and the characteristics of one OU relative to another. At sites with multiple OUs, where one or more OU cannot be treated with the same remedy, each OU must step through the phases of the Superfund process shown in Figure 2. For instance, at the Del Amo site, OU 1 (Soils and Non-Aqueous phase liquid (NAPL) addresses only those soils and NAPL occurring within the Del Amo site boundary. The Del Amo OU 2 (Waste Pits Area) addresses only the affected waste pits and surrounding soils (EPA 2015a). Both OUs required their own Record of Decision (ROD) and Remedial Action (RA). The OU 1 remedy involved excavating contaminated soils and containing them onsite (to name just one component of the chosen remedies), while OU 2 required a more aggressive remedy involving the construction of a concrete cap to seal the waste pits and an in-situ bioventing system to perform soil vapor extraction (SVE) to treat soil gas (EPA 2011a). The sheer complexity of some Superfund sites may very well mean that the cleanup process is applied in part or full to multiple components of contaminated media.

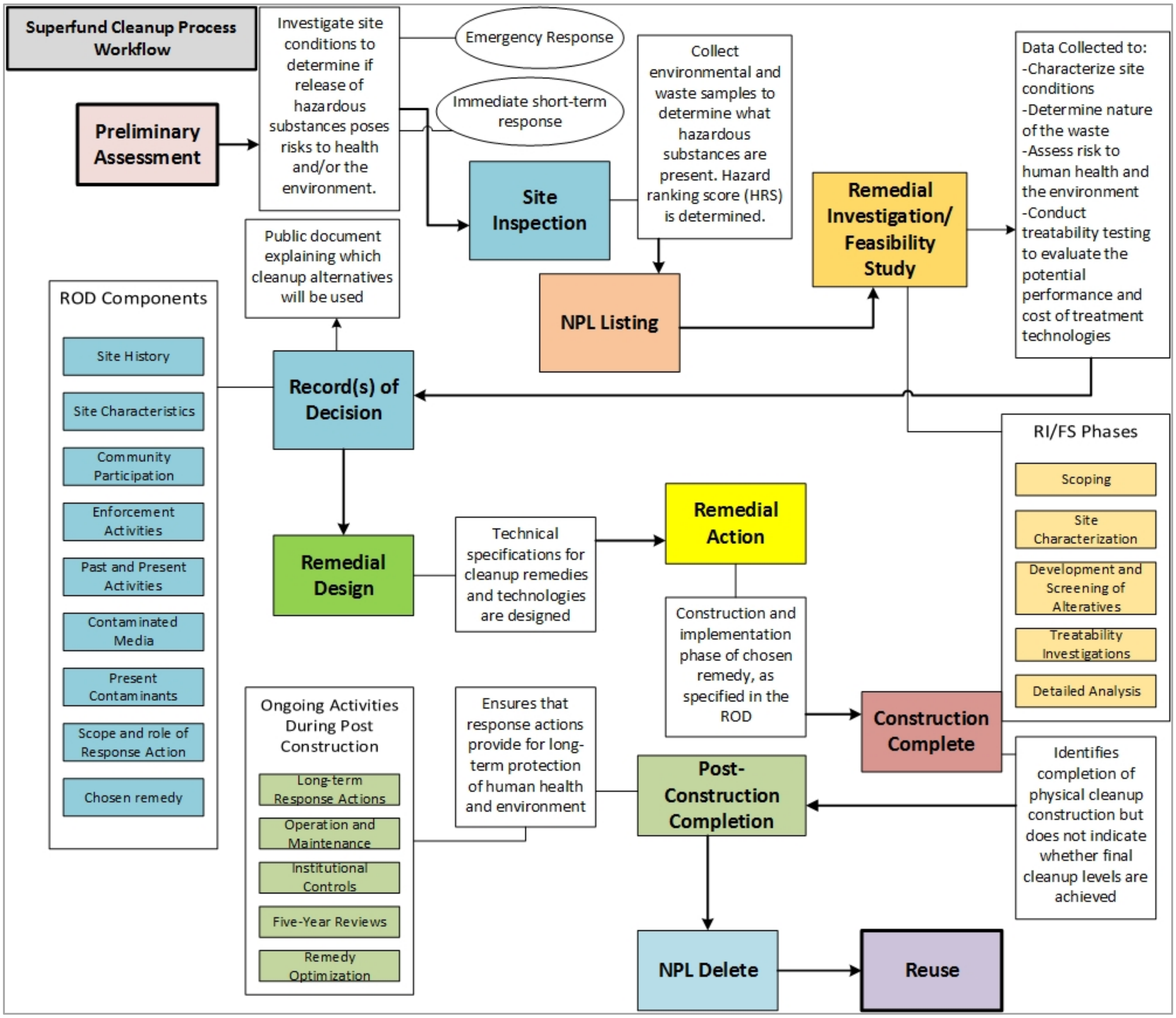

Figure 1 Superfund Cleanup Process Workflow

3.2 Site Characteristics

The Del Amo and Montrose sites are located in the City of Los Angeles. The sites lie between the larger cities of Torrance and Carson to the east and west, respectively. The residential community of approximately 300 households directly south of the sites is in an unincorporated area (County of Los Angeles). The immediate surroundings include light and heavy industrial as well as commercial land use. The Exxon Mobil refinery is located about 1.5 miles west of the sites. The sites lie on the predominately flat alluvial Torrance Plain, with deposits of sands, silts, and clays extending several hundred feet below ground. The closest body of water to the site is the Dominguez Channel, which is now concrete-lined but was originally a free-flowing stream in the Dominguez Channel Watershed. The Dominguez Channel drains an area of about 133 square miles of densely populated and industrial land use through southwestern Los Angeles (CRWQCB and EPA 2010). It is approximately 2,000 feet northeast of the Del Amo and Montrose sites. The channel drains about 62% of the Dominguez Watershed into the Los Angeles Harbor (West Basin Municipal Water District 2009). Two hydrologic subunits comprise the Dominguez Channel Watershed via an extensive network of underground storm drains: the northern subunit drains directly into the Dominguez Channel and the southern subunit empties into the Los Angeles and Long Beach Harbors via the Consolidated Slip (CRWQCB and EPA 2010).

Because the Dominguez Channel runs through densely populated and industrial areas, it receives various types of discharges and poses water quality issues that have been addressed by a number of water agencies and regulatory boards (CRWQCB and EPA 2010). More than 50 facilities are permitted to discharge directly into the channel, including 5 refineries, a generating station, the Terminal Island Treatment Facility, and others (WBMWD 2009). The Torrance Lateral, a concrete channel created for flood control, is located less than half of a mile south of the Del Amo and Montrose sites, and empties into the Dominguez Channel at the junction of the 405 Interstate and Avalon Blvd.

The residential area south of the sites is bounded by 204th Street (north), Torrance Blvd (south), Normandie Avenue (west) and New Hampshire Avenue (east). Two significant natural drainage ditches (the Normandie Ditch and the historic Kenwood Ditch) located south of the Montrose and Del Amo sites have been linked to accumulation of storm water and historic floods. The Kenwood Ditch ran along the west perimeter of Kenwood Avenue driveway lines, extending down gradient from 204th Street to Torrance Blvd. The “S” shape of Kenwood Avenue distinguishes it from all other straight-line residential streets in the study community, and it has sometimes been referred to as the “river” by long-standing residents of the area (US EPA 2001). Kenwood Avenue remains the lowest natural point in the local terrain (US EPA 2001). In the late 1960’s and early 70’s, the Los Angeles County Flood Control District replaced the Kenwood Ditch with the underground (now existing) Kenwood Drain, which is connected to a larger underground storm drainage network (US EPA 2001). Extensive construction occurred during the Kenwood Ditch removal, and subsequent drainage and construction projects have occurred in the community since, including two large-scale soil excavations as well as realignment and matching of streets and driveways.

There are 7 hydrostratigraphic units underlying the Del Amo and Montrose site (See Figure 2): the Upper Bellflower (UBF), the Middle Bellflower “B” Sand (MBFB Sand), the Middle Bellflower “C” Sand (MBFC Sand), the Lower Bellflower Aquitard (LBF), the Gage Aquifer, the Gage-Lynwood Aquifer, and the Lynwood Aquifer (EPA 2011a). The shallow groundwater units (UBF, MBFB, MBFC, LBF) are not sources of drinking water, but the Gage and Lynwood aquifers are of particular concern because the Gage aquifer merges with the deeper Lynwood and Silverado drinking water aquifers just two miles southwest of the site, near two municipal drinking water wells (ATSRD 2009). The implications of the hydrostratigraphic composition under the sites is discussed in more detail in a later section, but in general, the hydrologic characteristics of above-ground and underground drainage channels and networks as well as the groundwater aquifers are of crucial importance in understanding the scope of the groundwater contamination as well as contamination affecting the Los Angeles and Long Beach Harbors as well as the Pacific Ocean (mainly the Palos Verdes Shelf).

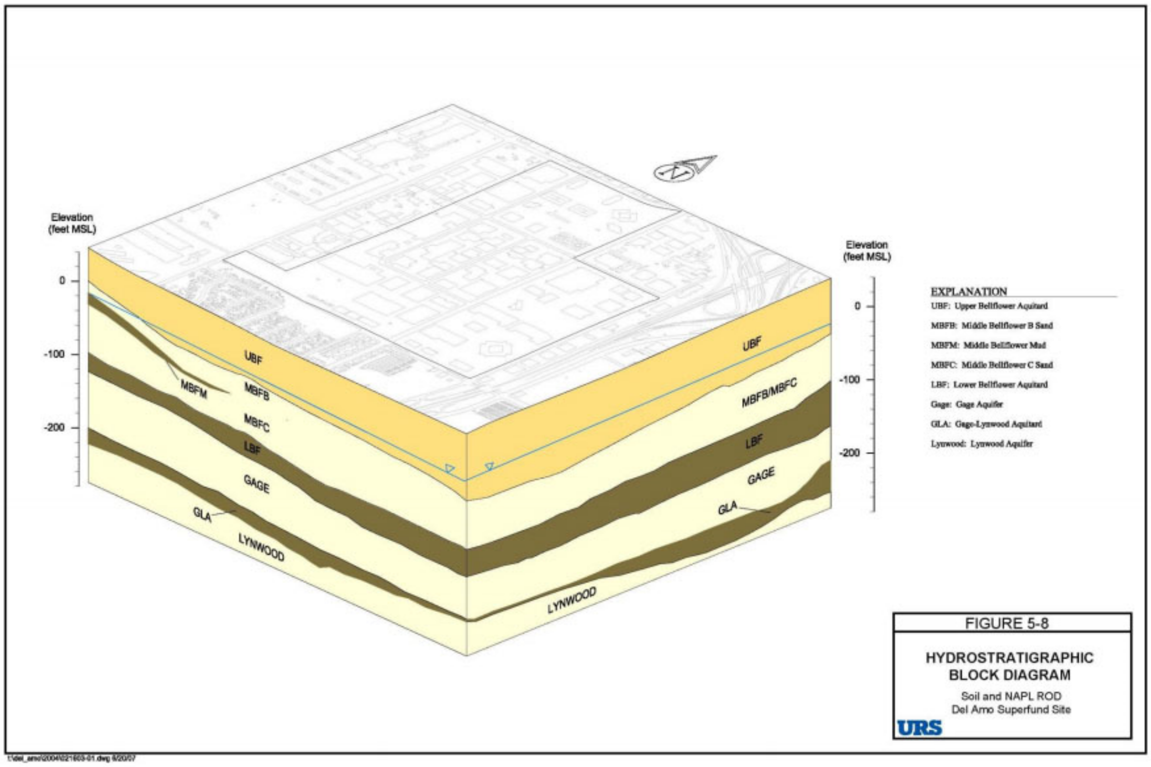

Figure 2 Hydrostratigraphic Block Diagram (EPA 2011b)

3.3 Del Amo Superfund Site History and Overview

The Del Amo site is approximately 280 acres in area, and sits at the junction of the 405 and 110 freeways (EPA 2015a). According to Works Progress Administration (WPA) land use maps from 1937, the former Del Amo site was composed almost entirely of undeveloped cropland and pasture (See Figure 3). Aerial imagery obtained from the 2007 Remedial Investigation (RI) for the Del Amo site shows that the area remained undeveloped through the year 1941, and by 1946 was developed for industrial manufacturing during World War II (See Figure 4). Specifically, the former Del Amo site operated as a synthetic rubber manufacturing plant consisting of three separate processing plants: a styrene plant operated by Dow Chemical Company, a copolymer plant operated by U.S. Rubber, Goodyear Tire & Rubber Co. and others, and a butadiene plant operated by Shell Oil Company (EPA 2007a).

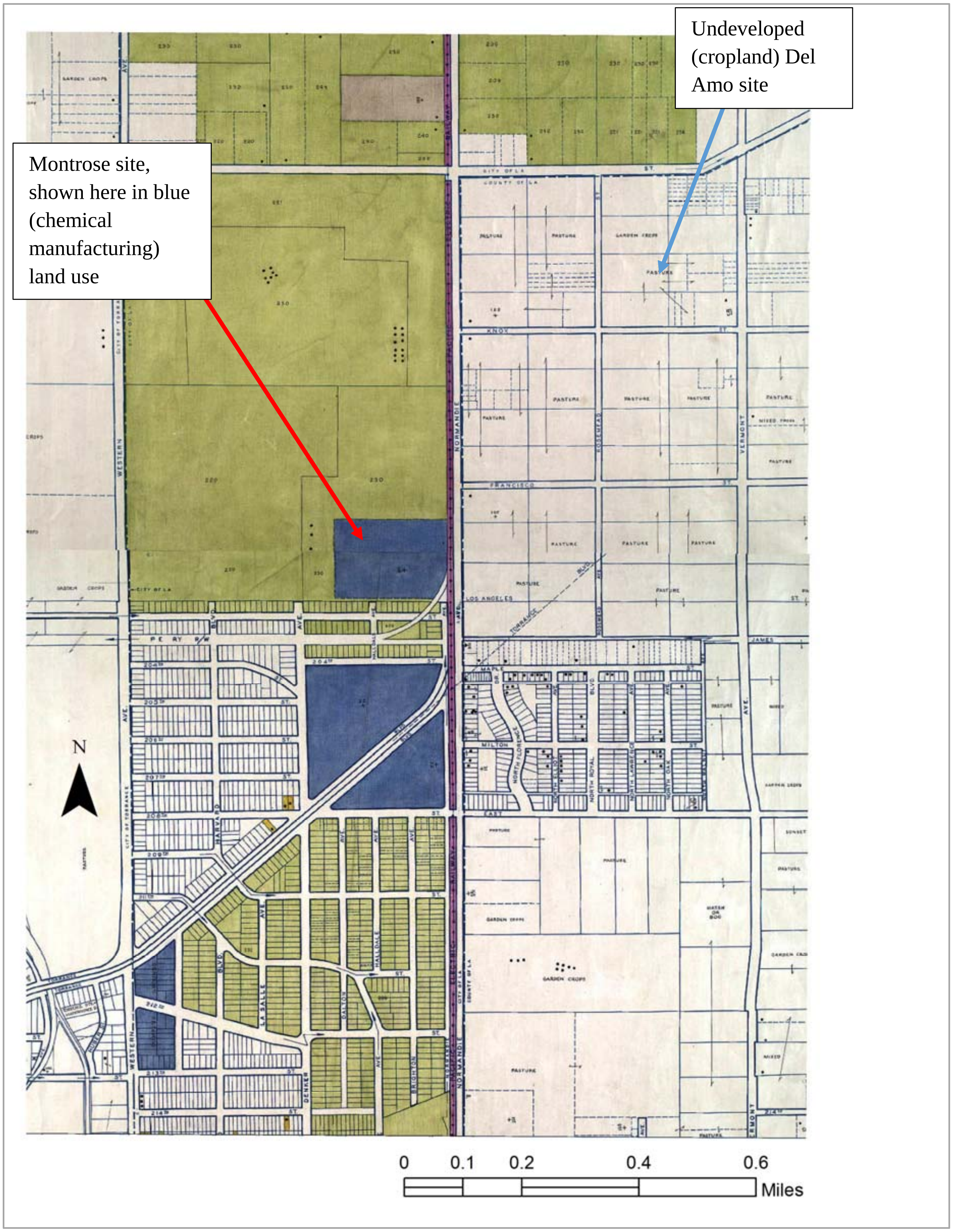

Figure 3 1937 WPA Land Use Map (USC 2015)

The United States government owned all three plants from 1942 until 1955, when it was sold to Shell Oil (EPA 2015a). Shell continued to operate all three plants at the Del Amo site until 1971, and in 1972, all operations ceased and the plants were dismantled. Today, most of the former rubber manufacturing site has been redeveloped as an industrial park (EPA 2015a). The site is still owned by Shell and is surrounded by industrial and commercial development along the east and west boundaries, the 405 freeway to the north, and residential areas directly south of the Del Amo site boundary.

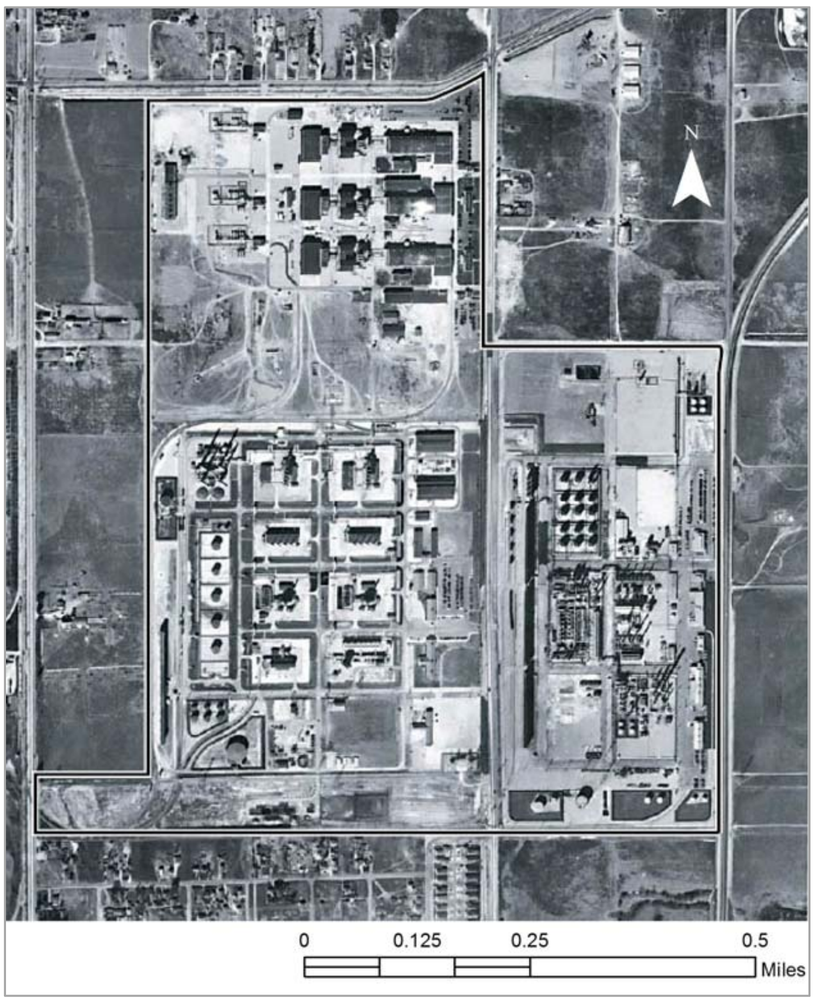

Figure 4 1946 Aerial Photo of the Del Amo Site (EPA 2007b)

During rubber manufacturing operations at the three processing plants on the Del Amo site, chemicals and waste products were released into the soil and groundwater beneath the site originating from leaks in pipelines, storage tanks, and processing units (EPA 2011a). In addition, waste was transferred to separator units, and settled sludge from the units was disposed of off-site or in a waste area in the south-west portion of the Del Amo site property known as the Waste Pits Area, shown in Figure 5 in the red box (EPA 2015a). The Waste Pits Area covers approximately 4 acres and included four unlined evaporation ponds and six unlined waste pits (EPA 2015a). The release and disposal of onsite waste resulted in contaminated soil and groundwater underneath the plant (EPA 2011a). The chemicals used by the plant include benzene, ethylbenzene, propane, butylene, styrene, and 1,3-butadiene and others (EPA 2011a). In 1972, by the time rubber manufacturing ceased and all three processing plants at the Del Amo site were permanently closed, the unlined pits and ponds that were still open were covered in soil and surrounded by a double chain-link fence (EPA 2015a). Most of the parcels on the former facility site have been redeveloped as an industrial park (EPA 2015a). More than 200 businesses occupy the site including a Holiday Inn, Coca Cola Bottling, University of Redlands (Torrance Campus), Herbalife International, Aerotek, FedEx, and restaurants (Esri Business Analyst 2013).

Figure 5 1956 Aerial Image of the Del Amo Site (EPA 2007b)

The Del Amo site consists of 3 OUs: OU 1, Soil and non-aqueous phase liquid on and around the Del Amo site boundary (but excluding the Waste Pits area), OU 2, the Waste Pits area and surrounding soils, and OU 3G, the dual-site groundwater contamination, which is shared with the Montrose site as a result of commingled contaminants originating from both facilities (EPA 2014b). (OU 3G is addressed in section 3.5 of this chapter). The ROD for OU 1 of the Del Amo site was issued in 2011 and revised in 2013. The selected remedies stated in the revised ROD include Institutional Controls (ICs), concrete capping of certain area on the site, engineering controls to regulate new construction projects which might result in exposure to contaminated (disrupted) soils and soil gas, soil vapor extraction (SVE) in shallow soils for indoor and outdoor source areas, and SVE for deeper source area soils (EPA 2011a). The ROD for OU 2 (the Waste Pits area and surrounding impacted soils) was issued in 1997 and included a RCRA-equivalent (Resource Conservation and Recovery Act) cap covering over the Waste Pits area, an SVE system underneath the Waste Pits to treat soil gas, and deed restrictions prohibiting future residential land use (EPA 1997g).

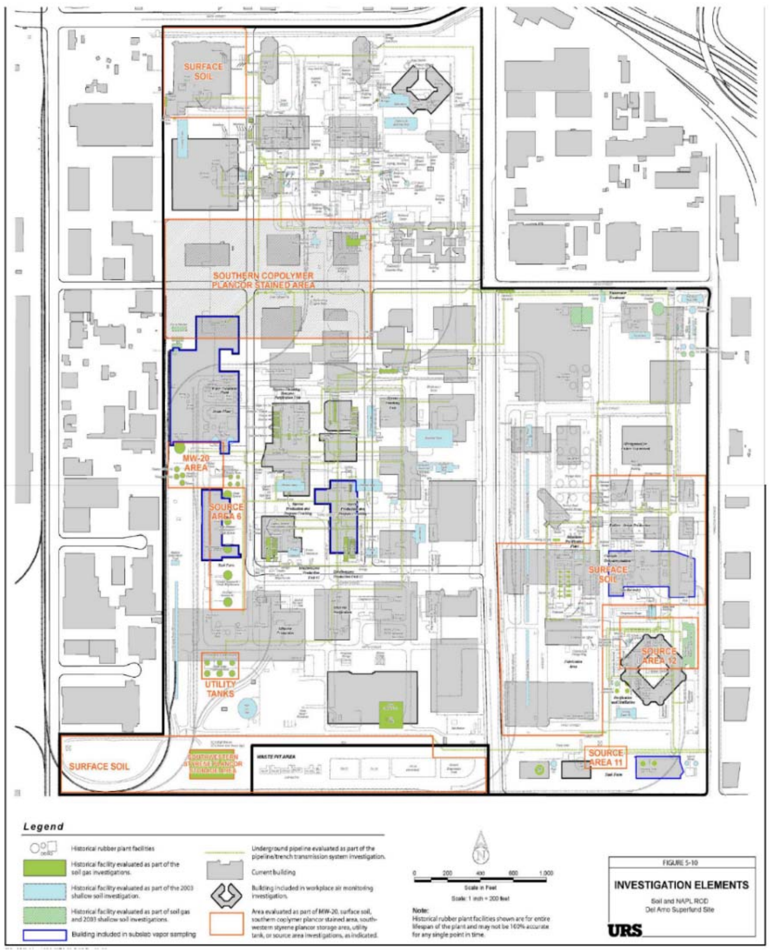

Figure 6 Map of Del Amo Historical Structures and Pipelines (EPA 2011c)

3.4 Montrose Superfund Site History and Overview

The Montrose site is approximately 13 acres in area, and is situated directly adjacent (west) to the former Del Amo facility. According to the WPA land use map from 1937 shown in Figure 3, the Montrose site was already used for chemical manufacturing, while the adjacent Del Amo site was virtually untouched cropland and pasture. EPA records do not specify any operations or land use at the Montrose site back in 1937, so it is unknown exactly what sort of chemical manufacturing took place during this time or which company owned the site. This information would be extremely valuable in piecing together even earlier activities at the site for historical purposes.

Montrose Chemical Corporation was one of the only companies in the US that manufactured the pesticide DDT (dichloro-diphenyl-trichloroethane). DDT production at the site occurred from 1947 to 1982 (EPA 2015b). Operations at the plant included manufacturing, packaging, and exporting DDT. After DDT was banned in the US in 1972, Montrose continued to manufacture and export the pesticide internationally and operated the plant until 1982, at which time the company permanently closed and dismantled (EPA 2015b). As a temporary measure to prevent DDT from surface soils to disperse via wind or storm water, Montrose re-graded and paved the majority of the plant in 1985. Currently the Montrose property is undeveloped and unoccupied (EPA 2015b). In 1984 the Montrose site was proposed for the NPL and was listed in 1989 as a Superfund site.

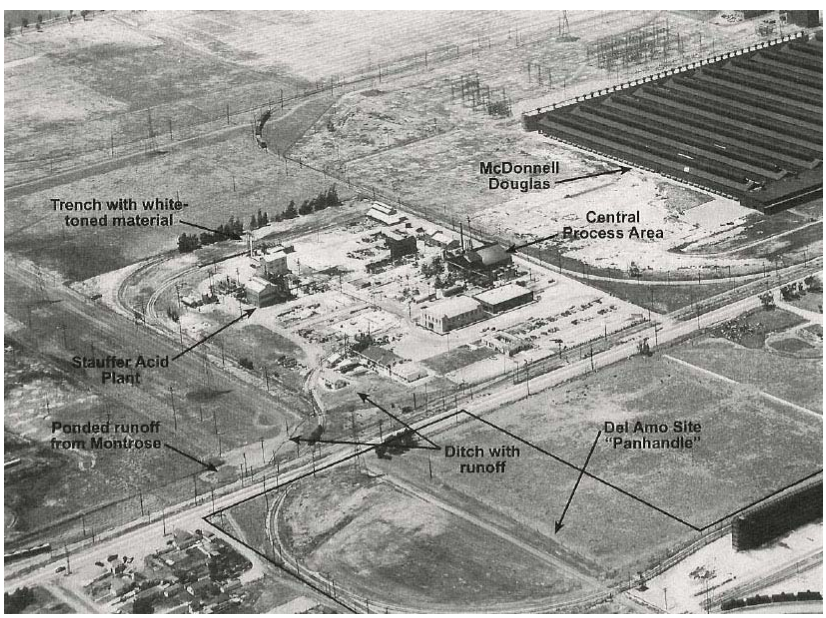

Figure 7 1953 Oblique Aerial Image of Montrose Site (EPA 2013b)

According to the US EPA (2001), the Montrose plant operated continuously 24 hours a day, 7 days a week, manufacturing DDT for a total of 35 years. It is estimated that during this time, 1.6 billion pounds of DDT were produced (US EPA 2001). Throughout Montrose site operations and at least up until 1953, releases of DDT in storm water runoff flowed into natural drainage paths originating at the southeast corner of the property as a result of sewer line blockages from the Montrose site (US EPA 2001). Runoff material included acidic wastewater and by-products of DDT such as chlorobenzene and chloral. Portions of the storm water pathway included the Jones Ditch and Normandie Avenue Ditch (immediately south, downgradient to the site), as well as the unimproved Kenwood Ditch, which ran along the western-most boundary of Kenwood Avenue (formerly Florence Avenue) beginning at 204th Street (formerly Maple Street) to the north, and ending at Torrance Blvd to the south (US EPA 2001). Wastewater that entered the Kenwood Ditch ponded in various locations along the ditch since these were the lowest-lying areas. US EPA (2001) estimates that approximately 156,000 to 233,000 gallons of waste water were discharged per day in the storm water pathway during any occurrence of sewage blockages at Montrose.

The contamination resulting from the Montrose Chemical Corporation DDT operations is substantial, far more so than the Del Amo site operations alone. DDT and DDT by-products persist in soil, do not dissolve easily in water, and accumulate in the fat cells of animals and humans. The scope of the contamination from Montrose can be traced to the drainage outlets such as White’s Point outfall (sanitary sewer) off the Palos Verdes Peninsula, on the Palos Verdes Shelf, along areas of the Torrance Lateral (open channel), Dominguez Channel, and the Consolidated Slip, where the Dominguez Channel empties into the Los Angeles Harbor (EPA 2015b).

In terms of remedial actions for Montrose, the site is divided into 8 OUs (See Figure 8). OU 5 (the Palos Verdes Shelf) is not managed by the EPA personnel that are in charge of the Del Amo or Montrose sites. For the purposes of this research, the wide scope of contaminated OUs is perhaps better illustrated in a Web GIS map, where a user can visualize the scale of DDT pollution by exploring each OU interactively. This is one component of the Web GIS story map for this project, which seeks to illustrate the spatial scope of a Superfund cleanup (to debunk the assumption that contamination is necessarily “contained” within the administrative geographic boundaries of a cleanup site). It is also beyond the scope of this research to discuss each Montrose OU and associated remedial action, but Appendix B includes a visual workflow of how the operable unit Web map is intended to work with the action link functions to create a dynamic user experience.

The next section addresses the dual-site groundwater contamination (OU 3G) which is coincident with both the Montrose and Del Amo sites and encompasses the greatest challenge for the cleanup: remediating the groundwater contamination to meet safe drinking water standards.

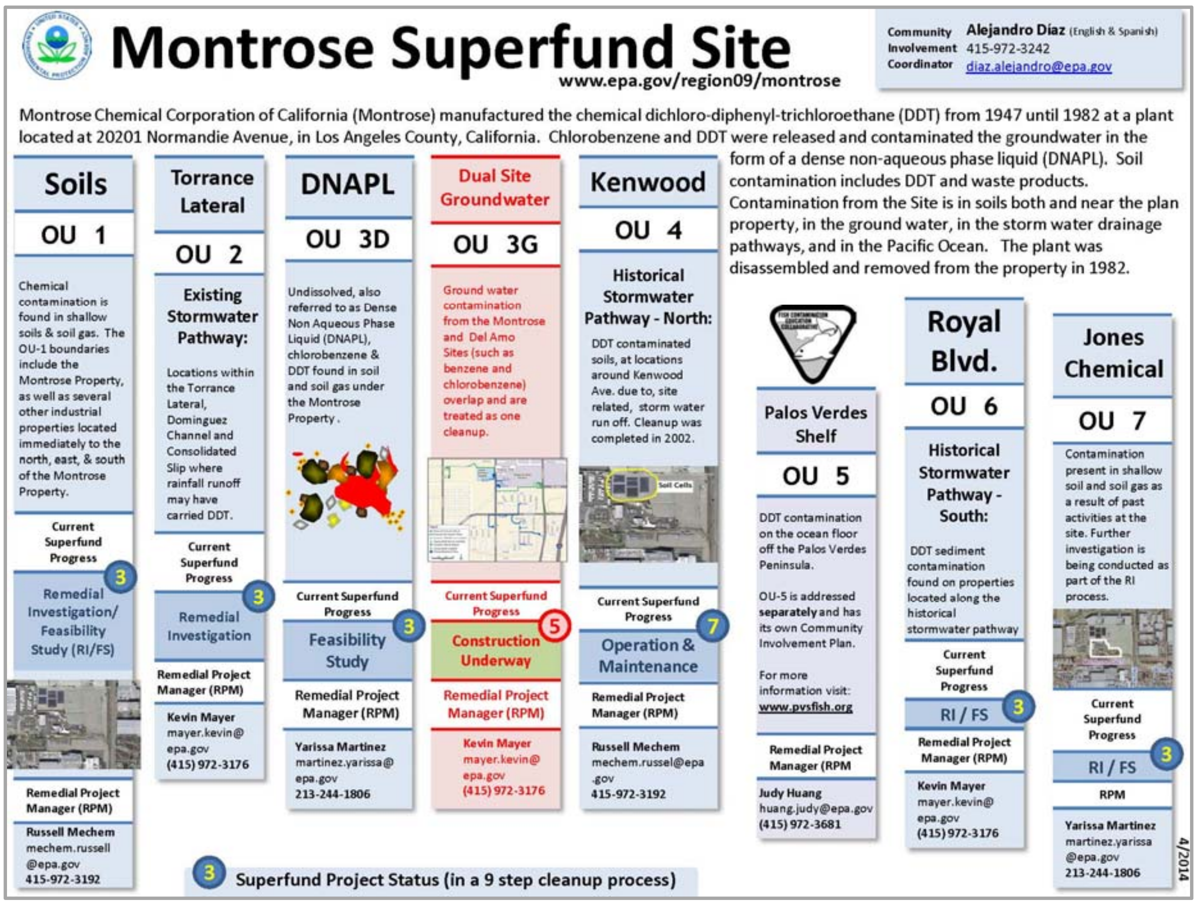

Figure 8 Montrose Site Operable Units (EPA 2014c)

3.5 Dual-Site Groundwater Contamination

In 1999, the ROD for the Dual Site Groundwater (OU 3G) was issued by the EPA to address the release of benzene, trichloroethylene (TCE), perchloroethylene (PCE), and dichloroethylene (DCE) from both the Montrose and Del Amo sites. The dual-site designation of an OU is rare in Superfund site cleanups, but given the close proximity of the sites and the fact that both facilities released many of the same contaminants, it would be a waste of resources and time to address the groundwater contamination remedy separately, per site (EPA 1999a).

The EPA is primarily concerned with remediating three different groundwater plumes, the chlorobenzene plume, the benzene plume, and the TCE plume. All three plumes behave differently due to their chemical constituents and their occurrence within different hydrostratigraphic units (i.e., groundwater aquitards and aquifers) that exist in layers below the sites. Groundwater modeling with GIS has been used extensively for understanding how the plumes will change and migrate under various parameters and scenarios. For the purpose of conceptualizing and visualizing this complex aspect of the cleanups in a Story Map, it is important to understand how boundaries are designated in Superfund cleanups.

The nature of Superfund challenges the notion of well-established boundaries based on property parcels (such as the boundaries of Del Amo and Montrose). Instead, the extent of the contamination determines the area or location of a Superfund site rather than just the source area of the contamination. The National Contingency Plan (NCP) defines "on-site" this way: "…The areal extent of contamination and all suitable areas in very close proximity to the contamination necessary for implementation of the response team" (EPA 1999a, 6-1). The EPA acknowledges that formal boundaries for the dual-site groundwater OU ROD are not determined by the Montrose and Del Amo site boundaries, and in accordance with the NCP, EPA writes: "each 'site' is neither congruent with nor confined by the boundaries of any specific property with which the former Montrose Chemical plant or former Del Amo plant were associated" (1999a, 6-1).

The idea that Superfund boundaries are defined by the spatial extent of the associated contamination rather than the sites themselves is a critical component of this project. In recognizing that the Del Amo and Montrose sites comprise multiple contaminated media, it is worth considering how a Web GIS might address this. The EPA's establishment of different OUs for the Del Amo and Montrose sites divides each spatial "piece" of the sites into manageable segments, so the OUs offer an organizational framework for their incorporation into the Story Maps. But there is an even more intriguing caveat regarding the Montrose site OUs that challenges the NCP's definition of "on site." The Montrose Superfund "boundaries" would logically include the extent of the groundwater contamination, but due to the persistence of DDT along water pathways and soils, the OUs for the site include locations far removed from the facility location and immediate surroundings. The Palos Verdes Shelf, the Pacific Ocean floor, and the Los Angeles Harbor are all receptacles of Montrose DDT, even though a different team of EPA personnel deals with these environmental media. Still, some might argue that these areas are all part of the same Superfund site, which introduces an opportunity within the Story Map narrative to confront these troubled boundaries in a visual and interactive platform.

Another important aspect to consider in the Story Map is how to address some of the spatial barriers or challenges to achieving the groundwater cleanup. Again, many of these components are inherently spatial, but are also mobile, biological processes occurring underground. According to the 1999 ROD, the greatest challenge associated with the dual-site groundwater remediation is the presence of non-aqueous phase liquid (NAPL), which has resulted in the establishment of another contested boundary of Superfund: an area so contaminated that is likely to remain so in perpetuity.

3.5.1 The Technical Impracticability Zone for NAPL Containment

Groundwater contamination usually occurs in one of three forms: 1) The dissolved phase (contamination is dissolved in water); 2) The sorbed phase (contamination is absorbed to soil particles); or 3) The residual phase, or NAPL phase (EPA 2011a). NAPL is the presence of a pure, undissolved state of a chemical (EPA 1998). Remedial actions for NAPL in groundwater are challenging due to the fact that while NAPL dissolves quickly in water, complete dissolution of NAPL contamination takes a very long time and is not removed easily from an aquifer (EPA 1999a). NAPL can remain in soils indefinitely, where it may continue to dissolve either directly into the groundwater, or indirectly via soil moisture percolation (EPA 1999a). Based on NAPL sources from Montrose and Del Amo and other areas of dissolved phase groundwater contamination, EPA determined that it is “technically impracticable” to remove enough NAPL to reduce the contamination to drinking water standards (EPA 1999b), so a Technical Impracticality (TI) waiver zone was established in the 1999 ROD to designate this areal extent. This zone is also coincident with the containment zone.

The establishment of the TI Waiver zone, or containment area, poses a number of issues to the cleanup process, chief among these is the possibility that this area may never be cleaned up according to protective standards for human health and the environment. This zone is the same area that citizens referred to as having a 3,000-5,000 year cleanup during the November 8th 2015 public meeting held by the EPA (see Figure 9). As above, there is the idea of “contested boundaries” in Superfund cleanups. The TI Waiver/containment zone represents a boundary of dispute between the community living in and around an area of persistent contamination and the EPA’s protective measure to prevent the contamination from spreading to drinking water aquifers. The inclusion of the groundwater contamination plumes and the TI waiver zone in a Story Map may present a more interactive and immersive environment to consider the complexity of this issue.

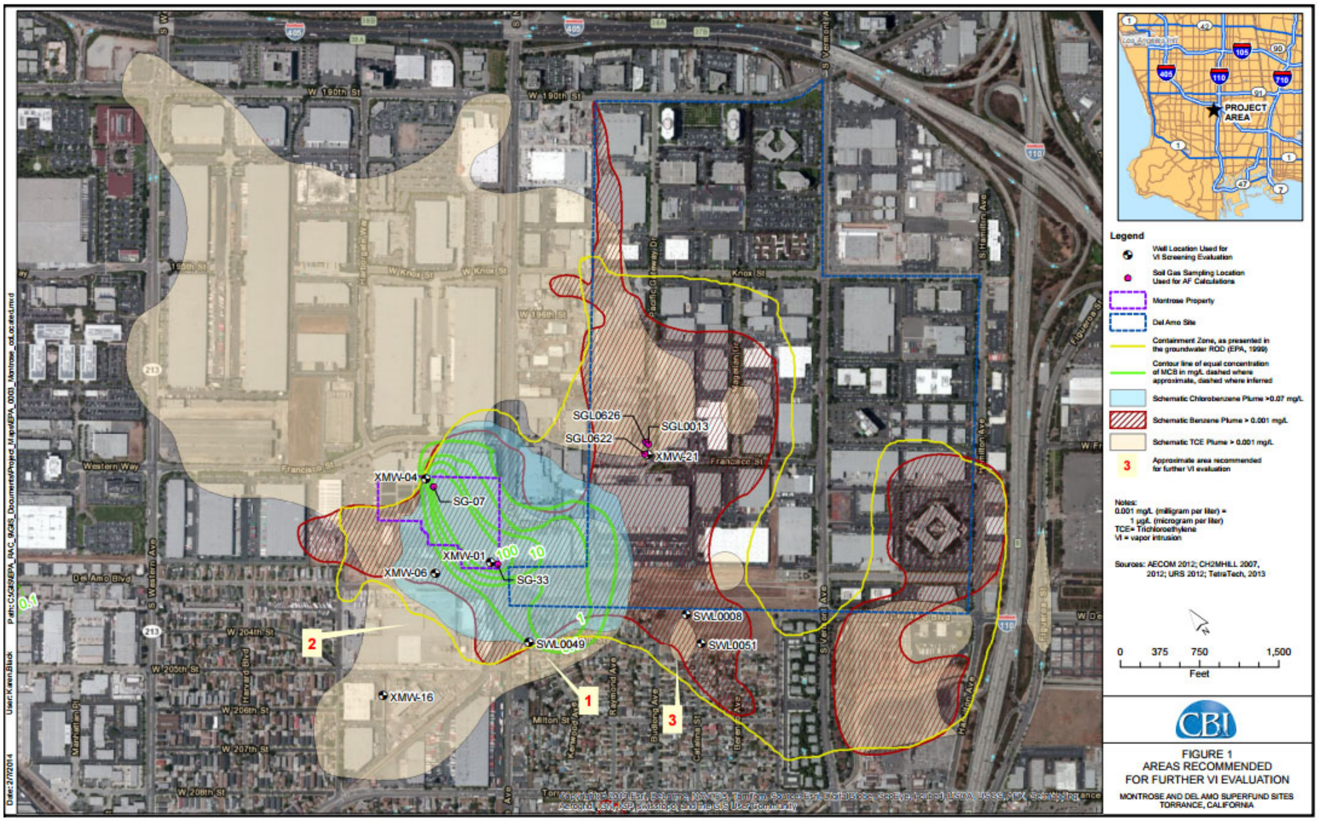

Figure 9 Groundwater Plume Map of Contamination for Del Amo and Montrose (EPA 2013c)

The map in Figure 9 shows one of many representations of the groundwater contamination. EPA technical documents and reports show numerous iterations based on various groundwater modelling techniques, variability of the sizes of the plumes, their occurrence in different hydrostratigraphic units, and the contaminant concentration contours. Another map provided by the EPA shows the extent of the Chlorobenzene plume as defined by the scope of the groundwater treatment remedy infrastructure (EPA 2014a), which is comprised of a network of underground pipes, injection wells, and extraction wells running underneath the extent of the community. With so many ways to conceptualize the dual-site groundwater OU (the most complex aspect of the cleanup), a key component of this research was to enlist the input of the DAAC for direction on how the Story Map would best communicate the groundwater contamination, as well as other spatial aspects of the cleanup.

In recognizing that the DAAC have been active the cleanups activities for nearly 23 years, their role in guiding the Story Map content and narrative threads was instrumental to this project. The following chapter explains the methods involved in establishing a research partnership with the DAAC, how this partnership evolved in a collaborative visioning of the project, and the goals and objectives of the Story Map defined by the DAAC steering committee. This chapter also explains the technical and programming components of the Story Map application, the data sources and methods involved in developing the Web maps, and how the mixed-media components were integrated to the Story Map to reflect the goals defined and narrative components defined by the steering committee.

CHAPTER 4: METHODS

To guide in the creation of the Story Map, a steering committee of three members of the Del Amo Action Committee (DAAC) was formed to help shape the narrative of the Del Amo and Montrose Superfund sites and engage the wider community for feedback. Regular meetings were held in focus group settings near the Del Amo and Montrose sites throughout the duration of this project, using a community-engaged research approach to establish the conceptual themes, map content, and mixed media materials to integrate into the Story Map. This research process was essentially a participant-observer method where I worked side by side with the DAAC and members of the wider community to create the Story Map. An Institutional Review Board (IRB) exemption was obtained for this approach.

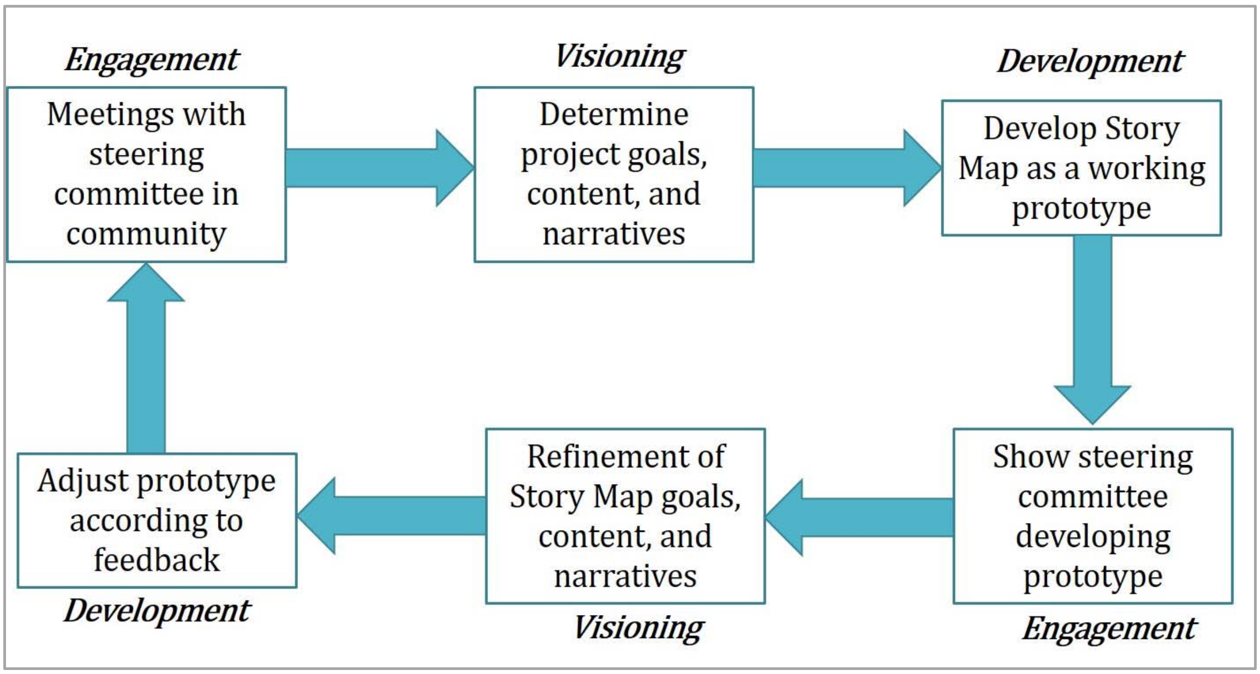

Figure 10 Community Engagement Methods Workflow

This chapter describes how my participation unfolded and shaped the choices of Web GIS technology and the narrative. In general, the focus group sessions reflected an iterative process of refining the research goals of this project during the development of the Web GIS tool from inception to deployment and evaluation. I revised the map according to the steering committee's feedback upon reviewing the story map tool in phases, rather than presenting the committee with a final version of the

Web GIS at the very end of the project. Regular interactions with the committee and immersion in the study community informed the final Web GIS story map and content. In this chapter, the programming and technology required to meet the committee's expectations in building the Web GIS components of this project are discussed, as well as the data and sources used to create the tool.

4.1 Phase One of DAAC Involvement and Project Definition

Prior to this project, there were no existing ties or relationships between myself and the Del Amo Action Committee (DAAC), nor was I connected to the organization via academic partnerships. As such, this research involved independent outreach efforts to connect with the DAAC and figure out if they were interested in participating in a mapping project for the Del Amo and Montrose sites. Initial attempts to get in touch via email with Cynthia Babich, the Director of the DAAC, were unsuccessful. In early January of 2015, I sent Ms. Babich an email with a direct proposition for a research project and received an immediate reply stating that she was interested. The first meeting for this project included Ms. Babich, Florence Gharibian, DAAC Board Chair, and myself. Both were very familiar with GIS and told me that at least three community mapping projects had been started for the Del Amo and Montrose sites, but none of these projects were finished.

Ms. Babich explained that she had created a number of hand-drawn maps throughout the duration of the cleanup. One map showed exposure pathways, drainage areas, and other patterns she noted in her community which she hand-drew and then overlayed with an aerial photo of the site. She indicated that her drawings matched the features on the aerial image, but that this map had been loaned to someone and was missing. Ms. Gharibian, a former analyst at the Department of Toxic Substances Control (DTSC), brought some of the maps created by the EPA, including a map (the same shown in Figure 7) of the groundwater contamination plumes underneath Montrose and Del Amo and the surrounding area. She explained that many of the maps used by the EPA were difficult to understand, even for people who were familiar with the cleanup sites and contamination. She also indicated that there was a lack of understanding in general about the history of the Del Amo and Montrose sites, particularly how the land use in the area underwent rapid industrial development during World War II. She said that land use maps and aerial images of the sites could be a rich visual way of communicating the historical changes that occurred at the sites.

Overall, Ms. Babich and Ms. Gharibian were open to guiding a GIS project about the Del Amo/Montrose sites, and based on the points they brought up during the meeting, an initial value proposition for this project was established: An online GIS tool would be useful to educate the public about the history of the Del Amo/Montrose Superfund sites. This proposition was used to form the initial research question for this project: Was it possible to develop a Web GIS to effectively communicate the history of the Del Amo/Montrose sites, under the oversight of the DAAC and possibly other members from the committee and/or community members?

4.1.1 Land Use Data Sources for Phase One of Web GIS Tool

The first iteration of this research indicated that the DAAC was interested in using land use maps and aerial images of the Del Amo and Montrose sites that showed historical changes in the sites prior to World War II to the present. Ms. Babich and Ms. Gharibian explained that aerial images of the sites had been used by the DAAC in the past for their own research, and that these maps were not digitized. It was unclear whether these maps could be feasibly obtained and digitized in a reasonable time frame, so other immediate options were assessed. The technical documents in the EPA websites for the Del Amo and Montrose Superfund sites were reviewed in detail to determine if aerial images were available. Remedial Investigation (RI) documents for the Del Amo Soil and NAPL operable unit (OU 1) included a PDF of aerial images of the 280-acre Del Amo site. The PDF included a series of 9 aerial images covering the entire extent of the site in 1928, 1941, 1946, 1956, 1967, 1971, 1979, 1992, and 2004. EPA (2007b) provided the document containing the imagery, but the direct source of the aerial images was not indicated in the document.

Because all documents provided by the EPA are in the public domain, it was decided that for the time being, image details derived from the URS-sourced document were sufficient for examining visual land use change at Del Amo prior to World War II through 2004. I took screenshots of the RI document and cropped each aerial image to the same dimensions. These were later used in the Web GIS tool as primary sources of imagery.

Additional sources of historical land use maps were considered due to their potential in providing a more complete and/or detailed record of land use and possible property ownership details. The following land use map sources were used in this project: Works Progress Administration (WPA) land use maps, Los Angeles County survey and tract maps, and 7.5 minute quadrangle topographic maps from the United States Geological Survey (USGS). WPA maps are useful in visualizing pre-World War II historic land uses, dating as early as 1935. These maps include color-coded land use categories for reference. Land surveys and tract maps provided by the Los Angeles County Department of Public Works are useful in determining ownership and general site details of a property parcel or tract. USGS topographic maps are more useful in assessing physical properties of an area such as elevation contours, hydrography, transportation, and historic place names.

Table 1 Imagery Data Sources for Historical Components of Web GIS Story Map

Data Type	Source	Description	Terms of Use	Project Integration/Purpose
Aerial imagery	EPA 2007b	9 aerial images of Del Amo boundary extent from year 1928-2004	Public record; Use limitations unspecified	Images clearly show industrial development of the site; Suitable for use in web visualization
Work Progress Administration Land Use Maps	The Huntington Library (Primary owner); USC Special Collections (2015)	2 sheets, one dated 1937 and the other 1953; Shows early undeveloped Del Amo property and Montrose (chemical manufacturing) in 1937; Shows the property owners for both sites in 1953 map	By permission	Detailed land use types shown for both areas in two different time periods; Provide different visual of land use development and industrialization of the area between both maps
Topographic Map	United States Geological Survey	3 maps of the Torrance 7.5 Minute quadrangle from 1924, 1951 and 1964	Public record	Overview land features over time (transportation lines, hydrography, industrial development)

4.2 Engagement with the DAAC and the EPA in the Study Community

A key aspect of this research included direct interaction with the DAAC, community members, and, incidentally, the EPA Community Involvement team and site manager for the Del Amo and Montrose Superfund sites in the study community. It was clear that meaningful correspondence and engagement with the DAAC was not ideal over email, so in late January 2015, I expressed interest in visiting the community to Ms. Babich, and was invited to attend a community outreach planning meeting with DAAC members and three employees from the EPA.

The meeting was in regards to a soil vapor intrusion study in which the EPA requested permission from residents in two community areas south of the Del Amo and Montrose sites (approximately 300 residences) to install temporary air sampling devices in the homes to test for TCE (Trichloroethylene) levels and other Volatile Organic Compounds (VOCs) (EPA 2014e). Based on recent groundwater monitoring results in a sampling well located near the corner of Kenwood Avenue and 204th Street (directly south of the Del Amo and Montrose site boundaries), the EPA and the DAAC were concerned about higher than usual TCE levels found at that well. TCE (also a type of VOC) exposure in humans can occur through direct ingestion of contaminated food or water, inhalation of TCE in the air, and dermal (skin) contact (US Department of Health and Human Services (HHS) 2009). TCE is used in hydroflurocarbon production, as a degreaser for metal parts, in both rubber production (as a solvent) and in chemical manufacturing of fungicides and pesticides, and is listed as a reasonably anticipated human carcinogen (HHS 2009).

According to Ms. Babich, the DAAC had been trying to get the EPA to perform indoor air sampling in the community for approximately four years, and the green light was given in January of 2015 for the EPA to begin the sampling. The purpose of the meeting between DAAC and the EPA at that time was to coordinate outreach efforts and touch base about permission requirements (sampling permission must be given by property owners), as well as how the sampling process worked. The EPA's primary outreach for the sampling was via mailers with information packets and permission forms to the owners of the properties within the sampling boundaries. According to the DAAC, the EPA did not target outreach mailers to residents (rather than property owners) in the community, many of whom rent their properties. This ultimately posed a problem because many residents were not informed about the sampling, which took place in late February and early March.

It appeared that the EPA and the DAAC worked together for mutual benefit; perhaps both groups recognized that they needed each other to make the sampling process successful. The DAAC, having direct ties to the residents as the main community group, could assist the EPA by explaining for example, where Spanish-speaking residents lived, which homes were built on concrete slabs, which residents were likely to be cooperative (and those that might not), etc. The importance of local expert knowledge on behalf of the DAAC was clear in this situation, particularly during the door-to-door outreach efforts that followed. In late February, I was allowed to walk around the neighborhood with Ms. Babich and EPA employees. We approached homes that had not yet agreed to the sampling, needed to make appointments for installing the sampling devices, or needed to provide signatures from the property owners for permission.

All of these experiences were invaluable to the process because they allowed me to observe the activities of the EPA and the DAAC, get a sense of the dynamic between these groups, and provided first-hand perspective and sense of the community as a researcher. Perhaps equally important was the context in which these interactions occurred. Over two decades after contamination from the Del Amo and Montrose sites was recognized with the discovery of DDT in soils in yards on 204th Street, the possible threat of exposure to an entirely different contaminant was being addressed along this same residential street.

4.3 Establishment of Web GIS Story Map and Platform

While engaging in outreach activities in the study community with the DAAC and the EPA, Ms. Babich introduced me to Cynthia Medina, a core member of the DAAC and a current resident in the community. It is important to note that many community members, like Ms. Babich and Ms. Gharibian remain active in the cleanups even though they no longer live in the neighborhood. A brief but productive discussion between Ms. Medina, Ms. Babich, and myself resulted in the definition of the Web GIS tool based on what I offered to them as options for either a Public Participation GIS (PPGIS) in which community members contribute to map content in an online environment, or a Web GIS Story Map, which could be a platform to communicate the story of the Del Amo and Montrose sites using web maps and mixed media. A PPGIS was ruled out immediately by both Ms. Babich and Ms. Medina, who explained that a similar project had been attempted years ago but never finished, and that ultimately a real-time PPGIS was not something that the community was likely to engage in. Ms. Medina noted that most of the people who remained in the community for the duration of the cleanups were older residents whose perspectives might be better captured in interviews. Something that had not been done, Ms. Babich noted, was a community history project. So, a Story Map that could explain the history of the Superfund cleanups using maps, images, videos, and oral histories or testimonies from current community residents would be a much better fit.

Based on this direction, a review of existing online story map platforms narrowed down two potential options: Esri's Story Maps (2015), available with an ArcGIS Online license and StoryMap JS (2015), an open source option geared towards journalists. These were the two options considered because they are the two leading platforms dedicated to the integration of web map content and multimedia for the development of presentation-style map narratives. The StoryMap JS platform is the open source alternative to Esri's proprietary Story Maps, and while the cost associated with future ownership of the Web GIS story map by the DAAC was certainly a factor to consider, the StoryMap JS was too limited in its capacity as an interactive GIS since it relies on either map images, or geotagged photos which are incorporated as map markers in the story map. By contrast, Esri's Story Maps product is far more flexible in terms of web map services integration, customization, user interaction, and the ability to create "map actions," which allow users to click on an action link within a section of text causing the map can zoom to a certain extent, popup, or reveal a new layer. Overall, better functionality, customization, and user interactivity were considered in the decision to use Esri's Story Maps.

4.4 Development of Web GIS Story Map Prototype in a Test Environment

For the purpose of showing the DAAC a working example of the Web GIS story map and to collect feedback from them, a basic prototype was created which incorporated a simple web map showing the boundaries of the Montrose and Del Amo Superfund sites, the aerial images of the Del Amo site, a WPA land use map from 1937 showing the two sites, a YouTube video created by the EPA about the Del Amo site cleanup, and a web map showing a sample groundwater plume. In this early stage in the development, the map content was based on the Superfund site boundaries and was created within ArcGIS Online using the Map Notes function to draw general polygons representing the sites and general plume shape. This was because the GIS/map components had not yet been established for the tool, so a simple preview of web map capabilities was offered in the first prototype to show the DAAC that map features and user interaction was possible within the story platform. The images were saved to a Picasa album and shared publicly as uniform record locators (URLs) to source within the application. The YouTube video was simply added to the application by referencing the video's URL.

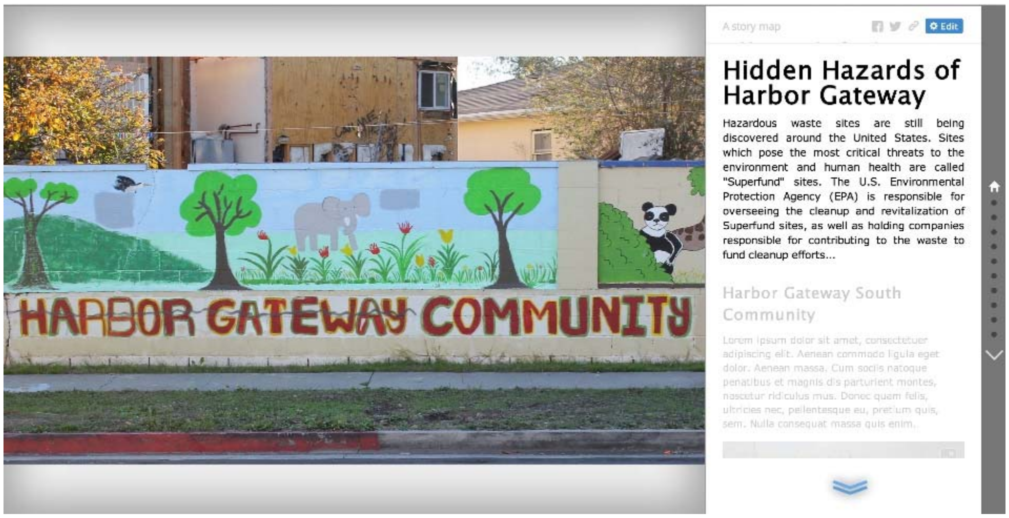

Figure 11 Story Map Prototype Introduction Page

Figure 12 Web Map Integration in Story Map Prototype

The web story map prototype was developed in an organizational ArcGIS Online account but was not shared publicly. This was done to protect the prototype from incidental viewing prior to its deployment, and also in order to encourage opportunities for the DAAC to provide feedback and reactions in person. (In other words, keeping the application private ensured that reviewing of the tool would be done in a focus-group setting, rather than through informal, email/virtual exchange.)

4.5 Feedback of Prototype from DAAC and Establishment of Major Narrative Threads

The feedback from the DAAC based on the story map prototype resulted in a number of decisions and helped to push the project forward significantly. First, the official steering committee for the project was confirmed to include Ms. Babich, Ms. Gharibian, and Ms. Medina. Second, the major narrative components were discussed and outlined (See Table 2). Third, Ms. Medina's granddaughter, Savannah, who lives in the study community and was present at the planning meeting, agreed to collect interviews from residents which could be videotaped or recorded, and then added to the story map. The steering committee believed it was important to represent the community youth in the story, and Savannah's involvement in gathering the testimonies placed her in a participatory role in the project. To this end, the steering committee decided that the story map should be called "Savannah's Story," in order to refocus the intent of the tool as an envisioning of the young generation that has grown up next to the Superfund sites. Fourth, arrangements were made for me to visit Ms. Babich's home and gather materials, maps, images, and other components, which I would incorporate into the story map.

Table 2 Narrative Categories and Content for Web GIS Story Map

Story Categories	Description	Associated Content
Introduction	Introduce Savannah's Story, the two Superfund sites, legacy of pollution, purpose of the story map	Image or collage representing the community
Background Information	Background of Superfund, description of the Del Amo and Montrose sites,	-Steps of Superfund cleanup process (links, text, or image) -Overview map of the Del Amo and Montrose sites
Historical Information	Del Amo and Montrose site histories, Activities and manufacturing at the sites, Industrial development of the area during World War II	-Web maps of historic site structures during operation of Del Amo and Montrose plants -Aerial imagery of Del Amo before and after the war -WPA land use map -Newspaper clips from 1943 edition of Torrance Herald
Contamination	Description of contaminants, Exposure pathways, Discovery of contamination, EPA involvement and site studies, investigations, etc.	-Web map showing where contamination was first found by residents -Hand drawn maps (images) of contamination and suspected fill material areas -Web map showing operable units
Relocation	Relocation story resulting in buyout and demolition of 53 homes south of the Del Amo Waste Pits	-Aerial imagery before and after demolition -Hand drawn map of homes in relocation zone -Park plans for future land use of demolished area
Kenwood Removal	EPA removal action of DDT in yards along historic drainage area along Kenwood Avenue	-Web map showing removal area with photo popups historical drains, creeks
Community Involvement (Recurring Narrative)	Perspective of community	-Resident testimonies (written, audio, video) -Images of community activities and demonstrations -Community rally (video)
Del Amo Action Committee (Recurring Narrative)	Perspective of DAAC	-DAAC testimonies

4.6 Programming and Technology Workflow for GIS Components of Savannah's Story

The development of the GIS components of this project occurred in tandem with conceptual development of the qualitative (mixed media) pieces of the story map, as well as immersive research of documents provided by the DAAC. This section deals specifically with the programming and technology workflow included in the development of the GIS components used to create and publish the web maps incorporated into the tool, as well as the data and sources.

ArcGIS Online was the primary platform used to develop the web components of the Story map, which included the story map web application itself, web map services developed in ArcMap 10.2 and published to ArcGIS Online, customized web map applications, and other web maps created directly in ArcGIS Online. Due to full integration of ArcGIS Online publication services within the ArcMap 10.2 software platform, all web services were deployed without the use of an additional hosting server. This eliminated the need for backend development of web content on a remote server, which in turn saved a great deal of time by speeding up the process of analyzing and publishing services locally. It was also beneficial in the organization, management, and customization of web GIS content since all of it was accessed directly in ArcGIS Online (through a browser). It should be noted however that other content (images, videos, documents, etc.) had to be hosted separately, and there was not an immediate solution to this during the development of the tool. A discussion of how the mixed method components were managed and hosted is discussed in the qualitative content workflow section of this chapter.

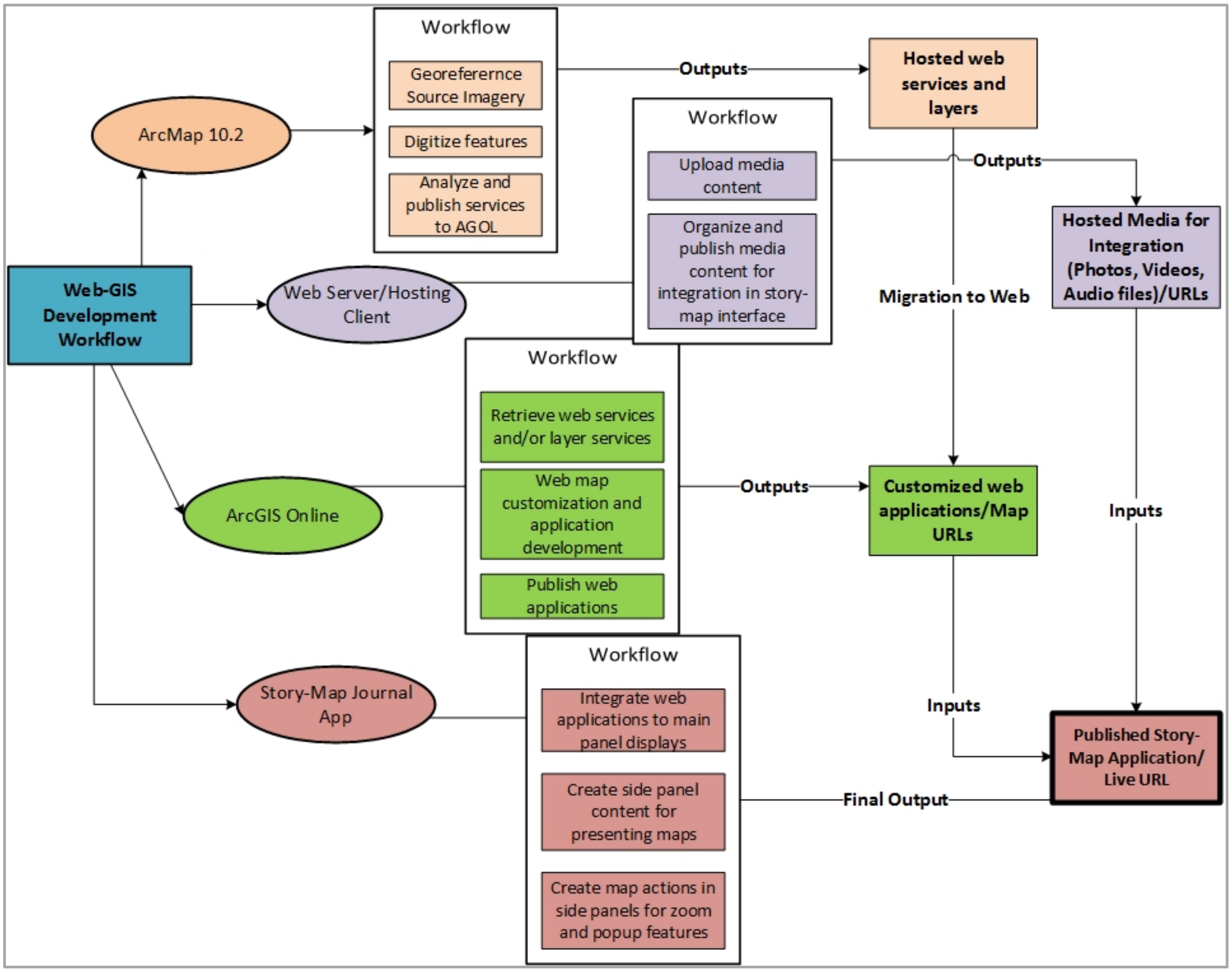

Figure 13 Programming Workflow for Story Map

Nearly all content published to ArcGIS Online from ArcMap was created by georeferencing map images collected from technical documents found in the EPA websites for the Del Amo and Montrose Superfund sites, or from a small collection of map images submitted from the DAAC, and then digitizing features and adding attribute data. A file geodatabase structure with feature classes was used to reflect the (spatial) categorical threads of the narratives (shown in Table 2 as communicated by the steering committee). For instance, a file geodatabase was created for historical pipelines and buildings at the Del Amo site, pipelines and buildings were created as feature classes and digitized from the georeferenced images. An imagery or topographic basemap from Esri was primarily used as the reference image while georeferencing EPA maps. The source maps often included existing building structures; thus, building outlines were used most often for placement of control points.

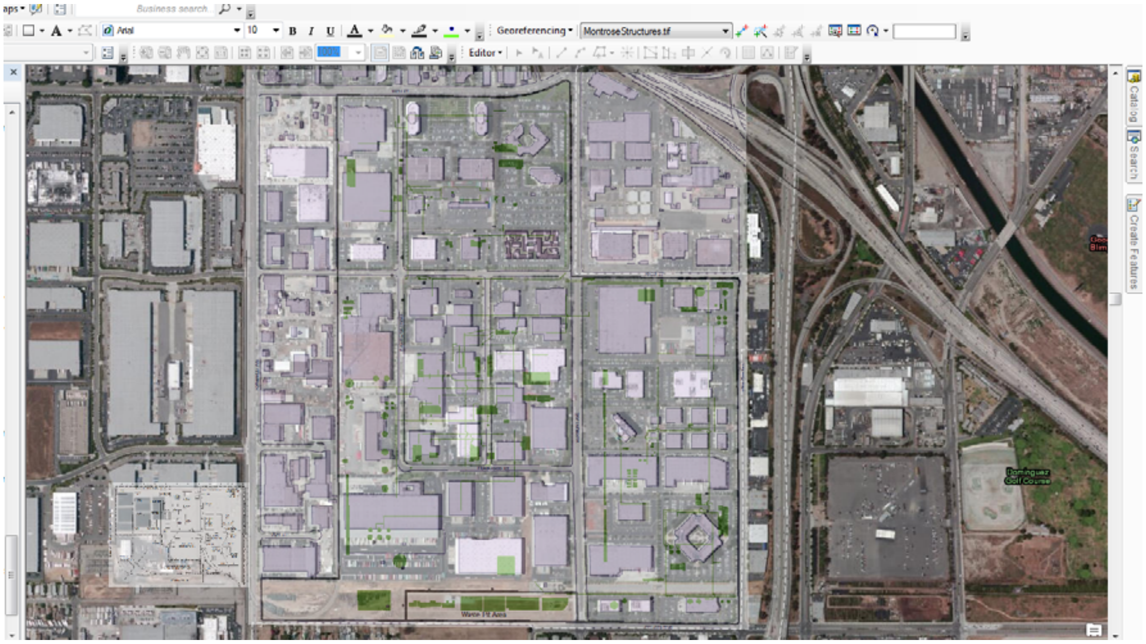

Figure 14 Georeferenced TIFFS of Del Amo Historical Structures (EPA 2007d)

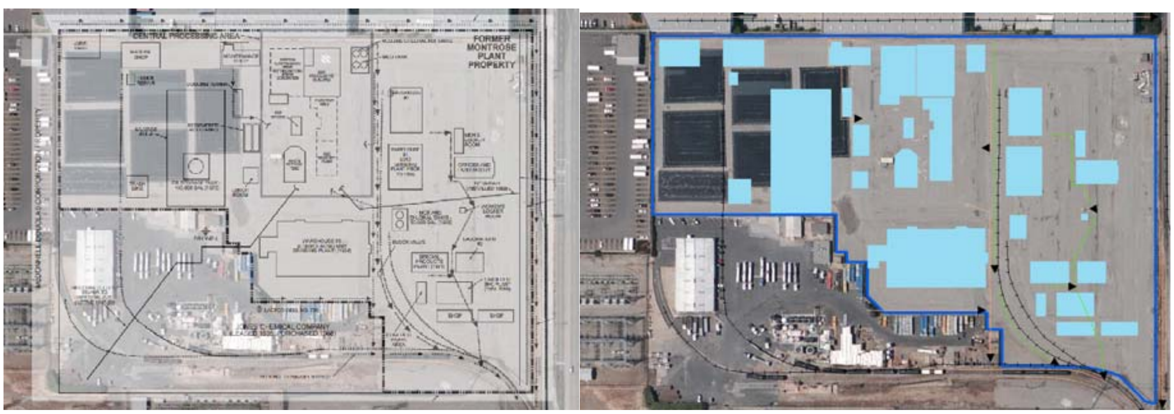

Figure 15 Georeferenced and Digitized Structures for Montrose (EPA 1999c)

The Del Amo and Montrose site boundaries were established by georeferencing EPA site maps, and these boundaries were further validated by using a shapefile of Los Angeles County building outlines provided by LA County Enterprise GIS (LAR-IAC 2012). Other GIS content for the Del Amo and Montrose sites was created in ArcMap 10.2 by georeferencing and digitizing EPA maps.

The Story Map includes a map showing current Superfund sites in California to put the Del Amo and Montrose sites into a broader context. The data source for this map included the EPA Region IX Superfund site website to verify the names of the Superfund sites, the date each site was listed on the NPL, and whether these sites were still active (meaning that site remediation was still ongoing). After the sites were checked, the DTSC's EnviroStor hazardous cleanup sites database (2007) was used to project the general location of each California Superfund site based on latitude and longitude fields provided for each site. The metadata did not include information regarding how these coordinates were derived. Sites such as facilities (like the Del Amo and Montrose sites) were projected and displayed within their boundaries. The San Fernando Valley Area 1 site (5,254 acres in area) was projected in a residential neighborhood between North Hollywood and Sun Valley. It is acknowledged that coordinate pairs are crude representations of the actual spatial extents of cleanup sites, but for general reference purposes these data are sufficient in an overview map. All of the GIS maps and their associated content/layers, data sources, and methods are listed in the sequence they appear in the Story Map tool in Table 3, below.

Table 3 Map Content, Sources, and Methods for Story Map Development

Map	Associated Content/Layers	Source(s)	Methods
Superfund Sites in California	Point features of site locations with name and NPL date listing	EPA Region IX Superfund website; DTSC EnviroStor database (2007) (CSV file)	Data compiled and formatted in Excel, projected points from lat/long in ArcMap
Overview Map/Savannah's Community	Polygon features for the Del Amo, Montrose sites, and Savannah's community (study area)	EPA site maps (TIFF images); Los Angeles County Enterprise GIS building footprints shapefile (2012); Esri Streets basemap	Georeferenced and digitized Superfund boundaries in geodatabase; Used street information to create community boundary feature class
Del Amo Site Historic Structures and Pipelines	Polygon features of historic structures Line features of historic pipelines	EPA (2007c) site maps of historic structures (TIFF images)	Georeferenced, digitized, and added attribute information in geodatabase feature classes
Montrose Site Historic Structures	Polygon features of historic structures Line features of rail lines, open drainage lines, and pipelines	EPA (1999c) site map of historic structures (TIFF images)	Georeferenced, digitized, and added attribute information in geodatabase feature classes
Contamination Plume Map	Polygon features of plumes, Del Amo, Montrose, and community boundaries	EPA (2013c) schematic plume map of TCE, benzene, and chlorobenzene plumes occurring in the water table unit (TIFF image)	Georeferenced, digitized, and added attribute information in geodatabase feature classes
Groundwater Remedy Infrastructure Map	Point features of injection and extraction wells; Line features for underground remedy pipelines; Polygon features of Del Amo and Montrose boundaries	EPA (2013a) groundwater remedy infrastructure map (TIFF image)	Georeferenced and digitized features in geodatabase

The process of integrating each of the maps and content created in ArcMap 10.2 to ArcGIS Online included sharing the maps as web services directly from the software interface, configuring each for feature access and cache building, adding metadata (descriptions, data sources, keywords, and access use constraints), and analyzing the map for errors. These maps were then published to an ArcGIS Online organizational account after which they were formatted, published within the organization as either web maps or web applications, and incorporated into the Story Map application. The Story Map, titled "Savannah's Story: Learning from the Past, Working Towards a Clean Future" was published after all content (web maps, images, videos, and audio clips) was integrated and shared in the public domain, and a web survey was created and embedded within the tool for users to review and evaluate the tool.

4.7 Integration of Qualitative/Mixed Media Components

The qualitative/mixed media components of the Story Map included images (aerial site photos, land use maps, hand drawn maps from the community, photos from the community, and photos from the web), videos (two YouTube videos from DAAC, transferred from VHS tapes), audio clips (2 interviews uploaded to Sound Cloud) and external links to documents and websites. All of the images (with the exception of those referenced from external URLs) were uploaded to a Picasa web album and shared as public images. A dedicated Gmail account was created called (DAACwebcontent@gmail.com) where the Picasa image folder was saved and a YouTube channel was created. This was done so that in the future, the mixed media content could be accessed by the DAAC if needed. Images in the Picasa album were also shared directly to Ms. Babich via Dropbox.

The process involved in incorporating the mixed media components was based on the same iterative process used for the GIS/map components, which relied on the regular feedback from the DAAC on what materials they wanted to add to the story map during its development in the test environment. The DAAC contributed a large amount of content directly. Most of the photos, the hand drawn maps, a few aerial wall maps that were photographed, some documents, and the video and audio content were given to me to scan, digitize, and/or transfer to the web as needed.

Most of these materials were integrated into the story map towards the end of the development/test phase. At this point, a great deal of development and customization of the web maps and story (text) content had been done on my end, but the tool needed to be closely reviewed and verified by the DAAC. Ultimately, Ms. Babich and I spent about six hours carefully looking through each piece of the story map. During this process, Ms. Babich edited many of the text/narration panels, and contributed all of the information in the “Contamination Discovered” story section. We determined that an additional video and some documents needed to be included, as well as more photos of the community members and youth. Ms. Babich shared a Dropbox folder with over 100 photos, mainly focusing on the youth activities and community events that occurred since 2000. These photos were instrumental in capturing the youth narrative of the Story Map, as well as a community park visioning ceremony. All of this new content was then added to the Web GIS story map and sections were arranged accordingly. The story map was published and shared publicly in late April of 2015. Ms. Babich circulated the Story Map to a handful of individuals, including an employee at the DTSC who provided detailed feedback used for the evaluation component of this project. This feedback (and other feedback from a current resident of the community and an individual who had no prior knowledge of the Del Amo and Montrose sites) is reviewed in Chapter 5 below.

CHAPTER 5: RESULTS

This chapter describes the structure of the Web GIS story map to provide an overview of how the web maps and mixed media were incorporated into the application. In addition, this section presents a few of the key story sections in the tool, a brief summary of the narrative thread associated with each, and a discussion of the associated user functionalities/interactive components. Lastly, this chapter presents the feedback gathered from individuals who reviewed the Web GIS story map. The feedback was provided by individuals with three unique perspectives: 1) A current resident in the study community; 2) An employee at the DTSC; and 3) An adult individual who was not familiar with the Del Amo and Montrose cleanups prior to reviewing the story map.

The next five sections present a few of the significant story panel sections included in the Story Map, their associated narratives, and the user functions and interactive capabilities available for each panel. Six panels (are shown in these sections, but the remaining sections can be viewed in the Appendix portion of this document.

5.1 Savannah's Community and the Del Amo and Montrose Sites

As seen in Figure 16, the third section panel in the story map introduces the Del Amo and Montrose Superfund sites in reference to Savannah's community, all three areas shown by their relative boundaries and proximity to each other. This section is intended to put all three areas into a geographic context in order for users to consider two important aspects of the story overall. First, this map clearly shows that the two Superfund sites are directly adjacent to each other, and second, that a residential community (Savannah's community) is located immediately south of the sites. A description of the community is provided in the side panel, along with an image of a fenced Superfund site (the Iron Horse Park site in Massachusetts). Below the image are four blue "action links" in bullet point form. When the user clicks on one of these, the map extent, location, and pop-up information adjusts according to the action configuration created for the link. So, when the user clicks the first link, "Click to zoom to the Del Amo Superfund site," the map zooms in closer to the Del Amo boundary, and a pop-up is revealed with some basic information about the site, and a photo of the site (see Figure 17). The remaining action links take the user to the Montrose site, Savannah's community, and Exxon Mobil refinery. The purpose of including the Exxon site was to show its proximity (just 1.5 miles west) to the Del Amo and Montrose sites, and Savannah's community.

Figure 16 Savannah's Community and Superfund Boundaries Story Map Section

Figure 17 Result of Clicking on Action Link for Del Amo Site

5.2 Historic Structures and Pipelines at the Del Amo Site

As part of the history of the Del Amo and Montrose sites, the EPA published site documents containing detailed maps showing former building outlines that existed at Del Amo and Montrose sites during the time they were in operation. The former structures and pipelines from both sites have either been removed or demolished (EPA 2011a), but they remain significant sources of data because they informed much of the soil sampling locations based on contamination that may have resulted from site processes associated with certain structures. For instance, hexavalent chromium was used as an anti-corrosive agent in cooling processes, so soils around the former cooling tower locations on the Del Amo site were tested specifically for this chemical (US EPA 2001). Historical building information has also been used heavily in site investigations, particularly for modeling potential exposure source areas in preliminary site assessments as well as providing an overall blueprint for how the sites operated (in terms of their processing and manufacturing flows, treatment and storage, and modes of disposing waste).

Figure 18 shows the Del Amo site historical structures and pipelines, as they were digitized from one of the EPA maps. The subtle light grey canvas basemap was chosen to highlight the structures, but the existing building outlines are still clearly visible. (It should be noted again, that almost all of the Del Amo site has been redeveloped as an industrial park, consisting of approximately 250 businesses, so the contrast of historic structures overlayed with existing businesses was an intentional framing of the location of the former rubber plant buildings in reference to the existing buildings on the site.) The structures themselves are color coded according to whether they were part of the styrene, butadiene or copolymer plants, or the Waste Pits area. The action links in the side panel direct the user to the each portion of the plant, and they can click on any of the structures to reveal a popup window showing the name of the former structure (such as Cooling Tower 3, Sump Tank, Blowdown Pit, etc.). A photo from the Torrance Herald in 1944 of the rubber manufacturing process was incorporated in the side panel between two sections of text, and shows the various factories, their location, and what materials were piped to the Del Amo facility.

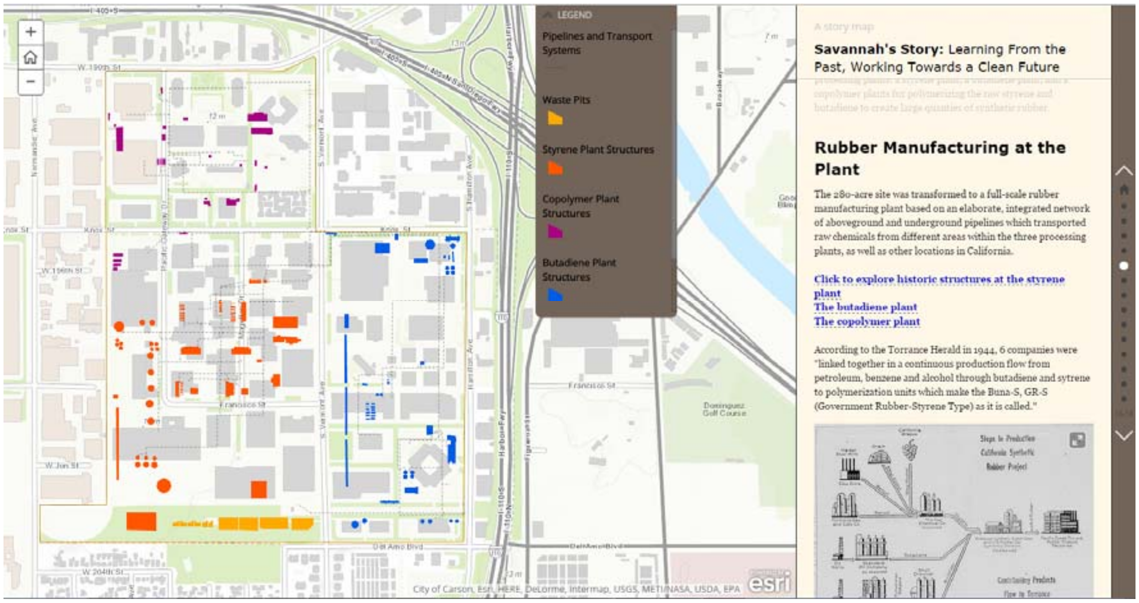

Figure 18 Del Amo Site Historical Structures and Pipelines Web Map

5.3 Permanent Relocation of Residents and Buyout

In 1994 the EPA conducted soil samples in residential homes directly south of the Del Amo waste pits as part of an ongoing Remedial Investigation/Feasibility Study. Results of 1994 soil studies on two residential backyards on the north side of West 204th Street did not show any contaminants related to the Del Amo site (such as benzene, styrene, naphthalene, ethylene, and others). However, bowling-ball sized chunks of 100 % technical grade DDT were discovered in these yards, (Peterson 1998) including that of Ms. Babich, who lived at 1055 West 204th Street (this address and home no longer exist). According to Ms. Babich, the 1994 discovery of DDT in her backyard and the home next to hers triggered community-wide concerns that the DDT contamination was not isolated to those two yards, and that backyard soil sampling was needed for many more homes. The DDT discovery in the first two backyards (adjacent to the waste pits) could not be attributed to the Del Amo site since Del Amo did not manufacture DDT at any time during its operations, nor could its presence in the soils be linked directly to disposal of the pesticide from Montrose. According to ATSDR (2004), the contaminated soil was thought to have been taken from the Montrose site and subsequently used as fill material during construction of the homes.

Upon the discovery of DDT in Ms. Babich's yard and her neighbor's yard, the EPA conducted the first DDT excavation in 1994 and included only Ms. Babich and her neighbor's soil (ATSDR 2004). Ms. Babich was present during the excavation and watched the soil being removed from her yard. Subsequent sampling of other backyards along West 204th Street determined that DDT was present in varying concentrations in these soils. Also in 1994, the EPA determined that a large-scale DDT removal action for approximately 30 residential yards on West 204th Street was necessary, at which point the families were temporarily relocated while EPA excavated the soils. Temporary relocation is not uncommon in circumstances where removal activities could expose residents to contaminants released during the removal actions. In general, temporary relocation of residents lasts for the duration of the removal action, and responsible parties or the EPA fund the relocation costs incurred during this time. If EPA funds the relocation (which was the case for the 204th Street removal in lieu of a responsible party), it helps to complete removal actions within a reasonable time frame of about 2-3 weeks (US EPA 2001). However, in this case the temporary relocation of the families lasted four years, from 1994 to 1997 (Peterson 1998).

During the start of the temporary relocation period in 1994, the Del Amo Action Committee (DAAC) was formed primarily to address community health issues in the neighborhood, but also to serve as a representative body for the residents of the community. The DAAC, led by Ms. Babich as executive director and several other residents from the community, lobbied for support from the EPA, DTSC, ATSDR, and Department of Health Services. The DAAC also engaged news outlets and reporters, toxicologists, universities, and political figures to address health concerns, the contamination, and plans for the permanent relocation of the residents in the relocation zone. Congresswoman Jane Harmon (D-Torrance) and Elliot Laws, Assistant Administrator of the EPA for Solid Waste and Emergency Response in Washington, D.C., met with the DAAC in July of 1994 to discuss the community's concerns in person and take a walking tour of the neighborhood. Part of the Story Map includes video footage from this meeting, and the walking tour. Residents of the community placed signs on their fences and garage doors that read: "I bought the American Dream: Pure DDT," "How much proof do you need??" and "I do not want my children to become part of your statistics." The footage was taken in the relocation area (which is now a 10-acre, fenced plot of patchy grass) and also shows the waste pits, which were visible at that time through a chain link fence.

Ultimately, the four-year temporary relocation of the 30 residents was prolonged due to a number of factors, but chief among these was the push for permanent relocation of these residents and a buyout of their homes within the relocation zone. In 1996, during the time of the relocation negotiations (which occurred between various stakeholders including Shell and Dow, EPA, DAAC, private consultants, property appraisers, the Army Corps. Of Engineers, and others), the EPA had only conducted 14 permanent relocations in the history of Superfund (US EPA 1996). Relocation tactics were not considered viable remedial actions per Superfund practices, but in 1996 the EPA recognized that permanent relocation may be necessary in extreme cases where human health could not be protected, or where engineering issues made structures unsafe for people to live in (US EPA 1996). In May of 1996, a Superfund Relocation Roundtable Meeting was held in Pensacola, Florida at the request of the EPA to gather stakeholders, community members, and other representatives to discuss the issue of permanent relocation in Superfund and how communities and the EPA might work together to shape an interim policy addressing a complex and costly process. Ms. Babich spoke of the current state of the Del Amo community, on behalf of the relocated families living for 2 years in hotels waiting to be told where to go, and the residents that remained in the community.

The Roundtable Session in Pensacola did not solve the problems for the Del Amo community. However, it did spark a dialogue about an issue of vital importance for communities seeking fair alternatives to living and raising children in an area that could pose health risks, or may be uninhabitable. The Del Amo permanent relocation was ultimately achieved via a convening of EPA, community stakeholders, Shell, Dow, DAAC, and others to compile a private buyout package. The package included the demolition of homes in the relocation zone, buyout of properties by Shell, and a robust permanent relocation plan to assist and support the relocated residents in finding a new (permanent) place to live. Shell, although they were not responsible for the DDT contamination that kicked off the whole series of events, funded the buyout and demolition of the homes (Peterson 1998). According to Peterson (1998), the buyout program was considered as a potential model for other communities to adopt in hazardous waste conflicts around the U.S. The demolition was completed in 1997, and under the buyout agreement, Shell and Dow were given the rights to decide on the ultimate land use for the buyout area, but a community advisory panel was appointed to guide in the decision (Peterson 1998). In May, 2015, 18 years after the demolition, the 10-acre plot is undeveloped, covered with soil and grass, and surrounded by chain link fence.

Figure 19 shows a map of the community with the homes included in the buyout colored in red. This map was used in addition to aerial color images of the buyout zone before and after the homes were demolished. In terms of communicating the impact of relocation in this community, the aerial before and after photos offer compelling visualizations of the transformed land, but the hand-made map in Figure 19 (contributed by Ms. Babich) speaks more to the fabric of the community. The colored-in footprints are records of homes included in the buyout, (like an inventory) but they are also the footprints of families, foundations, and memories. Overall, the relocation component of the Story Map affords multiple spatial renderings and considerations of an event that included not only the transformation of the built environment (the homes as well as the contaminated land underneath them), but also the transformation of relocated residents and those that remained in the neighborhood. In addition, the future land use of the empty plot of land remains in question.

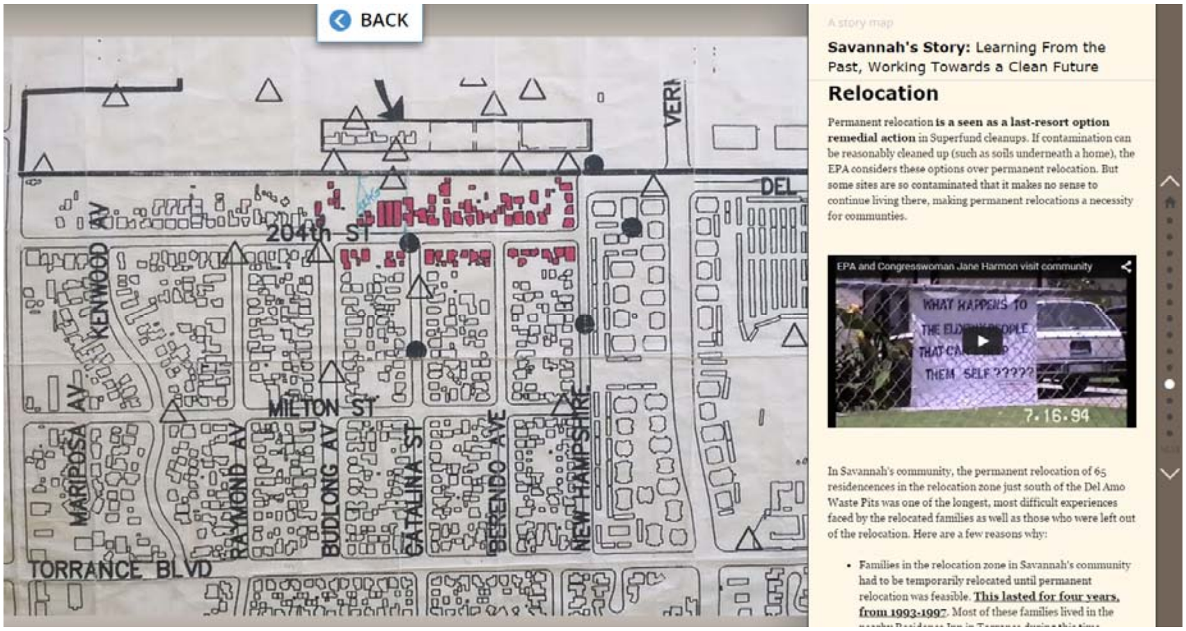

Figure 19 Paper Map of Del Amo Community Buyout Homes

5.4 Dual Site Groundwater Contamination and Treatment

The Del Amo and Montrose dual-site groundwater contamination section of the story map was included to allow users to visualize the spatial extent of the TCE, chlorobenzene, benzene, and Technical Impracticability (TI) waiver zone (also coincident with the containment zone). A description of the contaminants (and which facility or area they are believed to have originated from), their general characteristics and uses, and any cancer/health risks associated with them is described in the side panel section. It was also important to note in the side panel text that this map only represents the extent of these plumes as they occur in the shallower Upper Bellflower Aquitard (water table zone). The deeper groundwater plumes are actually much larger than those shown in Figure 20, which were digitized from an EPA map (EPA 2013c). The shallow groundwater plumes in the Upper Bellflower unit are a concern for soil vapor intrusion (TCE and other VOCs entering indoor residential air via small openings and/or cracks in the home's foundation).

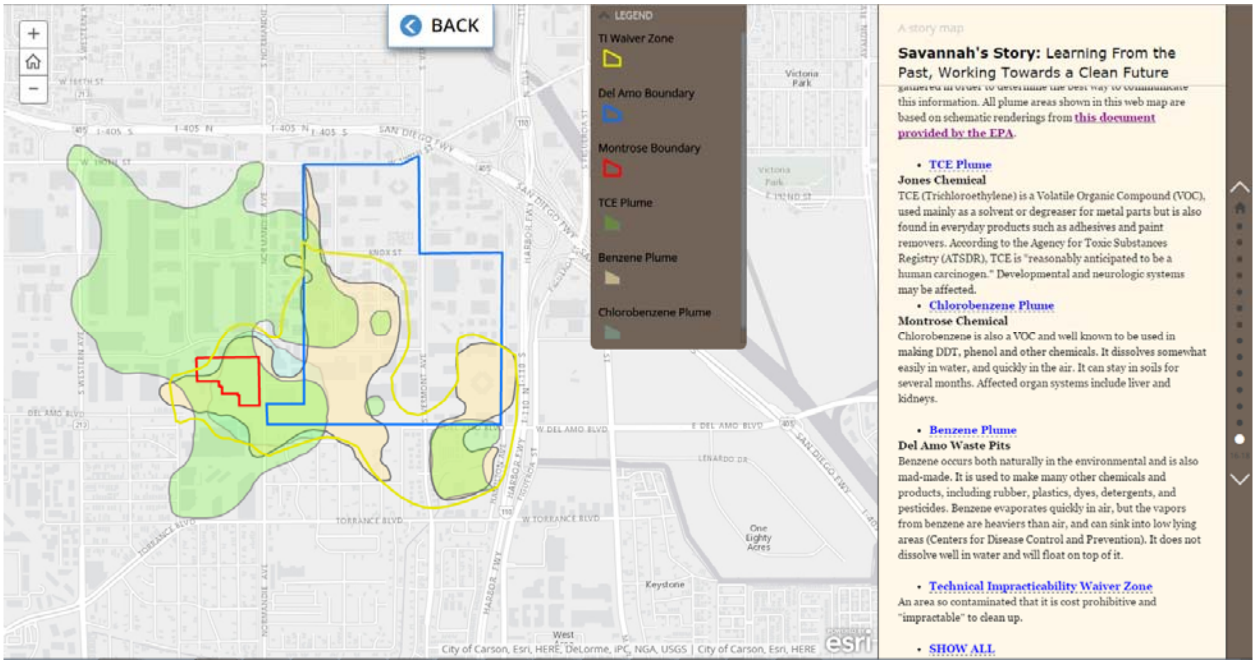

Figure 20 Groundwater Contamination Plume Web Map

A disclaimer was added to this section due to the limitations of this map to show the entire scope of the groundwater contamination plumes as they exist as different spatial extents within one or more hydrostratigraphic units. The disclaimer acknowledged that additional input and feedback from the community, the EPA, and other agencies such as the DTSC and RWQCB are needed in order to best represent the groundwater contamination such that data are not oversimplified. This is important to address because the groundwater remedy treatment system, which was constructed to pump, treat, and reinject treated groundwater back into the containment zone, is an ongoing topic of controversy. There are concerns from the community that para-Chlorobenzene sulfonic acid (pCBSA), a byproduct of DDT manufacturing (OEHHA 2015) and a present contaminant in the groundwater, will be reinjected back into the groundwater based on drinking water standards that may not be protective of human health. According to a recent report on pCBSA, a new baseline reinjection standard of 3 parts per million (ppm) for pCBSA in drinking water is recommended, which is much less than the 25 ppm standard established 15 years ago (OEHHA 2015). It is possible that pCBSA will be reinjected at 25 ppm, as established in the

1999 ROD, rather than the new 3 ppm standard. Specifically, there is concern that untreated pCBSA could migrate to the deeper drinking water aquifers if the less conservative reinjection standard is used.

This issue is not easily fixed. The remedial action plans established in the ROD (Record of Decision) are to be honored according to Superfund law and the NCP, which means that regardless of when the remedy was finalized and how much time has passed in the interim construction period, the objectives of the ROD must be followed. So, even if there are significant improvements in remedial technologies since the ROD was published, the original remedy plan and design will be used. Additionally, in light of new data and/or understanding of contaminants (such as the new reinjection standard for pCBSA), a remedy is still expected to operate within the terms and reinjection standards of the ROD. What this means in terms of the groundwater remedy treatment system is that if turned on, it is possible that pCBSA will be reinjected at the 25 ppm standard specified in the 1999 ROD, potentially affecting the protectiveness of the remedy. More specifically, a former community member posed a question during a November 8th, 2014 public meeting with the EPA. Ms. Gharibian asked, "[…] will [pCBSA] be removed sufficiently? Because the water that's treated in that groundwater treatment unit will ultimately go into the clean portion of our groundwater basin, and I see this as something we need to be very careful about" (EPA 2014d).

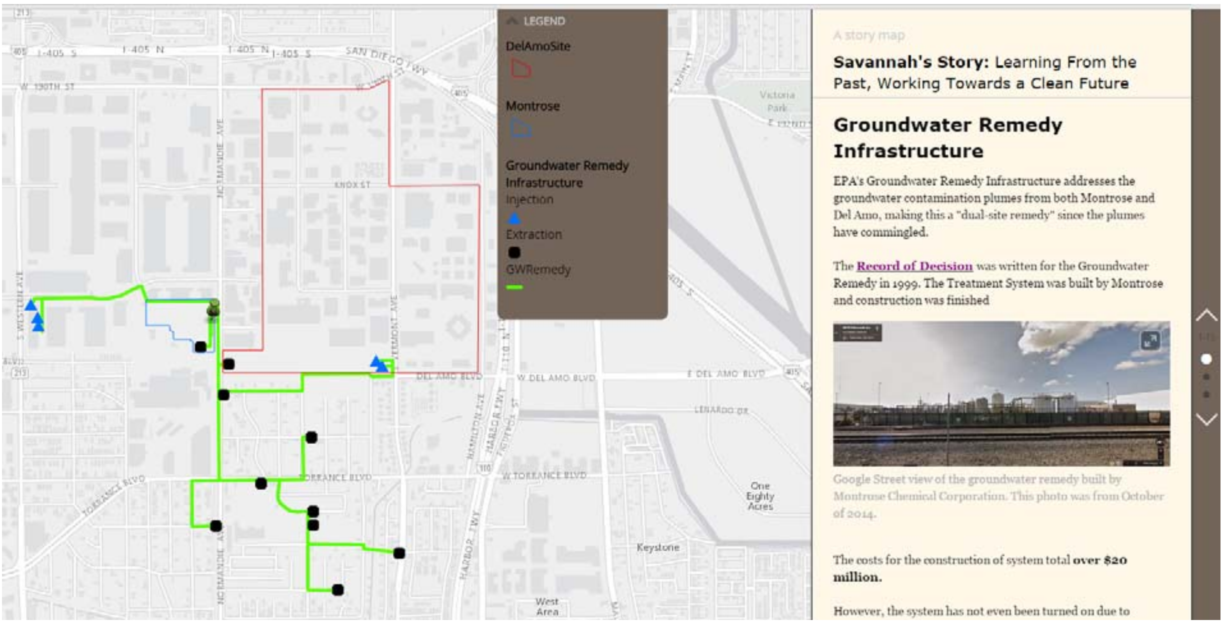

Figure 21 Groundwater Treatment Infrastructure Web Map

In February 2015, Montrose issued a Notice of Dispute to the United States and DTSC over the fact that the EPA has not allowed the groundwater treatment system to be turned on based on concerns raised by a citizen regarding the pCBSA reinjection standard (United States v. Montrose Chemical Corporation 2015). Montrose argues that by not allowing the system to be turned on, the EPA is in violation of the agreements laid out in the 1999 ROD (United States v. Montrose Chemical Corporation 2015). Specifically, Montrose states that:

> Under the Construction Partial Consent Decree, EPA's authority to modify the Statement of Work Plan or Work Plan (which includes the Test Plan) is limited to "ensur[ing] that the treatment system for the Chlorobenzene Plume as constructed will effectively implement the relevant elements of the remedy set forth in the ROD." Because EPA's proposed modification of the Test Plan does not seek to implement the remedy specified in the ROD, and instead seeks to determine whether the treatment system could achieve a pCBSA reinjection standard that differs from the ROD standard, the proposed modification conflicts with the ROD and the Construction Partial Consent Decree, and therefore is impermissible. (United States v. Montrose Chemical Corporation 2015, 1)

This is perhaps one of the most compelling aspects of the groundwater dispute and citizen influence in general (according to Montrose). To the extent that Montrose is accurate in attributing the Test Plan modification (and ultimately EPA's prohibiting the system from being turned on) to one citizen is not as important as what this might mean in the broader context of citizen involvement in Superfund. Environmental activists like the Del Amo Action Committee (and other organizations that are invested in representing communities impacted by hazardous site contamination) are often portrayed as action-oriented or even militant. But looking at the Del Amo/Montrose story in the long-view, much of what the DAAC and other community members have done might be best described as "community-informed *in*action." In other words, next steps might include stepping back and making a careful assessment of the implications of the remedy's implementation if the pCBSA reinjection issue is not adequately addressed. For the Story Map, the groundwater treatment system infrastructure is shown as built in a Web map so that users can visualize the intricate, $20 million, 15-year construction project. The accompanying text in the side panel explains how the EPA and the community have prohibited Montrose from turning on the system, establishing the current quandary in the cleanup process.

5.5 The Future of Savannah's Community

The concluding panel of the Story Map focuses on the youth living in the community as a way of impressing the overall narrative takeaway when the viewer reaches the end of the story. Focusing on Savannah's generation of 17 to 18-year olds who were born in the community, this section is comprised of pictures of youth from the community, and an embedded interview sound clip where Savannah interviews one her friends, Elizabeth, about what she thinks of her community and how she envisions the future. Youth in Savannah's generation face a crossroads in their lives revolving around whether they will go to college, move away, get jobs outside the community after completing high school, or return to the community to continue the struggle, The interview highlights the role of the cleanup effort in such critical decisions. The interview is brief but leaves a bleak impression of the state of the community. Elizabeth describes a community that doesn't care, people who have been unkind during door-to-door outreach efforts, and an environment that is unsafe and polluted. Her concluding statement is that people should leave the community because it is unsafe for them and their families.

5.6 Feedback from Story Map Reviewers

For the purpose of evaluating the Story Map, feedback was gathered from a small group of individuals who represent unique perspectives that may be useful in understanding different user experiences and takeaways. This method of evaluation is based on a reputational approach, whereby individuals were chosen based on criteria that distinguishes them from each other, and that also defines them within a broader user cohort. First, a current resident of the community evaluated the Story Map to provide an assessment of the tool from an insider perspective. This resident was aware of and involved in the Superfund cleanups, but was not part of the project's steering committee. Second, an employee from the DTSC was asked to evaluate the Story Map because of their perspective as a government representative involved in the cleanup sites. The DTSC participant may also provide specific feedback regarding the accuracy of the GIS components of the story as well as how the scientific information was represented (and the extent to which this information was also accurate). Third, a person was approached who does not live in California and had no knowledge of the cleanup sites prior to viewing the map. This participant could potentially offer a unique perspective regarding the story's effectiveness in explaining the story and engaging an outsider who has no stake in the community.

5.6.1 Current Community Resident Feedback

The feedback received from the current resident of the community, Scott Hookey (2015) included a short list of bullet points in response to some mechanical (spelling) errors, with two points that specifically spoke to the story map content. First, Hookey (2015) suggested that more depth be given to the epidemiological facts regarding the toxins mentioned in the story map. He wrote, "If you had more space, you could briefly explain the epidemiology of some of the toxins. (E.g., TCE is linked to birth defects in a woman's third trimester). As it validates why this is a topic of importance. I would look at page 122 of the 2004 ATSDR report. It is on the Del Amo EPA site […]" (Hookey 2015). Second, Hookey (2015) made note of the Superfund site map of California in the second panel, but suggested adding more information in the popup content: “I really like the interactive map of the Superfund sites in California on the NPL. For me, it would be cool to see their contamination site score, as it provides something to compare the scope of contamination. Just an idea.” Overall, the takeaways from the current resident perspective was that more specific health-related outcomes associated with exposure to toxins or COCs from the sites might better justify their inclusion in the story map, or at least attribute more information as to why these toxins are concerning. Similarly with the Superfund site map, Hookey (2015) indicated that the hazard ranking score would be a useful way of understanding the relative risks of one site in comparison to another.

5.6.2 DTSC Employee Feedback

Lee (2015) referred to her general impressions of the Story Map, then provided more specific suggestions for representing the groundwater contamination plumes and how the groundwater remedy treatment system is intended to work to reduce the contamination. Lee (2015) also addressed the issue of pCBSA (this was noted in the story map as a contaminant that is not included in the groundwater plume visualization/map because more feedback from the community, EPA, and other agencies was necessary to adequately represent this component).

Lee (2015) called the tool “effective […] for helping people who aren’t involved in the cleanup understand what happened and what is happening. I also thought it could provide a better understanding of the experience of nearby residents for regulators, especially for those who haven’t been involved since [the] beginning. The tone makes it approachable.”

Next, she went into a more focused discussion about the limitations of (and potential for) visualizing how the groundwater remedy is intended to interact with and treat the contamination plumes, as well as how pCBSA might be represented in the Story Map platform. Lee (2015) explained, “I think the tool would be more helpful if the graphical interface allowed for a better representation of what the remedy is and how it’s supposed to work (showing plume migration and the way the pumping is intended to counteract that and move the constituents).” She addressed the pCBSA with a similar recommendation:

“The discussion of [the] pCBSA issue could be enhanced by graphically showing the re-injection, the rate at which the volume of pCBSA would be reinjected, and the expected rate of migration of the pCBSA after reinjection” (Lee 2015). She concluded with a suggestion to represent the case for turning on the system, rather than representing only the perspective of those in the community who believe it will do more harm than good. Specifically, she wrote. “…It would be helpful to mention that others believe the remedy is needed to reduce the potential harm from the other constituents in the groundwater; and it might help people to understand that we (“we” meant broadly here) are trying to find a way to address both needs as quickly as we can” (Lee 2015).

5.6.3 External Evaluator Feedback

Two separate feedback responses were provided by the adult respondent with no knowledge of the Del Amo or Montrose cleanups. The first feedback response included a list of mechanical errors (spelling and syntax) within the story map text, as well as a few navigation issues and user-end experience problems. Among these, Friend (2015) mentioned display issues as she was not able to view all of the content in the Story Map side panel due to overflow. She also noted that the back button option in the main stage did not appear in some of the story panels when action links were clicked. Friend (2015) also referred to Savannah’s presence: “I can see that Savannah is a real person […] I don’t know why Savannah is significant – did she get sick?”

In Friend’s (2015) second wave of feedback, specific questions were raised that spoke specifically to the “so what?” question appropriate for any research project. She asked:

> How can [this tool] help me, as an outsider, connect my heart to these strangers? What makes them different from any angry mob that I see on TV? How are they not just looking for a reason to get someone else to pay for them to get out of their poverty- stricken neighborhood? (Questions possibly asked by calloused, cynical Americans who are tired of ambulance-chasing attorneys)...Is there a way to somehow connect the dots between the horrible facts of how the land was greatly contaminated, and the fact that these are real people who are suffering real consequences as a result of someone else’s negligence and apathy? (Friend 2015)

5.7 Summary and Synthesis of Feedback

The mechanical and syntax errors in the text portions of the Story Map were mentioned by two respondents and were the easiest to correct. The feedback from the current resident respondent included adding more information to the contaminant section for clarification of toxin exposure effects. A more comprehensive revisiting of how contamination risk for COCs should be approached is worth another conversation with the DAAC, particularly because a great deal of exposure information is disputed. This component of the Story Map should be carefully considered for accuracy of content, consistency of the type of information provided, and a more formal review of the authoritative sources to pool this information from, given that health agencies (and the EPA) have different risk and exposure thresholds (even carcinogen classification) associated with chemicals.

The addition of the hazard ranking score (HRS) is a viable change that can be made to the Superfund site feature layer in ArcGIS. At first consideration of this change/addition to the Superfund site feature class popup, it was assumed that the new field could only be created in ArcMap and then republished as a new map service. But there is a way to edit attribute tables directly in ArcGIS Online for a feature layer, so this component would not involve having to edit and republish the feature class from ArcMap.

Lee (2015) from the DTSC engaged the most challenging (as previously acknowledged) aspects and possible limitations of the Story Map as it was published as a GIS visualization tool. She spoke to a number of components that specifically engage the representations (Web maps) that are key in understanding the complexity of the groundwater cleanup. These issues are addressed in more detail in the following chapter, as they are better suited within a discussion for future work.

Friend (2015) (the individual with no knowledge of the Del Amo and Montrose cleanups) made note of a number of end-user issues, some of which may be improved on the development side, but others that appear to be user-specific. That some of the content was not visible in more than one browser is concerning, and this could be investigated by testing the tool on multiple computers to determine if some formatting can be done to prevent content overflow/display issues. The back button issue appears to be an internal application setting that might not be easily fixed without working within a customizable template. Friend's (2015) note about Savannah, although this was mentioned in the end-user experience context, brought up questions about whether Savannah truly has a meaningful presence in the Story Map. This aspect is being revisited in discussions with the DAAC and Savannah with regard to how her role can be better distinguished, or if an alternative title/focus should replace the theme entirely. Friend's (2015) last few comments which questioned the extent to which the Story Map was able to connect the contamination with a real community of people is discussed in the following chapter, as this feedback specifically addresses one of the major goals of this project, which was to engage users in an issue they may not be familiar with but could connect to.

CHAPTER 6: DISCUSSION AND CONCLUSION

In light of the feedback provided by the three participants, it was concluded that a reassessment of the Story Map's overall goals and target audience was necessary to guide the further revision and refinement of the tool. Moving forward, the Story Map may be more useful in encouraging a dialogue among the diverse group of stakeholders who are involved in the Del Amo and Montrose cleanups. Specifically, this chapter reflects on three key considerations for revising the Story Map: 1) Relevancy of the technology/tool to provide meaningful visualizations; 2) Effectiveness of the technology/tool within a Critical GIS framework to be understood, evaluated, and discussed by non-users and users of GIS alike; and 3) The extent to which the Story Map may better serve an internal audience of stakeholders, and how this may direct the development of the groundwater treatment Web GIS component of the tool to facilitate a dialogue about the most pressing issues facing the Del Amo and Montrose cleanups to date.

6.1 Considerations for Dynamic Web GIS Visualizations

The information provided by Lee (2015) spoke to the larger theme engaged earlier in this research, which cited the value of Critical GIS scholarship (Schuurman 2006; Kwan and Ding 2008; Wilson 2015) in insisting that geospatial technologies be more robust in their ability to be translated and understood by a wider audience, ultimately offering an equal playing field which can affect change (Wilson 2015). Lee (2015) recognized the potential value of the Story Map for regulators to understand the community's perspective, but also cited the potential for the tool to engage the GIS components in a more meaningful way. Specifically, she suggested the tool might better illustrate how the groundwater treatment system is intended to work in reducing the plumes and how this might play out in a visual graphic depicting flow direction, plume movement, reduction of different contaminants, etc. She imagines an animated model of how the remedy is intended to interact with and treat the different plumes.

This form of visualization, while first requiring a much better understanding of how the system is intended to operate, plume concentrations and their occurrence in hydrostratigraphic units, etc., deserves careful consideration of the programming and technology options. It might also require visual representation of uncertainty given the complexity of the groundwater resource and unknown effectiveness of the technologies. Further development of this component of the Story Map may provide a more active visualization tool for non-experts and experts alike, something to replace the static PowerPoint diagrams and plume maps shown in a dimly lit presentation room, as an interactive representation of a system that has been debated primarily in theoretical terms.

Two potential concepts were considered for developing a dynamic groundwater treatment visualization. The first concept considers whether a more robust Web application designed to work with the action link function in the story map could achieve this visualization (in terms of depicting movement, direction, and volume). One major limitation of this concept is that it doesn't address the visualization of the hydrostratigraphic units, which may be better served as a 3-D rendering. Another issue is that this visualization would depend on the user's engagement of the action links; it could not exist as a tool that might automatically "play" like a video. The second concept for this visualization considers a 3-D model of the groundwater plumes, the remedy infrastructure, and a cross section of hydrostratigraphic units created in a cube structure in ArcScene. The interaction of all three components could be captured as a video, with voice-over narration. Two anticipated limitations of the 3-D model-to-video rendering is whether it is robust enough to depict movement and direction, and that there does not seem to be much user engagement or interaction.

Overall, the evaluator's comments regarding the limitations of the Web GIS visualizations as they were presented in the Story Map may actually point to a potential within the tool to refocus the geospatial components. One major limitation of the project was the lack of raw spatial datasets to incorporate in the Web maps, as most of the data were digitized from existing EPA maps. The evaluator's response speaks to two potential qualities of the Story Map: its capacity to exist beyond this research, as well as its potential to make the geospatial elements more relevant to the cleanups. Interestingly, this potential outcome of the Story Map brings up even more notions of what constitutes the "participatory" in participatory Web or PPGIS. If there is an interest on behalf of regulators to contribute data and inform the Web maps in the tool, this opens up a new channel for participation, one that invites contributions from different groups to capture and communicate a very complex issue. What distinguishes the Story Map (in general) from other forms of Web PPGIS systems intended to capture, encode, and represent spatial scenarios or aggregate results of a consensus mapping project is that the Story Map is open-ended, or unfinished. Just like any story, the ones who are qualified to tell it are also the ones likely to share in its retelling; in this case, the Story Map is not a closed forum, but a staging ground for further discussions and future versions.

6.2 Reassessment of Story Map Target Audience

Friend (2015) questioned the tool's ability to connect the contamination to a real community of people. She posed an important question that other "detached" viewers or users of the tool might ask, which essentially speaks to the "So what, or why should I care?" question of any research. In this case, Friend (2015) recognized that this story may be redundant, echoing other examples of disenfranchised communities living near toxic waste sites. But to return to her actual question regarding the efficacy of the story overall, it seems that if the intention of the tool was to actively draw together the history of the contamination and its living legacy within a community of real people, the respondent is questioning a fundamental objective of the Story Map. In recognizing that there may be a flaw in the conceptual design of the Story Map such that users who are not familiar with the cleanups must stretch to connect the contamination, personally and emotionally, perhaps, with a group of real people. This may be an indication that the tool would be more useful for those who are familiar with or invested in the Del Amo and Montrose cleanups.

Friend's (2015) question about Savannah's purpose is understood as a limitation within the narrative framework to define her presence and role in a consistent manner throughout the Story Map, particularly if Savannah is the central mechanism for engaging an otherwise detached audience. Savannah's inconsistent presence in the Story Map also speaks to the broader narrative objective of the project posed by the steering committee, which was to stress the importance of the local neighborhood youth as the natural heirs to the DAA legacy of community activism, as well as the inheritors of the remaining contamination and decades of cleanup ahead. But if Savannah and Elizabeth (the only youth included in the Story Map) intend to carry the DAAC commitment forward, this is not communicated in the narrative. That said, the extent to which the tool promotes a lasting impression of the value of community activism, it does not do so through Savannah, Elizabeth, or the youth overall. This is not to discount the impact of Elizabeth's interview at the end of the Story Map in its candid and honest reflection of her community and the future. But community advocacy and youth empowerment are not gleaned from the concluding story panel.

That said, the Story Map was recognized by Lee (2015) as being a potential resource for regulators to understand the community and the DAAC, particularly if they are all sitting around the same table at stakeholder meetings. This supports the idea that a community Story Map has inherent value to regulators who care about the role of communities in site cleanups. Ms. Babich expressed a few times during this project that she feels she has to retell the community's story every time to any new personnel, analyst, consultant, or EPA employee who joins the Del Amo/Montrose cleanup team. Referring new stakeholders to the Story Map may be a way to avoid a lengthy explanation and introduction the community history and perspective. So, the Story Map's value as a community tool may be targeted to individuals who are newcomers to the project and should know the important role of the DAAC in the cleanups.

6.3 Conclusion

The feasibility of remediating the Del Amo and Montrose contamination within a reasonable time frame might seem like an insurmountable feat. To imagine achieving such a goal means recognizing that Superfund, as robust as it may be for enforcing cleanup standards and securing CERCLA provisions under Federal law, is not a cure-all for environmental hazards and disputes. Instead it is bolstered by creative solutions and strategies posed by unique minds around a meeting table. The Story Map may be an alternative setting that encourages dialogue among different groups who are invested in the same problem. It may also be a starting point for developing multiple scenarios and spatial visualizations of the intended goals of a cleanup activity or remedy, as well as a brainstorming tool for figuring out how to represent contested boundaries in Superfund cleanups.

For Del Amo and Montrose, these might include the boundaries of the groundwater plumes at all hydrostratigraphic levels, the future land use of the 10-acre buyout zone (now a fenced plot of patchy grass that sits like a question mark in the community), and the groundwater treatment system and its intended process if it was turned on. They might also include the storm water pathway from Montrose to the former Kenwood Ditch, and the DDT in the bodies of white croaker fish, along the Palos Verdes Shelf, and on the Pacific Ocean floor. Such are the troubled boundaries and spatial scales of contamination from Del Amo and Montrose, and the narratives that necessarily shaped them.

The EPA (under the agency's strongly publicized Community Involvement initiative) must create the spaces and opportunities for communication, participation, and knowledge- sharing for citizens affected by Superfund cleanups. Such spaces and opportunities may be particular critical in situations where a lack of community involvement is impeding the cleanup process. But overall, and particularly for the Del Amo/Montrose, communities will become involved and more informed because of their direct experiences living in a contaminated area. As such, their de facto involvement in the cleanup process defines their role as stakeholders, not as lay citizens situated among scientific professionals. All stakeholders have unique perspectives, skill sets, information, and ways of approaching problems and envisioning solutions. These contributions are of great value, but not so much if one group insists on facilitating and defining the spaces where participation and involvement are meaningful. Again, to return to the role of GIS, the map may function as a natural facilitator of discussion. Therefore, a community-engaged Story Map might be a conceptual vehicle to balance power in stakeholder discussions. Assuming that each stakeholder has a valuable perspective to share, the story maps might resemble chapters of a much larger book that include the technical and authoritative maps drawn by consultants and the EPA itself, rather than competing narratives.

To shift to a recent work of Critical GIS by Wilson (2015) on the opportunities for GIS, or simply "mapping," to inform the drawing of boundary lines, he states: "Across many of these developments has been a particular theory of action – which might also be called practice – wherein a difference is made and the world is intervened." (2). This may also be another form of spatial interrogation, and whether it is done in a GIS, in the field, with a pencil and paper, in an online environment, or a conference room, the act of grappling with and composing new and innovative ways of representing space and imagining future spaces is not just a job for GIS professionals, but for everyone. Web GIS technologies have been underutilized in Superfund site cleanups, and the Story Map in this project is presented as a historical record, a community mouthpiece, and a mechanism for tapping the potential to engage a dialogue between multiple stakeholders and create a staging area for developing more meaningful representations of spatial information, environmental processes, and visualizations of future scenarios and intended cleanup outcomes. This project demonstrates the effectiveness of spatial narratives for bringing relevancy to the current state of long-term Superfund cleanups through an understanding of the past. The role of Critical GIS in creating relevant avenues for critique was instrumental to the process of developing the tool on behalf of the community, as well as establishing long-term functional goals for the tool beyond the scope of this study.

What began as a community-engaged research project ended in the same context, it just became a much larger community. What this research process has shown is that those who are truly invested in an issue are necessarily part of a solution community. It is in no one's best interest to remain fixated on the dynamics between groups that set them apart, such as pitting citizen knowledge and expert knowledge against each other (Carver et al. 2000). Formidable knowledge gaps recognized in the Superfund cleanups and any other complex problem are opportunities to build bridges, and this is the kind of practice that must affect change. As seen in the case study of a complex Superfund site clean up in this study, the Story Map technology may well play a critical role in such social processes in the future.

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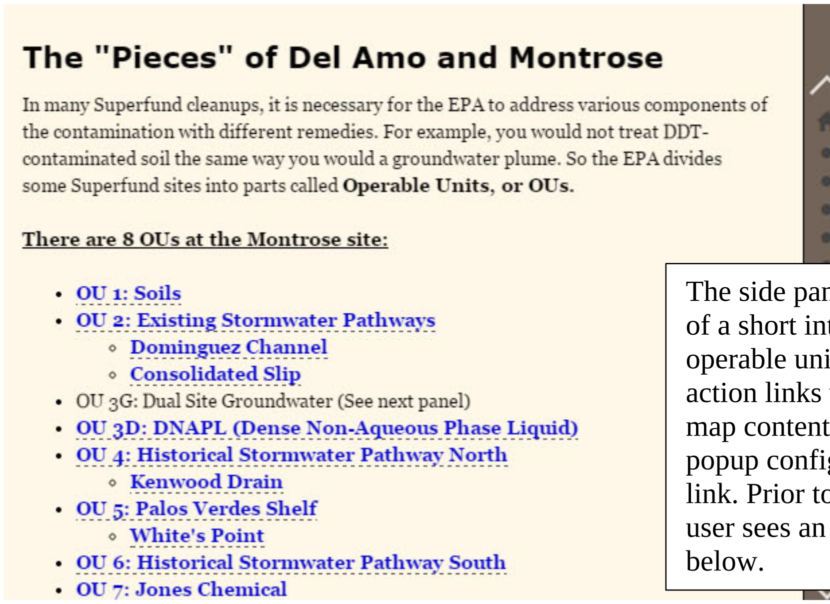
APPENDIX A: User Functionality Illustration of Operable Units in Story Map

The graphics and annotations provided in this appendix are intended to illustrate some of the dynamic aspects of the Story Map which allow the user to explore the Web map application content using the interactive action link function. The Del Amo and Montrose Operable Units Web map was incorporated into the Story Map after the original version was published. The purpose of this section is to show how the action links transform the map content, extent, and popup configurations in a workflow that enables the user to visualize and interact with the operable units included in the Del Amo and Montrose sites.

Figure 22 Web map of Del Amo and Montrose Operable Units

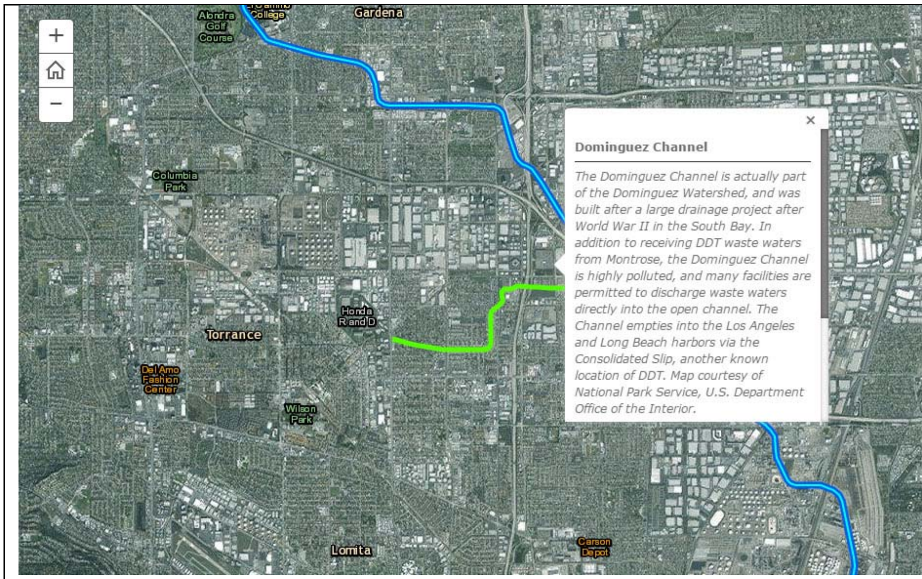


The side panel (left graphic) consists of a short introduction to the operable units, and the blue links are action links which engage the web map content, spatial extent, and popup configuration for each OU link. Prior to clicking the links, the user sees an overview map, shown below.

Figure 23 Side panel with Action Links for Operable Units in Story Map

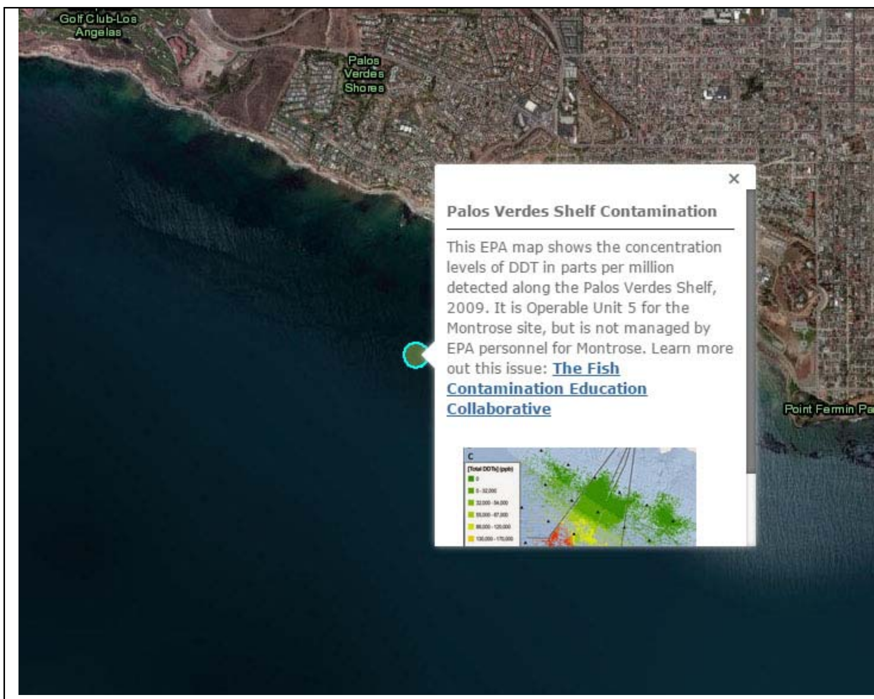
User clicks on "OU 2: Existing Stormwater Pathways action link, map extent changes to show the Torrance Lateral and a popup window with more information

Figure 24 Map Action for Montrose OU 2



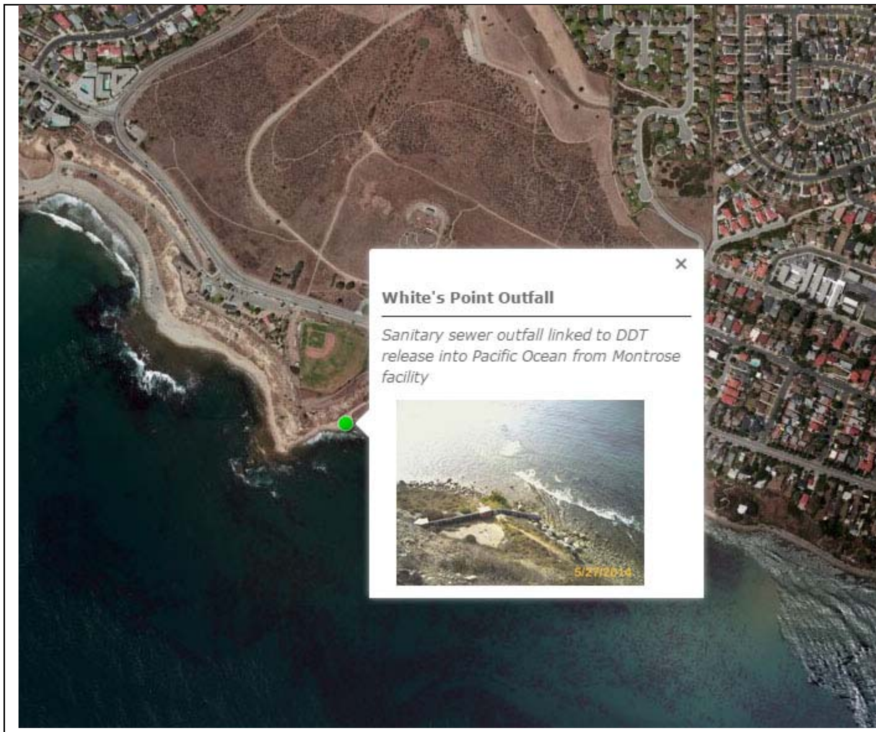
User clicks on action sub-link, Dominguez Channel and map extent zooms out to show where the Torrance Lateral and Dominguez Channel meet, with popup content showing more information and linked photo of Los Angeles Watershed Map

Figure 25 Map Action for Dominguez Channel and Torrance Lateral



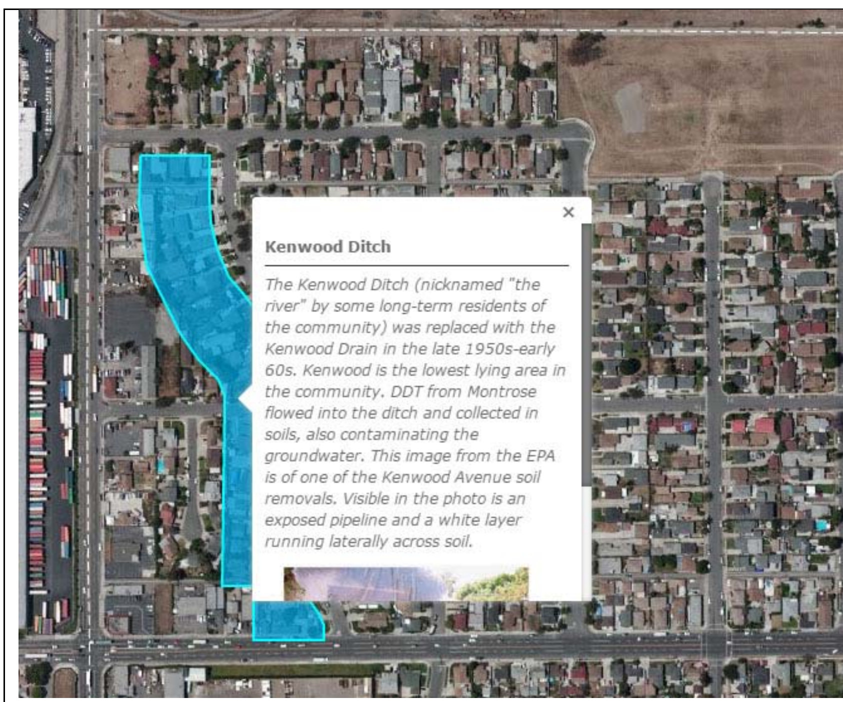
User clicks on OU 5, Palos Verdes Shelf action link, map extent changes to show general area of contamination in Pacific Ocean, with a link to The Fish Contamination Education Collaborative and a map image from the EPA showing DDT concentration along the Palos Verdes Shelf

Figure 26 Map Action for the Palos Verdes Shelf



User clicks on action link for White's Point to see where the DDT storm waters entered the ocean via the sanitary sewer outfall

Figure 27 Map Action for White's Point Outfall



User clicks OU 4: Historical Storm water pathway north, and the map extent shifts to the community to reveal the approximate boundary of the historic Kenwood Ditch. A popup window explains the significance of the Kenwood Ditch, which received DDT waste waters from the Montrose facility. An image from the EPA is show of a yard on being excavated on Kenwood.

Figure 28 Map Action for the Historic Kenwood Ditch

	When the user clicks the sub-link under OU 4, the Kenwood Drain layer is shown. The Kenwood Drain was built in the 1950s to replace the Kenwood Ditch. An image of storm drain construction plans for Kenwood Avenue is provided in the popup window, from the Los Angeles County Flood Control District, 1968.

Figure 29 Map Action for Kenwood Drain and Historic Ditch Overlay