Synapse
Energy Economics, Inc.

The Real Costs of Cleaning Up Nuclear Waste:
A Full Cost Accounting of Cleanup Options for the West Valley Nuclear Waste Site

November, 2008

AUTHORS

Alice Napoleon, Jeremy Fisher, PhD, and William Steinhurst, PhD of Synapse Energy Economics

Professor Michael Wilson, PhD of SUNY Fredonia

Frank Ackerman, PhD of the Global Development and Environment Institute at Tufts University

Marvin Resnikoff, PhD and Emily Brown of Radioactive Waste Management Associates

22 Pearl Street
Cambridge, MA 02139

www.synapse-energy.com
617.661.3248

Acknowledgements

This study was funded by grants from the New York State Legislature, thanks to the sponsorship of Senator Catharine Young (R - Olean). The grants were administered by the NYS Department of Environmental Conservation.

Thanks to the following individuals for reviewing the study: Stephen Lester, Science Director and Anne Rabe, BE SAFE Campaign Coordinator, Center for Health, Environment & Justice; Barbara Warren, Executive Director, Citizens' Environmental Coalition; Judith Einach, Director and Joanne Hameister, Steering Committee Chair, Coalition on West Valley Nuclear Wastes; and Diane D'Arrigo, Radioactive Waste Project Director, Nuclear Information and Resource Service.

For more information on the West Valley site, contact the following organizations:

Center for Health, Environment & Justice, Anne Rabe, 518-732-4538, annerabe@msn.com

Citizens' Environmental Coalition, Barbara Warren, 518-462-5527 X13, warrenba@msn.com

Coalition on West Valley Nuclear Wastes, Judy Einach, 716-316-5839, jeinach@yahoo.com

Nuclear Information & Resource Service, Diane D'Arrigo, 301-270-6477 X16, dianed@nirs.org

Table of Contents

Executive Summary

Thirty miles south of Buffalo, New York, the West Valley nuclear waste disposal site sits on a plateau slowly but certainly eroding away with time. In the 1960's, when the site was first procured and Nuclear Fuel Services was granted a contract to begin reprocessing nuclear fuels, the potential dangers were rapidly outweighed by the rampant enthusiasm for nuclear reprocessing infrastructure and the economic prosperity it promised. After nearly a half century, there is no doubt that this decision was a mistake for the region's safety and health. The six years in which this facility reprocessed nuclear fuel have been dramatically overshadowed by over two decades of fierce debate and impasse about the cleanup of the site and implications for the next decade, century, millennium, and untold years beyond.

The West Valley site holds vast stores of complex and toxic radioactive wastes, many of which will remain toxic for tens of thousands of years, some for millions of years[1]. Packaged in canisters, drums, cardboard boxes, and plastic bags, the list of contaminated wastes reads like a laundry list of dangerous elements: strontium-90, cesium-137, plutonium-238, -239, -240, and -241, uranium-238, curium-244, cobalt-60, americium-241, iodine-129, tritium, and thorium-234, amongst others.[2] These elements, if ingested or inhaled, lodge in human tissues, fat, or bone and are known to be responsible for leukemias and cancers at very low doses. There is no known safe level of exposure to radioactive chemicals—each exposure increases the likelihood that cancer and other health effects may occur.

Over the last two decades, a variety of federal and state agencies and national and local public interest groups have debated in the public, legislature, and court how to resolve a critical dilemma: the wastes at West Valley are not safe in their current configuration over short or long periods of time, but remediating the site will be expensive. To work towards a resolution, the Department of Energy (DOE), in consultation with New York State agencies, created a series of Draft Environmental Impact Statements (DEIS), the latest of which was released for internal agency review in 2005 (2005 draft DEIS). Although there is no recommendation given in the last DEIS, the document seemed to imply that leaving the bulk of the waste in the ground was an expedient and cost-effective way of remediating the site. DOE is in the process of revising the document and will be issuing a new DEIS in the near future.

Synapse was asked to evaluate and audit two of the cleanup Alternatives

---

[1] The half-lives of radionuclides buried at the West Valley site range from a few hours (i.e. rhodium-106) to 14,050,000,000 years or over 14 billion years (i.e. thorium-232). The decay rate for each radioactive isotope is known as a *half-life,* and each radionuclide has an individual half-life. A half-life is the amount of time it takes for one-half of the radioactive atoms to decay or transform into another element. For instance, in two half-lives one-fourth of the original radioactive atoms would remain, and so on.

[2] See Section 4 and Appendix B for details.

presented in the 2005 draft DEIS, working only from the DEIS and publicly available information.[3]

Full Cost Accounting Study

This study evaluated two cleanup Alternatives presented in the DEIS:

- Waste Excavation Alternative 1: Total exhumation of the wastes, off-site disposal, followed by complete site release for unrestricted use; and
- Buried Waste Alternative 2: Partial waste removal, stabilization of buried wastes for permanent onsite disposal.

The time period of analysis used in the DEIS was insufficient to determine the full cost of Buried Waste Alternative 2. In Waste Excavation Alternative 1, as soon as closure activities cease—in an estimated 73 years—the site is released to the public and there are no remaining costs. In Buried Waste Alternative 2 however, the site must be maintained into perpetuity. *In this case, perpetuity is not a dozen years, or even two or three generations—the radioactive waste buried at West Valley would have to be monitored, tracked, and maintained in place for tens of thousands of years. Despite this basic axiom, the DEIS only allocates a skeleton budget for 200 years.*

The total costs of this analysis must be taken as a whole, undiscounted cost. In standard capital investments, a discount rate is applied to account for future interest earnings. Over periods of 1000 years, any substantial discount rate implies that the health and wellbeing of future generations has no present value (i.e. no worth to us today). Since the plans being considered are ostensibly meant to protect the public for many generations, we cannot reasonably assume that there is no value to public heath in the year 1000. Therefore, the discount rate must be zero, or near zero. While the choice of a discount rate for short term decisions is an economic question, the choice of an intergenerational discount rate is a matter of ethics and policy.

As a practical necessity, we are compelled to use a precautionary approach at West Valley. We cannot know the costs which may occur if wastes are left buried at West Valley, but we do know if a release occurred, it would have expensive and disastrous consequences. The costs of exhuming radioactive contamination will be expensive in the short-term, but the costs of maintaining buried waste in an attempt to thwart future disaster will be far more expensive and far less certain. In a precautionary sense, we should excavate and move the wastes while we still know what is in the ground, how to handle it, and have some chain of responsibility still available.

[3] NYSERDA was willing and able to help answer some questions in late 2007, but a Freedom of Information request for analytical background data was denied by the DOE in early 2008.

Critical Analysis of DOE Cleanup Cost Estimates

In this study, we show the following analysis results.

1. The Department of Energy's DEIS analysis of Alternatives 1 and 2 are unrealistic, and, more importantly, incomplete. The DEIS uses a period of analysis far too short to reflect real costs and risks, and does not adequately address real harm risks as well as monetary costs to the public and the environment. The Buried Waste Alternative 2 did not take into account significant long-term costs, and inadequately protected public health and the environment—falling shy of a necessary budget by an order of magnitude or more.

2. Extending the period of analysis to 1000 years, a first step in setting a period more in line with the decay times for high-risk radioactive waste (yet not nearly long enough for some of the most dangerous radionuclides) reveals that the long-term site maintenance costs are burdensome and expensive. At 1000 years, the total cost of the Buried Waste option is nearly 25% higher than the Waste Excavation option.

3. The value of future lives and health is a strong argument for not using an economic discount rate in this analysis. However, if standard federal Office of Management and Budget discount rates (3% and 7%) are employed, Alternatives 1 and 2 cannot be said to be significantly different from an economic standpoint.

Evaluation of Social Costs

We evaluated two areas of social cost associated with the West Valley site: lost land revenues at the site and the costs of preventing exposure to downstream residents. Currently, the West Valley site poses a significant danger to residents and the downstream public. In other words, the site is a significant threat to those who live along and depend upon Buttermilk and Cattaraugus Creek, the residents of Buffalo and the large population along the shores of Lakes Erie and Ontario.

As long as residents are restricted from utilizing the land at the site, there will be lost land revenues. As a highly conservative hypothetical estimate, we assume that the remediated land could be used for agricultural purposes.[4] If the site were cleaned up to allow for agricultural use, it could bring in $130,000 a year, or $64,000 if half the site is released (possible under Buried Waste option after 217 years). These amounts are lost if the site is not cleaned up to allow such use.

Residents living downstream of the West Valley site are endangered by the risk of a radionuclide leak. We estimated water replacement costs if there were a catastrophic release of radionuclides approximately 500 years from the time of

[4] Our "conservative" estimate is defined here as the lowest reasonable cost, which in this case assumes that the land could be used for agricultural purposes; an "optimistic" estimate might assume that the land could be used for commercial or residential purposes for a significantly higher land value (one or two orders of magnitude).

closure expected in the Buried Waste option. The costs are substantial in the first year, at over $272.7 million dollars, and then decline to $27.5 million to maintain the Buffalo and Erie County Water Authority's water treatment plants. This water cost is only a case example, and does not include a substantial population on the shores of Lake Erie and Lake Ontario who could also be impacted by the release of radioactive waste from West Valley.

We evaluated both a rapid leak and a continuous leak scenario, and found that if just 1% of the radioactive waste stored at West Valley leaked starting 100 years from now, a large population of over 800,000 Lake Erie water users would be exposed. From 100 to 1,000 years into the future it is expected that the population of 400,000 people receiving Lake Erie water from the Sturgeon Point Water Treatment Plant would be exposed to up to 334,320 person-rem[5], resulting in the deaths of up to 334 people[6]. *If we suspect that there is a risk of radioactive waste exposure over the next thousand years, the costs of leaving radioactive waste in the ground (Alternative 2A) very quickly exceed the costs of exhuming and transporting wastes to a safer location (Alternative 1A).*

Evaluation of Closure Risks

We are not qualified to evaluate the risks of closure activities. The DEIS calculates risks for worker radioactivity exposure, morbidity and mortality during excavation, packaging, and transportation. Every closure activity poses a risk to workers and the more waste excavated, the higher these risks climb. In addition, if Alternative 2 included necessary erosion control maintenance for the millennia the wastes remain hazardous, there could be additional worker risks we were not able to quantify. The DEIS calculates that Waste Excavation Alternative 1 would result in many more injuries and radioactive exposure than Buried Waste Alternative 2 during the relatively short time period of excavation.

Evaluation of Post-closure and Geologic Risks

In Buried Waste Alternative 2, we must consider the risks of losing institutional controls at the site sometime after the closure which is likely a probability, rather than a possibility. *First, there is a fundamental obstacle in maintaining institutional controls due to the improbability of thousand-year continuity in either government or language.* Of the governments and nations that exist today, only Iceland has an unbroken lineage spanning the last thousand years. While something called the English language has existed for centuries, it changes fast enough so that modern readers cannot understand words written a thousand years ago. A look at literary classics of earlier centuries reveals the extent of change. A warning from the

---

[5] "Person-rem" is a measurement of the collective dose in rems that a specific population is exposed to over a certain time period. The person-rem units represent the average dose per person times the number of people exposed.

[6] Over 800,000 water users are served "downstream" of the West Valley site on Lake Eri, both in Erie County and the city of Buffalo, New York. This analysis reviewed only the impacts of contaminating the Sturgeon Point treatment plant, about 11 miles away from the Cattaraugus Creek outflow.

author of Beowulf, written in the English of roughly 1000 years ago, would be incomprehensible and meaningless to all but a handful of experts today. Therefore, there is no reason to assume that the DOE could adequately address safety and communication issues at West Valley for the Buried Waste option.

Second, there is the fundamental problem that erosion is a powerful and fast moving force at the site. West Valley sits on a geologically young landscape which is undergoing a relatively rapid rate of erosion. Within the next few hundreds years, erosion is estimated to create damaging gullies. For instance, at the rate of erosion anticipated for Franks Creek, we might anticipate a breach of the state licensed disposal area in less than 400 years. This region could expect to have over 500 new gullies form with erosion covering 20% of the plateau surface in the next 10,000 years. It is easy to imagine that if erosion is uncontrolled, at least one of these gullies will penetrate a buried radioactive waste area at the site. *Unless erosion and other institutional controls are rigorously maintained, we predict that the disposal areas could be breached in less than 1000 years and as quickly as 150 years from now without any controls in place.* This breach would be a catastrophic failure, leaking high concentrations of radionuclides into the local watershed and then quickly into Lake Erie. Can we count on a system design so sound and repairs made so frequently that the dangerous contaminated waste at the site is never released? Erosion control practices have short life spans, expected to last 10 to 25 years.

Since severe erosion problems are estimated to occur at the site within hundreds of years, clearly, the long-term disposal of buried waste at the site is not an environmentally sound approach. Currently, there is a large plume of contaminated groundwater moving towards Buttermilk Creek. However, even more worrisome for the downstream population and the priceless resource of the Great Lakes is the potential for streams near the site to undercut or expose wastes buried at the site. Burial of nuclear waste over the long-term is a flawed approach both because of the scientific uncertainty in predictions of geological events over millennia to come, and because burial of waste compromises the rights of future generations to equal treatment and free, informed consent.

The Buried Waste Alternative continues to pose a risk to nearby and downstream residents long after closure activities have ended. In contrast, the Waste Excavation Alternative leaves behind a contamination-free area after 73 years. While there are risks to workers during closure, these risks occur in a more controlled situation in which stringent oversight and project management can limit the potential for harm. In addition these risks are over when the last truck carrying contaminated waste leaves the site. (It is important, yet unfortunately beyond the scope of this analysis, to note that wastes which have left West Valley are not risk-free. Rather, they will have to be stored somewhere else and may also pose a threat to future generations.) Waste Excavation poses significantly lower risks to future generations after closure activities cease.

Full Cost Accounting: Waste Excavation vs. Burial Approaches

We adjusted the underlying budget assumptions and included enhanced erosion controls in Alternatives 1 and 2 to bring balance to their relative long term risks, calling the new options Waste Excavation Alternative 1A and Buried Waste Alternative 2A. We considered that: 1) erosion would need to be kept rigorously under control at the site; 2) security would need to be held at a relatively rigorous level to ensure intruders could not access wastes; 3) a spreading plume of contaminated groundwater would have to be remediated to prevent contaminants from entering the local watershed; and 4) the inevitable and powerful forces of time and erosion could eventually expose wastes catastrophically, leading to high costs of remediation for water consumers.

Our analysis found that Waste Excavation 1A is less expensive than Buried Waste 2A. [7] *Over 1000 years, Waste Excavation Alternative 1A costs $9.9 billion while Buried Waste Alternative 2A costs between $13 and $27 billion, depending on if a catastrophic release occurred accidentally or not.* [8]

[7] Under the assumptions of a non-discounted future.

[8] This does not include all the environmental, societal and public health costs due to resources or lack of data.

Table ES-1: Full Cost Accounting for Alternatives 1 and 2 (2005 draft DEIS) and modified Alternatives 1A and 2A, with and without a catastrophic release in year 500.

Closure Procedure	Alternative 1	Alternative 1A	Alternative 2	Alternative 2A	Alternative 2A
All costs in year 2005 $	Waste Excavation (2005 DEIS)	Waste Excavation (Modified)	Buried Waste (2005 DEIS)	Buried Waste (Modified, with Catastrophic Release)	Buried Waste (Modified, no Catastrophic Release)
Waste Management Area Closures	4,001,084,000	3,914,031,906	1,275,997,000	1,275,998,433	1,275,998,433
Contaminated Soil Cleanup	2,290,360,000	1,660,194,382	37,309,000	1,469,464,760	1,469,464,760
Leachate Treatment Facility	114,289,000	114,288,449	-	-	-
Container Management Facility	890,512,000	890,511,867	-	-	-
Dry Cask Storage Area	-	-	92,847,000	92,846,038	92,846,038
Institutional Controls Installations	-	-	62,205,000	394,354,222	394,354,222
Ongoing Costs (cumulative over analysis period)	-	-	359,450,000	9,580,951,999	9,580,951,999
Final Status Survey	-	-	3,480,000	3,479,670	3,479,670
Waste Disposal Costs	3,321,700,000	3,321,700,000	177,700,000	177,700,000	177,700,000
Water Replacement Cost	-	-	-	14,445,386,239	-
Unavailable Land Lost Revenue	$ -	$9,523,215	$ -	$78,477,945	$78,477,945
Total Costs					
Total Fixed Costs	10,617,945,000	9,910,249,818	1,649,538,000	17,937,707,307	3,492,321,068
Annual Costs over Analysis Period	-	-	359,450,000	9,580,951,999	9,580,951,999
Analysis Period (years)	73	1000	218	1000	1000
Total Costs over Analysis Period	$10,617,945,000	$9,910,249,818	$2,008,988,000	$27,518,659,306	$13,073,273,067

Findings and Recommendations

Based on our analysis, we make the following findings and recommendations.

1. Buried Waste Alternative 2 inadequately protects the health and environment of residents, and is an unrealistic cost. It poses a risk to residents and the downstream public if institutional and erosion controls fail while dangerous radionuclides are buried at West Valley.

2. Waste Excavation Alternative 1 poses a risk to onsite workers during the relatively short period of time for remediation activities. It also does not "solve" the problem of West Valley's nuclear waste disposal, rather it prevents further contamination, prevents a catastrophic release that could cause severe damage to populations in the Great Lakes region, and mitigates the problem by transferring the waste to a less risk-prone site.

3. Over a 1000 year timeframe, Waste Excavation Alternative 1 and 1A present the least risk to a large population and the lowest economic social and project cost.

Based on these findings, we recommend that the DOE and involved state agencies take the following actions as they develop the new DEIS for West Valley closure.

- Reject current assumptions about timeframe, institutional controls and continuity, and budget requirements as presented in Alternatives 2 through 4 in the 2005 DEIS due to their inability to adequately protect health, welfare and the environment as required by federal statute.

- Assume that, until shown otherwise, the safest and most economically viable option is to fully excavate the wastes buried at West Valley (Alternative 1).

- Explore other options for retrievable, monitored, above-ground storage of nuclear waste at a more stable site than West Valley. In addition, the full costs of remediating West Valley must be factored in to decisions being made for new reprocessing and nuclear power.

- In the new DEIS, revisit the following research topics more rigorously and with public input: 1) the probability of maintaining effective institutional controls over the expected lifetime of radioactive elements buried at the site; 2) the risk of erosion control failure with or without the maintenance of institutional controls; the rate of release and source of radioactive contamination should there be an erosion control failure; and 3) the potential for radioactively contaminated groundwater to move rapidly through sand layers in West Valley soils.

- In the new DEIS, revisit the following budget topics more rigorously and with public input: 1) the costs of addressing contaminated groundwater and drinking water for local populations and watersheds; 2) the economic costs of addressing contamination reaching and impacting Lake Erie; and 3) the economic opportunity cost of lost development ability at the site.

- Evaluate options for mitigating radioactive waste at West Valley based not only on project cost alone, *but also on project and post-closure risks over the expected lifetime of radioactive elements buried at the site.*

1. Introduction

1.1 Background

The purpose of this study is to assess the West Valley nuclear waste site, to evaluate the possibilities and costs for final remediation and to project the long term consequences of each of those options. This federal and state site, located approximately 30 miles south of Buffalo, New York, contains large quantities of long-lived radioactive and hazardous waste. Our study includes a critique of the existing U.S. Department of Energy (DOE) assumptions for West Valley remediation and recommending a sound economic and public policy basis for choosing among the options. These recommendations include alternative cost estimates, as well as recommendations for how to compare the costs and benefits of options with radically different time frames. We consider this last issue to be of significant importance and cannot overstress the fundamental differences between economic cost-benefit analysis over timeframes of one to a few decades and similar analyses spanning 10,000 years or more. The large uncertainties in project costs, markets, and regulation which are commonly seen in evaluating large construction projects, such as power plants with project lifetimes of 30 to 50 years, are known to be daunting. Those uncertainties pale in comparison to the challenges of project lives that exceed the duration of civilization. This study seeks to account for risks and costs over the first thousand years following site closure, a time period in which uncertainties emerge in such areas as institutional continuity and geologic stability.

This study also considers important issues and costs that have not been included in the previously issued government reports, such as environmental and other costs and risks that may be imposed on the West Valley area, as well as other regions that could be impacted by waste from the site. This examination of costs and risks allows for logical and reasonable comparisons among the options, properly taking into account the radically different time frames involved for some of the options. The basis of this study is a draft copy of a Draft Environmental Impact Statement (DEIS) produced by DOE, in consultation with state agencies such as the New York State Energy Research and Development Authority (NYSERDA) in 2005 (the “2005 draft DEIS”) and circulated through other government agencies for internal review. The DEIS proposed five alternatives, four of which explore decommissioning and closure options for the West Valley nuclear waste disposal site, and one which evaluates a “status quo” scenario. In this study, we consider the costs, risks and impacts of the 2005 draft DEIS Alternative 1 (Waste Excavation and disposed of off-site) and Alternative 2 (Buried Waste with partial removal) under a likely and credible worst case scenario that would make the options more or less appropriate.

The study also critiques the adequacy of the 2005 pre-release or draft DEIS in relation to the likelihood of remediation failure and the resulting risk of environmental and health damage and costs. This includes an assessment of

Alternative 2 (Waste Buried) if institutional and erosion controls fail at the site and radioactive wastes stored at the site leak into the local watershed, through the Seneca Nation of Indians territory, and into the Great Lakes. Such costs may include, for example, the costs of pollution in the Great Lakes watershed, if erosion and inadequate maintenance causes spreading of wastes to private drinking water wells, municipal wells and groundwater distant from the site; and economic impacts on downstream communities and residents harmed by accidents, polluted wells and other scenarios.

Finally, this study seeks to evaluate alternatives with more balanced risks. To this end, we adjusted Alternative 1 (Waste Excavation) and Alternative 2 (Buried Waste) as proposed by the DOE in the 2005 draft DEIS in terms of extent of material excavated, site security, and protections from erosional processes.

The authors have attempted to address and quantify environmental, societal, health and other costs where possible. However, it is important to note that some costs and issues associated with options for clean-up of the West Valley site could not be addressed in this report due to resources, capacity or lack of data. The following are areas not addressed in this report:

● *Public health costs:* Although public health costs are not discussed here, health effects from increased human exposure to radionuclides in the event of a catastrophic release, and the costs to treat those health effects, are important considerations for the choice of a clean-up plan.

● *Waste transported to other sites:* The comparative costs of burying waste at remote facilities and the environmental impact of doing so is a critical issue. It is beyond the scope of this study to do a Full Cost Accounting for the potential sites to which the exhumed waste or dismantled buildings would be sent, but chances are good that no site will be capable of completely isolating the waste for the extremely long time period that some of it remains radioactively dangerous. Comprehensive, life-cycle costs of disposal elsewhere must be factored into the decision-making process for radioactive waste management as well as for decisions currently being made to resume reprocessing in this country, open new radioactive waste burial grounds and to generate more radioactive waste from nuclear power and its fuel chain facilities.

● *Construction injuries:* Our critique of the 2005 draft DEIS calls for additional erosion controls to be built at the site in Alternative 2. Aside from a dollar cost, this construction (as in all construction projects) has an injury rate. Changes in the potential injury rate at West Valley associated with building additional controls have not been estimated.

● *New DEIS:* DOE and NYSERDA are in the process of developing a new Draft Environmental Impact Statement (DEIS), for release in late 2008 or early 2009. The authors of this report have not attempted to obtain an early release copy of this new DEIS.

- *Hazardous wastes:* There are significant repositories of hazardous and toxic wastes also stored at West Valley. The regulatory guidelines governing the cleanup of these wastes are different than those for the nuclear contamination, and the costs of hazardous waste remediation were not assessed in this analysis.

- *Probabilistic analysis of erosion:* In our analysis of Alternative 2, we explore a catastrophic release scenario. In this study, we used a set of internally consistent fixed assumptions, and so arrive at a single set of answers. The 2005 draft DEIS explores erosion and radionuclide exposure in a probabilistic fashion. We did not use a probabilistic treatment in this study.

We were unable to explore the potential for radioactive wastes to become more or less potent as a result of water treatment.

This study does not include calculations for:

- the human health and environmental costs or risks associated with exposure resulting from irrigation or the ingestion of animal products, wildlife, or fish;
- the human health and environmental risks and costs of radionuclides transferred by dust inhalation;
- the human health and environmental risks and costs which could occur if flood conditions wash radioactive materials already embedded in the soils around Buttermilk and Cattaraugus Creek sediments into Lake Erie;
- the reduction in value of properties surrounding the West Valley site as a result of the environmental stigma;
- the local and regional economic impacts of restoring the West Valley site to an unrestricted, fully productive state; or
- the additional costs of disposal of water treatment wastes if radioactive elements are released into public water supplies.

Definitions

Throughout this document, there are references to four levels of contaminated waste using the following technical definitions.

4. High-Level Radioactive Waste: wastes resulting from the reprocessing of spent nuclear fuel requiring permanent isolation[9]. The Nuclear Regulatory Commission (NRC) notes that the only way high-level waste becomes harmless is through decay, a process which “can take hundreds of thousands of years”.[10]

---

[9] Draft (EIS) Environmental Impact Statement. 2005. Decommissioning and/or long term stewardship at the West Valley Demonstration Project: U.S. Department of Energy report #DOE/EIS-0226-R. Chapter 4, p58. *Note, this document will appear as a shortened reference in the remainder of this document, for example as “2005 draft DEIS, Chapter 4, p58”*

[10] NRC, 2002. Radioactive Waste: Production, Storage, Disposal. NUREG/BR-0216, Rev. 2

5. Transuranic Radioactive Waste: radioactive wastes which are not included in the definition of “High-level radioactive waste”, but have half-lives longer than 20 years[11] (meaning that they can remain dangerous for generations or longer).

6. Low-Level Radioactive Waste: The term “low-level” *does not mean that these wastes are low-risk*. Low-level wastes are simply wastes which do not fall under the definition of “High-level” or “Transuranic,” but can still contain significant amounts of dangerous radioactivity. The DOE defines these wastes as having less than 100 nanocuries per gram of waste[12]. Throughout this document, the term “low-level waste” carries a technical definition (defined in the West Valley Demonstration Project Act and classified by the NRC[13]), but is not meant to imply that the wastes are considered in any way safe.

7. Low-Specific Activity Waste: wastes which have relatively low surface activities. In this document, the LSA materials tend to be industrial, construction, and soil wastes which have been exposed to contamination.

The term “institutional controls” has an important definition. The Environmental Protection Agency (EPA) and NYS Department of Environmental Conservation (DEC) both distinguish between institutional controls and physical controls, while the West Valley DEIS does not. In the EPA and DEC, institutional controls are “actions, such as legal controls, that help minimize the potential for human exposure to contamination”.[14] Such actions may include land deeds, control of land ownership or lease, and access to property. Physical controls are built infrastructure to reduce potential human exposure to contamination, such as containment features, walls, erosion barriers, pools, fences, and so forth. The West Valley DEIS uses the term “institutional control” to refer to both legal and physical barriers, and we will use the same definition. When we refer to a potential that institutional controls could fail, we mean that there is a potential that government oversight, long-term institutional memories or written records, or physical barriers may cease to be effective in preventing exposure to contamination at West Valley.

---

[11] 2005 draft DEIS, Chapter 4, p58

[12] 2005 draft DEIS, Chapter 4, p58

[13] Low-level radioactive waste (LLRW) is specifically defined for the West Valley site in Section 6 (6) of West Valley Demonstration Project Act and this is the controlling definition. LLRW is also classified by the Nuclear Regulatory Commission (NRC) in 10 CFR §61.55 which could apply to wastes sent off-site. In this report, we use the term low-level waste as it is defined in the Act. However, the authors and contributors to this report do not consider low-level waste to be low risk.

[14] US Environmental Protection Agency (US EPA). 2008. Institutional Controls (ICs). http://www.epa.gov/superfund/policy/ic/index.htm

1.2 History of the West Valley Site and Pending Cleanup Decisions

1.2.1 Description and Site History

The West Valley nuclear site is the nation's only venture into commercial reprocessing of irradiated nuclear fuel. Commercial reprocessing of nuclear material eventually was discontinued in 1977 under President Jimmy Carter.

The West Valley nuclear site includes 3,345 acres of land in the hamlet of West Valley, Town of Ashford, in Cattaraugus County, State of New York[15] (see Figure 1.1). It is 30 miles southeast of Buffalo, NY. Today New York State owns this land, having secured productive farmland for the endeavor early in the 1960s from 50 local farmers by eminent domain. At least two hundred fifty of the 3,345 acres have been contaminated by nuclear and hazardous wastes.

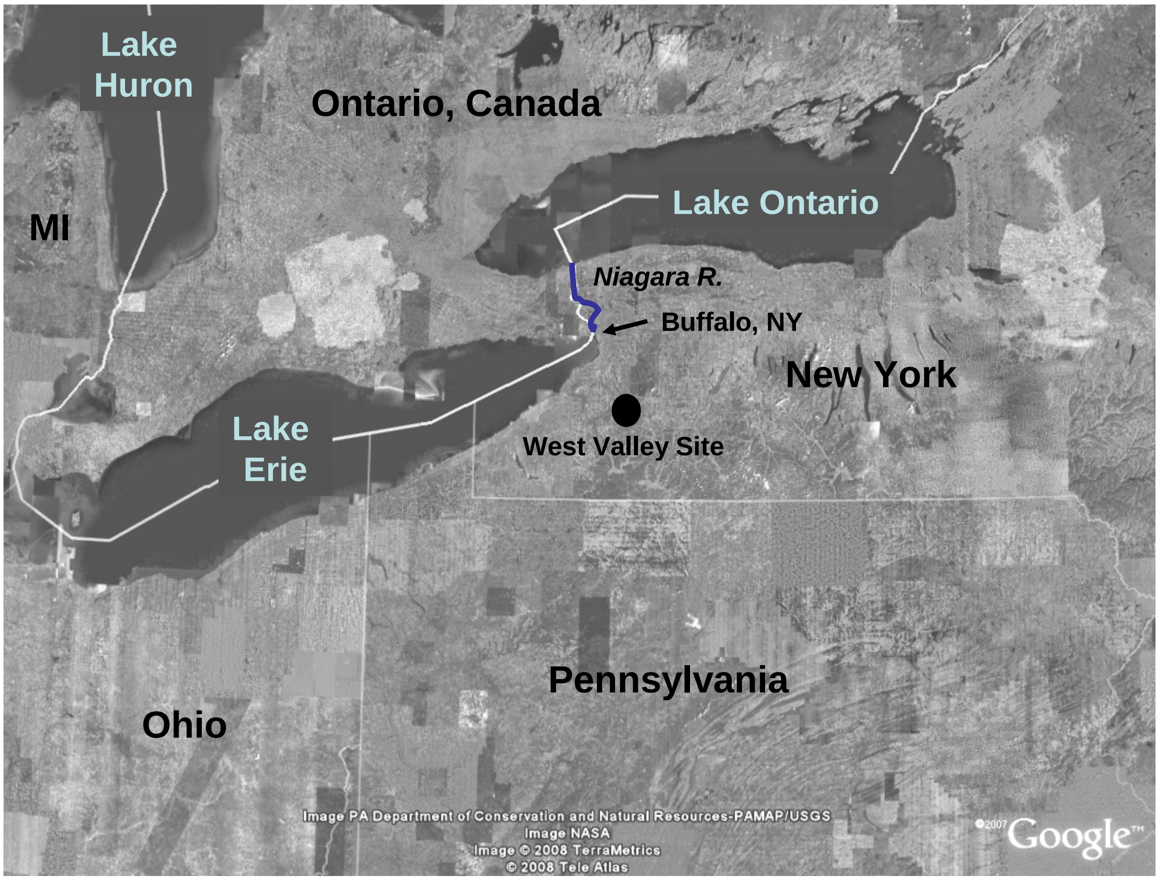


Figure 1.1
West Valley site relative to Great Lakes.

The West Valley site was chosen as the place to build a facility to reprocess

[15] 3,345 acres of WNYNSC is located in Cattaraugus County, with the remaining 14 acres in southern Erie County, NY (2005 draft DEIS, ch. 2, p. 2-2.)

irradiated nuclear fuel to recover plutonium and uranium because the community was perceived by authorities as sparsely populated, lacking sufficient employment opportunities, and had prevailing winds and groundwater characteristics that were seen as "favorable".[16]

By today's standards, with the advent of the National Environmental Policy Act (NEPA), EPA and DOE's own guidelines, a nuclear facility would not be allowed on land as erosion-prone as the West Valley site. In the early 1960s, however, local political leadership in the Town of Ashford supported a commercial reprocessing center, and the larger Western NY community's political and industry leaders heralded the reprocessing plant as sound economic development. The former Ashford Town Supervisor, William King, acknowledges that the town's support for a commercial nuclear reprocessing plant in Ashford under an earlier administration was a serious mistake and that the facility may have hampered the Town's long-term economic development.[17]

Atomic Energy Act of 1946

As submitted to Congress, the Atomic Energy Act of 1946 included two sections referencing the liberal sharing of nuclear information and technology. By the time the Act reached President Truman's desk, these two sections were replaced by sections calling instead for control of scientific and technical information. The Act provides for civilian management of the nuclear fuel chain yet includes some government oversight, suggesting that Congress and the President understood the power of nuclear technology.

In 1954, the Atomic Energy Commission (AEC) started a program to commercialize the entire nuclear fuel system, including power reactors and reprocessing of irradiated nuclear fuel.

Early Site History

The DOE provides a brief background on the genesis of the West Valley site. "Optimism about the future growth of the nuclear industry led the State of New York to set aside 3345 acres near West Valley, New York, and to encourage nuclear industries to locate there. Although fuel reprocessing had been practiced in the U.S. since 1944, large-scale fuel reprocessing in the U.S. had been conducted only at DOE facilities in Idaho, South Carolina, and Washington State, until NFS began operations at West Valley, NY."

"The NFS West Valley facility was the first and only private plant in the U.S. to reprocess spent nuclear fuel. The NFS facility was a PUREX (Plutonium Uranium Extraction) process plant with a design capacity of 300 tons of fuel per year. The PUREX process included storing spent fuel assemblies; chopping the assembly

---

[16] WNY Nuclear Service Center Study: Companion Report published by the US DOE, Washington, DC., 1978, Chap. 1, page 4.

[17] Personal correspondence.

rods; dissolving the uranium, plutonium, and radioactive products in acid; separating and storing the radioactive wastes, and separating uranium nitrate from plutonium nitrate. Two other commercial reprocessing facilities were built in the United States, but never operated."[18]

In 1970, the AEC amended its regulations (10 CFR §50) to require that after the chemical separation of plutonium and uranium, residual high level radioactive wastes generated at licensed reprocessing facilities would be solidified within five years and shipped to a Federal repository within 10 years.[19] In the same 1970 Federal Register announcement, the AEC reiterated that these high level wastes should be disposed of only at federally-owned repositories, but specifically exempted the existing wastes at West Valley. This issue of which level of government is responsible for the wastes at West Valley has been contentious for decades.

In 1959, New York established the Office of Atomic Development (OAD), the only state to accept a federally-initiated plan to form a public-private partnership to reprocess nuclear material. In 1961, the OAD purchased a 3,345-acre site in West Valley for what would become the Western New York Nuclear Services Center (WNYNSC) owned by Nuclear Fuel Services (NFS), a company that continues to this day. The public entities in this partnership were the AEC[20] and the New York State Atomic Research and Development Authority (NYSARDA)[21].

In 1963, a set of complex ownership contracts were signed between AEC, NFS, and NYSARDA. In the contract between NFS and NYSARDA, some of the provisions included generous conditions to NFS:

- NFS was given a lease for WNYNCS with rent paid to New York State; NFS would build, own and operate the reprocessing facility, the lease would expire on December 31, 1980 and if not renewed, New York would assume ownership of all the facilities;
- NFS would build for NYSARDA facilities for receiving irradiated fuel and storing wastes and would make related site improvements; NFS would manage and operate facilities that store high-level nuclear wastes in underground tanks, which when full would be turned over to NYSARDA for perpetual care. A "perpetual care" fund was established for the purpose of

---

[18] Plutonium Recovery from Spent Fuel Reprocessing by Nuclear Fuel Services at West Valley, New York from 1966 to 1972, Prepared by U.S. Department of Energy, February 1996. https://www.osti.gov/opennet/document/purecov/nfsrepo.html

[19] From Appendix F,,10 CFR §50: "High-level liquid radioactive wastes shall be converted to a dry solid as required to comply with this inventory limitation, and placed in a sealed container prior to transfer to a Federal repository in a shipping cask meeting the requirements of 10 CFR §71." Also, see WNY Nuclear Service Center Study Companion Report, DOE, January 1978, TID-28905-3.

[20] The AEC is a precursor to the Nuclear Regulatory Commission (NRC) and Department of Energy (DOE)

[21] NYSARDA eventually became the New York State Energy Research and Development Authority (NYSERDA)

enabling New York to replace the tanks every 50 years (this fund amounted to only $4.7 to $5.1 million by 1980).

NFS received a permit from AEC to begin construction on 250 acres at West Valley and construction of the NFS facility was finished in 1966. As early as 1963, however, wastes were already being buried at the State-licensed Disposal Area (SDA).[22]

The NFS reprocessing facility operated for six years (1966-1972) and reprocessed about 640 metric tons of irradiated fuel. In 1972, reprocessing ceased in order to double the plant reprocessing capacity, add additional types of reprocessing capacity, and reduce worker exposure to radiation. It was estimated these changes would cost $15 million and be complete in two years.

Changes in safety and environmental regulations since the original facility construction required NFS to undergo a complete licensing review. In 1976, NFS determined that to comply with the new criteria, including NEPA[23], would cost over $600 million. NFS decided instead to exercise their right to surrender responsibility for all wastes at the WNYNSC to NYSERDA. In September of 1976, NFS withdrew from the business of reprocessing irradiated nuclear fuel. After six years of operations, the WNYNSC never reprocessed fuel again.

The site has been plagued with problems from the start of the NFS operations through today, including leakage of radioactive and toxic waste in several areas, such as a significant underground plume of radioactive elements spreading through groundwater near the site.[24, 25, 26]. Waste from the site has been found as far away as the southwestern region of Lake Ontario in the sediment along the shore at the juncture of the Niagara River and Lake Ontario.[27] (Sections 5 & 6 and Appendix B provide a detailed description of contamination problems at the site).

The Last 30 Years

In 1981, President Carter signed the West Valley Demonstration Project Act (WVDPA) which directs DOE to solidify the high-level liquid wastes, clean up and close the site. West Valley Nuclear Services was selected as the prime contractor.

---

[22] Low-level radioactive waste (LLRW) is specifically defined for the West Valley site in Section 6 (6) of West Valley Demonstration Project Act and this is the controlling definition. LLRW is also classified by the Nuclear Regulatory Commission (NRC) in 10 CFR §61.55 which could apply to wastes sent off-site. In this report, we use the term low-level waste as it is defined in the Act. However, the authors and contributors to this report do not consider low-level waste to be low risk.

[23] NEPA: National Environment Protection Act

[24] U.S. Environmental Protection Agency, Region II, Summary Report on the Low-Level Radioactive Waste Burial Site, West Valley, NY (1963-1975), EPA-902/4-77-010

[25] WV Nuclear Services Company Investigation of Kerosene-TBP Movement in the NRC licensed Disposal Area, WNY Nuclear Service Center, WVCP-042, April, 1985

[26] US Geological Survey, Groundwater Hyrdrology and Subsurface Migration of Radioisotopes at a Low Level Solid Low Level Solid Radioactive Waste Disposal Site, West Valley, NY, Open File Report 77-566, 1977

[27] Joshi., SR. 1988. West Valley-Derived Radionuclides in the Niagara River Area of Lake Ontario. *Water, Air, and Soil Pollution*. **37**:111-120

Vitrification—mixing the high-level waste with melted glass—was chosen as the method for solidification. This process produced regulated waste products, and in 1986 DOE issued an Environmental Assessment (EA) of the method to be used and the resolution of the waste disposal issue. The EA proposal was to place the non-high level radioactive residue in containers and cover the collection with a dirt mound (a tumulus). DOE maintained that this proposal would not pose an environmental hazard and issued a Finding of No Significant Impact (FONSI).

The Coalition on West Valley Nuclear Wastes (CWVNW) and the Sierra Club Radioactive Waste Campaign protested the FONSI and went to court to get the DOE to conduct an Environmental Impact Study (EIS). After a year of negotiation, a court-ordered compromise was reached in which DOE agreed do a full EIS and the CWVNW agreed that the project could proceed as long as the project wastes were held in monitored and retrievable storage, pending decisions about final closure of the whole site.

The pretreatment of the high level liquid waste began in 1988. The liquid waste was pumped from the tank and filtered into two waste streams. The less concentrated radioactive waste, a mildly radioactive supernatant, was mixed with concrete and poured into cube-shaped containers. The DOE has been shipping these 20,000 drums to the Nevada Test Site for burial. In 1995, the high-level waste stream was sent to the rebuilt vitrification facility for solidification. Solidification of the treated high-level waste was started in 1996 and completed in 2002. The radioactive solid material remains on site, stored behind walls 4 feet thick in the Process Building.[28] These high level radioactive wastes are required to be disposed in a federally licensed high level radioactive waste repository. No such facility currently exists and it is debatable when one may be able to open.

1.2.2 Pending Cleanup Decisions

<u>Closure of the West Valley Site</u>

In 1987, DOE agreed to do a full EIS on the eventual closure of the site. A draft EIS (DEIS) was issued in 1996 with five different alternatives of how to clean up and close the site. In 2001, the DOE decided to split the EIS process into two parts, one handling waste management at the processing facility and the other handling total site closure options. The Final EIS for the first part, the "Waste Management EIS", was released in 2003. The second part of the DEIS was modified, and a new version was released in 2005 on "Site Closure Options." After splitting the EIS process in 2001, the Coalition on West Valley Nuclear Wastes (CWVNW) took legal action as they believed it was contrary to the National Environmental Policy Act (NEPA) and allowed the DOE to avoid certain problems with the 1996 DEIS, such as troubling erosion predictions. The case remains in Federal Court, under appeal and unresolved. DOE's new draft 2005 DEIS changed substantially in both structure and substance from the 1996 DEIS; some useful

[28] We discuss the waste streams and process building further in Section 3.

alternatives were eliminated, the estimated costs of cleanup changed radically, and there were significant changes to assumptions about erosion, safety, and contamination levels. Concerns raised by various New York State agencies appear to have prompted the DOE to work on yet another DEIS, expected to be released by late 2008 or early 2009. Currently, this process is one of the longest unresolved EIS procedures in US history[29].

The current administration's budget for the West Valley Demonstration Project has been reduced for several years in a row. Some of the cleanup actions require pilot test projects, which have been unable to proceed with tightening budgets. The federal government has made no end-state or final decision for the West Valley nuclear site, and thus there is no clarity about what standard of cleanup will be required. Concerned community and environmental organizations are seeking a commitment to fully clean up the site for unrestricted release or to an agricultural level of cleanup or better.

A theme that pervades the history of the West Valley nuclear site, and indeed many other nuclear waste sites, is ongoing conflict between state and federal governments, between government and the concerned public, between workers and owners/site managers, and between an old energy policy that promoted nuclear energy and an environmental policy grappling with the troubling question of how to handle nuclear waste. In this study, we explore some of the costs and questions associated with the long-term implications of waste disposal at the West Valley site.

1.3 The Setting

1.3.1 Topographical and Geological Setting

The West Valley site includes 3,345 acres of land primarily in northern Cattaraugus County[30] in southwestern New York State in a mostly forested region overlying a post-glacial landscape. The site sits 1400 feet above sea level on two plateaus, surrounded and bisected by two small creeks, Frank's Creek and Erdman Brook. The eastern edge of the site is perched about 160 feet above a larger waterway called Buttermilk Creek, which flows into the even larger Cattaraugus Creek. The Cattaraugus empties in Lake Erie (see Figures 1.1 above and 1.2 below)

Over 20,000 years ago, the earth's surface around the West Valley site was scraped and reshaped by glaciers, leaving a blank canvas upon which rivers, creeks, and streams began to create a landscape. The glaciers of the ice age retreated and advanced in several pulses, continually reworking the landscape. Approximately 16,000 years ago, the glaciers advanced over lake sediments, creating the clay-rich Lavery till, which underlies the site. The site can be

---

[29] Coalition on West Valley Nuclear Wastes, 2006 Fact Sheet

[30] 3,345 acres of WNYNSC is located in Cattaraugus County, with the remaining 14 acres in southern Erie County, NY (2005 draft DEIS, Chapter 2, p. 2-2.)

considered as resting on two plateaus (referred to as the north and south plateaus), divided by a creek. The plateaus are deposits of lake-bottom sediments uncovered when the lakes drained about 13,000 years ago. During this time, Buttermilk Creek eroded the landscape rapidly, cutting down 10 to 20 feet every thousand years. The area around the site is nowhere near equilibrium, with Buttermilk Creek still eroding at 4 to 10 feet every thousand years, and the gullies eroding much faster. Down-cutting and outward spread of these waterways will continue to cause substantial erosion at the West Valley site which is discussed further in Section 6 of this report.

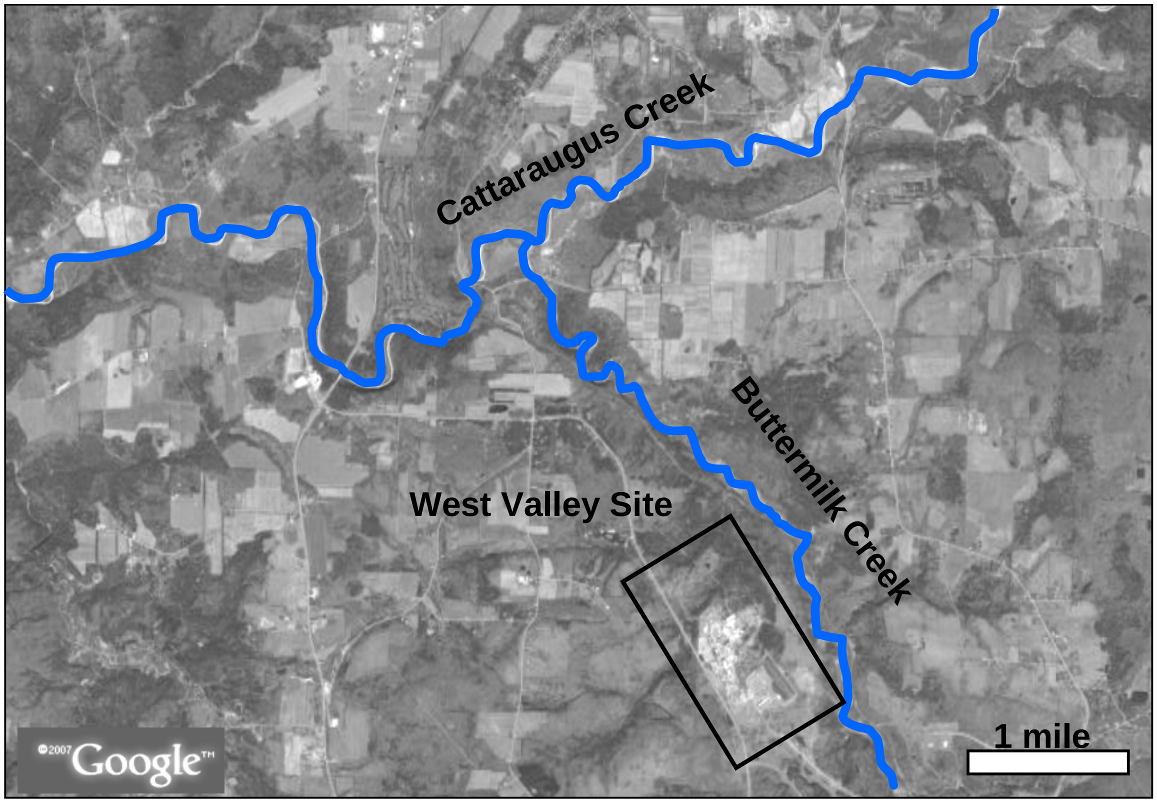


Figure 1.2
Region surrounding West Valley Site with local watershed indicated. Cattaraugus Creek flows west towards Lake Erie.

The soils immediately underlying the site have a large amount of clay and are relatively impermeable, meaning that water usually moves though them slowly. However, government monitoring studies have found that the soils are more permeable than expected, allowing groundwater to penetrate the waste disposal areas and carry contamination through underground fractures and sandy strata towards open streams. At West Valley, contaminated groundwater is traveling towards Buttermilk Creek (discussed in more depth in Section 6; see Figure 3.3).

1.3.2 Current Land Use and Natural Resources

Cattaraugus County lies on the New York-Pennsylvania border and is surrounded by the New York counties of Chautauqua, Allegany, Erie and Wyoming. The northwestern corner of the county is a short distance (roughly 5 miles) from Lake Erie, and about 60 miles south of Lake Ontario. It is 1,334 square miles in area and contains three Seneca Nation of Indian reservations: the Allegany Reservation, the Oil Spring Reservation and part of the Cattaraugus Reservation, which borders Cattaraugus Creek downriver of the West Valley site.[31]

Shaped by receding glaciers, the landscape of Cattaraugus County is characterized by rolling hills, rivers, and gorges. Much of the ground cover in the county consists of forests and grassy meadows, which provide sustenance and shelter for wild game such as deer and turkey. The Cattaraugus Creek watershed is home to extraordinary native flora and fauna, including an exploding population of bald eagles and an exceptional old-growth forest.[32] The area has been recognized by EPA as having the best environmental condition of any of the watersheds in the lower Great Lakes[33] and has been singled out for protection with its recent designation as a "Unique Area" by the New York State DEC.[34] Other natural resources include gas and oil, fresh water, and abundant hydro-power resources nearby at Niagara Falls.

Current land use in the county is dominated by residential acreage (29.7%), followed by parks, recreation and entertainment (25.8%), vacant (21.6%), and agriculture (19.9%) with little land area dedicated to commercial (0.6%), industrial (0.8%), and public & community services use (1.2%). Of Cattaraugus County's total assessed value in 2007, 47.1% was residential, and 31.3% was public & community services. The remaining assessed value was commercial (6.9%), parks, recreation and entertainment (6.6%), vacant (3.2%), agricultural (2.8%), and industrial (1.7%). The county has a significant amount of reclaimed land, 901 acres, which was formerly used for mining and has been made suitable for other uses, such as agriculture or recreation.[35]

1.3.3 Regional Economy

The West Valley site is located in the Town of Ashford in northern Cattaraugus County, within the Buffalo-Niagara region of western New York State. In the 19th and early 20th centuries, western NY's proximity and access to major water shipping routes promoted significant commercial and industrial development. Starting in the later part of the 20th century, innovation in air travel and federal

---

[31] US GenWeb. 2008. Cattaraugus County Towns and County. http://www.rootsweb.ancestry.com/~nycattar/history.htm

[32] T.P. Diggins and B. Kershner, "Canopy and Understory Composition of Old-Growth Riparian Forest in Zoar Valley, New York, USA," Natural Areas Journal 25, 219-227 (2005)

[33] U.S. EPA, New Index of Environmental Condition for Coastal Watersheds in the Great Lakes Basin, EPA/600/S-05/005, August 2005

[34] www.dec.ny.gov/environmentdec/36431.html

[35] Regional Knowledge Network, The Regional Institute, a unit of the University at Buffalo Law School at the University at Buffalo, The State University of New York. http://rkn.buffalo.edu/maps/topicmaps.cfm?Topic=105&Region=888, and http://rkn.buffalo.edu/data/topicdata.cfm?Topic=102&Region=888

policies promoting the development of highways favored these modes of transportation over the existing in-land shipping network, causing significant economic declines in the region. The Buffalo-Niagara region has faced economic stagnation, population loss, a weak real estate market, and a high concentration of sites with environmental contamination.[36] Although the economy has been depressed, there are positive signs that it is undergoing change. The general trend over the last decade in the Buffalo Niagara Region has been one of continuing transition from a manufacturing economic base to an economic base in sectors that require highly-educated and/or highly skilled labor, including education and health services, professional and business services, and financial services.[37] Showing signs of growth, the real estate market in the Buffalo-Niagara region has been affected by the current mortgage crisis much less than many other areas of the country.

Consistent with trends in the Buffalo-Niagara region, Cattaraugus County's manufacturing and agricultural economic sectors have declined significantly in the last few decades, 10% and 34% respectively, from 1990 to 2000.[38] Other business sectors have developed recently, including hospitality or tourism, services, transportation, and construction. Cattaraugus County draws residents from the nearby metropolitan areas of Buffalo and Rochester, NY; Cleveland, Ohio; and Toronto, Canada with its natural resources, such as the vast Allegany State Park. Ellicottville's skiing and vacation housing area, the new Seneca Allegany Casino Resort, and the rise of niches for snowmobiling and equestrian interests have helped boost the tourism industry. Tourism sites, such as parks, are in prominence as a primary economic development area in the county.[39] The local government's economic development efforts focus on tourism, pointing to expanded development of hospitality and other services.

As of 2000, some of the Town of Ashford's employment still lay in manufacturing at 20%. Educational, health and social services have grown to represent an even larger portion of employment at 22.2%. Employment in the town also consists of 11.2% in wholesale and retail trade, 8.9% in transportation, warehousing and utilities, 7.3% in the arts, entertainment, recreation, accommodation, and food services, and 7% in the construction industry.[40] The Cattaraugus Creek flood plain

---

[36] US EPA, Brownfields Showcase Community Fact Sheet: Niagara Region, New York. Available at http://www.epa.gov/swerosps/bf/html-doc/sc_niagara.htm

[37] University of Buffalo Regional Initiative. State of the Region Project. Economy: Job Growth update. November 2007. Available at http://www.regional-institute.buffalo.edu/sotr/index.cfm.

[38] U.S. Census. Table DP-3, Profile of Selected Economic Characteristics: 2000 Summary File 3 (SF 3) - Sample Data, Geographic Area: Cattaraugus County, New York.
U.S. Census. Table DP-3, Labor Force Status and Employment Characteristics: 1990 Summary Tape File 3 (STF 3) - Sample data, Geographic Area: Cattaraugus County, New York.

[39] Cattaraugus County Department of Economic Development, Planning & Tourism. 2005 Annual Report. Available at http://www.cattco.org/economic_development/resources/reports/.

[40] U.S. Census. Table DP-1. Profile of General Demographic Characteristics: 2000. Geographic area: Ashford town, Cattaraugus County, New York.

provides good locations for sport hunting and fishing, an important part of the Ashford economy and lifestyle.[41] Once a full and complete cleanup has been completed, the West Valley site and surrounding lands could also again provide good hunting and fishing sites as well.

The area also has transportation infrastructure and a strategic location near Lake Erie and between the cities of Buffalo and Rochester, as well as Cleveland, Ohio. The north-south Route 219 corridor connects Buffalo with northern Pennsylvania, the Seneca Allegany Casino Resort, and the Interstate 86 (I-86) Southern Tier Expressway. I-86 is the major east-west transportation link across southern New York and northern Pennsylvania. Rte. 219 will likely influence future development into adjacent areas, such as the cleaned up site, less than five miles to the east. An extension of the four-lane limited access highway from the Buffalo area is being discussed and, if it occurs, is expected to result in major residential development and increases in tourism to the areas of Ashford, Concord, Sardinia, Ellicottville and Salamanca.[42],[43]

The Seneca Nation of Indians (Seneca) has authority over two large territories and one small territory in Western NY. In general, new development in the territory is regulated by the tribal government. The Seneca territories have a somewhat different economy than the surrounding areas. Seneca members are employed in retail operations (especially gas and cigarettes), casino gambling operations, health care, and crop farming, with some off-territory labor in high steel construction, nursing and nursing aids, and other skilled professions. Also, the Seneca Nation has entered into cooperative agreements with the Department of Energy. [44,45]

---

[41] William King, Town Supervisor of Ashford, NY. Personal interview with William Steinhurst. October 2006.

[42] William King – Town Supervisor of Ashford NY, Gary Epolito – Town Supervisor of Concord NY, and Kathy Balus – Town Supervisor of Sardinia NY. Personal interviews with William Steinhurst. [October 2006]

[43] In 2000, the state received federal funding for final design, right-of-way acquisition, and reconstruction along US 219 from Springville to Salamanca. (http://www.fhwa.dot.gov/pressroom/fhwa0041.htm) NYSDOT received approval to extend the Route 219 freeway. (https://www.nysdot.gov/portal/page/portal/regional-offices/region5/projects/us-route-219/reports)

[44] Memorandum of Agreement Between the Seneca Nation of Indians and the U.S. Department of Energy, July 31, 2000.

[45] Memorandum of Agreement between the Seneca Nation of Indians and the U.S. Department of Energy, July 31, 2000.

2. Legal Framework

2.1 The Environmental Impact Statement Process

The federal Environmental Protection Agency (EPA) defines an Environmental Impact Statement (EIS) as a document needed for all major projects or legislative proposals significantly affecting the environment as required by the federal National Environmental Policy Act. EIS's are done by federal agencies and are used as an environmental assessment and decision making tool. EIS's are supposed to assess and describe all the positive and negative environmental effects of each possible action relating to a proposed project or cleanup. The law requires that the public be provided with opportunities to comment on draft EIS documents.

The National Environmental Policy Act (NEPA) [P.L. 91-190] went into effect in 1970 and required Environmental Impact Statements (EIS) be performed and a Record of Decision (ROD) be made public for any federal action that could have a significant effect on the environment. If a federal agency takes an action it must determine, with public comment and usually hearings, whether the action could significantly affect the environment. It must consider alternatives to the action, including taking no action. The law requires that there be a Scoping Period to identify the scope of the action and its potential environmental impacts. Once the scope is outlined, an Environmental Assessment (EA) is prepared and released for public comment and hearing. The agency then decides if there is potential for significant environmental impact. If the agency makes a Finding of No Significant Impact (FONSI), it may proceed with the action without further process. If it decides there is potential for significant impact, it proceeds to write a Draft Environmental Impact Statement (DEIS) and the public is invited to comment and hearings are held. The agency reviews public input and releases a Final Environmental Impact Statement (EIS) followed by another public comment period. Usually shortly thereafter, the agency makes a Record of Decision, or final decision, on the action. At any point, parties that have participated in the process can challenge the findings and decisions by appealing to the agency and/or going to the courts.

At West Valley, the EIS process has been extremely long and complicated.

2.2 Historical Actions and Future Plans at West Valley

An Environmental Assessment (EA) for West Valley was completed in 1986.[46] In 1986, the Coalition on West Valley Nuclear Wastes and the Sierra Club Radioactive Waste Campaign filed suit in federal district court in Buffalo.[47] A court-

---

[46] US DOE. 1986. Environmental Assessment for Disposal of Project Low-Level Waste, DOE/EA-0295.

[47] U.S. District Court, Western District of New York, Coalition on West Valley Nuclear Wastes et al. v. U.S. Department of Energy et al. Civ. Act. No. 86-1052C

directed settlement was reached in 1987, known as the Stipulation of Compromise Settlement, calling for a full Environmental Impact Statement (EIS) prior to site closure. As noted in Section 1, a Draft EIS was issued in 1996, and a pre-release or draft DEIS of 2005 has since been undergoing internal agency review. It is this pre-release 2005 draft DEIS which is reviewed in this document.

2.3 Site Responsibility

The licensing and remediation policies that apply to the West Valley site are complicated, and in some cases ambiguous and highly convoluted. The site cleanup is governed by a complex mix of various federal and state laws, regulations and guidance. Before the West Valley Demonstration Project Act was passed in 1980, nuclear activities at the site were governed by the Atomic Energy Act, Atomic Energy Commission's (AEC) 10 CFR §50 regulations, and the West Valley site license (CSF-1) issued by the AEC. The geographic area covered by the AEC license remains a matter of conjecture, as neither the license nor associated documentation specifies whether the license covers most of the 3300-acre site or just the central part of the site where most facilities are located. The license does not include the 14-acre State Disposal Area (SDA) that is covered by a separate license and permit issued by the State of New York.

2.3.1 Department of Energy's Role

In 1980, Congress passed the West Valley Demonstration Project Act that assigned certain responsibilities to the U.S. Department of Energy (DOE) and required the site license be amended to allow DOE's remediation work to proceed. As of 1980, licenses were administered by the U.S. Nuclear Regulatory Commission (NRC).[48] Under the terms of the license amendment, the CSF-1 site license was put "in abeyance" for the duration of the West Valley Demonstration Project until DOE's work at the site was complete. Thus, the license is inactive and procedures will need to be followed in the future to terminate, reinstate, and/or modify the license.

Under the West Valley Demonstration Project Act (the Act), DOE is required to do the following activities:

- Solidify the high level waste (HLW) at the site, develop containers for permanent disposal of the solidified HLW, and transport the solidified HLW to an appropriate federal repository as soon as feasible;[49]
- Dispose of "low level" radioactive waste[50] and transuranic waste produced by the HLW solidification process;[51] and

[48] The NRC is the successor to the AEC, intended by Congress to license and regulate, not promote, nuclear activities.

[49] See subsections 2(a)(1), (2), and (3) of the Act

[50] Low-level radioactive waste (LLRW) is specifically defined for the West Valley site in Section 6 (6) of West Valley Demonstration Project Act and this is the controlling definition. LLRW is also classified by the Nuclear

- Decontaminate and decommission the tanks and other onsite facilities in which HLW was stored, along with the facilities used for waste solidification and any material and hardware used in connection with the Project, in accordance with any NRC requirements.[52]

Figure 2.1
Canister containing vitrified (solidified in glass) high level waste at West Valley. (Photo from DEC.)

Solidification of the high-level waste (HLW) has been accomplished by a "vitrification" process that was carried out by DOE. This process created a highly radioactive mixture of waste and glass that is contained in 2-foot diameter, 10-foot-long metal canisters. There are about 275 of these canisters (see Figure 2.1 and Appendix B for more detail), all of which remain onsite, so the requirement that the solidified HLW be transported to an appropriate federal repository has not yet been completed. The Act's requirements of waste disposal, decontamination, and decommissioning have also not been completed. Some work has been done in these areas, but no final decision on waste disposal, decontamination, and decommissioning can be made until the EIS begun in the 1980s is completed in accordance with the National Environmental Policy Act (NEPA).

Regulatory Commission (NRC) in 10 CFR §61.55 which could apply to wastes sent off-site. In this report, we use the term low-level waste as it is defined in the Act. However, the authors and contributors to this report do not consider low-level waste to be low risk.

[51] See subsection 2(a)(4) of the Act

[52] See subsection 2(a)(5) of the Act

2.3.2 Nuclear Regulatory Commission's Role

The DOE and the Nuclear Regulatory Commission's (NRC) regulatory authority at West Valley is complicated. First, according to the West Valley Demonstration Project Act (Subsection 2(c)), the DOE shall enter into an agreement with the NRC to establish arrangements for an informal NRC review and consultation at the site. Second, formal NRC procedures on decontamination and decommissioning are mandated elsewhere in the Act, and NRC, for instance, has requirements for decontamination of the high level waste tanks. Similarly, under subsection 2(a)(4), NRC would likely be the agency with licensing authority for the types of waste disposal specified in the Act.

According to the federal NRC "West Valley Policy Statement"[53], the cleanup requirements are essentially the same as those set forth in NRC's License Termination Rule (10 CFR Part 20 Subpart E). Of concern to environmental and community groups monitoring the site is that NRC's Statement noted that there might be "flexibility" in meeting certain requirements of the License Termination Rule (LTR) at the site. However, while the NRC Statement indicates certain exemptions might be available, NRC staff have publicly stated on several occasions that the LTR requirements are expected to be met at the site.[54]

The NRC LTR cleanup requirements that must be met at the West Valley site are based on the expected toxicity of any residual or remaining wastes, and the dangers posed to the public. Below are some of the key LTR requirements.

- A site can be released for "unrestricted use" by the public if most or all wastes are removed *and* the subsequent radiation dose to an average member of a "critical group"[55] is not more than 25 millirems per year above background radiation. All residual radioactivity must be as low as reasonably achievable (ALARA).[56]
- The license can still be terminated if wastes remain at the site, but the site would remain "restricted." In this case, the radiation dose to an average member of the "critical group" cannot be greater than 25 millirems/year above background radiation, based on the assumption that there are restrictions (institutional controls).[57] If the site is expected to remain under restricted conditions, then the radiation dose to an average member of the "critical group" cannot be more than 100 millirems per year above

[53] Federal Register / Vol. 67, No. 22 / Friday, February 1, 2002 / Notices p. 5003 – 5012.

[54] NRC published these requirements in the form of a Federal Register notice called the "West Valley Policy Statement" on February 1, 2002.

[55] The "critical group" is roughly defined as the group of people reasonably expected to receive the greatest exposure from residual radioactivity at the site.

[56] See 10 CFR §20.1402 for this requirement. See also 10 CFR §20.1003 for definitions such as "critical group."

[57] See 10 CFR §20.1403(b).

background radiation in the event that institutional controls are lost or are no longer effective at the site.[58] Under exceptional circumstances (reviewed every five years or less) the limit of 100 millirems per year may be relaxed to 500 millirems per year.[59]

- Leaving wastes at the site, such that the site is expected to remain under restricted conditions, is *not* allowed unless it can be shown that further waste removal would result in net public or environmental harm, or unless it can be shown that the residual radioactivity of the remaining wastes is already as low as reasonably achievable (ALARA).[60]
- All "as low as reasonably achievable" or ALARA cleanup determinations must take into account any detriments, such as deaths from transportation accidents, that would result from additional decontamination and waste disposal.[61] When calculating doses for an average member of the critical group, the peak annual dose within the first 1,000 years after decommissioning must be calculated.[62]

DOE must meet the above requirements for the portions of the site for which the agency was assigned responsibility. NRC's procedure for assessing DOE's compliance with the LTR involves a Decommissioning Plan that is proceeding separately and in parallel with the Environmental Impact Statement process. DOE made two presentations in 2004 and 2008 to NRC on its Plan. After the first of these presentations, DOE and NRC agreed in 2004 that the following matters are addressed by DOE regulations and Orders and, therefore, will not be addressed in detail in the DOE Plan: 1) health and safety; 2) environmental monitoring and control; and 3) management of radioactive waste. However, although NRC agreed to have these issues fall under DOE procedures, it is restricted to the time period during which DOE is actively engaged in the West Valley Demonstration Project. Beyond that period, the NRC cleanup requirements would apply, as described above.

2.3.3 The State's Role

There are independent requirements and standards administered by New York State Department of Environmental Conservation (DEC) which apply to the site. Several states, including NYS, require stricter cleanup standards than the NRC. New York's DEC has its own radiological guidance[63] that requires cleanup of radioactive sites to 10 millirems per year, more protective than what NRC allows at

---

58 See 10 CFR §20.1403(e)(1).

59 See 10 CFR §20.1403(e)(2).

60 See 10 CFR §20.1403(a)

61 See 10 CFR 20.1402 and 20.1403(a).

62 See 10 CFR 20.1401(d).

63 Cleanup Guidelines for Soils Contaminated with Radioactive Materials (DSHM-RAD-05-01); http://www.dec.ny.gov/regulations/23472.html

25 millirems per year. As noted earlier, the state-licensed radioactive burial area (SDA) is also covered by separate state radiological license, permit and remediation procedures.

Under federal law, NYS is responsible for 10 percent of the costs and the federal government is responsible for 90 percent of the costs of remediation at the West Valley Demonstration Project site. (NY is responsible for all the costs of the State licensed Disposal Area.) New York is the only state that contributes to the cleanup of a high-level radioactive waste site, and to date, the state has contributed more than $250 million to the project. In 2007, the state filed a lawsuit to ensure that DOE remediated the site in a timely manner, and to seek damages for harm the federal government has caused to the state's natural resources. The lawsuit seeks to clarify the DOE's cleanup responsibility after recent workforce reductions and funding cuts by the DOE at the site. The Attorney General's Office and the New York State Energy Research and Development Authority (NYSERDA) filed the lawsuit to resolve these issues. A Federal Judge required NYSERDA and DOE to first work to resolve their differences through negotiations which started in 2007.

2.3.4 The Environmental Protection Agency's Role

The EPA also has standards that apply to the site, including the Safe Drinking Water Standards with Maximum Permissible Concentrations (MPCs) of radionuclides allowed in primary and secondary drinking water. These MPC’s are generally some of the most protective radiation contamination levels permitted with some exceptions. EPA has a goal of limiting pollutants to causing 1 in a million cancers, which is more protective than NRC and NYS’s guidance. The NRC and EPA also have a Memorandum of Understanding[64] outlining procedures they must follow if it appears the EPA standard will not be met. There are also requirements, imposed primarily by the federal Resource Conservation and Recovery Act (RCRA), which require remediation and regulation of chemical hazards at the site.

[64] Memorandum of Understanding Between the U.S. Environmental Protection Agency and the U.S. Nuclear Regulatory Commission; Consultation and Finality on Decommissioning and Decontamination of Contaminated Sites; [Federal Register: October 24, 2002 (Volume 67, Number 206)][Page 65375-65379]

3. Overview of DOE Cleanup Alternatives

3.1 Assessing Cleanup Options for West Valley

In 2005, the federal Department of Energy (DOE) developed a new Draft Environmental Impact Statement (DEIS) to evaluate the economic, health, and environmental aspects of five cleanup and closure alternatives at the West Valley site. The DOE's draft DEIS is undergoing review by New York State agencies, such as the New York State Energy & Research Authority (NYSERDA) and the Department of Environmental Conservation (DEC). At the time of this publication, the 2005 draft DEIS had not been formally reviewed by the New York state agencies. DOE will apparently release a new draft DEIS in 2008 or 2009. After reviewing the 1996 publicly-released DEIS, the report authors felt it was important to review up-to-date information and obtained a copy of the 2005 draft DEIS from the state agencies. In this section, we review the scope of the pollution problems at the West Valley Site ("site") to assess the cleanup options and any potential shortfalls in the DEIS. The site is large and a complex mix of toxic and nuclear wastes. After reviewing the 2005 draft DEIS, we have targeted our analysis on five areas of significant concern at the site:

- High-level Waste Tanks, now empty but contaminated with significant radioactive residue;
- Process Building, holding radioactive equipment and large quantities of solidified high-level waste;
- Groundwater Plume of strontium-90, with an imminent threat to the waters downstream of the site;
- Waste-filled trenches regulated by the Nuclear Regulatory Commission, known as the NRC-Regulated Disposal Area (NDA); and
- Waste-filled trenches regulated by the state, known as the State-Regulated Disposal Area (SDA).

There are other contaminated regions of the West Valley site, such as two lagoons, low-level waste storage buildings, and a drum cell facility. While the importance of remediating contamination at the entire site cannot be overemphasized, we have chosen to focus on the above-listed five areas of concern because the plans for these sites are markedly different between Alternatives and these separately and jointly pose some of the highest risks to nearby residents and downstream water consumers.

The areas of significant concern, as well as the remainder of the facilities at the West Valley site, have been divided by the DOE into twelve (12) Waste Management Areas (WMA). These are primarily distributed over two plateaus (the north and south plateau), which sit above the banks of Buttermilk Creek. See

Figure 3.1 for an overview map of the West Valley site and the WMA regions.

Figure 3.1
Overview of West Valley processing and disposal site. The numbered regions correspond to DOE-labeled waste management areas (WMAs). Primary process building is WMA 1. High-level waste tanks are WMA 3. Groundwater plume extends from WMA 1 through WMAs 2-5. State licensed Disposal Area (SDA) and NRC Disposal Area (NDA) are bounded by WMA 8 and 9, respectively. Rail tracks lead into the south corner of WMA 9. Buttermilk Creek is about 500 yards to the east of WMA 8.

3.1.1 Long-term disposal problems at the West Valley Site

The geological conditions of the West Valley site present numerous problems to the long-term disposal or storage of long-lived nuclear waste under Buried Waste Alternative 2. These can be organized into several broad categories outlined below, which are discussed in more depth in Section 6.

- The West Valley site sits on a highly erodible plateau, and is at long-term risk of collapsing into the Lake Erie watershed.[65]

---

[65] 1996 DOE DEIS, Volume 2, *Consequences of Erosional Collapse*, Table D-13, D-14, and *Overview of Erosional Process*, Appendix L.

- The soils underlying the West Valley disposal site are not impermeable: contaminated groundwater is able to seep into fractures and has been known to distribute through sand lenses and other sandy strata quickly.[66]
- The landscape around some of the contaminated waste storage facilities was wetland before operations began and parts of the site flood regularly.

The 2005 draft DEIS assumes that mechanical solutions such as walls, barriers, drainage ditches, will be adequate to control waste leakage at the site if wastes are interred onsite over long periods of time. Indeed, for these control mechanisms to operate successfully over the long-term requires that there is government and institutional continuity, adequate budget and personnel, and flawless design of the control mechanisms. While we can question if institutional continuity is likely or if budgets are likely to persist at West Valley for the next thousand years (see Section 5 for this discussion), one of the best indicators we have of the potential for control mechanism failure at the site is from the history of the site itself. Nuclear Fuel Services (NFS) ran a well-funded fuel reprocessing program under federal guidance for a short six years. During this time (and since) there have been numerous serious errors resulting in worker exposure and site contamination. For example:

- Solvents, acids, and corrosive liquids have leaked in several areas of the site, resulting in regions of radioactively contaminated soils and groundwater;
- Some facilities, such as the High-level Waste Tanks and the trenches at the NDA, were designed or installed inadequately, and fractures, leaks, and breakages have caused ongoing problems (see Sections 4 and 5, and Appendix B);
- Some activities, such as decontamination activities were poorly planned or engineered so that shortcut or emergency measures to prevent leaks, flooding or system failure have often been needed throughout the facilities at the site; and
- Despite design specifications, the facility has leaked and released contaminants numerous times. Even the best available controls have historically been inadequate to control contamination at the site.[67, 68, 69, 70]

---

[66] A sand lense is a non-continuous layer of sand which extends (usually horizontally) through other types of soils, such as the clays and silts at West Valley. Groundwater, which otherwise moves slowly through clay-rich soil, moves very quickly through sand. If contaminated groundwater seeps into an undetected or ignored sand lens, the plume could spread far faster than anticipated by groundwater models. A significant sand lense, a 1 foot thick body or lense of very coarse sand, was found in Trench 12 as described in the U.S. Environmental Protection Agency, Region II, *Summary Report on the Low-Level Radioactive Waste Burial Site, West Valley, NY (1963-1975),* EPA-902/4-77-010.

[67] U.S. Environmental Protection Agency, Region II, *Summary Report on the Low-Level Radioactive Waste Burial Site, West Valley, NY (1963-1975),* EPA-902/4-77-010

[68] *WV Nuclear Services Company Investigation of Kerosene-TBP Movement in the NRC licensed Disposal Area,* WNY Nuclear Service Center, WVCP-042, April, 1985

The next five sections briefly describe the status and concerns of the priority contaminated areas at the West Valley site. Figure 3.1 illustrates the layout of the West Valley reprocessing and disposal site. For details on the history of problems at some of these key sites, please refer to Appendix B.

3.1.2 High-level Waste Tanks

Four high-level waste (HLW) underground carbon steel tanks are at the High-Level Waste Storage and Vitrification Facility in Waste Management Area 3 (WMA 3) on the North Plateau as shown in Figure 3.1. These buried tanks were built to store high-level radioactive liquid waste generated from irradiated nuclear fuel reprocessing operations at the site. There are two large tanks 27 ft high and 70 ft across (see Figure 3.2 showing the 8D-1 and 8D-2 tanks) and two small tanks 12 ft in diameter (8D-3 and 8D-4). Approximately 600,000 gallons of high-level waste from irradiated fuel reprocessing generated from 1966 to 1972 was disposed of in these underground tanks.

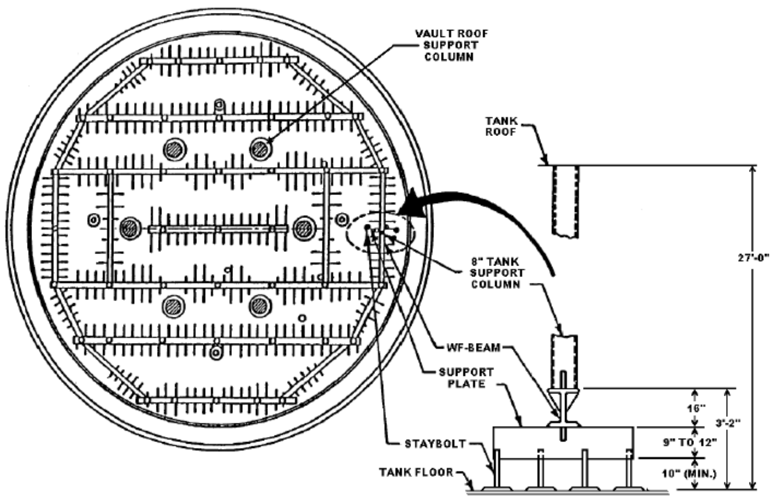


Figure 3.2
Interior map view of high-level waste tank gridwork. (Bottom of Tanks 8D-1 and 8D-2.)

The DOE was directed by Congress in the West Valley Demonstration Act to solidify the liquid high-level waste (HLW), dispose of wastes from the stabilization process, and decontaminate and decommission the facility.[71] From 1996 to 2002, much of the waste was removed from the tanks and vitrified, a process in which liquid wastes are mixed with molten glass to form a more stable solid waste package. There are now 275 canisters holding nearly 630 tons of vitrified waste in the Process Building.

---

[69] US Geological Survey, *Groundwater Hyrdrology and Subsurface Migration of Radioisotopes at a Low Level Solid Radioactive Waste Disposal Site, West Valley, NY,* Open File Report 77-566, 1977

[70] U.S. DOE, 1996 DEIS

[71] WVNSCO and Gemini Consulting Company. 2005. West Valley Demonstration Project, Residual Radionuclide Inventory Estimate for the Waste Tank Farm, Supplemental Report.

Although DOE has conducted this first phase of remediation, the underground tanks still hold high level waste liquid and radioactive sludge. The bottoms of the tanks are lined with a reinforcing grid (see the schematic in Figure 3.2). [72,73] In the large tank 8D-2, this grid has trapped a significant amount of highly radioactive sludge which has proven difficult to remove. Prior to vitrification of the waste, DOE estimated in 1996 that a heel of only 3,530 cubic feet would remain in tank 8D-2 after vitrification.[74] However, both fixed contamination (on the tank walls and surfaces) and mobile contamination (sludge and liquid waste) persists within the tank and we estimate that up to 4,620,000 curies of activity in up to 70,000 gallons (or 9,360 cubic feet of waste) may be at the base of the tank (see the assessment of remaining waste in Appendix B for details). DOE displayed perplexing optimism during the waste management process even though it was known that the gridwork and hardened sludge in the tank made the removal unique and difficult. In 1977 it was determined that washing the tank interior would not be adequate to remove the sludge.[75] Ultimately, after several cleaning efforts, highly radioactive sludge still remains in the tanks, rendering them a high level waste hazard.

The DOE estimates that the two larger tanks hold 14,000 and 5,000 gallons of residual HLW, while the smaller tanks are estimated to each contain 1,800 gallons of HLW. The small tanks contain a large amount of strontium-90 and cesium-137 while the large tanks contain significant amounts of strontium-90, cesium-137, and Plutonium 238, 239, 240, 241, as well as Americium-241.[76] Studies of this area of the site have found these tanks may be structurally unstable, dating from the facility's construction. The waste estimate of the HLW tanks has altered significantly since the 1996 draft DEIS[77]. By any estimate, the HLW tanks contain by far the most radionuclides in liquid form at the site.

Table 3.1 below presents the estimated radioactivity (termed "activity" and measured in curies) of the tanks' wastes from the DOE 1996 and 2005 draft DEIS estimates. Since radioactivity changes over time as elements decay, contamination estimates are given for a specific base year. In the 1996 DEIS, the DOE estimated how radioactive the wastes would be as of 2000. In the 2005 draft DEIS, activities are usually listed for a base year of 2005. For most elements, radioactivity decreases over time as the element decays (the exception is when a short-lived

---

72 US DOE and New York State Energy Research and Development Authority (NYSERDA). 2005. Draft Environmental Impact Statement for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center. DOE/EIS-0226-R.

73 Battelle, Prepared for the US Department of Energy (DOE). 1979. Preliminary Environmental Implications of Alternatives for Decommissioning and Future Use of the Western New York Nuclear Services Center. BMI-X698(Rev.).

74 US DOE and West Valley Nuclear Services Company (WVNSCO). 2002. High-Level Waste Tank Cleaning and Field Characterization at the West Valley Demonstration Project.

75 US GAO. 1980. Status of Efforts to Clean Up the Shut-Down Western New York Nuclear Service Center. EMD-80-69. June 6.

76 2005 draft DEIS, Appendix C, p16

77 1996 draft DEIS, Appendix C, p24

“parent” isotope decays into a long-lived “daughter”, producing more of the daughter isotope over time). Because of this natural decay, we would expect that the 2005 draft DEIS would show that the wastes are slightly less radioactive than in the 1996 DEIS; however the changes in radioactivity levels which we see in the 2005 draft DEIS are far smaller than can be accounted for by natural decay alone: the 2005 draft DEIS has estimated a much smaller volume of waste than the 1996 DEIS. Is this discrepancy because the assessment of the site is more accurate in 2005, or because the DOE is less willing to report large volumes of waste? For radionuclides tracked in both 1996 and 2005, *the 2005 draft DEIS now estimates a reduced inventory by nearly 40%.*

The HLW tanks all sit in underground vaults on top of supporting beams, a configuration not ideal for long-term storage. During construction in 1965, water filled the construction pit to a depth of 30 feet and the vaults and tanks, each weighing 2,850 tons, floated three to four feet off the concrete pad.[78] Mud washed under the vaults, and as the water was removed, the vaults settled on the mud at an angle. As a result, the top and bottom of the vaults cracked. Repairs were made, but it is still impossible to know the integrity of the vaults and the vaults continue to rest at an angle.[79,80] During a process to strengthen the tanks to relieve stress, cracks developed on the outside surface of the vault[81]. Because of these and other cracks, the highest risk tank (8D-1) was designated as a "spare tank", and was used to temporarily store lower level wastes during the vitrification (glass-forming) process described earlier.

According to DOE, the tanks were designed for a 50 year lifespan,[82] but standard industry practice only maintains such tanks for 40 years.[83] The tanks were placed in operation in 1966, and by any standard would now be at the end of their design use time period. These types of tanks also do not have a good record at other locations. For instance, of the 16 high level waste carbon steel tanks at the Savannah River site, 11 have leaked, with the primary cause being nitrate stress corrosion cracking.[84]

---

[78] US GAO. 1980. Status of Efforts to Clean Up the Shut-Down Western New York Nuclear Service Center. EMD-80-69. June 6.

[79] Lawrence Livermore Laboratory. 1978. Seismic Analysis of High Level Neutralized Liquid Waste Tanks at the Western New York State Nuclear Service Center, West Valley, New York. May.

[80] Sierra Club. 1979. Review of the Nuclear Regulatory Commission Seismic Study of the NFS Neutralized High Level Waste Tank.

[81] Sierra Club, *ibid*

[82] Battelle, Prepared for the US Department of Energy (DOE). 1979. Preliminary Environmental Implications of Alternatives for Decommissioning and Future Use of the Western New York Nuclear Services Center. BMI-X698(Rev.).

[83] WVNSCO. 1998. Supplement Analysis II of Environmental Impacts Resulting from Modifications in the West Valley Demonstration Project. DOE/EIS-0081 Supplement.

[84] Westinghouse Savannah River Company. 2001. Functions and Requirements for the Leak Mitigation System of the Savannah River Site Double Shell High Level Waste Tanks. WSRC-TR-2001-00438, Rev. 1.

	1996 DEIS (Y2000)			2005 draft DEIS (Y2005)			Difference between DEIS estimates		
Nuclide	**8D-1**	**8D-2**	**8D-4**	**8D-1**	**8D-2**	**8D-4**	**8D-1**	**8D-2**	**8D-4**
Sr-90	400	200,000	900	2,300	34,000	5,000	1,900	-166,000	4,100
Cs-137	200,000	200,000	1,000	250,000	86,000	2,200	50,000	-114,000	1,200
Eu-154		1,000	10				0	-1,000	-10
Pu-238	80	200	1	6	150	20	-74	-50	19
Pu-239	20	50	0	2	36	1	-19	-14	0
Pu-240		40	0	1	26	0	1	-14	0
Pu-241	600	200	10	44	740	15	-556	540	5
Am-241		2,000	8	0	380	3	0	-1,620	-5
CM-244		200	1	0	80	0	0	-120	-1

Table 3.1: Comparing radionuclide activity (in curies) in West Valley High Level Waste Tanks in the 1996 DEIS and 2005 draft DEIS. Parentheses indicate year of activity estimation. Negative values (in red) indicate that the estimated level of activity in the tank is lower in the 2005 draft DEIS than the 1996 DEIS. Tank 8D-3 was not as heavily contaminated and was not included.

As a result of the short-lived reprocessing project , a much larger quantity of radioactive waste was produced. In the pretreatment and vitrification process alone, approximately 18,000 71-gallon drums[85] or 1,278,000 gallons of low-level waste[86] and 1,250,000 lbs of vitrified solid glass high level waste stored in 275 canisters were produced. In addition, all four of the HLW tanks contain radioactive waste.

3.1.3 Contaminated Process Building

The Process Building on the north plateau was built by Nuclear Fuel Services (NFS) in 1963 to recover uranium and plutonium from irradiated fuel. The building

---

85 US DOE. 2007c. DOE News: West Valley Demonstration Project Achieves Milestone, 11,088th Low-Level Cemented Waste Drum Shipped Offsite. http://www.emcbc.doe.gov/files/news/Press%20West%20Valley%20Waste%20Drums%20Jul07.pdf. Accessed March 5, 2008. July 2.

86 Low-level radioactive waste (LLRW) is specifically defined for the West Valley site in Section 6 (6) of West Valley Demonstration Project Act and this is the controlling definition. LLRW is also classified by the Nuclear Regulatory Commission (NRC) in 10 CFR §61.55 which could apply to wastes sent off-site. In this report, we use the term low-level waste as it is defined in the Act. However, the authors and contributors to this report do not consider low-level waste to be low risk.

has a footprint of 130 × 270 feet, is 80 feet tall, and extends approximately 100 feet underground.[87] Various rooms (known as "cells") in the process building are contaminated from NFS activities, and the building now holds the 275 vitrified solid glass high-level waste canisters from the waste tanks. The process building is also the source of a groundwater plume of contamination extending to the northeast of the building.

The New York State Energy Research and Development Authority (NYSERDA) has stated that much of the monitoring and maintenance costs at the West Valley site are from maintaining the Process Building, unused except for storage since the early 1970s.[88] The DOE estimates that the building contains approximately 12,000 curies,[89] about two-thirds of which is from strontium-90 and cesium-137. Similar to the story at the high-level waste tanks, however, the contamination estimate has changed somewhat from the 1996 DEIS to the 2005 draft DEIS. Even taking into account decay periods, the amount of Plutonium-241 and Plutonium-238 decreased more than expected between the 2005 and 1996 draft DEIS estimates.

3.1.4 Groundwater Plume of Contamination

During NFS operations in the 1960s, an acid recovery line in the southwest corner of the process building leaked an unknown amount of radioactive nitric acid into the groundwater at the site.[90] This underground plume has polluted the groundwater with primarily Strontium-90 and its short-lived daughter Yttrium-90. The contaminated groundwater plume has concentrations of 10 microcuries per liter and extends 850 by 200 feet, which includes the entire region under the process building (see Figure 3.3). Concentrations of over 1.2 microcuries per liter have also been found on the east side of the process building. In 1995, a groundwater recovery system was installed to attempt to slow the plume. However, as of 2003, ground and surface water samples show that Strontium-90 levels still exceed government standards[91, 92]. The plume head (front of the spreading pollution) is now approaching Erdman and Franks Creeks on the east side of the site and is reaching, if not having already breached, an area of more rapid groundwater flow into Franks Creek[93].

The 1996 DEIS suggests that with current flow rates, a Cattaraugus Creek resident could expect doses up to 0.3 millirem (mrem) per year by 2010 and up to 1 mrem per year in 2050.[94] In contrast, DOE's 2005 draft DEIS now estimates that with no

---

[87] 2005 draft DEIS, Chapter 2, p6

[88] Personal correspondence Paul Bembia, NYSERDA. November, 2007.

[89] PC *ibid*

[90] 2005 draft DEIS, Appendix C, p36

[91] 2005 draft DEIS, Chapter 3, p40

[92] "In 2003, 11 monitoring wells had gross beta concentrations that exceeded the DOE Derived Concentration Guideline for strontium-90 (1.0 × 10-6 microcurie per milliliter)."

[93] 1996 draft DEIS, Chapter 4, p23

[94] 1996 draft DEIS, Chapter 5, p107

cleanup action, the plume will only reach a maximum dose of a greatly reduced 0.027 mrem per year in just under 100 years.[95, 96] While these doses are significantly lower than regulatory standards (EPA recommends no more than15 mrem per year from human-created sources: see Section 4), the release of radioactive groundwater into the local watershed represents a preventable dose to the public.

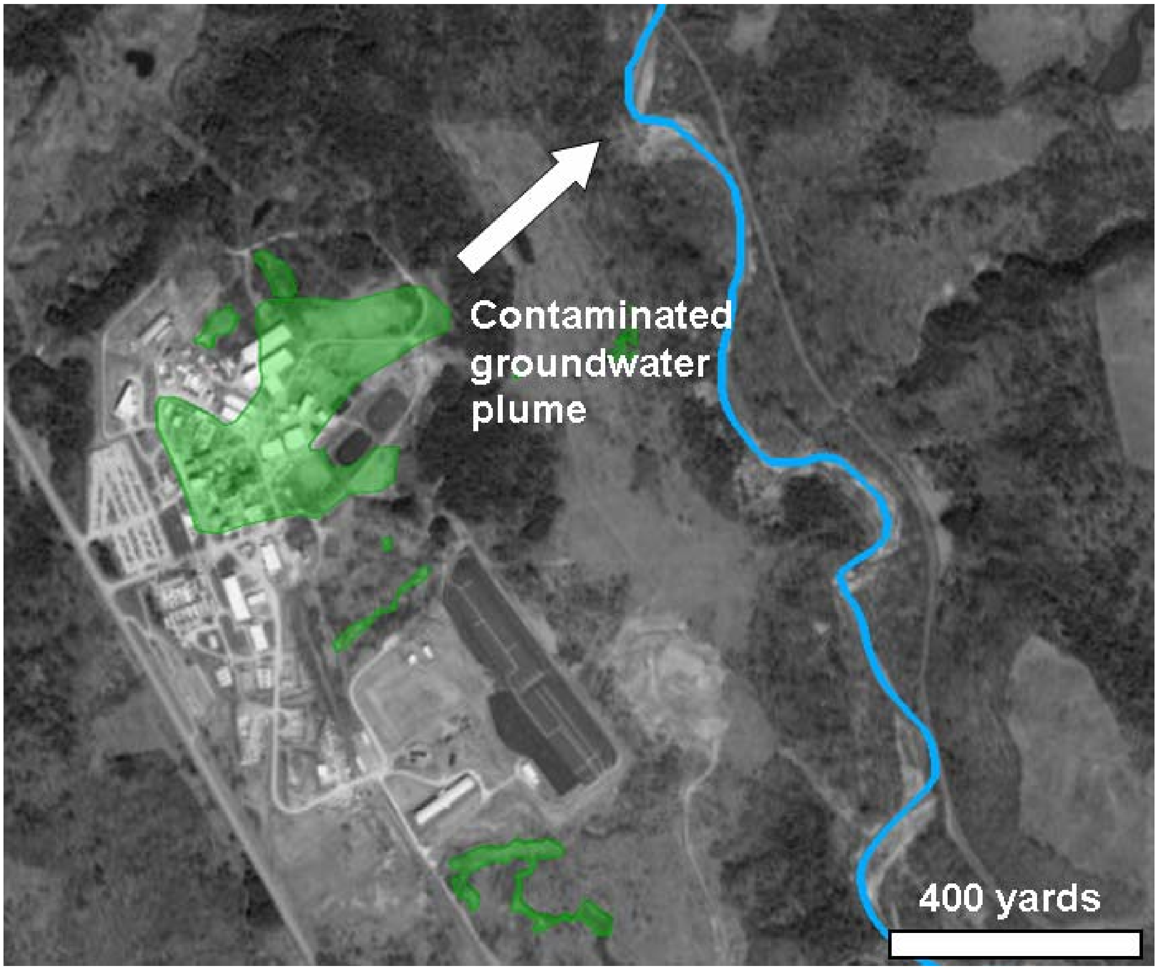


Figure 3.3
The groundwater plume contaminated with strontium-90 (indicated in green) is believed to have originated at the Process Building (WMA 1) and is migrating towards Buttermilk Creek (indicated in blue).

3.1.5 Nuclear Regulatory Commission Disposal Area (NDA)

The federal Nuclear Regulatory Commission (NRC) licensed Disposal Area (called the NDA) is located on the south plateau in Waste Management Area 7 (WMA 7)

---

95 2005 draft DEIS, Appendix H, p22

96 The 2005 draft DEIS also assumes that "mitigating actions are performed to minimize offsite impacts for the first 100 years, after which institutional controls lapse and the Process Building and High-Level Waste Tanks fail.

of the site. The NDA is approximately 400 feet wide and 600 feet long comprised of a series of trenches, pits and deep holes some as deep as 70 feet, storing approximately 363,000 cubic feet of mixed toxic and radioactive waste (see Figure 3.4 for diagram). The NDA received wastes with higher radioactivity than the adjacent state-operated trenches.

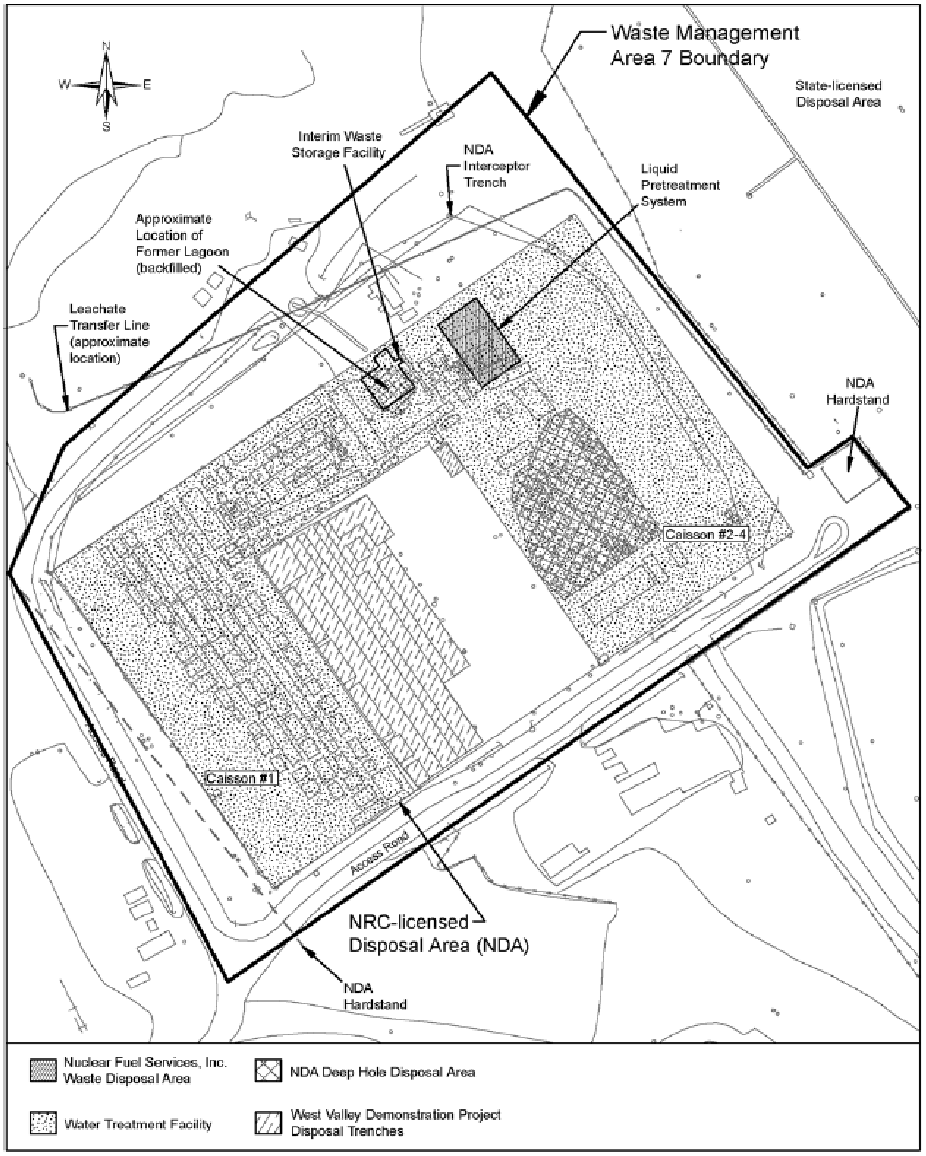


Figure 3.4
Diagram of NRC Disposal Area (NDA) trenches and holes. Entire area is currently covered over with soil.

The NDA was operated by Nuclear Fuel Services (NFS) under an NRC license for disposal of solid radioactive waste from irradiated nuclear fuel reprocessing operations. The NDA was licensed to bury all waste generated in the operation and maintenance of the reprocessing plant. After 1966, solid radioactive wastes that exceeded 200 millirad per hour and other materials not allowed in State-Licensed

Disposal Area (known as the SDA) were buried at the NDA. From 1966 until 1981, 163,000 cubic feet of radioactive waste was disposed of in a U-shaped area along the east, west, and north boundaries of the NDA. This region contains all types of reactor hardware, irradiated fuels, sludges, solvents, filters, discarded equipment, trash, dirt and some large unique items (such as an NFS railcar).[97] From 1982 until 1986, another 200,000 cubic feet of radioactive waste from decontamination and decommissioning activities at the site were buried in the NDA.[98] DOE notes that the contents of many buried containers are unknown as they were only recorded as "waste" [99] or "junk" [100] in the past. No new waste has been added to the NDA since 1986.

The NDA has a history of leakage. Groundwater has consistently penetrated and leaked into the trenches, creating a radioactive leachate (contaminated liquid) sitting at the bottom of the trenches and holes. The DOE estimates that there is up to one million gallons of "low level" leachate (defined as "low level" by its radioactivity, but still a substantial risk) in the bottom of the NDA trenches. The 2005 draft DEIS indicates that the NDA has an overall radionuclide activity of about 115,000 curies, primarily derived from cobalt-60, strontium-90, cesium-137, and plutonium-241.[101] In contrast, the 1996 draft DEIS estimates 132,000 curies buried in the NDA,[102] showing far higher concentrations of plutonium 238, 239, and 240 (by factors of 20, 4.5, and 3.8, respectively).

The NDA is bounded to the north and west by Erdman Creek (see Figure 3.6). The pathway from the NDA into the creek is blocked by an interceptor trench, installed below the weathered till layer when chemical and radiological wastes were found in a test well, migrating towards Erdman Creek.[103] It is unknown if or how effective this interceptor trench has been at the site.

In 1983, plutonium in a chemical solvent mix was detected migrating approximately 63 feet from the NDA. The leak apparently originated from eight drums in NDA holes 10 and 11. DOE found that the contamination did not move in a normal plume-like dispersion and appeared to perhaps have traveled through fractures. This is problematic because the movement of contamination through fractures and sand lenses is relatively *unpredictable* compared to the movement of a

---

97 US DOE and NYSERDA. 1996. Draft Environmental Impact Statement for Completion of the West Valley Demonstration Project and Closure of Long-Term Management of Facilities at the Western New York Nuclear Service Center. DOE/EIS-0226-D.

98 US DOE and New York State Energy Research and Development Authority (NYSERDA). 2005. Draft Environmental Impact Statement for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center. DOE/EIS-0226-R.

99 Oak Ridge National Laboratory (ORNL), R. Clapp and S. Herbes. 1985. Research Plan for Investigating Radionuclide Migration at the West Valley Facility Disposal Area.

100 1996 DEIS, Appendix C, p43

101 2005 draft DEIS, Appendix C, p26

102 1996 DEIS, Appendix C, p41

103 2005 draft DEIS, Appendix C, p26

groundwater plume through homogenous soils. In particular, if a fluid, such as a contaminant, finds a fracture or other path of least resistance, it can migrate through the ground many times faster than through non-fractured ground.

According to DOE, there are numerous small gullies and potential landslides or slumps penetrating into the northern corner of the NDA site from Erdman Creek,[104] raising serious concerns about the long-term stability of this site (see Section 6 for more information on site erosion).

3.1.6 State Licensed Disposal Area (SDA)

The State-licensed Disposal Area (SDA) on the south plateau of the site is roughly 15 acres and contains approximately 2.4 million cubic feet of waste, about as much as can be carried in 6,000 dump trucks. The waste is from various state projects and is buried in drums, crates, cardboard boxes, and plastic bags in 14 trenches[105] from a wide array of sources, including universities, industrial wastes, and commercial reactors (see Figures 3.5 and 3.6).

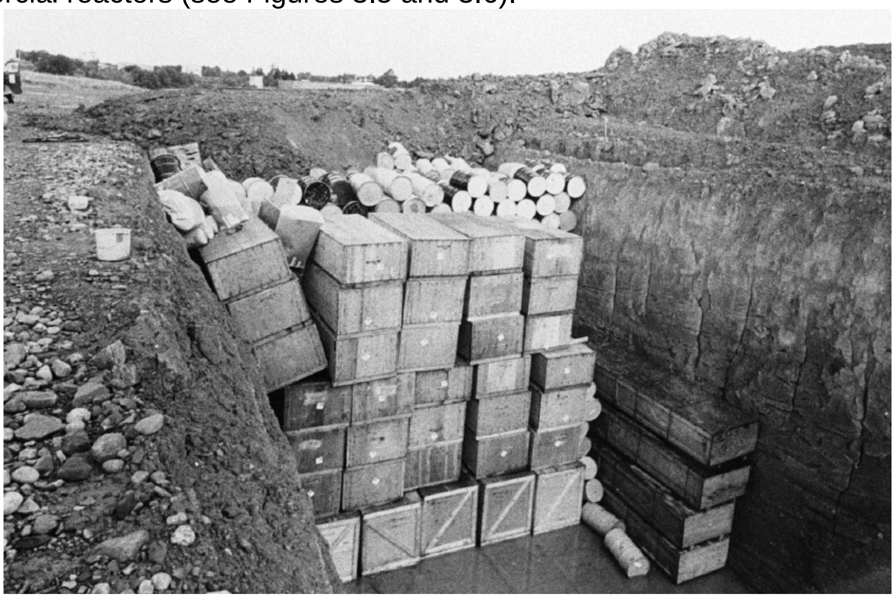


Figure 3.5
Photograph of wastes in wooden boxes and other canisters being loaded into a trench in State licensed Disposal Area (SDA).

The SDA site sits adjacent to the NDA on a plateau that is a terrace of Franks Creek called the "South Plateau". The northwest boundary is defined by the bank of Erdman Brook, and its east and southeast edges are constrained by the steep banks of Upper Frank's Creek, known as the "North Plateau". The 1996 DEIS indicates two active gullies that reach the boundary of the SDA, and several slumps and slides leading into Frank's Creek.[106] The SDA is comprised of two

---

[104] 1996 DEIS, Appendix L, p6

[105] 2005 draft DEIS, Appendix C, p28

[106] 1996 DEIS, Appendix L, p6

sections, the north disposal area and the south disposal area, each with seven trenches, and is currently covered by a geomembrane comprised of rock, dirt, fabric, and clay layers (see Figure 3.7 for location and layout). The SDA stopped accepting waste in 1975, when a trench cap broke, exposing waste and allowing contaminated water to flow out of the trenches.

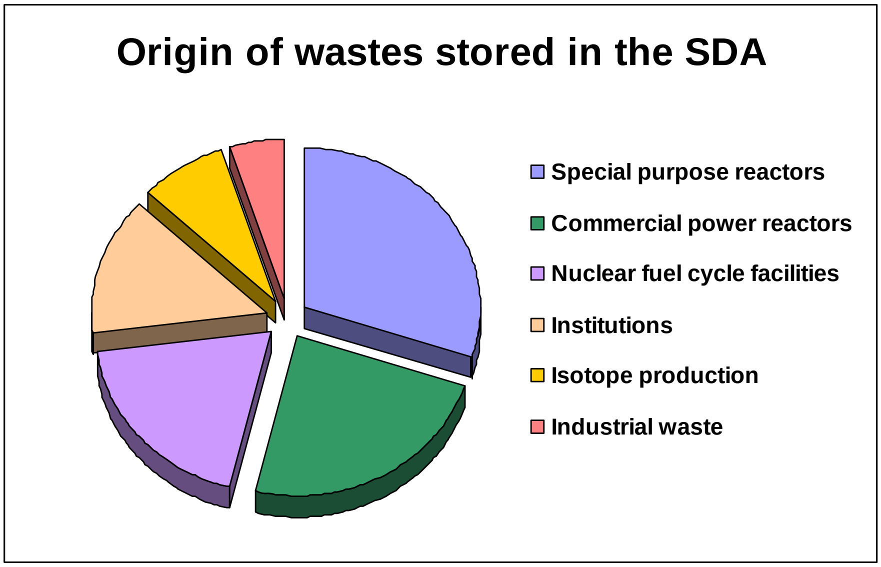


Figure 3.6
Origin of wastes stored at the State licensed Disposal Area (SDA) by volume.

It is known that the till below the SDA trenches is contaminated with tritium (a radioactive isotope of hydrogen) and other radionuclides. DOE believes that there is considerable leaking and leachate in the SDA trenches.[107] The 2005 draft DEIS estimates that SDA has an overall activity of 129,000 curies, with much of the activity due to tritium, nickel-63, cesium-137, a curiously large pool of meta-stable barium-137m and plutonium-238.[108]

The SDA is particularly vulnerable to groundwater seepage. Trench 14 of the SDA is adjacent to a wetland (see Figure 3.8), which is covered by a geomembrane; a second wetland is approximately 400 feet to the southwest.

Water was first publicly reported as seeping from the trenches in 1975, leading to the cessation of waste burial at the SDA. In a 1976 report, the federal Atomic Energy Commission (AEC) noted that NFS reported increasing water levels in closed burial trenches and that the possibility of overflow loomed. Water was especially quick to make its way into Trench 14, immediately adjacent to a former wetland area. Water was pumped from both the northern and southern sections of the SDA, treated, and released into the local stream from 1975 to 1981. The water entered the trenches from both infiltration and groundwater flow.

---

[107] 2005 draft DEIS, Chapter 2, p12

[108] 2005 draft DEIS, Appendix C, p30

In 1987, the continual water infiltration into trench 14 led NYSERDA to construct a concrete barrier four feet thick and 130 feet long, between a sandy area to the west of the trench. A sandy gravel area to the west of this barrier was then excavated and the area was refilled with clay. This barrier was ineffective as water within Trench 14 began to rise again. A slurry wall was installed in 1992 to the west of Trench 14 to control groundwater infiltration into the SDA. The slurry wall is 30 feet deep, 3 feet wide and 850 feet long (see Figure 3.7). We do not know how effective this system has been in preventing groundwater migration through the system.

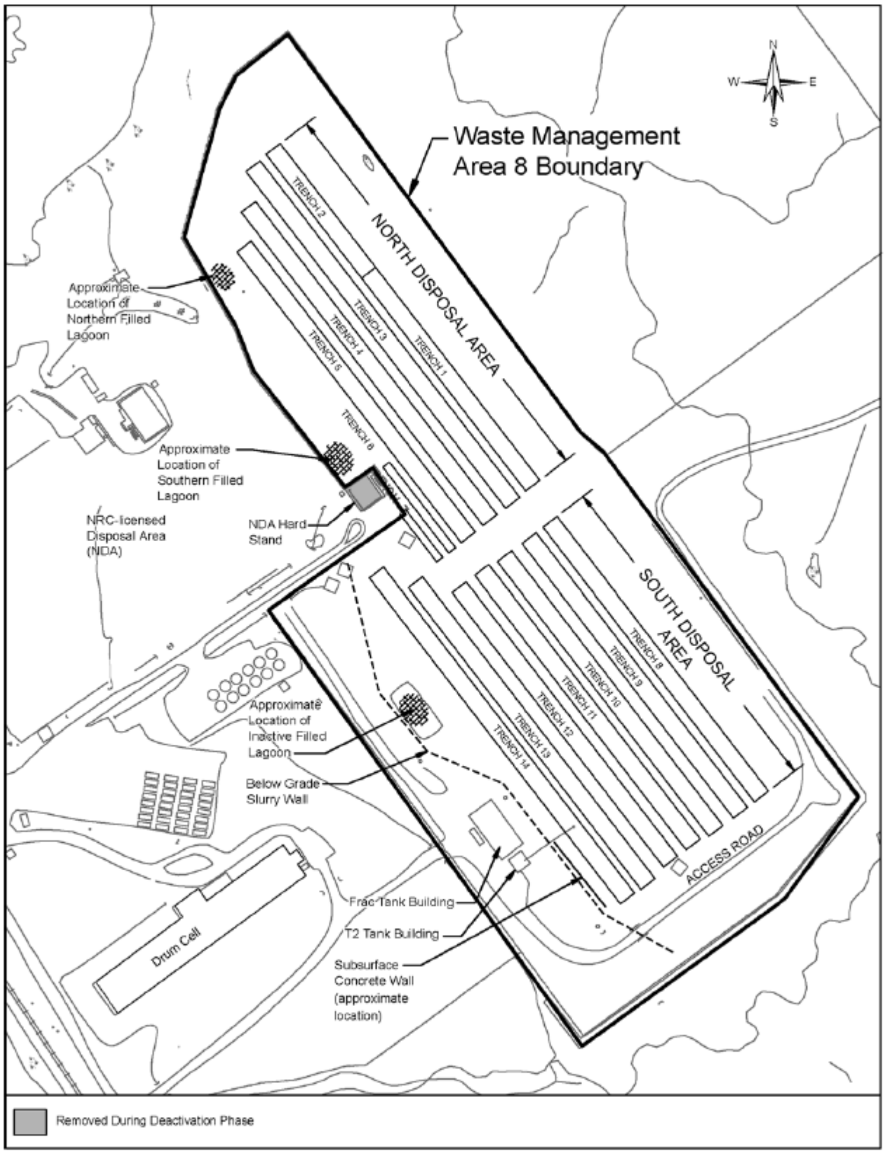


Figure 3.7
Diagram of State-licensed Disposal Area (SDA) trenches. Area is currently covered.

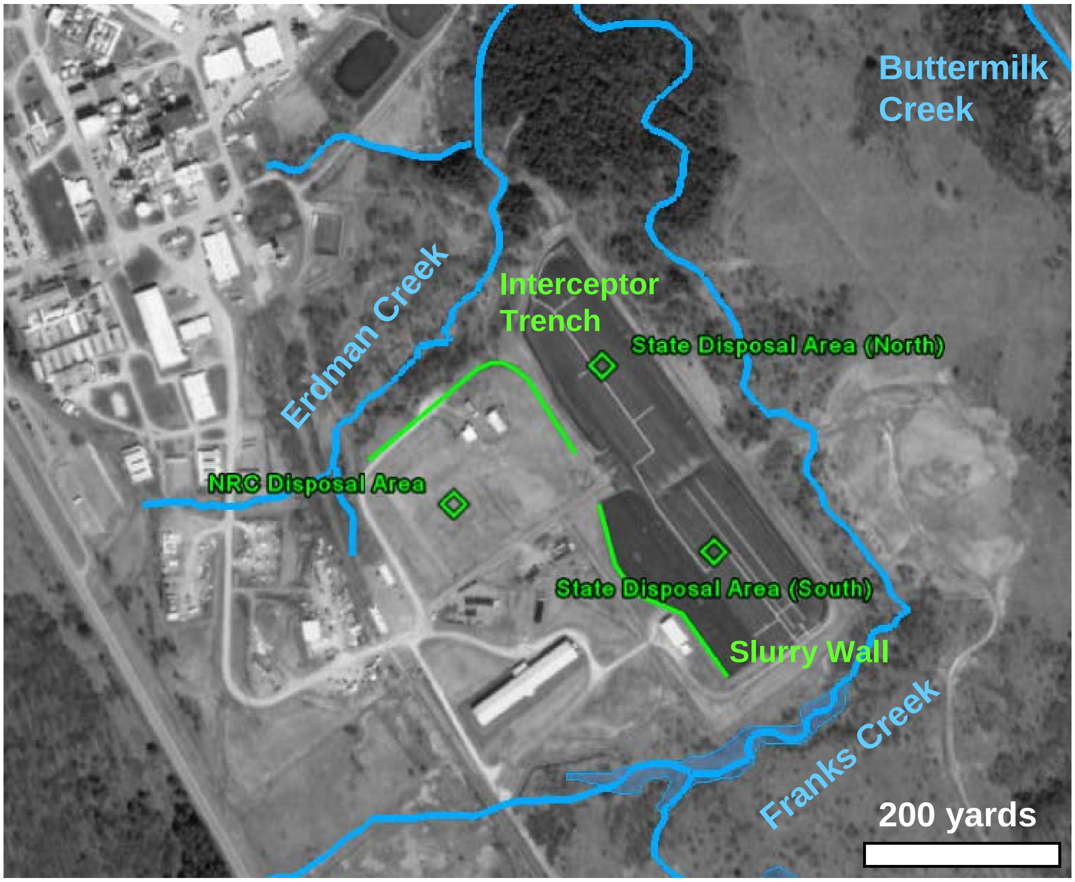


Figure 3.8
Location of NRC Disposal Area (NDA) and State Disposal Area (SDA) relative to local watershed (Erdman, Buttermilk and Franks Creek).

3.2 Cleanup Options

The Department of Energy's 2005 draft DEIS discusses five alternatives for remediation and decommissioning of the West Valley site. The five options are supposed to cover a range of risks and costs, but, as we will discuss in Section 9, they cannot necessarily be said to be comparable options. The cleanup options proposed by DOE are as follows.

- <u>Alternative 1, "Removal":</u> The waste is excavated, packaged and disposed of off-site, and the site is eventually released for public or unrestricted[109] use. DOE's estimated cost over the estimated 73 years to implement this cleanup is $10.6 billion. We will use the term "Waste Excavation" for Alternative 1.
- <u>Alternative 2, "Removal and Decay":</u> Some contaminated areas and buildings at the site are excavated and decontaminated, including the solid

[109] The term "unrestricted" here means that the site is deemed safe for any use after cleanup. No use or access is restricted.

glass (vitrified) high-level wastes, and shipped off-site, but the NDA and SDA buried wastes are left indefinitely. The cost over 16 years is estimated at $1.6 billion. We will use the term “Buried Waste” for Alternative 2.

- Alternative 3, “Prompt In-Place Closure”: Buildings and above-ground structures are demolished and removed, the solid glass (vitrified) high level wastes are stored in a new building on-site until a suitable disposal site is found, but the NDA and SDA buried wastes are left indefinitely. In addition, the high-level waste tanks are filled with cement and left in place. Cost over 31 years is $1.2 billion.
- Alternative 4, “Delayed In-Place Closure”: Nearly identical to Alternative 3, but the Process Building is not immediately demolished and is used to store the solid glass high-level wastes until a suitable site is found. In addition, the high-level waste tanks are filled with cement and left in place. Cost over 37 years is $1.2 billion.
- Alternative 5, “No Action”: Management of the site in its current state is continued indefinitely without any explicit efforts to remediate the site. This option is not considered viable by the DOE.[110] Cost over 100 years is $1.7 billion.

In the following section, we describe the DOE cleanup options. This study focuses in particular on Alternatives 1 and 2 as they are both the most politically likely options to be considered in their level of protection, certainty, or cost.

3.2.1 Waste Excavation and Off-Site Removal: Alternative 1

DOE calls "Alternative 1," or Waste Excavation, the option designed to clean up radioactive and hazardous waste contamination at the West Valley site to meet federal and state criteria[111] for closure and "unrestricted use". It would be the most complete cleanup of the site. Alternative 1 requires all the waste be excavated (or exhumed), packaged and removed off-site to federal facilities (to be determined). At the completion of these activities, which DOE estimates would take approximately 73 years, the site could be reused without any restrictions and would no longer pose a threat to downstream or nearby communities.

The Waste Excavation cleanup has an order of activities to slowly remove all materials at the West Valley site. We focus here on those activities related to the closure of the five “high priority” areas described earlier in Section 3.1.

High-Level Waste Tanks

A confinement structure would be constructed to remove the HLW tanks. This waste tank farm waste processing facility would be built over the underground

---

110 2005 DRAFT DEIS, Chapter 2-30

111 The site would need to meet criteria of the Nuclear Regulatory Commission (NRC), Resource Conservation and Recovery Act (RCRA), and the New York State Department of Environmental Conservation (NYSDEC).

tanks and would handle all waste removal, decontamination and demolition activities of the high level waste in the waste tanks.[112] The nearly nine-story facility would have a two-acre footprint[113] and three to five-foot thick walls (see Figure 3.9). All work on the HLW tanks would be handled by remote operation with robotic arms.

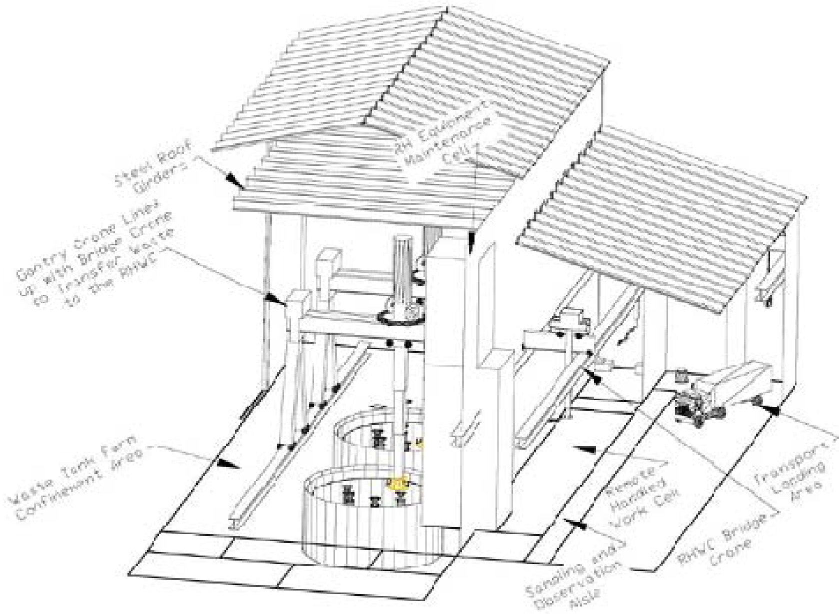


Figure 3.9
Confinement structure proposed in Waste Excavation Alternative 1 for the exhumation of the high-level waste tanks.

The most significant contamination in the HLW tanks is expected to be in the residual liquid in the bottom of tanks 8D-1 and 8D-2, holding 14,000 and 5,000 gallons of high level waste,[114] respectively, and in filters designed to capture radionuclides and remove excess liquid from wastes. The filters, estimated to hold 94,000 curies of cesium-137,[115] would be flushed out; the flushing liquid would be mixed into cement to form a Class C radioactive solid waste. The tank contents would be flushed and solidified with grout. These solids, as well the demolished tank shells, would be transferred into 55-gallon drums for off-site disposal.

Process Building

The process building would be demolished, aside from rooms required to support decommissioning activities. For example, the ventilation and contamination removal rooms will remain in operation to allow workers to remove the vitrified

---

112 Closure Engineering Report, Alternative 1. 2005. p100

113 Closure Engineering Report, Alternative 1. 2005. p103

114 This form of high level waste is termed transuranic (TRU), meaning that it contains heavy elements with very long half-lives.

115 Closure Engineering Report, Alternative 1. 2005. p120

(solid glass) high-level waste containers currently stored in the building.[116] At every stage, each room would be tested and decontaminated if possible before demolition occurs. DOE assumes that most of the equipment in the process building will be classified as NRC Class A and Class B waste, while building materials are classified as LSA (low specific activity).[117]

Groundwater Contaminated Plume

The DOE estimates that to reduce groundwater contamination doses down to 4 millirems per year, as required by federal statute, would require the removal of all contaminated groundwater above 42 picocuries per liter (pC/L). However, since it is unknown exactly where the polluted plume will have migrated to by the time excavation begins, the DOE proposes to dewater soils above 10 pCi/L,[118] a significantly larger area. To accomplish this task the DOE would drop heavy steel sheets into the ground at the 10 pCi/L boundary, pump out the groundwater from inside the giant steel ring (see Figure 3.10, below), and then remove the top two feet of soil. DOE estimates approximately 27 million gallons of water would be pumped from ditches and treated in a filter to remove the strontium-90, which they expect to find in concentrations ranging from 10 to 1,000,000 pC/L.[119] The remaining contaminated soils would be excavated to a depth of approximately 2 feet, dried at a custom-built soil-drying facility, and packaged for disposal off-site as low-level waste.

NDA and SDA Areas

Several new buildings would be required for processing and disposing of the waste in the NDA and SDA.[120] A leachate processing facility would be built to separate organics, solids, and radionuclides from leachate found in the bottom of the NDA and SDA trenches. The DOE estimates over 1 million gallons of leachate in the NDA and SDA would need to be pumped and processed.[121] A container management facility would be built to dry, sort, and package wastes excavated from the trenches and holes. The actual excavations would be done by remote crane operation under three enclosures or large sealed buildings surrounding NDA trenches 1-7 and the NFS holes, North SDA trenches 1-7 and the South SDA trenches 8 – 14.[122] NFS holes suspected to contain high-level waste would be covered with a secondary tent within the enclosure building to reduce contamination during excavation. All facilities built to process the NDA and SDA

---

116 Closure Engineering Report, Alternative 1. 2005. p87

117 Classes A, B, C and Greater-Than-C wastes are all in the so-called “low level” radioactive waste (LLRW) NRC classification; Low-specific activity (LSA) radioactive materials are non-fissile or are ‘excepted’ under 10 CFR 71.15, and which satisfy the descriptions and limits in 10CFR 71.

118 Closure Engineering Report, Alternative 1. 2005. p157

119 Closure Engineering Report, Alternative 1. 2005. p159

120 Closure Engineering Report, Alternative 1. 2005. p131

121 Closure Engineering Report, Alternative 1. 2005. p134

122 Closure Engineering Report, Alternative 1. 2005. p144-146

wastes would have to be decontaminated, decommissioned, and disposed of off-site as low-level waste.

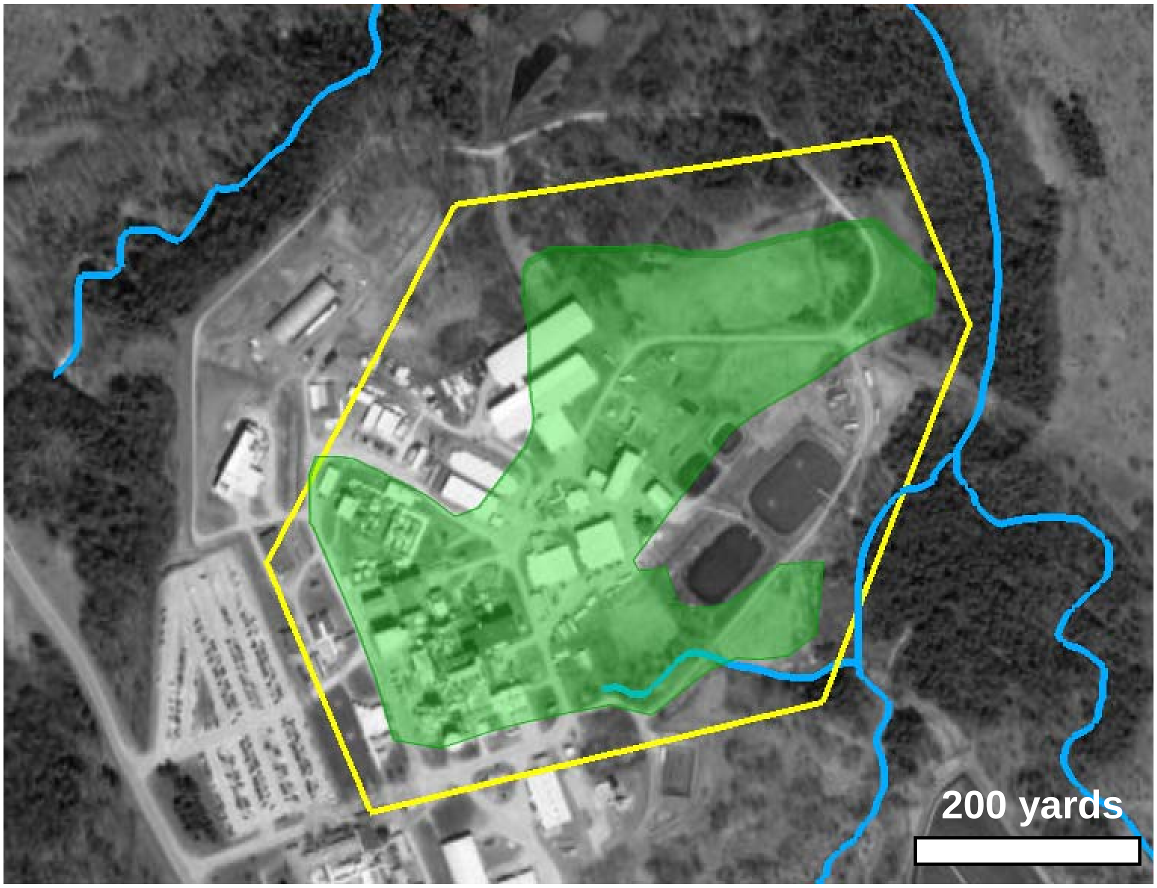


Figure 3.10
Buried steel sheet walls (yellow) proposed to confine the groundwater plume (green) at the West Valley site in Waste Excavation Alternative 1.

<u>DOE Estimated Cost for Alternative 1</u>

The DOE's DEIS estimates that Alternative 1 is the most expensive option at 10.6 billion dollars.[123] The largest single cost is disposing of the high-level wastes which are expected to be unearthed at the NDA and SDA facilities, and the high-level waste tanks. Currently, there are no government or commercial facilities available for the disposal of high-level wastes. However, for cost estimation purposes, the DOE uses costs estimated for the Yucca Mountain site, if that disposal facility becomes available. The estimate is for half a million dollars ($500,000) for a 31.4 cubic foot container disposal fee at Yucca Mountain. At over $21,000 per cubic foot ($ft^3$), the disposal costs of all high level wastes from the West Valley site are estimated to cost $3.3 billion dollars.

It is beyond the scope of this study to do a Full Cost Accounting for the potential

---

123 Closure Engineering Report, Alternative 1. 2005. p283-285

sites to which the exhumed waste or dismantled buildings would be sent, but it is likely that no site will be capable of completely isolating the waste for the extremely long time period that some of it remains radioactively dangerous. These costs must be factored in to the decisions being made currently to resume reprocessing, open new low-level radioactive waste burial grounds, and to generate more radioactive waste from nuclear power and its fuel chain facilities.

Other significant costs in the DEIS are the removal of the high-level waste tanks ($834 million), the excavation and closure of the NDA and SDA ($1,044 and $1,557 million, respectively), and the complete excavation of the strontium-90 groundwater plume ($2,100 million).[124] In Alternative 1, $7.3 billion are the actual costs of closure activities (in other words, they are *not* allocated for waste disposal costs). Of these $7.3 billion, a vast majority (over $5.5 billion) are wrapped up in the NDA, SDA, groundwater plume, and HLW tanks.

	Materials and Labor	Waste Disposal[125]	Contingency	Total Cost
HLW Tanks	539,923,154	69,812,367	224,407,743	834,143,264
Process Building	181,780,154	44,365,797	71,614,355	297,760,306
Groundwater Plume	192,567,978	1,487,137,213	419,926,298	2,099,631,489
NDA	519,094,293	316,348,598	208,860,724	1,044,303,615
SDA	852,696,251	392,525,959	311,305,553	1,556,527,763
Other facilities	935,197,681	170,214,163	358,466,782	1,463,878,626
HLW disposal				3,321,700,000
Total	,221,259,511	2,480,404,097	1,594,581,455	10,617,945,063

Table 3.2: Summary of Waste Excavation Alternative 1 costs in dollars, from 2005 draft DEIS.

3.2.2 Buried Waste, Partial Removal: Alternative 2

The Buried Waste Alternative 2 proposed by the DOE is apparently designed to remove accessible and immediately dangerous high level wastes from the site, but leaves the vast bulk of buried waste at the West Valley site indefinitely. According to DOE design, this alternative is structured to satisfy federal radiological criteria requirements in 10 CFR §20.1402[126] for the north plateau, while retaining “institutional controls” on the south plateau. The DOE classifies institutional controls into three categories of active / passive controls (guards and signs), land ownership, and physical controls (gates, fences, tanks, and other barriers).[127] Institutional controls are discussed in Section 5. In Alternative 2, institutional

---

124 These do not include the costs associated with the construction, operations, or closure of the leachate treatment facility, the container management facility, or the soil drying facility, which will all be used for the closure of these sites. These costs add up to over $1,135 million.

125 Waste disposal here refers to disposal of “low level” wastes (Class A through Class C), low-specific activity wastes, and non-contaminated wastes. High level wastes requiring special federal facilities for disposal are accounted for under HLW disposal.

126 2005 draft DEIS, Chapter 2-20

127 DOE, 2000. Institutional Controls in RCRA & CERCLA Response Actions. DOE/EH-413-0004.

controls include site fencing and security, guards, erosion barriers, and geomembrane covers over buried wastes. It should be noted that according to the DEIS and supporting documents, the risk assessment of the site assumes that institutional controls are "permanent" and "do not degrade."[128] DOE's Alternative 2 only includes actions at the site for 30 years, and then a period of "monitoring and maintenance" for 200 years thereafter. Although some highly radioactive wastes would remain hazardous for tens of thousands of years, the DOE's DEIS does not propose any plan for taking care of these wastes for more than the next two hundred years.

DOE appears to believe and assert that the implementation of Alternative 2 would pose a relatively low immediate risk to onsite workers and the surrounding population, and provides an argument that the Alternative could be implemented at a relatively low cost. Thus, we infer that this Alternative is likely to be pursued by the DOE. Contrary to this line of reasoning, our analysis will show that this alternative is neither prudent nor low risk, but we selected this option to scrutinize in more detail for the above reasons. Below is a summary of the DOE's Alternative 2 cleanup and closure activities for each of our high priority areas.

High-Level Waste Tanks

The decommissioning of the waste tank farm in Alternative 2 is nearly identical to the process in Alternative 1. A confinement structure would be built over the tanks, and all operations within the confinement structure would be done by remote operation with robotic arms. The tanks and their adjoining structures would be dissembled, size reduced, and packaged into drums and vaults for transportation to an off-site disposal or storage site. High-level liquid waste and suspended solids in the tanks would be mixed with grout to solidify the material, and transferred into 55 gallon drums for transfer to a disposal site.[129] Unlike Alternative 1, floor pads are left in place at the site. DOE assumes these structural concrete floor pads are not contaminated with radioactive wastes, and are not removed in this alternative.

Process Building

The process of deactivating and decommissioning the process building is nearly identical to that of Alternative 1 (waste excavation and removal). The building is first deactivated, pipes and connections removed, and radioactive waste kept in interim storage on-site is then removed for disposal off-site. The building is then decontaminated in stages and demolished in a controlled fashion to control residual waste. Unlike Alternative 1, floor pads are left in place at the site.

---

128 According to the 2005 draft DEIS, Appendix H, p18: "[I]mpacts take credit for institutional controls that prevent access to the waste management areas and maintain engineered features such as erosion control structures and engineered caps. The institutional controls are assumed to be in place permanently, and the erosion control structures and engineered cap do not degrade."

129 Closure Engineering Report, Alternative 2. 2005. p96

Groundwater plume

Unlike the Waste Excavation Alternative (1), the Buried Waste Alternative (2) does not seek to remove contaminated soils or the groundwater plume, nor does it prevent the migration of contaminated groundwater down towards open streams and rivers. The DOE DEIS proposes to isolate only the most highly contaminated groundwater and soil from under the removed Process Building (the source of the plume), pump out the water and remove the soils using conventional equipment.[130] The steel sheets would then be removed and the small area filled back in. The remaining groundwater plume, already moving towards Franks Creek, would not be touched.

NDA and SDA

One of the most significant differences between Alternatives 1 and 2 is if the NDA and SDA facilities are excavated and cleaned up, or left in the ground. In Alternative 1, all of the trenches are exhumed, while in Alternative 2 they are left in place and theoretically stabilized against erosion, infiltration, intruder penetration, and groundwater contamination over the short-term.

DOE proposes the following sequence of events for Buried Waste Alternative 2.

- Site preparation at the NDA[131] and SDA[132]
    - Removal of all surface structures at the NDA and SDA.
    - Seal the NDA interceptor trench that is currently draining contaminated groundwater. Construct a hydraulic barrier and French drain up-gradient of the NDA and SDA sites to prevent groundwater movement through the system.
    - Construct erosion controls, including surface drainage channels and a large dike to divert surface waters into a holding pond. Deploy riprap (large boulders wrapped in steel mesh) along the banks of Erdman Brook to prevent the stream from cutting towards the NDA and SDA areas.
- After these first actions, the site would be monitored, but untouched for 100 years. Periodically, the geomembrane covers would be replaced, allowing biodegradable items buried in the trenches to compact.
- After 100 years, the geomembrane covers would be replaced with “engineered multi-layer caps”, a combination of synthetic materials and soils.

130 Closure Engineering Report, Alternative 2. 2005. p152

131 Closure Engineering Report, Alternative 2. 2005. p125-129

132 Closure Engineering Report, Alternative 2. 2005. p144-148

Erosion Controls

Because of the vast amount of low to high-level radioactive waste remaining *in situ* (buried or in place) at the West Valley site after Alternative 2 closure, the erosion mitigation becomes extremely important. The DOE DEIS acknowledges the need for extensive erosion controls to be put in place to prevent gully migration, stabilize steep banks, and generally prevent highly contaminated subsurface materials from collapsing into the watershed.[133] The proposed controls and our analysis of these controls is discussed further in Section 9.

DOE Estimated Cost for Alternative 2

The DOE DEIS estimates that Buried Waste Alternative 2 will cost $1.6 billion in implementation costs and $2 million in annual maintenance costs.[134] The most expensive singular cost estimated for Alternative 2 is the closure of the high level waste tanks in WMA 3 at $772 million, slightly less than the $834 million estimated in Alternative 1. The primary reason for this discrepancy is that Alternative 1 requires that the concrete pads supporting the buildings be torn up and disposed of off-site, while Alternative 2 leaves them in place. The dismantling of the Process Building, requiring essentially the same process for decommissioning, has a similar cost between these two alternatives (Alternative 1: $298 mil, Alternative 2: $296 mil). There are wider gaps in the estimated decommissioning costs, however, for the groundwater plume and the closure of the NDA and SDA.

The relatively simple operation required to minimally mitigate the north plateau groundwater plume is estimated at a little over $37 million,[135] in stark contrast to the $2,099 million cost of Alternative 1. Since the vast majority of the groundwater remediation costs of Altermative 1 are tied up in disposal costs, it is important to understand exactly what sequencing and exposure limit choices would result in which costs, to fully assess these differences and allow for effective planning for exposure and costs. For example, the excavation of the groundwater plume must take place after the dismantling of the Process and several other buildings in Alternative 1 but could potentially occur much sooner than in the 47th year of decommissioning.[136] If moving this exhumation process to an earlier timeframe could potentially reduce costs by requiring a much smaller area of contamination to excavate, then clearly this should be included in the DEIS for Alternative 1.

---

[133] Closure Engineering Report, Alternative 2. 2005. p155

[134] Closure Engineering Report, Alternative 2. 2005. p248

[135] It is estimated that by the end of the 200 year monitoring and maintenance period, the bulk of the Sr-90 will have decayed, allowing the site to be released from licensure (**CER2-p155**).However, it is likely that by this time the groundwater will have migrated significantly, potentially starting to expose downstream water users to Sr-90 contamination.

[136] Closure Engineering Report, Alternative 2. 2005. p166

3.2.3 Buried Waste, Some On-Site Storage: Alternative 3

In what DOE calls Alternative 3, all facilities at the site are closed as quickly as possible without any major excavation processes. For example, while Alternative 2 removed at least the high level waste tanks, Alternative 3 prepares the tanks for internment and then leaves them in place permanently. Similar to Alternative 2, the north and south plateaus would have different cleanup approaches and final statuses under Alternative 3. The north plateau would be remediated to "satisfy the radiological criteria of 10 CFR §20.1403", while the south plateau would be "closed in-place and regulated/maintained under the appropriate regulatory authority," [137] responsibilities that are unclear and unbudgeted in the DEIS.

<u>Process Building</u>

The canisters of solid glass high level waste stored in the Process Building would be moved to a new on-site storage facility and the above-ground portion of the Process Building would be demolished. The demolition debris would be dumped into the underground cells of the Process Building and left in an "engineered rubble pile." [138] The canisters would remain in storage until a solution can be found for their permanent disposal at a federal repository. The DEIS estimates that this will require approximately 31 years of storage.

<u>High-Level Waste Tanks</u>

The DEIS suggests that the four underground high-level waste tanks would be filled with grout (cement) to stabilize the contents and sealed in place. The underground tank vaults would be covered with the rubble pile from the demolition from the Process Building and an "integrated engineered multi-layer cover" [139] would be built on top of the rubble pile. This "engineered multi-layer cover" is a series of dirt, cobble, and clay layers designed to prevent water from penetrating into the rubble pile too quickly. Two sets of "impermeable underground barrier walls" would be constructed around the waste piles to slow groundwater leakage into the high-level waste tank or process building area.

DOE notes that the physical integrity of the high level waste tanks is uncertain, and it is unknown how much strain from grout filling or future seismic activity (earthquakes) the high-level waste tanks can take.[140] (See Appendix B for a further discussion of this issue.) As described earlier, the tanks already have undergone significant stresses from misalignment during emplacement and may have suffered corrosive effects from holding acidic processing liquids. The vaults storing the tanks are known to have cracked from flooding and exposure to high temperatures during emplacement, and could fail if filled with grout, as proposed by the DEIS.

---

[137] 2005 DRAFT DEIS, p2-24

[138] 2005 DRAFT DEIS, p2-24

[139] 2005 draft DEIS, p2-25

[140] Battelle, Prepared for the US DOE, 1979

Groundwater Plume

The slurry walls which would be installed in the closure of the Process Building and High Level Waste Tanks are deemed by DOE to be sufficient for containing the high concentration of contamination at the source area of the groundwater plume. In Alternative 3, the remainder of the plume would not be treated, excavated or slowed. The DOE DEIS expects that much of this contaminated groundwater will decay in place, and no plans are in place to prevent the groundwater from flowing into the local watershed.

NDA and SDA Areas

The proposed closures of the NDA and SDA are similar to that proposed in Alternative 2, including demolishing surface buildings, building French drains to route away surface waters, installing slurry walls to slow groundwater infiltration, and constructing geo-engineered caps to slow erosion of the surface of the buried trenches. Similarly to Alternative 2, this proposal suggests that a large amount of material placed on top of the trenches (essentially burying them deeper) should be sufficient to prevent water and freeze/thaw erosion, animal and human intruders, groundwater infiltration and contaminated leachate escape.[141]

3.2.4 Buried Waste, Some Off-Site Disposal: Alternative 4

Alternative 4 is similarly to Alternative 3, with one significant difference. In Alternative 3, the vitrified (formed into solid glass) high level wastes which are now stored in the unstable Process Building would be removed to a temporary storage facility while the Process Building is demolished. In Alternative 4, the Process Building is maintained and supported while a federal facility is found for the high-level vitrified wastes. When a federal repository is located, the wastes will be transferred and the Process Building destroyed. The DOE estimates it will take approximately 30 years until the wastes can be transported off site. All other processes remain the same as Alternative 3.

3.2.5 No Cleanup Action: Alternative 5

DOE includes Alternative 5 in the DEIS for "comparison purposes as required by federal law under NEPA" [142] and it is not considered a viable alternative by the DOE. Nonetheless, it is illustrative to assess the resulting impact to the West Valley facilities under a "No Action" scenario. In Alternative 5, there would be "No Action" taken on remediation activities, instead this alternative calculates the cost of simply monitoring and maintaining the site in its current state. The DEIS anticipates that "when required, remediation actions would be taken in response to any releases of contamination." [143] This non-proactive direction essentially describes the handling of the facility since NFS began operations forty years ago.

[141] Closure Engineering Report, Alternative 3 p125.

[142] 2005 Draft DEIS, p2-30

[143] 2005 Draft DEIS, p2-31

High-Level Waste Tanks (WMA 3)

High-level waste tanks would be treated by dehydrating the contents with a tank and vault drying system (TVDS).[144] The DEIS supposes that if the high level waste tanks leak into their vault system, a system could be implemented such that liquids are dried, groundwater flow into the tank vault ceases, and contamination might be contained.[145] The TVDS system would cost approximately $3.6 million to install and cost $161 thousand annually to maintain.

Process Building (WMA 1)

The DEIS assumes that, similarly to the other alternatives, the piping, tubes, and equipment within the process building would have been removed and the remainder of the shell will have been decontaminated, but not deconstructed. The major utility systems (ventilation and electrical) of the building would stay in place.[146] Aside from monitoring and maintenance operations at the process building, the DEIS only estimates costs associated with replacing the roof every 25 years at a cost of approximately $2.6 million,[147] and generating 35,700 to 41,750 ft^3 of low-level radioactive waste. Disposal of this waste would presumably cost anywhere from $268 to $615 thousand, depending on the waste disposal facility and volume generated, unless stored onsite.

Groundwater plume

In the "No Action" scenario, the DOE recommends no specific action for remediation of the strontium-90 groundwater plume.

NDA and SDA Areas

No specific action is taken for maintaining or removing the NDA facility. The only maintenance stated to be required at the SDA is a periodic 25-year replacement of the geomembrane cover over the buried radioactive waste; the monitoring and maintenance of this facility would require 8.4 full-time equivalent (FTE) job positions.

DOE Estimated Cost of Alternative 5

The DEIS estimates costs for Alternative 5 based on recent fiscal year (2003-2004) monitoring and maintenance costs.[148] Using contemporary budgets, the DEIS assumes a total of six personnel on site at all times (four monitoring and maintenance and two security). Using these baseline estimates, the DEIS assumes that four full-time site managers would be required for continued operations, and estimates the number of personnel which would support these four

[144] Closure Engineering Report, Alternative 5. p71

[145] Closure Engineering Report, Alternative 5. p79

[146] Closure Engineering Report, Alternative 5. p65

[147] Closure Engineering Report, Alternative 5. p70

[148] Closure Engineering Report, Alternative 5 p65

managers. In total, Alternative 5 suggests that the facility could be maintained at an unknown safety level with approximately 77 full-time equivalent (FTE) personnel. This is a dramatic reduction from 500+ FTE workers at the site in 2003/2004 and consequently shrinks the expected budget from $103 million in 2004 to $13.8 million expected in the future (presumably in 2004 dollars).

The DEIS estimates that operations will run approximately $15.8 million every year, plus periodic costs for roof replacement and a tank vault drying system (TVDS). In all, this alternative is estimated to cost $1.64 billion over the next century, making it one of the least expensive approaches, although it is not a real cleanup option.

3.3 Summary of 2005 draft DEIS Options

The 2005 draft DEIS evaluates five Alternatives for remediating or maintaining the West Valley site. The last of these options, Alternative 5, is to leave the site in its current condition, an unlikely and dangerous proposition because of the instability of the infrastructure and landscape at West Valley. Waste Excavation Alternative 1 proposes to exhume all wastes, package them into shipping containers, and dispose or store them off-site at federal repositories. Buried Waste Alternative 2 proposes to excavate only some of the most dangerous materials at West Valley, leaving the largest waste deposits (the NDA and SDA) intact and buried. Alternatives 3 and 4 also suggest leaving the NDA and SDA intact, but also propose a highly speculative, uncertain, and potentially dangerous "grout filling" treatment for the aging high-level waste tanks interred at the site. Alternative 5 (business as usual) is not considered a viable closure activity in the 2005 draft DEIS. We argue that, after review, there is little possibility that Alternatives 3-5 could or should be pursued, as neither offers any form of certainty or safety for workers or the local or downstream populace in the near or distant future. This Full Cost Accounting Study examines more thoroughly Waste Excavation Alternative 1 and Buried Waste Alternative 2 and the DOE's underlying assumptions in their analysis.

4. Health, Radioactive Decay and Time Frames

4.1 Introduction

The primary areas of concern at the West Valley site include the high-level waste tanks, Nuclear Regulatory Commission (NRC) disposal area (NDA), state licensed disposal area (SDA), process building, groundwater plume, lagoons, low-level radioactive waste storage buildings,[149] and the drum cell facility. This section focuses on the high-level waste tanks, and NDA and SDA disposal areas due to the high levels of radioactivity buried within each.

4.2 Longevity of Radionuclides

Radionuclide or radioactive chemical contamination must be treated differently than other environmental contamination, such as toxic chemicals, due to their longevity. Many radionuclides take hundreds, thousands, or even millions of years to fully degrade their extremely hazardous properties, and thus the potential risk to future generations is great. Radionuclides are known carcinogens, or cancer-causing agents.

4.2.1 Decay Process

Radioactivity is the spontaneous transformation of an atom with an unstable nucleus which lets off ionizing radiation as it attempts to change into another more stable element.[150] The element that the radionuclide transforms into may also be radioactive and may in fact have a longer half-life than its predecessor. The released ionizing radiation is harmful because it can strip atoms of electrons and break chemical bonds, changing the genetic structure, thereby causing damage within the human body.

4.2.2 Decay Rates

The decay rate for each radioactive isotope is known as a *half-life,* and each radionuclide has an individual half-life. A half-life is the amount of time it takes for one-half of the radioactive atoms to decay or transform into another element. For instance, in two half-lives one-fourth of the original radioactive atoms would remain, and so on. It takes 10 half-lives for the radioactivity to be reduced to less than 0.1% of the original amount. The half-lives of radionuclides buried at the West Valley site range from a few hours (i.e. rhodium-106) to 14,050,000,000 years or over 14 billion years (i.e. thorium-232).

---

[149] Low-level radioactive waste (LLRW) is specifically defined for the West Valley site in Section 6 (6) of West Valley Demonstration Project Act and this is the controlling definition. LLRW is also classified by the Nuclear Regulatory Commission (NRC) in 10CFR61.55 which could apply to wastes sent off-site. In this report, we use the term low-level waste as it is defined in the Act. However, the authors and contributors to this report do not consider low-level waste to be low risk.

[150] Cember, H. 1996. Introduction to Health Physics. 3rd Edition. McGraw-Hill: New York, NY.

4.3 Buried Radioactive Materials

The report provides a more detailed discussion of the materials buried in the high-level waste tanks, NRC disposal area, and state licensed disposal area in Section 3 and Appendix B. The following is a brief summary of the radionuclides decay and time periods for the waste in these priority West Valley areas.

4.3.1 High Level Waste Tanks

The high-level waste tanks are described in Section 3. Tanks 8D-1 and 8D-2 are made of carbon-steel with an estimated lifetime of 40 to 50 years, while Tanks 8D-3 and 8D-4 are made of stainless steel. The wastes contained in these tanks are from the reprocessing of fuel. The tanks contain a sludge and liquid heel as well as fixed contamination on the interior surfaces. The primary radionuclides[151] contained within the tanks are strontium-90, cesium-137, europium-154, plutonium-238, plutonium-241, americium-241, and curium-244. The half-lives for these primary radionuclides range from 9 to 430 years. The longest lasting of all of the radionuclides in the HLW tanks, thorium-232, has a half-life of 14,050,000,000 years or over 14 billion years.

4.3.2 NRC Disposal Area

The NRC disposal area (NDA) is described in Section 3. The buried wastes are primarily the solid waste produced by the fuel reprocessing and low-level radioactive wastes generated during decontamination and decommissioning of facilities. The NDA includes holes with a depth of 45 to 50 feet. The primary radionuclides include carbon-14, cobalt-60, strontium-90, cesium-137, europium-154, plutonium-238, plutonium-239, plutonium-240, plutonium-241, and americium-241. The half-lives of these primary radionuclides range from 5 to 24,100 years. The longest lasting of all of the radionuclides in the NRC licensed disposal area, thorium-232, has a half-life of 14,050,000,000 years or over 14 billion years.

4.3.3 State Licensed Disposal Area

The state licensed disposal area (SDA) is described in Section 3. The wastes buried here include waste from special purpose reactors, commercial nuclear power reactors, nuclear fuel cycle facilities, institutions, isotope production, and general industrial waste. The primary radionuclides include tritium, carbon-14, iron-55, cobalt-60, nickel-59, nickel-63, strontium-90, yttrium-90, technetium-99, cesium-137, barium-137m, europium-154, thorium-234, protactinium-234m, uranium-238, plutonium-238, plutonium-239, plutonium-240, plutonium-241, and americium-241. The half-lives for these primary radionuclides range from minutes to 4,468,000,000 or over 4 billion years. The longest lasting of all of the radionuclides in the state licensed disposal area, uranium-238, has a half-life of 4,468,000,000 years or over 4 billion years.

---

[151] We define "primary radionuclides" as those with activities greater than 100 curies in the 1996 or 2005 draft DEIS reports

4.4 Health Impacts from Radionuclides

4.4.1 Exposure Pathways

Radionuclides from the high-level waste tanks, NDA area and SDA area will reach the public via various exposure pathways. As long-term institutional maintenance and control inevitably deteriorate the public will be able to enter the site and may receive exposures, characterized in the DEIS as "intruder" scenarios. Radionuclides will, and in some cases have already begun to, diffuse or escape into the groundwater. The NDA and SDA areas and state licensed disposal area do not have liners beneath them and the HLW tank vaults have a history of cracks, stressing, and are nearing the end of their predicted operational lifespan.

As discussed in Section 6 and in Appendix A, erosive forces are significant at the site and will cause "mass wasting" at some point in the future, leading to "chunks" of the NDA and SDA areas being released and entering nearby water bodies. This would lead to great quantities of radioactivity entering the surface water at one time. The onsite surface water feeds into Erdman's Brook and Frank's Creek, which flow into Buttermilk Creek, which flows into Cattaraugus Creek which empties into Lake Erie. Radionuclide contamination from West Valley is believed to have historically traveled along the shoreline of Lake Erie toward the Niagara River and into Lake Ontario, as West Valley-specific radionuclides have been detected in Lake Ontario.[152]

Radiation can enter the human body via inhalation or ingestion of radioactive materials or by external exposure that penetrates the skin. The most common types of radiation are alpha, beta, and gamma radiation. Except for the most energetic, alpha particles are generally unable to penetrate the outer skin layer, and so their entry into the body is effectively limited to open wounds and via inhalation and ingestion. Alpha particles have a large mass and charge and so once taken into the body they can cause a great deal of damage. Beta particles (free electrons) are lighter than alpha particles and are more penetrative; they can also enter the body via inhalation or ingestion. Most beta particles have enough energy to pass through the outer layer of the skin. Gamma particles can penetrate through the skin and reach the internal organs.

Ingestion can occur by drinking contaminated water, incidental ingestion of polluted soil or dust, growing food plants in contaminated soil, using contaminated water to irrigate crops, consumption of fish from contaminated bodies of water, consuming meat or dairy products from animals exposed to contaminated soil, feed, plants, or water, or when bathing or swimming in contaminated water. Ingested particles lead to exposure to the digestive system. Some of the ingested radionuclides are absorbed thereby exposing the kidneys and other organs. A portion of the radionuclides may concentrate in the thyroid or bone.

---

[152] Joshi, S.R. 1988. West Valley - Derived Radionuclides in the Niagara River Area of Lake Ontario. Water, Air, and Soil Pollution. Vol. 37, No 1-2, pp: 111-120..

Inhalation can occur by breathing in dried radioactive materials, such as a creek bed, when they are re-suspended or airborne. Inhalation of radioactive materials can lead to them becoming lodged within the lungs and continuing to decay, thereby irradiating the lung. Alpha and beta particles are the greatest risk to the body when inhaled because they transfer large amounts of energy to surrounding tissues leading to DNA and cellular damage.

The absorbed dose or harm to a human is discussed in measurement units of rem and is dependent upon the amount, type and energy of the radiation, the depth within the person at which the absorbed dose penetrates, and the characteristics of the radionuclide, especially where it concentrates. Doses are presented in units of rem or millirem (1 rem is equivalent to 1,000 mrem).

4.4.2 Health Effects

Radiation causes damage at the molecular, cellular, tissue, and whole organism level. Children and fetuses are more sensitive to radiation than adults because they are growing and their cells are dividing at a much greater rate.[153]

Instantaneous Exposure

An instantaneous radiation dose is a large dose taken into the body over a short period of time. Adverse health effects typically occur shortly after the exposure. Known instantaneous exposure effects at high doses include the following effects.[154]

Hemopoietic Syndrome (greater than 15 rem) - Changes in blood counts.

Gastrointestinal Syndrome (1,000 rem) - Signs of hemopoietic syndrome as well as severe nausea, vomiting, and diarrhea; death will occur within several weeks.

Central Nervous System Syndrome (2,000 rem) - Unconsciousness occurs within minutes of exposure and death occurs within hours to several days.

Temporary Sterility (30 rem to testes or 300 rem to ovaries)

Other adverse health effects include damage to the skin and eyes.[155]

Continuous Exposure

A continuous dose of radiation may occur from an exposure period that continues over a long period of time or from an exposure of inhaled or ingested radionuclides that become fixed within the body continuing to irradiate the tissue for a long period of time. Continuous exposures result in delayed adverse health effects.

Studies have been conducted on the survivors of the atomic bombings in Japan.

---

[153] United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). 2000. Report Vol. II: Sources and Effects of Ionizing Radiation: Annex G: Biological effects at low radiation doses..

[154] Cember, H. 1996. Introduction to Health Physics. 3rd Edition. McGraw-Hill: New York, NY.

[155] Cember, *ibid*

While these studies are primarily based on high level exposures, they represent the most comprehensive knowledge on effects to varying high and low levels of radiation. Other studies have been conducted on individuals working within the nuclear industry and those exposed to medical radiation. A linear no-threshold dose-response relationship is recognized by national and international organizations when assessing risk to low levels of radiation.[156] *That is, there is no safe level; each exposure increases the likelihood that cancer and other health effects may occur.*

Damage to the human's DNA is one of the primary effects from radiation to cells. This can result in an increased risk of developing cancer or a heritable disease. While cells are able to repair breaks in the DNA, repair is not always perfect, and can result in long-term cellular damage and mutation.

The most recognized long-term effects of radiation exposure are cancer and leukemia. A solid tumor cancer usually occurs within 10 to 50 years from the time of initial exposure, though this depends on the individual; leukemias have a shorter latency period. The most common cancers are those of the blood, bone, lung, thyroid, and skin. Cataracts and genetic effects can also occur. Mental retardation may occur to children exposed in utero, particularly if exposure occurs during critical periods of development. Other health effects include cataracts and increased risk for developing diseases of the circulatory, digestive, and respiratory systems.[157]

<u>Radionuclide Accumulation and Storage in the Body</u>

The chemical properties of radionuclides cause them to interact in the body differently. For example, iodine is normally taken up by the thyroid and thus radioactive iodine concentrates there leading to an increased risk of thyroid cancer. Strontium-90 and radium-226 have chemical properties similar to calcium and so collect in the bones and teeth where calcium is stored. This leads to an increased chance of an exposed individual developing bone cancer and leukemias.[158]

Another example of storage within the body can occur when alpha-emitting radionuclides are inhaled and becomes lodged within the lungs where alpha particles are emitted over time.

4.4.3 Radioactive Dose Regulations

"Background" radioactive exposure occurs due to naturally occurring radiation and from medical procedures. Naturally occurring radiation is composed of cosmic radiation, terrestrial radiation (from rocks and soil), and radon. In addition humans

---

156 UNSCEAR, *ibid*

157 Shimizu Y, Pierce DA, Preston DL, Mabuchi K: "Studies of the mortality of atomic-bomb survivors. Report 12, Part II. Noncancer mortality: 1950-1990." Radiat Res 1999;152:374-389.

158 US Environmental Protection Agency (EPA). Radiation Protection: Health Effects. 2008. Website URL: http://www.epa.gov/radiation/understand/health_effects.html. Accessed June 17, 2008.

may be exposed to anthropogenic radiation from x-ray exams and other medical exams and consumer products, such as televisions and smoke detectors that contain radioactive materials. These sources make up the "background" dose that all humans receive; this amount varies depending on location. It is important to note that any dose a person would receive from West Valley is in addition to this background dose, thereby increasing their risk for negative health effects.

The basic standard philosophy of radiation safety is to keep the risk to humans "as low as reasonably achievable" (ALARA). ALARA is based on the internationally accepted principle that any level of radiation can have negative effects to a human. The methods to prevent or minimize exposure include using shielding, reducing the amount of time in contact with radioactive materials, increasing the distance between radioactive materials and people, and reducing the quantity of radioactive material.

Whether an action to achieve greater protection—that is lower exposure—is "reasonable" (as required in ALARA) is usually determined by the nuclear industry or government regulating agency, not the exposed people who bear the increased risks. The ALARA decision incorporates economic factors and thus cannot be expected to or relied upon to reduce exposures in the practical world.

Public Exposures

There are a variety of government standards for radiation exposure. The federal standard for the maximum amount of radioactivity that a member of the public can be exposed to from a cleaned up site is 0.025 rem per year or 25 millirem per year.[159] For a functioning nuclear facility that allowable dose increases to 1% rem per year or 100 millirem per year.[160] The US Environmental Protection Agency (EPA) recommends that 0.015 rem per year or 15 millirem per year be observed as a dose level protective of the public.[161] The Department of Environmental Conservation (DEC) recommends 10 millirem per year.

Worker Exposures

The regulation for the dose to a nuclear worker in the United States is 5 rem per year.[162]

---

[159] US EPA. 1993. 40 CFR 190. Subpart B. Environmental Radiation Protection Standards for Nuclear Power Operations: Environmental Standards for the Uranium Fuel Cycle.

[160] US Nuclear Regulatory Commission (NRC). 2001. Consolidated Guidance: 10 CFR §20. Standards for Protection Against Radiation. NUREG-1736

[161] US EPA. 1997. Exposure Factors Handbook.(http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=12464)

[162] US NRC, *ibid*

4.5 Potential Radioactive Dose to Public

4.5.1 Methodology

It is important to note that people who enter the site in the future, or "intruders" as they are designated by the DOE, will receive extremely high doses as calculated in the 1996 and 2005 draft DEIS reports when institutional controls eventually deteriorate. Potential doses are calculated in Appendix B for downstream people getting their drinking water from Buttermilk Creek, Cattaraugus Creek, and Lake Erie.

Historic documents on the West Valley site and plant were reviewed prior to the formulation of this methodology. To calculate potential radiation doses to members of the public we made several general assumptions, and then completed a simple analysis of the movement of radioactivity, from the disposal areas or tanks through the groundwater to the nearby surface water. The doses were evaluated at 100 years, 200 years, 500 years, 1,000 years, 10,000 years, and 100,000 years in the future. The calculated doses are not meant to be completely conclusive, as conducting a more in-depth model would involve greater software capabilities and financial resources. Further, the DEIS reports do not provide the necessary detail to replicate their results. The calculations do, however, provide an estimate of the doses, given specific assumptions.

The doses to individual people and the total population would be higher than those presented here because people will be exposed for a time period greater than one year. The doses presented in this discussion, unless stated otherwise, are for the ingestion of contaminated surface water for one year.

4.5.2 Assumptions

The assumptions include specific values for the radioactive waste inventory at West Valley and the contamination of the soil and groundwater that were found in the 1996 DEIS, 2005 draft DEIS, or historic West Valley documents. In addition, the assumption was made that downstream receptors are only exposed via contaminated drinking water and that all of the drinking water for that person comes from the contaminated surface water source (Buttermilk Creek, Cattaraugus Creek, or Lake Erie). We were not able to take into account drinking contaminated milk, eating contaminated vegetables, fish, and meat, and inhaling radionuclides in this study. We also were not able to take into account the ingestion of drinking water from the sole source aquifer. (The entire Cattaraugus Creek Basin Area is a federally-designated sole-source aquifer.) We assumed a gradual erosion rate based on the discussion of erosion discussed in the 1996 DEIS and in Appendix A. In the event of mass wasting or a flood, the erosion could occur at a faster rate, leading to higher doses. We also assume a release rate from the NRC disposal area, state licensed disposal area, and high-level waste tanks. In reality the release rate may be greater or smaller, and vary over time. We attempted to provide lower and upper bounds for the likely doses.

We analyzed two scenarios which relate to Buried Waste Alternative 2. The first scenario (Scenario 1) assumes that 1% of the radioactivity is first released from the West Valley site at 100 years, 1,000 years, 10,000 years, and 100,000 years in the future. In the second scenario (Scenario 2), 1% of remaining radioactivity is continually released from the West Valley site beginning 100 years in the future, and thus the amount of radioactivity remaining at the site decreases each year. For this scenario the majority of the radioactivity has been released by the year 1,000 and so we calculate doses for 100 years, 200 years, 500 years, and 1,000 years in the future.

We did not look at the uptake of the entire radioactivity that will reach public water supplies via Lake Erie, and instead concentrated on the one in closest proximity to the outlet of Cattaraugus Creek which is the Sturgeon Point Water Treatment Plant. Additional radioactive material would enter water intakes closer to Buffalo.

4.5.3 Radioactive Dose Results

The dose estimate results for people living downstream from the site are described below in Scenario 1, while the dose estimates for the population drinking water from a Lake Erie intake source are described below in Scenario 2. For a further description of results describing both scenarios, please see Appendix B. We note that no ecological risk assessment was conducted in the 1996 or 2005 DEIS as the DOE states that relevant guidance is unavailable

Population doses are described with *person-rem units*. These are a measurement of the collective dose in rems that a specific population is exposed to over a certain time period. The person-rem units represent the average dose per person times the number of people exposed. We also calculated the *latent cancer fatalities* (LCF) by multiplying the person-rem dose by 0.0005, a rate used by NYSERDA and the DOE in the 1996 DEIS. The LCF is an estimated number of cancer fatalities expected to occur from radiation exposure in a given population. In our calculations the LCF values, unless specified otherwise, only pertain to the cancer fatalities that would occur as a result of radiation population dose in the specified year, and not to increased disease of the population over time.

An important difference between the calculations presented here and those presented in the 2005 DEIS is that they do not include a comparison to background dose. Any dose that a person receives as a result of contamination from the West Valley site is in addition to the background dose that they receive. Although DOE consistently refers to 360 mrem per year as a background dose, that amount includes the dose from radon. For a comparison, the environmental standard for normal operations of a uranium fuel cycle facility is that the dose does not exceed 25 mrem per year for members of the public.

<u>Onsite People Exposed</u>

Dose calculations to onsite persons are presented in the 1996 and 2005 DEIS. We do not recalculate these doses, but instead rely on the 1996 DEIS results as being the most indicative of the exposure to onsite persons. We do, however, consider these doses for a loss of institutional control are likely to occur given that controls will inevitably fail at some point in the future. A summary of those doses, as well as those from the 2005 DEIS can be seen in Appendix B, Table 5. As is discussed throughout this report, if the SDA, NDA, and HLW tanks are left in place, the institutional controls protecting them are likely to eventually break down due to a lack of institutional continuity and erosive forces. Doses calculated in the 1996 DEIS to onsite receptors should be considered as ones that could quite possibly occur. The doses calculated in the 1996 DEIS to onsite "intruders" are the greatest for the "resident farmer intruder." The doses for Alternatives 3, 4, and 5 to the "resident farmer intruder" range from 310 - 1,100,000 rem/yr, with the greatest dose coming from the HLW tanks. A person exposed to 1,100,000 rem/yr would die before receiving the entire dose. The risk to onsite persons in the future are enormous if the SDA, NDA, and HLW tanks are left in place.

4.5.4 Scenario 1: Dose Estimates for the Exposed Downstream Public

In the case of one percent (1%) of radioactivity leaking from the West Valley site in a particular year, we calculated doses to receptors (people) downstream at Buttermilk and Cattaraugus Creeks. Table 4.1 indicates minimum and maximum doses to these receptors (in mrem per year) if radiation were released so many years from now.

	Buttermilk Creek Consumer		Cattaraugus Creek Consumer	
Years from now	Minimum	Maximum	Minimum	Maximum
1,000	21,300	23,100	2,800	3000
10,000	2,900	3,400	380	440
100,000	230	260	30	34

Table 4.1: Doses to Buttermilk (local) and Cattaraugus (downstream) receptors in Scenario 1

All of these dose estimates are substantial and are well in excess of the federal and state standards, such as the Nuclear Regulatory Commission's (NRC) 25 millirem and Department of Environmental Conservation's (DEC) 10 millirem standards (See Section 2).

4.5.5 Scenario 2: Dose Estimates for Lake Erie Water Users at Sturgeon Point Water Intake

The total dose to the population, expressed in units of person-rems, was calculated for Erie County residents receiving drinking water from the Sturgeon Point Treatment Plant if 1% of the radiation leaks every year starting in year 100. The results of this analysis can be found in Appendix B. The total dose to the population was calculated assuming continual release of radioactivity from the West Valley site for the years 100, 200, 500, and 1,000 in the future. The results of the minimum and maximum values, given in total person-rem for a population of 400,000, are presented below in Table 4.2.

Years from now	Dose (person-rem)		Latent Cancer Fatalities (LCF)	
	Minimum	Maximum	Minimum	Maximum
100	0.01	8	0.000004	0.004
200	0.01	9	0.000005	0.004
500	19	8,710	0.01	4
1,000	0.1	41	0.00005	0.02

Table 4.2: Doses to Lake Erie consumers in Scenario 2

The total population dose from the year 100 through the year 1,000 is calculated to be 12,890 - 334,320 person-rem. These values were calculated using the population dose 95th -percent confidence intervals.

All of these dose estimates are substantial and are well in excess of the federal and state standards, such as the Nuclear Regulatory Commission's (NRC) 25 millirem and Department of Environmental Conservation's (DEC) 10 millirem standards. (A rem is 1000 millirems; See Section 2).

Latent Cancer Fatalities (LCFs) are the number of deaths that are expected to occur from exposure to a specific population. The calculated LCF over the 1,000 year time period is 6 - 157 using the conversion factor utilized by the DOE in the DEIS reports. A more conservative conversion factor results in a LCF range of 13 - 334. *This means that over the time period from 100 to 1,000 years into the future it is expected that 6 - 334 of the people receiving their water from Sturgeon Point Water Treatment Plan are expected to die of cancer as a result of their exposure to contaminated water from Lake Erie.* (This assumes that the current number of users remains constant at approximately 350,000 to 402,000 people in any given year.) This number only represents the population that receives their drinking water from the Sturgeon Point Water Treatment Plant. The number of cancer fatalities would be greater if it included the entire population, in the United States and Canada, which receive their drinking water from Lake Erie, although it would be spread throughout a larger total population.

Current municipal water treatment plants may remove some radionuclides during their filtration process, particularly plutonium, uranium, and americium, while other radionuclides, such as strontium will not be removed.[163, 164] Floc—particulates resulting from the removal of sediments contaminated during the cleaning process at the water treatment plants—must eventually be disposed of, presenting a further source of radioactive materials.

---

163 Joshi, S.R. 1988. West Valley - Derived Radionuclides in the Niagara River Area of Lake Ontario. Water, Air, and Soil Pollution. Vol. 37, No 1-2, pp: 111-120..

164 Gafvert, T, C Ellmark, and E Holm. 2002. Removal of Radionuclides at a Waterworks. Journal of Environmental Radioactivity. Volume 63 (2): 105-115.

4.6 Conclusion

The radioactivity buried in the high level waste tanks, NRC disposal area, and state licensed disposal area at the site poses an unacceptable risk to the populations in the surrounding area, including those that draw their water from Lake Erie and the Niagara River. *Given the 1996 DEIS dose calculations for onsite persons in the future—a scenario that will inevitably occur—potential doses from various exposure pathways could lead to enormous doses, illness and even death. The doses to people living downstream and those drinking contaminated surface water will also exceed regulatory standards, leading to adverse health effects as well as unnecessary deaths from cancer due solely to radiation exposure coming from the West Valley site.* Leaving these wastes in the ground will present a significant burden and public health threat to future generations as the radionuclides will be present for thousands to millions of years.

In our study, independent experts evaluated the potential for exposure to the local public and Lake Erie water consumers. This study evaluated both a rapid leak scenario, as well as a continuous leak scenario, and found that if just 1% of the radioactive waste stored at West Valley leaked (starting from 100 years from now), a population of 400,000 water users on Lake Erie would be exposed to 334,320 person-rem, resulting in up to 334 cancer deaths from West Valley waste.

5. Valuing the Future: The Viability of Long-Term Institutional Controls at the West Valley Site

Of the alternatives proposed by the Department of Energy (DOE), only Waste Excavation Alterative 1 would completely clean up the West Valley site and make the property available for unrestricted use. All of the other DOE alternatives leave radioactive waste, materials, and buildings in place, thus requiring continued vigilance, monitoring, engineered barriers, maintenance and corrective measures whenever a leak or breach in the barriers occurs. If the waste at West Valley is not fully cleaned up, nuclear wastes and polluted groundwater and soil will need to be monitored and contained for tens of thousands of years to prevent harm to nearby communities, fish, wildlife and the environment. Such monitoring and control activities are called either stewardship or *institutional control*.

Several of the DOE's DEIS alternatives require the maintenance of stewardship or institutional controls at West Valley for many thousands of years, while Waste Excavation Alternative, involving complete removal of all nuclear and toxic waste to disposal facilities off-site, requires less than a century of stewardship at the site. If adequate disposal or storage facilities are made available off-site,[165] then Alternative 1 differs sharply from the other remediation alternatives in terms of the length of time for which institutional control must be maintained.

In this section, we examine issues surrounding very long periods of time: continuity of governments and stewardship, language and warnings, ethical issues associated with leaving an enormous hazard and responsibility to future generations, and appropriately estimating and valuing future costs, as well as irreversible and irreparable harm.

5.1 Federal Requirements on Stewardship or Long-Term Controls at Polluted Sites

The federal Department of Energy (DOE) defines stewardship as *"all activities required to protect human health and the environment from hazards remaining after remediation is completed."*[166] DOE is required by law to implement long-term stewardship at federal facilities to ensure that site cleanup remedies remain effective and protective of human health and the environment for future generations. Of course, stewardship is only necessary at sites that have not been fully remediated, such as monitoring buried waste and addressing any toxic

[165] It is beyond the scope of this study to do a Full Cost Accounting for the potential sites to which the exhumed waste or dismantled buildings would be sent, but it is likely that no site will be capable of completely isolating the waste for the extremely long time period that some of it remains radioactively dangerous. These costs must be factored into the decisions being made currently to resume reprocessing, open new low-level radioactive waste burial grounds in supposedly impermeable clay, and to generate more radioactive waste from nuclear power and its fuel chain facilities.

[166] US DOE. 1999. From Cleanup to Stewardship.. http://lts.apps.em.doe.gov/center/companion.asp

leakage which can pollute groundwater. If a site is fully remediated with no remaining contamination, there is no need for any controls.

Stewardship includes both active and passive activities at the site. DOE's active controls include “activities to control risk at a site on a relatively frequent or continuous basis, such as operating, maintaining and monitoring the engineered controls implemented at sites” and may include fence repair, maintenance of erosion controls, or collecting water samples. Passive controls convey information about site hazards or limit access to the site, physically or legally, and may include physical barriers, ordinances, building permits or property deeds.[167] Stewardship activities can also include an evaluation of whether to apply newly discovered remediation technologies, emergency response to address spills or leaks, compliance oversight, natural and cultural resource management, information management, administration, budgeting, and site redevelopment.[168]

The DOE’s concept of stewardship encompasses institutional, physical or engineering controls as defined by the federal Environmental Protection Agency (EPA) and state Department of Environmental Conservation (DEC). According to EPA, institutional controls are “actions, such as legal controls, that help minimize the potential for human exposure to contamination.” [169] Such actions may include land deeds, control of land ownership or lease, and access to property. Physical or engineering controls are built infrastructure to reduce potential human exposure to contamination, such as walls, erosion barriers and fences.

The West Valley DEIS uses the term “institutional control” to refer to both institutional and engineering or physical controls, and we will use the same definition. When we refer to a potential that institutional controls could fail, we mean that there is a potential that government oversight, long-term institutional memories or written records, or physical barriers may cease to be effective in preventing exposure to contamination at West Valley. This report uses the two terms of stewardship and institutional controls interchangeably, referring to the range of long-term protective measures that are required at a site where nuclear waste is left after partial remediation.

Agencies and companies often advocate for institutional controls as an alternative to the high costs of complete cleanup. However, engineering and institutional controls are not foolproof and have failed at many sites, including West Valley, resulting in the need for additional remediation. The failure of controls occurred multiple times under active management and oversight at the West Valley site in the past.

For example, the two burial grounds on the site, the State Disposal Area (SDA)

---

[167] US DOE, *ibid*

[168] US DOE, *ibid*

[169] US Environmental Protection Agency (US EPA). 2008. Institutional Controls (ICs). http://www.epa.gov/superfund/policy/ic/index.htm

and the NRC-licensed Disposal Area (NDA), are located in dense clay and are unlined. In the 1970s, the series of trenches in the SDA filled with water and overflowed, creating vast areas of additional contamination. NYSERDA capped the SDA, installed monitoring probes and wells, and has since claimed that no further overflows have occurred.

The NDA, holding one of the nation's most complex mix of radioactive and hazardous wastes in a series of deep holes, has also experienced leaks. In 1983, plutonium and a solvent, kerosene, were found leaking from the NDA. A waste drum in one of the leaking holes was exhumed in 1986. The drum was dry and found to have ruptured welds and a lid sealed with duct tape. Other tanks buried at the same time have not been exhumed or checked for leaks. Lately it was determined that the NDA is close to overflowing in the same way the SDA overflowed. This year, DOE proposed capping the NDA and constructing water diversion trenches to prevent excursions.

In 1992, the DOE discovered an underground plume of radioactivity, primarily strontium 90, on the northern plateau that is traveling in groundwater on the north plateau. Strontium-90 has a half-life of 30 years, meaning it remains radioactive in some form for approximately 300 years. Monitoring wells were dug, and the source of the plume was determined to be under the Process Building from highly radioactive liquid waste that had leaked in the 1960s and was now migrating. Water from the plume was pumped and treated. This program, while helpful, created a considerable volume of waste filter medium and was not as effective as planned. When a second plume developed, an underground clay filter wall was installed to intercept and filter it but the plume circumvented this wall. Sheet piling also failed to stop it, and the problem continues to worsen as the plume migrates further every year. The plume now comes to the surface and leaks into Frank's Creek at dose rates far in excess of what is deemed safe. According to DOE, by the time the radioactive plume is offsite, there is sufficient dilution such that the radioactivity is not a threat to human health. DOE proposes demolishing the Process Building to get to where the source of the leak is thought to be. DOE also proposes an extensive, untested engineered barrier positioned at a point that they argue is economically most feasible for capturing the radioactivity and preventing it from migrating further. Beyond this barrier, lesser amounts of radioactivity will continue to migrate into Frank's Creek.

These incidents are not unique to the West Valley site and such failures speak to the unreliability of institutional and engineering controls as a long term strategy for preventing harm to people and the environment. Understanding that there is no guaranteed place or technology to truly isolate long-lasting radioactive waste, these failures suggest that the real solution is to first minimize future additional production of nuclear waste from atomic power, weapons and the nuclear fuel chain.

5.2 Maintaining Institutional Controls: How Long is a Thousand Years?

Wastes that would be left at the West Valley site under Alternatives 2, 3, 4, and 5 are extremely long-lived. For example, the longest lasting of all of the radionuclides in the high level waste tanks, thorium-232, has a half-life of 14,050,000,000 years or 14 billion years. Adequate safeguards for the long-lived radionuclides disposed (and their decay products) would have to be active and effective for tens of thousands of years. It is extremely difficult to assess how or whether the persistence of institutional controls can be ensured for that length of time. To put the period of time that the waste is hazardous in context, this study is only able to consider a much shorter period to assess the viability of even maintaining controls over 1,000 years at the site.

Maintaining institutional controls at a nuclear waste site first requires a continuity of government and language. This continuity is absolutely necessary but not sufficient to ensuring adequate controls are maintained at a site where highly hazardous waste, left unchecked, can pose major public health and environmental threats. Yet, even assuming the continuity of government and language, there are many reasons to doubt that institutional controls would remain in place over one thousand years or more. Some of the reasons include: poor record-keeping or institutional memory, insufficient appropriations of funds or changes in government leadership or priorities. A fundamental obstacle to maintenance of institutional controls, however, is the improbability of thousand-year continuity in either government or language.

A thousand years is a long time for any institutions of government to endure, let alone institutional controls at a particular waste site. It is of course impossible to look forward in time and see the world of 3008; as an alternative, we can look the other way, at the world of a thousand years ago. In 1008, Vikings were attacking England; the Norman Conquest was still decades away. Events that are now ancient history were still centuries in the future—the rise of Genghis Khan in central Asia, the Aztecs in Mexico and the Incas in Peru; the Black Plague; Columbus' voyage to the Americas; and Martin Luther's break with the Catholic Church. Of the governments and nations that exist today, only Iceland has an unbroken lineage spanning the last thousand years.

If the government of any country (other than Iceland) had made a commitment in 1008 to protect an important site for a thousand years, there is no guarantee that anyone would still know about that commitment today. Obligations to safeguard dangerous waste sites accepted in 1008 by the Holy Roman Empire, the Saxon kings who ruled England before the Norman Conquest, the Toltecs in Mexico (predecessors of the Aztecs), the Huari in Peru (predecessors of the Incas), or China's Song dynasty (960-1279), might not be remembered or honored in detail by the governments that have taken their places today.

A thousand years is also a long time in the history of language—long enough for a language to change beyond recognition. While something called the English language has existed for centuries, it changes fast enough so that modern readers cannot understand words written a thousand years ago. A look at literary classics of earlier centuries reveals the extent of change.

Shakespeare's famous plays date from about 400 years ago; they are still decipherable with some effort. Consider the opening lines from *Henry IV Part I*, in the unedited original:[170]

> *"So shaken as we are, so wan with care,*
> *Finde we a time for frighted Peace to pant,*
> *And breath shortwinded accents of new broils*
> *To be commenc'd in Stronds a-farre remote:*
> *No more the thirsty entrance of this Soile,*
> *Shall daube her lippes with her owne childrens blood:*
> *No more shall trenching Warre channell her fields,*
> *Nor bruise her Flowrets with the Armed hoofes*
> *Of hostile paces."*

The meaning is understandable to the patient reader, but Shakespearean spelling and diction now appear quite archaic.

Chaucer's poetry, written more than 600 years ago, is no longer fully understandable without footnotes; consider the opening lines to *The Canterbury Tales*:[171]

> *"WHEN that Aprilis, with his showers swoot,*
> *The drought of March hath pierced to the root,*
> *And bathed every vein in such licour,*
> *Of which virtue engender'd is the flower;*
> *When Zephyrus eke with his swoote breath*
> *Inspired hath in every holt and heath*
> *The tender croppes and the younge sun*
> *Hath in the Ram his halfe course y-run, …"*

Modern readers might (or might not) guess correctly that swoot means sweet, but would not likely realize that holt means forest or grove, or that croppes refers to twigs and boughs, not crops. The effort required to parse the archaic, unfamiliar style is greater than with Shakespeare; the difficulty of understanding old English is increasing as we look farther back in time.

The one classic of English literature that dates back a thousand years, *Beowulf*, is no longer readable, and has to be translated into modern English in order for

---

[170] Project Gutenberg's E-text of Shakespeare's First Folio, http://www.gutenberg.org/dirs/etext00/0ws1910.txt .

[171] The Project Gutenberg E-text of The Canterbury Tales and Other Poems by Geoffrey Chaucer, http://www.gutenberg.org/dirs/etext00/cbtls12.txt .

anyone but a few specialists to understand it.[172] Not only the words, but even some of the letters used in the original manuscript are unknown in modern English. Consider the opening lines from *Beowulf* in Table 5.1 (see also Figure 5.1), with the original on the left and a modern translation on the right:[173]

Original text	Modern translation
Hwæt! Wé Gárdena in géardagum	Listen! We --of the Spear-Danes in the days of yore,
þéodcyninga þrym gefrúnon·	of those clan-kings-- heard of their glory.
hú ðá æþelingas ellen fremedon.	how those nobles performed courageous deeds.
Oft Scyld Scéfing sceaþena þréatum	Often Scyld, Scef's son, from enemy hosts
Monegum maégþum meodosetla oftéah·	from many peoples seized mead-benches;
egsode Eorle syððan aérest wearð	and terrorized the fearsome Heruli after first he was
féasceaft funden hé þæs frófre gebád	found helpless and destitute, he then knew recompense for that

Table 5.1
Opening lines of *Beowulf*, original text and modern translation.

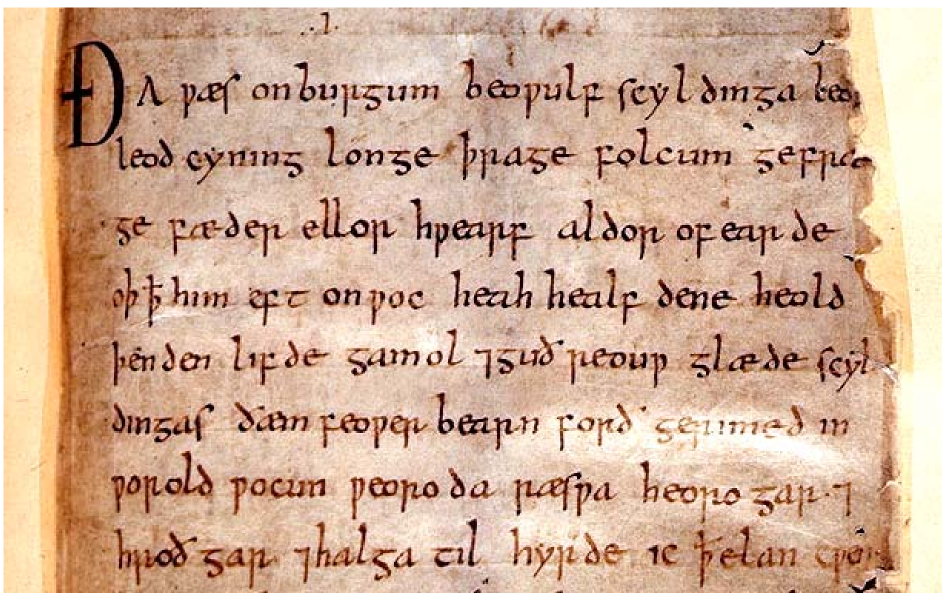


Figure 5.1
Detail from the original manuscript of Beowulf. [174]

Suppose that these authors had written signs, in the English of their day, warning

[172] The year that *Beowulf* was written is the subject of some debate, with most scholars dating it between the 8th and early 11th centuries.

[173] From “Beowulf on Steorarume (Beowulf in Cyberspace)”; website and translation by Benjamin Slade, http://www.heorot.dk/beo-intro-rede.html

[174] Source: British Library, http://www.bl.uk/onlinegallery/themes/englishlit/beowulflge.html

us to stay out of a dangerous waste site for the next thousand years. Shakespeare's warning, 400 years old, would require a bit of effort to decipher non-standard spellings and archaic usage. It would not be ideal for catching the attention of casual, non-literary intruders. Chaucer's warning, more than 600 years old, would be even more archaic, and might include a number of words whose meaning could not be understood or even guessed at by modern readers. The warning from the author of *Beowulf,* written in the English of roughly 1000 years ago would be incomprehensible and meaningless to all but a handful of experts today.

In 3008, when the English of this report is as ancient as the language of *Beowulf* is today, will casual readers and potential intruders on a waste site be able to read our warning signs? Or will our long-dead words be understandable only to a handful of literary scholars specializing in the old English of the twenty-first century?

The need to deal with safety and communication issues across millennia imparts a unique set of problems to nuclear waste issues. These have been addressed most fully in connection with the nuclear Waste Isolation Pilot Plant (WIPP) in New Mexico, and the proposed Yucca Mountain high-level nuclear waste facility in Nevada. Gregory Benford, a physicist and novelist who was involved in the design of WIPP, has written about the issues of communication across "deep time"—intervals beyond centuries, and potentially beyond the continuity of governments and languages.[175] The advance planning for WIPP drew up proposals for a wide range of nonverbal message formats, seeking to convey unmistakable, indestructible warnings and as much information as possible. Documents on the WIPP website describe a complex, ongoing process of development of multiple markers, combining words and pictures in several formats; a final decision is not needed until WIPP is closed, in 2030 or later.[176]

In short, the design of warnings of nuclear hazards that will persist through "deep time" is still an unsolved problem. Years of research and debate have not yet led to a viable solution at WIPP or the proposed Yucca Mountain site, if it is ever opened. There is no reason to assume that the Department of Energy could adequately address safety and communication issues at West Valley for the Buried Waste Alternative 2 option.

5.3 Discounting and the Economics of Cleanup Decisions: How Valuable is a Thousand Years?

There have been many attempts to calculate the costs and benefits of nuclear waste policy and site cleanup choices. These attempts face both the common problems of cost-benefit analysis of health and environmental policy, and some

---

[175] Gregory Benford, *Deep Time: How Humanity Communicates Across Millenia* (New York: Avon Books, 1999).

[176] Waste Isolation Pilot Plant, 2008. Webpage at http://www.wipp.energy.gov/

unique challenges related to the extremely long-term risks involved in nuclear waste disposal.

5.3.1 The Economics of the Long-Term

Cost-benefit analysis makes sense when all the costs, and also all the benefits, of a policy have meaningful, well-defined monetary prices. In such cases, the total dollar value of costs measures the resources required for the policy, while the total dollar value of benefits measures what society gets for those resources. Under those conditions, it is reasonable to accept the common interpretation of net benefits (total benefits minus total costs) as the quantitative measure of the policy's usefulness to society.

Those abstract conditions are rarely met in actual public health and environmental policy decisions. What is the dollar value of human lives saved, or health outcomes improved, or endangered species and unique environments protected? In a word, the most important benefits are frequently priceless. Contriving artificial prices for priceless values, as economists have often done for cost-benefit analysis, does not yield a sensible or complete measure of the value of life, health, and nature.

Questions of rights, as well as values, are often involved: for instance, do we have the right to deprive a traditional community, or a future generation, of clean air and water in order to increase current production and profits? In the words of the philosopher Immanuel Kant, some things have a price, or relative worth, while other things have a dignity, or inner worth. The inadequacy of cost-benefit analysis, in Kantian terms, can reflect the attempt to weigh costs, which usually have a price, against benefits, which often have a dignity.

Uncertainty provides an additional layer of complexity, and is often a fundamental obstacle to cost-benefit calculations. The benefits, or avoided damages, attributable to a policy may not be known: how much damage to human health and the natural environment would result if we fail to reduce greenhouse gas emissions, or allow exposure to a potentially toxic new chemical, or leave nuclear waste in the ground? Often there are a range of possibilities, but no information about the relative probabilities of better versus worse outcomes. In cases where there are warnings of serious potential harm, but little or no information about probabilities, it is often preferable to adopt a precautionary policy, based on reducing the harm from the credible worst case. The failure to heed early warnings of environmental hazards has frequently proved to be enormously costly in retrospect: the multi-billion-dollar losses associated with asbestos liability result primarily from industrial exposures to asbestos that occurred decades after the risks to human health were widely reported. When risks of failure are large, people often make decisions based on worst cases rather than averages; when going to the airport to catch a plane, do you leave time for an unusually bad traffic jam on the way? The same kind of thinking has typically been, and should be, applied to environmental policy decisions.

In addition to the issues of priceless benefits, rights that supersede monetary values, and the need for precautionary responses to uncertain risks, there is another problem with cost-benefit analysis that is particularly important in the case of nuclear waste: the valuation of the future. Other intergenerational problems such as climate change raise similar questions, but the time spans involved in nuclear waste disposal dwarf those encountered in other policy areas. The economics, and the unpredictable nature, of the far future are important aspects when evaluating nuclear waste options. These dilemmas interact with the other problems of cost-benefit analysis in the discussion of nuclear waste disposal.

An early article observed that cost-benefit analysis has serious limitations for nuclear waste issues, due to the long time periods involved, the scientific uncertainties about such long long-term projections, and the difficulty of assigning monetary values to many of the hazards that are involved.[177] A study of opinions about the proposed Yucca Mountain site, published in a leading economics journal, confirmed the importance of perceptions of safety, which cannot easily be outweighed by short-term compensation of surrounding communities:

> …compensation in the form of a rebate is unlikely to have a positive effect on siting a potentially hazardous facility, unless the risk is perceived to be sufficiently low to oneself and to others, including future generations. In the case of nuclear waste facilities, benefits are simply rejected out of hand unless the safety of the facility and the integrity of the siting process are assured.[178]

With impacts spanning centuries or millennia, decisions about discounting—in effect, about how to value the future—can easily dominate the analysis. A multi-criteria analysis found that different discounting methodologies and other changes in decision rules can determine the choice of the preferred policy for a long-term problem.[179] (The same conclusion also holds in the case of West Valley, as we will see in Section 8.)

One of the best-known authors to address nuclear waste issues is Kristin Shrader-Frechette, a scientist and philosopher at the University of Notre Dame. She argues that burial of nuclear waste in repositories such as the proposed Yucca Mountain site is mistaken, both because of the scientific uncertainty in predictions of geological events over millennia to come, and because burial of waste compromises the rights of future generations to equal treatment and free, informed

---

[177] P. Z. Grossman and E. S. Cassedy, "Cost-Benefit Analysis of Nuclear Waste Disposal: Accounting for Safeguards," *Science, Technology, & Human Values*, Vol. 10, No. 4. (Autumn, 1985), pp. 47-54.

[178] Howard Kunreuther and Douglas Easterling, "Are Risk-Benefit Tradeoffs Possible in Siting Hazardous Facilities?", *American Economic Review*, Vol. 80, No. 2, (May, 1990), pp. 252-256; quote from p. 255.

[179] Elizabeth Atherton and Simon French, "Valuing the Future: A MADA [multi-attribute decision analysis] Example Involving Nuclear Waste Storage," *Journal of Multi-Criteria Decision Analysis* Vol. 7 (1998), pp.304-321.

consent.[180] She calls for using monitored, above-ground storage of nuclear waste, so that future generations can make their own decisions and/or apply new technologies to the problem, without facing additional risks from unretrievable disposal as is contemplated under Buried Waste Alternative 2 in DOE's DEIS.

Questions of rights challenge the entire framework of a cost-benefit analysis; there is no meaningful dollar value for fundamental rights. Shrader-Frechette argues that in general, human rights must take precedence over cost-benefit calculations. In her view, every generation has the right to equal treatment and to give or withhold informed consent to avoidable environmental hazards. No generation has the right to impose its hazards on those who will come later. These principles, rather than calculations of cost, should determine our choices about nuclear waste. She calls for postponing a long-term disposal decision, and using monitored, retrievable storage of nuclear waste until the longer-term options are more securely and fairly settled.

5.3.2 Economic Discounting at West Valley

Similar issues of the rights of future generations arise in the economic and philosophical debates about the discount rate, the key parameter in economic analysis of the very long run. Economists *discount* future costs and benefits, expressing them in *present value* terms—a process that is nothing more than compound interest in reverse. For instance, at a 3 percent discount rate, $103 next year has a present value of $100 today, because $100 is the amount one would have to put in the bank today at 3 percent interest, in order to end up with $103 next year. (This example, like the entire discussion of discounting in this report, assumes the use of inflation-adjusted, or constant-dollar, amounts. The effects of inflation on future values are entirely distinct from this analysis; everything said here, and in most analyses of discounting, would be equally valid if the inflation rate was exactly zero for all future years.) For short- and medium-term *private financial decisions*, discounting is essential; it allows an individual investor to compare the costs and benefits of her own investment choices on a consistent basis in a timely manner.

For *intergenerational public policy decisions,* the case for discounting is much less compelling. This question has been discussed most thoroughly in the context of climate change, an environmental problem that may be second only to nuclear waste in the time spans it covers. For climate policies that incur costs today, with their most important benefits more than a century into the future, there is no single individual who experiences both the costs and the largest share of the benefits. Thus decisions with intergenerational impacts are not analogous to investments within a single lifetime. Rather than any single individual weighing complete costs

---

[180] Kristin Shrader-Frechette, *Burying Uncertainty: Risk and the Case Against Geological Disposal of Nuclear Waste* (University of California Press, 1993); “Duties to Future Generations, Proxy Consent, Intra- and Intergenerational Equity: The Case of Nuclear Waste,” *Risk Analysis* Vol. 20 No. 6 (2000), pp. 771-778.

against complete benefits—the assumption on which cost-benefit analysis is built—climate policy (like nuclear waste policy) consists of choices about what this generation will or will not do for those who will come later. *That is, the choice of an intergenerational discount rate is a matter of ethics and policy, not a market-determined economic decision.*

Using a framework that originated with the early twentieth-century economist Frank Ramsey,[181] it has become common to identify two separate aspects of long-term discounting, each contributing to the discount rate. One component of the discount rate is based on the expected upward trend in income and wealth. If future generations will be much richer than we are, they will need less help from us, and they will get less benefit from an additional dollar of income than we do. So we can discount benefits that will flow to our wealthy descendants, at a rate based on the expected growth of per capita incomes. Among economists, the income-related motive for discounting may be the least controversial part of the picture.

The other component of the discount rate is the rate that would apply if all generations had the same per capita income, or the rate of “pure time preference.” This is the subject of longstanding ethical, philosophical, and economic debate. On the one hand, there are reasons to think that pure time preference is greater than zero: both psychological experiments and common sense suggest that people are impatient, and prefer money now to money later. On the other hand, pure time preference of zero expresses the equal worth of people of all generations, and the equal importance of reducing climate impacts and other burdens on them (assuming that all generations have equal incomes).

These issues are central to the Stern Review, the British government’s much-discussed analysis of the economics of climate change.[182] Section 2 of the Stern Review provides an excellent discussion of the debate, and motivates Stern’s choice of a rate of pure time preference close to zero, and an overall discount rate of 1.4 percent. This discount rate alone is sufficient to explain Stern’s support for a substantial program of climate protection. At the higher discount rates used in more traditional analyses, the Stern program would look “inefficient,” since the costs would outweigh the present value of the benefits.

The Stern analysis is notable for using a lower discount rate than most economists would accept for cost-benefit analyses; that is, Stern places a greater value than most economists on events in the far future. For nuclear waste policy spanning a millennium, however, even the Stern discount rate is too high (and therefore Stern’s valuation of the future is too low). *Stern is persuasive in arguing that the rights of future generations, and the responsibility of the present generation to treat its descendants fairly, require that pure time preference be close to a zero discount*

---

[181] Frank P. Ramsey, (1928). "A mathematical theory of saving." *The Economic Journal* **138**(152): 543-59.

[182] Nicholas Stern, (2006). *The Stern Review: The Economics of Climate Change*. London, HM Treasury.

rate. Most of Stern's 1.4 percent discount rate comes from his assumption of a long-run average economic growth rate of 1.3 percent per year over the next 200 years, driving the income-related component of discounting. This is a moderate rate of growth in the short run, but much too rapid for thousand-year forecasts.

If per capita consumption were to grow at the Stern rate, an average of 1.3 percent per year, for the next 1000 years, our descendants in 3008 would be consuming an unimaginable quantity: 400,000 times as much as we are today. Currently, U.S. per capita consumption expenditures are about $33,000 per year; after 1000 years of 1.3 percent annual growth, annual consumption would be greater than $13 billion per person, in today's dollars. There is no rigorous basis for projecting economic growth over 1000 years—and as this example demonstrates, absurd results flow from assuming that even a modest rate of growth will continue through all those years. The only sensible long-run assumption is a zero average rate of growth of consumption. This could also result from climate change or other environmental constraints on future growth; the world has finite resources, and consumption cannot continue to grow indefinitely.

To summarize the implications for discounting of nuclear waste options, fairness requires that all generations be treated as equally important, as Stern has argued for climate change and Shrader-Frechette for nuclear waste. *This means that the pure time preference component of discounting—the discount rate that would apply if all generations had equal resources—must be very close to zero or zero.*[183] The income-related component of the discount rate cannot be large over 1000 years, because it is impossible to sustain even a moderate growth rate for that long. Both components, in other words, must be zero or very close to zero. As a result, the discount rate is also very small.

Indeed, in 2001, the DOE issued a *Report to Congress on Long-Term Stewardship*. At that time, the DOE decided that discounting should not be used when calculating future site maintenance costs for federal nuclear waste sites.

> "Moreover, net present value for costs are not used because it could appear to make costs disappear after 30 years. Because the Department has indicated that it is committed to considering the long-term costs and consequences of its decisions, net present value could appear to undervalue these long-term costs…In the case of long-term stewardship costs, life-cycle information is not appropriate, and annual costs are used instead. Defining 'life-cycle costs' for the long term is not meaningful in the same way that costs for projects with a predictable end point are calculated

[183] Stern argues for a small contribution to pure time preference, arbitrarily set at 0.1 percent per year, reflecting the small but non-zero probability that the human race, or at least the modern economy, will be destroyed within the coming year. That is, if we are only 99.9 percent sure that humanity will survive the next 12 months, then costs and benefits expected a year from now are only 99.9 percent as valuable as the same amounts would be today.

because there is no clear end point for long-term stewardship, in most cases…" [184]

The same conclusion—the discount rate for a 1000-year analysis must be zero or close to zero—can be reached by a different argument. The existence of standards for stewardship spanning 1000 years,[185] and the regulatory requirements for warnings and protection of sites that will remain dangerous for that long, must imply that we care today about health hazards, and opportunities for hazard reduction, that will be experienced in 3008. Costs and benefits incurred in that distant year must have a significant present value; otherwise, we could ignore them with impunity, and we could "prove" via discounting that it is not cost-effective to spend anything today on our successors a thousand years down the road.

In order for anything 1000 years from now to have a significant present value today, the discount rate has to be very low. At the Stern discount rate of 1.4 percent, considered implausibly low by many conventional economists, $1 million in 3008 has a present value of $1 today. Thus it would not be worth spending more than $1 today to prevent $1 million of harm in 3008. Cut the Stern rate in half, to 0.7 percent per year, and $1 million in 3008 is worth only $1,000 today. To validate the commonsense idea that outcomes in 3008 matter today, the discount rate must be no more than a few tenths of a percent per year or zero.

If outcomes deeper in time matter to us today, the maximum discount rate gets even closer to zero. Are we concerned about nuclear waste hazards that exist 10,000 years from now? At a discount rate of 0.14 percent per year, one-tenth of the Stern rate, $1 million in damages 10,000 years from now have a present value of less than $1 today. The destination of this line of argument is clear: *if we care about the impacts of today's nuclear waste, stretching across the depths of future time, then the only supportable discount rate is zero. Since every generation is of equal ethical worth, and there is no basis for assuming economic growth over the very long run, economic theory also endorses a discount rate of zero.*

[184] USDOE. January 19, 2001. Report to Congress on Long-Term Stewardship. Release No. R-01-025. p3-19.

[185] A 1993 DOE Order states that in managing uranium, thorium, and their decay products, controls should be designed for 1,000 years. "Control and stabilization features shall be designed to provide, to the extent reasonably achievable, an effective life of 1,000 years with a minimum life of at least 200 years." DOE Order DOE 5400.5 Ch IV 6.d.(1).(a). See Section 8.2.1 for further discussion.

6. Geologic Erosion Problems Seriously Impact the West Valley Site

Whether there can be long-term containment of the radioactive waste disposed of at the West Valley site as proposed under Buried Waste Alternative 2, will be largely determined by the site's geologic stability over the medium and long-term. The site sits on a geologically young landscape that is rapidly evolving, eroding and changing. The earth's surface at the West Valley site was scraped and reshaped by glaciers until as recently as 13,000 years ago (a very short period in geological time), leaving a blank canvas upon which rivers, creeks, and streams could begin to create a landscape. These streams have cut through the landscape rapidly, and although they do not pose a direct threat to the site today, erosion at West Valley is one of the most disconcerting aspects of leaving the wastes in the ground. As streams cut into the landscape, they will almost certainly expose buried wastes if erosion is not controlled, and the prospects for controlling erosion over several millennia are difficult to envision and potentially quite costly. As explained below, the region around the site will almost certainly continue to reshape and restructure for many more millennia, leaving us with the question: how serious are the erosion problems and how unstable is the landscape upon which the West Valley site sits?

In this report, we have chosen to focus specifically on erosion at West Valley. The buried wastes at the site could be released through two mechanisms:

1. Water enters a disposal trench or hole, contacts or saturates the waste, and becomes contaminated with radioactive elements. This polluted groundwater then seeps through the soils underlying the West Valley site, enters a stream, and causes surface water contamination downstream;
2. Streams surrounding the West Valley site cut into the banks of the site and eventually undermine or expose waste directly to the surface waters, causing severe contamination.

Groundwater contamination is already known to have already occurred at West Valley (see Section 3), and is also present at other major nuclear waste centers.[186] Although the hydrology at West Valley is very poorly understood, the contaminated groundwater plume which extends towards Buttermilk Creek has a relatively low concentration of contamination (yet still dangerous) as compared to the amount of contamination which could be released if a waste storage facility were undermined or destroyed. Since this analysis is concerned with the long-term implications of storing buried waste at the West Valley site, we concentrate on the critical question of erosion prevention at the site over the next thousand years, rather than groundwater control over the next hundred.

---

[186] The Hanford Site in Hanford, Washington stores significant amounts of nuclear waste and has a contaminated groundwater plume spread over much of the 80 square mile site. http://www.hanford.gov/cp/gpp/

6.1 Geologic Site History

The West Valley site is now a forested and agricultural landscape, but this was not always the case. Less than 13,000 years ago, portions of Upstate New York were still covered in glaciers which continually re-worked the land by scraping the bedrock, depositing hundreds of feet of gravels, soils, and fine clays, and trapping massive lakes in front of the ice. Our history starts about 19,000 years ago, when large glaciers covering the area started to retreat. The ice front retreated to northern Cattaraugus County by 16,000 years ago, leaving behind a lake over much of northern Cattaraugus County.[187] Thick layers of fine-grained sediment collected at the bottom of this lake, forming one of the important features of the West Valley site today. The ice then re-advanced from the north and then retreated again, re-working the landscape. The glaciers carved into this sediment, creating clay-rich soils called the Lavery and Defiance tills. The fine-grained Lavery till forms much of the upper layer of the soil plateaus underlying the West Valley site.[188] The glaciers retreated again about 15,300 years ago, and were replaced by yet another large lake. Finally, between 13,360 and 13,000 years ago, the lakes covering northern Cattaraugus County began to fall[189] exposing the soil plateaus around the site and allowing for very rapid erosion of the site (in geologic terms).

6.2 Erosion at the West Valley Site

The West Valley site sits 1400 feet above sea level on two plateaus, surrounded and bisected by three small streams, called Erdman Brook, and Quarry and Franks Creeks. The site overlooks the larger Buttermilk Creek which is about 200 feet below the site (see Figure 6.1). Buttermilk Creek flows into Cattaraugus Creek, a watershed which drains nearly 450 square miles[190] and flows to Lake Erie about 20 miles south of Buffalo, N.Y.

Buttermilk Creek and its tributaries cut down into terraces (see Figure 6.2). The terraces are remnants of the lake bottom and floodplains formed as a large glacial lake drained between 13,000 and 9,920 years ago. This was a time of rapid erosion, with Buttermilk Creek cutting down into the soils at 10 to 20 feet every thousand years.[191] More recently, Buttermilk Creek down-cutting may have slowed to 4 to 10 feet every thousand years. Experience in other maturing landscapes suggests that as soon as the streams have downcut as far as possible, *they will begin to erode outwards, widening their floodplain*. These processes are complex

---

[187] Muller, E. H., and P. E. Calkin. 1993. Timing of Pleistocene glacial events in New York State: Canadian Journal of Earth Science, vol. 30, p. 1829-1845.

[188] LaFleur, R.G. 1979. Glacial Geology and Stratigraphy of Western New York Nuclear Service Center and Vicinity, Cattaraugus and Erie Counties, New York. U.S. Geological Survey Open File Report 79-989

[189] Muller and Calkin, *ibid*

[190] USGS, 2007

[191] Albanese, J. R., S. L. Anderson, R. H. Fakundiny, S. M. Potter, W. B. Rogers, and L. F. Whitbeck. 1984. Geologic and hydrologic research at the Western New York Nuclear Service Center West Valley, New York: U.S. Nuclear Regulatory Commission Report No. NUREG/CR-3782.

and episodic, commonly proceeding at irregular rates.[192] The down-cutting and outward spread will continue to cause substantial erosion at the West Valley site.

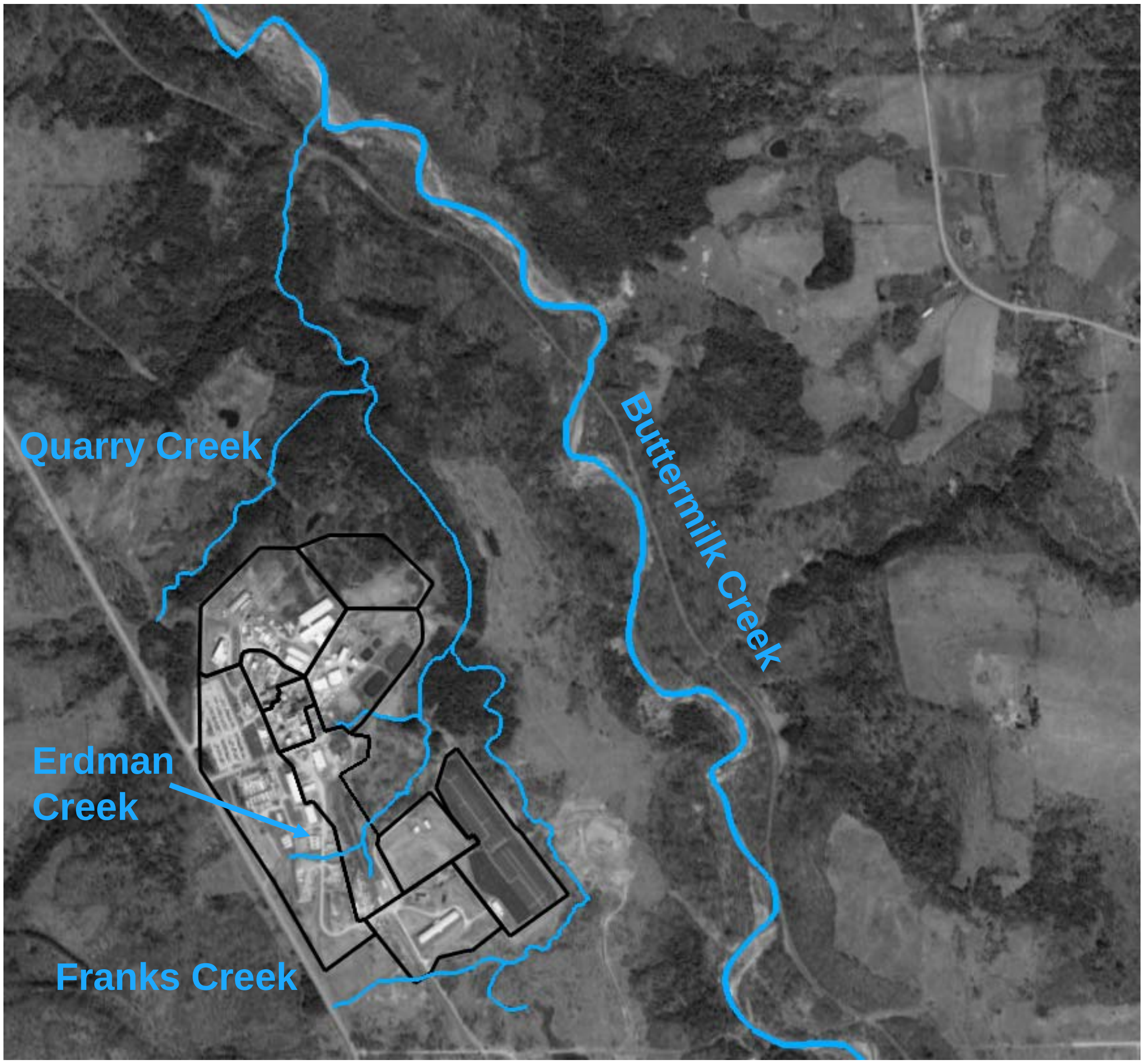


Figure 6.1
West Valley site relative to the local watershed. The local creeks indicated and labeled in blue. Both Franks and Erdman Creeks penetrate the West Valley waste management areas (in black).

6.2.1 Erosion Process of Landslides and Stream Down-Cutting

The erosion processes at the West Valley site include *gulley head advancement*, *stream down-cutting*, *knickpoint migration*, *stream side cutting*, *landslides* from stream down-cutting and side cutting, and *sapping,* which is erosion by groundwater exiting a slope from holes in the soil. Most of these processes have long been recognized at West Valley.

192 Wilson, M. P., and W. T. Boria. 1999. Holocene meander incision imposed across a buried valley wall: NY State Geological Association 71st meeting Guidebook Trip D-Sunday.

Generally, stream evolution proceeds in two fashions: existing streams cut downwards and outwards, and new streams cut upstream at their head causing *gully head erosion*. *Stream downcutting* occurs as a stream moves material at the bottom of the bed downstream. This is a more aggressive process in younger streams, such as Franks Creek and Erdman Brook.

Knickpoints (another word for waterfall) tend to migrate upstream as they cut back into the soil over which they fall. As rock at the waterfall ledge erodes, the waterfall moves backwards, or upstream. This can be a problem because deeper streams (i.e. downstream of the waterfall) tend to have wider valleys. Therefore, as knickpoints migrate upstream, they rapidly also cause lateral, or sideways, erosion. If a stream runs next to a waste dump, then as the stream erodes downwards, the edge of the stream valley will get wider and could undermine the waste. One way to attempt to prevent this erosion from occurring is to try to slow the process of *knickpoint migration*.

Another common process in both small and large streams is *stream side cutting*. This occurs as meanders (the sinuous path of a stream) widen outwards. Sinuous winding streams cut outwards far more quickly then they cut downwards. This can be seen in most streams where there are steep banks on the outside cuts of meanders (see Figure 6.2 where Buttermilk Creek cuts deeply into the West Valley site terrace). Currently, Buttermilk Creek is both side-cutting and down-cutting, with the side-cutting more evident. The younger tributaries, like Franks Creek, are primarily down-cutting. Routinely and frequently, a whole slope can be destabilized by these side-cutting processes, leading to *landslides* (see Figure 6.2).

Figure 6.2
Three-dimensional representation of West Valley site. The site is perched on a terrace 200 feet above Buttermilk Creek, and cut through by Franks and Quarry Creeks, as well as Erdman Creek (not indicated but near "West Valley" label). Landslides also noted on Buttermilk Creek that are cutting towards the site. Vertical exaggeration is 2.5 times normal. (Image and topography from Google Earth.)

Much of the historical erosion at the site has been down-cutting into existing glacial lake terraces. This erosion changed the face of the landscape by starting new gullies. When the glacial lakes receded 13,000 years ago, small streams began to cut down through the sediment at the bottom of the drained lake beds. As new streams cut downwards, gullies formed into the side slopes and formed a drainage network. Gulley heads can be seen forming today at the site and it is expected that the number of gullies will increase with time.

At the north end of Buttermilk Valley, where Cattaraugus Creek is joined, the bottom of Buttermilk Creek exposes shale which is a crumbly type of rock that breaks down easily under repeated wetting and drying. As new layers are exposed, this shale is ripped-up by floods in large chunks, which quickly disintegrate within a year or two.

Some landslides around the West Valley site are obvious, such as the one indicated in Figure 6.2 on the facing side of Buttermilk Creek. Other smaller landslides are less obvious, but we can detect their presence from the way partially collapsed trees bend back towards a vertical position (this indicates that they have been reoriented during their lifetime)[193]. Sharp edges at terrace ledges also indicate that a landslide has occurred and the corner of the ledge has not had enough time to become rounded (a more stable configuration). Larger landslides tend to occur adjacent to streams where stream side-cutting has destabilized the slope above, especially evident along Buttermilk Creek.

Occasionally, streams cutting towards each other intersect, cause a very sudden change in the shape and energy of the landscape. When one stream cuts under another (called stream piracy, because one stream “steals” the water from another), the stream which has been intruded upon may suddenly start to flow (and erode) much faster. For instance, Buttermilk Creek could soon intrude into the edge of the Franks Creek watershed. When this occurs, it would change the flow path of Franks Creek and cause it to erode much more rapidly. This process could alter groundwater flow patterns and sapping rates and directions. In fact, the groundwater flow paths could shift long before Franks Creek is "captured" by Buttermilk Creek. This type of capture could occur in a timeframe of 500 to 2,500 years.

6.3 Critique of DOE's Erosion Estimates

6.3.1 Inadequate Computer Modeling and DOE Assumptions that Site Erosion is a “Condition Not Expected to Occur”

The 2005 draft DEIS by the Department of Energy (DOE) included scenarios to explore the potential outcomes of each cleanup alternative. Critically, expected future releases of radionuclides from the site are almost entirely based on how much contaminated groundwater is able to reach surface water sources, and how much erosion is expected to expose buried wastes. The DEIS suggests that there is a high likelihood that contaminated groundwater will eventually reach surface waters, but at very low concentrations. However, DOE categorizes erosion as a “condition not expected to occur.” Presumably, this is because DOE is assuming rigorous and effective institutional controls will remain in place as long as dangerous waste remains buried at the site, which might prevent erosion from occurring. We discussed in Section 5 our concern about the likelihood of maintaining institutional controls, but what if we suppose, for arguments sake, that we *are* able to maintain controls at the site for 1,000 years or more? Each of these control systems would need to be replaced on a regular basis, for eventually erosion *always* wins. In this section, we discuss how the replacement costs for continually upgrading and replacing controls can become very expensive over the long term, if it is even possible.

What sort of situation might be expected if controls are slackened, or if erosion control measures fail? At what point in the future might we expect buried radioactive waste to make their way into the environment? The 2005 draft DEIS

[193] DEIS draft 1996, Volume III, part 3, p. 61

offers one view of this question by assessing the “conditions not expected to occur” with three scenarios—"favorable”, “likely” and “unfavorable” parameterizations of an erosion model. However, the DOE uses the SIBERIA erosion model, a model which has been critiqued as inadequate (see Appendix A on geology for more detail).

Computer models are best used for relatively simple geomorphologic processes. Even the best attempts at combining scaled lab models or computer models with extensive field data often lead to inaccurate predictions of river channel, shoreline, landslope or other behaviors on short time intervals. Modeling complex landscape-process interactions over long periods is far more problematic. Below we lay out some erosion predictions gathered from on-site observations and extensive academic research on similar geological formations and erosion processes.

6.4 Site Erosion Predictions

6.4.1 Estimated 500 Gullies, or Stream Splits, in 10,000 Years

Based on the glacial history and maps of landforms, we know that the soil plateaus of the Buttermilk valley began as raised flat areas with few gullies. We then estimate that the density of gullies near the site has increased with time to the large number of gullies currently observed. There are approximately an estimated 64 gullies and streams per square mile in this region (see Figure 6.3 for an overview of the drainage network surrounding the region). Over the roughly 15,000 year period that this landscape has evolved, we estimate that the density of gullies doubles every 3,000 years. This region could expect to have over 500 new gullies form in the next 10,000 years. It is easy to imagine that if erosion is uncontrolled, at least one of these gullies will penetrate a buried radioactive waste area at the site.

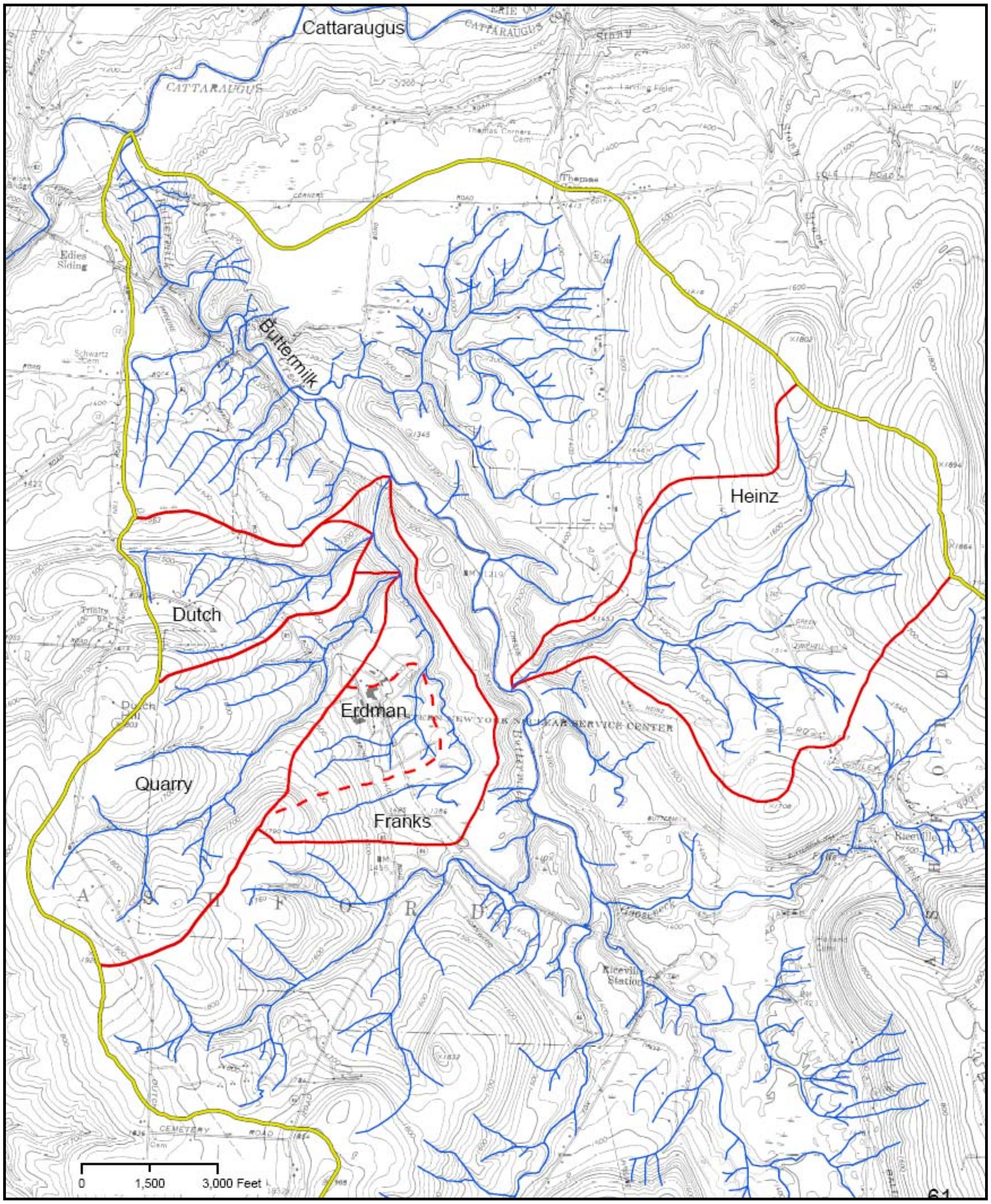


Figure 6.3

Drainage system around the West Valley site. Yellow line defines outside of the Buttermilk Creek watershed, which intersects with Cattaraugus Creek to the northwest of this image. The watersheds for Franks, Erdman, Quarry, Dutch, and Heinz Creeks are outlined in red. Many, but not all gullies, are portrayed on this topographic map.

6.4.2 Twenty Percent of Plateau Surface Estimated to Erode in 10,000 Years

As a landscape matures, the size and density of drainage networks increases as new gullies are formed. After reaching a critical density, gullies begin to merge into larger streams.[194,195] An observational study from 1952 shows a glacial landscape reaching maximum drainage density at 20,000 years.[196] Using a bench-scale (30 x 50 ft) experiment as a model for the evolution of the site landscape, we estimated that within 10,000 years, 20% of the plateau surfaces that are un-gullied today will have eroded away across the lower Buttermilk watershed. There are various reasons why this is a conservative rate. First, Buttermilk Creek tributary gullies at the site drop more rapidly and over more waterfalls than in the bench-scale model which lead to faster erosion rates in reality. Deforestation and impervious surface runoff increase erosion rates. Finally, we expect climate change to result in more severe storm events, when the most severe erosion occurs.

6.4.3 Erosion Will Create Damaging Gullies Within a Few Hundred Years

Observations by geological experts as well as by West Valley onsite personnel have recorded the movement of knickpoints by up to several feet per year. The 1993 West Valley Environmental Information Document[197] concluded from 35 years of repetitive air photos that the head cut on Franks Creek advanced an average of 7.5 feet per year and on Erdman Brook advanced 10.5 feet per year. From these rates, we would expect that within several hundred years, this erosion will have opened new areas on the adjacent plateaus to damaging gullies.

A 1983 report estimated that Buttermilk Creek was cutting down anywhere from 0.5 to 0.7 feet every century,[198] while a 1986 report estimated a cut-down rate of 1.8 feet every century.[199] The 1.8 feet figure was used by the DOE in the 1993 EID as a basis to calculate slope retreats for not only Buttermilk but also for Franks Creek, a gully.[200] These rates were later used in the 1996 EIS. The 1993 EID also refers to direct resurveying of the profile of Franks Creek itself as yielding a cut-down rate of 20 feet per century. Ultimately, the 2005 draft DEIS used rates of 32 feet per century for 240 years, followed by two feet per century for all long term calculations thereafter.[201] SIBERIA modeling fails to account for rapid gulley

---

[194] Parker, R. S. 1976. Experimental study of drainage system evolution (unpublished report): Colorado State University, Fort Collins, CO, U.S.A.

[195] Parker, R. S. 1977. Experimental study of drainage basin evolution and its hydrologic implication: Colorado State University Hydrology Paper 90, Fort Collins, CO, U.S.A., 58p.

[196] Ruhe, R. V. 1952, Topographic discontinuities of the Des Moines Lobe (Iowa-Minnesota): American Journal of Science, Vol. 250, p.46-56.

[197] (EID) Environmental Information Document. 1993. Volume III Hydrology; part 3, Erosion and Mass Wasting: prepared by West Valley Nuclear Services, Inc., for U.S. Department of Energy draft 1996 Environmental Impact Statement for closure of West Valley, NY nuclear waste facilities. (p11-12)

[198] LaFleur, R.G. 1979. Glacial Geology and Stratigraphy of Western New York Nuclear Service Center and Vicinity, Cattaraugus and Erie Counties, New York. U.S. Geological Survey Open File Report 79-989

[199] McKinney, T. F. 1986. Review of erosion projections: letter report from Dr. McKinney of Dames & Moore, Inc. to West Valley Nuclear Services, Inc., dated 7-8-1986. McKinney's report was circulated during July 1986 to NYSERDA, NYS Geological Survey, US-DOE, US-NRC, US-ACE, and USGS, and subsequently referenced in many reports.

[200] EID, *ibid*

[201] DEIS draft 2005, Appendix F, p56-57

deepening by conversion of convex to concave profile development and rapid knickpoint erosion. We assert that a rate of down-cutting of about 20 feet per century as actually measured[202]—not 32 feet per century for 240 years and 2 feet per century thereafter—is more appropriate. Because the side slopes are maintained by landslides at about 21°, we would anticipate that the edges of the plateaus will retreat about three feet for every foot of down-cutting. Therefore, Franks Creek could cause the plateau edge to retreat at a rate of nearly 60 feet every century. *At the rate of plateau-edge removal anticipated for Franks Creek, we might anticipate a breach of the northeast edge of the SDA in less than 400 years due to side-cutting alone.*

In addition, there are concerns about landslides and a Buttermilk side-slope retreat. The west wall of Buttermilk valley retreats by stream erosion, laterally cutting the toes of the side-slopes, leading to landslides and plateau edge retreat. The mapped terraces and fans east of Buttermilk (east of the SDA and lagoons) suggest that Buttermilk Creek has shifted west for several thousand years, and may continue to do so. Landslide retreat could capture Frank's Creek in several hundred to several thousand years.

6.4.4 Predicted System Failure from Erosion with Disposal Areas Breached

All the above factors suggest that erosion is a powerful and fast moving force at West Valley, and one which must be taken seriously for long term analysis. Landslides, gullies, and streams cutting all put the West Valley site at high risk of erosional failure. Unless erosion and other institutional controls are rigorously maintained, we predict that the disposal areas could be breached in less than 1000 years, even with the DOE-proposed controls in place, and as quickly as 150 years from now without any controls in place. This breach would be a catastrophic failure, leaking high concentrations of radionuclides into the local watershed and then quickly into Lake Erie (see section 6.6 for details).

6.5 The Viability and Costs of Erosion Controls

6.5.1 A Precautionary Reality

In reality, there is a significant probability that at some point in the future while the radionuclides still pose a threat, institutional controls will fail, a critical erosion control will be poorly engineered, or an unforeseen externality such as a major storm and flooding (see Figure 6.4) will result in a serious failure. Indeed, many of the erosion control mechanisms proposed in the 2005 DEIS have short design lives, raising the question: Can we count on a system design so sound and repairs made so frequently that the dangerous contaminated waste at the site is never released?

[202] DEIS draft 2005. Appendix F, p8 (60,000 mm per 1,000 years = ~19.6 ft per 100 years)

Structures like bridges can last decades to a century,[203] but culverts can be expected to last only 10-20 years (see Figure 6.4 for an illustration of the end of a culvert's useful life span). Erosion control practices have short life spans, such as debris basins, diversions, grade stabilization structures, concrete-lined channels, retaining walls, riprap linings, and vegetative linings—all of these controls are expected to last 10 to 25 years.[204] Other erosion control publications[205,206,207] suggest that flood control projects typically have life spans of only years to decades.

Figure 6.4
An example of unexpected severe erosion caused by flooding in Dover, New Hampshire, April 2007. [208]

Erosion control experts will usually not state design lives for their works. Contracts

---

[203] The recent Minneapolis catastrophe where a major highway bridge collapsed before its time would suggest that even carefully planned critical infrastructure can sometimes have unexpected catastrophic failure.

[204] NYS Soil and Water Conservation Committee. 2005. New York State Standards and Specifications for Erosion and Sediment Control. For the NYS Dept. of Environmental Conservation, Division of Water. Previously: New York Guidelines for urban erosion and sediment control. 1991. Empire State Soil and Water Conservation Society: Syracuse, NY.

[205] Nunnally, N. R., and E. A. Keller. 1979. Use of fluvial processes to minimize adverse effects of stream channelization: Water Resources Research Institute of the University of North Carolina, Report No. 144, 115pp.

[206] Nunnally, Nelson, R. 1978. Stream renovation - an alternative to channelization: Environmental Management, v. 2., No. 5, pp. 403-411.

[207] Keller, E. A., and E. K. Hoffman. 1976. Channel restoration-a sensible alternative to channelization: Public Works, Oct., pp. 70-72.

[208] Image attributed to Flickr (Golden ~Eye).

may not call for or even imply design lives. Most important is that completed erosion control work can fail or need significant renovations within months to a few years. It is clear that durable erosion controls are extremely difficult to achieve, especially in western New York's erodible glacial soils.

6.5.2 Improving Erosion Control Requirements and Costs

As described in Section 5 of this report, institutional controls are likely to fail over the long-term. Severe erosion problems are estimated to occur at the site within hundreds of years. Clearly, the long-term disposal of buried waste at the site is not an environmentally sound approach. However, for the sake of argument and a cost assessment, we have outlined an erosion control plan if wastes were kept at the site in the centuries to come to provide necessary improvements to the DOE DEIS plan.

Several mechanisms can improve the probability of retaining radioactive waste in situ or in place for an undetermined period of time. It should be emphasized that none of these control technologies and proposals have been vetted for long term stability (i.e. hundreds to thousands of years), and most of them are expected to perform well only for a period of decades. Therefore, strict and constant monitoring and maintenance would be required on these structures in perpetuity to prevent toxic releases. Under any conditions, it is very questionable that erosion at West Valley site could be effectively prevented for a thousand years.

Erosion Control Mechanism	Initial and Replacement Costs	Replacement Interval (in Years)
Franks Creek and other tributaries grade stabilization	$10-20,000,000	50
South Plateau gullies grade stabilization	$10-20,000,000	50
Impact of recurrence interval on erosion control[209]	$29,500,000	50
Gulley-head mats to prevent new gulley formation	$1,300,000	50
Buttermilk Creek grade stabilization	$25-50,000,000	50
Buttermilk Creek west bank stabilization	$15-30,000,000	25
Stabilizing other proximal creeks and drops, such as Heinz Creek	$25-75,000,000	50

Table 6.1. Estimated Costs of Improved Erosion Controls at West Valley Site

We identify four potential causes for failure in erosion controls over the long run and recommend improvements as well as their associated costs. We summarize the costs of these additional erosion controls in Table 6.1. These are the approximate costs for labor and materials only. In our final accounting, we add costs for waste disposal from old structures during replacement (an additional 51% cost) and a standard 25% contingency for unknown costs. Where a range of costs

[209] The impact of recurrence interval on erosion control takes into account the probability that rare flooding events (which have a certain recurrence interval) will destroy otherwise stable infrastructure.

are given in this table, we use the average cost.

Regional Drop Structures to Stabilize Creeks

We estimate that to stabilize Franks Creek, lower Quarry Creek, lower Dutch Creek, lower Buttermilk Creek, and Buttermilk gullies southeast of Franks Creek, it will require over 200 four-foot drop structures ranging from 50 to 200 feet wide (see Figures 6.5 and 6.6). Using conservative estimates from small-scale, non-contaminated projects, we estimate that installation of these drop structures will cost between $20 and $40 million and require replacement approximately every 50 years. These structures and costs are added to those outlined in the 2005 DEIS.

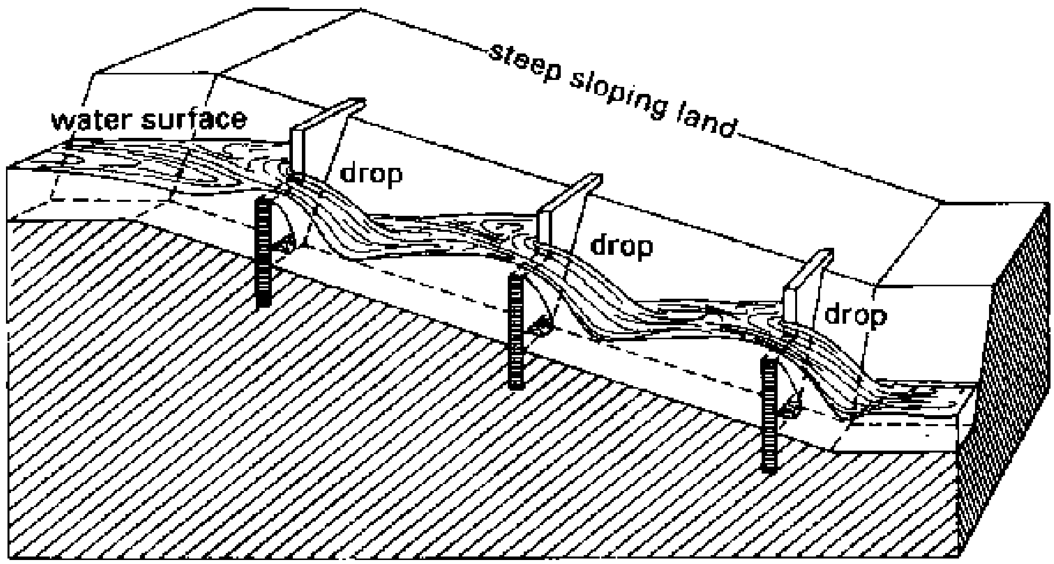


Figure 6.5
A schematic of a Drop Structure. The pools, separated by small drops, slow the flow and take away energy from the water. High velocity water has a much higher erosion potential. The drop structures can slow erosion both down and sideways, but must be maintained on a regular basis.

Improved Maintenance to Address Climate Change Storms and Flooding

The engineering requirements used to guide the 2005 DEIS assume that future climatic conditions will be similar to those found today in upstate New York. According to recent studies, climate change is estimated to increase winter precipitation by 20 to 30%, arriving in the form of more extreme rainfalls and longer storms.[210] We caution that potential increasing precipitation at the site from global climate change could require these structures to be larger and potentially require more frequent replacement or maintenance. Because construction and maintenance costs are sparsely described in the most recent DEIS Closure Engineering Report (CER), we conservatively double the implementation and maintenance costs for erosion control structures already listed in the 2005 draft

[210] Frumhoff et al., 2007. Confronting Climate Change in the U.S. Northeast; Science, Impacts, and Solutions. Union of Concerned Scientists.

DEIS to account for increasing precipitation and thus more extreme flooding events on a more regular basis.

Figure 6.6
A functioning drop structure. The steel ledges prevent water from flowing too quickly down this stream.

<u>Preventing Gully Formation</u>

The 2005 DEIS supposes that existing gullies could expand and extend upstream, but there is no provision for the creation and evolution of new gullies in the region. New gullies form from two processes: (a) when water running over a surface constricts to narrow streamlets that cut down into the soil and form a gully, and (b) when water seeping between grains of soil is forced to the surface (called sapping), undermining the soil and forming a gully. The site needs to use flexible concrete and steel cable mats to prevent gully formation at stream heads. We estimate that the installation of these mats at all potential headwaters in the site would run about $1.2 million initially.

<u>Preventing Landslides at Buttermilk Creek</u>

There are several large landslides on Buttermilk Creek that are destabilizing the south plateau region and may impinge on contaminated soil. They have the potential to change hydraulic gradients if they migrate westward into the Franks Creek watershed. The largest of these landslides is over 160 feet tall and about 350 feet long—about a 45% grade (see Figure 6.2). While no one knows how gentle a slope is needed for stability, we know that 21^{o} slopes (38% grades) are not stable at the site. To obtain “long term” stability, the slope would have to extend back about 500 to 800 feet, covering perhaps half the distance from Buttermilk

Creek to the SDA trenches, and impinging on the Franks Creek watershed significantly (see Figure 6.7). The non-stable regions are on the outside bends of the Buttermilk meanders, an area prone to severe undercutting. Without mitigation, these bends will continue migrating towards the contaminated south plateau and SDA trenches.

Figure 6.7
The natural resting slope of the materials at West Valley is less than 21 degrees, far shallower than current slopes on Buttermilk Creek (foreground). Even without additional downcutting, the embankment of Buttermilk Creek would not be stable until the slope retreats back several hundred feet. The area marked with orange hashes would be eroded away and the ledge would be at the upper orange line, about half way to the buried wastes at the State licensed Disposal Area (SDA). With downcutting and gully erosion, we could expect this line to migrate much further back.

Indeed, even the 2005 draft DEIS predicts that there will be backcutting along the Creeks at West Valley, but has inexplicably scaled back the risks associated with this type of erosion from the 1996 DEIS. In Figure 6.8, we show the plateau estimate from the 1996 DEIS and the 2005 draft DEIS after 1000 years of erosion.

The 1996 DEIS suggests that the plateau would be cut back far into the NDA and almost completely obliterate the SDA without erosional controls, while the 2005 draft DEIS suggests that only small corners of the NDA and SDA may be removed. It is unclear why this estimate changed so significantly in the intervening years between the 1996 and 2005 DEIS estimates, but whichever estimate is used, clearly there is significant uncertainty and tremendous risk of erosion penetrating the buried wastes at the West Valley site.

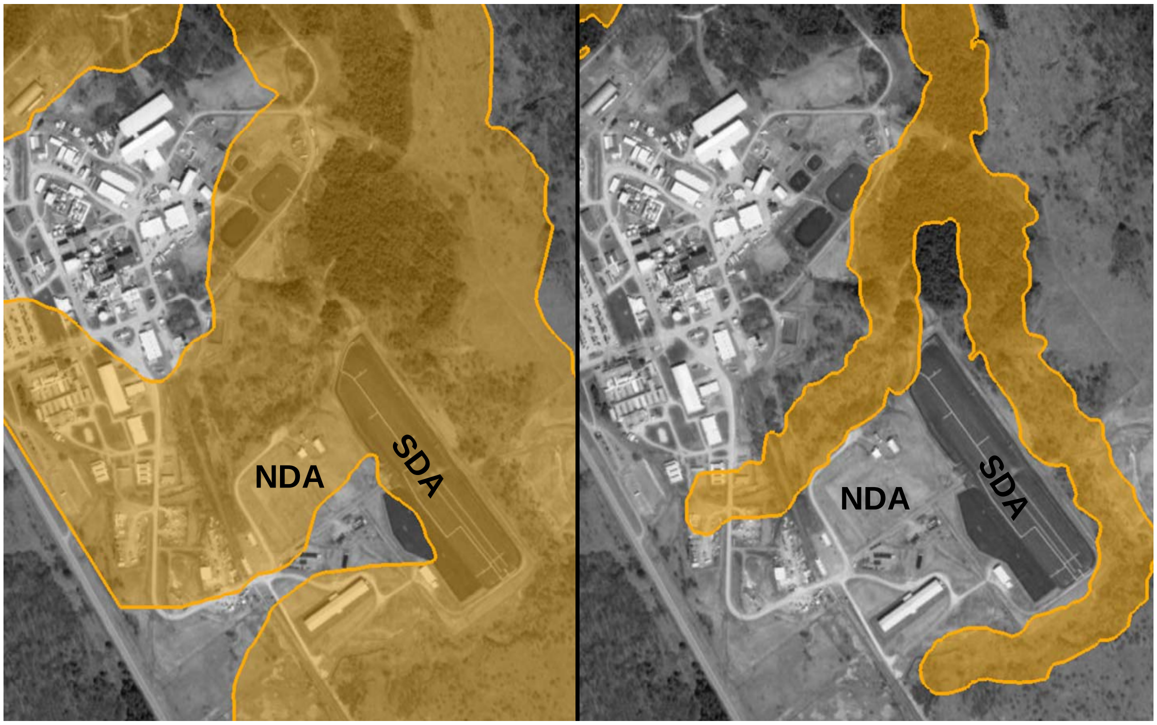


Figure 6.8
Erosion estimates from the 1996 DEIS (left) and the 2005 DEIS (right). The orange area indicates the region which would have eroded significantly in 1000 years. In the 1996 DEIS, the estimates of erosion nearly completely expose both the NRC Disposal Area (NDA) and the State licensed Disposal Area (SDA), while in the 2005 DEIS most of the waste is estimated to remain intact. [211]

Several steps would need to be implemented to prevent this slope from collapsing. First, the actual landslides need to be stabilized by stopping erosion at the base, and allowing the slope to reach a stable grade over time with maintenance to keep stabilization structures from being overwhelmed with material from above or undercut by the stream below. Alternatively, the slope could be re-graded with mass terrain movement, which would entail moving or removing nearly 237 million cubic feet of soil,[212] a costly potential. Regrading the slope will also need to be supported by stabilization of Buttermilk Creek against lateral and vertical erosion to

---

211 Sources: 1996 DEIS, Figure L-2; 2005 draft DEIS, Figure 4-20.

212 Steep slopes exist along 1.25 miles of Buttermilk Creek. Regrading 160 vertical feet from 46% to 20% grade would entail a movement of about 36,000 $ft^2 \times 1.25 \times 5280$ ft = 238 million ft^3.

stop slope undercutting and slide reactivation.

Next, Buttermilk Creek would need to be stabilized with twenty-eight large-scale drop structures (600 ft wide, 26 ft deep with 4 ft above grade) to prevent it from cutting downwards and destabilizing the north or south plateaus. We estimate that each large drop structure would conservatively cost just under $1 million each to install, for a total of $18 million, and last approximately 50 years.

The west bank of Buttermilk creek would need to be armored for nearly a two-mile segment of the creek (from below the North Plateau to the end of the South Plateau). Using 30 foot sheet piles, we estimate an initial cost of $15 million. Due to the potential for landslides above and against the armoring, in addition to stream undercutting, we would estimate that the sheet piles would need to be replaced every 20 years.

Finally, Heinz Creek, which enters Buttermilk opposite the site, is contributing to the landslide erosion. We feel it would only be prudent to reduce the deposition at the base of Heinz Creek by stabilizing part of that watershed as well. Heinz Creek is a large and steeply dropping stream with significant erosion potential. If erosion controls were to be implemented on Heinz Creek, anywhere from 250 to 500 drop structures at four foot intervals of elevation would need to be employed. Each of these 100 ft by 20 ft structures would run about $100,000,for a total of $25 to $50 million implementation, with a 50 year replacement.

<u>Groundwater Measurement Limitations</u>

The replacement schedule for monitoring wells and piezometers suggests replacement at 25 year intervals,[213] which will create space problems. If a location was monitored for 3,000 years at a 25 year replacement interval, then 120 wells will be needed per location. A 10 by 12 well grid will evolve during the 3,000 years. At a 5-foot spacing, the grid will occupy a space about 45 by 55 feet. *Thus, the wells themselves will interfere with measurements and hydraulic behavior of the aquifers.*

6.6 Potential Waste Migration into Waterways

A major concern with the Buried Waste Alternative is the potential for radioactive waste to be released and possibly impact water supplies. In order for there to be an off-site release of radioactive contamination, there must be a means to initiate that release from trenches, tanks or lagoons. Table 6-2 contains a partial list of the many future possibilities for causes of release, excluding human actions, of radioactivity from the West Valley site.

---

213 Closure Engineering Report Alternative 2. Section 5.2.1.1, p257.

Causes for Release of Radioactivity from the West Valley Site
1. Erosion breaches the walls or base of containment feature.
A. Gulley head advances into feature, including:
1) drain plugging by hail, snow, or litter, such as leaves during storm;
2) failure of edge of seal; or
3) undercutting by sapping or desiccation.
B. Meandering adjacent to containment feature Franks Creek or Erdman Brook.
C. Down-cutting adjacent to containment feature Franks Creek or Erdman Brook.
2. Landslides
3. Desiccation cracks, including:
A. Dewatering of soil by barriers, wells, erosion, etc.; or
B. Climate change with increased droughts.
4. Expulsion by fluid pressure, including:
A. Methane from wastes or shale gas; or
B. Radioactive contaminated gas release from breaching of seals with:
1) natural or artificial covers; or
2) barriers or trench walls.
5. Burrowers, including:
A. Ants; or
B. Plant roots.
6. Corrosion, including:
A. Metals; or
B. Soils
7. Bath-tubbing, when water fills trenches and overflows.
8. Impacts, such as meteorite.
9. Combinations of events or processes.
10. Other processes or events not yet perceived.

TABLE 6.2. Ten "Natural" Causes for Releases or Escape of Radioactivity from the West Valley Site.

Radiological waste releases may take a number of different paths of migration, including air-borne transport in the form of dust or gases, migration via water at base or storm flow rates, or by absorption into a food chain. Possible forms of radiological release include solid clay, non-clay, or organic particles, or alternately pent-up fluid as liquid or gas. Rates of release can be slow or rapid—either of which can have devastating consequences.

Two worse case scenarios of particular concern are the leaching of contaminants into public water supplies.

1. Scenario 1: Expanding desiccation allows slow or intermittent escape or exchange of trench water leachate into Erdman Brook or Franks Creek, which binds to clays or silts or oxide coatings on coarse sediments. Then contaminated liquid and sediment migrate to Buttermilk and

Cattaraugus Creek stream bed and point bars, and are also taken up by bacteria and food chain. Lastly, a 10 or 100 year storm event flushes the system, including gullies and desiccation cracks. The timeframe for Scenario 1 could be less than a century.

2. Scenario 2: After centuries, several trenches containing contaminated leachate are exposed by a landslide at the end of the trenches. This sudden exposure of the end of a trench will allow a release of fluid waste contents, in addition to the processes described in Scenario 1. Because of the need to have conditions that promote landslides, this scenario may occur in centuries.

Observation of the direction that water flows away from the West Valley site suggests that radionuclide waste sediments released from the site may have a clear pathway into the Cattaraugus Creek and the bodies of water it flows into, including Lake Erie and eventually the Niagara River and Lake Ontario. Previous research gave some insight, generally supporting annual average currents as eastward in the Eastern Basin of Lake Erie, but focused on the major currents in Lake Erie rather than details of longshore transport (the geological process by which sediments such as sand or other materials move along a coastline). As part of this study, the apparent connection of Cattaraugus Creek to the Niagara River (through Lake Erie) was investigated.

In a review of NOAA wind measurements over roughly 570 three-hour periods across April and May of 2002 and 2005, eastward transport—toward the City of Buffalo and the Niagara River—dominated. Sediment transport in longshore drift along the southeast shore of Lake Erie, the outlet of the Cattaraugus, is responsive to wind direction and consequent wave direction, frequently reversing (east-west-east-west) as weather fronts passed. Longshore currents adjacent to the southeast coast of Lake Erie were eastward approximately 78% of the time, westward approximately 18% and in transition at least 4% of the time. Satellite and air plane images that overlap with wind measurement data were also examined. *Combined with wind measurement data, these images reveal that Cattaraugus Creek sediment is the most important source of sediment to the south coast of the Eastern Basin of Lake Erie. Moreover, Cattaraugus Creek is a critical source of sediment to the Eastern Basin of Lake Erie and to the Niagara River and its delta in Lake Ontario, with periods in which the Creek is linked directly to the Niagara River by longshore transport.*

This pattern is consistent with the discovery of radionuclides identified as coming from the West Valley site in Lake Erie sediments in the Niagara River and Lake Ontario. Measurements in water and sediment samples reveal the presence of cesium-137 and lead-210 from West Valley in the Niagara River and Lake Ontario.[214] To arrive at these points, water-borne radionuclides would have been

[214] Joshi, S. R. 1988. West Valley-derived radionuclides in the Niagara River area of Lake Ontario: Water, Air, and Soil Pollution, vol. 37, p. 11-120.

transported along the northeastern shoreline of Lake Erie, towards the Niagara River, and passing by the Sturgeon Point Treatment Plant, the Van de Water Treatment Plant, and the water intakes for the city of Buffalo.

In the event of a “first flush” storm, one that follows a period of slow radioactive release and environmental accumulation, concentrations of pollutants often rise (rather than diminish or dilute) as the flood rises. However, the dose that reaches water supply intakes is dependant on how diluted the radioactive wastes become with each transition to a new water body. Any creek or shore zone will mix within itself fairly rapidly, over the distance of a few bed or bar forms or after a couple of eddies in currents. Thus, dilution will be simply a function of relative volumes that mix.

Dilution occurs with changes in flow (in cubic-feet-per-second). Like creeks and rivers, volumes of near-shore currents vary greatly through time, but data on actual measurements of currents within Lake Erie are lacking. However, an assessment of measured stream discharges, currents modeled by NOAA, and a qualitative review of remote sensing imagery, field observations, and dilution measurements suggest that sediments would be diluted roughly on the following scale for each of the following transitions, from lower to higher flow rates (Table 6.3).

Water body/waterway	Concentration
Erdman	1
Franks	1/10
Buttermilk	1/100
Cattaraugus	1/1,000
Lake Erie Shore	1/10,000
Niagara River	1/200,000

Table 6.3: Estimated concentration of sedimentary materials diluted, assuming concentration in Erdman Creek=1.

6.7 Summary

The long-term stability of buried waste at the West Valley site is highly questionable. Currently, there is a large plume of contaminated groundwater moving towards Buttermilk Creek. The contaminated soils and groundwater which are carrying the plume are complex and the hydrology is difficult to model; it is unclear if or when contaminants from the plume may reach surface waters. However, even more worrying for the downstream population and the priceless resource of the Great Lakes is the potential for streams near the site to undercut or expose wastes interred or buried at the site. West Valley sits on a geologically young landscape which is undergoing a relatively rapid rate of erosion.

There are numerous problems with a model of erosion at West Valley developed in the 2005 draft DEIS. The model is unable to predict gulley formation, inadequately estimates the rate of downcutting in some of the young and rapidly moving streams, and uses a method to describe erosion which does not reflect known physical processes at the site. In our estimation, the potential for wastes being exposed by rapid erosion over the next hundred to thousand years is far more likely than determined in the 2005 draft DEIS.

Preventing gulley erosion, stream migration, and landslides at West Valley will be difficult, if not impossible, over the long term. Over a period of years to decades, erosion control mechanisms can be effective under design conditions—however if the system maintenance is neglected, or if a rare extreme flood occurs, erosion control mechanisms can become ineffective quickly. For example, levees along rivers are not designed to allow floodwaters into cities and towns, and yet this is a regular occurrence throughout the Midwest. The probability that institutional controls, memory, and budgets will remain effectively in place throughout the next millennium is highly unlikely, and therefore we should be concerned about any plan to try to maintain critical control features if wastes remain at West Valley under Buried Waste Alternative 2.

For the purposes of this full cost accounting study, we assumed that, although unlikely, erosion control features are maintained for the next millennium. We then evaluated the site needs and added erosion controls which could protect the integrity of the site if maintained regularly over the next thousand years. This added infrastructure and maintenance requirement increases the cost of long term stewardship at West Valley significantly, but must be part of the accounting at the most fundamental level.

7. Societal Costs: Land Use and Water Impacts of Alternatives 1 and 2

In this section, we discuss costs to society, including devaluation of properties near the West Valley site, foregone economic productivity from the restricted portion of the site, and potential costs of replacement water supply in the event of a catastrophic release of radioactive waste due to failed institutional and engineering controls. Although public health costs are not discussed here due to limited resources, health impacts and medical costs due to increased human exposure to radioactive waste in the event of a catastrophic or routine, chronic releases are important considerations.

7.1 Land Use Values

The ability to use land, or conversely the inability to use it, affects communities and the environment through impacts on the economy, ecological balance, public health, and social and cultural systems. Effects on land use are an important component of any full-cost accounting, and particularly when considering the various possible impacts of the alternatives for cleaning up the West Valley site. For example, the Waste Excavation Alternative's goal of unrestricted use means the land could theoretically be redeveloped for agricultural, residential, commercial, or industrial purposes; bring back the tax base; and revitalize the local economy. On the other hand, the Buried Waste Alternative would result in only a small part of the site being available for such purposes, and still in close proximity to buried waste.

Most of the cleanup alternatives considered in the 2005 draft DEIS are expected to result in restricted use of some portion of the site or of the entire site due to substantial waste and contamination remaining at the site. Each alternative also poses some risk of damaging and reducing the value of nearby and downstream properties and communities. Most of the alternatives outlined in the 2005 draft DEIS strive for various remediation goals where the site's "end-state" would be largely contained contamination with continued monitoring (Alternatives 2 through 5). Only Waste Excavation seeks a cleanup goal where the entire site would be available for unrestricted land use. All of the other alternatives presented in the 2005 draft DEIS would result in severe restrictions on land use for the entire 3,345-acre site.[215] As noted earlier, Cattaraugus County has experienced a decline in its manufacturing and agricultural economic sectors. In the 19th and early 20th centuries, western NY's proximity and access to major water shipping routes promoted significant commercial and industrial development. Shifts in means of

[215] Under Alternatives 2 through 4, DOE proposes that a smaller portion of the site, 1,700 acres, could be released for other purposes, although the amount of land that could be released would be limited by the size of the buffer zone needed for waste that remained onsite. Alternative 5 would result in no land available for reuse (2005 draft DEIS, ch. 2, p. 2-32 – 2-33)

transportation and in domestic and international markets then caused significant declines in the region, and the Niagara-Buffalo area has suffered population loss, economic stagnation, a weak real estate market, and a high concentration of sites with environmental contamination.[216] However, the regional economy is showing signs of turning around, with the recent development of other business sectors, including tourism, services, transportation, and construction. In the future, it appears likely that this recent trend will continue. The proposed widening of Route 219 through much of Cattaraugus County to a four-lane limited access highway could further boost tourism in the Ashford/Concord/Sardinia and Ellicottville/Salamanca areas in the short term.[217] In the future, shifts in global climate systems could render upstate New York into a more attractive location relative to other areas and prompt a population shift to the cooler northern climate.

Two scenarios are relevant for the consideration of land use if Alternatives 1 or 2 were implemented. For the Waste Excavation Alternative, we assess societal benefits and estimated costs of remediating the site to unrestricted use. For the Buried Waste Alternative, we considered a scenario where improved controls prevented the release of the radioactive wastes from the site over the period of analysis, and a scenario where controls failed to prevent the catastrophic release of nuclear waste from the site.

7.1.1 Land Use Costs and Benefits: Waste Excavation Alternative 1

Alternative 1 cleans up the entire site to levels that allow for unrestricted use. Land-use costs are either not relevant to Alternative 1, or they are much smaller than the costs of Alternative 2. For example, under Alternative 1, the entire site would be available for the highest and best use of the property after clean-up.

The value of the site may also suffer from environmental stigma, even after remediation is finished: “physical cleanup does not usually eliminate the value loss resulting from stigma.”[218] However, impacts on property value diminish towards the later stages in the remediation cycle, as risk and uncertainty decrease.[219] Short of a release during remediation activities, environmental stigma would be much less likely to affect the market values of adjacent properties.

There is the possibility of human error leading to a release of radioactive waste during the remediation phase; such a release could put the value of the site and nearby properties at risk.

---

216 US EPA, Brownfields Showcase Community Fact Sheet: Niagara Region, New York. Available at http://www.epa.gov/swerosps/bf/html-doc/sc_niagara.htm

217 William King - Town Supervisor of Ashford, Gary Epolito - Town Supervisor of Concord, and Kathy Balus – Town Supervisor of Sardinia. Personal interview with William Steinhurst. Oct. 2006

218 Kinnard, William N. and Elaine M. Worzala. “How North American appraisers value contaminated property and associated stigma,” Appraisal Journal 67.3, Jul 1999: p 269.

219 Jackson, Thomas O. “Case Studies Analysis: Environmental Stigma and Monitored Natural Attenuation”. The Appraisal Journal, Spring 2004: 328-332.

7.1.2 Land Use Costs of Buried Waste with Controls: Alternative 2

Restricted Area of the West Valley Site

There are costs to society even if institutional controls and collective memory are sufficient to keep people from using or settling on the polluted site. If all or part of the site remains restricted, as DOE proposes for Alternative 2, society will have foregone future land uses for this portion of the site. Many productive uses of the site, such as agricultural, residential, recreational, commercial and industrial uses, would not be possible or safe for a radioactive site restricted by institutional controls. *When there are limits on the "highest and best use" of property[220], land values are significantly diminished.*

Loss of productive use of the site is represented by the difference between its unimpaired value—that is, absent contamination—and its impaired value after completion of any cleanup measures called for under the Buried Waste Alternative 2. The *impaired value* for any restricted portions of the site (such as federal NRC license restrictions) is probably zero or close to zero, because most uses of this land would not be allowed under Alternative 2 for 1,645 acres of the site. Although some industrial uses (e.g., a landfill) could still be permitted for the restricted portion of the site, even these businesses may shy away from the site if they perceive any risk or uncertainties associated with the site. For example, a business might be concerned with future liability for the health of on-site workers, the possibility that existing radioactive waste would compound its own remediation costs—i.e., clean up of the businesses' own emissions could be complicated by the presence of West Valley wastes—or disruptions to business if any of the institutional controls fail. For simplicity, we will assume that the property value is zero in the absence of total waste removal, because of the severe impairment on its productive capacity.

To determine the loss in land value due to continued contamination and restrictions on the use of the site, we compare the *unimpaired value* of the site—that is, if there were no contamination or restrictions on use of the site—to its impaired value. Assessing the *unimpaired value* of the site for the next few years is difficult, and much more so for the thousand-year period of analysis. The unimpaired value of a property in New York can be estimated by two different methods: the market approach and the income approach.[221, 222]

In the *market approach* to assessing land value, the property is compared to

---

[220] The highest and best use has a specific definition in appraisal. It is the use that produces the highest value of all of the uses that are physically, legally, and financially possible. (Jackson, Thomas O. and J. Michael Sowinski Jr. "Institutional Controls and Contaminated Property Valuation". The Appraisal Journal, Fall 2006: 328-332.)

[221] Office of Real Properties Services, 2008. http://www.orps.state.ny.us/pamphlet/assessjo.htm

[222] A third method, the cost approach, is focused on the cost of replacing human-made structures. However, structures are not considered here, as they are short-lived relative to the long time period over which radioactivity at West Valley site poses a health risk to inhabitants. The cost approach does not address land value.

similar, uncontaminated properties that have sold recently. This approach is widely accepted as an appropriate method for the assessment of vacant land. However, many factors affect market value, such as proximity to employment centers,[223] markets,[224] and natural resources from the site; aesthetic value;[225] unemployment and the cost of living in the area;[226] governmental tax, land use, resource conservation, and housing policies.[227] Rural land prices are partially determined by soil type, topography, and potential uses for the land, as well as by external variables such as climate, the price of rural commodities, costs of agricultural inputs (e.g., fuel and fertilizer) and interest rates.[228] In the case of West Valley, some of these factors may change dramatically over the period of analysis, such as climate change impacts, alternative land uses (f Rte. 219 is widened and increases residential development pressures), fuel costs and topography. The short-term outlook and sensitivity of the market approach to many local, regional, and even national factors makes this method unlikely to be reliable over the long period of analysis being considered in this study.

Another way to analyze the unimpaired value of land is to use the *income approach*, which involves calculating how much income a property can produce if rented, considering earnings, operating expenses, insurance, maintenance costs, and financing costs. The productive capacity of the land, absent contamination, should be based on anticipated land uses in the future. Of the uses that are physically, legally, and financially possible, what would be the highest and best use of an uncontaminated site similar to the West Valley site in the short-term, in a century or in a millennium from now? The social, economic, and ecological uncertainty posed by climate change makes an assessment of the possible physical, legal, and financial uses of the land somewhat speculative. Moreover, with the high likelihood of institutional discontinuity over the centuries to come (see Section 5), the legal constraints placed on the land are impossible to know at this juncture. As a hypothetical, agricultural use could be physically possible at an unimpaired and fully remediated site.

Currently the land use in Cattaraugus County is primarily residential, followed by parks, recreation and entertainment, vacant, and agricultural. However, data availability on land-only values is limited for residential use. Residential property

---

223 Bowes, David R. and Keith R. Ihlanfeldt. “Identifying the Impacts of Rail Transit Stations on Residential Property Values.” Journal of Urban Economics, 50:1, Jul 2001.

224 Gardner, Kent and Richard Barrows. “The Impact of Soil Conservation Investments on Land Prices”, American Journal of Agricultural Economics: Dec 1985 (Volume 67, Number 5), available from http://chla.library.cornell.edu/.

225 Bourassa, Steven C., Martin Hoesli, and Jian Sun. "The Price of Aesthetic Externalities" FAME Working Paper No. 98. Nov 2003.

226 Vermeulen, Wouter and Van Ommeren, Jos, 2005. Compensation of Regional Unemployment in Housing Markets. Tinbergen Institute Discussion Paper No. 05-093/3.

227 Consortium for Atlantic Regional Assessment, 2008. Land Use Primer. http://www.cara.psu.edu/land/lu-primer/luprimer08.asp

228 Eves, Chris. 1999. Modelling rural land values. Available from www.rics.org.

rental data usually includes both land and structures, the later of which would have a value that is incremental to the value of the land itself. Land for public parks, recreation and entertainment cannot be readily assessed by preferred, standard economic measures, such as price (as a reflection of willingness to pay), and valuation methods that have potentially large biases must be used instead.

In 2007, the average annual cropland rent was $39 per acre for the State of New York.[229] In comparison, values for residential and commercial land range from $1,400 to upwards of $7,000 per acre, 30-200 times more valuable than agricultural land.[230] However, with few other indicators as to an appropriate valuation for land, we chose one of the least optimistic values, that of agricultural rents reported by the U.S. Department of Agriculture (USDA).

It is important to note that if agriculture is the highest and best use of the site absent contamination, it will underestimate the value of the land under many probable economic development scenarios. Cattaraugus County has experienced a change in its land use patterns and economic base over the last several years, suggesting that a different highest and best use (such as residential or commercial zoning) may be most relevant in the decades to come. As noted earlier, there have been significant local efforts to promote tourism. In addition, the proposed widening of Route 219 through much of Cattaraugus County to a four-lane limited access highway could result in one or more major bedroom community residential developments and increases in commercial and industrial development as well as tourism to the Ashford/Concord/Sardinia area, as well as the Ellicottville/Salamanca area to the south.[231],[232] Assuming that commercial use is the highest and best use of the restricted portion of the property would yield a higher property value; however, the income value of commercial property varies widely based on the type of business and is fairly uncertain given that it is a departure from historical land uses in Cattaraugus County.

Effects on Nearby Properties

The choice of the Buried Waste Alternative has implications beyond the West Valley site boundaries. The land surrounding or downstream of the site already has and may continue to have in the future, an environmental contamination stigma. It may also suffer a reduction in property value as a result, even if that land (or water

[229] http://www.nass.usda.gov/Charts_and_Maps/Land_Values_and_Cash_Rents/index.asp

[230] Data on prices of vacant land were sparse at the time of this writing but suggest a higher rental rate for residential zoned property ($3,000-$7,500/acre/year), commercially-zoned property ($1,400-1,700/acre/year) and for industrial zoned property than for agricultural land, depending on existing utility access, presence of water on the property, and location, among other things,

[231] William King - Town Supervisor of Ashford, Gary Epolito - Town Supervisor of Concord, and Kathy Balus – Town Supervisor of Sardinia. Personal interview with William Steinhurst. Oct. 2006

[232] In 2000, the state received federal funding for final design, right-of-way acquisition, and reconstruction along US 219 from Springville to Salamanca. (http://www.fhwa.dot.gov/pressroom/fhwa0041.htm) NYSDOT received approval to extend the Route 219 freeway. (https://www.nysdot.gov/portal/page/portal/regional-offices/region5/projects/us-route-219/reports)

source for that land) is not actually contaminated. Affected properties would likely include those within the floodplain of, or drawing on water from, Erdman's Creek, Frank's Creek, Buttermilk Creek and Cattaraugus Creek, but other properties could be affected as well. This study is unable to undertake an assessment of the magnitude of this cost. A full cost accounting of the alternatives in the DEIS should include the costs of environmental stigma on property values for the centuries over which West Valley wastes pose a threat at the site.

In addition, the inability to put the site back to productive use can hinder local economic development, although it is difficult to quantify the economic impacts of this problem. Many brownfield redevelopment initiatives, such as the program in the Buffalo-Niagara region, are based on this premise.

7.1.3 Land Use Costs of Buried Waste with Failed Controls: Alternative 2

Sections 5 and 6 discussed the likelihood that institutional and erosion controls will fail over the time period that the West Valley wastes pose a hazard to public health and the environment. While the DEIS discusses the possibility of some scenarios where controls fail, it does not consider the damages to real estate, nor does it give sufficient weight to the likelihood of these failures.

Even a small leak from the nuclear waste inventory onto adjacent properties or into groundwater could greatly depress the value of affected properties. Immediately affected properties would likely include those abutting and within the floodplain of Erdman's Creek, Frank's Creek, Buttermilk Creek and Cattaraugus Creek. Next, would be properties going on to the Lake Erie region. The magnitude of this cost would depend on the timing of the leak, the scope and type of leaking contamination, and the current and future highest and best uses of any affected property, among other factors.

Other than in the Seneca Nation of Indians territories, agriculture is primarily outside of the flood plains for these creeks, and the waters from these creeks are not currently used for irrigation.[233] Other direct uses of Cattaraugus Creek water and land within its floodplain include tourism, sport hunting, and fishing. These activities are reportedly important to the Ashford economy and lifestyle.

7.2 Water Resources

The water resources in the region surrounding the site are especially valuable and vulnerable. First, the site lies in the Great Lakes Basin Area which is particularly valuable as the Great Lakes contain one-fifth of the world's surface fresh water. The Great Lakes, such as Lake Ontario and Lake Erie, are especially vulnerable to toxic contamination, because of the slow flushing of the waters and the longevity

[233] William King - Town Supervisor of Ashford, Gary Epolito - Town Supervisor of Concord, and Kathy Balus – Town Supervisor of Sardinia. Personal interview with William Steinhurst. Oct. 2006

and persistence of radioactive materials.[234] In addition, the site lies in the Cattaraugus Creek Basin Area which is a designated "sole source aquifer" by the federal Environmental Protection Agency (EPA).[235] This designation signifies a priority status to protect this groundwater resource since it provides drinking water in an area with few or no alternative sources. If contamination occurred, using an alternative source would be extremely expensive.

A major concern with the choice of a cleanup alternative is the potential for radioactive waste to be released and possibly impact water bodies near the site (see Figure 7.2 for schematic of pathway). There are many potential future causes of radionuclide escape into the local watershed, including both human actions during decommissioning[236] and during long-term onsite storage, as well as natural processes.[237] The mechanisms for release during decommissioning include building collapses, fires, truck or rail accidents, chemical reactions, drops, punctures and spills.[238] While the mechanisms for release during long term burial includes an accidental or intentional breach by a resident farmer,or during construction, or by a purposeful invader, or underground radionuclide migration and/or erosion at the site leading to the collapse or leakage of the wastes into local wells, streams and rivers. The potential for radionuclide release during decommissioning or transportation are very real risks, and are quantified to a point in the 2005 draft DEIS (in Appendix A). However, the potential for a large radionuclide release by benign neglect (in other words, the site is forgotten over hundreds of years) is also a very real concern, and one that is given short attention in the 2005 draft DEIS.

A large release would cause long-lived, severe damage to the environment, human health, property values, and the economy surrounding the West Valley site and immediately downstream of it. (See section 7.1 for a discussion of potential land use and economic impacts.) However, the impact of a release could reach much farther, given the potential for long-range water transport of waste particles. Radionuclide waste sediments that are released from the West Valley site have a clear pathway into the Cattaraugus Creek and the bodies of water it flows into, including Lake Erie and eventually the Niagara River and Lake Ontario (see Figure 7.1 for regional context). *Indeed, waste sediments from the West Valley site have been found as far away as the southwestern region of Lake Ontario*[239] even with institutional and erosion controls in place, calling into question the ability of these controls to adequately protect human health and the environment for the many

---

234 Great Lakes International Joint Commission 2008. http://www.ijc.org/en/home/main_accueil.htm

235 U.S. Environmental Protection Agency 2008. http://www.epa.gov/region02/water/aquifer/

236 See DEIS draft 2005, Appendix I

237 See DEIS draft 2005, Appendix H

238 DEIS draft 2005, Appendix I p14

239 Joshi., SR. 1988. West Valley-Derived Radionuclides in the Niagara River Area of Lake Ontario. *Water, Air, and Soil Pollution*. **37**:111-120

centuries over which the radioactive waste at West Valley would be hazardous. The financial consequences of rendering one of the earth's largest freshwater supplies unusable are massive, far outweighing any costs required to prevent such a disaster.

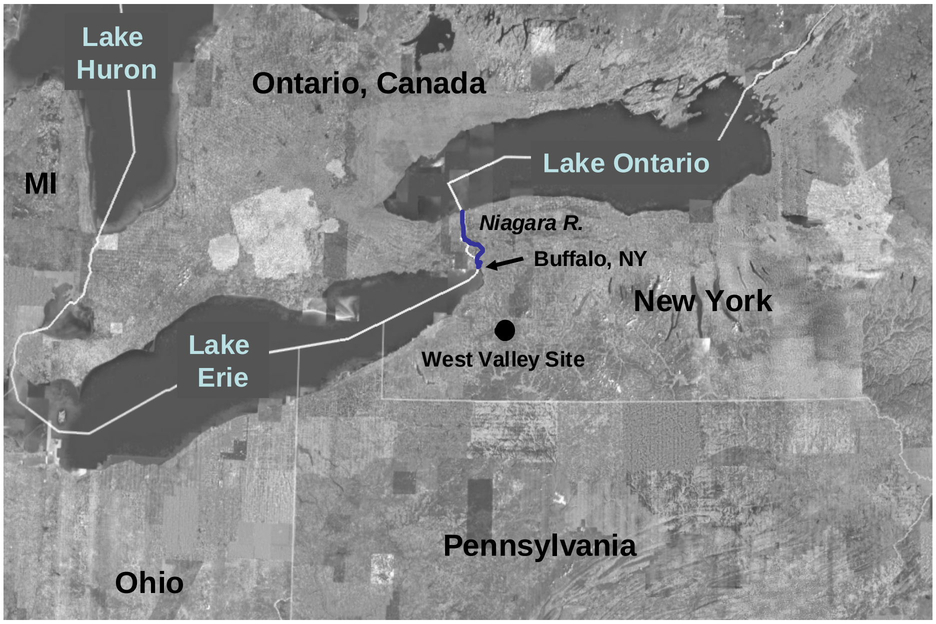


Figure 7.1
West Valley site relative to Great Lakes.

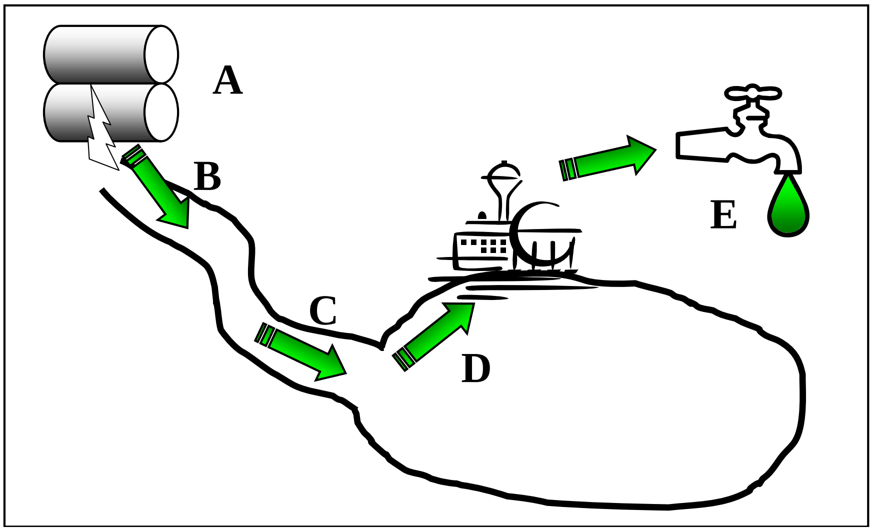


Figure 7.2
Schematic of contamination movement from West Valley to municipal water supply. (A) Erosion or intrusion at West Valley releases radionuclides from trenches or holes. (B) Radioactive waste enters local watershed (Buttermilk Creek). (C) Waste is carried downstream to Cattaraugus Creek and into Lake Erie. (D) Contaminated waters travel along Lake Erie longshore current and into a water treatment facility. (E) Radioactive waste contamination could enter drinking water supply.

7.2.1 Impacts of Lake Erie Contamination

Populations near and downstream of the site could be exposed to West Valley contaminants through a whole host of water uses. Currently, these water supplies are used for drinking and other domestic uses, such as cooking, bathing and clothes washing; commercial and industrial uses, including food processing; irrigation; fishing; swimming, boating, and other recreational uses; and cultural uses.

<u>Drinking Water</u>

Buffalo and much of the heavily populated areas of Erie County take their municipal water supplies from Lake Erie and the Niagara River. Several major drinking water intakes would likely be impacted by the release of contamination into Cattaraugus Creek. Radionuclides that escape from the West Valley site would travel down Cattaraugus Creek into Lake Erie, travel northeast along the shore and enter water intakes for Erie County and Buffalo (see Figure 7.2). The Erie County Water Authority (ECWA) provides water services for approximately 550,000 people throughout Western New York,[240] and the Buffalo Water Authority (BWA) provides water for 290,000 people in the Buffalo municipality.[241] The ECWA draws water from two pumping and treatment stations on Lake Erie (Sturgeon

---

[240] Erie County Water Authority. 2006. Annual Report. http://www.ecwa.org/anrep/2006.pdf

[241] Buffalo Water Authority, 2007. Annual Report. http://www.buffalowaterauthority.com/

Point in Derby, NY and Van de Water Treatment Plant in Tonawanda NY), while BWA draws from the Colonel Ward Pumping Station on the Emerald Channel at the mouth of the Niagara River, which draws water from the East branch of Niagara River. Combined, these two utilities treated over fifty billion gallons of water in 2006.

The Seneca also draw water supplies from Lake Erie and have expressed concern about contamination from the Cattaraugus Creek reaching and impacting the Lake. About 80% of Territory population receives drinking water from Lake Erie (other sources of potable water for the Seneca include groundwater wells). Data on water usage by the Seneca Nation of Indians was not found.

A number of other water authorities could be impacted by contamination escaping from the West Valley sites. Those that could be impacted by eastward longshore transport of sediments from the Cattaraugus Creek include the following.

- Niagara County Water District:
  - Near West River Rd. in Town of Grand Island (source: West branch of Niagara River
- Niagara Falls Water Board
  - Michael C. O'Laughlin Water Plant (source: East branch of Niagara River)
- Regional Municipality of Niagara, Ontario, Canada
  - Niagara Falls Water Treatment Plant (source: Niagara River via Welland River Channel)
  - Welland Water Treatment Plant (source: Lake Erie via Welland Ship Canal & Welland Recreational Waterway)
  - Rosehill Water Treatment Plant, Fort Erie (source: Lake Erie)
  - Port Colborne Water Treatment Plant (source: Welland Canal)
  - DeCew Falls Water Treatment Plant (source: intake canal from Welland Ship Canal, Lake Erie)

Also, several drinking water intakes west of the outlet of the Cattaraugus Creek could be impacted, including the following.

- City of Dunkirk, Lake Erie
- Erie Water Works, PA
  - Chestnut Water Treatment Plant, 17,500 ft into Lake Erie
  - Sommerheim Water Treatment Plant, 8,700 ft into Lake Erie

Contamination of any drinking water supplies would result in polluted and undrinkable water causing severe and potentially devastating health and economic impacts to communities. While drinking water is the most significant public health concern, water is also important for other domestic uses. If there were contamination such that the water was also not fit for dishwashing, personal hygiene, and the like, the quantity of alternative water supply needed and the public health problems would be even more severe.

<u>Fishing, Swimming, and Other Water Sports</u>

Fishing, swimming, kayaking, and boating are popular with both residents and visitors to the Great Lakes region. As noted in the previous section, tourism is an important economic development area in Cattaraugus County and beyond. The specter of radiological contamination in these waters—real or not—could have a devastating impact on the economy and resident's quality of life.

Above and beyond other water sports, swimming and fishing in water contaminated with radiological waste raise major public health concerns. Swimming poses a risk of accidental ingestion. Recreational swimming in Cattaraugus Creek is important to Seneca members, especially children. Fishing is also of significant concern. Consumption of fish from contaminated waters poses a public health risk, because contaminants can accumulate in aquatic organisms that are higher up the food chain. Accumulation varies by species, organ/body part (flesh, bone, liver, etc.), the type of radioactive material, and length of exposure to the radioactive material. For example, mussels are sensitive bioindicators of radiological contamination. Cattaraugus County residents engage in recreational fishing, and both recreational and subsistence fishing are important to members of the Seneca Nation of Indians. Moreover, recreational fishing by tourists is a significant part of the tourism industry on and off of the Seneca Territory.

Business Uses

Commercial and industrial businesses rely on Lake Erie and Lake Ontario waters for a number of uses, some of which would be jeopardized by water contamination. Changes in the availability and cost of obtaining high-quality water could impact employment in the Cattaraugus-Lake Erie-Niagara area, as companies become less competitive and are forced to downsize or even close business operations.

Sport fishing in the Great Lakes is estimated to attract over 1.5 million anglers, provide over $2.5 billion annually in direct retail sales, supporting nearly 60,000 jobs, and generating over $900 million in federal, state, and local taxes.[242] In 2006, New York alone attracted 247,000 Great Lakes Anglers, who supported over three thousand jobs and generated $28 million in state and local tax revenues.[243]

For instance, employing 35,500 people, the H.J. Heinz Company of Canada processes tomato products, baby food, soup, vinegar, pickles, beans, pasta, infant cereals, pet food, frozen dinners and foods. The Heinz Leamington plant consumes 30 to 35 percent of the 14.2 million gallons daily treated by the Union Water System, operated by the Ontario Ministry of Environment. All of Union Water System's water comes from Lake Erie via a 54 inch intake pipe, is strained to remove microscopic algae and then sent to an up-flow clarifier where polymers, activated carbon, and liquid alum are added. The water is then chlorinated, sent to rapid fan filters, and post-chlorinated. Additionally, Heinz treats its water with

[242] American Sportfishing Association. 2008. Sportfishing in America: An Economic Engine and Conservation Powerhouse. http://www.asafishing.org/

[243] ASA, *ibid*

chlorination, and water for kitchen operations is also sent through carbon filters.[244] It is doubtful that existing water treatment processes by either Union Water or Heinz would be able to filter out radioactive waste particles or dissolved radionuclides.

Irrigation

Irrigation is another current and likely future use of Great Lakes water.[245] Irrigation has not been noted from the Cattaraugus Creek, although the Seneca have expressed an interest in potentially using Cattaraugus Creek for irrigation in the future. A release of radiological waste would pose a problem for any irrigation from Lake Erie, Niagara River, and even Lake Ontario.

---

[244] Great Lakes Comission. 2008. "H.J. Heinz Company of Canada Ltd". in *Liquid Asset: Great Lakes Water Quality and Industry Needs.* http://www.glc.org/docs/liqasset/liqasset.html#hjhc

[245] Great Lakes Comission, 2006. *Annual Report of the Great Lakes Regional Water Use Database Repository*. http://glc.org/wateruse/database/pdf/2004-gallons.pdf

Other Cultural & Spiritual Concerns

The Seneca Nation of Indians place a very high value on protecting the whole balance and health of the Territory's ecology. Protecting river water quality is of particular importance, as these waters provide means for relating to "Mother Earth." Of course, no price can be set for resources that have such spiritual importance. (See Section 5 for a discussion of priceless resources.)

7.2.2 Catastrophic Release of Radioactive Waste Scenario: Impact on Lake Erie Water Consumers

In the case of a catastrophic infrastructure failure, consumers of Lake Erie's waters could be exposed to 8,710 person-rem *every year* as soon as 500 years from today (see Appendix B for more detail). In the event of a catastrophic release at West Valley, clean water would need to be brought in as an alternative to water systems drawing on Lake Erie and the Niagara, including the Buffalo Water Authority (BWA) and Erie County Water Authority (ECWA). Unfortunately, in the absence of detailed cost assessment studies, it is difficult to pinpoint the cost of these alternative supplies.

We estimated water replacement costs if there were a catastrophic release of radionuclides approximately 500 years from the time of closure expected in Buried Waste Alternative 2. We created a catastrophic release scenario with a simple storyline. In year 500, radioactive waste buried in a trench is exposed by erosion and quickly enters Lake Erie. By the time it is detected, emergency measures must be put in place to prevent contamination in the ECWA and BWA service areas. In response, the Federal Emergency Management Agency (FEMA) begins trucking in water from Mayville, NY on Chautauqua Lake, the nearest uncontaminated large water source on the American side of the border to serve only residential needs. For the next five years, water costs become less expensive as more efficient services are developed to transport water to residents. After five years (in year 505), a new treatment plant is completed with ion exchange technology to filter a majority of radionuclides out of the water stream. At this point, all water is run through this new system for the next 500 years.

Table 7.1 illustrates the costs and calculations to determine the replacement costs for water in Western New York. The costs associated with this emergency are substantial in the first year, at over $272.7 million dollars, but then decline to a steady $27.5 million to maintain the water treatment plants.

This water cost is only a case example, and does not include a substantial population on the shores of Lake Erie and Lake Ontario who could also be impacted by the release of radioactive waste from West Valley.

For the purposes of this analysis, we assume that the cost to truck in emergency water supplies for residential consumption could be as high as $8.80 per thousand gallons delivered initially,[246] but would be likely to drop significantly as these communities find cheaper, temporary solutions to the water crisis. For drinking and cooking uses only, the cost to truck in emergency water supplies would total about $273 million per year, delivered, for BWA and ECWA residential customers (see Table 7.1). This total does *not* include commercial, industrial, and institutional uses, some of which would require clean water (e.g., drinking, cooking, food processing, etc.) Moreover, it does not include alternative water supply for bathing, laundry, pools, dishwasher, or other domestic uses, as might be required under some scenarios.

Water Cost Basis	Value
ECWA customer population	550,000 [247]
ECWA water treatment volume	23,054,800,000 gal
BWA customer population	290,000 [248]
BWA water treatment volume	27,000,000,000 gal
Emergency trucking of water from Mayville, NY to Buffalo, NY	
Residential component of ECWA and BWA customer base	62% [249]
FEMA water truck costs	$20.50 / hr [250]
FEMA water truck capacity	14,000 gal / truck [250]
FEMA water trucks required per year to serve residential needs	2,216,713 truck runs
Turnaround capacity for each truck (trip to Mayville, NY, plus pump time)	6 hrs [251]
Total cost per year for water shipment	$272,655,646
New water ion exchange capacity	
Cost of ion exchange water filtration	$0.55 ($0.30 – $0.80) / 1000 gal [252]
	$0.73 / 1000 gal
Cost of filtration for all treated water in ECWA and BWA, per year	$27,530,140

Table 7.1: Cost calculation for emergency water delivery and long-term water treatment for Erie County and Buffalo Water Authorities.

A longer-term solution might involve designing, obtaining permits, and building infrastructure to channel water from another location via aqueducts. However, the cost and time to construct an aqueduct may be significant, depending on how clean and how far away the ultimate water source is, and how many right-of-ways need to be obtained. Another approach could be for these communities to build or upgrade existing treatment plants that are capable of removing contaminants from

[246] Cost is derived by dividing total trucking costs ($272.6 million) by the amount of water required for residential use (31 billion gallons per year)

[247] Erie County Water Authority. 2006. Annual Report. http://www.ecwa.org/anrep/2006.pdf

[248] Buffalo Water Authority, 2007. Annual Report. http://www.buffalowaterauthority.com/

[249] Approximated from ECWA utility documents

[250] FEMA, 2008. Schedule of Equipment Rates. http://www.fema.gov/government/grant/pa/eqrates.shtm

[251] Highly conservative estimate: Mayville NY is approximately 70 miles from Buffalo, requiring nearly a two hour trip in each direction.

[252] Federal Remediation Technologies Roundtable (FRTR), 2008. Screening Matrix and Reference Guide, Version 4.0. 4.48 Ion Exchange.

current water supplies. Some of the radioactive particles in the West Valley waste inventory are reduced by filtration, but some are not—including cesium, radium,tritium and strontium. Water treatment technologies that would effectively remove most of the waste products include ion exchange and reverse osmosis, both of which are considered Best Available Technologies (BAT) for radium, uranium, gross alpha activity, and beta particle activity, but are significantly more expensive than traditional water treatment methods. Costs for small ion exchange systems range from $0.30 to $0.80 per thousand gallons according to the Federal Remediation Technologies Roundtable,[253] or $0.73 per thousand gallons according to the EPA .[254] Reverse osmosis systems cost $3.02 per thousand gallons.[255] If all of BWA and ECWA water needs, including all residential, commercial, industrial and institutional demands, were served by treatment plants using ion exchange technology, costs would run about $27.5 million per year.[256]

---

253 Federal Remediation Technologies Roundtable (FRTR), 2008. Screening Matrix and Reference Guide, Version 4.0. 4.48 Ion Exchange.

254 U.S. EPA. Apr 21 2000. National Primary Drinking Water Regulations: Radionuclides. Federal Register (65)78: pp 21575-21628. http://www.epa.gov/EPA-WATER/2000/April/Day-21/w9654.htm

255 U.S. EPA. *ibid*

256 This number only includes replacement supply for customers of the Buffalo and Erie County water authorities. Other water authorities draw on the Niagara, Lake Erie, & Welland channel & canal. These other water authorities include the Niagara County Water District, the Niagara Falls Water Board, Regional Municipality of Niagara in Ontario, City of Dunkirk and Erie Water Works, PA.

8. Full Cost Accounting of Site Cleanup Options

In this section, we compare the economics of two alternatives for the long-term remediation of radioactive waste at the West Valley site. The waste poses a wide range of substantial risks to the local community as well as the downstream population, including the metropolitan population of Buffalo and other users of Lake Erie's waters. The risk of highly radioactive contamination extends not only to customers of public water supplies but also to the fisheries, ecological communities, and waters-at-large that constitutes the natural resource of Lakes Erie and Ontario. These resources are held in public trust by the State of New York and other government entities.

The alternatives discussed are complete waste exhumation (Alternative 1) and leaving in place buried waste with controls, and partial waste excavation (Alternative 2) from the 2005 pre-release Draft Environmental Impact Statement (DEIS) written by the federal Department of Energy (DOE) and its contractors. This DEIS is a replacement to the non-finalized and publicly issued 1996 draft DEIS. Both DEIS's offer five alternatives that, to the best of our understanding, were designed by the DOE to encompass a range of remediation options along a gradient of risks, with the alternatives posing higher exposure risks for the public generally costing less to implement (See Section 3). We have analyzed the two alternatives that represent reasonable extremes of risk and cost considered by the DOE in the 2005 draft DEIS. In this circumstance we do not analyze Alternatives 3 or 4 because we believe that it is unlikely that either of these two options could be implemented safely. We also assume that some form of remediation will occur at West Valley as required by statute, and so do not analyze the costs or risks of Alternative 5.

Waste Excavation Alternative 1 is the complete cleanup approach with waste excavation and off-site storage or disposal of wastes. DOE would decommission site buildings, remove all wastes, and clean up all contamination at the site so that it meets federal and state requirements (Nuclear Regulatory Commission's License Termination Rule, etc.). After all the wastes are removed and shipped off-site for storage or disposal, the closure activities would be concluded and the site would be available for "unrestricted release."[257] DOE states that this Alternative has the "highest" implementation risk[258] during cleanup. There would be essentially no risk to nearby communities and the environment after the cleanup. According to the DEIS, the implementation of Alternative 1 would take 73 years[259] and cost $10.62 billion.[260]

---

[257] 2005 draft DEIS p2-15

[258] 2005 draft DEIS Table 4-18

[259] 2005 draft DEIS p2-18

[260] 2005 draft DEIS, Table 2-10

Buried Waste Alternative 2 is the buried waste approach, with excavation and off-site disposal of a relatively small amount of waste at the site. DOE would remove only the most accessible and immediately dangerous wastes, leaving the bulk of buried wastes at the site for long-term monitoring and maintenance by the State of New York and DOE. DOE states that the 30-year implementation plan[261] imposes a "medium" risk on the local population.[262] However, we believe Alternative 2 also has a medium risk for the 117 year post-implementation monitoring phase[263] and a very high and increasing risk in the unfunded "long-term stewardship" phase. According to the draft DEIS, the total Alternative 2 cost is estimated at $2.01 billion[264] over 218 years, a value which does *not* include the cost of long term stewardship over the thousands of years this waste is expected to remain hazardous. Also for simplicity we used cost figures to meet the NRC's License Termination Rule cleanup requirements, however, both the Environmental Protection Agency and New York State have more protective cleanup standards which provide greater protection to area residents and water users.

8.1 Accounting for Risk and Time

8.1.1 Risk

Many radionuclides take hundreds, thousands, or even millions of years to fully degrade their extremely hazardous properties, and thus the potential risk to future generations is great. Radionuclides are known carcinogens, or cancer-causing agents. The half-lives of radionuclides[265] buried at the West Valley site range from a few hours (i.e. rhodium-106) to 14,050,000,000 years or over 14 billion years (i.e. thorium-232).

The risks of living near a highly radioactive waste site like the West Valley site include the probability of accidental releases over time into the air and drinking water supply, the possibility that workers, nearby residents, and anyone who visits the site might be exposed to toxic and radioactive contamination, and the exposure to workers excavating and transporting wastes during cleanup or monitoring. Using a variety of models, both the 1996 and 2005 draft DEIS documents attempt to quantify these risks over short time scales.

According to the 2005 draft DEIS calculations, onsite workers have an approximately equal maximum dose exposure from normal activities and potential

---

[261] 2005 draft DEIS p2-21

[262] 2005 draft DEIS Table 4-18

[263] 2005 draft DEIS p2-23

[264] 2005 Alt 2 Report, Table 4.5-1

[265] The decay rate for each radioactive isotope is known as a *half-life,* and each radionuclide has an individual half-life. A half-life is the amount of time it takes for one-half of the radioactive atoms to decay or transform into another element. For instance, in two half-lives one-fourth of the original radioactive atoms would remain, and so on. It takes 10 half-lives for the radioactivity to be reduced to less than 0.1% of the original amount. For more detail, see Section 4.

of accidents during closure at 4.1 and 3.5 rem per worker (Alternative 1 and 2 respectively).[266] Population doses are described with *person-rem units*. These are a measurement of the collective dose in rems that a specific population is exposed to over a certain time period. The person-rem units represent the average dose per person times the number of people exposed. Over the 73 years it is estimated to close the West Valley site following the recommendations of the Waste Excavation Alternative 1, workers are expected to be exposed to approximately 1170 person-rem, while in the 218 year process for closure under the Buried Waste Alternative 2, workers may be exposed to 498 person-rem (96% of this exposure occurs in the first 16 years, according to the DEIS modeling).[267]

The risk to the surrounding population during closure activities is significantly more disparate according to the 2005 draft DEIS. Over 73 years, accidents and normal operations at West Valley may expose off-site residents to 438 person-rem in Waste Excavation Alternative 1, while residents off-site would only be exposed to 1.9 person-rem over the 218 year implementation plan in Alternative 2. [268] The 2005 draft DEIS *does not* account for any accidental or intentional exposures to the public which may occur at the West Valley site after 218 years in Buried Waste Alternative 2, despite the fact that the wastes interred remain highly dangerous for thousands of years.

<u>Risk of Public Radionuclide Exposure</u>

The DEIS judges that amongst five cleanup alternatives reviewed, the overall relative risk of exposure is “highest” for Alternative 1, and “medium” for Alternative 2.[269] However, there is a huge gap in DOE's assessment. After all cleanup activities are completed, Alternative 1 leaves a decontaminated site, which poses little to no risk to nearby residents, site users and downstream residents, while Alternative 2 poses long-term threats, building up to an estimated exposure of 12,480 person-rem over the next 10,000 years for Lake Erie water users according to the 2005 draft DEIS.[270] The site also continues to pose dangerous radiation risks over at least the next 100,000 years, exposing Erie water-users to an estimated 136,180 person-rem.[271] These numbers are at the low end of the expected doses to the public, because they assume that all control mechanisms remain in place flawlessly for tens of thousands of years.

As discussed in Section 6 on the site geology, the insufficient site controls proposed in the 2005 draft DEIS for the Buried Waste Alternative 2 are likely to

---

[266] 2005 draft DEIS, Table 4-11

[267] Closure Engineering Reports, Alternatives 1 and 2. Table 4.2-2 in both documents.

[268] Person-rem for 1.5 million people within 50 miles of the West Valley site and 882,000 individuals served by the Sturgeon Point and Van de Water Treatment Plants; 2005 draft DEIS p4-11 and 2005 draft DEIS Table 4-4

[269] 2005 draft DEIS, Table 2-6

[270] 2005 draft DEIS, Table 4-29

[271] 2005 draft DEIS, *ibid*

result in catastrophic failure within the next thousand years. This Alternative leaves in place an increasingly dangerous and risky site, as each year there is an increasing chance that an infrastructure failure could allow an accidental radioactive waste release.

The DEIS calculates a dosage from a catastrophic release, but deems the release unlikely. In the case of a catastrophic infrastructure failure at the site, over 900,000 consumers[272] of Lake Erie's waters could be exposed to another 120,000 person-rem *every year* as early as 125 years from now[273] according to the DEIS estimates of the so-called "worst case scenario".

In our study, independent experts evaluated the potential for exposure to the local public and Lake Erie water consumers. This study evaluated both a rapid leak scenario, as well as a continuous leak scenario, and found that if just 1% of the radioactive waste stored at West Valley leaked (starting from 100 years from now), a population of 400,000 water users on Lake Erie would be exposed to 334,320 person-rem, resulting in up to 334 cancer deaths from West Valley waste.[274]

Radionuclide doses calculated for a person drinking water from the Buttermilk Creek and Cattaraugus Creek, and Erie County residents receiving drinking water from the Sturgeon Point Treatment Plant (one intake point) were substantial and well in excess of the federal and state standards (see Section 4). Latent Cancer Fatalities are the number of deaths that are expected to occur from exposure to a specific population. *Over 100 to 1,000 years into the future it is expected that up to 334 of the people receiving their water from Sturgeon Point Water Treatment Plan are expected to die of cancer as a result of their exposure to contaminated water from Lake Erie.*

The radioactivity buried at the site poses an unacceptable risk to the populations in the surrounding area, including those that draw their water from Lake Erie and the Niagara River. *Given the 1996 DEIS dose calculations for onsite persons in the future—a scenario that will inevitably occur—potential doses from various exposure pathways could lead to enormous doses, illness and even death. The doses to people living downstream and those drinking contaminated surface water will also exceed regulatory standards, leading to adverse health effects as well as unnecessary deaths from cancer due solely to radiation exposure coming from the West Valley site.* Leaving these wastes in the ground will present a significant burden and public health threat to future generations as the radionuclides will be present for thousands to millions of years.

Risk of Infrastructure Failure

The site infrastructure of institutional and engineering controls that is designed to

---

[272] Lake Erie water is brought to consumers "downstream" of the Cattaraugus Creek outflow from the Sturgeon Point and Van de Water treatment plants, serving Erie County and the City of Buffalo.

[273] 2005 draft DEIS, Table 4-34

[274] See the results of the "second scenario" in Appendix B for details.

contain the dangerous radioactive waste buried at West Valley must outlive the long-lived dangerous isotopes in the waste. A failure to do so endangers the local populace, the downstream communities, and the environments and populations on the shores of Lake Erie. However, each and every year that goes by requires continued infrastructure maintenance, rigorous monitoring of the wastes and groundwater, and intensive site security. Over time, interest and government budgets wane, institutional memories fade, and the ability to maintain the site decreases dramatically. *Over the decades, centuries and millennia, the chance that the site becomes neglected increases, leading to a higher chance that West Valley will deteriorate with a subsequently higher chance of losing site integrity.* Hence, over extended periods of time, the risks of Buried Waste Alternative 2 increase dramatically. DOE did not address these risks adequately in either of the DEIS's.

There is significant uncertainty about the ability of man-made structures and instruments to successfully contain radioactive wastes until they have decayed to benign levels—for tens of thousands of years and longer. (See Section 6.) It is even more uncertain if stable forms of governance and funding could ever be maintained to ensure site safety during the long radionuclide decay process. (See Section 5.) *Therefore, leaving buried wastes in place at West Valley is an extremely high risk option.*

There have been numerous critiques of the methods used to predict downstream and surface contamination, showing that the models used in the 2005 draft DEIS are biased towards an expectation of much less serious contamination over the long term. (See Section 6.)

To weigh the costs of Alternative 1 and Alternative 2 in comparable terms, we make some significant assumptions and alterations to the DEIS descriptions to ensure that the levels of risk are more similar. Finally, we compare the long-term gross costs and the net present value of the two Alternatives.

8.1.2 Net Present Value Assessment

Long-term running costs, such as annual monitoring costs for 10,000 years, can be evaluated in a number of ways. We use two methods here: the *gross cost* and the *net present value*. The *gross cost* is simply the annual costs of implementation, summed across all years in which those costs are applicable. This is the methodology employed in the 2005 draft DEIS. However, it is important to note that the Waste Excavation Alternative considers the period of applied costs to be the implementation and “monitoring and maintenance” phases only, and does not consider the costs of “long-term stewardship” once the wastes are shipped off-site.[275]

The *net present value* also sums total running costs, but converts future dollars to

[275] 2005 draft DEIS p2-20

today's equivalent value by discounting future costs. Thus, for long-running capital costs, a high discount rate would make future costs appear significantly less expensive. In some economic valuations, dollar values are lower in the future than today. This is because dollars used today could otherwise be invested and because there is a social preference for using, rather than holding, money. Discount rates—or the degree to which dollars in the future are worth less than today—are a matter of some debate, and so we examine a range of rates. Indeed, any picture of the future in which future generations are less well-off than current ones would result in a negative discount rate as the appropriate approach. This is likely to be the case if global climate change produces the disruptions in ecology, the economy, and other systems that are increasingly predicted by scientists—and it is likely to be the case at West Valley for high-risk remediation such as Buried Waste Alternative 2. The gross cost can be considered as a special case of the net present value, namely the net present value when the discount rate is set at zero. (See Section 5.) The following section uses information presented in both of the DOE's DEIS's to determine a gross cost and net present value for balanced versions of Waste Excavation Alternative 1 and Buried Waste Alternative 2.

At the end of these next sections, we present a total full cost accounting for the modified Alternatives (1A and 2A) as well as the original Alternatives (1 and 2). We then explore the impact of a discount rate on the results, and finally close with our recommendations.

8.1.3 Modified Alternatives Waste Excavation 1A and Buried Waste 2A

To compare the gross costs and net present values of Alternative 1 and Alternative 2 on a more level playing field, we made modifications to the assumptions of each alternative. In most cases, we have strengthened safety criteria according to expert judgment, or made costs internally consistent. These new alternatives are renamed Waste Excavation Alternative 1A and Buried Waste Alternative 2A, modifications of Alternative 1 and Alternative 2, respectively. Since we are striving to compare these alternatives on an "apples to apples" basis, it is important that they attempt to equally protect the general population and future generations to the same rigor. The differences between the 2005 draft DEIS Alternatives 1and 2, and our modified Alternatives 1A and 2A are summarized in Table 8.2 below. Costs are balanced in Alternative 1A and 2A with the following three types of modifications.

1. Extend the costs of maintaining site safety for 1000 years.[276]
2. Assess site safety expectations between alternatives, including cleanup of contamination plume, and improved institutional and erosion controls for Alternative 2.
3. Estimate new costs when underlying assumptions appeared unreasonable.

[276] The radioactive wastes buried at West Valley are expected to be dangerous for tens of thousands of years, but we choose to extend our analysis for 1000 years as explained later in the text.

8.2 Modifying DOE's Cleanup Alternative Cost Assessments

8.2.1 Extend Economic Analysis Period from 218 to 1,000 Years

The 2005 draft DEIS appears to present generous economic terms for all of the alternatives, by calculating a non-discounted gross cost for decommissioning. In other words, DOE seems to suggest that the cost of implementing decommissioning or cleanup activities in the future will cost just as much as it would to implement it today. Looking more closely, the DEIS has used a disingenuous accounting scheme. In the technical appendix, the DEIS calculates that the gross cost of Buried Waste Alternative 2 is over $2 billion dollars (Y2005$)[277] over 218 years. Work required after those first two centuries are lumped into an undefined (and unfunded) "long-term stewardship" phase.[278] *If the DEIS is unwilling to allocate the monies required to maintain the site after 218 years, we have to assume that the DEIS is under the impression that the future costs nothing at all.* In doing so, the DEIS has effectively decided that lives and safety after the year 218 do not matter.

Similarly, the DEIS reports in the summary[279] that Alternative 2 is expected to cost only $1.6 billion over a short 16 year period, while in reality, the technical appendix[280] of the DEIS estimates that the total cost should be closer to $2 billion over 218 years. What happens after the first 16 years? Because the long term monitoring and maintenance costs are outside of the project budget, they are unaccounted for, even though they comprise much of the cost of Alternative 2. What happens if the costs are extended for 1000 years rather than just 218 years or if the DEIS has underestimated the costs of erosion control, security, or maintence, much less social costs? In fact, we believe that this is the case, and explore the full costs of the Alternatives as proposed in the 2005 draft DEIS.

Why does the DEIS only calculate costs out to year 218? A calculation of costs for only two centuries for waste that is hazardous for thousands of years is grossly inadequate. If materials are left buried at the site, the costs of monitoring and maintenance would need to be continued through the centuries and millennia. What was DOE's rationale for using such an extremely inadequate time frame? *A DOE 1993 Order states that in managing uranium, thorium, and their decay products, controls should be designed for at least 1,000 years.*

> "Control and stabilization features shall be designed to provide, to the extent reasonably achievable, an effective life of 1,000 years with a minimum life of at least 200 years."[281]

---

277 Dollar values are in year 2005 real dollars (i.e. inflation does not matter in this analysis)

278 2005 draft DEIS p2-20

279 2005 draft DEIS, Table 2-10, Comparison of Resource Areas for Socioeconomics

280 The technical appendix is the "Closure Engineering Report" or CER attached to the DEIS document.

281 DOE Order DOE 5400.5 Ch IV 6.d.(1).(a)

The 2005 draft DEIS cost analysis extends to either the life of the project—such as unrestricted site release after 73 years in Waste Excavation—or to an arbitrary 218 year threshold as in Buried Waste. DOE is implying that that costs need only be tallied for the short period of 218 years, which is a critically shortsighted position. Clearly, those who will be impacted two centuries from now will be no less eager to prevent highly dangerous nuclear waste from entering their water or food supply.

We carry our full-cost accounting analysis for Alternative 1A and Alternative 2A out to 1,000 years, as a first step to begin to more accurately compare and assess real costs. However, by no means does this mean that the radioactive waste stored at the West Valley site would be considered safe at the end of 1,000 years. Long-lasting, toxic radionuclides will remain hazardous for tens of thousands of years. For example, the 1996 draft DEIS indicated that downstream residents and water users could be exposed to unacceptably high peak doses from erosion-caused failures at the site well over 1,000 years from now.[282] Under the legally binding federal NRC site requirements, DOE will need to show that remediation requirements can be met for at least 1,000 years, and perhaps as many as 10,000 years into the future.

8.2.2 Balancing Site Safety Expectations between Alternatives

To the best of our knowledge, the DOE has attempted in the 2005 draft DEIS to create a range of alternatives with varying levels of risk and cost. We assume that the purpose of this exercise was to allow the public and policymakers to choose a level of risk for which they are willing to pay. *However, it is intrinsically unfair to ask people charged with funding this clean-up process to make a decision without a clear and full understanding of the risks, and the DEIS fails to elucidate just how risky long-term disposal of nuclear waste could be at West Valley.* We attempt to provide some political and economic reality to the process. If nuclear waste remains interred or buried at the site, there are two foreseeable scenarios: either the site is maintained for millennia until the wastes have decayed down to safe exposure levels, or it is not.

Numerous studies, including the DOE's own analysis in the 1996 DEIS, suggest that *failing to maintain the site and prevent erosion into the future will be an unmitigated disaster.* Eventual seepage of contaminated groundwater, catastrophic failure as erosion undermines the waste trenches, or collapse of any of the retaining walls, berms, or trenches would result in widespread contamination and potentially render Lake Erie's water undrinkable. *The financial consequences of rendering one of the earth's largest freshwater supplies unusable are massive, far outweighing any costs required to prevent such a disaster.* Therefore, it is clear that if the wastes stay buried at the site, there is no other option than to use every necessary resource to prevent leakage. With these criteria in mind, we modified Buried Waste Alternative 2 with our best estimate of a scenario in which the

---

[282] 1996 DEIS, Appendix D.

interred wastes are protected.

It is important to note that although we improve Alternative 2A moderately, the site would still require much longer term maintenance than included in the cost-benefit calculations, which in turn, requires institutional continuity to provide the funds and oversight of this maintenance, a process by no means guaranteed over the next millennia.

8.2.3 Investigating Disparities of DOE Cost Assumptions

To create Alternative 1A and 2A, we closely examined DOE's underlying assumptions and costs of Alternative 1 and Alternative 2 in the 2005 draft DEIS. The cost streams are obscured throughout the DEIS, but pulling apart certain cost assumptions revealed disconcerting disparities between the alternatives. In addition, we tallied costs for additional site security and erosion controls beyond what is called for in the DEIS. The sections below lay out our modifications for Waste Excavation Alternative 1A and Buried Waste Alternative 2A. Unless otherwise noted in the following text, cost assumptions used by the DOE are maintained.

8.2.4 FOIA Request Denied by DOE

Before attempting to modify values supplied by the agencies, we submitted a Freedom of Information Act notice to the Department of Energy, requesting more detailed information and clarification on all the topics discussed below. The request was denied by the agency on the grounds that the draft DEIS was still in a preliminary stage, and therefore not yet a public document. In absence of clarifying information from the DOE, we made assumptions where necessary to adjust the risk and safety of the 2005 draft DEIS. This Full Cost Accounting study was only able to examine and modify a small fraction of the potential errors of omission or estimation we perceived to be present in the 2005 draft DEIS, and has largely focused on some of the most significant questions for the cost assessment of cleaning up the West Valley site.

8.3 Modifying Waste Excavation Alternative 1A Costs and Safety Requirements

Alternative 1 in the 2005 draft DEIS calls for complete exhumation, removal, and off-site disposal or storage of wastes.[283] Successful implementation would “allow for unrestricted release of the entire site[284] as defined in the cleanup guidance of the NRC License Termination Rule[285] and other government requirements (See Section 2.) As calculated by DOE, this alternative is over five times more

[283] 2005 draft DEIS p2-15

[284] The Western New York Nuclear Service Center is the land used for the West Valley Development Project and surrounding grounds.

[285] 2005 draft DEIS p2-15

expensive than the least expensive option, Alternative 2. The relatively high costs of this alternative are tied up in facility demolitions, the extraction of poorly defined quantities of wastes, and the cost of transporting and disposing of this waste in federal and commercial facilities.[286] While there may be grounds for challenging DOE's waste transportation costs and tipping fees for wastes at licensed sites, we will assume that the estimated costs in the DEIS for these items are relatively reasonable for planning purposes. [287] We have chosen *not* to narrow the safety margin proposed by the DEIS, and thus do not reduce the labor or material costs estimated to make it a safe site in perpetuity. We do, however, challenge some of the costs in Alternative 1. Our modified version of Alternative 1 is Alternative 1A.

8.3.1 Delaying Cleanup of Spreading Groundwater Pollution Results in Increased Costs

One of the most expensive individual costs of the Waste Excavation Alternative is the cost to extract and dispose of strontium-90 contaminated groundwater emanating from the Process Building. The DEIS proposes that the safest mechanism for reducing the risk to downstream receptors is to isolate the 200' by 850' plume[288] and physically extract both the groundwater as well as the polluted soil holding the groundwater. The mechanism for this extraction is three fold. First, the entire contaminated region is surrounded with sheet piling to (theoretically) halt the groundwater flow; second, the groundwater is extracted and treated with a custom-built portable treatment center; finally, the top two feet of soil would be excavated, dried, packaged, and shipped offsite as "low level" waste[289] at an estimated cost of $2,099,631,000.[290]

The DEIS suggests that this groundwater extraction and decontamination would be one of the last activities to occur in decommissioning or cleaning up the site, beginning after 47 years and lasting for another 22 years.[291] Because this activity begins after almost all other decommissioning activities have ended, the DEIS assumes that a much larger area should be remediated than is currently contaminated, since it is likely the contamination will have spread by the time this action is taken. While it could be argued that this shows some foresight in planning, it is more environmentally sound and potentially far more cost effective to

---

[286] It is beyond the scope of this study to do a Full Cost Accounting for the potential sites to which the exhumed waste or dismantled buildings would be sent, but it is quite possible that no site will be capable of completely isolating the waste for the extremely long time period that some of it remains radioactively dangerous. (See Section 5.)

[287] The argument can be made that the transportation assumptions in Alternative 1 are highly conservative, and therefore overpriced. In 2006, the DOE sent waste to the Nevada Test Site, carrying up to 1½ times as much waste per truck as assumed to be allowed in the 2005 draft DEIS (author's calculations). If these shipment costs are the standard, it is quite possible that the DEIS has overpriced the cost of waste disposal from West Valley.

[288] 2005 Alt 1 Report, p67

[289] 2005 Alt 1 Report, p158

[290] 2005 Alt 1 Report, p283. Table 4.5-1

[291] 2005 draft DEIS p2-19

immediately isolate and treat the contaminated groundwater and completely remove this waste. There is no justification for waiting nearly half a century to do the cleanup while the radionuclides spread and pollute more water and soil. The DEIS uses a somewhat convoluted method to choose the size of the area to be excavated. To conform to federal code, drinking water cannot exceed 4 mrem per year,[292] or according to the DEIS's calculations, 42 pCi/L. However, because the excavation will be performed so many years in the future, the DEIS assumes that the contamination will have spread to the area that is now only contaminated at 10 pCi/L in 2005,[293] and create a much larger polluted area.[294] Adding yet another buffer, the 2005 draft DEIS creates an extraction region well outside of the 10 pCi/L limit, nearly 80% larger.[295] When all is said and done, the extraction, export, and disposal of the North Plateau groundwater plume will require removing 28,500,000 cubic feet of waste. We do not estimate the reduced costs available to the government if the wastes are removed more expediently, although we hypothesize that they could be substantial. Lengthy government delays could result in wastes being interred longer than might be expected or desired, so we use the 28.5 million cubic feet waste cleanup design for both Alternative 1A and Alternative 2A for the sake of argument.

8.3.2 Correcting Cleanup Costs for Groundwater Plume

The costs of disposing of the groundwater plume are not consistent between Alternatives 1 and 2. In the Buried Waste Alternative in the DEIS, a small amount of highly radioactive material is expected to be extracted from the source area, and disposed of at a cost of $34.50 per cubic foot.[296] In contrast, the Waste Excavation Alternative includes a price of $52.18 per cubic foot for a much larger area.[297] The lower level waste we expect from Alternative 1 appears to be more expensive to dispose of in this estimation. The DEIS disposal costs from Alternative 1 are over $1,407 million, while Alternative 2 costs suggest that disposal would run closer to $983 million. In the absence of any other clarifying information (requested and denied by DOE), we assumed that the lower disposal costs from Alternative 2 were correct, and substituted these costs for a uniform assessment between Alternatives. Including materials and labor as calculated in the 2005 draft DEIS, we estimate the final cost of extracting the groundwater plume and disposing of 28.5

---

[292] 10 CFR §141

[293] Closure Engineering Report, Alternative 1., p157, 3.2.13

[294] According to author's estimates, the 10 pCi/L isopleth is at least twice as large an area as the 42 pCi/L isopleth. In the 1996 version of the DEIS, the DOE proposed excavating down to the 15 mrem per year isopleths, a more relaxed standard than the current 4 mrem per year. This would have involved the extraction of 4,000,000 cubic feet of soils, 1/7th of the volume estimated in 2005.

[295] Author's calculations from map data in the 2005 draft DEIS.

[296] This value of $34.50 per cubic foot is derived by dividing the total waste disposal costs of the groundwater plume in Alternative 2 ($10.5 million) by the total volume expected to be extracted (304,600 cubic feet). See Closure Engineering Report of Alternative 2.

[297] The DEIS estimates that the 28.5 million cubic feet of waste in Alternative 1 would cost over $1.407 million, at a cost of $52.18 per cubic foot. See Closure Engineering Report of Alternative 1.

million cubic feet of low-specific activity waste soils in Alternative 1A is $1,469,465,000 or $1.4 billion.

8.3.3 Adjusting Contingency Costs

The 2005 DEIS includes a contingency multiplier of 25% for all closure projects at the West Valley site. Contingency adders or multipliers are typically included in cost-based analysis to account for uncertainties in precise itemized costs, exactly how work will be performed, and work conditions at the time of project execution. In the case of the 2005 DEIS, a majority of costs were assigned a uniform 25% contingency margin which was apparently calculated by multiplying the sum of material, labor, and disposal costs by 0.25, and adding this to the sum of material, labor, and disposal costs. However, in Alternative 1, there were a number of circumstances in which contingency multipliers were calculated between 31-45% (including the closure of WMA 1, WMA 3, and the operations of the soil drying and container management facilities), and only two circumstances in Alternative 2 where contingencies exceeded 25% (the closure of WMA 1 and WMA 3). These higher contingency costs in Alternative 1 added over $213 million to the price tag of Alternative 1. Although requested, the DOE did not provide clarification in this discrepancy. Therefore, we adjusted the contingency multiplier such that it was uniformly 25% across all categories.

8.4 Modifying the Buried Waste Alternative 2A Costs and Safety Assumptions

Alternative 2 in the 2005 draft DEIS would clean up only a small portion of the site,[298] removing only the most readily transportable wastes,[299] and largely leaving the majority of buried wastes at the site. The remediated wastes would be transported off-site and buried waste areas would be covered with "geomembranes" (cap and cover) to prevent infiltration. Alternative 2 is estimated to cost $1,573 million over the 16 year implementation phase[300,301] and $2,009 million over the extended 218 year "interim management phase."[302] *The significantly lower apparent cost of Alternative 2 is a false comparison, as it leaves in place a high and increasing risk requiring continued vigilance, management, funding, and measures to mitigate instabilities caused by erosion.* We challenge the lax assumptions behind some of the DEIS cost estimates, particularly in safely securing wastes in the trenches, the overall integrity of the site, and the long-term maintenance costs. Our modified version of Alternative 2 is Alternative 2A.

---

298 Decontamination is of small selected areas to meet 10 CFR 20.1402 criteria for unrestricted release.

299 Vitrified high-level wastes, currently packaged and in storage

300 2005 draft DEIS, p2-37, Table 2-10

301 2005 Alt 2 Report, p248, Table 4.5-1

302 *ibid*

8.4.1 Correcting Scope of Groundwater Plume Cleanup Area

For Buried Waste Alternative 2, the 2005 draft DEIS proposes to extract only the source area from the north plateau groundwater plume. This activity would entail removing about 305,000 cubic feet, a far cry from the approximately 28,500,000 cubic feet to be extracted under Alternative 1. Why does the DEIS propose that only the source area be removed in Alternative 2, while the entire plume is to be removed in Alternative 1? If the standard for safety of downstream water users requires that the plume be entirely extracted, as in Alternative 1, we believe it is only prudent to use the same standard for Alternative 2. To match the standard of safety in Alternative 1, we will use the same extraction area for Alternative 2A removing 28,500,000 cubic feet of the plume soils at a cost of $1,469 million. We estimate that this process would occur after the process building has been demolished and removed in year 8, and will take as long as the removal process in Alternative 1, approximately 21 years.

8.4.2 Installing Improved Erosion Controls

The erosion model and estimates in the 2005 draft DEIS are inadequate. (See Section 6 for details.) Therefore, we propose a minimum set of erosion controls to prevent gullies, landslides and other mass-wasting processes from exposing the toxic nuclear contaminants buried at West Valley. These control features are not expensive to implement relative to other decommissioning activities and would attempt to preserve the integrity of the site. These controls must be maintained and replaced on a regular basis every 25 to 50 years. If the radionuclides were left in place, these systems could not be allowed to fail; degradation of the erosion and institutional controls could result in catastrophic future releases.

Our estimated implementation costs for erosion controls are broken down in Table 8.3. We gathered the costs of erosion controls from industrial sources at a cost per unit component (such as a square-foot cost for drop structures). We then multiplied these costs by the estimated size of each erosion control mechanism and the number of mechanisms required to prevent the plateaus from eroding. These values can be found in Section 6 and in more detail in the Geology Appendix (Appendix A). The costs for these control features are not parsed by labor and materials costs, and do not include the cost of disposal or contingency. Therefore, we estimate materials and labor costs in the same ratios used in the DEIS for smaller-scale erosion control mechanisms (18.4 and 81.6%, respectively). The cost of disposal also follows the DEIS ratio, and amounts to 51.1% of the combined materials and labor; the cost of contingency adds another 25%.

The costs tabulated in Table 8.1 are for the initial emplacement and construction of erosion control mechanisms. These barriers have a 50 year service life (except for the creek-side armoring, which is assumed to have a 25 year life). Similarly to the 2005 draft DEIS, we assume that at the end of a control mechanism's service life, the unit must be replaced in full. Therefore, these initial costs are repeated every 50 years (or, for the armoring, every 25 years).

Erosion Control Activity	Materials Cost	Labor Cost	Waste Disposal Cost	Contingency Cost	Total Cost
DEIS-estimated erosion control system construction [303]	$2,885,391 (18%)	$2,951,509 (82%)	$8,003,918 (51%)	$3,460,205 (25%)	$17,301,023
Franks, Quarry, and Dutch Creek drop structures	$3,689,660	$16,310,340	$10,229,720	$7,557,430	$37,787,150
Mesh structures or mats at gulley heads	$239,828	$1,060,172	$664,932	$491,233	$2,456,165
Stabilize bottom of Buttermilk landslide	$1,844,830	$8,155,170	$5,114,860	$3,778,715	$18,893,575
Buttermilk Creek drop structures	$5,073,283	$22,426,717	$14,065,865	$10,391,466	$51,957,331
Buttermilk Creek armoring	$4,150,868	$18,349,132	$11,508,435	$8,502,109	$42,510,544
Proximal stabilizations (Heinz Creek)	$9,224,151	$40,775,849	$25,574,300	$18,893,575	$94,467,875
South Plateau gulley grade stabilization	$2,767,245	$12,232,755	$7,672,290	$5,668,072	$28,340,362
Impact of recurrence interval on erosion controls	$5,442,249	$24,057,751	$15,088,837	$11,147,209	$55,736,046
Erosion Control Total Initial Cost	**$32,432,114**	**$143,367,886**	**$89,919,238**	**$66,429,809**	**$332,149,047**

Table 8.1: Improved Erosion Control Mechanisms for Buried Waste Alternative 2. Parentheses indicate the relative percentage of the total materials and labor cost (18 and 82%, respectively), the additional cost of waste disposal (51%) and contingency (an additional 25% reserve margin used throughout the DEIS for unforeseen contingencies or budget errors).

We estimate the total cost of erosion control to initially cost $332 million; replacements and maintenance will run approximately $7.8 million per year.

8.4.3 Improve Site Security

The 2005 draft DEIS proposes a fair amount of security at the site for the first 100 years of Alternative 2, but steps down the security force markedly thereafter. In the first century, it is expected that the area will have three security personnel onsite at all times.[304] After 100 years (Management Phase 1), security is reduced to a single local law enforcement officer performing a site check for two hours every day, five days per week.[305] It is not difficult to imagine a circumstance in which the security

---

[303] Erosion Control System Construction is the cost of erosion control as estimated by the 2005 draft DEIS. All other costs in this table are formulated by expert estimation.

[304] Closure Engineering Report, Chapter 2 p182

[305] CER, *ibid*

and integrity of the site could be compromised between such checks, especially given the harmful potential of the site. It would be prudent and safe to at least maintain the full compliment of security onsite as long as the material buried at site is hazardous. Therefore, we simply take the estimated annual cost of security operations in the first 100 year "management phase" (114.3 million), and extend this cost through the remaining analysis period of 1,000 years at an annual cost of $1.14 million[306] and a total cost of $1,122 million (years 17-1000). (See Table 8.5.)

8.4.4 Restricted Access Land Unavailable for Economic Use

Alternative 2 requires continued maintenance and major restrictions on the use of the site. The continued restrictions on 1645 acres of the 3345 acres after all closure activities have occurred means that other forms of economic activity cannot take place at West Valley. As discussed in Section 7, we explore a scenario in which those 1645 acres could otherwise be used for agricultural purposes, recognizing that under some scenarios, the land could be used for a much more valuable end, such as commercial or residential development. In New York, current land rental rates are $39 per acre (see Section 7). In Alternative 2a, there is an economic loss of $130,455 per year (on 3345 acres) until year 217, at which point the NRC license is expected to be reviewed for partial site release. At this point we assume, as in the 2005 draft DEIS, that half of the site could be released for general use, and the remainder (1645 acres) remains restricted for the remainder of our one thousand year analytical period at a loss of $64,155 per year.

8.4.5 Institutional Controls Fail Catastrophically in Year 500: Cost of Water Replacement in Erie County, New York

An expert geologist and a nuclear physicist reviewed the Buried Waste Alternative DEIS assumptions and found there is a significant potential for catastrophic site failure within the millennial time-scale at West Valley. (See Section 6, Appendix A for geology review, and Appendix B for a review of gradual radionuclide release scenarios.) While there have been several models of erosion potential at West Valley explored by Federal and State agencies, there are tremendous uncertainties surrounding potential failures. These include:

- the probability of institutional failure at the site (i.e. after dozens to hundreds of years, there is no longer a record of activity or waste at the site and erosion is uncontrolled);
- the pace of erosion in the absence of controls; and
- the probability of catastrophic failure even if erosion control mechanisms are maintained.

For example, in the 2005 draft DEIS, it appears as if the only scenario in which an erosion-based waste release could occur is if erosion controls are not adequately

---

[306] CER, *ibid*

maintained (a situation deemed “unlikely to occur”). However, built infrastructure is never fail-safe, even if maintained under code. Levee breaches by floods and storms, occasional earthen dam failures, and even advanced infrastructure failures, such as bridge collapses (i.e. the I-35 bridge in Minneapolis in July of 2007) are regular enough occurrences that they cannot be discounted even if there is theoretically adequate site maintenance.

After evaluating site conditions, we developed a scenario in which radionuclides buried at the SDA are exposed after 500 years, leak into the local watershed, and are eventually transported into Lake Erie’s longshore current. Even after significant dilution, the radionuclide concentration entering the Erie County Water Authority’s (ECWA) and the Buffalo Water Authority’s (BWA) intakes on Lake Erie pose a significant risk to water users[307]. We developed a cost scenario that assumes water supply from Lake Erie is unfit for consumption, which is explored in more depth in Section 7.2.2.

In brief, the leak scenario for Buried Waste Alternative 2a encompasses three phases:

1. an emergency phase in the catastrophic year[308], in which all potable water is replaced by bottled water brought in from a different region (cost: $272.6 million);
2. a cost reduction phase over four years, in which “imported” water becomes less expensive as temporary infrastructure is developed to serve ECWA demand (cost: $218 million declining to $54.5 million); and
3. a decontamination phase, where a water treatment plants are equipped with expensive ion exchange technology to mitigate contamination in delivered water (cost: $27.5 million per year).

The costs of this water replacement system are enumerated in Section 7.2.2.

8.4.6 Total Economic and Social Cost

Table 8.2 enumerates the total estimated costs of Alternatives 1, 1A, 2 and 2A, with and without a catastrophic release scenario. The detailed line-item costs are broken down at the end of this section in Table 8.5.

---

[307] The costs tabulated here are for a relatively small urban and rural population in Western NY, a population probably much smaller than that which could be affected by contamination reaching the Great Lakes. The case of a catastrophic release of radioactive waste from West Valley into the Great Lakes would be a disaster by any measure. For illustrative purposes, we calculated the costs for the immediately impacted population served by ECWA's Sturgeon Point water treatment facility.

[308] The catastrophic year, in this case, is evaluated for year 500, or 500 years past initial closure activities at West Valley.

	Economic Cost	Social Cost	Analysis Period	Total Cost
Waste Excavation Alternative 1 (2005 DEIS)	$10,618 million	$0*	73 years	$10,618 million
Alternative 1A (Modified for safety/ risk)	$9,901 million	$9.5 million**	1000 years‡	$9,910 million
Buried Waste Alternative 2 (2005 DEIS)	$2,009 million	$0*	218 years	2,009 million
Alternative 2A (Modified for safety/risk) (Catastrophic Release)	$12,995 million	$14,524 million**	1000 years	$27,519 million
Alternative 2A (Modified for safety/risk) (No Catastrophe)	$12,995 million	$78.5 million**	1000 years	$13,073 million

Table 8.2: Total Economic and Social Estimated Costs for Various Alternatives. * Social costs are unaccounted for in the 2005 DEIS; ** Social costs considered in Synapse analysis include lost land revenues (agricultural) and potential catastrophic release of radionuclides into Lake Erie. ‡ Alternative 1A includes complete site closure and release for public use after 73 years; no costs thereafter. See Table 8.5 for complete full cost accounting.

8.5 Full Cost Accounting Sensitivity Analysis

This section compares the costs of Alternatives 1A and 2A under varying assumptions about the discount rate. It concludes that at a zero discount rate, the full cost is significantly lower for Waste Excavation Alternative 1A than for Buried Waste Alternative 2A, even if a catastrophic failure does not occur. The zero discount rate is required on ethical grounds, and was endorsed by the Clinton Administration's DOE for long-term analysis of nuclear waste site remediation options, as discussed in Section 5. At positive discount rates, advocated by many economists and some government agencies, *the comparison does not result in a single solution:* some discount rates favor one alternative and some favor the other.

Our conclusion is in sharp contrast to the DEIS, which reports that Alternative 1 is far more expensive than Alternative 2. The difference is not due to discounting; the DEIS also uses a zero discount rate. Rather, it is due to the imprecision and incompleteness of the DOE's 2005 draft DEIS cost estimates, especially for Buried Waste Alternative 2. The ongoing costs for long-term stewardship in years 219 through 1000, included in our Alternative 2A but omitted by DOE in the DEIS, are particularly important at a zero discount rate*. The long-term costs are not large in* *any one year,*[309] *but they continue, year after year after year. They are the quantitative expression of the ominous liability bequeathed to future generations, under any alternative that fails to exhume and properly dispose of all contaminated material.*

In Figures 8.1 and 8.2, we illustrate the long term running costs of Alternative 1A and 2A. In the first of these two figures, we see that Waste Excavation 1A has significant costs through the first 73 years, particularly from year 46 to 73 as high level wastes are disposed of at a more secure site. In contrast, Buried Waste 2A has a brief period of intensive costs, largely ending after year 31. However, Alternative 2 has ongoing maintenance costs well into the future, and the potential for high costs associated with a catastrophic release of radionuclides into Lake Erie (see Figure 8.2).

If we use a zero discount rate, the total project cost for Alternatives 1A and 2A accumulate over the 1000 year analysis period. In Figure 8.3, the total cost of Buried Waste 2A exceeds that of Waste Excavation 1A after anywhere from 550 to 700 years, depending on if a catastrophic release of radioactive waste occurs at the West Valley site or not. If such a release were to occur earlier, the costs of Alternative 2A would exceed that of Alternative 1A that much faster. While over the short term (the next 80 years), the costs of Alternative 2A appear less costly, the absolutely critical maintenance costs make Alternative 2A exceedingly expensive over the millennia.

So which alternative costs more? The answer depends entirely on the discount rate. If the numbers are added up without discounting, Waste Excavation Alternative 1A is 24% cheaper than Buried Waste Alternative 2A with no catastrophic release, and half the price (54% cheaper) than Alternative 2A if there is a catastrophic release. Table 8.3 shows the final net present values (total cumulative discounted cost) of Alternative 1A and Alternative 2A with and without catastrophic releases assumed. However, at a 3% discount rate, Alternative 2A is marginally less expensive and at a 7% discount rate Alternative 1A is less expensive.

It is worth noting that the two versions of Alternative 2A (with and without a catastrophic release) appear to cost the same if discounted by either 3% or 7% (see Table 8.3, below). This is because the catastrophic failure occurs 500 years into the future, a time period so distant that a traditional discounting rate makes it nearly valueless today. For example, a billion dollars has a net present value of $381 at a 3% discount rate, and is worth less than a fraction of a penny at 7% rate. Yet, we know that a catastrophic release would be, in fact, catastrophic, and would cost future generations significantly. We can state definitively that discounting at traditional rates misrepresents the real cost of long-term problems.

---

[309] The long term annual costs in Alternative 2 are just under $10 million every year for monitoring and maintenance, and increase to $23 million if a new water treatment plant is required to filter radionuclides in Lake Erie.

Total cost over 1000 years (millions of Y2005$)	Not Discounted	3% Discount Rate	7% Discount Rate
Alternative 1A	$9,910*	$3,356	$1,324*
Waste Excavation			
Alternative 2A	$27,519	$2,488*	$1,559
Buried Waste			
Catastrophic Release Occurs			
Alternative 2A	$13,073	$2,488*	$1,559
Buried Waste			
No Catastrophic Release			

Table 8.3
Total net present value (discounted cost) of Alternatives 1A and 2A, with and without the catastrophic release in year 500, using discount rates of 0% (no discount), 3% and 7% (standard US discount rates). *Least expensive Alternative under each discount rate assumption. For full cost accounting, broken down by category, please see Table 8.5.

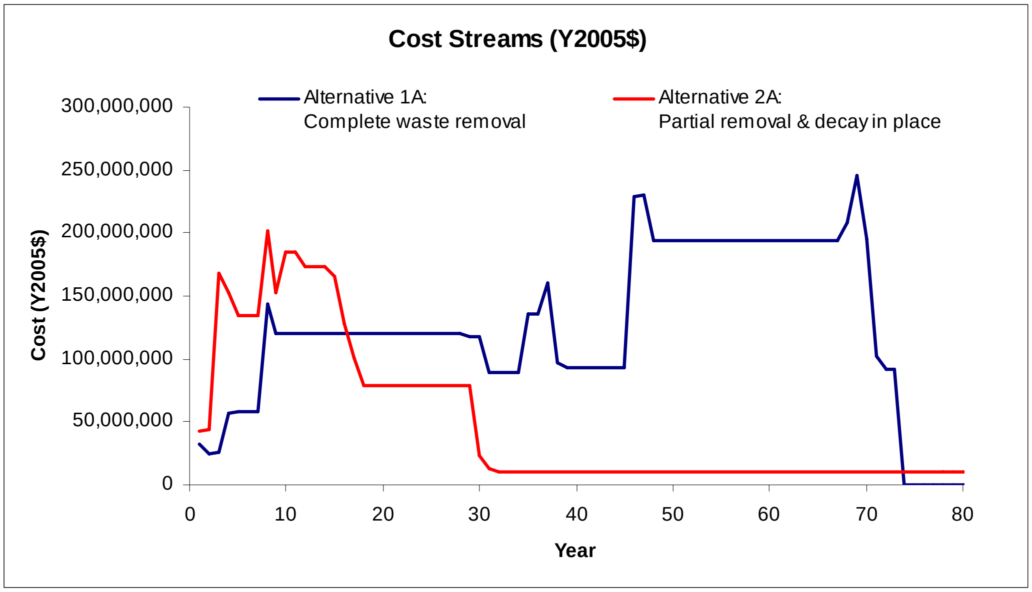


Figure 8.1
Cost streams of Waste Excavation Alternative 1A and Buried Waste Alternative 2A in 2005 dollars. The bulk of the work at West Valley in Alternative 1A occurs within the first 45 years, but high level wastes are only shipped offsite for disposal after year 46 – the cause of the large cost rise from year 46 to 73. Most of Alternative 2A is executed in the first 15 years and is largely finished by year 31. However, there are ongoing costs to maintain erosion controls well past year 80.

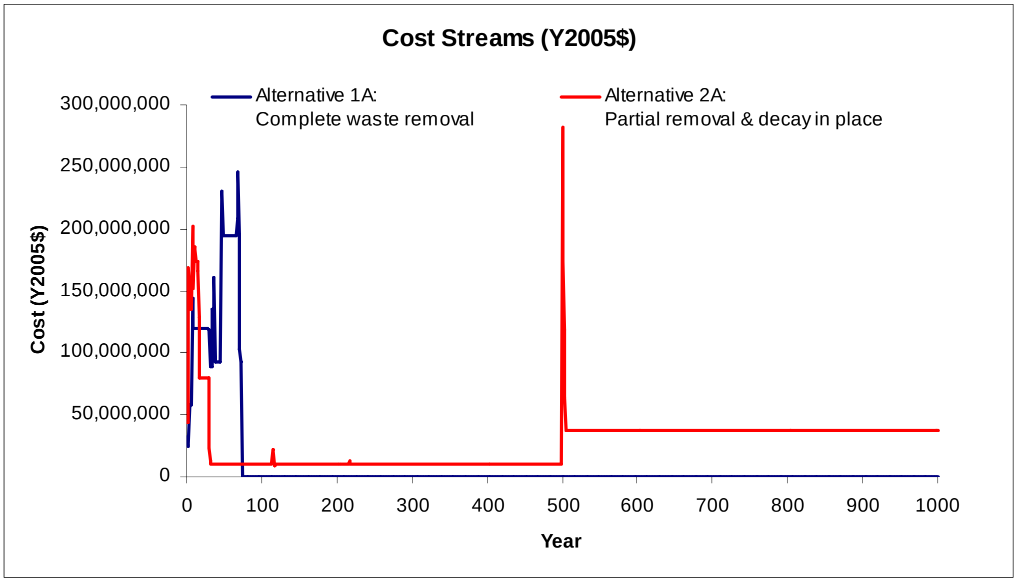


Figure 8.2
Cost stream of Waste Excavation Alternative 1A and Buried Waste Alternative 2A through the 1000 year analysis period. Alternative 1A ends in year 73. Alternative 2A requires continued maintenance through the analysis period. The high cost in year 500 is the cost to Erie County water users when a catastrophic release of radioactive waste occurs at West Valley in this scenario.

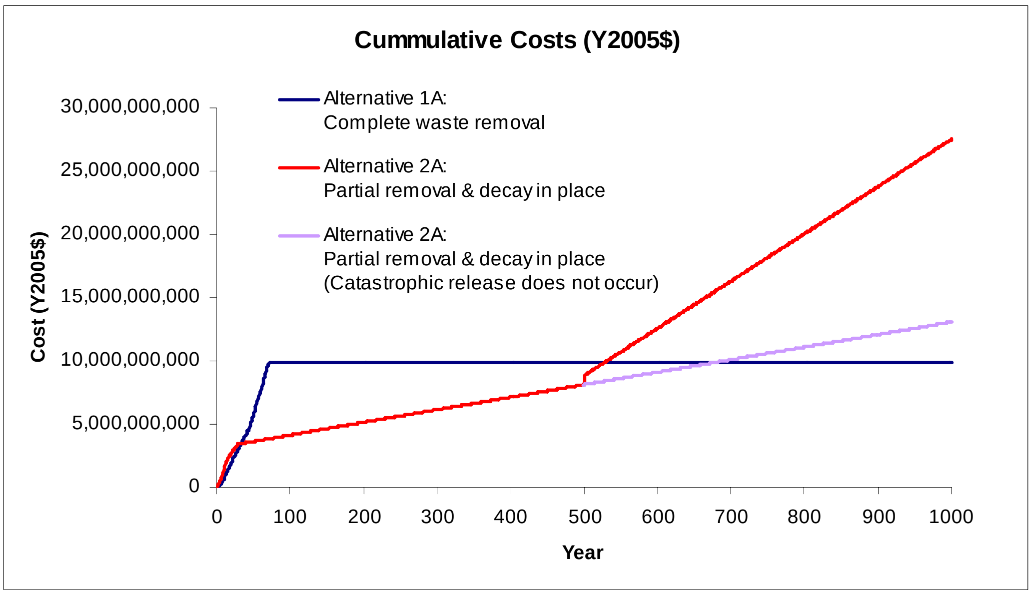


Figure 8.3
Cumulative cost stream for Waste Excavation Alternative 1A and Buried Waste Alternative 2A through the 1000 year analysis period (no discounting). Alternative 2A splits into two costs streams at year 500, with one scenario of a catastrophic release of radionuclides into Lake Erie. If release occurs, social costs for replacing water in the city of Buffalo drive the cost of Alternative 2A (red line) above short term costs of complete remediation in Alternative 1A (blue line). Even if catastrophic release does not occur (purple line), the costs of continually maintaining the site to attempt to forestall other catastrophic releases surpasses the cost of complete remediation in 700 years, well within the dangerous lifetime for most of the long-lasting radionuclides on site.

We do not think it is appropriate to use a discount rate in this very long term analysis because the process of discounting understates the value of future lives and safety. The following is a brief synopsis of this critical issue as described in Section 5. Every generation has the right to equal treatment and to give or withhold informed consent to avoidable environmental hazards. No generation has the right to impose its hazards on those who will come later. These principles, rather than calculations of cost, should determine our choices about nuclear waste. Thus, decisions with intergenerational impacts is a matter of ethics and policy, not a market-determined economic decision. The rights of future generations, and the responsibility of the present generation to treat its descendants fairly, require that pure time preference be zero or close to a zero discount rate*. If we care about the impacts of today's nuclear waste, stretching across the depths of future time, then the only supportable discount rate is zero. Since every generation is of equal ethical worth, and there is no basis for assuming economic growth over the very long run, economic theory also endorses a discount rate of zero.*

If however, for the sake of argument, we use a constant positive discounting rate, then Waste Excavation 1A is less expensive either at very near-zero rates (up to about 0.2%) or at high rates (above 5.5%). Buried Waste 2A is cheaper for relatively low rates, between 0.15% and 5.5% (see Figure 8.4).

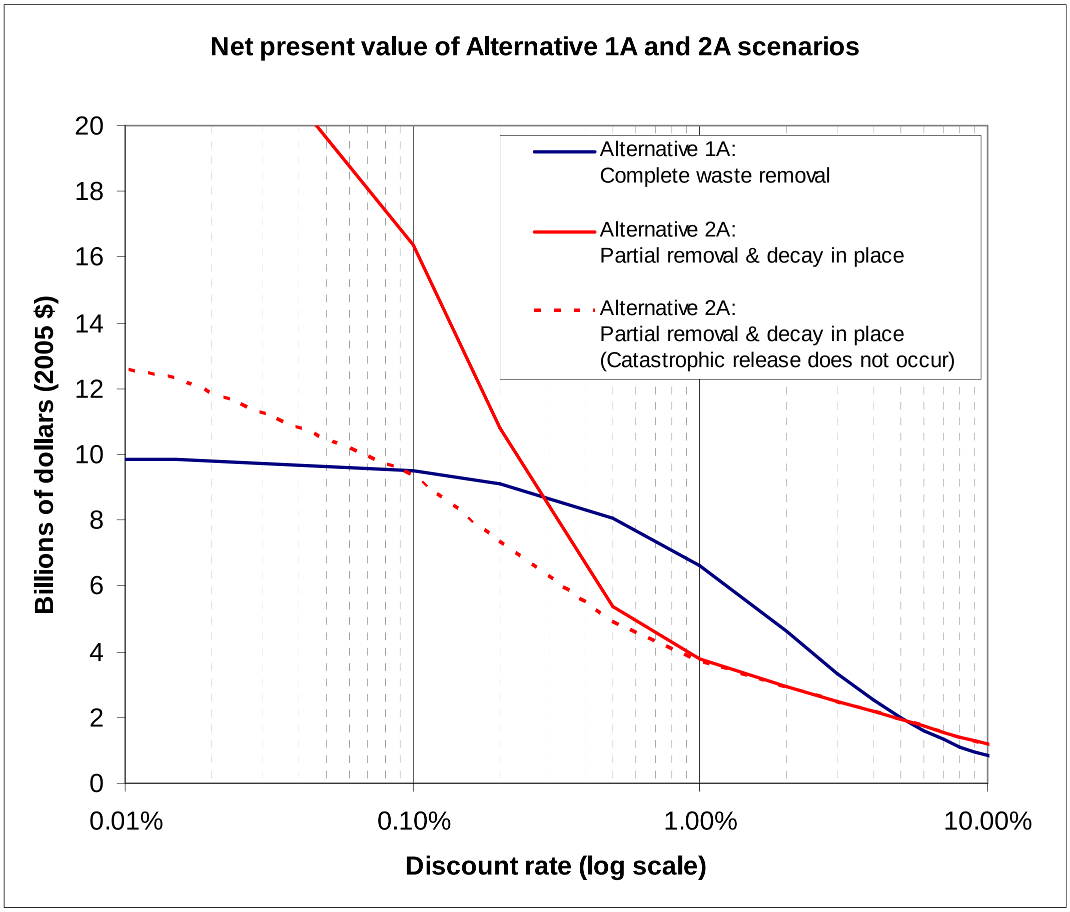


Figure 8.4
The net present value (total discounted cost) of Waste Excavation Alternative 1A and Buried Waste Alternative 2A, with and without a catastrophic release scenario. Note Alternative 1A is less expensive at very low discount rates (<0.2%) and high discount rates (>5.5%). In the intermediate space, Alternative 2A is less expensive.

Figure 8.4 shows the total discounted costs of Alternative 1A and 2A over a wide range of discount rates on a logarithmic scale. It is interesting that the curves in Figure 8.4 intersect twice when there are two discount rates at which the two alternatives have the same present value, which is a result of the changing time pattern of costs. At a zero or very near-zero discount rate, the long tail of annual costs under Alternative 2A, stretching out to 1000 years, outweighs the short- and medium-term costs of Alternative 1A. At low but above-zero discount rates, the greater costs of Alternative 1A in years 16 through 73 dominate the calculation. At high discount rates, the first 16 years loom largest, so that Alternative 2A is more expensive because of its “front-loaded” cost structure.

Interestingly, whether a catastrophic release occurs or not does not substantially change the analytical results. If the release does not occur, Alternative 2A remains less expensive down to a 0.1% discount rate, but is still more expensive at a zero discount rate and above a 5.5% discount rate. However, we know that a catastrophic release 500 years into the future would have massive economic, social, and health consequences, so while it appears immaterial in this analysis, this cost is a very important consideration in long term analyses.

Due to the extreme uncertainties of institutional control over the long-term, and the inequity issues of discounting as described earlier, we recommend using a zero discount rate for the West Valley full cost accounting analysis. This is in line with the Clinton Administration DOE policy in their Long Term Stewardship Report as noted earlier. However, for the sake of argument, we can look at what the federal Office of Management and Budget asks agencies to evaluate proposals with, which is both a 3% and a 7% discount rate. In this case, those two rates will give opposite answers on which Alternative is cheaper (see Table 8.3). At a 3% discount rate, Alternative 2A is less expensive, but at a 7% discount rate, Alternative 1A is less expensive.

8.6 Summary of Comparison of Alternatives

8.6.1 Economic Cost

Our analysis indicates that, under the assumptions of a non-discounted future, Waste Excavation Alternative 1A is economically less expensive than Buried Waste Alternative 2A. In this study, we show the following analysis results.

1. The 2005 draft DEIS analysis of Alternatives 1 and 2 are unrealistic, and, more importantly, incomplete. The DEIS uses a period of analysis far too short to reflect real costs and risks, and does not adequately address real harm risks as well as monetary costs to the public and the environment, both locally and downstream.
2. Extending the period of analysis to 1000 years, a first step in setting a period more in line with the decay times for high-risk radioactive waste (yet not nearly long enough for some of the most dangerous radionuclides) reveals that the long-term site maintenance costs at West Valley are burdensome and expensive. At 1000 years, the total cost of Buried Waste 2A is nearly 25% higher than Waste Excavation 1A.
3. The value of future lives and health is a strong argument for not using an economic discount rate in this analysis (in agreement with the assumptions of the 2005 draft DEIS). However, if standard federal Office of Management and Budget discount rates (3% and 7%) are employed, Alternatives 1A and 2A cannot be said to be significantly different from an economic standpoint.

We conclude that there is inadequate *economic* justification to choose one Alternative over the other. The costs in both Alternatives are high and there are too many uncertainties about what the future holds to justify either Alternative on the basis of the project costs alone.

8.6.2 Social Costs

We evaluated two areas of social cost associated with the West Valley site: lost land revenues at the site itself and the costs of preventing exposure to downstream residents. Currently, the West Valley site poses a significant danger to local residents and the downstream public. In other words, the site is a significant threat to those who live along and depend upon Buttermilk and Cattaraugus Creek, the residents of Buffalo and the large population along the shores of Lakes Erie and Ontario.

As long as residents are restricted from developing or utilizing the land at the West Valley site, there will be lost land revenues. As a highly conservative hypothetical estimate, we assume that the land could be used otherwise for agricultural purposes,[310] for a loss of $130,000 every year as long as the full site is restricted, or $64,000 if half the site is released (as is possible in Buried Waste Alternative 2A after 217 years). The opportunity cost of restricted land is quite low relative to the costs of remediation.

Residents living downstream of the West Valley site are endangered by the risk of a radionuclide leak at the site. For the purposes of this analysis, we assumed that if a leak occurred, there would be significant costs for remediation, but were not able to calculate health costs for exposed residents. We calculated remediation costs only of water contamination for Erie County Water Authority consumers; 500 years into the future (see Section 7 and 8.4.5 for a further description of this scenario). We estimated a cost of over $818 million in the five years after the catastrophe occurs, and then a continued cost of over $27.5 million every year thereafter to protect consumers from waterborne contamination. This instantaneous cost and then extended costs over the next 500 years very quickly adds to the social cost burden of keeping wastes buried at West Valley. If we suspect that there is a risk of radioactive waste exposure over the next thousand years, the costs of leaving radioactive waste in the ground (Alternative 2A) very quickly exceed the costs of exhuming and transporting wastes to a safer location (Alternative 1A).

8.6.3 Risks

The economic cost of Waste Excavation Alternative 1A over the long run appears to be less expensive than Buried Waste Alternative 2A, unless an economic discount rate is used, in which case neither choice is economically superior. The evaluation of economic consequence is, however, not complete without a discussion of risk, and there are many risks which should be evaluated at the West Valley site (See Section 8.1.1), including the risks of exposure and injury during closure, risks to future residents and off-site regions after the closure, and the inherent geological risks at West Valley (see Section 6).

---

[310] Our "conservative" estimate is defined here as the lowest reasonable cost, which in this case assumes that the land could be used for agricultural purposes; an "optimistic" estimate might assume that the land could be used for commercial or residential purposes for a significantly higher land value (one or two orders of magnitude).

8.6.3.1 Closure Risks

We are not qualified to evaluate the risks of closure activities for either Alternative 1A or 2A. The 2005 draft DEIS calculates risks for worker radioactivity exposure, morbidity and mortality during excavation, packaging, and transportation of both high and low-level wastes. Simply put, every closure activity at West Valley poses a risk to onsite workers, and the more waste excavated, packaged, and transported, the higher these risks climb. The DEIS appears to carefully consider the technology which would be required to excavate unknown toxic wastes from integrated dumping sites (such as the NDA), but at every stage human error and machine malfunction can put workers in harms way. Using industrial standards, the DEIS calculates that Alternative 1 would result in many more injuries and rems of exposure than Alternative 2 (see Table 8.4) during the relatively short time period of excavation activities. Detailed injury and exposure data from the 2005 draft DEIS are in Figures 8.5 and 8.6 at the end of 8.6.3).

	Worker Injuries (total reportable cases)	Total Worker Exposure (person-rems)
Alternative 1: Waste Excavation	612	1170
Alternative 2: Buried Waste	237	498

Table 8.4: 2005 draft DEIS estimation of worker injuries (as total reportable cases) and exposure during closure activities. (Injury data from Closure Engineering Reports, 2005 draft DEIS in Tables 4.2-1; radiation exposure from same reports in Tables 4.2-2).

Alternative 2 (and, by extension, 2A) poses significantly less risk to onsite workers during near-term closure activities than Alternative 1 according to the DEIS.

8.6.3.2 Post-closure and Geologic Risks

In Buried Waste Alternative 2, we must consider the risks of losing institutional controls at the site sometime after the closure which is likely a probability, rather than a possibility. First, there is a fundamental obstacle in maintaining institutional controls due to the improbability of thousand-year continuity in either government or language. While something called the English language has existed for centuries, it changes fast enough so that modern readers cannot understand words written a thousand years ago. There is no reason to assume that the agencies could adequately address safety and communication issues at West Valley for the Buried Waste Alternative 2 option for a millennium. (See Section 5.2.)

Second, there is the fundamental problem that erosion is a powerful and fast moving force at the site. West Valley sits on a geologically young landscape which is undergoing a relatively rapid rate of erosion. Within the next few hundreds years, erosion is estimated to create damaging gullies. For instance, at the rate of erosion anticipated for Franks Creek, we might anticipate a breach of the state licensed disposal area (SDA) in less than 400 years due to side-cutting alone. This region could expect to have over 500 new gullies form with erosion covering 20% of the plateau surface in the next 10,000 years. It is easy to imagine that if erosion is uncontrolled, at least one of these gullies will penetrate a buried radioactive waste area at the site. A breach would be a catastrophic failure, leaking high concentrations of radionuclides into the local watershed and then quickly into Lake Erie (see section 6 for details). Can we count on a system design so sound and repairs made so frequently that the dangerous contaminated waste at the site is never released? Erosion control practices have short life spans, expected to last 10 to 25 years.

Since, severe erosion problems are estimated to occur at the site within hundreds of years, the long-term disposal of buried waste at the site is not an environmentally sound approach. Currently, there is a large plume of contaminated groundwater moving towards Buttermilk Creek. However, even more worrying for the downstream population and the priceless resource of the Great Lakes is the potential for streams near the site to undercut or expose wastes buried at the site. Burial of nuclear waste over the long-term is a flawed approach both because of the scientific uncertainty in predictions of geological events over millennia to come, and because burial of waste compromises the rights of future generations to equal treatment and free, informed consent.

If erosion or institutional controls were lost at the site, the hazardous wastes could be liberated by geologic hazards and intruders (inadvertent or intentional). The buried wastes at West Valley in Alternative 2 (and 2A) continues to pose a risk to nearby and downstream residents long after closure activities have ended and the site reverts to regulatory stasis.

In contrast, Waste Excavation Alternative 1 (and 1A) leaves behind a decommissioned and contamination-free area after 73 years of closure activities. While there are risks to the onsite workers during the closure, the risks at West Valley are over when the last truck or railcar carrying contaminated waste leaves the site. It is important, yet unfortunately beyond the scope of this analysis, to note that wastes which have left West Valley are not risk-free. Rather, they will have to be stored or disposed somewhere else and may also pose a threat to future generations even if the site is more suitable than West Valley.

Alternative 1A poses significantly lower risks to future generations at or downstream of West Valley after closure activities cease.

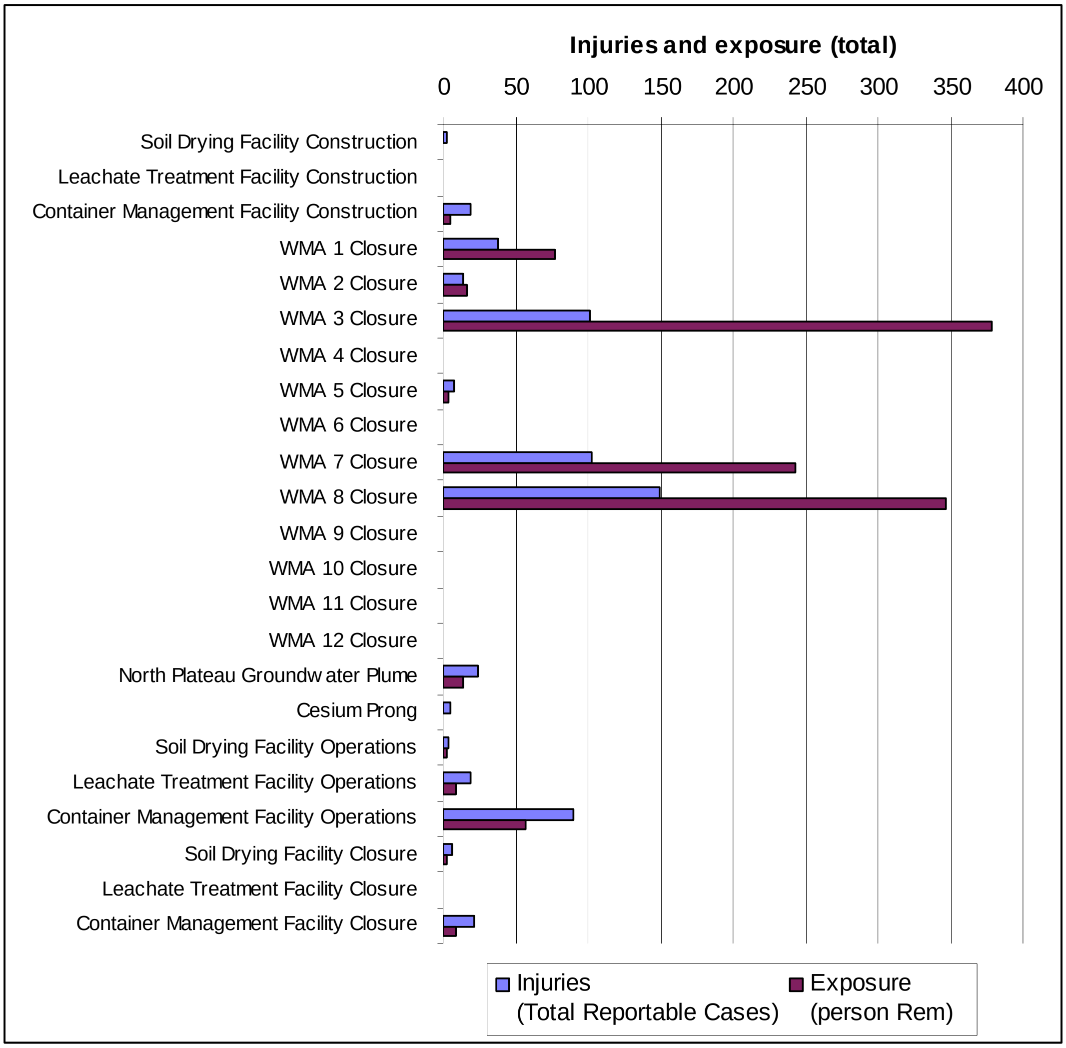


Figure 8.5
Occupational injuries and total on-site worker exposure from Waste Excavation Alternative 1 as calculated in the 2005 DEIS (see section 8.6.3.1)

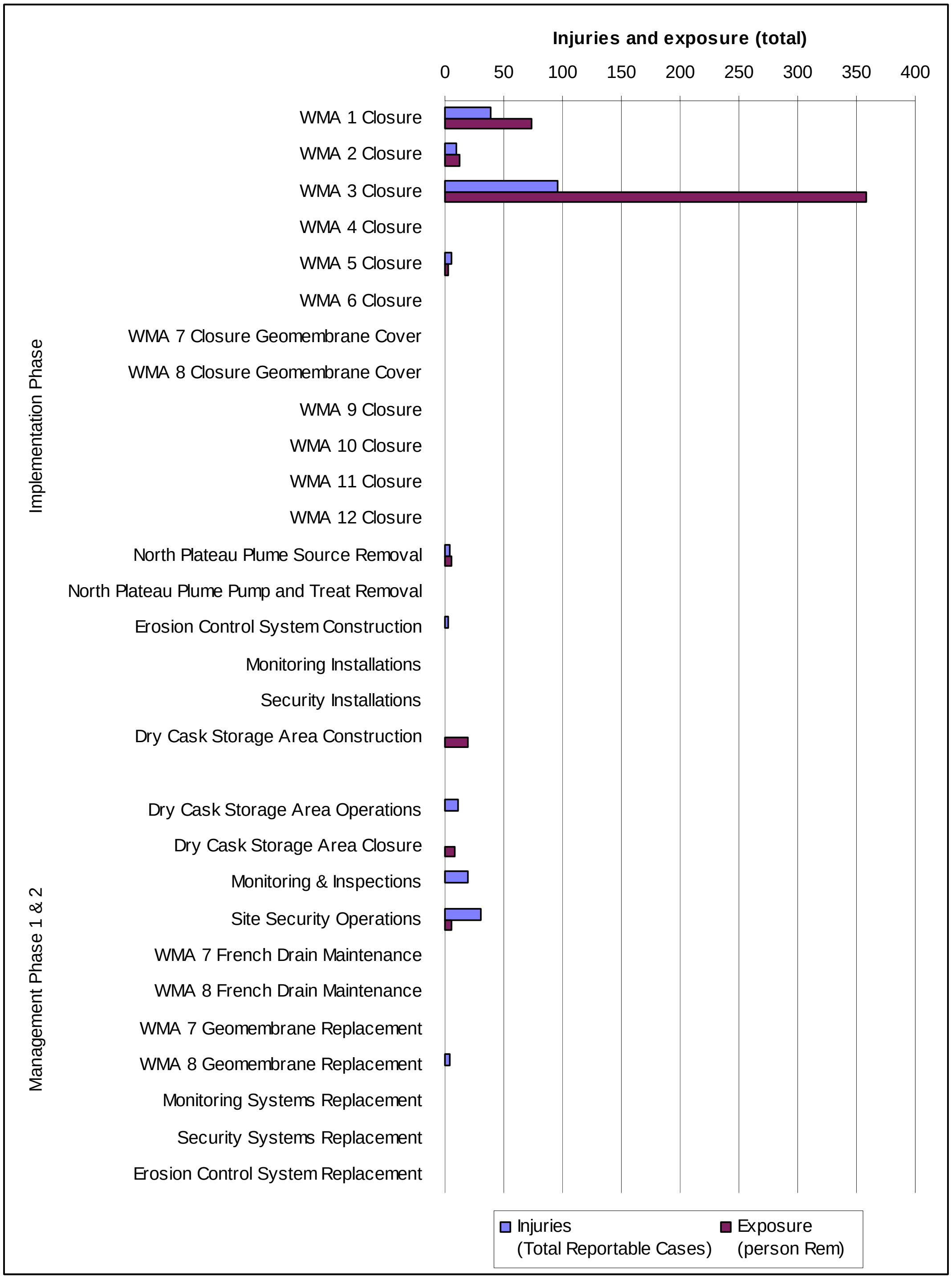


Figure 8.6
Occupational injuries and total on-site worker exposure from Buried Waste Alternative 2 as calculated in the 2005 DEIS (see section 8.6.3.1).

8.7 Recommendations

Based on our analysis of the Alternatives presented in the Draft Environmental Impact Statement for closure of West Valley created by the DOE (2005 draft DEIS), we make the following recommendations.

1. Alternatives 3, 4, and 5 cannot be considered appropriate alternatives as they pose significant short and long term risks to the public without addressing some of the most difficult problems at West Valley.
2. Buried Waste Alternative 2 inadequately protects the health and wellbeing of local residents and the downstream public, and is an unrealistic cost for the site requirements (see Sections 6.3 and 8.4, and Appendix A).
3. Buried Waste Alternative 2A, our modified version of Alternative 2, still poses a risk to local residents and the downstream public if institutional and erosion controls fail while dangerous radionuclides are buried at West Valley.
4. Waste Excavation Alternative 1 (and 1A) poses a risk to onsite workers during the relatively short period of time for remediation activities.
5. Waste Excavation Alternative 1 (and 1A) does not “solve” the problem of West Valley's nuclear waste disposal, rather it prevents further contamination of the site, prevents a catastrophic release from occurring that could cause severe damage to nearby populations and the Great Lakes region, and it mitigates the problem by transferring the waste to a less risk-prone site.
6. Over a 1000 year timeframe, Waste Excavation Alternative 1 (and our modified version 1A) presents the least risk to a large population and the lowest economic social and project cost.

Based on these findings, we recommend that the DOE, NYSERDA, DEC and other involved agencies take the following actions.

1. Reject current assumptions about timeframe, institutional controls and continuity, and budget requirements as presented in Alternatives 2 through 4 in the 2005 draft DEIS based on their inability to adequately protect health, welfare and environment as required by federal statute.
2. Assume that, until shown otherwise, the safest and most economically viable option is to fully excavate the wastes buried at West Valley (Alternative 1).
3. Explore other options for retrievable, monitored, above-ground storage of nuclear waste at a more stable site than West Valley.
4. Issue a new DEIS, revisiting the following research topics more rigorously and with public input:

   a. The probability of maintaining effective institutional controls over the expected lifetime of radioactive elements interred at West Valley site;
   b. The risk of erosion control failure with or without the maintenance of institutional controls at the West Valley site;
   c. The rate of release and source of radioactive contamination should there be an erosion control failure at the West Valley site; and
   d. The potential for radioactively contaminated groundwater to move rapidly through sand layers in West Valley soils.

5. Issue a new DEIS, revisiting the following budget topics more rigorously and with public input:
   a. The economic costs of addressing contaminated groundwater and drinking water for local populations;
   b. The economic costs of addressing contamination in local watersheds;
   c. The economic costs of addressing contamination reaching and impacting Lake Erie; and
   d. The economic opportunity cost of lost development ability at the West Valley site.
6. Evaluate options for mitigating radioactive waste at West Valley based not only on project cost alone, but also on project and post-closure risks *over the expected lifetime of radioactive elements buried at the site*.

Table 8.5: Full Cost Accounting for Alternatives 1 and 2 (2005 draft DEIS) and modified Alternatives 1A and 2A, with and without a catastrophic release in year 500.

(Table continues on next two pages)

Closure Procedure	Alternative 1	Alternative 1A	Alternative 2	Alternative 2A	Alternative 2A
All costs in year 2005 $	Waste Excavation (2005 DEIS)	Waste Excavation (Modified)	Buried Waste (2005 DEIS)	Buried Waste (Modified, with Catastrophic Release)	Buried Waste (Modified, no Catastrophic Release)
Waste Management Area Closures					
WMA 1 Closure	297,760,000	282,682,439	296,404,000	296,404,214	296,404,214
WMA 2 Closure	97,525,000	97,524,921	63,018,000	63,017,954	63,017,954
WMA 3 Closure	834,143,000	762,169,401	772,853,000	772,853,497	772,853,497
WMA 4 Closure	65,998,000	65,997,501	65,621,000	65,620,850	65,620,850
WMA 5 Closure	57,628,000	57,627,911	36,338,000	36,338,382	36,338,382
WMA 6 Closure	6,725,000	6,725,491	4,128,000	4,128,356	4,128,356
WMA 7 Closure	1,044,304,000	1,044,303,614	8,639,000	8,639,409	8,639,409
WMA 8 Closure	1,556,528,000	1,556,527,763	7,651,000	7,651,326	7,651,326
WMA 9 Closure	7,759,000	7,759,273	836,000	835,526	835,526
WMA 10 Closure	13,866,000	13,865,611	10,652,000	10,652,012	10,652,012
WMA 11 Closure	4,262,000	4,262,115	118,000	118,276	118,276
WMA 12 Closure	14,586,000	14,585,866	9,739,000	9,738,631	9,738,631
Contaminated Soil Cleanup					
North Plateau Groundwater Plume	2,099,631,000	1,469,464,760	37,309,000	1,469,464,760	1,469,464,760
Cesium Prong	60,222,000	60,222,091	-	-	-
Soil Drying Facility					
Construction	19,715,000	19,715,215	-	-	-
Operation	25,916,000	25,916,232	-	-	-
Closure	84,876,000	84,876,084	-	-	-
Leachate Treatment Facility					
Construction	3,865,000	3,864,816	-	-	-
Operation	106,846,000	106,846,104	-	-	-
Closure	3,578,000	3,577,529	-	-	-
Container Management Facility					
Construction	193,931,000	193,930,526	-	-	-
Operation	556,947,000	556,947,149	-	-	-
Closure	139,634,000	139,634,191	-	-	-

Table 8.5, Continued	Alternative 1	Alternative 1A	Alternative 2	Alternative 2A	Alternative 2A
	Waste Excavation (2005 DEIS)	Waste Excavation (Modified)	Buried Waste (2005 DEIS)	Buried Waste (Modified, with Catastrophic Release)	Buried Waste (Modified, no Catastrophic Release)
Dry Cask Storage Area					
Construction	-	-	42,707,000	42,706,600	42,706,600
Operations	-	-	44,791,000	44,790,603	44,790,603
Closure	-	-	5,349,000	5,348,835	5,348,835
Institutional Controls Installations					
Erosion Control System Construction	-	-	29,565,000	361,714,397	361,714,397
Monitoring Installations	-	-	6,391,000	6,390,531	6,390,531
Security Installations	-	-	2,933,000	2,933,294	2,933,294
WMA 7 Multi-layer cover construction	-	-	6,831,000	6,831,000	6,831,000
WMA 8 Multi-layer cover construction	-	-	16,485,000	16,485,000	16,485,000
Ongoing Costs (cumulative over analysis period)					
Monitoring and Inspections	-	-	139,192,000	683,428,988	683,428,988
Monitoring Systems Replacement	-	-	20,084,000	98,615,504	98,615,504
WMA 7 Maintenance (yrs 17-116)	-	-	5,366,000	5,366,312	5,366,312
WMA 7 Maintenance (yrs 119-218 or 119-1000)	-	-	3,265,000	28,800,793	28,800,793
WMA 8 Maintenance (yrs 17-116)	-	-	8,950,000	8,950,116	8,950,116
WMA 8 Maintenance (yrs 119-218 or 119-1000)	-	-	7,904,000	69,712,680	69,712,680
Security Systems Replacement	-	-	7,208,000	35,387,008	35,387,008
Security Operations (yrs 17-116)	-	-	114,306,000	114,305,518	114,305,518
Security Operations (yrs 119-218 or 119-1000)	-	-	18,573,000	1,008,174,669	1,008,174,669
Erosion Controls Replacement	-	-	34,602,000	7,528,210,411	7,528,210,411
Final Status Survey	-	-	3,480,000	3,479,670	3,479,670
Waste Disposal Costs					
GTCC	3,137,400,000	3,137,400,000	-	-	-
TRU	46,800,000	46,800,000	40,200,000	40,200,000	40,200,000
HLW	137,500,000	137,500,000	137,500,000	137,500,000	137,500,000

Table 8.5, Continued	Alternative 1	Alternative 1A	Alternative 2	Alternative 2A	Alternative 2A
	Waste Excavation (2005 DEIS)	Waste Excavation (Modified)	Buried Waste (2005 DEIS)	Buried Waste (Modified, with Catastrophic Release)	Buried Waste (Modified, no Catastrophic Release)
Water Costs					
Bottled water in catastrophic year (CY)	-	-	-	$272,655,646	
20% reduced cost in CY+1	-	-	-	218,124,517	
40% reduced cost in CY+2	-	-	-	163,593,388	
60% reduced cost in CY+3	-	-	-	109,062,259	
80% reduced cost in CY+4	-	-	-	54,531,129	
New water filtration for ECWA users	-	-	-	$13,627,419,300	
Unavailable Land Lost Revenue					
Land currently unavailable (3345 acres)	-	9,523,215	-	28,308,735	28,308,735
Land unavailable after closure (1645 acres)	-	-	-	50,169,210	50,169,210
Total					
Total Fixed Costs	10,617,945,000	9,910,249,818	1,649,538,000	17,937,707,307	3,492,321,068
Annual Costs over Analysis Period	-	-	359,450,000	9,580,951,999	9,580,951,999
Analysis Period (years)	73	1000	218	1000	1000
Total Costs over Analysis Period	**$10,617,945,000**	**$9,910,249,818**	**$2,008,988,000**	**$27,518,659,306**	**$13,073,273,067**

Table 8.5 (end): Full Cost Accounting for Alternatives 1 and 2 (2005 draft DEIS) and modified Alternatives 1A and 2A, with and without a catastrophic release in year 500.

9. Summary and Conclusions

Thirty miles south of Buffalo, New York, the West Valley nuclear waste disposal site sits on a plateau slowly but certainly eroding away with time. In 1961, when the site was first procured and Nuclear Fuel Services (NFS) was granted a contract to begin processing nuclear fuels at the site, the potential dangers were rapidly outweighed by the rampant enthusiasm for nuclear processing infrastructure and the economic prosperity it promised. After nearly a half century, there is no doubt that this decision was a mistake for the region's safety and health. The six years in which this facility successfully processed nuclear fuel have been dramatically overshadowed by over two decades of fierce debate and impasse about the cleanup of the site and implications for the next decade, century, millennium, and untold years beyond.

The West Valley site holds vast stores of complex and toxic radioactive wastes, many of which will remain toxic for tens of thousands of years. Packaged in canisters, drums, cardboard boxes, and plastic bags, the list of contaminated wastes reads like a laundry list of dangerous elements: strontium-90, cesium-137, europium-154, plutonium-238, -239, -240, and -241, uranium-238, curium-244, cobalt-60, americium-241, tritium, technetium-99, and thorium-234, amongst others.[311] These elements, if ingested or inhaled, lodge in human tissues, fat, or bone and are known to be responsible for leukemias and cancers at very low doses. There is no known safe level of exposure to radioactive chemicals—each exposure increases the likelihood that cancer and other health effects may occur.

Over the last two decades, a variety of federal and state agencies and national and local public interest groups have debated in the public, legislation, and court how to resolve a critical dilemma: the wastes at West Valley are not safe in their current configuration over short or long periods of time, but fixing West Valley will be expensive.

To work towards a resolution, the Department of Energy (DOE) and the New York State Energy Research and Development Authority (NYSERDA) created a series of Draft Environmental Impact Statements (DEIS), the latest of which was released for internal agency review in 2005 (2005 draft DEIS). Although there is no recommendation given in the 2005 draft DEIS, the document seemed to imply that leaving the bulk of the waste in the ground was an expedient and cost-effective way of closing and remediating the West Valley site.

Synapse was asked to evaluate and audit two of the Alternatives presented in the 2005 draft DEIS. Working only from the DEIS and publicly available information,[312] we determined that the DEIS fell critically short of delivering balanced Alternatives

---

[311] See Section 4 and Appendix B for details.

[312] NYSERDA was willing and able to help answer some questions in late 2007, but a Freedom of Information request for analytical background data was denied by the DOE in early 2008.

for guaranteeing the long-term safety of the West Valley site and the downstream public. The Alternatives which proposed permanently burying wastes on-site did not take into account significant long-term costs, and inadequately protected public health and wellbeing—falling shy of a necessary budget by an order of magnitude or more.

If the debate at West Valley is to be resolved through a quantitative means (for example, a cost-benefit analysis), it is critical that the analysis take into account the full range of costs entailed in each Alternative. A failure to do so undermines the public trust and ensures budget crises well into the future.

9.1 Lessons Learned

This analysis evaluated two Alternatives presented in the 2005 draft DEIS:

- Waste Excavation Alternative 1: Total exhumation of the wastes, off-site disposal, followed by complete site release for unrestricted use; and
- Buried Waste Alternative 2: Partial waste removal, stabilization of buried wastes for permanent onsite disposal.

We determined that the analytical period of analysis used in the 2005 draft DEIS was insufficient to determine the full cost of Buried Waste Alternative 2. In Waste Excavation Alternative 1, as soon as closure activities cease (in an estimated 73 years), the site is released to the public and there are no remaining costs. In Alternative 2 however, the site *must be maintained into perpetuity*. In this case, perpetuity is not a dozen years, or even two or three generations – the radioactive waste buried at West Valley would have to be monitored, tracked, and maintained in place for *tens of thousands of years*. Despite this basic axiom, the 2005 draft DEIS only allocates a skeleton budget for 200 years.

As we discuss in Section 5, it is nearly impossible to conceive of a form of language, much less a form of government or a budget which could last even a skim 1000 years (Iceland being the only example of such a continuous government today). However, given the benefit of the doubt that institutional continuity could last through the year 1000, we then needed to evaluate what sort of budget questions could be entailed over this time period. We considered that:

- Erosion would need to be kept rigorously under control at the site such that wastes are not undermined, contaminating the Great Lakes with radioactive waste;
- Security would need to be held at a relatively rigorous level at the site to ensure that farmers and hikers, unintentional interlopers, or intruders could not penetrate the wastes held at the site;
- A spreading plume of contaminated groundwater would have to be either remediated or excavated to prevent contaminants from entering the local watershed; and

- The inevitable and powerful forces of time and erosion could eventually expose wastes catastrophically, leading to high costs of remediation for water consumers.

We adjusted the underlying budget assumptions in Alternatives 1 and 2 to bring balance to their relative long term risks, calling the new options Alternatives 1A and 2A. Over 1000 years, Waste Excavation Alternative 1A costs $9.9 billion (all expended within 73 years, and then risk-free thereafter), while Buried Waste Alternative 2A costs between $13 and $27.5 billion, depending on if a catastrophic release occurred accidentally or not (see section 7.2 and 8.4 for details on this scenario).

9.2 In Closing

The total costs of this analysis must be taken as a whole, undiscounted cost. In standard capital investments, a discount rate is applied to account for future interest earnings. Over periods of 1000 years, any substantial discount rate (greater than a fraction of a percentage) implies that the health and wellbeing of future generations has no present value (i.e. no worth to us today). Since the plans being considered for West Valley are ostensibly meant to protect the public for many generations, we cannot reasonably assume that there is no value to public heath in the year 1000. Therefore, the discount rate must be zero, or near zero. While the choice of a discount rate for short term decisions is an economic question, *the choice of an intergenerational discount rate is a matter of ethics and policy* (see section 5.3.2 for details).

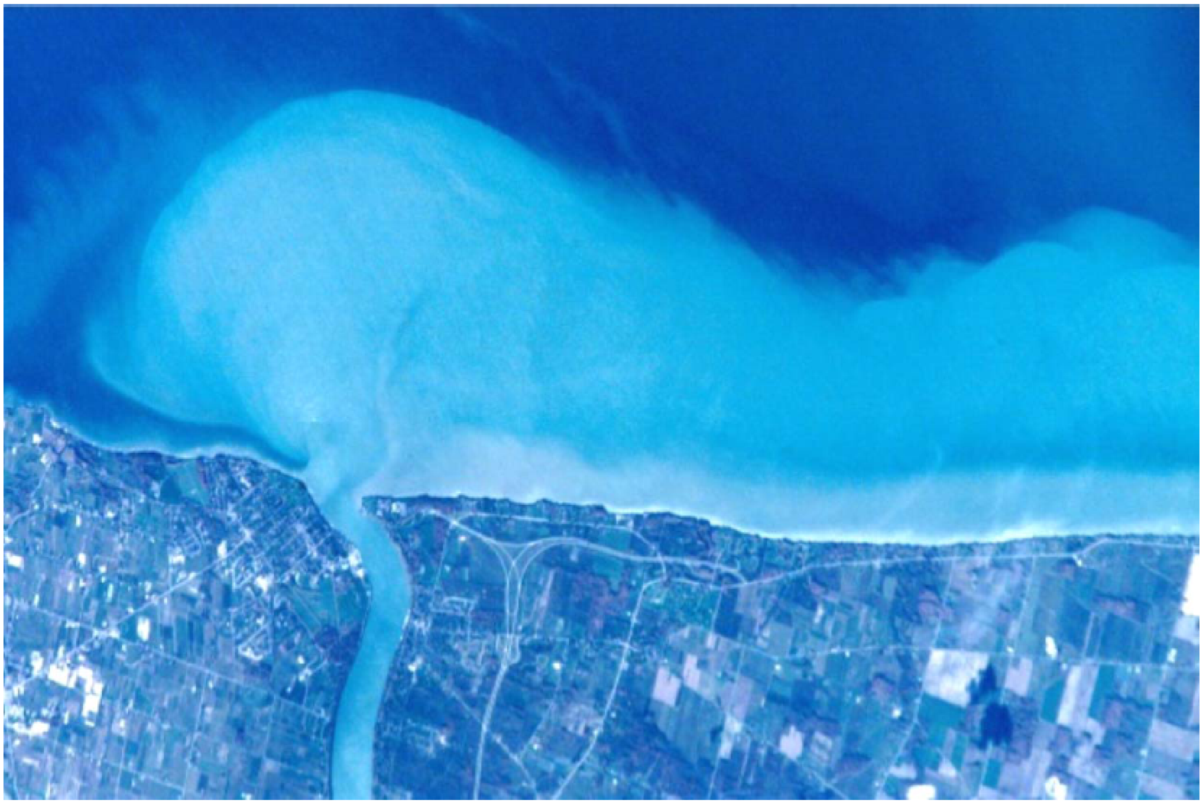
As a practical necessity, we are compelled to use a precautionary approach at West Valley. We cannot know the economic or health costs which may occur if wastes are left interred at West Valley, but we do know if a release occurred, it would have expensive and disastrous consequences. The costs of exhuming radioactive contamination at the site will be expensive in the short-term, but the costs of maintaining buried waste at the site in an attempt to thwart future disaster will be far more expensive and far less certain. In a precautionary sense, we should excavate and move the wastes at West Valley while we still know what is in the ground, how to handle it, and have some chain of responsibility still available.

Our analysis recommends that the DOE and NYSERDA issue a new DEIS with the following criteria.

1. Reject assumptions about timeframe, institutional controls and continuity, and budget requirements in Alternatives 2 through 4 in the 2005 draft DEIS based on their inability to adequately protect health, welfare and environment as required by federal statute.
2. Assume that, until shown otherwise, the safest and most economically viable option is to fully excavate the wastes buried at West Valley.

3. Explore other options for retrievable, monitored, above-ground storage of nuclear waste at a more stable site than West Valley.
4. Revisit and publicly vet assumptions about erosion risks, institutional continuity, budgets which account for the long-term costs of maintenance at West Valley, the expected timeframe of radionuclide decay and toxicity, and the costs to the downstream public along the shores of the Great Lakes.
5. Evaluate options for mitigating radioactive waste at West Valley based not only on project cost alone, but also on project and post-closure risks *over the expected lifetime of radioactive elements buried at the site*.
6. The West Valley site can be remediated practically, but it will require significant budgets, interagency cooperation, and a transparent and publicly involved process.

FIGURE 7b.



11-5-2001

NASA Astronaut Photography

Figure 7 B, Appendix C: Sediment Flow. This NASA satellite photo illustrates the sediment flow into Lake Ontario from the Niagara River.

The photo illustrates how sediment from a river, stream or canal mixes and disperses when it reaches a larger water body like a lake. However, if the West Valley site leaks contamination off-site, it could flow through adjacent creeks and make its way to the Great Lakes where it would pollute drinking water. Studies published in 1988 found radioactive sediments from the West Valley site in the southwestern region of Lake Ontario along the shore. (Joshi, S.R. 1988a. West Valley –Derived Radionuclides in the Niagara River Areal of Lake Ontario. *Water, Air, and Soil Pollution*. Vol.37, No.1-2,pp:111-120. January. Joshi, S.R. 1988b. West Valley Plutonium and Americium-241 in Lake Ontario Sediments off the Mouth of the Niagara River. *Water, Air and Soil Pollution*. Vol. 42, pp: 159-168.)