CLIMATE GUIDANCE FOR PHASE 1 STUDIES

WEST VALLEY DEMONSTRATION PROJECT
WESTERN NEW YORK NUCLEAR SERVICE CENTER

WEST VALLEY, NEW YORK

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Prepared for:
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This guidance was prepared under the supervision of Enviro Compliance Solutions, Inc. (ECS), on behalf of the U.S. Department of Energy (DOE) and the New York State Energy and Research Authority (NYSERDA) for the WVDP and WNYNSC, with expert consultation and contributions by the following Climate Scientists.

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The contributors, Vasilli Petrenko (Ph.D) of the University of Rochester, and Xuebin Zhang (Ph.D) of Environment Canada participated in an August 2012 Climate Change workshop and post-workshop conference, and offered valuable advice that served as the basis for this guidance. Their participation, expertise and advice are much appreciated.

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EXECUTIVE SUMMARY

This guidance was prepared for the West Valley Demonstration Project (WVDP) on behalf of the U.S. Department of Energy (DOE) and the New York State Energy Research and Development Authority (NYSERDA) to identify climate topics that may be included in WVDP Phase 1 Studies, and address two Foundation Questions developed by DOE and NYSERDA.

Climate Scientists were invited to participate in a Climate Change workshop in order to share their ideas on climate change topics as they relate to the decommissioning and/or long-term stewardship of the WVDP and the Western New York Nuclear Service Center (WNYNSC). The purpose of the workshop was to educate and inform DOE, NYSERDA and public stakeholders on the latest science regarding climate and climate change, address the Foundation Questions, and serve as a basis for this guidance. This guidance was edited and reviewed by the contributing Climate Scientists.

In preparation of this guidance, a detailed review of climate data used in the 2010 Final Environmental Impact Statement (FEIS) for the WVDP was performed to identify the type of climate data that may be needed or augmented for future Phase 1 Studies. In the 2010 FEIS, various storm events taken from 1986 publications, and precipitation estimates developed from local weather station data, were used in analytic and numeric models to simulate erosion over the short-term (up to 100 years). Local weather station data were also used to estimate future wetter climate conditions as input to a landform evolution model (LEM) to simulate erosion during the next 10,000 years.

Below is a summary of the DOE and NYSERDA Foundation Questions, and guidance to augment climate data referenced in the 2010 FEIS.

Foundation Question: What are the climate change issues that should be considered in WVDP Phase 1 Studies (i.e. soil erosion, engineered barriers, in-place closure)?

The Climate Scientists believe that the following issues should be considered in WVDP Phase I Studies, as appropriate.

- A Project Climate Database of historic precipitation and temperature may be complied for Phase 1 Studies. The Project Climate Database may be based on appropriate weather station data throughout the region where reliable precipitation records are available (see Section 3.1).
- A consistent scientifically-based approach to select precipitation depth for wet and dry years, and low and high precipitation intensity years for use in analytic and numeric models may be adopted (see Section 3.2.1).
- Site-specific precipitation distribution curves for design storms may be developed for the WNYNSC, and may be included in the Project Climate Database (see Section 3.2.2).
- "Downscaling" refers to the process of producing higher-resolution simulations of climate from low-resolution outputs of global circulation models (GCMs). Available downscaling projections through year 2100 may be included in the Project Climate Database, where future climate predictions up to 100 years are needed in Phase I Studies (see Section 3.2.3).

- Recent published climate model simulations that assess climate change over the next 100 to 150 years may provide additional insight into the range of possible climate conditions that may be used in the CHILD model over a 10,000 year time frame.

Foundation Question: How may climate change issues be evaluated during Phase 2 Decisionmaking for the decommissioning or long term stewardship for the WDVP?

Climate change issues may be assessed for the short-term (approximately 100 years) and long term (10,000 years). For decisionmaking regarding the decommissioning and long-term stewardship for the WVDP, the agencies may consider the following.

- Adopt state-of-the-art designs or processes to manage WVDP waste that have acceptable factors of safety so that designs and processes that account for foreseeable climate variations could be deemed reliable for approximately 100 years.
- Recognize that current state-of-the-art models that rely on climate change projections over the next 10,000 years have inherent uncertainties, arising from a number of sources including limited scientific understanding of some climate processes, limited spatial resolution of climate data due to computational resource constraints, and the unknown future impact of human society and technology on climate.

Climate models may reasonably provide plausible climate trends on the scale of decades to a couple of centuries. However, there are a few climate model simulations on the scale of multiple centuries, and those few should be viewed with caution. There is no well-defined upper limit on how high greenhouse gas concentrations in the atmosphere could rise in the future. There is direct linkage between greenhouse gas concentrations and global temperature, atmospheric water vapor concentrations, and magnitude of extreme precipitation events. Although, as a first-order approximation, design storm values may increase by approximately 25 percent by 2100, this approximation certainly does not represent an upper limit beyond 2100.

1.0 INTRODUCTION

This guidance was prepared for the West Valley Demonstration Project (WVDP) under the supervision of Enviro Compliance Solutions, Inc. (ECS), on behalf of the U.S. Department of Energy (DOE) and the New York State Energy Research and Development Authority (NYSERDA), to identify climate topics that may be included in WVDP Phase 1 Studies. Implementation of Phase 1 Studies and Phase 2 Decisionmaking was the selected remedy in the 2010 Final Environmental Impact Statement (FEIS) prepared for the WVDP. Description of and guidance for conducting Phase 1 Studies are provided in Appendix A.

This climate guidance includes discussions of the following.

- Objective for this guidance.
- Summary of a 2012 WVDP Climate Change Workshop that was hosted by DOE and NYSERDA to identify climate topics that may be relevant to Phase 1 Studies.
- Summary of climate data used in the 2010 FEIS.
- Climate change topics, recommended by Climate Scientists, that may be included in future Phase 1 Studies.

Each of these is discussed below.

1.1 Objective

This guidance addresses the following "Foundation Questions".

- What are the climate change issues that should be considered in WVDP Phase 1 Studies (i.e. soil erosion, engineered barriers, in-place closure)?
- How may climate change issues be evaluated during Phase 2 Decisionmaking for the decommissioning or long term stewardship for the WDVP?

This guidance document was edited and reviewed by the contributing Climate Scientists selected by DOE, NYSERDA and public stakeholders.

1.2 Climate Workshop

Climate Scientists were invited to participate in a Climate Change workshop in order to share their ideas on climate change topics as they relate to the decommissioning and/or long-term stewardship of the WVDP and the Western New York Nuclear Service Center (WNYNSC). The purpose of the workshop was to educate and inform DOE, NYSERDA and public stakeholders on the latest science regarding climate and climate change, address the Foundation Questions, and serve as a basis for this guidance.

The workshop was held at:

Ashford Office Complex, Room C-1
9030 Route 219
West Valley, NY
Thursday, August 2, 2012

During the workshop, the Climate Scientists gave 20-minute slide presentations in their specific research area of interest, followed by 10-minutes of open discussion (ECS, 2010). More detail regarding the scope of the Climate Change workshop is provided in Appendix B.

1.2.1 Presentations

The Climate Scientist participants and presentations are summarized below:

CLIMATE SCIENTIST	AFFILIATION	PRESENTATION
Dr. Vasilli Petrenko Assistant Professor	Dept. of Earth & Environmental Sciences University of Rochester, NY	The Paleoclimate Perspective
Dr. Xuebin Zhang Research Scientist	Climate Research Division Environment Canada, Toronto	Human Influences on Climate
Dr. Kenneth Kunkel Research Professor	Dept. of Marine, Earth & Atmospheric Sciences North Carolina State University, NC	Estimates of Current and Future Probable Maximum Precipitation
Dr. Arthur DeGaetano Associate Chair Professor	Dept. of Earth & Atmospheric Sciences Cornell University, NY	Variability in Local Rainfall Intensity & Rainfall Distribution Parameters

The remaining portion of the workshop was devoted to open discussion between the Climate Scientists and public stakeholders to address the Foundation Questions (ECS, 2012).

1.2.2 Topics

During the workshop, the Climate Scientist presented and discussed the following topics.

- Presently, greenhouse gas concentrations are much higher than at any time during the past 800 thousand years, and for this reason, it is extremely unlikely that another glacial period would occur in the Northeastern United States anytime in the next 100 thousand years.
- Rising temperatures, and changes in the frequency and magnitude of extreme precipitation, are likely consequences of anthropogenic influences on climate change.
- Rising air and ocean temperatures tend to increase the amount of water vapor in the atmosphere, which will tend to increase the amount of water that will be ultimately available for precipitation.
- During the early part of the 21st century, the frequency of extreme precipitation events has increased by as much as 74% across the Northeastern United States compared to the late 1950s to early 1960s.
- 100-year storm events as defined by data from 1950-1970 appear to occur as often as once every 66 years based on data observed from 1980-2009 in the Northeastern United States. Similar decreases in the return frequency of the 2-year and 50-year storm events have also been noted.
- Many past floods, particularly on the largest rivers, have resulted from snowmelt or rain falling on deep snowpack. Likely decreases in snow cover and drier summer soil conditions in the future may temper the risk of spring floods from extreme precipitation

events.

The Climate Scientists included supporting research observations and data in their respective slide presentations (ECS, 2012).

1.3 WVDP Description

WNYNSC is in northern Cattaraugus County (<1% in Erie County) approximately 30 miles south of Buffalo, New York. WVDP (167 acres), which is controlled by DOE, is located within WNYNSC (3,338 acres).

WNYNSC is within the 30 square mile Buttermilk Creek watershed (Figure 1). WVDP is within an approximately 1.8 square mile subwatershed within the Buttermilk Creek watershed, and is drained by Quarry Creek, Franks Creek and Erdman Brook (Figure 2). Elevations within the WVDP range roughly between approximately 1,250 to 1,400 feet above mean sea level (FEIS 2010, Appendix F, p. F-3). The WVDP includes the following features.

- Former irradiated nuclear fuel reprocessing plant with four associated underground radioactive waste storage tanks.
- Nuclear Regulatory Commission (NRC)-Licensed Disposal Area (NDA).
- State-Licensed Disposal Area (SDA).

These and other features within WVDP are shown on Figure 3. More detail regarding the WVDP is provided in the FEIS (2010).

2.0 CLIMATE DATA USED IN 2010 FEIS

In preparation of this guidance, a detailed review of the climate data used in the 2010 FEIS was performed to identify the type of climate data that may be needed or augmented for future Phase 1 Studies (see Appendix C). Below is a summary of models used in the 2010 FEIS that required climate data.

2.1 Models

The following climate data were used in analytic and numeric erosion model simulations for the 2010 FEIS.

- One analytic model used precipitation data obtained for the WVDP meteorological tower for the one-year period from March 1, 1990 to February 28, 1991.
- One numeric model used daily rainfall data from a single year recorded at the WNYNSC weather station in 1984. An annual precipitation of 113.8 cm (44.8 in) was selected.
- One numeric model simulator was used to stochastically project daily climatic conditions over a 100-year period from records supplied from the Little Valley, New York weather station (USDA 1995).
- A stochastic representation of rainfall and runoff was used in a numeric landform evolution model (LEM) in which a sequence of storm and inter-storm events was drawn at random from exponential frequency distributions (Eagleson 1978, and Tucker and Bras 2000) to simulate precipitation over the next 10,000 years. A mean rainfall intensity parameter (P=1.45 mm [0.06 in] per hour) was derived from 9.8 years of five-minute resolution precipitation data collected at the WNYNSC weather station.

Various storm events were used in numeric erosion model simulations. Rainfall for each storm event was taken from standardized maps developed by the Soil Conservation Service[1] (USDA 1986) using a Type II Soil Conservation Service storm. A global time step (Tg) of 0.1 years was selected for the LEM used in erosion studies. In order to simulate potential future wetter climate conditions, the mean precipitation intensity was doubled (i.e. P = 2.9 mm [0.11 in] per hour) for the LEM simulations.

2.2 Data Sources

Climate data used for erosion assessments were obtained from the following sources.

- Data from the WVDP meteorological tower from March 1, 1990 to February 28, 1991.
- Daily rainfall data for 1984, and 9.8 years of five-minute resolution precipitation data collected at the WNYNSC weather station.
- Data from the weather station at Little Valley, New York (USDA 1995).

[1] Now the National Resource Conservation Service (NRCS).

More detail regarding climate data used in the 2010 FEIS is provided in Appendix C.

3.0 CLIMATE GUIDANCE

Based on the Climate Change workshop, post-workshop conference, and preliminary discussions with the Phase 1 Studies Erosion Work Group (EWG), the following climate topics are recommended for inclusion in Phase 1 Studies.

- A Project Climate Database of historic precipitation and temperature may be complied for Phase 1 Studies.
- The Project Climate Database may be based on appropriate weather station data throughout the region where reliable precipitation records are available.
- Climate data inputs to various analytic and numeric models should be consistent among Phase 1 Studies.
- Assumptions for future climate change should be identified, and consistent among the Phase 1 Studies.

Climate Scientists emphasized that there are no simple methods for predicting future changes in rainfall depth, rainfall intensity, and storm occurrence. There is considerable uncertainty in estimating future climate conditions for the Northeastern United States, and elsewhere across the globe.

3.1 Project Climate Database

In keeping with the recommendations, a Project Climate Database, to include daily and sub-daily temperature and precipitation from appropriate weather stations, may be assembled. Climate Scientists recommend the following approach to assemble the database.

- Identify daily reporting weather stations with long, continuous records in western New York.
- Assess the homogeneity of the data record. Climate records are sometimes affected by non-climatic discontinuities that alter the consistency of the data. These might include small changes in locations, changes or malfunctions in instrumentation, or changes in site characteristics (i.e. vegetation impinging on the weather station). Selected weather stations included in the database should be as free as possible of such impacts.
- Assess the representativeness of the WNYNSC weather station data by comparing the 9.8 year precipitation record at the WNYNSC weather station[2] with daily and sub-daily (hourly, 15-minute and 5-minute) precipitation data from weather stations outside the WNYNSC. These comparisons are recommended because the five-minute resolution precipitation data at the WNYNSC appears to be limited to 9.8 years. It is uncertain if this limited time-period adequately represents the long-term precipitation for the

[2] Used for the Channel-Hillslope Integrated Landscape Development (CHILD) model. Mean Precipitation Intensity (P) was derived from 9.8 years of five-minute resolution precipitation data collected at the WNYNSC weather station (see Appendix C). The years used for the 9.8 years of five-minute resolution precipitation data were not reported (see FEIS, 2010, Appendix F).

WNYNSC area.

- Prepare a Project Climate Database with weather station locations linked to weather station temperature and precipitation data (daily and sub-daily). In addition to temperature and precipitation, weather station data may include location coordinates, station elevation, and the results of the WNYNSC weather station comparison suggested above.

The Project Climate Database should be accessible and compatible with numeric models used in Phase1 Studies.

3.2 Short Term Analyses

For the short term erosion assessment described in Appendix F of the 2010 FEIS, annual precipitation depth was computed as input for some erosion models (USLE & CREAMS), and precipitation depth and intensity for design storms were used as input data for other erosion models (SEDMOT II & WEPP). In addition, for one model (WEPP) daily climatic conditions over a 100-year period were statistically simulated based on local weather station data (see Appendix C).

Based on these uses of climate data, the Climate Scientists recommend approaches for the following:

- Selection of annual rainfall depth values.
- Selection of design storm rainfall depth and intensity values.
- Projection of short term (100 years) changes in rainfall depth and intensity values.

Each of these is discussed below.

3.2.1 Annual Rainfall

Analytic and numeric models used in the 2010 FEIS required input values for Mean Annual Precipitation (Pa) and Mean Precipitation Intensity (P). Variability in annual precipitation (wet and dry years) is caused by a range of conditions, including the number of days with rainfall, and frequency of extreme rainfall events[3].

An examination of the most recent 31 years (1981-2011) of Buffalo International Airport (BUF) climate data was conducted. This analysis identified the following key characteristics.

- The driest year of the last 31 years was 1995 (33.99” annual precipitation). During this year, there were only six days with at least one inch of precipitation.

[3] There is no specific threshold that defines when a precipitation event is designated as “extreme”. However, scientific research studies of extreme precipitation events typically include events with recurrence intervals no more frequent than once per year. Thus, 2-yr, 5-yr, 10-yr, 20-yr and 100-yr design storms would be considered extreme although obviously there are large differences in magnitude among these. In this guidance, “extreme” refers to events with recurrence intervals no more frequent than once per year.

- The wettest year was 1990 (50.89” annual precipitation). In that year, there were 11 days with at least one inch of precipitation.
- Wet and dry years do not necessarily coincide with years of high or low intensity precipitation, respectively[4].
- Precipitation in wet years is approximately 20 to 25 percent above the long-term average, while precipitation in dry years is approximately 15 percent below the long-term average.
- There appears to be a positive correlation between total annual precipitation and the number of days with precipitation of at least one-inch.
- There is little correlation between annual precipitation, and the single highest daily precipitation (maximum precipitation).

Based on these considerations, Climate Scientists suggest that selected weather station data may be examined to assess precipitation frequency and thresholds. To examine these data, a graphical presentation of daily precipitation frequency may be prepared for each year, for each selected weather station[5].

Precipitation Frequency

Annual precipitation frequency distribution is typically skewed where the right side (the side toward higher precipitation) has an extended tail. Characterization of this skewed distribution may allow for the selection of precipitation depth for wet and dry years, and precipitation for low and high intensity events and years.

Precipitation Thresholds

Precipitation data may be characterized by the number of days above and below certain percentiles (i.e. 10^{th} and 90^{th}), and total precipitation falling above and below these percentiles. A common threshold used to designate very dry years is the 10^{th} percentile[6]. Therefore, dry years may be selected from those years with annual precipitation less than the 10^{th} percentile. The corresponding threshold commonly used for designation of very wet years is the 90^{th} percentile. Wet years may be selected from those years with annual precipitation more than the 90^{th} percentile[7]. Precipitation for low and high intensity events may be selected based on the frequency and year(s) desired.

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[4] The wettest single day in 1990 (driest year) and 1995 (wettest year) was about the same (1.94” in 1990, 1.89” in 1995). The single wettest day (5.01”) occurred in 1987, a year with near average annual precipitation (42.15”), and near average number of days (7) with at least one-inch of precipitation.

[5] This is usually computed as the number of daily precipitation amounts in intervals of arbitrary size. For this application, use of an interval size (histogram) of 0.25 inches will likely allow discrimination of differences among years.

[6] The National Climatic Data Center uses 10^{th} percentile in the computation of their Climate Extremes Index, and the 90^{th} percentile to represent very wet years

[7] The single highest precipitation amount may also be recorded because there may not be a correlation between the highest precipitation and the highest percentile threshold.

3.2.2 Design Storms

Computer models selected in the FEIS to assess erosion potential in short term analyses used Type II design storms taken from standardized maps developed by the Soil Conservation Service[1] (USDA 1986). Design storms recommended by Climate Scientists from more recent published sources are provided in Table 1.

TABLE 1
RECOMMENDED DESIGN STORMS

Storm	Duration	Rainfall Depth[8]	
		cm	in
1-yr	24-hour	4.85	1.91
2-yr	24-hour	5.64	2.22
5-yr	24-hour	6.91	2.72
10-yr	24-hour	8.10	3.19
25-yr	24-hour	9.93	3.91
50-yr	24-hour	11.63	4.58
100-yr	24-hour	13.59	5.35
PMP	24-hour	62.7	24.7

Historically, Type II storms have been used to allocate precipitation from 24-hour design storms to shorter accumulation periods according to the characteristics of specific basins. Current practice and guidance from the National Resource Conservation Service (NRCS) suggest that site-specific distribution curves may be computed from published 24-hour and short-duration design storms. Type storm curves developed using the most recent New York and New England precipitation data indicate a change toward more intense (a great proportion of the 24-hour design storm occurring in a shorter time period) precipitation compared to the conventional Type II storm (Wright et al., 2012).

Given this change in practice and the publication of these site-specific distribution curves for New York[9], site-specific distribution curves may be developed for each weather station where needed in Phase 1 Studies. These site-specific distribution curves may be included as part of the Project Climate Database.

3.2.3 Projected Rainfall

Precipitation

In the current climate, a major control on extreme precipitation events is the amount of atmospheric water vapor. Climate Scientists have high confidence that extreme precipitation intensity will increase in the future due to the increases in ocean temperature as greenhouse gas concentrations increase in the atmosphere. Ocean temperature rise will increase atmospheric water vapor content near the ocean surface. Global circulation model (GCM)

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[8] Taken from: http://precip.eas.cornell.edu/ with technical details provided at http://precip.eas.cornell.edu/docs/xprecip_techdoc.pdf, Wright et al. (2010), and Schreiner et. al. (1978).
[9] Type curve adaptions are available on the following website http://precip.eas.cornell.edu/ under the Data & Products tab

simulations show that wind patterns will distribute these increases in water vapor across land areas. In a recent study (Kunkel et. al., 2012), simulations from seven different GCMs suggest that maximum water vapor concentration in the atmosphere will substantially increase during the 21st Century in western New York. For a high greenhouse gas emissions scenario, these increases were in the 20 to 30 percent range by 2100. Although other factors (frequency and intensity of meteorological systems that cause extreme precipitation) could have enhancing or moderating effects on future design storm values, there are no comprehensive studies that assess the magnitude of such influences. As a first order approximation, design storm precipitation totals (see Table 1) may increase by approximately 25 percent by 2100.

Intensity

GCM simulations are available for periods of 100 to 200 years into the future. However, the ability of GCMs to simulate the most extreme precipitation events at a local scale must be viewed as limited at this time because the spatial resolution of the models is too coarse. The typical GCM is run at a resolution of the order of 50 to 100 miles or more (i.e. the size of one side of a model grid box). In a storm that produces a precipitation total that meets or exceeds a design threshold, the extreme precipitation is typically localized to a smaller area than the model grid box dimension. In addition, many of the physical processes that are parameterized in models are not optimized for extreme events. For these reasons, the reliability of GCMs to assess extreme precipitation is not viewed as highly reliable at this time.

Downscaling

"Downscaling" refers to the process of producing higher-resolution simulations of climate from low-resolution outputs of GCMs. Statistical downscaling achieves this through the development of statistical relationships between large-scale atmospheric features that are well-resolved by GCMs and local climate conditions. The statistical relationships are developed by comparing observed local climate data with GCM simulations of recent historical climate. These relationships are then applied to the simulations of the future to obtain local high-resolution projections. One underlying assumption is that the relationships between large-scale features and local climate conditions in the present climate will not change in the future. Statistical downscaling approaches are relatively economical from a computational perspective, and can be easily applied to many GCM simulations.

A number of downscaling approaches have been developed. One of the more sophisticated is known as the Bias-Correction Constructed Analogs (BCCA) (Maurer et. al., 2010). This method produces daily resolution time series of precipitation. The method preserves the actual sequences of weather that occur in GCM simulations. A group of collaborators[10] produced a set of 53 projections through year 2100 from 15 separate GCMs. Data and information regarding these projections are available at the following web site accessible to the public:

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[10] Collaborators include: Climate Central, Lawrence Livermore National Laboratory, U.S. Bureau of Reclamation, Santa Clara University, Scripps Institution of Oceanography, U.S. Army Corps of Engineers, and the U.S. Geological Survey.

http://gdo-dcp.ucllnl.org/downscaled_cmip_projections/dcpInterface.html#Welcome

Specifically, the BCCA projections are available for the periods of 1961-2000, 2046-2065, and 2081-2100. A standard approach to examining the impacts of climate change is to run a model with data from the historical period, and then the future period, and then examine the difference. Given the available data, an approach to examine changes near the end of the 21st Century may be to run a model with data from the periods of 1981-2000 and 2081-2100. This may be done with each of the 53 projections to provide a distribution of possible outcomes.

These downscaled projections are at a very high spatial resolution of 1/8 degree latitude by 1/8 degree longitude. Therefore, they largely preserve the spatial variations in climate, and the grid point(s) in the vicinity of the WVDP site may reflect the climate conditions specific to that area. Climate Scientists suggest the use of BCCA projections for modeling applications where daily time series are needed.

Approach

To account for projected precipitation over the next 100 years, the following approach may be adopted.

- Assemble a set of downscaled precipitation time series for weather station locations in the Project Climate Database by accessing the BCCA archive containing data for multiple GCMs.
- Designate precipitation for wet (dry) and high (low) intensity years from the downscaled data[11], and include these series in the Project Climate Database.

As an alternative, the feasibility of using change in atmospheric water vapor as a surrogate for changes in design storm values may be explored[12].

3.2.4 Short Term Uncertainty

There are several sources of inherent uncertainty in determining present day design storms and projecting changes in precipitation and design storms over the next 100 years. Potential sources of uncertainty for present-day design storms include:

- The representativeness of the available observed precipitation record relative to the true population of precipitation.
- The choice of the statistical extreme value distribution chosen to represent observed precipitation data series.

[11] The approach described in Section 3.2.1 may be used here as well.

[12] This may be accomplished by first examining if the recent changes in design storm intensity can be explained by recent changes in atmospheric moisture, or alternatively, exploring the relationship between spatial changes in design storm values and spatial differences in atmospheric moisture.

- Statistical uncertainties related to the fitting an extreme value distribution to the precipitation data series.

For conditions during the next 100 years, additional uncertainties arise from:

- Limitations of scientific understanding of some climate processes influencing extreme rainfall.
- Differences in the parameterization of precipitation generating processes in climate models.
- The limited spatial resolution of climate model data.
- Statistical uncertainties related to the downscaling process.
- Unknowns regarding future anthropogenic changes to the climate system (i.e. future greenhouse gas emission rates).

3.3 Long Term Analyses

3.3.1 Selected Model

The Channel-Hillslope Integrated Landscape Development (CHILD) model was used in the FEIS to simulate landform evolution due to erosion during the next 10,000 years. CHILD used a stochastic representation of rainfall in which a sequence of storm and inter-storm events was drawn at random from exponential frequency distributions. For the FEIS, the mean rainfall intensity parameter (P) was derived from 9.8 years of five-minute resolution precipitation data collected at the WNYNSC weather station. A global time step (Tg) value of 0.1 years was selected for calibration and other computer simulations (see Appendix C).

In order to assess the potential for accelerated erosion due to future wetter climate conditions, mean precipitation intensity was doubled in the FEIS (i.e. 2.9 mm [0.11 in] per hour). Using this approach, precipitation frequency would remain the same, but rainfall intensity would be twice as much (see Appendix C). The uncertainty of using a very limited 9.8 year record to model a 10,000 year precipitation record is a cause for concern. The analyses described in Section 3.1 of this guidance may give some indication as to the representativeness of this short record relative to the longer term precipitation climatology.

The following topics were considered by the Climate Scientists in order to improve climate input data for the CHILD model to assess long-term erosion.

- Understanding of climate variations since the last ice age in the West Valley region to assist with CHILD model calibration.
- Assessment of the availability of reliable precipitation data that could be used to statistically downscale daily resolution precipitation to 5- or 10-minute precipitation accumulations.

- Assessment of past and future seasonal climate variations in temperature and precipitation that may account for variations in soil moisture and vegetative cover that may mitigate or facilitate soil erosion.
- Selection of feasible future climate conditions in order to simulate potential erosion outcomes over the next 10,000 years.

Each of these topics is discussed briefly below.

3.3.2 Climate Topics

Paleoclimate Conditions

At present, reliable paleoclimate data to infer past precipitation depth or intensity since the last glacial period are not available. Proxies, such as tree ring analysis, could shed some light on precipitation, temperature and moisture over seasonal time scales, but these data would only extend back in time for approximately 500 years. Some studies have examined vegetation and pollen associated with mammoth remains in sediment bogs, which may reflect climate conditions at the end of the last glaciation. Sediment records of regional lakes might provide insight into past extremes in runoff and sedimentation. Unfortunately, none of these proxies provide a complete picture of paleoclimate conditions.

An alternative approach might be to use GCM hindcasts of precipitation and temperature. These GCM simulations, using climate forcings believed to exist in past periods, would provide simulations of past temperature and moisture conditions. This output could be downscaled to daily (or perhaps hourly) precipitation using the same methods discussed in Section 3.2.3. One possibility is to use simulations from the Paleoclimate Modeling Intercomparison Project (PMIP).[13] One PMIP experiment modeled climate conditions in the mid-Holocene, about 6,000 years ago, when evidence suggests that summers in the Northern Hemisphere were warmer than today. Analysis of these simulations for western New York could shed light on whether warmer summer conditions at that time were likely wetter or drier than today.

Precipitation Data Downscaling

Downscaling of daily precipitation to sub-hourly time intervals, while feasible, would require a validation analysis to demonstrate that sub-hourly estimates of daily accumulations are accurate. One approach that could be considered is an extension of methods used to downscale monthly GCM data to daily resolution. The idea is to randomly assign future daily rainfall values to days with similar daily rainfall in the historical period, and then use the hourly proportions of the daily rainfall on the historical day to downscale the projected future daily rainfall. Using this approach, future projected precipitation will have the same within-day

[13] http://pmip.lsce.ipsl.fr/

distribution as in the past, but would not account for potential future changes in storm (or inter-storm) duration.

Another approach might be to fit statistical distributions to the historical hourly rainfall proportions on days within pre-specified (e.g. <0.1, 0.1-0.5, 0.5-1.0, 1.0-2.0, >2.0 inches) daily precipitation ranges, and then use these distributions to stochastically downscale the daily amounts. The statistical distributions could be constructed for intensity, duration and inter-storm duration, and relationships among these variables. This approach would be similar to a conventional stochastic weather generator approach, as currently used in the CHILD model, but would be constrained to daily amounts. Although continuation of historical duration, intensity and inter-storm duration are assumed, sensitivity to different intensities or durations could be assessed.

Seasonal Climate Variations

Most climate stations report daily maximum and minimum temperature in addition to precipitation. Therefore, a set of stations that include temperature could be assembled for the WVDP area. The same statistical techniques for downscaling described for precipitation data may also be used for temperature.

Future Climate Scenarios

As in the past, climate conditions over the next 10,000 years will likely depend on atmospheric carbon dioxide concentrations. While there are no fundamental limitations on the maximum concentration, the Climate Scientists consider that a quadrupling of carbon dioxide is a feasible working upper limit on global equilibrium concentrations. Quadrupling of carbon dioxide is also the highest concentration typically used in climate model simulations for the near future.

Future carbon dioxide concentrations in the atmosphere will depend heavily on future anthropogenic greenhouse gas emissions, and societal structure and values. Recent experimental computer simulations have assessed potential climate change outcomes for the foreseeable future. These are summarized below.

- The fifth phase of the Coupled Model Intercomparison Project (CMIP5) computer model experiment where an instantaneous quadrupling of carbon dioxide concentrations were imposed over a 150-year time period.[14]
- The Representative Concentration Pathways (RCP8.5) computer model experiment to account for future climate outcomes to 2100 assuming increases in greenhouse gas emissions from high energy demand with no global climate change policies.[15]

Results of these simulations may provide additional insight into the range of possible climate conditions that may be used in the CHILD model over a 10,000 year time frame.

[14] http://cmip-pcmdi.llnl.gov/cmip5/
[15] http://sedac.ciesin.columbia.edu/ddc/ar5_scenario_process/RCPs.html

3.3.3 Long Term Uncertainty

Current state-of-the-art models that rely on climate change projections have inherent uncertainties, arising from a number of sources including limited scientific understanding of some climate processes, limited spatial resolution of climate data due to computational resource constraints, and the unknown future impact of human society and technology on climate. Climate models may reasonably provide plausible climate trends on the scale of decades to a couple of centuries. However, there are a few climate model simulations on the scale of multiple centuries, and those few should be viewed with caution.

There is no well-defined upper limit on how high greenhouse gas concentrations in the atmosphere could rise in the future. There is direct linkage between greenhouse gas concentrations and global temperature, atmospheric water vapor concentrations, and magnitude of extreme precipitation events. Although, as a first-order approximation, design storm values may increase by approximately 25 percent by 2100, this approximation certainly does not represent an upper limit beyond 2100.

4.0 FOUNDATION QUESTIONS

As stated previously, the objective of this guidance is to address the Foundation Questions. Below is guidance addressing these questions.

Foundation Question: What are the climate change issues that should be considered in WVDP Phase 1 Studies (i.e. soil erosion, engineered barriers, in-place closure)?

The Climate Scientists believe that the following issues should be considered in WVDP Phase I Studies, as appropriate.

- A Project Climate Database of historic precipitation and temperature may be complied for Phase 1 Studies. The Project Climate Database may be based on appropriate weather station data throughout the region where reliable precipitation records are available (see Section 3.1).
- A consistent scientifically-based approach to select precipitation depth for wet and dry years, and low and high precipitation intensity years for use in analytic and numeric models may be adopted (see Section 3.2.1).
- Site-specific precipitation distribution curves for design storms may be developed for the WNYNSC, and may be included in the Project Climate Database (see Section 3.2.2).
- "Downscaling" refers to the process of producing higher-resolution simulations of climate from low-resolution outputs of global circulation models (GCMs). Available downscaling projections through year 2100 may be included in the Project Climate Database, where future climate predictions up to 100 years are needed in Phase I Studies (see Section 3.2.3).
- Recent published climate model simulations that assess climate change over the next 100 to 150 years may provide additional insight into the range of possible climate conditions that may be used in the CHILD model over a 10,000 year time frame.

Foundation Question: How may climate change issues be evaluated during Phase 2 Decisionmaking for the decommissioning or long term stewardship for the WDVP?

Climate change issues may be assessed for the short-term (approximately 100 years) and long term (10,000 years). For decisionmaking regarding the decommissioning and long-term stewardship for the WVDP, the agencies may consider the following.

- Adopt state-of-the-art designs or processes to manage WVDP waste that have acceptable factors of safety so that designs and processes that account for foreseeable climate variations could be deemed reliable for approximately 100 years.
- Recognize that current state-of-the-art models that rely on climate change projections over the next 10,000 years have inherent uncertainties, arising from a number of sources including limited scientific understanding of some climate processes, limited spatial resolution of climate data due to computational resource constraints, and the unknown future impact of human society and technology on climate.

Climate models may reasonably provide plausible climate trends on the scale of decades to a couple of centuries. However, there are a few climate model simulations on the scale of multiple centuries, and those few should be viewed with caution. There is no well-defined upper limit on how high greenhouse gas concentrations in the atmosphere could rise in the future. There is direct linkage between greenhouse gas concentrations and global temperature, atmospheric water vapor concentrations, and magnitude of extreme precipitation events. Although, as a first-order approximation, design storm values may increase by approximately 25 percent by 2100, this approximation certainly does not represent an upper limit beyond 2100.

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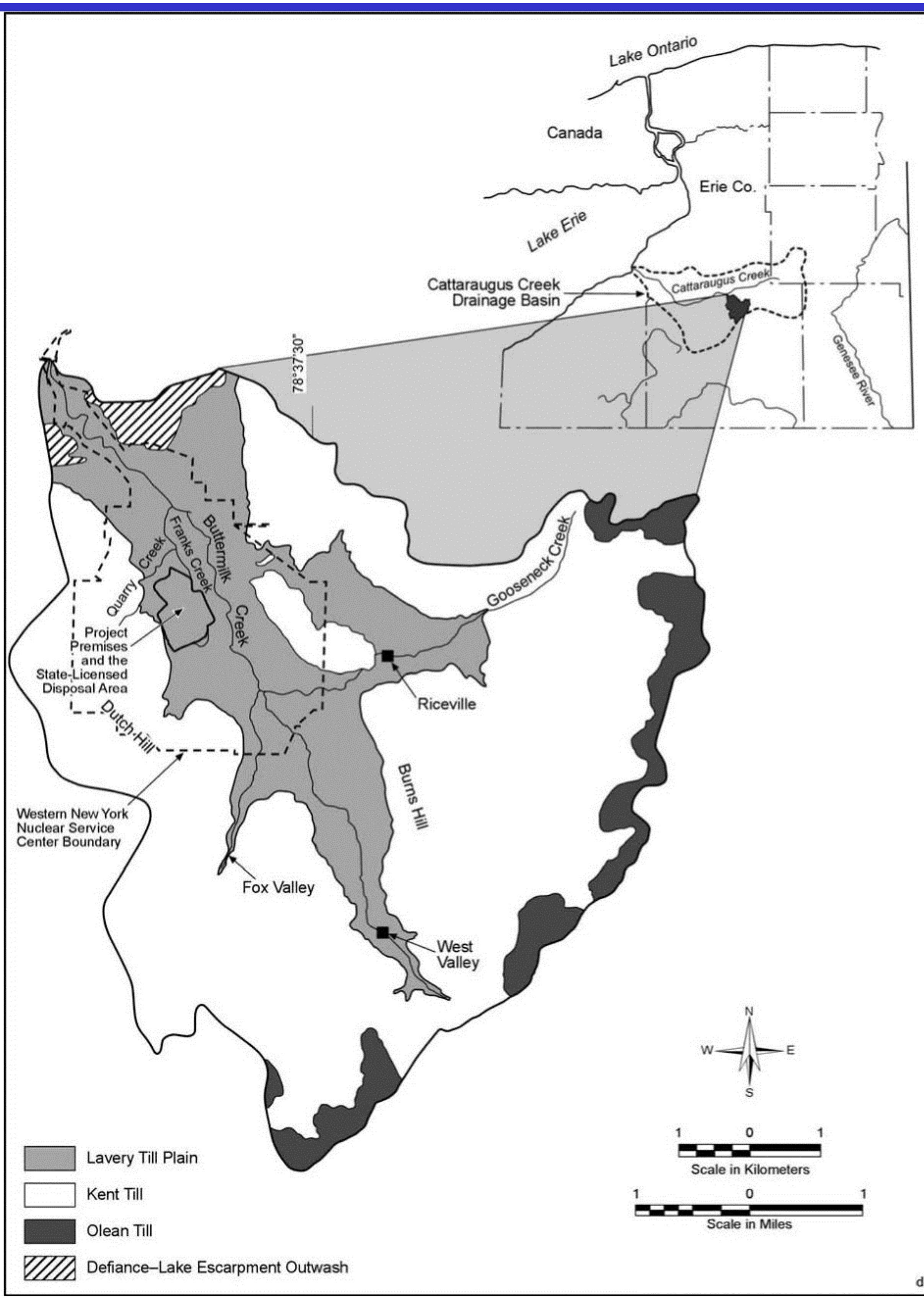
FIGURES



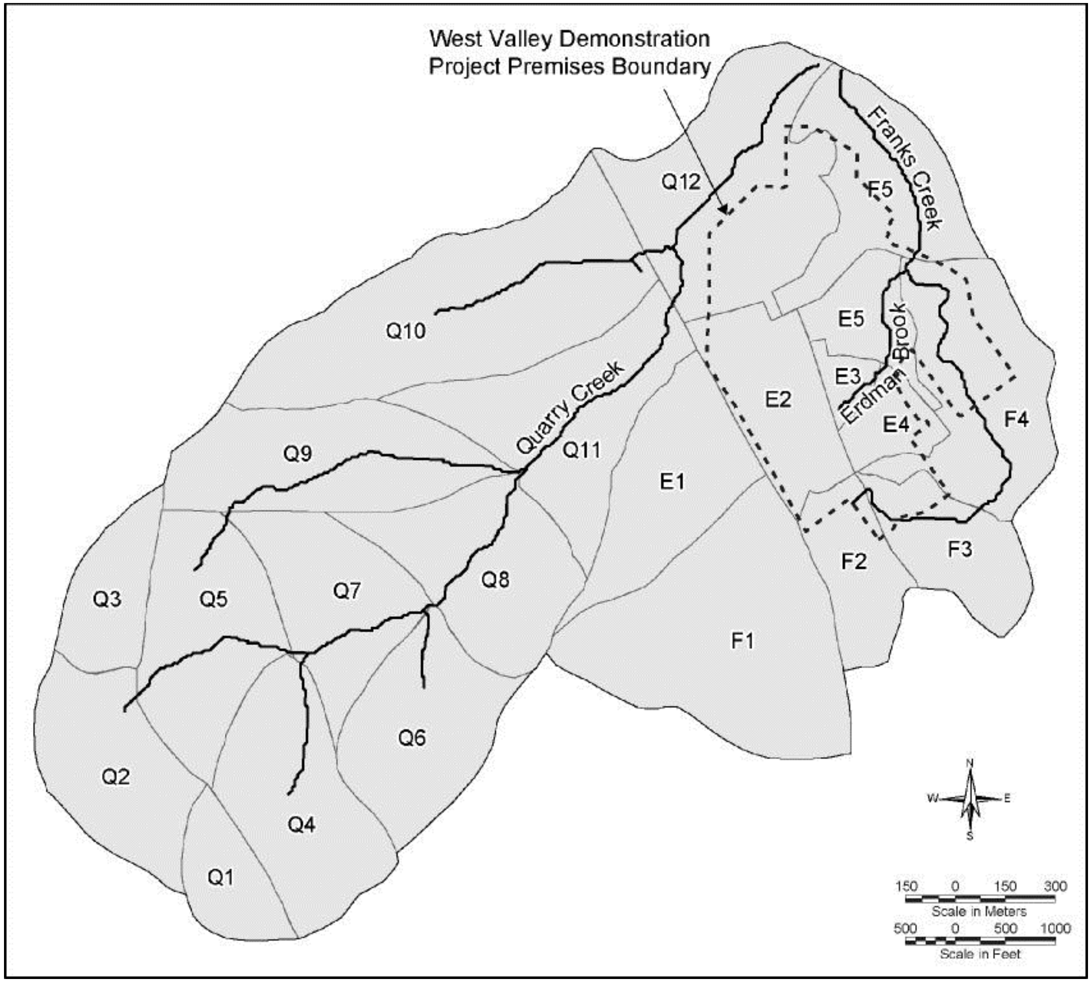
Taken from: FEIS, 2010, Final Environmental Impact Statement for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center: Co-lead agencies, U. S. Department of Energy and New York State Energy Research and Development Authority, West Valley, NY, January., Appendix F, p. F-4

ECS	Enviro-Compliance Solutions, Inc. 1571 Parkway Loop, Suite B Tustin, CA 92780	**BUTTERMILK CREEK WATERSHED** West Valley Demonstration Project West Valley, New York	**FIGURE 1**

Subwatershed	Area		
	Hect-ares*	Acres	Square miles
Quarry Creek			
Q1	10.26	25.35	0.040
Q2	20.63	50.98	0.080
Q3	10.30	25.45	0.040
Q4	26.24	64.84	0.101
Q5	23.01	56.86	0.089
Q6	20.63	50.98	0.080
Q7	17.82	44.03	0.069
Q8	24.30	60.05	0.094
Q9	32.65	80.68	0.126
Q10	45.79	113.15	0.177
Q11	26.35	65.11	0.102
Q12	34.49	85.22	0.133
Subtotal	292.47	722.693	1.131
Erdman Brook			
E1	21.24	52.48	0.082
E2	12.13	29.97	0.047
E3	2.99	7.39	0.012
E4	6.41	15.84	0.025
E5	9.32	23.03	0.036
Subtotal	52.09	128.714	0.202
Franks Creek			
F1	42.51	105.04	0.164
F2	12.24	30.25	0.047
F3	13.03	32.20	0.050
F4	27.58	68.15	0.106
F5	23.47	57.99	0.091
Subtotal	118.83	293.629	0.458^
GRAND TOTAL	**463.39**	**1145.04**	**1.791**

*Slightly different values are reported in FEIS 2010, Appendix F, p. 83

^ Reported as 0.28 square miles in FEIS 2010, Appendix F, p. 31



Q, F & E designations represent sub-watersheds for Quarry Creek, Franks Creek and Erdman Brook, respectively

Taken from: FEIS, 2010, Final Environmental Impact Statement for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center: Co-lead agencies, U. S. Department of Energy and New York State Energy Research and Development Authority, West Valley, NY, January., Appendix F, p. 81-82

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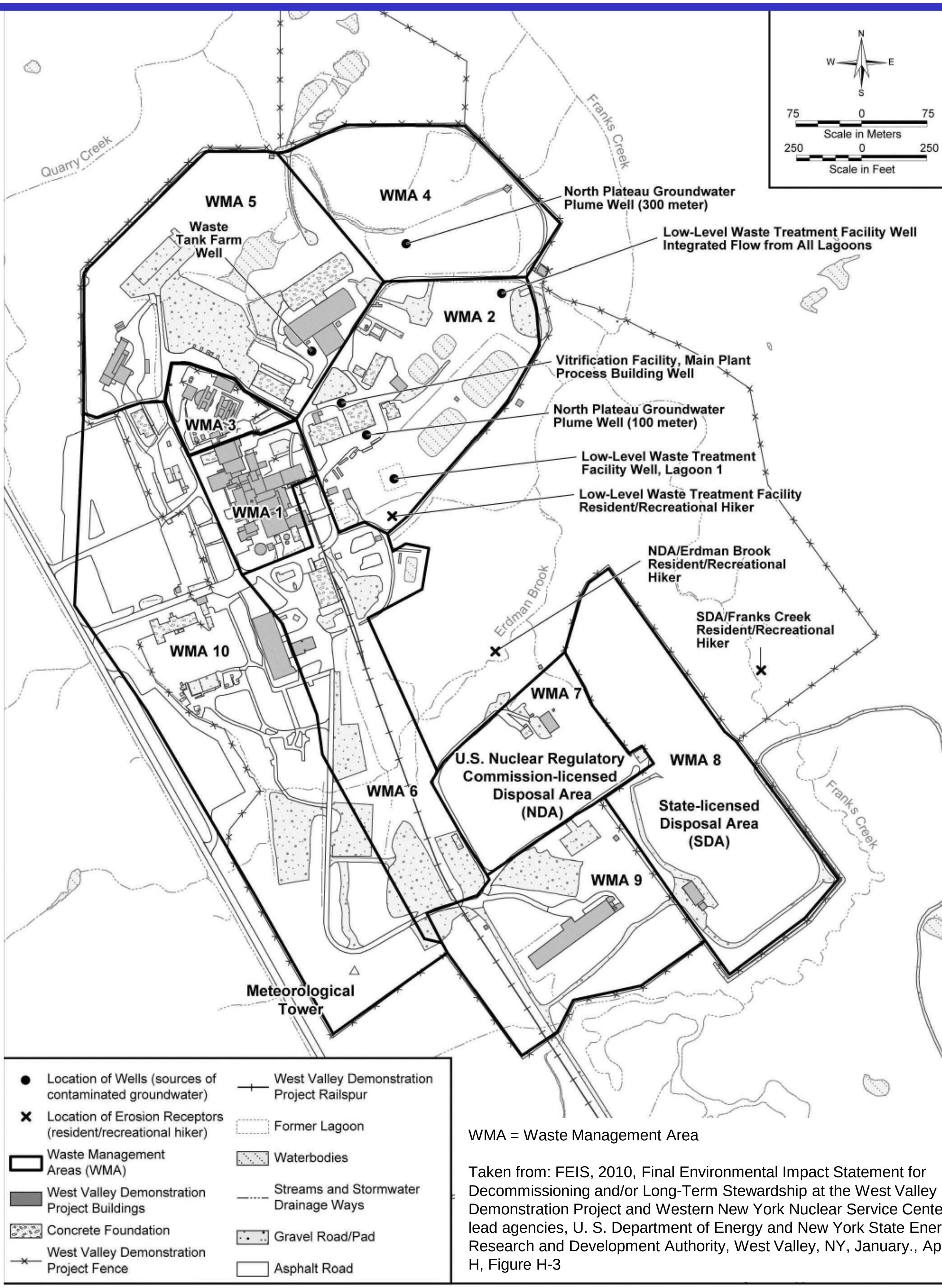
WVDP SUBWATERSHEDS

West Valley Demonstration Project
West Valley, New York

FIGURE 2



WMA = Waste Management Area

Taken from: FEIS, 2010, Final Environmental Impact Statement for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center: Co-lead agencies, U. S. Department of Energy and New York State Energy Research and Development Authority, West Valley, NY, January., Appendix H, Figure H-3

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Tustin, CA 92780

WVDP SITE PLAN

West Valley Demonstration Project
West Valley, New York

FIGURE 3

APPENDIX A

GUIDANCE FOR PHASE 1 STUDIES

Guidance for Identifying and Conducting Potential Phase 1 Studies on the Decommissioning and/or Long-Term Stewardship of the West Valley Demonstration Project and Western New York Nuclear Service Center

01/13/2011

Project Background

The New York State Energy Research and Development Authority (NYSERDA) and the U.S. Department of Energy (DOE) recently selected Phased Decisionmaking as the path forward for Decommissioning and/or Long-Term Stewardship of the West Valley Demonstration Project and Western New York Nuclear Service Center. Under the Phased Decisionmaking alternative, the work will be conducted in two phases. During Phase 1, which will take about 10 years, a number of highly contaminated facilities will be removed at a cost of approximately $1 billion. Also, during Phase 1, DOE and NYSERDA intend to conduct additional scientific studies in order to facilitate interagency consensus to complete decommissioning of the remaining facilities (hereafter "Phase 1 Studies"). According to DOE's Record of Decision (ROD), the Phase 1 Studies may address uncertainties associated with the long-term performance models, the viability and cost of exhuming buried waste and tanks, the availability of waste disposal sites, and technologies for in-place containment. NYSERDA's Findings Statement indicates that the studies should include, but not be limited to, analysis of soil erosion, groundwater flow and contaminant transport, engineered barriers, and uncertainty.

NYSERDA and DOE are committed to conducting Phase 1 Studies through a process that involves input from Subject Matter Experts (SME), an Independent Scientific Panel (ISP), the regulatory agencies and the public. The Phase 1 Study process is outlined in this document.

Guiding Principles

DOE and NYSERDA agree that the Phase 1 Study process will be conducted in accordance with the following guiding principles:

- The studies will be based on recognized scientific principles.

- The studies will be of sufficient scope to address the key issues, with consideration of recommendations by the SME and the ISP and input from the regulatory agencies and the public.

- The studies will be scoped such that study findings will be available within 8 years of the Phase 1 decisions.

Core Values of DOE/NYSERDA Team

- Team members will be treated with trust and respect regardless of affiliation or position
- Where differences of opinion exist, each agency will strive to understand the other person's or agency's position
- Each agency will respect the other agency's position
- Team members will engage in honest discourse
- Team members will strive to put sound science and the needs of the site ahead of the agencies' needs
- Team members will act with integrity and transparency

Expert Support and Facilitation

DOE and NYSERDA will solicit the opinions of SME specific to each PAS. The SME are technical experts in specific disciplines and will be tasked with evaluating the PAS and Phase 1 Studies. A three-member ISP will provide independent scientific guidance during the identification and scoping of scientific studies identified by the SME, and will review study plans and activities. The DOE/NYSERDA team will also secure professional facilitation services for the Phase 1 Study process.

Regulatory Input/Interaction

DOE and NYSERDA will hold routine meetings with the regulatory agencies to discuss the Phase 1 Study process, PAS, and individual scientific studies, their implementation, and results.

Public Input/Interaction

DOE and NYSERDA will hold regular meetings with the public (including the CTF, environmental groups, and other interested stakeholders) to discuss the Phase 1 Study process, PAS, and individual scientific studies, their implementation, and results.

Potential Areas of Study

The following list identifies PAS that have been compiled from various sources. The SME will consider this list and refine the list as needed in identifying Phase 1 Studies. The SME may recommend individual studies to address these PAS. The PAS and individual studies will be modified, as necessary, based on input by DOE and NYSERDA, SME, the ISP, the regulatory agencies, and the public.

- Soil erosion
- Groundwater flow and contaminant transport
- Catastrophic release of contamination and impact on Lake Erie
- Slope stability and slope failure
- Seismic hazard
- Probabilistic vs. deterministic dose and risk analysis
- Alternate approaches to, costs of, and risks associated with complete waste and tank exhumation
- Viability, cost, and benefit of partial exhumation of waste and removal of contamination
- Exhumation uncertainties and benefit of pilot exhumation activities
- In-place closure containment technologies
- Engineered barrier performance
- Additional characterization needs
- Cost discounting and cost benefit analyses over long time periods

Phase 1 Study Process

1. **Initial Meeting with Regulatory Agencies**
   DOE and NYSERDA held the initial meeting for the Phase 1 Study process with the regulatory agencies on June 15, 2010. Additional discussions will be held with the regulators on the process and on the PAS. DOE and NYSERDA will consider input from the regulatory agencies and will respond to comments.

2. **Initial Meeting with the Public**
   DOE and NYSERDA will hold a facilitated meeting with the public (including the Citizens Task Force (CTF), environmental groups, and general public) to present the Phase 1 Study process and the PAS. The public will be provided with an opportunity to ask questions and provide verbal and written comments on the material presented. DOE and NYSERDA will consider this input and respond to comments.

   DOE and NYSERDA discussed the Phase 1 Study process on June 23, 2010 during a Citizens Task Force (CTF) meeting. Two additional meetings with the public were held on August 3, 2010 (Quarterly Public Meeting) and August 25, 2010 (CTF).

3. **Evaluation of Potential Areas of Study**
   a. DOE and NYSERDA will assign SME for each PAS. A SME may be assigned to multiple PAS. DOE and NYSERDA will provide relevant background information on the PAS, including input received from stakeholders, to SME. DOE and NYSERDA communication, correspondence and direction to SME will be transparent between the agencies.

   b. The SME will evaluate their respective PAS and recommend to DOE and NYSERDA Phase 1 Studies.

   c. Guidance by Independent Scientific Panel: If differences of opinion prevent the SME from making a recommendation as described in item b., above, the SME may consult with the ISP in an attempt to resolve differences.

      i. **Option to Proceed in the Event of Continued Disagreement**
         If consultation with the ISP does not resolve outstanding differences, the SME will inform DOE and NYSERDA of the disagreement. DOE and NYSERDA may (1) decide to jointly conduct the disputed study, (2) decide not to conduct the disputed study, or (3) conduct the disputed study unilaterally, at the cost of the agency deciding to conduct the study unilaterally.

   d. When the SME make a recommendation(s) to: (a) conduct no additional scientific study of a PAS (including rationale) OR (b) conduct additional studies (including rationale and suggestions regarding priority), the recommendation(s) will be presented to DOE and NYSERDA.

      Following the SME presentation of their recommendation(s) to DOE and NYSERDA, the regulatory agencies will be briefed and the public will be briefed at a Public Meeting. During this facilitated meeting, the SME, ISP, DOE, and/or NYSERDA will be available to respond to questions and comments. Written comments may be presented to the DOE and NYSERDA, and DOE and NYSERDA will respond to these comments.

4. **Decisions on Phase 1 Study Activities**
DOE and NYSERDA, having considered the SME recommendations and input from the ISP, regulatory agencies and the public, will decide whether to proceed with the recommended studies.

a. Guidance by Independent Scientific Panel
DOE and NYSERDA may consult with the ISP at any time during this process. The ISP will review PAS, study plans, and study implementation.

5. **Implementation of Phase 1 Studies**
If the recommended studies are approved by DOE and NYSERDA, the SME will develop study plans by which to implement them. Studies will be conducted by or under the supervision of respective SME who will evaluate study findings, make necessary adjustments to study plans, and provide DOE and NYSERDA with an interpretation of study results.

6. **Routine Meetings with Regulatory Agencies**
DOE and NYSERDA will provide briefings to the regulatory agencies during the Regulatory Roundtable meetings held on a semi-annual basis at the site. DOE and NYSERDA will provide updates on the progress of Phase 1 Study process, including study results, reports, and interpretations, and the recommendations of the SME and ISP. DOE and NYSERDA will attempt to have SME and ISP members available at the meetings, either in person or on the telephone. The regulatory agencies will have the opportunity to ask questions of DOE and NYSERDA and to provide comments. In addition to these meetings, the regulatory agencies will have the opportunity to review study plans, progress reports, validated data, and results in order to provide technical comments. DOE and NYSERDA will consider this input and will make this available to the SME and ISP as they evaluate a particular PAS. DOE and NYSERDA will respond to regulator comments.

7. **Routine Meetings with Public**
DOE and NYSERDA will meet with the public throughout the Phase 1 Study process. DOE and NYSERDA will provide updates on the progress of the Phase 1 Study process, including study results, reports, and interpretations and the recommendations of the SME and ISP. DOE and NYSERDA will attempt to have SME and ISP members available at the meetings, either in person or on the telephone. The public will have the opportunity to ask questions of DOE and NYSERDA and provide comments. DOE and NYSERDA will consider this input and will make this available to the SME and ISP as they evaluate a particular PAS. DOE and NYSERDA will respond to comments.

8. **Independent, Agency-Neutral Contractor**
An independent, agency-neutral contractor that is jointly funded by DOE and NYSERDA shall administer contracts for all Phase 1 Study activities, including contracting with the facilitator, SME, ISP, and contractors performing study activities.

APPENDIX B

SCOPE FOR
WORKSHOP ON CLIMATE CHANGE

Scope for

Workshop on Climate Change and Phase 1 Studies at the West Valley Demonstration Project and Western New York Nuclear Service Center

Background

The New York State Energy Research and Development Authority (NYSERDA) and the U.S. Department of Energy (DOE) recently selected Phased Decisionmaking as the path forward for Decommissioning and/or Long-Term Stewardship of the West Valley Demonstration Project and the Western New York Nuclear Service Center (WNYNSC). During Phase One of the Phased Decisionmaking Alternative, which will take about 10 years, NYSERDA and DOE (the agencies) plan to conduct scientific studies to facilitate interagency consensus to complete decommissioning of the facilities remaining at the WNYNSC after the completion of Phase 1 decommissioning. The agencies have agreed on a facilitated process for identifying, designing, and implementing potential Phase 1 Studies that involves input from Subject Matter Experts (SME), a four-member Independent Scientific Panel (ISP), regulatory agencies, and the public.

NYSERDA and DOE have identified a number of Potential Areas of Study (PAS) that will be considered by SME for further evaluation through specific studies. These include, but are not limited to:

- Soil erosion*.
- Groundwater flow and contaminant transport*.
- Catastrophic release of contamination and impact on Lake Erie*.
- Slope stability and slope failure*.
- Seismic hazard.
- Probabilistic vs. deterministic dose and risk analysis*.
- Alternate approaches to, costs of, and risks associated with complete waste and tank exhumation.
- Viability, cost, and benefit of partial exhumation of waste and removal of contamination.
- Exhumation uncertainties and benefit of pilot exhumation activities.
- In-place closure containment technologies*.
- Engineered barrier performance*.
- Additional characterization needs.
- Cost discounting and cost benefit analyses over long time periods.

*** indicates primary area of focus**

Climate change in both the near- and long-term may have significant impacts on the PAS listed above. DOE and NYSERDA have agreed to hold a public workshop on climate change in which scientific experts will share their ideas on climate change topics as they relate to the decommissioning and/or long-term stewardship of the West Valley Demonstration Project and the Western New York Nuclear Service Center.

Foundation Questions

The foundation questions are intended to convey the overall problem to be addressed by the workshop:

- What are the potential impacts of climate change on the Phase 1 PAS?
- How may these impacts be evaluated in order to help the agencies reach consensus on Phase 2 decisions?"

Objectives

The objectives of this workshop are to:

- Allow the agencies and stakeholders to exchange information with climate change experts.
- Explore a range of expert perspectives on climate change including paleoclimatology, as it may relate to the future of the West Valley site.
- Engage with stakeholders as to their concerns regarding climate change, as well as their expectations of how these concerns can be addressed by Phase 1 Studies.
- Identify climate change-related issues for further consideration by Subject Matter Experts as they evaluate the PAS.
- Identify strategies for implementation of climate change analyses in the Phase 1 Studies.
- Improve the agencies' and stakeholders' overall knowledge of the current scientific understanding of climate change issues.
- Identify and help understand how climate change science may be applied to the Phase 1 PAS and Phase 2 decisions.

Scope and Deliverables

Enviro Compliance Solutions, Inc. (ECS) will invite climate change experts to participate in the workshop, and will provide the experts with relevant background information on the West Valley site and the Phase 1 Studies process. At a minimum, each expert will be provided with:

- Forward (NYSERDA's View) of the Final Environmental Impact Statement (FEIS) and DOE’s responses.
- FEIS Executive Summary.
- FEIS Appendix D - Overview of Performance Assessment Approach.
- FEIS Appendix E - Geohydrological Analysis.
- FEIS Appendix F - Erosion Studies.
- DOE's Record of Decision.
- NYSERDA's Findings Statement
- Phase 1 Studies Guidance.

Each expert will be asked to prepare a presentation (~20min) for the workshop with a focus on their specialty expertise on climate change, and their thoughts and perspectives on climate change as it may relate to the decommissioning and/or long-term stewardship of the West Valley Demonstration Project and the WNYNSC. The experts will travel to West Valley for a one-day workshop where they will give their presentation. Experts will also participate as members of a panel in a moderated question and answer session with agencies and stakeholders.

Following the workshop in coordination with ECS, each expert will be asked to provide ECS with a short written summary of their presentation. In an effort to facilitate interagency consensus, the expert panelists will be asked to collaborate with ECS as a group to deliver the group's thoughts, observations, and recommendations to the agencies with regard to addressing the topic of climate change through the Phase 1 Studies.

APPENDIX C

SUMMARY OF
2010 FEIS CLIMATE DATA

2010 FEIS CLIMATE DATA

Climate Data

Based on review of the 2010 Final Environmental Impact Statement (FEIS 2010), climate data were primarily assembled for the assessment of erosion within the Buttermilk Creek watershed and the WVDP subwatershed (FEIS 2010, Appendix F). Although groundwater modeling described in the FEIS assigned precipitation infiltration rates for different areas, these infiltration rates were derived from published values for various lithologic units, but not explicitly derived from climate or rainfall data (FEIS 2010, Appendix E, p. E-41)[1]. For this reason, review of climate data in this guidance focused on climate data reported for the erosion assessment (FEIS 2010, Appendix F).

Various analytic and numeric models were used in the FEIS to predict erosion over the short term (tens to hundreds of years) and landform evolution over the long term (ten thousand years) within the Buttermilk Creek watershed and WVDP subwatershed. These models are summarized below.

Erosion Short Term Analysis

Models

In the 2010 FEIS, four methods were selected to predict sheet and rill erosion rates at WNYNSC (FEIS, 2010, Appendix F, p. F-80) for tens to hundreds of years (FEIS, 2010, Appendix F, p. F-18). Analytic and numeric models used are listed below.

- The Universal Soil Loss Equation (USLE) was used to predict the average annual soil loss from individual subwatersheds. Precipitation data were obtained for the WVDP meteorological tower for the one-year period from March 1, 1990 through February 28, 1991 (FEIS 2010, Appendix F, p. F 80-81).
- The Sedimentology by Distributed Model Treatment (SEDIMOT II) surface erosion model (WVNS 1993) was used to simulate rainfall intensity and depth over a given time period to predict surface-water runoff volume, and soil volume washed from the ground surface. The model simulated 500 2-year storms, 100 10-year storms, 10 100-year storms, and one probable maximum precipitation (PMP) event over a 1,000 year time period (FEIS, 2010, Appendix F, p. F 82-84).
- The Chemicals, Runoff, and Erosion from Agricultural Management Systems (CREAMS) model was used to predict the average annual sediment yield from a small area (two-hectare, five acre) over a one-year period. The simulations used daily rainfall data from a single year as recorded at the WNYNSC weather station in 1984 (FEIS 2010, Appendix F, p. F-84). An annual precipitation of 113.8 cm (44.8 in) was selected from the 1984 data (FEIS 2010, Appendix F, Table F-15, p. F-86).
- The Water Erosion Prediction Project (WEPP) model was used to predict the sediment

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[1] Effective infiltration capacity (Ic), which includes aquifer recharge and evapotranspiration, and may contribute to baseflow in streams, was computed from precipitation data as part of the erosion studies reported in the FEIS (2010, Appendix F, p. F-29).

yield from hillslopes within the Franks Creek subwatershed (FEIS, 2010, Appendix F, p. 84). The model used 24-hour design storms with return intervals of 1, 2, 5, 10, 50 and 100 years to determine single-storm event sediment yields. The WEEP climate simulator was used to stochastically project daily climatic conditions over a 100-year period based on records from the Little Valley, New York weather station (USDA 1995)(FEIS 2010, appendix F, p. F-86).

These models were used to estimate erosion rates on an average annual or storm-by-storm basis (FEIS, 2010, Appendix F, p. F-19).

Storm Events

For the short-term analyses, various storm events were used depending on the model selected (SEDIMOT II or WEPP) (FEIS 2010, Appendix F, p. F-83). These storm events are listed below.

Storms for Short Term Analyses

STORM EVENTS USED IN 2010 FEIS

Storm	Duration	Rainfall Depth		Source*
		cm	in	page F-86
1-yr	24-hour	5.3	2.1	page F-83, 86
2-yr	24-hour	6.35	2.5	page F-86
5-yr	24-hour	8.1	3.2	page F-83, 86
10-yr	24-hour	9.4	3.7	page F-86
25-yr	24-hour	11.2	4.4	page F-86
50-yr	24-hour	11.9	4.7	page F-83, 86
100-yr	24-hour	13.2	5.2	page F-83
PMP	-	63.2	24.9	page F-86

*Page number in FEIS 2010, Appendix F

Rainfall for each storm event was taken from standardized maps developed by the Soil Conservation Service (USDA 1986) using a Type II Soil Conservation Service storm.

Erosion Long Term Analysis

Model

The Channel-Hillslope Integrated Landscape Development (CHILD) model was used in the FEIS to simulate landform evolution due to erosion over a 10,000 year time period. The CHILD model was calibrated using a Monte Carlo approach that tested the ability of the model to reproduce the modern landscape, starting from a reconstruction of the post-glacial ancient landscape (FEIS 2010, Appendix F, p. F-22). Climate conditions were held essentially constant during the calibration period (FEIS, 2010, Appendix F, p. F-23). The model used an irregular gridding method in order to represent different parts of the landscape at different spatial resolutions. Instead of using a single effective rainfall or runoff rate that represents a geomorphic average, CHILD provides the option of stochastic rainfall input.

CHILD used a stochastic representation of rainfall and runoff in which a sequence of storm and inter-storm events was drawn at random from exponential frequency distributions (Eagleson 1978, Tucker and Bras 2000). For the FEIS, the mean rainfall intensity parameter (P) was derived from 9.8 years of five-minute resolution precipitation data collected at the WNYNSC weather station. Individual storms were identified using an approach (Eagleson 1978) in which a storm is defined as any period of precipitation that is both preceded and followed by a two-hour or longer dry period. Rainfall depth and duration were computed for each storm, and mean values for depth and duration were computed for the entire length of record (up to 9.8 years).

Climate Input Data

The following climate input parameters for the CHILD model were computed from the 9.8 years of five-minute resolution precipitation data collected at the WNYNSC weather station (FEIS 2010, Appendix F, p. F-24 & 29).

Parameter	**Value**
Mean Annual Precipitation (Pa)	1.02 meters (3.35 feet)
Average Storm Duration	2.57 hours
Mean depth (of rainfall)	3.73 mm (0.15 inches)
Mean (average) Storm (precipitation, rainfall) Intensity (P)	1.45 mm (0.06 inches)/hour[2]
Precipitation-duration parameter (Fp)[3]	0.08 (8% of time during any given year)

According to the analysis provided in the FEIS, the CHILD model was relatively insensitive to global time step (Tg) as long as the value was sufficiently small. To determine a reasonable value for Tg, a series of 1,000-year sensitivity tests were conducted using the modern topography of Buttermilk Creek as an initial condition. Results showed that values of Tg of approximately one year or smaller produced very similar results[4]. A Tg value of 0.1 years was selected for calibration and other computer simulations (FEIS 2010, Appendix F, p. F-29).

Wetter Conditions

In order to assess the potential for accelerated erosion due to future wetter climate conditions, a "Wet" scenario was developed for the FEIS. The Wet scenario was designed to represent conditions in which mean precipitation intensity was twice the modern value estimated from 9.8 years of five-minute resolution precipitation data (i.e. 2.9 mm [0.11 in] per hour). Using this paradigm, precipitation frequency would remain the same, but rainfall intensity would double (FEIS, 2010, Appendix F, p. F-47).

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[2] According to the FEIS, this value falls within the range of monthly values obtained by Hawk and Eagleson (1992) (0.43 to 2.1 millimeters [0.02 to 0.08 inches] per hour) from hourly precipitation data at the Buffalo-Niagara International Airport, New York.

[3] According to the FEIS, precipitation-duration parameter (Fp) can be derived from mean annual precipitation (Pa) from the relation Fp = Pa/P.

[4] Based on average root-mean-square differences in model-cell height of less than 30 centimeters [11.81 inches] after 1,000 years of erosion.

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GLOSSARY

WVDP ACRONYMS AND ABBREVIATIONS

ACRONYMS and ABBREVIATIONS

A&PC	Analytical and process chemistry
ALARA	as low as is reasonably achievable
BCCA	Bias-Correction Constructed Analogs
BCG	Biota Concentration Guide
BP	Before present
CAM	Central-age model
CDDL	Construction and Demolition Debris Landfill
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CHILD	Channel-Hillslope Integrated Landscape Development
CFR	*Code of Federal Regulations*
CMS	Corrective Measures Study
dBA	decibels A-weighted
DCGL	Derived Concentration Guideline Limits
DEM	Digital Elevation Model
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EA	Environmental Assessment
ECL	Environmental Conservation Law
ECS	Enviro Compliance Solutions
EDE	effective dose equivalent
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
EPRI/SOG	Electric Power Research Institute/Seismic Owners Group
EWG	Erosion Work Group
FEIS	Final Environmental Impact Statement
FHWA	Federal Highway Administration
FONSI	Finding of No Significant Impact
FR	*Federal Register*
FTE	full-time equivalent
GCM	Global Circulation Model
GHG	Greenhouse Gas
GTCC	Greater-Than-Class C waste
HDPE	high density polyethylene
HEPA	high-efficiency particulate air
HIC	high-integrity container
HLW	High Level Radioactive Waste
HLWISF	High Level Radioactive Waste Interim Storage Facility
LCF	latent cancer fatality
LEM	Landscape evolution modeling
LiDAR	Light detection and ranging
LLW	low-level radioactive waste
LSA	Lag Storage Area
LWTS	Liquid Waste Treatment System
m	meter(s)

M&M	monitoring and maintenance
MAM	Minimum-age model
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MCL	maximum contaminant level
MEI	maximally exposed individual
MLLW	mixed low-level radioactive waste
MMI	Modified Mercalli Intensity
NAAQS	National Ambient Air Quality Standards
NDA	NRC-licensed Disposal Area
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutant
NFA	no further action required
NFS	Nuclear Fuel Services, Inc.
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission
NRCS	National Resource Conservation Service
NTS	Nevada Test Site
NYCRR	New York Code of Rules and Regulations
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
NYSDOL	New York State Department of Labor
NYSERDA	New York State Energy Research and Development Authority
OSL	Optical Stimulated Luminescence
PCB	polychlorinated biphenyl
PGA	peak horizontal ground acceleration
PM	particulate matter
PMF	probable maximum flood
PSD	Prevention of Significant Deterioration
RCRA	Resource Conservation and Recovery Act
rem	roentgen equivalent man
RFI	RCRA Facility Investigation
RH	remote-handled
ROD	Record of Decision
ROI	Region of Influence
SDA	State-Licensed Disposal Area
SEQR	State Environmental Quality Review Act
SME	Subject matter expert
SOW	Statement of Work
SPDES	State Pollutant Discharge Elimination System
STS	Supernatant Treatment System
SWMU	Solid Waste Management Unit
TAGM	Technical Assistance and Guidance Memorandum
TEDE	total effective dose equivalent
TRU	transuranic
TSCA	Toxic Substances Control Act
U-Pb	Uranium-lead

U.S.C.	United States Code
USGS	United States Geological Survey
USLE	Universal Soil Loss Equation
VRM	Visual Resource Management
WEPP	Water Erosion Prediction Project
WIPP	Waste Isolation Pilot Plant
WMA	Waste Management Area
WNYNSC	Western New York Nuclear Service Center
WVDP	West Valley Demonstration Project
WVNSCO	West Valley Nuclear Services Company, Inc.
°C	degrees Centigrade
°F	degrees Fahrenheit