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Re: Comments on scope and content of the Supplemental 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-S1)

Dear Mr. Krentz:

Thank you for the opportunity to provide comments on the Supplemental Environmental Impact Statement (SEIS) process. My detailed comments, including many comments submitted by the West Valley Citizen Task Force (CTF) and numerous additional comments, are listed below:

I. Alternatives to be considered, selection of Preferred Alternative, and involvement of other agencies

1. DOE and NYSERDA are planning "to identify a preferred alternative in the Draft SEIS."[1] The Preferred Alternative should comply with the Policies and Priorities of the West Valley Citizen Task Force (CTF) of which I am a member. Specifically, *the sitewide removal alternative should be selected as the Preferred Alternative*. This alternative would allow unrestricted release and would comply with our Policies and Priorities.

There has been no convincing evidence that the CTF Policies and Priorities could be met by hybrid alternatives that leave some waste onsite. As discussed below, hybrid alternatives appear to be interim measures that would not meet the CTF Policies and Priorities for final site closure.

The CTF has stated that the site does not provide a stable platform for the long term storage of radioactive waste. The Sitewide Close in Place alternative is therefore somewhat misleading. Given the factors such as extreme weather, erosion, earthquakes, etc., that contribute to site instability, there is no long term guarantee that the waste materials will *stay in place* for the duration of the hazard from long-lived radionuclides. Site-instability concerns include the potential for uncontrolled release of radionuclides resulting from soil erosion or bedrock movement. Site instability may also make future management, monitoring, and/or retrieval of radioactive wastes left on site impractical or impossible.

[1] 83 *Federal Register* 7464 (Feb. 21, 2018) at 7467, column 3.

2. Both the Town of Ashford and the Seneca Nation of Indians should participate in the SEIS as cooperating or involved agencies based on their special expertise in identifying and interpreting socioeconomic, cultural, and land-use impacts in relation to radiological impacts.

II. Issues and impacts that need to be considered if wastes are left onsite, and if site closure and license termination involve Restricted Release

3. Unrestricted release is preferred because it provides greater potential for site re-use and economic development, which in turn may serve as an economic "engine" for the local community and region.

4. Unrestricted release is preferred because it would facilitate reuse of site infrastructure improvements. Such improvements have been substantial during the course of the project and are unique for the local area.

5. Hybrid alternatives that use partial exhumation will target longer-lived radionuclides for removal and allow much of the shorter-lived cesium-137 (Cs-137) and strontium-90 (Sr-90) to decay in place to essentially undetectable levels during the next 300 years or so.[2] For alternatives other than unrestricted release, DOE and NYSERDA are required to assume of loss of institutional controls at some point in the future. Depending on the alternative, passive and active controls may be included, and options such as re-routing of streams may be considered. In looking at hybrid alternatives and their impacts and costs, Probabilistic Performance Assessment (PPA) contractor Neptune will break down source areas into units such that a cost benefit analysis can be performed that includes selective removal or delayed removal. A hypothetical situation is a cost comparison of full removal with selective removal addressing various cost increments and improvement in performance. Convincing evidence would be needed to show that the risk is acceptable and that the CTF Policies and Priorities could be met.

6. Erosion modeling (landscape evolution modeling) of the Buttermilk Creek watershed will be needed if any of the alternatives will depend on re-routing of streams. Current modeling of the Franks Creek watershed cannot support re-routing of streams into Buttermilk Creek. For example, if the headwaters of Franks Creek or Erdman Brook were re-routed away from the burial grounds and diverted into Buttermilk Creek at a point upstream from the Buttermilk-Heinz confluence, this would increase the flow rate of Buttermilk Creek past the area of active landsliding on the west bank of Buttermilk Creek, thereby accelerating the migration of the area of active landsliding toward the burial grounds. Erosion modeling (landscape evolution modeling) of Buttermilk Creek would be needed to assess how such a change in the stream networks would modify the evolution of the valley walls of Buttermilk Creek.

7. For any alternatives that involve future costs, a discount rate of *zero* should be assumed (in other words, future costs should *not* be discounted) unless a higher rate can be justified.[3] Such

[2] Radionuclides generally decay to negligible levels of radioactivity after 10 half-lives. The half-lives of Sr-90 and Cs-137 are both about 30 years, so the time required for these radionuclides to decay to negligible levels is about 300 years.

[3] For example, see A. Napoleon et al., *The Real Costs of Cleaning Up Nuclear Waste: A Full Cost Accounting of Cleanup Options for the West Valley Nuclear Waste Site* (Cambridge, MA: Synapse, 2008),

justification might be based, for example, on past and present estimates of clean-up costs for the West Valley site. If historical estimates of site clean-up costs have grown more slowly than the rate of inflation, then a discount rate higher than zero may be justified. If not, a discount rate higher than zero would not appear to be justified.

8. For various alternatives, impacts associated with future loss of funding should be addressed.

9. While the casks of high-level vitrified waste are expected to be removed to a federal repository in accordance with the West Valley Demonstration Project Act, it is possible but unlikely that no repository will be opened and that the high-level waste will remain onsite indefinitely. The ongoing presence of this waste, coupled with a presumption of eventual loss of institutional control, needs to be factored into the risks and impacts that will guide the Phase 2 decision. The ongoing presence of the high-level waste, while not a matter to be decided by the Phase 2 decision, would have impacts that are additive to the impacts currently being analyzed for the Phase 2 decision. As such, the ongoing presence of the high-level waste is a low-probability, high-consequences phenomenon whose combined impacts need to be addressed in accordance with environmental review requirements such as 6 NYCRR 617.9(b)(6)(iii).

III. Potentially significant adverse impacts to Community Character from waste left onsite

10. Radiological impacts currently recognized by DOE and NYSERDA include impacts to the general population and onsite workers,[4] with population impacts generally being rated against NRC's 25 millirem-per-year exposure standard for unrestricted release of the site. However, for any alternatives in which wastes are left in place, there may be significant adverse impacts to "Community Character" resulting from *radiological releases that substantially exceed background levels but do not exceed NRC's 25 millirem-per-year exposure standard for a maximally exposed individual*. Examples of such impacts are provided below. Note that effects on Community Character are a specific type of impact that must be considered under New York's State Environmental Quality Review (SEQR) requirements.[5] Such impacts would not apply to the No-Action alternative but would apply to the "actions" of any of the other alternatives.

11. For any alternative that leaves waste onsite, the Draft SEIS should address the adverse impacts on the community character of Ashford, including such impacts on the town's residents and its prospects for economic development, resulting from the stigma of radioactive waste.

12. For any alternative that leaves waste onsite, the Draft SEIS should address the adverse impacts on the community character of Concord, including such impacts on the town's residents and its prospects for economic development, resulting from the stigma of radioactive waste.

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available at http://westvalleyctf.org/DEIS-DP_Docs/Full_Cost_Study/WV_Full_Cost_Accounting_Report.pdf , pp. 9-10 and 81ff.

[4] 83 *Federal Register* 7464 (Feb. 21, 2018) at 7468, column 1.

[5] See NYSDEC, *The SEQR Handbook*, 3rd ed. (2010), pp. 87-89 and 204-05; also *Matter of Village of Chestnut Ridge et al. v. Town of Ramapo et al.*, 45 AD3d 74 (2d Dept. 2007) at 85-87 and 94-95.

13. For any alternative that leaves waste onsite, the Draft SEIS should address the adverse impacts on the community character of the Seneca Nation of Indians, including such impacts on the Nation's residents, traditional cultural practices, and prospects for economic development, resulting from any detectable above-background level of radioactive contamination moving along Cattaraugus Creek through the Nation's Cattaraugus Territory.

14. For any alternative that leaves waste onsite, the Draft SEIS should address the adverse impacts on the community character of Cattaraugus County, including such impacts on the county's residents, their enjoyment of Zoar Valley, Cattaraugus Creek, and prospects for tourism and economic development, resulting from any detectable above-background level of radioactive contamination moving along Cattaraugus and Buttermilk Creeks. The Draft SEIS should also consider impacts on the county's residents and its prospects for economic development, resulting from the stigma of radioactive waste.

15. For any alternative that leaves waste onsite, the Draft SEIS should address the adverse impacts on the community character of Erie County, including such impacts on the county's residents, their enjoyment of Zoar Valley and the lakeshore waterfront, and prospects for tourism and economic development, resulting from any detectable above-background level of radioactive contamination moving along Cattaraugus Creek from Springville to Irving, along the Lake Erie shoreline from Irving to Buffalo, and along the Niagara River shoreline from Buffalo to Tonawanda.

16. For any alternative that leaves waste onsite, the Draft SEIS should address the adverse impacts on the community character of the City of Buffalo, including such impacts on the city's residents, their enjoyment of the waterfront, and prospects for tourism and economic development, resulting from any detectable above-background level of radioactive contamination moving past and through the city's waterfront.

17. For any alternative that leaves waste onsite, the Draft SEIS should address the adverse impacts on the community character of other downstream communities in the U.S. and Canada, resulting from any detectable above-background level of radioactive contamination moving through their waterways or along their shorelines.

18. For any adverse impacts from wastes left onsite, the CTF and affected populations should be afforded the opportunity to determine the accuracy of the impact assessments.

19. The Draft SEIS should include support for assessments of the surrounding communities that focus on psychological/cultural/physical/spiritual impacts of living near the site. Such assessments should be facilitated through the CTF in collaboration with Roswell Park Comprehensive Cancer Center, the SUNY University at Buffalo School of Public Health, and the Seneca Nation of Indians. The schedule for these assessments should be outlined in advance and performed at a minimum of every 10 years. Outcomes should include action-orientated recommendations.[6]

[6] J. Johnson, J. Baldwin, R.C. Haring, S.A. Wiechelt, S. Roth, J. Gryczynski, and H. Lozano, "Essential information for disaster management and trauma specialists working with American Indians," Chapter 4

20. As stated in the CTF's 1998 Final Report, the Site Managers should recommend policies that will affect, ameliorate, or replace the losses to the community from the redirection in economic activity at the site, i.e., at the Western New York Nuclear Service Center. Procedures for instituting and implementing such policies should be explored and developed as part of the SEIS process.

IV. Other potentially significant adverse impacts from waste left onsite

21. Any alternative that leaves waste onsite may have other "non-tangible" impacts in addition to Community Character impacts. Any such "non-tangible" impacts to nearby communities and natural resources (including the Great Lakes, for example) should be identified and vetted as scoping issues for any site closure alternative other than full exhumation.

22. For any alternative that leaves or stores waste on any bedrock portion of the site which serves as a recharge area for the underlying bedrock-valley aquifer(s), (e.g., west of Rock Springs Road and some portions of the site east of Buttermilk Creek), the SEIS process would need to include studies to characterize the underlying bedrock-valley aquifer(s), and the Draft SEIS would need to assess impacts to such aquifer(s).[7] Current characterization of this/these aquifer(s) is too sparse to support waste storage or disposal within bedrock portions of the site that serve as recharge areas.

23. For any alternative that leaves waste onsite, the Draft SEIS should generate a detailed and comprehensive future plan for the detection of above-background levels of radioactive contamination that may be released and carried downwind and/or downstream. Current background and current standards should remain available as points of reference, and standards should be expressed not only in units of dose (such as millirems per year) but also in units of risk (such as cancer risk per million, which can be compared to policy goals such as a 1-in-one-million risk limit).

24. For any alternative that leaves wastes onsite, the scope of the SEIS should include items such as education, equipment, training, emergency response planning, redundant backup responses, medical preparedness, long-term health follow-up, environmental cleanup, and associated

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in A. Marsella, J. Johnson, P. Watson, and J. Gryczynski, eds., *Ethnocultural Perspectives on Disaster and Trauma: Foundations, Issues, and Applications* (New York: Springer SBM Publishing, 2008).

[7] See R.C. Vaughan, "Geologic and Hydrologic Implications of the Buried Bedrock Valley that Extends from the Western New York Nuclear Service Center into Erie County, N.Y.", in *Geology Reports of the Coalition on West Valley Nuclear Wastes* (East Concord, NY, 1994), available online at http://www.westvalleyctf.org/2008_Materials/2008-01-Materials/Core_Team_Issues-Vaughan_with_Appendices.pdf , at pp. 180-207 of the pdf file. See also Vaughan EIS comments §§ 50-56. [Note that citations to "Vaughan EIS comments" refer herein to my consolidated EIS comments, most of which can be found in the response-to-comments portion of the 2010 FEIS, available at https://www.wv.doe.gov/final/EIS-0226_F-Vol3-CRDPart1.pdf , on pdf pages 238-303. Some of the Vaughan EIS-comment appendices that were omitted from the 2010 FEIS volumes can be found at http://www.westvalleyctf.org/2008_Materials/2008-01-Materials/Core_Team_Issues-Vaughan_with_Appendices.pdf .]

adequate funding for said items. These items need to be administered on behalf of the public by various federal, state, county, city and town agencies in Western New York (WNY), including the Seneca Nation of Indians, as well as the country that is on the northern border of Lake Erie, Canada.

V. Maximally Exposed Individual (MEI) Dose Analysis

25. Dose analyses should include a resident fisherman living at the confluence of Buttermilk and Cattaraugus Creeks.

26. Dose analyses should include a resident farmer or other person living on the SDA or NDA.

27. As guidance on the magnitude of future dose to a resident farmer or other person living on the SDA or NDA, measurements should be taken during the SEIS process to determine concentrations of radon, iodine and other chemically volatile radionuclides under the burial ground geomembrane covers.

28. Results of dose analyses should be expressed not only in units of dose (such as millirems per year) but also in units of risk (such as cancer risk per million, which can be compared to policy goals such as a 1-in-one-million risk limit).

VI. Probabilistic Performance Assessment methodology issues

29. The PPA computer model runs will require *probability estimates for the input variables* (input parameters) that control or affect the predicted radiological doses. Probability distributions for these variables – potentially including variables such as rainfall, erodibility of till, or abstract variables that represent these real-world variables – are typically based on expert opinion. Scientists working in statistical risk assessment recognize potential problems such as expert overconfidence, lack of calibration, and lack of empirical validation of such probability estimates. Various scientists have recommended procedures that can guard against errors in expert estimates.[8] Such safeguards should be incorporated into the SEIS process, and should be described fully and transparently.

30. PPA computer model runs typically use Bayesian methods that require assumptions about the "prior" probability distributions of different variables.[9] Developing these "priors" or "prior distributions" can be procedurally difficult because the supporting data have not yet been applied to the distribution. Safeguards against poorly chosen "priors" should be incorporated into the SEIS process, and the safeguards should be described fully and transparently.

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[8] See K. Shrader-Frechette, "Uncertainty Analysis, Nuclear Waste, and Million-Year Predictions," in S.O. Hansson and G. Hirsch Hadorn, eds., *The Argumentative Turn in Policy Analysis* (Springer, 2016), 291-303, esp. pp. 298-99, and sources cited therein.

[9] For example, R.E. Kass and L. Wasserman, "The Selection of Prior Distributions by Formal Rules," *Journal of the American Statistical Association* **91**, 1343-70 (1996); H. Chipman et al., "The Practical Implementation of Bayesian Model Selection," IMS Lecture Notes - Monograph Series **38**, 65-134 (2001), available at http://www-stat.wharton.upenn.edu/~edgeorge/Research_papers/ims.pdf .

31. One or more scientists with specialized statistical expertise should be invited to speak on these issues (including expert estimates and prior distributions) at a CTF meeting or workshop in the near future.

32. The variables and assumptions in the model should be described in a transparent manner to the CTF and the public. More information should be presented in the following areas:

- What are the probability distributions for variables under best and worst scenarios that have the greatest influence on the models?
- What is the tolerance of these variables and the strength of the prior data used to support these probabilities?
- Which variables are described with assumptions supported by the weakest or least prior data?
- What degree of influence do these variables have on the final models?
- What procedures were run to describe and adjust for the influence these variables with weak prior data?
- Under the worst case scenarios, what influence do these variables have on the final models?

VII. General Modeling Considerations

33. Computer models are being used in the SEIS process to generate estimates of erosion, radiological dose, etc., for periods extending up to 10,000 years into the future. Modeling into the distant future for any purpose is an extraordinary challenge, and *it's important to understand whether a given model is realistic and trustworthy*. It's particularly important to have a good understanding of whether a model is realistic and trustworthy in circumstances such as this, where the model results will guide a decision affecting human health, safety, and the environment far into the future.

34. The models being used to support the SEIS process include both EWG (Erosion Working Group) erosion models and PPA models. A good understanding of whether they're trustworthy is important for both types of models.

35. A fundamental problem with the EWG erosion models is that they are *being developed* at the same time as they're being used as a basis for the Phase 2 decision.[10] The use of such young models is questionable, especially given the far-reaching consequences of the Phase 2 decision. In general, it is risky and unprotective to use models that are too young to have "stood the test of time" to support socially important decisions. To their credit, the EWG models aren't entirely new (they're based on earlier models dating back a couple of decades) and have been checked against a validation watershed east of Buttermilk Creek. However, these "credits" need to be balanced against the models' shortcomings and limitations such as their use of approximations and their use of proxy or surrogate parameters in place of field-measurable variables.

[10] G. Tucker et al., *Modeling Long-Term Erosion at the West Valley Demonstration Project and Western New York Nuclear Services Center*, Final Report, April 25, 2018, esp. pp. 212 and 215.

36. Such shortcomings are illustrated by the differences in performance among different versions of the models, some of which have input parameters that represent rainfall directly (via a stochastic procedure) while other versions use a deterministic procedure that represents rainfall indirectly as part of an erodibility factor such as K_1 or K_2. Part of the problem is that the models that represent rainfall directly *often perform no better in the calibration runs – and sometimes perform worse* – than their deterministic counterparts. Furthermore, none of the models that represent rainfall directly are among the EWG erosion models that perform reasonably well.[11] This indicates that:

- The EWG erosion models are unrealistic, i.e., they're not correctly representing real-world erosion. They're not able to combine direct representation of rainfall with reasonably good performance.
- The rainfall distributions of the best-performing EWG erosion model runs (those that are intended to support PPA modeling and the Phase 2 decision) can't be identified or checked against real-world rainfall distributions because of the way rainfall is represented indirectly as part of an erodibility factor.

37. Authors of the EWG erosion modeling report put a different "spin" on the conclusion expressed above. They say:

> We find that stochastic models do not calibrate any better than their deterministic counterparts, even given their additional free parameters. We interpret this as an indication that explicitly treating the rainfall distribution does not provide additional explanatory power in this region. This result indicates that use of an "effective" erodibility factor appropriately subsumes the effects of sequences of high and low runoff.[12]

Such an explanation can't overcome the fact that *if the models were realistic, they could achieve reasonably good performance in combination with direct representation of rainfall.*

38. At the very least, models need to be accessible, reproducible, and physically plausible in order to be deemed trustworthy and realistic.

39. Models that are trustworthy and realistic need to be sufficiently accessible that they can be reviewed and discussed. In other words, they shouldn't be opaque "black boxes" whose workings can't be deciphered. The way the EWG models handle rainfall is a prime example. As noted above, there's no straightforward relationship in the "best-performing" EWG erosion models between rainfall and the models' input variables.[13]

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[11] Id., Table 8.2 and Fig. 8.4, where models 100, 102, 104, 108, and 110 can be compared to models 200, 202, 204, 208, and 210, respectively, and all of these can be compared to the best-performing models such as 842, 802, 808, etc. See also high standard deviations in Tables C.12 through C.15.
[12] Id., p. 129.
[13] Id., where Table 8.2 shows the best-performing models and Table 8.1 shows the (free) input parameters for each model.

40. Accessibility can be provided, for example, by good documentation of the modeling algorithms & code and/or followup discussion that can clarify points that are unclear in the initial documentation. The Final Report on EWG erosion modeling[14] provides insufficient detail on the modeling algorithms and code, and it is unclear whether the expiration of the Phase 1 Studies contract with the EWG erosion modelers will allow any opportunity for followup discussion.

41. Models that are trustworthy and realistic need to be reproducible, meaning *the results should be the same or similar* when different research teams run the same or similar models. In part, this means that quantitative sensitivity analyses (showing how sensitive the model results are to the various input parameters) need to be fully documented, so that small variations in input parameters don't produce unexpectedly large differences in results.

42. Models that are trustworthy and realistic need to be physically plausible. In part, this means that the underlying physical processes need to be properly represented in the model. Examples involving knickpoints, mode of erosion (abrasion vs. plucking), runoff, slumping, earthquakes, etc., are discussed below.

43. Models that are trustworthy and realistic need to be physically plausible. In part, this means that the models' input parameters need to be accessible, field-testable, and consistent with real-world data. Examples involving stream flow rates are discussed below. If deterministic input parameters are being used, their values need to be realistic and defensible. If probabilistic input parameter ranges are being used, the ranges need to be reasonably broad and defensible, and the probability distributions within those ranges need to be realistic and defensible. Whenever a surrogate or proxy input parameter is used instead of a field-testable input parameter, its relationship to the field-testable parameter needs to be well-defined and quantitative, and a well-documented and quantitative sensitivity analysis is needed for each such relationship.

44. If families or "suites" of relatively similar models produce relatively similar results when they are run with identical input parameters, this may confer some limited level of assurance but cannot establish the necessary level of trustworthiness without the above criteria (accessibility, reproducibility, and physical plausibility) being met.

45. In reviewing results from suites of relatively similar models, it's important to remember that *the accuracy of the model(s) is paramount*. Only time will tell whether a given model or suite of models is accurate – so at the present time we must usually substitute "trustworthy" for "accurate" – but it's accuracy or trustworthiness that we ultimately need to assess, rather than model attributes such as elegance or model-to-model consistency or simplifications imposed by run-time constraints. For example, consistency of results from a suite of models may appear encouraging, but trust would be unfounded if all models in the suite share a common error or weakness.

46. The EWG erosion models cannot be considered trustworthy and realistic relative to the above criteria (accessibility, reproducibility, and/or physical plausibility) based on currently available information on the EWG erosion modeling.[15] Various examples are provided in these

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[14] Id.

[15] Id.

comments. The SEIS process and related processes (such as the Phase 2 decision and NRC license-termination process) should therefore not rely on EWG erosion modeling unless and until such modeling is revised and can meet the above criteria.

47. PPA modeling being prepared to support the SEIS process is not sufficiently complete to judge whether it is trustworthy and realistic based on the above criteria (accessibility, reproducibility, physical plausibility). Limited examples relating to PPA modeling are provided in these comments. It is unclear at this point whether the SEIS process and related processes (such as the Phase 2 decision and NRC license-termination process) should rely on the PPA models that are being developed. However, the current absence of trustworthy EWG erosion modeling will apparently create a major gap in the treatment of erosion in PPA modeling. Such a gap should receive immediate attention in the SEIS process.

48. If future circumstances or variables change greatly, such as an unexpected and severe precipitation or erosion event, then the Draft SEIS should include provisions for easy accessibility to modeling software to update the modeling, and to revise procedures.

49. Modeling software will evolve/improve over time, but it's crucial to preserve the exact software used for current modeling runs intended to support Phase 2 decisionmaking (essentially freeze it in time and preserve it) at the same time as the normal course of progress continues to make the software better/more realistic.

50. The time frame for site cleanup which is on the order of decades, and the uncertainties of institutional continuity, bring up questions about data, software, computer modeling accessibility, and hardware (equipment) integrity. For any alternative that leaves waste onsite, the Draft SEIS should include a detailed and comprehensive plan that allows for data and equipment integrity, accessibility, and interchangeability far into the future.

51. Data availability may evolve/improve over time, but it's crucial to preserve the exact data sets that have been used for current modeling runs that are intended to support Phase 2 decisionmaking (essentially freeze them in time and preserve them) at the same time as additional data collection continues.

VIII. Erosion modeling issues

52. Knickpoints and their upstream migration are a fundamental part of the erosion process on the Franks Creek watershed. As described by Beyer:

> Erosional processes acting on the Frank's Creek system may be differentiated between the V-shaped and U-shaped stream valley sections. The main erosion process on the [U-shaped] floodplain is the slow downcutting and meandering of the stream channel. Erosion scars on the adjacent hillslopes indicate how surface drainage patterns on the plateau have changed; these areas are more influenced by the sources and paths of water flowing over them than by any action of the main stream channel. The change from the [U-shaped] floodplain channel to the V-shaped channel occurs at a knickpoint. On

> Frank's Creek this change is total and abrupt. Erdman Brook has a transition zone between the two channel types that is several hundred feet long.
>
> The knickpoints behave like the advancing head of a gully. The erosion and retreat of the knickpoint allows gravel and cobbles to be freed and deposited at the base of the knickpoint. Turbulence at the base of the knickpoint agitates the collected gravel and cobbles, creating a scour pool. The gravel and cobbles subsequently deepen the channel by abrasion while moving downstream.
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> As the channel deepens, the surrounding banks fail via undercutting and slope failure. With bank collapse, more gravel and cobbles are released from the till and the former flat-bottomed floodplain disappears as the stream valley develops a V-shape. Reforestation also places an increasing load on the channel slopes until they sporadically fail by slumping and/or sliding….[16]

Beyer reports that, for Franks Creek, "the transition knickpoint between the V- and U-shaped channels has been moving upstream at a rate of about 2.3 meters (7.5 ft) per year for the past thirty-five years." For Erdman Brook, he reports the rate as about 3.2 meters (10.5 ft) per year.[17]

53. The preceding paragraph indicates that erosion in the U-shaped channel above the knickpoint is a distinctly different geomorphic process from erosion in the V-shaped channel below the knickpoint. The EWG erosion models fail to take this difference into account. In this respect, the EWG erosion models are substantially unrealistic and cannot be considered trustworthy.

54. The significance of knickpoint migration and the U- and V-shaped channels can also be explained as follows. The Franks and Erdman knickpoint locations can be extrapolated backward in time based on their current locations[18] and their above-quoted retreat rates. Such extrapolation, while approximate, will clearly show that the channels of both Franks Creek and Erdman Brook were entirely U-shaped until very recently (no more than a few centuries ago) in the vicinity of the burial grounds. Hence:

- The channels of both Franks Creek and Erdman Brook were U-shaped in the vicinity of the burial grounds during almost all of the 13,000-year postglacial period.
- The channels of both Franks Creek and Erdman Brook either are, or are rapidly becoming, V-shaped in the vicinity of the burial grounds.

Given Beyer's description of the qualitatively different erosion processes occurring in the U- and V-shaped channels within the modeled watershed, *the EWG modeling strategy of using post-glacial calibration runs to derive erodibility factors for modeling 1000 or 10,000 years into the future is entirely unsupported in the vicinity of the burial grounds*. If the models were realistic

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[16] B.M. Beyer, Hydrology Environmental Information Document (EID), Part 1, *Geomorphology of Stream Valleys*, West Valley Nuclear Services, WVDP-EIS-009, Rev. 0, 1/29/93, pp. 12-13.
[17] Id., pp. 11-12.
[18] DOE and NYSERDA, *Final 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 (2010), Fig. 3-18.

and trustworthy in all other respects, it might be reasonable to obtain erodibility factors such as K_1 or K_2 from post-glacial calibration runs (during the past 13,000 years), and to apply these erodibility factors to model runs that extend into the distant future, for any portions of the watershed that have *not* undergone a change from a U-shaped to a V-shaped channel.[19] But since this condition is not met in the vicinity of the burial grounds, the EWG modeling strategy can't realistically be applied.

55. The treatment of *runoff* in the EWG erosion models involves a substantial error and additional unresolved questions. As background, it's important to note that rainfall doesn't all flow downhill as runoff. Some percentage of rainfall soaks into the soil (thus contributing to groundwater recharge as well as uptake by plants and other evapotranspiration), while most of the remainder flows downhill as runoff. In a very light rain, there's essentially no runoff; almost all of the rainfall soaks into the soil. In a heavy rain, the soil may approach saturation, thus reducing the percentage that soaks in and increasing the percentage that goes to runoff. And it's important to remember that groundwater recharge must be balanced, locally or regionally, by groundwater *discharge* that provides the base flow that keeps streams flowing even in dry weather. Thus, on a local or regional basis, the annual average precipitation (both rain and snow) is equal to the sum of annual average runoff and annual average evapotranspiration. USGS maps compiled by Randall for the 1951-1980 period, while somewhat out of date with respect to climate change, are nevertheless very useful for general guidance.[20] For the West Valley area, Randall shows the annual average runoff as 24 inches (0.61 m).[21] This is the approximate amount of water that would have been available at the surface to cause erosion during the 1951-1980 period.[22] Climate change will certainly change the distribution of precipitation over time (more intense storms) and can be expected to increase evapotranspiration. Its effect on annual average runoff is less clear, and Randall's 24 inches (0.61 m) remains useful guidance.

56. While the EWG erosion models divert some rainfall to subsurface flow and allow it to rejoin surface flow within the modeled watershed,[23] it's not clear *where* the models allow the

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[19] Different K_1 values would likely be needed for U-shaped channels in till and V-shaped channels in till. Whether different K_2 values would be needed for the two different channel shapes in bedrock is less clear.

[20] A.D. Randall, *Mean Annual Runoff, Precipitation, and Evapotranspiration in the Glaciated Northeastern United States, 1951-80*, USGS Open-File Report 96-395 (1996).

[21] Id., Plate 1.

[22] While some number of inches per year would soak into the soil and flow beneath the surface as groundwater, and might thus be subtracted from Randall's 24 in/yr runoff, thereby making the surface flow less than 24 in/yr, *this would be counterbalanced on a local or regional basis by base flow,* so that the annual average amount available for surface flow in the West Valley area would have been about 24 inches during the 1951-1980 period.

[23] Tucker et al., op. cit., p. 233, which says "The bases of the hills represent locations where water emerges from the shallow subsurface to become surface flow that feeds the channel network" – but what hills? It is unclear whether the models have a fully developed water table (as in a MODFLOW model) or whether they rely on a generalized algorithm for groundwater discharge. If the latter, it's unclear whether all subsurface flow moves toward and into the nearest channel along the steepest available flow pathway and discharges there (essentially mimicking runoff), or whether all subsurface flow continues as groundwater until it reaches the lowest point in the watershed (the Franks-Buttermilk confluence) and discharges there, or whether subsurface flow travels and reemerges by some intermediate pathway.

subsurface flow to reemerge and become surface flow. This needs to be answered, and the answer can and should be checked against the *gaining* stream segments that Zadins refers to, either by conducting new field work or by gleaning such information from the sources cited by Zadins.[24] Furthermore, the EWG models need to be consistent with 1980-1983 field work that showed "Nearly 80% of gaged flow from the burial areas was runoff and the remaining 20% was base flow," while "the north plateau flow consisted of 30% runoff and 70% base flow," with the difference between the two plateaus attributed to soil composition.[25] Note that the geomembrane covers had not yet been placed on the burial grounds at the time this field work was done and thus cannot have contributed to the difference.

57. In the EWG erosion models, it's not clear whether and how soil saturation serves to limit or cap the modeled subsurface flow. This needs to be answered, and the answer needs to be shown to be realistic. For example, how do the models apportion surface and subsurface flow during a 1-year sub-time-step, where soil saturation may be reached early in the year (i.e., within hours for a heavy rainfall event), after which runoff becomes asymptotically constant for the duration of rainfall within the 1-year sub-time-step?

58. The outright error in treating runoff in the EWG erosion models is the assumption by Tucker et al. that the annual average runoff is 0.2 m/yr. This is entirely unrealistic, either as an annual average runoff value or in relation to annual average precipitation. Tucker et al. claim that:

> As a means of constraining watershed-scale effective infiltration capacity, we consider estimates of mean annual storm runoff in the region reported by DOE and NYSERDA (2010, Appendix F). These estimates ranged from 0.2 to 0.6 m/y, with most estimates closer to the lower end. Because 0.2 m/y is the more common value and more broadly representative of watershed runoff coefficients, we consider this the best current estimate.[26]

This is a gross misrepresentation of the cited source. In fact, Appendix F of the 2010 Final EIS lists four runoff values ranging from about 0.2 to about 0.6 m/yr, but these are differentiated by watershed, with the highest of the four values (0.579 m/yr) being listed specifically for the Franks Creek watershed.[27] It is disingenuous for Tucker et al. to ignore the 0.579 m/yr runoff value for the watershed they're modeling and to claim without any supporting citation that 0.2 m/yr is "more broadly representative of watershed runoff coefficients." Randall's value of 24 in/yr (0.61 m/yr) says otherwise. Indeed, the 0.579 m/yr value for the Franks Creek watershed and Randall's 0.61 m/yr value for the West Valley area are in good agreement, indicating that the

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[24] Z.Z. Zadins, *A Hydrogeologic Evaluation of "Geologic and Hydrologic Implication of the Buried Bedrock Valley that Extends from the Western New York Nuclear Service Center into Erie County, NY,"* Dames & Moore technical report, prepared for DOE and West Valley Nuclear Services Co. (August 1997), p. 6.

[25] F. O'Connor, Hydrology Environmental Information Document (EID), Part 2, *Surface Water Hydrology*, West Valley Nuclear Services, WVDP-EIS-009, Rev. 0, 1/29/93, p. 10.

[26] Tucker et al., op. cit., p. 149.

[27] DOE and NYSERDA, *Final 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 (2010), Appendix F, Table F-9.

EWG model runs should have used 0.6 m/yr runoff rather than the 0.2 m/yr value that was actually used. This threefold error in assumed runoff is a serious problem – especially given the key role that runoff plays in erosion – and is another reason why the current EWG modeling results cannot be considered realistic or trustworthy.

59. *Stream power*, the rate of energy dissipation per unit surface area, is a central part of many of the EWG erosion models[28] and is closely related to stream velocity through the relationship between kinetic energy and velocity, $E = ½mV^2$. One test that could be readily applied to the EWG erosion models is whether their modeled stream velocities at specified recurrence intervals match those shown in the West Valley Hydrology EID for specific reaches within the Franks Creek system.[29] This is not a sufficient test – it doesn't take climate change into account, can't overcome erroneous erodibility factors (erosion coefficients), etc. – but is a necessary test that can and should be done.

60. More generally, it's not clear whether the EWG erosion models reflect the physical reality that different rainfall intensities (from drought to drizzle to intense storms) have a major effect on stream velocity, stream power, and erosion. This lack of clarity is reflected on page 96 of the EWG erosion modeling report, where the phrase "If one assumes a linear relation between precipitation and erodibility…" and other discussion on the same page[30] imply that such a linear relationship exists – which is either wrong or imprecisely worded. Erosion and erodibility are not linearly related to a given amount of rainfall (e.g., 5 inches) in the absence of a known *rate* of rainfall. Five inches of drizzle over a prolonged period is far less erosive than a five-inch downpour.

61. As noted above, erosion is more directly related to runoff than to rainfall. In reality, there are several interrelated variables that need to be handled correctly in the models:

- *Runoff*, as discussed above.
- *Rainfall*, as discussed above and elsewhere in these comments.
- *Snowmelt, either by itself or combined with rainfall*. Neither of these annually occurring types of snowmelt events appears to be considered in the EWG erosion modeling,[31] yet both can contribute significantly to runoff, and their contributions can be expected to increase due to climate change (due partly to larger/more frequent temperature swings). As can be seen in Table 1, many of the highest annual flows recorded at the Gowanda gage on Cattaraugus Creek have occurred in winter months. This provides at least rough evidence of historical timing of peak flows (winter vs. summer) in the Franks Creek subwatershed.
- *Base flow*, which is considered to some extent in the EWG erosion modeling, as discussed above – but it's not clear whether base flow is reasonably correctly modeled, including in the headwaters of Franks Creek.

[28] Tucker et al., op. cit., pp. 33-37, 66-74, and 222ff.
[29] O'Connor, op. cit., p. 19 and Table 2-4.
[30] Tucker et al., op. cit., p. 96.
[31] The word "snow" appears in connection with paleoclimate on pp. 39-40, but nowhere else, in Tucker et al., op. cit.

Table 1: Annual peak streamflow on Cattaraugus Creek at Gowanda, NY[32]

Date	Annual peak streamflow (cfs)	
March 7, 1956	34,600	
March 17, 1942	32,600	
August 10, 2009	32,500	
September 14, 1979	31,200	
September 28, 1967	28,800	
January 22, 1959	27,000	
June 23, 1972	25,300	*
June 26, 1998	25,000	
December 22, 2013	24,800	
April 5, 1947	24,700	
January 19, 1996	24,600	**
January 23, 1957	22,900	
June 18, 1984	22,500	
October 2, 1945	21,100	
February 26, 1961	20,400	
March 30, 1960	19,700	
January 12, 2017	19,700	***
June 24, 1944	19,400	
March 1, 1955	19,400	
February 17, 1976	19,000	
March 5, 1964	18,900	
March 22, 1948	17,600	
November 25, 1950	17,600	
April 10, 2013	17,400	
March 17, 1963	17,100	
September 20, 1977	17,000	
December 30, 1942	16,800	
March 15, 2007	16,400	**
March 11, 2011	15,800	
April 5, 1978	15,200	
December 6, 1972	15,100	
May 24, 2004	15,100	
March 28, 1950	15,000	
July 14, 2015	15,000	

*Discharge due to Snowmelt, Hurricane, Ice-Jam or Debris Dam breakup
**Discharge is an Estimate
***Base Discharge changed during this year

[32] https://nwis.waterdata.usgs.gov/nwis/peak?site_no=04213500&agency_cd=USGS&format=html

62. There is apparent confusion in the EWG erosion modeling report between rainfall and runoff:

> Once a precipitation intensity has been selected for a sub-time-step, water erosion is applied for a fraction *F* of the sub-step duration. Here *F* is an intermittentcy factor that represents the fraction of an average year that precipitation occurs, defined as the total number of days with measurable precipitation divided by the total number of days in the year…[33]

The second sentence quoted here defines *F* in terms of a rainfall cutoff (annual fraction of days with measurable precipitation). The first sentence, saying that "water erosion" is applied in the model for that same fraction of time, implies that runoff and/or stream flow is cut off abruptly when the *F*-limit is reached. If the description is accurate, this aspect of the model is unrealistic.

63. The water-erosion laws used in the EWG modeling work assume that *plucking* of sediment grains and fragments, rather than *abrasion*, is the dominant form of erosion.[34] This fundamental assumption may be unrealistic. Compare Beyer's characterizations of the Buttermilk and Franks watersheds:

> Incision of Buttermilk Creek occurs mainly through the movement of the bedload [of gravel and cobbles] scraping the underlying soil or bedrock.[35]
>
> The knickpoints [on Franks Creek] behave like the advancing head of a gully. The erosion and retreat of the knickpoint allows gravel and cobbles to be freed and deposited at the base of the knickpoint. Turbulence at the base of the knickpoint agitates the collected gravel and cobbles, creating a scour pool. The gravel and cobbles subsequently deepen the channel by abrasion while moving downstream.[36]

Beyer continues by describing the ongoing incision and intermittent blockage of the V-shaped stream valley below the knickpoint, involving channel deepening and sidecutting which releases more gravel and cobbles. He notes that downcutting "continues by the movement of the bed load that erodes the native till along the channel bottom."[37]

64. There is currently no way to evaluate the treatment of rainfall in the EWG's stochastic erosion models because the length or duration of the global time step T_g is improperly omitted from the final modeling report.[38] Any comparison of the modeled rainfall to real rainfall distributions must be deferred until access to this crucial information is provided.

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[33] Tucker et al., op. cit, p. 60.
[34] Id., pp. 234-235.
[35] Beyer, op. cit., p. 9.
[36] Id., p. 13.
[37] Id.
[38] The time step duration (or its *distribution*, if not held constant) is apparently not provided in either Tucker et al., op. cit., or in G. Tucker, "Modeling long-term progressive erosion at the West Valley site," 2/28/18 QPM presentation.

65. The global time step T_g used in the stochastic models *may be ten years*. This was the time step identified by Tucker last year[39] for somewhat different rainfall algorithms, but an unequivocal statement of the global time step T_g is needed before the current EWG rainfall modeling can be checked against real rainfall distributions.

66. The 10-year time step used last year in EWG erosion modeling runs is unacceptably long; it introduced an unrealistic rainfall intensity-frequency distribution[40] into those model runs[41] and may have a similar effect on subsequent runs that will be used in the SEIS process to support the Phase 2 decision. The EWG erosion modelers have recognized that an unduly short global time step T_g may be problematic, at least for the models being used in 2010:

> The model is relatively insensitive to Tg as long as its value is 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 1 year or smaller produce very similar results (average root-mean-square differences in model-cell height of less than 30 centimeters (11.81 inches) after 1,000 years of erosion). A value of 0.1 years was used in calibration and forward runs.[42]

Given this recognition, a ten-year time step can't simply be introduced without discussion.

67. Even though the EWG erosion modeling report fails to mention the length of the global time step T_g, it indicates that sub-time-steps ranging from 5% to 100% of T_g may be used.[43] Such sub-time-steps are still too long. The problem is a sampling problem that can be described as follows. Sub-time-steps as long as a year (=10% of 10 yr) or half a year (=5% of 10 yr) are unlikely to provide correct representation of intense storm events. For the sake of illustration, assume that T_g = 10 yr and that the sub-time-step is one year, and consider a 100-year storm, meaning a 24-hour rainfall event with a return period of 100 years. Such a storm will occur or recur, on average, only one day in every 36,500 days (=100 x 365 days). Thus, on a given day, the probability of such a storm is 1/36500. If an erosion model used 1-day time steps and treated rainfall as an independent parameter, each day's rainfall could be chosen at random from a bowl of 36,500 slips of paper, only one of which would have "100-year storm" written on it. (Each slip, after being chosen, would be returned to the bowl so that it could be chosen again at random on a later day.) A model that ran for 1000 years would have a total of 365,000 daily drawings from the bowl (=1000 x 365 days), and the slip for "100-year storm" would be chosen, on average, ten times during the 1000-year modeling period. A model that ran for 10,000 years

[39] G. Tucker, pers. comm., May-June 2017.
[40] Note that the term "intensity" in the widely used phrase "intensity-frequency distribution" corresponds to rainfall "depth" – particularly the "depth" of 24-hour rainfall with a certain recurrence interval or probability – in the terminology of Tucker et al.
[41] For overview, see R.C. Vaughan, 6-28-17 CTF presentation, slide 10; also R.C. Vaughan, 9-27-17 CTF update presentation, slides 3 and 6-7.
[42] DOE and NYSERDA, *Final 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 (2010), Appendix F, page F-29.
[43] Tucker et al., op. cit., p. 60 and Table 5.2, where n_{ts} = 20 corresponds to 5%, etc.

would have a total of 3.65 million daily drawings from the bowl (=10,000 x 365 days), and the slip for "100-year storm" would be chosen, on average, a hundred times during the 10,000-year modeling period. Such models would realistically represent 100-year storms, assuming that the number of inches of rain in a 100-year storm was properly determined and appropriately adjusted for both climate change and paleoclimate. However, the EWG erosion models don't work this way. In these models, rainfall would effectively be chosen at random from a bowl of 36,500 slips of paper, only one of which would have "100-year storm" written on it, but slips would be chosen yearly (in accordance with the sub-time-step) rather than daily. Such a model that ran for 1000 years would have a total of 1000 yearly drawings from the bowl, and the slip for "100-year storm" would be unlikely to be chosen during the 1000-year modeling period. Such a model that ran for 10,000 years would have a total of 10,000 yearly drawings from the bowl, and there would be a less-than-even chance that the slip for "100-year storm" would be chosen at all during the 10,000-year modeling period. During hundreds or thousands of independently random modeling runs this sampling problem could be largely resolved, but the EWG modeling calibration runs are *not* independently random (the random seed is held constant in calibration[44]), and other problems remain unresolved as well. One of these other problems is that the best-performing EWG erosion models don't treat rainfall as an independent parameter, as discussed elsewhere in these comments. It's also not clear how stochastic EWG models that used a 1-year sub-time-step and treated rainfall as an independent parameter would deal with the situation in which the "100-year storm" slip is drawn from the bowl. *It's clear that the models would deliver a rainfall of about 5 inches* (this has generally been considered to be the 100-year storm) *to the modeled Franks Creek watershed every day for about 182 consecutive days*. This describes how the "100-year-storm" daily rainfall intensity would be drawn from a Weibull distribution, and how the models would hold this intensity constant for a fraction F (equal to about 0.5) of a 1-year sub-time-step.[45] Based on the August 2009 storm that delivered about 5 inches of rain, it is reasonable to presume that half a year of such storms, continuing day after day for 182 days, would severely erode both the real Franks Creek watershed and the modeled Franks Creek watershed. How the model would handle this – and whether any such result would simply be rejected by the modelers as an impossible outlier – are unclear. In sum, these are the main issues involved in the models' unrealistic time steps. And it should be noted that the above example of 36,500 slips of paper in a bowl will suffice for storms with average recurrence intervals of 100 years or less – but more intense storms with longer recurrence intervals also need to be considered for 1000- and 10,000-year model runs, involving more slips of paper in the bowl. The unresolved sampling and other issues outlined above would become increasingly problematic for such larger storms with longer recurrence intervals.

68. In summary, any and all such modeling runs need to have *recognizable* rainfall intensity-frequency distributions. Independent experts and the public must be able to review the rainfall intensity-frequency distributions, and must be able to compare them to realistic current rainfall distributions and to defensible estimates of paleo (post-glacial) and future (climate-change-adjusted) rainfall distributions.[46]

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[44] Tucker et al., op. cit., p. 95.

[45] Id., p. 60.

[46] Regarding paleo and future rainfall distributions, see Vaughan EIS comments §§ 166-71.

69. The various erosion modeling runs employ *other* input parameters in addition to their direct or indirect rainfall-distribution parameters. These other input parameters must likewise be reviewable, such that independent experts and the public can compare them to realistic field-tested or field-testable parameters. If any of these other parameters are not directly recognizable and field-testable, independent experts and members of the public will need to "translate" such parameters into quantitative measures that *can* be checked against reality.[47] Doing so will take time and require access to the computer code. Followup discussion with the EWG erosion modelers may also be needed, and they should remain available for this purpose.

70. Among the acknowledged limitations of the current EWG erosion models, one is sufficiently severe that it should immediately disqualify the models:

> None of the erosion models used in this study accounts for lateral erosion by streams, which can lead to valley widening. For this reason, the model projections do not address the possibility that the streams bounding the Site – Franks Creek, Quarry Creek, and Erdman Brook – could undergo valley-floor widening and thereby drive additional back-wearing of their valley walls.[48]

71. For all of the above reasons, including erroneous runoff values, the mismatch in erosional processes occurring in U-shaped and V-shaped valleys, the failure to incorporate snowmelt into the models, the unidentified duration of the global time step T_g, and the inability to model lateral erosion, *the current EWG erosion modeling results do not accurately represent reality, cannot readily be checked against reality, and cannot be accepted as trustworthy.*

IX. Site stability & integrity issues relating to seismic activity (earthquakes)

72. Evidence of two deep-seated faults – one at Sardinia and one at the north end of the US 219 bridge over Cattaraugus Creek near Springville – was released in 2001 in the Bay Geophysical seismic study,[49] but no follow-up work has been done to identify or clarify the strike of these faults, their geographic extent, their surface expression (if any), and their likelihood of reactivation. Such follow-up investigation is needed in the SEIS process in order to understand long-term seismic risks to site stability and containment integrity.[50]

73. The role of the seismically active Attica Splay of the Clarendon-Linden Fault needs to be understood.[51] The Sardinia fault identified by the Bay Geophysical seismic survey is particularly relevant because it is aligned with, and may be part of, the seismically active Attica Splay. The SEIS process needs to investigate and determine whether the Sardinia fault connects with the Attica Spay at/near Varysburg and also needs to investigate and determine whether it extends southwestward toward the West Valley site – and if so, how closely it approaches the site.

[47] Vaughan, 9-27-17 CTF update presentation, slide 8.
[48] Tucker et al., op. cit., p. 215.
[49] Bay Geophysical, *Seismic Reflection Survey to Identify Subsurface Faults near the West Valley Demonstration Project*, report prepared for West Valley Nuclear Services Company (Traverse City, MI: Bay Geophysical, 2001).
[50] Vaughan EIS comment § 57A.
[51] Vaughan EIS comments §§ 57A, 82, and 88.

74. Earthquakes pose a risk to slope stability. Extreme examples were seen in the 1964 Alaska earthquake,[52] while quakes of lesser magnitude will have similar but less dramatic effects on unstable or quasi-stable slopes. Relevant slopes at the West Valley site include the same valley walls, ravine walls, and gully walls that are subject to erosion and slumping. Thus, given the fact that seismic events will accelerate the overall loss of site integrity by causing large-scale landsliding, slumping, and mass wasting,[53] and given the acknowledged lack of any seismic component in the EWG erosion modeling runs,[54] *those erosion modeling runs need to be re-done with intermittent (probabilistic) seismic "jumps" incorporated into the models.*

75. An example of how seismic effects on slope stability can be modeled can be found in Appendix C-5 of an engineering report for the proposed expansion of a hazardous waste facility.[55] Applying such a model to slopes on the West Valley site would require site-specific values for soils and glacial fill materials, and would also require site-specific seismic information based on characterization of the Sardinia Fault, its relation to the Attica Splay, and other fault structures in the vicinity of the site.

76. Soil liquefaction may in some cases contribute to seismically induced slope failures; however, in other cases a slump-prone slope may fail in an abruptly accelerated episode of slumping without observable liquefaction. In any case, liquefaction of onsite soils adjacent to existing slopes needs to be investigated in the SEIS process and incorporated into landscape-evolution modeling.[56]

X. Site stability & integrity issues relating to possible aseismic movement of rock or soil

77. Aseismic (non-seismic) horizontal movement of large blocks of either *bedrock* or *overlying fill and soil* may be occurring on or near the site, over and above the known slumping and landsliding.[57] Any such movement of either rock or soil would be a type of topographic instability with potentially serious but currently uncharacterized effects on long-term site stability and containment integrity. The probability of such movement appears low but cannot be ruled out without further investigation. The SEIS process needs to engage in such investigation and needs to treat horizontal movement of either *bedrock* or *overlying fill and soil* as a low-probability but potentially high-consequences phenomenon in accordance with environmental review requirements such as 6 NYCRR 617.9(b)(6)(iii).

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[52] For example, see W.R. Hansen, "Effects at Anchorage," in *The Great Alaska Earthquake of 1964* (Washington: National Academy of Sciences, 1971), available online at http://www.westvalleyctf.org/2008_Materials/2008-01-Materials/Core_Team_Issues-Vaughan_with_Appendices.pdf , at pp. 30-140 of the pdf file.

[53] Vaughan EIS comments §§ 103-04.

[54] Tucker et al., op. cit., p. 216.

[55] Arcadis, RMU-2 Engineering Report (Rev. Nov. 2013), http://modelcity.wm.com/RMU/06-RMU-2%20Engineering_Report_Revised_November_2013.pdf .

[56] See especially R.C. Vaughan, "Geologic and Hydrologic Implications of the Buried Bedrock Valley…", op. cit., available online at http://www.westvalleyctf.org/2008_Materials/2008-01-Materials/Core_Team_Issues-Vaughan_with_Appendices.pdf , esp. pp. 203-207 of the pdf file.

[57] Vaughan EIS comments § 203.

78. If investigation shows horizontal movement of large blocks of bedrock, fill, and/or soil, the Draft SEIS should quantify and document the rate(s) of movement and associated implications or impacts on long-term site stability and containment integrity. Alternatively, if investigation shows that horizontal movement of large blocks of bedrock, fill, and/or soil can be ruled out, the Draft SEIS should document this conclusion and how it was reached.

79. *Horizontal bedrock movement?* Evidence of aseismic horizontal bedrock movement at one location in WNY comes from a paper by the late Prof. Wm. Brennan of SUNY Geneseo.[58] Brennan reported horizontal offset (partial blockage) in the steel casing of brine wells in the Wyoming valley near Wyoming and Warsaw, NY. The offset occurred at the depth of the thalweg of the adjacent bedrock valley, implying an essentially horizontal detachment surface or decollement in the local shale at the depth of the thalweg, with the movement of the overlying bedrock block driven by the prevailing regional compressive stress. Given the regional extent of this ENE-WNW-oriented tectonic stress, and given the fact that the Buttermilk valley's NNW-SSE alignment is even more favorably oriented (essentially perpendicular to the regional compressive stress), it is reasonable to investigate whether the type of bedrock movement observed by Brennan is also occurring in the West Valley site's injection wells which have remained inactive since about 1970. Some of the West Valley injection wells are known to be blocked by grout, but others are considered grout-free and could/should be checked for offset and/or casing blockage at the approximate depth of the adjacent bedrock-valley thalweg.

80. Effects of regional compressive stress in WNY bedrock are well-known to at least two members of the Phase 1 Studies Erosion Working Group (Fakundiny and Young), both of whom have written about such horizontally-oriented stress and its role in causing observable displacement of bedrock.[59] Fakundiny and coauthors have noted, for example, that "Foundation instability, produced by lateral expansion of rock into excavation voids, prevails throughout western New York and the Niagara Peninsula of Ontario, Canada…and is generally thought to be the result of regional stresses acting with a high, horizontal compressive component oriented in a generally east-west to northeast-southwest direction at shallow depths in the earth's crust…"[60]

81. *Horizontal soil/till movement?* Soils and tills are typically plastic materials that may undergo slow creep toward unbuttressed voids such as valleys, potentially including the Buttermilk valley. Possible evidence of such movement immediately southeast of the West Valley site has been described by Vaughan, EIS comments, § 105 and Figure 4. The work currently being done

[58] W.J. Brennan, "Stress-Relief Phenomena Observed During Solution Mining in Western New York," presented at Fall 1996 Meeting, Solution Mining Research Institute, Cleveland, Ohio.

[59] R. Fakundiny et al., "Structural Stability Features in the Vicinity of the Clarendon-Linden Fault System, Western New York and Lake Ontario," in *Advances in Analysis of Geotechnical Instabilities*, (University of Waterloo Press, 1978), esp. p. 121. The decollements shown therein in Figs. 15B (p. 162) and 19-20 (pp. 169-70) may also be relevant. See also A.S. Nieto and R.A. Young, "Retsof Salt Mine Collapse and Aquifer Dewatering, Genesee Valley, Livingston County, New York," in J.W. Borchers, ed., *Land Subsidence: Case Studies and Current Research* (Association of Engineering Geologists, 1998), esp. Fig. 8 and pp. 322-23.

[60] Fakundiny et al., op. cit., p. 121.

by Neptune risks missing such movement if any/every horizontal discrepancy in airphotos (relative to LiDAR maps) is assumed to be from airphoto distortion. The SEIS process should investigate whether horizontal soil/till movement is occurring, document the findings, and address the implications and impacts if any such movement is detected.

82. Slumping and landsliding are well-known modes of mass wasting (slope failure) that are widely observed in the Cattaraugus Creek basin, including well-known examples on Buttermilk Creek and elsewhere on the West Valley site. While slumping and landsliding may occasionally be accelerated by earthquakes, they usually operate as continual (sporadic) aseismic processes in which masses of soil or glacial fill move downslope, thus modifying the landscape[61] in concert with erosional processes such as plucking and abrasion. The masses of soil, typically but not always in the form of discrete blocks, move downslope due to gravity in combination with surface water that undercuts the toe of the slope and/or groundwater that seeps toward the face of the slope from behind. *The EWG erosion models treat slumping/landsliding as a form of creep,*[62] *but this is unrealistic for the typical form of slumping/landsliding found on the West Valley site and throughout the Cattaraugus watershed*. Creep involves plastic deformation with little or no loss of cohesion, while slumping/landsliding typically involves detachment (loss of cohesion) along a quasi-planar or rotational failure surface. As a result, slumping or landsliding usually opens up a water pathway behind any block that has slid downward. Creep doesn't do this. Thus, the approximation of using creep as a proxy for slumping/landsliding (without having established an onsite correlation) is unrealistic and adds to the uncertainty of the modeled results.

XI. Site stability & integrity issues relating to climate and rainfall

83. Effects of climate change that do not appear to be adequately incorporated into the EWG erosion model runs include lake-effect rain[63] and similar weather systems driven by prevailing winds off Lake Erie and associated precipitation in the "shadow" of the lake. The SEIS process should investigate such precipitation and whether it is changing over time, including whether the winds and precipitation levels have changed in the past 1000 years or so.

84. Erosion modeling for the West Valley site (both EWG and PPA modeling) needs to recognize and incorporate rapidly moving, organized thunderstorm systems, sometimes called *derechos* or mesoscale convective system (MCS)-organized convective storms. Two examples are the July 1942 storm in Smethport, PA (~30 inches rainfall in 4.75 hr), and the July 1996 Redbank storm near Brookville, PA (~5 inches in 4 hr), that have been reviewed and analyzed by Smith et al.[64] Both locations are on the western margin of the central Appalachians, less than 100 miles south of the West Valley site. While the orographic relief of these Pennsylvania sites is not identical to that of the West Valley site, there are similarities not only in topography but in

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[61] M.P. Wilson & R.A. Young, Phase 1 Erosion Studies, *Study 1 - Terrain Analysis*, Final Report, Vol. I (Feb. 2018), p. 79.
[62] Tucker et al., op. cit., pp. 34-35, 56-58.
[63] CTF memo entitled "Actions Needed Related to Potential [Climate] Change Impacts," July 27, 2015, available at http://westvalleyctf.org/2015_Materials/07/2015-07-27_Memo-Climate_Change_Considerations_Incorporation_in_Decisionmaking.pdf , esp. p. 6.
[64] J.A. Smith et al., "Extreme rainfall and flooding from orographic thunderstorms in the central Appalachians," *Water Resources Research* **47**, W04514 (2011).

the occurrence of "trains" of storms that stream generally eastward along a relatively stationary track for many hours, delivering exceptional rainfall accompanied by intense lightning. The Redbank storm, for example, "consisted of a system of multicellular thunderstorms that moved rapidly from Lake Erie across western Pennsylvania," involving a "multiple storms that tracked over Redbank Creek," with cloud-to-ground lightning flash densities ranging up to 2-3 strikes per square kilometer during the storm. This type of powerful "training" storm system was apparently involved in both the Smethport storm[65] and the August 2009 West Valley derecho or storm.[66] Storms of this type need to be incorporated into EWG and PPA erosion modeling.

85. An article by Prein et al.[67] finds that MCS-organized convective storms with a size of ~100 km are poorly represented in traditional climate models yet are increasing in frequency and intensity. For the West Valley area, these authors show a 50% to 70% increase in the frequency of MCSs (expressed as track density difference) relative to current conditions.[68] This trend, discussed by Feng as a "near doubling" of severe storms,[69] needs to be incorporated into EWG and PPA erosion modeling.

86. Climate experts at the August 2012 WVDP climate workshop noted that "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 ...[and] 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."[70] They also noted that, "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."[71]

87. Evidence continues to grow that intense storms will become more frequent, and that their intensity will increase. For example, a recent article by Prein et al.[72] shows hourly extreme

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[65] Id.
[66] C.O. Szabo, W.F. Coon, and T.A. Niziol, *Flash Floods of August 10, 2009, in the Villages of Gowanda and Silver Creek, New York*, USGS Scientific Investigations Report 2010-5259.
[67] A.F. Prein et al., "Increased rainfall volume from future convective storms in the US," *Nature Climate Change* **7**, 880-86 and Supplementary Information (Dec. 2017), esp. Supplementary Fig. 2(e).
[68] Id., Supplementary Fig. 2(e).
[69] Z. Feng, "Near doubling of storm rainfall," *Nature Climate Change* **7**, 855-56 (Dec. 2017).
[70] Enviro Compliance Solutions Inc., "Climate Guidance for Phase 1 Studies" (Nov. 2012), pp. 9-10.
[71] Id, p. 2.
[72] A.F. Prein et al., "The future intensification of hourly precipitation extremes," *Nature Climate Change* **7**, 48-52 (Jan. 2017). The authors are using a pseudo global warming (PGW) approach to "perturb the lateral boundary conditions of ERA-Interim with a high-end scenario (RCP8.5) 95-year ensemble monthly mean climate change signal from 19 Coupled Model Intercomparison Project Phase 5 Models" (CMIP5).

precipitation in the West Valley area increasing by 35% to 49% as a result of climate change in both winter (Dec.-Jan.-Feb.) and summer (June-July-Aug.), where "extreme" precipitation, defined as the 99.95th percentile of hourly precipitation, corresponds to the maximum precipitation that occurs on average once every season.[73] The same article shows the exceedance probability of hourly extreme precipitation increasing by about 130% (winter) and 165% (summer) in the West Valley area, relative to a 2000 to 2013 control period.[74] Such effects of climate change, including larger temperature fluctuations and the resulting changes in both direct rainfall and runoff from snowmelt, and also including periods of increasing drought interspersed with increased storminess, need to be adequately and transparently incorporated into EWG and PPA erosion modeling.

88. It is not that clear that the sensitivity analyses for the EWG erosion modeling runs cover the intensity-frequency increases for intense storms.[75] Sensitivity analyses for these intensity-frequency increases, and for the incorporation of such increases into models employing relatively long (e.g., 10-year) time steps, need to be defensibly and transparently incorporated into the SEIS process.

89. The EWG erosion models are employing unrealistically and unacceptably low levels of future climate change. The Multivariate Adaptive Constructed Analogs (MACA) climate scenarios that are being used to represent climate change in the EWG erosion models[76] are adding relatively little intensity and frequency to the current level of intense storms. The EWG models are assuming increases of approximately 9% in mean annual precipitation, 1% in mean wet day frequency, and 12% in mean wet day intensity,[77] and the models' three "future climate scenarios" assume increases in the neighborhood of 8% to 12% in mean wet day precipitation.[78] These trivial increases are inconsistent with the increases outlined in the preceding paragraphs. Incorporation of climate change in the SEIS process must be more than a token effort; it needs to reflect current science. Modeling runs that do not adequately represent climate change need to be re-done.

90. The EWG erosion models assume no further climate change beyond year 2100.[79] This is inconsistent with the August 2012 WVDP climate workshop where it was noted that, "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."[80]

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[73] Id., Fig. 1 and related text.
[74] Id., Fig. 2 and related text.
[75] Tucker, QPM presentation, op. cit., slide 6, does not show such a sensitivity analysis. As discussed elsewhere in these comments, it's clear that the EWG erosion modeling (as reported by Tucker et al., op. cit.) does not treat precipitation and runoff (from both rain and snow) in a realistic manner. The modeling thus provides no clear and direct basis for understanding the effects of precipitation and runoff on model results (or conversely, for understanding the sensitivity of model results to precipitation and runoff).
[76] Tucker, QPM presentation, op. cit., esp. slides 19-20.
[77] Id., slide 19, where values interpreted from the currently available version (a paper copy of the slide) are 1250/1150 = 109%, 0.48/0.475 = 101%, and 7.0/6.25 = 112%.
[78] Id., slide 20, where values interpreted from the currently available version (a paper copy of the slide) are 6.72/6.25 = 108% and 7.0/6.25 = 112% for RCP-4.5 and RCP-8.5, respectively.
[79] Id., slide 20.
[80] Enviro Compliance Solutions Inc., op. cit, p. v.

91. Genuine uncertainties in numerical values that represent climate change need to be handled probabilistically in a robust and transparent manner. While this should go without saying in PPA modeling, it is also an important point in the EWG erosion modeling that will guide the PPA modeling. Specifically, EWG erosion model results based on erroneous or unsupported inputs cannot be accepted as inputs into PPA modeling.

92. Paleoclimate needs to be reconstructed based on the best available evidence and needs to be adequately and transparently incorporated into EWG and PPA erosion modeling.[81]

93. The period of approximately 4000 years of minimal Buttermilk Creek downcutting (between about 10,000 and 6000 years before present), as identified by the EWG report by Wilson and Young,[82] needs to be linked to causal factors such as reduced rainfall or other evidence-based factors.

94. It is not that clear that the sensitivity analyses for the EWG erosion modeling runs cover the range of rainfall rates (including a cessation or at least a greatly reduced rate of rainfall) for the period between about 10,000 and 6000 years before present when Buttermilk Creek downcutting was minimal.[83] While there may be other explanations for this period of minimal downcutting, one such explanation would be a prolonged "paleo drought" (a near-absence of rainfall) during the 4000-year period.[84] Sensitivity analyses showing the sensitivity of EWG model results to the rainfall assumed during calibration runs for this 4000-year period – including results for the limiting case in which no rainfall occurs in any time step during this period – must be provided. These sensitivity results must also be appropriately incorporated into PPA model runs.

95. The recently released EWG erosion modeling report says that the results of the EWG sensitivity tests "showed that climate-driven variation over time in the erodibility coefficient has only a small influence on the model's output…"[85] This is not a credible conclusion because Tucker and the other EWG modelers didn't directly use rainfall as a time-varying input parameter in their models, nor did they rely on any paleoclimate research[86] such as the work reviewed and presented by Wilson and Young.[87] Instead of looking at paleoclimate research, Tucker and the other EWG modelers consulted a long-period climate model simulation known as TRACE21ka. And instead of using rainfall as a time-varying input parameter, they varied the erodibility coefficient for their model-calibration runs. Based on the results, they concluded[88]

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[81] Vaughan EIS comments §§ 166-68.
[82] Wilson & Young, op. cit., esp. Figs. 4.10-3 and 4.10-4.
[83] Tucker, QPM presentation, op. cit., slide 6, does not show such a sensitivity analysis. As discussed elsewhere in these comments, it's clear that the EWG erosion modeling (as reported by Tucker et al., op. cit.) does not treat paleoclimate rainfall variation as an independent parameter and thus provides no clear and direct basis for understanding its effect on model results (or conversely, for understanding the sensitivity of model results to paleoclimate variation).
[84] Or, for example, a prolonged drizzle-dominated period with little or no storminess.
[85] Tucker et al., op. cit., p. 96.
[86] Id..
[87] Wilson and Young, op. cit., § 4.9 ("Paleoclimate Factors"), on pp. 79-83.
[88] Tucker et al., op. cit., p. 96.

that paleoclimate variations didn't make much difference and that "the calibration procedure assumed a steady climate over the calibration period." This approach begs the question. It fails to treat paleoclimate as an independent parameter, assumes that it can be represented by a different parameter (the erosion factor or erodibility coefficient which, for example, fails to distinguish between U-shaped and V-shaped valleys), and concludes based on this circular logic that paleoclimate variations don't make much difference and that the calibration model runs could simply assume a steady climate over the calibration period.

96. The EWG erosion modeling report explains that the EWG erosion model-calibration runs employed the erodibility coefficient as a proxy or surrogate for paleoclimate variation through time, such that the erodibility coefficient was allowed "to either increase or decrease over time, reaching a stable value after a specified period of time has elapsed…" Specifically, "the erodibility coefficient was set to stabilize at 5,000 years into the model run, representing 8,000 years ago," where 8,000 years ago was the time at which the TRACE21ka climate model predicted that "the annual precipitation rate and its apportionment among various forms became approximately steady…"[89] This allowed erodibility to vary by an adjustment factor of 50% to 150%, *but only during the first 5,000 years of a 13,000-year model-calibration run.*

97. Unresolved issues in the EWG erosion modeling report[90] include a lack of clarity on the quantitative proxy relationship between rainfall and erodibility coefficient (including how the known non-linearity between precipitation and erosion is handled) and the resulting sensitivity relationship between these two variables. Other such issues include a) the disregard for paleoclimate research, some of which was specifically presented by Wilson and Young, and the substitution of a presumably easier-to-plug-in climate model; b) the uncritical acceptance of the climate model's paleoclimate stabilization 8,000 years ago, contrary to what paleoclimate research has shown; and c) the loss of realism and field-testability when rainfall and erodibility coefficient are rolled into one rather than being independently variable input parameters.

98. Differences between paleoclimate research and TRACE21ka climate model results – or between different paleoclimate research studies – shouldn't necessarily be decided in favor of one over the other. But by using only the TRACE21ka climate model results, the EWG erosion model runs have arbitrarily truncated the range of input variability and thus failed to demonstrate the sensitivity of model results to this type of input. This is a microcosm of the problem (arbitrary choice of deterministic values) that PPA modeling is meant to overcome – and if such a problem can't be overcome in the current EWG erosion modeling which provides such major guidance to the PPA modeling that will support Phase 2 decisionmaking, then the PPA modeling shouldn't be considered trustworthy.

99. Genuine uncertainties in numerical values that represent paleoclimate need to be handled probabilistically in a robust and transparent manner. While this should go without saying in PPA modeling, it is also an important point in the EWG erosion modeling that will guide the PPA modeling. Specifically, EWG erosion model results based on erroneous or unsupported paleoclimate inputs cannot be accepted as inputs into PPA modeling.

[89] Id.

[90] Id.

XII. The question of silt- or sandstone strata acting as an erosion-resistant sill that could explain periods of slower Buttermilk/Franks incision during the paleoclimate period

100. According to the EWG erosion modeling report:

> The presence of siltstone- and sandstone-bearing strata in the vicinity of the WNYNSC provides a plausible explanation for the periods of slower incision observed in the time-versus-elevation plot of the Franks Creek outlet because these sections of strata are significantly more resistant to erosion than the surrounding sections composed primarily of shale.[91]

While this is a marginally possible explanation for the ~4000-year pause in downcutting reported by Wilson and Young,[92] it's a secondary explanation relative to the climate explanation that Wilson and Young considered primary:

> While resistant strata control of terracing in response to base level was active and significant, the maintenance of elevation for thousands of years was likely from climate conditions as discussed in the preceding paleoclimate section, but base-level control from sandstone at 1274-feet could assist terrace development.[93]

There are three main questions here. First, there's the question of whether sandstone strata at 1274 ft elevation could act as a sufficiently erosion-resistant sill to reduce Buttermilk Creek incision to a near-zero rate for ~4000 years. Second, it's questionable whether such strata would have extended far enough eastward into the *preexisting bedrock valley* to prevent the creek from meandering eastward off the resistant sill and into more readily erodible glacial fill in a much shorter time frame than 4000 years. Third, if the resistant bedrock sill did indeed extend far enough eastward to prevent the creek from meandering off the edge of the sill for thousands of years, there's a question of whether the resistant sill, once it was breached and no longer exposed to direct erosion from the flowing creek, could have disappeared so completely in the past 6000 years that the west wall of the bedrock valley apparently has no remnant bulge or knob at 1274 ft elevation. Instead, the west wall of the bedrock valley appears to have an essentially smooth upstream-downstream profile at 1274 ft elevation.

101. *Review of stratigraphic evidence*. If siltstone- and sandstone-bearing strata within the local bedrock formed an erosion-resistant sill, perhaps the caprock of a waterfall, in the lower reaches of Buttermilk Creek during the period from about 10,000 to 6000 years ago when the creek's incision essentially stopped for ~4000 years, *the elevation of the top of the sill must have been in*

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[91] Id., p. 144.
[92] Wilson & Young, op. cit., Figs. 4.10-3 and 4.10-4. Note that the EWG erosion modeling report refers to "the time-versus-elevation plot of the Franks Creek outlet," but the main evidentiary question involves a pause in Buttermilk Creek incision. This of course affects the Franks-Buttermilk confluence, but the directly relevant elevation history involves the Buttermilk channel. The discussion herein thus focuses on elevation history of the Buttermilk channel.
[93] Id., p. 84.

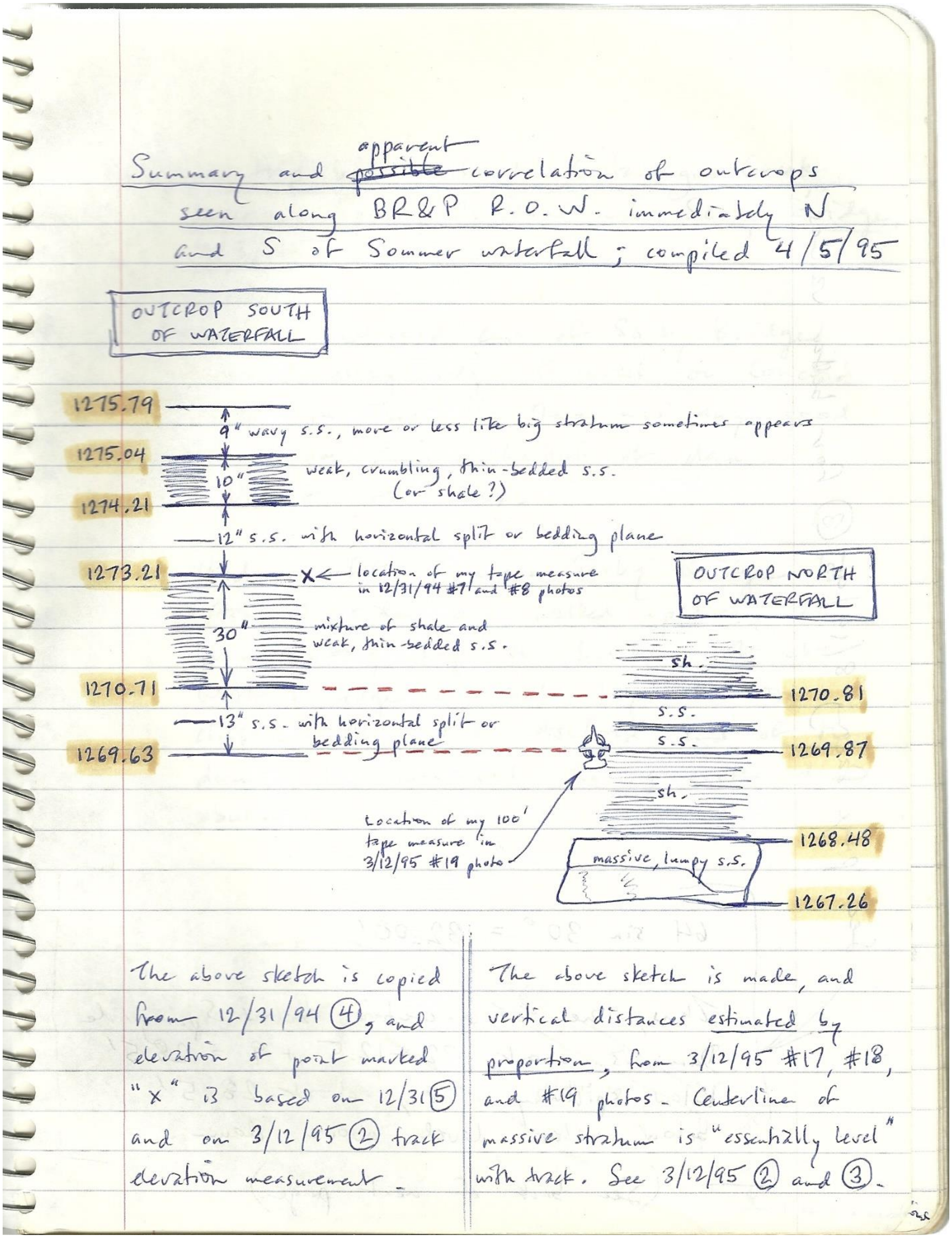

Fig. 1: Caprock (~1274′) of waterfall as described in R. Vaughan field notebook

the neighborhood of 1250 to 1290 feet above sea level.[94] Wilson and Young have identified a candidate for such a sill, namely, the caprock of a "14-foot waterfall topping at 1274-feet in the west slope of Buttermilk valley across from Tree Farm."[95] As rough criteria for erosion resistance, they note that "sandstone is much more resistant than shale when sandstone thicknesses exceed 1.0 foot" and suggest that "a relatively-thick (4+ feet) resistant sandstone section" would be capable of prolonged erosion resistance.[96] My own field work between 1993 and 1995 included measurements of the same waterfall caprock at about 1274 ft elevation that Wilson and Young refer to. Fig. 1, a copy of my notebook page that summarizes those measurements, shows sand- or siltstone strata interbedded with shale over an 8.5-foot interval, with the individual sand- or siltstone beds ranging up to about 14.5 inches and having a combined thickness of about 4 feet. Judged by Wilson and Young's criteria, these strata would be marginally capable of resisting erosion for thousands of years. Some loss of resistance is introduced by the shale interbeds and by the observed bedding-plane fractures, and the resistance would of course depend greatly on the degree of vertical fracturing or jointing in these strata where they formerly extended eastward into the bedrock valley. Generally speaking, bedrock in the vicinity of the West Valley site is highly fractured,[97] but there's no way to reconstruct the pervasiveness of fracturing within the bedrock valley where the strata are now missing.

102. *Stratigraphic context*. The aforementioned strata at ~1274 ft elevation are *not* part of the Laona Member of the Canadaway Formation[98] as suggested in the EWG erosion modeling report[99] and as I had thought in the early 1990s.[100] Instead, these strata belong to a packet of sand/siltstones within the Gowanda Member of the Canadaway Formation, as determined from my field work and review of numerous well logs in the mid-1990s. This work has allowed both the Laona Member and a lower sand/siltstone bed that I call Ledge "A" to be mapped eastward from the outcrop locations where Tesmer had identified the Laona. Both beds can be identified in outcrop on or near the West Valley site:

- Laona Member can be seen in outcrop near the intersection of Dutch Hill and Boberg Rds. (about 42.456°, -78.675°) at about 1560 ft elevation. Thus, the Laona is too high to have been the hypothetical erosion-resistant sill that would have consisted of an eastward continuation of the strata at ~1274 ft elevation in the Buttermilk Valley.[101]

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[94] Based on Wilson & Young, op. cit., Fig. 4.10-3. Note that the elevation range of 1250 to 1290 feet refers to modern or current elevation. No correction is made for glacial rebound or changes in sea level.
[95] Id., p. 84 and Fig. 3.4-3.
[96] Id., pp. 76 and 38.
[97] For example, see Vaughan EIS comments §§ 83-84.
[98] The stratigraphic terminology used here is that of Tesmer (*Geology of Cattaraugus County, NY*, published as *Bulletin of the Buffalo Society of Natural Sciences*, Vol. 27, 1975), who refers to the Canadaway Formation and its constituent members which include the Dunkirk, South Wales, Gowanda, Laona, Westfield, Shumla, etc.
[99] Tucker et al., op. cit., p. 144ff.
[100] See R.C. Vaughan et al., "Confirmation of Anomalous Westward Dip between Springville and West Valley, N.Y.", esp. p. 2, Table 2, and Appendix II, in *Geology Reports of the Coalition on West Valley Nuclear Wastes* (East Concord, NY, 1994), op. cit.
[101] The Shumla Member, suggested by Tucker et al., op. cit., as another possibility, is stratigraphically higher than the Laona and thus impossibly high.

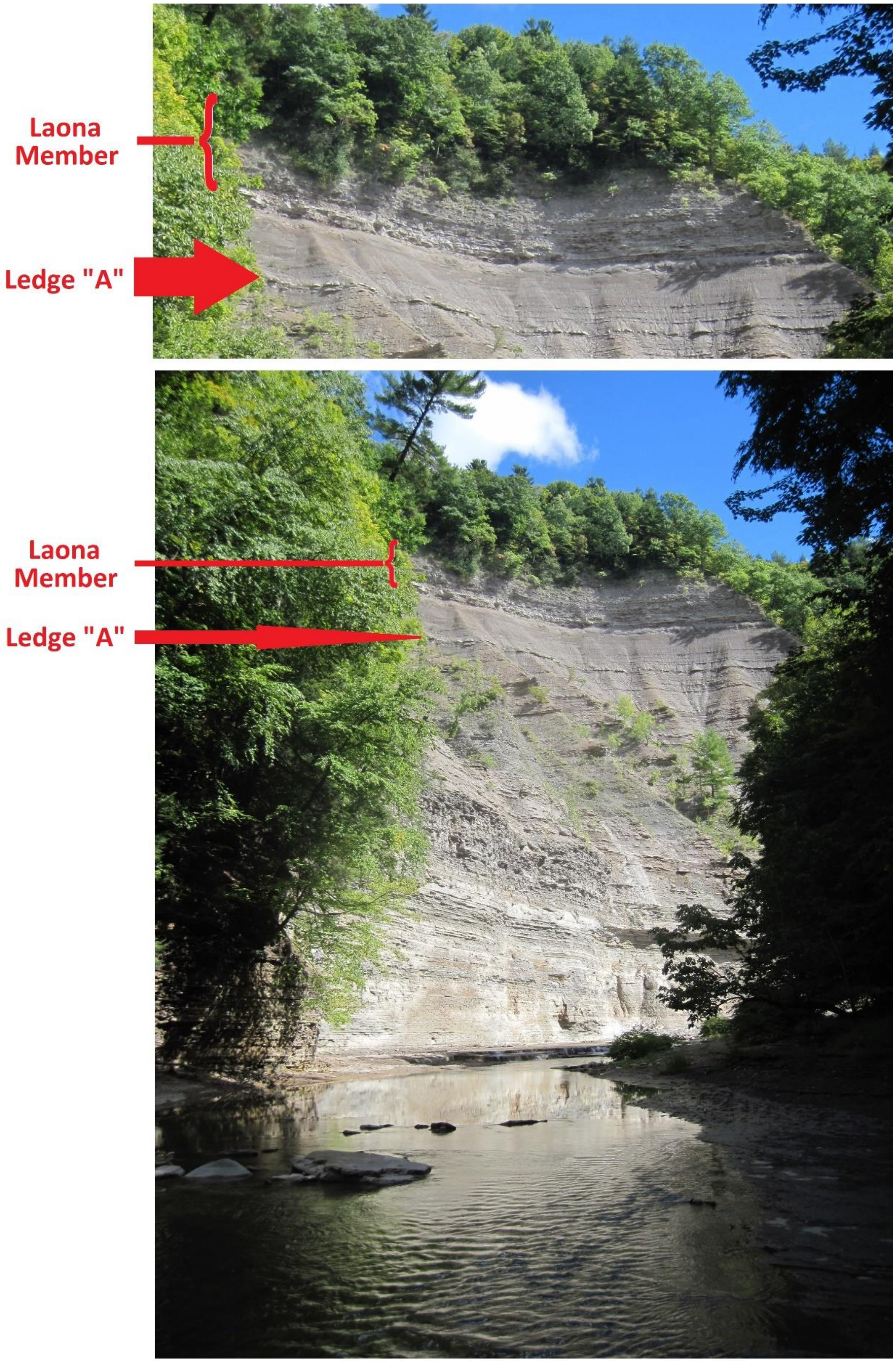

Fig. 2: South Branch of Cattaraugus Creek at about 42.4205°, -78.8806°

- Ledge "A" can (or recently could) be seen in outcrop along Dutch Hill Rd. south of Edies Rd. (about 42.466°, -78.676°) at about 1470 ft elevation, and also at another nearby location southwest of the Dutch Hill-Edies intersection. This bed is also too high to have been the hypothetical erosion-resistant sill corresponding to an eastward continuation of the strata at ~1274 ft elevation in the Buttermilk Valley
- Ledge "A" also forms the caprock of the waterfall on Quarry Creek west of Rock Springs Rd. (about 42.447°, -78.662°). Again, this bed is too high to have been the hypothetical erosion-resistant sill corresponding to an eastward continuation of the strata at ~1274 ft elevation in the Buttermilk Valley.

I have identified both beds (Laona Member and Ledge "A") at various other locations, including a high cliff on the east side of the South Branch of Cattaraugus Creek where both beds can be seen in the same outcrop (about 42.4205°, -78.8806°), shown here for reference in Fig. 2. All of these identifications are based partly on evidence of northwest thinning of the various beds within the Canadaway Formation,[102] partly on my extensive mapping of the base of the Dunkirk Member (base of the Canadaway Formation) based on review of numerous well logs, partly on the principle that the interval between the base of the Dunkirk Member and the Laona Member must vary in a reasonably consistent manner over the mapped area,[103] etc. If needed, I can share additional information on these outcrop locations and my mapping of the base of the Dunkirk, etc.

103. *Additional stratigraphic context*. Whether the aforementioned strata at ~1274 ft elevation correspond to the caprock of the waterfall in Connoisarauley Creek is unclear. The strata at ~1274 ft elevation do extend westward at least a mile or two as a distinctive (and somewhat thinner) sand/siltstone bed that can be seen between about 1208 and 1218 ft elevation in the Cattaraugus Creek gorge near the U.S. 219 bridges.[104]

104. *No recognizable geomorphic evidence*. If siltstone- and sandstone-bearing strata such as the 1274 ft caprock strata formed an erosion-resistant sill that protruded into the bedrock valley, why is there no remnant of this erosion-resistant bedrock sill? Given its high degree of resistance to erosion, some remnant would likely have survived the past 6000 years – during which time the erosive flow of the creek had already breached the hypothetical sill and was simply flowing past (not directly against) whatever remained of the sill.

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[102] As noted in R.C. Vaughan, J. Sullivan, and C. Osterhoudt, "The Geology of Zoar Valley and the Cattaraugus Creek Watershed," *Nature Sanctuary Society of WNY Monograph in the Natural Sciences*, Vol. I (January 2013), p. 2.

[103] The northwest thinning noted in this same sentence applies to various intervals within the Canadaway Formation, including the interval from the base of the Dunkirk to the Laona – but the principle expressed here, regardless of such thinning, is that *stratigraphic intervals within these sedimentary beds won't vary wildly from one location to another but will exhibit reasonably consistent variation*.

[104] See Vaughan et al., "Confirmation of Anomalous Westward Dip between Springville and West Valley, N.Y.", op. cit., Table 2 and Appendix II, where I and coauthors referred to this bed as the "big stratum" in our 1993 field work. Our elevation of ~1280 ft for this bed at the top of the upper Buttermilk Creek waterfall was revised based on additional field work in 1994-1995, resulting in the values shown above in Fig. 1.

105. *Configuration of resistant bedrock sill relative to bedrock valley.* There can be no doubt that the existing bedrock valley is older than the last glacial retreat, and it is essentially certain that the bedrock valley continues northward, at some depth and width, into Erie County.[105] If so, it is essentially certain that the hypothetical bedrock sill did not entirely block or bridge the preexisting bedrock valley to an elevation of ~1274 feet during the period from 10,000 to 6000 years ago. If the sill merely narrowed the bedrock valley but did not extend far enough eastward to block the valley entirely, it is implausible that Buttermilk Creek would have taken ~4000 years to meander far enough eastward to "find" the more easily erodible glacial fill on that side of the bedrock valley. This implausibility is not an impossibility, but it adds to the weight of evidence that the hypothetical bedrock sill never existed.

106. *Irrelevance of the USGS well reported by Bergeron.* The EWG erosion modeling report says that "Inspection of a USGS summary well log (69-USGS1-5) (Bergeron, 1985) compiled from wells drilled near the WNYNSC reveals a resistant member composed of shale interbedded with numerous thin layers of siltstone at an elevation of approximately 1,200 feet above sea level (see Table 11.1), which is close to the current elevation of Buttermilk Creek's river bed at its confluence with Franks Creek."[106] This doesn't appear relevant to the downcutting history discussed in the EWG erosion modeling report. See also the report's Table 11.1 which shows an excerpt from the summary well log for the USGS well. There are two problems with the report's claim that a "resistant" member "composed of shale interbedded with numerous thin layers of siltstone" is found at an elevation of approximately 1200 feet. First, the elevation of approximately 1200 feet appears irrelevant for resistant strata. See above discussion and Wilson and Young's Figs. 4.10-3 and 4.10-4. How (or at what geographic location) would resistant strata at an elevation of 1200 feet account for a pause in Buttermilk incision? Second, the claim about a "resistant" member appears entirely inconsistent with information quoted from the geologic log in the EWG erosion modeling report's Table 11.1. The phrases "Shale, weathered," "Shale interbedded with numerous thin layers (most less than 0.01 ft but some up to 0.1 ft) of medium to coarse-grained siltstone," and "Shale, as above but with much less interbedded siltstone" cannot be reasonably interpreted as "resistant."

107. The SEIS process may or may not engage in further investigation of local stratigraphy and erosion-resistant strata capable of "stalling" Buttermilk Creek incision for ~4000 years. While such geologic investigation may be beyond the scope of the SEIS process, the above discussion suggests that the following logic and course of action might be warranted:

- Erosion-resistant strata acting as a sill or caprock at ~1274 ft elevation in the Buttermilk Valley would provide a marginally possible explanation for the ~4000-year pause in Buttermilk incision.
- Paleoclimate variation, particularly a cessation or near-cessation of storminess for ~4000 years, would provide an equally plausible or more plausible explanation.
- *Some* reasonable explanation is needed for the ~4000-year pause in Buttermilk incision, but erosion modeling need not make a binary choice between such explanations.

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105 R.C. Vaughan, "Geologic and Hydrologic Implications of the Buried Bedrock Valley…", op. cit., and sources cited therein; also Zadins, op. cit.

106 Tucker et al., op. cit., p. 145.

- EWG erosion modeling could and should the treat erosion-resistant sill scenario and the paleoclimate-variation scenario as end members in a spectrum of explanations, and should perform separate model-calibration runs for each of these end members. In accordance with this "end member" logic, climate would remain constant during the resistant-sill calibration runs. Precipitation would cease entirely for 4000 years but climate would otherwise remain constant (effectively truncating the modeling by 4000 years) during the paleoclimate-variation calibration runs.
- Such "end member" calibration runs, combined with 1000-year and/or 10,000-year modeling runs, would show the *sensitivity of model results* to the choice between the resistant-sill scenario and the paleoclimate-variation scenario. With this information in hand, less extreme paleoclimate variations (e.g., not necessarily a complete drought but a prolonged drizzle-dominated period with minimal storminess) could also be applied to the modeled Franks Creek watershed.

XIII. Site stability & integrity issues relating to gullies and to stream piracy or capture

108. The work done on gullies in the EWG erosion modeling report is rudimentary[107] and thus unable to provide a realistic assessment of the risk that gullies pose to site integrity.

109. The formation of new gullies, and the headward advance of new and existing gullies, need to be characterized and incorporated into any erosion modeling that will support the Phase 2 decision.

110. The work done on stream capture in the EWG erosion modeling report is rudimentary[108] and thus unable to provide a realistic assessment of the likelihood of stream capture.

111. Stream capture, including stream capture initiated by seepage and piping, needs to be characterized and incorporated into any erosion modeling that will support the Phase 2 decision.[109]

XIV. Protection of water resources, floodplain ecology, and air quality

112. For any alternative that leaves waste onsite, the SEIS process should address attainment of water-resource goals such as "fishable, swimmable, drinkable," other measures of ecological protection,[110] as well as other measures intended to protect public health, safety, and enjoyment of affected waterways such as Zoar Valley and Lake Erie.

113. The 2014 aerial radiological survey of the Cattaraugus Creek corridor downstream from the Western New York Nuclear Service Center identified five areas in which gamma radiation

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[107] Tucker et al., op. cit., p. 25ff. and 95.
[108] Id., pp. 462-465.
[109] Vaughan EIS comments §§ 187-88.
[110] Newly completed New York Natural Heritage riparian assessment: See http://buffalonews.com/2018/03/23/watersheds-in-cattaraugus-county-among-healthiest-in-new-york-state-data-shows/ and http://www.nynhp.org/treesfortribsny

exceeded background.[111] At least one of these five areas was in the floodplain of Cattaraugus Creek where radiological contamination carried downstream from 1966-1972 West Valley reprocessing operations is a likely or plausible source of the elevated radioactivity. Followup soil sampling and testing of the five areas was conducted in 2015 by MJW Technical Services, Inc. Radionuclide-specific results from the soil tests from all five areas and corresponding background areas should be made available for at least two of the radionuclides commonly associated with reprocessing (Sr-90 and Cs-137). If any of the radionuclide-specific test results from floodplain areas are substantially above background, then biotic uptake processes should be investigated and characterized in the SEIS process. Depending on the results, radionuclide fate, transport, and bioaccumulation may also need to be addressed. All such results are relevant not only to historical contamination but also as guidance on downstream impacts from any wastes left onsite as a result of the Phase 2 decision. All such results should be reported in a floodplain and wetland assessment and also in a floodplain statement of findings incorporated into the Final SEIS or Record of Decision.[112]

114. For any and all exhumation, demolition, or remediation scenarios, there should be an extensive network of equipment to perform real-time monitoring of air and water for possible radionuclide releases, both on- and offsite.

XV. Anticipating Future Technological Capability and Changing Economic Circumstance

115. DOE and NYSERDA will be making a decision on a path forward for the West Valley Demonstration Project based on currently available technology, economics, and safety. The Preferred Alternative selected as a result of the SEIS process could be sitewide removal, sitewide closure in place, or a hybrid solution. Sitewide removal would meet the CTF's recommendations for a Preferred Alternative. A hybrid solution, if chosen over sitewide removal, would likely be based upon the technical complexities associated with sitewide removal, the expense associated with sitewide removal, or the relative safety of partial waste removal. However, these criteria are not static. With the timeframes discussed for implementation of the next phase of site closure, new technology to address the removal of wastes will become available. The economics of a hybrid preferred alternative will also change in time. Lastly, in time, several factors will significantly impact both site worker safety *and the safety of long term onsite storage.* Consequently, a decision to implement a hybrid solution for waste removal at the West Valley site cannot be deemed to be a final decision, but only another interim step or "Phase 2 plus." Therefore, reassessment of the preferred alternative plan of action, relative to the three criteria identified, would have to be completed again sometime in the future.

116. As described above, the likelihood that new technology will become available is important to consider for any interim hybrid alternative. A useful comparison can be found in the "technology-forcing" provisions of the Clean Air Act. These provisions have allowed enforceable deadlines to be set for *reducing air emissions below levels that could be met with current technology*, the idea being that the deadline would encourage and support the

[111] Remote Sensing Laboratory, National Securities Technologies, LLC, *An Aerial Radiological Survey of the Western New York Nuclear Service Center* (October 2015).
[112] See 83 *Federal Register* 7464 (Feb. 21, 2018) at 7468, column 3, for context.

development of new air pollution control technology capable of meeting new emissions standards. By this logic, sitewide removal is a better choice than a hybrid alternative because it would encourage and support the development of new cleanup technology, rather than simply waiting for new technology to appear.

117. According to the Features, Events, Processes and Scenarios (FEPS) Analysis prepared by Neptune:

> Deliberate and intentional intrusion scenarios are difficult FEPS to consider in terms of probability. There is no precedent to draw upon (e.g., there has been no known deliberate removal of waste from closed permanent waste disposal facilities). Regardless, intentional intrusion would not be expected to result in appreciably different doses than many unintentional intrusion scenarios involving direct waste exposure (e.g., mining and drilling). Additionally, all of the unintentional intrusion FEPS that are applicable at a waste disposal facility assume that institutional and societal knowledge of wastes has been lost. If such knowledge has been lost, then logically it is highly unlikely that any sort of intentional intrusion would occur (i.e., a potential intruder would have no knowledge of buried wastes). Conversely, if institutional/societal knowledge is not lost, then none of the unintentional intrusion FEPS would be applicable (e.g., it is highly unlikely that a known radioactive waste disposal facility would be mined for gravel). As all regulatory frameworks and previous PAs [performance assessments] assume loss of institutional/societal knowledge and focus on unintentional intrusion, the choice is made here to also focus on this. Therefore, all intentional intrusion FEPS are globally excluded.[113]

Given the fluctuations and upheavals seen throughout history in social/civic/ethical attitudes and governance structures, it appears unprotective to assume that intentional intrusion can be entirely ruled out. Recent historical examples of such fluctuations and upheavals can be seen, for example, in parts of Europe in the 1930s, parts of Southeast Asia in the 1970s, and parts of the Middle East at the present time. Intentional intrusion should be included in the scope of the SEIS process.

XVI. Conclusion

118. The many gaps and deficiencies outlined above need to be addressed and resolved. The SEIS process and associated Phase 2 decision will not be defensibly supported unless/until these issues are addressed and resolved.

119. The original Citizen Task Force, following nearly two years of study and deliberation in preparation of the 1998 Final Report to help guide decisionmaking for the long term management and cleanup of the WVDP site, came to the unanimous conclusion that the site is in no way suitable for the long term, permanent storage or disposal of long-lived radionuclides. Unlike arid regions of the West which are geologically stable and better suited for storage and disposal of nuclear waste, the West Valley site receives excessive precipitation annually causing routine flooding and rapid erosion events, and is less stable from geologic and seismic forces.

[113] Neptune, FEPS Analysis, § 5.2.4.4.1, Intentional Intrusion.

Large and small population centers downstream of the site rely on our water resources for drinking water, fishing and other water-oriented recreation, traditional cultural practices, and aesthetic enjoyment by local residents and tourists alike. The ensuing twenty years of additional study and monitoring, documentation of recurring severe storm and erosion events, plus a better understanding of the future effects of climate change on Western New York weather, only serve to reinforce that the West Valley Demonstration Project site is simply unsuitable for the permanent storage or disposal of any radioactive wastes. Based on this primary tenet, current Citizen Task Force members believe that the only Phase 2 decision which can ensure public health and safety for decades and centuries into the future is the eventual sitewide removal of all wastes.

Thank you for your attention to these comments.

Sincerely,

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Professional Geologist/Environmental Scientist

cc: A. Snyder, U.S. Nuclear Regulatory Commission
West Valley Citizen Task Force members