

Probabilistic Performance Assessment and how it can (but shouldn't) be abused or misused

Raymond C. Vaughan, Ph.D.

**West Valley Citizen Task Force meeting
October 28, 2020**

1

BACKGROUND

At the July 2019 CTF meeting, Dr. Alan Hutson provided an overview of probabilistic performance assessment (PPA) and statistical analysis.

At the June 2020 CTF meeting, I recommended that we ask Prof. Kristin Shrader-Frechette to do a presentation to the CTF – and/or a pre-meeting workshop. I also said I'd be willing to do a more elementary presentation.

On the July 8 CTF Agenda Work Group call, we decided that I would do my presentation in September or October, and the CTF would then be in a better position to understand whether a presentation in early 2021 from Prof. Shrader-Frechette might be useful.

2

2

BACKGROUND

Alan Hutson, Ph.D., Chair of Biostatistics and Bioinformatics at Roswell Park Comprehensive Cancer Center.



Kristin Shrader-Frechette, Ph.D., Professor at University of Notre Dame in Depts. of Philosophy and Biological Sciences, *specializing in quantitative risk assessment* – especially where radiological and energy-related risks affect public health and ecology. Member of West Valley Independent Scientific Panel (ISP).



3

3

PROBABILISTIC PERFORMANCE ASSESSMENT (PPA)

For many years I have supported the use of PPA as the best way to *address uncertainty* and predict West Valley site performance

(See Vaughan EIS comments dating back to 1996. My EIS comments are *an ongoing set of comments* that is readily available, such as in the 2010 EIS response to comments posted on DOE's West Valley website.)

PPA can be used responsibly and transparently – or can be manipulated and abused. *At the West Valley site, the evidence points to a biased and quiet (not transparent) choice of input probability distributions.*

4

4

PROBABILISTIC PERFORMANCE ASSESSMENT (PPA)

PPAs are different from Deterministic Performance Assessments in which a *single value* (a best estimate, or an estimate that's said to be conservative) is used for each of the input parameters in the assessment.

For example, in assessing future human exposure from the West Valley site, the *rate of erosion* is an important input parameter. Is the erosion rate equal to X, based on one information source? Or might it be Y or Z, as indicated by other information sources?

Deterministic assessments require the user to pick a single value (such as X or Y or Z – or an average?)

PPA uses a *probability distribution* based on X, Y, Z

5

5

Dealing with Uncertainty in PPA

- Input probability distributions are necessary for each parameter in the model to represent uncertainty
- Some key parameters include...
 - Inventory
 - Kd
 - Erosion rates



6

Dealing with Uncertainty in PPA

- **Input probability distributions** are necessary for each parameter in the model to represent uncertainty
- Some key parameters include...
 - **Inventory**
 - Kd
 - **Erosion rates**

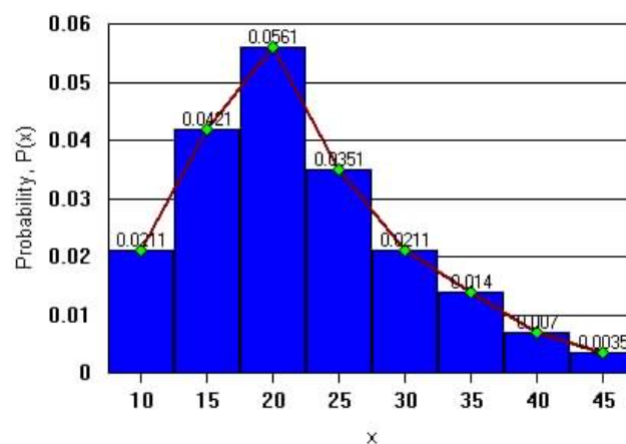


Neptune and Company, Inc • August 2020

7

7

Probability Distribution



Source: pindling.org

8

8

Types of Information

- Different sources of information can be used to inform distributions
 - Observational Data (Cookies, Erosion, Hyd. Cond.)
 - Modeling results (Erosion, inventory)
 - Experimental Studies (Kd)
 - Literature review and interpretation (Kd)
 - Expert elicitation
- Combinations of sources are used where possible
- Despite the variety of possible sources, data are sometimes sparse



Types of Information

- Different sources of information can be used to inform distributions
 - Observational Data (Cookies, Erosion, Hyd. Cond.)
 - Modeling results (Erosion, inventory)
 - Experimental Studies (Kd)
 - Literature review and interpretation (Kd)
 - Expert elicitation
- Combinations of sources are used where possible
- Despite the variety of possible sources, data are sometimes sparse – **but you need to look!**



Inventory or “source term” of Plutonium-239 (Pu-239) buried in the NRC-licensed Disposal Area (NDA)

11

11

NDA Inventory

- Distributions are developed based on information from previous studies
 - NFS burial records – “data”, but of variable quality (i.e. inconsistent data)
 - URS 2000 calculations – essentially a model of potential maximum site inventory
- There are two pieces of related information here
- Not the same as two “data points”



12

NDA Inventory

- Distributions are developed based on information from previous studies
 - **NFS burial records** – “data”, but of variable quality (i.e. inconsistent data)
 - **URS 2000 calculations** – essentially a model of potential maximum site inventory
 - **and --?**
- There are two pieces of related information here (**why only two?**)
- Not the same as two “data points”

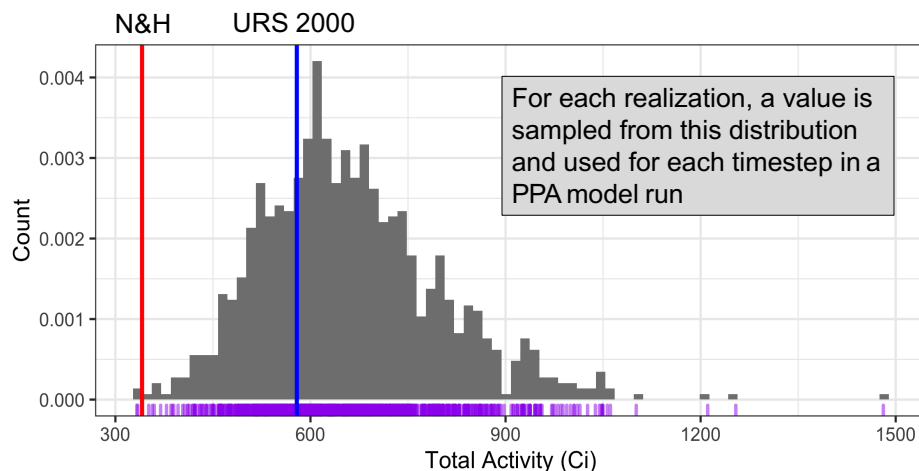


Neptune and Company, Inc • August 2020

13

13

^{239}Pu for all NDA Decision Units and Times of Disposal



Neptune and Company, Inc • August 2020

14

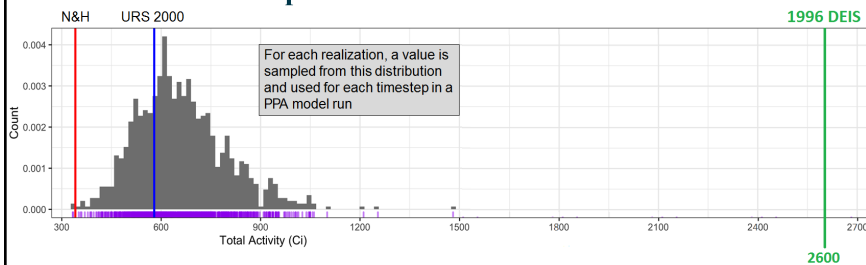
14

But something's missing here...

15

15

^{239}Pu for all NDA Decision Units and Times of Disposal

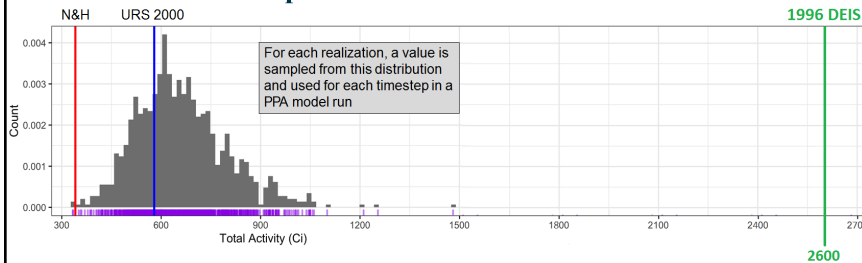


There's at least one more source of information (DOE and NYSERDA's 1996 Draft EIS, showing 2600 curies of Pu-239 in the NDA, mostly on buried filters) that's missing from the probability distribution developed by Neptune.

16

16

^{239}Pu for all NDA Decision Units and Times of Disposal



Did Neptune not know about this third source of information? Or did they deliberately reject it?

Neither of these is a good explanation.

17

17

Neptune *should be* aware of the 2600-curie inventory of Pu-239 in the NDA, based on:

- The 1996 DEIS (*issued by DOE and NYSERDA*)
- Vaughan EIS comments, esp. comment 111

If Neptune is aware of the 2600-curie value, there's *no reasonable basis for ignoring it*. Any uncertainty about the value needs to be handled responsibly and transparently.

Perhaps DOE and NYSERDA would say, yes, the value is from our own 1996 document – but is it credible?

18

18

Is the 2600-curie Pu-239 source term from the 1996 Draft EIS a credible value for NDA?

- **Wrong question. It requires a yes/no (deterministic) response to uncertainty that probabilistic assessments are meant to avoid.**
- **The value is uncertain (as my EIS comments acknowledge) – *but not zero probability***

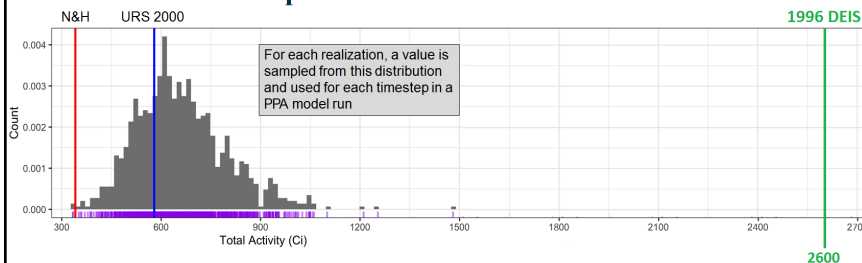
DOE and NYSERDA issued this value in 1996 but now can't trace the source of it. Failure to preserve supporting information can't justify outright rejection of this 2600-curie value.

Maybe a 10% or 20% probability that the Pu-239 source term in the NDA is 2600 curies??

19

19

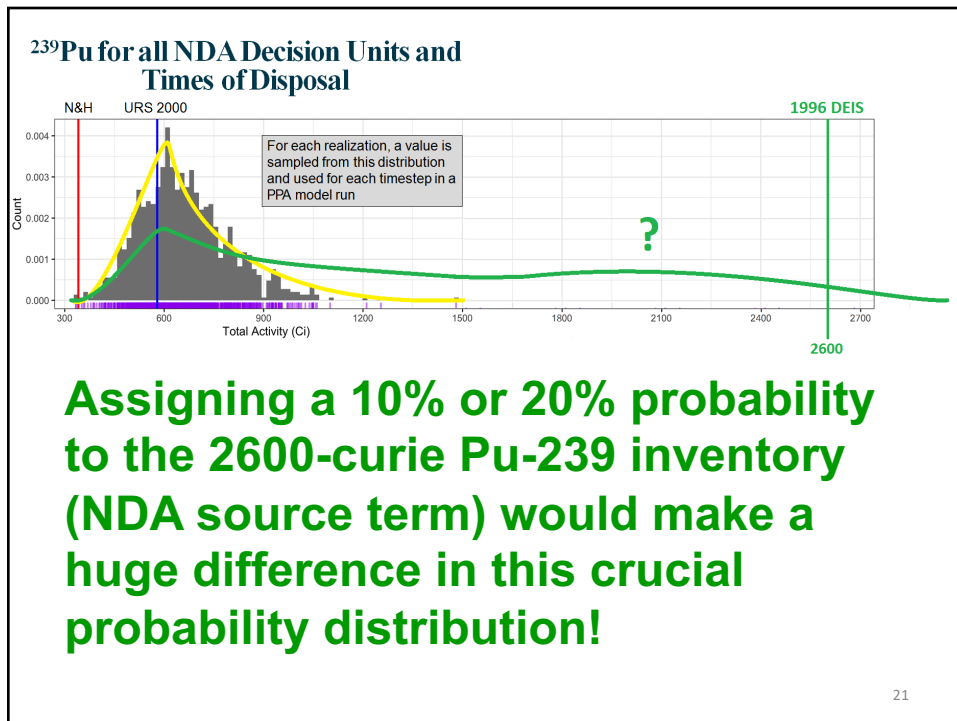
²³⁹Pu for all NDA Decision Units and Times of Disposal



Assigning a 10% or 20% probability to the 2600-curie Pu-239 inventory (NDA source term) would make a huge difference in this crucial probability distribution!

20

20



21

NDA inventory or source term

The purpose of PPA (avoiding deterministic choices of input values) is defeated when there's a deterministic choice to use certain information sources and reject others

This is a fundamental source of bias in any case, but the problem becomes worse when done quietly (secretly)

22

22

Rate of erosion

23

23

As with the NDA inventory, erosion predictions are greatly affected by choosing the information sources:

- **Which sources to accept and use?**
- **Which sources to reject and omit?**

Here again, the PPA will be biased by yes/no decisions about *which sources will be accepted and used for erosion*

At the West Valley site, how long does it take for erosion to cut into the burial trenches and start releasing wastes?

24

24

There are very large differences in the results from different methods used to predict erosion rates at the West Valley site, including:

- Hydrologic modeling in 1996 Draft EIS
- Neptune's work on the headward advance rate of onsite gullies
- Landscape evolution models used for 2010 EIS and Phase 1 studies

Which to accept, which to reject?

25

25

- Hydrologic modeling in 1996 Draft EIS predicts severe erosion of SDA, NDA, etc.
- Neptune's work on the headward advance rate of onsite gullies – probably an intermediate rate of erosion?
- Landscape evolution models used for 2010 EIS and Phase 1 studies predicts near-zero erosion of SDA, NDA, etc.

Which to accept, which to reject?

These will be the basis for *the most important input probability distribution* in the entire PPA process. A crucial choice – will it be done responsibly?

26

26

Erosion rate predicted by 1996 DEIS, with color added by Synapse (2008). The light brown areas are predicted to be eroded in 1000 years.

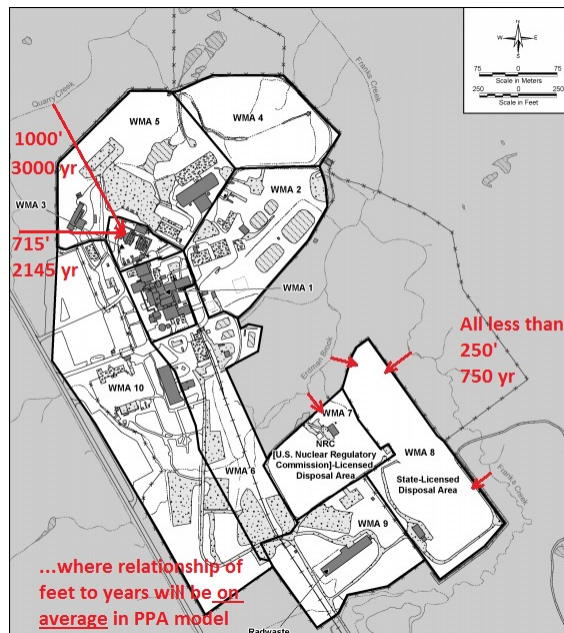
DOE and NYSERDA issued this DEIS in 1996 but now tend to reject it and *can't find the supporting data*. This doesn't justify rejecting the erosion studies done by/for the agencies in 1996.



27

27

Neptune's work on gully advance rate apparently finds erosion rates somewhat less than the 1996 studies – perhaps similar to the rates shown here?? *(These are my interpretations based on what Neptune said at the 11/14/18 QPM.)*



28

28

DOE and NYSERDA tend to favor the Landscape Evolution Model used for the 2010 EIS and Phase 1 studies.

This modeling predicts an extremely low erosion rate for the SDA, NDA, etc. – but it has many defects that are listed and explained in the CTF scoping comments dated 5/21/18 and Vaughan scoping comments dated 5/23/18. These defects have not been addressed.

LANDSCAPE EVOLUTION MODEL

29

29

We don't have current information on how Neptune's PPA and the EIS process are handling erosion. (It's been a long time since Neptune has provided an update.)

However, based on limited/outdated information, it appears that the Input Probability Distribution for the PPA will be based on Neptune's gully advance rate and on the problematic Landscape Evolution Model. The 1996 erosion work is apparently being rejected.

30

30

Erosion rate at West Valley site

The purpose of PPA (avoiding deterministic choices of input values) will be defeated if there's a deterministic choice to use certain information sources and reject others

This is a fundamental source of bias in any case, but the problem becomes worse when done quietly (secretly)

31

31

SUMMARY

Probabilistic performance assessments (PPAs) depend on input probability distributions, as shown here for erosion rate and for the NDA's inventory of Pu-239. These serve as important examples.

PPAs are not trustworthy unless their supporting distributions are done responsibly and transparently.

32

32

Questions?

Any recommendations on:

- inviting Prof. Shrader-Frechette to do a presentation to the CTF in early 2021?
- inviting Neptune to respond* to my presentation in early 2021?
- inviting Dr. Hutson to respond* to my presentation in early 2021?

*to respond particularly to the points I've made, so we're not just talking past each other

33

33

34

34



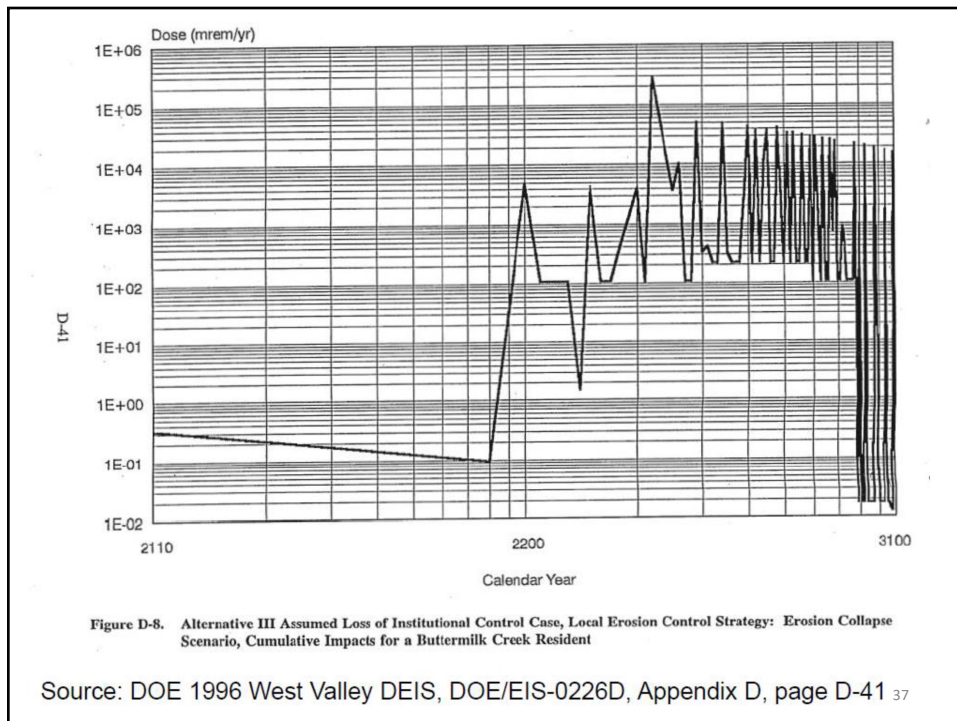
35

**2010 response by DOE and NYSERDA to Vaughan EIS
comments on NDA and SDA source-term uncertainties**

- 110-65** The uncertainty regarding the NDA and SDA inventory estimates is recognized. Conservatism about inventory is one of the many elements of conservatism used in the environmental consequence analysis.
- 110-66** The inventory of the NDA was revised in 2000 (URS 2000), and this is considered the best reasonably conservative estimate for the NDA inventory. The uncertainty in this and other inventory estimates is acknowledged in this EIS.

36

36



37

The 1996 Draft EIS indicates that the NDA contains about 2600 curies of Pu-239. See page C-42 (Table C-9).

38

38