Erosion Component of the West Valley PPA Model

Kelly Crowell, John Tauxe,
Paul Black, Dan Levitt

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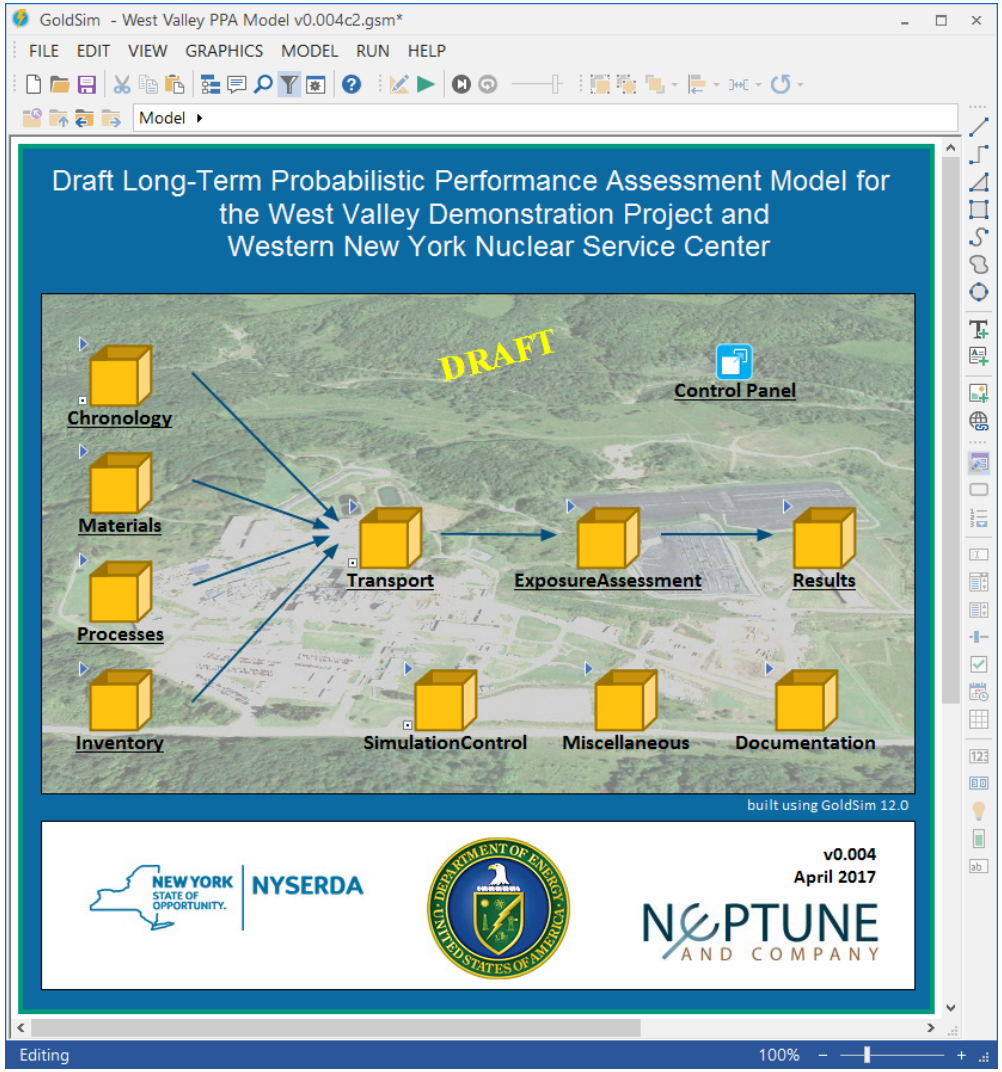
NEPTUNE AND COMPANY

The West Valley PPA Model

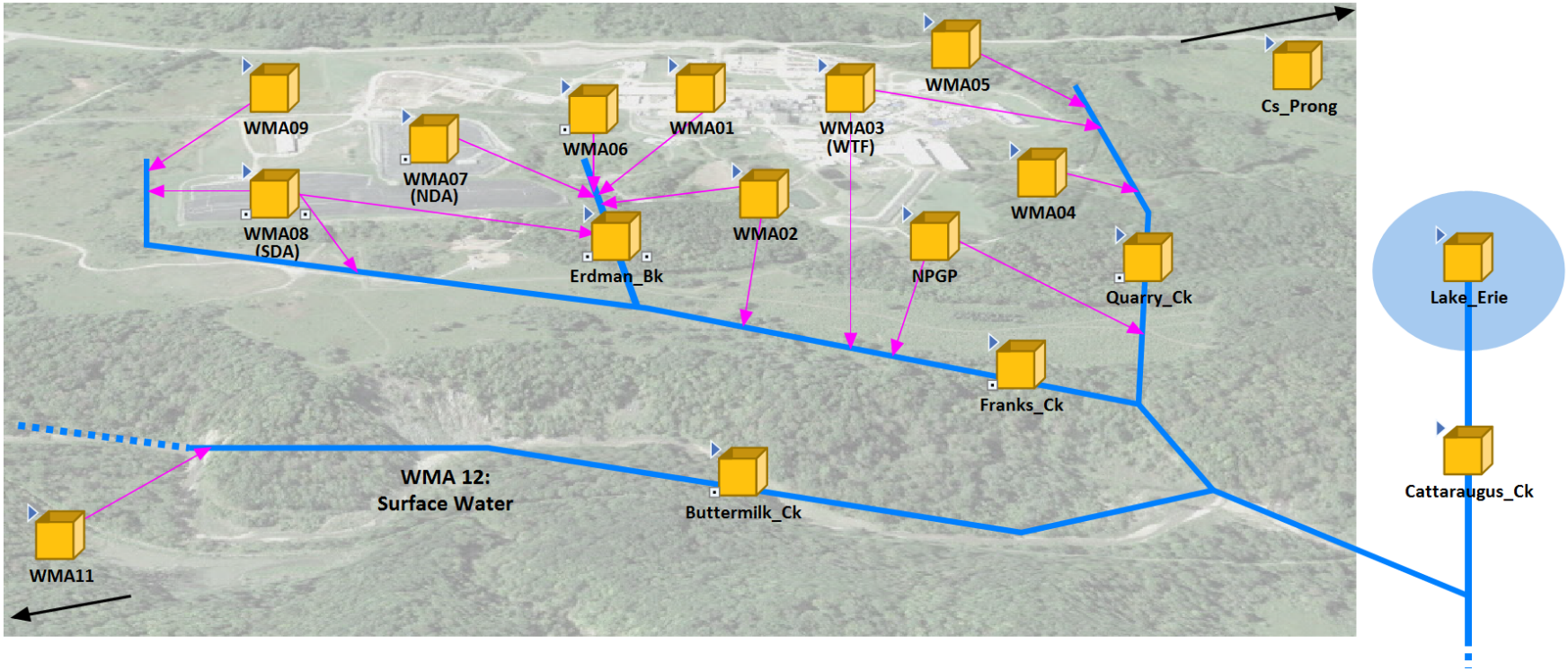


We are in the midst of model development.

The West Valley PPA Model is built using the GoldSim system modeling platform (under Windows). Player versions of GoldSim are available, so anyone will be able to explore and run the model.

www.goldsim.com

High-Level Layout of the Model



- The West Valley PPA Model is a GoldSim model of risk to humans and the environment.
- Erosion is one phenomenon of many that affects this risk and dose.

Supporting Process Models

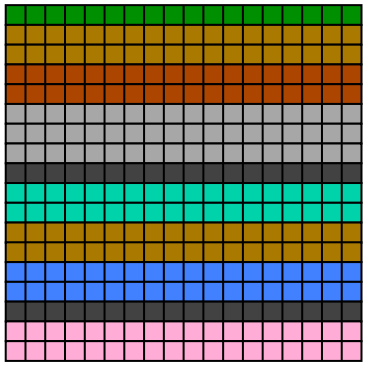
- groundwater flow
- erosion
- atmospheric dispersion
- surface water and sediment transport

Process *vs.* System Model

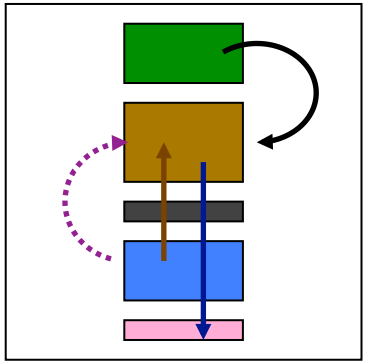
Process Model

- Specific processes (e.g. groundwater flow, erosion, etc.)
- Considerable complexity between coupled processes, fine spatial resolution, etc.
- Aimed towards understanding details of the physical system
- Example: The Erosion Working Group (EWG) erosion models

Process Model



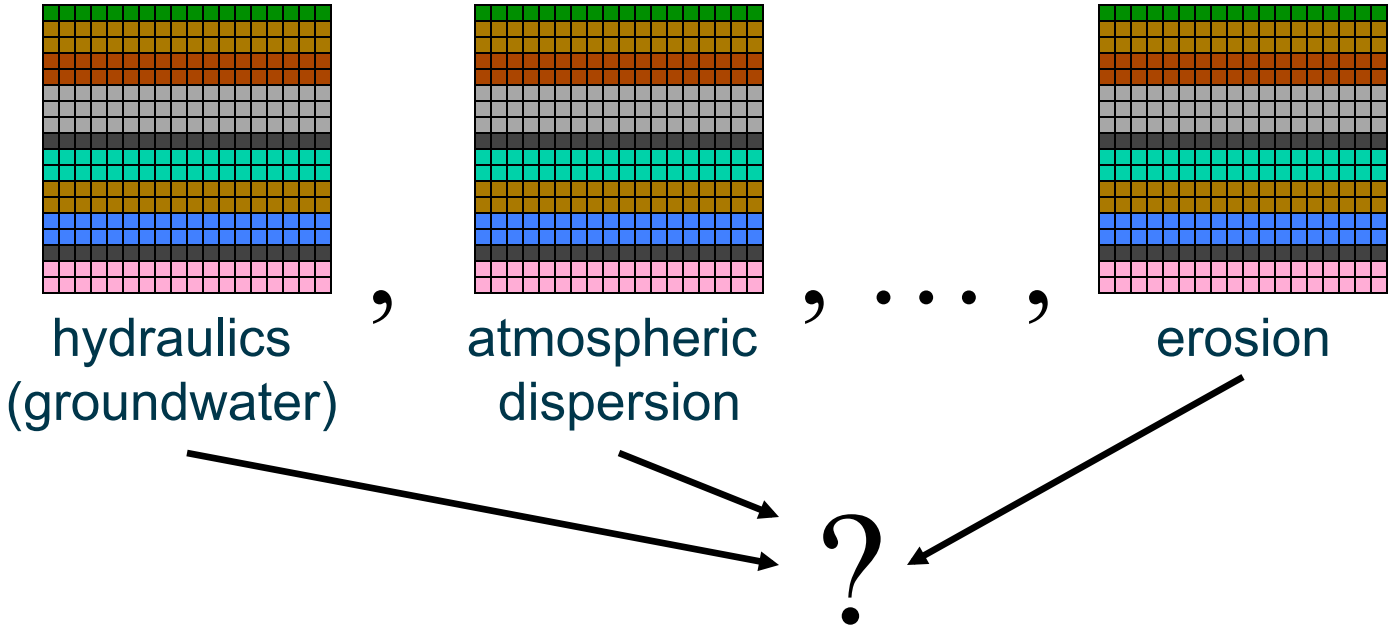
System Model



System Model

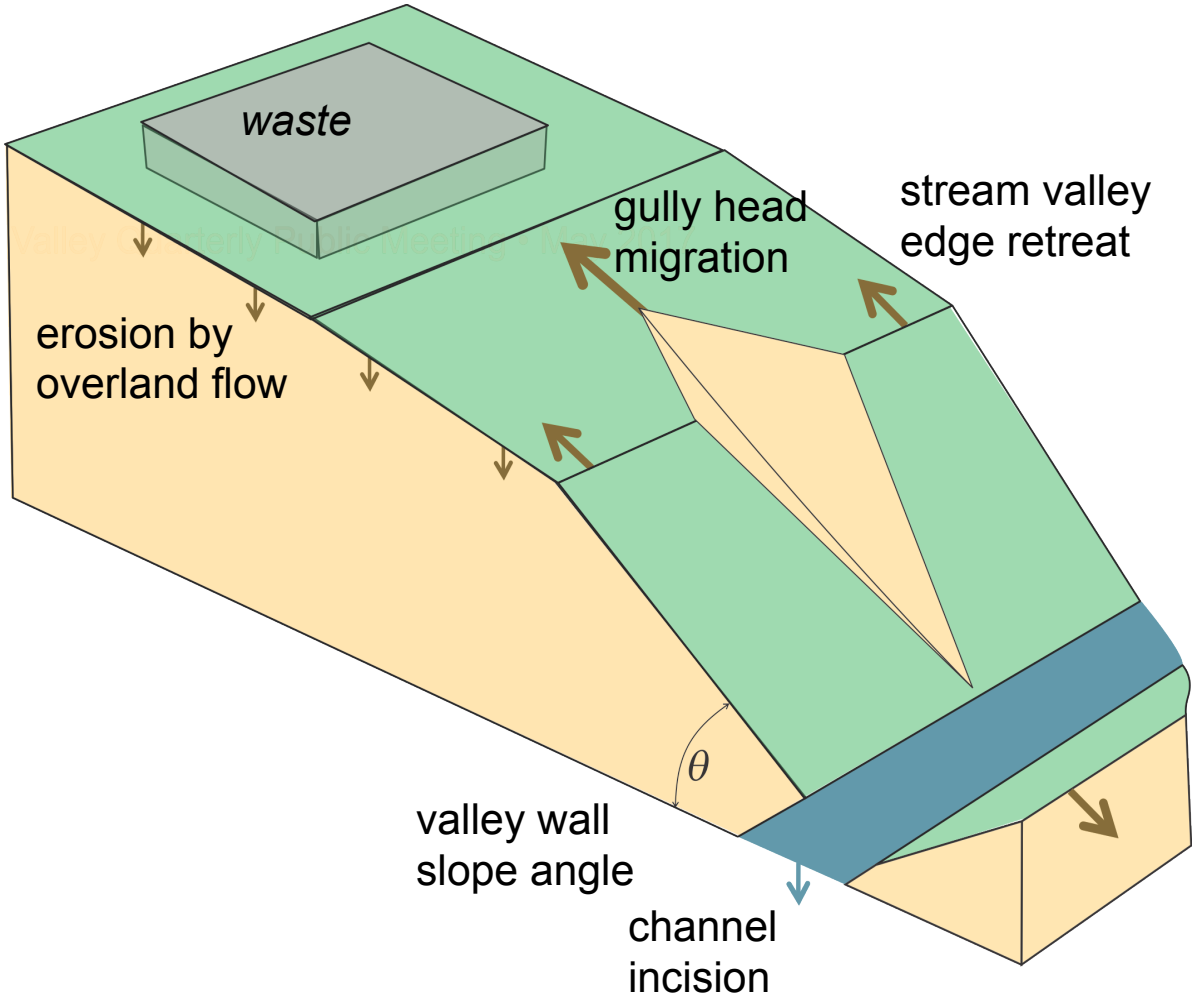
- Multiple coupled processes represented
- Simple until need for added complexity is demonstrated
- Based on characterizing and managing uncertainty in context of decisions to be made
- Example: The West Valley PPA Model

Discrete Process Models



Integrating the results of models with different physics and assumptions is problematic at best. Each model may have different assumptions/conditions, and is “unaware” of other processes. Assessing uncertainty and sensitivity of the system is impossible.

Conceptual Model



Hillslope profiles are shortened by either or both gully erosion, stream valley widening

Overland flow (sheetwash, rills) is considered to have minor landscape-forming effect by comparison

Conceptual Model

The hillslope segment is shortened by erosion from the following processes:

- Gullies
  - Inception or reactivation
  - Gully head migration
- Stream valley widening/valley edge migration
  - Landslides caused by channel incision and lateral migration
  - Tree root-bound block slides
  - Soil creep

Conceptual Model

Erosion rates are affected by features, events and processes (FEPS) such as:

- precipitation
- drainage area
- topography
- soil properties
- vegetation
- land use

Implementation

Probability distributions for the various erosion rates are developed from available lines of evidence such as

- literature (general and site-specific)
- small-scale process models
- field data – prior studies; EWG Studies 1 & 2
- Landscape Evolution Model – EWG Study 3
- multi-date aerial photography, LiDAR datasets
- elicitation of expert opinion

Initial broader assumptions may be used in the model to test sensitivity to inputs.

Small-scale process model for gully erosion

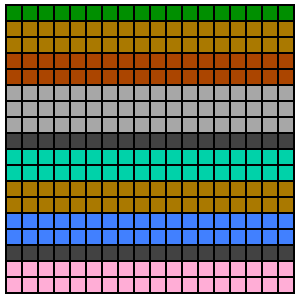
- A small-scale process model is used to predict gully erosion based on the relevant FEPS.
- Inputs to this small-scale gully model are provided, based on the lines of evidence, as either:
  - probability distributions (for a complete probabilistic model)
  - an experimental design (allows choosing designed input values from an underlying distribution or from a range of values).
- Probabilistic model inputs for the PPA erosion sub-model are developed from these erosion simulations using model abstraction (or reduced order modeling).
- The sensitivity analysis of the PPA Model compares these model inputs to modeled “endpoints” (such as risk and dose) to find the most sensitive inputs.

Model Abstraction

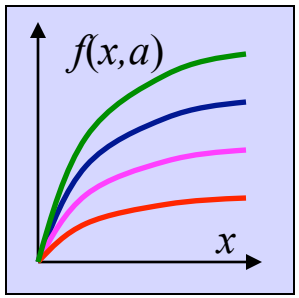
- What is model abstraction?
  - Simplifying a model to capture the essence of the important relationships (i.e., fewer parameters)
  - Decreasing computational complexity
  - An approximation to the original model
- Model abstraction methods
  - Uses statistical methods to generate an input probability distribution or model, and to match the process model with the system model needs.
    - e.g. global regression equation for volumetric gully head retreat rate[1] as a function of: *area*, *rainy day average precipitation*
  - Probabilistic modeling supports proper analysis of uncertainty
  - Combine with expert opinion as necessary and appropriate.

[1] VanMaercke et al., 2016

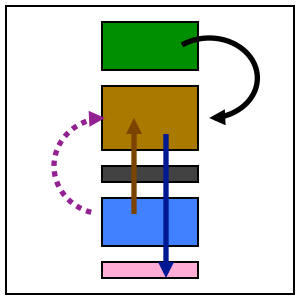
Incorporating Process Models by Abstraction



A process model is run to produce a range (or suite) of results.

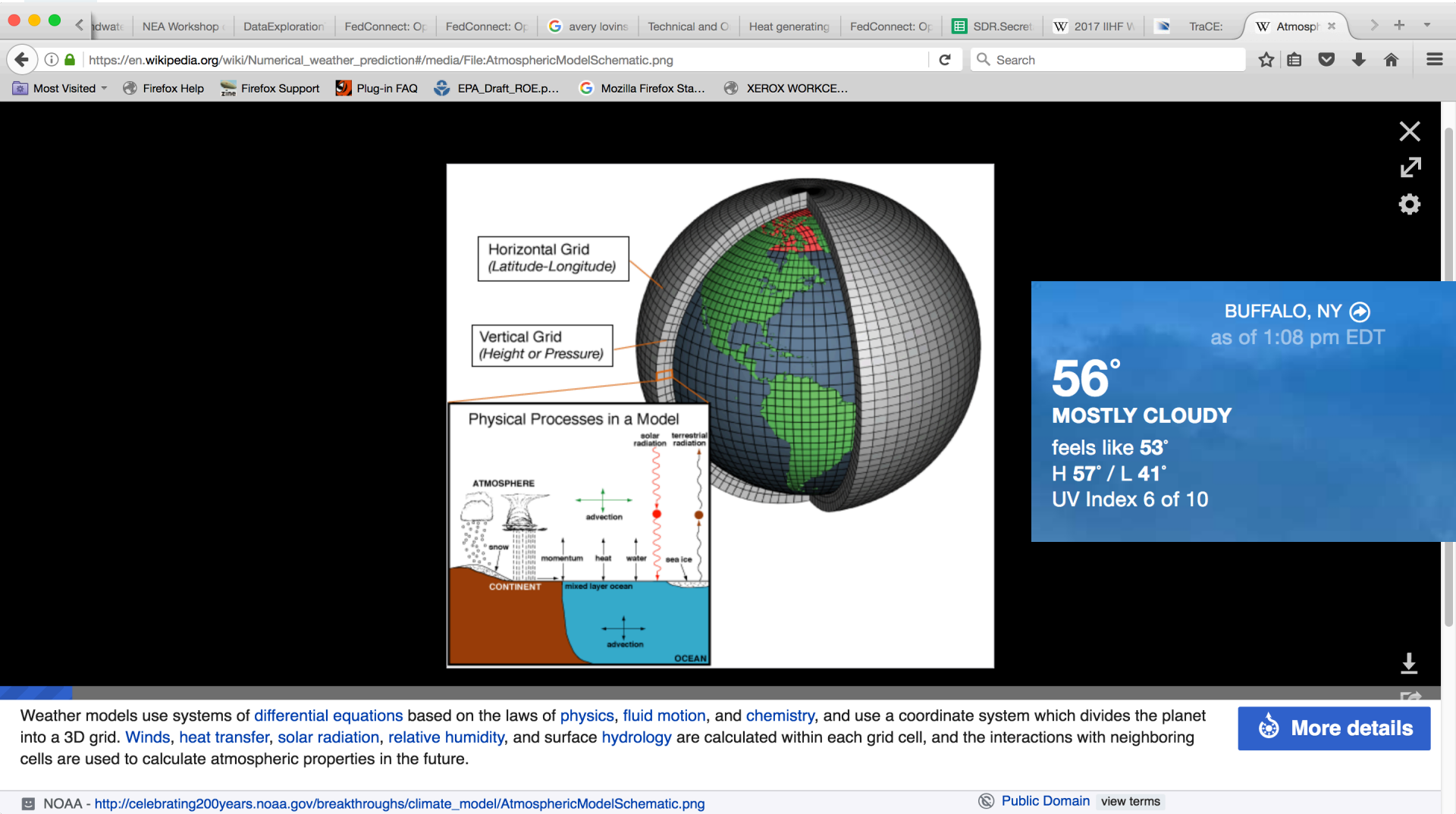


The process model is simplified into a response function.



This function is incorporated into the PPA system model.

Just like Weather Forecasting!



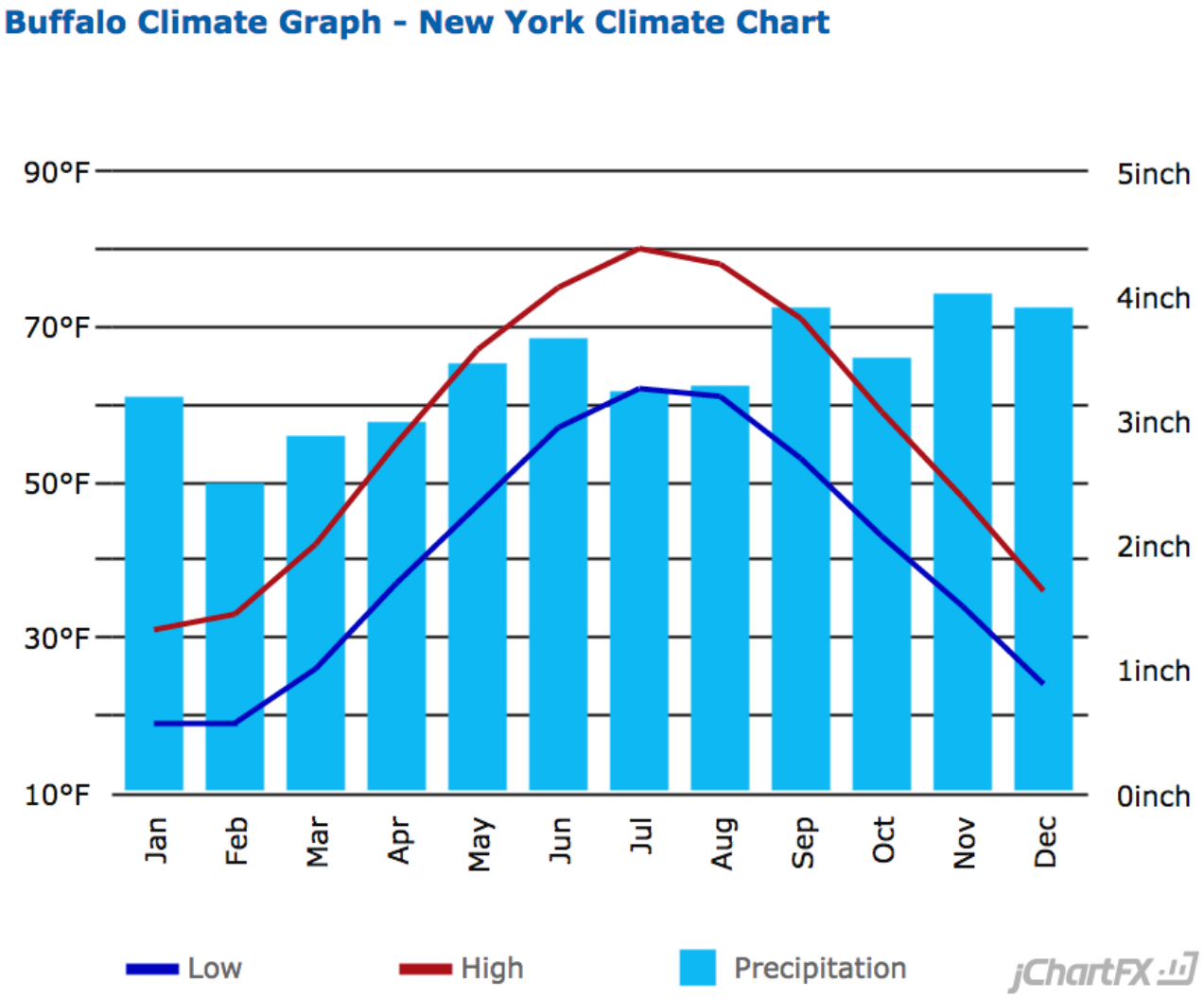
Weather models use systems of differential equations based on the laws of physics, fluid motion, and chemistry, and use a coordinate system which divides the planet into a 3D grid. Winds, heat transfer, solar radiation, relative humidity, and surface hydrology are calculated within each grid cell, and the interactions with neighboring cells are used to calculate atmospheric properties in the future.

More details

NOAA - http://celebrating200years.noaa.gov/breakthroughs/climate_model/AtmosphericModelSchematic.png

Public Domain view terms

But what about future projections?



Needs of the PPA Model

- Timing of encroachment onto each facility by gullies or hillslope erosion
- Nature of intrusion, i.e. does encroachment result in a sudden or a gradual release of contaminants?

Summary of Erosion Information

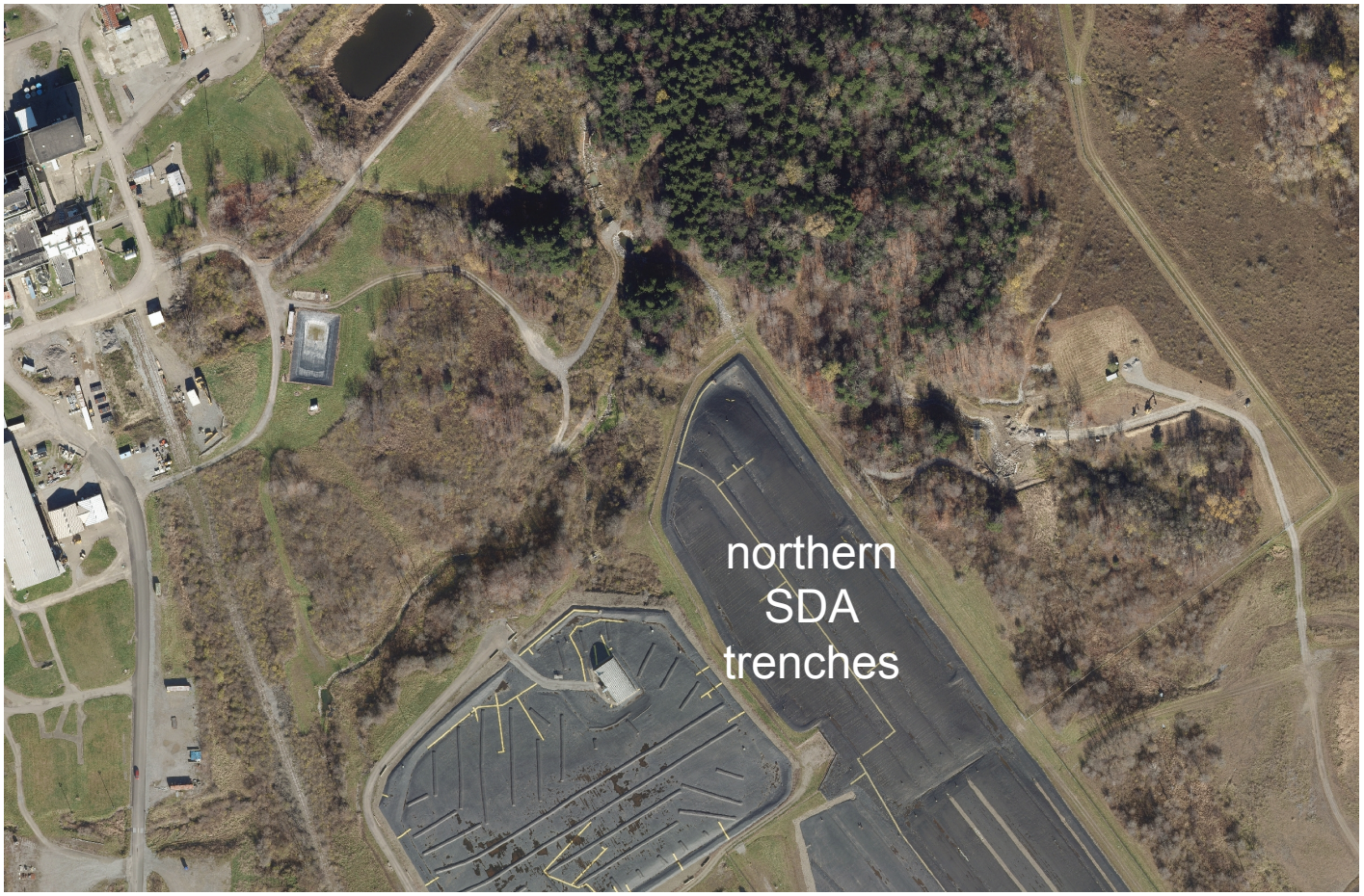
- Erosion modeling is one of many components contributing to risk and dose predicted by the PPA model.
- Model abstractions are developed to decrease complexity and computational burden.
- Conceptually, erosion shortens a hillslope profile which links a facility with a stream (or streams).
- Probability distributions for erosion process rates are being developed from appropriate lines of evidence.
- EWG LEM effort may provide lines of evidence for distributions on process model parameters, terrain lowering.
- Broad assumptions/simple distributions may be used for early model development and sensitivity tests.

Implementation of Erosion in the West Valley PPA Model

Now that we have seen what is needed from the erosion process modeling, let's look at the implementation in the West Valley PPA Model.

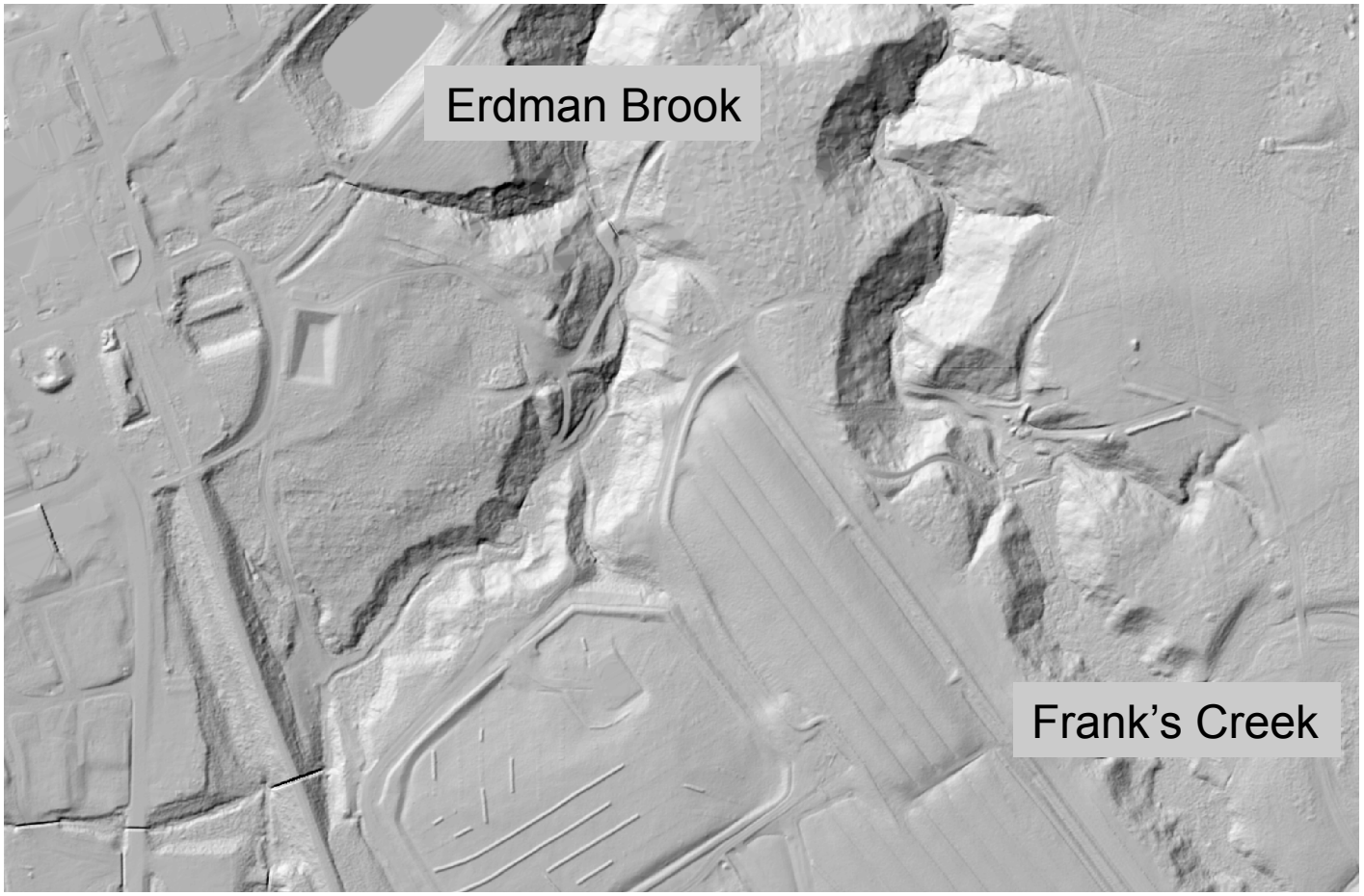
Example: The SDA

Example: Northern SDA Trenches



2015 orthoimage
courtesy NYSERDA

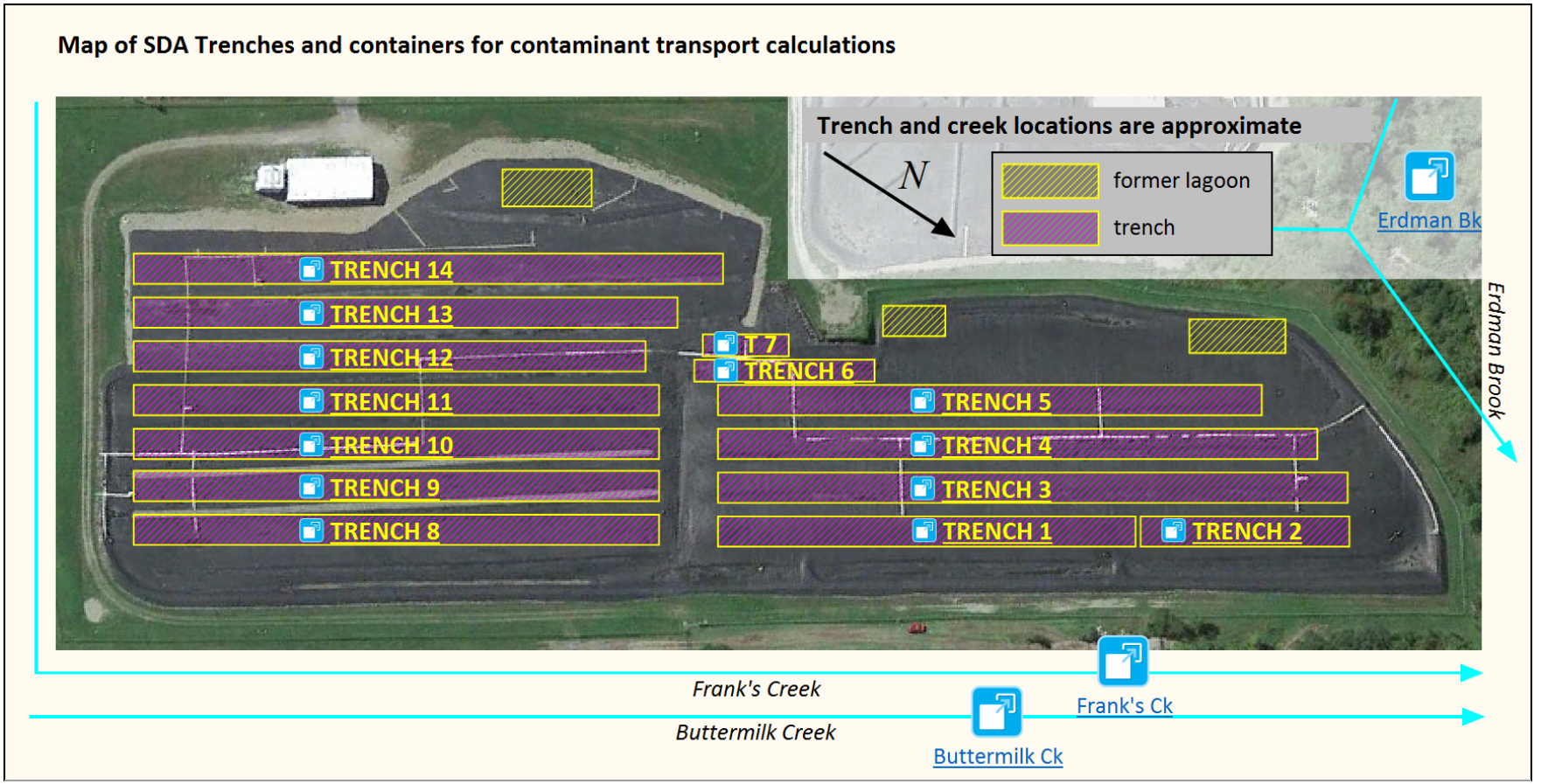
Example: Northern SDA Trenches



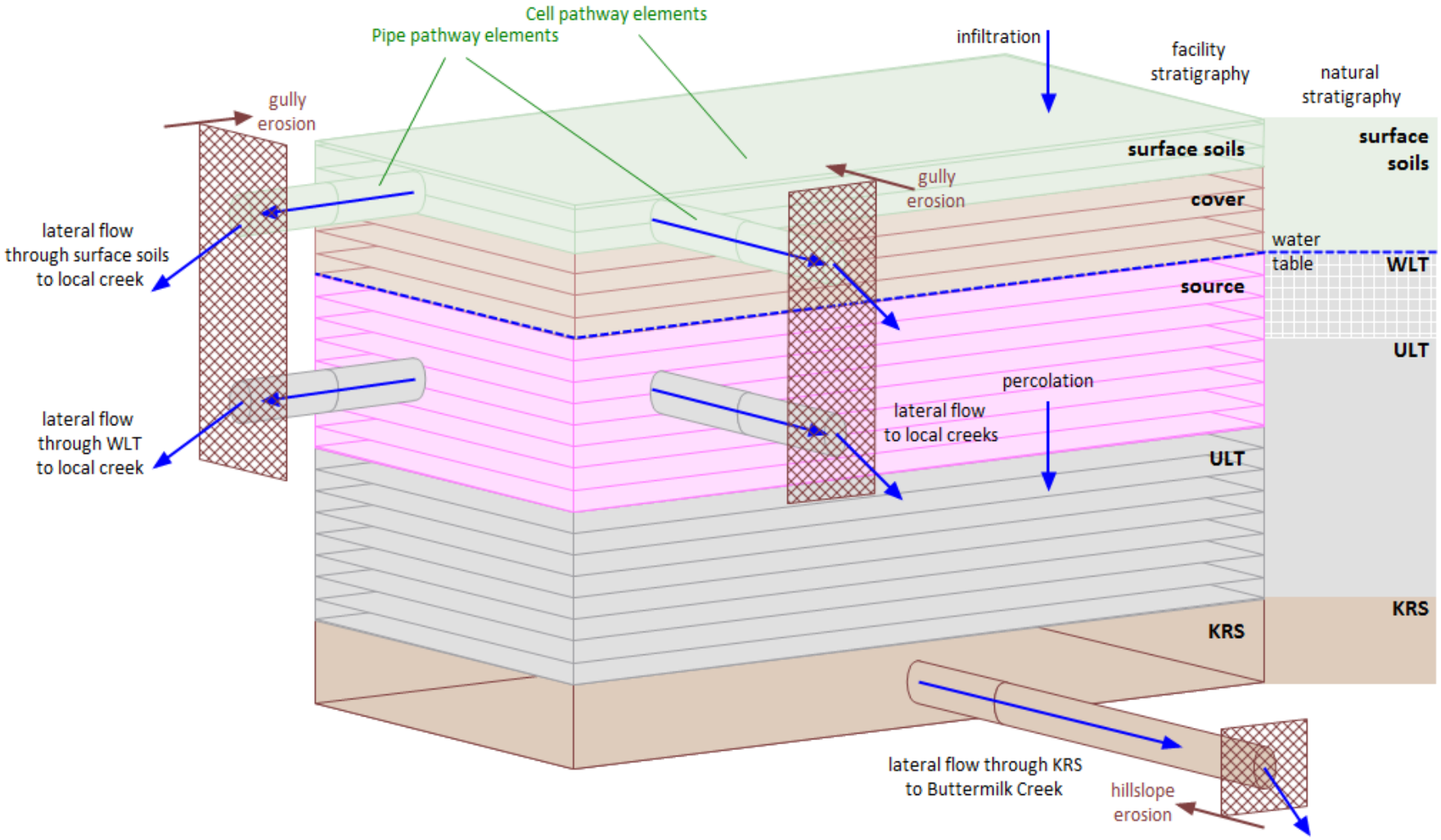
2015 LiDAR topography
courtesy NYSERDA

Recall the SDA Layout

The nearby creeks are necessarily abstracted to linear features with distances to the trenches. (*Not to scale, here.*)



Advective Water Flow Cells & Pipes



Erosion Modeling for the SDA

Gullies and hillslope failures migrate toward the trenches at appropriate rates, eventually intersecting them and causing all the waste to move from the affected trench into the creek.