Comparison of RESRAD and GoldSim Platforms for Evaluation of NORM Disposal Sites

Authors: K. Catlett, P. Black, R. Perona, S. Van Sickle, G. Occhiogrosso, A. Fleury

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Neptune Modeling Philosophy

- Keep it simple but not too simple
- Probabilistic models
  - Create more realistic, less conservative models
  - Allow full global sensitivity analysis to be performed
  - Reduce uncertainty in decisions
  - Optimize site performance
- Technically defensible, transparent, open, traceable

RESRAD-Onsite vs GoldSim

- RESRAD-Onsite is a purpose-built model for calculating dose and dose-based soil guidelines.
  - Well-tested and relatively simple to use, but limited to on-site exposure from a single, homogeneously-contaminated soil source.

- GoldSim is a general probabilistic Monte Carlo modeling platform, with tools for radionuclide transport.
  - Flexibility to address any transport pathways, waste geometry, and engineered systems.
  - GoldSim can be used for a variety of applications to support decision-making and risk analysis.

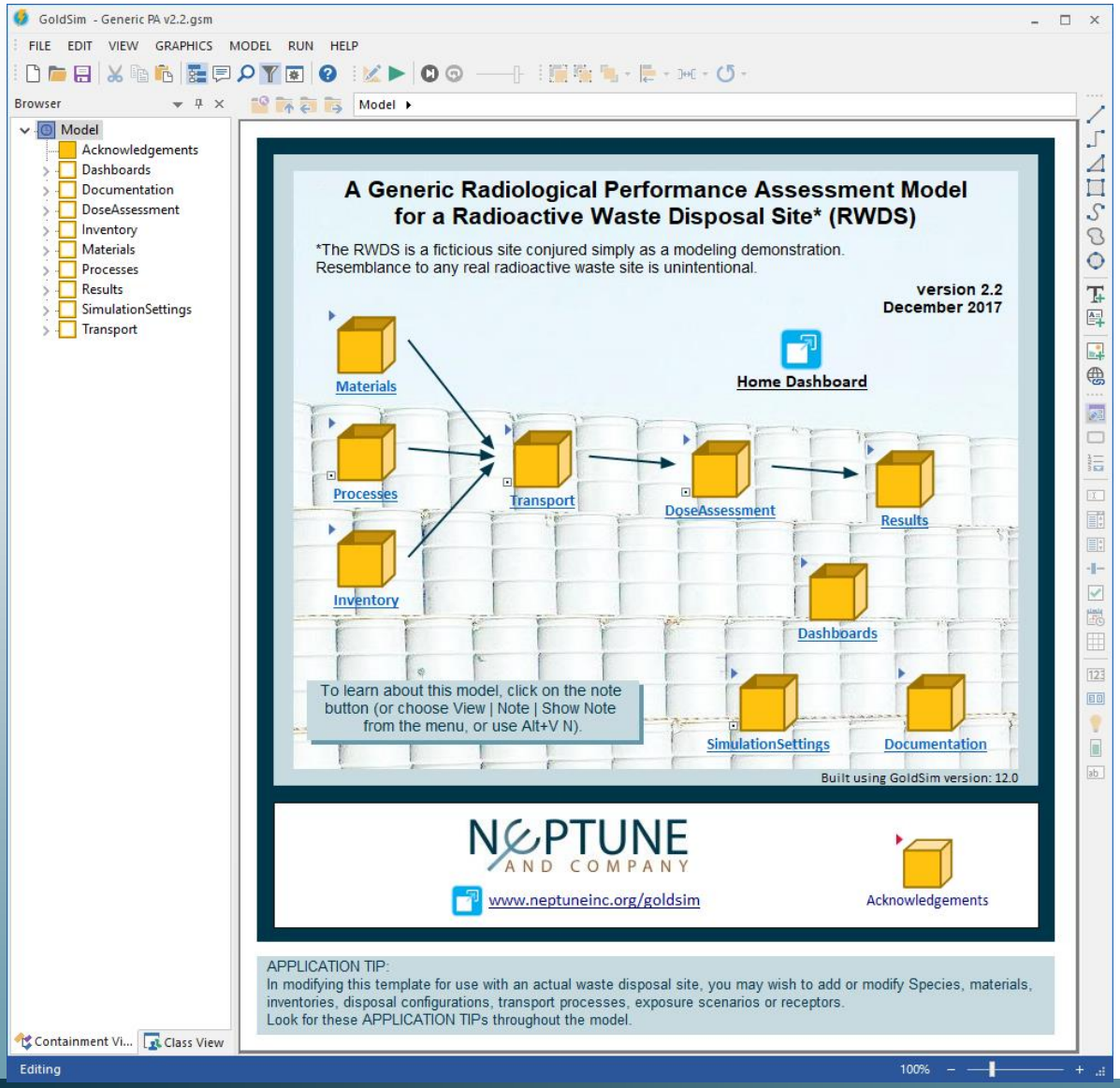
RESRAD-Offsite

RESRAD-Offsite is a newer member of the RESRAD family of software that provides better support for modeling subsurface radiological disposals.

Functionality of RESRAD-Offsite additional to that provided in RESRAD-Onsite includes:

- A source term module for release of radionuclides with infiltration as an instantaneous, uniform, or 1st order rate process.
- Evaluation of groundwater and air dispersion transport, and dose calculations, for off-site receptors.

A GoldSim Performance Assessment Model



PA Models in GoldSim provide information that can be used for site licensing, waste removal, waste limit regulations, and waste acceptance criteria decisions.

Radon Modeling Comparison

- Radon flux is modeled using Fick's diffusion and a finite difference approach in both RESRAD and GoldSim.

- GoldSim integrates radon air diffusion with diffusion of other radionuclides in water and air, and ingrowth of radioactive progeny along the path of diffusion.
  - ^{222}Rn parents move upwards via diffusion in pore water.
  - ^{222}Rn decays as it moves upwards, allowing the evaluation of dose related to the buildup of ^{222}Rn progeny (specifically, ^{210}Pb, ^{210}Po) in the cap.

EXAMPLES

- RCRA Subtitle C, Disposal Facility in Idaho

- Los Alamos National Laboratory, Material Disposal Areas A and T
- Disposal Facility Performance Assessment at Oak Ridge National Laboratory
- IAEA Model Comparisons: Zapadnoe Uranium Mill Tailings Site

Idaho Disposal Facility

- Limitations in previous RESRAD analysis overestimated dose because conceptual site model did not match RESRAD inherent structure.
- Objective was to improve previous site performance modeling and waste acceptance criteria by:
  - evaluation of site-specific environmental transport and exposure pathways;
  - reducing unrealistic protective biases.
- The RESRAD model “protectively” focused on groundwater pathways, even though there is compelling evidence that they are incomplete.

Pathways Comparison (1)

Transport pathway (Exposure route)	RESRAD	CSM
Infiltration to groundwater	×	–
Drinking water	×	–
Garden irrigation and livestock	×	–
Irrigation → soil (ext, soil ing, produce, dust inh)	×	–
Cover erosion—sheet and rill erosion	×	×
Reduced cap thickness (radon inh)	×	×
Cover erosion—gully erosion		–
Exposed waste (ext); locally enhanced infiltration		–
Gas-phase diffusion	×	×
Radon inhalation	×	×
Deposition of ^{222}Rn decay products in cover (ext, soil ing, produce, dust inh)		×
Water-phase diffusion		×
Radionuclides in cover (ext, soil ing, produce, dust inh)		×

ext: external radiation
ing: ingestion
inh: inhalation

– intentionally not included
(blank) not available to include

Pathways Comparison (2)

Transport pathway (Exposure route)	RESRAD	CSM
Plant root uptake by native plants		×
Deposition on ground surface (ext, soil ing, produce, dust inh)		×
Ingestion by cattle (meat ing)		×
Animal burrowing		×
Mixing of cover material (ext, soil ing, produce, dust inh)		×
Human intrusion (Cell 16: drilling of a water well)		×
Cuttings on surface or in mud pit (ext, soil ing, produce, dust inh)		×
Human intrusion (Cell 16: excavation for a residence)		×
Direct exposure to waste; subsequent exposure to excavated cap material (ext, soil ing, dust inh)		×

ext: external radiation
ing: ingestion
inh: inhalation

– intentionally not included
(blank) not available to include

Idaho Disposal Facility Results

- Decreased doses by more than an order of magnitude because of elimination of incomplete pathways and capability of building a site-specific model.
- Integrated Rn modeling in GoldSim increased Rn flux by about 3 times compared to previous RESRAD modeling.
- Optimize site by having a more realistic CSM.

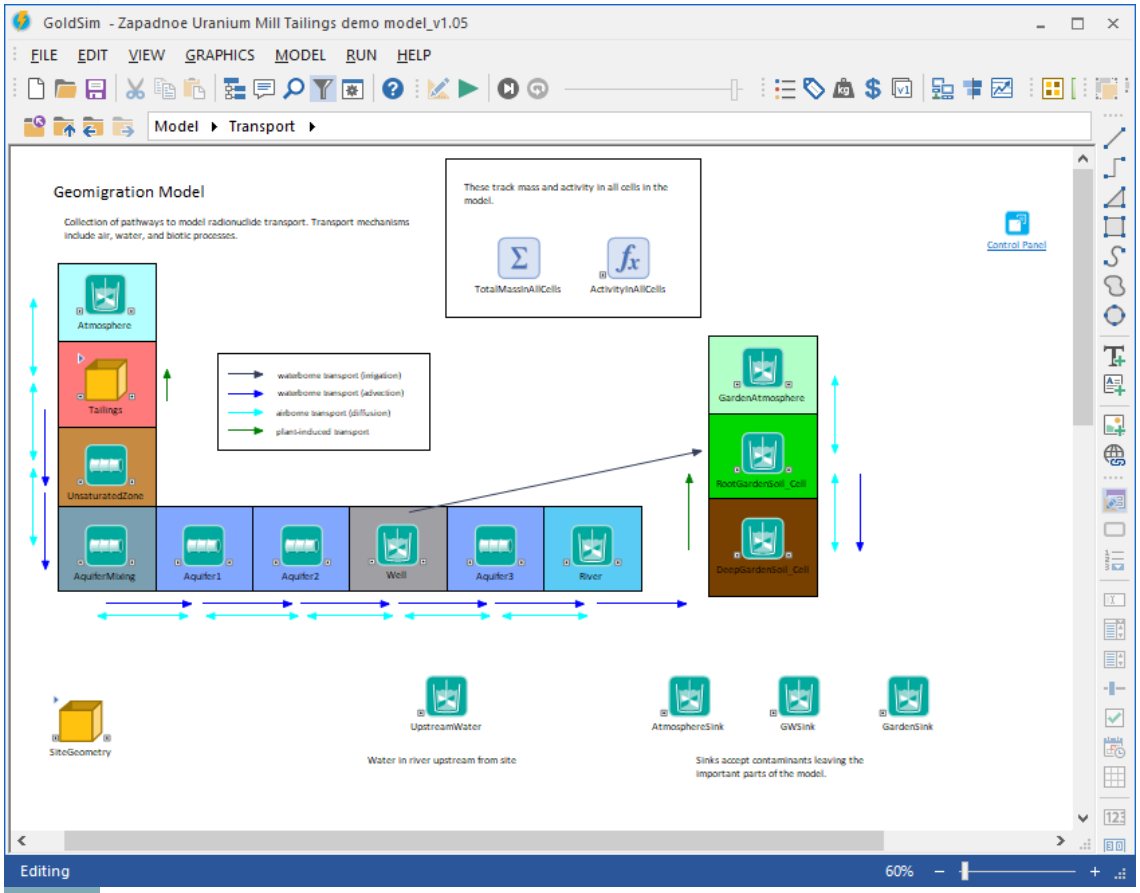
LANL MDAs A&T Example

- Transport and dose modeling was conducted using the RESRAD-OFFSITE software package.
- Key assumptions resulted in doses to ~40,000 Ci of transuranics under a few feet of cover to be minimal:
  - During 1000 years of institutional control no deep-rooted plants, burrowing animals or human activity (besides trespasser) are allowed.
- Bottom line: RESRAD software was suitable for demonstrating that dose will be negligible for 1000+ yrs, under strict assumptions, but it cannot assess risk from burrowing animals and deep plants, which other models at the site have shown to be important.

Oak Ridge Disposal Facility Example

- RESRAD-OFFSITE was used to model groundwater pathway risks for a radioactive waste disposal facility Performance Assessment.
- RESRAD does not support dynamic cover evolution over time and so limited “what if” games were played to try to address system dynamics.
- Very limited probabilistic analyses were done because of RESRAD constraints.
- Bottom line: define project modeling and decision objectives and then select the best-suited platform instead of selecting RESRAD first, and then try to figure out ways to overcome its limitations.

Zapadnoe Uranium Mill Tailings Site



- IAEA working group comparison of multiple modeling tools. Demonstration model.
- Species: Pb-210, Po-210, Ra-226, Rn-222, Th-230, U-234, U-238
- Exposure Receptors: Onsite Worker, Offsite Resident
- Exposure Pathways: External Irradiation, Inhalation (radon & dust), Ingestion (fish, vegetables, soil)

GoldSim vs RESRAD in a Nutshell

RESRAD
works well when model structure matches site and decision needs (e.g., screening assessment)

- Simple
- Default values
- Free
- Regulatory requirement

GoldSim
optimizes site performance and decision making

- Completely flexible
- Site-specific pathways or characteristics
- Fully probabilistic - captures uncertainty
- Integrated radon transport

GoldSim Advantage

GoldSim supports:

- Evaluation of all potential site-specific pathways
- More flexible probabilistic analysis
- Optimization of long-term decision making, including future disposal, closure, and stewardship
  - where to dispose waste
  - how deep
  - cover type and structure
  - engineered systems
- Within-model documentation