GOLDSIM USER CONFERENCE POSTER ABSTRACTS

1. Development of Soil Inventory Model for the Hanford Site using GoldSim

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The Hanford Site located in southeast Washington state received large volumes of liquid discharges (several billion liters) to over 400 waste sites during nuclear weapons material production mission (1944 – 1988). Over 200 types of waste streams have been identified resulting in over 6000 records of releases to the soil. A soil inventory model is developed in GoldSim to quantify the liquid discharge volume at each waste site along with discharged inventory of about 50 constituents (chemicals and radionuclides) based on probability distribution functions of waste stream compositions, liquid volume released over time, and waste stream density. An analytic calculation approach is adopted to determine the statistical mean and variance to describe the uncertainty in the discharged inventory that forms the input to the contaminant transport model. The analytic calculation approach is deemed superior to the Monte-Carlo based sampling approach.

2. Using GoldSim in a Missouri River Oxbow Lake Restoration Project

Author: Charles Ikenberry, FYRA Engineering

It is well-established that phosphorus is typically the limiting nutrient for algal growth and a driver of eutrophication in freshwater lakes. Therefore, phosphorus reduction is a common objective of lake management. This poster describes the application of GoldSim for a water and phosphorus mass-balance approach that quantifies distinct fluxes and the potential impacts of water quality improvement strategies in shallow, oxbow lake adjacent to the Missouri River in Council Bluffs, Iowa. Key inputs and processes include precipitation, upstream diversions, evaporation, overflow, groundwater/seepage, phosphorus sedimentation, and sediment-phosphorus release, which was informed by assessment of sediment chemistry. The approach illustrates variations in annual phosphorus loading rates, quantifies the temporal importance of internal vs. external loading, and estimates potential benefits of various water quality improvement alternatives. Improvement strategies include watershed BMPs, management of diversion flows and seepage rates, alum injection of diversion inflows, establishment of in-lake wetlands, dredging, and internal loading control. The stochastic features in GoldSim informed both model calibration as well as selection/prioritization of lake restoration strategies.

3. Case Study Database Structure in Support of Simulation Modeling

Author: Warren Farr, Informed Dynamic Solutions

Simulation models are used to gain a deeper understanding of how complex problems unfold over a specified timeframe. Such an understanding can result in more effective and lasting policy decisions. Building useful simulation models requires the careful collection of a wide variety of information and data "artifacts" about the system being modeled. Collected artifacts are used to inform the structure and parameterization (and thus behavior) of the model. While many different artifact collection techniques are understood in detail, little attention has been paid to how a collection of such artifacts should be organized for optimal use. Such a database structure will deliver easy collection and reporting of artifacts before, during, and after the modeling process, and increase model transparency, understanding, and supportability. This poster describes the elements and structure of such a case study database.

4. Water Balance Model for an Underground Mine in the Great Lake Region

Authors: David Hoekstra, SRK Consulting
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This poster will present the key components of a comprehensive water balance model developed to support a Pre-feasibility study of an underground metal mine in the Great Lake Region. The model includes the underground mine component, process areas, and a remote tailings facility, as well as the surrounding watersheds, drainages, and lakes to evaluate the impact of the mine on the surrounding environment. SRK developed several modules to support the water balance, including stochastic rainfall and temperature generation, snow pack and snow melt behavior, lake ice up and ice out volumes, stream routing, and dynamic tailings stage storage curves. The model is being used to evaluate many aspects of the mine plan, including backfilling campaigns, inter-basin transfers, and excess or surplus water conditions.

5. Optimization of Tank Farm Waste Removal by Implementation of an Objective Function to Minimize Cost of Removal While Considering Dose to the Receptor of a 435.1 Performance Assessment

Authors: Ryan Childress, WRPS
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Glenn Taylor, WRPS

This optimization model is an add-on to a stochastic tank farm performance assessment model, which has been developed prior to retrieval of tank waste, to give us insight on how much, and of what phase waste is needed to be removed to meet the performance objectives of a DOE Order 435.1 Performance Assessment. Retrieval of waste from tank farms can be extremely expensive, so the objective function focuses on reducing removal cost, while the required condition is that the maximum annual performance objective dose of <15 mrem from the Groundwater Pathway still be met. Before the optimization model is run, the stochastic tank farm model must be run with non-retrieved phasic inventories, which then passes a given dose based on a non-retrieval case in mrem/yr based on a chosen cumulative probability. We know that Technetium-99 is our main risk driver based on both our process and stochastic system models, so we use a Technetium-99 removal fraction for each tank as our optimization variables. The combination of these two models could be utilized to aid retrieval decisions in the near future.

6. Incorporation of Muk3D modelling into GoldSim

Author: Carlo Cooper, MineBridge Software Inc.

A limitation within GoldSim when modelling Tailings Storage Facilities (TSFs) is that they can only be represented as 2D (storage elevation curves) or 3D approximations using simplified pond/beach models. Building on the work done by GoldSim to integrate Python code into models using the External DLL element, we can now integrate 3D modelling capabilities into a GoldSim simulation.

Muk3D is a commonly used tool for the design of TSFs and allows users to undertake conceptual designs and detailed staging using 3D tailings deposition models. It has the capability to have models driven by external programs such as Excel and GoldSim.

This poster demonstrates several applications where a 3D model has been integrated into a GoldSim model. These applications include integration of tailings deposition into a simple water balance for long range TSF planning, optimization of starter dam elevations, and generating animations driven by GoldSim simulations.

7. Scaling Input Distributions for Probabilistic Models

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It is important to address scaling issues when building probabilistic models. Typically for radioactive waste performance assessment models, probabilistic models are run using one value from each input distribution over the entire modeled time. The distributions represent the current state of knowledge in the mean of the input variable over the spatial region of interest and over the time period of the model run. This poster focuses on the time factor in input distribution scaling because it presents more serious conceptual and distributional challenges than the spatial factor. One of the challenges in temporal scaling is the effect of non-linearity on propagation of distribution uncertainty through to uncertainty in results.

Different scaling scenarios were investigated by comparing three analysis tools: analytical mathematical representations, R statistical software, and GoldSim Monte Carlo simulation software. A simple linear model, a multiplicative model, a quadratic model and a square root model were the initial scaling scenarios for each of these tools.

The effects of temporal scaling were demonstrated by investigating two different time scales. For one set of models, the input distributions were scaled to represent the expected mean value of the input variable over the 100 years of simulation, and one value from that distribution was chosen for the entire elapsed time. The other set of models was set up so that the input distributions represented the expected value on an annual time scale, and a new value from that distribution was chosen every year (at every time step which equaled a year) for 100 years.

Results show good agreement across the three analysis tools. As expected, the linear models have identical results for the two different time scales, and the non-linear models diverge in the results for different time scale implementation. The implications of this work point to the need for careful consideration of input distribution temporal scaling.

8. Evaluating Ecological Risks in the West Valley Probabilistic Performance Assessment

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Performance assessments (PAs), whether probabilistic or point estimates, have focused on evaluating human health effects of radionuclides. In the past it was asserted that protecting human health would automatically protect the environment, but this blanket had been questioned so tools and methodologies to directly estimate non-human biota dose were developed and have been readily available since the early 2000s. For example, the Biota Dose Assessment Committee (BDAC) guidance led to the development of the RESRAD-BIOTA software to implement this guidance. Parallel efforts have been in place in Europe with the development of the ERICA tool (Environmental Risk from Ionising Contaminants: Assessment and Management). More recently, interpretation of the requirements of DOE Order 458.1 have led some waste management facilities to include ecological risks in addition to human health effects in their PAs. We have recently applied methodologies to assess ecological risks within probabilistic PAs (PPAs) for the West Valley site in western New York.

One of the challenges in applying the non-human biota assessment models to PPAs is that ecological risk assessments following EPA or DOE guidance start with protective screening assessments before moving into more site-specific ecological risk assessments. Conservative assumptions bias the screening assessments and greatly overestimate the risks posed by contaminants. Although the screens are biased they can be useful in ruling out model spatial domain areas or types of biota from requiring further assessment. In some cases, the results of the screen can entirely rule out ecological risks from further assessment. For a refined and unbiased estimate of dose to non-human biota, one would typically conduct site-specific studies to better define exposure through the food web or adverse effects based on ecotoxicity studies of weathered contaminant mixtures. However, for PPAs that consider future site conditions after the loss of institutional control, such site-specific studies are not possible. What is done for the site-specific future ecological risk models is to develop a distribution of population doses or exposures and calculate the distribution of possible adverse effects to future ecological populations. This approach considers both radionuclide and chemical inventory. For the West Valley site, the model spatial domains include riparian and aquatic environments located downstream of the waste disposal areas. These riparian and aquatic environments represent linear exposure elements for some wildlife population and require special consideration of exposures to individuals and to populations along such spatial domains. At a minimum, wildlife foraging should be biased along the axis of such water bodies. The riparian and aquatic environments also have threatened and endangered species, which should have greater levels of protection given their rarity. One of the challenges in conducting ecological risk assessments is how to evaluate threatened and endangered species in the future. This might be best handled by evaluating potential for impacts on individuals of feeding guilds with species that are currently threatened or endangered. We also have to consider how ecological populations might change as a result of climate change. It is a more difficult problem to predict what species might become rare in the future, and how to best assess future populations of threatened or endangered species.

9. GoldSim Plotting Hacks to Enhance Communication of Results and Make Life Easier for the Harried GoldSim Developer

Author: Paul Haby, Stantec Consulting Services Inc.

This presentation describes several unique approaches for creating and enhancing GoldSim time series plots. The first tip demonstrates use of vectors to convey additional information about a single time series result (such as month or season, model calibration period, or operational status of a system). The second tip describes a method to display non-scenario related data in Scenario Mode plots. The final tip describes an array-based method to simplify creation and maintenance of numerous related plots containing multiple data series (such as in the case of water quality constituents at multiple monitoring locations).

10. Matrix Lookup Table for Modelling Tailings Pond Development

Author: Aaron Brisbin, Golder Associates

An important part of developing a water balance model for mine sites is modelling the storage capacity and surface are of the tailings impoundment as this is typically the largest water storage reservoir at a mine site. Tailings impoundments behave unlike other reservoirs for storing water since the continual deposition of supernatant tailings material will change the storage characteristics of the impoundment. By using a matrix lookup table in Goldsim, we can more accurately reflect the true water level-storage capacity of the impoundment between successive modeled deposition conditions. This allows for more accurate modelling of what is typically the largest storage reservoir and evaporative loss source on a mine site.

11. Sulphate Estimate through Ion Balance

Authors: Christina James, SRK Consulting
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Observed increasing sulphate concentrations in a Tailings Storage Facility (TSF) pond at an operating mine in BC has implications for compliance with discharge requirements. SRK reviewed the TSF water chemistry data and found that the rate of sulphate increase is linked through ion balance to increasing sodium and calcium concentrations. SRK used a water and load balance to evaluate potential sources of these ions. In addition to the loading from known water sources at the site, including process reagents, SRK found that a load linked to the rate of ore processing was needed to calibrate modelled concentrations to monitoring data. An increased rate of calcium release was assumed during a period when the mine was processing weathered oxide ore. Conceptually, the calcium source is leaching of weathering products formed in the ore by natural weathering during stockpiling. Sodium was assumed to be released at a constant 'per tonne of ore processed' rate. Based on experience elsewhere, SRK has conceptualized that sodium is released by ion exchange between calcium in solution and sodium held in clay minerals. The release rates were derived from the observed increase in calcium and sodium concentrations within the TSF. Calcium and sodium concentrations in the TSF pond were estimated by mass balance. Sulphate predictions in the model are calculated based on an ion balance with sodium and calcium. Sulphate concentrations are only expected to stabilize when sodium and calcium loads added to the pond are balanced by removal processes such as entrainment of process water in the tailings voids. Estimates of sodium and calcium loads to the pond provide input on the long term sulphate trends, and into decisions about management of the TSF pond.

12. Water Banking in Arizona: The Joint Recovery Model

Author: Ken Seasholes, Central Arizona Project

In the past two decades, 11 million acre-feet of Colorado River water has been recharged in the aquifers to Central and Southern Arizona. More than a third of that has been stored by the Arizona Water Banking Authority, primarily for times of shortage on the Colorado River. The "recovery" (pumping) of that water is a joint responsibility of the AWBA, the Arizona Department of Water Resources, and the Central Arizona Project. To facilitate planning and policy development, CAP, in coordination with AWBA and ADWR, has developed a GoldSim model that can evaluate the timing, frequency and magnitude of recovery over a wide range of scenarios.

The "Joint Recovery Model" processes data from the US Bureau of Reclamation's Colorado River Simulation System model, along with water use projections, and policy variables, all of which are accessible through a GoldSim dashboard. The model makes extensive use of GoldSim's array functions and advanced visualizations in Excel. The model has played a prominent role in an ongoing multi-agency stakeholder process, and is part of an effort to develop shared analytical tools among Arizona's major water institutions.

13. A Simpler Way to Implement a Process Model in GoldSim

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System-level Performance Assessment (PA) models rely on specific process level models for some inputs, such as infiltration. For probabilistic PA, the value of the process model output depends on the values of input parameters that also vary in the PA model. The simplest conceptual solution is to draw values of the input parameters from their distributions, run the process level model at these values, and then use the output where it is needed in the PA model. However, this solution is unsatisfactory for multiple reasons: (1) the PA Model should be set up such that new runs can be made and distributions can change without having to go back and run the process-level model; (2) calling the process model from the system model is possible, but technical difficulties remain in coupling the two; and (3) there is no uncertainty in the process-level model results incorporated into the PA model. Therefore, it is desirable to develop a method that maps the values of PA Model inputs to process level model outputs, in real time within the PA Model set up and using as simple of a map as possible without losing key features of the relationship. This has been termed “model abstraction” because information about process model runs is “abstracted” to be used with the PA model.

A common method for model abstraction is the use of common statistical models, such as linear regression, which have performed well in many settings where the process is actually driven by just a few inputs that are simply modeled. The problem gets more challenging when the number of inputs and outputs that need to be modeled gets large and when there are physical constraints among the many process-level outputs that needs to be maintained for the PA model (e.g. mass balance between layers). It is therefore necessary to have a simpler approach that is possible to implement in situations where the time and effort for the comprehensive multivariate modeling is not possible.

A simple “nearest neighbor” approach is presented to overcome these problems using a stochastic watershed model as an example process model. Stochastic inputs to the process model include average precipitation, temperature, wind speed, relative humidity, and solar radiation. Outputs include flow rates of water and sediment in numerous reaches which eventually feed contaminant transport elements. The watershed model is first run thousands of times with input values meant to adequately cover the joint input space of the PA model inputs and the output vectors are saved. The matrix connecting the values of the inputs and outputs for each process-level run is provided to the GoldSim model in the form of data element vectors. This keeps the vector of outputs together, never breaking any physical constraints coming from the process model (such as conservation of mass). When a GoldSim model realization is begun and values of inputs (parameters) are sampled from probability distributions, a script element in GoldSim iterates through the different combinations of process model input parameters and finds the “closest” process-level model realization in terms of values of the inputs. The outputs associated with that “closest” realization are then selected in GoldSim and applied to their respective contaminant transport elements for the given realization.

In the example presented, the effectiveness of this method is demonstrated by comparing outputs of a process model realization to its initial “nearest neighbor” realization when it is instead forced with GoldSim-sampled input parameters. To accomplish this, the GoldSim draws from the various input parameter distributions are exported and used to parameterize a new realization of the process model. The outputs from this realization are compared to the “nearest neighbor” realization chosen in the corresponding GoldSim simulation.