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GENII: Environmental Concentrations

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Define the Assessment Question!

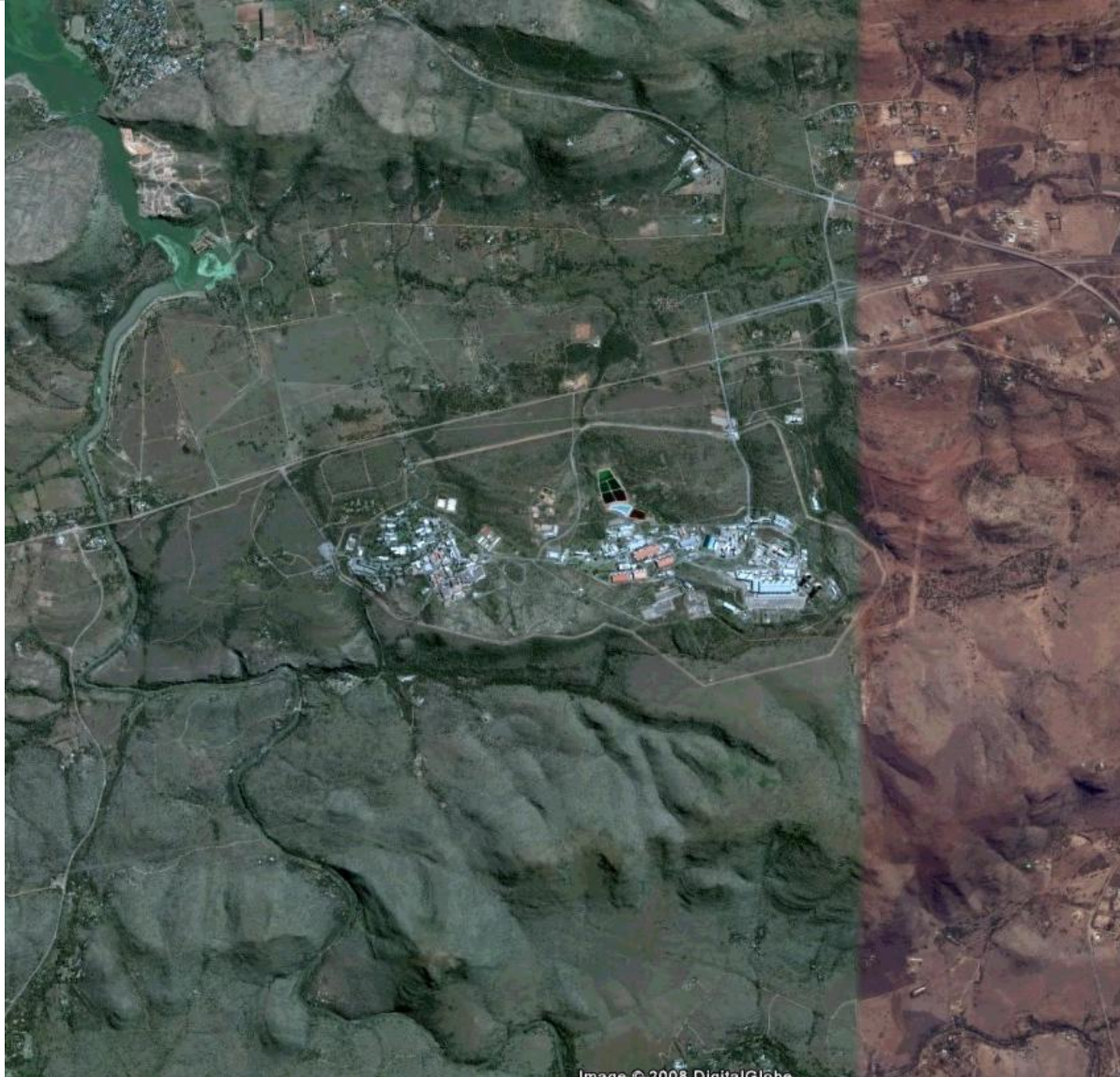
- ▶ **Features, events, and processes (FEPs)**
- ▶ **Exposure Scenarios: A scenario is a conceptual model that describes patterns of human activity, events, and processes that result in radiation exposure to people.**
- ▶ **Pathways of exposure**
 - **External**
 - **Inhalation**
 - **Ingestion**

Plant and Animal (Terrestrial) Models



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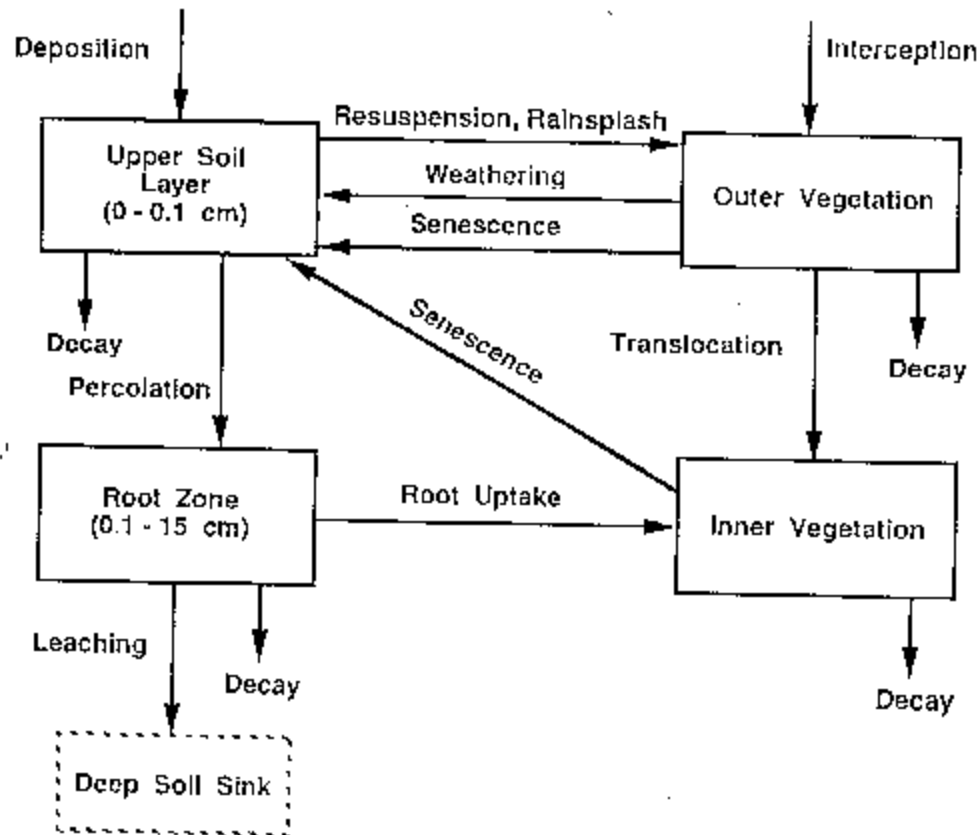


Terrestrial Transport & Accumulation Models

- ▶ Different methods must be applied to different questions
- ▶ Model selection depends on:
 - Spatial scales
 - Temporal scales
 - Available data
- ▶ Models may be dynamic or steady-state



Dynamic Soil and Vegetation Compartments





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Modeling Assumptions

- ▶ **Climate**
- ▶ **Future land use**
- ▶ **Human activities**
 - **Behavior**
 - **Food consumption**
 - **Mobility**

Terrestrial Scenarios

- ▶ **Intrusion (drilling, excavation, archeology)**
- ▶ **Farming (gardening)**
- ▶ **Industrial**
- ▶ **Residential**
- ▶ **Recreational (fishing, hunting, swimming)**
- ▶ **(Anything people can do anywhere)**



External Exposure - Air

▶ Infinite plume

- Plume large enough that edge effects negligible
- Energy emitted = energy absorbed per unit volume

▶ Finite plume

- Dose is a function of plume dimensions
- Point-kernel space integration
- Approaches infinite plume at long distances

External Exposure – Soil and Sediment

- ▶ Air & Irrigation deposition
 - Infinite plane or slab approximation
 - Detailed shielding calculation for indoors vs outdoors
- ▶ Sediment buildup
 - Shore width factor (correction to infinite plane)

Soil Ingestion

- ▶ Inadvertent ingestion
 - Generally small amounts
 - Higher in children than adults
 - Generally higher in “indigenous peoples”
 - Generally only important for radionuclides of very low environmental mobility
 - Generally <100 mg/day

Biotic Transport



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- ▶ Buried-waste to surface transport
 - Plant roots
 - Burrowing animals

Food Chain Pathways

- ▶ Vegetation uptake
 - Air-to-plant deposition
 - Water-to-plant deposition
 - Soil-to-plant uptake
- ▶ Animal uptake
 - Plant-to-animal-product transfer
 - Water-to-fish uptake



Air-to-Plant Deposition

- ▶ **Deposition “velocity”**
- ▶ **Interception fraction**
- ▶ **Weathering/retention**
- ▶ **Translocation**

Deposition Velocity

- ▶ **Depends on:**
 - **Windspeed**
 - **Plant cover**
 - **Humidity**
 - **Particle size**
 - **Chemical interactions**

Interception Fraction

► Depends on:

- **Biomass (mass of plants per unit area)**
- **Leaf area index**
- **Day/night**
- **Leaf type**

Weathering / Retention



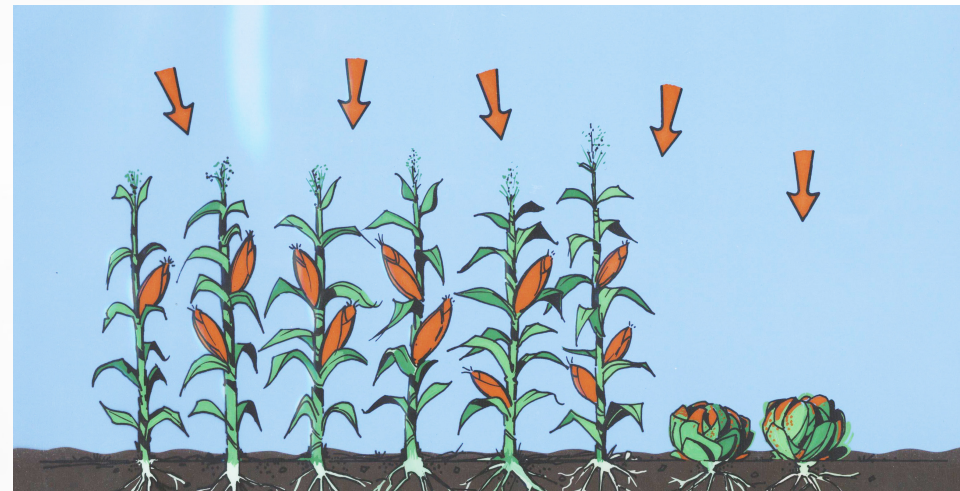
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- ▶ **Depends on:**
 - **Leaf type**
 - **Rainfall**
 - **Volatilization**
 - **Plant growth**

Translocation

- ▶ Depends on:
 - Species of plant
 - Chemical form
 - Radionuclide



Water-to-Plant Deposition

- ▶ Interception fraction
- ▶ Splashup
- ▶ Weathering
- ▶ Translocation



Soil-to-Plant Uptake



- ▶ Generally treated with a concentration ratio:
- ▶ $CR = [Ci/kg \text{ plant per } Ci/kg \text{ of soil}]$
 - Wet or dry plant?
 - Species
 - Soil characteristics (K_d ?)
 - Analog concentrations
 - Rooting depth

Plant Roots

- ▶ **Alfalfa roots to 10 meters**
- ▶ **High CR nuclides preferentially moved**
- ▶ **Plant litter accumulates on surface**



Plant-to-Animal Products

- ▶ Generally treated with a transfer factor
- ▶ $F_m = [C_i/L \text{ milk per } C_i/\text{day ingested}]$

- Vegetation density
- Season/temperature
- Stable element intake
- Stage of lactation



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Water-to-Fish Uptake

- ▶ Generally treated with a bioaccumulation factor (bioconcentration factor)
- ▶ $BF = [\text{Ci/kg fish per Ci/L water}]$
 - Temperature
 - Salinity
 - Stable element concentration
 - Species

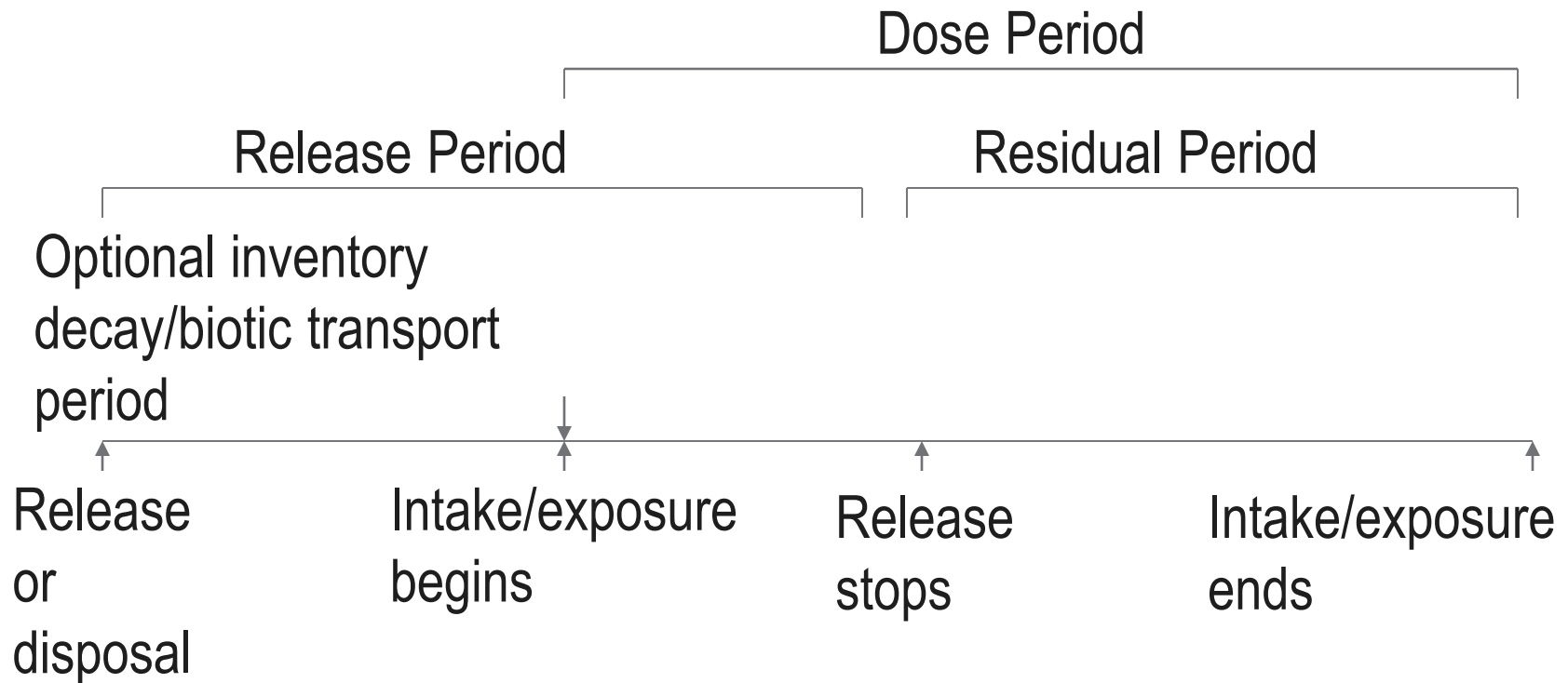




Modifying Factors

- ▶ **Holdup time - harvest to consumption**
- ▶ **Food preparation losses - washing**
- ▶ **Water treatment plants - filtration**
- ▶ **Food distribution networks**

GENII V.2 Time Line



GENII “Exposure” Module



Exposure_Pathways



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GENII Acute Exposure Module - exp4

File Defaults Reference Help

Controls | Water | Soil | Agriculture | Pathways |

Ref: 0 ☒ Animal product ingestion
Ref: 0 ☐ Terrestrial food crop ingestion
Ref: 0 ☒ Aquatic food ingestion
Ref: 0 ☒ Recreational surface water
Ref: 0 ☐ Debug testing

Duration of exposure period 1.0 yr Ref:
End of release period 1.0 yr Ref:
Duration of acute exposure 1.0 day Ref:
Absolute humidity, used only for tritium model 0.008 kg/m³ Ref:
Fraction of plants roots in surface soil 1.0 fraction Ref:
Average rain rate, when raining 1.0 mm/d Ref:

GENII Acute Exposure Module - exp4

File Defaults Reference Help

Controls | Water | Soil | Agriculture | Pathways |

Ingestion

Ref: 0 ☐ Meat
Ref: 0 ☐ Poultry
Ref: 0 ☒ Milk
Ref: 0 ☐ Eggs
Ref: 0 ☐ Leafy vegetables
Ref: 0 ☐ Root vegetables
Ref: 0 ☐ Fruits
Ref: 0 ☐ Grains
Ref: 0 ☒ Fish
Ref: 0 ☐ Mollusca
Ref: 0 ☐ Crustacea
Ref: 0 ☐ Aquatic plants
Ref: 0 ☒ Drinking water
Ref: 0 ☐ Inadvertent shower water
Ref: 0 ☐ Inadvertent swimming water
Ref: 0 ☐ Inadvertent soil

Inhalation

Ref: 0 ☒ Inhalation of Outdoor Air
Ref: 0 ☐ Inhalation of Indoor Air
Ref: 0 ☐ Suspended or resuspended soil

External

Ref: 0 ☒ Swimming external
Ref: 0 ☐ Boating external
Ref: 0 ☒ Shoreline external
Ref: 0 ☐ Soil external
Ref: 0 ☒ External air
Ref: 0 ☒ Finite plume model

Human Exposure Pathways

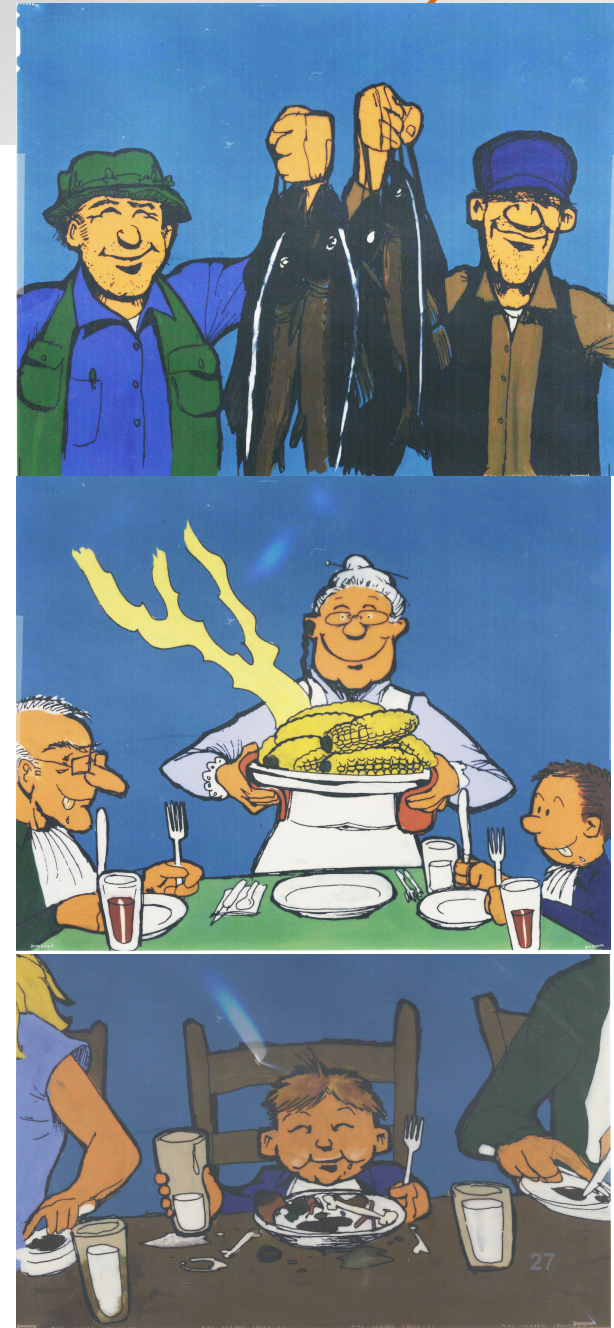
- ▶ External
 - Transported air
 - Soil
 - Swimming
 - Shoreline
- ▶ Inhalation
 - Transported air
 - Resuspended soil
 - Volatilized indoor air pollutants from water



Human Exposure Pathways

► Ingestion

- Leafy vegetables
- Other vegetables
- Fruit
- Grain
- Meat
- Milk
- Poultry
- Eggs
- Fish
- Crustaceans
- Molluscs
- Water plants
- Drinking water
- Shower water
- Swimming water
- Soil





This module requires a lot of data...

GENII Acute Exposure Module - exp4

File Defaults Reference Help

Controls Water Soil Agriculture Pathways

General Animal water Irrigation sources Irrigation rates Irrigation times

Ref: 0 ☐ Aquatic foods from salt water (vesus fresh water)

Ref: 0 ☐ Treatment plant purification of domestic water

Ref: 0 ☐ Residential irrigation

Source of residential irrigation: None

Irrigation rate for residential land: 35.0 in/yr

Irrigation time for residential land: 6.0 mon/yr

Source of domestic water: Surfacewater

Indoor volatilization factor for radon: 0.1 l/m³

Indoor volatilization factor for radionuclides: 0.0 l/m³

Delay time in water distribution system: 1.0 day

Shoreline sediment density: 15.0 kg/m³

GENII Acute Exposure Module - exp4

File Defaults Reference Help

Controls Water Soil Agriculture Pathways

General Animal Food Food Crop Intake delays

Yield Dry/Wet Ratio Translocation Factor Acute Forage Soil Intake
Biomass Consumption Storage Time Diet Fraction Growing Period

Standing biomass (wet) for meat animal feed: 1.6 kg/m² Ref: 0

Standing biomass (wet) for poultry animal feed: 1.6 kg/m² Ref: 0

Standing biomass (wet) for milk animal feed: 1.0 kg/m² Ref: 0

Standing biomass (wet) for egg animal feed: 1.6 kg/m² Ref: 0

Standing biomass (wet) for meat animal forage: 1.0 kg/m² Ref: 0

Standing biomass (wet) for milk animal forage: 1.5 kg/m² Ref: 0

Each tab has many sub-tabs

GENII: Accident Model – 4 Seasons

- Selected earlier, when the module scenario is being defined

Object General Information

Easting coordinate	0 km	Class	Human Exposure & Risk
Northing coordinate	0 km	Group	Exposure Pathways
Elevation	0 km	Object Id	exp4
User Label	Exposure_Pathways	Previous Model	GENII V.2 Acute Exposure Module

Select from Applicable Models

- GENII V.2 Acute Exposure Module
- GENII V.2 Chronic Exposure Module
- GENII V.2 NESHAPS Exposure Pathways Module
- MEPAS 5.0 Exposure Pathways Module

Non-applicable Models

- GENII V.2 Near Field Exposure Module

Model Description

MODULE VERSION
2.10.1 Compiled September 2012

MODULE DESCRIPTION
GENII V.2 Acute Exposure Module

The GENII acute exposure module may be used to estimate concentrations in exposure media for groundwater, surface water, and atmospheric transport pathways. The analysis accepts concentration data for waterborne pathways, and atmospheric transport values. The results of the analysis are written in short-term and annual increments for the duration of exposure defined by the user. Exposure pathways include domestic water use (including irrigation of home gardens), agricultural product consumption, aquatic food consumption, recreational surface water activities, and soil contamination pathways. Losses by leaching, harvest removal, and radioactive decay from the surface soil are evaluated.

Limitations:
The atmospheric transport output file (ATO) can have data for a maximum of 1 time period, 20 distances, and 36 directions, or a square array of 41x41. A maximum of 100 time points can be defined for each data set in the water concentration file (WCF).

VALID CONNECTIONS
Valid Input Reads
1 to 1 con required as input
0 to 1 wcf Aquifer required as input
0 to 1 wcf Surface Water required as input

Ok Cancel

GENII V.2 Acute-Deposition Food Pathways

- ▶ GENII V.2 presents results for 4 seasons (Winter/spring/summer/autumn)
- ▶ “Seasons” are surrogates for complex sets of underlying assumptions about plant growth, weathering, uptake, and time-to-harvest
- ▶ Selection of season depends on meteorological input (this is related to the uncertainty capability)
- ▶ *Seasons below the equator are reversed!*
A minor change in an external file to adjust...

