Requests for information

Hydrology in the SR-Site radionuclide transport model

From R-10-02 to TR-10-06

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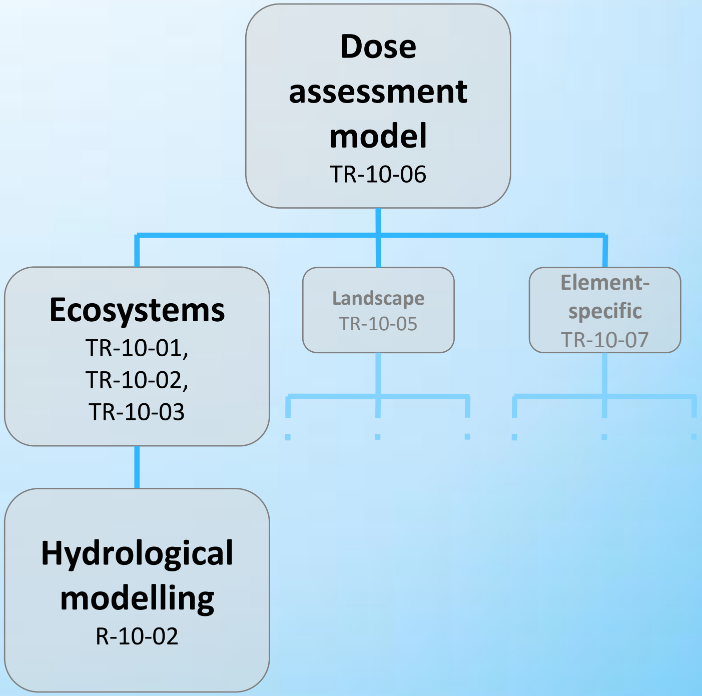
SSM, Stockholm – 19th November 2013

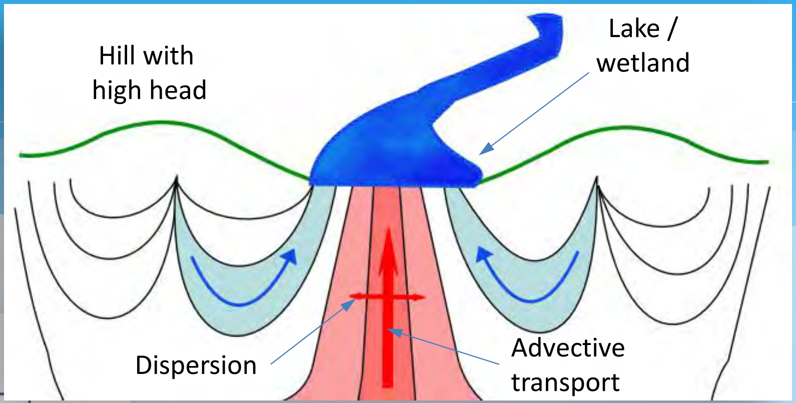
Background

- SSM's Review of the SR-Site License Application
- Radionuclide transport model in the dose model
  - Hydrological modelling
    - MIKE-SHE (R-10-02)
  - Parameterisation and parameters
    - Ecosystem description (TR-10-01)
  - Dose Assessment model
    - Application (TR-10-06)
- This meeting
  - Requests for information
    - What we need to be sure we understand
  - The most efficient way of communicating
  - Thanks for coming



Our understanding

- Concept



- Water balance
  - "Average object"

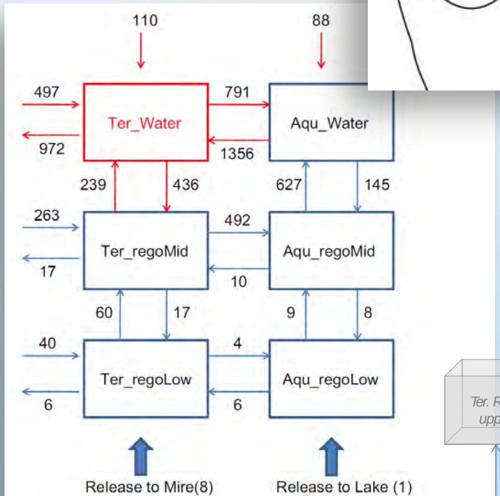
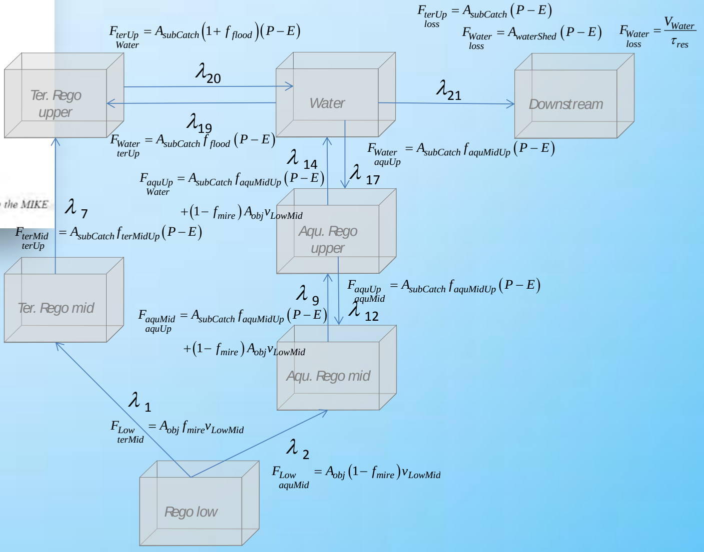


Figure 8-5. Advective fluxes (units in mm y^{-1}) for an average lake-mire object obtained from the MIKE SHE simulations and transformed to a box model.

- Assessment model
  - Advective fluxes

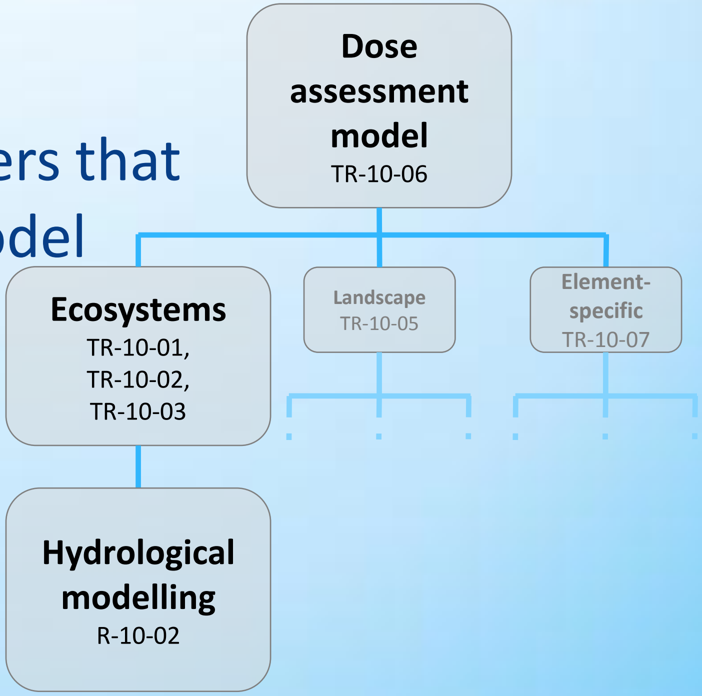


Modelling

- Typical Swedish Lake

Themes

- The "average object"
- Development of the radionuclide transport model
- Derivation of hydrological parameters that *drive* the radionuclide transport model



The “average object”

Where do the numbers come from?

How are they used in the model?

How are they justified?

MIKE-SHE - Basis for SR-Site Hydrology

- MIKE-SHE in R-10-02
  - *Network of independent basins*
  - *… results were extracted and delivered to the dose calculations …*
  - *Tool for defining mass balance in compartment models*

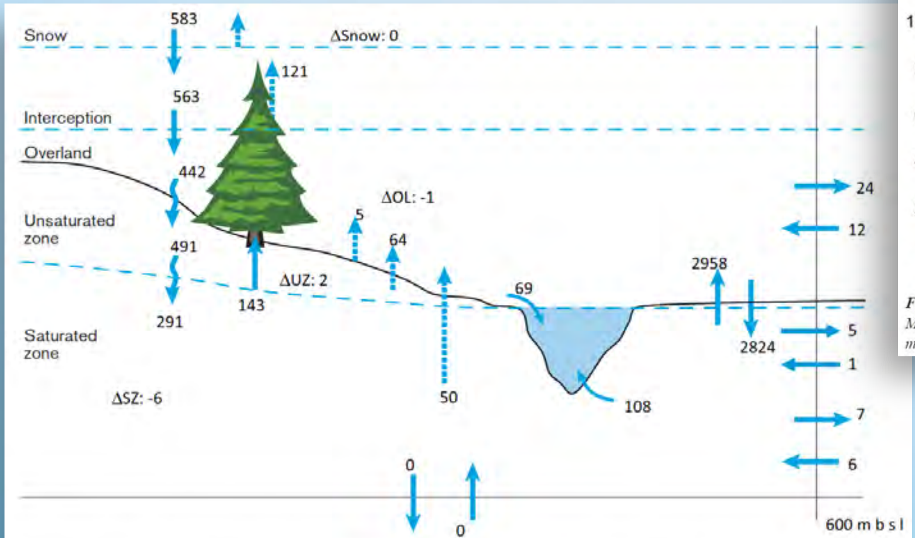


Figure 5-22. Water balance from the 10000AD_10000QD model for the catchment area of object 116.

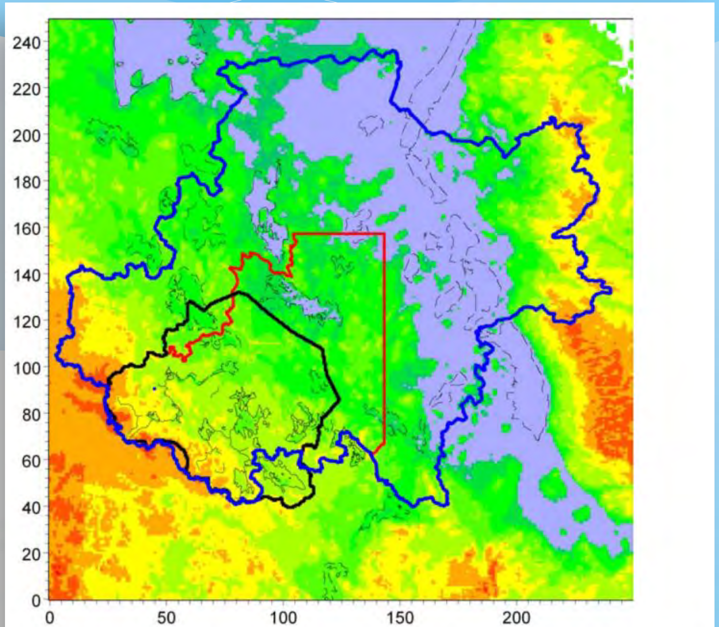


Figure 8-1. MIKE SHE model area in the "pre-modelling" (red line) shown together with the SDM-Site MIKE SHE model area (black line) and the final SR-Site regional model area (blue line) considered in the modelling presented in Chapters 5 and 6 of this report.

Water balance

- Dose assessment model (TR-10-06)
  - *Radionuclide transport model*
  - Results from MIKE-SHE (R-10-02) interpreted in TR-10-01
- The "Average Object"
  - Six lake/mire objects in present day terrestrial landscape
    - Treated as a sample of future objects
    - Snapshot at 5000 CE
      - Other times are available
  - Mass balance using advective velocities
    - aka "area normalised flows"
- *Does MIKE-SHE describe agriculture land*?

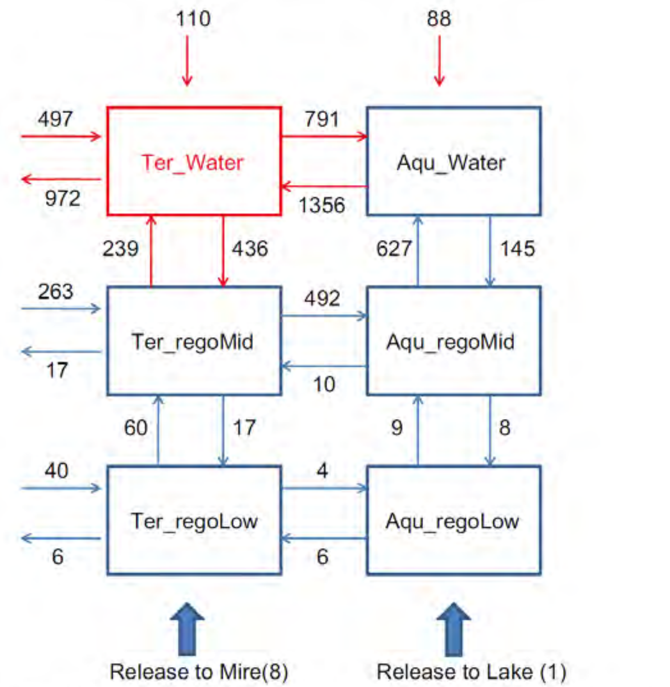
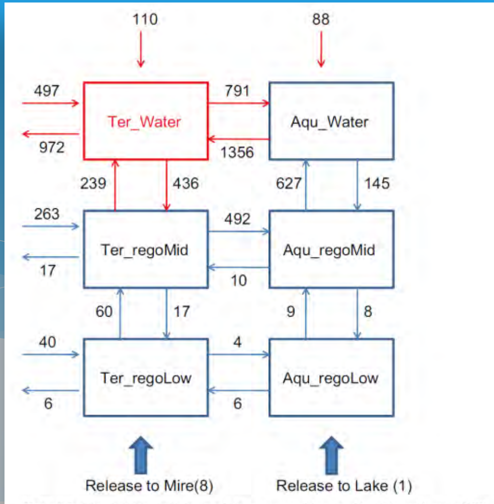


Figure 8-5. Advective fluxes (units in mm y^{-1}) for an average lake-mire object obtained from the MIKE SHE simulations and transformed to a box model.

The "average object"

- Six present day lake/mire objects
  - … because the MIKE-SHE model can be verified
- Treated as a statistical sample
  - What is the output from MIKE-SHE?
  - How are the numerical values derived/combined?
- Are mass balance schemes available for each basin in the landscape?
- Are they available for the different times?



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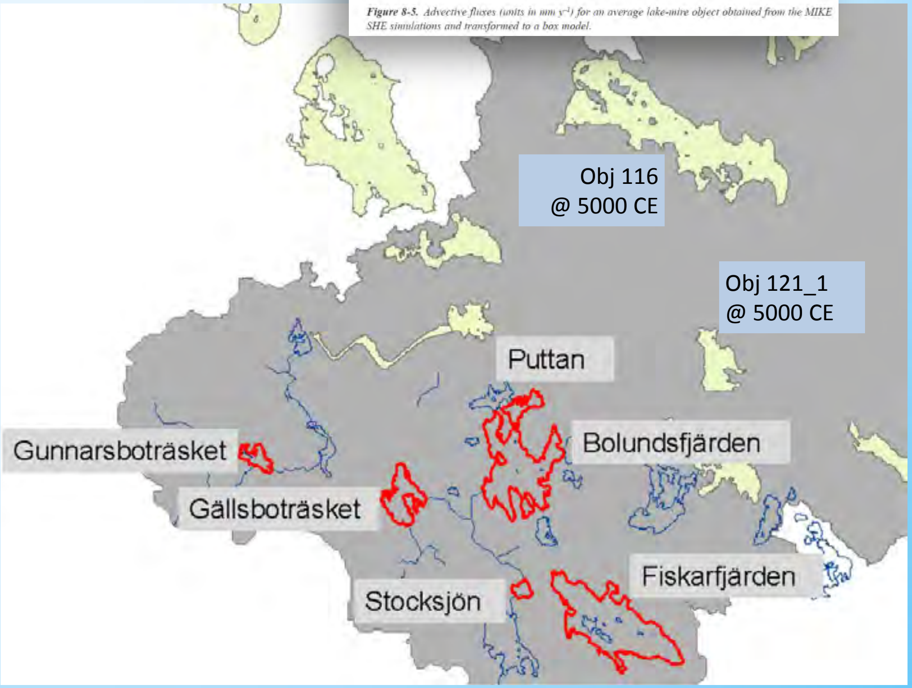
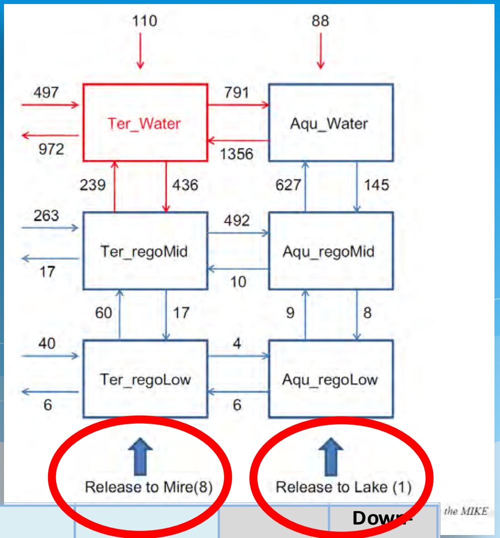


Implicit mass balance



- "Average object"
  - Does it add up?

	geosphere	sub-catchment	Ter_regoLow	Ter_regoMid	Ter_Water	Aqu_regoLow	Aqu_regoMid	Aqu_Water	Atm	Down-stream
geosphere										
sub-catchment			40	263	497					
Ter_regoLow				60		4				6
Ter_regoMid			17		239		492			17
Ter_Water				436				791		972
Aqu_regoLow			6				9			
Aqu_regoMid				10		8		627		
Aqu_Water					1356		145			
Atm					110			88		
Upstream										
Inflow	0	0	63	769	2202	12	646	1506	0	995
Outflow	0	800	70	765	2199	15	645	1501	198	0
Balance	0	-800	-7	4	3	-3	1	5	-198	995
% difference		100.0%	10.0%	0.5%	0.1%	20.0%	0.2%	0.3%	100.0%	100.0%

Derivation of parameters in the radionuclide transport model

How do they relate to the "average object"?

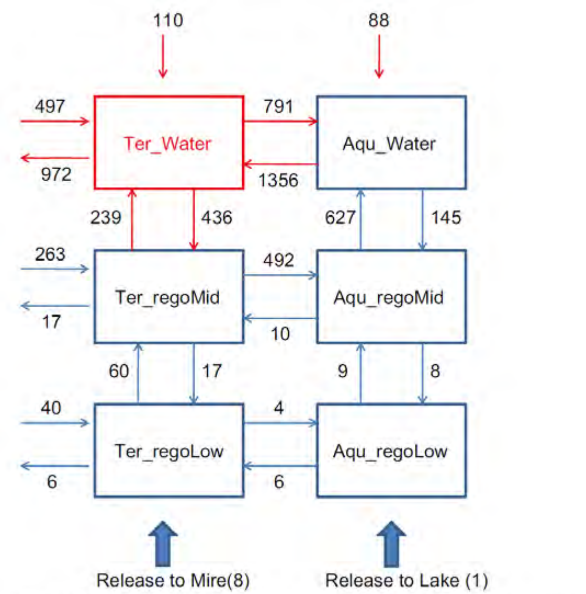
How are they used in the radionuclide transport model?

How is object evolution accounted for?

“Evolution” of the hydrological description

- R-10-02 → TR-10-01 → TR-10-06
  - Structures: R-10-02 ≠ *TR-10-01*
  - The *parameterisation: TR-10-01 ≠ TR-10-06*
- *What is the reasoning behind this?*
- *Implementation in TR-10-06*
  - *There are lots of logic-switches*
    - *Is the “average object” hydrology universally applicable?*
  - *Can we see a full description of the code*
    - *Appendix 1 of TR-10-06 as pseudocode?*

```
if ( have_water AND time_GE_threshold_start )
    area_subcatch · runoff · (1.0 + Flooding_coef ) /
    ( Ter_area_obj · Ter_poro_regoUp · Ter_z_regoUp · Ter_R_regoUp )
else
    0.0
end
```



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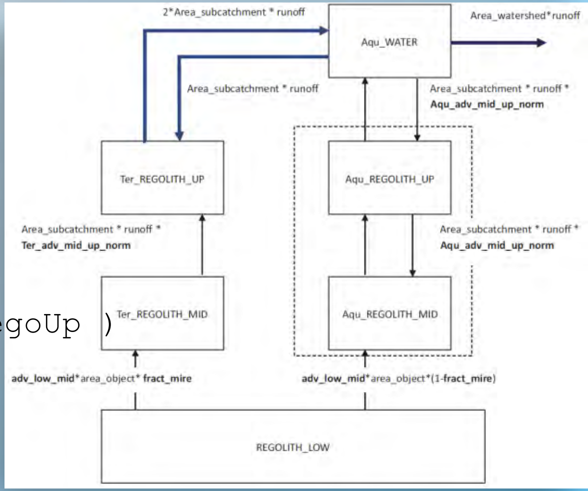

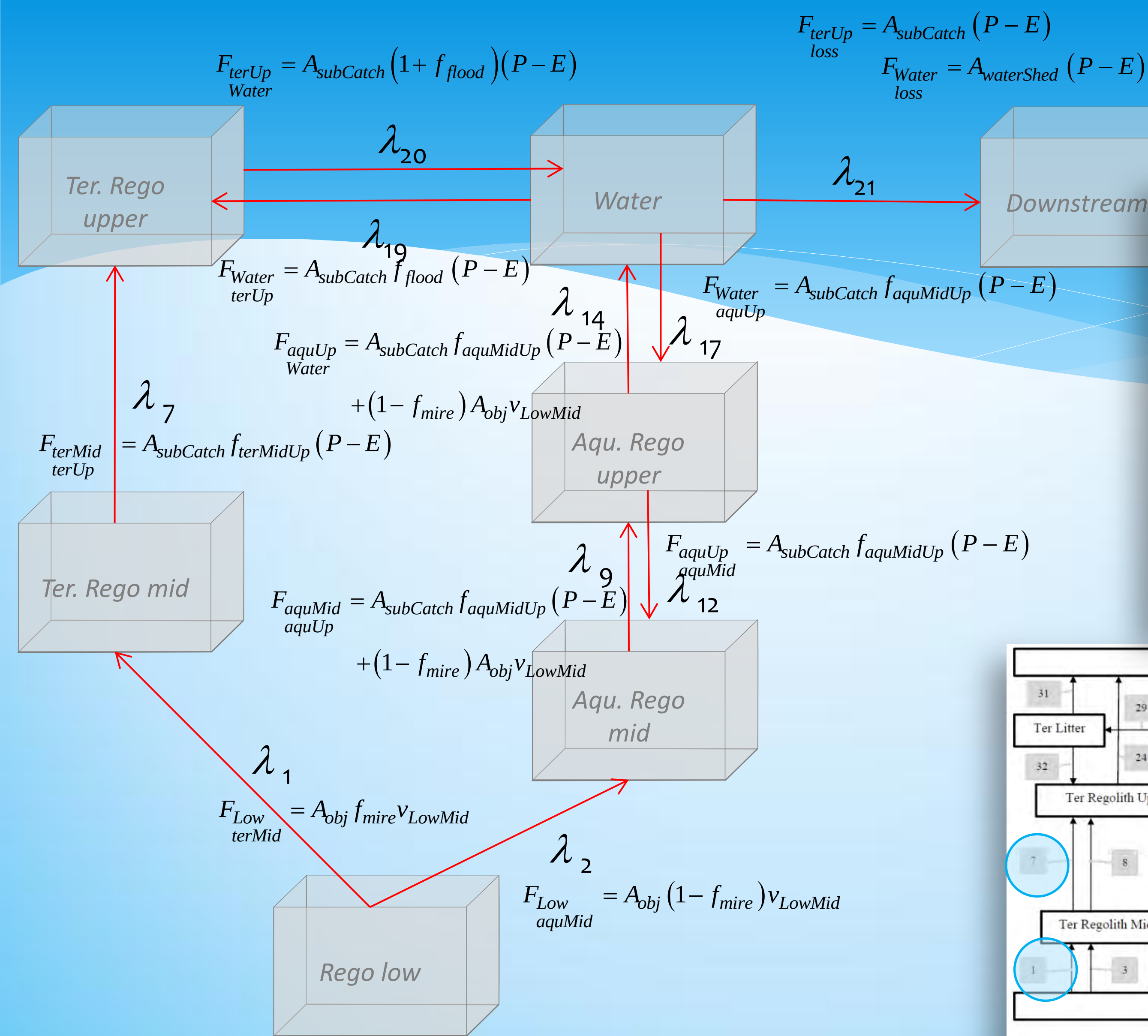

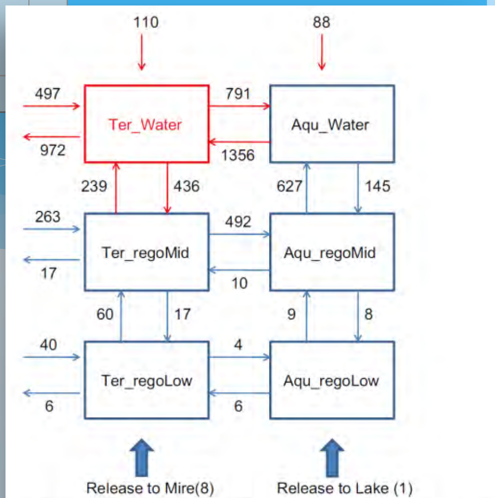

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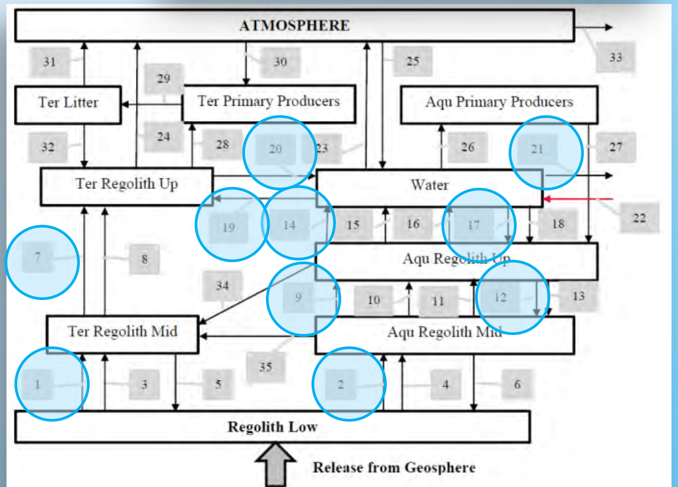


Figure A-1. Conceptual representation of the Radionuclide Model for the biosphere. The boxes represent model compartments and the black arrows represent radionuclide fluxes calculated with Transfer Rate Coefficients. The red arrow represents inflows with surface waters from adjacent biosphere objects.

Evolution of objects in the landscape

generic

Flux	from	to	Expression
$F_{Low\ terMid}$	Low	terMid	$A_{obj} f_{mire} v_{LowMid}$
$F_{Low\ aquMid}$	Low	aquMid	$A_{obj}(1-f_{mire})v_{LowMid}$
$F_{terMid\ terUp}$	terMid	terUp	$A_{subCatch} f_{terMidUp}(P-E)$
$F_{terUp\ Water}$	terUp	Water	$A_{subCatch}(1+f_{flood})(P-E)$
$F_{Water\ terUp}$	Water	terUp	$A_{subCatch} f_{flood}(P-E)$
$F_{aquMid\ aquUp}$	aquMid	aquUp	$A_{subCatch} f_{aquMidUp}(P-E) + (1-f_{mire})A_{obj}v_{LowMid}$
$F_{aquUp\ aquMid}$	aquUp	aquMid	$A_{subCatch} f_{aquMidUp}(P-E)$
$F_{aquUp\ Water}$	aquUp	Water	$A_{subCatch} f_{aquMidUp}(P-E) + (1-f_{mire})A_{obj}v_{LowMid}$
$F_{Water\ aquUp}$	Water	aquUp	$A_{subCatch} f_{aquMidUp}(P-E)$
$F_{Water\ loss}$	Water	Downstream	$A_{waterShed}(P-E)$

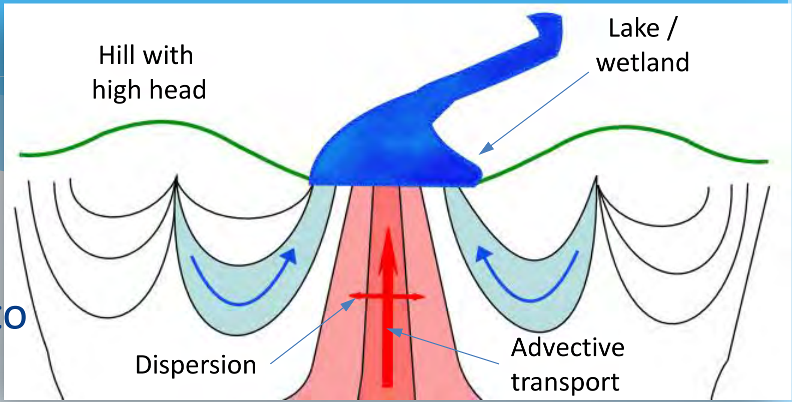
Object 116

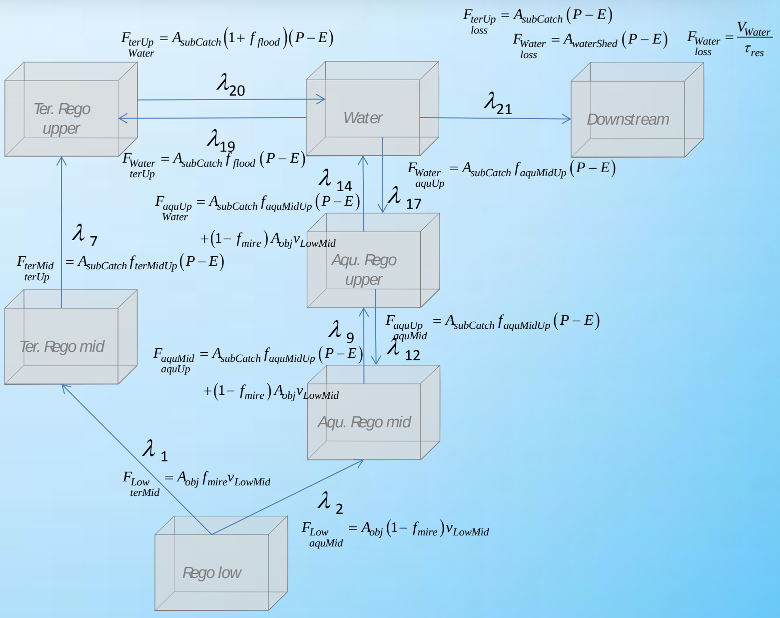
		Date CE		
parameter	Units	4500	5000	65000
A_{ter}	m^2	0	807600	1137600
A_{aqu}	m^2	4379850	753600	423600
$A_{obj} = A_{ter} + A_{aqu}$	m^2	4379850	1561200	1561200
$A_{subCatch}$	m^2	14103000	14103000	14103000
$A_{watershed}$	m^2	10392300	14103000	14103000
$v_{Low\ Mid}$	$m\ a^{-1}$		0.044	
$f_{terMid\ terUp}$	-		0.31	
$f_{aquMid\ aquUp}$	-		0.64	
$P-E$	$m\ a^{-1}$		0.186	
f_{mire}	-		0.98	
f_{flood}	-		1.3	

- Evolution via ***areas***
- *Relative fluxes constant **for all** objects*

Numerical values ~ TR-10-01

- The six flows:
  - Upwards *velocity* out of lower regolith: *Adv_low_mid* = $v_{\substack{Low \\ Mid}}$
  - Fraction of flow from lower regolith directed to mire: *fract_mire* = f_{mire}
  - Net precipitation: *Runoff* = $P - E$
  - Fraction of infiltration to catchment moving laterally in terrestrial subsystem: *Ter_adv_midup_norm* = $f_{\substack{terMid \\ terUp}}$
  - Fraction of infiltration to catchment moving laterally in aquatic subsystem: *Aqu_adv_midup_norm* = $f_{\substack{aquMid \\ aquUp}}$
  - Fractional lateral flux from subcatchment to wetland: *flooding_coef* = f_{flood}
- *Object specific or not?*





Adv_low_mid = $v_{\substack{Low \\ Mid}}$

- Upward flux from the lower regolith
  - Vertical flux (internal)

$$v_{\substack{Low \\ Mid}} = \begin{pmatrix} \text{outflow from} \\ \text{lower regolith} \end{pmatrix} - \begin{pmatrix} \text{Inflow to} \\ \text{lower regolith} \end{pmatrix}$$

$$= \left(v_{\substack{terLow \\ terMid}} + v_{\substack{aquLow \\ aquMid}} \right) - \left(v_{\substack{terMid \\ terLow}} + v_{\substack{aquMid \\ aquLow}} \right)$$

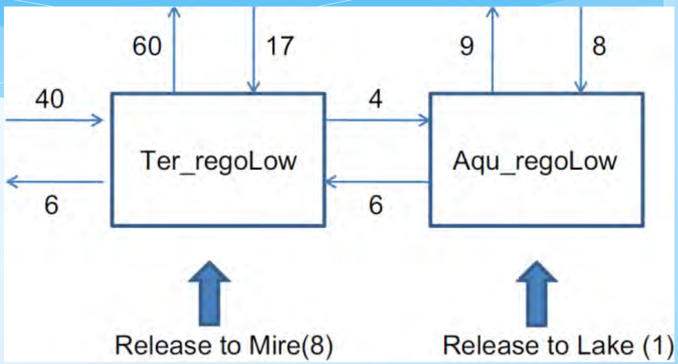
$$= 60 + 9 - 17 - 8 = 44$$

  - External to the object

$$v_{\substack{Low \\ Mid}} = \begin{pmatrix} \text{External inflow to} \\ \text{lower regolith} \end{pmatrix} - \begin{pmatrix} \text{Downstream loss} \\ \text{from lower regolith} \end{pmatrix}$$

$$= \left(v_{\substack{subCatch \\ terLow}} + v_{\substack{geo \\ terLow}} + v_{\substack{geo \\ aquLow}} \right) - \left(v_{\substack{terLow \\ Downstream}} \right)$$

$$= 40 + 10 - 6 = 44$$



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% difference		100.0%	10.0%	0.5%	0.1%	20.0%	0.2%	0.3%	100.0%	100.0%

The *normalised* fluxes ~ *the drivers*

- ***Ter_adv_mid_up_norm*** = $f_{\substack{terMid\\terUp}}$

$$f_{\substack{terMid\\terUp}} = \frac{net\ flux\ through\ terMid}{total\ water\ flux\ in\ basin}$$

$$= \frac{\sum_{j \neq terMid} v_{\substack{terMid\\j}} - \sum_{i \neq terMid} v_{\substack{i\\terMid}}}{total\ water\ flux\ out\ of\ basin}$$

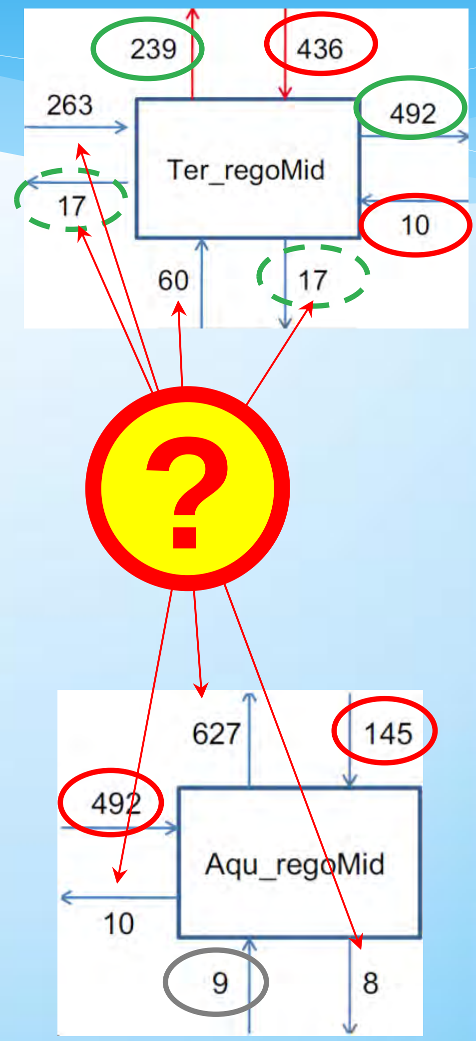
$$= \frac{\left(v_{\substack{terMid\\terWater}} + v_{\substack{terMid\\aquMid}} + {\color{red} v_{\substack{terMid\\terLow}}}\right) - \left(v_{\substack{terWater\\terMid}} + v_{\substack{aquMid\\terMid}}\right)}{v_{\substack{terWater\\Loss}} + v_{\substack{terMid\\Loss}} {\color{gray} + v_{\substack{Low\\Loss}}}}$$

$$= \frac{(239 + 492 + {\color{red}17}) - (436 + 10)}{972 + 17 {\color{gray} + 6}} \approx 0.31$$

- ***Aqu_adv_mid_up_norm*** = $f_{\substack{aquMid\\aquUp}}$

$$f_{\substack{aquMid\\aquUp}} = \frac{v_{\substack{aquWater\\aquMid}} + v_{\substack{terMid\\aquMid}} {\color{gray} + v_{\substack{aquLow\\aquMid}}}}{v_{\substack{terWater\\downstream}} + v_{\substack{terMid\\downstream}} {\color{gray} + v_{\substack{terLow\\downstream}}}}$$

$$\equiv \frac{145 + 492 {\color{gray} + 9}}{972 + 17 {\color{gray} + 6}} \approx \frac{145 + 492}{972 + 17} \approx 0.64$$



Summary of RFIs

RFI summary - 1

- MIKE-SHE
  - MIKE-SHE results with SDM-Site, pre-modelling and regional model areas – are they the same as far as the “average object” is concerned?
  - How were the mass balance schemes to the six lake/mire objects at 5000 CE combined to give the “average object” fluxes?
  - Can we have access to the mass balance schemes for the six objects at the three times?
    - *Deeper access to flow fields in SICADA?*
  - What is the “normalising area”?
  - Does the input from the bedrock change on transition from aquatic to terrestrial conditions?

RFI summary - 2

- Translating the “average object” into the dose model
  - When was the structure of the hydrological fluxes in the radionuclide transport model decided?
  - Can a rationale for the changes in structure be presented?
  - Can we see a detailed, step-by-step derivation of the of the numerical values for the six constant hydrological parameters?
- Implementation in the dose modelling
  - Can we see the coding of the dose model as used?
    - Our interest is the translation to the “average object” to situations like those in Object 121_03
  - Why was the “average object” approach used rather than using the output from MIKE-SHE for each of the basins?

End presentation