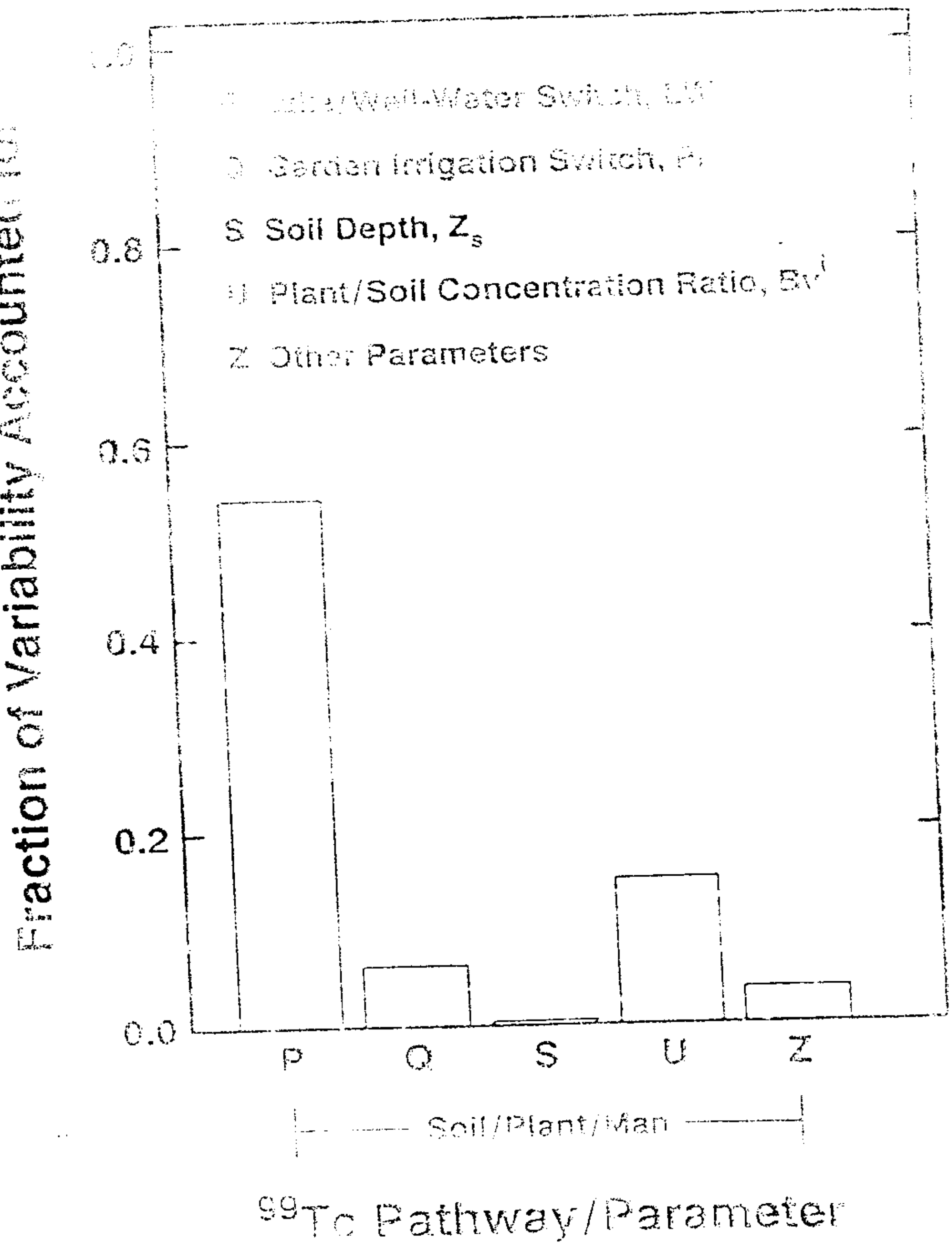
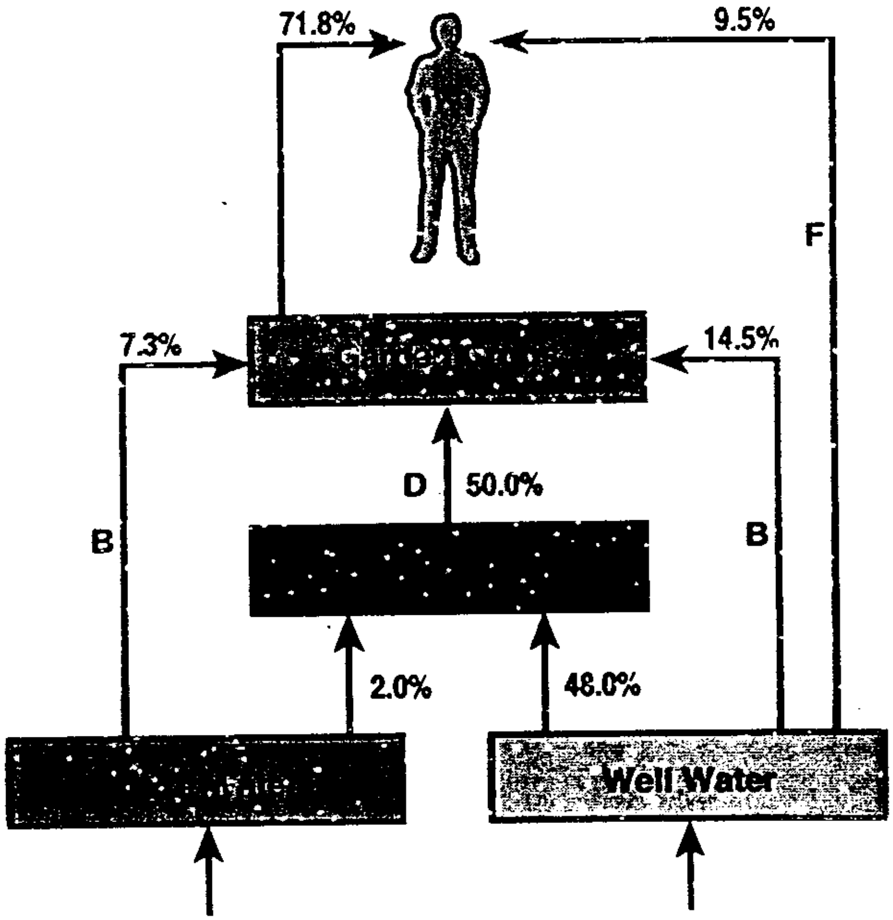
Sensitivity analysis

- essential part of modeling
- lots of ways to do this
- related to PDFs, need to know what range of values can be expected
- guides interpretation and future work

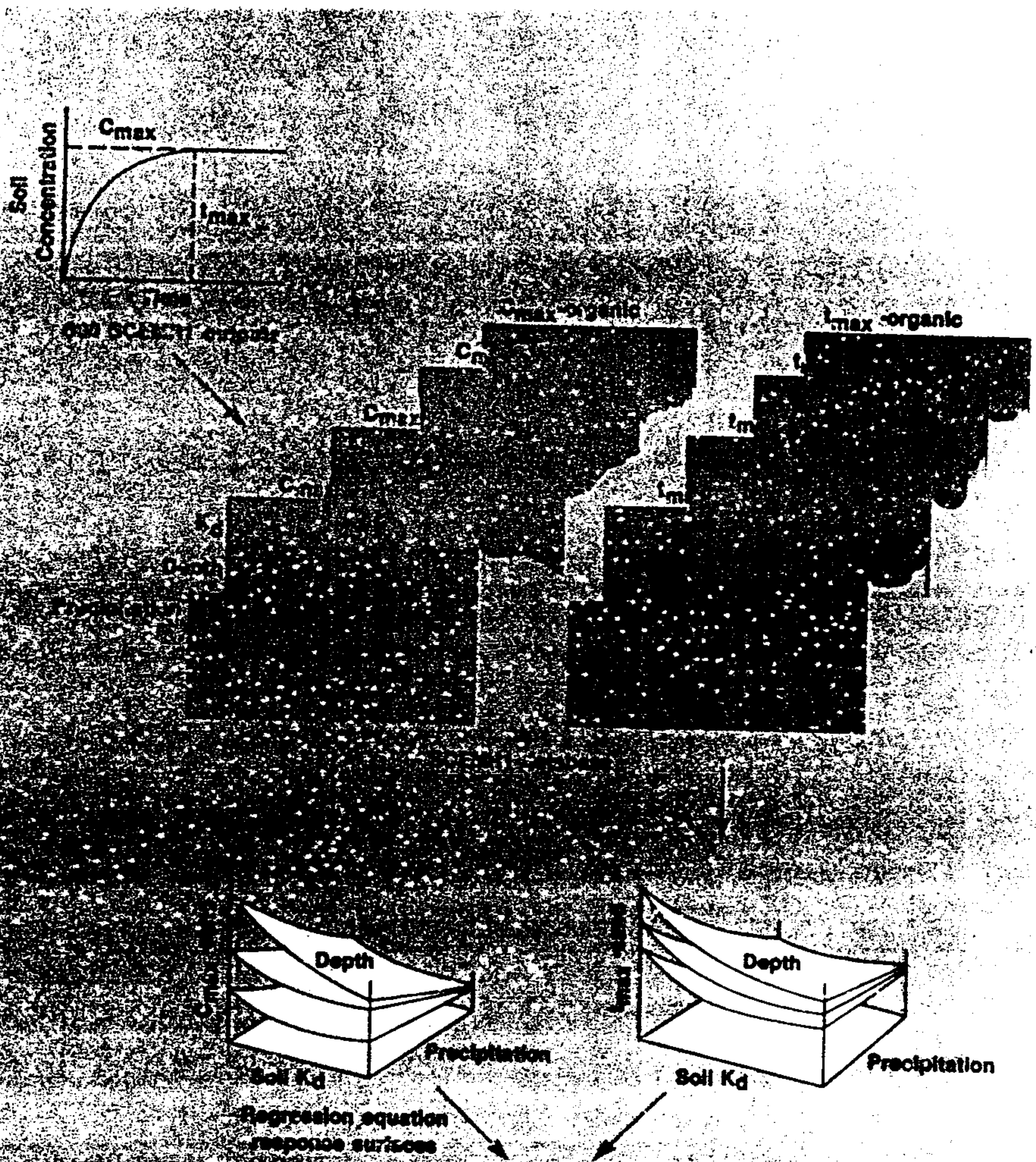

Garden Irrigation Switch,
S Soil Depth, Z_s
Plant/Soil Concentration Ratio,
Z Other Parameters
Fraction of Variability Accounted For
0.8
0.6
0.4
0.2
0.0
P
Q
S
U
Z
Soil/Plant/Man
^{99}Tc Pathway/Parameter

The Most Important Pathways Contributing to the ^{129}I Dose to Man



Model simplification

- especially for sub-models
- faster to compute
- simpler to interpret and explain
- allows use of research-level models in assessment applications



$$R^{G}(t) = \exp\left\{-\left[\frac{\rho\exp(-\beta_1)}{\gamma} + \lambda_i + \eta_i + \phi_i\right] t\right\}$$

$$R^{I}(t) = \exp\left\{-\left[\frac{\rho\exp(-\beta_2)}{\gamma} + \lambda_i + \eta_i + \phi_i\right] t\right\}$$

SYVAC response function

$$(DISP)_{TG} = (4.87 \cdot A_T^{1/8} - 3.56)/UWGH$$

Specific activity models

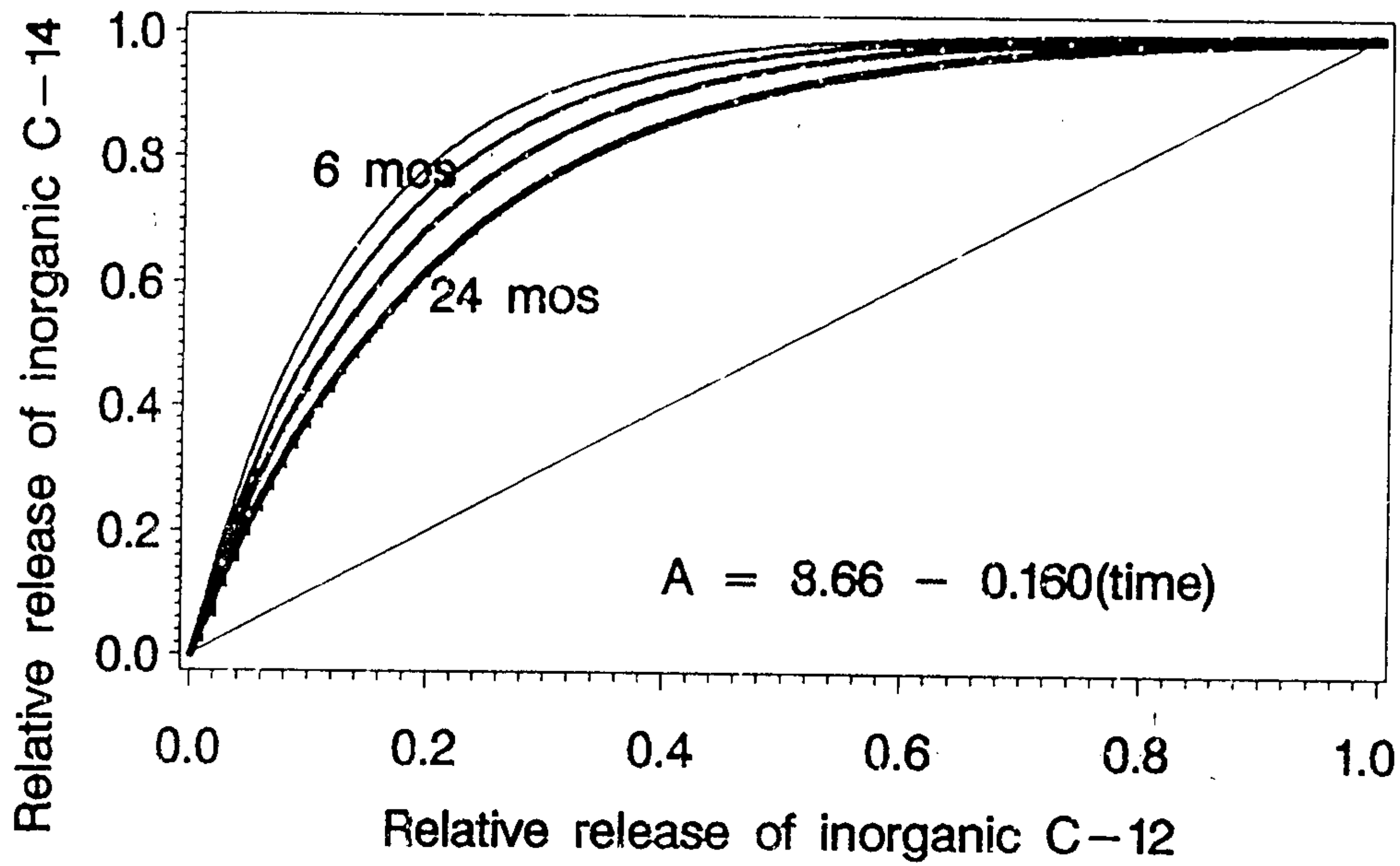
- a radionuclide and a stable nuclide of the same element, if in contact and of the same chemical species, will mix and exchange until there is the same radionuclide/stable-nuclide ratio throughout the system.

Terminology

- specific activity
- isotope ratio
- isotopic equilibrium
- mixing pool
- isotope fractionation

Things to remember

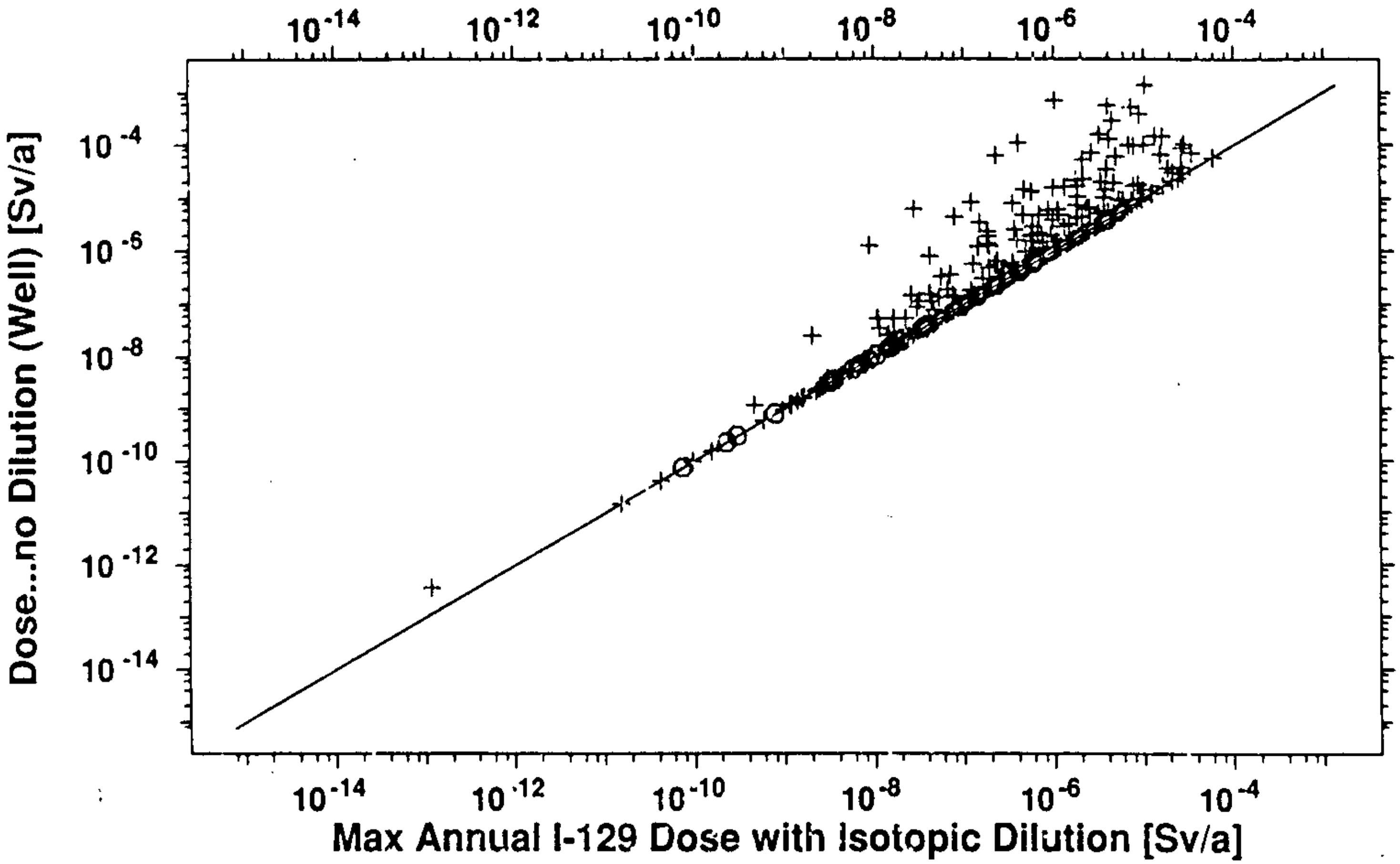
- isotopic exchange will occur even when there is no mass exchange, even against a chemical gradient
  - a little difficult to measure
  - convenient if you can assume that isotopic equilibrium has occurred and isotopic fractionation is minor



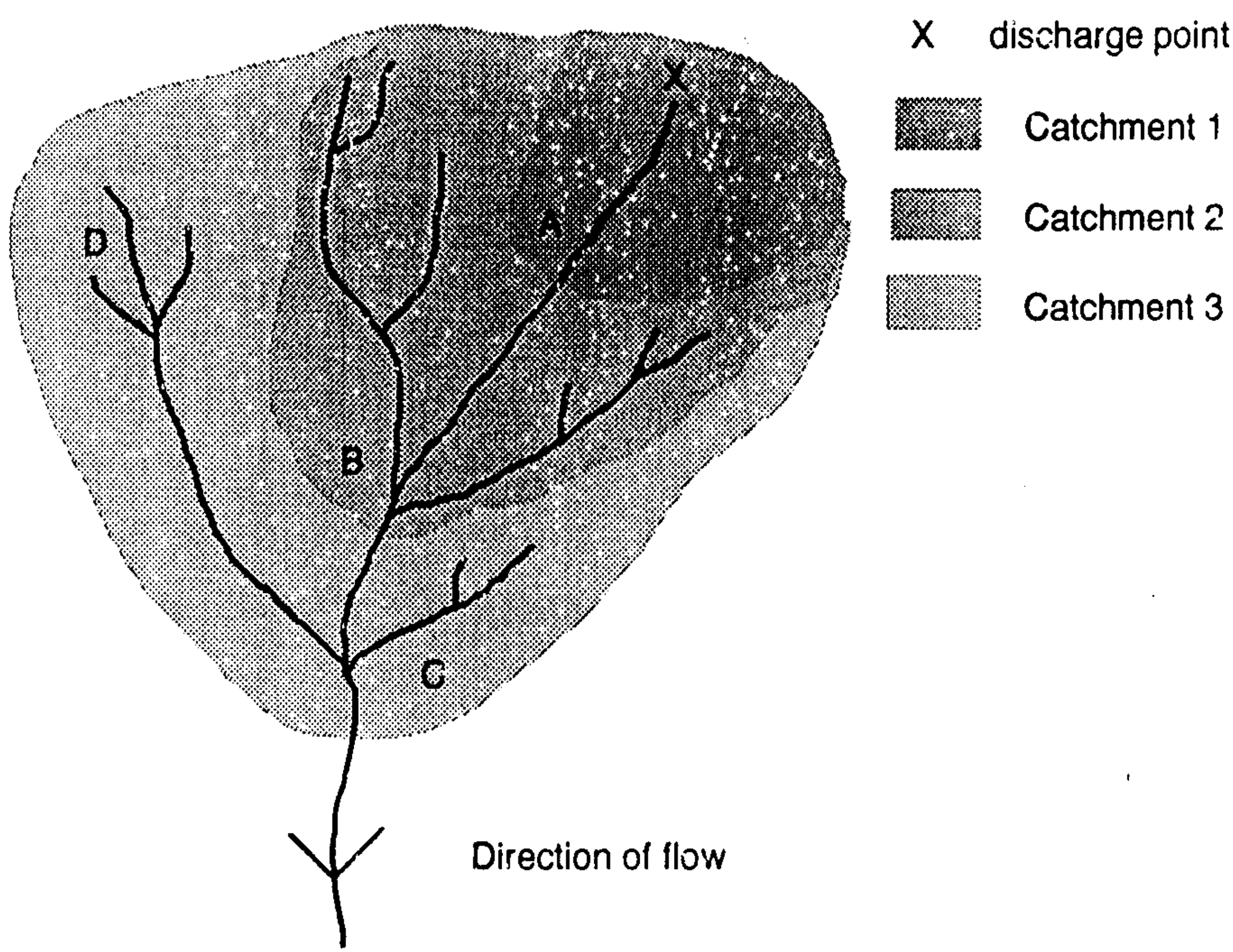
1.0
0.8
0.6
0.4
0.2
0.0
Relative release of inorganic C−14
6 mos
24 mos
A = 8.66 − 0.160(time)
0.0
0.2
0.4
0.6
0.8
1.0
Relative release of inorganic C−12

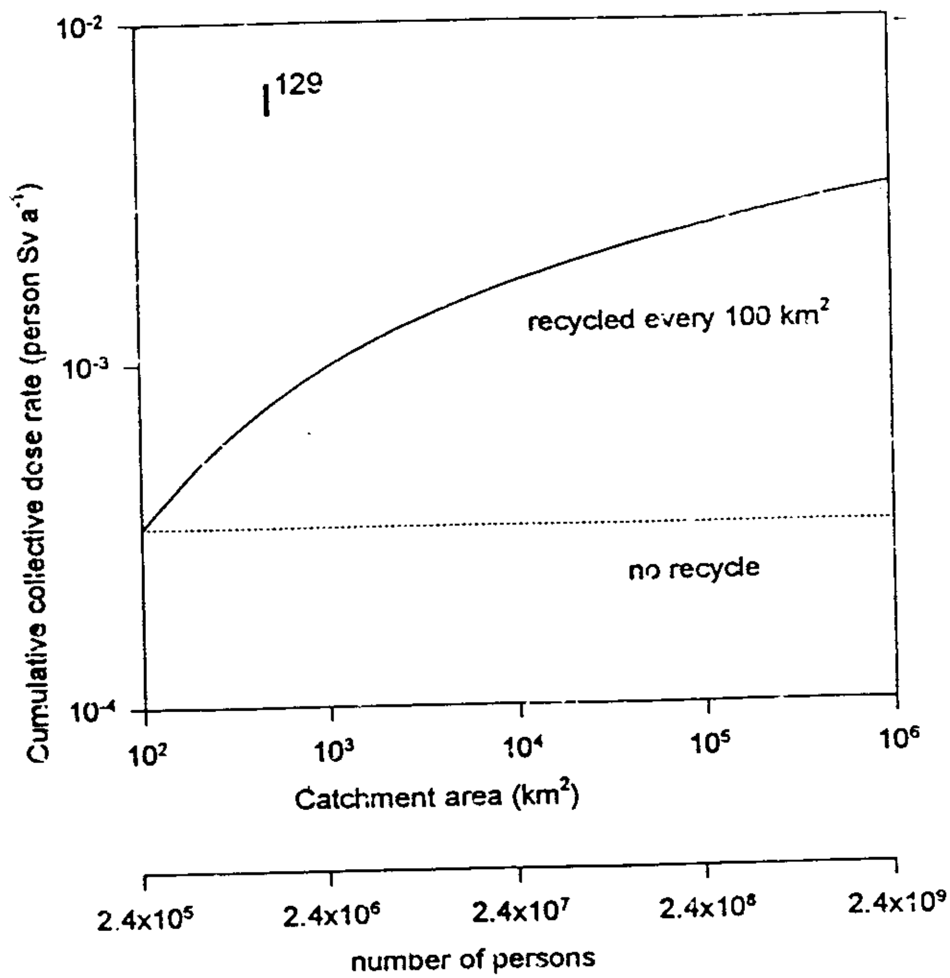
Examples of use

- population dose models
- geosphere dose limit model
- simple alternative models

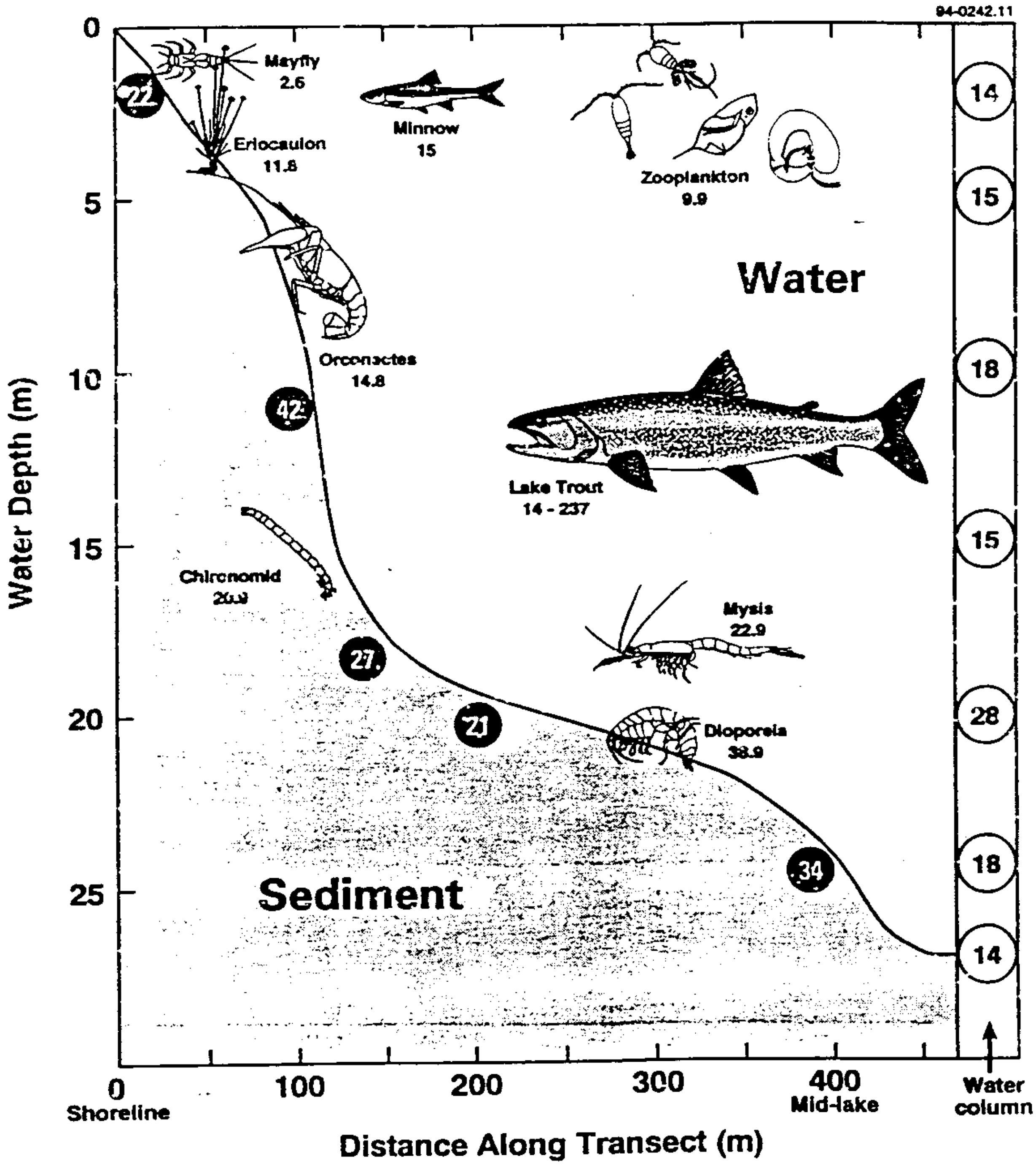


10 -14
10 -12
10 -10
10 -8
10 -6
10 -4
Dose...no Dilution (Well) [Sv/a]
Max Annual I-129 Dose with Isotopic Dilution [Sv/a]

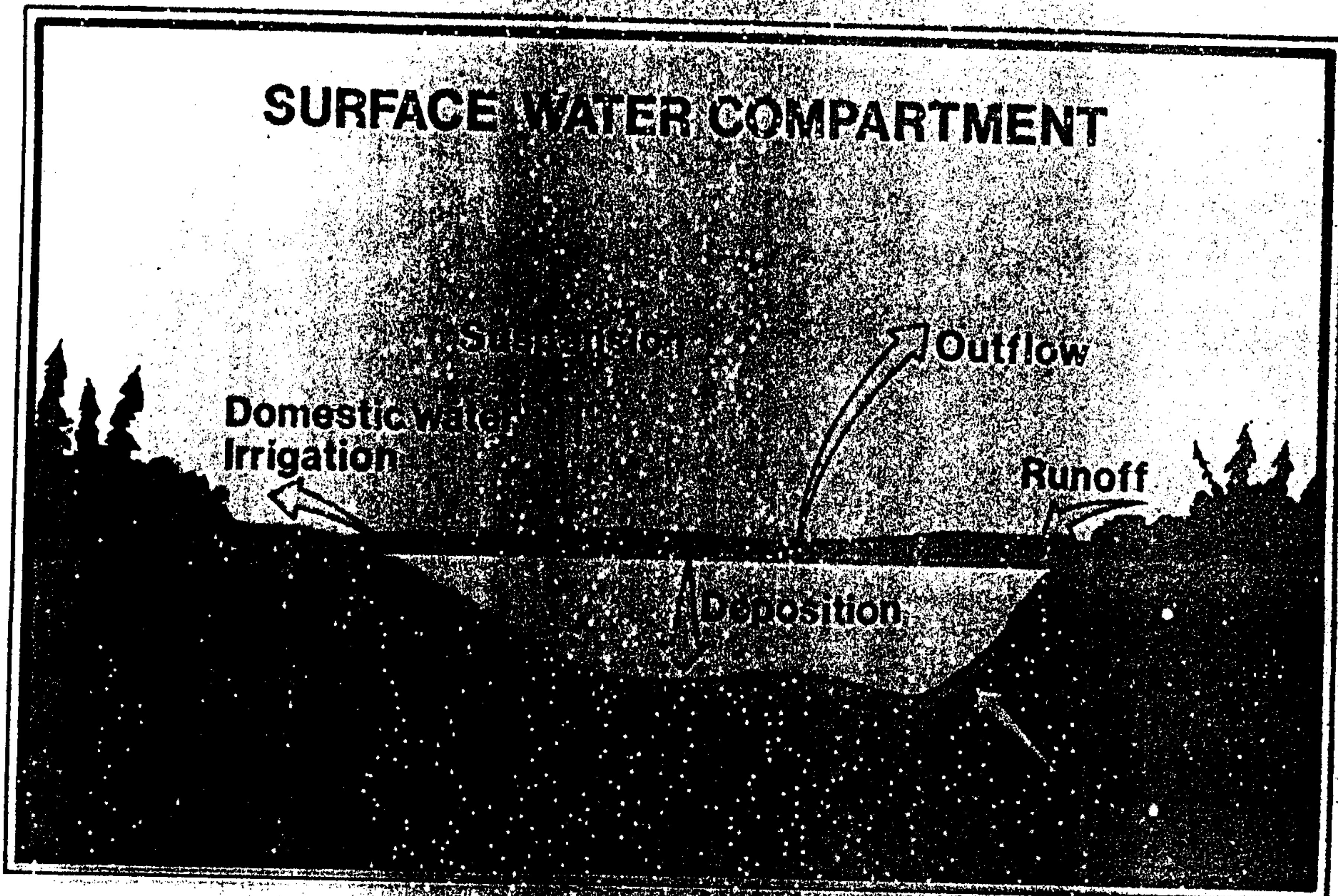

X
A
B
C
D
X discharge point
Catchment 1
Catchment 2
Catchment 3
Direction of flow

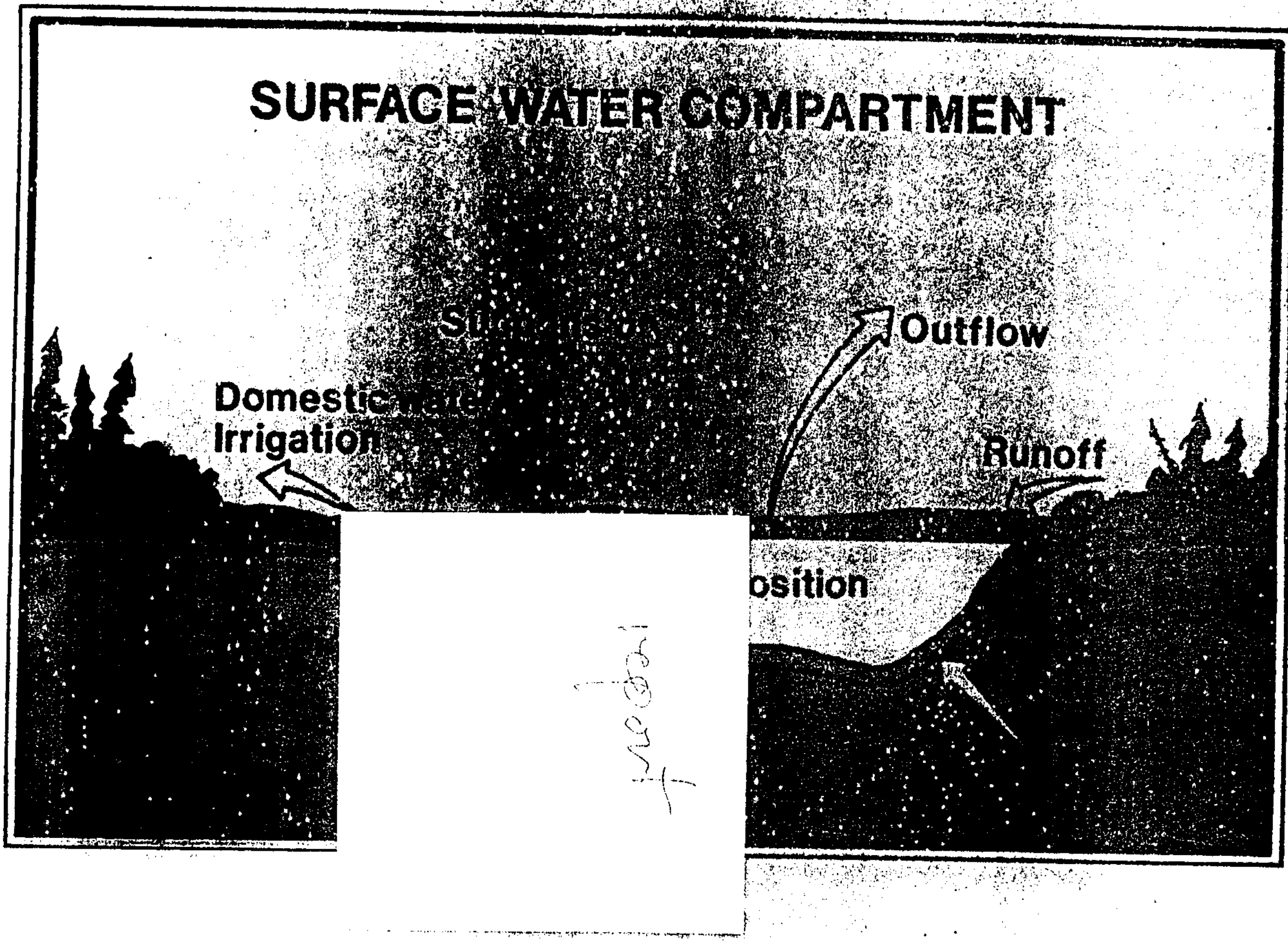


I^{129}
Cumulative collective dose rate (person Sv a^{-1})
10^{-2}
10^{-3}
10^{-4}
recycled every 100 km^2
no recycle
10^2
10^3
10^4
10^5
10^6
Catchment area (km^2)
$2.4x10^5$
$2.4x10^6$
$2.4x10^7$
$2.4x10^8$
$2.4x10^9$
number of persons



Observed specific activities (Bq/g C) in a Canadian Shield lake (from Sheppard et al. 1994a).


SURFACE WATER COMPARTMENT
Suspension
Outflow
Domestic water
Irrigation
Runoff
Deposition


SURFACE WATER COMPARTMENT
Outflow
Domestic
Irrigation
Runoff

The mass balance equation for nuclide i in the lake water is

$$\frac{dM_{w,i}(t)}{dt} = X_{1,i}(t) + \lambda_{i-1} \cdot M_{w,i-1}(t) - A_d \cdot R \cdot M_{w,i}(t)/V_1$$

$$- \alpha_i \cdot M_{w,i}(t) - \lambda_i \cdot M_{w,i}(t) - \epsilon_i \cdot M_{w,i}(t)$$

where $M_{w,i}(t)$ = total amount of nuclide i in lake water (mol) at time t (a),

$X_{1,i}(t)$ = total annual input of nuclide i to the lake ($mol \cdot a^{-1}$) at time t (a),

A_d = terrestrial catchment area of the lake (m^2),

R = runoff in the lake's terrestrial catchment ($m \cdot a^{-1}$),

α_i = rate constant describing the net rate of transfer of nuclide i from water to sediment (a^{-1}),

λ_i, λ_{i-1} = radioactive decay constants for nuclides i and i - 1 (precursor to i) (a^{-1}),

ϵ_i = rate constant describing the rate of gaseous evasion of nuclide i to the atmosphere (a^{-1}), and

V_1 = volume of the lake (m^3).

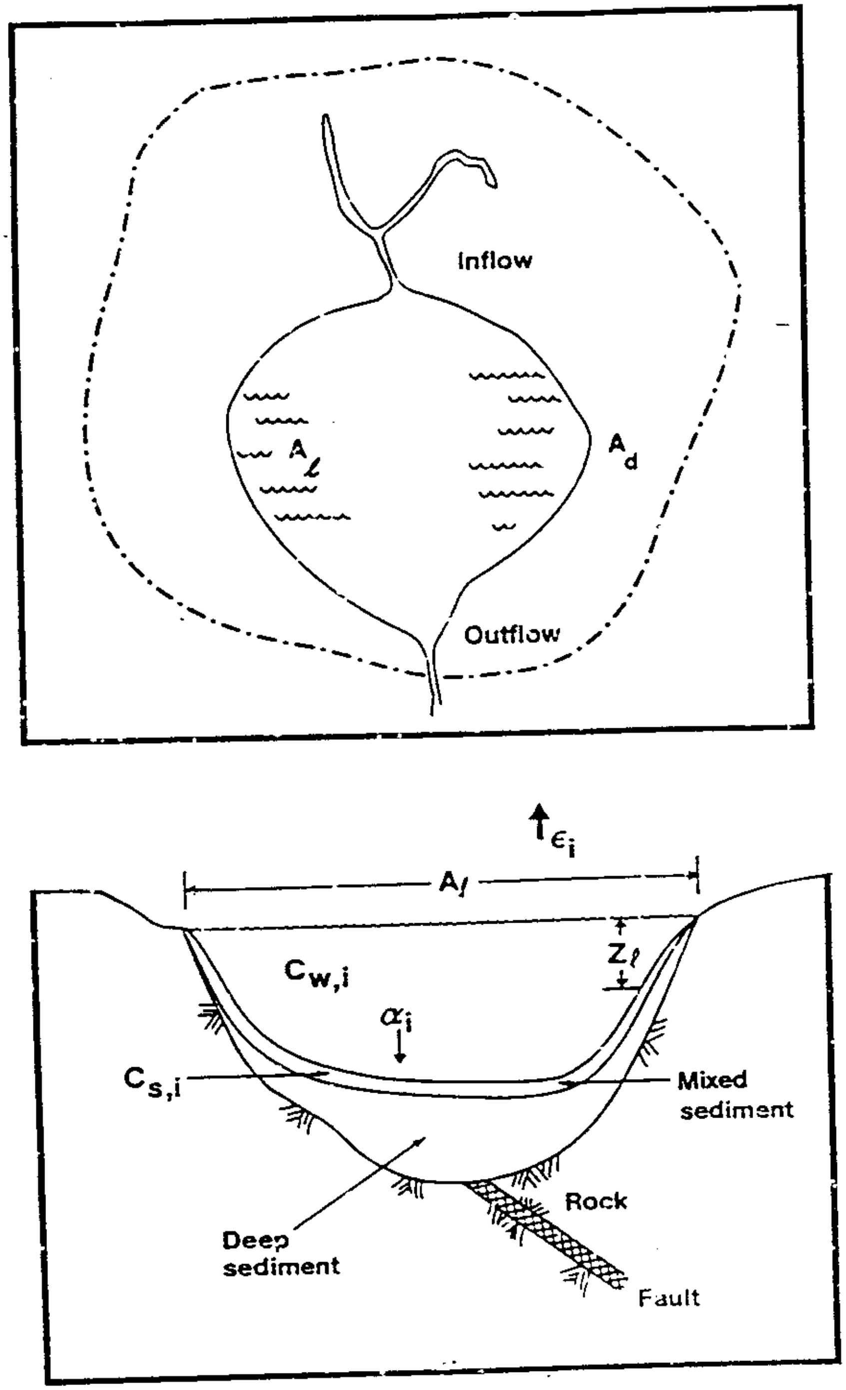
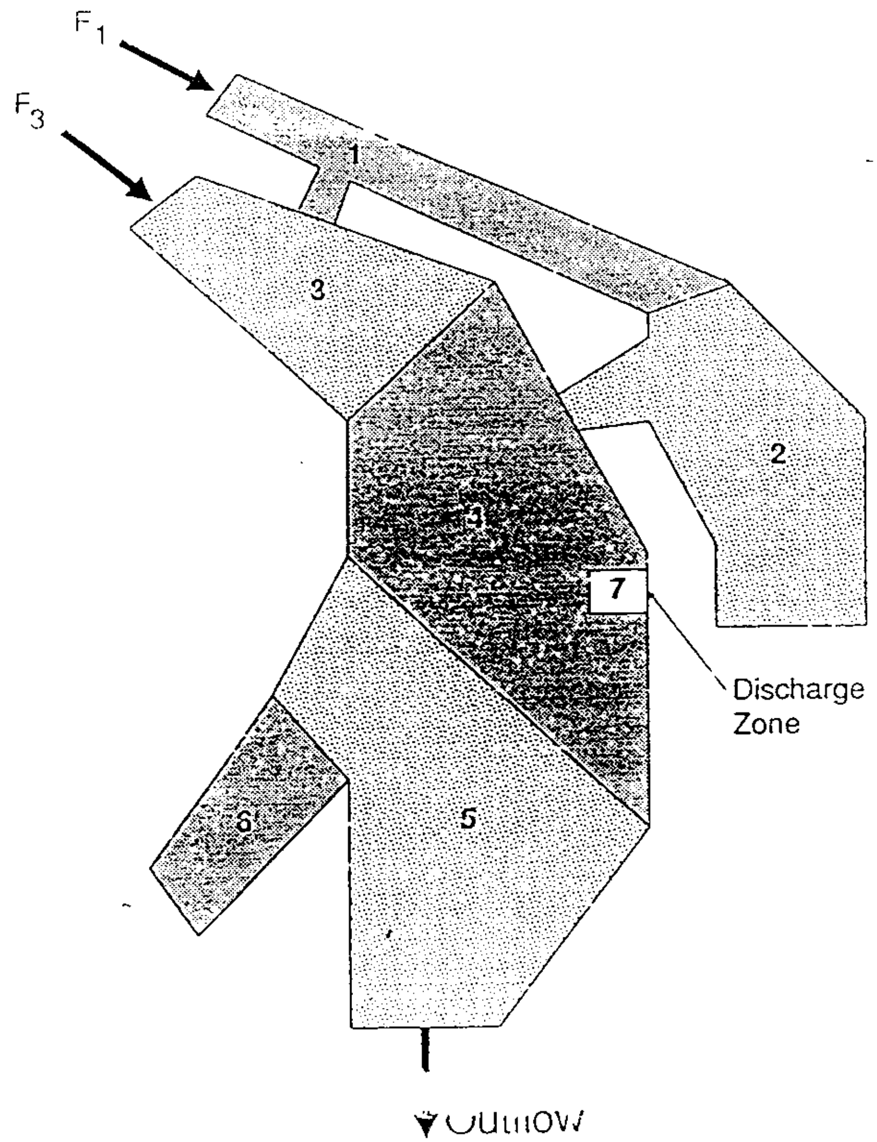
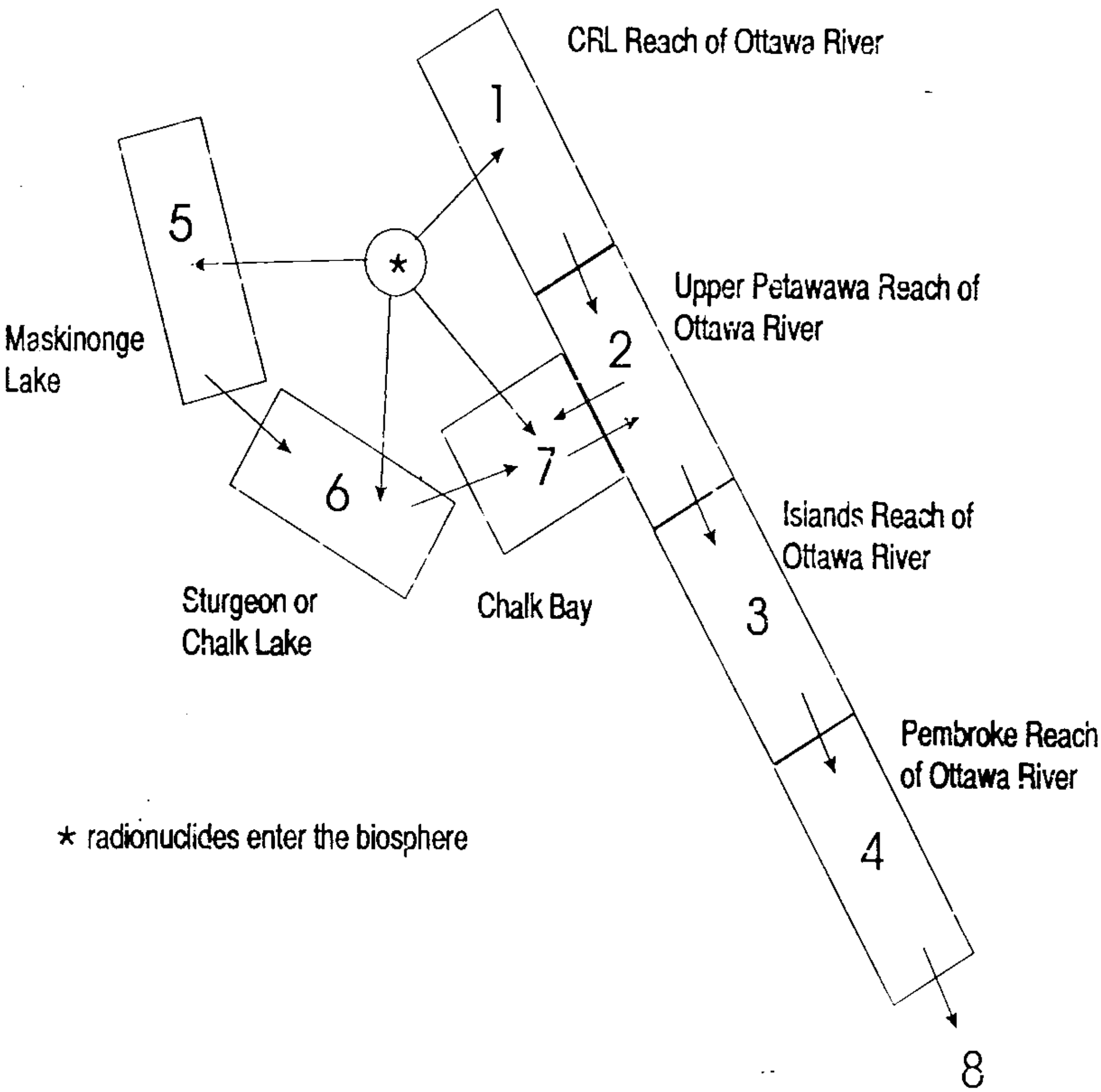


FIGURE 3: Generic Lake Typical of Canadian Shield Lakes.
A_d = catchment area,
A_l = lake area,
$C_{w,i}$ = concentration of nuclide i in water,
$C_{s,i}$ = concentration of nuclide i in sediment,
α_i = nuclide i transfer rate from water to sediment,
ϵ_i = gaseous evasion of nuclide i, and
Z_l = lake mean depth.

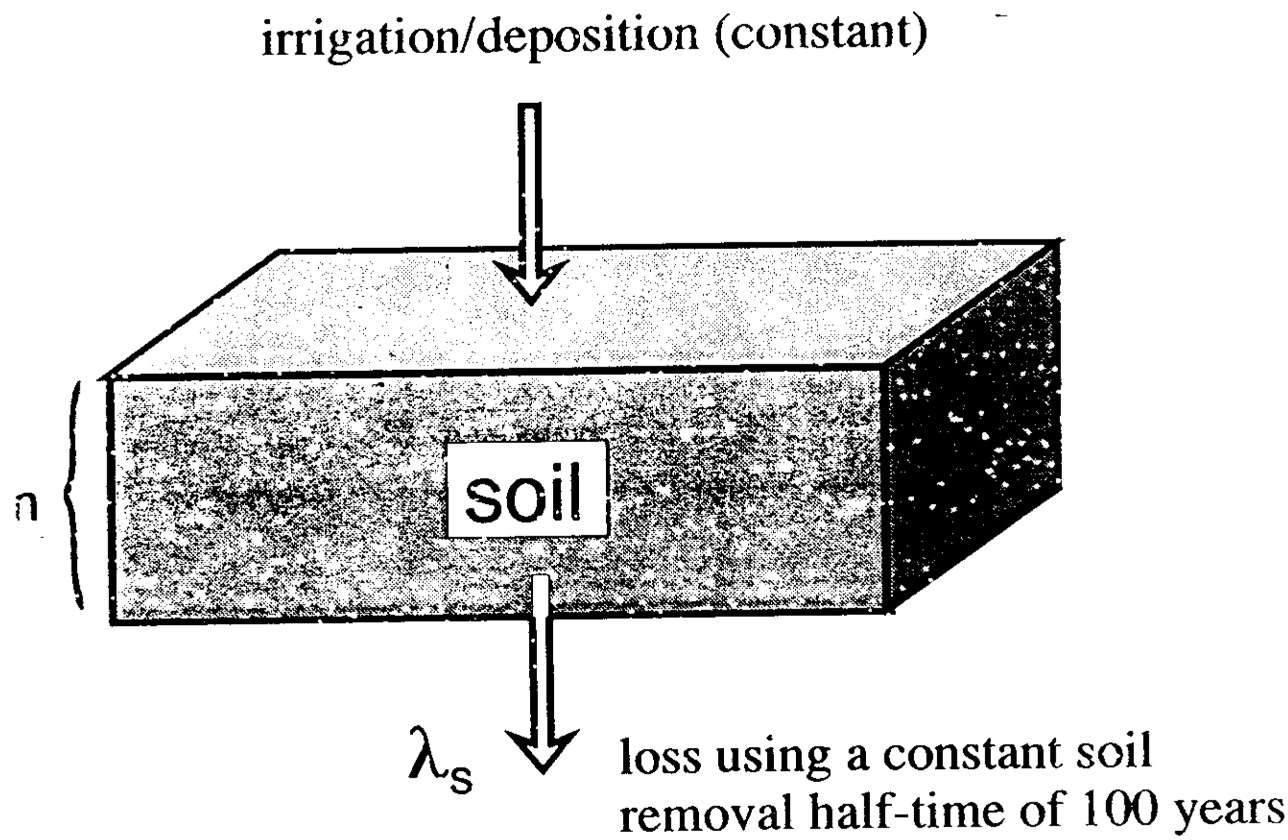
LAKE COMPARTMENTS



L&ILW CRL LAKE MODEL



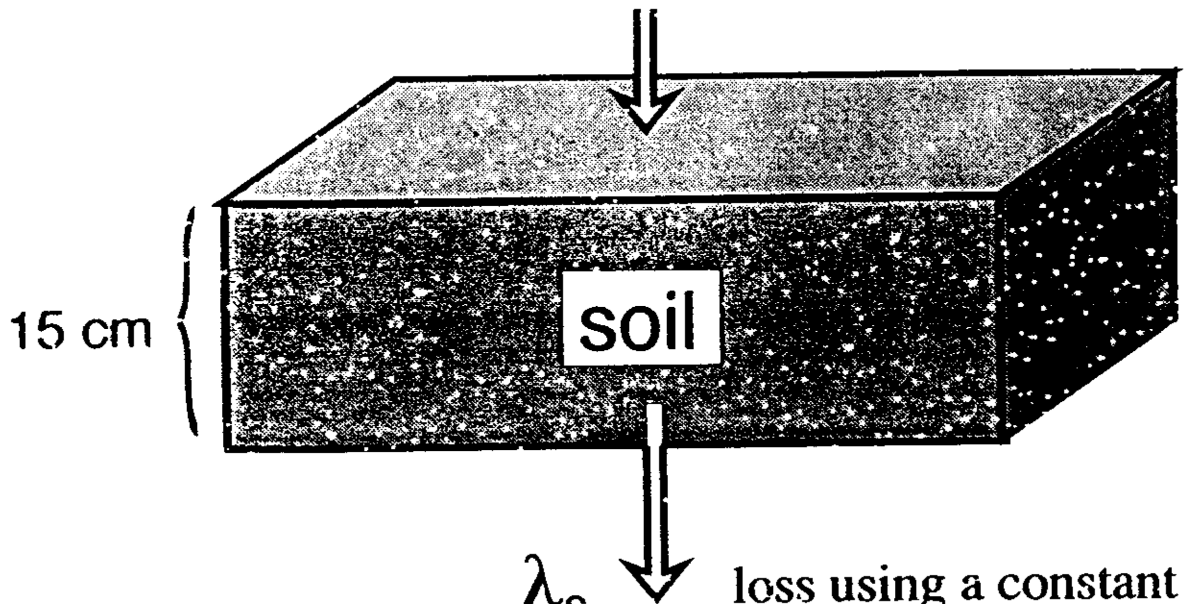

SOIL COMPARTMENT
Suspension
Irrigation
Runoff


irrigation/deposition (constant)
soil
λ_s
loss using a constant soil removal half-time of 100 years

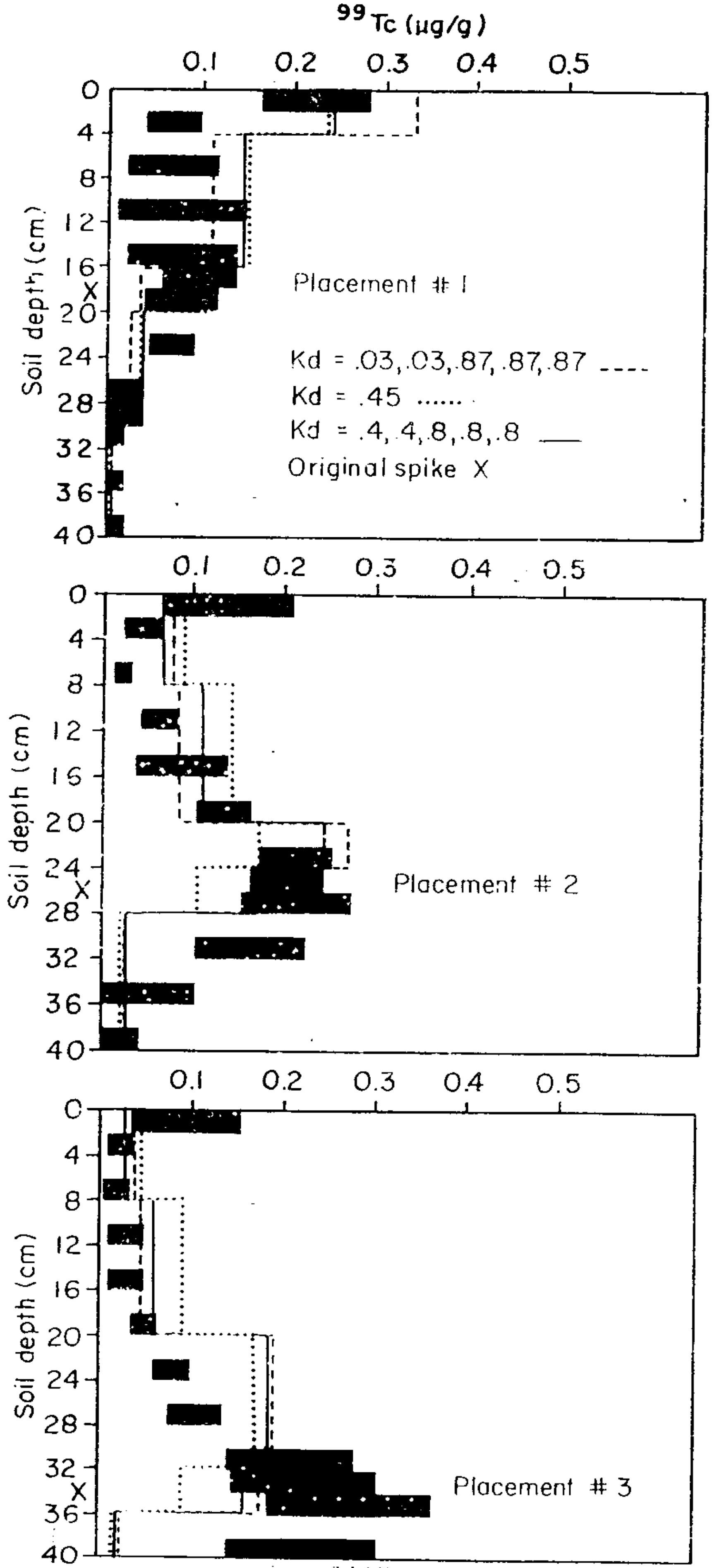
CSA

regulatory model
sfc dep
<u>only</u>

irrigation/(



loss using a constant soil
removal half-time of 100 years

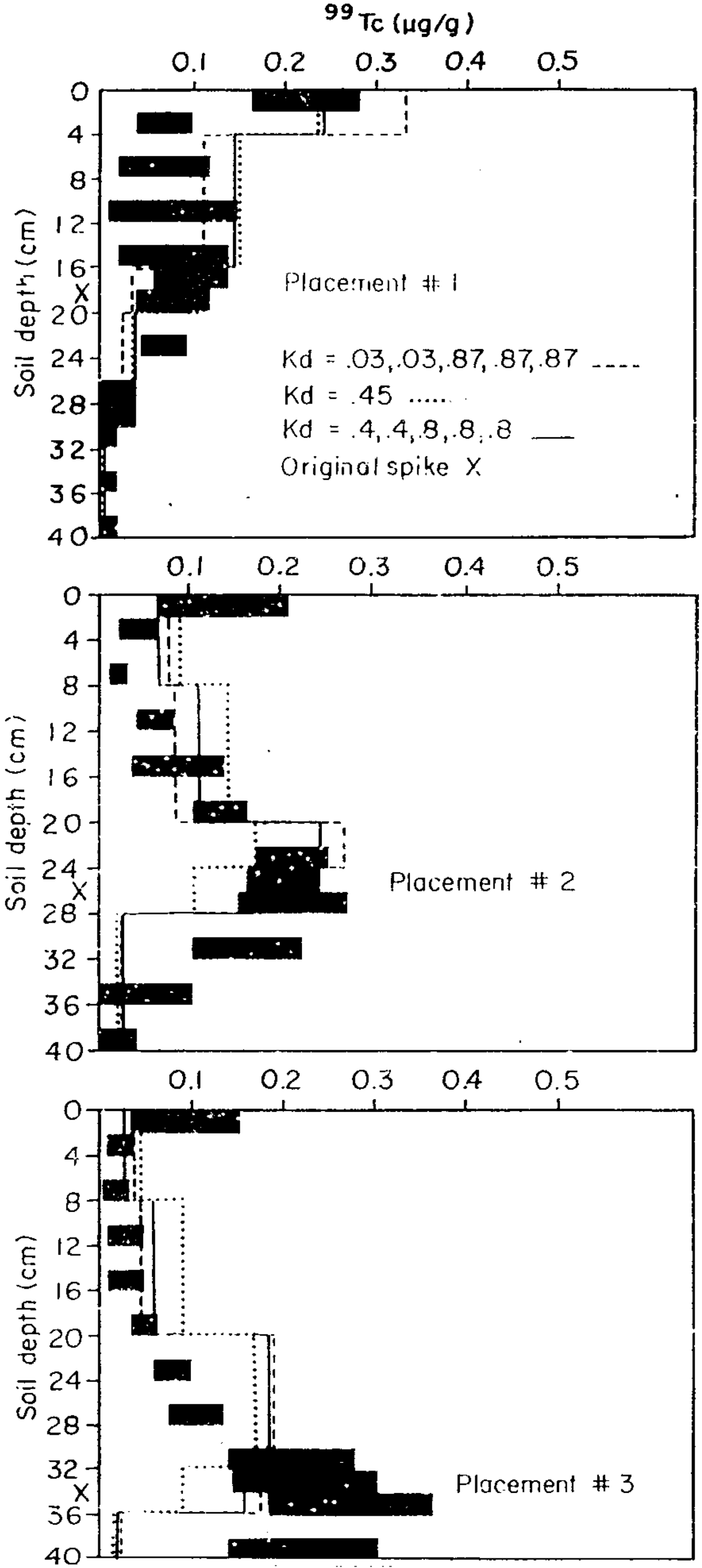


^{99}Tc (μg/g)
0.1 0.2 0.3 0.4 0.5
Soil depth (cm)
0 4 8 12 16 20 24 28 32 36 40
X
Placement # 1
Kd = .03,.03,.87,.87,.87
Kd = .45
Kd = .4,.4,.8,.8,.8
Original spike X
Placement # 2
Placement # 3

PROCESSES AND PATHWAYS CONTRIBUTING TO SOIL CONCENTRATIONS IN THE VARIOUS FIELDS

Soil and Fields	Nuclide Transport Processes				Contributing Pathways		
	Advection with Water	Gaseous Evasion	Cropping Losses	Decay/ Ingrowth	Groundwater Contamination	Irrigation	Atmospheric Deposition
Deep Soils (≥ 0.5 m deep)							
Garden	Yes	Yes	Yes	Yes	Yes+	In 90% of runs	Yes
Forage field	Yes	Yes	Yes	Yes	Yes+	In 2% of runs	Yes
Woodlot	Yes	Yes	Yes	Yes	Yes+	No	Yes
Peat bog*	Yes	Yes	No	Yes	Yes	No	Yes
Shallow Soils (< 0.5 m deep)							
Garden	Yes**	No	No	Yes	Yes	No	Yes
Forage field	Yes**	No	No	Yes	Yes+	No	Yes
Woodlot	Yes**	No	No	Yes	Yes+	No	Yes
Peat bog*	Yes**	No	No	Yes	Yes+	No	Yes
Sediment as Soil	Yes	No	No	No	Yes	No	No

* The peat bog is modelled only if the soil type is organic and the critical group burns peat for energy.
** Uniform mixing in a single layer.
\+ If area of terrestrial discharge is sufficiently large.

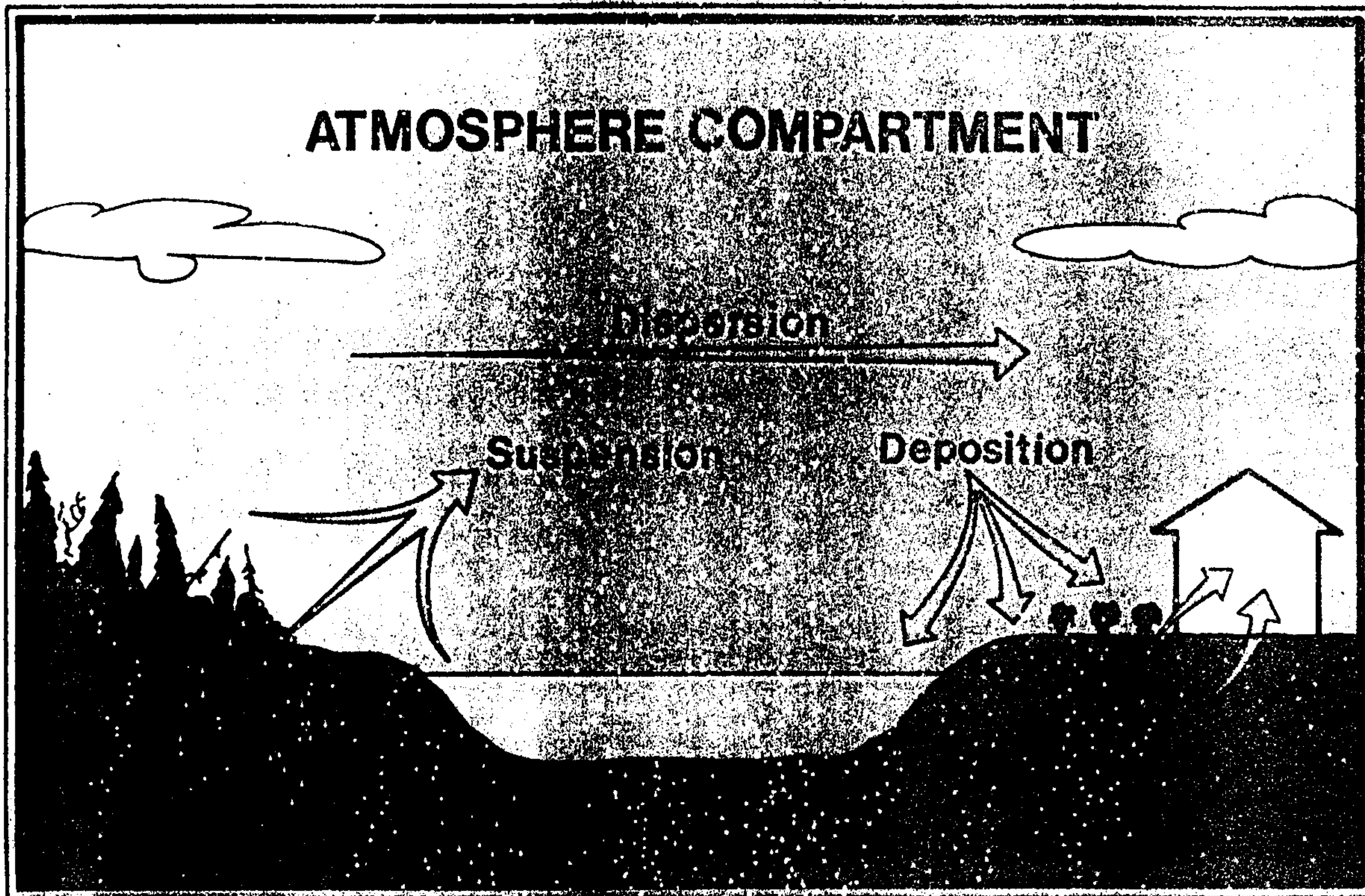


99Tc (μg/g)
0.1
0.2
0.3
0.4
0.5
Soil depth (cm)
0
4
8
12
16
20
24
28
32
36
40
X
Placement # 1
Kd = .03,.03,.87,.87,.87
Kd = .45
Kd = .4,.4,.8,.8,.8
Original spike X
Placement # 2
Placement # 3

PROCESSES AND PATHWAYS CONTRIBUTING TO SOIL CONCENTRATIONS IN THE VARIOUS FIELDS

Soil and Fields	Nuclide Transport Processes				Contributing Pathways		
	Advection with Water	Gaseous Evasion	Cropping Losses	Decay/ Ingrowth	Groundwater Contamination	Irrigation	Atmospheric Deposition
Deep Soils (≥ 0.5 m deep)							
Garden	Yes	Yes	Yes	Yes	Yes+	In 90% of runs	Yes
Forage field	Yes	Yes	Yes	Yes	Yes+	In 2% of runs	Yes
Woodlot	Yes	Yes	Yes	Yes	Yes+	No	Yes
Peat bog*	Yes	Yes	No	Yes	Yes	No	Yes
Shallow Soils (< 0.5 m deep)							
Garden	Yes**	No	No	Yes	Yes	No	Yes
Forage field	Yes**	No	No	Yes	Yes+	No	Yes
Woodlot	Yes**	No	No	Yes	Yes+	No	Yes
Peat bog*	Yes**	No	No	Yes	Yes+	No	Yes
Sediment as Soil	Yes	No	No	No	Yes	No	No

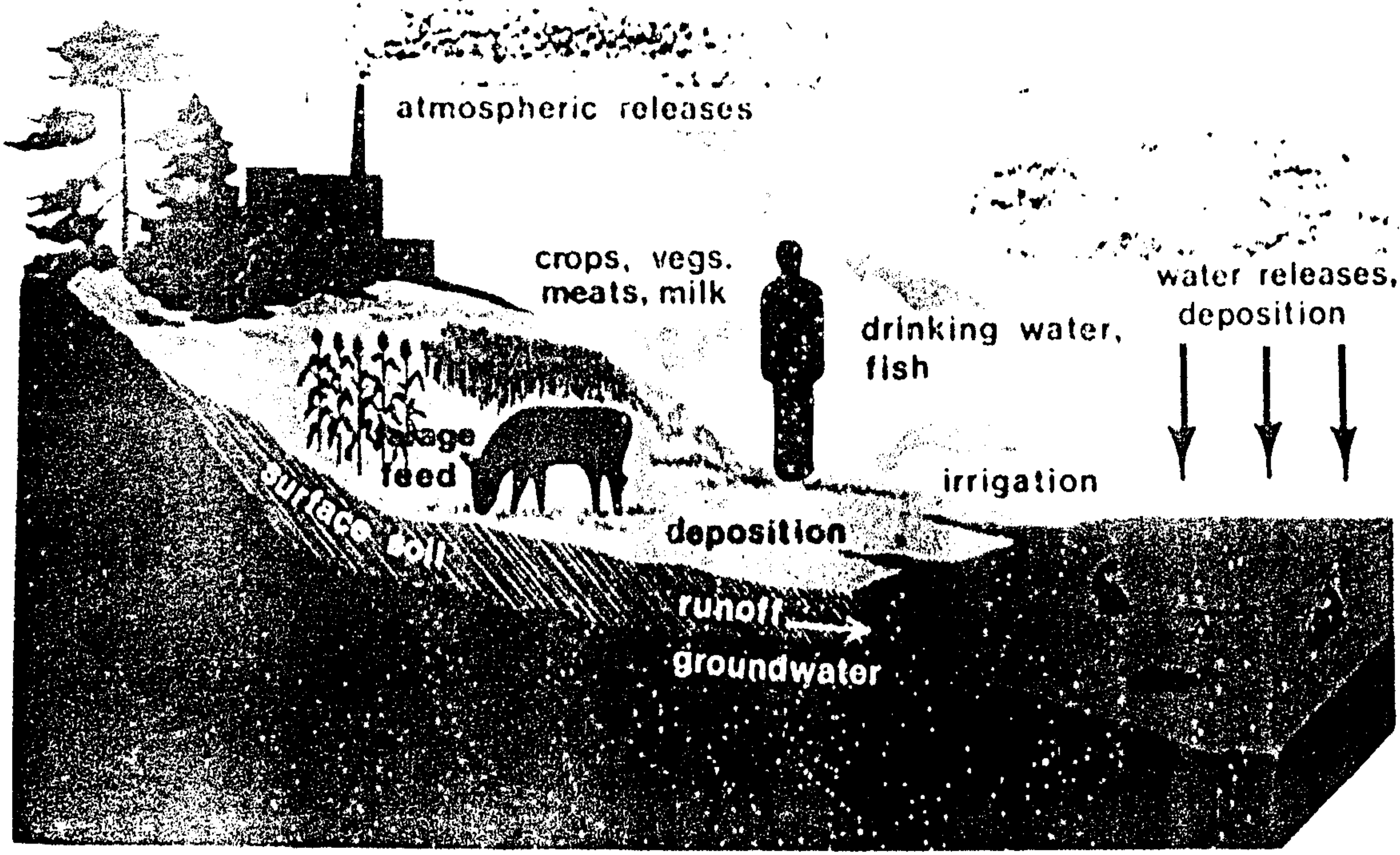
* The peat bog is modelled only if the soil type is organic and the critical group burns peat for energy.
** Uniform mixing in a single layer.
\+ If area of terrestrial discharge is sufficiently large.


ATMOSPHERE COMPARTMENT
Dispersion
Suspension
Deposition

PATHWAYS CONTRIBUTING TO OUTDOOR AIR CONCENTRATIONS

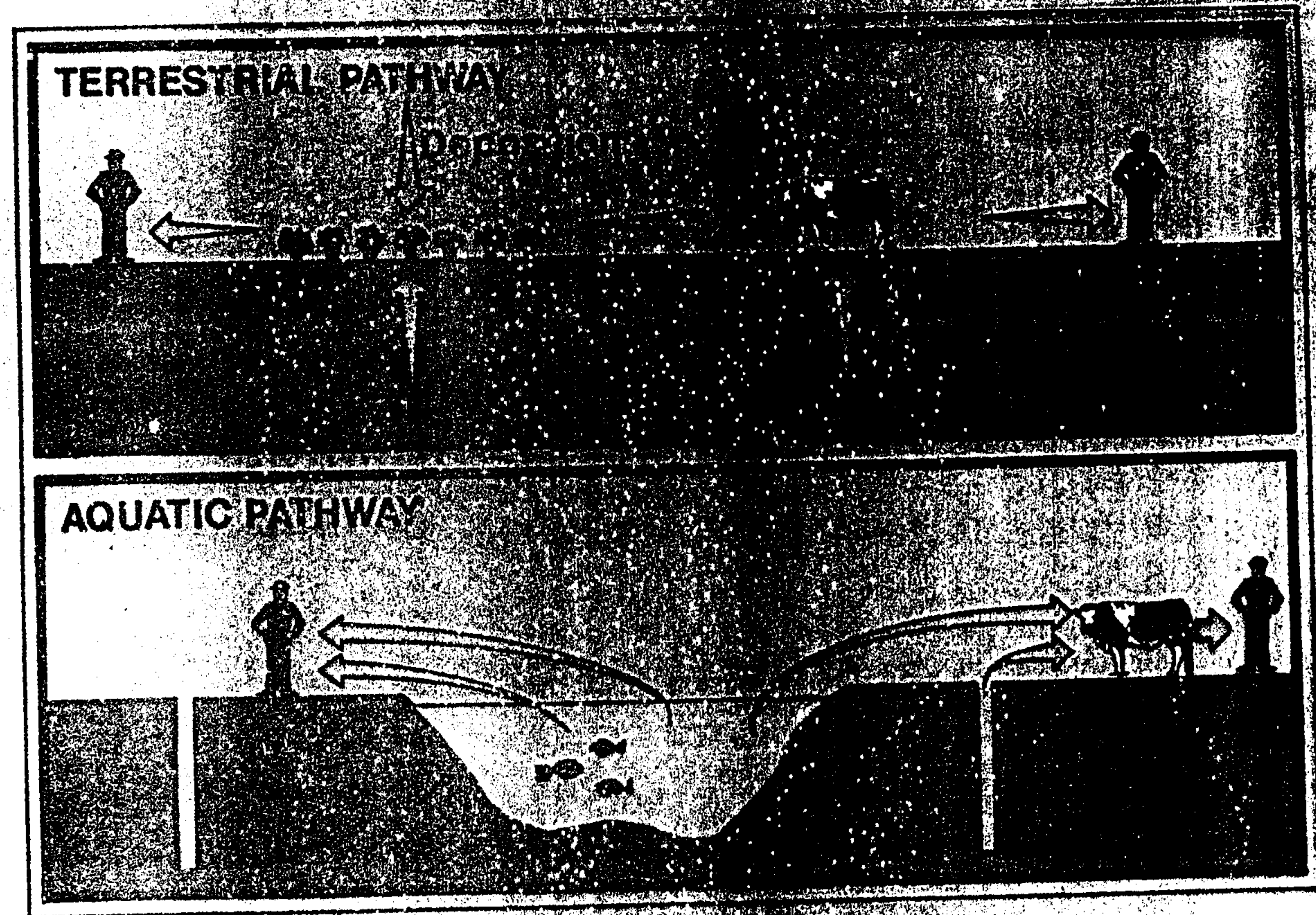
Pathway	Nuclide				All Other Nuclides
	^{14}C	^{79}Se	^{129}I	^{222}Rn	
Terrestrial Particles	X	X	X	X	X
Aquatic Particles	X	X	X	X	X
Terrestrial Gases	X	X	X	X	
Aquatic Gases	X		X	X	
Agricultural Fires	X	X	X	X	X
Energy Fires	X	X	X	X	X
Land-Clearing Fires	X	X	X	X	X

pathways leading to internal exposure of man



WNRE

FOOD-CHAIN PATHWAYS



Definition of the critical group

contemporary, futuristic, ancient?

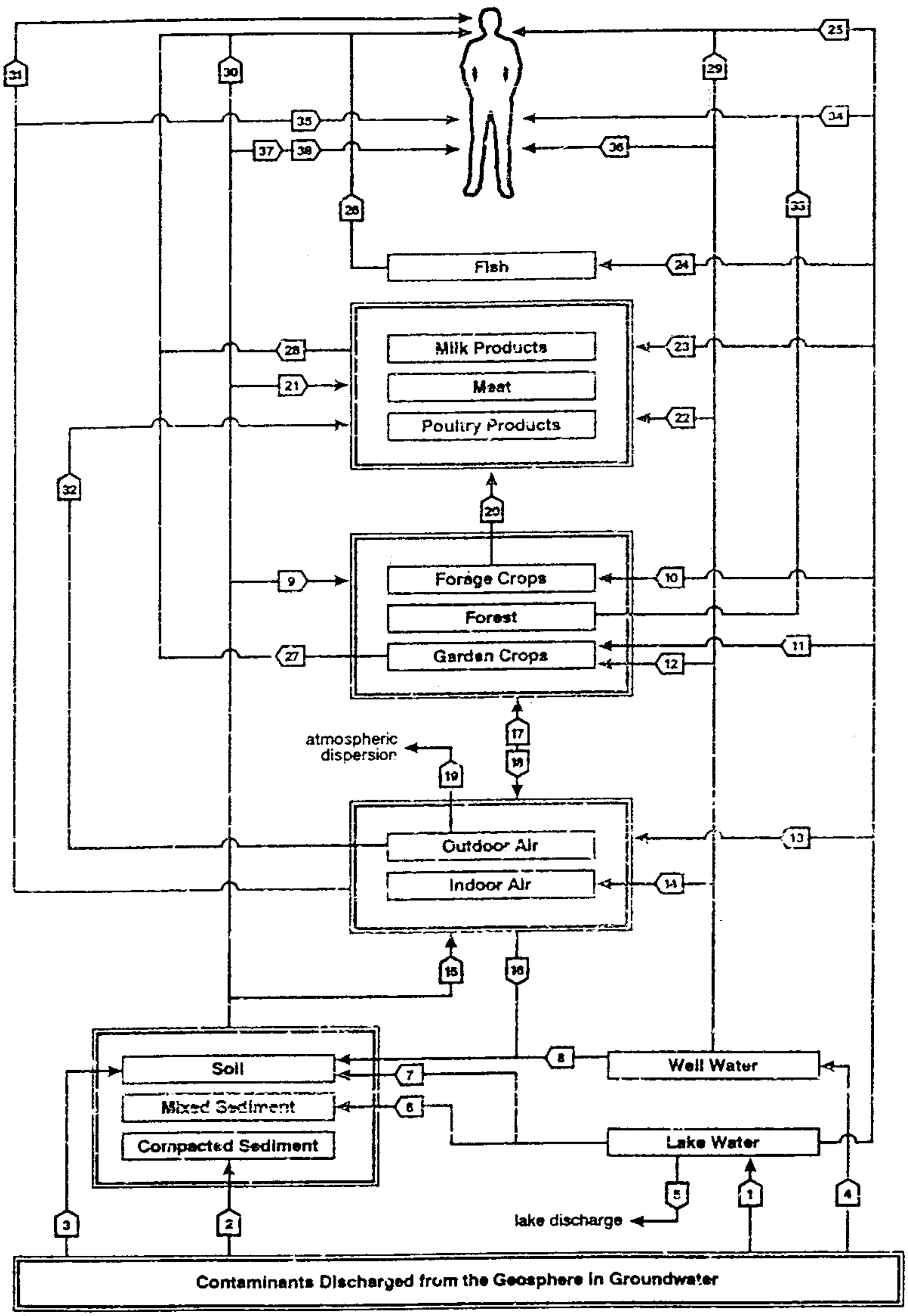
- technology, detection of hazard, health care
- diet

self sufficient?

- what fraction of resources are local?

'standard' man or diverse?

always present?



Fish
Milk Products
Meat
Poultry Products
Forage Crops
Forest
Garden Crops
atmospheric dispersion
Outdoor Air
Indoor Air
Soil
Mixed Sediment
Compacted Sediment
Well Water
Lake Water
lake discharge
Contaminants Discharged from the Geosphere in Groundwater

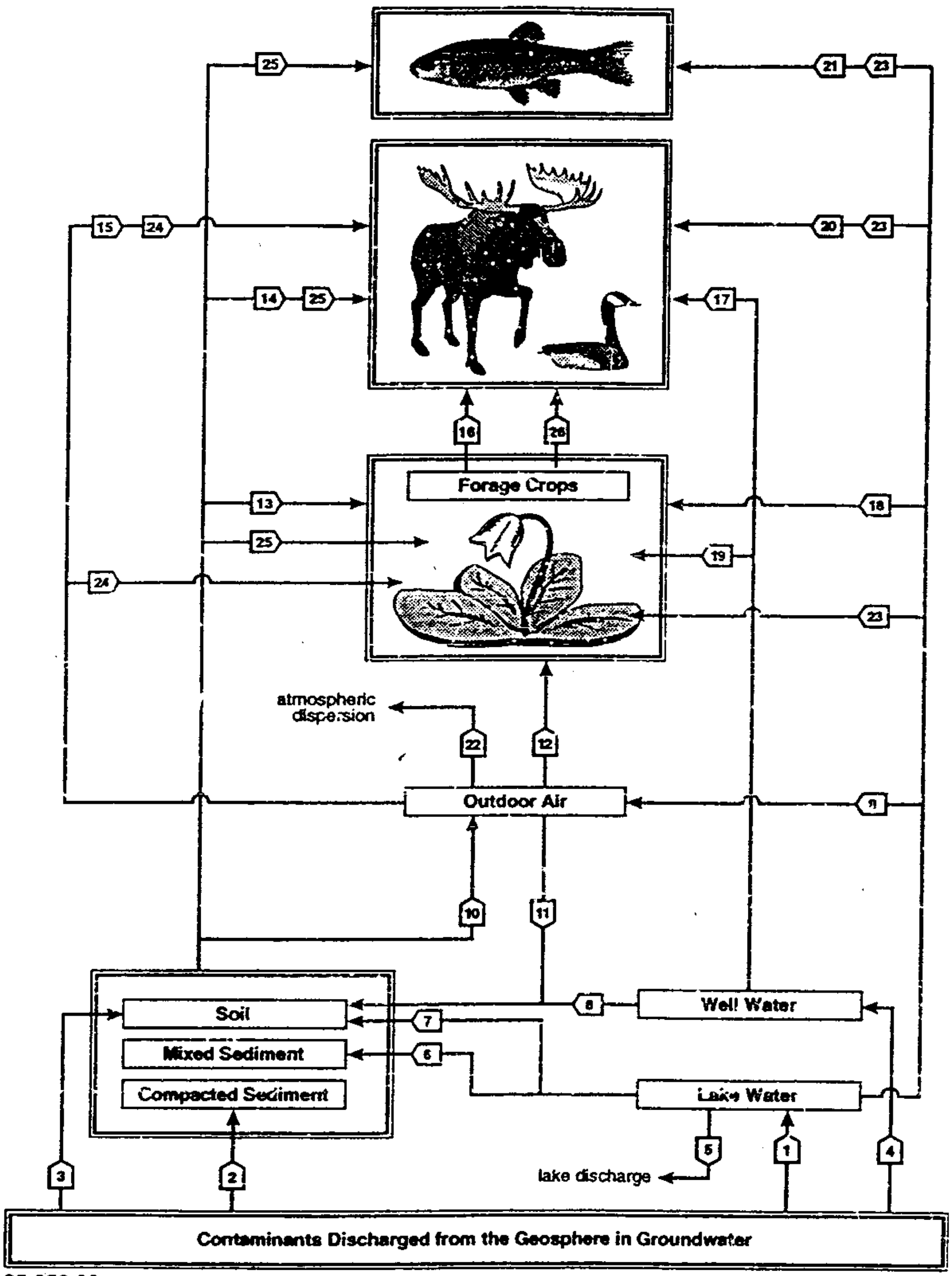
95-050.05

TOTAL DOSES AT 10,000 YEARS FOR 11 LIFESTYLE SCENARIOS

	Scenario	Dose ($Sv \cdot a^{-1}$)
1.	Vegetarian	1.0×10^{-17}
2.	Vegetarian with dairy	8.0×10^{-18}
3.	Vegetarian with diary and eggs	8.1×10^{-18}
4.	Meat	6.6×10^{-20}
5.	Poultry/eggs	8.7×10^{-20}
6.	Dairy	7.0×10^{-20}
7.	Fish	4.8×10^{-20}
8.	Aboriginal/northern mixed	6.4×10^{-19}
9.	Aboriginal/northern meat	6.9×10^{-18}
10.	Aboriginal/northern bird	7.3×10^{-18}
11.	Aboriginal/northern fish	5.9×10^{-18}
	Median case simulation	2.9×10^{-18}

Note: Scenario doses are based on well or lake water with or without irrigation, which ever gave the highest value.

From TR-719, COG-95-542



25
21
23
15
24
20
23
14
25
17
16
26
Forage Crops
13
18
25
19
24
23
atmospheric dispersion
22
12
Outdoor Air
9
10
11
Soil
Mixed Sediment
Compacted Sediment
8
Well Water
7
6
Lake Water
5
lake discharge
1
4
3
2
Contaminants Discharged from the Geosphere in Groundwater

95-050.06