UNDERSTANDING RISK PART TWO:

ENVIRONMENTAL DOSE and RISK

Walt Kubilius

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UNDERSTANDING RISK

- Part 1: Expressing Concentrations
- Part 2: Environmental Dose and Health Risk
- Part 3: Remedy Selection

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evaluating a waste unit

CONCENTRATION

How much is there

DOSE

How much people will be exposed to

HEALTH RISK

How harmful it is

REMEDY

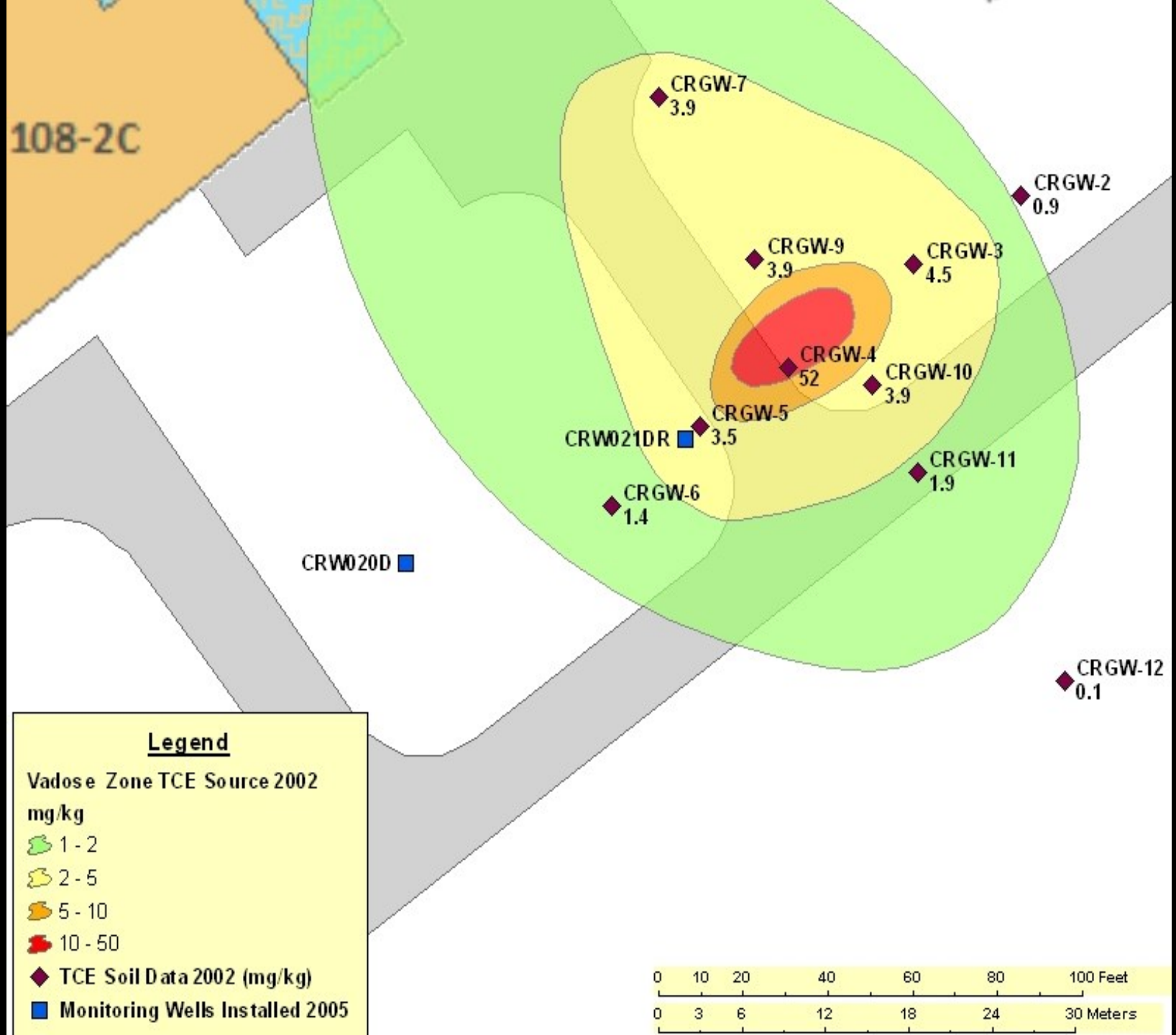
How to protect the people

CONCENTRATION

How much is there

CONCENTRATION UNITS	**SOIL**	**GROUNDWATER** **SURFACE WATER**
NON-RAD (e.g. TCE, Pb)	mg/kg (ppm) ug/kg (ppb) µg/kg	mg/L (ppm) ug/L (ppb) µg/L
RAD (e.g. Cs-137)	pCi/g	pCi/L

Geiger counter demo


108-2C
CRGW-7
3.9
CRGW-2
0.9
CRGW-9
3.9
CRGW-3
4.5
CRGW-4
52
CRGW-10
3.9
CRGW-5
3.5
CRW021DR
CRGW-11
1.9
CRGW-6
1.4
CRW020D
CRGW-12
0.1
Legend
Vadose Zone TCE Source 2002
mg/kg
1 - 2
2 - 5
5 - 10
10 - 50
TCE Soil Data 2002 (mg/kg)
Monitoring Wells Installed 2005
0 10 20 40 60 80 100 Feet
0 3 6 12 18 24 30 Meters

evaluating a waste unit

CONCENTRATION

How much is there

DOSE

How much people will be exposed to

DOSE

Amount of a contaminant absorbed/ingested/inhaled by a receptor (person or animal)

RADIOLOGICAL: Amount of ***radiation energy*** absorbed by a receptor

CHEMICAL: Amount of ***contaminant mass*** ingested or inhaled by a receptor

RADIOLOGICAL DOSE

Amount of ***radiation energy*** absorbed by a person

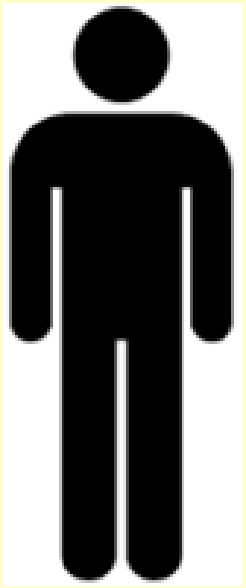
Measured as “rem”

(Roentgen Equivalent Man)

ACUTE DOSE: high dose over short period of time

CHRONIC DOSE: low dose over long period of time

ACUTE RADIATION DOSE



1 meter

1 curie Cs-137

for 1 hour....

dose = about 1 rem

ACUTE RADIATION DOSE

< 100 rem	no symptoms
100→800 rem	acute radiation syndrome (ARS) with recovery
> 800 rem	fatal

ACUTE RADIATION DOSE EXAMPLE

HIGH LEVEL WASTE sludge: 6 curies/liter Cs-137

a 2-liter bottle holds 12 curies

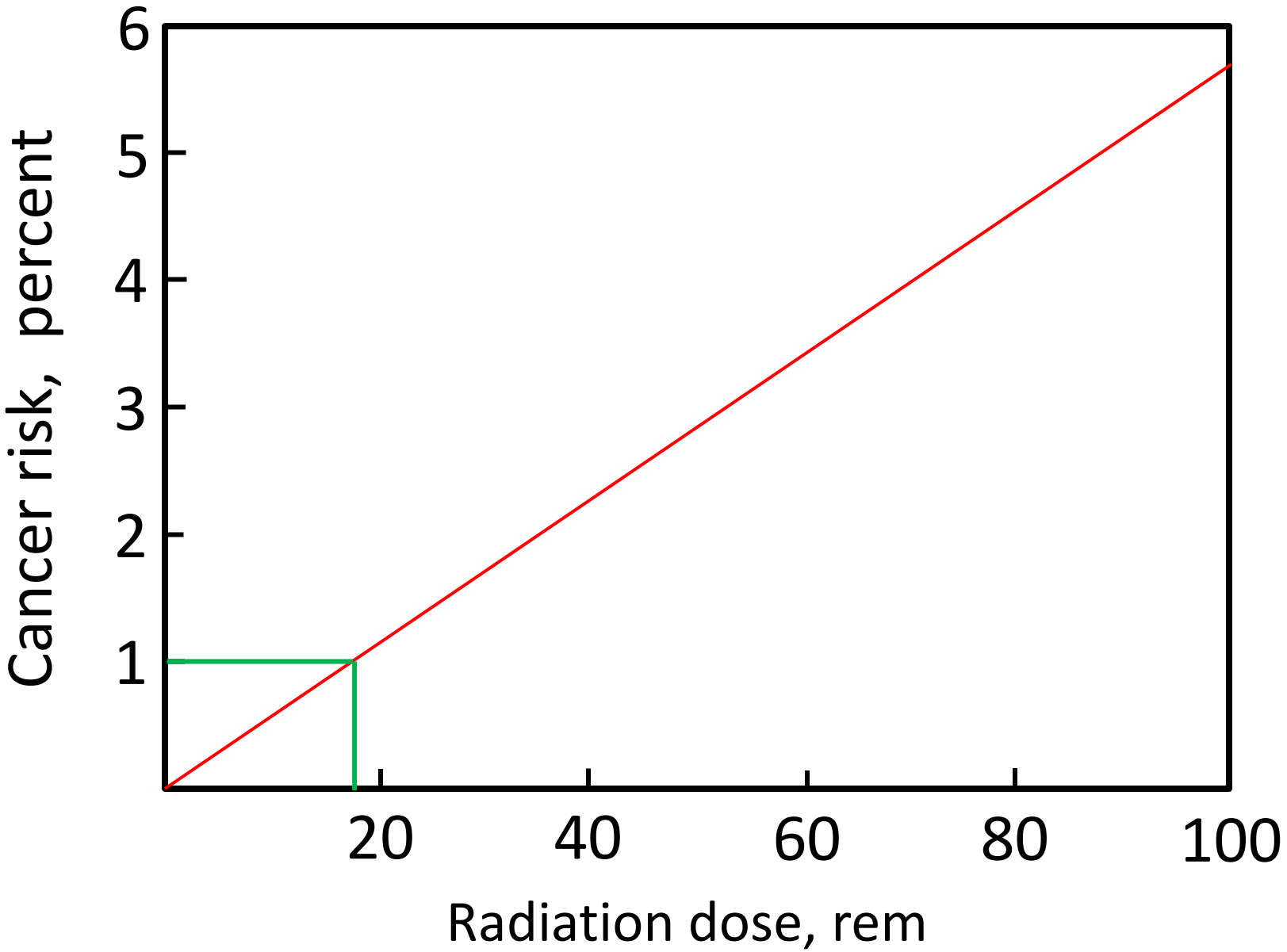
1 bottle, 8 hours – minimal ARS

3 bottles, 8 hours – serious ARS

10 bottles, 8 hours – fatal dose

High dose = ARS

Low dose = cancer risk



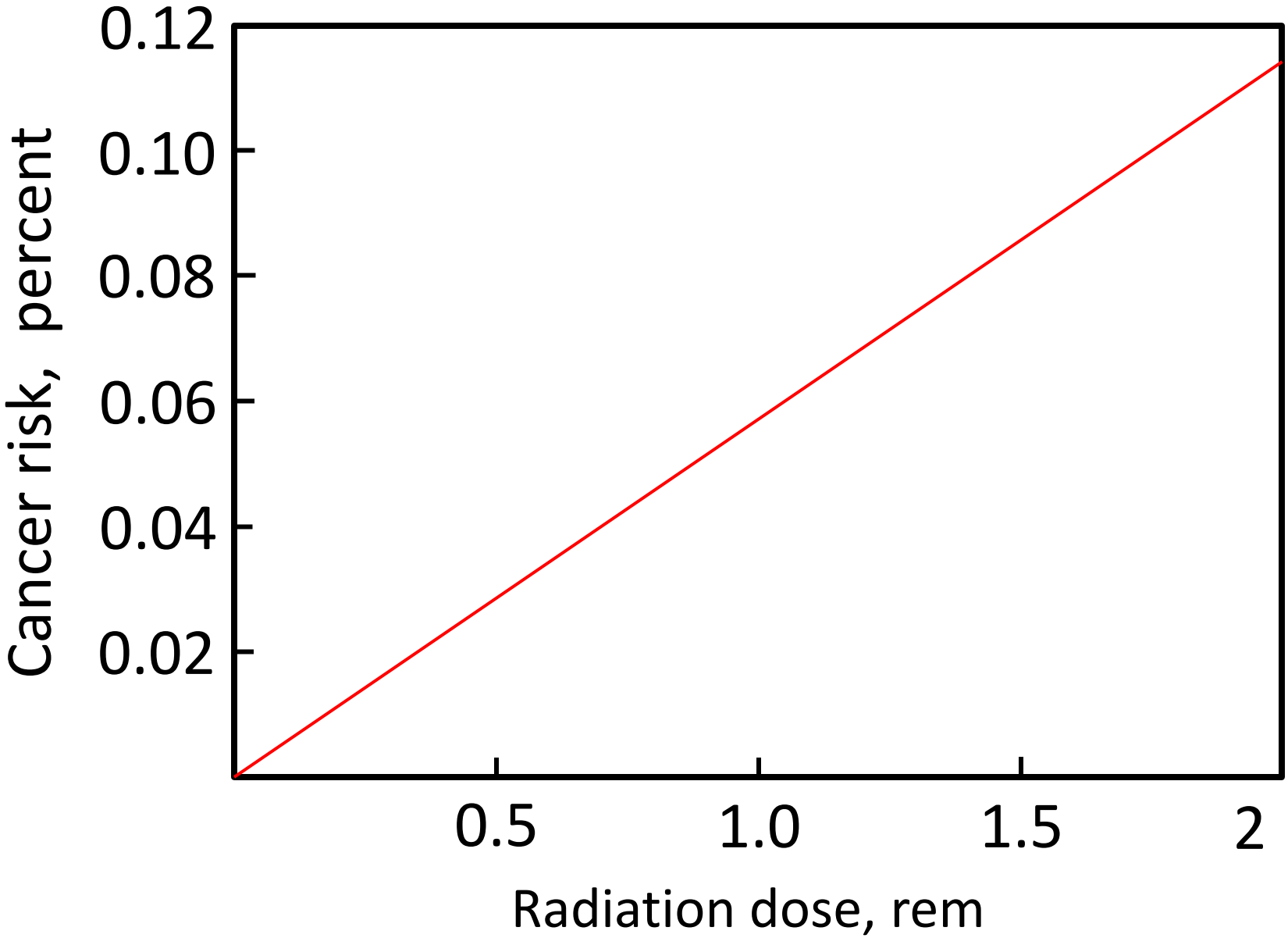
Source: EPA 402-R-99-003

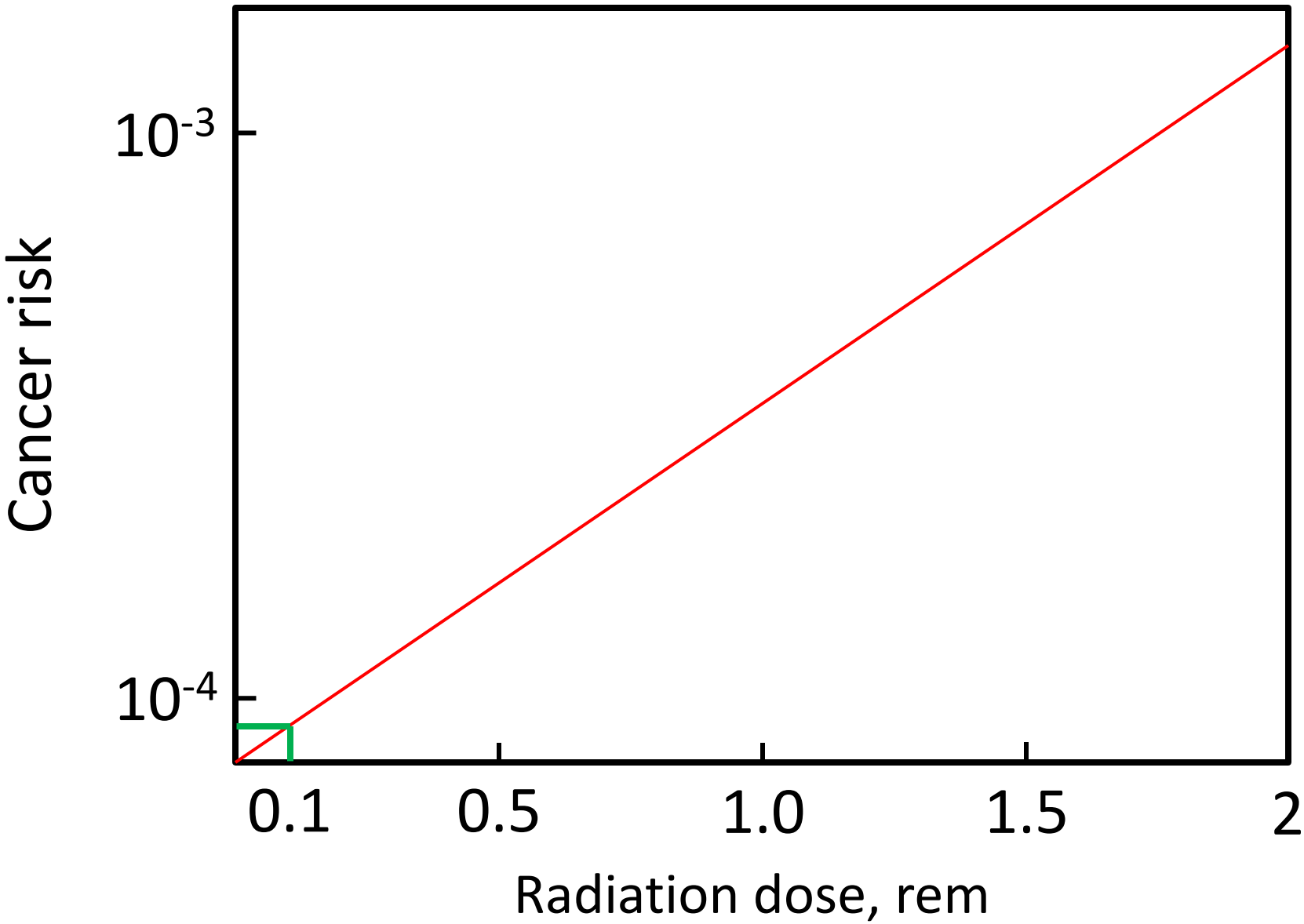
17 rem: 1% lifetime cancer risk

10^{-2} human health risk

POWERS OF TEN

$\frac{1}{100}$	0.01	10^{-2}
$\frac{1}{1,000}$	0.001	10^{-3}
$\frac{1}{10,000}$	0.0001	10^{-4}
$\frac{1}{100,000}$	0.00001	10^{-5}
$\frac{1}{1,000,000}$	0.000001	10^{-6}


0.12
0.10
0.08
0.06
0.04
0.02
Cancer risk, percent
0.5
1.0
1.5
2
Radiation dose, rem


Cancer risk
10^{-3}
10^{-4}
0.1
0.5
1.0
1.5
2
Radiation dose, rem

CHEMICAL DOSE

Amount of ***contaminant*** absorbed by a person

Measured as mg/kg:

mg of absorbed contaminant per kg of body weight

evaluating a waste unit

CONCENTRATION

pCi/g, pCi/L
ug/kg, ug/L
mg/kg, mg/L

DOSE

rem, mrem
mg per kg body weight

HEALTH RISK

probability of long-term health impact

REMEDY

RISK ASSESSMENT

- SRS follows a protocol based on EPA guidance & approved by EPA & SCDHEC
- Use concentration data to determine expected health risk to public in the future
- Health risk expressed as a probability (e.g. 10^{-4} lifetime cancer risk)
- Soil & groundwater treated separately

EPA RISK ASSESSMENT GUIDANCE

Who could be exposed to contaminants in the future?

Future resident

Future industrial worker

EXPOSURE SCENARIO

- FUTURE RESIDENT
  - 26 years, 350 days/yr, 24 hr/day
- FUTURE INDUSTRIAL WORKER
  - 25 years, 250 days/yr, 8 hr/day

Assumptions of ingestion/inhalation rates, dermal contact, etc.

EPA ACTION LEVEL

The soil contaminant concentration which will lead to a 10^{-6} lifetime cancer risk for a future resident or industrial worker

metals, organics: Regional Screening Level (RSL)
radiologicals: Preliminary Remediation Goal (PRG)

EXAMPLE

Hypothetical waste unit where estimated surface soil average concentration is:

TCE 52 mg/kg

EXAMPLE (continued)

Residential RSL for TCE is 0.94 mg/kg
(= 10^{-6} lifetime cancer risk)

$$\frac{52 \text{ mg/kg}}{0.94 \text{ mg/kg}} = 55.3$$

RISK = 55.3×10^{-6} or **5.53×10^{-5}**

EXAMPLE (continued)

Industrial RSL for TCE is 6.0 mg/kg
(= 10^{-6} lifetime cancer risk)

$$\frac{52 \text{ mg/kg}}{6.0 \text{ mg/kg}} = 8.7$$

RISK = 8.7 x 10^{-6}

EXAMPLE (continued)

Residential risk = 5.5×10^{-5}

Industrial risk = 8.7×10^{-6}

CUMULATIVE RISK

- If multiple Contaminants of Concern are present, risk is calculated for each
- Risks are added to find **CUMULATIVE RISK**

CUMULATIVE CANCER RISK (SOIL)

- Surface soil $< 10^{-6}$ — no further action
- Surface soil 10^{-6} to 10^{-4} — possible remediation
- Surface soil $> 10^{-4}$ — must remediate

- Soil at any depth $> 10^{-3}$ — must remediate

GROUNDWATER & SURFACE WATER

Risk for groundwater & surface water is evaluated differently, but the objective is the same:

protect the health of the public

The major concern is to prevent people from drinking contaminated water

EPA defines Maximum Contaminant Levels (MCLs):

highest acceptable contaminant concentrations in drinking water

EPA MCLs (ug/L)

- TCE 5
- PCE 5
- Benzene 5
- Ethylbenzene 700
- Vinyl chloride 2
- Toluene 1,000

- Antimony 6
- Arsenic 10
- Barium 2,000
- Copper 1,300
- Lead 15
- Mercury 2

EPA MCLs (pCi/L)

- Tritium 20,000
- Strontium-90 8
- Radium 5
- Iodine-129 1

If groundwater has (or is predicted to have) one or more contaminants at concentrations exceeding their MCLs or RSLs:

a remedy will be determined by EPA, SCDHEC, & DOE