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Methodology of Ecological Risk Assessment

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REPUBLIC OF TURKEY
MINISTRY OF ENVIRONMENT
AND URBANISATION

Environment and Climate Action
Sector Operational Programme

Persistent
Organic
Pollutants

Why?

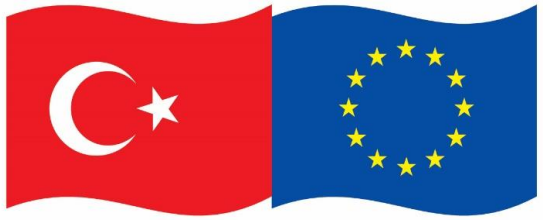
Increasing the effect of anthropogenic pressures on environmental components

- devastation of the environment
- destruction of environmental components
- reduction of self-cleaning ability
- soil erosion
- air, soil and water pollution

Difficult assessment of impacts on individual components of the environment

- the size and diversity of ecosystems
- a number of anthropogenic influences

Currently the best available prediction tool potential danger to the structure and function of ecosystems is ecological risk assessment



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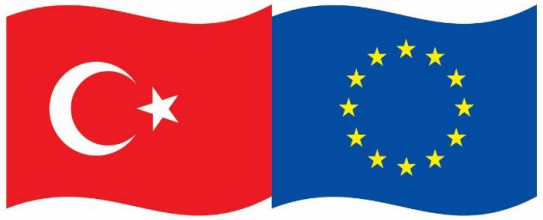
Risk definition

Quantitative term expressing probability (ie number in the range 0 - 1) with which it occurs in a given situation and at given extent of exposure to the test subject system

- 0 no damage at all
- 1 damage occurs in all cases

- Zero level of risk does not exist
- Natural or anthropogenic origin



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Risk definition

- The risk should be measurable depending on your impact and the likelihood that it will occur
- Severity can be described differently depending on situation

- Acute risk (a disaster of which there is a significant exposure exceeding system maintenance)
- Real (relating to the current situation, but not catastrophic proportions)
- Potential (prospective evaluation)

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Sources of risk

Anthropogenic

- GMOs
- Synthetic organic compounds, pesticides
- Asbestos fibers, coal dust, acid rain, contamination surface and groundwater,
- Ozone depletion

Natural

- Short-term
- Long-term
- Volcanic eruption
- Floods
- Landslides

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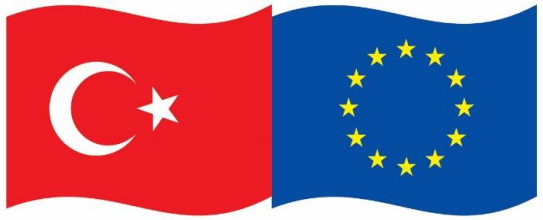
Ecological risk assessment (EcoRA)

- Any activity related to chemicals (production, transport, use, disposal, etc.) is a source of risks for both humans (health risks) as well as for the environment (ecological risks)
- The methodology for assessing environmental risks has been evolving since about 1980
- The concept of health and environmental risk assessment is based on materials developed by the US EPA in 1983-1987 and early was adopted as the basis for EU documents in the 1990s
- Environmental risk assessment - was derived from the practice in the assessment risks to human health, environmental hazard assessment environment and environmental impact assessment



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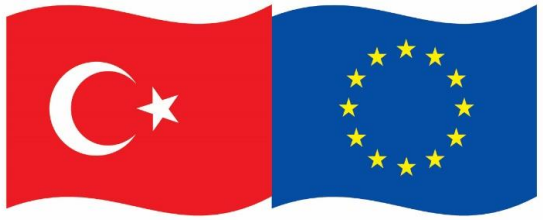
Ecological risk assessment (EcoRA)

The process for assessing the likelihood of living the environment may be affected due to exposure action of one or more environmental stressors - chemicals, soil change, diseases, invasive species and climate change

The process of collecting, organizing and analyzing information to estimate the likelihood of adverse reactions effects on non - human organisms, populations, or ecosystems as a result of exposure to one or more stressors

Potential Hazard Prediction Tool a negative effects of stressors on structure and function ecosystem



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Ecological risk assessment (EcoRA)

The EcoRA process is a comprehensive impact assessment proces human activities to the state of ecosystems

- **Evaluation is applied to the impact of natural, but also anthropogenic processes on ecosystems**
- **Most evaluations focus mainly on the consequences of those anthropogenic**
- **The ultimate goal of environmental risk assessment is prospective (predictive) or retrospective assessment the influence of stress factors on ecosystems and their components**

Ecological risk assessment (EcoRA)

Prospective

- It mainly presents an analysis of potential risks related to planning of interventions in ecosystems
- Methodologically involves capturing the initial state and risk assessment made at the level of potential estimates
- As the only form, it includes a significant possibility of prevention

Retrospective

- Assessments caused by the need to capture possible negative effects in the past, possibly also capture the current state of the system.
- Relatively very complicated situation, the success of the analysis depends on availability of information on sources of pollution.
- Risk assessment from releases or other past events and evaluation risks associated with the future consequences of these events.
- Eg. these include the continuing toxic effects of accidents - the spread of contaminants to other areas, etc.
- The output of the assessment of old loads can be, for example, remediation recommendations, etc.

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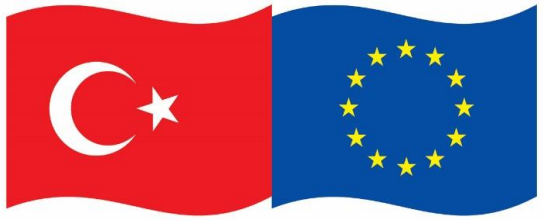
Ecological risk assessment (EcoRA) - definition

- **Toxicity** - the ability of a substance to damage a living organism is given physico-chemical properties
- **Danger** is therefore a set of toxic (complex stress) effects that occur under the given exposure conditions, resp. exposure conditions giving rise to the set of effects.
- **Evaluation of effect (toxicity)** - determination of nature and extent adverse effects due to the dose
- **Stressor:** a physical, chemical or biological unit that can cause a negative reaction



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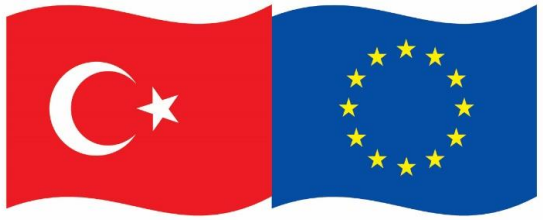
Ecological risk assessment (EcoRA) - definition

- **Danger (hazard)** - is the ability of a chemical have an adverse effect on the environment which is determined by physical and chemical properties substances, qualitative concept
- **Hazard prediction (hazard identification)** prediction or hazard identification - involves a process hazard recognition and prediction
- **Expression of risk** - the ratio between the number of individuals that per certain exposure conditions will suffer an overall harm the number of individuals exposed to the same factor for the same exposure conditions



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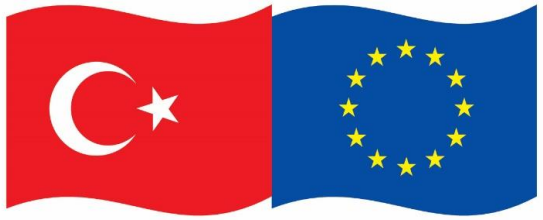
Ecological risk assessment (EcoRA) - definition

- **Exposure** is understood as the contact of a chemical with external ones boundaries of the organism or with a defined part of the environment (ecosystem).
- **Exposure conditions** - characterize target populations (objects)
- **Endpoint** - a measurable parameter related to the effect
- **Receptor** - a plant, animal, community of organisms, or ecosystem, which is exposed to environmental stressors
- **Effect** - a qualitative concept (hepatotoxic, genotoxic ..)
- **Response** - a measurable measure of the same (change in activity liver enzyme)
- **Dose** - the amount of a substance entering the body during exposures per unit body weight and unit time (eg. $mg.kg^{-1}.d^{-1}$)



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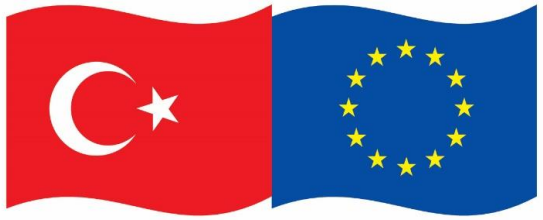
Ecological risk assessment (EcoRA)

- Interdisciplinary proces
- Methodological standardization is absolutely necessary (defense against excessive cost increases, or purposeful abuse of complicated and unclear methodology)
- The need for a standardized methodology is enforced it he extent of the problems addressed and the need to pass on uniform, albeit more general, instructions for their solution.
- Although the EcoRA process is clearly scientific basics and development, from a practical point of view it must be about simplified routine process, with the option of un ambiguous checks and repetitive applications
- Currently clearly the best developer the approach for using EcoRA is the US EPA approach

Methodology of Ecological risk assessment (EcoRA)

- A generally standardized procedure, the individual steps of which lead for risk assessment and management
- Sequence of steps related to problem formulation parametric assessment of exposure and biological effects; and risk characterization.
- The analysis also includes a final recommendation for interpretation identified risks and their management
- For the key elements determining the success of the whole proces evaluation must be considered a representative wording problem and the selection of adequate evaluation target parameters
- The course of this process has relations not only to scientific evaluation of the effects of stress factors, but also to the legislative background, contaminant content standards and other legislation regulations. It is therefore a complex process.



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General scheme of ecological risk assessment (EcoRA)

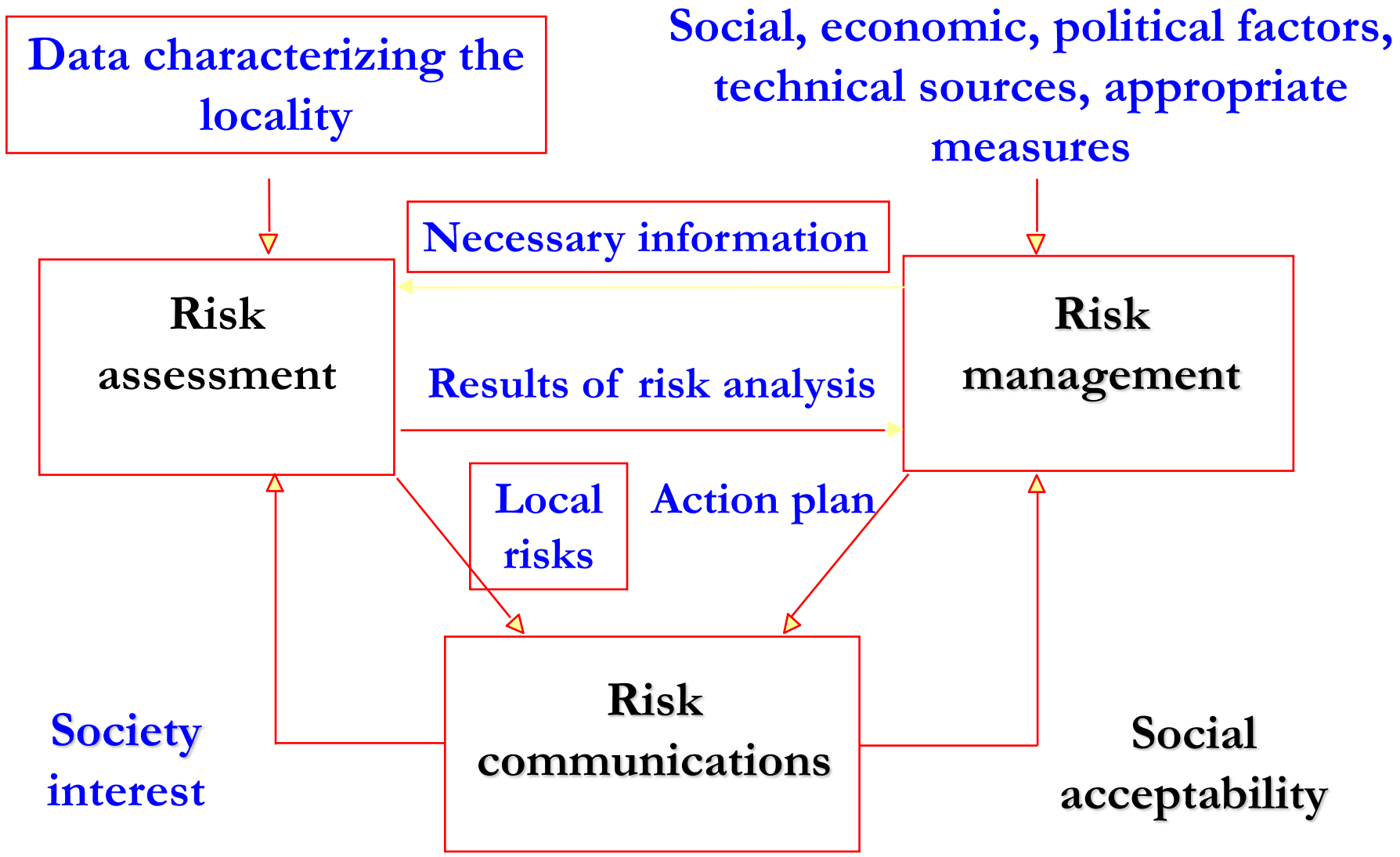
Complex process – simplified diagram

- Problem formulation, Source identification problem
- Analysis

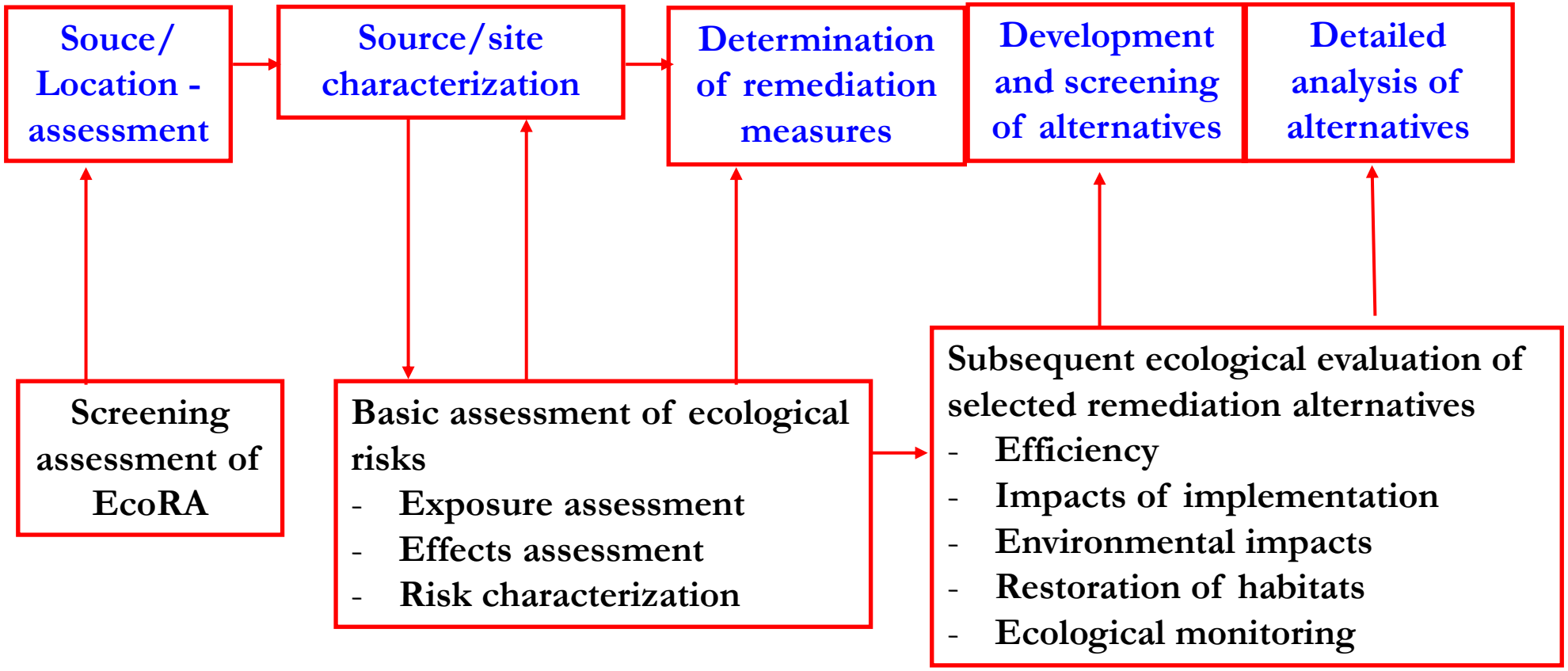
A) Exposure assessment + B) Effect assessment

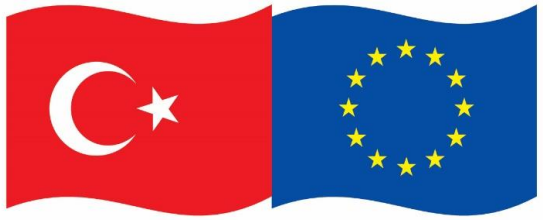
- Risk characterization
- Expert interpretation
- Risk management, legislative steps and support organizational support

Components of risk analysis and relationships between them



The role of environmental risk assessment in various stages of the process





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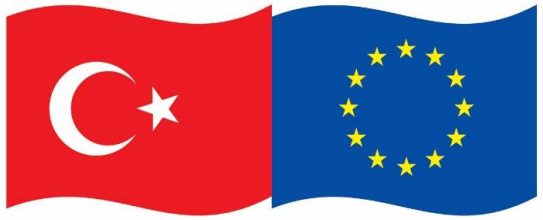
Ecological Risk Assessment (EcoRA)

The process of evaluating the likelihood of the occurrence of adverse environmental effects that have occurred or may occur as a result of exposure to one or more stressors.



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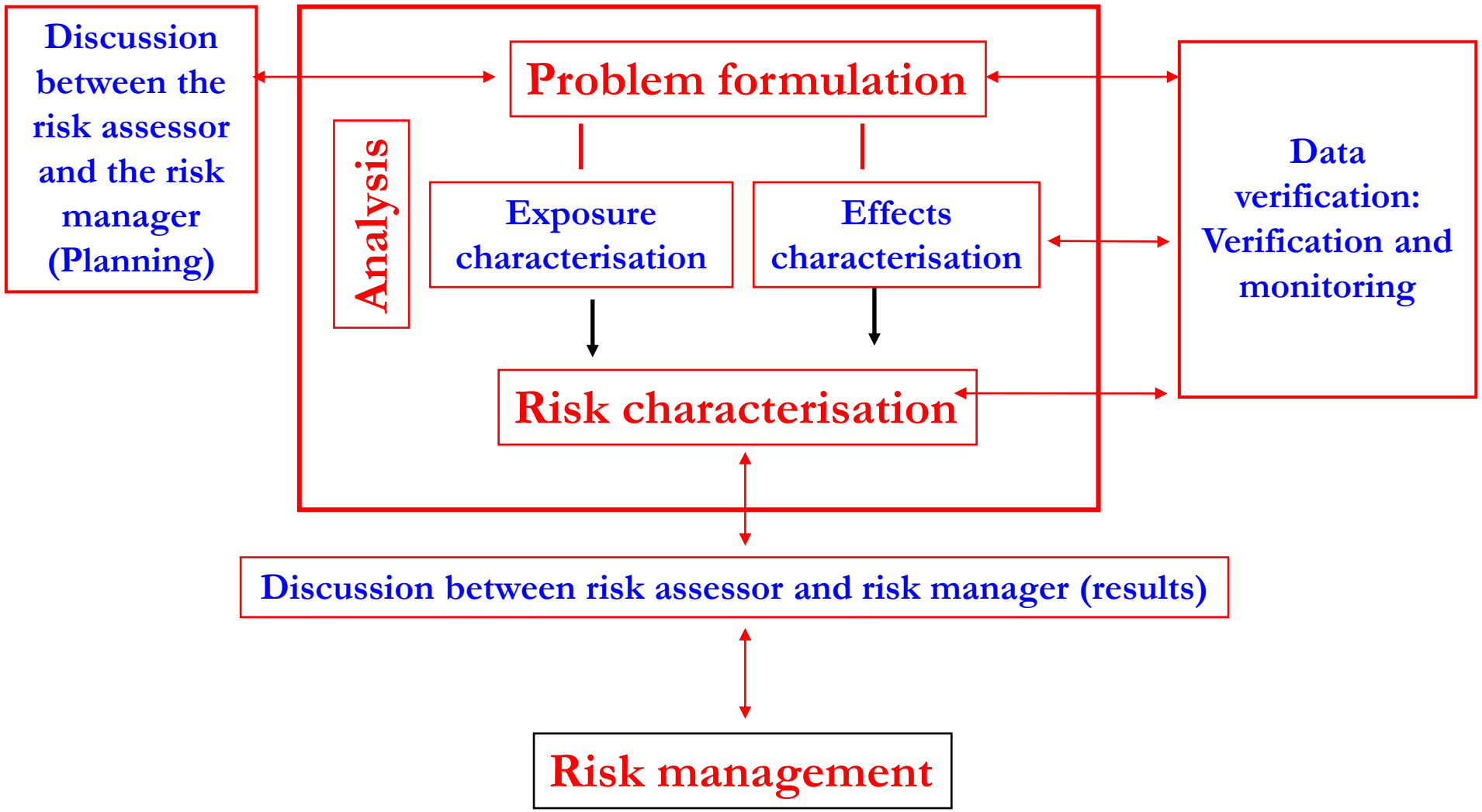
EcoRA is site specific, but contains basic standard procedures

Each location is unique:

- History of use, types of contaminants and their distribution
- Available data
- Status of environmental components
- Ecological resources
- Exposure scenarios

The risk assessment framework is the same for all sites

Ecological Risk Assessment Guidelines (U.S. EPA, 1998)

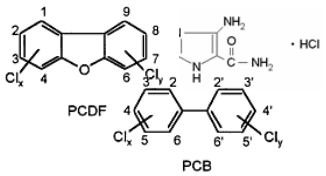


Problem definition = complex information survey

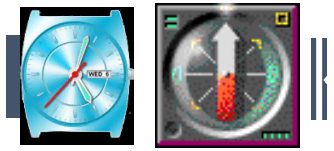
Environmental characteristics

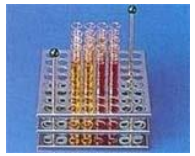
Source of contamination

Compounds of interest



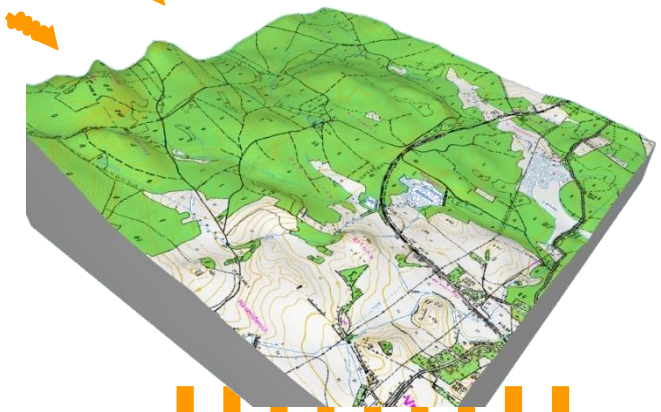
EXPOSURE





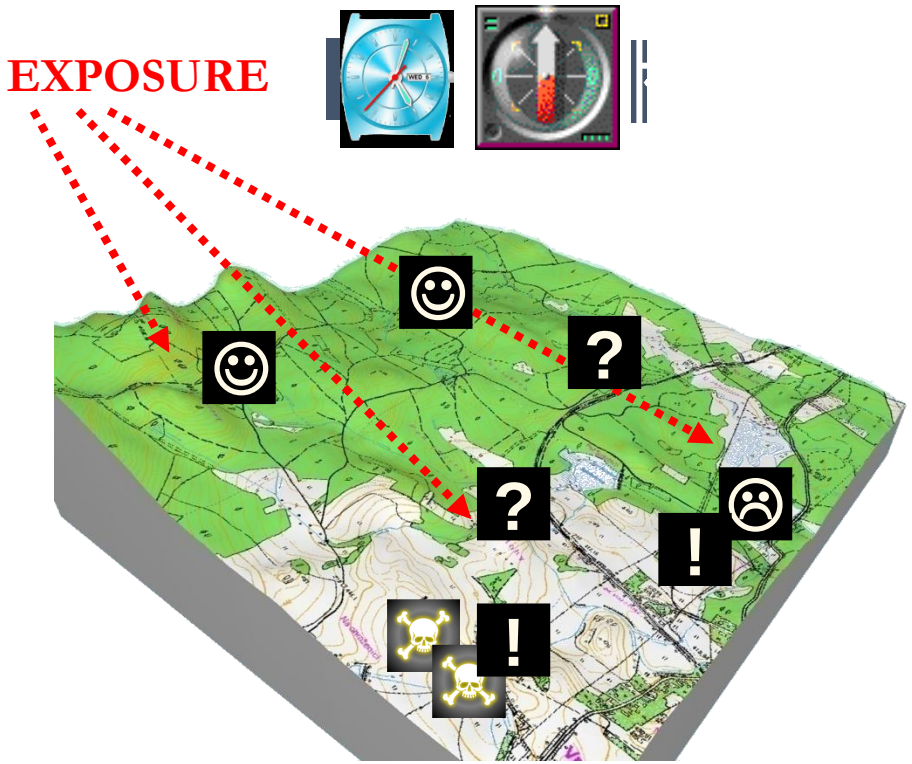
Pilot (screening) test

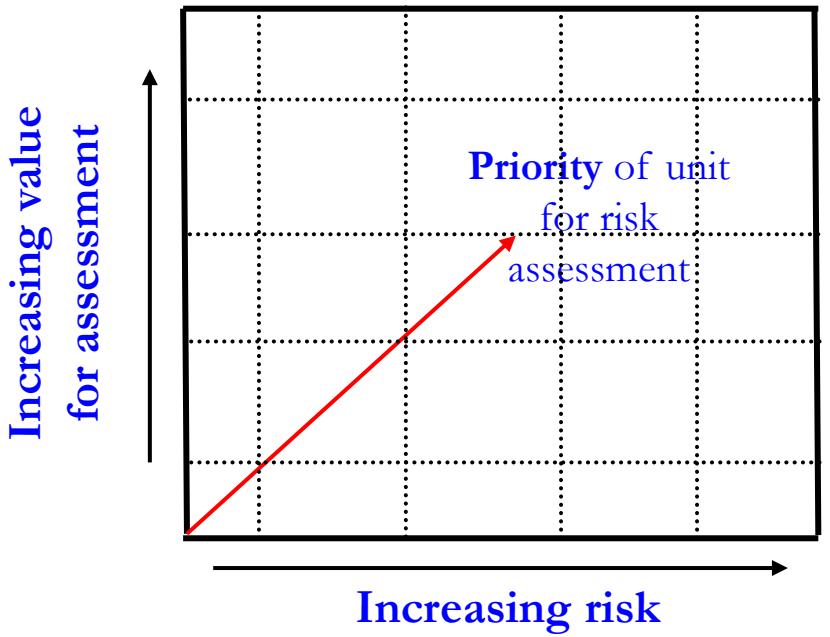
Development of exact situation plan integrates also exposure assessment (at least at screening level)



COMPARTMENTS ACCORDING TO POTENTIAL RISK

Problem definition generates comprehensive SITUATION PLAN





☺ Background sites with no influence of exposure

? Uncertain influence and/or uncertain assessment endpoint

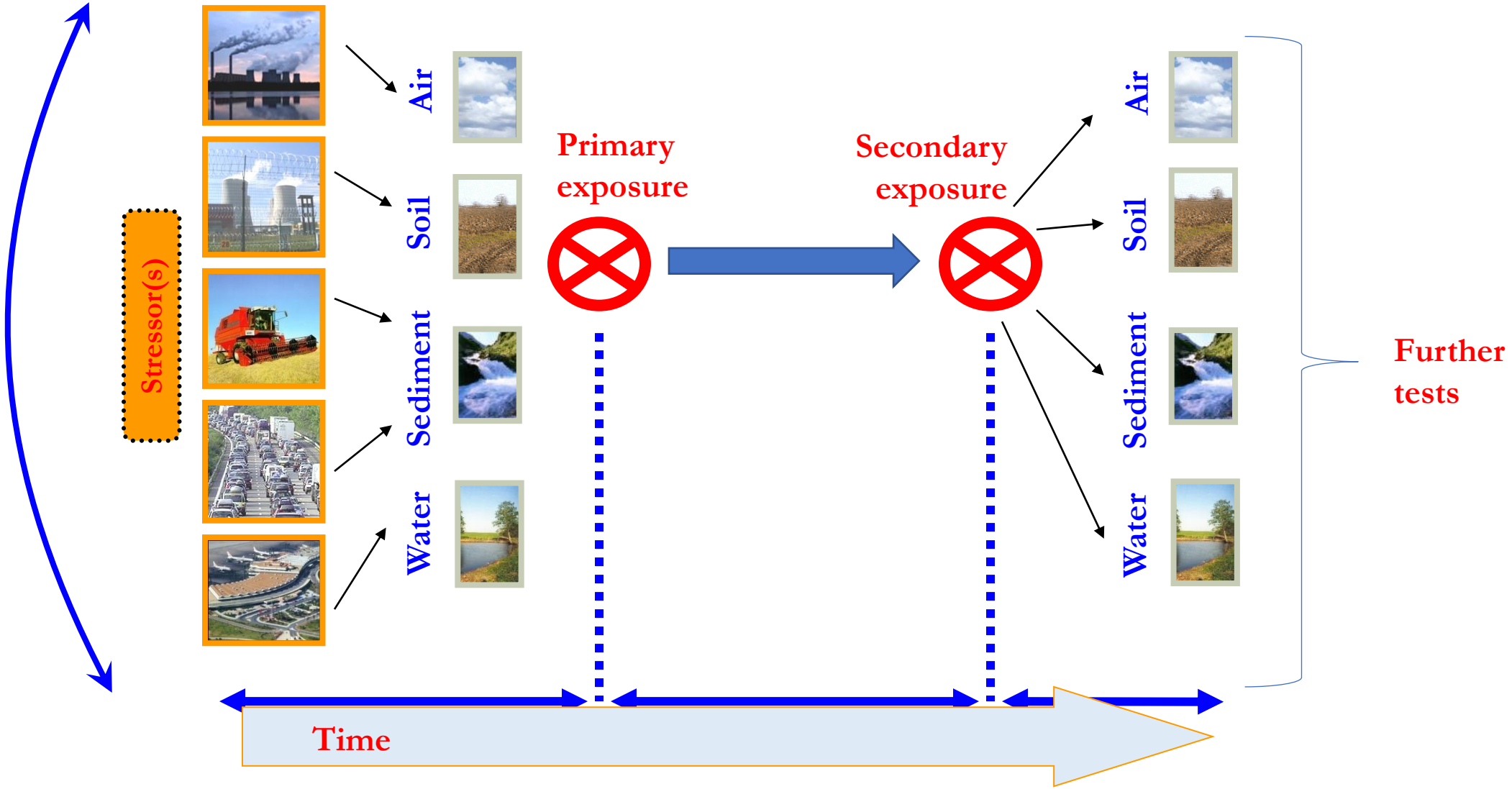
! Potentially affected sites, still clean or with negligible effect

☹ Area with probable and substantial toxic impact

☠ Already strongly affected area with remarkable effects

Assessment scenario and basic principle: „Where is the problem“

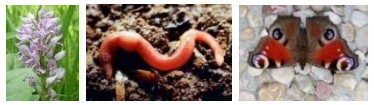
Scenario is in direct relation to estimated (predicted) exposure pathways: all further analyses follow from this starting point



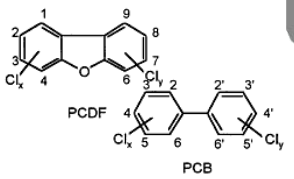
Scenario as milestone of the assessment process

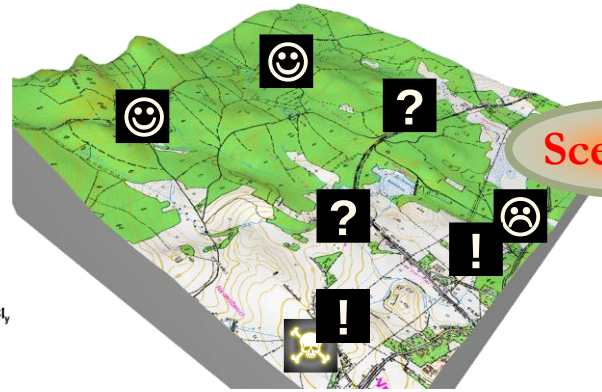
Source of contamination

Environmental characteristics

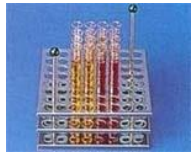


Compounds of interest





SITUATION PLAN



Pilot tests (screening)

Scenario

Primary exposure

Secondary exposure

- Soil
- Sediment
- Water
- Air
- Biota

- Soil
- Sediment
- Water
- Air
- Biota

Further tests

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Eight steps of environmental risk assessment (US Superfund approach)

EPA Superfound Ecological Risk Assessment Guidance

Step 1: Screening level evaluation
- Problem formulation
- Site visit
- Toxicity assessment

Step 2: Screening level evaluation
- Exposure assessment
- Risk calculation

Scientific/ Management Decision Point

Step 3: Formulate the problem
- Rated endpoints
- Conceptual model
- Exposure paths
- Questions / hypotheses

SMDP

Step 4: Study Design / DQOs
- Significance of evidence and data
- Measured endpoints
- Work and sampling plan

SMDP

Step 5: Verify the field sampling plan

SMDP

Step 6: Site research and data analysis

SMDP

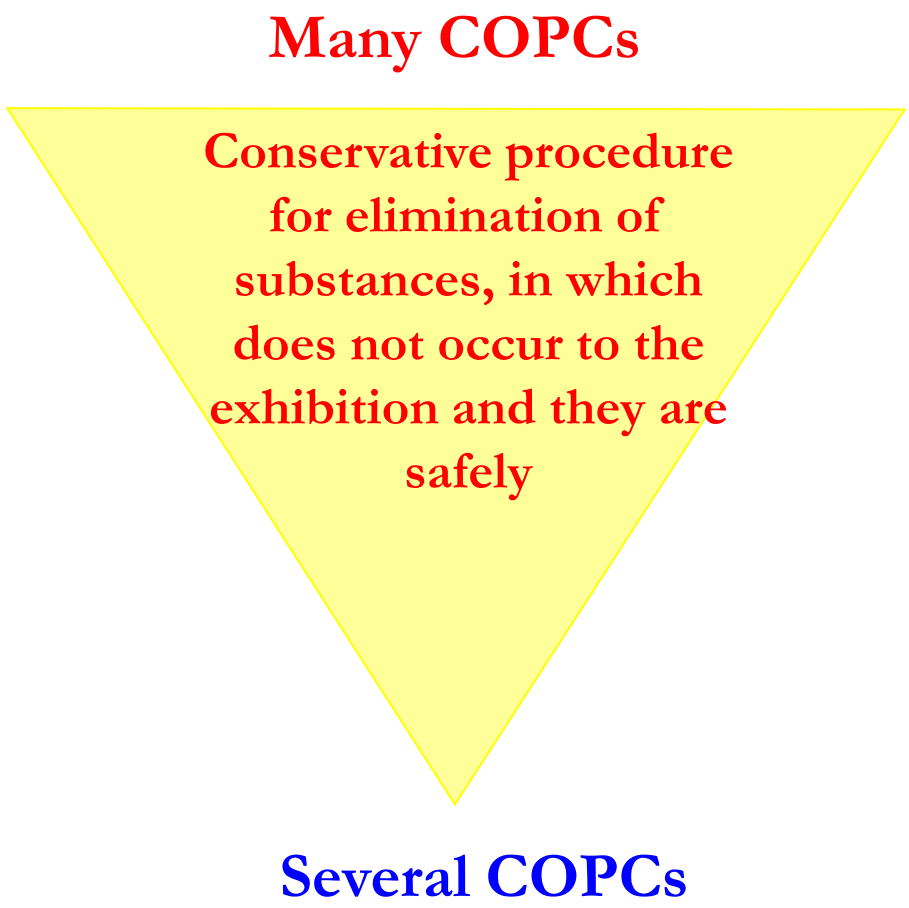
Step 7: Risk characterization

Step 8: Risk management

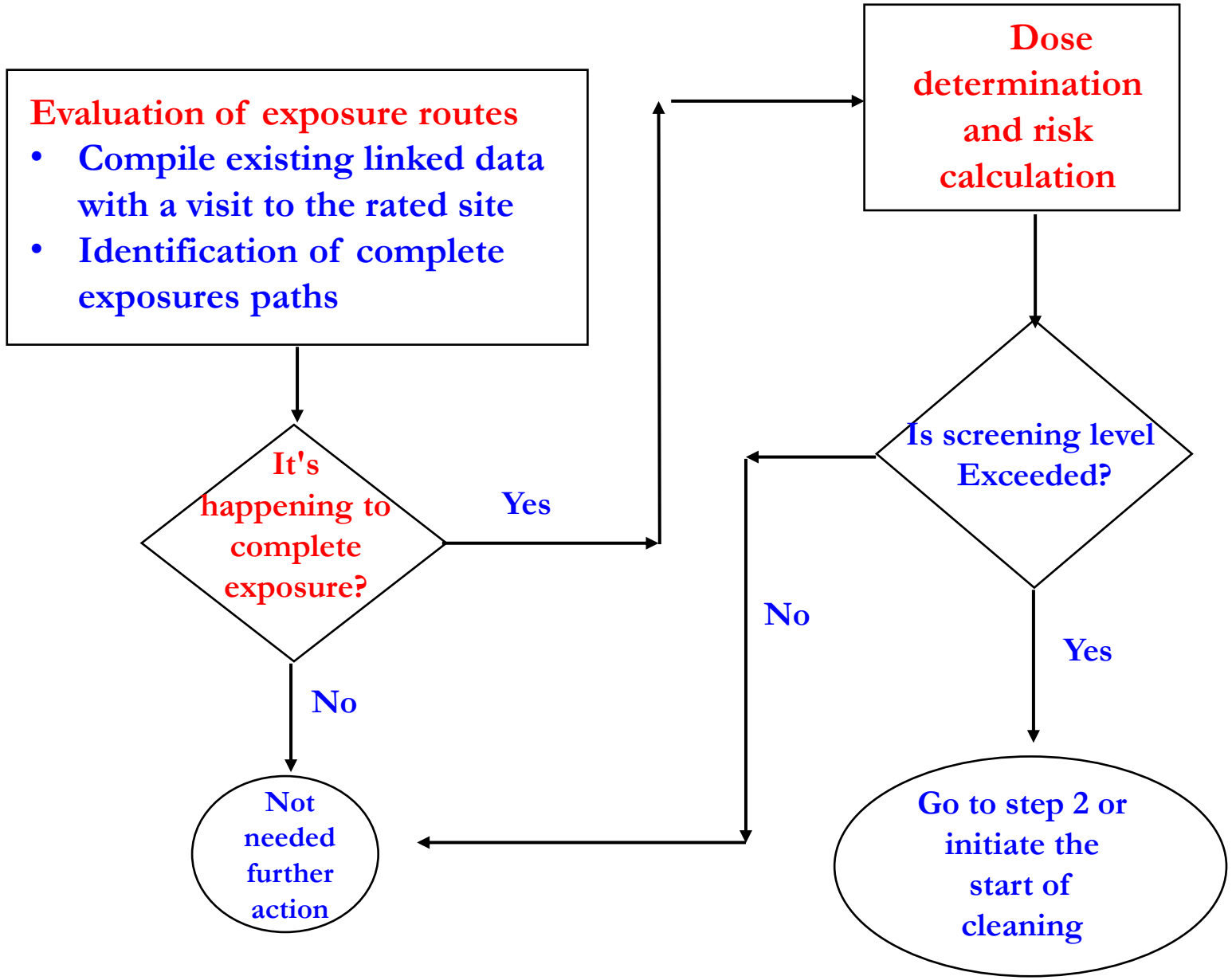
SMDP

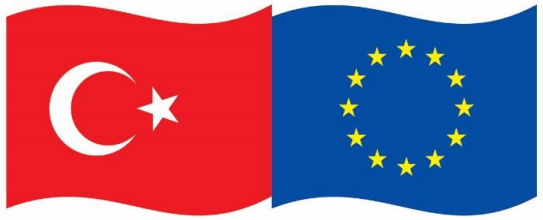
EcoRA – screening assessment

- Elimination of those components for which there are no complete routes of exposure
- Elimination of those components that are present in amounts less than the "safe" concentration
- Leaving those components that exceed the "safe" concentration (COPCs)



EcoRA – screening assessment





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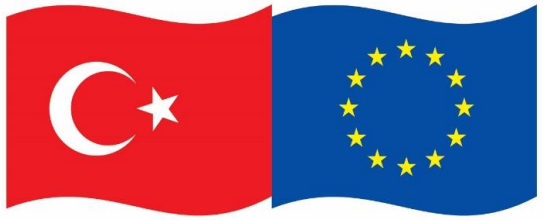
Problem formulation

- Environmental assessment and contaminants
- Fate and transport of the contaminant
- Ecotoxicity and receptors
- Complex exposure routes
- Evaluation and measurement of endpoints



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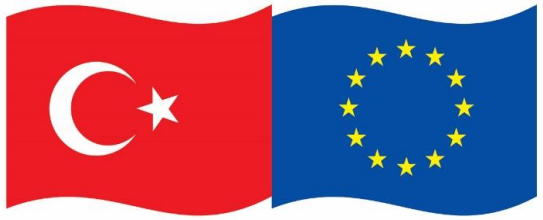
What information do we need?

- General assessment of the site
- Physical properties
- Sampling and monitoring plan
- Occurrence and distribution of different habitats
- Ecological resources
- Ecotoxicological data

All this data is obtained from existing sources - the aim of this section is not to obtain new data



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Site visit

Identification of potential areas of interest:

- Contaminated areas or components of the environment
- Ecological receptors present
- Areas with a clear ecological impact
- Areas or components with separate or perceptible risk

Carrying out the first evaluation of the locality or area and their ecological resources

With the participation of all stakeholders

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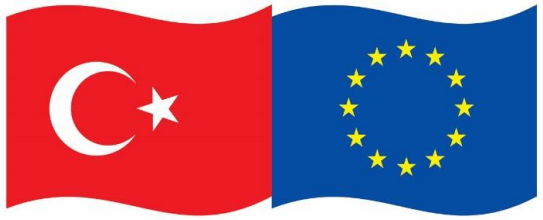
Pollutants

UNDP



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Risk assessment

Risk assessment according to US EPA

- Human Health
- Ecological risk assessment

- EcoRA vs. ERA
- Environmental risks - Environmental risk assessment (ERA) is used to describe the risks to due to the presence of contaminants in the environment
- Ecological risk - Ecological risk (EcoRA) – refers risks to non - human organisms, populations and ecosystems

Problem formulation

Creating an information base for further evaluation

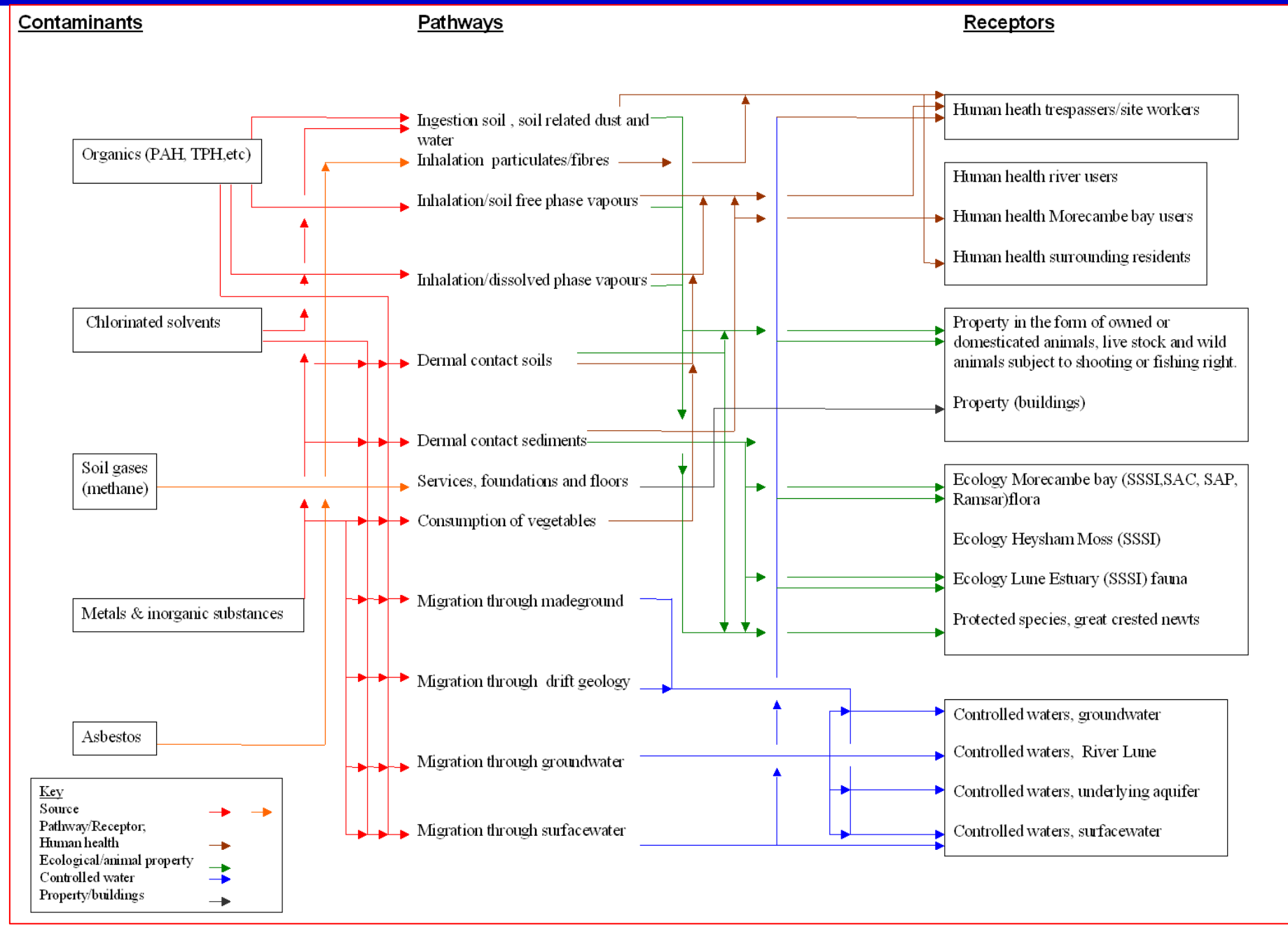
- Description of the specific situation
- Delimitation of the area of interest
- Hazard identification in relation to specific sources, and stressors

Information is obtained in theoretical form and by research of interest areas

Main outputs of this phase

(a) selection of appropriate biological systems for evaluation and determination parameterization of their characters
(b) the development of an EcoRA conceptual model with a definition strategy for further action
(c) identification of an appropriate EcoRA scenario

Conceptual model



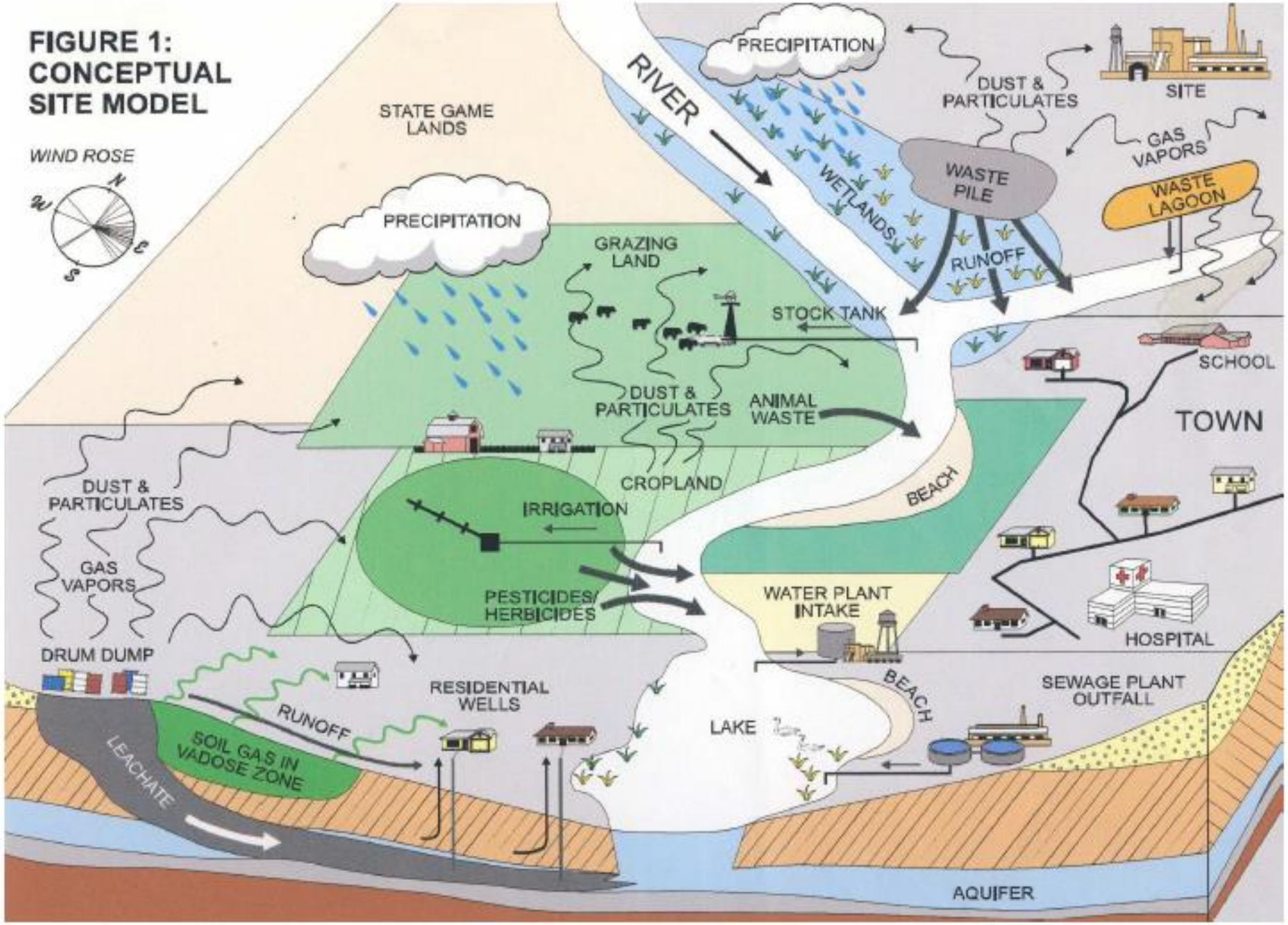
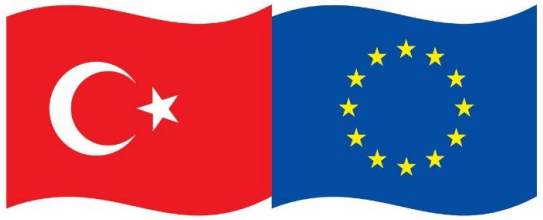


FIGURE 1:
CONCEPTUAL
SITE MODEL
WIND ROSE
N
W
E
S
STATE GAME
LANDS
RIVER
PRECIPITATION
DUST &
PARTICULATES
SITE
GAS
VAPORS
WASTE
PILE
WETLANDS
WASTE
LAGOON
RUNOFF
PRECIPITATION
GRAZING
LAND
STOCK TANK
SCHOOL
TOWN
DUST &
PARTICULATES
ANIMAL
WASTE
BEACH
DUST &
PARTICULATES
CROPLAND
IRRIGATION
GAS
VAPORS
PESTICIDES/
HERBICIDES
WATER PLANT
INTAKE
HOSPITAL
DRUM DUMP
RESIDENTIAL
WELLS
BEACH
SEWAGE PLANT
OUTFALL
RUNOFF
LAKE
SOIL GAS IN
VADOSE ZONE
LEACHATE
AQUIFER



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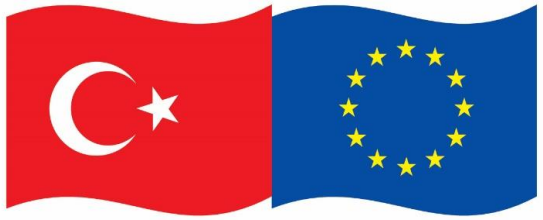
Key elements of a conceptual site model

- Site history and setting
- Potential contaminants of concern – contaminant properties and behaviour
- Potential areas of environmental concern (Source Zones)
- Geology and stratigraphy
- Regional and local
- Overburden – sedimentary, glaciology, depositional processes
- Bedrock – fracture networks, representative elementary volume
- Hydrogeology



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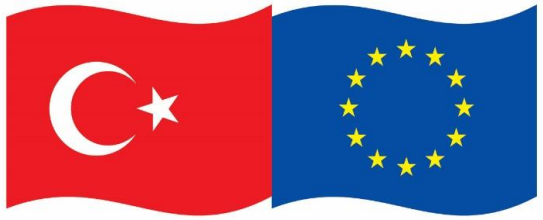
Analysis

- Exposure assessment and effect assessment closely related.
- It must be coordinated with the characterizing activities physical and chemical properties of the monitored site or areas.
- Despite the very close connection of these evaluations, they do not exist standard approaches or a specific set of EcoRA methods for all places - each rating is unique and site specific.



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Exposure assessment

- Basic premise for the existence of effects
- It is expressed in relation to demonstrably present stressors in the environment or as a function of dose - for example, according to expected food intake
- The sources, routes, size, frequency and duration of exposure of an individual, part of a population or ecosystem to a monitored chemical are described

Exposure assessment

There are three basic tools for exposure assessment usually apply simultaneously:

- direct measurement of pollutant concentrations in the environment (chemical monitoring)
- measurement of the concentration of the substance or its metabolites in organisms (biological monitoring)
- mathematical model describing the fate and transport of matter in life environment

The target parameter of exposure assessment is to determine the concentration substances in the environment, designated PEC (Predicted Environmental Concentration ").

The first step in exposure assessment is to estimate the local PEC in individual components.

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Effect assessment

- Dose-response analysis
- Studied the relationship between the amount of a chemical present in the environment and the degree of side effect – response
- Assessment of the effect of a stressor and its degree of action on a living organism, receptor
- Biological receptor - a biological system that will be used to identification of existing or potential effects of stressors and on which will document the danger of the stressor for the evaluated area of interest and its ecosystems
- Effect - qualitative concept (hepatotoxic, genotoxic)
- Response - measurable rate - change in liver enzyme activity,…
- Dose - the amount of substance entering the body, the environment

Effect assessment

It is necessary to define before the actual assessment of the effects (in the formulation phase of the EcoRA problem) organisms (receptors) for which the effect will be evaluated done

Methodical procedure and selection of suitable biological ones models depended on the specific situation and mostly combines ecotoxicological bioassays and bioindication procedures operated in in situ conditions.

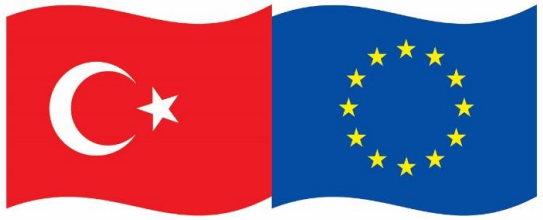
The aim of the analysis is to find the so-called PNEC (Predicted No Effect Concentration) - concentration that does not cause adverse effect on the environment.

Mathematical and statistical methods and the study of quantitative relationships between structure and biological activity of chemicals.

$$PNEC = ECn / f$$

Ecn - effective concentration, which is considered a suitable model low effect

f - safety factor (1-1000) = degree of knowledge of the effects (precautionary principle)



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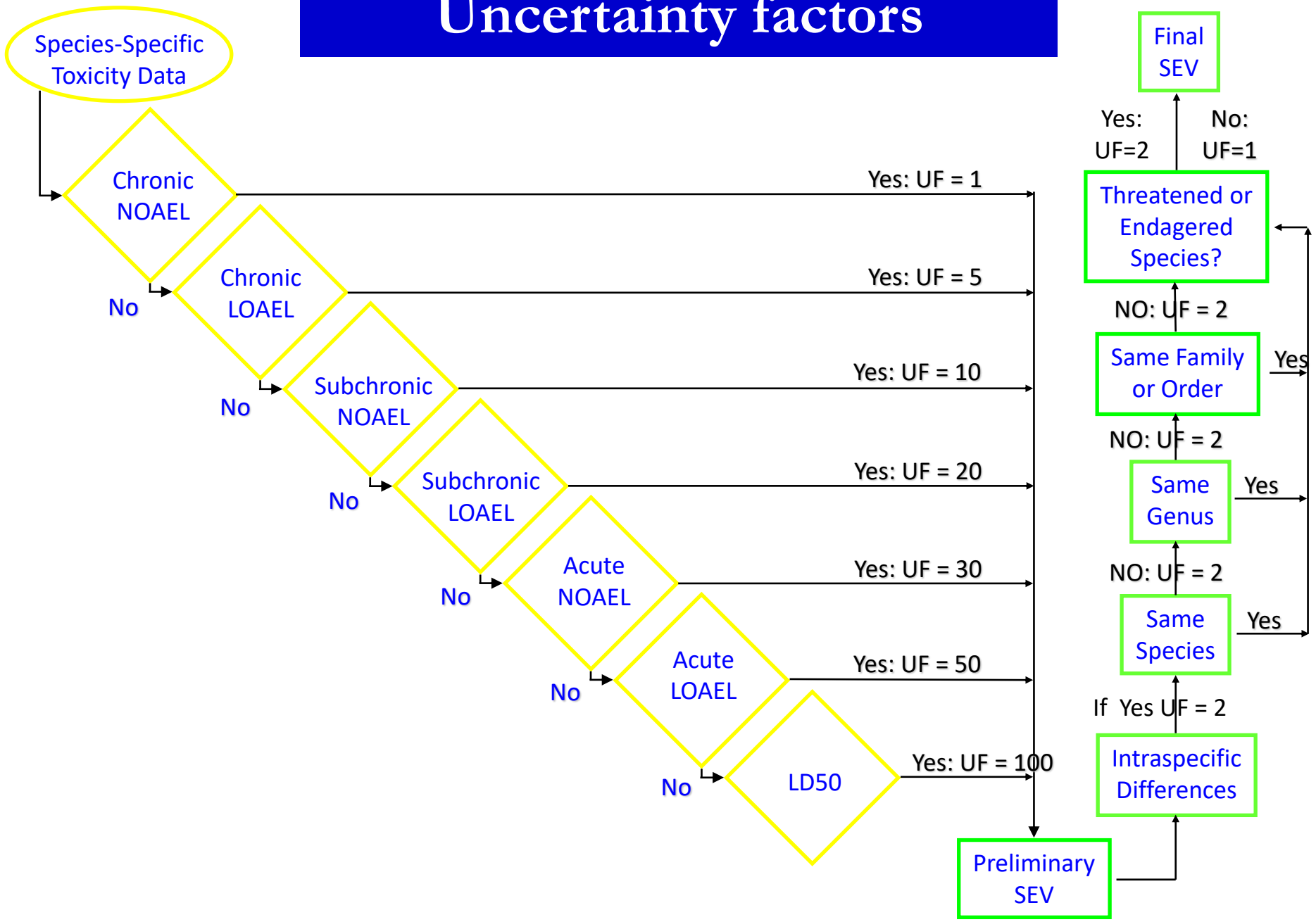
Acceptance criterion

HI = PEC / PNEC

<1 - the risk of application of the substance is acceptable the expected concentration in the environment is lower than the safe concentration estimate, which can cause a negative effect

> 1 - risk unacceptable

Uncertainty factors



Methodology of exposure and effects assessment

There is no specific set of methods for all locations – each assessment is unique

EcoRA has to deal with the many species of organisms they have different sensitivity to chemicals

Methodological procedure and selection of suitable biological models depending on specific situation

Often combines ecotoxicological bioassays and bioindication procedures operated in *in situ* conditions

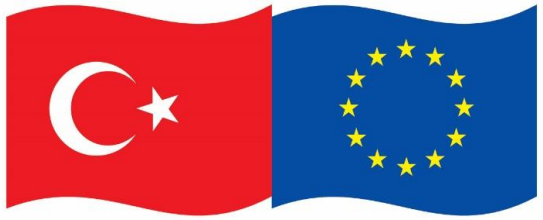
Due to difficulties in obtaining toxicity data for all organisms in the ecosystem, it is a recognized practice to test selected ones representatives of major taxonomic groups and use them as substitute for the whole system - questionable

Risk characterisation

- Summary of the results of previous steps,
- Risk quantification, discussion of in accuracies and uncertainties that estimate individual parameters
- Characterized by the size of the individual and total dose equivalent for the most sensitive species, or for biological system indicating some significant value in a given ecosystem

Factors that need to be taken into account

- Is the risk acute or chronic?
- What is the severity of the impacts?
- What is the time they occur?
- There is a risk to one animal species or many species?
- How many organisms are in danger?



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Ecological risk assessment (EcoRA)

- **Risk management** - The process of determining the appropriate risk response measures

- **Uncertainty** - Lack of confidence in prediction assessment of the risks that may arise from natural variability in natural processes, inaccurate or incomplete knowledge or errors in execution assessment

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Risk characterisation

Some approaches used for answers of these issues include:

- Field observation studies (surveys)
- Categorical rankings
- Process models that rely on partially or completely on theoretical approximation of exposure and effects
- Comparison of exposure and effect data

Risk management

- Summary of EcoRA outputs

- Based on knowledge of the type and degree of risk, an analysis follows risk acceptability for the continued existence of the evaluated systems

- Possibility to take preventive measures, changes in a specific situation towards risk reduction, etc.

- Risk management must always include the following components:

a) justification of the application - no application may be accepted, provided that the social benefit does not significantly outweigh the potential risk
b) risk optimization - the risk should be kept so low level, as it is economically and socially reasonable achievable
c) compliance with limits - limits must be met for individuals from population
d) thorough control of all participants in the process according to the degree responsibilities

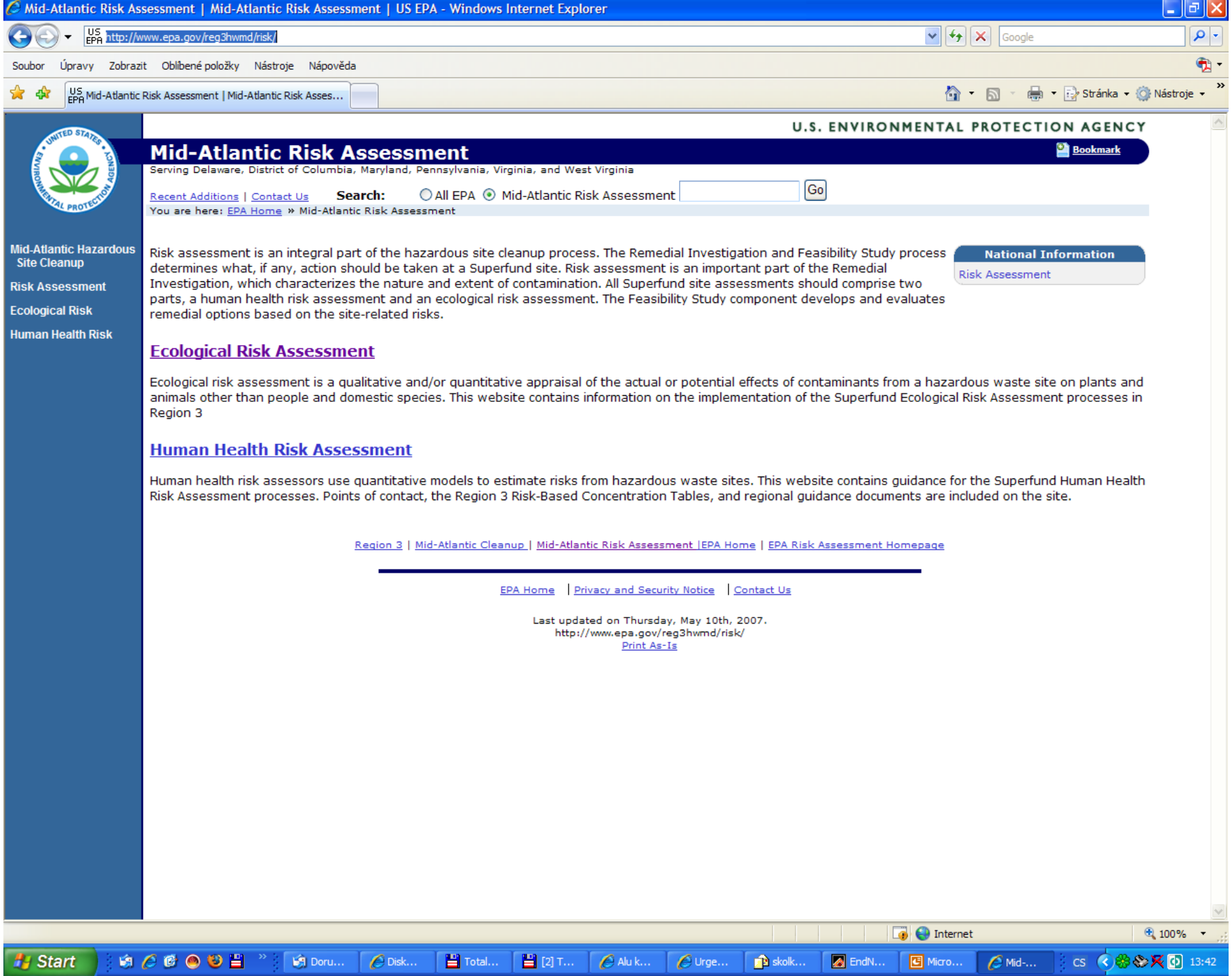
Sources of information

- **EU** – http://eurlex.europa.eu/cs/index.htm)
- US Environmental Protection Agency (EPA) - www.epa.gov
- IRIS – Integrated Risk Information System - www.epa.gov/iris
- ATSDR – Agency for Toxic Substances and Disease Registry – atsdr1.atsdr.cdc.gov
- Decisions of EU Parliament and EU Councial (ES) n. 1907/2006 REACH

US EPA - https://www.epa.gov/risk/risk-assessment-guidelines

- FRAMEWORK FOR ECOLOGICAL RISK ASSESSMENT (EPA/630/R-92/001) - 1992
- Guidelines for Ecological Risk Assessment (EPA/630/R-95/002F) - 1998
- Ecological Risk Assessment Guidance for Superfund (EPA 540-R-97-006) - 1997

ECHA - Technical Guidance Document on Risk Assessment - https://echa.europa.eu/documents/10162/16960216/tgdpart2_2ed_en.pdf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Mid-Atlantic Hazardous Site Cleanup
Risk Assessment
Ecological Risk
Human Health Risk
Risk assessment is an integral part of the hazardous site cleanup process. The Remedial Investigation and Feasibility Study process determines what, if any, action should be taken at a Superfund site. Risk assessment is an important part of the Remedial Investigation, which characterizes the nature and extent of contamination. All Superfund site assessments should comprise two parts, a human health risk assessment and an ecological risk assessment. The Feasibility Study component develops and evaluates remedial options based on the site-related risks.
National Information
Risk Assessment
Ecological Risk Assessment
Ecological risk assessment is a qualitative and/or quantitative appraisal of the actual or potential effects of contaminants from a hazardous waste site on plants and animals other than people and domestic species. This website contains information on the implementation of the Superfund Ecological Risk Assessment processes in Region 3
Human Health Risk Assessment
Human health risk assessors use quantitative models to estimate risks from hazardous waste sites. This website contains guidance for the Superfund Human Health Risk Assessment processes. Points of contact, the Region 3 Risk-Based Concentration Tables, and regional guidance documents are included on the site.
Region 3 | Mid-Atlantic Cleanup | Mid-Atlantic Risk Assessment |EPA Home | EPA Risk Assessment Homepage
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Last updated on Thursday, May 10th, 2007.
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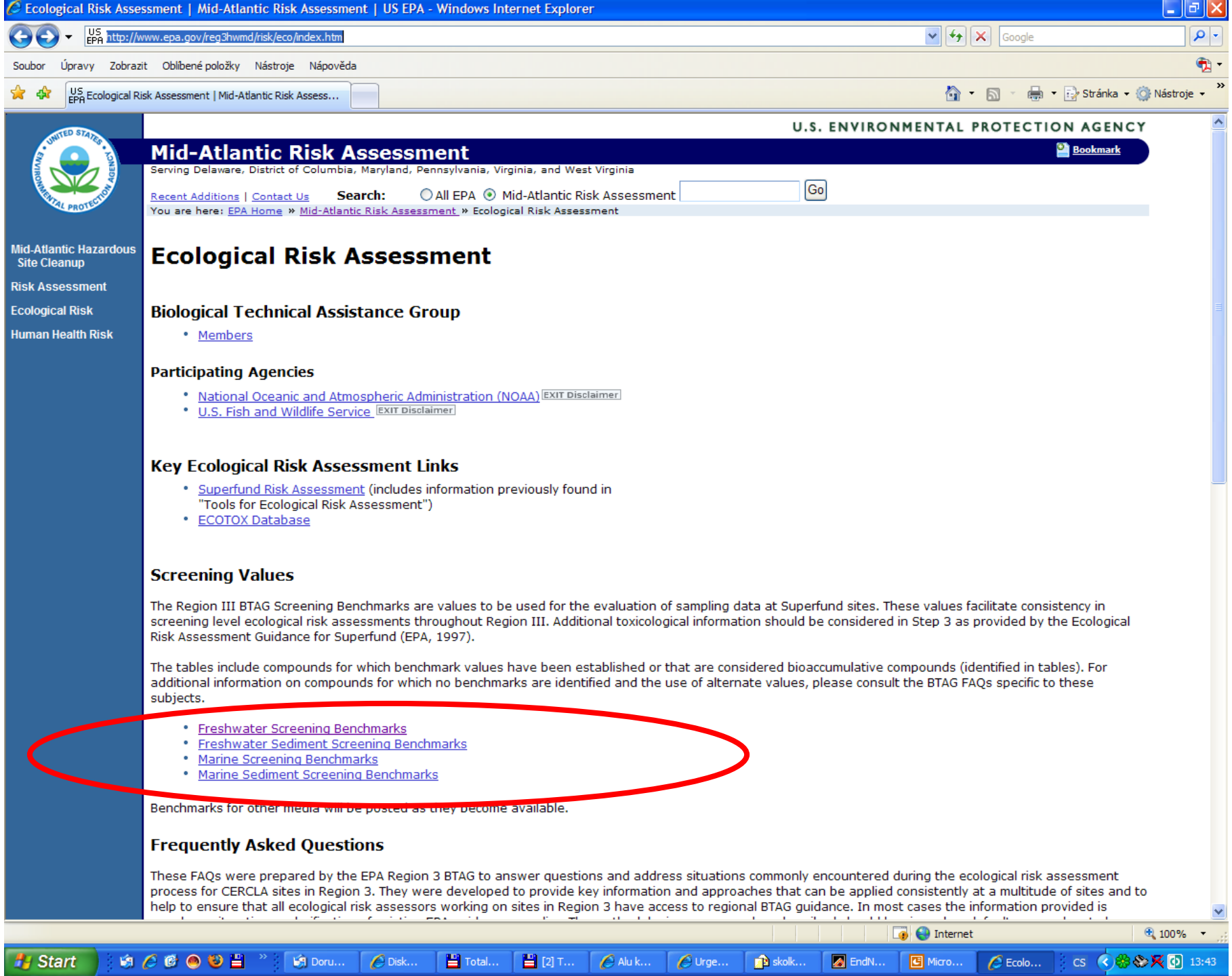
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Mid-Atlantic Hazardous Site Cleanup
Risk Assessment
Ecological Risk
Human Health Risk
Ecological Risk Assessment
Biological Technical Assistance Group
Members
Participating Agencies
National Oceanic and Atmospheric Administration (NOAA) EXIT Disclaimer
U.S. Fish and Wildlife Service EXIT Disclaimer
Key Ecological Risk Assessment Links
Superfund Risk Assessment (includes information previously found in "Tools for Ecological Risk Assessment")
ECOTOX Database
Screening Values
The Region III BTAG Screening Benchmarks are values to be used for the evaluation of sampling data at Superfund sites. These values facilitate consistency in screening level ecological risk assessments throughout Region III. Additional toxicological information should be considered in Step 3 as provided by the Ecological Risk Assessment Guidance for Superfund (EPA, 1997).
The tables include compounds for which benchmark values have been established or that are considered bioaccumulative compounds (identified in tables). For additional information on compounds for which no benchmarks are identified and the use of alternate values, please consult the BTAG FAQs specific to these subjects.
Freshwater Screening Benchmarks
Freshwater Sediment Screening Benchmarks
Marine Screening Benchmarks
Marine Sediment Screening Benchmarks
Benchmarks for other media will be posted as they become available.
Frequently Asked Questions
These FAQs were prepared by the EPA Region 3 BTAG to answer questions and address situations commonly encountered during the ecological risk assessment process for CERCLA sites in Region 3. They were developed to provide key information and approaches that can be applied consistently at a multitude of sites and to help to ensure that all ecological risk assessors working on sites in Region 3 have access to regional BTAG guidance. In most cases the information provided is
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Ecological Risk Assessment

Freshwater Sediment Screening Benchmarks

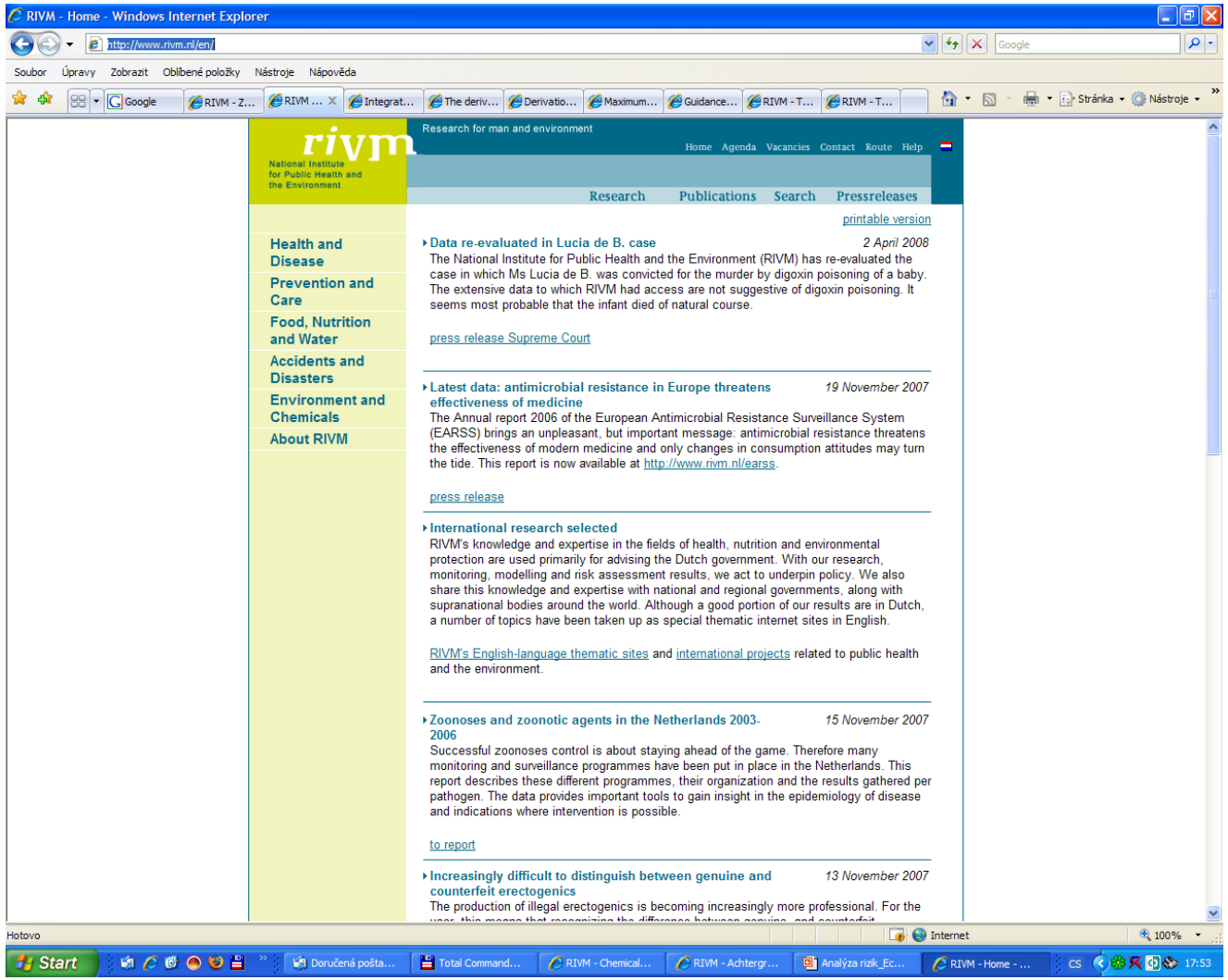
- Screening Benchmarks Table
- Notes & References
- Hierarchy for Selection of Freshwater Sediment Benchmarks
- Downloadable Files

CAS#	Analyte	FW Sed (mg/kg)	Ref	End Note	Class of Compound	Bioaccumulative-B°
71-55-6	1,1,1-Trichloroethane	0.0302	a,b	1	Volatile	
79-34-5	1,1,2,2-Tetrachloroethane	1.36	a,b	1	Volatile	
127-18-4	1,1,2,2-Tetrachloroethylene (PCE)	0.468	a,b	1	Volatile	
79-00-5	1,1,2-Trichloroethane	1.24	a,b	1	Volatile	
79-01-6	1,1,2-Trichloroethene (TCE)	0.0969	a,b	1		
92-52-4	1,1-Biphenyl	1.22	a,b	1	PAH	
75-35-4	1,1-Dichloroethene (1,1-Dichloroethylene)	0.031	a,b	1	Volatile	
75-35-4	1,1-Dichloroethylene	0.031	a,b	1	Volatile	
634-66-2	1,2,3,4-Tetrachlorobenzene	0.702	a,b	1	Other Semi-Volatile	B
87-61-6	1,2,3-Trichlorobenzene	0.858	a,b	1	Other Semi-Volatile	
95-94-3	1,2,4,5-Tetrachlorobenzene	1.09	a,b	1	Other Semi-Volatile	B
120-82-1	1,2,4-Trichlorobenzene	2.1	a,b	1	Volatile	B
95-63-6	1,2,4-Trimethylbenzene				Volatile	B
95-50-1	1,2-Dichlorobenzene	0.0165	a,b	1	Volatile	B
156-60-5	1,2-Trans-Dichloroethylene	1.05	a,b	1	Volatile	
541-73-1	1,3-Dichlorobenzene	4.43	a,b	1	Volatile	B
542-75-6	1,3-Dichloropropene (1,3-Dichloropropylene)	0.0000509	a,b	1	Volatile	
542-75-6	1,3-Dichloropropylene	0.0000509	a,b	1	Volatile	
106-46-7	1,4-Dichlorobenzene	0.599	a,b	1	Volatile	B
99-99-0	1-Methyl-4-nitrobenzene (4-Nitrotoluene)	4.06	a,b	1	Other Semi-Volatile	
58-90-2	2,3,4,6-Tetrachlorophenol	0.284	a,b	1	Other Semi-Volatile	
1746-01-6	2,3,7,8-TCDD-Dioxin	0.00000085	d		Dioxin/Furans	B
51207-31-9	2,3,7,8-TCDF		d	2	Dioxin/Furans	B
93-72-1	2,4,5-TP (Silvex)	0.675	a,b	1	Volatile	
93-76-5	2,4,5-Trichlorphenoxyacetic acid	12.3	a,b	1	Phenoxycaceticacid Herbicide	
88-06-2	2,4,6-Trichlorophenol	0.213	a,b	1	Other Semi-Volatile	
118-96-7	2,4,6-Trinitrotoluene (TNT)	0.092	e		Other Semi-Volatile	
120-83-2	2,4-Dichlorophenol	0.117	a,b	1	Other Semi-Volatile	
105-67-9	2,4-Dimethylphenol	0.029	f	3	Other Semi-Volatile	
121-14-2	2,4-Dinitrotoluene	0.0416	a,b	1	Other Semi-Volatile	

rivm
National Institute for Public Health and the Environment

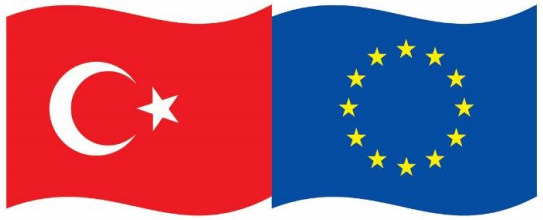
Research for man and environment

http://www.rivm.nl/bibliotheek/rapporten/601501001.html



ECOTOX Database

http://cfpub.epa.gov/ecotox/



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