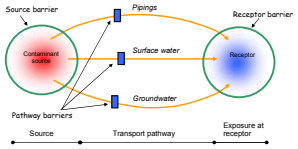
RISK-BASED PRIORITIZATION OF CONTAMINATED SITES



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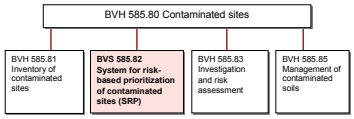
Background

- The SNRA is managing more than 20 000 properties - a large number are expected to be contaminated
- SNRA has initiated the development of a set of guidelines



- National prioritization of available resources
- Acknowledgements: Lars Grahn and Hans Kronberg (SWECO VIAK); Tommy Hammar (County of Kalmar); Per Olsson (County of Västra Götaland); Mark Elert (Kemakta), Pär-Erik Back (Geo Innova AB).

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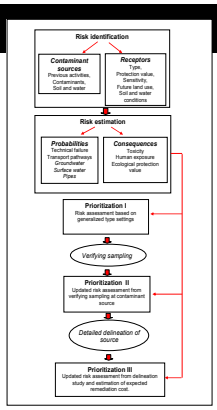
SPR Framework

A three-step prioritization procedure:

1. After initial inventory of potentially contaminated sites
2. After investigations aimed at verification of contaminant sources
3. After investigations aimed at spatial delineation of contaminations.

In the third prioritization step, the expected remediation costs are considered

Guidelines and software tool (SPR computer model)



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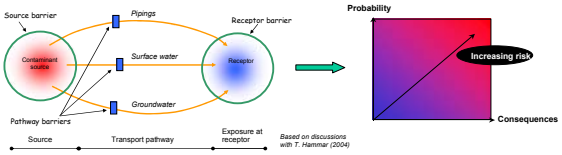
Conceptual Model and Risk definition



- *Receptor* = source area and external receptors
- *Risk* = Probability of failure x Consequences of failure
- *Failure* = when negative effects appear due to activity at the contaminant source.
- *Consequences of failure* = the degree of negative effects

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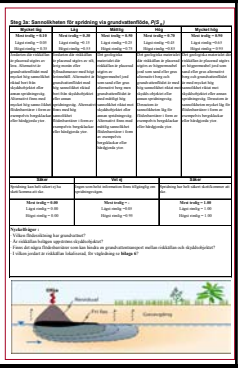
Risk estimations

- Bayesian approach for integration of hard and soft information
- Quantitative estimations of probabilities:
  1. the probability of contaminant release at the source
  2. the probability of non-functioning source barriers
  3. the probability of contaminants remaining in the source area
  4. the probability of transport pathways between the source and the receptor (including combinations of pathways and pathway barriers)
  5. the probability of non-functioning protection barriers at the receptor
- Guidance manual for elicitation of soft information
- Generalized type settings in step 1, updating with hard data in steps 2 and 3



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Risk estimations

- Factors in consequence analysis:
  1. Toxicity for humans
  2. Possible pathways for human exposure
  3. Residence time of humans at the receptor
  4. Toxicity for ecosystems
  5. Protection value of ecosystems
- Data-base on:
  1. Mobility
  2. Toxicity for humans
  3. Toxicity for ecosystems (in soil and water)
- Guidance manual for consequence estimations

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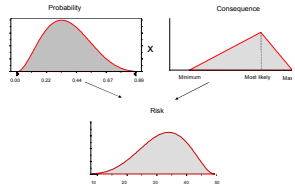
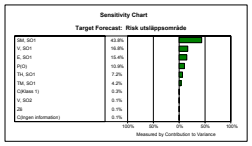
Uncertainty analysis





- Uncertainties of the probability estimations represented by a beta-distribution
- Uncertainties of the consequences are represented by triangular or binomial distributions.
- The resulting uncertainty of the risk is calculated by statistical simulation (Monte Carlo).
- Sensitivity analysis used to identify the most uncertain variables in the risk calculation.

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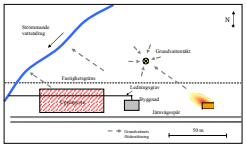
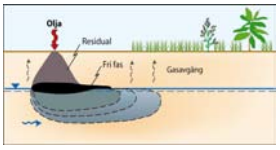
Risk estimations – overview of procedure

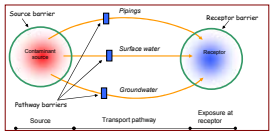
1. Inventory of risk sources and receptors



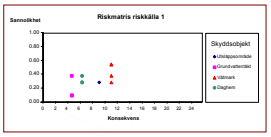
2. Description of risk sources and transport pathways



3. Estimations of probabilities and consequences



4. Estimations of risks and uncertainties



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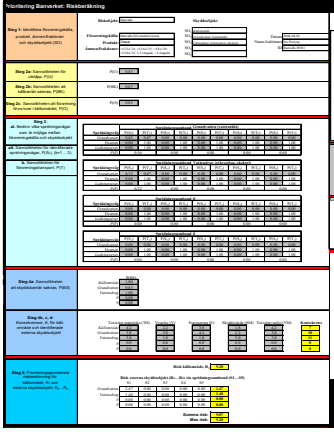
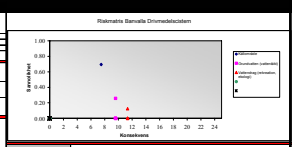
SPR Computer model





- Information manager – data base
- Risk calculations
- Graphical display
- Uncertainty analysis
- Manual

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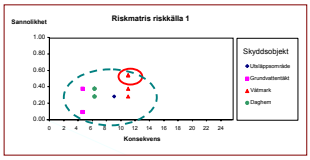
Prioritization Step 1

Two approaches:

1. **The maximum risk value**
2. **The total risk value**



- The first approach acknowledges the worst case situation, ignoring the number of receptors
- The second approach acknowledges the total risk situation, giving higher priority to contaminant sources with the potential to have impact on several receptors

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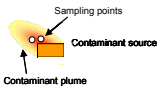
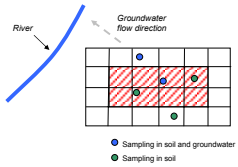
Step 2: Verifying sampling

- Directed at the contaminants source
- Hot-spots and diffuse sources





- Hot-spot sampling and random stratified sampling

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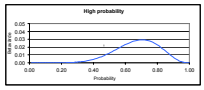
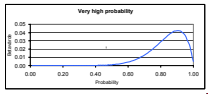
Step 2: Updating of risk estimations

1. Did the investigation indicate the precence of a contaminant source?
2. What is the reliability of your results?
3. Bayesian updating of probability estimations for contaminant source factors
4. Risk estimation





	Yes (y) / No (n)	What is the reliability of your observation? Assign in %	Prior probabilities	Updated probabilities
Did the investigation indicate a contaminant release?	y	95%	P(U) = 0.30	P(U) = 0.91
Did the investigation idicate a non-functional source barrier?	n	70%	P(BK) = 0.90	P(BK) = 0.60
Did the investigation indicate contamination to be present in the source area?	y	50%	P(O) = 0.50	P(O) = 0.67

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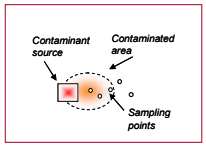
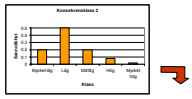
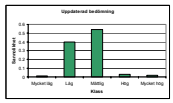
Step 3: Delineation of contamination

- Guidance manual for delineation sampling
- Updating of estimations on transport pathways and consequences at the receptor
- Procedure for probability updating analogous to Step 2
- Updating of consequences based on improved exposure analysis and protection value analysis
- Updating of risk estimation







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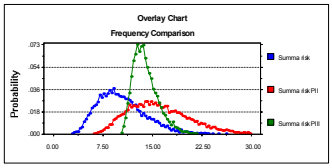
Updating of risk estimations

- Updating of risk estimations is made automatically in SPR computer model as new information becomes available
- Uncertainty estimations updated with respect to the reliability of the new information
- Uncertainties of risks updated by Monte Carlo simulations
- Step-wise guidance manual and example descriptions



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Estimation of expected remediation costs

- Assuming excavation and disposal
- Cost calculations included in the SPR computer model
- Considers explicitly:
  - Soil volume
  - Contaminant concentrations
  - Transport distance
  - Costs for disposal

Kostnadsberäkning

Värden som skall föras in (röd markering)

	Värde	Enhet
Volym	**5 000**	m^3
Densitet	**1.8**	ton/m^3
Transportavstånd till deponi		
Föroreningsklass 1	**30**	km
Föroreningsklass 2	**50**	km
Föroreningsklass 3	**300**	km
Deponibehandling		
Föroreningsklass 1	**50**	kr/ton
Föroreningsklass 2	**300**	kr/ton
Föroreningsklass 3	**800**	kr/ton

Fördelning av volymer på föroreningsklass

	Klass 1	Klass 2	Klass 3
Volym per föroreningsklass (m^3)	**3 000**	**1 200**	**800**
Ton per föroreningsklass	5 400	2 160	1 440

Resultat

	Mängd	Enhet	A'pris	Kostnad	Totalt	Fördelning
Arbeten på saneringsplatsen	5 000	m^3	315 kr	1 575 000 kr	**1 575 000 kr**	36%
Transport till deponin					**682 200 kr**	16%
Föroreningsklass 1	5 400	ton	45 kr	243 000 kr		
Föroreningsklass 2	2 160	ton	50 kr	108 000 kr		
Föroreningsklass 3	1 440	ton	230 kr	331 200 kr		
Deponibehandling					**2 070 000 kr**	48%
Föroreningsklass 1	5 400	ton	50 kr	270 000 kr		
Föroreningsklass 2	2 160	ton	300 kr	648 000 kr		
Föroreningsklass 3	1 440	ton	800 kr	1 152 000 kr		
Summa	**5 000**	m^3	**870 kr**		**4 350 000 kr**	

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Prioritization index Step 3

- Third prioritization step considers risk and cost:

$$\Phi_{tot} = \frac{R_{tot}}{E_{tot}} \qquad \Phi_{\max} = \frac{R_{\max}}{E_{tot}}$$

- Cost-effective prioritization
- The highest possible risk reduction for a specific investment
- Prioritization of resources on a national level

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Final comments on the SPR method

- A structured and step-wise approach to risk assessment
- Formal handling and explicit display of uncertainties
- Transparent
- Guidance for use of subjective information
- Mandatory for all SNRA regions
- First step currently performed in 3 out of 5 regions
- Course events on method and computer model to ensure equivalent assessments between regions
- Seminars to discuss and exchange experiences from applications
- Similar method developed for county authorities in Västra Götaland

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