Applying the REMEDE Toolkit: *An H_2SO_4 acid spill in Sweden*

REMEDE

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Conference on ELD - use of resource equivalency methods for remedying environmental damage under Annex 2

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REMEDE Toolkit: 5 steps

- Step 1: Initial Evaluation
- Step 2: Determine/Quantify damage (Debits)
- Step 3: Determine/Quantify gains (Credits)
- Step 4: Scaling Remediation & Remediation Costs
- Step 5: Monitoring/Reporting
- Sensitivity Analysis

REMEDE - Resource Equivalency Methods for Assessing Environmental Damage in the EU

REMEDE - Resource Equivalency Methods for Assessing Environmental Damage in the EU

Helsingborgs brandförsvar

HELSINGBORG

Step 1: Initial Evaluation

- This is a relatively simple & straight-forward equivalency analysis. “Simple” because:
  - Assumes complete (and fast) recovery to baseline
  - Well-defined area of impact (12 hectare harbour)
  - A well-defined baseline (7 years of ecological data collected by the municipality)
  - Simplified ecological assumptions (no modeling needed)

Step 2: Determine/Quantify Damage (Debits)

2.1 Identify a “metric” to measure environmental change & quantify the metric with ecological data

2.2 Define baseline level of habitat services

2.3 Calculate the debits (interim loss to the public)

Step 2.1: Identify a “metric”

- Resources affected by acid spill:
  - Water column
  - Fish
  - Plant species living on harbour bottom
  - Benthic organisms living on harbour bottom
  - * Sediment habitat *

- Our Metric: We will measure the level of habitat services provided by the “sediment habitat”
  - Importantly -> recovery of “sediment habitat” will lead to recovery of the other affected resources

Step 2.1: Quantify the "metric"

- A metric needs to be *quantified* in order to be used in an equivalency analysis
- How can we quantify the level of habitat services provided by "sediment habitat" ? Three options:
  1. Total number of species (richness)
  2. Species density (abundance)
  3. Total weight of species (biomass)

Because it is dynamic (i.e., damage occurring over time), the unit of measurement for our metric is "***hectare years***"

Step 2.2: Define baseline level of habitat services

Table 1: Defining the baseline in a "Before-and-after" approach

Sampling Site	Sampling Time Period	Richness	Abundance	Biomass
Harbour Centre	**Before (Average '98-'04)**	**14.1**	**2296**	**24.6**
Harbour Centre	After (3 weeks)	0	0	0
Harbour Centre	After (8 weeks)	3	192	3.84
Harbour Entrance	**Before (Average '98-'04)**	**24.1**	**9263**	**42.2**
Harbour Entrance	After (3 weeks)	0	0	0
Harbour Entrance	After (8 weeks)	13	696	4.33

We implicitly assume that richness, abundance, or biomass are good proxies for the level of habitat services **(our metric)**

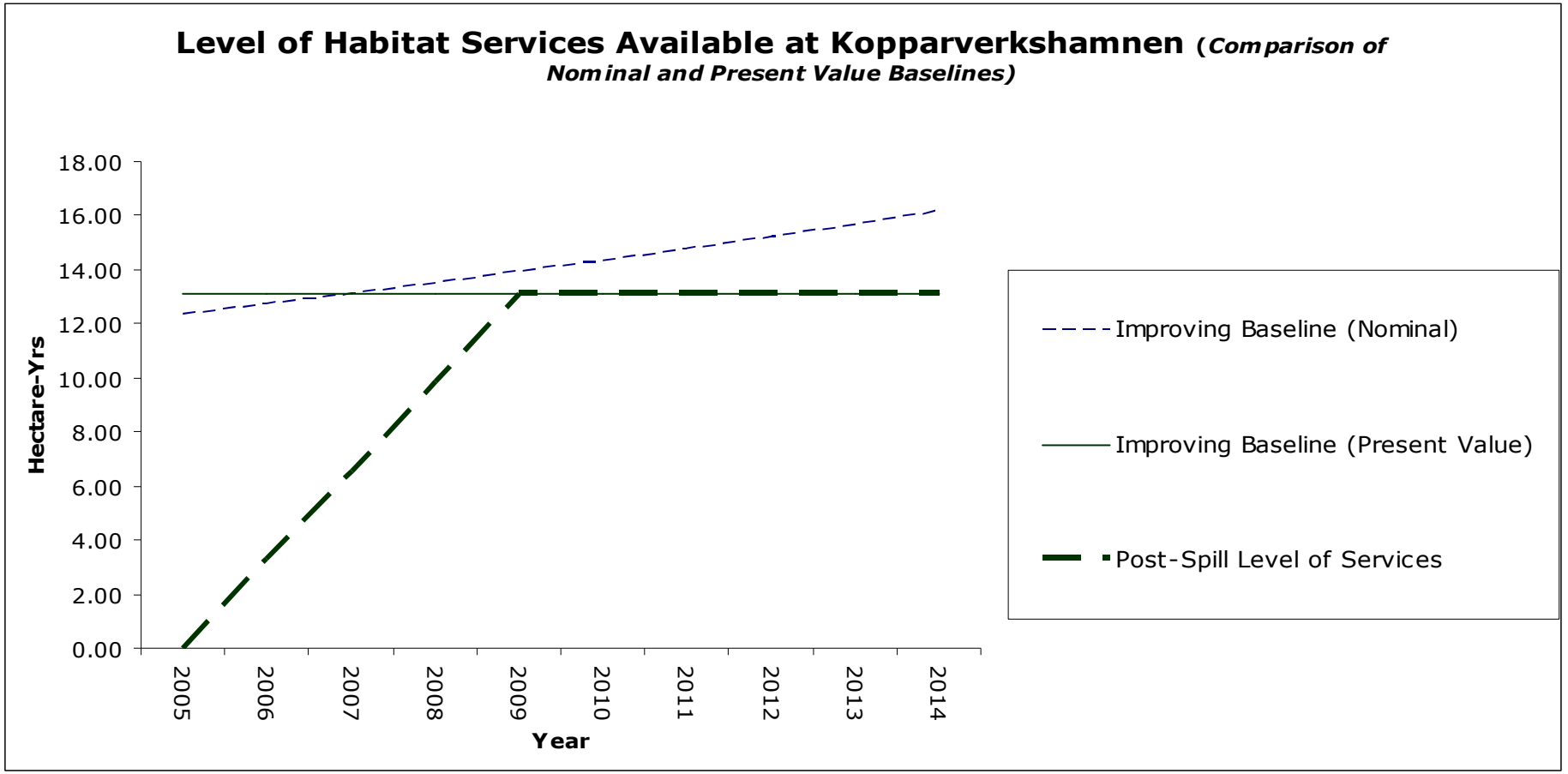
Step 2.2: Define baseline (Cont.)

- Two conclusions from our “before” data (‘98-’04)
  1. Highly industrialised & polluted site
  2. Improving baseline condition (e.g., reduced pollutants)

No. 1. implies that a polluted pre-spill environment cannot justify remediation to “pristine” levels

No. 2. implies that the interim loss includes an additional foregone improvement loss

Step 2.3: Calculate the Debits



Step 2.3: Calculate the Debits (Cont.)

Key assumptions (inputs) used in Debit Calculations	
Category	**Assumption for determining "debits" (environmental damage)**
Primary Remediation	**None**
Start year	**2005**
End year	**2009**
Base year for analysis	**2007**
Degree of service loss	**100% service loss**
Recovery rate	**Linear over 4 years (25% annually)**
Baseline	**Defined by "quantification metrics"**
Improving baseline **	**Improving by 3% per year**
Discount Rate	**3 %**
Spatial extent	**12 hectare harbour**
*** Will vary "improving baseline" assumption in sensitivity analysis*	

Step 2.3: Calculate the Debits (Cont.)

Quantifying baseline level of habitat services from harbour sediment					
Year	Hectare-yrs of Habitat Services	Improving Baseline	Hectare-yrs Improving baseline (nominal)	Discount/ Compound Factor	Hectare-yrs Improving baseline (present value)
2004	-	-	-	-	-
2005	12.00	*1.03*	12.36	*1.06*	**13.11**
2006	12.00	*1.06*	12.73	*1.03*	**13.11**
2007	12.00	*1.09*	**13.11**	*1.00*	**13.11**
2008	12.00	*1.13*	13.51	*0.97*	**13.11**
2009	12.00	*1.16*	13.91	*0.94*	**13.11**
2010	12.00	*1.19*	14.33	*0.92*	**13.11**
2011	12.00	*1.23*	14.76	*0.89*	**13.11**
2012	12.00	*1.27*	15.20	*0.86*	**13.11**
2013	12.00	*1.30*	15.66	*0.84*	**13.11**
2014	12.00	*1.34*	16.13	*0.81*	**13.11**
Totals					**131.13**

In the absence of the spill, the harbour would have provided 13.11 hectare-years of habitat services annually

Step 2.3: Calculate the Debits (Cont.)

Calculating the Interim Loss of sediment habitat			
Year	Hectare-yrs of Habitat Services (present value)	Annual Percent Service loss	Damage due to spill compared to present value of baseline
2004	-	- %	-
2005	**13.11**	100%	13.11
2006	**13.11**	75%	9.83
2007	**13.11**	50%	6.56
2008	**13.11**	25%	3.28
2009	**13.11**	0%	0.00
2010	**13.11**	0%	0.00
2011	**13.11**	0%	0.00
2012	**13.11**	0%	0.00
2013	**13.11**	0%	0.00
2014	**13.11**	0%	0.00
Totals	-	-	**32.78**

Step 3: Determine/Quantify Gains (Credits)

- Identify remediation options that offset damage:
  1. Remove existing contamination in the harbour
  2. Restore existing (or new) marine reserves in the area
  3. Restoration of seagrass (eelgrass) habitat

We select "restoration of seagrass" for illustration purposes … but all 3 options are good examples of *compensatory remediation* (if scaled correctly)

Step 3: Determine Gains (Cont.)

Key assumptions (inputs) used in Debit/Credit Calculations		
Category	**Assumption for determining "debits" (environmental damage)**	**Assumption for determining "credits" (environmental remediation)**
Discount Rate	**3 %**	**3 %**
Baseline	**Defined by "quantification metrics"**	**Defined by "quantification metrics"**
Base year for analysis	**2007**	**2007**
Start year	**2005**	**2008**
End year	**2009**	**(no end, benefits received in perpetuity)**
Degree of service loss/gain	**100% service loss**	**30% service gain (i.e., above existing baseline)**
Annual loss/gain	**Linear over 4 years (25% annually)**	**Linear over 3 years (10% annually)**
Spatial extent	**12 hectare harbour**	***To be determined through "scaling remediation"***

Step 4: Scaling Remediation

- Scaling remediation means estimating how much remediation (hectares) is needed to offset the damage

- To determine how much remediation will offset the damage, we first estimate the *per unit* credits from remediation
  - Referred to as Discounted Service Hectare-Years, or DSHYs

Step 4: Scaling Remediation (Cont.)

Scaling Remediation - Estimating "Per Unit" Credits			
Year	**Annual Service GAIN (percent in decimals)**	***Discount Factor***	**"Per Unit" Credit (DSHYs)**
2007	0	1.00	0
2008	.10	0.97	0.10
2009	.20	0.94	0.19
2010	.30	0.92	0.27
2011	.30	0.89	0.27
2012	.30	0.86	0.26
2013	.30	0.84	0.25
2014	.30	0.81	0.24
2015	.30	0.79	0.24
In perpetuity	…	…	…
	Total per unit Credits		**9.7**

Step 4: Scaling Remediation (Cont.)

- Now we compare these values to scale the appropriate amount of remediation
- To scale, we divide the total damage (32.78 hectare years) by the per unit gains (9.7 DSHYs)
  - = Total damage / per unit credits from remediation
  - = 32.78 / 9.7
  - = 3.4 hectares
- Thus, 3.4 hectares of seagrass remediation provided today (in 2007) is enough to offset the damage that occurred in the 12 hectare harbour between 2005 and 2009

Step 4: Remediation Costs

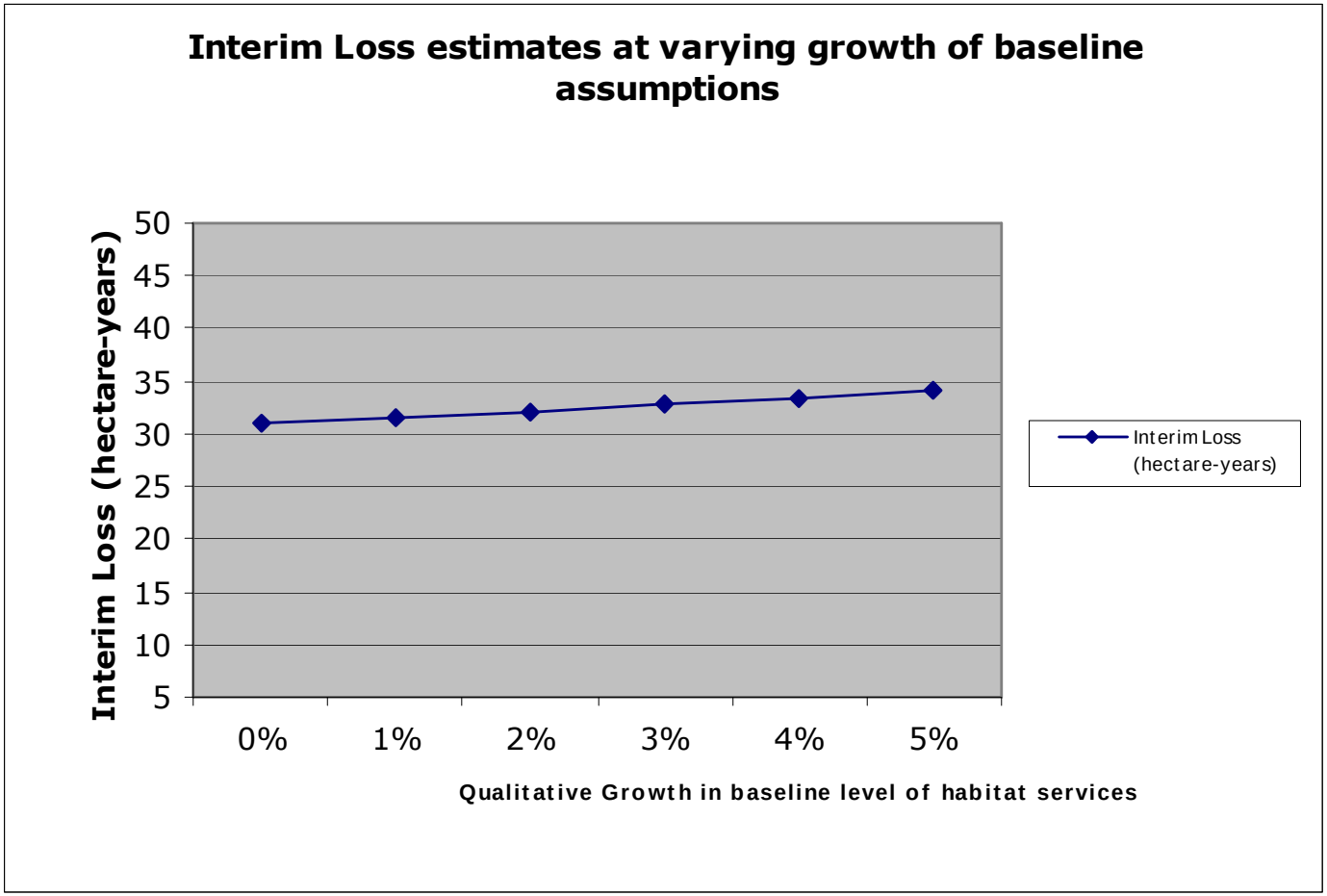
- How much will it cost to plant seagrass?
  - Permitting costs
  - Collect, prepare, install plants
  - Annual (or semi-annual) Monitoring
  - Overhead
  - Contingency costs

- Fronseca 2002 estimated ~€105,000 /hectare.
- Thus, approximately ~€350,000 in environmental liability
- May only be a rough approximation of costs in Sweden

Step 5: Monitoring & Reporting

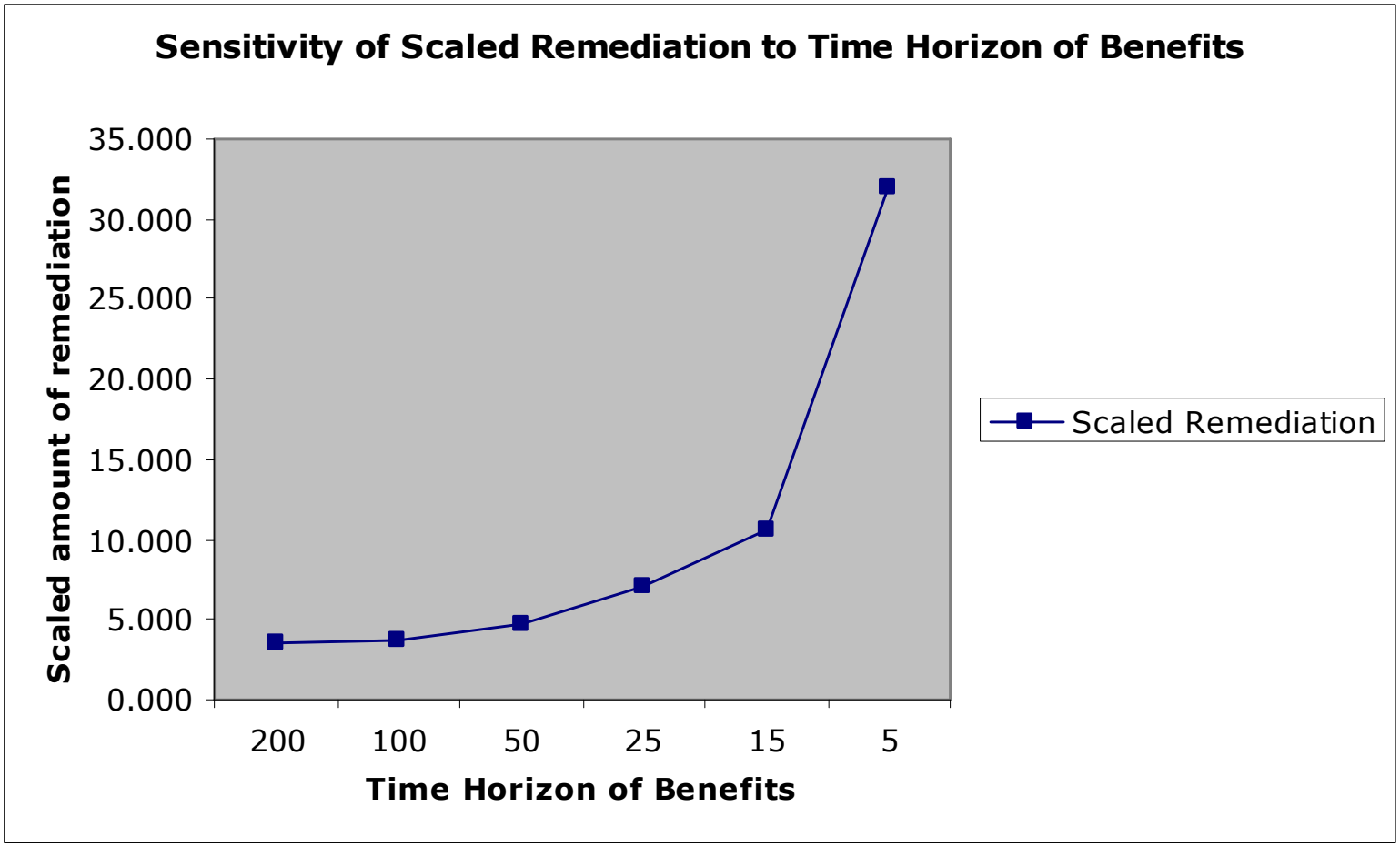
- Monitoring plan for seagrass remediation
  - Objective: To ensure the estimated seagrass remediation gains are actually *provided* in the future
  - Monitoring (twice a year) should be based on the quantification metrics (richness, abundance, biomass)
  - Contingency plans should be explicit in the event that the estimated gains are not actually realized several years into the future

Sensitivity Analysis:
Improving baseline & interim loss



Sensitivity Analysis:

Time Horizon for Benefits & scaled remediation



Conclusions

- The environmental liability in a S2S equivalency analysis is based on a *replacement cost* approach
  - Some may argue, instead, that the cost of remediating habitat may not be related to the value the public places on its damage (i.e., it could be higher or lower)

- 7 years of ecological data were valuable to analysis
  - Without evidence detailing the historically polluted harbour, the operator may have (wrongly) been required to remediate to a “pristine” level
  - Without evidence of an improving baseline, the public’s loss of habitat may have been insufficiently compensated