REMEDE

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REMEDE

Resource Equivalency Methods for Assessing Environmental Damage in the EU

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1. Introduction

The REMEDE project aims to develop methods and techniques known as "resource equivalency" (RE) to assist the implementation of Annex II of the Environmental Liability Directive (ELD). The purpose of the ELD is to establish a common framework for the prevention and remediation of environmental damage at a reasonable cost to society. Annex II of the ELD identifies the requirements which must be met to ensure the public is adequately compensated for environmental damage. Because the RE methods developed by REMEDE for Annex II are equally applicable to three other relevant EU Directives relating to environmental damage[5], the Project's outputs will be widely relevant to policy-makers and other involved parties in the EU.

The primary output of the Project is the REMEDE Toolkit describing the principles and steps to be taken in resource equivalency approaches. The Toolkit will provide a framework that will guide users[2] through the main steps and methodologies to ensure a credible and defensible assessment of damage and remediation.

The second significant output of the Project is a series of case studies of environmental damage in Europe (some actual events, others hypothetical). The purpose of the case study approach is to (1) test the principles and methods described in the Toolkit and (2) illustrate the use of RE methods in practice. This document (Deliverable 11 of REMEDE) further explains the objective of the case study approach (Section 2), summarizes previous case study applications (Section 3), describes the process of selecting final case studies (Section 4) and identifies each studies' key analytic focus (Section 5). The final selection of case studies is presented in Section 6, with supporting information provided in Annexes.

This report relies on various information sources, including the previous deliverables of REMEDE, previously conducted case study analyses by interested stakeholders, and the expert opinions of those on the REMEDE team. The individual case studies will rely on published and unpublished reports describing environmental damage from actual incidents, as well as some hypothetical data to illustrate the finer details of the REMEDE methods.

2. Purpose of Case Studies and this Document

This section will elaborate on the purpose of the case study component within the larger project and then describe the specific purpose of this document – the Case Study Selection Report (Deliverable (D) 11).

2.1 Purpose of REMEDE Case Studies

The case study approach within the REMEDE project serves two primary and simultaneous objectives: (1) test the principles and methods described in the Revised Toolkit (D10); and (2) illustrate the use of RE methods in practice. In addition, by selecting specific examples of environmental damage the case study approach will highlight the types of damage cases anticipated in the EU. These purposes are explained further below.

[5] These three Directives will be referred to throughout this document; they are the Environmental Impact Assessment (EIA) and Habitats and Wild Birds (H & WB) Directives.

[2] It is important to note what the REMEDE project does **not** provide. It does not make a policy judgment about whether or not a particular incident will or will not trigger the application of ELD or other relevant Directives; nor does it assess the determination of the significance of damage, the type of the baseline that should be used, or the selection of primary remediation.

I. **Testing and improving the Toolkit**. The case studies will provide a mechanism to improve upon the Revised Toolkit (D10), which will be edited in light of the case study experience to produce the Final Toolkit (D13). The purpose is to adapt and improve D10 to reflect lessons learned from the case studies to ensure applicability in the EU context.

II. **Illustrating Resource Equivalency principles**. The case studies will illustrate the Revised Toolkit's approach and methods and provide concrete examples of how these might be implemented. Given the relatively new and abstract nature of RE methods, this style of problem-based learning is an effective way to convey sometimes complex concepts and applications. As noted above, this illustration process will also highlight areas of the Revised Toolkit (D10) that need strengthening.

III. **Highlighting examples of anticipated types of environmental damage that will be covered by ELD and other relevant Directives.** The studies will be selected to ensure they represent relevant examples of anticipated damage under the four EU Directives – including cause and type of damage. This includes both *ex ante* analyses for damage that has not happened but may occur as part of a planned activity (e.g., in the context of EIA and Habitats and Wild Birds Directives) and *ex post* analyses which take place after the incident causing the damage (e.g., in the context of the ELD). The strategic selection of case studies will also demonstrate the variable requirements of the relevant EU Directives.

2.2 Purpose of the Case Study Selection Report (D11)

The purpose of this document is to identify a set of criteria for ensuring relevant examples of anticipated damage in the EU; propose a set of case studies that meet these criteria; explain the analytic focus of each proposed study; and make a final selection of studies. In short, the report will:

I. Define criteria for selecting relevant and informative case studies;

II. Propose specific incidents of environmental damage (some actual, others hypothetical) to illustrate Toolkit principles;

III. Provide a consistent format and structure for all Case Study analyses to facilitate Toolkit testing (provided in Appendix A);

IV. Describe the analytic focus[6] of each suggested study which is based, in part, on the research plans developed by each case study author;

V. Subject to comments from the European Commission, make a final selection of case studies that meet the criteria discussed in this report and that provide a relevant set of environmental damage cases that will benefit future decision-makers across Member States.

3. Background & Previous Case Study Analyses

[6] The analytic focus for each case study described in this report is not binding and may change during the case study application. The focus of each study is described as envisioned at the beginning of November, 2007.

Previous case study analyses related to the future impacts of the ELD have made assessments about the type of incidents, expected environmental damage, and subsequent remediation. These efforts, which have been recently numerous prior to the ELD's entry into force in April 2007, attempt to discern likely future impacts on the insurance sector, operators and other stakeholders, and raise as many questions as they do suggestions.

An important difference between these previous efforts and the purpose of the REMEDE case studies is that the former focus specifically on the ELD, whereas the latter focus more broadly on the three relevant EU Directives dealing with environmental damage and remediation. In addition, the objective of these previous analyses was to highlight issues that need further clarification in the implementation of the ELD in general, whereas the REMEDE case studies will focus on the specific steps of the Toolkit in the context of resource equivalency methods. By doing so, the REMEDE case studies will respond to the issues raised by these previous case studies.

Below we briefly review these previous efforts and summarise some of the key conclusions. The purpose is to compare (1) the anticipation for future types of environmental damage; and (2) the analytic focus of these previous efforts with the broader objective of the REMEDE project.

I. **Ad-hoc Industry Group case studies**. A group of operators developed their anticipation of future damage cases under the ELD and potential economic impacts based on four primary hypothetical spill events, including numerous "alternative scenarios" that develop from these main incidents. The incidents included: (1) an explosion and fire from an unintended chemical reaction at a manufacturing plant that killed fish and birds at a lake with special environmental designation; (2) a waste product release from an above-ground storage tank that coincided with a 100 year flood event and impacted a river's flora and fauna; (3) a derailing of a train carrying trichloroethylene (TCE) that impacted a shallow aquifer and nearby river; and (4) an oil spill from a barge carrying fuel oil that collided with a dock, releasing the oil and affecting riparian vegetation and waterfowl. The principles and recommendations arising from the case study exercise was the need for a reasonable, balanced and predictable liability regime under the ELD that would ensure consistent implementation across Europe. With regards to the damage assessment process, the case studies raised several questions about the resource equivalency analysis but did not provide answers. These case studies are available at the following website: http://www.nrdonline.com/EUELD/.

II. **Insurance Industry White Paper study**. The Comité Européen des Assurances (CEA) reviewed the implications of the ELD with respect to the insurance industry and included a brief consideration of three case studies. The first two were based on actual historic events: (1) a 1986 fire in a warehouse storing agricultural chemicals in Switzerland that led to damage to aquatic flora and fauna and killed several tons of fish in the River Rhine, affecting countries from Switzerland to the Netherlands (Sandoz AG Schweizerhalle); and (2) a 1998 collapse of a waste retention dam of a mining complex in Southern Spain, killing all aquatic life that came into contact with the sludge (Boliden Apirsa SL, Aznalcollar Spain)[4]. These studies concluded that little information was available on the historic costs of environmental damage, thereby making it difficult to estimate the incremental cost associated with the ELD. The third case study was a hypothetical exercise involving a diesel oil spill from a licensed industrial facility that contaminated groundwater, a neighbouring river and a protected estuary. This study concluded by noting that little experience exists for estimating *interim losses* from such an incident, but that reasonable methods to estimate such losses could allow for such

[4] A REMEDE case study will examine this 1998 toxic spill in Spain. See Section 5.1.2.

damage to be insurable in the future (REMEDE aims to explain methods to estimate interim losses).

III. **Environmental Liability Directive Conference (March 13-15, 2007 London).** A conference to assist operators in their preparation for the ELD presented three case studies. These included an oil spill from a power station which polluted river and marine waters and beaches; a pipeline release that impacted a recreational fishery; and a slow chemical leak impacting groundwater. The primary focus of this conference was to provide a hands-on application of a habitat equivalency analysis for operators.

IV. **Workshop on Annex II of the ELD by the Spanish Ministry of Environment (April 18 2007, Madrid).** The Spanish Ministry of the Environment organised a workshop on Annex II of the ELD. While the Spanish law transposing the ELD was, at the time, already in Parliament, this was the first workshop on Annex II of the Directive in the country. The workshop was attended by over 60 Spanish participants from the central and autonomous governments, insurance, industry and NGOs. Presentations included three hypothetical case studies to demonstrate the applicability and implementation of Annex II. The first case study addressed a spill during the transport of hazardous bulk liquids and examined three scenarios: (1) immediate recovery and minimal environmental liability; (2) slow recovery and the need for compensatory remediation; and (3) non-recovery and the subsequent need to assess the social welfare loss from the damaged resource. The second case study examined possible releases from an actual pharmaceutical company and developed three damage scenarios (based in part on actual releases documented by the local authorities). This study discussed the applicability of different aspects of Annex II. The third case study examined potential applicability of Annex II to an actual pig farm following a release of pig waste into a nearby river. The study described a scenario where the river was polluted, resulting in the need for compensatory remediation. The case studies demonstrated the approaches to damage assessment and remediation selection.

4. Case Study Approach

The REMEDE case study approach is to develop two scales of studies that will demonstrate the various methods contained in the Revised Toolkit.

- **In-depth Case Studies**. Up to six detailed case studies will be analyzed that follow the entire REMEDE Toolkit framework (See Section 4.1 below). The objective of these studies is to provide an example of a complete RE analysis from beginning to end. Appendix A includes the template for reporting the case studies to ensure similar scope and format across studies.

- **Shorter Case Studies**. In addition, the Project will provide numerous short example studies that generally focus on some (or all) aspect(s) of the Toolkit that can benefit from further illustration. In some cases, these shorter example studies may run through all steps of the Toolkit, but in a briefer format than the in-depth studies.

Both types of case studies will focus on specific assumptions, steps and methods within equivalency analysis. Importantly, each case study will illustrate certain complexities and implementation challenges likely to confront future decision-makers in the application of resource equivalency methods.

4.1 Structure and Format

Because the case studies will test and illustrate the Revised Toolkit (D10), all case study analyses will follow the Toolkit's structure. Following the expert workshop in February 2007 (D9), an initial Toolkit Outline was completed on March 31st (Draft Toolkit (D8)). This Outline was expanded into the Revised Toolkit (D10) and distributed to the team to aid the work on case studies (D12). Thus, the structure of each case study will include the five major steps of equivalency analysis presented in the Revised Toolkit:

1. **Initial Evaluation.** The first step is an initial evaluation of the appropriate level of detail of the analysis and data availability.

2. **Determining and Quantifying the Damage (the Debits).** The purpose of damage determination and quantification is to establish the amount of lost resource or service over time that should be offset by remediation projects.

3. **Determining and Quantifying the Gains from Remediation (the Credits)**. This step – which should be considered simultaneously with the first two steps – involves the consideration of potentially suitable complementary and compensatory remediation projects.

4. **Scaling Complementary Remediation Actions**. This step begins with a calculation to estimate the amount (or size of a project) required to offset the damage calculated in Step 2. It also involves consideration of various criteria before selecting a final remediation project.

5. **Monitoring and Reporting**. The remediation plan should ensure that project goals, implementation details, engineering plans and designs, and biological plans and designs are carried out to ensure success of the complementary and compensatory remediation that is actually provided.

To ensure a consistent and similar format across final case study reports (D12), a template has been developed. This template – included in Appendix A – provides similar headings, content, and length across REMEDE case studies. The goal is to ensure the case study analyses are concise and non-technical and will be restricted to approximately 20 pages or 12,000 words (plus appendices and references). Maps, tables, figures, and photographs will be used to illustrate the applications.

These key headings will reappear in all in-depth case studies because of their importance and central place in an equivalency approach. However, some of the short case studies may choose to focus within a particular step in order to illustrate complexities, rather than cover all steps.

4.2 Key Issues of the Toolkit

In addition to the consistent format and structure, the majority of case studies will cover key issues of the Toolkit that are particularly important to illustrate. Although it is not possible for every case study to discuss all aspects, our intention is to ensure the most important aspects of resource equivalency methodologies arise in multiple case studies. These will include:

- **Selection of a metric**: The metric is the unit of measurement in the assessment of damaged resources or services. The metric is used both for assessing damage (debit) and scaling remediation (credit) and is a critical aspect of equivalency analysis. All case studies will illustrate the process of selecting an appropriate metric and implementing it

effectively, based on site-specific considerations. The case studies will illustrate the various categories of metrics described in the Toolkit. For example, some studies will contrast the use of alternative metrics to assess a given damage incident, while others will demonstrate how the selection of a metric has a strong effect on the final remediation decision.

- **Baseline**: Defining the baseline status of a resource is a critical component of equivalency analyses, and one which the REMEDE Toolkit leaves to Competent Authorities. However, our case studies will focus particular attention on the alternative methods for defining the baseline (e.g., before-and-after, reference locations, ecological modelling, etc.). Some *ex post*[5] case studies will demonstrate more than one approach for the same incident in order to illustrate how the alternative approach may impact the final outcome.

- **Natural recovery:** Assumptions about the speed with which a resource recovers has a significant impact on the damage and remediation estimates. Therefore, some case studies will illustrate how the interim loss calculation is affected when a recovery rate is based on (1) primary remediation or (2) natural recovery (i.e., without primary remediation). For example, the benefits of primary remediation can be clearly shown by comparing the interim loss under a scenario with and without primary remediation. Primary remediation will necessarily reduce the size of the interim loss and hence the need for compensatory/complementary remediation but may or may not affect overall costs/liability. We recognise that natural recovery is not always realistic. For example in the Doñana study the damage was so large that "natural recovery" would not have been a viable option. On the other extreme, small-scale damage events often argue for natural recovery, which would make aggressive primary remediation activity seem unrealistic. However, in the majority of our case studies we will demonstrate how damage estimates are theoretically affected by alternative recovery assumptions.

- **Cost of remediation:** The final selection of a compensatory or complementary remediation project among various competing alternatives often relies on an estimate of project costs. Thus, we feel it is important to illustrate the methods for estimating costs of restoration projects. Our focus will be on the general methods to develop cost estimates, rather than the cost estimates for a particular case study or for a general type of restoration activity.[6]

- **Uncertainty**: There is significant uncertainty associated with all stages of equivalency approaches (e.g., baseline, discount rate, recovery assumptions, etc.). One way of addressing this uncertainty is to conduct sensitivity analysis on various key assumptions by identifying the range (difference between the minimum and maximum outcomes) of possible remediation estimates and using this range as a measure of uncertainty (larger ranges indicate greater uncertainty). This aspect of the analysis will be strengthened during the case studies.

4.3 Application to Future Damage Incidents

Case study illustrations will provide useful applied examples of equivalency analysis for Toolkit users, but it is important to note differences between REMEDE case studies and future equivalency analyses of environmental damage. Below we summarise some considerations in interpreting the lessons to be learned from these applied case studies.

[5] This may not be appropriate in *ex ante* cases where the availability of baseline information may argue for a "before – and -after" approach only.

[6] A CEA case study analysis commented, "to support … Insurability, it is recommended to elaborate scenario-based case studies and try to build up hypothetical estimations of costs linked to the ELD" (p.16 Conclusions).

- **Length of time.** The relatively short period of time allowed for the research and analysis of REMEDE case studies may not be indicative of the length of time to conduct future resource equivalency analyses. The site-specific nature of damage will be the primary determinant of the length of analysis (e.g. complicated pathways or extensive damage will lead to longer time frames); however, even simple damage incidents will likely take longer than REMEDE's illustrated case studies because the latter benefit from already-existing studies and data, which may or may not exist in real cases. In addition, the time and effort necessary for stakeholder consultation that is likely to be conducted in real cases are not necessary here.

- **Multiple solutions to each case study.** It is important that each case study is not interpreted as the only acceptable approach suggested by the Toolkit; rather each study should demonstrate the Toolkit's consistent and general framework for how to consider key issues. The application of the Toolkit could theoretically lead to multiple acceptable remediation schemes at a given site. The framework does not provide a "one-size-fits-all" solution to each case of environmental damage.

- **Multiple cost estimates for environmental liability**. Because a case study represents only one remediation suggestion (out of a set of multiple plausible outcomes) for a damage incident, the associated cost estimate represents a "best guess" for a chosen scenario. The actual cost estimate will certainly vary depending on local labour rates, local regulations and final negotiation between authority and operator. The methods used to estimate the costs of remediation (e.g. environmental liability) should be of greater interest to the Toolkit reader than the actual cost estimate.

- **Creativity required**. Future resource equivalency analyses will require a certain amount of creativity, which cannot be adequately illustrated through a finite number of case studies. Effective resource equivalency methods require a heuristic approach, where analysts learn to develop their own approaches to handle the site-specific nature of future incidents they will face. Such methods underscore the importance of creativity in selecting metrics and identifying reasonable remediation projects.

- **Non-linear approach**. Application of the seemingly *linear* steps identified in the Toolkit will not lead to an effective RE analysis. In this sense, *linear* refers to the inherent step-by-step process in the Toolkit (e.g., collect information, quantify damage, quantify remediation, select project, monitor results). To develop an effective RE analysis, one must think in terms of an *iterative* process that continually re-assesses the primary objective of remediation in light of new information, alternative approaches and cooperative decision-making. This key point will be further demonstrated in the final Toolkit.

4.4 Criteria for Selecting Relevant Case Studies

To select case studies that meet the purpose and objective outlined in Section 2.2, we identify a number of criteria. These criteria were discussed within the REMEDE team, with the participants at the February 2007 consultative workshop and with other stakeholders. The criteria are grouped into different categories to reflect the different aspects we think are important in selecting case studies (e.g., geography, environmental damage, methodology, and policy). Table 1 summarises the criteria used. Appendix B summarises all suggested case studies from Section 5 against these criteria.

Table 1: Summary of Criteria used in Selection of Case Studies	
Criteria	**Definition**
Geography	
EU Member State(s)	Name of country/ies that the incident occurred in (some incidents are hypothetical or assumed to occur in a general region).
Biogeographical regions in the EU	Corresponds to the EU classification system for ecological habitats. For a detailed map, see Appendix C.
Environmental Damage	
Cause of incident	A simple description of the incident.
Ex post vs. ex ante	Identifies type of damage incident: *ex post* (following an unanticipated damage or imminent threat of the damage such as a spill) or *ex ante* (prior to an expected damage such as an infrastructure project). While ELD context is of course *ex post*; the context of other Directives REMEDE needs to cover are *ex ante*.
Media type	Identifies the environmental media impacted by the incident such as species, biodiversity, water (quality and/or quantity), land/soil - on the basis of the classification in the ELD.
ELD Incident type	For case studies that fit under the ELD only - identifies the type of event that led to environmental damage. PREMISES may include pollution leaks at a facility or premises. PROCESSES may include pollution seeping through a faulty / poorly maintained filter or manufacturing process. PRODUCTS generally include pesticides and similar hazardous substances and their misuse or illegal use (e.g., farmers and pesticides).
Migratory species	Identifies whether the case study deals with unique compensatory remediation issues associated with migratory species (e.g., distance between damaged site and remediated site) – with the intention of showing 'off site' or distant remediation options.
Ecological and/or human use	Identifies the focus of remediation efforts as being on ecological resources (e.g., species, habitat, etc.) and/or human use of resources (e.g., recreational loss such as a boating, fishing, swimming, etc.).
Methodology	
Treatment of baseline	Describes how the study will define the baseline. Most studies will consider alternative approaches to handling the baseline, as described in the Toolkit.
Environmental metric(s)	Identifies the environmental metric(s) to be considered in the case study, where metric refers to the unit in which damage costs and remediation benefits are to be measured.
Resource equivalency approach(es)	Identifies the type of resource equivalency method that could be used to assess the damage: Service to Service (e.g., habitat services, flood control, etc); Resource to Resource (fish, birds, etc); value to value (recreational use value or non-use value placed on resources); or value to cost.
Recovery assumption	Is the damaged environment assumed to recover on its own (natural recovery) or with the help of primary remediation?
Treatment of future uncertainty	Uncertainty arises throughout a resource equivalency analysis and case studies should reflect the variety of assumptions or parameters that may have uncertainties associated with them and illustrate how to handle these. This criteria discusses how the case study treats uncertainty in its analysis.
Sensitivity analysis of key assumptions	Identifies key assumptions that will be varied in order to illustrate principles of resource equivalency (e.g., discount rate, recovery rate etc).
Level of effort/analysis	Is the level of effort in characterising the damage and the subsequent compensatory remediation likely to require complex assumptions and modelling efforts, or can it be estimated using simplifying assumptions and calculations? (e.g., simple vs. moderate vs. complex).

Table 1 (cont.): Summary of Criteria used in Selection of Case Studies	
Criteria	**Definition**
Policy	
EU Directive (within scope of REMEDE)	The relevant EU Directive under which damage assessment would be required. Multiple Directives may be applicable to some damage cases. ELD, EIA, H&WB need to be covered by REMEDE.
Synergy with other research projects	Identifies whether the case study provides a unique synergy or collaboration with other EU-sponsored or other projects (does not mean that the case study duplicates existing effort, but that it provides some additional value to REMEDE and the other project(s)) both for REMEDE and the other project(s) concerned).
Transboundary issue	Identifies whether transboundary issues related to the damaged site (e.g., does the damage occur on a boundary between Member States?) or on the remediated site (e.g., are there transboundary issues related to the proposed remediation project?). This criterion is related to the migratory species criterion presented above.

5. Proposed Case Studies

Given the criteria suggested in Table 1 above, the REMEDE case study approach is to identify potential case studies and determine whether they meet the criteria. Importantly, our selected group of studies should demonstrate considerable variation across these criteria to ensure that illustrations are widely applicable.

Below we summarise the proposed set of case studies (Section 6 details the final selection decision), including a description of the type of environmental damage and the proposed analytic focus. Appendix B contains a spreadsheet that summarises the proposed case studies against the criteria listed in Table 1.

The case studies and, more importantly, their context as described here are not binding and may change throughout the case study application. They are described below as envisioned at the beginning of November, 2007.

5.1 In-depth Case Studies

5.1.1 Tank collapse & chemical release (Sweden)

On February 4, 2005, a chemical tank owned by the Kemira Group along Sweden's south-western coast (near the town of Helsingborg) collapsed, releasing approximately 16,300 tonnes of 96 percent sulphuric acid into the harbour (Kopparverkshamnen), which connects to the Baltic Sea. The sulphuric acid spread through the harbour and, being denser than water, sunk to the bottom where it impacted sediments and benthic organisms that live on the harbour bottom. Environmental tests of the sediment in the harbour revealed lethal impacts on flora and fauna that live in the sediment. Follow-up investigations have shown that the ecological impacts (e.g., to biodiversity) were restricted to the harbour and that natural recovery (without primary remediation) is taking place. Water pollution impacts were also evident based on post-incident sampling, but pollution dissipated quickly due to the nature of acid dilution in water. Human use impacts from the spill appear to be less significant; therefore, this analysis focuses on biodiversity damage resulting from contamination of harbour bottom sediment.

The incident occurred within Europe's *Continental* Biogeographical Region, which extends into the southern Swedish Coast. The 12-hectare harbour is within an inter-tidal marine environment and has been used for industrial purposes since the late 1800s, resulting in a polluted environment (e.g., heavy metals and organics) in which highly tolerant species are found. Based on semi-annual environmental monitoring initiated by the local municipality in 1996, the harbour has been experiencing natural ecological recovery, including improved species diversity and reduced concentration of pollutants in the sediment.

This case study will illustrate a relatively straight-forward resource equivalency approach for estimating environmental damage and appropriate compensatory remediation following an *ex post* chemical release. Because the area is assumed to make a complete recovery to baseline, complementary remediation is not estimated. This study assumes that the actual spill would have triggered remediation requirements under the Environmental Liability Directive (ELD), had it occurred after April 2007. The analytic focus will be on considerations for selecting an environmental metric and estimating a baseline condition when reliable ecological information exists. The study will demonstrate both a "before-and-after" and "reference location" approach to defining the baseline condition of the resource. In addition, the study will conclude with a sensitivity analysis which will (1) illustrate how different inputs impact the conclusions of the analysis and (2) demonstrate an approach to assessing uncertainty.

5.1.2 Mining tailings spill (Doñana National Park, Spain)

The nature reserve of Doñana is situated in the delta of the Guadalquivir River (Southwest Spain). This area encompasses 106,000 ha of protected land of natural systems including aeolian sheets, marshes, coastline and river estuary. It is divided in two parts, the National Park (50,720 ha) and the Natural Park (55,323 ha). Its international importance was recognised by the International Biosphere Reserve in 1980, by the Ramsar Convention in 1982, and it was declared a World Heritage Site by UNESCO in 1995. Currently it is included in the Nature 2000 network as a special protection area under the Wild Birds Directive.

On 25 April 1998 a breach of the tailings dam of a pyrite mine – belonging to the company Boliden Apirsa - resulted in the release of 6 million m^3 of acidic water and toxic sludge high in heavy metals. Contaminated material washed 40 km down the Guadiamar River and extended over a zone of approximately 400 m beyond the banks on both sides of the river. The land surface affected by the toxic mud encompassed 4,286 ha, including at least three habitats listed in Annex I of the Habitats Directive. The spill was diverted away from the National Park by a series of hastily constructed barriers. The contaminated waters remained in the Entremuros area within the Doñana Natural Park. Over 2,650 ha, i.e. about 5% of the Park, was affected.

All the habitats on the Guadiamar riverbed were destroyed and the complete fish and shellfish population disappeared (30 tonnes of dead fish were removed, including ecologically important species listed in Annex II of the Habitats Directive), as a consequence of burial, blows, gill blocking and the drastic change in water properties (low pH and low dissolved oxygen). Ninety terrestrial vertebrates were found dead, but it is not clear to what extent these were directly related to the incident. Thousands of tons of heavy metals were mixed with the mud. Most of these metals were in the form of insoluble sulphides and, therefore, they remained on site. Nevertheless, unknown amounts of dissolved metals were discharged into the lowest part of the Guadalquivir River.

The purpose of the Doñana case study is to test - in a unique, particularly large and ecologically highly valuable site - resource and value based equivalency methods of both ecological and socioeconomic impacts of a toxic spill from the perspective of nearly 10 years of recovery. The Doñana case should illustrate the Toolkit with regard to:

- Ecological and economic impact assessment and valuation (e.g., V2V approach);
- Testing different metrics;
- Testing alternative remediation options;
- Analysis of distributional aspects, in both spatial and temporal dimensions; and
- Uncertainty and information quality management.

5.1.3 Chronic mining pollution (Czech Republic)

This case study addresses the effects of mining, particularly coal mining, on terrestrial habitats in north-western Czech Republic (Bohemia). The case study focuses on the use of alternative metrics to describe environmental damage and recovery. We also consider the extent to which primary remediation results in recovery of damage ecosystems and ecological functions. The case study analysis is based on quantitative modelling of a hypothetical system. However, the hypothetical system is illustrative of a large number of historically damaged locations in north-western Czech Republic and is based on extensive data that have been collected over the past 15 years by various researchers.

The ecological effects of coal mining include adverse impacts at the species, habitat, and landscape levels. Ecological functions of landscapes also have been disrupted. This study will examine information on the ecological consequences of coal mining to describe an illustrative case study of how resource equivalency methods can be used to calculate environmental damage. The analysis will describe damages to resources, habitats, and services using several different metrics, including vegetative cover, biodiversity, and temperature amplitude. The goal is to calculate environmental damage using available data for terrestrial remediation projects. In particular, this study will demonstrate how liabilities may be sensitive to the selection of the metric used to describe the service losses.

5.1.4 Forest fires in the Bages-Berguedà Region (Spain)

On July 4-8, 1994, a large forest fire occurred in the region of Bages-Berguedà (Catalonia, North East Spain). This fire (hereafter, BABE wildfire) was presumably caused by the malfunctioning of a power line. There are previous cases in the same region and in neighbouring areas where power companies have been legally declared liable for the accidental ignition of wildfires due to poorly maintained power lines. Official reports on forest fires in Mediterranean countries estimate that between 17-21 percent of forest fires are caused by power line malfunctions.

The BABE wildfire burned approximately 25,000 hectares of Black pine (*Pinus nigra*). Black pine forests are included in the Annex I of the EU Habitats Directive (no. 9530: *Sub- Mediterranean montane forests with endemic black pines*) and are assigned a high priority for conservation. Sub-Mediterranean black pine forests are present in Italy, Greece, Corsica and Spain. The BABE wildfire had an extraordinary impact both in ecological and socio-economic terms. Black pine is a sensitive species to fire and natural post-fire regeneration is very limited. The new forest landscape that appears after a fire event includes the presence of large areas without tree regeneration or significant changes in the forest tree species (e.g., mixed oak coppices arisen through re-sprouting). Overall the wildfire reduced the total area of Black pine in Catalonia by one-third. The wildfire also impacted popular recreational activities such as hunting and mushroom-picking, and other tourist-related activities. Natural re-colonisation of the burnt area by black pine is expected to take an extraordinarily long time, even following primary remediation such as seeding and planting.

This case study will illustrate a resource equivalency approach for estimating environmental damage and compensatory remediation within a terrestrial habitat protected under the EU Habitats Directive due, possibly, to an incident that would be covered by the ELD. The study is unique in that it addresses long-term environmental damage (e.g., over several decades) and will also include an analysis of uncertainty associated with the potential occurrence of future fire events in the area – in other words, the uncertainty of baseline. Accounting for the probability of future forest fires reduces the amount of required compensatory remediation compared to an assumption of no future forest fires. The case study will illustrate:

- Considerations in selecting among various potential environmental metrics (e.g., biomass, trees, forested area, and habitat index) in terrestrial habitats;
- The application of a value-to-value equivalency approach based on empirical estimates of how benefits change over time and by identifying the alternatives preferred by the public (based on primary data collection); and
- Sensitivity analyses of key variables (e.g., differences in metrics, single/multiple metrics, distance decay functions, on-site/off-side remediation).

5.1.5 Yamal pipeline river crossing (Poland)

This case study will address the terrestrial and aquatic damages caused by construction of the Yamal Pipeline crossing of the Vistula River in Poland. The Yamal-Europe natural gas pipeline was completed in 1999 and is a 4,196-km-long pipe connecting natural gas fields on the Yamal peninsula, Russia, with Germany. The pipeline length includes 680 km in Poland. This case study will examine the *ex post*[7] environmental damage resulting from a major river crossing.

Terrestrial damages were caused by excavation of forest, riparian shrub, and grassland habitats. Primary remediation was undertaken following construction. Secondary damages, which were not addressed through primary remediation, included adverse effects of noise, vehicles, dust, light, and other construction-associated stressors on wildlife. Aquatic damages to sediments, water quality, fish, and aquatic invertebrates also were caused by excavation of river sediments during construction. Secondary damages were caused by deposition of dredge spoils in the river, as well as other construction-related activities. This study will use a habitat equivalency framework to calculate total environmental damages, reflecting the benefits of primary remediation performed following construction. Relative habitat scalars are applied to damaged terrestrial habitats (forest, shrub, grassland) to enable compensatory remediation of higher-valued forest habitat.

5.1.6 Construction of a Trans-National Highway

This case study will provide an example of how resource equivalency analysis can be used to calculate, on an ex ante basis, the relative environmental damages and associated liabilities of two highway construction alternatives. The study will illustrate how potential damages to protected species and habitats from two construction alternatives can reflect a total cost of construction that incorporates the environmental externalities imposed by road development. Information on habitat and species scarcity from existing cases will be used to develop indices of Natural Value, Habitat Fragmentation, Resource Scarcity, and Biological Diversity. These indices can be used to develop habitat scalars that are incorporated into resource equivalency

[7] The REMEDE Toolkit generally describes *ex ante* assessments as those covering planned infrastructure projects where damage is known and anticipated (generally covered by the EIA, and H & WB Directives). *Ex post* projects are generally described as assessments that take place after unforeseen incidents or imminent threat of damage. The equivalency methodology applied under both assessments is identical. This case study is slightly different in that it was known the investment was to take place, but the environmental impacts that occurred turned out to be different to those stated in the EIA of the investment. Thus, the assessment is made after the damage took place.

calculations. By calculating environmental damages on an ex ante basis, environmental damages can be incorporated into decision-making on infrastructure development.

5.2 Proposed Shorter Case Studies

5.2.1 River Itchen water abstraction (UK)

This case study uses an *ex ante* assessment of the effects of abstraction for public water supply on the ecological integrity of the River Itchen Special Area of Conservation (SAC) within the county of Hampshire, England. Licenses for abstraction for public water supply in England are issued by the Environment Agency. Licenses that are likely to have an adverse effect on a Natura 2000 site are for England and Wales assessed in accordance with Article 6(3) of the Habitats Directive to determine if this is indeed the case. In this case, the assessment has shown that the population of Atlantic salmon (a species listed in Annex II of the Directive) and the floating *Ranunculus* habitat (a habitat type listed on Annex 1 of the Directive) are adversely affected by the levels of abstraction.

In reality, the Environment Agency is currently in discussion with the public water supply companies to identify an approach to offsetting these impacts. This case study will take the hypothetical scenario in which the Agency decides to grant abstraction licenses despite the negative assessment on the grounds of overriding public interest in accordance with Article 6(4) of the Directive. The review of experience in the EU Member States undertaken in REMEDE Deliverable 6B has identified two examples where such an approach has been taken in the past (Norfolk Valley Fens SAC water abstraction license, UK, and La Brena II reservoir construction, Spain).

Resource equivalency analysis will be used to identify compensation necessary to meet the requirements of Article 6(4) of the Habitats Directive for ensuring that the overall coherence of the Natura 2000 network is protected. It will examine flow requirements (e.g., water quantity) for migrating salmon. The study will discuss various possible metrics (e.g. pros/cons), but focus quantification on salmon (R2R). It will also consider human use of the resource, for example, angling use and public appreciation based on a benefits transfer approach from existing economic literature. This case may also consider relationships between compensatory requirements of the Habitats Directive and those of the Water Framework Directive.

5.2.2 Coastal defence and marine habitats (UK)

This case will take an *ex ante* example of compensation requirements arising from development undertaken in accordance with Article 6(4) of the Habitats Directive – that is development approved despite a negative impact on a Natura 2000 site or sites due to the requirements of overriding public interest. Several cases have arisen in the UK where proposals for the construction of coastal defences have been assessed as having an adverse effect on the integrity of Natura 2000 sites, due to the effects of predicted sea level rise over the lifetime of the defences. Examples will be considered from the Humber Estuary on the north east coast of England and from Hayling Island on the south coast. Both examples involve impacts on Natura 2000 sites (both Special Areas of Conservation (SAC) and Special Protection Areas (SPA)). The threat to inter-tidal habitat from sea level rise has been termed 'coastal squeeze', and occurs where the twin influences of rising sea level and an artificially hardened coastline result in a reduction in the extent and ecological function of the intervening inter-tidal zone. This often comprises areas of inter-tidal mud and sandflat and saltmarshes, together with the populations of wild birds associated with these habitats, within Natura 2000 sites.

This case study will consider options for compensation in accordance with Article 6(4) of the Habitats Directive using the predicted loss of habitat and the species populations associated with these as the metric. Habitat loss predictions will be based upon the construction of coastal defence. In the UK, the body responsible for constructing the proposed coastal defences is considered liable for provision of compensatory habitat to offset the impacts of coastal squeeze arising from the replacement defences.

The case study will examine the data and techniques that can be used to establish baseline conditions and will rely on models to estimate environmental damage (e.g., changes in habitat structure and function) due to coastal defence measures. It will focus on contrasting approaches for remediation of predicted inter-tidal habitat damage; in particular, it will contrast the quantity of remediation required using a discounted approach (e.g., under the ELD) and the approach required to ensure the coherence of Natura 2000 (e.g., under the Habitats Directive). The study will illustrate issues surrounding the discounting of environmental impacts (e.g., debits and credits) over long time horizons (e.g., 50 years or more).

5.2.3 Trans-boundary compensation for migratory birds (UK)

This case will consider *ex ante* assessments of the impact of two container terminal port developments in the UK on habitats used by migrant bird populations. In both cases, the habitat lost or damaged is important for wintering waterfowl populations that breed in high arctic and tundra habitats and migrate to over-winter on the western Atlantic sea-board. During migration, the birds depend on habitat in several Member States of the EU (and non-EU States) for breeding and as staging posts.

This case will focus on the relationship between the extent and type of compensatory inter-tidal habitat provided and the geographical displacement of this habitat from the impacted site. It will also consider the relationship between maintaining the ecological coherence of Natura 2000 (as required by the Habitats Directive) and the need to compensate the human population at the impacted site for damages to their local environment. The focus will be on how to remediate damage to habitat used primarily by species that travel over long migration routes. In particular, it will consider remediation across Member State boundaries.

5.2.4 Airbus facility expansion within Mühlenberger Loch (Germany)

This case study is an *ex ante* assessment of compensation measures arising from development activities within a protected area known as "Mühlenberger Loch" in Northern Germany. In order to extend the Airbus industrial facility, a part of the Mühlenberger Loch protected area was infilled between 2001 and 2003. The impacted area (the Mühlenberger Loch Ramsar Site) consisted of tidal freshwater mudflats that supported tidal estuary habitat, waterfowl populations, endemic plant species, and nursery functions for different fish species. The main loss of habitat resulted from dyke construction between March and October 2001, though disturbance and sedimentation impacts in adjacent environments may continue for several years.

The German Federal Nature Conservation Act regulates the mitigation of impacts on the natural environment since 1976. In 1993 the principle of habitat banking was introduced. The German experiences made in this context provide for important lessons learned that are of great value also for the implementation of the Habitat and Environmental Liability Directives on the European scale. This case study will focus on the relationship between the extent and type of compensatory habitat when remediation is considered far from the impacted site. For example, it will address the issue of how remediation requirements might differ when distance

from the damaged site is considered. This analysis will be similar to the Trans-boundary compensation for migratory birds (UK) study (section 5.2.3) in that it focuses on remediation far from the impacted site. However, this study will focus on the impact of short to intermediate distances between impacted and remediated sites within a Member State (the UK study will focus on remediation across Member State boundaries as well as into non-Member States).

In addition this case will consider failure probability and how this might be incorporated into remediation projects. That is, what considerations are important in scaling remediation to ensure the proposed remediation project delivers the required environmental 'credits'.

5.2.5 Compensation in the form of habitat banking (Germany)

This case study will use both *ex ante* and *ex post* assessment procedures to evaluate habitat banking. In particular, the study will focus on the Hof Hasemann Foundation. Land owned by the Hof Hasemann Foundation is placed in a pool of compensatory areas that provides areas for compensation for development projects. In the past it has been used for mining of clay, construction of wind power stations, road building, and the building of a cycling track. The system is often cited because it is meant to be very cost efficient.

The ecologically significant areas of Hof Hasemann are recognised for their ecological values. The ecological values are available for purchase, and thus compensatory measures can take place either before or after an incident has occurred (e.g., *ex ante* or *ex post*). It also represents an opportunity to provide compensatory areas in highly populated regions. The case study will consider the pros and cons of utilising a "habitat bank" to fulfil remediation requires under the ELD and relevant Directives. For example, it will consider potential cost savings when remediation objectives can be easily purchased from existing areas, and also consider circumstances when metrics used for damage determination are reconciled with definitions provided by a habitat bank. Most importantly, this study will identify key criteria that must be met by a habitat banking remediation option to ensure it meets the requirements of the ELD.

5.2.6 Hydroelectric power water use (EdF) (France)

This case study will conduct an *ex post* assessment of longstanding water use practices by hydroelectric power stations and river training within the tri-border region of the Rest-Rhine. Due to its geographic location, this region is of common interest to France, Germany and Switzerland and management depends on trilateral environmental co-operation.

This section of the Rest-Rhine is heavily managed with several hydropower stations that guide the river away from its natural channel, which is blocked by locks and barrages. Only during periods of high discharges are adjacent areas flooded. River training and water use has negatively impacted the waterway including its habitats, species and water quantity. A number of environmental organisations are working to restore the area.

The French and Swiss licence for using hydropower in the Kembs/Upper Rhine, operated by the French company Electricité de France (EdF), will expire on the 31 December 2007. Therefore there is an opportunity to adopt a new licence with compensatory measures for the damages caused in this Rest-Rhine region. In addition, this new licence would fulfil their national obligations under the Water Framework Directive. Importantly, this case study will focus on compensatory remediation to offset damage to river habitats from modified water quantity practices. The study will calculate compensatory measures based on modelling approaches of stream flows and will consider both resource-to-resource and service-to-service approaches.

5.2.7 Hypothetical grounding of a container ship (UK)

This case study is loosely based on an actual event – the "Napoli" container ship that was grounded in a sensitive reef area in January 2007. The "MV Naples" is a medium-sized container ship that had difficulties in the English Channel and was deliberately run aground in order to reduce damage to itself and to other ships. The ship ran aground in a Natura 2000 site (also a European Marine Site), valuable both for its reefs and its seabirds. A portion of the reef was damaged and the hull of the vessel suffered structural impacts that resulted in an oil spill that killed 10,000 seabirds. Containers of chemicals and other products released from the stranded vessel resulted in further damage to the reef and other marine organisms. The coast guard decided to unload the ship in order to reduce further major risk, but this resulted in tug boats and other vessels causing further damage due to anchoring and dynamic positioning. Eventually the empty vessel was towed off with a patched hull, causing additional damage to the reef.

In addition to the ecological damage to the reef, the stranding of the boat led to negative human welfare impacts associated with a disamenity. A nearby coastal marine park that attracts recreationists was besieged with visitors who were curious to view the damaged boat. The park authorities insist that such visitation was not beneficial as it did not provide the type of visitor experience the park would like to promote. Thus, an assessment of welfare impacts associated with impacted recreational use may be relevant.

5.2.8 Fuel tank explosion in the River Hamble (UK)

This proposed case study is based on a hypothetical study that British Petroleum developed in their analysis of potential ELD impacts. In this hypothetical study, a fuel tank at a permitted site located alongside the River Hamble explodes, releasing contaminants into the river and nearby waterways. Large quantities of fuel enter surface waters via the hard standing and soils, and fuel also seeps into groundwater. Contaminated water flows into the Southampton Estuary, which is subject to Special Protected Area and Special Area of Conservation designations. Tidal motion spreads the contamination to cover a 20 km area within three hours before containment measures are in place, damaging tourist beaches, protected salt marshes, oyster and clam beds, shellfish and bathing waters protected under EU Directives. Hypothetical data can be generated and assumptions made about the difficulty of identifying reasonable compensatory remediation projects.

5.2.9 Groundwater contamination of drinking water supply (UK)

This study would be based on an actual underground aquifer in Cambridge, UK, that was impacted by contaminants from a nearby tannery. The aquifer served as the primary water supply. By assuming that a tannery facility utilising carcinogenic chemicals (e.g., chromium) in their production process is considered to fall under Annex III of the ELD[8], this study could assume that damage to this groundwater resource and the services it provides is compensable.

This case study would examine how to handle compensatory remediation from a groundwater supply that is also used for drinking water. Civic liability laws would most likely provide legal compensation to individual consumers of the drinking water. However, the ELD would provide compensatory remediation to the public associated with damage to natural resource services. These resource services may include the provision of future drinking water supply, provision of water quantity to other groundwater or surface waters, or merely the non-use values it provides to the public. Contaminated groundwater is particularly challenging in damage assessment because damage can be to the groundwater resource itself, and/or the

[8] Activities under Annex III are those for which strict liability applies. That is, if the tannery were an Annex III facility, it would be responsible for groundwater damage even in the absence of fault associated with its production or activities.

groundwater can serve as a pathway to damage other resources. For example, contaminants may be carried via groundwater to a point of discharge to surface water which may receive the adverse environmental impact. Alternatively, groundwater contaminants may lead to damage to flora or fauna with which it comes into contact.

5.2.10 Landfill leachate contamination to a wetland (UK)

This suggestion is based upon a case study conducted several years ago by the Royal Society for the Protection of Birds (RSPB) related to their investigation of the ELD. Leachate is formed when water passes vertically through waste in a landfill. Whether or not leaking leachate causes environmental damage through contact with groundwater or surface water depends upon how it is collected or treated by the landfill. In this particular case study, a sensitive wetland (Lodmoor, near Weymouth in Dorset) with SSSI protection (Site of Special Scientific Interest, designated within the UK) was impacted by a landfill. Contamination from the leachate leads to a marked detrimental effect on the site's biodiversity. The pollution damages invertebrate communities which, in turn, is considered responsible for the disappearance from the site of breeding wading birds such as redshank and snipe.

Previous primary remediation at the site (carried out by the current managers, RSPB) has included conversion of wet grassland (the original habitat) to reed-bed habitat, which helps to remove pollutants and improve water quality. This study would examine potential compensatory remediation assuming a long time frame for recovery.

5.2.11 Bothnia railroad construction project (Sweden)

The Bothnia Rail Line is a major on-going construction project in Northern Sweden. The 190 kilometre long railway is anticipated to be complete in 2011. The northernmost part of the Bothnia Line passes through Natura 2000 sites in the delta and flatlands of the Umeå River (both SPA classified in accordance with the EU Birds Directive and SAC designated in accordance with the EU Habitats Directive). This area is particularly important for migratory birds, as it provides foraging and resting places and is situated at the crossroads of two important migration routes. In June 2003, after receiving the opinion of the EU Commission, the Swedish government decided to grant permission for this section of the line, subject to a comprehensive compensation package. In total, the railroad impacts 97 hectares of Natura 2000 site including 13 hectares of direct impact (and additional hectares to less valuable sites).

This case study would examine an *ex ante* infrastructure project with special consideration to the comparison between the compensation package provided by the local authorities and a compensation package that might be recommended through an application of the REMEDE Toolkit.

The case study would also consider the issues regarding methodological and theoretical issues associated with land preservation or designation of nature reserves as compensatory remediation. It might address issues of a dynamic baseline i.e., what would have happened to the newly designated land in the absence of the remediation project. Fair and effective compensation should provide a positive "net environmental gain". Without ensuring a positive net gain, remediation off-sets may be criticized for under-compensating the public and not achieving the objectives of the Habitats Directive.

5.2.12 ***Baia Borsa mine spill (Romania)***

This study is based on an actual mining spill that occurred in January 2000 in Romania. It is similar to the Doñana case study (see Section 5.1.2), but with two differences: (1) this case involves cross-boundary impacts (Hungry and Yugoslavia); and (2) the impacted area was an already heavily contaminated industrial area prior to the spill, with significant health impacts on the local communities. As a result of the Mining Directive (Directive 2006/21/EC), these types of mining spills will be covered by Annex III of the ELD.

6. Final selection

The REMEDE Project Team met in Ghent, Belgium 25 – 28 June 2007 to discuss the proposed case studies listed in Section 5. The discussion focused on the individual and unique analytic focus of each case study to ensure the Toolkit would be adequately illustrated. As part of the discussion at this meeting – as well as prior input from the Commission – the Project Team made a final selection of 11 case studies. The factors leading to the decision to include these 11 and to exclude the remaining studies are summarised as follows:

- These case studies provide opportunities to illustrate the most important aspects of the Toolkit including the baseline determination, the selection of metrics, and the development of unique remediation alternatives. In addition, these studies will demonstrate how the Toolkit can be adapted to a diverse set of Directives – each of which presents slightly different policies toward environmental compensation.

- The selected studies represent reasonable and likely types of damage. The vast majority are based on actual events and therefore provide realistic cases. Some studies represent relatively simple and straight-forward analyses, while others illustrate the increasing complexity associated with large damage incidents or sensitive ecological areas.

- The selected studies provide ample opportunity to consider hypothetical extensions (e.g., scenarios) in order to better illustrate the more general description contained in the Toolklt. The scenarios will be varied in order to provide concrete applications of RE methods.

- The seven excluded studies added only marginal value in terms of the expected types of environmental damage envisioned by the Project Team or by other experts who have developed similar prospective environmental liability studies (See Section 3).

- The potential analytic focus for the seven excluded studies, in many ways, duplicated the selected 11 studies. The selected studies provide a sufficiently strong variation across the key selection criteria (see Appendix B).

Table 2 below summarises the final selection of studies and provides references to learn more about each study.

Table 2. Summary of Case Studies	
Case Study Title	**Summary of Study**
Selected In-depth Case Studies	
Tank collapse & chemical release (Sweden)	5.1.1
Mining tailings spill (Doñana National Park, Spain)	5.1.2
Chronic mining pollution (Czech Republic)	5.1.3
Forest fires in the Bages-Berguedà Region (Spain)	5.1.4
Yamal pipeline river crossing (Poland)	5.1.5
Construction of a Trans-National Highway	5.1.6
Selected Shorter Case Studies	
River Itchen water abstraction (UK)	5.2.1
Coastal defence and marine habitats (UK)	5.2.2
Trans-boundary compensation for migratory birds (UK)	5.2.3
Airbus facility expansion within Mühlenberger Loch (Germany)	5.2.4
Compensation in the form of habitat banking (Germany)	5.2.5
Excluded Case Studies	
Hydroelectric power water use (EdF) (Kembs/France)	5.2.6
Hypothetical grounding of a container ship (UK)	5.2.7
Fuel tank explosion in the River Hamble (UK)	5.2.8
Groundwater contamination of Drinking Water Supply (UK)	5.2.9
Landfill leachate contamination to a wetland (UK)	5.2.10
Bothnia Railroad Construction Project (Sweden)	5.2.11
Baia Borsa Mine Spill (Romania)	5.2.12

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Appendix A: Format for Case Study Reports

This Appendix contains a template of the final case study reports to ensure consistency across case study analyses. This template is designed for the six full length case studies; the remaining studies focus instead on individual aspects of the toolkit.

Executive Summary

1. Introduction

Very short punchy outline of the case with emphasis on key points it will illustrate or focus on. In addition there needs to be an explanation of why it is environmental damage (e.g. ELD, Habitats Diective Art 6(3) or EIA Directive – it could be one or more of these), ex ante/ex post.

There is no need to consider significance of damage or what magnitude of damage would be necessary for an incident to meet the threshold of environmental damage defined by the ELD. This discussion is outside the scope of REMEDE. Therefore, case studies assume that damage is deemed to be significant.

2. Initial Evaluation.

Description of what happened or is planned to happen (ex post/ex ante): data availability, scale of assessment effort and so on. This is equivalent to Step 1 (initial evaluation) described in the Toolkit.

3. Determining the Debits

This is equivalent to Step 2 of the Toolkit and it comprises the following sub-sections.

3.1 Baseline
Description of baseline – limited to or focused upon features that may form possible metrics. Include exploration of different approaches to establishing baseline if appropriate.

3.2 Metrics
Discussion of choice of metrics – relate to requirements of Directives for which the equivalency analysis is being undertaken.

3.3 Debits
Quantify the debits by reference to selected metric or metrics taking into account the benefits from primary remediation/natural recovery.

4. Determining the Credits

This is equivalent to Step 3 of the Toolkit and comprises the following sub-cases.

4.1 Remediation alternatives
Review options for compensatory and complementary remediation. Primary remediation may need to be described but need not be analysed – since primary remediation is outside the scope of REMEDE.

4.2 Calculating the credits
Calculate the benefits that will be gained by implementing complementary and compensatory remediation projects.

5. SCALING REMEDIATION

5.1 Quantity of Remediation

This equates to Step 4 of the Toolkit. Scaling is performed to determine the scale or quantity of remediation to implement. This will ensure that, over time, the discounted flow of services from the remediation projects (the credit) is equal to that lost in the impacted area (the debit).

5.2 Cost of Remediation

An estimate of **Cost** for the remediation projects needs to be identified identified. Cost estimates should include the following elements: planning; mobilisation; preliminary-sampling; implementation; operation & management; oversight by competent authority; monitoring and reporting; overhead and contingency.

6. Monitoring and Reporting

This is Step 5 of the Toolkit.

Case studies should also present some consideration of appropriate monitoring requirements for the remediation option(s) recommended. Monitoring requirements would be linked to the selected metrics, type of damage, type of remediation project and so on.

One of the objectives of REMEDE is to set a reporting format for equivalency assessments for future cases under the relevant Directives. This report itself is an example of such a format. A summary table here of each step, assumptions used and the findings would be helpful.

7. Conclusions

Reinforce main points of the case study with reference to the key points mentioned in the introduction, lessons learnt and suggested revisions for the Toolkit.

References

Appendix B: Summary of case studies against selection criteria

- *The characteristics of the case studies are as of November 2007 and may change during the course of the case study application.*

Table B.1. Summary of six selected "in-depth" case studies

Criteria	Tank collapse & chemical release	Mining tailings spill	Chronic mining pollution	Forest fires in the Bages-Berguedà Region	Yamal pipeline river crossing	Construction of a Trans-National Highway
Geography						
EU Member State(s)	Sweden	Spain	Czech Republic	Spain	Poland	Hypothetical location base
Biogeographical regions in the EU	Continental	Mediterranean	Continental	Mediterranean	Continental	Continental
Environmental Damage						
Cause of incident	acute chemical spill in harbor	acute mining waste spill	Chronic mining waste release	forest fire damage	infrastructure project - energy	infrastructure project - road
Ex post vs. ex ante	ex post	ex post	ex post	ex post	ex poste	ex ante
Media type	Species diversity in marine environment	human use, water	land, soil, terrestrial biota	species	land and water	wetland, forest
ELD Incident type	premises	premises	premises	process	n/a	n/a
Migratory species	no	yes; migratory birds, aquatic life	yes; migratory birds	no	no	yes; migratory birds, migrating mammals
Ecological vs. human use	ecological	ecological & human use	ecological	ecological & human use impacts	ecological	ecological
Methodology						
Treatment of baseline	before & after / reference location	before & after	before & after, reference location	before & after	before & after; reference site information	Predictive (ex ante) using existing site data
Environmental metric(s)	acres of habitat area scaled to a habitat index	birds, fish, habitat, money	biodiversity, vegetative cover, thermal alterations	trees, habitat, biomass, money	habitat	species, habitats, natural value index, fragmentation index, scarcity index, biodiversity

Table B.1. Summary of six selected "in-depth" case studies						
Criteria	**Tank collapse & chemical release**	**Mining tailings spill**	**Chronic mining pollution**	**Forest fires in the Bages-Berguedà Region**	**Yamal pipeline river crossing**	**Construction of a Trans-National Highway**
Resource Equivalency Approach	S2S	V2V	R2R, S2S	R2R,V2V	S2S	R2R, S2S
Recovery assumption	natural recovery	primary remediation	primary remediation	primary remediation	primary remediation	natural recovery
Treatment of future uncertainty	sensitivity analysis	-	*sensitivity analysis*	recovery rates may change due to future risks of forest fires	sensitivity analysis	sensitivity analysis
Sensitivity analysis of key assumptions	discount rate, recovery rate, service loss, time period of benefits	remediation options, metrics	Service loss metrics, biodiversity recovery	differences in metrics/with-without money/distance decay functions/on- and off-side implementation/	service loss metrics; remediation failure likelihoods	service loss metrics; remediation failure likelihoods
Level of effort/analysis	simple	complex economic modeling	complex modeling	complex modeling	complex modeling	complex modeling
Policy						
EU Directive (within scope of REMEDE)*	ELD, WFD	ELD, H&WB,WFD	H&WB	ELD	H&WB	HD
Synergy with other research projects	-	EU sponsored Aquamoney	-	EU funding for INTERREG III A project (I3A-100-1-E)	-	-
Transboundary issue	no	no	no	no	no	no

* HD: Habitats Directive; H&WB: Habitat and Wild Birds Directives; WFD: Water Framework Directive; ELD: Environmental Liability Directive

Table B.2. Summary of five selected "shorter" case studies					
Criteria	**River Itchen water abstraction**	**Coastal defence and marine habitats**	**Trans-boundary compensation for migratory birds**	**Airbus facility expansion within Mühlenberger Loch**	**Compensation in the form of habitat banking**
Geography					
EU Member State(s)	UK	UK	UK	Germany	Germany
Biogeographical regions in the EU	Atlantic	Atlantic	Atlantic	Continental	Continental
Environmental Damage					
Cause of incident	water quantity loss (e.g., extraction)	chronic loss of habitat	ship terminal construction impacting birds	extending industrial facilities into marshland	provision of areas for compensation
Ex post vs. ex ante	ex ante	ex ante	ex ante	ex-ante	ex-ante/ex-post
Media type	water	land & marine environ.	habitat	land, water, wetland & habitat	land, moorland
ELD Incident type	n/a	n/a	n/a	n/a	n/a
Migratory species	Yes (salmon)	Yes	Yes	Yes	no
Ecological vs. human use	ecological & human use	ecological	ecological	ecological	ecological
Methodology					
Treatment of baseline	Before & after	Before & after	Before & after	Before & after	Before & after
Environmental metric(s)	No. of Salmon, area of impacted habitat, economic value of salmon	habitat loss	No. birds, bird habitat	habitat loss & species loss	ecological upgrading, eco-points

Table B.2. Summary of five selected "shorter" case studies					
Criteria	**River Itchen water abstraction**	**Coastal defence and marine habitats**	**Trans-boundary compensation for migratory birds**	**Airbus facility expansion within Mühlenberger Loch**	**Compensation in the form of habitat banking**
Resource equivalency approach(es)	R2R, S2S, V2V	R2R: bird S2S: intertidal habitat	R2R: habitat (int'l)	R2R (HEA)	R2R (fish, birds, etc); V2V (recreational use value or non-use value placed on resources); or V2C
Recovery assumption	Natural recovery	Natural recovery	Natural recovery	primary	n/a
Treatment of future uncertainty	Use of precautionary principle in determining remediation	-	-	failure probability in remediation	Banking reduces uncertainty related to managing remediation projects
Sensitivity analysis of key assumptions	Future effect of climate change on precipitation patterns	-	-		resource loss and time period of compensatory remediation
Level of effort/analysis	simple/moderate	simple/moderate	simple/moderate	simple/moderate	simple/moderate
Policy					
EU Directive (within scope of REMEDE)*	HD & WFD	HD	H&WB	H&WB	HD
Synergy with other research projects	-	-	-	n/a	n/a
Transboundary issue	no	no	YES - Birds habitat in Med. & Arctic	Distance from remediaiton site, but within member state borders	no

* HD: Habitats Directive; H&WB: Habitat and Wild Birds Directives; WFD: Water Framework Directive; ELD: Environmental Liability Directive

Appendix C: Biogeographical Regions in Europe

Source: European Environment Agency
http://dataservice.eea.europa.eu/atlas/viewdata/viewpub.asp?id=2038