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OPERATIONAL QUESTIONS RELATED TO THE IMPLEMENTATION OF THE ANNEX II OF THE ELD

***CAVEAT*:**

This document is a very preliminary draft, which does not reflect an official position of the Commission. It is meant to trigger discussion and comments (it proposes a first set of questions, with tentative elements of answer). MS are invited to comment on both its structure and content, as well as to indicate possible additional questions to address, and to provide information that could / would be taken into account in a revised version.

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Hiba! Definiálatlan Szövegtár-elem.

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1. INTRODUCTION

An environmental liability regime has existed in the USA for many years. In essence, the EU regime introduced by the Environmental Liability Directive (ELD) is not fundamentally different from the US one. Although the latter is retroactive, and in this sense more complicated than the EU one, it has been successfully implemented. Exactly as we are facing them now, the US administrations, judges and competent authorities have been confronted with choices over interpretation and operational implementation options. They took decisions (sometimes not immediately the best ones) which enhanced our understanding of issues at stake. We can thus benefit from the rich US experience, and ***be sure that, whatever the problem we are confronted with, there is already at least one possible solution to it.*** It is however not a priori certain it is the best fitted to our specific contexts (EU, nation and region-wide), and may need to be adapted accordingly.

In order to allow for a maximum degree of flexibility and adaptation to local needs, and in accordance with subsidiarity, the ELD and its Annex II set out a framework and broad implementation principles, but leaves a number of domains to Member States' (MS) choices and / or discretion. It is why, for instance, calculation methods and conventions were not made explicit within the annex II.

On the other hand, in these domains (see concrete examples below), slight changes in MS' transposition and implementation choices (all consistent with the ELD) may have significant consequences on final costs for operators. This is obviously the case for assessing interim losses (and thus final aggregate liabilities). This might become problematic with respect to fair competition and internal market proper functioning. Moreover, some concepts are totally new in countries where no significant national environmental liability regime existed before.

It is therefore necessary to fix (to the degree appropriate) the many remaining degrees of freedom as soon as possible, in order not to hamper the operators' ability to assess ex ante the amount and nature of their liability, as well as their own room of manoeuvre within ELD framework. Not fixing them might impact investment and economic activity negatively, and induce insurers and other financial stakeholders to assume the worst scenario (in their point of view), leading to higher premiums.

The transposition process is expected to clarify most issues at stake, but there is a general feeling among MS that enhanced cooperation and sharing is needed in order to best prepare for transposition. They thus asked the Commission to issue a compilation and discussion paper, "consisting of questions and answers to annex II of the ELD. Among others, the following will be dealt with: how do you commute interim losses, what are the reference periods, calculations basis, monetary evaluation, best techniques etc." Clearly, the principal demand is to illustrate the nature and stakes of choices left to MS, and formulate concrete proposals.

The present draft document tries to address some of these issues and to attract MS' attention on potential implementation, interpretation or theoretical problems.

2. BACKGROUND AND MAIN FEATURES OF THE ELD (REMINDER)

The Commission published in 1993 a Green Paper on environmental liability, which led to the publication of a White Paper in 2000 and the adoption of a legislative proposal in January 2002.

The Environmental Liability Directive (ELD), N° 2004/35/EC, was adopted on 21 April 2004 and entered into force on 30 April 2004.

It addresses environmental liability both with regard to prevention and remediation. Application begins on 30 April 2007.

The ELD provides for a **Community-wide** framework, respecting and reflecting the **subsidiarity principle**. Concretely, this means that there is a clear division of labour among the various stakeholders:

- The Directive is to ensure a minimum harmonisation of essential rules for identifying and assessing actions for remedying environmental damage;
- MS are to ensure that operators undertake / finance preventive & remedial measures;
- Interest groups are to follow & eventually challenge this action (all natural and legal persons affected by environmental damage / with sufficient interest / alleging the impairment of a right are entitled to submit observations to the competent authorities and request its action, and Article 12(1)(4) explicitly mentions NGOs as to enter *ex qualitate* in this category).

The ELD tries to implement the "**Polluter pays**" principle: those who cause or threaten to cause damage *to the environment* are held financially liable for their deeds.

One of the most important characteristics of the directive is that remediation is meant to be a priori in kind (service-to-service / resource-to-resource).

Moreover, **the ELD does not make coverage** by appropriate financial security products (e.g. insurance) **compulsory, but only encourages it** (although some stimulating, and at this stage speculative, legal research, such as Prof. Bocken's, lead to the unexpected conclusion that some kind of coverage is indeed imposed by the wording of Article 8 and 14…).

2.1. Coverage

Environmental damage is defined as damage to 'biodiversity' (i.e. to species and natural habitats, as identified under the EU 1992 Habitats and 1979 Birds Directives, or determined by MS for equivalent purposes), to water and to land (if there is a risk of harm to human health).

There are two distinct liability regimes. For professional activities listed in Annex III, liability is strict. For the other activities, actors are liable only if 1) there is fault or negligence and 2) damage are to protected species and natural habitats.

The ELD only applies to damage caused after 30 April 2007 (there is no retrospective effect).

2.2. Exemptions:

The ELD provides for a variety of exemptions, e.g. in the following cases:

- Damages already covered by international instruments listed in Annex IV (i.e. including marine pollution / oil spills) provided the international instrument is in force in the Member State concerned;
- Previously identified adverse effects which results from an act expressly authorised by the relevant authorities in accordance with the Wild Birds Directive (79/409/EEC) or the Habitat Directive (92/43/EEC) or equivalent provisions of national law;
- 'Force majeure';
- Nuclear damage;
- Activities serving national defence or security;
- Pollution from diffuse sources.

NB: An operator is […] not required to bear the cost of preventive or remedial actions, when he can prove that the environmental damage or imminent threat of such damage was caused by a third party and appropriate safety measures were in place.

On top of those exemptions, Member States **may allow** the operator not to bear the cost of remedial actions where he demonstrates that he was not at fault or negligent and also in the cases of Fully-fledged Permit Defence or State of the Art/Development Risk Defence.

- Fully-fledged Permit Defence is defined in Art. 8 (4) (a) of Directive 2004/35/EC as follows: *"an emission or event expressly authorised by, and fully in accordance with the conditions of, an authorisation conferred by or given under applicable national laws and regulations which implement those legislative measures adopted by the Community specified in Annex III";*
- State of the Art/Development Risk Defence is defined Art. 8 (4) (b) of Directive 2004/35/EC as follows: *"an emission or activity or any manner of using a product in the course of an activity which the operator demonstrates was not considered likely to cause environmental damage according to the state of scientific and technical knowledge"*

2.3. General modalities of remediation

2.3.1. Principles

Under both liability regimes, preventive or remedial measures are to be taken, respectively, in the event of an imminent threat of damage or when damage occurs.

Damaged or destroyed elements of the environment are to be restored or replaced by identical, equivalent or similar natural assets, as the case may be, either on the site of the incident or, if need be, on an alternative site, in order to reinstate the environment to its condition prior to the occurrence of damage. In other words, the general principle set by the ELD is remediation ***in kind***.

National authorities' room of manoeuvre on remediation depends on the type of damage:

- Decontamination of soil, i.e. land, is foreseen until it no longer poses any significant risk of adversely affecting human health.
- ELD is more demanding (but also less precise in its prescriptions) for damage to protected species and natural habitats, and water.

2.3.2. Rules set out for damages to biodiversity and water

Those responsible for the damage are to restore, *as far as possible*, the damaged environment to its baseline. This can consist of active actions or of natural recovery, both with respect to losses of environmental resources and losses of environmental services.

Primary remedial actions are to restore the damaged natural resources and/or services to, or towards, baseline condition on the very damaged site. **Complementary remedial actions** need to be undertaken when primary remedial actions are not sufficient to return the damaged site back to its baseline condition (in other words, if it was returned towards its baseline condition, but not to it.) **Compensatory remedial actions** compensate for the "interim loss" of natural resources and services i.e. the lower level of environmental services as long as primary restoration (and, if needed complementary ones) are not fully achieved. None of them do imply financial compensation to members of the public.

The different categories of damage's remediation are defined in section 1 of annex II.

The competent authority is clearly responsible for the list of the different options to be 'considered' with respect to remediation actions (section 1.2.1 of Annex II). Indeed, Art 7 states that 'operators shall identify (…) potential measures and submit them to the authority for its approval', but Article 6.2 states that the latter 'may, at any time, (…) take, require the operator to take or give instructions to the operator concerning all practical steps (…)'.

Whilst the initial proposal said that the authorities should favour the least costly option, the final version of the ELD doesn't include this principle, which means that, in spite of section 1.3.3.b of annex II ('the competent authority is entitled' – but not obliged!- 'to decide that no further remedial measure should be taken if (…) the cost of the remedial measures that should be taken to reach baseline condition or similar level would be disproportionate to the environmental benefits to be obtained'), no option should *a priori* be excluded because of its higher cost.

2.3.3. Rules set out for damages on land

Those responsible for damages on land are only to remove any significant risk of adversely affecting human health, taking account of the land's current or future use.

3. LIST OF POSSIBLE QUESTIONS

3.1. What is an environmental damage / service / good?

3.1.1. Text of the directive

A priori, Article 2 (e.g. through point 1 and 13) answers the question:

"1. '*environmental damage' means:*

(a) damage to protected species and natural habitats, which is any damage that has significant adverse effects on reaching or maintaining the favourable conservation status of such habitats or species. The significance of such effects is to be assessed with reference to the baseline condition, taking account of the criteria set out in Annex I; Damage to protected species and natural habitats does not include previously identified adverse effects which result from an act by

an operator which was expressly authorised by the relevant authorities in accordance with provisions implementing Article 6(3) and (4) or Article 16 of Directive 92/43/EEC or Article 9 of Directive 79/409/EEC or, in the case of habitats and species not covered by Community law, in accordance with equivalent provisions of national law on nature conservation.

(b) water damage, which is any damage that significantly adversely affects the ecological, chemical and/or quantitative status and/or ecological potential, as defined in Directive 2000/60/EC, of the waters concerned, with the exception of adverse effects where Article 4(7) of that Directive applies;

(c) land damage, which is any land contamination that creates a significant risk of human health being adversely affected as a result of the direct or indirect introduction, in, on or under land, of substances, preparations, organisms or micro-organisms;

2. 'damage' means a measurable adverse change in a natural resource or measurable impairment of a natural resource service which may occur directly or indirectly;

3. 'services' and 'natural resources services' mean the functions performed by a natural resource for the benefit of another natural resource or the public;"

3.1.2. Issues at stake

Whilst the concepts are thus quite well defined, situations are sometimes more complicated in practice. Specifically, the services that the environment provides are (at least partially) what economists call public goods. In all cases, only part of their service is reflected in market-based values.

An example is clean water in a river provides a range of services including amenity services (people like to walk along rivers, swim, sail and go fishing in them), ecological functions (supporting animals and plants), and water supply. Only part of these functions are physically assessed and quantified, and few have a market price. Often, one doesn't know how many fish lived in the polluted river or how many people used it for leisure, pleasure and other activities. Even when this is known, the economic value of the service depends on the availability of substitutes: the significance and importance of river pollution differs depending on whether it is the sole source of clean water / fishing opportunities / water habitat in the region. In other words, the above mentioned services are not limited to the damaged river but also to potential substitute rivers.

As a result, the impact of pollution of a river may be difficult to assess and especially difficult to value. Hence the ELD decision to focus on remediation of the damages (as opposed to valuation and monetary compensation of the damage). This will be developed in section 3.3.

When it turns to practical restoration, it is also to be noted that, as soon as there are no prices for an environmental service, private agents have little incentive to supply them and a market for such goods and services often fails to develop. In other words, in most cases, there are no off-the-shelf, ready-to-use, solutions and some remediation will have to be tailor-made. If one approaches liability through the cost of restoration of ‘equivalent’ services, which is basically the philosophy of the ELD, the absence of already known, ex-ante, prices for the said ‘equivalent’ service is a problem. For instance, it will be difficult for insurers to insure operators at the adequate price, because, in fact, they don’t know the likely cost of a possible damage (restoration is possible, but it cost will only be perfectly known when the damage occurs: there is no pre-existing market for such service). Even if they know the risk (distribution of probabilities), insurers don’t know what statisticians call the ‘payments’ (attached to each possible outcome).

3.1.3. Tentative conclusions

Once the focus on service instead of value is cleared, there are two obvious issues to tackle operationally: the lack of knowledge about potential damaged sites / replacement costs, and the availability of replacement services.

With respect to the first issue, the Environmental Impact Assessment Directive (85/337 revised by 97/11) imposes the evaluation of the potential impacts of operators’ new activities on the environment. In some specific cases (e.g. Natura 2000 or Seveso Directive at EU level, as well as some specific national legislations), even old plants and activities are covered. However, these are exceptions and not all ELD-covered activities benefit from an existing environmental risks evaluation. When operators ask for insurance coverage, it is likely some form of ex ante analysis will be done. Transposition should consider possible schemes that could enhance / facilitate / provide incentives for such evaluations and also the benefits of coordination with the insurance industry.

The issue of replacement costs is partially addressed in the section dealing with banking habitats below.

With respect to the availability of replacement services, the issue is addressed in section 3.6.2, dealing with habitat banking.

3.2. What does the ELD mean when referring to “baseline”?

3.2.1. Text of the directive

The notion of baseline is decisive in order to define interim losses, compensatory and complementary remediation. It is defined in Art2 – 14:

> “ *‘baseline condition' means the condition at the time of the damage of the natural resources and services that would have existed had the environmental damage not occurred, estimated on the basis of the best information available*”.

3.2.2. Possible interpretations

Imagine the damage is done to environmental services with a strong cyclical nature or to a service that is already deteriorating (due to climate change or other damages excluded from the scope of the directive by Recital 13, and so on). This definition can have two different interpretations.

a) The first part of Art 2 – 14 defines the baseline as the “condition at the time of the damage”. This implies that one doesn’t take account of the fact that the service was already deteriorating, and one obliges operators not only to compensate for the damage they caused, but also for the decline that pre-existed their polluting action.

b) The second part of Art 2 – 14 defines the baseline as “what would have existed had the environmental damage not occurred”. This implies you take into account the existing trend on the basis of the “best information available” and limit liability solely to the damage actually caused by the polluter.

3.2.3. Issues at stake, and formalisation

Clearly, in the first case, you may overestimate liability. On the other hand, the second interpretation requires the competent authority to assess “what would have existed had the environmental damage not occurred”. Assuming a flat baseline clearly simplifies operational computations. Both options thus have their advantages but require different levels of resources to be devote to the competent authority.

For example, suppose that some environmental damage occurs close to a river and halves the population of its wild salmons (this situation is inspired by the ‘Black Bird’ one detailed in annex 1), so that it decreases from 20.000 to 10.000 adult because of it. Intuitively, the ‘primary’ legal obligation/liability imposed to the body responsible, i.e. “restoring the damaged environment to the baseline”, is to take adequate measures so that the population grows back to 20.000. Imagine it is possible in 5 years. If a growing population of bears or similar salmons predators is such that the salmon population would not have stayed at 20.000, ‘had the environmental damage not occurred’, intuition is however not obvious anymore. Let’s assume that the salmon population would have been 18.000 and not 20.000 within 5 years. If obliged to restore up to 20.000, the operator is in fact obliged to compensate both for his damage and for the bears… If only obliged to restore up to 18.000, the operator, de facto, doesn’t exactly restore the ex ante status. The key problem here is of course the alternative scenario model: what would exactly have happened ‘had the damage not occurred’ is in fact not known with absolute certainty, and subject to conjectures and hypotheses.

3.2.4. Tentative conclusions

Although it might lead to overvaluation of environmental damages, for practical reasons, it is simpler to decide that, in principle, ‘baseline condition' means the condition at the time of the damage of the natural resources and services. In cases where trends are significant, obvious <u>and</u> already known, however, the competent authority should try to estimate what would have existed had the environmental damage not occurred.

In order to respect this proposed two-step decision rule, we use a generic indexing for ‘baseline’ in the formula listed below, so that it remains valid whatever the context. Specifically, we call g_t^b the ‘baseline’ number of environmental goods / service. In general, g_t^b is fixed and equals the value of the environmental goods / service at the precise time of the damage: g^b. But, in cases where a trend is significant, obvious <u>and</u> already known, the formula remains valid and g_t^b is a true varying variable (hence the t index in subscript) which has to be estimated by the competent authorities.

3.3. What are the resource-to-resource or service-to-service equivalence approaches referred to in the ELD?

3.3.1. Text of the directive

Section 1.2.2. of Annex II:

> "*When determining the scale of complementary and compensatory remedial measures, the use of resource-to-resource or service-to-service equivalence approaches shall be considered first. Under these approaches, actions that provide natural resources and/or services of the same type, quality and quantity as those damaged shall be considered first. Where this is not possible, then alternative natural resources and/or services shall be provided. For example, a reduction in quality could be offset by an increase in the quantity of remedial measures*."

Section 1.2.3. clearly says that other methods may be considered, but only if and when the former is not possible.

3.3.2. Habitat Equivalency Analysis

"Resource-to-resource or service-to-service equivalence approaches" implicitly refers to Habitat Equivalency Analysis, which has been widely used over the last ten years by the US National Oceanic and Atmospheric Administration (NOAA) who have developed the methodology and key analytical tools involved in the restoration cost approach. Two seminal papers of US NOAA are annexed to this paper.

As defined by Kevin E. Kohler and Richard E. Dodge of the US National Coral Reef Institute, "Habitat Equivalency Analysis (HEA) is a means to determine the amount of compensatory restoration required to provide services that are equivalent to the interim loss of natural resource services following injury".

Their institute provides free software to facilitate calculation of Compensatory Restoration following Natural Resource Injury[1]. In it, as said by the authors, "the lost services are calculated from the time of injury until the end of the recovery process. Recovery could be either via natural recovery or active restoration. The compensatory restoration services are calculated from the time of commencement through process of the chosen restoration. An injury to natural resources therefore involves a time component during which the ecological services that the resources provide are lost and over which the services of any compensatory restoration are gained. HEA uses a discounting procedure to account for asset valuation in that the total asset value is equal to the present discounted value of the future stream of all services from the natural resource or the compensatory resource. This concept of discounting is explained by an individual's preference for goods and services at any given time. Discounting takes into account that the further into the future that a service is provided, the less it is valued today. Therefore, the HEA approach is particularly well suited for analysis because it can be used to quantify the loss and recovery of resources and includes this time factor."

[1] See http://www.nova.edu/ocean/visual_hea/index.html for details.

The US system doesn't differentiate between 'complementary' and 'compensatory' restoration, and the previous definition only deals with 'compensatory' restoration in ELD terms (i.e. the remediation compensating for interim losses). However, it equally holds 'complementary' remediation under ELD, i.e. for restoration required to provide services up to baseline when primary restoration (i.e. restoration in the exact and precise kind of the damage services on the very spot of the damage) is not sufficient to attain the baseline.

The principal concept underlying HEA is that the public can be compensated for the past loss of services provided by a habitat or natural resource through replacement projects providing additional services or resources of the same type. It should be emphasised that the concept of the *services* provided by a natural resource is central to the approach. Such services are defined in Part 11 (Natural Resource Damage Assessments) of the US Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as "the provision of habitat, food and other needs of biological resources, recreation, other products or services used by humans, flood control, ground water recharge, waste assimilation, and other such services that may be provided by natural resources." (11.71 (e)).

Whereas, traditionally, when damage occurs, the objective is to give a monetary evaluation of it and to impose a corresponding fine on the responsible operator in the case of HEA the focus is on compensation of services attached to the damage good. It avoids time-consuming monetary valuation studies in order to approach damage through replacement (consequences) instead of compensation (essence).

3.3.3. Issues at stake

Although extensively used, HEA is sometimes criticised. The annexed Elsevier paper by R. W. Dunford, Th.C Ginn and W. H. Desvousges provides a comprehensive description of its possible limits: "HEA has several restrictive assumptions that are not met in many situations and its input parameters are not known with certainty, which can lead to substantial differences between HEA results and the 'true' amount of compensation for losses resulting from oil spills or hazardous-substance release. Critical assumptions of HEA include a preference for compensation with the same services as were injured, a fixed proportion of habitat services to habitat value, and a constant value of service over time. HEA also requires that complex ecological services are expressed as a single metric and that the incremental effects of spills / releases are estimated reliably over time".

Some other criticisms are also made (cf. the annexed bibliography), but, more than anything else, it is not sure that this method, which has been originally developed for oil spills (which are excluded from the scope of the ELD), although later widely applied in other US damages as well, is adapted to the specific European context.

3.3.4. ELD interaction with the Habitat directive (92/43/CEE) ***To be developed by January the 15th***

Art. 6.4. of the Habitat Directive (HD) states:

> "*If, in spite of a negative assessment of the implications for the site and in the absence of alternative solutions, a plan or project must nevertheless be carried out for imperative reasons of overriding public interest, including those of a social or economic nature, the Member State shall take all compensatory*

measures necessary to ensure that the overall coherence of Natura 2000 is protected."

Interaction between the ELD and the HD have to be cleared and studied further.

3.3.5. Contribution of the EC-funded REMEDE project

In order to provide input to the wider HEA debate, the Commission launched, through DG RTD, a research project, called REMEDE (for Resource Equivalency Methods for Assessing Environmental Damage in the EU) in order to better understand issues at stake about the desirability and feasibility of transposing US methods in a EU context. Specifically, the consultants will assess the use of equivalent resource scaling approaches in the context of biodiversity damage and other environmental damages that cannot be fully remediated on site.

The proposed research is explicitly linked to the implementation of Directive 2004/35/EC, although it will also benefit the implementation and use of other EC Directives that have been put in place to protect the environment, including biodiversity, natural habitats and wild flora and fauna (resp. Directive 85/337/EEC & 92/43/EEC).

The goal of REMEDE is to develop, test and disseminate resource equivalency methods appropriate for determining the scale of complementary and compensatory remedial measures necessary to adequately offset environmental damage. The project draws from both US experience, in terms of methodological developments and implementation issues encountered, and experience of the EU Member States. It aims to apply and develop these methodologies in accordance with the requirements of the Environmental Liability Directive and the EIA and Habitats Directives, in order that a standard guidance can be applied to all damage cases in the EU.

The project brings together ecologists, economists and legal experts from the USA and Europe to review experience in the application of resource equivalency methods, draft a guidance document for the EU, test the guidance through application to at least four case studies in different Member States, and disseminate the guidance to relevant stakeholders. Throughout the project stakeholder consultation and peer review will be used to ensure the best possible results.

Whilst, it is unlikely that the final report will be available before 2007, the Commission will share intermediate results and reports with MSs.

3.3.6. Tentative conclusions

As long as the REMEDE project is not completed, it will be difficult to draw any definitive conclusion over the questions raised in section 3.3 over the suitability and adaptability of HEA methods to the European specific context.

The ELD wording (cf. section 3.9) implicitly considers that the benefit of avoiding monetary valuation techniques is sufficient to justify a position of principle in favour of HEA methods. Discussions should focus on how to adapt it, and on the possible use of banking habitats (cf. section 3.6.2). The two NOAA papers have been annexed in order to induce first reactions with respect to overall HEA principles, broad mechanisms and potential problems within each national environmental framework.

3.4. What about natural recovery within the ELD framework?

3.4.1. Text of the directive

Art 7.3. :

> *"Where several instances of environmental damage have occurred in such a manner that the competent authority cannot ensure that the necessary remedial measures are taken at the same time, the competent authority shall be entitled to decide which instance of environmental damage must be remedied first. In making that decision, the competent authority shall have regard, inter alia, to the nature, extent and gravity of the various instances of environmental damage concerned, and to the possibility of natural recovery."*

Section 1.2.1. of Annex II :

> *"Options comprised of actions to directly restore the natural resources and services towards baseline condition on an accelerated time frame, or through natural recovery, shall be considered".*

3.4.2. Issues at stake

Natural recovery consists in using, partially or totally, the 'natural' capacity of the environment to recover from environmental damages. For oil spills, but not only for them, it is sometimes the best solution from an environmental point of view (i.e. more rapid solutions involve solvent which are not environmentally neutral).

Its main drawback is the delay in coming back to baseline. Its main advantage is, at least in most cases, a lower cost for operators (part of the remediation scheme is associated with no cost, as made 'for free' by nature).

Overall, the range of possible technical remediation schemes is bounded, both with respect to cost and time, between natural recovery, at one extreme, and immediate recovery, whatever its costs, at the other.

It is to be noted that, although generally less expensive, natural recovery schemes do not by themselves satisfy the polluter payer principle and only do so when combined with accompanying measures. Indeed, since natural recovery cannot be immediate, there will always be interim losses, which have to be compensated for, according principles expressed in section 1.c of Annex II. In other words, operators do not pay for natural recovery, but instead pay for the accompanying remediation measures. These potential charges deter unsustainable behaviours and satisfy the polluter payer principle as they induce them to integrate the risk of pollution in their production function.

The key issue with natural recovery, and its inclusion or not within the list of possible options to be considered by the competent authorities, will depend on the induced implication, or not, of irreversible effects on the environment. Indeed, with natural recovery, it usually takes years before returning back to baseline, and such a period without decent (and sometime minimal) environmental services may have irreversible effects on the vast chain of causes which do have a relation with the said environmental services. The longer the restoration, the wider (in general) the indirect effects. As a consequence, if natural recovery induces too much irreversibility, it will not satisfy with the criterion mentioned in section 1.3.1 of Annex II which imposes considering '*benefits to each component of the natural resource and/or service' (see infra).*

3.4.3. Tentative conclusions

Natural recovery has two main advantages: it minimises human intervention and is generally cheaper, even when combined with other remediation actions. As such, it should generally be one of the options considered by competent authorities. Transposition processes could mention it as such.

3.5. How will the competent authority select options to be considered among the technically feasible ones?

3.5.1. Text of the directive

Within these two extremes of immediate restoration whatever its cost and maximal use of natural recovery, the possibilities are numerous if not infinite.

In the 'salmon' example already used for the 'baseline' section above, for instance, one can simply let nature do its work, and count on natural population growth. One may also try to improve natural population growth (by limiting fishing or simply increasing the survival rate of 'smolts' - young salmons). Introducing 10.000 salmons (or a bit more to compensate for those that will not adapt to their new habitat) is another option, and so on. For each of these options, there may also be different technical solutions, more or less rapid, and associated with different costs. And one may of course decide to work on all those fronts although insisting more on one or another element.

The competent authority is clearly responsible for the list of the different options to be 'considered' with respect to remediation actions (section 1.2.1 of Annex II). In order to help it, section 1.3.1. provides a list of possible concerns:

> *"The reasonable remedial options should be evaluated, using best available technologies, based on the following criteria:*
>
> - *The effect of each option on public health and safety,*
> - *The cost of implementing the option,*
> - *The likelihood of success of each option,*
> - *The extent to which each option will prevent future damage, and avoid collateral damage as a result of implementing the option,*
> - *The extent to which each option benefits to each component of the natural resource and/or service,*
> - *The extent to which each option takes account of relevant social, economic and cultural concerns and other relevant factors specific to the locality,*
> - *The length of time it will take for the restoration of the environmental damage to be effective,*
> - *The extent to which each option achieves the restoration of site of the environmental damage,*
> - *The geographical linkage to the damaged site."*

This already impressive opening of possible concerns given to the competent authority is reinforced by other sections:

Art 7 says that

‘operators shall identify (…) potential measures and submit them to the authority for its approval’, but Article 6.2 said first that the latter ‘may, at any time, (…) take, require the operator to take or give instructions to the operator concerning all practical steps (…)’.

Section 1.2.1. of Annex II insists on considering the widest range of possibilities:

“Options comprised of actions to directly restore the natural resources and services towards baseline condition on an accelerated time frame, or through natural recovery, shall be considered”.

Section 1.3.3. specifies that

”the competent authority is entitled’ but not obliged ‘to decide that no further remedial measure should be taken if (…) the cost of the remedial measures that should be taken to reach baseline condition or similar level would be disproportionate to the environmental benefits to be obtained.”

3.5.2. Problems

The key point here is that this is a list of both non-prioritised *and* competing / incompatible criteria. And the key problem is that mentioning the ‘length of time it will take for the restoration’ (although perfectly legitimate ceteris paribus), may encourage authorities to systematically impose the most rapid solution, whatever its cost. It may also limit the actual impact of Article 7.3’s incitation to use natural recovery, which is generally much less costly, even if induced interim losses are compensated for.

The problem would be somewhat mitigated if there were few ELD-compatible options, and if the number of them was not be directly dependant on some of the said criteria. But this is not the case. Indeed, the introduction of complementary and compensatory remediation allows (in theory) for an endless number of possible remediation schemes (cf. infra, section 3.8.5), all of which are a priori perfectly compatible with the directive.

If no guidance at all is given ex ante about the priorities and weight given by the authorities to the criteria listed in section 1.3.1, operators may consider technical solutions which privilege one (unknown as less important) given criteria at the expense of another one (unknown as more important). This doesn’t mean that the selection among possible options should be mechanic, but at least that some indication be given about the relative weight of the many criteria possibly to be considered. Not doing this would increase the burden imposed on operators, as remediation proposals impose technical and feasibility studies which do have a cost. From the competent authorities’ point of view, if some solutions are not ex ante eliminated (as less compatible with the priority criteria), there will also be more options to be considered, with higher administrative costs and delays in the administrative process.

Lack of prioritisation also induces legal uncertainty, as an authority may well, due to precaution criteria, give the priority to effects ‘on public health and safety’ over ‘cost’ or ‘relevant social, economic and cultural concerns’, and then be contradicted in appeal by judges referring to the same Article 7.3, or, on the contrary, as already mentioned, exacting the most rapid remediation scheme, whatever its costs... In such a case, it would be up to the operator to adapt to the changing decisions. It might even possible that he would be asked by the competent authority, in some cases, to undo measures already implemented, and bear the related costs.

Indeed, Article 6 obliges operators to take action 'without delay' (Article 6). Art 7. *may* limit the scope of this obligation (jurisprudence *may* allow operators to wait for some endorsement before acting), but, the way articles 6 and 7 will interact in this respect remains somewhat unclear. If Article 6 is understood strictly, operators will be obliged to intervene without any hint about the final decision criteria of the authorities, and, more specifically, without being certain that their proposal will finally be endorsed by them… If it is not understood so strictly, in order not to risk being obliged to remediate again from scratch (and duplicate costs), operators might be induced to wait for initial feedback from the authorities before initiating remediation. This would not be good for environment.

Moreover, the abovementioned legal uncertainty will dissuade operators from appealing in Court against competent authorities' decisions (and specifically plea Article 7.3), as final outcomes cannot be anticipated at all, and lawyers cannot refer to clear-cut principles. Of course, some may argue that courts establishing principles though previous practice, the less certain the more likely operators are to appeal. On the other end, in a statistical point of view, this doesn't hold as uncertainty on payments diminishes risk-aversion weighted net expected values. As pursuits do have a cost, if you take account of risk aversion, people will consider the significant probability of them being condemned by courts and increasing the total cost of the procedure, and abstain.

If priorities and weights are not clarified at national levels, differences with respect to compliance costs (and thus competitive positions) will happen from authority to authority within each Member State. If this is not done homogeneously among MSs (e.g. with respect to 'length of time it will take for the restoration'), the same problem will be posed at the EU levels, with possible implications for internal market fair competition rules.

3.5.3. Issues to be fixed at the transposition level, and related stakes

In the proposal which led to the adoption of the ELD, Annex II stated that "If several options are likely to deliver the same value, the least costly one shall be preferred". This principle has not been retained in the final version of Annex II, as indeed, the hierarchy among the many criteria listed can be better assessed at a lower level.

The implicit assumption here was that methods and criteria would converge over time, and that the absence of general rules provides for more flexibility in situations which are by nature always specific. Although the fear of legal action is lower in Europe, the US experience also provided strong hope that negotiation and cooperation would prevail between operators and their competent authorities. Nevertheless, some MS do have a strong tradition of guidance, and it is also obvious that additional precisions through such guidance could accelerate a convergence process. The risk with the present situation is indeed that diverging trends coexist until jurisprudence intervenes, which will take years.

Although it doesn't seem to be the case in the first transposition texts transmitted to the Commission, the solution could be a clear preference given *ceteris paribus* to one of the many criteria listed, be it cost reduction (as in first Commission's drafts) or any other one, felt to be better adapted to the local circumstances. If it is not clearly considered as a second range criterion, MSs will definitely have to be more precise over the interaction of the 'length of time it will take for the restoration' criterion with Article 7.3.

3.5.4. *Tentative conclusions*

It is difficult to take full account of the previous issues as it would be illegal to exclude a priori any of the criteria listed in section 1.3.1 and inadequate not to take account of specific cases (e.g. Natura 2000).

Although not saying that least costly options should a priori be preferred, it could be desirable, in the light of Lisbon and for homogeneity, to specify in transposition that considerations of cost would, ceteris paribus, be given a particular weight, except in the few specific and specified cases referred to above, and under the general precondition that options would satisfy overall public health and safety provisions.

Such a provision would sooth insurers' and operators' concern about possible 'extremist' interpretations, although not preventing, in very specific cases (but then with due and adequate justification) prevalence of other criteria.

3.6. What are the commonalities and differences with the US system?

3.6.1. *Overall Commonalities*

Both EU and US frameworks do have the same goal, which is expressed in Art 1 of the ELD: "The purpose of this Directive is to establish a framework of environmental liability based on the 'polluter-pays' principle, to prevent and remedy environmental damage." Annex II also draws very heavily on US legislation, particularly (although, paradoxically, oil spills are excluded from the EU scheme) on Part 990 of the Oil Pollution Act 1990 (OPA), which provides detailed regulations for undertaking natural resources damage assessments (NRDA). It reproduces extracts from the OPA regulations, sometimes *verbatim.*

Specifically, the US and EU approaches are very similar in the sense that both opted (in the US case after extensive controversy) to approach damage remediation through the cost of replacing an environmental service, and not through using economic valuation techniques to infer a price for the (damaged) environmental service (see below, section 3.9). It is the reason why both NOAA guidelines and two case studies derived from the US experience have been annexed to the present paper.

Although less fundamental, it is also to be noted that both in the EU and in the USA, a claim will also include the reasonable cost of performing the damage assessment. Indeed, in the ELD, all "*costs which are justified by the need to ensure the proper and effective implementation*" of the Directive must be included. Concerning more specifically administrative costs, reference was made to Recital 19, which states that "*Member States may provide for a flat-rate calculation of administrative, legal, enforcement and other general costs to be recovered*."

However, the EU scheme mirrors the US one in a highly condensed form, in as much as the original US document, which extends to some 20 pages, and provides a detailed picture of the purpose and procedures for undertaking NRDA, is collapsed into less than 3 pages in the ELD. As a consequence, the precise degree of commonalities will depend on further expansion of this condensed principles, which will happen through transposition and jurisprudence.

3.6.2. *Operational differences*

In spite of overall similarity in terms of philosophy and principles, however, both frameworks do not apply to the same kind of damages. On top of exemptions listed in Article 4 (and one of them is oil spills, which are the very basis and first object of the US liability regime), the EU scheme only addresses ‘significant adverse’ risks (cf. Article 2.1). On the other hand, competent authorities are obliged to intervene once they are aware of a related damage, whereas the US scheme leaves possible pursuits to the discretion of the authorities.

Another main difference, which concerns operational issues, relates to non-primary remediation. In the EU tradition with respect to damage remediation, e.g. within the ‘habitat directive’ framework (92/43/CEE), compensatory remediation is imposed to happen within and in consistence with the Natura 2000 network. In the US tradition, compensation can be much more unrelated with the original place of the damage, and operators can use habitats banking in order to fulfil their obligations with respect to environmental liability.

The general ELD framework lies ‘somewhere’ between those two extremes, but the exact location will definitely depend on transposition. MS will have to clarified the universe of possibilities in that respect too.

Section 1.1.2 of annex II to the ELD states that: “ The purpose of complementary remediation is to provide a similar level of natural resources and/or services, including, as appropriate, at an alternative site, as would have been provided if the damaged site had been returned to its baseline condition. Where possible and appropriate the alternative site should be geographically linked to the damaged site, taking into account the interests of the affected population.” Compensatory remediation too is to be done “at either the damaged site or at an alternative site.”

In both cases, it is not clearly said what ‘where possible and appropriate’ exactly means. In the USA, a specific market developed to allow operators to find ready on the shelves similar restoration project to compensate for the damaged ones. They can turn to a ‘habitat bank’ exactly as they turn to any other service provider. If they destroyed 1000 acres of a specific kind of forest, there are ‘habitat bankers’ having already identified a site where restoration of that kind is needed, and can be very rapidly undertaken (minimising interim losses). If there is no project of the very same kind, there are some ‘translation techniques’ to define how many acres of the ‘closest’ available specie equal 1000 acres of the original damaged one. Does the ELD allow habitat banking like in the USA? If so, under which conditions? This will have to be cleared at some stage during transposition.

In economical terms, issues at stake and consequences on implementation costs might be significant. If one allows habitat banking, on the one hand, the stakeholders who actually suffered from the damage might get lower compensation. On the other, at least in some cases, the cost for operators may be lower, the whole implementation much easier, and, possibly, the overall aggregate benefit for the environment higher. Indeed, if one is quite loose on the link between the original damage and the location of the complementary and compensatory remediation, it is likely that some habitat banking activities will develop, and it is also likely that they will benefit to habitats where previous damages (which are not covered by the ELD) are particularly significant.

Let's come back to the salmon pollution example, and let imagine that, for whatever technical reason, it is impossible to remediate on the very site of the damage.

If the directive is interpreted strictly, remediation will have to happen in the same region and for the same kind of fish, and it is not certain that it is going to be the most possible useful use of resources. In any case, it is unlikely that habitat banking will develop, as the statistical chances to need restoration in one given region on one given specie / service / resource are small. As a consequence, restoration project will have to be tailor-made, which means that it will have to be preceded by feasibility studies, and involve higher costs.

If it is interpreted loosely, restoration may happen much further away, in a river which is, maybe, more important to wild life preservation and suffered from graver (ante 2007) pollution. You may well have habitat banking activities developing in such very severely environmentally-affected areas, especially if the 'similarity' criterion is also quite loosely understood.

Of course, there are some key questions, which cannot be answered at this stage: Who will trigger habitat banking? How will they start off? Will they be totally private-sector driven? What level of monitoring and public implication? The EU authorities benefit from the long US experience and know how in that field, however. And there is one certainty: if habitat banking is allowed, restoration projects will be available on the shelves and implemented very rapidly at lower cost. Under this hypothesis, the ELD would certainly not be very useful for the very stakeholder having suffered from the damage (they might be too far away to actually benefit from the 'equivalent' restoration, and this would contradict one of the objective of section 1.1.2), but it would be a very efficient instrument to address some of the many severe pollution, which, due to the non-retroactivity of the ELD, cannot benefit from a liability regime to be restored. And this could be argued as more 'appropriate' in a global environmental perspective (NB: in Natura 2000 areas, which are particularly priceless, the reasoning doesn't apply, as restoration outside the Natura 2000 network couldn't be more justified).

3.6.3. Tentative conclusions

Banking habitat cannot be a systematic solution (e.g. not in Natura 2000 sites). But presents many advantages and it is thus not to be excluded either. If criteria are considered as proposed in section 3.5.4, banking habitat should develop 'naturally' in random cases, and be also spontaneously excluded in cases where a specific situation imposes a specific criterion to be given more weight, with induced tailor-made remediation solutions. In such a point of view, the only precaution to take would be to specify within the transposition process that recourse to habitat banking cannot be rejected a priori, and to check that the national / regional legal system allows for this kind of specific services to develop.

3.7. How does one compute interim losses?

3.7.1. Text of the directive

Section 1.1.3 of Annex II states that “compensatory remediation shall be undertaken to compensate for the interim loss of natural resources and services pending recovery. This compensation consists of additional improvements to protected natural habitats and species or water at either the damaged site or at an alternative site. It does not consist of financial compensation to members of the public.”

Subsection (d) of section 1 specifies that “interim losses' means losses which result from the fact that the damaged natural resources and/or services are not able to perform their ecological functions or provide services to other natural resources or to the public until the primary or complementary measures have taken effect. It does not consist of financial compensation to members of the public.”

3.7.2. Mathematical translation of the text of the directive

Mathematically, it is quite easy to translate this into a simple formula (once again, which does not refer to an amount or a fine to be paid by check, but to scaling remediation measures to be implemented in the field, a priori in kind, *i.e.* service-to-service, good-to-good, resource-to resource and so on) :

Let’s say that the discount rate is 4% (the rate applied by the Commission services when doing Impact Assesments). Let’s call g_t^i the number of environmental goods / services available at time t under option i. Let’s call g_t^b the number of environmental goods which would have been available at time t if the damage had not occurred. Let’s decide that the zero-year is that of the damage and let’s call y^i the year where remediation allows to cross back baseline under scenario i.

Under such assumptions, interim losses expressed in year 0 terms are:

$$IL^i = \sum_{t=0}^{y^i} (g_t^b - g_t^i)/(1.04)^t$$

Expressed in percentages, which is usual, the formula is:

$$IL^i = \sum_{t=0}^{y^i} (g_t^b - g_t^i)/\left[g_0^b.(1.04)^t\right]$$

This formula can of course be refined (and it is the case in the annexed US guidance documents) by decomposing g_t^i and g_t^b in terms of level of service per acres / km² (x_t^i and b_t),value per acre / km² -year of the service provided (V_t^i)and number of injured acres / km² (J)… It can also integrate a generic variable for the discount rate instead of 1.04. We preferred to use a nominal value, and, if it is 3 or 5% instead of 4%, to recall that the IL^i formula then applies with 1.03 or 1.05 instead of 1.04. It can finally also integrate the time of the presentation of the claim and so on. In other words, we decided to simplify here, but one can use the more general US formula provided in annexes if more precision is preferred.

3.7.3. 'Hidden' choices impacting significantly computed outcomes

The problem with such a formula is that the g_t^i and g_t^b variables are not given, but constructed: their value highly depends on conventions, and so does, by induction, the value of the interim losses. Specifically, the g_t^i and g_t^b values depend both on the choice of the zero-basis and on the reference-timing.

In the said formula, the zero-year is that of the damage, and implicitly, it is expressed in 'good of that year' values. But, unless otherwise specified, the competent authority might consider itself entitled to decide that g_0^i and g_0^b values should refer to another zero-year. It can be, in theory, either the moment of the damage, the moment of the authority's decision, the moment where the baseline is crossed again, the moment where all kinds of remediation are completed, or any other moment… If another origin is chosen for the zero-year, the formula is derived from the latter by multiplying IL^i by the discount factor applied to the damage period. For example, if the zero-year is exactly three year after the damage, it will be IL^i x 1.04^3. Transposing the formula is quite easy.

The impact of the choice of the moment of the value assessment is much trickier, and the shorter the interim period, the greater the impact it has on the value of interim losses. Let's take the extreme case of an accident which fully destroys a given environmental service but is remediated within one year. If one decides to asses the level of damage for any given year's 'interim losses' at the beginning of the period, the interim losses for the first year is 100%. If one decides to asses the level of damage for any given year's 'interim losses' at the end of the period, the interim losses for the first year is 0%.... In fact 'remediation' for year 'y' means nothing as long as you don't make some conventions about it.

3.7.4. Concrete example of the magnitude of impacts related to those 'hidden' choices

Let's take a case where

a) the damage totally destroyed the environmental service,

b) it takes exactly one year after the damage for the competent authority to take a decision and 25% of the damage is remediated at this precise first anniversary of the damage and

c) it takes exactly two year for the operator to cross the baseline (i.e. 100% of the damage is remediated at the precise second anniversary of the damage).

There are 9 'simple' different ways to calculate interim losses, all of which equally in conformity with the directive:

1) Zero point is damage; reference is the beginning of each period:
IL= 100% / 1 + 75% / 1.04 + 0% / $(1.04)^2$ = 1.721%
2) Zero point is the authority decision; reference is the beginning of each period:
IL= 100% x 1.04 + 75% / 1 + 0% / $(1.04)^2$ = 1.790%
3) Zero point is baseline-crossing; reference is the beginning of each period:
IL= 100% x 1.04^2 + 75% x 1.04 + 0% / 1 = 1.862%
4) Zero point is damage; reference is the end of each period:
IL= 75% / 1 + 0% / 1.04 + 0% / $(1.04)^2$ = 0.750%

5) Zero point is the authority decision; reference is the end of each period:
IL= 75% x 1.04 + 0% / 1 + 0% / $(1.04)^2$ = 0.780%
6) Zero point is baseline-crossing; reference is the end of each period:
IL= 75% x 1.04^2 + 0% x 1.04 + 0% / 1 = 0.811%
7) Zero point is damage; reference is the simple mean for each period:
IL= [(100 + 75) / 2%] / 1 + [(75 + 0) / 2 %] / 1.04 + 0% / $(1.04)^2$ = 1.236%
8) Zero point is the authority decision; reference is the simple mean for each period:
IL= [(100 + 75) / 2%] x 1.04 + [(75 + 0) / 2 %] / 1 + 0% / $(1.04)^2$ = 1.285%
9) Zero point is baseline-crossing; reference is the simple mean for each period:
IL= [(100 + 75) / 2%] x 1.04^2 + [(75 + 0) / 2 %] x 1.04 + 0% / 1 = 1.336%

NB: Options 3, 6 and 9 above are exactly options 2, 5 and 8 multiplied by a 1.04 factor (which is also true with respect to options 2, 5 and 8 compared to options 1, 4 and 7)… exactly as, by definition of discounting techniques, individuals are assumed to be totally neutral when they are offered one euro today, 1.04 current euros in one year and $(1.04)^2$ current euros in two.

On top of those 9 'simple' formulas, you have all weighted ones. Indeed, if remediation is not linear, the average is neither the value at the middle of the year nor the average of the value at the beginning and at the end of the year. Everything depends on the the speed with which the environmental services are restored[2]. In any case, if you are not sure that the progression is linear, you have to make assumptions about the path of the remediation, and make a trade-off between the quality of your measure and its practicability. You have to decide whether you will use half-yearly / quarterly / monthly / weekly / daily -discounted mean, and whether some periods (because of their specific environmental service) should be more weighted than other. For instance, one may perfectly argue that months when natural reproduction happens should be weighted more…

In other words, once again, the final value of your formula is not given, but constructed on assumptions, conventions and micro-decisions. And the impact of such choices is not negligible. Just as a reminder, and to refer again to the above example, 1.336% is 78% more than 0.75%... The issue is not only quantitative but also qualitative. It is indeed to be noted that the two major conventions studied in this section do have different, although related consequences:
- The choice of the zero-base is less important in the sense that, if a given choice makes interim losses to be lower in absolute values, it does the same to compensatory measures. In other words, this choice doesn't impact the content of the restoration itself. Values do have a political sense, so it is important, but, instrumentally, not so.
- The choice of the moment you consider values does impact the content of the project itself. It is obvious when restoration occurs within one year. Depending on the choice made, you will have to do compensatory action, or not!

3.7.5. Possible elements to be considered when fixing choices

It is now clear that choices on methods and conventions do have a huge impact on interim losses. Even in a very simplistic case, you end up easily with a multiplicity of

[2] If the progression is logarithmic and losses totally remediated within one year, for instance, losses are very big for the first month, which is weighted by a close-to-one factor if discount initiates at the damage date, and almost inexistent for the last month (which discount rate is close to (1+I)/12, where I is the annual discount rate).

possible significantly different outcomes, all of them equally compatible with the ELD. Fixing ex ante through transposition such choices would enhance predictability and reduce costs.

The problem is that, mathematically and economically speaking, no option is per se better than another, although some are of course more difficult or easy to implement, and more or less favourable to operators than others. Specifically, from the operators / insurers point of view, option 4 is clearly more interesting as it minimises interim losses. Politically and administratively, it is also interesting in the sense that it provides a very strong incentive to react quickly: if Zero point is damage and reference is the end of each period, you don't have interim losses (and thus compensation remediation) if you manage to cross baseline within one year. As interim losses compensation is always complicated when remediation in kind on the same spot cannot go beyond baseline, this might be a tremendous simplification for implementation.

Indeed, as already said, *the above formulas are not expressed in monetary terms*, but in goods of a given year. To come back to a former example, it is expressed in salmons of a given specie of a given river of a given year. But it is not always possible to remain in such a unit, and especially for compensation of interim losses. For instance, if a river cannot feed more than the population which lived in it before the damage, it will not be possible to compensate above baseline in the same river. Some 'translation' into another unit will be needed. In some extreme cases, where the damage caused the extension of a given specie, the 'translation' will be almost impossible. Even if the said liability will have in fine to give way to some remediation in kind (through improvement of some environmental services elsewhere), it will neither be in the same nor even in a similar kind. There are some techniques to handle these problems (the DG RTD research project investigates this issue and is expected to provide for more clarity on this). And in such case, all abovementioned differences are likely to have concrete impacts. It makes a difference to differentiate between current / nominal and discounted / actual values, and to value liabilities in a specified value.

3.7.6. Tentative conclusions

Although a bit counterintuitive in the sense that it would de facto mean that damages would only be measured one year after the damage itself, the easiest convention would be to take damage as the zero-point, and to measure values for each period at its end. As already said, it would minimise interim losses (& corresponding compensations) and provide incentive to react quickly. Incidentally however, this would create a difference with US practices (where zero-point seems to usually be the deposit of the claim, and where values seems to generally be measured at the beginning of periods).

3.8. How do you compute compensatory remediation?

3.8.1. Text of the directive

As stated in section 1-c of Annex II, "'Compensatory' remediation is any action taken to compensate for interim losses of natural resources and/or services that occur from the date of damage occurring until primary remediation has achieved its full effect".

When it is not possible to remediate damages immediately or almost immediately, there are some Interim losses, and, according to the polluter-payer principle and sound economic reasoning, they have to be compensated for (otherwise, it creates a clear sub-optimal economic equilibrium and moral hazard).

In such an occurrence, remediation 'above baseline' is imposed by the ELD.

3.8.2. Mathematical translation of the text of the directive

The ELD provisions are conceptually quite simple: they relate to remediation 'above baseline' up to a given level such as discounted value of the said compensatory remediation over time equals interim losses.

Mathematically speaking, using the same conventions as above, and, in order not to multiply complexity, *taking the simplest convention among the many listed in the previous section* with respect to the zero-base (i.e. when it is the occurrence of the damage, which allows to only discount one way), the compensatory remediation is formed by the many *possible* g_t^i following the y' instant where baseline is crossed derived from the last part of the following equation:

$$IL^i = \sum_{t=0}^{y^i} \frac{(g_t^b - g_t^i)}{(1.04)^t} = compensatory\,remediation = \sum_{t=y^i}^{\infty} \frac{(g_t^b - g_t^i)}{(1.04)^t}$$

If another zero-base is chosen, the formula is derived easily. Similarly, as already said for the Interim losses formula, the equation can be precised (and integrate differences between damage, claim-presentation, beginning of replacement project and so on), as it is done in the US guidance. In the present paper, we decided to simplify what is already rather complicated to focus on the essential notions (and let readers go to the annexed papers to find more refined formulas).

What is to be basically understood is that, in geometric terms, if one draw the curve of difference of the environmental service / population of good and so on over time (between baseline and option i) expressed in net present values, this means that all options for which the area comprised below the origin is equal to that above it are equivalent to total immediate restoration (and equivalent among themselves).

3.8.3. Concrete example of possible compensatory measures computation

In order to illustrate that the said equation offers infinity of solutions, let's come back to our salmons' example.

Imagine that there is a very costly but technically possible way to *immediately* double the said population of salmons and immediately come back to the 20.000 salmons' population. This option will of course have to be considered.

But there are certainly also other combinations of the above-mentioned possible actions, which allow the salmon population to return to baseline within 3, 5, 10 years and so on…

It is very likely that some of these other combination will be much less costly than the first one. For instance, if there is another option which allows going back to baseline within 4 years at half the cost through enhancing natural recovery, why shouldn't it be considered (Article 7.3. even imposes to do so) ? If the river was long ago damaged by other pollutions (which, because there is no retroactivity in the ELD, are not covered), what about if there is another option which allows to triple the population of salmons within 12 years at the fourth of the price? And so on! Both in an environmental and in an economical perspective, it would be nonsense not to at least assess the respective merits of all those possibilities. But how to proceed?

First, as long as the remediation is not immediate, you have to take account of interim losses. Concretely, for 5, 12 or *x* years, there will be less salmons in the river, and there will thus be less environmental services provided by the salmon population. Second, as always in economy, you will have to take account of the individuals' preference for the present: everybody prefers the damage to be restored today than in 4, 11 or (x-1) years. Concretely, this means that comparisons will have to be made in net present values.

Let's consider an alternative option under which remediation is linear and completed within 4 years. In such a case, the rough 'interim losses' are 10,000 for the 'n' damage year, 7.500 for n+1, 5.000 for n+2, 2.500 for n+3 and 0 for n+4. With a 4% discount rate, discounting techniques assume that 7500 in one year is equivalent to 7500 / (1.04) now, 5000 in two years is equivalent to :5000 / [(1.04) x (1.04)] now and so on..

In net present value terms (i.e. expressed in terms comparable to the zero-interim loss of the first option in year n), this first alternative option represents then a loss of :

$10{,}000 + 7{,}500 / 1.04 + 5{,}000 / (1.04)^2 + 2{,}500 / (1.04)^3 = 24{,}145.71$ salmons / year n.

3.8.4. Issues at stake (based on our concrete example)

As long as this loss is not adequately compensated for, there will be no possibility to justify on purely environmental basis the choice of option 2 compared to that of option 1 (immediate full restoration). But, if, instead of only restoring the environment to its baseline, the operator goes a bit further and compensate for the lost 24,146 salmons / year n, things become different.

Let's imagine that, instead of restoring the population to 20,000, the operator keeps restoring a fifth year, up to 22,500. For an infinite period of time (assuming hereafter constant population), the environmental service will be provided by a higher population, and thus be higher. More precisely, you will have an excess of 2,500 salmons / year, which, expressed in net present value, i.e. in year n terms, represents, for year z, a value of $2{,}500 / (1.04)^z$. per year. If you add all those value up to the infinite, this additional 2,500 salmons represent an excess of:

$$\sum_{t=4}^{\infty} \frac{2{,}500}{(1.04)^t} \text{ salmons / year n.}$$

In purely environmental terms, as $\sum_{t=4}^{\infty} \frac{2{,}500}{(1.04)^t} > 24{,}146$, option 2 is preferable is this example.

In fact, option 2 will be preferable to option 1 as long as the operator raises the salmon's population to a P value such as:

$$24{,}145.71 = \sum_{t=3}^{\infty} \frac{(P - 20{,}000)}{(1.04)^t} \Leftrightarrow \frac{24{,}145.71 \times (1.04)^3}{(P - 20{,}000)} = (\sum_{t'=0}^{\infty} 1.04^{-t'}) = \frac{1.04}{0.04}$$

In our example, the P value is thus equal to $24{,}145.71 \times 1.04^2 \times 0.04 + 20{,}000 = 21{,}045$.

Similarly, another option 3, which would allow (also linear) primary remediation in 10 years instead of 5 would be 'environmentally' totally equivalent to option 1 and 2 as long as it produces P_t' values such as:

$$Interim\ Losses = \sum_{t=0}^{9} \frac{10{,}000 - 1{,}000 \times i)}{(1.04)^t} = \sum_{t=10}^{\infty} \frac{(P_t' - 20{,}000)}{(1.04)^t},$$

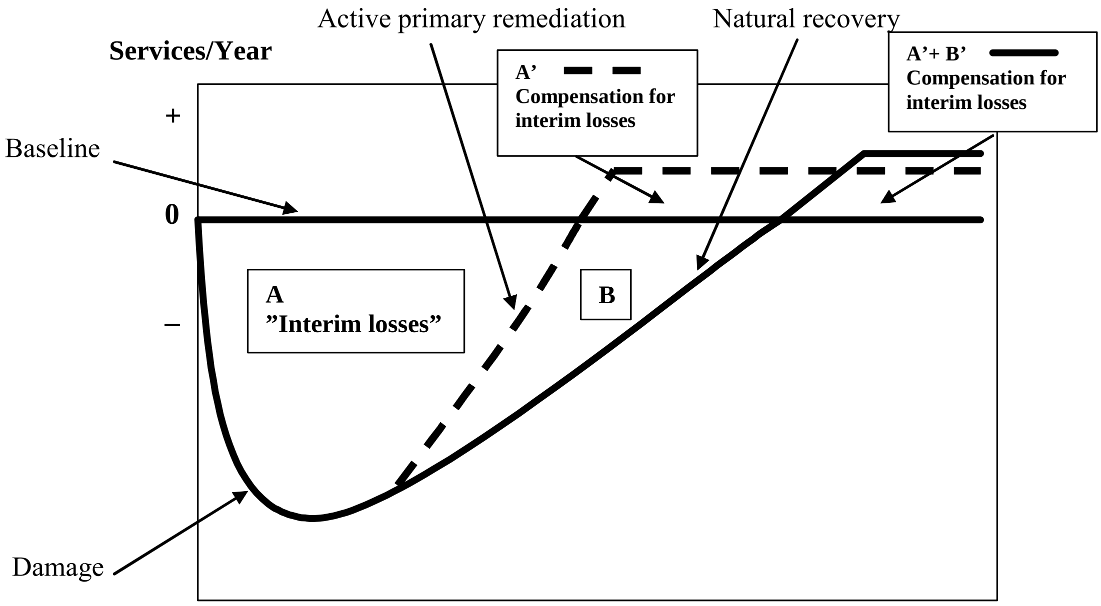
And so on.

What is important is that, as long as interim losses are used in relation to compensatory remediation, the choice of the reference date is less impacting. For instance, if you compute values at the end of the period instead as computing them at the beginning, interim losses will be lower, but values necessary to compensate them after crossing the baseline will also be lower. In other words, it compensates, although conventions still do have an impact.

The main conclusion is that most rapid remediation schemes are not necessarily maximising environmental welfare. There are mathematic methods to compare possible restoration projects, and it is easy to say when a longer but less expensive one is nevertheless preferable to immediate remediation. Introducing and validating the said mathematical methods in transposition processes could provide adequate instruments to competent authorities and be a way to increase predictability about their future choices among existing options.

*3.8.5. Formalisation (**NB**: this section will be expanded in the next version)*

In a nutshell and as already said, as long as the area below the 'baseline' shape is compensated by the area above it, interim losses are compensated and operational options are economically equivalent. Mathematically speaking, the ELD doesn't make any differences between options characterised by A and A+B interim losses and A' and A'+B' compensations



Similarly, it wouldn't make any difference either with a third option (which is not drafted in the above schema in order not to make it even more complicated, but can be intuitively derived from it) which would be characterised by A+B+C interim losses and A'+B'+C' compensations. The 'equivalency' sole condition is that:

0 = A-A'= (A+B)-(A'+B') = (A+B+C)-(A'+B'+C') = … (A+B+….N)-(A'+B'….+N').

3.8.6. Tentative conclusions

With respect to formula, it is up to MS to decide whether they prefer to express it in such a simplified (aggregated) way in their guideline, or the more detailed US one (see annexed documents). This will of course have no impact on the final result. In order to enhance homogeneity and because it would not make sense to use different discounting rates (e.g. within the same monetary zone), it is advised not to use a variable for interest rate, and to take a given rate.

Whatever the presentation of the formula, it is clear that the choice among the many options proposed to the competent authority should take into account the abovementioned calculations, and ensure that the final choice is providing more 'total' replacement service. It is also important to convey to operators and stakeholders the two basic ideas that the ELD allows for a multiplicity of possible remediation projects, and that it will, except in cases where remediation is almost immediate, be necessary to go beyond baseline.

3.9. What about monetary valuation?

3.9.1. Text of the directive

As already mentioned in section 3.6, the ELD framework, as the US one, is clearly approaching environmental liability through damage remediation and not through evaluation of the damage itself. This doesn't mean that competent authorities may not use monetary valuation, but that it can only be done in case where alternative (non-monetary) methods are not feasible.

This perfectly reflects in section 1.2.3. of Annex II: "*If it is not possible to use* the first choice resource-to-resource or service-to-service equivalence approaches, then alternative valuation techniques shall be used. The competent authority *may* prescribe the method, for example monetary valuation, to determine the extent of the necessary complementary and compensatory remedial measures. *If* valuation of the lost resources and/or services is practicable, but valuation of the replacement natural resources and/or services cannot be performed within a reasonable time-frame or at a reasonable cost, then the competent authority may choose remedial measures whose cost is equivalent to the estimated monetary value of the lost natural resources and/or services.

The concrete proceeding induced from the directive is clear: first give priority to primary restoration, i.e. remediation in kind on the very site of the damage, resource-to-resource, good-to-good, service-to-service... Once it is done, as much as possible and adequately, try to compensate for compensatory and complementary remediation through 'similar' resource-to-resource, good-to-good, service-to-service restoration. If it is not possible, turn to other solutions.

Due to the absence of retroactivity in the EU scheme, this shouldn't be difficult in the first years of implementation. It is indeed quite likely that the first row of post-2007 damages will happen in places which have been for long affected by environmentallyrisky activities. As a consequence such damages will often not be the first ones of their kind, and it will be quite easy to remediate beyond baseline on the same place. Let's imagine a chemical factory polluted a river in 2004, and does it again in 2008. Due to the first accident, the fish population halved, and due to the second, it halves again. If the population index is 100 in 2003, it was only 50 before the first ELD-covered damage and 25 after it. It is much likely it will be physically possible to reach 50 (i.e. that no complementary remediation will be needed) and even to go beyond 50 (i.e. that compensatory restoration will be possible on the very site of the damage beyond baseline). In such a case, you need neither resource equivalent methods nor monetary valuation.

But, with time, a case will appear where such 'simple' service-to-service remediation on the very spot of the damage will not be technically feasible. In such cases, the competent authorities will have to use Resource scaling Methods (e.g. habitat equivalent), and if it is not possible, monetary valuation methods.

3.9.2. Issues at stake

Although clearly considered as a second best, the ELD thus doesn't exclude the possibility to use monetary valuation.

Basically, economic valuation methods, which date back to the 1940s and which practical use in policy and project appraisal have increased since the 1970s, are based of the notion of willingness to pay (WTP) or accept. An individual's preferences for different goods are indeed reflected in the amount of goods, services or money an individual is willing to give up within a given time period to purchase those goods (this is the economic definition of WTP). Environmental economists have developed a range of techniques that provide estimates of WTP for environmental services in the absence of actual market prices. Broadly these can be grouped into those which infer values indirectly from actual market behaviour ("*revealed preference*") and those which ask consumers what they would be willing to pay for environmental services ("*stated preference*").

There are two forms of valuation approach:

- *value-to-value*: the monetary value of the benefits of proposed remedial actions and the monetary value of the interim losses are both estimated. Thus a Euro estimate of a damage is compared with a Euro estimate of the resources delivered by the remedial actions. In other words, the value of damages is set equal to the value of environmental resources delivered by the remedial actions.
- *value-to-cost*: the monetary value of the interim losses is estimated and the equivalent money is spent on compensatory remedial actions irrespective of what the money buys. In other words, the value of the damages is set equal to the cost of the environmental resources delivered by the remedial actions. The actual value of these environmental resources may be more or less than the cost of providing them.

The use of monetary valuation in damage assessments in the USA to value both the damage and the compensatory remedial actions (the value-to-value approach) has been infrequent, if at all. It has been more common to use value-to-cost since this is simpler. Furthermore, monetary valuation has most frequently been used to value the more tangible services provided by environmental resources such as impacts on beach recreation or fishing due to oil spills.

In spite of considerable experience in using these techniques, the reliability of estimates is often criticised: results are denounced as depending on questionnaires setting, valuations are said to take insufficient account of individual's budget constraints... Studies using them in order to estimate some historical oil spill damages however ended up with huge values, which oil companies couldn't accept. Following the Exxon Valdez oil spill in 1989, specifically, the contest was such that a panel of leading economists, including two Nobel Prize winners, had to be called to determine what role *Contingent valuation* (or CV: a stated preference technique,) should play in regulations for natural resource damage assessments for the Oil Pollution Act (OPA). They concluded that CV, when properly designed, was an appropriate method for uncovering non-use values for use in legal proceedings relating to the said assessments.

The practical implications of using CV techniques for the ELD implementation have not yet been assessed.

3.9.3. Tentative conclusions

Monetary valuation is not a preferred instrument in the ELD framework more for practical than for theoretical reasons. There will be cases where it will be required. Further research might be needed to anticipate possible problems.

4. CONCLUSION

Although jurisprudence will anyhow, *in fine*, have the last word, enhancing as soon as possible predictability for operators / insurers and guidance from MS to competent authorities would definitely smooth the implementation process of the directive. Choices and discretion left by the ELD is indeed substantial, and narrowing down the universe of possibilities with respect to possible understanding of the Directive would be achievable through the transposition process. As demonstrated above many issues can be fixed.

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APPENDIX 1: BLACKBIRD MINE EXAMPLE

Background

1) Blackbird Mine is an inactive mine site located in east-central Idaho in the United States. The mine is situated between two drainage basins, Big Deer Creek and Blackbird Creek, both of which flow into Panther Creek. The mine site consists of approximately 360 hectares (ha.) of private land, and about 4 000 ha. of unpatented mine claims held by private corporations on National Forest System lands. Ninety-nine percent of the Panther Creek basin is National Forest, and less than 1% is privately owned.

2) The remedial actions undertaken were of the same type and quality, and the resource-to-resource approach was used.

Incident Description

3) Mining of cobalt and copper began at the site in the 1890s and continued until the 1960s. Several studies over the past 25 years document the release of hazardous substances including cobalt, copper, nickel and zinc, from the mine site, and identify actual or potential sources of those releases into Panther Creek and its tributaries.

Size of Damage

4) The Panther Creek Drainage contains approximately 400 miles of perennial streams and includes nearly 100 miles of streams suitable for anadramous fish. Highly contaminated discharge from the mine affected habitat in the lower 25 miles of Panther Creek, and presents a passage barrier that blocks access to remaining upstream habitat.

5) Surface water resources downstream of the mine were found to suffer injury from copper and cobalt releases. The injured resources included surface water, streambed fauna, resident and anadramous fish, ecosystem services and human services. Damage occurred over a number of years, while mining activities were taking place and after they ceased. For the purposes of liability, only those losses occurring after 1980 were considered. Damage to the ecosystem was deemed to be reversible, but only through active intervention: natural recovery would not be sufficient to return ecosystem services to baseline level.

Determining the Baseline

6) It was determined that restoration of Panther Creek to its baseline was possible, in other words, with the implementation of appropriate remediation activities the damage would be reversible. However, restoration would only be possible over a lengthy time scale.

7) Naturally spawning chinook salmon were selected as the metric for measuring restoration success. This was on the assumption of a high degree of correlation between salmon vitality and overall ecosystem health, so that as the salmon population is restored, other resources would be restored as well. In fact, other resources would recover on their own shortly after water quality restoration, while salmon would not.

8) Primary restoration options were identified in order to achieve two objectives:

   i) *restoration of water quality:* This was the first requirement for restoration, and was necessary before any biological restoration could take place; and
   ii) *restoration of chinook salmon populations:* Following restoration of water quality, options aimed at restoring chinook salmon populations to baseline levels could be implemented.

9) Restoration of water quality was classified as a clean-up activity, and therefore not included in the primary restoration options, but as a pre-requisite to primary restoration. Selection of primary restoration options therefore focused on measures to restore salmon populations, to be implemented after this time.

Selection of Primary Remedial Actions

10) Options aimed at restoring chinook salmon populations fall into two categories: *re-introduction of naturally spawning salmon* into Panther Creek; and *smolt survival activities* to increase the survival rate of smolts (young salmon) within the creek. The two activities are interrelated: either action (or set of actions) would not be as successful performed independently of the other. In other words, in-stream work to improve smolt survival increases the effectiveness of the hatchery, and vice versa. In-stream smolt survival activities alone would not be expected to restore baseline until 2150, due to the small stray rate of salmon into Panther Creek. Salmon, by instinct, return to the stream where they were reared to spawn. Salmon re-introduction alone could restore populations to their baseline levels, but not within any reasonable time frame, and not as cost-effectively as when combined with smolt survival activities.

Thus, it was decided to combine actions from both categories, on both cost-effectiveness grounds, and the expected size of interim losses from implementation of one activity in isolation.

11) Remedial actions selected were as follows:

- *1. Salmon re-introduction:* Artificial propagation strategies were selected over natural reintroduction strategies in order to achieve a return to baseline within an acceptable time frame. The plan to restore naturally spawning salmon included:
  - *trapping adults from selected donor drainage systems:* for the first few years, natural
  - migrating adults from a selected donor drainage would be trapped;
  - *an expansion of an existing hatchery*: trapped adults would be transported to a hatchery for spawning, egg incubation, hatching and rearing to the pre-smolt life stage;
  - *construction of acclimation ponds on Panther Creek*: pre-smolts would be transported to the Panther Creek system and places in the acclimation pond for grow-out and smolting.

  Adult salmon are expected to return to Panther Creek 2 to 3 years after smolts are released; and

  - *construction of an adult fish trap on Panther Creek*: after 2-3 years, half of the returning adult fish would be trapped in the Panther Creek fish weir and transported to the hatchery for spawning, egg incubation, hatching and rearing. The remaining half would be allowed to migrate upstream to spawn naturally.
  - The process of trapping and transporting 50% of the adults would continue until the number of returning adults reaches baseline conditions, which is projected to occur in 2021.

- *2. Smolt survival activities:* This category entailed increasing the number of healthy smolts leaving Panther Creek. Final measures included:
  - *channel meander reconstruction:* to increase available spawning and rearing habitat by decreasing channel gradients and velocities, and increasing the length of the channel;
  - *riparian corridor fencing:* to restore stream bank stability, riparian vegetation and fish habitat in areas that are affected by livestock grazing; and
  - *construction of off-channel rearing habitat:* these are designed to protect juveniles and may be screened to keep out larger fish.

12) These measures represented those judged most biologically beneficial and cost-effective for restoration.

Identifying Compensatory Restoration Projects

13) Whilst it was thought that the first-best solution would be work within the Panther Creek drainage system as a closer replacement to the lost resources and services, a lack of available land limited the options available. Full compensation for interim losses through resource restoration options therefore also required projects outside the drainage system to be considered. Off-site options were availableIn addition to enhanceing the productivity of Panther Creek beyond its baseline level, to accelerate the rate of recovery to baseline, and to increase salmon populations were also increased in the rest of the basin system.

14) It was determined that such restoration projects would provide the same type of resources and services as those lost. The occurrence of salmon captures the level of service restoration since the conditions necessary for salmon vitality (good water quality, adequate migration, spawning and rearing habitat) are also necessary to support steelhead, resident fishes, streambed fauna and other services lost in the Panther Creek drainage. Therefore, spawning chinook salmon was identified as an appropriate metric to scale compensatory restoration projects.

15) Differences in the quality of services provided by the injury and replacement resources were also identified. Qualitative research was undertaken, to gain information on the public's preferences for wild relative to hatchery chinook salmon. The participants preferred wild salmon to hatchery reared salmon, given the viability and genetic diversity of wild stocks. However, faced with a reduction in wild stocks, participants considered a run restoration scenario of the type proposed by the trustees, using a hatchery-assisted programme to rear wild donor stocks from an adjacent drainage, to be a close substitute to wild stocks. As a result, the trustees determined the salmon to be restored by the selected restoration methods and wild salmon to be of comparable value.

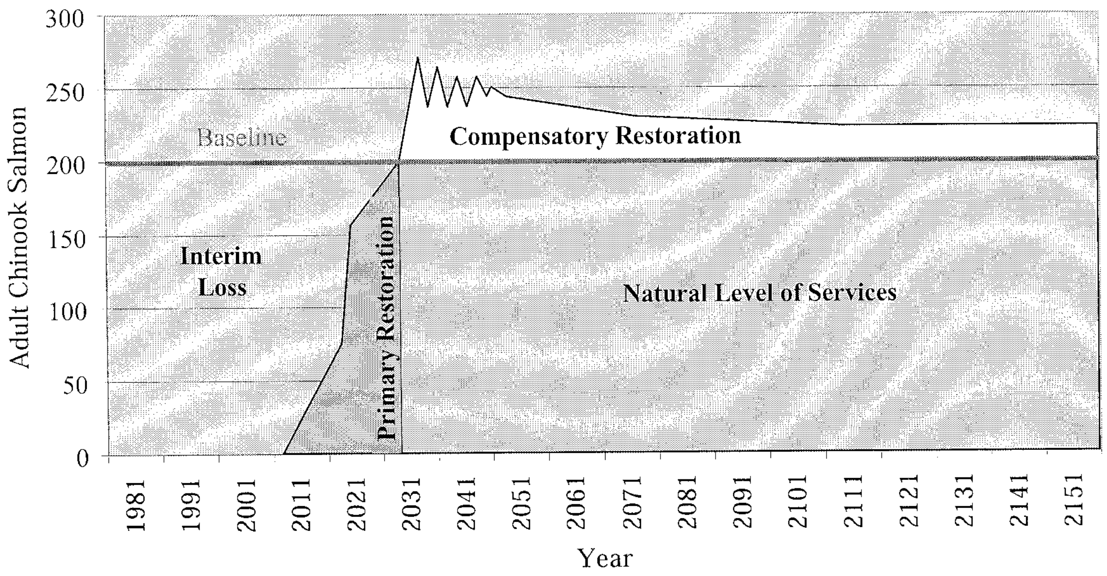
16) Given comparability in type, quality and value of the lost and replacement resources, the proposed off-site compensatory restoration project was retained and the 'resource-to-resource' approach for scaling compensatory actions was used.

Measuring Interim Losses / Scaling Restoration Projects

17) The appropriate mix and scale of restoration actions was estimated through a salmon life cycle model that projects adult returns and smolt outward migrations in Panther Creek as a function of the restoration actions. The model tracks adult returns to baseline and the cumulative losses from 1980 in order to estimate interim losses. A discount factor of 3% was applied to the calculation of interim losses and restoration gains.

18) The most feasible and cost-effective actions to return the salmon population to baseline and to equate the present discounted value of restored salmon with the present discounted value of salmon lost due to the injury were identified.

Figure 1: Primary and Compensatory Restoration Scaling Components of Panther Creek



19) The metric for injured resources and services is the number of adult chinook salmon returning to spawn annually. Baseline is the level of salmon population given the current downstream impediments and current on-site conditions but for the discharge. It is assumed to be constant and equal to 200 adult spawners. Prior to the restoration, the level of services is zero. Services begin to recover with the biological restoration activities, and the life cycle model predicts the recovery trajectory. Initiation of salmon recovery and return to baseline are expected to occur in 2005 and 2021 respectively.

20) With restoration targeted for Panther Creek, compensatory actions were designed to enhance the productivity of the site beyond the baseline level of services. These compensatory actions were also intended to accelerate the rate of recovery to baseline. Thus, the compensatory services begin to accumulate in 2021, the same time as baseline is restored.

21) The major components of the final salmon restoration plan included:
- restoration of chinook salmon through rearing the progeny of a suitable donor stock in an existing Idaho hatchery for release into Panther Creek;
- construction of a fish barrier/trap and acclimation ponds to capture returning adults and to imprint juveniles;
- creation of 2 acres of off-channel habitat in Panther Creek to improve juvenile rearing conditions (100 year project life);

- realignment of 1.2 miles of Panther Creek that has been channelised and straightened to conform to its natural meander pattern; and construction of riparian corridor fencing to exclude livestock (50 year project life);
- fencing 2 miles of private land along Panther Creek to exclude livestock and allow regeneration of riparian habitat, improving spawning and rearing conditions for anadramous salmonids (50 year project life);
- fencing 8 miles of private lands along other Salmon River basin tributaries to exclude livestock and allow regeneration of riparian habitat, improving spawning and rearing conditions for anadramous salmonids.

Outcome of the Settlement

22) The responsible parties had to remediate the mine site and water quality in accordance with the clean-up programme, and implement a Biological Restoration and Compensation Plan (BRCP). The BRCP is designed to restore, enhance and create anadramous salmonid habitat on site-impacted and out-of-basin streams; fund supervision of the BRCP implementation, and; make cash payments for past damage assessment and response costs.

23) Under the terms of the settlement, the responsible party agreed to carry out the salmon restoration plan. Implementation will proceed over a period of years, with measures in Panther Creek timed to coincide with water quality remediation, which is expected in 2005. It is estimated that the total cost will be $9 million, excluding damage assessment costs.

APPENDIX 2: LAVACA BAY EXAMPLE

Background

1) In the Lavaca Bay assessment in the South East of the US, there was sediment injury (from mercury contamination by an industrial site) mostly in the open waters of Lavaca Bay, yet the remedial action was marsh creation. In other words, the remedial action was not of the same type and quality. In this case, science experts identified value differences were between open water sediments and marshIn this case, it was necessary to establish equivalence between different types of habitat. This was done using the Habitat Equivalency Analysis framework. Using the habitat exchange rate it provided, the service-to-serviceresource-to-resource approach could be used and the need for monetary valuation avoided.

Incident Description

2) Alcoa began operations at its Point Comfort, Texas facility (PCO) in 1948 on 3,000 acres of land on the eastern shore of Lavaca Bay. Between 1948 and the present, Alcoa has constructed and operated several types of manufacturing processes, including alumina refining, aluminum smelting, carbon paste and briquette manufacturing, gas processing, and chlor-alkali processing. The site has a long history of releases including, notably, the discharge of mercury-containing wastewater into Lavaca Bay from chlor-alkali processing operations.

AnalysisSize of Damage

3) Injuries to three types of habitats were identified: estuarine low marsh, oyster reef, and subtidal unvegetated sediments (softbottom benthic habitat). Injuries to these habitats occured due to both the effects of contamination and effects of response actions. The interim losses due to contamination are quantified as the degree of direct injury to benthos, and as reductions in provision of food supporting fish populations. The response habitat losses are quantified by the amount of habitat that is permanently removed or suffers some period of additional service losses in the course of controlling contamination.

4) Account was taken of changes in the magnitude and extent of the injury over the assessment period. Similarly, some of the response actions can result in year-to-year

differences in the level of losses. For example, remedial dredging temporarily disturbs open bay bottom habitats. For habitat services that are only temporarily affected, the recovery path indicates how soon these services will recover. The interim and response action losses were added together to get annual habitat losses by type. The discounted sum of service losses were was determined using a three-percent discount rate

Table 1. Discounted Habitat Losses

Habitat	Discounted Resource Losses (in acre-years[3])
Open-bay bottom	2035.61
Dredge Island Marshes Other Marshes	747.12 81.93
Dredge Island Marshes Other Marshes	747.1281.93
Oyster Reefs	244.72

5) Table 1 summarizes the discounted acre-years of service losses by habitat type. There are two types of estuarine low marsh habitat incorporated into the analysis. The distinction between these two marsh types is related to differences in the quality of services provided by these habitats. The Dredge Island marsh was established on spoil material, is relatively young and therefore is expected to provide a similar quality of services to the marsh that will be created as restoration. The remaining marsh injured is expected to be relatively more productive in providing services than the Dredge Island marsh since it is a more 'natural' marsh than the one that formed on Dredge Island and is, therefore, expected to be more productive in providing services than the created marsh. Because the quality of services is different, different amounts of restoration will be required. The interim service losses are calculated from 1981 through 1999. The response losses are calculated for response actions initiated through the end of 1999.

Type and Scale of Actions

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[3] Acre years represents the discounted sum total of a habitat's service losses in a way similar to expressing the sum total of a work team's services to its employer in man-years.

6) Two types of habitat restoration projects were selected: oyster reef creation and estuarine low marsh creation/enhancement. These projects directly offset the losses to oyster reefs and marshes, respectively. For losses to subtidal unvegetated sediments, the nature of the Lavaca Bay site is such that direct restoration of subtidal unvegetated sediment services is not desirable. It was determined that marsh restoration is was deemed an appropriate restoration alternative to compensate for injuries to subtidal unvegetated sedimentsthese losses.

7) A habitat exchange rate was developed between marsh services and open-bay bottom services, applying the so called Habitat Equivalency Analysis framework, to ensure that habitat services were provided that were equivalent to those that were lost. This exchange rate accounts for differences in services and the quality of services provided by uninjured subtidal unvegetated soft-sediment benthic habitat relative to natural marsh habitat. After considering the opinions of scientific experts, an exchange rate of 5:1 was chosenarrived at. That is, the value of ecological service flows from five acres of subtidal unvegetated softsediment benthic habitat in Lavaca Bay is was found equivalent to the value of service flows provided by one acre of natural Lavaca Bay marsh. This analysis was specific to the habitats in the Lavaca Bay system and was based on the habitat services judged to be most important given the types of habitats affected.

Table 2 contains the habitat loss results after applying the subtidal sediments-marsh exchange rate. The discounted losses associated with subtidal unvegetated soft-sediment benthic habitat have been converted and added to the discounted marsh losses.

8) Table 2. Discounted Habitat Losses After Exchange

Habitats	**Discounted Acre-years**	**Discounted Acre-Years After Exchange**
Open-bay bottom	2035.61	--------
Dredge Island Marshes Other Marshes	747.12 81.93	747.12 489.05
Dredge Island Marshes Other Marshes	747.1281.93	747.12489.05
Oyster Reefs	244.72	244.72

9) With the losses in habitats expressed in terms of the kind that are to be provided through restoration, the next steps were to estimate the benefits of restoration projects and determine the restoration project scale to just offset these losses.

10) Habitat benefits were estimated in a similar way to the process for calculating habitat losses. The process started with the number of quality-adjusted acres for each restoration project. The quality adjustment accounted for the fact that the restoration site in its initial state can vary in the services it provides and the fact that the project's services cain addition to differing in productivity from the lost services. Accounting for how the habitat services change over time and how long it takes for the restoration project habitat to provide full services determines the services provided per year by habitat type. Applying the discount rate results in the calculation of the additional areas of various types of habitat to be created. Finally, the Habitat Equivalency Analysis method was used to determine the overall scale of the oyster reef and marsh projects. For created oyster reefs constructed in 2001, the HEA results indicate that 9.3 acres of oyster reef are needed to offset the losses described above. For marsh restoration completed in 2001, the analysis indicates 31.94 acres of created marsh are necessary to offset the losses associated with the Dredge Island marshes. An additional 29.32 acres of created marsh are required to offset the losses associated with injures to subtidal unvegetated sediments and other marsh habitat. The amount of marsh to be created totals 61.3 acres.

DESCRIPTION OF SELECTED PROJECTS

Selection of Actions

11) As noted previously, the type and scale of remedial actions needed to compensate for interim ecological losses from contamination and response actions initiated through the end of 1999, are the creation of at least 9.3 acres of oyster reef and at least 61.3 acres of marsh. The selected oyster reef and marsh projects are discussed below.

Marsh Restoration Project

12) Intertidal marsh will be created along the north shore of Powderhorn Lake. Under this alternative, property will be utilized, and possibly the Powderhorn Lake site, and a shallow subtidal section of Powderhorn Lake adjacent to these two properties. The marsh will be created by scraping down an area of approximately 31 acres of existing land to appropriate elevations for planting marsh and creating tidal channels. The dirt from the 31 acres will be placed into Powderhorn Lake to create approximately 39

additional acres of marsh. A breakwater will be constructed on the southern edge of the newly created marsh to protect against erosion.

13) Once the construction has been completed and the area is ready for planting, *Spartina alterniflora* plugs will be planted where the elevations are appropriate for this species. *Spartina patens* may be planted at higher elevations.

14) The marsh will contain both primary and secondary channels and open water areas up to 25 percent of the total marsh area for that portion constructed on currently existing land and up to 40 percent for that portion constructed on currently existing water areas. The marsh will be constructed so that there will be no planted marsh areas more than 10 meters from a primary or secondary channel, to maximize its function. Details concerning the design of the marsh and project monitoring plan will be developed prior to construction.

15) Regardless of whether any of the marsh creation is actually constructed on the Powderhorn Lake property itself, it is anticipated that this property will be protected to help ensure full ecological service flows from the marsh constructed on the adjacent property. The anticipated marsh project, as currently envisioned, would provide additional ecological benefits by increasing the circulation in the existing marsh on the Powderhorn Lake property by creating channels from the new marsh into the old marsh, thereby enhancing the existing marsh's ecological function. The breakwater and new marsh would also serve to protect some of the existing marsh from erosion, which is presently reducing the existing marsh.

Oyster Reef Restoration Project

16) Two different options for creating oyster reef habitat in lower Lavaca Bay were considered. The first would involve the construction of at least 9.3 acres of oyster reef that would be expected to function at a very high level similar to natural oyster reefs. The specific project location for this first oyster reef restoration option within lower Lavaca Bay has not been selected, but it will be at a location where water depth, salinity, and substrate firmness are suitable for oyster reefs. Under this option, a foundation of rock would be placed on the sediment and a shell, or other material suitable for oyster and mussel settlement, layer would be placed on this base. Details concerning the construction and monitoring of this reef will be developed if this restoration option is chosen.

17) The second option is to create a much larger area of oyster reef, constructed on clay-rich spoil material that would be placed on top of mercury contaminated sediments southwest of the Dredge Island. This option is the preferred option provided that some other entity is conducting dredging in an uncontaminated area and is willing to use the spoil material in a beneficial manner to cover the contaminated sediment. This clay-rich sediment layer would serve as a foundation upon which a thin layer of appropriate substrate would be placed for oyster and mussel settlement.