3.0 APPROACH TO THE ECONOMIC ANALYSIS

3.1 IDEAL APPROACH

This section outlines the ideal approach that would be applied to the project if there were no limitations in terms of data or knowledge gaps. The purpose of doing so is to assess the gap between what should be done in an optimal situation, and what could be done in practice (Lvovsky *et al.*, 2000; Pearce and Koundouri, 2003).

The ideal approach to the economic analysis of the POPs Project would be to implement a comprehensive cost-benefit analysis (CBA). A CBA is defined as:

> *a technique that compares the monetary value of benefits with the monetary value of costs in order to evaluate and prioritize issues …. In its simple form, CBA uses only financial costs and financial benefits…. A more sophisticated CBA approach attempts to put a financial value on intangible costs and benefits (e.g., the cost of environmental damage or the benefit of quicker and easier travel to work)* (World Bank, 2009)[1].

The CBA is a widely used and recognized technique for assessing public policies and projects from an economic perspective (Arrow *et al.*, 1996). The CBA allows decision-makers to determine whether financial resources should be allocated to these policies or projects[2]. In the ideal POPs Project, a CBA would be used to assess if the risk management scenarios proposed for the AHSL site provide more benefits than they cost.

In an ideal scenario, project costs and benefits are estimated separately and compared using present value techniques, as described below.

3.1.1 Assessing Project Benefits

Inventory of Project Benefits

The benefits of the risk management scenarios include human health and environmental components.

- <u>*Health benefits*</u>

Scientific evidence indicates that exposure to POPs - even at low concentrations - may cause a wide range of adverse effects to human health (Strawson, 1997; Strober, 1998; see Appendix A5). The risk management scenarios proposed for the hotspot aims to minimize exposure of the site workers and the surrounding population. This is expected to result in a reduction in the incidence and severity of human health effects related to POPs, and thus a reduction in the associated costs. A "saved cost" is a benefit; therefore the reduction of negative health

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[1] http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/ENVIRONMENT/0,contentMDK:21324891~isCURL:Y~pagePK:148956~piPK:216618~theSitePK:244381,00.html [Accessed March 9, 2009].

[2] For that purpose, a CBA is more suitable than a cost-effectiveness analysis (CEA). A CEA would have identified the most effective way of spending available resources to address the POP –contamination without indicating whether allocating these resources to this issue is "worthwhile" *per se.*

impacts due to POPs on the hotspot population represents a primary benefit of the proposed risk management scenarios.

- *Environmental benefits*

It is recognized that contamination by POPs has negative impacts on the environment whose value will decrease in terms of direct use (e.g., reduced fish harvesting), indirect use (e.g., loss of biodiversity) and non-use (legacy of contamination to future generations). The reduction of soil and water contamination expected to result from the proposed risk management scenarios will translate into better quality environmental resources and services to the population (i.e., in environmental benefits).

Quantification of the Benefits

Quantification of the human and environmental benefits provided through the implementation of the risk management scenarios requires an understanding of:

- the extent to which the risk management scenarios will reduce human and environmental exposure; and
- the reduction of health and environmental impacts caused by the reduction in exposure; that is, an exposure-response relationship.

Valuation of Project Benefits

Various techniques are available to allocate a monetary value to benefits for which no market or market-clearing price exists.

- *Valuation of Health benefits*

To estimate health benefits in monetary terms, a standard technique, used by the World Health Organization (WHO), is the valuation of disability-adjusted life-years (DALY). The DALY is an economic parameter which extends the concept of potential years of life lost due to premature death to also include equivalent years of "healthy" life lost due to poor health or disability (WHO, 2008). The DALY combines in one measure the time lived with a disability, and the time lost due to premature mortality, both of which are plausible outcomes of contaminant exposure. The concept is further described in Box 1.

The DALY approach is deemed the most appropriate for the present project because of (i) its conceptual simplicity; and (ii) the availability of DALY estimates. Application of the DALY approach is further described in Section 4.2.

To estimate environmental benefits in monetary terms, the selection of a valuation method depends primarily on the nature of the environmental good or service considered, in particular whether a market exists for it (such as fish production) or not (e.g., maintenance of biodiversity). In the latter case, prices must be derived from hypothetical markets, using a variety of techniques, such as the contingent valuation method (World Bank, 1998). This method requires extensive data requirements, associated with significant time and costs, and was beyond the scope of this project.

Box 1 The Disability-Adjusted Life Year (DALY).

DALYs for a disease or health condition are calculated as the sum of the years of life lost due to premature mortality (YLL) in the population and the years lost due to disability (YLD) for incident cases of the health condition. In other words,

$$DALY = YLL + YLD$$

The years of life lost (YLL) correspond to the number of deaths multiplied by the standard life expectancy at the age at which death occurs. The basic formula for YLL is the following for a given cause, age and sex.

$$YLL = N \times L$$

where:

N = number of deaths

L = standard life expectancy at age of death in years

Because YLL measures the incident stream of lost years of life due to deaths, an incidence perspective is also taken for the calculation of YLD. To estimate YLD for a particular cause in a particular time period, the number of incident cases in that period is multiplied by the average duration of the disease and a weight factor is applied that reflects the severity of the disease on a scale from 0 (perfect health) to 1 (dead). The basic formula for YLD is:

$$YLD = I \times DW \times L$$

where:

I = number of incident cases

DW = disability weight

L = average duration of the case until remission or death (years)

Source: *Murray CJL and AD Lopez (1996). The Global Burden of Disease. Cambridge: Harvard University Press*

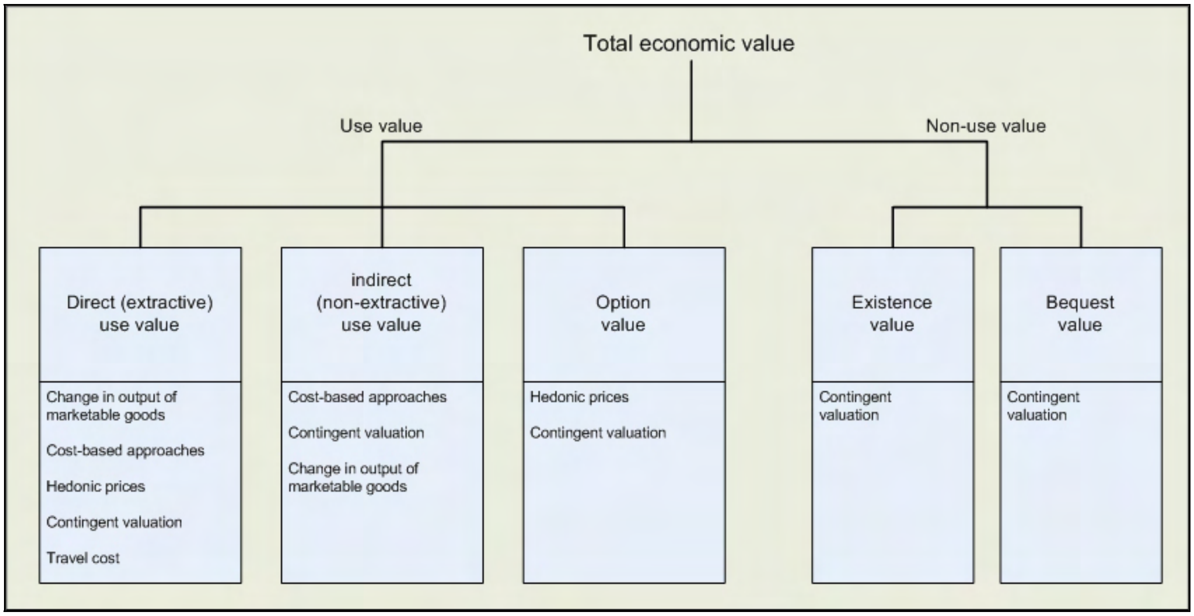
- *Valuation of Environmental benefits*

From an economic perspective, environmental assets are seen as providing **a flow of goods and services**, physical as well as aesthetic, intrinsic, moral, etc. The total economic value (TEV) is defined as the (discounted) sum of the net values associated with each of these goods and services (Turner *et al.*, 2003; Cavuta, 2003). Consequently, estimating the environmental benefits (or costs) of a given project amounts to measuring the variation of the TEV of the environmental assets impacted by the project (i.e., the value of the change caused by the project in the flow of environmental goods and services).

The TEV can be disaggregated into several categories corresponding to the nature of environmental goods and services and the type of associated value. For some of them (typically tangible goods, such as agricultural production), valuation in monetary terms is relatively straightforward since the market provides prices that reflect the values that society places on that good or service. In many cases though, market prices either do not exist or do not adequately reflect the value of the good or service considered (World Bank, 1999)[3]. For example, what price should be assigned to biodiversity, or to beautiful scenery?

In the cases where no adequate market exists for the environmental good or service considered, representative prices must be derived from surrogate markets (as is the case with the hedonic prices or travel cost methods) or hypothetical markets (use the contingent valuation method). Figure 1 presents a standard breakdown of the TEV into its individual components, as well as the methods available for estimating the value of these components.

Figure 1 Breakdown of Total Economic Value and valuation methods for environmental resources and services.



Source: World Bank, Environmental Assessment Source Book Update #23, 1998

The valuation of environmental benefits expected from the implementation of the risk management scenarios could be achieved by using the methodologies listed in Figure 1. The extent of the data requirements - and the associated costs and time required – are key criteria for choosing the most appropriate methodology; **it can also be an obstacle to undertaking any valuation at all.**

The scope of the present project did not allow for the use of any of the methodologies listed in Figure 1. This limitation is compounded by the fact that no dose–response relationship is available to quantify environmental benefits (in physical terms, such as increased agricultural productivity).

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[3] For a more comprehensive description of the Total Economic Value, see: Freeman (1993); Perman (2003); Tietemberg T., (1996) Pearce and Warford (1993) and http://www.mfe.govt.nz/publications/water/waitaki-option-existence-values-jan05/html/page3.html.

3.1.2 Assessing Project Costs

Project costs include:

- Direct costs (including investment costs and operating costs) associated with the various components of the project (design and construction of infrastructure, development and implementation of management systems, etc.); and

- Indirect costs, which derive from the negative impacts caused by the project, whether they are economic (e.g., loss of productivity due to more stringent safety procedures), social (e.g., adverse health impacts) or environmental (e.g., clearing a forested area leading to the unavailability of firewood and food for the population, increased greenhouse gas emissions, loss of biodiversity, etc.). At the AHSL site, indirect costs are expected to be limited to potential loss of productivity related to the implementation of risk management scenarios on the hotspot sites. Although some minor externalities may occur, their impact on the economic valuation of the scenarios is considered negligible.

A cost estimate is obtained through the following steps:

- *Identify Cost Categories*: the risk management scenarios subject to the analysis need to be broken down into components that can be described in quantitative terms. The scenarios can be divided into small items which may be estimated individually based on unit costs, or into larger components for which a global cost can be derived from similar projects;

- *Gather cost data*: unit costs must be assessed for each of the cost items identified. This unit cost list can be drawn from ancillary data (market survey, statistical collection, etc.) or from direct consultation with providers. Cost studies conducted for similar projects can also be used; and

- *Adjust costs to local conditions*: where applicable, cost data must be adjusted to take into account the specific characteristics of the project under consideration, including timing (costs estimated in past years must be escalated to account for inflation), local market conditions, etc.

The quality of the estimate depends on the availability and accuracy of quantitative data at each of these steps.

3.1.3 Determining Present Value of Project Costs and Benefits

Project costs and benefits are incurred at different times during a project's life. Discounting allows the expression of a stream of costs or benefits as one number in present value terms; it ensures that more weight is attached to present than the future.

Present value is calculated as follows:

$$PV(Benefits) = \sum_{t=1}^{N} \frac{B_t}{(1+r)^t} \qquad PV(Costs) = \sum_{t=1}^{N} \frac{C_t}{(1+r)^t}$$

where: B_t = benefit in year t, C_t = cost in year t, r = discount rate and N = project life, in years .

3.1.4 Comparing Costs and Benefits

The estimated benefit and cost streams form the basis of several measures of project viability, as follows:

- *Net Present Value (NPV):* NPV is the number that results when the discounted value of the expected costs of an investment are deducted from the discounted value of the expected benefits. Projects with a NPV greater than zero (when discounted at a suitable rate) are worth undertaking. NPV is an *absolute* measure of project viability.

- *Benefit – Cost Ratio (BCR)*: the BCR is the ratio of the present value of the economic benefit stream to the present value of the economic costs stream of a project, each discounted at the same discount rate. The ratio should be greater than 1.0 for a project to be acceptable[4]. For example, a BCR of 1.25 indicates that for every US$ 1 of cost, the project will return US$ 1.25 of benefit. BCR is a *relative* measure of viability.

- *Internal Rate of Return (IRR):* the IRR is the discount rate at which the present value of costs equals the present value of benefits. Alternatively, IRR is the discount rate at which NPV = 0 and BCR = 1.0. If IRR exceeds the opportunity cost of the capital, the project is considered to be economically sound and worth pursuing. [5]

The steps required for conducting a comprehensive CBA, under ideal conditions, are summarized in Figure 2.

3.2 LIMITATIONS TO IMPLEMENTATION OF THE IDEAL APPROACH

Several limitations prevent the implementation of the CBA process for assessing the economic impacts of POPs in the four case studies:

- **Difficulty of establishing a dose-response or exposure-response function for health impacts due to POPs**: despite the recognized link

[4] A project may have a low positive NPV (because it is a small project) at the same time as it has a high BCR (because benefits are significant compared to costs).

[5] The IRR is a criteria to be used with caution because: (i) it cannot be calculated for all projects (e.g. projects where the stream of net benefits is strictly positive for each year or projects with more than one change from negative net benefits to positive net benefits); and, (ii) "it is a mathematical concept and not an investment criterion for evaluating alternative cash flows. When the cash flows are irregular, with net costs occurring in the later years of the project, it will give unreliable results in the ranking of alternative options"(Treasury Board of Canada 2007).

between POPs exposure and health impacts, establishing an unequivocal relationship between POPs-exposure and adverse health impacts has yet evaded scientists (Herkovits, 1998). Reasons include: (i) the fact that humans can be exposed successively and/or simultaneously to a variety of toxic substances, making it virtually impossible to determine which one is **actually** responsible for a certain disease (while all of them could **potentially** be responsible); (ii) the limited availability of detailed epidemiological studies; and (iii) the difficulty of measuring exposure, especially over long periods of time (Abelsohn *et al.*, 2002). In fact, there is no available exposure-response or dose-response equation that would allow us to derive a quantitative estimate of a disease incidence (and severity) in the population from its level of exposure to, or contamination by, POPs.[6]

- **Difficulty of establishing a dose-response function for environmental impacts due to POPs:** for the same reasons described above, there is no readily available equation to quantitatively link contamination by POPs and environmental impacts. Therefore, environmental benefits are assessed in qualitative terms only.

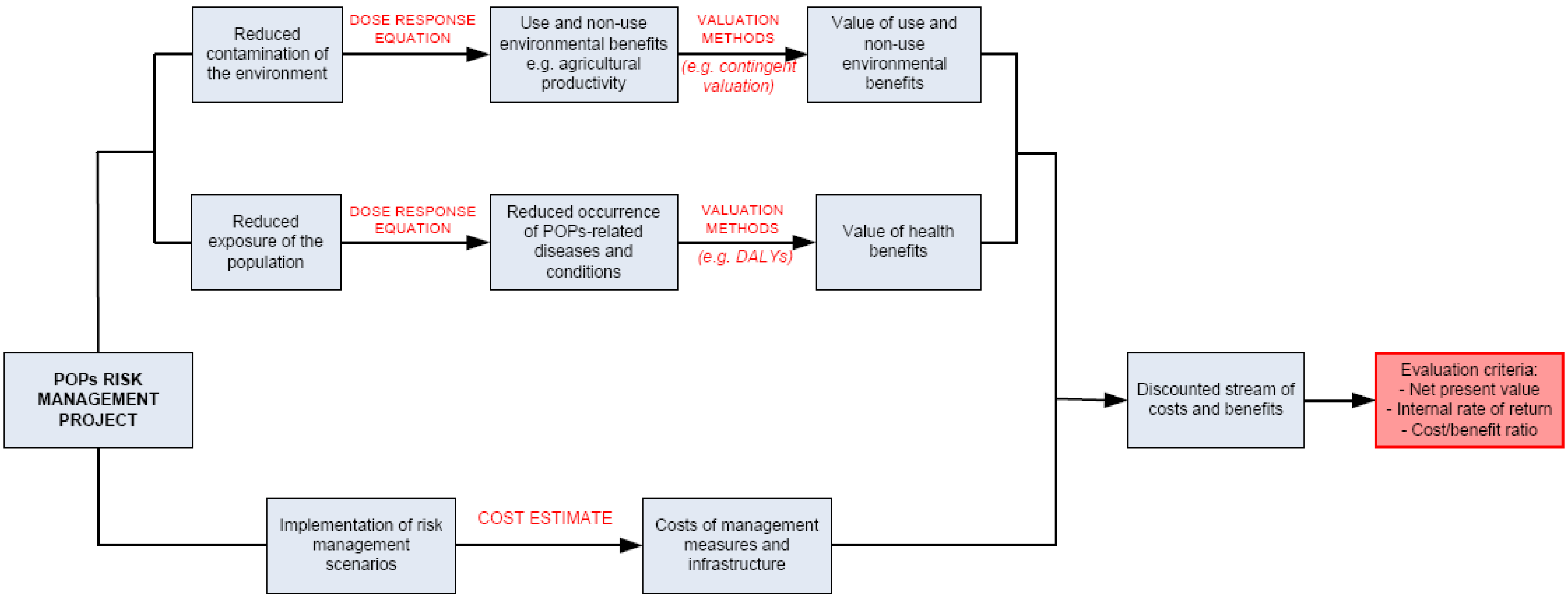
- **Difficulty of estimating the reduction in exposure achieved through the implementation of the risk management scenarios**: the effects of the risk management scenarios on reducing the contamination of the environment by POPs, and the resulting exposure of the population, are assessed only from a qualitative perspective. The multiple exposure pathways between the environment and human population make it difficult to draw a quantitative link between both aspects.

- **Limited primary data gathering**: the terms of reference for the POPs Project did not include the acquisition of primary information, such as might be obtained through a detailed health survey or economic valuation survey (e.g., contingent valuation or hedonistic prices). As a result, the scope of the economic analysis was constrained by the availability of secondary data.

Upon consideration of these points, it was deemed impossible to meet the data requirement of the ideal approach. A refined and simplified methodology was therefore developed in order to proceed with the economic analysis.

[6] "Although several studies seem to indicate a dose-response ratio for POPs […], it seems irresponsible to suggest a threshold concentration for adverse effects of these substances" (Herkovits, 1998). http://www.chem.unep.ch/pops/POPs_Inc/proceedings/Iguazu/herkovits.html

Figure 2 Ideal Process of a Cost Benefit Analysis.



3.3 METHODOLOGY EMPLOYED

In consultation with the World Bank, the approach to the economic analysis was reformulated to address the following: **given the costs of the various risk management scenarios, how significant do the positive health impacts need to be to ensure the scenarios would pass a cost–benefit analysis test (such as NPV>0)?**

The key steps of the methodology employed are as follows:

- **<u>Step 1</u>**: Estimate the cost of the risk management scenarios;
- **<u>Step 2</u>**: Determine the stream of benefits (in dollar terms) that would enable NPV to be $\geq$ 0 for each scenario. The following assumptions were made:
    - The time horizon over which benefits occur is set at 20 years. In theory, there is no end to the benefit stream, as reduced exposure to POPs will affect future generations as well as current ones. However, the application of a discounting rate reduces the value of costs and benefits occurring in the distant future close to zero[7]. In addition, uncertainty about how the situation on the site would evolve (independently of the project considered) also makes the analysis unreliable beyond a certain date (Fuguitt and Wilcox, 1999); and
    - The benefits are considered to start in Year 2 and to be regularly distributed in time (i.e., benefits are the same each year from Year 2 to 20).
- **<u>Step 3</u>**: Quantify the benefits in terms of human health impacts:
    - The approach and unit of account retained to measure human health impacts is the DALY;
    - There is no market-clearing price providing the value of a DALY; therefore this value needs to be determined using other valuation techniques. A benefit transfer approach was applied, as described in Section 4.2; and
    - The benefits will be measured in terms of health impacts by dividing their value in dollars by the unit value of a DALY.
- **<u>Step 4</u>**: Quantify the benefits in terms of reduced negative human health impact. The health benefits required to have NPV=0 for each scenario have been estimated *in absolute terms* in the previous step. This benefit also

[7] A benefit of 100 occurring in year 20 represent a contribution of less than 40 to the present value of benefits when using a discount rate of 5%.

needs to be estimated *in relative terms*; that is, expressed as a percentage reduction in the total DALYs at the site.[8]

- **Step 5**: Determine whether these benefits are achievable through the implementation of the risk management scenarios.

Figure 3 illustrates how the standard approach to a CBA was modified for the POPs-Project.

[8] The number of DALYs at the site is used as a point of comparison because the analysis is conducted at a local scale: the risk management measures under consideration are site-specific; and the positive health impacts will affect only the population potentially exposed to site-related contamination.