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ENVIRONMENTAL IMPACTS OF WASTEWATER USE PRACTICES

In cooperation with

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EXECUTIVE SUMMARY

The use of reclaimed water exerts an impact on the environment. If this practise is to be implemented full-scale and accepted by stakeholders and users, the positive and negative aspects need to be carefully determined. It should be borne in mind that reclaimed water could be the only (new) economic and environmentally adequate resource available in a number of locations for years to come. The balance between offer and demand can be re-equilibrated in a sustainable way when practicing reuse.

To determine the environmental impact of reclaimed water use, it is necessary to develop the necessary tools to carry out environmental impact analysis, assessment and evaluation and be fully conversant with the rules and regulations related to the practise.

Due to the several possible uses of such water, there is a need to attain a certain quality of reclaimed water depending on the type of use. Five groups of reclaimed water use are considered:

- urban uses other than tapwater;
- agricultural;
- industrial;
- environment and leisure; and
- groundwater recharge.

The last (groundwater recharge) is sometimes not considered as a possibility due to the hazards associated with it. Use as tapwater is not considered at all for possible reuse.

The quality of reclaimed water is nowadays defined by a few analytical parameters and even by regulations, but the need arises to improve the method used to determine the qualitative aspects; perhaps not by increasing the number of analyses but implementing complementary tools, such as risk assessment or good reuse practises. There is a lack of physical-chemical and toxicity-related parameters. The strong relationship between environmental impact and risk assessment practises should be noted.

Reclaimed water use is to be fully implemented in the coming years in arid and semi-arid regions of Europe due to the increase in water demand, the lack of new resources and, perhaps, climatic change. For this reason the relative tools, communication policies and practical application of reclaimed water needs to be addressed. Several procedures are described for the determination of environmental impacts, although as in any case of environmental impact analysis, objectivity is very difficult to attain.

Environmental impact analysis or assessment is fully regulated in the European Union (EU) and the United States (US), but it is not exactly applied to reclaimed water use. The reasons could be a lack of European regulations on reclamation and reuse, mainly because of the different water needs in the European continent.

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1. INTRODUCTION: BASIC CONCEPTS

Human activities exert an influence on the environment, changing several of its characteristics and modifying others. Methods of assessing such changes have been evolving for decades, since the initial simple acknowledgement of changes up to the more sophisticated mathematical models in use nowadays.

Simply put, the activities of man cause “environmental impacts”. The way to assess such environmental impact changes with the activity being studied; when dealing with wastewater reclamation and use[1], several tools can be employed, trying to establish the relationships between this new, non-conventional water resource, the environment, and human health.

Environmental impact assessments is amongst the tools used over the last decades of the XXIth century and have been evolving, generating “secondary” tools like risk assessment and management. Nowadays, they are used to indicate health and environmental risk analysis as the more advanced tools in wastewater reclamation and use. Nevertheless, there is a certain lack of development of an environmental impact tool with respect to reuse, which will later affect the full development of risk assessment and management.

For the development of this chapter, it is important to establish from the beginning that environmental impacts can be both positive and negative. In the case of wastewater reclamation and use, the positive impacts should be more significant than the negative, otherwise it is pointless to establish reuse.

1.1 State of the art: Wastewater reclamation and reclaimed water use

The concept of reuse, a term used to define a new use of wastewater having been treated up to a defined quality, has been evolving for decades. Everyone is acquainted with the subject, but the names have changed and are somewhat different, depending on the author and region of the world.

It seems that “water recycling” has now been adopted as the preferred term for generic water reclamation and use, in view of the acceptance and success of other urban recycling programmes (AATSE, 2004). As happened with the implementation of the term “biosolids” instead of “sludge reclamation”, “water recycling” could almost be a marketing definition because of the disappearance of “waste” and the appearance of the term “recycling”, which in this instance seems to have positive connotations.

Wastewater reclamation and use (water recycling) is now common practise all over the arid and semi-arid areas of the world, in populated humid areas where water demand exceeds the offer, and where is a will to reduce the negative impacts associated with wastewater disposal.

The conclusion seems to be that water recycling should be considered as the global term for reclamation and use, while reclamation is the additional treatment needed for water to be reused (used again).

Before any further discussion, it should be borne in mind that all over the world huge amounts of untreated, raw wastewater are used for crop irrigation or disposed of into water bodies, causing significant problems to the environment and human health.

[1] In this document, wastewater use will be employed, as it is considered more applicable than wastewater reuse.

When reclaimed wastewater (not untreated wastewater) is used in a properly planned way, it signifies that the water authorities have exerted a “proactive” action, issuing a permit and becoming in some way responsible for the entire procedure.

Before issuing permits, water authorities need to be reasonably sure that the system does not constitute a hazard to people or the environment. Safeguarding against possible hazards requires the use of adequate and appropriate tools.

Today there are two important tools for the assessment of what happens when reclaimed wastewater reaches the environment:

i. environmental impact calculations or assessments; and
ii. risk assessments in relation to the environment and humans.

When setting out to establish environmental impacts, we need to make an initial separation: the agent responsible for (or causing) the impact and the “receiving” body.

The responsible agent will be the reclaimed wastewate r. Two different aspects should be considered here: reclamation and use.

Reclamation: as stated previously, reclamation is the wastewater treatment performed to produce a quality good enough for the effluent to be used.
Reuse (reclaimed water use): the act of releasing reclaimed wastewater into the environment.

Therefore, it seems necessary to distinguish between the impacts caused by the reclamation and reuse processes.

1.1.1 Wastewater treatment

Wastewater treatment should be considered from several points of view:

a) in relation to the water cycles. We can consider two cycles; the natural and the anthropic;
b) from the socio-economic aspect. Every society must decide up to which point it can afford the costs associated with sanitation;
c) health considerations. Sanitation is a word derived from ‘health’, which indicates that the primary objective of wastewater recovery and treatment is to reduce the diseases associated with the unplanned disposal of wastewater; and
d) the technological side. From the previous considerations, the price of energy, the technological level - a type of technology must be selected for every case. The concept is called Best Available Technology (BAT).

Water is diverted from the natural cycle and passes to the anthropic cycle for use. There are several points of contact in both cycles. After extraction and use there are returns to the natural cycle, from pipeline losses to the disposal of treated wastewater. In every case - after treatment or reclamation - wastewater reaches the environment. It has to be decided which method (disposal, reuse) causes a “better” environmental impact.

Wastewater treatment has usually been defined and implemented to obtain a quality to comply with the laws; i.e., the 91/271 EU Directive. Quality is assessed mainly using two parameters, organic matter (BOD or COD) and suspended solids (SS). It can be said that there is no direct relationship between the quality demanded and the health point of view. It could also be stated that, indirectly, the elimination of SS leads to the elimination of pathogens associated to particulate organic matter.

Treatments can be classified into intensive and extensive. Intensive treatments use a certain amount of energy but a reduced amount of space. Extensive treatments on the contrary, rely on natural energy but occupy a lot of space. In the US, EU countries, and in most developed countries, activated sludge has been the selected technology for almost all medium and large-size facilities. Concerns arise when dealing with small populations; certain countries have developed extensive systems while others use intensive technologies, sometimes not well adapted to this size.

In the EU, as mentioned above, Directive (91/271) states the quality of treated wastewater and the time when the treatment facilities must be built, depending on the size of the population served. Mainly, a secondary treatment must be guaranteed in most cases, with additional nutrient elimination in defined locations. There are similar requirements in other countries.

In almost all cases, the possibility of reuse was not considered at the time of building the wastewater treatment facility. As a consequence, the relationship between secondary treatments and reclamation treatments are not easy.

1.1.2 Wastewater reclamation

The step following secondary treatment but prior to reuse is reclamation. Considered as advanced or tertiary treatments, reclamation procedures are established to guarantee a water quality fixed by regulations or recommendations for reuse.

Reclamation treatments can also be intensive or extensive, and their purpose is to generate water that can be used with acceptable risks. It means that a further reduction of contaminants is needed. This reduction is usually centred in a certain degree of disinfection, i.e., elimination of pathogens and a further reduction of chemicals.

Because it is impossible to determine all pathogens present in the water, there is a need to rely on indicators. Nevertheless, the existing fully accepted indicators, coliforms or *E. coli*, do not provide adequate information on all pathogens. It should also be mentioned that such indicators are being used to define the effectiveness of the treatments, including reclamation, which is not at all adequate. On the other hand, there are index organisms, like protozoa, that are to be specifically determined because there are no indicators for them.

Regarding chemicals, it can be said that there is usually a huge amount of compounds present in wastewater, from drugs of any type to products used in households or generated in the small and large industries present in towns. It makes it difficult to control all chemicals in water to be reclaimed or reclaimed.

Regular reclamation facilities should have two treatment steps. The first one is a kind of pre-treatment, in order to further eliminate suspended solids; the second is disinfection. Several treatments, especially extensive, are capable of achieving a similar quality of water with a single step. For the elimination of chemicals, there is a need to further develop adequate methods. Physical-chemical treatments, addition of flocculants/coagulants, or extensive treatments with long residence time, appear to be adequate in this instance. It could coincide with the first step described. Soil-based systems also seem to be capable of reducing the amount of chemicals present in water.

Over the last decades, seasonal storage has been implemented in several parts of the Mediterranean in order to increase the resources available, but at the same time this storage exerts an effect on the reclaimed water quality.

Nevertheless, there are several studies that indicate the existence of a great number of chemical contaminants, from endocrine disruptors (oestrogen-like substances) to commonly used drugs (antibiotics, Ibuprofen, etc.) in fully reclaimed water. There is no evidence of what happens with these compounds when reclaimed water is used.

The lack of information and of adequate analytical tools can generate problems when trying to establish the environmental impact of several types of use. In order to overcome this problem, the multiple barrier concept is sometimes applied to reclamation systems, which means that several treatments are applied for further safety, each one capable of guaranteeing a certain degree of quality.

In any event, reclamation procedures need to be reliable; quality of reclaimed water, especially at the point of use, should be guaranteed at all times.

1.1.3 Reuse

Once reclaimed, wastewater is used. There are several possibilities for use, from agricultural irrigation to stream recharge. In each case, the following points should be defined:

a) the quality legally established;
b) the application system;
c) the contact between the water and the receiving media, including man;
d) the effects of such contact;
e) what happens with the water once in the environment; and
f) what happens with the different matrix in contact with reclaimed water.

All these circumstances could be important when establishing the environmental impact of reclaimed water recycling. The reuse procedures need to be fully studied; there is a tendency nowadays to certificate all the processes by means of well developed tools, like ISO or EMAS. It should be considered whether traceability could be implemented for reuse (what is called follow-up in the manufacturing or food and pharmaceutical industries).

In any case, a flow diagram can be defined (see Figure 1). It should be mentioned that reuse can be undertaken legally and illegally at different points of the anthropic water cycle.

1.1.4 The state in Europe and the Mediterranean

Today, wastewater is being used either treated or untreated, depending on several factors. Because use of raw wastewater is illegal, or alegal, no further reference will be made to it but to say that it is common practise in a lot of places in the Mediterranean. The main consequence of such activity is that legal reuse is acquiring bad connotations and becoming more difficult to implement. A lot of crops irrigated with raw wastewater can grow perfectly, even better than those irrigated with fresh water.

The main requirement for water around the Mediterranean is agricultural irrigation. Consequently, it is logical that reclaimed water is mostly used for the same purpose. The secondary use is for groundwater recharge, irrigation of parks and golf courses, and occasionally for other purposes like car washing, industries, air conditioning, etc.

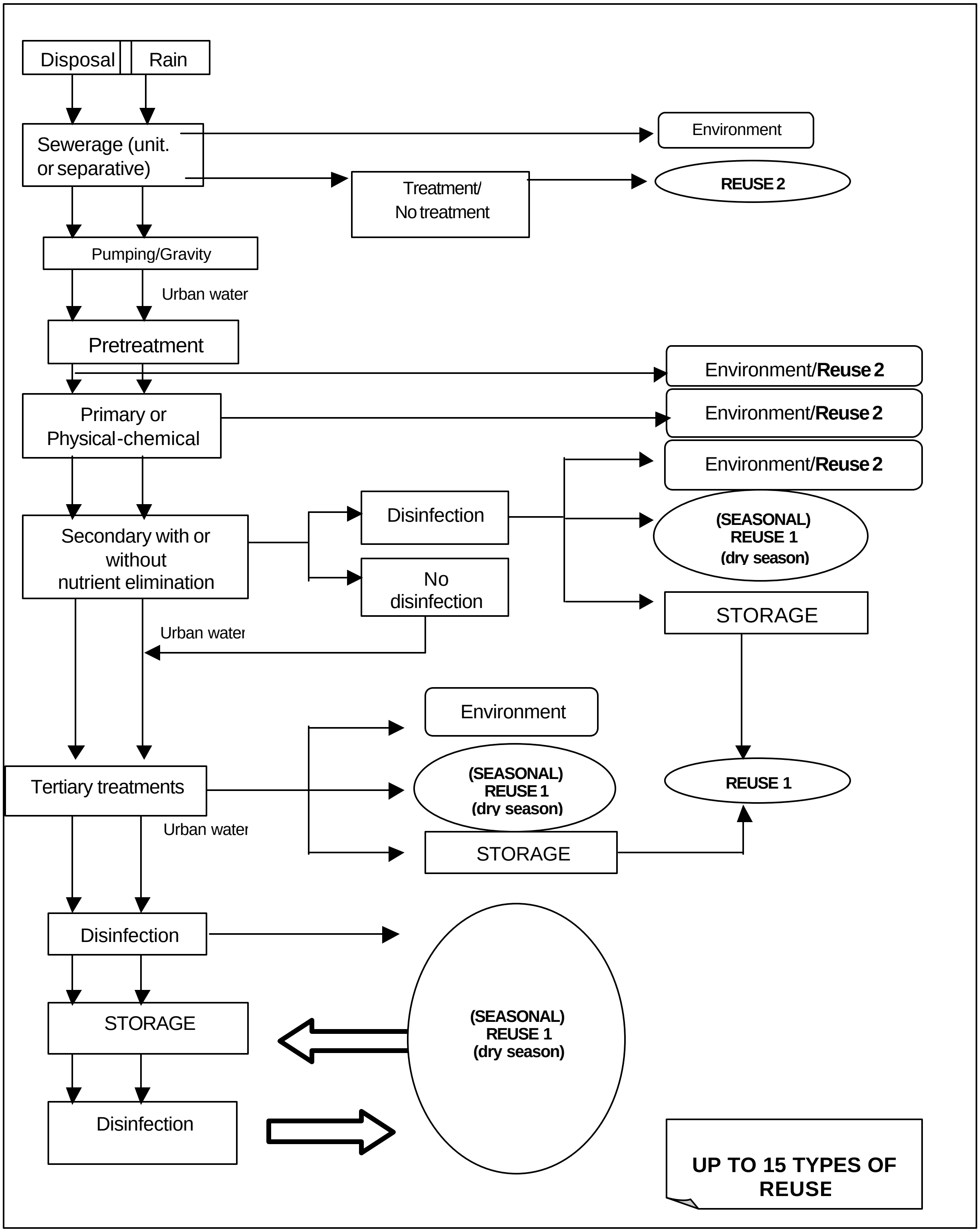

Figure 1. Flow diagram of use with urban waters (modified from Salgot *et al.*, 2004). Reuse 1: planned, legal. Reuse 2: unplanned, illegal/alegal.

In the south of Europe and eastern Mediterranean, several countries have rules and regulations on reuse, while in others the WHO or EPA recommendations are followed more or less directly. In the main, wastewater treated up to a certain level is being used, and is sometimes adequately reclaimed. The reclamation processes after secondary treatment can vary from intensive (physical-chemical plus filtration and disinfection) to extensive (infiltration-percolation, lagooning, etc.). Nevertheless, the amount of treated wastewater being used is presently not really important in relation to the total amount of water used, although the demand for new water resources is important. It seems that over the next decade, this situation could be inverted, especially in Spain, where the conditions seem to be fairly good for further implementing the practise of reuse.

In the remaining areas of the Mediterranean several circumstances are to be outlined: from the case of Israel where almost all wastewater is reclaimed and used, even with exemplar reclamation procedures, like the Dan Region system, to the north of Africa, where reuse is well established in Tunisia and not implemented at all in Morocco and Algeria. Studies are being developed in Egypt and there are diverse situations in the rest of the basin.

1.2 State of the art: Environmental impact

Environmental impact studies started “legally” in 1969 in the US, with the National Environmental Policy Act (NEPA). The main principle embodied in NEPA was the requirement of an environmental impact statement (EIS). An EIS was required for every federally funded project that might significantly affect the environment, which of course could include water reclamation and use projects. Projects that would require EISs were those that might affect water quality, fish and wildlife populations, noise levels, or air quality in our environment (Rowe and Abdel-Magid, 1995).

New terminology arose in conjunction with the process of complying with the requirements of NEPA. Three of the most significant new terms are “environmental inventory”, “environmental assessment” and “environmental impact statement” (Canter, 1977).

Environmental Inventory is a complete description of the environment as it exists in an area where a particular proposed action is being considered. The inventory is compiled from a checklist of descriptors for the physical, biological, and cultural environment and serves as the basis for evaluating the potential impacts on the environment, both beneficial and adverse, of a proposed action point.

<u>Environmental Assessment</u> represents the key step in meeting the requirements of NEPA. In essence, it is an attempt to evaluate the consequences of a proposed action on each of the descriptors in the environmental inventory. The essential steps in an environmental impact assessment are:

1. prediction of the anticipated change in an environmental descriptor;
2. determination of the magnitude or scale of the particular change; and
3. application and importance or significance factor of the change.

<u>Environmental Impact Statement</u> (EIS) is a document written in a format specified by NEPA. The EIS represents a summary of the environmental inventory and the findings of the environmental assessment. Environmental impact statements are also referred to as “environmental statements”, “impact statements”, “environmental impact reports”, and others.

The Council on Environmental Quality (CEQ, USA) issued guidelines on the preparation and content of the statements. A brief outline of the content of EIS is as follows (Rowe and Abdel-Magid, 1995):

1. a description of the proposed action, a statement of its purposes, and a description of the environment affected, including information, summary, technical data, and maps and diagrams where relevant, adequate to permit an assessment of potential environmental impact by commenting agencies and the public;
2. the relationship of the proposed action to land use plans, policies, and controls for the affected area. This requires a discussion of how the proposed action may conform or conflict with the objectives and specific terms of approved or proposed federal, state, and local land use plans, policies, and controls, if any, for the area affected;
3. the probable impact of the proposed action on the environment, including environmental costs in the decision-making process;
4. alternatives to the proposed action, including, where relevant, those not within the existing authority of the responsible agency;
5. any probable adverse environmental effects, which cannot be avoided (such as water or air pollution, undesirable land use patterns and damage to life systems, urban congestion, threats to health, or other consequences adverse to the environment);
6. the relationship between local short term uses of man's environment and the maintenance and enhancement of long term productivity;
7. any irreversible and irretrievable commitments of resources that would be involved in the proposed actions; and
8. any indication of what other interests and considerations of federal policy are thought to offset the adverse environmental effects of the proposed action.

As early as 1977, Canter made a description of the impacts of a sewage treatment plant (see Table 1), describing mainly the negative ones. With the elapse of time, the problems did not change so much, although the ways of deal with them and possible solutions evolved. It should be noted that there are certainly positive impacts. These are stated in Table 2, prepared specially for the purpose.

Table 1

Direct and indirect negative impacts of a sewage treatment plant [a]
(modified from Canter, 1977).

	Primary effects	**Secondary effects**	**Tertiary effects**
	Adverse impacts - Direct		
	Erode soil during construction.	Degraded aquatic habitat or stream.	Decreased fisheries.
	Periodic releases of noxious gases and pathogen organisms.	Decreased surrounding property values.	Changed socioeconomic composition of neighbourhood [b].
	Adverse impacts - Indirect		
Short-term	Short-term employment (associated to the construction).	Temporary housing.	Do not occur.
		Increased traffic on local streets.	Traffic congestion, noise, smog.

a: impacts are described for illustrative purposes only; a complete matrix for a sewage plant would contain many more impacts within each of the respective cells of the matrix. A separate matrix could be constructed for beneficial impacts.

b: irreversible impact.

Table 2

Direct and indirect positive impacts of a sewage treatment plant.

	Primary effects	**Secondary effects**	**Tertiary effects**
	Positive impacts - Direct		
Short-term	Localized wastewater disposal could disappear.	Improved aquatic habitat of stream.	Wildlife in streams can recover.
Long-term	Local impacts disappear, soil and groundwater improve.	The value of the whole properties serviced improves.	Environmental standards improve in all the area.
	Positive impacts - Indirect		
Short-term	Construction employment.	Water for reuse. Sludge for application.	More sustainable municipality.
Long-term	Permit/encourage residential development within service area. Low number of employees in the facility.	Increase in tourism and environment related activities are possible.	Local Agenda 21 is established with respect to water.

Since 1977, environmental impact studies or statements (EIS) have become more complicated. At present we refer mainly to the EIA (Environmental Impact Assessment) and the term “environmental impact” is still quoted, but neither has the same broad meaning initially intended.

It is considered that an environmental impact study needs to deal primarily with the assessment of the impacts caused. The impacts must be on:

a) the ecosystem, considering the biocoenosis (the living part) a nd the biotope (the non-living part). Obviously, there is an strong relationship between the two;
b) man. Because of the interrelation of man with the ecosystems, where he draws the food and water needed to survive; and
c) man’s properties: animals, buildings, etc.

From here, a specific system must be selected to develop the procedure of the impact assessment.

Nevertheless, the spirit of the EIS has lasted up until now, and it can be found in extremely recent publications (RAMSAR, June 2004): *in recent years, the concepts of environmental impact assessment (EIA) and the strategic environmental assessment (SEA) have increasingly come to be seen as necessary components of international environmental policy and law. Two important milestones in this process were Agenda 21 and the Rio Summit declaration from the UN conference on the Environment and Development in 1992, both of which contained provisions calling for EIAs to be undertaken for activities likely to impact adversely on the environment. The successor World Summit on Sustainable Development in Johannesburg in 2002 produced a Plan of implementation, which calls for using EIA procedures “at all levels”.*

Increasingly, EIA is viewed as an instrument (one among many) for furthering specific environmental and societal objectives, especially sustainability. EIA is sometimes seen as a means (again one of many) of achieving more open, informed, coordinated, unbiased, and systematic planning and decision-making (Lawrence, 2003).

A relatively new tool, as stated by Nixon *et al.* (2003) establishes what is called DPSIR framework, for driving forces and pressures on the environment, the consequent state of the environment and its impacts and the responses undertaken, and the link between each of these elements.

Jain *et al.* (2002) indicate that the international community is increasingly concerned with environmental issues. This is reflected in the increase of international environmental organizations, the investment nations are making to protect the environment, and the fact that environmental issues are taking centre-stage during meetings between world leaders.

During this period, a parallel development was being formed in Europe. The Commission and the European Parliament issued and modified a number of Directives to describe such types of work and to enforce the application of EIA and SEA (see Part 2).

It should be noted that in 1990 UNEP published a report named “An approach to environmental impact assessment for projects affecting the coastal and marine environment” (UNEP 1990).

1.2.1 The basics

EIA is defined (Lawrence, 2003) as a systematic process of:

- determining and managing (identifying, describing, measuring, predicting, interpreting, integrating, communicating, involving, and controlling);
- potential (or real) impacts (direct and indirect, individual and cumulative, likelihood of occurrence);
- proposed (or existing) human actions (projects, plants, programmes, legislation, activities) and their alternatives; and
- environment (physical, chemical, biological, ecological, human health, cultural, social, economic, built, and interrelations).

When endeavouring to study the impacts on the ecosystem, conventional tools can be used (e.g., scenario development, LCA). It is also possible to adapt them or develop new tools, like HACCP (hazard assessment and critical control points) or GRP (good reuse practises).

There is a certain amount of confusion today between risk and environmental impact studies. In some way, both types of study coincide in assessing hazards related to the environment and health. The first type (HACCP) focuses more on health hazards, while the impact studies have a tendency to focus more on the environmental aspects.

Additionally, there are many studies relating to environmental auditing, which adds more confusion.

It should be noted that because reclamation and use is a decision taken by stakeholders, several tools to aid decision-making must be considered.

Environmental impact has several potential aspects to work on, to be explained later, while risk assessment, management and communication are today being developed as a tool in the water field.

1.2.2 Water quality considerations

Impact is to be quantified. For this apparently simple statement, a lot of analytical work is needed. So, a problem arises when trying to decide on which analysis, how many, and the cost implied.

It is not a simple matter to make decisions on what to analyze in a water body, how to sample it and which analyses are to be performed *in situ* or in the sample. Additionally, we need to bear in mind that the number of contaminants in a water sample is enormous. In order to systematize, a division is usually made among biological contaminants and chemical ones.

According to Metcalf & Eddy (1991), the important water quality parameters relating to water discharges are dissolved oxygen (DO), suspended solids, bacteria, nutrients, pH and toxic chemicals, including volatile organics, acid/base neutrals, metals, pesticides, and PCBs. Nevertheless, during the last decade, it appears that other parameters also became important, like viruses, protozoa, endocrine disruptors and other microcontaminants resulting from human activities (see Table 3).

Table 3

Important water quality parameters relating to wastewater discharges and reclaimed wastewater environmental application.
Metcalf & Eddy (1991); Salgot *et al.* (2001).

Parameter	**Type of control**	**Treated wastewater: importance**[1]	**Reclaimed water: importance**
Dissolved oxygen (DO).	In situ, can be continuous.	For life; levels under 4 or 5 mg/L detrimental for aquatic life.	Depending on the system.
Suspended solids.	Laboratory; depends on the analytical method.	Affect water quality turbidity and several disinfection procedures (e.g., UV). If settled can lead to toxicity, benthic enrichment and sediment oxygen demand.	Usually, total elimination or nearly.
Bacterial pathogens indicator: coliforms.	Complicated: Usually results after two days. Indirect determination: indicators.	Usually used to determine the capacity of the treatment to disinfect.	Standards give high importance to this parameter. Limits the type of use.
Pathogenic viruses.	Direct determination very expensive. Indirectly through bacteriophage.	Not accorded.	Seldom determined. This is a gap in the control of reuse.

Parameter	Type of control	Treated wastewater: importance[1]	Reclaimed water: importance
Nematode.	Eggs of several species. Presence, not viability nor infectivity.	Eliminated by sedimentation processes.	Compulsory in several regulations.
Protozoa.	Direct (*Giardia* cysts and *Cryptosporidium* oocysts). Presence, not viability nor infectivity.	Eliminated by sedimentation processes, not by several types of filtration.	Not well established.
Nutrients.	N, P.	High content leads to eutrophication.	Useful if used for irrigation.
pH.	*In situ*, can be continuous.	Excess of acids and bases affects ecological balances.	Depends on the site of application (e.g., acid soils accept basic pH).
Toxic chemicals.	Difficult. Usually requires biocontrols and sophisticated calculation tools.	Detrimental effects on aquatic life or humans, upon ingestion of water, fish or shellfish.	As it is usually difficult to eliminate with advanced treatments causes the same effects.
Total salts content. Organic matter.	Can be continuous. Different ways. Difficult in reclaimed water (b.d.l.).	Problems for advanced biological treatments. Increases DO demand.	Problems if used for crop irrigation. Depends on the type of use. Usually no problems for irrigation. Can hold pathogens.
Endocrine disruptors.	Expensive and difficult. Highly specialized.	If treated wastewater is disposed into water bodies.	To be studied. Can be eliminated using natural systems.
Drugs.	Expensive and difficult. Highly specialized.	If treated wastewater is disposed into water bodies.	To be studied.

b.d.l. below detection limit.

Following background or scoping activities with respect to contaminants, data collection and evaluation are required. This involves (Rowe and Abdel-Magid, 1995):

- contaminant identification;
- contaminant concentrations from key sources and its transport by air, water, or soil;
- characteristics of the source; and
- characteristics of the environmental setting that affect the fate, transport, and persistence of the contaminants.

The sampling of background levels of a contaminant is important in order to separate naturally occurring site-related contaminant levels to non-site-related levels.

The amount of analytical data used to be scarce, unless generated for a specific study or research. There are several reasons for data scarcity, from economic to the lack of willingness. In spite of the existence of specific regulations, it is difficult to obtain data from the operators and managers of reuse facilities.

1.2.3 Specific site considerations

When wastewater (reclaimed or not) is applied to a specific site, there is a list by media (air, water, soil, biota, etc.) of important parameters that should be considered in environmental impact studies (see Table 4). These significant parameters must be further studied. The parameters to be studied also depend on the specific use for the reclaimed water.

1.3 Reclaimed water as a resource

Extremely important factors for the countries reusing reclaimed water are the availability, reliability and cost of this new water resource. As previously explained, there are different options for use, and the integrated management of water resources should have as a main objective the allocation of the water for uses depending on the quality and risks incurred.

Although in theory it appears simple, in practise it is not. The reason for this is lack of transport infrastructures and difficulty in obtaining different water qualities within the same reclamation facility. Centralization vs. decentralization of reclamation facilities is one of the main discussions related to this aspect.

Table 4

Important parameters that may need to be obtained during site sampling investigations (modified from Rowe and Abdel-Magid, 1995).

Type of modelling	**Modelling parameters**	**Comments**
Source characteristics.	Geometry, physical/chemical conditions, emission rate, emission strength, geography.	Variability and capacity of the treatment system to handle.
Soil.	Particle size, dry weight, pH, redox potential, mineral class, organic carbon and clay content, bulk density, soil porosity.	If reclaimed water is applied to soils or soils are used for advanced treatment.
Groundwater.	Head measurements, hydraulic conductivity (pump and slug test results), saturated thickness of aquifer, hydraulic gradient, pH, redox potential, soil-water partitioning.	For groundwater recharge or if percolation is suspected.
Air.	Prevailing wind direction, wind speeds, stability class, topography, depth of waste, contaminant concentration in soil and soil gas, fraction organic content of soils, silt content of soils, percent vegetation, bulk density of soil, soil porosity.	If human settlements are located in the vicinity of the facility.

Type of modelling	Modelling parameters	Comments
Surface water.	Hardness, pH, redox potential, dissolved oxygen, salinity, temperature, conductivity, total suspended solids, flow rates and depth for rivers/streams, estuary and embayment parameters such as tidal cycle, saltwater incursion extent, depth and area, lake parameters such as area, volume, depth, depth of the thermocline.	When reclaimed water reaches water bodies or if reuse detracts water from the bodies (no disposal).
Sediment.	Particle size distribution, organic content, pH, benthic oxygen conditions, water content.	Accumulation processes are important if resuspended or disposed.
Biota.	Dry weight, whole body, specific organ and/or edible portion chemical concentrations, percent moisture, lipid content, size/age, life history stage.	Bioaccumulation processes.

Apart from the technical or technological constraints other limitations exist, including the acceptance of the resource by the end-users, which is not as simple as it seems (see Table 5). There are several reasons for this, from the willingness to pay for a “second hand” resource to the fear that the market will not accept a product irrigated by reclaimed water.

Table 5

Reclaimed water as a resource: planning aspects, stakeholders, opinions and concerns.

Subject	Identification	Observations
Engineering.	Capacity to identify and solve any problem during reclamation and reuse project definition.	Research/adaptation is required to the new technologies and improvement of the existing ones.
Economy.	Economic feasibility of the project, from construction to the O&M and control costs.	Willingness/capacity to pay for the resource.
Rules and regulations.	Existing or future.	If existing, allow for good planning procedure when defining quality and allowed uses of water.
Environmental Impact Assessment.	Compulsory or volunteer impact assessment of reclaimed water use.	All environmental matrices should be considered (including man).
Social features: public acceptance.	The idea of reuse must be accepted by the users and stakeholders.	Key issue for the project being accepted and implemented. Several factors must be identified: mainly socio-cultural and educational.

Subject	Identification	Observations
Administration support.	Several administrative levels must support and accept the projects (local, regional, state, etc.).	It is suggested that decisions be taken by fewer entities, otherwise project feasibility cannot be guaranteed.
Financial tools.	Method of project and activity financing is important (including payment for the water).	Subsidies, taxes, credit lines, must be carefully identified in the planning phase before the start of a project. Otherwise, viability of the project is extremely compromised.
Operation and management capacity.	Technological capacity to maintain operational and reliable water treatment facilities.	Absolutely necessary for every project: energy, qualified workers, parts, etc.
Control capacity.	Availability of control tools (including chemical, biological, toxicology, etc.) for products, facilities, indirect problems, etc.).	Even in highly developed countries not all technologies are available (e.g., full control of viruses or parasites).

2. RULES AND REGULATIONS: WASTEWATER RECYCLING AND ENVIRONMENTAL IMPACT

Only in a few countries and states has water reclamation and use become well-established and the value of reclaimed water fully recognized. In these areas, laws and regulations mandate water reuse under certain conditions (Salgot and Angelakis, 2001). Regulations refer to actual rules that have been passed and are enforceable by governmental agencies. Guidelines are not enforceable but can be used in the development of a reuse programme (Angelakis and Asano, 2000; Angelakis and Bontoux, 2000).

As for any activity related to the environment, environmental impact studies, standards, criteria, rules, guidelines, good practises, risk assessment and management, and other measures which try to regulate wastewater reclamation and use, must be prepared and, following actual policies, made public prior to adoption. This activity may generate comments from the public and organizations, and subsequent modifications can influence, often decisively, the type of criteria which will finally be published and enforced.

When legal extracts or recommendations related to water recycling are fixed, it is established that wastewater reclamation is necessary, thus guaranteeing the desired quality of water. Reclamation and use (recycling) go together in any type of operation of this kind which is legally made and planned.

At this point, it is necessary to state that the development of theoretical tools for the safe use of reclaimed wastewater and for other environmental related activities has several focuses:

- in the field of wastewater reclamation and use, the United States, Israel, and Australia as countries and WHO as an organization have been the leaders. Up to now, there has been no common EU policy on wastewater recycling which is, perhaps, the cause of the strong difference on water resources availability and demands among the northern and southern countries of the Union; and

- EU and the USA have been taking a leading role in environmental impact.

In Europe, the EU has been taking a leading with respect to Environmental Impact studies because of:

a) the ever increasing exchanges between all Mediterranean countries;
b) the different development conditions; and
c) the rulemaking capacity.

2.1 Wastewater reclamation and use

Water is essential to society and is increasingly used for agricultural irrigation, especially in arid or semi-arid climates where good conditions for crop development exist. For this reason, it seems logical that agricultural irrigation predominates in water reuse. This is why regulations issued for reclaimed water use are mainly developed for agricultural irrigation. In this case, recycling criteria focus principally on sanitary and environmental protection and refer to (Crook, 1998):

- wastewater (reclamation) treatments;
- reclaimed water quality;
- treatment reliability;
- distribution systems; and
- control of areas where reclaimed water is used.

The traceability of several products irrigated with reclaimed water has begun to be questioned and there is discussion on the necessity to include quality parameters relative to the “agriculture-related” quality of water in reuse regulations or laws (e.g., salinity). Since the main scope of criteria is to protect public health, it seems unreasonable to include agricultural characteristics in the norms, but this is not a unanimously accepted statement.

For uses other than irrigation, guidelines or regulations are not so well developed, mainly because there are less reuse cases and opportunities. There are some records in relation to groundwater recharge, aquaculture, and cooling or other industrial uses (Asano, 1998).

The acceptability or adequacy of reclaimed water for any specific use depends on its physical, chemical and microbiological quality and mainly on the sanitary risk related to this quality. The infrastructure for reuse includes the wastewater treatment and reclamation facilities, the distribution network, and the storage facilities, if necessary or compulsory. One obvious measure is the assessment of treatment reliability and of the entire reuse infrastructure. The design and performance of distribution systems are important to guarantee that reclaimed wate r does not degrade before its uses and is not used improperly. Open-air storage can result in water quality degradation due to micro-organisms, algae or suspended solids, and it can cause bad odours or give colour to reclaimed water. Nevertheless, if properly managed, open storage systems can improve the quality of the resource (Salgot and Angelakis, 2001).

Control of the areas where reclaimed water is used is paramount to reduce sanitary and environmental risks. It must be reiterated that risk and environmental impact reduction to acceptable levels is to be the final objective of all guidelines and regulations related to the reuse of water (Vergès and Salgot, 2003).

When considering wastewater recycling, any prospective user must know the legal, social, and economic limitations existing in his country. Regulations can be based on the establishment of the end-product quality criteria or in the definition of the reclamation equipment of wastewater (compulsory or as a reference). Discussion arises when considering whether the end product is the reclaimed water or the goods that are produced using such water (lettuces, fruits, etc.). In any case, equipment and regulations could be complemented by using additional tools, like Good Reuse Practises (GRP), HACCP systems (Hazard Assessment and Critical Control Points), or similar.

In some non-agricultural wastewater reclamation practises, different legal problems can arise, usually related to the water resources legislation of the country. For example, when groundwater is recharged with reclaimed water, it must be clear who the water owner is in order to avoid future problems. In non-coastal areas and arid climates it may happen that urban treated or untreated wastewater is the only water that flows in the streams. The users downstream rely on that flow and have rights to it. In those cases, it is not feasible to use wastewater upstream for other purposes.

Legal dispositions could have a different rank. In some cases, regulations have legal status (California, Italy), and are more enforceable than recommendations (e.g., WHO, 1989; US EPA, 1992 and 2004).

Usually, reclaimed water quality is fixed, almost always independently from other considerations, using standards. Standard figures must depend on several concepts, such as (Salgot and Angelakis, 2001):

(1) economic and social circumstances;
(2) legal capacity from the different entities and implicated administrations;
(3) human health/hygienic degree (endemic illnesses, parasitism);
(4) technological capacity;
(5) previously existing rules and/or criteria;
(6) crop type;
(7) analytical capacity;
(8) risk groups possibly affected;
(9) technical and scientific opinions;
(10) environmental impacts, including impacts on modified ecosystems; and
(11) other miscellaneous reasons.

From these, five types of factors can be initially distinguished:

1) socio-economic: the main budgetary limitation for reclamation and use is the cost associated with the advanced treatment methods needed to reach the qualities established in the regulations, and with the costs for water storage and distribution. The cost related to the compulsory analytical tasks necessary guarantee that reclaimed water fulfils the desired and required quality, should also be included;
2) legal aspects: establish the basic conditions for reuse, and could also refer to liability, taxes, penalties and other related aspects. There are different types of legal extracts, more or less enforceable or just recommendations. Administrative permissions must be included here;
3) health and hygiene: the sanitary conditions of the population where reuse will be carried out is extremely important because the biological quality of the wastewater depends on it. The incidence and prevalence of parasitic, viral or bacteriologic illnesses is reflected in the wastewater quality, even in reclaimed wastewater (Touyer, 1997). Health education, especially for the population that will use the reclaimed water, can contribute to the reduction of the risk inherent to the practise;
4) technical or technological: it is important to identify, on a case-by-case basis, realistic outcomes of wastewater treatment processes; both conventional (secondary) and advanced (including disinfection) must be considered. They should be studied from different points of view, especially technological and technical capacity. With regard

to the type of treatment, several standards and recommendations indicate methods of reference capable of reaching a microbiological quality good enough for reuse without additional treatment. In other cases, physico-chemical treatments plus disinfection are advocated; but other types are being studied. Disinfection is a basic tool in this case; and

5) other considerations: the parameters mainly described in regulations are the biological ones, especially coliforms and nematode eggs. Viruses and protozoa are seldom included. Nevertheless, it seems necessary to determine whether other non-biological (chemical) parameters exist that can influence the health risk derived from reuse practises.

All these standards and quality regulations have been a matter of discussion among scientists, health and legislation stakeholders, engineers, etc., because of the numerical expression of such standards and secondly because of the parameters to be controlled. Much discussion has been taking place among research teams and regulating bodies, even from the same country, on the quality that reclaimed water must meet for reuse with an acceptable risk degree. A summary of this can be found in Table 6.

Existing laws, rules and regulations could have been issued, as explained previously, from two different points of view:

a) the water qualities approach; and
b) the uses approach.

When using the water quality approach, a number of water qualities are designed and possible uses are defined for each. If the uses approach is preferred, then for each use a given quality is defined.

It should be mentioned that either the number of uses or the qualities are strictly limited. Some time ago, the Spanish Government (CEDEX, 1999) prepared a decree (finally not issued) with 14 possible uses defined (see Table 7). For each use, a defined water quality was given. On comparing the qualities, five types of water could be defined.

As a result of this unpublished decree, the regional Catalonian Government (ACA, 2003) prepared its own version containing five water qualities, and the possible uses of each quality are defined later in this document.

It seems to be commonly agreed that rules or recommendations cannot rely on such a number of uses, and it would easier to establish several groups for the different types of reuse. There is an initiative in Spain in this regard, as indicated in Table 8.

With respect to the quality of reclaimed water, nowadays the parameters in use for defining reclaimed water quality are very few and are almost always devoted to health-related hazards. As pathogenic organisms, it is possible to find (Campos, 1999):

- bacteria;
- viruses;
- helminth-nematode;
- other helminths;
- protozoa;
- fungi; and
- algae (toxins).

<u>Table 6</u>

Factors to be considered in recycling programmes, with influence on legislation.

Factor	**Comments**
Economic and social circumstances.	Socio-economic circumstances of the country. Comparison of prices with “first-hand” water. Costs associated with the reclamation procedure (including treatment, storage, distribution, analysis, etc.). Political priorities for the use of reclaimed water. Public and official acceptance. Communication policies. Marketability of products.
Administrative factors.	Water concessions, permits, disposal authorizations, control tasks, etc.
Health and hygiene factors.	Sanitary condition of the population. Workers’ health. Health/sanitary education (public, administrative officers, people implied).
Technical/technological capacity.	Realistic outcomes of wastewater treatment processes. Reference treatments (e.g., lagoons, activated sludge, etc.). Disinfection procedures. Relative cost of treatments. Reliability. Wastewater treatment facilities building, operation and maintenance capability.
Analytical capacity.	Nowadays, mainly devoted to “bacterial” parameters. Virus, nematode eggs and protozoa are to be determined. Chemicals are increasingly being considered (especially microcontaminants): toxicity and ecotoxicity.
Type of irrigation/crop.	Will determine the biological quality accepted. To differentiate the final use of the irrigated crop (landscaping, sports fields, food to be eaten uncooked, etc.).
Risk assessment.	Comprehensive tool for control: HACCP systems are to be implemented.
Laws, rules and criteria.	To be determined for each specific site. Implementation of Good Reuse Practises. Precautionary principle implementation.
Administrative controls.	The real use of reclaimed water is to be controlled (authorized uses). Who will perform the quality and use controls?
Environmental impacts. Miscellaneous reasons.	Relationships of the reclamation site to the surrounding environment. Both positive and negative impacts should be considered. Apply/Issue rules and regulations adapted to local conditions.

Table 7

Categories of reclamation depending on final use. Adapted from CEDEX, 1999.

Number of use	Type of reclaimed water use
1	Residential uses: private garden irrigation, toilet flushing, home air-conditioning systems, car washing.
2	Urban uses and facilities: irrigation of open access landscape areas (parks, golf courses, sports fields, etc.), street cleaning, fire-fighting, ornamental impoundments and decorative fountains.
3	Greenhouse crop irrigation.
4	Irrigation of raw consumed food crops. Fruit trees sprinkler irrigated.
5	Irrigation of pasture for dairy or meat animals.
6	Irrigation of crops for the canning industry and crops not raw-consumed. Irrigation of fruit trees except by sprinkling.
7	Irrigation of industrial crops, nurseries, fodder, cereals and oleaginous seeds.
8	Irrigation of forested, landscape and restricted access areas. Forestry.
9	Industrial cooling, except for the food industry.
10	Impoundments, water bodies and streams for recreational use in which public contact with the water is permitted (except bathing).
11	Impoundments, water bodies, and streams for recreational use in which public contact with the water is not permitted.
12	Aquiculture (plant or animal biomass).
13	Aquifer recharge by localized percolation through the soil.
14	Aquifer recharge by direct injection.

As indicated in Table 9, there are a few indicator organisms. TC, FC and *E. coli* are in full use, especially the second and third. The main problem arising in this instance is the lack of significance of coliforms as indicators for viruses and other pathogens.

Up until now, viruses have to be determined directly, although it seems that bacteriophage could be a good indicator if a general agreement could be reached on this possibility. Although one would assume determination of the presence pathogenic to be a necessity, there are few rules requiring it.

The WHO and a number on non-US rules and regulations establish the need to determine Nematode eggs (of three species) in reclaimed water to be used. Nevertheless, as Asano (1998) indicates, the determination of nematode eggs, unless performed in really contaminated wastewater, is a frustrating and expensive control. It appears that the rules are to establish the presence and not the viability of the eggs. The indication to determine the eggs of *Taenia* species if reclaimed water is to be used for irrigation of fodder crops, can be rarely found.

Table 8

Latest initiatives in Spain on groups and types of reuse.

Group of uses	Types of use included
1. Urban uses.	1.1. Residential (home) uses: private garden irrigation, toilet flushing, domestic air conditioning, car washing.
	1.2. Urban uses and services: irrigation of public urban green areas reg (parks, sport fields, etc.), street cleaning, fire fighting watering schemes, fountains and other ornamental water.
2. Agriculture uses.	2.1. Greenhouse crops. Irrigation of crops to be consumed uncooked. Fruit trees sprinkler irrigated.
	2.2. Irrigation of fodder for cattle producing meat or milk. Irrigation of crops destined to be canned and other crops to be consumed after cooking. Fruit tree irrigation except with sprinkler. Ornamental flowers irrigation. Aquiculture.
3. Industrial uses.	3.1. Industrial air cooling, except the agrofood industry.
4. Environmental and leisure uses.	4.1. Golf course irrigation.
	4.2. Ponds, streams and other water bodies, for recreational purposes where public access is allowed, bathing.
	4.3. Ponds, streams and other water bodies, for recreational purposes where public access is not allowed.
	4.4. Woodland, green areas and other areas not accessible to the public.
5. Groundwater recharge.	5.1. Groundwater recharge by localized percolation through the soil.
	5.2. Groundwater recharge by direct injection.

Protozoa are beginning to be considered a matter of concern in wastewater recycling. The determination of *Giardia* cysts and *Cryptosporidium* oocysts is not easy and, for the moment, is very expensive and subject to a lot of false positives.

Additional studies are required to determine the real incidence (if any) of fungi and algae in wastewater reclamation and use.

Finally, it seems that a novel development in studies could be the development of bio-indicators for environmental impacts and toxicity problems.

From all the explanations obtained, the conclusion reached is that the use of standards is absolutely necessary under present conditions; the quality of reclaimed water should be set by such standards, independent of other considerations.

Table 9

Pathogenic and determined organisms (index organisms) and indicators in water recycling.

Organism	Indicator/s	Comments
Bacteria.	Coliform group: Total. Coliforms (TC), Faecal. Coliforms (FC), *E. coli.*	Mainly used FC and *E. coli.* Not good indicators for other organisms.
Viruses.	Enteroviruses (direct determination). Bacteriophage (indicators).	Bacteriophages are now being investigated as indicators for viruses and bacteria.
Helminth-nematode.	n.a. (*Clostridium* spores are under study).	*Ascaris*, *Trichuris* and *Ancylostoma* are the three species mainly determined (by searching for eggs); but cannot be strictly considered as indicators.
Other helminths.	n.a.	*Taenia* species are sometimes indicated for animal transmission research or determination.
Protozoa.	n.a.	*Giardia* cysts and *Cryptosporidium* oocysts are determined. Alternative PCR techniques are being introduced.
Fungi.	n.a.	Under study.
Algae.	n.a.	Algal toxins are of concern.
Bio-indicators.	n.a.	Free-living or cultured organisms are used for determination of impacts for toxicity / ecotoxicity studies.

n.a. not applicable.

2.2 Environmental impact

As indicated above, there are two main focuses for environmental impact regulations, EU and the United States. As the approach in both cases is relatively similar and a basic explanation of the US approach has been covered in Part 1, we will focus exclusively on Europe.

The Commission of the European Communities (CEC) Directive 85/337/EEC came into force in 1988 and was updated and amended by Directive 97/11/EC. The Commission decided that the (EIA) system should promote two sets of objectives (Jain *et al.*, 2002):

1. to avoid distortion of competition and misallocation of resources by harmonizing environmental controls; and
2. to ensure that a common environmental policy is applied throughout the EEC.

Several statements are important for our purposes (wastewater reclamation and use):

In Article 3: the environmental impact assessment shall identify, describe, and assess in an appropriate manner, in the light of each individual case, and in accordance with articles 4 to 11, the direct and indirect effects of a project on the following factors:

- human beings, fauna and flora;
- soil, water, air, climate, and the landscape;
- material assets and the cultural heritage; and
- the interaction between the factors mentioned in the first, second, and third indents.

In Article 5, point 3: the information to be provided by the developer … shall include at least:

- a description of the project, comprising information on the site, design and size of the project;
- a description of the measures envisaged in order to avoid, reduce, and, if possible, remedy significant adverse effects;
- the data required to identify and assess the main effects, which the project is likely to have on the environment;
- an outline of the main alternatives studied by the developer and an indication of the main reasons for his choice, taking into account the environmental effects; and
- a non-technical summary of the information mentioned in the previous indents.

There are additional Directives and other legal extracts referring to environmental impact. A short description can be found in Table 10 and in Appendix 1.

Jain *et al.* (2002) provided an insight into the different evolutions of EIA all over the world, summarized in Table 11.

Table 10

Summary of environmental legislation and EU directives related to environmental impact.

Document title	**Number/ Reference/Date**	**Contents/Subject Matter or Objectives**
(EIA) Environmental Impact Assessment Directive.	85/337/EEC 27 June 1985.	Assessment of the effects of certain public and private projects on the environment.
Council Directive amending Council Directive 85/337/EEC.	97/11/EC 3 March 1997.	Amends Directive 85/337/EEC.
SEA (Strategic Environment Assessment) Directive.	2001/42/CE 27 June 2001.	The purpose of the SEA Directive is to ensure that environmental consequences of certain plans and programmes are identified and assessed during their preparation and prior to adoption. The public and environmental authorities can give their opinion. The public is informed on the final decision.
Directive providing for public participation in respect of the drawing up of certain plans and programmes relating to the environment, and amending with regard to public participation, and access to justice Council Directives 85/337/EEC and 96/61/EC.	2003/35/EC 26 May 2003.	The objective of the directive is to contribute to the implementation of the obligations arising under the Aarhus Convention, in particular by: (a) providing for public participation in respect to the drawing up of certain plans and programmes relating to the environment; and (b) improving public participation and providing for provisions on access to justice within Council Directives 85/337/EEC and 96/61/EC.
Directive on environmental liability with regard to the prevention and remedy of environmental damage.	2004/35/CE 21 April 2004.	To establish a framework of environmental liability based on the "polluter-pays" principle, to prevent and remedy environmental damage. Will guarantee the prevention and repair of the damage caused to the environment (water resources, soil, fauna, flora and natural habitats) as well as the liability of the polluter.
Implementation of Directive 2001/42 on the assessment of the effects of certain plans and programmes on the environment.	Not dated.	Strategic Environment Assessment (SEA) Directive clarification.

Document title	Number/ Reference/Date	Contents/Subject Matter or Objectives
Report from the Commission to the European Parliament and the Council on the application and effectiveness of the EIA Directive (Directive 85/337/EEC as amended by Directive 97/11/EC). How successful are the member states in implementing the EIA Directive.	Not dated.	Five-year report: summary of findings and actions to be taken, and the five-year review with detailed information on the issues regarding the application of the EIA Directive, prepared on the basis of answers by information provided by the Member States.
Communication from the Commission. Science and Technology, the key to Europe's future – Guidelines for future European Union policy to support research.	COM (2004) 353 final 16 June 2004.	Supporting the Union's political objectives. Topics should be given particular attention, especially with regard to collaborative research: health, consumer protection, energy, the environment, etc.

Table 11

Summary of EIA state-of-the-art around the world, modified from Jain *et al.* (2002).

Country	Title/year	Comments
Canada.	Federal and provincial laws/1973.	Well-developed.
Philippines.	Presidential Decree/1977.	EIA requirement, not so much and incorrectly applied.
Korea. Brazil.	Environmental conservation Law of 1980. National Environmental Policy Law /1981.	Centralized EIA system, only for large projects. Unclear and hardly applied.
Australia, Japan.	Specific legislation for EIA.	
Iran, Malaysia, Hong-Kong, New Zealand, Republic of Korea, Thailand, Colombia, Venezuela, Mexico.	General legislation; no EIA specific.	Empowers a government agency to require EIA for particular projects.
Bangladesh, Indonesia, India, Pakistan, Sri Lanka, Papua New Guinea.	No requirements.	Informal procedures to incorporate environmental consideration in the planning of specific projects.
Nepal, Afghanistan, Fiji, Uruguay, Perú. Argentina.	Lack of any formal requirement. Does not require.	 Voluntary EIA studies are encouraged.
EIA in Europe.		See Appendix 1 and Table 9.

3. APPLICATION OF THE DIFFERENT RECLAIMED WATER USE POSSIBILITIES

Reclaimed wastewater can be used for several purposes; all of which have special characteristics that exert a strong influence on the environmental impact analysis derived from the reuse.

Because the number of reuse options is high (see Table 6 in Part 2), the main ones will be further studied and simple insights provided into those which are less common:

- irrigation (non-urban);
- groundwater recharge;
- urban reuse; and
- other.

The relevant characteristics of environmental impact on the reuse possibilities are described below. It should be noted that reclamation systems are not considered.

3.1 Irrigation (non-urban)

In most regions of the world, insufficient water is the prime cause of limitation on agricultural productivity. In semi-arid or arid regions, intensive crop production is all but impossible without supplementing the meagre rainfall provided by nature (Brady and Weil, 1999). Irrigation can cover the total plant watering, or just be supplementary. In the first instance, all water needed by the plant is provided by irrigation. This happens in extremely arid areas or when the growing season coincides with the dry season.

In other instances, water is provided when there is insufficient rain during the growth period. Irrigation is to be used in:

- landscaping: golf courses, home lawns, flower beds, public parks, etc., and
- food and wood (biomass) production.

3.1.1 Classical irrigation

The water used for expanded irrigation comes largely from reservoirs and the pumping of groundwater out of deep aquifers (Brady and Weil, 1999). Among the problems facing irrigated agriculture in the future is the slowly dwindling availability of irrigation water from both of these conventional sources. The reasons for reduced availability include:

- increased competition for water from a growing population of urban water users and industry;
- over pumping of aquifers that has led to falling water tables;
- reduction of storage capacity of existing reservoirs by siltation with eroded sediments; and
- increased recognition of the need to allow a portion of river flows to go unused by irrigation in order to maintain fish and other habitats downstream.

When studying irrigation, various methods of water-use efficiency are employed to compare the relative benefits of different irrigation practises and systems. A simple measure of water-use efficiency compares the amount of water allocated to irrigate a field to the amount of water actually used by the irrigated plants. In this regard, most irrigation systems are very inefficient, with as little as 30 to 50% of the water that is taken from the source ever reaching the plant roots (Brady and Weil, 1999). Further consideration should be given to the type of irrigation and possibility of adapting some or all irrigation systems so that unused water is captured for reuse. At present a lot of reclaimed water is not used and lost by runoff.

It is then necessary to consider the types of irrigation (modified from Brady and Weil, 1999) in order to establish impacts:

- <u>surface</u>: water is applied to the upper end of a field and allowed to distribute itself by gravity flow. The water can also be distributed in furrows graded to a slight slope; or in border irrigation systems the land is shaped into broad strips. Part of the water is lost by evaporation and the rest can percolate, be lost by runoff or become tail water;

- in <u>sprinkler</u> irrigation, water is sprayed through the air onto a field, simulating rainfall. Thus, the entire soil surface, as well as plant foliage (if present) is wetted. 5 to 20% of the water is lost by evaporation or windblown mist as the drops fly through the air. A small amount can also percolate, be lost by runoff or become tail water; and

- microirrigation: only a small portion of the soil is wetted by these systems. The best established system is drip (or trickle) irrigation, in which tiny emitters attached to plastic tubing apply water to the soil surface alongside individual plants. In some cases, the tubing and emitters are buried 20 to 50 cm deep so the water soaks directly into the root zone. In either case, water is applied at a low rate (sometimes drop by drop) but at a high frequency, with the objective of maintaining optimal soil water availability in the immediate root zone while leaving most of the soil volume dry. Other forms of microirrigation that are especially well adapted for irrigating individual trees include spitters (microsprayers) and bubblers (small vertical standpipes). The bubblers and spitters require that a small level basin be formed in the soil under each tree. In this case, really few amounts of water are being lost.

There are two main serious problems related to the quality of water being applied and to the efficiency of the irrigation water in stimulating plant production (Brady and Weil, 1999):

- salinity buildup. Most irrigation systems are located in semi-arid and arid regions, where the levels of soluble salts in the drainage water and, in turn, in the streams and rivers are relatively high. When this water is added to the soil and percolation takes place, still more salts are dissolved from the soil itself, making the drainage water even more saline than the originally added water. As the drainage water is repeatedly used downstream, the salt buildup in the water can become very damaging to both the physical and chemical properties of the soils to which the water is applied; and

- efficient water use. Practises to enhance water-use efficiency must begin with the collection of water in watersheds and the careful pumping of water from aquifers. Next, distribution canals must be lined or replaced with pipelines to avoid the major losses that occur before the water even gets to the farm field. The most efficient irrigation system feasible must be selected and kept in top operating conditions. In the field, the use of crop residues or mulches to reduce evaporation from the soil surface while simultaneously reducing the soil temperature can also enhance overall productivity and water-use efficiency.

It should be established that with the same water quality, the selection of an irrigation system with high water use efficiency can reduce the negative impacts in some cases.

3.1.2 Reclaimed water irrigation

When dealing with treated wastewater (reclaimed water) for irrigation, there are several statements to be considered:

a) Types of irrigation

Because the risks derived from wastewater use are derived from contact with the environmental matrix and man, the systems which reduce that contact must be the most adequate. Therefore:

- surface irrigation promotes contact with the plants irrigated. If the plant is of vegetable type (e.g., lettuce) there is direct contact and hazards are increased;
- sprinkler irrigation promotes the formation of aerosols, and consequently the dispersion of micro-organisms, especially with strong winds. Additionally, pathogens could easily reach the surface of the plant, thus increasing the risk; and

- microirrigation/localized irrigation can reduce contact with the plant, especially when using buried equipment. Microsprayers, on the other hand, increase the risks as indicated for sprinklers.

b) Salinity buildup

When using reclaimed water the salt content is greater than in the “original” water. Salt increases are caused mainly by human excreta and domestic activities, industries, salty water entrance into the sewerage, and also by evaporation. This results in the problems associated to the salinity increase. Surface irrigation tends to counteract the problem because of associated soil leaching, while microirrigation increases localized salt contents, due to the scarce amounts of water applied which do not leach the soil.

c) Nutrients

If wastewater has not been treated for the elimination of nutrients, the contents of N and P must be considered and deducted from the amount of fertilizers; otherwise salinity problems are increased and groundwater contamination can appear.

Depending on the type of irrigation used (see Table 12), several aspects must be considered:

1. Agriculture

For food-crops, there is the need to avoid contact of the edible part with reclaimed water.

For non-food crops, no important specific inconveniences are described. Trees usually grow fast and without wood problems if the amount of water provided is adjusted to the needs of the species.

In both cases, formation of aerosols should be reduced to a minimum and work should not be carried out when strong winds prevail.

2. Landscape (non-agricultural)

The impact on golf courses could be due to the type of irrigation (entirely by spraying) and the possibility of contact with the players and neighbouring residents. Care must be taken with the runoff and irrigation should not be performed in very windy conditions and when there are no players on the course.

For landscape and forest irrigation, it must be ensured that there is no entry to the sites - at least while irrigating - and that no wildlife is affected by the changes or diseases caused by the reclaimed water application. Runoff is again to be controlled.

Table 12

Irrigation uses of reclaimed water, modified from Brissaud *et al*., 2004.

Type of use	Specific use	Water quality
Agriculture.	Food crops.	For reclaimed water: rules or regulations. River water and freshwater do not usually have quality-related rules.
	Non-food crops.	
	Aquaculture (biomass).	Specific recommendations (WHO).
Non-agricultural irrigation.	Golf course irrigation.	For reclaimed water, as indicated by rules or regulations. Freshwater does not usually have quality-related rules.
	Landscape.	
	Forest.	

3.2 Groundwater recharge

When referring to groundwater recharge, there is always artificial recharge. The definition of artificial recharge is: the techniques or operations which have the main objective of allowing better aquifer management by increasing the water resources and creating reserves, by means of a direct or indirect intervention in the natural water cycle (Custodio and Llamas, 1996). Groundwater recharge is, so far, not recommended by WHO because there is not enough scientific evidence that there are no health risks.

Among the main objectives of the recharge, there are several related to recharge with reclaimed water:

- supplement available groundwater resources;
- reduce or eliminate (even increase) groundwater level drop;
- compensate natural recharge lost by human activities;
- improve the coastal aquifer situation;
- use aquifers as a storage media for water, instead of using surface facilities;
- improve joint uses of surface and groundwater;
- avoid the movement of bad quality waters inside the aquifer;
- increase availability of good quality water through blending;
- increase leaching of salts and other contaminants;
- use the soil aquifer system for wastewater treatment;
- reclaim treated wastewater, store it, and complete the treatment using the soil/aquifer system;
- reduce, mitigate or even eliminate subsidence caused by overexploitation of groundwater;
- compensate negative effects of hydraulic and civil works;
- maintain flows in a stream or levels in lakes during low waters; and
- use the aquifer as a water transportation media.

There are basically two types of groundwater recharge/application:

- on-surface (indirect, over the soil); and
- deep injection (direct injection onto the aquifer).

On-surface irrigation has the advantage of employing the treatment capacities of the soil, which constitutes and additional barrier, while direct injection has the main disadvantage of introducing water directly into the aquifer. Direct injection is considered more hazardous than indirect (Table 13).

Table 13

Groundwater recharge uses of reclaimed water. Modified from Brissaud *et al*., 2004.

Type of use	**Specific use**	**Observations**
Groundwater recharge.	Direct recharge.	Potable quality if treated for domestic uses. Pre-potable if other source.
	Indirect recharge.	Through soil formations.

There are several surface works that can be employed for recharge:

- lagoons or ponds;
- channels, trenches or furrows;
- pits;
- areas for surface infiltration; and
- river bed actuations.

Deep works, for direct injection or entering are:

- wells;
- absorption or diffusion wells;
- drains or galleries in the bottom of a well;
- trenches filled with gravel reaching the phreatic level; and
- natural sinks, ravines or fissures in karst areas.

Possible problems can be attributed to:

- reduction of recharge capacity;
- social acceptance;
- pollution of aquifers used for potable water supply;
- hazard/risk increases; and
- extraction abuses.

In both cases, reduction of the recharge capacity (clogging) can be attained by soil surface alterations, addition of too much suspended matter, or biological activity. The causes of clogging are usually the presence of suspended solids and/or gas bubbles in the recharge water or bacterial growth in and surrounding the well. Other causes can be chemical precipitations in the water, soil and well; clay swell or dispersion, and soil structure erosion and subsequent aquifer obstruction.

Once reclaimed water reaches the aquifer, there are several phenomena which can occur:

- organic matter reduction;
- water odour and taste correction; and
- adsorption of some organic matter compounds.

It should be noted that reaction in saturated media is much slower than in non-saturated media. In addition, bacterial flora in groundwater is usually scarce.

In general, groundwater recharge presents several disadvantages:

- huge (surface) application areas are needed;
- if reclaimed water is injected, energy is necessary;
- recharge increases groundwater pollution risks;
- not all water added can be recovered;
- great surface demand for the system to be operative;
- instant demands cannot be satisfied (low rate answer) ; and
- problems with legal status of the water.

3.3 Urban reuse

Water in urban areas is used for several purposes; mainly domestic, but also for cleaning streets, managing sewerage systems, landscaping and cleaning streets, etc. It should be said that in several areas of the world, the possibility of using reclaimed water for drinking purposes has been considered (e.g., Lauer and Rogers, 1998), but only in Windhoek (Namibia) was it implemented some 30 years ago and is well documented (Van der Wal, 2002).

In urban systems, several types of water coincide in time and in space. For example, there is water supplied to houses, wastewater, systems for supplying other qualities of water, or water present in the cities due to other circumstances (irrigation, temperature conditioning, groundwater and surface waters, stormwater, runoff, seawater, etc.). All such types must be managed in an integrated way, which is not always easy, mainly because of the hazards generated when “tapwater” is mixed, purposely or not, with the other types.

The two main water-related systems in practically all urban environments are the water supply (theoretically absolutely safe to drink) and the wastewater system (the sewerage). However, other factors exist, like the management of stormwater. The problem is even greater in coastal urban areas where the management of wastewater and stormwater is inextricably linked to overall coastal management objectives. While wastewater and stormwater management constitute an immense enterprise, they take place in the context of a multitude of other human activities and natural processes within the coastal zone (NRC, 1993).

Most coastal water-quality problems result from human activities associated with populations concentrated along the coasts. As the population grows, the world becomes increasingly urbanized, and people are concentrated along the coasts or beside lakes and rivers. Usually, sewerage systems (with or without wastewater treatment) discharge into the sea or existing water bodies, and sometimes create new streams or small lakes. Nevertheless, the total quantity of direct discharges to waters (streams, lakes, bays, estuaries and the open ocean) from municipal and industrial facilities does not tell the whole story. There are inputs from a variety of other sources. Urban, industrial, and agricultural runoff, as well as pollutants, discharge into rivers upstream of coastal areas or lakes, have all been recognized as significant sources of pollutants to all types of water (surface, groundwater, seawater). In general, the volume of runoff and amount of debris and contaminants in runoff increases with increasing urbanization and suburbanization.

Municipal wastewater comes from a variety of sources including households, schools, offices, hospitals, and commercial and industrial facilities. Stormwater runoff comes from streets, parking lots, roofs, lawns, commercial and industrial developments, construction sites, farmland, forests, and a number of other settings (NRC, 1993).

As stated, a lot of urban water uses can be defined (see Table 14). Not all of the mentioned uses require an extremely high water quality, and the desideratum should be the use of adapted water qualities; i.e., use water depending on the quality demands of the use.

Table 14

Urban water uses; modified from Brissaud *et al.*, 2004.

Type of use	Specific use	Water quality
Urban domestic "potable"*.	Drinking. Hygiene.	Maximum quality (suitable for drinking purposes).
	Cooking/food-related.	
Urban commercial.	Drinking, cooking and hygiene in hotels, restaurants, and similar.	
Urban fountains.	Drinking.	
Urban "general" not for drinking but related to domestic.	Air conditioning.	*Legionella* absence. Conditioned for non-scaling.
	Toilet flushing.	Disinfected.
Urban not domestic.	Fire protection.	Disinfected.
	Irrigation of public spaces.	
	Irrigation of private spaces.	
	Urban cleaning (streets, etc.).	
	Sewerage management.	Secondary treatment of wastewater.

* Several agencies and international organizations never contemplate this use, because they consider the associated risks to be unacceptable.

Part of the defined uses can be also included under the term 'landscaping', or more generally, 'irrigation' (public and private spaces irrigation), which has been explained above.

Water is usually supplied to urban systems with a unique quality, the maximum quality, i.e., potable. From an economic point of view, it means a waste of resources and money.

The question arises, what role should reclaimed water play in this complex water-related system?

There are several possible cases. In great urban areas, even in the Mediterranean, it could happen that due to the abandonment of urban aquifers, the water table is rising. In such instances, reclaimed water use is illogical and it is not practised. In other towns, the aquifer is overexploited and does not reach the city. Reuse in this instance makes good sense because water scarcity counsels it. Another feature that causes economic concern is the need to establish a dual distribution system in towns. However, this would not be feasible in the old parts of cities as the disadvantages would easily outweigh the benefits. It should be considered for areas where there are new building developments, or in new great buildings.

It is important to note that reused water should only be used for drinking, or other uses which call for potable quality, as a very last option, even if this practise meets with positive reception.

The main uses for reclaimed water in towns seem, at present, to be irrigation of green spaces (parks) or cleaning processes.

3.4 Other types of reuse

There are many other possibilities for the reuse of water in modern society. A number of them are listed in Table 15.

Table 15

Water uses other than urban, irrigation or groundwater recharge; modified from Brissaud *et al.*, 2004.

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Type of use	Specific use	Water quality
Industry.	Food-related.	Tapwater quality.
	Pharmaceuticals and similar.	
	Cooling water*.	Constituents related to scaling, corrosion, biological growth, and fouling to be controlled. *Disinfection for *Legionella.*
	Boiler feed. Process water.	
	Heavy construction.	
Livestock.	Watering and dairy operations.	Should be “potable”.
	Fish farming.	Specific rules (WHO) for the use of reclaimed water.
Water-related sports, leisure activities.	Contact allowed.	Specific rules for bathing water quality.
	Contact not allowed. Snowmaking.	Specific rules and regulations if reclaimed water is used.
Stream and water body recharge.	Habitat wetlands.	Toxicity for aquatic and water-related wildlife.
	Lakes and ponds.	
	Enhancement of marsh and similar.	
	Stream flow augmentation.	
Hydroelectric power use.	Power generation.	No need for quality rules but management of resources are essential.

The possibility exists to use reclaimed water instead of other supplies for several types of use. Those indicated are not the main ones, which use a significant amount of water resources, except for industry and livestock. The consumptive or non-consumptive character of each use should be taken into account.

It must be noted that hydroelectric use is an “extreme” non-consumptive use, i.e., water passes through turbines but is immediately returned to the environment. Quality is of no importance in this instance.

4. PROSPECTIVE: DEVELOPMENT OF THE RELATIONSHIP ENVIRONMENTAL IMPACT/RECLAIMED WATER USE

Wastewater reclamation and reuse will increase over the next decades, from an activity localized in a reduced amount of countries and/or regions to a widespread practise all over the world.

In some instances, reuse is to be put into practise because of the scarcity of water resources, which is practised in arid or semi-arid regions, where water resources are unbalanced, clearly “against” the demand side.

Nevertheless, in countries with a theoretical surplus of available water, reuse is also practised on grounds of reducing the negative impacts of treated wastewater disposal or in order to cover point demands of water resources.

In all cases, it is known that reclaimed water exerts an impact, as explained in the previous chapters. Consequently, if reuse practises are to be increased, environmental impact studies will become more and more vital.

At present, the main uses of reclaimed water are related to irrigation, which implies the existence of positive and negative impacts on irrigated land. On the other hand, there is an excess of reclaimed water even after the demand for agricultural irrigation has been met, especially in heavily populated areas. This is partly due to high demands and partly to the lack of agricultural land. In this context, additional reuse possibilities are considered as being more at risk than the previous ones. Groundwater recharge, urban uses and stream flow augmentation are increasing worldwide as the final destination of reclaimed water.

At present, we can consider there is a need to develop more detailed tools for environmental impact and risk assessment, management and communication for increasing practises.

In a broad sense, if risk is to be considered in a highly integrated way, it should include environmental impact. However, up until now, environmental impact and risk are considered separately.

Environmental impact is more related to environmental problems associated with reuse, while risk is mainly devoted to problems related to human health.

4.1 Tools in the future

The tools to determine the relationships environmental impact/reclaimed water use require further development. The direction of such developments could be, for example:

- application of environmental impact analysis in specific cases, especially small facilities;

- relationships with/redefinition of tools for alternative approaches to wastewater reclamation and use, e.g., use of natural ecosystems for reclamation purposes; and
- development of communication policies on environmental impact of reclaimed water use.

4.2 Related tools

A lot of work has been undertaken on the subject of environmental impact of projects related to building activities, or land use-related activities. Several of the tools employed for such procedures can and must be adapted to reclaimed water use.

As an example, the following are considered useful, with possibilities of adaptation, to serve as a basis for environmental impact studies:

a. LCA (Life Cycle Assessment);
b. EIA (Environmental Impact Assessment); and
c. HACCP (Hazard Analysis and Critical Control Points).

All of these have well developed procedures, which can be applied or transformed for use in environmental impact analysis.

4.3 Communication policies

Communication policies are becoming the common courses of action of many governments, as well as of the EU. Communication policies must be developed by specialists because a lot of variables can interfere with people's perception of wastewater reclamation and use. The NIMBY (Not in My Backyard) approach is also "useful" when dealing with water reuse.

A further development of economic and social impact assessment can be found in Appendix 2.

4.4 Prospects

The Mediterranean is one of the regions of the world where wastewater reclamation and use has more potential for development. The special characteristics of this area (high tourism, agricultural demand, recurrent droughts, etc.) define an ever increasing need for water resources, which can not be satisfied with conventional ones.

Therefore, non-conventional resources appear as one of the possible solutions to fill the gap, although more integrative approaches seem to be correct, like global management of water resources.

Initiatives for issuing rules and regulations wherethey do not exist, the establishment of common international policies in determined regions (e.g., north and south of the Mediterranean), and consideration of the existence of a global market for food, will determine the future of reuse.

Again, technologies for cheaper wastewater reclamation are needed. In this regard, membrane technologies and natural systems will play an important role in the years to come.

4.5 Practical application

Environmental assessment must be developed with a rigorous structure, allowing clear separation between cause and effect. When assessing the environmental impacts of a given project, four major elements are involved (modified from Jain *et al.*, 2002):

1. determine the activities associated with implementing the action or the project;
2. identify environmental attributes (elements) representing a categorization of the environment such that changes in the attributes reflect impacts;
3. evaluate environmental impact (i.e., the effects of the *activities* (1, above) on the *attributes* (2, above)): and
4. report findings in a systematic manner.

1. The activity.

A comprehensive list of activities associated with implementing the project or action throughout its life cycle should be developed. The levels of detail would depend upon the size and type of the project.

2. Environmental attributes.

Consisting of both natural and human-caused factors, the environment is admittedly difficult to characterize because of its many attributes (elements or matrix) and the complex interrelationships amongst them. Anticipated changes in the attributes of the environment and their interrelationships are defined as potential impacts.

An environmental assessment (EA) or environmental impact statement (EIS) is prepared to characterize the environment and potential changes to be brought about by a specific activity. It is necessary that a complete description, hence understanding, of the environment to be affected is first achieved.

A wide variety of impact assessment methodologies have been developed, and virtually all of them employ a categorization of environmental characteristics of some form.

All lists of environmental attributes (see Table 16) are a shorthand method for focusing on important characteristics of the environment. It should be recognized that any such listing is limited and, consequently, may not capture every potential impact. The more complete the listing, the more likely it is to reflect all important effects on the environment, but this may be expensive and cumbersome to apply.

4.5.1 Determining environmental impact

The distinction between "environmental impact" and "change in an environmental attribute" is that changes in the attributes provide an indication of changes in the environment. In a sense, the set of attributes must provide a model for the prediction of all impacts. The steps in determining environmental impact are:

1. identification of impacts on attributes;
2. measurement of impacts on attributes; and
3. aggregation of impacts on attributes to reflect impact on the environment.

Table 16

Examples of environmental attributes.

Items	Appl.	Items	Appl.
Air	P	***Ecology***	Y
1. Diffusion factor	P	27. Large animals (wild and domestic)	P
2. Particulates	P	28. Predatory birds	P
3. Sulphur oxides	P	29. Small game	P
4. Hydrocarbons	N	30. Fish, shellfish and waterfowl	Y
5. Nitrogen oxide	N	31. Field crops	Y
6. Carbon monoxide	N	32. Threatened species	P
7. Photochemical oxidants	N	33. Natural land vegetation	P
8. Hazardous toxicants	N	34. Aquatic plants	P
9. Odours	P	**Sound**	N
Water	Y	35. Physical effects	
10. Aquifer safe yield	Y	36. Psychological effects	
11. Flow variations	Y	37. Communication effects	
12. Oil	N	38. Performance effects	
13. Radioactivity	N	39. Social behaviour effects	
14. Suspended solids	Y	**Human aspects**	Y
15. Thermal pollution	Y	40. Lifestyles	P
16. Acid and alkali	Y	41. Psychological needs	N
17. Biochemical oxygen demand (BOD)	Y	42. Physiological systems	N
18. Dissolved oxygen (DO) 19. Dissolved solids	Y Y	43. Community needs **Economics**	P Y
20. Nutrients	Y	44. Regional economic stability	Y
21. Toxic compounds	Y	45. Public sector review	Y
22. Aquatic life	Y	46. Per capita consumption	Y
23. Faecal coliforms	Y	**Resources**	P
Land	Y	47. Fuel resources	N
24. Soil stability	Y	48. Non-fuel resources	Y
25. Natural hazards	Y	49. Aesthetics	Y
26. Land-use patterns	Y		

Appl.: Applicability to reclaimed water use purposes.
Y: yes; N: No; P (Partially)

The conditions for estimating environmental impact are measurement of attributes with (positive scenarios) and without (zero scenario) the project or activity under consideration at given point in time. Consideration of the potential for impact if no action is taken, that is, maintaining the status quo, is called the no action alternative (again zero scenario in other terms).

While *affected environment* describes the condition of the environment when the action is proposed to take place, the environment will not remain static over time. If a hypothetical “proposed action” were implemented, the impact would be the degree of change over time if the action were taken, compared to the condition of the environment over the same span of time if the action were not taken. It should be noted that the impact would not be the comparison between the proposed actions over time compared to the ambient environment prior to the point of action.

For other alternatives, either the comparison can be of the impacts of the proposed action, or all alternatives can be compared to the no-action alternative.

Both approaches are used; the only caution is for consistency throughout the analysis and clear explanation of which approach is used.

There is a difficulty in that data for a “with activity” and “without activity” projection of impacts are hard to obtain, and results are hard to verify.

4.5.2 Identifying impacts

The list of environmental attributes that might be evaluated is practically infinite because any characteristic of the environment is an attribute. Therefore, it is necessary to reduce the number of attributes to be examined. Duplicative, redundant, difficult to measure, and obscure attributes may be eliminated in favour of those that are more tractable. This procedure is only valid if the remaining attributes reflect all aspects of the environment. This means that some attributes, even if difficult to measure or conceptualize, may remain to be dealt with. Thus, identification of impacts is based on review of potentially affected attributes to determine whether they will be affected by the subject activity.

A complex amount of procedures and data is needed for establishment of the Environmental Impact in any form used for the establishment, determination or analysis. More information can be found in Appendix 2.

Because of the difficulties and complexity of the environmental impact procedures, a summarized table has been developed (Table 17), which includes two entries, the types of reuse and the possible impacts on different matrices.

As for the types of reuse, five have been considered, following the last initiatives (2003 and 2004) of several stakeholders. It is noted that in several countries, potable uses are not allowed and are even illegal. This is also the policy of the WHO.

In Table 16, the types and uses of every type are detailed. Naturally, the classification included cannot be taken as mandatory, but seems a logical division of the different possibilities for use. There is an additional reason related to water quality: a quality can be defined for each type, i.e., the possibilities for use are also grouped in relation to the quality. The table does not include every possible environmental impact, but only the more relevant ones.

Upon creating this type of table for the given project, the question arises of how to quantify (i.e., deal objectively with the items) the established impacts. There are several possibilities for quantification, numerical or by letters, which in either case depend on the objectivity of the evaluator. A further description can be found in Appendix 3.

Table 17

Summary of some environmental impacts (main ones for each case) for the different uses and matrices affected

Type of reuse		Flora		Fauna		Social and cultural*		Economic*	
		+	-	+	-	+	-	+	-
1. Urban uses	1.1. Residential uses	Gardens and parks	N	N	N	Reduced use of tapwater	Public acceptance	Allows supply and economic development if other sources are not available	Really high Treatment and Control costs. Implementation of dual systems
	1.2. Urban uses and services	Increases the possibilities to have green areas	Allochthonous species can be used	Urban “wild” fauna can increase because of water availability	Urban “wild” fauna can increase because of water availability	Reduces use of tap (high quality) water	Public acceptance	Allows supply and economic development if other sources are not available	High Treatment and Control costs
2. Agricultural uses	2.1. Greenhouse and “uncooked” crops	Productivity increase	Weeds can appear	Increase of food availability	Increase diseases associated with reclaimed water (fodder-related)	Improvement of quality of life	Changes in the patterns of life and cultural values	Increase of water availability	Commercialization channels are needed.
	2.2. Other agricultural irrigation uses	Productivity increase	Weeds can appear	Increase of food availability	Increase diseases associated with reclaimed water (fodder-related)	Improvement of quality of life	Changes in the patterns of life and cultural values	Increase of water availability	Commercialization channels are needed.
3. Industrial uses	3.1. Industrial air cooling	N	N	N	N	N	N	Low price water available	Additional treatment costs

Type of reuse		Flora		Fauna		Social and cultural*		Economic*	
		+	-	+	-	+	-	+	-
4. Environ-ment and leisure uses	4.1. Golf courses irrigation	Additional flora (not grass) will benefit from increased humidity	Usually allochthonous plants are used.	Usually increases	Creates problems in the courses (e.g., rabbits)	Reclaimed water used for this purpose is not discussed as a resource	A few players or users could complain about the water	Increase of incomes in the area	Additional treatment and control costs
	4.2. Environment free-water with public	Increase of aquatic plants	Changes of plant species in the system	Increases aquatic- and land-associated fauna	Undesired fauna can appear (e.g., mosquitoes and seagulls). Changes of species	Water-related landscapes are usually appreciated	A few users could complain about the water	Could be the unique water available at an acceptable cost	Additional treatment and control costs
	4.3. Environment free-water without public	Increase of aquatic plants	Changes of plant species in the system	Increases aquatic- and land-associated fauna	Undesired fauna can appear (e.g., mosquitoes and seagulls)	Water-related landscapes are usually appreciated	Change of typical landscape features could be not appreciated	Improves intangible values (e.g. aesthetic)	N
	4.4. Landscape irrigation not accessible to the public	Increased productivity	Diseases associates to water	Increase the amount of fauna	Diseases associated with reclaimed water	Increases aesthetic values	Could reduce classical landscape features	Can increase commercial biomass	N
5. Ground-water recharge*	5.1. Indirect recharge	Increases water related species on surface	Aerobic species can suffer from excess water	More water available on surface	Diseases associated with reclaimed water	Increases the water resources available	Recovered water could not be accepted	Increases economic development (more water available)	The quality of water can be reduced
	5.2. Direct recharge	N	N	Amount of water increase in water bodies related to aquifers	Reduced amounts of water on surface	Increases the water resources available	Recovered water could not be accepted	Increases economic development (more water available)	Additional treatment and control costs

N: not applicable or negligible

* Not recommended by WHO until enough scientific evidence is provided.

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APPENDIX 1

LEGAL APPROACH

In this appendix, a short review of the most important legislation related to the Environmental Impact issued in the European Union is provided.

1. Council Directive of 27 June 1985 on the assessment of the effects of certain public and private projects in the environment. (85/337/EEC). Official Journal L175, 05/07/1985. pp. 0040-0048.

… it is necessary to achieve one of the Community's objectives in the sphere of the protection of the environment and the quality of life;
… general principles for the assessment of environmental effects should be introduced with a view to supplementing and coordinating development consent procedures governing public and private projects likely to have a major effect on the environment;
… development consent for public and private projects which are likely to have significant effects on the environment should be granted only after prior assessment of the likely significant environmental effects of these projects has been carried out; whereas this assessment must be conducted on the basis of the appropriate information supplied by the developer, which may be supplemented by the authorities and by the people who may be concerned by the project in question;
… the principles of the assessment of environmental effects should be harmonized, in particular with reference to the projects which should be subject to assessment, the main obligations of the developers and the content of the assessment;
… projects belonging to certain types have significant effects on the environment and these projects must as a rule be subject to systematic assessment;
… projects of other types may not have significant effects on the environment in every case and whereas these projects should be assessed where the Member States consider that their characteristics so require; Whereas, for projects which are subject to assessment, a certain minimal amount of information must be supplied, concerning the project and its effects;
… the effects of a project on the environment must be assessed in order to take account of concerns to protect human health, to contribute by means of a better environment to the quality of life, to ensure maintenance of the diversity of species and to maintain the reproductive capacity of the ecosystem as a basic resource for life;

This Directive shall apply to the assessment of the environmental effects of those public and private projects which are likely to have significant effects on the environment.

… Member States shall adopt all measures necessary to ensure that, before consent is given, projects likely to have significant effects on the environment by virtue inter alia, of their nature, size or location are made subject to an assessment with regard to their effects.
… The environmental impact assessment may be integrated into the existing procedures for consent to projects in the Member States, or, failing this, into other procedures or into procedures to be established to comply with the aims of this Directive.

… The environmental impact assessment will identify, describe and assess in an appropriate manner, in the light of each individual case and in accordance with the Articles 4 to 11, the direct and indirect effects of a project on the following factors:

- human beings, fauna and flora,
- soil, water, air, climate and the landscape,
- the inter-action between the factors mentioned in the first and second indents,
- material assets and the cultural heritage.

… The information to be provided by the developer … 1 shall include at least:

- a description of the project comprising information on the site, design and size of the project,
- a description of the measures envisaged in order to avoid, reduce and, if possible, remedy significant adverse effects,
- the data required to identify and assess the main effects which the project is likely to have on the environment,
- a non-technical summary of the information mentioned in indents 1 to 3. 3.

<u>Types of projects possibly related to wastewater reclamation and reuse</u>

Agriculture
(b) Projects for the use of uncultivated land or semi-natural areas for intensive agricultural purposes.
(c) Water-management projects for agriculture.
(d) Initial afforestation where this may lead to adverse ecological changes and land reclamation for the purposes of conversion to another type of land use.

Infrastructure projects
(f) Dams and other installations designed to hold water or store it on a basis.
(i) Installation of long-distance aqueducts.

Other projects
(d) Waste water treatment plants.

INFORMATION ASKED FOR:

1. Description of the project, including in particular:
    - a description of the physical characteristics of the whole project and the land-use requirements during the construction and operational phases,
    - a description of the main characteristics of the production processes, for instance, nature and quantity of the materials used,
    - an estimate, by type and quantity, of expected residues and emissions (water, air and soil pollution, noise, vibration, light, heat, radiation, etc.) resulting from the operation of the proposed project.

2. Where appropriate, an outline of the main alternatives studied by the developer and an indication of the main reasons for his choice, taking into account the environmental effects.

3. A description of the aspects of the environment likely to be significantly affected by the proposed project, including, in particular, population, fauna, flora, soil, water, air, climatic factors, material assets, including the architectural and archaeological heritage, landscape and the inter-relationship between the above factors.

4. A description (1) of the likely significant effects of the proposed project on the environment resulting from:

- the existence of the project,
- the use of natural resources,
- the emission of pollutants, the creation of nuisances and the elimination of waste;

and the description by the developer of the forecasting methods used to assess the effects on the environment.

5. A description of the measures envisaged to prevent, reduce and where possible offset any significant adverse effects on the environment.

6. A non-technical summary of the information provided under the above headings.

7. An indication of any difficulties (technical deficiencies or lack of know-how) encountered by the developer in compiling the required information.

(1) This description should cover the direct effects and any indirect, secondary, cumulative, short, medium and , permanent and temporary, positive and negative effects of the project.

2. Council Directive of 3 March 1997 amending Directive 85/337/EEC on the assessment of the effects of certain public and private projects on the environment.
Official Journal no. l073, 14/03/1997 p. 0005

Only several differences if comparing with the previous Directive are exposed here.

…Community policy on the environment is based on the precautionary principle and on the principle that preventive action should be taken, that environmental damage should as a priority be rectified at source and that the polluter should pay;

… experience acquired in environmental impact assessment, as recorded in the report on the implementation of Directive 85/337/EEC, adopted by the Commission on 2 April 1993, shows that it is necessary to introduce provisions designed to clarify, supplement and improve the rules on the assessment procedure, in order to ensure that the Directive is applied in an increasingly harmonized and efficient manner;

… it is appropriate to make additions to the list of projects which have significant effects on the environment and which must on that account as a rule be made subject to systematic assessment;

… projects of other types may not have significant effects on the environment in every case; whereas these projects should be assessed where Member States consider they are likely to have significant effects on the environment;

<u>Directive 85/337/EEC is hereby amended as follows:</u>

Article 2 (1) shall be replaced by the following:

'1. Member States shall adopt all measures necessary to ensure that, before consent is given, projects likely to have significant effects on the environment by virtue, inter alia, of their nature, size or location are made subject to a requirement for development consent and an assessment with regard to their effects. These projects are defined in

2. The following paragraph shall be inserted in Article 2:
'2a. Member States may provide for a single procedure in order to fulfil the requirements of this Directive and the requirements of Council Directive 96/61/EC of 24 September 1996 on integrated pollution prevention and control

Article 3 shall be replaced by the following:

The environmental impact assessment shall identify, describe and assess in an appropriate manner, in the light of each individual case and in accordance with Articles 4 to 11, the direct and indirect effects of a project on the following factors:

- human beings, fauna and flora;
- soil, water, air, climate and the landscape;
- material assets and the cultural heritage;
- the interaction between the factors mentioned in the first, second and third indents.

In article 5

3. The information to be provided by the developer in accordance with paragraph 1 shall include at least:

- a description of the project comprising information on the site, design and size of the project,
- a description of the measures envisaged in order to avoid, reduce and, if possible, remedy significant adverse effects,
- the data required to identify and assess the main effects which the project is likely to have on the environment,
- an outline of the main alternatives studied by the developer and an indication of the main reasons for his choice, taking into account the environmental effects,
- a non-technical summary of the information mentioned in the previous indents.

<u>In Annexes</u>

Relevant information

ANNEX I

11. Groundwater abstraction or artificial groundwater recharge schemes where the annual volume of water abstracted or recharged is equivalent to or exceeds 10 million cubic metres.
13. Waste water treatment plants with a capacity exceeding 150 000 population equivalent as defined in Article 2 point (6) of Directive 91/271/EEC (5).
15. Dams and other installations designed for the holding back or permanent storage of water, where a new or additional amount of water held back or stored exceeds 10 million cubic metres.

ANNEX II

1. Agriculture, silviculture and aquaculture
(a) Projects for the restructuring of rural land holdings;
(b) Projects for the use of uncultivated land or semi-natural areas for intensive agricultural purposes;
(c) Water management projects for agriculture, including irrigation and land drainage projects;

10. Infrastructure projects
(l) Groundwater abstraction and artificial groundwater recharge schemes not included in Annex I;
(m) Works for the transfer of water resources between river basins not included in Annex I.

11. Other projects
(c) Waste-water treatment plants (projects not included in Annex I);
ANNEX III

SELECTION CRITERIA

1. Characteristics of projects
The characteristics of projects must be considered having regard, in particular, to:

- the size of the project,
- the accumulation with other projects,
- the use of natural resources,
- the production of waste,
- pollution and nuisances,
- the risk of accidents, having regard in particular to substances or technologies used.

2. Location of projects
The environmental sensitivity of geographical areas likely to be affected by projects must be considered, having regard, in particular, to:

- the existing land use,
- the relative abundance, quality and regenerative capacity of natural resources in the area,
- the absorption capacity of the natural environment, paying particular attention to the following areas:
  (a) wetlands;
  (b) coastal zones;
  (c) mountain and forest areas;
  (d) nature reserves and parks;
  (e) areas classified or protected under Member States' legislation; special protection areas designated by Member States pursuant to Directive 79/409/EEC and 92/43/EEC;

(f) areas in which the environmental quality standards laid down in Community legislation have already been exceeded;
(g) densely populated areas;
(h) landscapes of historical, cultural or archaeological significance.

3. Characteristics of the potential impact
The potential significant effects of projects must be considered in relation to criteria set out under 1 and 2 above, and having regard in particular to:

- the extent of the impact (geographical area and size of the affected population),
- the transfrontier nature of the impact,
- the magnitude and complexity of the impact,
- the probability of the impact,
- the duration, frequency and reversibility of the impact.

ANNEX IV
INFORMATION REFERRED TO IN ARTICLE 5 (1)

1. Description of the project, including in particular:
   - a description of the physical characteristics of the whole project and the land-use requirements during the construction and operational phases,
   - a description of the main characteristics of the production processes, for instance, nature and quantity of the materials used,
   - an estimate, by type and quantity, of expected residues and emissions (water, air and soil pollution, noise, vibration, light, heat, radiation, etc.) resulting from the operation of the proposed project.

2. An outline of the main alternatives studied by the developer and an indication of the main reasons for this choice, taking into account the environmental effects.

3. A description of the aspects of the environment likely to be significantly affected by the proposed project, including, in particular, population, fauna, flora, soil, water, air, climatic factors, material assets, including the architectural and archaeological heritage, landscape and the inter-relationship between the above factors.

4. A description (6) of the likely significant effects of the proposed project on the environment resulting from:
   - the existence of the project,
   - the use of natural resources,
   - the emission of pollutants, the creation of nuisances and the elimination of waste,

and the description by the developer of the forecasting methods used to assess the effects on the environment.

5. A description of the measures envisaged to prevent, reduce and where possible offset any significant adverse effects on the environment.

6. A non-technical summary of the information provided under the above headings.

7. An indication of any difficulties (technical deficiencies or lack of know-how) encountered by the developer in compiling the required information.

(7) This description should cover the direct effects and any indirect, secondary, cumulative, short, medium and , permanent and temporary, positive and negative effects of the project.

3. Directive 2001/42/ on the assessment of the effects of certain plans and programmes on the environment. (SEA: Strategic Environment Assessment Directive)
Official Journal NO. C 129 , 25/04/1997 P. 0014

… article 174 of the Treaty provides that Community policy on the environment is to contribute to, inter alia, the preservation, protection and improvement of the quality of the environment, the protection of human health and the prudent and rational utilization of natural resources and that is to be based on the precautionary principle;

… environmental protection requirements are to be integrated into th e definition of Community policies and activities, in particular with a view of promoting sustainable development.

… the Fifth Environment Action Programme: Towards sustainability… affirms the importance of assessing the likely environmental effects of plans and programmes.

… environmental assessment is an important tool for integrating environmental considerations into the preparation and adoption of certain plans and programmes which are likely to have significant effects on the environment of the member states, because it ensures that such effects of implementing plans and programmes are taken into account during their preparation and before their adoption.

… the adoption of environmental assessment procedures at the planning and programming level should benefit undertakings by providing a more consistent framework in which to operate by the inclusion of the relevant environmental information into decision-making. The inclusion of a wider set of factors in decision-making should contribute to more susta inable and effective solutions.

… action is therefore required at Community level to establish a general environmental assessment framework which will remedy these deficiencies and thereby contribute to the pursuit of the environmental objectives set out in the Treaty;

… in order to contribute to more transparent decision-making and with the aim of ensuring that the information supplied for the assessment is comprehensive and reliable, it is necessary to provide that authorities with relevant environmental responsibilities and the public are to be consulted during the assessment of plans and programmes, and that appropriate time frames are set, allowing sufficient time for consultations, including the expression of opinion.

… the environmental report and the opinions expressed by the relevant authorities and the public, …, should be taken into account during the preparation of the plan or programme and before its adoption or submission to the legislative procedure.

OBJECTIVE

… to provide for a high leve l of protection of the environment and to contribute to the integration of environmental considerations into the preparation and adoption of plans and programmes with a view to promoting sustainable development, by ensuring that … an environmental assessment is carried out…

SCOPE

An environmental assessment …shall be carried out for plans and programmes … which are likely to have significant environmental effects.

… an environmental assessment shall be carried out for all plans and programmes,

(a) which are prepared for agriculture, forestry, fisheries, energy, industry, transport, waste management, telecommunications, tourism, town and country planning or land use…
(b) which, in view of the likely effects on sites, have been determined to require an assessment…

ENVIRONMENTAL REPORT

… where an environmental assessment is required…, an environmental report shall be prepared in which the likely significant effects on the environment of implementing the plan or programme, and reasonable alternatives taking into a ccount the objectives and the geographical scope of the plan or programme, are identified, described and evaluated.

… the environmental report prepared… shall include the information that may reasonably be required taking into account current knowledge and methods of assessment, the contents and level of detail in the plan or programme, its stage in the decision-making process and the extent to which certain matters are more appropriately assessed at different levels in that process in order to avoid duplication of the assessment.

CONSULTATIONS

… including the public affected or likely to be affected by, or having an interest in, the decision-making subject to this Directive, including relevant non-governmental organisations, such as those promoting environmental protection and other organisations concerned.

MONITORING

Member states shall monitor the significant environmental effects of the implementation of plans and programmes in order, inter alia, to identify at an early stage unforeseen adverse effects, and to be able to undertake appropriate remedial action.

ANNEX I.
INFORMATION

The information to be provided… is the following:

(a) an outline of the contents, main objectives of the plan or programme, and relationship with other relevant plans or programmes;
(b) the relevant aspects of the current state of the environment and the likely evolution thereof without implementation of the plan or programme;

(c) the environmental characteristics of areas likely to be significantly affected;
(d) any existing environmental problems which are relevant to the plan or programme including, in particular, those relating to any areas of a particular environmental importance…
(e) the environmental protection objectives, established at international, Community or member state level, which are relevant to the plan or programme and the way those objectives and any environmental considerations have been taken into account…
(f) the likely significant effects[1] on the environment including on issues such as biodiversity, population, human health, fauna, flora, soil, water, air, climatic factors, material assets, cultural heritage including architectural and archaeological heritage, landscape and the interrelationships between the above factors;
(g) the measures envisaged to prevent, reduce and as fully as possible offset any significant adverse effects on the environment of implementing the plan or programme;
(h) an outline of the reasons for selecting the alternatives dealt with, and a description on how the assessment was undertaken including any difficulties (such as technical deficiencies or lack of know-how) encountered in compiling the required information.
(i) a description of the measures envisaged concerning monitoring …
(j) a non-technical summary of the information provided under the above headings.

1: These effects should include secondary, cumulative, synergistic, short, medium, and , permanent and temporary, positive and negative effects.

ANNEX II.
CRITERIA FOR DETERMINING THE LIKELY SIGNIFICANCE OF EFFECTS…

1. The characteristics of plans and programmes, having regard, in particular to

- the degree to which the plan or programme sets a framework for projects and other activities, either with regard to the location, nature, size, and operating conditions or by allocating resources;
- the degree to which the plan or programme influences other plans and programmes…
- the relevance of the plan or programme for the integration of environmental considerations in particular with a view to promoting sustainable development;
- environmental problems relevant to the plan or programme;
- the relevance of the plan or programme for the implementation of Community legislation on the environment (e.g. plans and programmes linked to waste-management or water protection).

2. Characteristics of the effects and of the area likely to be affected, having regard in particular, to

- the probability, duration, frequency and reversibility of the effects;
- the cumulative nature of the effects;
- the transboundary nature of the effects;
- the risks to human health or the environment (e.g. due to accidents);
- the magnitude and spatial extent of the effects (geographical area and size of the population likely to be affected);
- the value and vulnerability of the area likely to be affected due to:
  - special natural characteristics of cultural heritage;
  - exceeded environmental quality standards or limit values;
  - intensive land-use;
- the effects on areas or landscapes which have a recognised national, Community or international protection status.

4. *Directive providing for public participation in respect of the drawing up of certain plans and programmes relating to the environment and amending with regard to public participation and access to justice Council Directives 85/337/EEC and 96/61/EC.*
Official Journal L 156 , 25/06/2003 P. 0017 – 0025

… Community legislation in the field of the environment aims to contribute to preserving, protecting and improving the quality of the environment and protecting human health.

Community environmental legislation includes provisions for public authorities and other bodies to take decisions which may have a significant effect on the environment as well as on personal health and well-being.

Effective public participation in the taking of decisions enables the public to express, and the decision-maker to take account of, opinions and concerns which may be relevant to those decisions, thereby increasing the accountability and transparency of the decision-making process and contributing to public awareness of environmental issues and support for the decisions taken.

(Participation, including participation by associations, organisations and groups, in particular non-governmental organisations promoting environmental protection, should accordingly be fostered, including inter alia by promoting environmental education of the public.

On 25 June 1998 the Community signed the UN/ECE Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters (the Århus Convention). Community law should be properly aligned with that Convention with a view to its ratification by the Community.

Among the objectives of the Århus Convention is the desire to guarantee rights of public participation in decision-making in environmental matters in order to contribute to the protection of the right to live in an environment which is adequate for personal health and well-being.

Article 6 of the Århus Convention provides for public participation in decisions on the specific activities listed in Annex I thereto and on activities not so listed which may have a significant effect on the environment.

Article 7 of the Århus Convention provides for public participation concerning plans and programmes relating to the environment.

OBJECTIVE
Article 1

The objective of this Directive is to contribute to the implementation of the obligations arising under the Århus Convention, in particular by:

(a) providing for public participation in respect of the drawing up of certain plans and programmes relating to the environment…

PUBLIC PARTICIPATION
Article 2

To that end, Member States shall ensure that:

(a) the public is informed, whether by public notices or other appropriate means such as electronic media where available, about any proposals for such plans or programmes or for their modification or review and that relevant information about such proposals is made available to the public including inter alia information about the right to participate in decision-making and about the competent authority to which comments or questions may be submitted;

(b) the public is entitled to express comments and opinions when all options are open before decisions on the plans and programmes are made;

(c) in making those decisions, due account shall be taken of the results of the public participation;

(d) having examined the comments and opinions expressed by the public, the competent authority makes reasonable efforts to inform the public about the decisions taken and the reasons and considerations upon which those decisions are based, including information about the public participation process.

3. Member States shall identify the public entitled to participate … including relevant non-governmental organisations meeting any requirements imposed under national law, such as those promoting environmental protection.

… Reasonable time-frames shall be provided allowing sufficient time for each of the different stages of public participation required by this Article.

AMENDMENTS TO PREVIOUS DIRECTIVES

Several amendments to Directives 85/337/EC and 96/61/EC appear, which affects:

85/337/EC:

- definitions
- ways of information
- type of information

96/61/EC:

- definitions
- ways of information
- access to justice

5. *Directive 2004/35/CE of the European Parliament and of the Council of 21 April 2004 on environmental liability with regard to the prevention and remedying of environmental damage.*

Specific aspects of interest for the wastewater reclamation and reuse activities:

ON THE PREVIOUS CONSIDERATIONS:

… The fundamental principle of this Directive should therefore be that an operator whose activity has caused the environmental damage or the imminent threat of such damage is to be held financially liable, in order to induce operators to adopt measures and develop practises to minimise the risks of environmental damage so that their exposure to financial liabilities is reduced…
… For the purposes of assessing damage to land as defined in this Directive, the use of risk assessment procedures to determine to what extent human health is likely to be adversely affected is desirable.
… This Directive should apply, as far as environmental damage is concerned, to …occupational activities which present a risk for human health or the environment … as regards damage to protected species and natural habitats, to any occupational activities other than those already directly or indirectly identified by reference to Community legislation …
…Those activities should be identified, in principle, by reference to the relevant Community legislation which provides for regulatory requirements in relation to certain

activities or practises considered as posing a potential or actual risk for human health or the environment…
… Not all forms of environmental damage can be remedied by means of the liability mechanism. For the latter to be effective, there need to be one or more identifiable polluters, the damage should be concrete and quantifiable, and a causal link should be established between the damage and the identified polluter(s). Liability is therefore not a suitable instrument for dealing with pollution of a widespread, diffuse character, where it is impossible to link the negative environmental effects with acts or failure to act of certain individual actors.
… An operator should not be required to bear the costs of preventive or remedial actions taken pursuant to this Directive in situations where the damage in question or imminent threat thereof is the result of certain events beyond the operator's control. Member States may allow that operators who are not at fault or negligent shall not bear the cost of remedial measures, in situations where the damage in question is the result of emissions or events explicitly authorised or where the potential for damage could not have been known when the event or emission took place.
… Operators should bear the costs relating to preventive measures when those measures should have been taken as a matter of course in order to comply with the legislative, regulatory and administrative provisions regulating their activities or the terms of any permit or authorisation.
… Persons adversely affected or likely to be adversely affected by environmental damage should be entitled to ask the competent authority to take action. Environmental protection is, however, a diffuse interest on behalf of which individuals will not always act or will not be in a position to act. Non-governmental organisations promoting environmental protection should therefore also be given the opportunity to properly contribute to the effective implementation of this Directive.
The relevant natural or legal persons concerned should have access to procedures for the review of the competent authority's decisions, acts or failure to act.

ON THE SCOPE:

… environmental damage caused by any of the occupational activities listed in Annex III, and to any imminent threat of such damage occurring by reason of any of those activities;
damage to protected species and natural habitats caused by any occupational activities other than those listed in Annex III, and to any imminent threat of such damage occurring by reason of any of those activities, whenever the operator has been at fault or negligent.

PREVENTIVE ACTIONS

… where environmental damage has not yet occurred but there is an imminent threat of such damage occurring, the operator shall, without delay, take the necessary preventive measures.

PREVENTION AND REMEDIATION COSTS

The Member States may allow the operator not to bear the cost of remedial actions taken pursuant to this Directive where he demonstrates that he was not at fault or negligent and that the environmental damage was caused by:

- 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, as applied at the date of the emission or event;

- 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 at the time when the emission was released or the activity took place.

5. REQUEST FOR ACTION

Natural or legal persons:

a) affected or likely to be affected by environmental damage or
b) having a sufficient interest in environmental decision making relating to the damage or, alternatively,
c) alleging the impairment of a right, where administrative procedural law of a Member State requires this as a precondition,

shall be entitled to submit to the competent authority any observations relating to instances of environmental damage or an imminent threat of such damage of which they are aware and shall be entitled to request the competent authority to take action under this Directive.

What constitutes a "sufficient interest" and "impairment of a right" shall be determined by the Member States.

To this end, the interest of any non-governmental organisation promoting environmental protection and meeting any requirements under national law shall be deemed sufficient for the purpose of subparagraph (b). Such organisations shall also be deemed to have rights capable of being impaired for the purpose of subparagraph (c)

2. The request for action shall be accompanied by the relevant information and data supporting the observations submitted in relation to the environmental damage in question.

3. Where the request for action and the accompanying observations show in a plausible manner that environmental damage exists, the competent authority shall consider any such observations and requests for action. In such circumstances the competent authority shall give the relevant operator an opportunity to make his views known with respect to the request for action and the accompanying observations.

4. The competent authority shall, as soon as possible and in any case in accordance with the relevant provisions of national law, inform the persons referred to in paragraph 1, which submitted observations to the authority, of its decision to accede to or refuse the request for action and shall provide the reasons for it.

ANNEX 1

CRITERIA REFERRED TO IN ARTICLE 2(1)(A)

The significance of any damage that has adverse effects on reaching or maintaining the favourable conservation status of habitats or species has to be assessed by reference to the conservation status at the time of the damage, the services provided by the amenities they produce and their capacity for natural regeneration. Significant adverse changes to the baseline condition should be determined by means of measurable data such as:

- the number of individuals, their density or the area covered,
- the role of the particular individuals or of the damaged area in relation to the species or to the habitat conservation, the rarity of the species or habitat (assessed at local, regional and higher level including at Community level),
- the species' capacity for propagation (according to the dynamics specific to that species or to that population), its viability or the habitat's capacity for natural regeneration (according to the dynamics specific to its characteristic species or to their populations),
- the species' or habitat's capacity, after damage has occurred, to recover within a short time, without any intervention other than increased protection measures, to a condition which leads, solely by virtue of the dynamics of the species or habitat, to a condition deemed equivalent or superior to the baseline condition.

Damage with a proven effect on human health must be classified as significant damage.

The following does not have to be classified as significant damage:

- negative variations that are smaller than natural fluctuations regarded as normal for the species or habitat in question,
- negative variations due to natural causes or resulting from intervention relating to the normal management of sites, as defined in habitat records or target documents or as carried on previously by owners or operators,
- damage to species or habitats for which it is established that they will recover, within a short time and without intervention, either to the baseline condition or to a condition which leads, solely by virtue of the dynamics of the species or habitat, to a condition deemed equivalent or superior to the baseline condition.

6. *Implementation of Directive 2001/42 on the assessment of the effects of certain plans and programmes on the environment*
Undated paper.

"Plan" and "programme" and several statements of the Directive are more exactly defined.

There are several points that will help to understand exactly statements in the Directives. Examples are included:

Point 3.56, p. 17:
The Directive uses a rather neutral word ("relevance") in this criterion. Both positive and negative contributions to the implementation of Community legislation need to be

considered here. It is important to ensure that the full range of Community legislation on the environment is taken into account.

Point 3.57 (p. 18):
Many uncertainties exist, and insufficient or missing data and inadequate knowledge may make it difficult to decide whether significant effects are likely. Nevertheless, is assumed that a rough estimation of the effects should always be possible.

Point 3.58 (p. 18):
The nature and characteristics of the likely effects will influence their significance in the context within which they are being considered. For example, it is relevant to consider whether the probability or frequency of effects will be very low (accidental cause) or whether the effects will occur continuously. Moreover, the more complex (e.g. due to synergies and accumulation), the more widespread, or the more serious the effects, the more likely is that they should be considered “significant”.

Point 3.59 (p. 18):
An equally important factor to be considered is the area likely to be affected by the plan or programme and consequently by its effects. It should be noted that it is not only areas that have a designated protection status which are required by the Directive to be given attention. The particular value or vulnerability of the area likely to be affected may make it more likely that effects must be considered significant there.
Point 3.61 (p. 18):
Applying the criteria for determining potential environmental effects require a comprehensive and systematic approach. … For identifying likely significant effects the “receptors” of these effects should be considered (i.e. biodiversity, population, human health…). The characteristics noted should also be taken into account (whether the effects are secondary, cumulative, synergistic…).

Chapter 5 (pp. 23 and following ones) is devoted to the environmental report, which is the central part of the environmental assessment required by the directive. It also forms the main basis for monitoring the significant effects of the implementation of the plan or programme.

The environmental report must be subject to consultation, it must be taken into account during the preparation of the plan or programme and, when the plan or programme is adopted, information must be of sufficient quality to meet the requirements of the Directive.

The environmental report should be a coherent text or texts. It could be part of a document on sustainability assessment covering also social and economic effects, or a sustainability assessment covering also social and economic effects.

The obligation to identify, describe and evaluate reasonable alternatives must be read in the context of the objective of the Directive which is to ensure that the effects of implementing plans and programmes are taken into account during their preparation and before their adoption… It is essential that the authority or parliament responsible for the adoption of the plan or programme as well as the authorities and the public consulted, are presented with an accurate picture of what reasonable alternatives there are and why they not are considered to be the best option… The alternatives chosen should be realistic.

Annex I, p. 27 and following.

… Information on the relationship with other relevant plans or programmes sets the plan or programme in a broader context… The term “the relevant aspects” refers to environmental effects that are relevant to the likely significant environmental effects of the plan or programme. These aspects could be of a positive as well as of a negative nature. The information must concern the current state of the environment, which means that it should be as up to date as possible… This requirement can be seen as corresponding to the so-called zero-alternative often applied in environmental impact assessment procedures.

Monitoring, p. 43 and following.

… Member State’s duties are to be extended after the planning phase to the implementation one and lay down the obligation to monitor the significant environmental effects of the implementation of plans and programmes. It enables the results of the environmental assessment to be compared with the environmental effects which in fact occur… The Directive does not prescribe how the significant environmental effects are to be monitored … The Directive also does not define the meaning of “monitor”. Monitoring can be generally described as an activity of following the development of parameters of concern in magnitude, time and space… Monitoring can also be a means of verifying the information in the environmental report.

… Monitoring has to cover the significant environmental effects. These cover, in principle all kinds of effects, including positive, adverse, foreseen and unforeseen ones.

7. Report from the Commission to the European Parliament and the Council on the application and effectiveness of the EIA Directive (Directive 85/337/EEC as amended by Directive 97/11/EC). How successful are the member states in implementing the EIA Directive.

This is the 5 years report: summary of findings and actions to be taken, and the 5 years review with detailed information on the issues regarding the application of the EIA Directive, prepared on the basis of answers by information provided by the Member States.

FINDINGS

This Commission's report examines key areas of the operation of the EIA directive:

- screening: the determination whether an EIA is required for a specific project,
- scoping: the identification of the issues to be covered by the environmental impact statement,
- review: the examination of the environmental impact statements and other information submitted,
- decision making,
- consideration of alternatives,
- public participation,
- quality control.

There is a wide variation in approach to the setting of thresholds across the European Union. There are very large differences in the levels at which thresholds have been set.

In some member states, the consideration of alternatives is a central focus of the EIA process, elsewhere the consideration of alternatives appears to be less complete than it might be. The majority of member states require assessment of the zero alternative and other project alternatives.

The assessment of health impacts is not a particularly strong feature of current practise. There is evidence to suggest that health impacts are considered to be less relevant to EIA, and/or to a certain extent covered by other legislation. There is some evidence to suggest that health impacts are considered under other headings such as pollution or risk.

ARRANGEMENTS FOR KEY STAGES

Following the adoption of 97/11/EC, and the application of the rulings… Member States developed the following types of screening thresholds ofr projects in Annex II of the EIA Directive:

- <u>inclusion</u> or mandatory thresholds or criteria – projects of a certain size or to particular locational or other characteristics which requires mandatory EIA;
- <u>indicative</u> or guidance thresholds or criteria – thresholds are provided as a guide only – projects above a given size or other threshold/criteria levels are considered more likely to require EIA, while projects below these thresholds are considered less likely to require EIA, but will still need to be

screened on a case-by-case basis for te likelihood of significant environmental effects; and

- exclusion thresholds or criteria – projects below a given size or of particular locational or other characteristics which do not require EIA.

SCOPING

The purpose of scoping is to focus the environmental assessment on the main or significant impacts. The scoping process, therefore, requires a detailed characterisation of a project and its receiving environment in order to identify all potential impacts and from that to ascertain which of those impacts are likely to be significant.

A range of methods appear to be used in scoping exercises including checklists, matrices, impact chains and modelling, with expert judgement most frequently relied upon. In many cases, no specific methodology is prescribed, partly in recognition that various techniques may be appropriate in different circumstances.

DEFINITIONS

The previous directives and "legal" pieces use several definitions. The ones interesting this work are reproduced here:

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,
(b) water damage, which is any damage that significantly adversely affects the ecological, chemical and/or quantitative status and/or ecological potential, of the waters concerned,
(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. "Protected species and natural habitats" means:
(a) the species mentioned in Article 4(2) of Directive 79/409/EEC or listed in Annex I thereto or listed in Annexes II and IV to Directive 92/43/EEC;
(b) the habitats of species mentioned in Article 4(2) of Directive 79/409/EEC or listed in Annex I thereto or listed in Annex II to Directive 92/43/EEC, and the natural habitats listed in Annex I to Directive 92/43/EEC and the breeding sites or resting places of the species listed in Annex IV to Directive 92/43/EEC; and
(c) where a Member State so determines, any habitat or species, not listed in those Annexes which the Member State designates for equivalent purposes as those laid down in these two Directives;

4. "conservation status" means:
(a) in respect of a natural habitat, the sum of the influences acting on a natural habitat and its typical species that may affect its natural distribution, structure and functions as

well as the survival of its typical species within, as the case may be, the European territory of the Member States to which the Treaty applies or the territory of a Member State or the natural range of that habitat;

The conservation status of a natural habitat will be taken as "favourable" when:
- its natural range and areas it covers within that range are stable or increasing,
- the specific structure and functions which are necessary for its maintenance exist and are likely to continue to exist for the foreseeable future, and
- the conservation status of its typical species is favourable, as defined in (b);

(b) in respect of a species, the sum of the influences acting on the species concerned that may affect the distribution and abundance of its populations within, as the case may be, the European territory of the Member States to which the Treaty applies or the territory of a Member State or the natural range of that species;

The conservation status of a species will be taken as "favourable" when:
- population dynamics data on the species concerned indicate that it is maintaining itself on a basis as a viable component of its natural habitats,
- the natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future, and
- there is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a basis;

5. "waters" mean all waters covered by Directive 2000/60/EC;

6. "operator" means any natural or legal, private or public person who operates or controls the occupational activity or, where this is provided for in national legislation, to whom decisive economic power over the technical functioning of such an activity has been delegated, including the holder of a permit or authorisation for such an activity or the person registering or notifying such an activity;

7. "occupational activity" means any activity carried out in the course of an economic activity, a business or an undertaking, irrespectively of its private or public, profit or non-profit character;

8. "emission" means the release in the environment, as a result of human activities, of substances, preparations, organisms or micro-organisms;

9. "imminent threat of damage" means a sufficient likelihood that environmental damage will occur in the near future;

10. "preventive measures" means any measures taken in response to an event, act or omission that has created an imminent threat of environmental damage, with a view to preventing or minimising that damage;

11. "remedial measures" means any action, or combination of actions, including mitigating or interim measures to restore, rehabilitate or replace damaged natural resources and/or impaired services, or to provide an equivalent alternative to those resources or services as foreseen in Annex II;

12. "natural resource" means protected species and natural habitats, water and land;

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

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;

15. "recovery", including "natural recovery", means, in the case of water, protected species and natural habitats the return of damaged natural resources and/or impaired services to baseline condition and in the case of land damage, the elimination of any significant risk of adversely affecting human health;

16. "costs" means costs which are justified by the need to ensure the proper and effective implementation of this Directive including the costs of assessing environmental damage, an imminent threat of such damage, alternatives for action as well as the administrative, legal, and enforcement costs, the costs of data collection and other general costs, monitoring and supervision costs.

'project' means:
the execution of construction works or of other installations or schemes,
other interventions in the natural surroundings and landscape including those involving the extraction of mineral resources;

'developer' means:
the applicant for authorization for a private project or the public authority which initiates a project;

'development consent' means:
the decision of the competent authority or authorities which entitles the developer to proceed with the project.

plans and programmes shall mean plans and programmes, including those co-financed by the European Community, as well as any modifications to them:

- which are subject to preparation and/or adoption by an authority at national, regional or local level or which are prepared by an authority for adoption, through a legislative procedure by Parliament or Government, and
- which are required by legislative, regulatory or administrative provisions.

environmental assessment shall mean the preparation of an environmental report, the carrying out of consultations, the taking into account of the environmental report, and the results of the consultations in decision-making and the provision of information on the decision.

environmental report shall mean the part of the plan or programme documentation containing the information required.

"'the public' means: one or more natural or legal persons and, in accordance with national legislation or practise, their associations, organisations or groups;

'the public concerned' means: the public affected or likely to be affected by, or having an interest in, the environmental decision-making procedures referred to in Article 2(2); for the purposes of this definition, non-governmental organisations promoting environmental protection and meeting any requirements under national law shall be deemed to have an interest; "

EIA – Environmental Impact Assessment: the continuous assessment procedure that contains several individual stages such as screening, scoping and public participation.

EIA Directive – the Directive as a hole: i.e. Directive 85/337/EEC as amended by 97/11/EC.

Environmental Information, including the EIS (Environmental Impact Statement): the report, document, or set of documents produced or paid for by the developer to provide the environmental information required by the EIA Directive and which forms the basis for public participation and the consultation of environmental authorities and is submitted to the competent authority for consideration.

Screening is that part of the EIA process which determines whether an EIA is required for a particular project.

Scoping is the process of determining the content and extent of the matters which should be covered in the environmental information to be submitted to a competent authority for projects which are subject to EIA.

OTHER EU-LEGISLATION RELATED TO EIA:

IPPC-Directive (96/61/EC),
SEVESO-Directive (96/92/EC),
EMAS-Regulation ((EEC) No 1836/93), and
Habitats Directive (92/43/EEC).

Other reports of interest:

- Interrelationships between IPPC, EIA, SEVESO Directives and EMAS regulation. Final report. December 1998. IMPEL network.
- Convention on Biological Diversity. Decision VI/7. Identification, monitoring, indicators and assessments.
- Fourth Ministerial Conference Environment for Europe. Aarhus, Denmark, June 1998. Convention on access to information, public participation in decision-making and access to justice in environmental matters.. United Nations. Economic Commission for Europe.

Websites:

http://www.cde.ua.es/cde/doce.htm
http://www.europa.eu.int/comm/environment/eia/home.htm
http://www..biodiv.org/decisions/default

APPENDIX 2

PROCEDURES FOR THE DETERMINATION OF ENVIRONMENTAL IMPACTS

In this appendix, several practical aspects of the environmental impact analysis are detailed. The literature sources are Jain *et al.* (2001), Lawrence (2003) and Rowe and Abdel-Magid (1995).

A2.1. Baseline characteristics

The nature of the impact is determined by the conditions of the environment prior to the activity. Base data are information regarding what the measure of the attributes would be (or is) prior to the activity at the project location. Because the measurement and analysis of environmental impact cannot take place without base data, identifying the characteristics of the base is critical.

Geographic and temporal characteristics are to be determined. There may be significant differences in impact on attributes for a given activity in different areas and times.

For example, the impact of similar projects on water quality in an area with abundant water supplies and the impact in an area with scarce water resources would differ significantly. The spatial dispersion of different activities introduces one of the difficult elements in comparing one activity and its impact with another.

Time may also pose problems for the impact analysis. It is essential to ensure that all impacts are examined over the same projected time period. Furthermore, to adequately compare (or combine) activity impacts, it is necessary that the same time period (or periods) apply.

Identifying the impact of a project in an attribute leads directly to the second step of measuring the impact. Ideally, all impacts should be translatable into common units. This is, however, not possible because of the difficulty in defining impacts in common units (e.g. on income and on rare or endangered species). In addition to the difficulties in quantitatively identifying impacts are the problems that arise because quantification of some impacts may be beyond the state of the art. Thus, the problems of measuring and comparing them with quantitative impacts are introduced.

Quantitative measurements
Some attributes, such as BOD for example, may be measured and changes projected. Quantitative measurements of impact are measures of projected change in the relevant attributes. These measurement units must be based on a technique for projecting the changes into the future. The changes must be projected in the basis of a no-activity alternative. One difficulty in assessing the quantitative change arises from the fact that changes in different attributes may not be in common units. In addition, there are difficulties in assessing the changes in the attributes through the use of projection techniques.

Qualitative measurements
Changes in some attributes of the environment are not amenable to measurement. The attribute may not be defined well enough in its relationship to the overall environment to determine what the most adequate measurement parameter might be. Therefore, instead of a specific measure, a general title and definition may be all that is available. For example, one may project that the aesthetic elements of a view may be degraded,

but a quantified measure may not be available. In such cases, it may be necessary to rely on expert judgment to answer the question of how attributes will be affected by the subject project.
It is extremely difficult to compare all environmental parameters with one another. There is no single answer, but there are diffe rent techniques to perform it. One of them is the weighing system made by groups of experts.

A2.2. Secondary impacts

Secondary or indirect consequences for the environment should be addressed, especially as related to infrastructure investments that stimulate of induce secondary effects in the form of associated investments and changed patterns of social and economic activity. These effects may be produced through their impact on existing community facilities and activities, through induced new facilities and activities, or through changes in natural conditions. A specific example calls out possible changes in population patterns and growth that may have secondary and indirect effects upon the resource base, including land use, water and public services. In the biophysical environment, the secondary impacts can also be important.

A2.3. Cumulative impacts

A single activity may produce a negligible effect on the environment. However, a series of similar activities may produce cumulative effects on certain aspects of the environment. This raises the question on how to deal with these potential cumulative effects. The most obvious solution is to prepare impact assessments on brad programs rather than on a series of component actions. Unfortunately, the definition of activities at the program level may be so vague as to preclude identification of impacts on the attributes of the environment. Nevertheless, review of activities at the program level, requiring enough detail to evaluate impacts, is the best way to handle the problem of cumulative impacts.

In real life, determination of cumulative impacts on an ecosystem is rather complex. Conceptually, cumulative impacts should include impacts on environmental attributes by different activities of the project and incremental stresses placed on the environment as a result of present or planned projects, and degradation which might result due to the interrelationship of affected attributes.

Table A2.1. Incorporating principles of Cumulative Effects Analysis (CEA) into the Components of Environmental Impact Assessment (EIA).

EIA components	CEA Principles
Scoping	Include past, present, and future actions. Include all federal, non-federal and private actions. Focus on each affected resource, ecosystem, and human community. Focus on truly meaningful effects.
Describing the affected environment	Focus on each affected resource, ecosystem, and human community. Use natural boundaries

Determining the environmental consequences	Address additive, countervailing and synergistic effects. Look beyond the life of the action. Address the sustainability of resources, ecosystems and human communities.

A2.4. Reporting findings

The results of impact analysis process are documented in one or more of the following:

1. An assessment
2. A finding of no significant impact
3. A draft statement
4. A final statement.

A2.5. Methodologies

Jain *et al.* (2001) indicate the existence of several methodologies for the environmental assessment. Depending on the specific needs of the user and the type of project being undertaken, one particular methodology may be more useful than another. To select the most appropriate tools, the following key considerations may be useful:

- Application

Is the analysis primarily a decision, an information, or a regulatory compliance document?

A decision document is vital for determining the best course of action, while an information document primarily reveals implications of the selected choices.

A decision document analysis generally requires greater emphasis on identification of key issues, quantification or direct comparison of alternatives. An information document requires a more comprehensive analysis and concentrates on interpreting the significance of a broader spectrum of possible impacts.

A study whose sole purpose is for regulatory compliance combines the two approaches.

- Alternatives

Are alternatives fundamentally different?

If differences are fundamental, the impact significance should be measured against some absolute standard, since impacts will differ in type as well as size. On the other hands, incrementally different alternative sets permit direct comparison of impacts and a greater degree of quantification.

- Public involvement

Does the role of the public in the analysis involve substantive preparation of studies, especially those destined for public review?

Substantive preparation allows use of more complex techniques, such as computer or statistic analysis, that might be difficult to explain.

- Resources

How much effort, skill, money, and data and what computer facilities are available?

Generally, embarking on the more qualitative analyses will require more of everything, especially time.

- Time

Is there an announced project schedule?

The time for preparation of environmental documentations is severely underestimated – or omitted entirely.

- Familiarity

Is the preparer familiar with both the type of action contemplated and the physical site?

Greater familiarity will improve the validity of a more subjective analysis of impact significance.

- Issue significance

How big is the issue being dealt with?

The bigger the issue, the greater the need to be explicit, to quantify and to identify key issues. Arbitrary weights or formulas for trading off one type of impact (e.g. environmental) against another (e.g. economic) become less appropriate as the stakes increase.

- Controversy

Are the activities known to be controversial?

Certain types of actions are inherently controversial, or carry high potential to raise public ire and "politicians" involvement.

A2.6. Methodologies

There are six types of methodologies:

- Ad hoc

Provide minimal guidance for impact assessment beyond suggesting broad areas of possible impacts, rather than defining the specific parameters within the impact area which should be investigated. They may be effective when the preparers are unusually experienced in the type of action being examined and require only reminders.

- Overlays

These methodologies relay upon a set of maps of a project area's environmental characteristics (physical, social, ecological, aesthetic). These maps are overlaid to produce a composite characterization of the regional environment. Impacts are identified by noting the congruence of inherently antagonistic environmental characteristics within the project boundaries. The GIS (Geographical Information System) is a modern development of this method.

- Checklists

These methodologies present a specific list of environmental parameters to be investigated for possible impacts, or a list of agency activities known to have caused environmental concern. They may have considerable value when many repetitive actions are carried out under similar circumstances. They do not, in themselves, establish a direct cause-effect link, but merely suggest lines of examination. They may or may not include guidelines about how parameter data are to be measured and interpreted.

- Matrices

The matrix methodologies incorporate both a list of project activities and a checklist of potentially affected environmental characteristics. In a way, the matrix presents both alternatives from the checklist approach (i.e. both attributes and activities) to be considered simultaneously. Te two lists are then related in a matrix which identifies cause-and-effect relationships between specific activities and impacts. Matrix methodologies may either specify which actions affect which environmental characteristics or simply list the range of possible actions and characteristics in an opne matrix to be completed by the analyst.

- Networks

These methodologies work from a list of project activities to establish cause-condition-effect relationships. They are an attempt to recognize that a series of impacts may be triggered by a project action. Their approaches generally define a set of possible networks and allow the user to identify impacts by selecting and tracing out the appropriate project actions.

- Combination computer-aided

These methodologies use a combination of matrices, networks, analytical models, and a computer-aided systematic approach to:

1. Identify activities associated with implementing major federal programs.
2. Identify potential environmental impacts at different user levels.
3. Provide guidance for abatement and mitigation techniques.
4. Provide analytical models to establish cause-effect relationships to quantitatively determine potential environmental impacts.
5. Provide a methodology and a procedure to utilize this comprehensive information in responding to requirements of EIS preparation.

A2.7. Impact identification

Comprehensiveness. A full range of direct and indirect impacts should be addressed, including ecological, physical-chemical pollution, social-cultural, aesthetic, resource supplies, induced growth, regional economy, employment, induced population or wealth redistributions, and induced energy and land-use patterns.

Specificity. A methodology should identify specific parameters (subcategories of impact types), such as detailed parameters under the major environmental categories of air, water, ecology, etc. to be examined.

Isolating project impacts. Methods to identify project impacts, as distinct from future environmental changes produced by other causes, should be required and suggested.

Timing and duration. Methods to identify the timing (short-term operational versus operational phases) and duration of impacts should be required. (Data sources should also be listed for impact measurement and interpretation).

Data sources. Identification of the data sources used to identify impacts should be required. (Data sources should also be listed for impact measurement and interpretation).

A2.8. Impact measurement

Explicit indicators. Specific measurable indicators to be used for quantifying impacts upon parameters should be suggested.

Magnitude. A methodology should require and provide for the measurement of impact magnitude as distinct from impact significance.

Objectivity. Objective rather than subjective impact measurements should be emphasized. Professional judgments should be identified as such, although they may be the only criteria available in many cases.

A2.9. Impact interpretation

Significance. Explicit assessment of the significance of measured impacts on a local, regional, and national scale should be required.

Explicit criteria. A statement of the criteria and assumptions employed to determine impact significance should be required.

Uncertainty. An assessment of the uncertainty or degree of confidence in impact significance should be required.

Risk. Identification of any impacts having low probability but high damage or loss potential should be required.

Alternatives comparison. A specific method for comparing alternatives, including the no-action alternative, should be provided.

Aggregation. A methodology may provide a mechanism for aggregating impacts into a net total or composite estimate. If aggregation is included, specific weighing criteria or processes to be used should be identified. The appropriate degree of aggregation is a hotly debated issue on which no judgment can be made at this time.

Public involvement. A methodology should require and suggest a mechanism for public involvement in the interpretation of impact significance.

A2.10. Impact communication.

Affected parties. A mechanism for linking impacts to the specific affected geographical area or social groups should be required and suggested.

Setting description. A methodology should require that the project setting be described to aid statement users in developing an adequate overall perspective.

Summary format. A format for presenting, in summary form, the results of the analysis should be provided.

Key issues. A format for highlighting key issues and impacts identified in the analysis should be provided.

NEPA compliance. Guidelines for summarizing results in terms of the specific points required by NEPA and subsequent CEQ regulations should be provided.

In addition to the above “content” criteria, methodological tools should be evaluated in terms of their resource requirements, replicability, and flexibility.

A2.11. Resource requirements

Data requirements. Does the methodology require data that are presently available at reasonable acquisition or retrieval cost?

Personnel requirements. What special skills are required? How many persons will be needed to implement the methodology? Do you have them available?

Time. How much time is required to learn to use/and or apply the methodology?

Costs. How do costs using a methodology compare to costs of using other tools?

Technologies. Are any specific technologies (e.g. use of a particular computer software) required to use a methodology?

A2.12. Reliability

Replicability. Can the results be repeated given the same or similar conditions?

Ambiguity. What is the relative degree of ambiguity in the methodology? Does it measure what it says is measured?

Analyst bias. To what degree will different impact analysis using the methodology tend to produce widely different results? Now much of the methodology is really subjective?

A2.13. Flexibility

Scale flexibility. How applicable is the methodology to projects of widely different scale?

Range. For how broad a range of project or impact types is the methodology useful in its present form?

Adaptability. How readily can the methodology be modified to fit project a situation other than those for which was designed?

Comparison of methodologies. Methodologies can be rated for their degree of compliance with the 20 content criteria discussed above.

A2.14. Cumulative impact analysis

For some time, evaluators of environmental effects have realized that the most significant environmental effects may result not from the direct effects of a particular action, but, rather, from the cumulative effects of multiple actions over time.

What has regularly been overlooked is the effect of the proposed action, taken in the context of many other actions, proposed and real, of many other entities. Cumulative impact assessment has been given less attention due to limitations in structured methodologies and procedures, as well as difficulties in defining the appropriate geographic (spatial) and time (temporal) boundaries for the impact analysis.

The CEQ defines cumulative effect as “the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonable foreseeable future actions regardless of what agency or person undertakes such other actions”.

Table: Screening questions

No.	Questions	Rating	Score
1	What is the approximate cost of the construction project?	High Medium Low	10 5 0
2	How large is the area affected by the construction or development activity?	High Medium Low	10 5 0
3 4	Will there be a large, industrial type of project under constructions? Will there be a large, water-related construction activity?	Yes No Yes No	10 0 10 0
5	Will there be a significant waste discharge or generation of hazardous wastes?	Yes No	10 0
6	Will there be a significant disposal of solid waste (quantity and composition) on land as a result of construction and operation of the project?	Yes No	10 0
7	Will there be significant emissions (quantity and quality) to the air as a result of construction and operation of the project?	Yes No	10 0
8	How large is the affected population?	High Medium Low	10 5 0
9	Will the project affect any unique resources (geological, historical, archaeological, cultural, or endangered and threatened species?	Yes No	10 0
10	Will the construction be in a floodplain?	Yes No	10 0
11	Will the construction and operation be incompatible with adjoining land use in terms of aesthetics, noise, odour, or general acceptance?	Yes No	10 0
12	Can the existing community infrastructure handle the new demands placed upon it during construction and operation of the project (roads/utilities/health services/vocational education/other services?	Yes No	10 0

Possible scores range from 0 to 120. Within this range, the following three levels of projects are defined:

Level I: small-impact projects = scores 0-60
Level II: Medium-impact projects = scores 60-100
Level III: High-impact projects = scores > 100.

APPENDIX 3

ECONOMIC AND SOCIAL IMPACT ASSESSMENT

The information from this appendix is extracted from Rowe and Abdel-Magid (1995); Jain *et al.* (2002), Lawrence (2003) and AATSE (2004).

The public is increasingly aware of the impacts generated by the projects or implementation of policies related to the environment. This can be caused by the increasing attention that the media devote to the environment-related affairs or because of an increase of the education in that sense. In any case, and following the directives of almost all states or supranational bodies, communication is becoming a transversal policy.

Then, it is to say that if the public – any public – expresses a concern – any concern – then it may be established that a valid concern exists. The twist on this is that it need not be further proven. At least with respect to the existence of a social concern, the expression of a problem may be equated with its presence. The converse need not be true, however.

Valid problems may exist which are not necessarily perceived by the public or voiced by any group. The problem here is that of determining which concerns and to what degree, might be valid foci for inclusion within an environmental assessment or impact statement.

Economic impact analysis is a component of environmental impact analysis that is frequently misunderstood. The relevance of economics as an element of the environment is difficult to rationalize, particularly when economics has been set forth as an equal and opposite factor to be traded off against the environment. However, just as the ambient environmental setting within which a project is to take place determines the effect that project will have on the environment, so the economic setting within which a project is to take place will affect the environment.

This is based on the fact that the environment, in its broadest sense, covers all the factors that affect the quality of a person's life. This quality is determined by all the factors contributing to health and welfare, for both the short term and the long term. A general list of factors that describe the environment in this context includes both ambient biophysical conditions such as air, ecology, water, land and noise and the existing social, political, end economic structure of a community. The economic conditions per se might be affected just as is air of water.

Certainly, today lesser-developed countries and regions often state themselves to be willing to trade environmental (ecological) quality for a beneficial change in their economic condition. Knowledge and understanding of the economic consequences of an action (positive and negative) can no longer be separated from the environmental impact analysis.

Economic impact analysis would normally consider effects on both economic *structure* (e.g. the mix of economic activities such as forestry, agriculture, industry, commerce) and economic *conditions* (e.g. income, employment levels, inflation rate). Measurement of effects on both the economic structure and conditions is appropriate. As a result, consequences of projects such as changes in employment, income, and wealth for a community are used to describe the economic aspects of environmental impact. These factors, however, should be weighed with environmental (i.e. biophysical) gains and losses. In this analysis it is useful to divide economic factors into two categories, the first relating to a description of the economic structure, and the second to a description of economic conditions.

Table A3.1. Structure and conditions of economic factors

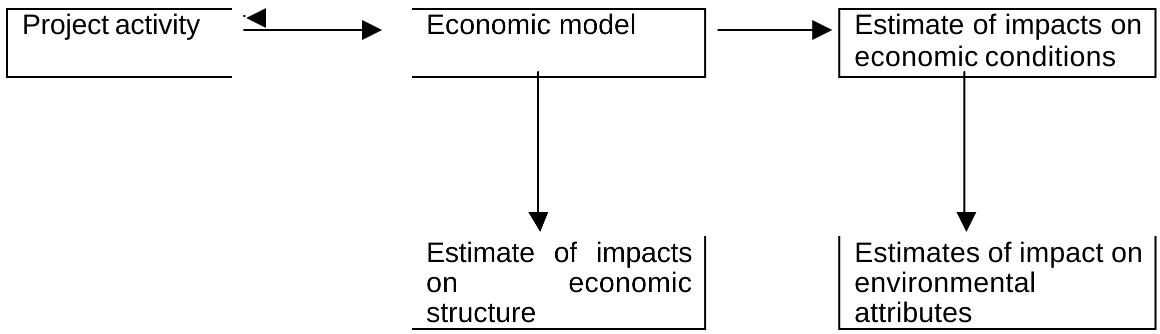
Structure	Mix of	Employment by industry
		Public versus private sector income
	Mix of	Economic activity by industry and commercial sector
		Income distribution Wealth distribution
Conditions		Income per capita
		Employment level
		Changes in wealth
		Levels of production by sector

The relationship of economic impact to environmental impact has its basis in the fact that changes in economic conditions lead to direct or indirect effects on the environment. Increases (or decreases) in income, production or outputs in the society are leading to changes in effluents. Those changes are caused by the production and consumption of goods and services. Changes in the quantity and nature of these effluents affect the environment.

Direct observation of economic structure and conditions is difficult, although generally easier than many other environmental attributes. Economic effects have been modelled formally for many years, because of this, a model of the economic system is usually used to estimate and project resulting effects. Models are constructed so that changes resulting from project activity can be traced through the effect on the economic variables of structure and conditions. Further, currency is naturally quantified, and many data on such factors as income, tax collections, public expenditures, and investment are already collected by various state and federal agencies for other purposes.

Project activity is the force (exogenous) that drives the economic model. The model estimates impacts on economic conditions and/or structure. The changes in economic conditions are translated, usually through another model, into impacts on other environmental attributes.

Figure A3.1. The relationships between project activity and impacts.



There are several models that might be employed in this framework to help in estimating the effects of project activities in the environment. Two of these models, the *input-output* and the *economic base*, are the most commonly employed. The even more common *cost-benefit* analysis is normally used primarily for project justification and support.

Both of the models (input-output and economic base) are operational and have been applied hundreds of times in specific impact analyses. Thus, they represent applied approaches to dealing with the economic aspects of environmental impact analysis.

The first approach can be used to develop detailed estimates of changes in structure and the secondary impacts in the local economy, while the second approach provides a brad estimate of the effect of economic conditions in a community where changes have been introduced by project activity.

Dealing with the social impact assessment is of particular importance the consideration of qualitative effects which are not easily captured by conventional methods. It is in this area, an area called social impact assessment, that specific considerations of the effects on people and their relationships are studied.

Today, social impact assessment is recognized as important because it represents a method to capture the effects of programs and projects on the quality of life. The parameters range from health and education to recreation and community cohesion. It has also been viewed, and correctly so, as very difficult to conduct because the measurement of social impacts, which are of necessity qualitative, is not easy. Once they have been measured, there are no solid objective standards against which the changes can be compared to say if they are “good” or “bad”.

Historically, the most widely used method for social impact assessment was the case study. This approach relies extensively on the creativity of the person conducting the study to find the critical factors to be analyzed. In addition, the data collected, which provide the historical, current, and projected future, tend to be qualitative and anecdotal. Involvement of people in the community is practised in case studies through interviews and meetings.

The methods to be used, which underlie social impact assessment, range from trend analysis to scenarios. These methods are all aimed at obtaining a view of the future with respect to social parameters. Some methods are very objective and analytical, and other are subjective and qualitative. People react differently to the method that is being employed. The more analytical and abstract the method, the more argumentative and defensive are people in the community being analyzed. The qualitative and opinion-based approaches have the strong advantage of involving people from the affected area in the analysis. This improves communications, understanding, and involvement. These factors are critical to the success of social impact assessment, a fact which significantly distinguishes this aspect of environmental impact assessment from the other traditional dimensions.

Table A3.2. Scheme for Social Impact Assessment (SIA)

1. Establish a baseline	a. Identify key issues b. Identify data sources
2. Forecast changes 3. Evaluate changes	
4. Identify how to respond	a. Weigh available mitigation b. Weigh need for compensation
5. Evaluate how to respond	a. Recommend mitigation b. Recommend compensation
6. Monitor	a. Evaluate effectiveness b. Make adjustments

Another important factor is that, for social impact assessment, there is seldom a definitive answer or forecast. There are lots of “if this, then thats” and significant uncertainty and risk. When methods and approaches are used to derive a definitive answer which disguises the uncertainty and risk, people in the affected community realize it and tend to be argumentative and contentious.

Trend analysis

This method is based upon extrapolation of past developments and changes into the future. It is simple to do, and the techniques can be as ordinary as visual interpretation of directions (from a graph or chart) or as complicated as multiple regression techniques based on statistics and mathematical modelling.

This method is very useful as a “first cut” at possible future outcomes. The main weakness of trend analysis is that usually the models are simple relationships that include time and, as a result, may not be particularly accurate or compelling.

Content analysis

This method is very useful and popular because it relies on the analysis of secondary sources (newspapers, journals, magazines) for expressions of opinions, judgment, and expectations. One weakness of this method is that ideas about unexpressed or unexplained issues would not be analyzed. Another weakness is that it remains an indirect indicator of social concerns. It is really an evaluation of newsworthiness of an issue, and is dependent totally upon the perspicacity of the reporter and editor, much less upon the feelings of the members of the general public, and still less upon objective analysis of the probable change.

Other methods are:

Case study, Delphi, Participant observation, similarity, dynamic simulation, inference from theory, surveys, and scenarios.

Table A3.3. Example of list of socioeconomic attributes. Two levels.

Demographic and population effects	Physical environmental quality effects
Age	Particulates (air)
Sex	Odour (air)
Race/ethnicity	Suspended solids (water)
Education completed	Thermal (water)
Occupations	Communication (noise)
Household composition	Social behaviour effects (noise, etc.)
Government fiscal effects	
Tax rates	Public health status effects
Tax burden	Number/type of facilities
Expenditures	Number/type of personnel by skill level
Revenues	
Debt	Occupancy patterns
Educational effects	Cost of health care
Enrolment	Special services (elderly, low income)
Facilities	
Teacher supply/qualifications	Quality of drinking water supplies
Student-teacher ratio	Family status effects
Achievement (graduates/dropouts)	Marital status
Finance	Family size
Housing status effects	Marriage
Enumerations	Divorce
Ownerships/rental patterns	Composition
Characteristics by type, age, size	Public safety effects
Cost/rent	Fire protection
Construction starts	Police protection
Availability ratios by type	Ambulance service
Labor force effects	Rescue service
Employment	Recreational opportunity effects
Labor force participation	Type of facilities
Employment distribution (by sector)	Ownership
	Participation
Employment opportunities	Distribution/accessibility
Economic status effects	Cultural alternative effects
Regional economic stability	Historical/prehistoric sites
Income	Unique human settlements
Income distribution	Local government (functions-responsiveness access to) effects
Energy expenditures	
Industrial sector effects	Planning
	Regulation, standard setting
	Protection of welfare
	Education
	Administration
	Enforcement

The stakeholders need to know the potential effects on the community or region of large construction projects to enable to plan for potential changes in temporary and permanent employment in an area.

Changes in employment and in locally produced and consumed goods and services are the cornerstones of information needed to estimate impacts. The added people and activities will require augmented public and private services that will cost more money to deliver. Increased income to the population and resultant increases in assessed value of property will, in turn, generate additional public revenue. Before the community can deliver the services demanded, careful planning by responsible community entities is required. A detailed projection of the expected effects of a project on expanding the labour force should be made as a first step in this planning process.