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Title of Paper: **Charting relationships between water supply and community livelihood and national economic welfare**

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Abstract
Water is recognised as an economic good and government and private enterprises invest money in an attempt to gain the greatest returns from this economic good. However, existing methods of assessing 'the greatest return' do not place a monetary value on the benefits of water supply to communities or to the country's economy (GWP 2003; Pond et al. 2008). In this paper we discuss our first ideas towards developing a method to estimate the community and national benefits of upgrading small water supply systems. This paper provides a starting point to defining those benefits by identifying conceptual relationships between a water supply system and quality of life indicators. These relationships are presented in terms of a flow chart, in which the water supply system is defined in terms of its inputs and attributes. Community welfare is defined in terms of generally accepted quality of life parameters; and national welfare is defined in terms of Gross Domestic Product (GDP). The chart highlights which relationships are well understood and which relationships require greater analysis to significantly improve the understanding of the benefits of water supply systems. The chart will be useful in helping local and national decision makers to consider the impacts of their decisions on the water supply system itself, community-level quality of life indicators, and GDP.

This paper summarises the relationships identified during the literature review phase of the first author's PhD candidature. The next phase involves development of models to analyse and quantify those relationships.

Introduction
Water is recognised as an economic good and government and private enterprises invest money in an attempt to gain the greatest returns from this economic good. However, existing methods of assessing 'the greatest return' do not place a monetary value on the benefits of water supply to communities or to the country's economy (GWP 2003; Pond et al. 2008).

Water supply systems contribute to economic growth by providing clean drinking water, thereby improving quality of life; and by providing water to businesses for both domestic and production purposes. The UN Millennium Development Goals (MDGs) were initiated in September 2000 with the aim of improving quality of life worldwide (UN 2002). Since that time, world leaders have acknowledged that infrastructure development, renewal and maintenance are critical to meeting the MDGs (OECD 2006). Table 1, adapted from Willoughby (OECD 2006, p.71), shows how convenient and adequate water and sanitation infrastructure can contribute to the MDGs.

Table 1. Potential Contributions of Infrastructure to Millennium Development Goals (Source: OECD 2006, p.71)

	MDG	Infrastructure Contribution
1	Reduce poverty and hunger	**Household water**: Reduces morbidity and mortality, time spent fetching water, and enterprise interruptions, and improve nutrition, with significant effects on poor people's productivity. **Sanitation**: Reduces illness and expenditure on medical treatment (itself a significant factor in poverty). **Water management structures**: Irrigation and flood control structures can greatly increase incomes and nutrition levels of the poor if they are managed to maximise benefits to the community as a whole, and especially if they support production of labour-intensive crops.
2	Full primary education coverage	**Household water**: Good home water supply increases school attendance (especially by children with literate mothers) and increases learning capacity. **Sanitation**: Good sanitation/water helps attract good teachers.
3	Gender equality in education	**Household water**: Facilitates release of girls for school and reduces absences due to sickness. **Sanitation**: Good school sanitation and water facilities increase girls' attendance. **Water management structures**: Less drudgery for women in obtaining water for household needs.
4	Reduce < 5 mortality	**Household water**: Good home water supply greatly reduces child mortality, especially if mother is literate. **Sanitation**: Decreases child mortality and improves nutrition. **Water management structures**: More ample supplies of water for household use.
5	Maternal mortality reduction	**Household water**: Improves general maternal health and deliveries. **Sanitation**: Improved sanitation reduces maternal illness.
6	Communicable disease	**Household water**: Clean water important for disease treatment, and for formula milk (HIV mothers). **Sanitation**: Effective water disposal reduces malaria mosquito breeding. **Water management structures**: Care needed to avoid adverse health consequences of man-made changes in water regimes.
7	Environmental protection	**Household water**: Crucial for meeting the household water target under this goal. **Sanitation**: Crucial for meeting the sanitation target and combating urban environmental degradation. **Water management structures**: Sound planning, design and op. of water-related structures are key in protecting environmental resources and accommodating growing populations.
8	Framework for development	**Household water**: Water improvement much needed in least developed countries. **Sanitation**: Sanitation high priority in least developed countries.

In terms of the first MDG, reducing poverty and hunger, the Center for Disease Control and Prevention (2005) estimates there are four billion episodes of diarrhoea, resulting in two

million deaths worldwide every year. Water supply systems also promote health and education, as shown in MDGs 2 through 7, and economic growth, as suggested by MDG 8.

Globally there is a move to privatise the water sector in order to improve efficiencies in service delivery, yet in many cases privatisation has worsened economic conditions (Kikeri and Kolo 2005; Estache, Goicoechea and Trujillo 2006). As it is widely acknowledged that government regulation is required to ensure communities benefit appropriately, this paper aims to incorporate quality of life benefits in computing the total returns resulting from the development of a new or existing water supply system.

Literature review

Quality of Life Indicators

There are about two dozen quality of life indicators in use throughout the world to gauge national welfare (Burke 2004), but the main three the Ministry of Economic Development (MED) looks to in New Zealand are the UN Human Development Index (UNHDI), the Economist Intelligence Unit's Quality of Life Index, and the more strictly economic Gross Domestic Product (Ministry of Economic Development et al. 2007). The UNHDI comprises life expectancy, education and purchasing power parity (PPP) income, whereas the Economist's indicator comprises the measures listed below (The Economist 2005):

1. **Material wellbeing:** GDP per person, at ppp in $.
2. **Health:** Life expectancy at birth, years.
3. **Political stability and security:** Political stability and security ratings.
4. **Family life:** Divorce rate (per 1,000 population), converted into index of 1 (lowest divorce rates) to 5 (highest).
5. **Community life:** Dummy variable taking value 1 if country has either high rate of church attendance or trade-union membership; zero otherwise.
6. **Climate and geography:** Latitude, to distinguish between warmer and colder climes.
7. **Job security:** Unemployment rate, %.
8. **Political freedom:** Average of indices of political and civil liberties. Scale of 1 (completely free) to 7 (unfree).
9. **Gender equality:** Ratio of average male and female earnings, latest available.

The Economist Intelligence Unit has measured their QOL indicator against a Life Satisfaction Survey, and has found that GDP accounts for more than 50% of the variation between countries in life satisfaction. While it is widely agreed that GDP on its own is not an appropriate measure of quality of life, most quality of life indicators include income or some form of material well-being as one of the primary variables. Income provides consumption choices and allows us to buy services such as health care, education, welfare, environmental protection and security (Ministry of Economic Development et al. 2007). In New Zealand, the Royal Commission on Social Policy concluded that

> [New Zealanders] have said that they need a sound base of material support including housing, health, education and worthwhile work. A good society is one which allows people to be heard, to have a say in their future, and choices in life ... [they] value an atmosphere of community responsibility and an environment of security. For them, social wellbeing includes that sense of belonging that affirms their dignity and identity and allows them to function in their everyday roles. (MSD 2007)

The MED and MSD use economic and social indicators to measure progress towards goals and evaluate effectiveness of economic and social policy; many of these indicators overlap, or are inter-connected, as in the areas of health (life expectancy), knowledge and skills (participation in early childhood education, school leavers with higher qualifications, participation in tertiary education, and educational attainment of the adult population), paid work (unemployment and employment), and economic standard of living (income per person, income inequality) (Ministry of Economic Development et al. 2007; Ministry of Social Development 2007).

Other government departments in New Zealand use the Social Deprivation Index, which indicates socio-economic status for small geographic areas. The Deprivation Index ranges from 1 to 10 (least to most deprived) and comprises the following components (Statistics New Zealand 2006):

1	Income	People aged 18–64 receiving a means tests benefit
2	Employment	People aged 18–64 years who are unemployed
3	Income	People living in equivalised households with income below an income threshold (Equivalisation: method used to standardise household composition and size.)
4	Communication	People with no access to a telephone
5	Transport	People with no access to a car
6	Support	People aged less than 65 years living in a single parent family
7	Qualifications	People aged 18–64 years without any qualifications
8	Living Space	People living in equivalised households below a bedroom occupancy threshold
9	Owned Home	People not living in own home

Water Supply Systems' Contribution to Quality of Life

Domestic water use affects health, which in turn affects education – a key indicator for skills and talent. A study by Curtis and Cairncross (Pond and Pedley 2008, p.7) suggests the health benefits of water supply are manifested more through improved access to water, and therefore greater water quantity, than through improvements in water quality.

A well functioning water supply allows people to go about their lives with a degree of certainty about the water available for use, which provides a sense of stability. The presence of a water supply system can be integral in the development or even existence of a community.

People's Contribution to National Productivity

In addition to having the right to enjoy basic health and sanitation, people contribute to economic development through their work, through the number of hours worked (labour utilisation) and output for each unit of paid work (labour productivity). Utilisation and productivity drive GDP growth, and are a function of their underlying determinants, as shown in Figure 1.

Human capital, the knowledge and skills our workforce possess, contributes significantly to economic development, but existing human capital indicators do not adequately explain GDP growth (NZIER 2004). In Southland, for example, GDP per capita is above average for the country but a low proportion of the population have formal qualifications. Some other facets of quality of life may help in accounting for national economic well-being and growth.

Water Supply Systems' Contribution to National Economic Welfare

In a report prepared for the MED, O'Fallon (2003) emphasises that investment in infrastructure projects should target national benefits. The MED states that:

> The economic benefits of infrastructure have been the subject of debate for a number of decades. A broad consensus now exists that an appropriate level of public infrastructure has a positive productive effect on economies, in both the short and long term. Further, the evidence suggests that, over the long term, public investment in infrastructure encourages greater levels of private investment. (Ministry of Economic Development et al. et al 2007)

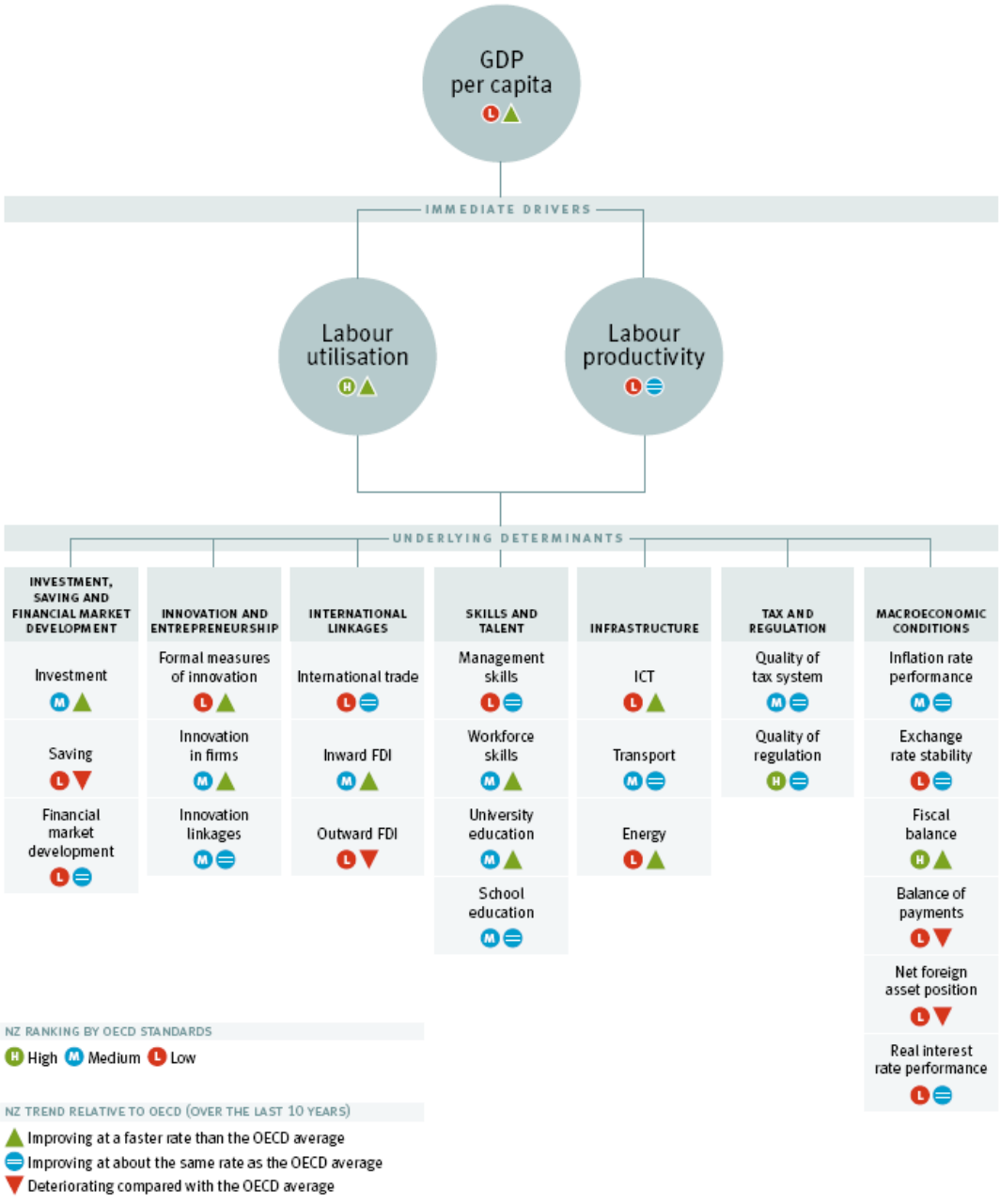

Figure 1. Underlying factors of GDP
(Source: Ministry of Economic Development et al, 2007)

Pond and Pedley (2008) state that it is necessary to accurately describe a physical situation and link causal factors in order to convincingly value socio-economic costs and benefits. The UNSD (2007) has developed a system for accounting for relationships between water and the economy, as shown in Figure 2 and Figure 3. A related set of tables is used to evaluate economic output of water used. This system does not address benefits to quality of life. Water is used by households and industry; in both cases, productivity relies on water quality, quantity, accessibility, and reliability.

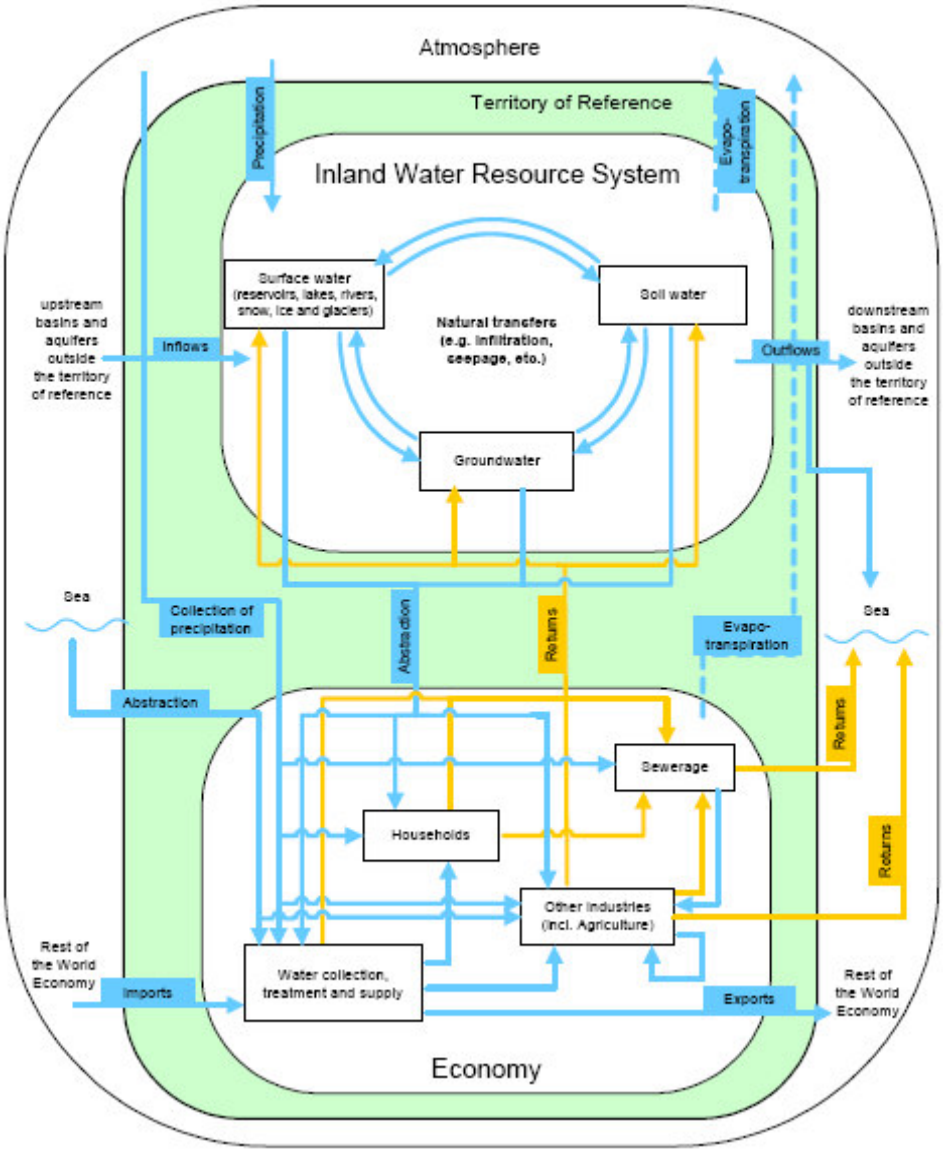

Figure 2. Main flows within the inland water resource system and the economy
(Source: UNSD 2007)

Existing Methods for Evaluating Benefits of Water Supply Systems

In New Zealand, the drinking water policy arm of the Ministry of Health (MoH) allocates funding for technical support and capital assistance to communities having a high deprivation index who can demonstrate financial need and risk to their existing water supplies (MoH

2006). The existing system does not measure community or national benefits arising out of water supply system upgrades.

Water supply systems are built or upgraded in order to meet users' quality, quantity, accessibility, and reliability needs. Water supply systems are also upgraded or renewed in order to improve operator safety, reduce resource and energy use, reduce environmental contamination, reduce risks of failure by introducing resiliency, redundancy, or improving operability controls and efficiency.

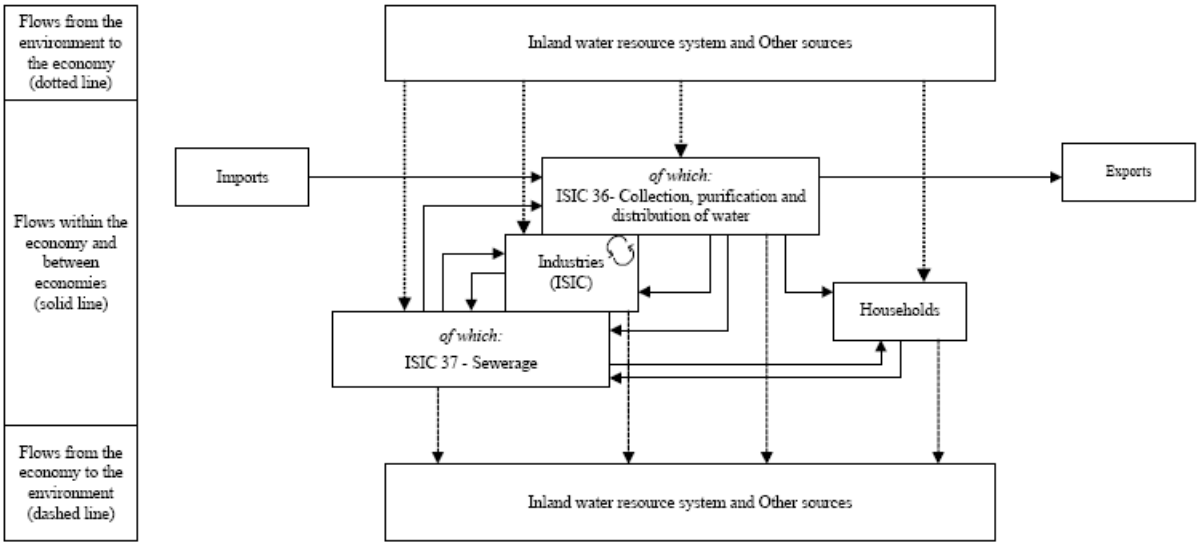

Figure 3. Detailed description of physical water flows within the economy
(Source: UNSD 2007)

Benefits of water supply upgrades are typically evaluated in financial terms, in terms of reduced maintenance and operational costs, and reduced risks to system failure and public health. Maintenance costs are defined in terms of operator attendance, power usage, chemical usage, and replacement of equipment and parts. A water supply system upgrade that proposes a gravity-fed system rather than a pumped system, or parts with longer expected lives, would imply economic benefits. The benefits of improved water quality to a community's general well-being, however, are not so readily calculated.

Economic, Social, and Environmental Sustainability

Sustainability defines the extent to which an activity can continue into the future. When evaluating the contribution of a water supply system to economic, social, or environmental well-being, it is important to consider the long-term effects on people, the economy, and the environment; a sustainable long-term solution may be one that appears to provide substandard benefits in the short term. Azar et al. (1996) (Figure 4) have developed socio-ecological sustainability indicators that focus on the following four principles, which are generally represented in terms of rates of use or extraction relative available resources:

1) Substances we extract must not accumulate in the ecosphere
2) Substances we produce must not accumulate in the ecosphere
3) Physical production and diversity conditions must not deteriorate
4) Resource use must be efficient and adequate to meet human needs

Purpose
This paper provides a starting point to evaluating the community and national benefits arising out of a new or upgraded water supply system. We take both a top-down and bottom-up approach by illustrating (1) the physical flows between the water resource and the economy, (2) the labour flows between physical or economic component; and (3) the attributes of the water supply system and their relationship to labour utilisation and productivity.

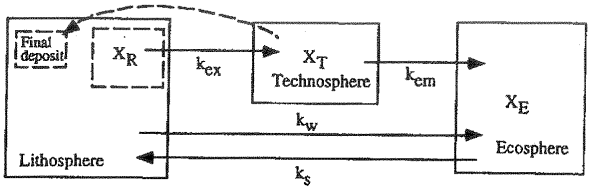

Figure 4. Socio-ecological relationships
(Source: Azar et al., 1996)

Methodology
We have developed a map showing the physical, social, and economic flows between the water supply system and (1) the ecosystem, (2) the economy, and (3) quality of life. The feedback loops represent downstream and future flows. Figure 5 shows the basic relationships between water supply system inputs and attributes and selected quality of life indicators, where the blue lines denote physical flows, green denotes social flows, and brown represents economic flows.

We show Gross Domestic Product (GDP) as an element within quality of life; we use GDP as a proxy for standard of living because (1) it represents material well-being, an important quality of life indicator; (2) it allows us to express benefits in monetary terms, which would help governments understand the economic benefits to the country; and (3) it is measured quarterly, and for most countries, which provides us with a time series with frequent and regular data points.

Conclusion
It is important to consider the physical (environmental), economic, and social relationships in order to understand the factors influencing quality of life. It is also important to consider the longer term behaviours of each of these relationships. Our map provides a starting point to understanding the wider benefits of water supply systems, their existence and any changes in level of service.

In the next phase of our research we will look to examine each relationship more in depth and attempt to quantify the relationships between the various components. The next phase will require careful examination of cause-effects relationships.

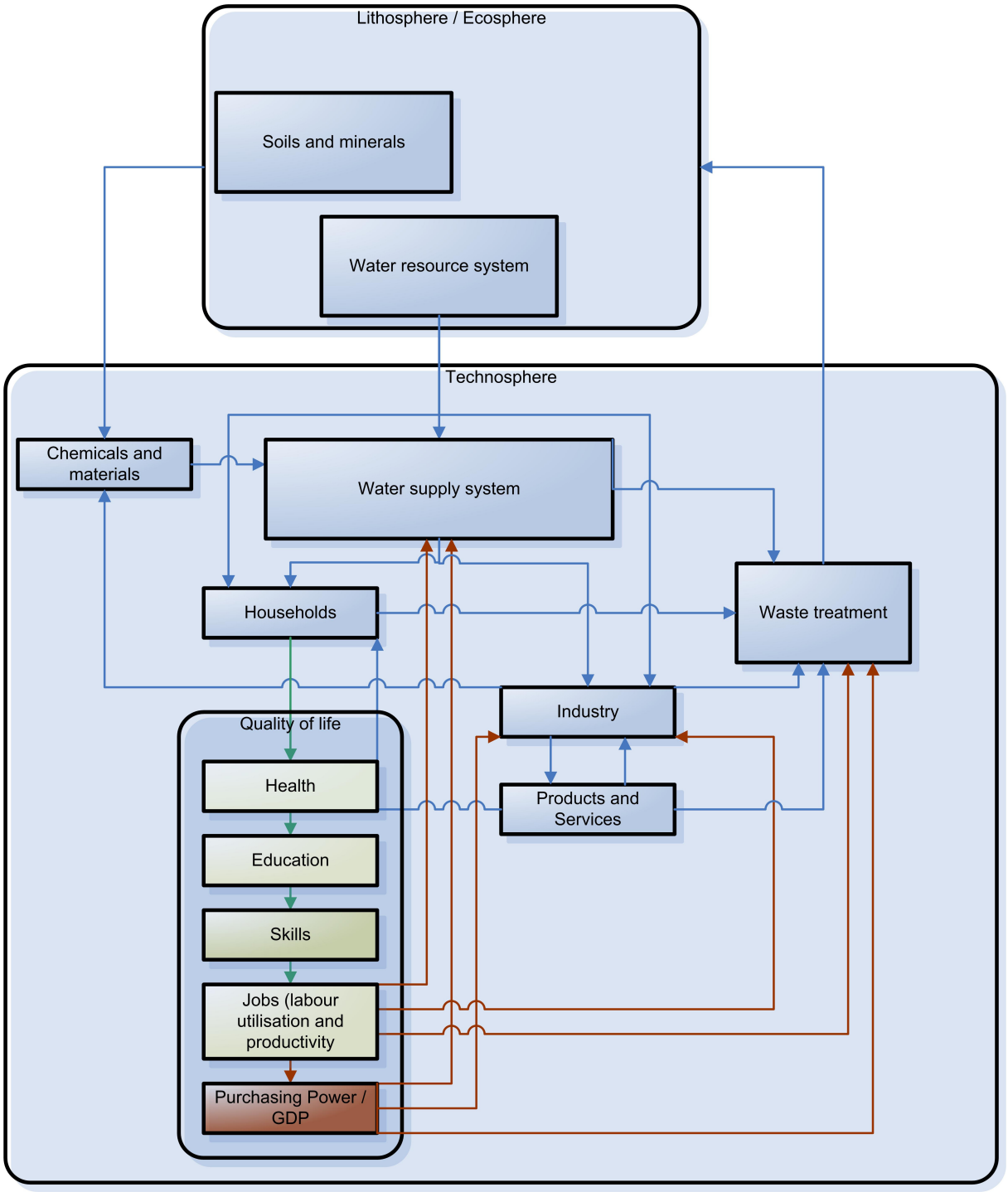

Figure 5. Basic relationship between water supply system and quality of life indicators

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