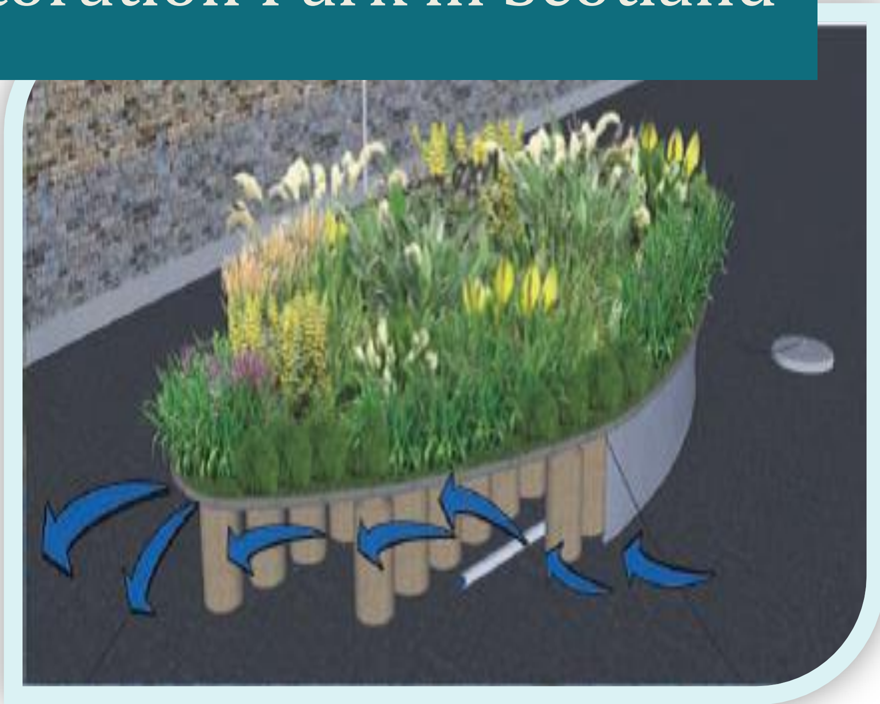
Scotland's centre of expertise for waters

Piloting a Water Restoration Park in Scotland



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This document was produced by:

Sue Morris, Andrew Cuthbert and Emily Hastings
The James Hutton Institute
Craigiebuckler
Aberdeen AB15 8QH
Scotland, UK

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Objectives of research

1. Investigate potential markets for reclaimed water by mapping the main (non-household) blue water users; assess the amount of blue water used; and consider users' likely interest in reclaimed waste water.
2. Identify the regulatory framework for reclaimed water, the water quality standards required, and any other parameters needed to satisfy potential market requirements.
3. Analyse information from Scottish Water asset data about the short list of wwtw currently being considered for pilot location.

Key findings

- Scottish non-household users of blue water use a great deal of potable water for non-potable purposes. The potential demand for reclaimed water is therefore high, especially if water quality requirements are met for specific purposes, and the water is cheaper than potable standard.
- The UK has been slow to implement waste water reclamation, and this is true for most European countries. Many commentators attribute this to human disinclination to use waste water and the apparent abundance of water in this region. Scientists commonly state that while the need for reclaiming waste water is established and the technology is there, both legislative and psychological or perceptual changes are needed if water recycling is to be taken up.
- Key policy drivers for implementation of water reuse in the UK are the Urban Waste Water Treatment Directive's encouragement[1] of "appropriate" reuse of treated waste water; the Water Framework Directive requirements that will result in more businesses considering water reuse (because of reduced abstraction and more stringent discharge consents needed to achieve good water status); and UK catchment abstraction management strategies that will reduce the capacity of water users to abstract.
- There are no specific regulations or UK or Scottish guidelines on water standards for reclaimed water. Experts indicate that for reclamation of waste water to gain impetus in the UK, a regulatory framework is needed, and also a demand management approach.

[1] The Directive does not include obligations to reuse treated waste water.

- Analyses of the Scottish Water shortlisted sites for the pilot Water Restoration Park facility indicate that a number of sites are suitable but that pilot success will depend on engaging local businesses as customers.

Policy implications

The report concludes with suggested options for pilot location. In brief, these are:

1. Focus on Scottish Water itself as a customer for reclaimed water.

2. Select a local authority as a partner in the initiative, as a customer for reclaimed water and select a suitable, local wwtw.

3. Focus on one or more potential customers that Scottish Water would like to encourage as buyers of reclaimed water, and engage with them to agree water quality and volumes required to enable their use of reclaimed water.

4. Select a wwtw where Scottish Water have identified a need for landscaping/upgrading and engage in discussions with the potential customer base.

Waste water reclamation and recycling is a new area of sustainable water management in Scotland. Interest in using reclaimed water needs to be fostered through (i) developing national guidelines to ensure public health, and (ii) by engaging with potential user communities (e.g. farmers, local authorities, commercial enterprises) and the consumers of their products (e.g. supermarkets, the general public) to raise awareness of the economic and environmental benefits of reclaimed water.

Research undertaken

We reviewed the literature to identify significant non-household blue water users; current regulatory frameworks governing the use of reclaimed water; and relevant water quality standards for potential end users. Findings were also used to discuss the potential interest in reclaimed water in Scotland.

We analysed data from Scottish Water's asset database, examining OPEX and CAPEX costs for 16 sites to identify potential pilot sites to trial the treatment system. We included additional information about these shortlisted sites and their local contexts to develop a matrix and produce a ranking of suitability to assist Scottish Water in selecting the pilot location using both quantitative and qualitative data.

Key words: reclaimed water; non-potable uses; quality standards; public perception

1. INTRODUCTION

This report responds to a CREW call down request submitted by Scottish Water to support its establishment of a pilot Water Restoration Park (WRP) at a waste water treatment works (wwtw) to reclaim, recycle and market the waste water. This CREW research seeks to investigate potential locations to pilot a WRP facility, regulatory frameworks and potential markets for the recycled water.

The ultimate aim of this initiative by Scottish Water (SW) and Biomatrix Ltd is to obtain value from waste water instead of discharging it to a receiving water body (as traditional wwtw do), therefore reducing blue water consumption, and waste water treatment costs. An added benefit of the WRP could be in supporting established treatment systems which may currently be struggling to maintain compliance with required standards.

In this report, we define reclaimed water as "the end product of wastewater reclamation that meets water quality requirements for biodegradable materials, suspended matter and pathogens" (Levine et al, 2004). Reclaimed water also refers to water that is treated to a lesser standard than drinking water. This is both to conserve drinking water, and to provide water treated to standards appropriate to use, e.g. in agriculture and industry. We use the term 'recycled water' to refer to use of reclaimed water.

This report is presented in three parts:
1) **Potential markets for reclaimed water**: main blue water users (non-household) that could benefit from this initiative; the amount of blue water used; and their likely interest in using reclaimed waste water.

2) **Regulatory framework for reclaimed water**: water quality standards required and any other parameters needed to satisfy potential market requirements.

3) **Establishing the pilot Water Restoration Park facility**: analysis of information about the wwtw currently being considered for pilot location.

1.1 Background to the research

Scottish Water has been awarded funds from the Technology Strategy Board to build a Water Restoration Park facility, preferably next to an existing wwtw (to be confirmed). The facility will treat different influent streams of waste water by replicating ecological restoration, using a cascade of natural treatment processes. This solution ought to reduce CAPEX (lower installation and major upgrade costs) and OPEX (lower energy requirements, chemical use etc.) when compared to traditional wwtw, with the added value of an attractive landscape.

To establish the pilot WRP facility, Scottish Water are teaming up with Biomatrix Water. The company is based in Moray and has been designing/building floating water treatment system technology for a number of years.

1.2 Why reclaim waste water?

Reasons for reclaiming waste water are widely documented in the literature. While arid regions have pioneered waste water reclamation and recycling, even countries (like the UK) which historically have been known for abundant water supply, are increasingly interested in reclamation. This is due to an increasing unpredictability of water supply in an environment of climate change (drought and flood risk), and also recognition that energy, chemicals, human resources and as a consequence funds, are being wasted to treat non-potable water to unnecessary potable standards. In addition, some characteristics of reclaimed water can be more beneficial for a particular use than fully treated water. For example, reclaimed water has additional benefits for the agriculture industry. Having been through a less thorough treatment process than drinking water, reclaimed water contains higher amounts of certain elements, including nitrogen, that can help fertilise plants. Conversley, potable water has chlorine or fluoride added that may be detrimental to plant growth (Hartman, undated). In Israel, which is a world leader in recycling wastewater, nearly 70% of wastewater is treated and reused for agricultural purposes, mainly for the irrigation of non-food crops and animal fodder in accordance with stringent permits issued by the Ministry of Health (Jewish Virtual Library, 2013).

1.3 How is reclaimed water used?

The main use of reclaimed water world-wide is agricultural irrigation, followed by urban uses including irrigation of public parks, gardens and cemeteries, but also for street cleaning, fire fighting, and ornamental uses, as well as water bodies and streams for recreational use, aquaculture and sewerage management (Aquarec, 2006). Industrial water reuse is less common but is practiced in countries including Spain, Belgium, Poland and Italy (CIWEM, 2007). Existing guidelines focus on reuse of reclaimed water in agriculture, and to a lesser extent, aquaculture. There are few guidelines on reuse in industry, although this use is commonly cited in literature on reuse potential. Uses include cooling of industrial processes, such as metal foundries; cooling towers in power plants; absorption chillers for air conditioning; evaporative cooling in horticultural greenhouses; CIP (Clean in Place) of industrial machinery; car, truck and pallet washing; cement mixing; recharging aquifers; snow making in ski resorts; recycling to public toilets; underground injection for oil and gas extraction; and mining.

1.4 Recycled water and human health

Much research investigates how recycled water may affect human health, and the findings are mixed. Crook (2005) found no incidences of illness or disease from either microbial pathogens or chemicals, concluding that risks of using reclaimed water for irrigation are the same as using potable water. Reclaimed water was also found to be safe for agricultural uses in studies by the US National Academies of Science (1996) and York et al (2008). Other studies found serious public health concerns about pathogens in the water (LaPara et al, 2006). Many pathogens cannot be detected by current testing methods (Oliver, 2005), and recent literature questions the validity of testing for "indicator organisms" as a proxy for pathogens (Harwood et al, 2005). There is some concern that existing guidelines do not include identification of interactions between heavy metals and pharmaceuticals, which may foster the development of drug resistant pathogens in waters derived from sewage (Tsai, 2008).

There are also issues about the use of treated waste water for industrial cooling. Cooper (2012) notes that of the 5,400 power plants in the USA, 60 use reclaimed municipal waste water for cooling. Most of these further disinfect the reclaimed wastewater, using treatment chemicals at the plant. Cooper identifies concerns about 'cooling tower airborne emission, and transport of pathogens and trace contaminants from the reused WWTP effluent.' He also notes the issue of drift, which is 'the discharge of small droplets of water from a cooling tower exhaust. These drift droplets contain the same constituents as the cooling water, and may include bacteria, viruses, and trace chemical constituents' (Cooper 2012).

2.0 POTENTIAL MARKETS FOR RECLAIMED WATER

This section uses available data on current non-domestic use of water to identify high water users, the amount of water they use, and the current market for reclaimed water in Scotland. While it is envisaged that the Scottish Water pilot Water Restoration Park will initially be seeking local markets for the reclaimed water, we include information about water use in Europe and England and Wales as potential future markets.

2.1 Key points

- Globally, agriculture is the main water user; in Europe, especially Western Europe, most water is used for industrial cooling.
- In the UK, the bulk of abstracted water (50%) is used for public water supply; the remainder is used in agriculture, fish farming, industry, and electricity generation.
- Despite the high profile use of reclaimed waste water in the London Olympic complex in 2012, it appears that the main barrier to using such water in the UK (as in the rest of Europe) is the perceived lack of need, and public distaste.
- Legislative initiatives, including a robust framework for reclaimed water quality standards, and changes in public perceptions are commonly cited as key drivers in developing a market for reclaimed waste water.
- While the Water Resources (Scotland) Act 2013 introduces new measures to reduce water abstractions without Ministerial approval, exemptions have been made for some major water users. This means that for these potential markets the economic driver to use reclaimed waste water for appropriate functions is also reduced.

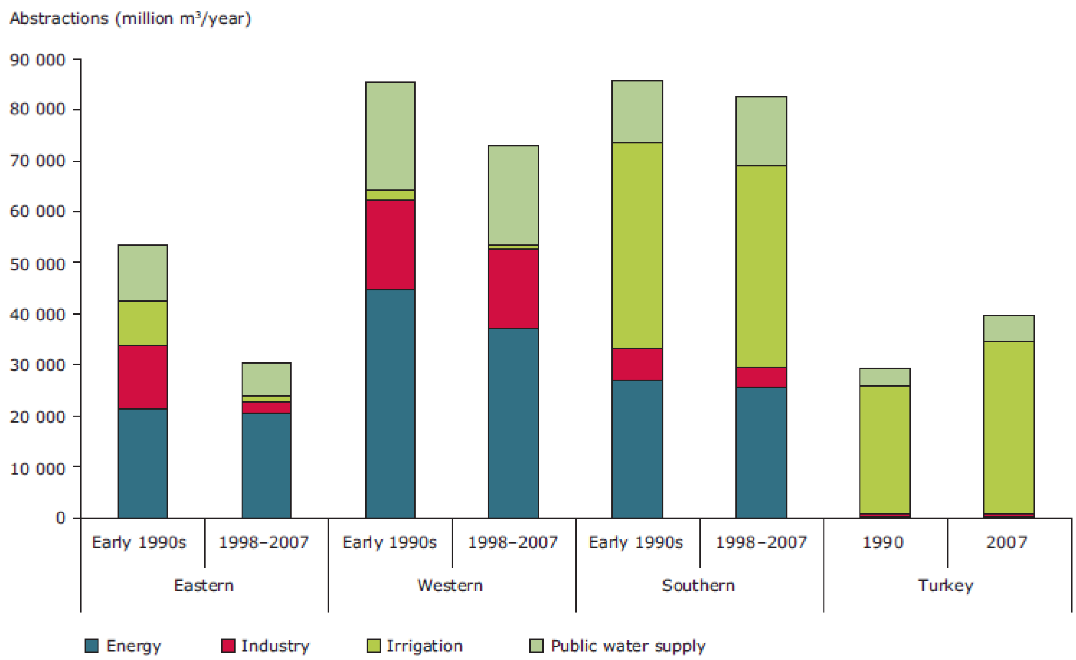
2.2 High water use sectors

2.2.1 Europe

According to the OECD (2004), agricultural producers use the largest volume of water globally. However, the European Environment Agency (2010) shows that for Europe the majority of water (45%) is abstracted for cooling in energy production. Looking only at Western Europe, this figure rises to over 50%. Agriculture is the next largest water user in Europe (22%), closely followed by public water supply (21%). The remaining 12% is used in industry.

Figure 1 shows the breakdown of abstractions in European regions by these sectors from the early 1990s to 2007. The figure shows that many millions of litres are abstracted per year, with Western Europe almost at equally high levels as the South throughout the period.

Figure 1 Water abstraction in Europe by sector, early 1990s, 1998-2007

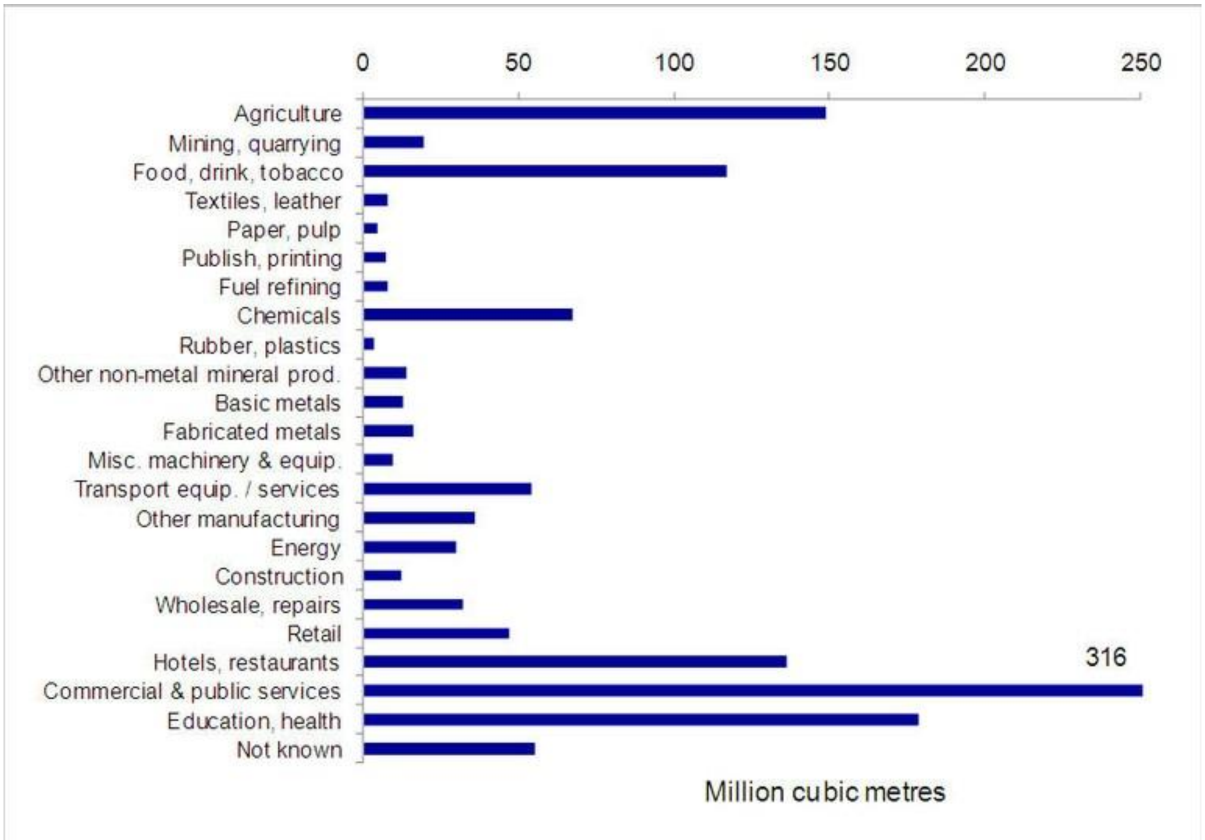


Source: EEA (2010a) Water resources: quantity and flows, p10

2.2.2 England & Wales

Over 14 billion cubic metres of water are abstracted from UK freshwater sources, the vast majority (12.4 billion cubic metres) in England and Wales (EEA, 2010b). About half of all abstraction is taken by the public water supply and the remainder by agriculture, fish farming, industry, and electricity generation. One third of abstraction for public supply is for non-household use. The remaining public supply is used by a variety of industries (figure 2).

Figure 2 Public Water Supply use by industrial sector, England & Wales, 2006/07



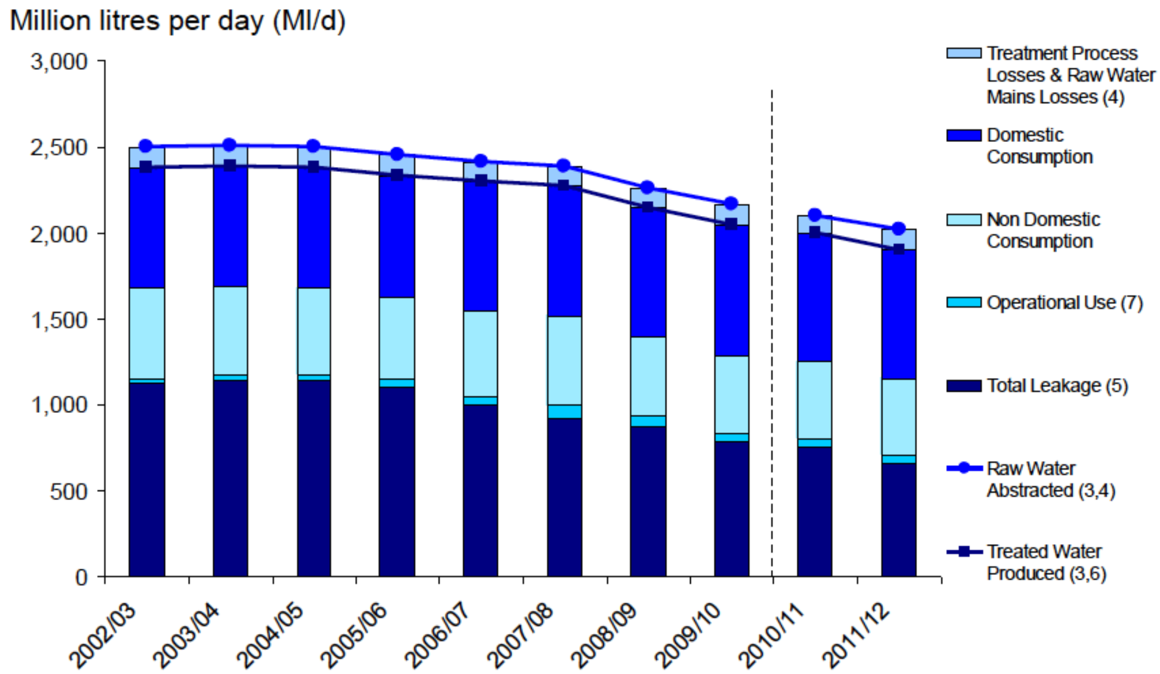
Source: EEA (2010c)

2.3 Potential for using reclaimed waste water in Scotland

2.3.1 Extent of potential markets

As reported for Europe as a whole, Scotland's abstraction rates have been reduced in recent years, partly due to changes in the industrial landscape but also to increased water efficiency and leakage reduction. Despite this, the rate of supply for non-domestic use has remained fairly constant (Scottish Government, 2012). It appears that the rate of supply for operational use has also remained constant. Supply rates for operational use are increasing slightly, although the total volume is much smaller than for domestic and non-domestic sector supply (figure 3). As a consequence, Scottish Water themselves could be considered as a potential market for reclaimed water.

Figure 3 Water Abstracted and Supplied, Scotland, 2002/03-2011/12



Source: Scottish Government 2012, p26

The largest enterprises in Scotland are among the highest water users, particularly agriculture and fisheries (Table 1). Construction is also a high water using sector and one of the largest employers in Scotland. Construction projects are generally short term and transient in nature and therefore, demand could be inconsistent. However, construction projects can suffer from a lack of a fixed water supply, therefore water tankers are necessary in some instances to ensure supply. This could be considered when selecting a site for the WRP pilot.

Table 1: Enterprises in Scotland by sector and employee numbers

Industry	Total	0 Employees	1-49 Employees	50-249 Employees	250+ Employees
Agriculture, Forestry and Fishing	19,360	11,895	7,440	20	5
Mining and quarrying, utilities	1,935	1,345	465	55	70
Manufacturing	14,380	8,540	4,980	605	255
Construction	46,940	35,420	11,095	285	140
Motor trade incl. vehicle repairs	6,535	3,520	2,895	75	45
Wholesale trade	8,455	4,670	3,310	300	175
Retail trade incl. fuel sales	20,190	9,395	10,265	230	300
Transportation and storage	20,590	17,375	2,855	220	145
Accommodation and food service ac	17,195	5,985	10,815	270	125
Information and communication	12,540	9,820	2,515	110	90
Financial and insurance activities	2,615	1,290	1,120	80	130
Real estate activities	5,590	3,140	2,325	80	45
Professional, scientific and technical	36,635	26,170	9,945	340	185
Administrative and support service a	17,380	11,690	5,165	285	240
Education	16,950	15,725	1,080	90	55
Human health and social work activit	23,465	17,855	5,120	355	135
Arts, entertainment and recreation	15,095	12,300	2,620	125	50
Other service activities	21,920	15,280	6,490	100	50
Total[1]	**307,770**	**211,420**	**90,490**	**3,625**	**2,230**

Source: Scottish Government, (2006a) [1]Excludes central and local government.

Table 1 excludes central and local government. Because local authorities use water for many purposes, including street cleaning and irrigation of public green space, these may also be usefully considered in establishing the pilot WRP. Scottish Government (2006b) gives a breakdown of Scottish economic sectors by local authority. This is reproduced in Annex 5 of this report. These data indicate that the market for reclaimed waste water is potentially high; however, other sources suggest that at present there is little demand.

Reclaimed water achieved high profile when it was recycled in the London 2012 Olympic Park initiative. CREW contacted the Olympic Delivery Authority (ODA) to obtain information about the reclamation process and use of the recycled water. Thames Water partnered the ODA in developing the facility. Table 2 shows how the recycled water was used.

Table 2 Water recycling by user/use, London Olympics 2012

End user	Type of use
*Olympic Stadium	Irrigation
Handball Arena	WC flushing
Velodrome	WC flushing
Parklands and Public Realm	Irrigation
Eton Manor	WC flushing and irrigation
Main Press Centre	WC flushing
Energy Centre	Cooling water demand
**Aquatics Centre	WC flushing
Athletes' Village	Irrigation and pond top up
*Due to the uncertainty around transformation of the Olympic Stadium, the toilets were not part of the non-potable network **The Aquatics Centre had an independent water recycling system using the pools filter backwash water.	

Source: Olympic Delivery Authority (2012)

Waste water was reclaimed using a water recycling plant located at Old Ford close to the Olympic park. In the absence of guidelines for reclaimed water quality, the ODA used bespoke standards, largely based on the United States Environment Protection Agency's guideline 'Urban Re-use". The ODA also worked with the Environment Agency and Health Protection Agency to develop a Water Safety Plan approach to recycling reclaimed waste water.

The ODA notes that the goodwill associated with the Games helped to overcome 'significant barriers' to the initiative from consumers and regulators, and suggest that the regulatory framework created for the Old Ford water recycling plant could be used in future water reclamation schemes in the UK.

Old Ford WRP: Source ODA (2012)

2.3.2 Potential interest in buying reclaimed water

Despite the success of the ODA initiative, it appears that there is little potential interest in reclaimed water in Europe. The UK has been slow to implement waste water reclamation, and this is true for most European countries (Aquarec, 2006). California, Israel, Japan, and Australia are seen as leaders in the field. McCann (2008) argues that in the UK, both regulators and the general public find the concept of recycled waste water difficult to understand, and this is associated with low levels of acceptance. Than (2012) argues that while the need for reclaiming waste water is established and the technology is there, both legislative and psychological or perceptual changes are needed if water recycling is to be taken up.

The Chartered Institution of Water and Environmental Management (CIWEM) agree, and has been arguing since 2002 for 'a coherent government policy on water reuse' together with 'authoritative reclaimed water quality standards that are realistic and protect public health and the environment' (CIWEM, 2007). They argue that these are needed to support development of water reclamation in the UK. The pressure group Waterwise (BBC, 2006) view increased use of effluent as a possibility in the UK, but emphasise the key driver for this is demand management.

The House of Lords Science and Technology committee (2006) stated that "there is scope for greater industrial use of wastewater that has been treated to a sub-potable standard" and that Government should investigate how to encourage this. The main policy drivers envisaged to affect the implementation of water reuse include: the Urban Waste Water Treatment Directive's encouragement of "appropriate" reuse of treated waste water; the Water Framework Directive requirements that will result more businesses considering water reuse because of reduced abstraction and more stringent discharge consents needed to achieve good water status; and UK catchment abstraction management strategies that will reduce capacity of water users to abstract.

In Scotland, the context for water abstraction has been changed by the Water Resources (Scotland) Act 2013 recently passed (27 February 2013) by the Scottish Parliament. Part 2 of the Act concerns control of water abstraction, and provides that any abstraction of water in Scotland above 10 mega litres per day (or other amount specified by regulation) needs approval from Scottish Ministers. Exemptions set out in section 7 of the Act include the major users of water in Scotland. Exemptions include Scottish Water in the exercise of its core functions, or where the sole purpose of abstraction is generating electricity by hydro power, irrigating agricultural/horticultural land, or operating a fish farm, quarry or coal mine.

2.3.3 Key barriers to uptake of reclaimed waste water

CIWEM (2008) report that recent studies have shown people 'do not like experiencing other people's waste and would possibly be concerned if they were aware of current practices of indirect recycling'. CIWEM argue that allaying public concerns about waste water recycling centres on 'whether or not additional standards are required for the control of waste water discharges, associated with future development of reuse opportunities'. They refer to a recently completed project that produced a protocol for developing water re-use criteria (UKWIR, 2005). While the protocol refers to drinking water supplies, its proposed framework of standards for the control of waste water discharges also aims to support more general acceptance of current use of treated and blended waste water as a raw water source.

Others agree that public perceptions of reclaimed water appear to be negative. Jeffrey (2011) found the amount of waste water reused in the UK to be negligible, and linked this to a deep rooted reluctance among British people to use reclaimed 'grey' water in homes and businesses. Courtis (2011) argued that the key barrier to take-up of waste water reclamation and recycling technologies are perceived public health concerns. He found that manufacturers and buyers 'believe their brand image would be compromised if they were seen to be using less than top-quality water'.

Waterwise provide some general information on the use of reclaimed water. We contacted Waterwise and were told that:

- Irrigation of food crops is unlikely to be a potential use. Their discussions with the food growers industry indicated they are not interested in water 'which has touched a toilet' because they perceive this to be damaging to their business.
- At least one major supermarket chain refuses to buy food which has been irrigated by recycled water. However, if the water is released to a river, they are happy to extract a few metres downstream and then use.
- Anglian Water treat waste water to a higher standard than drinking water and sell to the electronics manufacturing industry.

There appears to be some tension between producers and their customers about the standards of water needed for irrigation. Tyrrel et al (2004) studied required standards for irrigation of salad crops. They report that some of the multiple retailers in the UK favour a standard for irrigation water close to that which would meet the requirements for drinking water (i.e. absence or infrequent presence of E. coli in 100 ml water). The study's review of standards suggests that this may be an unnecessarily cautious and expensive option, a position supported by the salad growing industry which advocates a proportionate, science-based approach to the development of grower protocols rather than the adoption of an excessively precautionary principle.

3.0 REGULATORY FRAMEWORK FOR RECLAIMED WATER

3.1 Key points

- There are no specific regulations or UK or Scottish guidelines on water standards for reclaimed water.
- Countries with national regulations on the treatment of waste water for non-potable use are those where reclamation has become widely used, and regulations generally cover a wide range of contaminants.
- Experts indicate that for reclamation of waste water to gain impetus in the UK, a regulatory framework is needed, and also a demand management approach
- Managing demand for reclaimed water involves addressing a major issue for its uptake; potential customers are generally slow to accept non-potable use of waste water.
- Existing regulations and guidance from other countries are often specifically for water reuse in agriculture and aquaculture, rather than industry. Most regulations and guidelines are based on a risk assessment framework for protecting public health.

- Current debates include the issue of how stringent standards for waste water reuse should be, with the need for high standards to reassure consumers balanced against realistic and economic options that take account of regional differences and local conditions.
- There are World Health Organisation (WHO) and UNEP guidelines for waste water reuse for some regions. Some countries have additional requirements, such as treatment for Helminth eggs in Brazil (to address health issues related to tape worms).

3.2 Regulations on reclaimed water quality standards

Currently, there are no regulatory water quality standards in the UK for non-potable water (Environment Agency, 2008:11; Tyrrel et al, 2004). Article 12 of the Urban Waste Water Treatment Directive (91/271/CEE) sets out specific requirements for biodegradable industrial waste water discharges from certain industrial sectors, where the waste water is not treated by urban waste water treatment plants before discharge to receiving waters. The Directive makes reference to wastewater reuse in Europe, but states only that: "treated wastewater shall be reused whenever appropriate".

Statutory standards exist in other jurisdictions, but to date there are only a few countries where wastewater reclamation and recycling is well enough established to have led to specific regulations. Examples include the USA (particularly California), Singapore, Australia, Japan, and China. These are all places where legislation, technologies and good practice on wastewater reclaiming and recycling have improved markedly and are more developed than in Europe (Angelakis et al, 2007).

In the USA, the Clean Water Act promotes water reuse to reduce polluting discharges. There is no federal code specifically addressing water reuse; instead regulatory requirements are via case- and site-specific discharge permits issued to waste water dischargers through the National Pollutant Discharge Elimination System. Each state is therefore responsible for water reuse quality standards. State regulatory requirements generally involve definitions of treatment levels and/or establishing numerical standards for the reused water. Monitoring for water quality parameters of biochemical oxygen demand, turbidity, and total (or faecal) coliform counts is also commonly required (Wu, 2006).

The literature on waste water recycling standards notes that the Californian statutes are widely used as a basis for water quality regulation in countries with high standards for recycled water, e.g. Israel and Australia (Aquarec, 2006). California's 2011 revision of its Title 22 Statutes Related to Recycled Water (devoted to reuse) is very specific as to how reclaimed water quality objectives are to be achieved. It requires several barriers and controls, and a system of quality assurance to be established. These are regulated under the California Department of Public Health Regulations Related to Recycled Water, January 2009. Chapter 3, Articles 3, 4 and 5 are set out in full in Annex 1 of this report.

Israel's Waste Water Regulations 2010 (Ministry of Environmental Protection, 2010a) set the required standards for: unrestricted agricultural irrigation in general and for irrigation in specific areas of the country; restricted agricultural irrigation; and discharge to rivers from both large and small wastewater treatment plants. The regulations outline 36 parameters and these are set out in Annex 2 of this report.

3.3 Guidelines for reclaimed water standards

Guidelines for reclaimed water standards are more common than statutory provisions. The UK has guidelines based on the Bathing Water Directive, which relate to the intended use of the reclaimed waste water (Environment Agency, 2008:21); however, these are for grey systems in household or commercial premises rather than reclaimed water from waste water treatment works.

Guidelines have been developed for the use of reclaimed waste water in agriculture and aquaculture (WHO, 1989), for waste water reuse in the USA (US Environment Protection Agency, 2012) Europe (Aquarec, 2006), Australia (Environment Protection and Heritage Council, 2008), the Mediterranean region (Kamizoulis et al, 2005), Israel (Ministry of Environmental Protection, 2010) and Japan (United Nations Environment Programme, 2013). In Europe, the World Health Organisation (WHO) guidelines underpin standards for recycling waste water in most countries, although often with their own additional criteria, e.g. additional treatment requirements or use limitations relating to public health considerations. Outside Europe, most countries view the WHO guidelines as insufficiently stringent for public health protection in industrialized countries (Angelakis et al, 2007). The WHO 1989 guidelines have subsequently been revised (Smith 1993, Blumenthal et al, 2000) with more stringent standards now recommended for use of recycled water in irrigation and agriculture (WHO, 2006). Key tables from the WHO 2006 guidelines are set out in Annex 3 of this report.

More recently, an EU-funded research project (Aquarec) aimed to develop guidelines for water reuse in Europe (Aquarec, 2006), referring to both the California Title 22 statutes and the WHO 1989 guidelines, noting that many national guidelines are based on these. Aquarec's proposed guidelines for reclaimed water reuse include compiled chemical limits derived from existing guidelines, and a method for risk assessment that is based on the European Technical Guidance Document on Risk Assessment, based on the Commission Directive 93/67/EEC, Commission Regulation (EC) 1488/94 and Directive 98/8/EC. The Aquarec guidelines are set out in full in Annex 4 of this report.

Despite the growing interest in, and implementation of, waste water reclamation and recycling, Kamizoulis et al (2005) state that 'there is still a controversy between the defenders of strict water quality criteria for an absolute protection of public health and the defenders of a pragmatic stance promoting non-potable water uses with less restrictive water quality criteria.'

Kamizoulis et al developed guidelines specifically for the Mediterranean region. These are based on the principle that 'wastewater quality guidelines or criteria should reflect the potential for regional variations in climate, water flow and wastewater characteristics and should be designed to protect individuals against realistic maximum exposures'. Kamizoulis et al also argue that wastewater quality guidelines should be: realistic about local conditions (epidemiological, socio-cultural and environmental); affordable; and enforceable. Their categories for recycled water reuse are: (i) urban and residential reuses, landscape and recreational impoundments; (ii) unrestricted irrigation, landscape impoundments (contact with water not allowed), and industrial reuses; (iii): restricted agricultural irrigation; (iv) irrigation with recycled water application systems or methods (drip, subsurface, etc.) providing a high degree of protection against contamination and using water more efficiently.

4.0 ESTABLISHING THE PILOT WATER RESTORATION PARK FACILITY

Scottish Water provided CREW with data on its shortlist of 16 potential sites for the pilot restoration park. For each of these sites we estimated CAPEX (capital) and OPEX (operational) costs. We also used data supplied by Scottish Water and other data obtained independently, about the circumstances of these wwtw and potential local customers of reclaimed water in each locality. Using the resulting matrix[2] of the sites/factors, rankings were assigned based on quantitative and qualitative factors to each site in an attempt to show which sites have most potential for a successful pilot.

We also took into account other considerations, in particular the likely lack of interest in reclaimed water at this early stage in its use, in the UK. Based on these factors, we recommend that the pilot is most likely to succeed if one of the following options is adopted.

4.1 Options for establishing a pilot

1. Focus on Scottish Water itself as a customer for reclaimed water
2. Select a local authority as a partner in the initiative, as a customer for reclaimed water and select a suitable, local wwtw
3. Focus on one or more potential customers that SW would like to develop for water reclamation uses, and engage with them to agree water quality and volumes required to enable their use of reclaimed water.
4. Select a wwtw where SW has identified a need for landscaping/upgrading engage in discussions with the potential customer base.

1. Scottish Water is likely to be the easiest customer for this pilot. They are a key blue water user in carrying out their core functions and have good data on water quality required for these. Piloting with a SW customer allows technology testing in-house while discussions with other potential customers take place regarding their needs and attitudes.

2. Local authorities use water for irrigation/watering public spaces/planters, cleaning streets and buildings, public transport, and water features among other uses. A local authority may be interested in partnering with SW in this pilot. If so, an added advantage is that this customer would be guaranteed to be close to the wwtw so distance for transport of water would be minimised. In the current public sector finance climate, local authorities are likely to want to reduce their water costs, and participation

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[2] The matrix developed for this report has been supplied separately to Scottish Water. It is not reproduced in this report as it includes confidential information.

in this pilot may help them achieve sustainability objectives. This option would need data on local authority water use and how they receive water i.e. piped or shipped in by tanker and how it is stored.

3. and 4. These allow SW to focus on a wwtw they wish to upgrade/landscape and means selection of a customer is based on geographical location/wwtw capability or on an identified sector they are keen to involve in water reclamation.

4.2 Additional considerations

For a pilot facility to be successful, the Water Restoration Park team need to adopt guidelines, which are acceptable to potential consumers in the selected pilot areas, and engage with them to establish willingness to become involved in a pilot.

For longer-term roll out of the WRP facility, more comprehensive guidelines, specifically tailored to the Scottish context and covering the range of potential consumers are needed. Because there is no established market in Scotland for reclaimed water, and the greatest barrier to achieving this is a lack of public awareness of the need to conserve water resources, and negative attitudes towards reclaiming waste water, a demand management approach is likely to be needed for roll out.

5.0 REFERENCES

Angelakis, A.N., Durham, B., Marecos do Monte, M.H.F., Salgot M., Wintgens T., Thoeye, C. (2007) Wastewater recycling and reuse in Eureau countries: with emphasis on criteria used, EUREAU EU 1/2 Recycling & Reuse Working Group EU1/2-07-WR-40(1) January 2007, http://www.surreycc.gov.uk/__data/assets/pdf_file/0003/168744/Further-Information-1-Water-Reuse-and-Recycling-in-Eureau-Countries.pdf) (accessed 9 May 2013)

Aquarec (2006) Guideline for quality standards for water reuse in Europe, http://www.amk.rwth-aachen.de/fileadmin/user_upload/aquarec/WP2_D15_Guideline_for_quality_standards_for_water_reuse_in_Europe.pdf (accessed 9 May 2013)

Blumenthal, Ursula J.; Duncan Mara, D.; Peasey, Anne; Ruiz-Palacios, Guillermo; Stott, Rebecca (2000) Guidelines for the microbiological quality of treated wastewater used in agriculture: recommendations for revising WHO guidelines, Bulletin of the World Health Organization, vol.78, http://www.scielosp.org/cgi-bin/wxis.exe/iah/ (accessed 9 May 2013)

California Department of Public Health (2011) Title 22 Statutes Related to Recycled Water & the California Department of Public Health, June, http://www.cdph.ca.gov/certlic/drinkingwater/Documents/Lawbook/RWstatutes2011-01-01.pdf (accessed 9 May 2013)

Chartered Institution of Water and Environmental Management (CIWEM) (2007) Water reuse: a sustainable alternative water supply for industry in the UK? CIWEM Briefing, www.ciwem.org/FileGet.ashx?id=978&library=Public%20Access (accessed 9 May 2013)

CIWEM pages, February 2008, http://www.ciwem.org/knowledge-networks/panels/water-resources/water-reuse.aspx (accessed 9 May 2013)

Cooper, Ivan (2012) Reusing Municipal Wastewater for Power Generation Cooling Towers – Opportunities and Obstacles, NC Currents, Summer 2012, Golder Associates, http://www.golder.co.uk/en/modules.php?name=Publication&sp_id=255&page_id=212#/!ts=1363189427259 (accessed 9 May 2013)

Council of the European Communities. Bathing water quality Directive 2006/7/EC, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:064:0037:0051:EN:PDF (accessed 9 May 2013)

Council of the European Communities. Urban Waste Water Treatment Directive (91/271/CEE) http://europa.eu/legislation_summaries/environment/water_protection_management/l28008_en.htm (accessed 9 May 2013)

Crook, James (2005) Irrigation of Parks, Playgrounds, and Schoolyards: Extent and Safety. Alexandria, VA: WateReuse Research Foundation, http://www.watereuse.org/product/04-006 (accessed 9 May 2013)

Environment Agency (2008) Greywater: an information guide, http://www.highland.gov.uk/NR/rdonlyres/4F44CF29-5BC5-43FD-A68F-EF390F972B45/0/GreywaterRecyclingInfoGuide.pdf (accessed 9 May 2013)

Environment Protection and Heritage Council (2008) Recycled water quality: A guide to determining, monitoring and achieving safe concentrations of chemicals in recycled water, http://www.scew.gov.au/archive/water/pubs/wq_agwr_rpt_uniquest_recycled_water_quality_final_200806.pdf (accessed 9 May 2013)

European Environment Agency (2010a) European Environment State and Outlook- Water resources: quantity and flows, http://www.eea.europa.eu/soer/europe/water-resources-quantity-and-flows (accessed 9 May 2013)

European Environment Agency (2010b) Freshwater (United Kingdom), http://www.eea.europa.eu/soer/countries/uk/soertopic_view?topic=freshwater (accessed 9 May 2013)

European Environment Agency (2010c) Part C Freshwater drivers-and pressures-UK, http://www.eea.europa.eu/soer/countries/uk/soertopic_view?topic=freshwater (accessed 9 May 2013)

Hartman, Dennis (undated) Advantages and disadvantages for recycling water, http://www.ehow.co.uk/list_6120478_advantages-disadvantages-recycling-water.html (accessed 8 May 2013)

Harwood, Valerie J.; Levine, Audrey D.; Scott, Troy M.; Rose, Joan G. (2005) Validity of the Indicator Organism Paradigm for Pathogen Reduction in Reclaimed Water and Public Health Protection, Applied and Environmental Microbiology, Vol.71

House of Lords Science and Technology committee (2006) Water Management report, Authority of the House of Lords, http://www.foundation.org.uk/events/pdf/20060606_Selborne.pdf (accessed 9 May 2013)

Jeffrey, Paul (2011) Addressing society's attitude to local water recycling, presentation to the Royal Academy of Engineering autumn meetings on Engineering the Future, http://www.raeng.org.uk/news/releases/pdf/1_Paul_Jeffrey_Water_Series.pdf (accessed 8 May 2013)

Jewish Virtual Library (2013) Environmental Protection in Israel- water quality, http://www.jewishvirtuallibrary.org/jsource/Environment/envt.html#water (accessed 8 May 2013)

Kamizoulis, G., Bahri, A., Brissaud, F., Angelakis, A.N. (2005) Wastewater Recycling and Reuse Practices in Mediterranean Region: Recommended Guidelines, http://www.a-angelakis.gr/files/pubrep/recycling_med.pdf (accessed 8 May)

LaPara, Timothy; Firl, Sara (2006) The Importance of Municipal Sewage Treatment in the spread of Antibiotic resistance, 106th General Meeting of the American Society for Microbiology

Levine, Audrey D., Asano, Takashi (1 June 2004).Peer Reviewed: Recovering Sustainable Water from Wastewater, Environmental Science & Technology 45: 203A.doi:10.1021/es040504n. (accessed 9 May 2013)

McCann, Bill (2008) Reuse of water in the EU and the Mediterranean, Water 21, Journal of the International Water Association, April 2008, p. 42-44

National Academy Press (1996) Monterey Regional Water Pollution Control Agency Use of Reclaimed Water and Sludge in Food Crop Production. Washington, DC, http://www.mrwpca.org/recycling/recycling_process.php (accessed 9 May 2013)

OECD (2004) Key Environmental Indicators, http://www.oecd.org/environment/indicators-modelling-outlooks/31558547.pdf (accessed 8 May 2013)

Oliver, James D. (2005) The Viable but Nonculturable State in Bacteria, J. of Microbiology p.93-100

Olympic Delivery Authority (2012) Learning Legacy: The Old Ford Water Recycling Plant and non-potable water distribution network, http://learninglegacy.independent.gov.uk/documents/pdfs/sustainability/old-ford-case-study.pdf 9a (accessed 8 May 2013)

Scottish Government (2012) Key Scottish Environment Statistics 2012: Public Water Supplies - Water Abstracted and Supplied 2002/03-2011/12, http://www.scotland.gov.uk/Publications/2012/08/2023/26 (accessed 8 May 2013)

Scottish Government (2006a) Scottish Corporate Sector Statistics, http://www.scotland.gov.uk/Topics/Statistics/18389/TableD2006 (accessed 8 May 2013)

Scottish Government (2006b) Scottish Corporate Sector Statistics http://www.scotland.gov.uk/Topics/Statistics/18389/Table72006 (accessed 8 May 2013)

Smith, MD and Shaw, RJ (1993) Technical Brief No.37: Re-Use of Wastewater, Waterlines: Journal of Appropriate Technologies for Water Supply and Sanitation, 12(1), pp.15-18

State of Israel Ministry of Environmental Protection (2010a) Public Health Regulations (Effluent Quality Standards and Rules for Sewage Treatment), http://old.sviva.gov.il/bin/en.jsp?enPage=e_BlankPage&enDisplay=view&enDispWhat=Object&enDispWho=Articals^l6433&enZone=wastew_law (accessed 8 May 2013)

State of Israel Ministry of Environmental Protection (2010b) Maximum Monthly Averages for Dissolved and Suspended Elements and Compounds and for Different Parameters in Effluents for Unrestricted Irrigation and Discharge to Rivers,

State of Israel Ministry of Environmental Protection (2010c) Upgraded Effluent Quality Standards, http://old.sviva.gov.il/bin/en.jsp?enPage=e_BlankPage&enDisplay=view&enDispWhat=Object&enDispWho=Articals^l2092&enZone=Wastewater_Treatment (accessed 8 May 2013)

Than, Ker (2012) Reclaimed Wastewater for Drinking: Safe but still a tough sell, National Geographic News, January 31, http://news.nationalgeographic.com/news/2012/01/120131-reclaimed-wastewater-for-drinking/ (accessed 9 May 2013)

Tsai, Kan-Jen (2008) Bacterial Heavy Metal Resistance, Osaka Biology

Tyrrel. S.F, Knox, J.W., Burton, C.H., Weatherhead, E.K. (2004) Assuring the microbiological quality of water used to irrigate salad crops: an assessment of the options available Final Report to Horticultural Development Council by Institute of Water & Environment, Cranfield University, https://dspace.lib.cranfield.ac.uk/handle/1826/7002 (accessed 9 May 2013)

UKWIR (2005) UK Water Industry Research (UKWIR)/American water works association Research Foundation (AwwaRF) and Water Reuse Foundation (WRF) (2005) Protocol for developing water re-use criteria with Reference to Drinking Water Supplies, http://www.waterboards.ca.gov/water_issues/programs/grants_loans/water_recycling/research/02_011.pdf (accessed 9 May 2013)

United Nations Environment Programme (2013) Summary of Innovative Practices in JAPAN Submitted to the Ministerial Consultations of the 23rd session of the Governing Council/Global Ministerial Environment Forum http://www.unep.org/gc/gc23/documents/JAPAN-INNOVATIVE-PRACT.pdf (accessed 8 May 2013)

US Environmental Protection Agency (2012) Guidelines for Water Reuse**,** http://www.golder.co.uk/en/modules.php?name=Publication&sp_id=255&page_id=212 (accessed 8 May 2013)

Waterwise (2006) http://news.bbc.co.uk/1/hi/uk/6056206.stm (accessed 8 May 2013)

WHO (1989) Health guidelines for the use of wastewater in agriculture and aquaculture, http://whqlibdoc.who.int/trs/WHO_TRS_778.pdf (accessed 8 May 2013)

WHO (2006) Guidelines for the safe use of wastewater, excreta and greywater, 3rd edn, Vol II, pp35-45, http://whqlibdoc.who.int/publications/2006/9241546824_eng.pdf (accessed 8 May 2013)

Wu, Laosheng (2006) *Reclaiming Wastewater for Beneficial Uses*, Southwest States and Pacific Islands Regional Water Program, USA, http://ag.arizona.edu/region9wq/pdf/factsheet_RWQ004.pdf (accessed 9 May 2013)

York, David; R. Holden, B. Sheikh, L. Parsons (September 2008) "Safety and Suitability of Recycled Water for Irrigation of Edible Crops". *Proceedings of the 23rd Annual WateReuse Symposium*.

ANNEX 1 CALIFORNIA RECYCLED WATER REGULATIONS

CALIFORNIA DEPARTMENT OF PUBLIC HEALTH REGULATIONS RELATED TO RECYCLED WATER JANUARY 2009, CHAPTER 3, ARTICLES 2, 3 AND 4

ARTICLE 2. SOURCES OF RECYCLED WATER

§60302 Source specifications
The requirements in this chapter shall only apply to recycled water from sources that contain domestic waste, in whole or in part.

ARTICLE 3. USES OF RECYCLED WATER

§60303 Exceptions
The requirements set forth in this chapter shall not apply to the use of recycled water onsite at a water recycling plant, or wastewater treatment plant, provided access by the public to the area of onsite recycled water use is restricted.

§60304 Use of recycled water for irrigation
(a) Recycled water used for the surface irrigation of the following shall be a disinfected tertiary recycled water, except that for filtration pursuant to Section 60301.320(a) coagulation need not be used as part of the treatment process provided that the filter effluent turbidity does not exceed 2 NTU, the turbidity of the influent to the filters is continuously measured, the influent turbidity does not exceed 5 NTU for more than 15 minutes and never exceeds 10 NTU, and that there is the capability to automatically activate chemical addition or divert the wastewater should the filter influent turbidity exceed 5 NTU for more than 15 minutes:

(1) Food crops, including all edible root crops, where the recycled water comes into contact with the edible portion of the crop,
(2) Parks and playgrounds,
(3) School yards,
(4) Residential landscaping,
(5) Unrestricted access golf courses, and
(6) Any other irrigation use not specified in this section and not prohibited by other sections of the California Code of Regulations.

(b) Recycled water used for the surface irrigation of food crops where the edible portion is produced above ground and not contacted by the recycled water shall be at least disinfected secondary-2.2 recycled water.

(c) Recycled water used for the surface irrigation of the following shall be at least disinfected secondary-23 recycled water:

(1) Cemeteries,
(2) Freeway landscaping,
(3) Restricted access golf courses,
(4) Ornamental nursery stock and sod farms where access by the general public is not restricted,
(5) Pasture for animals producing milk for human consumption, and
(6) Any nonedible vegetation where access is controlled so that the irrigated area cannot be used as if it were part of a park, playground or school yard

(d) Recycled wastewater used for the surface irrigation of the following shall be at least undisinfected secondary recycled water:

(1) Orchards where the recycled water does not come into contact with the edible portion of the crop,
(2) Vineyards where the recycled water does not come into contact with the edible portion of the crop,
(3) Non food-bearing trees (Christmas tree farms are included in this category provided no irrigation with recycled water occurs for a period of 14 days prior to harvesting or allowing access by the general public),
(4) Fodder and fiber crops and pasture for animals not producing milk for human consumption,
(5) Seed crops not eaten by humans,
(6) Food crops that must undergo commercial pathogen-destroying processing before being consumed by humans, and
(7) Ornamental nursery stock and sod farms provided no irrigation with recycled water occurs for a period of 14 days prior to harvesting, retail sale, or allowing access by the general public.

(e) No recycled water used for irrigation, or soil that has been irrigated with recycled water, shall come into contact with the edible portion of food crops eaten raw by humans unless the recycled water complies with subsection (a).

§60305 Use of recycled water for impoundments

(a) Except as provided in subsection (b), recycled water used as a source of water supply for non-restricted recreational impoundments shall be disinfected tertiary recycled water that has been subjected to conventional treatment.

(b) Disinfected tertiary recycled water that has not received conventional treatment may be used for non-restricted recreational impoundments provided the recycled water is monitored for the presence of pathogenic organisms in accordance with the following:

(1) During the first 12 months of operation and use the recycled water shall be sampled and analyzed monthly for *Giardia*, enteric viruses, and *Cryptosporidium*. Following the first 12 months of use, the recycled water shall be sampled and analyzed quarterly for *Giardia*, enteric viruses, and *Cryptosporidium*. The ongoing monitoring may be discontinued after the first two years of operation with the approval of the department. This monitoring shall be in addition to the monitoring set forth in section 60321.
(2) The samples shall be taken at a point following disinfection and prior to the point where the recycled water enters the use impoundment. The samples shall be analyzed by an approved laboratory and the results submitted quarterly to the regulatory agency.

(c) The total coliform bacteria concentrations in recycled water used for non-restricted recreational impoundments, measured at a point between the disinfection process and the point of entry to the use impoundment, shall comply with the criteria specified in section 60301.230 (b) for disinfected tertiary recycled water.

(d) Recycled water used as a source of supply for restricted recreational impoundments and for any publicly accessible impoundments at fish hatcheries shall be at least disinfected secondary-2.2 recycled water.

(e) Recycled water used as a source of supply for landscape impoundments that do not utilize decorative fountains shall be at least disinfected secondary-23 recycled water.

§60306 Use of recycled water for cooling
(a) Recycled water used for industrial or commercial cooling or air conditioning that involves the use of a cooling tower, evaporative condenser, spraying or any mechanism that creates a mist shall be a disinfected tertiary recycled water.
(b) Use of recycled water for industrial or commercial cooling or air conditioning that does not involve the use of a cooling tower, evaporative condenser, spraying, or any mechanism that creates a mist shall be at least disinfected secondary-23 recycled water.
(c) Whenever a cooling system, using recycled water in conjunction with an air conditioning facility, utilizes a cooling tower or otherwise creates a mist that could come into contact with employees or members of the public, the cooling system shall comply with the following:

(1) A drift eliminator shall be used whenever the cooling system is in operation.
(2) A chlorine, or other, biocide shall be used to treat the cooling system recirculating water to minimize the growth of *Legionella* and other microorganisms.

§60307 Use of recycled water for other purposes
(a) Recycled water used for the following shall be disinfected tertiary recycled water, except that for filtration being provided pursuant to Section 60301.320(a) coagulation need not be used as part of the treatment process provided that the filter effluent turbidity does not exceed 2 NTU, the turbidity of the influent to the filters is continuously measured, the influent turbidity does not exceed 5 NTU for more than 15 minutes and never exceeds 10 NTU, and that there is the capability to automatically activate chemical addition or divert the wastewater should the filter influent turbidity exceed 5 NTU for more than 15 minutes:

(1) Flushing toilets and urinals,
(2) Priming drain traps,
(3) Industrial process water that may come into contact with workers,
(4) Structural fire fighting,
(5) Decorative fountains,
(6) Commercial laundries,
(7) Consolidation of backfill around potable water pipelines,
(8) Artificial snow making for commercial outdoor use, and
(9) Commercial car washes, including hand washes if the recycled water is not heated, where the general public is excluded from the washing process.

(b) Recycled water used for the following uses shall be at least disinfected secondary-23 recycled water:

(1) Industrial boiler feed,
(2) Nonstructural fire fighting,
(3) Backfill consolidation around nonpotable piping,
(4) Soil compaction,
(5) Mixing concrete,
(6) Dust control on roads and streets,
(7) Cleaning roads, sidewalks and outdoor work areas and
(8) Industrial process water that will not come into contact with workers.

(c) Recycled water used for flushing sanitary sewers shall be at least undisinfected secondary recycled water.

ARTICLE 4 USE AREA REQUIREMENTS

§60310 Use area requirements

(a) No irrigation with disinfected tertiary recycled water shall take place within 50 feet of any domestic water supply well unless all of the following conditions have been met:

(1) A geological investigation demonstrates that an aquitard exists at the well between the uppermost aquifer being drawn from and the ground surface.

(2) The well contains an annular seal that extends from the surface into the aquitard.

(3) The well is housed to prevent any recycled water spray from coming into contact with the wellhead facilities.

(4) The ground surface immediately around the wellhead is contoured to allow surface water to drain away from the well.

(5) The owner of the well approves of the elimination of the buffer zone requirement.

(b) No impoundment of disinfected tertiary recycled water shall occur within 100 feet of any domestic water supply well.

(c) No irrigation with, or impoundment of, disinfected secondary-2.2 or disinfected secondary-23 recycled water shall take place within 100 feet of any domestic water supply well.

(d) No irrigation with, or impoundment of, undisinfected secondary recycled water shall take place within 150 feet of any domestic water supply well.

(e) Any use of recycled water shall comply with the following:

(1) Any irrigation runoff shall be confined to the recycled water use area, unless the runoff does not pose a public health threat and is authorized by the regulatory agency.

(2) Spray, mist, or runoff shall not enter dwellings, designated outdoor eating areas, or food handling facilities.

(3) Drinking water fountains shall be protected against contact with recycled water spray, mist, or runoff.

(f) No spray irrigation of any recycled water, other than disinfected tertiary recycled water, shall take place within 100 feet of a residence or a place where public exposure could be similar to that of a park, playground, or school yard.

(g) All use areas where recycled water is used that are accessible to the public shall be posted with signs that are visible to the public, in a size no less than 4 inches high by 8 inches wide, that include the following wording : "RECYCLED WATER - DO NOT DRINK". Each sign shall display an international symbol similar to that shown in figure 60310-A. The Department may accept alternative signage and wording, or an educational program, provided the applicant demonstrates to the Department that the alternative approach will assure an equivalent degree of public notification.

(h) Except as allowed under section 7604 of title 17, California Code of Regulations, no physical connection shall be made or allowed to exist between any recycled water system and any separate system conveying potable water.

(i) The portions of the recycled water piping system that are in areas subject to access by the general public shall not include any hose bibbs. Only quick couplers that differ from those used on the potable water system shall be used on the portions of the recycled water piping system in areas subject to public access.

ANNEX 2 ISRAEL'S 36 PARAMETERS FOR UNRESTRICTED IRRIGATION

One of the aims of Israel's regulations for reuse of waste water is to facilitate the recovery of effluents as a water source. Requirements for unrestricted irrigation use include maximum levels for dissolved and suspended elements and compounds, and 36 different parameters in effluents for unrestricted irrigation and discharge for rivers. **Maximum Monthly Averages for Dissolved and Suspended Elements and Compounds and for Different Parameters in Effluents for Unrestricted Irrigation and Discharge to Rivers**

Parameter	Units	Unrestricted Irrigation*	Rivers
Electric Conductivity	dS/m	1.4	
BOD	mg/l	10	10
TSS	mg/l	10	10
COD	mg/l	100	70
Ammonia	mg/l	10	1.5
Total nitrogen	mg/l	25	10
Total phosphorus	mg/l	5	1
Chloride	mg/l	250	400
Fluoride	mg/l	2	
Sodium	mg/l	150	200
Faecal coliforms	Unit per 100 ml	10	200
Dissolved oxygen	mg/l	<0.5	<3
pH	mg/l	6.5-8.5	7.0-8.5
Residual chlorine	mg/l	1	0.05
Anionic detergent	mg/l	2	0.5
Total oil	mg/l		1
SAR	$(mmol/L)^{0.5}$	5	
Boron	mg/l	0.4	
Arsenic	mg/l	0.1	0.1
Mercury	mg/l	0.002	0.0005
Chromium	mg/l	0.1	0.05
Nickel	mg/l	0.2	0.05
Selenium	mg/l	0.02	
Lead	mg/l	0.1	0.008
Cadmium	mg/l	0.01	0.005
Zinc	mg/l	2	0.2
Iron	mg/l	2	
Copper	mg/l	0.2	0.02
Manganese	mg/l	0.2	
Aluminum	mg/l	5	
Molybdenum	mg/l	0.01	
Vanadium	mg/l	0.1	
Beryllium	mg/l	0.1	
Cobalt	mg/l	0.05	
Lithium	mg/l	2.5	
Cyanide	mg/l	0.1	0.005

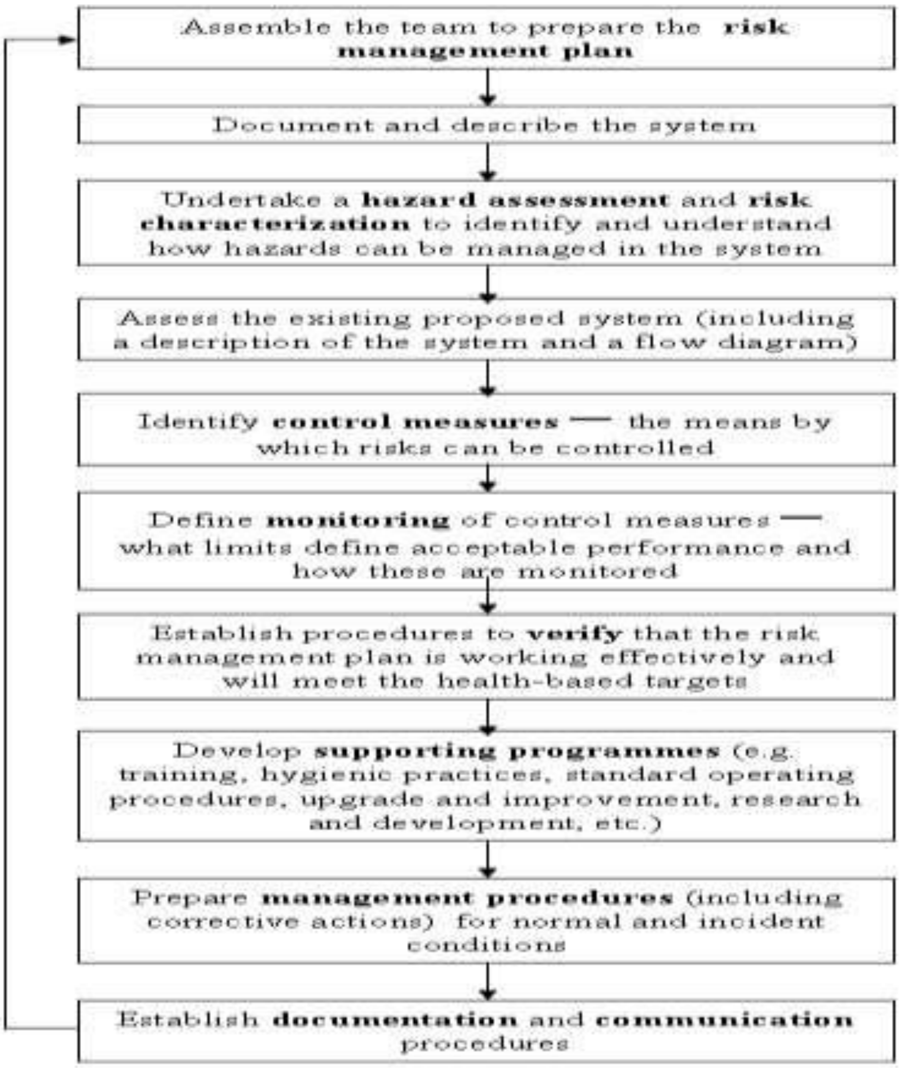
* From soil, flora, hydrological and public health considerations. Source: State of Israel Ministry of Environmental Protection, 2010

ANNEX 3 WHO GUIDELINES 2006

WHO 2006 http://whqlibdoc.who.int/publications/2006/9241546824_eng.pdf

The guidelines are based on the Stockholm Framework an integrated approach combining risk assessment and risk management to control water-related diseases and develop health-based guidelines and standards in terms of water- and sanitation-related microbial hazards.

Regulation: Preparation risk management plan



Source: Robert Bos (2011) **From the Stockholm Framework onwards**, World Health Organization, presentation, http://www.worldwaterweek.org/documents/WWW_PDF/2011/Thursday/T6/Which-Water-Quality-for-Which-Users/From-the-Stockholm-Framework-onwards.pdf

Health risks, hazards and recommended standards are set out in the WHO tables:

Table 2.1 Examples of hazards and exposure routes associated with the use of wastewater, excreta and greywater in agriculture and aquaculture, p20

Table A1 Elements and important considerations of the Stockholm framework

Framework component	Process	Considerations
Assessment of health risk	Hazard assessment Environmental exposure assessment Dose-response analysis Risk characterization	Best estimate of risk — not overly conservative Equivalence between risk of infection and risk of disease Health outcomes presented in disability adjusted life years (DALYs); facilitates comparison of risks across different exposures and priority setting Risk assessment is an iterative process — risk should be periodically reassessed based on new data or changing conditions Risk assessment is a tool for estimating risk and should be supported by other data (e.g. outbreak investigations, epidemiological evidence, microbiological risk assessment and studies of environmental behaviour of microbes) Process depends on quality of data Risk assessment needs to account for short-term under-performance
Tolerable risk/health targets	Health-based target setting based on risk assessment Define water quality objectives	Need to be realistic and achievable within the constraints of each setting Set using a risk-benefit approach; should consider cost-effectiveness of different available interventions Should take sensitive subpopulations into account Index pathogens should be selected for relevance to contamination, control challenges and health significance (more than one index pathogen may be needed)
Risk management	Based on health-based targets Define other management objectives Define measures and interventions Define key risk points and audit procedures Define analytical verifications	Risk management strategies need to address rare or catastrophic events. A multiple barrier approach should be used. Monitoring — overall emphasis should be given to periodic inspection/auditing and to simple measurements that can be rapidly and frequently made to inform management. Hazard analysis critical control point (HACCP)-like principles should be used to anticipate and minimize health risks.
Public health status	Public health surveillance	Need to evaluate effectiveness of risk management interventions on specific health outcomes (both through investigation of disease outbreaks and evaluation of background disease levels) Establish procedures for estimating the burden of disease, to facilitate monitoring of health outcomes due to specific exposures Burden of disease estimates can be used to place water-related exposures in the wider public health context, to enable prioritization of risk management decisions Public health outcome monitoring provides the information needed to fine-tune risk management through an iterative process

Source: Adapted from Bartram, Fewtrell & Stenström (2001), http://www.who.int/water_sanitation_health/wastewater/wsh0308app.pdf

ANNEX 4 GUIDELINES FOR WATER REUSE QUALITY IN EUROPE

Aquarec, 2006, Guideline for quality standards for water reuse in Europe[3].

Table 10 Overview of the compiled chemical limits for reclaimed water reuse from existing guidelines and proposed chemical limits depending on the specific use [mg / L] (p25)

	1	**2**	**3**	**4**
Parameter /chemical category*	**Private, urban and irrigation**	**Environmental and aquaculture**	**Indirect aquifer recharge****	**Industrial cooling**
Parameters of very high analytical frequency (daily - weekly)				
pH	6.0 – 9.5	6.0-9.5	7 – 9	7.0-8.5
BOD	10 - 20	10 - 20		
COD (or TOC)	100	70 – 100 (10 – 15)	70-100	70
Dissolved oxygen	> 0.5	> 3	> 8	> 3
AOX			25	
UV 254 absorbance [cm-1 · (10)3]	30 - 70	30 - 70	10	
Electrical conductivity [µS/cm]	3000	3000	1400	
TSS	10 - 20	10 - 20		10 - 20
Active chlorine (only if chlorination)	0.2 – 1.0	0.05		0.05
Total Kjeldahl N	15 – 25	10 - 20		10
Ammonium-N	2 - 20	1.5	0.2**	1.5
Parameters of high analytical frequency (monthly)				
Sodium absorption ratio [mmol/L$^{0.5}$]	5	5		
Na	150	150 - 200		200
Nitrate			25	
Chloride	250	250 - 400	100	400
Sulphate	500	500	100	
Total P	2 – 5	0.2 – 1		0.2

***** Adapted from parameters are also given in the original table for medium (monthly – one year)/low analytical frequency (once per year – once per 5 years

[3] http://www.amk.rwth-aachen.de/fileadmin/user_upload/aquarec/WP2_D15_Guideline_for_quality_standards_for_water_reuse_in_Europe.pdf

** When performing indirect aquifer recharge there has to be an option for the operator not to desalinate, if the recovered water is not used for potable uses, or even if used as potable water. This can be done at higher dilution of the aquifer. This is also true for the other salinity parameters like boron and the ammonium concentration. In the case of water for indirect recharge the ammonium concentration should be permitted to be up to 20 ppm, depending on the aquifer conditions.

Risk assessment (p27)

'The chemical and microbial limits for different reclaimed water uses need a reliable risk assessment, especially for the not assessed compounds like the organic trace pollutants and for several microorganisms. The risk assessment should follow the European Technical Guidance Document (TGD) on Risk Assessment, based on the Commission Directive 93/67/EEC, Commission Regulation (EC) 1488/94 and Directive 98/8/EC. Part I Chapter 2 of the TGD describes the human risk assessment and in Part II Chapter 3 the environmental risk assessment is specified. The human and environmental risk assessment proceeds always in the following sequence:

a. hazard identification
b. dose (concentration) – response (effect) assessment
c. exposure assessment and
d. risk characterization.'

Annex 5 Scottish enterprises by local authority areas

	A, B, D, E Primary Industries			C Manufacturing			F Construction			G Wholesale, retail and repairs		
Local Authority area	Number of enterprises	Total Scottish employment	Turnover (£ millions)	Number of enterprises	Total Scottish employment	Turnover (£ millions)	Number of enterprises	Total Scottish employment	Turnover (£ millions)	Number of enterprises	Total Scottish employment	Turnover (£ millions)
Aberdeen City	235	23,360	32,246	470	11,010	2,930	650	6,280	809	1,225	19,930	3,360
Aberdeenshire	3,140	13,530	3,390	670	11,250	2,011	1,440	7,540	951	1,485	15,420	2,615
Angus	685	3,000	349	225	4,360	692	470	2,000	193	625	5,710	897
Argyll & Bute	880	2,620	485	175	1,400	173	390	1,740	139	695	4,670	687
Clackmannanshire	55	370	42	70	1,950	367	145	840	79	240	2,330	296
Dumfries & Galloway	2,130	7,010	684	295	6,600	1,045	680	3,410	275	1,025	10,300	1,480
Dundee City	30	360	126	195	4,790	706	370	3,380	325	840	12,710	1,728
East Ayrshire	490	2,480	400	185	4,050	550	335	1,860	201	625	6,360	888
East Dunbartonshire	65	390	170	125	1,380	203	390	1,740	197	465	4,670	642
East Lothian	310	2,180	748	150	2,190	238	345	1,920	240	470	3,600	525
East Renfrewshire	70	240	16	80	670	70	260	1,230	190	435	3,420	409
Edinburgh, City of	170	3,560	1,227	470	7,570	1,283	1,340	10,160	2,170	2,495	36,500	6,121
Eilean Siar	260	760	108	60	420	49	125	830	65	185	1,470	224
Falkirk	150	*	*	225	*	*	435	3,490	455	790	10,520	2,010
Fife	675	5,030	1,409	570	12,740	2,856	1,050	6,710	725	1,680	20,750	2,882
Glasgow City	85	5,440	3,666	780	19,200	2,804	1,410	16,750	2,621	3,400	50,070	8,275
Highland	2,250	7,360	1,412	510	6,900	915	1,410	6,810	732	1,585	16,130	2,344
Inverclyde	40	170	18	75	2,660	368	145	520	45	390	4,860	719
Midlothian	140	710	70	120	1,690	170	320	2,620	251	390	4,980	726
Moray	685	2,110	257	190	5,510	891	435	2,260	184	590	5,960	768
North Ayrshire	270	1,420	548	180	4,130	1,140	380	2,170	222	660	6,940	1,044
North Lanarkshire	195	3,080	2,229	475	11,600	1,990	1,035	9,980	1,614	1,460	20,690	3,525
Orkney Islands	725	1,690	122	55	450	60	130	790	52	175	1,340	189
Perth & Kinross	1,065	*	*	270	*	*	715	4,000	417	1,110	10,730	1,634
Renfrewshire	140	780	245	285	8,450	1,625	560	4,320	649	925	13,850	3,006
Scottish Borders, The	1,245	4,460	425	275	5,310	411	650	2,980	211	855	7,300	1,000
Shetland Islands	515	1,500	885	70	900	146	140	730	55	175	1,550	314
South Ayrshire	450	1,520	176	145	4,460	1,189	365	1,920	202	805	8,780	1,300
South Lanarkshire	680	6,140	2,420	560	11,840	1,572	1,075	7,770	871	1,630	19,130	2,995
Stirling	405	1,270	162	165	2,510	374	425	2,610	552	725	7,370	1,381
West Dunbartonshire	50	250	17	120	2,330	542	215	1,310	101	410	4,870	605
West Lothian	160	880	154	280	8,050	1,560	515	5,070	620	940	14,940	2,790
Scottish Total[6]	**18,150**	**112,340**	**60,335**	**8,030**	**178,810**	**43,136**	**18,000**	**125,700**	**16,416**	**25,040**	**357,820**	**57,379**

H Transport and storage			I Accommodation and food service			M Professional, scientific and technical			Total		
Number of enterprises	Total Scottish employment	Turnover (£ millions)	Number of enterprises	Total Scottish employment	Turnover (£ millions)	Number of enterprises	Total Scottish employment	Turnover (£ millions)	Number of enterprises	Total Scottish employment	Turnover (£ millions)
285	7,080	1,474	520	10,350	436	2,775	23,020	3,852	8,495	138,470	48,483
375	3,460	457	580	5,510	199	2,740	8,500	2,153	12,850	80,400	12,701
125	1,160	146	275	2,320	89	515	2,160	204	3,745	27,170	2,992
140	1,530	122	470	4,580	199	345	1,300	66	4,005	26,020	2,379
40	340	26	100	780	31	155	440	26	1,150	10,090	1,003
260	2,520	247	560	4,660	199	385	1,690	106	6,650	46,590	4,678
80	1,650	113	325	4,240	159	375	2,310	118	3,305	48,770	4,390
120	1,260	94	245	1,730	60	270	1,050	57	3,070	27,070	2,757
75	450	33	140	1,470	56	510	1,130	74	2,670	18,240	1,787
90	720	42	230	2,260	85	385	1,610	115	2,780	21,140	2,325
50	570	28	135	1,390	50	415	830	62	2,240	13,460	1,048
270	10,360	1,517	1,400	24,060	1,084	3,290	22,180	2,343	15,715	230,860	20,683
50	480	35	100	760	28	75	320	30	1,095	6,520	665
180	2,880	318	260	2,900	107	520	1,670	120	3,605	41,300	18,193
255	3,350	251	785	8,100	313	1,180	4,500	306	8,595	94,570	10,416
305	13,490	988	1,480	22,030	878	2,620	26,670	2,446	16,095	292,290	30,161
350	3,980	324	1,040	11,010	445	1,060	3,920	308	10,545	77,620	7,718
55	850	103	150	1,480	54	255	820	47	1,625	20,800	2,105
85	850	62	155	1,270	45	280	1,450	125	2,150	19,020	1,737
95	1,030	73	260	2,330	81	270	940	52	3,230	26,160	2,603
130	1,360	107	330	3,030	108	355	1,330	122	3,090	28,570	3,815
475	7,310	705	540	5,260	188	685	3,120	355	6,610	88,700	12,739
45	660	69	80	700	18	75	360	21	1,495	7,090	593
165	2,340	131	525	6,180	261	645	2,340	179	6,065	50,960	9,204
235	7,350	1,137	340	4,670	204	610	3,040	356	4,440	64,630	8,385
140	1,080	71	370	2,930	106	475	1,600	128	5,145	32,890	2,722
60	760	127	85	820	28	85	390	22	1,355	8,410	1,668
130	2,500	339	350	4,470	184	380	1,500	124	3,620	34,730	4,103
365	4,610	364	590	6,180	240	985	4,100	453	8,075	86,370	10,358
115	1,000	66	320	3,840	307	585	2,040	154	3,905	34,170	3,561
60	840	249	165	1,700	58	210	790	96	1,740	19,030	2,098
215	3,410	251	305	3,440	129	545	2,960	546	4,290	59,490	7,341
4,995	**91,190**	**10,070**	**12,440**	**156,440**	**6,426**	**23,235**	**130,090**	**15,166**	**152,030**	**1,781,560**	**245,413**

CREW Facilitation Team

James Hutton Institute
Craigiebuckler
Aberdeen AB15 8QH
Scotland UK
Tel: +44 (0) 844 928 5428

Email: enquiries@crew.ac.uk

www.crew.ac.uk