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PROCEEDINGS OF THE KELVIN CONFERENCE

The River Kelvin; History and Natural history

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INTRODUCTION

This one day conference, organised by the Kelvin Biodiversity Network (principally comprising representatives of Glasgow Natural History Society, Friends of the River Kelvin, the Royal Society for the Protection of Birds, the Clyde River Foundation and The Conservation Volunteers) took place in the Graham Kerr Building, University of Glasgow on 6th June 2015, as a contribution to the 2015 Glasgow Science Festival. The meeting was well attended and included lively discussions. As a follow-up, the GNHS excursion programme included three events: a medicinal plants hunt in Kelvingrove Park, organised by the RSPB; a Bioblitz in Kelvingrove Park, also organised by the RSPB; and a walk from Summerston to Balmore, organised by FORK. In addition to the Abstracts of the talks presented, these proceedings include written-up and updated versions of the talks (marked * below), provided by some but not all of the speakers. We are grateful to all who were able to do this.

ABSTRACTS of PRESENTATIONS

Welcome and Introduction

Roger Downie (President, Glasgow Natural History Society) and Sally Johnson (Chair, Friends of the River Kelvin)

Origins of the Kelvin Biodiversity Network for which the conference is the first output. The conference is intended partly as a celebration of the river; its history, its biodiversity and its potential as a resource for the people of Glasgow. But also as an opportunity to discuss how the river could be improved and what threats it faces.

The River Kelvin: route and resource from pre-history to the 20th century*

John Hume (John lectured in industrial and economic history at the University of Strathclyde 1964-84, then worked for Historic Scotland until 1999. He has a particular interest in the industries of the West of Scotland, especially those of the Clyde and Kelvin)

In this presentation, I will look first at the role of the Kelvin and its valley in relation to transport and communications in west central Scotland. The main body of the talk will be an examination of the river as a source of water-power and process water for a wide range of industries, from the Middle Ages to the later 20th century.

Glasgow's biodiversity: the importance of the Kelvin corridor*

Cath Scott (Natural Environment Officer: Biodiversity and Ecology, Land and Environmental Services, Glasgow City Council)

Glasgow's Local Biodiversity Action Plan was launched in 2001 to protect and enhance habitats and species, and raise awareness of the importance of the natural heritage. Glasgow is rich in biodiversity, which is protected through an extensive green network of designated sites including Sites of Special Scientific Interest, Local Nature Reserves, Sites of Importance for Nature Conservation and Green Corridors. Nationally and locally important habitats and species can be found in the urban environment. Partnership projects have delivered key targets for management, restoration and creation of wetland, woodland and grassland habitats. The River Kelvin is a well-loved major wildlife corridor in Glasgow connecting people to nature and forming the framework of the green network.

Are we caring for the Kelvin? Biodiversity research and public engagement

Willie Yeomans (Clyde River Foundation)

The Clyde River Foundation (CRF) is a local charity which researches the ecology of the Clyde and its tributaries and promotes environmental education and community engagement throughout the catchment. The Kelvin sub-catchment represents approximately 12% of the total Clyde system river length. The Kelvin is recovering ecologically from more than a century of man-made pollution and physical change. Since 2002, the CRF has monitored the fish and invertebrate communities and species at key sites to generate long-term data sets and to investigate specific management issues. Other scientific work has included fish habitat surveys of the main tributaries; assessing effects of flood defence and land drainage on channel sinuosity; and mapping the occurrence of invasive, non-native riparian plants. CRF education programmes have worked from P3 to PhD levels across the Kelvin system and we reconnect people of all ages with the river to improve environmental stewardship. Recently, we have developed community engagement projects in close collaboration with the River Kelvin Angling Association and the residents of

Twechar, in the upper catchment. This paper will provide a brief overview of previous, ongoing and planned CRF work in and around the Kelvin, and ask whether we are taking sufficient care of 'Glasgow's second river'.

The changing flora of the Kelvin*
Keith Watson (Curator of Natural History, Glasgow Museums)
Reviewing historical records from herbarium specimens and old literature, and comparing with the many modern field records, readily reveals that the riparian flora of the Kelvin is constantly changing. Much of this is in response to the actions of humans over the last 150 years or so. Many years of engineering, landform changes and pollution, in addition to changing attitudes to bankside land management, have dramatically altered the habitat that the current flora has inherited. A few native species are long gone but many are still present, but the abundance and diversity of non-native species is now an obvious feature of the lower urban stretches. Is this change in species composition a negative development and should we be trying to put the clock back to a previous time? Or should we be celebrating the floral diversity that we now find and admire the dynamic nature of our ever changing flora?

Connecting people to the Kelvin; celebrating and enhancing our city's wildlife
Katherine Jones (Public affairs manager, SW Scotland region, RSPB Scotland)
The River Kelvin offers a fantastic opportunity for people to connect with nature in the heart of the city. Winding through some of Glasgow's most deprived communities, as well as the more well-heeled West End, the river lays down the challenge to us of how to engage more people, from a wider audience, with our city's wildlife. RSPB research has shown that children play out in nature less than ever before, which is creating a generation disconnected from nature, and this talk will explore some of the work that RSPB Scotland, alongside our many local partners, is doing around the river Kelvin to start to turn this trend around.

Power from the Kelvin: past and future*
Neil Phillips (Sustainable energy consultant)
As many as ten mills have used the water-power of the Kelvin within the current city boundary in the past, and the weirs which maintained a head of water are still in place. Given the overall policy to increase Scotland's usage of renewable energy sources, the talk will discuss the economic viability and practical prospects of harnessing the Kelvin's energy for modern purposes.

How the Kelvin makes a great place
Gillian Dick (Glasgow City Council, Place Strategy and Environmental Infrastructure)
This talk will outline the City's emerging development plan and its placemaking policy. It will discuss how the environment of the Kelvin contributes to a great place.

Discussion session*
A set of facilitated small group discussions on the issues facing the Kelvin and how they can be addressed. This paper provides the discussion topics, but not the contributions made by participants.

In addition
The conference also included a poster display and a picture quiz. A version of the poster prepared by Kate Arnold and colleagues (SEPA) on 'Ecological monitoring of the lower Kelvin, 1979-2014'* is included in these proceedings.

The River Kelvin: route and resource from pre-history to the 20th century

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INTRODUCTION

The River Kelvin is not a large stream except in times of spate, but it is the largest tributary of the Clyde in the vicinity of Glasgow, and as such was for many centuries a significant location for water-powered and water-using industries connected with that settlement. Its valley narrows to a gorge in several places, so that sites for large industries were restricted; on the other hand, the concentration of the flow at these points made the construction of weirs to impound water easier and more effective.

The Kelvin rises in the central rift valley in the neighbourhood of Kilsyth, and flows west and then south, entering the Clyde opposite Govan. It is generally a slow-flowing river, except in its last fall at Partick, where a ridge of hard rock creates a natural weir. This proved an effective site for water-mills, and up-stream artificial weirs were built at several points. Some of the millsteads thus created were probably used from early historic times. Another use of the waters of the Kelvin was to feed the summit level of the Forth and Clyde Canal. Its construction, from 1768, involved diverting some of the headwaters of the river into Townhead Reservoir, near Banton, east of Kilsyth. Mill-owners were inevitably concerned about the effect this would have on their operations, and legal action resulted in an agreement regarding compensation water.

Apart from the uses of the water of the Kelvin for generating water-power, and to supply the canal, it was also used for boiler and condensing water for steam engines, and for process water, especially in paper-making and calico printing, and for the disposal of liquid waste (including human excrement). Despite growing levels of pollution, the section of the river from Kelvindale to Kelvingrove, where it flows through a succession of gorges, was much appreciated for its scenic beauty. At Kelvingrove the widening of the valley created an area which, when landscaped, formed excellent pleasure grounds. These were important in making the Park area a select and architecturally-refined suburb of the growing city. Kelvingrove Park was also used as the setting for the city's three major exhibitions in the years before the First World War, in 1888, 1901 and 1911. Finally, in the last, tidal, section of the river, at Partick, it was used as water-space for shipbuilding and ship-repair, from the 1840s to the 1960s. In addition to these water-using functions, the river valley, in some sections, provided useful transport routes, some used by riverside industries, though strictly this falls outside the scope of this paper, the rest of which deals thematically with the different classes of use identified above.

Power

Over the centuries the most important use of the river for power was for grain milling. The Vitruvian (vertical) waterwheel was invented in Roman times, but it appears that it was introduced into Britain on a significant scale with the advent of the feudal system in the 11th-12th century, with the accompanying concentration of control of the people in the hands of the landowners. The construction of relatively large water-powered mills, which the tenantry were obliged to use, was a characteristic aspect of feudalism. To generate enough power for these mills vertical wheels were essential, as were good millsteads. The millsteads of Partick were excellent in this respect. The Bunhouse Mills (Fig. 1) and the Bishop's Mills (Fig. 2) were probably the oldest, as they appear to have been well-established when the Bunhouse Mills were granted in the 1560s to the Incorporation of Bakers in Glasgow. Other mills in and around Partick, which followed, were the Scotstoun Mills (Fig. 3, the only ones in the village), the Clayslaps Mills (Fig. 5), and the Slit Mills (Fig. 6), originally built for making iron nail- rod, which used an extension of the Bishop's Mills lade for its water-supply. Also within the present Glasgow boundary were the Garrioch and North Woodside mills, and possibly the first South Woodside mills. The Bunhouse and Clayslaps mills produced flour, probably from imported wheat, while the others were oatmeal mills. The Garrioch, North Woodside (and possibly the South Woodside) mills had gone out of production by the mid-19th century, and the site of the Garrioch Mills was incorporated into the landscaping of the north bank of the river in the 1870s. In the later 19th century the technique of roller milling eliminated the older one of stone grinding, for flour production; the Clayslaps Mills were abandoned and the Bunhouse Mills were sold and replaced by the Regent Mills (Fig. 7). The Scotstoun Mills were similarly redeveloped for roller milling (Fig. 4). This complex also produced milled products for feeding horses and cattle, and the Bishop's Mills, too, concentrated on that side of the business. The Regent Mills were acquired in 1910 by the Scottish Co-operative Wholesale Society, and continued to make their 'Lofty Peak' flour until about 1960. Both it and the Bishop's Mills continued to use some water-power into the 20th century. The Slit Mills disappeared when the Stobcross Branch of the North British Railway was constructed in the 1860s. The millstead of South Woodside was used for the construction of a water-powered cotton-spinning mill, the first such mill in Glasgow (Fig. 8). The water supply from the Kelvin was barely adequate to power it, and it did not long survive the introduction of steam-powered cotton mills. It was supplanted by a power-loom cotton weaving factory, which probably used river water for its steam engine (see below).

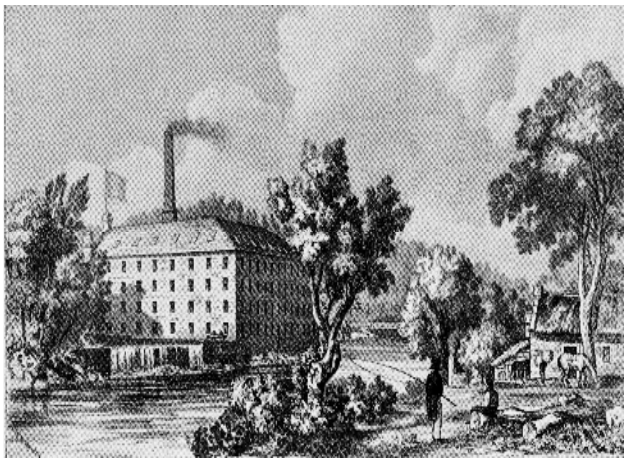

Fig. 1. Bunhouse Mills c1840 (Incorporation of Bakers

Fig. 2. Bishop's Mills c1966 (author's photograph)

Fig. 3. Scotstoun Mills early 19th century (Napier, 1873)

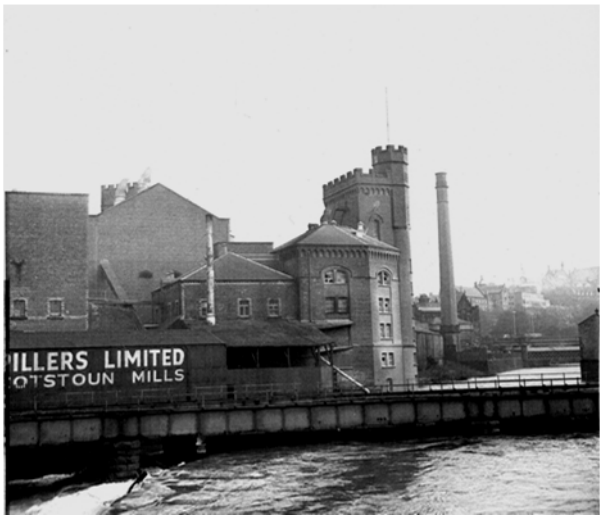

Fig. 4. Scotstoun Mills c1966 (author's photograph)

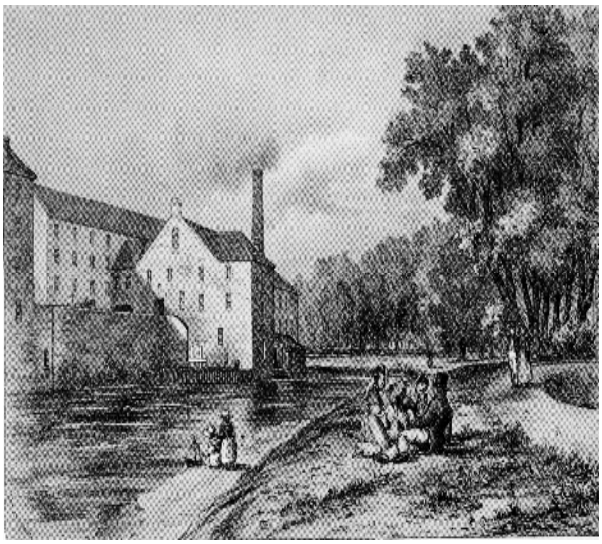

Fig. 5. Clayslaps Mills c1840 (Anon., 1931)

Fig. 6. Slit Mills 1848 (Simpson, unpublished)

Fig. 7. Regent Mills c1890 (Stratten, 1891)

Fig. 8. South Woodside Cotton Mill c1900 (Glasgow Museums)

It is also worth mentioning that in the 18th century, at the Balgray Paper Mills (see below), there was also a snuff mill, in which the stalks of tobacco leaves were ground to make the fine powder which is the basis of snuff.

The last user of Kelvin water for power was the North Woodside Mills, rebuilt in 1846 as a flint-grinding mill (Fig. 9). It continued to be solely water-powered until it closed in about 1960. It had a central water wheel (Fig. 10) which drove rotating paddles in circular water-filled tubs which pushed blocks of chert over flint nodules which had been roasted (calcined) in a kiln. The chert wore away the nodules, producing a milky suspension of powdered flint. This was then dried to produce a paste, which was packed into barrels for transport to potteries, where it was used as a component of glazes.

Remains of weirs survive to remind us of lost mills. The most complete are the weirs for Kelvindale Paper Mills at Maryhill (Fig. 11), and of the North Woodside Mills, below the Queen Margaret Drive road bridge. The Bunhouse Weir (Figs. 12; 13), between the Kelvingrove Museum and Art Gallery and Glasgow University, is still largely intact, but only fragments remain of the Clayslaps Mills weir, just downstream from the Kelvin Way bridge. The remains of the South Woodside Mills weir (below the Great Western Road Bridge at Kelvinbridge) and the Scotstoun Mills weir's remains can be seen, when the river is low, below Partick Bridge.

Fig. 9. North Woodside Flint Mill c1930 (Glasgow City Archives)

Fig. 10. Wheel, North Woodside Flint Mill 1959 (John Shaw-Dunn)

Fig. 11. Weir, Kelvindale Paper Mills 1965 (author's photograph)

Fig. 12. Weir, Bunhouse Mills late 19th century (author's collection)

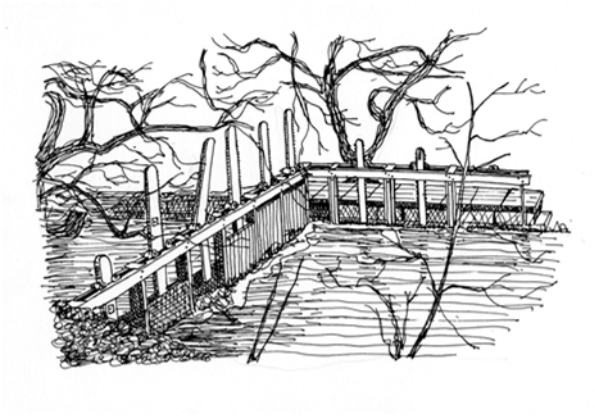

Fig. 13. Sluices Regent Mills c1970 (author's drawing)

Process Water

This term is used to describe water used in the making of something. Several of the industries on the Kelvin may reasonably be assumed to have used river water in the processes they carried on. Two of these industries certainly did: paper-making and calico-printing. There were two paper mills on the river within our area: Dalsholm, upstream from Maryhill, and Kelvindale (Fig. 14, also known as Balgray). The techniques used in paper-making changed in the 19th century, when hand paper-making was superseded by machinery, but as far as water is concerned the principle remained the same. A thin 'soup' of plant fibres, suspended in water known as 'stuff', was then spread thinly on a fine wire sieve, and the water was then removed either by gravity, or by suction. The resulting sheet of fibres was then dried to make paper. Both the Kelvin mills drew water from the river, filtered it, and then until the later 20th century returned the waste water to the river. This contained some fibrous material and if coloured paper was being made, water-soluble dyes. Paper-mill effluent fermented in its passage down-river, absorbing oxygen, making a foul smell, and rendering the river inhospitable to fish and other riverine life. The Dalsholm mill closed in the 1960s, and the Kelvindale mill in the late 1970s. Both have been demolished.

There were at least two, probably more, calico-printing works on the Kelvin in our area, at Maryhill (Figs. 15; 16) and Partick (Fig. 17). In both of these, filtered water would have been used to prepare cloth for printing and washing out excess dyestuffs and mordants (used to fix the dyes to the cloth) and bleaching agents. The contaminated water would have been returned to the river. The quantities would, however, have been much smaller than those produced by paper mills.

Fig. 14. Kelvindale Paper Mills 1930 (Glasgow City Archives)

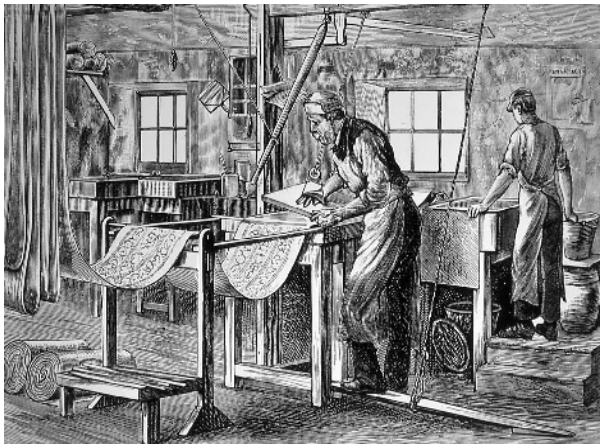

Fig. 15. Hand printing of calico late 19th century (author's collection)

Fig. 16. Former calico-printing works, Maryhill, 1966 (author's photograph)

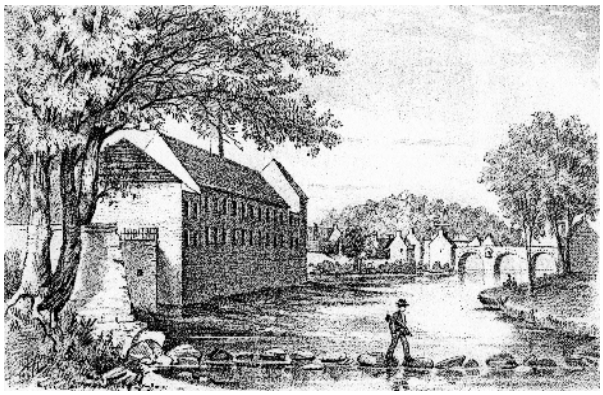

Fig. 17. Partick Print Works mid-19th century (Napier, 1873)

The North Woodside Flint Mill (and probably the Garrioch Mill) used river water in the grinding process, and probably returned some to the river, containing a fine suspension of calcined flint (silicon dioxide).

Cooling and condensing

Other industries in the area used river water for cooling, notably the Dawsholm Gas Works. Smaller-scale users of river-water for cooling were concerns which used steam engines for power, including as well as the paper-mills and gas works the Bunhouse, Regent, Scotstoun and Bishop grain mills in Partick and the Partick Sewage Pumping Station (Fig. 18). In a river with such a small volume the heat pollution produced by this use could at times have been considerable.

Waste disposal

It is in the nature of rivers that they were until comparatively recent years used to dispose of human and animal excreta, and for surface-water drainage. The use of the 'Snow Bridge' (the first turnpike road bridge at Partick) to dispose of snow from the streets, contaminated with horse excrement, is an extreme case of such a practice. Apart from this very intermittent use the quantity of such material in most of the Kelvin was probably not great. In the tidal section of the river, below the first Partick Bridge, however, drainage from the village would have been supplemented by tidal influx of both industrial waste and sewage from Glasgow, and from vessels using the river.

Fig. 18. Partick Sewage Pumping Station c1966 (author's photograph)

Water space

The amenity use of the Kelvin in its course through Glasgow has been referred to above, as has the probable use for water-borne communication between the Clyde and the upper reaches of the river in prehistoric and early-historic times. This last section of my narrative is, however, dominated by the use of the tidal section of the river by shipbuilders and repairers. There were three of these, two on the west bank and one on the east. The first of these was the firm of Tod and MacGregor (Fig. 19), who started building iron ships on the west bank, on the angle between Kelvin and Clyde, in 1847. Immediately adjacent to their yard the firm of Thomas Seath built a few ships before Tod and MacGregor constructed a graving dock and a 'patent slip' for ship repair on the site of the Seath berths. On the east bank the firm of A. and J. Inglis (Fig. 20) established a similar business, from 1864, though they did not have a graving dock. Tod and MacGregor, their successors D. and W. Henderson, Thomas Seath and Co. and A. and J. Inglis all used this stretch of the Kelvin for launching and fitting out vessels, and for repairing and refitting ships. For these purposes the river was dredged most of the way up to the old Partick Bridge. There was also for a time in the 19th century a rowing-boat ferry across the mouth of the Kelvin.

Fig. 19. Tod and MacGregor's Shipyard 1860s (author's collection)

Fig. 20. A. and J. Inglis's Yard, Pointhouse c1950 (Glasgow City Archives)

CONCLUSION

This outline of the industrial uses of the Kelvin brings into focus their possible effects on the modern biology of the river. Though as recently as the 1960s it was seriously polluted by paper-making waste, such pollution is by its nature short-lived. There may be residues of calico-printing chemicals (heavy metal mordants) in silts in the littoral. Other possible contaminants are heavy metals leached from coal ash produced in riverside factories and in the steam locomotive depot at Dawsholm, but given the frequent spates this river experiences this is unlikely. It is possible that in the vicinity of Dawsholm Gas Works coal-tar residues may still exist. As a research exercise it might be worth sampling and analysing both river-bed (especially above weirs) and littoral silts.

ACKNOWLEDGEMENTS

I greatly appreciate the invitation from Professor J.R.Downie to take part in the Kelvin Biodiversity Conference and for his help and encouragement in preparing this paper for publication. I am most grateful to the staffs of the Mitchell Library, Glasgow City Archives, and Glasgow Museums and Art Galleries for help over many years, and for permission to reproduce material in their collections.

At a more personal level, I must thank my old friend Dr. John Shaw-Dunn for his photograph of the North Woodside Flint Mill (Fig. 10). Finally, in retrospect, I must mention John Robertson, dead these many years, whose enthusiasm for the Kelvin was inspirational.

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The following proved particularly helpful in the preparation of this paper and some were the sources of the illustrations, used with permission.

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Glasgow's biodiversity: the importance of the Kelvin corridor

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ABSTRACT

Glasgow's Local Biodiversity Action Plan was launched in 2001 to protect and enhance habitats and species, and raise awareness of the importance of the natural heritage. Glasgow is rich in biodiversity, protected through an extensive green network of designated sites including Sites of Special Scientific Interest, Local Nature Reserves, Sites of Importance for Nature Conservation and Green Corridors. Nationally and locally important habitats and species can be found in the urban environment. Partnership projects have delivered key targets for management, restoration and creation of wetland, woodland and grassland habitats. The River Kelvin is a well-loved major wildlife corridor in Glasgow connecting people to nature and forming the framework of the green network.

ABBREVIATIONS

British Trust for Ornithology (BTO), Butterfly Conservation Scotland (BCS), Forestry Commission Scotland (FCS), Glasgow and Clyde Valley Green Network Partnership (GCVGNP), Glasgow City Council (GCC), Glasgow Natural History Society (GNHS), North Lanarkshire Council (NLC), Royal Society for the Protection of Birds (RSPB), Scottish Natural Heritage (SNH), Scottish Ornithologists' Club (SOC), Scottish Wildlife Trust (SWT), The Conservation Volunteers (TCV) and Woodland In and Around Town (WIAT).

Glasgow's Local Biodiversity Action Plan

Glasgow's Local Biodiversity Action Plan (LBAP) was launched in 2001 and is very much a partnership process (Glasgow's Biodiversity Partnership, 2001). The LBAP focuses on protection and enhancement of habitats and species, and awareness- raising. Over the years Habitat Action Plans (HAPs) and Species Action Plans (SAPs) have been produced. Since 2008 these are now grouped under the following broad habitats and/or categories:

Woodland: includes broad leaved and mixed woodland, and wet woodland HAPs. By protecting, managing and enhancing woodland, SAPs are

delivered through protecting the associated species including badger, bluebell, wood crane's-bill and toothwort.

Wetland: includes a wide range of habitats from raised bogs to ponds (raised bog, marsh, reedbeds, swamp, fen, wet woodland, standing open water, rivers and streams HAPs). By protecting, managing and enhancing wetland, SAPs are delivered through protecting the associated species which include water vole, otter, jack snipe, reed bunting, palmate newt, tufted loosestrife, common frog, common toad, Atlantic salmon, dragonflies and damselflies, bog-rosemary and bog-mosses.

Peatland restoration is highlighted as a national priority because of the many ecosystem services it provides including carbon sequestration and biodiversity (Scottish Government, 2015).

Grassland: includes acid grassland, neutral grassland and dwarf shrub heath HAPs. By protecting, managing and enhancing grasslands, SAPS are delivered through protecting the associated species which include skylark, small pearl-bordered fritillary, common frog, common toad, burnet-saxifrage and sheep's-bit.

Farmland: this does not spring to mind as a typical habitat in Glasgow but the urban fringes have large areas of farmland and agricultural grant schemes are a good opportunity to manage these areas positively for biodiversity and can deliver woodland, wetland and grassland actions.

Built up areas and gardens/awareness-raising: Engaging the public is particularly important in urban areas like Glasgow and is a large focus of the LBAP.

LBAP refresh

The LBAP is an on-going process and is being refreshed. The updated LBAP will focus on ecosystems to streamline action plans and focus resources to achieve maximum benefit for biodiversity.

A major aspect of this is the Biological Audit for the city because it is essential to know as much as possible about the biodiversity in the City and surrounding areas to assist with prioritising key habitats and species for action. Glasgow Museums have been working on a major update. The Audit is now (September, 2016) up to 6486 species and counting.

The LBAP refresh is an opportunity to include recent updates and discoveries. One example is water voles that no longer fit under the Wetland Habitat Action Plan.

Water vole update

In 2008, in response to a pest control query, water voles were discovered living away from water. Water voles living away from water are termed fossorial which means mole-like as they lead a more subterranean lifestyle. Since 2008 more and more sites have been discovered in the east end of Glasgow.

Research on these animals has been on-going as a collaboration between Glasgow City Council (GCC) and the University of Glasgow. In 2014 a grant-funded Masters by Research project was set up with GCC, University of Glasgow and Glasgow Natural History Society (GNHS) to carry out scientific research. The research found that the fossorial populations can occur at densities not seen before in the UK (Stewart, 2015). The unusual behaviour and population density means that Scottish Natural Heritage now consider this population to be of national significance (R.Raynor, pers.comm.). Glasgow's LBAP will be updated to reflect this unusual discovery.

Wildlife sites

The protection of biodiversity starts with the protection of sites. Sites of Special Scientific Interest (SSSIs), Local Nature Reserves (LNRs), Sites of Importance for Nature Conservation (SINCs), Green Corridors and parks amount to over 100 sites protected with environmental designations in the City Plan.

Habitat connectivity and integrated habitat networks are being recognised nationally as vital for biodiversity but this has always been recognised in Glasgow. All major watercourses in Glasgow are designated SINCs and major transport corridors are designated Green Corridors.

Glasgow Biodiversity Partnership Projects

The biodiversity process in Glasgow is very much a partnership process. Table 1 shows just a few examples of projects that have taken place in the city since the launch of the LBAP.

The River Kelvin corridor

Overview

Intact watercourses such as the River Kelvin are particularly important wildlife corridors in urban areas, especially as many others are fragmented due to historic land use changes and development.

Glasgow Museums manages the biological records for Glasgow which informs the Biological Audit which is the basis for the LBAP and the following statistics were generated using the River Kelvin SINC boundary. At least 2524 different species have been recorded in the River Kelvin corridor (River Corridor SINC and 500m buffer) within Glasgow. The biological audit for Glasgow now stands at 6486 species which amounts to the River Kelvin corridor having 39% of all the species found in Glasgow. Of these, 461 (7%) species are (in Glasgow terms) unique to the River Kelvin. It is not easy to interpret these statistics. Some of the unique species are not necessarily good news because for example one of them is the non-native signal crayfish. However, it is

safe to say that the large number of records is due to the recording efforts of many individuals, groups and organisations, which demonstrates the appeal of this iconic river.

Some of the biodiversity highlights of the river are otter, badger, bats (common and soprano pipistrelle, brown long-eared and Daubenton's), kingfisher and dipper. Atlantic salmon has been one of the success stories of the Clyde catchment. Salmon returned to the Clyde and the River Kelvin after being absent due to pollution. Improvements in water quality assisted their return. Otter have returned to sites formerly occupied, but are perhaps feeding on the salmon.

Project Title	Description	Key Biodiversity Target	Lead Organisations
Woodland partnership	FCS lease of GCC woodlands	Woodland HAPs and awareness	FCS and GCC
Woodland management	Woodland management and access improvements	Woodland HAPs	FCS and GCC (WIAT funded)
Seven Lochs Wetland Park	Landscape scale biodiversity, heritage and access project	Wetland HAPs awareness and access	FCS, GCC, GCVGNP, NLC, SNH and TCV
Glasgow's Living Waters	Pond creation and management & monitoring	Wetland HAPs	Buglife, Froglife and GCC
Cathkin Marsh	Wetland management and access	Wetland HAPs	GCC and SWT
Pond Naturalisation	Naturalisation of park ponds	Wetland HAPs	GCC
Commonhead Moss	Bog restoration project	Raised Bog HAP	GCC and SWT
Green Stimulus	Restoration of all GCC lowland raised bogs	Raised Bog HAP	FCS, GCC, GCVGNP, SNH and TCV
Meadow Trial Project	Meadow creation trials	Grassland HAPs	GCC and SNH
Glasgow's Buzzing	Meadow creation and management & monitoring	Grassland HAPs	Buglife and GCC
Farmland Birds	Habitat creation and management & monitoring	Farmland and awareness	GCC, RSPB, SOC and Starling Learning
Biodiversity In Glasgow (BIG)	Monitoring of birds and butterflies	All HAPs and awareness	BCS, BCS and GCC
Habitat Restoration Project	Habitat enhancement and management & awareness raising	All HAPs and awareness	GCC, SWT and TCV
Local Nature Reserves	Declaration and promotion of Local Nature Reserves	All HAPs and awareness	Friends' of Glasgow's LNRs, GCC and SNH
Giving Nature A Home	Habitat creation and management & awareness raising	All HAPs and awareness	RSPB Scotland and wide partnership
Biological Audit	Management and interpretation of biological data	All HAPs and SAPs	GCC, Glasgow Museums, GNHS and all of LBAP partnership
Fossorial Water Voles	Scientific research on Glasgow's non aquatic water voles	Water Vole SAP	GCC, GNHS, SNH and University of Glasgow
Eco Schools and Bird Friendly Schools	School grounds biodiversity projects	Urban and awareness	GCC and RSPB Scotland
Awareness raising	Large scale events such as BBC Springwatch , RSPB Wildlife Garden Festival, International Biodiversity Day, Pollok Family Day, Conferences and numerous engagement activities and events	Greenspace and awareness	LBAP partnership

Table 1. Glasgow Biodiversity Partnership projects

Sites

The River Kelvin SINC: The SINC covers the full length of the River Kelvin in Glasgow and includes the river, bankside vegetation and associated sites. Habitat management and creation has been carried out by GCC in parks and greenspace adjoining the river (Figure 1).

Fig.1. Wildflower meadow creation at Kelvingrove park.

Millichen Flood SINC: This is privately owned farmland that is part of the natural floodplain of the river. Typical birds include thousands of geese in winter (mainly pink-footed goose and greylag goose), good numbers of wigeon and teal (when the Flood is flooded in winter) and passage waders (in autumn). Summer migrants include grasshopper warbler, willow warbler, whitethroat, swallow, sand martin and house martin. RSPB Scotland (Glasgow Group), Kelvin Clyde Greenspace and Starling Learning have previously carried out habitat enhancements and monitoring projects here for farmland birds including tree sparrow, reed bunting and yellowhammer.

Dawsholm Park LNR: This site is owned and managed by GCC. The main habitat is woodland. There are small areas of wildflower meadow as well as ponds and the river. Recent projects include woodland management which was carried out by GCC funded by a grant from Forestry Commission Scotland to diversify the age structure of the woodland and control rhododendron. New areas of woodland have been created and meadows enhanced as part of community events and Froglife created a new pond.

Recently the Friends of Glasgow's Local Nature Reserves (an NGO established in 2011) have carried out a lot of activities and events including guided walks, litter picks, installation of bird and bat boxes, and hedge planting. RSPB Scotland volunteers have been enhancing the meadows.

Botanic Gardens: This is a much more formal site with plant collections in the glasshouses and the famous Kibble Palace. However, general management of the Botanic Gardens incorporates biodiversity enhancements and the grounds include the River Kelvin. Recent projects include the creation and enhancement of wildflower meadows and in collaboration with the RSPB Scotland, the installation of a 'bug hotel'- a wall with crevices for a range of invertebrates to find shelter.

Kelvingrove Park: The River Kelvin is probably best known at Kelvingrove Park, as the central feature of the designed landscape of the park. BBC Breathing Places helped raise the profile of biodiversity and in 2007 a large BBC Springwatch event was held in the park, delivered by the Council, BBC and the LBAP partnership. Over 25,000 people attended. The event was not just about one day of activities it was about leaving a lasting legacy. Kelvingrove Park now has a naturalised pond, butterfly garden and wildflower meadow that are cared for at volunteer activities organised by GCC in partnership with RSPB Scotland, The Conservation Volunteers and GCC. Since 2007, Kelvingrove Park has been the location for Bioblitz days organised by the RSPB, attracting volunteers to record as much biodiversity as possible in a single day.

Biodiversity: the way forward

The LBAP refresh will focus resources to maximise biodiversity delivery within the City. Updated actions and objectives will provide new measurable targets. As part of its biodiversity duty GCC is committed to mainstreaming biodiversity into all its activities. Capacity building, in times of reduced resources, is key to effective project delivery. The LBAP process is an example of a successful partnership project. The aim is to continue with the existing partnership and to expand to develop new projects with a wider range of organisations to build capacity.

ACKNOWLEDGEMENTS

The Biological Audit is updated by many individuals, groups and organisations. Thanks go to GNHS, in particular the Changing Flora of Glasgow surveyors including the late Peter Macpherson, GCC Conservation and CRS, Glasgow Museums Biological Records Centre, Buglife for invertebrates including wildflower meadows, SEPA for aquatic invertebrates, Clyde & Argyll Fungus Group and

others too numerous to mention. Richard Weddle updated the records data for this article.

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The changing flora of the Kelvin

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When looking at the significance, conservation and management of the flora of a particular place one has to be aware of its past history as well as its current diversity. When the place is a dynamic stretch of a mostly urban river many factors come into play.

Historically one has to ask the question: what constitutes the flora at any particular moment in time? Assuming that some information with which to make an assessment is available, do we know if it has been like this for a long time? A brief review of literature, old paintings and images readily shows that there have been dramatic changes to the landscape along the River Kelvin, both rural and urban, and thus changes to the habitats. In Glasgow, the industrial revolution had a huge impact on the river as can be seen from the earliest maps to the present day; additionally there are numerous photographs from the twentieth century which graphically show built developments along the banks and often a lack of any suitable habitat for plants and animals.

However, in more recent times, certainly in urban areas, there has been some rewilding of many sections of the river. Abandoned structures have been colonised, and rubble has mixed with alluvial sands to create habitat niches along the river's margins. Initially colonised by ephemeral weeds and herbaceous perennials, scrub soon develops and semi-natural woodlands are now establishing throughout (locally enhanced by planting). Rural stretches have been affected by agricultural changes, and although some broad areas of relatively unimproved grassland occur along the old levees many are no longer grazed, resulting in dense tall herbs and scrub spread.

Water quality has also changed. Since the heavily polluted days of the 19th and early 20th century, much effort has been directed at cleaning up the water. The return of the salmon in the 1980s is testimony to the success of this work, supported by less showy survivors such as several pondweeds and floating bur-reed. However, although appearing much cleaner, agricultural improvements upstream result in high nutrient inputs to the water course.

Plants are good at recolonising past disturbed places, but current ground and water conditions are not the same as those previously encountered. This can affect which species can recolonise and, of great relevance to the urban context, there are many more non-native plants in the local area than was the case 200 years ago.

There are some 250 species of vascular plant that have been recorded along the Kelvin over recent times, and herbarium and literature sources indicate nearly half of these are named from the Kelvin in the 19th century (unfortunately, place names are seldom cited for common species). About 13 natives are now extinct (e.g. the oak fern collected in 1840 by William Gourlie: Fig.1) but the vast majority are still to be found, although not always in large populations; native woodland survivors include wood speedwell (Fig.2), ramsons, dog's mercury, wood stitchwort (Fig.3), wood melick, wood sedge, moschatel and bluebell.

However the old botanists would be surprised, if not shocked, by the many new arrivals that can be found along the riverbanks (Fig.4). Many non-natives have been around for a long time but quite a few have spread in more recent times, good examples being fringe-cups, pick-a-back-plant, summer snowflake (Fig.5) and few-flowered garlic, the latter now carpeting areas with its bright green, pungent leaves in early spring, but soon disappearing back underground before the summer. Some newcomers are strangely exotic such as skunk cabbage and purple toothwort; the former was known to be established near the Allander tributary in Milngavie but was later noted in the mud of the old weir at Kelvingrove in the 1990s. The toothwort has been known from the Glasgow Botanic Gardens since 1915 but has so far not spread any further. Some plants found are nationally quite rare such as the round-leaved saxifrage (Fig.6), which was collected from the Fin Glen catchment up in the Campsie Hills in 1924.

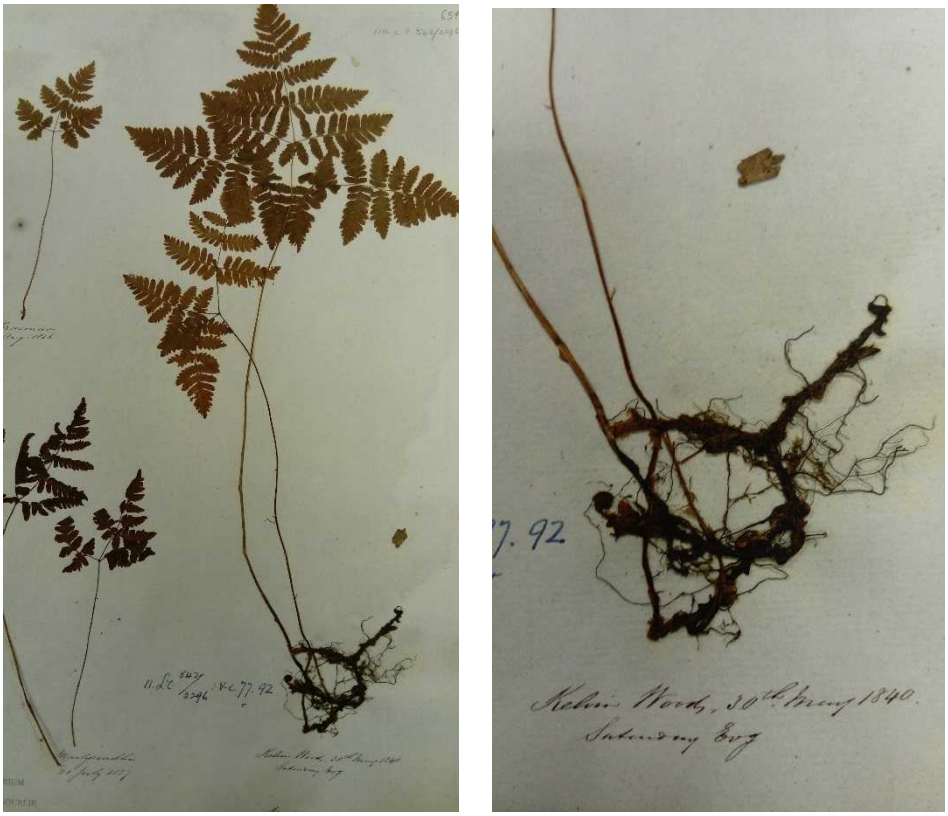

Fig.1. Oak fern, *Gymnocarpium dryopteris* collected by William Gourlie, 1840, Herb GL.

Fig.2. Wood speedwell, *Veronica montana*, native of old woodlands.

Fig.3. Wood stitchwort, *Stellaria nemorum*, native of riverbank woodland.

Fig.4. The riverbank near the University with giant hogweed and Japanese knotweed

Fig.6. Round-leaved saxifrage, *Saxifraga rotundifolia*, rare alien, known since 1915.

Fig.5. Summer snowflake, *Leucojum aestivum* a recently spreading non-native.

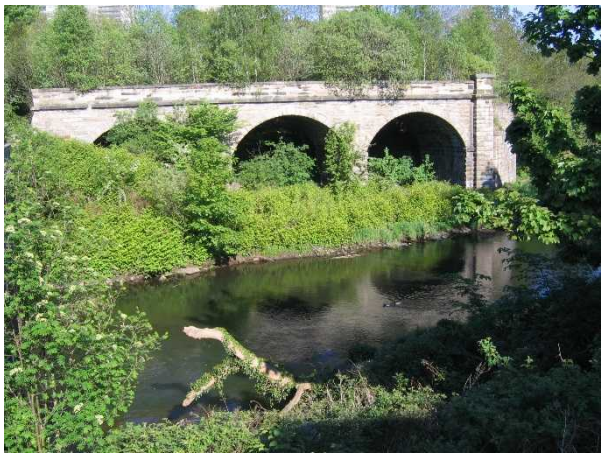

Fig.7. Japanese knotweed stand below the old railway bridge, Kelvindale.

Other new residents include the now notorious Invasive Non-Native Species (INNS): Japanese knotweed, giant hogweed and Indian balsam. Giant hogweed can be an impressive sight and despite repeated efforts at poisoning, remains a highly visible presence. The balsam was known to Lee (1933) who described it as "naturalised and growing profusely on the banks of the Kelvin". This is certainly the case today, and it appears to have become even denser over the last 25 years.

Japanese knotweed (Fig.7) is perhaps the most maligned of the INNS, with a burgeoning industry thriving on its elimination. Official guidance and the popular press all report that it eliminates native species and that nothing can live under its dense canopy. Recent sampling of the spring flora at several knotweed stands along the riverbanks, some going back eight years, have shown there to be over 40 species found growing under the knotweed canopy, both native and non-native. This observation contrasts with the popular view, and agrees with the opinion of the late Oliver Gilbert (Gilbert, 2001) concerning similar riverbank populations in Sheffield. Is the Japanese knotweed a growing menace or a naturalised feature of the riverbank ecology?

Today the river is viewed as an attractive place for recreational activities and somewhere to escape, away from our busy urban lives on the streets just a few metres above the banks. To many non-botanists this appeal takes no note of the provenance of the colourful vegetation. If it is attractive now, should we leave it alone and allow nature to continue to take its course? Could we really eradicate non-natives even if we so wished? What would it be like if there were no non-natives? There are lots of difficult questions but few simple answers. Ultimately, who decides what the river and its banks should look like?

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Power from the River Kelvin: Past and Present

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Positive Solutions Glasgow, Friends of the Earth Scotland

Editor's note: Neil Phillips sadly died, after a short illness, while this article was in production. His activism and expertise on sustainable energy will be greatly missed.

History and Background

Since the 1500's the River Kelvin has played a part in the industry and economy of Glasgow especially Partick. Thomas the Rhymer spoke about The Miller of Partick.

At one point or another there have been mills operating on eight sites along the river within the city boundary, some of which had several names. Starting at the Bearsden / Glasgow City Boundary and travelling south down the river they were Killermont Saw Mill, Dawsholm Paper Mill (demolished in 1970's), North Woodside Mill (gunpowder, meal, dyes, flint – 1750 to 1963), South Woodside Mill (the largest cotton mill in Glasgow and the only one water p.wered), Clayslaps Mill (New Mill of Partick,1517: Waulk, Malt), Bunhouse Mill (Archbishop's Mill, Lyons Mill & later Regent Flour Mill) – 1717 ruinous but replaced by Lyons Mill in 1735 – lint, malt, snuff, flour. The building shown (Fig.1) is now flats but was the main production unit.

Below Bunhouse was the Scotstoun Mill later operated by Rank Hovis McDougall for the production of flour. This was the last operating mill, closing in 2010 but by then no longer water powered. Further down and close to the junction with the River Clyde were the sites of the Partick Old Mill / Slit Mill, and Bishops Mill.

In order to power the mills a series of weirs and lades were constructed (Fig.2). Most of the weirs still exist but there is only one remaining lade, which is silted up. This could be cleared but restoration work would be required on the sluice gate.

Hydro Technology & Types of Turbine

There are many designs of turbine which have been installed at sites across the UK (Fig.3). The most suitable turbines for the River Kelvin will be either crossflow turbines or undershot wheels.

Turbine Principles

If you wish to generate energy and power from water you need three things – head (height), flow, and availability of flow plus an allowance for shut down maintenance (Fig.4).

As an example: For a river with a flow rate of 50 litres per second and a 15 metre head the power of a typical turbine would be:

Power = 50l/s x 15m x 9.98 x 0.75(efficiency) x 0.9(friction) /1000 = 5.05kW

The third element is availability of flow. If you assume 75% availability, how much electricity could be generated?

Electricity = 5.05 x 24 x 365 x 0.75 = 33,179kWh, which is enough electricity for about six houses.

So why has the Kelvin been used as a source of power? It is because it has water levels for flows from 2 to 200m3/sec = 2,000litres/sec to 200,000litres/sec. This means that it can be used again to generate electricity. However, it does have head limitations. From above the Killermont Weir to below the Natural Tidal Limit (NTL) Weir, the head is only 10 metres, of which 3 metres is the head across the weir.

What power could the Kelvin generate at NTL? Take a mid-range flow of 10,000litres/s; head = 3metres; turbine efficiency 0.85%; friction losses = 10%; then power = 10,000l/s x 3m x 9.98 x 0.85 x 0.9 /1000 = 229kW.

The third element is availability of flow. Let us assume 90% (it could be as high as 95%). So how much electricity could be generated?

Electricity = 229 x 24 x 365 x 0.9 = 1,805,759kWh. A typical house will use about 4,500kWh per year, so the output from this weir could meet the demand of 400 houses.

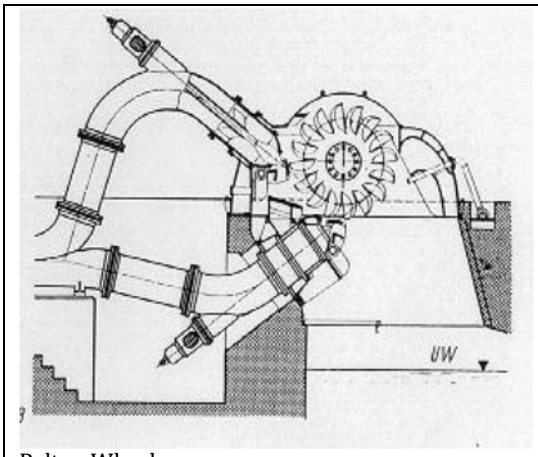
Capital cost including grid connection would be about £850,000; maintenance and management would cost about £68,000 per year. If the electricity can be connected direct to properties and used, the typical cost of electricity will be 12.8p per kWh.

Fig.1. Bunhouse Mill at the present day, from the side and above.

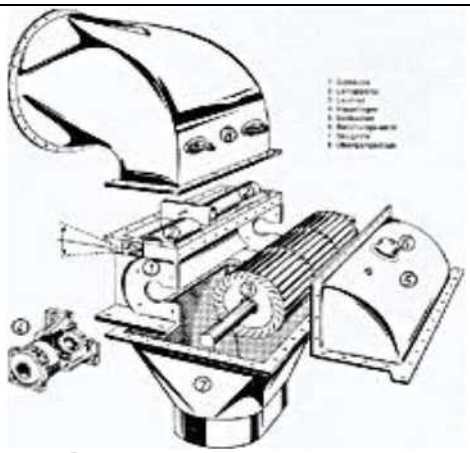
Killermont Weir Dawsholm Weir

North Woodside Weir and Lade Bunhouse Weir (Natural Tidal Weir)

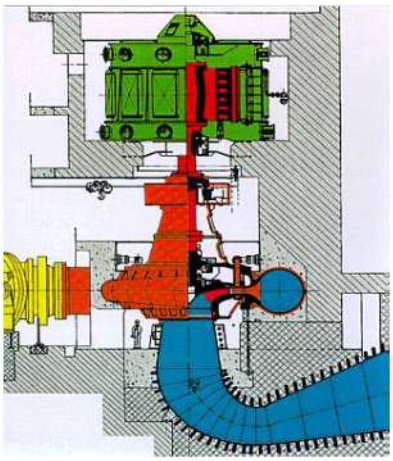
Fig.2. The weirs of the River Kelvin, from above.



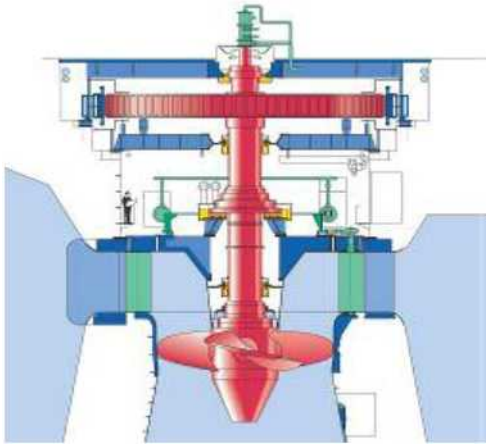
Pelton Wheel



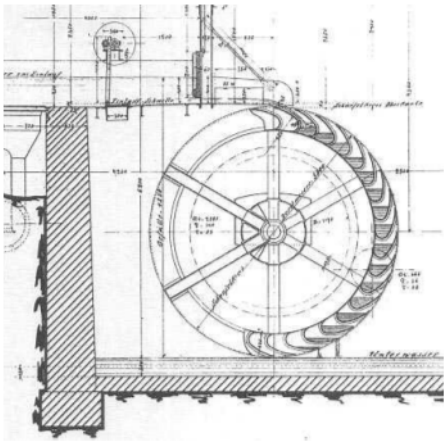
Crossflow



Francis Turbine



Vertical Caplan



Overshot Wheel

Undershot Wheel

Fig.3. Types of turbine for installation on rivers.

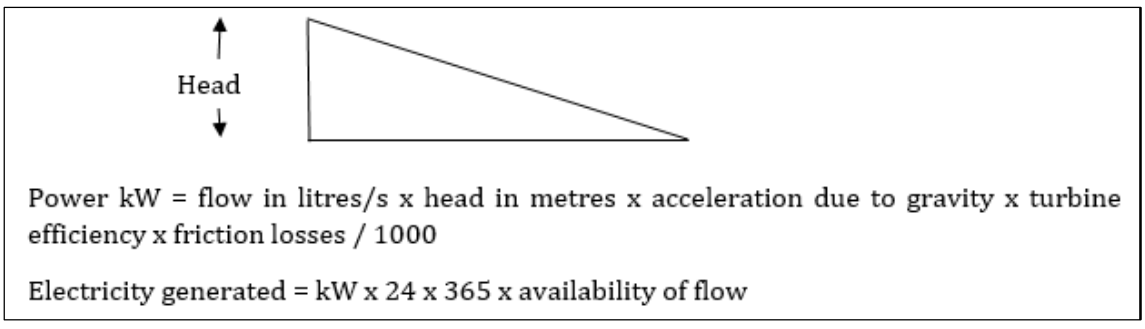


Fig.4. Basic hydropower potential.

Generation savings = 1,805,759kWh x £0.128 = £231,137; feed-in tariff for turbines between 100kw and 500kW = 12.67p per kWh – index linked for 20 years; generation income = 1,805,759 x £0.1267 = £228,790.Savings + Income = £231,137 + £228,790 = £459,927. So simple payback = £986,000 / £459,927 = 2.14 years.

However, because there are no residential properties in the immediate vicinity, direct connection to 400 houses will not be possible so the electricity will have to be exported to the grid. Here there are no savings because of use and the export feed- in tariff is only 4.5p per kWh.

Income = 1,805,759 x £0.045 = £81,259, so simple payback = £1,666,000 / £81,259 = 20 years.
Carbon conversion for electricity = 0.53748; annual tonnes of carbon saved = 1,805,759 x 0.53748 / 1000 = 971tCO_2.

So the secret of the economic use of hydro-electricity is to use as much as possible on site. This gives us a problem with using the Kelvin because there are few high load demands close to the river. The BBC has gone, and Rank Hovis McDougall has gone. The Kelvin Hall & old Transport Museum temporarily closed for refurbishment and re-opened in 2016 as a sports and exhibition centre. The two Kelvingrove weirs combined could supply Kelvingrove Art Gallery and Museum although the head here is only 1.5m, and the electricity demand is not known.

The NTL Weir could supply the student flats on the old Western Engineering site (100), the student flats on the old Edmundson electrical site (100), the West Village student flats in Castlebank Street (700), the new student flats in Keith Street (170), and the new Vita student flat development on Castlebank Street (500).

There is potentially another site where the River Kelvin passes below the Forth and Clyde Canal aqueduct. Just west of this point are Maryhill Locks where if flow was ducted from above them through a turbine and into the bottom basin there would be a head of 9.5 metres. Unfortunately, it is not known what the availability of flow would be. It is unlikely that sufficient flow would be available for a 100kW turbine but one of say 30kW might be possible. A hydro scheme on the Kelvin at this point could be used to supplement this scheme. The output from both could supply electricity to a tower block of flats in Collina Street.

Glasgow University have commissioned a feasibility study to see if sufficient power for their development of the Western General Hospital site could be generated by a water source heat pump sited near to where the Snow Bridge crosses the river. The results of this are not yet known.

Anyone interested in learning more about small scale hydro could consult: Boyle,Godfrey (editor) (2012). *Renewable energy: power for a sustainable future* (3rd edition). Oxford University Press, Oxford and the Open University, Milton Keynes.

Discussion session

You have heard our speakers; this is your chance to discuss the issues they have raised, and any others that occur to you. We have listed a number of topics that we think will provoke some discussion, but we will be very happy if you decide to tackle some different ones. We will ask you to choose which of three groups to join for the discussion session. Each group will have three of our topics as their agenda, plus a reserve if you manage to deal with them all quickly. Each group will be led by a facilitator and will be asked to choose a scribe, whose job is to record the main points made in the discussion, and feed them back to us. The facilitator will also ask if you have any additional topics you wish to discuss.

TOPICS

Group A

1. Harnessing the Kelvin's power : are you in favour of making the investments and infrastructural changes needed to make the river a source of sustainable energy, and if so, under what conditions?
2. The banks of the Kelvin, and the river itself, have been invaded by a range of 'alien' plants and animals; should we aim to eliminate these and, if so, what resources are you in favour of spending on this task?
3. The Kelvin Biodiversity Network is a loose assembly of local groups with an interest in the river; this conference is its first substantial activity. Are you keen that the network should continue, and if so, suggest some activities for it which would not be pursued by constituent groups (such as Glasgow Natural History Society, or Friends of the River Kelvin) alone.

Group B

4. We can think of everyone living in the vicinity of the Kelvin as having a stake in the future of the river. In terms of the river's biodiversity, how can different groups of stakeholders be encouraged to take an active interest? Groups like early years children, primary and secondary school pupils, students, unemployed adults, adults with additional needs, older people, artists….
5. If you had £500 or £5000 to spend on exploring/protecting/documenting/celebrating the biodiversity of the Kelvin, how would you spend it?

6. What sources of funding should be explored to support further work on the biodiversity of the Kelvin?

Group C

7. Our uses of the Kelvin have changed greatly over the years, leaving remnants of a more industrial past, such as derelict bridges and the remains of old factories; should we now see the river as an oasis of countryside in the city, or are we prepared to support riverside developments such as more housing and hydropower generators?
8. Politicians talk a lot of 'red lines'. In terms of potential developments along the Kelvin, what would be your red lines?
9. Many users of the Kelvin are likely to be ignorant of its past but interested in learning more. If you were to be involved in developing an interpretation resource related to the river and its past, would you favour putting resources into a leaflet, fixed display boards (such as those at the Flint Mill), or new media?

Ecological monitoring of the lower River Kelvin by SEPA, 1979 – 2014

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INTRODUCTION

SEPA and its predecessor organisation have monitored the River Kelvin (Fig.1) since 1979 for the general purpose of pollution control and also for classification into one of five quality categories for the EU Water Framework Directive (WFD). The categories are High, Good, Moderate, Poor and Bad. The classification is derived using data from macroinvertebrate, diatom and macrophyte samples.

Macroinvertebrates

Ecology staff from the Clyde River Purification Board (CRPB) began regularly collecting invertebrate samples from the River Kelvin in 1979. The furthest downstream site was called Kelvin Hall and was located just upstream of the confluence with the River Clyde.

Fig 1. Sampling for invertebrates in the River Kelvin

In 1983 that site became inaccessible due to building works, so since 1984 samples have been collected from the river in Kelvingrove Park. Over these past 35 years there have been slight changes to the methods used for sample collection and analysis, and these have been taken into account while preparing the information here.

Between 1979 and 1987 the Trent Index was the means for quantifying water quality. These scores are shown in Fig. 2. The Trent Index was replaced by BMWP (Biological Monitoring Working Party) and ASPT (Average Score Per Taxon) scores in 1989. These are shown in Fig. 3 and Fig. 4.

In 1999 stoneflies began appearing in samples, indicating an improvement in quality, perhaps associated with the diversion of effluent from Torrance Sewage Works to the Kelvin Valley Sewer (KVS). However, quality remained variable and many samples were still dominated by worms until around 2005 when samples began to indicate good quality more consistently following the diversion of other sewage effluents to the KVS. Since 2005, stoneflies and pollution-sensitive cased-caddis such as Leptoceridae and Brachycentridae (pictured Fig. 3.) have been present in nearly all samples. The Macroinvertebrate quality category improved to Moderate in 2007 and has been good since 2008. Unfortunately though, sewage effluent still floods the river intermittently when pipes and tanks become overloaded or blocked with sewage debris.

Phytobenthos (diatoms).

Typically each sample contained between 30-40 taxa. The EQR (Ecological Quality Ratio) indicates fluctuating ecological status based on diatoms. Samples with EQRs >0.6 indicate Good status and are dominated by taxa such as Achnanthidium minutissimum. Declines in EQR between 2008-09 and 2012-13 (Fig.5) could suggest the site is still nutrient enriched, with abundant taxa such as Navicula gregaria, Navicula lanceolata and Amphora pediculus recorded (Fig.5, L-R).

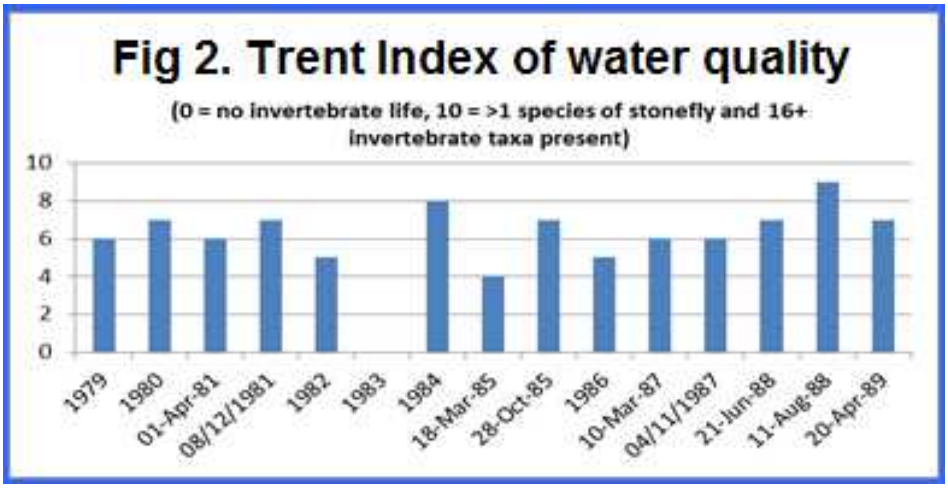

Fig 2. Trent Index of water quality

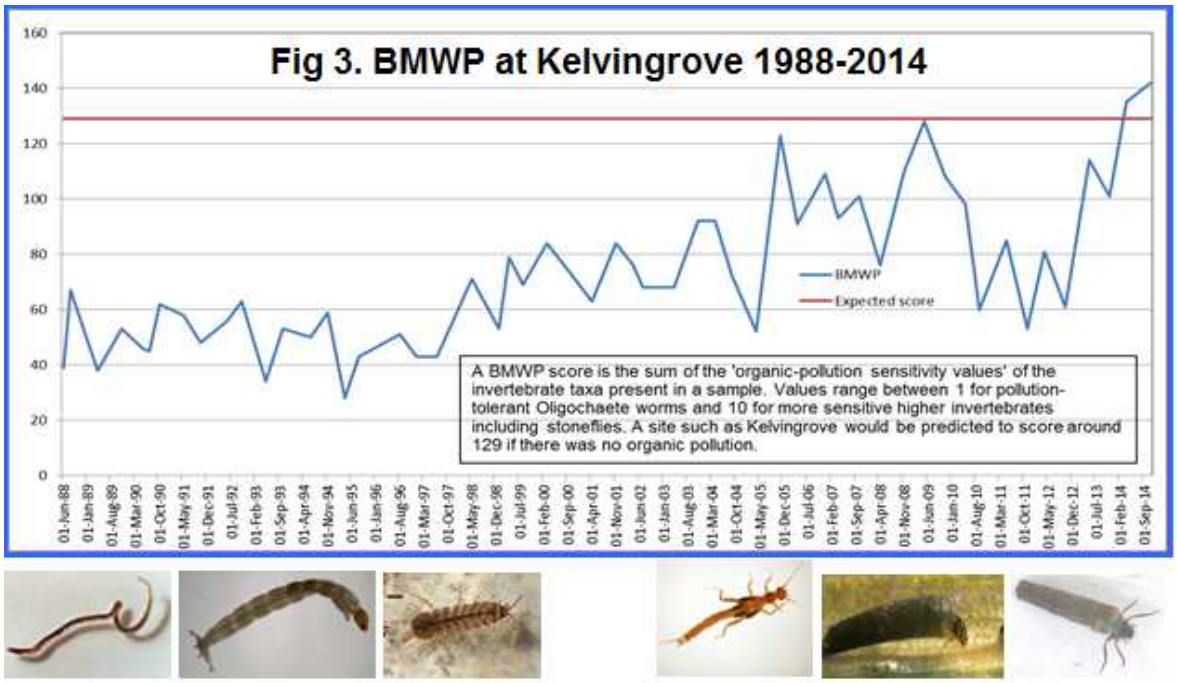

Fig 3. BMWP at Kelvingrove 1988-2014

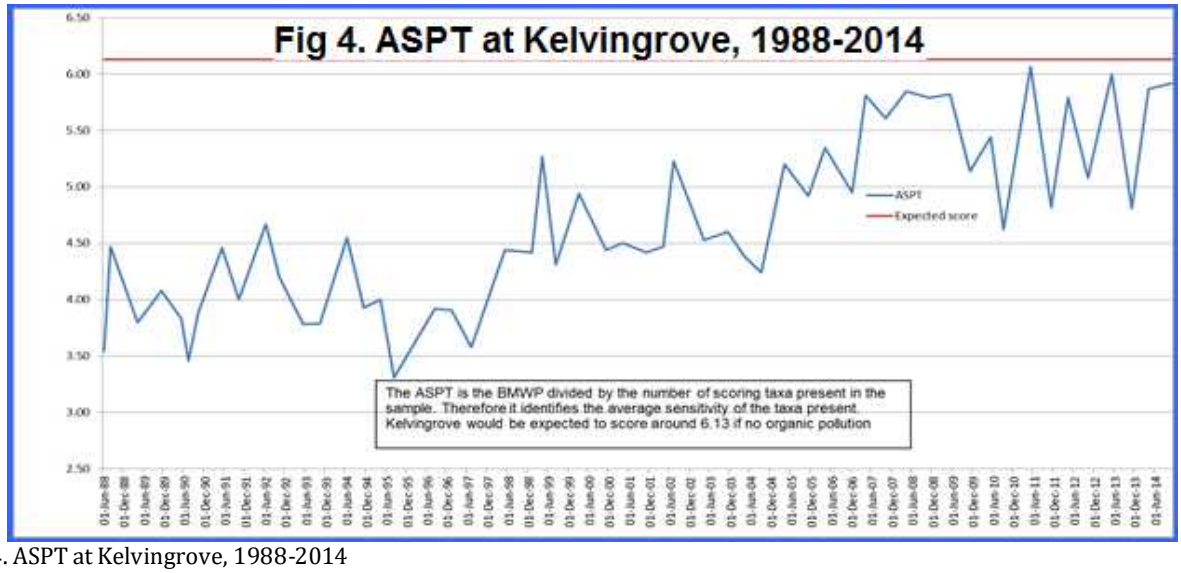

Fig 4. ASPT at Kelvingrove, 1988-2014

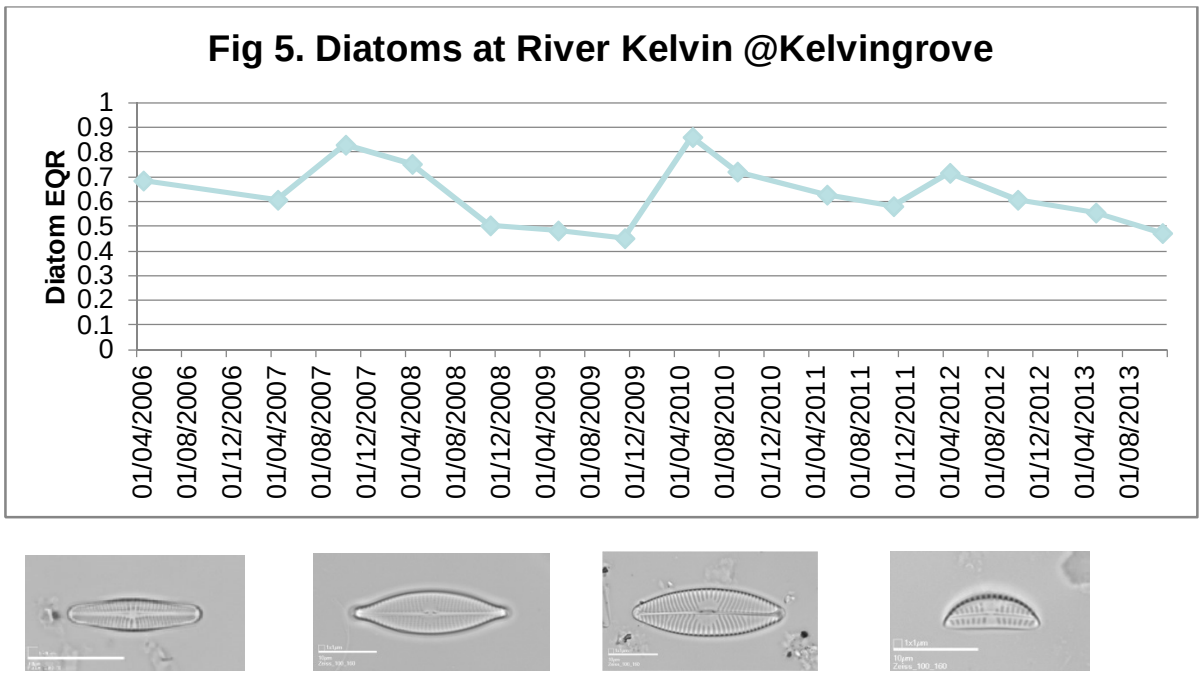

Fig 5. Diatom EQR data for the River Kelvin, 2006-2013.

*Macrophytes.*Macrophyte diversity and abundance were recorded at three sites along the length of the River Kelvin in 2009, with a River Macrophyte Nutrient Index (RMNI) assigned to each taxon, indicating sensitivity to nutrient enrichment. RMNI Scores range from 1 (highly sensitive) to 10 (highly tolerant). The species present indicate nutrient enriched conditions and Moderate status at Kelvingrove (Fig.6), but, overall Ecological status for WFD was Good for macrophytes, due to upstream sites on the River Kelvin scoring relatively better.

NB Kate Arnold wrote the invertebrates section; Alison McLeman the macrophytes, and Jan Krokowski the diatoms.

Dominant macrophytes species recorded during 2009 survey at Kelvingrove	RMNI
Cladophora glommerata	7.5
Phalaris arundinacea	7.52
Vaucheria sp(p)	8.41
Fontinalis antipyretica	5.4
Leptodictyon riparium	7.57
Myosotis scorpioides	6.83
Callitriche sp.	6.67
Mimulus guttatus	5.79
Sparganium erectum	8.34

Fig 6. RMNI scores from the River Kelvin at Kelvingrove