Urban Watercourses in Glasgow's East End

study to end flooding, improve environment & amenities

by

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It has long been recognised that there can be conflict between economic development and protection of the environment. Urban runoff can have a profound affect on the aquatic environment. Watercourses can be subject to extensive changes in hydrology, channel morphology and water quality. Glasgow's watercourses are typical of many others found in urban locations. As urbanisation occurred, watercourses were often regarded as safety hazards or seen as an inconvenience. Historically, they have been hidden behind fences or walls or routed in culverts or concrete channels, thus preventing public access. Where open channel sections are accessible, the watercourses are frequently used as a dumping ground.

Glasgow: River Clyde courtesy Hyder Consulting

In July 2002, a storm with an estimated 100 year return period, resulted in widespread flooding in the East End of Glasgow. The entire expected rainfall for the month fell in just ten hours. Approximately 1500 residents living in 500 homes were affected, many of which were located in some of the poorest areas in Scotland. Cars were even completely submerged in some of the worst affected areas. It was estimated that 80% of the flood victims were on benefits and most did not have insurance.

This event triggered political interest and led to some lively debate between Scottish Water (SW) and Glasgow City Council (GCC) as to the cause of flooding in some locations. It became clear that there was significant hydraulic interaction between sewers and water courses both via combined sewer overflows and overland flow. It also became clear that a joint approach would be required to identify the right technical solution.

Development of a strategic plan

Responsibilities for stormwater management in Scotland are divided between numerous parties. Since the 2002 flooding event, it was recognised that a joint strategy was required to address the drainage problems in Glasgow. An integrated approach to master planning was required to address the needs of all stakeholders. Scottish Water (SW) appointed *Hyder Consulting Ltd (HCL)* to undertake the role of Lead Consultant for the Glasgow Strategic Drainage Plan. To guide and promote the plan, a Steering Group was formed comprising SW, Scottish Environment Protection Agency (SEPA), GCC, and Scottish Enterprise (SE).

The Plan area was defined as the Waste Water Treatment Works (WWTW) catchments of Daldowie, Dalmarnock, Dalmuir and Shieldhall (combined population 1.1 million). The four WWTW catchments cover six local authority areas: Glasgow City, East Renfrewshire, East Dunbartonshire, North Lanarkshire, West Dunbartonshire and South Lanarkshire. Main focus for Stage 1 of the study has been the East End of Glasgow (Dalmarnock WWTW catchment) where drainage problems and development constraints are particularly concentrated. However, the methodology developed for the East End will be applied on a wider basis, to areas of Glasgow which suffer from similar problems. Key objectives of the project are:

* **flood risk reduction:** the flood risk from both sewers and watercourses is unacceptable in many areas;

* **removal of development constraints:** lack of capacity and other deficiencies with the drainage infrastructure is now hampering regeneration efforts and much needed economic development;

* **water quality improvements:** many of Glasgow's urban watercourses have been heavily modified over the years with culverts replacing open channels. Whilst performance of the sewerage system is dependent on the safe operation of numerous CSOs discharging surplus stormwater to watercourses, existing water quality is unacceptable and needs to be improved to meet increasingly stringent legislative requirements;

* **habitat improvement:** urban regeneration should provide opportunities for improving the environment and open watercourses should be considered in this regard;

* i**ntegrated investment planning:** the likely level of investment required to address development constraints, flooding and water quality needs to be understood.

Urban watercourse problems

As with many areas in the UK today, the infrastructure put in place by our predecessors is now under strain. Progressive urbanisation has put immense pressure on Glasgow's drainage infrastructure, primarily due to the associated increase in impermeable cover since the drainage system was first built.

* **water quality:** water quality is generally poor, mainly class C or D in Glasgow's East End. This degradation can mainly be attributed to CSOs, cross-connections, and untreated urban run-offs. Baseflows are low because the combined sewer system intercepts the majority of surface water;

* **water quantity:** the East End has been subject to flooding for many years, with records going back to the 1940s;

* **physical structure:** culverting of watercourses has been a common practice associated with urban development. Burying streams was historically thought of as an acceptable means of gaining development land. Some of the watercourses in the East End are culverted for up to 90% of their length. These man made structures affect the flow characteristics of the watercourse, increasing the velocity of flow and reducing the opportunity for attenuation. A great deal of maintenance is also required to minimise flood risk due to debris and siltation.

Previous attempts to analyse the East End watercourses in isolation using a conventional river approach had proved unsatisfactory. It was considered more appropriate to use sewer modelling techniques and to analyse both sewer and watercourse systems together. A simplified (macro) model was constructed using infoworks CS, partly from existing verified models and partly from asset data collected from SW and GCC. The model includes 1800 nodes, 40 CSOs and 4 pumping stations.

The macro model allows the level of interaction between the sewers and watercourses to be quantified for the first time. Many of the trunk sewers run parallel to and have a greater capacity than, the culverted watercourses. In some locations, watercourse flows have been diverted into the trunk sewer. In others, CSOs spill large volumes from the sewer system. Assessment of a five year return period storm for the Molendinar Burn show that over 60% of the flow at the Burn's outlet to the River Clyde had entered via CSOs.

Improvement options

Simulations carried out using the macro model have been used to assess deficiencies in the network. This allowed outline remedial measures to be identified to deal with water quantity and water quality deficiencies. The strategic planning process is also identifying opportunities for adopting a more sustainable approach to drainage, rather than using only traditional hard engineering solutions.

Watercourse solutions

Typical urban watercourses are often of little value to both people and nature, as is the case in many parts of Glasgow. Soft engineering practices and greater consideration to how watercourses are managed has provided a chance to restore the downgraded stretches of burns and rivers which run through the city.

The study has identified opportunities to address capacity problems in the watercourses. The use of on-line and off-line attenuation ponds has been considered along with daylighting of buried water courses. These measures provide the additional benefit of providing amenity and habitat improvements and can increase the value of adjacent properties and brownfield sites.

A total of 23 areas have been identified where attenuation ponds could be potentially sited, as well as 30 sections of watercourses for de-culverting. According to Glasgow's City Plan, the greenspace network accounts for over 20% of the city's total area, providing significant scope for remedial measures to be introduced. It is important to recognise that these on-line and off-line ponds are not SUDS and would only be used to attenuate flows in watercourses. These facilities would not be used to attenuate or treat urban runoff directly, but they are a component in the overall stormwater master plan.

Stormwater management solutions

Sustainable stormwater management techniques have been used worldwide to control and manage the quantity and quality of urban runoff. Sustainable Urban Drainage Systems (SUDS) involve a rethinking of stormwater management, moving away from traditional piped surface water drainage systems, to softer engineering solutions that are closer to natural drainage regimes and help promote wider environmental objectives. Although SUDS are not flood prevention measures, they have a valuable role to play in reducing the rate of runoff and controlling pollutants from urban developments. Introducing SUDS can achieve multiple outcomes: effective stormwater drainage, water quality improvements in runoff, aquatic habitat creation and protection, stormwater recycling and amenity value.

The East End of Glasgow has significant areas of green space and brownfield sites which could be used to accommodate SUDS. The following explains the methodology behind the hierarchical approach to selection of potential SUDS sites:

* separately sewered areas (in relatively new developments) were assessed to generate an understanding of whether they discharge into the combined sewer network or to watercourses;
* large properties were identified and categorised into: Institutional, Commercial and Industrial (based upon a decision framework developed by Stovin and Swan). This allowed identification of properties where SUDS retrofitting was potentially feasible;

* motorway drainage produced significant amounts of runoff, which discharged into combined sewers and watercourses. An assessment of various asset databases identified the destination of this runoff;

The total contributing area of each of these categories were calculated. Analysis was then carried out using the macro model, to assess the hydraulic impact of removing these contributing areas. Hydraulic modelling has indicated that whilst individually they might provide little benefit, by grouping potential sites the cumulative effect could lead to a considerable reduction in spills and flood volumes.

Habitat enhancement

The introduction of SUDS, daylighting of watercourses and the creation of on-line ponds for attenuating flows in streams and rivers, will all provide the opportunity to create new wildlife habitats. The East End of Glasgow has significant areas of green space and brownfield sites, both of which could be utilised.

Consideration was given to the scope for implementing ecological principles into the design and management of SUDS and other soft engineering structures. It was recognised that these schemes are part of a wider environment and as such should be integrated with existing semi-natural habitats, as well as with the needs of development. Above ground waterbodies can be designed to maximise their wildlife value by providing: irregular profile and shapes, providing shallow pools, avoiding planting of exotic species, creating islands, encouraging shaded areas.

The soft engineering approach allows water to be used as a feature rather than being conveyed as quickly as possible in below ground structures. Ponds and wetlands can be assets to the community, as they can enhance the quality of life by providing attractive and tranquil green space in the midst of an urban environment. SUDS such as swales can also be used to provide recreational linkages (such as maintained paths and trails) and wildlife corridors between systems or between other waterbodies.

Conclusions

The Glasgow Strategic Drainage Plan represents an innovative planning approach to dealing with the complexity of issues surrounding the management of urban drainage. The multi-agency approach has allowed all parties to work together to find the best solutions. Ultimately, this benefits both the agencies involved, the environment and the people affected by drainage related problems.

The physical interaction between sewers and watercourses in the East End of Glasgow required an integrated analysis of both systems. The macro model has allowed the full extent of the interaction to be quantified for the first time In addition, a much better understanding of the true causes of flooding has been achieved.

The Strategic planning approach has also permitted a good appreciation to be gained of the potential for using softer engineering techniques to address the identified deficiencies. Knowledge of areas with potential for SUDS retrofit of watercourse deculverting/attenuation broadens the range of possibilities when integrated improvement options are being developed.

Whilst the habitat and amenity advantages of these options are understood, integrated modelling has allowed the full hydraulic benefits to be properly measured. ■

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