The Forres (Burn of Mosset) Flood Alleviation Scheme has been nominated for a Saltire Award as it demonstrates a very close working relationship between the Client, Designer and Contractor to deliver a quality project which hugely benefits the whole of the local community. The project has been delivered by the Moray Flood Alleviation (MFA), which is an integrated team comprising The Moray Council, Royal Haskoning, Morrison Construction and EC Harris, and it has been delivered under budget and 8 weeks early, which is as a result of the close relationship between the MFA team as it resulted in the design being tailored to meet build-ability.

The MFA team have previously worked together on the Lhanbryde Flood Alleviation project, and it is currently in the process of delivering another flood scheme in Rothes. There are a further two projects planned for construction in the future, which again will be delivered by the MFA team.

The project was officially opened in August 2009 by Richard Lochhead MSP.

The parties nominated for the award are as follows:

Client       The Moray Council
Designer     Royal Haskoning
Contractor  Morrison Construction
Cost Consultant  EC Harris

The following provides more details regarding the project:

**DESIGN**

**Excellence in Concept**

Flood storage at Chapelton was selected as the primary component of the flood alleviation scheme after a thorough evaluation of alternatives. The chosen solution makes excellent use of the natural topography; a natural bowl situated just upstream of Forres with a narrow outlet valley. This allows a large storage capacity to be delivered using a relatively small dam. The location is also good because it provides a high degree of control over all major inflows upstream of Forres.

**Originality of Design**

There are two aspects of the design that stand out as original:

- **Baffled Crump Weir.** A Baffled Crump Weir is the primary mechanism for controlled discharge from Chapelton Dam. It is the first to be constructed in the UK and has a maximum discharge of 8.5m$^3$/s. The structure provides a more constant discharge over a range of hydraulic heads when compared to a conventional fixed orifice. Therefore, in the context of a flood storage reservoir, it makes more efficient use of the available storage volume. There are no moving parts and it permits passage of fish during low flows. A physical model was used to confirm the hydraulic performance. The attached sketch illustrates the baffled crump weir concept (please refer to the Section 4 of the Supplementary Information pack – sketch titled “Chapelton Dam Baffled Crump Weir”).

- **Chapelton Dam Spillway.** The overtopping spillway will only function when the flood storage reservoir is full, which will be less than once every 100 years. Nonetheless, it is designed to withstand the severe hydraulic forces that will occur during these extreme “reservoir safety” events. The design team balanced the technical requirements with constructability and aesthetics and developed an original design comprising Open Stone Asphalt on the upper portion of the spillway slope and a voided concrete slab on the lower portion, where the
velocities and turbulence will be greater. Both designs provide a robust solution, whilst allowing the surface to be grassed.

Open Stone Asphalt has been used as wave protection on dams previously, but this is probably the first use on a large spillway. The solution has many benefits, including: robustness, flexibility to accommodate settlement of the underlying earth fill and it is easily placed to complex shapes (a weakness of other concrete block type solutions).

The attached sketch illustrates the voided concrete slab and open stone asphalt solutions (please refer to the Section 4 of the Supplementary Information pack – sketch titled “Chapelton Dam Spillway”).

Suitability for Purpose & Performance

The scheme was officially opened on 28 August 2009. One week later, 93mm of rain was recorded over a thirty-hour period in the Burn of Mosset’s catchment. The scheme successfully operated and prevented the flooding of hundreds of properties; to the obvious relief of residents. The economic flood damages without the scheme would have been approximately £9million.

Aesthetic and Environmental Harmony

Chapelton Dam is located in a rural setting upstream of Forres. The area has no formal environmental designations, but it is nonetheless alive with wildlife. It is also adjacent to Sanquhar Woods, a popular recreational area. The sites within Forres are also in visually sensitive areas, which the local community proudly uses for “Britain in Bloom” style competitions. The following examples illustrate how the engineering works were integrated into the landscape to provide aesthetic and environmental harmony:

- Chapelton Dam is comparable to an iceberg: the majority of the engineering is hidden below ground. The engineering, including the spillway (see “originality of design”) and stilling basin, is covered in topsoil and grassed. At first glance the stilling basin appears to be a large grassy bowl. However, beneath this surface lie two layers of large rock armour.
- Chapelton Dam has a curved alignment to maximise the spillway length in the space available and provide pleasing aesthetics. A long spillway is required to accommodate the extreme flood events. The valley is relatively narrow at the dam site and therefore the spillway is actually partially cut into the hillside.
- The concrete retaining walls are clad with stone. In the most visually critical areas, such as the flood defence wall through Mosset Park, the cladding is locally sourced sandstone, but in other areas reconstituted stone has been used.
- The existing flood defences along the Burn of Mosset within the flood storage reservoir were locally breached such that a proportion of the flow was diverted into the adjacent floodplain. These works will manage the transition from a perched channel confined by man-made defences towards a more natural arrangement. The resulting wet woodland habitat and floodplain will have benefits for both sediment management and wildlife. It will also be almost maintenance free.

The works put in place are only the first step in the process. The geomorphological and ecological development of the area will be mainly driven by occasional high-flow events. The high-flow event on 4 Sept 2009 initiated some changes that have exceeded the team’s expectations.

A representative from Scottish Natural Heritage recently commented “…I was really impressed to see this area of work and just how well the water is spreading out across the area. The area provides a really good example of…measures that can be taken to try and reconnect our rivers with their floodplains…” (Scottish Natural Heritage, 13 November 2008).
Economy of Materials and Labour

The following are two examples of where the design has been developed to minimise materials and labour requirements, both on and off site:

- At an early stage it was decided that it would be beneficial to construct Chapelton Dam and other embankments from fill sourced on site. This delivered significant benefits, not least hugely reduced materials, labour and environmental impacts associated with transportation. The team worked hard to match the design to the materials available in the borrow area. The natural material was an un-homogeneous mix of sands and gravels, with occasional layers of silt. A balance was achieved between the design requirement for low-permeability fill and the construction requirement to minimise the amount of processing.

- Mass concrete with polypropylene macro fibres was used for various components where the structural stresses were minimal, such as the steps around the control structure and foundation block for the upstream coarse trash screen. This eliminated the time, cost and materials associated with conventional reinforced concrete solutions.

Community Benefit

Delivery of the scheme has obviously provided great benefit to the whole community. Prior to the scheme, almost 20% properties in Forres were at risk during a 1 in 100 year event. Without intervention, the economic damage over the next fifty years would exceed £43million; not to mention the social and human cost. The scheme provides a standard of defence of at least 1 in 100 years, including an allowance for climate change up to the 2080s.

The scheme also provides a benefit to the community for the 99% of the time when the flood defence function is not required. Careful design has integrated the engineering and aesthetic requirements and delivered a scheme that will be a valuable asset for the community at all times. This is exemplified by the steady stream of local residents that now walk through the area and positively comment on how nice it looks.

Overall Management of the Project

Moray Flood Alleviation is an integrated team comprising the Moray Council, Royal Haskoning, Morrison Construction and EC Harris. The team worked together to deliver the stated aim of delivering effective flood alleviation as soon as possible. The following are some examples of how working as an integrated team made a positive contribution towards this aim:

- Morrison Construction contributed to the development of the design and management of risk. One example that illustrates the benefits of this approach is the management of seepage through and under Chapelton Dam. The choice was high-specification (low-permeability) earth fill vs lower-specification (high-permeability) fill combined with an impermeable cut-off wall. The final solution utilised the lower-specification fill, but included a sheet pile cut-off. This provided a robust solution that met the team’s risk, technical, construction and financial criteria. It also allowed the finite amount of higher specification fill from the borrow area to be utilised elsewhere. As a result of this decision, the team also targeted the ground investigations to manage the pile drivability risk.

- The concept of the “Scheme Manager” was used throughout the project. The Scheme Manager’s role was to advise The Moray Council and co-ordinate the efforts of all parties to deliver the shared goal of delivery of effective flood alleviation as soon as possible. Royal Haskoning provided the Scheme Manager during the feasibility and design phases. The role was handed over to Morrison Construction during the construction phase.

- A vast amount of data and knowledge was accumulated over the nine years from beginning investigations to completion of the scheme. The long-term nature of the MFA integrated team meant that a number of key individuals have been involved in the project throughout its
duration and thus ensured that this knowledge was retained. It also helped to establish beneficial working relationships with local businesses and the town’s community, who have since given positive feedback regarding the project.

- The Forres (Burn of Mosset) FAS is one of five flood alleviation schemes being delivered by Moray Flood Alleviation. It benefited from:
  
  o Lessons learned from the first scheme to be completed (Lhanbryde), such as improved contract administration and reporting procedures.
  o Commonality of designs and specifications, such as re-use of performance specification principles for dam earthworks.

Health and Safety

Health and safety was an important consideration throughout the design process. “Hazards in Construction” and “Hazards in Operation” assessments were undertaken at key points in the design process. Because of the integrated team approach (see “overall management of the project”), these assessments benefited from input from the designer, contractor and the operator.

One of the key health and safety features is that the scheme is designed such that all areas are safely accessible by the public; there are no areas that are “off limits”. This was a deliberate decision, which recognised the fact that the area has always been used by the local community for recreation, that it would be impossible to exclude members of the public and that the finished scheme would be largely unsupervised.

Outstanding or Special Merit

Chapelton Dam is an outstanding example of how good design can integrate the aesthetics and environmental requirements with the engineering requirements. Chapelton Dam is a large raised reservoir as defined by the Reservoirs Act. As such there is a lot of heavy engineering in order to accommodate the associated extreme design conditions, including passing the 1 in 10,000 flood event. Notwithstanding this, the overall appearance of Chapelton Dam is of an elegantly curved dam surrounded by large grassy areas.

CONSTRUCTION

The construction of the Forres Burn of Mosset flood alleviation scheme has been a magnificent example of delivering a scheme that has produced an asset for the community. The Moray Flood Alleviation Team has designed and constructed a scheme that has integrated engineering and aesthetic requirements that will be a valuable asset for the community at all times. The majority of the engineering in the dam and stilling basin hidden below ground, making the dam and stilling basin aesthetically pleasing. In addition, the local community can utilise the area for leisure activities.

Ingenuity

Many aspects of the construction had created concern prior to commencement of the works, not least the problems associated with the constraints relating to the period June to October when no work in The Burn of Mosset could be done due to fish spawning. It was not possible to construct the Chapleton Dam control structure and crump weir within a season which effectively meant that the programme time for the construction straddled two seasons. It was also a requirement to re-divert the existing burn through the control structure on completion. Various options were considered to mitigate this problem and the team decided that the most advantageous option was to squeeze a temporary sheet piled wall between the existing Mannachie Burn and the corner of the proposed control structure. This system relied on achieving a reasonable seal of the pile clutches and
control of water ingress by pumping. The installation of 50 No VL605 sheet piles went successfully and subsequent pumping ensured that the control structure commenced four months earlier than planned. Several burn diversions were implemented during the construction of Chapleton Dam. The diversion channels were lined with material that was unsuitable as spawning grounds, which also mitigated programme constraints.

**Enterprise**

Another concern was the presence of the existing water table. To enable stable conditions for excavation and forming a reasonable platform for the 80t bored piling rig, we installed a dewatering system in the form of well points. Further concerns related to the earthwork fills required for Chapleton Dam and associated flood embankments throughout other areas of the scheme. Analysis of the testing available from Ground Investigations at the site revealed that only 36% and 77% of samples from the borrow pit and stilling basin excavations respectively complied with the grading and uniformity specifications for Type 4 and 5 fill materials. In carrying out the works, by selection and mixing, Morrison Construction were able to influence the grading and uniformity of the soils to meet the specification. This method also achieved the angle of shearing resistance and the permeability required by the specification. All fill material was won from the borrow pit located on site and no material was imported.

**Economy of Construction**

The project has been undertaken with the focus on final cost and budget. The approach taken by the team encouraged up front reporting and innovation. The early contractor involvement (ECI) contributed to the development of the design and management of the risks. One of the successes was the selection of sheet piles, as opposed to grouting or other alternatives, as means of controlling seepage under and through the Chapleton Dam. The ground investigation was also adapted to target the management of pile drivability risks. The drivability risks were further reduced by developing a number of alternative plans, which would be implemented if the piles refused above the required penetration depth. The team approach also allowed the contractor to contribute to the development of the design and management of the risk with regard to the choice of high-specification (low-permeability) earth fill vs. lower specification (high permeability) fill combined with an impermeable cut-off wall. The final solution utilised the lower-specification fill, but included a sheet pile cut-off. This provided a robust solution that met the team’s risk, technical, construction and commercial criteria. It also allowed the finite amount of higher specification fill from the borrow area to be utilised elsewhere.

The spillway and stilling basin will only function when the flood storage reservoir is full, which will be less than once every 100 years. Nonetheless, it is designed to withstand the severe hydraulic forces that will occur during these extreme “reservoir safety” events. Conventional solutions, such as a large concrete basin were dismissed because of the adverse aesthetics and the potential issues relating to the build-up of water pressure underneath. The team balanced the technical requirements with constructability and aesthetics and developed a permeable voided concrete slab. This is a robust solution that allows dissipation of water pressures and enables the growth of grass.

As mentioned previously, it was decided at an early stage that it would be beneficial to construct Chapleton Dam and other embankments from fill sourced from within the site. The team worked hard to match the design and construction requirements. This delivered significant benefits, not least hugely reduced traffic impact and reduced the cost in comparison to importing the fill.
Another example of savings to the project is that the fill for Chapleton Dam and other embankments was produced by screening material excavated from the borrow area. Material in the excess of 75mm was initially set aside. A crusher was brought to site which enabled the waste material to be processed into a Type 1 sub base material, suitable for the permanent road construction around the site.

In addition, approximately 10,000 tonnes of heavy rock armour was used within Chapleton Dam stilling basin. This supply was sourced from an existing quarry less than 1km from the site which resulted in minimised transport costs and significantly reduced traffic impacts.

The effects and result of the hard work put in by the team resulted in the project being completed two months ahead of schedule and within budget.

**Physical Achievement**

Mr Peter Haslam, Project Sponsor of The Moray Council quoted:

“I challenged the team to deliver flood alleviation and complement the environment. My measure of success was that the Scheme should be “invisible” and prevent flooding. Not only was the challenge met, but the Scheme was delivered ahead of programme and under budget. In addition, damages of 40% of the total cost were avoided in September 2009. The team excelled and the outcome is very pleasing.”

The scheme was officially opened on 28 August 2009 and one week later on 4 September 2009 it successfully prevented flooding of hundreds of properties to the obvious relief of the residents of Forres. Bob Hellyer (Vice Chairman Forres Community Council) said “praise where praise is due….there is no doubt in my mind that had it not done its job we would have seen a different story” (Forres Gazette, 9 September 2009)

**Skill of Execution and Management**

In order to deliver the design and construction of the Forres Burn of Mosset Flood Alleviation Scheme, an outstanding team of professionals and skilled operatives were assembled.

**Quality of Construction**

The delivery of the final product has been efficient and to the quality demanded by the team. The Client is delighted with respect to the completed project and all are satisfied that the quality delivered in the project will protect the residents of Forres from flooding for many years to come. In addition, Chapleton Dam has become an attraction to the public as an area for recreation and walking.

**Performance**

The construction period for the project was 103 weeks. To achieve completion 8 weeks early demonstrates that all of the foregoing actions contributed to this excellent performance. Close liaison with the design team resulted in the design being tailored to meet build-ability. The project had to be planned around the constraints arising from fish, birds, badgers, bats and otters. Close working relationships and early involvement of SEPA, SNH and Historic Scotland addressed this problem and benefited the overall progress on site.

**Health, Safety and Environment**

Considerate Constructors awarded a Performance Beyond Compliance certificate for the project. This was awarded on the basis that the site scored at least four points in the eight sections, Considerate, Environment, Cleanliness, Good Neighbour, Respect, Safe, Responsible and Accountable. The score achieved was 36 out a possible 40. Only 5% of construction sites manage to obtain such a good result.
Outstanding or Special Merit

This project demanded a high level of management to deal with the many work fronts not only at Chapleton Dam but also other areas throughout Forres and Rafford. This could only be achieved by a very close relationship with the residents and businesses of Forres. It was paramount that all stakeholders were consulted and inconvenience reduced to a minimum.