

## Computational Fluid Dynamics Modelling for Dams

### Identifying the need

Hydraulic modelling and analysis are critical components in the design or assessment of any dam project. Aspects of design where modelling provides important inputs include:

- Analysis of spillway arrangements to assess flow behaviour
- Design optimisation
- Derivation of static and dynamic loading as an input to structural design
- Assessment of flow conditions in and around fishways to optimise their effectiveness
- Assessment of potential for erosion around hydraulic structures.

Of particular importance is the ability to rapidly provide results to allow the early consideration and optimisation of alternatives. Modelling of structures using Computational Fluid Dynamics (CFD) techniques provides this capability and its use has gained broad acceptance in the dams industry over recent years as an important design tool for hydraulic structures.

### Solutions

GHD have developed extensive in-house capabilities and experience in the modelling of structures using CFD techniques. A particular focus of this experience has been in the analysis of hydraulic conditions in relation to dams and other hydraulic structures and the assessment of the fluid-structure interaction.

This in-house capability and experience includes the use of a range of CFD modelling packages such as STAR CCM+, ANSYS CFX, FLUENT and OpenFOAM. Modelling using

these software packages has been effectively used in the design of spillways, outlet works, fishways and other dam-related structures. The use of CFD techniques allows for model arrangements to be generated quickly and is particularly beneficial in the assessment of design alternatives and optimisation.

### Benefits

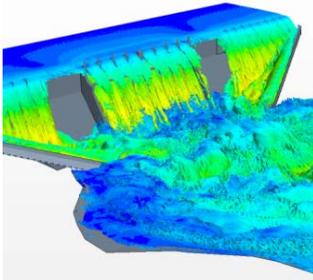
CFD modelling is particularly beneficial in the earlier stages of analysis and design where the construction of physical models would be prohibitive on the basis of cost and time. Current CFD techniques allow for the rapid creation of models and evaluation of the hydraulic behaviour for new or existing structures. When coupled with the ability to quickly test an array of potential scenarios, this enables the incorporation of innovative design solutions that may otherwise not have been considered during the design selection process prior to the advent of CFD capabilities.

Our extensive experience and in-house capabilities in CFD modelling is backed by one of the largest dedicated dams engineering teams across the globe.

### Experience

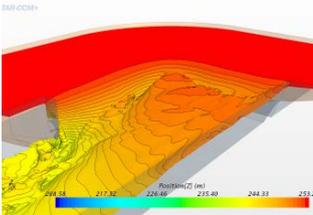
GHD has extensive experience in projects involving hydraulic modelling and analysis using CFD techniques. GHD applies its client relationship focus and in-depth dams engineering experience, working closely with client representatives to address key concerns, constraints and issues. Once identified and analysed, sound engineering options are developed to provide tailored solutions to suit the project at hand.

Some recent projects that GHD has delivered for our clients and which detail our experience and capabilities in this field are described below.



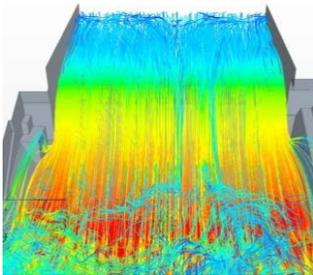
### Somerset Dam – Flood Upgrade Feasibility Study, Queensland, Australia

The project included the three-dimensional modelling of a 50 m high concrete gravity dam with a gated overflow spillway, including overtopping of the spillway bridge and gates, and complex abutment flow conditions. Key aspects analysed included: discharge efficiency of the total spillway; hydraulic loading on the gates, gate operating equipment and bridge structure; jet impingement on the rock abutments; loads on sluices; and behaviour of the stilling basin. The results from the modelling were used as inputs for the structural assessment of the dam, spillway gates, and other associated structures; assessment of potential abutment erosion; and assessment of the capacity and structural adequacy of the existing sluice valves.



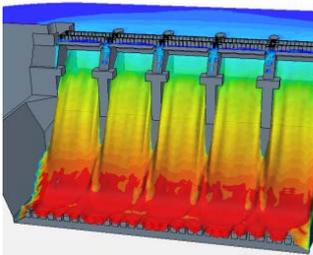
### Kangaroo Creek Dam Upgrade, South Australia, Australia

A 3D CFD model of a complex side-channel spillway arrangement was developed to inform the detailed design process of the upgrade of the dam and spillway. Options to increase the flood discharge capacity of the spillway were assessed. Options investigated included a variety of crest extension options, chute geometries, and flow streamlining options. The results from the CFD modelling were used as inputs to the detailed design prior to undertaking a scale physical model study for validation of the design.



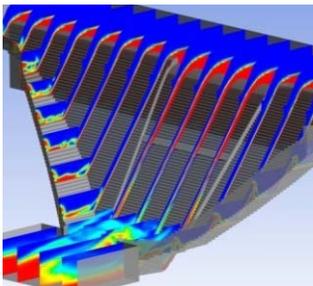
### Awoonga Dam – Review of Spillway Hydraulic Performance, Queensland, Australia

Awoonga Dam experienced the flood of record in January 2013 as a result of ex-Tropical Cyclone Oswald, which peaked at about 8.3 m over the spillway. The spillway performed well but suffered damage to sections of the concrete, possibly due to cavitation, and erosion in the downstream unlined channel. GHD was engaged to undertake an assessment of the hydraulic performance of the 35 m high ungated concrete gravity spillway structure and downstream channel. This assessment included 2D and 3D CFD modelling of the spillway, engineering geological assessment of the spillway, assessment of energy dissipation, comparison with past performance and prediction of future performance in extreme flood events.



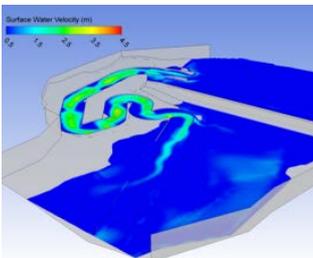
### North Pine Dam – Spillway Gate Superstructure Review, Queensland, Australia

The modelling was undertaken as part of a structural assessment and review of potential upgrade options for the spillway gate superstructure at North Pine Dam. This included three-dimensional simulations of the complete spillway and superstructure, which features a spillway bridge and five radial gates at various stages of rotation. The objective of the CFD modelling was to quantify the effects of static and dynamic loading from extreme spillway discharges on the structure and gates, including assessment under complex flow conditions and overtopping scenarios. The results of the CFD modelling fed into the structural assessment, upgrade options assessment, concept design of the preferred option and cost estimates.



### Design of the Enlarged Cotter Dam – Canberra, Australia

GHD was the design partner for the Bulk Water Alliance which delivered the Enlarged Cotter Dam, an 85 m high roller-compacted concrete structure. As part of the design optimisation process, GHD undertook 2D and 3D CFD modelling of the complex stepped spillway arrangement. The modelling was invaluable in optimising the design of the non-standard stilling basin and assessing the interaction of flow from the central primary spillway and the secondary spillways over each abutment prior to commencing a physical model study. GHD was also responsible for technical direction and project management of the 1:45 scale physical model of the spillway that was used for design verification and final optimisation.



### Burrum River No 1 Weir Fishway – Hervey Bay, Queensland

2D and 3D CFD modelling was undertaken by GHD to model complex hydraulic conditions for the design of the Burrum River No 1 Weir Fishway. The design incorporated both a high flow and low flow channel to facilitate two very different hydrological conditions: one being low flows in the dry season limited to environmental releases from the weir and high flows during spill events and floods. The velocity profiles and turbulent conditions were modelled as well as water levels through the fishway. The modelling was critical to ensuring that the design met both biological and engineering design criteria.

To touch base with the key person in your region, visit [www.ghd.com/dams](http://www.ghd.com/dams)

