Environmental issues and management for hydropower peaking operations

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Hydropower peaking operations

- Hydropeaking is when a station turns on and off several times per day to meet peak demand.
- Peaking operations can give rise to a range of environmental impacts which require careful assessment and management.

Middle Gordon River, Tasmania, Australia

- Many examples shown here are from the Gordon power scheme in Australia, where a major investigation of peaking impacts has been undertaken in the downstream river system.

Hydrological assessment

- For a peaking station, a typical hydrograph shows twice-daily fluctuations from off to full capacity discharges, with some variability as the station is drawn upon to follow the load demands.

Water quality – stratified lakes

- Downstream effects on water quality depend on the storage configuration and off-take depth.
- If the storage is deep and stratifies and the off-take is low, the power station can inject unseasonally cold water into the receiving environment
- With peaking discharges, the downstream river may experience frequent temperature and dissolved oxygen fluctuations.

Measures to address water quality impacts

- Storage geometry can minimise or avoid stratification.
- Siting upstream of a significant tributary can ensure mixing of power station discharges with water of ambient temperatures.
- Multi-level or high off-take structure, or reservoir level management, can ensure release of oxygenated and ambient temperature water.
- Air injection in the turbines can ensure sufficient oxygenation of water releases.
- Re-regulation storage can allow water temperature to reach ambient before release downstream.

Riparian Vegetation

- Downstream impacts with any hydro operations arise due to waterlogging, inundation and reduced light penetration.
- With peaking operations these risks are reduced because the riparian zone is drained and exposed to sunlight daily.
- There can still be limited regeneration and recruitment, because seedlings can not establish on the banks where water levels rise rapidly several times per day.
- Bank stability is a key influence on riparian vegetation.

Measures to address riparian vegetation impacts

- Reduced summer discharge allows riparian plants to grow and reproduce, and recruitment to occur during the season of greatest metabolic activity.
- 24-48 hour weekly shutdowns reduce stress of waterlogging and inundation.
- Facilitate regeneration through direct-seeding of the river banks with local species.
- Implement measures to improve physical stability of the riverbanks.

Fluvial geomorphology

- With peaking operations, impacts on channel form are due to the rate and frequency of water level rise, the time at maximum water level, and the rate and frequency of water level drop.
- A rapid increase in water level causes scour.
- If river banks are highly saturated, rapid drawdowns result in high pore water pressures as the water drains out of the banks.
- With peaking operations drawdowns are frequent, but the pore water pressure can be low because the banks will not be as saturated.

Measures to address geomorphology impacts

- Ramp-up and/or ramp-down rules slow water level rise and fall.
- Restricting magnitude and/or duration of maximum discharges reduces bank saturation.
- Minimum environmental flow reduces drainage slope and so pore water pressure out of bank, and lessens scour of the bank toes.
- Physically buttressing riverbanks.
- Measures that retain riparian vegetation.

Macroinvertebrates

- Power station discharges can reduce species diversity and abundance of aquatic insects and microcrustaceans.
- Low flows with the power station off can result in limited available habitat; high flows with the power station on can result in higher depths and current velocities than optimal for some species.
- With peaking operations, frequent water level as well as temperature changes cause high stresses on the instream biota.

Measures to reduce macroinvertebrate impacts

- A minimum flow ensures that a proportion of the channel is permanently inundated so that the channel maintains a constant macroinvertebrate community when the power station is off.
- A ramp-up rule reduces shear stresses on the bed by reducing water surface slopes on the rising limb of the hydrograph.
- A ramp-down rule reduces incidences of stranding by slowing the water level decline.

Fish and migratory aquatic species

- Baseload discharge patterns can reduce fish populations in the downstream environment due to:
  - reduced macroinvertebrate food supplies;
  - loss of snag habitat on the channel margins; and
  - impacts on spawning and migration cues due to changes in the seasonality of flows (and in cases temperature).
- The migratory needs of aquatic species are very individual to particular species, river systems, hydrological and climatic conditions.

Distribution of fish communities

- This picture shows increases in the diversity of fish species moving downstream from the Gordon Power Station.
- The red lines mark significant gorges – these present obstacles to fish migration under baseload discharge patterns due to sustained high flow releases.
- Peaking operations provide more frequent opportunities for migration through such barriers, because low velocity opportunities are presented right through the migratory season.

Obstacles to upstream fish migration

This slide shows Abel Gorge on the Gordon River downstream of the Gordon Power Station.

Measures to reduce impacts to migratory aquatic species

- Partial or stepped ramp-down provide cues to the fish of dropping flows hence reducing the potential for fish stranding.
- A minimum environmental flow indirectly benefits fish that need macroinvertebrates for food supply.
- Restocking with native species.

Summary of hydropeaking management measures

- Water management options – include minimum environmental flows, power station ramping rules, and controlling durations of full gate discharges.
- Localised ‘treatment’ options – include bank protection works, bank revegetation works, fencing/stock exclusion, fish re-stocking.
- Major capital works – include re-regulation storage, flow diversion works.

Influence of a minimum environmental flow

- There is a significant increase in the amount of habitat available with a minimum environmental flow.
- The aim is to determine the minimum flow that optimises habitat availability, current velocities and depths for species present, and economic viability of the power scheme.

Assessing minimum flow requirements

- Flow objectives and downstream values need to be made clear at the start, as trade-offs will be required.
- Different species have different flow and habitat preferences.
- The optimal flow, depth and substrate need to be assessed for each species.

Assessing ramping rules

- Groundwater profiling and modelling of saturation and drainage rates in the riverbanks can be used to develop ramping rules to minimise bank erosion.

- In the Gordon River, the power station must ramp down from its maximum discharge of 250 m^3/s at a rate of 30 m^3/s per hour, until it reaches 150 m^3/s. It must stay at 150 m^3/s for at least one hour before shutting down.

Construction of a re-regulation storage

This picture shows the Poatina Power Scheme in Tasmania, where a re-regulation storage is being contructed to receive the tailrace discharges.

Re-regulation storage – dampening flow changes

This re-regulation storage will dampen 60% of the flow variability due to peaking discharges.

Conclusion

- A number of environmental issues can arise downstream of a hydropeaking station.
- Good understanding of the downstream hydrology and ecosystem processes is essential.
- A range of mitigation and management measures can be drawn upon to address environmental issues due to hydropeaking.