# Dams and Geology

*(An excerpt from **Silenced Rivers: The Ecology and Politics of Large Dams**, by Patrick McCully)*

## The Morphological Effects of Dams

All rivers carry sediments eroded from the soils and rocks over which the river, and the water flowing into it, pass. All dams and reservoirs trap some of this sediment, especially the heavy gravels and cobbles, and thus starve the river downstream of its normal sediment load. Large reservoirs and dams without low level outlets will typically trap more than 90 per cent, and sometimes almost 100 per cent, of incoming sediment. Clear water below a dam is said to be 'hungry': it will seek to recapture its sediment load by eroding the bed and banks of the river. The sediment picked up by the hungry river may be deposited further downstream, and erosion (degradation) of the riverbed below the dam will then replaced by its raising (aggradation) further downstream.

Over time all the easily erodible material on the riverbed below the dam will eventually be removed, and the bed will become 'armoured' with rocks. An armoured riverbed below a dam does not have the gravels needed for spawning of fish such as salmon and as habitat for benthic (river-bottom) invertebrae such as insects, molluscs and crustaceans. These benthic creatures are an important food source for fish and waterfowl. Meanwhile aggradation of the channel may also reduce the area of gravels by smothering them in silt.

Riverbeds are typically eroded by several metres within a decade of first closing a dam. Within nine years of the closure of Hoover Dam, hungry water had washed away more than 110 million cubic metres of material from the first 145 kilometres of riverbed below the dam, lowering it in places by more than four metres. The deepening of the Colorado has undermined bridge foundations and rendered useless numerous intakes for the supply of municipal and irrigation water. Riverbed deepening will also lower the groundwater table along a river, causing a drop in the level of water in wells on the floodplain and threatening to dry out local vegetation. The related erosion of riverbanks — the banks of the Colorado below Hoover have in places been scoured back as much as 15 metres in a year — can undermine riverside property and structures such as road embankments and flood control levees.

In the long run, the major impact on the downstream river channel will often be to make it deeper and narrower, turning wide braided, meandering rivers with gravel bars and beaches and multiple channels into relatively straight single channels. The regulation by dams of the Platte River in Nebraska, for example, has shrunk one stretch of its channel by three-quarters, from a width of one kilometre late in the last century to just 265 metres in the 1960s. Reduced channel capacity is especially likely where undammed tributaries wash their sediments into a regulated river which no longer has the regular flood flows which would previously have dislodged them. Reducing a braided river to a single channel will greatly diminish the diversity of plants and animals it can support.

## Hungry Plains

*. . . especially in the part called the Delta, it seems to me that if . . . the Nile no longer floods it, then, for all time to come, the Egyptians will suffer.*

***Herodotus***
*History, c.442 B.C.*

Before the High Aswan Dam the Nile carried an average of some 124 million tonnes of sediment to the sea each year and deposited another 9.5 million tonnes or so on the narrow floodplain and delta which are home to almost all of Egypt's people. In ancient times the Nile's silt was regarded with awe: soil scientist Daniel J. Hillel writes that it 'was considered the prototype and mother lode of all material substances.' Today more than 98 per cent of the Nile's sediment drops to the bottom of the vast Nasser Reservoir. The loss of the silt -- which is low in nitrogen but rich in silica, aluminium, iron and other vital trace elements -- is believed by many to have had a serious effect on Egyptian agriculture, resulting in the need for ever larger amounts of artificial fertilizers and a long-term decline in trace element levels in soils. The silt also used to add around one millimetre to the depth of the soil every year.

The loss of sediment is particularly significant in the delta, an area the size of Northern Ireland which constitutes two-thirds of Egypt's cropland. Deltas are formed by the accumulation of tens of thousands of years of deposits of river sediments partly counteracted by their settling and compaction and by erosion from the sea. Remove the incoming sediment, and the land will subside and be eaten away. The slow accretion of the Nile Delta was reversed with the construction of the Delta Barrage in 1868. Other dams built on the Nile throughout the 20th century further reduced the sediment reaching the delta but it was only with the building of the High Dam that the Nile all but ceased to wash sediments into the Mediterranean. Today the Nile no longer has a true delta.

Over the last millennium the Nile has reached the Mediterranean through two distributaries — the Rosetta and Damietta Promontories — which have built their own 'sub-deltas'. The most severe erosion has been on the western side of Rosetta Promontory which retreated by nearly six kilometres between 1900 and 1991, washing out to sea a lighthouse and a resort and flooding coastal villages. A replacement lighthouse built one kilometre inland in 1970 is now 'offshore a long distance away from land.' Before the closure of the High Dam in 1966 the rate of retreat was around 20 metres per year; by 1991 the annual rate had accelerated to 240 metres.

Most of the rest of the delta coastline is being eaten away at an annual rate of around five to eight metres. Increasing soil exhaustion and salinity (both related to the loss of silt and the expansion of perennial irrigation after the Nile was regulated by the High Aswan Dam), the long-term rise in the level of the Mediterranean due to global warming, and the subsidence of the Egyptian coast because of geological factors compound the crisis facing the delta.

The sediment discharged through the Mississippi Delta has fallen by more than half since 1953 mainly because of the huge dams built on the Missouri (the Mississippi's main tributary and sediment supplier). A massive programme of stabilizing the channel of the Mississippi with rip-rap (boulders) and concrete for navigation and flood control purposes has also deprived the river of the sediments that it would previously have torn away from its banks. The result of sediment deprivation, together with land subsidence due to oil and gas extraction, is that 10,000 hectares of Louisiana disappear into the sea each year. Author John McPhee describes one of the Mississippi Delta parishes as 'coming to pieces like an old rotted cloth.'

## Hungry Coast

The consequences of robbing rivers of sediment extends out from their mouths to affect long stretches of coastline which now have to face erosion from the waves without the sediments from the land which once replenished them. Sediments move along shorelines, washing on and off beaches with waves and tides, within geographic units known as 'littoral cells'. These include the sediment sources (mainly rivers and cliff erosion), the shoreline along which the sediments migrate, and their final sinks (mainly currents to deep water and submarine canyons).

Since the 1920s dams have reduced by four-fifths the sediment reaching the coast of Southern California. This has had dramatic effects on the region's beaches which are now partly maintained at great expense with sand dredged from offshore. The beaches in a 90-kilometre long littoral cell north of San Diego were more than 300 metres wide in 1922. Today some have entirely disappeared. The beaches once protected cliffs from wave erosion; their disappearance has led to cliff collapses which caused millions of dollars of damage to property and roads during the 1980s.

One of the most dramatic examples of dam-caused coastal erosion is along the Bight of Benin east of the mouth of the Volta River in Ghana. Akosombo Dam has virtually halted the supply of sediment to the Volta estuary and so to the eastward-flowing coastal current. The shoreline of neighbouring Togo and Benin is now being eaten away at a rate of 10 to 15 metres per year. The sea advanced by 20 metres in places during a single storm in 1984, taking with it a large chunk of the main Ghana-Togo-Benin highway. A project to strengthen the Togolese coast with groynes and boulders has cost $3.5 million for each kilometre protected, yet even the project's supervisors admitted that by stopping sediments being washed off one stretch of shore it would reduce the beach-building material available further along the coast and so accelerate coastal erosion in Benin.

*Read the next section in this chapter, Dams and Water Quality (/node/2194)*