Thinking About Rivers

By David W. Mayhood

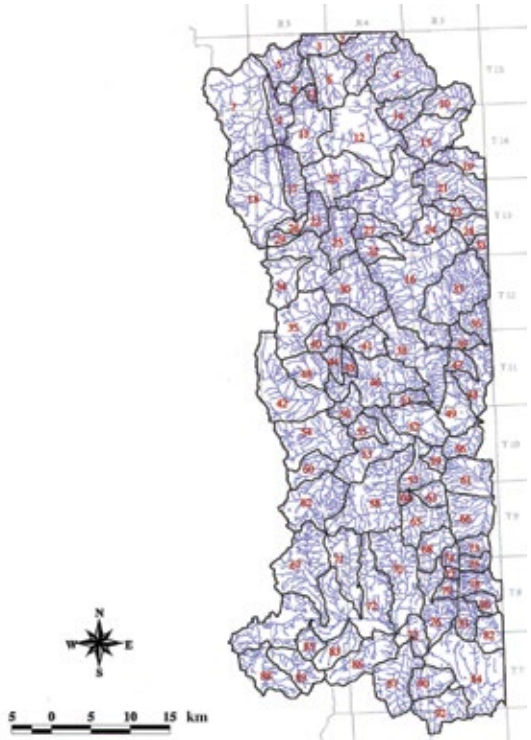
Man's engineering capabilities are nearly limitless. Our economic views are too insensitive to be the only criteria for judging the health of the river organism. What is needed is a gentler basis for perceiving the effects of our engineering capabilities. This more humble view of our relation to the hydrologic system requires a modicum of reverence for rivers.

— Luna Leopold, A Reverence for Rivers. Geology 5:429-430 (1977)

Not Just Plumbing

There is something deeply troubling about the way we think about rivers.

Several years ago I gave evidence at a public hearing. A power company was seeking approval for a dam on the Peace River. This was the second go-around for the proposal: a previous panel had rejected the same project some years earlier, requesting more studies.



Dense stream networks with their drainage basin boundaries making 90 small watershed ecosystems in the Highwood, Willow, Oldman, Livingstone, and Crowsnest drainages. Used with permission. GIS analysis by Ecology Center, Bozeman, MT, published in M. D. Sawyer et al, Southern East Slopes Cumulative Effects Assessment, *1997.*

The new hearing considered extensive evidence from the proponent relating to the economic need for the project; dam design; hydrology; ice; sediment transport and deposition; fish populations, habitat, distribution, and passage; and more. It was good work, but I was interested in something else. At least part of my evidence centred, in one way or another, on the ***value*** of fishes and the larger ecosystem of the Peace River. The proponent seemed to be minimizing this aspect.

I recall in my testimony talking about a sucker species unusual in Alberta, but often common where it occurs. This species had been found in the proposed dam area in the past, but now was absent from collections despite the proponent's extensive sampling. Was it already extirpated, perhaps by dam operations upstream in B.C.? If so, this represented an already-realized loss to the Peace system, and to Alberta, before any dam is placed on the Peace within the province.

I also argued, based on available data, that just one of the common fishes, another sucker, was likely to number at least in the low hundreds of thousands — a sizeable population. The proponent had felt that, based on catch rates, they were not especially abundant. I described why these species are ecologically important, even though we do not know their full role in this ecosystem. I clearly remember quoting Aldo Leopold's famous dictum: "To keep every cog and wheel is the first precaution of intelligent tinkering" to make the point.

I had had very limited time to prepare my case but, when done, I thought I had explained the "ecosystem value" issue clearly enough. Nope. At the end of my testimony, the panel allowed a local gentleman to ask me a question. To paraphrase him from memory:

"Nobody fishes for suckers, or anything else in the river, for that matter. What good are they? Can you tell me? Let's just build the dam and be done with it."

My answer, I confess, did me no credit with this fellow.

The dam was approved, but never built for economic reasons. Now a new proponent wants to build a much larger dam near the same place. Much of the same data and

Kananaskis River circa 1970 exhibits a complex riparian zone and floodplain, with many lateral tributaries. This watershed ecosystem has been heavily impacted by hydroelectric dams and associated exotic fish introductions. PHOTO: © D. MAYHOOD

arguments will be trotted out to support that proposal. And again, I strongly suspect, the value of the Peace River as a functioning ecosystem will be ignored.

The Peace River dams are just two of dozens that are likely to be proposed on all of Alberta's major rivers in the next few decades to deal with water supply, flood control, and hydroelectric power. These projects look at rivers as plumbing. According to this view, rivers carry water, and that is all they are good for. Or, they are seen as plumbing that threatens to burst, destroying homes and infrastructure. Rivers are seen merely as flowing water to be controlled by physical infrastructure.

Here I describe another way to think about rivers. This way of thinking acknowledges their complexity, and the many other values of rivers that are simply ignored in the "river as plumbing" view. What I hope I can give you is a way of thinking about rivers that helps you judge the many proposals for dams and other control works that will be coming our way in the near future. For simplicity, I will consider only dams, but my comments apply to any river control structure, and more broadly, to any human effect on rivers.

Balancing Accounts

First, though, let me dispense with an argument that is advanced whenever a dam is proposed. These plans are always accompanied by some estimate of the economic value of the dam and that figure is commonly in the hundreds of millions of dollars annually or, often in the low billions, in terms of the one-time replacement value of property saved from flooding. The economic value of the river, *left as a free-flowing river*, is never mentioned. In effect, it is assigned a value of zero. The economic cost of losing the natural river is simply ignored.

This is clearly ludicrous. It is like totting up only the deposits in your bank account, ignoring all the payments you make against it, and declaring yourself in the black.

There are many services provided by free-flowing rivers, often called ecosystem services. Ecosystem services are those provided by ecosystems from their normal functioning, such as water purification, nutrient cycling, waste decomposition, and water supply. Robert Costanza and his colleagues have calculated the global value of freshwater ecosystem services. They estimate that lakes and rivers globally are worth US$2.3-2.5 trillion annually for the ecosystem services they provide.

Using their unit values with Alberta Government data on river and lake area, I recently estimated the total economic value of ecosystem services from Alberta's waters (not including wetlands) at US$24.4 billion annually. The Peace River system alone, which carries something more than 40 percent of the flowing water in Alberta, is likely worth billions of dollars in ecosystem services annually. It is pretty clear that the value of ecosystem services of any of our major river systems will be at least in the hundreds of millions of dollars *every year*.

These estimates for Alberta are no more than back-of-an-envelope calculations, but they do make the point that the economic value of ecosystem services from an Alberta free-flowing river is likely to be comparable to that of any dam that might be built on it. This value cannot simply be ignored when evaluating dam proposals.

But it's done all the time.

Rivers and Watersheds

Rivers do not stand alone: they are integral parts of drainage networks connecting entire watersheds. Watersheds with their drainage networks form ideal unit ecosystems conceptually. They are hierarchically arranged over large areas, one within another, tightly adjoined but distinctly separated by heights of land except at their outlets, where the watercourses that drain them meet.

Watershed ecosystems are four-dimensional. Within watersheds, terrestrial areas are tightly tied together by the dense network of watercourses that drain them, and all of these change over time. The aquatic and terrestrial realms are integrated parts of the whole ecosystem, not separate elements.

A riparian zone flanks the watercourses. It becomes the zone of interaction between land and water. This zone is typically the most productive, biologically-active part of the ecosystem, important far out of proportion to the relatively small area it occupies. The riparian-riverine-tributary network so formed connects the watershed from headwaters to mouth, forming critical habitats and corridors for movement of fish, insects, wildlife, and birds. Disturbances, especially floods, distributed over time, and of various magnitudes, create a patchwork of physical habitats in this zone. These become a template on which plant communities of different ages develop, creating a mosaic of habitats for wildlife, birds and invertebrates. Many plants disperse upstream and down along this corridor, which typically offers many disturbed surfaces for their establishment.

Leaf litter and woody debris washing into watercourses from hillslopes and uplands powers aquatic food chains through decomposition. Birds, wildlife, invertebrates and their foods move in both directions between riparian zone and terrestrial sys-

A mosaic of productive habitats dominates the riparian zone of the Bow River near Carseland. PHOTO: © D. MAYHOOD

tem. Those moving inland die or their feces are deposited, becoming incorporated into upland forests or grasslands. These effects are often measurable far from the watercourses where they originate. Bears, wolves, bats, and many birds carry stream-derived nutrients far inland. On some alluvial river systems, surface water fauna have been found in abundance in groundwater more than a kilometre from the open channels where they must complete their life cycles. They are connected to those channels by a hyporheic zone underlying channels and the riparian margin (the hyporheic zone is the groundwater beneath a stream or river bed which supports bacteria, fungi, and invertebrate animals that are important in nutrient cycling).

Ecologists work under the strong suspicion that, in an ecosystem, everything is connected to everything else. We think that if we change something in the system here, something will happen over there. This is an oversimplification, but decades of research broadly support the view.

"We may conclude then that in every respect the valley rules the stream," wrote stream ecologist Noel Hynes. By this he meant that watershed source rock determines ion availability, soil, and slope; soil and climate determine the vegetation; and the vegetation determines the supply of organic matter, which drives nutrient delivery and ultimately the productivity of the stream. And on and on.

Because of these connections, landscape change in the uplands of a watershed affects watercourses draining them. Cultivation, clear-cutting, roads and grazing affect the physical and biotic stability of the terrestrial and aquatic realms, significantly altering the distribution and abundance of aquatic organisms from bacteria and fungi to fish. These tight downhill-uphill linkages between the land and the water in the watershed ecosystem mean also that changes wrought by humans on the system can have large effects. We know that these effects can be expressed both upstream and downstream, downhill and uphill, and sometimes even outside the watershed.

One remarkable example makes these points. Working in Yellowstone National Park, Arthur Middleton and his colleagues recently documented how lake trout illegally introduced into Yellowstone Lake contributed to a decline in the growth of an elk population. The lake trout preyed on native cutthroat trout, reducing their population, thereby shrinking spawning runs of cutthroats into tributary streams. Grizzlies that formerly relied on these runs for part of their spring food supply were forced to look elsewhere. They successfully redirected their attention to elk calves, causing a significant drop in elk recruitment, and reduced growth in the population of elk. Because the elk are migratory, the effect would be felt upstream, downstream, and even outside of the Yellowstone Lake watershed ecosystem.

It is important to understand that any perturbations that reduced the size of cutthroat trout spawning aggregations, such as overfishing or habitat destruction, would have had similar effects. The Yellowstone example is very unlikely to be unique.

The Lynx Creek watershed (Carbondale River drainage) has been extensively logged, burned, and roaded. This has increased water temperatures and the loading of sediment, including some heavy metals and nutrients. Overall water quality in the stream has decreased. PHOTO: © D. MAYHOOD

A Greater Reverence for Rivers

When Luna Leopold, a hydrologist and fluvial geomorphologist, called so eloquently for a modicum of reverence for rivers, he was speaking about rivers explicitly as plumbing systems. He wanted authorities to recognize that rivers are self-adjusting, but only within limits, and that serious problems result when the limits are not respected.

Here I urge Albertans toward a more comprehensive understanding of rivers. Rivers are not just plumbing. River networks are integral parts of much larger watershed ecosystems. Perturbations in watersheds can have surprising, often profound effects, and not just in a downstream or downhill direction. Perturbations in rivers will be reflected upstream, downstream and into the hyporheic/groundwater zones in the drainage network, downhill from the active channel through the groundwater and riparian zone, uphill from the riparian zone and floodplain over hillslopes to uplands via mobile bird, wildlife and insect populations.

For these reasons we need a more inclusive paradigm. We need a reverence, not just for rivers, but for where rivers come from — watershed ecosystems.

Dave Mayhood is principal of FWR Freshwater Research Limited, in Calgary. He specializes in the ecology of inland waters, especially the effects of watershed development on Alberta's southern Rocky Mountain East Slopes, and on the conservation biology of the native fishes that live there.

Coleman 1923: Why people don't belong on floodplains PHOTO: © GLENBOW MUSEUM