Hydro and Sustainable Development: An Example From The Pacific Northwest, USA

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The development of two small hydro plants by a group of farmers with no previous experience in this field Involved overcoming a number of technical and bureaucratic challenges. The approach to planning, and the overall philosophy of 'learning from the ecosystem', resulted In a project which is sociologically, ecologically and economically sound, as well as the formation of an integrated group of local stakeholders who have worked together to achieve multiple benefits from the scheme.

Aerial view of the Farmers Canal (right side of photo) conveying water from Hood River (left side). The Farmers' Canal provides both hydropower and irrigation water.

This case study begins as a story of the Farmers Irrigation District (District), which is in Hood River County, Oregon, USA, about 100 km east of Portland, USA. The District began delivery of irrigation water in 1874 via open canals from the main stem of the Hood River and its tributaries, serving about 2350 ha of high-value orchard land. Operation and maintenance revenue for the irrigation district is obtained from assessments on the orchardists, but historically there was never sufficient money to enhance the irrigation water delivery system. This economic shortfall made it difficult to deliver adequate and reliable volumes of water for fruit production. Inefficient water delivery resulted in poor crops, which kept farm revenue low, making it impossible to increase assessments to address system improvements. The people of the District felt trapped in an endless negative cycle.

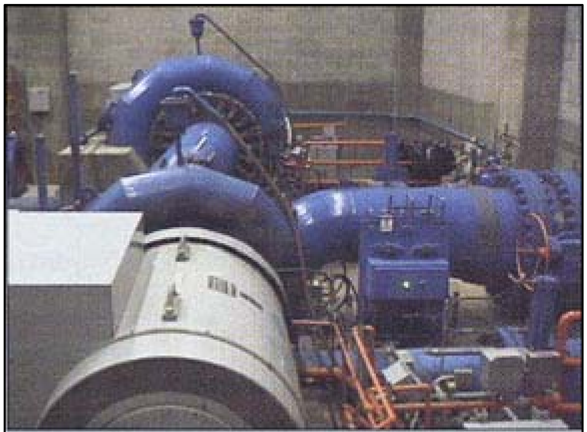
In 1974, the District began studying the feasibility of developing small-scale hydropower facilities. A pilot hydro project appeared promising, and the District began the process of designing and constructing two hydroelectric facilities. The goal was to realize substantial revenue with which to enclose the entire water delivery system in pipes and provide pressurized water delivery to irrigated agriculture in western Hood River County. The District had stumbled into its first steps toward sustainable development.

1. System description

Because the topography of the District's watershed is characterized by large elevation changes, District engineers designed two hydro plants staged to exploit the full potential of the elevation changes and available flow. The upper hydroelectric facility is positioned such that its tailrace discharges into the forebay pond of the lower hydroelectric plant. With this configuration, the upper system water also passes through the lower system, thus optimizing hydroelectric revenue.

To construct the hydropower facilities, the District borrowed US$12 million in revenue and general obligation bonds from the Oregon State Department of Energy Small-Scale Energy Loan Programme. The upper hydroelectric plant is driven by a 1.8 MW Pelton turbine with an 8 km-long, 0.9 m-diameter penstock. The plant has a hydraulic capacity of 1 m'/s with 220 m of head. The lower hydro plant has a total capacity of 3 MW and consists of two Francis turbines of 1 MW and 2 MW. Water is conveyed to the Francis units through a 1.2 m-diameter, 3.25 km-long penstock. The two units operate under 110 m of head with a total plant flow of 3 m3/s. The 2 MW unit has a hydraulic capacity of 2 m3/s; the 1 MW unit has a capacity of 1 m3/s.

In January 1985, the lower plant was connected to the Bonneville Power Administration grid. The upper facility was connected in November 1986. Annual combined production of the hydropower facilities is now as high as 25 GWh/year, producing annual revenue of as much as US$ 2.5 million. As expected with a run-of-river facility, actual annual production varies as a function of precipitation, snow pack, and stream flow. Annual maintenance requirements and other infrastructure limitations also influence annual production.



The 1 MW (foreground) and 2 MW Francis units.

2. Process and solutions

2.1 Start-up problems

When the District began producing electricity in 1985, several major problems became evident. The system was inefficient and dependent on archaic canals for water delivery. While these canals were capable of delivering some water during the summer months, they often failed during the winter, making it impossible to keep water flowing to the plants. Mechanical failures were common, and remote control and alarm systems, although state-of-the-art for their time, were unreliable. In the early years of operation, all project revenue had to be directed to debt service. If the plants were off-line even for a brief period, the District would be in default on its loans and the orchardists, already unable to meet their own operating expenses, would have to make up the shortfall. District staff people were exhausted by the schedules required to keep the system operating.

Water delivery to the orchards and the turbines remained poor; crops were not optimal because of the lack of reliable water; and no additional money was available to enhance the District's conveyance system. The turbines, located to take full advantage of elevation changes and available flow, were perceived to be in direct competition with the irrigators. Interpersonal conflicts and blame-based behaviour ruled. There was serious strife among irrigators. District staff, and the District Board of Directors. There was heavy turnover in staff and directors, and it was difficult to establish a team familiar with the operational requirements and long-term vision of the District.

One other major factor contributed to the start-up problems of the hydropower plants. This factor held the seed of a solution, but this was not apparent at first. When the District borrowed the US$ 12 million and constructed the power facilities, not all of the water rights necessary to realize full project revenue were in place. State and District officials were not concerned about this shortcoming, since the water right acquisition process was believed to be perfunctory. However, much to the surprise of the Government officials at the time, a new Oregon state law, called the 'one dead fish' law, was adopted before the water rights were received. The new law required that no small-scale hydro project could be constructed if it had the potential to kill even one individual fish. This was not a 'no-net loss' standard. Instead, this new law said 'no loss'. The fish agencies were extremely skeptical of the value of hydropower production, and the District was told that no additional water rights would be forthcoming. This meant that the District would be bankrupt.

It was this seemingly final 'no' that induced a community and District paradigm shift. Unless the District began to explore the idea of making decisions based on the needs of fish, there would be no future. A new process began under the following slogan: "Let fish be our guide".

2.2 A new way of business

We let fish lead us to economically, ecologically, and sociologically sound decisions. The paradox of allowing ourselves to be taught by our 'adversary' created solutions previously unimagined. We could no longer see our issues as 'win-lose' or 'trade-off'. We began to imagine less polarized scenarios and to use the creative tension of a problem to lead us to a solution. Instead of looking at pipe projects and watershed restoration projects as an expense, we began to see that these projects could increase revenue. If a watershed's health is restored and water is delivered to orchardists without waste, then more water is available for fish and farms.

To address the perceived competition for water between the generators and irrigators, we gave irrigators low-flow sprinkler heads. These allowed people to irrigate more effectively with far less water. Orchardists learned that applying less water with increased frequency often reduced operating costs and enhanced fruit quality. The conserved water resulting from this low-flow sprinkler head strategy was then available for the generators, which resulted in slightly increased revenue. The increased revenue, no matter how sparse, provided for pipe construction in the worst sections of canal, which increased available flow; this in turn increased revenue, which increased total pipe construction. By respecting the fish, we discovered a positive feedback loop that allowed us to build and operate our system in a sustainable way.

2.3 Roadblocks, detours and open roads

We still needed to optimize our hydropower system flow to meet debt service reliably and provide adequate water to orchardists. Even though we had some early conservation success stories, the fish agencies were not interested in watching yet another small-scale hydro facility dry up more tributaries. We approached the local fish agencies with some humility, and were surprised when the fish agency representatives asked how much water we would need. District staff and directors knew that additional water was necessary for the economic feasibility of the project and the community, but we did not know how much, having no flow data. As we began struggling with the question of need, we learned of a seminar in British Columbia on new flow modelling techniques, entitled 'The Hydrology of Ungauged Sites in Mountainous Terrain'. This pointed the way to a comprehensive solution. We then began to plan our future in an ecosystem context.

2.4 Resolution

The Oregon Water Resources Department and fish agencies identified appropriate instream flows, and we developed a spreadsheet programme to project hydropower revenue after meeting fish-flow requirements. This revealed that fish needs could be fully addressed, and there would still be enough water to optimize hydropower production. The District, letting fish be its guide, gained the full support of the Oregon Water Resources Department and Federal and State fish agencies. In contrast to a few years back, when water rights had been denied, all parties were in favour of the project. In 1990, the District was granted the previously requested water rights. In return for the additional water, the District agreed to install fish screens at all diversions. The District also agreed to adopt minimum flow standards and complete ongoing watershed restoration projects on Green Point Creek, a major tributary in the Hood River Sub-basin.

Revenue began to stabilize, and progress was made with our stream restoration work. More flow and more revenue became available to enhance on-farm irrigation efficiency, agricultural production, and fruit quality. As more pipe was installed and pressure water became available without pumping, the District not only produced more electricity, but also decreased the consumption of electricity. With better revenue, we were also able to fund the design and installation of a comprehensive remote telemetry system. The system monitors project diversions, flows, canals, and gate systems, and transmits data to the District's computer network. The system allows for alarms to be sent to pagers so that system operators can respond quickly. The telemetry system has further optimized revenue, greatly decreased operational and maintenance expenses, and improved the quality of life for District staff.

Farmers Canal Horizontal fish screen on Hood River: first full scale, NOAA Fisheries approved, horizontal fish screen. This replaces an old rotary drum screen system, which did not meet contemporary criteria for fish protection.

2.5 Fish screens

In compliance with its commitment to install fish screens, the District constructed vertical panel or rotary drum screens on its diversions. However, operation and maintenance costs were high, and water diversion was unreliable because the screens would frequently fail. The District lost several hundred thousand dollars each year because of interrupted water diversion. Nonetheless, we were committed to protecting fish and were unwilling to compromise our promise to the fish agencies. Keeping this commitment was a struggle at times. On the other hand, despite the shortcomings of the screens, hydroelectric revenue was substantially higher (the project was operating at a profit, and irrigation water delivery and grower satisfaction were at an all-time high).

Although the hydropower system was far from optimized, overall costs had decreased, revenue had increased, and agricultural production improved. In 1995, we wrote Oregon's first irrigation district water conservation and management plan and adopted it as District Policy. It seemed we were on the right path.

2.6 A flood and an unhappy partnership

In February 1996, a rain-on-snow event induced flood flows of impressive magnitude, annihilating our screen facilities and most of the major conveyance canals. It was the worst of times about to become the best of times, but not without leaving the District nearly bankrupt. The previously mentioned debt service on US$ 12 million borrowed from the Small-Scale Energy Loan Program was still substantial. Flood restoration costs exhausted bond payment reserves, and the District was unable to meet debt service. The Oregon State Audits Division audited the District's financial statements and concluded that the District's expenditures for sustainable projects could not continue.

The State of Oregon threatened to take over the project, focusing on strict, short-term economic considerations including the imposition of increased assessments on the orchardists. In the course of the audit, however, it was discovered that the Oregon Department of Energy had not passed savings on to the District after several bonds were refinanced. In response, the Small-Scale Energy Loan Program reduced District debt service and reserve requirements substantially. Interest on reserve accounts, which were re-established with debt service savings, was also required to be passed to the District. These changes allowed the District to transcend the economic difficulties induced by the flood and realize net proceeds from hydroelectric revenue.

2.7 Opportunity through crisis

The post-flood circumstances were unsettling to the District people. Their livelihoods were at stake. In addition to the nearly bankrupt status of the District, orchardists were without early-season water. Even so, emergency funds were filtering in, and growers agreed to pay additional assessments to meet emergency expenses. Several community-minded orchardists offered their equipment and labour to begin diversion restoration.

Two hopeful growers working on the District's Dead Point Creek diversion asked permission to construct an innovative, passive, horizontally oriented screen system, one the District had been testing for several years. The screen was in its early stages of development, yet it was refined enough to overcome the historical limitations of horizontal screens. The growers working on the diversion project believed in the horizontal technology and were sure that the horizontal screen would be much quicker to construct.

2.8 New screen technology mitigates fish migration problems

A fateful decision was made to accept the growers' suggestion and restore the Dead Point diversion with the new horizontal screen technology. Using this new style of screening, the diversion was restored within one week. The screen worked well. It required little cleaning, fish passed upstream and downstream without injuries of any kind, and sediment and debris did not foul the screen. Operation and maintenance costs decreased, and reliable, uninterrupted, and steady diversion caused the hydroelectric revenue to increase.


The Gate Creek horizontal screen, an innovative horizontal screen system in place at the Gate Creek diversion, a small source of water for both hydropower and reservoir storage for irrigation and recreation.

The promising performance of the Dead Point Creek screen and support from local fish agencies encouraged further enhancement of this new technology. The District installed other small versions. In 1999, we installed a full-scale prototypical screen at a test site on a 2 m3/s diversion. At this prototype site, and at a test site in Denver, Colorado, esoteric hydraulic studies conducted by hydraulic engineers and modellers demonstrated surprising flow attributes conducive to reliable and efficient fish passage and cleaning characteristics. Assessments by fish biologists in the private sector and at universities demonstrated that fish could pass over these horizontal screens without mortality or injuries of any kind. In 2001, based on the results of these extensive tests, State and Federal fish agencies directed the District to construct the first full-scale version of this screen at a diversion on the Hood River.

The new horizontal flat-plate fish screen, as it has come to be called, enhances the diversion operation. The screen system is good for irrigators and hydroelectric producers alike. It reduces operational costs, eliminates debris and sediment from the diverted water, and safely passes fish of all species and life stages.

3. The birth of a sustainable vision

As the horizontal screen technology was refined, fish agencies and District directors encouraged the inventors to seek a patent. They wanted to make the screen available to diversion facilities throughout the western USA and Canada. Some private sectors sought the rights for the screen technology, but the District directors and inventors adhered to the belief that the technology should be developed in a manner that furthered the public good. They wanted the technology to continue to save fish and enhance diversion: to be sociologically, ecologically, and economically sound.

Accordingly, the inventors of the technology sought a patent and signed over all rights for the patent to the Farmers Irrigation District. The patent, and all subsequent patents, will be held in perpetuity in the public domain. The needs of fish and farms will hold the highest priority.

Large diameter HDPE installation: replacing an inefficient (and ecologically unsound) hydropower and irrigation supply canal with large diameter highdensity polyethylene pipe. The pipe project was funded with surplus hydropower revenue.

4. Emergence of the Consortium

For the Farmers Irrigation District to market and construct its screen product for the public domain, several entities had to be formed. The District established the Farmers Conservation Alliance to dedicate screen proceeds to projects of a sustainable nature. The Farmers Conservation Alliance created and now controls the Northwest Riverworks, which will design, develop, market, and construct the horizontal screen technology for the protection of fish and farms.
Through the Farmers Conservation Alliance, all screen royalties and profits are dedicated to:

- installing more screens;
- enclosing canals;
- developing new sustainable technologies;
- establishing and enhancing agency partnerships;
- encouraging sustainable agricultural practices;
- supporting farm labour;
- establishing health insurance programmes for farm owners and families;
- developing farm labour child care and early education programmes;
- constructing pressure water systems;
- increasing in-stream flow;
- restoring watersheds; and,
- decreasing costs associated with agricultural production.

5. Conclusion

Our process is relatively young; we do not pretend to have extensive knowledge. Our turning point came when we committed ourselves to learning from our ecosystem. We are pleased with the way hydropower has taught us to think systemically. Today, Hood River County has an integrated watershed group which includes fishermen, loggers, farmers, State and Federal agencies, construction workers, environmentalists, and the private sector. The horizontal fish screen patent has been issued. Our restored stream, Green Point Creek, has the highest fish biomass in the Hood River Sub-basin. No farmer goes without water, and every year we return more flow to our streams. Our hydropower system operates at a substantial profit.

Our greatest aspiration is that we conduct ourselves in a manner that contributes and does not exploit. Our journey with hydropower and sustainable development has taught us to listen well and respect others. How well we do this defines how successful we will be.

Final construction work on a distribution manifold for a fully pressurized irrigation system funded with surplus hydropower revenue. The pressure pipe system replaces archaic, inefficient irrigation canals.

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