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<th>Title of Journal</th>
<th>A. Title for Conference or Meeting</th>
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<th>Date(s) of Conference or Meeting</th>
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<td>Chicago, IL</td>
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**5. REVIEWS**

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<td>C. Williams</td>
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**6. Applied Technology Material Referenced**

| [ ] Yes | [ ] No |

7. Release Level

| [ ] Public | [ ] Limited Distribution |

8. Author/Requestor

| M. D. Betsch | 6/21/96 |

9. Responsible Manager

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DISCLM-2.CHP (1-91)
Abstract: In an effort to cost-effectively utilize surplus facilities and equipment at the U.S. Department of Energy Hanford Site in Washington State, water purification pools (K Pools) are currently being used as an aquaculture facility for rearing various cold-water fish species. These pools, which are located in the 100 K East Area near the Columbia River, were built in 1955 and operated at full capacity until 1971 to provide up to 300 million gallons of treated cooling water per day to the K Area reactors.

The Yakama Indian Nation, the Washington Department of Fish and Wildlife, the Washington State legislature, and Westinghouse Hanford Company, proposed using the Hanford Site K Area water treatment pools for rearing and acclimating warm-water species such as walleye, blue gill, white sturgeon, crappie, channel catfish, and large and small mouth bass for Washington lakes. The Pollution Prevention and Resource & Energy Management Teams were challenged to investigate how to isolate a fixed quantity (140,000 gallons) of rearing water, heating it to acceptable temperature levels (60 - 80 degrees Fahrenheit) for optimally raising these species the year around, and recirculating the warmed water through rearing tanks.

ICF Kaiser Hanford Energy Management and Westinghouse Hanford Company Pollution Prevention teamed to conduct a feasibility study in fiscal year 1996, to determine the most energy-efficient method for heating Columbia River water in an existing sand filter structure.
1 Background

The sand filters which were studied for potential reuse are located on the northern end of the 100 K East Area water filtration plant on the Hanford Site. This plant is located about one-half mile from the Columbia River. The sand filters were originally part of a system which was used to provide cooling water to the nearby K Reactors. This Cold War operation took place until 1971, at which time the K Reactors were closed for eventual decontamination and decommissioning.

Recently, it was decided to study the concept of putting the sand filter structures back into use for warm water fish-rearing purposes. Because the water that circulated through the water purification pools (K Pools) and associated sand filters was clean river water, there is little chance of the structures being radioactively contaminated. To date, separate K Pools have been used successfully for raising a variety of cold water fish species, including white sturgeon and fall chinook salmon, as well as for providing potable water to the 100 K Area of the Hanford Site for fire and service water purposes.

2 Objectives

A conceptual project consists of placing eight 8-ft diameter tanks and two 20-ft diameter tanks on the floor of an empty K Pool. The smaller tanks will be used to rear various warm-water fish, such as channel catfish, walleye, large mouth bass, small mouth bass, crappie, and blue gill. The larger tanks will rear white sturgeon. Because all fish species to be used for this project are warm-water species, it is necessary to maintain the water temperature between 60 and 80 degrees Fahrenheit year round to grow the fish most efficiently. A raise in temperature of approximately 30 degrees Fahrenheit during the coldest month is required to maintain the warm-water fish rearing program.

The concept being investigated (Figure 1.1) is to use a sand filter as the header pool, where water will be heated before being circulated to the fish-rearing tanks located on the floor of an adjacent empty K Pool. After the water flows to the rearing tanks by the force of gravity, it will then be pumped back to the sand filter volume for treatment and then reheated.

3 Procedure

3.1 Design Consideration of Existing Sand Filter

As part of the feasibility study, a design analysis was conducted to determine the usefulness of the existing sand filters and associated media for reuse. Most of the existing structures needed for its implementation are in good working condition. All of the valves in these structures are believed to be in working
condition, but may need maintenance before they can be reused. Because the sand filter was not originally designed as a water-holding volume, some valves may need to be added to prevent flow into the clear well, a storage system that holds water for use at the 100 K Area that cannot be contaminated with fish water. The backwash pipe located near the bottom of the sand filter provides access to the clear well for the filtration plant. Therefore, a blind flange can be inserted into the backwash pipe to ensure that contamination of the clear well does not take place. Modifications that may be needed to carry out the conceptual project include the addition of pumps and piping to create a closed circulation pathway to the fish-rearing tanks and back.

The only potential challenge for this concept is the possible need to backwash the sand filter medium. Although there are no current plans for this procedure, it should be recognized that back washing the filter may require extensive modifications to the system. The original backwash lines have been capped and the pumps removed, so it will be impossible to complete the procedure as the system currently exists. Another issue regarding this potential challenge of back washing may be disposal of the backwash discharge water. Regulations prohibit discharging backwash into the Columbia River, so additional piping and pumps will have to be constructed to route the water to a settling basin.

3.2 Methods and Baseline

Once it was determined that the existing sand filter and K Pool designs were appropriate for proposed project, a study was conducted to determine the most energy efficient method for heating the river water. Two analytical methods commonly used at the Hanford Site were utilized for identifying the most energy efficient opportunity available. The two methods used were the Pollution Prevention Opportunity Assessment (PPOA) and the Building Life Cycle Cost (BLCC).

The PPOA model is an approved U.S. Department of Energy method for identifying and ranking pollution prevention initiatives. A PPOA consists of identifying activities which generate waste, examining the activities for material inputs and waste output, and identifying ways to reduce waste and conserve energy through a cost benefit analysis.

The BLCC method includes economic analysis of proposed capital investments that are expected to reduce long-term operating costs of buildings or building systems. Two or more competing designs can be evaluated to determine which has the lowest life cycle cost. The life cycle costs computations for a project are automatically performed from a project data file.

Since this project is in design, there was no baseline information available in which to compare alternatives against.
Therefore, liquid propane was used as the baseline which is the standard method used on the Hanford site. The baseline information included heating approximately 140,000 gallons of water in the header pool and maintaining the temperature between 60-80 degrees Fahrenheit for optimal fish growth. It was estimated that approximately 450,500 BTU's/hour would be required.

3.3 Analysis

Alternative 1--Excess Water Heater from 2750-E Building

An existing 16 year-old solar water heater is currently available for excess from the 2750-E Building at Hanford. The solar system on building 2750-E has not been maintained due to control system failure since its installation in 1980. The solar system has been disconnected and dismantled and is ready for excess.

The system consists of two tanks each with an 82 gallon capacity. The condition of the solar energy receiver surfaces, heat transfer fluid tubing and reflection/conduction insulating material inside each one of the four collector assemblies is in excellent condition. The condition of the solar collector housings and mounting braces is also appears to be in good condition. Although the overall unit is reusable, there are several upgrades which should be completed before reuse such as flushing the system and replacement of a pump. Removing and reinstalling the solar water heater is estimated to cost approximately $4,000. In addition, the upgrades will cost an estimated $1,200 for a payback of 1.2 years.

Alternative 2--Water Source Heat Pump

A water source heat pump will pull Columbia River water into a heat exchanger, strip heat from the water and then discharge it back into the river at a reduced temperature. Water enters at an average temperature of 50 degrees Fahrenheit and passes through an evaporator. The heat is adsorbed and then delivered back to the river approximately 10 degrees cooler. A condenser delivers the heat to the sand filter structure while a compressor recirculates the refrigerant around and between the evaporator and condenser. Entering fluid temperatures below 45 degrees Fahrenheit requires an antifreeze solution. The capital equipment cost for the water source heat pump is approximately $15,000 including implementation. The total payback is 4.4 years.

Alternative 3--Solar Panels

A solar panel converts about 70% of the energy that falls on it to thermal energy for heating. For Eastern Washington, this represents an average daily energy delivery of about 856 BTU's per square foot of panel area. The solar collector is a heat exchanger which can be
used to collect thermal energy as well as to distribute thermal energy.

One collector (50 sq ft) produces approximately 42,800 BTU's/day. The collectors are manufactured using "over-molding" process whereby the headers and risers become one piece of plastic--there are no seams or welds. The "over-molded" construction virtually eliminates wind load and the collectors are certified to withstand 180 mile per hour winds. The individual tubes also enable the roof to "breathe" which prevents moisture from being trapped under the collector. Since each tube is able to expand and contract independently, cracks and leaks due to wear and tear of thermal expansion and contraction are eliminated. High head pressures are eliminated which protects the collector against clogging. Lower head pressure keeps pumping requirements to a minimum which helps maximize efficiency. One collector costs about $250 for a total capital cost of $39,600 including installation costs. The payback is over 9 years.

Alternative 4--Shred and Cube Weeds for Feed to a Boiler

Tumbleweeds and noxious weeds are abundant on the Hanford site. Over 700 acres of harvestable acres are available for collection. This alternative involves shredding and cubing tumbleweeds, nuisance weeds (Tumble Mustard) and noxious weeds (Yellow Starthistle, Russian Knapweed) as feed to a small biomass boiler which will in turn heat water to maintain the required temperature. This action would be best done in the summer months when weeds are the driest and the cubes can be stored for year-round use.

The fuel cubes produced have characteristics similar to those of coal or hog fuel and can be used in most industrial boilers. Agriculture wastes similar to the weeds found on the Hanford site have been successfully cubed by offsite companies. Agriculture waste such as wheat straw, rice straw, oat straw, flax, water hyacinths, and sudan grass have a moisture content between 8% and 18%, a bulk density between 25 and 34 pounds per cubic foot, and produce 4.5 to 12 tons per hour.

The steam generating system consists of a combination firetube/watertube steam boiler. Steam from the boiler system is piped to a heat exchanger where energy is transferred to the water stream of the main process. A bottom feed boiler which would accept shredded feed stock from 1" - 3" in size can be used with the same efficiency.

The heat exchanger consists of a plate pack of a calculated number of embossed plates with perimeter gaskets clamped between two carbon steel plates by means of tie rods. The plates have openings at corners to direct process and service fluid flows through the passageways between plates. Fluids flow alternately between every other plate in order to achieve correct heat transfer almost always in true counter current condition. The total implementation cost, including the boiler, cuber, and heat exchanger is $577,900. There is
a negligible payback because a negative cost savings is associated with this particular opportunity.

Discussion

It has been previously demonstrated by the Yakama Indian Nation that large number of fish can be successfully raised in the Hanford 100 K Area surplus water purification pools. Thus, suitable rearing facilities are in place and the Yakama Indian Nation possesses technical fish-rearing skills in the form of a large staff of experienced fish biologists, culturists, and technicians to supply warm-water species for sports fishing purposes.

The recommended alternative is utilizing the excess solar water heater from the 2750-E Building. Solar technology is safe, clean and efficient and reuse of the existing solar water heater from the 2750-E Building provides the greatest payback in close to 1 year and the upgrades to the unit and the associated costs are minimal.

The disadvantage for solar in this application is the heat generation capacity necessary for the winter months and the resulting high system cost. In the winter months, it may be necessary to supplement the solar technology with liquid propane during inclement or very cold weather. Since a constant water temperature is not critical to fish life, it may be possible to let the temperature drop some during the 3-4 month period of extremely cold weather. The implementation cost of a liquid propane tank and heater is less than $4,000 and the cost for liquid propane is minimal.

Cubing tumbleweeds and noxious weeds is not a viable solution due to the high cost of capital equipment and associated labor charges. Additionally, National Environmental Policy Act (NEPA) documentation may be required as harvesting this waste source is potentially a major federal action significantly affecting the quality of the human environment. The NEPA documentation is an added expense not calculated in the payback.

The solar panel system is an efficient energy source. However, the payback is over 9 years due to the initial capital cost of $36,000. A water source heat pump, on the other hand, will provide a good water heating method as the temperature of the Columbia River water is ideal for this type of setup. However, the disadvantage is the high initial capital cost.

Further, it is recommended to place a pool cover over the sand filter structure and the fish tanks to keep evaporative heat losses to a minimum. A pool cover can reduce heat loss by 70%.
Putting the proposed fish-rearing concept into use could be highly beneficial to the area's economy. In addition, it would also provide a purpose for the currently idle structures. The study concluded that the existing design of the sand filter and associated media are satisfactory for heating river water and rearing warm water fish species. The most energy efficient heating method is to utilize an existing solar water heater from the 2750-E Building.

Figure 1.1 The K Basin warm water fish rearing program conceptual design.