State of California The Resources Agency

Memorandum

Date June 5, 2006

To Frank Wernette, Environmental Program Manager I
Department of Fish and Game
4001 North Wilson Way
Stockton CA 95205

From **Department of Water Resources**

Subject: Response to CALFED Ecosystem Restoration Program's external review of *Northern Pike Containment System at the Outlet of Lake Davis on Big Grizzly Creek*

Attached are the Department of Water Resources responses to the comments Darryl Hayes provided on the design of the *Northern Pike Containment System at the Outlet of Lake Davis on Big Grizzly Creek*

If you have additional questions, please contact Gordon Enas at (916) 653-7589 or by e-mail at enas@water.ca.gov, or myself at (916) 651-9618, or by e-mail at tfrink@water.ca.gov.

Ted Frink, Chief
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Attachments

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External Review Form
CALFED Ecosystem Restoration Program
Northern Pike Containment System at Lake Davis

Reviewer: Darryl Hayes, P.E.
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Affiliation: California Bay Delta Authority Engineering Consultant (CH2M HILL)

Conflict of Interest Statements:
I have no financial interest in this proposal.
- Correct

Please explain any connection to proposal, to applicant, co-applicant or subcontractor or to submitting institution (write "none" if no connection):

None

General Review Questions:

1. **Goals.** Are the goals and objectives for the project clearly stated?

Yes. This project is intended to prevent the release of live northern pike, including eggs and larvae, through the Dam's low level outlet. This is viewed as an interim measure (between 2 to 5 years) until the northern pike can be eradicated from the reservoir. There is reference to other low level release alternatives considered; however, they are not specifically discussed. Interim measures to kill larger fish from the outlet have been implemented since the pike has taken residence in the reservoir using a grating attached to the energy dissipater wall. It is unclear if this method was successful at preventing some smaller fish from live release into the lower river over the past several years. **Lake Davis Fish Containment Committee Response: Visual observations and results from one published study (Rischbieter 2000) indicate that most fish are severely injured and unlikely to survive after exiting through the grater. (Rischbieter, Douglas. 2000. Structures to prevent the spread of nuisance fish from Lake Davis, California. *North American Journal of Fisheries Management* 20:784-790.) DWR has collected anecdotal information suggesting the grater occasionally allows smaller fish (most 2-3 inches, one observation up to 6 inches) to pass without immediate fatality; to date, only a few individual bullheads have been observed and most of these were severely injured and unlikely to survive.**

2. **Approach.** Is the approach well designed and appropriate for meeting the objectives of the project?

The approach to preventing fish escape is straight forward; however, there is little precedent to using strainers on a dam outlet for this purpose. Conventional facilities for fish exclusion are positive barrier fish screens installed on the inlet or below the dam; however, they have been dismissed for reasons unclear in this proposal. Strainers are used on many pump applications to remove fine debris and could be used in preventing fish from escaping as well. Because there is little precedence for this type of application, its application should be considered experimental in nature. If the system fails, it appears that the existing outlet works will not be compromised and it can be easily rebuilt. **Lake Davis Fish Containment Committee Response: We considered installing a fish screen within the channel downstream of the dam. The strainers were selected over the fish screens for several reasons:**

1) **Cost appeared to be equivalent to fish screens and could be lower.**
2) **Construction of the strainers may require less time and would definitely meet the project timeline.**
3) **Environmental permitting was more streamlined based on the designs presented at the time.**

In addition, the strainers were viewed as fail-safe; the screens would introduce pike into Big Grizzly Creek before the pike are removed.

There is no documentation on the appropriateness of using 1 mm opening strainers to prevent all lifestages from exiting the outlet. While this mesh is about the same size or smaller than the eggs, larvae may be smaller. The probability of survival through this system is likely very small, but without data to back this up, 100 percent fish kill should not be expected. A pilot test to look at survival of surrogate fish and egg survival through various sizes of mesh at similar pressures and velocities in a small strainer unit would be advisable if there is time. If this is not possible, different mesh size baskets could still be exchanged with those planned for purchase if necessary. Some biological testing of the system should be completed following project implementation to verify the effectiveness since this project should be viewed as a full scale pilot project. **Lake Davis Fish Containment Committee Response:**

<u>Egg Size</u>

Reference 1 - The following is an excerpt from *<u>Pike: Biology and Exploitation</u>*, John F. Craig, ed. 1996:

"The ovulated oocyte is spherical and its diameter is usually in the range of 2.3 to 2.5 mm given by Frost and Kipling (1967) for Windermere pike. Young females may produce 1.5 mm ova (Chauveheid and Billard, 1983). Fertilized eggs are larger due to the process of hydration of the egg envelope which occurs in water: 2.8 mm (range 2.6-2.9 mm) for Windermere pike eggs 3 h after fertilization (Frost and Kipling, 1967), 2.2-3.4 (Carbine, 1944), or 2.4-3.0 (Steffens, 1976)."

Embryos and Larvae Size

Reference 2 - The following is in part from Bry (1996) and Raat (1988):

After hatching, the yolk sac embryos are attached to plants by adhesive glands on the top of their heads. The yolk sacs are absorbed after 5 to 16 days, after which the larva release from the plant and become free-swimming. At the end of the embryonic period, fry are 0.45 -0.51 inches (11.5-13mm) long. At 0.80 inches (20mm), the young pike are considered to be in the larval stage (Bry 1996) and will migrate from spawning areas to sparser vegetated areas. Growth in the larval stage has been estimated to be about 0.40 inches (10 mm) per week in the Great Lakes region (Raat 1988).

Figure 1 is a picture of three northern pike yolk sac embryos lying next to a penny to indicate scale. Figure 2 is an image of a penny lying under a metric ruler, showing that the numeral 1 in the date is approximately 1 mm in height, and that the penny is approximately 19 mm in diameter. Referring back to Figure 1, it is estimated that the pike embryos are approximately 8 to 9 mm in length. The head is estimated to be approximately 1 mm in diameter.

Figure 1 – Northern Pike Embryos

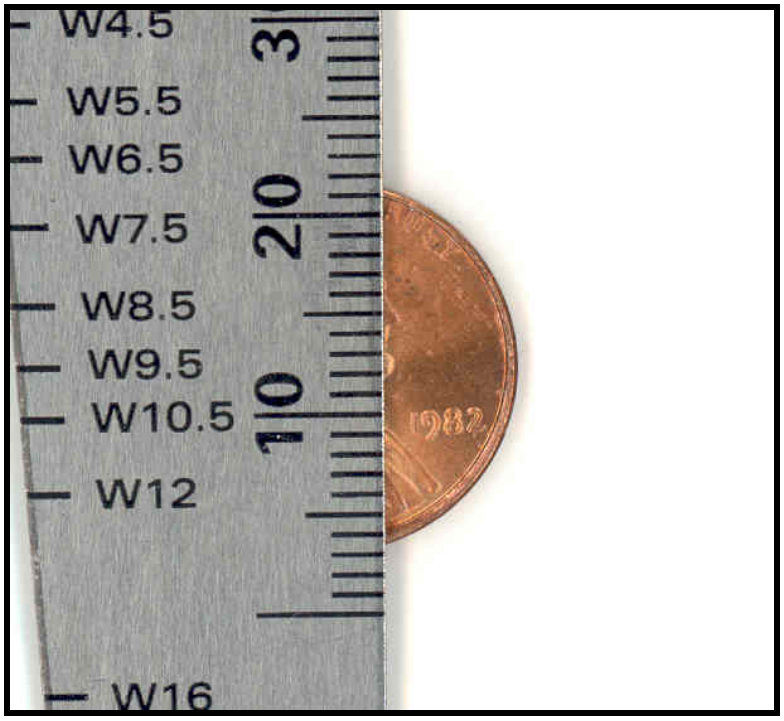

Figure 2 – Penny Dimensions

Screen Size Criteria

Reference 3 - The following are excerpts from *FISH SCREENING GUIDE FOR WATER INTAKES*, Chris Katopodis, February 1992:

"Screen mesh size: Clear openings of the screen (the space between strands) should not exceed specific values. These values depend on species, sizes and body shapes of the fish to be screened. Turnpenny (1981) examined 24 marine and freshwater fish and developed the following general relationship for fish screens placed at water intakes:

$$M = \frac{L}{0.0209L + 0.6564 + 1.199F} \qquad (1)$$

where:

***M* = screen mesh size (mm).**
***L* = minimum length (mm) of fish excluded.**
***F* = fineness ratio, the ratio of length to the greater of either maximum body depth or maximum body width.**

Mesh sizes recommended for screening walleye *(Stizostedion vitreum)* and northern pike *(Esox lucius)* are presented in Table 1. They were derived from equation (1) and adjusted after comparison with similar criteria used in practice."

Table 1. Mesh size criteria for fish screens.

Minimum fork length (mm)	Maximum screen mesh size (mm)	
	Walleye (F=5.5)	Northern Pike (F=7.0)
25	2.5	2.5
40	4.5	4.0
50	6.0	5.0
60	7.0	6.0
80	9.0	7.5
100	10.5	9.0
150	14.0	12.0
200	17.5	15.0

Evaluation of 1 mm Wedge Wire for Containment of Pike Eggs, Embryos and Larvae

Reference 1 indicates that the minimum size of pike eggs from young females is 1.5 mm and larger females produce eggs larger than 2 mm. Once the eggs are fertilized and hydrated, their size increases. Therefore, wedge wire with a 1 mm slot opening should be suitable for containment of pike eggs.

From figure 1, the yolk sac embryos are estimated to be 8 to 9 mm in length with a head diameter of approximately 1mm. At this size, it may be possible for the embryo to pass through a 1 mm opening; however, reference 2 indicates that the embryos attached to plants by adhesive glands on the top of their heads which decreases the possibility of this life stage passing through the 1 mm filter. At the end of the embryonic period fry are 0.45 -0.51 inches (11.5-13mm) long and become free swimming larvae.

Table 1 gives a slenderness ratio of 7.0 for northern pike for use in equation 1, reference 3. If a fork length of 11.5 mm for small larval pike is substituted in Equation 1, the resulting screen opening size is 1.24 mm.

Discussion and Conclusion

California fish screen criteria for 25 mm steelhead fry is 1.75 mm for slotted openings. Table 1 suggests a mesh opening size of 2.5 mm for 25 mm pike fry. Determination of a screen slot size to contain early life stages of northern pike is balancing act between the risk of discharge of pike with the rate of plugging of the

containment strainers. The smaller the openings in the strainer screens, the quicker the strainers will plug. If the openings are too large, eggs or larval pike may be discharge downstream.

The proposed 1 mm screen size appears adequate for containment of pike eggs and larval sized juveniles over 10 mm. There is a small chance that yolk sac embryos could be discharged through a 1 mm screen if they don't attach to vegetation upon hatching and are subject to a flow pattern in the reservoir that directs them to the outlet. Since the reservoir outlet is deeply submerged and hydraulically distant from prime pike spawning habitat, it is unlikely that embryonic pike would survive predation and/or discharge through the reservoir outlet during the short period of time that they are of a size that could pass through a 1 mm strainer screen.

Therefore, we conclude that 1 mm is an appropriate strainer mesh slot size for containment of the early life stages of northern pike.

The approach to cleaning the strainer units during flow release operations is also not well understood. Specifically, it is unclear how individual basket strainers will be cleaned without completely shutting down the outlet. The drawings included do not show isolation valves for each strainer unit. The ability to maintain minimum downstream flows during daily inspection or cleaning of the strainers may not be acceptable. **Lake Davis Fish Containment Committee Response: Each strainer has a valve on the inlet and outlet. The cleaning process will include isolating the strainer from the system by closing the valves, removing the basket and replacing with a clean one. The dirty basket will be removed from the strainer and cleaned off-site. Additional baskets have been purchased so that the strainer can be returned to service immediately without waiting for the original basket to be cleaned.**

If maintaining some downstream flows are necessary, consider putting a temporary strainer on the 10-inch pipe, or adding isolation valves upstream of each strainer. **Lake Davis Fish Containment Committee Response: Once the strainer system is in place the 10-inch pipe will no longer be used, except for during an emergency drawdown.**

3. **Feasibility.** Is the approach fully documented and technically feasible? What is the likelihood of success?

Overall I agree that this system should provide a high level of protection against the live release of eggs and larvae through the low level outlet if properly maintained and operated. The following are specific comments on the design drawings submitted for review:

1) Isolating individual strainers for inspection or cleaning is not provided. It appears that the entire outlet must be shut off at the existing control valve for cleaning. This may disrupt the continuity of downstream flows. **Lake Davis Fish Containment Committee Response: A 24" butterfly valve is attached upstream and downstream of each strainer. See Drawing C1-4.**

2) Valves upstream from each unit should be provided to allow for removal of an individual strainer unit for cleaning or repair without compromising the entire filtering operation. **Lake Davis Fish Containment Committee Response: A 24" butterfly valve is attached upstream and downstream of each strainer. See Drawing C1-4.**
3) The text indicates that flows through individual strainers should be between 10 and 23 cfs. Outlet flows are up to 190 cfs, indicating flows will be over 30 cfs per unit if all in operation with equal flows. If this is a flow criteria, than additional strainers should be provided for the higher flows. Redundancy of at least one strainer unit may also be advisable. These issues may have been addressed in the final design. **Lake Davis Fish Containment Committee Response: Eight strainers will be installed. Each strainer has a capacity of 25 cfs. The 10-23 cfs refers to the range of stream releases that will be required through the 10-inch pipe while the strainers are being installed.**
4) Details of the trashracks on the existing intake are described but not shown. Cleaning of a trashrack with a smaller opening that the existing rack may need to be anticipated. These trashracks may be necessary for strainer protection more than for the exclusion of larger fish. Larger fish will not escape the small strainer. **Lake Davis Fish Containment Committee Response: Modifications to the existing trashracks may be required if a significant amount of large debris is collected in the strainers. This determination will be made after the strainers are in operation.**
5) Details of attaching the fish grater at the end of the relocated emergency outlet are not shown. Attaching this grater to pipe exit will require substantial support due to the high exit velocities. **Lake Davis Fish Containment Committee Response: The exact connection detail is still under consideration.**
6) Loss of the existing dissipater wall may cause erosion at the new pipe outfall. While this is not anticipated to cause dam instability, erosion may cause additional siltation or bank instability in the localized area of the outfall. Protection measures may be required. **Lake Davis Fish Containment Committee Response: There is the potential for erosion to occur downstream of the outlet pipe. The existing channel however, is lined with naturally occurring bedrock which will provide a level of protection from erosion. In addition, the discharge pipe will discharge into the channel, not onto the stream bank. We expect movement of about 4 inches of loose material initially. After that, water should discharge directly on to bedrock. Because we expect minimal impact to the bedrock channel and a less than significant impact to water quality, we decided to leave the discharge design as is.**
7) Static head may be up to 110 feet at this outfall. Thrust loads at the pipe 90 degree bends should be resisted. This should be accommodated in the design. **Lake Davis Fish Containment Committee Response: Provisions for resisting thrust and seismically induced forces have been incorporated into the design.**
8) It is unclear why the 30-inch pipeline is reduced to a 24-in pipeline downstream of the strainer units. This could result in pipe velocities up to 60 feet per second at full capacity. Exit velocities of 60 feet per second may also erode the area

downstream of the outfall. This may have been considered in the design, but no details are provided for the reduction in pipe diameter. **Lake Davis Fish Containment Committee Response: Both the outlet pipe from the strainer and the emergency outlet pipe are 30" diameter steel pipe. The pipe reduces to a 24" diameter pipe to accommodate the strainers. The 24" strainers were selected because they are more readily available from strainer manufacturers. Larger strainers usually require a longer lead time and which would delay the project.**

9) A suitable anchor strap at the end of the exit pipe should be provided. Exit velocities of up to 60 fps are likely to cause some pipe instability. **Lake Davis Fish Containment Committee Response: Provisions for resisting thrust in the pipe have been incorporated into the design. To achieve an exit velocity of 60 fps the flow through the 24" strainers would have to equal 200 cfs. This flow rate however, does not consider the head loss through the additional piping, strainers and valves. It is very unlikely that the exit flow will reach 200 cfs. Our design estimate is about 120 cfs.**

Specific Review Questions:

1. Does the project have the potential to effectively screen all life forms of northern pike?

As described above, there is a high probability that this system will prevent survival of all life forms downstream of the strainers. A test to verify its effectiveness using some fish surrogate should be completed following installation if this can not be demonstrated prior to project implementation. **Lake Davis Fish Containment Committee Response: See response for appropriateness of using 1 mm opening beginning on page 2.**

2. Does the project approach include adequate contingencies to ensure successful implementation?

Contingencies are not well addressed. Isolation valves upstream of each strainer unit could allow for partial operation of the strainer system if there is a problem with one or more units out of service. **Lake Davis Fish Containment Committee Response: See response on page 6.**

The attachment of the fish grater to the 30-inch pipe is not clearly shown. This may be necessary if emergency releases can not be accommodated through the strainers. **Lake Davis Fish Containment Committee Response: See comment to #5 on page 7.**

3. As designed, will the containment structure as a whole and the filtering devices individually function for a sufficient period of time to allow for the DFG to fully eradicate pike from Lake Davis (assuming a successful pike eradication project can be implemented within the next two years)?

Strainer units are used for industrial pumping applications and should perform for the life of the project. This system is likely to require extensive maintenance over the life of the project to operate effectively. **Lake Davis Fish Containment Committee Response: We have budgeted for daily cleaning of the strainers. The cost of the operation and maintenance through FY 2010 is included in the total cost of the project.**

Miscellaneous comments:

In completing this review, I discussed general project and background information with George Heise, DFG, and T.C. Liu, DWR.

It is assumed in this review that all design issues related to the outlet have been or will be adequately addressed. I have been informed that the Division of Safety of Dams is not concerned with the project implementation and that design details have been adequately developed to address all dam safety and dam operations issues.

DWR or the ERP should be committed to ensuring that this facility is operated, maintained, and protected as designed.

I also had an experienced dam engineer from CH2M HILL (Roger Lidquist) review this design as well. He was unfamiliar with this application being used elsewhere and was most familiar with intake screen applications. He also had several dam safety/release issues that are beyond the scope of this review. He concurred with the general comments above.