Davis Hydro, LLC.
27264 Meadowbrook Drive
Davis, California, 95618
530 753-8864 Fax 530 753-4707
Email: Dick@davishydro.com

August 25, 2010

The Honorable Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 – 1st Street, NE, Mail Code PJ-12.3
Washington, DC 20426 *filed electronically*

Re: Comments on the June 2010 Draft Environmental Impact Statement, P-606 License Surrender

Dear Ms. Bose:

Process

We have filed extensive comments on the DEIS on 7/26/2010 (FERC Accession No. 20100726-5012), and wish to have those acknowledged and incorporated. At your second Public Hearing on the DEIS, due to time constraints and previous speakers, we had to rush through our comments. The complete comments, as they would have been presented, are attached as Attachment 1. Please incorporate them into the public record.

Federal Data Quality Act

We again require that all data and studies used in your EIS be presented accordance with the 2002 Federal Data Quality Act (DQA) as well as standard NEPA procedures for supporting studies. Data used shall be presented in the proper context and identify the source along with the supporting data or models so that the public can assess for itself whether there may be some reason to question the objectivity of the sources. Id-DQA.

DQA requires that the substance of information disseminated must be accurate, reliable and unbiased. Id. FERC must identify the sources of the disseminated information, the methods used to produce it, and provide full, accurate, and transparent documentation. 67 F.R. at 8460. NEPA and DQA requires that sound statistical research methods must be used to generate original and supporting data and develop analytical results. Id. at 8459. Data subjected to formal, independent, external peer review, is presumed to be of acceptable objectivity, although such a presumption is rebuttable.

Substance

The remarks below, address only the Kilarc facility and the analysis of its components in this draft of the EIS, for it is clear to us that the Kilarc facility and the South Cow represent completely different issues and opportunities for all concerned – both the community and the fish.

No Significant Anadromy Possible

Bob Carey in his public remarks on 8/17/2010 before the FERC, addressed the CDFG Memorandum introducing the idea that steelhead could pass both Whitmore Falls, and the reference paper cited by CDFG. He carefully read the cited paper and applied it to the situation at the Whitmore Falls. He showed clearly that the probability of significant use of the waters above the Whitmore Falls by rainbow trout for anadromy is nearly impossible. Attachment 2 to this letter is the key memorandum by CDFG staff. Attachment 3 is the reference paper cited. The conclusion is clear to anyone who reads the reference, and places it in the geographic context so well described by Mr. Carey of fish conditioned by 250 miles swim from the sea.

Upstream passage of fish and the presence of fish in the ten miles between the Whitmore Falls and the Kilarc Project are not negatively impacted by the project. Many people have testified that there are no steelhead and very few trout above Whitmore Falls.

If there is no anadromy many miles below the Kilarc project, what then are we doing even mentioning it in the EIS except to eliminate it from consideration?

<u>Water Temperature and Habitat Destruction</u>
The Kilarc Project lowers water temperature in the Old Cow. How much is to be determined, but it is clearly greater than zero. It is also clear that a major water quality issue on the lower Old Cow and Cow Creek is high temperature caused by many factors that we can address, but helped by the cooling effect of the Kilarc Project. Therefore, on temperature alone, - however small the effect, removing the project will harm, i.e. "Take", steelhead lower in the Creek. If any action resulting from the disposition of the Kilarc facility "Takes" anadromous fish, which are known to exist in the Cow, please include this "Take" in the EIS. It can be estimated from the studies on temperature effects Dr. L. Thompson of UCDavis.

<u>Long Term Habitat Destruction from Fire</u>
Removal of the Kilarc facility will increase the prevalence of fires in the area over the long term. Fire destroys the soils structure and increases rapid erosion into the Creeks we are trying to protect. This marginal increase in fires will statistically decrease habitat long term, and will decrease any fish resources in the area. Well below the Whitmore Falls and in the South Cow this negative environmental impact will result in a "Take" of an endangered species – as they are well documented in the Upper Cow and upper reaches of the South Cow.

<u>Fishing Pressure</u>
Removal of this very popular Kilarc Reservoir and its put-and-take fishing spot will drive fishers downstream to others fishing areas closer to the Main stem of the Sacramento River where they may catch steelhead or potential steelhead. This represents additional fishing pressure take represents a "take". Please include this "Take" in the EIS.

<u>Acid Rains</u>
Removal of this renewable resource will have as a direct consequence the continuation of a natural gas/coal mix in the greater California electric power market. The acid rains, heavy metals, and other contamination will be spread downwind across the Midwest poisoning to a microscopic extent many millions of square miles of habitat of endangered fish. The effects of pH and other contaminants on this species is well known from the literature. This indirect pervasive effect, much like global warming, represents a statistical "Take" of many - fish and other species notably amphibians across our country.

In the EIS please include this "Take"' not only of steelhead by all affected species impacted by changes in acid rains – Frogs and many well documented species of the acid rain-burned Green Mountains of Vermont are typical examples. "Take" of all species should be considered. Ignoring these incremental national and global effects by an agency that espouses Federal environmental domain is disappointing.

Replacement Power Construction

Removal of the Kilarc facility and the construction of any replacement power plants will have direct and indirect consequences throughout our economy. The economic multipliers are reflected with EPA environmental multipliers showing how for any economic activity there is a consequential environmental degradation. In this case, they are twice as large as normal due to both the site demolition and the *de novo* new site construction.

These construction impacts extend throughout our economy and destroy habitat and wildlife just as far. Some of the impact is resident on endangered species and indeed even the potential steelhead across these United States. This "Take" should be considered. These are National/ International effects on all national/international species of concern. In summary, in the EIS, please incorporate the national effects of demolition of green power resources.

Resident Fish and Habitat Diminution

Assuming that water were returned to the Kilarc bypass reach, and assuming that the small trout population there expanded, what would be the consequences? The fish that are present in the Old Cow are derived from fish that have been in this area for over 100 years augmented by the fish from hatcheries. Any anadromous fish would have (by definition) long ago left. This means that these "resident adapted" or "resident mode" or "resident eco-response" or "resident form" (depending on the author) fish will expand and emit juveniles downstream. Way downstream these juveniles will compete in known steelhead areas and put selection pressure on steelhead juveniles competing for the same resources. This competitive pressure with listed steelhead and possibly (to a small extent) juvenile salmon for habitat represents a "Take" of these species. Please include this "Take" in your analysis.

I will stop here. This has all been said before in many earlier filings by ourselves and others. Unfortunately, these filings were neither considered nor yet incorporated into the draft EIS.

The destruction of Green power generation, the fish, our atmosphere, the community, and incrementally the thousands of affected species by Federal Agencies should only be done if there is overwhelming evidence of some higher goal. In the EIS, please make it clear what is this goal.

Alternatives

Davis Hydro has put forth somewhere over 4 evolving Alternatives to demolishing the Kilarc site – all of them can be enabled by willing participants within the FERC process. They started on an early idea that we could use significant parts of the revenues from the Kilarc facility to sponsor resource enhancement. The Davis Hydro Alternatives have evolved. They evolve daily as in any adaptive management plan; we learn as we are going. They evolve because the genetic and epigenetic sciences under us is evolving even faster. It is evolving due to constructive parallel analyses by the newly enlightened fish resource Agencies such as the EIS on the Hatchery operations.

Goals and the Law

When Davis Hydro first came upon this project, it was seen as an opportunity to use the hydropower to help protect or enhance an endangered species.

> *Davis Hydro will, if allowed, use its resources through and with the Kilarc Foundation to help the fish whether or not there are any endangered species.*

This is important because it is unlikely there is any speciation, or even profound genetic effects at play in the issues before us such as steelhead anadromy. The law, and even its intent, may not be applicable. Science has moved on, especially in the last two years. Epigenetic effects on the surface of a quasi-stable O. *mykiss* genome are the probable cause of most anadromy, eco-responses, and most likely the cause of failure to thrive in the first year from hatcheries. This science is rapidly changing as we understand the modulation of genome expression of phenotypic behaviors from what would be an appropriate allele. Science is now far ahead of the law, and our efforts want to be directed at the fish, not at the law.

Davis Hydro, working with fish geneticists will develop this further in future filings or working papers as the science develops[1]. Suffice it to say, our ability to help these fish appears to have nothing to do with "Endangered Species", little to do with genetics, and nothing to do with the extremely rare fish that might pass up the Whitmore Falls. It does have a great to do with intent and actions.

Our intent from our fist conversation with CDFG is that we will figure our how use this project to help the fish or we will not do the project. We are figuring out what to do as the science changes underneath us. We are learning, and a review of the dates of much of the recent work on, anadromy, steelhead, restoration genetics, and the CDFG hatchery EIS shows, everyone else is also learning at an ever increasing rate. We want to be part of that recovery.

Intent

We do not speak only of promises. We have set up the Kilarc Foundation LLC for the long term handling of resource enhancement and related research projects. We have committed a percentage certain of profits from any operation of the Kilarc facility into that entity. We have stated that frankly we are not interested in discussing the applicability of the Endangered Species Act, or arguing about the rare passage up the Whitmore falls; we are interested in helping the fish, and we are committed to it, and we want to get to work.

---

[1] A brief review of the changing landscape of the understanding of steelhead anadromy can be had by anyone observing recent scientific papers and their dates or by searching on "steelhead epigenetics" in Google, Science Citation Index, or any good biological scientific search engine.

Actions

It is not easy to take many actions to date due to lack of control of the site, or cooperation with PG&E or any State or Federal agency. However, the following are underway:

Underway

1. We have set up the Kilarc Foundation and will fund it to the extent possible.

2. We have started by starting a Restoration Genetics program to address the problems identified by the USFWS/CDFG 2010 Hatchery EIS/EIR. This has led to a comprehensive temperature monitoring program of the Old Cow to define the target temperature regime we will be restoring fish into. This temperature, flow and water quality profile definition will be extended into other target Creeks for the benefit of new eco-adapted restoration projects in the future.

3. We have retained a fish genetics consultant and specialists on fish screening.

4. We have studied the whole of the Old Cow and much of the bypass with numerous other biologists looking for the most effective use of this resource and what we can do down on the Cow.

5. We have started a dialog with the Olsen Project downstream asking them to engage with us in studying the Old Cow habitat area, to see if we can enhance it.

6. We have outlined a program of micro-spawning grounds to be seeded with fish or egg-cases to be distributed up and down the Sacramento River. This will restore small local-eco-adapted stocks of fish that do not suffer from the epi-genetic problems endemic in the larger hatcheries.

We have proposed and the Kilarc Foundation may fund carrying out the following activities, if permitted:

Proposed Actions

1. Research
    a. Spawning
        i. In-gravel studies
        ii. Cover, hydraulics, composition
        iii. Predation In and post emersion
    b. Informal Screening
        i. We will test and display numerous screens in the Kilarc Canal showing how fish can be screened by ranchers economically
    c. Herding studies
        i. Fish herding studies started at UC Davis can be continued here, for the benefit of fish resource management everywhere.
    d. Physical Facilities

i. Wet/ Dry Lab. Research facilities, bunkhouse provided
ii. Fully instrumented study areas
iii. On-Canal and Up Old Cow study areas made available

2. Eco-System Restoration
   a. Kilarc Foundation will choose and fund cost effective off-site projects – fences, screens, easements, run-off controls
   b. Seek matching grants to extend screening
   c. Work with WSRCD on joint-funded projects
   d. Possible hands-on maintenance of diversion screens

3. Restoration Genetics
   a. In headrace a prototype of different types of micro spawning beds to be established in targeted tributaries around the upper Sacramento
   b. Temperature profiles and spatial studies to match genotype sources to target spawning beds.
   c. Support for expansion of State and Federal conservation genetics program.

4. Production
   a. In Kilarc Channel the production of genetically appropriate stocks to restock Cow Creek. This is a small effort.
   b. In other off-site spawning beds, inseminate these beds with appropriate genotype epigenetic encoding to the diverse target micro-ecosystems we are seeding. This is necessary for proliferation. This is expected to be a large effort and very controversial. It will be fraught with failures, difficult to measure success, but <u>essential</u> for rapid restoration of a diverse healthy population in the Sacramento.

5. As Davis Hydro, we will start an education outreach program at the Kilarc Reservoir that will have as elements
   a. Spawning demonstration and explanation
   b. Field run-off pollution explanations and demo
   c. Several different types of economical low-maintenance screens.
   d. Hands-on workshops for showing ranchers how to protect their fish: screening and irrigation plans, drawings, controllers, material lists, subsidies, handholding, encouragement to protect <u>their</u> fish … we are dead serious.
   e. School-kid level demonstration and explanation: Paper handouts and tours of brood ponds, screens, and
   f. Websites with
      i. All applicable papers and explanatory material on how to save the fish
      ii. Background and details of fish screens

iii. Programs for conservation easements
iv. Contacts for getting help

In Conclusion

We ask that the next draft Environmental Impact Statement consider all applicable Alternatives and studies requested two years ago. We ask FERC assist in holding meetings with the resource agencies to see if we can find some common ground. It is extremely disappointing to be dealing through FERC with the very people we want to work with to help the fish. We again request a new direction in the EIS.

We again hold out our hand to the fish Resource Agencies saying we cannot do this alone, please help. Fish restoration requires source stocks, genetic labs, access to spawning grounds, and coordination with other programs. Restoration transplanting, for example, requires a correct balance of appropriate effective population size into any area where there is indigenous ancestral stock. This is fraught with risk, for the bottlenecking of the transplant eliminates many alleles that may have been useful, yet importing too many overwhelms local resistant alleles and leads to out-breeding depression. This is currently as much an art as science. We would like to be useful as we can be in helping larger entities establish a plethora of small targeted inoculants, tailored in their origin to survive the restoration transplant.

In closing, we at Davis Hydro have come upon this problem/opportunity 3 years ago. We wish to be the field hands and possibly to some extent the science out reach team for the restoration process. Our friends in genetics and soon in epigenetics are not generally in the field with field experience. We see ourselves working in that vane. We see many failures ahead as pointed out by an earlier CDFG review. We are not afraid of failure, for we know that that is a statistical reality in this field. We are relieved that it appears that the steelhead behavior is not a fragile – perhaps not an uncommon allele expression, but an epigenetic imprint that is passed between generations for expression when conditions permit. This is yet to be tested. Given that this is a new field and a very new line of research, we expect and welcome overcoming problems. We have started and we hope to succeed based on our expanded reading in restoration genetics, and applied genomics.

FERC, Davis Hydro asks you to start again to help us save the fish, and by doing so save the Community its needed services and in passing the accompanying planet.

Respectfully submitted,

Richard D Ely

Richard D. Ely
Davis Hydro, LLC

cc: P-606 Service List

CERTIFICATE OF SERVICE

I hereby certify that I have on this day served the foregoing document by first class mail postage prepaid or email upon each person designated on the official service list compiled by the Secretary of the Commission in this proceeding.

Dated at Fair Oaks, CA this 25th day of August 2010.

Kelly W. Sackheim

Kelly W. Sackheim, Principal
Sackheim Consulting
5096 Cocoa Palm Way
Fair Oaks, CA 95628

Attachment 1: Presentation Prepared but Not Presented Due to Time Constraints

Remarks of Dick Ely / Davis Hydro / 8 /17/10
FERC Public Hearing P-606

Thank you for coming FERC, NMFS, CDFG/CA {rep}, etc.

It has become apparent to many that to protect the Kilarc Facility, we need to address the protection of all fish in this area. Expressed differently, **to save Kilarc is to save fish**. So my remarks tonight, address the restoration of trout and steelhead fish to the area, for that is a minimal condition to preserve the Kilarc facility and our objective.

Everyone in this room is interested in the health and welfare not only of the community, but also of the natural resources in which we live. *Is there anyone in this room who is not interested in the health of the trout in the Whitmore area? Is anyone here not interested in returning the Cow Creek in so far as possible to a fertile trout stream filled with anadromous fish at least up as far as they will go.*

We, at Davis Hydro join that community goal and the use of the resources of the Kilarc facility to address the same objective.

We have been active on this journey learning how to restore fish in the Old Cow for the past 3 years. We have met hundreds of local residents and similar numbers of fishermen from neighboring communities, and I have not met a single person who is not interested in having a lot of healthy fish native in the area. The reason we are here, - the reason for this meeting, is not a question of wanting to help the fish, it is only the best method of how to do it.

Currently, I am a passive Guardian in the Sierra Club. However, years ago, in New England, I was an officer and committee chair. We and other environmental groups worked with agencies and activists to help anadromous salmon. We sought to stop both massive Dickey-Lincoln Dam Project on the St. John and other projects – mostly nuclear back in the 1970’s.

I went into small hydro and various wind technologies to find environmentally acceptable solutions to the growing demand for electricity. We have always sought to use small hydro to enhance fish and the environment at the same time. We built turbines and helped people at over 20 sites all over the world as alternatives to oil, coal, and nuclear power.

Later, at the University of California at Davis, with Joe Cech, we researched fish-friendly low head turbines that will pass fish both ways mostly for irrigation canals and use in the third world. After that, we developed a fish herding technology for guiding fish past hazards or toward good spawning grounds. That work led us to the Cow Creek Watershed Management Group looking for a test area for that technology. As we have studied the problems of the steelhead trout and Salmonids, we are now moved into the study of species restoration and conservation genetics, with a special interest in the epigenetic processes which are applicable here.

With this background, DH extend our hand, in a common interest community, to the agencies to ask not only how can we fight to save the community resource, but rather how can we use our community resources to meet our common objective of enhancing fish.

In effect, we ask - starting on the day we heard about the Kilarc Reservoir, the day we met Mike Barry of CDFG, "What can we do to meet and exceed all possible objectives of the fish resource agencies. – How do we use the Kilarc Project to enhance fish.

Enough of Davis Hydro's past. Now what we are doing .

Earlier this year. We formed and funded the non-profit Kilarc Foundation to address restoration of trout populations in the Northern Sacramento River area. The Kilarc Foundation will channel money and boots-on-the-ground from hydro operations to improve trout, anadromy, and possibly other Salmonids in the Northern Sacramento Area. The non-profit Foundation is currently funded by Davis Hydro and is seeking directors from the Community who are interested in the long term health of the fish. It will be partially funded in the future by Kilarc revenues, but we hope to give up all management or directorship responsibility. The Kilarc Foundation has as its mission to restore fish to the streams of the upper Sacramento. We welcome partnering with the Agencies, and ask that they advise and serve as committee members giving direction to these efforts.

The Foundation is initially engaged in five separate but connected efforts to address use of the Kilarc facility for the fish. These include Genetics, Habitat restoration, steelhead Production, Research, and Education.

These have all been discussed at length in working papers and filings on our website. Tonight, I will only focus in on only the Genetics area. I focus briefly on genetics because it is fundamental to our mission and the most difficult to understand and address in the field successfully.

On January 11th, of this year, the CDFG released its Environmental Impact Report on Hatchery operations. This document was a stunning denunciation of the Federal and State practices of operating hatcheries in California. This excellent work is the largest Mia Culpa document by any group of agencies I have ever seen, and I have been in the environmental business for over 40 years. It is an extraordinary admission by these agencies of their culpability in destroying the health, genetic diversity and viability of Salmonids in the Sacrament River basin.

We all know that water quality and ecosystem destruction is a major cause of fish loss. If this habitat degradation is one half of the cause of fish demise, hatchery practices and consequential genetic diversity collapse comprise most of the other half.

Let me explain briefly, because from this genetic calamity comes the opportunity, if not obligation, for restoration.

The hatcheries have produced many hundreds of thousands of fish from a relatively small number of parents. In effect, the hatcheries have released thousands of hatchery adapted fish that were brother and sisters. Because some of these fish later return, and breed again, most fish released from hatcheries are siblings or near cousins. These poorly-adapted siblings now perfuse most of the northern Sacramento Basin. The limited genetic diversity created by these hatcheries and ecosystem degradation have had the following effects:

Inbreeding Depression (What happens if you marry your sister)

- Results in: poor reproduction, small size, and
- the expression of recessive traits'.

We know what happens in humans when inbreeding occurs. You are familiar with the effects of marrying in family in humans – it is the same for fish.

Lack of diversity

- Greater vulnerability to disease,
- lack of adaptability to different habitats, and weather changes and
- severely reduced evolution potential for selection has fewer options to work with.

There are many other derived effects – all negative, which I shall skip!

Suffice it to say, we cannot just "produce more fish". Even allowing the survivors of the hatcheries to reproduce may limit recovery of healthy stocks for many years.

Inadequate Federal Conservation genetics programs must now evolve to extensive fish restoration genetics efforts throughout the state. Restoration genetics is an extremely complex blend of science, art, luck, and population management. Restoration genetics is a "new" science - it is the art of learning how to rebuild a population in a geographic area. It is in no way simple. To date it has a track record, in other species, with at-best mixed results.

Davis Hydro, through and with the Kilarc Foundation is anxious to undertake our small component of this work, Our work has started in acquiring a staff fish geneticist, and an field study of the Old Cow.

To successfully restore fish in an area, the environment they come from has to match the area you are planting them in. Each fish carries an epigenetic signature imprinted on its genome by the environment on how to survive in a particular ecosystem. This is passed for parent to child, and a careful mach as to be made for the progeny of source fish to survive.

Annual temperature signatures are currently considered to be the most critical environmental variable triggering migratory behavior not only for anadromy but also to the correct temperature waters for survival. Since we are initially focusing on Kilarc, we have started a multi year river flow and temperature study down the Old Cow.

The temperature data collection and study has already started with 10 temperature data loggers in place from above the projects all the way down past the South Cow junction. They will record hourly for two years before recovery. Annual temperature signatures are important because they are a key component to match any the source populations used.

We are researching epigenetics, or the modulation of gene expression by the environment appears, from the literature to be the best explanation, the rainbow/steelhead trout dichotomy. It is the basis of habitat adaptation, and it the basis of some needed research. {This is a possible cause of hatchery depression}.

Epigenetics is an even newer science than Restoration Genetics, but may more easily explain both the occasional behavior of anadromy and the survivability difficulties of introduced stocks.

We need to balance fish population introductions making them large enough to provide genetic diversity but small enough so as not to overwhelm any remaining local adapted or ancestral genotypes. The Foundation will develop a protocol re-establishment and promote it as an example for sites and other communities to follow as we rebuild small local eco-adapted populations of Salmonids. For it is the health of this resource that causes agencies to threaten the demolition of the Kilarc facility.

This is our mission. To preserve the Kilarc for fishing, ourselves, and the community – we must, Restore the Fish.

In closing, we, with the community, reach out our hand not in only cooperation but in dedication to the restoration of the Steelhead to the upper Sacramento. We reach out our hand in cooperation with the resource agencies to be an engine of discovery as to how to do this difficult work throughout the area. We reach out to PG&E asking for their cooperation in our studies and understanding that should, we take over the project, our efforts will produce a 100 or a thousand more fish that would be possible under the flow restrictions you were facing.

We reach out to Sierra Pacific, another natural resource company. We will unilaterally go before the state Forest Board and work to get regulations changed to let you support our efforts. We want you as renewable resource partners, and we want your conservation efforts to be seen.

Finally, we can only do this with the community, for it is the community who controls the habitat for the fish. If the Community wants to save the Kilarc, we need your cooperation in habitat restoration. Please join us in transforming the Kilarc facility into a shining example of natural resource protection and enhancement.

The burden to do the work is on us. The burden of research, of proof will be on us, but if successful we will share the benefit with all.

Thank, You

Attachment 2

State of California

Memorandum

Flex your POWER

To: Files

Date: February 27, 2002

From: Curt Babcock
Northern California-North Coast Region
Department of Fish and Game

Subject: Old Cow Creek, Shasta County

On January 16, 2002, Fisheries Biologist Teri Moore, Environmental Scientist Jennifer Bull, and Staff Environmental Scientist Curt Babcock visited upper Whitmore Falls on Old Cow Creek in Shasta County to assess whether the falls are a barrier to upstream migration of steelhead (*Oncorhynchus mykiss*). On February 21, 2002, Teri Moore and Curt Babcock visited lower Whitmore Falls and revisited upper Whitmore Falls for the same purpose. Upper and lower Whitmore Falls are located in Section 21, Township 32 North, Range 01 West, approximately 1,000 feet and 2,500 feet downstream from the Whitmore Road crossing of Old Cow Creek, respectively.

The flows on January 16 were low (approximately 50 cubic feet/second) and the water temperature was measured at 38 degrees Fahrenheit at 1100. The upper falls consist of a main falls to the left of center where the majority of water flows. The upper falls height was measured in the center from the falls crest to plunge pool water elevation at 9.5 feet. The plunge pool was not measured for depth. The plunge pool and habitat downstream for approximately 300 feet were snorkeled. No fish were observed, which is not uncommon at that water temperature. On February 21 the flows were approximately 2,900 cubic feet/second (U.S. Geographic Survey Millville stream gage data). The water flow at this and higher levels may provide other routes for passage.

The lower falls consist of a clear fall on river left that was approximately 7 to 8 feet in height and a chute/falls on river right that was approximately 6 feet total drop in water elevation and would provide the easiest route for passage. The landowner stated that the plunge pool depth was approximately 10 to 20 feet.

The lower falls are probably not a barrier to steelhead at most flows as the falls height is well within a steelheads vertical leaping capability and the chute/falls to the river right may be an easier route. The upper falls approach a steelheads leaping capability of 11 to 14 vertical feet (Powers and Orsborne 1985). At higher flows, the plunge pool elevation would rise and the falls height consequently decrease, decreasing the effort needed for passage. We concluded that steelhead may be able to ascend the upper falls.

Attachments

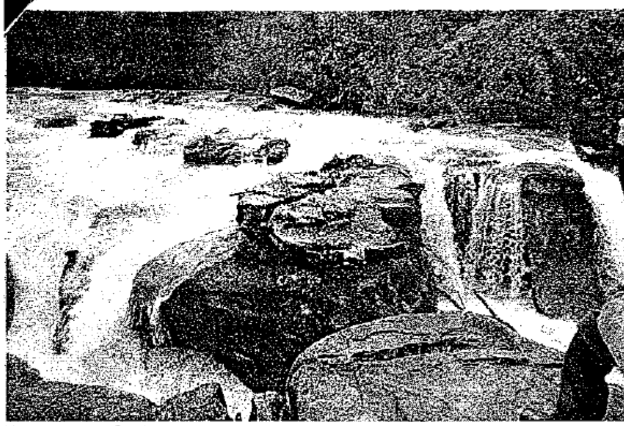
CB:sh

cc: R. Benthin, M. Berry, and A. Manji
Northern California-North Coast Region, Redding

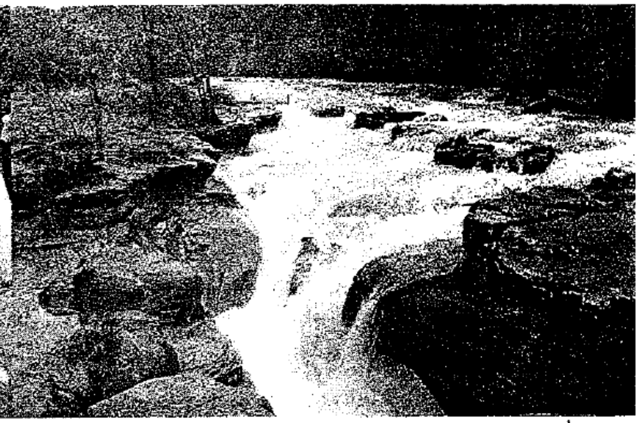
References:

Powers, P.D., and J.F. Orsborne. 1985. Analysis of barriers to upstream fish migration; an investigation of the physical and biological conditions affecting fish passage success at culverts and waterfalls. Albrook Hydraulics Laboratory, Washington State University, Pullman Washington, submitted to: Bonneville Power Administration, Project No. 82-14.

itmore Falls - [illegible] Cow Creek



lower falls



lower falls - chute on river right

lower falls - chute on river right

lower falls - river left

upper falls

upper falls

Attachment 3: Excerpts from

FINAL PROJECT REPORT

Part 4 of 4

Analysis of Barriers to Upstream Fish Migration

An Investigation of the Physical and Biological Conditions Affecting Fish Passage Success at Culverts and Waterfalls

Prepared by

Patrick D. Powers
and
John F. Orsborn

Albrook Hydraulics Laboratory
Department of Civil and Environmental Enqineerinq
Washinqton State University
Pullman, Washinqton 99164-3001

Submitted to

Bonneville Power Administration

Part of a BPA Fisheries Project on the

DEVELOPMENT OF NEW CONCEPTS IN FISHLADDER DESIGN

Contract DE-A179-82BP36523

Project No. 82-14

Auqust, 1985

FISH CAPABILITIES

Swimming Speeds

The objective of this section is to document values for the upper limits of swimming speeds, leaping capabilities and swimming distances for adult salmon and steelhead trout, and to evaluate their performance in a format useful for analyzing barriers. In order to differentiate between water velocity, fish velocity and relative velocity of the fish to the water, the term "speed" will be used to denote the rate of motion of the fish as an object with respect to a reference plane. Relative speed will denote the difference between fish speed and the velocity of the water, that is:

$$VR = VF - VW \tag{1}$$

where VR = relative speed of the fish to the water; VF = speed of the fish; and VW = velocity of the water.

Ranqes of speeds are classified in the literature accordinq to the function, or relative speeds which fish can maintain. The classification of speeds published by Hoar and Randall (1978) which will be used in this study, is:

sustained - normal functions without fatigue,

prolonged - activities lasting 15 seconds to 200 minutes which result in fatigue

burst - activities which cause fatigue in 15 seconds or less.

Ranges of speeds for these classification are shown in Table 1 from Bell (1973).

Table 1. Fish speeds of average size adult salmon and steelhead trout as reported by Bell (1973).

Specie	Fish Speed (fps) Sustained[b]	Prolonged[b]	Burst
Steelhead	0-4.6	4.6-13.7	13.7-26.5
Chinook	o-3.4	3.4-10.8	10.8-22.4
Coho	o-3.4	3.4-10.6	10.6-21.5
Sockeye	0-3.2	3.2-10.2	10.2-20.6
Pink & Chum[a]	0-2.6	2.6-7.7	7.7-15.0

[a] Pink & Chum salmon values estimated from leap heights of 3 to 4 ft at waterfalls.
[b] Called cruising and sustained, respectively, in Bell (1973).-

Bell suggests that fish normally employ sustained speed for movement (such as migration), prolonged speed for passage through difficult areas, and burst speed for feeding or escape purposes.

For determining fish passage success over waterfalls and through culverts, some percentage of the upper limit of burst speed will be used which will depend on the physical condition of the fish. To determine actual values of these percentages, a study was conducted on coho and chum salmon swimming up a high velocity chute at Johns Creek Fish Hatchery near Shelton, Washington (see Appendix II). From this study it was concluded that most of the time the salmon were swimming at 50%, 75% and 100% of their maximum burst speeds suggested by Bell (1973), depending on the condition of the fish. These percentages will be used to define a coefficient of fish condition (C_{fc}). Values for C_{fc} are given in Table 2. with the corresponding characteristics of each. From Table 2. the actual speed that should be used for passage analysis is:

$$VF = VFB(C_{fc}) \qquad (2)$$

where VFB = maximum burst speed suggested by Bell (1973) Table 1; and C_{fc} = coefficient of fish condition, Table 2.

Table 2. Coefficient of fish condition (C_{fc}). Values based on observations and data taken for coho and chum salmon at Johns Creek Fish Hatchery near Shelton, Washington, December, 1983.

Fish Condition	Coefficient(C_{fc})
Bright; fresh out of salt water or still a long distance from spawning grounds; spawning colors not yet developed	1.00
Good; in the river for a short time; spawning colors apparent but not fully developed; still migrating upstream	0.75
Poor; in the river for a long time; full spawning colors developed and fully mature; very close to spawning grounds	0.50[a]

[a] C_{fc} = 0.50, corresponds to the upper limit of prolonged speed from Table 1.

Leaping Capabilities

When fish leap at waterfalls, their motion can best be described as projectile motion (i.e. curved two-dimensional motion with constant acceleration). Neglecting air resistance, the equations for projectile motion are:

$$x = (V_o \cos\theta)t, \text{ and}$$

$$y = (V_o \sin\theta)t - (1/2)gt^2$$

where x = horizontal distance the projectile travels, y = vertical distance the projectile travels, V, = initial velocity of the projectile, 8 = angle from the horizontal axis the projectile is fired, t = time, and q = acceleration of gravity (32.2 ft/sec^2). Rewriting the equations for x and y in terms of the components that relate to fish leaping at a waterfall yields:

$$XL = [VF(\cos\theta L)]t \text{ and} \quad (3)$$

$$HL = [VF(\sin\theta L)]t - (1/2)gt^2 \quad (4)$$

where XL = horixontal distance or range of the leap at some time (t), HL = height of leap at some time (t), VF = fish speed, θL = angle of leap from the plunge pool, and g = acceleration of gravity acting downwards (32.2 ft/sec^2). By combining equations (3) and (4) and eliminating t from them, we obtain:

$$HL = (\tan\theta L)XL - g(XL)^2/2(VF\cos\theta L)^2 \quad (5)$$

which relates HL and XL and is the fish trajectory equation. Since VF, θL and g are constant for a given leap, equation (5) has the parabolic form of:

$$HL = b(XL) - C(XL)^2$$

Hence the trajectory of a fish is parabolic. Equation (5) is plotter! in Figures 7, 8 and 9 for six species of salmon and trout leaping at angles of HO, 60 and 40 degrees. These leaping curves will be utilized later to analyze leaping conditions at a barrier. At the highest point of the fish's leap, the vertical component of the velocity is zero, that is:

$$VF_y = VF(\sin\theta L) - gt = 0$$

Solving this equation for t gives:

$$t = VF(\sin\theta L)/g$$

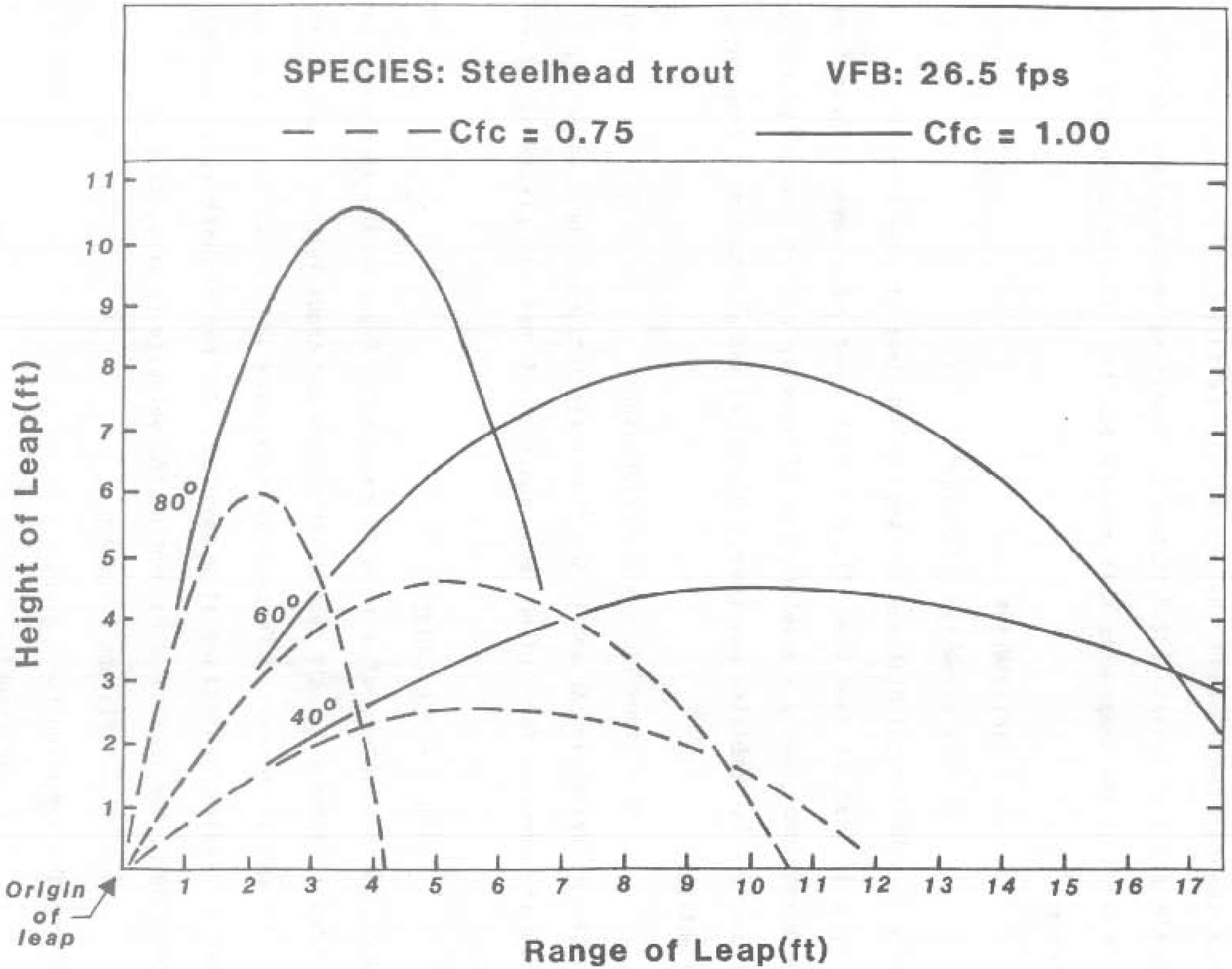


Figure 7. Leaping curves for steelhead trout.

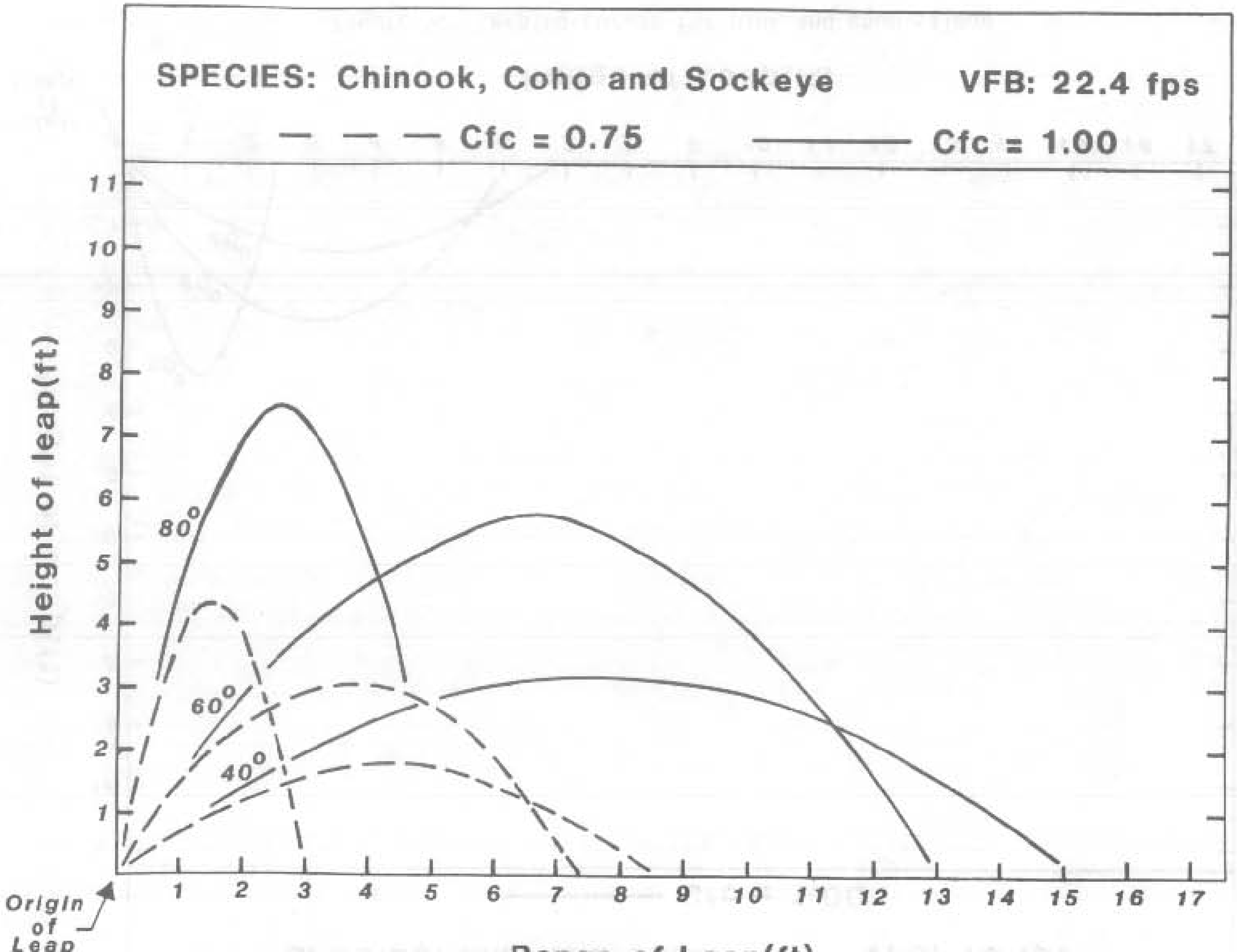


Figure 8. Leaping curves for chinook, coho and sockeye salmon.

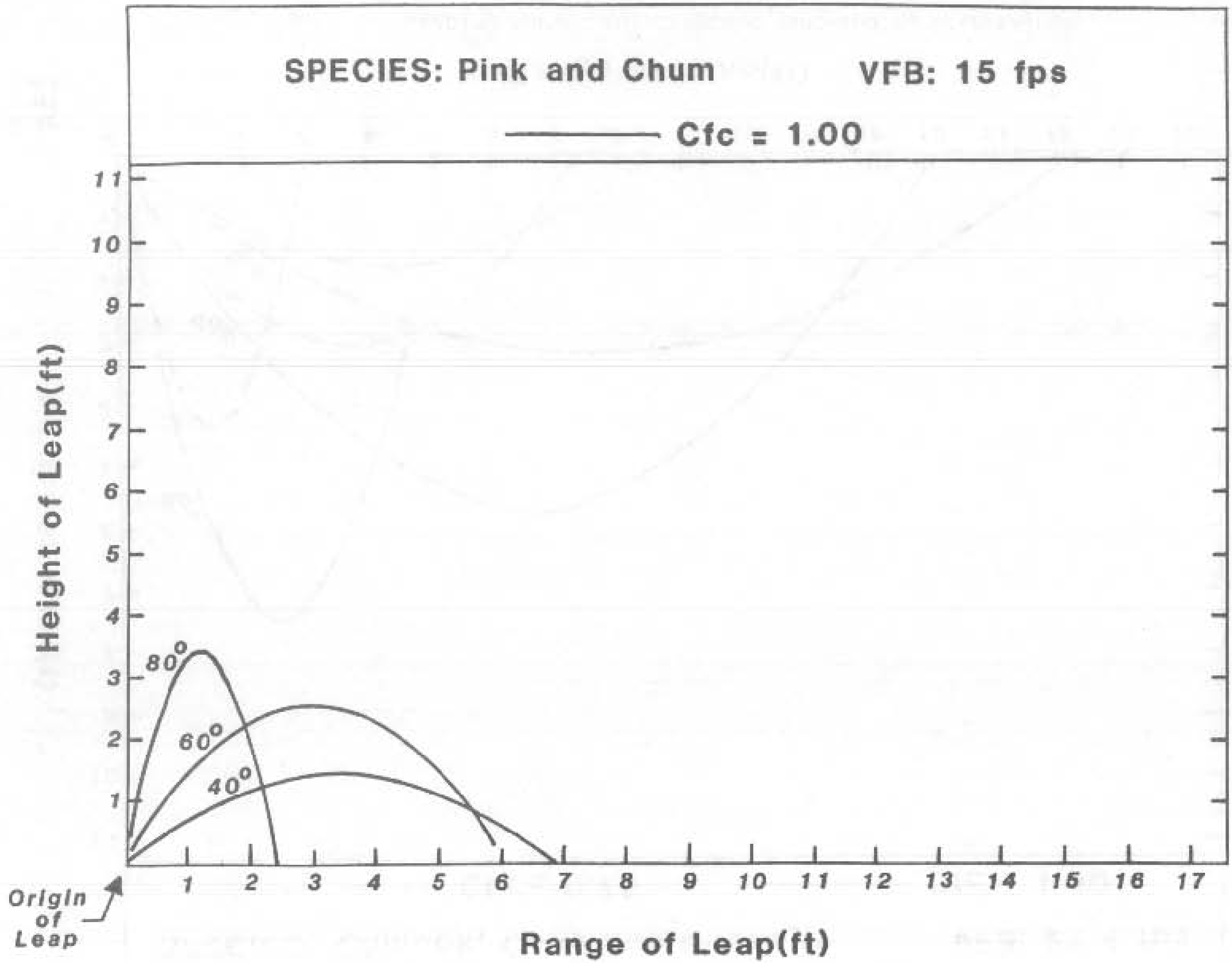


Figure 9. Leaping curves for pink and chum salmon.

Substituting this equation for t into equation (3) and (4) yields:

$$HL = (VF(\sin\theta L))^2/g - (1/2)(VF(\sin\theta L)^2)/g$$

$$HL = (VF(\sin\theta L))^2/2g \tag{6}$$

$$XL = VF^2(\cos\theta L)(\sin\theta L/g) \tag{7}$$

Equations (6) and (7) give the maximum height of the fish's leap and the horizontal distance traveled to the maximum height.

Bell (1973) suggests the following formula for computing velocities at which fish leave the water surface:

$$VF = (2g(HL))^{0.5}$$

Solving this equation in terms of the leap height (HL) gives the same result as equation (6), using a leaping angle of 90° to the water surface. Aaserude (1984) noted that to determine the true leaping height above the water surface, the length of the fish should be added to equation (6) because the fish uses its full propulsive power up until the point the fish's tail leaves the water, and once in the air skin drag can he neglected. Since equation (6) and (7) do not include the additive effects of fish length or an upward velocity component often found at the foot of a waterfall in the form of a standing wave (Stuart, 1964), they will be used here as conservative values from the accepted literature.

Swimming Performance

Swimming performance is a measure of the speed which a fish can maintain over a period of time (endurance). The distance a fish can swim is a function of the water velocity, fish speed and fatigue time. Bell

(1973) suggests that burst speed can be maintained-for an estimated 5 to 10 seconds. Relating this range of fatigue time to the range of burst speeds from Table 1, the swimming distances can he computed from:

$$LFS = (VF - VW)TF \tag{8}$$

where LFS = length the fish can swim, VF = fish speed, VW = water velocity, and TF = time to fatigue. Equation (8) is plotted in Figures 10, 11 and 12 for six species of salmon and trout. An example calculation will show how these figures were derived.

Specie: steelhead

Burst Speed Range: 13.7 to 26.5 fps

Fatigue Time Range: 5 to 10 seconds

Water Velocity: 10 fps

Coefficient of Fish Condition: 0.75

$$LFS = [26.5\ (0.75) - 10]5 = 49 \text{ ft, or}$$

$$LFS = [13.7\ (0.75) - 10]10 = 3 \text{ ft.}$$

Therefore the maximum distance an adult steelhead trout can swim given the condition of the fish and a mean water velocity of 10 fps, is 49 ft. This calculation assumes the water depth to be great enough to submerge the fish and that no air is entrained in the flow. The results are in Fig. 12.

Evans and Johnston (1980) suggest that the distance the fish can swim against a given water velocity is best defined by the curves prepared by Ziemer (1961) which reflect the swimming performance of salmon, steelhead, and smaller trout (Fig. 13). This curve was developed assuming a relative fish speed (VR) of 2.0 fps. From the study reported in Appendix II, it was determined that the average relative speeds for coho and chum salmon swimming up the velocity chute were 1.9 and 2.1 fps respectively, but ranged from values of 1.0 to 3.0 fps. Because of this wide variation, it appears that calculating the maximum distance a fish can swim by simply using relative fish speed does not accurately describe the magnitude of a single passage attempt.

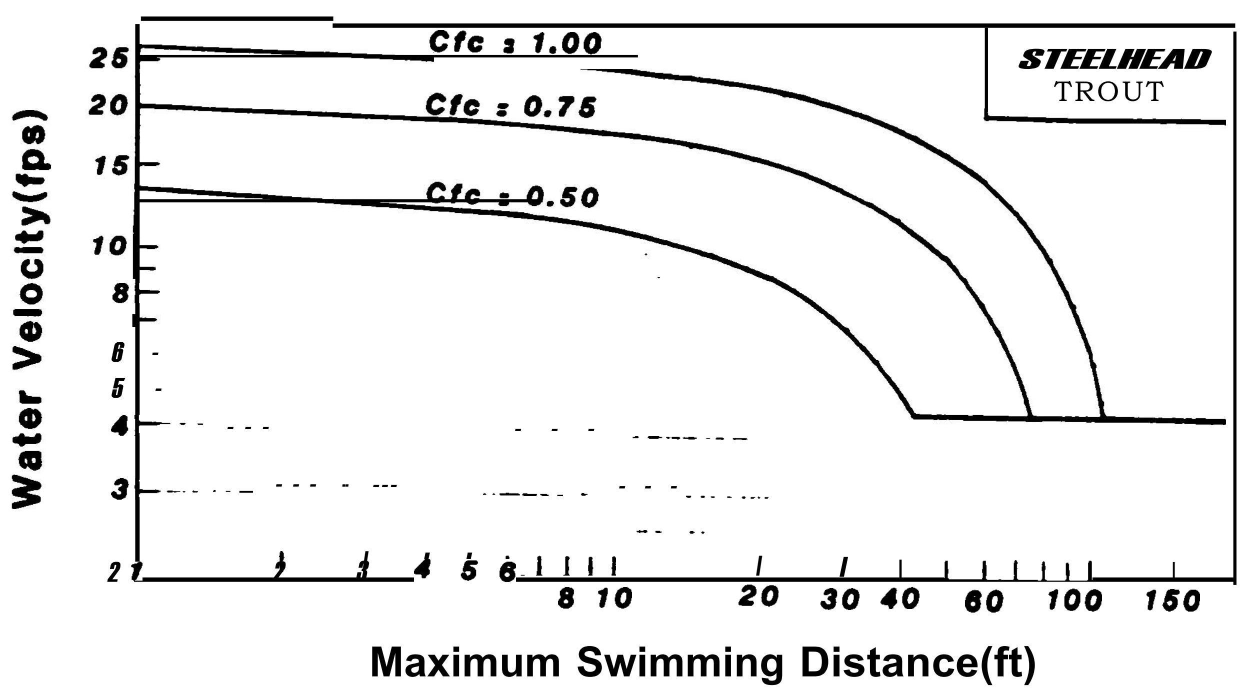


Figure 10. Maximum swimming distance for steelhead trout under three fish conditions.

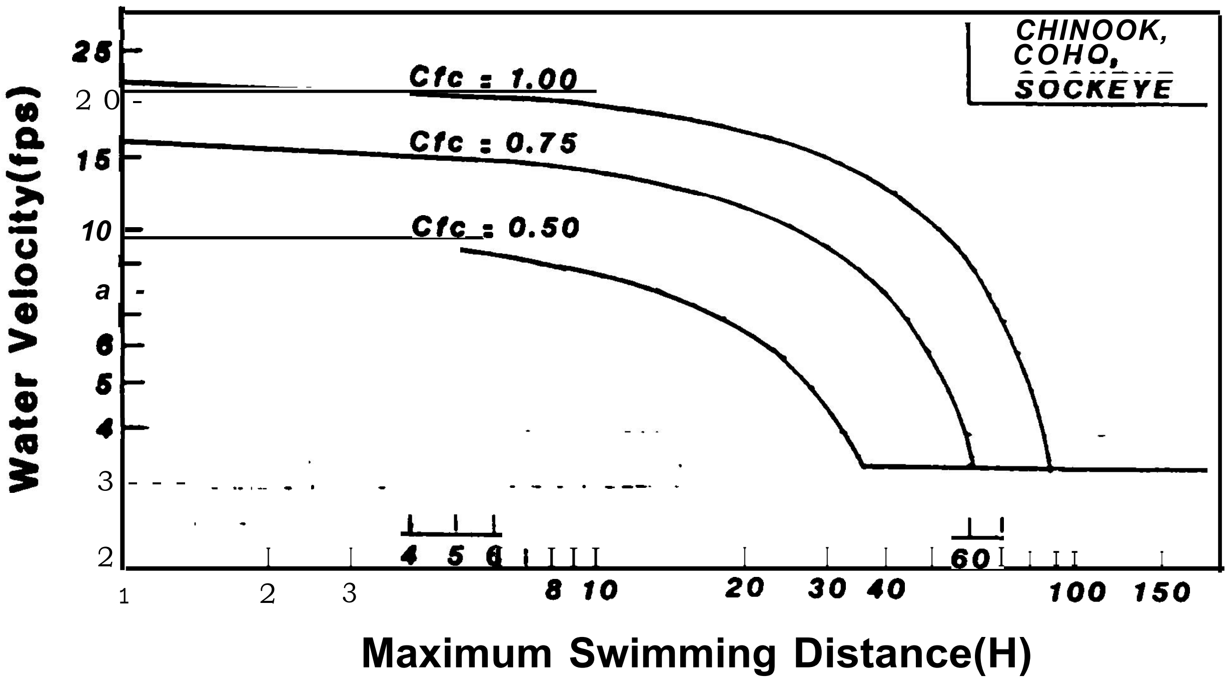


Figure 11. Maximum swimming distance for chinook, coho and sockeye salmon under three fish conditions.

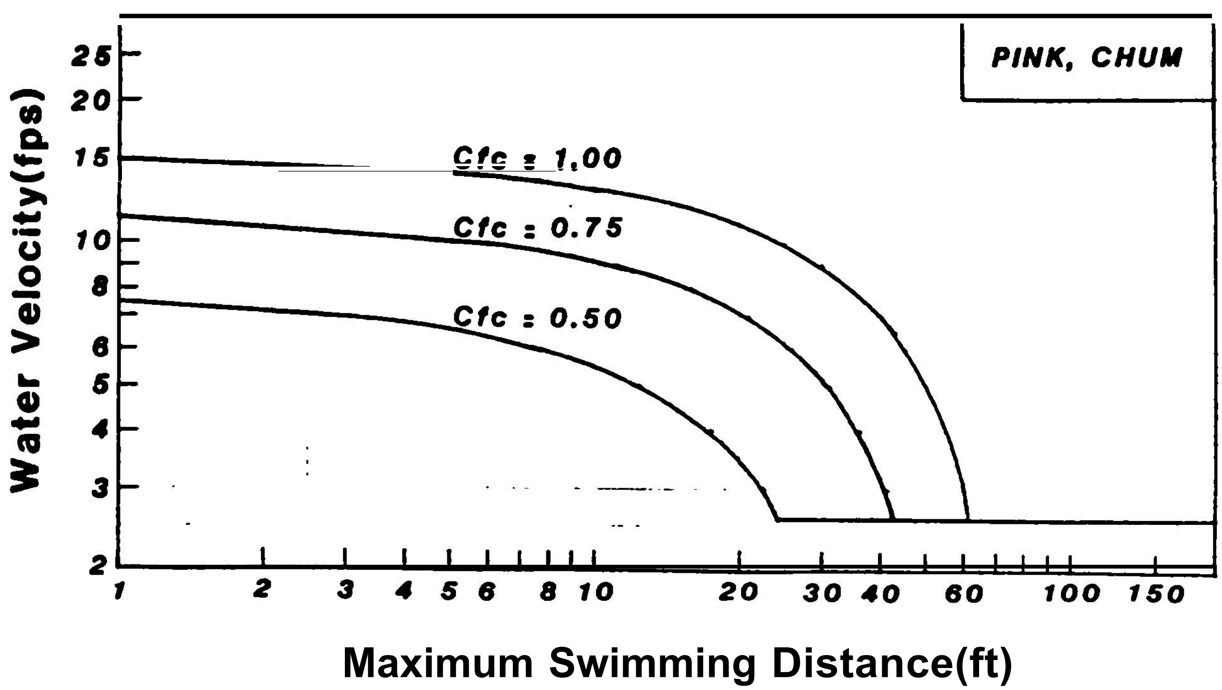


Figure 12. Maximum swimming distance for pink and chum salmon under three fish conditions.

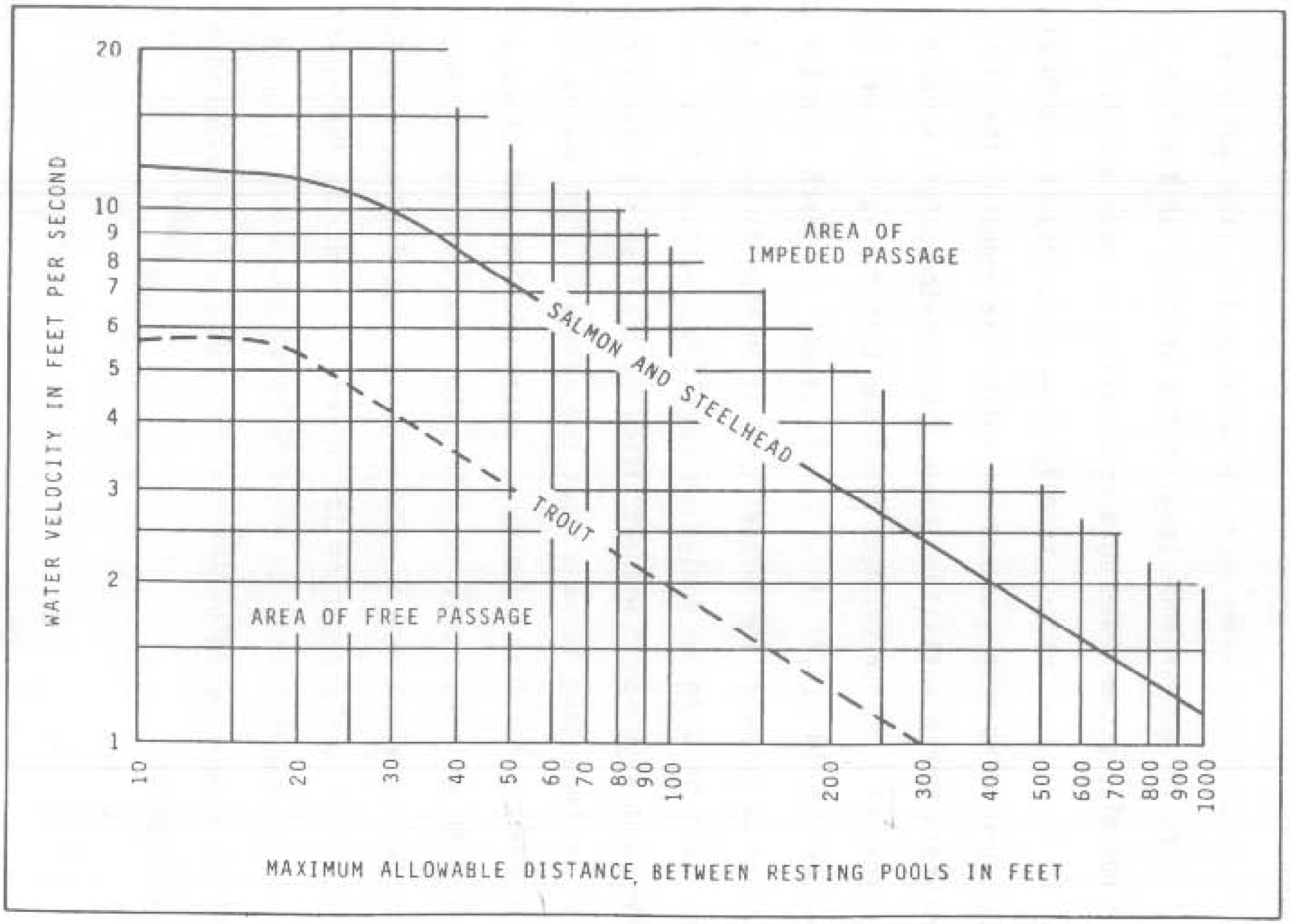


Figure 13. Swimming performance of salmon and trout from Evans and Johnston (1980). Curve developed by Ziemer, State of Alaska, Department of Fish and Game.

"Any factor interrupting or affecting the supply system (oxygen intake) as well as those affecting the propulsive system itself, affects swimming performance" (Webb, 1975). Both of these conditions exist when there is insufficient water depth to submerge the fish while it is swimminq. Partial submergence impairs the ability of the fish to generate thrust normally accomplished by a combination of body and tail movement. Also, if its gills are not totally submerged, they cannot function efficiently, promoting oxygen starvation while also reducing the fish's ability to maintain burst activity. Evans and Johnston (1972) suggest a minimum water depth of 6 in for resident trout and 1 ft for salmon and steelhead. Dryden and Stein (1975) state "In all cases, the depth of water should be sufficient to submerge the largest fish attempting to pass." This limitation will be used in analyzing barriers, because this would be the minimum depth requirement without affecting the fish's propulsive system.

It is important to note that the values of fish speeds suggested by Bell (1973) are for fish swiming in water without entrained air (black water). In extreme cases of sufflation the density of the water/air mixture (white water) will be reduced and detract from the propulsive power of the fish's tail, reducing its speed. To summarize the equations that describe the capabilities of fish in terms of swimming speed, leaping capabilities and swimming performance, Table 3 is provided with a nomenclature of terms.

Table 3. Fish capability equations for swimming and leaping.

Type of Motion	Equation	
Swimming	$VR = VF - VW$	(1)
	$VF = VFB(C_{fc})$	(2)
	$LFS = (VF - VW)TF$	(8)
Leaping	$HL = [VF\,(\sin\theta L)]^2/2g$	(6)
	$XL = VF^2(\cos\theta L)(\sin\theta L)/g$	(7)

where:

VR = relative swimming speed of the fish,

VF = fish speed,

VW = water velocity,

VFB = burst speed of fish,

C_{fc} = coefficient of fish condition,

LFS = maximum swimming distance of fish,

TF = time to fatigue,

HL = height of leap,

XL = horizontal distance of leap at fish's high point,

θL = angle of leap from water surface, and

g = acceleration of gravity (32.2 ft/sec^2).