APPENDIX C

AQUATIC

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TABLE OF CONTENTS

CHINOOK SALMON

SPECIFIC HABITAT REQUIREMENTS
FOR
ADULT, EMBRYO, AND JUVENILE

The following graphs indicate the relative quality of the primary stream habitat variables that affect overall habitat quality for the various life stages of chinook salmon. For the Walla Walla River Basin Reconnaissance Study we are using these Habitat Suitability Index curves to define a target level for the various habitat attributes. We recognize that only a limited number of the habitat attributes referenced are actually manageable within the scope of this study.

Defined below are the variables defined by the U.S. Fish and Wildlife Service in the *Habitat Suitability Index Models and Instream Flow Suitability Curves: Chinook Salmon* report by R. F. Raleigh, W. J. Miller, and P. C. Nelson, as being the most important for each life stage. Note that a Suitability Index of 1 indicates the optimum level for that attribute.

ADULT -- Habitat attributes that affect the ability of adults to enter the spawning streams, to find suitable holding habitat until time to spawn, and to survive and spawn successfully in freshwater, riverine habitats.

a. pH (V^1)
b. Temperature (V^2)
c. Minimum dissolved oxygen (V^3)
d. Percent pool habitat (V^4)
e Pool class (V^5)

EMBRYO -- Habitat attributes affecting the ability of the developing embryos and intergravel yolk sac fry to develop, hatch, and emerge from the gravel successfully.

a. Minimum dissolved oxygen (V^3)
b. Minimum or maximum temperature (V^6)
c. Maximum or maximum temperature (V^7)
d. Percentage spawning gravel size (V^8)
e. Average water column velocity (V^9)
f. Percent fine sediment (V^{10})
g. Average base flow (V^{11})
h. Average peak flow (V^{12})

JUVENILE -- Habitat attributes that affect the ability of the juveniles to survive in the riverine environment.

a. pH (V^1)
b. Maximum temperature (V^2)
c. Minimum dissolved oxygen (V^3)

-- Habitat attributes that are necessary for stream productivity and food supply essential to sustain juveniles during the period of freshwater rearing.

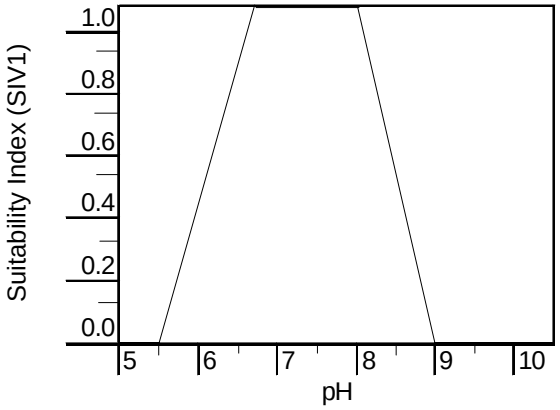
d. Substrate class (V^{13})
e. Percent riffle-run fine sediment (V^{14})
f. Nitrate nitrogen concentration (V^{15})

-- Habitat attributes that affect the quantity and quality of juvenile rearing habitat.

g. Percent pool habitat (V^4)
h. Pool class (V5)
i. Average base flow (V^{11})
j. Average peak flow (V^{12})
k. Percent cover (V^{16})
l. Percent substrate cover (V^{17})
m. Percent riffle-run fine sediment (V^{14})

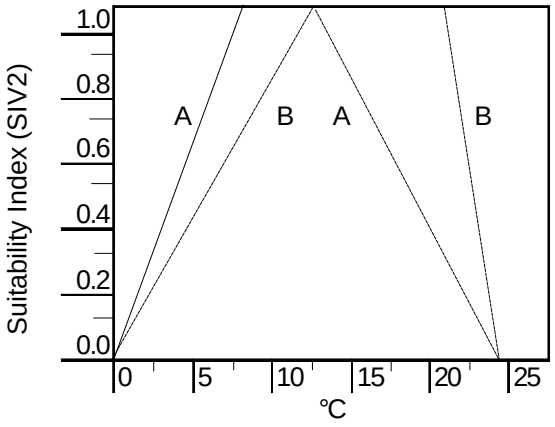
Variables	Suitability Graphs

V_1 Annual maximal or minimal pH. Measure during the summer to fall season. Use the measurement with the lowest SI value.



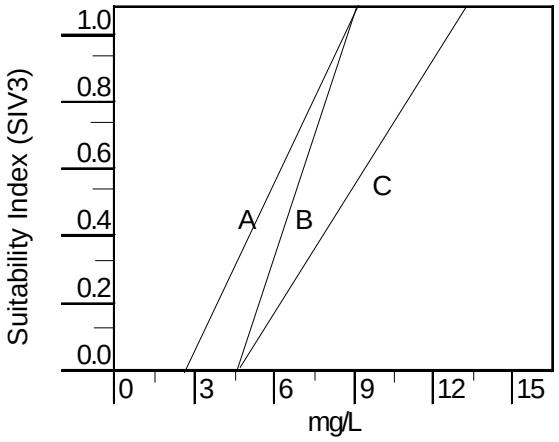
V_2 Maximum temperature during warmest periods when adults or juveniles are present. Measure at locations where problems may exist. Downriver, migration block areas and stream resident locations.

A = Pre-spawning Adults
B = Juveniles

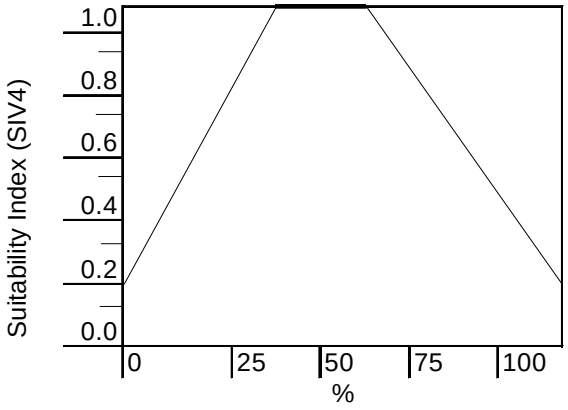


V_3 Minimum dissolved 0_2 level during egg and pre-emergent yolk sac fry period, and during periods of occupation by adults and juveniles.

A. ≤5 °C
B. >5 - ≤ °C
C. >10 °C



V_4 Percent pools during the late growing season low water period.

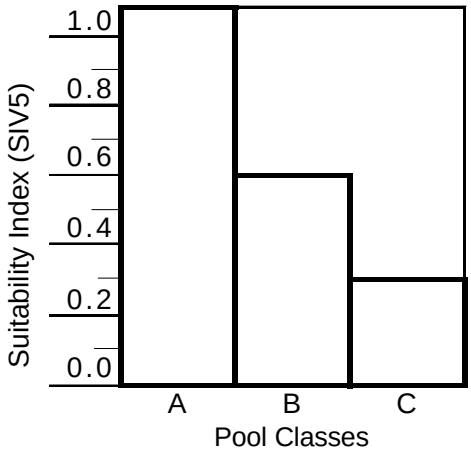


V_5 Pool class rating during the late growing season low flow period.

A. ≥30% of the habitat classified as pools is composed of 1st class pools.

B. ≥10% but <30% of the habitat classified as pools is composed of 1st class pools or ≥50% is 2nd class or better pools.

C. <10% of the habitat classified as pools is composed of 1st class pools and <50% is 2nd class pools.



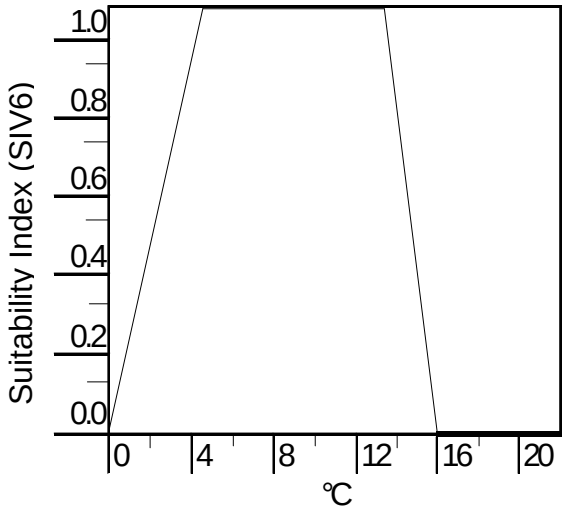
First-class pool: Large and deep. Pool depth and area are sufficient to provide a low velocity resting area for several adult chinook. More than 30% of the pool bottom is obscure due to surface turbulence, turbidity, or the presence of structures such as logs, boulders, or overhanging objects. Or, the greatest pool depth is ≥1.5 m in streams ≤5 m wide or ≥2 m in streams >5 m wide.

Second-class pool: Moderate size and depth. Pool depth and area are sufficient to provide a low velocity resting area for a few adult chinook. From 5 to 30% of the bottom is obscured by surface turbulence, turbidity, or the presence of structures. Typical 2nd class pools are large eddies behind boulders and low velocity moderately deep areas beneath overhanging banks and vegetation.

Third-class pool: Small in area, or shallow, or both. Pool depth and area are sufficient to provide a low velocity resting area for one to very few adult chinook. Cover, if present, is in the form of shade, surface turbulence, or very limited structure. Typical 3rd class pools are wide, shallow areas of streams or smaller eddies behind boulders. The entire bottom of the pool may be visible.

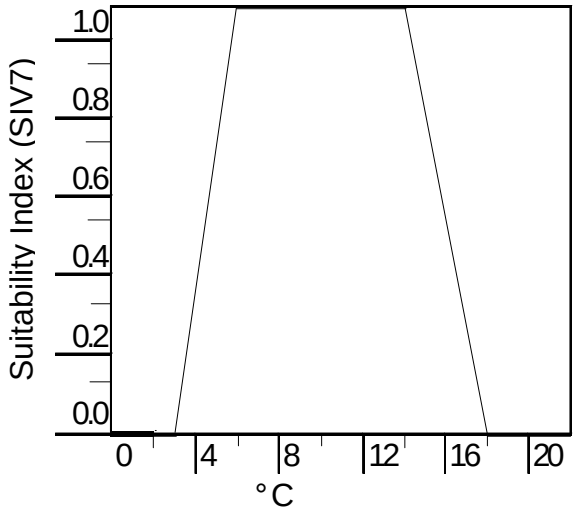
V_6 Maximum or minimum temperature at beginning and end of first month of spawning of late summer or fall spawning stocks. Use the temperature that yields the lowest SI.

Minimum temperature must remain $\geq$4.5 °C for $\geq$3.5 weeks after fertilization.



*v_7 Maximum or minimum temperature at beginning and end of embryo incubation period. Use the temperature that yields the lowest SI.

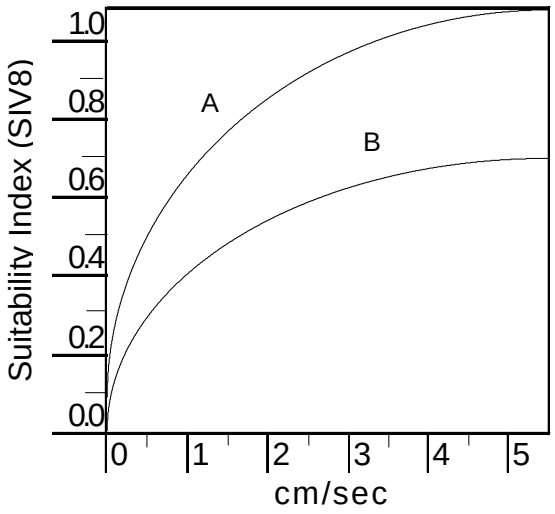
*Use for spring spawning stocks only.



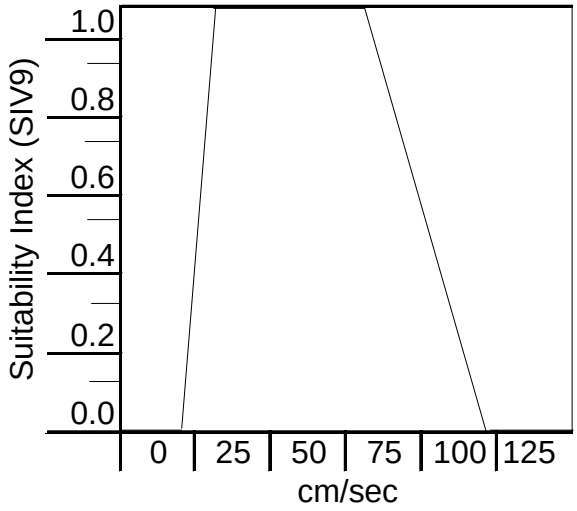
V_8 Percentage of spawning gravel in each of two classes: A. 2-10.6 cm. B. 0.3-≤2, and ≥10.6-15 cm. Measure during or within 30 days after spawning.

Record total area (m^2) of gravel in each class. To derive an SI score, use the best substrate until the sample contains an area equal to 5% of the entire chinook habitat area sampled. If class B substrate must be included to obtain a 5% sample, derive an arithmetic mean SI score from the two individual SI scores obtained from the graph.

$V_8SI = \frac{SIA + SIB}{2}$

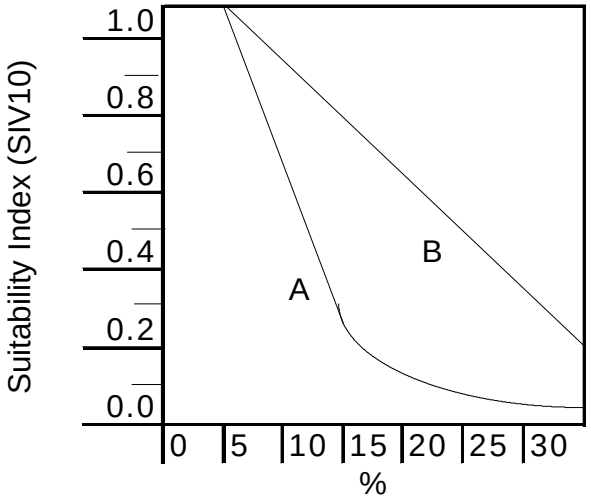


V_9 Average water column velocity (cm/s) over areas of spawning gravel used by chinook salmon during period of spawning and embryo development. Measure only at depths ≥20 cm and at same location as gravel (V_8).

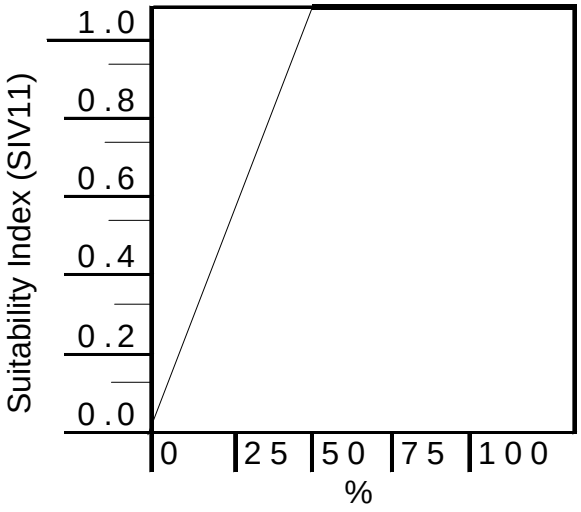


V_{10} Average percentage of fines in spawning gravel in major spawning areas. Measure within 30 days after spawning is over and at the same sites as V_8.

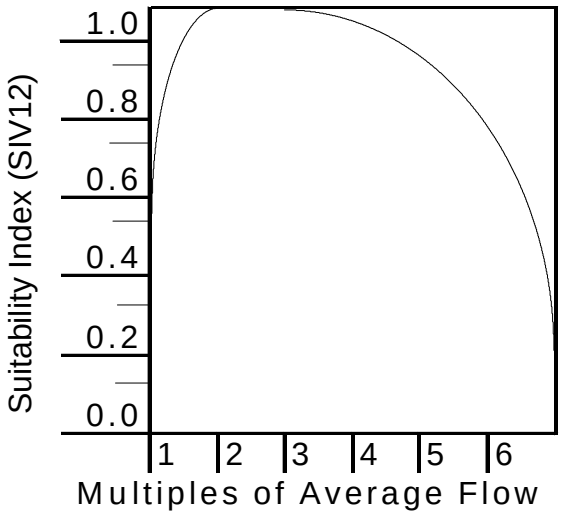
A. Fines $\leq$0.8 mm in size (silt).
B. Fines >0.8 to 30 mm in size (sand).



V_{11} Average annual base flow during the late summer to winter low-flow period as a percentage of the average annual daily flow. For embryo and preemergent fry use the average and low flows that occur during intergravel occupation period.



V_{12} Average annual peak flow as a multiple of the average annual daily flow. For embryo habitat suitability use the peak flow measurement that occurs from the gravel.

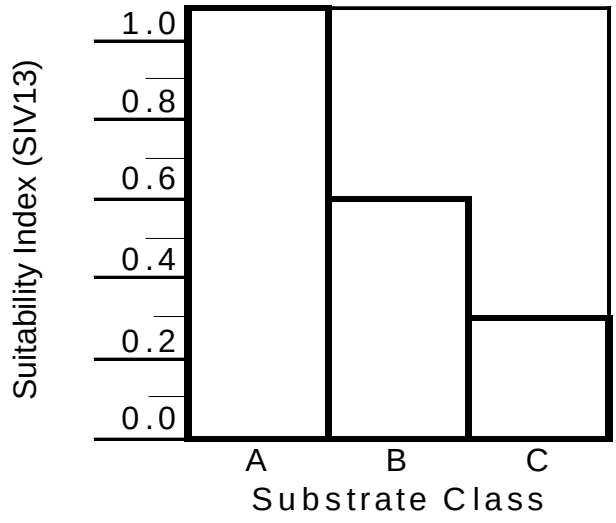


V_{13} Predominant (≥50%) substrate type in riffle-run areas for food production indicator. Measure in juvenile rearing and upstream areas.

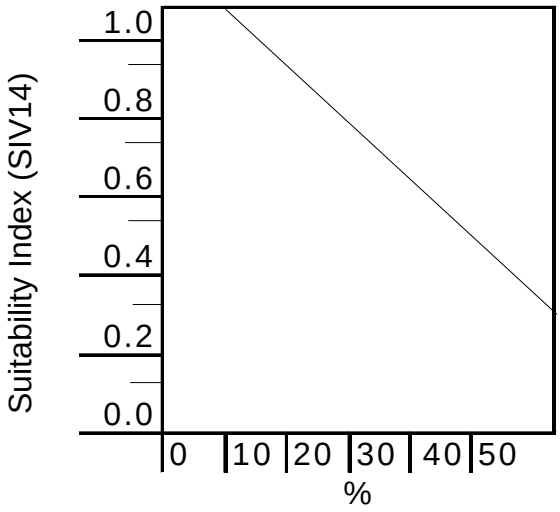
A: Rubble or small boulders (or aquatic vegetation in spring areas) dominate; limited amounts of gravel, large boulders, or slab rock may be present.

B. Rubble, gravel, and boulders occur in roughly equal amounts, or gravel or small boulders predominant. Fines, large boulders, or slab rock may be present in moderate quantities (≤25%).

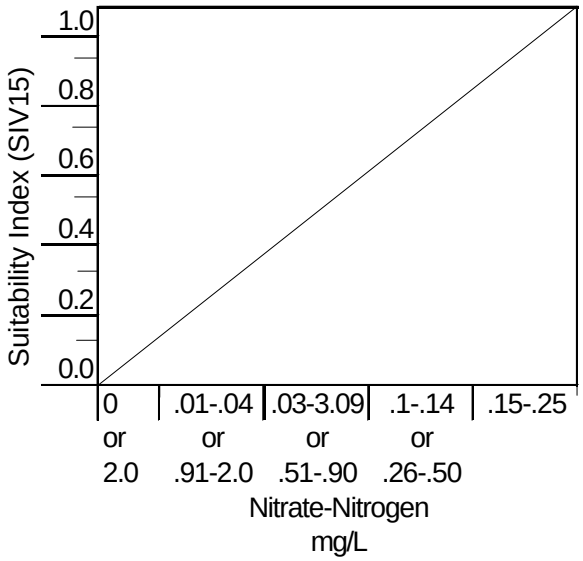
C. Fines, slab rock, or large boulders predominate. Rubble or gravel are insignificant (≤25%).



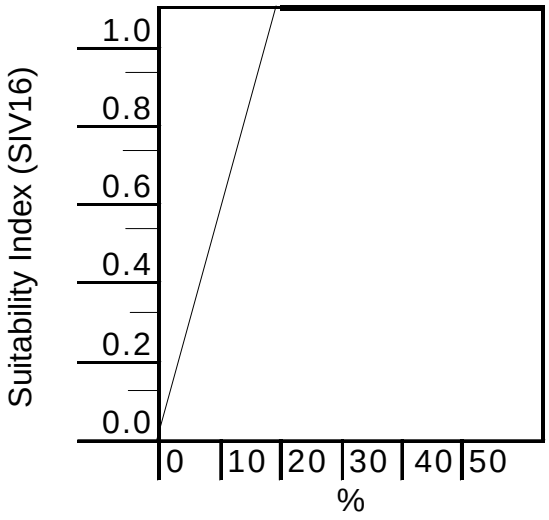
V_{14} Average percentage of fines (<3 mm) in riffle-run areas. Measure in juvenile rearing areas during average flow period.



V_{15} Levels of late summer nitrate-nitrogen (mg/L). Measure after spawner die off.

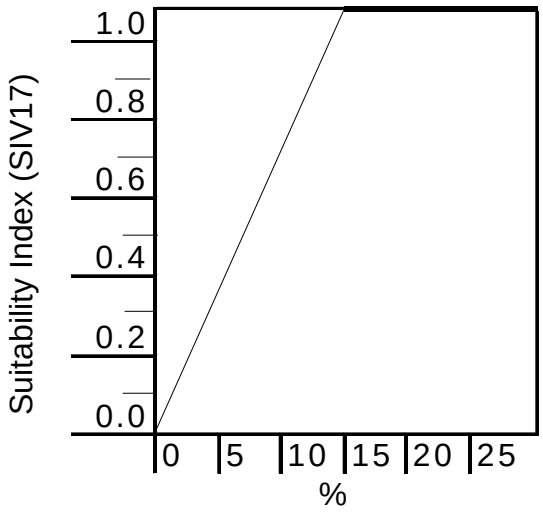


V_{16} Percentage of stream area providing escape cover. Measure during late summer-fall average to low flow period at depths $\geq$15 cm and with bottom velocities $\leq$ cm/s.



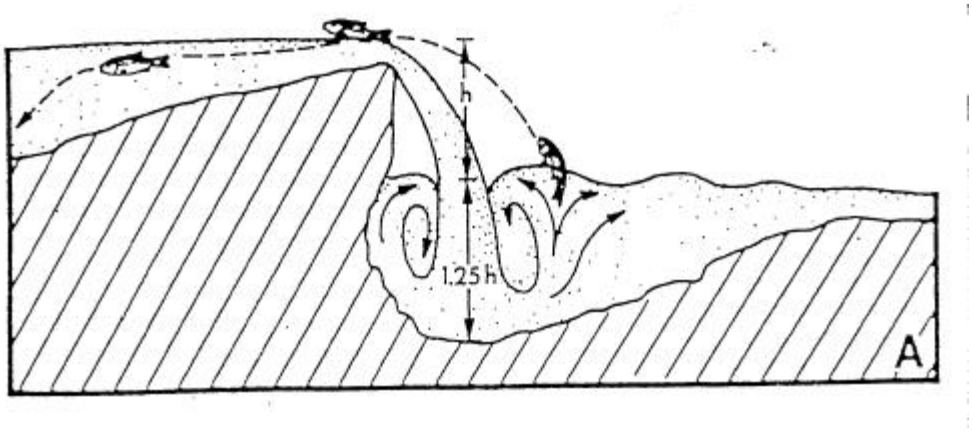
*V_{17} Percentage of area providing substrate cover (boulders >10 cm and <40 cm diameter). Measure at same time and areas as V_{16}.

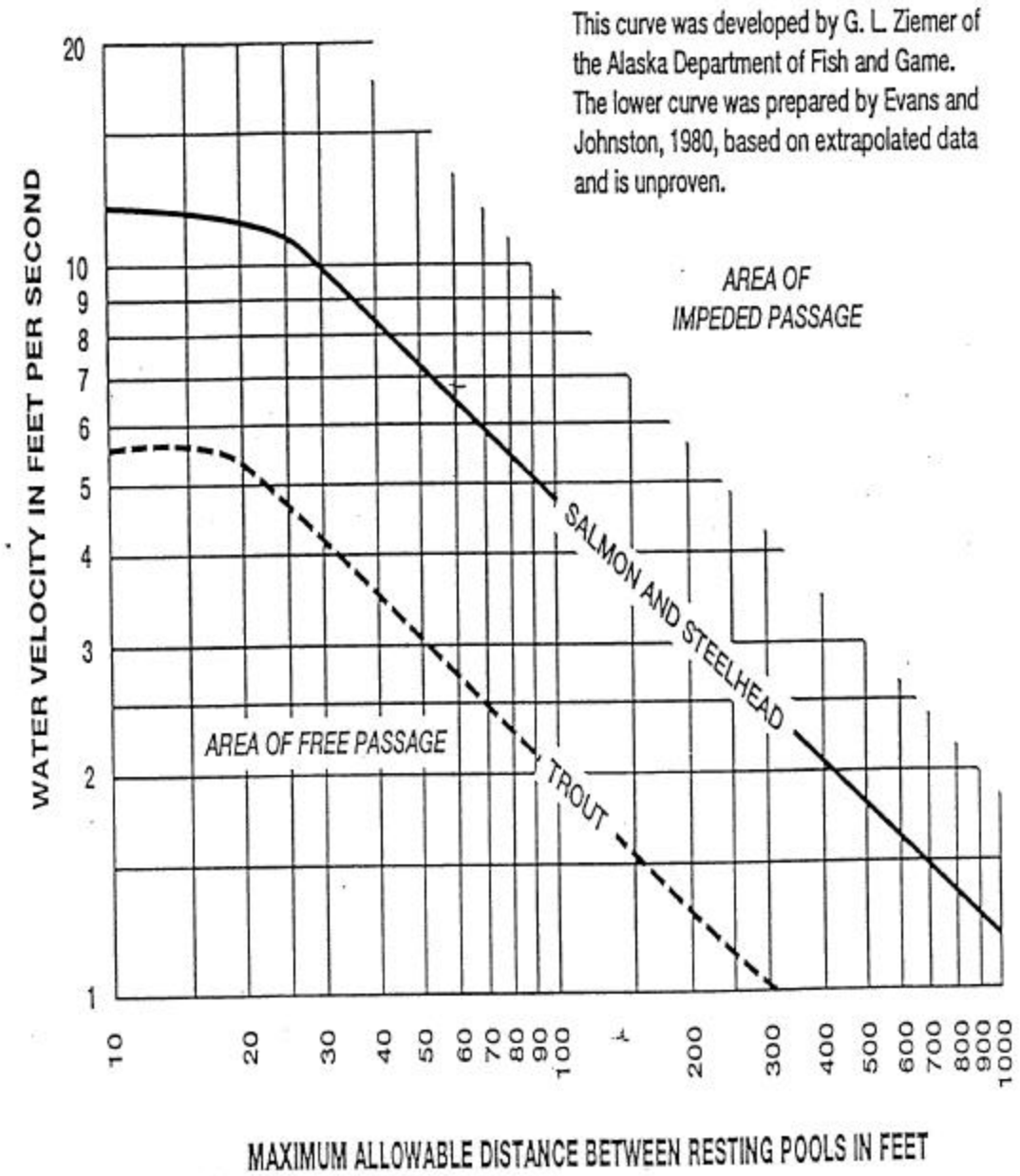
*Use only for juveniles that over-winter in the freshwater.



PASSAGE CRITERIA FOR CHINOOK SALMON

Temperature Range (Bell 1986)	3.3-13.3°C.
Minimum Depth National Marine Fisheries Service Unofficial Criterion (Brian Nordlund personal communication)	0.3 m (1 ft)
Maximum Velocity National Marine Fisheries Service Unofficial Criterion (Brian Nordlund personal communication)	4.8 m/sec (16 ft/sec)
Depth of Jumping Pool (Eiserman et al., 1975)	1.25 Jumping Height (See Figure Below)




This curve was developed by G. L. Ziemer of the Alaska Department of Fish and Game. The lower curve was prepared by Evans and Johnston, 1980, based on extrapolated data and is unproven.
AREA OF IMPEDED PASSAGE
AREA OF FREE PASSAGE
SALMON AND STEELHEAD
TROUT
WATER VELOCITY IN FEET PER SECOND
20
10
9
8
7
6
5
4
3
2
1
10
20
30
40
50
60
70
80
90
100
200
300
400
500
600
700
800
900
1000
MAXIMUM ALLOWABLE DISTANCE BETWEEN RESTING POOLS IN FEET

List of Acronyms

cm	centimeters
cm/s	centimeters per second
°C	degrees Celsius
≥	greater than or equal to
>	greater than
≤	less than or equal to
<	less than
L	liter
m	meters
m^2	meters squared
mg	milligrams
mg/1	milligrams per
mm	millimeters
0_2	oxygen
%	percent
pH	hydrogen-ion concentration
sec	seconds
SI	suitability index
V	variability
V	variable