

# **FRED Reports**

KENAI RIVER WEIR STUDY

by  
Lowell S. Barrick

Number 44



**Alaska Department of Fish & Game**  
Division of Fisheries Rehabilitation,  
Enhancement and Development

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February 1985

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## 1.0 FOREWORD

The Kenai River is a valuable natural resource. The river's assets are many, but of particular interest to the Alaska Department of Fish and Game (ADF&G) is the fish resource that this river sustains. All five species of Pacific salmon inhabit the waters of the Kenai River, and it is because of these fish that this weir investigation study was conducted.

ADF&G has been managing the Kenai River fisheries since statehood. However, with the tremendous increase in population in the Anchorage and Kenai Peninsula areas, primarily since the pipeline construction years of the 1970's, the management of the fisheries has approached a crisis level. In general terms, the crisis has been caused by too great a demand for a resource (salmon) of limited quantity. The term, limited, is used because, although the ADF&G has some knowledge of the magnitude of the various salmon runs, precise numbers are not known. It is precise, numerical information that is needed if the salmon populations in the Kenai River are to be maintained.

This report describes the investigations that have been conducted in an attempt to determine the feasibility of constructing a weir (a physical barrier used for the purpose of counting fish) in the Kenai River.

## 2.0 BACKGROUND

ADF&G has been counting the salmon in the Kenai River for about 25 years. Counting these fish, however, has been a difficult task. Some of the many factors that make counting fish in the Kenai River difficult follow:

1. Turbidity of the glacial water.
2. Large dimensions (width and depth) of the river.
3. High-water velocities and discharge.
4. Heavy debris and sediment loads.
5. Large tidal fluctuations in the lower reaches of the river.
6. Severe icing conditions.
7. Mass migrations of large numbers of salmon during brief intervals.

8. Milling and intermixing of salmon species.
9. Weir operations conflicting with boat traffic.
10. Environmental considerations.
11. Financial limitations.

Because of these counting difficulties, ADF&G has tried many methods for enumerating the salmon runs:

1. Electronic counting (sonar).
2. Aerial counts of clear water tributaries.
3. Foot/boat surveys to count carcasses and observe spawning activities.
4. Gravel pumping (egg/fry counts of redds to estimate spawning).
5. Adult trapping (nets and fishwheels).
6. Juvenile trapping (fyke traps).
7. Fish tagging techniques.
8. Creel census of sport fishermen.
9. Monitoring commercial fishing operations.

Although all of these techniques provide some useful data, the information is imprecise and usually is not available in a timely manner. Because of these reasons, the investigation into the feasibility of constructing a weir was initiated. This feasibility study addresses site selection, types of construction, operation considerations, and estimated construction costs.

### 3.0 WEIR EVALUATION

#### 3.1 Initial Investigations (April 1984)

In initial discussions with the fishery managers, the following criteria/guidelines were established:

1. Any weir should be located below Rivermile (RM) 13.
2. The weir should have the capability of counting all salmon species, with the possible exception of pinks.

3. The weir should provide a means whereby the fish can be seen and counted visually.
4. Provisions should be made for the passage of boat traffic with a minimum of inconvenience to the boaters.
5. Operational/maintenance factors need to be addressed.
6. Environmental concerns need to be addressed.
7. Efficiency of operations to be given consideration over the cost of construction or operations.

Armed with the preceding guidelines, several reconnaissance trips were made to the Kenai River to gather data needed to select and evaluate potential weir sites. Figure 1 shows the three principal sites under investigation during the early part of the study.

#### 3.1.1 Weir Site at RM 12.6

This site (Figure 2) was investigated primarily because of its promising physical attributes; i.e., ease of construction and operations. At this location, the river width is narrowed by the presence of an island located near the center of the river. The plan would be to block the right channel (as viewed looking downstream) with a floating weir to divert the upstream migrants to the shallower, left channel for counting. In the left channel, the migrant fish would be forced to the surface over a submerged weir, where they would be visually counted and/or trapped as appropriate.

Good attributes of this site are:

1. The river is not affected by tidal action.
2. Because of the island, the river channel is narrowed into two smaller (workable) channels.
3. The riverbed consists of gravel that will permit the construction of a structurally stable weir foundation.
4. Site accessibility is good because of the presence of an existing road on the right bank.
5. Salmon at this RM are definitely upstream migrants and are not likely to retreat downstream.

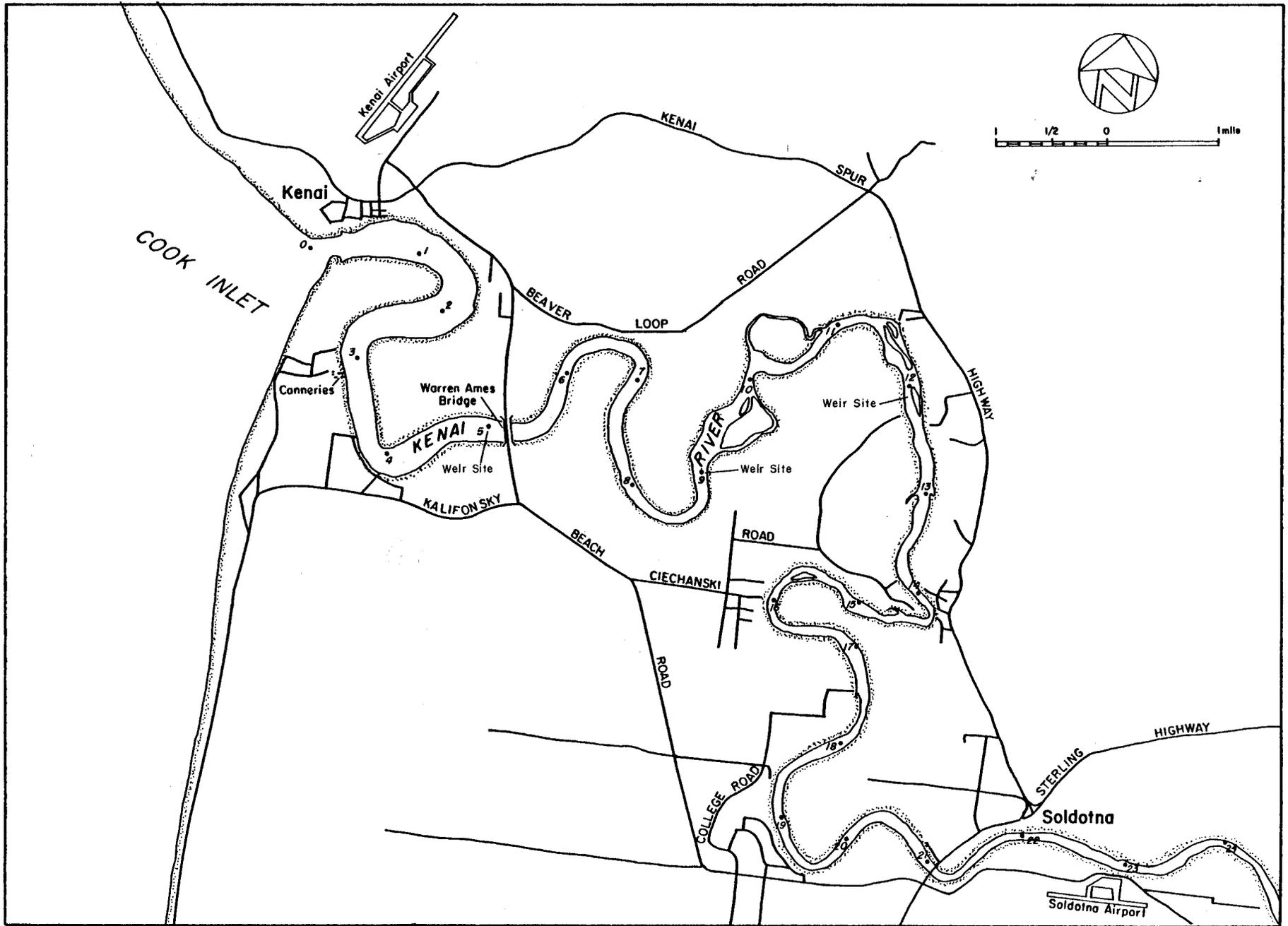


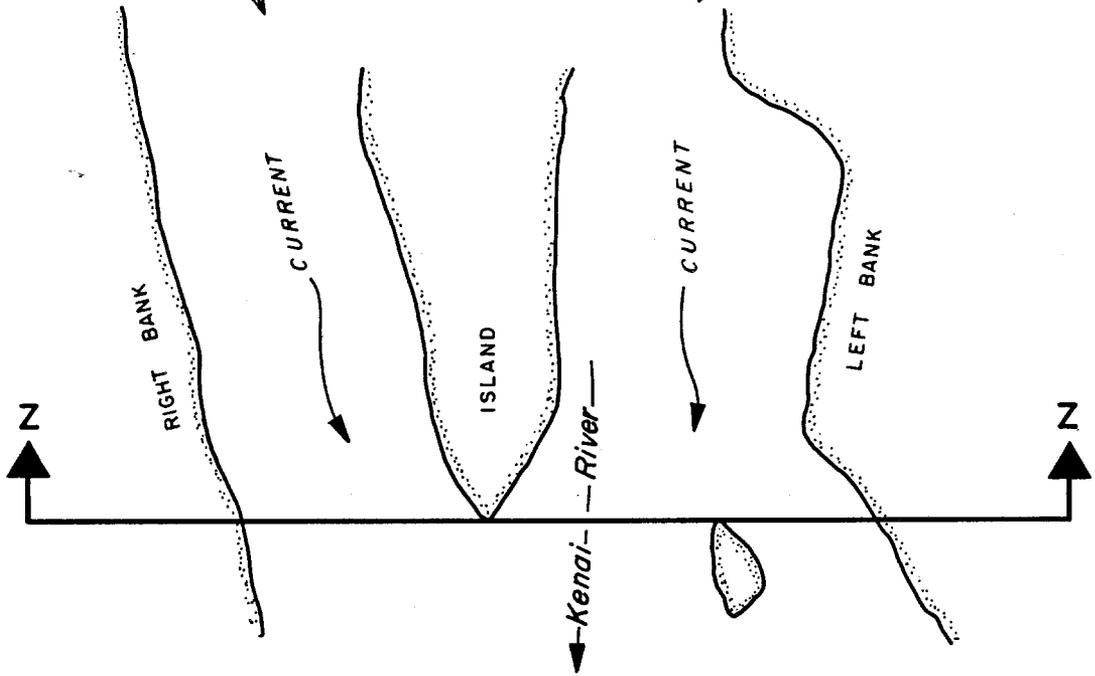
Figure 1. Kenai River from RM 0 to RM 22.

**VELOCITIES IN RIGHT CHANNEL**

5.2 fps on 6/6/84  
5.3 fps on 7/10/84

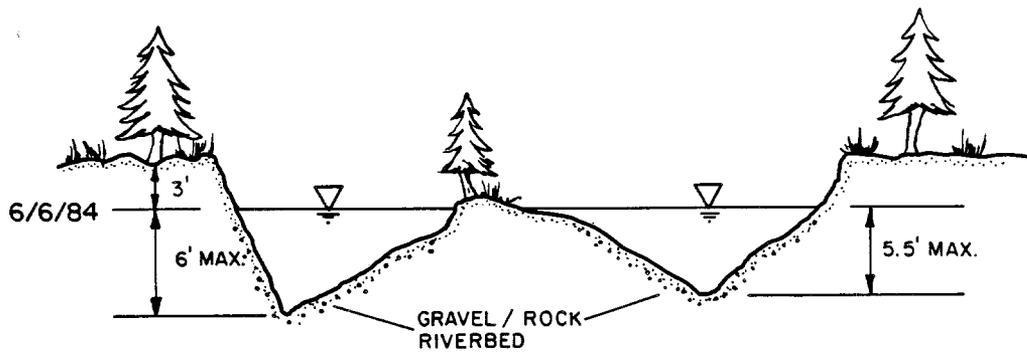
**VELOCITIES IN LEFT CHANNEL**

1.5 fps on 6/6/84  
4.6 fps on 7/10/84



**PLAN VIEW**

1" = 200'



**SECTION Z-Z**

HORIZ. 1" = 200' VERT. 1" = 10'

Figure 2. Weir site at RM 12.6.

Site deficiencies are:

1. The velocity, especially in the right channel, becomes very fast during freshets. This would necessitate the construction of strong (costly) structures.
2. Boat traffic is very heavy, which complicates weir operations.
3. This site is upstream of a significant portion of the chinook spawning area; therefore, its value as a chinook counting station is reduced.
4. The island at RM 12.6 is one of 17 islands comprising the Kenai River Islands State Recreation site. Its use as a weir site may not be permitted.
5. The riverbank lands are private property, and acquisition of the property could be difficult and costly.

For reasons that are addressed in Section 3.2, this site was eventually eliminated from further consideration. For these reasons, a site concept and cost estimate were not prepared for this site.

### 3.1.2 Weir Site at RM 9.0

The site, shown in Figures 3 and 4, is similar to the site at RM 12.6. As with the upriver site, the channel at this point is narrowed by the presence of an island. The operation would be similar to the RM 12.6 operation in that the salmon would be diverted to the shallower left channel for counting. The facility would consist of a floating diversion weir in the right channel and a submerged counting weir in the left channel.

Good attributes of this site are as follows:

1. The main channel is reduced to two narrower channels by the presence of an island; i.e., facilitates construction.
2. Velocities in this section of the river are lower than those at RM 12.6.

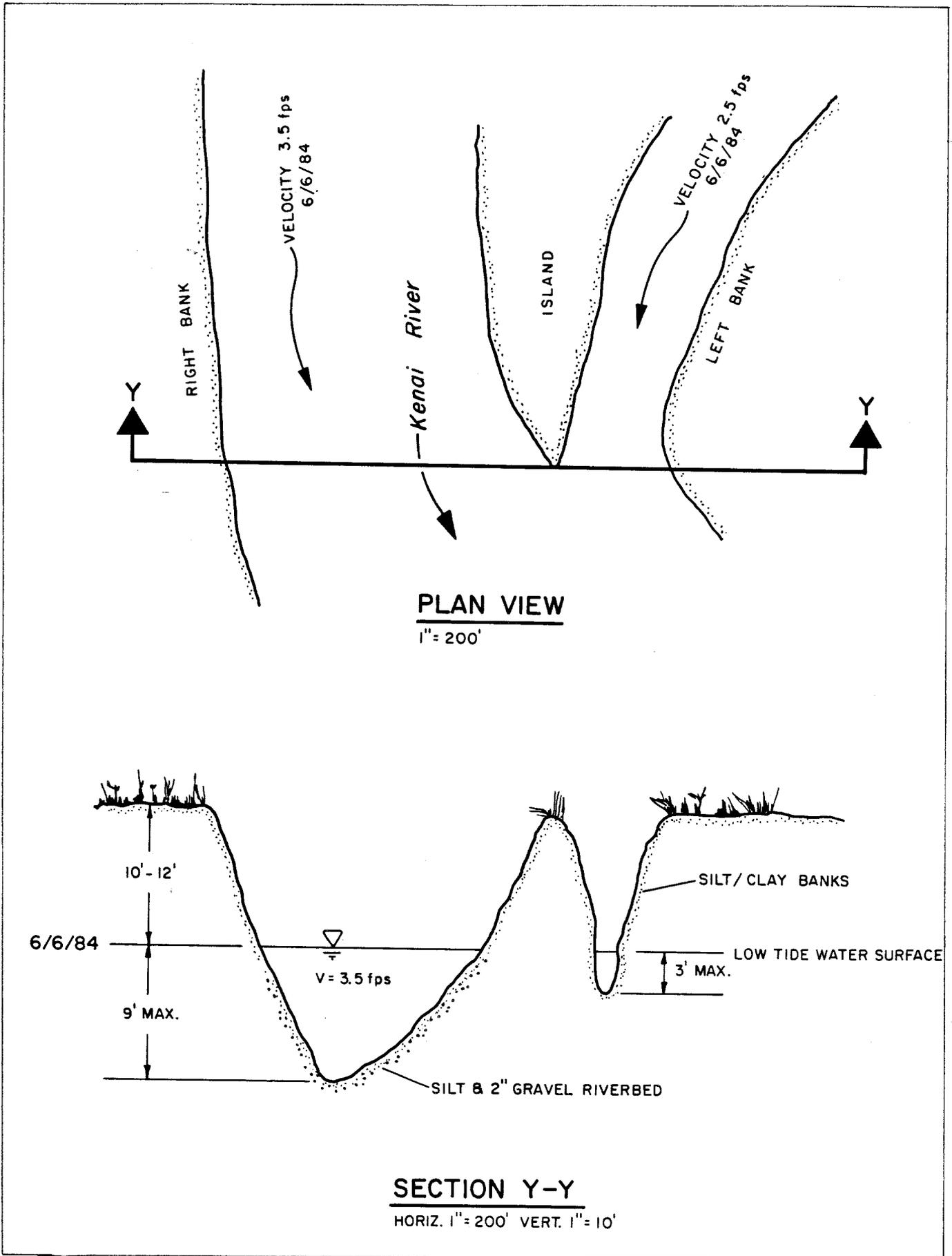


Figure 3. Weir site at RM 9.0 (plan and profile).

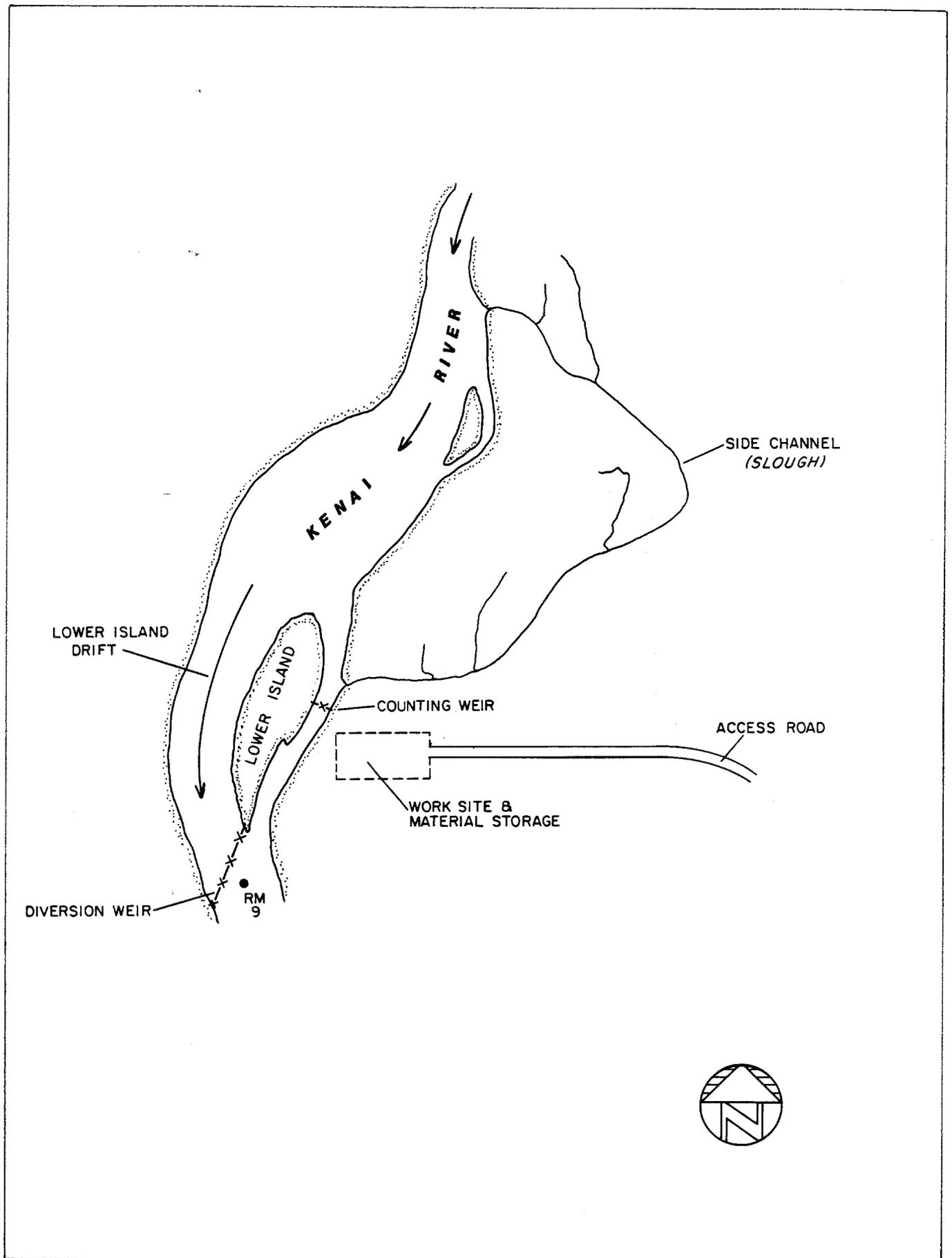


Figure 4. Weir site at RM 9.0 (weir layout).

3. Although the riverbed consists of silt materials, it is still suitable for pile-driven-type construction.
4. Site access is marginal. Access roads would have to be constructed if wheeled vehicles were used for construction. Because of the tidal influence, this site is accessible to construction equipment by barge. If road access were not constructed, then the operations personnel would be required to commute via skiff. Skiff transportation would not be unduly troublesome as logistics could be accomplished from sites located 1 to 2 miles upstream or downstream.
5. The riverbank lands are borough property and should be subject to easier acquisition than the private property at RM 12.6. This land is, however, prime wildfowl habitat, and because of its wetlands classification, the construction of a weir, even though it is a resource management tool, might not be permitted.

Site deficiencies are as follows:

1. The site is under tidal influence, which complicates construction and operations.
2. Site access is marginal - not particularly good nor bad.
3. Boat traffic (fishermen) is not as heavy as at RM 12.6 but is still heavy enough to conflict with weir operations.
4. This area of the river may contain salmon that are milling about in search of different river systems.
5. The schooling of pink salmon may complicate counting operations.
6. Winter icing is a major problem.

For reasons that are addressed in Section 3.2, this site was given lower priority than was the site at RM 5.0, which is discussed in the next section. For this reason, only the Anderson•Bjornstad•Kane•Jacobs, Inc., (A•B•K•J) net-weir concept was developed for this site.

### 3.1.3 Weir Site at RM 5.0

This site, shown in Figures 5, 6, and 7, was investigated because of its good accessibility to the New Beaver Loop Road, the shallow water which is present downstream of the Warren Ames Bridge, slower water velocity, and because it is not considered to be practical to count salmon at locations further downstream. This last consideration is based on the assumption that large numbers of the salmon that enter the Kenai River and reach RM 5 may be bound for other river systems and may eventually leave the Kenai River. The idea is to avoid counting "strays" by starting the count upstream of straying limits.

Good attributes of this site are as follows:

1. The low-tide water levels are relatively shallow; the center portion of the river goes dry on some tides.
2. The river velocities are relatively slow with zero velocities and reverse currents occurring at the change of tides.
3. A stable riverbed and banks similar to RM 9.0.
4. Excellent access both from a construction and an operational standpoint.
5. Minimal conflict with boat traffic.
6. The riverbanks are borough property, and access to the site should not be difficult. The wetlands classification could, however, preclude weir construction/operations at this location.

Site deficiencies are as follows:

1. Tidal fluctuations of up to 20 feet are a major problem in the design and in the weir operations.
2. It is thought that the milling of salmon bound for other systems (strays) could cause operational problems.
3. The schooling of large numbers of pink salmon could cause difficulties with counting operations.

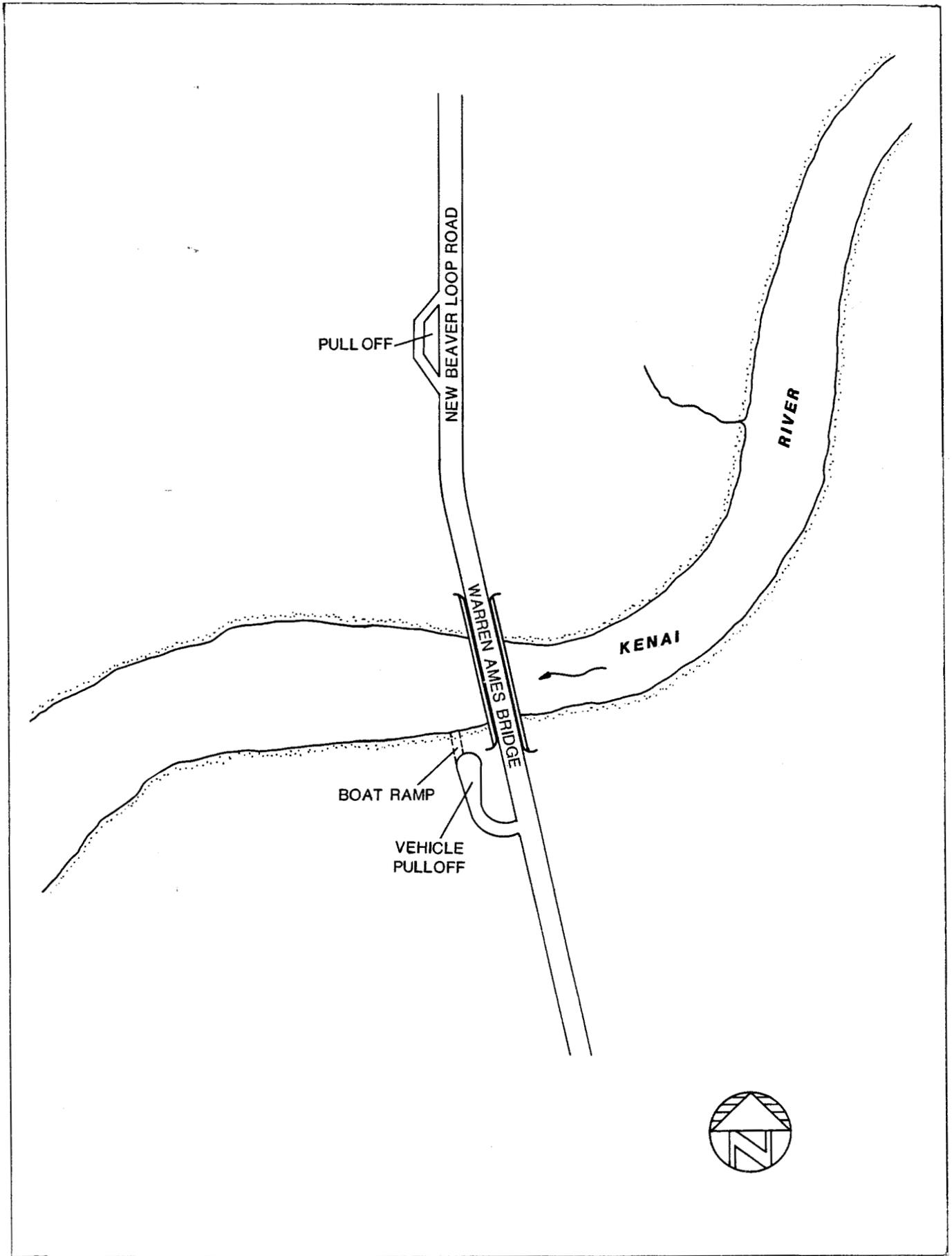


Figure 5. Weir site at RM 5.0.

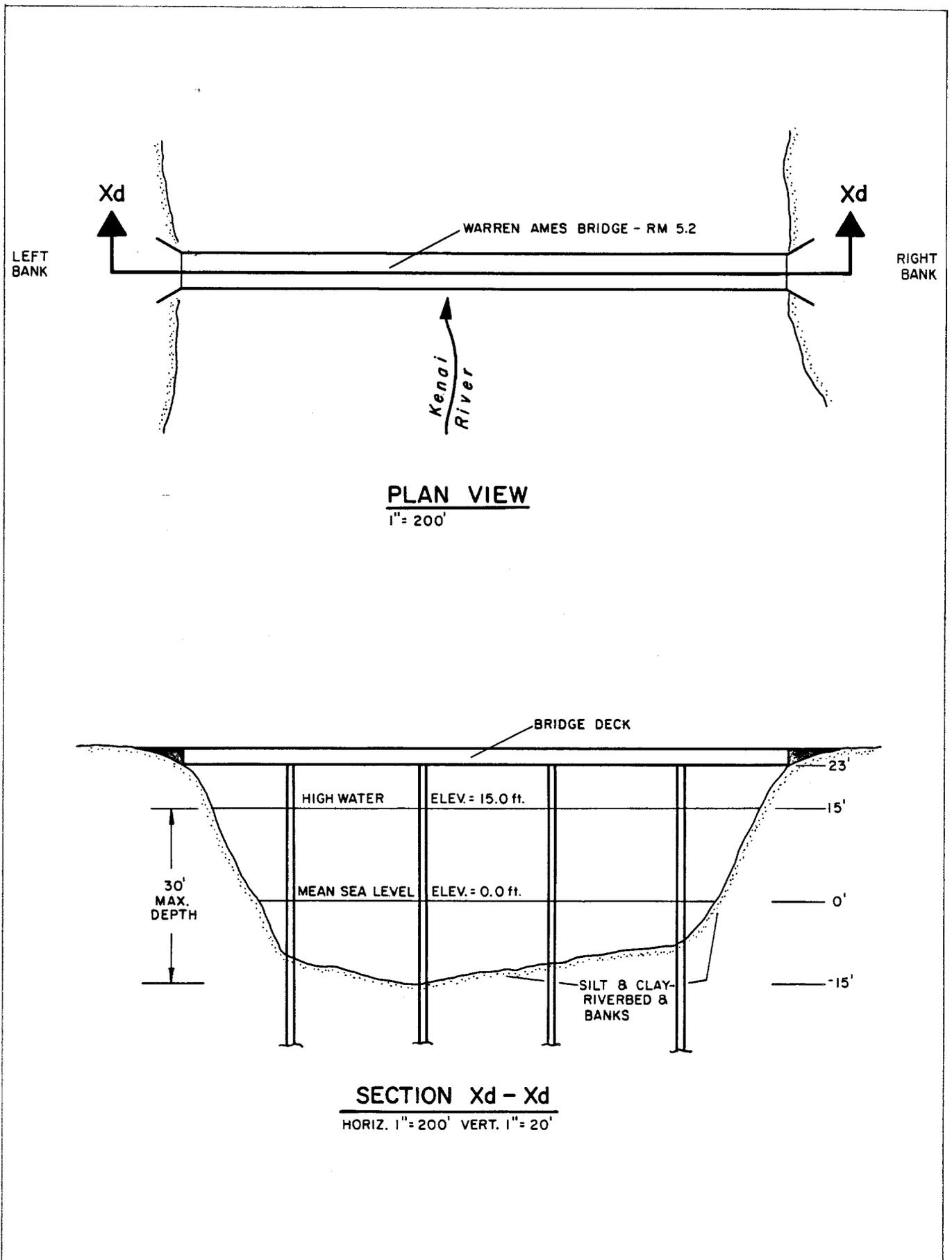


Figure 6. Weir site at RM 5.0 (section at bridge looking downstream).

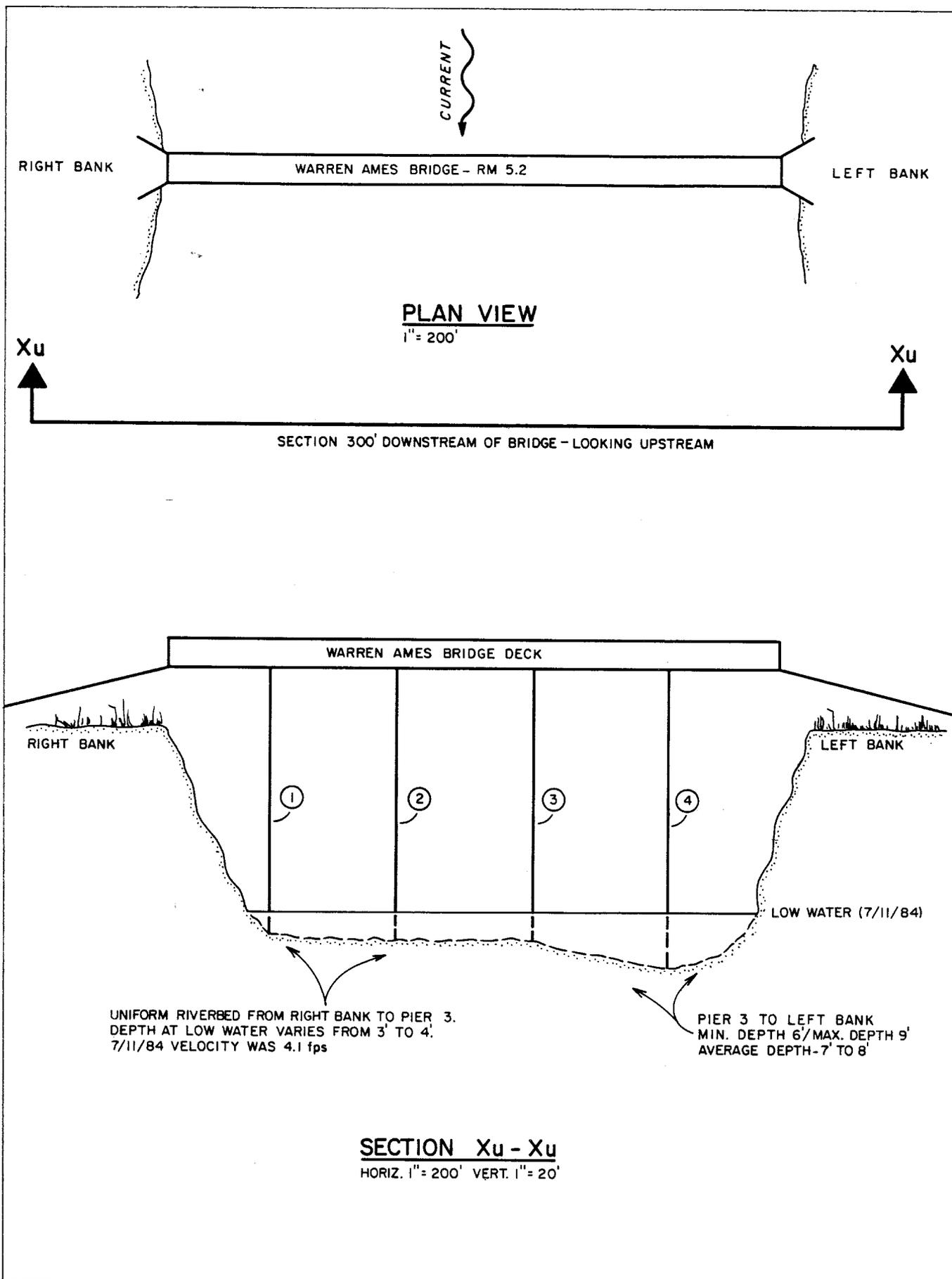


Figure 7. Weir site at RM 5.0 (section downstream of bridge looking upstream).

4. Winter icing is a very serious problem in this area. It is believed that it is economically impractical to build a permanent (year-round) structure at this location.

Two cost estimates for a seasonal structure were prepared for this site. The details and cost estimates for the two concepts appear in Section 4.0.

### 3.2 Modified Investigations (August 1984)

On 5 August 1984, a project status review was held with the directors of the fisheries divisions and one of the Deputy Commissioners. The decisions reached at that meeting were as follows:

1. In order to minimize conflict with fishermen, further investigations were to be confined to sites downstream of RM 9 and preferably downstream of the "Big Bend Drift", which is located between rivermiles 8 and 9. This decision eliminated the site at RM 12.6 from further consideration and reduced the importance of the site at RM 9.0.
2. Emphasis was placed on selecting a site, developing a concept, and preparing a cost estimate by early February 1985. The February deadline was selected so that the cost information could be used to modify the FY '86 CIP budget to include funding for a weir. In order to meet the compressed deadline, authorization was given to hire a fisheries consultant to expedite the field work and to develop a cost estimate prior to the February deadline.

Based on the foregoing directions, the following activities have taken place:

1. A contract was signed with the engineering consulting firm of Anderson•Bjornstad•Kane•Jacobs, Inc. to review the site information gathered by ADF&G personnel and to develop a weir concept with RM 5.0 given primary consideration.

2. The consultant's concept report was completed at the end of September. The details of that study are contained in a separate report titled Feasibility Study - Kenai River Adult Salmon Counting Weir. In summary, the consultant's concept consists of a floating net weir to be constructed at RM 5.0 for a project cost of \$1,530,000. Project costs included \$1,252,000 for construction plus \$280,000 for design and construction services. See Section 4.1.1 of this report for details of the consultant's concept.
3. The consultant's report was distributed to the fisheries divisions for review and comment.

### 3.3 Current Investigations (November 1984)

At a Cook Inlet review meeting held in Anchorage on 25 October 1984, the consultant's concept for a net weir was reviewed. The net-weir concept was not favorably received, and the general consensus was that a net weir was not practical. The conclusions/decisions reached at the Anchorage meeting and the conclusions/decisions reached at a Soldotna meeting held on 12 December 1984 included the following:

1. The net-weir concept was not to be given further consideration.
2. Uncertainties and operational problems with any concept necessitate further study, and funding for weir construction should not be included in the FY '86 CIP request.
3. Consensus was that a strictly physical barrier weir does not appear to be practical. Further studies should pursue the use of a barrier weir in conjunction with electronic counting methods; i.e., the use of a barrier weir to direct the fish into a confined area for counting by electronic methods.
4. Concern was expressed that counting fish in the "lower" stretches of the river would lead to confusing results because of the presence of large numbers of strays. Fisheries managers at the Soldotna meeting recommended investigating the section of the river between RM 9.5 and RM 11.5. RM 11.5 was suggested as the upstream limit for a weir; beyond that point, too many

chinook salmon are lost to spawning, and it was felt that operational conflicts with boat traffic would be too intense.

5. Although no consensus was reached, some managers at the Soldotna meeting felt that if a weir were constructed downstream of RM 11.5, its operation could include closure of a section of the river to boat traffic.

The concepts that appear in Sections 4.1 and 4.2 were based on field investigations made prior to December 1984. An attempt was made to look at the river from RM 9.5 - RM 11.5 during the Soldotna trip of December 12, but ice conditions prevented travel by boat or by foot upstream of RM 10. A visit to a potential site at RM 9.8 was made, but the ice and snow conditions made collecting meaningful information impossible. Investigations of this section of the river cannot be made until after the 1985 spring breakup.

#### 4.0 WEIR CONCEPTS AND COST ESTIMATES

##### 4.1 RM 5.0

###### 4.1.1 A·B·K·J, Inc. - Net Weir

ADF&G personnel rejected the concept of using a net weir in the Kenai River. The net concept (Figure 8) is summarized here, however, because it has merit and could possibly be adapted for use on other rivers. This summary will also provide a comparison with other concepts and will help preserve the information for future reference. For complete details of this concept, refer to the 21 September 1984 report by Anderson·Bjornstad·Kane·Jacobs, Inc. titled Feasibility Study - Kenai River Adult Salmon Counting Weir.

The consultants selected their net concept over other concepts, which incorporated wood, metal or plastic pickets or other net configurations, because of construction and operational considerations. As shown in Figure 8, the A·B·K·J concept consists of two nets and a shear boom stretched diagonally across the river. The shear boom is designed to deflect large debris such as trees and root systems to the shore where it is removed from

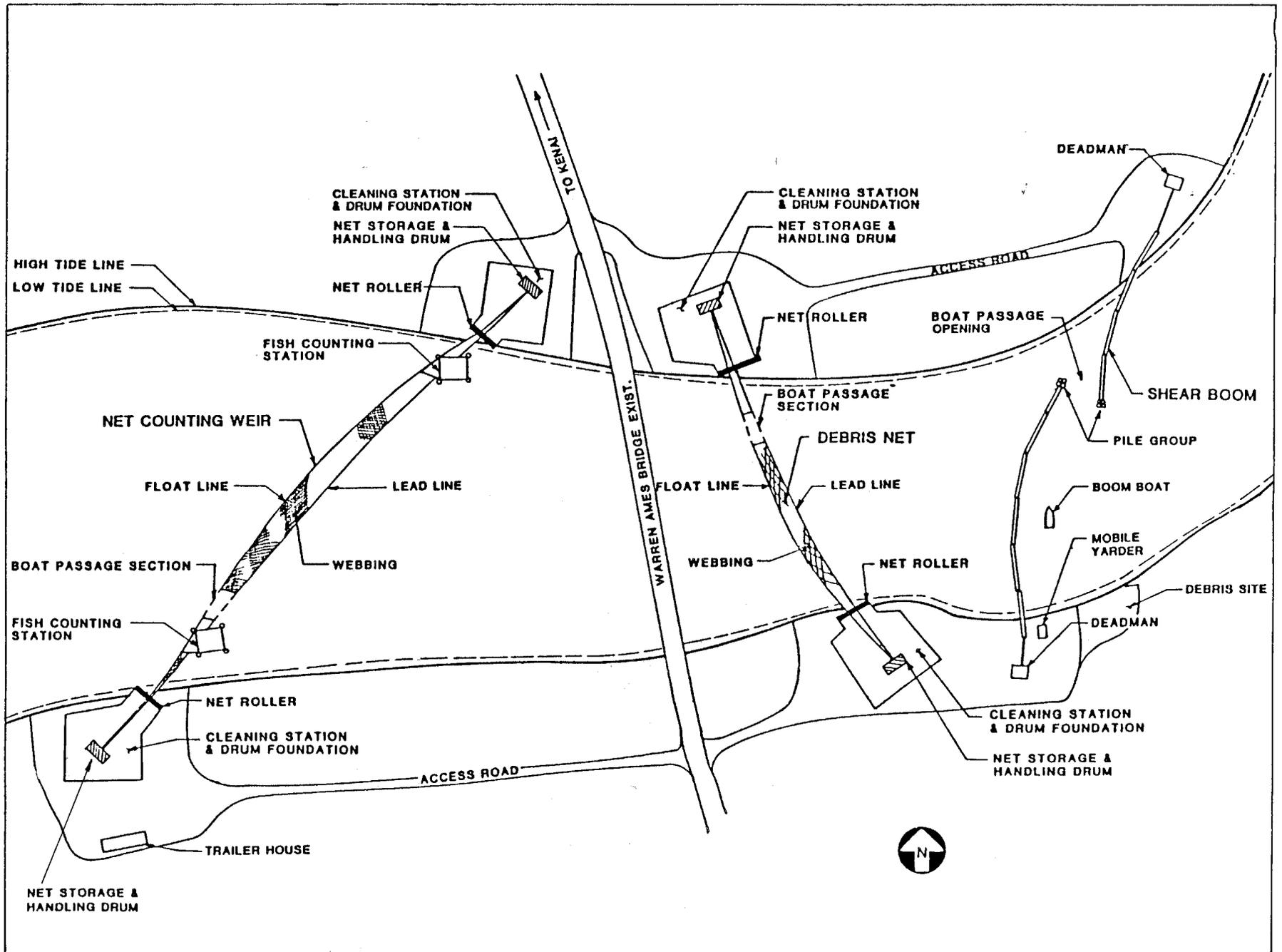


Figure 8. A.B.K.J, Inc. - net weir at RM 5.0.

the water. The upstream net acts as a filter for smaller debris such as tree branches and grass; the downstream net is the counting weir. The weir's design causes the salmon to rise to the surface at each bank where they are counted visually. Drums on both banks are used to pull the nets out of the water for cleaning and maintenance. The clean half of each net remains in the water (fishing/filtering) while the dirty half is pulled onshore for cleaning. This weir is designed to be installed each spring and removed each fall. Two valued aspects of this design are as follows: (1) Because it is removed each fall, it avoids the major construction costs of providing a year-round, ice resistant weir foundation, and (2) since the equipment is readily movable, this weir could be easily transported to other sites if situations so warranted. Table 1 is a summary of the estimated costs for the A·B·K·J concept.

#### 4.1.2 ADF&G - Pipe Weir

The RM 5.0 site is favored from an engineering standpoint primarily because of the good access and reduced water velocities; however, as pointed out in Section 3.1.3, this site has its deficiencies, too.

The pipe concept, shown in Figures 9 through 14, was devised to overcome the three objections that were voiced most frequently concerning the net weir; i.e., namely, the problem of injury to fish (gilling adults and scaling juveniles), the problem of net fouling by debris, and the conflict with boat traffic. The pipe weir incorporates the use of floating plastic pickets that are not unduly harmful to fish and should present less of a fouling problem than does a net. The boat conflict and debris problem are eliminated by providing 200-foot openings along both riverbanks. The following synopsis describes the construction and the operation of the pipe weir.

The pipe weir is a compromise between a visual counting facility and an electronic counting facility; it removes some of the uncertainties of electronic counting measures by forcing the migrants to confined areas along both banks, where they are counted electronically.



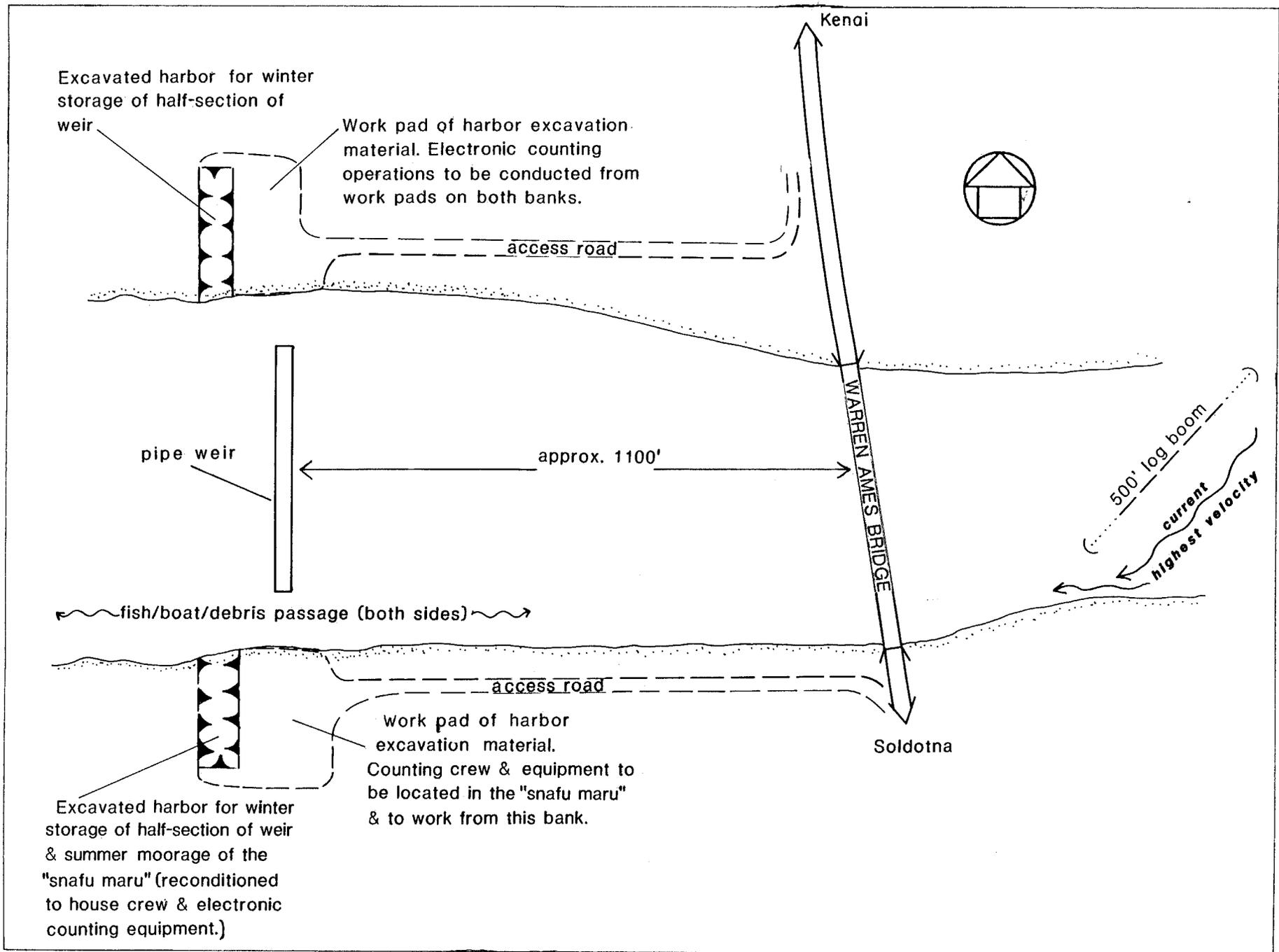


Figure 9. ADF&G - pipe weir (site layout).

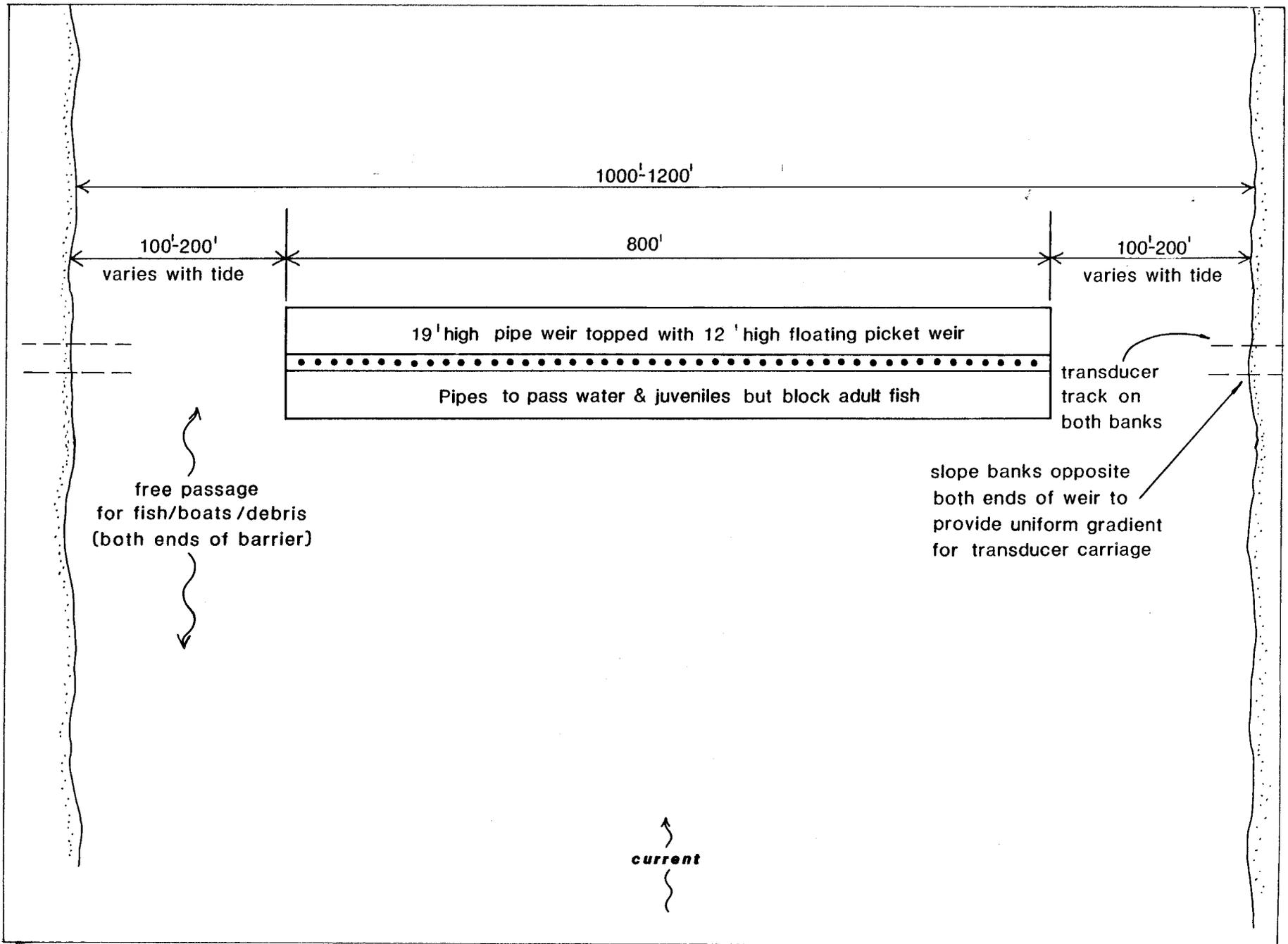
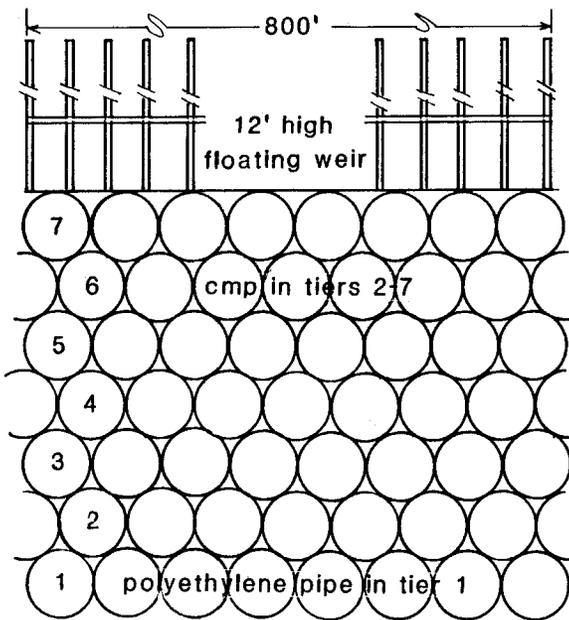
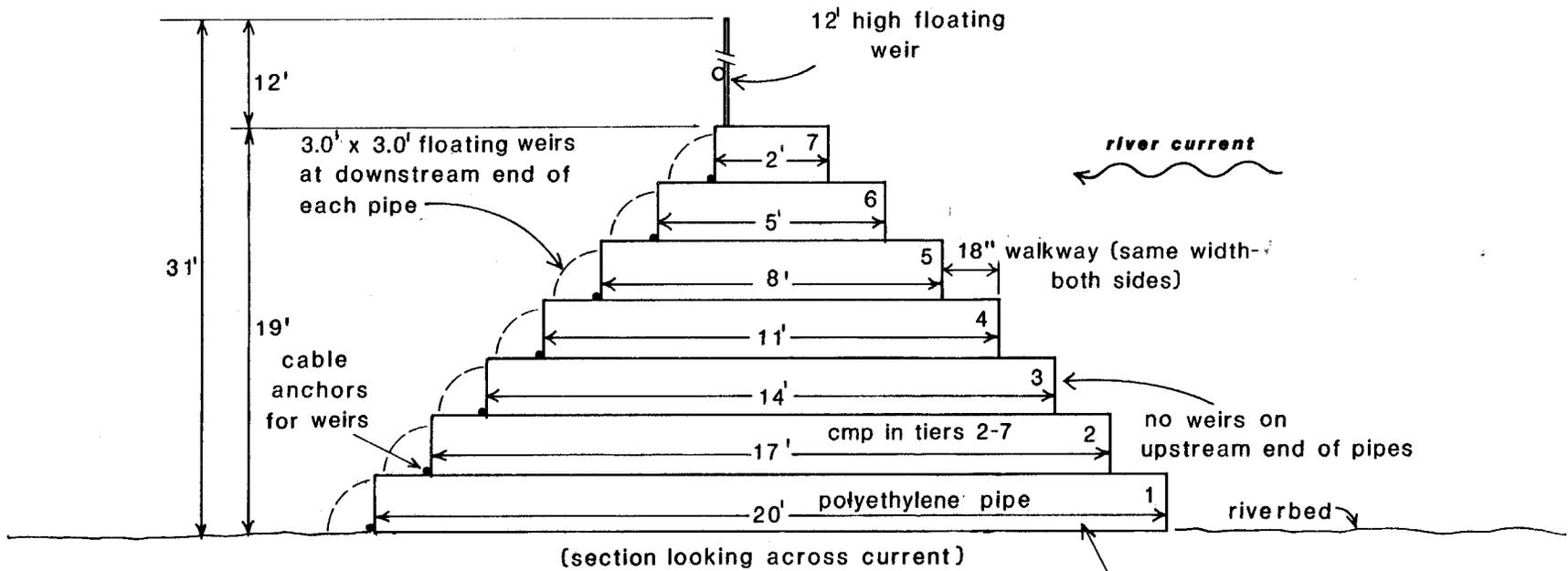


Figure 10. ADF&G - pipe weir (plan view).



16 pipes in bottom tier to be sealed and valved. Structure to be floated into place, flooded and sunk. Remove in the fall by blowing ballast. Store half of weir in moorage areas excavated in each bank.

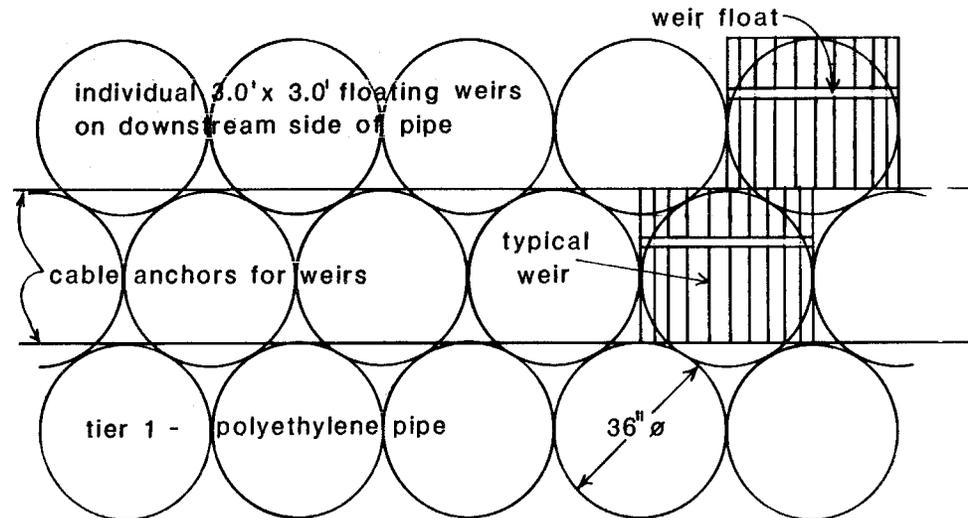


Figure 11. ADF&G - pipe weir (cross section and details).

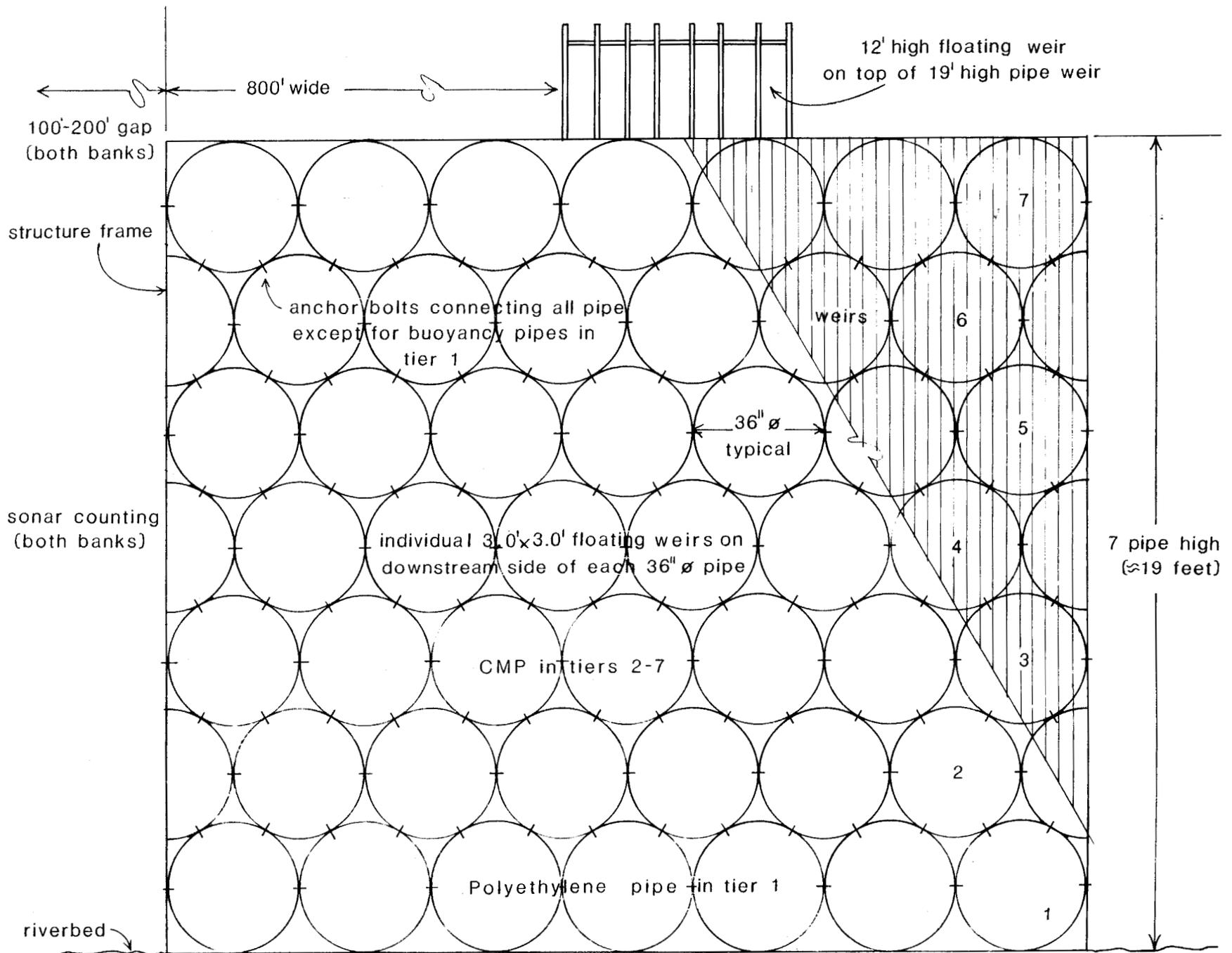


Figure 12. ADF&G - pipe weir (pipe details).

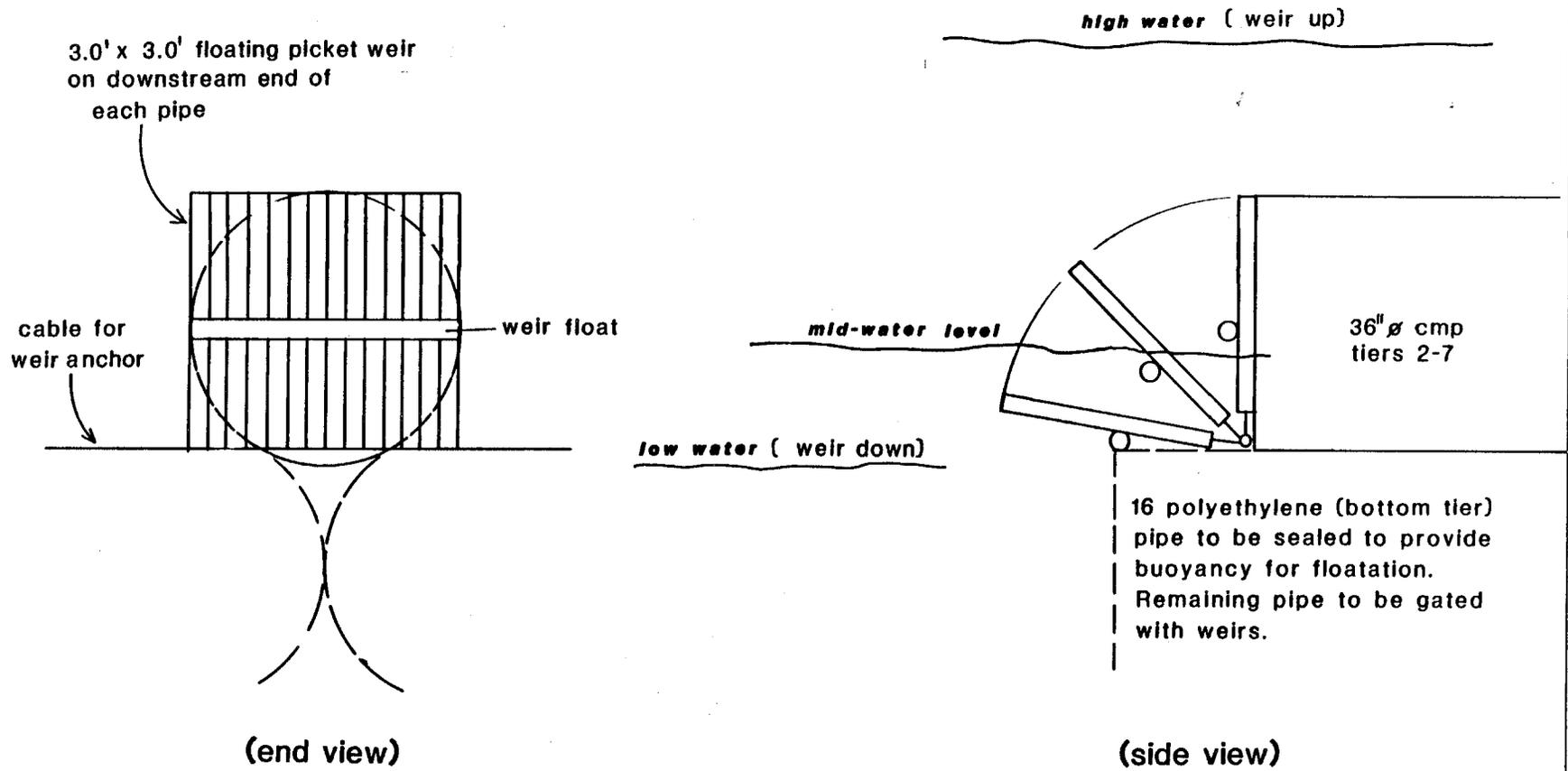
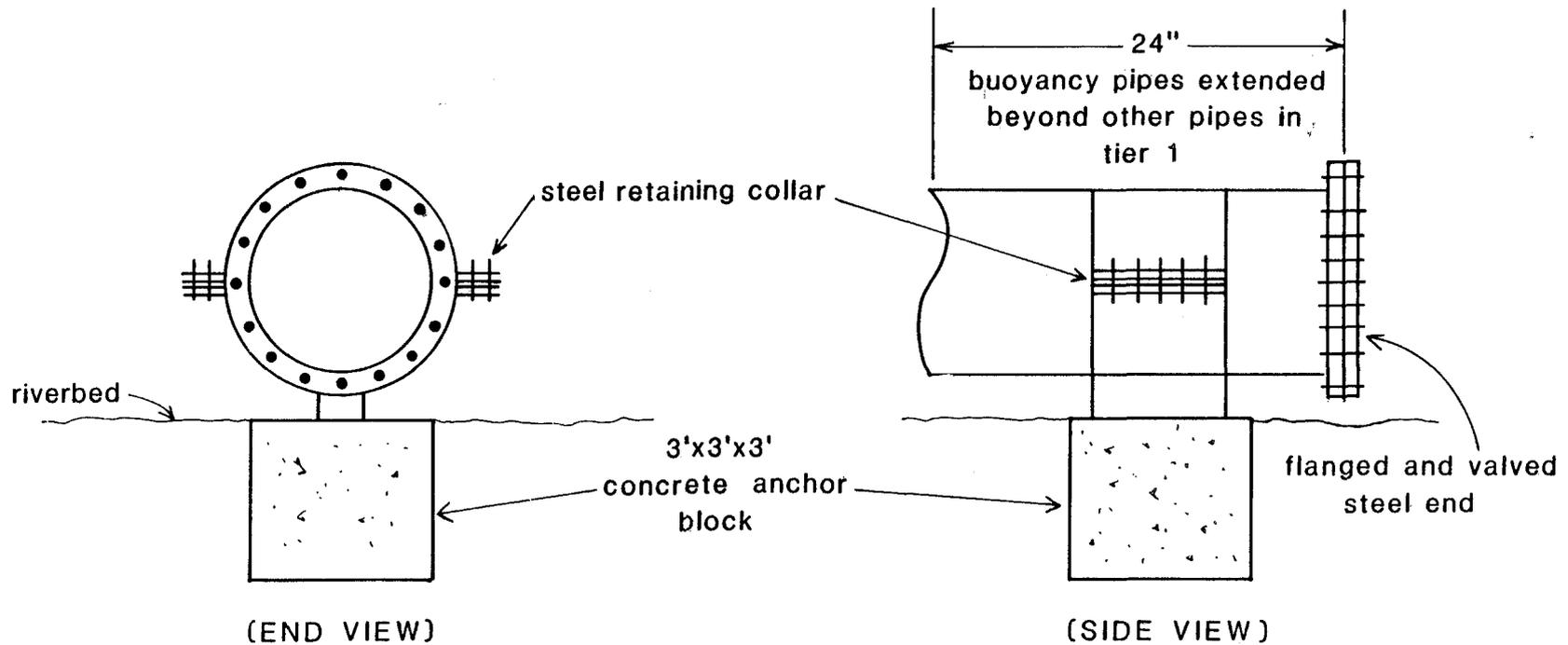


Figure 13. ADF&G - pipe weir (submerged weir details).



16 buoyancy pipes are to be spaced at 50' intervals and anchored at each end by 3'x3'x3' concrete anchor blocks attached to steel retaining collars. Ends of buoyancy pipes are to be flanged and valved to permit flooding with water and clearing by compressed air.

Figure 14. ADF&G - pipe weir (pipe anchor details).

The weir is constructed of 36" diameter ( $\emptyset$ ) pipe. The lower tier consists of polyethylene pipe, which provides floatation for the structure; while the remaining tiers, consisting of corrugated metal pipe (CMP), constitutes the barrier. The structure will not reach the surface during high tides; so, a floating picket weir on top of the structure is used to prevent salmon from swimming over the top. Floating pickets, covering the downstream side of each pipe, prevent salmon from traveling through the structure. The nature of the floating weir, combined with the upstream log boom, minimizes the amount of debris adhering to the structure. The pipe weir will block the center 800 feet of the river, and the salmon, boats, and debris will pass through the openings along both banks. The weir crew will operate the facility from an ADF&G vessel (referred to as the "Snafu Maru") that will be moored in a harbor excavated in the left bank. The weir is seasonal in that it will be floated into position each spring and sunk onto mooring blocks. In the fall, the structure will be refloated and moved into the storage harbors excavated into the riverbanks. Table 2 is a tabulation of the estimated costs for the pipe weir.

#### 4.2 RM 9.0

##### 4.2.1 A.B.K.J, Inc. - Net Weir

A net-weir concept has certain advantages over the standard picket-weir concept; i.e., minimal disturbance to the environment and adaptability to variations in water level and riverbed conditions. Its use at RM 9.0 is depicted in Figure 15. The department, however, has decided not to pursue the concept of a net weir.

The net weir at RM 9.0 would operate similarly to the net weir at RM 5.0. The primary difference between the two sites is that the RM 5.0 site is more accessible because of its close proximity to the New Beaver Loop Road. However, the shear boom for the RM 9.0 site is located near the end of Angler Drive, so access to the "old" Beaver Loop Road is possible at RM 9.0.

The cost of a net weir, built at RM 9.0, would be comparable to the cost shown in Table 1.

Table 2. Cost of ADF&G pipe weir at RM 5.0.

CLASS OF WORK OR MATERIAL	QUANTITY	UNIT	MATERIALS/LABOR		TOTAL COST
			PRICE/UNIT	EXTENSION	
A. Weir Structure					
1. 36" Ø Polyethylene Pipe	5,404	ft	\$51.83/ft	\$280,089	
2. PE Pipe Frt (Sea - Kenai)	5,404	ft	12.51/ft	67,604	
3. PE End Plates	32	each	1300/each	41,600	
4. 36" Ø CMP	15,219	ft	12.78/ft	194,499	
5. CMP Frt (Wasilla -Kenai)	15,219	ft	1.25/ft	19,024	
6. Concrete Anchors	32	each	156/each	4,992	
7. Weir Frame	2	each	2500/each	5,000	
8. Pipe Bolts	9,879	each	1.50/each	14,818	
9. 3/8" Wire Rope	11,200	ft	0.75/ft	8,400	
10. Cable Clamps	475	each	1.05/each	499	
11. Surface Weir (1m x 5m Jap)	270	panel	312/panel	84,240	
12. Weir frt (Yokohama - Anch)	1	L.S.	150,000	150,000	
13. Submerged Weir	2,100	panel	40/panel	<u>84,000</u>	
Total Item A = -----					\$954,765
B. Harbors/Pads/Road					
1. Uncl. Exc. & Fill	22,000	c.y.	\$6/cy	\$132,000	
2. Gravel Surface	2,000	c.y.	10/cy	<u>40,000</u>	
Total Item B = -----					\$172,000
C. Transducer Carriage	= 2	each	\$5000/each	\$10,000	----- \$10,000
D. 500 Ft Log Boom					
1. Treated Wood Poles (45')	11	each	\$375/each	\$4,125	
2. 125 lb. Danforth Anchors	4	each	425/each	1,700	
3. 3/8" Galv. Chain	400	ft	2.90/ft	1,160	
4. Galvanized Shackles	8	each	5/each	40	
5. Fasteners	24	each	10/each	240	
6. Misc (Wire Rope)	1	L.S.	100/L.S.	<u>100</u>	
Total Item D = -----					\$7,365

-continued-

CLASS OF WORK OR MATERIAL	QUANTITY	UNIT	MATERIALS/LABOR		TOTAL COST
			PRICE/UNIT	EXTENSION	
E. Weir Facilities					
1. Crew Housing (Snafu Maru)	1	L.S.	\$25,000	\$25,000	
2. Weir Tender (boat)	1	L.S.	15,000	<u>15,000</u>	
Total Item E =	-----				\$40,000
F. Contingency					
10% (Items A thru E minus frt)	-----				\$94,750
G. Contractors' Fee					
15% (Items A thru E minus frt)	-----				Say = \$142,125
H. Total Construction Cost					
Items A through F	-----				\$1,421,005*

\* In addition to this amount, approximately \$100,000 in electronic equipment is required. As of 1985, ADF&G has the needed electronic equipment on hand but if a weir were to be constructed, then new electronic equipment should probably be purchased at the same time.

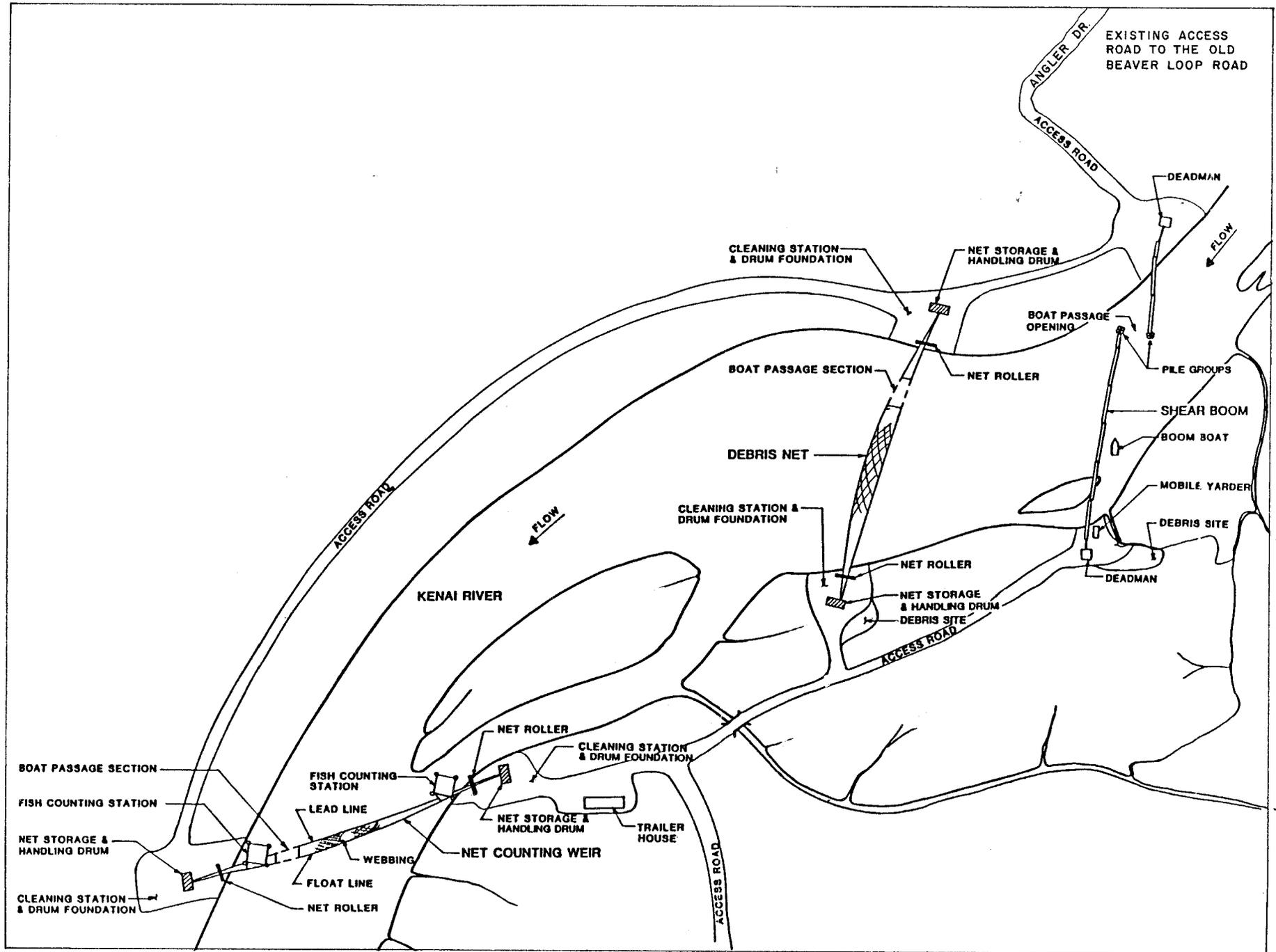


Figure 15. A.B.K.J, Inc. - net weir at RM 9.0.

#### 4.2.2 Other Concepts at RM 9.0

Initially, it was thought that RM 9.0 would be a viable site to locate a conventional weir: an island facilitates construction; the velocities are manageable; the tidal fluctuations are not as severe as at RM 5.0; and the riverbed is stable. However, on closer inspection, it was found that the riverbed profile contains steep gradients, and the right channel is very deep at high tides. The combined problems of riverbed profile, water depths, and ice conditions preclude building a conventional weir unless it is supported on a foundation of piling, concrete, or large rock fill. Although construction of that type is not impossible, it is very expensive, and maintaining the foundation would also be costly and labor intensive. For these reasons and for the concerns expressed by the fisheries managers over the boat traffic and the straying salmon problem, it was decided not to continue the investigations at this site.

#### 4.3 RM 9.8

The site (Figure 16) was first discussed at a meeting held in Soldotna on 12 December 1984. The site was considered because it is narrow: 250 feet wide during periods of low flow and about 400 feet wide during periods of high flow. This natural narrowing of the river lends itself to an electronic-type counting operation where the salmon are restricted to a 200 to 250-foot counting zone along the right bank. Because of the extreme icing condition of the water and the riverbanks that were encountered on December 12, it was impossible to collect data concerning riverbed profile, widths, and depths or water velocities. The following attributes/deficiencies of the RM 9.8 site are based on a single, superficial inspection of the site. Additional field data are needed to supplement these cursory observations.

Good attributes of this site are:

1. Because of a sandbar located near the left bank, the channel width is reduced to about 250 feet during periods of low flow. During periods of high flow, the channel width

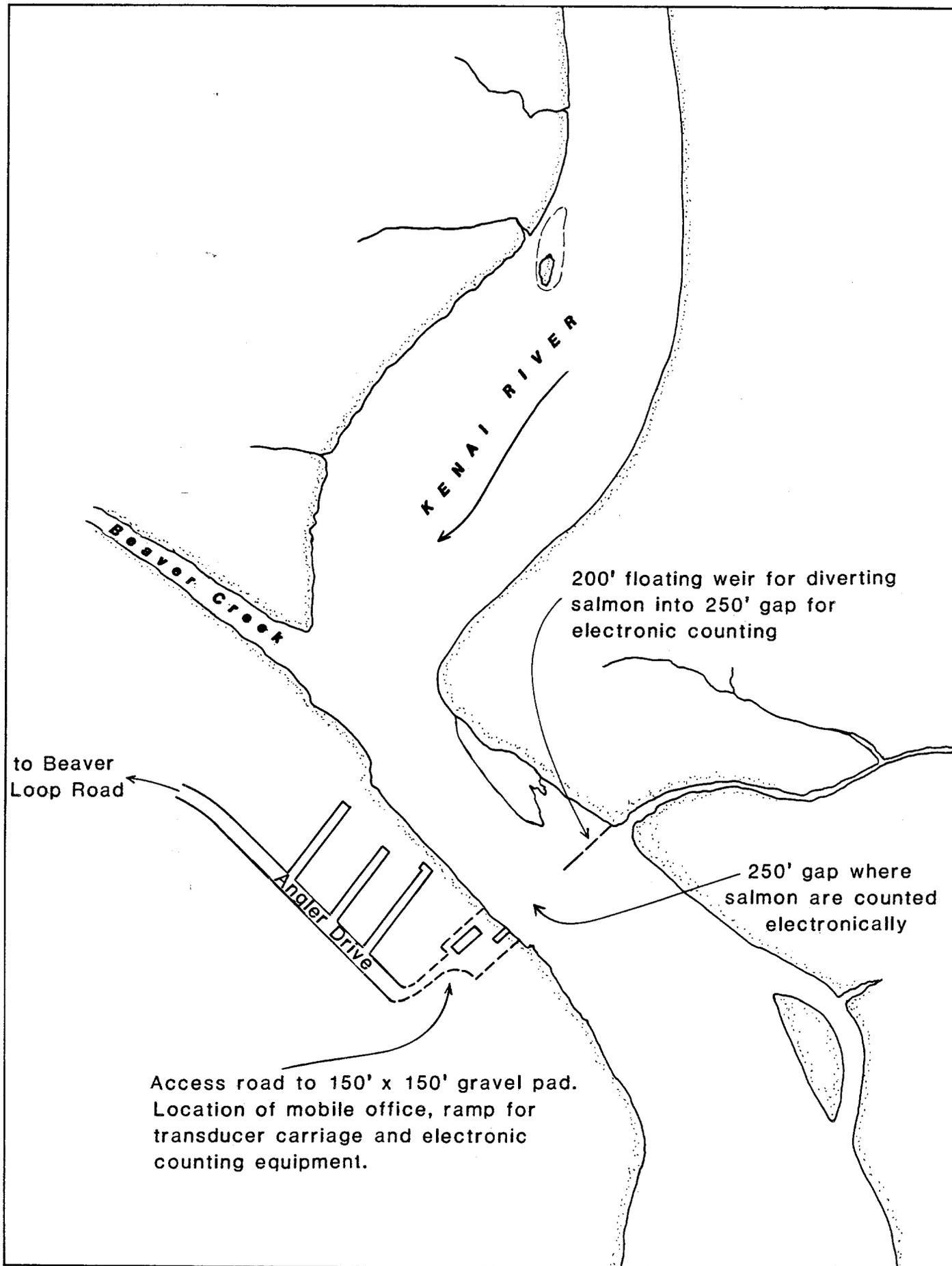


Figure 16. Weir site at RM 9.8.

appears to be about 400 feet. The narrow width greatly reduces the amount of weir construction required.

2. Access is good as the prospective site is within 500 feet of Angler Drive on the right bank.
3. Land acquisition should be reasonable. A 20.96 acre parcel, located at the south end of Angler Drive, is private property and is assessed at \$17,800. The purchase or lease of a one-acre parcel should be possible.
4. The tidal range could not be determined, but it is less severe than at RM sites 9.0 and 5.0.
5. From the placement of houses near the right riverbank, the stream channel appears to be relatively stable. The bank stability is less critical for weir operations than it is for the placement of houses.
6. The salmon inhabiting this section of the river are believed to be upstream migrants, and the counting of incidental strays is not considered to be a problem.

Site deficiencies are:

1. The water depth and velocity could not be measured so that data are uncertain at this time. However, as this site is a variation of RM 9.0 and the RM 12.6 sites, these conditions are not thought to be insurmountable.
2. The Beaver Creek Drift fishery exists in this section of the river, and conflicts with boat traffic could be a major problem.
3. The drift fishery exists because it is thought that salmon school along the right bank in this section of the river. Schooling fish could also be a problem for electronic-counting operations.

Table 3 is a tabulation of the estimated cost for constructing a salmon counting facility at RM 9.8.

Table 3. Cost of weir at RM 9.8.

CLASS OF WORK OR MATERIAL	QUANTITY	UNIT	MATERIALS/LABOR		TOTAL COST
			PRICE/UNIT	EXTENSION	
A. Work Station					
1. Land Acquisition	1	AC	\$2,000	\$2,000	
2. Unc. Fill	2,300	c.y.	6.00	13,800	
3. Gravel Surfacing	500	c.y.	20.00	10,000	
4. Transducer/Boat Ramp	1	L.S.	500	<u>500</u>	
Total Item A = -----					\$26,300
B. Station Equipment					
1. Mobile Office (used)	1	L.S.	\$20,000	\$20,000	
*2. Weir Tender (boat)	1	L.S.	7,000	7,000	
3. Electronic Counting Eq.	1	L.S.	100,000	100,000	
4. Transducer Carriage	1	L.S.	5,000	5,000	
5. Floating Weir	200	L.f.	45.00	<u>9,000</u>	
Total Item B = -----					\$141,000
Total Facility Costs = -----					\$167,300

\*The department has sufficient electronic equipment on hand to start operations. However, new replacement equipment should be purchased if a permanent (long term) counting station is to be constructed.

#### 4.4 RM 10.3

The site (Figure 17) was first discussed at a meeting held in Soldotna on 12 December 1984. The fisheries managers suggested this site for the following reasons:

1. This location is thought to be above the straying limits for most salmon.
2. It appears to be a location where the salmon migrate through rapidly without undue holding or milling.
3. It is not in a popular drift-fishing area such as the Beaver Creek Drift or the Eagle Rock Drift.
4. It is not so far into the chinook salmon spawning grounds as to seriously detract from the counting operations.
5. The Kenai River was designated as a "Special Management Area" by the Alaska Legislature in 1984. Heavy emphasis is being placed on habitat protection, establishing wetlands, and similar conservation practices. The RM 10.3 site may be the best weir site from a conservation perspective because it would not require the disturbance of much riverbank habitat. The operation would be conducted entirely instream during summer months, and there would be no significant alterations to the environment caused by the weir operations. According to the Kenai River management regulations that are currently being formulated, it could be that only an instream weir operation such as is proposed for RM 10.3 would be permitted.

Because of climatic and access conditions, it is presently impossible to collect physical data such as river velocities and depths or riverbed conditions. The collection of data of that type will have to be delayed until after the 1985 spring breakup. The weir concept depicted in Figure 17 is based on data derived from reviewing maps and aerial photographs. Therefore, the concept and the cost estimate that is tabulated in Table 4 must be considered preliminary.

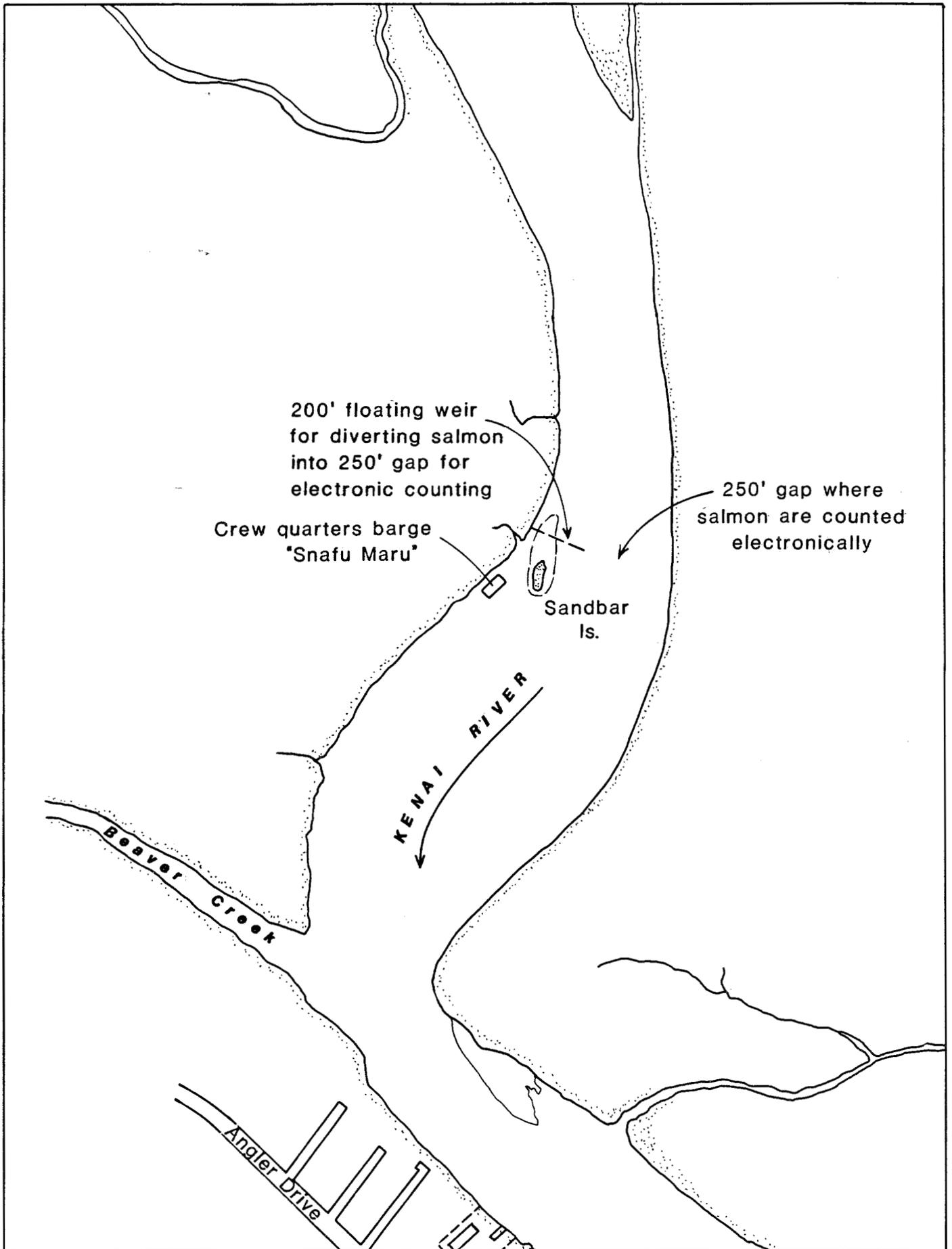


Figure 17. Weir site at RM 10.3.

Table 4. Cost of weir at RM 10.3.

CLASS OF WORK OR MATERIAL	QUANTITY	UNIT	MATERIALS/LABOR		TOTAL COST
			PRICE/UNIT	EXTENSION	
A. Crew Quarters Barge Modification	1	L.S.	\$25,000	\$25,000	
B. Weir Tender (boat)	1	L.S.	7,000	7,000	
* C. Electronic Counting Eq.	1	L.S.	100,000	100,000	
D. Floating Weir	200	L.f.	45.00	<u>9,000</u>	
Total Facility Costs = -----					\$141,000

\* The department has sufficient electronic equipment on hand to start operations. However, new replacement equipment should be purchased if a permanent (long term) counting station is to be constructed.

## 5.0 CONCLUSIONS

Several facts were highlighted during this study:

1. ADF&G management personnel are not in agreement as to the need for a salmon counting weir.
2. There is no consensus as to which species of salmon should be counted. The opinions vary from counting all species to counting chinook salmon only.
3. There is no consensus as to where (section of the river) a weir should be located. However, the majority of support seems to be for the section of river from RM 9.5 to 11.5.
4. There is no consensus as to how the count should be conducted; i.e., visually, electronically, or a combination of both.
5. There is considerable disagreement among managers as to the impact of weir operations on boat traffic. The views vary from prohibiting all boat traffic through a weir to not interfering with boat traffic at all.
6. There is agreement that reliability of operations must be the dominant consideration in constructing a weir; i.e., construction cost is of secondary importance.
7. Field investigations to date indicate that it is structurally possible to build weirs at some locations. The weir designs are site-specific, and operation and construction costs will vary significantly with the site selected. Also, it cannot be predicted at this time just what type of construction may be permitted by the Kenai River Management Authority (KRMA). The KRMA has invoked a six-month ban on riparian development while management regulations are being developed. The permitting of any weir operation would come under close scrutiny. To be permitted, weir construction would have to be site-specific and the operational procedures clearly defined.

## 6.0 RECOMMENDATIONS

It is structurally possible to weir the Kenai River, but the operational methods and the construction costs will vary in accordance with the site that is selected. Before a final decision on whether or not to weir the Kenai River can be reached, the following actions need to be accomplished:

1. ADF&G fisheries managers must resolve items 1 through 5, which are discussed in the conclusions section.
2. Based on the resolution of the five factors in item 1, detailed site-specific engineering data in the form of topographic information, riverbed profiles, velocities, depths, materials investigations, and other such data must be collected at the selected site.
3. In conjunction with item 2 and because of the impact that a weir may have on the river hydraulics, riparian habitat, and salmon migrations, it is recommended that the selected site undergo hydraulic model studies. Correspondence with personnel at the Washington State University hydraulic laboratory (Appendix A), indicates that modeling on a 1:50 scale could be done for approximately \$50,000 per site. Information gained from the model studies would be invaluable in determining which weir concept was most appropriate for a specific site. See Appendix A for more details concerning hydraulic modeling.
4. Based on the data collected in items 2 and 3, a detailed weir concept, operational plan, and cost-estimate have to be developed.
5. Using the detailed concept prepared in item 4, procedures to obtain permits through the Kenai River Management Authority must be initiated. Those procedures have not yet been established, and it may include obtaining individual permits through the U.S. Army Corps of Engineers and other agencies; it could entail writing an Environmental Impact Statement.

6. Based on the timing and success of obtaining construction permits, ADF&G would then initiate action to secure construction funding.
7. Final design activities should proceed as permitting and funding dictate.
8. A development schedule, based on ADF&G support for a weir, could be as follows:

Feb - Apr 1985: Resolution of items 1 through 5 of Section 5.0.

Apr - Dec 1985: Collect and evaluate field data described in items 2 and 3 of Section 6.0.

Nov 1985 - Jan 1986: Prepare detailed concept for weir and obtain ADF&G consensus for the project.

Feb - Jun 1986: Initiate permitting and funding actions. Start final design when permitting and funding is assured.

Jul 1986 - Jun 1987: Construction initiated. Funding, permitting, and the type of construction will dictate when construction begins. If development proceeds smoothly, construction could be completed in 1986. If delays occur, then construction would probably take place in 1987.

## 7.0 ACKNOWLEDGEMENTS

So many people within the Department of Fish and Game contributed material and ideas for this study that I will not try to list them individually. This writer received much help from many individuals within the Divisions of Commercial Fisheries, FRED, Habitat, and Sport Fisheries. Because I did work so closely with some people, I wish to acknowledge the additional contributions of the following FRED personnel: George Cunningham for his help on the field trips, Carol Schneiderhan for drafting all the figures, and Katherine Aschaffenburg for doing the typing.

Special thanks go to several people in the private sector who provided much helpful information at no cost to the Department of Fish and Game: Ed Donahue, P.E., of Port Orchard, WA, who reviewed all the concepts and provided many good suggestions; John Hutchins, P.E., of Seattle, WA; and Jim Bomford, P.E., of Victoria, BC, who reviewed several concepts and provided information that was used in the cost tables. Professor John Orsborn of the Washington State University hydraulics laboratory provided the information in Appendix A.

Also, I wish to acknowledge the excellent contributions of Messrs. Hiroshi Kato and Toru Itabashi of Tokyo, Japan, who provided specific details as to the construction, cost, and shipping of a Japanese-style floating weir. Much of the idea for the pipe weir was based on the Japanese weir concept. Messrs. Kato and Itabashi are planning a trip to Alaska during the summer of 1985 to help ADF&G personnel evaluate the possibility of using the resistance board-weir in the Kenai River.

APPENDIX A

12-19-84

1/5

Mr. Lowell Barrick  
Alaska Dept. of Fish & Game  
Division of Fisheries Rehabilitation,  
Enhancement and Development.  
Box 3-2000  
Juneau, AK 99802

Dear Lowell:

SUBJECT: Hydraulic Model Studies  
of Kenai River Fish Barrier  
and Counting Station

Just crossing Puget Sound from  
Bremerton to Seattle on the ferry after  
talking to Ed about your Kandi  
River project. He was very interested  
in my suggestion that a physical,  
hydraulic model study would  
answer a lot of the design questions  
for you.

There are many benefits which can  
be derived from doing a physical  
model study which include:

- (1) ease of making inexpensive  
and rapid changes to  
demonstrate possible design  
modifications;
- (2) documentation by video tape,  
movies or still photographs;

2/5

(3) Ease and benefit of demonstration to lay people;

(4) The inclusion of any desired discharge and/or tidal sequence; and

(5) The extension of the model into flow ranges for which prototype data may not be available.

Direct benefits to your project would include the determination of:

(1) flow patterns, and scour and deposition areas;

(2) the effects of ice and debris on the structure;

(3) forces on the structure, from which anchorage design forces could be determined;

(4) which designs give the best design performance; and

(5) any other hydraulic-structural factor you might wish to consider.

I only had the River Mile map to refer to, but if you are dealing with a 1000-ft.

wide reach of stream, <sup>3/5</sup>  
and depth fluctuations of  
from 4 to 40 ft, and  
assuming a 1:50 scale  
model, we would be  
dealing with a model about  
20 ft wide and 2 ft. long,  
depending on the length of  
reach to be covered (only 2000 -  
3000 ft, or 40 - to 60' long).

We have the space available  
to handle such a model  
(called COMPREHENSIVE, because  
it covers the whole site).  
Also, we have a multiple  
phase tide generator which  
can be easily installed to  
handle that phase of the  
project.

I don't recall the level of  
maximum flows you are  
dealing with there, but we  
can easily supply what  
ever is needed, depending  
on the final model scale.

We might want to consider the  
use of "SECTIONAL" models of  
the structures, built at  
a larger scale, to determine  
more accurately such things  
as forces on the alternative

barriers. These can be placed in existing <sup>4/5</sup> flumes.

Without having more detailed information on the site, flow regimes, bed load and potential designs to be tested, it is difficult to give you an accurate estimate of the model study costs. ROUGHLY, to build the comprehensive model and test it for a few barriers, we are talking in the \$50,000 range. Each sectional model would be in the \$8000 - \$10000 range. If more tests are needed for the comprehensive model they would run ABOUT an additional \$4000 - 5000 a month for 22 working days. These are total estimated costs including salaries, wages, benefits, supplies and materials, travel to the site, report preparation and overhead. So considering an active research and testing program with both types of models it would run \$70000 - \$80,000. With more information I can prepare a more accurate and detailed estimate. But, the real winner is that

5/5  
These model studies pay for themselves many times over in terms of reducing risk, optimizing design and reducing uncertainty.

For future contacts my address and phone are listed below:

John F. Orsborn  
Albrook Hydraulics Laboratory  
Washington State University  
Pullman, WA 99164-3001  
(509) 335-1404

If you cannot reach me, <sup>at 1404,</sup> the Secretary will answer (after 3 rings) and you can ask for me or:

Alan F. Babb, Director  
Albrook Hydraulics Laboratory  
Alan will be aware of this potential project.

I will probably be in the Lab Dec 27-28.  
When I arrive home on the 21st I will send you some information about the laboratory and our research programs.

We have developed a fisheries engineering option at the MS level in Hydraulic Engineering, and this project would fit well into that program.

Please call if you have any questions. What is the approximate time frame for the project?

Sincerely, Jack Orsborn

12-21-84

Dear Lowell:

As a follow up on my letter of the 19th about the Kenai Project, I have enclosed two brochures about our Albrook Hydraulics Laboratory programs.

One other factor I should mention about the study is that if your engineers are going to design the project we should work with them very closely. If you are going to hire a consulting firm to do the design we should be working with its engineers and biologists, as well as a FRED representative.

Field data on the river for about 1000' upstream and downstream of the site will be needed to design and construct the model.

What is the approximate schedule for the project?

If you need more information give me a call.

Sincerely,  
Jack Orsborn

Alan Babb's Direct phone No. is 509 335-4548

# WASHINGTON STATE UNIVERSITY

PULLMAN, WASHINGTON 99164

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DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING  
HYDRAULIC ENGINEERING SECTION (509/335-4546)

January 21, 1985

Mr. Lowell S. Barrick, P.E.  
Chief Engineer  
Alaska Department of Fish and Game  
FRED Division  
PO Box 3-2000  
Juneau, AK 99802

Dear Lowell:

Thanks for your package of information on the Kenai River weir project. It sounds very challenging.

Based on a preliminary review of the material, some of the design considerations which could be derived from a physical, hydraulic model would be:

- (1) Visual observations of flow patterns, scour, and deposition at depth, related to river discharge, which cannot be visually observed in the prototype;
- (2) Relationship of water-surface profiles to bed form;
- (3) Calibration of velocities in the vicinity of the weir, and attraction velocities (as a function of river flow) for migration conditions of each of the five (5) salmon species;
- (4) The influence of the tidal bore on weir operation, and the design height of the weir required to account for both floods and/or tides;
- (5) Methods for bypassing debris and minimizing weir clogging (and thus increased loading) by matching site geometry and weir geometry with fish preferences and capabilities;
- (6) The calibration of stage-discharge relationships in the river, with and without the barrier; and
- (7) Possibly a way to sample large numbers of fish, such as magnetic flux meters, or causing the fish to pass through a "wide," shallow off-stream channel so they can be visually observed.

Mr. Lowell S. Barrick, P.E.  
January 21, 1985  
Page 2

My first impression is that the best site would be Number 4 at RM 10.3. The weir (barrier) would come off the right shore (looking downstream) at the upstream end of the bend (see sketch), and run diagonally at about 30° to the straight reach for about 700-800 feet to the left shore (east?).

Larger floating debris would tend to move towards the outside of the bend (left bank), and fish would tend to move along the barrier to the right bank. They could be routed through a channel built around the end of the weir in the shore (assuming the bank is low enough).

These are just some preliminary ideas, but they do present some possibilities which can be explored in the hydraulic model. Neither sites 2 or 3 appear to be as stable as site Number 4, and both are complicated by side channels and/or tributaries. Site Number 1 at the bridge would be much larger and would tend to cause the most interference to boats. Site 4 ("assuming" boaters use the lower 12 miles), would block the least river boating surface area of the four sites.

Why is the weir constrained to the lower 12 miles--access, site conditions, loss of fish to tributaries or --?

According to your schedule, early in FY '86 would be the time in which the hydraulic model study should be conducted. It would be even better to start in August of 1985 to allow more time to gather field data, evaluate alternatives in the model, and provide design information, assuming you decide to proceed.

I hope these remarks will be of assistance and look forward to further contacts.

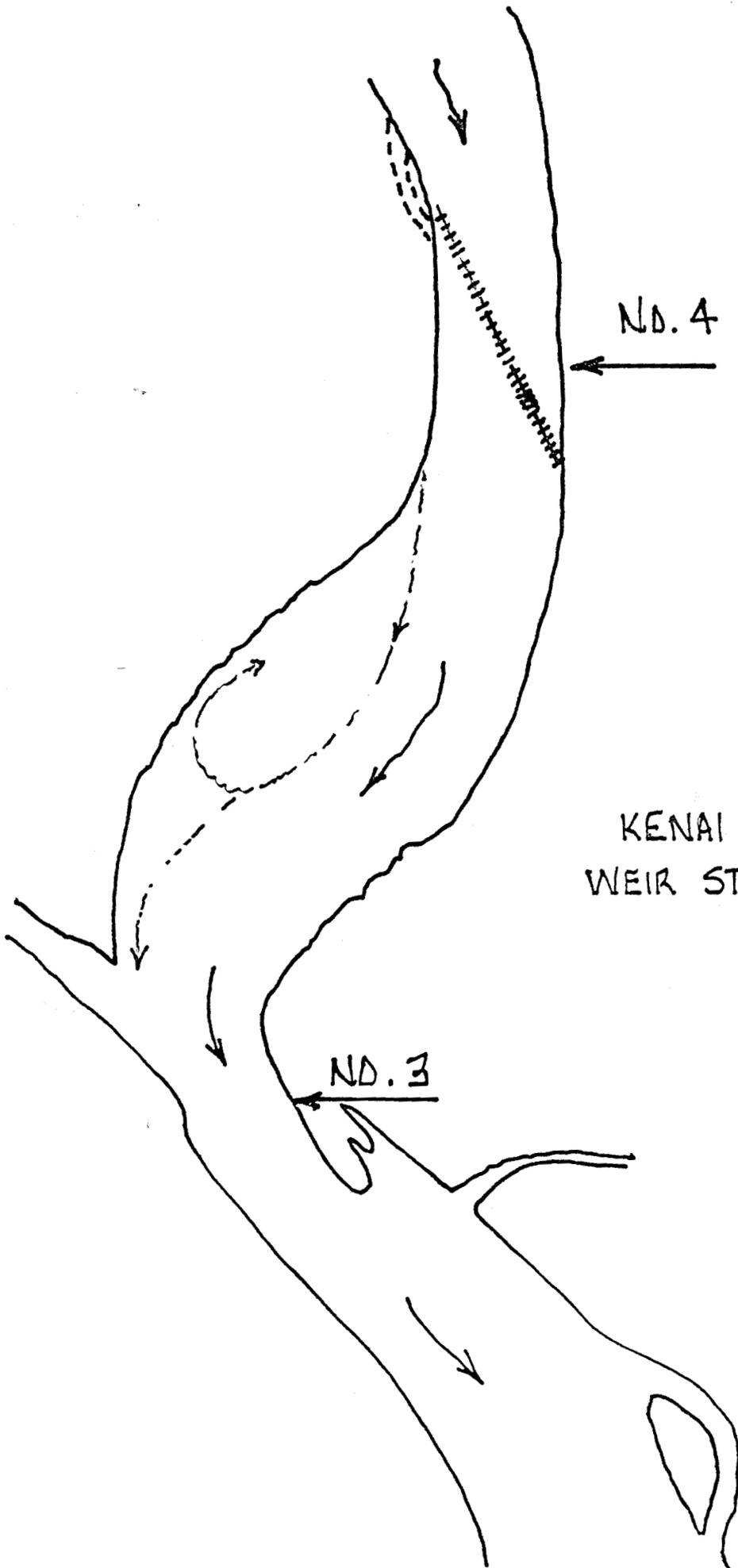
Sincerely,



John F. Orsborn, P.E.  
Professor and  
Hydraulic Engineer

JFO:d1

Enclosure



KENAI RIVER FISH  
WEIR STUDY AREAS

SCALE: 1" = 400'  
JFO 1-21-85

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