State of California

Memorandum

Date : August 25, 1989

To : Steve Kashawada
Division of Planning

DRAFT

From : Douglas Denton
Department of Water Resources
Northern District

EXHIBIT CT 37

Subject: Draft Santa Ynez Instream Flow Need Study

The following draft report presents the results of an Instream Flow Incremental Methodology (IFIM) study performed by the Northern District Environmental Branch during May through August 1989. This study was done at the request of the Division of Planning to help identify potential fishery mitigation measure which could be used to offset any negative fishery impacts resulting from enlargement of the Bradbury Dam/Lake Cachuma Project. This study covers the area from Bradbury Dam to Buellton.

The basic results of the IFIM study is a series of curves relating flow levels in the Santa Ynez River to the amount of fishery habitat created assuming suitable water quality conditions. These curves provide the basis for determining the fishery impacts of alternative flow release schedules. The report also recommends additional work that should be performed by a fishery biologist or consultant to provide the remaining information needed to evaluate suggested fishery mitigation proposals.

To limit report size, this IFIM report contains mainly end product summarized information calculated from the basic data collected in May and June. The basic depth, velocity, substrate and surveying data, curve plotting points, transect cross sections, photographs and other backup information is readily available if needed.

This is a draft report which we expect to modify in response to any comments received by September 18. If questions arise during your review of this draft, you may wish to call Bill Mendenhall who was the primary investigator during this study.

DRAFT

Attachment

SURNAME | Douglas Denton | |

BACKGROUND

The Santa Ynez River lies 25 miles north of Santa Barbara and runs west to the Pacific Ocean. Its watershed is approximately 900 square miles. The basin runoff is controlled by three dams. The largest and newest is Bradbury Dam which creates Lake Cachuma. Bradbury Dam is the furthest dam downstream, 47 miles upstream from the ocean. Approximately two-thirds of the precipitation in the watershed falls above Lake Cachuma.

Photo 1. Looking easterly at Bradbury Dam and Lake Cachuma. Santa Ynez River Reach 1 is in the foreground.

Historically, the Santa Ynez River was a major spawning and nursery stream for anadromous trout (steelhead), and supported the largest run of steelhead in southern California. Prior to completion of the Cachuma Dam Project in 1953, an estimated 20,000 steelhead spawned in the Santa Ynez River and nearly all accessible tributaries below Gibralter Dam located approximately 18 miles above Bradbury Dam.

In order to help determine the effects of various alternative instream flow release schedules on trout habitat in the Santa Ynez River below Cachuma Reservoir, the Northern District

Department of Water Resources performed an Instream Flow Needs Study. Field data for this study was collected during May and June 1989. Data collection had to coincide with groundwater recharge releases from Cachuma Reservoir, because at other times during the spring through fall period the stream is normally dry under the present operating schedule. Because of the limited water supply available for recharge, streamflows only reached the Buellton area. Therefore, this study was confined to the approximately 13 miles of stream from Bradbury Dam to the City of Buellton. The maximum flow release from the dam during the field data collection period was 120 cfs and the minimum was 25 cfs.

The Santa Ynez River recharges a very limited ground water basin. The geologic formations composing the overbanks of most of the upper river are largely impervious. Thus for the portion of the basin above Buellton, the river channel is the ground water basin. The river channel acts as a subsurface water storage reservoir. Consequently, ground water extraction has a direct, but variable, effect on surface flow resulting from Cachuma Reservoir releases. Any future fishery flow releases must take into account the ground water extraction effects on surface flow in order to assure that adequate flow exists for habitat maintenance at various stream locations.

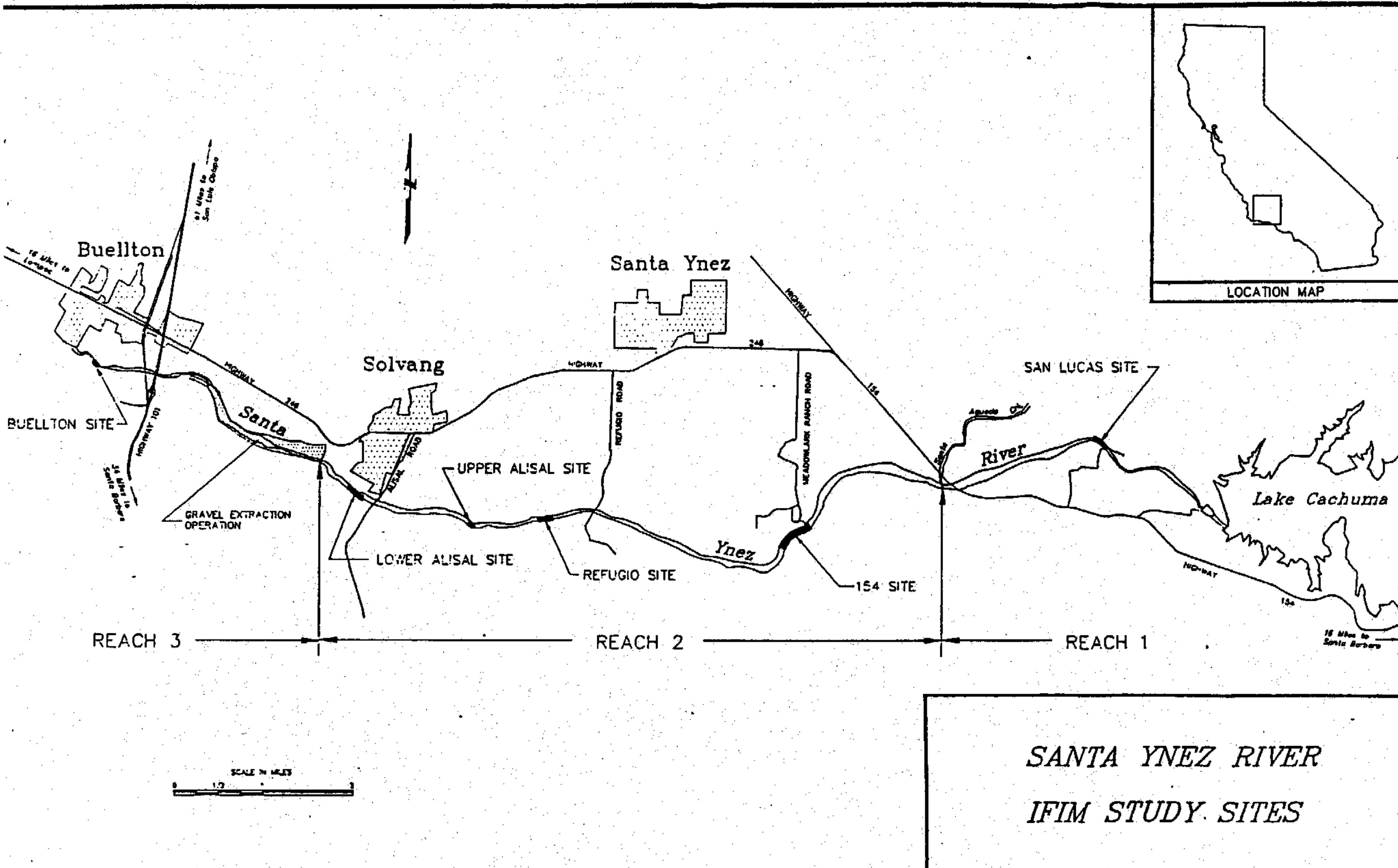
While reading this report it may be helpful to occasionally refer to Appendix A which contains a glossary of technical terms used in IFIM Studies.

STUDY AREA DESCRIPTION

The 13-mile study area from Bradbury Dam to Buellton is characterized by a repeating series of pools, runs and riffles. Typically, the flood channel is approximately 600 feet wide with a narrower low flow channel averaging around 100 feet. Large quantities of good quality spawning gravels are found throughout the entire study area. Much of the spawning-size gravel is found in storage in the stream bed above the low flow channel. There is a fair amount of vegetation in the channel as shown in Photo 2. Willows, cottonwoods and mule fat are the most common stream channel vegetation.

We subdivided the study area into three reaches. These reaches define areas that are similar in slope, channel geometry, and substrate. Reach 1 is from Bradbury Dam to the confluence of Santa Agueda Creek near the Highway 154 bridge. Reach 2 is from Santa Agueda Creek to an area approximately 0.6 miles downstream of the Alisal Road Bridge. From this point, Reach 3 extends down to Highway 101 bridge at Buellton (Figure 1).

Figure 1



SANTA YNEZ RIVER

IFIM STUDY SITES

Photo 2. Vegetation and boulders in channel at San Lucas Site.

Reach 1 is 2.9 miles long and is characterized by a series of pools connected by runs with chutes. The pool type changes from a deep main channel pool near the dam to shallower, wider pools near Santa Agueda Creek. The substrate is generally cobbles and boulders, too large for spawning; however, there are a few pockets of good spawning size gravels in the low water channel. Basically, this area has been scoured of gravel by spills from the dam combined with the blockage of gravel migration by the dam. There is a considerable amount of spawning size gravels in storage on the banks. The spawning habitat in reach 1 could be greatly improved if nearby available gravel was screened and placed in the low flow channel. There is a passage barrier for juvenile fish created by a pipeline approximately 0.9 miles upstream from the Highway 154 bridge. The water flows over the pipeline and falls into a pool. Adults should be able to pass without trouble, but the younger fish cannot. This pipeline may need to be relocated if a fishery biologist determines that it creates a significant problem.

Reach 2 covers a distance of 7.3 stream miles and is the largest reach. The influx of smaller gravels from Santa Agueda Creek and other tributaries increases the amount and quality of spawning gravels in comparison to that available in Reach 1. The stream flood and low flow channels widens in Reach 2. This reach is characterized by alternating runs and riffles with a few pools. Only occasional deep main channel pools exist in this reach. Most pools are shallow and have fine sediment in the bottom.

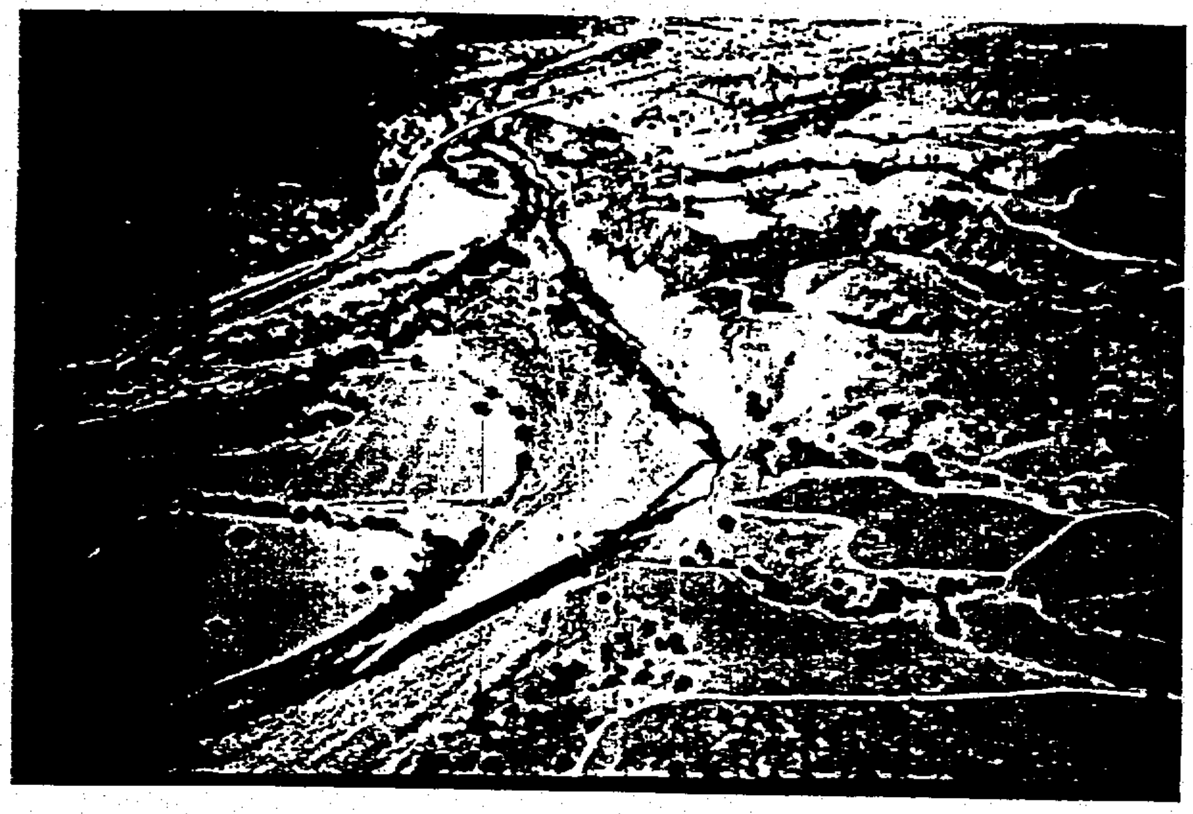
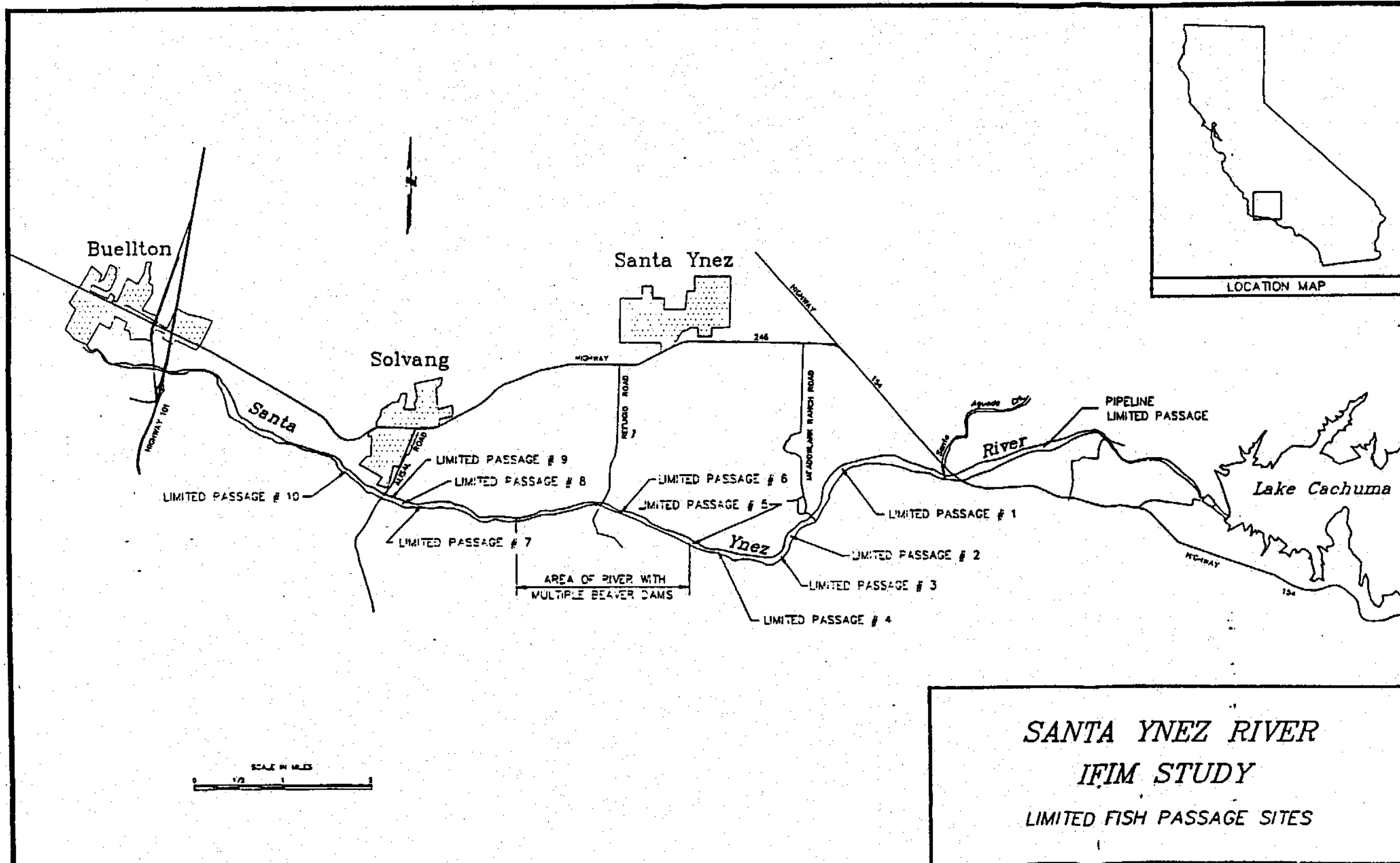


Photo 3. Aerial view of Reach 1.

There are 10 low flow fish passage barriers in this reach. Most of these are created by a wide, shallow, braided channel that adult fish could not pass through at flows below 30 cfs (Table 1). These could be easily fixed by channelization work using a bulldozer. Figure 2 shows the location of these spots. Table 1 shows the estimated minimum flow at which these barriers are passable by adult fish.

Figure 2



SANTA YNEZ RIVER

IFIM STUDY

LIMITED FISH PASSAGE SITES

Table 1

Minimum Flow for Barrier Passage

Barrier No. (See Figure 2)	Estimated Required Flow (cfs)
1	40
2	30
3	30
4	30
5	30
6	30
7	20
8	30
9	30
10	40

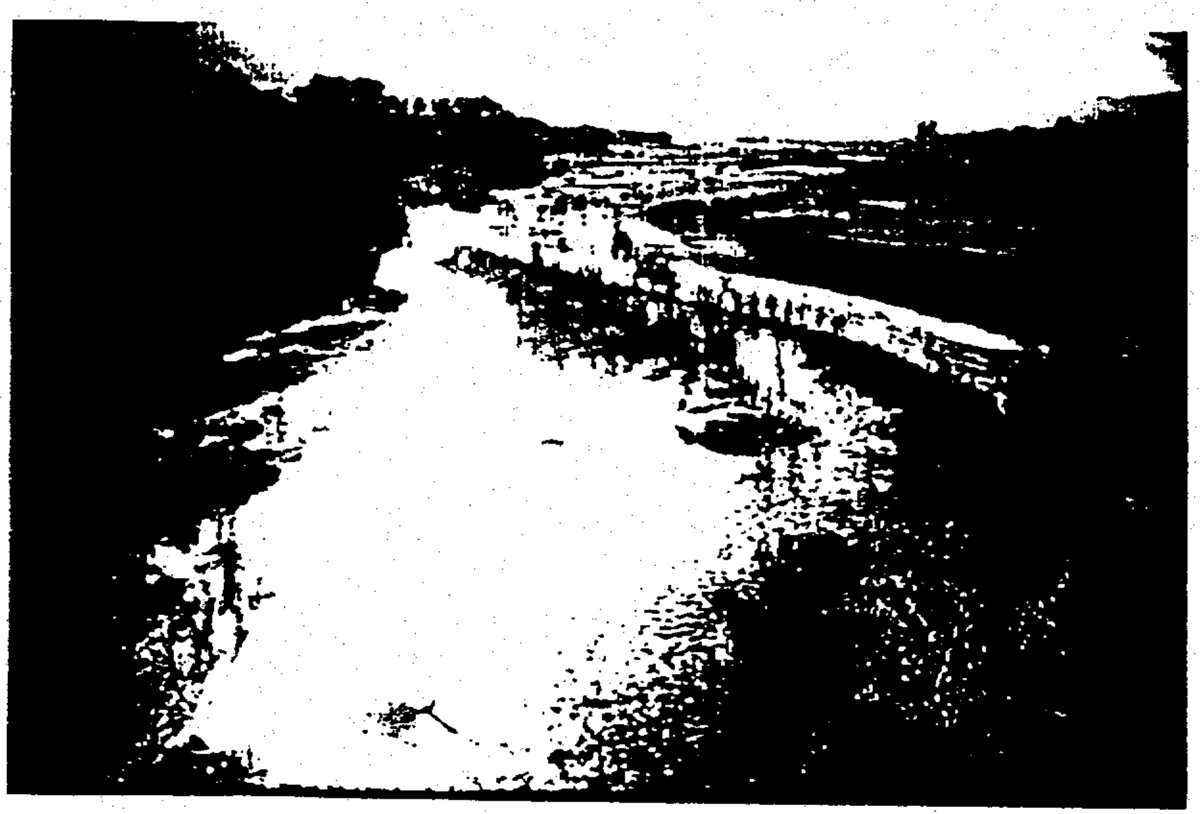


Photo 4. Shallow-braided low flow passage problem area #10 near Lower Alisal Site.

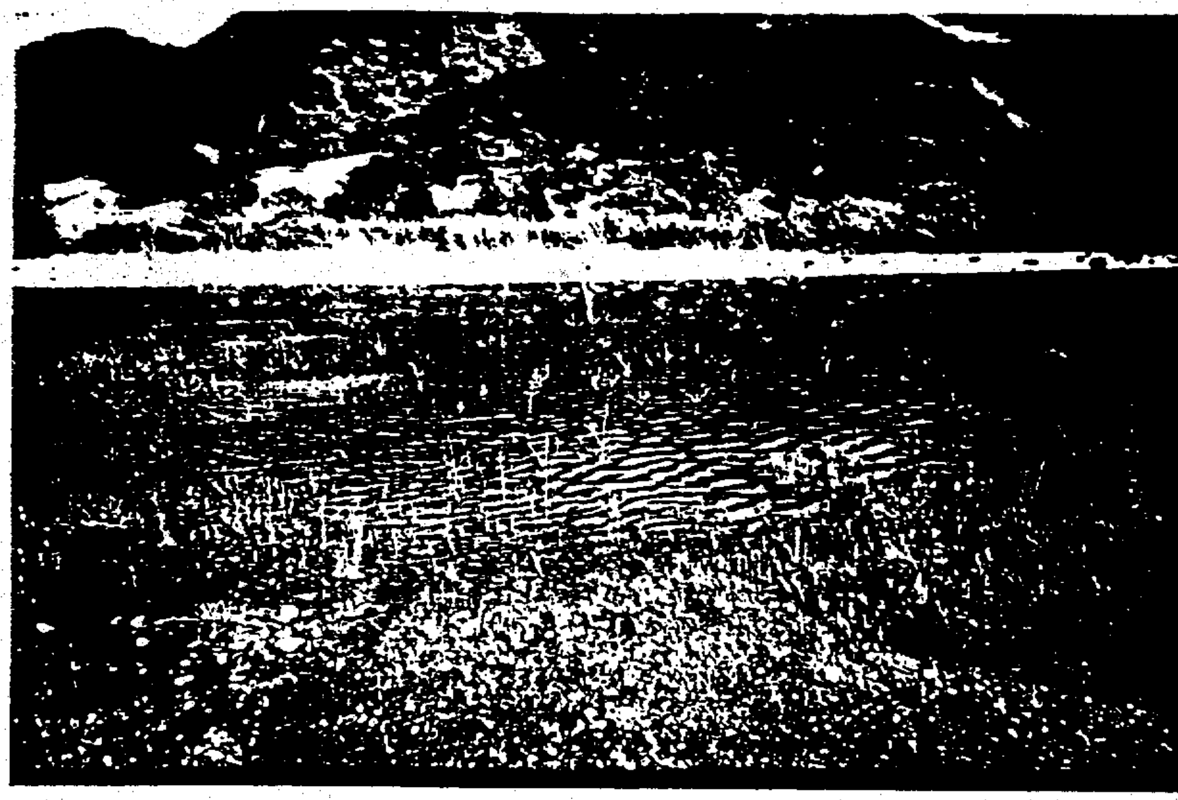


Photo 5. Wide shallow channel passage problem area #2 located near HWY 154 Site.

There are some passage problems for downstream migrant juveniles caused by approximately a dozen beaver dams located in the 2.0 mile stretch of river just upstream from the Upper Alisal Site. Figure 2 shows the general area of these beaver dams.

Reach 3 is a 2.8 mile portion of the river located at the end of the study area that has experienced historic and ongoing heavy gravel mining. The riverbed has been lowered as much as 10 feet by gravel extraction. The low flow channel has been relocated by the gravel operation and averages approximately 12 feet in width and 2.0 feet in depth (see Photo 7). The channel is straight with little vegetative cover. The substrate consists of excellent quality spawning gravels.

Photo 6. Beaver dam passage problems for fry and juvenile steelhead just above Refugio Site.

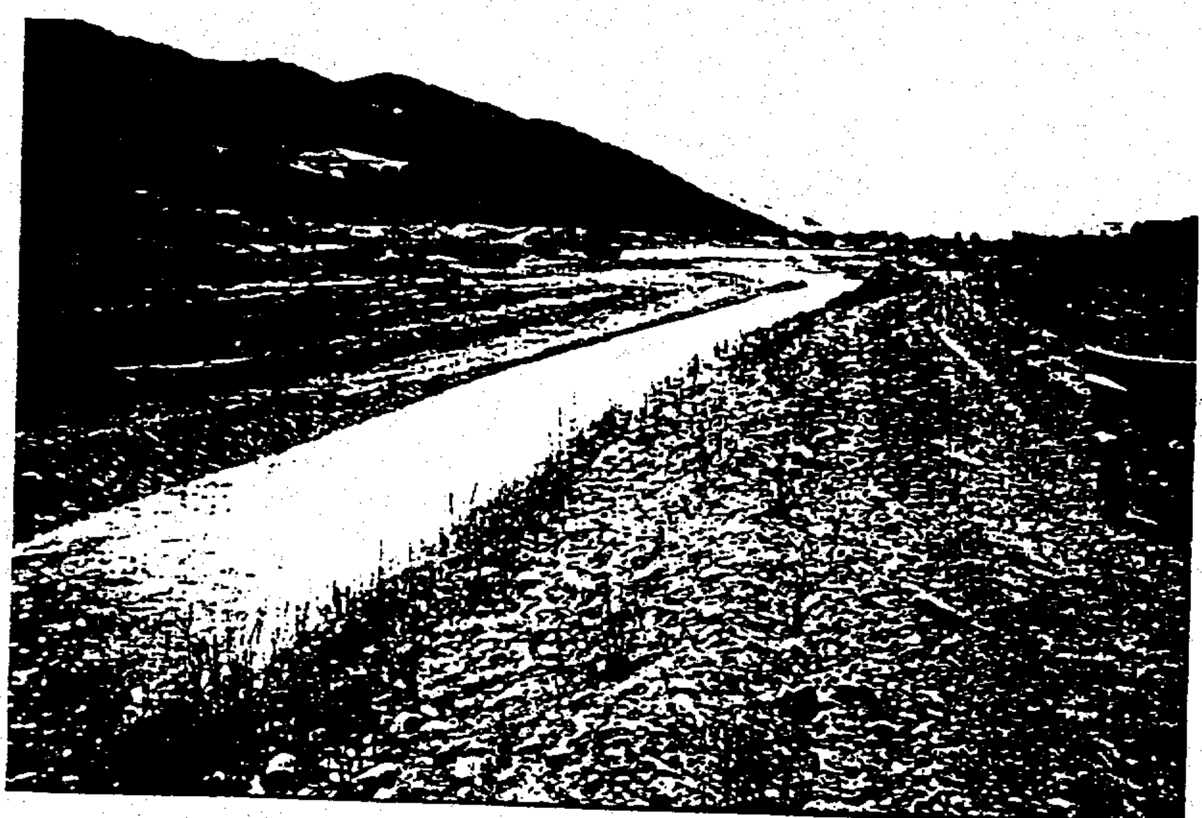


Photo 7. Gravel mining relocated river channel 1.5 miles below Alisal Road Bridge.

Instream Flow Incremental Methodology

Since the 1970s various methods have been developed to determine the affects of changing flows on fish habitat. Currently, the most acceptable method is the Instream Flow Incremental Methodology (IFIM). IFIM allows the user to assess the effects of various stream flows on the habitat required by different species and lifestages of fish. The IFIM was developed by the U.S. Fish and Wildlife Service in Fort Collins, Colorado. It is the most rigorous and currently accepted methodology and is suitable for assessing the effect of changing flows upon steelhead in the Santa Ynez River system.

IFIM Limitations and Need For Additional Study

An IFIM Study is field data intensive and results in a computer model of available flow-related fishery habitat. However, the results from the model should be viewed as only one of several tools to be used in reaching fishery mitigation decisions. Other tools and techniques are water temperature and quality studies, historic and current site specific fishery data, economic analysis of specific mitigation proposals and negotiations to agree on needed flow releases.

Basically, the information contained in this report will allow future investigators to determine the amount of fishery habitat occurring at various flows, assuming acceptable water quality and temperature conditions are met. It identifies the greatest or optimum habitat that can be created as well as habitat existing at lower flows. It does not provide an answer as to what flows should be released considering economics, available water supply, or other project constraints. Also quantity of habitat cannot be accurately converted to numbers of fish which will use this habitat. Methods exist for attempting a rough approximation, but they are widely discredited because of their speculative nature. Frequently, a better approach is to make experimental releases based upon an IFIM study and monitor the results.

In the recommendation section of this report we have listed work items that should be done to give the additional information needed to participate in negotiations aimed at determining a mutually agreeable instream flow release schedule.

Study Site Selection

In 1987 the California Department of Fish and Game (DFG) established study sites in preparation for an IFIM Study on the Santa Ynez River from Lake Cachuma to the ocean. After walking the entire river they decided to do a "critical" site analysis. This means that they picked study sites which appeared to contain the best existing steelhead habitat. If DFG had completed their IFIM study they would have assumed at whatever flow was optimum for the selected critical sites would also be good for the areas not modeled. DFG was planning to use natural runoff streamflow to collect the field data needed to run the hydraulic computer model. However, DFG's contract to perform this work was canceled before suitable flows became available.

When the Northern District was ask to continue the IFIM Study we agreed to use groundwater recharge releases from Bradbury Dam and collect field data in the river downstream as far as adequate flowing water was available. With the help of Tom Petersen of the Santa Ynez Water Conservation District (SYWCD) we were able to estimate that the flowing water would end near Buellton. After walking the study area we decided to use the "representative" reach method rather the "critical" reach method. With the aid of a DFG Biologist, Charlie Brown, who participated in the earlier study, we initially selected four of DFG's original critical study sites including one near Buellton, Alisal Road, Refugio Road, and Highway 154. Since we were doing a representative reach study we felt we needed to add two more study sites to get a better model for the study area from the Bradbury Dam to Buellton. We added a study site on the San Lucas Ranch and one above Alisal Road. See Figure 1 for location and names of study sites.

After the study sites were selected we located 40 transects from which depth, velocity and substrate data were collected. See Appendix B for site maps which show transect locations.

Study Site Descriptions

Six study sites were used to model the entire river contained within the three study reaches.

The **San Lucas Site** which is close to Bradbury Dam is a run-chute-pool combination. A transect was located to represent each of these features. Because of the large substrate and lack of gravels, this site offers mainly rearing habitat. Spawning gravels have been washed downstream and recruitment from upstream is blocked by the dam.

The **HWY 154 Site** is a run-riffle-pool combination. Several transects of each feature were chosen. This site offers both spawning and rearing habitat. A total of 10 transects were chosen. Generally, the five lower sites downstream from Santa Aqueda Creek have spawning gravels in the riffles and runs with silts and sands in the pools. Santa Aqueda creek contributes most of the sand and gravel to this reach.

Photo 8. HWY 154 Site.

The Refugio Site is a run-pool combination. Like the HWY 154 Site, it offers both spawning and rearing habitat. Six transects were chosen to model this site.

The **Upper Alisal** represents pool habitat. Because of the fine substrate, it offers little habitat for rearing or spawning. It was the only location within the 13-mile study area which contained standing water prior to flow releases from the dam.

This area may be critical to preservation of fish life during extreme low flow periods. Four transects were selected to model this site.

Photo 9. Refugio Site

The **Lower Alisal** site is a riffle-run-pool combination. Run-pool combinations are repeated several times throughout the site. All the pools were of the main channel type. Fourteen transects were chosen to model this site which provides good quality spawning and rearing habitat.

The **Buellton Site** is a riffle-run combination. Three transects were chosen to model this site. Almost all the water released from the dam had infiltrated into the streambed before reaching the Buellton Site. The Buellton Site provides good spawning and rearing habitat if adequate, good quality flow is available.

Photo 10. Buellton Site

Computer Modeling of Habitat at Various Flows

The relationship between flow and habitat availability was determined using the Physical Habitat Simulation program (PHABSIM) developed as part of the IFIM. PHABSIM combines the results of a hydraulic model, either IFG-4 or the water surface profile (WSP) models with physical and biological criteria required to sustain fish life. The result is an estimate of the amount of useable habitat available at incremental flows. The hydraulic model simulates the depths and velocities in the stream channel transects at numerous flows by using one full data set and several stage-discharge measurements. The PHABSIM program models a channel transect by dividing it into a collection of cells, as shown in Figure 3. Each cell represents a homogeneous microhabitat unit where velocity, depth, substrate and cover are uniform at a given flow. The hydraulic model simulates the depth and velocity for each cell for unmeasured discharges using data collected at measured flows.

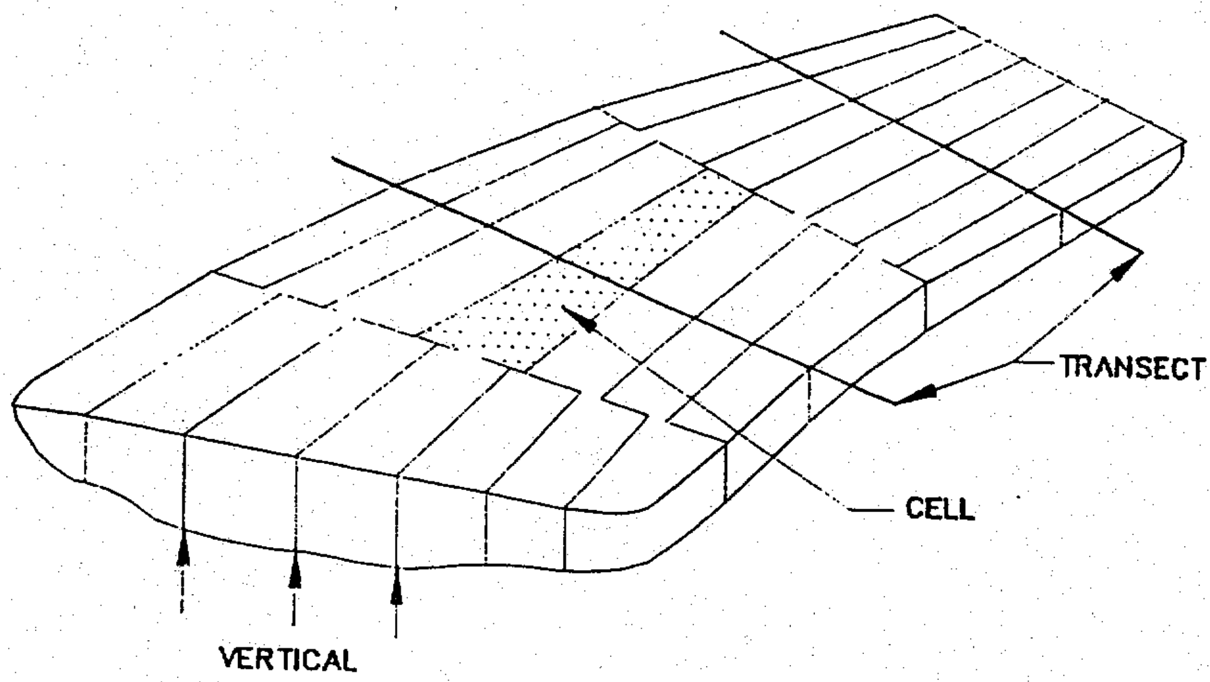


Figure 3. Cell matrix of the computer simulated stream reach used to predict physical habitat conditions.

The hydraulic data was then entered into a habitat simulation program, called HABTAT. Here the cell's suitability as habitat is determined for the target species at each lifestage by comparing the fish's preference for depth, velocity and substrate with that available in the cell. This preference information was taken from standard "textbook curves" published by the Instream Flow Group. An index of useable area, called weighted useable area (WUA) is then obtained for each cell, by multiplying the preference for each parameter, (between 0 and 1) times the area of the cell. The HABTAT program then sums available habitat for all cells to yield the total WUA for the study site being modeled. This is done for each flow simulated (from 0 to 180 cfs) by increments of 4 cfs. The WUA at each flow can then be plotted producing WUA vs Q curves.

Field Data Collection

The physical and hydraulic habitat measurement methods used during this study were developed by the USFWS Instream Flow Group and are briefly described below. Each transect was located by a pair of benchmarks placed above the expected high flow release elevation. A transect profile was created by measuring substrate type and elevations at from 20 to 40 vertical points along the transect. Water surface elevations (WSE) were determined for each transect by averaging the two WSE measurements taken near the edge of water on the left and right banks. All elevations were referenced to a permanent benchmark whose elevation was estimated by using a quad map. Transect elevations were measured to the nearest 0.1 ft and WSE to the nearest 0.01 ft. Distance between headstakes and along transects were measured to the nearest 0.1 ft.

Photo 11. Data collection and WSE measurements.

Cells were established at intervals across each transect depending upon habitat conditions. Water depth and velocity are measured at each cell vertical. Mean column velocities were measured, per standard USGS procedures, to the nearest 0.05 ft/s, using a price meter mounted on a top setting rod.

Water depth was measured to the nearest 0.05 ft using the top setting rod.

This data was collected along each of the 40 study transects at the high flow release. Later, two additional stage-discharge data sets were collected at each transect, except for the Buellton Site where only one additional stage-discharge data set was collected due to the lack of water flow. Stage-discharge measurements were made at intermediate and low flow conditions. By taking WSE near the left and right banks of each transect and making a flow discharge measurement at each study site, we developed a stage-discharge curve for each transect. This stage-discharge curve was used to calibrate the PHABSIM model.

Habitat Mapping

The purpose of the habitat mapping work is to match the 14 miles of unmeasured reaches of the study area with similar portions of the 1 mile of modeled study sites. This is necessary in order to expand the WUA vs Q curves to represent the entire study area and not just the portion of river where the study site transect measurements were taken. The procedure used for expanding the study sites to the entire river is described below.

The study area was walked and each general feature (pool-riffle-run) was mapped and categorized. Data about width, depth, velocity, and substrate was estimated for each feature. Using this data, the mapped feature was modeled by choosing a study site area of same general characteristics. Modeling simply consisted of applying the results from the habitat simulation of the study site to the similar mapped feature. The results were adjusted so that the mapped feature would represent its proper weight in the total WUA calculation of the entire study area.

Habitat Preference

Habitat used by fish is defined as the hydraulic and physical characteristics immediately surrounding observed fish in their natural environment. The IFIM study procedure uses velocity, depth, substrate, and cover to define habitat. However, water temperature and water quality also must be suitable in order for this habitat to be acceptable for fish use. Habitat preference is a measure of a fish's preference, given unlimited choice of habitat conditions, to use certain types of habitat conditions during various phases of their lifecycle. Habitat preference is determine by comparing the observed frequency of habitat use with the frequency at which these conditions occur within the stream system.

Development of stream specific fish preference curves is a major task which requires numerous underwater observations of fish use. No steelhead were available in the study area for observation so we used standard textbook preference curves for steelhead trout taken from the USFWS Instream Flow Group Paper No. 4. The three lifestages investigated where fry, juvenile and spawning. The preference curves for these lifestages are included in
Appendix D.

WUA vs Q Curve Interpretation

The main findings of the Santa Ynez Instream Flow Study are presented in a series of curves that plot weighted usable area (WUA) of steelhead trout habitat versus flows (Q) in various modeled reaches of the river. In this study, curves were generated to model spawning, juvenile and fry habitat. Below is an typical curve.

This graph represents the relationship between the amount of habitat available (shown as an equivalent amount of perfect habitat) for the juvenile lifestage of steelhead and the amount of stream flow. Each point on the curve represents the amount of WUA in square feet available at a particular flow. This WUA is always less than the total area inundated by water, because never in nature is all of the area perfect for the lifestage being analyzed. In fact, almost no area is actually perfect, but almost all has some usability to fish. Each less-than-perfect area is multiplied by its percentage of optimum utility and listed as a reduced amount of perfect area, called weighted usable area. Only in this way can total amounts of area be easily compared as the flow changes.

When all of the individual WUA vs Q points are taken together, they comprise a curve that gives useful information and allows comparisons.

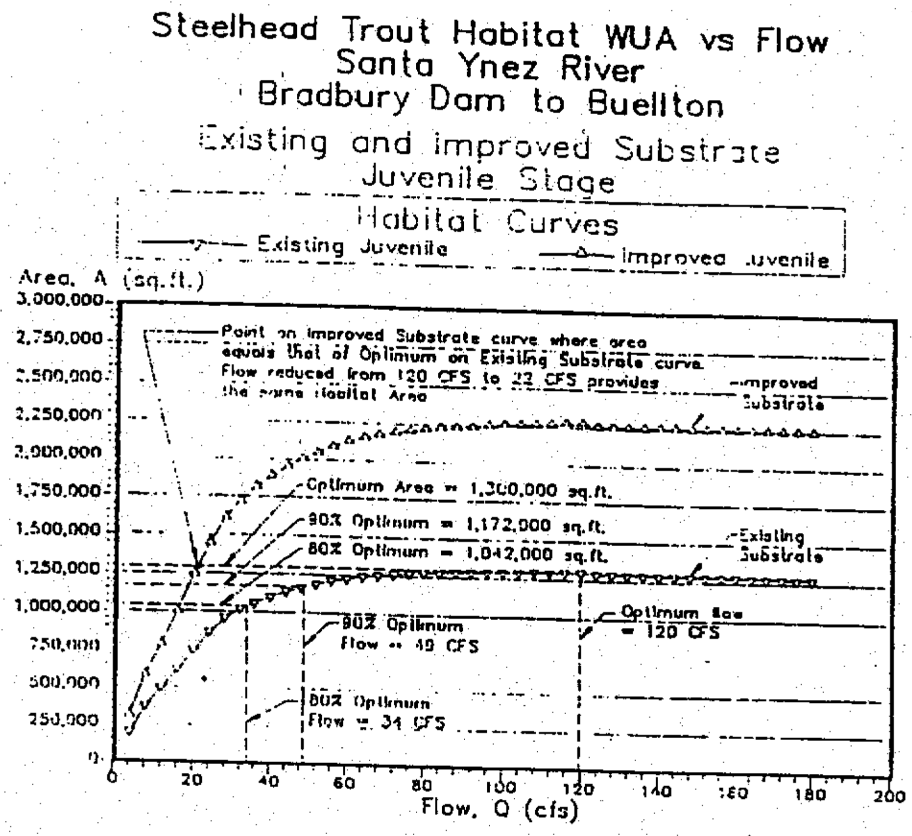


Figure 4. Typical WUA vs Q curve with notes to demonstrate the habitat improvement resulting from gravel substrate replenishment.

Appendix C contains the WUA vs Flow Curves. These curves each contain plots for three lifestages: spawning, juvenile and fry. The first and second sets of curves show WUA for existing substrate and improved substrate, respectively. The third set presents both existing substrate and improved substrate on the same plot for the purposes of comparison.

The only parameter changed to "improved" condition is the substrate. This can be done by placing clean gravel of suitable gradation in the streambed. It is a standard fishery restoration technique that has been used on numerous streams.

The total area of habitat available is not necessarily the most important factor in interpreting these curves, although there is often a correlation between this area and numbers of fish. The steepness of the curves, or the rapidity with which they approach optimum habitat, must also be considered. For example, some of the curves in this study achieve near-optimum habitat area with only half the flow required at optimum.

Others are more linear, requiring near-optimum flows to yield near-optimum habitat area. Both of these curve characteristics should be considered in selecting the "best" or recommended flow release schedule.

Other warnings that should be heeded in interpreting the curves are:

1. There is usually no year-round "best flow". The flow should be varied for different steelhead lifestages occurring at different times of the year. The flow level needed to maintain suitable temperatures and allow for fish passage should be identified and provided for.

2. "Best flows" aren't necessarily equivalent to dam releases. Groundwater infiltration occurs in the Santa Ynez River as water flows downstream, resulting in gradual flow decreases. Municipal and agricultural pumping removes water from underground storage. This in-channel groundwater pumping should be accounted for in setting fish flow releases from the dam which will actually result in the negotiated "best" flow downstream. Similarly, seasonal tributary inflow to the river will normally decrease necessary dam releases. Finally, there are some flow situations not modeled, such as flows required to clean stream gravels, to sustain proper instream temperatures, to encourage smolts to leave the stream system and for adults to enter.

Interpretation of IFIM Study WUA vs Q Curves

WUA vs Q curves were developed for each of the 40 transects where data was collected. Information from these transects in the study area were combined in a way that modeled the four main river reaches listed below:

1) The entire river from Bradbury Dam to Buellton
2) The first three miles downstream of the dam
3) The first two miles downstream of the dam
4) The first mile downstream of the dam

Reaches 2, 3, & 4 which represent all or part of the first 3 miles below the dam were emphasized in alternatives because this area is most likely to contain suitable water temperatures.

Alternative One (1), which represents the entire study area is the most commonly used curve in instream flow needs assessments. The second, third and fourth were undertaken mainly to investigate the option of "holding" rearing fry and juveniles in the upper reach with relatively low flows during hot weather. High water temperatures will be lethal to steelhead in the main river at some locations downstream of the dam during low flow release periods.

For the river from Bradbury Dam to Buellton (Alternative 1), which encompasses the entire study site, the optimum flows were determined as follows:

Alternative 1 - Optimum Flow

	Existing Substrate Habitat (cfs)	Improved Substrate Habitat (cfs)
Spawning	100	120
Juveniles	120	120
Fry	52	56

Though the optimum flow increases as the habitat improves, the peaks of the "improved" curves represent more habitat area than the peaks for existing substrate habitat. The "improved" curves look much the same as the "existing", but with greater magnitudes of habitat throughout. Another way of comparing these curves is by finding the optimum flow on the "existing" curves and drawing horizontal lines to the left until the "improved" curves are intersected. The corresponding flows, which provide the same areas of habitat, are much lower. The following table demonstrates this.

Alternative 1
Constant Habitat Flow Requirement Comparsion

Lifestage	Existing Substrate Optimum Flow (cfs)	Corresponding Improved Substrate Flow (cfs)	Habitat Area at Both Flows (sq. ft.)
Spawning	100	48	310,600
Juvenile	120	22	1,300,000
Fry	52	6	881,000

Many of the WUA vs Q curves are steep at the beginning and flatten out as flow increases. This indicates that large amounts of habitat area are quickly generated as flows increase only moderately. For example, by examining the total area curves in Appendix C, 90% of optimum habitat could be achieved for juveniles and fry with only 49 and 22 cfs with existing substrate, respectively, and 52 and 27 cfs with improved substrate. A flow of only 60 cfs provides at least 70% of optimum habitat for all life stages, using either existing or improved substrate.

Spawning and rearing habitat may be improved simultaneously. Spawning habitat is optimum where mean velocities are about 1.6 feet per second, around the bottom of the channel bed. Rearing habitat is optimum when velocities are much lower, which occurs along the sides of faster moving water, or perhaps across the entire channel in shallow pools. Therefore, placing 2 to 6 inch gravel in steeper channel bottoms and 6 inch and larger gravels in shallow pools would improve both types of habitat simultaneously at low to moderate flows.

Alternative Two (2), modeling the first three miles downstream of the dam, generated curves not too different from the river as a whole, except that magnitudes of habitat area are much lower. There is much less habitat available for spawning than for any other lifestage, though it is dramatically increased (by eleven times) with improved substrate. On the other hand, juvenile substrate is already at optimum because this section of the river contains many boulders which are optimum habitat for juveniles. Another finding from the curves is that flows required to achieve existing substrate optimum habitat could be reduced while maintaining the same habitat area if the substrate is improved. The following table demonstrates this:

Alternative 2
Constant Habitat Flow Requirement Comparison

Lifestage	Existing Substrate Optimum Flow (cfs)	Corresponding Improved Substrate Flow (cfs)	Habitat Area at Both Flows (sq. ft.)
Spawning	100	10	4,600
Juvenile	180	175 *	540,000
Fry	88	26	308,000

* This high value is misleading. The 90% optimum flow is only 88 cfs, the 80% flow is 59 cfs, and the 70% flow is 42 cfs. The 50% optimum flow of 25 cfs, which would still provide half the WUA for juveniles, is nearly the same as the 100% optimum flow for fry, 26 cfs.

Another interpretation of the data for Alternative 2 is that 65 cfs would provide 70% of optimum habitat area for any lifestage, with spawning again requiring the most flow.

Alternative Three (3), modeling the first two miles downstream of the dam, is very similar to alternative four in terms of curve shape and flow peaks. A major difference is that by dropping the last mile, about half of the habitat area is lost for existing and improved substrate rearing and improved substrate spawning. Existing substrate spawning is nearly the same, implying that the third mile is bereft of any spawning substrate. A summary table of peak existing substrate flows and the effect of improving substrate but maintaining the same habitat area follows:

Alternative 3
Constant Habitat Flow Requirement Comparison

Lifestage	Existing Substrate Optimum Flow (cfs)	Corresponding Improved Substrate Flow (cfs)	Habitat Area at Both Flows (sq. ft.)
Spawning	100	14	4,500
Juvenile	180	175 *	268,000
Fry	92	29	162,000

* This high value is misleading. The 90% optimum flow is only 97 cfs, the 80% flow is 68 cfs, the 70% flow is 48 cfs. The 50% optimum flow of 25 cfs, which would still provide half the WUA for juveniles, is nearly the same as the 100% optimum flow for fry, 27 cfs.

Alternative Four (4), modeling the first mile downstream of the dam, generated several curves with two distinct peaks, which would seem to imply that there are two optimum flows. This is not the case, however. The number of transects used to model this stretch is too few to provide smooth curves.

The most unusual feature of the graph is that there is essentially no spawning habitat under existing conditions. An extremely large improvement in spawning habitat can be effected here by improving the gravels. Rearing habitat is about one sixth that of the first two miles, even with improvement. The second mile below the dam provides nearly all of the existing substrate spawning habitat, and only in the second mile is there significant rearing habitat.

To summarize a comparison of Alternatives 2, 3 and 4, the best habitat by far is gained by providing optimum or near-optimum flows in at least the first two miles, with replacement of large channel-bottom boulders by 1-inch to 4-inch gravels to augment spawning. Rearing requires little or no substrate improvement, since improving it to a "perfect" state makes little difference. The least expensive improvement in this reach of the river appears to be the replacement of about one and one-half feet of boulders in the bottom of the channel bed with 1-inch to 4-inch gravels.

TEMPERATURES AND WATER QUALITY

Basic water temperature and water quality data were collected from June 2 through June 7, 1989, as part of the IFIM Study. Figure 5 shows the data collection locations. The water temperature data are summarized in Table 2. Because of the short duration of streamflows an equilibrium state was never fully reached. Therefore, accurate conclusions about water temperatures resulting from sustained flow releases are not possible using this short-term data.

Some basic water quality tests were run in the field. These were pH, dissolved oxygen, and electrical conductivity. While this data does not indicate any apparent problem, it is also inconclusive because of the short period of monitoring. Additional water temperature and quality data below Bradbury Dam must be collected and analyzed in order to determine if it is possible to establish year-round suitable habitat conditions for steelhead.

TABLE 2

Water Temperatures During Flow Release Period 1989

Site Name	Maximum Temperature (°F)						Minimum Temperature (°F)					
	6/2	6/3	6/4	6/5	6/6	6/7	6/2	6/3	6/4	6/5	6/6	6/7
Dam	64	64	62	62	62	66	61	60	60	61	60	60
San Lucas		64	63	63				61	61	61		
Santa Ynez River Bridge		71	65	68		73	60	60	60		60	
Highway 154		75	74	70	72	81	62	61	60	62	56	
Gainey Crossing		78	68	69	68	78	61	61	61	62	62	
Upper Alisal		76	75	74	73	77	62	62	61	64	65	
Lower Alisal			74	71	73	74		61	62	65	65	
Buellton					74	72					68	66

FINDINGS

Draft Findings (assuming acceptable temperature, water quality, and constant flow conditions throughout the study area).

1. Optimum steelhead habitat flows for the reach of stream between Bradbury Dam and Buellton with existing substrate conditions is 52 cfs for fry, 120 cfs for juveniles, and 100 cfs for spawners. By improving the substrate (replenishing gravels) the same quantity of habitat can be obtained by releasing 6 cfs for fry, 22 cfs for juveniles and 48 cfs for spawners.

2. Significantly large amounts of habitat can be created with flows considerably lower than optimum. For example, throughout the entire study reach 40 cfs results in providing 96 % of optimum habitat for fry, 84 % for juvenile and 45 % for spawning. Other habitat vs flow relationships can be determined by examining the curves in Appendix D and the Table 3 in Appendix E.

3. The one-to-three-mile reach immediately below Bradbury Dam is the area of highest potential for steelhead mitigation because it contains the coolest water temperatures. Within the first two miles below the dam optimum flows with existing substrate is 92 cfs for fry, 180 cfs for juvenile and 100 cfs for spawning. An equivalent amount of habitat can be obtained with improved substrate at 29 cfs for fry, 175 cfs for juvenile and 14 cfs for spawning. Because of the flatness of the WUA vs Q at the top, the high flow of 175 cfs for improved substrate for juveniles is misleading. The 90 % optimum flow is 97 cfs,the 80 % flow is 68 cfs, and the 70 % flow is 48 cfs.

   The same information can be obtained for the first mile and the first three miles below the dam by referring to the graphs in Appendix C and the tables in Appendix E.

4. Within the upper three miles, the habitat increases very rapidly per unit increase in flow for fry and juvenile stages from flows of 4 to around 25 cfs. This indicates that significant increases in rearing habitat is possible with low flow releases. Also, low flow releases greatly improve the aesthetic qualities of the stream channel which attracts public recreation use. Considerable wildlife use occurs at low flows.

5. The reach immediately below the dam could be greatly improved for fish mitigation by placing screened and washed spawning gravels in the main channel, digging fish resting and predator escapement pools and planting riparian vegetation to shade the water for maintenance of cool temperatures.

RECOMMENDATIONS

1. The information in this report should be used as a tool for answering questions related to the amount of steelhead habitat resulting from any proposed alternative flow release schedule. This study does not decide the "best" flow release schedule but provides much of the information needed to reach a negotiated agreement on this issue with control agencies and other interested parties.

2. Additional water temperature and quality information is needed to determine how far downstream from Bradbury Dam suitable water conditions can be maintained to support steelhead rearing and spawning. The one week period of temperature data collected during our study is inadequate to answer this question.

3. A qualified fishery consultant who has experience with steelhead and IFIM studies should be contracted to perform the following work:

    a. Extend these IFIM report findings downstream to the mouth of the river.
    b. Investigate steelhead enhancement opportunities around the river estuary and on Salsipuedes Creek.
    c. Interpret the existing IFIM curves from a biologist's viewpoint during future discussions of mitigation alternatives.

4. If any significant spills occur past Bradbury Dam within the next couple of years and the spit at the river mouth is breached, a fish monitoring program should be conducted to determine if adult steelhead migrate to the base of the dam. If migration does occur, experimental flow release adequate to allow spawning and rearing could be made and the results monitored. Much more could possibly be learned through onsite experimentation than through additional fishery studies.

5. The construction of a low flow channel from the mouth of Salsipuedes Creek to the estuary should be investigated. This investigation should include the following work items:

    a. Determine the amount of flow needed at critical migration barriers for fish passage.

    b. Size the low flow channel to carry flow for migration.

    c. Determine cost of reconstruction. Lompoc Flood Control District is interested in clearing the channel from Lompoc to the estuary. The District's permits could require it to construct part of this low flow migration channel.

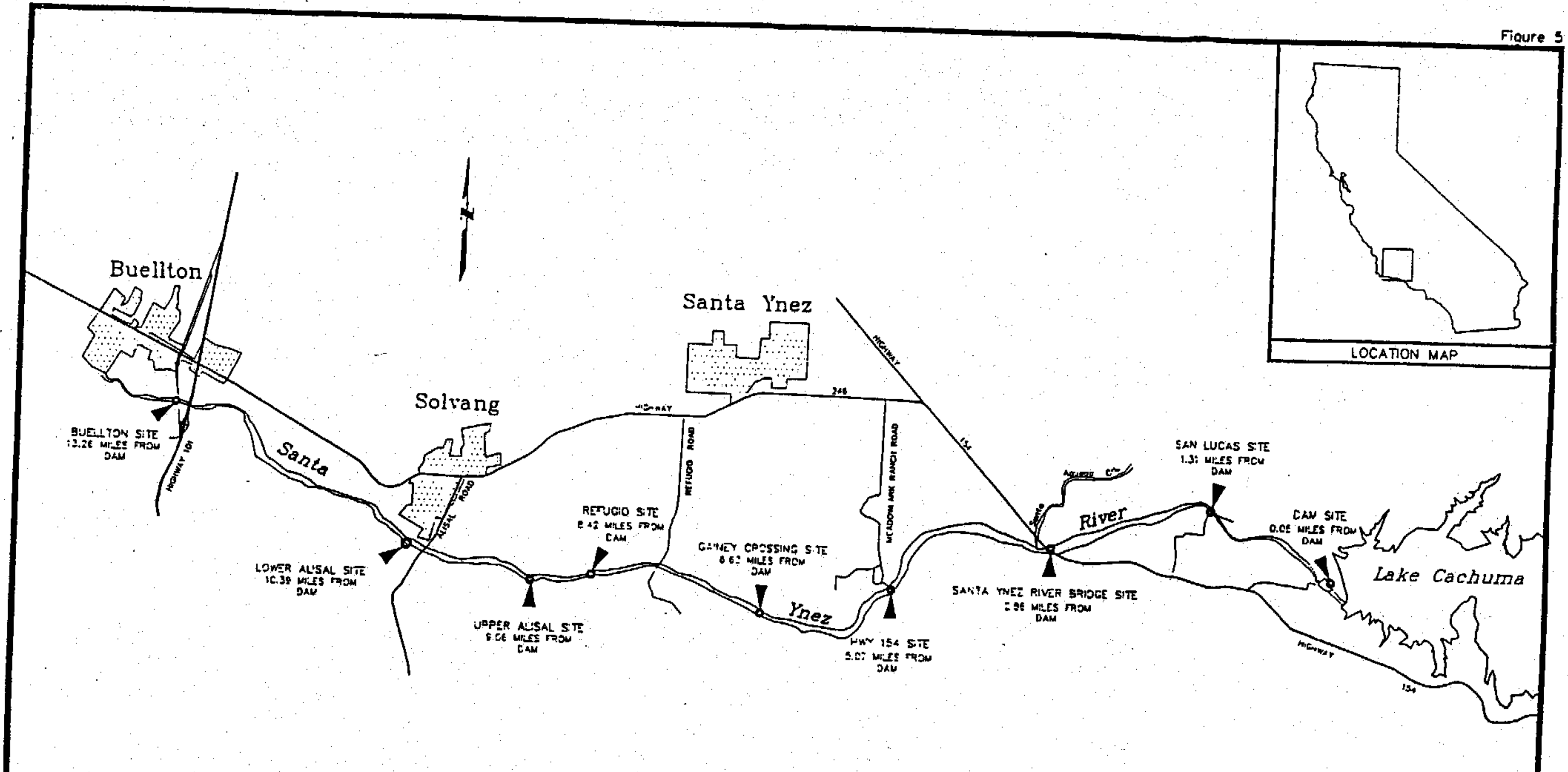
6. We didn't develop WUA vs Q curves for the incubation and adult lifestages mainly because they are usually not the critical lifestages. To run these additional two preference curves we need the input from a fisheries biologist. They can be run and incorporated into the final report if the biologist recommends doing so.

7. A hydrology study to show the effect of tributary inflow, infiltration and pumping on instream flows throughout the study area should be performed.

8. Work should be conducted to investigate the possibility of supplying water to the mouth of Salsipuedes Creek by way of the river, a canal, pipeline, wells, or the Lompoc sewage treatment plant.

APPENDIX A
Glossary

Figure 5



SANTA YNEZ RIVER
IFIM STUDY

MAX-MIN TEMPERATURE DATA
STATIONS FROM JUNE 2-7, 1989

GLOSSARY OF TERMS

Chute

A narrow, confined channel through which water flows rapidly. The average depth is greater than one foot and the average velocity is greater than three feet per second (fps).

Cover

Overhead or in river objects which help camouflage fish from predators. Overhanging limbs, large rocks or logs and an uneven water surface caused by turbulence act as cover.

Fish Lifestages

Fry - A salmonoid that has hatched but is not yet a juvenile (fingerling). Fry have two stages:

Small - a fish that has hatched from the egg that has not absorbed the yolk sac.

Advanced - a fish that has absorbed the yolk sac but is less than one inch in length.

Juvenile - A salmonoid that is between approximately one and three inches long.

Smolt - A young salmonoid longer than three inches that is changing physiologically so that it can live in the ocean.

Adult - A salmonoid that has reentered the river from the ocean and is holding until it is time to spawn. Lifestage may or may not exist in a given stream, depending on the race and geographical location of fish.

Spawning - This is the lifestage of fish that have reentered the river and are proceeding upriver to spawn or are already spawning.

Instream Flow Group

U.S. Fish and Wildlife Service experts on IFIM and other habitat evaluation methodologies, based in Colorado. Their address is:

National Ecology Research Center
2627 Redwing Road
Fort Collins, Colorado 80526-2899

Instream Flow Incremental Methodology (IFIM)

Cell by cell analysis of stream transect data (depth, elocity, and substrate) wherein fish preferences are compared at each flow step to environmental conditions existing at that flow. At each step, the fish preferences for depth, velocity and substrate are multiplied together and then multiplied by the cell width to generate the weighted usable area per thousand feet for a particular lifestage at that flow. The cell areas per thousand feet are then multiplied by the cell lengths and divided by one thousand to yield the weighted usable area (WUA) for a particular lifestage at a given flow. These areas are summed together to obtain the study area WUA. The WUA is calculated at many flows, resulting in a WUA vs Flow (Q) curve.

Optimum Habitat (Area)

The maximum amount of weighted usable area available for some lifestage, in the range of flows modeled. This occurs at the peak on the WUA vs Flow curves.

PHABSIM (Physical Habitat Simulation)

A collection of computer programs that perform the analysis portion of an IFIM. These programs model the hydrology of a stream and compare this information to fish preference data to calculate the quantity of fish habitat existing at various flows.

Pools

Main Channel Pool - A large pool that extends across most or all of the stream width. They usually have one bedrock bank and occur at bends in the stream. The velocities are less than one fps and depths are generally greater than those in smaller, more numerous pools (normal pool).

Normal Pool - A portion of channel in which the average velocity is less than one fps, with no restrictions on depth. Rearing habitat is found mostly in shallow pools.

Run

A channel with a long and uniform cross-section and a straight, low-gradient profile. Depths are greater than one foot and velocities are greater than one fps.

Riffle - Spawning habitat occurs mostly in runs.

Low Gradient Riffle - Shallow (generally less than 0.7 feet deep) cross-sections with velocities greater than one fps but less than 1.6 fps, and depths less than one fps.

High Gradient Riffle - Channels with gradients (profile grades) greater than a four foot drop per hundred feet (4%) and velocities greater than 1.6 fps. Average depths are greater than 0.7 feet but less than one foot.

Study Area

The total stream area under investigation. It is normally subdivided into two or more study reaches.

Study Reach

A subdivision that brackets a portion of the study area and contains generally similar physical and/or hydrological characteristics.

Study Site

The smallest division of a study area which brackets a reach of stream, normally two to ten stream widths in length. Study sites are normally selected on the basis of their ability to represent other large stream areas (reaches). Sometimes they are selected because of their unique characteristics such as good spawning or rearing habitat.

Substrate

The stream bottom composed of material such as silt, sand, gravel and/or bedrock. This is the material that fish spawn in and that smaller fish use for cover. It also provides the habitat where many of the food organisms live.

Target Species

The species being studied in order to improve its habitat, or the most important species of several in a study.

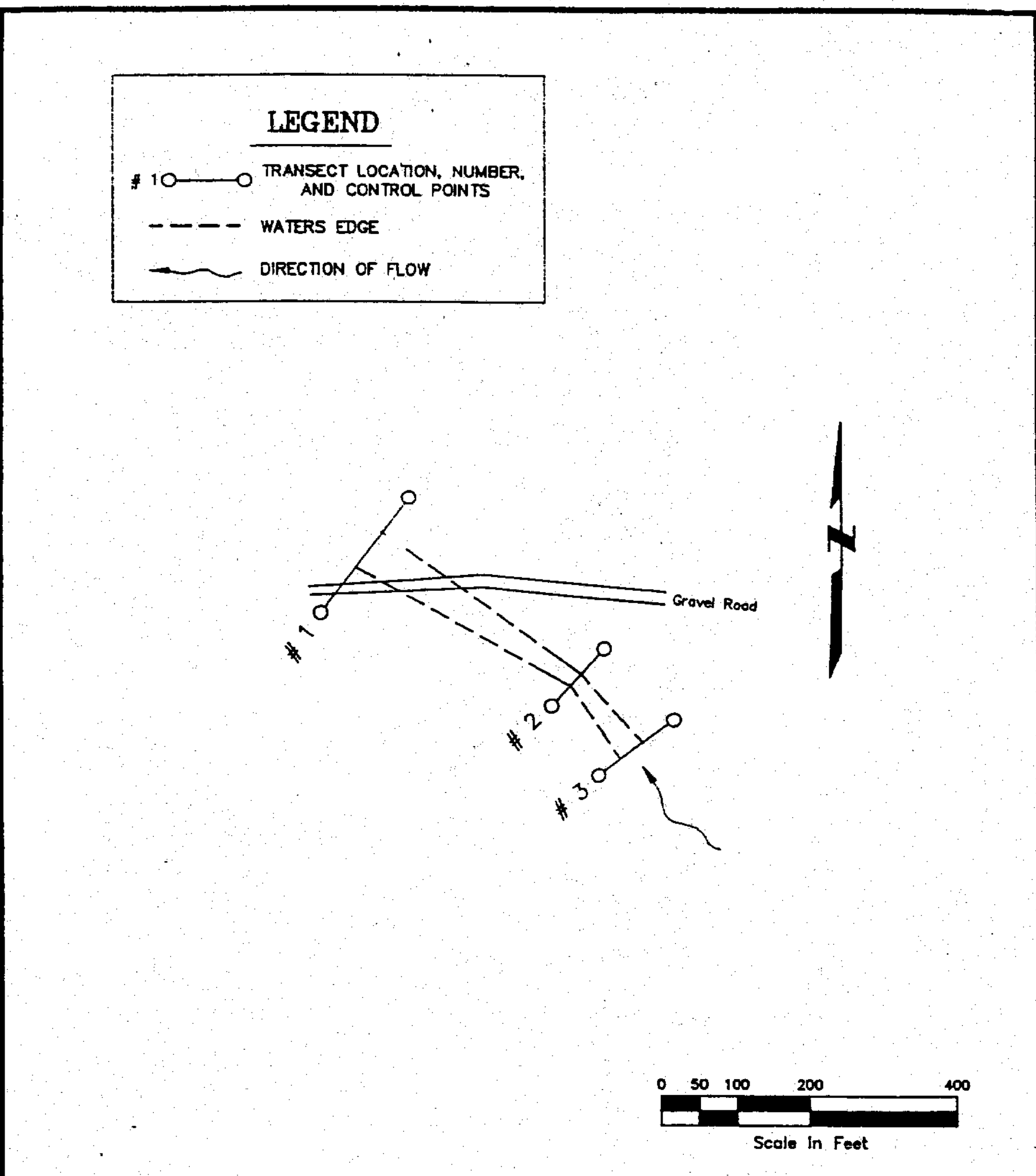
Transect

A stream cross-section established perpendicular to the direction of flow. Distance, elevation, substrate, velocity, depth and cover data is collected along the transect.

Weighted Usable Area (WUA)

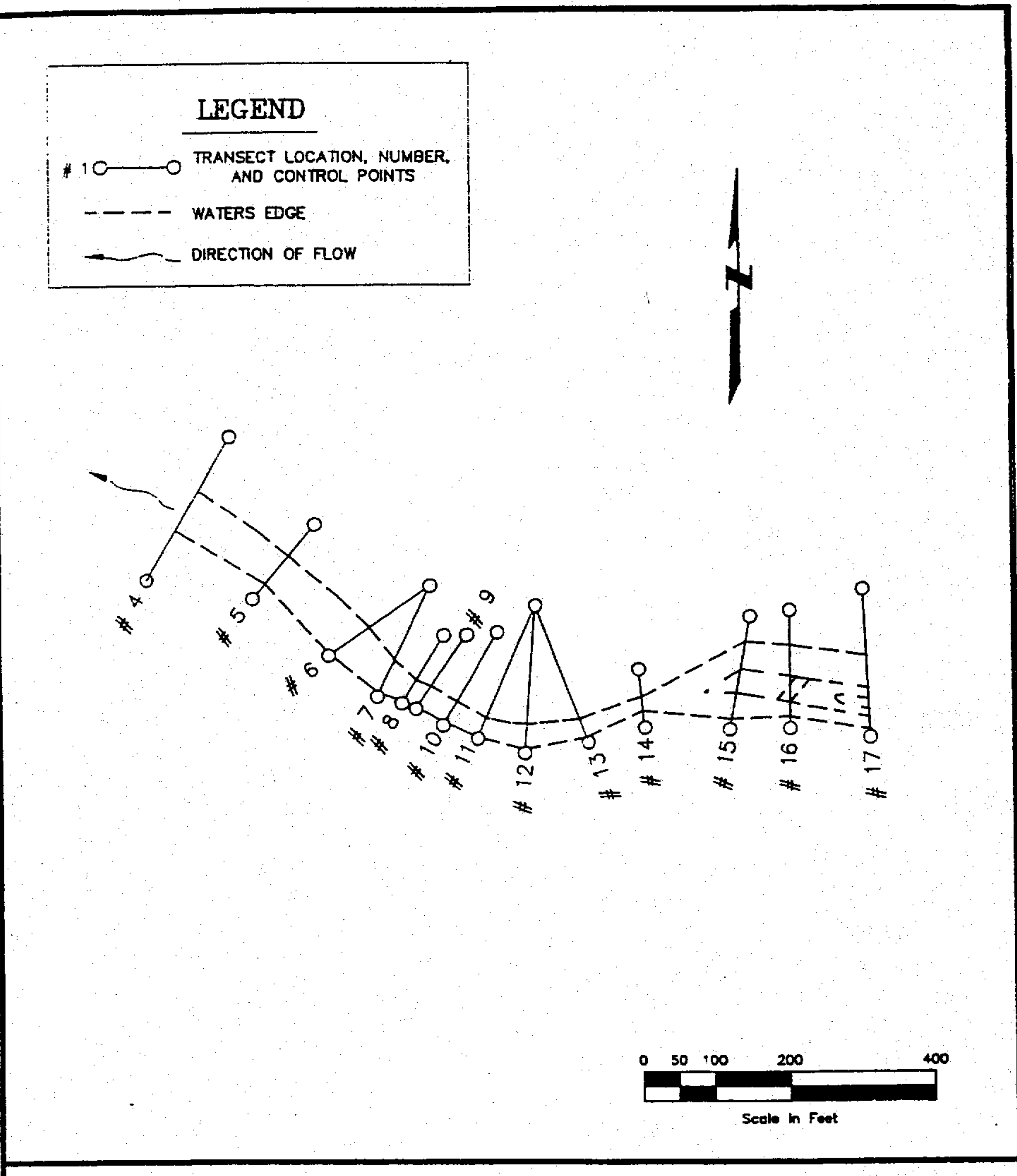
The amount of "perfect" area available for use by the target species (steelhead) during a given lifestage. This area is computed by multiplying each less-than-perfect area by its percentage of optimum usability, yielding an equivalent amount of "perfect" area.

APPENDIX B
Site Maps



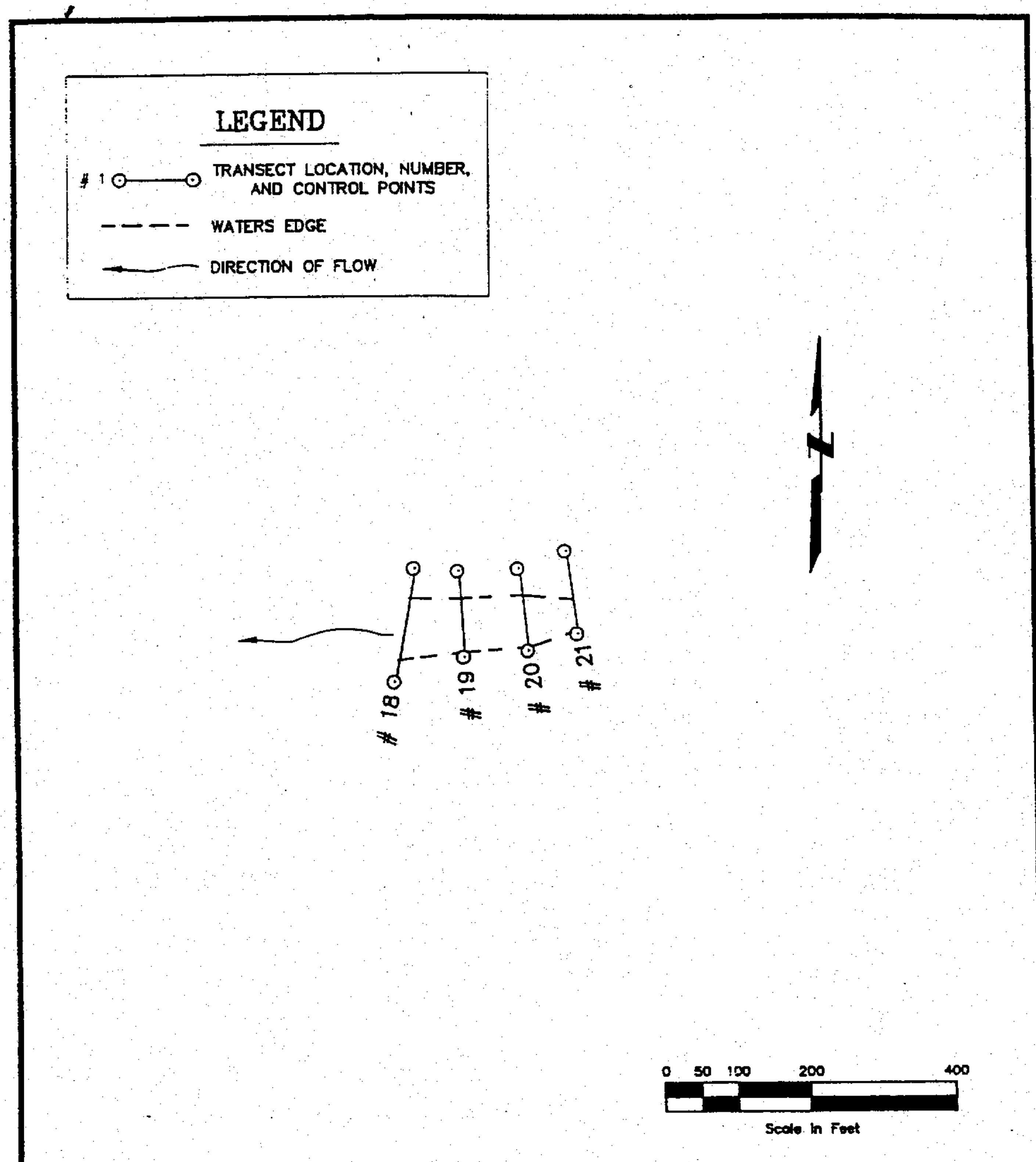
SANTA YNEZ RIVER

BUELLLTON SITE



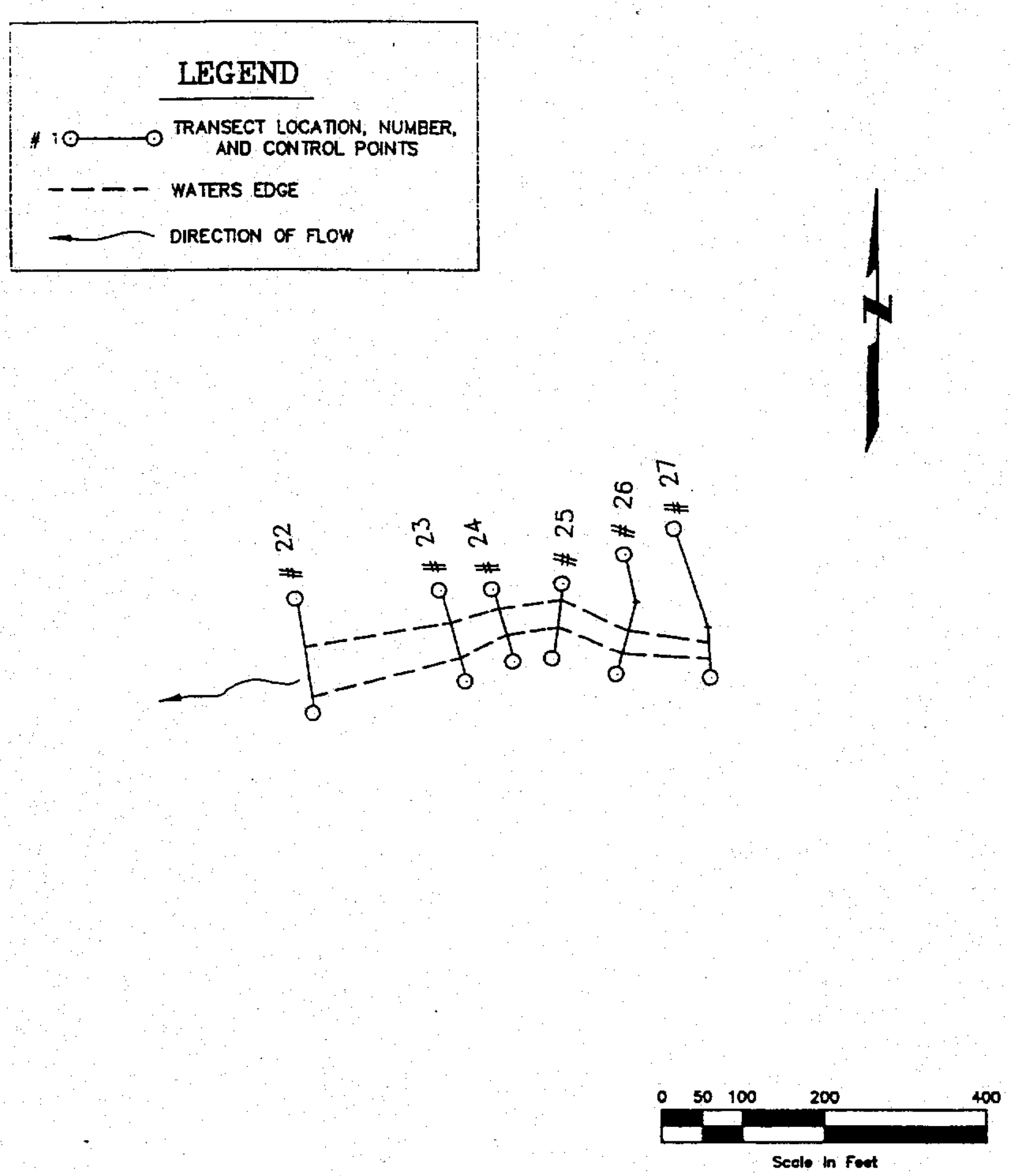
SANTA YNEZ RIVER

LOWER ALISAL SITE



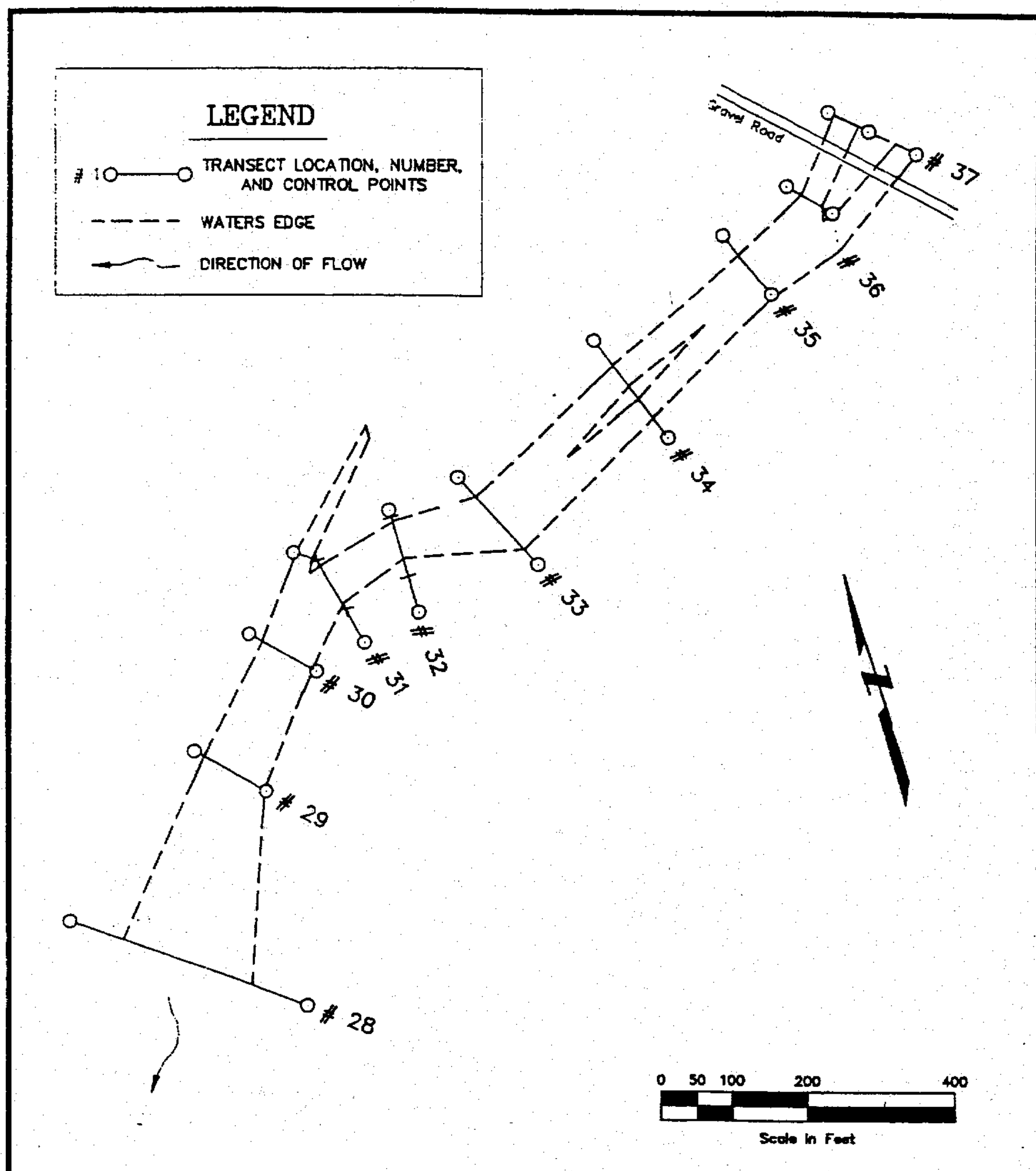
SANTA YNEZ RIVER

UPPER ALISAL SITE



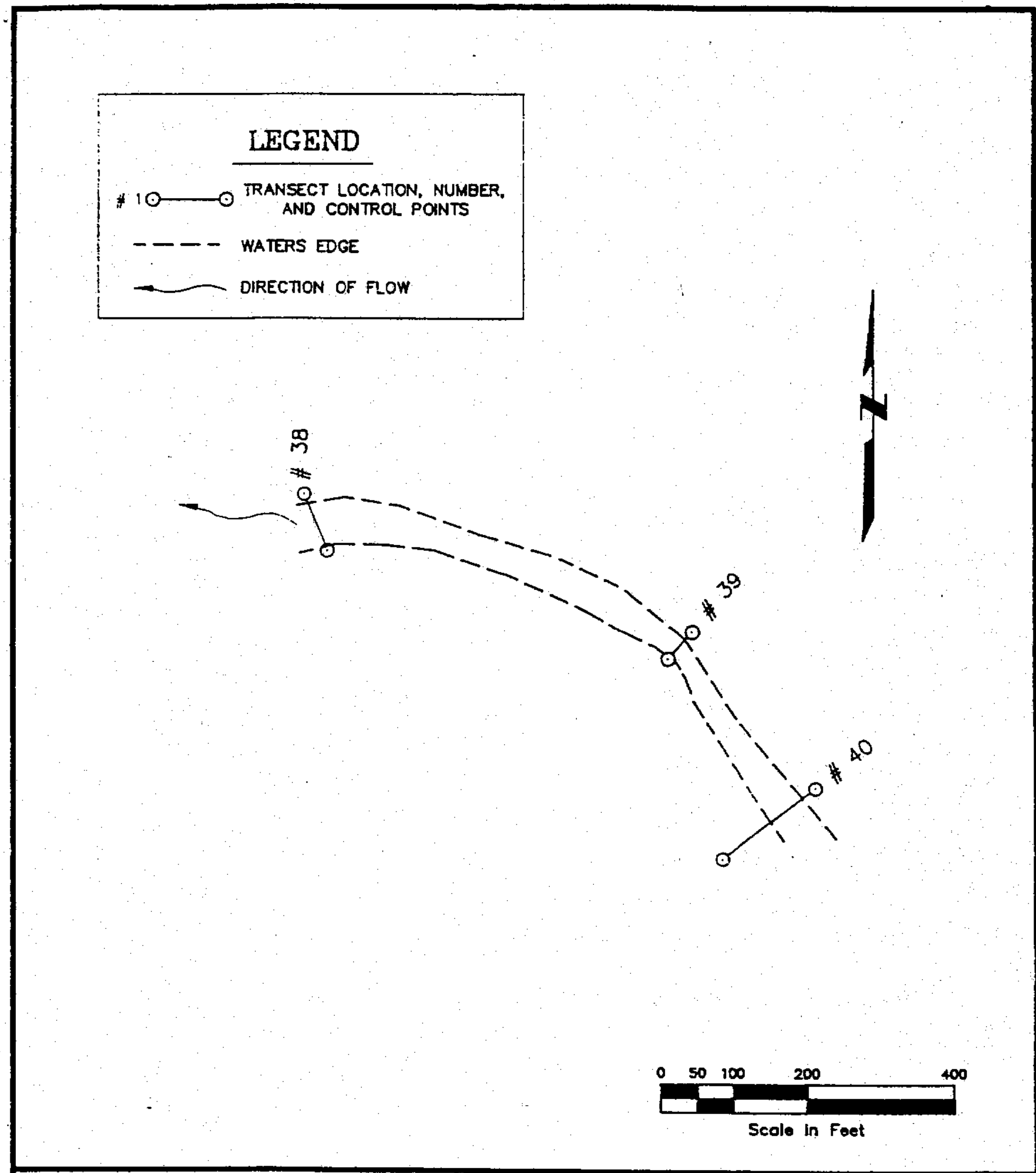
SANTA YNEZ RIVER

REFUGIO SITE



SANTA YNEZ RIVER

HIGHWAY 154 SITE



SANTA YNEZ RIVER

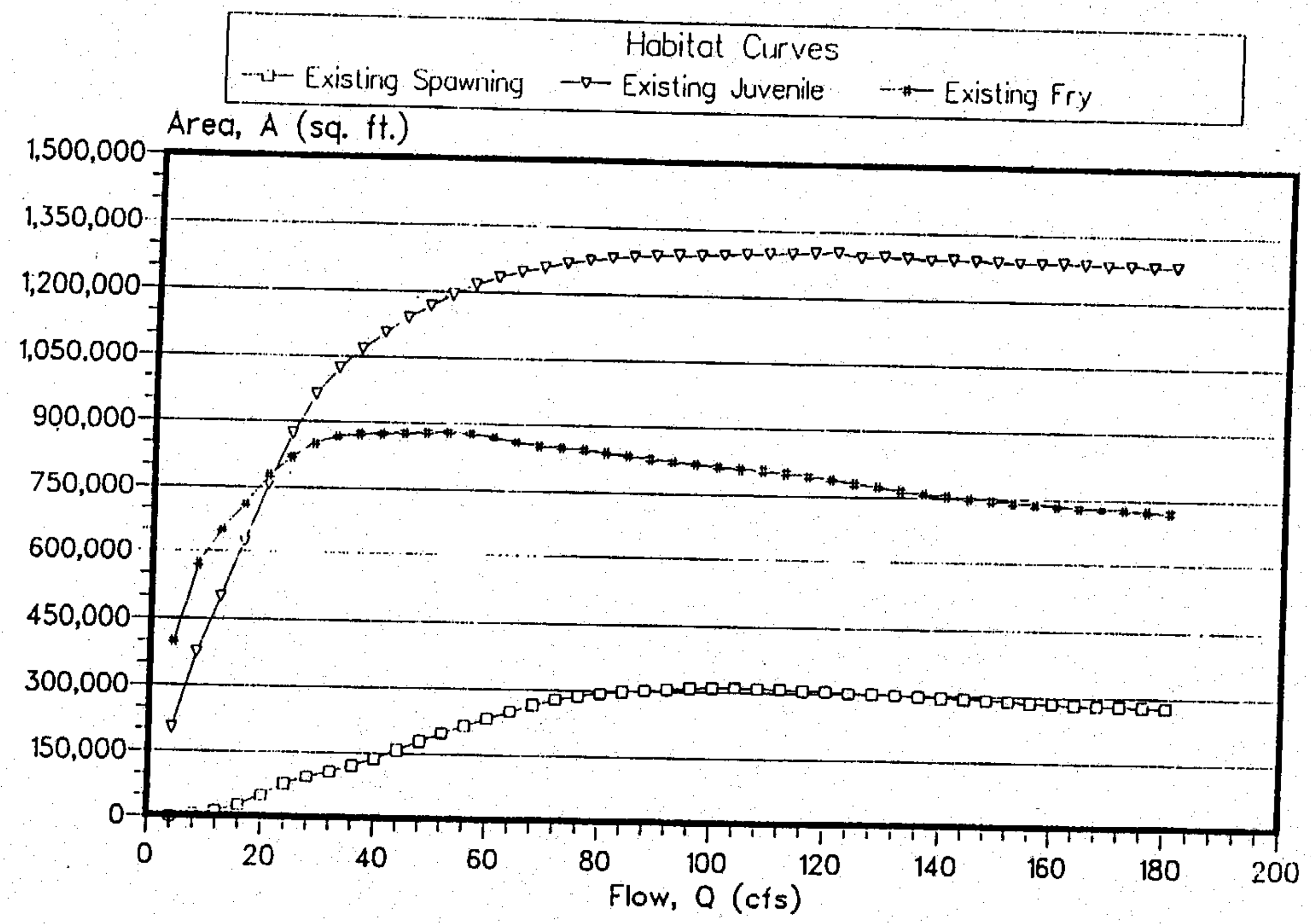
SAN LUCAS SITE

APPENDIX C

WUA vs Q Curves

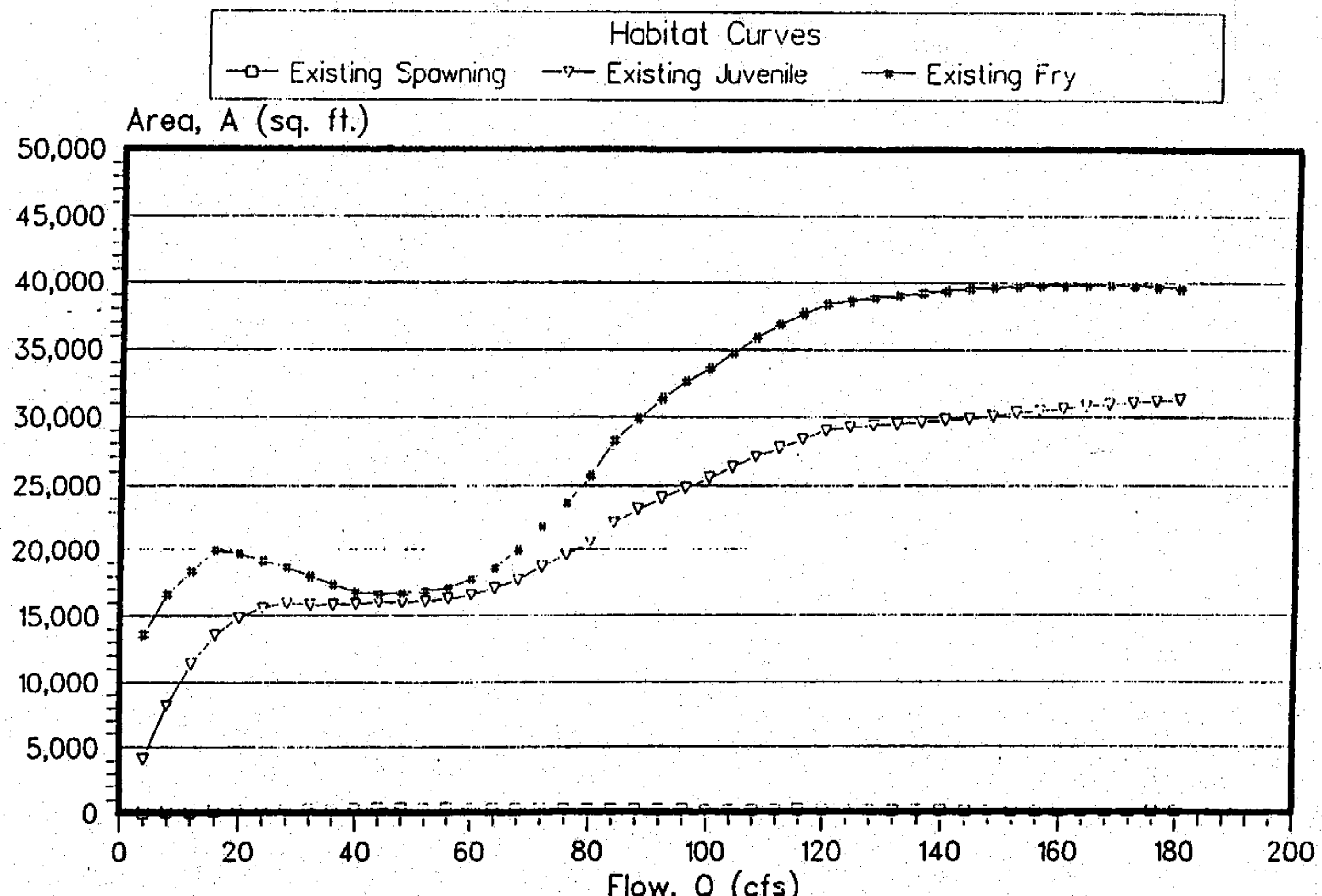
Steelhead Trout Habitat WUA vs Flow
Santa Ynez River
Bradbury Dam to Buellton

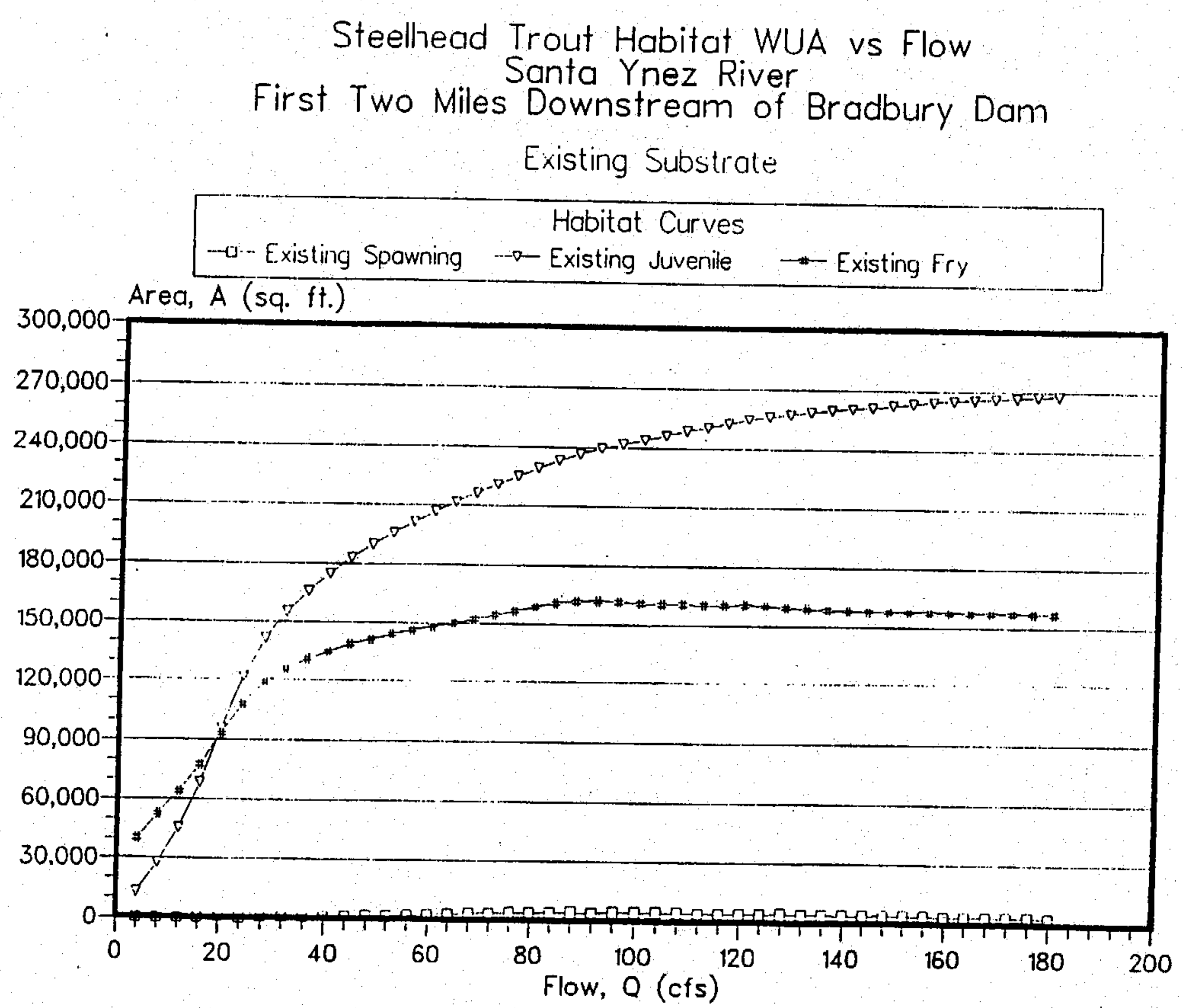
Existing Substrate

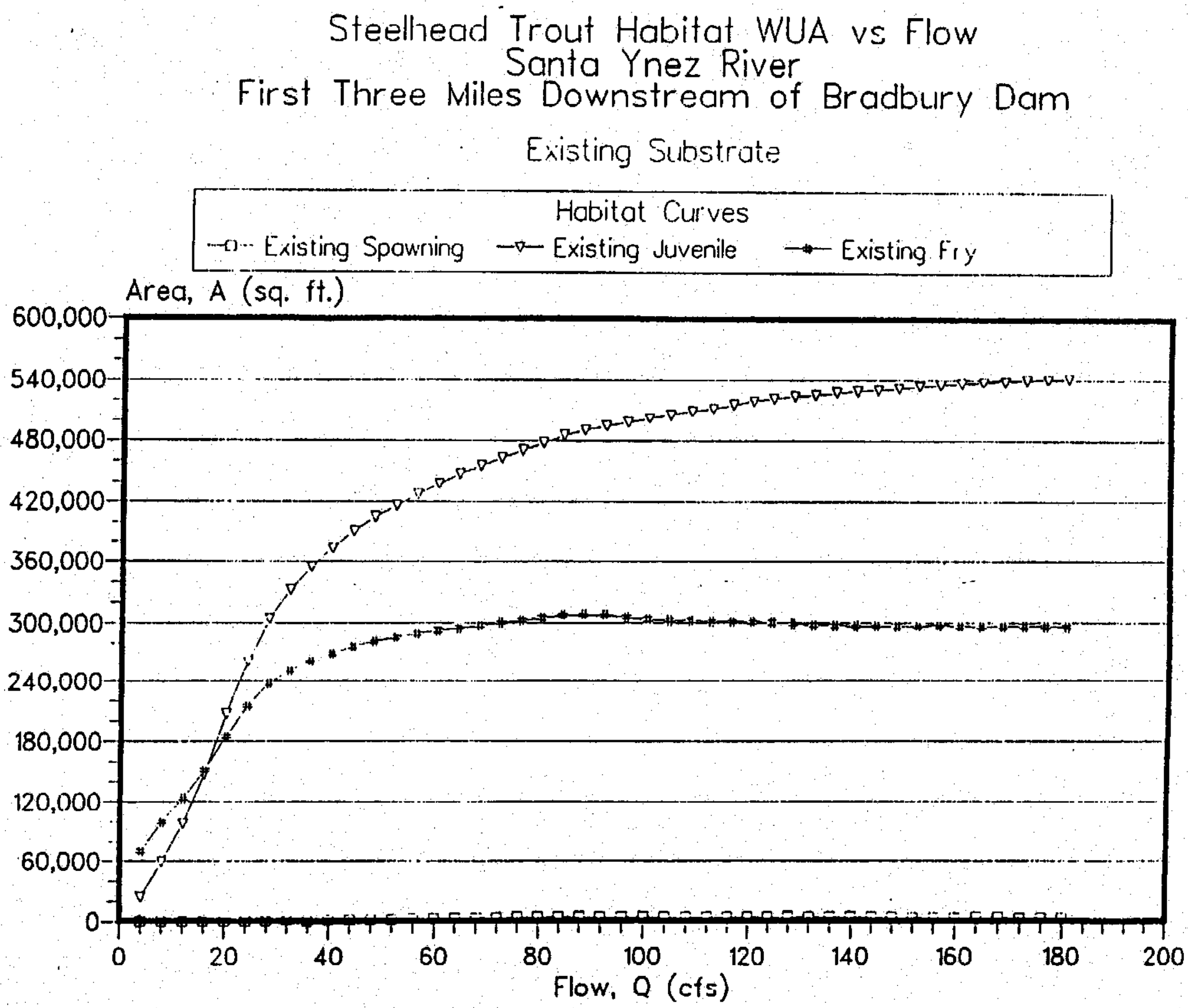


Steelhead Trout Habitat WUA vs Flow
Santa Ynez River
First Mile Downstream of Bradbury Dam

Existing Substrate

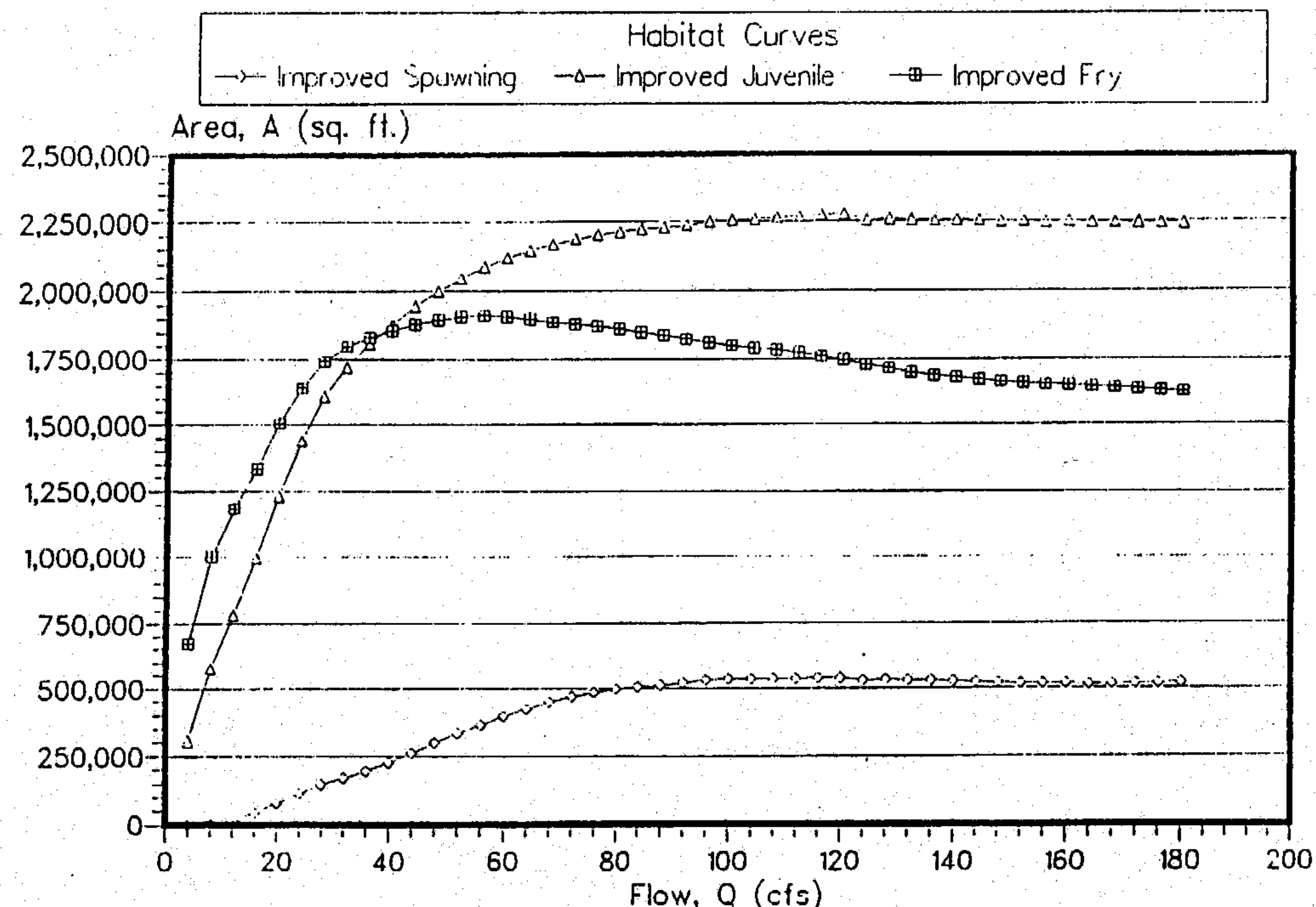



Steelhead Trout Habitat WUA vs Flow
Santa Ynez River
First Two Miles Downstream of Bradbury Dam
Existing Substrate
Habitat Curves
Existing Spawning
Existing Juvenile
Existing Fry
Area, A (sq. ft.)
300,000
270,000
240,000
210,000
180,000
150,000
120,000
90,000
60,000
30,000
0
0
20
40
60
80
100
120
140
160
180
200
Flow, Q (cfs)


Steelhead Trout Habitat WUA vs Flow
Santa Ynez River
First Three Miles Downstream of Bradbury Dam
Existing Substrate
Habitat Curves
Existing Spawning
Existing Juvenile
Existing Fry
Area, A (sq. ft.)
600,000
540,000
480,000
420,000
360,000
300,000
240,000
180,000
120,000
60,000
0
0
20
40
60
80
100
120
140
160
180
200
Flow, Q (cfs)

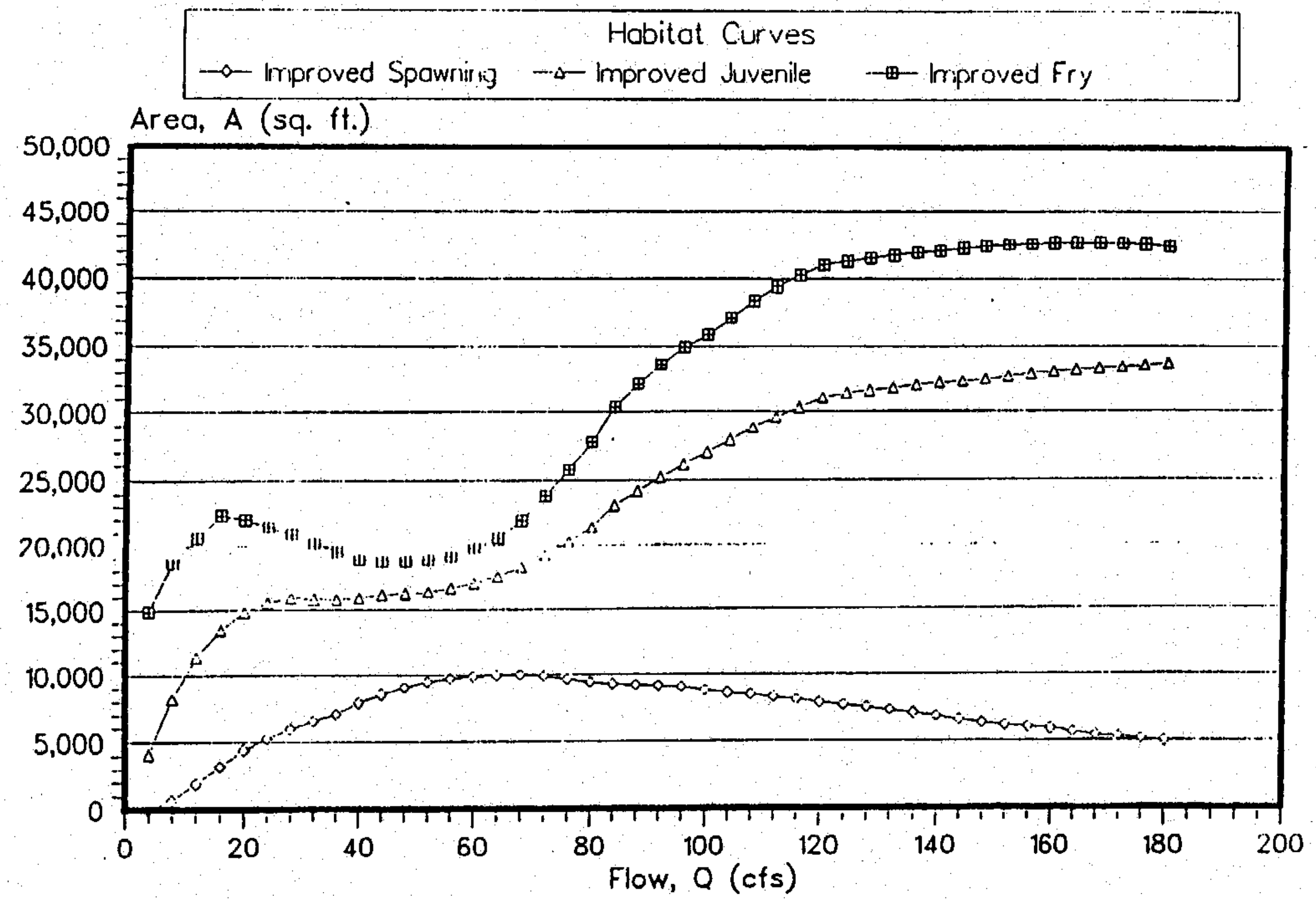
Steelhead Trout Habitat WUA vs Flow
Santa Ynez River
Bradbury Dam to Buellton

Improved Substrate



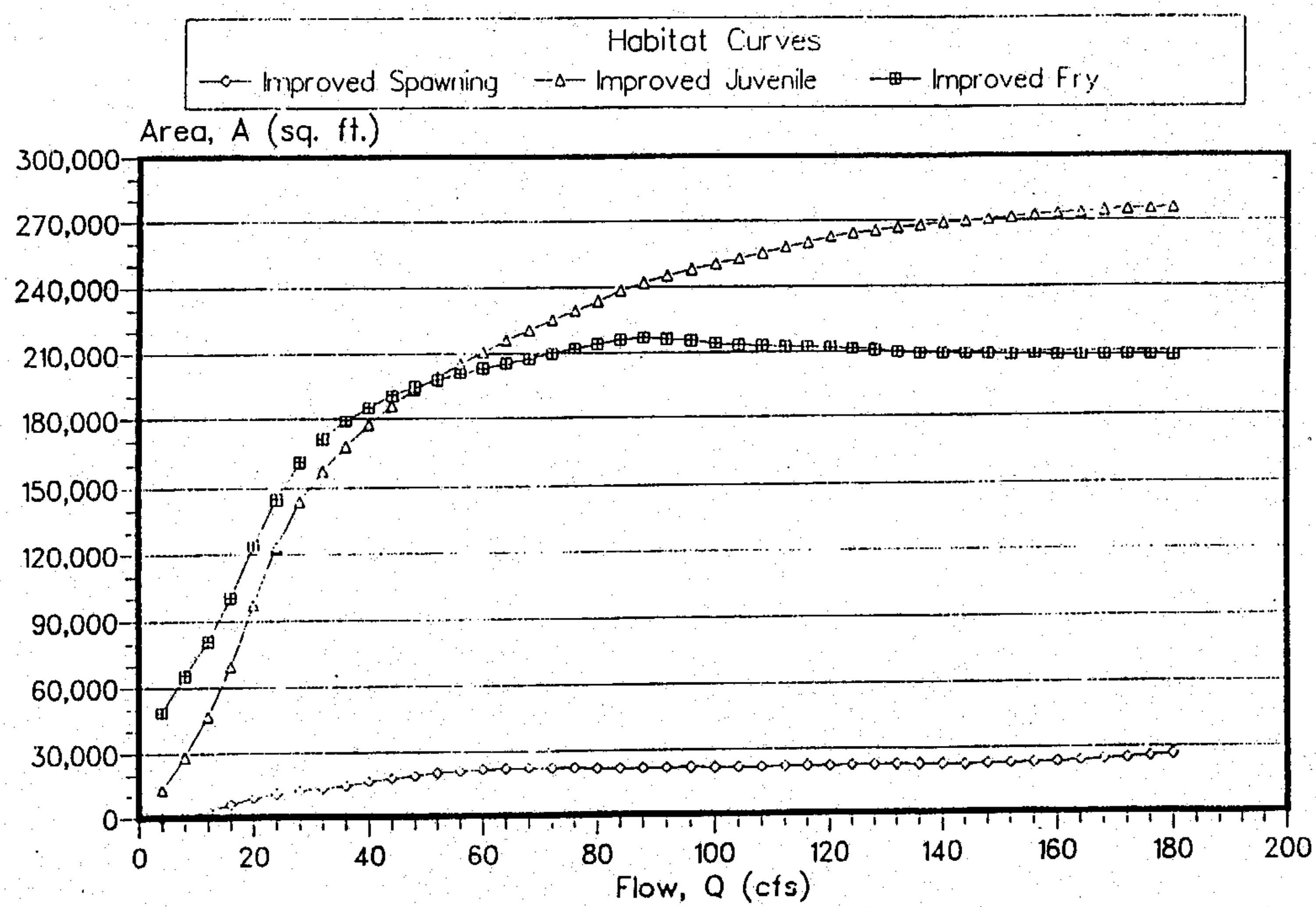
Steelhead Trout Habitat WUA vs Flow
Santa Ynez River
First Mile Downstream of Bradbury Dam

Improved Substrate



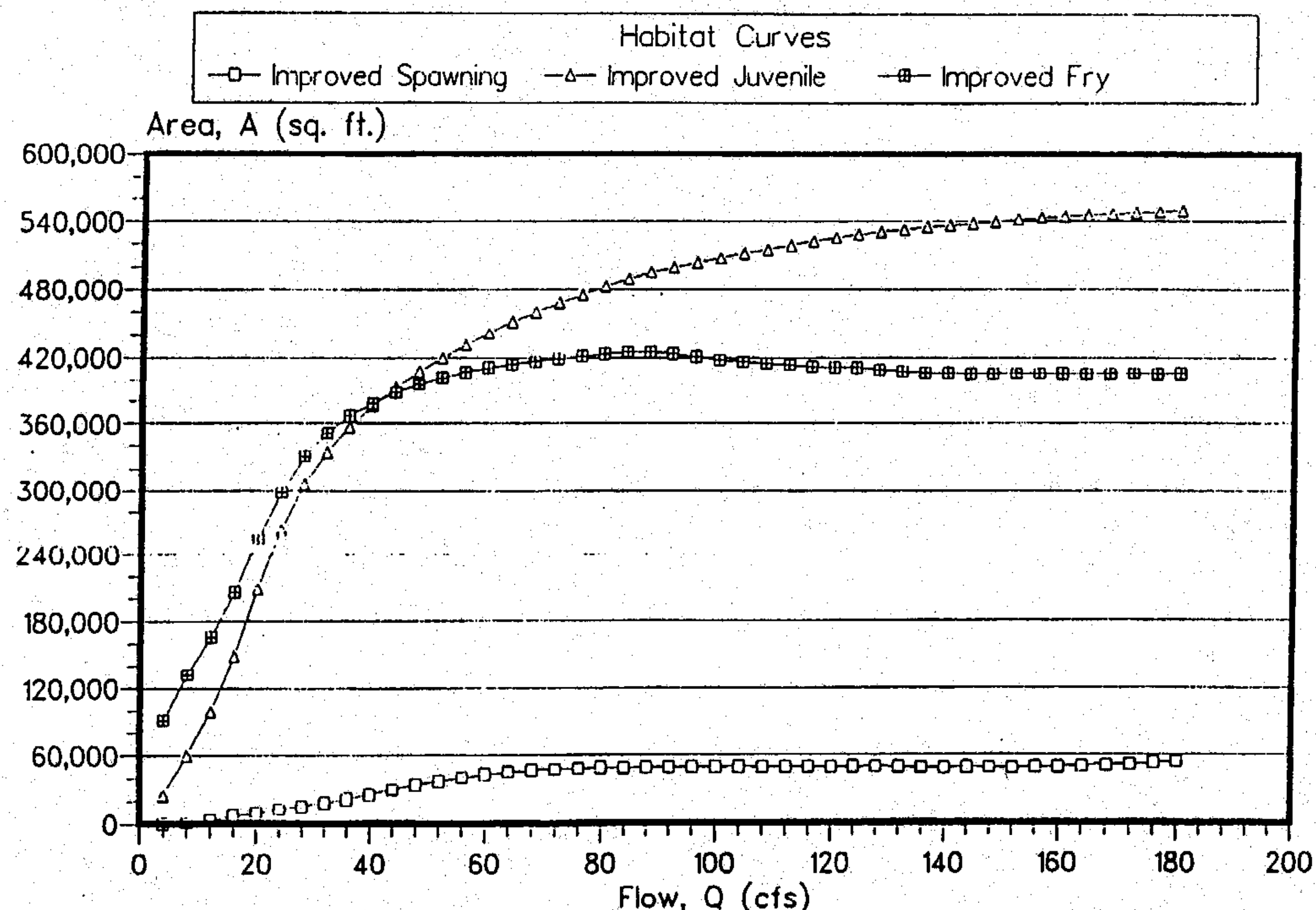
Steelhead Trout Habitat WUA vs Flow
Santa Ynez River
First Two Miles Downstream of Bradbury Dam

Improved Substrate



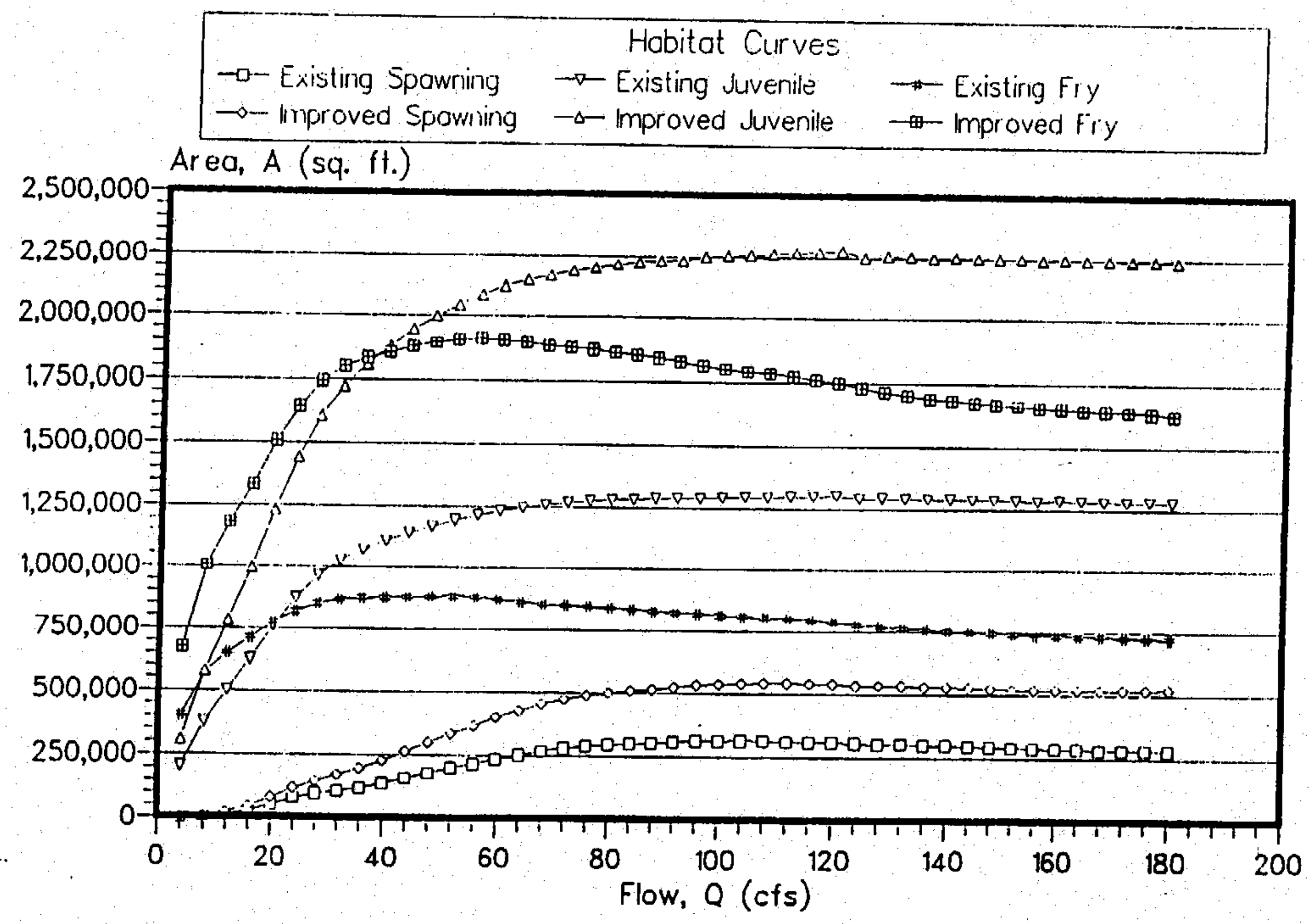
Steelhead Trout Habitat WUA vs Flow
Santa Ynez River
First Three Miles Downstream of Bradbury Dam

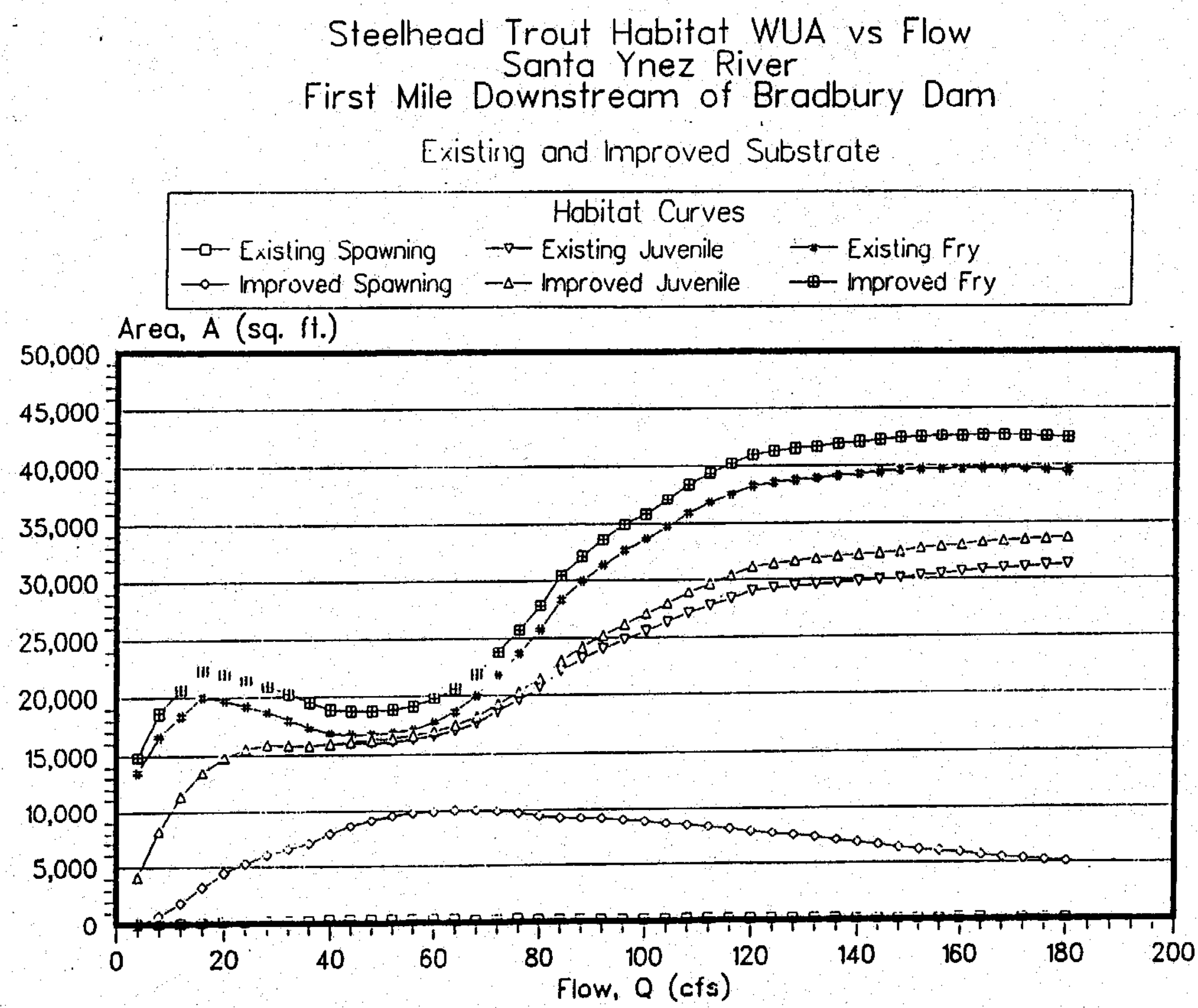
Improved Substrate

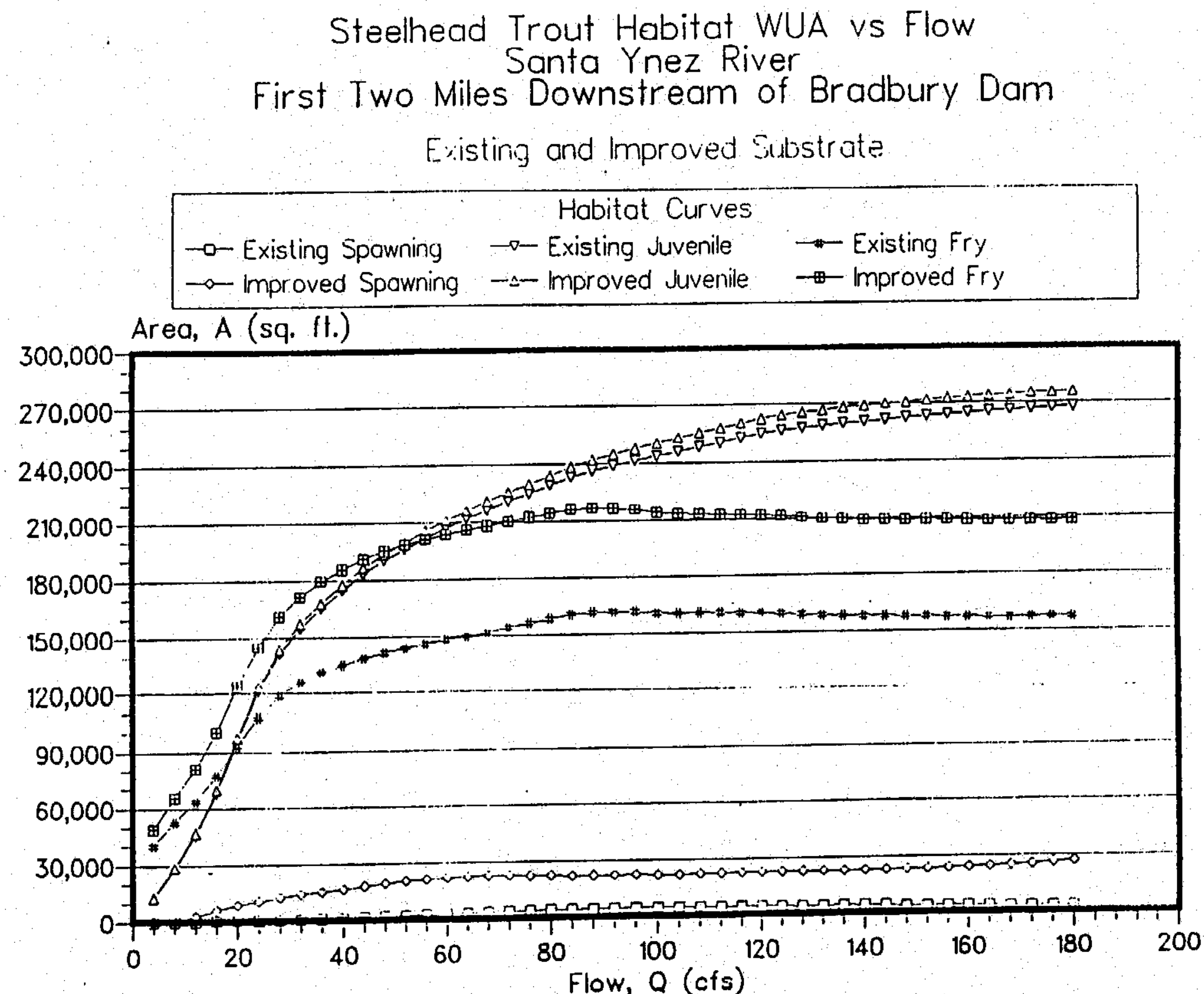


Steelhead Trout Habitat WUA vs Flow
Santa Ynez River
Bradbury Dam to Buellton

Existing and Improved Substrate

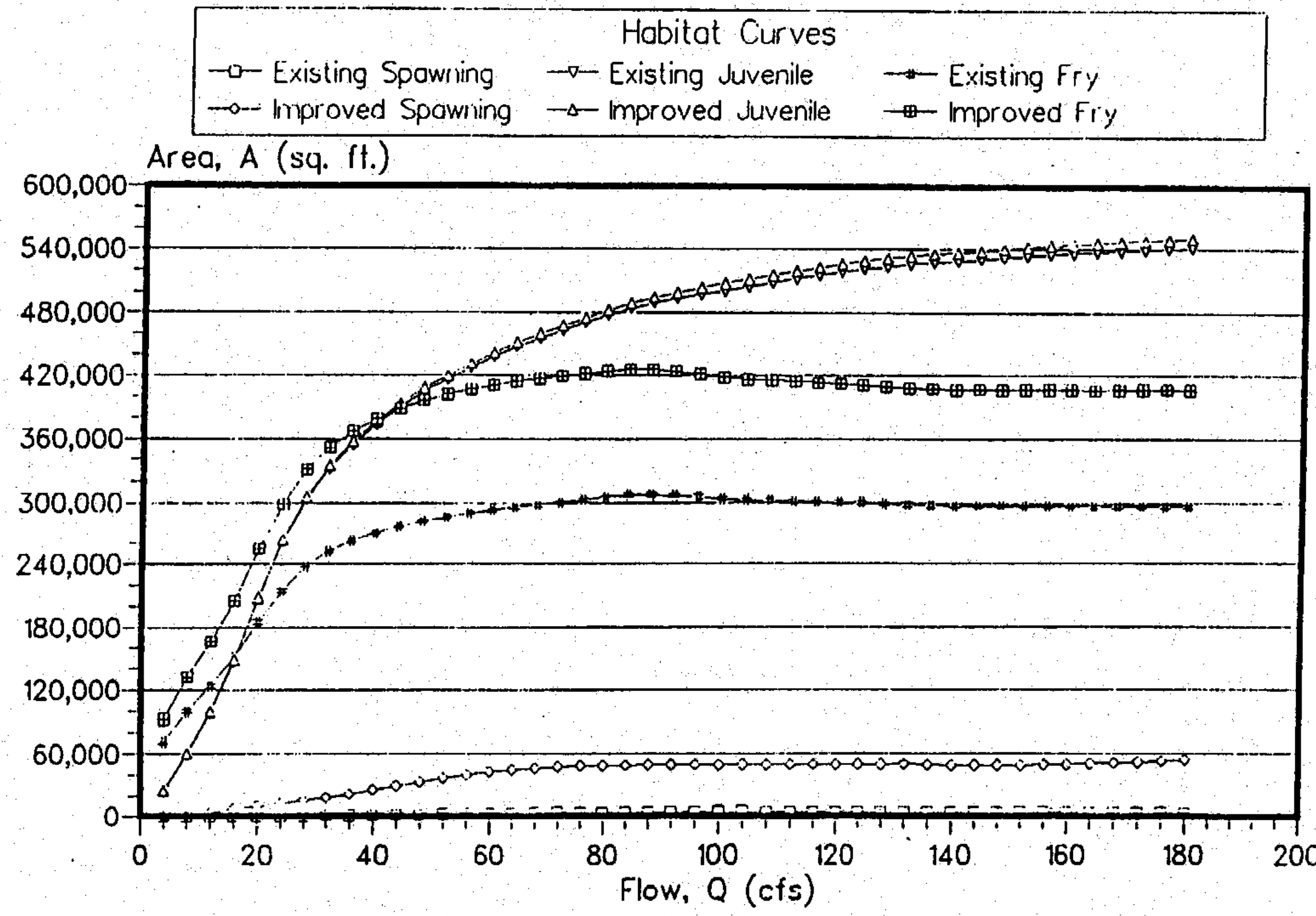



Steelhead Trout Habitat WUA vs Flow
Santa Ynez River
First Mile Downstream of Bradbury Dam
Existing and Improved Substrate
Habitat Curves
Existing Spawning
Improved Spawning
Existing Juvenile
Improved Juvenile
Existing Fry
Improved Fry
Area, A (sq. ft.)
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
0
20
40
60
80
100
120
140
160
180
200
Flow, Q (cfs)


Steelhead Trout Habitat WUA vs Flow
Santa Ynez River
First Two Miles Downstream of Bradbury Dam
Existing and Improved Substrate
Habitat Curves
Existing Spawning
Improved Spawning
Existing Juvenile
Improved Juvenile
Existing Fry
Improved Fry
Area, A (sq. ft.)
300,000
270,000
240,000
210,000
180,000
150,000
120,000
90,000
60,000
30,000
0
0
20
40
60
80
100
120
140
160
180
200
Flow, Q (cfs)

Steelhead Trout Habitat WUA vs Flow
Santa Ynez River
First Three Miles Downstream of Bradbury Dam

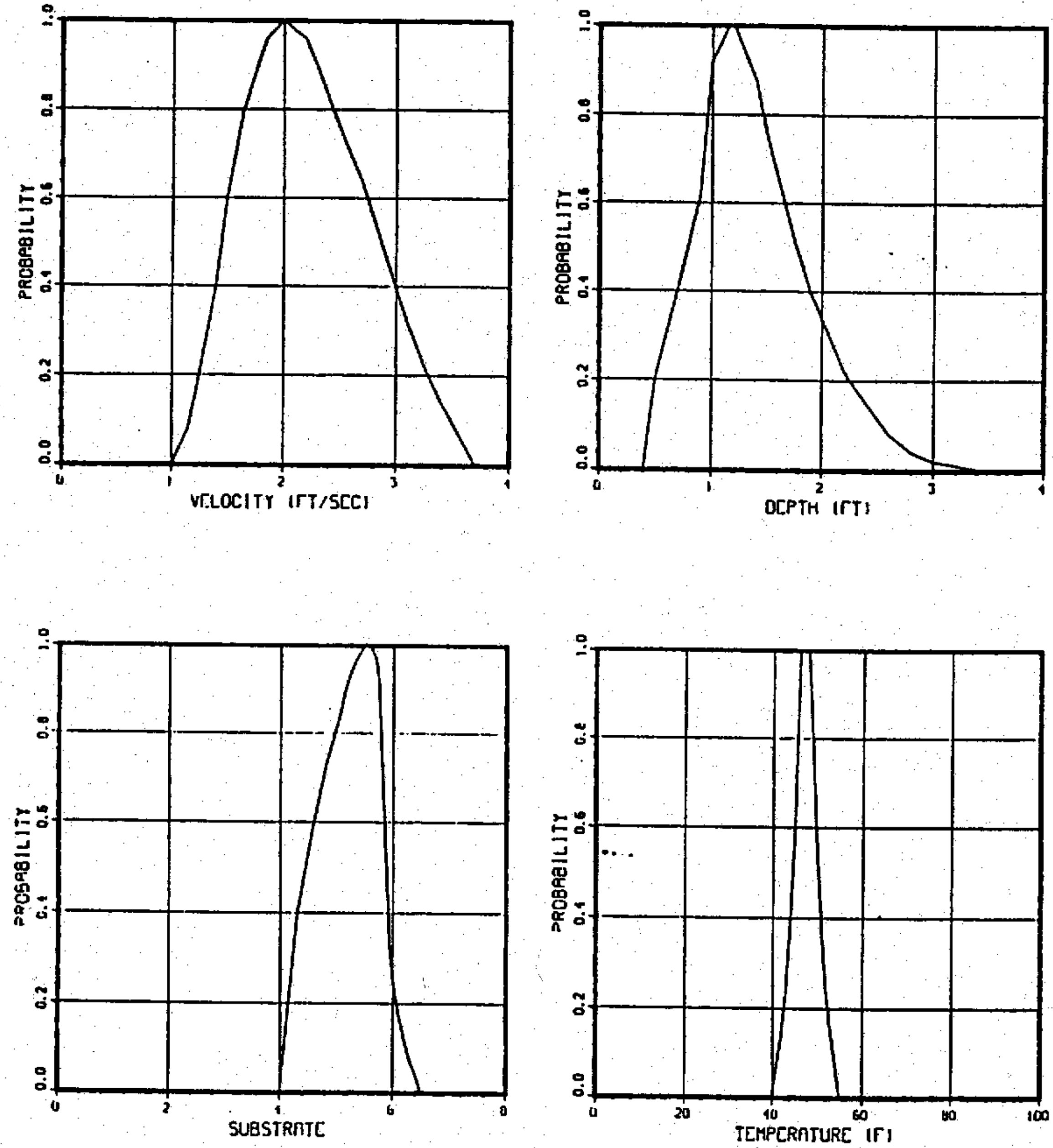
Existing and Improved Substrate



APPENDIX D
Preference Curves

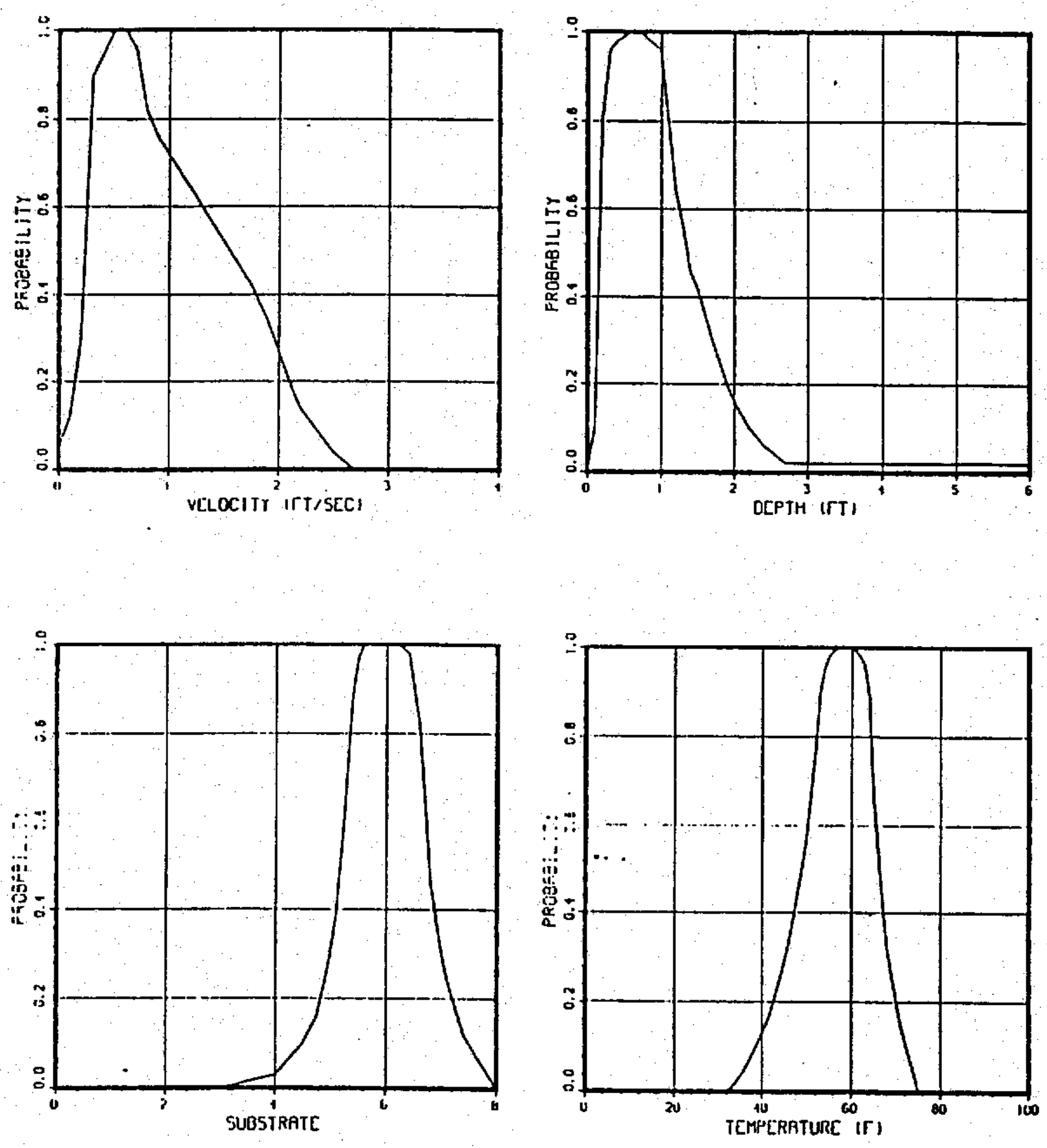
WINTER STEELHEAD

11010 SPAWNING 78/01/24.



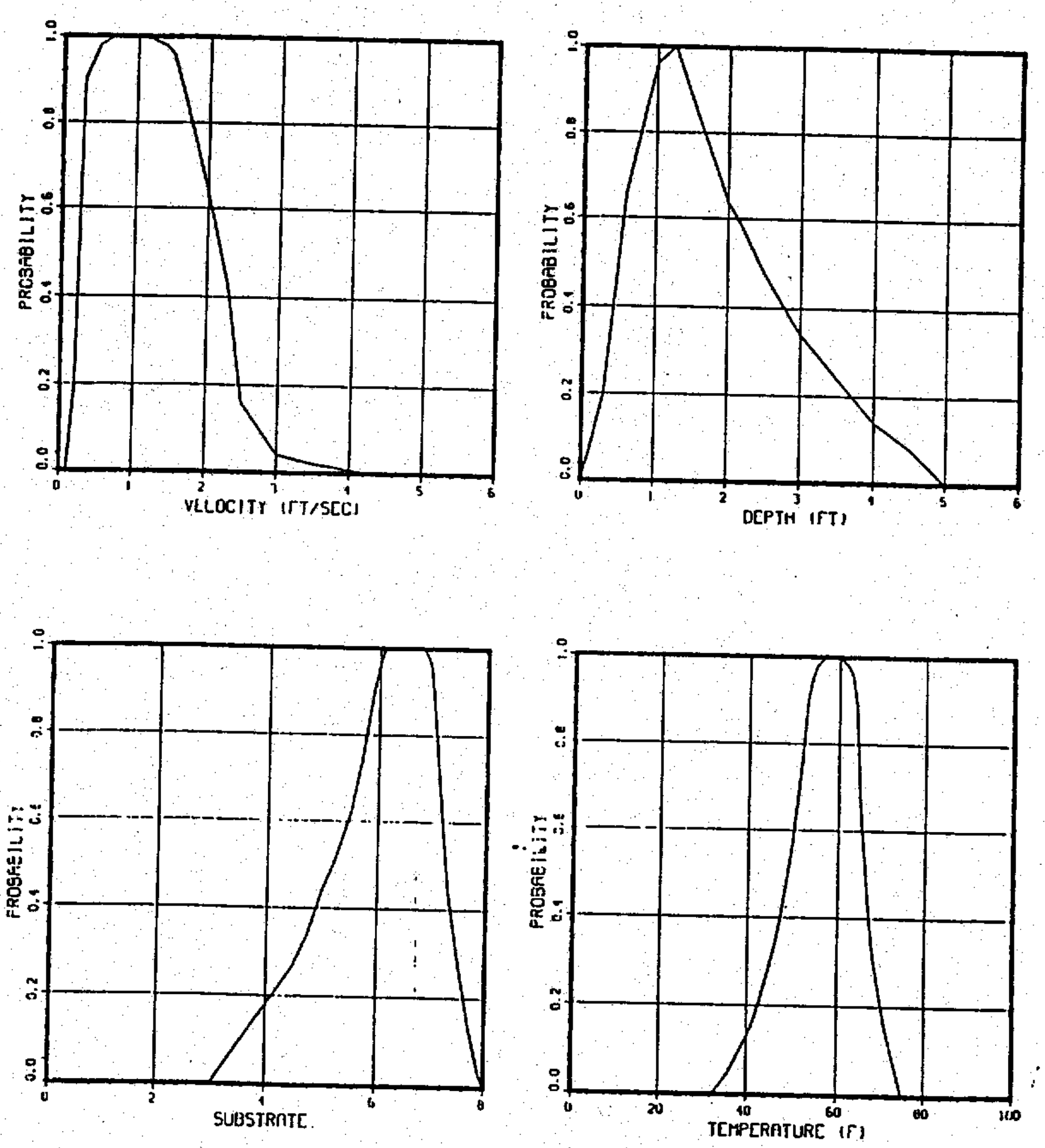
WINTER STEELHEAD

11000 FRY 78/01/24.



WINTER STEELHEAD

11001 JUVENILE 78/01/24.



APPENDIX E

Tables of Flow to Maintain Various Levels of Habitat

REQUIRED FLOW TO MAINTAIN VARIOUS LEVELS OF STEELHEAD HABITAT

(Habitat levels are expressed as a percentile of optimum and in thousands of square feet. Flows are in cfs.)

Alternative 1 - Bradbury Dam to Buellton

Percentage of optimum habitat area	Existing Substrate: Spawning		Existing Substrate: Juvenile		Existing Substrate: Fry		Improved Substrate: Spawning		Improved Substrate: Juvenile		Improved Substrate: Fry	
	Flow	Area	Flow	Area	Flow	Area	Flow	Area	Flow	Area	Flow	Area
10	17	31	<4 cfs	130	<4 cfs	88	17	54	<4 cfs	228	<4 cfs	191
20	22	62	5	261	<4 cfs	176	23	108	6	456	<4 cfs	383
30	28	93	9	391	<4 cfs	264	31	162	10	684	<4 cfs	574
40	37	124	13	521	<4 cfs	352	39	215	14	911	5	765
50	44	155	17	651	5	440	45	269	18	1,139	7	956
60	50	186	21	782	7	528	51	323	23	1,367	11	1,148
70	56	217	26	912	10	616	58	377	28	1,595	16	1,339
80	64	248	34	1,042	15	704	65	431	37	1,823	21	1,530
90	72	279	49	1,172	22	793	76	485	52	2,051	27	1,721
100	100	310	120	1,303	52	881	120	538	120	2,279	56	1,913

Alternative 2 - First Three Miles Downstream of Bradbury Dam

Percentage of optimum habitat area	Existing Substrate: Spawning		Existing Substrate: Juvenile		Existing Substrate: Fry		Improved Substrate: Spawning		Improved Substrate: Juvenile		Improved Substrate: Fry	
	Flow	Area	Flow	Area	Flow	Area	Flow	Area	Flow	Area	Flow	Area
10	24	0	<4 cfs	54	<4 cfs	31	14	5	<4 cfs	55	<4 cfs	43
20	38	1	13	108	<4 cfs	62	21	11	13	110	<4 cfs	85
30	43	1	17	162	7	92	29	16	17	165	8	128
40	48	2	21	216	12	123	36	21	21	220	12	170
50	52	2	25	271	16	154	41	27	25	275	17	213
60	57	3	31	325	20	185	47	32	31	330	20	255
70	63	3	41	379	24	215	52	38	42	385	24	298
80	70	4	58	433	30	246	60	43	59	440	30	340
90	80	4	88	487	44	277	76	48	88	494	42	383
100	100	5	180	541	88	308	180	54	180	549	84	425

REQUIRED FLOW TO MAINTAIN VARIOUS LEVELS OF STEELHEAD HABITAT

(Habitat levels are expressed as a percentile of optimum and in thousands of square feet. Flows are in cfs.)

Alternative 3 - First Two Miles Downstream of Bradbury Dam

Percentage of optimum habitat area	Existing Substrate: Spawning		Existing Substrate: Juvenile		Existing Substrate: Fry		Improved Substrate: Spawning		Improved Substrate: Juvenile		Improved Substrate: Fry	
	Flow	Area	Flow	Area	Flow	Area	Flow	Area	Flow	Area	Flow	Area
10	26	0	<4 cfs	27	<4 cfs	16	11	3	<4 cfs	28	<4 cfs	22
20	38	1	13	54	<4 cfs	32	15	5	13	55	<4 cfs	43
30	44	1	18	80	7	49	19	8	18	83	<4 cfs	65
40	48	2	22	107	12	65	24	11	22	110	13	87
50	53	2	26	134	17	81	31	13	27	138	17	108
60	58	3	34	161	21	97	39	16	35	166	21	130
70	64	3	47	187	26	113	47	19	48	193	26	152
80	70	4	66	214	35	129	57	21	68	221	33	173
90	80	4	95	241	55	146	161	24	97	248	49	195
100	100	5	180	268	92	162	180	27	180	276	88	217

Alternative 4 - First One Mile Downstream of Bradbury Dam

Percentage of optimum habitat area	Existing Substrate: Spawning		Existing Substrate: Juvenile		Existing Substrate: Fry		Improved Substrate: Spawning		Improved Substrate: Juvenile		Improved Substrate: Fry	
	Flow	Area	Flow	Area	Flow	Area	Flow	Area	Flow	Area	Flow	Area
10	8	0	<4 cfs	3	<4 cfs	4	9	1	<4 cfs	3	<4 cfs	4
20	11	0	6	6	<4 cfs	8	12	2	7	7	<4 cfs	9
30	13	0	9	9	<4 cfs	12	15	3	10	10	<4 cfs	13
40	16	0	14	12	7	16	19	4	16	13	6	17
50	19	0	25	16	16	20	23	5	58	17	14	21
60	22	0	72	19	76	24	28	6	76	20	76	26
70	26	0	83	22	83	28	36	7	86	24	83	30
80	32	0	97	25	94	32	41	8	99	27	98	34
90	39	0	115	28	108	36	47	9	116	30	104	38
100	52	0	180	31	164	40	68	10	180	34	164	43