AQUACULTURE IN IDAHO and Nationwide

by

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S/George W. Klontz
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PREFACE

This report constitutes the first in-depth description of the food fish industry in Idaho. The data presented were collected during individual interviews, when possible, with each commercial fish farm manager. The discrepancies between the previously published 1972 data (Klontz, 1973) and the 1972-1974 data presented in this report were resolved through further discussions with the fish farmers. It became apparent that the 1973 survey questionnaire for the 1972 data was misinterpreted which resulted in several millions of pounds of fish being recorded twice.

The Idaho food fish industry has grown steadily for the past two decades although it is presently in a period of tremendous flux. We have neither tried to analyze the flux nor tried to predict the outcome. We feel that it is safe to say that the industry will survive the environmental and economic pressures and will, in all likelihood, be better for it.

The main thrust of this report is to provide an accurate current description of the food fish industry. In doing so, we have documented both positive and negative facets--many of which have never been printed until now.

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Aquaculture, by definition, is the practice of raising fish and shellfish in closely managed habitats. The practice of raising aquatic animals in varying degrees of intensity has been considered by many to be the aquatic counterpart of agriculture. In many respects the comparison is valid. Both employ the substrates of earth or water upon or in which to raise animals or plants. However, aquaculture more appropriately would be analogous to animal husbandry rather than agriculture in general.

Aquaculture, like other forms of animal husbandry, can be economically productive only under sociologically settled conditions. The earliest records of fish culture come from China about 4,000 years ago when types of goldfish were raised for ornamental purposes. The practice of raising fish for human consumption was recorded first about the year 1,000 BC. From that time until now, aquaculture has slowly increased to the point that it, in some Asian countries, provides a major source of dietary protein for man. In 1973, the world production of fish and shellfish for human consumption through aquaculture was more than five million tons. This figure excludes the production of bait, sport, and ornamental fish and shellfish (Pillay, 1973).

Fish husbandry methods used in the United States may be classified as either intensive or semi-intensive. In semi-intensive fish culture the ponds are 3-5 feet deep and cover 1-2 surface acres. The water supply to the ponds is often meager--in some cases consisting only of intermittant surface run-off after a rainstorm. The fish are fed a prepared diet to supplement the natural food available. The annual yields average from 2,000-4,000 pounds per surface acre. In intensive fish culture the ponds are relatively small (1,500-16,000 cubic feet) and have between 8 and 48 water changes per day. Fish are stocked in the ponds on the basis of pounds of fish per cubic foot of water volume or gallons per minute of inflowing water. The fish are fed a prepared diet as their sole source of nutrition. The annual yields have been as high as 500,000 pounds per surface acre.

* * * * *

The purpose of this report is to describe the aquacultural industries of Idaho and their relationships to those of the United States from the aspects of: 1) quantity and quality of water used; 2) production and marketing; 3) economic significance; 4) current factors affecting the industries; 5) future prospects.

The scope of this report includes freshwater fish raised for human consumption and for bait in recreational fishing. Included also is the crayfish (or crawfish) industry. The culture of saltwater fish and shellfish or mariculture is not included because of its complexity and lack of any counterpart in Idaho.

Data for this report were collected during July, 1974 through personal interviews with the general manager and/or fish culturist-in-charge of each food fish farm in Idaho. Each person involved responded willingly to the information gathering process. The water chemistry data were collected at the same time. In addition, the data relative to aquaculture in the United States was obtained from persons with similar involvement as ours in several areas of the country.

Chapter II SUMMARY

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The aquaculture industries of the United States are quite complex in their structure. The major species raised for human consumption are rainbow trout and channel catfish. The bait fish and crayfish industries are primarily oriented to providing biological lures for sports fishermen.

The channel catfish industry is located mainly in the southern states where the aquatic environment is suitable for their optimum growth and reproduction. Very little catfish farming, other than for fee fishing, is located north of Arkansas and Tennessee and west of Texas. In 1973 the gross revenues from sales of channel catfish as a food item were slightly more than $26 million.

The rainbow trout industry is located mainly in Idaho, however, all states except Texas, Louisiana, and Mississippi have developed habitats suitable for trout farming and fee fishing. In 1973 the estimated gross sales revenues from the Idaho trout industry were between $20-25 million of an estimated $25-27 million nationally.

There are several factors influencing--both positively and negatively--the future growth of the food fish industry. Some are, in decreasing order of importance:

U.S.	Idaho	
1	1	Marketing practices
2	3	Increasing production costs
3	4	Water resources development
4	2	Federal limitations on fish farm effluent quality
5	6	Federal and state regulations regarding interstate shipment of live fish and/or their products
6	5	Fish husbandry practices

The negative influences of the foregoing factors have peculiar and individual scopes of activity. Some overlap with others and some are independent of other factors. Each could be resolved or modified through what might be termed a "symphonic orchestration" of the major segments of the food fish industry; namely, sales and marketing, production, and processing. In addition to coordination within the food fish industry, there must be federal and state involvement in terms of financial and manpower assistance.

Chapter III HABITAT

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An accepted definition of habitat is "the natural abode of an animal or plant." Since most fish farms do not provide a natural environment for fish, it is of little value to describe all aspects of the fish's habitat. Therefore, this section will deal with the requirements of cold and warm water species in terms of the important chemical and physical parameters of the fish's natural environment that must be reproduced and regulated in a fish farm to achieve survival and good growth.

Temperature

Water temperature exerts an extremely important role in aquatic habitat in that it affects the solubility of gases, the viscosity of water, the dissociation and stability of dissolved and suspended substances, and the well-being of fish. Fish growth, respiration, and reproduction are all directly influenced by the temperature of their environment. A change in temperature will have an indirect effect on fish by altering the physical and chemical environment. Temperature is the most critical factor regulating respiration, since it determines the solubility of oxygen and the amount of oxygen available to the organism. Its relationship to oxygen will be discussed in more detail in the section on dissolved oxygen. In cold blooded animals, temperature, metabolism, and respiration are interrelated, and often oxygen consumption is used as an index to measure metabolic rates.

There is an inverse relationship between water viscosity and temperature. As temperature decreases the water will become more viscous and the energy a fish must expend for movement will increase. Thus, it is desirable to keep the temperature of the water near the upper end of the optimum temperature range to reduce the expenditures of energy for movement and increase weight gains.

1) Cold Water Species: Each cold water species has a characteristic range of thermal tolerance beyond which it cannot survive. The thermal death point for pink salmon, *Oncorhynchus gorbuscha*, is around 22° C (71.6° F) while the death point temperature for rainbow trout, *Salmo gairdneri*, is 28° C (82.4° F). Brook trout, *Salvelinus fontinalis*, has a thermal death point in the range of 23-25° C (73.4-77° F). Thermal death points are not fixed; they will vary depending on the life stage of the fish and on the temperature at which the fish is acclimated. Generally, the earlier life stages cannot withstand as high a temperature as can an adult of the same species. Also, as the acclimation temperature is increased, the maximum temperature a fish can withstand increases slightly.

The maximum temperature compatible with the well being of adult brook trout and rainbow trout are about 14-18° C (57.2-64.1° F) and 13.6° C (56.5° F), respectively. The reported maximum temperature for reproduction and egg development is about 13° C (55.4° F) for *Salmo* sps., although the Hagerman

National Fish Hatchery has successfully incubated eggs in 15° C (59° F) water. Above 15° C (59° F) temperature the hatching success will diminish.

As a general rule, for every ° F decrease from the optimum water temperature for the particular species, there is a corresponding 5% decline in the growth rates of juvenile fish. Therefore, for maximum production rates it is necessary to have waters near the maximum temperature compatible with the well-being of the species, in the 13-18° C range (55.4-64.4° F), depending on the species.

2) Warm Water Species: For channel catfish, *Ictalurus punctatus*, the main warm water food fish produced commercially, to maintain good growth rates and satisfactory food conversions, temperatures should be in the 23.8-32.2° C (75-90° F) range. The Report to the Fish Farmers (1970) reports that 28.8° C (84° F) is the best temperature for optimum growth. For fry and fingerlings temperatures of 21.2-29.4° C (70-85° F) should be maintained and for egg hatching the temperature should be in the 23.8-26.7° C (75-80° F) range. The Report to the Fish Farmers (1970) also suggests that temperatures below 18.4° C (65° F) or above 29.4° C (85° F) should be avoided in culturing catfish as growth is slowed to a virtually imperceptible rate.

For baitfish the median heat tolerance limit, the temperature at which one-half the population will survive for a given period of time, is in the range of 33-39° C (91.4-102.3° F) for 24 hour survival. As a rule of thumb, the Aquatic Life Advisory Committee (1956) states that a temperature 2.5° C (4.5° F) lower than the median tolerance limit should allow all members of the population to survive. However, the optimum temperature may be as much as 15° C (27.1° F) lower, especially for spawning and hatching. Warm water ponds commonly fluctuate annually from 10-21.2° C (50-70° F) in the spring to 26.7-32.2° C (80-90° F) in the summer months in the temperate zone.

Dissolved Oxygen

The solubility of oxygen in water is influenced by the temperature of the water, the concentration of salts in the water, and the partial pressure of oxygen in the atmosphere. The rate of oxygen uptake by water is determined by the velocity of the water, wave action, and the area of the air-water interface.

Temperature of the water and the solubility of oxygen are inversely related. The saturated concentrations of dissolved oxygen increase as temperature decreases with distilled water having the capability of holding 14.6 ppm (mg/l) at 0° C (32° F) and only 11.3 mg/l at 10° C (50° F).

The salinity of the water also inversely affects the dissolved oxygen saturation level. While distilled water can absorb 14.6 ppm of oxygen at 0° C (32° F), water of the same temperature having a chloride concentration of 5000 ppm has an oxygen saturation of 13.8 ppm. However, in the range of salt concentrations that freshwater fish tolerate, the effect of salts on dissolved oxygen levels is negligible. Fresh water fishes, in general, have a salinity tolerance of 7-8 parts per thousand (ppt) sodium chloride, providing there is no direct toxicity of the substances that constitute the salinity concentration.

The partial pressure of a gas is a function of barometric pressure and it is therefore related to elevation above sea level. As elevation increases the barometric pressure declines and correspondingly, the partial pressure of oxygen declines. This results in water having a lower capacity to hold dissolved oxygen. The solubility of oxygen in distilled water may be calculated for any barometric pressure by using the following formulae. The relationship between temperature and dissolved oxygen concentrations is curvilinear; however, two linear equations can be used to describe the relationship in the different temperature ranges.

$$\text{mg/l dissolved oxygen} = \frac{(P-U) \times 0.678}{35+t} \quad (\text{for } 0\text{-}30^{\circ}\text{ C}) \ (32\text{-}86^{\circ}\text{ F})$$

$$\text{mg/l dissolved oxygen} = \frac{(P-U) \times 0.827}{49+t} \quad (\text{for } 30\text{-}50^{\circ}\text{ C}) \ (86\text{-}122^{\circ}\text{ F})$$

where P = barometric pressure (mm Hg)
t = temperature ($^{\circ}$ C)
U = saturated vapor pressure (mm Hg)

Oxygen enters the water by diffusion at the air-water interface. This process is aided by increasing the area of the interface, increasing water velocity, and increasing agitation and wave action.

For each species of fish there is a minimum level of dissolved oxygen below which a species cannot respire adequately and will die. However, at concentrations between the lethal level and optimum conditions, fish will still be adversely affected by a lack of sufficient oxygen. Their ability to resist currents, find and capture food, escape danger, grow and reproduce will be impaired.

Dissolved oxygen is rapidly consumed via respiration and oxidation processes in a crowded fish farm situation. Factors which regulate fish activity, such as carbon dioxide concentrations, loading densities, and pond flow patterns will all affect oxygen consumption. Consumption will also vary with species, sex, and season of the year. Also the levels of organic matter in the fish raceway or pond will increase the biochemical oxygen demand (BOD) in the water. Therefore, the oxidation of organic matter will decrease the total amount of oxygen available for fish. The rate of oxygen consumption is also regulated by the temperature of the water. As temperature increases the fish's resistance to low oxygen concentrations will decrease and its respiration rate will markedly increase. Fish will use several times the amount of oxygen at 25° C (77° F) than at 10° C (50° F). As a general rule, for every 10° C (18° F) increase in temperature, fish will consume twice the amount of oxygen.

Liao (1971) found that oxygen uptake rates of salmonids was proportional to water temperature and inversely proportional to fish size as shown in the following formula.

$$O_2 = KT^n W^n$$

Where O_2 = oxygen uptake in lbs. O_2/100 lbs. fish/day
K = rate constant
T = water temperature, ^oF
W = fish size, lb./fish
m,n = slopes

For trout this relationship is shown in Figure 1.

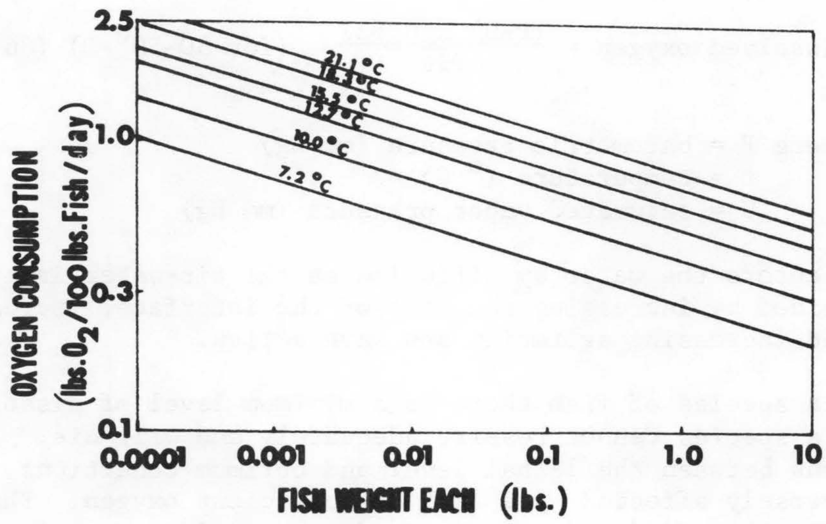

Figure 1. Oxygen consumption at different temperatures (adapted from Liao, 1971).

In recommending suitable dissolved oxygen concentrations the Aquatic Life Advisory Committee (1955) advises the following be considered:

1. The minimal oxygen requirements of the fish.
2. The necessary margin of safety required to allow for activity, increased body temperature, increased carbon dioxide, lowered pH, and the presence of toxic substances.
3. The fact that a fish may tolerate a low oxygen concentration for a few hours, but will not thrive if this level is maintained indefinitely.
4. A well-rounded fish population does not occur in areas where oxygen content falls below 3 ppm and a coarse fish population does not occur when the oxygen concentration falls below 2 ppm.

5. The quantity of dissolved oxygen in natural waters may fluctuate over a wide range.
6. A fall in oxygen concentrations to anoxial level, even for a short time, or infrequently, may destroy the fishing potential of a stream, if not the entire fish population.
7. The recommendations of an average value for dissolved oxygen would not set the critical lower limit on the permissible oxygen level.

1) Cold Water Species: Ellis (1940) reported that a good mixed fish fauna exists if the dissolved oxygen concentration is upward of 5 ppm. Leitritz (1969) agrees that the lowest safe level of dissolved oxygen for trout is 5 ppm but states that 7 ppm is preferable as the minimum requirement.

The results of several studies on the minimum concentrations of dissolved oxygen required for rainbow trout to exist are shown in Table 1.

Table 1. The minimum concentrations of dissolved oxygen at which rainbow trout can exist.

Dissolved Oxygen ppm	Temperature ^{o} C	Reference
2.5	19-20	Gutsell, 1929
2.4-3.7	16	Water Pollution Research, 1956
1.05-2.06	18.5	Burdick, et. al., 1954
0.83-1.42	11.1	Burdick, et. al., 1954

The interrelationships between temperature and dissolved oxygen as they affect survival is illustrated in Figure 2 using data for coho salmon. Notice that as temperature decreases there is an exponential decrease in the dissolved oxygen concentration required for survival. The reason the dissolved oxygen concentrations are very low in Figure 2 is that the author was basing his experiment on 24-hour survival. For juvenile coho salmon to exist and grow they would require much higher levels of dissolved oxygen. However, this form of relationship between temperature, dissolved oxygen, and survival holds true for all cold water species.

Dissolved oxygen concentrations below 3 ppm will cause labored breathing and below 2.5 ppm will asphyxiate rainbow trout. In general, any increase in temperature will lower resistance to low dissolved oxygen concentrations.

2) Warm Water Species: Allen (1971) states that catfish may survive but will not grow where oxygen concentrations are less than 3.0 ppm. He also recommends maintaining at least 4.0 ppm; however, for short periods of time, levels as low as 0.5 to 1.5 ppm will sustain life.

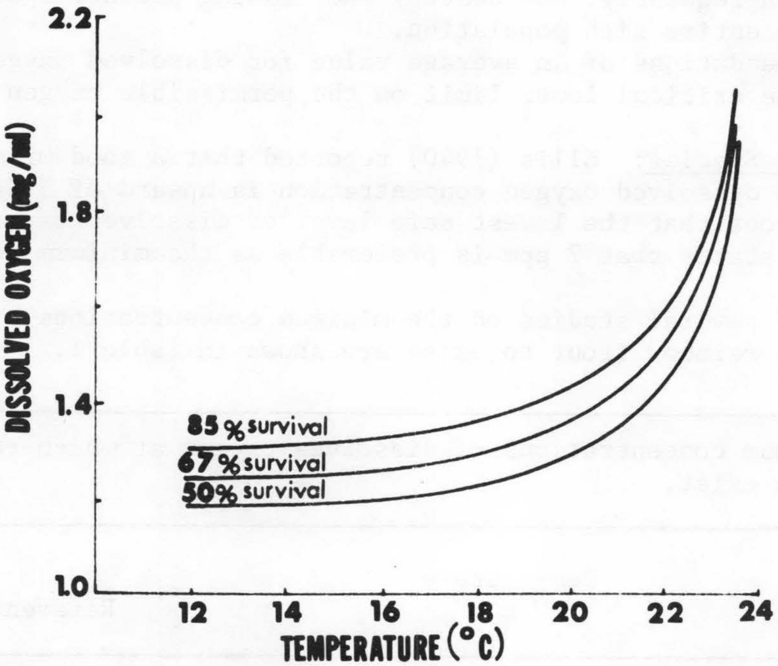

Figure 2. The influence of dissolved oxygen and temperature on 24-hour survival of juvenile coho salmon in the fall season (adapted from Davidson, et. al., 1959).

The Aquatic Life Advisory Committee (1955) recommends the following for warm water fish habitats: "The dissolved oxygen content of warm water fish habitats shall not be less than 5 ppm during at least 16 hours of any 24-hour period. It may be less than 5 ppm for a period not to exceed 8 hours within any 24-hour period, but at no time shall the content be less than 3 ppm."

Where low dissolved oxygen concentrations are a problem in fish farming, there are numerous easy and relatively inexpensive management techniques to alleviate this problem. Anything that will agitate the water surface or cause turbulence will cause oxygen to diffuse into the water.

pH

pH is the logarithm of the reciprocal of the hydrogen ion concentration in moles per liter. The pH scale extends from 0 (very acidic) to 14 (very alkaline), with a pH of 7 corresponding to neutrality at 25° C. The excess concentration of hydrogen ions may adversely affect water for one or more beneficial uses, it therefore is a measure of a potential pollutant. Thus, the pH value of the water may control the existence of species and their growth and well-being, regardless of the nature of the acid or alkali. However, often the specific acid or alkali itself may have direct effects on fish life. Indirectly, pH affects fish by controlling the concentrations of other solutes in the water.

The presence of carbonates, phosphates, borates, and similar ions give water a buffering capacity so that an addition of an acid or base is less likely to be deleterious to the system. Thus, the presence of weakly dissociated acids and bases will affect not only the value of pH but also the ease with which pH can be altered. The pH of the water enters into the calculations for determining carbonate, bicarbonate, and carbon dioxide concentrations since the occurrence and rate of several related processes is determined by the pH level.

Fish have both an upper and lower pH tolerance limit. Ellis (1937) reports that the pH of natural waters varies from 6.7 to 8.6 with 90% of the good mixed fish fauna occurring between 6.7 and 8.2. Although some fishes have been found in waters at pH values as low as pH 5 and as high as pH 10. In waters having a pH outside this range, nutrients will become unavailable for fish production. For fish culturing in fresh waters, Wedemeyer (1974) suggests a pH range of 6.0 to 9.0 and Spotte (1970) recommends a pH range of 7.0 to 9.0.

Of the water in the United States that support a good fish fauna, Ellis (1937) reports that only 5% have a pH less than 6.7; 50% have a pH less than 7.6; and 95% have a pH less than 8.3. Waters slightly on the alkaline side of the pH scale tend to support more fish than slightly acid waters. This may be due to the fact that there is a relationship between pH and the mineral content of the water.

Even if the water remains within the pH range of 6.0 to 9.0, the addition of acid or alkali may adversely affect fish. The effects may be due to the acid or alkali itself, entirely apart from its effect on pH, or because the pH has an effect on other solutes in the system. Some substances are toxic at low pH, while others become toxic at high pH.

The Aquatic Life Advisory Committee (1955) states that if highly dissociated inorganic acids are added to the water they usually will not be toxic above pH 5. Below pH 5 they may become toxic and affect gill tissue. On the other hand, organic acids and weakly dissociated inorganic acids may be toxic to fish above pH 5, either due to direct toxicity or because the acid is able to penetrate the fish and affect blood pH.

In waters that have a very high pH the addition of mineral acids may cause the release of CO_2 in large enough amounts to harm fish. Lowering the pH by addition of acids also increases the toxicity of heavy metals. This relationship will be discussed in some detail in a subsequent section.

Below pH 9, strongly dissociated inorganic alkalies are not generally toxic to fish; however, organic and weakly dissociated alkalies may be toxic. In waters having high organic loads, an increase in pH will affect the toxicity of substances such as ammonia, ammonium hydroxide, and ammonium salts.

The range of pH cptimum for a given fish species depends on temperature, dissolved oxygen, prior acclimatization, and the content of various anions and cations. All things considered the Aquatic Life Advisory Committee (1955) recommends:

"1. That pH be recognized as a poor criterion for the expression of toxicity of acids and alkalies in general, and that its use be restricted to the control of the addition of highly dissociated inorganic acids and alkalies known to be non-toxic within the pH range of 5-9.

2. That at no time shall acid be added in quantities sufficient to lower the pH below 5, nor alkalies sufficient to raise the pH above 9; and that, insofar as possible, pH values be maintained between 6.5 and 8.5 to maintain the productivity of the water for aquatic life."

Acid should not be added in sufficient quantity to lower the total alkalinity to less than 20 mg/1.

1) Cold Water Species: *Salmo* sps. can live in water up to pH 9.8. The lower limit of tolerance for salmonids in general is between pH 3.5 and 4.0 and within the range of pH 4.5 to 5.0 reproduction will be curtailed and eggs and fry will have poor, if any, survival.

2) Warm Water Species: Allen (1971) suggests that pH be maintained between 6.6 and 8.5 for best production. Warm water species cannot withstand the acidity that cold water species can. Between pH 6.0 and 6.5 cold water species are basically unaffected while in warm water species reproduction will not occur.

Alkalinity

Alkalinity is the ability of the water to accept protons and is primarily due to the presence of bicarbonate (HCO_3^-), carbonate ($CO_3^=$), and hydroxide (OH^-) components of natural waters, and to a lesser degree, due to borates, silicates, phosphates, and organic substances. Alkalinity is usually expressed in terms of milligrams per liter of equivalent calcium carbonate. The two most important negative ions are $CO_3^=$ and HCO_3^-, especially HCO_3^- which is dominant in the natural pH ranges of most waters. These are also the primary buffers in water; thus, they inhibit a change in pH. They also will neutralize the withdrawal or addition of CO_2. The total effect of HCO_3^-, $CO_3^=$, and OH^- is termed the total alkalinity. The concentration of either of these three forms is governed by the temperature, total mineral content, and pH of the water. Thus, there are five conditions of alkalinity possible; carbonate, bicarbonate, and hydroxides alone or mixtures of carbonates and hydroxides. Phenolphthalein indicator will measure that fraction due to hydroxide and half of the carbonate. A methyl orange indicator will measure the total alkalinity due to all three components.

Carbonate and bicarbonate ions are supplied from three sources--the reaction of free CO_2 with water,--the reaction of mineral carbonates with free CO_2 in water, and--bacterial reduction processes.

CO_2 in the atmosphere is very soluble in water and reacts with water to produce carbonic acid. This compound dissociates to release bicarbonate ions which can further dissociate to release carbonate ions. This reaction, shown below, is regulated by the pH of the water. At a pH between 7.5 and 8.3 bicarbonate ions predominate.

$$2H_2O + 2CO_2 \rightleftharpoons 2H_2CO_3 \rightleftharpoons 2H^+ + 2HCO_3^- \rightleftharpoons 2H^+ + 2CO_3^=$$

The most important source of $CO_3^=$ and HCO_3^- is the reaction of water and CO_2 with mineral carbonates. In hard waters there is usually a reserve of calcium and magnesium carbonates which will dissociate and neutralize any increase in pH. A typical reaction is shown below.

$$CaCO_3 + CO_2 + H_2O \rightleftharpoons Ca^{++} + 2HCO_3^-$$

The third source is the bacterial reduction process which forms $CO_3^=$ and HCO_3^-, especially during ammonification and deamination.

Natural waters that support food fish fauna vary from 5 ppm to 350 ppm with the upper end of the scale being considered more beneficial to fish life. Waters with extremely low alkalinities may be deficient in some minerals. For warm and cold water fishes, Wedemeyer (1974) suggests an alkalinity of at least 20 ppm as $CaCO_3$ for fish culture. Another source (Allen, 1971) recommends that for catfish production a minimum of 50 ppm is desirable. Strong alkalies are not usually lethal to mature fish if their concentrations are insufficient to raise the pH above 9.0. If increases in alkalinity are caused predominantly by bicarbonates, alkalinity does not seem to harmfully affect aquatic life.

Hardness

Hardness is usually defined as a water quality parameter that represents the total concentration of calcium and magnesium ions expressed as calcium carbonate. However, if present in significant concentrations other polyvalent metals such as iron, aluminum, manganese, strontium, and zinc should be included. Sodium and potassium are not considered because of their high solubilities.

When the hardness is greater than the sum of carbonate and bicarbonate alkalinity, that amount of hardness which is equivalent to the total alkalinity is termed carbonate hardness; the amount of hardness in excess of this is termed noncarbonate hardness.

Hardness may range from near zero to hundreds of mg/l $CaCO_3$ depending on the source. Generally speaking, it is preferable to have a moderately high hardness. The threshold of resistance to several toxins increases considerably as water becomes harder. Allen (1971) recommends at least 50 ppm be maintained for catfish production.

Specific Conductance

Specific conductance yields a measure of a water's capacity to carry an electrical current. It is related to the concentration of ionized substances in the water at a particular water temperature. The magnitude of the specific conductance is influenced by the type of dissolved substances, their actual and relative concentrations, and the ionic strength of the water. Most inorganic acids, bases, and salts are good conductors while organic compounds are very poor conductors. Mainly the dissolved solids which affect conductance are carbonates, bicarbonates, chlorides, sulfates, and phosphates. Most natural waters will vary from 50-500 micromhos/cm but highly mineralized water will exceed 1000. Extremely high values, over 800-1000 micromhos/cm may be detrimental to fish well-being. Within the range with fish compatibility, as the conductance increases, the susceptibility to disease and the toxicity of many toxins will decrease. Ellis (1944) found that for inland fresh waters the range of conductance for good mixed fauna lay between 150-500 mhos x 10^{-6} at 25^{o} C. Good mixed fish faunas were not found where specific conductance was greater than 2000 mhos x 10^{-6} at 25^{o} C.

Ammonia

In aquaculture, ammonia originates from the mineralization of organic substances by bacteria and from excretion by the fish themselves, ammonia being the main form of nitrogen excreted by fish.

Unionized ammonia is very toxic to fish and should never exceed 0.1 ppm (as total NH_4^+). Its degree of toxicity is governed to a degree by the concentration of undissociated ammonium hydroxide in the water, which in turn is a function of pH and temperature. This relationship is illustrated in Figure 3. The following illustration shows the reaction that occurs when fish excrete ammonia into water. The ionization of NH_3 is a pH and temperature

$$\text{Fish} \rightarrow \underset{\text{unionized toxic form}}{NH_3} + H_2O \rightleftharpoons NH_4OH \underset{\text{pH dependent}}{\rightleftharpoons} \underset{\text{ionized form}}{NH_4^+ \; OH^-}$$

dependent equilibrium reaction. A high concentration of ammonium ions at a low pH may not be as toxic as it will be at a high pH value. The toxicity to fish will increase by 200% between pH 7.4 and pH 8.0. Spotte (1970) points out that even at sublethal levels, ammonia will have four adverse effects: 1) it increases the susceptibility of fish to other unfavorable conditions

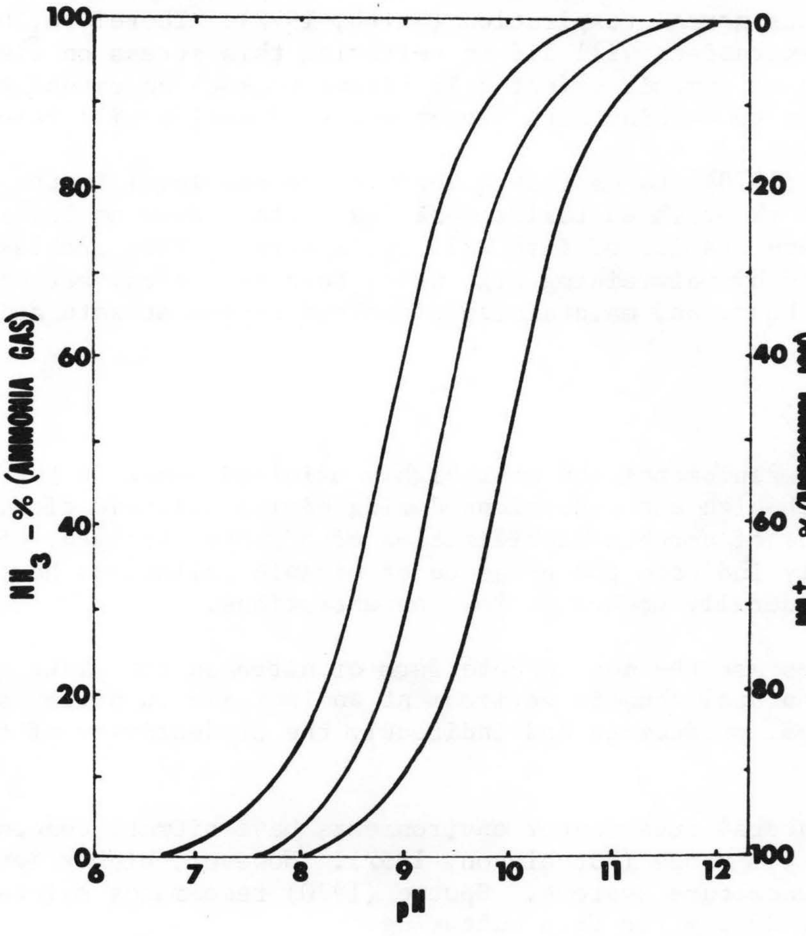

Figure 3. The effect of temperature and pH on ammonia and ammonium ion concentrations in water.

such as low dissolved oxygen concentrations, 2) it inhibits normal growth, 3) it decreases fecundity, and 4) it decreases the resistance to disease.

Carbon dioxide concentrations of 15-60 ppm, by lowering pH, will reduce the possibility of ammonia toxicity. Also, as the concentration of dissolved oxygen increases the toxicity of ammonia will decline. High, but nonlethal, ammonia concentrations, will cause extensive proliferation of epithelium which prevents normal respiration (Smith, 1972). Therefore, high dissolved oxygen concentrations will aid in relieving this stress on fish respiration. Toxic levels of ammonia effect gill tissue to such an extent that the ability of hemoglobin to combine with oxygen and suffocation will result.

Spotte (1970) states that a chronic ammonia level is the most serious problem that the fish culturist must deal with. Even at low concentrations the growth and stamina of fish will be impaired. This problem can in part be alleviated by maintaining high water turnover rates, between one and two changes per hour, and maintaining dissolved oxygen at saturation.

Nitrates

Nitrate represents the most highly oxidized phase in the nitrogen cycle and may reach high concentrations during biological oxidation. They are the final product of aerobic stabilization of organic nitrogen. High concentrations usually indicate the presence of organic pollution; however, in natural waters it generally occurs at low concentrations.

Nitrates are the most usable form of nitrogen for plant growth; therefore, in a natural aquatic environment an increase in nitrates will directly increase algal production and indirectly the productivity of the whole ecosystem.

Most natural fresh water environments have nitrate concentrations in the .5 ppm to 5 ppm range (Hutchinson, 1957). However, higher levels will usually occur in aquaculture systems. Spotte (1970) recommends maintaining nitrate levels below 20 ppm for fish culturing.

Metals

The following is a categorization of metals as to their toxicity to fish life.

Extremely toxic	Moderately toxic
Copper	Arsenic
Silver	Chromium
Mercury	Iron
Beryllium	Manganese
	Vanadium
	Aluminum

Highly toxic	Non-toxic
Cadmium	Calcium
Uranium	Magnesium
Zinc	Sodium
Selinium	Potassium
Lead	
Nickel	

The heavy metals of lead, mercury, copper, and zinc are present in trace amounts in natural waters. All are toxic to life at very low concentrations and many are lethal at concentrations less than 1 ppm.

The toxicity of a heavy metal depends on seven factors, according to Spotte (1970). These are: 1) pH; 2) dissolved oxygen; 3) temperature; 4) the volume of the solution in relation to size of fish; 5) frequency with which the solution is renewed; 6) synergism with other substances; and 7) the level of organics. Other factors to consider are hardness, turbidity, CO_2 concentrations, and fish species.

The pH of the water is probably the most important factor. In many instances, a shift in pH may cause dissociation of the metal compound. Usually this means a more rapid penetration of the fishes' membranes and consequently an increase in toxicity. Generally, heavy metals are more toxic in soft, neutral waters than in hard, alkaline waters. In hard waters the toxicity of heavy metal salts is reduced by precipitation of carbonates and other insoluble compounds.

Increases in dissolved oxygen also will nullify the toxic effects of some metals by simply making respiration easier.

Increases in temperature will increase the toxicity of salts of heavy metals to fish. As the temperature is increased out of the range of optimal conditions for the fish species, this additional stress makes the fish more susceptible to the metal toxicity. However, even within the temperature range for the well-being of the species an increase in temperature will usually increase the toxicity of the metal by increasing the activity of the ion on gill tissues.

Metal concentrations only infrequently cause problems in aquaculture. Three of the more common metals that may reach toxic levels in a fish culturing environment are copper, zinc, and lead.

1) Copper: Copper is found in several enzymes and serves as a respiratory pigment in blood proteins. It is also used to treat some infections in fish and in controlling aquatic vegetation. It is toxic to fish at levels less than 1 ppm and has a synergistic effect with zinc. As a toxic element copper forms insoluble organometallic compounds on gill tissues, which will interfere with respiration. In hard water the toxicity of copper salts is reduced by precipitation of copper carbonate. Chelation with organics will also render copper less toxic.

2) Zinc: Zinc is needed for some enzymatic functions and occurs in many proteins. Zinc, like copper, is used in treatment of several fish infections. Zinc chloride and zinc sulfate are highly soluble in water while zinc carbonate, zinc oxide, and zinc sulfide are insoluble in water. Consequently, some zinc will precipitate readily in natural waters. Zinc is also toxic at levels less than 1 ppm depending to some degree on other water quality parameters. The toxicity of zinc salts is increased as dissolved oxygen decreases and as water temperature increases. Since zinc is used in the galvanizing process for pipes, it is essential to avoid using galvanized pipes in fish farms and hatcheries.

3) Lead: In areas where limestone and galena are present some natural waters may contain as much as 0.4-0.8 ppm of lead. However, most natural waters seldom contain more than .02 ppm lead. Once again, concentrations less than 1 ppm are lethal to fish. If lead salts are present, coagulated mucus will begin to form on the gills and then on the body of the fish. In soft water, lead is extremely toxic. Also, lead is more toxic at low concentrations of dissolved oxygen.

Settleable Solids and Suspended Solids

These solids, whether organic or inorganic substances, have a greater effect on fish populations in a natural environment than in a fish farm where artificial feeding occurs. In a stream environment, for instance, suspended solids will limit light penetration; therefore, reducing algae production. The settleable solids may cover and reduce the productivity of food producing areas or cover spawning grounds. Thus, the real effect on fish is via a reduction of the food supply.

In aquaculture settleable solids may cause a build-up of sludge on the bottom. During the decomposition of this organic matter undesirable substances may be produced. Also the biochemical oxygen demand of the sludge may cause a reduction of dissolved oxygen concentrations if the water turnover rate is not adequate.

The suspended solids may reach levels where gill tissues may be affected. Therefore, Wedemeyer (1974) suggests that for both warm and cold water species, the concentrations of total and suspended solids should remain below 80 ppm for optimum health in fish culturing.

Chapter IV

AQUACULTURE in the UNITED STATES

Chapter IV AQUACULTURE in the UNITED STATES

The terms "cold water fish culture" and "warm water fish culture" have been applied to denote those species having water temperature optima in the 40-60° F (4-16° C) and 60-85° F (16-29° C) ranges respectively (Table 2). Until a few years ago these water temperature optima fairly well regionalized these two groups of fish. Cold water fish were raised along the northeastern Atlantic shore, through the Great Lakes area, the Rocky Mountain states, and the Pacific Coast states. The warm water fish were fairly restricted to the southeastern Atlantic and Gulf Coast states and in the southern midwestern states. Utilization of waters unsuitable for warm water or cold water fish culture during certain seasons has afforded the raising of warm water fish during the summer months and of cold water fish during the winter months on the same farm. The subsequent distribution of both groups of fishes has been so great that only Texas, Louisiana, and Mississippi do not have commercial cold water fish farms and 11 states do not have commercial warm water fish farms (Figure 4).

For convenience, the commercial aquaculture industry could best be categorized into those fish farms producing food fish and those producing bait fish. At this time nearly all the food fish production consists of rainbow trout and channel catfish. Small quantities on the order of a few thousand pounds annually of other catfishes and buffalo, a catostomid, are produced for food. In recent years, increasing quantities of market-sized Pacific salmon have been produced on both the Pacific and Atlantic coasts.

The bait fish industry consists primarily of the production of a wide variety of minnows and shiners for use as live bait for recreational fishing.

The freshwater crayfish (crawfish) industry provides a product for both human consumption as well as for bait fishing.

Each food fish industry will be considered in detail from the aspects of history, methods of farming, and water requirements. The bait fish and crayfish industries will be considered to a lesser degree as their inclusion into the State of Idaho is not unlikely.

Organization of Aquaculture Industries

The commercial aquaculture industries in the United States are very complex. No two fish farms are alike from the standpoints of pond design, water utilization, feeding practices, fish density per unit of water volume, and fish husbandry methods. For convenience they may be categorized into seven basic components plus five major and ten minor supportive components.

The basic components are:

1) Egg Producer: At a typical brood stock or egg producing facility, fish are raised to sexual maturity--usually 2-3 years--and spawned

Table 2. List of cultured freshwater fish in the United States.

	Genus & Species	Warm Water	Cold Water	Diet: Herbivorous	Diet: Carnivorous
Clupeids					
Threadfin shad	*Dorosoma petenense*	XX			XX
Gizzard shad	*Dorosoma cepedianum*	XX			XX
American shad	*Alosa sapidissima*	XX			XX
Salmonids					
Pink salmon	*Oncorhynchus gorbuscha*		XX		XX
*Chum salmon	*Oncorhynchus keta*		XX		XX
Sockeye salmon	*Oncorhynchus nerka*		XX		XX
*Chinook salmon	*Oncorhynchus tshawytscha*		XX		XX
*Coho salmon	*Oncorhynchus kisutch*		XX		XX
*Cutthroat trout	*Salmo clarki*		XX		XX
Golden trout	*Salmo aguabonita*		XX		XX
*Rainbow trout	*Salmo gairdneri*		XX		XX
Steelhead	*Salmo gairdneri*		XX		XX
*Atlantic salmon	*Salmo salar*		XX		XX
*Brown trout	*Salmo trutta*		XX		XX
*Brook trout	*Salvelinus fontinalis*		XX		XX
Dolly varden	*Salvelinus malma*		XX		XX
Lake trout	*Salvelinus namaycush*		XX		XX
Grayling	*Thymallus arcticus*		XX		XX
Esocids					
Grass pickerel	*Esox americanus vermicularis*	XX			XX
Northern pike	*Esox lucius*		XX		XX
Muskellunge	*Esox masquinongy*		XX		XX
Chain pickerel	*Esox niger*	XX			XX
Cyprinids					
*Goldfish	*Carassius auratus*	XX		XX	
*Carp	*Cyprinus carpio*	XX		Omnivorous	
*Golden shiner	*Notemigonus crysoleocas*	XX			XX
*Redfin shiner	*Notropis umbratilis*	XX			XX
*Fathead minnow	*Pimephales promelas*	XX		Omnivorous	
Catostomids					
*Black buffalo	*Ictiobus niger*	XX			XX

Table 2. Continued.

Genus & Species		Warm Water	Cold Water	Diet: Herbivorous	Diet: Carnivorous
Ictalurids					
*White catfish	*Ictalurus catus*	XX			XX
*Blue catfish	*Ictalurus furcatus*	XX			XX
Black bullhead	*Ictalurus melas*	XX			Omnivorous
Yellow bullhead	*Ictalurus natalis*	XX			XX
Brown bullhead	*Ictalurus nebulosus*	XX			XX
*Channel catfish	*Ictalurus punctatus*	XX			Omnivorous
Cyprinidontids					
*Mummichog	*Fundulus heteroclitus*	XX			XX
*Killifishes	*Fundulus*	XX			XX
Poecilids					
*Gambusias	*Gambusia affinis*	XX			Omnivorous
Percichthyids					
White perch	*Morone americana*	XX			XX
White bass	*Morone chrysops*	XX			XX
Stripped bass	*Morone saxatilis*	XX			XX
Centrarchids					
*Green sunfish	*Lepomis cyanellus*	XX			XX
*Bluegill	*Lepomis macrochirus*	XX			XX
*Redear sunfish	*Lepomis microlophus*	XX			XX
Largemouth bass	*Micropterus salmoides*	XX	XX		XX
Smallmouth bass	*Micropterus dolomieui*	XX			XX
Crappie	*Pomoxis*	XX			XX
Percids					
Sauger	*Stizostedion canadense*	XX	XX		XX
Walleye	*Stizostedion vitreum vitreum*	XX	XX		XX
Cichlids					
*Tilapia	*Tilapia mossambica*	XX		XX	

*Reported to be raised commercially.

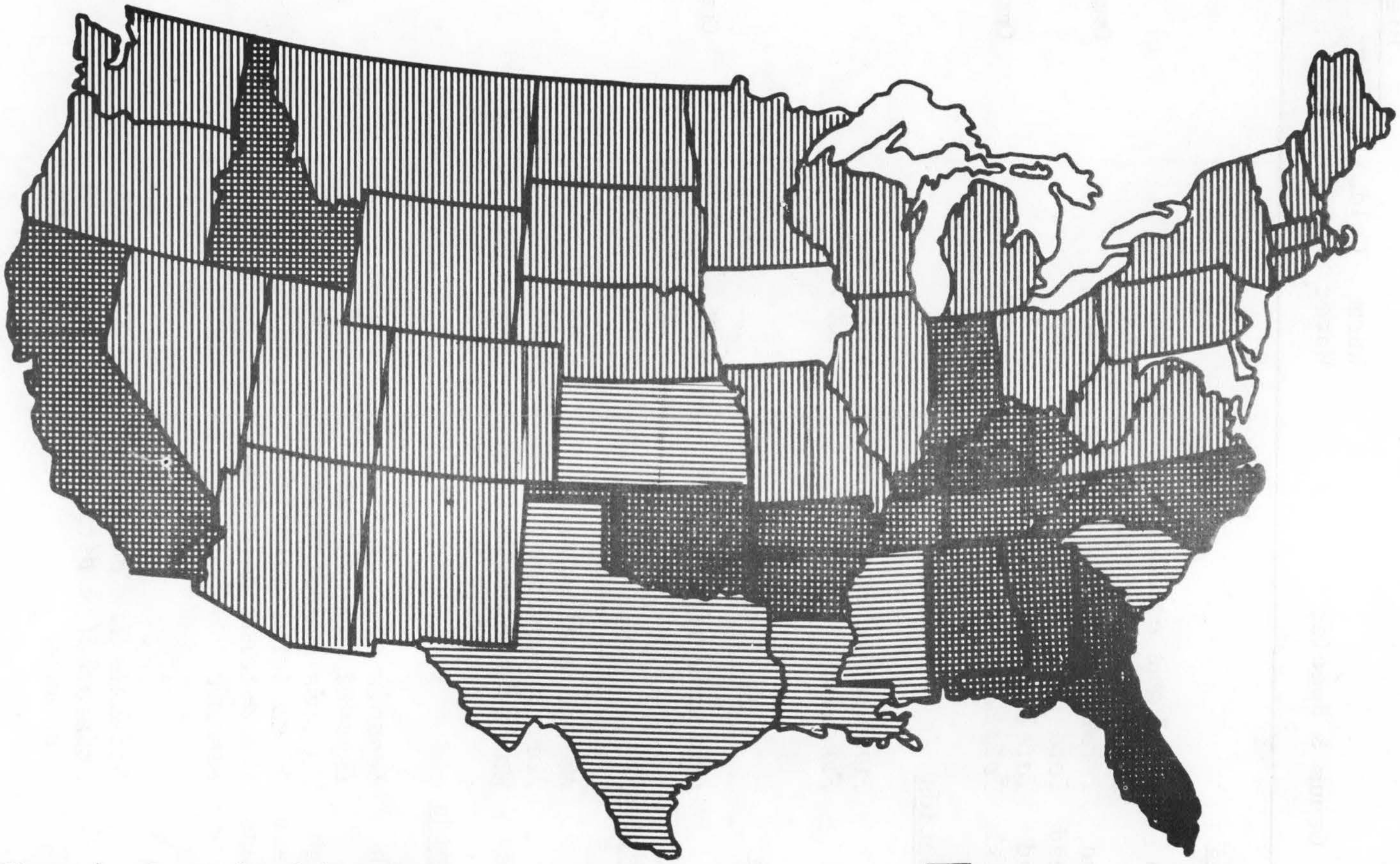

Figure 4. Geographical distribution of rainbow trout and catfish farms in the United States.

manually or naturally for three to four successive years before they are either sold for processing or fee fishing stock. The fertilized eggs may be sold as eyed-eggs or may be incubated and hatched to be sold subsequently as fry or fingerlings.

The ponds used in a brood stock operation are usually much larger than those in a grower operation. Also the fish are stocked in the ponds at a very low density.

According to lists published in 1974 by Fish Farming Industries, Catfish Farmers of America, and the U.S. Trout Farmers Association, in 1973 there were 45 channel catfish brood farms, 18 channel catfish egg producers, 7 rainbow trout brood farms, and 9 rainbow trout egg producers. There are undoubtedly more than those listed in each category.

2) Fingerling Producer: At a typical fingerling production farm, fingerling fish (1"-5" long) are raised from eggs taken on the premises or purchased elsewhere. These fish are sold alive to individuals who raise them to marketable size for human consumption and to individuals who operate fee fishing facilities.

In 1973 there were 110 channel catfish and 22 rainbow trout fingerling producers listed by the trade associations.

3) Market Fish Producer: At a typical facility producing market-sized rainbow trout, purchased eyed-eggs are incubated and hatched. The resultant fry are raised intensively to market-size--approximately 10"-14" long--at which time they are transferred alive to processing plants, which may or may not be on the premises. Depending upon the water temperature, a marketable rainbow trout can be produced in 10-18 months from time of hatch.

At a typical facility producing market-sized channel catfish, eyed-eggs either from on-site brood fish or purchased, are incubated and hatched. The resultant fry are raised intensively or semi-intensively to market-size--10"-20" long--at which time they are transferred alive to processing plants. At some farms, purchased fingerlings are raised to market-size. Depending upon the water temperature and other factors, a market-size channel catfish can be produced in 10-24 months from time of hatch.

In 1973 222 rainbow trout farms and 1,755 channel catfish farms producing market-size fish were listed by the USTFA, NMFS, and CFA (Table 3).

4) Grow-out or Farm Pond Operator: In a typical farm pond facility fish are raised for a producer from 4"-6" to market-size with the operator being paid on the pounds gained. The producer may or may not retain title to the fish and may or may not provide the food and professional assistance. The time required to produce a market-

Table 3. Number of commercial fish farms in the United States by state.

	Trout	Catfish		
	Commercial	Commercial	Live-haulers	Fee
Alabama	1	416	1	345
Alaska	-	-	-	-
Arizona	2	-	6	-
Arkansas	2	144	16	29
California	9	37	6	85
Colorado	30	-	-	3
Connecticut	2	-	-	-
Delaware	-	-	-	-
Florida	4	18	-	6
Georgia	1	82	2	3
Hawaii	1	-	-	-
Idaho	28	1	3	-
Illinois	3	-	2	159
Indiana	4	1	13	-
Iowa	-	-	1	-
Kansas	-	91	-	51
Kentucky	1	9	10	-
Louisiana	-	167	6	37
Maine	1	-	-	-
Maryland	-	-	2	8
Massachusetts	2	-	-	-
Michigan	18	-	-	16
Minnesota	2	-	-	1
Mississippi	-	534	8	230
Missouri	4	-	66	87
Montana	4	-	-	-
Nebraska	1	-	11	-
Nevada	1	-	-	-
New Hampshire	1	-	-	-
New Jersey	-	-	2	-
New Mexico	3	-	11	8
New York	5	-	2	-
North Carolina	6	6	5	-
North Dakota	1	-	-	7
Ohio	8	-	8	118
Oklahoma	1	48	-	2
Oregon	2	-	-	-
Pennsylvania	15	-	4	32
Rhode Island	-	-	-	-
South Carolina	-	25	-	-
South Dakota	2	-	-	7
Tennessee	6	82	1	79
Texas	-	94	15	10
Utah	4	-	-	1

Table 3. Continued.

	Trout	Catfish		
	Commercial	Commercial	Live-haulers	Fee
Vermont	-	-	1	1
Virginia	2	-	1	-
Washington	10	-	-	-
West Virginia	1	-	-	35
Wisconsin	38	-	2	-
Wyoming	2	-	-	-
	222	1,755	199	1,360

- = None reported

size fish is usually 4-6 months depending upon the water temperature and level of management.

In 1973 there was no category assigned to this segment of the aquaculture industry by the NMFS, CFA, and USTFA. Several individuals around the country were asked for their opinions about the size of this segment and none would venture a guess.

5) Processor: At a typical food fish processing plant, which may or may not be integrated with a fish production facility, live fish are received for processing into one of the following fresh or frozen marketable items (Table 4):

Table 4. Dress-out figures for an 11.3" rainbow trout.

	Ounces		Dress Loss
	Range	Average	% Round Weight
Round weight	8.6-9.9	9.25	0
Dressed weight	6.9-7.9	7.4	20
Boned weight	6.0-6.9	6.45	31.3
Fillet weight	5.0	5.0	46

a) Dressed - trout have the gills and viscera removed; the head, tail, and fins are intact. Catfish may or may not have the head removed posterior to the pectoral girdle and may or may not be skinned. Dressed fish are usually individually packed prior to freezing. Frozen fish are usually packed in five pound cartons.

b) Boned - trout have the gills, viscera, backbone, and rib bones removed; the head, tail, and fins are intact. Very few catfish are processed in this fashion. Boned fish are usually individually packed prior to freezing. They also may be individually breaded in egg batter and cracker meal.

c) Fillet - this product consists of just the edible portion of the fish--the body musculature after the head, gills, fins, bones, and skin have been removed. Frequently the fillets are individually quick frozen (IQF) prior to being put up in five pound packages.

Many food fish processing plants have specialty items to offer. For example, there is the Continental Boned which is a trout boned from the dorsal aspect. The product is then suitable for stuffing and serving in an upright position. Another form is the Boned and Stuffed in which the fish has been boned in the usual fashion and stuffed with a proprietary mixture. Rainbow trout are also offered as Smoked Fillets.

In 1973 there were 7 trout processors and 19 catfish processors listed by the NMFS, CFA, and USTFA. This did not include those market fish producers processing only the fish they raise.

6) Live-Haulers: The main function of this segment of the industry is to haul live fish from one farm to another or to a processing plant or to a fee fishing (pay-lake) facility. Rainbow trout and channel catfish are usually hauled great distances (500-2,000 miles) in insulated tanks mounted on trucks or trailers. In most instances refrigeration and oxygen are provided and in some cases the tanks are heated for mid-winter hauls. Some fish tanks are equipped with water circulation pumps and charcoal filters. Tanks used to haul fish for short distances are usually just insulated and provided with compressed air or oxygen.

In 1973 26 individuals offered live fish transportation service on a fee basis according to the NMFS, CFA, and USTFA. This did not include those fish farms live-hauling their own fish. For example, the Catfish Farmers of America listed 199 catfish farms in the United States having live-haul capabilities.

7) Fee-Fishing or Pay-Lake: In this segment of the industry, persons visiting one of these facilities has the opportunity to personally catch their own fish dinner. Fees are based upon the size or weight of the fish caught and the other services offered.

Fish for fee-fish facilities are purchased from fingerling producers or from egg producers who have culled their potential brood stock. Several rainbow trout egg producers and channel catfish farms have fee-fishing capabilities integrated into their operations.

A 1972 survey of trout fee-fishing facilities in Georgia revealed that the average operator had 1.75 acres of ponds, was visited by 1,200 patrons, sold more than 7,400 pounds of trout, and had a net profit of $5,000 for his labor and management (Brown <u>et</u>. <u>al</u>., 1973).

A 1973 survey by the National Marine Fisheries Service provided a state-by-state listing of the 1,360 catfish pay-lake operators (Table 3). Several states did not respond--if they had, the number would undoubtedly be much larger (Orovetz, 1973).

There is only meager information about the size of the trout fee-fishing industry. It could be assumed that it should be equivalent to the catfish pay-lakes.

The major supportive components of the aquaculture industry are:

1) <u>Feed Manufacturing</u>: There are at least 18 catfish feed manufacturers and 14 trout feed manufacturers (Heffernan, 1974). Each has its own formulation proprietarily designed to meet the nutritional requirements of rapidly growing food fish. In many respects they are all quite similar. In general, catfish rations contain:

Protein	28-39%
Carbohydrate	10-20%
Fat	5-10%
Fiber	10-20%
Essential trace minerals	

In general, trout and salmon rations contain:

Protein	32-55%
Carbohydrate	9-12%
Fat	5-14%
Fiber	15-17%
Essential trace minerals	

Many of the wide ranges in ingredients are due to the different types of diets for a particular sized fish; i.e., fry have a higher protein requirement than do fingerlings.

The prepared feeds are sold either in bulk or in 50-pound bags. The rations are in the form of grade-size, dry crumbles and pellets. Some catfish feed manufacturers "puff" their pellets so they will float rather than sink when fed to the fish. One salmon feed is sold as moist pellets which require their being frozen for storage then thawed prior to feeding.

2) <u>Equipment Manufacturing</u>: All segments of the industry use equipment designed to facilitate their operations. The major pieces of equipment are fish pumps, fish tanks, fish graders, eviscerators, feed

storage bins, transport tanks, fish feeders, water chillers and heaters, UV sterilizers, various filters and screens, and water pumps. The minor pieces of equipment, costwise, are nets, boots, rain gear, gloves, rope, boats, rakes, hoses, and packaging materials, to mention a few. Many items are readily available and others are custom designed to be used at a specific site for a specific purpose. Prices for equipment range from a few dollars to several thousand dollars per item.

3) Chemical and Pharmaceutical Manufacturing: All fish farms, no matter how large or small, use or have used several chemical and/or pharmaceutical agents in the course of their operations. Chemicals are used to control weeds, plankton growth, unwanted fish, and several infectious and noninfectious diseases of fish. Pharmaceuticals are used to control external and internal infectious diseases.

For a chemical or pharmaceutical agent to be used on food fish it must be approved for use by the Food and Drug Administration. At the present time there are only three antibacterial drugs and one chemical anesthetic approved for use in or on food fish.

4) Public Transportation: According to the best estimates, 40 million pounds of processed fresh or frozen trout and catfish are transported annually from the processing plants to wholesalers, restaurants, and hotels. The majority of these products are carried by public transportation; i.e., truck, air, rail, and boat. The remainder is transported via privately owned trucks and freezer vans.

5) Construction Industry: It is difficult to estimate how many fish farms or other segments of the aquaculture industry annually renovate existing facilities or construct new facilities. The majority of these jobs are handled by private contractors because the average fish farm does not have either the equipment or the professional expertise. The types of jobs vary from reworking dirt ponds or digging new ones to designing and constructing an entirely integrated fish farm.

The minor supportive components of the aquaculture industry are:

1) Public freezer storage
2) Food brokerages
3) Restaurants and hotels
4) Supermarkets
5) Fresh fish markets
6) Advertising agencies
7) Public utilities
8) Insurance brokers
9) Public accountants
10) Attorneys

By relegating these to a "minor supportive" position does not imply that they are dispensible. Any one of the items might be dispensible but taken as a whole they form the mainstay of aquaculture in that they constitute the market segment of the industry. Without these components there would be no aquaculture industry.

Trout and Salmon Production

Trout and salmon culture, also called salmonid culture, consists of raising several species of salmonids for food and recreation purposes. Of all the species raised, rainbow trout are produced in the greatest numbers although the brook trout, cutthroat trout, brown trout, coho salmon, chinook salmon, chum salmon, and Atlantic salmon are also raised but more for fee-fishing than as a food item.

History of Trout Culture: The business of raising trout for market began in the 1870's on the Atlantic coast. The main product of the early commercial trout farms was adult brook trout which were offered on the fresh fish markets of large eastern cities. The eggs stripped from the ripe females were a secondary consideration as a saleable item. In the early 1900's brook trout farming became considerably important. Fish farms increased in number and existing fish farms increased their capacities by constructing raceways 8 feet wide, 2 feet in depth, and often a mile or more in length. There was an abundant supply of water. Food for the fish was obtained from packing house products such as spleen, liver, heart, and lungs which were ground together with frozen bottom fish and fed as a thick paste.

Rainbow trout were officially introduced into eastern United States waters in the 1880's. Their introduction into commercial fish farming did not occur until the early 1900's. At that time they were raised primarily as a hobby-type of operation by private fishing clubs.

From the early 1920's until after World War II, private trout hatchery development proceeded very slowly because of the high availability of sport-caught fish and the low market demand. In the late 1940's until the present the trout industry has grown at a very rapid rate. The most rapid growth has occurred in the processed fish segment of the industry.

Production data for the pounds of fish--both live and processed--sold annually in the United States are very difficult to obtain. Data often quoted in trade and scientific journals are very misleading and conflicting. There are several reasons for this among which are: 1) the highly competitive nature of trout farmers; 2) a lack of a concerted effort on the part of the trade associations to document these data; 3) an overzealous author; 4) the apparent lack of involvement in the product- and production-associated problems of the private trout grower by state and federal agencies other than those directly concerned with conservation.

Present Status: The 1974 United States production of market-size trout will be 16-20 million pounds with an estimated value of $25 million in processed form, according to Clay Robinson, the past Executive Secretary of the

U.S. Trout Farmers Association (Robinson, 1974). Based upon data collected during the 1974 Idaho trout farm survey, that figure is probably correct (cf p. 59). Accurate production data on a state-by-state basis, however, are not available for the trout industry.

Even with the lack of corroborative production data, it is safe to state that the trout industry is growing. Evidence for this comes from feed manufacturers who state that they are selling more trout feed than ever before. The egg producers are also making similar comments with respect to egg sales. The major question arising from these comments concerns whether the increased feed and egg demands are due to increased production by existing farms or to new farms and fee-fishing ponds. It should also be noted that production of processed trout has not increased dramatically, albeit steadily.

Currently, the main trout production states are Idaho, California, Wisconsin, Michigan, Colorado, and Pennsylvania (Table 3).

As with every consumer item, the cost of producing a pound of trout has increased during the past three years (Table 5). However, the wholesale price per pound has not increased accordingly, in fact, during 1973, some prices decreased (Table 6). (cf Factors Affecting Aquaculture)

Table 5. Average cost in the United States to produce a pound of dressed trout.

	1972	1973	1974
Feed	.15	.30	.30
Labor	0.06	0.07	0.075
Power and equipment	0.03	0.035	0.035
Office management	0.07	0.075	0.075
Eggs and losses	0.05	0.055	0.06
Sub-total	.36	0.535	0.545
Shrinkage	.11	0.12	0.12
Processing, packaging, and freezing	0.12	0.135	0.135
Total	0.59	0.79	0.80

Source: Robinson, 1974.

Table 6. Prices per pound of trout f.o.b. processing plant.

	1972	1973	1974
Live	0.52-0.55	0.65-.70	.60-.65
Dressed	1.20-1.24	1.12-1.20	1.33-1.46
Boned	1.42-1.48	1.34-1.43	1.61-1.69
Fillets	1.79-1.82	1.85-1.90	2.10-2.18

Source: Robinson, 1974.

Habitat: The physical and chemical parameters of water required for optimum fish growth and reproduction have been discussed previously in this report (see Chapter III, Habitat). To reiterate some of the specifics for rainbow trout:

Temperature: 50-60^{o} F (10-15^{o} C)
Dissolved oxygen: >6 ppm at the outfall
pH: 7.3-8.2
CO_2: <2 ppm
NH_3 (unionized): 0.018 ppm at the outfall
Alkalinity: 150-250 ppm as calcium

Water with chemical qualities in these ranges should be capable of supporting fish at a level of one-half pound of fish per cubic foot of water per inch of average length of fish. Accordingly, if water were used to provide a turnover time of 30-45 minutes in the ponds, the annual production should be 10,000 pounds of fish per cfs. There are very few trout farms currently obtaining this production per cfs. Those which are apparently are having no difficulty doing so.

If the production potential of 1 cfs of water were applied only to new water; i.e., water initially entering a fish farm, the increasing practice of reusing 90% of the water after reconditioning will magnify the 10,000 pounds production per cfs to 100,000 pounds production per cfs. This could be misleading in that fish production per cfs new water will increase but fish production per cubic foot of rearing space will likely remain the same or decrease. Were the proposed EPA guidelines for quality of water being discharged from a fish farm to be enacted into law, several of the existing trout farms may elect to recondition water in recycling systems in order to comply with the regulations. (cf Factors Affecting Aquaculture)

Catfish Production

Catfish farming in the United States is a relatively diverse industry when compared to the other fish farming industries (Greenfield, 1970). The majority of market-size fish producers begin their production cycle with purchased fingerlings. Of those beginning with eyed-eggs obtained from their own brood stock, the majority have fingerlings for sale. There are very few eyed-egg shipments in the catfish industry mainly due to difficulties in handling them. Many fingerling producers begin the production cycle with purchased fry. Thus, during the lifetime of a catfish being grown to market-size, it may have been on as many as three or four farms, often many miles apart.

History of the Catfish Industry: Catfish farming, or more appropriately channel catfish farming, began in the Lower Mississippi River Delta in 1959. In 1960 there were approximately 250 acres in production. In 1963 there were 2,370 acres in catfish. Data are not available on production during those years. The majority of fish grown were sold as fresh fish in local markets. During 1965 an estimated 15 million pounds of channel catfish were produced from 14,000 acres of ponds. The majority of the fish were sold as live fish to pay-lake operators. Approximately 10% or 1.5 million pounds of the 1965 production went into local food markets and restaurants (USDI, 1967).

In 1968-69 there were 26,000 acres in production and an estimated 12-20 million pounds of processable catfish were sold. Almost 90% of the farms were in Mississippi, Arkansas, Louisiana, and Texas. It was also estimated that during this period $13.5 million had been invested in ponds, equipment, fish, processing facilities, etc. (E.D.A., 1972).

Data collected from a survey conducted by the National Marine Fisheries Service in 1972 revealed that (Anon., 1973):

1) In 1970, 34 million pounds of channel catfish were harvested from 40,000 commercial acres.
2) In 1971, 38.1 million pounds of channel catfish were harvested from 43,100 commercial acres.
3) The average price paid was 36 cents per pound, live weight in 1971.
4) The major catfish producing states were:

Mississippi	18,569 acres	21,039,000 lbs.
Arkansas	11,565	8,800,000
Texas	3,924	1,800,000
Louisiana	3,182	2,700,000
Alabama	1,440	1,400,000
California	873	500,000
Tennessee	759	280,000
Missouri	755	192,000
Oklahoma	567	not reported
Georgia	494	not reported
Kansas	351	not reported
South Carolina	262	not reported
Illinois	238	not reported

Present Status: The 1974 production of processed channel catfish through June was 8,603,631 pounds (Table 7). This was an increase of 2,255,842 pounds compared to the same period in 1973. The total 1973 production was 49,809,483 pounds live weight and had a value of $26,188,354 (Table 8). The distribution breakdown for 8 states is presented in Table 9 (Anon., 1974).

Table 7. Production-inventory sales data (national processors).

1973	Finished Processed Product[1]	Cumulative Production	Ending Inventory	Change Inventory	Net Sales[2]	Prices Paid[3]
	Pounds					¢/lb
Jan.	1,274,456	1,274,456	770,471	176,051	1,450,507	.32-.36
Feb.	1,351,488	2,625,944	675,859	94,612	1,446,100	.32-.42
Mar.	1,343,812	3,969,756	500,909	174,950	1,518,762	.36-.45
Apr.	831,196	4,800,952	352,810	148,099	979,295	.42-.55
May	753,731	5,544,684	271,533	81,277	835,009	.42-.50
June	793,105	6,347,789	283,853	12,320	780,785	.45-.50

[1]Whole, skinned, collarbone removed, tail on, individually frozen and/or fresh.
[2]Previous month's inventory, plus current month's production, less current month's inventory.
[3]Prices paid to farmer, harvested, at plant site.

1974	Round Weight Processed[1]	Cumulative Production	Ending Inventory	Change Inventory	Net Sales	Prices Paid[2]
	Pounds					¢/lb
Jan.	1,266,699	1,266,699	866,884	49,532	805,468	.45-.50
Feb.	1,417,602	2,684,301	690,365	176,519	935,892	.45-.50
Mar.	1,733,909	4,418,210	729,734	39,369	1,014,570	.42-.50
Apr.	1,355,378	5,773,588	652,736	76,998	983,478	.40-.50
May	1,394,504	7,168,092	648,797	3,939	870,664	.40-.50
June	1,435,539	8,603,631	457,832	190,965	934,785	.45-.50

[1]Total live weight of fish delivered for processing.
[2]Prices paid to farmer, harvested, at plant site.

Source: National Marine Fisheries Service, 1974.

Table 8. Farm-raised food size catfish production summary, 1973.

State	Commercial Acres	Harvested Acres	Pounds (Live Weight)	Other Production (Raceways, Cages, Tanks)	Value
Arkansas	9,197	5,276	7,993,429		$ 4,156,583
California	917	391	568,200	5,000	544,540
Florida	241	158	238,545	280,000	305,941
Kansas	1,141	610	438,564		315,766
Kentucky	49	14	10,650		10,117
North Carolina	59	29	29,100		14,550
Oklahoma	919	445	457,355		352,163
Texas	2,391	1,337	1,718,540	57,500	1,527,394
1/					
Alabama	4,773	2,460	3,690,000		1,845,000
Georgia	1,607	884	1,326,000	907,500	1,116,750
Louisiana	4,241	2,333	3,499,500		1,749,750
Mississippi	26,112	14,362	25,851,600		12,925,800
South Carolina	399	220	330,000	118,500	224,250
Tennessee	1,381	760	1,140,000	316,500	728,250
2/					
Arizona	41	22	22,000		11,000
Illinois	462	254	254,000	80,000	167,000
Indiana	47	26	26,000		13,000
Missouri	619	341	341,000		170,500
Others	37	20	20,000	90,000	10,000
			47,954,483	1,855,000	
NATIONAL TOTAL	54,633	29,942	49,809,483		$26,188,354

1 Production estimated from reported acreage.
2 Production and acreage estimated.

Source: National Marine Fisheries Service, 1974.

Table 9. Farm-raised catfish market/production analysis, 1973.

State	Processor	Local Retailer	Live-Hauler	Pay-Lake	Total Pounds
		Market Movement			
		Pounds (Percent)			
Arkansas	3,037,503 (38%)	1,678,620 (21%)	2,717,766 (34%)	559,540 (7%)	7,993,429
California	5,732 (1%)	143,300 (25%)	149,032 (26%)	275,136 (48%)	573,200
Florida	362,982 (70%)	20,742 (4%)	15,556 (3%)	119,265 (23%)	518,545
Kansas	74,556 (17%)	96,484 (22%)	144,726 (33%)	122,798 (28%)	438,564
Kentucky		4,300 (40%)		6,350 (60%)	10,650
North Carolina		16,600 (57%)	7,000 (24%)	5,500 (19%)	29,100
Oklahoma	41,162 (9%)	283,560 (62%)	68,603 (15%)	64,030 (14%)	457,355
Texas	248,646 (14%)	532,812 (30%)	621,614 (35%)	372,968 (21%)	1,776,040
					1,776,040
TOTAL	3,770,646 (14%)	2,776,418 (24%)	3,724,297 (31%)	1,525,587 (13%)	11,796,883

Source: National Marine Fisheries Service, 1974.

It is interesting to note that since 1972 the United States commercial catfish production data has been compiled by fishery marketing specialists in the National Marine Fisheries Service. Although there are not data from other sources, contradictory or otherwise, the catfish farmers are apparently satisfied with this service. It is unfortunate that this service is not afforded to the rainbow trout farmers.

Habitat: The physical and chemical parameters of water required for optimum warm water fish growth and reproduction have been discussed previously in this report (see Chapter III, Habitat). To reiterate some of the specifics for channel catfish:

Temperature: >70^{o} F (21^{o} C) for 180-210 days/year
range 55-90^{o} F (13-32^{o} C)
pH: 6.5-8.5
Dissolved oxygen: >3 ppm
CO_2: <2 ppm
Alkalinity: >40 ppm

Water in channel catfish farms is used in static or slow moving systems with the chief use of new water being to make up that lost through evaporation. Most of the new water comes from wells. Generally a 1,000 gpm well will supply sufficient water for 40 surface acres of ponds--a turnover time of 27 days for ponds 3 feet deep.

Pond sizes range from 0.5 surface acres to more than 100 surface acres and in depth from 2.5 feet to 8 feet. The deeper ponds are used in northern climates to prevent winter-kills.

Bait Fish Production

This multimillion dollar business is a unique American enterprise. Its main goal is to produce live bait for sports fishermen. The industry is reported to be relatively new--within the past 30 years; however, it was preceded by many years of commercial harvesting and sale of wild stocks.

Goldfish were among the earliest bait fish produced with Maryland, Indiana, and Missouri leading in terms of numbers produced and shipped to other states. Today several species of minnows--principally golden shiners, redhorse shiners, fathead minnows, goldfish, spottail shiners, and stonerollers--are raised for the bait fish industry (Toole and Tiller, 1969). Currently, Arkansas has 29,091 acres, Minnesota has 12,900 acres, Mississippi has 1,740 acres, Louisiana has 1,500 acres, and Missouri has 1,200 acres of bait fish production. There is no record on numbers of fish produced by these states.

Water requirements for minnow production are virtually the same as for any warm water fish, with one exception--minnows apparently do much better in water systems having a turnover time of 24-48 hours. They do have a wider temperature tolerance range than most warm water fish but prefer water in the upper 70^{o} F (21^{o} C) range. A well-managed farm should produce between 80-100 thousand minnows per acre per year.

Based upon the foregoing acreage listed (46,431 surface acres), assuming the ponds are 3 feet deep and a 48-hour turnover time, the bait minnow industry in the states listed could use 63.3 million gallons of water per day (MGD).

Crawfish (Crayfish) Production

The commercial freshwater crayfish industry began in the 1880's with major harvest areas in the Pacific Northwest, Wisconsin, and Louisiana. In recent years the Louisiana crayfish production has dominated the industry with 11 million pounds per year--about half of which is produced in commercial ponds. At this time, the commercial crayfish farms are in southern Louisiana with 44,000 acres of managed ponds (Comeaux, 1974).

The art of raising crayfish commercially is so new that the habitat requirements are not well understood. Most farms provide ponds with water and vegetation so the crayfish will grow and reproduce as though they were in an unmanaged situation. Some farms are looking seriously at providing supplemental feed for their crayfish, and some are trying other innovative management techniques. Their results have not been made public.

Economic Importance

Annual dollar values for the gross and net incomes for each of the segments of the aquaculture industry; i.e., egg producer, fingerling producer, etc., are not compiled as such. The few economic data that are available are collated by industry types; i.e., trout, catfish (market-size and fingerling), crayfish, bait fish, and fee-fishing (Table 10). These data were derived by extrapolation of production costs and sales volumes.

Table 10. Economic value of selected segments of the aquaculture industry.

	Number of Farms	Value $\$ \times 10^6$	Feed Costs $\$ \times 10^6$
Rainbow trout	222	25.0	7.5
Channel catfish:			
Market-size	1,755	26.2	17.9
Fingerlings	Not recorded	10.0	6.2
Fee-fishing	1,360	16.3	Not recorded
Bait fish	Not recorded	175.0	Not recorded
Crayfish	Not recorded	18.0	Not recorded
Total	3,337+	270.5	31.6+

It is unfortunate that no labor statistics are available. If the generally accepted statement that it requires one man-year to produce 100,000 pounds of rainbow trout or channel catfish is valid, the estimated labor force required for the 1973 production was 200 man-years for trout and 900 man-years for catfish. Based upon an average hourly wage of $3.50 (including fringe benefits) or an annual salary of $7,200, the trout industry spent $1.4 million for labor and the catfish industry spent $6.4 million--or a total of $7.8 million.

In viewing the overall economic picture of the aquaculture industry, one must keep in mind that 85% of the catfish industry is located in the Lower Mississippi Delta states of Mississippi, Louisiana, Arkansas, Alabama, and Texas. Also, 90% of the rainbow trout industry is in Idaho. The influence of the aquaculture industry on the state and local economies takes on a new perspective when we consider that the catfish industry alone contributed over $51 million to the gross financial picture of five states. Figures for the other aquaculture industries of those states are not available; but it could be assumed that their contribution was measured in the millions of dollars. In Idaho, the rainbow trout industry contributes an estimated $20-25 million from sales, labor, and feed purchases to the gross economy of three counties in the state.

Factors Affecting the Industry

In the opinions of many individuals directly concerned with the aquaculture industry there are four major factors affecting the industry. Vying for top priority are marketing practices and the proposed EPA effluent guidelines. In third and fourth places, respectively, are management practices and water resource development. Each of these national concerns of a rapidly growing industry are, in many respects, interrelated even though they have been prioritized. Each issue of the four trade journals (The Catfish Farmer and World Aquaculture News, American Fishes and U.S. Trout Farmer, Fish Farming Industries, and Aquaculture and The Fish Farmer) contains submitted articles and editorial comments about each of these factors. It would be nearly impossible to present the breadth and depth of published views on each of the four factors affecting the industry. Everyone, it seems, has his or her own view about the nature of the problems and the manner(s) in which solutions should or could be effected. Therefore, a general overview of each of the factors affecting the industry will be presented in an attempt to show how each affects the industry, either in part or in the whole.

1) Marketing Practices: A marketing survey conducted by the University of Arkansas in 1973 fairly well sums up the marketing problem. The survey stated: "The low ratio of sales per thousand store patrons observed in the study suggests that an economically feasible level of sales is not attained under present marketing practices" (Pippin and Morrison, 1974).

Both the trout and catfish industries have extensive advertising in restaurant magazines, newspapers, restaurant menus, trade journals, and national magazines. These campaigns are financed by individual industry members through their dues to the U.S. Trout Farmers Association and the Catfish Farmers of America. During the summer of 1974 the U.S. Trout Farmers Association made some drastic cut-backs in their national activities by discontinuing the majority of their activities. A portion of their discontinued activities has been assumed by the Catfish Farmers of America. The primary reason for this move was the lack of financial support from its members. Just how much this will alter trout sales is, at best, speculative.

The food fish industry for the past 2-3 years has been in the jaws of a pair of economic pincers. One jaw represents the low over-the-counter prices for processed fish and the other represents the ever increasing costs of production. The pincers nearly closed with finality during the price freeze in late 1972. In 1973 the industry was struggling for survival. The situation is bleak in 1974 with frozen inventories of processed fish at all time highs but as many fish farmers put it: "It could be a lot worse." This could be construed as optimistic pessimism or pessimistic optimism.

The Department of Commerce reported that in 1973 the per capita consumption of seafood and seafood products increased to 12.6 pounds--the highest since record-keeping began in 1909. This figure represents a total of approximately 2.6 billion pounds, 65-70% of which came from fisheries outside the United States.

If the United States population grows at an annual rate of 1% and the food fish consumption stays at 12.6 pounds per capita, there should be an annual increased market demand of 77 million pounds (live-weight) of food fish. Also, if imports remain the same, the increased demand for domestic food fish should be 19.25 million pounds. Unfortunately, there are no data to suggest what portion of the 12.6 pounds per capita annual consumption is commercially grown food fish.

The subject of imported fish is concerning the catfish industry. Imports of fresh catfish, mainly from Brazil, are hindering the market demand for domestic catfish. In 1973 more than 6 million pounds were imported and so far in 1974, if the trend continues, imports of fresh catfish will exceed 8 million pounds. The story here is the usual situation of imports being cheaper to produce and offered in the marketplace at a price substantially less than comparable domestic products.

2) <u>EPA Effluent Guidelines</u>: In 1974 the Environmental Protection Agency, the administrator of the Federal Water Pollution Control Act Amendments of 1972, presented a "Development Document for Proposed Effluent Limitations Guidelines and New Source Performance Standards for Fish Hatcheries and Farms." This document brought all segments of the food fish industry together, as nothing else could, to a common cause; namely, opposition to the proposed effluent standards.

The final effluent standard limitations are in preparation and are due to be enacted in October, 1974. Public hearings are being held at various parts of the country to discuss the proposed ruling. If the proposed limits are adhered to, all flow-through and pond culturing systems used to raise native fish will have some form of effluent treatment by 1983.

3) Management Practices: Current fish farm management practice problems are in many instances contributory to both the marketing problems and the effluent problems. Fundamentally, many management practices are behind the times with respect to water utilization, nutrition, pond loading (fish density), disease control, and fish farm economics. The industry today is operated very much the same as it was 15-20 years ago. Diseases--both infectious and noninfectious--take the same toll of fish now as they did years ago. On a national basis, 40-60% of the future food fish die before becoming market-sized. It is estimated that 30¢ of each dollar spent to raise food fish goes for some aspect of disease; e.g., mortality, control, prevention. In some respects this high cost is surprising as the majority of successful fish farmers have been in business for more than 10 years and most of these have been fish farming for more years than that.

Basic and applied research in commercial fish farming problems is virtually nonexistent. Most research being conducted is done with federal funds in federal conservation facilities--and the findings of those researches are very often not applicable to commercial industry. The one exception is the S-83 project in catfish farming which is a 12-state cooperative research program funded by state and federal monies. A few universities are beginning to provide formal courses for educating future fish farmers. Continuing education courses are also being offered to fish farmers by university extension services. Many of these courses are offered at fish farms while others are offered at universities and federal facilities. From surveys conducted after the courses, they have been very instrumental in assisting the fish farmers improve their product through management practices.

4) Water Resource Development: The availability of new water suitable for fish farming either warm water or cold water species is diminishing. The construction of new fish farms using flow-through water systems has declined steadily during the past 5 years. Many potential water sources for fish farming have deteriorated in the past two decades to the point where they will probably never be reclaimed to their original state no matter what efforts are applied.

The practice of flood and sprinkler irrigation of agricultural crops using water from deep or shallow wells or from reservoirs and streams has also had its effect on the fish farming industry. In some areas irrigation pumping has decreased the water supplies to nearby fish farms. In cases where the water level became critical the fish farmers had to draw water from greater depths which exerted a financial burden resulting from drilling costs and increased pumping costs.

On the positive side, flood control by impoundment of midwestern rivers has had a beneficial effect on fish farming by reducing the threat of flooding. However, the use of impounded waters for fish farming has not been too widely accepted because of their unsuitable quality. Most fish farms cannot afford the expense of having to clean-up the water before it is used for fish raising.

Federal and State Regulations Relating to Aquaculture

In 1973 the Congressional Committee on Merchant Marine and Fisheries issued "A Compilation of Federal Laws Relating to Conservation and Development of Our Nation's Fish and Wildlife Resources, Environmental Quality, and Oceanography." This 706 page document is complete through the 92nd Congress.

The following are considered to have either direct or indirect application to the commercial aquaculture industry of the United States:

1) Fish Research and Experimentation Program (16 U.S.C. 778-778h):
"The Secretary of the Interior is authorized and directed to establish an experiment station or stations for the purpose of carrying on a program of research and experimentation--

a) to determine species of fishes most suitable for culture on a commercial basis in shallow reservoirs and flooded rice lands;

b) to determine methods for production of fingerling fishes for stocking in commercial reservoirs;

c) to develop methods for the control of parasites and diseases of brood fishes and of fingerlings prior to stocking;

d) to develop economical methods for raising the more desirable species of fishes to a market-size;

e) to determine, in cooperation with the Department of Agriculture, the effects of fish-rice rotations, including crops other than rice commonly grown on rice farms, upon both the fish and other crops; and

f) to develop suitable methods for harvesting the fish crop and preparing it for marketing, including a study of sport fishing as a means of such harvest."

2) Regulation of Interstate Transportation of Black Bass and Other Fish (16 U.S.C. 851-856):
"It shall be unlawful for any person--

a) to deliver or receive for transportation, or to transport, by any means whatsoever, in interstate or foreign commerce, any black bass and other fish, if such persons knows or in the exercise of due care should know that 1) such delivery or transportation is contrary to the law of the State or any foreign country from which such black bass or other fish is found or transported, or is contrary to other applicable law, or 2) such black bass or other fish has been either caught, killed, taken, sold, purchased, possessed, or transported, at any time, contrary to the law of the State or foreign country, in which it was caught, killed, taken, sold, purchased, or possessed, or from which it was transported, or contrary to other applicable law;

b) to purchase or receive any such black bass or other fish, if such person knows, or in the exercise of due care should know, that such bass or fish has been transported in violation of the provisions of this chapter;

c) receiving any shipment of black bass or other fish transported in interstate or foreign commerce to make any false record or render a false account of the contents of such shipment, if such person knows, or in the exercise of due care should know, that such record or account is false. For the purposes of this section, the provisions of section 10 of Title 18, shall apply to the term 'interstate or foreign commerce.' (May 20, 1926, ch. 346, 2, 44 Stat. 576; July 2, 1930, ch. 801, 46 Stat. 845; July 30, 1947, ch. 348, 61 Stat. 517; July 16, 1952, ch. 911, 2, 66 Stat. 736; Dec. 5, 1969, Pub. L. 91-135, 9(a), 83 Stat. 281).

Amendments

1969 - Pub. L. 91-135 designated existing provisions as pars. (1), (2), and (3), redesignated cls. (1) and (2) as (A) and (B) in par. (1) and proscribed therein conduct contrary to the laws of any foreign country, revised the provisions of the section to clarify the nature of the various violations, also imposed penalties upon a person who in the exercise of due care should know that he is committing one of the enumerated violations, made par. (3) applicable to transportation in foreign commerce, and made applicable the definition in section 10 of Title 18 to the term 'interstate or foreign commerce.'

1952 - Act July 16, 1952, substituted 'fish' for 'game fish' wherever appearing.

1947 - Act July 30, 1947, included other game fish in addition to black bass, committed references to particular species of black bass, and inserted general provisions with reference to acts contrary to other applicable laws.

1930 - Act July 2, 1930, amended section generally."

3) <u>Water Bank Act (16 U.S.C. 1301-1311)</u>:
"The Congress finds that it is in the public interest to preserve, restore, and improve the wetlands of the Nation, and thereby to conserve surface waters, to preserve and improve habitat for migratory waterfowl and other wildlife resources, to reduce runoff, soil and wind erosion, and contribute to flood control, to contribute to improved water quality and reduce stream sedimentation, to contribute to improved subsurface moisture, to reduce acres of new land coming into production and to retire lands now in agricultural production, to enhance the natural beauty of the landscape, and to promote comprehensive and total water management planning. The Secretary of Agriculture (hereinafter in this chapter referred to as the 'Secretary') is authorized and directed to formulate and carry out a continuous program to prevent the serious loss of wetlands, and to preserve, restore, and improve such lands, which program shall begin on July 1, 1971. (Pub. L. 91-559, 2, Dec. 19, 1970, 84 Stat. 1468)."

4) Wild and Scenic Rivers Act (16 U.S.C. 1271-1287):
"It is hereby declared to be the policy of the United States that certain selected rivers of the Nation which, with their immediate environments, possess outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values, shall be preserved in free-flowing condition, and that they and their immediate environments shall be protected for the benefit and enjoyment of present and future generations. The Congress declares that the established national policy of dam and other construction at appropriate sections of the rivers of the United States needs to be complemented by a policy that would preserve other selected rivers or sections thereof in their free-flowing condition to protect the water quality of such rivers and to fulfill other vital national conservation purposes. (Pub. L. 90-542, 1(b), Oct. 2, 1968, 82 Stat. 906)."

5) Environmental Education Act (20 U.S.C. 1531-1536):
"(a) The Congress of the United States finds that the deterioration of the quality of the Nation's environment and of its ecological balance poses a serious threat to the strength and vitality of the people of the Nation and is in part due to poor understanding of the Nation's environment and of the need for ecological balance; that presently there do not exist adequate resources for educating and informing citizens in these areas, and that concerted efforts in educating citizens about environmental quality and ecological balance are therefore necessary.

(b) It is the purpose of this chapter to encourage and support the development of new and improved curricula to encourage understanding of policies, and support of activities designed to enhance environmental quality and maintain ecological balance; to demonstrate the use of such curricula in model educational programs and to evaluate the effectiveness thereof; to provide support for the initiation and maintenance programs in environmental education at the elementary and secondary levels; to disseminate curricular materials and other information for use in educational programs throughout the Nation; to provide training programs for teachers, other educational personnel, public service personnel, and community, labor, and industrial and business leaders and employees, and government employees at State, Federal, and local levels; to provide for the planning of outdoor ecological study centers; to provide for community education programs on preserving and enhancing environmental quality and maintaining ecological balance; and to provide for the preparation and distribution of materials by mass media in dealing with the environment and ecology. (Pub. L. 91-516, 2, Oct. 30, 1970, State. 1312)."

6) Water Resources Planning Act (42 U.S.C. 1962):
"In order to meet the rapidly expanding demands for water throughout the Nation, it is hereby declared to be the policy of the Congress to encourage the conservation, development, and utilization of water and related land resources of the United States on a comprehensive and coordinated basis by the Federal Government, States, localities, and private enterprise with the cooperation of all affected Federal agencies, States, local governments, individuals, corporations, business enterprises, and others concerned. (Pub. L. 89-80, 2, July 22, 1965, 79 Stat. 244)."

7) National Environmental Policy Act (42 U.S.C. 4321-4347):

"The purposes of this chapter are: To declare a national policy which will encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; to enrich the understanding of the ecological systems and natural resources important to the Nation; and to establish a Council on Environmental Quality. (Pub. L. 91-190, 2, Jan. 1, 1970, 83 Stat. 852)."

8) Environmental Quality Improvement Act (42 U.S.C. 4371-4374):

"(a) The Congress finds--

1) that man has caused changes in the environment;
2) that many of these changes may affect the relationship between man and his environment; and
3) that population increases and urban concentration contribute directly to pollution and the degradation of our environment.

(b) (1) The Congress declares that there is a national policy for the environment which provides for the enhancement of environmental quality. This policy is evidenced by statutes heretofore enacted relating to the prevention, abatement, and control of environmental pollution, water and land resources, transportation, and economic and regional development. (2) The primary responsibility for implementing this policy rests with State and local governments. (3) The Federal Government encourages and supports implementation of this policy through appropriate regional organizations established under existing law.

(c) The purposes of this chapter are--

(1) to assure that each Federal department and agency conducting or supporting public works activities which affect the environment shall implement the policies established under existing law; and

(2) to authorize an Office of Environmental Quality, which, notwithstanding any other provision of law, shall provide the professional and administrative staff for the Council on Environmental Quality established by Public Law 91-190. (Pub. L. 81-224, Title II, 202, Apr. 3, 1970, 84 Stat. 114)."

9) Pollution Control in Navigable Waters (33 U.S.C. 1251-1376):

"The objective of this chapter is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. In order to achieve this objective it is hereby declared that, consistent with the provisions of this chapter--

1) it is the national goal that the discharge of pollutants into the navigable waters be eliminated by 1985;

2) it is the national goal that wherever attainable, an interim goal of water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water be achieved by July 1, 1983;

3) it is the national policy that the discharge of toxic pollutants in toxic amounts be prohibited;

4) it is the national policy that Federal financial assistance be provided to construct publicly owned waste treatment works;

5) it is the national policy that areawide waste treatment management planning processes be developed and implemented to assure adequate control of sources of pollutants in each State; and

6) it is the national policy that a major research and demonstration effort be made to develop technology necessary to eliminate the discharge of pollutants into the navigable waters, waters of the contiguous zone, and the oceans.

It is the policy of the Congress to recognize, preserve, and protect the primary responsibilities and rights of States to prevent, reduce, and eliminate pollution, to plan the development and use (including restoration, preservation, and enhancement) of land and water resources, and to consult with the Administrator in the exercise of his authority under this chapter. It is further the policy of the Congress to support and aid research relating to the prevention, reduction, and elimination of pollution and to provide Federal technical services and financial aid to State and interstate agencies and municipalities in connection with the prevention, reduction, and elimination of pollution.

It is further the policy of Congress that the President, acting through the Secretary of State and such national and international organizations as he determines appropriate, shall take such action as may be necessary to insure that to the fullest extent possible all foreign countries shall take meaningful action for the prevention, reduction, and elimination of pollution in their waters and in international waters and for the achievement of goals regarding the elimination of discharge of pollutants and the improvement of water quality to at least the same extent as the United States does under its laws.

Except as otherwise expressly provided in this chapter, the Administrator of the Environmental Protection Agency (hereinafter in this chapter called 'Administrator') shall administer this chapter.

Public participation in the development, revision, and enforcement of any regulation, standard, effluent limitation, plan, or program established by the Administrator or any State under this chapter shall be provided for, encouraged, and assisted by the Administrator and the States. The Administrator, in cooperation with the States, shall develop and public regulations specifying minimum guidelines for public participation in such processes.

It is the national policy that to the maximum extent possible the procedures utilized for implementing this chapter shall encourage the drastic minimization of paperwork and interagency decision procedures, and the best use of available manpower and funds, so as to prevent needless duplication and unnecessary delays at all levels of government (June 30, 1948, ch. 758, Title I, 101, as added Oct. 18, 1972, Pub. L. 92-500, 2, 86 Stat. 816)."

10) Soil Conservation (16 U.S.C. 590ff):
"It is recognized that the wastage of soil and moisture resources on farm, grazing, and forest lands of the Nation, resulting from soil erosion, is a menace to the national welfare and that it is declared to be the policy of Congress to provide permanently for the control and prevention of soil erosion and thereby to preserve natural resources, control floods, prevent impairment of reservoirs, and maintain the navigability of rivers and harbors, protect public health, public lands and relieve unemployment, and the Secretary of Agriculture, from now on, shall coordinate and direct all activities with relation to soil erosion and in order to effectuate this policy is authorized, from time to time--

1) to conduct surveys, investigations, and research relating to the character of soil erosion and the preventive measures needed, to publish the results of any such surveys, investigation, or research, to disseminate information concerning such methods, and to conduct demonstrational projects in areas subject to erosion by wind or water;

2) to carry out preventive measures, including, but not limited to, engineering operations, methods of cultivation, the growing of vegetation, and changes in use of land;

3) to cooperate or enter into agreements with, or to furnish financial or other aid to, any agency, governmental or otherwise, or any person, subject to such conditions as he may deem necessary, for the purposes of this chapter; and

4) to acquire lands, or rights or interests therein, by purchase, gift, condemnation, or otherwise, whenever necessary for the purposes of this chapter. (Apr. 27, 1935, ch. 85, 1, 49 Stat. 163)."

* * * * *

One federal regulation not listed in this compilation is the revised Title 50--Wildlife and Fisheries, Subchapter B, Part 13, Section 7. These regulations pertain to the importation of live or dead salmonids and read: "Except for the salmonids of the fish family Salmonidae, all species of live or dead fish, mollusks and crustaceans, or parts thereof, or their eggs, may be imported, transported, and possessed in captivity without a permit, for scientific, medical, educational, exhibition, or propagational purposes upon the filing of a written declaration with the District Director of Customs at the port of entry as required under 13.12. No such live fish, mollusks, crustacean, or any progeny or eggs thereof, may be released into the wild except by the State wildlife conservation agency having jurisdiction over the area of release or by persons having prior written permission from such agency.

Notwithstanding authority granted Federal agencies in 13.4, all live or dead fish or eggs of salmonids of the fish family Salmonidae are prohibited entry into the United States for any purpose unless such importations are by direct shipment, accompanied by a certification that the importation is free of the protozoan Myxosoma cerebralis, the causative agent of so-called 'whirling disease,' and the virus causing viral hemorrhagic septicemia or 'Egtved disease.' The certification shall be signed in the country of origin by a designated official acceptable to the Secretary of the Interior, as being qualified in fish pathology, or in the United States, by a qualified fish pathologist designated for this purpose by the Secretary of the Interior.

Nothing in this part shall restrict the importation and transportation of dead fish or dead eggs of salmonids of the fish family Salmonidae when such fish or eggs have been processed by canning, pickling, smoking, or otherwise prepared in a manner whereby all spores of the protozoan Myxosoma cerebralis, the causative agent of so-called 'whirling disease' and the virus causing viral hemorrhagic septicemia or so-called 'Egtved disease' have been killed. Salmon landed in North America and brought into the United States for processing or sale, or any salmonid caught in the wild in North America under a sport or a commercial fishing license shall be exempt from the requirement for certification."

* * * * *

During the current 93rd Congress, 12 bills were introduced which, if enacted, will have direct influence on commercial aquaculture. Two bills transfer into the Department of Agriculture the aquaculture functions now exercised by the Department of Interior. Three bills are classified as consumer protection bills to provide inspection of fish processing plants and fish products. Each delegates the responsibility to a different administrative department; i.e., Interior, Agriculture, and H.E.W. Three bill authorize the Department of Agriculture to establish fish disease control programs. Four bills are each entitled "Fish Disease Control Act" and are enabling legislation for either the Department of Commerce or the Department of Interior to establish fish disease control programs. The most recent information concerning these 12 bills is that none are likely to be enacted. If this is the case, it can be assumed that newly designed proposed legislation will be introduced into the first session of the 94th Congress.

In 1955, the American Fisheries Society Committee on Importation of Fish and Eggs reported that of the 24 states with laws regulating the importing or planting of live fish or their eggs in state waters, all had the power to prevent the introduction of diseased fish or eggs, or both. However, only 2 states had personnel qualified to conduct inspection, although 22 believed that they could obtain help from their universities.

Ten years later, the Bureau of Sport Fisheries and Wildlife (now the United States Fish and Wildlife Service) conducted a survey to update the 1955 report. Of the lower 48 states, seven did not respond. Of the 20 states reporting not having legislation for inspection, reports, or certification of live fish or their eggs, or both, 7 had reported having such legislation in the 1955 survey.

Of the states requiring certification disease status on imported fish and/or eggs, California has the most rigidly enforced regulations. As a result of California's efforts, more states are taking a concerned interest in fish disease certification. Montana has recently begun an active certification program.

At the present time no states apparently have any regulations pertaining to the intrastate transportation of live fish other than obtaining a permit for doing so. There are, however, very specific regulations regarding the release of fish into public waters by private individuals.

All states having large commercial aquaculture industries require the individual farms to have permits for their operations.

Appraisal of Future Needs

The greatest future--as well as present--need facing the commercial food fish industry is growth. Every segment of aquaculture must grow; but each must grow in terms of the whole. The interrelationships of production, processing, and marketing must be what can best be described as a symphonic orchestration. If the need for growth is faced squarely and shared collectively, total growth will be a reality. The question is: "How?"--"How will consumption of commercially raised food fish be increased?" "How will marketing practices create a greater consumption of food fish?" "How will processing and packaging methods assist marketing of fresh and frozen food fish?" "How will fish farm management assist in changing processing and packaging of food fish to meet the consumer preferences sought and by in-depth marketing practices?"

It is well outside the scope of this report to attempt a complete discussion of methods by which the "How" questions can be answered. If, however, the marketing segment of the aquaculture industry does undertake the task of increasing consumption of farm-raised food fish, it might start with the comparative nutritive values of fish to red meat and poultry (Table 11). If these statistics are accepted, there are other interesting facts available. Fish are about 85-95% digestible and they are relatively low in fat compared to beef and pork. Certain fishery products often are prescribed to heart patients because of the low (60-75 mg/100 gm of fish) cholesterol level.

In 1972 an article in one of the association journals stated: "It is estimated that some 50,000,000 men and women are enrolled in organized groups dedicated to reduce their body weights. Their program calls for the serving of fish two or three times a week. Sales programs would emphasize trout should be included at least once a week with these people. An eight-ounce trout once a week would be 26 pounds of trout per person per year. Twenty-six pounds times 50,000,000 people would create a sizable market. With a good, well-coordinated program there is no reason the trout industry should not have a substantial part of this market" (Robinson, 1972). Upon reading this, it seems to be a very realistic approach to generating more business. However, if it were to come to pass that 50 million people decided to eat one 8-ounce trout per week per person, the food fish industry scales would be as out of balance as they are now--only in the opposite direction!

Table 11. Nutritive value of selected raw animal products per 100 grams edible portion.

Food Item	Protein %	Fat %	Carbohydrates %	Energy Calories
Beef[a]	18.0	21.0	0.0	266
Chicken[b]	18.6	4.9	0.0	124
Eggs	12.9	11.5	0.9	163
Milk[c]	3.5	3.5	4.9	65
Pork[a]	10.2	52.0	0.0	513
Trout, rainbow	21.5	11.4	0.0	195
Catfish, channel	17.6	3.2	0.0	Not recorded

[a]Carcass
[b]Whole chicken: skin, flesh, giblets
[c]Whole milk

Compiled by Thousand Springs Trout Farms, Inc., Buhl, Idaho

Twenty-six pounds for each of 50 million people per year would mean an increased consumption of 1.3 billion pounds of trout--or 65 times what is now produced annually. The increased production demand would require an additional 130,000 cfs of water flowing through 650 million cubic feet of new ponds. These estimates are based upon the generalizations that 1 cfs will be sufficient water for 10,000 pounds of trout per year and that two pounds of trout occupy one cubic foot of water. Needless to say, there just is not sufficient new water to accomplish this task using single-pass water systems. It is also doubtful that there would be sufficient diet ingredients, especially fish meal, to feed that great a production increase.

* * * * *

For the producing segment of the industry to grow, several decisions must be made. First, production should be paced with sales and marketing and not the other way around as it appears to be currently. The trade journals regularly have articles presenting the shortcomings of food fish sales and merchandising. In many cases these are authored by production-oriented persons, which does not make the articles any less valid--a little more biased perhaps. There are, to our knowledge, no comprehensive reports of in-depth studies to increase consumer awareness of farm-raised food fish. Second, plans must be formulated and implemented to comply with the EPA requirements for the quality of water being discharged from fish farms. Several methods of treating the discharge have been suggested--all varying in the amount of capital outlay and increased cost of production each will require. What percentage of the fish farmers who would elect to either decrease production or go out of business is unpredictable. In either case, a net loss of production is likely to occur within the next few years.

The third decision to be made is in fish farm management improvement--that is, the orderly flow of fish culture practices occurring from the eyed-egg stage to the market-sized fish. Water, feed, and ponds must be utilized to their optimum. Certain infectious diseases of fish are going to be designated at the state level as undesirable and fish harboring their causative agents will not be permitted entry from other states. Also, fish within a state will be destroyed if found harboring specified disease-producing agents. Thus, a high priority must be placed on the health management of food fish. As was stated previously, of the eyed-eggs incubated, hatched, and raised to market-sized fish, only 40-60% live to become a consumer item. Not only is the actual loss of the fish expensive, the loss-of-production potential is even greater.

Again, the question "How?" arises; certainly not by legislating against it in the form of unrealistic regulation of interstate shipment of live or dead fish and/or their products. This type of legislation could hinder rather than promote industry growth. Legislation is needed to establish and to maintain ongoing programs in education, service, and research (both basic and applied) at federal, state, and private levels so that those diseases representing a real threat to the conservation and commercial sectors of aquaculture are controlled by whatever means practical.

A study committee of the National Academy of Sciences recommended, following nearly two years deliberations on aquatic animal health:

"The need for increased food and feed derived from the aquatic environment is an issue that should be faced squarely. The fish and shellfish resources of marine and fresh waters are limited. The most important man-made stresses limiting these resources are environmental degradation and over-exploitation. Diseases and kills in aquatic animals, as a consequence of these imbalances, impose still further losses.

Concern about diseases of aquatic species is important not only as they contribute to depletion or extinction of species but also as a hazard to the health and nutritional well-being of man. There is no known clearly defined institutional mechanism whereby focus can be placed on programs in aquatic animal health, other than for marine mammals. Identified are the relationships between environmental quality and aquatic animal health that are central to the issue of continued supplies of aquatic animals for use by man. Recommendations are that:

1) Steps be taken to minimize deleterious alterations of the environment, particularly those alterations having an undesirable effect on the health of aquatic animals.

2) Research on health of aquatic animals consider not only existing problems and disease but anticipate future problems, particularly diseases that result from changing or deteriorating environments. Existing programs concerned with basic and applied research must be augmented with personnel, funds, and facilities. A favorable climate for such research must be fostered and proper communication maintained if redundancy is to be avoided and available research funds wisely spent.

3) Coordination of state and federal regulations for movement and transfer of animals as they related to control of disease be established and maintained.

4) Greater effort be devoted to securing international agreements for effective disease control.

5) A program be developed for interaction of appropriate committees of the National Academy of Sciences that relate to the aquatic environment. Special attention should be given to proper communication of problems and to continual re-evaluation of priorities. The NAS should maintain a continuing interest in health of fish and shellfish through committees involving environmental scientists, resources scientists, fish disease specialists, and animal health scientists.

6) Adequate education and training programs be established to produce personnel competent to prevent, diagnose, control, and conduct research on diseases of aquatic animals.

7) Grants-in-aid be provided by state, federal, and private agencies to assist the training of qualified people and for construction of training and research facilities.

8) A technical manual be developed to provide uniform and effective nomenclature and procedures for identification and diagnosis of diseases of aquatic animals.

9) A national fish and shellfish disease recording and reporting center be established, augmented by private and public diagnostic services.

10) An advisory council be formed within the federal government to delineate needs and priorities and to see that appropriate programs are implemented." (National Academy of Sciences, 1973)

Chapter V AQUACULTURE in IDAHO

Chapter V AQUACULTURE in IDAHO

In 1973 the commercial food fish industry in the State of Idaho produced an estimated 19.22 million pounds of rainbow trout and channel catfish or nearly 90% of the United States production of processed rainbow trout and nearly 70% of the United States commercial production--both processed and live trout. The developing channel catfish industry contributed nearly 200,000 pounds to the total figure. The gross value of fish produced in Idaho in 1973 has been estimated at $25 million. This fact has even greater added significance when one considers that this industry, for the most part, is locally owned and functions entirely within the state except for the importation of some fish food and egg stocks (both exceptions have tended to be consolidated within the state during the last few years). The product is then almost completely exported out of the state resulting in a tremendous net income to the state.

It is the consensus of opinion among several rainbow trout producers that by 1977 there will be an additional 20 million pounds of fish produced, bringing the total to 39 million pounds with a calculated dollar value of nearly 50 million. If their past history of growth is any indication, this industry goal is realistic.

The primary reason for the phenomenal growth of this meat producing industry is the availability of large quantities of water optimally suited for raising both rainbow trout and channel catfish. New sources of water at both 58° F (15° C) and 80° F (27° C), optimum for rainbow trout and channel catfish respectively, are being developed.

History of Commercial Aquaculture in Idaho

It should be stated at the outset that the historical information presented is based upon personal interviews with the major participants in the food fish industry of Idaho. When all the gathered information was being assembled it became apparent that quite a number of the dates and names of persons involved were contradictory. The apparent contradictions were resolved through further consultation and the results are presented, hopefully, correctly.

The first commercial fish farm in Idaho was started in 1909 at the Devil's Corral Spring near Shoshone Falls in Jerome County. Fish raising operations were discontinued after a year or so--presumably due to the slow market for hatchery fish. The site remains today virtually unchanged over the past 65 years.

In 1919 two commercial fish farms began operations. Frame Trout Farm, located beneath the SH 74 Bridge in Twin Falls, was operated by the Frame family until 1946 when it was acquired by McQuire, McQuire, and Miller. The McQuires operated it as a market-size fish producing farm until 1973, at which time virtually all fish culture activities ceased.

The other commercial fish farm, operated by Morris Davis and Ralph Nelson, was at Papoose Springs near Pocatello. The property was acquired from Meader who started brood stock operation in 1914. Davis and Nelson, in many respects, are largely responsible for developing rainbow trout farming in the Blackfoot-Pocatello-Springfield area. In addition, Nelson established several trout farms in the Buhl-Wendell area. The Papoose Springs trout farm was acquired by Thousand Springs Trout Farms, Inc. in 1967 and are currently operating it.

In the 1920's fish farming was made possible in the Thousand Springs area of the Snake River through the congressional activities of Congressman Mays of Utah. His action opened the Snake River bottomland to homesteading instead of its being maintained by the federal government. Congressman Mays did have good reason for his actions--he owned a trout ranch near what is now the Idaho Department of Fish and Game Niagra Springs Steelhead Hatchery.

In 1928 Jack Tingey started the Snake River Trout Farm, the first food fish farm and hatchery using the Hagerman Aquifer water. One of his first fish culturists was Percy Greene, who later established two still-operating trout farms. Tingey marketed his first crop in 1929 and gradually increased his annual production to several thousands of pounds. The farm was sold to Bob and Barnee Erkins in 1952 who are still involved in its operation.

Sometime during the 1920's Caribou Trout Farm at Soda Springs was established. It was and still is a brood stock or egg-producing facility. The present owner, Al Dunn, acquired it in the 1940's from George Isaac who acquired it in 1938 from Meader.

In 1929, the Perrine family began raising rainbow trout in the Snake River canyon near Twin Falls. The site became in 1970 what is now known as Royal Catfish Industries, near Blue Lakes Trout Farm.

In 1935 Percy Greene started raising trout at what is now Greene's Trout Farm, one mile east of Twin Falls along the rim of the Snake River canyon. In terms of acres of land utilized this was, and is, the most extensive trout farm in the Twin Falls-Buhl area. It is exceeded in land area in the state only by Crystal Springs Trout Farm at Springfield.

By 1936 the first profits from rainbow trout farming were realized. That year an estimated 555,000 pounds of rainbow trout were marketed by Snake River Trout Farm, Frame Trout Farm, Greene's Trout Farm, and Papoose Springs Trout Farm. Annual production remained at that level until after World War II.

In 1946, Art Wylie, who began his fish culturing career at Frame Trout Farm, established the Canyon Trout Farm on Rock Creek near Twin Falls. Also at that time, Frame Trout Farm was sold to the McQuire family.

In 1947, Davis and Nelson leased spring water rights from Robert Houghland of Springfield and started what is now Crystal Springs Trout Farm. These facilities were operated in later years by Porter Houghland, Robert's son. Clear Springs Trout Company leased them from the Houghland's in 1973. This operation served as both a brood stock and market-size fish producing facility.

Also in 1947, Earl Hardy and Al Iverson, now of Idaho Trout Processors, Inc., began what is currently Rainbow Trout Farms. One site is at the head of Cedar Draw near Filer and the other is at the head of the Mendini Seepage Drain near Buhl.

There are no accurate production data for the years preceeding 1950. One can only speculate that there were between 500,000 and 750,000 pounds (live weight) of rainbow trout produced annually by the 9 trout farms in production.

In 1951-52 the trout industry began an abortive attempt to become nationally recognized. The Rocky Mountain Troutman's Association (RMTA) was a short-lived marketing cooperative headed by Howard Sly of Twin Falls. The demise of this organization was to have long-lasting, but understandable, effects on the activities of future state and national organizations. At the time of its demise in 1952, there was a flurry of national activity to create the U.S. Trout Farmers Association (USTFA), whose stated objectives were to promote rainbow trout as a food item and to provide lines of communication among trout growers. The USTFA policy prevailed because the Idaho trout growers did not want an organization created for price-fixing, an objective of the RMTA. However, the USTFA was to run into financial support difficulties in the early 1970's and be forced to regroup during 1974.

Also in 1951-52, four new rainbow trout farms were started. Rimview Trout Company near Niagra Springs was operated by Milford Schmekpepper who sold it to Bob Teachott in the 1960's. Ralph Nelson started a farm at Crystal Springs a mile or so upriver from Niagra Springs. He also started Indian Springs Trout Farm near Blackfoot. Jim Ellis built Idaho Springs Trout Farm using water from Saddle Spring and "Vardis Fisher Springs." The fish he produced were shipped alive to a processing plant in Reno, Nevada. This farm was purchased by Thousand Springs Trout Farm, Inc. in 1958.

In 1956, Snake River Trout Company (now Snake River Trout Farm, Thousand Springs Trout Farms, Inc.) built its first processing plant and equipped it with automated facilities. It was the first of its kind in the trout industry.

Also in 1956, Blue Lakes Trout Farm was built by Percy Greene and Stan Miller. The site was near the outfall of Blue Lakes Springs downriver from Twin Falls. Percy Greene and his son, Mike, operate it today. The operation of the original farm was turned over to Percy's son-in-law, Ron Kasel.

Construction of new trout farms slowed somewhat in the early 1960's. Rangen's Research Hatchery was established in 1962 to test newly formulated trout feeds in actual production situations. In 1966 construction began on Clear Springs Trout Company's main facility and Clear Lakes Trout Farm, both adjacent to the Snake River Trout Farm near Buhl.

In 1967 Thousand Springs Trout Farms, Inc. purchased Papoose Springs Trout Farm from Meader and Verret.

In 1969 trout farm construction activity picked up. Clear Springs Trout Company purchased the Nelson Trout Farm at Crystal Springs near Niagra Springs, and began to construct their Crystal Springs facility. Sandlin, Lemon, and Standal established Aquaculture Industries, Inc. at Magic Springs near the Hagerman National Fish Hatchery. It was sold in 1973 to Marine Protein Corporation.

By 1970 the annual production of trout had increased to 6.5 million pounds (live-weight). The reported production for 1971 and 1972 respectively was 12 million pounds and 23.03 million pounds (live-weight). The 1971 production estimate was made by general consensus of the trout growers. The 1972 production estimate was made from individual responses to a survey questionnaire distributed and collated in 1973. The 1973 production estimate is a revision from the 27.43×10^6 lb previously reported (Klontz, 1973). The error became apparent after it was discovered that the 1973 survey questionnaire had been misinterpreted by the processing segment of the industry. During those two years the Jones and Sandy facility was started under the leadership of Gerald Martin, recently retired from the Bureau of Sport Fisheries and Wildlife Service. Clear Springs Trout Company initiated the farm pond system in which individuals raised trout from 4-8 inches to market-size. Clear Springs retained title to the fish, supplied the feed and professional assistance, and paid the farm pond operator for the pounds of gain. During 1972 there were 40 farm pond sites with a total of 180 ponds, all within a 10 mile radius of Buhl. This operation was expanded to 46 operators in 1973 contributing an estimated 3.5 million pounds of live trout to the market. Royal Catfish Industries also started a fish raising operation during those years on the old Perrine Fish Farm near Blue Lakes Trout Farm. In addition to raising rainbow trout, they had a well drilled to obtain some over 100° F (37.78° C) water to mix with the 59° F (15° C) water and raise channel catfish. This was done under the leadership of Leo Ray.

In 1972, Leo Ray left Royal Catfish Industries to start his own catfish raising facility on the Kerpa property near Banbury Hot Springs. After a year, he moved to a new site and formed Fish Breeders of Idaho. Also in 1972, Ben Howard of Challis started a rainbow trout brood stock farm not far from the Hot Springs on the east side of Challis.

In 1973, Clear Springs Trout Company began construction on their Box Canyon facility--some 1.1 million cubic feet of fish rearing space supplied with 300 cfs of water brought from Box Canyon Springs across the Snake River. Also, Thousand Springs Trout Farms, Inc. added another trout farm to their already long list. Batise Springs Trout Farm was constructed on the banks of the Port Neuf River near their Papoose Springs facility. Frame Trout Farm discontinued their operation except for their small brood stock inventory during the summer of 1973.

So far, 1974 has been a somewhat disappointing year. Royal Catfish Industries discontinued their operation in May. Clear Springs Trout Company discontinued their farm pond operation. Blind Canyon Aquaranch, the only farm pond facility operating, is currently raising fish for Thousand Springs Trout Farms, Inc. The rest are sitting and waiting for the market to improve. The most recent note in this historical documentation of the Idaho aquaculture industry came on September 30, 1974. The flume carrying water from Box Canyon Springs to the pipe under the Snake River and into the Clear Springs Trout

Company's Box Canyon facility disintegrated resulting in the death of several hundred thousand pounds of trout. This was in all likelihood the largest single disaster ever to have occurred in the aquaculture industry.

Description of the Industry

The Idaho Fish and Game Department issued 72 permits to raise fish commercially in 1974. The majority of the permit holders reside in Twin Falls, Jerome, and Gooding Counties. Larger farms use water from springs emerging from the massive aquifer system terminating for many miles along the base of the northeasterly canyon wall of the Snake River. Other farms use water from springs arising on the flat land south and west of the Snake River.

The commercial food fish industry in Idaho is rather complex. No two individual fish raising facilities are alike from the standpoints of pond design, water utilization, feeding practices, fish density per unit of water volume, and fish husbandry methods. For convenience the industry can be divided into six basic components plus five supportive components.

The basic components are:

1) Egg Producers: there are five commercial sources of eyed rainbow trout eggs in Idaho. Of these, three are currently using the eggs produced solely for their use while the remaining two have statewide and out-of-state sales.

   At a typical brood stock or egg producing facility rainbow trout are raised to sexual maturity--usually three years--and spawned manually for three to four successive years before they are sold either for processing or fee-fishing stock. A survey of fish farms conducted in 1973 was not designed to take into account the number of eggs taken on these farms. One owner of a brood stock farm reported having taken over 50 million eggs in 1972, the majority of which were sold to fish farmers in other states.

2) Growers: there are 14 separate companies (28 farms) raising rainbow trout in Idaho. In addition, one is raising channel catfish, three are raising coho salmon on a trial basis, and one is raising cutthroat trout.

   In this type of operation, salmonid eyed-eggs are hatched and the resultant fry are raised to either market-size or farm pond stocking size. Some fish are live-hauled to other states for stream stocking and for fee-fishing operations. Approximately 10-14 months are required to produce a market-size fish in 59° F (15° C) water. The channel catfish are received in the fingerling stage from sources outside the state.

3) Grow-out or Farm Pond Operators: in 1973 and early 1974 there were 46 individuals within a 10-15 mile radius of Buhl raising fish for

growers. In this type of operation, the grower transfered 6"-8" fish from his facility to the farm pond for rearing to market-size (approximately 12"-13"). The grower, retaining title to the fish, supplied the feed and professional assistance. The time required to produce a marketable fish in a farm pond was 4-6 months. Farm pond operators were paid on the net gain in pounds of fish. Many farm ponds did not operate the year around because of inadequate water quality and quantity. In general, the appearance of fish produced in a farm pond was better than those produced in a high density raceway situation because of the low stocking rate of fish per unit of water volume. In mid-1974, the farm pond activity was discontinued because of over-production.

4) Processors: there are six trout and catfish processing plants in Idaho, all within the Twin Falls-Buhl area. All are integrated with a fish-raising facility. Each receives fish from their associated fish raising operation and several others.

   In 1972 they processed over 20 million pounds of fish and over 18 million pounds in 1973, the decrease being due to production cutbacks to meet market demands. The fish were marketed as dressed (eviscerated) and iced, dressed and frozen, boned and frozen, boned and breaded, and continental dressed. The usual packaging was in five pound lots with each fish individually wrapped. The shipments were destined for wholesale houses all over the United States and Canada.

5) Fee-Fishing or Fish-out Pond Operators: there are at least 16 individuals raising rainbow trout and brook trout for fee-fishing. In this operation a person visiting the facility has an opportunity to catch his or her own trout dinner. A fee is charged based on either the length or weight of fish caught.

   None of these operations was visited during the 1973 and 1974 surveys because the surveys were designed to document the health and management status of commercial fish and the fee-fishing operations would have minimal input.

6) Live-haulers: at least four fish farmers ship live fish of varying sizes for stocking ponds in other states. In addition, there is one individual who contracts to haul live fish but is not associated with any fish farming operation. Affecting this venture is the increasing number of states requiring live fish and/or eggs be certified free of specified disease producing agents. At this time Idaho has no such regulations on fish or eggs entering the state.

The supportive components are:

1) Feed Manufacturers: there are at least three manufacturers of fish feed in Idaho. Two are associated with a fish raising operation, one of which produces feed for use solely within the parent operation. The other sells fish feed nationwide and also maintains an

up-to-date fish nutritional research facility. The third fish feed producer is not associated with a fish raising operation but is part of a large feed milling company.

2) Transportation: some of the fish processors maintain their own freezer trucks while the rest use public transportation--airlines, freezer trucks, stage lines--for distributing their product.

3) Construction: during the past 3-4 years many fish farms have expanded and/or updated their facilities tremendously. One farm alone in 1973 used over 10,000 cubic yards of reinforced concrete in expanding the fish raising capabilities. The economic benefit to the local construction industry is not known, nor is it known if only local workers were used.

4) Packaging Materials Manufacturers: in the majority of processing operations only boxes manufactured and printed in Idaho are used. The economic effect on state industry of this practice is not known.

5) Employment: in 1973 approximately 302 persons were directly employed in the food fish raising and processing industry in Idaho. Of these approximately 147 were involved in raising fish *per se* and 155 were involved with the processing operations (Table 12). The number of people in Idaho indirectly affected by the food fish industry is not known.

Table 12. Summary of components in the food fish industry of Idaho.

	1972	1973	1974
Employees (No.)			
Fish culture (full time)	159	132	118
(part time)	13	15	39
Processing	140	155	185
Number of facilities engaged in:			
Egg production	5	5	5
Market-size fish production	22	23	25
Processing	6	6	6
Grow-out (farm pond)	40	46	1
Number of facilities operating	25	26	28
Plus farm pond operations	(40)	(46)	(1)

Present Status

The food fish industry of Idaho is a complex, integrated food animal industry, as was described in the previous section. At the present time it ranks as the second largest food animal producing industry in Idaho (beef is the largest).

The current practice of fish husbandry in the food fish industry of Idaho consists of six basic elements: fish, container, water, nutrition, management, and money. The overall philosophy of fish husbandry might be expressed qualitatively in the following fashion:

$$\frac{\text{Management}}{\text{(Fish:Container:Water) + Nutrition}} \longrightarrow \text{Money}$$

It might be expressed verbally as the concept that the relationship of the Fish is to its Container is to the Water all plus Nutrition and all under Management results in Money. Each of these will be considered in as much detail as available data will permit (Table 13).

1) Fish: Rainbow trout are the predominant food fish raised. Channel catfish, coho salmon, cutthroat trout, and blue catfish are raised in decreasing order of amounts. In 1973 there were 26.91 million food fish raised in Idaho. As of 1 July 1974 there were 50.4 million food fish being raised in Idaho, a 5.3% increase in standing crop compared with that of 1 July 1973.

The majority of the fish were raised in 1973 for marketing as processed fish. About 0.75 million fish were transported alive for stocking in waters in other states. Less than 0.25 million fish were maintained as brood fish or spawners.

2) Container: The types and dimensions of containers (ponds, raceways, troughs, vats) used to raise food fish are quite varied. Only the more recently established fish farms are using uniformly designed fish raising containers. The older fish farms have highly varied types of containers--with many types appearing on the same farm.

In 1973 there were 1,060 ponds with a water capacity of 12.66 million cubic feet used to raise food fish. During 1973 several fish farms increased their fish raising capacities by as much as 50%. One farm alone increased its production capabilities by 100 ponds containing 1.1 million cubic feet of water.

The majority of the containers are designed for multiple use of water; i.e., flowing from one pond to another as many as six times before it is discharged. In general, the construction of the majority of containers is reinforced concrete with the older farms having ponds of either dirt or board walls with gravel bottoms. As these deteriorate to the point of being nonfunctional they are replaced with reinforced concrete walls and bottoms.

All the ponds except a very few are capable of being drained completely as well as remaining dry for extended periods. Those ponds in series must be drained as a unit since there is no collateral water supply permitting the isolation of any one pond.

Table 13. Summary of production data for the food fish industry in Idaho.

	1972		1973		1974	
Production (lbs x 10^6 live-weight)	23.03		19.22		22.31[i]	
Number of eggs eyed and shipped or incubated (x 10^6)	62.58		165.32		ii	
Fish on hand at survey (x 10^6)	Nos.	Lbs.	Nos.	Lbs.	Nos.	Lbs.
Eggs	-	-	-	-	3.54	na
1"-3"	-	-	-	-	18.1	0.059
3"-6"	-	-	-	-	15.0	0.556
6"-9"	-	-	-	-	10.3	1.774
9"-12"	-	-	-	-	6.4	3.050
12"	-	-	-	-	0.6	0.553
	-	-	47.75	5.678	50.4	5.993
Mortalities (%)						
Eggs	16.5		18.4		ii	
1"-3"	15.5		16.0		ii	
3"-6"	6.5		12.7		ii	
6"-9"	)		5.6		ii	
9"-12"	) 6.4		3.8		ii	
12"	)		1.5		ii	
Cumulative	44.9		58.0		ii	
Number of fish produced (x 10^6)	38.65		26.91		31.23[i]	
Ponds						
Number	997*		1060*		1110*	
Volume (cu. ft. x 10^6)	10.83		12.66		13.75	
Water flow (cfs)						
Permit	2363.8		2663.8		2663.8	
Maximum	2400.2		2684.4		2684.4	
Minimum	1802.4		2174.0		2109.6	
Feed conversion (lbs feed/lb gain)	1.7		1.88		ii	
Range	1.4-2.0		1.4-2.3		ii	
Cost per pound gain (¢)[iii]	37.0		48.8		ii	

- Not recorded
* Does not include 180 farm ponds (1973-74: volume unknown; 1972: volume 4.37 x 10^6 cu. ft.)
[i] estimated
[ii] not estimatable
[iii] includes feed, labor, utility costs only--no capital amortization, etc.

3) Water: The water source for fish farms in the Twin Falls-Buhl area comes from a) the Hagerman Aquifer--1,662 cfs; b) the aquifer south and west of the Snake River--approximately 113.8 cfs. The other fish farms outside the Twin Falls-Buhl area use 296.2 cfs from various aquifers (Table 14).

The quality of the inflowing water varies with the aquifer. A summary of the water quality data for the five major water sources used for aquaculture is presented in Table 15 and 16.

Table 14. Summary of water use by Idaho trout farms, 1974.

Total use:	2,185.3 cfs
Regional use:	
Bear River Basin	22.7 cfs
American Falls-Pocatello region	386.4 cfs
Hagerman Aquifer	1,662.4 cfs
Wells or springs south of the Snake River	80.4 cfs
Surface waters south of the Snake River	33.4 cfs

NOTE: Values are flows for the day the individual farms were sampled.

Table 15. Regional water quality summary of food fish farms in Idaho.

Parameter	Bear River Drainage	American Falls-Pocatello Region	Hagerman Aquifer	Wells or Springs South of the Snake River	Surface Waters South of the Snake River
Temperature, °C	9.2	12.5	14.8	13.4	15.2
Dissolved oxygen, ppm	5.20	9.26	9.61	9.12	9.3
pH	7.25	7.69	8.13	7.94	7.99
Specific conductance µmhos at 25° C	2024	1276	986	1915	1793
Alkalinity, ppm as $CaCO_3$	350	199	166	319	267
Nitrate nitrogen, ppm	2.22	1.38	1.16	4.12	3.37
Phosphate, P, ppm	0.035	0.042	0.019	0.018	0.050
Calcium hardness ppm as $CaCO_3$	(1) 359	170	117	228	189
	(2) 256	121	68	98	136
Total hardness, ppm as $CaCO_3$	(1) 633	306	216	382	351
	(2) 548	287	172.9	335	311
Ca, ppm	102.5	48.3	26.5	39.1	54.5
Na, ppm	37.0	40.8	36.0	88.9	77.0
K, ppm	4.8	6.4	6.9	7.9	7.4
Mg, ppm	71.0	28.9	25.0	41.9	42.5

(1) Hach kit determinations made on site.
(2) Back calculations from Atomic Absorption Spectrometric analyses.

Table 16. Water quality summary for all food fish farms combined, 27 farms.

Parameter		Mean	Range
Temperature, ^{o}C		14.8	9.2-29.0
Dissolved oxygen, ppm		8.7	5.20-11.15
pH		8.0	7.25-8.48
Specific conductance, μmhos at 25^{o} C		1234	648-2296
Alkalinity, ppm as $CaCO_3$		195	127-350
Nitrate nitrogen, ppm		1.94	.45-5.02
Phosphate, P, ppm		0.027	0.008-0.147
Calcium hardness, ppm as $CaCO_3$	(1)	153	80-359
	(2)	96	25-142
Total hardness, ppm as $CaCO_3$	(1)	273	163-653
	(2)	226	103-548
Ca, ppm		38.10	10.00-102.50
Na, ppm		48.00	22.50-107.50
K, ppm		6.88	4.00-12.50
Mg, ppm		30.36	16.50-71.00

(1) Hach kit determinations made on site.
(2) Back calculations from Atomic Absorption Spectrometric analyses.

The majority of fish farms in the Twin Falls-Buhl area discharge water from the ponds directly into the Snake River. Several fish farms discharge water from the ponds into streams 1-2 miles from the point where they enter the Snake River. Three fish farms in the Clear Lakes area near Buhl discharge approximately 750 cfs water into Clear Lake which overflows into the Snake River.

The quality of the discharge water leaving the fish farms is not recorded collectively. Each fish farm in applying for its interim water discharge permit did conduct or have conducted certain water quality determinations; however, this information was not available for presentation in this report. In general, it might be assumed that the quality of the discharge is altered with respect to suspended solids, settleable solids, BOD, and ammonia at several times during the day depending upon the feeding and pond cleaning schedules. It might also be assumed that each individual fish farm has its own "thumbprint" with respect to water discharge quality because of the great variation in pounds of fish raised per unit of water flow or volume between any two fish farms. If Willoughby's assumptions on the pollutional effects of fish farms are correct (Willoughby, 1972), then during 1973, 19 million pounds of fish were fed 35.7 million pounds of feed resulting in 10.7 million pounds of waste material (uneaten feed, undigested feed, fecal material, metabolites) being discharged from fish farms in Idaho. On a daily basis there is an estimated standing crop of 6.5 million pounds of fish being raised. They are fed, on the average, 3% of their body weight or 195 thousand pounds of feed daily. At the current feed conversion rate of 1.8, 58.5 thousand pounds of solid waste are produced daily. It is unfortunate that these assumptions stand unverified.

4) Nutrition: In all cases recorded, fish farms are using dry pelleted feeds to satisfy the nutritional requirements of the food fish being raised. Of the 24 fish farms visited, 13 are using bulk feed stored in free-standing, outside bins, 20 are using sacked feed kept in dry storage rooms, and 11 are using both bulk and sacked feeds.

There are five brands of feed being used in Idaho food fish farms: Rangen's, Silver Cup, Moore-Clark, Two-B's, Shamrock, and IdaBest. Rangen's, Shamrock, and IdaBest are manufactured in Idaho. Moore-Clark and Silver Cup feeds are manufactured in Utah. The brands of feed are distributed among the fish farms visited as follows:

Rangen's only	10
Rangen's and IdaBest	1
Rangen's and Silver Cup	7
Rangen's, Silver Cup, and IdaBest	1
Silver Cup and Two-B's	4
Rangen's, Silver Cup, and Two-B's	1
Rangen's and Shamrock	1
Silver Cup and Moore-Clark	1
Rangen's, Silver Cup, and Moore-Clark	2

During 1973, the fish farms ranged from $350 (the price per ton f.o.b.) to $480 depending upon the brand, pellet size, and feed ingredient price fluctuations. Prices had declined somewhat by mid-1974.

Methods of feeding fish are varied depending upon the fashion in which the ponds are laid out. Manual feeding or broadcasting is practiced at all fish farms with 11 using it as a sole means of feeding fish. Truck-mounted or track-mounted blowers are used at 12 fish farms in conjunction with manual feeding. The blower feeding method uses bulk bins with motor-driven blowers to propel the feed through large bore pipes out over the ponds as the vehicle is driven beside or over the pond. There is one farm using automatic feeders and one using demand feeders for small fish. At most farms the daily amount of feed required is based upon a percentage of the body weight of the fish. A chart listing suggested feeding levels for different sizes of fish in water from 40-60° F (4.44-15.56° C) is available from all feed manufacturers. The majority of the fish farmers, however, have established their own feeding levels based upon desired rate of growth, water flow, and past experience.

5) Management: The subject of management as it applies to fish husbandry encompasses the application of many techniques to raise food fish profitably. Each individual fish farm has its own unique set of criteria for evaluating and implementing one method over another. In some operations the design is such that only a particular method of management may be used--in others, the design is such that a great deal of flexibility in choice methods is present.

One of the basic considerations of fish farm management is having a good system of records so the orderly flow of activities can be followed. Data on pond loading, feed levels, mortality, and weight or length gain all permit management forecasting. All the fish farms use some sort of record-keeping method; however, not all are consistent--even on an individual farm--as record-keeping is considered to be the drudge work of raising fish. It is very easy to let a day or two go by without making an entry and not feel any immediate consequences; however, they are usually felt later.

Fish husbandry management is arbitrarily divided into four phases each dealing with a specific age group of fish: eggs, fry (1"-3"), fingerlings (3"-6"), stockers (6"-12"), and marketables (12"+). Each has its unique water, container, nutritional, and therefore, management requirements.

a) Egg Incubation: Fish farms other than those maintaining brood stock receive eyed-eggs from commercial sources within Idaho or from other states. These eggs are usually shipped by air freight in iced trays. When the eggs are received they are acclimated from ice water temperature to the incubation temperature used at the farm--usually 56-58° F (13-14° C). This must be done slowly over a period of hours to prevent death of the embryos.

When the eggs are acclimated to incubation temperature they are placed in shallow trays in a single layer or in baskets many layers deep. Trays of eggs are either stacked into deep troughs with baffles to provide upwelling currents of water through each stack or in Heath incubators in which water flows through each tray in an upwelling direction beginning with the top tray and progressing to the bottom tray. The baskets are either placed into deep troughs or into incubation boxes--in both the water flow is upwelling at a rate to gently roll the eggs. The time usually required for hatching is 21-23 days in 56-58° F (13-14° C) water.

In 1973, the food fish industry eyed an estimated 165.32 million salmonid eggs of which 50.47 million were incubated for hatching. The loss during the incubation period was 18.4% or 9.29 million eggs. The major cause of loss was egg infertility. Smothering due to silt and low water flow ranked next in importance.

b) Fry: In all fish farms the emergent yolk sac fry are removed from the incubating trays or baskets and put into either shallow or deep troughs. When nearly all the sac fry have absorbed their yolk material ("buttoned up") they are started on feed dispensed either by hand or from automatic feeders. They are fed several times during the day an amount based upon the feed formulation approximately 7-9% of their body weight depending upon the water temperature. This management phase lasts for 3-5 weeks depending upon the facilities.

In 1973, 50.47 million eggs developed into 41.18 million fry. Of these 6.59 million (16.0%) died from various causes--chief among which were the respiratory diseases.

c) Fingerlings: In this phase the fish are in outside ponds and are growing rapidly--in some cases over an inch per month. The fish are fed according to charted levels--about 4-5% of their body weight daily depending upon the water temperature. During this phase the stocks are inventoried by number of fish per pound and total pounds once or twice a month and are distributed to other ponds when the density of fish so indicates. On some fish farms the fish are separated or "graded" by size groups at the time they are distributed to new ponds.

In 1973, 41.18 million fry developed into 34.59 million fingerlings. Of these 4.39 million (12.7%) died of various causes--chief among these were respiratory diseases and "redmouth" disease, a systemic bacterial infection.

d) Stockers: During this management phase the fish either are transported to farm pond (grow-out) operations, fee-fishing establishments, or remain on the farm until they are of processable size. Inventorying and grading are done at monthly intervals at most fish farms. Since the growth rate has slowed appreciably, the level of feeding drops down to 1-3% of the body weight of fish per day depending upon the water temperature.

In 1973, 34.59 million fingerlings developed into 30.20 million stockers. Of these 3.29 million (10.9%) died of various causes--chief among which were systemic bacterial diseases and noninfectious (management) diseases.

e) Marketables: In this phase of management the fish are of market-size and are shipped from the rearing ponds to the processing plants. During 1973, 26.91 million food fish were processed or were sold as live fish.

The mortalities in this group were not estimated but many did occur. The main cause of death was attributed to mechanical injury during the harvesting procedure. Harvesting was done by crowding the fish into the lower end of rearing ponds and removing them by the netsfull to be transported in hauling tanks to the processing plant. In the majority of cases the dead fish were not rendered unsuitable as food; thus, the financial loss was negligible.

6) Money: The economy of the Idaho food fish industry is one of slow growth until after World War II. During the 1950's and 1960's the gross value increased at a virtually exponential rate. This growth slowed somewhat in 1970-71. In the years 1972-74, the years for which considerable economic data are available, economic growth fairly well levelled off (Table 17).

The primary reasons for the leveling have been: increased labor costs, increased feed costs, steady product prices, increased inventories of frozen fish, increased loss of fish during the rearing period. Each of these items will be discussed as they related to one another and to the entire industry in the section dealing with factors affecting the industry.

Table 17. Economic analyses of production data for the food fish industry of Idaho during 1972-74.

	1972	1973	1974
Cost per pound produced (¢)	37	48.8	-
Labor (50.4%)	18.6	24.5	-
Feed (48.3%)	17.8	23.5	-
Utilities (1.3%)	.5	.6	-
Average price paid per lb. ($)			
Round weight	.53	.67	.63
Dressed	1.22	1.16	1.40
Boned	1.45	1.39	1.65
Pounds x 10^6 produced (round weight)	23.03	19.22	22.31[i]

[i]Estimated

State and Federal Hatcheries in Idaho

Currently, Idaho Fish and Game Department operates 20 trout and salmon hatcheries. Seventeen are in the Snake River and Salmon River drainages. The remaining three are in the Pend Oreille-Coeur d'Alene drainage. The Department plants live fish in nearly all the public fishing waters in Idaho. In 1973-74 over 26 million fish were distributed at a production-distribution cost of $0.43 per pound (Table 18). A comprehensive report on these hatcheries is presented by Kramer, Chin, and Mayo (1972).

Table 18. Summary of 1973 production by conservation hatcheries in Idaho.

	National Fish Hatcheries	Idaho Fish and Game Department
Number of hatcheries	3	20
Employees - full time	28	27
part time	18	16
Ponds - number	182	343
cubic feet	393,900	1,514,643
Water - use (cfs)	156.2	543.3
turnover (min)	42	32.2
Fish distributed		
Nos. x 10^6	11.156	26.241
Lbs x 10^6	0.716	1.050
Food conversion	1.9	1.9

The U.S. Fish and Wildlife Service operates three National Fish Hatcheries in Idaho. Two are on the Clearwater River drainage and one in the Hagerman area of the Snake River. In 1973-74 over 11 million fish were distributed from these hatcheries at a production-distribution cost of $0.78 per pound.

The overall philosophy of managing a conservation hatchery--whether it be state or federal--differs greatly from that of a commercial fish farm. First, conservation hatcheries are allocated a fixed sum of money with which to raise fish for release. In other words, their product results from money. The commercial fish farms, on the other hand, tend to be production rather than product oriented in that their production results in money. Second, fish in conservation hatcheries are generally not as crowded or pushed nutritionally as those in a commercial facility. The reason for this being that the conservation fish is expected to be able to fend for itself for extended periods of time--often years--following release. Research data indicates that fish destined for release to the wild contribute more to the fishery if they are raised in conditions which approximate those into which they will be released. A similar analogy may be seen in comparing range cattle with feedlot cattle.

Factors Affecting Commercial Aquaculture in Idaho

The main positive factor affecting the aquaculture industry of Idaho is its consolidation into three adjacent counties. With the exception of three owner-managed farms the fish raising segment of the industry is headquartered within a few miles of Buhl. This has a tremendous impact on the economy of the area by contributing $20-25 million of outside money to the overall financial picture. The outside money comes chiefly from the sale of processed trout throughout North America. In addition, out-of-state feed sales by one of the nation's major fish feed manufacturers located in Buhl and out-of-state sales by a growing fish culture equipment manufacturer in Twin Falls contribute significantly to the local economy. Knowledgeable estimates have placed the entire gross contribution to the economy of Twin Falls, Gooding, and Jerome counties at over $30 million annually. These observations must be taken into account when any activities which may directly or indirectly affect the industry are considered.

In addition to the financial contribution to the economy of three counties, the industry is consolidated into two and perhaps three legislative districts. The fish farmers are thereby afforded a sizable legislative lever should they decide to take advantage of it.

One drawback to the geographic consolidation is on the available labor force. In the Buhl-Twin Falls area several industries; i.e., plastics, feed manufacturers, machinery manufacturers, compete with the fish farmers for unskilled labor. This, in part, explains the great turnover in labor force in the fish farms.

At the present time the food fish industry is not organized per se. Several prominent members of the industry are reconsidering the benefits and drawbacks of forming an Idaho Food Fish Commission, which was considered in depth last year but failed to receive total industry support. The locating of the executive offices of the United States Trout Farmers Association in Buhl will have an additional impact on consolidating the food fish farmers so that their interests will have some cohesive influence at the state and federal levels.

From the foregoing section on the present status of the food fish industry in Idaho, several negative factors are apparent which affect the present status as well as production potential in years to come. Among them are: marketing, loss-of-production potential, increased feed costs, labor, water development practices, and management practices. Each of these is sufficiently significant to merit some in-depth discussion.

1) Marketing: The major concern about marketing of food fish was stated in an earlier section; namely, current practices are inadequate to promote increased sales of food fish over the counter or in restaurants. The majority of trout processors have the largest inventory of frozen, processed fish they have ever carried. Some producers have resorted to live sales rather than increasing their inventory. The food animal industry unlike hard-goods industries, must move their product when it is a certain size or it becomes a financial liability--it keeps on growing and must be fed to keep it presentable for the consumer. Today's 5 million pounds of live marketable fish on hand will become next week's 5 million plus several thousand pounds of live economic liability.

The primary problem with marketing, as was discussed earlier (see page 39), is that it has been guided by production rather than the other way around. This fact is evident in the numbers of over-sized fish on hand and the size of the frozen inventory in storage. Too few of the companies maintain an adequate sales, merchandizing, and marketing staff.

The secondary problem with marketing is its expense. A good advertising campaign for a product is expensive and must, therefore, be supported by the sponsoring industry. The U.S. Trout Farmers Association is a trade association with good marketing connections. This past year nationwide financial support from the USTFA from the trout farmers and feed manufacturers was inadequate to maintain the organization at the level it was operating. As a result, the association was forced to discontinue its Washington, D.C. office (and staff) and its bimonthly publication. Plans now are to regroup the USTFA and to retain what advertising it can afford. Association news will be disseminated through one of the two remaining aquaculture publications: "The Commercial Fish Farmer and Aquaculture News" and "Aquaculture and the Fish Farmer."

2) Loss-of-production Potential: In 1970 the cost of producing a pound of rainbow trout in Idaho was \$0.37. This included the price of the egg (\$0.35) and the feed and labor costs. In 1973 the cost of producing this fish was \$0.488 per pound--a 24.2% increase.

The financial losses due to dead fish were estimated to be $553,250 in 1972 and $904,300 in 1973--a 39% increase (Table 19). These figures were derived from the purchase or production costs of the following:

1) Eggs cost $3.50 per 1,000 in 1972 and $4.50 per thousand in 1973 or $0.35 and $0.45 each for 1972 and 1973, respectively, f.o.b. the egg producer's farm.

2) 1"-3" group: 2" fish were worth $0.54 each ($0.19 for feed and labor plus $0.35 egg cost) in 1972. They were worth $0.70 each ($0.45 egg cost plus $0.25 for feed and labor) in 1973.

3) 3"-6" group: 4.5" fish were worth 2.1¢ each (1.8¢ for feed and labor plus 0.35¢ egg cost) in 1972. They were worth 2.82¢ each (2.37¢ for feed and labor plus 0.45¢ egg cost) in 1973.

4) 6"-12" group: 9" fish were worth 15.8¢ each (15.5¢ for feed and labor plus 0.35¢ egg cost) in 1972. They were worth 20.90¢ each (20.45¢ for feed and labor plus 0.45¢ egg cost) in 1973.

The feed and labor costs were derived from the average production costs per pound exclusive of capital outlay. The average weight per fish in each group was obtained from the Manual of Fish Culture, Appendix A.I (Bowen and Studdard, 1970).

Table 19. Production and loss estimates for 23 food fish farms in Idaho during 1972-73.

	Production					
	Nos. (millions)		Cost $ (thousands)		Cost ¢ (each)	
	1972	1973	1972	1973	1972	1973
Eggs	62.58	50.47	219.0	227.1	0.35	.45
1"-3"	52.26	41.18	282.2	288.3	0.54	.70
3"-6"	44.16	34.59	927.3	975.4	2.1	2.82
6"-12"	41.29	30.20	6,523.0	6,312.0	15.8	20.90

	Loss					
	% Prod. Nos.		Nos. (millions)		Cost $ (thousands)	
	1972	1973	1972	1973	1972	1973
Eggs	16.5	18.4	10.32	9.29	32.12	41.8
1"-3"	15.5	16.0	8.1	6.59	43.74	46.1
3"-6"	6.5	12.7	2.87	4.39	60.27	128.8
6"-12"	6.4	10.9	2.64	3.29	417.12	687.6
				Total	553.25	904.3

Comparing the percent of total loss each group constitutes for 1972 and 1973, they are quite similar (Table 20). The numerical loss in the egg and 1"-3" groups declined in 1973 but the numerical and monetary losses in the 3"-6" group nearly doubled. The cause for this was not determined because it became obvious some time after the survey was completed and neither time nor financing permitted a follow-up study. However, these data should be taken into account by the food fish farmers for future planning.

Table 20. Percent total financial loss by size groups.

	1972	1973
Eggs	6	5
1"-3"	8	5
3"-6"	11	14
6"-12"	75	76

The actual loss-of-production potential was not calculated because of the limited data available. Before this can be done with some measure of validity the baseline (or "normal") mortality in each size group must be determined. Just from looking over the data available, it should be safe to assume that the loss-of-production potential (or the money lost by fish dying instead of going to market) was substantial in 1972 and was more so in 1973.

The mortalities in each of the four age groups of fish; i.e., eggs, 1"-3", 3"-6", and 6"-12", varied significantly among the fish farms. However, the overall mortality was quite uniform among them. The approximate ratio of infections disease mortalities (Table 21) to noninfectious disease mortalities (Table 22) were 4:1 overall. Most of the respondents did agree, nonetheless, that many outbreaks of infectious disease were precipitated by handling or crowding stresses.

The major cause of egg mortalities was infertility. Fungus (Saprolegnia sp.) and silting were minor causes of egg loss.

The most frequent cause of mortalities in 1"-3" fish was gill disease. It could not be determined if this was bacterial gill disease or some other form of gill disease. All respondents who reported having severe problems with gill disease stated that outbreaks were abated in most cases by using one of the many external antimicrobial drugs. Thus, it could be assumed that bacteria were in some way involved with the disease outbreak. Infectious pancreatic necrosis and infectious hematopoietic necrosis outbreaks were sporadic in 1972 and 1973; however, the resultant mortalities were usually quite high. The most frequently occurring noninfectious disease problem in this age group was fin erosion, which is considered to be a management problem aggravated by crowding and prolonged suboptimal feeding levels. Although

Table 21. Percent mortalities in four age groups by major cause in 23 private fish-raising facilities in Idaho in 1972 and 1973.

	Egg		1"-3"		3"-6"		6"-12"	
Disease	%	No. Farms	%	No. Farms	%	No. Farms	%	No. Farms
Gill disease			5-35	13	1-10	10	1-3	9
Hagerman redmouth			20	1	1-10	10	1-5	9
Aeromonas redmouth					2-10	6	1-7	7
Furunculosis			5	1	1	1	3-5	2
Columnaris							NE	4
Bacterial kidney disease					2	1	1	1
Saprolegnia sp.	NE	4			NE	4	NE	5
Ichthyophonus					NS	6	NS	7
Protozoa					NE	12		
Metazoa					NE	12		
Infectious pancreatic necrosis			5-60	4	30	1		
Infectious hematopietic necrosis			10-50	2	30	1		

NE - Not Estimated
NS - Not Significant

Table 22. Incidence of major noninfectious diseases in four age groups in 23 private fish-raising facilities in 1972 and 1973.

	Egg		1"-3"		3"-6"		6"-12"	
Disease	%	No. Farms	%	No. Farms	%	No. Farms	%	No. Farms
Fin erosion			1-50	10	1-80	20	1-80	20
Tail erosion					1-50	13	1-50	14
Soreback					2-5	10	2-5	12
Strawberry disease							1-2	4
Low dissolved oxygen	10	2	2-10	7	2-10	7	NE	6
Ammonia			NE	6	NE	6	NE	6
Crowding			10-20	2	0.5-2	8	0.5-3	5

NE - Not Estimated

there were no mortalities attributed to fin erosion, the incidence was sufficiently high to reduce productivity of affects lost of fish.

The most frequent causes of mortalities in the 3"-6" fish were gill disease and "redmouth" disease. Again, it could not be determined if this was truly bacterial gill disease; however, treatment with external antibacterial drugs was effective in most cases. The "redmouth" disease mortalities were due to infections of either RM bacterium (the causative agent of Hagerman Redmouth Disease or Enteric Redmouth Disease as it is now called) or Aeromonas liquefaciens (the causative agent for Bacterial Hemorrhagic Septicemia). Either type was controlled by feeding systemic antibacterial drugs. There were many cases in which the incidence of the disease was quite low and the disease was allowed to run its course without treatment. In these cases, the resulting total mortality was often greater than if treatment were instituted.

The incidence of fin erosion, tail erosion, and "soreback" in the 3"-6" fish was very high in 1972 and 1973. The effect of these diseases was great in that the fish would become esthetically unappealing. The only effective treatment was to reduce the numbers of fish per pond--an impractical measure according to most fish farmers.

The most frequent causes of mortalities in the 6"-12" fish were attributed to "redmouth disease, gill disease, and furunculosis. Most respondents also recorded having had significant die-offs due to handling stresses and low dissolved oxygen. In this size group the chief problem was the high incidence of fin erosion, tail erosion, "soreback", and "strawberry" disease, however, these conditions seldom caused death. Fish with soreback or strawberry disease were withheld from distribution or marketing until the erosions disappeared with the result that they grew beyond optimum market size and had to be sold at a loss.

3) Increased Feed Costs: In the past two years fish meal, the main protein constituent in fish feed, became in very short supply. The Peruvian fish meal industry was facing a disaster because of the lack of fish off their coast which was brought about by climatic changes and the previous years of overfishing the resource. This sent the prices of fish feed ingredients soaring to unprecedented heights. Prices began to decrease within the past few months but they are still very high, according to most fish farmers.

The fate of the Peruvian fish meal industry is still in doubt. The trout feed manufacturers are having to find acceptable substitutes for it such as soybean meal and Alaska herring meal.

4) Labor: During the 1974 survey many fish farm managers remarked that the labor turnover in the past year had been more than usual. In their opinions, young people are not attracted to this type of work because of the low pay scale; but the hourly wage cannot be raised because of the already shrinking profit margin. At the present time labor constitutes an estimated 50.4% of the production costs and an undetermined portion of the processing costs.

Persons starting out as inexperienced fish culturists are paid the minimum scale. Their tasks include cleaning ponds and screens, picking up dead fish, cleaning ponds, feeding fish, and maintaining the grounds around the fish farm. Later they can "graduate" into grading fish by size and weight to equalize pond loadings and selecting market-size fish for processing. Since raising fish is a seven-day a week profession, the individual sometimes is asked to take his or her normal weekend in the middle of the week. All these tend to discourage individuals who have never been exposed to this way of life previously. As a result, they seek employment where they are not in water eight hours a day and are paid more with an opportunity for more rapid advancement.

There is also a shortage of fish culture-oriented college graduates, according to several fish farm managers. The reason for this is that few universities offer curricula or even specific courses in fish culture and disease. Even fewer offer continuing education courses in the aquacultural sciences for persons already in the industry.

5) Water Development Practices: When the fish farm managers were questioned during the 1974 survey about their views of future water availability, they unanimously responded that they were highly concerned about it. The most commonly recorded statement was, "I would like to see the spring flows stabilized." At the present time many of the springs in the Twin Falls-Buhl area decrease in flow measurably during certain times of the year. The decrease is thought to be associated mainly with the diminished recharge of the aquifer in the eastern part of the state. One farm during this period is forced to reduce its fish carrying capacity by nearly one-third because of diminished spring flows. Also during February 1974 the temperature of Niagra Springs dropped to 54-55° F (12-13° C). After several weeks they returned to their historic constant 59° F (15° C). This was speculated to be due to changes in aquifer recharge pattern.

The fish farmers in the Thousand Springs area of the Snake River are very concerned about the possibility that legislation might allow future depletion of the spring flows in this area back to their historic levels--some 2,000 cfs below the recorded average flow of 6,000 cfs. If this were to occur, a severe hardship would befall the aquaculture industry in this region. Fish farms have been operating here since the late 1920's and, because of the available water, have increased in number. If the current flow were to be reduced, approximately one-third of them would be forced out of business or into capital outlay to recondition water.

6) Management Practices: In the past 2-3 decades of intensive fish culture in the United States there has been very little innovative application of newly developed fish husbandry methods. The majority of the new methods have been developed by the state and federal fish hatchery systems and are, for the most part, unsuited to raising commercial fish.

Management practices, as was stated previously, embodies the orderly flow of fish husbandry techniques for the eyed-egg stage to the time when the fish enters the processing plant. They should be designed so as to

Management practices

permit adequate forecasting of production to enable the marketing segment to sell the product for the best price. Inherent in the orderly flow of activities is the application of methods to keep the production costs at a minimum by decreasing the incidence of diseases--both infectious and noninfectious. To accomplish this, special attention must be paid to pond loadings, feeding techniques, growth rates, water flows through ponds, and fish handling techniques. All of these, optimized, will result in a better product for less cost of production.

It was gratifying to see during the 1974 survey that some farms were forecasting the growth of fish by applying projected pond-by-pond feeding regimens. This has not occurred before. However, before this technique becomes beneficial more precise methods of determining numbers of fish per pound and total pounds of fish per pond must be devised. Current methods give results that are difficult to apply to projections of growth with any great degree of validity.

Appraisal of Future Needs

Any discussion of the future of the food fish industry must center about the availability of water in adequate quantity and quality. At the present time all rainbow trout farms, except for many farm pond operations, use free-flowing spring water with no standby pumping capabilities. Some farm pond operations use diverted surface run-off from irrigation canals in which to raise fish. The only catfish farm operating in the state uses 90° F (32° C) water from a pumped well.

In 1973, the pounds of fish per cfs was 8,030--a decrease from 10,960 pounds per cfs in 1972 (Table 23). Under current management methods, a rule-of-thumb is that one cfs can support an annual fish production of 10,000 pounds. Water flow through the ponds should be such that there is complete replacement of the water every 30-45 minutes.

Table 23. Analyses of production data in the food fish industry of Idaho during 1972-74.

	1972	1973	1974
Pounds produced per man-year	141,723	140,909	173,754
Pounds produced per cfs	10,960	8,030	9,578
Pounds produced per cu. ft. water	2.13	1.52	1.62
Average water replacement time in ponds (min.)	75.2	88	98

In 1973 the average replacement time was 88 minutes--a decrease in turnover time from the 75.2 minutes estimated in 1972. This implies that more cubic feet of ponds are producing less fish per cfs of water in-flow. The projected 1974 figures are even more foreboding--the turnover time is estimated to be 98 minutes and the production per cfs at 9,578 pounds. As the turnover time increases the fish carrying capacity of a cubic foot of water decreases because of decreased oxygen and increased ammonia. Currently water is used as single-pass flow-through with reuse an average of 2-5 times. Between ponds water falls 1-4 feet from the outfall of one pond into the head-end of the successive pond thereby permitting an estimated 90% replacement of dissolved oxygen.

With few exceptions, water from fish farms is discharged untreated into the Snake River or into receiving streams which enter the Snake River a mile or so distant from the fish farm. This discharge has the following qualitative characteristics:

Reduction of dissolved oxygen
Increased amounts of: carbon dioxide
ammonia-nitrogen
nitrite-nitrogen
nitrate-nitrogen
phosphate-phosphorous
suspended solids
settleable solids
Increased biological oxygen demand (BOD).

The quantitative aspects of the effluent vary with the amount of water, turnover time, pounds of fish in the system, feeding level, and pond design. The proposed EPA effluent guidelines (see Section IV) will regulate the amounts of each in the discharge by limiting the amount of suspended and settleable solids per weight of fish in the system.

What, then, are the possible alternatives to be considered by the food fish industry and water resource agencies in order for the industry to maintain its viability, let alone meet its anticipated growth levels? The following are several possibly applicable methods to resolve this critical problem:

1) By 1980 the following could be done:

a) Concrete line all existing dirt ponds.
<u>Justification</u>: This will increase the carrying capacity, decrease disease incidence, decrease labor costs, increase self-cleaning action, and increase water utilization efficiency.

b) Redesign and construct new ponds rather than renovate "tired" ponds.
<u>Justification</u>: New pond designs afford increased water utilization efficiency, increased fish production, decreased labor costs, decreased disease incidence, and increased self-cleaning action.

c) Implement innovative fish husbandry practices.
<u>Justification</u>: Many new methods of forecasting fish production

have been devised. Their application will increase production, decrease the cost of production, increase product quality, increase water utilization efficiency, and decrease the loss-of-production potential. Implementation of new methods will be facilitated through continuing education in the form of short courses, self-study, or correspondence courses, and services supplied by state and federal agencies.

d) Implement effluent treatment methods to comply with the EPA regulations (Table 24).
<u>Justification</u>: Permit limitations for effluent from individual fish farms will require that one of the listed methods (or suitable equivalent) be an integral part of the fish farm operations.

Table 24. Pollutant load achievable through alternate methods of treating effluent from flow-through systems.

Treatment Method	Suspended Solids[b]	Settleable Solids[a]
No treatment	2.6	0.8
Settling of cleaning flow	2.2	0.7
Vacuum cleaning	2.2	0.7 - 1977 level
Settling entire flow w/o sludge removal	1.4	<0.1
Settling entire flow w/ sludge removal	1.3	<0.1 - 1983 level
Stabilization ponds	1.0	<0.1
Aeration and settling 5-hour	1.0	<0.1
Aeration and settling 10-hour	-	<0.1
Recycle reconditioning	0.3	<0.1

[a]Reported as ml/1 Source: EPA, 1974.
[b]Reported as kg/100 kg fish on hand/day except for settleable solids.

e) Investigate the possibility of raising other species of cold water food fish rather than increasing rainbow trout production.
<u>Justification</u>: Rainbow trout production places very heavy demands on available fish meal supplies for dietary requirements and on water use. The selection of a fish that would have consumer acceptance, use water of less quality and quantity than rainbow trout, and be less expensive than trout to raise should be investigated. A prime candidate would be one of the carps. Small fish could be collected from the reservoirs along the Snake River and transported to fish farm ponds to be raised to market-size. They are an herbivorous fish, thus removing the demand for fish meal. They could be raised efficiently in ponds receiving water from trout ponds thereby reducing the biological

load in the trout pond effluent and the demand for new water for increased production of food fish.

f) Investigate the possibility of using effluent from food fish farms rather than water pumped from deep wells for irrigation of agricultural crops.
<u>Justification</u>: The number of pumping wells for irrigation within a 20-mile radius of the larger food fish farms has increased significantly during the past 5-10 years. Their drawdown--real or potential--effect on the Hagerman Aquifer has never been documented.

By investigating the potential utilization of food fish farm discharge water as irrigation water several benefits to both the aquaculture and agriculture industries could be realized. Among them are: biologically enriched irrigation water (with the price and availability of fertilizer, this could be a boon), reduction of pumping and treatment costs by both industries sharing the pumping costs, thereby satisfying EPA requirements at minimal expense. The report by Ralston <u>et</u>. <u>al</u>. (1974) should be reviewed for an in-depth discussion of ground water use.

g) Investigate other methods of spring flow stabilization.
<u>Justification</u>: The food fish industry using the water from the Hagerman Aquifer is in serious jeopardy if the recharge of the entire aquifer is not intensively evaluated with all the sophisticated methods available. An industry of this magnitude and potential must be afforded the opportunity to grow. To be sure, water flows are not the only limiting factor for growth but without water all other factors cease to be important.

h) Investigate the potential of raising warm water food fish in either geothermal water or the effluent from steam-fired electrical generators.
<u>Justification</u>: The demand for high quality food fish will increase. Food fish--especially the herbivorous species--do not compete with man for space or dietary ingredients. The annual yield of fish in intensive culture systems approaches 0.5 million pounds per surface acre. Their food conversion is approximately 1.5; i.e., it requires 1.5 pounds of food to produce a pound of fish. The State of Idaho has the water quality and quantity potential to be the nation's center for high quality, warm water food fish.

2) By 1990 and 2000 the following should be done:

a) Completely re-evaluate those practices and recommendations suggested for implementation by 1980.

b) Implement the results of those investigations suggested for consideration by 1980.

The means to satisfy the foregoing alternatives and recommendations will come from legislation, policy changes, research, education, and extension services. Legislative measures and policy changes must be contributory rather than inhibitory for all industries and agencies concerned. Some suggested considerations include:

1) Legislative

a) regulations on importation of live fish and/or their products without certification with respect to certain designated agents of infectious disease.

b) statutes creating state agency involvement with the food fish industry to protect established and potential water resources for aquacultural uses.

c) statutes creating state-sponsored extension services for ongoing assistance to the aquaculture industry and providing the funds therefore jointly with the aquaculture industry.

2) Policy Changes

a) The Idaho Department of Water Resources must give high priority to the aquaculture industry of Idaho as an established nonconsumptive user of the water resources in the state. In some respects, the water resource requirements of the aquaculture industry should supersede those of the agricultural industry.

b) The U.S. Department of Commerce must initiate a program to collect, collate, and disseminate information relative to the rainbow trout and salmon industry as it has done for the catfish industry.

c) The Idaho Fish and Game Department should consider purchasing larger size (12"-16") fish for stocking purposes from commercial fish farmers rather than incurring the additional expense of raising over-legal size fish for sports fishing.

d) The riparian rights statutes should be re-evaluated to permit limited utilization of aquaculture practices for certain species in lakes and stream impoundments.

3) Research

a) Federal and state funds must be made available to promote development of innovative or adaptable methods of marketing, fish husbandry, disease diagnosis and control, and water utilization for commercial fish farms. The expenditure of such funds could have an estimated benefit:cost ratio of greater than 10:1. The results of applied research should be disseminated to the industry through seminars, short courses, and symposia.

b) Federal and state funds must be made available for basic research on fish diseases, nutrition, genetics, and physiology. Fish pond design must satisfy the basic social and mobility requirements of the species of fish to be raised. Many potential food fish species cannot be raised economically because of the lack of information concerning their dietary, space, and water requirements.

4) Education

a) Universities offering curricula in fishery sciences must include courses providing classroom and applied exposure to aquaculture. At this time the demand for educated aquaculturists exceeds the supply. A year or so ago, Paul Osborn, a fish culturist of some renown, stated that one of the trying things for him was that he had to spend some months training new employees before they could fit into his operation--even though they were college graduates.

b) Community colleges should have vocational training for future fish culture technicians. As with graduate fish culturists, the demand for fish culture technicians exceeds the supply. The educative programs will succeed if teaching faculty promote the fish husbandry profession.

5) Extension Services

a) Universities and appropriate state agencies must establish ongoing programs to provide on-site services to the aquaculture industry of Idaho. Support funds should come from both the commercial food fish industry and legislative appropriation.

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Journal of Fisheries Research Board of Canada
California Fish and Game Journal
Fish Disease Leaflets, BSFW
Fishery Bulletin, NMFS
Special Scientific Report - Fisheries, BSFW

APPENDIX

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Research Technical Completion Report
IDWR Project 45-080
April 1974 - December 1974

APPENDIX TO

A REPORT OF AQUACULTURE IN THE UNITED STATES

WITH PARTICULAR REFERENCE TO IDAHO

by

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Fishery Resources

and

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Watershed Management

College of Forestry, Wildlife and Range Sciences

Submitted to

Idaho Department of Water Resources
Statehouse Annex
Boise, Idaho 83720

September 1974

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Idaho Water Resources Research Institute
University of Idaho
Moscow, Idaho

John S. Gladwell, Director

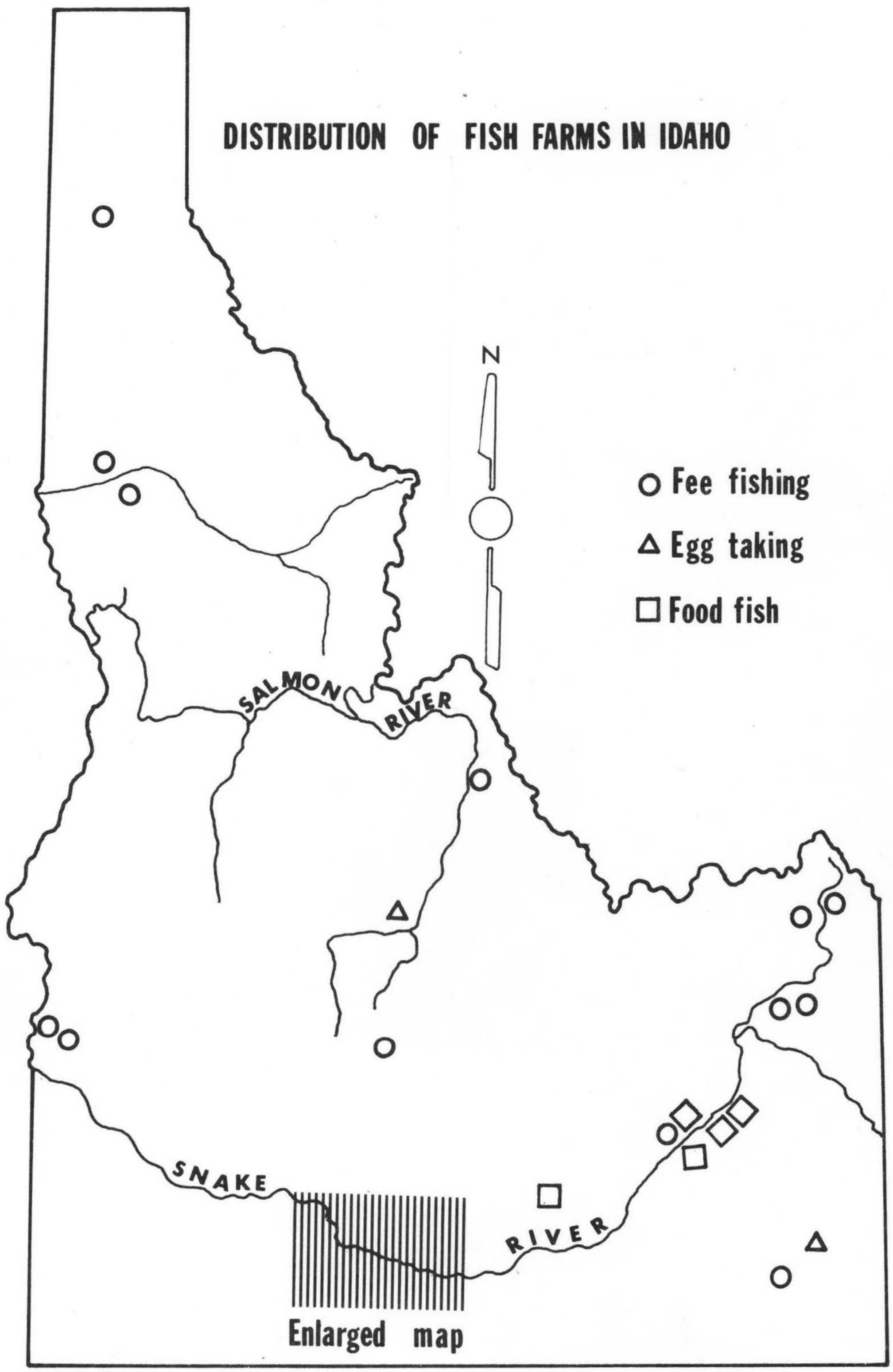
INTRODUCTION

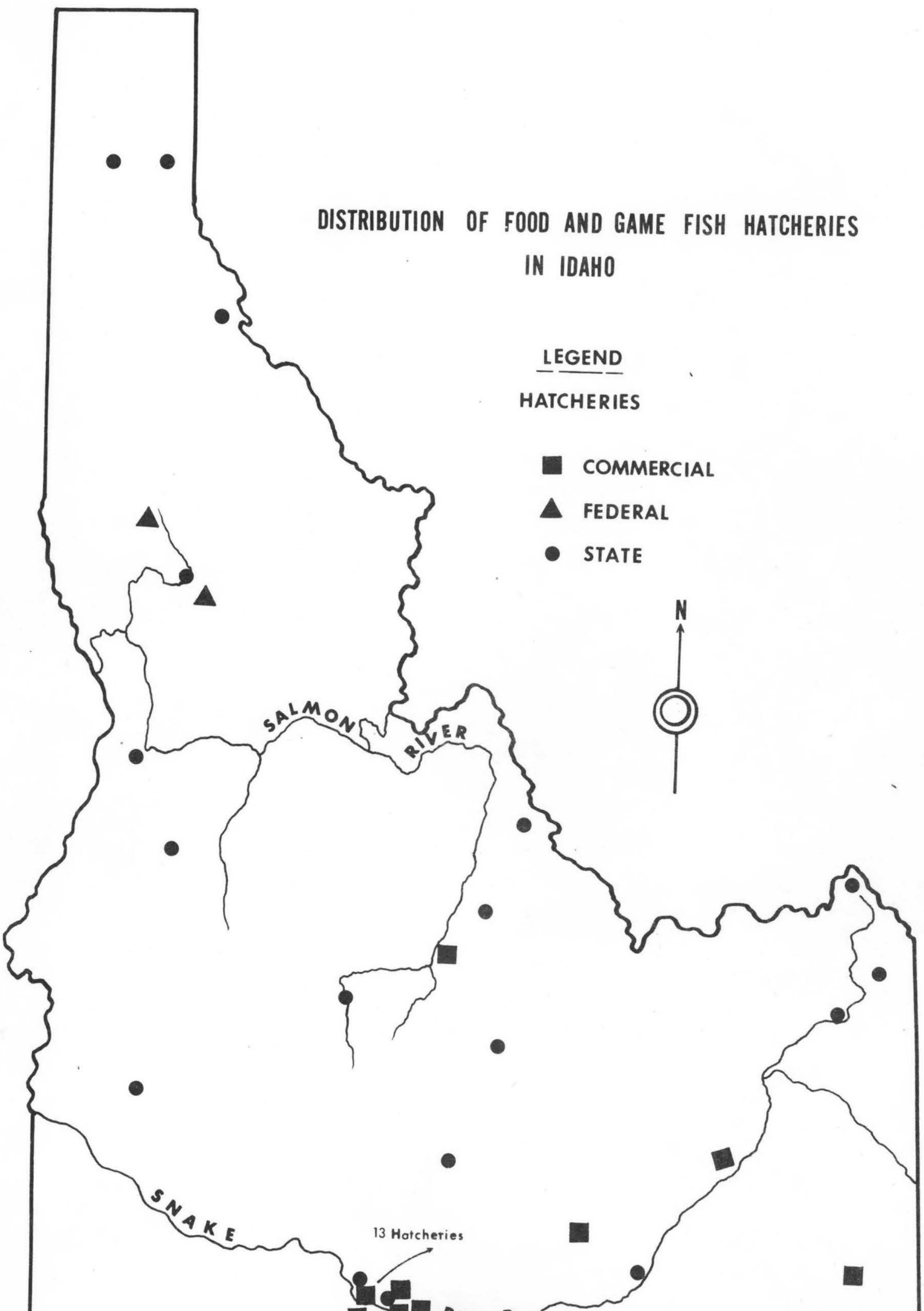
This supplement to the Report on Aquaculture in the United States with Particular Reference to Idaho contains a list of the commercial food fish farms in Idaho. Together with the list is an aerial photograph of each, a description of the water quality and quantity used by each, and a diagramatic outline of each facility to illustrate the water flow pattern. Finally, the questionnaires used during the 1973 and 1974 surveys are included to illustrate the types of data gathered.

The uses to which this supplement may be put are many. It should provide the fish farm managers with a new management perspective of their facilities. After attending to the marketing needs of the food fish industry, they must attend to the problems associated with optimal utilization of available water. In addition, the information will provide the state and federal agencies with a better understanding of the water problems--quality and quantity--of the aquaculture industry. Hopefully, ensuing regulations pertaining to the aquaculture industry will reflect some of the information collated here.

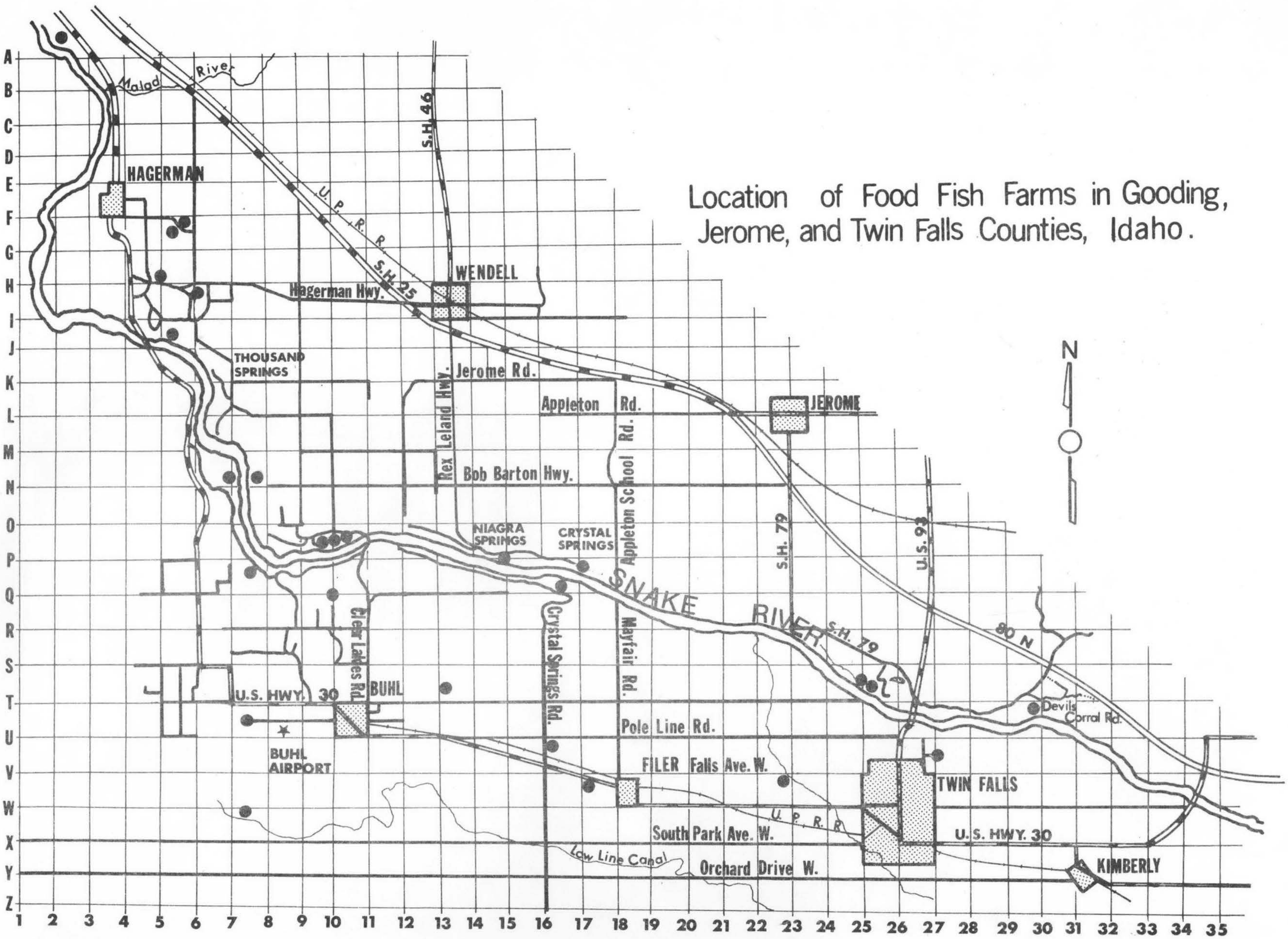
Educators responsible for providing their students with factual, up-to-date information about aquaculture should find this supplement useful. Researchers interested in studying the various fish health management problems occurring in intensive fish culture should also find this supplement beneficial to their planning.

Throughout the report and this supplement we have tried to keep from revealing the proprietary information. If any reader feels that we have revealed confidential information, we apologize. Several persons, including commercial fish farmers, reviewed the drafts and we followed their suggestions explicitly.


DISTRIBUTION OF FISH FARMS IN IDAHO
N
Fee fishing
Egg taking
Food fish
SALMON
RIVER
SNAKE
RIVER
Enlarged map


DISTRIBUTION OF FOOD AND GAME FISH HATCHERIES IN IDAHO
LEGEND
HATCHERIES
COMMERCIAL
FEDERAL
STATE
N
SALMON RIVER
SNAKE RIVER
13 Hatcheries

Location of Food Fish Farms in Gooding, Jerome, and Twin Falls Counties, Idaho.



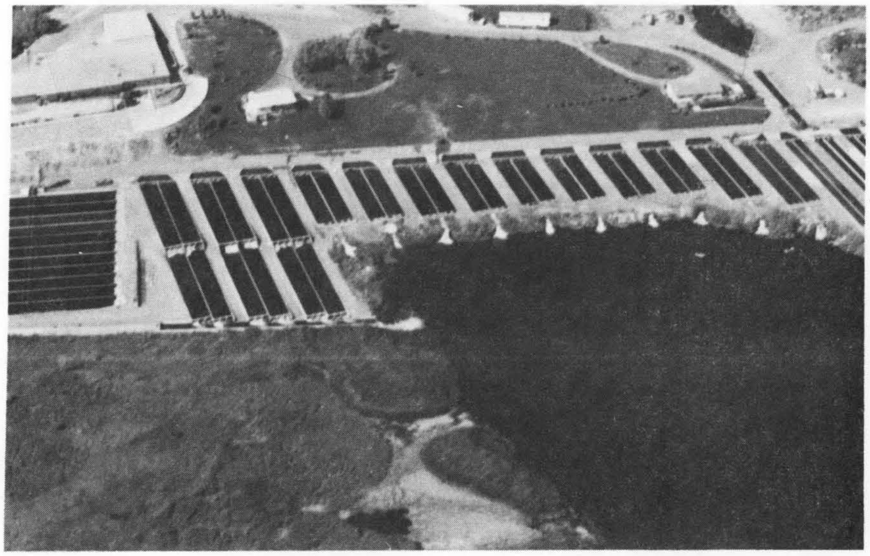
Commercial Food Fish Farms in Idaho

		Plate
Clear Springs Trout Co. Route 4, Box 548 Buhl, Idaho 83316		
	Clear Springs Trout Farm, Buhl	1
	Crystal Springs Trout Farm, Hagerman	2
	Crystal Springs Trout Farm, Springfield	3
	Box Canyon Trout Farm, Buhl	4
Thousand Springs Trout Farms, Inc. Route 4, Box 232 Buhl, Idaho 83316		
	Snake River Trout Farm, Buhl	5
	Indian Springs Trout Farm, Blackfoot	6
	Papoose Springs Trout Farm, Pocatello	7
	Batise Springs Trout Farm, Pocatello	8
	Idaho Springs Trout Farm, Hagerman	9
Idaho Trout Processors, Inc. 1306 Vista Avenue Boise, Idaho 83705		
	Rainbow Trout Farms, Buhl and Filer	10
	Clear Lakes Trout Farm, Buhl	11
	Canyon Trout Farm, Twin Falls	12
Blue Lakes Trout Farm, Inc. P.O. Box 1237 Twin Falls, Idaho 83301		
	Blue Lakes Trout Farm, Twin Falls	13
	Greene's Trout Farm, Twin Falls	14

	Plate
Jones and Sandy Livestock Co. Box 265 Hagerman, Idaho 83332	15
Fish Breeders of Idaho 2914 Alta Vista Drive Twin Falls, Idaho 83301	16
Royal Catfish Industries P.O. Box 757 Twin Falls, Idaho 83301	17
Rim View Trout Co., Inc. P.O. Box 7503 Boise, Idaho	18
Caribou Trout Ranch P.O. Box 57 Soda Springs, Idaho 83276	19
Marine Protein Corporation Magic Springs Trout Farm P.O. Box 326 Hagerman, Idaho 83332	20
Rangen's Trout Research Laboratory Hagerman, Idaho 83332	21
White Water Trout Farm Hagerman, Idaho 83332	22
Valley Trout Farms, Inc. Route 2 Buhl, Idaho 83316	
Valley Trout Farm #1, Buhl - Ellis	23
Valley Trout Farm #2, Buhl - Ellis	24
Valley Trout Farm #3, Buhl - Yodek	25
Valley Trout Farm #4, Buhl - Weaver	26
Blind Canyon Aqua Ranch Route 1 Wendell, Idaho	27
Crystal Springs Ranch, Inc. Box 109 Buhl, Idaho 83316	28

Plate

Gouge-eye Rainbow Trout Farm Challis, Idaho	No photograph available
Rainbow Farms, Inc. Box 277 Nampa, Idaho	No photograph available



CLEAR SPRINGS TROUT FARM

Clear Springs Trout Co.
Route 4, Box 548
Buhl, Idaho 83316

Started in 1966

Map Location: 0-9

Water Source: Clear Lake Springs

Water Flow: 225 CFS (Max.)
195 CFS (Min.)

Water Discharge: Clear Lake

Water Temp.: 58°F 14.2°C

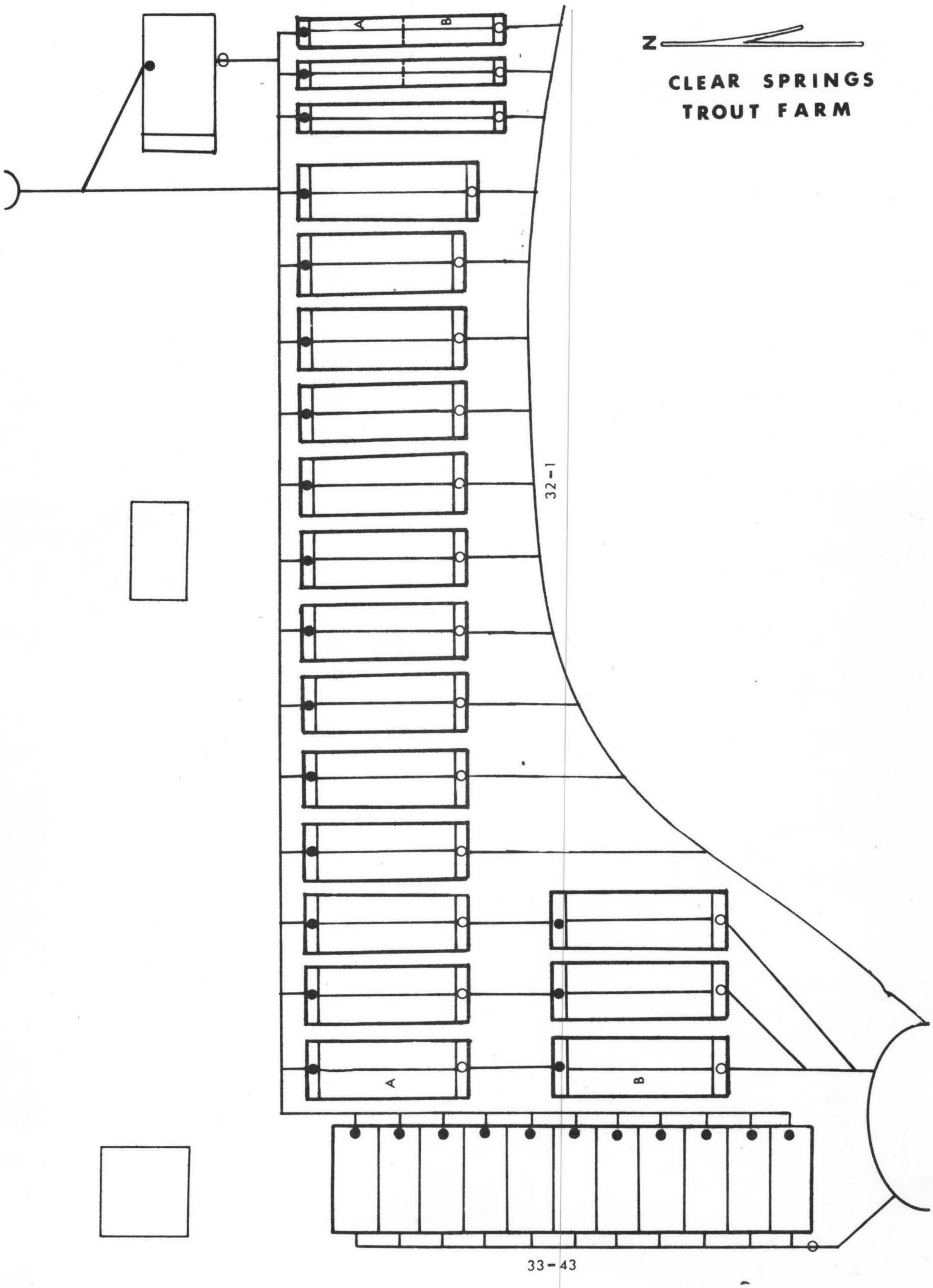
Water Chemistry:

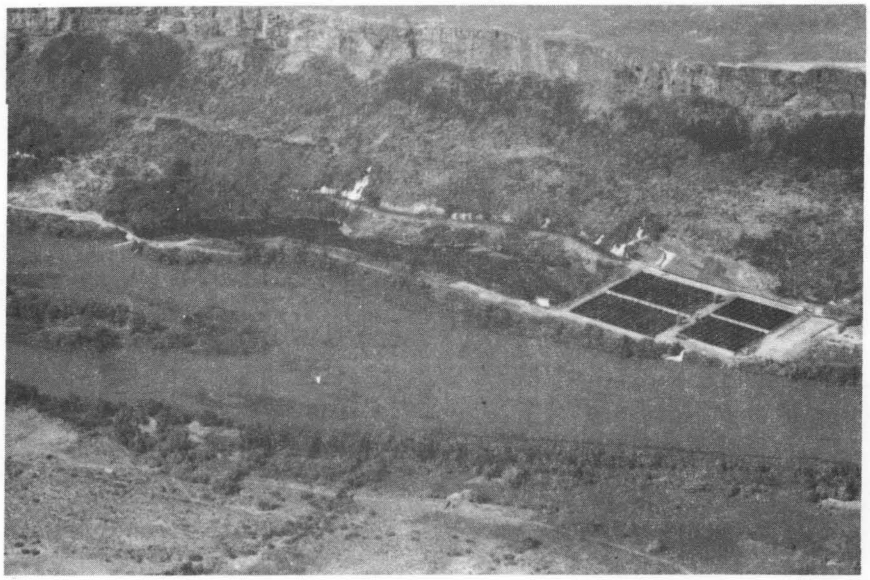
Dissolved Oxygen	9.2 ppm	Alkalinity	154 ppm
pH	7.88	Conductivity	861 μmhos
Nitrate	0.92 ppm	Phosphate	0.19 ppm
Hardness (Calcium)	103 ppm	Hardness (Total)	188 ppm
Calcium	25 ppm	Sodium	32.5 ppm
Potassium	5 ppm	Magnesium	24 ppm

Fish Rearing Space: 279,000 cubic feet in 53 ponds

Water Replacement Time: 20.7-23.89 minutes

Flow Diagram 1





CRYSTAL SPRINGS TROUT FARM

Clear Springs Trout Co.
Route 4, Box 548
Buhl, Idaho 83316

Started in 1969

Map Location: P-17

Water Source: Crystal Springs

Water Flow: 250 CFS (Max.)
150 CFS (Min.)

Water Discharge: Snake River

Water Temp.: 59°F 14.0°C

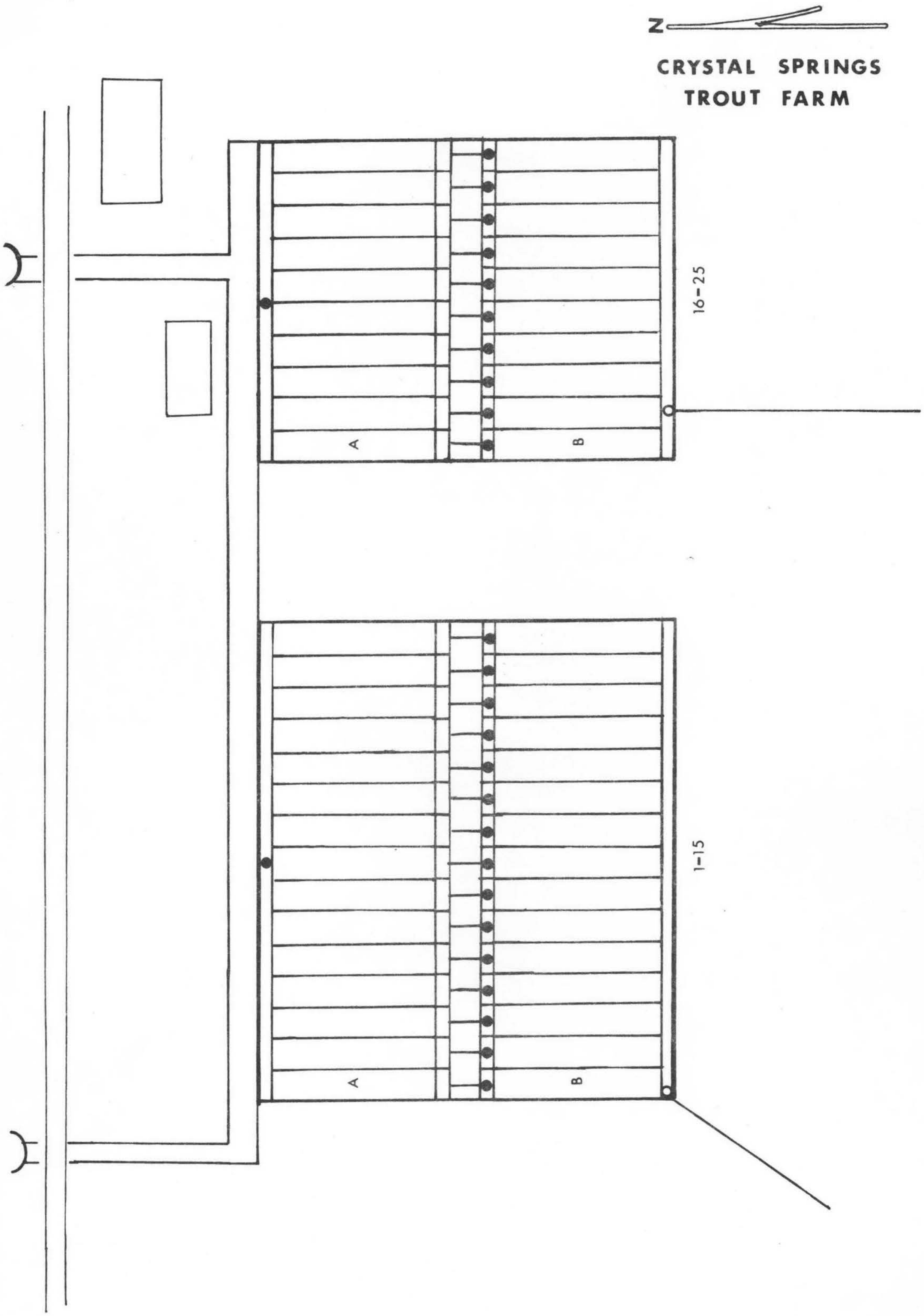
Water Chemistry:

Dissolved Oxygen	9.80 ppm	Alkalinity	205 ppm
pH	8.05	Conductivity	1145 µmhos
Nitrate	1.40 ppm	Phosphate	0.19 ppm
Hardness (Calcium)	154 ppm	Hardness (Total)	291 ppm
Calcium	38 ppm	Sodium	47 ppm
Potassium	7.5 ppm	Magnesium	34 ppm

Fish Rearing Space: 648,000 cubic feet in 50 ponds

Water Replacement Time: 43.2-72 minutes

Flow Diagram 2



CRYSTAL SPRINGS TROUT FARM, #1-3

Clear Springs Trout Co.
Route 4, Box 548
Buhl, Idaho 83316

Started in 1942

Map Location: Bingham County

Water Source: Springs and Farm #2 Effluent

Water Flow: 100 CFS (Max.)
60 CFS (Min.)

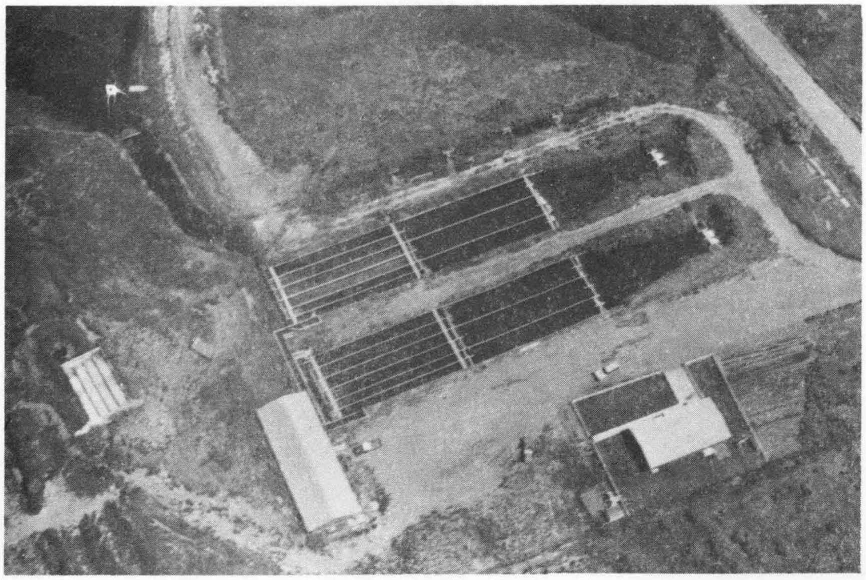
Water Discharge: Canal

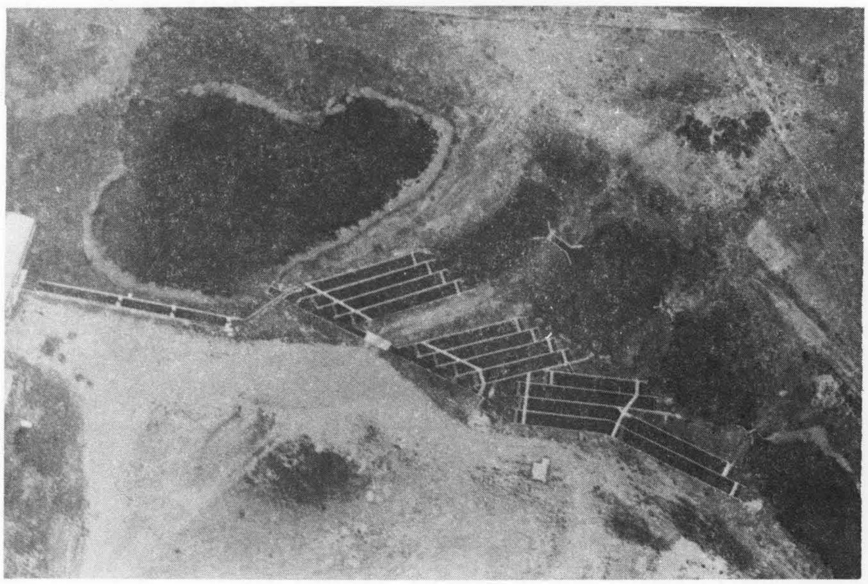
Water Temp.: 50-52°F 11.2°C

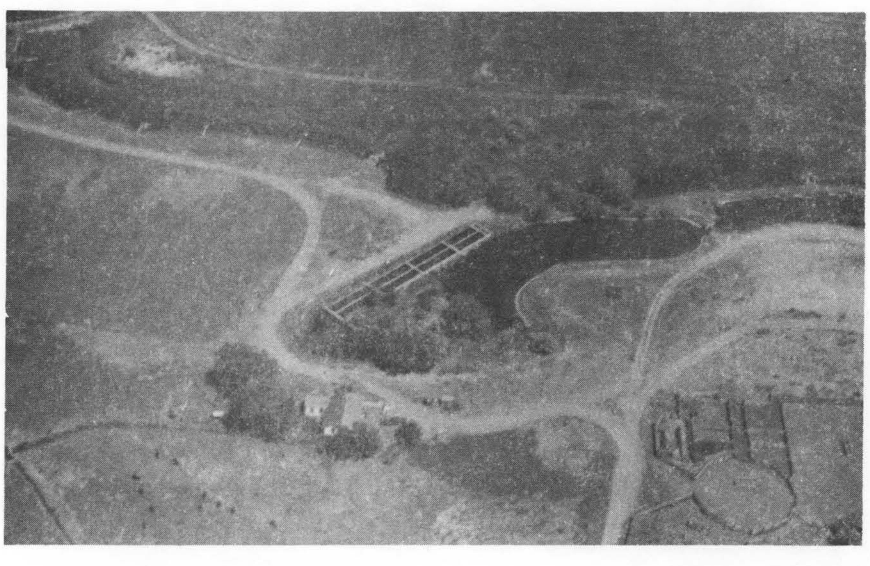
Water Chemistry:	#1	#2	#3
Dissolved Oxygen	-9.25 ppm	10.90 ppm	-9.6 ppm
Alkalinity	-257 ppm	-240 ppm	-171 ppm
pH	-7.60	-7.55	-7.70
Conductivity	-1925 µmhos	-1942 µmhos	-1063 µmhos
Nitrate	1.00+ ppm	1.00+ ppm	-1.00+ ppm
Phosphate	0.30 ppm	0.28 ppm	0.13 ppm
Hardness (Calcium)	205 ppm	205 ppm	171 ppm
Hardness (Total)	377 ppm	394 ppm	308 ppm
Calcium	47 ppm	45 ppm	54 ppm
Sodium	67.5 ppm	67.5 ppm	28 ppm
Potassium	7.5 ppm	6.5 ppm	8 ppm
Magnesium	42.5 ppm	22.5 ppm	42 ppm

Fish Rearing Space: 288,500 cubic feet in 55 ponds

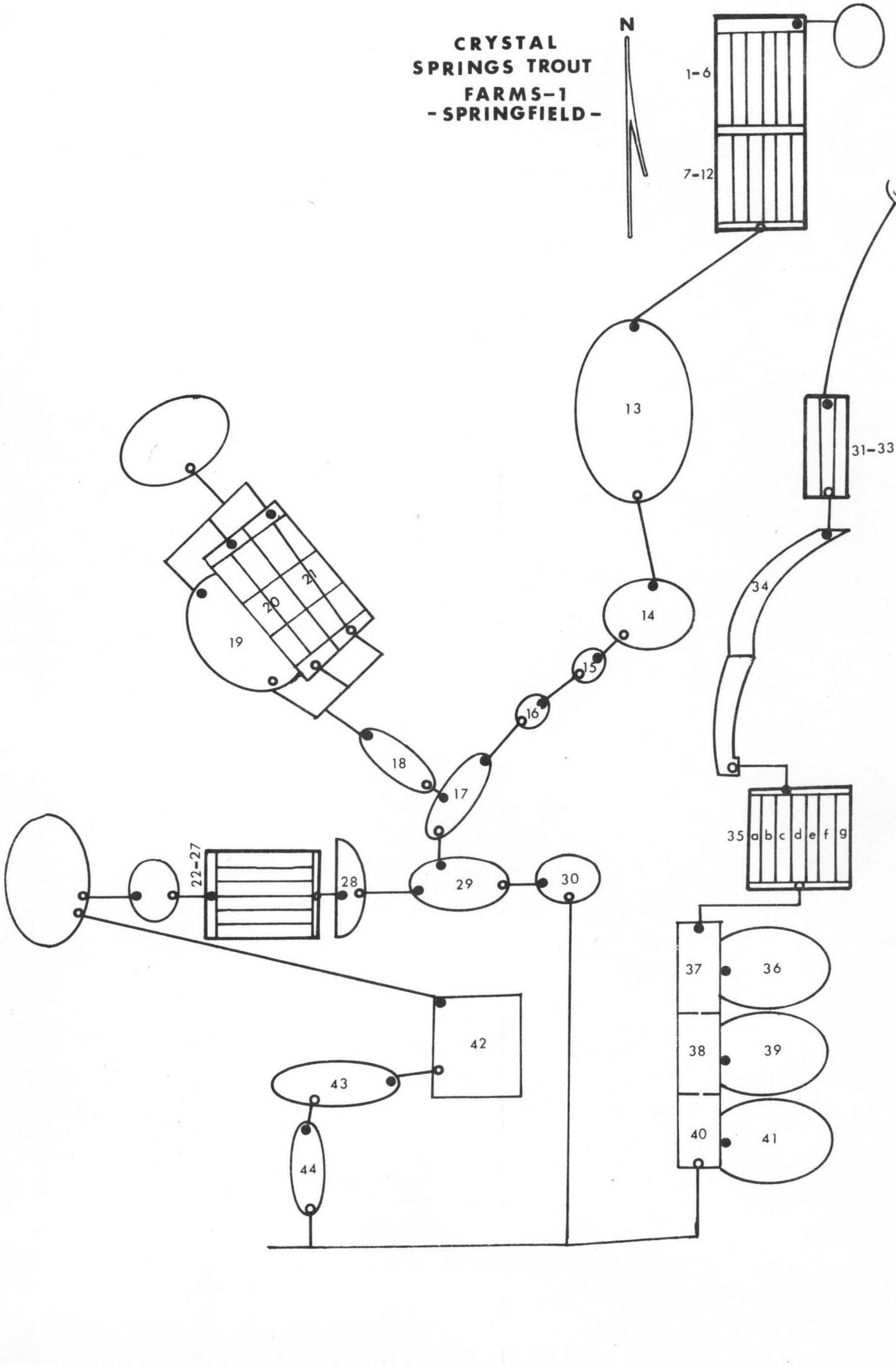
Water Replacement Time: 28.8-80.1 minutes



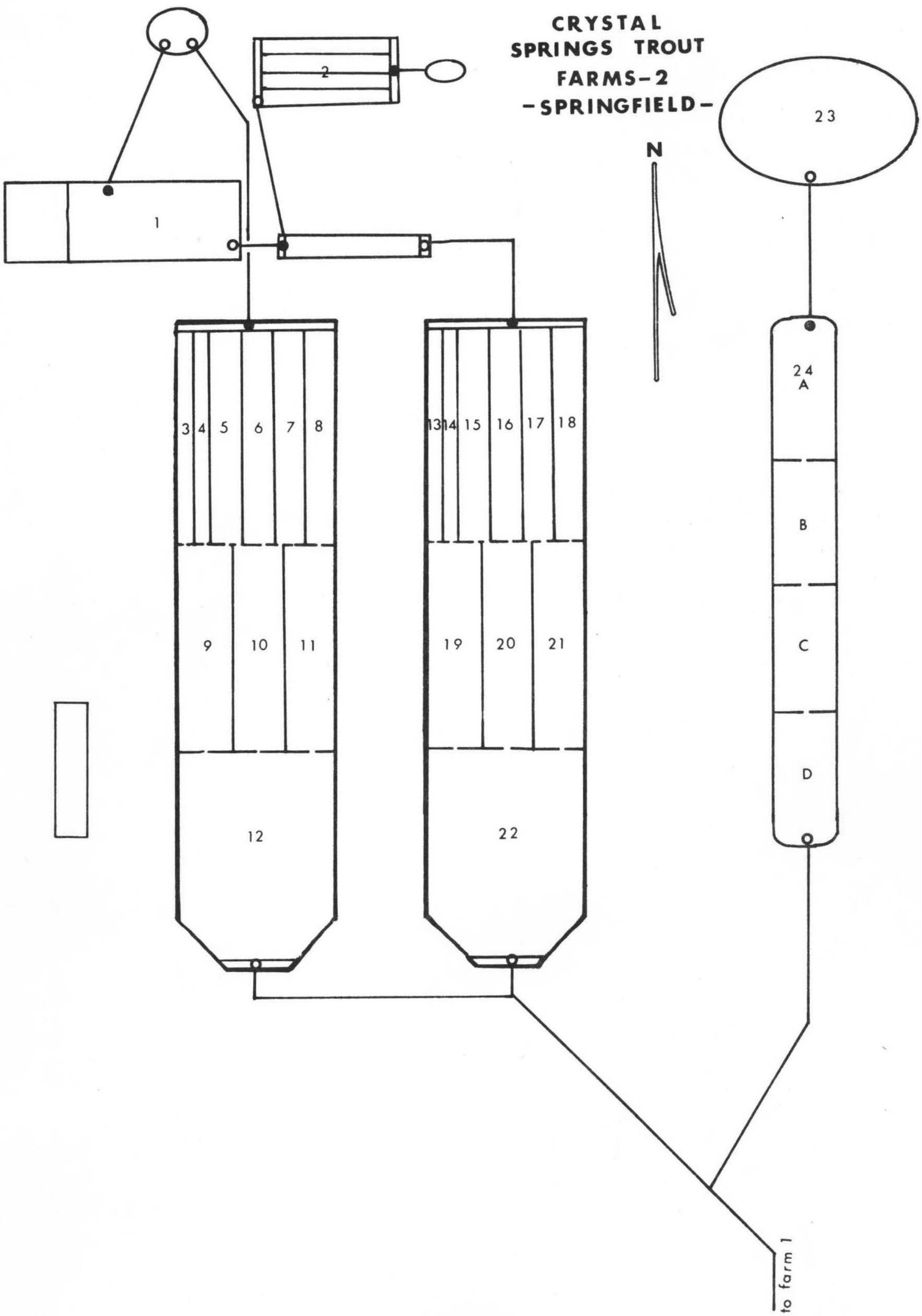




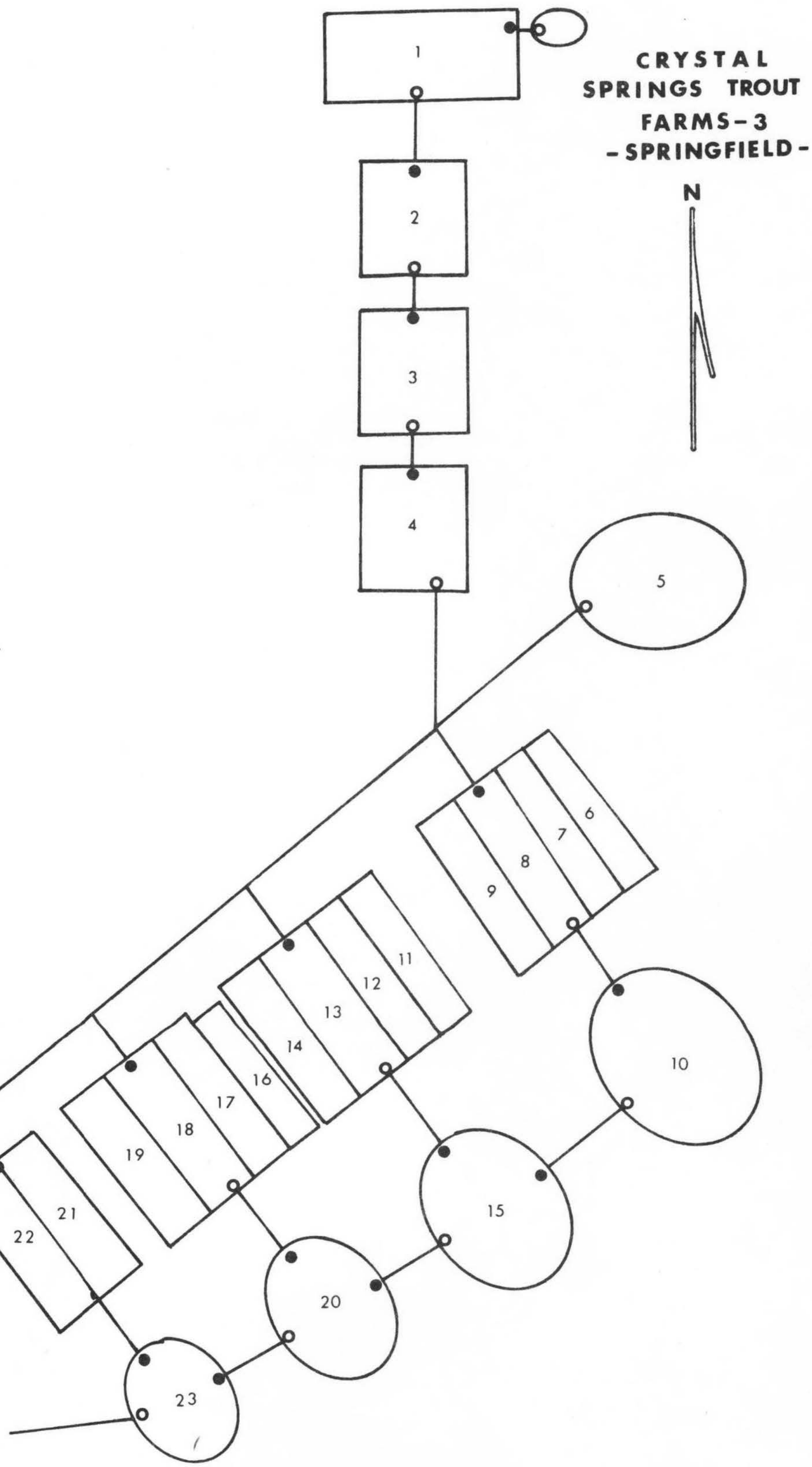
Flow Diagram 3

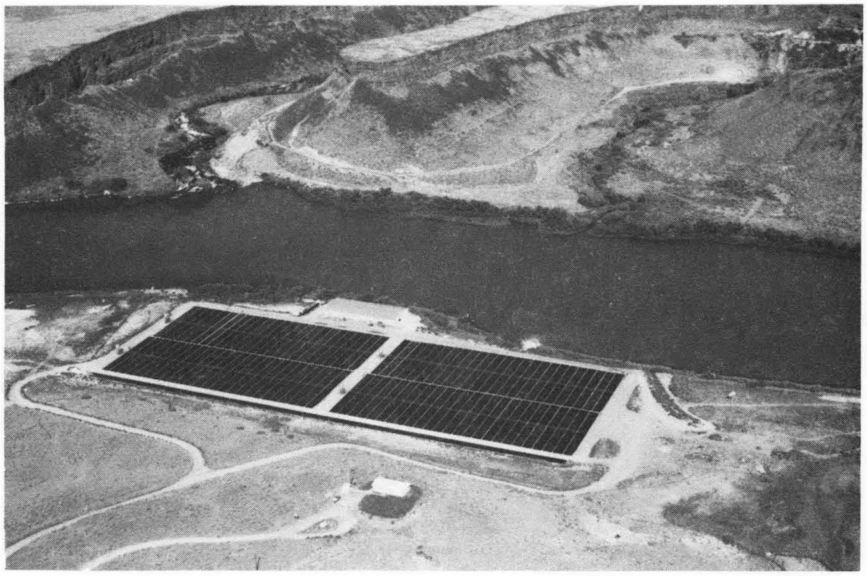


Flow Diagram 4



Flow Diagram 5





BOX CANYON TROUT FARM

Clear Springs Trout Co.
Route 4, Box 548
Buhl, Idaho 83316

Started in 1973

Map Location: N-7

Water Source: Box Canyon Springs

Water Flow: 325 CFS (Max.)
242 CFS (Min.)

Water Discharge: Snake River

Water Temp.: 58°F 15.0°C

Water Chemistry:

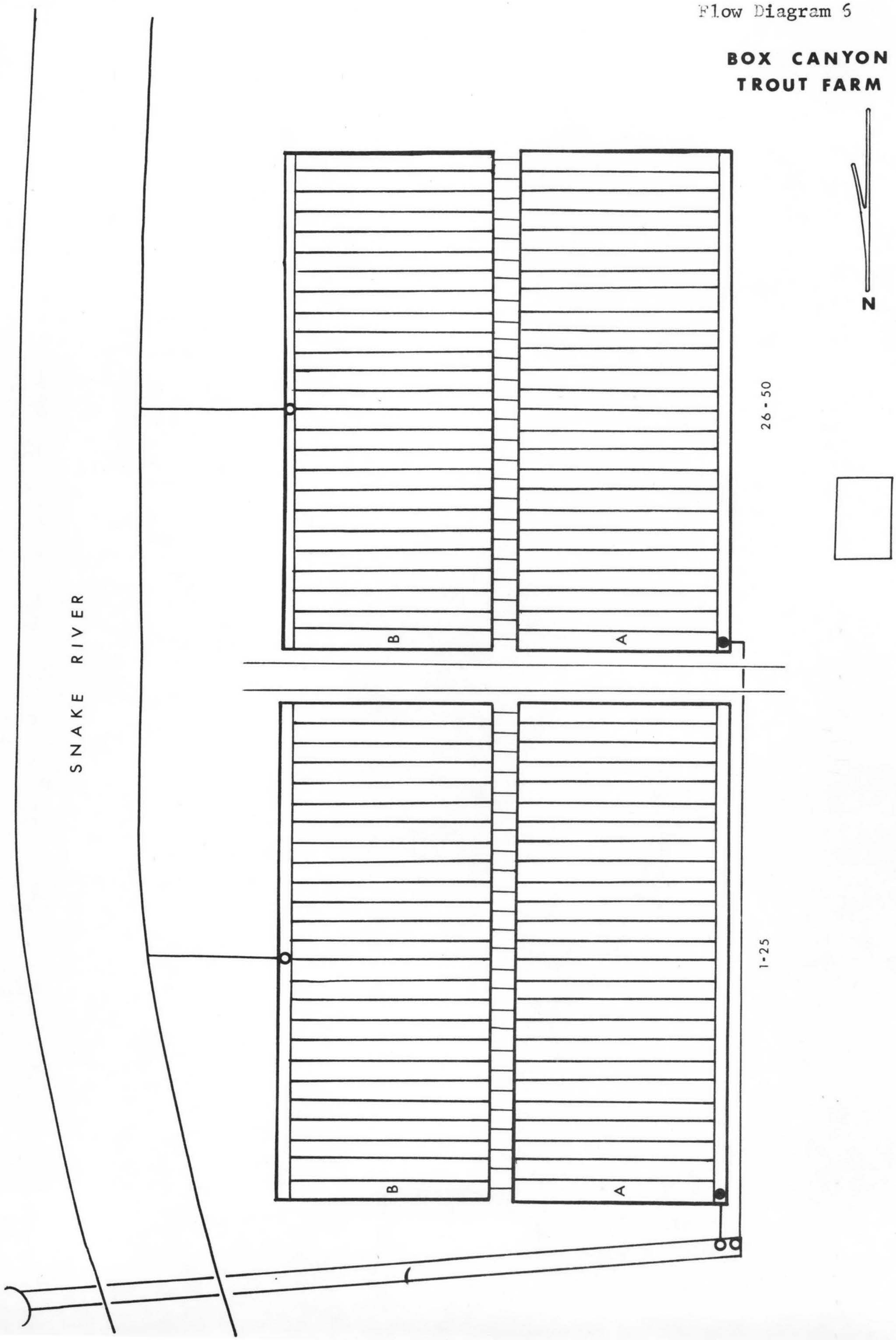
Dissolved Oxygen	11.10 ppm	Alkalinity	120 ppm
pH	8.45	Conductivity	648 µmhos
Nitrate	0.62 ppm	Phosphate	0.29 ppm
Hardness (Calcium)	86 ppm	Hardness (Total)	188 ppm
Calcium	17.5 ppm	Sodium	31 ppm
Potassium	7 ppm	Magnesium	19 ppm

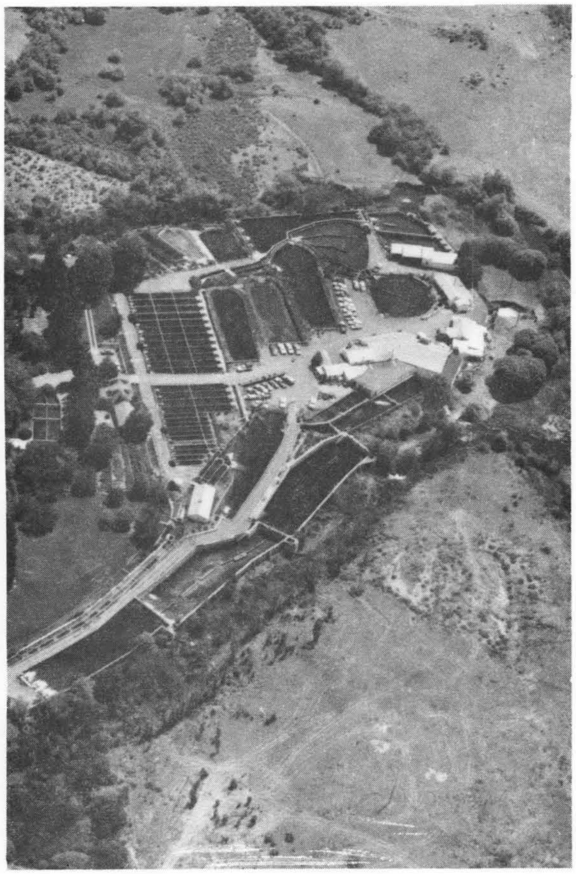
Fish Rearing Space: 1,134,000 cubic feet in 100 ponds

Water Replacement Time: 58-78 minutes

Flow Diagram 6

BOX CANYON TROUT FARM





SNAKE RIVER TROUT FARM

Thousand Springs Trout Farms, Inc.
Route 4, Box 232
Buhl, Idaho 83316

Started in 1928

Map Location: O-11

Water Source: Thousand Springs

Water Flow: 129.5 CFS (Max.)
96.6 CFS (Min.)

Water Discharge: Clear Lake

Water Temp.: 58°F 14.1°C

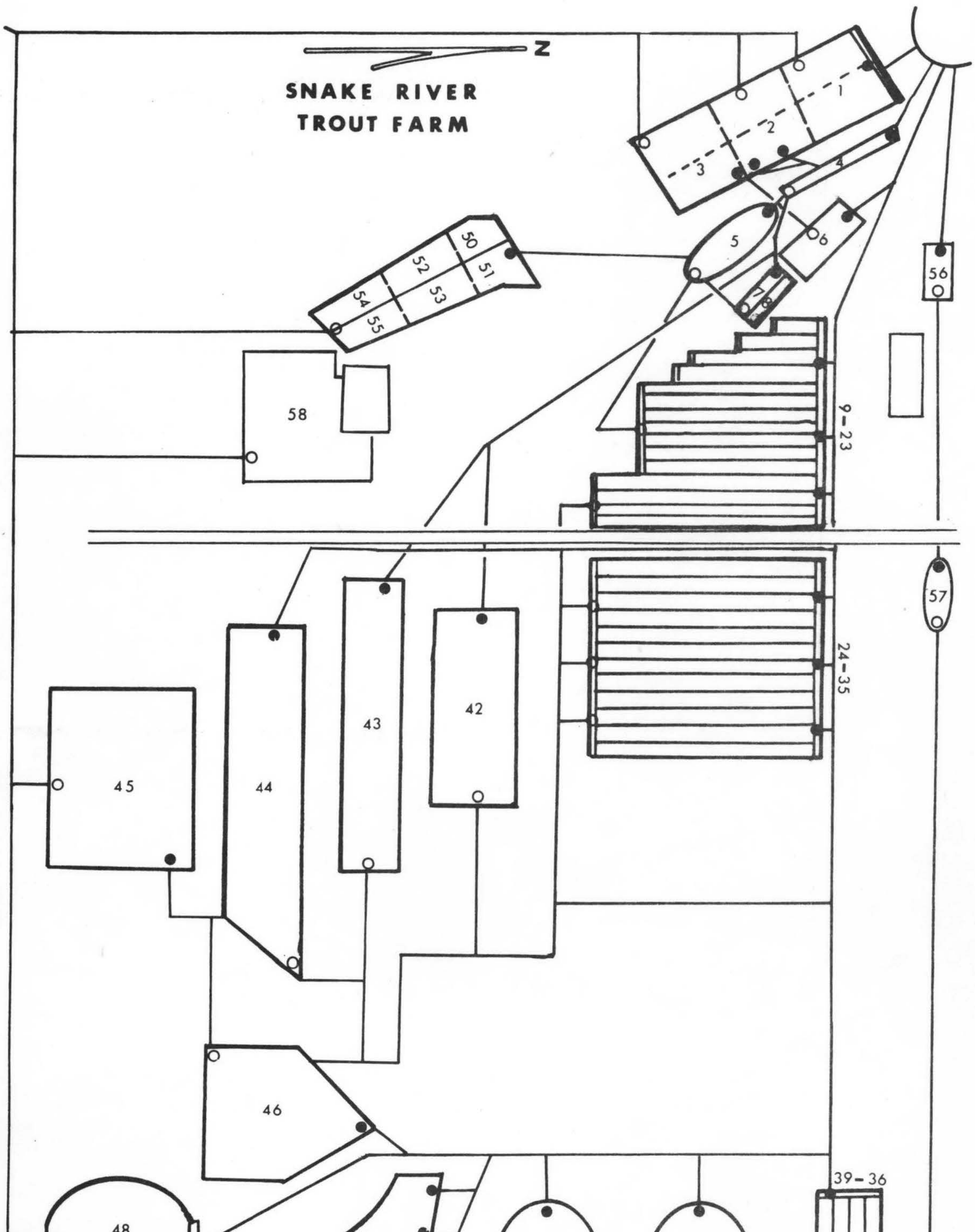
Water Chemistry:

Dissolved Oxygen	9.25	ppm	Alkalinity	205	ppm
pH	8.28		Conductivity	1198	µmhos
Nitrate	2.02	ppm	Phosphate	0.18	ppm
Hardness (Calcium)	137	ppm	Hardness (Total)	257	ppm
Calcium	37	ppm	Sodium	39	ppm
Potassium	6	ppm	Magnesium	31	ppm

Fish Rearing Space: 299,900 cubic feet in 55 ponds

Water Replacement Time: 38.5-51.7 minutes

Flow Diagram 7



INDIAN SPRINGS TROUT FARM

Thousand Springs Trout Farms, Inc.
Route 4, Box 232
Buhl, Idaho 83316

Started in 1952

Map Location: Bingham County

Water Source: Springs

Water Flow: 231.1 CFS (Max.)
125 CFS (Min.)

Water Discharge: Snake River

Water Temp.: 52°F 13.5°C

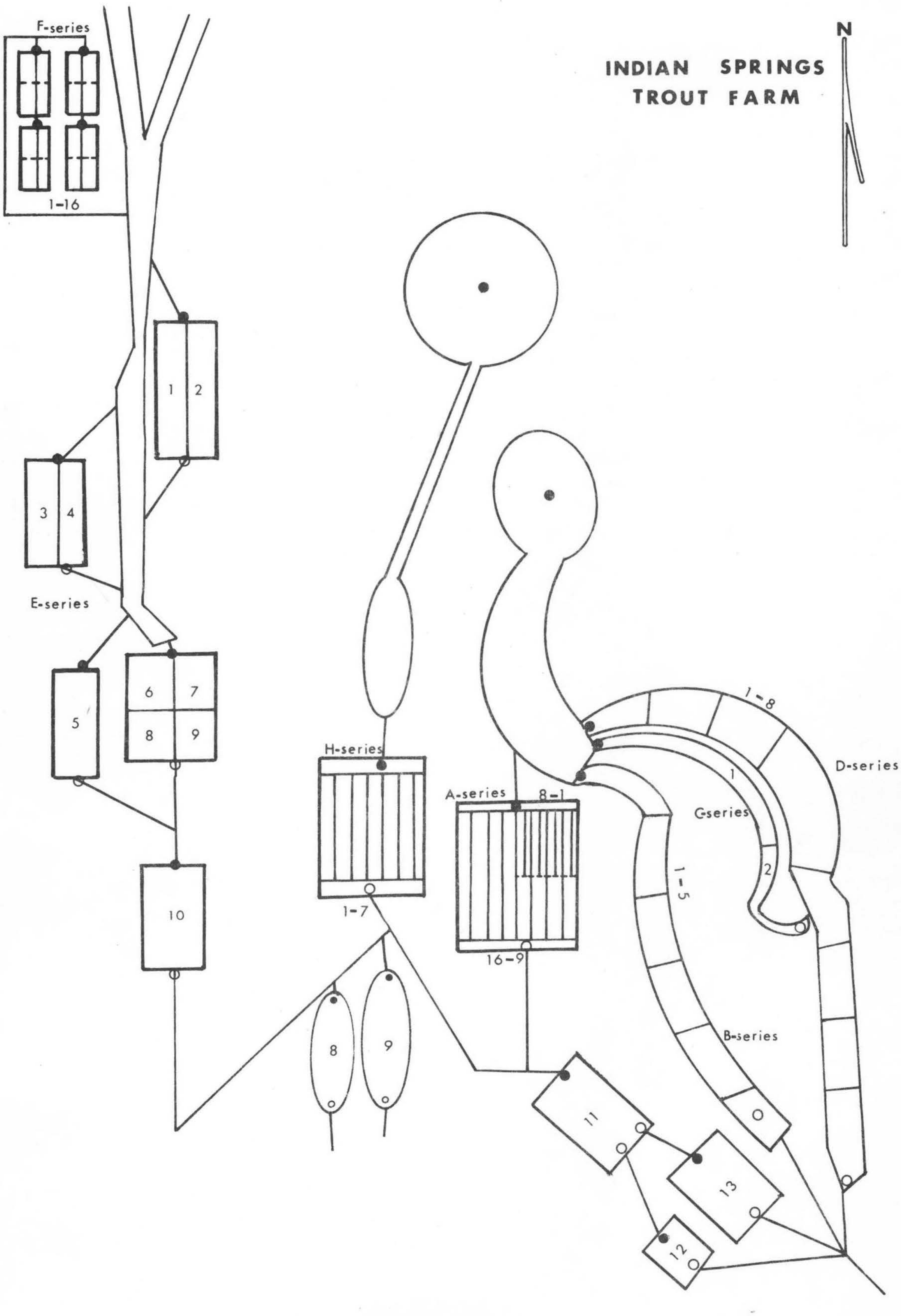
Water Chemistry:

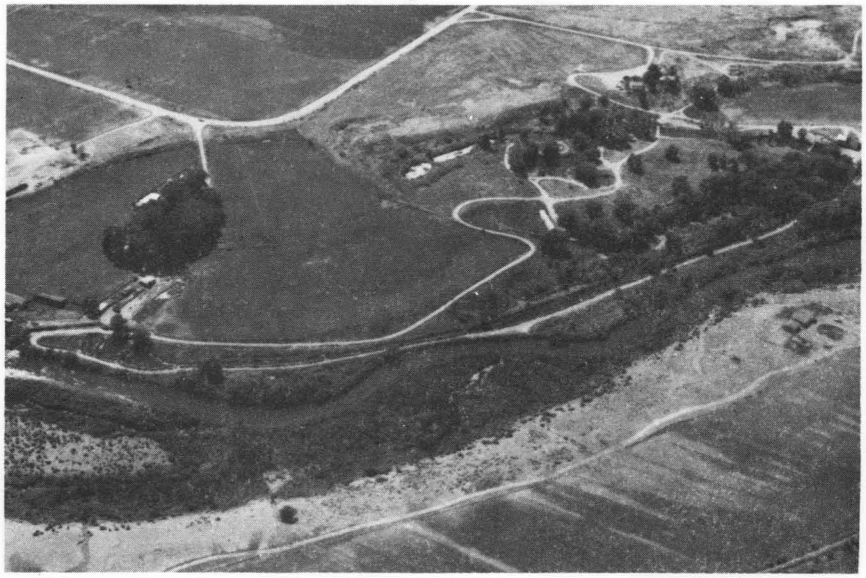
Dissolved Oxygen	12.2-6.5 ppm	Alkalinity	-222 ppm
pH	7.8-8.0	Conductivity	989-1013 µmhos
Nitrate	0.90 ppm	Phosphate	0.16 ppm
Hardness (Calcium)	171 ppm	Hardness (Total)	291 ppm
Calcium	53.75 ppm	Sodium	26.125 ppm
Potassium	4.625 ppm	Magnesium	23.5 ppm

Fish Rearing Space: 415,500 cubic feet in 62 ponds

Water Replacement Time: 29.9-55.4 minutes

Flow Diagram 8





PAPOOSE SPRINGS TROUT FARM

Thousand Springs Trout Farms, Inc.
Route 4, Box 232
Buhl, Idaho 83316

Started in 1914

Map Location: Bannock County

Water Source: Springs

Water Flow: 44 CFS (Max.)
37.7 CFS (Min.)

Water Discharge: Portneuf

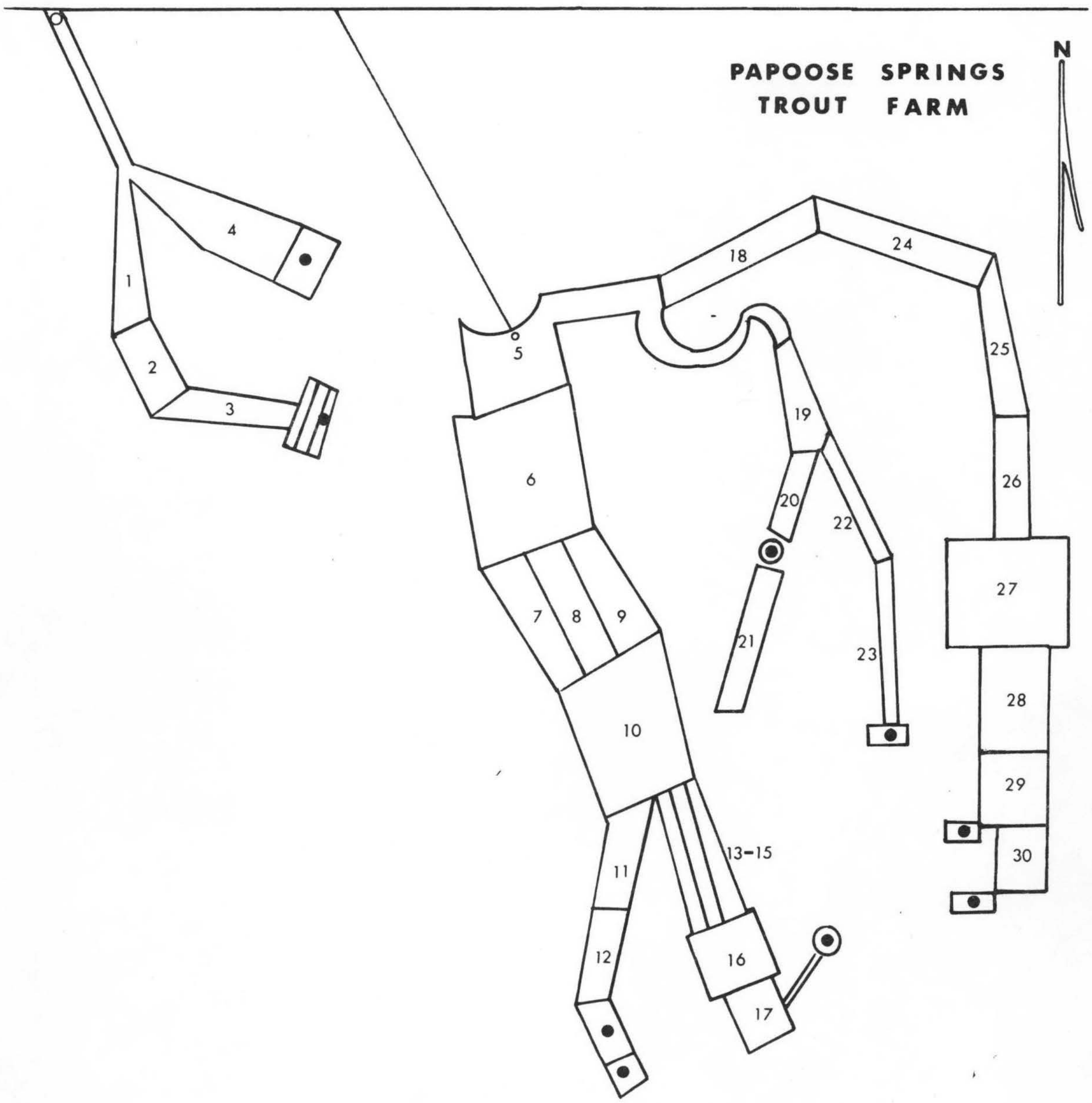
Water Temp.: 48-58°F 13.0°C

Water Chemistry:

Dissolved Oxygen	-6.70 ppm	Alkalinity	-223 ppm
pH	-7.70	Conductivity	-942 µmhos
Nitrate	-223 ppm	Phosphate	0.27 ppm
Hardness (Calcium)	153 ppm	Hardness (Total)	-257 ppm
Calcium	-42.5 ppm	Sodium	30 ppm
Potassium	4.75 ppm	Magnesium	23.75 ppm

Fish Rearing Space: 109,100 cubic feet in 30 ponds

Water Replacement Time: 41.3-48.2 minutes


PAPOOSE SPRINGS
TROUT FARM
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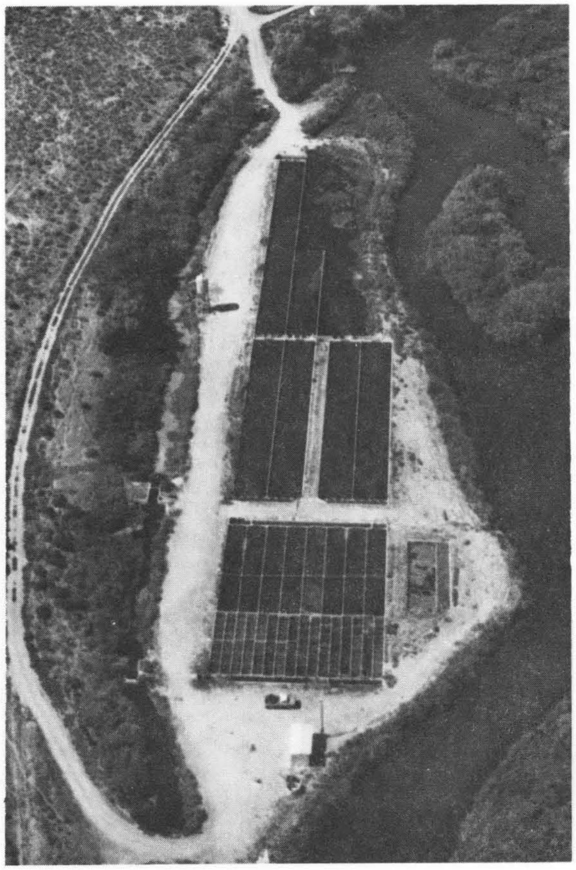


BATISE SPRINGS TROUT FARM

Thousand Springs Trout Farms, Inc.
Route 4, Box 232
Buhl, Idaho 83316

Started in 1973

Map Location: Bannock County

Water Source: Springs via Rowland Creek

Water Flow: 29 CFS (Max.)
20.2 CFS (Min.)

Water Discharge: Portneuf

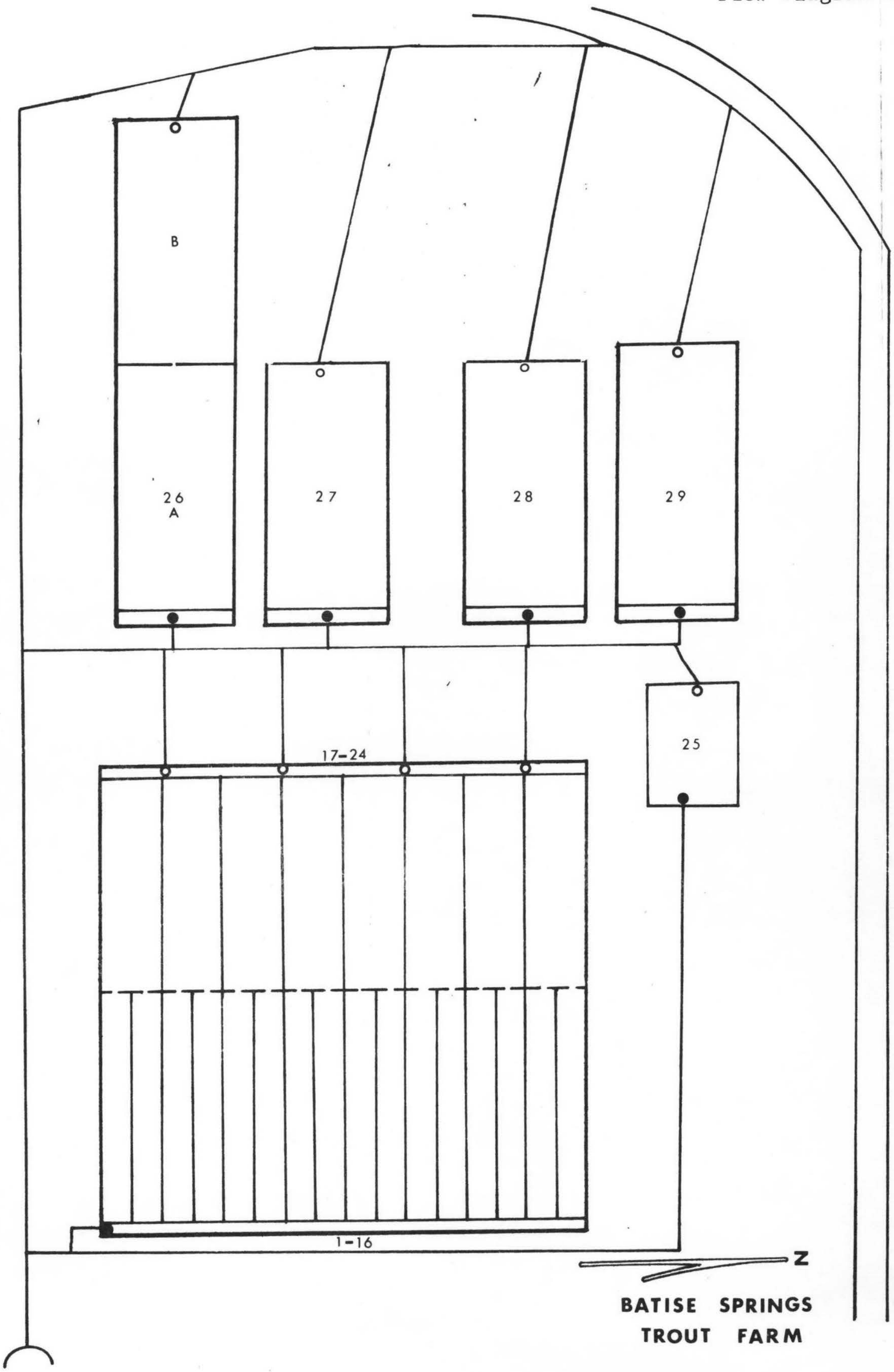
Water Temp.: 55-58°F 14.7°C

Water Chemistry:

Dissolved Oxygen	-10.10 ppm	Alkalinity	-223 ppm
pH	-7.65	Conductivity	-1308 µmhos
Nitrate	-1.00+ ppm	Phosphate	1.46 ppm
Hardness (Calcium)	154 ppm	Hardness (Total)	274 ppm
Calcium	47.5 ppm	Sodium	44.5 ppm
Potassium	8 ppm	Magnesium	28 ppm

Fish Rearing Space: 106,440 cubic feet in 29 ponds

Water Replacement Time: 49.7 minutes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17-24
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Z
BATISE SPRINGS
TROUT FARM

IDAHO SPRINGS TROUT FARM

Thousand Springs Trout Farms, Inc.
Route 4, Box 232
Buhl, Idaho 83316

Started in 1951 — Map Location: F-5

Water Source: Tupper Springs, Hewitt Springs, Billingsley Creek

Water Discharge: Billingsley Creek — Water Flow: 203 CFS (Max.)
143 CFS (Min.)

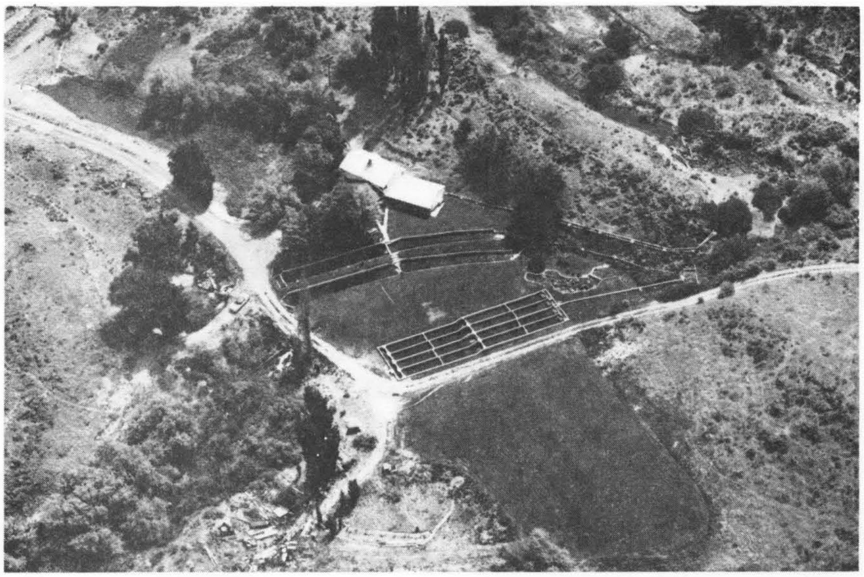
Water Temp.: 58°F 15.6°C

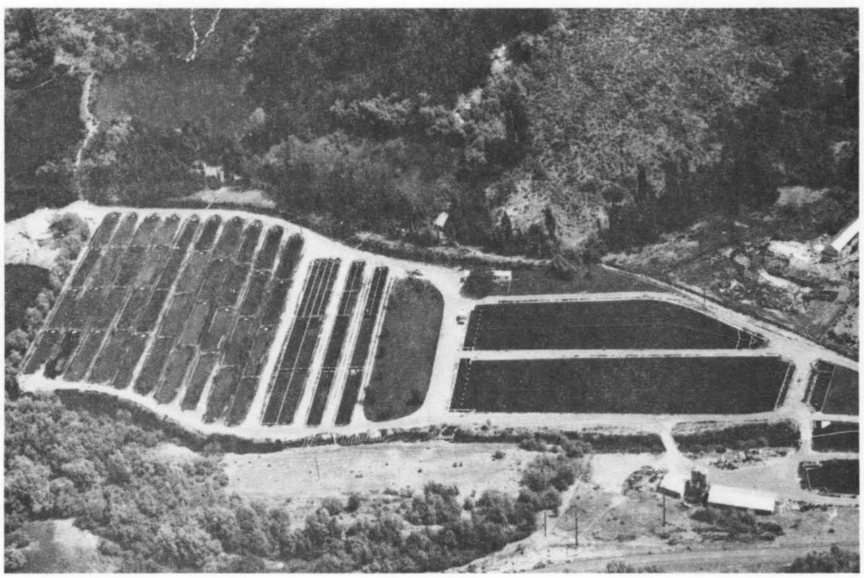
Water Chemistry:

Dissolved Oxygen	9.35 ppm
Alkalinity	137 ppm
pH	8.05
Conductivity	708 μmhos
Nitrate	0.90 ppm
Phosphate	0.29 ppm
Hardness (Calcium)	68 ppm
Hardness (Total)	171 ppm
Calcium	14.33 ppm
Sodium	26 ppm
Potassium	5.19 ppm
Magnesium	22.16 ppm

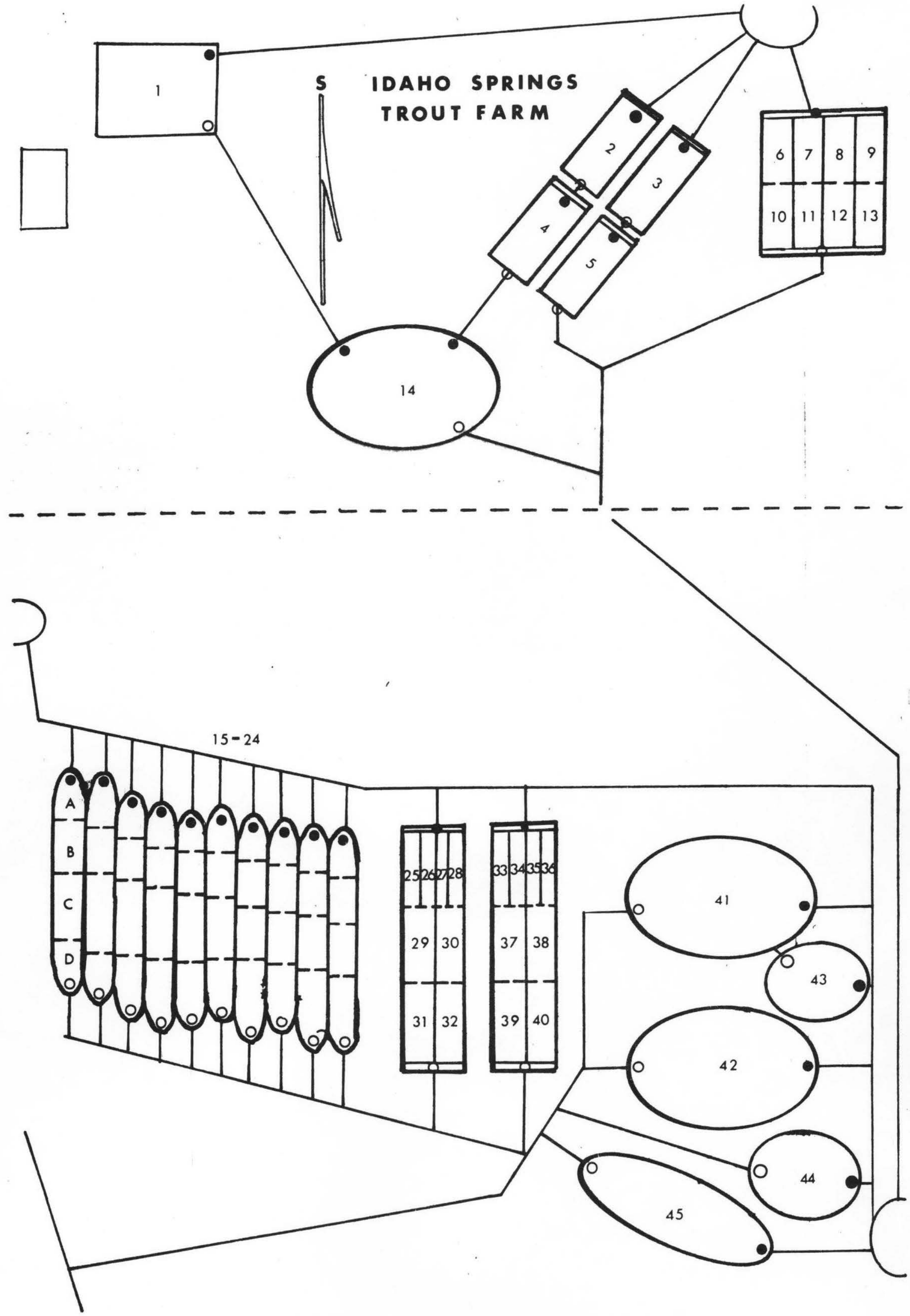
Fish Rearing Space: 404,600 cubic feet in 69 ponds

Water Replacement Time: 33.2-47.0 minutes





Flow Diagram 11



RAINBOW TROUT FARMS, BUHL

Idaho Trout Processors, Inc.
1302 Vista Avenue
Boise, Idaho 83705

Started in 1947

Map Location: Q-10

Water Source: Seep Tunnel

Water Flow: 12 CFS (Max.)
6 CFS (Min.)

Water Discharge: Mendini Seepage Drain

Water Temp.: 58°F 14.1°C

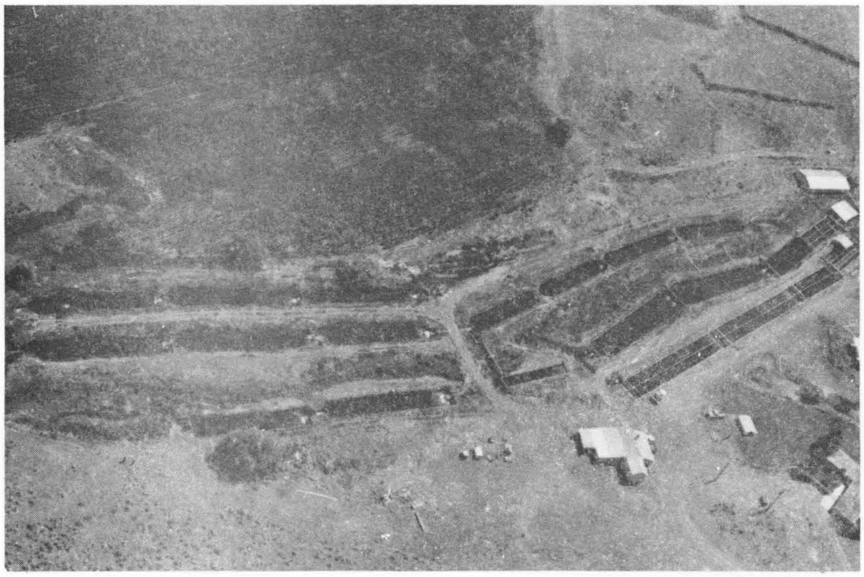
Water Chemistry:

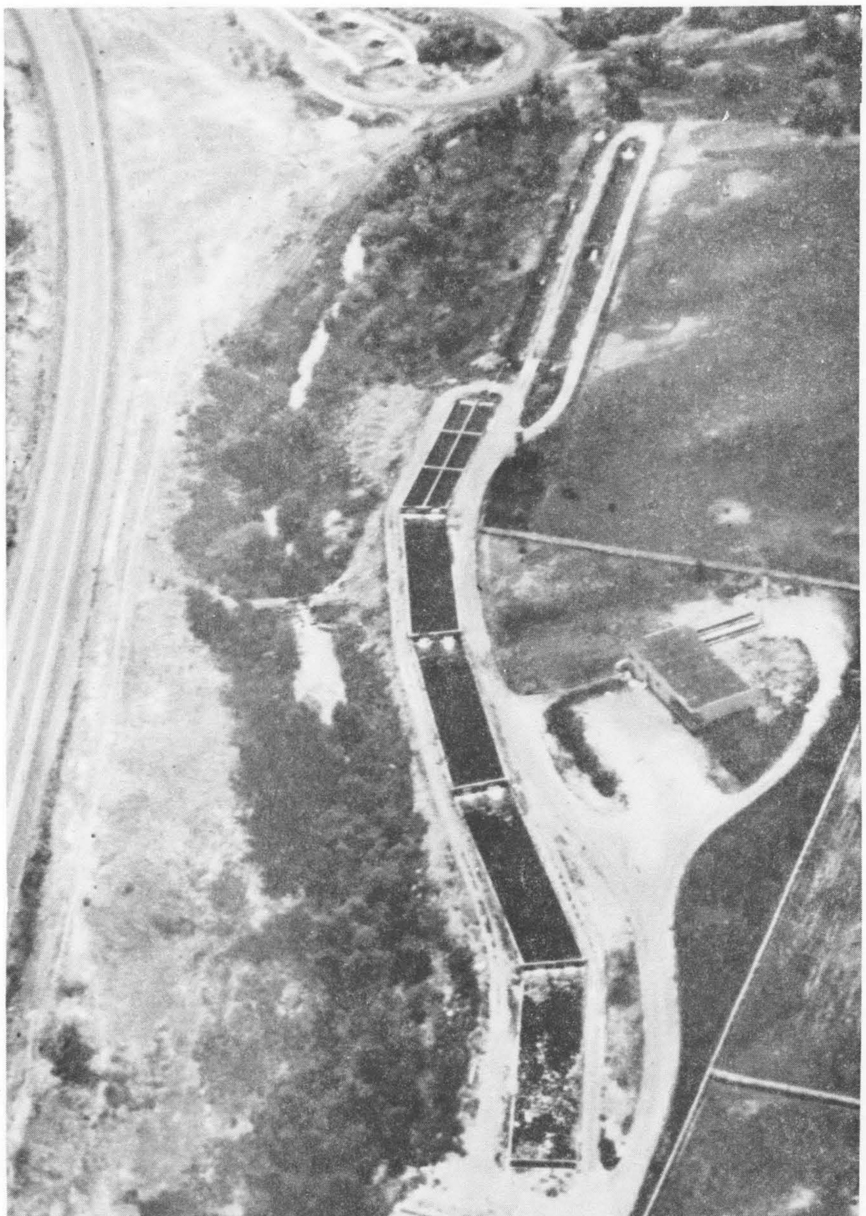
Dissolved Oxygen	8.75 ppm	Alkalinity	359 ppm
pH	7.90	Conductivity	1764 µmhos
Nitrate	3.50 ppm	Phosphate	0.18 ppm
Hardness (Calcium)	223 ppm	Hardness (Total)	342 ppm
Calcium	48 ppm	Sodium	107 ppm
Potassium	12.5 ppm	Magnesium	49 ppm

Fish Rearing Space: 73,500 cubic feet in 24 ponds

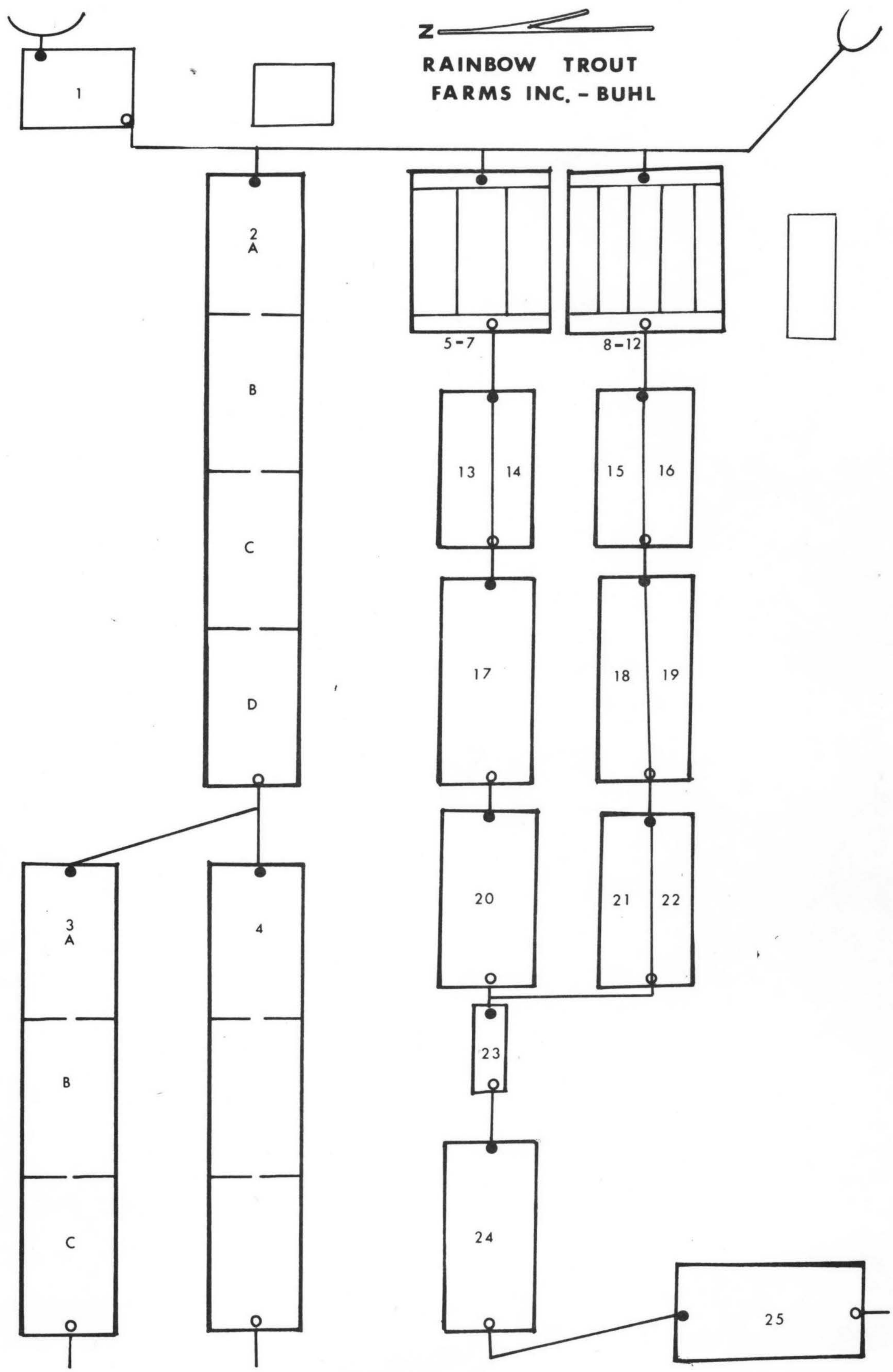
Water Replacement Time: 102.0-204 minutes

(





Flow Diagram 12



RAINBOW TROUT FARMS, FILER

Idaho Trout Processors, Inc.
1302 Vista Avenue
Boise, Idaho 83705

Started in 1947

Map Location: V-17

Water Source: Seep Tunnel

Water Flow: 25 CFS (Max.)
12 CFS (Min.)

Water Discharge: Cedar Draw

Water Temp.: 58°F 13.4°C

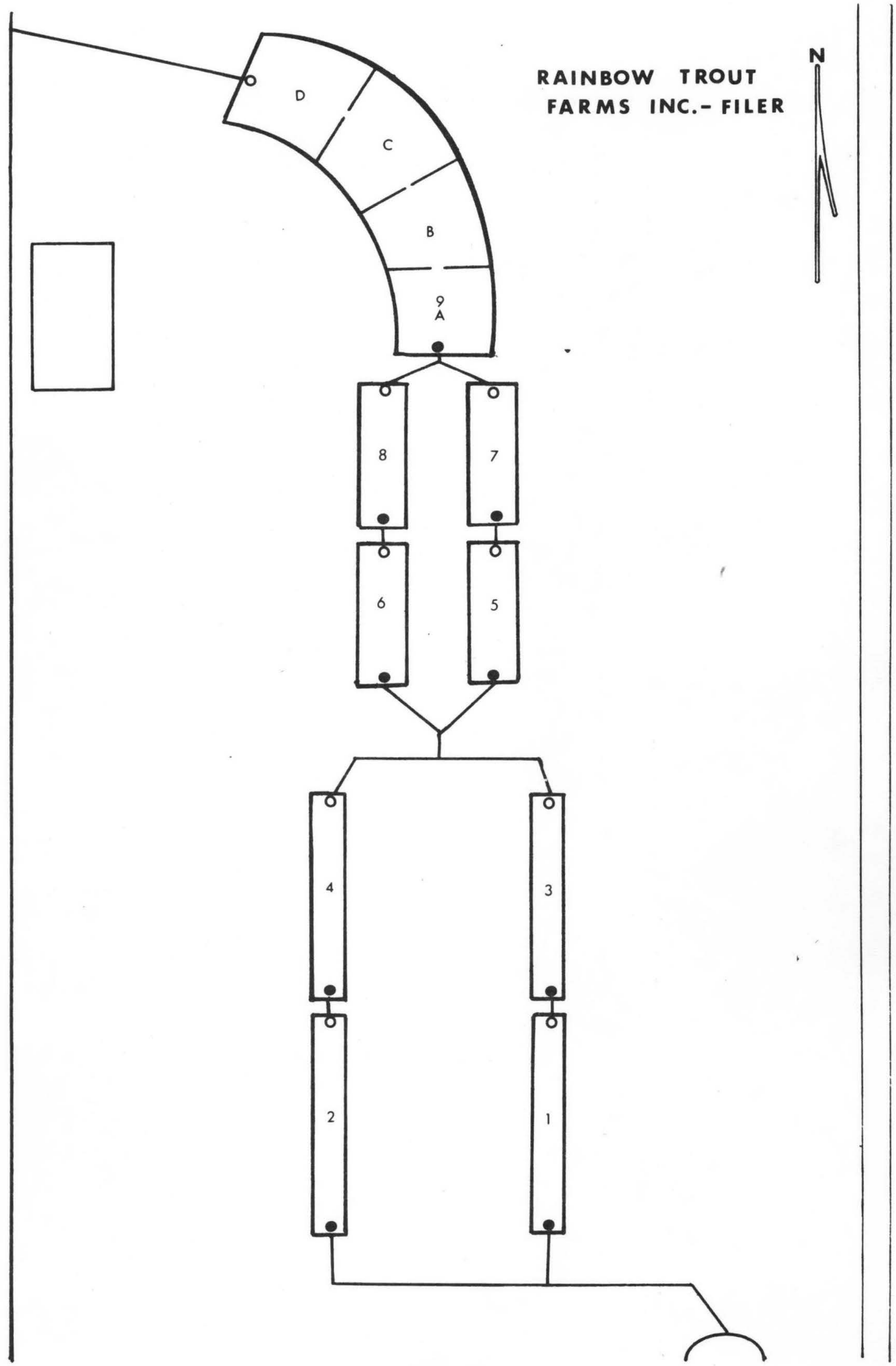
Water Chemistry:

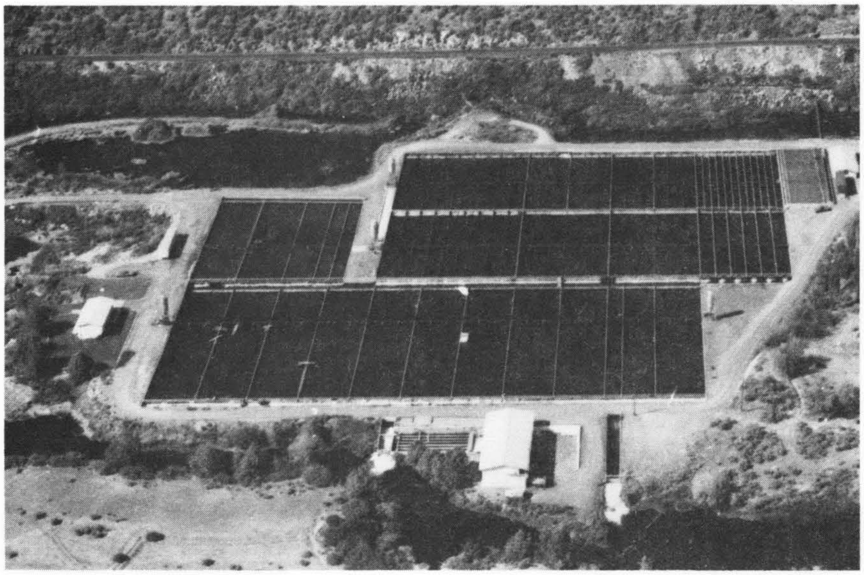
Dissolved Oxygen	8.90 ppm	Alkalinity	291 ppm
pH	8.22	Conductivity	1860 µmhos
Nitrate	2.60 ppm	Phosphate	0.27 ppm
Hardness (Calcium)	205 ppm	Hardness (Total)	377 ppm
Calcium	42 ppm	Sodium	91 ppm
Potassium	6.5 ppm	Magnesium	51 ppm

Fish Rearing Space: 88,800 cubic feet in 12 ponds

Water Replacement Time: 59.2-123.3 minutes

Flow Diagram 13





CLEAR LAKES TROUT FARM

Idaho Trout Processors, Inc.
1302 Vista Avenue
Boise, Idaho 83705

Started in 1960

Map Location: 0-10

Water Source: Thousand Springs

Water Flow: 173 CFS (Max.)
148 CFS (Min.)

Water Discharge: Clear Lake

Water Temp.: 58°F 14.1°C

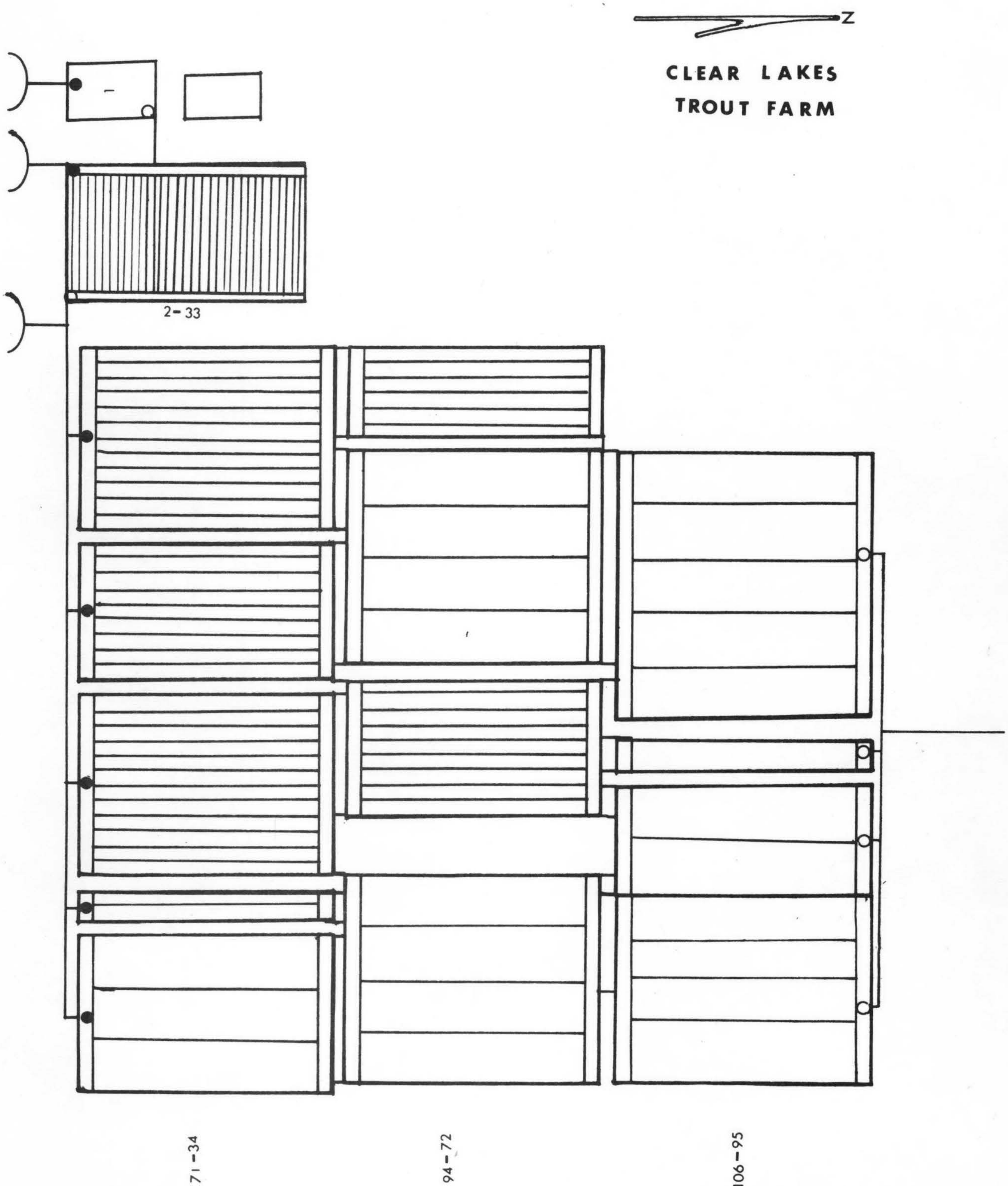
Water Chemistry:

Dissolved Oxygen	9.35 ppm	Alkalinity	171 ppm
pH	8.27	Conductivity	979 µmhos
Nitrate	1.11 ppm	Phosphate	0.18 ppm
Hardness (Calcium)	103 ppm	Hardness (Total)	205 ppm
Calcium	18 ppm	Sodium	30 ppm
Potassium	5.5 ppm	Magnesium	22.5 ppm

Fish Rearing Space: 1,040,900 cubic feet in 101 ponds

Water Replacement Time: 100.2-135.5 minutes

Flow Diagram 14



CANYON TROUT FARM

Idaho Trout Processors, Inc.
1302 Vista Avenue
Boise, Idaho 83705

Started in 1946

Map Location: V-23

Water Source: Seep Tunnel

Water Flow: 15 CFS (Max.)
7 CFS (Min.)

Water Discharge: Rock Creek

Water Temp.: 54°F 12.6°C

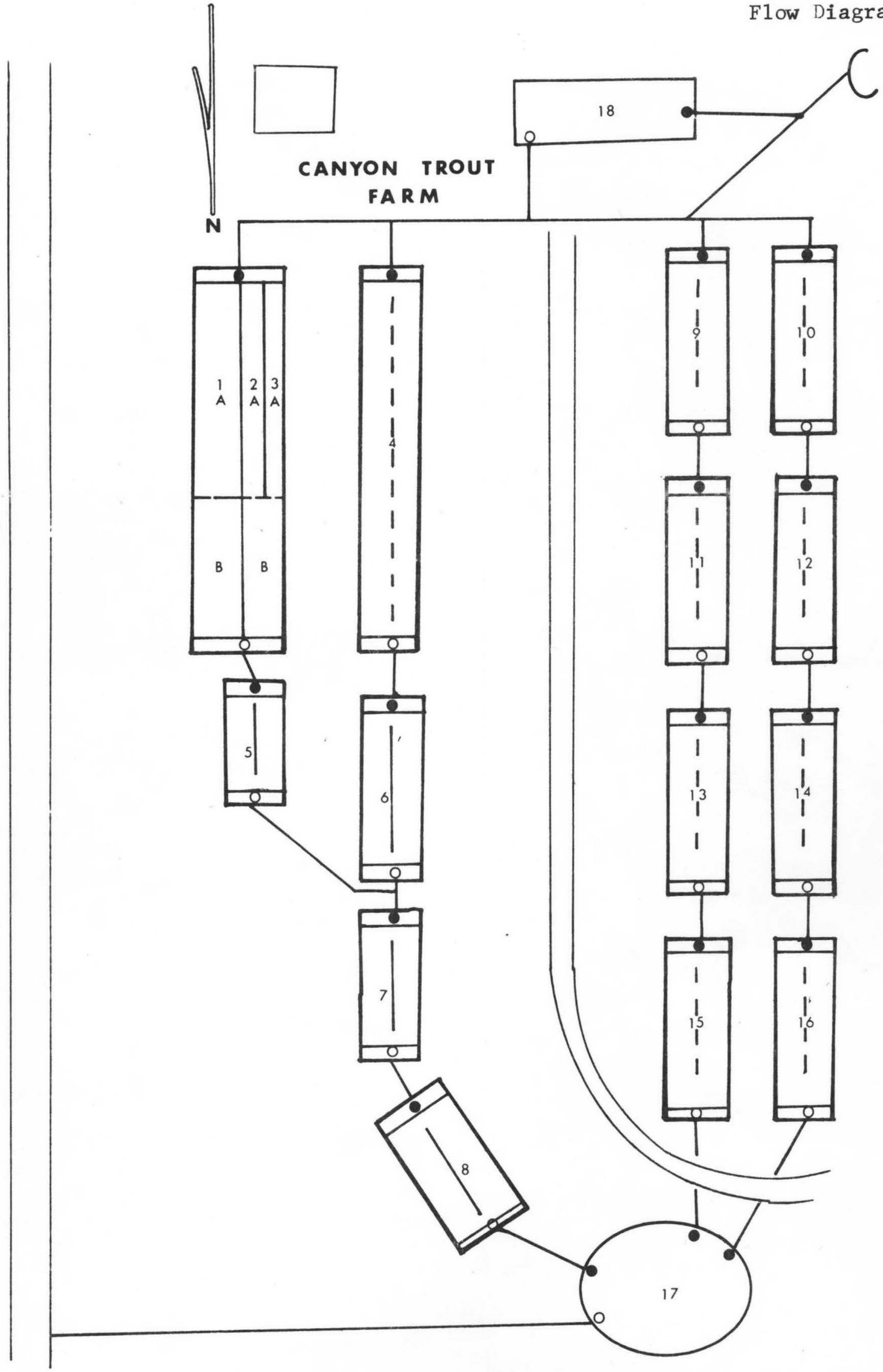
Water Chemistry:

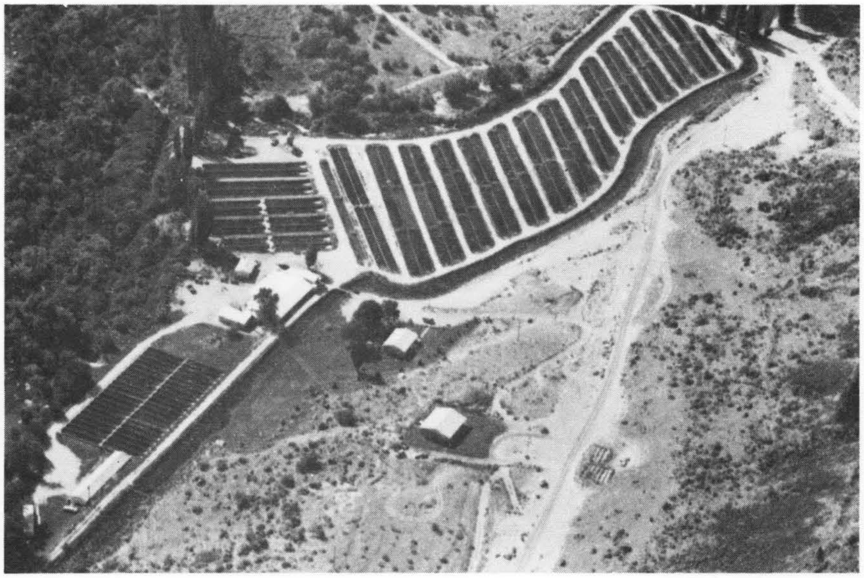
Dissolved Oxygen	9.70 ppm	Alkalinity	308 ppm
pH	7.70	Conductivity	2121 µmhos
Nitrate	3.50 ppm	Phosphate	0.08 ppm
Hardness (Calcium)	257 ppm	Hardness (Total)	428 ppm
Calcium	50 ppm	Sodium	88 ppm
Potassium	7 ppm	Magnesium	51 ppm

Fish Rearing Space: 129,100 cubic feet in 17 ponds

Water Replacement Time: 143.4-307 minutes

Flow Diagram 15





BLUE LAKES TROUT FARM

Blue Lakes Trout Farm, Inc.
P.O. Box 1237
Twin Falls, Idaho 83301

Started in 1956

Map Location: T-25

Water Source: Blue Lake Springs

Water Flow: 194 CFS (Max.)
150 CFS (Min.)

Water Discharge: Snake River

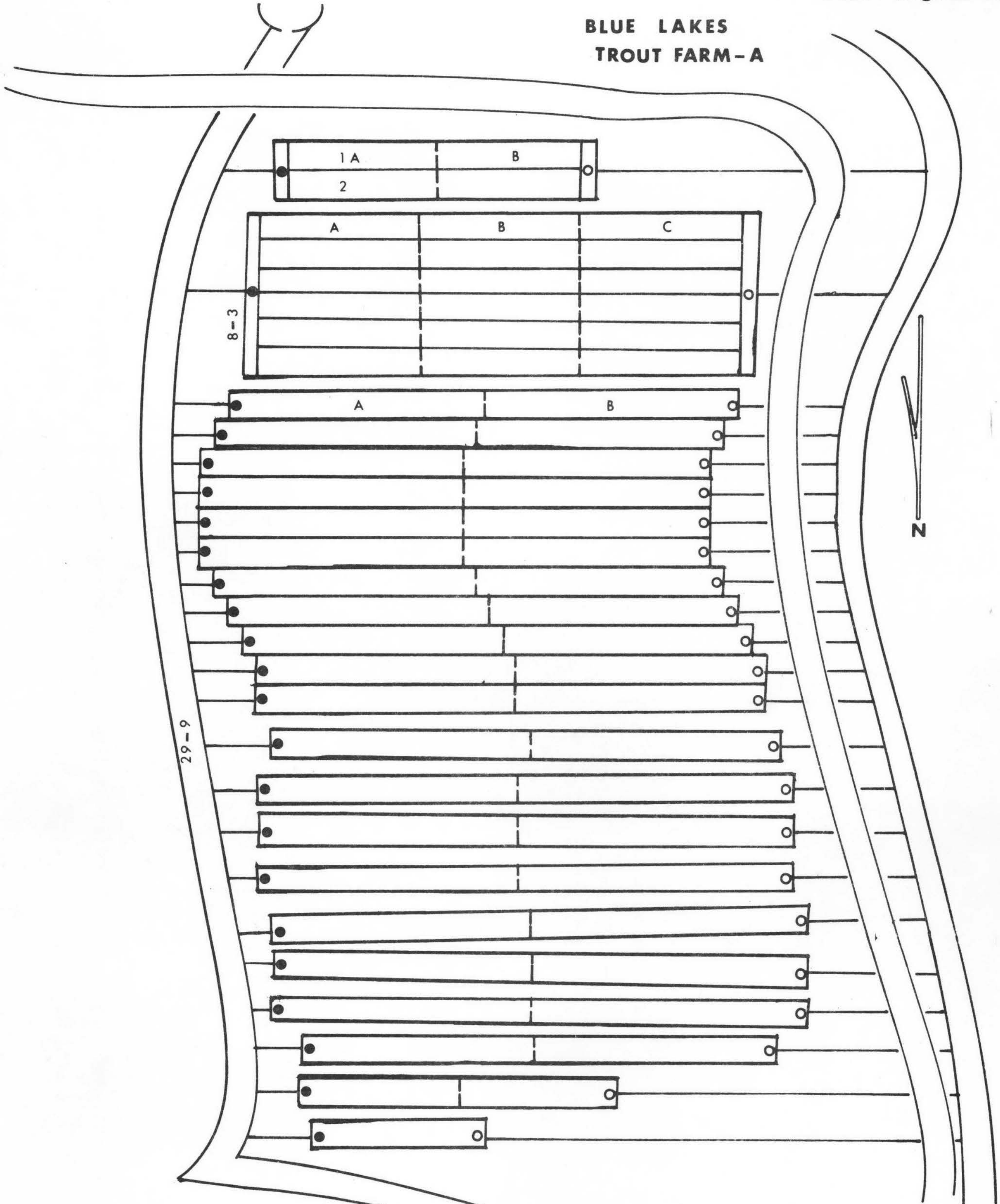
Water Temp.: 58°F 15.8°C

Water Chemistry:

Dissolved Oxygen	9.80 ppm	Alkalinity	188 ppm
pH	8.15	Conductivity	1304 µmhos
Nitrate	1.29 ppm	Phosphate	0.09 ppm
Hardness (Calcium)	154 ppm	Hardness (Total)	257 ppm
Calcium	37.5 ppm	Sodium	51 ppm
Potassium	10 ppm	Magnesium	28 ppm

Fish Rearing Space: 465,000 cubic feet in 60 ponds

Water Replacement Time: 39.9-51.6 minutes


BLUE LAKES
TROUT FARM-A
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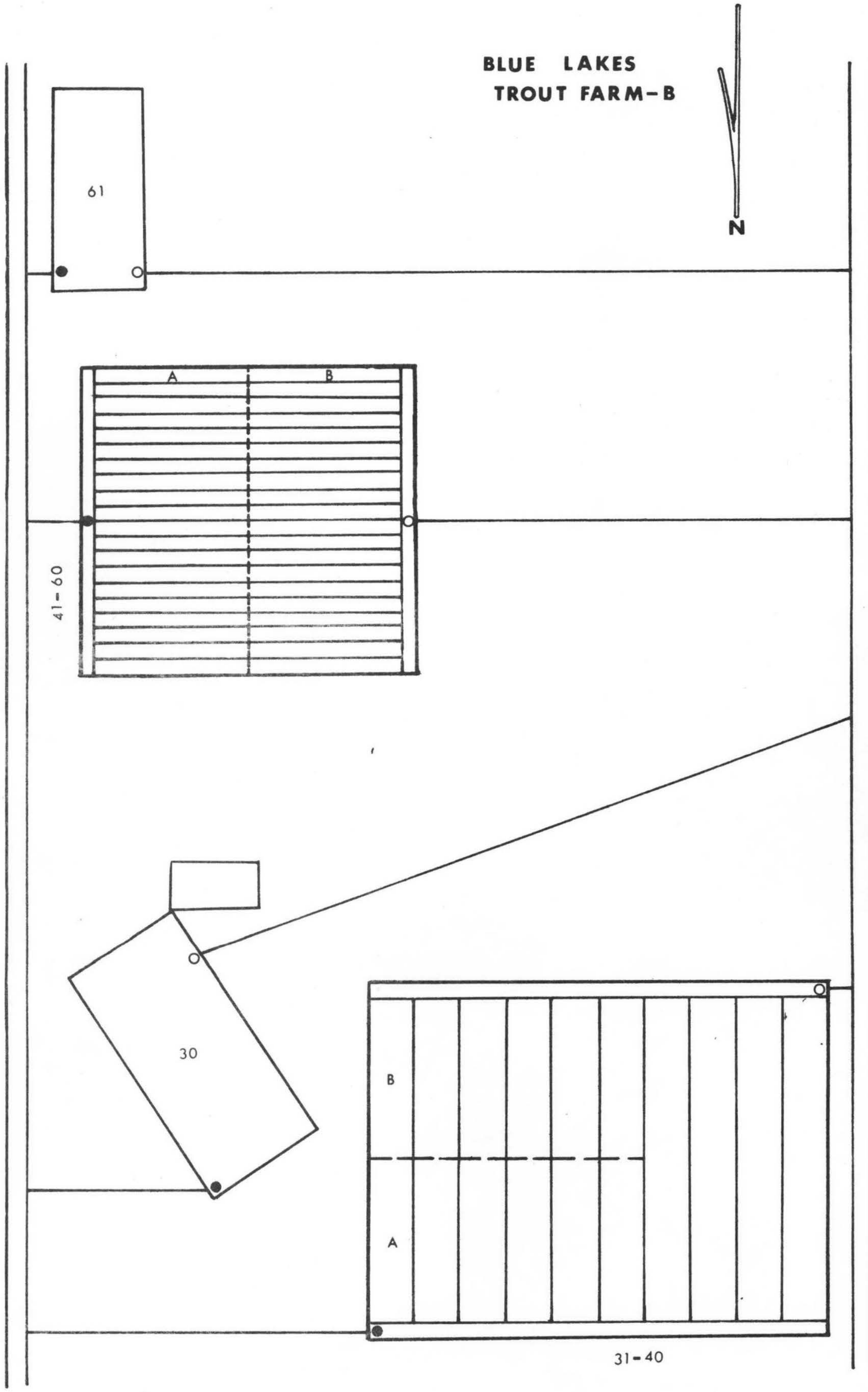
Flow Diagram 17



GREENE'S TROUT FARM

Blue Lakes Trout Farm, Inc.
P.O. Box 1237
Twin Falls, Idaho 83301

Started in 1935

Map Location: U-27

Water Source: Seep Tunnels and Springs

Water Flow: 28.8 CFS (Max.)
23 CFS (Min.)

Water Discharge: Snake River

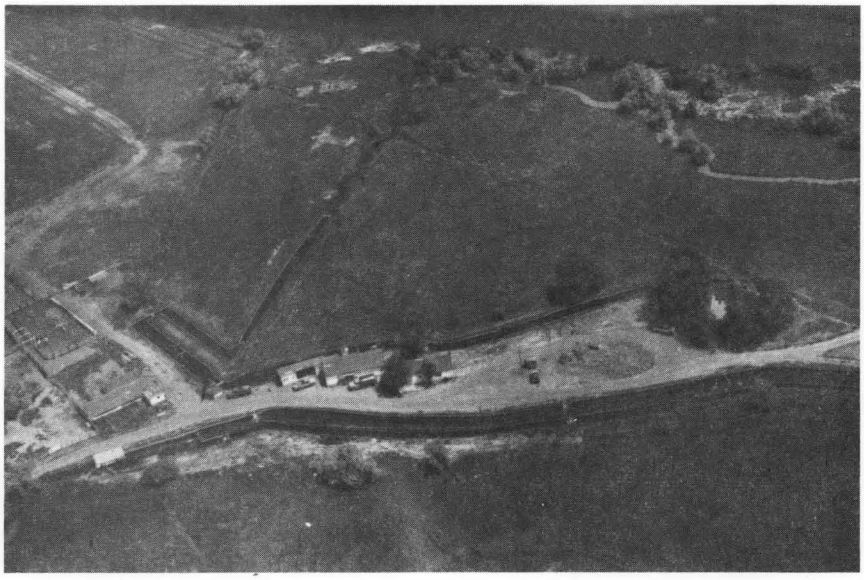
Water Temp.: 52°F 14.2°C

Water Chemistry:

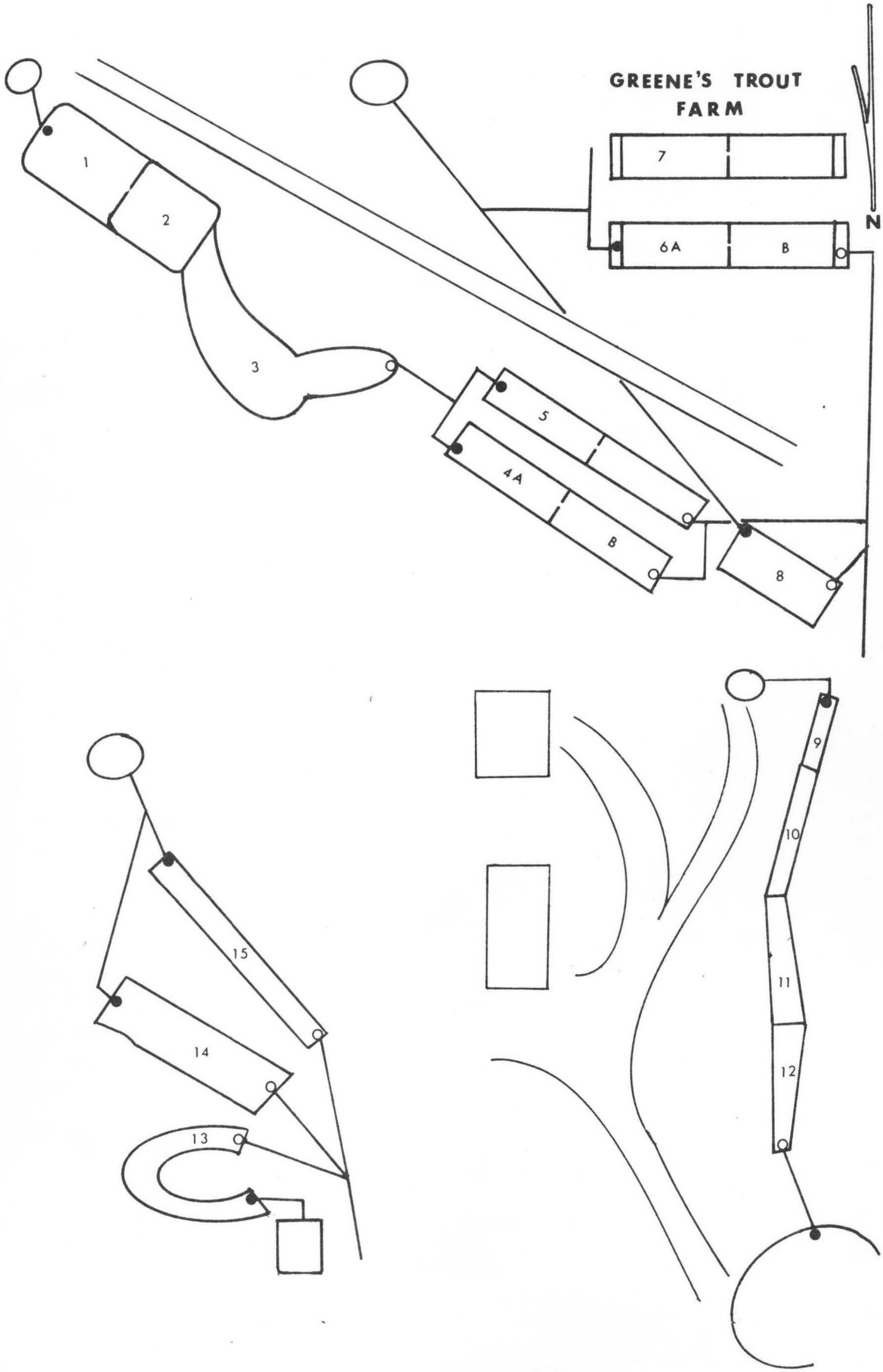
Dissolved Oxygen	10.57 ppm
Alkalinity	308 ppm
pH	7.85
Conductivity	2296 µmhos
Nitrate	4.30 ppm
Phosphate	0.10 ppm
Hardness (Calcium)	257 ppm
Hardness (Total)	428 ppm
Calcium	52 ppm
Sodium	94 ppm
Potassium	7.3 ppm
Magnesium	46 ppm

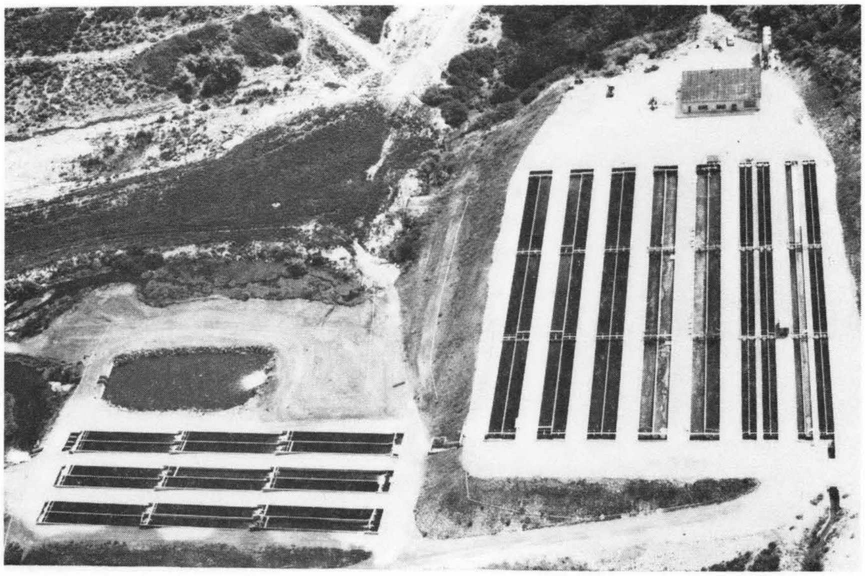
Fish Rearing Space: 2,676,000 cubic feet in 25 ponds

Water Replacement Time: 1,548-1,939 minutes (includes large pond)



Flow Diagram 18





JONES & SANDY TROUT FARM

Jones & Sandy Livestock Co.
Box 265
Hagerman, Idaho 83332

Started in 1971 — Map Location: H-5

Water Source: Three Springs and Weatherby Springs — Water Flow: 72 CFS (Max.) 30 CFS (Min.)

Water Discharge: Billingsley Creek — Water Temp.: 58°F 15.5°C

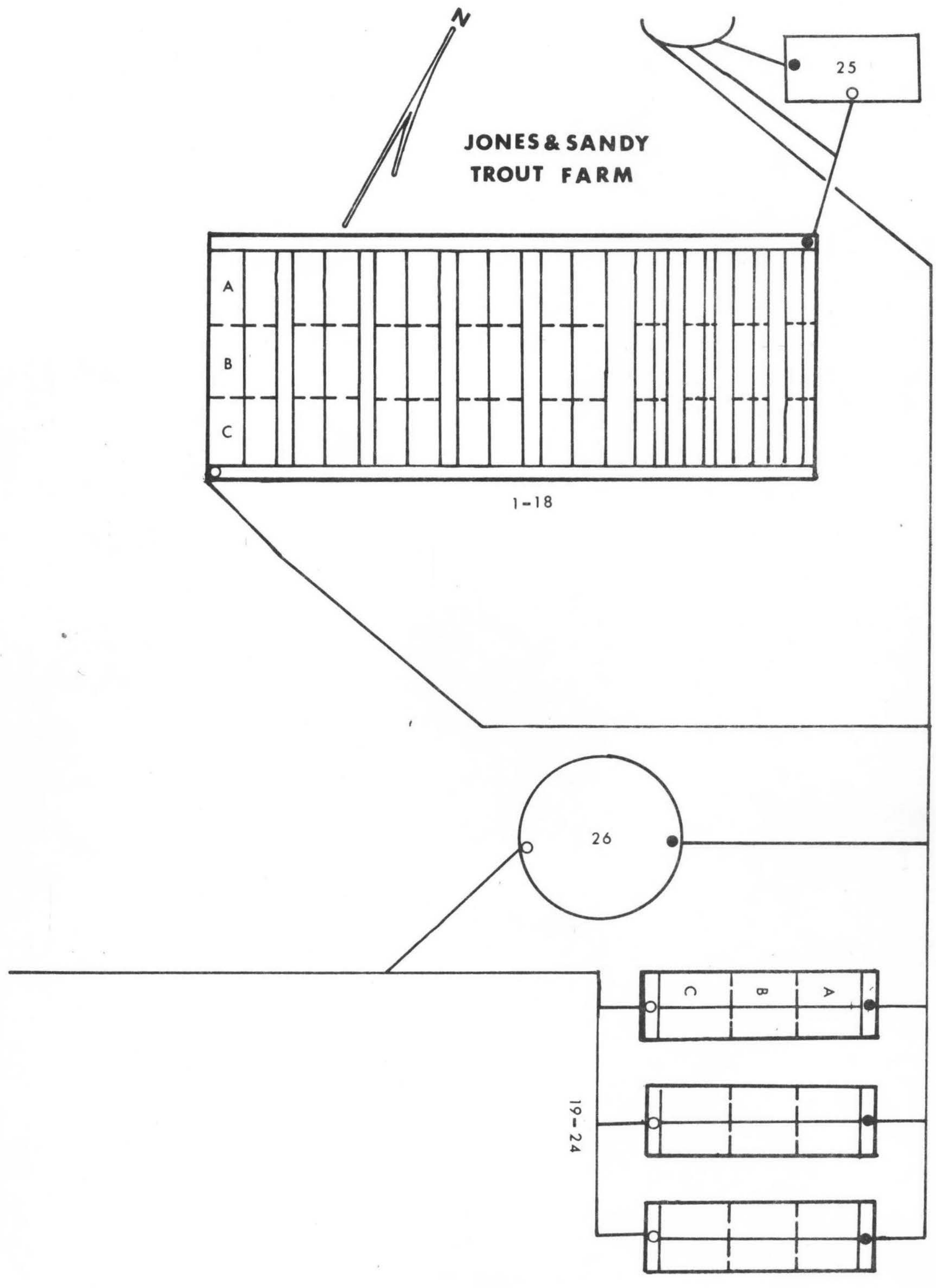
Water Chemistry:

Dissolved Oxygen	9.30 ppm	Alkalinity	154 ppm
pH	8.18	Conductivity	770 µmhos
Nitrate	0.87 ppm	Phosphate	0.16 ppm
Hardness (Calcium)	86 ppm	Hardness (Total)	171 ppm
Calcium	17.5 ppm	Sodium	30 ppm
Potassium	7.3 ppm	Magnesium	22.5 ppm

Fish Rearing Space: 145,900 cubic feet in 72 ponds

Water Replacement Time: 33.7-81.0 minutes

Flow Diagram 19



FISH BREEDERS OF IDAHO

Fish Breeders of Idaho
2914 Alta Vista Drive
Twin Falls, Idaho 83301

Started in 1972

Map Location: P-7

Water Source: Wells, Seepage, Irrigation Overflow

Water Discharge: Snake River

Water Flow: 13 CFS (Max.)
6 CFS (Min.)

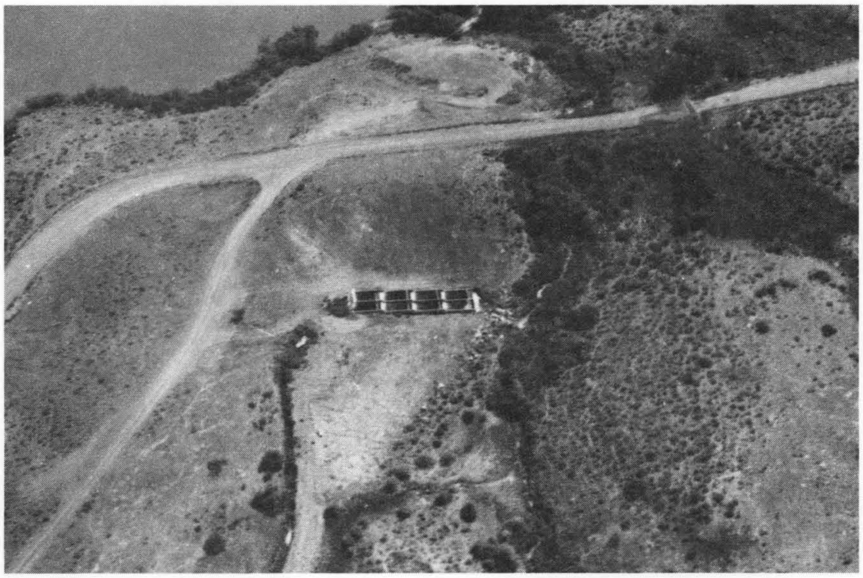
Water Temp.: 60-95^{o}F 29^{o}C

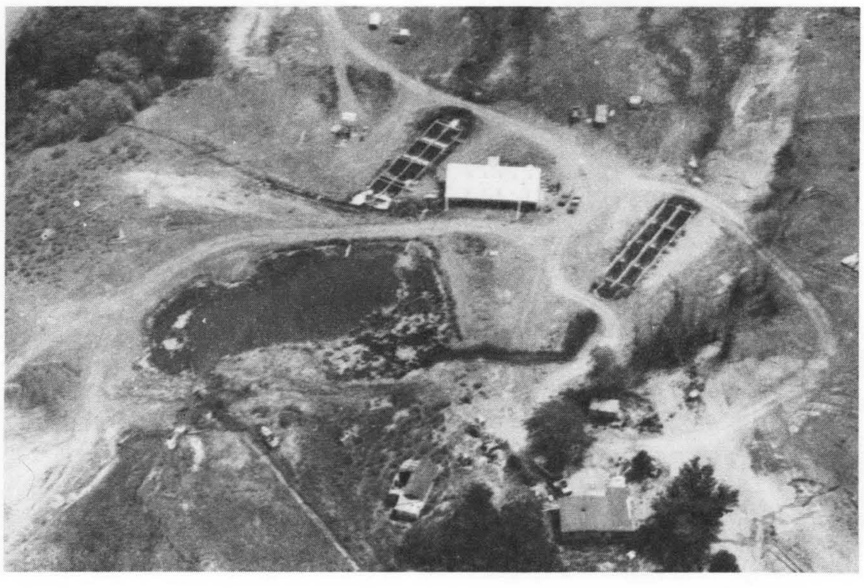
Water Chemistry:

Dissolved Oxygen	6.80-5.60 ppm
Alkalinity	188-205 ppm
pH	8.45-8.50
Conductivity	936-988 µmhos
Nitrate	0.39-0.50 ppm
Phosphate	0.38 ppm
Hardness (Calcium)	86-103 ppm
Hardness (Total)	154-171 ppm
Calcium	16.5 ppm
Sodium	69.25 ppm
Potassium	5.5 ppm
Magnesium	16.5 ppm

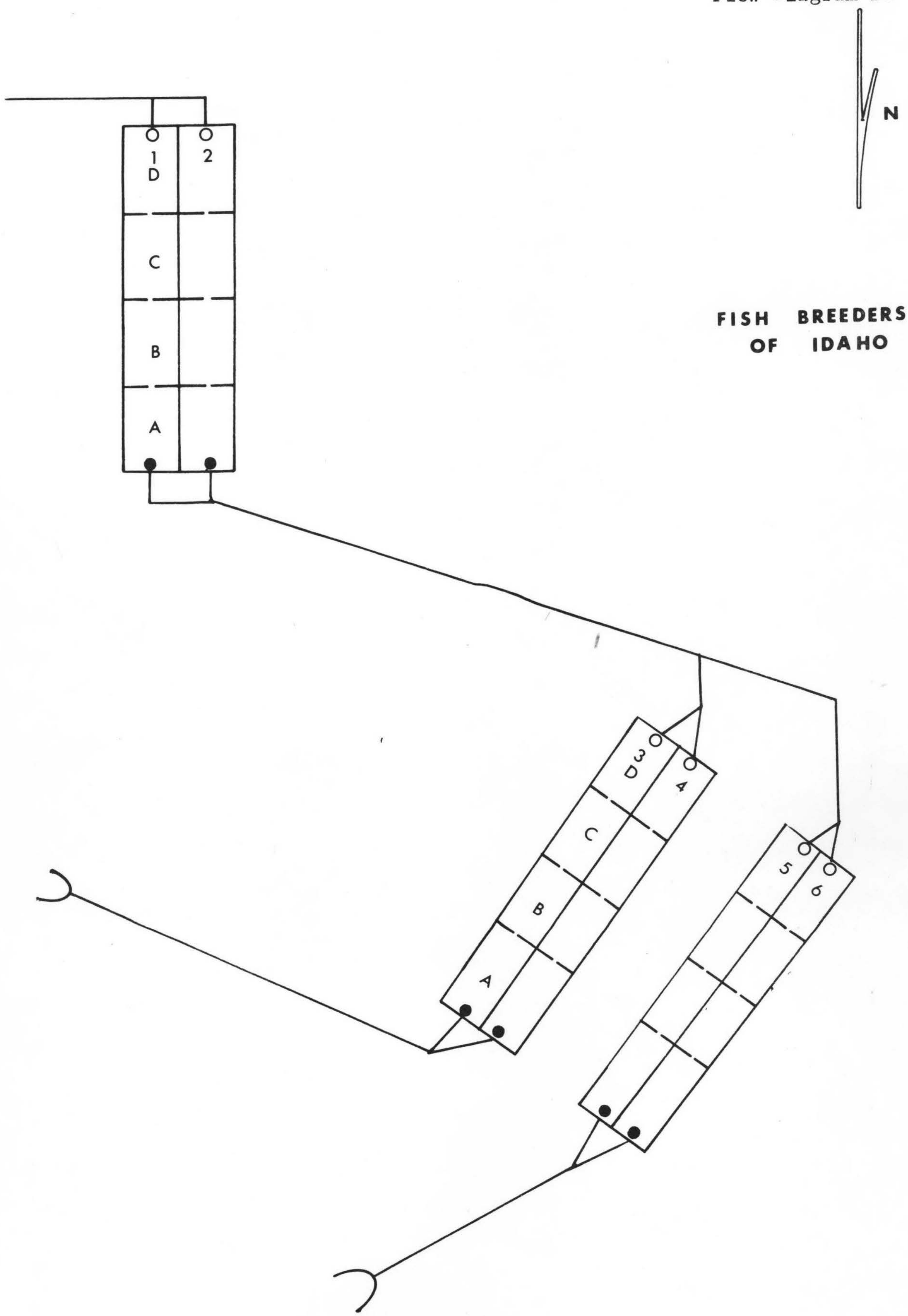
Fish Rearing Space: 19,200 cubic feet in 20 ponds

Water Replacement Time: 24.6-53 minutes





Flow Diagram 20



ROYAL CATFISH INDUSTRIES

Royal Catfish Industries
P.O. Box 757
Twin Falls, Idaho 83301

Started in 1929
Out of Business

Map Location: S-25

Water Source: Springs and wells and tailwater from Blue Lakes

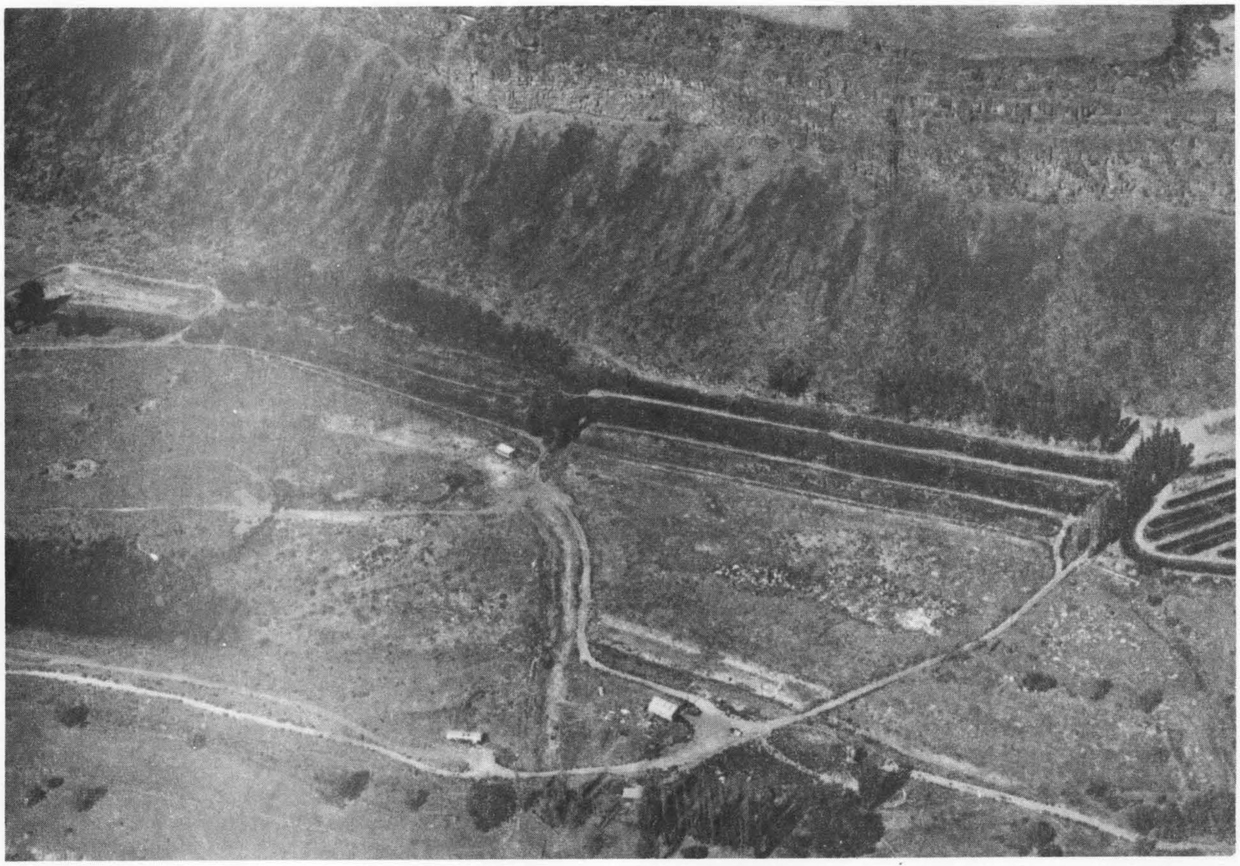
Water Discharge: Snake River

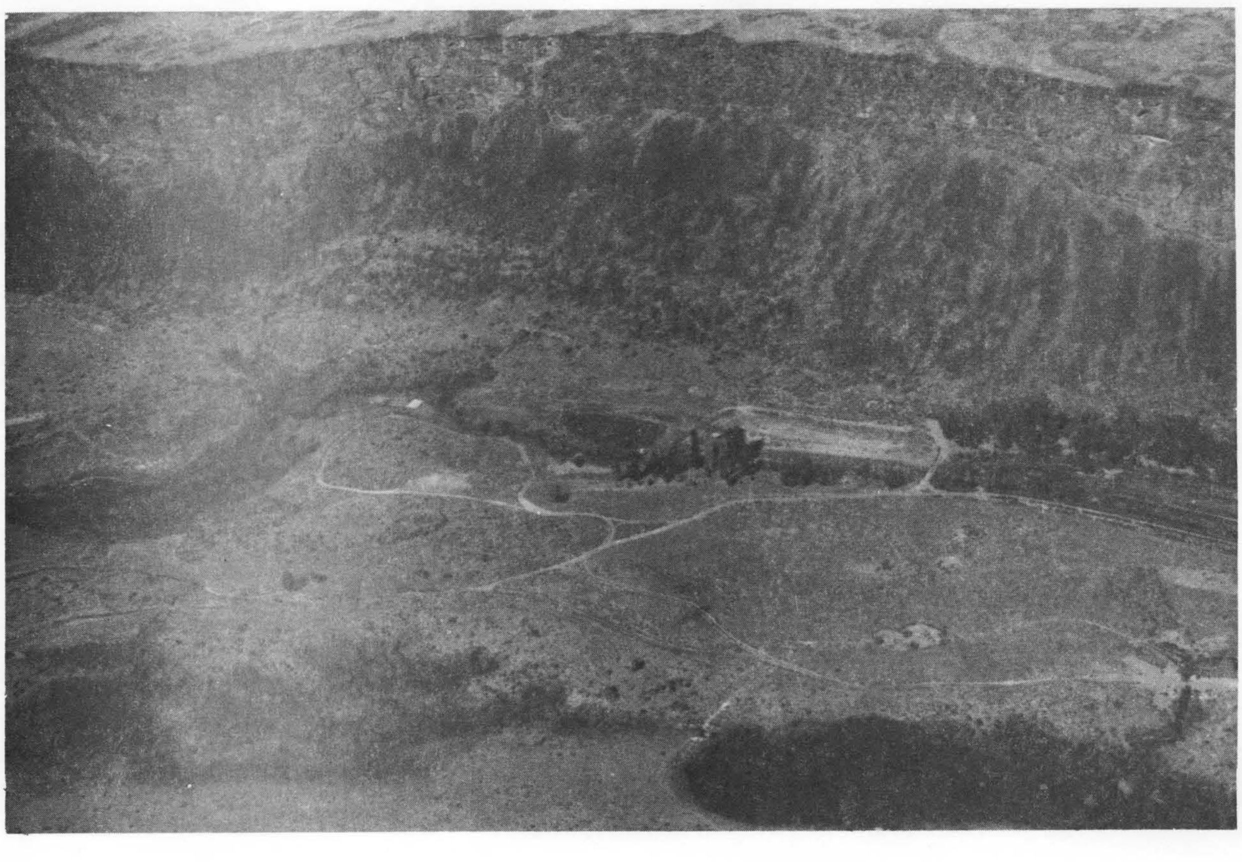
Water Flow: 44 CFS (Max.)
35 CFS (Min.)

Water Chemistry: Not Sampled

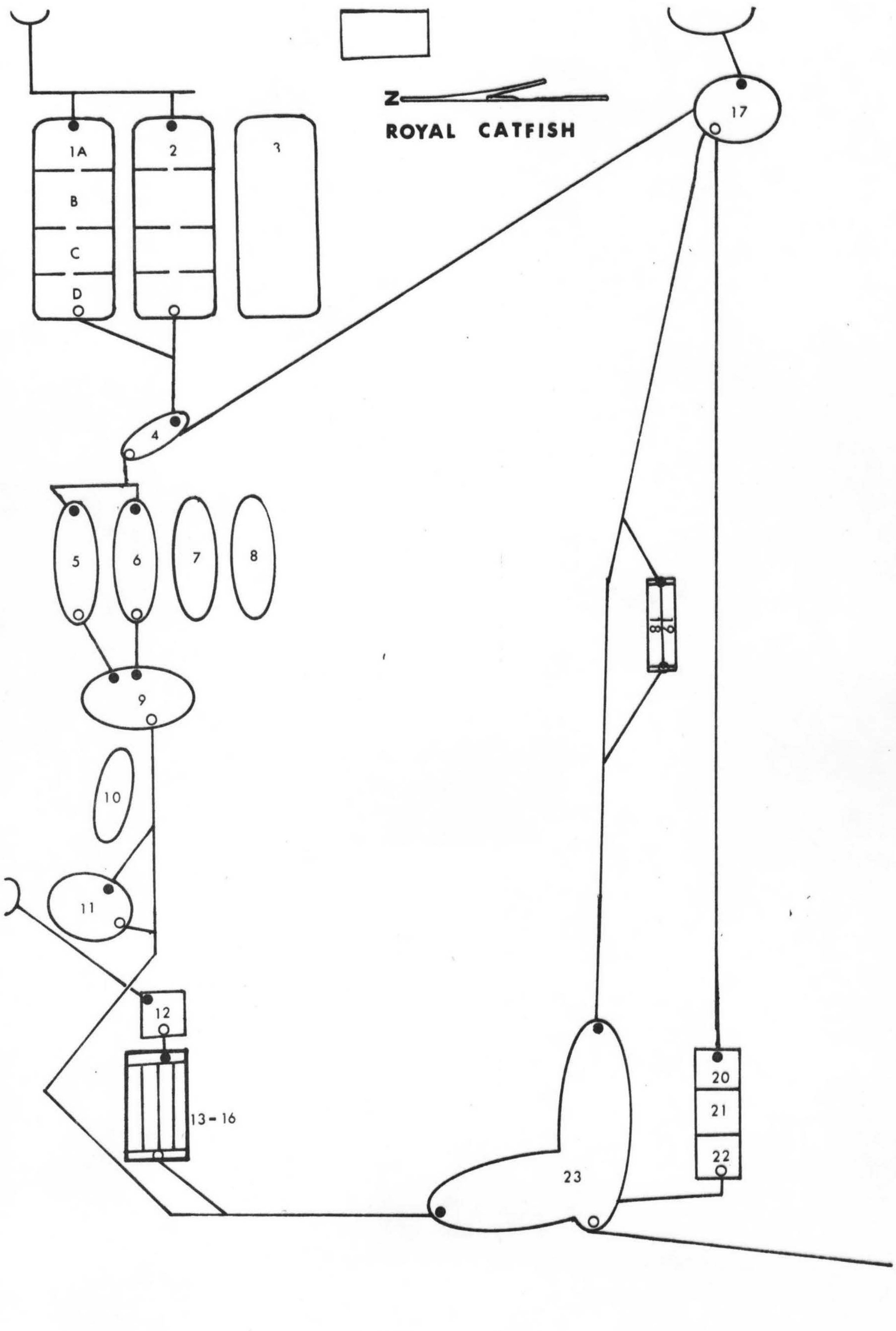
Fish Rearing Space: 434,200 cubic feet in 30 ponds

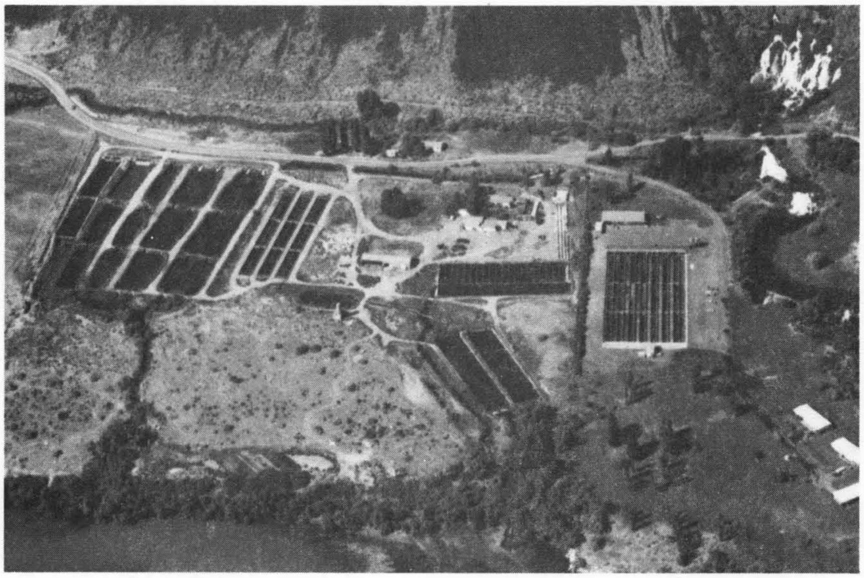
Water Replacement Time: 164.4-206.6 minutes





Flow Diagram 21





RIMVIEW TROUT FARM

Rimview Trout Co., Inc.
P.O. Box 7503
Boise, Idaho 83705

Started in 1951

Map Location: P-15

Water Source: Niagra Springs

Water Flow: 130 CFS (Max.)
95.3 CFS (Min.)

Water Discharge: Snake River

Water Temp.: 56-58°F 14.1°C

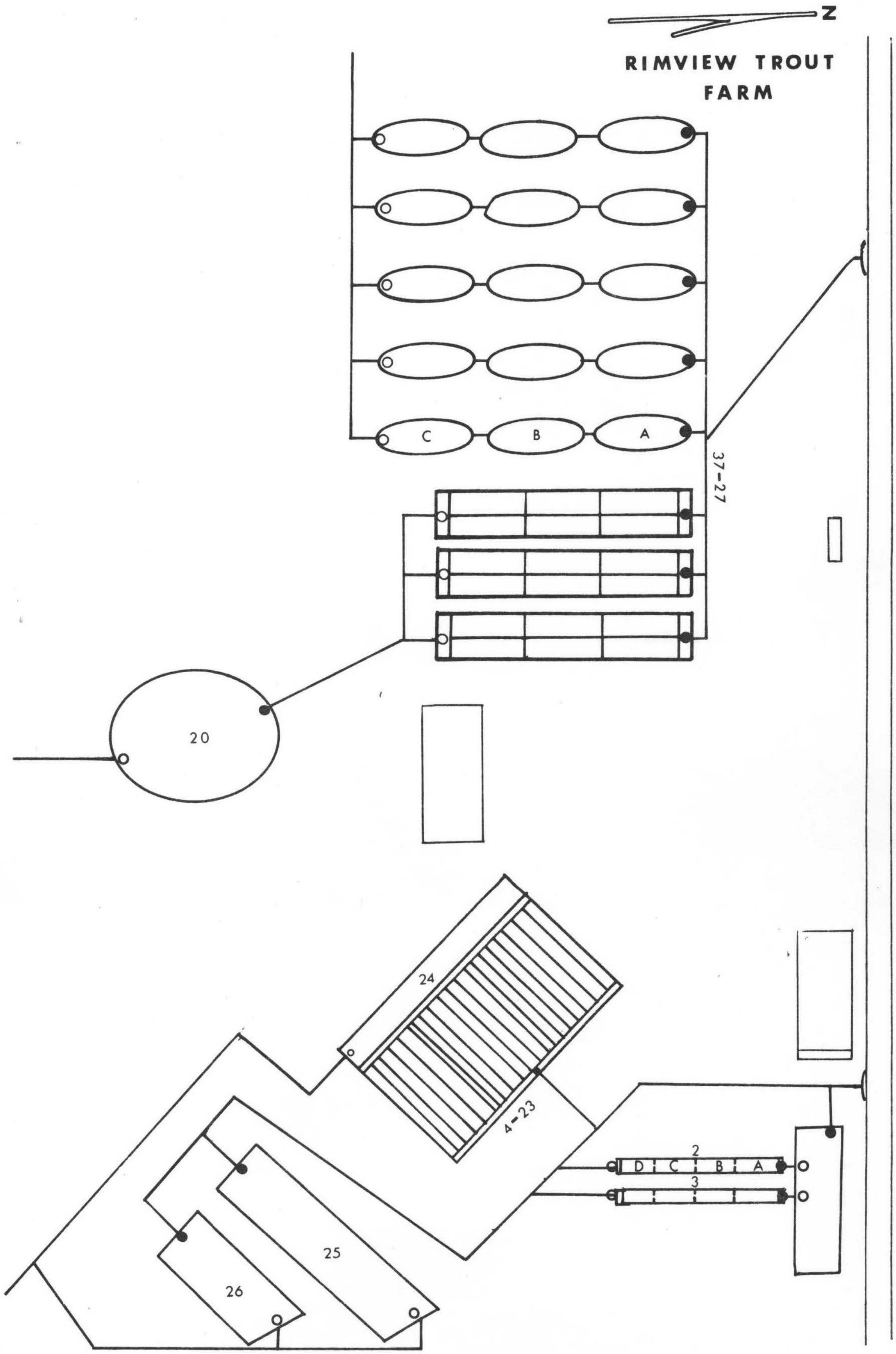
Water Chemistry:

Dissolved Oxygen	9.80 ppm	Alkalinity	-171 ppm
pH	-8.05	Conductivity	-1419 µmhos
Nitrate	-1.09 ppm	Phosphate	0.21 ppm
Hardness (Calcium)	-137 ppm	Hardness (Total)	-222 ppm
Calcium	34 ppm	Sodium	34 ppm
Potassium	7 ppm	Magnesium	26 ppm

Fish Rearing Space: 360,000 cubic feet in 63 ponds

Water Replacement Time: 46.1-62.9 minutes

Flow Diagram 22



CARIBOU TROUT RANCH

Caribou Trout Ranch
P.O. Box 57
Soda Springs, Idaho 83276

Started in 1938

Map Location: Caribou County

Water Source: Springs

Water Flow: 30 CFS (Max.)
22.7 CFS (Min.)

Water Discharge: Fish Hatchery Creek

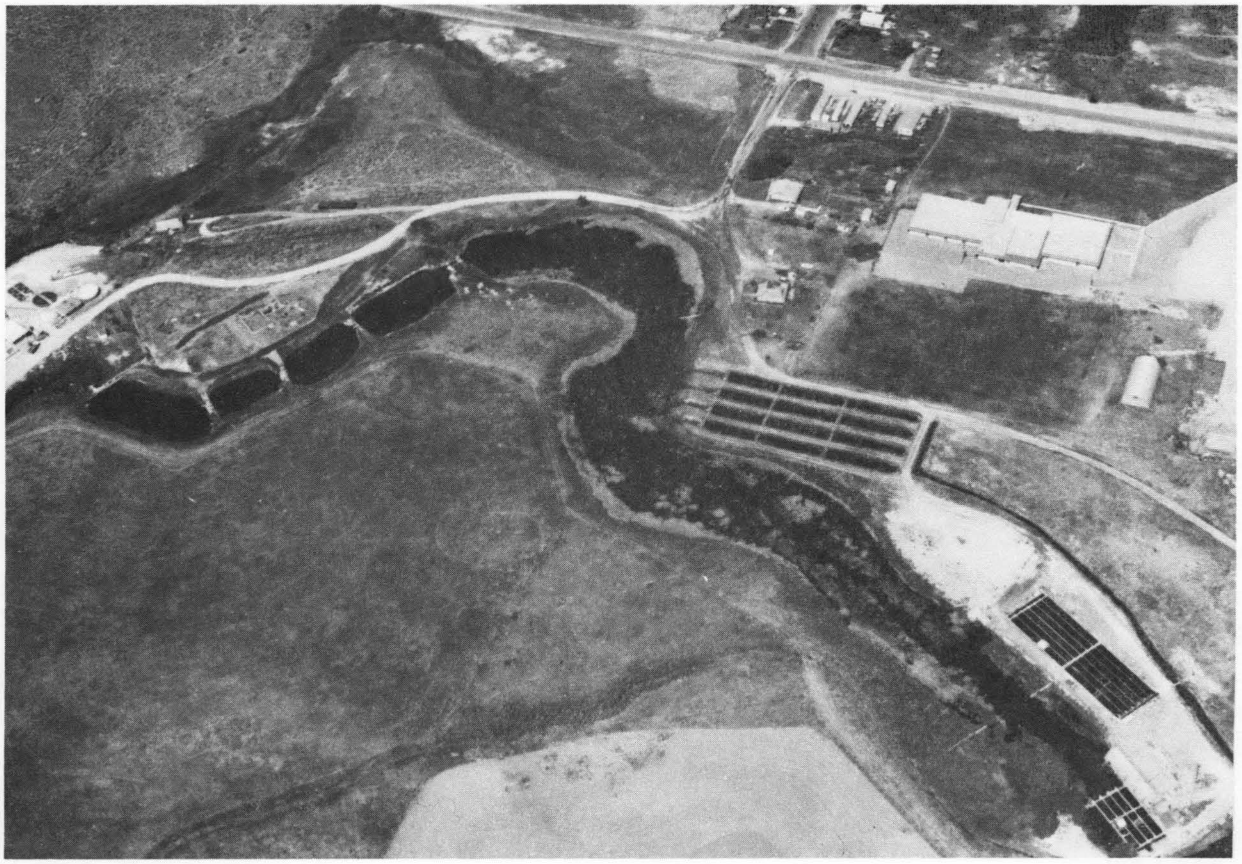
Water Temp.: 47-57°F 9.2°C

Water Chemistry:

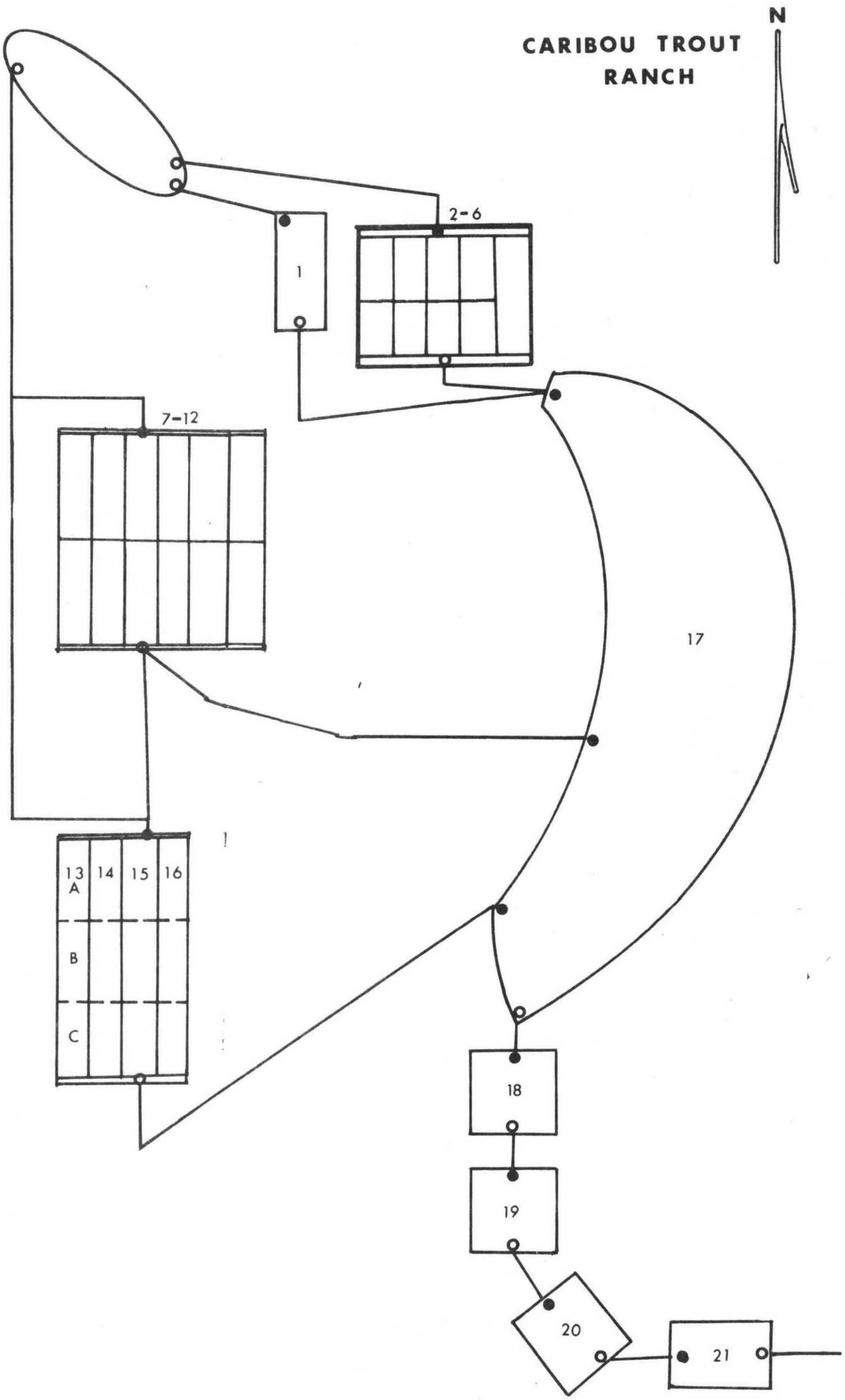
Dissolved Oxygen	-5.20 ppm	Alkalinity	-394 ppm
pH	-7.25	Conductivity	-2024 µmhos
Nitrate	-0.50 ppm	Phosphate	-0.35 ppm
Hardness (Calcium)	-257 ppm	Hardness (Total)	428 ppm
Calcium	102.5 ppm	Sodium	37 ppm
Potassium	4.75 ppm	Magnesium	71 ppm

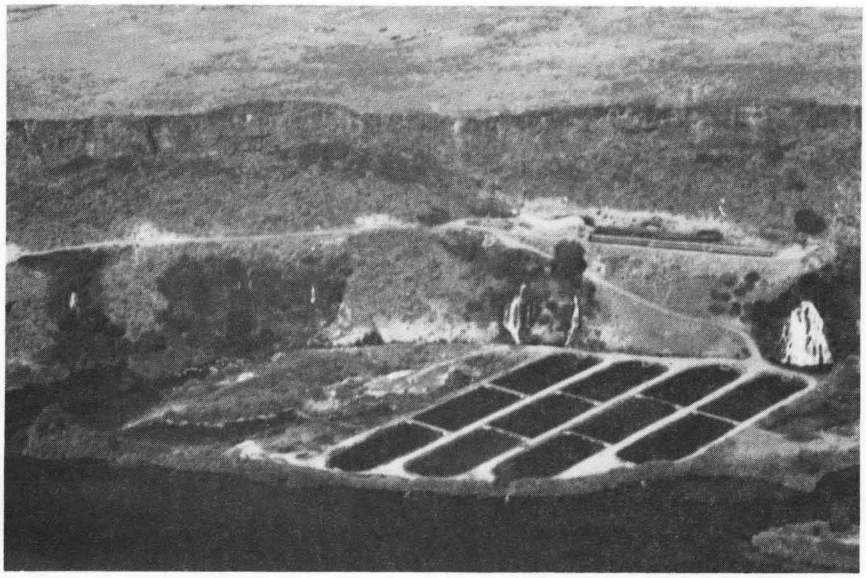
Fish Rearing Space: 1,666,300 cubic feet in 35 ponds

Water Replacement Time: 925.7-1,223 minutes (includes large pond)



Flow Diagram 23





MAGIC SPRINGS TROUT FARM

Magic Springs Trout Farm
P.O. Box 326
Hagerman, Idaho 83332

Started in 1969

Map Location: J-5

Water Source: Magic Springs

Water Flow: 215 CFS (Max.)
200 CFS (Min.)

Water Discharge: Snake River

Water Temp.: 58°F 15.2°C

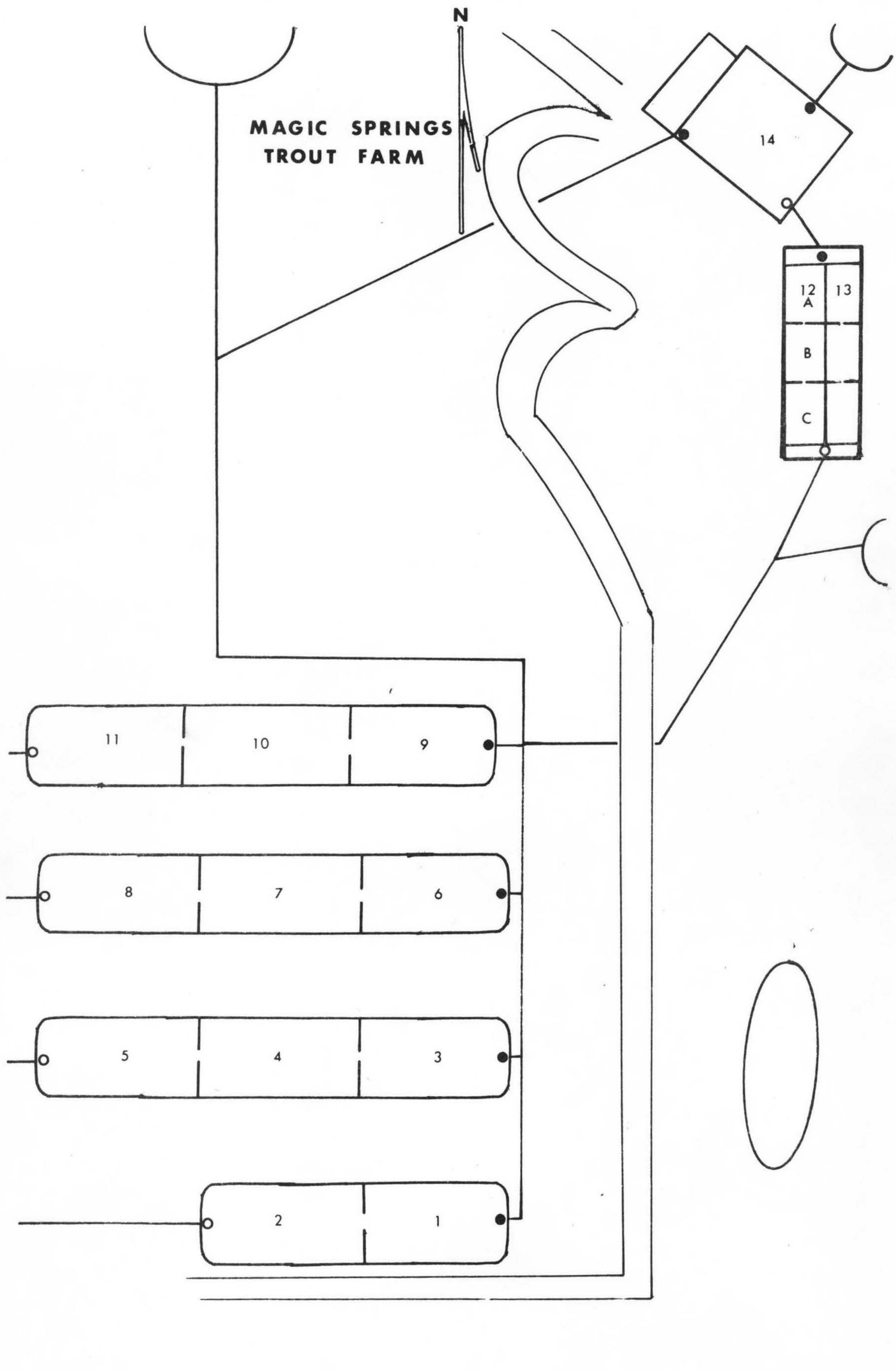
Water Chemistry:

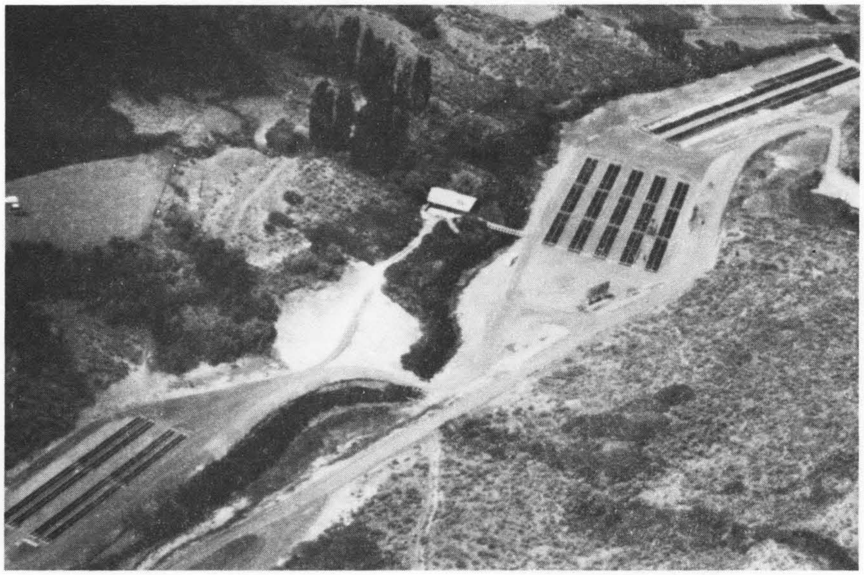
Dissolved Oxygen	8.80 ppm	Alkalinity	120 ppm
pH	8.30	Conductivity	683 µmhos
Nitrate	0.62 ppm	Phosphate	0.14 ppm
Hardness (Calcium)	86 ppm	Hardness (Total)	171 ppm
Calcium	10 ppm	Sodium	27 ppm
Potassium	8 ppm	Magnesium	21 ppm

Fish Rearing Space: 994,800 cubic feet in 17 ponds

Water Replacement Time: 77.1-82.9 minutes

Flow Diagram 24





RANGEN'S TROUT RESEARCH HATCHERY

Rangen's Trout Research Hatchery
Hagerman, Idaho 83332

Started in 1962

Map Location: H-6

Water Source: Curran Tunnel

Water Flow: 50 CFS (Max.)
35 CFS (Min.)

Water Discharge: Billingsley Creek

Water Temp.: 59°F 15.3°C

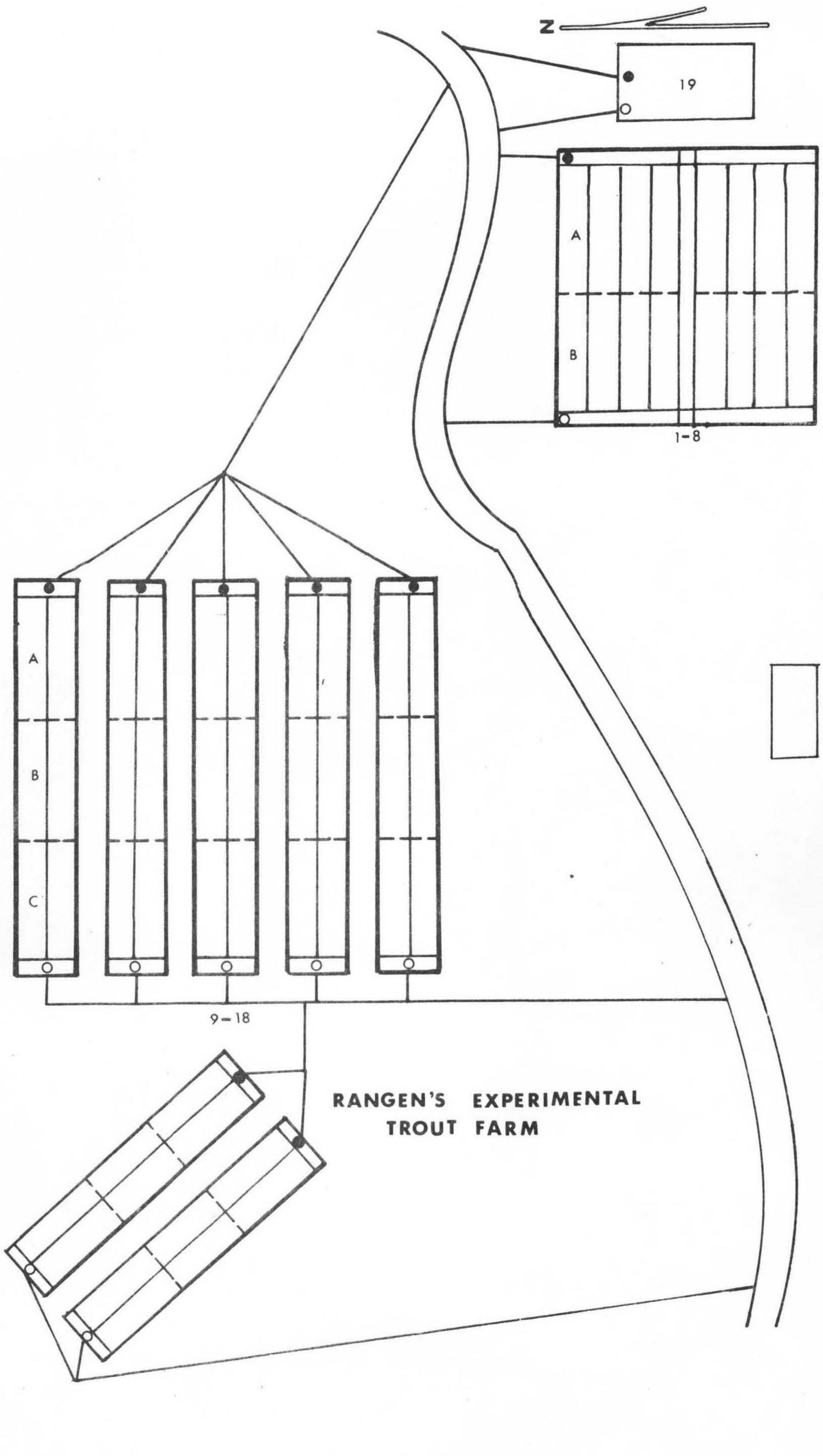
Water Chemistry:

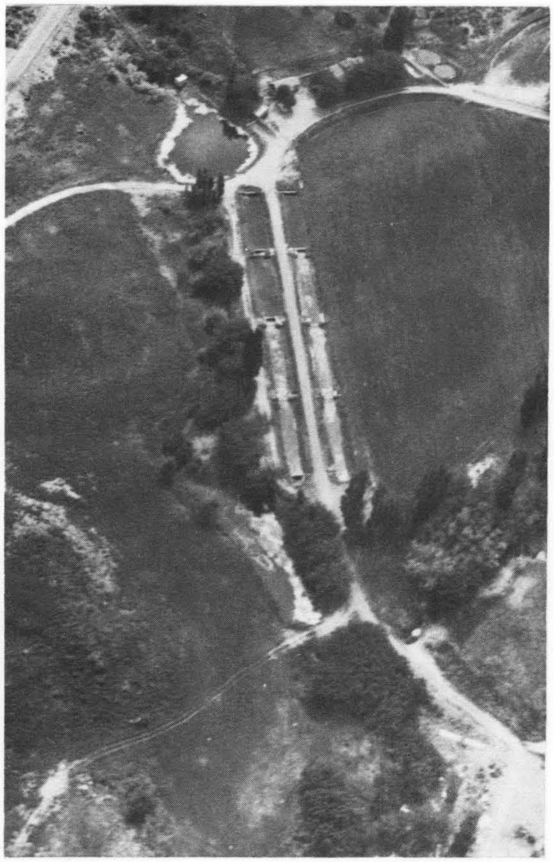
Dissolved Oxygen	9.80 ppm	Alkalinity	154 ppm
pH	8.15	Conductivity	791 µmhos
Nitrate	0.92 ppm	Phosphate	0.08 ppm
Hardness (Calcium)	103 ppm	Hardness (Total)	171 ppm
Calcium	10 ppm	Sodium	22.5 ppm
Potassium	4.5 ppm	Magnesium	19 ppm

Fish Rearing Space: 81,600 cubic feet in 58 ponds

Water Replacement Time: 27.2-38.8 minutes

Flow Diagram 25





WHITEWATER TROUT FARM

Whitewater Trout Farm
Hagerman, Idaho 83332

Started in 1966

Map Location: A-2

Water Source: Springs

Water Flow: 18 CFS (Max.)
8 CFS (Min.)

Water Discharge: Stoddard Creek

Water Temp.: 58°F 15.5°C

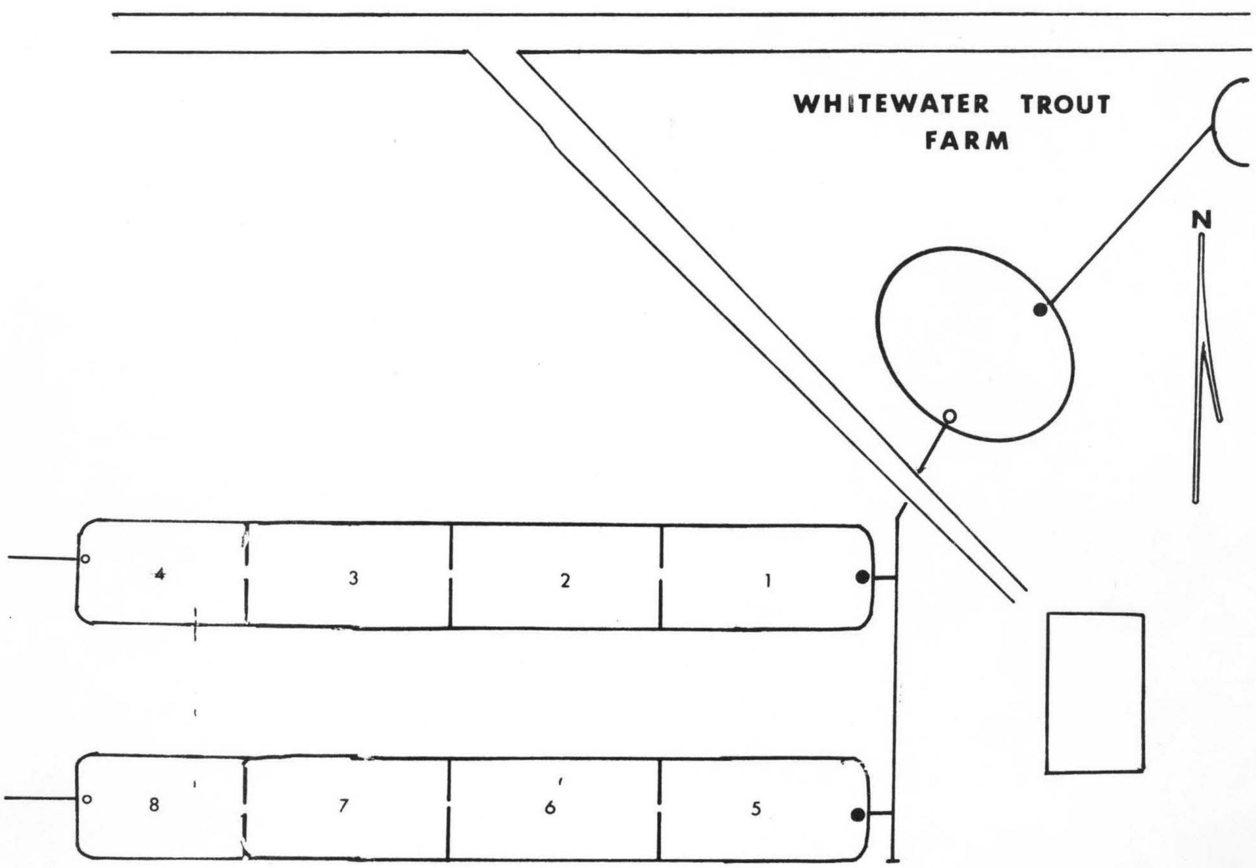
Water Chemistry:

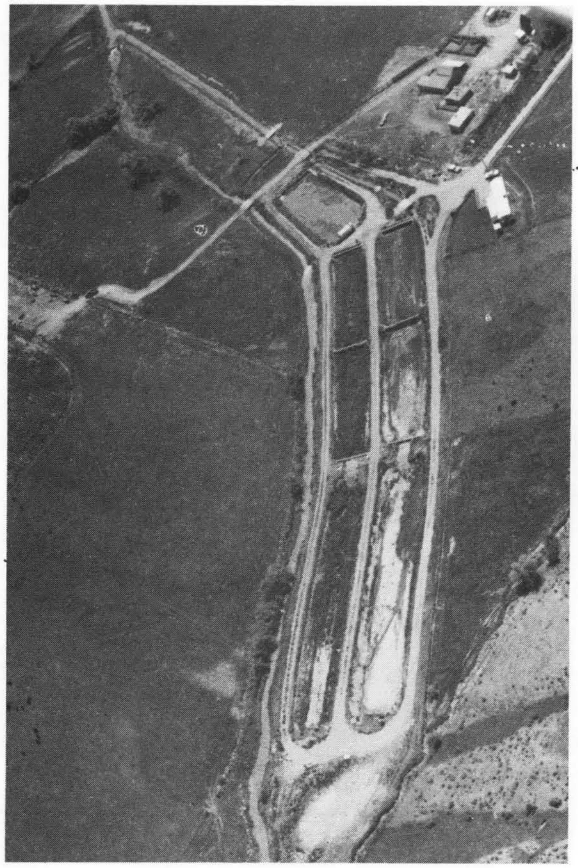
Dissolved oxygen	8.55 ppm	Alkalinity	274 ppm
pH	8.12	Conductivity	1310 µmhos
Nitrate	1.82 ppm	Phosphate	0.32 ppm
Hardness (Calcium)	171 ppm	Hardness (Total)	274 ppm
Calcium	50 ppm	Sodium	64 ppm
Potassium	12 ppm	Magnesium	39 ppm

Fish Rearing Space: 112,000 cubic feet in 8 ponds

Water Replacement Time: 103.7-233.3 minutes

Flow Diagram 26





VALLEY TROUT FARM, #1

Valley Trout Farms, Inc.
Route 2
Buhl, Idaho 83316

Started in 1974 - Not In Operation

Water Source: Irrigation Overflow

Water Discharge: Irrigation Canal

Map Location: T-7

Water Flow: 15 CFS (Max.)
15 CFS (Min.) (est.)

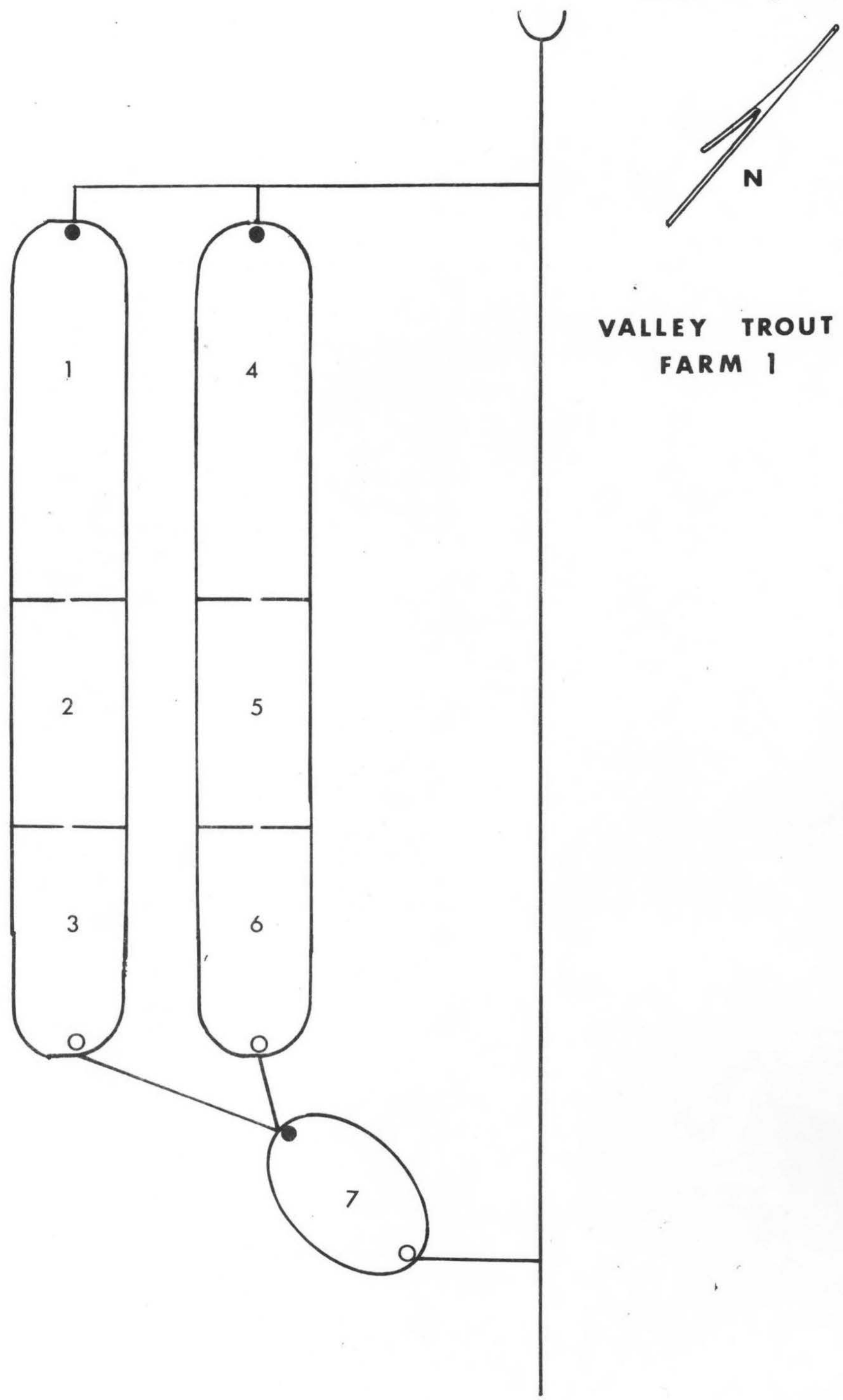
Water Temp.: 46-61°F 15.1°C

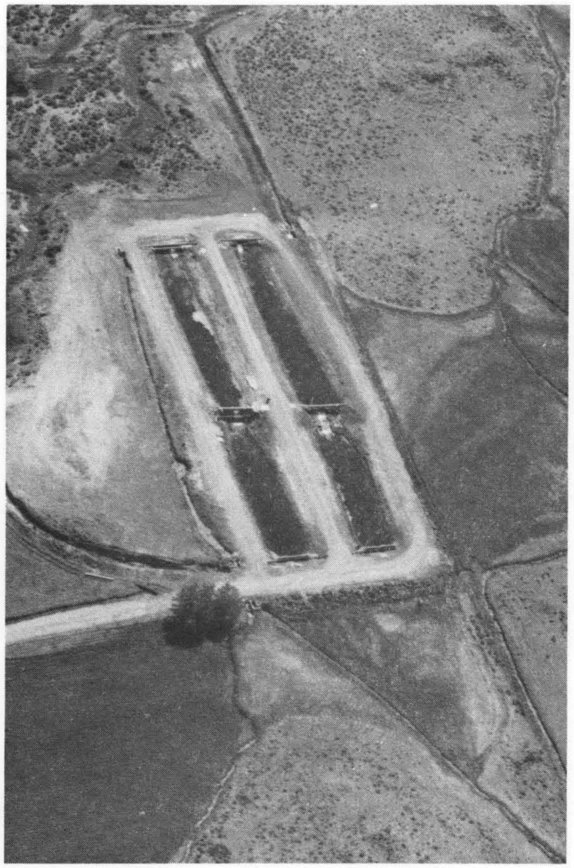
Water Chemistry: Not Sampled

Fish Rearing Space: 27,800 cubic feet in 7 ponds

Water Replacement Time: 30.8 minutes (est.)

Flow Diagram 27





VALLEY TROUT FARM, #2

Valley Trout Farms, Inc.
Route 2
Buhl, Idaho 83316

Started in 1974 - Not In Operation

Water Source: Irrigation Overflow

Water Discharge: Irrigation Canal

Map Location: W-7

Water Flow: 25 CFS (Max.)
25 CFS (Min.)

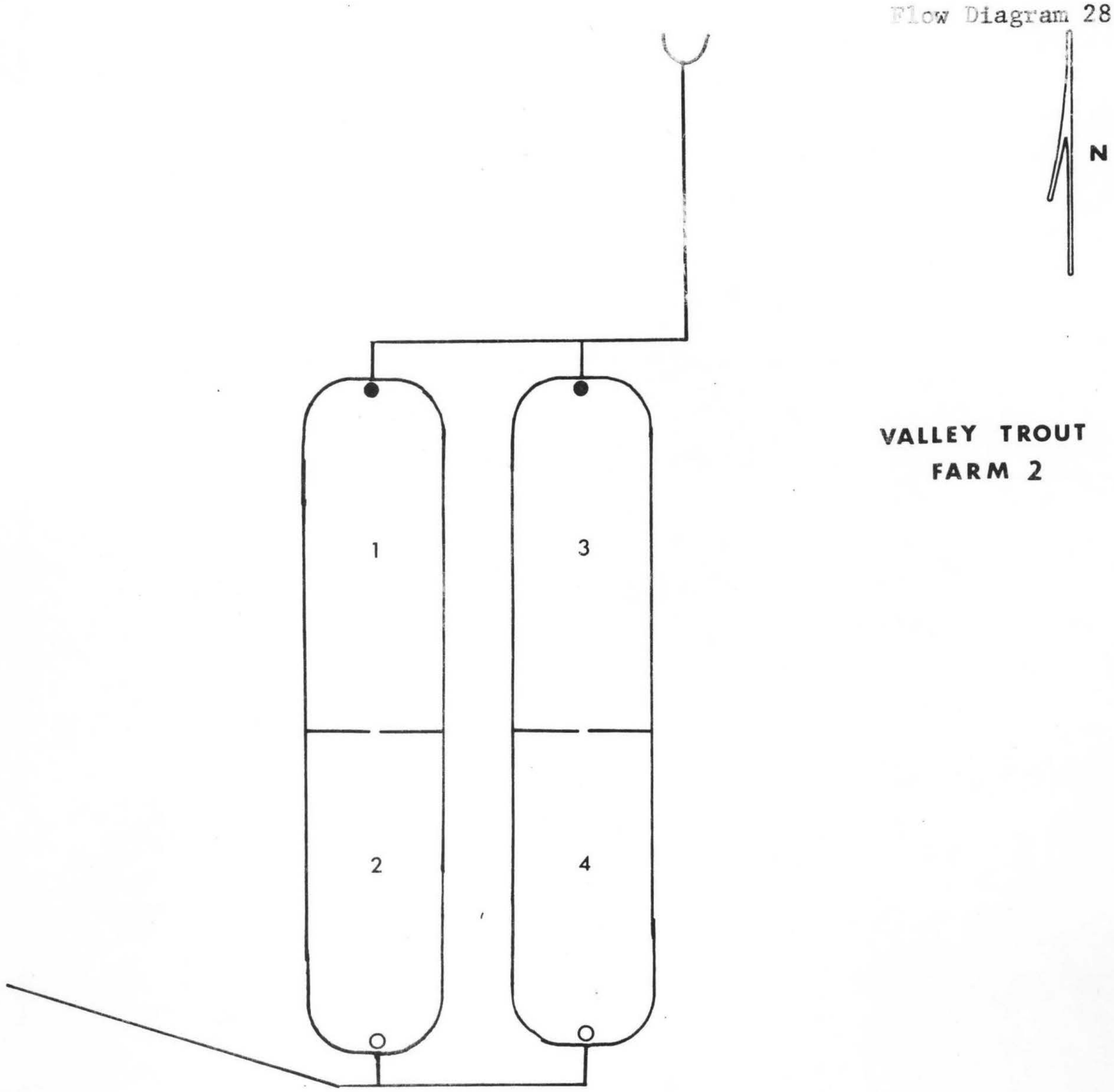
Water Temp.: 52-56^{o}F 15.7^{o}C

Water Chemistry: Not Sampled

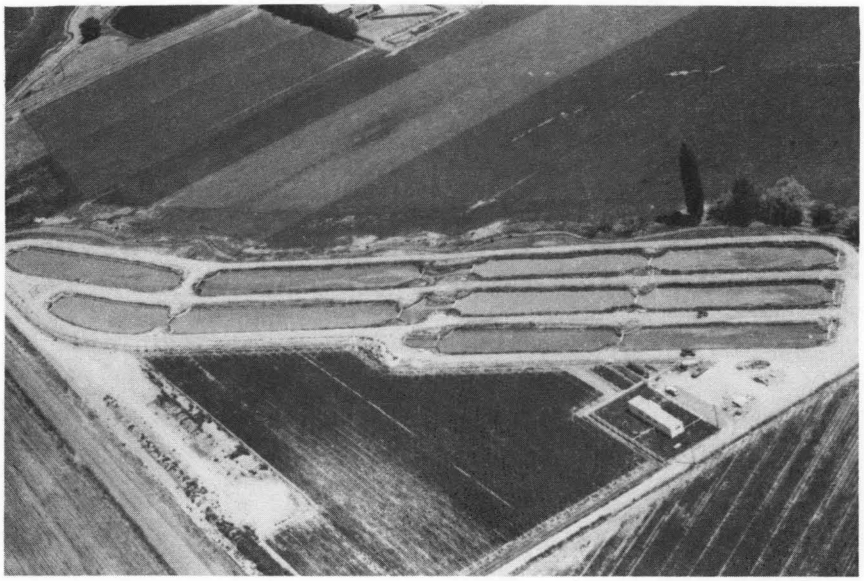
Fish Rearing Space: 300,000 cubic feet in 4 ponds

Water Replacement Time: 200 minutes (est.)

Flow Diagram 28



VALLEY TROUT
FARM 2



VALLEY TROUT FARM, #3

Valley Trout Farms, Inc.
Route 2
Buhl, Idaho 83316

Started in 1972

Map Location: U-16

Water Source: Irrigation Overflow

Water Flow: 140 CFS (Max.)
49 CFS (Min.)

Water Discharge: Irrigation Canal

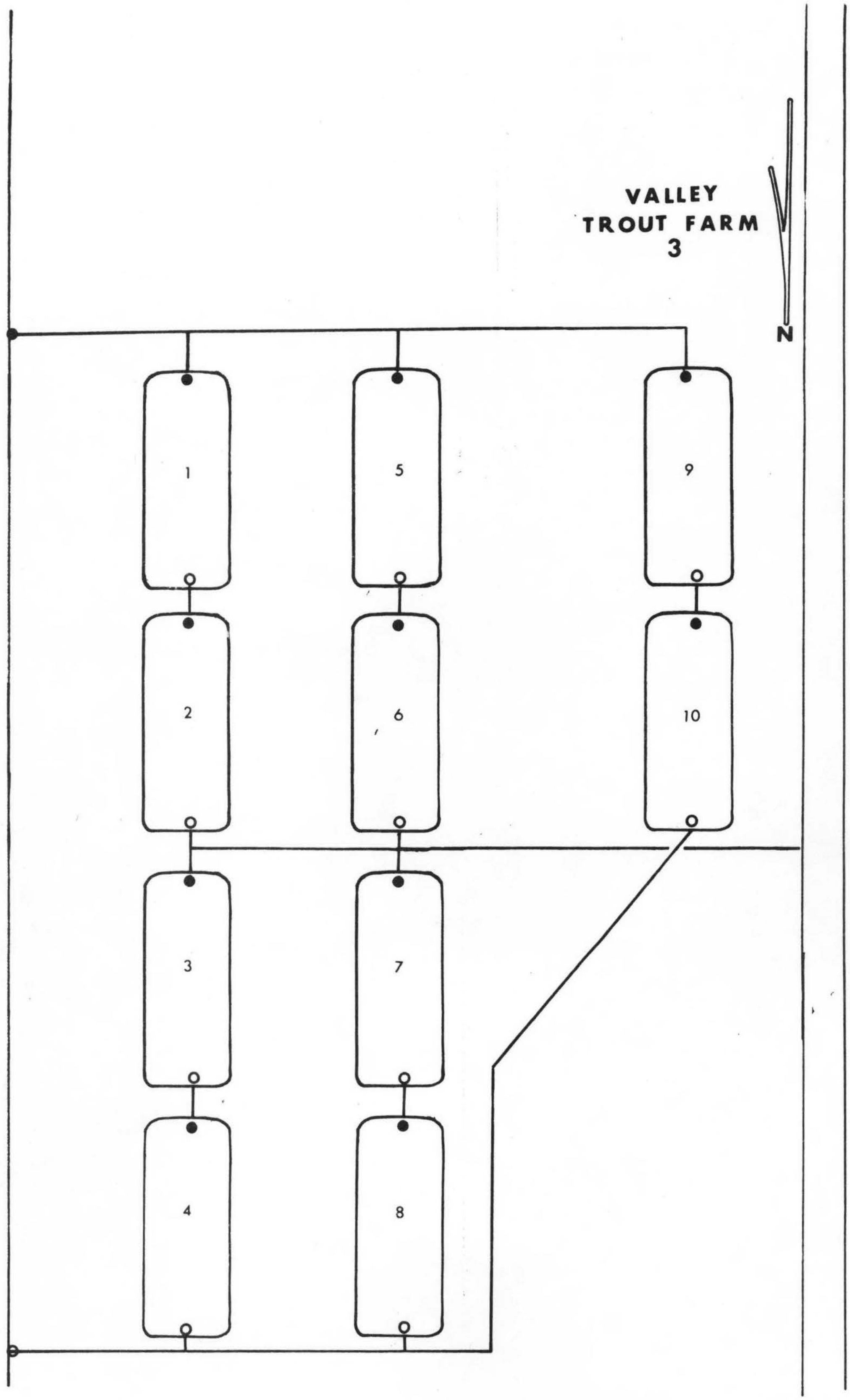
Water Temp.: 49-61°F 17.1°C

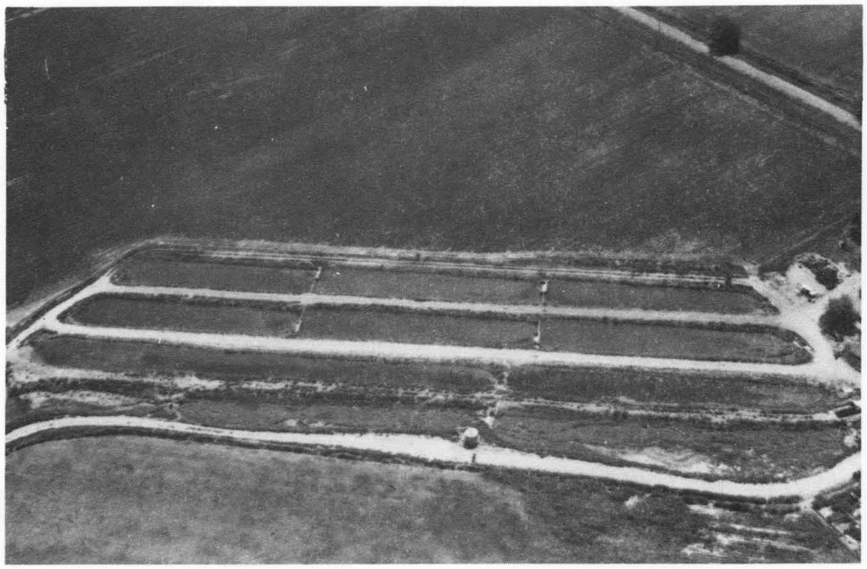
Water Chemistry:

Dissolved Oxygen	8.10 ppm	Alkalinity	240 ppm
pH	8.13	Conductivity	1291 µmhos
Nitrate	1.60 ppm	Phosphate	0.90 ppm
Hardness (Calcium)	120 ppm	Hardness (Total)	274 ppm
Calcium	57 ppm	Sodium	60 ppm
Potassium	7.5 ppm	Magnesium	39 ppm

Fish Rearing Space: 300,000 cubic feet in 10 ponds

Water Replacement Time: 35.7-102 minutes


VALLEY
TROUT FARM
3
N
1
5
9
2
6
10
3
7
4
8



VALLEY TROUT FARM, #4

Valley Trout Farms, Inc.
Route 2
Buhl, Idaho 83316

Started in 1974 - Not In Operation

Map Location: T-13

Water Source: Seep Tunnel

Water Flow: 20 CFS (Max.)
20 CFS (Min.)

Water Discharge: Irrigation Overflow

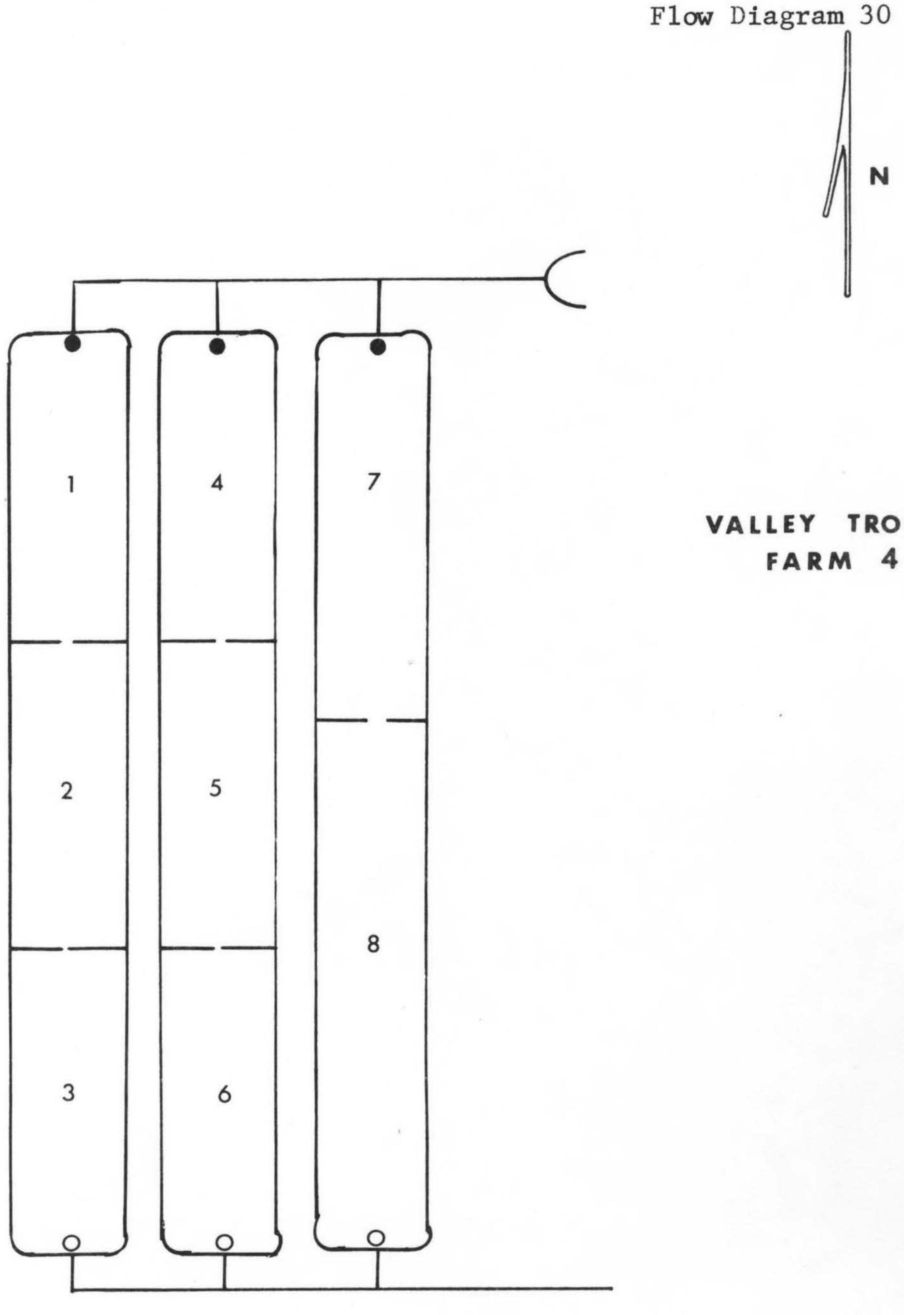
Water Temp.: 52-56°F 15.5°C

Water Chemistry: Not Sampled

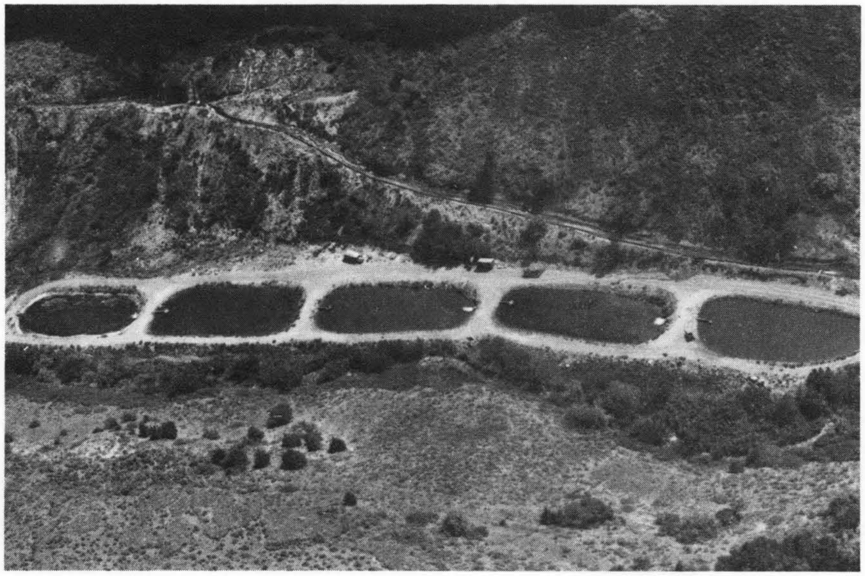
Fish Rearing Space: 288 cubic feet in 8 ponds

Water Replacement Time: 240 minutes

Flow Diagram 30



VALLEY TROUT FARM 4



BLIND CANYON TROUT FARM

Blind Canyon Trout Farm
Route 1
Wendell, Idaho 83331

Started in 1971

Map Location: N-8

Water Source: Blind Canyon Springs

Water Flow: 10 CFS (Max.)
7 CFS (Min.)

Water Discharge: Snake River

Water Temp.: 58°F 14.3°C

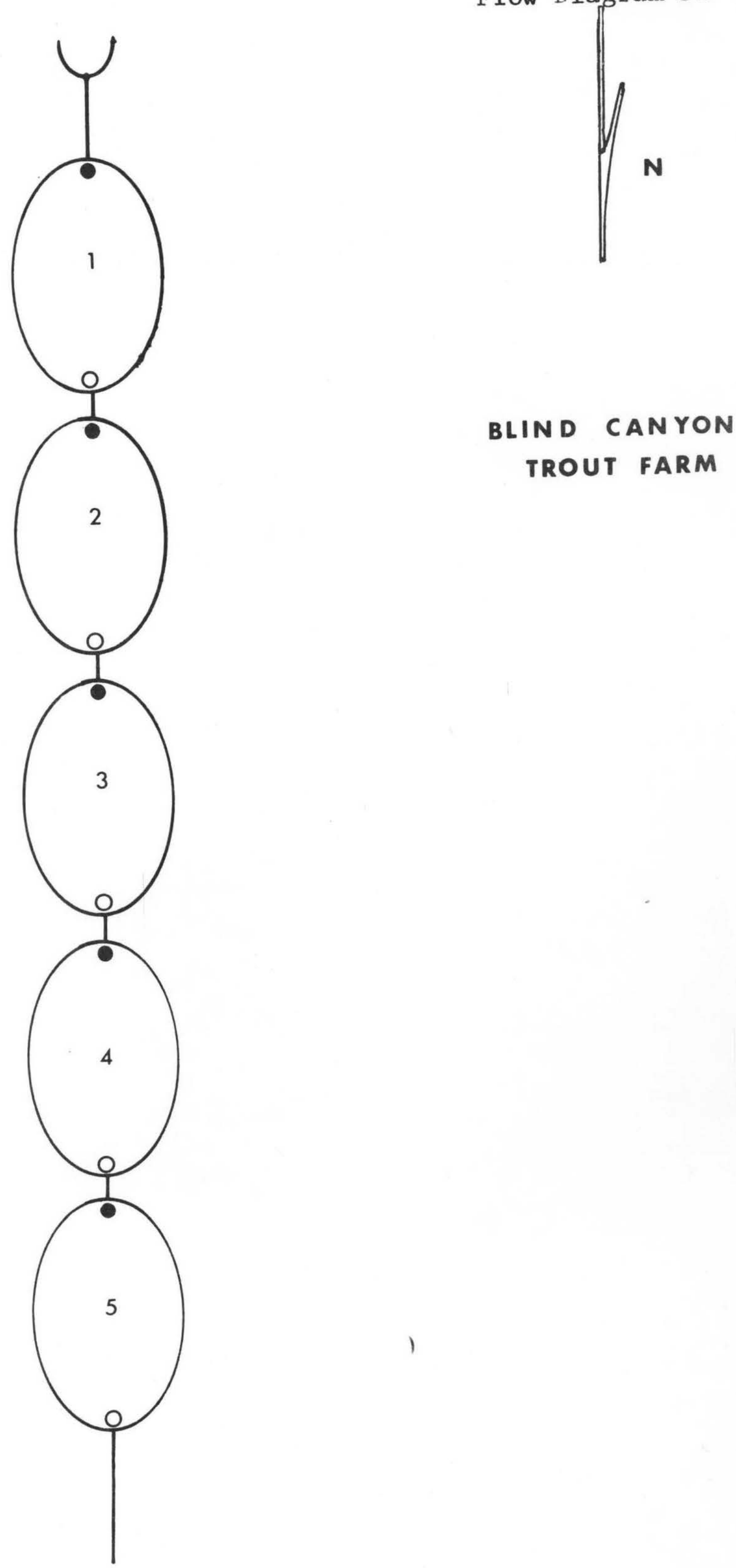
Water Chemistry:

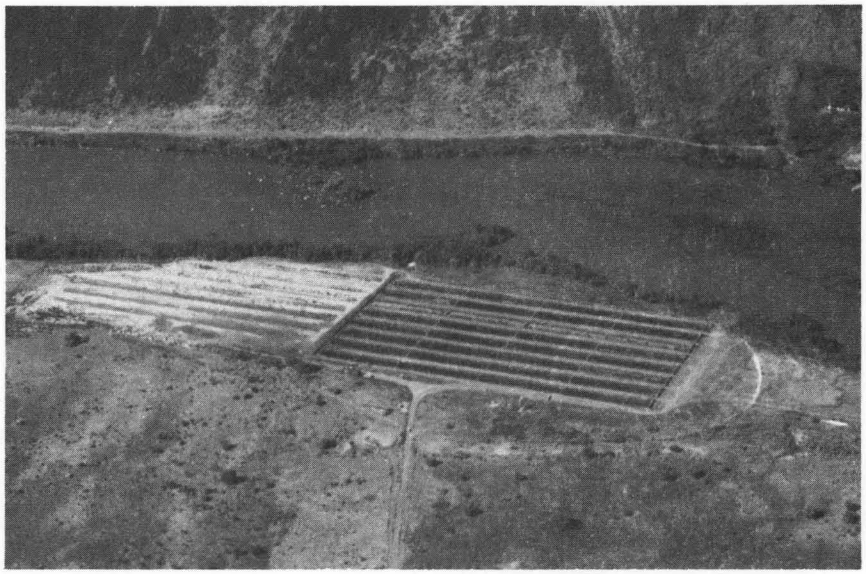
Dissolved Oxygen	9.35 ppm	Alkalinity	154 ppm
pH	7.85	Conductivity	659 µmhos
Nitrate	0.74 ppm	Phosphate	0.18 ppm
Hardness (Calcium)	103 ppm	Hardness (Total)	188 ppm
Calcium	18 ppm	Sodium	30 ppm
Potassium	5.5 ppm	Magnesium	22.5 ppm

Fish Rearing Space: 90,000 cubic feet in 5 ponds

Water Replacement Time: 150-214 minutes

Flow Diagram 31





CRYSTAL SPRINGS RANCH, INC.

Crystal Springs Ranch, Inc.
Box 109
Buhl, Idaho 83316

Started in 1973

Map Location: Q-16

Water Source: Crystal Springs

Water Flow: 100 CFS (Max.)
50 CFS (Min.)

Water Discharge: Snake River

Water Temp.: 59°F 14.5°C

Water Chemistry:

Dissolved Oxygen	11.15 ppm	Alkalinity	188 ppm
pH	8.00	Conductivity	1252 µmhos
Nitrate	1.34 ppm	Phosphate	16 ppm
Hardness (Calcium)	137 ppm	Hardness (Total)	274 ppm
Calcium	35 ppm	Sodium	43 ppm
Potassium	7.3 ppm	Magnesium	31 ppm

Fish Rearing Space: 384,000 cubic feet in 32 ponds

Water Replacement Time: 64-128 minutes

1973 Idaho Aquaculture Survey

File No. ______________

Facility Name: ____

Address: ____

Map Locator: ____

County: ____

Phone No: ____________________ Year Started: ____________________

Manager: ____________________ Original? (If not-who?) __________

No. staff: ____________________ ______________________________

____

____

Function:

Brood stock:

In-state sales: ______________

Out-of-state sales: ______________

States: ______________________

____

____

____

Fingerlings:

Source: ______________________

In-state sales: ______________

States: ______________________

____

____

____

Catchables:

Source: ______________________

In-state dist: ______________

Out-of-state dist: ______________

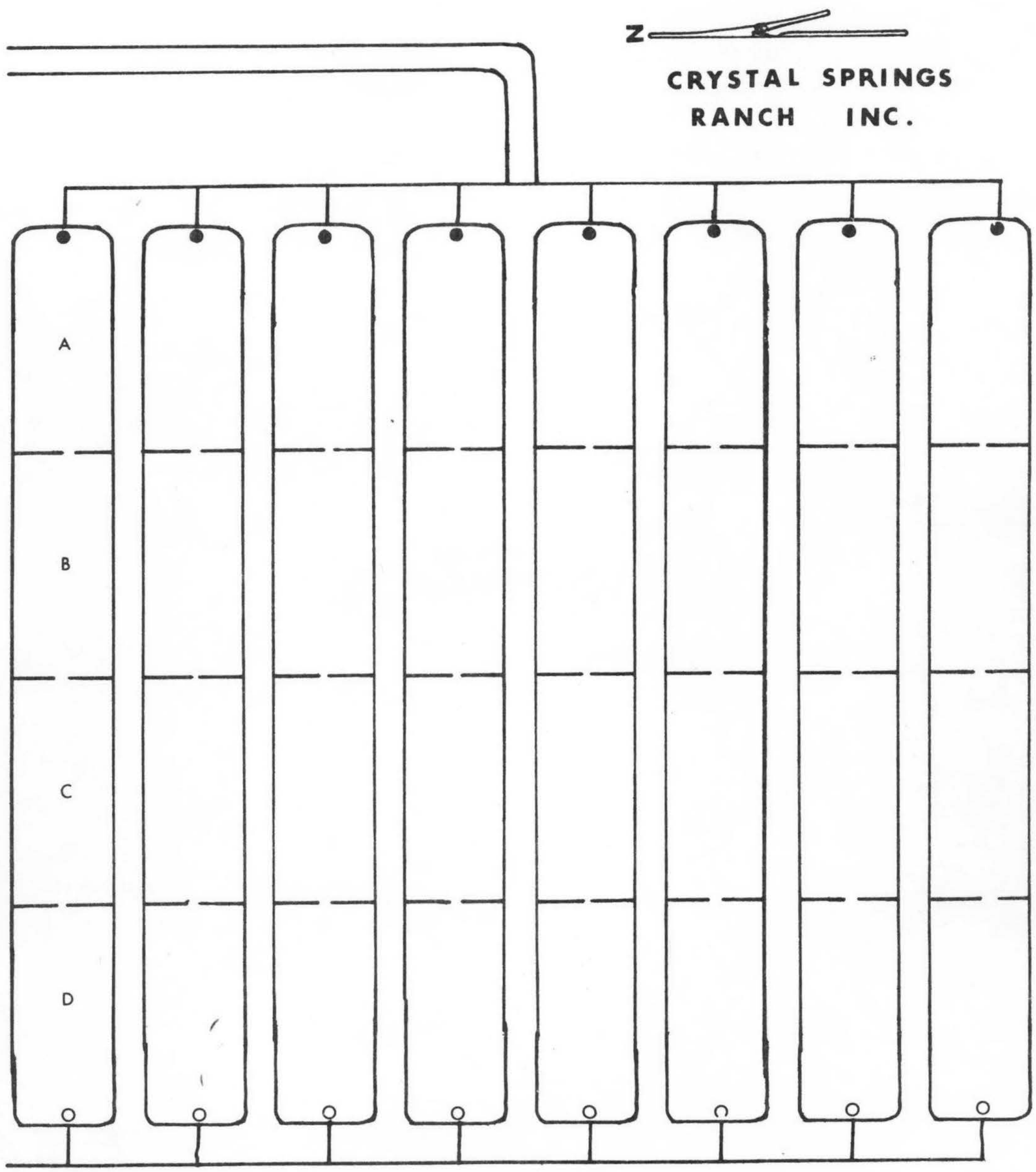
States: ______________________

____

____

____

Flow Diagram 32



File No. ______________

Processed:

Source: ______________
Processor: ______________
Supplier: ______________
Packaging: ______________
____
____
No. employees: ______________
PH Insp.: ______________

Processor: ______________

Fish raising units:

	No.	Size	Const.
Raceways			
Ponds			
Vats			
Troughs			
Incubators			

Water supply:

Source ______________

Flow ______________

Use ______________

Temp. (daily av.)

Jan	______	July	______
Feb	______	Aug	______
Mar	______	Sept	______
Apr	______	Oct	______
May	______	Nov	______
June	______	Dec	______

D.O.	intake -	______	outfall -	______
NH_3	intake -	______	outfall -	______
NO_2	NO_3	______	Alkalinity	______

Production:

Species: ______________

____

No. fish on hand: ______________

No. fish prod. ann.: ______________

 File No. ______________

Lbs. fish prod. ann.: Less than 100,000 ____________
200,000-500,000 ____________
500,000-1,000,000 ____________
1,000,000-3,000,000 ____________
3,000,000-7,000,000 ____________
more than 7,000,000 ____________

Nutrition:

Brand: ______________________ Cost: ________________________

Storage: ____________________

Feeding techniques: ___________

Management:

Temperature records ___________

Feed records _________________

Mortality records ____________

Inventory frequency ___________

Production cost/lb to processor: ___________________________

Feed cost/lb: ____________________

Labor cost/lb: ___________________

Utilities cost/lb: ________________

Lbs/produced/man year: _____________

Loss-of-production potential:

Fry mortality:

3"-6" mortality:

6"-12" mortality:

Additional comments: ____

File No. ______________

Disease History

Most serious problems: (disease, age of fish, % mortality, treatment, time of year)

Viral: ______________________________

____

____

____

Bacterial: ______________________________

____

____

____

____

____

Parasitic: ______________________________

____

____

____

____

Environmental: ______________________________

____

____

____

Nuisance problems: ______________________________

____

____

____

____

Certification: ______________________________ Dates: ______________

Comments: ______________________________ Biologists: ______________

____

____

____

____

____

File No. ______________

Fish Examined: Date: __________ Number: _______ Age: __

External: ______________________

____

Internal: ______________________

____

Gram stain: ____________________

____

Additional comments: ____

 File No. ____________

Have the following diseases ever occurred in this facility? If so, when? approx. mortality, age of fish, treatment (drug, dosage, efficacy)?

Bacterial Gill Disease ____________

____

Ceratomyxa ____________

____

Channel Catfish Virus Disease ____________

____

Columnaris Disease ____________

____

Furunculosis ____________

____

Henneguya ____________

____

Ichthyophonus ____________

____

IHN ____________

____

IPN ____________

____

Bacterial Kidney Disease ____________

____

Redmouth - Aeromonad ____________

____

- Hagerman ____________

____

Sore Back ____________

____

Strawberry Disease ____________

____

File No. ______________

What are your opinions on:

Federal Fish Disease Legislation?

What diseases do you think ought to be checked for fish and/or eggs entering Idaho?

The formation of a state commission for food fish farmers in Idaho?

1974 Idaho Aquaculture Survey

Date: ______________________________ File No. ______________________

Name of Facility: ___________________

Address: ___________________

___________________ Year Started: ___________________

Owner: ___________________

Number of Employees: (FT) ______________ (PT) ______________

Water Source:

Flow: (permit) ____________ Max.: __________ Min.: __________

Temperature: Jan ______ July ______

Feb ______ Aug ______

Mar ______ Sept ______

Apr ______ Oct ______

May ______ Nov ______

June ______ Dec ______

Dissolved Oxygen: ___________________ Alkalinity: ___________________

Suspended Solids: ___________________ Conductivity: ___________________

pH: _____________ Total Organics: ___________________

CO_2: _____________ NO_3: ___________________

Total Hardness: ___________________

Water Discharge Site:

Fish Raised:

Species: ______________________ % __________

______________________ % __________

______________________ % __________

______________________ % __________

On Hand:

Eggs __________

1"-3" __________

3"-6" __________

6"-9" __________

9"-12" __________

12" __________

*How are loadings determined: ______________________

____

1973 Production ______________________

1974 Production (estimated) ______________________

*If the 1973 and the 1974 production figures are quite different, what is this due to? (circle one)

1) Increase/decrease in pond numbers
2) Increase/decrease in pond loadings
3) Increase/decrease in work force
4) Reorganization/no change in managerial personnel

1973 cost of production: __________¢/lb

Comments: ______________________

____

____

____

____

____

____

____

____

Feed:

Brand(s): ____________________

____

Storage: ____________________

Annual Consumption: ________________________

Conversion: ______________________________

1"-3" ________

3"-6" ________

6"-9" ________

9"-12" ________

12" ________

Method of Feeding: ____

Average Mortalities (1973):

Egg ________

1"-3" ________

3"-6" ________

6"-9" ________

9"-12" ________

12" ________

Infectious disease/noninfectious disease ratio: _________________

Management Procedures:

Incubation method(s): ______________________________________

Annual number of eggs (1973): ___________________________

Grading:

Method: ____

Frequency: ____

Records:

Feed (daily): ____________ Growth: ______________

Mortalities (daily by pond): _____ (daily by lot): _________

*Cause determined?

Pond Loadings: ____

Future Plans:

1980 - Fish ______________________________

____

Ponds ______________________________

____

Water ______________________________

____

Nutrition ______________________________

____

Management ______________________________

____

1990 - Fish ______________________________

____

Ponds ______________________________

____

Water ______________________________

____

Nutrition ______________________________

____

Management ______________________________

____

2000 - Fish ______________________________

____

Ponds ______________________________

____

Water ______________________________

____

Nutrition ______________________________

____

Management ______________________________

____