GLEN CANYON DAM TAILWATER

RAINBOW TROUT STRAIN LITERATURE REVIEW AND EVALUATION

Prepared For

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DRAFT

Prepared By

William E. Davis
Environmental Consultant
2124 W. Comstock
Chandler, AZ 85224

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ABSTRACT

A literature search was conducted for information on performance of rainbow trout strains which may be used to replace the Bel-Aire strain in a tailwater fishery below Glen Canyon Dam on the Colorado River. Information was compiled on 164 strains and brood stocks for nine performance characteristics. Evaluations were limited because of a lack of consistent information; however pair-wise comparisons found in the literature were used to evaluate 21 strains for best spawning period, food conversion, growth in first year, survival and catchability. Although additional evaluation is needed, the Eagle Lake strain showed the most promise for this application. A wild Colorado river strain held at Bellvue Research Hatchery in Colorado also shows good results in riverine habitat but little comparative information was available.

TROUT STRAIN STUDY

1.0 EXECUTIVE SUMMARY

The Glen Canyon Dam Environmental Impact Statement is assessing impacts of alternative dam operations on the downstream aquatic environment of the Colorado River. Alternative operations would change the aquatic habitat for rainbow trout with the intent of enhancing their growth, survival and reproduction. The goal in this fishery is development of trophy trout and changing dam operations is offered as one alternative to achieve the goal.

The report gathered information supporting another approach to achieving trophy trout, namely, finding another strain of trout to stock in the river. As the report demonstrates, rainbow trout have an enormous capacity for genetic manipulation. This capacity has made it possible to tailor a strain to meet specific management objectives. Also, existing variation among strains indicate some strains have significantly better potential for becoming trophy size because of innate tendencies to avoid capture, live longer, grow faster, etc.

A literature search was conducted to gather information on performance of rainbow trout strains which may be used to replace the Bel-Aire strain in the tailwater fishery. Information was compiled on 164 strains and brood stocks for nine performance characteristics. Evaluations were limited because of a lack of consistent information; however pair-wise comparisons found in the literature were used to evaluate 21 strains for best spawning period, food conversion, growth in first year, survival and catchability.

Although additional evaluation is needed, the Eagle Lake strain showed the most promise for this application. A wild Colorado river strain held at Bellvue Research Hatchery in Colorado also shows good results in riverine habitat but little comparative information was available.

TROUT STRAIN STUDY

2.0 INTRODUCTION

The U.S. Bureau of Reclamation is preparing an Environmental Impact Statement (EIS) on the impacts of operation of Glen Canyon Dam on downstream environments. The cold water releases from the Dam created conditions for introduction of trout but over the years, there have been mixed results of these introductions.

This study was conducted to determine if an available strain of rainbow trout could be found which would perform better in the Colorado River below Glen Canyon Dam (Lee's Ferry) than the current strain for the alternatives developed by the EIS team.

The following section provides some background on this subject and discusses the approach taken in this study. Although an extensive database is discussed, the literature search and evaluation are believed to be only the initial steps in determining the viability of rainbow trout strain in this habitat.

2.1 Background

Rainbow trout (*Oncorhynchus mykiss*) currently exist on every continent except Antarctica. The original distribution was primarily to the Pacific Ocean coastal drainages of North America and Asia (MacCrimmon- [57]; Kendall [186]). Recent name changes from *Salmo gairdneii* to *Oncorhynchus mykiss* reflect a consensus by taxonomists on their origin. The "Kamchatkan" trout (*Salmo mykiss*) of Asia and the Rainbow trout (*Salmo gairdneii*) are believed to form a single species with *mykiss* having nomenclature priority. The genera name *Oncorhynchus* also has priority and is a more appropriate name for Pacific Ocean salmonids than is the Atlantic Ocean genera *Salmo*.

First descriptions of rainbow trout were made by Richardson in 1836 (MacCrimmon [57]) but phenotypic differences among local forms led to several specific names. Only recently have all the specific names been lumped under the single name *mykiss*. The species *mykiss* historically ranged from Alaska to Mexico and along the Asian portion of the northern Pacific Ocean.

In the late 1800's, rainbow trout eggs from Baird on the McCloud River in northern California began to be distributed to other locations, the first consignment to a private hatchery in Caledonia, New York. According to MacCrimmon [57]"

> "From 1874 to 1879, all rainbow trout shipped outside of their native range were of stock collected by J.B. Campbell. In July 1879, the United States Fish Commission established a trout station on Crooks Creek, a tributary to the McCloud

River, and began to collect and ship eggs out of California. By 1880, Illinois, Iowa, Maryland, Minnesota, Missouri, North Carolina, Pennsylvania, West Virginia, and Wisconsin, Michigan, and New Hampshire had received consignments of ova from Crooks Creek".

Significant evidence exists that rainbow trout strain development commenced at the Baird site on the McCloud River. The first incident was probably a native steelhead and rainbow trout cross to form the "Shasta rainbow" (Needham and Behnke, [69]). Subsequent distribution of McCloud River eggs around the world plus crosses with rainbow trout in other Pacific Coast waters has resulted in a proliferation of hybrids in the last 100+ years. (McKean and Brook [142]; Kincaid and Berry [163]; MacCrimmon [57]' MacCrimmon [58]; Needham and Behnke [69]; Berg and Gall [6]; Busack and Ball [13]; Crawford [19]; Paaver [72]; Scott, Hewitson and Fraser [80]; Shrader and Berry [141]; Kincaid [178])

The following description of rainbow trout by McAfee is found in Calhoon [5]:

> "Rainbow live in streams (ranging from small alpine brooks to large lowland rivers), lakes, and reservoirs of varying physical and chemical character, generally preferring riffle and fast-water areas. In lakes, rainbow are limnetic, particularly in fluctuating reservoirs and deep, oligotrophic lakes where most food is available in the open water or on the surface. They frequently forage near rocks or weeds close to the bottom in natural lakes.
>
> "Rainbow tolerate water temperatures from about 32 to over 80 degrees F., but prefer temperatures below 70 degrees F. Their range of tolerance depends on the oxygen content of the water, size of fish, and the degree of acclimation. They prefer well-oxygenated water but can survive at very low oxygen levels, the level tending to be less at lower temperatures and longer periods of acclimation. They generally do well in waters of varying pH, with documented cases ranging from 5.8 to 9.5.
>
> "Rainbow trout first mature at ages 1 to 5, and live a maximum of 7 to 11 years, depending on strain and locality, though few exceed 6 years. Longevity is influenced by many interrelated factors. Most nonanadromous fish usually spawn at age 3, with males commonly maturing earlier than females. Size at maturity is extremely variable, ranging from 5 inches in the headwaters of coastal streams to over 10 pounds in some lakes and steelhead rivers. In California, mature resident rainbow trout are typically under one pound in streams and one to three pounds in large lakes.

"Wild rainbow trout normally spawn in streams, preferring riffles of moderate gradient and the lower ends of pools, although they will spawn in lake outlets if suitable inlets are lacking. They usually spawn once a year, from February to June, depending on water temperature, strain, and locality, but may not spawn until July or August in cold waters at high elevations. Selective breeding has produced strains that ripen in all months except May and June in California hatcheries. Rainbow hybridize readily with cutthroat and golden trout.

"Rainbow tend to migrate more than other trouts at spawning time, with the distance depending on race of fish and stream accessibility. Stream populations tend to move upstream and, if possible, into tributaries. Lake inhabitants migrate up inlets, when possible, with distances ranging up to over 30 miles from large British Columbia lakes."

2.2 Definitions

Much confusion exists in surveyed literature regarding terminology. Stock, broodstock, native broodstock, hatchery broodstock, natural broodstock and strain are terms applied to various genotypes. The terms are often used interchangeably in literature creating the confusion. The purpose of defining the genotype is to establish a breeding population with a similar history or origin and a set of characteristics different from others. These characteristics have been quantified for production traits, noncaptive performance traits and physiological, behavioral, and biochemical traits (Schrader and Berry [145]). The following definitions have been proposed by R. Simon (Geneticist, U.S. Fish and Wildlife Service) (Berry [7]):

"Broodstock - A fish population residing at a single location (hatchery, stream, lake, etc.) as a self sustaining interbreeding unit maintained either naturally or artificially. Periodic introductions of fish from other sources may or may not have occurred in the recent past.

Native Broodstock - Self-perpetuating broodstock maintaining itself in natural environments (lakes, reservoirs, ponds, or streams) without supplementation by fish reared in hatcheries within the recent past.

Hatchery Broodstock - Broodstock maintained by man in hatchery environment (tanks, raceways or ponds) for at least one generation.

Natural Broodstock - Broodstock maintained in natural environment by a combination of natural spawning and periodic supplementation with fish reared in hatchery environment for some period of time.

Strain - A fish population which as resided at a single location (hatchery or natural body of water) as an interbreeding unit without major introductions from an outside source for a period of at least 30 years or a broodstock derived from such a population and maintained thereafter without major introductions. This definition is based on the concept that a population residing in a particular environment for a long period of time will undergo selection enabling it to better survive and thrive in the environment. As this evolution process continues, gene frequencies move toward equilibrium. Strain differences will be established once the total gene pool of two populations, so separated, has changed sufficiently to produce significant differences in the performance of the two populations. The time period (30 years) chosen is arbitrary, but allows from 8 to 15 generations for selection pressures to change gene frequencies and for random mating to move these new gene and genotype frequencies into equilibrium except for tight linkage situations.

Stock - a fish population derived from a mixture of strains within the past 30 years, which has not evolved sufficiently to be called a strain. The term stock is used as a miscellaneous category to cover broodstocks which are recently developed and cannot properly be called strains. The term broodstock is one magnitude of classification lower than strain or stock. Broodstock will be synonymous with strain or stock in the case where the strain or stock consists of only one broodstock."

This study attempts to sort the strains of rainbow trout from the stocks and broodstocks; however, often this is done empirically. Names present in surveyed literature such as Whitney, Arlee, DeSmet, Shasta and Erwin may be considered strains but obtaining pure members of these strains from a particular source may be difficult. Sources claiming to have a Whitney strain, for example, actually may have a mixture representing mostly Whitney genotype but containing genes from other stocks or strains **(Appendix A)**.

2.3 Support for Strain Usage

Hybridization between species or within a species has been used by man to produce organisms uniquely fitted for a particular use or task. Examples exist among agriculturally-important crops and animals (e.g., tomatoes, cotton, cattle, swine, etc.) as well as among socially-important plants and animals (e.g., roses, dogs, race horses, etc.). These hybridizations often produce organisms which are capable of living in environments or having traits previously unavailable to one or another or both parents. This may be called ecological expansion and is similar to expansions

occuring more slowly as a result of evolutionary changes and speciation (Lewontin and Birch [54]).

In addition to hybridization, transplants of organisms by man to other geographic areas outside their normal range enables existing organisms to extend their range. This was the case when McCloud River rainbow trout eggs were transplanted to similar environments around the world. This may be called geographical expansion (Lewontin and Birch [54]).

Little doubt exists that trout productivity can be enhanced by genetic selection. Trout hatchery staff have long noted the differences in growth rate, percentage hatch, weight gain, etc. when rainbow trout from different areas are used or crossed (Kincaid, Bridges and von Limbach [49]; Klupp [51]; Klupp, Heil and Prichner [52]; Linder, Sumari, Hyholm and Sirkkomaa [55]; McKay, Friars and Ihassen [62]; Ming [64]; Moring [66]). Hatchery staff have created trout capable of faring better in suboptimal temperatures or of gaining weight in local environments better than local trout. This is essentially an acceleration of the evolutionary process as it emphasizes the enhancement of specific traits. In addition, controlled breeding of fish, like trout, may be more effective than other animal species because of characteristics such as external fertilization, high fecundity, high fertility, short generation interval, moderately high inheritability for some important traits, and large phenotypic variability (Kincaid and Berry [163]).

Currently, many agencies and biologists are attempting to match rainbow trout strains to a specific environment [References - 1,2,4,5,6,7,8,9,11,20,26,43,46,65,54,112,141]. Evaluations of strains for specific application is occurring in several states, Canadian provinces and foreign countries. Unusual applications include tailwaters, pot-hole lakes, exceptionally cold or warm waters, high elevation lakes, above waterfalls, and commercial (Ayles [4]; Binns and Eisenman [9]; Brauhn and Kincaid [11]; Havens [43]; Hudy and Berry [46] Lewontin and Birch [54]; Moring [65]; Modde, Young and Archer [112]; Shrader and Berry [141]).

2.4 Objectives of Glen Canyon Trout Strain Study

2.4.1. Definition of Issue

This study summarizes surveyed information on trout strains (**Appendices A to E**). This will help to determine if a trout strain (or strains) exists or can be developed which will survive, grow and reproduce better than present strains in the river below Glen Canyon Dam. The trout strain(s) must also meet the goals and objectives of the public as represented by various resource management agencies (e.g., Arizona Game and Fish Department, National Park Service, and Bureau of Reclamation.)

Trout were introduced by Arizona Game and Fish Department (Department) downstream of Glen Canyon Dam in the mid-1960's to take advantage of the new cold water habitat. For the first 17 years, no record was kept of which strain of rainbow trout was introduced. Despite this omission, the fishery which developed in the 1970's was soon considered one of the best in the U.S. Large trout, in the 15 pound range, became commonplace. However, the "blue-ribbon" fishery of the 1970's and early 1980's originated from an unknown strain or strains. In the early 1980's, the trout size decreased and immediately became the subject of controversy.

Several factors were changing during this time to complicate finding the causative factor or factors: increased fishing pressure, lack of stocking, and sustained high flows. In the mid-1980's, fishing pressure decreased, Department stocking resumed, and fluctuating flows commenced. After 1986, the average fish size began to increase but the increase has been extremely slow. In late 1990, the number of trout in poor condition peaked and a significant number died.

Fluctuating flows from Glen Canyon Dam potentially affect trout populations downstream. Impacts may be occuring from stranding, desiccation of redds and displacement during periods of feeding and spawning (Maddux, et.al. [118]). There are indications growth problems are largely due to too many fish for the available food supply (Arizona Wildlife News [187]) and less productive water from Lake Powell (Cole & Kubly [189]). The significance of all these impacts to trout populations is currently being assessed by the Department as part of the Glen Canyon Environmental Studies (GCES).

Trout integrate all the impacts, from whatever source, with the result being a lack of growth, unhealthy or even dead fish and a group of disgruntled anglers. Finding the causative factor or factors responsible for the situation is complicated. Current data indicate the trout strain being stocked (i.e. Bel-Aire) is having some trouble in this environment (Arizona Wildlife News [187]). Perhaps only through extreme management measures will the Department be able to produce larger and healthier fish.

A report prepared in 1989 by Davis [181] titled "Use of Trout Strains in the Colorado River Downstream of Glen Canyon Dam" summarized readily available information on trout strains. The goal of the report was to see if there was a strain which would match up with the existing environment so as to produce a trout population capable of better survival, growth and reproduction.

Davis concluded that no systematic effort existed in the GCES to determine the capabilities of various strains to thrive under a variety of field conditions. Also, the trout habitat in the Colorado River below Glen Canyon Dam is only partially understood. This means the ideal match up of strain and environment is not

likely to occur except by chance with the present level of knowledge.

2.4.2. Objectives of Study

The GCES efforts are focused on finding the degree of impacts from operation of Glen Canyon Dam as part of an Environmental Impact Statement (EIS) (U.S. Department of Interior [117] and [185]; Maddux [118]). For trout, the effort is intended to see what dam operations are doing to effect survival, growth and reproduction. IF impacts are found, one approach to correcting them would be to modify the operations to reduce impacts.

This approach to solving problems assumes the original decision on trout strain(s) was a good one. Once made, the habitat must be changed to match the requirements of the Bel-Aire trout strain. This approach assumes that the Bel-Aire strain has the same habitat requirements as other strains of rainbow trout and modifications of dam operations are necessary to benefit any strain of rainbow trout. This is most likely not true.

Another approach is to assume the habitat, below Glen Canyon Dam will persist, and see whether there are rainbow trout strains which can survive, grow and reproduce better in the present habitat. This approach assumes the original decision to use the Bel-Aire strain may not have been the best one and that other trout strains have differing habitat requirements.

Realistically, the most likely result of a study of habitats or of differing trout strains is a point between two extremes: neither complete modification of habitat or no modification of habitat. Instead, this study assumes that perhaps a trout strain or other habitat condition can be found which will require less modification to the habitat than that presently anticipated to benefit Bel-Aire rainbow trout now existing in the river.

The approach consists of investigating alternative rainbow trout strains rather than alternative environments. The Goal and Objectives to be met include the following:

Goal: To determine if an available strain of rainbow trout can be found which will perform better in the Colorado River below Glen Canyon Dam than current stocks for the alternatives developed by the EIS team.

Objectives

1. Compile known information on the performance characteristics of strains of trout.

2. Identify tailwaters which are similar to Lee's Ferry.

3. Evaluate available strains of rainbow trout against conditions resulting from current operating regimes.

The comparison of several different trout strains was intended to identify one or more strains that could function better in the present habitat. The trout strains identified may benefit more from changes to the habitat than the existing trout population.

2.5 Scope of Work

This study initiates review of literature on strains which may ultimately lead to a strain with characteristics suitable for use in the Glen Canyon Dam tailwater on the Colorado River.

The investigation focused on gathering existing information to meet the objectives (**Appendices A-E**). Interviews with biologists and anglers indicated little information was accumulated locally about strains. Many of the objectives were previously identified for study by the GCES. The integration plan developed by Dr. Duncan Patten, Senior Scientist for the GCES, was the most recent example. The investigation of strains is intended to be an integral part of the GCES and Environmental Impact Statement process currently underway for the dam operations. Several key areas were investigated:

1. A review of available trout strains;
2. A review of strain performance;
3. An inventory of tailwater trout systems;
4. A review of tailwater management; and
5. An inventory of literature on trout strains.

Sources were checked for information on potentially-usable rainbow trout strains and their: 1) growth, 2) catchability, 3) fightability, 4) dispersal/migratory tendencies 5) adaptability to fluctuation flows, 6) food habits 7) habitat preferences, 8) reproductive needs and 9) survival. Initially, approximately 166 differently-named strains, stocks and broodstocks were identified in the literature. This was later trimmed to reflect duplications. No attempt was made to conclude whether these strains still exist since they may exist in private hatcheries or the wild even though no longer retained in state or federal hatcheries.

In addition, tailwaters were identified that have environmental and flow conditions similar to those found below Glen Canyon Dam. For each tailwater, attempt was made to list the strains stocked, performance record, growth rate, and habitat for the trout listed (**Appendix D**).

The third and final step in the program was to evaluate the available strains of rainbow trout. A comparison was made for each strain and their performance (i.e., growth, survival, catchability, food conversion and spawning month).

3.0 LITERATURE SEARCH AND SURVEYS

3.1 Literature Search

Nearly 200 articles, reports, theses and other documents were obtained or copied during research for this report. All documents of interest were transferred to the Arizona Game and Fish Department upon completion of the contract.

The search for literature was initiated by contacting the Fish and Wildlife Reference Service (FWRS) in Bethesda, Maryland (Wilson [188]) for a complete search of their database.

Citations from the FWRS are those produced under the Federal Aid in Fish and Wildlife Restoration, Anadromous Fish Conservation, Endangered Species Grant Programs, and through the Cooperative Fishery and Wildlife Research Units. The initial search produced 86 major and minor citations using the key words "rainbow" and "strain" together. Key word "rainbow" had 961 citations whereas "strain" had 204 citations. In addition to the initial database search, a search was conducted using the key words "trout" and "dam tailwater", "tailwater", "hydroelectric" or "turbine". This retrieval yielded 30 citations. References used by Kincaid [178] also were extensive and these three sources helped form the initial base of information.

The computer searches and references were followed by review of bibliographies in each citation. The bibliographies of all articles, reports, and other documents collected were reviewed for other documents pertinent to the subject at hand, and needed materials added to the list of publications being sought. As copies were obtained the listing was transferred to the Bibliography. Additional publications were sought but not obtained for a variety of reasons: document lost, out of print, unavailable, or could not be sent in time for inclusion in study.

3.2 Surveys

In addition to literature searches, brief telephone and personal surveys were conducted. Federal and state hatchery personnel were contacted in 26 western states (west of Mississippi River) (**Appendix C and E**). Information was obtained on trout strains being held and how they are used (**Appendix C**). Also, a survey of tailwater systems was made by telephone (**Appendix E**). A variety of information on these systems was compiled by which to better understand relative success and failures of these systems. Information from these 19 surveys has been incorporated in the appropriate report sections.

4.0 GENERAL INFORMATION RELATED TO TROUT STRAINS

Genetic variability exists within and between strains of rainbow trout. This variability is probably adequate to enable fisheries biologists to tailor a strain to meet many of the unique demands of a specific habitat. Genetic breeding methods are available to improve a group of characteristics to yield a strain which may benefit from a habitat such as the Colorado River below Glen Canyon Dam.

There are obvious differences between natural lakes and artificial reservoirs in terms of productivity, stabilized water quality, water level fluctuation and others. These factors usually are not discussed in the literature and therefore will not be considered further. Suffice to say these influences are assumed to be equal for all strains studied.

The applicability of results from trout strain studies in lentic (slack water) systems elsewhere to the Colorado River system is in doubt. Measurements of growth, reproduction, survival or other characteristics like catchability or fightability would have questionable application. The studies may be of some use where information on a strain performance in lotic (running water) systems is supported by information in lentic systems.

4.1 Growth

Kincaid [178] discussed various aspects of growth and how strains vary. His survey showed fall-spawning strains weighed nearly twice as much as winter-spawning strains at two years of age. He attributed this marked difference to the domestic origin of fall strains and a history of selection for faster growth whereas winter strains contained both domestic and wild strains. After two years, the growth rates were more similar but strain differences still existed at three years. In general, faster growing fish convert food more efficiently, thus in hatchery situations they are cheaper to grow to catchable size. However, the relationship between good hatchery growth and good growth in a lake or river is highly variable.

4.1.1 Hatchery

Growth of various trout strains in hatcheries has been one of the key elements in deciding whether a strain is valuable to a stocking program. Food conversion ratios and growth rates determine how many fish of catchable size may be produced with a budget dollar.

Available growth information on various strains must be viewed cautiously. Many factors may influence hatchery growth rate

besides strain including water temperature, water volume, water chemistry, fish density, type of holding facility and amount and type of food. Information on many of these influences is usually not available in the same report which provides growth information.

4.1.2 Field

Growth of trout strains under field conditions is more difficult to determine than in a hatchery. Also, influences on growth in the field include those listed above under Section 4.1.1 plus other factors like predation and competition with other species. Influences in the field are often more exaggerated than in a hatchery since the very purpose of a hatchery is to provide the most ideal conditions for growth.

These reasons emphasize the difficulty biologists have in obtaining comparative growth information in the field. In most cases, the data are useful only for comparisons within a system and not between systems. Any strain variable adds to the difficulty. Multiple strain introductions in a system like the Colorado River below Glen Canyon Dam adds to the confusion in attempting to decipher growth responses.

Literature on growth of specific strains under field conditions is limited. Also, in many instances, the applicability of growth result data to the situation below Glen Canyon Dam can be questioned because habitat conditions are unique.

Kincaid and Berry [163] warn against using captive (hatchery) data on growth (or other performance characteristics) to predict performance in the natural environment. Many variables associated with a natural environment are eliminated or reduced in a hatchery so as to enhance growth and thereby be more cost effective in producing pounds of trout for recreational anglers.

4.2 Performance

4.2.1 Catchability

Catchability refers to the susceptibility of a fish to being caught by conventional sport fishing techniques. For stocked fish, it refers to the return to the creel or the number caught compared with the number planted. Determining catchability is important in evaluating the value of a particular strain. Trout which are easily caught are a minimal challenge to anglers, are less likely to remain in the fishery long enough to become large, and require more frequent stocking. Early harvest effectively reduces survival to larger sizes, reducing the weight-landed-to- weight-planted thus increasing the cost to provide fish to the anglers' creel (Rawstron, [76]). Conversely, trout which are difficult to catch raise the level of dissatisfaction of average anglers, are more

incline to become large, and require less stocking. For example, the Bel-Aire strain currently stocked at Lee's Ferry is considered highly catchable by some anglers whereas the previously stocked Kamloops strain yielded poor returns to the creel, probably due to a lower catchability.

Catchability may reflect either an innate tendency to avoid conventional sport fishing techniques or habitat preferences which make them less available to these techniques (e.g., prefer deep pools) or both. Literature is sparse on the subject of catchability and even more sparse on the reasons.

Catchability generally appears to be directly related to length of time a strain has been domesticated (Mueller [103]). Wild or semi-wild strains are less susceptible to angling than domestic strains (Dwyer and Piper [28]). A strain, one generation removed from the wild (Fish Lake), was less catchable than a strain two generations removed (McConaughy) which was less than the Winthrop or Spring Standard domestic strains (Mueller [103]). Mueller had mixed results between strains on susceptibility to angling at different lengths. Some strains showed differences in mean length of fish caught versus those stocked (Winthrop and Erwin) whereas some strains showed no differences (Arlee and DeSmet).

In a study by Cordone and Nicola [17], catchability of Kamloops trout was shown to vary considerably depending on the age of stocking. When Kamloops fingerlings were stocked as young of the year, the return varied from 2 to 5 percent. Returns improved dramatically when the fish were stocked at 12-14 months of age, but added time in the hatchery increased production cost.

4.2.2 Fightability

This section summarizes information on the fightability of various rainbow trout strains. This refers to the vigor by which a fish will fight being caught. Trout which are especially stubborn about being caught are more desirable to anglers and therefore preferred for stocking.

Fightability, probably more so than catchability, is a function of the condition of trout. Healthy trout with condition factors of 1.00 or greater are stronger and therefore more likely to resist landing by anglers than those with poorer condition factors. Trout capable of maintaining good condition in habitats along side trout of poorer condition may be a function of natural variation within a strain but it also may be due to different strains.

Fightability may be directly related to the ability, swim until fatigued. Trout capable of fighting well may be those with a genetically-related stamina characteristic (Klar, Stalnaker and

Farley [50]). Klar, et.al. [50] suggested some rainbow trout, namely those with a close relationship to steelhead, may have less potential lactate buildup under conditions of oxygen stress and therefore have the advantage of superior performance.

Others discussed in Klar, et.al. [50] looked at swimming performance in relation to such factors as size, temperature and ambient oxygen concentrations. Davis [182] surveyed literature on swimming speeds and endurance in fish and found speeds to vary with factors described by Klar but also to vary with species and motivation. Davis concluded that speeds fall generally into three categories: cruising, sustained and sprint. Each speed requires a different amount of muscular energy; however, in contrast to cruising and sustained speeds, sprint speeds cannot be maintained indefinitely because glycogen, the energy source during these sprints, is limited. One information source surveyed determined that muscles used during sprinting have sufficient glycogen energy to provide a maximum of 140 seconds of swimming under ideal conditions. Since fighting an angler may be similar to stress under sprint conditions, trout are similarly limited in the time they can sustain a fight.

Sprint speeds also vary with species of salmonids and, as Klar, et.al. [50] suggested, probably vary with strain of rainbow. In flume studies on the Columbia River, only 5 percent of chinook salmon negotiated an 85 foot long flume flowing 16 feet per second whereas 50 percent of steelhead negotiated the distance (Davis [182]). These data support the Klar, et.al. [50] report which points to steelhead or steelhead/rainbow crosses as having exceptional stamina.

4.2.3 Dispersal and Migration

This section explores the literature on dispersal and migration of rainbow trout strains. Dispersal refers to the tendency of a fish to move away or spread out from the point of stocking or hatching to a new, permanent location. Migration means to conduct routine or periodic movements to and from sites. Knowing the tendency of trout to disperse or migrate has important implications to fisheries managers attempting to track angler success within a sport fishery.

Dispersal of trout following stocking has been attributed to such factors as fish condition, streamflow, water temperature, physical features of streams, catchability, competition, and available food but only limited data have implicated genetic characteristics as a causative mechanism (Moring and Buchanan [63]). Needham and Behnke [69] suggested that trout movements may be due to original crosses with anadromous steelhead. Since the McCloud River rainbow probably was a cross between a native rainbow trout and steelhead, the tendency of today's broodstocks to move may be an inherited character.

In the Colorado River below Glen Canyon Dam, most angling occurs upstream of Lee's Ferry within the first 16 miles below the Dam. Fish spawned or stocked within this 16 mile reach must remain there to provide recreational angling since areas downstream have extremely limited access. If these trout were to move downstream of Lee's Ferry and out of the heavily fished areas, they could be considered an economic as well as a recreation loss. Replenishment by additional stocking would add to the cost of maintaining a desired catch rate.

Little specific information on dispersal or migration was found in the surveyed literature or among surveyed biologists. One strain, Roaring River, used extensively in Oregon was found to have a strong downstream movement following stocking (Moring [63]). Kamloops rainbow are known to move somewhat (Rogers [106]; Cordone and Nicola [17]) but most are stocked in reservoirs where movement is not a factor.

4.2.4 Adaptability to Hydroelectric Flows

This section summarizes available information which has explored this subject. The subject is discussed in more detail in Section 5.0. Hydroelectric flows are flows which fluctuate in volume which thereby vary downstream velocities and depths. Variation in depth and velocities change habitats causing adjustments by trout. These adjustments may be more easily made by some strains of rainbow trout than others. Trout adapting more easily to this situation may have a competitive advantage over other trout which translates to better growth, reproduction and survival rates.

Most biologists interviewed regarding tailwater fisheries with fluctuating flows did not have any information on this subject. They recognized the difficulty in assessing such a complex factor but most have taken the approach of simply recommending reduction in fluctuations. The consensus was the fluctuating zone was a "dead zone" where food for trout could not become established long enough to contribute to growth. This may suggest trout more detached from benthic portions of the fluctuating zone as a food source (e.g., high piscivorous tendency) may be less stressed by a fluctuating flow regime.

4.2.5 Piscivorous Tendencies

Trout which are especially predacious on fish (e.g., Kamloops) have important implications to fisheries managers. For example, trout may be able to achieve larger sizes by making the transition from smaller food (like *Gammarus*) to eating small fish. Also, knowing such a tendency exists may encourage stocking of larger sized fish to reduce predation.

Trout have a tendency to cannibalize their young but will also eat other fish. Early stomach analyses conducted below Glen Canyon Dam showed a dramatic rise in forage for threadfin shad in 1969-70 following about five years of mostly benthic food sources (Stone et.al. [129 to 136]). This rise in piscivorous feeding probably corresponds with the availability of shad from Lake Powell plantings passing through the dam hydropower units.

Growth during this period began to accelerate, possibly in response to the shad availability. An interesting note about the shad is their availability appeared to be confined to winter months. Stomach analyses taken in fall and spring showed virtually no shad. Shad populations in Lake Powell fluctuate widely in response to changes in primary productivity and predation by striped bass. It could be speculated that the drop in trout growth below Lee's Ferry may well be tied to the drop in productivity in Lake Powell with the corresponding threadfin-shad changes as a precursor.

4.3 Habitat

4.3.1 General

Rainbow trout have shown an inherent ability to adapt to a variety of situations world-wide including hatcheries, impoundments and natural waters (MacCrimmon [57]). They are found in lotic and lentic water situations whenever certain chemical, physical and biological conditions are met. According to MacCrimmon's survey the following are some habitat preferences for rainbow trout based on his world-wide survey:

Temperature	-	12 to 20° C
Spawning Temperature	-	temperature must drop below 13° C seasonally and be above 5° for good survival
Growth Temperature	-	worthwhile contribution to local fisheries occurs when temperature is between 15-20° for prolonged periods each year.
Precipitation Rate	-	above 26 cm. per year to create sufficient freshet.
Dissolved Oxygen	-	greater than 4 parts per million
Alkalinity, siltation, mineralization & pH	-	there is recognition of the importance of these parameters on the ecology of salmonids but "precise data are totally inadequate for a valid assessment of the significance... on present world

Strain evaluations have been conducted in both lotic and lentic habitats. These evaluations include review of growth, survival, catchability, spawning success, etc. for a variety of strains. Most studies compared hatchery and wild settings for each strain or made comparisons between strains within a specific setting. Section 6.0 provides an overall assessment of these comparisons.

4.3.2. Tailwaters

Lotic habitats such as the Colorado River below Glen Canyon Dam characteristically are highly variable both temporally and spatially. Natural lotic habitats have a potential for significantly greater variability than regulated systems such as the Colorado River. Prior to closure of Glen Canyon Dam, no trout occurred in the area eventually inundated by Lake Powell (McDonald and Dotson [137]). Although no chemical conditions were found in the river "that would be deleterious to fish life," "the high turbidity and scouring action of sand undoubtedly affects the bottom fauna and aquatic plants found in the rivers and large tributaries." In addition, water temperature in July of 1958 at Lee's Ferry was recorded at 29°C.

This habitat was not acceptable to trout but was the home to an estimated 17 species of endemic and non-endemic fishes. Trout, as all species, have a range of tolerances for certain chemical, physical and biological factors collectively defining their habitat needs. The range for temperature, at least, was exceeded for trout prior to dam closure.

Tailwaters are a special set of river segments distinguished by being below a dam. Stocking trout in cold waters below dams takes advantage of a new habitat. In general, the habitat is highly productive in the first decade or so after reservoir filling, paralleling productivity within the reservoir. This relatively high productivity soon tapers off in accordance with many factors, unique to each reservoir, such as size of reservoir, nutrient content of inundated soils, inflow and outflow rates, etc (Petts[126]).

Dams with variable releases, such as Libby Dam on the Kootenai River in Montana, withdraw relatively warm hypolimnion water in the winter and change to warm epilimnion water in the summer. This arrangement provides an ideal year-round temperature somewhere between 7 and 13° C.

4.3.3 Cold Water Habitat

Cold water conditions are defined in this report as being less than 12°C. Trout are well-adapted to surviving in cold water but under most natural settings seasonal warming occurs which

accelerate production of food organisms and results in increased trout growth. Uniformly cold water is unique and although trout may survive under these conditions, growth rates from one strain to another may be different.

The hypolimnetic releases from Glen Canyon Dam are consistently cold, varying between 6°C and 12°C even though air temperatures may range from -12°C to 40°C. Mean water temperature at Lee's Ferry during 1984-86 studies was 9.7°C (Maddux et.al [118]; Davis [181]). These cold conditions also persist downstream over 240 miles. Summer temperatures rise about 3-5°C whereas winter temperatures drop about 1-2°C in this stretch of river.

The uniform temperature below Glen Canyon Dam creates relatively uniform growth in trout. This has made determination of growth rates more difficult. Food availability, stress periods, etc. may not be as dramatic thus computing how much annual growth occurs from scale ring counts is replaced by more cumbersome otolith counts.

Temperatures are important influences on the length of egg incubation periods as well as survival and growth of young trout. Colder temperatures extend the period of egg fertility, the incubation period and may create excessive mortality (MacCrimmon [57]). Brook, brown and lake trout eggs develop normally at temperatures colder than rainbow trout; however rainbow trout strain variations may be significant also with regard to reproduction in cold water (Ayles and Baker [5]).

4.4 Reproduction

4.4.1 Genetics

As described earlier, in Section 2.0 Introduction, one strain of rainbow trout is not genetically isolated from other strains. Genetic variation exists within a species (as well as between species) and these variations carried along in a pure line may be called strains or breeds. For example, there are many strains or breeds of dogs yet all dogs may interbreed. The same is true for rainbow trout when a particular trait or characteristic is kept isolated in a pure line.

A study by Ferguson, Danzman and Allendorf [34 & 35] compared developmental schedules of various rainbow trout strains. They were concerned that little information was available on intraspecific developmental differences even though much had been written on interspecific differences. Their rationale was that to understand the evolutionary significance of genetic differences between species, it was necessary to have information about the amount and distribution of genetic variation within a species.

Ferguson, et.al. [34 & 35] found significant differences in mean hatching time and developmental rates for most comparisons between strains. They also found significant differences in enzyme activity between the strains apparently correlated with hatching. Strains with higher levels of heterozygosity developed faster than less heterozygous strains. This suggests "substantial genetic variation affecting the developmental process in rainbow trout."

Kincaid and Berry [163] noted that most genetic studies "...that analyze the protein products of individual genes (alleles) have found that gene frequencies vary significantly among strains." They continued by saying "Work with rainbow trout...have...shown high amounts of genetic variation within local populations."

Aquacultural genetics is apparently very primitive in comparison with agricultural science, yet great potential exists. Fish breeding characteristics and large phenotypic variability offer much promise (Kincaid and Berry [163]). These characteristics will allow significant improvements in productivity. More importantly for the Glen Canyon Dam tailwater fishery, it is obvious adequate genetic potential exists for performance characteristics of an existing or newly created strain to be matched with the management requirements for the fishery.

4.4.2 Interbreeding

Since the late 1800's at the McCloud River in California, stocks of rainbow trout from one area have been crossed with stocks from other areas. Also, there have been crosses with steelhead and cutthroat trout which has enlarged the genetic diversity of rainbow trout broodstock. Additionally, specific characteristics such as hatching time or morphology have been encouraged by isolating stocks or accentuated with crosses.

A variety of natural environments as well as social pressures (e.g., summer fishing season) have played a role in strain development. Fisheries managers have made artificial selections within hatcheries to develop stocks especially adapted to a variety of environments (Kincaid [178]). Such approaches added to the genetic variety already available within the species.

Studies by Ferguson et.al. [35] showed a great deal of variety in developmental rates when various strains were crossed. Slower, intermediate and faster rates were observed depending on the particular strain crosses used. The only pattern emerging was that "there were significant maternal effects in that reciprocal hybrids did not show identical developmental rates and more closely resembled the maternal than the paternal parent." In general, they concluded that "there is substantial variation in the genetic control of development in this species."

Kincaid [178] and Kincaid and Berry [163] emphasized the importance of understanding the complexity of strain and broodstock development before embarking on any program to control the genetic variability of rainbow trout. The origin and genetic makeup of the Bel-Aire strain used in the Colorado River below Glen Canyon Dam may not be the same as the Bel-Aire strain used elsewhere. Also, the strains' origin must be traced to determine the capabilities to perform well in the canyon environment.

4.4.3 Natural Spawning

Strains of rainbow trout spawned in hatcheries for many generations become "domesticated" strains. In contrast, naturally-occuring strains isolated in natural waters which are captured and eggs artificially hatched are "wild" strains. The domesticated strains often have retained traits which may be disadvantageous to successful natural spawning simply because the hatchery environment allows these marginal genotypes to survive. The wild strains, in contrast, are forced to lose those traits which are disadvantageous. This mechanism is described in the strain literature. Strains which are wild or one or two generations removed from the wild are generally better natural spawners than domestic strains (Ayles and Baker [5]; Fredenberg [152]; Mueller [103]; Berry [7]).

5.0 GENERAL INFORMATION RELATED TO TAILWATER FISHERIES

5.1 Environmental Conditions

River regulation by large dams creates conditions downstream which are, in some respects, quite similar from one dam to another. Releases for hydroelectric generation are consistently cold, hypolimnetic water of a character dictated by the physical conditions within the reservoir. In this respect, the dams cause certain physical conditions to develop which in turn yield water of a similar physical, chemical and biological condition.

In this section, environmental conditions in some rivers downstream of dams will be described. These tailwaters are typically adopted as trout habitat by state game and fish agencies because the conditions are usually best inhabited by trout. Differences from one tailwater fishery to another occur and this section describes information in the literature on environmental variables which may affect tailwater fishes.

5.1.1 Flows

Release patterns from dams to tailwaters are established for a number of reasons, including:

* flood control;
* water demands;
* hydropower generation;
* navigation;
* recreation; and
* ecological management

The release pattern from one dam to another therefore may be markedly different. For purposes of this study, the releases from large dams with hydroelectric generation are most applicable since these are similar to Glen Canyon Dam releases.

In general, flows in tailwaters below hydroelectric dams are influenced to a significant degree by electrical demands elsewhere. Water released generates electricity and flows may rise and fall with increasing or decreasing electrical demand. This simplified pattern is then altered by the other reasons for water releases shown above. The extent to which dam operations follow the simplified pattern is a function of the priorities placed on these other reasons for releases.

Water volumes released to tailwaters are a function of the release reasons given above but more importantly due to:

* inflow volume;
* reservoir capacity relative to inflow volume;
* seasonal precipitation; and
* flood control capacity.

The volume of water passing downstream can have both beneficial and detrimental effects on a tailwater fishery. The capacity of trout strains to deal with conditions created by flow volumes is a characteristic which may be important to choosing a successful strain.

Flow releases to a tailwater habitat dictate much of the physical conditions for trout. Depth, velocity, pool and riffle dimensions and ratios may be determined at any location in the river by dam releases. Ideal flow conditions for trout wherein they may successfully survive, grow and reproduce have been identified for different ages and sizes. Data are lacking however, on success of different trout strains with regard to flow conditions. This suggests either no differences between strains have been noticed during studies with other primary goals or no studies have been conducted but differences exist. Some literature and personal discussions suggest certain strains perform better in lakes than streams or rivers; however, little information is provided to established why performance is different.

5.1.2 Temperature

Thermal stratification within reservoirs upstream of dams occurs for significant portions of the summer. Releases from the hypolimnion during stratification is consistently cold (<10° C) whereas epilimnion releases may vary, reflecting local climatic conditions. In colder months when stratification has disintegrated, releases from deep reservoir waters remain cold but may actually be warmer than tributaries. This pattern holds for large, deep reservoirs but may vary with small or shallow reservoirs.

A cold water condition is conducive to trout production, hence the creation of numerous tailwater trout fisheries in areas without a significant natural trout population (e.g., Missouri). Although other fish species may survive under cold temperatures, often some facet of their habitat requirements reduces their viability. These may include hatching temperature or food type and production. Eventually, species well adapted to cold temperatures gain in their ability to compete and increase in numbers.

Trout strains apparently vary in their ability to survive, grow and reproduce under tailwater temperature conditions. All trout are capable of surviving in cold water but some strains have better survival capability. A strain with enhanced survival capability should have the edge in a competitive situation over a strain with reduced capability.

Most tailwaters inventoried followed a similar temporal temperature pattern as the Glen Canyon Dam tailwater. This usually consists of colder summer temperatures due to hypoliminion releases from a stratified reservoir. Winter temperatures may be warmer in southern latitudes. In one tailwater system (Libby Dam in Montana), the releases are reversed (winter hypoliminion and summer epilimnion) to keep temperatures higher. The spatial pattern for temperature below dams is usually unique due to the river corridor. The spatial pattern below Glen Canyon Dam is unique because: 1) the water volume is large; 2) the canyon is steep and 3) the gradient is steep. This prevents the temperature from rising more than 5°C in flowing over 240 miles downstream (U.S.Dept. of Interior [117]; Maddux [118]).

Cold water also affects sustained swimming speed of trout (Webb, [127]). Cold water associated with high velocities requires more energy for trout to maintain their positions. Strains more cold-water adapted would be less impacted and possibly maintain a competitive edge over other strains.

5.1.3 Water Quality

The quality of water below Glen Canyon Dam is influenced by many factors. Climate and geology are the primary forces influencing water chemistry but land use, soil types and vegetation are important secondary variables. These factors are unique to the Colorado River drainage area as they are to each tailwater system. Tributaries to the Colorado River downstream of Glen Canyon Dam are also unique and have often profound influences on water quality (Cole and Kubly [189]).

Lake Powell is another major factor affecting the quality of water in the dam tailwater. For parameters of significance to trout, the reservoir influences are probably the most important. The reservoir affects the transfer of material downstream, acting as a sink to trap such important water quality parameters as sediment and nutrients. Also, temperature, as described earlier, is dramatically changed by reservoir thermal stratification.

In such a large system as Lake Powell, the adjustment of many water quality parameters to a new equilibrium may involve changes among many different components of the system. This adjustment began immediately upon dam closure but equilibrium may require tens or even hundreds of years to attain (Petts [126]).

Water of the new reservoir floods soils and dissolves minerals and nutrients making them available for primary producers and ultimately to trout. Continuously flooded soils eventually reduce the amount of dissolved minerals and nutrients making them less available to aquatic productivity.

5.1.4 Productivity

Biological conditions in a dam tailwater enter a transition stage upon dam closure. Continuous adjustment to new physical and chemical conditions occurs as the new reservoir matures. In general, the biological conditions will continue in a transition stage until the physico-chemical situation stabilizes which, as mentioned above, may require tens or even hundreds of years.

The sudden inundation of mineral- and nutrient-rich soils often causes new reservoirs to be extremely productive for the first decade or so (Petts [126]). As nutrients are lost to the reservoir bottom and replenishment falls off, productivity drops. Downstream productivity follows the same cycle with early high productivity followed by gradual decrease in available nutrients and lowered productivity.

Trout productivity in tailwaters by necessity will follow this pattern. The Glen Canyon Dam tailwater fishery was known for large and abundant fish during the first 10 to 15 years but productivity has decreased in the last decade. Further study is needed of stomach contents of trout during the 1970's and 1980's to see if productivity increases and decreases were related to availability of threadfin shad from Lake Powell (Stone [134].

In tailwaters surveyed elsewhere, the pattern for productivity following dam closures has been similar to Glen Canyon Dam. Trout strains used elsewhere have shown some ability to offset some of the decline in productivity by having lower catchability and higher survival. In general these strains are wild or nearly so rather than domestic.

5.2 Management Programs

Much of the following information was obtained from direct interviews with biologists working on fisheries in tailwater systems (**Appendix D**).

5.2.1 Harvest Levels

Tailwater fisheries vary in harvest level like most fisheries. In systems employing domestic strains, such as Arlee or Shepherd of the Hills, which have a high catchability, harvest levels are high. In contrast, self-sustaining wild populations have reduced harvest levels due to a lower catchability. Fisheries with more wild trout often yield more larger fish to the creel because fish are longer lived, are not caught in the first or second year and therefore have been around long-enough to attain a significant size.

The Arlee strain, used widely in Montana, has a life expectancy of two years and is highly catchable. The Fish

Lake/DeSmet strain also widely used in Montana will live five or more years and is less catchable. Pounds of fish returned to the creel per pound planted may be similar for both strains but the average size of DeSmet trout is much larger.

The rainbow trout planted in Lake Mohave below Lake Mead are a mixture of strains. In the last 4-5 years, at least six strains have been used including Eagle Lake, Wytheville, Erwin, Bel-Aire, Tasmanian, Fish Lake/DeSmet. These originate from the U.S. Fish and Wildlife Service Willow Beach Hatchery and the Nevada Department of Wildlife Lake Mead Hatchery. Harvest levels for these strains run about 30 percent, with about one million 8 to 9 inch fish planted each year and 300,000 caught. In the last two years populations of striped bass have increased 300-500% and trout returns have dropped, probably as a result of predation by striped bass but also due to lower fishing pressure.

Annual stockings of Bel-Aire strain rainbow trout in the Colorado River below Glen Canyon Dam amount to about 80,000-100,000. Catch rate has been increasing in recent years toward 1.00 fish per hour whereas creeled fish or harvest rate has remained relatively steady at about 0.14 fish per hour. Annual harvest is about 40 percent.

5.2.2 Regulations

Fisheries managers have attempted to improve fishing through regulation changes. Limits on size, number, gear, season and species are employed with varying degrees in tailwater fisheries. The Green River below Flaming Gorge has a slot limit between 13 and 20 inches and allows two fish less than 13 inches and one greater than 20 inches. This has been done in conjunction with less stocking to reduce the number of fish in the river thereby increasing the average size. Lake Taneycomo in Missouri has a five trout limit and no slot limit. However, 80,000 ten-inch Shepherd of the Hills strain rainbow are planted each month to sustain the fishery. Provo River below Deer Creek Dam receives some rainbow trout (variety of strains) each spring from plantings made in the reservoir spilling downstream. The tailwater is an historic brown trout and walleye fishery and rainbow are relatively new; therefore the angling regulations prohibit keeping any rainbow trout but allow anglers to keep both brown trout and walleye. Artificial lures and flies only are allowed in the aforementioned tailwaters. Lake Mohave below Hoover Dam has a 10 rainbow trout limit without a size limit and allows the use of bait. The Colorado River below Glen Canyon Dam utilizes a 16 to 22 inch slot limit, two fish limit of which only one may be over 22 inches. Flies and artificial lures are the only angling gear types allowed.

5.3 Spawning

5.3.1 Stranding

Stranding of spawning trout due to fluctuating flows has not been noted in other tailwater fisheries investigated. This includes areas with fluctuations similar to the Colorado River below Glen Canyon Dam:

San Juan River below Navajo Dam - New Mexico
Flathead River below Hungry Horse Dam - Montana
Kootenai River below Libby Dam - Montana
Green River below Flaming Gorge Dam - Utah
Flathead River below Kerr Dam - Montana
Lake Taneycomo below Table Rock Dam - Missouri

Although flow fluctuations are similar in these tailwaters, many factors are different between the systems. In some systems, the fluctuation may be as high but the ramping rate is much lower while in others the spawning habitat is extremely poor due to armoring or lack of gravel. However, no biologist interviewed was aware of a stranding problem within their tailwater system (**Appendix D**).

5.3.2 Seasonal Differences

Seasonal differences in flow fluctuations do occur so time of spawning may be critical. Most domestic strains of rainbow trout are fall spawners whereas most wild strains are spring spawners. This spawning arrangement is consistent with natural cooling and warming cycles for rivers. In the Colorado River tailwater, temperatures are much more uniform which suggests some divergence to the normal spawning times for trout.

Domestic strains such as Bel-Aire are described as fall-winter spawners whereas wild strains like Fish Lake, DeSmet and Colorado River are described as spring-early summer spawners. Comparison of seasonal flow fluctuations with strain spawning period may provide another basis for selecting one strain over another. Spring flow fluctuations in the Colorado River are less dramatic than fluctuations in winter or summer. Therefore, wild strains may be a better choice when attempting to minimize impacts to trout spawning.

6.0 EVALUATION OF STRAINS

6.1 Strain Description

This section provides a brief description of prominent strains from the literature reviewed. The strains are listed alphabetically:

The **Arlee strain** - Developed by the State of Montana, selected for its fall spawning period and fast growth. The strain is a domesticated fall spawner, originating from a cross between a Donaldson and an unidentified Missouri strain in 1955. Widely used by Montana Department of Fish, Wildlife and Parks, but is currently being phased out due to low spawning potential and low survival in the wild (Mueller [103]; Ferguson et.al. [34]).

The **Beity strain** was brought to Utah from Valley, Washington, in 1969 (Berry & Hudy [8]).

The **Bel-Aire strain** probably originated with the McCloud River strain and arrived at Glen Canyon by a typically-circuitous route that most strains traverse. The Crystal River Hatchery in Colorado is the home of the broodstock for the Glen Canyon Bel-Aire strain. The strain has been maintained at Crystal River since 1973. Prior to 1973, the strain was cultured at the Rifle Falls Hatchery for two years and before Rifle, it was cultured at its namesake state hatchery in Bel-Aire, Colorado. The Bel-Aire Hatchery strain apparently originated from the Wigwam strain at Ten Sleep, Wyoming whereas the Wigwam strain probably originated from the Hot Creek Hatchery in California. Bel-Aire are early spawners, with high fecundity, good fertility and fast growth. Typically, Colorado Division of Wildlife is able to plant 10" catchables by May after spawning in the fall (Riger, Appendix D).

The **Cape Cod strain** is a domesticated rainbow trout developed from eggs originally brought from the commercial Cape Cod Hatchery, Massachusetts, to the Spokane Hatchery in Washington in 1941-1942. Eggs from that brood stock were transferred to Roaring River Hatchery in 1967 and a brood stock was established in 1971 (Moring [66;150]).

The **Coleman strain** was established at the Coleman National Hatchery, Anderson, California, in 1949 from a shipment of Kamloops trout eggs from Pennask Lake, British Columbia. Over the years at Coleman it was mixed with steelhead and resident rainbow trout from Battle Creek, a Sacramento River tributary. The broodstock maintained by the Hot Creek hatchery is the result of a 1968 importation of fish from Coleman. Due to the past mixing of strains, it is no longer considered to be a Kamloops strain (Busack and Gall [13]; Dayfield [169]).

The **Davis strain** is a general purpose strain developed in 1968 at the University of California at Davis' Fisheries Biology Research Facility from a cross of the Hot Creek and Virginia strains. Beginning in 1978, the Davis strain replaced the Virginia strain at the California Department of Fish and Game Mt. Shasta and Darrah Springs hatcheries (Busack & Gall [13]).

The **De Smet strain** is a mixed domestic and wild stock. Wild fish of Lake De Smet, Wyoming are captured and artificially spawned with eggs hatched in hatchery. This strain spawns in winter and is widely used by Wyoming Department of Game and Fish but is currently being replaced by a more catchable strain, the Eagle Lake.

The **Donaldson strain** was developed through 40 years of selective breeding by Dr. Lauren Donaldson of the University of Washington in Seattle. Donaldson strain trout show rapid hatchery growth at relatively warm temperatures, and after stocking they grow rapidly and tolerate temperature fluctuations well. This strain is widely used to restock reclaimed waters in its home state. Their rapid growth under such circumstances results in the reduction of the time it takes to provide a useable fishery. In Minnesota they are stocked primarily in lakes because of their rapid growth and catchability (Close, et. al. [160], Soldwedel & Pyle [161]).

The **Eagle Lake strain** is a distinct subspecies (O. m. aquilurum) of rainbow originally collected in Eagle Lake, Lassen County, California. Eagle Lake is a large alkaline natural lake with a maximum depth of about 21 m and less than 5 m deep over two-thirds of its area. Water temperatures normally do not exceed 24 degrees C. The California Department of Fish and Game began trapping spawning rainbow trout at Pine Creek, a tributary of Eagle Lake, in 1956 and rearing their progeny for return to the lake. There is virtually no natural spawning at Eagle Lake, so the entire population is dependent on these infusions of hatchery-reared fish.

The strain was selected as a federal broodstock because the adult fish are piscivorous and because Eagle Lake trout tolerate higher alkalinity than other members of the rainbow-cutthroat complex. It has outstanding genetic diversity which should help it meet changes in its environment.

Two stocks of Eagle Lake trout are maintained at the Darrah Springs and Crystal Lake hatcheries, California: the wild or Pine Creek stock, and a hatchery stock (referred to as Eagle Lake Domestic). There is virtually no difference between the two stocks. "Wild" Eagle Lake trout are raised from eggs taken at the Lake, while "domestic" Eagle Lake trout are the progeny of "wild" trout raised to maturity and spawned at the

hatchery. There is no continuing hatchery broodstock. Both stocks have been used in restocking Eagle Lake, although since about 1970 the domestic stock has been used almost exclusively in restocking the Lake and providing fish for management programs.

Most Eagle Lake trout mature at three years of age (460 to 560 mm) and have been reported to live to 11 years. Growth in Eagle Lake is excellent, with one-year-old fish planted at 200 to 230 mm reaching 430 to 460 mm in a year. Their food habits include aquatic insects, shrimp, snails, and tui chubs (Gila bicolor). Stocked catchables have had good return rates in reservoir fisheries with a high percentage of weight returned to anglers, and with fish being harvested up to three years after release (Busack and Gall [80]; Calhoun [15]; McAfee [15a]; Partridge [167]; Rawstron [77]).

The **Erwin strain** is a good domestic, fall-spawning strain originating from the Wytheville strain of Virginia. It was sent to Erwin, Tennessee in 1973 and cultured as the Erwin strain. It is widely used in Montana and maintained at the Ennis National Fish Hatchery.

The **Fast Growth** strain was derived from fish which have been domesticated for several generations (Reinitz, Orme, Lemm and Hitzel [78]).

The **Fish Lake strain**, a cross between the Arlee and Old Fish Lake strains, has the highest variability of rainbow strains. It is a spring spawner, does well in both the hatchery and in the wild. It originated from Fish Lake, Utah and is one generation removed from the wild source.

The **Harrison Lake strain** overwinters well in the wild, exhibits longevity, establishes spawning runs and reproduces in the wild. It has potential for trophy size, and exhibits catch rates of 0.2 to 0.5 fish per angler hour in large Montana reservoirs.

The **Hayspur strain** originated at the Hayspur State Fish Hatchery, Bellevue, Idaho. The original broodstock resulted from a cross between the Hot Creek strain and a local rainbow trout, probably from Silver Creek, Blaine County, Idaho, around 1910. Since then, various strains have been introduced to the broodstock, including Gerrard Kamloops in 1965; rainbow trout from Roaring River, Oregon, in 1983; and Hot Creek rainbow trout in 1983. Brood fish are selected for body conformation and heavy spotting. Sexual maturity is normally reached at three years, with spawning from September through December. Hatchery growth is excellent, with fish average about 3.0 kg in three to eight years, and some brood fish reaching 7.0 kg in five to six years (Partridge [167]).

The **Hot Creek** strain is a McCloud strain that was imported into the Hot Creek Hatchery, Crowley Lake, Mono County, California, in 1933 from the federal hatchery at Springville, Utah where it had long been maintained. It thereupon became known as the Hot Creek strain, and has been maintained there since. In 1952 and 1953 Hot Creek females were bred to Mt. Whitney males to increase genetic variability in the Hot Creek strain (Busack & Gall 1980; Dollar and Katz [25]).

Idaho may have been of McCloud River origin, but this is uncertain (Dollar and Katz [25]).

Junction Kamloops was established in 1964 in Junction Reservoir, Mono County, California, from eggs obtained from the Oregon Department of Fish and Wildlife's egg-taking stations at Diamond Lake, Douglas County, Oregon. A fishery with Kamloops trout as the sole salmonid present had been established in Diamond Lake in 1955 with eggs from Pennask Lake, British Columbia. Some of the eggs sent to California from Diamond Lake may have been taken from or fertilized by domestic rainbow trout, because fingerlings from the McCloud strain were planted in the lake in 1962 and may have mixed. The strain is maintained at the Hot Creek hatchery, California (Busack & Gall [13]).

The **Kamloops strain** trout are fall-spawning, well-domesticated, long-lived, successful in large lakes, and large at maturity. They grow rapidly, survive well, spawn at a late age, handle hatchery stresses well, maintain a good growth rate (25 mm per month at 6 degree C) in high or low water temperatures, and are described as very vigorous compared to other strains. They are notoriously piscivorous in their native range, probably accounting for their rapid growth. Kamloops disperse quickly after stocking, reducing immediate angling mortality and resulting in older, larger fish in the creel. The strain has potential for "trophy" fisheries. Boat anglers are usually more successful than shore anglers at catching Kamloops because of the strain's preference for the limnetic zone.

The Kamloops strain originated in Canada in 1944, possibly at Kootenay Lake, British Columbia, and served as broodstock at Trout Lodge Hatchery, Tacoma, Washington. They were used to start the brood fish at the commercial Skane Fish Hatchery, Moses Lake, Washington, in 1973. Skane broodstock have been selected for color, size and egg number, with no known introductions of other strains.

Kamloops is primarily a lake fish, with natural spawning in tributaries, where the young spend variable amounts of time before migrating to the lake. They spawn from April through June, with peak spawning in May. They commonly hatch in July

and are planted as fingerlings either in October at about 20/oz or in the following spring from 1-3/oz. The Kamloops not only grows more slowly than the domesticated strains but displays greater size variation. Kamloops have been distributed throughout the western United States. Eggs for the strain are available from the Skane Fish Farm (Close, Colvin and Hassinger [160], Cordone and Nicola [17]; Partridge [167]; Shrader & Berry [145]).

The **Lassen strain** (also referred to as Mt. Lassen) was produced from a cross between Kamloops strain from Canada and the Mt. Shasta strain. It has been maintained at the Mt. Lassen Trout Farm, a commercial hatchery in Red Bluff, California, for over 20 years.

The strain reportedly exhibits good growth (0.6 kg in one year in 13 degree C water), handles hatchery stresses well, and is described as very hardy in its ability to tolerate marginal water quality. Fish are spawned monthly on an annual basis (Partridge [167]).

The **Madison strain** trout are easily cultured and are stocked in both lakes and streams. It is the mainstay of Minnesota's hatchery and stocking program, although high immediate angling mortality has been reported in Lake Superior. Acceptable angler returns and benefit:cost ratios resulted in the development of a trout reclamation program in the late 1950's utilizing the Madison strain (Close and Hassinger [89]; Close, Colvin and Hassinger [160]).

The **McCloud strain** probably no longer exists in a pure form but it formed the basis for most domestic rainbow strains in use around the world. The strain originated on the McCloud River at Baird in California when eggs were taken from existing wild trout. In the late 1800's McCloud River eggs were transferred to sites around the world where adequate habitat existed.

The **McConaughy strain** originated from wild fish collected from the North Platte River and other tributaries to McConaughy Reservoir, Nebraska. This rainbow trout population evolved from hatchery stocking of North Platte Valley streams during 1911 to 1945. After 1945, populations in many of the tributary streams were influenced by larger adfluvial rainbow trout from McConaughy Reservoir. The strain is now considered to be self-sustaining. The adults in McConaughy Reservoir are spring spawners that migrate into the tributaries in the late fall and spring. The juveniles remain in the streams for a year before moving down into the reservoir. The wild McConaughy strain may not perform as well as domesticated strains in the hatchery, but it has shown the ability to survive in a pond environment for up to four years.

The McConaughy is a piscivorous fish that is highly successful in a two story fishery, shows good carryover from year to year, and is variable in size. It has high angler satisfaction, with the wild fish being less susceptible to angling mortality than the domesticated strains (Dayfield [169]; Dwyer and Piper [28]; Partridge [167]; Van Nelson [90]).

The **Mt. Lassen** - see Lassen

The **Mt. Shasta** - see Shasta

The **Mt. Whitney** - see Whitney

The **Neosho strain** was developed at the U.S. Fish and Wildlife Service' Neosho Hatchery at Neosho, Missouri, by interbreeding a number of rainbow trout stocks since 1891. The parent strains apparently included Wytheville, McCloud River, Madison Valley, Montana, and others (Dollar & Katz [25]).

The **New Jersey strain** is the result of many years of selective breeding at the New Jersey State (Charles O. Hayford) Fish Hatchery, Hackettstown, New Jersey. Desirable characteristics included early spawning, rapid growth and disease resistance (Soldwedel and Masser [170]; Soldwedel and Pyle [161]).

The **Oak Springs strain** is a long-established domesticated strain that probably had connections with the Roaring River strain at various times in the past hundred years. Fertilized eggs from a highly domesticated, heterogeneous broodstock in Utah were brought to Oak Springs Hatchery in 1923 and have been mixed with at least one other strain since then. It is widely used in eastern Oregon trout stocking (Moring and Youker [150]; Moring, [66]).

The **Old Fish Lake** strain was the offspring of trout taken as eggs from a naturally reproducing population in Fish Lake, Utah. The lake, located at 2,400 m elevation, had been stocked with rainbow trout from a variety of sources before brood fish were collected there and taken to the Fish Genetics Laboratory in June 1973. Since this strain was maintained by a mixture of natural reproduction and supplemental plantings originating from the same stock, it was considered to be a natural strain (Brauhn & Kincaid [11]; Reinitz, et. al.[78]).

The **Pennask** strain is a wild strain from Pennask Lake in British Columbia, Canada, where it is a small-sized native with no history of introductions (Ming [64]).

The **Pit River** strain was developed during 1968 to 1970 from native Pit River rainbow which ran up Sucker Springs Creek to the Pit River hatchery. This strain is noted for being

resistant to Ceratomyxa, and so is used for stocking Ceratomyxa-infested waters. It is maintained by the Crystal Lake Hatchery, California (Busack & Gall [3]).

The **Premier** strain is a wild strain from Premier Lake in British Columbia, Canada. It was developed in the late 1960's through introductions of a domesticated strain from Washington State and wild strains from Beaver Lake (B.C.) and Pennask Lake (Ming [64]).

The **Roaring River** strain originally came to Oregon from the Meader Trout Farm, Idaho, in 1937, and a broodstock was established at Roaring River Hatchery in 1940. While the strain was essentially isolated and inbred for more than 30 years in Oregon, it was a heterogeneous mixture of many strains before that time. Development of the strain may have included inbreeding with anadromous steelhead (Moring [66]).

The **Sand Creek** strain originated from Sand Creek, Beulah, Wyoming which was frequently stocked with rainbow trout. It is a semi-wild strain maintained at the U.S. Fish and Wildlife Fish Genetics Laboratory at Beulah since 1971 (Reinitz, Orme, Lemm and Hitzel [78]).

The **Shasta strain** (also referred to as the Mt. Shasta strain) originated at the Mt. Shasta State Fish Hatchery, California, to obtain a winter-spawning rainbow strain. The strain was developed in 1950 and 1952, by crossing the Hot Creek strain (formerly a McCloud strain via Springerville, Utah) with a strain from Meader's Trout Farm, Pocatello, Idaho. The Meader broodstock was developed over many years using various trout strains nationwide, possibly including cutthroat trout from the Portneuf River.

Initially, Shasta brood stock spawned from November through February, but as a result of further selection they now spawn almost exclusively in January and February. Peak spawning takes place in early February. Progeny from these fish are planted as fingerlings at about 4-6/oz. in July, August and September.

The Shasta strain is selected for its rapid growth, reaching sexual maturity in two years. It is considered to be an ideal production fish with success in stocking programs, showing rearing success under all types of hatchery conditions. Growth is reported as being excellent, with fish reaching about 2.0 kg in four years.

Shasta has performed well in natural environments when compared with the Coleman and Mt. Whitney strains. Shasta showed a high average ratio of pounds caught to pounds planted and a low average cost per pound to the creel. Like the Mt.

Whitney strain, the Shasta strain is reportedly more vulnerable to shore anglers than Coleman, but does not tend to emigrate like the Mt. Whitney and Coleman strains. The strain is now maintained by the Mt. Shasta and Darrah Springs hatcheries in California (Busack & Gall [13]; Cordone and Nicola [17]; Dollar and Katz [25]; Needham & Behnke [69]; Partridge [167]; Rawstron [75,76]).

Shepherd of the Hills strain is named for the hatchery located near Branson, Missouri. The hatchery was built as part of a mitigation plan during construction of Table Rock Dam in 1957. Trout from the federal Neosho Hatchery were transferred to the hatchery and have been maintained as a broodstock. Electrophoresis work on this fall-spawning strain in 1981 demonstrated a close relationship to the Hot Creek and McCloud River strains in California (Murphy, Appendix E).

The **Spring Standard Growth strain** was derived from fish domesticated for several generations. The strain was developed from Donaldson, New Zealand and Sand Creek strains. Eggs are maintained at the Fish Genetics Laboratory at Beulah, Wyoming (Reinitz, et. al. [78]).

The **Sun Valley** strain is a domesticated strain bred from one or more domesticated strains originating in the State of Washington (Ming [64]).

The **Tensleep strain** originated from the McCloud River, California, stock that was maintained in several state and federal hatcheries before eggs were shipped to the Tensleep, Wyoming, Hatchery in 1956. The exact pedigree of the strain is unknown, but the strain is well-domesticated. Originally early-spring spawners, they have been selectively bred for fall spawning (Shrader & Berry [145]).

The **Virginia** strain origin has been traced back to the Federal Wytheville Hatchery in Virginia, where eggs first arrived in 1882 from the McCloud River Station. This original strain was crossed with rainbow trout from other sources until 1930 when a selective breeding program was initiated. Virginia strain eggs were shipped to California in 1955 to meet a need for rainbow trout eggs during the summer, and the resulting fish were first spawned at Mt. Shasta State Hatchery in 1957. Spawning occurs from the middle of July through September with no well-defined peak. Eggs from August spawners usually hatch in late September or early October and are planted as fingerlings at about 2.5/oz in April. The strain is maintained by the Mt. Shasta and Darrah Springs hatcheries in California (Cordone and Nicola [17]).

The **West Virginia strain** originated from trout from the Wytheville Federal Hatchery in Virginia (Dollar and Katz [25]).

The **Whitney strain** (also referred to as the Mt. Whitney strain) was developed from about 1918 to 1930 by the Mt. Whitney State Fish Hatchery in Independence, Inyo County, California. The current broodstock has a complicated genetic background that includes California rainbow trout (possibly derived from McCloud stock), Klamath and Eel River steelhead, Kamloops rainbow trout (possibly from Pennask Lake, British Columbia), and cutthroat trout from Lahontan Basin, Nevada, and possibly, Oregon, sources.

The original spring spawning time (from March through May, peaking in early April) has been retained. Hatching is in early June, and they are planted as fingerlings in September at about 3/oz. Mt. Whitney trout generally mature at two years of age, with spawning occurring from March through May, peaking in April. They have shown good hatchery growth, reaching over 2.0 kg in four years, and are somewhat more disease resistant than some other California strains. Whitneys generally comprise the bulk of the small fingerlings stocked in California coldwater lakes and reservoirs in the summer and fall.

Comparison of Mt. Whitney trout with other domestic and wild strains in natural environments has shown variable results. Generally, Mt. Whitney fish were similar to Coleman Kamloops and Shasta in terms of catchability and growth, but did not yield as high a ratio of pounds caught to pounds planted; and total cost of fish to the angler's creel was higher for the Mt. Whitney and Shasta strains. While the Mt. Whitney strain had similar survival rates as a wild strain in alpine lakes without a predatory species present, they had significantly poorer survival than the wild strain when released in lakes containing brook trout Salvelinus fontinalis. The Mt. Whitney strain shows a greater tendency for emigration than the other strains (Busack and Gall [13]; Busack, Halliburton and Gall [14]; Cordone and Nicola [17]; Partridge [167]; Rawstron [75,76]).

The **Winthrop strain** is a domestic winter spawning strain originating from a private stock from Cape Cod, Massachusetts in 1936. It has been used successfully in put-and-take fisheries and is maintained at Fish Technology Center in Bozeman, Montana for research and development (Dolan and Piper [104]).

The **Wytheville** is a domestic strain descended from an 1882 shipment of McCloud River eggs to the Wytheville Hatchery, California, into which two other McCloud strains were introduced in the 1920's. It is an excellent hatchery fish with great management potential in put-and-take fisheries when fast initial growth rates and high initial return are desired. It is used extensively in the stocking programs in several states. (Busack & Gall [13]; Dayfield [169]; Dollar and Katz [25]).

6.2 Evaluation Criteria

Many factors could be important when assessing the advantage one strain may have over another. In the present evaluation, data were available for only a handfull of factors. However, these factors are important and therefore become the evaluation criteria:

Growth	-Weight gain in first year
Catchability	-Return to creel, number returned versus number planted. Also, high susceptibility to angling may mean less available for catch in later years when the fish is larger.
Survival	-Ability to survive in the wild which also includes low susceptibility to angling. This may mean more available for catch in later years when fish is larger.
Food Conversion	-Efficiency in converting food to fish flesh is a measure of possible ability to attain and maintain good condition under marginal conditions.
Spawning Month	-Assumes spawning in spring or late winter would be advantageous compared with fall or winter.

Information is not available for all strains or broodstocks for all these criteria but good information is available for about 21 strains. These 21 strains are compared with each other for each criteria in Section 6.3.

6.3 Matrix Comparison

The matrix visually presents pair-wise comparisons of 21 strains for a particular attribute (e.g., spawning period). The comparisons are developed from information in the literature. For example, the Winthrop strain demonstrated superior growth in a comparison with Arlee, DeSmet and Erwin strains (Mueller [103]). The matrix number for Winthrop is 20 so 20 appears in boxes 1, 5, and 8 corresponding with Arlee, DeSmet and Erwin strains, respectively.

By comparing each of the strains directly with each of the other strains, and identifying the best (according to the literature) on a one-to-one comparison, a cumulative comparison is possible. This comparison was done in a matrix with all of the strains on both horizontal and vertical axes when information was available. Thus, the diagonal, which compares each strain with itself, is eliminated as meaningless, while the boxes of the matrix show which of the strains performed better for that given character.

MATRIX COMPARISON OF TROUT STRAINS

Spawning Period - Assumes Spring Spawning is best followed by Winter, Fall and Summer.

STRAIN		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
ARLEE	1	◄	1	3	4	5	6	7	1	9	1	11	12	1	14	15	1	17	18	19	20	1
BEL-AIRE	2	1	◄	3	4	5	6	7	2	9	2	11	12	+	14	15	16	17	18	19	20	2
CAPE COD	3	3	3	◄	+	5	6	7	3	9	3	11	12	3	14	15	3	17	+	19	20	3
COLEMAN	4	4	4	+	◄	5	6	7	4	9	4	11	12	4	14	15	4	17	+	19	20	4
DE SMET	5	5	5	5	5	◄	+	7	5	+	5	11	+	5	+	15	5	17	5	19	+	5
DONALDSON	6	6	6	6	6	+	◄	7	6	+	6	11	+	6	+	15	6	17	6	19	+	6
EAGLE LAKE	7	7	7	7	7	7	7	◄	7	7	7	+	7	7	7	+	7	+	7	+	7	7
ERWIN	8	1	2	3	4	5	6	7	◄	9	8	11	12	13	14	15	16	17	18	19	20	+
FISHLAKE	9	9	9	9	9	+	+	7	9	◄	9	11	+	9	+	15	9	17	9	19	+	9
HOT CREEK	10	1	2	3	4	5	6	7	8	9	◄	11	12	13	14	15	16	17	18	19	20	21
KAMLOOPS	11	11	11	11	11	11	11	+	11	11	11	◄	11	11	11	+	11	+	11	+	11	11
MCCONAUGHY	12	12	12	12	12	+	+	7	12	+	12	11	◄	12	+	15	12	17	12	19	+	12
ROARING RIVER	13	1	+	3	4	5	6	7	13	9	13	11	12	◄	14	15	16	17	18	19	20	13
SAND CREEK	14	14	14	14	14	+	+	7	14	+	14	11	+	14	◄	15	14	17	14	19	+	14
SHASTA	15	15	15	15	15	15	15	+	15	15	15	+	15	15	15	◄	15	+	15	+	15	15
SHEPHERD	16	1	16	3	4	5	6	7	16	9	16	11	12	16	14	15	◄	17	18	19	20	16
SPRING STD.	17	17	17	17	17	17	17	+	17	17	17	+	17	17	17	+	17	◄	17	+	17	17
TEN SLEEP	18	18	18	+	+	5	6	7	18	9	18	11	12	18	14	15	18	17	◄	+	20	18
WHITNEY	19	19	19	19	19	19	19	+	19	19	19	+	19	19	19	+	19	+	+	◄	19	19
WINTHROP	20	20	20	20	20	+	+	7	20	+	20	11	+	20	+	15	20	17	20	19	◄	20
WYTHEVILLE	21	1	2	3	4	5	6	7	+	9	21	11	12	13	14	15	16	17	18	19	20	◄

(-) No Information
(+) No difference

A number indicates the strain with the desirable character in a 1:1 comparison with another strain.

MATRIX COMPARISON OF TROUT STRAINS

Food Conversion- Assumes efficient converters will have an advantage in a natural habitat.

STRAIN		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
ARLEE	1	◄	-	3	-	-	1	7	8	9	-	11	-	13	14	15	1	-	1	+	-	1
BEL-AIRE	2	-	◄	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CAPE COD	3	3	-	◄	-	-	3	7	8	9	-	+	-	3	3	15	3	-	3	3	-	3
COLEMAN	4	-	-	-	◄	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DE SMET	5	-	-	-	-	◄	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DONALDSON	6	1	-	3	-	-	◄	7	8	9	-	11	-	13	14	15	16	-	18	19	-	21
EAGLE LAKE	7	7	-	7	-	-	7	◄	7	7	-	7	+	7	7	15	7	-	7	7	-	7
ERWIN	8	8	-	8	-	-	8	7	◄	+	-	8	-	8	8	15	8	-	8	8	-	8
FISHLAKE	9	9	-	9	-	-	9	7	+	◄	-	9	12	9	9	15	9	17	9	9	20	9
HOT CREEK	10	-	-	-	-	-	-	-	-	-	◄	-	-	-	-	-	-	-	-	-	-	-
KAMLOOPS	11	11	-	+	-	-	11	7	8	9	-	◄	-	11	11	15	11	-	11	11	-	11
MCCONAUGHY	12	-	-	-	-	-	-	+	-	12	-	-	◄	-	-	15	-	17	-	-	20	-
ROARING RIVER	13	13	-	3	-	-	13	7	8	9	-	11	-	◄	14	15	13	-	13	13	-	13
SAND CREEK	14	14	-	3	-	-	14	7	8	9	-	11	-	14	◄	15	14	17	14	14	-	14
SHASTA	15	15	-	15	-	-	15	15	15	15	-	15	15	15	15	◄	15	-	15	15	-	15
SHEPHERD	16	1	-	3	-	-	16	7	8	9	-	11	-	13	14	15	◄	-	18	19	-	21
SPRING STD.	17	-	-	-	-	-	-	-	-	17	-	-	17	-	17	-	-	◄	-	-	20	-
TEN SLEEP	18	1	-	3	-	-	18	7	8	9	-	11	-	13	14	15	18	-	◄	19	-	+
WHITNEY	19	+	-	3	-	-	19	7	8	9	-	11	-	13	14	15	19	-	19	◄	-	19
WINTHROP	20	-	-	-	-	-	-	-	-	20	-	-	20	-	-	-	-	20	-	-	◄	-
WYTHEVILLE	21	1	-	3	-	-	21	7	8	9	-	11	-	13	14	15	21	-	+	19	-	◄

(-) No Information
(+) No difference

A number indicates the strain with the desirable character in a 1:1 comparison with another strain.

MATRIX COMPARISON OF TROUT STRAINS

Growth - Assumes weight gain in first year should be fast for Spring Spawners and moderate for Fall spawners.

STRAIN		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
ARLEE	1	◄	-	3	-	1	1	7	8	-	10	1	-	13	-	15	1	-	-	1	20	1
BEL-AIRE	2	-	◄	-	-	-	-	+	-	-	-	2	-	-	-	-	-	-	-	-	-	-
CAPE COD	3	3	-	◄	-	-	3	7	-	-	10	3	-	13	-	3	3	-	-	3	-	3
COLEMAN	4	-	-	-	◄	-	-	4	-	-	-	-	-	-	-	4	-	-	-	4	-	-
DE SMET	5	1	-	-	-	◄	-	-	8	-	-	-	-	-	14	-	16	17	18	-	20	21
DONALDSON	6	1	-	3	-	-	◄	7	-	-	10	6	-	13	-	15	16	-	-	6	-	21
EAGLE LAKE	7	7	+	7	4	-	7	◄	-	-	10	7	7	13	-	15	7	-	-	7	-	7
ERWIN	8	8	-	-	-	8	-	-	◄	-	-	-	-	-	-	-	-	-	-	-	20	-
FISHLAKE	9	-	-	-	-	-	-	-	-	◄	-	-	9	-	14	-	-	17	-	-	20	21
HOT CREEK	10	10	-	10	-	-	10	10	-	-	◄	10	-	10	-	10	10	-	-	10	-	10
KAMLOOPS	11	1	2	3	-	-	6	7	-	-	10	◄	11	13	-	15	16	-	-	11	-	+
MCCONAUGHY	12	-	-	-	-	-	-	7	-	9	-	11	◄	-	-	15	-	17	-	19	20	-
ROARING RIVER	13	13	-	13	-	-	13	13	-	-	10	13	-	◄	-	13	13	-	-	13	-	13
SAND CREEK	14	-	-	-	-	14	-	-	-	14	-	-	-	-	◄	-	14	17	18	-	-	-
SHASTA	15	15	-	+	4	-	15	7	-	-	10	15	15	13	-	◄	15	-	-	15	-	15
SHEPHERD	16	1	-	3	-	16	16	7	-	-	10	16	-	13	14	15	◄	-	18	16	-	16
SPRING STD.	17	-	-	-	-	17	-	-	-	17	-	-	17	-	17	-	-	◄	-	-	20	-
TEN SLEEP	18	-	-	-	-	18	-	-	-	-	-	-	-	-	18	-	18	-	◄	-	-	-
WHITNEY	19	1	-	3	4	-	6	7	-	-	10	11	19	13	-	15	16	-	-	◄	-	21
WINTHROP	20	20	-	-	-	20	-	-	20	20	-	-	20	-	-	-	-	20	-	-	◄	-
WYTHEVILLE	21	1	-	3	-	21	21	7	-	21	10	+	-	13	-	15	16	-	-	21	-	◄

(-) No Information
(+) No difference

A number indicates the strain with the desirable character in a 1:1 comparison with another strain.

MATRIX COMPARISON OF TROUT STRAINS

Survival - Assumes return to creel by trout in second or third year is better than in first year.

STRAIN		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
ARLEE	1	◄	-	-	-	5	-	7	8	-	-	-	-	-	-	-	-	-	-	-	1	-
BEL-AIRE	2	-	◄	-	-	-	-	7	-	-	2	-	-	-	-	-	-	-	-	-	-	-
CAPE COD	3	-	-	◄	-	-	-	-	-	-	-	-	-	13	-	-	-	-	-	-	-	-
COLEMAN	4	-	-	-	◄	-	-	7	-	-	-	4	-	-	-	4	-	-	-	4	-	-
DE SMET	5	5	-	-	-	◄	-	-	5	+	-	-	-	-	14	-	16	-	18	-	5	-
DONALDSON	6	-	-	-	-	-	◄	-	-	-	-	11	-	-	-	-	-	-	-	-	-	-
EAGLE LAKE	7	7	7	-	7	-	-	◄	-	-	-	-	7	-	-	7	-	-	-	-	7	-
ERWIN	8	8	-	-	-	5	-	-	◄	-	-	-	-	-	-	-	-	-	-	-	8	-
FISHLAKE	9	-	-	-	-	+	-	-	-	◄	-	-	12	-	14	-	16	17	18	-	20	9
HOT CREEK	10	-	2	-	-	-	-	-	-	-	◄	10	-	-	-	-	-	-	-	-	-	-
KAMLOOPS	11	-	-	-	4	-	11	-	-	-	10	◄	-	-	-	15	-	-	-	11	-	-
MCCONAUGHY	12	-	-	-	-	-	-	7	-	12	-	-	◄	-	-	15	-	17	-	-	20	-
ROARING RIVER	13	-	-	13	-	-	-	-	-	-	-	-	-	◄	-	-	-	-	-	-	-	-
SAND CREEK	14	-	-	-	-	14	-	-	-	14	-	-	-	-	◄	-	14	-	18	-	-	-
SHASTA	15	-	-	-	15	-	-	7	-	-	-	15	15	-	-	◄	-	-	-	15	-	-
SHEPHERD	16	-	-	-	-	16	-	-	-	16	-	-	-	-	14	-	◄	-	18	-	-	-
SPRING STD.	17	-	-	-	-	-	-	-	-	17	-	-	17	-	-	-	-	◄	-	-	17	-
TEN SLEEP	18	-	-	-	-	18	-	-	-	18	-	-	-	-	18	-	18	-	◄	-	-	-
WHITNEY	19	-	-	-	-	-	-	-	-	-	-	11	-	-	-	15	-	-	-	◄	-	-
WINTHROP	20	1	-	-	-	5	-	-	8	20	-	-	20	-	-	-	-	17	-	-	◄	-
WYTHEVILLE	21	-	-	-	-	-	-	-	-	9	-	-	-	-	-	-	-	-	-	-	-	◄

(-) No Information
(+) No difference

A number indicates the strain with the desirable character in a 1:1 comparison with another strain.

MATRIX COMPARISON OF TROUT STRAINS

Catchability - Assumes trout which are less catchable are more likely to contribute to trophy fish in later years.

STRAIN		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
ARLEE	1	◄	-	1	-	1	-	1	1	-	-	-	-	-	-	-	-	-	-	-	20	-
BEL-AIRE	2	-	◄	-	-	-	-	2	-	-	-	2	-	-	-	-	-	-	-	-	-	-
CAPE COD	3	1	-	◄	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-
COLEMAN	4	-	-	-	◄	-	-	4	-	-	-	4	-	-	-	-	-	-	-	-	-	-
DE SMET	5	1	-	-	-	◄	-	7	8	-	-	-	-	-	-	-	-	-	-	-	20	-
DONALDSON	6	-	-	-	-	-	◄	-	-	-	-	11	-	-	-	-	-	-	-	-	-	-
EAGLE LAKE	7	1	2	-	4	7	-	◄	-	-	-	-	7	-	-	+	-	-	-	-	-	-
ERWIN	8	1	-	-	-	8	-	-	◄	-	-	-	12	-	-	-	-	-	-	-	20	21
FISHLAKE	9	-	-	-	-	-	-	-	-	◄	-	-	12	-	-	-	-	17	-	-	20	-
HOT CREEK	10	-	-	-	-	-	-	-	-	-	◄	11	-	-	-	-	-	-	-	-	-	-
KAMLOOPS	11	-	2	-	4	-	11	-	-	-	11	◄	-	-	-	15	-	-	-	19	-	-
MCCONAUGHY	12	-	-	-	-	-	-	7	12	12	-	-	◄	-	-	-	-	17	-	-	20	-
ROARING RIVER	13	-	-	3	-	-	-	-	-	-	-	-	-	◄	-	-	-	-	-	-	-	-
SAND CREEK	14	-	-	-	-	-	-	-	-	-	-	-	-	-	◄	-	16	-	14	-	-	-
SHASTA	15	-	-	-	-	-	-	+	-	-	-	15	-	-	-	◄	-	-	-	15	-	-
SHEPHERD	16	-	-	-	-	-	-	-	-	-	-	-	-	-	16	-	◄	-	16	-	-	-
SPRING STD.	17	-	-	-	-	-	-	-	-	17	-	-	17	-	-	-	-	◄	-	-	17	-
TEN SLEEP	18	-	-	-	-	-	-	-	-	-	-	-	-	-	14	-	16	-	◄	-	-	-
WHITNEY	19	-	-	-	-	-	-	-	-	-	-	19	-	-	-	15	-	-	-	◄	-	-
WINTHROP	20	20	-	-	-	20	-	-	20	20	-	-	20	-	-	-	-	17	-	-	◄	-
WYTHEVILLE	21	-	-	-	-	-	-	-	21	-	-	-	-	-	-	-	-	-	-	-	-	◄

(-) No Information
(+) No difference

A number indicates the strain with the desirable character in a 1:1 comparison with another strain.

7.0 SUMMARY AND RECOMMENDATIONS

The matrices display a wide range of available information for each strain for the criteria examined. The gaps in information may be filled by further investigation in some instances but for most strains, the information simply has not been generated. For example, little information on the Bel-Aire strain was found in the literature by which to compare its value relative to other strains. In contrast, some strains have fair amounts of information but are probably unsuitable for use (e.g., Arlee) or no longer are available for production (e.g., McCloud). Also, some information exists which could not be obtained in time to be included in the report. Most notable among the reports not obtained in time were those evaluating strain performance prepared by the Utah Cooperative Fisheries Unit at Utah State University.

There appears to be enormous capacity in rainbow trout for meeting a variety of management objectives. For purposes of this study, the following criteria are viewed as more favorable:

Spawning Period - Preferably late winter or early spring for natural spawn with emergence timed for April-May. This time period may vary from the hatchery spawn period due to differences between hatchery and natural water temperatures. Strains with spring spawning periods matching this criterion include Eagle Lake, Kamloops, Shasta, Spring Standard, Fish Lake and Whitney. Strains with late Winter spawning include DeSmet, Donaldson, McConaughy, Sand Creek and Winthrop.

Food Conversion - More efficient converters probably will have an advantage after hatching over less efficient converters. This is true most notably in a natural setting where food is likely to be less available than in a hatchery. Strains with good food conversion rates spawning in spring include Eagle Lake, Shasta, Kamloops, and Fish Lake. Late winter spawners with comparatively good food conversion include Sand Creek and Winthrop.

Growth - Growth in the first year as measured by weight gain is a decided advantage in a natural setting; however, in areas subject to intense fishing pressure, fast growth may mean the fish will enter the catchable size the first fishing season.

More moderate or slower growing fish would enter the prime fishing season in their second year and thereby be significantly larger. This is a further advantage of selecting an appropriate spawning period. Therefore, fast growing spring spawners or moderate growing fall-winter spawners would probably work best. Strains with moderate growth rates as spring spawners include Eagle Lake, Shasta, Spring Standard and Kamloops. Late winter spawners with such growth rates include Sand Creek and Winthrop.

Survival - As a measure of the ability of a trout to survive the rigors of life in a wild environment after stocking, including avoiding anglers, high survivability is desirable. This measure is nearly the opposite of catchability. Strains with good survivability in the wild, spawning in spring include Eagle Lake, Shasta and Spring Standard. Late winter spawners with good survival include Sand Creek and De Smet.

Catchability - Trout with a low catchability will remain in the fishery longer, grow bigger and produce more trophy sized fish. This would seem to be desirable over the yield of more fish of smaller size. Strains with lower susceptibility to angler pressure as spring spawners include Eagle Lake, Kamloops and Fish Lake. Late winter spawners with lower catchability include McConaughy.

These recommendations taken individually are likely to not produce a trophy trout fishery. Also, collectively they may fail because other factors beyond strain character work to their defeat. This could include management practices such as fishing seasons, gear restrictions, bag limits, etc. Closing the river to fishing during spawning could encourage more wild or natural-spawned recruitment and reduce cost of maintaining the population.

The goal is to produce trophy fish; therefore, fish must be able to avoid capture or grow fast or both to attain trophy status. Trout with a propensity toward largeness (e.g., Kamloops, Eagle Lake) must also be trout that avoid capture and can survive well in the wild. The Eagle Lake strain appears to have the necessary qualities to achieve trophy status in the Colorado River. Another strong candidate is the Kamloops strain. Both the Eagle Lake and

Kamloops are long-lived strains but may have to be planted at catchable size rather than fingerling to achieve success. The dramatic improvement in success by planting catchable-size Kamloops trout was documented in one report (Cordone and Nicola [17]) but probably applies to other strains (like Eagle Lake) as well.

Another strain showing some promise even though little information is available is the wild Colorado River Rainbow strain. One study (Nehring [153]) showed considerably better riverine survival for this strain in the Gunnison and Rio Grande Rivers when compared with the Bel-Aire strain.

RAINBOW TROUT STUDY

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APPENDIX A

STRAINS AND BROODSTOCKS IDENTIFIED FROM LITERATURE

APPENDIX A. RAINBOW TROUT HYBRIDS/STRAINS/BROODSTOCKS
Listed in surveyed literature

6F2
A13
Accelerated Growth
Alaska
Albino
American
Aravuse
Arlee Late
Arlee Early
Arvokala
Australian
Beitey
Bel-Aire
Bellefonte
Bellvue
Bennett Spring
Beulah
Big Lake
Big Spring
Blue Spring Trout Farm
Bothwell
Butley
Caledonia
Cape Cod
Caribou
Chamber Creek
Cheesman
Chernorechensk
Christiansen
Coleman
Coleman Kamloops
Colorado River Rainbow
Convict Lake
Cook Creek
Danish
Davis
Deschutes
DeSmet
Domestic Stock
Donaldson
Eagle Lake
Emerald
Emerson
Ennis
Erwin
Estonia
Fall Standard
Fast Growth
Fish Lake
Fraser Valley
Ganaraska
Gerrard
Goldendale
Golden-London
Golden-White Sulpher Sprgs.
Goosens
Grampian
Growth
Hartman
Hatsina
Hayspur
Hildebrand
Home
Hot Creek
Hot Creek Fall Spawner
Huntsdale
Idaho
Irrideus
Isle of Man
Japanese
Junction
Kamloops
Kemmeces City Reservoir
Keyla-Yoa
Kitoi
Klamath
Kumagaya
Lassen
Leetown accelerated growth
London
Madison
MacCleary
Manchester
Manx
Massachusetts
McCloud
McConaughy (A)
McConaughy (B)
Meader
Michigan
Miller
Missouri
Mt. Lassen (see Lassen)
Mt. Shasta (see Shasta)
Mt. Whitney (see Whitney)
Narva

Nashua
New Jersey
New Zealand
Neosho
Nevin
Nisqually
Normandale Fall
Nottawasaga
Oak Springs
Oregon Diamond Lake
Osceola
Parkview-spring
Parkview-fall
Penask
Pidula
Pine Creek
Pit River
Premier
Pylula
Qu'Apelle
Randolph
Redband
Redfin
Reynoldsdale
Roaring River
Roosna-Alliku
Ropsha
Saarioinen
Saimaanlohi
Sand Creek
Saugeen Fall
Sevier Valley
Shasta
Shepherd of the Hills (aka Shepherd)
Siikataimen
Silver King Creek
Skamania
South Tacoma
Spokane
Spring Standard Growth (or Standard)
Stevenson
Sun Valley
Sundalsora
Swanson
Tagwerker
Tahoe
Talarik
Tasmanian
Ten Sleep
Tomalonis
Tunkwa
Twice-Spawners
Univ. Washington
Valley Creek
Virginia
Vokhnya
Walhalla
Western Fisheries Center
West Virginia
W. Virginia Bicentennial
Whitebrook
White Sulpher Springs
Whitney
Wigwam
Wigwam fall-spawn
Winter-Spawners
Winthrop
Wisconsin
Wytheville
Yakima
Yellowstone Rainbow

APPENDIX B

LOCATION OF ARTICLES ON SPECIFIC STRAINS OR BROODSTOCKS (NUMBERS REFER TO ARTICLES LISTED IN BIBLIOGRAPHY)

APPENDIX B.

Rainbow Trout Hybrid/Strains

STRAIN NAME	BROOD STATE	MONTH SPAWN	GENETICS REPRODUCT.	GROWTH	CATCH-ABILITY	MIGRA-TION	SUR-VIVAL	HABI-TAT	FOOD HABIT	TAIL WATER	OTHER
6F2				91/154			154	154			142
A13			53/55	53/55							
ACCELERATED GROWTH				7/78/115					78		
ALASKA				115							
ALBINO	UT		87/163	7/163			163				
AMERICAN			53/55	53/55							
ARLEE	MT,CT	9/11	21/22/30	20/22/23	101/103/163	101	21/91/101	20/21/22		152	22/149
			31/34/35	91/101/103			103/149	154/163			
			79/101/163	149/152/163							
AUSTRALIAN				179			179			179	
BEITEY				7/141	8/141	8	8/50	8	7		
BEL-AIRE	CO	9-12	117/118/180	117/118/177	117/118/177	117/118	117/118	180	117/118	117/118	142
			128-137/181	128-137/	128-137/180	128-137/180	128-137/153		128-137	128-137	153
				181	181		177/180/		180	180	
BELLEFONTE											142
BELLVUE											90
BENNETT SPRINGS	MO	10	163	163			163				
BEULAH	CT	8	83/163	163			163				
BIG LAKE				43			43				142
BIG SPRING											142
BLUE SPRING TROUT FARM											142
BOTHWELL											142
BUTLEY			83								
CAPE COD	OR	12	19/29/163	163	63/65/66	63/65/66	157/158		63/65	142/156	142/150
					150/163	150/156-158	163		66/87		151/156
CARIBOU			29/83								
CHAMBER CREEK			79								42
CHEESMAN			90				90	90			
CHRISTIANSEN			83								
COLEMAN	CA	12	13/163	46/76/77	46/106/163	46	46/77/106		76		142
				106/163	169/178		163/169/178				
				169/178							
COLEMAN KAMLOOPS				75/76/167	75/167		75/167				
COLORADO R. RBT							153				153
CONVICT LAKE				178	15/178		15/70				70
COOK CREEK											142
DANISH			53/55/72	53/55							
DAVIS			13								
DESCHUTES			87	87	87						
DESMET			33/48/86	7/92/103	86/92/103	92	48/86/92		7		152
			87/167	141/149/152	141/167		103/141/149				
				167/174			174				

STRAIN NAME	BROOD STATE	MONTH SPAWN	GENETICS REPRODUCT.	GROWTH	CATCH-ABILITY	MIGRA-TION	SUR-VIVAL	HABI-TAT	FOOD HABIT	TAIL WATER	OTHER
DONALDSON	MO	3	48/53/55 72/102/163	53/55/89 102/160/161 163/170	89/163	167/169	48/160/161 163/170	57	161		142
EAGLE LAKE	CA	2	13/33-35 87/163/167	22/77/163 167/169/177 178	167/169/177 178		77/163/169 177/178		87		142
EMERALD			90/175	175		159		90			159
EMERSON											142
ENNIS			43/88				43/84	88	88		
ERWIN	WI	8	25/30/31 34/35/86 163	25/30/103 163	86/103/163		86/103/163	31			142
ESTONIA			72								
FALL STANDARD				7/11/178	11		11/140				
FAST GROWTH				7/11/78/115	11		11		78		
FISH LAKE	UT	3	28/87/163	7/11/28/78 104/107/115 141/174/178 163	11/28/104 107/141/163 178		11/28/104 107/141/163 174/178		7/78		142
GANARASKA											142
GERRARD											142
GOLDENDALE	WA	11	19/163	163			163				
GOOSENS			41	41					41		
GRAMPIAN			29								
GROWTH	SD	10	163	163			163				
HARTMAN	CO	1	163	163			163				
HAYSPUR	ID	10	87/163	163/167	87	167	163	167			142/167
HILDEBRAND			30/31/33-35	30							
HOME			83								
HOT CREEK	CA	7	12/13/14/36 37/42/69/79 87/161/163 167/176	10/36/37/87 163/167/178	10/87/163		70/153/163	27/57			42/142 153
HUNTSDALE	PA	9	163	163			163				
IDAHO			14	4/5			4/5				
ISLE OF MAN				5			5				
JAPANESE			72								
JUNCTION			13								
KAMLOOPS	CT	9	13/15/17/53 55/72/87 162/163/167 179/180/181	10/17/53/55 89/106/141 145/160/162 163/178/180	10/15/17/89 106/141/163 178/180/181	106/141 162	15/17/87/89 106/141/160 162/163/178 180/181	57/180 181	87/141 145/180 181		142 142
KEMMECES C. R.			17								142
KITOI	AK			43			43				
KLAMATH				87		87			87		
KUMAGAYA			1								

STRAIN NAME	BROOD STATE	MONTH SPAWN	GENETICS REPRODUCT.	GROWTH	CATCH-ABILITY	MIGRA-TION	SUR-VIVAL	HABI-TAT	FOOD HABIT	TAIL WATER	OTHER
LASSEN			35-37/167	5	168	167	5				142
LEETOWN A. G.											142
LONDON	OH	12	163	163			163				142
MADISON	MN	11	101	101/149/160	89/101	101	84/89/101				101/149
				163			160/163				
MACCLEARY			42/86	86							42
MANCHESTER	IA	9	48/49/86	7/25/49/163	86/163/178	74	48/49/74	25			
			163	178			163/178				
MANX				5			5				142
MASSACHUSETTS				15/178	15/178		15/178				178
MCCLOUD			12/14/19/25	4/5/7/25			4/5	6/13/19/25			12/142
			69/80/87					57/58/72/80			163/169
			167/178					141			178
MCCONAUGHY			34/35/83/86	28/90/104	28/86/93	141/167/175	28/104/107	90/175			142
			159/167	107/115/159	104/107/169		141/169/175				
				169/175/178	178		178				
MEADER	ID		19/37/87	37	19						
MICHIGAN	NY	8	163	163			163				
MILLER								124/125			
MISSOURI											142
NASHUA	CT	9	163	163			163				142
NEW JERSEY				170			170				161
NEW ZEALAND			48/80/83	7/80/115	141	80	48/174		7		
				141/174							
NEOSHO				25							
NEVIN			86		86						
NISQUALLY				5			5				142
NORMANDALE FALL			59	59							59
NOTTAWASAGA											142
OAK SPRINGS			87	87	66/150	66/150		66/87			151
OSCEOLA	WI	1	163/186	163	86		86/163				
PARKVIEW-SPRING	NM	4	163	163			163				
PARKVIEW-FALL	NM	10	163	163			163				
PENASK				4/5/64/173			4/5		173		142
PINE CREEK			13								
PIT RIVER			13								
PREMIER				64/173					173		
QU'APELLE				5			5				
RANDOLPH	NY	9	163	163			163				
REDBAND	OR	5	163	163			163				142
REDFIN											169
REYNOLDSDALE	PA	10	163	163			163				
ROARING RIVER	MO	10	163	163	63/65/66	63/65/66	157/158/163	87	63/65/66		156
					150/163	150/156-158			87		
SAND CREEK	UT	10	48/87/163	7/46/78/141	46/87/141	46	46/48/143	7/78			142/143
				143/163/174	163		163/174				

STRAIN NAME	BROOD STATE	MONTH SPAWN	GENETICS REPRODUCT.	GROWTH	CATCH-ABILITY	MIGRA-TION	SUR-VIVAL	HABI-TAT	FOOD HABIT	TAIL WATER	OTHER
SAUGEEN FALL			59	59							
SHASTA	CA, WI	2	13/14/17/42 34-37/69 167/179	10/17/36/37 46/75/76 106/167/178	10/17/46 106/167/178	75/167	17/46/75 106/178	57	76		42/142
SHEPHERD - HILLS	MO	11	87/163 143/174	7/46/141 174	46/141/163	46	46/143/163 174		7		142/143
SILVER KING CRK.			12								142
SKAMANIA											142
SO. TACOMA	WA	9	19/163	163			163				
SPOKANE	WA	12	19/79/163	163			163				
SPRING STANDARD			24/86	78/104/107 115/178	86/104/107 178		86/104/107 140/141/178		78		
STEVENSON											142
SUN VALLEY				64							173
SUNDALSORA			19	5			5				142
SWANSON	AK	4	163	43/163			43/163				142
TAGWERKER											142
TAHOE				87				87			
TALARIK	AK			43			43				
TASMANIAN				177	87/177		153/177	87			142
TEN SLEEP	UT	12	87/163	7/46/141 143/145/163 174	46/141/163	46/141/145	46/141/143 163/174		7/141 145	143	142
TAMALONIS											142
TUNKWA			17	4/5			4/5				42/142
TWICE-SPAWNER			1	1							42
UNIV. OF WASH.			83								
VALLEY CREEK			101	101	101	101	101				42
VIRGINIA			13/14/42 178	10/17/36/37 178	10/17/178		17/178				
WATERING HOLE			16								
WALHALLA						74	74				142
WEST. FISH CNTR.											42/142
W. VIRGINIA	WV	9	42/163	163/169	169		163/169				
WHITEBROOK			29/83								
WHT. SULPHER SP.	CT	9	163	163			163				
WHITNEY	CA	8	1/12/13/14 19/36/37/42 71/87/179	17/36/37/46 75/76/107 163/167/178	7/10/15/17 46/163/167 178	75	15/17/46/70 75/167/178	57	76	42	
WIGWAM	WY	11	163	163			163				142
WINTHROP			67/83	28/103/104 107/178	28/103/104 107/178		28/67/103 104/107/178		28		142
WISCONSIN			86		86		86				
WYTHEVILLE		11	14/48/49 163	7/11/25/49 91/163	163	74	11/48/49/74 163/178	25/57			142
YAKIMA			19								

APPENDIX C

INTERVIEWS WITH HATCHERY PERSONNEL

TROUT STRAIN STUDY - INTERVIEW FORM
HATCHERY

Name Adam Mendoza, Mgr. Date 8/26/91

Agency Hotchkiss Hatchery, CO Phone (303) 872-3170

1. *What rainbow trout strains are hatched or reared in your facility?*

McConaughy
Tasmanian
Arlee
Shasta
Colorado River Cutthroat

2. *Into what habitat are the strains usually stocked? (Lake/reservoir, stream, river or tailwater)*

Mostly Reservoirs, Cutthroat in Stream

3. *How are the strains used? (Put/take, self-sustaining, etc.)*

McConaughy and Shasta, self-sustained

4. *Can you provide names and telephone numbers of biologists that we should contact re: strain specifics, management methods, regulations, etc.?*

Fisheries Assistance office in Pinetop- Jim Hansen

Ennis Hatchery- Wes Orr

TROUT STRAIN STUDY - INTERVIEW FORM
HATCHERY

Name Timothy Cleary, Mgr. Date 8/23/91

Agency Greers Ferry Hatchery, AR Phone (501) 362-3615

1. *What rainbow trout strains are hatched or reared in your facility?*

Last three year:

Arlee	Eagle Lake
Erwin	Fish Lake
Shasta	Wytheville

2. *Into what habitat are the strains usually stocked? (Lake/reservoir, stream, river or tailwater)*

Tailwaters - all; Greers Ferry Reservoir, Little Reservoirs all; Red River, Lake Ouachita, S. Ark., Lake Hamilton, Lake Greeson; Some go to Texas in winter.

3. *How are the strains used? (Put/take, self-sustaining, etc.)*

Put & take; Put, grow and take - no habitat for trout in the state.

4. *Can you provide names and telephone numbers of biologists that we should contact re: strain specifics, management methods, regulations, etc.?*

No info. on strain evaluation - They don't do it.

TROUT STRAIN STUDY - INTERVIEW FORM
HATCHERY

Name Richard Shelton, Mgr. Date 8/23/91

Agency Mammoth Sprg. Hatch., AR Phone (501) 625-3912

1. *What rainbow trout strains are hatched or reared in your facility?*

   No trout - Warmwater only

2. *Into what habitat are the strains usually stocked? (Lake/reservoir, stream, river or tailwater)*

3. *How are the strains used? (Put/take, self-sustaining, etc.)*

4. *Can you provide names and telephone numbers of biologists that we should contact re: strain specifics, management methods, regulations, etc.?*

TROUT STRAIN STUDY - INTERVIEW FORM
HATCHERY

Name William Lindsay, Mgr. Date 8/23/91

Agency Norfork Hatchery, AR Phone (501) 499-5255

1. *What rainbow trout strains are hatched or reared in your facility?*

Erwin Fish Lake
Wytheville McConaughy
Arlee Bel Aire
Shasta Kamloops

2. *Into what habitat are the strains usually stocked? (Lake/reservoir, stream, river or tailwater)*

95% go into tailwaters - all strains-largest Federal hatchery by production - White River below Beaver Reservoir; Table Rock Reservoir, MO (Lake Taneycomo); 93 miles of White River & 5 miles of N. Fork of White River; Norfork Reservoir tailwater below Tenkiller Dam, Illinois River

3. *How are the strains used? (Put/take, self-sustaining, etc.)*

Most are put and take - 9" fish - state; stocking same strains in same waters.

4. *Can you provide names and telephone numbers of biologists that we should contact re: strain specifics, management methods, regulations, etc.?*

He's the one to call.

TROUT STRAIN STUDY - INTERVIEW FORM
HATCHERY

Name Ms. Chris Hanson, Asst. Mgr. Date 8/23/91

Agency Leadville Hatchery, CO Phone (719) 486-0189

1. *What rainbow trout strains are hatched or reared in your facility?*

Arlee (Domestic)	Shepherd of the Hills (in the Past)
Erwin (domestic)	Tasmanian (past)
Shasta (domestic)	Eagle Lake (past)

2. *Into what habitat are the strains usually stocked? (Lake/reservoir, stream, river or tailwater)*

All habitats/all strains - they take what is available.

3. *How are the strains used? (Put/take, self-sustaining, etc.)*

Several different programs

4. *Can you provide names and telephone numbers of biologists that we should contact re: strain specifics, management methods, regulations, etc.?*

Tech. Centers - they don't do any evaluations. They prefer Snake River cutthroats.

TROUT STRAIN STUDY - INTERVIEW FORM
HATCHERY

Name Karen Kilpatrick, Asst. Mgr. **Date** 8/3/91

Agency Natchitoches Hatcheries, LA **Phone** (318) 352-5324

1. *What rainbow trout strains are hatched or reared in your facility?*

   No Trout - warmwater only.

2. *Into what habitat are the strains usually stocked? (Lake/reservoir, stream, river or tailwater)*

3. *How are the strains used? (Put/take, self-sustaining, etc.)*

4. *Can you provide names and telephone numbers of biologists that we should contact re: strain specifics, management methods, regulations, etc.?*

TROUT STRAIN STUDY - INTERVIEW FORM
HATCHERY

Name Douglas Aloisi, Asst. Mgr. **Date** 8/23/91

Agency Neosho Hatchery, MO **Phone** (417) 451-0554

1. *What rainbow trout strains are hatched or reared in your facility?*

   Arlee - Western
   Shasta
   Erwin
   Fish Lake
   -these are available when needed, hatched 4 times a year.

2. *Into what habitat are the strains usually stocked? (Lake/reservoir, stream, river or tailwater)*

   All go into tailwater Lake Taneycomo

3. *How are the strains used? (Put/take, self-sustaining, etc.)*

   Put and take **may** be some reproduction in tributaries.

4. *Can you provide names and telephone numbers of biologists that we should contact re: strain specifics, management methods, regulations, etc.?*

   Gordon Proctor, MO - Dept. Conservation, Shepherd of the Hills Hatchery, (417) 334-4865

TROUT STRAIN STUDY - INTERVIEW FORM
HATCHERY

Name Greg Kindschi, Asst. Dir. **Date** 9/23/91

Agency Bozeman Hatchery, MT **Phone** (406) 587-9265

1. *What rainbow trout strains are hatched or reared in your facility?*

   Erwin
   Shasta
   Arlee
   Kamloops
   They have had others - they are a research facility.

2. *Into what habitat are the strains usually stocked? (Lake/reservoir, stream, river or tailwater)*

   They don't production-rear fish.

3. *How are the strains used? (Put/take, self-sustaining, etc.)*

   Very little put & take.

4. *Can you provide names and telephone numbers of biologists that we should contact re: strain specifics, management methods, regulations, etc.?*

   (He may try and send some research reports)

TROUT STRAIN STUDY - INTERVIEW FORM
HATCHERY

Name Robin Wagner, Fisheries Biol. **Date** 8/23/91

Agency Creston Substation, MT **Phone** (406) 755-7870

1. *What rainbow trout strains are hatched or reared in your facility?*

   Eagle Lake - The major brood stock/source
   Arlee
   Shasta

2. *Into what habitat are the strains usually stocked? (Lake/reservoir, stream, river or tailwater)*

   Mostly lakes - Alkaline & warm, potholes; some tailwater lower Crow Creek - Small impoundment on Flathead Reservation- cold water with a lot of sediment - poor success - Eagle Lake.

3. *How are the strains used? (Put/take, self-sustaining, etc.)*

   Mostly put and take on reservations, stock ponds, prairie potholes - all with no inflow or outflow - **Eagle Lake** strain do very well. Grow to 1"/month. Not very piscivorous. Eat shrimp and leeches.

4. *Can you provide names and telephone numbers of biologists that we should contact re: strain specifics, management methods, regulations, etc.?*

   Bob Thompson, Hatchery Mgr. for E.L. Culture
   For strain evaluation, call Robin Wagner - the only fish biologist. Tailwater Fishery below Libby Dam, MT - Coldwater Fishery - doing very well. Kootenai River, Jim Bashro, MT - State Fish, Wildlife and Parks - Kalispell

TROUT STRAIN STUDY - INTERVIEW FORM
HATCHERY

Name Wesley Orr, Mgr. **Date** 8/23/91

Agency Ennis Hatchery, MT **Phone** (406) 682-4847

1. *What rainbow trout strains are hatched or reared in your facility?*

Kamloops Eagle Lake
McConaughy Harrison Lake
Shasta
Arlee
Erwin

2. *Into what habitat are the strains usually stocked? (Lake/reservoir, stream, river or tailwater)*

They don't track where they are being stocked.

3. *How are the strains used? (Put/take, self-sustaining, etc.)*

Doesn't know.

4. *Can you provide names and telephone numbers of biologists that we should contact re: strain specifics, management methods, regulations, etc.?*

Call **Orr** for info. on **Hatchery** performance - They go to about 35 states, 60-70 facilities.
Not much in the way of reports on strain evaluation

TROUT STRAIN STUDY - INTERVIEW FORM
HATCHERY

DRAFT

Name Bryan Kenworthy, Asst. Mgr. **Date** 8/23/91

Agency Lahontan/Marble Bluff, NV **Phone** (702) 265-2425

1. *What rainbow trout strains are hatched or reared in your facility?*

   No Rainbows- only Lahontan Cutthroat

2. *Into what habitat are the strains usually stocked? (Lake/reservoir, stream, river or tailwater)*

3. *How are the strains used? (Put/take, self-sustaining, etc.)*

4. *Can you provide names and telephone numbers of biologists that we should contact re: strain specifics, management methods, regulations, etc.?*

   Try: Scott Yess, Parker (602) 667-4785
   James N. Hanson, Pinetop (602) 338-5246
   Stewart Leon, Pinetop (602) 338-5119
   Fishery Resource Offices

TROUT STRAIN STUDY - INTERVIEW FORM
HATCHERY

Name Barbara Giesecke, Mgr. **Date** 8/23/91

Agency Mescalero Hatchery, NM **Phone** (505) 671-4401

1. *What rainbow trout strains are hatched or reared in your facility?*

Eggs are shipped in for these strains:

Shepherd of the Hill	Wytheville
Eagle Lake	McConaughy
Erwin	Tasmanian
Arlee	Kamloops

2. *Into what habitat are the strains usually stocked? (Lake/reservoir, stream, river or tailwater)*

All go into Lakes & Ponds except Rio Doso Creek, on Mescalero Reservation where they stock April or July-Aug. eggs - when they reach 8" - mostly Erwin.

3. *How are the strains used? (Put/take, self-sustaining, etc.)*

Mostly put and take, nothing self-sustaining.
Mostly on Indian Reservations and the Indians do very little Creel Survey.

4. *Can you provide names and telephone numbers of biologists that we should contact re: strain specifics, management methods, regulations, etc.?*

*Pete Stine, Regional Office (505)766-2347, Bozeman, MT - is doing some strain evaluations.
Dexter Hatchery does not deal with Rainbows.
(She may send some strain evaluation info/report)

TROUT STRAIN STUDY - INTERVIEW FORM
HATCHERY

Name Jack Call/H. Webster, Biotech. **Date** 8/23/91

Agency Garrison Dam Hatchery, ND **Phone** (701) 654-7451

1. *What rainbow trout strains are hatched or reared in your facility?*

   Shasta
   Eagle Lake
   Arlee

2. *Into what habitat are the strains usually stocked? (Lake/reservoir, stream, river or tailwater)*

   No streams - Missouri River
   Tailwater below Garrison Dam - not sure of strain

3. *How are the strains used? (Put/take, self-sustaining, etc.)*

   Mostly put, grow and take - 5" fish sometimes larger if requested.

4. *Can you provide names and telephone numbers of biologists that we should contact re: strain specifics, management methods, regulations, etc.?*

   They don't do management on fish after they leave the hatchery.
   Try N.Dak. State Fishery office in Jamestown - Jerry Weigel (701) 252-4634
   Baldhill & Valley City don't raise salmonids

TROUT STRAIN STUDY - INTERVIEW FORM
HATCHERY

Name Kenneth Davenport, Mgr. **Date** 8/23/91

Agency Tishomingo Hatchery, OK **Phone** (405) 384-5463

1. *What rainbow trout strains are hatched or reared in your facility?*

   None. They raise warmwater fish only

2. *Into what habitat are the strains usually stocked? (Lake/reservoir, stream, river or tailwater)*

3. *How are the strains used? (Put/take, self-sustaining, etc.)*

4. *Can you provide names and telephone numbers of biologists that we should contact re: strain specifics, management methods, regulations, etc.?*

   State Hatcheries only, for trout - try Don Driscull (405) 521-3722

TROUT STRAIN STUDY - INTERVIEW FORM
HATCHERY

Name Clair Sudbeck, Biotechnician **Date** 8/23/91

Agency Gavins Point, SD **Phone** (605) 665-3352

1. *What rainbow trout strains are hatched or reared in your facility?*

   No brood stock - eggs come in
   Wytheville (but they may be discontinued)
   Arlee
   Donaldson has been discontinued

2. *Into what habitat are the strains usually stocked? (Lake/reservoir, stream, river or tailwater)*

   Both into small impoundments on small streams - reservations and military bases.

3. *How are the strains used? (Put/take, self-sustaining, etc.)*

   Put and take only; water not good enough to sustain a fishery.

4. *Can you provide names and telephone numbers of biologists that we should contact re: strain specifics, management methods, regulations, etc.?*

   Wes Orr, Enms, MT
   *Try Fish Genetics Lab, Leetown, WV

TROUT STRAIN STUDY - INTERVIEW FORM
HATCHERY

Name Robert Lindsey, Mgr. **Date** 8/23/91

Agency Inks Dam Hatchery, TX **Phone** (512) 793-2474

1. *What rainbow trout strains are hatched or reared in your facility?*

   No rainbows - warmwater - no trout strains in Texas. Stock a few in Fort Hood Military Base - put & take - use whatever Mescalero NM Hatchery is stocking

2. *Into what habitat are the strains usually stocked? (Lake/reservoir, stream, river or tailwater)*

3. *How are the strains used? (Put/take, self-sustaining, etc.)*

4. *Can you provide names and telephone numbers of biologists that we should contact re: strain specifics, management methods, regulations, etc.?*

   Mescalero Hatchery, NM - Barbara Giesege, Mgr.
   A.E. Woods - Texas State Fish Hatchery, San Marcos
   (512) 353-0313? Bill Bowling (sp?), Pat Hudson

TROUT STRAIN STUDY - INTERVIEW FORM
HATCHERY

Name Edith A. Erfling, Mgr. **Date** 8/23/91

Agency Jones Hole Hatchery, UT **Phone** (801) 789-4481

1. *What rainbow trout strains are hatched or reared in your facility?*

Arlee
Kamloops
Sand Creek
Ten Sleep
Eagle Lake
Shepherd of the Hills

2. *Into what habitat are the strains usually stocked? (Lake/reservoir, stream, river or tailwater)*

Kamloops/Eagle Lake/Arlee - in reservoirs
Some Eagle Lake go into river, occasionally
No tailwaters

3. *How are the strains used? (Put/take, self-sustaining, etc.)*

Mostly put and take or put/grow and take (5-8")

4. *Can you provide names and telephone numbers of biologists that we should contact re: strain specifics, management methods, regulations, etc.?*

*Roger Snidervan, Utah Game & Fish (801) 885-3164
He has done studies on Kamloops, Eagle Lake and McConaughy
Re: Flaming Gorge Reservoir

TROUT STRAIN STUDY - INTERVIEW FORM
HATCHERY

Name Henn Gruenthal, Mgr. **Date** 8/23/91

Agency Jackson Hatchery, WY **Phone** (307) 733-2510

1. *What rainbow trout strains are hatched or reared in your facility?*

   None - cutthroat, Lake and Brown only

2. *Into what habitat are the strains usually stocked? (Lake/reservoir, stream, river or tailwater)*

3. *How are the strains used? (Put/take, self-sustaining, etc.)*

4. *Can you provide names and telephone numbers of biologists that we should contact re: strain specifics, management methods, regulations, etc.?*

TROUT STRAIN STUDY - INTERVIEW FORM
HATCHERY

Name DeeDee Roberts, Fishery Asst. **Date** 8/23/91

Agency Saratoga Hatchery, WY **Phone** (307) 326-5662

1. *What rainbow trout strains are hatched or reared in your facility?*

   Erwin - hatch (eggs from Ennis, MT)

2. *Into what habitat are the strains usually stocked? (Lake/reservoir, stream, river or tailwater)*

   Saratoga Lake

3. *How are the strains used? (Put/take, self-sustaining, etc.)*

   Put and take, no natural reproduction

4. *Can you provide names and telephone numbers of biologists that we should contact re: strain specifics, management methods, regulations, etc.?*

   Ennis Fish Hatchery
   Strain evaluation would be done by the state.
   We should try the Federal Fishery Assistance Office

TROUT STRAIN STUDY - INTERVIEW FORM
HATCHERY

Name John Riger, Hatchery Mgr. **Date** 11/26/91

Agency Colorado Div. of Wildlife **Phone** (303)963-2665

1. *What rainbow trout strains are hatched or reared in your facility?*

   Tasmanian - heavier than Bel-Aire as broodstock
   Bel-Aire -
   50°F year round spring water

2. *Into what habitat are the strains usually stocked? (Lake/reservoir, stream, river or tailwater)*

   Bel-Aire - lakes best but plant in a lot of water
   Tasmanian - fingerlings in streams

3. *How are the strains used? (Put/take, self-sustaining, etc.)*

   Bel-Aire raised to 10" catchables and planted in put-and-take situations.
   Tasmanian raised to fingerlings and planted in streams to grow-up for later catch.

4. *Can you provide names and telephone numbers of biologists that we should contact re: strain specifics, management methods, regulations, etc.?*

   Mary McAfee biologist studied Bel-Aire (303) 248-7179

TROUT STRAIN STUDY - INTERVIEW FORM
HATCHERY

DRAFT

Name John Kerwin, Hatchery Mgr. **Date** 7/3/91

Agency Wash. State Wildlife Dept. **Phone** (206) 753-2902

1. *What rainbow trout strains are hatched or reared in your facility?*

   Meader, Yakima, Whitney, McCloud/Packwood

2. *Into what habitat are the strains usually stocked? (Lake/reservoir, stream, river or tailwater)*

   Variety of Lakes, Streams, and rivers
   Mostly lakes as fry or fingerlings.

3. *How are the strains used? (Put/take, self-sustaining, etc.)*

   Meader, Yakima, McCloud as catchables.
   Whitney as natural spawners.

4. *Can you provide names and telephone numbers of biologists that we should contact re: strain specifics, management methods, regulations, etc.?*

   Will send report on broodstocks in west with contact names.

TROUT STRAIN STUDY - INTERVIEW FORM
HATCHERY

Name Jim Griggs/Trent Stickle **Date** 7/5/91

Agency Ore. Dept Fish & Wildlife **Phone** (503) 229-55410x386

1. *What rainbow trout strains are hatched or reared in your facility?*

   Klamath (wild), Cape Cod, Roaring River, Deschutes, McCloud Domestic) plus mixtures, Oak Springs.

2. *Into what habitat are the strains usually stocked? (Lake/reservoir, stream, river or tailwater)*

   Roaring Rivers to lakes as moves downstream.
   McCloud and mixtures to streams and lakes.

3. *How are the strains used? (Put/take, self-sustaining, etc.)*

   Variety of uses statewide.

4. *Can you provide names and telephone numbers of biologists that we should contact re: strain specifics, management methods, regulations, etc.?*

   Will send material

TROUT STRAIN STUDY - INTERVIEW FORM
HATCHERY

Name Al Havens **Date** 7/18/91

Agency Alaska Dept. Fish & Game **Phone** (907) 745-5016

1. *What rainbow trout strains are hatched or reared in your facility?*

   Swanson and Big Lake
   Evaluated strains extensively in FRED reports (Fisheries Rehabilitation, Enhancement and Development)
   Only Swanson R. strain widely used.

2. *Into what habitat are the strains usually stocked? (Lake/reservoir, stream, river or tailwater)*

   Landlocked lakes only - mainly on Kenai Peninsula.
   Do well in cold water but need summer growing season.
   No tailwater fisheries in Alaska.

3. *How are the strains used? (Put/take, self-sustaining, etc.)*

   Put-and-take.

4. *Can you provide names and telephone numbers of biologists that we should contact re: strain specifics, management methods, regulations, etc.?*

   Bill Hauser ADFG (907) 267-2172
   Statewide perspective

TROUT STRAIN STUDY - INTERVIEW FORM
HATCHERY

Name Gary Wall, Hatchery Mgr. **Date** 7/18/91

Agency Alaska Dept. Fish & Game **Phone** (907) 428-1347

Irv Brock, Fish Culture Project Leader

1. *What rainbow trout strains are hatched or reared in your facility?*

   Swanson River
   Grow to about 15" in 5 years; few grow beyond 26".

   Suggested looking at Taklika Strain - grows large but may not be available outside of the state.

2. *Into what habitat are the strains usually stocked? (Lake/reservoir, stream, river or tailwater)*

   Lakes; most applications in low TDs water; Low winter temperatures but warm (15°C) summer temperatures.

3. *How are the strains used? (Put/take, self-sustaining, etc.)*

   Put-and-take; but some spawning occurs in lake tributaries.

4. *Can you provide names and telephone numbers of biologists that we should contact re: strain specifics, management methods, regulations, etc.?*

   Al Havens in Palmer - (901) 745-5016
   Info. on field performance available.

APPENDIX D

INTERVIEWS WITH BIOLOGISTS REGARDING TAILWATER FISHERIES.

TROUT STRAIN STUDY - INTERVIEW FORM
TAILWATER FISHERIES

Name: Mike Hatch Date: 7/11/91

Agency: New Mexico Game & Fish Phone: (505) 827-7905

Tailwater: San Juan River Below Navajo Dam

1. What strains of rainbow occur in your fishery?
No strain info.- Use their own broodstock, very inbred- from Australia, Wyoming,etc. Called "Heinz 57"- Cold Water adapted.

2. What other trout occur in there?
Natives - Rio Grande Cutthroat & Gila Trout. Have stocked Yellowstone & Snake River Cutthroat, Brown Trout, Brook Trout, Eagle Lake.

3. Are there any reports on field performance for the strains?
Several - out of Montana- Graduate Thesis: try USFWS Ref. Service Hensler, 1987. (301)492-6403 Bethesda, MD.

4. What kind of flows (CFS)? Hydropower? Fluctuating flows?
Not dealing with trout performance. Studied rainbows in lakes only.

5. What are water temperatures? Seasonal changes?
see above.

6. How old is the dam? Fishery?
Navajo Dam, 1963; stocking since 1964; Eagle Nest Res., 1927, stocking since 1927; Chochiti Res., 1975; Abiquiv Res., 1963, stocking since 1963; El Bado, build or stock date not given.

7. Is there information on WQ or nutrient level?
no answer given

8. What is the condition factor for the strain?
"Heinz 57" - below Navajo 1.1-1.2, sometimes up to 1.3

9. What is the growth rate in the wild?
Growth to 6½" first year; 4½ - 5" growth, years 2 & 3; 4 - 4½" growth, 4th year.

10. What size are they when planted?
2 - 3" fingerlings

11. Do they have any information on:
fightability-"57" - substandard

catchability-"57" - very catchable

dispersal- "57" - sedentary

spawning- Natural Reproduction below all reservoirs but Chochiti.

12. Are there studies on impacts from fluctuating flows?
Not in New Mexico - contact IMFI team - has biblio of this stuff - Ft. Collins, CO, "Instream Flow Incremental Methodology: Study Team - Ken Bovee West.Ener.& Land, USF Team, USFWS, 2625 Redwing Rd., Ft. Collins,CO 80526.

13. Do they know of any other tailwater fisheries?
Flaming Gorge

TROUT STRAIN STUDY - INTERVIEW FORM
TAILWATER FISHERIES

Name: Tom Parks Date: 7/9/91

Recommended by Jim Darling, Montana Fisheries

Agency: USBR, Billings Phone: (406) 657-6733

Montana National Research Specialist, MT Projects

Tailwater: Monitoring Temps/WQ at Yellowtail Dam.

1. What strains of rainbow occur in your fishery?

2. What other trout occur in there?

3. Are there any reports on field performance for the strains?

4. What kind of flows (CFS)? Hydropower? Fluctuating flows?

5. What are water temperatures? Seasonal changes?

3.5 - 4°C to 15° C. Coldest in Summer, Warmest in Oct.-Nov.

6. How old is the dam? Fishery?

7. Is there information on WQ or nutrient level?

May send a comprehensive report. "The effects of Supersaturation of dissolved gases on the fishery of the Yellowtail River..."

8. What is the condition factor for the strain?

9. What is the growth rate in the wild?

10. What size are they when planted?

11. Do they have any information on:
fightability-

catchability-

dispersal-

spawning-

12. Are there studies on impacts from fluctuating flows?

Doesn't Know of any.

13. Do they know of any other tailwater fisheries?

Canyon Ferry Reservoir, Helena, MT.; Clark Canyon Reservoir, Dillon, MT.; Tiber Reservoir, Chester, MT.

TROUT STRAIN STUDY - INTERVIEW FORM
TAILWATER FISHERIES

Name: Jim Darling Date: 7/9/91

Recommended by Thurston Dotson

Agency: Montana Fisheries Div. Phone: (406) 252-4654

Reg.5 Fish. Mgr., Billings

Tailwater: Yellowtail Dam

1. What strains of rainbow occur in your fishery?

Eagle Lake, McConaughy, Arlee- E.L. & McCon. go into reservoirs. DeSmet. In Tailwaters is mostly DeSmet, some Arlee.

2. What other trout occur in there?

Brown, Cutthroat, Eastern Brook, Yellowstone Cutthroat, a few Lake, DeSmet (recently)

3. Are there any reports on field performance for the strains?

No, not for strains

4. What kind of flows (CFS)? Hydropower? Fluctuating flows?

2000-3000 cfs or above, required. Up to 12,000 this spring, now about 10,000. Drought years down to 1500 or less. Hydro yes. Not peaking, not much fluctuation.

5. What are water temperatures? Seasonal changes?

Ask USBR - Tom Parks (406) 657-6733 for temperature information as he has been monitoring temps.

6. How old is the dam? Fishery?

Closed 1965, stocked before that by USFWS. Stocking rainbows began in 1966 by Montana Fisheries. Not Browns, moved in from the Yellowstone. Most recent stocking was Oct. 1983. Stopped since.

7. Is there information on WQ or nutrient level?

Talk to Tom Parks

8. What is the condition factor for the strain?

Will send information. Varies widely

9. What is the growth rate in the wild?

8" in one year - Rainbow - no strain; 11" - year 2; 13" - year 3; 16" - year 4; some up to 20" in 4 years.

10. What size are they when planted?

Fingerlings (3-4") - one area up to 6-7". Age about 3 is catchable.

11. Do they have any information on:

fightability-Rainbows - Good

catchability-Rainbows - Good, better than brown, brook and cutthroat which are easy.

dispersal- Yellowstone Rainbows travel a lot (up to 100 miles), DeSmet descendants migrate 20 miles or so. Arlee - not sure;

spawning-run. Arlee is poor repro, fast growing. Arlee does well. DeSmet established strong

12. Are there studies on impacts from fluctuating flows?

Lower Flathead Study - DoSanto; Hungry Horse Dam, Region, W. Montana, Jim Bashro, (406) 752-5501

13. Do they know of any other tailwater fisheries?

Bighorn River below Yellowtail - 4,000-8,000 trout/mile; Stillwater River, Mystic Lake Dam, Montana Pwr. Co., Fort Peck, Bob Needham; Canyon Ferry Dam, Hauser Dam & Holter Dam - Steve Leathe, Great Falls (454-3441); Dick Vincent did an article on strain evaluation.

TROUT STRAIN STUDY - INTERVIEW FORM
TAILWATER FISHERIES

Name: Thurston Dotson Date: 7/8/91

Agency: Montana Fisheries Division Phone: (406) 444-2447

Tailwater: Big Horn River below Yellowtail Dam

1. What strains of rainbow occur in your fishery?
Arlee, Eagle Lake, DeSmet, McConaughy, Kamloops, Arlee x Eagle Lake Hybrid.

2. What other trout occur in there?
Brown and Brook. They stock 575 lakes and reservoirs; only 20 streams

3. Are there any reports on field performance for the strains?
No reports - DJ reports - Dingell-Johnson - No consolidated reports.

4. What kind of flows (CFS)? Hydropower? Fluctuating flows?
Fort Peck to Bighorn; Missouri River. Both have hydropower - extreme fluctuations. Arlee

5. What are water temperatures? Seasonal changes?
Nothing specific- above 32° Winter; above 55° summer.

6. How old is the dam? Fishery?
Fort Peck - 1930's; Yellowtail -early 1960's; both have had a stocked fishery since being build.

7. Is there information on WQ or nutrient level?
In D.J. reports - Ask Regional Managers for the Dams

8. What is the condition factor for the strain?
Around (English Measure) - 0004

9. What is the growth rate in the wild?
Below Ft. Peck - moderate - about 6"/year; Yellowtail - 14-15" per year.

10. What size are they when planted?
4-6" fingerlings

11. Do they have any information on:
fightability- All strains are excitable.

catchability- This varies, Arlee & E.L. are very catchable, as is their hybrid. Kamloops & DeSmet less catchable (Moderate); McConaughy more open water-shoreline fishery Catchable. Not tailwater.

dispersal- All disperse.

spawning- DeSmet & E.L. spawn well; Arlee Moderately &; McConaughy - No inform.; DeSmet is the best spawner.

12. Are there studies on impacts from fluctuating flows?
Ask Region 3 Fish Biologist - Dick Vincent, Mgr. (994-4042)

13. Do they know of any other tailwater fisheries?
Chinook Salmon Below Garrison Dam, N. Dakota; Libby Dam, Kootenei; Ft. Peck Reservoir;

TROUT STRAIN STUDY - INTERVIEW FORM
TAILWATER FISHERIES

Name:George Lopez (Asst. Chf.-Hatcheries) Date: 7/8/91

Agency: New Mexico Dept of Game & Fish Phone: (505) 827-7905

Tailwater:San Juan River below Navajo Dam

1. What strains of rainbow occur in your fishery?
Doesn't know - they take what is available. They stock about 710 total sites.

2. What other trout occur in there?
Doesn't know.

3. Are there any reports on field performance for the strains?
They don't report on strains.

4. What kind of flows (CFS)? Hydropower? Fluctuating flows?
Abiquiu - building hydropower - Relatively old dam. Fluctuates widely. Ask Mike Hatch.

5. What are water temperatures? Seasonal changes?
Ask Mike Hatch - (505) 827-7905

6. How old is the dam? Fishery?

7. Is there information on WQ or nutrient level?

8. What is the condition factor for the strain?

9. What is the growth rate in the wild?

10. What size are they when planted?
Most are catchable, about 9".

11. Do they have any information on:
fightability-

catchability-

dispersal-

spawning-

12. Are there studies on impacts from fluctuating flows?
Doesn't recall. Talk to Steve Sharon in Wyoming.

13. Do they know of any other tailwater fisheries?
Below Navajo Reservoir. They stock rainbows, but don't look at strain identification.

TROUT STRAIN STUDY - INTERVIEW FORM
TAILWATER FISHERIES

Name: Tom Mandis, Research Hatch. Mgr. Date: 7/8/91

Agency: Colorado Div. of Wildlife Phone: (303) 482-1141

Tailwater: Delores River below McPhee Dam

1. What strains of rainbow occur in your fishery?
6F2 - Fed. Gov't Strain for fast growth. Stocking occurs in 100's of places. Brood fisheries in Carbondale, Bel Air, and Tasmanian.

2. What other trout occur in there?
Colorado River Rainbow - getting rid of green back

3. Are there any reports on field performance for the strains?
Doesn't know - talk to Tom Powell, Regional office

4. What kind of flows (CFS)? Hydropower? Fluctuating flows?
Doesn't know - Yampa Hydropower but goes into ponds. No tailwaters.

5. What are water temperatures? Seasonal changes?
52.6° Hatchery - doesn't know stream temperature - 40-45° Winter, 60-64° Summer; Up to 58-59° in summer.

6. How old is the dam? Fishery?
Stocking 6F2 - for 10 years; Arlee Strain, 5-6 years.

7. Is there information on WQ or nutrient level?
Tom Powell

8. What is the condition factor for the strain?
000405 - Arlee; 00045 - 6F2

9. What is the growth rate in the wild?
Up to 10-12" in one year

10. What size are they when planted?
6F2 - 10"; Arlee - Fingerlings and catchables.

11. Do they have any information on:
fightability-No

catchability-6F2 - good; Arlee - ?

dispersal- Depends on Food Availability

spawning- Arlee - Oct.-Nov.; 6F2 - Sept-Oct.

12. Are there studies on impacts from fluctuating flows?
Not on Flows; try Tom Powell

13. Do they know of any other tailwater fisheries?
No
Note: Try McConaughy for Warm Water; Look into "Colorado River Rainbow".

TROUT STRAIN STUDY - INTERVIEW FORM
TAILWATER FISHERIES

Name: Tom Powell Date: 7/8/91

Agency: Colorado Div. of Wildlife Phone: (303) 484-2836x318

Tailwater: Delores River Below McPhee Dam

1. What strains of rainbow occur in your fishery?
6F2 for put & take; Eagle Lake - Fingerling Plan; Tasmanian and Bel Aire.

2. What other trout occur in there?
Wild strain from Colorado River strain - Spring Spawning - Stocking into brood stock.
States can have federal aid report research through Denver Public library- AGFD can get it for the asking.

3. Are there any reports on field performance for the strains?
Stream evaluations - Eagle Lake, Tasmanian, Bel Aire 6F2 (poor stock); Mary McAphee; Research Librarian - for reports- Jackie Boss (x370); Fax (303) 490-2621; CO Research Cntr. Library, CO Div. Wild. 317 W. Prospect, Ft.Collins, CO 80526

4. What kind of flows (CFS)? Hydropower? Fluctuating flows?
Wide variations in flows- many streams -not many under 10 feet wide. Most are larger. Fingerlings mostly, a few catchable. Montrose is looking at variable flows - have a report on flow regimes.

5. What are water temperatures? Seasonal changes?
Temperature info. on streams, related to species, no strains.

6. How old is the dam? Fishery?
Tasmanian & Bel Aire - early 1960's; Colorado River - 5 years. Others 10-25 years.

7. Is there information on WQ or nutrient level?
Yes- not related to strains. Mine dumps pollute -heavy metals- PhD study on productivity of high mountain streams.

8. What is the condition factor for the strain?
Eagle Lake did better and lived longer but less catchable. Condition f's vary by time and conditions. Eagle Lake would rate higher because it is harder to catch, takes longer.

9. What is the growth rate in the wild?
Eagle Lake is high.

10. What size are they when planted?
Mostly fingerlings - 4-4½"; range from 3-6".

11. Do they have any information on:
fightability-no

catchability-in reports

dispersal- no

spawning- not in reports

12. Are there studies on impacts from fluctuating flows?
No - to rainbows but no strains

13. Do they know of any other tailwater fisheries?
Delores Below McPhee Dam - they plant Colorado River Rainbow - When there is no natural reproduction - planting is not annual because they are established. McPhee does not have hydropower, is an Ag. Irrigation Dam and Storage. Releases sometimes dramatic changes. Down to about 10 cfs and up to ? (50-80? cfs). Barry Nehring is doing study on relationship of water flows vs. migration of fishes- (rainbow/cutthroat). B. Nehring- 2300 S. Townsend Ave., Montrose, CO 81401 (303) 249-3431.

TROUT STRAIN STUDY - INTERVIEW FORM
TAILWATER FISHERIES

Name: Dick Vincent Date: 7/22/91

Recommended by Thurston Dotson & Jim Darling. - STRAIN EVALUATION REPORT

Agency: Montana Fisheries Division Phone: (406) 994-4042

Reg. 3 Fisheries Mgr.

Tailwater:

1. What strains of rainbow occur in your fishery?

2. What other trout occur in there?

3. Are there any reports on field performance for the strains?

4. What kind of flows (CFS)? Hydropower? Fluctuating flows?

5. What are water temperatures? Seasonal changes?

6. How old is the dam? Fishery?

7. Is there information on WQ or nutrient level?

8. What is the condition factor for the strain?

9. What is the growth rate in the wild?

10. What size are they when planted?

11. Do they have any information on:
fightability-

catchability-Arlee Good.

dispersal-

spawning-
(Survival)- Arlee - only 3 months in streams - not good for self-sustaining; (Arlee is disliked by this fisheries manager).

12. Are there studies on impacts from fluctuating flows?

Wade Fredenberg - below Yellowtail Reservoir -Cold, good trout fishery. Yellowtail not stocked, self sustaining, but he's not sure what's in there - wild fish, not well documented.

13. Do they know of any other tailwater fisheries?

They had the best luck with Wild strains, hatching and rearing young. Pick fish from a similar stream, catch.

TROUT STRAIN STUDY - INTERVIEW FORM
TAILWATER FISHERIES

Name: Roger Snidervan Date: 11/25/91

Agency: Utah Wildlife Resource Div. Phone: (801) 885-3164

Tailwater: Green River Below Flaming Gorge Dam

1. What strains of rainbow occur in your fishery?
13-20" slot; Fish Lake; DeSmet; 2 fish under 13" and 1 fish over 20".

2. What other trout occur in there?
OWHI Brook trout -(not good); Snake River Cutthroat also put in, but none lately; Colorado Cutthroat (no carry over); Brown.

3. Are there any reports on field performance for the strains?
Annual reports of agency; USBR funded studies; Rainbow trout survived well.

4. What kind of flows (CFS)? Hydropower? Fluctuating flows?
Yes; flows are for peaking; 800-4200 cfs daily.

5. What are water temperatures? Seasonal changes?
1978, selective withdrawal structure put in to raise temp.; 54°F now; 40°F before (Outlet @ 200 feet before); 1/3" per month to 1" per month now.

6. How old is the dam? Fishery?
1962 it was built and fishery commenced then.

7. Is there information on WQ or nutrient level?
USGS does sampling at two sites.

8. What is the condition factor for the strain?
>1.00 (Guess)

9. What is the growth rate in the wild?
First year - 1"/mo.; into slot of 13", growth declines; too many fish but decreased stocking to help growth.

10. What size are they when planted?
6" in May but grows 1"/mo. by end of first year.

11. Do they have any information on:
fightability-No complaints about vigor; except older fish don't do well; do better than Cutthroat trout it seems.
catchability-Rainbow trout easier caught than Cutthroat or Brown Trout.

dispersal- Studied, some movement when small; but since stock larger, not as much but some move.

spawning- Yes, but no survival;

12. Are there studies on impacts from fluctuating flows?
Yes, a lot, by USBR funding.

13. Do they know of any other tailwater fisheries?
San Juan Riv. below Navajo; Compensatory declining growth; keep raising slot but not much success; some work on stomach analysis; feed on invertebrates and Gammarus but no piscivorous evidence.

TROUT STRAIN STUDY - INTERVIEW FORM
TAILWATER FISHERIES

Name: Barry Hansen Date: 11/22/91

Referred by Jim Darling, Montana Fisheries

Agency: Confed.Salish & Kootenai Tribes Phone:(406) 675-2700x355

Tailwater:Flathead River below Kerr Dam (Tailwater Fishery Rept.)

1. What strains of rainbow occur in your fishery?
Maybe Eagle Lake Strain from upstream. Wild stock unknown background - some Eagle Lake planted in tribs. upstream - not much Rainbow trout Fishery below dam.

2. What other trout occur in there?
Brown, Cutthroat (plus bass and pike).

3. Are there any reports on field performance for the strains?
Eagle Lake not done well - not over wintering - no info.

4. What kind of flows (CFS)? Hydropower? Fluctuating flows?
Hydro: Low -1200 cfs, High - 1500 cfs; Daily fluctuations of about 8000 cfs max.

5. What are water temperatures? Seasonal changes?
Warm surface temp. in summer - surface outlet so ambient water temperature.

6. How old is the dam? Fishery?
1938 - No data since 1986.

7. Is there information on WQ or nutrient level?
Good data on water quality; oligotrophic lake.

8. What is the condition factor for the strain?
No info. but could be computed.

9. What is the growth rate in the wild?
Tributaries have phenomenal growth but different than flow from oligotrophic lake.

10. What size are they when planted?
Eagle Lake in @ 150 mm. long.

11. Do they have any information on:
fightability-no idea

catchability-Eagle Lake high rate as are cutthroats

dispersal- no idea but a concern

spawning- not overwintering, but may be migrating out

12. Are there studies on impacts from fluctuating flows?
Not as primary study but did some 1983-86 (plus IFIM studies)

13. Do they know of any other tailwater fisheries?
Yellowtail Dam - Bighorn River - Ken Frazer 252-4654; Kootenai below Libby Dam - Don Skaar (406)293-4161
Requested to have a copy of our strain report sent to Box 278, Pablo, MT, 59855

TROUT STRAIN STUDY - INTERVIEW FORM
TAILWATER FISHERIES

Name: Kent Gilge Date: 7/11/91

Recommended by Bob Needham-Reg. 6 Mgr.

Agency: Montana Fisheries- At Chinook Phone: (406) 357-2893

Tailwater: Bighorn River below Yellowtail Dam

1. What strains of rainbow occur in your fishery?

2. What other trout occur in there?

3. Are there any reports on field performance for the strains?
Not in streams, reservoirs only.

4. What kind of flows (CFS)? Hydropower? Fluctuating flows?
Streams are small, mountain, brook trout streams - 8 to 9 cfs.

5. What are water temperatures? Seasonal changes?

6. How old is the dam? Fishery?

7. Is there information on WQ or nutrient level?
No- will try to send some info. to Sue M.

8. What is the condition factor for the strain?

9. What is the growth rate in the wild?

10. What size are they when planted?

11. Do they have any information on:
fightability-too abstract, don't know

catchability-Arlee is by far the best, Eagle Lake is about twice as catchable as DeSmet

dispersal- All are about the same

spawning-

12. Are there studies on impacts from fluctuating flows?
No.

13. Do they know of any other tailwater fisheries?
Other contacts: Steve Leathe, Reg. 4 Mgr. 454-3441 for strain info.; Dick Vincent = "Mr. Trout Stream". Arlee Growth & Catchability has topped all other strains, but their longevity is short -about 2 years is an old fish. They spawn most months. Reproduction causes problems. Good for put & take; Arlee will eat just about anything, including cigarette butts. Eagle Lake and DeSmet are preferred for long-term fisheries.

TROUT STRAIN STUDY - INTERVIEW FORM
TAILWATER FISHERIES

Name: Bob Needham Date: 7/11/91*(short)
Recommended by Thurston Dotson
Agency: Montana Fisheries Div Phone: (406) 228-9347
Reg. 6 Mgr., Glascow,
Tailwater: Fort Peck Dam

1. What strains of rainbow occur in your fishery?

2. What other trout occur in there?

3. Are there any reports on field performance for the strains?

4. What kind of flows (CFS)? Hydropower? Fluctuating flows?

5. What are water temperatures? Seasonal changes?

6. How old is the dam? Fishery?

7. Is there information on WQ or nutrient level?

8. What is the condition factor for the strain?

9. What is the growth rate in the wild?

10. What size are they when planted?

11. Do they have any information on:
fightability-

catchability-

dispersal-

spawning-

12. Are there studies on impacts from fluctuating flows?

13. Do they know of any other tailwater fisheries?
He was too busy to talk - suggested that we call Kent Gilge at Chinook, 357-2893.

TROUT STRAIN STUDY - INTERVIEW FORM
TAILWATER FISHERIES

Name: Doug Sakaguchi, Fish Biologist Date: 11/25/91

Agency: Utah Wildlife Resource Div. Phone: (801) 489-5678

Tailwater: Provo River below Deer Creek Dam - Brown Trout

1. What strains of rainbow occur in your fishery?
In by accident, go over spillway, rainbow trout not stocked below Dam. (Sand Creek, Fish Lake/DeSmet, Tensleep, Shepherd Hills, Skanes Kamloops, Mixtures).

2. What other trout occur in there?
Brown trout; lot of fishing pressure in reservoir; lot of Walleye in reservoir, so will not plant trout anymore.

3. Are there any reports on field performance for the strains?
No studies.

4. What kind of flows (CFS)? Hydropower? Fluctuating flows?
Hydropower; release constant 80 cfs plus some spill in spring; more released in summer for irrigation and power-up to 400 cfs.

5. What are water temperatures? Seasonal changes?
Not much info. on it.

6. How old is the dam? Fishery?
1941; Browns in for 40+ years.

7. Is there information on WQ or nutrient level?
Not much.

8. What is the condition factor for the strain?
1.3 (guess) when leaving reservoir.

9. What is the growth rate in the wild?
Good in reservoir but are caught quickly below reservoir.

10. What size are they when planted?
8-10" when planted in lake in fall; 13-15" by spring.

11. Do they have any information on:
fightability-no information.

catchability-no information.

dispersal- Some movement out of reservoir but little down stream.

spawning- None to speak of.

12. Are there studies on impacts from fluctuating flows?
Studies prepared on brown trout but not published.

13. Do they know of any other tailwater fisheries?
Below Strawberry Reservoir with cutthroat and brown; Flaming Gorge

TROUT STRAIN STUDY - INTERVIEW FORM
TAILWATER FISHERIES

Name: Bill Murphy Date: 11/25/91

Agency: Missouri Dept. Conservation Phone: (417) 334-4865
White Water River System

Tailwater: Lake Taneycomo (tailwater) & Table Rock Dam & Reservoir

1. What strains of rainbow occur in your fishery?
Shepherd of the Hills and many others from federal (Including Ennis).

2. What other trout occur in there?
Mixtures of planted rainbow.

3. Are there any reports on field performance for the strains?
---

4. What kind of flows (CFS)? Hydropower? Fluctuating flows?
Varies with demand. No patterns; from 2 feet to 12 feet deep X 60 feet wide.

5. What are water temperatures? Seasonal changes?
54°F in fall; 47-48°F in Summer; 44° - Feb.

6. How old is the dam? Fishery?
1958

7. Is there information on WQ or nutrient level?
Yes

8. What is the condition factor for the strain?
.0004055

9. What is the growth rate in the wild?
.024" daily change in length; a function of water temp. 15-16 mo. to produce 10" fish.

10. What size are they when planted?
10"

11. Do they have any information on:
fightability-Anglers are pleased with performance.

catchability-Must be easy; some studies; 80,000 planted/mo.; Of 80,000 planted, 90% are caught in 2½ mos. - lot of angling pressure.

dispersal- Big ones will move upstream after planting; 10" will move some.

spawning- Less than 1% survival from spawning; no stranding occuring.

12. Are there studies on impacts from fluctuating flows?
Doesn't know of any.

13. Do they know of any other tailwater fisheries?
Call pathologist in metro office. Gary Camenisch (417) 837-6880.

TROUT STRAIN STUDY - INTERVIEW FORM
TAILWATER FISHERIES

Name: Mark Lere Date: 11/25/91

Agency: Montana Fisheries Division Phone: (406) 444-4628

Tailwater: 3 Reservoirs on Missouri - Canyon Ferry, Hauser, Holter

1. What strains of rainbow occur in your fishery?
Wild Rainbow trout in tailwaters and stocking in reservoirs; Arlee strain; DeSmet also in Canyon.

2. What other trout occur in there?
Crosses of Arlee and Wild Spring spawners; Whitefish, Kokanee Salmon, Brown Trout.

3. Are there any reports on field performance for the strains?
Most work in reservoirs, in highwater will flush and be caught out quickly; wild trout do well and out compete.

4. What kind of flows (CFS)? Hydropower? Fluctuating flows?
Hydro, no peaking, flat flows, run of river.

5. What are water temperatures? Seasonal changes?

6. How old is the dam? Fishery?
Canyon - 2 mill. acre feet - 1955; Hauser - 1907; Holter - 1911.

7. Is there information on WQ or nutrient level?
A little, good nutrient levels, high production of Kokanee.

8. What is the condition factor for the strain?
Population estimates plus condition factor for Rainbow trout.

9. What is the growth rate in the wild?
Arlee only live about 2 years; 18" in 2½ years; a plateau in growth; some info. available.

10. What size are they when planted?
Fingerlings (4")

11. Do they have any information on:
fightability-

catchability-Arlee is shorter lived; better catchability; wild survive better.

dispersal- Arlee does move a little.

spawning- Some fall spawning but crosses with wild now spawning in spring.

12. Are there studies on impacts from fluctuating flows?
Minimum flows desired; FERC relicensing; no fluctuations expected to maintain.

13. Do they know of any other tailwater fisheries?
Since all natural reproduction, no tailwater.

Dick Vincent suggested not stocking Domestics because they will depress natural reproduction."

TROUT STRAIN STUDY - INTERVIEW FORM
TAILWATER FISHERIES

Name: Laney Hanzel Date: 11/25/91

Agency: Montana Fisheries Division Phone: (406) 752-5501

Tailwater: Hungry Horse Reservoir Tailwater

1. What strains of rainbow occur in your fishery?
Some rainbow trout; planted 20 years ago - no idea of strain name originally but now rare.

2. What other trout occur in there?
Bull trout and cutthroat main fish managed; white fish.

3. Are there any reports on field performance for the strains?

4. What kind of flows (CFS)? Hydropower? Fluctuating flows?
Armoring in fluctuating zone, no fines left - 125 cfs to 10,000 change (daily) temp. mitigation program coming with multilevel outlet but no flow change.

5. What are water temperatures? Seasonal changes?

6. How old is the dam? Fishery?

7. Is there information on WQ or nutrient level?

8. What is the condition factor for the strain?
Rare fish and good condition.

9. What is the growth rate in the wild?
No idea.

10. What size are they when planted?
Self-sustaining.

11. Do they have any information on: Not for rainbow.
fightability-

catchability-

dispersal-

spawning-

12. Are there studies on impacts from fluctuating flows?
No

13. Do they know of any other tailwater fisheries?
Libby Dam - Don Skaar - 293-4161; Hauser, Holter and Canyon Ferry - Mark Lere 444-4628.

TROUT STRAIN STUDY - INTERVIEW FORM
TAILWATER FISHERIES

Name: Don Skaar Date: 11/22/91

Agency: Montana Fisheries Division Phone: (406) 293-4161

Tailwater: Kootenai River below Libby Dam

1. What strains of rainbow occur in your fishery?
Unknown - no rainbow trout planting; some coastal rainbow trout which hybridized with cutthroat trout; some Kamloops - Piscivorous after 14", grow large, doing well - planted in reservoir but drift downstream as fingerlings.

2. What other trout occur in there?
Cutthroat

3. Are there any reports on field performance for the strains?
Used Kamloops to control Kokanee in reservoir; long time to catch them; survival is good; spawn at 6 years.

4. What kind of flows (CFS)? Hydropower? Fluctuating flows?
12000 cfs - 5-10,000 cfs change.

5. What are water temperatures? Seasonal changes?
Withdrawn from Hypo. in winter; surface in summer ; 55° in summer.

6. How old is the dam? Fishery?
19 years for Dam and Fishery - Kamloops since 1988.

7. Is there information on WQ or nutrient level?
Some information - phosphorus below detection level (.01µ/L); EC-1-300.

8. What is the condition factor for the strain?
No info.

9. What is the growth rate in the wild?
Up to 31 lbs. - 5-10 lb. range - good growth rate common.

10. What size are they when planted?
Kamloops probably come through as fingerlings.

11. Do they have any information on:
fightability-

catchability-Not here that long to tell.

dispersal- No indication of it.

spawning- Some, but restrictions on ramping rate - some in main channel April to Sept. 4'/24 hours; Sept. to April 6'/24 hrs.

12. Are there studies on impacts from fluctuating flows?
Only studied thru macro invertebrate; fluctuation zone was dead zone, unless stabilized long enough to gain colonization of invertebrates.

13. Do they know of any other tailwater fisheries?
Missouri - Steve Leathe - Fish Mgr. Great Falls (406) 454-3441; Ft. Peck Res./Missouri Riv. - Bill Widenheft (406) 526-3471. Duncan R. knows Kamloops strain and Ennis NFH is source of Kamloops; no longer in wild.

TROUT STRAIN STUDY - INTERVIEW FORM
TAILWATER FISHERIES

Name: Lamont Turner & Mike Burrell Date: 11/25/91

Agency: Nevada Department of Wildlife Phone: (602) 486-6738

Tailwater: Lake Mohave plantings below Lake Mead

1. What strains of rainbow occur in your fishery?
Eagle lake strain from March from Montana; Wytheville, Tennessee in fall.

2. What other trout occur in there?
Striped bass numbers increased 3-500% in last few years which impacts trout.

3. Are there any reports on field performance for the strains?
No

4. What kind of flows (CFS)? Hydropower? Fluctuating flows?
5-30,000 cfs; hydropower, peak loading; fluctuating flows.

5. What are water temperatures? Seasonal changes?
Less than 10°C year round below dam.

6. How old is the dam? Fishery?
1935

7. Is there information on WQ or nutrient level?
Yes

8. What is the condition factor for the strain?
Available from creel data; some caught in electrofishing.

9. What is the growth rate in the wild?
No recent data

10. What size are they when planted?
8-10"

11. Do they have any information on:
fightability-

catchability-Returns are way down. This may be due to combination of increased striped bass predation and less pressure.

dispersal-

spawning- No spawning. Run-of-river style lake so habitat not conducive to spawning.

12. Are there studies on impacts from fluctuating flows?
No

13. Do they know of any other tailwater fisheries?

DRAFT

TROUT STRAIN STUDY - INTERVIEW FORM
TAILWATER FISHERIES

Name: Pete Carboni Date: 11/25/91

Agency: USFWS - Willow Beach Phone: (602) 767-3456

Tailwater: Lake Mohave Downstream of Lake Mead/Hoover Dam

1. What strains of rainbow occur in your fishery?
Last 4-5 years; Erwin (from Ennis NFH); Bel-Aire and Tasmanian (Crystal); Eagle Lk. (Creston NFH); Fish Lake - DeSmet (Utah); 5-6 strains/ year received.

2. What other trout occur in there?
Tasmanians always seem to do better than others; Colorado Strains (Bel-Aire and Tasmanians) seem to do better.

3. Are there any reports on field performance for the strains?
No work by USFWS; some work by Arizona GFD.

4. What kind of flows (CFS)? Hydropower? Fluctuating flows?
10-20,000 cfs; some elevation changes due to hydropower use.

5. What are water temperatures? Seasonal changes?
< 10°C, Hoover Dam and increases south toward Davis Dam.

6. How old is the dam? Fishery?
1935 Dam; 1961 for hatchery below dam.

7. Is there information on WQ or nutrient level?
Yes.

8. What is the condition factor for the strain?
Could compute but did not know.

9. What is the growth rate in the wild?
No idea after last 4-5 years.

10. What size are they when planted?
8 to 9" planting slightly larger now.

11. Do they have any information on: No info. on any; AGFD may know answers.
fightability-

catchability-

dispersal-

spawning-

12. Are there studies on impacts from fluctuating flows?
Not aware of any.

13. Do they know of any other tailwater fisheries?

APPENDIX E

STATE AND FEDERAL HATCHERY PERSONNEL CONTACTED

TROUT STUDY

STATE HATCHERIES AND TROUT STRAINS

ARIZONA

Arizona Game and Fish Department (602) 942-3000
2222 W. Greenway Road
Phoenix, AZ 85023
Roger Sorenson - Hatchery manager

ARKANSAS

Arkansas Game and Fish Commission
#2 Natural Resources Drive
Little Rock, AR 72205
Mike Gibson (Asst. Chief--Fisheries/Hatch) (501) 525-8606
Hot Springs

State-owned hatcheries:

Andrew H. Hulsey Hatchery, Lake Hamilton (501) 525-8606
Warmwater fisheries, no trout.

Centerton Hatchery, Centerton (501) 795-2470
Larry Red, Mgr. - Trout

Joe Hogan Hatchery, Lonoke (501) 676-6963
Barry Beavers, Mgr. (501) 223-6385
Warmwater fisheries, no trout.

Lake Hamilton Hatchery, Hot Springs (501) 525-8606
Don Brader, Mgr.

Spring River Fish Hatchery, Mammoth Springs (501) 625-7521
Melissa Jones, Mgr. - Rainbows

William H. Donham Hatchery, Corning (501) 857-3876
David Caldwell, Mgr.
Warmwater fisheries, no trout.

CALIFORNIA

California Fish & Game Dept., Sacramento (916) 445-3531
Bruce Barngrover (for hatchery info?)
State of California
The Resources Agency
Department of Fish and Game, Region
1701 Nimbus Road, Suite "A"
Rancho Cordova, CA 95670

State-owned hatcheries:

Region 1, Redding (916) 246-6511
Iron Gate Hatchery
Mount Shasta Hatchery
Mad River Hatchery
Trinity River Hatchery
Darrah Springs Hatchery
Crystal Lake Hatchery

Region 2, Rancho Cordova (916) 355-0978
Feather River Hatchery
American River Hatchery

Nimbus Hatchery
Central Valley Hatchery
Mokelumne River Fish Installation

Region 3, Yountville (707) 944-2011
Warm Springs Hatchery

Region 4, Fresno (209) 222-3761
Moccasin Creek Hatchery
San Joaquin Hatchery

Region 5, Long Beach (213) 590-5177
Hot Creek Hatchery
Fish Springs Hatchery
Black Rock Rearing Ponds
Mount Whitney Hatchery
Fillmore Hatchery
Mojave River Hatchery
Imperial Warmwater Hatchery

49 page list of private hatcheries, many with trout.

COLORADO
Dept. of Natural Resources
Division of Wildlife
6060 Broadway
Denver, CO 80216-1000
Lou Kroeckel (303) 291-7358
Strains they "have had at one time or another":

Arlee	Bel-Aire
Colorado River	DeSmet
Eagle Lake	Erwin
Fish Lake	McConaughy
Sand Creek	Tasmanian
6F2	Emerald Lake (rainbow/cutthroat hybrid)

State-owned hatcheries:
Fish Research Hatchery, Bellvue (303) 482-1141
Tom Mandis
Strain info
Crystal River Hatchery, Carbondale (303) 963-2665
John Riger
Broodfish, primarily cutthroat
Bellvue Watson Hatchery, Bellvue (303) 482-1659
David Smeltzer
Chalk Cliffs Rearing Unit, Nathrop (719) 395-2378
Eric B. Hughes
Chatfield Planting Base (303) 791-1850
Clark Baker
Durango Hatchery, Durango (303) 247-4755
Robert G. Little
Finger Rock Rearing Unit, Yampa (303) 638-4490
Keith Hicken
Glenwood Springs Hatchery, Glenwood Springs (303) 945-5293

Rich Kolecki
Broodfish, primarily rainbow
Las Animas Hatchery, Las Animas (719) 456-0499
Roderic Swanson
Mt. Shavano Hatchery, Salida (719) 539-6877
J. Melvin Rose
Pitkin Hatchery, Pitkin (303) 641-0265
Dennis Eicher
Poudre Rearing Unit, Bellvue (303) 881-2187
Arlene Ganek
Pueblo Hatchery, Pueblo (719) 561-0691
Thomas G. Kingsley
Rifle Falls Hatchery, Rifle (303) 625-1865
Edwin J. Allen
Roaring Judy Hatchery, Almont (303) 641-0190
Terrance Robinson
Wray Hatchery, Wray (303) 332-5382
K. David Schnoor

List of 36 private hatcheries, most in CO, 17 trout

IDAHO

Idaho Fish & Game Dept., Fisheries, Boise (208) 334-3791
Bill Hutchinson-Hatcheries Mgr.

IOWA

Iowa Department of Natural Resources, Des Moines (515) 281-5145
Manchester Hatchery (515) 927-3276
Decorah Hatchery (515) 382-8324
Big Spring Hatchery (515) 245-2446

KANSAS

Kansas Wildlife & Parks, Topeka (913) 296-2281
Operations Office, Pratt, KS (316) 672-5911 X 196
Bob Hartman

LOUISIANA

Louisiana Dept. of Wildlife & Fisheries, Baton Rouge
Arthur Williams (hatchery info) (504) 765-2333
There are no trout hatcheries in LA, put and take only.

MINNESOTA

Minnesota Dept. of Natural Resources
Division of Fish and Wildlife
Section of Fisheries, Box 12
500 Lafayette Road
St. Paul, MN 55155-4012

Fisheries- Pat (612) 296-3325
State-owned hatcheries:

French River Coldwater Hatchery, Duluth (218) 723-4881
Spire Valley Hatchery, Remer (218) 792-5164
Crystal Springs Hatchery, Altura (507) 796-6691
Peterson Hatchery, Peterson (507) 875-2625
Lanesboro Hatchery, Lanesboro (507) 467-3771
St. Paul Hatchery, St. Paul (612) 772-7950

List of 31 private rainbow or trout hatcheries in MN

MISSOURI

Missouri Department of Conservation
2901 West Truman Blvd.
P.O. Box 180
Jefferson City, MO 65102-0180

Leroy Heman, Asst. Chief, Fisheries/Hatcheries (314) 751-4115

Broodstock info:
Gary Camenisch, Fish Pathologist (417) 895-6880
Springfield Fish Disease Lab
2630 N. Mayfair, Springfield, MO 65803
Univ of Missouri, Natural Resources
Robert A. "Bob" Pierce, Jr. (314) 882-4337
(private fishery info)

State-owned hatcheries:
Shepherd of the Hills Hatchery, Branson (417) 334-4865
Gordon Proctor, Manager
Trout
Montauk Hatchery, Salem (314) 548-2585
Thomas D. Perry, Jr., Mgr.
Bennett Spring Hatchery, Lebanon (417) 532-4418
Ronald D. McCullough

Roaring River Hatchery, Cassville (417) 847-2430
Jerry W. Dean, Mgr.
Maramec Spring Hatchery, St. James (314) 265-7801
Eldred E. Gallagher

List of 56 private hatcheries, 9 with rainbow trout.

MONTANA

Montana Dept. of Fish, Wildlife & Parks
Fisheries Division, Helena (406) 444-2449
Thurston Dotson, Hatchery Bureau Chief (406) 444-2447
They use:
Arlee - reservoirs & tailwaters
Arlee/Eagle Lake cross
Eagle Lake
DeSmet - tailwaters
Kamloops
McConoughy - reservoirs

State-owned hatcheries:

Big Springs Trout Hatchery, Lewistown (406) 538-5588
Jack Boyce, Mgr.
Bluewater Springs Trout Hatchery, Bridger (406) 668-7443
Gary Shaver, Mgr.
Flathead Lake Salmon Hatchery, Somers (406) 857-3744
Stewart Kienow, Mgr.
Giant Springs Trout Hatchery, Great Falls (406) 454-5734
Bruce Chaney, Mgr.
Jocko River Trout Hatchery, Arlee (406) 726-3344
James Crepeau, Mgr.
Miles City Fish Hatchery, Miles City (406) 232-4753
Paul Butterfield, Mgr.
Murray Springs Hatchery, Eureka (406) 889-3489
Jim Schreiber, Mgr.
Washoe Park Trout Hatchery, Anaconda (406) 563-2531
Mark Hamilton, Mgr.
Yellowstone River Trout Hatchery, Big Timber (406) 932-4434
Daryl Hodges, Mgr.

Private hatcheries:
Bitterroot Trout Farm, Hamilton (406) 363-3598
Joe Farley
Rainbow trout
Crystal Creek Trout Ponds, Turah (406) 258-6639
Mike Davis
Rainbow trout
Hamilton Trout Company, Hamilton (406) 363-1795
Herman Hamilton
Donaldson trout, Arlee rainbow
Harriman Trout Company, St. Ignatius (406) 745-4355
Alan or Margaret Harriman (406) 745-3317
Rainbow, brown & cutthroat trout
Kinney Trout Ponds, Laurel (406) 628-7405
Stan Kinney
Trout
Nelson's Spring Creek Ranch, Livingston (406) 222-6560
Roger Nelson
Arlee rainbow, brown trout
Rainbow Springs, Livingston (406) 222-3922
Tom Morgan
Rainbow, cutthroat
Sekokini Springs Trout Farm, Columbia Falls (406) 387-5547
Cary King
Rainbow & brook trout
Spring Creek Trout Ranch, Big Timber (406) 932-4387
Bob Bovee
Rainbow trout

The Confederated Salish and Kootenai Tribes, Flathead Agency
Tribal Fisheries Department

NEBRASKA

Nebraska Game & Parks Commission, Lincoln (402) 471-0641
Larry Zadina (402) 471-5495
Monty Matson, Dist 4, N. Platte, for info. (308) 532-8025

They don't hatch rainbows or maintain brood stock, see notes for minimal strain info. Fish come from WY:

Rock Creek Hatchery
Grover Creek Rearing Station
Bob Singley (402) 893-5468
Grove Front Rearing Station (402) 893-5468
Bob Singley

NEVADA

Nevada Wildlife ? (not Carson City), Fisheries
Don Junell (Staff Biol.-Brood Stock Prog.) (702) 688-1500
Nevada has one, private, hatchery:
Curt Baughman (702) 779-2231
Gallagher Hatchery, Ruby Valley, NV

NEW MEXICO

New Mexico Dept. of Game & Fish, Santa Fe (505) 827-7911
Fisheries Management
George Lopez (Asst. Chief--Hatcheries) (505) 827-7905
They have six state and no private hatcheries.
Apparently did not send hatchery info as promised.
No strain info, they use their own "Heinz 57" strain.

NORTH DAKOTA

North Dakota Game & Fish Dept., Bismark (701) 221-6300
Bob Frohlich (Fisheries Technician) (701) 221-6346
Jerry Weigel (in charge of hatcheries) (701) 252-4634
ND has no state and two private hatcheries:
Missouri River Trout Ranch, Stanton, ND
Terry Ernst phone?
Dakota Trout Ranch
Harold Erickson (701) 652-3446
The best info on rainbows would be from:
Garrison Dam National Fish Hatchery
Tom Pruitt (701) 654-7451

OKLAHOMA

Oklahoma Fish and Game Dept., Oklahoma City, OK
Dept. of Wildlife Conservation (405) 521-3852
Don Driscoll (for hatchery info) (405) 521-3721
(or 521-3722)

OREGON

Oregon Dept. of Fish & Wildlife
4412 Silverton Road NE
Salem, OR 97305

Portland (503) 229-5410
Bob Hooten (Trout Prog. Leader, 7/1/91) (503) 229-5410 X369
Jim Griggs (was Trout Prog. Leader, 15 years) (503) 229-5410
Salem, OR (District Office) (503) 378-6925
Ken Daly--Warmwater Fish Biologist
Corvallis (503) 737-3241

List of 33 state-owned hatcheries, no species listed.
List of 15 private hatcheries, 6 with rainbow trout

SOUTH DAKOTA

South Dakota Dept. of Game, Fish and Parks
Fisheries Staff (605) 773-3384
Pierre
Bob Hanten (Div. Staff Spec.-Fisheries) (605) 773-4508
Rapid City
Mr. Ford (author) (605) 394-2391

TEXAS

Texas Parks and Wildlife Dept., Austin, TX
Fish hatcheries, Hazel Jones (512) 389-4859

UTAH

Utah Wildlife Resource Division, Salt Lake City
Joe Valentine, Hatcheries Mgr. (801) 538-4808

WASHINGTON

Washington State Dept. of Wildlife
600 Capitol Way, Olympia, WA 98501-1091
Fisheries Dept., Olympia
Dept. of Wildlife (Handles Hatcheries) (206) 753-5700
John Kerwin (Hatchery Prog. Mgr.) (206) 753-2902
List of 33 state-owned hatcheries and rearing ponds.
List of 71 private trout farms.

WYOMING

Wyoming Game and Fish Dept.
4500 Bishop Boulevard
Cheyenne, WY 82006
Fisheries Mgmt., Cheyenne (307) 684-2801
Fish Division
John Baughman (Asst. Chief-Fisheries) (307) 777-4559
Wayne Fornstrom, Hatcheries Superv., Pinedale (307) 367-4353
Steve Sharon (Hatchery Coordinator) (307) 234-3606
Casper Dist. Office

List of 13 private hatcheries, 6 specify trout, 6 in WY

FEDERAL HATCHERIES AND TROUT STRAINS

ARIZONA

Alchesay/Williams Creek, Whiteriver, AZ (602) 924-4321
Lawrence J. Wirtanen, Mgr.
Bob Davis, Asst. Mgr.

Willow Beach, Boulder City, NV (602) 767-3456
Lyle R. Miller, Mgr.
Peter Carboni, Asst. Mgr.

ARKANSAS

Greers Ferry, Heber Springs, AR (501) 362-3615
Timothy M. Cleary, Mgr.
Kenneth Boyles, Asst. Mgr.
Arlee — See interview sheet for details.
Eagle Lake
Erwin
Fish Lake
Shasta
Wytheville

Mammoth Spring, Mammoth Spring, AR (501) 625-3912
Richard L. Shelton, Mgr.
No trout, warmwater fish only.

Norfork, Mountain Home, AR (501) 499-5255
William K. Lindsay, Mgr.
Jim Wencker, Asst. Mgr.
Arlee — See interview sheet for details.
Bel Aire
Erwin
Fish Lake
Kamloops
McConaughy
Shasta
Wytheville

CALIFORNIA

Coleman. Anderson, CA (A) (916)365-8622
Gene F. Forbes, Mgr. (916) 365-8781
Wesley Raistakka, Asst. Mgr.

COLORADO

Hotchkiss, Hotchkiss, CO (303) 872-3170
Adam Mendoza, Mgr.

Norman Hines, Asst. Mgr.
Arlee — See interview sheet for details.
McConaughy
Tasmanian
Shasta

Leadville, Leadville, CO (719) 486-0189
Duane E. Monk, Mgr.
Doug Alcorn, Asst. Mgr.
Arlee — See interview sheet for details.
Erwin
Shasta
Eagle Lake (in the past)
Shepherd of the Hills (in the past)
Tasmanian (in the past)

IDAHO

Dworshak/Kooskia Complex, Ahsahka, ID **(A)** (208) 476-4591
Wayne . Olson, Mgr.
Jon Streufert, Asst. Mgr.

Kooskia (substation), Kooskia, ID **(A)** (208) 926-4272
Speros K. Doulos, Asst. Mgr.

Hagerman, Hagerman, ID **(A)** (208) 837-4896
David S. Bruhn, Mgr.
Tom Shaw, Asst. Mgr.

IOWA

No federal hatcheries?

KANSAS

No federal hatcheries?

LOUISIANA

Natchitoches, Natchitoches, LA (318) 352-5324
T. Anthony Mayeux, Mgr.
Karen M. Kilpatrick, Asst. Mgr.
No trout, warmwater fish only.

MINNESOTA
No hatcheries?

MISSOURI

Neosho, Neosho, MO (417) 451-0554
David Hendricks, Mgr.
Douglas Aloisi, Asst. Mgr.
Arlee (Western) — See interview sheet for details.
Erwin
Fish Lake

Shasta

MONTANA

Bozeman, Bozeman, MT (406) 587-9265
Charlie Smith, Dir.
Greg Kindschi, Asst. Dir.
Arlee See interview sheet for details.
Erwin
Kamloops
Shasta

Creston (substation), Kalispell, MT (406) 755-7870
Bob Thompson, Mgr.
Adam Mendoza, Asst. Mgr.
Mr. Robin Wagner, Fisheries Biol.
Arlee See interview sheet for details.
Eagle Lake
Shasta

Ennis, Ennis, MT (406) 682-4847
Wesley H. Orr, Mgr.
John Shrable, Asst. Mgr.
Arlee See interview sheet for details.
Eagle Lake
Erwin
Harrison Lake
Kamloops
McConaughy
Shasta

NEBRASKA

No federal hatcheries?

NEVADA

Lahontan/Marble Bluff Complex, Gardnerville, NV (702) 265-2425
Duane L. Wainright, Mgr.
Bryan R. Kenworthy, Asst. Mgr.
Lahontan cutthroat only, no rainbows.

NEW MEXICO

Dexter, Dexter, NM (505) 734-5910
Buddy L. Jensen, Mgr.
Roger Hamman, Asst. Mgr.
James Brooks, Asst. Mgr.
No rainbow trout.

Mescalero, Mescalero, NM (505) 671-4401
Barbara Giesecke, Mgr.
Arlee See interview sheet for details.
Eagle Lake

Erwin
Kamloops
McConaughy
Shepherd of the Hills
Tasmanian
Wytheville

NORTH DAKOTA

Baldhill Dam (substation), (Admin. by Valley City NFH)
No salmonids.

Garrison Dam, Riverdale, ND (701) 654-7451
Tom Pruitt, Mgr.
Jack Call, Asst. Mgr.
Arlee See interview sheet for details.
Eagle Lake
Shasta

Valley City, Valley City, ND (701) 845-3464
Matt Bernard, Acting Mgr.
No salmonids.

OKLAHOMA

Tishomingo, Tishomingo, OK (405) 384-5463
Kenneth Davenport, Mgr.
No trout, warmwater fish only.

OREGON

Eagle Greek, Estacada, OR **(A)** (503) 630-6270
Douglas K. Dysart, Mgr.
Melvin M. Englehardt, Asst. Mgr.

Warm Springs, Warm Springs, OR **(A)** (503) 553-1692
Gary R. White, Mgr.
Micheal L. Paiya, Asst. Mgr.

SOUTH DAKOTA

Gavins Point, Yankton, SD (605) 665-3352
Herb Bolling, Mgr.
Lynn Lee, Asst. Mgr.
Mr. Clair Sudbeck, Biotech.
Arlee See interview sheet for details.
Wytheville

TEXAS

Inks Dam, Burnet, TX (512) 793-2474
Robert Lindsey, Mgr.
No rainbow trout, warmwater fish only.

San Marcos, San Marcos, TX (512) 353-0011
William M.Seawell, Mgr.
Tom Brandt, Asst. Mgr.
No rainbow trout, warmwater fish only.

Uvalde, Uvalde, TX (512) 278-2419
Lloyd Strobeck, Mgr.
No rainbow trout, warmwater fish only.

UTAH

Jones Hole, Vernal, UT Vernal (801) 789-0351
Don P. Toney, Proj. Ldr. Jones Hole (801) 789-4481
Edith A. Erfling, Hatchery Mgr.
Arlee See interview sheet for details.
Eagle Lake
Kamloops
Sand Creek
Shepherd of the Hills
Ten Sleep

WASHINGTON

Abernathay, Longview, WA (A) (206) 425-6072
David A. Leith, Mgr.
Laurie G. Fowlwr, Asst. Mgr.

Carson, Carson, WA (A) (509) 427-5905
Bruce McLeod, Mgr.
John A. Davis, Asst. Mgr.

Entiat (substation), Entiat, WA (A) (509) 784-1131
Daniel Davies, Asst. Mgr.

Leavenworth/Entiat/Winthrop Cplx, Leavenworth, WA (509) 548-7641
Gregory A. Pratschner, Mgr. (A)

Little White Salmon/Willard Complex, Cook, WA (A) (509) 538-2755
Jack E. Bodle, Mgr. (509) 538-2305
Jack Manning, Jr., Asst. Mgr.

Makah, Neah Bay, WA **(A)** (206) 645-2521
Daniel D. Sorenson, Mgr.

Quilcene, Cuilcene, WA **(A)** (206) 765-3334
Lawrence J. Teller, Asst. Mgr.

Quinault, Neilton, WA **(A)** (206) 288-2508
Phillip E. Martin, Mgr.

Spring Creek, Underwood, WA **(A)** (509) 493-1730
Edward LaMotte, Mgr.

Willard (substation), **(A)** (Admin by Little White Salmon)

Winthrop (substation), Winthrop, WA **(A)** (509) 996-2424
William L. Wallien, Asst. Mgr.

<u>WYOMING</u>

Jackson, Jackson, WY (307) 733-2510
Henn Gruenthal, Mgr.
Dale Bast, Asst. Mgr.
No rainbow trout, cutthroat, Lake and Brown only.

Saratoga, Saratoga WY (307) 326-5662
James E. Hammer, Mgr.
Kerry Grande, Asst. Mgr.
Erwin See interview sheet for details.

(A) = Anadromous