



**CLEAR
SPRINGS
FOODS®**

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DEPARTMENT OF
WATER RESOURCES

December 3, 2008

Mr. John K. Simpson
Barker, Rosholt, & Simpson LLP
1010 West Jefferson
Suite 102
Boise, Idaho 83702

RE: Expert Report

Dear Mr. Simpson:

Enclosed please find my Expert Report in the matter of "The Mitigation Plan of the North Snake and Magic Valley Ground Water Districts Implemented by Applications for Permit Nos. 02-10405 and 36-16645 and Application for Transfer No. 74904 to Provide Replacement Water for Clear Springs Snake River Farm.

Sincerely,

John R. MacMillan, Ph.D.
Vice President

Enclosure

**EXPERT REPORT OF
JOHN R. MACMILLAN, PH.D.**

I. QUALIFICATIONS AND BACKGROUND

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6 1. I make this statement as an employee of Clear Springs Foods, Inc. in which I
7 serve as Vice President of Research and Environmental Affairs. I am an expert in
8 aquaculture science, fish pathology and health management, minor animal species drug
9 approval, environmental regulation, seafood quality assurance, and aquaculture public
10 policy. I hold Bachelor of Science (1973, University of Maryland), Master of Science
11 (1976, Michigan State University), and Doctor of Philosophy (1980, University of
12 Washington) degrees. I was a Senior Research Fellow at the Medical School, University
13 of Washington (1980 -1982) conducting research in radiobiology and developing models
14 of cellular senescence. A list of my professional memberships, professional activities,
15 research activities, publications and other scholarly activities, offices held in professional
16 and scientific organizations and service positions, honors and awards, and civic and
17 community activities is contained in a copy of my most recent curriculum vitae, which is
18 attached hereto as Exhibit "1."
19

20 2. My experience related to aquaculture, fish health management, water quality
21 management, physiologic requirements of fish, and seafood quality assurance spans over
22 28 years. I am currently Vice President of Research and Environmental Affairs at Clear
23 Springs Foods. Clear Springs Foods was founded in 1966 and I joined the company as
24 Director of Research and Development in 1990. As Research Director and Vice
25 President of Research I direct a staff conducting research and development on a variety of
26 issues related to aquaculture of rainbow trout including their environmental requirements,
27 fish health management (vaccine and stress responses), fish culture, brood stock
28 improvement, and environmental science. In 1991 I conducted an evaluation of the water
29 quality in the Snake River. Prior to accepting a position with Clear Springs Foods I was
30 an Associate Professor of Veterinary and Aquatic Animal Medicine at Mississippi State
31 University, College of Veterinary Medicine. During that time I conducted fish disease
32 research including physiologic responses of fish to various stressors, pathogens and

33 toxins. I also taught veterinary students and served as major professor for both Master's
34 Degree and Doctor of Philosophy degree students.

35

36 3. From 1982 until 1985 I served as an Area Extension Fisheries Specialist for
37 Mississippi State University. In this position I primarily provided fish disease diagnostic
38 and fish health management services to the Mississippi catfish industry. I conducted
39 research on various fish diseases including impact of various environmental conditions
40 on fish production capacity and fish survival.

41

42 4. I served as a Senior Research Fellow in the Department of Pathology, School
43 of Medicine at the University of Washington from 1980 until 1982. I conducted basic
44 cell biology and pathology research looking at potential mechanisms of cellular
45 senescence. Cellular kinetics and modeling were my primary research focus using bone
46 marrow transplant and radiobiological techniques.

47

48 5. I currently serve on the Idaho Board of Environmental Quality. I have served
49 on this board since its inception in 2000. From 2004-2006 I served as the Board
50 Chairman. I was initially appointed to the Board by Governor Dirk Kempthorne who
51 reappointed me in 2003. I was recently re-appointed by Governor Butch Otter (2007)
52 with term expiration in 2011. The Board of Environmental Quality has decision making
53 responsibilities over proposed environmental rules and has quasi-judicial responsibilities
54 during contested cases in which parties object to departmental decisions.

55

56 **II. Purpose of Report**

57

58 The North Snake and Magic Valley Ground Water Districts propose to mitigate for their
59 injury to Clear Springs Foods Snake River Farm complex based on the 2005 water
60 delivery order, by:

61

62 1. Pumping Snake River Farm effluent waste water or Clear Lake water into the Snake
63 River Farm complex head ditch.

64 2. Pumping spring water from their Spring No. 1, or Spring 1 and 2, to the Snake River
65 Farm complex head ditch.

66 3. Drilling a well at about the location of their Spring No. 1 down to a depth of 200 feet
67 and pumping water to the Snake River Farm complex head ditch.

68

69 **What seems clear from these mitigation proposals is that the parties have little**
70 **understanding about rainbow trout, their sensitivity to stress, basic fish health**
71 **management and the science of intensive, flow-through aquaculture.** Yet informed
72 decision as to the suitability and utility of these mitigation water's *in lieu* of gravity fed
73 spring water from existing springs requires just such understanding of fish biology
74 including physiological impacts of various factors constituting water quality and the
75 impact of fish pathogens, chemicals and drugs and interrupted water supply on
76 intensively reared fish. It also requires knowledge about the farming of rainbow trout in
77 flowing water systems. This report describes the general practice of flowing water fish
78 culture and provides analysis of impacts from each water quality factor individually and
79 collectively on fish production capacity. Peer reviewed scientific literature provides the
80 basis for this analysis.

81

82 **Opinions expressed in this matter**

83

- 84 • Rainbow trout are complex, physiologically integrated vertebrate aquatic animals.
- 85 • Commercially reared rainbow trout are farmed intensively and fed a nutrient
86 dense, high energy diet.
- 87 • Rainbow trout are farmed in flow-through, serial reuse systems.
- 88 • Water quality suitable for intensive rainbow trout husbandry is diminished with
89 each water use necessitating progressive change in husbandry with each use. The
90 usefulness of Snake River Farm food fish production facility effluent water for
91 intensive rainbow trout production is zero.
- 92 • Intensive fish husbandry causes significant physiologic stress.
- 93 • Intensive aquaculture requires more stringent water quality conditions than that
94 required for extensive aquaculture or wild fish.

- 95 • The purposes for which commercially raised rainbow trout are raised are different
96 than for public conservation production. This creates different environmental
97 requirements.
- 98 • Physiologic stress reduces fish adaptability and ability to withstand additional
99 stress, increases susceptibility to disease (infectious and non-infectious), and
100 reduces fish performance capacity.
- 101 • Stress shifts the bioenergetic flow of feed resources (energy and protein) away
102 from somatic growth toward maintenance of homeostasis thus negatively
103 impacting fish production.
- 104 • Existent research reports demonstrate the impact of individual stresses and
105 stressors on homeostasis but stress most frequently occurs simultaneously from a
106 variety of factors. The impact of multiple stress factors on fish is real but poorly
107 researched.
- 108 • Eggs, fry and fingerlings are the most sensitive life stages of rainbow trout.
- 109 • Early life stages of rainbow trout are immunologically naïve and more sensitive to
110 most diseases compared to later life stages.
- 111 • Recirculation of effluent water will increase fish stress, will diminish carrying
112 capacity, will increase disease prevalence, severity and fish loss, and will create
113 food safety problems.
- 114 • Pumping water from other springs, from a well or from effluent will decrease
115 water delivery certainty, increase physiologic stress when delivery fails, create
116 food safety issues and would diminish utility of existing water rights.

117 **III. Foundation of Opinion**

118 The basis of the opinions expressed in this report arise directly from the rainbow trout,
119 it's biology, it's farming under intensive flowing water commercial conditions, it's
120 response to water quality diminishment, bioenergetics, and various food safety and
121 quality issues. These factors significantly impact the profitability of commercial
122 operations and the competitive position of Clear Springs Foods.
123
124

125
126

127 **A. Rainbow Trout Biology**

128

129 General Characteristics

130

131 Rainbow trout are native to both shores of the North Pacific Ocean (Pennell et al. 2001)
132 but now has a global distribution due to its relative temperature adaptability and human
133 instituted transplantation (Wolf and Rumsey 1985; Laird and Needham 1988). Most fish
134 biologists classify the rainbow trout as a spring spawner (February to June) although
135 selective breeding in hatcheries and photoperiod control enables trout to breed throughout
136 the year (Gall and Crandell 1992). Clear Springs Foods uses photoperiod control at the
137 Snake River Farm Complex brood facility to manipulate timing of ovulation and ensure
138 year round supply of selectively bred rainbow trout. Feral populations tolerate
139 temperatures of 0 to 25° C while excellent growth under conditions of good water quality
140 occurs at 15 to 20° C (Gall and Crandell 1992). Fornshell (2002) reports the optimal
141 rainbow trout growth temperature for intensively farmed trout is 15°C. Male fish mature
142 at 9 to 12 months of age under hatchery conditions while feral fish mature at 2-3 years
143 depending on water temperature and food availability. The species is amenable to
144 genetic modification via selective breeding (Gall and Crandell 1992). Stocks do show
145 wide variation of spawning times, growth and carcass quality, taste, and swimming
146 performance (summarized by Gall and Crandell 1992). The rainbow trout while
147 adaptable, maintains a relatively narrow environmental scope due to high oxygen
148 demands, sensitivity to xenobiotics, carnivory, sensitivity to water quality perturbations
149 and physiologic complexity. This feature has enabled aquaculture of rainbow trout
150 through-out the world but not on the same scale as occurs at Clear Springs Foods.

151 **Optimal growth conditions for the rainbow trout occur where the water**
152 **temperature is at the rainbow trout optimum (15° C), where water temperature**
153 **does not fluctuate during grow-out (10-16 months), where water is saturated with**
154 **dissolved oxygen, where metabolites of fish are absent, where there are no drug or**
155 **pesticide contaminants in the water, infectious disease agents are absent and water**
156 **flow does not fluctuate over a 0-72 hour time frame.** The 1000 Springs area of Idaho,
157 where spring water comes from the Eastern Snake Plain Aquifer, has historically
158 provided such optimal conditions. This area provides a large volume of essentially

159 pristine water with optimal constant water temperature and other water quality
160 characteristics (Fornshell 2002).

161
162 **The rainbow trout (*Oncorhynchus mykiss*) is a physiologically sophisticated,**
163 **complex, aquatic vertebrate animal whose organ systems are physiologically**
164 **integrated and interdependent.** In contrast to plants but similar to terrestrial vertebrate
165 animals, the trout is composed of ten primary organ systems (skeletal, muscular,
166 digestive, excretory, respiratory, circulatory, nervous, endocrine, immune and
167 reproductive) specially adapted to function together in a particular environment, in this
168 case water. The similarities and differences are noteworthy.

169
170 **Aquatic animals must expend considerable energy to obtain sufficient oxygen from**
171 **water because of oxygen's low solubility in water.** In contrast, terrestrial animals have
172 a ready supply of oxygen with which to drive metabolism. Trout are able to obtain
173 dissolved oxygen using a very unique and sophisticated but also very fragile gill
174 architecture which when combined with multiple types of hemoglobin molecules in
175 erythrocytes enables trout to survive in reduced (compared to air) oxygen environments.
176 Even with these anatomically sophisticated organs, the trout is only able to extract 30-
177 40% of the available dissolved oxygen (Jones and Randall 1978). The trout gill is
178 covered by a complex but also very thin epithelium that is the site of a multitude of vital
179 functions including gas exchange, regulation of ion movements between fish and water,
180 acid-base regulation, and excretion of waste nitrogen. **Unlike the terrestrial animal's**
181 **lungs, this fragile gill epithelium is constantly exposed to the water the fish live in**
182 **(i.e. their own wastes). It is constantly under challenge by water quality conditions**
183 **that are less than optimum. Flowing-water aquaculture continually renews the**
184 **environment minimizing accumulation of metabolic wastes.**

185
186 In contrast to humans (and most mammals) that have a single main hemoglobin
187 component in erythrocytes, fishes commonly exhibit hemoglobin multiplicity (different
188 "iso-hemoglobins" that occur in the same individual at the same or different stages of its
189 development) and hemoglobin polymorphism (different "allo-hemoglobins" in

190 genetically different strains of the same species) (Jensen et al. 1998). Each hemoglobin
191 type responds differently to oxygen availability or acid-base conditions with different
192 oxygen binding capacity. The rainbow trout has at least nine types of hemoglobin (Fago
193 et al. 2002). These different hemoglobin's may occur all at once but in different
194 abundance within individual fish (Tun and Houston 1986; Marinsky et al. 1990).
195 Rainbow trout subjected to variable conditions of dissolved oxygen or photo-period over
196 a 2-3 week period can shift the relative abundance of hemoglobin isomorphs. The
197 bioenergetic impacts of this shift have not been well researched but low and fluctuating
198 dissolved oxygen concentrations have been associated with diminished fish growth
199 (Smart 1981).

200

201 **Rainbow trout may compensate for less than optimal dissolved oxygen in the water**
202 **by increasing the number of oxygen carrying red blood cells but there is a**
203 **consequent additional physiological burden that is incurred which deprives the fish**
204 **of energy or protein that would otherwise be put to growth.** This is similar to humans
205 living at high altitudes where increased numbers of erythrocytes are produced over time
206 to help in delivery of oxygen. In trout, an acute response to low oxygen occurs with
207 release of effete (aged) red blood cells from the spleen and appears related to adrenergic
208 stimulation of the spleen (Wells and Weber 1990). While primarily a lymphomyeloid
209 organ, the spleen also removes aging erythrocytes that are nevertheless functional when
210 released back into the blood stream. The increased number of circulating red blood cells
211 is assumed to be a physiological adjustment to maintain oxygen transfer to tissues. It is
212 suspected that trout actually increase production of erythrocytes in response to
213 chronically low dissolved oxygen. This does come at a physiological price- too many red
214 blood cells may be detrimental (Erselv and Gabuzda 1974). Experimental evidence
215 indicates elevated hematocrit (polycythemia) of 55 % (compared to a normal of 30%)
216 may be detrimental to rainbow trout by compromising oxygen transfer to tissue (Val et al.
217 2002). The impact of long-term polycythemia in trout has not been examined but a rise
218 in hematocrit is associated with an exponential rise in blood viscosity, and consequently
219 in the work that has to be performed by the heart (Wells and Weber 1991).

220

221 Many terrestrial vertebrate animals are homeothermic (maintain thermal homeostasis
222 primarily by regulating their metabolic rate) while fish (but also reptiles and amphibians)
223 are poikilothermic or ectotherms in which their body temperature is primarily controlled
224 by the external environment. The consequence of ectothermy is that metabolism varies
225 with temperature. Ectotherms also have more complex metabolisms than homeotherms
226 in that important chemical reactions in ectotherms may have 4-10 enzyme systems that
227 operate at different temperatures. In contrast, a homeotherm may have just one enzyme
228 system. The bioenergetic consequence of multiple enzyme system is unclear since little
229 research has been devoted to this area.

230

231 The differences between homeothermy and ectothermy are significant, and there are
232 advantages and disadvantages. Because metabolism is so variable in ectotherms they do
233 not easily support complex, high energy organ systems such as complex brains. But, for
234 the same body weight, fish need only 1/3 to 1/10 of the energy of homeotherms. This has
235 certain advantages in that all other factors being equivalent, feed conversion to flesh is
236 more efficient in fish than in mammals and other homeotherms.

237

238 A significant disadvantage to ectothermy is that animals may be more sensitive to
239 environmental disturbances than homeothermic animals. Rainbow trout appear to be far
240 more sensitive to such disturbances than homeothermic animals or plants. Terrestrial
241 homeotherms have lungs that while delicate, are maintained in a well protected body
242 cavity and receive relatively constant air supply with constant content of oxygen gas. In
243 contrast the breathing apparatus of rainbow trout (mouth, buccal pump, gills and
244 hemoglobin) is fragile and easily damaged by pathogens, toxins and suspended solids in
245 the water. The re-circulation of waste water or water from Clear Lake proper to the Snake
246 River Farm would cause damage to the respiratory structures of rainbow trout and would
247 be detrimental to fish production. Most importantly oxygen is often in short supply in the
248 aquatic environment compared to a terrestrial environment. The immune system of trout
249 while sophisticated is more primitive than and not as responsive as the immune system of
250 humans, cows or mice. For example, the trout immune system appears to be temperature
251 sensitive (Yamaguchi et al. 1980). Feral rainbow trout appear very sensitive to stress

252 which adversely affects their growth and survival. When rainbow trout are raised under
253 intensive commercial aquaculture conditions their sensitivity to even minor
254 environmental or management changes is magnified. The rainbow trout is also very
255 sensitive to various carcinogens and metal toxicities (Kotsanis and Illopoulou-
256 Georgudaki 1999; Daglish and Nowak 2002). For example, chronic exposure to arsenic
257 can cause liver hyperplasia and kidney fibrosis in rainbow trout. **Illustrative of the**
258 **exquisite sensitivity of rainbow trout is that the US Environmental Protection**
259 **Agency (EPA) uses the rainbow trout as one of their required test organisms in**
260 **whole effluent toxicity (WET) tests.**

261
262 As introduced above, rainbow trout have all of the basic organ systems that other
263 vertebrate animals have albeit theirs evolved to accommodate the challenges of an
264 aquatic environment. These organ systems and their functional interfaces would likely be
265 damaged by the re-circulation of waste water or Clear Lake water, or the use of any
266 contaminated water as proposed by the Ground Water Districts.

267
268 Circulatory system- The circulatory system of trout is designed to transport nutrients and
269 gases, hormones and wastes through the body. It consists of a four chambered heart
270 (sinus venosus, atrium, ventricle and bulbous arteriosus), extensive vasculature and a
271 blood flow path that takes de-oxygenated blood directly from the heart to the gills where
272 blood is re-oxygenated and waste CO₂ and ammonia removed.

273
274 Nervous system- While trout do have a primitive brain their nervous system seeks to
275 accomplish the same basic things a nervous system in human's does- to relay electrical
276 signals through the body. The nervous system directs behavior and movement and along
277 with the endocrine system, controls physiological processes such as digestion and
278 circulation. The brain of trout is divided into three basic sections but does not have a
279 neo-cortex thus fish cannot feel pain.

280
281 Digestive system- The digestive system consists of the mouth, esophagus, stomach, and
282 the intestine. Trout do not chew their food although they do have teeth for holding and

283 grasping prey. They also have a liver and pancreas that functions very similarly to that of
284 terrestrial vertebrates. In trout there are also pyloric ceca that function in digestion and
285 probably osmoregulation (Veillette et al. 2005). Taste buds are located in the mouth and
286 esophagus and may also occur on the skin.

287

288 Excretory system- A significant challenge for fish, as for all animals whether aquatic or
289 terrestrial, is to maintain water and dissolved solutes in the body in balance. This process
290 is called osmoregulation and it is an active, energy dependent process. Rainbow trout are
291 hyper-osmoregulators (Marshall and Grosell 2006) because they live in a dilute
292 environment where there is diffusive ion loss and osmotic water gain across the large
293 surface area of the gill epithelium. The sodium chloride (NaCl) content of their body
294 fluids is approximately 40% that of sea water (Evans 1987). The trout produces a large
295 volume of extremely dilute urine in a kidney specialized for electrolyte absorption. The
296 kidney of trout has numerous glomeruli and extensive renal tubules. The urine is not as
297 dilute as fresh water so some salt is lost. Salt lost must continually be replaced and this is
298 accomplished partly by food and partly by active, energy dependent, absorption of
299 chloride and sodium from the water by special cells on the gills variously called chloride
300 or mitochondria-rich cells (Marshall and Grosell 2006).

301

302 Reproductive system- The reproductive system consists of either female or male gonads.
303 At Clear Springs Foods only female rainbow trout are raised in production. The female
304 trout becomes sexually mature at a later age (2 years) than many males (1 yr) under
305 intensive culture. All female populations allow for greater uniformity in growth and
306 ensure consistent flesh quality at harvest, and are generally more bioenergetically
307 efficient because they are able to direct feed resources into somatic tissue development
308 rather than reproductive tissue.

309

310 Immune system- The immune system of trout functions fundamentally like that in
311 evolutionarily advanced vertebrates although there are some key differences. There is
312 both innate and acquired immunity. Innate immunity derives from all those elements
313 with which an individual is born and that are always present and available at very short

314 notice to protect the individual from foreign challenges. These elements include the skin,
315 mucous membranes and the cough reflex. In addition to these physical barriers there are
316 chemical influences such as pH, secreted fatty acids, the enzyme lysozyme, and serum
317 proteins such as β -lysin, various polyamines, kinins and complement. Granulocytes and
318 macrophages are also part of innate immunity. Acquired immunity, which only occurs in
319 vertebrate animals, is specific to a particular foreign challenge and it is only acquired
320 following an initial contact with the foreign challenge or immunogen. Initial contact
321 leads to the activation of lymphocytes and the synthesis of antibodies with specificity
322 against the foreign agent. By this process the individual acquires the immunity to
323 withstand and resist a subsequent attack by, or exposure to, the same offending agent.

324
325 The immune system of trout does have some additional important differences. For
326 example, blood forming tissue (erythrocytes and leukocytes) is principally located in the
327 interstium of the kidney and spleen rather than in bone marrow. The trout immune
328 system is also temperature sensitive and impacted by season (Yamaguchi et al. 1980).
329 Rainbow trout held at constant temperature are subject to seasonal suppression of
330 antibody responses suggesting that photoperiod still affects immunity. Similar to higher
331 vertebrate animals, the immune system is sensitive to the impacts of stress becoming
332 depressed if stress is acute or chronic. Stress causes many changes in the physiologic
333 systems of the body including those associated with tissue repair, phagocytosis
334 (engulfment), inflammation and the immune system (Ellis 1981). Stress modulates many
335 of the defense mechanisms in trout and higher vertebrates. Unfortunately this modulation
336 is most often injurious. In its most significant form stress (discussed further below)
337 induces the General Adaptation Syndrome (Selye 1950) that modulates the neuron-
338 endocrine system which in turn modulates the immune system. The impact of hormones
339 on lymphocyte function can be profound and adverse. For example stress appears to
340 depress phagocytosis by macrophages in rainbow trout (Narnaware et al. 1994). Stress
341 then sets the stage for enhanced susceptibility to disease and diminished growth. **In**
342 **recognition of the immune system depression associated with stress, fish health**
343 **managers strive to minimize stress and anticipate disease outbreaks within about**

344 two weeks of stressful events. They also strive to prevent the introduction of
345 pathogens into rearing systems in hopes of preventing infectious disease.

346

347 **Development of the immune system appears to occur gradually as the trout**
348 **matures.** While fry are capable of mounting a humoral immune response very early in
349 ontogeny (within 1 month), the ability to respond to different antigens develops
350 incrementally over time (Tatner 1986). Response to thymus dependent antigens appears
351 to develop later than to particulate (thymus independent) antigens. Part of the delay may
352 arise because processing of antigens may not be as efficient at the early life stages. By 3-
353 4 months of age the immune response to both thymus dependent and independent
354 antigens appears fully mature.

355

356 **Respiratory system-** The respiratory system consists of gills by which the fish breathes
357 water. When first hatched, the respiratory system appears rather rudimentary so much of
358 gas exchange may occur through the entire body. A swim bladder is also present in
359 rainbow trout and is used to maintain neutral buoyancy in water. Functioning similar to
360 gills, there is a counter current blood-gas exchange process (see below). Neutral
361 buoyancy helps reduce the amount of energy needed to swim.

362

363 **Endocrine system-** The endocrine system of trout, together with the nervous system
364 controls the physiology of the fish. They function to ensure homeostasis (maintenance of
365 a stable internal state) in response to many factors (both internal and external). The
366 endocrine system is generally organized like those in higher vertebrates although the
367 location, form or function may at times differ. For example *in lieu* of parathyroid glands
368 trout have Stannius corpuscles which are the source of hypocalcin involved in the
369 regulation of calcium and a urophysis which is important in controlling osmoregulation
370 (Matty 1985). Interrenal cells (generally located in the anterior part of the kidney in
371 association with the post-cardinal vein; Donaldson 1981) suffice for part of an adrenal
372 gland (adrenal cortex in mammals) that secretes the corticosteroids glucocorticoid
373 (cortisol) and mineralcorticoid (aldosterone) hormones. Glucocorticoids help maintain
374 blood pressure and respond to stresses. In excess glucocorticoids inhibit inflammation

375 and the immune system. Mineralcorticoid hormones impact the use of fats and protein.
376 The other equivalent part of an adrenal gland (adrenal medulla) in trout is the chromaffin
377 cells which line the walls of the posterior cardinal vein (Reid et al. 1998). Chromaffin
378 cells produce catecholamines such as dopamine, norepinephrine (noradrenaline) and
379 epinephrine (adrenalin). Cortisol and epinephrine are important hormones in response to
380 stress. Both exocrine and endocrine pancreatic tissues are present in trout but not as a
381 discrete organ. Exocrine pancreas is diffused throughout the adipose tissue that
382 surrounds the pyloric caeca. The exocrine pancreas produces digestive enzymes that
383 flow into the ascending intestine. Endocrine tissue (i.e. the islets of Langerhans) are
384 present in Brockman bodies located on the periphery of the kidney and at times near the
385 pyloric caeca. The pituitary is believed to be a significant controller of hormone activity,
386 just as in terrestrial vertebrates, but significant hormonal control may also occur through
387 the gills (Olson 1998). The gill itself may even be an endocrine organ.

388

389 **While all organ systems of the trout are essential, functionally interdependent and**
390 **affected by stress**, an understanding of some basics about gills may be most helpful for
391 ultimately appreciating the negative impact all of the mitigation proposals at issue would
392 have on rainbow trout aquaculture as conducted at Clear Springs Foods. The gills are
393 particularly important because of their intimate exposure to the aquatic environment and
394 their fragility and sensitivity to changes in that environment.

395 Water Breathing: Gill Physiology and Function

396 **The gills of rainbow trout play a central role in gas exchange, ion regulation, acid-**
397 **base balance and nitrogenous waste excretion** (Sardella and Branner 2007). They are
398 the “primary corridor for molecular exchange between the internal milieu of a fish and its
399 environment” (Olson 1996). Ammonia excretion occurs through the gills via a diffusion
400 gradient as does oxygen and CO₂. The gills also provide an internal regulatory function
401 through their ability to modify plasma hormones. The anatomy of the gills has been well
402 described by Olson (1996) so the anatomy will only be summarized here. The rainbow
403 trout has four pairs of gill arches (four arches per side) that are covered by a gill flap or
404 operculum. There are two rows of gill filaments on each gill arch. The number of

405 filaments in rainbow trout is not well documented but is approximately 100-140 per arch
406 (Shewmaker, personal communication). Each filament is covered by hundreds to perhaps
407 thousands of lamellae. Water is pumped by the fish during breathing from the buccal
408 cavity (mouth) to the opercular (gill) chambers. On each side of each gill filament are
409 rows of shelf-like respiratory lamellae where gas exchange and exchange of other
410 molecules takes place. The greater the number of filaments and the greater the number of
411 lamella, the greater is the surface area available for gas exchange. The lamellae, where
412 gas exchange via diffusion occurs, are very thin, only about 2 cells thick (mean of 6.37
413 μm ; Hughes 1984) and easily damaged.

414 **What makes the exchange via diffusion work most efficiently is a countercurrent**
415 **system.** The direction of blood flow in fish gills is opposite (countercurrent) to that of
416 water flow. The gradient of oxygen tension (difference in oxygen tension between the
417 fish blood and the surrounding water) is the driving force governing oxygen uptake
418 (Jobling 1994) but the oxygen concentration is sensed by the fish to help regulate how
419 much water must be pumped over the gills in order for the fish to obtain sufficient
420 oxygen. Thus water with relatively high oxygen tension is exposed to blood with
421 relatively low oxygen tension. The greater the differential, the more efficient is the
422 diffusion. The more efficient the diffusion, the more efficient is the trout. Even still,
423 only 30-45% of the total available oxygen is removed from water passing over the gill
424 due to constraints of diffusion, gill disease and other conditions (Jones and Randall
425 1978).

426 The vascular anatomy of the fish gill has also been well characterized (Olson 2002a;
427 Olson 2002b). There are three blood flow pathways in the lamella, an outer and inner
428 marginal channel and the lamellar sinusoid. The highly vascularized gills, extensive
429 surface area (filaments and lamellae) and very thin lamella optimize opportunity for gas
430 to diffuse in or out. Any factor, such as would be present in re-circulated waste water,
431 which diminishes these respiratory elements individually or collectively adversely affects
432 trout ultimately reducing production. For example, acid-base disturbances cause fish to
433 readjust transport mechanisms in the gills perhaps by manipulating the surface area of

434 branchial chloride cell surface area (Goss et al. 1994). The readjustment is energy
435 dependent.

436 The flux of oxygen from the water to the sites of consumption in fish tissue has been well
437 described by Nikinmaa and Salama (1998) and consists of the follows steps: (1)
438 **breathing movement continuously brings new oxygen molecules in contact with**
439 **lamella. (2) Oxygen diffuses down its tension gradient from the ambient water into**
440 **the capillaries of the gills. (3) Oxygen binds to hemoglobin in erythrocytes. The**
441 **amount of oxygen bound per unit volume of blood depends on the number of**
442 **erythrocytes, the prevailing oxygen tension, and the oxygen-binding properties of**
443 **the hemoglobin molecule. (4) Oxygen is transported in the bloodstream from the**
444 **gills to the sites of consumption. (5) In tissue capillaries, the tension of oxygen**
445 **decreases and consequently, oxygen dissociates from hemoglobin. (6) Oxygen**
446 **diffuses from the capillaries to the oxygen-requiring sites, mainly mitochondria,**
447 **within the cells.** Since the mitochondrial oxygen tension is very close to zero, the rate of
448 oxygen diffusion per unit area in a given tissue (with a unique diffusion coefficient for
449 oxygen) is the function of the diffusion distance between the capillaries and the
450 mitochondria and the oxygen tension of capillary blood. Factors that increase diffusion
451 distance or create barriers to diffusion, such as is associated with bacterial gill disease,
452 will be detrimental to the animal. Use of re-circulated waste water, Clear Lake water, or
453 any other contaminated water would likely lead to bacterial gill disease which create
454 barriers to gas diffusion which if extensive, would be catastrophic to individual fish or a
455 population of intensively reared fish.

456 Hemoglobin, present in erythrocytes, greatly increases the carrying capacity of oxygen,
457 carbon dioxide (CO₂), and hydrogen (H⁺) in blood (Jenesen et al. 1998). Various
458 molecular and cellular control mechanisms account for hemoglobin's remarkable
459 properties and these have been reviewed in a variety of texts (e.g. Perry and Tufts 1998).
460 These mechanisms include various allosteric interactions between binding sites,
461 conformational changes and multiple functions of hemoglobin. Hemoglobin is for
462 example subject to Bohr, Root and Haldane effects which result in shifts in oxygen
463 binding properties enabling oxygen to be unloaded at appropriate times and CO₂ to be

464 bound for release into the water by the gills. What is critical is that these essential
465 molecular control features are subject to disturbances that adversely impact oxygen
466 carrying capacity and oxygen delivery to tissues. **Where these disturbances are**
467 **significant, as would occur with re-circulated waste water, less oxygen is present to**
468 **nourish tissues resulting in diminished fish growth and injury.**

469 Environmental and internal factors can cause the oxygen dissociation curves to shift to
470 the right or left (lowering or raising the oxygen affinity, respectively; Heath 1987). For
471 example as pH is lowered, or the CO₂ is raised, the oxygen dissociation curve shifts to the
472 right causing the hemoglobin oxygen-carrying capacity to be decreased. **This has broad**
473 **implications for the survival of fish, bioenergetics and ultimately over-all fish**
474 **production.** It is common to see blood acidosis (lower blood pH) in fish exposed to
475 hypoxia. Decreased delivery of dissolved oxygen in flow-through aquaculture facilities
476 occurs whenever water is used, re-circulated or an interrupted supply occurs. This causes
477 injury to fish production capacity. While we cannot be certain of the extent of
478 disturbance, the catastrophic consequences could be great and do not justify the risk
479 associated with re-circulation of waste water or use of other contaminated water sources.

480 The epithelium of the gill filament is composed of five major cell types including
481 squamous pavement cells, mucous cells, heavily innervated neuroepithelial cells,
482 accessory cells and chloride or mitochondrial-rich cells (Evans 1987). The epithelium of
483 the lamellae (sometimes referred to as secondary lamellae) consists of two major cell
484 types- the superficial cells and the basal cells that replace the superficial cells over time.
485 **It is crucial to fish survival and fish production that these complex and vital cell**
486 **systems be kept intact and function efficiently.** Research now indicates that while
487 reserve capacity exists in fish for gas exchange, detrimental effects occur to other gill
488 functions (e.g. osmoregulation or ammonia nitrogen excretion) if the gills are
489 compromised by disease or exposure to toxic elements. For example, damage to the gill
490 from bacterial gill disease or other agents may adversely impact blood pressure regulation
491 in trout (Hoagland et al. 2000). Exposure of rainbow trout to copper (e.g. copper sulfate)
492 appears to adversely affect osmoregulation and ammonia excretion (Lauren and
493 McDonald 1985).

494 Early Life Stages

495

496 Early life stages are generally most sensitive to stress and disease. These stages include
497 the egg, larvae or alevin, fry, fingerling and sub-adult.

498

499 Egg- Building an animal with distinct organs requires the coordination of cell identity
500 and cell behavior during embryogenesis. This makes the fish egg highly sensitive to all
501 kinds of low-level environmental changes to which it might be exposed (von
502 Westernhagen 1988). It is the earliest embryonic stages (before gastrulation) that are
503 more vulnerable than embryos that have completed gastrulation. Salmonid eggs are
504 relatively large and well known to require high concentration of dissolved oxygen
505 (Pennell et al. 2001). This is attributed to a demanding surface to volume relationship.
506 Dissolved oxygen must enter the egg via simple diffusion. The greatest demand for high
507 concentrations of dissolved oxygen occurs just before hatching. **Rainbow trout eggs**
508 **are most sensitive to nitrate toxicity compared to later life stages** (Kincheloe et al.
509 1979). A variety of environmental and stress factors are also known to impact teleost
510 reproduction (Billard et al. 1981). Adverse brood stock feeding, temperature and water
511 quality can also cause low fertilization and hatching rates.

512

513 Yolk-sac or alevin- the single most sensitive life stage in the fish life-cycle is the yolk-sac
514 or alevin stage (von Westernhagen 1988). At this stage organs are developed but just
515 barely. The alevin gut is present but not functioning. Nutrition occurs via absorption of
516 the nutrient rich yolk. When the yolk is nearly used, the alevin's behavior changes from
517 negative geotropism and avoidance of light to that of swimming upward into the water
518 column. It is at this time that the swim bladder is filled by swallowing air (Tait 1960),
519 learn to feed and deal with conspecific rivals. The gills of alevin are only poorly
520 developed and hence very susceptible to challenge from toxins and bacteria that may
521 cause gill disease. At this stage of development oxygen diffuses in via both the gills and
522 the skin. The lateral line, important for mechanoreception, develops sometime after
523 hatching (Blaxter 1988). If these sensitive life stages are exposed to any of a number of
524 possible stressors, development would be imperiled and massive death occur.

525 Fry- once the yolk sac has been absorbed the fish is called a fry. At this stage the trout is
526 able to take feed. The majority of biological traits, including physiological rates, are size
527 dependent (Jobling 1994). While large fish generally consume more oxygen than small
528 fish, small fish on a unit-weight basis, consume more oxygen. This occurs because the
529 metabolic rate of the smaller fish is greater than the larger fish. Once the fry stage is
530 complete fish are referred to as fingerlings and then sub-adult.

531
532 **At hatching through to the next 3 months of life (fry through fingerling) the young**
533 **fish are immunologically less developed.** They are consequently immunologically
534 naïve and have not developed significant immunity to common pathogens. It is at this
535 stage that trout are most susceptible to both infectious and non-infectious diseases.
536 Indeed it is at this stage that trout are most susceptible to IHNV, one of the most
537 problematic diseases affecting rainbow trout (Groff and LaPatra 2000).

538
539 Bioenergetics

540
541 How fish utilize high energy- nutrient dense food fed in today's commercial fish farms is
542 critical to the financial success of the fish farms. Feed costs typically account for 60-80 %
543 of the total cost of production (Westers 2001). **The primary aims of fish farming are**
544 **to maximize fish survival and growth at minimal cost** (Knights 1985).

545 **Unfortunately, all of the mitigation proposals from the Ground Water Districts will**
546 **decrease fish survival, decrease growth and production capacity, and increase**
547 **production costs.**

548
549 Fishes, like all organisms, use ingested food resources (C) as building blocks in the
550 synthesis of tissues (production, P) and as fuel in the metabolic processes that power this
551 synthesis and other physicochemical work (R) (Calow 1985). Physicochemical work is
552 commonly referred to as metabolism. Some of the resources introduced in feed are lost
553 as waste products (E). All biological systems obey the laws of thermodynamics so the
554 flow of food resources can be summarized as follows:

555
$$C = P + R + E$$

556 Metabolism can be dissected into a number of subcomponents: standard metabolism (R_S)
557 which is the metabolism of an animal at rest; routine metabolism (R_R) which is the
558 animals metabolism when routinely active; feeding metabolism (R_F) which is the
559 metabolism of the animal just after feeding (sometimes known as specific dynamic action
560 or effect), and active metabolism (R_A), which is the metabolism of the animal undergoing
561 sustained activity (e.g. swimming). Thus

$$R = R_S + aR_{R-S} + bR_{F-S} + cR_{A-S}$$

562
563
564 where a , b and c are constants expressing the fraction of time that each type of
565 metabolism is used. P represents both somatic (P_g) and/or reproductive components (P_r).
566 Both somatic growth and development of reproductive components are important to
567 Clear Springs Foods, but at Snake River Farm complex the focus is on maximizing
568 somatic growth. That is why only female fish are raised at our farms. Female fish are
569 used because of flesh quality concerns associated with sexual maturity and the need to
570 focus feed resources on somatic growth (i.e. flesh) rather than reproductive products.
571 Sexual maturity of rainbow trout generally occurs at 2 yrs of age in female rainbow trout
572 while male trout may become sexually mature at 1 yr of age. Clear Springs Foods
573 harvests fish generally from 10-16 months of age. By using female fish and harvesting
574 by about 16 months of age we minimize food resource diversion by individual trout into
575 reproduction. Finally E consists of feces (F), urea and ammonia (U), and miscellaneous
576 secretions such as mucus (Muc) (Calow 1985). Thus, the equation representing the
577 disposition of ingested food resources becomes:
578

$$C = (R_S + aR_{R-S} + bR_{F-S} + cR_{A-S}) + (P_g + P_r) + (F + U + Muc)$$

579
580
581 Since food resources are finite (there is only so much food a fish can eat) and the
582 resources available for allocation in the fish are finite, resources used in one aspect of
583 metabolism will not be available for use in others. For the intensive production of
584 rainbow trout, it is essential that somatic growth be emphasized since that means more
585 muscle mass for sale. Factors that shift resources away from somatic growth are
586

587 detrimental to commercial food fish production. Such detrimental factors include, but are
588 not limited to, stress, physiological shifts needed to maintain homeostasis, adaptation to
589 new environmental or inconstant environmental conditions, pathogen challenge, and
590 chronic infections. All of these factors would likely be present with the mitigation
591 proposed by the Ground Water Districts.

592

593 Since fish are dynamic systems involving inputs and outputs which are constantly
594 changing, none of the symbols in the bioenergetic equations above are constants. As
595 conditions deviate from optimum, fish must expend more energy to compensate and
596 maintain homeostasis which diminishes the energy that can be devoted to growth. Many
597 abiotic factors that affect rates of food consumption and metabolism may be expected to
598 have a profound influence on the growth of fish. The fish farmer's task is to enable fish
599 to display rates of growth that approach the full physiological potential of the fish. Thus,
600 it is essential that stresses and stressors are minimized. At Clear Springs Foods, selective
601 breeding of rainbow trout has focused genetic resources on somatic growth resulting in
602 about a 50% improvement in growth rate of our trout over time. **The physiological**
603 **potential of Clear Springs Foods selectively-bred rainbow trout has been**
604 **significantly improved compared to wild or other domestically raised rainbow trout.**
605 **All of the proposed mitigation projects would be detrimental to the expression of**
606 **these selected characteristics and would be unacceptable.**

607

608 The metabolic rate of fed fish are higher than those of fish deprived of food, and regular
609 provision of food can lead to rates of metabolism being maintained well above those
610 recorded for unfed fish (Jobling 1994). There is a well established post-prandial
611 increase in the rate of oxygen consumption. The increase in oxygen consumption is
612 readily evident in 24 hr measured dissolved oxygen concentrations in raceways. The
613 increase is generally 2-3 times the pre-feeding level. The peak usually occurs within a
614 few hours after the end of a meal, and the metabolic rate then gradually declines to the
615 pre-feeding level. The post-prandial increase in metabolic rate results from the energy
616 requirement for the digestion, absorption and storage of nutrients, for the deamination of
617 amino acids and synthesis of excretory products, and for the biosynthesis, turnover and

618 deposition of tissue components (Jobling 1994). While feeding is going on, the
619 homeostatic work of the fish must continue. It is at feeding and during post-prandial
620 elevation in metabolism that fish are probably most sensitive to stress.

621

622 **Much of this report identifies factors or processes that injure the production**
623 **capacity of the Snake River Farm. The mitigation efforts proposed by the Ground**
624 **Water Districts each, or collectively, will cause decreased fish production capacity.**
625 **In addition, re-circulating waste water will significantly increase fish morbidity and**
626 **mortality. All the mitigation proposals will be detrimental to the realization of the**
627 **physiological potential of Clear Springs Foods selectively bred rainbow trout.**

628

629 Stress

630

631 All species of fish are designed by natural selection to live in a certain optimum
632 environment (Priede 1981). Indeed, organisms live within a limited range of conditions
633 due to evolutionarily optimized structural and kinetic coordination of molecular, cellular,
634 and system processes. While individual cells or molecules may function well under a
635 variety of physiologic conditions, the increasing complexity of organs, organ systems and
636 their interdependence to form the animal create functional constraints (Pörtner and A. P.
637 Farrell. 2008). What is evolutionarily optimum for one species may not be optimum for
638 another. For example channel catfish have a wider temperature and dissolved oxygen
639 tolerance than do rainbow trout. Presumably the environment in which channel catfish
640 evolved was more variable than where rainbow trout evolved.

641

642 Yet, fish even under the best of conditions, live under dynamic chemical and physical
643 conditions (Wedemeyer and McLeay 1981). Fish are continually impacted by the normal
644 demands of the aquatic environment. Fish must physiologically work to maintain
645 homeostasis (i.e. physiologic stability) to accommodate this environmental dynamism
646 and are successful up to a point- as long as the limits of accommodation are not
647 exceeded. **As the fish works to maintain homeostasis, there is an energy drain (Lugo**
648 **1978), loss of adaptability and a reduction of performance capacity (Schreck 1981).**
649 Superimposed on the routine stress of living in the normal chemical and physically

650 dynamic aquatic environment, fish in intensive aquaculture are exposed to even more
651 adverse conditions from operating procedures such as handling, crowding, grading,
652 competing at high population density, consumption of high energy-nutrient dense feeds,
653 high concentrations of pathogens and disease treatments, and decline in water quality
654 associated with high population density and water use (Wedemeyer and McLeay 1981).

655 **The challenge for fish producers is to control and/or minimize the stresses that can**
656 **be controlled and seek to accommodate stress that cannot be readily controlled.**

657 **Water quality, management practices, feed, fish pathogens and disease, and disease**
658 **treatments are examples of stresses that can be controlled.**

659

660 Environmental conditions which can debilitate but are not necessarily lethal when they
661 occur singly, include exposure to low concentrations of aquatic contaminants, unionized
662 ammonia, nitrite, carbon dioxide (especially in recirculating systems), unfavorable
663 temperatures, hypoxia, atypical light levels, total suspended solids, physical trauma, and
664 population densities in hatcheries dictated more by production goals than by biological
665 considerations (Wedemeyer and McLeay 1981; Piper et al. 1982). All of these, singly or
666 together, can impose a considerable load, or stress, on homeostatic mechanisms of the
667 fish. While fish farmers most often focus on the whole animal in fact, not only can the
668 fish as a whole organism be stressed, but the diverse complement of individual cells in
669 the fish as well. As the internal milieu changes, a cell must continually adapt to maintain
670 their viability (Kedersha and Anderson 2002). In response to stress cells continually
671 modify the repertoire of proteins they synthesize. These proteins affect individual cells
672 and ultimately the entire animal.

673

674 Stress that exceeds physiological tolerance limits will be lethal. **Use of re-circulated**
675 **waste water will be lethal to early life stages of fish raised at Snake River Farm. Use**
676 **of re-circulated waste water could be lethal but will most assuredly damage and**
677 **impair the growth and quality of later life stages. Use of other spring or ground**
678 **water of inferior quality to what is currently used would also impair growth. Less**
679 severe stress, that is acute or chronic, will load or limit physiological systems thereby
680 reducing growth and predisposing the fish to infectious diseases if pathogens (the cause

681 of infectious disease) are present (Wedemeyer and McLeay 1981; Pickering 1981).
682 Stress also reduces the capacity of a fish to accommodate additional stress (Schreck
683 1981). The recovery time from stress depends upon the severity and duration of the
684 initial stress (Schreck 1981). As discussed previously in the bioenergetics section, stress
685 shifts the distribution of energy and food ingredients (e.g. protein and energy) resources
686 away from somatic growth into self-preservation.

687
688 At some physiological point, sufficient stress can occur to induce a distinct stress
689 response in which hormones are released that cause a coordinated cascade of physiologic
690 changes. This is commonly known as the General Adaptation Syndrome (GAS) first
691 proposed by Hans Selye (1950). The GAS is also known as the “stress response.”
692 Wedemeyer and McLeay (1981) define primary, secondary and tertiary alterations
693 associated with the “stress response.”

- 694 • Primary alteration
 - 695 ○ Release of adrenocorticotrophic hormones from the adenohipophysis (part
 - 696 of the pituitary gland)
 - 697 ○ Release of “stress hormones” (catecholamines and corticosteroids) from
 - 698 the interrenal tissues
- 699 • Secondary alterations
 - 700 ○ Blood chemistry and hematological changes such as hyperglycemia,
 - 701 hyperlactemia, hypochloremia, leucopenia, and reduced blood clotting
 - 702 time.
 - 703 ○ Tissue changes, such as depletion of liver glycogen and interrenal ascorbic
 - 704 acid
 - 705 ○ Metabolic changes such as a negative nitrogen balance, and oxygen dept.
 - 706 ○ Diuresis with resultant blood electrolyte loss
- 707 • Tertiary alterations
 - 708 ○ Impaired growth and spawning success
 - 709 ○ Increased disease incidence (infectious and non-infectious)
 - 710 ○ Death several weeks after the stress with no apparent warning (Mazeaud
 - 711 and Mazeaud 1981).

712 The sensitivity of a trout to stress is dependent on a variety of factors. Fundamentally the
713 primary response, i.e. the adrenergic response, is simply very sensitive. Stress thus
714 results in an increase in the plasma concentration of catecholamines very fast (Mazeaud
715 and Mazeaud 1981). In the rainbow trout the concentration of catecholamines (adrenaline)
716 can rise several hundredfold within a few minutes (Matty 1985). Following an acute
717 stress in salmonids it may take several days before the concentration of adrenalin goes
718 back down to "normal" levels. The secondary alteration associated most often with the
719 adrenaline rush following acute stress is an alteration in osmoregulation. Chronic stress,
720 if of sufficient magnitude, can induce long-term elevation in plasma adrenaline with long
721 term implications to growth and fish performance. Some stresses may not be of
722 sufficient magnitude to induce a "stress response" characterized by the release of
723 catecholamines and corticosteroids. For example respiratory dissolved oxygen stress or
724 CO₂ stress responses may be primarily mediated by a neural pathway, without elicitation
725 of hormones (Hughes 1981). These types of stress can be more readily accommodated
726 by the fish by increased ventilation or breathing rate. **Various aspects of**
727 **accommodation have been reviewed by Fontaine (1993). While stress that induces**
728 **the need for accommodation may be tolerable, it causes increased expenditure of**
729 **energy with subsequent diminishment in protein accrual and hence decreased**
730 **growth of somatic tissue.**

731

732 The intensification of salmonid culture and the consequent rearing of fish in man-made
733 environments have resulted in the fish being exposed to a number of stresses which they
734 do not experience at all in the natural environment or do not experience to the same
735 degree. One category of stress occurs as a consequence of the artificial environment
736 itself and can include such factors as temperature, rate of change of temperature, salinity
737 change, stocking density, abrasion, oxygen concentration, free ammoniac concentration,
738 pH and water velocity (Donaldson 1981). Donaldson (1981) states further that
739 salmonids in particular are sensitive and responsive to those stresses mediated by the
740 hypothalamic-pituitary-interrenal (HPI) axis.

741

742 Wedemeyer and McLeay (1981) identify additional environmental stressors that are
743 debilitating to both warm and cold water fishes. Among the stressors they identify are
744 dissolved oxygen less than 6 mg/L at temperatures of 10-15° C, crowding, chronic low
745 oxygen (4 mg/L), particulate matter in water and unionized ammonia concentrations of
746 0.02 mg/L or greater.

747

748 There appear to be a number of consequences of stress in addition to the consequences of
749 stress mentioned above. Lesel (1981) reports that stress causes a change in the digestive
750 tract microflora of fish and accelerates the passage of material through the entire
751 digestive tract. This may decrease the availability of nutrients to the fish from otherwise
752 good feed. van de Salm et al. (2002) provide evidence that exposure to stressors leads to
753 multiple changes in the skin epithelium which are mediated by cortisol. In addition stress
754 of upstream rainbow trout may impact downstream fish. Tao et al. (2004) demonstrated
755 that conspecifics exposed to stressed trout skin or trout skin extract caused elevated
756 cortisol levels in non-stressed fish.

757

758 Biology of Disease

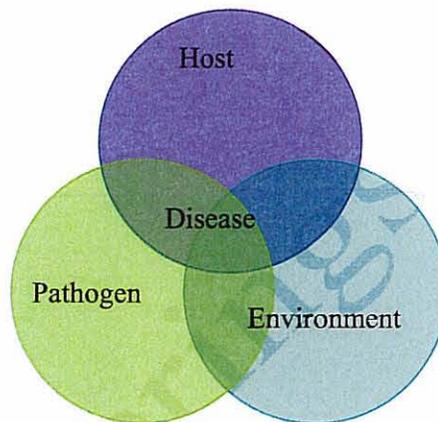
759

760 **The rainbow trout's tolerance of adverse influences is limited by the ability of its**
761 **cells, organs, organ systems, and the whole fish to sustain injury. Whenever the**
762 **cells, organs, organ-organ systems, and whole fish adaptive capability is overtaxed,**
763 **damage results. Such damage may be sublethal and permit recovery, or more**
764 **intense or prolonged, resulting in death. The adapted, the sub-lethally injured, and**
765 **the dying animal are merely stages in a continuum of progressive encroachment on**
766 **the animals homeostasis.** For the trout farmer, all challenges to homeostasis are
767 important because they impact fish performance and ultimately profitability. Adaptation
768 is an energy demanding process that diminishes feed conversion efficiency and reduces
769 overall production capacity. Sublethal injury further diminishes fish performance and
770 profitability. Management efforts by the fish farmer to prevent mortality of compromised
771 fish, including use of drugs, can be very costly. Prematurely dead trout (i.e. death not
772 occurring at the processing plant) reduces overall profitability and may ultimately result

773 in loss of customers dependent on a reliable supply. The closer to optimum the farmer
774 can manage the production environment, the close to maximum profitability.

775

776 While disease is part of a continuum of cellular and whole organism physiologic efforts
777 to maintain homeostasis, it is also the result of an interaction between the host, pathogen
778 and environment (Sneiszko 1974). A convenient way to envision that interaction is with
779 the venn diagram below.



780

781 **A susceptible host is of course essential for disease. A fish at its physiologic**
782 **optimum is far less likely to suffer disease than a fish physiologically compromised.**

783 Considerable research (e.g. Wedemeyer and McLeary 1981; Ellis 1981) indicates that
784 fish subjected to sufficient stress that activates the General Adaptation Syndrome (above)
785 are likely to succumb to diseases such as Motile Aeromonas Septicemia or develop
786 disease from various fungi. Even stress that does not invoke the GAS may compromise
787 the host making it more susceptible to pathogenic bacteria or the sequelae associated with
788 mild viral infections. **The environment then becomes an important element in**
789 **disease because the environment often determines the extent of physiologic work the**
790 **host must exert to accommodate.** The environment can be the direct source of toxins

791 (e.g. arsenic, copper, zinc, KMnO_4 , un-ionized ammonia), of physical factors such as
792 temperature, gas bubbles or suspended solids, or of factors that compromise normal
793 physiologic function (e.g. nitrite that causes methemoglobinemia). **Finally, a suitable**
794 **pathogen is required. Not all pathogens are equally as virulent or able to cause**
795 **disease.**

796

797 While disease can occur without a pathogen, of particular challenge in intensive
798 aquaculture is the prevalence of a variety of potential pathogenic organisms. The
799 pathogens may be opportunistic (e.g. *Aeromonas hydrophila*, *Flavobacterium*
800 *psychrophilum* and *Trichodina spp.*) or obligate (e.g. infectious hematopoietic necrosis
801 virus- IHN or *A. salmonicida*, the cause of furunculosis). Obligate parasites may also
802 infest rainbow trout such as *Ichthyophthirius multifiliis* and *Myxobolus cerebralis*. The
803 bacteria associated with bacterial gill disease may be obligate (*F. columnare*) or
804 opportunistic (various yellow pigmented bacteria and *A. hydrophila*). There are also
805 pathogens of indeterminate nature. These include *Ichthyobodo* and *Ichthyophonus*. With
806 the exception of *M. cerebralis*, all of these pathogens, as well as others are endemic in the
807 1000 Springs aquaculture industry and at Snake River Farm. What varies is that the
808 abundance and concentration of pathogens increases with serial use. Fortunately, the
809 mere presence of a pathogen in or on a fish does not necessarily lead to disease (Groff
810 and LaPatra 2000). The host must be susceptible (e.g. stressed) and an environment
811 suitable for pathogen survival and inimical to the host may need to be present.

812

813 Biosecurity

814

815 **Stress (such as from pathogens) to the extent it is introduced by man is**
816 **unacceptable. For example, the movement of fish pathogens within rearing units or**
817 **farms is controllable if proper precautions are taken. Use of re-circulated waste**
818 **water or mitigation water from whatever the source containing pathogens is**
819 **unacceptable.** Infectious diseases inevitably occur in aquaculture but the risk of
820 pathogen transfer can be minimized through an Integrated Pest Management Plan (IPM)
821 (LaPatra and MacMillan 2008). An IPM includes various biosecurity measures,

822 surveillance for early detection of pathogens or disease, timely treatment, and the use of
823 various nonchemical methods of reducing disease incidence. Non-chemical methods
824 include proper selection of fish, use of vaccines, pathogen vector control, site fallowing
825 and stock management to break pathogen life-cycles (LaPatra and MacMillan 2008).

826

827 Because fish pathogens can significantly impact intensive aquaculture profitability and
828 there are few effective treatments for most diseases affecting rainbow trout, considerable
829 management effort is directed at biosecurity at Clear Springs Foods. Much of this
830 management effort is focused on avoiding the introduction and the movement of
831 pathogens. At Clear Springs Foods Snake River Farm an IPM has been implemented.
832 Fundamentally only spring water is used. Spring water is largely free of most potential
833 fish pathogens because, depending on where the springs originate, there are no fish that
834 might harbor pathogens present. Water is not re-circulated or inter-mingled. Water is
835 used (see diagram in flow-through aquaculture section) in a linear series of raceways to
836 ensure immuno-competent fish are the ones most likely exposed to pathogens. **At**
837 **subsequent use raceways fish loading and feeding rates are also reduced in**
838 **recognition of the additional stress from diminished water quality those fish are**
839 **subject to.** Water is maintained in a single raceway series, it is not intermingled thus
840 limiting opportunity for farm-wide epizootics. A bird exclusion cage completely
841 surrounds Snake River Farm. Predator control measures are in place. Nets and hauling
842 equipment are disinfected. Visitors are excluded from most sensitive rearing areas such
843 as the Hatch House. Hand washing and foot bath disinfections prior to nursery (hatch
844 house) entry is mandatory. Water used in the hatch house is only first-use spring water.
845 Any eggs used in production are inspected and certified pathogen free. The spring water
846 source is covered so there is less opportunity for contamination. Early life stages are
847 reared in the best, most pathogen free water available (i.e. first use). Feed is
848 manufactured using heat and pressure to eliminate potential fish pathogens.

849

850 Not only are pathogens a focus of biosecurity concern but chemicals and toxins as well.
851 There are many chemicals that can be inadvertently or purposefully introduced into water
852 supply or feed that could harm fish or cause them to be unsafe for human consumption.

853 Some chemicals are acutely toxic causing death within a very short time while others are
854 more chronic adversely impacting fish health over a long time period. Some chemicals
855 could bio-accumulate over time if there were periodic exposure. These issues are very
856 similar to those of concern to public drinking water suppliers albeit the rainbow trout may
857 be even more sensitive than humans depending on the particular poison.

858

859 Because of these biosecurity concerns Clear Springs Foods instituted a concerted effort to
860 improve security and reduce potential access to spring water feeding the Snake River and
861 Clear Lakes Farms. Clear Springs Foods now owns and controls much of the access to
862 the talus slopes (up to the canyon rim on the north side of Clear Lake Road) from which
863 the springs are believed to emanate. Additionally Snake River Farm complex spring
864 water collection is covered to further limit access to spring water by unauthorized
865 individuals. **Clear Springs Foods would oppose any delivery of water that is not**
866 **similarly secure from unauthorized access.**

867

868 Selective Breeding at Clear Springs Foods

869

870 Rainbow trout used in aquaculture have been domesticated for over 100 years (Gall and
871 Crandall 1992). Clear Springs Foods has been selectively breeding its strain of rainbow
872 trout for over 23 years (since 1985). Selective pressure has focused on growth rate with
873 co-selection for disease resistance (IHN and cold water disease). The selection and
874 grow-out of each generation has occurred at the Snake River Brood Operation housed at
875 the Research and Development Station (part of the Snake River Farm Complex). Water
876 supplied to this facility is first use spring water. All hatching and rearing has occurred in
877 this water since the breeding program began. It is essential that that continue. Water
878 quantity available to the Snake River Farm Complex has steadily declined over time
879 necessitating continued diminishment of water flow to the brood stock and research
880 programs located at the Research Division facility. This decline causes more stress on
881 sensitive life stages. It is known that an animal's robustness, adaptability, and resilience
882 arise within the context of environmental, genetic, biochemical and morphological
883 elements of the animal and environment. Selection for fast growth under these

884 conditions gives rise to an integrated organism response. **It is essential for the success**
885 **of this program that water flows do not diminish further and that use of pristine**
886 **spring water is maintained.**

887
888 Vaccination at Clear Springs Foods

889
890 Clear Springs Foods relies heavily on the use of various vaccines as it attempts to manage
891 aquatic animal health. Vaccines have potential to prevent infectious disease as long as
892 other factors do not compromise their efficacy. As discussed above and below, various
893 environmental conditions, environmental constancy, stress factors (physiologic and
894 operational), and immunologic competency all impact vaccine efficacy. These vaccines
895 are developed by Clear Springs Foods scientists and are manufactured at the Clear
896 Springs Foods Research and Development Center. Clear Springs Foods produces
897 autogenous vaccines that are only used at their own farm operations. Vaccines of
898 variable effectiveness have been developed for enteric redmouth disease, IHN disease,
899 and coldwater disease. Of the three, the most effective is for ERM disease.

900 **Recirculation of waste water will diminish vaccine efficacy. Interrupted water**
901 **delivery will stress early life stages and impair vaccine efficacy. Decreases in water**
902 **quantity will also impair vaccine efficacy by causing additional stress. Decreased or**
903 **intermittent water supply will adversely impact existent research programs devoted**
904 **to development of effective vaccines and selective breeding.**

905
906 **IV. Determinant's of Fish Production Capacity and Negative Consequences of**
907 **Mitigation as Proposed**

908
909 **A. Why 1000 Springs for production of rainbow trout?**

910
911 The foundation for rainbow trout production in the US was well established by about
912 1870 (Stickney 2001) but such production was directed at fishery conservation. Fish
913 production for fishery conservation purposes (stocking in public waters) is less intensive
914 than commercial food fish production such that physiologic demands on the fish are
915 generally less. Additionally conservation fishery fish culture typically produces a batch
916 or single cohort of fish while commercial production typically relies on a continuous,
917 sequential, multiple cohort production program (Westers 2001). Commercial rainbow

918 trout production, particularly in the 1000 Spring's area did not begin until about 1928
919 when C.S. (Jack) Tingey (reported as either a former Secretary of State for Utah, a
920 Conservation Officer, or both) started the Snake River Trout Company (currently owned
921 and operated by Clear Springs Foods, Inc.). The reason the Snake River Trout Company
922 was started is conjecture but IDWR (1975) suggests it was because of an abundant water
923 supply, water quality, and proximity to market. An earlier attempt at commercial
924 rainbow trout production occurred in 1910 when a farm was started at Devil's Corral
925 Spring near Shoshone Falls but this venture did not last long due to poor market
926 conditions. **An aquaculture development time-line is attached (Exhibit "2").**

927

928 **Application of the scientific method to unravel the limits and factors enabling**
929 **intensive fish farming is ongoing but did not begin until about 1930-1940** when joint
930 research conducted at New York State Laboratory and the Hagerman Tunison Laboratory
931 (now the University of Idaho Hagerman Aquaculture Experiment Station) developed a
932 dry feed formulation that replaced those originally made from animal carcasses. In the
933 early 1940's dry diets were first tested at Tupper's Trout Farm in Hagerman. In the
934 1950's David Haskell with the New York Fish Conservation Department first applied
935 analytical investigation to the art of flowing water fish culture (Soderberg 1995). He
936 provided a quantitative approach to the definition of chemical and biological parameters
937 affecting fish in confinement and allowed fish culture to progress from art to science.

938

939 The early Idaho trout aquaculture pioneers had fortuitously established rainbow trout
940 aquaculture in the 1000 Springs area not knowing that it provided the ideal location for
941 commercially intensive rainbow trout production. Today Idaho in the 1000 Springs area
942 produces approximately 70% of all the rainbow trout produced in the US for human
943 consumption (Fornshell 2002). The large volume of gravity fed, essentially pristine
944 spring water at nearly constant water temperature (58° F) 24 hours per day, seven days a
945 week with little short-term fluctuation in flow and saturated with dissolved oxygen is
946 now known to provide the optimum environmental conditions for maximal rainbow trout
947 production using flow-through fish culture techniques. That and the continued

948 development of scientific understanding about rainbow trout and trout aquaculture allow
949 aquaculture to prosper in Idaho.

950

951 **The scientific understanding of rainbow trout physiologic needs, how those needs**
952 **vary with life stage, and development of efficient feeds allows determination of fish**
953 **farm carrying capacity and permissible stocking density. The goal of intensive,**
954 **high-density aquaculture is to maximize carrying capacity (Clark 2003). Carrying**
955 **capacity is the maximum permissible loading rate (fish weight per unit of water flow) that**
956 **results in effluent dissolved oxygen at the predetermined minimum allowable oxygen**
957 **tension (Soderberg 1995; Procarione 1999). In Idaho fish farms must comply with State**
958 **water quality standards. Dissolved oxygen must be discharged to public waters at 6 mg/L**
959 **or greater. Fish density is primarily dependent on volume of water flow because flow**
960 **determines the amount of oxygen available for fish respiration and the degree of**
961 **metabolite dilution. The maximum permissible density (fish weight per volume unit of**
962 **rearing space) is determined by the hydraulic characteristics of the rearing unit (e.g.**
963 **raceway) and the physical, physiological and behavioral spatial requirements of the fish.**
964 **Environmental factors that deviate from spring water quality (including water volume)**
965 **and reliability diminish a fish farms carrying capacity and maximum permissible loading**
966 **rate and fish density, and diminish the utility of water associated with Clear Springs**
967 **Foods water rights. Because pumping waste water, or pumping spring or ground**
968 **water cause all of these things, it is unacceptable.**

969

970 **B. Flowing water fish culture**

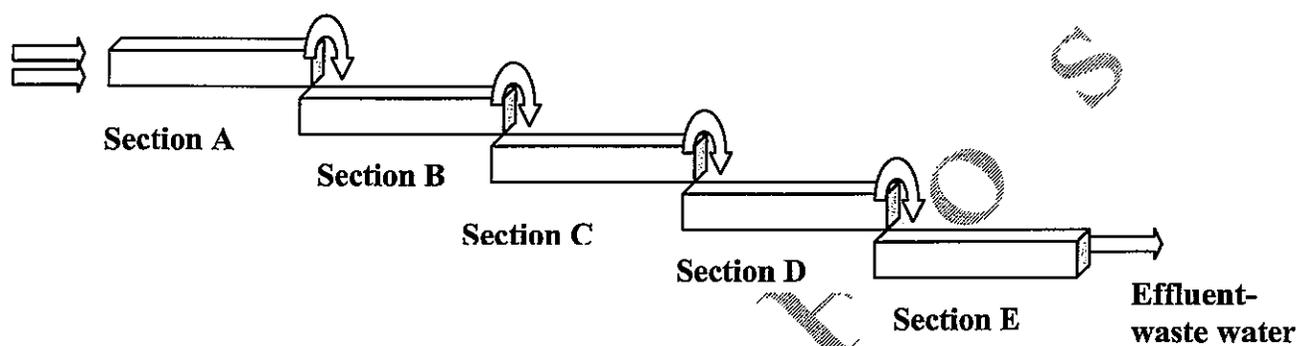
971

972 Many texts describe the intricacies of aquaculture production systems including flowing
973 water fish culture techniques (e.g. Piper et al. 1982; Soderberg 1995; Black and Pickering
974 1998; and Wedemeyer 2001). In this part of the report I will only describe the general
975 process of flowing water aquaculture because it has relevance for understanding how
976 water quality changes with use. Flowing water systems afford the greatest control
977 compared to other types because they allow for quantitative analysis of production
978 capacity based on water quality measurements and amount of waste generated (Westers

979 2001). Because rainbow trout are sensitive to water quality conditions compared to many
980 other types of fish, such control is critical. **Use of waste water or water of suspect**
981 **water quality is consequently not acceptable.**

982
983

Over-view of Flow-through System at Snake River Farm



984

985 Flow-through aquaculture using raceways, as occurs at the Snake River Farm, is
986 characterized by linear flow from one raceway to the next. The typical hydraulic pattern
987 approximates plug flow in which all elements of the water move with the same horizontal
988 velocity. The consequence is that there is a water-quality gradient from the inlet
989 (entering Section A) to the outlet (Section E effluent). In the diagram above, Section A
990 water quality or fish production utility is greater than Section B and so on
991 ($A > B > C > D > E$). Aquaculturists often refer to this as serial reuse but in fact the water in
992 each section is only used once in that section. There is no recirculation of water and
993 water is not re-used in that sense but it is used multiple times. There is an attempt at each
994 raceway to remove solid wastes and replace some dissolved oxygen used during fish
995 production. At the end of each raceway is a quiescent zone that captures solid wastes.
996 These wastes are removed at least weekly. With each drop in elevation there is some
997 degree of dissolved oxygen replenishment. In this process there is some rejuvenation in
998 the utility of the water for fish production. If a single very long raceway were used there
999 would not be much opportunity to control waste accumulation or opportunity to replenish
1000 some of the dissolved oxygen used during fish production.

1001

1002 The use of this type of aquatic animal production system requires various production
1003 accommodations. The best water quality is used to husband the youngest, most

1004 immunologically naïve fish. In the diagram above this occurs in Section A. As the fish
1005 grow and become more immunologically competent they are moved to water of poorer
1006 quality (less production value), Section B. This process continues until the fish reach
1007 Section E where they are held until harvest. To accommodate the progressive decline in
1008 water quality there is a progressive decrease in fish loading (lbs/cfs) and a decrease in
1009 feeding rate.

1010
1011 The general fish production flow is from egg to fry to grow-out and harvest. The process
1012 is continuous year-round. As fish increase sufficiently in size and physiological
1013 tolerance, they are graded and moved along to downstream raceways with fish of similar
1014 size. Flow-through farms are designed so that water flows from one raceway to another
1015 in series. As fish become more tolerant of diminished water quality they are moved
1016 down-stream. Harvest of rainbow trout for human consumption occurs when they reach
1017 market size which varies generally from 1 to 2 lbs each. Such grow-out may require as
1018 much as 2 years depending on water quality and feed conversion.

1019
1020 Pristine spring water is referred to as first use water and it is used for egg incubation and
1021 hatching, for first stocking of fry and/or fingerlings, and for brood stock. First use water
1022 at the Snake River Farm generally has optimal water quality conditions. It is saturated
1023 (or nearly so) with dissolved oxygen, has no or very limited waste products from other
1024 fish, and no or very few numbers or quantity of fish pathogens. At Snake River Farm we
1025 also use some excellent quality water that has been used for our brood stock and selective
1026 breeding programs. This water, while some of its production utility has diminished from
1027 the pristine spring water, nevertheless retains most of the quality deemed essential for
1028 early life stage rearing in the Snake River Farm Section A. The reason the water retains
1029 significant utility is that brood stock production is not nearly as intensive as at Snake
1030 River Farm where fish are raised for food production. Additionally the brood stock have
1031 been reared in essentially pathogen free water so it is unlikely fish pathogens occur that
1032 could impact naïve, downstream fish.

1033

1034 Juvenile fish for grow-out are in first use water for approximately 3 months during which
1035 they grow, consume dissolved oxygen, excrete wastes, become more physiologically
1036 tolerant of less optimal water quality conditions and become more immuno-competent
1037 (better able to withstand bacterial or viral pathogens). At the end of three months these
1038 fish are now large enough and old enough to be graded and moved to less optimal water
1039 quality conditions immediately down stream. It is at this time they are better able to
1040 withstand greater challenge from pathogens that are more likely to occur (and at higher
1041 density) in downstream locations. This process continues through each serial use of
1042 water. The worst water quality on the farm is the last use (Section E). Generally only
1043 about 50-55% of the dissolved oxygen in first use raceways is present. Un-ionized
1044 ammonia concentration has increased as has carbon dioxide, total suspended solids
1045 (TSS), biological and chemical oxygen demand (BOD and COD) and the concentration
1046 of bacteria and other pathogens in the water column. pH has decreased relative to first use
1047 ponds. During late spring and summer the water temperature may have increased about
1048 1° C from first use water. In the winter the water temperature may decrease 1-2° C.
1049 **Each of these changes affect the quality and quantity of rainbow trout produced.**

1050

1051 **The production capacity of raceways denied water of suitable quality will suffer**
1052 **reduced production which causes financial injury. Use of waste water in any**
1053 **raceway will cause injury because its carrying capacity will be reduced. Using**
1054 **water subject to intermittent supply will diminish certainty which will increase**
1055 **operating costs and diminish carrying capacity.**

1056

1057 **C. Water supply**

1058

1059 Just as with dairies and other animal production systems, one of the most important
1060 factors impacting production is water quality (Westers 2001). Water used at dairies is not
1061 re-circulated to the dairy because it is incompatible with milk production and dairy cow
1062 survival- so too with rainbow trout in flow-through production systems. Water quality is
1063 a term used to describe the chemical, physical, and biological characteristics of water,
1064 usually in respect to its suitability for a particular purpose which in this case is to
1065 maximize fish production. The impact of water quality (in all of its dimensions) on fish

1066 production capacity is profound and it has been scientifically dissected over time to
1067 characterize many of the individual factors that make up “water quality.” It is the
1068 speciation of water quality into its component parts that will constitute much of the
1069 remainder of this report. There are however other factors besides water quality that are
1070 important to fish farming and that impact production and market success. **Recirculation
1071 of waste water directly impacts some of these factors as does use of water from
1072 uncontrolled and unreliable sources.**

1073

1074 Food Safety and Marketability

1075

1076 **Federal food safety requirements ultimately require that water and animal feed
1077 used for growing fish for human consumption must not contaminate the fish.**

1078 Contaminated fish are then classified as adulterated. The Federal Food, Drug, and
1079 Cosmetic (FD&C) Act (1938) (US Code, vol. 21, section 342) provides that food is
1080 “adulterated” if it meets any one of the following criteria: (1) it bears or contains any
1081 “poisonous or deleterious substance” which may render it injurious to health; (2) it bears
1082 or contains any added poisonous or added deleterious substance (other than a pesticide
1083 residue, food additive, color additive, or new animal drug, which are covered by separate
1084 provisions) that is unsafe; (3) it bears or contains a pesticide chemical residue that is
1085 unsafe. The Environmental Protection Agency (EPA) establishes tolerances for pesticide
1086 residue in foods which are enforced by the FDA. For rainbow trout, there are no
1087 established pesticide tolerances. **This means that even trace amounts of pesticide,
1088 herbicides or other “deleterious” substances would adulterate the food. Water
1089 entering a fish farm consequently needs to be free of substances that could be
1090 absorbed by the fish and contaminate the flesh, even with minute quantities.**

1091

1092 In this case, if the spring water proposed for mitigation purposes is exposed to pesticides
1093 associated with golf course care, potential exists for fish contamination by uptake from
1094 the water. Typical chemicals used on golf courses include 2,4-D, pendimethalin, 2,4-DP,
1095 dicamba and chlorpyrifos. **Clear Springs Foods does not know what pesticides or**

1096 **herbicides are used by the Clear Lake Country Club but any use that contaminates**
1097 **spring water would be unacceptable.**

1098

1099 Further, spring or ground water diversions and water flow paths must be secured from
1100 intentional or inadvertent contamination. Because of heavy automobile traffic in the area
1101 of Snake River Farm and potential access by individuals of ill-intent, Clear Springs Foods
1102 has attempted to protect its water sources. Much of the property surrounding the area
1103 where currently used springs emanate is owned by Clear Springs Foods or Idaho Trout
1104 Company. Clear Springs Foods owns much of the talus slope up to the canyon rim in the
1105 area where the Snake River Farm Complex of springs are believed to emanate. The
1106 Snake River Farm Complex water collection system has been physically covered.

1107 **Biosecurity of water supply is an essential component of the Snake River Farm**
1108 **complex and it would be unacceptable to deliver water to this complex that is less**
1109 **biosecure than currently delivered.**

1110

1111 Contaminants also include microbiological and parasitological elements. Certain
1112 parasites of fish can cause marketability issues in addition to “adulterating” the food.
1113 Various nematodes, cestodes, digenetic trematodes and copepods can infect trout
1114 appearing in eyes, gills, skin or muscle. The life cycle of these parasites is often complex
1115 involving intermediate hosts (such as birds) or snails. Water sources should be protected
1116 from the intermediate host or other vectors. Water supplying a fish farm needs to be bio-
1117 secure so that such parasites do not have opportunity to infest trout. At Clear Springs
1118 Foods, all farms are enclosed in bird netting in part to prevent piscivorous birds from
1119 defecating in water and releasing infective parasites and moving diseased fish from one
1120 raceway to another. **At Snake River Farm, Clear Springs Foods has covered much of**
1121 **the water diversion and collection area significantly reducing public access and**
1122 **access to potential pathogen vectors. Spring water not generally protected poses a**
1123 **biosecurity threat to Clear Springs Foods Snake River Farm complex research,**
1124 **selective breeding and fish production and would be unacceptable.**

1125 Contaminants can also arise from plants and blue-green bacteria. These contaminants
1126 taint the taste (off-flavor) or organoleptic qualities of the flesh making them less desirable
1127 to consumers. Certain plants are more prone to releasing off-flavor compounds than
1128 others. Two chemical compounds, Geosmin and 2-Methylisoborneol (MIB), have been
1129 identified as the cause of a majority of off-flavor incidents in rainbow trout although
1130 others occur as well (Selli et al. 2006). Geosmin and MIB are secondary metabolic
1131 products of some species of bluegreen algae and actinomycete bacteria. MIB causes a
1132 flavor to be imparted to the flesh described as "musty" or "lagoon" and geosmin results in
1133 "earthy" or "woody" flavors. These two compounds are extremely potent. Geosmin and
1134 MIB can be tasted in the water by humans at concentrations of 0.01 and 0.03 parts per
1135 billion (ppb), respectively. A number of other less frequent off-flavors have been
1136 recognized such as moldy, astringent, rotten and sewage for which no chemical
1137 compounds have been identified. Off-flavor compounds can be absorbed in a matter of
1138 minutes once they are present in water. Fish absorb chemical compounds through their
1139 gill membranes as well as through their digestive tract. The compounds are fat soluble
1140 and are stored in fatty tissues. The amount of off-flavor absorbed by fish seems to be
1141 related to water temperatures, environmental concentrations and exposure time. Off-
1142 flavor in recirculating aquaculture systems (a production system in which water is reused
1143 over again after re-conditioning) is a common and a persistent problem (Masser et al.
1144 1999). Algae may also affect fish health through the production of toxins and through
1145 mechanical damage to fish gills (Munro and Roberts 1989). What is clear is that off-
1146 flavor causing compounds can be produced in water which if used to culture rainbow
1147 trout could impart unacceptable flavor properties making the fish un-marketable.

1148 **Water in which extensive plant and algae growth occurs cannot be used by Clear**
1149 **Springs Foods because of the likely occurrence of off-flavor compounds.** The
1150 Ground Water Districts have proposed combining Spring 1 and Spring 2 for diversion to
1151 the headwaters of the Snake River Farm Complex. Examination of Spring 1 during
1152 summer months indicate extensive plant growth (including algae) occurs. It is likely off-
1153 flavor compounds would be produced which would render the water unuseable for
1154 rainbow trout aquaculture.

1155 Drugs and chemicals used at trout farms are potential contaminants of other fish. The
1156 FDA limits the use of drugs to those drugs that are federally approved as a New Animal
1157 Drug Application (NADA), an Investigative New Animal Drug Application (INAD), or
1158 through an extra-label application under veterinary prescription. Drugs approved under
1159 an NADA (<http://www.fda.gov/cvm/aqualibtoc.htm>) include oxytetracycline (NADA
1160 038-439), florfenicol (NADA 141-246), and ormetoprim-sulfadimethoxine (NADA 125-
1161 933). These are all antimicrobial therapeutic agents that have mandatory withdrawal
1162 times (the time after treatment when fish are not exposed to the antibiotic before they can
1163 be harvested for human or animal consumption). For oxytetracycline the withdrawal
1164 time is 21 days, for florfenicol the withdrawal time is 12 days and for ormetoprim-
1165 sulfadimethoxine the withdrawal time is 42 days. Populations of fish (those in a
1166 raceway) exposed to an antimicrobial are segregated so they do not enter the food chain
1167 before they have met their withdrawal requirements. A veterinarian may prescribe the
1168 extra-label use of a drug and typically ensure sufficient withdrawal time has occurred by
1169 ensuring harvest does not occur for at least 180 days. Other drugs potentially used
1170 include formalin (NADA 137-687, 140-831, and 140-989) and hydrogen peroxide
1171 (NADA 141-255). Potassium permanganate and copper sulfate are water treatments for
1172 disease management that may also be used at various locations within a raceway series.
1173 The use of any drug or water treatment chemical is highly variable depending on the
1174 incidence of specific diseases. **Use of re-circulated waste water is unacceptable to**
1175 **Clear Springs Foods because such action would likely and unpredictably**
1176 **contaminate fish with drugs and chemicals used to treat diseases in fish held in later**
1177 **water uses.**

1178 Water supplies for fish farms must also be bio-secure. International and domestic events
1179 in the past 10 years have elevated concern that foods, including that produced at fish
1180 farms, could be subject to terrorist attack. The concern is that contaminants could be
1181 placed in water that makes the farmed fish unsafe for human or animal consumption.
1182 These could include chemicals or microbiologic agents. Control of access to the water
1183 supply is thus important. Biosecurity has become a critical issue to third parties
1184 (consumers) and has become subject to scrutiny during Clear Springs Foods third party

1185 audits. The Public Health Security and Bioterrorism Preparedness and Response Act of
1186 2002 prescribe actions that are intended to prevent malicious, criminal or terrorist actions
1187 that could impact food safety. As part of that effort FDA developed “Food Producers,
1188 Processors, and Transporters: Food Security Preventive Measures Guidance” (Oct. 2007)
1189 that identifies various actions all food producers and manufacturers are expected to
1190 implement. These actions include steps to secure water supplies from access to the
1191 public. Control of the water supply is an important element based on this guidance.
1192 **Spring water supplies open to the public are less desirable than secure sources and**
1193 **would be inconsistent with food safety expectations. Clear Springs Foods has gone**
1194 **to considerable effort where practicable to prevent public access to water used on its**
1195 **fish farms. The Snake River Farm Complex water supply is relatively well**
1196 **protected from public access. The springs proposed for use by the Ground Water**
1197 **Districts are not bio-secure.**

1198 Risk

1199 Certainty of water supply is also an important element of fish farming risk considerations
1200 and investment decisions. Water supplies that are of predictable quality and quantity
1201 allow certainty for investment in fish, feed and the other elements of normal business
1202 planning. Gravity delivered spring water flow, while some of the quantity is variable
1203 over a year and varies from year-to-year, is not subject to immediate curtailment
1204 interruptions. The Snake River Farm 1955 water right had been available with constant
1205 quantity (no seasonal variation) throughout the year until 2001. In 2001 and since then
1206 even this supply has become more variable. **The relative constancy of gravity fed**
1207 **spring water permits quantitative estimates of important environmental needs (e.g.**
1208 **dissolved oxygen) and allows estimates of potential metabolite concentrations so that**
1209 **stocking of fish in each section (A-E) for production purposes can be optimized. The**
1210 **Ground Water Districts propose to pump waste water, or to pump spring water or to**
1211 **pump ground water to the Snake River Farm Complex head waters. Because pumped**
1212 **water is subject to unpredictable failure due to loss of power (Masser at al. 1999;**
1213 **Soderberg 1995), there is increased uncertainty and hence risk to the water supply for the**
1214 **complex. Pumped water is occasionally used in public, conservation hatcheries or in**

1215 small scale commercial farms but is too unreliable for large commercial ventures with an
1216 established customer base. Use of waste water increases risk of catastrophic disease and
1217 risk of product adulteration. Use of unsecured Spring 1 and Spring 2 water
1218 (contaminated by golf course herbicide and pesticides) or with access to the public
1219 increases the risk of product adulteration. Use of pumped ground water is subject to
1220 increased risk from interrupted delivery.

1221 Importance of water quality constancy

1222 **As previously discussed, various environmental factors can shift the bioenergetics of**
1223 **rainbow trout away from somatic growth.** The more constant is the water quality and
1224 the closer it is to optimum (i.e. to gravity fed pristine spring water) the less energy
1225 resources need be diverted toward homeostasis, and greater resource (energy and protein
1226 from feed) can be directed toward somatic growth.

1227 To the fish farmer, impaired food conversion efficiency can be a sensitive indicator of
1228 stress (Smart 1981). Poor water quality, or even fluctuations in water quality, may cause
1229 significant reductions in appetite, growth and food conversion efficiency. Fluctuation in
1230 dissolved oxygen content adversely affects feed conversion (Smart 1981). Smart (1981)
1231 also reports that elevated CO₂ concentration may accompany the use of groundwater or
1232 may occur when water is re-cycled. Affected fish may show not only a depression of
1233 appetite, growth or food conversion, but decreased ability to withstand stress associated
1234 with normal hatchery procedures.

1235 Variation in water quality also affects the predictive ability of fish farmers. Operational
1236 adjustments are already made to accommodate diminished water quality associated with
1237 serial use. These adjustments include reduction in fish loads, reduced feeding, and extra
1238 water aeration. These adjustments are predictable and accounted for in the method of
1239 production. The adjustments are based on modeling and practical experience. Re-
1240 circulation of waste water, the quality of which by its very nature would be in-constant,
1241 would unpredictably contaminate first use water making management problematic. **No**
1242 **matter what life stage or raceway use, re-circulated waste water would reduce**

1243 **production or carrying capacity and quality of fish. It would reduce the over-all**
1244 **carrying capacity of Snake River Farm and would be incompatible with our**
1245 **selective breeding and research program.**

1246 **D. Re-circulating waste water would reduce dissolved oxygen and pumped water,**
1247 **whether from springs or from the ground could deliver gas supersaturated water.**
1248 **Ground water may also have diminished dissolved oxygen. These will decrease the**
1249 **carrying capacity of the Snake River Farm Complex.**

1250 There are a variety of factors that can limit rainbow trout survival, fish performance (e.g.
1251 food consumption, efficient feed conversion, and fillet yield) and fish farm production
1252 capacity but dissolved oxygen is most often considered the first limiting factor. This is
1253 because the availability of oxygen in water is in finite supply and can be rapidly depleted
1254 biologically and chemically.

1255 Oxygen is essential for all types of aerobic life including rainbow trout through all life
1256 stages. Oxygen is a terminal electron acceptor in cellular metabolism. Without oxygen
1257 the ability to efficiently convert energy into a usable form is curtailed. Thus the aerobic
1258 metabolic capacity of a fish is primarily limited by the ability of the gills to extract
1259 oxygen from the water. Unfortunately, unlike air that is composed of about 21% oxygen,
1260 fresh water contains only a fraction of this in a useable gaseous (O₂) form. Only when
1261 oxygen is in its gaseous form can it be used by rainbow trout. The oxygen composing
1262 nearly 89 % (by atomic mass unit) of the water molecule (H₂O) is tightly bonded to
1263 hydrogen and consequently not available for respiration. Only the dissolved oxygen
1264 occurring in molecular "pockets" that exist in the loose hydrogen-bonded networks of
1265 water molecules can be used.

1266 The physical chemistry delineating how gases such as oxygen behave in water was
1267 established over 200 years ago (Dalton's Law and Henry's Law). Essentially the amount
1268 of oxygen or any other gas that can be dissolved in freshwater is a function of the partial
1269 pressure of gas (e.g. oxygen) in the atmosphere and its solubility. Solubility is dependent
1270 on the partial pressure of oxygen in air above the water and on water temperature. In

1271 this case air is composed of 20.95% oxygen and its (oxygen) partial pressure is 159 mm
1272 Hg at sea level. At higher altitude the partial pressure of oxygen decreases in proportion
1273 to the decrease in barometric pressure (approximately 11.2 per cent per kilometer)
1274 (Prosser, 1973). At 3200 ft elevation (approximate elevation of Snake River Farm) the
1275 solubility of oxygen in water is decreased about 10% from sea level. The colder the
1276 water temperature, the more soluble is oxygen. The maximum solubility of oxygen in
1277 pure freshwater occurs at about 0-4° C so that the maximum oxygen content of water at
1278 equilibrium with air at sea level is 13.2 mg/L while at 20° C there is only 9.4 mg/L
1279 (Prosser 1973) possible. At 15° C and 3200 ft elevation, the maximum dissolved oxygen
1280 content of water is 9.0 - 9.2 mg/L. As previously mentioned, the minimum acceptable
1281 concentration of dissolved oxygen for rainbow trout is 5-6 mg/L. This means that there is
1282 only 3-4 mg/L dissolved oxygen available for fish production. Oxygen gas must diffuse
1283 into the water and this occurs optimally at the air-water interface. The solubility of
1284 oxygen in water is only about 1/30 of that in air (Nikinmaa and Salama 1998) and 1/8
1285 that of carbon dioxide (CO₂). The rate of oxygen diffusion into water is also quite
1286 different from air. The rate of oxygen diffusion is only 1/100,000 of that in air
1287 (Nikinmaa and Salama 1998). The amount of dissolved oxygen in water is most often
1288 expressed in concentration units (mg/L or ppm). When water is saturated (100%) with
1289 dissolved oxygen it means the maximal amount of dissolved oxygen the water can
1290 contain is occurring. This is the ideal situation for trout farming and occurs with first use
1291 spring water.

1292 Since dissolved oxygen exerts no measurable pressure itself, for fish respiration
1293 considerations, the amount of dissolved oxygen is more usefully expressed as tension
1294 with the tension of dissolved oxygen in water defined as the pressure of oxygen with
1295 which the gas is in equilibrium (Jobling 1994). In practice, the terms partial pressure and
1296 tension are used interchangeably. **The end result is that the amount of oxygen in**
1297 **water is far less than in air and from a practical standpoint constitutes the first**
1298 **limiting factor for fish.** The fish gill however capitalizes on the diffusion process
1299 (movement of oxygen from an area of higher tension to lower) to capture sufficient
1300 oxygen for life. This property has significant implications for re-oxygenation of rearing

1301 water in flow-through aquaculture systems and how fish are able to efficiently remove
1302 oxygen for respiration.

1303 Whilst the oxygen concentration determines the volume of water that must be pumped
1304 over the gills in order for the fish to obtain a given amount of oxygen, the rate at which
1305 oxygen will diffuse from the water to the blood will be dependent upon the oxygen
1306 tension. Thus, oxygen tension is also an important factor determining the performance of
1307 fish (Jobling 1994). The oxygen requirement of fish depends mainly on species, activity
1308 and fish size. Sensitivity to oxygen is very species dependent. Salmonid species such as
1309 the rainbow trout have been shown to be among the most sensitive to oxygen
1310 concentration (Dean and Richardson 1999). Food intake and growth of rainbow trout
1311 may become depressed if oxygen concentrations fall below 6-7 mg/L (Jobling 1994).
1312 Westers and Pratt (1977) report the minimum (in contrast to the optimum) dissolved
1313 oxygen concentration for salmonids is 5-6 mg/L. Smart (1981) considers the minimum
1314 dissolved oxygen concentration to be 5 mg/L. Water about to be discharged from the
1315 Snake River Farm (Section E) has a dissolved oxygen concentration of 4-5 mg/L.

1316 While there is disagreement among experts as to the practical minimum, there is not
1317 disagreement that fish performance is best when the water is saturated with dissolved
1318 oxygen. Not only can fish performance as measured by feed consumption be impacted
1319 by dissolved oxygen saturation levels, fillet qualities can be impacted. Lefevre et al.
1320 2007) report that fillet yield is greater at 100 % dissolved oxygen saturation or slightly
1321 above saturation compared to lower (74%) saturation levels.

1322 What is less clear is whether **variation** in dissolved oxygen content can also have an
1323 adverse impact on feed conversion or fish growth. Thus Smart (1981) reports that at least
1324 in some production situations such variation causes the conversion ratio to be adversely
1325 impacted. Further, while dissolved oxygen above some minimum may not impact feed
1326 conversion efficiency, it does impact carrying capacity. The greater the quantity of
1327 dissolved oxygen present, the greater is the carrying capacity of the system (Clark 2003).
1328 Carrying capacity is the maximum permissible loading rate and loading rate is the weight
1329 of fish per water flow unit (Soderberg 1995). Glencross (2008) demonstrated that

1330 reduced dissolved oxygen concentration down to a minimum of 5.7 mg/L did not impact
1331 feed conversion efficiency but it did decrease feed intake in rainbow trout. **The net**
1332 **result is decreased fish production.**

1333 Carrying Capacity

1334

1335 Knowledge of the oxygen consumption rate of fish allows direct calculation of their
1336 water requirements (Soderberg 1995). Willoughby (1968), Liao (1971), and Muller-
1337 Fuega et al (1978) all developed empirical formulae for oxygen consumption rates for
1338 trout. Westers (2001) summarizes the process stating that there are several ways to
1339 express and determine carrying capacity of intensive, flow-through aquaculture systems.
1340 Capacity can be expressed as the maximum allowable weight of fish per unit of flow
1341 (loading), per unit of space (density), or as maximum production per year. Regardless of
1342 how carrying capacity is expressed, it is dependent on the fish's tolerance of rearing
1343 water quality and its changes caused by metabolic activity (Westers 2001). Dissolved
1344 oxygen, ammonia, carbon dioxide, nitrite and suspended solids are particularly important
1345 (Westers 2001). Theoretical estimates of carrying capacity are frequently made (e.g.
1346 Klontz 1991; Soderberg 1995; Westers 2001; and Fish Factory 2004) but it is not until
1347 fish are placed into production over several years, where all of the vagaries of biology,
1348 fish strain, water quality, operations management, feed quality, and pathogens are in
1349 place that the actual carrying capacity can be determined. **Pristine, first use spring**
1350 **water contains the maximum possible useful dissolved oxygen so is the preferred**
1351 **water source.**

1352

1353 **E. Waste water will have elevated concentrations of carbon dioxide. Ground water**
1354 **could have elevated and or supersaturated levels of CO₂.**

1355

1356 Carbon dioxide (CO₂) is a waste product of respiration and is potentially toxic to rainbow
1357 trout. Physiological disequilibria may cause upsets in acid-base balance which could
1358 have impacts on fish health. As fish respire, CO₂ gas is excreted into the water as it
1359 passes over the gills. The physiology of CO₂ excretion is intimately tied to oxygen and

1360 the gills. A brief review of CO₂ excretion physiology is appropriate because damage to
1361 gills (e.g. bacterial gill disease) or upsets in its excretion impact overall fish health and
1362 fish production capacity.

1363

1364 Tufts and Perry (1998), Brauner and Randall (1998) and Henry and Heming (1998) well
1365 describe the physiology of carbon dioxide excretion. Basically metabolism produces CO₂
1366 at variable rates that are dictated by aerobic metabolic requirements. In aqueous solution,
1367 CO₂ acts as a weak acid, and consequently the processes of CO₂ transport/excretion and
1368 acid-base balance are closely linked. To avoid acid-base imbalances, CO₂ production is
1369 matched by CO₂ excretion under steady-state conditions. The processes of O₂ uptake and
1370 CO₂ excretion share common pathways, are governed by several mutual principles, and
1371 are intricately related. As blood arrives at the gill, it contains carbon dioxide
1372 predominantly in the form of HCO₃ dissolved in the plasma. Within the transit time
1373 through the gill vasculature (approximately 0.5 to 2.5 seconds; Cameron and Polhemus
1374 1974), sufficient HCO₃ is converted to molecular CO₂ and in healthy gills, is excreted at
1375 a rate that matches production at the tissues. In a single passage through the gill,
1376 approximately 12-35% of blood CO₂ is excreted (Perry 1986). The rapid change from
1377 bicarbonate to carbon dioxide appears to be catalyzed by carbonic anhydrase in
1378 erythrocytes. The CO₂ then enters the plasma and traverses the gill epithelium by
1379 diffusion. CO₂ entering the water is removed physically by ventilatory convection and
1380 chemically by hydration to HCO₃ and H⁺ within a boundary layer adjacent to the gill
1381 epithelium. This conversion appears to be mediated by carbonic anhydrase. The
1382 physical and chemical removal of CO₂ from the ventilatory water serves to maintain the
1383 diffusion gradients as blood flows through the gill. Factors that can dramatically impair
1384 this process include bacterial gill disease and epitheliotropic IHNv infection. In these
1385 cases the gill disease causes increased production of mucus that enlarges the boundary
1386 layers and increases both the diffusion resistance to oxygen and CO₂ transfer and the
1387 resistance to water flow through the gills.

1388

1389 CO₂ in freshwater is nearly 200 times more soluble in freshwater than is oxygen (Wetzel
1390 1975) and obeys normal solubility laws within the conditions of temperature and pressure

1391 encountered in lakes and streams. The amount of CO₂ dissolved in water from
1392 atmospheric concentrations is about 0.6 mg/L at 15° C. Critical to fish culture is the
1393 buffering capacity of the CO₂-HCO₃⁻-CO₃²⁻ equilibrium system. Thus waters such as the
1394 spring water delivered to the Snake River Farm have an alkalinity that generally resists
1395 changes in pH as CO₂ is excreted during intensive fish farming. Indeed, the differential
1396 between influent pH and effluent pH at Snake River Farm is generally only about 0.5
1397 units. Nevertheless, CO₂ concentrations can rise above 10 – 20 mg/L which is believed
1398 to be toxic to rainbow trout (Oelßner et al. 2002).

1399
1400 Smart (1981) reports that elevated concentrations of free CO₂ are of significance to fish
1401 culturists when ground water is used. He also found that in intensive rearing systems
1402 employing re-oxygenation, metabolically produced CO₂ will accumulate in the water and
1403 would be detrimental to fish.

1404 The harmful effects of CO₂ on fish are well characterized. They include reductions in
1405 oxygen affinity and oxygen capacity of the blood (Alabaster et al. 1957; Basu 1959;
1406 Saunders 1962). Klontz (1973) has suggested that 12 mg/L CO₂ may be detrimental to
1407 growth and 20 mg/L may be lethal.

1408

1409 **F. Waste water will have a lower pH than first use spring water. Ground water and**
1410 **spring water proposed for mitigation has an unknown pH.**

1411

1412 The pH of water is an important factor in fish production because of direct physiological
1413 impacts but also because of the significance pH has on other water quality factors such as
1414 ammonia (pH and temperature shifts ammonia between the toxic un-ionized and non-
1415 toxic ionized forms). pH also impacts the toxicity of copper (Lauren and McDonald
1416 1985).

1417

1418 Generally a pH of 6.5-9.0 is recommended (Piper et al. 1982) for good physiological
1419 functioning of most fish including rainbow trout. Given the total alkalinity (buffering
1420 capacity) of Snake River Farm spring water (ca. 150 mg/L as CaCO₃), it is unlikely pH

1421 alone would be a limiting factor for rainbow trout aquaculture. However, environmental
1422 pH affects the toxicity of ammonia, hydrogen sulfide and metals.

1423

1424 **G. Waste water will have elevated or reduced water temperature from optimum.**

1425 **The water temperature of the proposed spring water or ground water is unknown.**

1426

1427 Temperature is well known to significantly affect the metabolism of poikilothermic
1428 animals such as rainbow trout (Prosser 1973). Temperature can impact rates of
1429 development (Blaxter 1988), membrane permeability (Alderdice 1988), and oxygen
1430 consumption and solubility in water. Temperature has significant impact on chemical
1431 equilibria especially that associated with ammonia. In summer months the water
1432 temperature of Snake River Farm effluent can exceed 16° C. This temperature could
1433 adversely impact embryonic development or at the least would change the rate of
1434 embryonic development. Elevated temperature would also increase the amount of un-
1435 ionized ammonia which is toxic to all life stages of rainbow trout.

1436

1437 Thermal windows of animals likely evolved to be as narrow as possible to minimize
1438 physiological maintenance costs (Pörtner and Farrell 2008). Thus different species
1439 populations may have different optimal and critical temperatures. For example, two
1440 populations of sockeye salmon in the Fraser River in British Columbia, Canada have
1441 optimal and critical temperatures that differ by 2° to 3° C (Farrell et al. 2008). **Changes**
1442 **in water temperature resulting from re-circulation of waste water or pumped water**
1443 **(from other springs or ground water) could have a significant impact.**

1444

1445 **H. Waste water will have elevated total ammonia nitrogen and toxic un-ionized**
1446 **ammonia concentrations which will decrease fish growth and could affect survival.**
1447 **The concentration of ammonia nitrogen and un-ionized ammonia concentrations in**
1448 **the spring and ground water proposed for mitigation is unknown.**

1449

1450 Ammonia is the primary nitrogenous waste product of rainbow trout and depending upon
1451 its form, may be toxic. Ammonia excretion increases in fish following a meal (Handy

1452 and Poxton 1993) reflecting increased production associated with the breakdown of
1453 ingested protein. Ammonia is considered by many to be the second limiting factor (after
1454 dissolved oxygen) for rainbow trout aquaculture (Fornshell 2002). When ammonia is
1455 dissolved in water, a pH and temperature dependent equilibrium is established between
1456 un-ionized ammonia (NH₃) and ammonium ions (NH₄⁺): NH₃ + H₂O = NH₄⁺ + OH⁻. Un-
1457 ionized ammonia in the water is keenly toxic to rainbow trout while it is the NH₄⁺ that is
1458 internally toxic. Un-ionized ammonia is freely diffusible across gill membranes into the
1459 blood and it is the ammonia form that is excreted from fish across the branchial
1460 epithelium (Henry and Heming 1998). Consequently even slightly elevated
1461 concentrations of un-ionized ammonia in water will decrease the diffusion gradient,
1462 impairing ammonia excretion. Ammonia is 1000 times more soluble in water than is CO₂
1463 (Ip et al. 2001). Elevated ammonia concentration in the water leads to reduced
1464 swimming and depressed growth.

1465
1466 The toxicity of ammonium in the fish is due to a multitude of actions (Ip et al. 2001).
1467 Ammonium causes muscle depolarization and interference with energy metabolism
1468 through impairment of the tricarboxylic acid (TCA) cycle, inhibition of key enzymes
1469 including isocitrate dehydrogenase, α-Ketoglutarate dehydrogenase and pyruvate
1470 dehydrogenase. Ammonium affects ionic balance reducing Na⁺ influx and K⁺ loss
1471 through substitution of NH₄⁺ for K⁺ in Na⁺, K⁺ ATPase. Ammonium acts on the central
1472 nervous system causing hyperventilation, hyperexcitability, coma, convulsions and
1473 ultimately death. Unfortunately most studies dealing with ammonia toxicity of fish are
1474 conducted on starved, resting and stress free animals under static conditions. In
1475 aquaculture, fish are likely more sensitive to ammonia toxicity during feeding when
1476 oxygen would be lowest, and because of the general elevation of stress due to crowding
1477 and other water quality factors (Ip et al. 2001).

1478
1479 High energy-high protein diets currently fed to fish (including at Clear Springs Foods
1480 Snake River Farm) in intensive culture systems result in high levels of ammonia as the
1481 principal nitrogen-containing excretory product so that where water is re-circulated
1482 without any treatment, toxic ammonia levels will build up (Munro and Roberts 1989). A

1483 safe level of un-ionized ammonia, where no other physiological stresses exist, is 0.02
1484 mg/L (Munro and Roberts 1989; Westers 2001).

1485

1486 Smart (1981) suggests that because water flow is usually sufficiently high ammonia in
1487 serial use systems is rarely a problem unless the farm is receiving ammonia-polluted
1488 water or there is water re-cycling. The Ground Water Districts propose to re-cycle waste
1489 water from the Snake River Farm which is unacceptable.

1490

1491 **I. Waste water could have elevated nitrite concentrations which would be**
1492 **hazardous to trout survival. Spring or ground water could have elevated nitrate or**
1493 **nitrite concentrations.**

1494

1495 Nitrite causes a functional anemia in which the oxygen-carrying properties of
1496 hemoglobin are blocked. Nitrite and other oxidizing agents convert functional
1497 hemoglobin to methemoglobin, which does not bind oxygen (e.g. Jensen et al. 1987;
1498 Jensen 1990). This decreases the oxygen capacity of blood markedly which reduces
1499 oxygen transport to the tissues. Under these circumstances less than 100 % oxygen
1500 saturation in the water may be very detrimental as would even low levels of CO₂ (Hughes
1501 1981).

1502

1503 At the Snake River Farm progressively increasing concentrations of nitrate-nitrite
1504 nitrogen have occurred in spring water since 1990. In one particular spring, the
1505 concentration has increased to over 13 mg/L. The maximum contaminate level for nitrate
1506 nitrogen in Idaho is 10 mg/L (IDAPA 58.01.11.200.01). While the source of nitrate-
1507 nitrite nitrogen in the spring water feeding the Snake River Farm complex is unknown, its
1508 occurrence has increased fish production concerns for Clear Springs Foods. Rainbow
1509 trout actively take up nitrite and chloride ions as part of their osmoregulatory efforts.
1510 This allows nitrite to be concentrated in the plasma with respect to the environment and
1511 magnifies the toxic effects of nitrite in water (Westers 2001). In addition to diminished
1512 oxygen carrying capacity of the blood, nitrite toxicity is associated with necrosis of trout
1513 retina (Hofer and Gatumu 1994). Nitrate in water can also be detrimental to salmonid

1514 egg survival. Kincheloe et al. (1979) demonstrated that concentrations of nitrate at 5-10
1515 mg/L was toxic to developing eggs and early fry stages of rainbow trout. **Use of waste**
1516 **water, spring water or ground water with increased nitrite or nitrate concentration**
1517 **would be unacceptable to Clear Springs Foods.**

1518

1519 **J. Waste water will have elevated concentrations of total suspended solids (TSS)**
1520 **which will stress all life stages of trout. This is unacceptable to Clear Springs Foods.**

1521

1522 Total suspended solids (TSS) is composed of uneaten fish feed and fecal material at
1523 Snake River Farm. Influent spring water has no detectable TSS. When solids settle to
1524 raceway bottoms and in quiescent zones it contributes to biological oxygen demand and
1525 potential areas of anoxia and hydrogen sulfide production (Colt and Tomasso 2001).
1526 Because TSS at the Snake River Farm is by nature organic, it also fosters increased
1527 bacterial loads in the water column. Such loads arguably increase the prevalence of
1528 bacterial gill disease. TSS is most frequently associated with interference with gas
1529 exchange but can also abrade gill tissue causing inflammation. Coughing is a response to
1530 such irritation but may also precipitate upon gill surfaces and interfere with the diffusion
1531 of oxygen into the blood (Herbert et al. 1961).

1532

1533 **K. Waste water will have higher loads of fish pathogens. Pathogens such as IHNV**
1534 **are not present in spring water. Unsecured, unprotected spring water could have**
1535 **foreign pathogens and could have common pathogens which would expose naïve fish**
1536 **to significant threat. Ground water containing foreign or opportunistic pathogens**
1537 **would expose naïve fish to threat. This is unacceptable to Clear Springs Foods.**

1538

1539 Pathogens typically impacting commercial culture of rainbow trout.

1540

1541 Groff and LaPatra (2000) identify the various pathogens that are most likely to impact
1542 intensive rainbow trout aquaculture. They also discuss the epizootiology, pathogenesis,
1543 diagnosis, and treatment and prevention of the diseases associated with the pathogens.
1544 Of the common bacterial pathogens they identify *A. hydrophila*, *A. sobria*, *A. caviae* and

1545 *A. salmonicida*, *F. columnare*, *F. psychrophilum*, and *F. branchiophilum*, *Yersinia*
1546 *ruckeri*, and *Renibacterium salmoninarum*. The cause of strawberry disease remains
1547 uncertain but has most recently been associated with a rickettsial agent (Lloyd et al.
1548 2008). Of the bacterial diseases most problematic in commercial trout aquaculture in the
1549 1000 Springs area, coldwater disease (caused by *F. psychrophilum*) and bacterial gill
1550 disease associated with *F. branchiophilum* are most problematic.

1551
1552 *F. psychrophilum* appears to be wide spread in freshwater environments and is endemic
1553 in freshwater salmonid facilities (Groff and LaPatra 2000). The bacterium has been
1554 isolated from the external surfaces of salmonids (Holt et al. 1993). Cutaneous lesions
1555 may predispose fish to infection and subsequent disease. Juvenile fish have increased
1556 susceptibility to disease. Transmission is horizontal and can occur either directly from
1557 fish to fish or **indirectly through the water** (Holt et al. 1993). Disease is most severe at
1558 15° C (Groff and LaPatra 2000). Coldwater disease often occurs in association with IHN
1559 disease (LaPatra 2003). Infection with *F. psychrophilum* is not only associated with
1560 mortality and morbidity but may cause significant deformity (LaPatra 2003). Deformity
1561 of rainbow trout results in quality downgrading in the market or is a complete loss.

1562
1563 Bacterial gill disease is most frequently associated with *F. branchiophilum* although other
1564 environmentally common bacteria may be isolated as well (Ferguson 1989). *F.*
1565 *branchiophilum* causes chronic morbidity with low mortality in rainbow trout although
1566 mortality may approach 25% (Speare et al. 1991). The primary economic impact of the
1567 disease is due to the chronic morbidity that results in reduced feed conversion and,
1568 consequently, reduced growth rate (Groff and LaPatra 2000). The bacteria are
1569 transmitted horizontally through the water. Disease is generally associated with poor
1570 environmental quality such as increased turbidity, ammonia concentrations, and density
1571 or decreased dissolved oxygen concentrations (Turnbull 1993). BGD is associated with
1572 chronic hyperplasia of secondary lamellar epithelium (Ferguson et al. 1991; Turnbull
1573 1993). Fusion of adjacent primary filaments may occur with severe disease. Morbidity
1574 and mortality are most probably due to compromised branchial respiration and
1575 osmoregulation (Groff and LaPatra 2000). As with most diseases of trout there are few

1576 remedies. The general strategy is to prevent BGD by ensuring optimal environmental
1577 quality is maintained and to reduce stress (Groff and LaPatra 2000). The use of copper
1578 sulfate and potassium permanganate is common but this result's in only temporary relief.
1579 The use of copper sulfate is a compromise decision between its therapeutic efficacy and
1580 its potential toxicity. Copper is known to adversely impact osmoregulation and ammonia
1581 excretion (Lauren and McDonald 1985). **There are no FDA approved treatments**
1582 **specific for BGD.**

1583
1584 Of the viral pathogens likely to impact rainbow trout aquaculture, IHNV has the greatest
1585 impact and will be reviewed here. IHNV is a rhabdovirus that is endemic in the 1000
1586 Springs area (LaPatra 2003). Mortality associated with IHNV can be very high (up to
1587 80%; LaPatra 2003). The primary reservoir of infection is carrier salmonids (Wolf
1588 1988). Viral transmission can occur directly and indirectly. IHNV is known to be present
1589 in fish mucus (LaPatra et al. 1989) of naturally infected rainbow trout. Fish with clinical
1590 disease have high titers of virus in the feces, urine, and mucus that will facilitate viral
1591 transmission during epizootics. The virus is stable in freshwater and can remain
1592 infectious for several months. The virus enters trout via the gills and ingestion (Drolet et
1593 al. 1994). Severe disease generally occurs in juvenile and subadult fish less than two
1594 years old with the highest mortality in fish less than six months of age (Wolf 1988).
1595 Temperature appears to be a significant modifying factor with warmer temperatures
1596 (above 15.5 C) reducing problems (LaPatra 1998). Life stage also appears to be a
1597 significant factor. Thus the hematopoietic form of infection occurs typically in the
1598 youngest, most naïve life stage (LaPatra et al. 2008). The neurotropic form occurs most
1599 often in more mature fish and the epitheliotropic form occurring on the gills most often
1600 occurs in much larger fish. **Treatment in all cases is by avoidance of the virus. Waste**
1601 **water will contain IHNV and its use in any raceway is unacceptable to Clear Springs**
1602 **Foods. Use of spring water containing sources of IHNV is unacceptable to Clear**
1603 **Springs Foods.**

1604
1605 Infectious pancreatic necrosis virus (IPNV) is a birnavirus that can cause disease in a
1606 variety of salmonids. Rainbow trout are among the most susceptible of salmonids (Groff

1607 and LaPatra 2000). Like IHN and some of the bacterial pathogens, the reservoir of
1608 infection is other salmonids, i.e. rainbow trout. Transmission is directly from contact
1609 with infected fish or indirectly through the water. Carrier fish can shed virus indefinitely
1610 in the feces and urine. All ages are susceptible to infection although clinical disease
1611 generally occurs in fish less than six months of age (Wolf 1988; Traxler et al. 1998).
1612 Mortality can be rapid and severe. **Treatment is by avoidance. Re-circulation of**
1613 **waste water would spread IPNV and is unacceptable to Clear Springs Foods. Use of**
1614 **spring water containing sources of IPNV is unacceptable to Clear Springs Foods.**

1615
1616 A variety of parasites can infest rainbow trout but the most problematic is due to the
1617 protozoan *I. multifiliis*. Infestation by *I. multifiliis* (Ich) or white spot can cause
1618 significant morbidity and mortality. This particular parasite invades into various
1619 epithelial surfaces such as the skin and gills causing osmoregulatory challenges for the
1620 fish (ref). As long as water flows are sufficient, the parasite while present is not likely to
1621 reach critical concentrations. **Treatment is by avoidance** and occasionally copper
1622 sulfate may be used. **Re-circulation of waste water would spread *I. multifiliis* and is**
1623 **unacceptable to Clear Springs Foods. Use of spring water containing sources of *I.***
1624 ***multifiliis* is unacceptable to Clear Springs Foods.**

1625
1626 *Ichthyophonus hoferi*, a mesomycetozoaen parasite (Mendoza et al 2002), also occurs in
1627 rainbow trout at the Snake River Farm. The epizootiology of this parasite is poorly
1628 understood but pathologically can occur in a variety of tissues especially the heart. The
1629 consequence is that rainbow trout infected by *I. hoferi* have reduced swimming stamina
1630 (Kocan et al. 2006). It does occur most often in larger fish. **Use of re-circulation waste**
1631 **water or other spring water containing this parasite is unacceptable to Clear**
1632 **Springs Foods.**

1633
1634 Bacterial gill disease (BGD) is a particularly serious problem of intensive salmonid
1635 culture (Ferguson 1989). All of the conditions predisposing to the disease are not known
1636 although overcrowding is thought to be a significant factor. The disease is characterized
1637 by filamentous bacteria on the gill surface of fish suffering clinically from respiratory

1638 distress (Ferguson 1989). Adverse environmental and disease conditions (elevated TSS,
1639 diminished oxygen, elevated CO₂ or ammonia, epitheliotropic IHN virus infection) and
1640 other factors appear to pre-dispose to BGD. **Introduction of re-circulated waste water
1641 to early life stage rearing areas is likely to increase the prevalence and severity of
1642 BGD and is unacceptable to Clear Springs Foods.**

1643

1644 *Flavobacterium* spp. Are commonly recovered from affected gills. With time there is
1645 lamellar fusion with entrapment of debris, obliteration of interlamellar spaces and
1646 frequently mucous metaplasia. *Flavobacter columnari* can also occur on the gills causing
1647 severe wide-spread necrosis of all gill elements.

1648

1649 **L. Waste water will contain fish disease treatment drugs and chemicals which will
1650 expose all fish to potential toxicity and potential contamination. This is
1651 unacceptable to Clear Springs Foods.**

1652

1653 Copper sulfate is a parasiticide used to treat fish, other external parasite infestations and to
1654 help manage bacterial gill disease. While it can be effective it is also detrimental.

1655 Exposure of rainbow trout to copper at 12.5 to 200 ppb for 12 to 24 hours causes osmo-
1656 regulatory problems (Lauren and McDonald 1986). Apparently copper exposure affects
1657 tight junctions between cells allowing Na⁺ and Cl⁻ to more readily diffuse across the gill
1658 epithelium. Copper treatment has also been found to adversely impact ammonia
1659 excretion in trout (Lauren and McDonald 1986). Wootten and Williams (1981) report
1660 that a CuSO₄ treatment of 0.5 mg/L for 1 hr caused changes in various hematological
1661 parameters and serum enzyme levels. These effects lasted at least for 24 hrs. Serum
1662 enzymes elevated included lactate dehydrogenase (LDH), hydroxybutyric dehydrogenase
1663 (HBDH), glutamic oxaloacetic transaminase (GOT) and glutamic pyruvate transaminase
1664 (GPT)- all enzyme elevations associated with liver damage. **Use of Snake River Farm
1665 waste water in a pump-back process will expose healthy fish to copper sulfate
1666 thereby causing toxicity and diminishing growth potential.**

1667

1668 **Because pump-back of effluent would increase the prevalence and severity of gill**
1669 **disease, it is likely increased use of copper sulfate would be required. Even if the**
1670 **copper was effective, it would increase osmo-regulatory and ammonia excretion**
1671 **problems thereby diminishing fish production capacity. If pumped spring water or**
1672 **ground water were to fail to be delivered, environmental conditions would occur for**
1673 **even short times that would likely increase the prevalence and severity of gill**
1674 **diseases thereby necessitating increased use of copper. Increased copper use causes**
1675 **increased osmoregulatory and ammonia regulation problems which diminishes fish**
1676 **growth and farm production.**

1677
1678 Potassium permanganate (KMnO_4) is an oxidizing agent used to manage bacterial gill
1679 disease. It oxidizes organic matter including bacteria on gills. Use of pump-back water
1680 during times of KMnO_4 use would expose healthy fish to this chemical potentially
1681 adversely impacting their sensitive respiratory surfaces, their feeding response and
1682 growth potential. It would expose eggs and very sensitive young fish to this chemical.

1683
1684 Various antibiotics are used to treat certain fish diseases. These antibiotics are mixed in
1685 feed and fed to affected populations for 7-10 days. During that time antibiotic
1686 contaminated TSS and solids are generated. Use of waste water in a pump-back
1687 procedure would contaminate healthy fish including those near harvest. There are no
1688 rapid tests for antibiotics in farmed fish so fish could potentially be marketed that are
1689 contaminated with antibiotics. **This would not be acceptable to Clear Springs Foods.**

1690
1691 **M. Waste water will contain hormones released by female trout that could impact**
1692 **the developmental physiology of eggs and fry, and could alter growth characteristics**
1693 **of early life stages. Use of waste water is unacceptable to Clear Springs Foods.**

1694 **Spring and ground water could also contain hormones or endocrine disrupting**
1695 **compounds. Spring or ground water containing hormones or endocrine disrupting**
1696 **compounds would not be acceptable to Clear Springs Foods.**

1697

1698 The impact of environmental, hormonally active substances on the endocrine and
1699 immune system of fishes is only beginning to be studied yet appears significant (Segner
1700 et al. 2006). Rainbow trout are known to release chemical cues to con-specifics through
1701 the gills and in the urine. These chemical cues are typically water soluble and include
1702 alarm pheromones, steroids and prostaglandins. The rainbow trout releases urine borne
1703 pheromones in bursts and these can have physiological impacts on other rainbow trout
1704 including on the immune system, growth, and cross-talk between different endocrine
1705 systems. These substances may modulate growth and disease. Stress itself may cause the
1706 release of stress hormones that may in turn elicit components of the stress response in
1707 non-stressed fish (Toa et al. 2005). The stress response has been clearly shown to be
1708 disadvantageous for somatic growth and thus considerable management effort is directed
1709 at minimizing stress. **Waste water that contains stress hormones and used in place of
1710 spring water would be unacceptable to Clear Springs Foods.**

1711
1712 The elevated nitrate-nitrite nitrogen detected in some of the incoming spring water
1713 entering the Snake River Farm complex has raised concern that other compounds may
1714 also be present. Among these compounds are hormones and endocrine disrupting
1715 chemicals. Hormones conceivably could include those derived from cows. **Spring or
1716 ground water containing such hormones would be unacceptable to Clear Springs
1717 Foods.**

1718
1719 **V. Research requirements for first use spring water**

1720
1721 The Research and Development Division, which includes the Snake River Brood Station,
1722 at Clear Springs Foods conducts primarily applied research focused on optimizing fish
1723 production and ensuring consistent, high quality trout are produced economically and in
1724 an environmentally responsible manner. Work areas include environmental science, fish
1725 health management, fish culture, reproduction and breeding, and fish nutrition. The
1726 Division also serves as a major service organization for the company. These work areas
1727 include water quality analyses that are conducted according to “Good Laboratory
1728 Procedures” including a quality assurance program to satisfy water discharge

1729 requirements specified by the US Environmental Protection Agency. Feed ingredients
1730 and finished feed and food fish products are monitored for their nutritional qualities.
1731 Clinical diagnostics are conducted on juvenile fish from Operations and spawning adult
1732 fish are routinely monitored for pathogens that could be detrimental to egg production.
1733 New adult rainbow trout with enhanced genetics produced at the Division through the
1734 selective breeding program are certified specific-pathogen-free before they are allowed
1735 entry into the egg production program. Additionally, vaccines are produced and tested
1736 used on juvenile and adult fish that are owned by Clear Springs.

1737

1738 The Research and Development Division is a state-of-the-art facility not equaled
1739 anywhere else in the world for a single private aquaculture company. Research faculty
1740 consists of two PhD and two MS scientists along with 13 technical and administrative
1741 staff. The dry laboratories consist of sophisticated scientific instrumentation used in
1742 medical research, microscopy, clinical chemistry, immunology and analytical chemistry.
1743 The wet laboratory consists of a specific pathogen free room for future broodstock and
1744 selective breeding of about 150 families annually and a specific pathogen infected room
1745 for fish health research. A fish rearing facility (1/3 operations size) completes the
1746 Research and Development Division but the Division also serves as an important egg
1747 production facility for Farm Operations primarily during the spring and summer months.
1748 Clear Springs Foods has a significant economic investment in and need for this Division.

1749

1750 The Research and Development Division currently uses about 37 cfs of first-use spring
1751 water originating from the Eastern Snake Plain Aquifer. Over time the quantity of water
1752 devoted to this operation has diminished because of declines in spring water flow and the
1753 need to provide sufficient water flow to the Snake River Farm for fish production
1754 purposes. The Research Division could use more water if it were available. Use of
1755 pump-back water is infeasible for the same reasons it is not feasible in the Snake River
1756 Farm itself- waste water has pathogens and decreased water quality which would cause
1757 production failure, significantly reduce the utility of the water and eliminate its use for
1758 research purposes. Spring water however has constant temperature (15° C), has a high
1759 dissolved oxygen content (9.2 ppm) and is virtually pathogen free which are all critical

1760 water quality parameters that must be maintained to ensure success of all of the
1761 Division's programs. Mitigation of flows to this facility by pumping back water from our
1762 Snake River Farm after passing through five successive production raceways where fish
1763 are continually fed and grown and occasionally get sick would significantly jeopardize
1764 the research and service activities described above. Currently there are over 12,000 adult
1765 rainbow trout at this facility that provide eggs for the company in the spring and summer
1766 months. Within these adult populations are the 4,000 selected adults which possess the
1767 most superior genetic stock of the Clear Springs strain of rainbow trout. Each fish is
1768 tagged with a small computer chip for individual identification and this code corresponds
1769 to the entire pedigree of that particular animal. In addition to these fish there are 16,700
1770 yearling rainbow trout with enhanced genetics produced through the selective breeding
1771 program which must be certified specific-pathogen-free before they are allowed entry
1772 into the egg production program on an annual basis. Additionally, 13 million eggs are
1773 produced annually by the Division that must be specific-pathogen-free before they are
1774 shipped to our production facilities.

1775

1776 **Besides not being pathogen free, if fish were reared or incubated in water**
1777 **contaminated with the Snake River Farm's effluent or Clear Lake, many of these**
1778 **young fish and eggs would not survive or would be significantly compromised.**

1779 Additionally, the research activities that go on in the Research and Development Division
1780 require pristine spring water or the results are not valid and will not be reproducible
1781 because of the extreme variability of effluent water after it has passed through the Snake
1782 River Farm. Selected breeding evaluations, nutritional studies for sustainable aqua-feeds,
1783 and the development of vaccines for enhanced animal welfare would no longer be
1784 possible. In summary mitigation of spring water flows to the Clear Springs Foods
1785 Research and Development Division with water from our Snake River Farm after passing
1786 through five successive production raceways where fish are continually fed and grown
1787 would have a significant economic impact on the production of valuable fish and eggs.

1788 **Additionally it would significantly compromise the capability of the company to**
1789 **conduct economically viable research. The Division's activities and personnel would**

1790 **have to be significantly reduced if this type of water flow mitigation were put into**
1791 **place.**

1792

1793 **The use of pumped spring or pumped ground water at Research and Development**
1794 **is also infeasible. Experiments, brood stock selection, and production of eggs are all**
1795 **highly dependent on continuous water flow. Pumped water, subject to**
1796 **unpredictable curtailment is unacceptable to Clear Springs Foods.**

1797

1798 Water from the Snake River Brood program is subsequently used at the Snake River
1799 Farm. It is used for some early life stage grow-out occurring in the A section of the farm.
1800 While the quality or growth potential of this water is not as good as pristine spring water,
1801 we nevertheless accept the water quality compromise because otherwise there is
1802 insufficient water flows for production expectations and because the utility of the water is
1803 still good. We do not want to waste the quality of water that still exists. Water for brood
1804 stock and eggs produced at the Snake River Brood Station is not used as intensively as
1805 would occur at the Snake River Farm itself. It maintains a substantial growth potential,
1806 does not usually contain dangerous fish pathogens such as IHNV and would not contain
1807 treatment drugs.

1808

1809 **VI. NPDES Permit**

1810

1811 The Federal Water Pollution Control Act, also known as the Clean Water Act (CWA, 33
1812 U.S.C. § 1251 et seq.) is a comprehensive water quality statute designed to “restore and
1813 maintain the chemical, physical, and biological integrity of the Nation’s waters” (33
1814 U.S.C. § 1231(a)). In order to meet this objective, the CWA imposes certain obligations
1815 on the federal Environmental Protection Agency (EPA) and state environmental
1816 protection agencies (Idaho Department of Environmental Quality; IDEQ). EPA must
1817 establish technology-based standards for discharges from point sources, including fish
1818 farms, to waters of the United States. These technology-based limits are imposed
1819 through National Pollutant Discharge Elimination System (NPDES) permits (33 U.S.C.
1820 §§ 1311, 1314, 1342). In Idaho the NPDES permits are issued by EPA. While EPA is

1821 required to set technology-based limits, Idaho, as with all other states, are required to
1822 adopt Water Quality Standards (IDAPA 58.01.02). The Water Quality Standards consist
1823 of designated uses of state waters, water quality criteria to protect those uses, and an
1824 antidegradation statement (33 U.S.C. § 1313c: 40 C.F.R. § 131.6). NPDES permit limits
1825 are consistent with State WQS. The Snake River Farm discharges to Clear Lakes which
1826 in turn discharges to the Snake River. These water bodies are both designated for cold
1827 water biota and primary recreation (IDAPA 58.01.02.140). In addition, the Snake River
1828 is designated for salmonid spawning. The water quality criteria developed for these
1829 designations are as follows:

1830
1831 Cold water biota: dissolved oxygen needs to exceed 6 mg/L at all times; the maximum
1832 daily average temperature must be 19° C or less; the ammonia concentration is dependent
1833 on temperature and pH.

1834
1835 Salmonid spawning: dissolved oxygen needs to be greater than 6 mg/L or 90% of
1836 saturation; the water temperature must be 13° C or less with a maximum daily average of
1837 9° C; the ammonia concentration is dependent on temperature and pH.

1838
1839 To determine if a water body meets beneficial uses, IDEQ relies on a Water Body
1840 Assessment Program and has developed a River Fish Index. The Index measures the
1841 biological integrity of a water body based on fish assemblages. If a water body is
1842 meeting the cold water biota or salmonid spawning beneficial use, it will have a species
1843 composition, diversity and functional organization comparable to that of the natural
1844 (undisturbed by man) habitats of the region. For cold water biota the fish assemblage
1845 consists of salmonids, sculpin, sucker and dace. The water quality criteria would be
1846 consistent with habitat in which this particular assemblage occurs.

1847
1848 A commercial trout farm is not intended to mimic the natural habitat or circumstances for
1849 which cold water biota or salmonid spawning conditions would occur. Commercial trout
1850 farms raise a single species of fish (i.e. rainbow trout) at far higher densities than would
1851 occur in their natural habitat. Farmed fish are fed a nutrient dense-high energy diet very

1852 different than what is available in the natural habitat. Farmed trout have been
1853 domesticated for over 100 years. At Clear Springs Foods, a selective breeding program
1854 has selected fish for peak performance in first use spring water. Farmed fish are raised
1855 under far more stressful conditions than occurs in natural habitats. Consequently water
1856 quality requirements are considerably different. Indeed, the water quality requirements
1857 for farmed fish are more stringent than for wild fish. Mere compliance with the water
1858 quality requirements stipulated in the NPDES permit would not suffice for intensive
1859 commercial production of rainbow trout as occurs at the Snake River Farm complex. The
1860 carrying capacity of the farm would be significantly reduced if only NPDES permit
1861 requirements were fulfilled.

1862

1863 **VII. The process of drilling a well as proposed so near to the Snake River Farm**
1864 **production facility may adversely impact fish behavior and compromise fish growth**
1865 **and health.**

1866

1867 The impact of noise or music on fish performance has only recently been explored. In
1868 recently published research, Papoutsoglou et al. (2008) demonstrates that certain types of
1869 music (Mozart, K525) had a positive stimulative impact on gilthead seabream raised in a
1870 re-circulation system. Whether Mozart merely masked adverse sounds associated with
1871 pumps and filters used for re-circulation aquaculture is unknown. However, regardless of
1872 the reason, sound does appear to have an impact on fish. **Clear Springs Foods is**
1873 **opposed to drilling near our Snake River Farm where potential sounds could have**
1874 **an adverse impact on ongoing fish production. We also are opposed to noise from**
1875 **pumps used to deliver water from any source because of its probable negative**
1876 **impact on fish production.**

1877

1878 **VIII. Pumped water of any kind is subject to interrupted delivery and to gas super-**
1879 **saturation. Fish, whether for research, brood stock, or food production require un-**
1880 **interrupted water delivery 24 hrs/day, 7 days/week, 365 days/year. Water used for**
1881 **early life stages and production must not be supersaturated with gases that cause**
1882 **gas bubble disease or trauma.**

1883 In air the partial pressures of nitrogen and oxygen are 0.78 and 0.21 respectively (Munro
1884 and Roberts 1989). With pumped water supplies, air and water may be drawn into the
1885 pump together so that the air is compressed by the pump, resulting in greater solution of
1886 oxygen and nitrogen. Additionally, ground water would likely contain gases at higher
1887 pressure than surface water. Ground water is typically not saturated with oxygen, but is
1888 supersaturated with nitrogen and may have high levels of carbon dioxide (Munro and
1889 Roberts 1989; Batzios et al. 1998). Once drawn up to higher elevation some gas will
1890 come out of solution leading to gas bubble disease in all life stages of rainbow trout. Gas
1891 bubble disease occurs under supper-saturation conditions when gas, typically nitrogen,
1892 accumulates in the blood stream of fish (similar to the bends in SCUBA divers). The
1893 bubble blocks blood flow causing focal and disseminated necrosis. Advanced sac-fry and
1894 newly “buttoned-up” fry will develop visible bubbles in the body cavity, pressing the
1895 yolk sac out of the way or opening the seam on newly “buttoned-up” fry (Wood 1968).
1896 Gas bubbles that occur in fingerling, yearlings and adults often lead to blindness and
1897 death. Distress and ultimately death follows. The economic consequences of gas bubble
1898 disease can be significant (Batzios et al. 1998).

1899
1900 **IX. Recirculation aquaculture is subject to catastrophic failure, is very expensive,**
1901 **causes bio-accumulation of drugs and has water quality problems.**

1902 Recirculation aquaculture systems are subject to catastrophic fish losses (Masser et al.
1903 1999; Sumerfelt et al. 2001, Ismond 1996; Lee 1992; and Summerfelt et al. 2004).
1904 Additionally they are complex because they require extensive water treatment, space
1905 consumptive to house the treatment system, and are expensive.

1906
1907 **X. Ground water may be chemically different than current spring water, could**
1908 **contain elevated arsenic and other chemicals, and be saturated with gases that could**
1909 **cause gas bubble disease.**

1910
1911 The ground water proposed for mitigation purposes is of unknown character. We do
1912 know from Clear Springs Foods own processing plant well that ground water quality may
1913 have significantly different physico-chemical differences from the spring water currently

1914 received. The water temperature of the ground water may be significantly warmer and
1915 arsenic concentrations significantly higher. We do know that rainbow trout are sensitive
1916 to toxicity from chronic arsenic exposure (Kotsanis and Illiopoulou-Georgudaki 1999).
1917 **It is unacceptable to Clear Springs Foods to use mitigation ground water whose**
1918 **physico-chemical character is significantly different from currently used surface**
1919 **water.**

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2253 **EXHIBIT "1"**

2254 *Curriculum Vitae*

2255 **John R. MacMillan**
2256 **Clear Springs Foods, Inc.**
2257 **P.O. Box 712**
2258 **Buhl, Idaho 83316**
2259 **208-543-3456**
2260 **randy@clearsprings.com**

2261 **Education**

2262 B.Sc. University of Maryland, College Park, Maryland, USA. 1974.
2263 Conservation and Resource Development.
2264 M.Sc. Michigan State University, East Lansing, Michigan, USA. 1976. Fishery
2265 Biology.
2266 Ph.D. University of Washington, Seattle, Washington, USA. 1980. Fish
2267 Pathology.

2272 **Professional Experience**

2273 1998-present. Vice President of Research and Environmental Affairs. Clear
2274 Springs Foods, Inc., Buhl, Idaho, USA. Responsible for all research,
2275 environmental management, regulatory affairs, and quality assurance (seafood
2276 safety) for large, vertically integrated seafood (farm raised rainbow trout)
2277 company.
2278 1990-1998. Director of Research and Development. Clear Springs Foods, Inc.,
2279 Buhl, Idaho, USA.
2280 1985-1990. Associate Professor of Veterinary and Aquatic Animal Medicine.
2281 College of Veterinary Medicine, Mississippi State University,
2282 Starkville, Mississippi, USA.
2283 1982-1985. Area Extension Fisheries Specialist. Mississippi State University,
2284 Stoneville, Mississippi, USA.
2285 1980-1982. Senior Research Fellow. Department of Pathology, School of
2286 Medicine, University of Washington, Seattle, Washington, USA.
2287 1976-1980. Research Microbiologist. United States Fish and Wildlife Service.
2288 Seattle, Washington.

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Ancillary Experience

2007-present. Comprehensive Aquifer Management Plan (CAMP) Advisory Committee. Idaho Governor Appointment as Spring representative.

1999-present. President, National Aquaculture Association.

2000-present. Idaho Board of Environmental Quality. Vice-chairman (2002-2004) and Chairman (2004-2006). Appointment by Idaho Governor and confirmation by Idaho Legislature.

2007. Testified before US House of Representatives Committee on Natural Resources; Subcommittee on Fisheries, Wildlife and Oceans. National Offshore Aquaculture Act of 2007.

2006. Expert. Joint FAO/WHO/OIE Expert Consultation on Antimicrobial Use in Aquaculture and Antimicrobial Resistance. Seoul, Republic of Korea, June 13-16, 2006.

2006. Testified before US Senate Committee on Science, Commerce, and Transportation; National Ocean Policy Subcommittee. Senate Bill 1195.

2000-2005. Minor Use Minor Species (MUMS) Coalition. Chairman (2000-2005). Successfully passed through US Congress the Minor Use and Minor Species Animal Health Act of 2004.

2000-2004. United States Department of Agriculture (USDA) Aquaculture Effluents Task Force. Member.

2000-2002. American Academy of Microbiology. Colloquium steering committee "The role of antibiotics in agriculture (2002).

2001-present. Alliance for Prudent Use of Antibiotics (APUA). Facts About Antibiotics in Animals and Their Impact on Resistance (FAAIR II). Scientific expert.

2000-2001. Chairman, Joint National Association of State Aquaculture Coordinators-National Aquaculture Association Committee on National Aquatic Animal Health Management Plan Development.

1995-1997. President United States Trout Farmers Association.

1994-1995. President Idaho Aquaculture Association.

1992-1993. President, American Fisheries Society, Fish Health Section.

2345 1990-2008. Joint Subcommittee (FDA-USDA) on Aquaculture, Quality
2346 Assurance in Aquaculture Working Group.

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2349 **Honors, Awards, and Certifications**

2350

2351 FDA Commissioners Award, 2005.

2352 AFS/FHS Board Certified Fish Pathologist. 1985-present.

2353 U.S. Jaycees Outstanding Young Man of the Year. 1982.

2354 Raymond J. Huff Memorial Scholarship. 1978, University of Washington.

2355 E.P.A. Scholarship. 1974-1976. Michigan State University.

2356 Eagle Scout. 1968.

2357

2358 **Publications**

2359

2360 Landolt, M.L., J.R. MacMillan, and M. Patterson. 1977. Detection of an
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- 2409 **MacMillan**, J.R. 1984. Enteric septicemia of catfish (ESC). Mississippi
 2410 Cooperative Extension Service Information Sheet No. 1264.
- 2411 **MacMillan**, J.R. 1984. Potassium permanganate for fish ponds. Mississippi
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Learn from the Best

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History of Aquaculture in Idaho

2504

2505 The artificial propagation (production of young) of fish began in ponds in China about
 2506 3000 years ago but it was not until market demand for seafood significantly increased
 2507 (sometime after 1950), and the application of scientific methods and technology
 2508 development occurred that commercial aquaculture (fish grow out at high density)
 2509 became feasible in Idaho and globally. In Idaho, this conjunction occurred in late 1950-
 2510 1965. A time line of rainbow trout aquaculture follows.

2511

2512 1700-1790: over-fishing, pollution and dams deplete various wild species of fish
 2513 in US and in Europe. This creates demand for wild fish stock replacement.

2514

2515 1790-1850: Fish culture becomes well established in Western Europe, the
 2516 Balkans, and in Scandinavia. Fry for culture are captured from the wild and used
 2517 for re-stocking in public waters.

2518

2519 1853: First artificial propagation of brook trout occurs in the US (Theodatus
 2520 Garlick and H.A. Ackley) in Ohio. Trout feed consists of boiled lean meat, egg
 2521 yolk, liver, heart, and clabbered milk. Maggot factories established (meat and
 2522 entrails suspended over fish ponds) to feed fish.

2523

2524 1866-1870: Brook trout, Atlantic salmon, American shad, whitefish, lake trout,
 2525 and yellow perch successfully propagated and cultured. All fish raised for
 2526 stocking in public waters.

2527

2528 1870: Fish culture practiced in 19 of 37 states plus territories of Colorado and
 2529 Kansas. State Fish Commissions culture designed for restoration of fishery
 2530 resources. Foundation of fish culture well established for fishery conservation.

2531

2532 1870-1950: Fish diets continue to be composed of ground meat (horse, cattle, and
 2533 carp) particularly liver, heart and spleen.

2534

2535 1909: First commercial fish farm in Idaho at Devil's Corral Spring near
 2536 Shoshone Falls. Farm closed one year later in 1910 presumably because there
 2537 was no fish market.

2538

2539 1915-1930: Warren Meader pioneers rainbow trout brood stock and egg
 2540 production at farms near Pocatello (Papoose Springs) and Soda Springs (Caribou
 2541 Trout Farm later sold to Clear Springs Trout Co. and renamed Soda Springs).

2542

2543 1919: Frame Trout Farm in Twin Falls opens. Farmed continuously until 1973.

2544

2545 1920: Snake River bottomland opened to homesteading allowing land below the
 2546 Snake River Canyon rim to be developed, thus allowing for fish farm

2547 development at headwaters of springs. In the late 1920's Burt Perrine, son of L.B.
2548 Perrine, began raising trout in the Snake River Canyon near Twin Falls at a site
2549 close to the current Blue Lakes Trout Farm. This farm became Royal Catfish
2550 Industries and operated until 1975. Also in the 1920's, the Southern Idaho Fish &
2551 Game Association (a sportsman's club) began construction of a hatchery in Rock
2552 Creek Canyon. The club leased the facility to the Idaho Fish & Game in 1931,
2553 and then to the College of Southern Idaho in 1976. CSI now uses the farm for its
2554 aquaculture training program.
2555
2556 1928: Jack Tingey starts Snake River Trout Company (located at the current
2557 location of Clear Springs Foods Snake River Farm). Farm consists of earthen
2558 ponds. Ted Eastman and Percy Greene employed by Jack Tingey. Tingey's
2559 vision was to develop a trout farm dedicated to producing food fish. He was
2560 successful in developing fresh trout markets as far away as Chicago where he
2561 shipped product with ice departing from Shoshone on the old REA rail system.
2562
2563 1930-1933: Hagerman National Fish Hatchery (USFWS) built for conservation
2564 fishery.
2565
2566 1932: In response to Idaho Power's filing on all springs in the Hagerman Valley,
2567 the "1932 Decree or New International Decree" resolved water rights for those
2568 people who settled the area and claimed water rights since the late 1800's from
2569 Billingsley Creek, Riley Creek and various springs. This decree also established
2570 that the common source of water for this area was the underground aquifer
2571 generally to the east of Hagerman. Many of these properties would later expand
2572 the beneficial use of their water to include fish propagation on small farm ponds
2573 when technology advanced to the point that aquaculture became profitable
2574 through the "Clear Springs Farm Pond Program".
2575
2576 1935: Percy Greene establishes Greene's Trout Farm on south side near Twin
2577 Falls.
2578
2579 1930-1940: Joint research conducted at a New York State laboratory and
2580 Hagerman's Tunison lab (now the University of Idaho Hagerman Experiment
2581 Station) developed dry feed formulations that replaced those originally made from
2582 decaying animal carcasses. In the early 1940's, dry diets were first tested at
2583 Tupper's Trout Farm in Hagerman.
2584
2585 1938: George Isaac purchases Caribou Trout Farm for trout egg production from
2586 Warren Meader.
2587
2588 1940: IDF&G acquires Tucker Ranch property for Hagerman State Fish Hatchery
2589 and Wildlife Management Area. Thirteen ponds for bass, bluegill and catfish
2590 were constructed by 1942. First IDF&G trout hatchery building built by 1942
2591 with full construction completed by 1949.
2592

2593 1946: Art Wylie establishes Canyon Trout Farm on Rock Creek. Ted Eastman
2594 returns from WWII again finding employment with Jack Tingey and then with
2595 Bob Erkins at Snake River Trout Company.
2596

2597 1948: Earl Hardy and Al Iverson establish Rainbow Trout Farm at head of Cedar
2598 Draw (now part of Idaho Trout Company).
2599

2600 1949: Rangen Inc., founded in 1925, starts its Aquaculture Division, providing
2601 high quality dry diets based on formulations developed by the Tunison lab in
2602 Hagerman. Food conversion ratios drop from 5:1 using carcasses to present
2603 efficiencies of 1.25:1 using dry feeds.
2604

2605 1950- present: Selective breeding of rainbow trout for growth in flowing water
2606 culture conditions begins in Washington.
2607

2608 1951-1952: Rimview Trout Company started near Niagara Springs by Milford
2609 Schmekpepper. Ralph Nelson starts Crystal Springs Trout Farm near Niagara
2610 Springs.
2611

2612 1952: Rainbow trout aquaculture starts in Great Britain. Bob Erkins purchases
2613 Snake River Trout Company from Jack Tingey. Eventually changes name to
2614 1000 Springs Trout Company.
2615

2616 1953: US Trout Farmers Association formed to enhance communication and
2617 technology transfer throughout the United States.
2618

2619 1956: Snake River Trout Company builds first local processing plant- previous
2620 processing capacity in area very limited. Automated processing equipment
2621 installed thereafter. Blue Lakes Trout Farm built by Percy Greene and Stan
2622 Miller. A processing plant was added to Rainbow Trout Farm (now Idaho Trout
2623 Company).
2624

2625 1958: David Haskell (New York Fish Conservation Department) establishes
2626 scientific principles of flowing water fish culture. Definition of chemical and
2627 biological parameters affecting fish in confinement takes fish culture from art to
2628 science.
2629

2630 1960: Al Dunn purchases Caribou Trout Farm from George Isaac.
2631

2632 1962: Rangen Inc.'s Research Hatchery established. Notable research
2633 accomplishments include: development in mid-1980's of a stable form of Vitamin
2634 C now included in all aquatic animal feeds world wide (Rangen sold the formula
2635 to Hoffman-LaRoche); collecting efficacy data in mid-1990's to support FDA
2636 approval of BASF's pigment canthaxanthin (dietary pigment that turns trout and
2637 salmon flesh red); collecting manufacturing data in late 1970's to support FDA

2638 approval of the first of only 3 medicated feeds ever to be approved for fish; fish
2639 vaccine development; and feed product and ingredient testing.
2640
2641 1964: Idaho Trout Company builds new processing plant in Filer.
2642
2643 1965: Rainbow trout market demand spurs growth of trout industry in California,
2644 Colorado, Montana, Missouri, Wisconsin, West Virginia and North Carolina.
2645
2646 1966: Clear Springs Trout Company formed (Ted Eastman President). Clear
2647 Springs Trout Company builds Clear Lake Farm. Earl Hardy acquires trout farm
2648 at the Clear Lake site.
2649
2650 1966-1979: Clear Springs Trout Company successively builds and expands
2651 seafood processing plant at current location.
2652
2653 1968: Norman Standal starts building ponds for Whitewater Farm.
2654
2655 1969: Clear Springs Trout Company purchases Crystal Springs Trout Farm (near
2656 Niagara Springs). Eliminates existing facility which consisted of earthen ponds,
2657 develops efficient water capture structure and builds existing modern farm. Idaho
2658 Power sells properties with spring water, allowing for larger hatchery
2659 development. George Lemmon and Norman Standal establish Magic Springs
2660 Trout Farm near the Hagerman National Fish Hatchery on one of those properties.
2661
2662 1970: Jones Trout Farm (Billingsly Creek) built on family ground owned since
2663 1896.
2664
2665 1972: 1000 Springs Trout Farm is sold to Inmont Corporation of New Jersey.
2666 Clear Springs Trout Company starts farm pond grow-out system. Production of
2667 rainbow trout and other farmed aquatic species expands greatly through the
2668 1980's.
2669
2670 1973: Clear Springs Trout Company builds Box Canyon Trout Farm and expands
2671 its processing plant. Babington demand feeders designed and built.
2672
2673 1975-1980: First fish pump, automatic live fish grader, and boning tool built and
2674 patented by George Lemmon. Idaho Trout Company acquires Rim View Trout
2675 Farm and builds a second processing plant at Clear Lakes Trout Farm (?).
2676
2677 1978: Clear Springs Trout Company builds fish feed mill in Buhl.
2678
2679 1981: Clear Springs Trout Company purchases 1000 Springs Trout Company
2680 from Inmont Corporation. Rebuilds Snake River farm and builds research
2681 building. Rebuilding completed in 1988.
2682

2683 1983: Clear Springs Trout Company installs hydroelectric operation at Box
2684 Canyon.
2685
2686 1985: Clear Springs Trout Company purchases Caribou Trout Farm from Al
2687 Dunn and builds Soda Springs Brood Farm.
2688
2689 1987. Magic Valley Steelhead Hatchery built. Part of the Lower Snake River
2690 Fish and Wildlife Compensation Plan to mitigate for dams.
2691
2692 1991: Clear Springs Trout Company purchases Coast Oyster Company in
2693 Washington. Clear Springs Trout Company changes name to Clear Springs
2694 Foods, Inc. to reflect broader product offerings. Clear Springs Foods further
2695 automates processing plant with introduction of robotic cutting machines and pin-
2696 bone removal equipment.
2697
2698 1996: Clear Springs Foods acquires existing Pillsbury Oven Baked Bean plant in
2699 Buhl and reconstructs to form a specialty products plant.
2700
2701 2000: An Employee Ownership Plan and Trust (ESOP) is established and the 400
2702 Clear Springs Foods employees purchase 100% ownership of the company
2703 through the beneficial trust.
2704
2705 2001: Clear Springs Foods completes long-term trout supply contract with
2706 Chilean trout producer.
2707
2708 2003: Clear Springs Foods completes two long-term trout production facility
2709 leases at Briggs Creek.
2710
2711 2005: Clear Springs Foods completes additional long-term supply agreement
2712 with additional South American trout producers.
2713
2714 2006: Idaho produces 70-75% of all farm raised trout in the US. Approximately
2715 561 trout farms are located throughout the US (42 states). United Nations
2716 projects aquaculture supplies 40-45% of all seafood consumed globally.
2717
2718 2006-2007: Clear Springs Foods completes major automation update at
2719 processing and specialty products facilities.
2720

Global Seafood Market and Aquaculture

2721
2722
2723 In the US there has been a seafood trade deficit for well over 20 years. In 2006 this trade
2724 deficit was over \$8 billion. Imports of shrimp, salmon, tilapia, and other seafood create
2725 an extremely competitive market in which product price, quality, product availability and
2726 choice determine consumer purchasing decisions. These conditions prevail in the current
2727 seafood market compelling all US fish farmers and seafood processors to seek production
2728 cost reductions, greater production and processing efficiencies and product choice if they

2729 are to remain competitive. Natural resource barriers (i.e. availability of suitable water)
2730 and the technologic aquaculture challenge associated with some species (e.g. rainbow
2731 trout) preclude the excessive production of these species in many countries.
2732

2733 Capture fisheries have historically provided all seafood in the US and most of the world.
2734 As wild stocks have dwindled from over fishing and effects of pollution, and sustainable
2735 catch has been maximized, aquaculture has become an increasingly important supplier of
2736 seafood for human consumption (in 2007 about 45% according to the United Nations
2737 Food and Agriculture Organization). Seafood consumption itself has grown steadily in
2738 the US since the early 1980 (from about 12 lb/capita to 16.5 lb/capita). Starting
2739 sometime in the 1950s interest in commercial fish farming began to grow throughout the
2740 US and globally. This interest occurred because of market demand for consistent supply
2741 and quality of seafood. According to the United Nations, the phenomenal growth in
2742 world aquaculture over the last fifty years has been most notable in Asia and the Pacific
2743 regions. World aquaculture has grown at an average annual rate of 8.8 percent from 1950
2744 to 2004. Production in the last fifty years has grown from less than a million tones in the
2745 early 1950s to 60 million tones in 2004 (United Nations). Nearly 70% of aquacultured
2746 products are produced in China. The potential to enhance food supply in low income,
2747 food deficit countries and the economic opportunity for all fish farmers fostered increased
2748 emphasis on aquaculture science and technology development ultimately leading to
2749 today's modern aquaculture industry. Over 442 aquatic animal species are farmed for
2750 human consumption, sport fishing and stock enhancement. The year round availability of
2751 some farmed species such as Idaho rainbow trout and consistency of high quality allow
2752 Idaho rainbow trout to compete for consumer purchase in the North American market.
2753

2754 Rainbow trout competes in the US market with other seafood and with poultry, pork and
2755 beef. Consumer price remains a significant factor in purchase decisions. Much of the
2756 imported farm raised seafood arrives at significantly lower price than domestic seafood
2757 because international labor costs (particularly China, SE Asia and South America) are
2758 very much lower. Additionally environmental constraints on international production are
2759 much less than in the US further creating significant operational cost disadvantages to US
2760 producers.
2761

2762 Idaho produces 70-75% of all rainbow trout produced in the US for human consumption.
2763 Total production of rainbow trout in the US has been essentially constant over the past 20
2764 years averaging around 55 million lbs per year. Fluctuations in total production arise
2765 because of variation in water flows, drought, floods, disease and predators, and market
2766 forces. Barriers to trout production in the US are lack of suitable water resources and
2767 production costs. Rainbow trout production volume in Idaho varies but is about 40
2768 million pounds per year. The production capacity of Idaho, and any other trout producer,
2769 is determined by water availability, water quality, and the application of technology.
2770

2771 Aquatic animal production method significantly impacts production costs. Some aquatic
2772 animal species can be intensively raised in stagnant warm water ponds (e.g. channel
2773 catfish, basa, and tra). Others are primarily raised in open water (ocean, lake, large river)
2774 net pens (e.g. salmon, tuna and sea bass). Most rainbow trout grown in the US are

2775 intensively produced in flowing water culture systems because of the stringent water
2776 quality requirements of this species. Commercial success of rainbow trout farming
2777 demands intensive culture practices provided by flow-through water systems.

Learnings from the
FISHING