Infrastructure and Operations Audit of the Hagerman National Fish Hatchery Partial Recirculating Aquaculture System 2022

Hagerman National Fish Hatchery
Lower Snake River Compensation Plan

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Executive Summary

On August 2, 2022, Nathan Wiese, Program Coordinator LSRCP, Brian Thompson, Hatchery Manager, and Sage Hallenbeck, Assistant Hatchery Manager, conducted a high-level one-day infrastructure and operations assessment of the Partial Recirculating Aquaculture System (PRAS) at the Hagerman National Fish Hatchery.

The purpose of this document is to provide the Lower Snake River Compensation Plan (LSRCP) and other stakeholders ample conceptual-level information of the current infrastructure challenges. The goal is to incorporate audit findings into a 10-year strategic plan for LSRCP that will maximize in-house and external improvement opportunities by developing solutions that fit resources, budgets, and supportive programs in a logical sequence. These efforts are intended to significantly improve water quality, program capacity, efficiency, and flexibility at the facility and ultimately increase opportunities for LSRCP to meet adult mitigation targets.

The LSRCP plans to assess all spring/summer Chinook rearing facilities within the program prior to the 10-year spring/summer Chinook Program Review for the Independent Scientific Review Panel (ISRP) in December 2022. With this review, the LSRCP intends to identify strategies toward improving performance of achieving project area goals of 58,700 spring/summer Chinook salmon adult returns. From 2004-2017, the LSRCP averaged 29,115 spring/summer Chinook salmon adult returns and failed to achieve the project area goal on any year during the period.

At Hagerman National Fish Hatchery, the assessment has identified that the current PRAS/Control raceways could be used to produce an additional 1,000,000 summer Chinook sub-yearling smolts at 50 fish per pound for June releases or 480,000 summer Chinook yearling smolts at 20 fpp. These fish would be released at the Sawtooth Fish Hatchery for comparison to standard releases. Total cost is estimated at $0.10/sub yearling smolt for a $50,000 annual budget and $0.15/yearling smolt ($72,000) with a $48,000 chiller infrastructure need.

Maximize production capacity of Hagerman National Fish Hatchery

Program	Current Chinook Smolts	Proposed Smolts
PRAS sub-yearling SCS	0	500,000 @ 50 fpp
Control Rwys sub-yearling SCS	0	500,000 @ 50 fpp
PRAS yearling SCS	0	240,000 @ 20 fpp
Control Rwys yearling SCS	0	240,000 @ 20 fpp
Total	**0**	**480,000 - 1,000,000**

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1 Scope

On August 2, 2022, Nathan Wiese, Program Coordinator LSRCP, Brian Thompson, Hatchery Manager, and Sage Hallenbeck, Assistant Hatchery Manager, conducted a high-level one-day infrastructure and operations assessment of the Partial Recirculating Aquaculture System (PRAS) at the Hagerman national Fish Hatchery.

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This audit is a kick-off effort to assess all spring/summer Chinook rearing facilities within the LSRCP program prior to the 10-year spring/summer Chinook Program Review for the Independent Scientific Review Panel (ISRP) in December 2022. With this review, the LSRCP intends to identify strategies toward improving performance of achieving project area goals of 58,700 spring/summer Chinook salmon adult returns. From 2004-2017, the LSRCP averaged 29,115 spring/summer Chinook salmon adult returns and failed to achieve the project area goal on any year during the period.

2 Background

The Hagerman National Fish Hatchery (Hatchery) is located along the Snake River, about 30 miles west of Twin Falls, Idaho at a point three miles south and two miles east of Hagerman, Idaho. The Hatchery was authorized by 46 Stat, 371 on May 21, 1930 and was established in 1932. Construction of the physical facilities commenced in 1932; fish production began in 1933. The primary goal of the Hatchery, at that time, was the production of rainbow trout for stocking in Idaho, eastern Oregon, and northern Nevada.

In the late 1970s the Hatchery became part of the Lower Snake River Compensation Plan (LSRCP) which was authorized by the Water Resources Development Act of 1976, Public Law 94-587. The LSRCP is designed to mitigate for fish and wildlife losses caused by the construction of four dams on the lower Snake River. For its part in the LSRCP program, the Hatchery's primary production goal was changed from resident rainbow trout to steelhead trout. The Hatchery was extensively remodeled during 1984 to accommodate this change.

There are 78 outside raceways at the Hatchery. Of these, 66 are devoted to LSRCP steelhead production and 12 are reserved for other programs which the Fish and Wildlife Service (Service) deems appropriate. Other major facilities include two hatchery-rearing buildings with a total of 60 rearing tanks, a water chiller building, an administration-visitor facility building, a combination shop/four-stall garage, four residences, an oil/paint storage building, and two general storage buildings.

The Hatchery's water supply emanates from the Eastern Snake Plain Aquifer via a complex of springs at a constant 59 degrees Fahrenheit with a flow rate of approximately 30,000 gallons per minute.

In 2014, the LSRCP constructed a Partial Recirculating Aquaculture System (PRAS) at the Hatchery to address dwindling water supplies. The PRAS consists of three circular tanks, each 30 ft diameter, 6 ft deep, 3,885 ft^3 rearing volume and produce 90,000 steelhead smolts at 4.5 fpp annually. Original PRAS design memos also included plans for experimental Age-0 spring/summer Chinook production (Jack Christiansen, pers. comm.) to address adult mitigation shortfalls for the LSRCP.

In 2018, the U.S. Fish and Wildlife Service and Idaho Department of Fish and Game (IDFG) entered into a Memorandum of Understanding transferring operations and management of the Hatchery to IDFG personnel.

The LSRCP adult return goal for A-run and B-run steelhead reared at Hagerman NFH and released in the Salmon River is to return 13,600 adult steelhead to the Snake River Basin upstream of Lower Granite Dam. To meet that goal, the Hatchery annually produces 1.56M steelhead smolts at 4.5 fish per pound (fpp) to meet at target size of 180-250 mm in total length (Proposed Recovery Plan for Snake River Salmon, NMFS 1995).

Table 1. Hagerman NFH Sawtooth Smolt to Adult survival rate

Brood Year	Salmon-Hagerman/Sawtooth
2000	1.09%
2001	1.20%
2002	1.28%
2003	0.71%
2004	1.63%
2005	1.60%
2006	1.55%
2007	2.90%
2008	0.92%
2009	1.67%
2010	1.32%
2011	1.48%
2012	1.57%
2013	1.54%
2014	0.12%
2015	0.58%
2016	0.29%
	1.26%

2.1 PRAS Background

The Hatchery PRAS has been studied intensively as a trial system since Brood Year 2014 with steelhead. Initial studies have successfully reared steelhead at a 50% re-use rate to produce smolts of identical size, health, body composition, and 90%+ on-station survival (Figure 1 and USFWS 2016 & 2017). Unfortunately, outmigration survival and resulting adult return rates have lagged significantly behind fish reared in control raceways (Figures 1 & 2). Ongoing studies are examining potential swimming speeds and have identified feeding regimes as possible parameters to modify to improve post-release performance.

Figure 1. Steelhead reared at Niagara Springs Fish Hatchery, Magic Valley Fish Hatchery, Hagerman National Fish Hatchery Raceways, and Hagerman National Fish Hatchery Partial Recirculating Aquaculture System, March 2021.

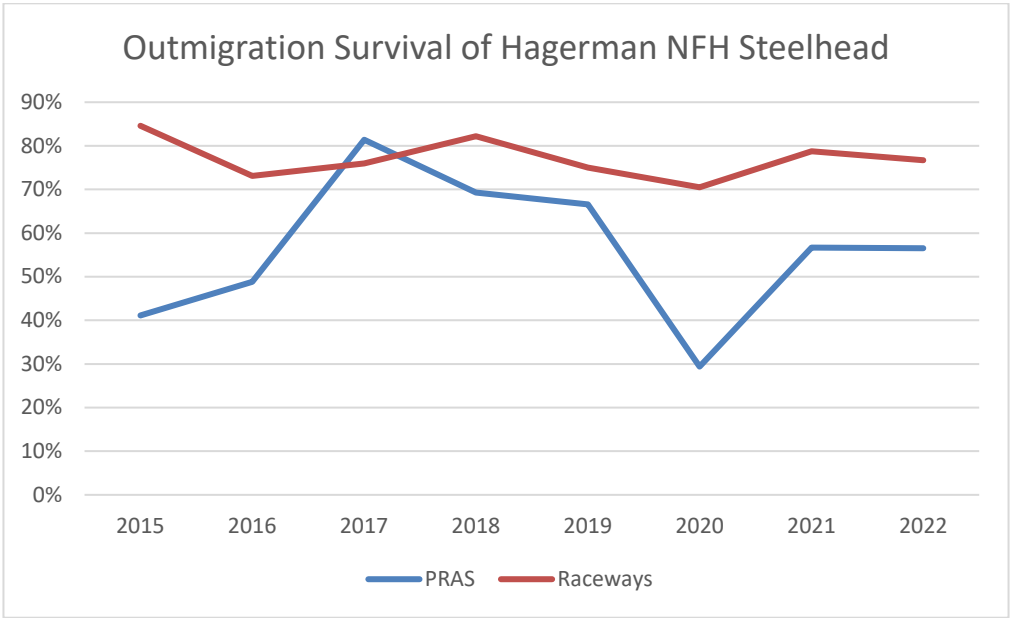

Figure 2. Outmigration survival of Hagerman National Fish Hatchery Steelhead, Release Year 2015-2022.

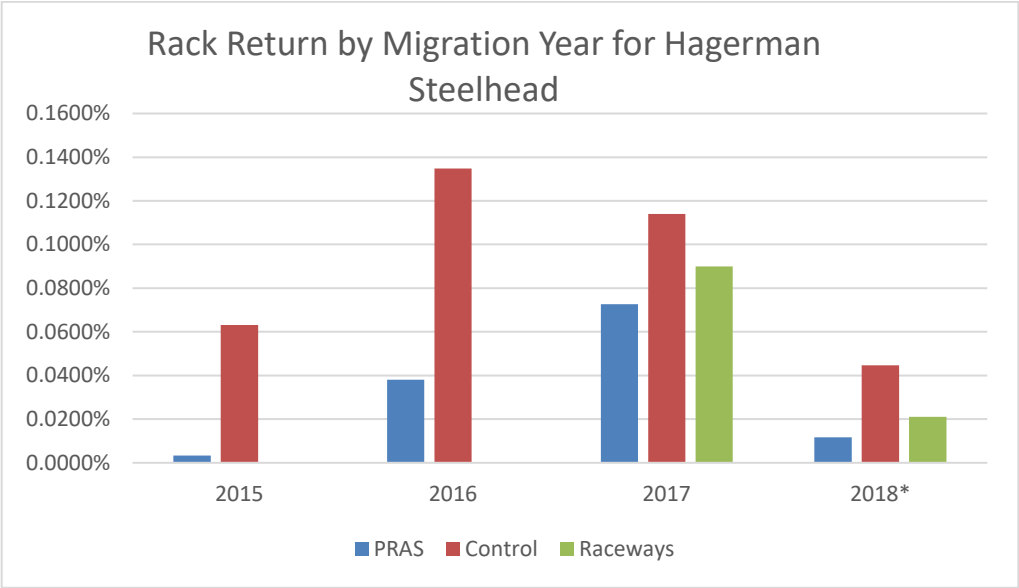

Figure 3. Rack Returns of adults from migration years 2015-2018 for control, raceways and PRAS systems at Hagerman National Fish Hatchery.

2.2 Chinook Background

Hagerman National Fish Hatchery reared Fall Chinook for release at the confluence of the Snake and Columbia Rivers from 1977 to 1985 when the program was transferred to Lyons Ferry Fish Hatchery. Total rearing numbers ranged up to 700,000 smolts and size at release was around 40 fish per pound (fpp). Growth rates were listed at 0.75" per month, but annual reports noted significant growth differences with diets. Diets were produced at Abernathy Fish Technology Center.

From 1982 to 1984 Hagerman reared spring Chinook salmon from Rapid River and Kooskia hatcheries. These smolts were reared to 30 fpp and the program was discontinued after 1984 due to Bacterial Kidney Disease concerns.

Currently (2022), fall Chinook salmon are commonly reared between 12 fpp as yearlings and 50 fpp as sub-yearlings. The LSRCP is evaluating converting remaining fall Chinook salmon to sub-yearlings (fpp) to reduce jacking rates and program costs. In the last decade, fall Chinook salmon sub-yearlings have survived to adulthood well. A small component (15%) of fall Chinook salmon sub-yearlings "holdover" in the Lower Granite and other pools created by the hydrosystem. However, these "holdover" subyearlings account for a significant (25%+) component of the returning adult fall Chinook salmon (NOAA 2018). Anecdotally, these "holdover" sub-yearlings grow very quickly in the summer and fall months in the productive reaches of the snake river and quickly surpass the 12 fpp release size of comparable yearlings (Darren Ogden pers comm).

Spring/summer Chinook salmon are commonly reared between 12 to 25 fpp within the LSRCP between temperatures of 36 to 55 F as yearlings and 100 fpp as sub-yearlings. The Hatchery's 59 F water temperatures are warm for spring/summer Chinook and offer an opportunity to attempt a fall Chinook sub-yearling life history. Previous work with spring/summer Chinook sub-yearlings have released 100 fpp parr in the Fall (September). These releases have produced very poor adult return rates (<0.1%). Accelerating growth to target June releases at 50 fpp would match fall Chinook salmon releases and potentially capture benefit of some smolts "holding-over" in the Lower Granite and other associated dam pools.

Initial trials to rear Sawtooth stock Chinook at Springfield Hatchery (IDFG Sockeye facility) were unsuccessful. These trials were part of the Shoshone-Bannock Tribe's Crystal Springs Hatchery Chinook project adjacent to Springfield Hatchery. Part of the performance issue was attributed to water hardness differences between Sawtooth (79 ppm CaCO3) and Springfield (236 ppm CaCO3). Hagerman has a water hardness of about 137 ppm CaCO3 and Pahsimeroi Hatchery is at 162 ppm CaCO3 (Appendix D). Anecdotally, Sawtooth stock summer Chinook have been reared at Pahsimeroi with limited effect suggesting that transfer to Hagerman water supplies would not be affected by water hardness differences.

Facility	Hardness (CaCO3)
Sawtooth	79 ppm
Hagerman	137 ppm
Pahsimeroi	162 ppm
Crystal Springs	236 ppm

2.3 Infrastructure

2.3.1 Hatchery Water Supply

The Hatchery's water supply emanates from the Eastern Snake Plain Aquifer via a complex of springs at a constant 59 degrees Fahrenheit with a flow rate of approximately 30,000 gallons per minute.

Supply water to the PRAS is from Spring 17 which provides approximately 2.7 cubic feet per second (1210 gpm) for the system.

2.3.2 Broodstock Collection

Steelhead broodstock are collected at the Sawtooth Fish Hatchery weir and the East Fork Salmon River satellite facility. Approximately 1.85 M green eggs are collected from 345 steelhead pairs at the Sawtooth weir and another 14 pairs at the East Fork satellite facility. Approximately 106,000 of the green eggs from 21 pairs are utilized for the PRAS. Sawtooth Fish Hatchery ships eyed eggs to the Hatchery between 370 and 450 Tus in May and June.

2.3.3 Incubation

The Hatchery receives eyed eggs in May and June and expects a 92% eyed to release survival on-station. Upon receipt, eyed eggs are disinfected with Iodine at 100-ppm for 10 minutes and then placed into upwelling incubator at 20,000 to 30,000 eggs per jar with a flow rate of 6 to 8 gpm.

2.3.4 Nursery Rearing

Flows in Nursery rearing tanks are ramped up to, and then maintained at 100 gpm. Fish are reared inside to a density index of 1.0 and a max flow index of 1.2. Feeding typically begins 15 to 17 days post-hatch when 80% of the fry achieve swim-up. During rearing in the hatchery buildings fish are fed Rangen or Skretting Fry food 8 hours per day at a minimum frequency of once per hour. In late August, fish are moved utilizing marking crew fish pumps from the Hatchery Buildings to the marking trailers.

2.3.5 Outdoor Rearing

Steelhead are reared in three flow-through banks of raceways at a maximum density index of 0.30 and a maximum flow index of 1.20. All outdoor raceway fish are hand fed daily with Skretting floating steelhead feed up to November and 2.5mm feed. Once fish are on 2.5mm, the feed is delivered to demand feeders utilizing the CableVey system.

Steelhead smolts are programmed to meet 4.5 fpp (215mm) using a Hatchery Constant feeding method once they are moved to outdoor rearing. Growth is generally held below 0.8" per month although maximum growth could achieve 1.5" per month.

During the entire outside rearing cycle, all raceways are cleaned (swept) twice weekly. Fish are sampled monthly to estimate mean size and growth rate. Length frequency checks are done periodically and just prior to release.

2.3.6 Release

All of the HNFH steelhead smolt releases are trucked utilizing four 5,000 gallon, 40 foot stainless steel tankers, each tanker comprised of five 1,000 gallon compartments. Each compartment has fish life support (LS) systems consisting of a water agitator and oxygen stones to help sustain fish life during transport. Tankers are equipped with a liquid oxygen bottle, 2 back up compressed oxygen bottles and an 8 kW generator to operate life support system. An alarm system on the trailer will notify the driver of any LS problems. A maximum of 1,000 lbs of steelhead per compartment at roughly 5,000 lbs of fish per tanker delivered in one truckload. Hauling occurs Monday through Friday during April. Hauling is coordinated with several hatcheries to minimize traffic and safety concerns. IHOT fish transportation guidelines and NZMS HACCP plans are followed.

PRAS steelhead have generally been hauled the first week of April (first group out) along with raceway control fish for comparison to their release site at the Sawtooth Weir.

2.3.7 Settling Pond

The Hatchery maintains a Best Management Practices (BMP) plan for cleaning wastes from the facility to meet NPDES requirements. Cleaning waste is diverted to Off-Line Settling Basins (OLSB). The total surface area of the OLSB is 22,816 ft2 which can be split into two cells (248 ft x 46 ft each). Each cell can treat a maximum of 5,750 gpm or about 6 outdoor raceways simultaneously.

3 Operations

3.1.1 Marking

Steelhead are adipose fin clipped in late August at approximately 120 fpp. Marking trailer fish counts for each raceway are used for initial raceway inventory. Daily mortality is subtracted from each raceway to obtain a running tally on total fish numbers. Fish observations are performed daily checking for flashing and abnormal behavior while feeding and mort picking.

Marks and tags are verified by IDFG prior to release. Length-at-release standard of 180 to 250 mm is used to guide culture practices. Steelhead are projected for an average size of 215 mm at release. Sample counts are performed monthly on representative raceways and tanks. Length-frequency measurements are taken prior to transport, as well as precocial checks.

3.1.2 PIT Tagging

PIT tags are inserted into 17,200 smolts annually for Comparative Smolt Survival (CSS) studies and Monitoring and Evaluation (M&E) purposes.

4 Operational/Infrastructure Changes for Program Efficiency

4.1.1 Add 1M Summer Chinook sub-yearlings Rearing in PRAS/Control Rwys

Given the post-release survival challenges of steelhead in the Hagerman PRAS system, it may be time to examine an alternative rearing strategy. Rather than holding size back with reduced feeding regimes in 59 F water, the facility would target an acclimation size of 6 fpp for the end of December. Then, the 90K PRAS smolts and 66K smolts from control raceway could be transferred to acclimation in the Salmon basin (Yankee Fork Dredge Ponds, East Fork satellite or Sawtooth trout pond may be suitable locations) and subsequently released in April. This approach would mirror programs from Lyons Ferry Fish Hatchery that move fish from large rearing lakes to acclimation in winter months (January) and subsequently rear fall Chinook sub-yearlings in the vacated rearing space.

After transfer, the facility could bring on summer Chinook fry from Sawtooth Fish Hatchery. 500,000 fry would arrive at 1200 fpp and be reared to 50 fpp by mid-June (Appendix B) as sub-yearlings. An additional 500,000 fry would be reared in the three control raceways. Releases would occur at the Sawtooth for comparison to traditional 20 fpp yearling smolt releases. Consideration would need to be taken for interaction with sockeye outmigration timing (May-June) within current HGMP's.

Early rearing for the PRAS would occur in existing hatchery tanks to acclimate before circular rearing. Raceway reared Chinook would be directly ponded to raceways similar to Rapid River and Dworshak hatcheries.

Program costs are estimated at $0.10/smolt for feed, marking, fish health, and transport. Existing labor needs would remain the same. Total cost is estimated at $100,000 annually.

Appendix B outlines a monthly production strategy for the program per 500,000 sub-yearling summer Chinook group.

4.1.2 Replace 156K Steelhead smolts with 480K summer Chinook yearlings Rearing in PRAS/Control Rwys

Hagerman National Fish Hatchery has successfully returned steelhead at a 1.26% Smolt to Adult Return (SAR) between 2000-2016. At that rate, removing the steelhead produced in the PRAS and control raceways (156,000) would leave an annual production target of 1,404,000 steelhead smolts returning an average of 17,690 adults annually. That total is above the 13,600 adult goal for the program.

The subsequent rearing space would accommodate rearing of 480,000 summer Chinook yearling smolts (20 fpp) for acclimation at Sawtooth Fish Hatchery in April (Appendix C). PRAS, control raceways, and Sawtooth reared smolts would all be released at the same location for comparison purposes.

The LSRCP, IDFG, and the Shoshone-Bannock Tribe have been working on plans to improve survival of the Upper-Salmon B program at Magic Valley Fish Hatchery. These plans could improve B-program survival by two-fold or more and mean less steelhead smolts are needed to make the 11,660 adult target goal for the facility. Exploring spring/summer Chinook options at Hagerman National Fish Hatchery could be applied to Magic Valley hatchery as well if rearing space opened up.

Annual program costs are estimated at $0.15/smolt for feed, marking, fish health and transport ($72,000). Additional chiller capacity would be needed at Sawtooth Fish Hatchery to hold Chinook fry May (1200 fpp) for transfer to Hagerman. An adequately sized unit was recently purchased by Dworshak National Fish Hatchery for $48,000 with in-house installation.

Maximize production capacity of Hagerman National Fish Hatchery

Program	Current Chinook Smolts	Proposed Smolts
PRAS sub-yearling SCS	0	500,000 @ 50 fpp
Control Rwys sub-yearling SCS	0	500,000 @ 50 fpp
PRAS yearling SCS	0	240,000 @ 20 fpp
Control Rwys yearling SCS	0	240,000 @ 20 fpp
Total	**0**	**480,000 - 1,000,000**

5 References

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6 Appendix A. Monthly Production Strategy – Hagerman National Fish Hatchery

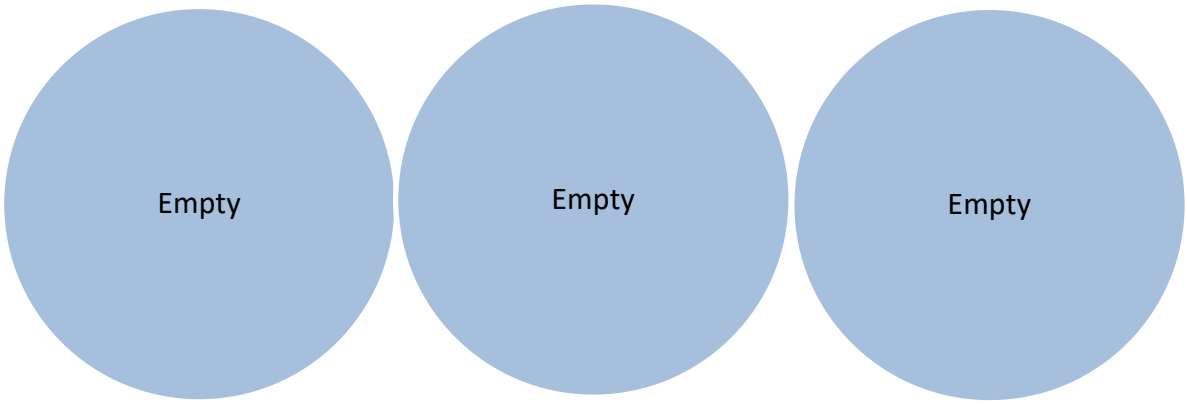
6.1.1 January

Upwellers

Early Rearing – 3 tanks (282 cu ft) 345 gpm at 59 F

170,000 SCS @ 1200 fpp and DI = 1.16
170,000 SCS @ 1200 fpp and DI = 1.16
170,000 SCS @ 1200 fpp and DI = 1.16

PRAS Rearing – 3 tanks (11,133 cu ft) 1210 gpm at 59 F



6.1.2 February

Upwellers

Early Rearing – 3 tanks (282 cu ft) 345 gpm at 59 F

Empty
Empty
Empty

PRAS Rearing – 3 tanks (11,133 cu ft) 1210 gpm at 59 F

6.1.3 March

Upwellers

Early Rearing – 3 tanks (282 cu ft) 345 gpm at 59 F

Empty
Empty
Empty

PRAS Rearing – 3 tanks (11,133 cu ft) 1210 gpm at 59 F

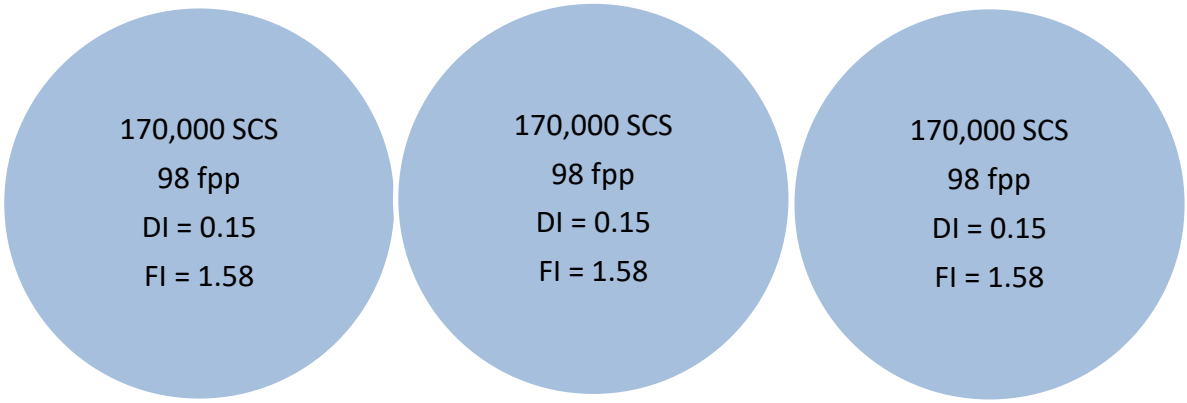
6.1.4 April

Upwellers

Early Rearing – 3 tanks (282 cu ft) 345 gpm at 59 F

Empty
Empty
Empty

PRAS Rearing – 3 tanks (11,133 cu ft) 1210 gpm at 59 F



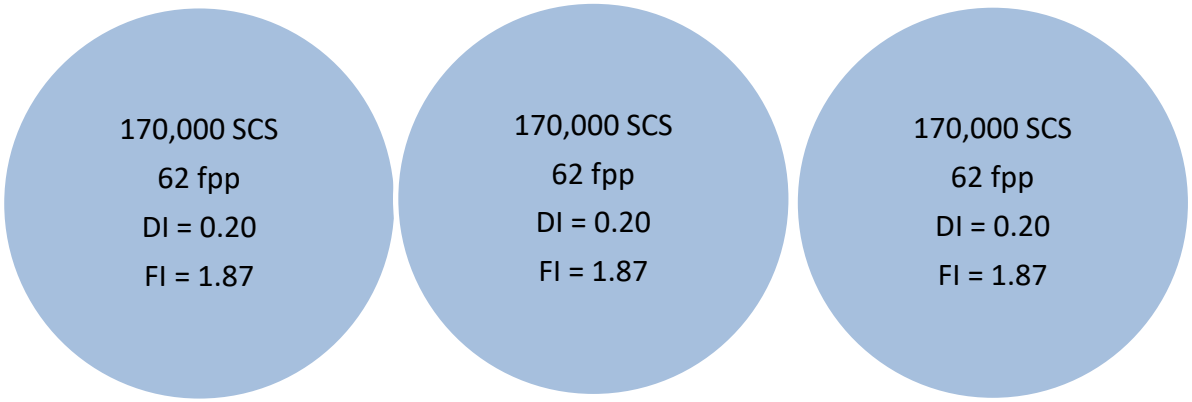
6.1.5 May

Upwellers

Early Rearing – 3 tanks (282 cu ft) 345 gpm at 59 F

Empty
Empty
Empty

PRAS Rearing – 3 tanks (11,133 cu ft) 1210 gpm at 59 F



6.1.6 June

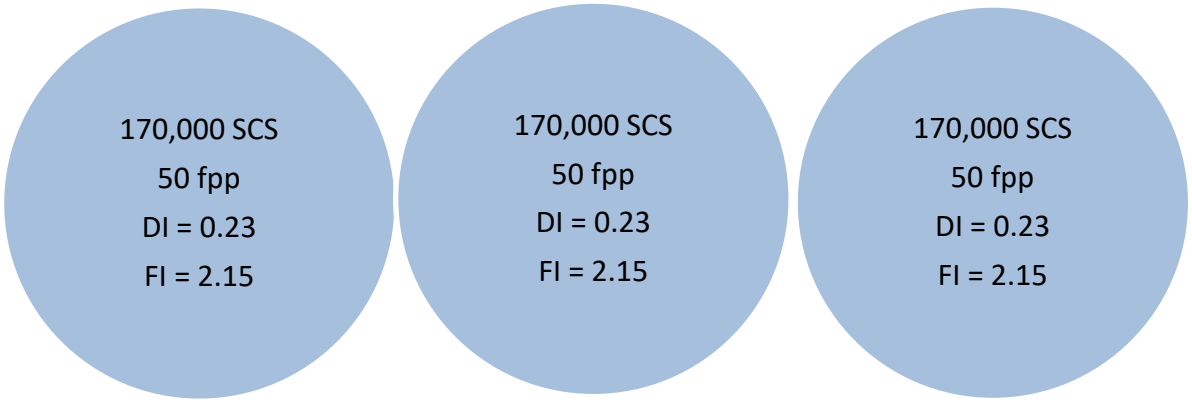
Upwellers

99,000 STT eyed eggs in 3 incubators

Early Rearing – 3 tanks (282 cu ft) 345 gpm at 59 F

Empty
Empty
Empty

PRAS Rearing – 3 tanks (11,133 cu ft) 1210 gpm at 59 F



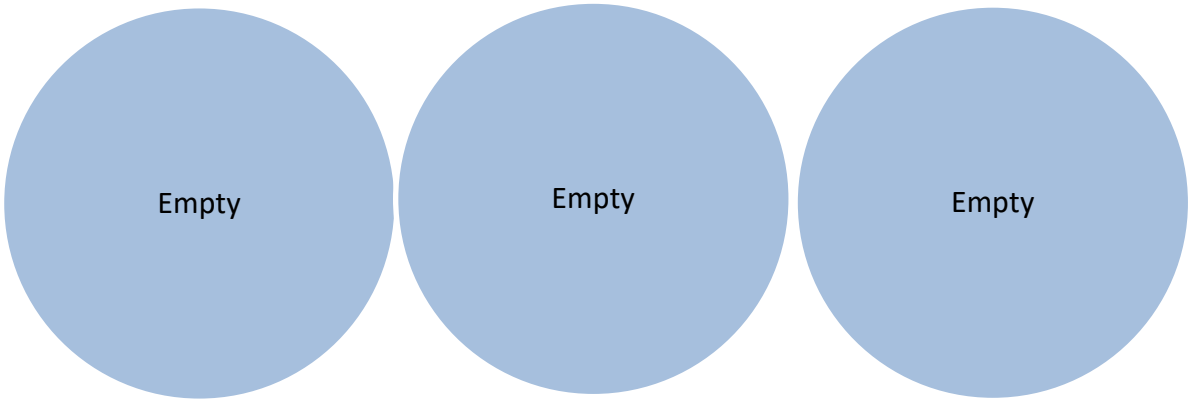
6.1.7 July

Upwellers

Early Rearing – 3 tanks (282 cu ft) 345 gpm at 59 F

31,000 STT @ 250 fpp, DI=0.62, FI=0.51
31,000 STT @ 250 fpp, DI=0.62, FI=0.51
31,000 STT @ 250 fpp, DI=0.62, FI=0.51

PRAS Rearing – 3 tanks (11,133 cu ft) 1210 gpm at 59 F



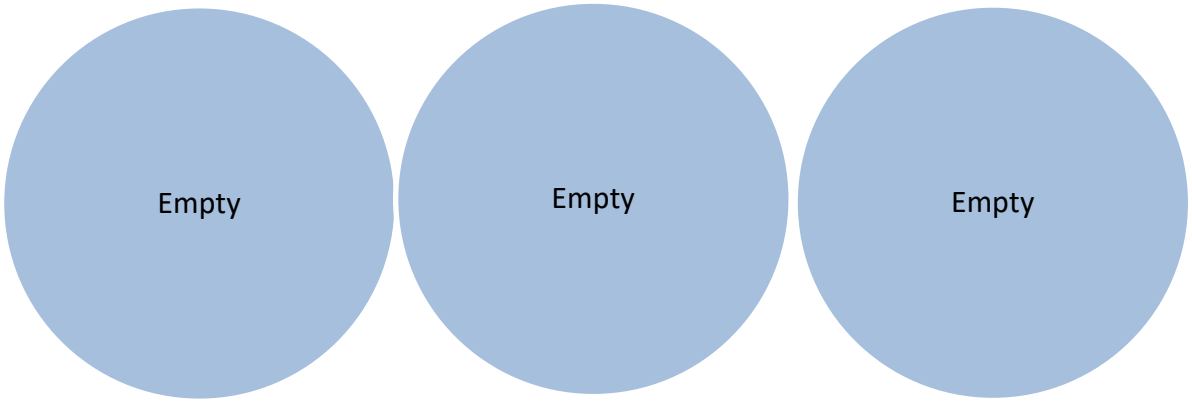
6.1.8 August

Upwellers

Early Rearing – 3 tanks (282 cu ft) 345 gpm at 59 F

30,500 STT @ 120 fpp, DI=0.99, FI=0.81
30,500 STT @ 120 fpp, DI=0.99, FI=0.81
30,500 STT @ 120 fpp, DI=0.99, FI=0.81

PRAS Rearing – 3 tanks (11,133 cu ft) 1210 gpm at 59 F



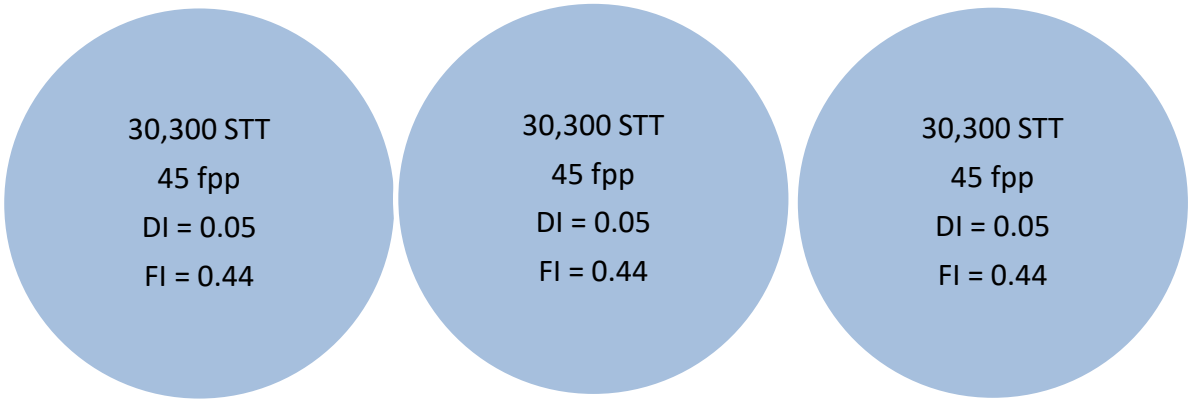
6.1.9 September

Upwellers

Early Rearing – 3 tanks (282 cu ft) 345 gpm at 59 F

Empty
Empty
Empty

PRAS Rearing – 3 tanks (11,133 cu ft) 1210 gpm at 59 F



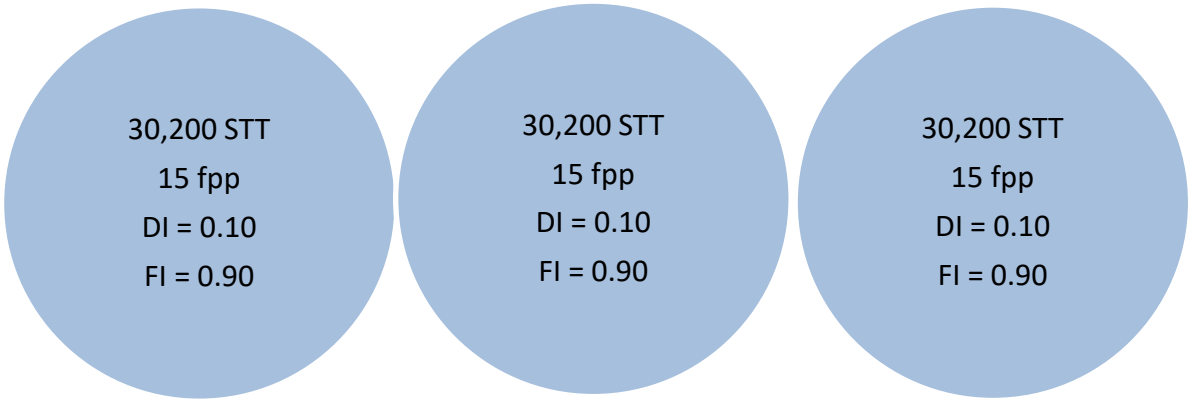
6.1.10 October

Upwellers

Early Rearing – 3 tanks (282 cu ft) 345 gpm at 59 F

Empty
Empty
Empty

PRAS Rearing – 3 tanks (11,133 cu ft) 1210 gpm at 59 F



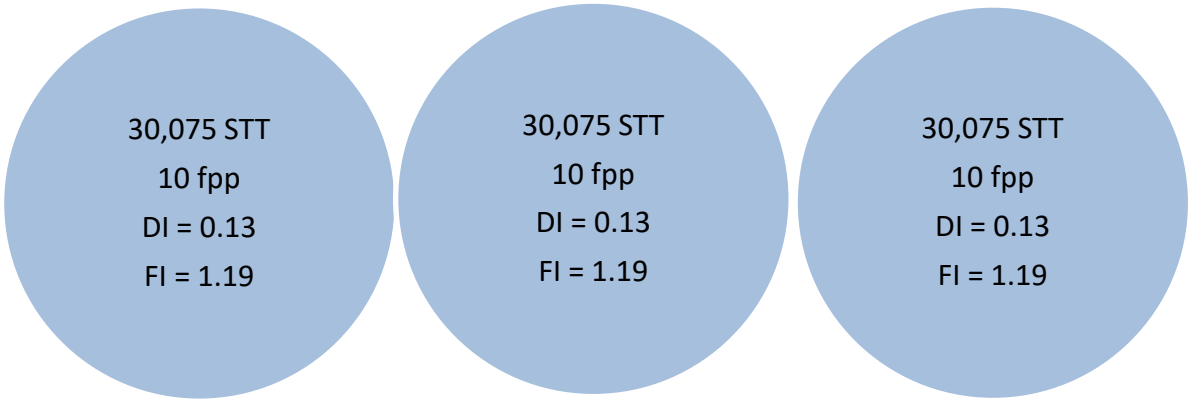
6.1.11 November

Upwellers

Early Rearing – 3 tanks (282 cu ft) 345 gpm at 59 F

Empty
Empty
Empty

PRAS Rearing – 3 tanks (11,133 cu ft) 1210 gpm at 59 F



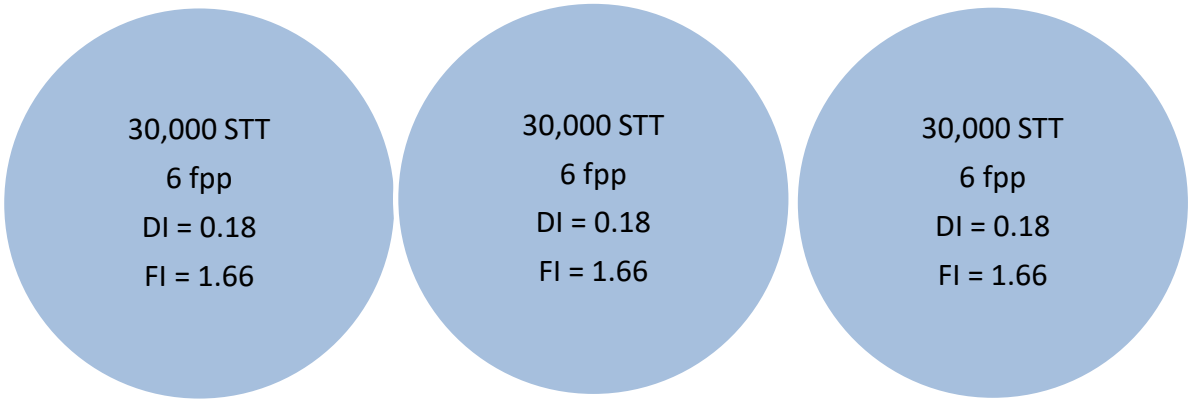
6.1.12 December

Upwellers

Early Rearing – 3 tanks (282 cu ft) 345 gpm at 59 F

Empty
Empty
Empty

PRAS Rearing – 3 tanks (11,133 cu ft) 1210 gpm at 59 F



7 Appendix B. Spring Chinook Feeding Schedule - SubYearlings

Hagerman National Fish Hatchery, Spring Chinook Feed Projection

DATE	# FISH	Daily Morts	Feed Rate % BWD	FPP	Weight (lbs)	Feed/Day (lbs)
1-Jan-22	525,000	1,000	3.2%	1200	438	14
8-Jan-22	518,000	500	3.2%	967	536	17
15-Jan-22	514,500	500	2.8%	785	655	18
22-Jan-22	511,000	250	2.8%	652	784	22
29-Jan-22	509,250	100	2.6%	543	938	24
5-Feb-22	508,550	100	2.6%	459	1,108	29
12-Feb-22	507,850	100	2.2%	388	1,310	29
19-Feb-22	507,150	100	2.2%	335	1,512	33
26-Feb-22	506,450	100	2.0%	290	1,744	35
5-Mar-22	505,750	100	2.0%	254	1,989	40
12-Mar-22	505,050	100	2.0%	223	2,267	45
19-Mar-22	504,350	75	2.0%	195	2,584	52
26-Mar-22	503,825	75	1.8%	171	2,946	53
2-Apr-22	503,300	75	1.8%	152	3,317	60
9-Apr-22	502,775	75	1.8%	135	3,735	67
16-Apr-22	502,250	75	1.8%	119	4,206	76
23-Apr-22	501,725	50	1.8%	106	4,736	85
30-Apr-22	501,375	50	1.8%	94	5,333	96
7-May-22	501,025	50	1.8%	83	6,005	108
14-May-22	500,675	50	1.8%	74	6,761	122
21-May-22	500,325	20	1.6%	66	7,613	122
28-May-22	500,185	15	1.6%	59	8,466	135
4-Jun-22	500,080	11	1.6%	53	9,414	151
11-Jun-22	500,000	10	1.4%	48	10,469	147

8 Appendix C. Spring Chinook Feeding Schedule – Yearlings

Hagerman National Fish Hatchery, Spring Chinook Feed Projection (Yearlings - 20 fpp)

DATE	# FISH	Daily Morts	Feed Rate % BWD	FPP	Weight (lbs)	Feed/Day (lbs)
15-May-23	266,000	1,000	2.5%	1200	222	6
22-May-23	259,000	500	2.5%	994	260	7
29-May-23	255,500	500	2.2%	835	306	7
5-Jun-23	252,000	250	2.2%	714	353	8
12-Jun-23	250,250	100	2.0%	614	408	8
19-Jun-23	249,550	100	2.0%	537	465	9
26-Jun-23	248,850	100	1.8%	470	530	10
3-Jul-23	248,150	100	1.8%	416	596	11
10-Jul-23	247,450	100	1.8%	368	672	12
17-Jul-23	246,750	100	1.6%	326	756	12
24-Jul-23	246,050	100	1.6%	293	841	13
31-Jul-23	245,350	75	1.6%	262	935	15
7-Aug-23	244,825	75	1.4%	235	1,040	15
14-Aug-23	244,300	75	1.4%	214	1,142	16
21-Aug-23	243,775	75	1.4%	194	1,254	18
28-Aug-23	243,250	75	1.4%	177	1,376	19
4-Sep-23	242,725	50	1.2%	161	1,511	18
11-Sep-23	242,375	50	1.2%	148	1,638	20
18-Sep-23	242,025	50	1.2%	136	1,776	21
25-Sep-23	241,675	50	1.0%	126	1,925	19
2-Oct-23	241,325	20	1.0%	117	2,060	21
9-Oct-23	241,185	15	1.0%	109	2,204	22
16-Oct-23	241,080	11	1.0%	102	2,358	24
23-Oct-23	241,000	10	1.0%	96	2,523	25
30-Oct-23	240,930	5	1.1%	89	2,700	30
6-Nov-23	240,895	5	1.1%	83	2,908	32
13-Nov-23	240,860	5	1.1%	77	3,132	34
20-Nov-23	240,825	5	1.0%	71	3,373	34
27-Nov-23	240,790	5	1.0%	67	3,609	36
4-Dec-23	240,752	5	0.9%	62	3,862	35
11-Dec-23	240,717	5	0.9%	59	4,105	37
18-Dec-23	240,682	5	0.9%	55	4,363	39
25-Dec-23	240,647	5	0.8%	52	4,638	37
1-Jan-24	240,612	5	0.8%	49	4,898	39
8-Jan-24	240,577	5	0.8%	47	5,172	41

15-Jan-24	240,539	5	0.8%	44	5,462	44
22-Jan-24	240,504	5	0.8%	42	5,768	46
29-Jan-24	240,469	5	0.8%	39	6,091	49
5-Feb-24	240,434	5	0.8%	37	6,432	51
12-Feb-24	240,399	5	0.8%	35	6,792	54
19-Feb-24	240,364	5	0.8%	34	7,172	57
26-Feb-24	240,326	5	0.8%	32	7,574	61
4-Mar-24	240,291	5	0.8%	30	7,998	64
11-Mar-24	240,256	5	0.9%	28	8,446	76
18-Mar-24	240,221	5	0.9%	27	8,978	81
25-Mar-24	240,186	5	1.0%	25	9,544	92
1-Apr-24	240,151	5	1.0%	24	10,185	102
8-Apr-24	240,113	5	1.1%	22	10,898	120
15-Apr-24	240,078	5	1.1%	20	11,737	129

9 Appendix D. Water Quality Parameters

Water Quality parameters, Hagerman, Pahsimeroi, Sawtooth, Springfield Fish Hatcheries. 2021							
Primary IOC Contaminants	**Hagerman National - Spring 17**	**Hagerman National- Main Spring**	**Pahsimeroi (Ground)**	**Pahsimeroi (Surface)**	**Sawtooth**	**Springfield**
Arsenic			ND	ND	0.0025	0.0022
Barium			0.0652	0.0935	<0.05	0.080
Cadmium	<0.001	<0.001	ND	ND	<0.0005	< 0.0005
Chromium	0.00284	0.00284	0.0042	0.0029	<0.0002	0.003
Mercury	<0.01 ug/L	<0.01 ug/L	ND	ND	<0.0002	< 0.0002
Nickel			ND	ND	<0.02	< 0.02
Selenium	<0.001	<0.001	0.0014	ND	<0.0005	< 0.005
Sodium			4.5	7.4	6.6	28.0
Flouride			ND	ND	1.010	0.44
Secondary and Other IOC Contaminants						
Chloride			3.7700	4.3400	ND	36
Iron	<0.01	<0.01	0.0872	0.0189	<0.05	< 0.05
Manganese			ND	0.0018	<0.005	< 0.005
Dissolved Solids	160.000	200.000			ND	336
Zinc			0.0156	ND	<0.01	< 0.01
Silver			ND	ND	<0.001	< 0.001
Sulfate			13.8000	14.8000	6.000	54
Calcium			38.5000	42.2000	28.200	63.0
Hardness (as $CaCO_3$)	120	137	148	162	79	236
Magnesium	14.9	15.0	12.5	13.8	2.0	19.4
pH	7.4	7.7	8.0	8.0	7.5	7.4
Potassium	3.5	3.5	0.8	1.4	0.5	4.1
Lead	<0.001	<0.001	ND	ND	<0.005	< 0.005
Copper	<0.001	<0.001	ND	ND	<0.01	< 0.01
Comments						
Alkalinity (mg/l)	125.000	124.000			81.700	185
Ammonia (mg/l)	0.160	<0.05			ND	< 0.04
Gasoline (mg/l)					ND	
Lube Oil (mg/l)					ND	
Diesel (mg/l)					ND	
Nitrate/N	0.960	1.000	<1	<1	<0.02	1.9
Nitrite/N			<1	<1	<0.01	< 0.01
Flow (cfs)	2.70		0.3125	18-20	13-34	19
Temperature (^{o}F)	59	59	50	47-53	32-72	50