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# 1996 MCNARY DAM, ICE HARBOR DAM, AND LOWER MONUMENTAL DAM SMOLT MONITORING PROGRAM

## ANNUAL REPORT

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# 1.0 INTRODUCTION

The Washington Department of Fish & Wildlife (WDFW) assumed responsibility for the Smolt Monitoring Program at McNary Dam on the Columbia River in 1990 and at the new juvenile collection facility at Lower Monumental Dam on the Snake River in 1993. In 1996, Smolt Monitoring Program activities also began at the new juvenile collection facility located at Ice Harbor Dam. This report summarizes the 1996 Smolt Monitoring work at all three sites. The work at Ice Harbor consisted of Gas Bubble Trauma (GBT) monitoring only.

In general, the 1996 passage season at both the McNary and Lower Monumental sites can be characterized by reduced passage of juveniles through the collection systems due to elevated river flows and spill, and low (<1%) overall facility mortality rates most likely resulting from cooler water temperatures. In accordance with the National Marine Fisheries Service recommendations (NMFS, 1995) all spring migrants were bypassed at McNary Dam in 1996. Mechanical problems within the McNary collection system resulted in collection and sampling activities being delayed until April 18 at this site, while sampling and collection began on the scheduled starting date of April 1 at Lower Monumental Dam. Monitoring operations were conducted through December 14 at McNary Dam and through October 28 at Lower Monumental Darn. An ongoing transportation evaluation summer migrant marking program was conducted at McNary Dam in 1996 by the NMFS. This necessitated the sampling of 394,211 additional fish beyond the recommended sampling guidelines. All total, 509,237 and 3 1,2 19 juvenile salmonids were anesthetized and individually counted, examined for scale loss, injuries, and brands by WDFW Smolt Monitoring personnel in 1996 at McNary Dam and Lower Monumental Dam, respectively. An additional 7,778 fish, 5,634 fish, and 1,42 1 fish were examined for symptoms of Gas Bubble Trauma by WDFW and NBS personnel at McNary, Lower Monumental, and Ice Harbor Dams as part of the Smolt Monitoring Program. Three hundred wild zero age chinook were also examined for GBT symptoms by WDFW personnel on the. Hanford Reach during SMP PIT tagging operations.

# 2.0 SUMMARY OF ANESTHETIC PRACTICES

## 2.1 ANESTHETIZATION OF SAMPLE FISH

The anesthetic practices used at McNary Dam and Lower Monumental Dam in 1996 were similar to those used in 1995. These included:

1) Documentation of the concentration of MS222 used in the re-circulating anesthetic system.

2) Documentation of the concentration of benzocaine and tricaine used in the pre-anesthetic system.

3) Documentation of the time that fish were held in the pre-anesthetic (induction time).

4) Documentation of total daily sample tank mortality. This information is normally included as part of the daily data summary.

5) Documentation of post handling mortality.

6) Direct observation by the anesthetist of the number of raceway mortalities.

## 2.2 CONCENTRATIONS

### Pre-anesthetic System - McNary Dam

The pre-anesthetic stock solution was changed this year at the McNary site. The season was started with a stock solution of 50 grams tricaine/liter of water. This solution was used from April 19 until May 18 but was determined to be to weak and on May 19 a stock solution of 100 grams/liter was initiated. This was used from May 19 until June 16. The NMFS began marking zero age chinook on June 17 for transportation research. The NMFS provided an anesthetist and anesthetic for this program. The pre-anesthetic stock solution was changed at this time to 450 grams of benzocaine/gallon of alcohol. This stock solution was used by NMFS personnel for this program from June 17 until August 18. At the conclusion of the NMFS marking program. WDFW personnel returned to using tricaine per agency policy on August 19 and continued doing so for the remainder of the season.

In 1996, the average tricaine concentration used in the pre-anesthetic system by WDFW personnel was 82.5ppm or nearly double the average benzocaine concentration (44.3ppm) used in the same system during the previous year ( 1995). During the NMFS 1996 marking program, the average benzocaine concentration was 44.2ppm. In 1996 it was often necessary in 1996 to vary the anesthetic concentrations to achieve the required results. The minimum concentration when using tricaine was 18.0ppm with the maximum at 96. lppm. When using benzocaine, the minimum concentration was 28.6ppm and the maximum was 71.4ppm. Water temperature plays a key role in how fish react to anesthetic with higher temperatures associated with greater sensitivity. Both benzocaine and tricaine were used when temperatures exceeded 60°F. Concentrations at that tune ranged from 28.6ppm to 96.1 ppm with an average of 7 1 .Oppm (Appendix Table 1).

### Pre-anesthetic System - Lower Monumental Dam

A stock solution of 450 grams of benzocaine per gallon of alcohol was used throughout the 1996 season at Lower Monumental Dam. The 1996 pre-anesthetic concentrations averaged 37.0ppm in 1996 compared to 42.9ppm in 1995. The only concentration used in 1996 was 37.0ppm (Appendix Table 2). The use of benzocaine as a pre-anesthetic will continue at this site until the existing supply is exhausted and then tricaine will be substituted, per WDFW policy.

### Re-circulation System - McNary Dam

At McNary Dam, the MS222 concentrations in the re-circulating anesthetic system were recorded daily (Appendix Table 3). Starting concentrations ranged from O.Oppm to 36.0ppm and averaged 24.2ppm which is comparable to the 1995 average of 2 1.4ppm. There was no addition of anesthetic to the re-circulation system this year. This has been done periodically in the past to compensate for: A) flush water dilution or B) the removal of anesthetic from the re-circulating water by thousands of sample fish but was determined to be unnecessary in 1996.

### Re-circulation System - Lower Monumental Dam

Anesthetic was not added to the Lower Monumental re-circulation system from September 11 through October 28 due to the low (<15) numbers of fish present in the daily samples. Outside of this time period MS222 was added to the system each day sample processing was conducted during the 1996 sampling season

and the concentrations ranged from 15.6ppm to 25 .Oppm with an average of 24.4ppm (Appendix Table 4). During the 1996 sample season no extra anesthetic was added to the Lower Monumental re-circulation system.

## 2.3 INDUCTION AND EXPOSURE TIMES

Sample fish are exposed to anesthetic in two phases at McNary and Lower Monumental Dams.

Phase 1: An allotment of fish is crowded into the pre-anesthetic tank and anesthetized with MS222(McNary Dam) or benzocaine(Lower Monumental Dam). All fish in each allotment experience the same period of exposure to MS222 or benzocaine because all fish are removed at the same time from the tank and are then passed to the sorting trough.

Phase 2: Fish are removed from the sorting trough individually and therefore individual fish are exposed to MS222 for varying periods of time.

### Time In The Pre-anesthetic System - McNary Dam

The total time (induction time) that fish were held in pre-anesthetic during the 1996 season ranged from 2.0 minutes to 6.0 minutes and averaged 3.5 minutes overall (Appendix Table 1). This is similar to the 1995 average induction time of'3.9 minutes. It is also recommended that an induction time of not less than two minutes be observed when water temperatures exceed 60 "F. Water temperatures exceeded 60 °F from June 28 through October 17. During this period the induction times ranged from 2.0 to 5.5 minutes with an average time of 3.4 minutes.

### Time In The Pre-anesthetic System - Lower Monumental Dam

Induction time ranged from 2.7 minutes to 4.8 minutes with an average of 3.8 minutes (Appendix Table 2) in 1996. This compares to an average induction time of 3.5 minutes in 1995. Facility water temperatures exceeded 60 degrees from June 18 through October 19, and during this period the induction times ranged from 2.7 to 4.3 minutes with an average time of 3.7 minutes.

## 2.4 POST HANDLING MORTALITY

### McNary Dam

In 1995 the NMFS initiated a massive summer migrant Transportation Evaluation coded wire tagging program which required the handling of additional zero age chinook by the McNary SMP crew. This program was continued in 1996. The marked fish were sent to raceways 5, 9 east, and 9 west and held with other fish from the daily samples and mortalities from this marking program are included in the post-handling mortality rates discussed here. The 1996 post handling mortality rate equalled 1.3% which is based upon complete mortality counts from raceways 5, 9 east, and 9 west. This is a slight increase from the 1995 post handling mortality rate (0.9%). The sample tank mortality rate is based primarily on pre-handling mortality but is related to the sampling program. For example, of the 4,9 14 mortalities counted from the sample, only 492 were the direct result of handling. The remaining 4,422 were removed from the sample tank-prior to pre-anesthetization and handling. The 1996 sample tank mortality rate based upon all 4,9 14 mortalities counted was still relatively low (1 .0%) but slightly higher than that of 1995 (0.9%). By comparison, system

mortality was also low in 1996 (0.8%) but also higher than that of 1995 (0.4%). Favorable environmental conditions such as cooler water temperatures which normally correspond to high river flows have been shown to have a profound effect on the overall rate of mortality. In general, elevated river flows and cooler water temperatures in both 1995 and 1996 may have contributed to lower rates of mortality for all species and this is particularly evident from the lack of zero age chinook mortality resulting from thermal stress during the summer outmigrations of both years. In conclusion, although both post-handling and sample tank mortality rates were slightly higher in 1996 than in 1995 this was also the case for the mortality rate of all fish entering the collection system. It does therefore not appear that the sampling program resulted in excessive mortality in 1996.

### Lower Monumental Dam

The only measure of the post-handling mortality rate is the recovery of mortalities from raceway 1. All mortalities are recovered from raceway 1 at Lower Monumental Dam and a complete mortality count and mortality rate is therefore available. However, this rate is somewhat inflated by the incidental loading of transportation fish into raceway 1 during the barge and truck loading of raceway 2. Due to the configuration of the raceway loading system, fish must be diverted to the adjacent raceway 1 while raceway 2 is being drained during transportation vehicle loading operations. Fish that are passed into raceway 1 during this time are not counted in the raceway 1 loading total but probably result in some additional mortalities which are included in the post-handling statistics. Therefore, the raceway 1 mortality rate should be considered the best index of post-handling mortality resulting from the sampling system and the reported rate should be considered a maximum. The raceway 1 mortality rate was 0.1% in 1996 compared to 0.2% in 1995. Sample tank mortality was higher in 1996 (1. 1%) than in 1995 (0.6%) but, similar to what was observed at McNary Dam, system mortality at Lower Monumental Dam was also higher in 1996 (0.2%) than in 1995 (0.1%).

## 2.5 SUMMARY

The anesthetic procedures used by McNary and Lower Monumental SMP personnel in 1996 were very similar for the two sites and similar to what was used in 1995. Compared to the previous year, 1996 mortality rates were generally higher in all areas of the collection system at both sites, including the sampling systems. However, these mortality rates were still low overall in all areas and did not appear to be greatly aggravated by the sampling program. For the second year in a row, environmental conditions appear to have had a favorable affect on the mortality rates of fish passing through the collection systems at both sites.

A memorandum was issued on June 27, 1995 from the WDFW pathologist office prohibiting the use of benzocaine by WDFW personnel. Benzocaine, unlike tricaine, is not currently registered by the U.S. Food and Drug Administration (FDA) for use on food fish. Unfortunately, inherent to the design of the sampling systems at all transportation sites are pre-anesthetic systems utilizing disposable anesthetic. Because the anesthetic currently cannot be recovered from these systems, a change from benzocaine ($65/kg) to tricaine ($375/kg) represents a significant increase in anesthetic costs. At McNary Dam benzocaine was used by the NMFS marking program, Tricaine was used as the pre-anesthetic by the SMP crew throughout the rest of the season. The concentration of tricaine necessary to properly pre-anesthetize the fish was found to be roughly double that of benzocaine. Therefore, the changeover from benzocaine to tricaine as a pre-anesthetic has resulted in a significant increase in SMP anesthetic costs at the McNary site. Currently, at the Lower Monumental site, the anesthetic used in the sampling program is purchased by the Corps of Engineers and is not part of the annual SMP budget. Per WDFW policy, tricaine will be used as the pre-anesthetic at the Lower Monumental site once the existing benzocaine supply has been exhausted. This will also result in a

significant annual cost increase to the anesthetic purchaser.

In October of 1996, SMP personnel visited Lyons Ferry Hatchery to witness a test demonstration of the use of clove oil as a fish anesthetic on adult steelhead. This demonstration was part of ongoing clove oil testing by WDFW pathologists which began in April of 1996. Thus far, the initial findings have shown favorable results. Anesthetic concentration, induction time, and recovery time are similar to tricaine. The cost of clove oil ($1.60/ml) is much less than tricaine ($3.20/gm) and does not require a 2 l-day holding period before fish can be released to open waters. The holding period is not enforced with juvenile salmonids because these fish are not expected to be consumed by humans within the 2 l-day period. However, other fish are regularly anesthetized with juvenile salmonids at Corps of Engineer operated fish facilities that may be caught and consumed by anglers within a 2 l-day period. These include adult bass (Micropterus sp.), channel catfish (Ictaluras punctatus), two species of panfish (Pomoxis sp.), adult American shad (Alosa sapidissima), yellow perch (Perca flavescens), and several species of sunfish (Lepomis sp.). The test results suggest that clove oil, which is currently under low regulatory status by FDA, might be used as a suitable low cost substitute for tricaine in SMP sampling operations.

In response to this, a small amount of clove oil was used at the McNary site on a trial basis; first with juvenile American shad, and then with zero age fall chinook. Juvenile American shad are extremely anesthetic sensitive and normally incur a very high rate of mortality due to anesthetization. Two groups of juvenile shad were exposed to clove oil at a 50ppm concentration. The results indicated that direct mortality resulting from clove oil was similar to or less than what is normally observed with tricaine. Juvenile fall chinook were then exposed to clove oil in the pre-anesthetic system at a 50ppm concentration. The induction time was similar to that of tricaine and there were no direct mortalities. The pre-anesthetized fish were then processed via normal SMP procedure and passed to the holding raceway along with other fish from the daily sample.

Although far from conclusive, the tests so far do suggest that clove oil may be a suitable low cost substitute for tricaine in SMP site operations and that substitution of clove oil for tricaine would require no physical modification to the existing systems such as would be the case for other alternative anesthetics substitutes such as carbon dioxide gas, Further testing of clove oil is needed before full scale use can be implemented, however.

## 3.0 SPECIAL DATA COLLECTION 1996

### 3.1 ELASTOMER VISIBLE IMPLANT MARKED YEARLING CHINOOK

1996 was the fourth year that yearling chinook from the Lyons Ferry Hatchery program were marked with visible elastomer implants (VI) in the adipose eyelid tissue just posterior to the eye. Three implant colors (red, *green,* and blue) were used in 1996. The fish were marked to distinguish Snake River chinook from other chinook stocks released into the Columbia River system. All of the fish released from the 1996 Lyons Ferry program were VI marked on either the left or the right side with one of the three colors. None of the marked fish were transported by barge below Ice Harbor Dam as was the case for a portion of the release in past years, although those fish marked with a blue VI tag were transported and released above Lower Granite Dam at Pittsburgh Landing.

Most (404,270) of the 1996 left red VI marked outmigrants available to reach McNary Dam were yearling fall chinook from the Lyons Ferry Hatchery, although some (7,756) were mis-marked fish from the Similkameen River release. Right blue VI marked spring chinook (114,299) were released into the Snake

River above Lower Granite Dam at Pittsburgh Landing. The remaining VI marked fish (right red, left green, right green) were all spring chinook which were released into the Tucannon River in March and April of 1996.

Visible implant marked fish were recovered at both the Lower Monumental and McNary sites (Tables 1 and 2). Overall, VI marked fish recovered at the McNary site in 1996 were 7mm smaller on average than those recovered at the Lower Monumental site. Travel time between the two sites was roughly one week. Left red VI marked fish were composed primarily of yearling fall chinook and: 1) had the highest recovery rates, and 2) arrived in the best condition at both sites.

Fish condition deteriorated as the fish moved from Lower Monumental to McNary as evidenced by the

**Table 1. Summary** of **elastomer visible implant yearling chinook recovered at Lower Monumental Dam** in 1996.

| Category | Right Red | Left Red | Right Green | Left Green | Right Blue | Total |
|---|---|---|---|---|---|---|
| **Recovery Data** | | | | | | |
| Released | 89,437 | 404.270 | 35,369 | 5363 | 114,299 | 648,638 |
| Sampled (Rate) | **295 (0.3%)** | 2,488 (0.6%) | 116 (0.3%) | 19 (0.4%) | 188 (0.2%) | 3,106 (0.5%) |
| Collected (Rate) | **11,400 (12.7%)** | **91,327 (22.6%)** | **5,120 (14.5%)** | 945 (18.0%) | 9,112 (8.0%) | 117,904 (18.2% |
| P. Index (Rate) | 16.332 (18.3%) | 134,613 (33.3% | **7,431 (21.0%)** | **1.380 (26.2%)** | **13,827 (12.1%)** | 173,583 (26.8% |
| **Arrival Timing** | | | | | | |
| **10th Percentile** | **April 16** | **April 14** | **April 23** | **April 18** | **April 24** | **April 14** |
| **50th Percentile** | **April 29** | **April 18** | **May 7** | **May 9** | **April 28** | **April 20** |
| **90th Percentile** | **May 15** | **April 27** | **May 21** | **May 17** | **M a y 7** | **May 4** |
| **Size and Condition** | | | | | | |
| **Forklength(mm)** | **146** | **164** | **150** | **148** | **168** | **161** |
| **Descaled (%)** | **4.7.** | **0.8** | **12.1** | **10.5** | **3.7** | **1.8** |

**Table 2. Summary of elastomer visible implant yearling chinook released in the Snake River system and recovered at McNary Dam in 1996.**

| Category | Right Red | Left Red | Right Green | Left Green | Right Blue | Total |
|---|---|---|---|---|---|---|
| **Recovery Data** | | | | | | |
| Released | 89,437 | 404,270 | 35,369 | 5,263 | 114,299 | 648,638 |
| Sampled (Rate) | 113 (0.1%) | 689 (0.2%) | 38 (0.1%) | 9 (0.2%) | 53 (0.04%) | 902 (0.1%) |
| Collected (Rate) | 5,470 (6.1%) | 34,340 (8.5%) | 1,810 (5.1%) | 430 (8.2%) | 2,580 (2.3%) | 44,630 (6.7%) |
| P.Index (Rate) | 10,892(12.2%) | 71,009 (17.6%) | 3,656 (10.3%) | 821 (15.6%) | 5,041 (4.4%) | 91,419 (14.1%) |
| **Arrival Timing** | | | | | | |
| 10th Percentile | April 27 | April 21 | April 27 | April 22 | April 28 | April 22 |
| 50th Percentile | May 10 | April 26 | May 12 | May 3 | May 2 | April 27 |
| 90th Percentile | May 18 | May 4 | May 22 | May 21 | May 16 | May 13 |
| **Size and Condition** | | | | | | |
| Forklength | 143 | 158 | 150 | 148 | 167 | 154 |
| Descaled (%) | 10.6 | 5.5 | 18.4 | 11.1 | 11.3 | 7.1 |

increase in scale loss. This same general pattern of increase between the two sites was also documented in 1995 and 1994. In 1996 the descaling rate (1.8%) for VI marked fish was triple that of 1995 at Lower Monumental Dam. The 1995 descaling rate (0.6%) for VI fish recovered at Lower Monumental Dam was similar to that of 1994 (0.8%). However, the 1996 descaling rate for VI fish recovered at McNary Dam (7.1%) was half that of 1995 (14.3%), and comparable to that of 1994 (6.2%). The deterioration in fish condition as fish moved from Lower Monumental to McNary Dam in 1996, 1995, and 1994 is most likely due to the cumulative effect of passage through the turbines, spillways, and passage systems at Lower Monumental and Ice Harbor Dams, and possible predation hazards in the reservoirs.

For comparison to the descaling rates observed at McNary Dam for red, green, and blue VI marked yearling spring and fall chinook which originated from the Snake River system, VI yearling summer chinook which were released from the Similkameen (left orange VI) river on the Mid-Columbia exhibited lower rates of scale loss (5.2%) when recovered at McNary (Table 3). This is comparable to those of the left red VIs (5.5%). These fish passed five hydroelectric projects prior to arriving at McNary Dam. Fish originating from the Mid-Columbia have consistently shown lower rates of descaling than those originating from the Snake River even when passing a similar number of hydroelectric projects. The lower left orange VI descaling rates suggest that the higher rates observed for Snake River origin VI fish and other unmarked yearling chinook in 1996 probably cannot be attributed to passage through the McNary bypass system but rather resulted from sources located upstream of McNary Dam.

**Table 3. Summary of elastomer visible implant yearling chinook released in the Similkameen River and recovered at McNary Dam in 1996.**

| Category | Left Orange | Left Red | Total |
|---|---|---|---|
| **Recovery Data** | | | |
| Released | 306,660 | 7,756 * | 314,416 |
| Sampled (Rate) | 461 (0.2%) | | 461 (0.2%) |
| Collected (Rate) | 15,036 (4.9%) | | 15,036 (4.9%) |
| Passage Index (Rate) | 34,792 (11.3%) | | 34,792 (11.3%) |
| **Arrival Timing** | | | |
| 10th Percentile | May 1 | | May 1 |
| 50th Percentile | May 20 | | May 20 |
| 90th Percentile | June 2 | | June 2 |
| **Size and Condition** | | | |
| Forklength (mm) | 158 | | 158 |
| Descaled (%) | 5.2 | | 5.2 |

Approximately 7,756 yearling summer chinook were mis-marked in 1996 with left red VI tags and were therefore indistinguishable from left red VI marked yearling fall chinook from Lyons Ferry Hatchery.

In general, all four VI mark colors recovered in 1996 (red, green, blue, and orange) were distinct and easy to identify. This is in contrast to the yellow VI used in 1994 which closely matched the coloration of the adipose eyelid tissue and was therefore difficult to identify. Fragmentation of the elastomere appeared to be less of a problem in 1996 and 1995 than in 1994 and therefore color distinction was also less of a problem in the last two years.

### 3.2 GAS BUBBLE TRAUMA

Smolt Monitoring Program personnel attended a single day training seminar pertaining to the examination of juvenile salmonids for symptoms of gas bubble trauma (GBT) at the USGS/BRD field station located in Cook, Washington prior to the start of field operations. Examination of 100 yearling chinook and 100 steelhead were conducted three times per week beginning April 11 at Lower Monumental Dam and April 19 at McNary Dam. This examination schedule was increased to every other day beginning April 29 at McNary and April 30 at Lower Monumental in response to elevations in total dissolved gas. The microscopic examinations were conducted at both sites and were coordinated with BRD personnel who also participated in the examinations. Examinations on an every other day schedule continued through the end of the examination period at Lower Monumental (June 29) and through July 5 at McNary at which time the McNary schedule was reduced to three times per week. On June 24, due to the change in run composition, 100 zero age chinook per esamination day were used to replaced the yearling chinook and steelhead at the McNary site. GBT examinations of zero age chinook were continued at the McNary site through September 1. All fish

were collected upstream of the separator at both sites and were scanned for PIT tags. PIT tagged fish were returned to the separator. Other examined fish were sent to the sample holding raceway at McNary to be bypassed or transported and were bypassed at Lower Monumental. A total of 7,778 fish were examined for GBT at the McNary site and 5,634 at the Lower Monumental site.

As part of SMP contract operations, yearling chinook and steelhead were also examined for GBT symptoms at the new juvenile collection facility at Ice Harbor Dam. The Ice Harbor facility is not a transportation site and unlike the McNary and Lower Monumental sites, the sampling system is not manned 24 hours per day. Because of this, sampling was conducted at Ice Harbor once or twice per week in conjunction with COE quality control work beginning April 19 and ending June 28. The target goal was 100 yearling chinook or steelhead per sampling day but this goal was generally unattainable late in the spring outmigration period due to low numbers of fish and a maximum sampling system operation period of 4 hours per sampling day. Due to the relatively short holding period, fish examined for GBT symptoms at Ice Harbor Dam were not collected upstream of the separator as at McNary and Lower Monumental but were simply routed through the sampling system and examined. All fish examined at Ice Harbor Dam were scanned for PIT tags and bypassed. BRD personnel did not share in the GBT examinations at Ice Harbor Dam and all examinations were therefore conducted by WDFW personnel. A total of 1,421 fish were examined for GBT symptoms at Ice Harbor Dam in 1996.

As part of ongoing Smolt Monitoring Program operations, 3,000 wild zero age fall chinook are PIT tagged on the Hanford Reach each year in conjunction with a Pacific Salmon Treaty coded wire tagging program (see "Research" section). For the first time since the Hanford PIT tagging program was initiated in 199 1, SMP personnel observed wild zero age fall chinook with GBT symptoms during sorting operations in 1996. The GBT technicians from the Lower Monumental site were subsequently summoned to perform microscopic examinations at the Hanford site on June 12 and 13. A total of 300 fish were examined and 30 (10.0%) were found to have symptoms of GBT.

The 10% GBT rate generated from the microscopic examinations, although disturbing, is probably not indicative of the actual GBT rate incurred by the entire wild zero age fall chinook population for two reasons. First, millions of fall chinook rear on the Hanford Reach and the 300 fish sample is quite small in comparison. Second, the capturing schedule was generally split morning and evening. Fish captured in the morning were brought directly to the net pens and tagged later that same day while fish captured in the evening were held overnight and tagged the following day. CRITFC personnel measured total dissolved gas at various locations on the Hanford Reach during the tagging operation period and determined that total dissolved gas in the main river channel near the netpen location was approximately 115%. However, total dissolved gas was found to have dissipated to approximately 105% in the offchannel rearing areas where fish were being captured (Tom Backman, personal communication). Because mixing of evening and morning catches occurred in the net pens and at the CWT trailer, fish from each capturing period could not be distinguished during GBT sampling. Therefore it is unknown whether the measured GBT rate was indicative of the condition of fish which were removed directly from rearing areas or the result of fish being held overnight in water at a higher saturation level. Generally it can be concluded that the high volumes of spill and subsequent elevations in total dissolved gas which occurred in 1996 did appear to impact the wild zero age fall chinook population inhabiting the Hanford Reach, but the extent of this impact is unknown.

# 4.0 RESEARCH

## 4.1 WDFW ZERO AGE CHINOOK PIT TAGGING

### Objectives

Tagging of wild zero age upriver bright fall chinook from the Hanford Reach of the Columbia River with Passive Integrated Transponder (PIT) tags by McNary SMP personnel began in 1991. This was the third year zero age fall chinook were PIT tagged at the Priest Rapids Hatchery and the second year at the Ringold Hatchery. In 1996, the tagging program at the Priest Rapids Hatchery was conducted by the USFWS under contract for the FPC and at Ringold Hatchery by WDFW personnel as part of an ongoing hatchery evaluation program. Although only the Hanford Reach PIT tagging program was conducted by WDFW SMP personnel, a comparison of the arrival timing and recovery rates of all three groups (Hanford Reach, Priest Rapids Hatchery, and Ringold Hatchery) of PIT tagged zero age summer migrants arriving at McNary Dam in 1996 is included in this section.

The specific objectives of the 1996 PIT tagging program were: 1) index the arrival timing of wild and hatchery zero age upriver bright fall chinook to McNary Dam and 2) collect information regarding relative survival rates.

### Methods

#### Ringold Hatchery

Zero age chinook were PIT tagged at the Ringold Hatchery by WDFW personnel on June 12 and mixed with the general hatchery population. The marking goal was 1,500 fish not less than 60mm in forklength. These fish were released on June 29. All fish were held for 48 hours to assess delayed mortality and tag loss. Fish were not re-interrogated after 48 hours but tag loss was assessed by recovery of extruded tags from the holding containers.

#### Priest Rapids Hatchery

Zero age chinook were marked by USFWS personnel at the Priest Rapids Hatchery on May 29 and 30. These fish were divided into approximately three equal sized groups, held with the general hatchery population, and then released with the first (June 15), third (June 19) and with the fifth and final (June 23) hatchery release groups. All tagged fish were held overnight to assess delayed mortality and tag loss. Tag loss was based upon recovery of extruded tags during the 24-hour holding period.

#### Hanford Reach

The 1996 marking objective for wild zero age chinook was 3,000 fish with a fork length ≥ 60mm. The methods used to capture, hold, mark, and release wild subyearling chinook in 1996 were essentially the same as those described in Wagner (1996), a brief description and changes are given below .

As in 1994-95, Umatilla and Yakama tribal personnel captured fish with beach and stick seines. The fish

were then transferred by jet boat to a holding area located at the ferry landing, anesthetized, and hand sorted by size within the WDFW coded wire tagging (CWT) trailer. A portion of the fish with fork lengths equal to or greater than 60mm were PIT tagged. PIT tags were applied with individual syringe injectors. The injector needles were disinfected with ethyl alcohol after each use to minimize the possibility of disease transmission between fish. Marked fish were transferred by jet boat several miles below the ferry landing and released. A group of PIT tagged fish were held overnight to assess 24 hour delayed mortality and tag loss.

Fish used for this marking program were netted from holding pens used by the CWT program. Fish with fork lengths $\leq$ 49mm were returned to the river. Fish with fork lengths $\geq$ 50mm but $<$ 60mm were adipose fin clipped and given to the CWT marking program. Fish to be PIT tagged were held in aerated five gallon buckets of water and then delivered to the tagging station.

The tagging station was set up outside the abandoned storage garage used in 1994-95. The tagging station was moved during the day to keep the equipment and fish in the shade. Water temperatures were monitored at the tagging station and water was frequently changed in the anesthetic and recovery containers.

## Results

Analysis of the 1996 data and comparison to past years is conducted under two basic assumptions. 1) The collection efficiency of the McNary bypass system remains constant and comparable from year to year, and 2) the distribution of fish per unit of river flow is equivalent for the powerhouse and the spillway (1 to 1 spillway efficiency ratio) and remains constant from year to year. Both of these assumptions may have been challenged in 1996. During the winter of 1995-96, the standard length traveling screens in units 1-6 were replaced with new Extended Length Bar Screens (ESBSs) at McNary Dam specifically to increase the guidance of zero age summer migrants. Units 1-6 are in the primary fish collection area of the McNary powerhouse. Fish guidance efficiency studies have indicated that the ESBSs have increased fish guidance efficiency (FGE) rates when compared to standard length traveling screens. These new screens may confound direct comparisons of the 1996 data to previous years. In addition, during 1996 there were several partial and complete days when the facility was not operating during the summer migration period (June 1 to August 3 1) due to mechanical difficulties within the bypass system. These facility down periods undoubtedly resulted in the loss of data for this research. In addition, high volumes of spill have occurred at McNary Dam during the peak summer outmigration periods of both 1995 and 1996 and it is not possible to verify that the 1 to 1 spillway efficiency ratio remains true during high spill periods.

### Ringotd Hatchery

A total of 1,486 zero age chinook were PIT tagged at Ringold Hatchery, mixed with the general hatchery population. and released on June 29. The target minimum size of these fish was 60mm in forklength and the actual size of the marked fish ranged from 56mm to 110mm. The average size of fish marked in 1996 was 83. 1mm similar to that of 1995 ( 82.8mm). Virtually all (99.9%)of the fish handled were large enough to mark in 1996. Direct mortality due to tagging was 1.5% and delayed mortality was zero. Tag loss based upon recovery of extruded tags from the holding containers was also zero after 48 hours.

A total of 295 of the 1,486 PIT tagged fish (19.9%) were interrogated at McNary Dam (Table 4). The mean arrival date for all fish was July 3 with 4.1 days of in-river/travel time. When fish were grouped by fork length no real differences in mean arrival dates or mean travel times were evident in 1996. This was because 87.1% of the total passage for this group occurred in a four day period. July 1 to July 4. The recovery rates calculated by fish size increment did not show the trend seen in past years with PIT tagged wild summer

migrants ( i.e., larger fish having progressively earlier arrival times with higher recovery rates). In contrast to the expected trend, when the individual 1996 interrogations were expanded to account for tagged fish which passed over the spillway (passage index) the group which was smallest at release (60mm-69mm) had the highest recovery rate and the group which was largest at release (100mm-109mm) had the lowest recovery rate (Table 4). Overall, 41.4% of the tagged fish were estimated to have passed McNary Dam. The 1996 overall passage index rate was very similar to that seen in 1995 (43.4%).

**Table 4. Recovery rates and passage timing of PIT tagged zero age chinook released from Ringold Hatchery in 1996.**

| Fork length (mm) | Number Released | Number Recovered | Recovery Rate (%) | Mean Arrival Date | Mean Travel Time (Days) | Passage Index (%) |
|---|---|---|---|---|---|---|
| 50-59 | 2 | 0 | 0.0 | NA | NA | NA |
| 60-69 | 66 | 13 | 19.7 | July 3 | 4.0 | 60.0 |
| 70-79 | 448 | 84 | 18.6 | July 3 | 4.7 | 37.6 |
| 80-89 | 632 | 136 | 21.5 | July 2 | 3.9 | 43.6 |
| 90-99 | 312 | 59 | 18.9 | July 2 | 3.6 | 39.7 |
| 100-109 | 24 | 3 | 12.5 | July 3 | 4.1 | 27.9 |
| 110-119 | 1 | 0 | 0.0 | NA | NA | NA |
| Total | 1,485 | 295 | 19.9 | July 3 | 4.1 | 41.4 |

**Priest Rapids Hatchery**

A total of 3,017 zero age chinook were marked at the Priest Rapids Hatchery on May 29 and 30. These fish were divided into approximately three equal sized groups, held with the general hatchery population, and then released with the first (June 15), third (June 19), and fifth and final (June 23) hatchery release groups. Both direct and delayed mortality was similar for each of the three groups and averaged 0.6%. Tag loss after 24 hours was negligible. Overall, 95.7% of the fish handled were large enough to mark; first group - 93.1% (65mm minimum marking size), second group - 96.1% (65mm minimum marking size), third group - 97.9% (70mm minimum marking size)). The marked fish ranged in size from 61mm to 105mm and averaged 82.2mm in fork length in 1996. In comparison, the average sizes of fish tagged in 1995 and 1994 were 75.5mm and 85.3mm, respectively.

The first group of PIT tagged zero age chinook were released from Priest Rapids Hatchery on June 15. These were the first to arrive at McNary Dam followed by the second (June 19) and third (June 23) release groups. A total of 320 of the 2,994 PIT tagged fish (10.7%) were interrogated as they passed through the collection system at McNary Dam (Table 5). This compares to an overall recovery rate of 24.4% in 1995. The mean arrival date and in-river/travel time was July 3 and 14.7 days respectively. Tagged fish were grouped by 10mm size increments and, with the exception of the 70mm - 79mm release group on June 23, larger fish had progressively earlier arrival times and shorter in-river/travel times. Similar to fish originating from Ringold Hatchery, the expected increase in recovery rates with increases in fish size was once again not observed for zero age migrants originating from Priest Rapids Hatchery. Individual interrogations were

expanded to account for tagged fish that were spilled and the expanded passage index count equalled 23.7% of the fish tagged. This compares to a passage index of 34.0% in 1995.

Unlike 1995, each release group had very similar mean arrival dates, total recovery, and passage index rates. Similar to what was observed for PIT tagged fish originating from Ringold Hatchery in 1996 and contrary to what was expected, the group that was smallest at release (60mm - 69mm fork length)from Priest Rapids Hatchery had the highest recovery and passage index rates (Table 5). This was true for two of the three release groups and all three release groups combined.

**Table 5. Recovery rates and passage timing of three groups of PIT tagged zero age chinook released from Priest Rapids hatchery in 1996.**

| Fork length (mm) | Number Released | Number Recovered | Recovery Rate (%) | Mean Arrival Date | Mean Travel Time (Days) | Passage Index (%) |
|---|---|---|---|---|---|---|
| June 15 | | | | | | |
| 60-69 | 111 | 17 | 15.3 | July 2 | 17.5 | 46.6 |
| 70-79 | 557 | 60 | 10.8 | July 4 | 19.9 | 23.4 |
| 80-89 | 326 | 31 | 9.5 | June 29 | 14.6 | 22.9 |
| 90-99 | 11 | 1 | 9.1 | June 23 | 8.1 | 21.0 |
| 100-109 | 0 | 0 | NA | NA | NA | NA |
| Total | 1,005 | 109 | 10.9 | July 2 | 17.9 | 25.8 |
| June 19 | | | | | | |
| 60-69 | 4 | 1 | 25.0 | July 6 | 17.4 | 76.1 |
| 70-79 | 260 | 31 | 11.9 | July 7 | 19.0 | 24.0 |
| 80-89 | 648 | 61 | 9.4 | July 3 | 14.4 | 20.5 |
| 90-99 | 87 | 10 | 11.5 | June 28 | 10.0 | 27.9 |
| 100-109 | 0 | 0 | NA | NA | NA | NA |
| Total | 999 | 103 | 10.3 | July 4 | 15.4 | 22.3 |
| June 23 | | | | | | |
| 60-69 | 0 | 0 | NA | NA | NA | NA |
| 70-79 | 78 | 4 | 5.1 | July 8 | 15.2 | 10.1 |
| 80-89 | 450 | 49 | 10.9 | July 4 | 11.4 | 22.1 |
| 90-99 | 435 | 53 | 12.2 | July 3 | 10.4 | 26.6 |
| 100-109 | 26 | 2 | 7.7 | June 28 | 5.4 | 18.4 |
| Total | 989 | 108 | 10.9 | July 3 | 10.9 | 23.0 |
| Combined Total | | | | | | |
| 60-69 | 115 | 18 | 15.7 | July 2 | 17.5 | 47.7 |
| 70-79 | 896 | 95 | 10.6 | July 5 | 19.4 | 22.4 |
| 80-89 | 1,424 | 141 | 9.9 | July 2 | 13.4 | 21.5 |
| 90-99 | 533 | 64 | 12.0 | July 2 | 10.3 | 26.7 |
| 100-109 | 26 | 2 | 7.8 | June 28 | 5.4 | 18.4 |
| Total | 2,994 | 320 | 10.7 | July 3 | 14.7 | 23.7 |

**Hanford Reach**

A total of 3,118 zero age chinook were marked during the four day marking program, June 10 through 13 (Table 6). Tagged fish forklengths ranged from 53mm to 100mm and averaged 62.5 mm. A total of 19,197 wild zero age chinook were sorted during the four day tagging program, resulting in a overall markable rate of 16.9% (Table 6). The 1996 percent markable rate was low, but falls within the range of rates seen in past years (Table 7).

**Table 6. 1996 Hanford Reach PIT tag summary.**

| Marking and Handling Record | | | | | | Mortality | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Direct | | Delayed | | |
| Date | Number Tagged | Number <60mm | Number Rejects | Total Handled | Mark Percent* | # | % | #Held | #Morts | % |
| June 10 | 656 | 3.992 | 57 | 4.705 | 15.2 | 34 | 5.2 | --- | --- | --- |
| June 11 | 1.019 | 3.985 | 19 | 5.023 | 20.7 | 67 | 6.6 | 49 | 2 | 4.1 |
| June 12 | 920 | 4,425 | 32** | 5.377 | 17.7 | 28 | 3.0 | --- | --- | |
| June 13 | 523 | 3.556 | 13 | 4,092 | 13.1 | 32 | 6.1 | --- | --- | --- |
| Total | 3.118 | 15.958 | 121 | 19,197 | 16.9 | 161 | 5.2 | 49 | 2 | 4.1 |

* The markable percent is equal to: (# Tagged + # Rejected)/(Total Handled).
** Twenty fish greater than 59mm were given to NBS for ATPase sampling.

**Table 7. The percent zero age chinook large enough to be PIT tagged, Hanford Reach 1991-96.**

| Year | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 |
|---|---|---|---|---|---|---|
| Markable % | 39.9 | 86.5 | 11.5 | 44.2 | 20.1 | 16.9 |

Of the 3,118 fish tagged, 16 1 (5.4%) were recovered as direct mortalities (Table 6). The daily direct mortality rate due to handling and tagging was variable during the four days of tagging. Direct mortality peaked on June 11 at 6.6%. While these rates are higher than seen in past years tagging conditions (water temperatures, fish size, and dissolved gas levels) were not. conducive to handling fish.

One group of PIT tagged fish were held to measure delayed mortality and tag loss. Fifty fish were tagged and held with an equal number of non-tagged (control) fish for twenty four hours. One fish from each group died while being held before the test began. Two tagged mortalities and one control mortality were recovered at the end of the test. This resulted in a delayed mortality rate of 4.1% for tagged fish and 2.0% for the control group. Tag loss was determined to be zero.

Of the 2,957 fish released, a total of 257 wild PIT tagged zero age chinook were interrogated at McNary Dam for an overall recovery rate of 8.7% (Table 8). The mean arrival date was July 8 and the average in-river/travel time of 27.1 days. Fork lengths of tagged fish interrogated at McNary Dam ranged from 57mm to 97mm and averaged 62.8mm. As expected based upon past observations, when the tagged fish were grouped by fork length, larger fish had higher recovery rates, earlier mean arrival dates, and shorter mean in-

river/travel times (Table 8). With the exception of 1995, these trends have been seen for wild zero aged chinook tagged in the Hanford Reach since 199 1. In 1995, the larger groups of zero aged wild chinook did not have increased recovery rates. lndividual 1996 recoveries were expanded to account for fish passing over the spill gates. This resulted in a passage index of 25.1% for wild zero aged chinook at McNary Dam in 1996 (Table 8). This compares to a passage index rate of 20.1% in 1995.

**Table 8. Recovery rates and passage timing of zero age chinook PIT tagged on the Hanford Reach in 1996.**

| Fork length (mm) | Number Released | Number Recovered | Recovery Rate (%) | Mean Arrival Date | Mean Travel Time (Days) | Passage Index (%) |
|---|---|---|---|---|---|---|
| 50-59 | 463 | 41 | 8.9 | July 10 | 28.7 | 18.8 |
| 60-69 | 2,342 | 201 | 8.6 | July 9 | 27.8 | 26.1 |
| 70-79 | 137 | 12 | 8.8 | June 24 | 12.0 | 25.4 |
| 80-89 | 13 | 2 | 15.4 | July 6 | 27.8 | 31.1 |
| 90-99 | 2 | 1 | 50.0 | June 14 | 3.4 | 100.0 |
| Total | 2,957 | 257 | 8.7 | July 8 | 27.1 | 25.1 |

## Discussion

Four factors effect the 1996 data analysis.

Factor 1) **Facility Shutdowns.** This year as in 1994, the McNary juvenile collection facility was not operated during a portion of the zero age chinook outmigration due mechanical difficulties. From July 2 1 to July 29 the collection facility was not operational because of debris blockages on the primary dewatering screens in the collection channel. The peak passage periods for both groups of hatchery fish appeared to be well over prior to July 2 1. Unfortunately, wild fish from the Hanford Reach were still arriving at McNary Dam just prior to the full facility shutdown. In addition, there were seven partial days of facility operation during the summer outmigration period (June 1 to August 3 1). A portion of the 1996 PIT tag recoveries were undoubtedly lost during this time period as a result of partial and complete facility shutdowns.

Effect: Shutdown of the passive interrogation system **dwers the overall interrogation/recovery rate and passage index rates** for all groups of PIT tagged fish.

Factor **2) Increased River** Flow. Similar to 1995, 1996 can be characterized as a high flow year with high river flow lasting through most of the summer outmigration period.

Effect: Overall increases in total river flow would be expected to **decrease travel time** to McNary which in theory would be expected to **increase survival rates. interrogation rates. and passage index rates**.

Factor 3) **Increased Spill**. **Also** similar to 1995, increased volumes of spill occurred at McNary Dam well into the summer outmigration period.

Effect: Increased spill rates would not be expected to change overall survival rates to McNary Dam **or**

passage index rates but would be expected to **decrease interrogation (recovery) rates through the** bypass system.

Factor 4) **ESBS Installation** In 1996 extended double length submersible bar screens were installed in the primary collection units at McNary Dam with the intent of increasing fish guidance efficiency (FGE), primarily the FGE of zero age summer migrants.

Effect: Replacement of standard length submersible traveling screens with extended (double) length submersible bar screens would be expected to result in higher fish guidance efficiency and in a corresponding **increase in interrogation rates and passage index rates.**

These four factors tend to confound the 1996 data analysis. All analysis and conclusions are based upon passive interrogations at McNary Dam and two of the listed factors (2&4) tend to increase interrogation rates while two factors (1&3) tend to decrease interrogation rates.

Given the confounding influence of the four listed factors, analysis of the 1996 PIT tag recovery data for zero aged chinook originating from Ringold Hatchery, Priest Rapids Hatchery, and the Hanford Reach yielded somewhat mixed results when compared to the expected results and to the results reported in past years. The expected results or trends when the tagged fish are grouped incrementally by forklength are: 1) larger fish will have an earlier mean arrival date, 2) a shorter in-river/travel time and 3) higher recovery rates. These expectations are based on the assumptions that larger fish can swim faster, arrive earlier, and have shorter in-river times resulting in less exposure to predation. Therefore, recovery rates would be expected to be higher for larger fish. Wild and hatchery zero age fish tagged in 199 1 to 1994 displayed all three of the expected results/trends. In 1995 both 1) and 2) were observed for all tagged groups. However, higher recovery rates for larger fish were not observed for any of the PIT tag groups in 1995. In fact, wild zero age chinook tagged in the Hanford, Reach showed progressively lower recovery rates, unadjusted for spill volumes, as forklengths increased. Oddly similar, both groups of hatchery fish PIT tagged in 1996 also had decreasing recovery rates with fish size. PIT tagged hatchery zero aged chinook from the Ringold Hatchery had such a compressed migration in 1996 that no trends can be seen in mean arrival dates or mean in-river/travel times when grouped incrementally by forklength. Individual release groups from the Priest Rapids Hatchery did show some earlier mean arrival dates and decreasing mean in-river/travel times as fish size increased and this was especially true for the June 23 release. In 1996, the only group that displayed all three expected results were the zero aged wild chinook from the Hanford Reach.

Under the two assumptions stated at the beginning of the Results section; with increased spill volumes and total river flow we would expect to see decreased total interrogation rates, but an increase in the total passage index rates for all groups. However, when comparing the interrogation rates of 1995 to 1996 we see decreases for all groups in 1996. This is consistent with factors 1(facility shutdowns) and 3(increased spill), but contrary to factors 2(increased river flow)and 4(ESBS Installation). The only group that showed a corresponding increase in total passage index rate was the wild zero age chinook group. This is consistent with the expected effects of factors 2 and 4 but not of l(Factor 3 - increased spill- would in theory not be expected to change the passage index rate only redistribute the number of fish passing through the powerhouse and spillway). In addition, both groups of hatchery fish failed to show increased recovery rates with fish size and generally displayed lower recovery rates for larger fish.

These results call into question the assumption that the distribution of fish per unit of river flow is equivalent for the powerhouse and the spillway (1 to 1 spillway efficiency ratio). When PIT tagged groups of zero aged chinook did not display the expected results/trends in 1995 several possible explanations were given. One of

those was that the increases in total discharge and spill volumes may have been the cause. In 1996, once again increased river flows and dramatic increases in spill volumes (Table 9) may have invalidated the 1 to 1 spillway efficiency ratio assumption. Since larger fish did not exhibit lower recovery rates prior to 1995, it may be that only large volumes of spill or a large difference in amount of flow through the powerhouse versus the spillway results in a shift from a 1 to 1 spillway efficiency ratio. Because of concerns about impingement, the units with ESBSs were operated at lower loads, limiting total powerhouse flows in 1996.

**Table 9. Daily average powerhouse and spill volumes, McNary Dam 1991-1996.**

| | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 |
|---|---|---|---|---|---|---|
| Powerhouse (kcfs) | | | | | | |
| June | 195.5 | 174.3 | 181.6 | 164.1 | 156.7 | 132.6 |
| July | 173.6 | 114.6 | 159.2 | 140.2 | 174.2 | 143.5 |
| August | 151.1 | 101.3 | 113.6 | 86.9 | 135.7 | 146.3 |
| Spill (kcfs) | | | | | | |
| June | 79.4 | 0.0 | 53.1 | 37.7 | 119.0 | 247.3 |
| July | 48.2 | 0.0 | 0.0 | 11.7 | 45.4 | 100.9 |
| August | 9.2 | 0.0 | 0.0 | 1.9 | 0.0 | 35.6 |

**Second Year Recoveries**

On Snake River system a portion of zero age wild PIT tagged fall chinook are actually recovered as yearlings during the spring following tagging. The PTAGIS database was queried in 1996 for second year recoveries of Hanford Reach wild PIT tagged fall chinook at McNary Dam which were released in 199 1 through 1995. In contrast to what has been observed on the Snake, no second year recoveries of Hanford Reach PIT tagged fall chinook were found.

## Conclusions

The 1996 data is influenced by conflicting factors that make it difficult to analyze and in some ways noncomparable to the results of past years. The decreasing recovery rates observed for some groups of larger fish in each of the past two years is interesting. Since it is unlikely that larger smolts actually have lower survival rates, these results do call into question the validity of the 1 to 1 spillway efficiency ratio for larger fish under high volumes of spill. It is known that salmon parr inhabit the slow velocity near shore areas during rearing and then move to the higher velocity channel areas to migrate as smolts. Migration distribution is generally surface orientated. Given these life history traits, it follows logically that larger more smolted fish may tend to follow the stronger surface currents associated with the McNary spillway and the thalweg of the channel during high volumes of spill. This would result in larger fish simply being spilled at a higher rate than smaller fish which is consistent with at least some of the PIT tag recovery results observed during the past two high flow years.

Because of the extreme differences in river conditions present in 1996 compared to recent past years, nothing

can be inferred about the influence of increased FGE which may have resulted from installation of the new ESBSs. In addition, no data exists to define how changes in FGE resulting from new screen installation at McNary Dam might affect the guidance of large versus small fish.

When the 1996 zero age fall chinook PIT tag data is simplified and Iooked at in general terms of each fish source (Ringold Hatchery, Priest Rapids Hatchery, and the Hanford Reach) the same general basic trends as have been seen in past years are evident. Fish from the Ringold Hatchery were on average huger than those from the Priest Rapids Hatchery (83. 1mm versus 82.2mm) at time of tagging and larger than those from the Hanford Reach (62.5mm). Once again, Ringold Hatchery fish had the shortest average in river/travel time and the highest unadjusted recovery rates followed by fish from Priest Rapids Hatchery and then by wild fish from the Hanford Reach.

In addition, it does not appear that juvenile fall chinook originating from the Columbia River between McNary and Priest Rapids Dams residualize, holdover, and outmigrate during the second year of life as may have been the case for juvenile fail chinook originating from the Snake River above Lower Granite Dam.

## 4.2 RESEARCH AT MCNARY DAM

### NMFS Summer Migrant Transportation Evaluation

From June 17 to August 15, the National Marine Fisheries Service coded wire tagged 328,948 subyearling chinook as part of ongoing transport benefit research. Of the fish marked, 182,290 were bypassed and 146,658 were transported Daily sample rates were increased to reach the NMFS marking goals. It was estimated that an additional 394,211 fish were sampled to meet the NMFS marking goals. Bypassed fish were held for approximately 24 hours before release. A total of 1,999 mortalities (1.1% delayed mortality rate) were recovered from the marked fish during holding prior to bypass, Because marked fish held for transport were mixed in with other sample fish, no post-marking mortality rate is known for the transport group.

### Lethal GBT monitoring

From May 7 to June 8, Montgomery Watson Engineering personnel performed lethal GBT examinations on 298 hatchery steelhead at McNary Dam. The sacrificed fish were first collected and examined for symptoms of GBT by the WDFW SMP or the BRD personnel using non-lethal GBT examination protocols.

### ATPase study on Elastomere Tagged Hatchery Yearling Chinook

In a joint research project the WDFW and the U.S. Fish and Wildlife Service sampled selected elastomere tagged hatchery yearling chinook collected from April 27 to May 23 in the daily sample. Fish were sampled by McNary SMP personnel and held in garbage cans. Data collected included ATPase, length, weight and morphology. ATPase samples were taken using the non-lethal macro sampling technique. A total of 166 fish were handled, no direct mortality was recorded. After sampling, the fish were sent to the sample recovery/holding raceway and bypassed.

### 4.3 RESEARCH AT LOWER MONUMENTAL DAM

**Radio Tag Studies**

In 1996, the BRD released radio tagged juvenile chinook into the Snake River above Little Goose Dam. Twenty three of these tagged fish were sampled at Lower Monumental Dam during SMP operations. The tags were removed by SMP personnel and returned to the BRD laboratory located Cook, Washington.

On June 25, four hatchery steelhead were provided to the BRD by the Lower Monumental SMP. These fish were fitted with internal radio tags and released into the tailrace of Ice Harbor Dam.

**Assessment of Stress**

On May I 1 and 12, the Lower Monumental SMP provided 94 steelhead to the University of Idaho as part of a stress assessment study. The fish were sacrificed and blood samples were taken to evaluate physiological indicators of stress.

## 5.0 FULL SAMPLE DESCALING

Beginning in 199 1, all live sample fish were examined for scale loss at McNary Dam and beginning in 1993 at Lower Monumental Dam. At McNary Dam, a total of 504,292 fish were individually examined for scale loss in 1996. The 1995 descaling rates ranged from 2.5% for wild steelhead to 11.6% for hatchery sockeye and averaged 5.6% for all species of fish. Overall, the 1996 descaling rate (5.6%) was nearly identical to that of 1995 (5.5%, Table 10). A total of 30,864 fish were examined for scale loss at the Lower Monumental site in 1996. Descaling rates ranged from 2.3% for wild subyearling chinook to 8.2% for hatchery steelhead and averaged 5.8% for all groups of fish combined. Overall, the 1996 descaling rate (5.8%) although similar to the rates observed in other past years was higher than that of 1995 (4.3%, Table 11).

**Table 10. 1995 and 1996 descaling rates for juvenile fish sampled at McNary Dam.**

| Year | CH-1 | CH-0 | SH-H | SH-W | COHO | SOCK-H | SOCK-W | TOTAL |
|---|---|---|---|---|---|---|---|---|
| 1995 | 11.1% | 4.7% | 8.7% | 4.2% | 8.8% | 5.7% | 18.3% | 5.5% |
| 1996 | 7.8% | 5.6% | 6.0% | 2.5% | 4.9% | 11.6% | 11.5% | 5.6% |
| Difference | -3.3% | +0.9% | -2.7% | -1.7% | +3.9% | +5.9% | -6.8% | +0.1% |

**Table 11. 1995 and 1996 descaling rates for juvenile fish sampled at Lower Monumental Dam.**

| Year | CH-1H | CH-1W | CH-0H* | CH-0W | SH-H | SE-W | SOCK-H | SOCK-W | TOTAL. |
|---|---|---|---|---|---|---|---|---|---|
| 1995 | 4.2% | 3.2% | 2.4% | 3.5% | 5.1% | 1.9% | 4.8% | 13.6% | 4.3% |
| 1996 | 4.5% | 4.1% | NA | 2.3% | 8.2% | 2.7% | 6.7% | 5.9% | 5.8% |
| Difference | +0.3% | +0.9% | N | A | -1.2% | +3.1% | +0.8% | +1.9% | -7.7% | +1.5% |

* Hatchery subyearling chinook were not released above Lower Monumental Dam in 1996.

## 6.0 RECOMMENDATIONS

1. Use of tricaine in the pre-anesthetic systems should be continued consistent with WDFW policy and FDA 'regulations. However, the application of clove oil as a fish anesthetic may be a cost saving alternative to tricaine. In addition, the 2 l-day withdrawal period currently required for food fish anesthetized with tricaine may not be required for food fish exposed to clove oil. Further testing of clove oil is needed before widespread application can be approved. However, preliminary tests to determine if clove oil in its present form can be successfully used in pre-anesthetic systems or enclosed pipe re-circulation systems such as are the standard at mainstem Smolt Monitoring Program sites.

2. Examination of fish for GBT symptoms at the new Ice Harbor Dam juvenile collection facility should be continued in 1997. Because Ice Harbor is not a COE transportation site, currently the sampling system is only operated for a maximum of 8 hours per week and the facility is not manned 24 hours per day as is the case at McNary and Lower Monumental. If expansion of COE operations at the Ice Harbor site occur in the future, then expansion of SMP operations should occur concurrently.

## 7.0 LITERATURE CITED

Wagner, P. 1995 McNary Dam and Lower Monumental Dam Smolt Monitoring Program. Annual Report. Washington Department of Fish and Wildlife. Prepared for United States Department of Energy. Bonneville Power Administration. Division of Fish and Wildlife. Project Number 87- 127. BPA Agreement Number DE-FC79-88BP38906. October 1996.23 pages.

# 8.0 APPENDICES

Appendix Table 1. Pre-anesthetic induction time (minutes) and concentrations at McNary Dam, 1996.

| | A tank | | | | B tank | | | |
|---|---|---|---|---|---|---|---|---|
| Date | ppm | Time | Time | Time | ppm | Time | Time | Time |
| 02-Apr | | | | | | | | |
| 03-Apr | | | | | | | | |
| 04-Apr | | | | | | | | |
| 05-Apr | | | | | | | | |
| 06-Apr | | | | | | | | |
| 07-Apr | | | | | | | | |
| 08-Apr | | | | | | | | |
| 09-Apr | | | | | | | | |
| 10-Apr | | | | | | | | |
| 11-Apr | | | | | | | | |
| 12-Apr | | | | | | | | |
| 13-Apr | | | | | | | | |
| 14-Apr | | | | | | | | |
| 15-Apr | | | | | | | | |
| 16-Apr | | | | | | | | |
| 17-Apr | | | | | | | | |
| 18-Apr | | | | | | | | |
| 19-Apr | 18.01 | 5.00 | 6.00 | 6.00 | 30.02 | 6.00 | 6.00 | 6.00 |
| 20-Apr | 36.03 | 4.50 | 4.25 | 4.25 | 48.04 | 5.00 | 5.50 | 5.00 |
| 21-Apr | 36.03 | 5.00 | 4.00 | 5.00 | 48.04 | 5.50 | 5.00 | 5.00 |
| 22-Apr | 60.05 | 5.00 | | 5.00 | 60.05 | 5.00 | 5.00 | 5.00 |
| 23-Apr | 72.05 | 5.00 | 4.50 | 4.50 | 60.05 | 5.50 | 4.00 | 5.50 |
| 24-Apr | 60.05 | 5.00 | | 5.50 | 72.05 | 5.50 | 3.50 | 4.00 |
| 25-Apr | 72.05 | 4.50 | 5.00 | 5.00 | 72.05 | 4.50 | 5.00 | 5.00 |
| 26-Apr | 72.05 | 2.50 | 5.50 | 4.50 | 60.05 | 4.00 | 4.00 | 4.00 |
| 27-Apr | 60.05 | 4.00 | 5.00 | 5.00 | 60.05 | 3.75 | 4.50 | 4.50 |
| 28-Apr | 60.05 | 4.00 | 5.00 | 4.00 | 60.05 | 4.00 | 4.00 | 4.00 |
| 29-Apr | 60.05 | 4.00 | | 4.00 | 60.05 | 4.00 | 4.00 | 4.00 |
| 30-Apr | 60.05 | 4.00 | | 4.00 | 60.05 | 4.00 | 4.00 | 4.00 |
| 01-May | 60.05 | 4.00 | | 4.50 | 60.05 | 5.00 | 4.50 | 4.50 |
| 02-May | 60.05 | 4.00 | | 4.50 | 60.05 | 4.00 | 4.00 | 4.00 |
| 03-May | 60.05 | 4.00 | 4.00 | 4.00 | 60.05 | 4.00 | 3.75 | 4.00 |
| 04-May | 60.05 | 4.50 | 4.50 | 4.00 | 60.05 | 3.50 | 3.00 | 4.25 |
| 05-May | 60.05 | 4.50 | | 4.50 | 60.05 | 4.50 | 4.00 | 4.00 |
| 06-May | 60.05 | 4.00 | | 4.50 | 60.05 | 4.50 | 4.50 | 4.50 |
| 07-May | 60.05 | 4.50 | | 4.50 | 60.05 | 4.50 | 4.50 | 4.50 |
| 08-May | 60.05 | 4.50 | | 4.50 | 60.05 | 3.50 | 3.50 | 4.00 |
| 09-May | 60.05 | 4.00 | 3.50 | 4.50 | 60.05 | 4.50 | 3.50 | 4.00 |
| 10-May | 60.05 | 4.25 | 3.50 | 4.75 | 60.05 | 3.25 | 4.00 | 4.00 |
| 11-May | 60.05 | 4.00 | 4.50 | 4.00 | 60.05 | 3.75 | 3.50 | 3.00 |
| 12-May | 60.05 | 4.50 | 4.50 | 4.50 | 60.05 | 4.00 | 4.50 | 4.25 |
| 13-May | 60.05 | 4.00 | 4.00 | 4.00 | 60.05 | 3.75 | 4.00 | 4.00 |
| 14-May | 60.05 | 4.00 | 4.50 | 4.00 | 60.05 | 4.50 | 4.50 | 4.50 |
| 15-May | 60.05 | 4.50 | 4.50 | 4.00 | 60.05 | 4.00 | 4.25 | 4.25 |
| 16-May | 60.05 | 3.50 | 4.00 | 3.50 | 60.05 | 4.00 | 4.25 | 3.00 |
| 17-May | 60.05 | 4.50 | 4.25 | 4.00 | 60.05 | 4.00 | 4.25 | 3.00 |
| 18-May | 60.05 | 4.00 | | 4.00 | 60.05 | 4.00 | 4.00 | 4.00 |
| 19-May | 60.05 | 4.50 | 4.75 | 4.50 | 60.05 | 4.50 | 4.50 | 4.50 |
| 20-May | 72.05 | 3.50 | 4.00 | 3.00 | 72.05 | 3.50 | 3.50 | 3.50 |
| 21-May | 72.05 | 3.50 | 3.50 | 3.50 | 72.05 | 3.50 | 3.50 | 3.50 |
| 22-May | 72.05 | 4.00 | 3.25 | 3.00 | 72.05 | 4.00 | 4.00 | 3.00 |
| 23-May | 72.05 | 3.75 | 3.75 | 4.00 | 72.05 | 4.00 | 4.00 | 4.00 |
| 24-May | 72.05 | 3.75 | 4.00 | 3.75 | 72.05 | 4.00 | 4.00 | 4.00 |
| 25-May | 72.05 | 3.75 | 4.00 | 3.75 | 72.05 | 4.00 | 4.00 | 4.00 |
| 26-May | 72.05 | 3.75 | 4.00 | 4.00 | 72.05 | 3.75 | 4.00 | 4.00 |
| 27-May | 72.05 | 4.00 | 4.50 | 4.50 | 76.86 | 4.00 | 3.75 | 3.75 |
| 28-May | 72.05 | 4.00 | 4.00 | 4.00 | 72.05 | 4.25 | 4.00 | 4.00 |
| 29-May | 72.05 | 3.75 | 3.00 | 3.25 | 72.05 | 3.50 | 3.00 | 2.50 |
| 30-May | 72.05 | 4.00 | 3.75 | 4.00 | 72.05 | 3.75 | 3.50 | 3.50 |
| 31-May | 72.05 | 4.00 | 4.00 | 4.00 | 72.05 | 3.50 | 3.75 | 3.75 |
| 01-Jun | 72.05 | 3.75 | 3.50 | 4.00 | 72.05 | 3.00 | 3.50 | 3.50 |
| 02-Jun | 72.05 | 4.00 | 4.00 | 4.00 | 72.05 | 4.00 | 4.00 | 4.00 |
| 03-Jun | 72.05 | 4.50 | 4.00 | 4.00 | 72.05 | 4.00 | 4.00 | 4.00 |
| 04-Jun | 72.05 | 4.00 | 4.00 | 4.00 | 72.05 | 4.00 | 4.00 | 3.50 |
| 05-Jun | 72.05 | 3.75 | 3.75 | 4.00 | 72.05 | 3.00 | 4.50 | 3.50 |
| 06-Jun | 72.05 | 4.00 | 4.00 | 3.50 | 72.05 | 3.00 | 3.75 | 2.50 |
| 07-Jun | 72.05 | 4.00 | 4.00 | 3.25 | 72.05 | 4.50 | 4.00 | 4.00 |
| 08-Jun | 72.05 | 5.00 | 5.00 | 5.00 | 96.07 | 2.25 | 3.00 | 3.50 |
| 09-Jun | 72.05 | 4.00 | 4.50 | 4.00 | 84.06 | 4.00 | 4.00 | 4.00 |
| 10-Jun | 72.05 | 4.00 | 4.00 | 4.00 | 72.05 | 4.00 | 4.00 | 4.00 |
| 11-Jun | 72.05 | 4.00 | 4.00 | 3.25 | 72.05 | 4.00 | 4.00 | 4.00 |
| 12-Jun | 72.05 | 4.00 | | 4.00 | 72.05 | 4.00 | | 4.00 |
| 13-Jun | 72.05 | 4.00 | 4.25 | 4.00 | 72.05 | 4.00 | 4.00 | 4.00 |
| 14-Jun | 72.05 | 4.00 | | | 72.05 | 4.00 | 4.00 | 4.00 |
| 15-Jun | 72.05 | 4.00 | 4.00 | 4.00 | 72.05 | 4.00 | 4.00 | 4.00 |
| 16-Jun | 72.05 | 4.00 | | 4.25 | 72.05 | 4.00 | 4.25 | 4.25 |
| 17-Jun | 42.83 | 4.50 | 4.50 | 4.50 | 71.39 | 4.50 | 4.25 | 4.50 |
| 18-Jun | 71.39 | 4.50 | 4.50 | 4.25 | 48.54 | 4.25 | 4.50 | 4.50 |
| 19-Jun | 48.54 | 4.50 | 4.50 | 4.50 | 48.54 | 4.50 | 4.00 | 3.00 |
| 20-Jun | 48.54 | 4.50 | 4.00 | 4.50 | 48.54 | 4.50 | 4.00 | 3.25 |
| 21-Jun | 48.54 | 2.50 | 3.00 | 3.50 | 48.54 | 3.00 | 3.00 | 4.00 |
| 22-Jun | 48.54 | 2.50 | 3.00 | 3.00 | 48.54 | 2.50 | 3.00 | 3.50 |
| 23-Jun | 48.54 | 3.00 | 3.00 | 3.00 | 48.54 | 2.50 | 3.00 | 2.50 |
| 24-Jun | 48.54 | 4.00 | 3.50 | 3.00 | 48.54 | 3.50 | 3.75 | 3.00 |
| 25-Jun | 48.54 | 3.00 | 3.00 | 3.00 | 48.54 | 2.50 | 2.00 | 2.50 |
| 26-Jun | 48.54 | 4.25 | 3.50 | 4.25 | 48.54 | 3.50 | 3.50 | 3.00 |
| 27-Jun | 48.54 | 2.00 | 3.00 | 3.00 | 48.54 | 3.00 | 3.00 | 3.00 |
| 28-Jun | 48.54 | 3.00 | 3.50 | 3.25 | 48.54 | 3.50 | 4.00 | 4.25 |
| 29-Jun | 48.54 | 3.50 | 3.75 | 4.00 | 48.54 | 3.75 | 3.50 | 3.50 |
| 30-Jun | 42.83 | 2.00 | 3.50 | 4.00 | 42.83 | 2.50 | 3.00 | 3.50 |
| 01-Jul | 42.83 | 2.00 | 2.50 | 3.50 | 42.83 | 3.00 | 3.00 | 3.50 |
| 02-Jul | 48.54 | 3.50 | 3.00 | 3.50 | 48.54 | 3.00 | 2.75 | 3.50 |
| 03-Jul | 42.83 | 3.50 | 3.50 | 4.00 | 42.83 | 3.75 | 4.00 | 3.75 |
| 04-Jul | 42.83 | 2.50 | 3.00 | 3.50 | 42.83 | 3.00 | 3.00 | 3.50 |
| 05-Jul | 42.83 | 3.50 | 3.75 | 3.25 | 42.83 | 3.50 | 3.00 | 4.50 |
| 06-Jul | 42.83 | 2.50 | 3.50 | 3.50 | 42.83 | 3.00 | 3.50 | 3.50 |
| 07-Jul | 36.03 | 3.00 | 3.00 | 3.00 | 36.03 | 3.00 | 3.00 | 3.00 |
| 08-Jul | 36.03 | 3.50 | 3.00 | 3.00 | 36.03 | 3.00 | 3.00 | 3.00 |
| 09-Jul | 36.03 | 3.50 | 3.00 | 3.50 | 36.03 | 3.00 | 3.50 | 3.50 |
| 10-Jul | no sample | | | | no sample | | | |
| 11-Jul | 36.03 | 3.50 | 3.00 | 3.00 | 36.03 | 4.00 | 3.50 | 3.50 |
| 12-Jul | 36.03 | 3.00 | 4.00 | 3.50 | 36.03 | 3.50 | 3.50 | 4.50 |
| 13-Jul | 36.03 | 3.00 | 3.50 | 3.50 | 36.03 | 4.00 | 3.50 | 4.00 |
| 14-Jul | 36.03 | 3.00 | 3.50 | 3.50 | 36.03 | 3.50 | 3.50 | 4.00 |
| 15-Jul | 36.03 | 4.00 | 4.25 | 3.50 | 36.03 | 3.50 | 4.00 | 4.50 |
| 16-Jul | 36.03 | 4.00 | 3.50 | 4.00 | 36.03 | 3.50 | 4.00 | 4.00 |
| 17-Jul | 36.03 | 3.50 | 4.50 | 4.50 | 36.03 | 4.00 | 4.00 | 4.50 |

| | A tank | | | | B tank | | | |
|---|---|---|---|---|---|---|---|---|
| Date | ppm | Time | Time | Time | ppm | Time | Time | Time |
| 18-Jul | 42.83 | 2.50 | 3.50 | 4.00 | 42.83 | 3.50 | 4.00 | 4.00 |
| 19-Jul | 28.56 | 2.75 | 4.50 | 4.50 | 48.54 | 4.50 | 4.00 | |
| 20-Jul | 42.83 | 5.00 | 5.00 | 4.50 | 42.83 | 3.00 | 4.00 | 4.00 |
| 21-Jul | no sample | | | | no sample | | | |
| 22-Jul | no sample | | | | no sample | | | |
| 23-Jul | no sample | | | | no sample | | | |
| 24-Jul | no sample | | | | no sample | | | |
| 25-Jul | no sample | | | | no sample | | | |
| 26-Jul | no sample | | | | no sample | | | |
| 27-Jul | no sample | | | | no sample | | | |
| 28-Jul | no sample | | | | no sample | | | |
| 29-Jul | no sample | | | | no sample | | | |
| 30-Jul | no sample | | | | no sample | | | |
| 31-Jul | 42.83 | 4.00 | 4.50 | 4.50 | 42.83 | 4.00 | 4.00 | 4.50 |
| 01-Aug | 45.69 | 2.50 | 3.50 | 4.00 | 42.83 | 3.00 | 3.00 | 2.50 |
| 02-Aug | 45.69 | 3.00 | 2.50 | 4.00 | 42.83 | 3.00 | 3.50 | 3.00 |
| 03-Aug | 45.69 | 3.50 | 4.00 | 4.00 | 42.83 | 3.50 | 3.50 | 4.00 |
| 04-Aug | 45.69 | 3.50 | 4.00 | 4.00 | 45.69 | 3.75 | 4.00 | 4.00 |
| 05-Aug | 45.69 | 3.50 | 3.00 | 3.00 | 45.69 | 3.00 | 3.50 | 2.50 |
| 06-Aug | 45.69 | 4.50 | 3.00 | 2.50 | 45.69 | 3.00 | 3.00 | 3.00 |
| 07-Aug | 45.69 | 3.50 | 3.00 | 3.00 | 45.69 | 3.00 | 2.50 | 3.50 |
| 08-Aug | 45.69 | 3.00 | 3.50 | 3.50 | 45.69 | 2.50 | 3.50 | 3.00 |
| 09-Aug | 45.69 | 4.00 | 3.50 | 3.50 | 45.69 | 3.00 | 3.50 | 3.50 |
| 10-Aug | no sample | | | | no sample | | | |
| 11-Aug | no sample | | | | no sample | | | |
| 12-Aug | 45.69 | 3.50 | 3.50 | 4.00 | 45.69 | 4.00 | 4.00 | 4.00 |
| 13-Aug | 45.69 | 3.50 | 3.00 | 3.50 | 45.69 | 3.00 | 3.50 | 3.50 |
| 14-Aug | 45.69 | 3.00 | 3.00 | 3.50 | 45.69 | 3.50 | 3.00 | 3.50 |
| 15-Aug | 45.69 | 3.50 | 3.50 | 3.00 | 45.69 | 3.00 | 3.50 | 3.00 |
| 16-Aug | 45.69 | 3.25 | 3.50 | 3.50 | 42.83 | 3.50 | 3.50 | 4.00 |
| 17-Aug | 45.69 | 4.00 | 4.00 | 4.00 | 45.69 | 4.00 | 4.00 | 5.00 |
| 18-Aug | 45.69 | 4.00 | 4.50 | 4.00 | 45.69 | 3.50 | 3.50 | 4.00 |
| 19-Aug | 84.06 | 4.00 | 4.00 | 3.00 | 84.06 | 3.50 | 3.50 | 3.50 |
| 20-Aug | 84.06 | 4.00 | | 4.00 | 84.06 | 2.50 | | 3.00 |
| 21-Aug | 84.06 | 3.25 | | 3.00 | 72.05 | 3.50 | 4.00 | 2.50 |
| 22-Aug | 84.06 | 3.00 | 3.25 | 4.00 | 84.06 | 3.50 | 4.00 | 3.25 |
| 23-Aug | 72.05 | 3.00 | 4.25 | 4.00 | 72.05 | 3.50 | 3.50 | 3.00 |
| 24-Aug | 72.05 | 3.25 | 4.00 | 3.75 | 72.05 | 3.75 | 3.50 | 4.75 |
| 25-Aug | 84.06 | 3.50 | 4.00 | 4.00 | 84.06 | 4.00 | | 3.50 |
| 26-Aug | 84.06 | 4.00 | 4.00 | 4.00 | 84.06 | 3.00 | 3.50 | 3.50 |
| 27-Aug | 84.06 | 4.50 | | 4.50 | 84.06 | 4.50 | | |
| 28-Aug | 72.05 | 4.00 | 4.25 | 4.00 | 72.05 | 5.00 | 5.00 | 3.00 |
| 29-Aug | 84.06 | 4.00 | | 3.50 | 96.07 | 3.25 | | |
| 30-Aug | 84.06 | 3.25 | | 3.25 | 84.06 | 5.00 | 3.00 | 3.75 |
| 31-Aug | 84.06 | 3.50 | | 3.50 | 84.06 | 3.75 | 3.75 | 4.00 |
| 01-Sep | 84.06 | 3.75 | 3.50 | 3.50 | 84.06 | 3.00 | 3.00 | 3.50 |
| 02-Sep | 84.06 | 3.50 | | 4.00 | 84.06 | 3.00 | 3.50 | 3.50 |
| 03-Sep | 72.05 | 5.00 | | 3.00 | 84.06 | 4.50 | 4.00 | 2.75 |
| 04-Sep | 84.06 | 3.50 | | 2.50 | 84.06 | 2.75 | 2.50 | 2.25 |
| 05-Sep | 84.06 | 4.00 | | 4.00 | 84.06 | 4.00 | 3.50 | 3.50 |
| 06-Sep | 84.06 | 3.00 | | 3.50 | 84.06 | 3.00 | | 3.00 |
| 07-Sep | 84.06 | 3.75 | | 3.00 | 84.06 | 3.00 | | 3.00 |
| 08-Sep | 84.06 | 3.50 | 3.25 | 3.50 | 84.06 | 3.25 | 3.00 | 3.25 |
| 09-Sep | 84.06 | 3.50 | | 3.50 | 84.06 | 3.50 | 3.50 | 4.00 |
| 10-Sep | 84.06 | 3.50 | | 2.50 | 84.06 | 3.00 | 3.50 | 2.50 |
| 11-Sep | 84.06 | 2.75 | | 2.75 | 72.05 | 3.00 | 3.50 | 3.00 |
| 12-Sep | 96.07 | 3.00 | 3.00 | 3.00 | 96.07 | 3.00 | 3.00 | 3.00 |
| 13-Sep | 96.07 | 2.75 | 2.75 | 3.00 | 96.07 | 3.25 | 3.00 | 3.00 |
| 14-Sep | 96.07 | 3.00 | 2.75 | 2.75 | 96.07 | 3.00 | 3.00 | 2.75 |
| 15-Sep | 96.07 | 3.00 | | 2.75 | 96.07 | 3.00 | 3.00 | 2.75 |
| 16-Sep | 96.07 | 3.00 | | 2.75 | 96.07 | 3.00 | | 3.00 |
| 17-Sep | 96.07 | 3.00 | | 3.00 | 96.07 | 3.00 | | 3.00 |
| 18-Sep | 96.07 | 3.00 | | 3.00 | 96.07 | 3.00 | 3.00 | 3.00 |
| 19-Sep | 96.07 | 3.00 | | 3.00 | 96.07 | 3.00 | | 3.00 |
| 20-Sep | 96.07 | 3.00 | 3.00 | 3.00 | 96.07 | 3.00 | 3.00 | 3.00 |
| 21-Sep | 96.07 | 3.00 | 3.00 | 3.00 | 96.07 | 3.00 | 3.00 | 3.00 |
| 22-Sep | 96.07 | 3.00 | | 2.50 | 96.07 | 3.00 | | 3.00 |
| 23-Sep | 84.06 | 2.50 | | 3.50 | 84.06 | 3.50 | | 3.00 |
| 24-Sep | 84.06 | 3.50 | | | 84.06 | 3.50 | | 3.50 |
| 25-Sep | 96.07 | 3.00 | | 3.00 | 96.07 | 3.00 | | 3.00 |
| 26-Sep | 96.07 | 3.00 | | 3.00 | 96.07 | 3.00 | | 3.00 |
| 27-Sep | 96.07 | 3.00 | | 3.00 | 96.07 | 3.00 | | 3.00 |
| 28-Sep | 96.07 | 3.00 | | 3.00 | 96.07 | 3.00 | | 3.00 |
| 29-Sep | 96.07 | 3.00 | | 3.00 | 96.07 | 3.00 | | 3.00 |
| 30-Sep | 84.06 | 4.00 | | 4.00 | 96.07 | 3.50 | | |
| 01-Oct | 84.06 | 3.75 | | 3.75 | 84.06 | 3.50 | 3.50 | 3.50 |
| 02-Oct | 96.07 | 3.00 | | 3.00 | 96.07 | 3.00 | | 3.00 |
| 03-Oct | 84.06 | 3.50 | | | 84.06 | 3.50 | | |
| 04-Oct | 96.07 | 3.00 | | | 96.07 | 3.00 | | |
| 05-Oct | 96.07 | 3.00 | | | 96.07 | 3.00 | | |
| 06-Oct | 96.07 | 3.00 | | | 96.07 | 3.00 | | |
| 07-Oct | 96.07 | 3.50 | | | 96.07 | 3.50 | | |
| 08-Oct | 96.07 | 2.50 | | | 96.07 | 2.50 | 2.75 | |
| 09-Oct | 96.07 | | | | 96.07 | | | |
| 10-Oct | 96.07 | 3.00 | | 3.50 | 96.07 | 3.50 | 3.50 | 3.50 |
| 11-Oct | 96.07 | 3.00 | | 3.00 | 96.07 | 3.00 | | 3.00 |
| 12-Oct | 96.07 | 3.00 | | 3.00 | 96.07 | 3.00 | | 3.00 |
| 13-Oct | 96.07 | 3.00 | | 4.00 | 96.07 | 3.00 | | 3.50 |
| 14-Oct | 96.07 | 3.50 | | 4.00 | 96.07 | 3.50 | | 4.00 |
| 15-Oct | 96.07 | 3.00 | | 3.00 | 96.07 | 2.50 | 3.00 | 2.50 |
| 16-Oct | 96.07 | 3.00 | 3.00 | 3.00 | 96.07 | 2.75 | 3.25 | 3.50 |
| 17-Oct | 96.07 | 3.50 | 3.00 | 3.25 | 96.07 | 3.00 | 3.00 | 3.00 |
| 18-Oct | 96.07 | 3.50 | 3.25 | 3.25 | 96.07 | 3.00 | 2.50 | 3.00 |
| 19-Oct | 96.07 | 3.00 | 2.25 | 3.00 | 96.07 | 3.00 | 3.00 | 2.50 |
| 20-Oct | 96.07 | 3.75 | 3.75 | 3.50 | 96.07 | 3.50 | 3.50 | 3.50 |
| 21-Oct | 96.07 | 3.75 | 3.75 | 3.75 | 96.07 | 3.75 | 3.75 | 3.75 |
| 22-Oct | 96.07 | 3.75 | 3.75 | 3.75 | 96.07 | 3.75 | 3.00 | 3.50 |
| 23-Oct | 72.05 | 4.00 | 4.00 | 4.00 | 96.07 | 3.00 | 3.00 | 3.00 |
| 24-Oct | 96.07 | 2.50 | 2.50 | 2.50 | 96.07 | 2.75 | 3.00 | 3.00 |
| 25-Oct | 96.07 | 2.50 | 2.50 | 3.00 | 96.07 | 2.50 | 2.50 | 2.50 |
| 26-Oct | 96.07 | 3.00 | 3.00 | 3.00 | 96.07 | 3.00 | 2.50 | 3.00 |
| 27-Oct | 96.07 | 2.50 | 3.00 | 3.00 | 96.07 | 3.00 | 3.00 | 3.00 |
| 28-Oct | 96.07 | 3.75 | 3.50 | 3.75 | 96.07 | 3.50 | 3.50 | 3.50 |
| 29-Oct | 96.07 | 2.50 | 2.75 | 2.50 | 72.05 | 4.00 | 3.50 | 4.00 |
| 30-Oct | 72.05 | 4.00 | 4.00 | 4.00 | 72.05 | 3.75 | 3.50 | 4.00 |
| 31-Oct | 96.07 | 4.00 | 4.00 | 3.00 | 96.07 | 4.00 | 3.25 | 3.00 |
| 01-Nov | 96.07 | 2.25 | 2.50 | 5.50 | 96.07 | 2.50 | 3.00 | 2.50 |

**Season Summary**

| | A & B tanks Time | A & B tanks ppm |
|---|---|---|
| minimum | 2.0 | 18.0 |
| maximum | 6.0 | 96.1 |
| average | 3.5 | 74.8 |
| Total days | 240 | |

**At or Above 60° F** June 29 - Oct 16, 1996

| | A & B tanks Time | A & B tanks ppm |
|---|---|---|
| minimum | 2.0 | 28.5 |
| maximum | 5.5 | 96.1 |
| average | 3.4 | 71.0 |
| Total days | 109 | |

Appendix Table 1. Continued.

| | A Leak | | | | B Leak | | | |
|---|---|---|---|---|---|---|---|---|
| Date | mm | Time | Time | Time | mm | Time | Time | Time |
| 02-Nov | 96.07 | 2.25 | 2.25 | 2.50 | 96.07 | 2.50 | 2.50 | 3.0 |
| 03-Nov | 96.07 | 4.00 | 3.00 | 3.00 | 96.07 | 3.00 | 2.50 | 2.5 |
| 04-Nov | 96.07 | 3.50 | 3.00 | 3.00 | 96.07 | 3.00 | 3.00 | 3.5 |
| 05-Nov | 96.07 | 2.50 | 3.00 | 3.00 | 96.07 | 2.50 | 3.00 | 3.0 |
| 06-Nov | 96.07 | 2.75 | 2.25 | 2.50 | 96.07 | 2.50 | 2.50 | 3.0 |
| 07-Nov | 96.07 | 3.50 | 3.00 | 2.50 | 96.07 | 3.25 | 3.00 | 3.0 |
| 08-Nov | 96.07 | 2.50 | 2.50 | 3.00 | 96.07 | 2.25 | 2.50 | 2.0 |
| 09-Nov | 96.07 | 2.75 | 2.00 | 3.00 | 96.07 | 2.00 | 3.00 | 2.2 |
| 10-Nov | 96.07 | 2.50 | 2.00 | 2.50 | 96.07 | 2.50 | 2.00 | 2.5 |
| 11-Nov | 96.07 | 3.50 | | 3.50 | 96.07 | 3.50 | | 3.5 |
| 12-Nov | 96.07 | 3.50 | | 3.00 | 96.07 | 2.75 | 3.00 | 3.5 |
| 13-Nov | 96.07 | 3.50 | | 3.50 | 96.07 | 3.50 | 3.50 | 3.5 |
| 14-Nov | 96.07 | 3.00 | 2.75 | 3.00 | 96.07 | 3.00 | 3.00 | 3.0 |
| 15-Nov | 96.07 | 2.25 | | 3.00 | 96.07 | 3.00 | | 2.2 |
| 16-Nov | 96.07 | 2.50 | | 2.50 | 96.07 | 2.25 | 2.25 | 2.5 |
| 17-Nov | 96.07 | 2.50 | | 2.50 | 96.07 | 2.25 | 2.25 | 2.2 |
| 18-Nov | 96.07 | 3.50 | | 3.50 | 96.07 | 3.50 | 3.50 | 3.5 |
| 19-Nov | 96.07 | 3.00 | 2.75 | 3.00 | 96.07 | 3.25 | 2.25 | 2.2 |
| 20-Nov | 96.07 | 3.00 | 2.75 | | 96.07 | 3.25 | 2.50 | 2.7 |
| 21-Nov | 96.07 | 3.00 | 2.75 | 3.00 | 96.07 | 3.00 | 3.00 | 3.0 |
| 22-Nov | 96.07 | 2.50 | 2.25 | 2.75 | 96.07 | 2.25 | 3.00 | 2.5 |
| 23-Nov | 96.07 | 2.25 | 3.50 | | 96.07 | 2.25 | 2.50 | 2.5 |
| 24-Nov | 96.07 | 3.50 | 3.75 | 3.75 | 96.07 | 3.50 | 3.75 | 3.5 |
| 25-Nov | 96.07 | 3.50 | 3.50 | 3.50 | 96.07 | 3.50 | 3.50 | 3.5 |
| 26-Nov | 96.07 | 2.75 | | 2.50 | 96.07 | 2.50 | 2.75 | 2.5 |
| 27-Nov | 96.07 | 2.50 | | 2.50 | 96.07 | 2.00 | | 2.5 |
| 28-Nov | 96.07 | 3.00 | | 3.00 | 96.07 | 3.00 | 3.00 | 3.0 |
| 29-Nov | 96.07 | 2.25 | | | 96.07 | 3.00 | | 3.0 |
| 30-Nov | 96.07 | 2.50 | | 2.50 | 96.07 | 2.25 | | 2.5 |
| 01-Dec | 96.07 | 3.75 | | 3.50 | 96.07 | 3.50 | | 3.5 |
| 02-Dec | 96.07 | 3.50 | | 3.50 | 96.07 | 3.50 | | 3.5 |
| 03-Dec | 96.07 | 3.00 | | 3.50 | 96.07 | 3.50 | | 3.0 |
| 04-Dec | 96.07 | 3.00 | | 3.00 | 96.07 | 3.00 | | 3.0 |
| 05-Dec | 96.07 | 3.00 | | | 96.07 | 2.50 | | |
| 06-Dec | 96.07 | 3.00 | | | 96.07 | 2.25 | | 2.2 |
| 07-Dec | 96.07 | 2.50 | | | 96.07 | 2.00 | | |
| 08-Dec | 96.07 | | | | 96.07 | | | |
| 09-Dec | 96.07 | 3.50 | | | 96.07 | 3.50 | | |
| 10-Dec | 96.07 | 3.00 | | | 96.07 | 2.75 | | |
| 11-Dec | 96.07 | 3.00 | | | 96.07 | 4.00 | | |
| 12-Dec | 96.07 | 3.00 | | | 96.07 | 3.00 | | |
| 13-Dec | 96.07 | 2.50 | | | 96.07 | 2.25 | | |
| 14-Dec | 96.07 | 2.50 | | | 96.07 | 3.00 | | |
| 15-Dec | 96.07 | 3.50 | | | 96.07 | 3.50 | | |

Appendix Table 2. Pre-anesthetic induction time (minutes) and concentrations at Lower Monumental Dam, 1996.

| | A tank | | | | B tank | | | | A & B tanks |
|---|---|---|---|---|---|---|---|---|---|
| Date | ppm | Time | Time | Time | ppm | Time | Time | Time | Time |
| 02-Apr | 37.0 | 43 | | | 37.0 | 50 | | | 47 |
| 03-Apr | 37.0 | 43 | | | 37.0 | 35 | | | 39 |
| 04-Apr | 37.0 | 43 | 43 | | 37.0 | 34 | 40 | | 40 |
| 05-Apr | 37.0 | 50 | 50 | | 37.0 | 50 | 45 | | 48 |
| 06-Apr | 37.0 | 43 | | | 37.0 | 43 | | | 43 |
| 07-Apr | 37.0 | 43 | | | 37.0 | 40 | | | 42 |
| 08-Apr | 37.0 | 50 | | | 37.0 | 43 | | | 47 |
| 09-Apr | 37.0 | 43 | | | 37.0 | 40 | 43 | | 42 |
| 10-Apr | 37.0 | 40 | | | 37.0 | 40 | 43 | | 41 |
| 11-Apr | 37.0 | 43 | 40 | 40 | 37.0 | 41 | 43 | 43 | 42 |
| 12-Apr | 37.0 | 40 | 40 | 40 | 37.0 | 43 | 40 | 43 | 41 |
| 13-Apr | 37.0 | 43 | 43 | 40 | 37.0 | 43 | 43 | 43 | 43 |
| 14-Apr | 37.0 | 43 | 43 | 40 | 37.0 | 40 | 40 | 40 | 41 |
| 15-Apr | 37.0 | 43 | 43 | 43 | 37.0 | 43 | 43 | 43 | 43 |
| 16-Apr | 37.0 | 40 | 40 | 43 | 37.0 | 43 | 40 | 43 | 42 |
| 17-Apr | 37.0 | 43 | 43 | 50 | 37.0 | 43 | 40 | 43 | 44 |
| 18-Apr | 37.0 | 43 | 43 | 43 | 37.0 | 43 | 40 | 40 | 42 |
| 19-Apr | 37.0 | 42 | 43 | 43 | 37.0 | 40 | 43 | 40 | 42 |
| 20-Apr | 37.0 | 43 | 43 | 40 | 37.0 | 40 | 40 | 40 | 41 |
| 21-Apr | 37.0 | 43 | 42 | 50 | 37.0 | 40 | 42 | 40 | 43 |
| 22-Apr | 37.0 | 40 | 50 | 43 | 37.0 | 43 | 40 | 43 | 43 |
| 23-Apr | 37.0 | 43 | 43 | 43 | 37.0 | 40 | 40 | 40 | 42 |
| 24-Apr | 37.0 | 40 | 43 | 50 | 37.0 | 43 | 33 | 43 | 42 |
| 25-Apr | 37.0 | 43 | 43 | 43 | 37.0 | 33 | 33 | 33 | 38 |
| 26-Apr | 37.0 | 40 | 40 | 40 | 37.0 | 40 | 40 | 40 | 40 |
| 27-Apr | 37.0 | 40 | 40 | 40 | 37.0 | 43 | 43 | 43 | 42 |
| 28-Apr | 37.0 | 42 | 42 | 32 | 37.0 | 40 | 42 | 33 | 38 |
| 29-Apr | 37.0 | 40 | 40 | 43 | 37.0 | 43 | 40 | 40 | 41 |
| 30-Apr | 37.0 | 40 | 40 | 40 | 37.0 | 40 | 30 | 40 | 38 |
| 01-May | 37.0 | 40 | 40 | 43 | 37.0 | 40 | 33 | 34 | 38 |
| 02-May | 37.0 | 40 | 40 | | 37.0 | 40 | 40 | 40 | 40 |
| 03-May | 37.0 | 40 | 40 | | 37.0 | 40 | 40 | 40 | 40 |
| 04-May | 37.0 | 40 | | | 37.0 | 40 | 40 | 40 | 40 |
| 06-May | 37.0 | 40 | 40 | | 37.0 | 40 | 43 | 42 | 41 |
| 06-May | 37.0 | 40 | 45 | 40 | 37.0 | 40 | 40 | 43 | 41 |
| 07-May | 37.0 | 40 | 40 | 40 | 37.0 | 40 | 30 | 40 | 38 |
| 08-May | 37.0 | 33 | 33 | 34 | 37.0 | 34 | 40 | 40 | 36 |
| 09-May | 37.0 | 33 | 40 | 40 | 37.0 | 40 | 34 | 33 | 37 |
| 10-May | 37.0 | 32 | 43 | 42 | 37.0 | 33 | 34 | 33 | 36 |
| 11-May | 37.0 | 33 | 33 | 40 | 37.0 | 40 | 34 | 40 | 37 |
| 12-May | 37.0 | 40 | 34 | 40 | 37.0 | 33 | 33 | 33 | 35 |
| 13-May | 37.0 | 34 | 35 | 40 | 37.0 | 40 | 30 | 40 | 36 |
| 14-May | 37.0 | 34 | 42 | 42 | 37.0 | 32 | 33 | 40 | 37 |
| 15-May | 37.0 | 40 | 40 | 40 | 37.0 | 33 | 34 | 35 | 37 |
| 16-May | 37.0 | 40 | 35 | 40 | 37.0 | 35 | 30 | 40 | 37 |
| 17-May | 37.0 | 33 | 40 | 40 | 37.0 | 33 | 35 | 40 | 37 |
| 18-May | 37.0 | 40 | 40 | 40 | 37.0 | 40 | 33 | 35 | 36 |
| 19-May | 37.0 | 40 | 33 | 40 | 37.0 | 33 | 33 | 40 | 37 |
| 20-May | 37.0 | 40 | 33 | 33 | 37.0 | 33 | 33 | 40 | 35 |
| 21-May | 37.0 | 33 | 40 | 40 | 37.0 | 33 | 40 | 40 | 38 |
| 22-May | 37.0 | 33 | 40 | | 37.0 | 42 | 33 | 40 | 38 |
| 23-May | 37.0 | 43 | 41 | | 37.0 | 42 | 40 | 43 | 42 |
| 24-May | 37.0 | 40 | 40 | 40 | 37.0 | 43 | 40 | 40 | 41 |
| 25-May | 37.0 | 33 | 40 | 40 | 37.0 | 40 | 30 | 40 | 37 |
| 26-May | 37.0 | 33 | 33 | | 37.0 | 40 | 42 | 40 | 38 |
| 27-May | 37.0 | 35 | | | 37.0 | 40 | 33 | 33 | 35 |
| 28-May | 37.0 | 40 | 40 | | 37.0 | 33 | 40 | 33 | 37 |
| 29-May | 37.0 | 33 | 34 | | 37.0 | 33 | 40 | 40 | 36 |
| 30-May | 37.0 | 40 | 40 | | 37.0 | 40 | 40 | 33 | 38 |
| 31-May | 37.0 | 33 | | | 37.0 | 33 | 40 | 40 | 37 |
| 01-Jun | 37.0 | 33 | | | 37.0 | 33 | 40 | 40 | 37 |
| 02-Jun | 37.0 | 33 | | | 37.0 | 33 | 30 | 40 | 34 |
| 03-Jun | 37.0 | 40 | 40 | | 37.0 | 33 | 33 | 33 | 36 |
| 04-Jun | 37.0 | 40 | 40 | | 37.0 | 42 | 34 | 42 | 39 |
| 05-Jun | 37.0 | 40 | 40 | | 37.0 | 42 | 33 | 40 | 39 |
| 06-Jun | 37.0 | 33 | 40 | | 37.0 | 40 | 33 | 44 | 38 |
| 07-Jun | 37.0 | 40 | 40 | | 37.0 | 33 | 40 | 33 | 37 |
| 08-Jun | 37.0 | 40 | 40 | | 37.0 | 40 | 34 | 43 | 38 |
| 09-Jun | 37.0 | 32 | 43 | | 37.0 | 40 | 40 | 40 | 39 |
| 10-Jun | 37.0 | 40 | 40 | | 37.0 | 43 | 42 | 40 | 41 |
| 11-Jun | 37.0 | 40 | 40 | | 37.0 | 40 | 40 | 40 | 40 |
| 12-Jun | 37.0 | 35 | 40 | | 37.0 | 34 | 40 | 40 | 38 |
| 13-Jun | 37.0 | 40 | 40 | | 37.0 | 42 | 42 | 40 | 41 |
| 14-Jun | 37.0 | 40 | | | 37.0 | 40 | 40 | 40 | 40 |
| 15-Jun | 37.0 | 40 | | | 37.0 | 43 | 40 | 40 | 41 |
| 16-Jun | 37.0 | 40 | | | 37.0 | 40 | 43 | 43 | 42 |
| 17-Jun | 37.0 | 33 | | | 37.0 | 43 | 40 | 40 | 39 |
| 18-Jun | 37.0 | 33 | | | 37.0 | 43 | 40 | 33 | 37 |
| 19-Jun | 37.0 | 40 | 40 | | 37.0 | 40 | 42 | 33 | 39 |
| 20-Jun | 37.0 | 40 | 40 | 40 | 37.0 | 40 | 40 | 33 | 39 |
| 21-Jun | 37.0 | 40 | | | 37.0 | 31 | 33 | 40 | 38 |
| 22-Jun | 37.0 | 30 | | | 37.0 | 40 | 33 | 40 | 38 |
| 23-Jun | 37.0 | 34 | | | 37.0 | 40 | 30 | 42 | 38 |
| 24-Jun | 37.0 | 33 | | | 37.0 | 40 | 33 | 40 | 37 |
| 25-Jun | 37.0 | 40 | | | 37.0 | 33 | 40 | 40 | 38 |
| 26-Jun | 37.0 | 40 | | | 37.0 | 33 | 33 | | 35 |
| 27-Jun | 37.0 | 40 | | | 37.0 | 33 | 33 | | 35 |
| 28-Jun | 37.0 | 33 | | | 37.0 | 33 | 33 | | 33 |
| 29-Jun | 37.0 | 40 | | | 37.0 | 40 | 33 | 40 | 38 |
| 30-Jun | 37.0 | 32 | | | 37.0 | 43 | 40 | 40 | 38 |
| 01-Jul | 37.0 | 43 | | | 37.0 | 43 | 43 | | 43 |
| 02-Jul | 37.0 | 33 | | | 37.0 | 32 | 33 | 33 | 33 |
| 03-Jul | 37.0 | 43 | 43 | | 37.0 | 31 | 40 | 33 | 38 |
| 04-Jul | 37.0 | 33 | 33 | | 37.0 | 33 | 30 | 33 | 32 |
| 05-Jul | 37.0 | 40 | | | 37.0 | 32 | 40 | 33 | 35 |
| 06-Jul | 37.0 | 42 | | | 37.0 | 33 | 42 | 40 | 39 |
| 07-Jul | 37.0 | 40 | 40 | | 37.0 | 30 | 33 | 40 | 37 |
| 08-Jul | 37.0 | 33 | | | 37.0 | 40 | 40 | 33 | 37 |
| 09-Jul | 37.0 | 33 | 41 | | 37.0 | 31 | 40 | 33 | 36 |
| 10-Jul | 37.0 | 33 | 43 | 40 | 37.0 | 43 | 40 | 40 | 40 |
| 11-Jul | 37.0 | 43 | 40 | | 37.0 | 33 | 33 | 33 | 38 |
| 12-Jul | 37.0 | 43 | 43 | | 37.0 | 33 | 34 | 43 | 39 |
| 13-Jul | 37.0 | 32 | 33 | | 37.0 | 31 | 33 | 34 | 33 |
| 14-Jul | 37.0 | 33 | 32 | 43 | 37.0 | 40 | 32 | 33 | 35 |
| 15-Jul | 37.0 | 32 | 40 | | 37.0 | 40 | 40 | 40 | 38 |
| 16-Jul | 37.0 | 40 | 40 | 42 | 37.0 | 43 | 31 | 40 | 39 |
| 17-Jul | 37.0 | 40 | 33 | 33 | 37.0 | 40 | 40 | 40 | 38 |

| | A tank | | | | B tank | | | | A & B tanks |
|---|---|---|---|---|---|---|---|---|---|
| Date | ppm | Time | Time | Time | ppm | Time | Time | Time | Time |
| 18-Jul | 37.0 | 42 | 40 | | 37.0 | 40 | 33 | 33 | 38 |
| 19-Jul | 37.0 | 40 | 40 | | 37.0 | 43 | 33 | 40 | 39 |
| 20-Jul | 37.0 | 40 | | | 37.0 | 41 | 40 | 43 | 41 |
| 21-Jul | 37.0 | 40 | | | 37.0 | 42 | 33 | 40 | 39 |
| 22-Jul | 37.0 | 40 | | | 37.0 | 33 | 33 | 40 | 37 |
| 23-Jul | 37.0 | 33 | | | 37.0 | 35 | 42 | 40 | 37 |
| 24-Jul | 37.0 | 40 | | | 37.0 | 42 | 40 | 41 | 41 |
| 25-Jul | 37.0 | 33 | | | 37.0 | 41 | 40 | 40 | 39 |
| 26-Jul | 37.0 | 40 | | | 37.0 | 41 | 43 | 43 | 42 |
| 27-Jul | 37.0 | 40 | 40 | | 37.0 | 40 | 33 | 40 | 39 |
| 28-Jul | 37.0 | 43 | | | 37.0 | 31 | 33 | 40 | 37 |
| 29-Jul | 37.0 | 40 | | | 37.0 | 40 | 41 | 40 | 40 |
| 30-Jul | 37.0 | 40 | | | 37.0 | 40 | 33 | 42 | 39 |
| 31-Jul | 37.0 | 43 | | | 37.0 | 33 | 33 | 40 | 37 |
| 01-Aug | 37.0 | 40 | | | 37.0 | 33 | 40 | 33 | 37 |
| 02-Aug | 37.0 | 40 | | | 37.0 | 40 | 40 | 40 | 40 |
| 03-Aug | 37.0 | 34 | | | 37.0 | 40 | 33 | 40 | 37 |
| 04-Aug | 37.0 | 40 | | | 37.0 | 33 | 40 | 43 | 38 |
| 06-Aug | 37.0 | 40 | | | 37.0 | 40 | 40 | 40 | 40 |
| 06-Aug | 37.0 | 40 | | | 37.0 | 34 | 40 | 40 | 38 |
| 07-Aug | 37.0 | 32 | | | 37.0 | 33 | 32 | | 32 |
| 08-Aug | 37.0 | 33 | | | 37.0 | 35 | 33 | 33 | 33 |
| 09-Aug | 37.0 | 53 | | | 37.0 | 33 | 40 | | 42 |
| 10-Aug | 37.0 | 40 | | | 37.0 | 40 | 40 | 33 | 38 |
| 11-Aug | 37.0 | 33 | | | 37.0 | 33 | 30 | | 32 |
| 12-Aug | 37.0 | 33 | | | 37.0 | 40 | 43 | 40 | 39 |
| 13-Aug | 37.0 | 40 | | | 37.0 | 34 | 33 | | 36 |
| 14-Aug | 37.0 | 40 | | | 37.0 | 33 | 40 | | 38 |
| 15-Aug | 37.0 | 33 | | | 37.0 | 34 | 40 | | 36 |
| 16-Aug | 37.0 | 33 | | | 37.0 | 33 | 30 | | 32 |
| 17-Aug | 37.0 | 40 | | | 37.0 | 40 | 34 | | 38 |
| 18-Aug | 37.0 | 40 | | | 37.0 | 34 | 33 | | 36 |
| 18-Aug | 37.0 | 40 | | | 37.0 | 33 | 40 | | 38 |
| 20-Aug | 37.0 | 40 | | | 37.0 | 40 | 40 | | 40 |
| 21-Aug | 37.0 | 40 | | | 37.0 | 43 | 33 | | 38 |
| 22-Aug | 37.0 | 40 | | | 37.0 | 34 | 33 | | 36 |
| 23-Aug | 37.0 | 33 | | | 37.0 | 40 | 40 | | 38 |
| 24-Aug | 37.0 | 42 | | | 37.0 | 41 | 32 | | 38 |
| 25-Aug | 37.0 | 40 | | | 37.0 | 33 | 33 | | 35 |
| 26-Aug | 37.0 | 33 | | | 37.0 | 40 | 40 | | 38 |
| 27-Aug | 37.0 | 32 | | | 37.0 | 34 | | | 33 |
| 28-Aug | 37.0 | 40 | | | 37.0 | 43 | 40 | | 41 |
| 29-Aug | 37.0 | 30 | | | 37.0 | 33 | | | 32 |
| 30-Aug | 37.0 | 50 | | | 37.0 | 33 | 38 | | 39 |
| 31-Aug | 37.0 | 33 | | | 37.0 | 40 | | | 37 |
| 01-Sep | 37.0 | 43 | | | 37.0 | 33 | | | 38 |
| 02-Sep | 37.0 | 33 | | | 37.0 | 43 | 50 | | 42 |
| 03-Sep | 37.0 | 40 | | | 37.0 | 43 | | | 42 |
| 04-Sep | 37.0 | 40 | | | 37.0 | 43 | | | 42 |
| 05-Sep | 37.0 | 40 | | | 37.0 | 40 | | | 40 |
| 06-Sep | 37.0 | 41 | | | 37.0 | 40 | | | 41 |
| 07-Sep | 37.0 | 33 | | | 37.0 | 40 | | | 37 |
| 08-Sep | 37.0 | 33 | | | 37.0 | 33 | | | 33 |
| 08-Sep | 37.0 | 40 | | | 37.0 | 40 | | | 40 |
| 10-Sep | 37.0 | 40 | | | 37.0 | 42 | | | 41 |
| 11-Sep | 37.0 | 40 | | | 37.0 | 40 | | | 40 |
| 12-Sep | 37.0 | 40 | | | 37.0 | 40 | | | 40 |
| 13-Sep | 37.0 | 34 | | | 37.0 | 33 | | | 33 |
| 14-Sep | 37.0 | 30 | | | 37.0 | 40 | | | 35 |
| 15-Sep | 37.0 | 40 | | | 37.0 | 40 | | | 40 |
| 16-Sep | 37.0 | 33 | | | 37.0 | 40 | | | 37 |
| 17-Sep | 37.0 | 30 | | | 37.0 | 40 | | | 35 |
| 18-Sep | 37.0 | 30 | | | 37.0 | 34 | | | 32 |
| 18-Sep | 37.0 | 20 | | | 37.0 | 33 | | | 27 |
| 20-Sep | 37.0 | 40 | | | 37.0 | 40 | | | 40 |
| 21-Sep | 37.0 | 33 | | | 37.0 | 40 | | | 37 |
| 22-Sep | 37.0 | 33 | | | 37.0 | 33 | | | 33 |
| 23-Sep | 37.0 | 33 | | | 37.0 | 40 | | | 37 |
| 24-Sep | 37.0 | 30 | | | 37.0 | 33 | | | 32 |
| 25-Sep | 37.0 | 30 | | | 37.0 | 33 | 40 | | 34 |
| 26-Sep | 37.0 | 40 | | | 37.0 | 33 | | | 37 |
| 27-Sep | 37.0 | 40 | | | 37.0 | 40 | | | 40 |
| 28-Sep | 37.0 | 40 | | | 37.0 | 33 | | | 37 |
| 29-Sep | 37.0 | 40 | | | 37.0 | 40 | | | 40 |
| 30-Sep | 37.0 | 40 | | | 37.0 | 40 | | | 40 |
| 01-Oct | 37.0 | 30 | | | 37.0 | 40 | | | 35 |
| 02-Oct | 37.0 | 40 | | | 37.0 | 40 | | | 40 |
| 03-Oct | 37.0 | 43 | | | 37.0 | 33 | | | 38 |
| 04-Oct | 37.0 | 43 | | | 37.0 | 40 | | | 42 |
| 05-Oct | 37.0 | 33 | | | 37.0 | 40 | | | 37 |
| 06-Oct | 37.0 | 40 | | | 37.0 | 42 | | | 41 |
| 07-Oct | 37.0 | 40 | | | 37.0 | 43 | | | 42 |
| 08-Oct | 37.0 | 40 | | | 37.0 | 43 | | | 42 |
| 09-Oct | 37.0 | 40 | | | 37.0 | 43 | | | 42 |
| 10-Oct | 37.0 | 30 | | | 37.0 | 44 | | | 37 |
| 11-Oct | 37.0 | 30 | | | 37.0 | 40 | | | 35 |
| 12-Oct | 37.0 | 30 | | | 37.0 | 40 | | | 35 |
| 13-Oct | 37.0 | 30 | | | 37.0 | 30 | | | 30 |
| 14-Oct | 37.0 | 30 | | | 37.0 | 43 | | | 37 |
| 15-Oct | 37.0 | 30 | | | 37.0 | 43 | | | 37 |
| 16-Oct | 37.0 | 30 | | | 37.0 | 40 | | | 35 |
| 17-Oct | 37.0 | 30 | | | 37.0 | 40 | | | 35 |
| 18-Oct | 37.0 | 30 | | | 37.0 | 43 | | | 37 |
| 18-Oct | 37.0 | 30 | | | 37.0 | 43 | | | 37 |
| 20-Oct | 37.0 | 30 | | | 37.0 | 40 | | | 35 |
| 21-Oct | 37.0 | 30 | | | 37.0 | 43 | | | 37 |
| 22-Oct | 37.0 | 30 | | | 37.0 | 43 | | | 37 |
| 23-Oct | 37.0 | 33 | | | 37.0 | 43 | | | 38 |
| 24-Oct | 37.0 | 30 | | | 37.0 | 43 | | | 37 |
| 25-Oct | 37.0 | 40 | | | 37.0 | 43 | | | 42 |
| 26-Oct | 37.0 | 30 | | | 37.0 | 30 | | | 30 |
| 27-Oct | 37.0 | 33 | | | 37.0 | 43 | | | 38 |
| 28-Oct | 37.0 | 30 | | | 37.0 | 33 | 30 | | 31 |
| 29-Oct | | | | | | | | | |
| 30-Oct | | | | | | | | | |
| 31-Oct | | | | | | | | | |
| 01-Nov | | | | | | | | | |

**Season Summary**

| | A & B tanks Time | A & B tanks ppm |
|---|---|---|
| minimum | 2.7 | 37.0 |
| maximum | 4.8 | 37.0 |
| average | 3.8 | 37.0 |
| Total days | 210 | |

**At or Above 60° F June 18 - Oct 18, 1996**

| | A & B tanks Time | A & B tanks ppm |
|---|---|---|
| minimum | 2.7 | 37.0 |
| maximum | 4.3 | 37.0 |
| average | 3.7 | 37.0 |
| Total days | 124 | |

**Appendix Table 3. Re-circulating anesthetic (MS222) concentrations - McNary 1996.**

| Date | ppm Starting | Date | ppm Starting | Date | ppm Starting | Date | ppm Starting | Date | ppm Starting | Date | ppm Starting |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 28-Mar | | 15-May | 22.5 | 02-Jul | 17.0 | 19-Aug | 22.5 | 06-Oct | 27.0 | 23.Nov | 27.0 |
| 29-Mar | | 16-May | 22.5 | 03-Jul | 17.0 | 20-Aug | 22.5 | 07-Oct | 5.0 | 24-Nov | 22.5 |
| 30-Mar | | 17-May | 27.0 | 04-Jul | 17.0 | 21-Aug | 22.5 | OS-Ott | 27.0 | 25-Nov | 27.0 |
| 31-Mar | | 18-May | 27.0 | 05-Jul | 17.0 | 22-Aug | 22.5 | 09-Oct | 9.0 | 26-Nov | 22.5 |
| 01-Apr | | 19-May | 21.0 | 06-Jul | 17.0 | 23-Aug | 22.5 | 10-Oct | 36.0 | 27-Nov | 18.0 |
| 02-Apr | | 20-May | 27.0 | 07-Jul | 17.0 | 24-Aug | 22.5 | 11-Oct | 36.0 | 28-Nov | 22.5 |
| 03-Apr | | 21-May | 27.0 | 08-Jul | 17.0 | 25-Aug | 22.5 | 12-Oct | 36.0 | 29-Nov | 22.5 |
| 04-Apr | | 22-May | 27.0 | OQ-Jul | 17.0 | 26-Aug | 22.5 | 13-Oct | 27.0 | 30-Nov | 0.0 |
| OS-Apr | | 23-May | 27.0 | 10-Jul | 17.0 | 27-Aug | 22.5 | 14-Oct | 36.0 | 01-Dec | 22.5 |
| 06-Apr | | 24-May | 27.0 | 11-Jul | 17.0 | 28-Aug | 22.5 | 15-Oct | 36.0 | 02-Dec | 22.5 |
| 07-Apr | | 25-May | 27.0 | 12-Jul | 17.0 | 29-Aug | 22.5 | 16-Oct | 27.0 | 03-Dec | 22.5 |
| 08-Apr | | 26-May | 27.0 | 13-Jul | 17.0 | 30-Aug | 22.5 | 17-Oct | 36.0 | 04-Dec | 23.4 |
| 09-Apr | | 27-May | 27.0 | 14-Jul | 17.0 | 3 I-Aug | 36.0 | 18-Oct | 23.4 | 05-Dec | 22.5 |
| 10-Apr | | 28-May | 27.0 | 15-Jul | 17.0 | 01-Sep | 9.0 | 19-Oct | 22.5 | 06-Dec | 22.5 |
| 11-Apr | | 29-May | 27.0 | 16-Jul | 17.0 | 02-Sep | 36.0 | 20-Oct | 27.0 | 07-Dec | |
| 12-Apr | | 30-May | 27.0 | 17-Jul | 17.0 | 03-Sep | 22.5 | 21-Oct | 27.0 | 08-Dec | |
| 13-Apr | | 31-May | 27.0 | 18-Jul | 17.0 | 04-Sep | 22.5 | 22-Oct | 31.5 | 09-Dec | |
| 14-Apr | | 01-Jun | 27.0 | 19-Jul | 17.0 | 05-Sep | 36.0 | 23-Oct | 31.5 | 10-Dec | |
| 15-Apr | | 02-Jun | 27.0 | 20-Jul | 17.0 | 06-Sep | 36.0 | 24-Oct | 22.5 | I I-Dee | |
| 16-Apr | | 03-Jun | 27.0 | 21-Jul | 19.4 | 07-Sep | 36.0 | 25-Oct | 22.5 | 12-Dec | |
| 17-Apr | | 04-Jun | 27.0 | 22-Jul | 19.4 | 08-Sep | 36.0 | 26-Oct | 29.7 | 13-Dec | |
| 18-Apr | | 05-Jun | 27.0 | 23-Jul | no sample | 09-Sep | 36.0 | 27-Oct | | 14-Dec | |
| 19-Apr | 23.4 | 06-Jun | 27.0 | 24-Jul | no sample | 10-Sep | 36.0 | 28-Oct | 27.0 | 15-Dec | |
| 20-Apr | 23.4 | 07-Jun | 27.0 | 25-Jul | no sample | 11-Sep | 36.0 | 29-Oct | 27.0 | | |
| 21-Apr | 23.4 | 08-Jun | 27.0 | 26-Jul | no sample | 12-Sep | 22.5 | 30-Oct | 22.5 | | |
| 22-Apr | 23.4 | 09-Jun | 27.0 | 27-Jul | no sample | 13-Sep | 36.0 | 31-Oct | | | |
| 23-Apr | 22.5 | 10-Jun | 27.0 | 28-Jul | no sample | 14-Sep | 36.0 | 01-Nov | 22.5 | | |
| 24-Apr | 23.4 | Il-Jun | 27.0 | 29-Jul | no sample | 15-Sep | 36.0 | 02-Nov | | | |
| 25-Apr | 23.4 | 12-Jun | 27.0 | 30-Jul | no sample | 16-Sep | 27.0 | 03-Nov | 27.0 | | |
| 26-Apr | 21.5 | 13-Jun | 27.0 | 31-Jul | 19.4 | 17-Sep | 27.0 | 04-Nov | | | |
| 27-Apr | 22.3 | 14-Jun | 27.0 | Ol-Aug | 18.8 | 18-Sep | 36.0 | 05-Nov | 27.0 | | |
| 28-Apr | 22.5 | 15-Jun | 27.0 | 02-Aug | 19.4 | 19-Sep | 36.0 | 06-Nov | 27.0 | | |
| 29-Apr | 22.5 | 16-Jun | 27.0 | 03-Aug | 22.5 | 20-Sep | 36.0 | 07-Nov | 27.0 | | |
| 30-Apr | 22.5 | 17-Jun | 23.2 | 04-Aug | 22.5 | 21-Sep | 36.0 | 08-Nov | 22.5 | | |
| Ol-May | 22.5 | 18-Jun | 23.2 | 05-Aug | 19.4 | 22-Sep | 27.0 | 09-Nov | 22.5 | | |
| 02-May | 23.4 | 19-Jun | 23.2 | 06-Aug | 18.8 | 23-Sep | 27.0 | 10-Nov | 27.0 | | |
| 03-May | 21.5 | 20-Jun | 20.4 | 07-Aug | 19.9 | 24-Sep | 36.0 | 11-Nov | | | |
| 04-May | 22.5 | 21-Jun | 20.4 | 08-Aug | 18.8 | 25-Sep | 27.0 | 12-Nov | 27.0 | | |
| 05-May | 22.5 | 22-Jun | 20.4 | 09-Aug | 19.4 | 26-Sep | 36.0 | 13-Nov | | | |
| 06-May | 22.5 | 23-Jun | 10.2 | 10-Aug | no sample | 27-Sep | 36.0 | 14-Nov | | | |
| 07-May | 21.5 | 24-Jun | 10.2 | 11-Aug | 22.5 | 28-Sep | 36.0 | 15-Nov | | | |
| 08-May | 23.4 | 25-Jun | 10.2 | 12-Aug | 19.4 | 29-Sep | 27.0 | 16-Nov | | | |
| 09-May | 21.5 | 26-Jun | 10.2 | 13-Aug | 18.8 | 30-Sep | 36.0 | 17-Nov | | | |
| 10-May | 21.5 | 27-Jun | 17.0 | 14-Aug | 19.4 | 01-Oct | | 18-Nov | | | |
| 11-May | 22.5 | 28-Jun | 13.6 | 15-Aug | 18.8 | 02-Oct | 36.0 | 19-Nov | | | |
| 12-May | 22.5 | 29-Jun | 13.6 | 16-Aug | 22.5 | 03-Oct | 36.0 | 20-Nov | | | |
| 13-May | 23.4 | 30-Jun | 17.0 | 17-Aug | 22.5 | 04-Oct | | 21-Nov | | | |
| 14-May | 21.5 | 01-Jul | 17.0 | 18-Aug | 22.5 | 05-Oct | | 22-Nov | | | |

| Year Summary | |
|---|---|
| Avg. | 24.2 |
| Min. | 0.0 |
| Max. | 36.0 |

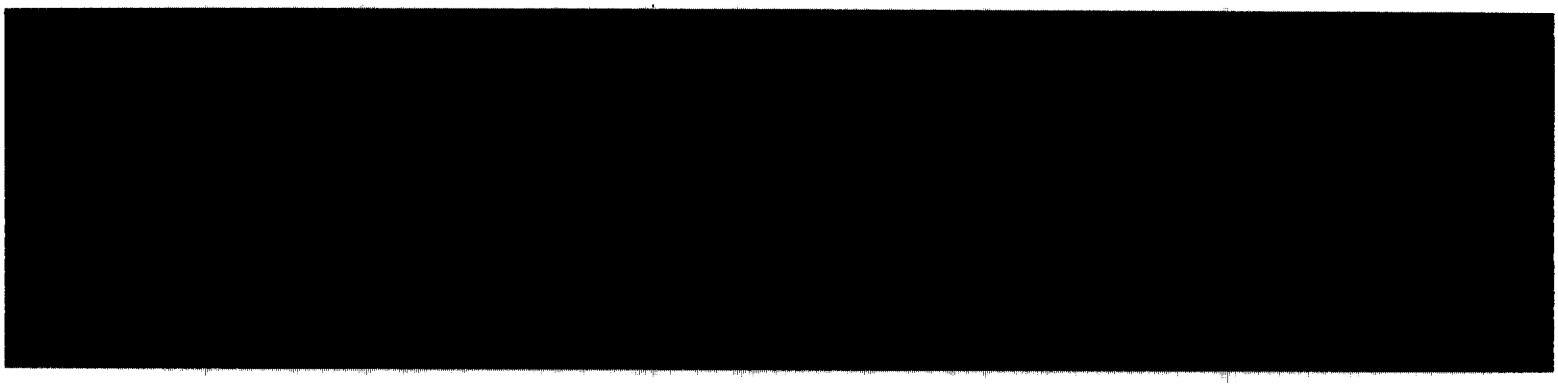
Appendix Table 4. **Re-circulating** anesthetic (MS222) concentrations - Lower **Monumental** 1996.

| Date | ppm | | Date | ppm | | Date | ppm | | Date | ppm | | Date | ppm | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Starting | Addition | | Starting | Addition | | Starting | Addition | | Starting | Addition | | Starting | Addition |
| 02-Apr | 19.8 | | 20-May | 25.0 | | 07-Jul | 25.0 | | 24-Aug | 25.0 | | 11-Oct | | |
| 03-Apr | 19.8 | | 21-May | 25.0 | | 08-Jul | 25.0 | | 25-Aug | | | 12-Oct | | |
| 04-Apr | 19.8 | | 22-May | 25.0 | | 09-Jul | 25.0 | | 26-Aug | 25.0 | | 13-Oct | | |
| 05-Apr | 19.0 | | 23-May | 25.0 | | 10-Jul | 25.0 | | 27-Aug | | | 14-Oct | | |
| 06-Apr | 19.8 | | 24-May | 25.0 | | 11-Jul | 25.0 | | 28-Aug | 25.0 | | 15-Oct | | |
| 07-Apr | 19.8 | | 25-May | 25.0 | | 12-Jul | 25.0 | | 29-Aug | | | 16-Oct | | |
| 08-Apr | 19.8 | | 26-May | 25.0 | | 13-Jul | 25.0 | | 30-Aug | 25.0 | | 17-Oct | | |
| 09-Apr | 19.8 | | 27-May | 25.0 | | 14-Jul | 25.0 | | 31-Aug | | | 18-Oct | | |
| 10-Apr | 19.8 | | 28-May | 25.0 | | 15-Jul | 25.0 | | 01-Sep | 25.0 | | 19-Oct | | |
| 11-Apr | 15.6 | | 29-May | 25.0 | | 16-Jul | 25.0 | | 02-Sep | | | 20-Oct | | |
| 12-Apr | 15.6 | | 30-May | 25.0 | | 17-Jul | 25.0 | | 03-Sep | 25.0 | | 21-Oct | | |
| 13-Apr | 15.6 | | 31-May | 25.0 | | 18-Jul | 25.0 | | 04-Sep | | | 22-Oct | | |
| 14-Apr | 15.6 | | 01-Jun | 25.0 | | 19-Jul | 26.0 | | 05-Sep | 25.0 | | 23-Oct | | |
| 15-Apr | 25.0 | | 02-Jun | 25.0 | | 20-Jul | 25.0 | | 06-Sep | | | 24-Oct | | |
| 16-Apr | 25.0 | | 03-Jun | 25.0 | | 21-Jul | 25.0 | | 07-Sep | 25.0 | | 25-Oct | | |
| 17-Apr | 25.0 | | 04-Jun | 25.0 | | 22-Jul | 25.0 | | 08-Sep | | | 26-Oct | | |
| 18-Apr | 25.0 | | 05-Jun | 25.0 | | 23-Jul | 26.0 | | 09-Sep | 25.0 | | 27-Oct | | |
| 19-Apr | 25.0 | | 06-Jun - | 25.0 | | 24-Jul | 25.0 | | 10-Sep | | | 28-Oct | | |
| 20-Apr | 25.0 | | 07-Jun | 25.0 | | 25-Jul | 25.0 | | 11-Sep | 25.0 | | 29-Oct | | |
| 21-Apr | 25.0 | | 08-Jun | 25.0 | | 26-Jul | 25.0 | | 12-Sep | | | 30-Oct | | |
| 22-Apr | 25.0 | | 09-Jun | 25.0 | | 27-Jul | 25.0 | | 13-Sep | | | 31-Oct | | |
| 23-Apr | 25.0 | | 10-Jun | 25.0 | | 28-Jul | 25.0 | | 14-Sep | | | 01-Nov | | |
| 24-Apr | 25.0 | | 11-Jun | 25.0 | | 29-Jul | | | 15-Sep | | | | | |
| 25-Apr | 25.0 | | 12-Jun | 25.0 | | 30-Jul | 25.0 | | 16-Sep | | | | | |
| 26-Apr | 25.0 | | 13-Jun | 25.0 | | 31-Jul | | | 17-Sep | | | | | |
| 27-Apr | 25.0 | | 14-Jun | 25.0 | | 01-Aug | 25.0 | | 18-Sep | | | | | |
| 28-Apr | 25.0 | | 15-Jun | 25.0 | | 02-Aug | | | 19-Sep | | | | | |
| 29-Apr | 25.0 | | 16-Jun | 25.0 | | 03-Aug | 25.0 | | 20-Sep | | | | | |
| 30-Apr | 25.0 | | 17-Jun | 25.0 | | 04-Aug | | | 21-Sep | | | | | |
| 01-May | 26.0 | | 18-Jun | 25.0 | | 05-Aug | 25.0 | | 22-Sep | | | | | |
| 02-May | 25.0 | | 19-Jun | 25.0 | | 06-Aug | | | 23-Sep | | | | | |
| 03-May | 26.0 | | 20-Jun | 25.0 | | 07-Aug | 25.0 | | 24-Sep | | | | | |
| 04-May | 25.0 | | 21-Jun | 25.0 | | 08-Aug | | | 25-Sep | | | | | |
| 05-May | 25.0 | | 22-Jun | 25.0 | | 09-Aug | 25.0 | | 26-Sep | | | | | |
| 06-May | 25.0 | | 23-Jun | 25.0 | | 10-Aug | | | 27-Sep | | | | | |
| 07-May | 25.0 | | W u n | 25.0 | | 11-Aug | 25.0 | | 28-Sep | | | | | |
| 08-May | 25.0 | | 25-Jun | 25.0 | | 12-Aug | | | 29-Sep | | | | | |
| 09-May | 25.0 | | 26-Jun | 25.0 | | 13-Aug | 25.0 | | 30-Sep | | | | | |
| 10-May | 25.0 | | 27-Jun | 25.0 | | 14-Aug | | | 01-Oct | | | | | |
| 11-May | 25.0 | | 28-Jun | 25.0 | | 15-Aug | 25.0 | | 02-Oct | | | | | |
| 12-May | 25.0 | | 29-Jun | 25.0 | | 16-Aug | | | 03-Oct | | | | | |
| 13-May | 25.0 | | 30-Jun | 25.0 | | 17-Aug | 25.0 | | 04-Oct | | | | | |
| 14-May | 25.0 | | 01-Jul | 25.0 | | 18-Aug | | | 05-Oct | | | | | |
| 15-May | 25.0 | | 02-Jul | 25.0 | | 19-Aug | 25.0 | | 06-Oct | | | | | |
| 16-May | 25.0 | | 03-Jul | 25.0 | | 20-Aug | | | 07-Oct | | | | | |
| 17-May | 25.0 | | 04-Jul | 25.0 | | 21-Aug | 25.0 | | 08-Oct | | | | | |
| 18-May | 25.0 | | 05-Jul | 25.0 | | 22-Aug | | | 09-Oct | | | | | |
| 19-May | 25.0 | | 06-Jul | 25.0 | | 23-Aug | 25.0 | | 10-Oct | | | | | |

| Yur Summary | ppm Starting | Addition |
|---|---|---|
| Minimum | 16.6 | 0.0 |
| Maximum | 26.0 | 0.0 |
| Avenge | 24.4 | 0 . 0 |

. **note:** Starting **August 16 sample examinations** look place **every** other **day.**

** **note:** Starting **September** 11 no anesthetics **were** added to the **re-circutation** tank due to **low numbers** of **fish.**



Bonneville Power Administration

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