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IN THE UNITED STATES DISTRICT COURT

FOR THE EASTERN DISTRICT OF CALIFORNIA

SAN LUIS & DELTA-MENDOTA WATER AUTHORITY and WESTLANDS WATER DISTRICT, Plaintiffs, vs. SALLY JEWELL, as Secretary of the U.S. Department of the Interior; U.S. DEPARTMENT OF THE INTERIOR; U.S. BUREAU OF RECLAMATION; MICHAEL L. CONNOR, as Commissioner, Bureau of Reclamation, U.S. Department of the Interior; and DAVID MURILLO, as Regional Director, Mid-Pacific Region, Bureau of Reclamation, U.S. Department of the Interior, Defendants	Case No.: 13-cv-01232-LJO-GSA **DECLARATION OF JOSHUA STRANGE**

I, JOSHUA S. STRANGE, Ph.D., declare as follows:

I. Qualifications

1. I am employed by Stillwater Sciences as a Senior Fisheries Biologist wherein I perform a wide-range of duties as part of a multidisciplinary team of environmental resource professionals. We serve a full spectrum of clientele, including a variety of governmental agencies, NGOs, tribes, hydropower companies, construction firms, and irrigation and water districts. My overall training is in aquatic ecology, which is widely inclusive, and I have specific expertise in fish biology, fish physiology and bioenergetics, fish migration and behavior, fish

disease ecology, fish population dynamics, plus instream flows, habitat use, and restoration. My academic degrees include a Bachelor of Science in Fisheries Biology from Humboldt State University, and a Ph.D. in Fisheries Biology from the School of Aquatic and Fisheries Sciences at the University of Washington. I have completed graduate level courses in hydrology and statistics, and taught a comprehensive fish ecology course at Humboldt State University. I have conducted extensive applied research in the Klamath–Trinity basin and have first-hand knowledge of its rivers and fishes, in particular the migration behavior, run-timing, and fish health dynamics of all races of Chinook and coho salmon. I previously worked both part and full time for the Yurok Tribe as a research biologist for ten years, and my Ph.D. dissertation research was funded in part by the National Science Foundation.

2. My dissertation research focused on adult Chinook salmon migration in the Klamath-Trinity basin and was initiated in 2002 prior to the Klamath River fish kill in September of that year. I was on the lower Klamath and Trinity rivers daily tracking adult Chinook salmon by boat, airplane, and road during the summer and fall of 2002 and was one of the initial responders on September 19th 2002 to the first reports of salmon mortality from the day before. I have personal, first-hand knowledge of the river conditions, monitoring data, and salmon behavior leading up the 2002 fish kill and in subsequent years thereafter. The peer-reviewed publications resulting from my dissertation research established the upper thermal limits to upstream migration in adult Chinook salmon, comprised the first large-scale published study of estuarine behavior of adult Chinook salmon, and revealed the migration patterns and migration timing of all major runs of adult Chinook salmon in the Klamath River basin starting from estuary entry until arrival to spawning grounds or hatcheries.

3. I have designed, led, and assisted with numerous studies of fish health and disease ecology for juvenile and adult salmonids in the Klamath-Trinity basin, including but not limited to annual monitoring of Ich and columnaris levels in adult fall run Chinook salmon in subsequent years after the 2002 Klamath River fish kill. As part of these studies I have conducted extensive work in the field and laboratory and have collaborated with fish pathogen experts and researchers at the U.S. Fish and Wildlife Service (USFWS) CA-NV Fish Health Center and the Department

of Microbiology at Oregon State University (OSU) among others. I have participated in the Klamath Fish Health Assessment Team (KFHAT) and have helped provide leadership for the core group of fish disease researchers in the Klamath-Trinity basin that organizes the annual Klamath Fish Health Conference. I have thoroughly researched the various scientific explanations for why and how the 2002 fish kill happened, and for why and how Ich outbreaks occur, including interviewing authors of relevant papers from other Ich fish kills of adult salmonids and controlled experimental studies on Ich. I was the author of the technical memorandum (Strange 2010a) that formed the basis of the original fall flow release recommendations to the Trinity River Restoration Programs (TRRP). The TRRP fall flows subgroup used this report to develop the first comprehensive fall flow release criteria to protect mixed-stock fall run Chinook salmon, and coho, in the lower Klamath River (in 2010). I have been an active participant in the TRRP's fall flows subgroup and associated coordination and management meetings. In light of my expertise on fish disease ecology and migration behavior, I have provided technical assistance and input on ESA consultations regarding listed Southern Oregon/Northern California coho ESU (includes Klamath and Trinity coho), Klamath hydro-relicensing, the Trinity Management Council, and the Secretarial Determination process for the Klamath River settlements. I have assisted collaborators at the USFWS, USGS, and OSU in developing fish disease modules and epidemiological models that interface with larger population models.

4. I have experience reviewing, developing, and conducting limiting factors analysis for salmonids using a variety of quantitative life-cycle models in the California Central Valley, California coast, Alaska, and the Klamath-Trinity basin for coho, Chinook salmon, and steelhead/rainbow trout to assess population level effects. These modeling efforts have often included instream flow analysis and water temperature models with a variety of management scenarios including climate change. I have monitored and analyzed water temperature data throughout the Klamath-Trinity basin.

5. I am actively involved in environmental review and research in the Sacramento-San Joaquin basin for a variety of fish species with an emphasis on the Sacramento-San Joaquin

Delta and listed species such as Delta smelt and winter and spring run Chinook salmon. I recently completed comprehensive environmental review of available information, study results, and management actions pertaining to the Delta as the lead author on fisheries resources of the Delta as part of the development of the CVP/SWP OCAP Remand EIS.

6. I am an active member of the American Fisheries Society and have organized conference sessions and been invited as a plenary speaker at other professional conferences. I provide peer-review for submitted manuscript for a variety of fisheries journals. I have published multiple articles in peer-reviewed fisheries journal and authored numerous technical reports and conference presentations. A partial statement of my qualifications is provided as Exhibit 1.

II. Scope of declaration

I intend to discuss the following in my declaration and testimony as needed: 1) The causative and contributing factors in the 2002 Klamath River fish kill including leading explanations and hypothesizes, the role of river flows, origin of water, water velocities, turn-over rates, water temperature, fish densities, fish size, run size, fish migration behavior, pathogen behavior, and timing and trajectory of lethal infections. 2) The rationale and evidence supporting the protective fall flow recommendations to reduce the likelihood of future Ich outbreaks, including the biology and pathology of Ich. The process of development of protective flow release recommendation by the TRRP fall flows subgroup from 2010 to 2014 and the impacts of past special and protective flow releases. 3) Protective flow recommendations for remainder of 2014, which considers the probable volumes of water required and available, current river and fish conditions, and the level of uncertainty versus confidence in this assessment and effectiveness of protective flows. Included in this is the risk and consequences of no protective flows releases, or a stoppage of releases, in 2014. 5) A review of the low likelihood of significant non-target negative biological impacts as identified by the TRRP fall flows subgroup.

III. The best available science on the 2002 Klamath River Fish Kill

1. I previously conducted a comprehensive and independent review and analysis of the 2002 Klamath River fish kill and of the primary pathogen responsible, a motile parasite commonly called Ich (*Ichthyophthirius multifiliis*). The results are represented in precise, technical detail in Strange 2010a but are summarized below in less technical language[1].

2. The key to understanding the 2002 fish kill in the lower Klamath River lies primarily in the biology of Ich (Figure 1). The biology of Ich is very well established because it is one of the paramount diseases of concern in the aquarium trade and in freshwater fish farming (typically called white spot disease), and as such is the subject of a very large body of studies and published literature. In recirculating water systems, such as used in the aquarium trade, aside from toxic chemicals the primary treatment is to regularly replace the tank water with clean water which reduces the number of parasites swimming around in the water to attack and infect skin tissues of fish in the system. In flow-through water systems such as often used in hatcheries and in freshwater fish farms, the primary treatment is to increase the amount of water flowing through the system. Increasing the flow rate in a flow-through system removes parasites by flushing them out of the system. Also, the high velocities help to disrupt the Ich parasites ability to encounter fish by swimming to them and attaching to their skin or gills (Ich typically kills by causing loss of gill function and asphyxiation). Ich parasites are small and have tiny hairs (cilia) that allow them to swim but only weakly in relation to water currents and the swimming ability of fish. This swimming stage of Ich is the infective stage and is how it “moves” from an infected fish to a non-infected fish and is the key life-stage to disrupt in order to reduce the risk of an Ich outbreak. A study in a controlled hatchery setting, found that increase water flow, and specifically water velocities and turnover rates, was the most effective means to prevent Ich

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[1] A secondary parasite, the bacterium *Flavobacterium columnare* (columnaris), often goes hand in hand with Ich, but in combination Ich comes first because it provides and opening in the skin for the bacteria to enter, also columnaris can infect fish without Ich being present from minor scratches and cuts that fish get during the course of their migration and surviving predators and fisheries. For this reason and others I will focus on Ich.

outbreak and reduce mortality rates (Bodensteiner et al. 2002). Importantly this occurred at all fish densities tested suggesting that fish densities are not a controlling factor in Ich outbreaks but rather a contributing factor. It's also important to note that while this study clearly demonstrated the paramount importance of flow for Ich outbreaks, and specifically the water velocities and turnover rates, it would be scientifically invalid to transfer the quantitative values measured in this controlled hatchery study to a river setting for another fish species. Rather measurements would have to be taken at variety of river flow conditions with and without outbreaks and the study would essentially have to be repeated in any new setting. In the case of the Klamath River, repeating such a study is neither readily possible nor desirable but we do know with certainty that the low flows in 2002 resulted in water velocities and turnover rates that were sufficiently low to allow for an explosive Ich outbreak. The need for Ich parasites to be mobile, but their limited ability to move in currents, helps explains why the unusually lows flows of 2002 caused conditions that allowed a rapid and highly lethal outbreak of Ich. This is also consistent with the observation that no Ich outbreaks have occurred in years with protective flows, including 2013. In other words, Ich outbreaks are "easy" to prevent with sufficient flows even with a lot of fish and less than ideal water quality or temperature.

3. Furthermore, the biology of Ich and the controlling vs. contributing factors for outbreaks can be understood further by examining evidence from all known outbreaks that have occurred in wild salmonids. Such outbreaks have occurred, and caused large scale mortality, in three locations: in tributaries to Babine Lake British Columbia (several years; Traxler et al. 1999), in a tributary to the Sacramento River (Butte Creek over two years; CDFG 2004), and in the lower Klamath River (one year only; Foott 2002; Guillen 2003; Belchik et al. 2004; Turek et al. 2004). Several important lines of evidence emerge from these fish kills: 1) the outbreaks in BC occurred at cold water temperatures that are ideal for salmon (13-15ºC), which proves that warm or stressful water temperatures are not required for serious Ich outbreaks; 2) all of these outbreaks occurred in rivers or reaches that had artificially reduced flows (again low water velocities and turnover rates); and 3) all of these outbreaks occurred with adult salmon that were

holding prior to spawning (i.e. not migrating) with the exception of fish in the Klamath River, which were just beginning their upstream migration.

4. This last point is notable for several reasons. Actively migrating salmon would be unlikely to suffer an Ich outbreak compared to fish that were holding in one location prior to spawning because migrating fish are actively swimming upstream and that would make it difficult for a free swimming Ich to encounter and attach to a fish. If there was localized hot spot of a higher concentration of Ich parasites, then migrating fish would be beyond such an area relatively quickly. My dissertation research provided the answer to the mystery of why an Ich outbreak occurred in migrating fish: Klamath fall and Trinity fall run have a rather unusual behavior of migrating rapidly out of the estuary and upstream a short distance, and then they essentially suspended their migration for 7 to 10 days and mill around in deep pools and slowly move from Blue Creek (river kilometer 26) to the confluence of Trinity River after which point they resume steady and comparatively rapid upstream migration to spawning grounds or hatcheries (Strange 2012). This is true for fish at the front of the run, in the middle, and at the tail and under a wide range of flow and water temperature conditions, in all years, and with or without pulsed flows and is not associated with the use of thermal refuges (Strange 2012) or temperatures in excess of their upper thermal limits to migration (Strange 2010b). In other words, the fish involved in the 2002 Klamath River Ich outbreak were essentially behaving more like fish holding in one location, which increases the risk of Ich outbreaks for these fish in any year when flows get too low. Finally, while fish density is not a controlling factor, the more fish that are present and the larger their body size, the more total Ich parasites that can be shed from infected fish to infect more fish (i.e. average fish body size multiplied by abundance equals total volume of fish in the run and available to be infected). Warm water temperature is not necessary for an Ich outbreak but it does speed up the rate at which Ich can complete its life cycle and spread from one fish to another (e.g., ~ 7 days at 20ºC; e.g., Dickerson and Dawe 1995). These factors result in the potential for rapid, explosive spread of Ich outbreaks (exponential growth rate curve) wherein a small initial number of infected fish can lead to the rapid infection of very large numbers of fish. Termed a “super-infection”, this appears to be what happened in

September of 2002. Based on the actual water temperatures involved, I calculated September 7th as the approximate date when the infection reached a critical mass. That was when fish kill initiated its exponential growth phase as allowed by the conditions at that time. Even though the first dead bodies were not observed until September 18th, by September 20th, thousands of dead salmon where washing up for miles and then just a few days after that all the fish that were going to die had died.

5. Again, this dynamic of the delay between the window of infectivity and actual death, and the rapidity of the exponential spread of infection during super-infectious conditions, illustrates why it is problematic to nearly impossible to simply monitor for signs of Ich infections and then have an emergency release of high flows that would successfully and reliably prevent substantial mortality from occurring. In addition, there is time needed to verify that Ich infections are actually at a level that warrants release of water, then time to get official approval to release the water, and then the two day travel time for the water to reach the lower Klamath River from either Lewiston Dam or Iron Gate Dam. At best it would likely take four days from the first observations of Ich infections by field biologists before the protective flows would arrive to the lower Klamath River. Four days would be more than enough time for the exponential spread of Ich to result in a lethal dose of Ich parasites to tens of thousands of adult salmon, such as occurred in 2002.

6. Monitoring of the fall Chinook salmon run for general fish health to determine the level of Ich infection year in and year out was initiated starting in 2003 and every year since including 2013 (McCovey and Strange 2011). If moderate levels of Ich infections were observed but no outbreak and mass mortality occurred in a given year, then it would indicate that there is high threshold of infectivity could be monitored and interrupted. However, the opposite was found and only few fish infected (as in 2 or 3) with Ich and at very low infection severity (i.e., barley any parasites) from 2003 through 2013 have been documented (McCovey and Strange 2011). This strongly suggests an “on-or-off” threshold relationship where low background levels of Ich always exist, likely from resident fish species (e.g., native suckers, speckled dace, or even juvenile salmon), but when conditions are not favorable for the spread of Ich, the threshold is

"off" and it's at non-detectable levels among adult salmon. Then as soon as conditions are favorable for the spread of Ich, the threshold turns "on" and can quickly turn into an explosive "super-infection".

7. This is why it is so important to prevent an outbreak of Ich before it gets started with proactive supplemental flows. Even so protocols were developed, by myself and the TRRP fall flows sub-group, for triggering an emergency release of a larger magnitude pulsed flow in order to quickly respond if an Ich outbreak was starting and to hopefully spare a percentage of fish that otherwise would have died. Based on the time delay for the arrival of water and the rate of spread of infection in 2002, however, that percentage would be minor compared to the percentage that would still perish. The need for an emergency release based on Ich detections was considered highly unlikely if the preventative actions were taken as recommended.

8. In summary, while there is still always some residual uncertainty involved fish disease ecology involving wild fish in a large rugged river, the biology of Ich is very well established as is the importance of flows in controlling Ich outbreaks.

IV. Protective Flow Recommendations Explained

1. Given the importance of flow, I conducted an analysis of summer and fall minimum flows in the lower Klamath River basin (at rkm 13), which showed that flows below 2,500 cfs occur infrequently and flows near or below the critically low level of 2,000 cfs have only occurred in 6 years: in combination with a larger than average run in 1988 and 2002 (Figure 2) and in combination with much smaller runs in 1991, 1992, 1994 and in a year of unknown run size in 1977 (Figures 2 and 3). Conversely, flows of approximately 2,500 cfs have occurred frequently since 1978 without any Ich outbreaks including as recently as 2001, 2007, 2008, and 2009. I consider flows in the lower Klamath River of 2,500 cfs to be the absolute minimum required for a reasonable level of confidence that an Ich outbreak is unlikely to occur with disease risk decreasing as flows increase beyond this minimum threshold. Flows below 2,500 cfs are likely to result in substantial risk of an Ich outbreak with risk increasing as flows further decrease. Flows at or below 2,000 cfs are likely to result in an unacceptably high level of risk of

an epizootic under all circumstances. Thus in combination, <u>if the goal is to prevent another Ich outbreak from occurring then flows should never be allowed to fall below 2,500 cfs during the peak of the fall Chinook salmon migration season regardless of run size or other factors</u>. It's worth noting that using a completely different technique, CDFW staff identified the same flow level as the threshold for substantial fish kill risk and a target for fish kill prevention flows (Turek et al. 2004).

2. During years with large projected run sizes, even higher base flows are recommended in order to maintain protective conditions as compared to years with smaller projected run sizes. <u>At low flows (i.e., > 2,500 cfs) even the lower potential fish densities associated with small run sizes could be sufficient to allow for the initiation of an Ich outbreak</u>. <u>Higher fish densities associated with larger runs may not result in higher risk of an Ich outbreak initiating, but larger numbers of fish increase the speed and inertia of the spread of an Ich outbreak due to the higher number of infectious theronts released at the completion of each successive Ich life cycle</u> (e.g. 10,000 infected fish can produced vastly more infectious theronts than 1,000 infected fish). Due to this dynamic, extra caution is needed during years when run sizes are projected to be large (defined as greater than or equal to the run size in 2002 of 170,000 fall Chinook salmon), but again that also does not mean that a predicted run-size of ~93,000 fall run Chinook salmon in 2014 reduces the need for the minimum protective flows of 2,500 cfs. The higher the flow the less the risk of an Ich outbreak, e.g. 3,200 cfs is more protective than 2,500 cfs. An additional 300 cfs is recommended as the <u>minimum</u> increase required to provide an adequate level of protection during years with larger run sizes. Thus the threshold for protective flow releases recommended increased from 2,500 cfs to 2,800 cfs during years with a projected run of ≥ 170,000 fall Chinook salmon, such as for 2012 and 2013. Again, in years with a projected run of < 170,000 fall Chinook salmon the threshold for protective flow releases has always been recommend at 2,500 cfs.

3. Fall Chinook salmon (Klamath stocks in particular) hold extensively and migrate slowly through the lower Klamath River below the confluence of the Trinity River as part of their apparent normative migration behavior strategy (Strange 2012). This makes them especially

vulnerable to *Ich* infection and mortality with pathogen transmission risk increasing as flows decrease. These relationships are consistent with the low flows that occurred before and during the 2002 fish kill as compared to the absence of Ich outbreaks in years with larger runs but higher flows (Guillen 2003; Belchik et al. 2004; Turek et al. 2004). There is only one prior year on record (1988) when flows were as low and runs were as high as 2002, but no Ich outbreak occurred. It is not known why an Ich outbreak did not occur during those years; it could indicate that the risk of an Ich kill is not 100% at such flows, or that continued ecological degradation (e.g., decreased water quality and increased secondary pathogens) in the Klamath River has increased the risk of Ich outbreaks at such flows. All other years with low flows equivalent or lower than 2002 also had much lower run sizes (e.g., 1994 the next largest run-size at approximately 80,000 fall Chinook salmon), and while there is uncertainty is terms of the importance of run-size, smaller run sizes are not considered to adequately compensate for low flows in terms of risk of an Ich outbreak.

4. Risk adverse decision making is especially critical given on-going cumulative ecological degradation, which could result in increasing disease risk in the future at a given flow, and could have contributed to a fish kill in 2002 but not in 1988 or even the drought years in the 1990s. Ecological degradation resulting in high pH, free ammonia, and microcyctins are especially toxic to salmonids and are a known stressor during the summer and fall in the Klamath River. These stressors are on top of secondary pathogens the infected adult salmon upon returning to the Klamath River, such as the myxosporidian diseases that kill juvenile salmonids every year, which appear to be getting incrementally worse over time and are exacerbated by drought conditions. For example, monitoring data for 2014 indicates that is likely the worst year on record for juvenile infection and mortality from these myxosporidian diseases. It’s notable that both microcystis and myxosporidians tend to impact the internal organs the most (including the liver), which are critical to immune function. Myxosporidians also enter the fish primarily though the gills, which is also the primary mode of entry of Ich and the most common site of columnaris infection.

V. <u>Protective flow recommendations for the remainder of 2014</u>

1. Due to the concern over the projected low flows in 2014 and an associated increase in stressors and secondary pathogens, I circulated a technical memorandum to relevant parties (e.g., KFHAT and the USBR) on August 15th 2014 updating the projected flow conditions and fish kill risk for 2014 (Strange 2014, Exhibit 2). In order to reduce the significant risk of another Ich outbreak and associated serious mortality levels to the incoming run of fall Chinook salmon in 2014, I reemphasized the recommendation that protective flows of no lower than 2,500 cfs be maintained in the lower Klamath River during the peak of fall Chinook salmon migration season (with flows measured at the USGS gauge KNK at river kilometer 13<u>). I concluded that a fish kill via an Ich outbreak was more likely than not for the 2014 fall Chinook salmon run without supplemental protective flows</u>. Given the water volume constraints facing the USBR due to drought, water management, and competing demands, the USBR convened a technical meeting on August 19th 2014 to determine what emergency options might be possible to protect fish health and avert an Ich outbreak using less volumes of water than a standard preventive release while also not waiting for an Ich outbreak to be detected to take action. I attended that meeting and recommended that water could be conserved by shortening the duration of water releases at the back end and instead creating a brief larger pulse flow at the front end that would arrive at the beginning of the peak fall Chinook migration season in order to flush the river of any Ich and other pathogens that had built up over the season, dilute toxic microcystis, and get any spring/summer run Chinook salmon lingering in the lower Klamath River such as at the Blue Creek thermal refuge to move upriver into the Trinity River.

2. The resulting flows schedule set by the USBR is deemed to provide a sufficient but minimum level of protection of migrating adult salmon from the risk on an Ich outbreak given current and expected conditions. This recommendation will require the least volume of

water possible to provide reasonable protection. The larger pulsed flow will serve to help flush out any Ich infective life-stages to provide a less infectious environment for the head of the fall run. The protective increased baseflows of 2,500 cfs will then be extended at least through September 14th to prevent any residual Ich from being able to initiate an outbreak and thereafter ramped down appropriately to un-augmented baseflows. The volume of water required to meet this recommendation will depend on the level of tributary inflows and accretions to the lower Klamath River during this time, but current projections indicate that it will most likely be 25,000 AF, which is less than was used during most all previous protective fall flow releases.

3. If the protective flows as initiated by the USBR are implemented, I anticipate, with a moderate to high level of confidence, that no Ich outbreak will be able to initiate and thus no additional emergency flow release will be needed either. <u>Failure to provide supplemental flows, or ending the flows prematurely, make it more probable than not that an adult fish kill will occur this year.</u>

4. This recommendation represents the best compromise available at this time given the current drought conditions, constraints on available water volumes and competing demands, but is likely to provide adequate protection from an Ich outbreak such as occurred in 2002. Stopping these protective flows now that they have started would be very risky and would results in an unacceptably high level of risk as fish will be drawn out of the estuary to begin there holding period in the lower Klamath River. This determination is based on my professional opinion with consideration for conditions in 2014 and the best available scientific information.

VI. Evaluation of potential negative biological consequences

1. The likelihood and consequences of potential negative biological consequences being realized from a protective fall flow release have been greatly exaggerated and erroneously evaluated based on the court documents and proceeding from 2013. I will briefly describe the

likelihood and consequences and the supporting logic and evidence therein below for fish species and can expound further if so desired by the court.

2. Potential impacts from and the degree of variation from the natural flow regime: 1) Flows of 2,500 cfs are below the median flow value for the lower Klamath River and with within the natural flow regime for that reach. Flows of ≥ 4,000 cfs occur regularly over the period of record for the lower Klamath River as well as do sudden increases and slower decreases associated with natural precipitation based freshets (Figure 2 bottom graph). The magnitude of protective flow releases during the summer and fall in the upper Trinity River are more rare but do have historic precedence as shorter duration flash floods and fall freshets, with fall freshets appearing to be occurring less frequently and not as early in recent decades, perhaps due to climate change. Thus the protective flow releases can be considered unnatural in the upper Trinity River depending on their duration and magnitude but are within the environmental variability experienced over the evolutionary history of the species involved. Also, the likelihood and consequences of any potential negative impacts should be evaluated on their specific information and logic as opposed to over-generalized assumptions. On the lower Trinity River, where I have direct observational experience for the 2003 and 2004 pulsed flows, ceremonial flows, and the 2012 and 2013 protective flow releases, such higher flows appeared to have benefits to water quality and temperature, a reduced nuisance algae (very notable in 2012 and 2013), improve rearing conditions and habitat area for juvenile salmonids including coho if present, and better migratory conditions for adults. A full accounting of the impacts of the increased fall flows, based on research and monitoring, may or would be predicted to actually show a net benefit and unintended positive consequences to a variety of fish species and life-stages in the Trinity and Klamath rivers. I would hypothesize that this would apply to increased summer base flows as well, partly demonstrated by the enhance productivity and survival for salmonids in spring fed river systems that maintain higher flows and colder water temperatures during the summer compared to non-spring fed rivers in the same region. Simply put, based on an extensive body of information and published literature, increased releases of cold, clean reservoir water is predicted to benefit cold-water species in the arid west wherein summer water

quality and habitat conditions are generally poor and limiting. Several authors studying climate change and the resiliency and management of salmon populations (i.e., Thompson et al. 2012) concluded that proactively using increased flow releases from large, cold water storage reservoirs during the warm season could greatly benefit salmon populations and are even predicted to be a necessity in some cases to prevent the extinction of species (ESUs) dependent on cold over-summering habitat such as spring run Chinook salmon and inland populations of coho salmon. This dynamic will certainly apply to the Trinity River given the most recent global warming projections and timelines, especially when combined with the serious disease risk for adult salmon and the annual disease mortality for juvenile salmon in the lower Klamath River with both diseases (from Ich for adults and malaria-like myxosporidians for juveniles) showing strong evidence for being less likely or less lethal at higher flows (i.e., fish health and survival positively correlated with flows). At the time of Trinity River flow study and ROD, predictions of global warming magnitudes and rate of change were tame compared to now, and the serious disease risk and problems of the lower Klamath River were not yet known. In combination, this leads to an obvious logical and emerging hypothesis that more water than is contained in ROD allocations in all but wet years will likely be needed meet TRRP goals and to restore Trinity River fisheries as mandated by Congress, and to ensure salmon population adult escapement levels that support public and Tribal trust harvestable surpluses. This hypothesis will continue to be evaluated as the data accumulates and scientific consensus continues to emerge but no discussion of summer and fall flows in relation to the ROD and impacts of increased flows would be complete without an objective understanding of these issues and emerging hypotheses.

3. Spring and fall Chinook salmon hybridization and red dewatering: highly unlikely and of minimal consequence because 1) the protective flow release dates through the 2nd (or even 3rd) week of September were designed to cover the peak migration season for Klamath and Trinity fall Chinook salmon in the lower Klamath River but also exclude the spawning season for spring Chinook salmon that begins the last week of September (fall Chinook generally spawn even later) based on extensive data of redd counts and dates, which means redd dewatering and egg incubation impacts from water temperature changes are also not a realistic concern. This was

evaluated in relation to 2013 protective release by both the USFWS and by North State Resources (as hired by Westlands) (note: the "up to 20% of spring Chinook salmon redds that could be dewatered" as quoted by Mr. Hanson in his 2013 declaration refers to the maximum possible for the very few spring Chinook salmon that spawn prior to the third week of September based on the maximum count for all years during that period, not the average and not for the entire population of spring Chinook, thus the "up to" qualifier); 2) hybridization is already occurring due to spring Chinook salmon being forced to spawn in fall Chinook salmon spawning reaches due to blocked access of their historic habitat by the Trinity dams (spatial overlap), thus any potential additional hybridization (highly unlikely) due to protective flow releases would have minimal consequence; 4) six years of extensive migration behavior data that I collected showed that fish did not migrate faster (or slower) as a result of pulsed flows and demonstrated run-specific migration behaviors that were consistent regardless of flow conditions and with and without fall pulsed flows such as occurred in 2003 and 2004, which is consistent with findings in other larger rivers as opposed to smaller river where flows become more important for allowing migration to be possible (Strange 2012); this data also showed that fish counting weirs on the Trinity River can extensively delay migrating adult salmon, and during some of these pulsed flows these weir had to be partially dismantled thereby decreasing fish delays at the weir and giving the erroneous perception of earlier arrival to spawning grounds due to pulsed flows (note: arrival to spawning grounds and actual spawn timing are not directly related). This data and my personal observations also show that sand bar closures at the mouth of the Klamath River are very rare and do not influence the run-timing of spring versus fall Chinook salmon or contribute to their spawning segregation (run-timing and spawn timing are largely under genetic control, and the Klamath River is too large to have estuarine sand bar closures like many smaller California rivers such as the Russian River).

4. Potential Pacific lamprey impacts: 1) the non-adult life-stages of Pacific lamprey, which rear in sandy and soft sediments, are highly mobile and when disturbed simply swim away to a new location. The observation by Stutsman 2005 of increased larval lamprey catches in rotary crew trap(s) shows increased mobility as a result of the pulsed flows but this report did not

contain evidence that this was harmful or that it constituted migration as opposed to relocation. One notable, exception is if they are lured into an area that they can't swim away (i.e., an channel bank depression) from that would later be dewatered causing stranding mortality; however, as long as ramping rates are appropriate during decreasing flows then stranding should not be an issue, and fall flows ramping rates will not be any different than are used for other parts of the ROD hydrograph during more critical windows of time such as the spring when young-of-the-year lamprey are newly emergent.

5. Potential impacts to Trinity River coho salmon: higher flows would likely increase the inundation of channel margins (depending on the actual water surface elevations involved), which increases the availability of the type of sheltered habitats of inundated vegetation and woody debris with cover from predators, excellent feeding stations, and refuge for any non-preferred higher velocities that juvenile coho salmon are especially noted for seeking out and using. This habitat/flow relationship would be expected to be similar to those for spring flows, for which rearing habitat is maximized at flows well above summer and fall baseflow levels. This dynamic of inundation of channel margins is common and widely known in-stream flow methodologies and habitat use studies, such as for coho in larger rivers (i.e., Beechie et al. 2005). Potential impacts to Sacramento and Delta fishes and cold-pool management: these potential impacts are primarily based on the temperature of releases from the Spring Creek inflow to Keswick from the Trinity diversion and reservoir refill probabilities and the extent of refill for 2015. The fact that much only 25,000 AF will be used will reduce the risk of speculative harm especially in relation Shasta reservoir levels.

VII. <u>Literature Cited</u>

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VIII. <u>Tables and Figures</u>

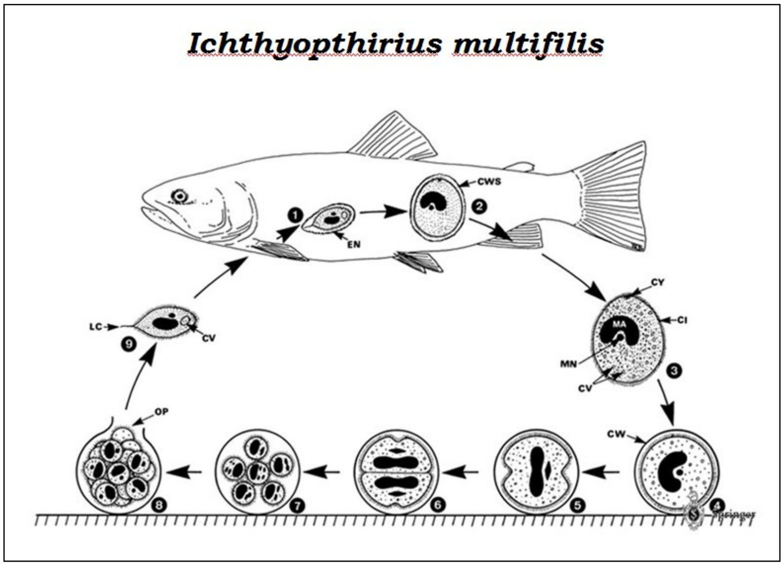

Figure 1. Life cycle of Ich showing the parasitic trophonts stages (#1 and 2), the mature ciliated trophont stage (#3) attaches to benthic substrate before dividing into tomites (#7 and 8), which are then released as the ciliated theront stage (#9) that must actively swim and find a suitable host within approximately 24 to 72 hours. Ich cannot tolerant salt or brackish water.

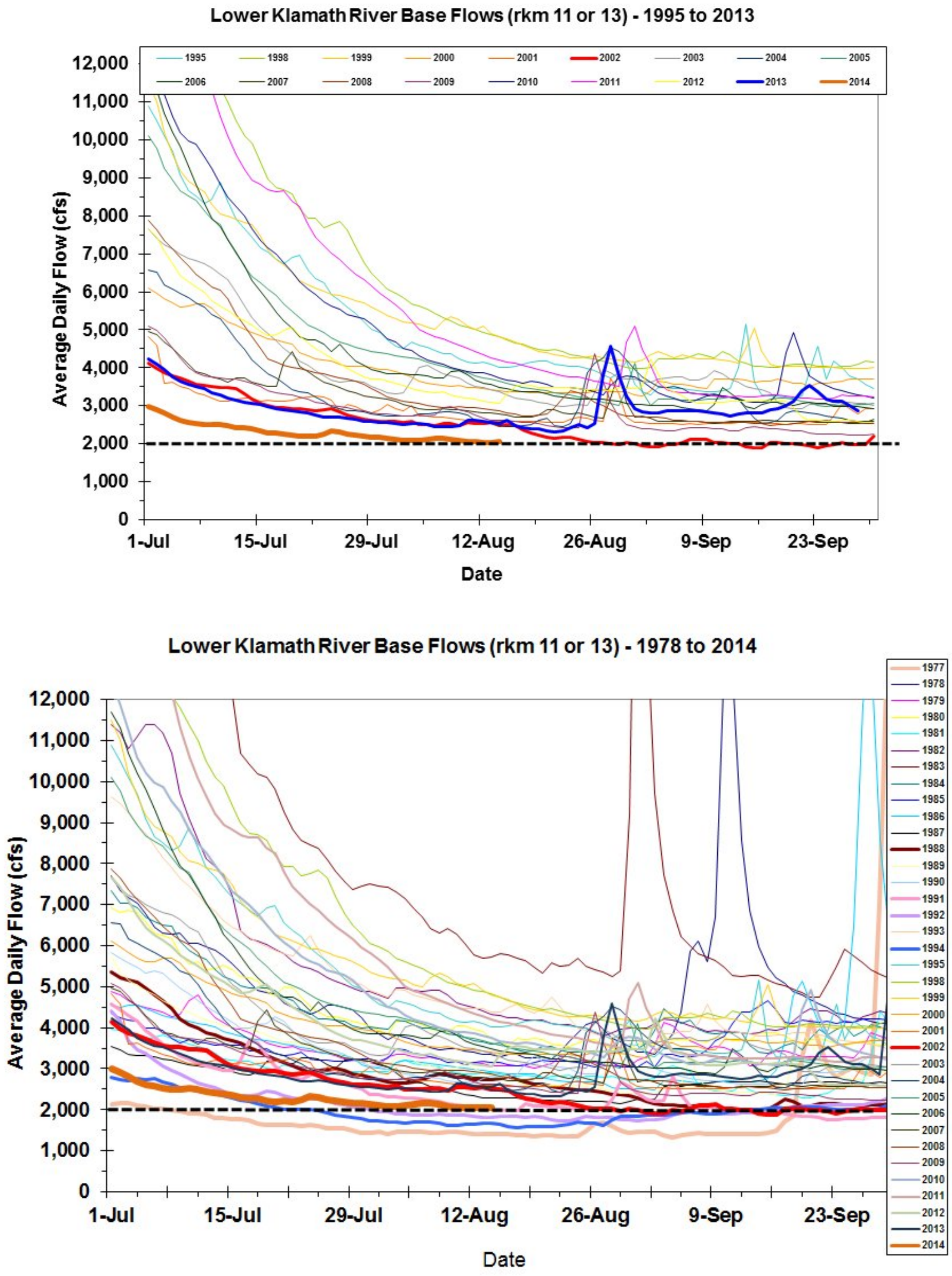

Figure 2. Available flow data for the lower Klamath River (rkm 11 or 13; USGS Gauge #11530500 KNK) from and from 1995 to 2014 (top graph) and 1977 to 2014 (bottom graph) showing 2002 fish kill flow of ~2,000 cfs flow. Mean monthly flows for August and September during the period of record are approximately 3,100 cfs.

I declare under penalty of perjury under the laws of the State of California and the United States that the foregoing is true and correct.

Executed this 26th day of August 2014, at Arcata, California.

/s/ Joshua Strange, Ph.D. (as authorized 8/26/2014)
Joshua Strange, Ph.D.