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Review of the Flow Proposal in the Russian River Draft Biological Assessment (2004)

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Prepared for
Sonoma County Community Development Agency

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EXECUTIVE SUMMARY

The U.S. Army Corps of Engineers (USACE), the Sonoma County Water Agency (SCWA), and the Mendocino County Russian River Flood Control and Water Conservation Improvement District (MCRRFCD) have proposed modifying flow releases now prescribed under State Water Resources Control Board Order D1610. The agencies have undertaken a Section 7 Consultation under the Endangered Species Act with NOAA to determine how proposed flow modifications (Flow Proposal) and other changes in operational and maintenance activities would affect listed salmonid species and their habitats in the mainstem Russian River. The Draft Russian River Biological Assessment (Draft BA)(Entrix 2004) was distributed in January 2004 with the final Assessment scheduled for completion in fall 2004.

The lower baseflows in the Flow Proposal would substantially change how residents perceive and utilize the mainstem Russian River in the summer. In order for many Russian River residents to willingly relinquish recreational opportunities and incur economic hardships, they must be convinced of the Flow Proposal's benefits. A formal request for scientific review of the Flow Proposal was initially developed by Friends of the Russian River (FORR) and presented to the Russian River Redevelopment Oversight Committee (RRROC) in response to residents' concerns. An independent science panel was commissioned by the Sonoma County Community Development Agency with approval by RRROC.

The Review Panel found that potentially critical impacts to Russian River salmon and steelhead populations have either not been assessed or have not been assessed adequately in the Draft BA. The Panel also identified elevated health risks to Russian River residents that could result if the Draft BA's Flow Proposal was implemented. Following is a summary of conclusions Panel members drew from their review:

1. The conclusion that the Flow Proposal will result in flow regimes that more closely mimic "natural" conditions is not justified in the Draft BA and supporting documents. The hydrologic analyses leading to the Flow Proposal need to be re-evaluated.
2. The Draft BA does not assess contemporary status of listed salmonid species under D1610 nor state goals for improvement.
3. Average and median monthly temperatures used in the habitat analysis are extremely poor descriptors of the thermal environment a fish experiences in the Russian River.
4. The Draft BA lacks clear water temperature thresholds.
5. The impact of releasing critically dry minimum baseflows on downstream migration is not adequately addressed in the Draft BA.
6. The habitat analysis in the Draft BA has too many biases and analytical weaknesses to warrant the conclusion that D1610 flows are harming salmon and steelhead populations in the mainstem Russian River.
7. Geomorphic changes from historical conditions are not considered in the habitat assessment.

8. The Draft BA does not provide adequate scientific justification for concluding that a closed Russian River estuary will improve salmonid rearing habitat.
9. The Draft BA does not consider alternative management strategies for the estuary.
10. A more detailed water quality model of conditions in the estuary/lagoon is needed given the substantial uncertainty in water quality consequences of low flow conditions.
11. The Flow Proposal would enhance the potential for increased water quality heterogeneity due to increased vertical thermal stratification. The water quality model used to predict changes under the Flow Proposal should be improved to include variations in temperature and dissolved oxygen in vertical profiles.
12. The Flow Proposal will increase the maximum water temperatures in lower reaches of the river and reduce the dissolved oxygen content.
13. The Draft BA does not address the potential that low flow conditions could enhance the methylation of mercury.
14. The Draft BA does not adequately address decreased dilution of pollution. Pollutants identified in the Russian River basin include nitrates, phosphates, pathogens, diazinon and metals including copper, chromium, mercury and zinc.
15. The impacts of the proposed changes in the operation schedule of the inflatable dam to endangered species, flooding, and geomorphology are not evaluated by the Draft BA.
16. The Draft BA does not explain the impact of the Flow Proposal on groundwater supplies.
17. The Draft BA does not adequately explain how the system will be operated to maintain precise flows.
18. Although the Flow Proposal is not likely to directly affect the channel shape, it could have a long term impact on channel geomorphology via changes in vegetation and bank stability.
19. The Draft BA does not address impacts of the Flow Proposal on *Ludwigia* populations.

An initial Natural Flow Proposal (Beach, 1999) for modifying current management of mainstem Russian River flows under D1610 was presented as an appealing, straightforward formula for recovering salmon and steelhead populations—more natural flows produce more salmon. However, the Draft BA's intentions, stated in the Executive Summary (p. xxxvii), do not match this simple formula. The Flow Proposal favored in the Draft BA does not require a return to natural flows nor is salmon and steelhead recovery the intended goal. Instead, the Draft BA strives for marginal salmon and steelhead habitat improvement over D1610. A closed Estuary is the driver for sharply reducing baseflows below Guerneville without a thorough analysis of whether or not the listed species will actually benefit from the closure. The last objective stated in the Executive Summary of the Draft BA is, "Develop additional water supply measures to meet future demand while protecting fish habitat." While this objective can clearly be considered a future benefit, although perhaps not by all residents, increasing the use of the mainstem Russian River as a water conveyance structure would seem to come at considerable cost. The Draft BA assures the public that salmon and steelhead are not put at risk, and may even benefit.

The Draft BA, however, does not take into account that Russian River anadromous salmonid populations exist at the environmentally harsh southern fringe of their species geographic ranges. Salmon populations rely on the few, but favorable, wet water years to offset increasingly common dry water years farther south along the Pacific coast. The few good years for these species are not being managed for, but rather eliminated or downgraded into normal water years. This salmon management strategy of providing minimal environmental conditions, unquestioned in the Draft BA, has failed throughout the Pacific Northwest. The system is altered in many ways, not just in its flow regime. As tributaries in the Russian River Basin endure more cumulative watershed effects and increased diversions, anadromous salmonid life history strategies demanding healthy tributaries may become less and less advantageous. Fewer viable life history strategies, increasingly focused on the mainstem, mean elevated risks for sustaining basin-wide populations. The mainstem channel will likely take on more responsibility in the future (e.g., supporting a Chinook run). The Flow Proposal dismisses the opportunity to manage the lower Russian River as an opportunity for supporting salmonid recovery rather than as a liability.

Does D1610 Work?

The Draft BA makes only a cursory assessment of D1610's impacts on the Basin's anadromous salmonids and arrives at no firm conclusion. Nevertheless D1610 is offered as the baseline from which to compare the Flow Proposal, without first adequately determining whether flow management under D1610 is causing today's fish populations to rise, decline, or remain steady. Marginal improvement over an existing management regimen is not setting the bar very high in the Draft BA.

Mainstem River Temperatures

Mainstem water temperatures have always challenged Russian River salmon and steelhead. As fish populations rely more and more on the mainstem, due to cumulative impacts on the tributaries and on the Estuary, small water temperature increases can have considerable impact. An effective analysis of water temperature effects along the mainstem Russian River must establish clear thresholds for assessing potential impacts from proposed baseflow changes and be capable of assessing small daily temperature changes. The Draft BA accomplishes neither. By using the median of the daily average temperatures within a given month over many years, the analysis is insensitive to daily and inter-monthly temperature change. Water temperature thresholds that consider not just magnitude but also duration, timing, and frequency of water temperatures are needed. The Draft BA's water temperature scoring system applied to the median monthly temperature does not establish these thermal thresholds. Biological temperature effects derived from the literature are misapplied in the temperature scoring system. After considerable effort, the panel could not conclude whether the Flow Proposal would produce benign water temperature effects (relative to the undetermined effects under

D1610) or significantly greater effects (including improvement) on salmon and steelhead in the Russian River mainstem. Near-term global warming, over the next 25 years, warrants adding 1.0 C to 1.5 C to baseline temperature values in the Draft BA's modeling and analyses.

Mainstem River Habitat

The habitat analysis included in the Draft BA (Appendix F) has too many biases and analytical weaknesses to warrant the conclusion that D1610 baseflows are harming salmon and steelhead populations in the mainstem Russian River. The Draft BA's Flow Proposal recommends reducing baseflows below those prescribed under D1610 in the Russian River below Healdsburg, even though field studies for quantifying mainstem habitat-baseflow relationships were limited to the mainstem channel above Cloverdale. Recent geomorphic changes to the mainstem channel were not considered in the habitat assessment. Physical criteria presented in the Draft BA for identifying juvenile salmon and steelhead habitats considered mainstem channel areas where water depths are greater than 3.3 ft as unsuitable for all juvenile life stages. In McBain & Trush, Inc.'s diving experience, the heads of pools (often much deeper than 3.3 ft) are typically prime rearing areas for juvenile Chinook and older steelhead juveniles. The habitat-baseflow analysis penalizes riffles at higher baseflows for not providing more than 10% Chinook fry and juvenile rearing habitat, even though riffles primarily provide fry and younger/smaller juvenile habitat along their margins where velocities are low and depths shallow. These margin habitats migrate up and down the riffles' banks as baseflow changes, and typically constitute only a minor percentage of the total riffle area. The only way to reduce velocities and depths (to meet the stated habitat criteria) throughout a riffle is to almost de-water it. Forcing fry and juvenile Chinook habitat criteria onto riffles produces a high bias favoring low baseflows.

The Draft BA offers no analysis of warmwater predator response to reduced baseflows, even though higher water temperatures and reduced flow velocities are highly likely to encourage predator populations. Water primrose (*Ludwigia hexapetala*) expansion in the lower mainstem, not considered in the Draft BA, could significantly impact diurnal dissolved oxygen thresholds for juvenile salmonids and other aquatic animals.

Temperature or Habitat Availability?

With the increasing role of the mainstem channel, which need is more immediate for recovering salmon and steelhead populations basinwide: lower mainstem water temperatures or more mainstem physical habitat? The Draft BA strategizes that the risk of higher water temperatures is acceptable in order to produce more habitat. Members of the science panel consider the low abundance of rearing anadromous salmonid juveniles in the Russian River mainstem is most likely driven by high water temperatures and predators, rather than by physical habitat availability. Unfortunately, the Draft BA's use of the median mean monthly water temperature provides no clear basis for quantitatively assessing potential thermal impacts to population recovery. While the amount of habitat also is important, the Draft BA does not provide the information necessary for assessing habitat abundance with respect to likely limiting factors (e.g., the amount of 2+ juvenile steelhead habitat) as a function of baseflows. Does water temperature outweigh physical habitat? The Draft BA cannot say.

Health Concerns

The lower Russian River mainstem receives considerable recreational use year-round, but especially in the summertime. Decreased dilution and consequently increased concentration of pollutants already identified in the Russian River basin (nitrates, phosphates, pathogens, diazinon, septic tank discharges, and metals including copper, chromium, mercury, and zinc) are likely under the Draft BA's Flow Proposal. Elevated bacterial pathogen concentrations already are common in the Russian River at Healdsburg Memorial Beach and at Monte Rio Beach. Bacterial concentrations in the summertime would likely increase due to decreased baseflows. *Ludwigia*, an aggressive aquatic weed that grows in dense mats along shorelines and into still or slow-flowing water of the Laguna de Santa Rosa and parts of the lower mainstem Russian River, harbors the species of mosquito that has been identified as a carrier of the West Nile Virus. Lower baseflows likely will encourage water *Ludwigia* expansion. As lower baseflows reduce dissolved oxygen and increase nutrient concentrations, they could enhance mercury mobilization into groundwater and ultimately increase mercury levels in fish and shellfish.

Downstream Water Supply

To the extent that the Russian River recharges the aquifer downstream of the diversion, increasing the volume of the diversion will lower the water table, potentially affecting water wells downstream of Mirabel Dam. The Draft BA does not address this issue.

The Estuary

Estuaries can play a major role in salmonid life histories, especially as a productive haven for juvenile salmon and steelhead from mid-summer through early-autumn. The Draft BA does not provide adequate scientific justification for concluding that a closed Russian River Estuary will significantly improve or degrade salmonid rearing habitat. The response of water quality subject to low baseflows in a closed or open estuary remains highly uncertain. A detailed water quality model for the estuary/lagoon is needed before alternative management strategies for the Estuary can be explored.

Recommendations

Following is a summary of major recommendations from the review:

1. Develop annual hydrographs (using daily average discharge) and thermographs (using hourly temperatures) for each water year and each protocol (e.g., natural flows, D1610, and the Flow Proposal) analyzed at selected locations along the mainstem Russian River. The locations employed in the Draft BA seem reasonable. Simply overlaying the thermographs for the three protocols in a Wet water year for the period of June 10 through June 25, for example, would be highly instructive for assessing juvenile Chinook salmon migrating downstream past Healdsburg. This assessment cannot currently be done from the Draft BA.

2. Establish explicit temperature thresholds for specific anadromous salmonid life stages within the context of each species life history strategies in the Russian River Basin in order to analyze and evaluate the roles of the estuary and mainstem in producing returning adult steelhead and salmon.

3. Develop a hydrologically-based water year classification system built on unregulated total annual runoff and that includes multiple categories of wet years as well as dry—for example, Extremely Wet, Wet, Above Normal, Below Normal, Dry, and Critically Dry.

4. Convert annual hydrographs to "annual habigraphs" by developing quantitative relationships between streamflow and habitat abundance of specific salmon and steelhead life stages over the full range of unregulated mainstem baseflows. Consider expert habitat mapping as an alternative to more conventional habitat quantification methodologies.

5. Conduct an analysis of potential warmwater predator population response to the proposed flow changes.

6. Improve the water quality model used for the Draft BA to include variations in temperature and dissolved oxygen in vertical profiles of pools. Consider encouraging pool stratification to maintain areas of cooler temperatures and higher dissolved oxygen.

7. Analyze the relative effects on water quality of surface water and groundwater discharges to the Russian River. Groundwater contributions could possibly be detected on the basis of temperature, pH, dissolved O_2 or CO_2, or total dissolved salts (e.g., electrical conductivity). Effects of the Flow Proposal on water gaining (aquifer discharge) or losing (aquifer recharge) regimes could in turn affect water quality in the river and in water supply wells near the river.

8. Consider potential impacts to water supply systems below Mirabel Dam through modeling or other methods.

9. Monitor mercury levels in fish or shellfish in the river and estuary. Studies of changes in mercury in fish due to changes in flow regime may bear on flow effects on other chemical pollutants. Monitoring for bacteria should also be conducted. Water quality monitoring should include groundwater from wells near the river.

10. Examine water quality below the inflatable dam during the period after its emplacement as an analog of low flow conditions. In particular, how much does temperature increase? Does local biological activity indicate an increase in water quality heterogeneity? Do pools of oxygen-depleted water develop? Does temperature stratification of water develop in deep pools?

11. Develop a detailed water quality model for the Estuary that considers all pollutants currently included on the EPA's 303(d) listing and on the watch list.

12. Analyze the impacts of the proposed March-January operation of the inflatable dam at Mirabel on upstream flooding and sediment deposition.

13. Map current *Ludwigia* populations. Determine where the proposed low flow regime will result in conditions that encourage the spread of *Ludwigia.*

1 INTRODUCTION

The U.S. Army Corps of Engineers (USACE), the Sonoma County Water Agency (SCWA), and the Mendocino County Russian River Flood Control and Water Conservation Improvement District (MCRRFCD) propose modifications to operation and maintenance activities now prescribed under SWRCB Decision 1610. The agencies have undertaken a Section 7 Consultation under the Endangered Species Act with NOAA to determine whether their proposed modifications would affect listed salmonid species and their habitats in the mainstem Russian River, positively and/or negatively. The Draft Russian River Biological Assessment (Draft BA)(Entrix 2004) was distributed on January 16, 2004. The final Biological Assessment is scheduled for completion in the fall of 2004.

Prunuske Chatham, Inc. (PCI) was retained by the Sonoma County Community Development Agency (SCCDA) to coordinate an independent review of the flow management part of the proposed project. The Draft BA states that under the Flow Proposal, "releases from Warm Springs and Coyote Valley dams would be modified to improve rearing and migration conditions for salmonids in the Russian River, Dry Creek, and the Estuary." Specific objectives of the Flow Proposal identified in the Draft BA are to:

- Reduce velocities in Dry Creek and the upper Russian River in summer.
- Conserve the cold water pool in Lake Mendocino through the late summer.
- Enable SCWA to meet future transmission system demands arising from approved developments in SCWA's water contractor's service areas.
- Allow the sandbar at the mouth of the Russian River to be closed in the summer.

The proposal for a scientific review of the Flow Proposal was initially developed by Friends of the Russian River (FORR) and presented to the Russian River Redevelopment Oversight Committee (RRROC) in response to residents' concerns. The full proposal consisted of two parts: (1) a technical review of the flow proposal with an analysis of economic impacts and (2) a monitoring program based on the technical review. This report contains the findings of the technical review. The economic analysis is being conducted independently of the scientific review. As changes in the Russian River which affect its actual or perceived fish habitat, cleanliness, odor or aesthetics may be of significant economic concern to the communities of the Lower Russian River, an economic analysis of the proposed project is vital for a thorough assessment. Water quality monitoring will be undertaken by FORR beginning July 2004.

After a summary of the process followed by the review panel, the review is organized by general topic. Section 4 addresses issues directly relating to Russian River salmon and steelhead populations and habitat. Section 5 addresses water quality issues for both listed species and humans. Hydrologic and geomorphic issues are covered in Section 6, impacts on *Ludwigia* populations in Section 7. Although the review focused on impacts to listed fish and their habitats addressed in the Draft BA, panel members also identified issues that could affect human health or broader environmental quality and should be considered under the California Environmental Quality Act (CEQA) and the National Environmental Protection Act (NEPA) should the project proceed.

2 THE REVIEW PROCESS

The review was conducted by a five-member panel. Two of the members, Fred Euphrat, Ph.D. and Dan Wickham, Ph.D., donated their time as Board members of FORR. Their primary role was to participate in a one-day meeting of the panel, act in an advisory capacity, and provide local information as needed. The three remaining panel members, Daniel Malmon, Ph.D.; William Murphy, Ph.D.; and Bill Trush, Ph.D. were selected based on qualifications and the following independence criteria:

- They were not under contract with the Sonoma County Water Agency or had been under contract with them on projects relating to the Russian River at any time within the past three years.
- They had not participated within the last three years in any advocacy effort in support or opposition to policies, programs or projects of the Sonoma County Water Agency or any other agency or office of the County of Sonoma that concern the environmental condition of the Russian River watershed.
- With the exception of the panel members provided by FORR, they were not currently nor had been within the past three years under contract with or served on the board of FORR.

Final selection was approved by an Advisory Committee consisting of Brent Smith, SCCDA; Tom Lynch and Bruce Maher, both RRROC member; Steve Fogle, Executive Director of the Russian River Chamber of Commerce; and Don McEnhill, Russian Riverkeeper.

On January 30, the Review Panel met in Forestville for a one-day meeting and tour of the watershed. The Panel members agreed to focus their review on the following two questions:

1. Will the proposed flow regime increase the number of returning adult steelhead and salmon?
2. What are the risks to people and to fish from the flow proposal?

Members also agreed on a schedule to complete the review by March 30. At the February 2004 meeting of the Section 7 Public Policy Facilitating Committee, the completion date of the final BA was extended to September 2004, which allowed the Panel more time. SCWA staff members were extremely helpful in tracking down and procuring copies of reports.

3 SALMON AND STEELHEAD IN THE RUSSIAN RIVER BASIN

Salmon and steelhead have evolved complex, multiple life-history strategies to survive changing environmental conditions. As context to evaluating further changes in diverting and manipulating flows, an examination of salmon and steelhead life-history strategies in the mainstem Russian River and its tributaries is not only interesting storytelling but also a necessary first step in evaluating the Draft BA.

3.1 Chinook Salmon

The long, narrow shape of the Russian River Basin with its few large tributaries and many small tributaries forced Chinook salmon to rely heavily on the mainstem for spawning, egg incubation, and juvenile rearing. Because Chinook salmon are not as acrobatic as steelhead or coho salmon, they often do not utilize small streams. In late spring and summer, the mainstem channel, once favorable habitat to fry and juveniles, shifted to becoming a liability. Water temperatures rose rapidly and baseflows ebbed sharply. Pools became isolated by flow trickling through the connecting riffles or flowing subsurface. By necessity, the Chinook population had to complete the freshwater phase of its life cycle before the mainstem Russian River channel became too hostile.

Adult salmon migrated into the Russian River once the sandbar broke and made the Estuary accessible some time between late summer and early winter. The first few high flow events in the fall, typically small by the standard of winter floods, provided the impetus for fish to ratchet their way into the upper mainstem and bigger tributaries. These early flow events also prevented high densities of adults in lower mainstem pools, thereby greatly reducing the risk of transmitting diseases. Soon after migration, spawning occurred from November through January. Chinook fry emerged February through March when the river's flow was still cold.

As spring runoff from the landscape subsided, and mainstem streamflows dropped rapidly, water temperatures heated rapidly downstream, just as they do today. Favorable water temperatures for rearing juvenile Chinook salmon lasted longer in the upper mainstem Russian River than in the lower mainstem. Chinook fry taking advantage of favorable temperatures upstream would eventually face the necessity of leaving before water temperatures downstream became too stressful.

Chinook populations probably adopted several life-history strategies. Lower mainstem temperatures may have been unfavorable but not lethal in a healthy mainstem Russian River. Redwoods towering 250 feet (ft) to 300 ft may have provided significant shade in a then narrower mainstem channel. Fog likely extended farther inland fostered by the redwood forests. Oxbow lakes and complex meandering patterns provided overhangs, eddies and other complexities for Chinook and all fish—structure that has since been simplified by logging, agriculture, flood control and other development.

Chinook juveniles, pre-smolts, and smolts could have migrated through the lower mainstem and directly into the Pacific Ocean by early- to mid-summer while experiencing a period of no net-growth or slim growth, but at least prevailing. Alternatively, they may have migrated quickly through the lower mainstem and encountered a productive closed estuary, which offered them growth for several months, before entering the Pacific Ocean. The periodicity charts show that juvenile Chinook generally completed their outmigration to the Pacific Ocean or the estuary by the end of June. In wetter years, juvenile Chinook would stay longer in the upper mainstem and tributaries, thereby adding to their size before embarking on their seaward migration. In drier water years, the role of the estuary probably gained importance. Each Chinook life-history strategy, therefore, could have been the best strategy under different water year conditions.

3.2 Steelhead

Chinook salmon had the advantage of not requiring an over-summer stay in the mainstem or tributaries. The freshwater phase of their life cycle before entering the Pacific Ocean required roughly half a year. Steelhead did not have this luxury. Generally, a juvenile steelhead must remain two or more years before entering the Pacific Ocean as a smolt—experiencing at least two summers in the river basin. Steelhead, therefore, required life history strategies that coped with the precipitous drop in summer flow and the escalation of warm water temperature, yet still allowed them to grow to a size that as a smolt entering the Pacific Ocean gave them a reasonable chance of returning as an adult two or several years later.

Adult steelhead are much more adept at migrating into small tributaries and spawning in small gravel pockets than are Chinook salmon. Steelhead adults tended to enter the Russian River Estuary beginning mid-December and continuing through mid-April, when the likelihood of experiencing high flow assisted their spawning migration into the Basin's mountainous headwaters. Steelhead tended to spawn in the tributaries and not the mainstem. These headwater environments stayed much cooler in summer than the mainstem, though the surface flows typically became so low that many small tributaries would go dry. Some juveniles remained in headwater environments for two or three years (or longer), while redistributing themselves within the tributaries, then migrated during springtime to the mainstem and down to the Pacific Ocean. Others remained in prime headwater locations, matured into trout, and reproduced in freshwater.

Still other steelhead juveniles left the headwater tributaries as yearlings (0+) or one-year olds (1+), and attempted to reside over the summer in bigger tributaries or the mainstem river. This strategy was risky to each individual, but offered big rewards. Productivity in the large tributaries and mainstem was high; the opportunity to grow quickly and large was countered by the great risk of being eaten and exposure to lethal or sub-lethal water temperatures. Deep pools, only partially mixed by very low summer baseflows, encouraged thermal stratification; temperatures at the pool bottoms would have been favorable when the temperature in shallow runs and riffles would have been highly stressful or even lethal. Chronic stress often led to fungal and other diseases that killed outright or allowed predators an easier chase. The primary function of most 0+ and 1+

juveniles in the mainstem channel, those that chose or were forced into this life history strategy, was often as prey for the much fewer 2+ and 3+ juveniles. Juveniles that over-summered in the mainstem generally migrated to the Estuary or Pacific Ocean the following February through mid-May, again when water temperatures were cool and baseflows relatively high.

3.3 Coho Salmon

Coho salmon, the "in-between" species, is less acrobatic than steelhead, but more so than Chinook salmon. Juvenile coho salmon require generally only a little more than one year of freshwater rearing. Adult coho tend to enter rivers slightly later than Chinook adults but earlier than most adult steelhead. Consequently, the life-history strategies of Chinook salmon or steelhead would make an imperfect fit for coho salmon populations.

Coho salmon tend not to utilize the mainstem for spawning or juvenile rearing. They have evolved to favor moderately small to large tributaries, especially those that meander through the extensive floodplain and lower terraces of the Russian River and particularly those close to the Pacific Ocean. Unfortunately, the coho's preferred tributaries were centers of early and sustained human settlement and have been severely degraded. These tributaries are typically of low gradient, sinuous, often incised, and almost always dominated by the accumulation of large wood that forms deep and complex pools. The coho's one over-summer rearing is spent in these pools, with the pre-smolts and smolts migrating to the mainstem the following February through May, followed by migration to the Pacific Ocean. Juvenile coho salmon do not seem to be the lovers of estuaries as are juvenile Chinook salmon and steelhead.

3.4 All Three Together

A fat large smolt generally has the best chance of surviving the ocean and returning to the Russian River as a spawning adult. For steelhead smolts, seemingly minor increments in size can have major consequences on ocean survival. As juveniles and pre-smolts drift down the mainstem in spring and early summer, they have the opportunity to grow. A temporary stay in the estuary for a month, or several, also is an opportunity to grow. The importance of the lower Basin to grow fish, in its estuary and through its lower mainstem, is under-valued. Often biologists want to minimize time spent in the mainstem. This may (a BIG may) be desired for river mainstems that have been highly simplified geomorphically (i.e., bank armoring destroying habitat complexity) with highly regulated flows. Although the lower Russian River has its share of simplification and regulation, it should be managed as an opportunity rather than as a liability.

As tributaries in the Russian River Basin endure more degradation, anadromous salmonid life history strategies demanding healthy tributaries will become less and less advantageous. Fewer viable life history strategies mean elevated risks for sustaining populations. This will have direct consequence on how the Russian River should be managed in the future and strongly calls into question the efficacy of releasing natural flows. The mainstem channel must take-on more responsibility for sustaining the Basin's populations.

3.5 Natural flows and salmon recovery?

Could the return of natural flows, as opposed to flow regulation under D1610, recover salmon and steelhead populations in the Russian River Basin? This seemed to be the hypothesis, at least as perceived and reported by the public. The Russian River Biological Assessment Flow Alternatives, Addendum to "Alternatives: Evaluation of Management Actions (ENTRIX, 2003) states, "*The objective of the NFP [Natural Flow Proposal] is to mimic as closely as possible the flow regime that would be present in the mainstem Russian River under unregulated conditions, while meeting the requirements of water rights in the Russian River that are senior to those associated with the CVD Project* (p. 2-8 Section 2.3)." An editorial in the Santa Rosa Press Democrat (2/8/03, River Unplugged: What's good for the fish may be bad for people) reports: "*Mimicking the natural flow will help kill non-native predators and create a healthier habitat for young coho and steelhead*." Another article in the Santa Rosa Press Democrat (by Spencer Soper, 1/22/04, titled Outrage over Russian River Report) gives a more in-depth description: "*Reducing flows would return the river to conditions that more closely resemble its natural state before reservoirs were built upstream and water released during dry months to meet urban and agricultural demands. The low-flow plan aims to address concerns from federal regulators that the Water Agency's existing operations pose a threat to coho and chinook salmon and steelhead trout because the river flows too swiftly for them to effectively feed and thrive*."

However, the Executive Summary of the Draft Biological Assessment (January 16, 2004) simply lists (p. xxxvii) modifying flow releases as an objective with no mention of a return to natural flows or of increasing salmon and steelhead populations:

- *Modify flow releases from Warm Springs Dam and Coyote Valley Dam (after the State Water Resources Control Board (SWRCB) modifies SCWA's water-right permits).*
- *Lower instream flows during the summer in Russian River and in Dry Creek below those required under SWRCB Decision 1610 (D1610) to improve summer habitat for listed fish species.*
- *Eliminate artificial breaching of the sandbar at the river mouth during the summer to improve summer rearing habitat.*
- *Develop additional water supply measures to meet future demand while protecting fish habitat.*

More salmon habitat presumably improves salmon population size, provided the right habitat is increased. At least this is what the Draft BA seems to endorse. The Draft BA sets its own bar of achievement very low with respect to habitat: improve habitat conditions over those created under D1610. As reviewers, one key question immediately surfaced. How are the Russian River's salmon and steelhead populations faring under the present D1610? If this is to be the standard for comparing a preferred flow allocation proposal, then a determination must have been made as to how well D1610 performs. Marginal improvements over a poorly performing D1610 protocol would likely not reverse or arrest failing salmon and steelhead populations. The minimum goal should be habitat improvement necessary to begin the recovery process.

But what if we don't know the status of the populations, knowing only that at one time salmon and steelhead were considerably more abundant than today? The Draft BA offers no predicted future status of salmon populations under D1610. Are they holding steady, declining, or increasing? Singling out the effects of flow regulation from other cumulative impacts would make prediction especially challenging, although not impossible. In confronting this uncertainty, the recommended strategy for altering and diverting flows from the Russian River should have a conservative basis aimed at minimizing risk and encouraging recovery. The Draft BA should have adopted fundamental strategies for doing this, but did not. Instead an opposite approach has been adopted. Predicted temperature increases are simply explained away by labeling them as minor and of no significance. Our concern with the overall tenor of the Draft BA includes:

First, using environmental conditions created by D1610 as a standard for comparing other flow proposals is irresponsible. Procedurally this may be how baselines are selected in environmental assessments. However, our responsibility as reviewers is to inform the public of likely environmental ramifications. The Draft BA should have attempted to establish a conservative management system for flow regulation that would be expected to achieve recovery, modeled annual hydrographs and thermographs, and then applied thresholds and flow-habitat relationships for a quantitative evaluation. D1610 and other flow proposals could have been evaluated relative to this conservative management system in a similar fashion (modeling hydrographs and thermographs and applying thresholds).

Second, the risk already to listed fish species is already high. Russian River anadromous salmonid populations exist at the environmentally harsh southern fringe of their geographic range. Salmon populations rely on the few but favorable Wet water years to offset increasingly common Dry water years farther south along the Pacific coast. The importance, or even appropriateness, of one life history strategy over another in a given year can be pre-determined by the type of water year. Wet water years are fundamentally different from Dry water years. If the mainstem is managed to flow as if there is an ongoing Dry year while unregulated tributaries are responding to a true Wet year, must steelhead develop a new life history strategy? Synchronizing dam releases to compliment natural hydrologic conditions throughout the Basin seems an obvious management goal. Yet the Draft BA takes the present system of classifying water year type in D1610 as a given for proposed allocation protocols, when this water year classification system should have been re-evaluated. Presently water years are classified as Normal, Dry, and Critically Dry. What happened to Above Normal, Wet, and Extremely Wet? The few good years for these species at the southern fringe of their ranges are not being managed for, but rather eliminated. By eliminating good years, management shifts more of the burden of risk onto the Russian River salmon and steelhead populations.

Third, flow management should accommodate the changing role of the Russian River mainstem for supporting the Basin's Chinook salmon and steelhead populations. The mainstem will likely become increasing responsible for producing the Basin's 2+ and older juvenile steelhead that exceed 160 mm long and have the greatest likelihood of returning as adults. This life-stage requires faster and deeper water than habitat for younger juvenile steelhead. Requiring the mainstem to assume new (or greater) responsibilities generates unique challenges. For example, cold hypolimnial dam releases in the summer below both dams create highly favorable thermal environments for rearing juvenile Chinook. However, the time comes when juvenile Chinook must head to sea. If the new 'headwaters' (i.e., immediately below the dams) are unseasonably cool, juveniles may delay departure. Downstream water temperatures rapidly increase especially under low baseflows, such that the lower-middle and lower mainstem water temperatures can exceed stressful thresholds before juveniles begin their migration downstream. 'Routing' Chinook juvenile and smolt outmigrants must be explicitly considered in evaluating both dam releases particularly from mid-May to the end of June.

Fourth, global warming warrants adding 1.5ºC to baseline temperature values in the modeling and analyses.

4 SPECIFIC COMMENTS FROM REVIEW OF FISH HABITAT AND SURVIVAL ISSUES

4.1 The conclusion that the Flow Proposal will result in flow regimes that more closely mimic "natural" conditions is not demonstrated in the Draft BA.

Major changes to recommending natural flows in the upper/middle mainstem from April through September occurred as the Natural Flow Proposal (Beach, 1999) morphed into the Draft BA's Flow Proposal. D1610 stipulates 185 cfs (cubic feet per second) minimum baseflows April through August and 150 cfs for September, while the Natural Flow Proposal (NFP) had a 185 cfs minimum baseflow April through May and natural flows as minimum baseflows for June through September. Subsequently in the Addendum (ENTRIX, 2003 Table B-2), the natural flow provision was eliminated (changed to a minimum baseflow of 50 cfs from June through September) and the April through May baseflows were reduced to 100 cfs. Attempts to trace the scientific justification behind these changes, and other changes in Addendum Table B-2, in the Draft BA met with little success.

Use of the term "natural" has been very misleading. The Natural Flow Proposal (NFP) is not natural, nor does the Draft Biological Assessment ever explicitly claim it is (p.2-8 Section 2.3). The Proposed Water Rights Permit Terms (June 13, 2003) for the Enhanced Natural Flow Proposal (ENFP) requires summer flows higher than natural summer minimum baseflows and winter/spring flows lower than natural winter/spring minimum baseflows. Only during the transition from spring to summer does the ENFP approximate natural minimum baseflows. The duration of this annual window, when regulated flows approximate natural minimum baseflows, will likely be shortened if the NFP or ENFP is implemented (especially for wetter years) as opposed to contemporary D1610 flow regulation, and will clearly be further impacted by the Proposed Water Rights Permit terms (June 13, 2003). A recommended 50 cfs mainstem flow between the East Fork Russian River confluence and the Dry Creek confluence under the ENFP (June 1 through October 30) receives the same transitional poor habitat score (from 3 to 2) for juvenile steelhead rearing habitat as do elevated baseflows greater than 275 cfs (Addendum, Table B-2, p. B-3) under D1610.

Although misleading, there are elements of a natural flow policy in the evolution of flow allocation protocols. The existing protocol, State Water Resources Control Board D1610 has no natural flow provisions. Table 1 lists several allocation protocols offered along the evolutionary pathway, beginning with D1610 and ending with the Draft BA's Flow Proposal.

Table 1. Evolution of Minimum Baseflow (Q_{min}) Prescriptions Under Normal Water Supply Conditions.

State Water Resources Control Board Decision 1610

Healdsburg

Q_{min} = 150 cfs January through March
Q_{min} = 185 cfs April and May
Q_{min} = 185 cfs June through August
Q_{min} = 150 cfs September through December

Guerneville

Q_{min} = 125 cfs Year Round

Natural Flow Proposal 1999

Healdsburg

Q_{min} = 150 cfs January through March
Q_{min} = 185 cfs April and May
Q_{min} = natural flow June through September (i.e., the unimpaired flow must be maintained regardless of its magnitude)
Q_{min} = 150 cfs October through December

Guerneville

Q_{min} = 125 cfs January through March
Q_{min} = 150 cfs April and May
Q_{min} = natural flow June through September (i.e., the unimpaired flow must be maintained regardless of its magnitude)
Q_{min} = 125 cfs October through December

Natural Flow Proposal February 3, 2003 (p.2-9 Table 2-1)

Healdsburg

Q_{min} = 150 cfs January through March
Q_{min} = 185 cfs April and May

Q_{min} = natural flow June through October (i.e., the unimpaired flow must be maintained regardless of its magnitude) up to 150 cfs
Q_{min} = 150 cfs October through December

Guerneville

Q_{min} = 125 cfs January through March
Q_{min} = 150 cfs April and May
Q_{min} = natural flow June through October (i.e., the unimpaired flow must be maintained regardless of its magnitude) up to 125 cfs
Q_{min} = 125 cfs November through December

Proposed Water Rights Permit Terms June 13, 2003

Healdsburg

Q_{min} = 150 cfs January through March
Q_{min} = 100 cfs April and May
Q_{min} = 50 cfs June through October
Q_{min} = 150 cfs October through December

Guerneville

Q_{min} = 125 cfs January through March
Q_{min} = 150 cfs April and May
Q_{min} = 35 cfs up to 125 cfs with natural flow within this interval June through September
Q_{min} = 125 cfs October through December

Flow Proposal January 16, 2004 (p.4-21 Table 4-2 and p.4-22 Table 4-3)

Healdsburg

Q_{min} = 150 cfs January through March
Q_{min} = 100 cfs April and May
Q_{min} = 50 cfs June through October
Q_{min} = 150/75 cfs November through December

Guerneville

Q_{min} = 125 cfs January through March
Q_{min} = 150 cfs April and May
Q_{min} = 35 cfs up to 125 cfs with natural flow within this interval June through September (though baseflows can be less than 35 cfs when managing the Estuary)
Q_{min} = 125 cfs October through December

Our goal here is not to fully describe each proposed protocol; the reader can do this using references cited in our review. However, it would be no easy task. Rather our purpose is to show that as the Natural Flow Proposal aged, it became even less natural (Addendum Table B-2). Did the recommended Flow Proposal in the Draft BA have the modifier "Natural" removed for this reason?

4.2 The Draft BA does not assess if salmon and steelhead populations are currently improving, still declining, or staying about the same under D1610.

Not only is natural flow missing from the stated objectives, but an increase in salmon and steelhead populations is not a clear objective either. The Draft BA does not assess the contemporary status of salmon and steelhead populations in the Russian River Basin. Are populations improving, still declining, or staying about the same under D1610? Is the goal of 'improving' habitat sufficient to stabilize declining populations or recover stable populations presently below historic numbers? Rather, an "improvement" of existing summer habitat and habitat protection under increased future water demand is the objective. The Draft BA never provides a quantitative goal for habitat improvement, i.e., the amount of additional habitat needed to recover salmon and steelhead populations or explicit temperature goals. The Draft BA sets an ill-defined bar very low.

The Draft BA in Appendix C, Section C.1.3.1.1 (beginning p. C-1-11) reviews temperature criteria *"to quantify the effect of temperature change on salmonid persistence*." The term "persistence" is not qualified, but it seems to hold out the possibility that the proposed flow allocation protocol may produce water temperatures relatively unfavorable to those produced by D1610. Are salmon and steelhead populations persisting today under D1610 (even though these populations have declined), so that any slight increase in water temperatures under the recommended flow allocation proposal would still let the populations persist into the future? The Draft BA temperature analysis provides no explicit goal.

Evaluation criteria were developed by assigning scores to temperature ranges identified in reviewing pertinent scientific literature from the Pacific Northwest. Presumably these scores would function as thermal thresholds. This effort culminated in Table C-3: Temperature Evaluation Criteria by Species and Life-History Stage (Draft Biological Assessment, Appendix C, p. C-1-12). Modeled water temperatures at various mainstem locations under each proposed flow allocation protocol were then scored for thermal suitability using Table C-3.

4.3 Average and median monthly temperatures are extremely poor descriptors of the thermal environment a fish experiences in the Russian River.

For each flow allocation protocol, the Draft BA takes the predicted daily average temperature for each day in a given month over the entire hydrologic record (January 1, 1929 to September 30, 1995) and computes the median daily average temperature for that month. For example, there are 66 Julys between 1929 and 1995, for a total of 2046 days. The model predicts the average daily temperature for all these days in each July by applying one of the allocation protocols (e.g., D1610). Next these daily average temperatures are ranked, from coolest to warmest. The median daily average temperature is then selected, where 50% of the 2046 days among all the Julys have daily average temperatures cooler and 50% of the 2046 days have average daily temperatures warmer, than the median daily average temperature. If the July median daily average temperature at Cloverdale modeled under the D1610 protocol is 22ºC, then half the days among all 66 Julys had warmer daily average temperatures. Whew. The Draft often simply states (for example) "the water temperature for June was...", when really meaning " the median of the daily average water temperatures for all Junes was …"

We have not examined the water temperature model employed in the analyses, and thus have assumed the modeled water temperatures accurately and precisely predict mainstem water temperatures. No model error has been reported in the Draft BA or shows up in the graphics. Model validation also is missing in the Draft BA. An example of how well the model performs, by comparing predicted water temperatures to field measured data for a specific year and month (e.g., for example, the continuous WY2002 temperature data presented in Cook (2003)), should be included.

Table 2 (reconstructed from the Addendum (ENTRIX, 2003) and the Draft BA displays predicted water temperatures and available average daily flows (Q) for three water allocation protocols: D1610, NFP, and Flow Proposal. How can D1610 @ Ukiah have only a 0.1 C lower median July temperature than the Flow Proposal, when their respective minimum baseflows are 185 cfs and 50 cfs, but the median flow is much higher, while the NFP has a 0.6ºC higher temperature change over a much more modest discharge change? Why was a 50 cfs minimum baseflow for the Middle and Upper Russian mainstem stipulated in the Flow Proposal? How often did 50 cfs prevail as the daily average flow (or ever, given senior water right obligations)? Without annual hydrographs and annual thermographs for each flow protocol in each water year, meaningful analysis (or technical review of that analysis) that relies on median monthly values is impossible.

Table 2. Comparison of Predicted Daily Average Water Temperature and Average Daily Flow (Q) from the Russian River Biological Assessment Flow Alternatives Addendum (February 3, 2003) and the Draft Biological Assessment (January 16, 2004) (under All Water Supply Conditions and Current Demand) for July.

Ukiah		
Russian River Biological Assessment Flow Alternatives Addendum		
D1610	Median temp = 16.3ºC	Median Q = 260 cfs
NFP	Median temp = 16.8ºC	Median Q = 135 cfs
Draft Biological Assessment		
D1610	Median temp = 16.1ºC	Median Q = 261 cfs
Flow Proposal	Median temp = 16.2ºC	Median Q = 163 cfs
Hopland		
Russian River Biological Assessment Flow Alternatives Addendum		
D1610	Median temp = 18.6ºC	
NFP	Median temp = 20.0ºC	
Draft Biological Assessment		
D1610	Median temp = 18.5ºC	Median Q = 250 cfs
Flow Proposal	Median temp = 19.0ºC	Median Q = 152 cfs

Cloverdale

Russian River Biological Assessment Flow Alternatives Addendum		
D1610	Median temp = 19.9ºC	Median Q = 230 cfs
NFP	Median temp = 20.9ºC	Median Q = 100 cfs
Draft Biological Assessment		
D1610	Median temp = 19.9ºC	Median Q = 234 cfs
Flow Proposal	Median temp = 20.3ºC	Median Q = 140 cfs

Healdsburg

Russian River Biological Assessment Flow Alternatives Addendum		
D1610	Median temp = 23.7ºC	
NFP	Median temp = 23.9ºC	
Draft Biological Assessment		
D1610	Median temp = 23.6ºC	Median Q = 208 cfs
Flow Proposal	Median temp = 23.8ºC	Median Q = 119 cfs

It is necessary to go through these explanations to appreciate how distant the Draft BA really is from assessing potential biological effects due to water temperature. Figure A-15 in the Addendum (p. A-16) is a plot of the median (50%) daily average water temperature for July (on the Y-axis) versus distance along the mainstem Russian River (on the X-axis) for each allocation protocol (e.g., D1610 and Natural Flow Proposal). Near Cloverdale (approximately river mile 68), the median daily average temperature under D1610 rules is 19.9ºC and 20.9ºC under the Natural Flow Proposal. At first glance these water temperatures may not appear overly stressful for steelhead juveniles. But what do they really mean?

From late spring through early-fall, afternoon water temperatures will be much hotter than water temperatures at dawn. Over a 24 hour cycle, water temperatures will vary up to 6ºC or more. A minimum 4ºC swing in water temperature for the middle Russian River is a conservative estimate. This means that an average daily water temperature of 22ºC will have a biologically significant portion of that day at water temperatures up to 24ºC and briefly higher. A juvenile steelhead experiences a predictably variable thermal environment that is more stressful at one time of day (at mid-afternoon) than another (at sunrise) and from one day to the next (e.g., early in August opposed to late-August).

4.4 The Draft BA lacks clear water temperature thresholds.

In the Addendum (ENTRIX, 2003) Table B-3 (p. B-4) presents evaluation criteria for temperature by species and life-history stage. Discrete temperature ranges are assigned a score from 0 to 5 and then back to 0. Presumably a score of 5 is considered the best. Unfortunately, the Addendum provides no information on what each score means, physiologically or ecologically.

Table C-3 from Appendix C in the Draft BA provides ranges of temperatures for each score value, but does not offer the significance of each score value. For example, what does a score of 2 for juvenile steelhead rearing, with a range in temperature of 20.0ºC to 23.9ºC mean? The literature review on p. C-1-15 Appendix C briefly discusses studies, but establishes no significance to the scoring. The scores may appear as thresholds, but thresholds to what? Does a score of 3 or greater eliminate water temperature from being a physical environmental variable jeopardizing salmon "persistence" in the mainstem Russian River?

Table 3. Water Temperature Evaluation Criteria for Steelhead Rearing Temperature

Score	Description	Range (C)	Color	Physiological Response
5	Optimal	12.8 to 15.6	Purple	
4	Excellent	15.6 to 18.0	Blue	
3	Suitable (good)	18.0 to 20.0	Green	
2	Stressful (poor)	20.0 to 23.9	Yellow	
1	V. Stressful	23.9 to 26.0	Orange	
0	Lethal	> 26.0	Red	Imminent Death

The Draft BA takes these criteria, based primarily on physiological studies performed at constant temperatures of varied duration and acclimation, and directly applies them to the median daily average temperatures modeled under different flow allocation protocols at several locations along the mainstem Russian River. The median daily average temperature can be considered an index, as the Draft BA notes, where the D1610 protocol is compared to the Flow Proposal. But it is not biologically meaningful. It clearly cannot be considered equivalent, i.e., eliciting the same physiological response, to the physiological response from exposure to constant water temperatures measured in laboratory studies.

A score of 5 is considered optimal or preferred (p. C-1-11 Appendix C, Draft BA) and a score of 0 is (p. C-1-11 Appendix C. Draft BA) the "*lowest magnitude temperatures that can result in* [direct] *mortality*." Draft BA, Appendix F. Flow-Habitat Assessment Study, p.9 (first complete paragraph) describing water temperature effects on habitat uses: optimal, near optimal, suitable, somewhat stressful, extremely stressful. Do these correspond to the 5 through 1 ranked scores? But on p.13 other modifiers are used: more stressful, adequate, and excellent. At top of p. C-11 the modifier 'sub-optimal' is used. Then on p.11 (bottom): "*…somewhat stressful, but still suitable for rearing provided adequate food is available*." Then on p. C-10 the modifier 'less than optimal' is used. Also on p. C-10: "*However, water temperatures in this reach are thought to regularly exceed the optimal range for Chinook salmon and steelhead, although they remain suitable*." The Draft BA is not clear as to what the scores meant or how the scores were used to establish threshold temperature effects.

EPA tackled this same problem of equivalency using the maximum 7 day average of the daily maxima (7DADM). (*Need reference*. p.18):

> *This metric can also be used to protect for sub-lethal or chronic effects (e.g., temperature effects on growth, disease, smoltification, and competition), but the*

> *resultant cumulative thermal exposure fish experience over the course of a week or more needs to be considered when selecting a 7DADM value to protect for these effects. A general conclusion from these studies on fluctuating temperature regimes (which is what fish generally experience in rivers), is that fluctuating temperatures increase juvenile growth rates when mean temperatures are colder than the optimal growth temperature derived from constant temperature studies, but will reduce growth when the mean temperature exceeds the optimal growth temperature. When the mean temperature is near or above the optimal growth temperature, the "mid-point" temperature between the mean and the maximum is the "equivalent" constant temperature. This "equivalent" constant temperature then can be directly compared to laboratory studies done at constant temperatures. For example, a river with a 7DADM value of 18ºC and a 15ºC weekly mean temperature (i.e., diurnal variation of +/- 3ºC) will be roughly equivalent to a constant laboratory study temperature of 16.5ºC (18ºC – 3ºC/2). Thus, both maximum and mean temperatures are important when determining a 7DADM value that is protective of chronic temperature effects, such as reduced growth rates."*
>
> *"For many rivers and streams in the Pacific Northwest, the maximum 7DADM temperature is about 3 C higher than the maximum weekly average (Dunham et al. 2001; Chapman 2002). Thus, when considering what 7DADM temperature value protects for chronic effects, EPA added 1-2 C to the constant temperatures that scientific studies indicate would be protective for chronic effects (see Table 1 for summary of studies done under constant temperatures). It is important to note that there are also studies that analyzed sub-lethal effects based on maximum or 7DADM temperature values which need not be translated for purposes of determining protective 7DADM temperatures*."

The 7DADM is just one conservative alternative for developing thermal threshold criteria under daily fluctuating river temperatures. The Draft BA must adjust its temperature evaluation criteria to account for daily fluctuating water temperatures. A Sonoma County Water Agency staff report (2003), providing weekly maximum and weekly average summer water temperatures at several Russian River mainstem locations, documents a 2º C difference (in Figure 8 of the report) in August between the weekly maximum and weekly average water temperature in the Alexander Reach near Ukiah. Using the EPA adjustment, the daily average temperature (roughly 21ºC) would not have the physiological effect of approximately 21.0ºC (69.8ºF) water but approximately of 22.2ºC (72.0 F) water.

The Draft BA references NCRWQCB water quality objectives for the Russian River Basin that conclude a maximum 7-day average stream temperature of 17.8 C (64.0 F) would likely protect salmonid species. Perhaps this is why the upper temperature (18 C) for a score of 4 (excellent) was chosen, although considering a daily average of 18 C as "excellent" for rearing juvenile steelhead seems optimistic.

While EPA recognized (*need reference* 2002, p.19) the importance of a variable 7DADM between water years, the agency supported exempting unusually warm conditions:

> *"In order to have criteria that protect designated uses under the CWA, the criteria need to apply nearly all the time. However, EPA believes it is reasonable for a State's or Tribe's WQS to exempt unusually warm conditions in determining attainment with temperature numeric criteria. On way to do this would be to base attainment on the 90th percentile of the yearly maximum 7DADM values calculated from a yearly set of values of years or more."*
>
> *"The rationale for some type of exemption for unusually warm conditions is that infrequent peaks in water temperature, typically due to unusually hot air temperatures, is a natural component of the environment and these infrequent conditions should not drive compliance determinations. Salmonids may experience some adverse effects during these periods, but by definition, they would only be allowable 1 in 10 years."*

The Draft BA, by selecting the median or 50th percentile of the daily average water temperatures, effectively exempts the hotter half of all days in any given month. No scientific justification is provided for selecting the 50th percentile.

Surprisingly, the Draft Biological Assessment does not take advantage of fish surveys to evaluate temperature scores. Thermographs monitored in areas where steelhead juveniles reside throughout the summer would be highly instructive, though not decisive, in adding "meat to the bones" of the temperature scoring system the Draft adopts (e.g., Are 2+ juvenile steelhead abundant and large in the mainstem where the median daily average temperature score is 2, 3, and/or 4?).

4.5 Pie charts are substitutes for substantive analysis.

The Draft BA reports the frequency of temperature scores at different mainstem locations for each species and lifestage over the entire record, from January 1, 1929 to September 30, 1995. These frequencies are portrayed as numerous pie charts in the Draft BA. Does the yellow part occur in mid-May to early-June in Normal years and drier, a critical time of year and water year type for emigrating Chinook fry? Users of the Draft BA are provided no insightful analysis, only a portrayal of flawed temperature score frequencies spanning 66 years lumped into each pie chart. The underlying logic appears to be: if the pie chart for the proposed allocation protocol looks similar to the D1610 pie chart, then there is no significant impact to population persistence.

4.6 Annual thermographs are a more informative approach to assessing temperatures.

Hourly temperatures can be used for assessing chronic, sub-lethal, and lethal temperature effects. Fundamental steps would be: (A) compute annual hydrographs using hourly flows for the unimpaired flow, D1610, NFP, ENFP, and Proposed allocation protocols for each water year (using the present system for water year classification) from WY1960 (first complete WY since Lake Mendocino operational) to the present at key locations along the mainstem channel, (B) model annual thermographs for each annual hydrograph in (A) at hourly intervals, (C) develop chronic and lethal temperature thresholds from the scientific literature and reviewed by a 3 member scientific panel (lots of good candidates in California; possibly one river temperature modeler and two fish biologists … one physiological and the other ecological), (D) plot the number of days each chronic, sub-lethal, and lethal threshold is exceeded for specific time periods (e.g., mid-May through late-June when Chinook fry are migrating and water temperatures are rising) as the dependent variable (Y-axis) and annual runoff (unimpaired total ac-ft) on the X-axis as the independent variable … for each allocation protocol including unimpaired flows (i.e., there would be 5 curves on this plot), (E) re-convene the scientific panel to (i) interpret the results (e.g., noting threshold responses in the curves and relating these responses back to the fish and the river ecosystem) and (ii) recommend additional analyses that challenge other norms and assumptions (e.g., the water year classification procedures; 1-2 C for global warming by 2030), (F) re-reconvene scientific panel, reassess all results, then draft evaluation and make recommendations. This approach would provide a transparent assessment to agencies and residents that incorporates scientific expertise in temperature analysis and evaluation. All these steps (A through F) would constitute the temperature analysis that would be used in the overall Biological Assessment. Given the potential major, if not over-riding, importance of water temperature in sustaining the mainstem's increasing role of supporting the Basin's salmon and steelhead fishery, this level of effort is easily justified.

4.7 The impact of releasing critically dry year minimum baseflows on migration has not been satisfactorily analyzed.

A 35 cfs baseflow in the lower Russian River mainstem during a Critically Dry year would strain adult migration. Not only could temperatures be excessive, but many riffle depths would be marginal.

April through June is the time for providing juvenile Chinook mainstem rearing habitat (Draft BA, Appendix C, Table C-1, p. C-1-4). Juveniles must migrate downstream before mainstem water temperatures in late spring or early summer become excessive. Thus the later half to later third of this time period (early-May through mid-June) can be particularly stressing. Water years with higher baseflows during this time period would improve survival and growth; brief and modest increases in discharge can encourage juvenile outmigration. The NFP's provision of making unimpaired flow the minimum baseflow at Healdsburg might have provided more favorable flows, thus potentially achieving a benefit over the D1610 baseflows. But the Draft BA flow recommendation, subsequent to the NFP, removes these potential benefits: minimum baseflows are lower in April and May and June baseflows are diminished and less variable.

The best allocation protocol for Chinook juveniles in May/June can be scientifically evaluated at Healdsburg (or elsewhere), but not with the inadequate analyses provided in the Draft Biological Assessment. Water temperature would be the most important variable. A chronic threshold for water temperature must be designated using daily thermographs (e.g., 4 consecutive days when afternoon water temperatures exceed a given value), and not the monthly median of the daily mean temperature (see general comments on temperature analysis and explanation for this phrase). Hourly water temperatures would then be modeled from April through June over a range of representative water year types (Critically Dry through Extremely Wet) for all allocation protocols including daily unimpaired flow. The allocation protocol that extends the window of favorable juvenile rearing (i.e., temperatures remain below the chronic threshold) the farthest into June over the widest ranging water year types (and possibly performing better than unimpaired flows) would deserve consideration. This analysis, and several other potential analytical approaches for quantifying impacts, should be performed given the potentially severe impacts to Chinook populations.

4.8 Juvenile routing is not satisfactorily analyzed.

Summertime water temperatures higher up the mainstem can be considerably cooler than downstream. This can have profound influence on salmon populations if tampered with. Rearing juveniles exposed to unseasonably cool dam releases may not begin their downstream migration until too late, when lower mainstem temperatures are highly chronic or lethal. Warm Springs Dam and Coyote Valley Dam have this potential. Routing anadromous juveniles downstream, particularly Chinook juveniles, should be integral to any management strategy for diverting and/or manipulating river flows. No such strategies, or evaluation of strategies, relative to routing fish are evident in the Draft Biological Assessment.

4.9 The habitat analysis reported in the Draft BA has too many biases and analytical weaknesses to warrant the conclusion that D1610 baseflows are harming salmon and steelhead populations in the mainstem Russian River.

Three principal documents were reviewed that related anadromous salmonid habitat to mainstem Russian River flows: Addendum (ENTRIX, 2003), the Draft BA and Appendix F of the Draft BA. While many other documents were examined, these three underpin the scientific foundation for the earlier NFP and ENFP proposals and current Flow Proposal.

4.9.1 Baseflows in the habitat analysis.

A field study was undertaken to quantify the relationship between baseflows and anadromous salmonid habitat quality and relative abundance for the mainstem Russian River above Cloverdale. Appendix F (p.9) summarizes the field study results: "*Habitat availability in the study sites was observed to vary with flows, and was moderately abundant overall at low and intermediate flows. At Sites 1, 4, 5, 7, 9, 10, and 11, habitat rated as high as 40-60 percent suitable for at least one species/lifestage at low flows, intermediate flows, or both. At Sites 2, 3, and 6, availability of habitat ranged no higher than 10-25 percent suitable for any species/lifestage at any flow; in general, habitat availability was greatest at the lowest flow and decreased gradually as flows increased. The availability of optimal habitat for fry and juvenile life stages of steelhead and Chinook salmon is substantially reduced at the highest study flow (release of 275 cfs) as compared to conditions at lower study flows.*" The Addendum concludes (bottom of p.2-6): "*The flow-habitat study indicated that the best potential habitat conditions for salmonid rearing in the upper mainstem Russian River occurred when flow releases from CVD were approximately 125 cfs. Flow releases of 190 cfs provided good rearing habitat conditions, but flow releases of 275 cfs or greater were unsuitable for salmonid rearing in the upper mainstem.*" The field study relies on many assumptions, implied and explicit, several of which greatly bias the conclusion. For example, the habitat criteria and scoring consider water depths greater than 3.3 ft unsuitable for Chinook and steelhead juvenile habitat, even though portions of the main channel greater than 3.3 ft can be providing some of the best habitat for older steelhead juveniles.

Three baseflow releases from Coyote Valley Dam were evaluated in the 2001 field study and presented in Appendix F: 125 cfs, 190 cfs, and 275 cfs. Presumably if the intent was to contrast habitat availability in present flows under D1610 relative to historic flows, then both should be represented in the study design. Does the 275 cfs baseflow represent D1610 regulation and the 125 cfs a natural baseflow? Unfortunately, the hydrologic analyses provided (refer to previous comments) make this difficult to assign. Historic summer flows in the Upper Russian River mainstem (e.g., Hopland to Cloverdale) were much lower than 125 cfs, and much higher than 275 cfs in the winter and spring.

Why is a minimum baseflow of only 35 cfs prescribed for the mainstem channel at Guerneville, while the mainstem channel with almost half the contributing drainage at Healdsburg receives a 50 cfs minimum baseflow in the Flow Proposal? Shouldn't baseflows be roughly proportional to drainage area and channel dimension? While this flow arrangement goes back to D1610, the present Draft Biological Assessment should be capable of addressing this question. Otherwise, how were the new baseflow prescriptions scientifically derived (i.e., 100 cfs rather than 50 cfs change from the NFP to the Flow Proposal)? The field study attempting to quantify rearing habitat only extended downstream to Cloverdale.

A very big problem for the Draft Biological Assessment is Table B-2 of the Addendum (p. B-3) titled "*Flow Evaluation for the Russian River by Species and Lifestage*." Somehow, Table 4C in Appendix F was transformed into Table B-2 of the Addendum. Habitat evaluations for flows greater than 275 cfs and less than 125 cfs are presented in Table B-2 even though the field study only quantified habitat at 125 cfs, 190 cfs, and 275 cfs (e.g., Table 4C in Appendix F). If slow and shallow is good for Chinook fry habitat, why do flows less then 115 cfs get poor habitat scores? Spawning habitat evaluations are presented in Table B-2 with no spawning habitat data presented in Appendix F. The units of measure have changed: from percentages of channel area in Appendix F Table 3C to habitat scores that are never clearly defined (i.e., What does a score of 2 mean?) in Addendum Table B-2. Perhaps this transformation can be explained or has been addressed in other un-reviewed documents. But there are bigger problems with the Russian River mainstem habitat analysis.

4.9.2 Habitat criteria used in the habitat analysis.

The conclusion from the habitat field study is that the D1610 baseflows are too fast. From July 1 until the first significant fall rains, juvenile salmonid habitats identified in the phenology (or periodicity) chart of the Draft Biological Assessment (Figure 2-3, p. 2-41) are juvenile coho salmon and juvenile steelhead habitats. As noted, coho tend to avoid rearing in the mainstem. Therefore, above Healdsburg, juvenile steelhead rearing is the key habitat that must be provided in the summer. Chinook fry have grown into juveniles, and then migrated downstream by the end of June. Steelhead fry also have grown into small juveniles by June's end.

Table 4C in Appendix F Attachment C (p. C-15) presents the field study's results by fish species/life stage and flow release. The last row presents percentages of channel area designated as optimal juvenile steelhead habitat. Roughly 75% of the study sites (sites 1, 2, 3, 4, 5, 6, 7, 8, 12, and 13) show no distinctive trend in habitat abundance over the three baseflow releases: 125 cfs, 190 cfs, and 275 cfs. Sites 9, 10, and 11 do show a distinctive trend of more habitat at the lowest flow. Site 10 was adjacent to Site 11, both near Commisky Station (Appendix F, Attachment C, p. C-9). The cross section at Site 9 was extremely narrow (Appendix F, Attachment D, p. D-11). The very sharp drop in habitat for steelhead juveniles from 125 cfs to 190 cfs, amounting to a small change in stage, was difficult to explain. Unfortunately, no water stages (or associated discharges) are shown on the cross sections, but the wetted width for the 275 cfs release seems to have been no greater than 27 ft. However Appendix F, p. E-26 lists a 16 cfs discharge in cross section No. 9 during the 275 release.

Juvenile steelhead must be sufficiently large before acquiring a reasonable chance of surviving the ocean and returning as spawning adults. This generally means that the abundance of older juveniles, 2+ and greater, is key to recovering steelhead populations. Younger age classes typically do not limit population size. As discussed previously, these older juveniles rear in perennial tributaries or the upper mainstem even though many are born in tributaries that dry-up in summer. As tributaries become more impacted by land conversions and flow withdrawals, the mainstem channel must assume a bigger role in growing more and larger juveniles to ultimately sustain the Basin's steelhead population. Therefore, all juvenile steelhead age classes might be found in the mainstem channel, but the key life-stage is the 2+ and older age class.

The youngest age class (0+) prefers shallower and slower flows than 1+ juveniles, that in turn prefers shallower and slower flows than 2+ and older juveniles. Cover preferences also change. Finer substrate offers cover to 0+ juveniles that would be highly unsuitable for 2+ juveniles. Sharp transitions from fast to slow currents (as in shallow and deep pool entrances) are highly valued by 2+ and older juveniles especially if large cover is available nearby.

The habitat criteria for juvenile steelhead used in the field study include all age classes. Yet depths greater than 3 ft often provide the best habitat for 2+ and older juvenile steelhead. Problems arise when attempting to include all age classes in one set of habitat criteria. If depths greater than 3.3 ft deep were included, but the low velocity criterion remained unchanged, most of the channel bed incorrectly would be considered habitat at most baseflows. Physical criteria for assessing juvenile steelhead habitat must be separated by age class.

Habitat criteria for 2+ and older juveniles are not set in stone. Depths greater than approximately 1.5 ft should be considered (with no upper depth limit), as well as velocities greater than at least 0.75 ft/sec and probably no greater than 3.0 ft/sec (though in deep channel sections with large substrate cover even this value as a mean column velocity can provide excellent habitat). The fall-out of assigning one set of criteria to all juvenile steelhead age classes is a highly significant bias against identifying the baseflows needed for the habitat of older age classes, the age class most likely limiting adult population size. Note that no part of the channel bed greater than 3.3 ft deep in the preference criteria is considered suitable habitat for any species juvenile life-stage. This bias is translated into recommending low baseflows.

Yet historical Russian River baseflows during the summer rearing period for 2+ steelhead in the mainstem were much lower than 125 cfs. Historic summer baseflows probably did provide poor 2+ steelhead rearing habitat. Deep stratified pools likely provided limited refuge, but this would have forced 2+ juveniles into a smaller space thus reducing feeding opportunities and requiring more energy expenditure dedicated to defending territories. The end result of a summer's crunch-time is that the few survivors were exceptionally big and consequently most likely to be successful smolts. More, but smaller, smolts originated from the perennial tributaries, where an individual's growth would not have been as high, but survival was likely better.

Early emergent Chinook fry have almost no swimming ability capable of resisting flow velocities much greater than 0.5 ft/sec or actively alluding predatory fish. Slow and shallow portions of the main channel (with cover) therefore provide necessary refuge during this vulnerable life-stage. But historically, Chinook fry emerged from redds when mainstem baseflows were high. Late-winter and early-spring daily average flows typically exceeded 1000 cfs in the mainstem Russian River. How do we resolve the apparent contradiction of having a life stage vulnerable to fast and deep flow occurring when flows typically ran fast and deep?

What about today? If we relied on the Addendum, particularly on Table B-2 (p. B-3), historic mainstem baseflows were bad for early emergent Chinook fry. From February 1 to April 30, a flow range between 250 cfs and 500 cfs receives a habitat score of 1. Though the Addendum makes no claim that early emergent fry habitat limits the Chinook's present population or population recovery, the report cites Table B-2 as one supporting rationale for the NFP or ENFP recommendation. On p.2-8 the Addendum states: "Issue 2. Velocities in the upper mainstem of the Russian River are higher than optimum for salmonid rearing." We need to know how much 'optimal' Chinook fry habitat exists throughout the mainstem channel, not the relative abundance of habitat in riffles (that Chinook fry avoid, except along the margins).

Why does the Draft BA evaluate riffles as likely habitat for fry Chinook? They may occur on the fringe (as observed in the field), but the only way to 'make' abundant fry habitat throughout riffles is to substantially de-water the riffles. The habitat criteria consider water depths greater than 3 ft unsuitable for juvenile Chinook habitat. On the Mad River, the most utilized habitat by Chinook juveniles was in the water at the heads of pools, where the juveniles hold and feed in the bubble curtain about midway from the bottom to the surface (older juvenile steelhead also utilized these areas, though remaining closer to the bottom).

Mainstem channels are geomorphically diverse. Pools, riffles, point bars, and mid-channel islands, to identify just a few geomorphic features, collectively create a complex hydraulic environment. Locations with slow and shallow flow can be found even in the steepest and narrowest channel reaches under very high flows. The question becomes not whether early emergent Chinook fry habitat existed, but whether such habitat was sufficiently abundant. Without embarking on a detailed analysis, the amount of early emergent fry habitat under historic flows and in the historic mainstem channel (and larger tributaries) likely was not limiting the Chinook population.

The hydraulic complexity of mainstem channels, that provides habitat for all age classes, is the direct result of structural complexity and variable baseflows. Is having 60% to 80% or even 25% to 40% of the channel area as optimal or suitable habitat for a given species/life-stage at a single discharge (or narrow range of discharges) a good thing? A first response would be that "more is better"; the Draft Biological Assessment seems to have adopted this perspective.

A convincing argument can be made otherwise, using Chinook fry in the mainstem above Cloverdale. If 40% to 60% of the channelbed area is suitable habitat for Chinook fry, small increases in discharge can make that part of the channelbed inhospitable. Perhaps this would be acceptable if the baseflow remained constant or fluctuated narrowly within an optimal range. But newly emerged Chinook fry need slow and shallow habitat beginning February and lasting through April, when mainstem flows are highly variable. A mainstem channel that can deliver sufficiently abundant and high quality habitat over a wide range of discharges would seem to be a better environment for fry Chinook, rather than a mainstem channel providing abundant habitat at a low baseflow but little habitat at higher flows. Rivers and salmon have opted for the former. What are the management implications? This means, at a broad conceptual level, that mainstem baseflows must be managed WITH tributary flow inputs above Healdsburg. It also means there is no such thing as an "optimal" fish habitat baseflow for the mainstem Russian River.

In summary, applying habitat descriptors adopted in the reports to the results (especially Table B-2), natural flows were unsuitable for juvenile steelhead rearing most of the year and for Chinook fry in late-winter and early-spring—and other life stages as well. This clearly seems at odds with the Draft Biological Assessment's overall tenet that a return to natural flows would improve salmon and steelhead populations.

4.10 River productivity is not adequately considered in the habitat analysis.

Macrobenthic invertebrate production would be "optimal" when water temperatures range from 50 to 60 F and the riffles' cobbles are inundated by 0.5 to 1.0 ft of flow no faster than a mean velocity of approximately 2.5 ft/sec. In this case, "optimal" would mean the most invertebrate biomass produced (with units of $g/m^2/day$). What percent of the riffle area is productive macrobenthic invertebrate habitat over a range of historic flows yet receiving temperature scores of 4 and 5? Inundating riffles in the spring, when water temperatures are highly favorable for most macroinvertebrates, provides a large input of food for quickly growing juvenile Chinook and steelhead before unfavorable summer water temperatures set in. This growth pulse could be an important factor for Chinook smolt vigor and 2+ steelhead oversummer survival. Minimum spring baseflow releases that attempt to transform riffles into 40% to 60% fry and juvenile Chinook habitat, i.e., baseflows recommended in the Draft BA, are likely providing habitat that is not limiting fish but harming mainstem productivity.

4.11 Another approach to assessing habitat should rely on annual hydrographs and habitat mapping.

The Draft BA adopts a good strategy of evaluating salmonid habitat-flow relationships in the mainstem by relying on direct observation from professional fish biologists. Although considerable effort has been dedicated to defining salmon habitat through physical habitat descriptors (e.g., water depth and velocity), experienced biologists are best at integrating all variables onsite and evaluating the unexpected.

The flow study sought to identify a responsive habitat-flow relationship within a narrow range of baseflows. The results do not support the Draft BA's conclusions (as stated previously). To determine the range of baseflows providing 2+ juvenile steelhead habitat, and recognizing that optimum baseflows do not exist in nature, the methodology must quantitatively inform us of how much high quality habitat exists at a given baseflow.

The mainstem Russian River is ideal for employing expert habitat mapping. The premise for expert habitat mapping is simple. Expert habitat mapping (EHM) accounts for spatial and hydraulic complexity by mapping habitat at known streamflows onto a scaled channel basemap generated by low altitude aerial photography. Mapping is done in the field by experienced biologists. Each hydraulically complex portion of channelbed considered to function as habitat by the expert mappers is drawn onto this large-scaled basemap. Each identified habitat patch is called a 'habitat polygon.' Life stages that can be habitat mapped include emergent fry, older juvenile, and adult spawning life stages for Chinook, coho, and steelhead.

This methodology could readily be applied to habitat units or representative channel reaches to quantify habitat throughout each section of the Russian River mainstem and in Dry Creek. Habitat mapping must be performed with biologists in wetsuits, i.e., in the field, not in the office. EHM relies on combining field experience, insight, and quantitative habitat criteria to identify and quantify habitat in complex habitat units. Physical microhabitat requirements, including flow depth and velocity, of important life stages have been formalized as Habitat Suitability Indices (HSI curves) for salmon and steelhead in Northern California. These HSI curves would serve as guidelines to the expert habitat mapping team. Expert mappers must adopt a mutual and repeatable standard for mapping, and should map as a team. The base map must be of sufficient scale to outline each habitat polygon boundary accurately. Orthorectified aerial photographs at a scale of 1 inch: 200 ft should be used. Digitized polygons would be superimposed onto the aerial photo base maps and included as documentation.

4.12 Channel confinement has likely altered historic flow–habitat relationships.

The mainstem Russian River channel has changed with increasing flow regulation. Channel bank confinement from encroaching riparian vegetation, channelbed downcutting, and decreased sinuosity have likely altered the historic (natural) relationship between baseflows and anadromous salmonid habitat. Often confinement creates a functionally smaller channel, forcing historic baseflows to become faster and deeper. The Trinity River is a good example of historic baseflows creating excessive velocities for Chinook fry rearing habitat within the confined channel banks of the present mainstem channel. The Draft Biological Assessment does not address this possibility for the Russian River mainstem. Perhaps historic baseflows in the present channel would diminish Chinook fry rearing habitat from late winter through spring. Inspection of the channel cross sections in Appendix F did not reveal conspicuous signs of low flow channel confinement, but more analysis and field surveying would be necessary before concluding this. Unfortunately these cross sections do not, and should, have the stage heights of each experimental flow labeled. The possibility that channel confinement has significantly altered flow – habitat relationships constitutes another serious drawback to the Draft BA's natural flow evaluation.

5 SPECIFIC COMMENTS FROM REVIEW OF WATER QUALITY ISSUES

Surface water quality depends on the quality and quantity of water sources and chemical and physical processes that occur along the water flow path, including mixing with other surface and groundwater sources and biological and thermal effects. Important water quality characteristics include: dissolved oxygen content; concentrations of dissolved nutrients for plant and algae growth; concentrations of other dissolved constituents including salts, dissolved metals, and other pollutants; turbidity; and temperature.

Reduction of dry-season flow in the Russian River resulting from reduced supply from Eel River water transfer and reduced releases from Lake Mendocino and Lake Sonoma are likely to have the following general effects on water quality:

1. Increased influences on Russian River water quality from local surface water and local groundwater sources along the flow path including decreased dilution of pollution
2. Greater lateral heterogeneity in water quality upstream from the estuary due to influences of local sources, diminished mixing at lower flow rates, and more evolved water quality characteristics resulting from longer residence times
3. Increased thermal stratification in deep pools of the upper river
4. Lower late-dry-season temperature in the upper river if cold water from the hypolimnion of Lake Mendocino is not depleted before the end of the dry season
5. Decreased dry-season fluctuations in estuary water quality if breaching of the sand bar at the river's mouth is eliminated

The Draft BA provides an extensive evaluation of low flow effects. Most water quality characterizations and conclusions reached in that document are reasonable within the scope of the data considered. Many of the observations presented in this review are based on information in that report and are consistent with conclusions of that report. However, large uncertainties persist in important details of effects due to low flow conditions. Particular concerns include the extent of increase in water quality heterogeneity that would be expected under low flow conditions, the extent of increased concentration of pollutants due to decreased dilution, and the water quality conditions in the estuary/lagoon when the sandbar remains intact through the summer.

5.1 Impacts of the Flow Proposal on water quality characteristics upstream of the estuary

5.1.1 Water quality evolution

In general, surface water chemistry initially evolves from precipitation dominated conditions to conditions dominated by water-rock-biology interactions. Increasing total dissolved salts and increasing ratio of dissolved $Ca(HCO_3)_2$ to NaCl typically characterize the initial evolution of water chemistry. In surface waters that are subject to evaporation and precipitation of $CaCO_3$, total dissolved salts continue to increase and $Ca(HCO_3)_2$/NaCl decreases toward values in seawater. Longer residence times under low flow conditions in the Russian River would lead to greater evolution of general water quality characteristics and larger differences in water chemistry between the upper reaches of the river and the upper end of the estuary. The greater proportion of water derived from local sources along the flow path, e.g., from agricultural or domestic runoff or groundwater discharge, would also increase water quality heterogeneity under low flow conditions. Higher flow velocities increase turbulent mixing, which homogenizes water chemistry. **Low flow conditions would enhance the potential for increased water quality heterogeneity due to increased vertical thermal stratification. Heterogeneity due to diminished lateral mixing transverse to the principal flow direction would also be increased.**

5.1.2 Temperature

Dry-season Russian River water temperature is significantly lowered relative to natural conditions by releases of relatively cold water from deep levels of stratified reservoirs. River water temperature increases with flow downstream and with time through the summer. Under present flow conditions, temperature in the mainstem of the Russian River drops at the confluence with Dry Creek because of controlled low temperature releases from Lake Sonoma. Cooler coastal air temperatures, coastal fog, and canopies that block sunlight result in cooler water temperatures in coastal reaches of the system.

Decreased dry-season flow would tend to increase the downstream temperature gradient and the maximum water temperatures in lower reaches of the river. Low flow releases would tend to preserve water temperature stratification in Lake Mendocino through the summer leading to lower temperature water in the upper reaches of the river at the end of the summer than under higher flow conditions.

Turbulent mixing at higher flows disrupts stratification of water due to density differences. **Lower flows may permit increased temperature and density stratification in pools in the upper Russian River, particularly in local areas of cool**

groundwater or sub-gravel flow discharge. In general, reaches of the lower Russian River are too shallow for temperature stratification.

5.1.3 Dissolved Oxygen

Low flow conditions would tend to reduce the dissolved oxygen content of the river water. Dissolved oxygen contents depend principally on temperature, biological activity, degradation of organic matter, and turbulence that causes mixing with air. Dissolved oxygen levels in Russian River water are high because of atmospheric buffering. The amount of oxygen that can dissolve in water increases with decreasing temperature. Increased temperature in the lower reaches of the river under to low flow conditions would lead to lower dissolved oxygen due to solubility controls. Late summer cool water below Lake Mendocino could have higher oxygen contents than if the water was significantly warmer. Decreased turbulence would reduce mixing of air with water and lead to lower dissolved oxygen content, particularly where there are sinks for oxygen such as degrading organic matter. An increase in the influence on water quality by mixing with polluted water or oxygen poor groundwater discharge could lead to local conditions of low dissolved oxygen.

5.1.4 Turbidity

Turbidity due to suspended sediments is generally low during the dry season in comparison to high flow conditions. **Low flow conditions are unlikely to have large effects but could diminish turbidity due to suspended sediments.** Increased turbidity is possible due to locally increased biological activity (e.g., growth of planktonic algae in areas of increased nutrient concentrations).

5.1.5 Pollutants

Decreased dilution of pollution would be a principal effect of low flow conditions. Pollutants generally include nutrients (e.g., nitrates and phosphates), pathogens (e.g., bacteria), and organic and inorganic chemicals from natural or anthropogenic sources. Higher nutrient concentrations from septic or municipal discharge systems or agricultural discharges would lead to increased growth of aquatic plants and algae. Local accumulations and decomposition of organic matter could lead to low dissolved oxygen concentrations. The potential for pollution from the pesticide diazinon and metals including copper, chromium, and zinc are noted in the watershed and the concentrations of these and other pollutants would increase in the Russian River with decreasing dilution.

Elevated bacterial pathogens are common in the Russian River at Healdsburg Memorial Beach and Monte Rio Beach, and their concentrations would be likely to increase due to decreased dilution.

Attention to limiting the introduction of pollutants to the river can have a large positive effect on water quality. Increased attention to limiting pollution would be necessary under low flow conditions.

5.1.6 Mercury

The environmental mercury cycle couples interactions between solids, solid-solution interfaces, liquid metal, aqueous solutions, air, and biological systems. Natural inorganic mercury occurs primarily as cinnabar (HgS) and native metal liquid. Transport of mercury in fluvial systems is predominantly as particulate matter. A strong chemical potential promotes oxidation of metallic mercury and of sulfide in cinnabar under Earth surface conditions, but the rate of oxidation may be slow and is commonly mediated by biology. Maximum concentrations of inorganic mercury controlled by the solubilities of metallic mercury or cinnabar under reducing conditions are very low, less than micromolar. Under moderately oxidizing conditions mercury can exist as a monovalent or divalent cations in aqueous solution. Thermodynamic data indicate appreciable stability fields for aqueous Hg_2^{2+} and $Hg(OH)_2^0$ species. Mercury is likely to adsorb strongly as divalent cations to hydrous ferric oxides at pH above 6 or 7. Hg^{2+} binds with methyl groups to form CH_3Hg^+ and $(CH_3)_2Hg^0$, both of which are biomagnified in trophic hierarchies, potentially becoming a severe neurotoxin to people who consume fish. Production and occurrence of methylmercury is a complex function of mercury supply, solid and aqueous physical chemistry, and microbiology. Micro-environmental effects, mercury toxicity, biologically mediated kinetics, and catalysis at solid-solution interfaces all contribute to the complexity of the hydrobiogeochemical mercury cycle. Low oxygen levels and increased concentrations of nutrients and bacteria can promote the conversion of metallic mercury to methylmercury.

Mercury was detected in storm water runoff from Santa Rosa in one sample from October 1998 at a level above the CTR aquatic life criterion (ENTRIX, 2004). Elevated mercury has been measured in bottom water in Lake Mendocino and Lake Sonoma (ENTRIX, 2004). **Low flow conditions could lead to an increase in local environments where the water is depleted in oxygen and becomes reducing. Methylation of mercury could occur in these conditions.** Mercury levels in fish and shellfish should be monitored.

5.2 Impacts of the Flow Proposal on water quality characteristics of the estuary

Water quality in the estuary undergoes large, rapid changes when the sandbar is breached and when the sandbar barrier is reestablished. Breaching leads to mixing of seawater with freshwater, high salinity up to three miles inland of the river mouth, lower temperatures, and higher oxygen contents in deep water. Flushing with seawater also discharges accumulated pollutants. Closing the sandbar barrier initially leads to stratification with dense, cool, saline water at depth. Subsequent to sandbar closure the temperature increases and the oxygen content decreases in deep estuary water. Large fluctuations in salinity, temperature, and dissolved oxygen following periods of relative stability have adverse effects on biology as conditions change.

Low flow conditions would lead to persistent, dry season, fresh water conditions in the "estuary" (lagoon) if the sandbar is not breached. These conditions would be more stable than those occurring with periodic sandbar breaching. Water quality characteristics in the lagoon are difficult to predict. The potential for water stratification and de-oxygenation of deep water would persist under low flow conditions. Water would continue to flow through the lagoon and through the sandbar, so pollutants would be flushed. However, conditions of increased concentrations of pollutants due to decreased dilution would apply to a fresh water lagoon as well as to the river under low flow conditions. Available data on the Russian River estuary system reflect frequent artificial breaching of the sandbar, mixing of seawater and fresh water, and stratification following reestablishment of the barrier. Water quality characteristics of estuary water under low flow conditions presented in ENTRIX (2004) are highly speculative. They are based largely on observations on estuaries of the Central California Coast, which are reported in a San Jose State University document (Smith, 1990, cited in ENTRIX, 2004). **Studies of these systems provide important comparisons, but effects on the Russian River could differ significantly because of differences in geography (e.g., sand bar dynamics, water depth, climate), hydrology, chemistry (e.g., sources and sinks of constituents), and biology.**

5.3 Questions and Areas for Additional Inquiry and Data Collection

Effects of low flow regime on water gaining (aquifer discharge) or losing (aquifer recharge) regimes could affect water quality in the river and in water supply wells near the river. A useful study would focus on the relative effects on water quality of surface water and groundwater discharges to the Russian River. Groundwater contributions could possibly be detected on the basis of temperature, pH, dissolved O_2 or CO_2, or total dissolved salts (e.g., electrical conductivity).

A variety of monitoring studies could illuminate controls on water quality in the Russian River. Mercury levels in fish or shellfish in the river and estuary would be useful in the context of well established mercury pollution and toxic effects. Studies of changes in mercury in fish due to changes in flow regime may bear on flow effects on other chemical pollutants. Monitoring for bacteria should be conducted. Water quality monitoring should include groundwater from wells near the river.

Water quality below the inflatable dam during the period after its emplacement should be examined as an analog of low flow conditions. In particular, how much does temperature increase? Does local biological activity indicate an increase in water quality heterogeneity? Do pools of oxygen-depleted water develop? Does temperature stratification of water develop in deep pools?

Deliberations and recommendations of the North Coast Regional Water Quality Control Board should be followed with regard to low flow conditions.

The final or follow-up version of the July 2002 Russian River Basin Fisheries Restoration Plan of the California Department of Fish and Game should be examined when it is released.

Water quality effects of low flow conditions on the estuary are particularly important and uncertain. Studies of similar systems on the California Coast provide important comparisons, but effects on the Russian River could differ significantly because of differences in geography (e.g., sand bar dynamics, water depth, climate), hydrology, chemistry (e.g., sources and sinks of constituents), and biology.

Models for water flow and water quality could improve the reliability of predictions of effects of low flow conditions on the Russian River. The HEC-5Q simulations (RMI, 2001) demonstrate the feasibility of generating such models and the ability of such models to reasonably represent observed conditions. Improvements to these models could be made to include variations in temperature and dissolved oxygen in vertical profiles. Also, a more detailed model of conditions in the estuary/lagoon would be warranted given the substantial uncertainty in water quality consequences of low flow conditions.

6 SPECIFIC COMMENTS FROM REVIEW OF GEOMORPHIC/HYDROLOGIC ISSUES

6.1 The hydrologic analyses leading to the Flow Proposal should be re-evaluated.

The Flow Proposal (ENTRIX, 2004) stipulates that flows in the Russian River below Mirabel Dam "would be the greater of 35 cfs or the 'natural flow'…[which] is intended to mimic the flow of the Russian River under predevelopment conditions" (p. 4-22). This natural flow "is defined as 11.77 times the four-day running average of the gauged flow of Austin Creek…"

The analyses in the *Russian River Natural Flow Proposal* (Beach, 1999*)* that lead to the low flow prescription do not appear to be statistically sound. Among other things, the analysis should consider the fact that flow values are not randomly distributed, but related in time. Although we did not receive the corresponding graphs containing the data, the description mentions that "the scatter plots…exhibit a non-linearity which is not evident in the coefficients of determination" (p. 13), indicating that simple linear regression is not valid. Furthermore, the data used in this analysis are not adequately described. Do the regressions include both winter and summer flows? Do they include data prior to the construction of the two large dams, or only since? If they include post-dam data, how does this derivation mimic "predevelopment conditions"? More defensible time series approaches could be used here relatively easily, and they would also be able to incorporate other factors such as rainfall, drainage area, land cover, etc.

The approach of prescribing low flows based on multiples of tributary flows makes the following questionable assumptions: (1) that the flow in the Russian River is primarily related to flow in a single tributary stream located in its watershed, (2) that mainstem flow is related to tributary flow in a simple linear fashion, and most importantly (3) that the "predevelopment" flow is the optimal low flow for the desired objective(s) in the first place.

The system is altered in many ways, not just its low flow regime. Therefore restoring a hypothetical "natural flow" may not necessarily be the optimal strategy for anybody—people or fish. The low flow prescriptions could be more beneficial if they were tied to some balance of ecological (temperature, velocity, depth, water quality) or economic (recreation and tourism) goals, rather than ill-defined reconstruction of a "predevelopment" or "natural flow" condition.

6.2 The impacts of the proposed changes in the operation schedule of the inflatable dam to endangered species, flooding, and geomorphology are not evaluated by the proposal.

The Draft BA states, "The inflatable dam is typically raised in May and lowered in October-November. Depending on water supply conditions, the dam may be raised as early as March, and lowered as late as January (p 4-8)." The statement that the changed operation schedule will be entirely "dependent on water supply conditions" raises several issues. Other factors should be considered when deciding the operation schedule, including: (1) the life cycles of endangered species; (2) the increased risk of flooding; and (3) the associated erosion and sedimentation problems that could occur if a high flow event were to occur when the dam is inflated).

The several-mile long, dam/pool/water-diversion complex could negatively impact fish passage in both directions. Would fish be able to find their way through a 3-mile long pool of still water and over a large vertical barrier? Would a fish 3 miles away be able to detect the notch pictured in Photo 27 (p. 10-15)? The current May-October schedule mostly avoids the main migration periods for all three species (see Figure 2-3 of the Entrix report). [though good years with higher flows would likely have Chinook runs in mid-May through mid-June or even later] The proposed March-January schedule only has the dam deflated in February. This means the dam and pool would be present up to 11 months of the year (depending on water supply conditions), including the entire duration of the Coho and Chinook immigration periods (3 of 3 months and 5 of 5 months, according to Figure 2-3), 2/3 of the steelhead run, and most of the outmigration periods.

From a geomorphic perspective, the current May-October inflation period avoids most of the high flow season. The new March-January schedule would increase the probability that the dam will be inflated during a large flood event (especially because the dam has to be deflated slowly, p. 3-46). This could result in flooding problems, especially in the area around the Sonoma County Water Agency wells. Furthermore, potentially significant geomorphic and habitat-related problems could result if a large flood encounters the long reach of zero water surface slope. Sediment will deposit upstream of the dam, leading to probable bed material fining and potential habitat degradation for several miles above the dam. Also, since many contaminants and nutrients in the watershed bind to fine sediment, these materials are likely to accumulate in the pool during elevated flow periods. Below the dam, in a large flood there is the potential for channel narrowing and lowering, and bed coarsening. These geomorphic changes would be accompanied by changes in bank stability, vegetation type and density, and water temperature.

The proposed March-January operation schedule would increase the probability of such events. However, this possibility does not appear to have been studied. We recommend a detailed analysis of the impacts of such an event, and how they could be avoided. At a minimum, a statistical analysis of the flooding history could help determine an operation schedule that would reduce the probability of this happening to an acceptable level of risk.

6.3 The Draft BA does not explain the impact of the Flow Proposal on groundwater supplies.

Increasing the annual duration of impoundment and diversion at the inflatable dam would result in more water being diverted from the river. The Low Flow Proposal aims to increase the diversion from 75,000 AFY to 101,000 AFY at the diversion facility, thus reducing downstream flows by an average of 26,000 AFY (p. 4-14). No mention is made of interannual variability.

It would help to evaluate the impact of the increased diversion on groundwater supply in the context of a water budget. Although one has been modeled (Flugum, 1996) the water budget should be explained in order to demonstrate the magnitude of the impacts of increasing water diversions. Is 26,000 AFY a large or a small fraction of the water budget? One should not have to track down an obscure consulting document to find out the answer, because it is central to the proposed changes. The document needs more explanation of the water budget, its uncertainties, and the potential impact of the proposed changes on downstream water availability.

To the extent that the Russian River recharges the aquifer downstream of the diversion, increasing the volume of the diversion will lower the water table, affecting water wells downstream of Mirabel. This effect could be quantified using groundwater modeling exercises. The impact of this change is impossible to know without further study.

6.4 The Draft BA does not adequately explain how the system will be operated to maintain precise flows.

Regulating the downstream flows could be a complex operation depending not only on pumping rates but also on: inflow; infiltration rates through materials with complex patterns in infiltration capacity; evaporation from the pond surface; and flow under, over, and around the dam itself. It would help to elaborate on whether this is difficult to do from an engineering standpoint, or clarify whether there will be large discrepancies between the prescribed flows and the actual flows due to all the potential uncertainties.

6.5 Although the Flow Proposal is not likely to directly affect the channel shape, it could have a long term impact on channel geomorphology via changes in vegetation and bank stability.

Nearly all the geomorphic work in the Russian River occurs due to direct storm runoff, not during the dry season base flow; thus changing low flow values is not likely to influence the shape of the channel directly. The main geomorphic impact of changing the low season releases would probably be through their influence on bank vegetation, which affects bank stability and therefore channel width.

The proposal also suggests criteria for flood control (high flow) operations. The purpose of these operations “to the extent possible, [is] to prevent local flooding at Hopland, which generally occurs when flows in the Russian River exceed 8,000 cfs” (p. 4-3).

Using a local flooding threshold to determine flood control targets seems reasonable. However, in Section 3, the document indicates that the flood control thresholds were set based on an analysis of the hypothetical flow above which bank erosion is said to begin. What is the basis of the high flow targets - flooding or bank erosion?

The assumption in the bank erosion threshold analysis described on pp. 3-9 to 3-11 and in Appendix C that bank erosion occurs during a 1.1-year event seems somewhat arbitrary. A bed mobility calculation, for example, would provide a more realistic lower threshold for bank erosion. If this "bank erosion threshold" is used in practice to manage flood flows, it needs more thorough analysis.

6.6 The Draft BA does not provide adequate scientific justification for concluding that a closed Russian River estuary will improve salmonid rearing habitat.

At the bottom of p. 4-22 (and elsewhere) the Draft BA states, "A closed system is expected to improve rearing habitat for salmonids in the lower part of the river". Is this a hypothesis or a conclusion? Clearer explanation is needed.

6.7 The Draft BA does not adequately define the threshold for breaching the sandbar.

The Draft BA also states "artificial breaching would be undertaken when an imminent threat of flooding exists, or when the [water surface elevation] of the lagoon…will reach the 10-foot flooding elevation within 48 hours" (p. 4-31). The breaching threshold should be better defined to eliminate the risk of uncertainty and potential legal problems later on. If there is to be artificial breaching in order to avoid flooding, the timing should be laid out more explicitly, such as when National Weather Service forecasted storm totals (QPF) are larger than an agreed-upon amount.

6.8 The Draft BA does not consider alternative management strategies for the estuary.

For example, purchasing the flood-prone property in Jenner would remove one variable and simplify the question of how to best to manage the estuary system.

6.9 Additional comments outside the scope of the Flow Proposal.

a. The proposal to consolidate all the channel maintenance and sediment clearing activities in the watershed has considerable merit. However, these activities should be carried out within the context of an improved sediment budget for the watershed and tributaries which accounts for both gravel and fine sediment supplies. Like the water supply, the sediment load of the Russian River is a finite commodity with economic and ecological value. The allocation of this resource should be based on better knowledge of how much of it exists.
b. Can the costs of the proposed channel and vegetation maintenance program be offset by auctioning licenses to gravel miners to excavate in selected places where it would benefit bank protection, flood protection, and habitat? This could this help cover the costs of restoration and monitoring.

c. The vegetation maintenance plan should prioritize removal of nonnative invasive plants such as *Arundo donax*. This action benefits both flood control and habitat value.
d. A qualified, impartial scientist with a background in channel restoration and fluvial geomorphology should review both the "Channel Maintenance" and "Restoration Actions" components of the Draft BA.

7 REVIEW OF OTHER ISSUES

7.1 The Draft BA does not address impacts of the Flow Proposal on *Ludwigia* populations.

Ludwigia hexapetala, water primrose, is a perennial aquatic plant native to South America and the southeastern United States. In California, it is an aggressive weed that grows in dense mats along shorelines and into still or slow-flowing water. *Ludwigia* is rampant in the Laguna de Santa Rosa and is also common in parts of the mainstem Russian River. It spreads vegetatively through plant fragments. As plants are disturbed during higher flows, they exhibit a "baling effect", gathering into large bundles that trap sediment and create excellent conditions for new growth (Verdone, 2004). Because *Ludwigia* harbors the species of mosquito that has been identified as a carrier of the West Nile Virus, it poses a significant risk to human health. *Ludwigia* also affects water quality for fish and other aquatic wildlife by impacting diurnal dissolved oxygen levels. During the day as photosynthesis occurs, it produces more oxygen than it consumes, while at night the massive colonies can significantly reduce dissolved oxygen. In anaerobic conditions, such as can exist in warm, slow-moving water, decomposing plants create a slimy, smelly organic ooze on the channel bottom.

Sonoma State University graduate student Lily Verdone has identified three factors that affect the growth and spread of *Ludwigia hexapetala*—shade, velocity and water depth (Verdone, 2004). Each of these factors could be affected by the proposed low flow regime. *Ludwegia* does not thrive or establish in areas of deep shade. The low-flow proposal could reduce river channel width, thereby exposing bare banks inside of the established stream-side vegetation corridor to full sun and encouraging *Ludwigia* proliferation. *Ludwigia* grows best in areas of slow-flowing water with a depth of less than 90 centimeters. Even minor reductions in flow velocity and depth could result in new colonies of *Ludwigia.*

Ludwigia's growth rate may also increase as nutrient levels increase. If the proposed low-flow conditions concentrate nutrients, Ludwigia could grow even more vigorously than it already does. Verdone will be conducting a nutrient growth experiment this summer to examine growth rates under varying nitrogen and phosphate levels.

Recommendations for additional data collection:
1. Map current *Ludwigia hexapetala* populations. Determine where the proposed low flow regime will result in conditions that enable the spread of *Ludwigia.*

Assess the probability of new colonization by comparing existing populations with areas of potential new habitat.

2. Determine water velocity thresholds for *Ludwigia hexapetala* growth.
3. Assess the results of Verdone's nutrient experiments. If *Ludwigia hexapetala* growth is stimulated by increased levels of nitrogen and phosphate, determine the probability, frequency and duration that the proposed low flow regime could result in growth-stimulating nutrient concentrations.

8 REFERENCES

Note: The references are incomplete, and will be finished in the final report of the review.

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