TECHNICAL MEMORANDUM ◦ JULY 2013

North Gualala Water Company Pumping Limit Recommendations

PREPARED FOR

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Cover photos: Various locations in the North Fork Gualala River in 2011 and 2012.

Table of Contents

Tables

Figures

1 INTRODUCTION

1.1 Water Rights Permitting Background

The North Gualala Water Company (NGWC) holds water right Permit 14853, which authorizes the diversion of up to 2.0 cubic feet per second (cfs) of water from the North Fork Gualala River for municipal use. The NGWC makes diversions under Permit 14853 through NGWC's Production Wells (PW) 4 and 5. These wells are located approximately 200 feet (ft) from the North Fork Gualala River and pump water from alluvial materials adjacent to the river.

A 1978 State Water Resources Control Board (SWRCB or State Board) order on a NGWC petition for change in the authorized place of use in Permit 14853 established the present bypass flow requirements for the permit. These bypass flow requirements, which specify the minimum flows that must be in the river when any pumping of PW 4 and 5 is occurring, vary over the course of the calendar year, as follows:

- 40 cfs (15 November to 29 February)
- 20 cfs (1 March to 31 May)
- 4 cfs (1 June to 14 November)

The North Fork Gualala River's natural unimpaired (without diversion) flows during the 15 November to 29 February and the 1 March to 31 May bypass periods frequently are less than these minimum bypass flow requirements. However, the NGWC still must pump these wells to meet the demands of its municipal water customers during such conditions. To help address this issue, the NGWC has filed water right Application 31792 with the SWRCB. This application seeks a permit that will authorize NGWC to pump up to 0.7 cfs (185 acre-feet annual limit) of water from PW 4 and 5 during the 15 November through 31 May period. This permit would authorize the NGWC to divert water during times when diversions are not authorized under Permit 14853 (i.e., when flows are less than the bypass requirements in Permit 14853).

The NGWC has also filed petitions for extension of time for Permit 14853 with the SWRCB. These petitions request extensions of the deadline in Permit 14853 for applying water to full beneficial use. If these petitions are granted, then the NGWC will be authorized to continue to increase its diversions under Permit 14853 (when such diversions are authorized) as necessary to meet the demands of NGWC's customers.

In 2010, the State Board adopted its *Policy for Maintaining Instream Flows in Northern California Coastal Streams* (SWRCB 2010). The primary objective of this Instream Flow Policy is to ensure that the administration of water rights occurs in a manner that maintains instream flows needed for the protection of fishery resources (SWRCB 2010). To achieve this objective, the Policy establishes principles and guidelines for maintaining instream flows for the protection of fishery resources. The Policy allows water rights applicants and petitioners to implement the policy principles through regionally protective criteria (Section 2.2 of SWRCB 2010) or site-specific studies (Appendix C of SWRCB 2010).

For Application 31792 and the petitions for extension of time for Permit 14853, the NGWC has elected to conduct site-specific studies to help determine instream flow criteria that are protective of fishery resources in the North Fork Gualala River.

1.2 Site-specific Study Background

At the initiation of the site-specific study process, representatives of the NGWC met with representatives of SWRCB Division of Water Rights (DWR), National Marine Fisheries Service (NMFS), California Department of Fish and Wildlife (CDFW), and consultants. The purpose of this initiation meeting and the associated site visit was to discuss the NGWC's Application 31792 and petitions for extension of time for Permit 14853. The meeting was held on Thursday, 6 January 2011 at the NGWC offices and on the North Fork Gualala River. Issues covered during the meeting included:

- Introduction and background of the NGWC,
- Petitions for extension of time for Permit 14853 (Application 21883),
- Application 31792 and potential alternatives,
- Field visit to the river and PW 4 and 5,
- Development of a site-specific study plan and reconnaissance assessment, and
- Determination of which site-specific studies would be required and which studies would not be required.

This meeting also included discussions of the community's water use, NGWC's pumping of PW 4 and 5 and water rights history, North Fork Gualala River hydrology, other water sources, anadromous fish use of the river and critical life history periods, California Environmental Quality Act (CEQA) documentation, and project timelines. This multi-faceted discussion provided a holistic view of the project context. It was agreed during the meeting that upstream adult salmonid migration passage was the critical issue that would require a site-specific study (Phase I study). It also was agreed that the background information for all the study elements specified in Appendix C of SWRCB (2010) would be addressed through a Reconnaissance Assessment (RA) and study plan. It was agreed that development of the Phase II study plan (juvenile passage and rearing habitat) for the petitions for extension of time for Permit 14853 (Application 21883) would occur at a later date.

A follow-up email from the DWR dated 7 February 2011 indicated approval for combining the RA and Phase I study plan in one document. This combined RA and study plan (Stillwater Sciences 2011a) was submitted to the DWR on 14 March 2011. The DWR forwarded the RA and study plan to CDFW and NMFS for review and comment. No comments were received from CDFW or NMFS on the RA and Phase I study plan and it was finalized on 2 June 2011.

On 8 June 2011, a conference call was conducted that included representatives of DWR, NMFS, CDFW, NGWC, and consultants for the purpose of identifying fisheries-related issues of concern that would lead toward the development of the Phase II site-specific study plan for the petitions for extension of time for Permit 14853 (Application 21883). Issues of concern included potential effects of NGWC's pumping of PW 4 and 5 on juvenile steelhead passage over riffles, juvenile steelhead rearing habitat, and benthic macroinvertebrate production. In the interest of time, and in acknowledgement that the river hydrograph was falling, the 8 June 2011 conference call participants agreed that adult steelhead passage data collection could commence prior to completion of the Phase II study plan.

The draft Phase II study plan was submitted to the DWR on 11 July 2011. The DWR forwarded the draft to CDFW and NMFS. Comments were received from NMFS on 5 August 2011 and incorporated into the final study plan. No comments on the Phase II study plan were received

from CDFW. The study plan (Stillwater Sciences 2011b) was finalized on 5 October 2011 and submitted to the DWR.

Field data collection on the Phase I study commenced on 27 April 2011 and was completed on 4 August 2011. The Phase II study field work began on 12 July 2012 and ended on 5 October 2012. The Site-specific Studies Report (Stillwater Sciences 2012), which presents the results of the Phase I and Phase II studies, was submitted to the DWR on 31 December 2012. CDFW submitted comments on the report on 27 February 2013. No comments were received from NMFS. NGWC submitted responses to CDFW's comments on 22 May 2013.

In summary, the Phase I and II study plans were developed in consultation with the state and federal regulatory agencies, were subject to formal review periods, and incorporated comments on the draft plans that were received from DWR and NMFS. The study plans were implemented as approved and any variances from the plan were explained in the Site-Specific Studies Report.

1.3 Purpose of This Technical Memorandum

The purpose of this technical memorandum is to describe the recommended limits on NGWC's pumping of PW 4 and 5 at various North Fork Gualala River flows and under various conditions. These recommendations are based, in part, on the results of the Phase I and II studies and, if implemented, will be protective of adult and juvenile salmonids in the North Fork Gualala River.

2 RECOMMENDED PUMPING LIMIT SCHEDULES

2.1 New Maximum Authorized Pumping Rates

The NGWC is considering asking the SWRCB to reduce the maximum authorized pumping rate in Permit 14853 from the current rate of 2.0 cfs to: (a) 0.7 cfs during 15 November through 31 May; and (b) 1.0 cfs during 1 June through 14 November. These reductions would significantly reduce the potential for NGWC's pumping of PW 4 and 5 to have impacts on adult and juvenile salmonids and other aquatic resources in the North Fork Gualala River. Additional reductions in pumping rates would occur in accordance with the proposed schedules of pumping limits described in the following sections of this report.

2.2 Pumping Limit Schedule for Adult Steelhead Migration Season

2.2.1 Adult steelhead migration pumping limit season

DeHaven (2008) determined that the steelhead spawning season in the Gualala River ran from the first day after 1 November that the Wheatfield Fork Gualala River gage (or Navarro gage) exceeded 500 cfs to 30 April. This season matches closely to the general depiction of the adult upstream migration season in Figure 1. DeHaven based his determination on data he collected during several years of spawning surveys. Typically, the spawning season began between 22 November and 22 December (DeHaven 2010). However, it is likely that adult steelhead enter the Gualala River estuary as soon as the sand bar between the estuary and the ocean breaches.

The frequency and duration of the sand bar closure is a function of river flow and wave action. A record of whether the bar was open was kept during the fish passage data collection effort for the Site-Specific Studies Report. Although no data on wave action were collected, the fish passage data sheets recorded that the sand bar was open to the ocean when North Fork Gualala River

flows were 40 and 60 cfs, and that the sand bar was closed when North Fork Gualala River flows were 10 and 20 cfs. The sand bar opened and closed intermittently during the week of 28 January 2013 when the North Fork Gualala River flow was 20 cfs (J. Bower, NGWC, pers. comm., 4 February 2013). The sand bar was fully closed when the North Fork Gualala River flow was 18 cfs (J. Bower, NGWC, pers. comm., 4 February 2013).

For the development of the pumping limit recommendations in this report, we recommend that the adult steelhead migration season be deemed to begin when the sand bar first breaches after 1 November and that this season end on 15 June of each year. Given that the sand bar typically breaches when North Fork Gualala River flows approach 20 cfs, we recommend that daily observations of the sand bar and daily recordings of the sand bar condition (open or closed) begin on the first day after 1 November when the maximum daily flow at the USGS North Fork Gualala River gage exceeds 15 cfs and continue through 15 June.

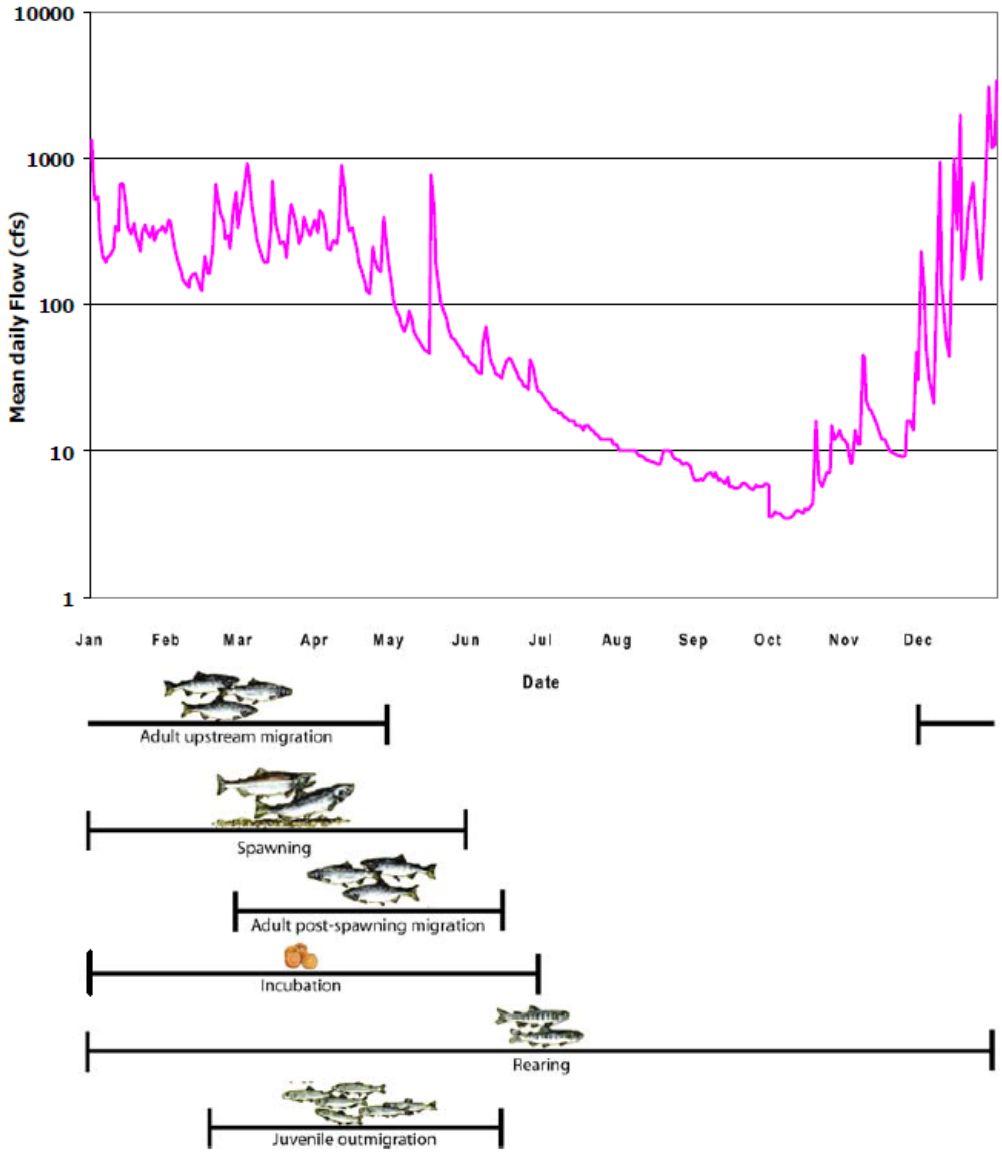

Figure 1. USGS North Fork Gualala River gage (#11467553) daily mean flow for period of record (2000–2006) and generalized steelhead life history timing.

2.2.2 Pumping limit schedule initiation

The approved Phase I study plan included using the Thompson (1972) protocol to help determine flows necessary for adult steelhead passage. The Thompson (1972) protocol states that adequate fish passage for adult steelhead is provided when riffle depth is at least 0.6 ft for a continuous 10% of the riffle's width and a total of 25% of the riffle's width. The Phase I study determined that a flow in the North Fork Gualala River to maintain at least 0.6 ft of water depth over the 10% continuous riffle width occurred at 23 cfs (Stillwater Sciences 2012). The Phase I study also determined that 25% of the total riffle width was greater than 0.6 ft deep at a river flow of 40 cfs. Because the Thompson (1972) protocol requires that both the 10% and 25% riffle width criteria be satisfied, the Phase I study determined that 40 cfs was necessary to provide adequate adult steelhead passage under this protocol.

However, adult steelhead typically have body widths that are less than 0.5 ft and therefore do not require migration lanes in riffles that are 10% or 25% of the total channel width. For example, Bell (1991) recommended a minimum passage width of 1 ft for large bodied salmon in the design of fishways. Similarly, upstream adult steelhead passage was considered feasible by R2 Resources (2008) when a minimum 2-ft wide contiguous portion of the cross-section profile had a depth equaling or exceeding minimum depth criteria. In addition, steelhead (and other adult salmonids) are very capable of passing riffles that are shallower than their body depths (See Figure 3-1 in Stillwater Sciences 2012).

Based on these factors, we recommend that the NGWC pumping limits begin when North Fork Gualala River flows during the adult steelhead migration season drop to 30 cfs or less. The 30 cfs flow rate is 7 cfs higher than the 23 cfs flow rate that occurs when the 10% continuous riffle width criterion is satisfied, as determined in the Phase I study (Stillwater Sciences 2012). The Site-specific Studies Report (Stillwater Sciences 2012) determined that, at a 30 cfs river flow, there will be 15% of continuous riffle width that is >0.6 ft deep. At a river flow of 30 cfs, post-spawn runback steelhead (kelts) also will have unhindered passage during their downstream migrations, especially because they are much thinner than pre-spawned adults and are travelling with the current.

We recommend that the pumping limits shift from the schedule for the adult migration season that is described in this section 2.2 to the schedule for the juvenile rearing season that is described below in section 2.3 if the sand bar between the Gualala River estuary and the ocean closes for more than two weeks during the adult migration season. It is expected that such a two week window following sand bar closure will be sufficient to allow unhindered passage for kelts through the diversion-affected reach and access to the estuary. If the sand bar later re-opens before 15 June, then the pumping limits would shift back to the schedule for the adult migration season.

This pumping limit schedule would not be in effect when North Fork Gualala River flows exceed 30 cfs.

2.2.3 Adult steelhead migration pumping limit schedule

The NGWC is considering asking the SWRCB to reduce the maximum authorized pumping rate in Permit 14853 from the current rate of 2 cfs to: (a) 0.7 cfs during 15 November through 31 May; and (b) 1.0 cfs during 1 June through 14 November. Besides these reductions in maximum authorized pumping rates, we recommend that NGWC also be subject to a schedule of pumping limits that will begin to go into effect when North Fork Gualala River flow drops to 30 cfs or less.

This schedule will specify incremental decreases in maximum authorized pumping rates as the North Fork Gualala River hydrograph continues to recede. We recommend that the maximum authorized pumping rate during this season will at no point exceed 5% of the river flow, as measured at the USGS North Fork Gualala River gage.

Thalweg depth measurements were taken at the D2 riffle crest during the 2011 Phase I data collection effort. The D2 riffle was the shallowest riffle in the Phase I study area during 2011 and was located immediately downstream of the USGS gage. When plotted on a graph (Figure 2), a riffle crest depth-to-flow regression curve was developed based on the following equation:

$$Y = 0.1549X^{0.3889}$$

Where: Y = thalweg depth (ft) and X = flow at USGS gage

Using this regression curve and assuming that the PW 4 and 5 total pumping rate has a 1:1 correspondence to reductions in river flows (the maximum possible effect that this pumping can have on river flows), the predicted impact of maximum pumping rates on riffle crest depth and fish passage depth can be estimated. At a river flow of 30 cfs, a 0.7 cfs pumping rate would change the thalweg riffle crest depth by <0.01 ft (Table 1). Similarly, a 0.5 cfs pumping rate would result in a 0.01 ft change in riffle crest depth at a river flow of 10 cfs. Therefore, it can be expected that the effect on riffle depth would be approximately 0.01 ft if pumping rates always are kept at or below 5% of the river flow, as measured at the USGS North Fork Gualala River gage.

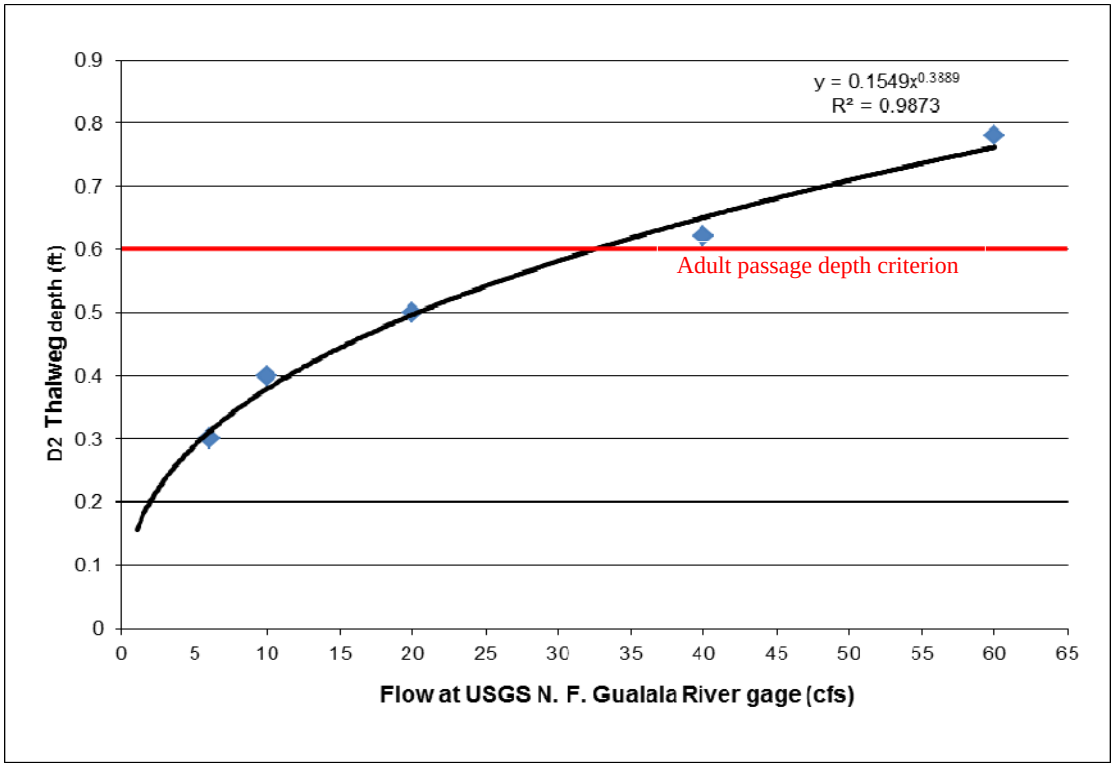

Figure 2. Thalweg depth at the downstream reach cross-section D2 in the North Fork Gualala River (Stillwater Sciences 2012).

Table 1. Thalweg riffle crest depth-to-flow relationship at the D2 riffle.

Flow (cfs) at USGS North Fork Gualala River gage	Thalweg depth (ft)	Pumping rate (cfs)	Post-pumping thalweg depth (ft)	Change in thalweg depth (ft)
30	0.58	0.7	0.57	<0.01
25	0.54	0.65	0.5	<0.01
20	0.50	0.6	0.49	0.01
15	0.44	0.55	0.44	<0.01
10	0.38	0.5	0.37	0.01

We recommend the adult steelhead migration pumping limit schedule be in effect during the period from the first breaching of the sandbar after 1 November through 15 June. We also recommend that this schedule be in effect for two weeks following any closure of the bar during this period. If one of these circumstances is not in effect, then the juvenile bypass flow schedule discussed in the following section would be in effect. If the sand bar re-opens any time before 15 June, then the adult migration schedule would go back into effect. Either this schedule or the following schedule for juvenile steelhead rearing would in effect at any time, but both schedules never would be in effect at the same time.

2.3 Pumping Limit Schedule for Juvenile Steelhead Migration Season

Juvenile steelhead migration primarily occurs during two life history stages. The first type of movement occurs during the smolting process when juvenile steelhead migrate downstream during the spring and early summer to the Gualala River estuary and the ocean. The water depths in riffles typically do not limit passage during the smolt migration period because this type of passage occurs when river flows still are relatively high. The second type of juvenile movement occurs year-round during freshwater residency and includes the following types of movements: (a) dispersal in response to high fish density or territorial competition, (b) searches for food resources or improved water quality conditions, and (c) flights to escape predation pressures. Very low flows in the late summer or fall may inhibit one or more of these types of passage by freshwater rearing steelhead.

The body length of a steelhead smolt ranges from 6 to 8 inches (Bell 1991). Based on Powers and Orsborn's (1985) length-to-height ratio of 5:1, an 8-inch fish would have a body depth of 0.13 ft (1.6 inches). Age 0+ and 1+ (younger) fish would have smaller body depths. In contrast, the Phase II study concluded that a 0.2 ft depth criterion would allow for adequate juvenile steelhead passage over riffles. The Phase II study utilized the Thompson (1972) 10% continuous and 25% total riffle width protocol for juvenile steelhead. The Phase II study determined that the criteria of 10% continuous and 25% total riffle widths being least 0.2 ft deep were met at a North Fork Gualala River flow of about 1 cfs (Stillwater Sciences 2012).

These criteria are likely to be more than sufficient for juvenile steelhead migration, because a juvenile steelhead that has a body width of 0.1 ft migrating through a 20-ft-wide riffle with suitable depth does not actually require either the 10% continuous (2 ft) or 25% total (5 ft) width to be able to pass.

2.3.1 Juvenile steelhead pumping limit season

We recommend that juvenile steelhead passage bypass flow requirements begin on 16 June and end when the sand bar at the mouth of the Gualala River first breaches after 1 November. In addition, we recommend that juvenile bypass flow requirements be in effect if the sandbar closes for more than two weeks during the adult bypass flow season. With these criteria, the juvenile steelhead migration pumping limit schedule will be in effect whenever the adult steelhead migration pumping limit schedule is not in effect.

2.3.2 Pumping limit schedule initiation

We recommend a sliding scale pumping limit schedule that will go into effect when North Fork Gualala River flows drop to 10 cfs or less, with incremental decreases in the maximum authorized pumping rates as the river hydrograph continues to recede. These pumping limits would not be in effect when river flows exceed 10 cfs.

2.3.3 Juvenile steelhead pumping limit schedule

We recommend that once North Fork Gualala River flows at the USGS gage drop to 10 cfs or less, the maximum authorized pumping rate would not exceed 1.0 cfs or 10% of the river flow at any time. The sliding scale pumping limit schedule for juvenile steelhead was developed using a similar method as that used to develop the adult steelhead pumping limit schedule.

Thalweg depth measurements were taken at the shallowest riffle crest (D3) identified during the 2012 Phase II juvenile passage data collection effort[1]. Thalweg depth data were collected at river flows of 9.4, 8.2, 5.3, 4.8, and 3.0 cfs. When plotted on a graph (Figure 3), a riffle crest depth-to-flow regression curve was developed based on the following equation:

$$Y = 0.1133X^{0.5543}$$

Where: Y = thalweg depth (ft) and X = flow at USGS gage

Using the regression curve and assuming that the PW 4 and 5 total pumping rate has a 1:1 correspondence to reductions in river flows (the maximum possible effect that this pumping can have on river flows), the predicted impact of pumping rates on riffle crest depth and fish passage depth can be estimated. At 10 cfs, a 1.0 cfs pumping rate would change the thalweg riffle crest depth by 0.03 ft (Table 2). Similarly, a 0.1 cfs pumping rate would result in a 0.01 ft change in riffle crest depth at a river flow of 1 cfs. It can be expected that the effect on riffle depth would be in the range of 0.01–0.03 ft if pumping rates always are kept at or below 10% of the river flow as measured at the USGS North Fork Gualala River gage. Therefore, implementation of the pumping limit flow schedule is expected to have insignificant effects on juvenile fish passage.

[1] The D2 riffle was the shallowest riffle during the 2011 Phase I study. D3 was the shallowest riffle during the 2012 Phase II study.

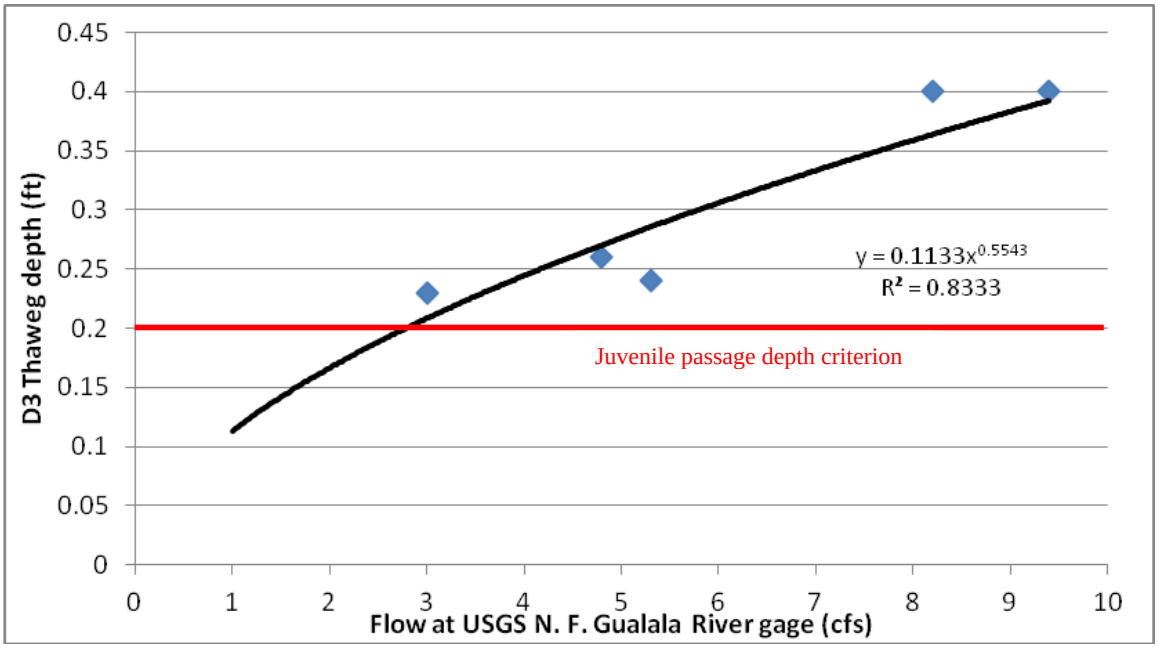

Figure 3. Thalweg depth at the downstream reach cross-section D3 in the North Fork Gualala River (Stillwater Sciences 2012).

Table 2. Thalweg riffle crest depth to flow relationship at the D3 riffle in response to well pumping.

Flow (cfs) at USGS gage	Pre-pumping thalweg depth (ft)	Pumping rate (cfs)	Post-pumping thalweg depth (ft)	Change in thalweg depth (ft)
10	0.41	1.0	0.38	0.03
9	0.38	0.9	0.36	0.02
8	0.36	0.8	0.34	0.02
7	0.33	0.7	0.31	0.02
6	0.31	0.6	0.29	0.02
5	0.28	0.5	0.26	0.02
4	0.24	0.4	0.23	0.01
3	0.21	0.3	0.19	0.02
2	0.17	0.2	0.15	0.02
1	0.11	0.1	0.10	0.01

2.4 Edgewater Habitat

2.4.1 Seasonal appropriateness

As described in the Site-specific Studies Report (Stillwater Sciences 2012), the greatest potential for impacts to steelhead fry associated with the loss of edgewater habitat would occur during the spring and early summer and at riffles. This is because the spring and early summer are when fry emergence occurs, these fry are actively utilizing the large substrate in the edgewaters at riffles,

and river flows are relatively high. The loss of edgewater habitat during the late summer and fall has lesser impacts because by that time the fish have grown larger and mostly inhabit deeper and faster water.

Differences in edgewater habitat availability for steelhead fry at various river flows were assessed by calculating the changes in the wetted channel width at the adult fish passage cross-sections. In general, riffle cross-section wetted widths decreased as North Fork Gualala River flows dropped from 60 to 6.4 cfs in 2011 (Table 3). In 2011, the upstream reach cross-sections averaged a 56% decrease in wetted channel width as flows dropped from 60 to 6.4 cfs, while the cross-sections in the downstream reach narrowed by an average of 24%. This reduction in wetted width resulted in a corresponding decrease in shallow edgewater habitat areas. However, the decrease in edgewater habitat occurred after the time when steelhead fry utilization of these habitats would be heaviest.

Table 3. Riffle cross-section widths within the North Fork Gualala River Phase I study reach in 2011 (Stillwater Sciences 2012).

Cross-section	Riffle cross-section wetted width (ft)				
	60 cfs	40 cfs	20 cfs	10 cfs	6.4 cfs
U1a	88.2	80	66	24.3	10.5
U1b	nd	39.7	38	36.8	19.3
U2	30.1	29.3	27.5	26.5	21.7
D1	47.8	46.1	42	41.4	40.6
D1b	nd	59	44	42.7	41.3
D2	66.4	66	52	52.6	49.3

As stated above, riffle cross-section width data were collected at river flows of 60, 40, 20, 10, and 6.4 cfs during the 2011 Phase I study. When plotted on a graph (Figure 4), a riffle width-to-flow regression curve for cross-section D2 (shallowest riffle during the Phase I study) was developed based on the following equation:

$$Y = y = -0.0043x^2 + 0.6251x + 45.118$$

Where: Y = riffle width (ft) and X = flow at USGS North Fork Gualala River gage

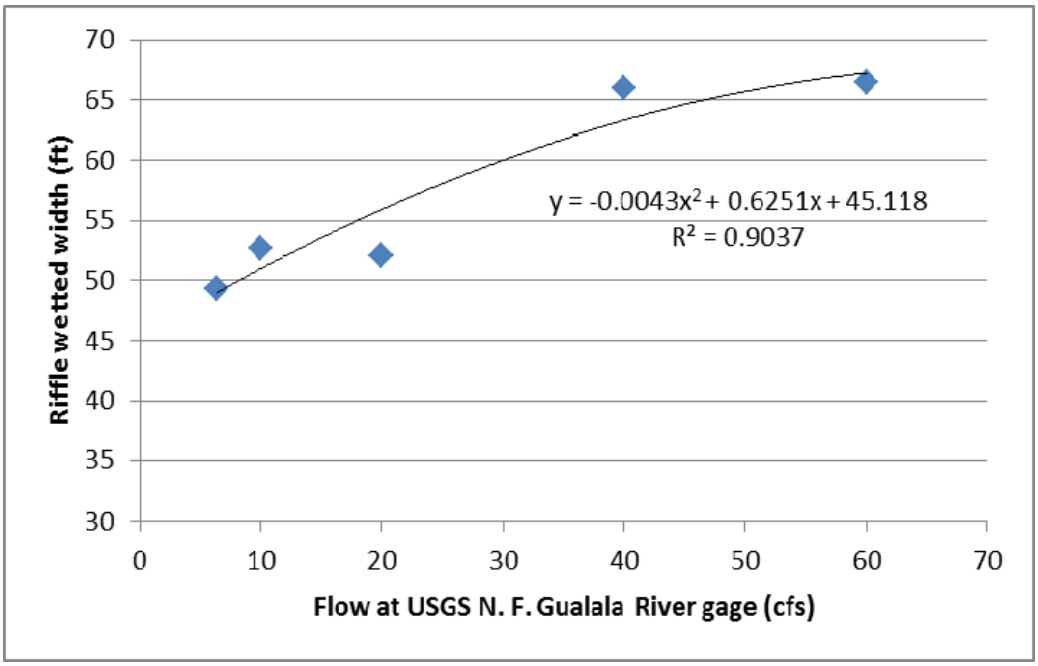

Figure 4. Riffle width to discharge relationship at the D2 cross-section during the Phase I study (Adapted from data in Stillwater Sciences 2012).

Using the regression curve equation and assuming that the PW 4 and 5 total pumping rate has a 1:1 correspondence to reductions in river flows (the maximum effect that this well pumping can have on river flows), the predicted impact of the proposed maximum authorized adult steelhead passage pumping rates on riffle width and edgewater habitat can be estimated. The adult steelhead passage season is the period of time when edgewater habitats are being utilized by fry. At a river flow of 30 cfs, a PW 4 and 5 total pumping rate of 0.7 cfs would reduce riffle width from 60 to 59.7 ft. At a river flow of 10 cfs, a 0.5-cfs pumping rate would reduce riffle width from 50.9 to 50.6 ft. These very small reductions in riffle widths indicate that the maximum pumping rates proposed for adult steelhead passage protection are expected to have only minimal impacts on the amount of edgewater habitat in the reach of the North Fork Gualala River that may be affected by this well pumping.

2.5 Benthic Macroinvertebrates

Benthic macroinvertebrate (BMI) assessment data were collected during the juvenile passage field effort. The data show that riffle area and preferred BMI habitat [riffles >0.3 ft deep and water velocity >1 foot per second as described in the Phase II study plan (Stillwater Sciences 2011b)] availability decreased as river flows declined during the summer and fall months. In some cases, the percentages of cross-section widths that met the BMI criteria dropped to 0 at a river flow of 3 cfs. Riffle area in the upstream and downstream reaches decreased by an average of 41 and 27 percent, respectively, as the river flow decreased from 9.4 to 3.0 cfs (Stillwater Sciences 2012).

Even though the 0.3 ft depth criterion was not met at the lower river flows, BMI production did not actually stop. Mayfly larvae were observed under cobbles in shallow edgewaters and juvenile steelhead were consistently observed actively feeding in the pools downstream of riffle cross-sections when river flows were approximately 3 cfs. In addition, Stillwater Sciences (2009)

recorded macroinvertebrate drift rates that ranged from 21 to 93 mg/hr with a density of between 0.234 and 0.741 mg/m³ while river flows ranged from 1.4 to 3.9 cfs.

It is unknown if the observed reduction in preferred BMI habitat, in response to decreasing flows in the North Fork Gualala River, resulted in any significant adverse effects on juvenile steelhead. Other food resources were available from tree canopy, streamside brush, insect production in pools and runs, and at least some drift from riffles. The low number (one to five) of fish observed in the pools downstream of the study riffles indicated that demand and competition for food resources may have been relatively low. Because a greater reduction in riffle area occurred upstream of the PW 4 and 5 reach, where river flow was lower, it was likely that the amount of BMI drift was also correspondingly less upstream. However, the potential effects of the pumping would occur in and downstream of the PW 4 and 5 reach and not upstream, so we conducted a riffle area change analysis to determine the potential effects of the proposed pumping schedule on riffle area. We focused on riffles because this is where a significant amount of BMI production occurs.

The D2 riffle was selected for this analysis because it was the widest riffle within the pumping-affected reach of the North Fork Gualala River, had the flattest cross-section between the thalweg and wetted edges, and experienced the greatest decrease in riffle area (1,620 to 1,046 ft²) as the hydrograph declined during the Phase II study (Stillwater Sciences 2012). In addition, effects of well pumping would be most acute during the low flow season when riffle areas are the smallest. Using riffle area and flow data from the Phase II study (Stillwater Sciences 2012), a riffle area-to-flow regression curve for riffle D2 was developed (Figure 5) based on the following equation:

$$y = -14.116x^2 + 270.07x + 330.82$$

Where: y = riffle area (ft²) and x = flow at USGS North Fork Gualala River gage

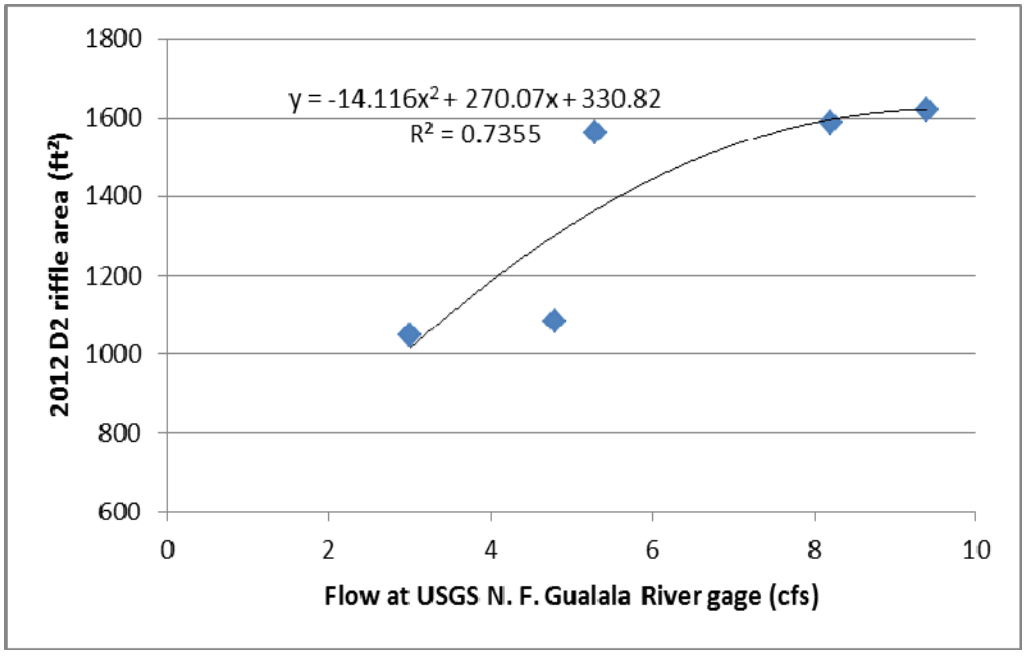

Figure 5. Riffle area to flow relationship at the D2 riffle during the Phase II study (adapted from data in Stillwater Sciences 2012). Note: The steep decrease in riffle area between the 5.3 and 4.8 cfs flows was due to the development of a dry mid-channel bar.

Using this regression curve equation and assuming that the PW 4 and 5 total pumping rate has a 1:1 correspondence to reductions in river flows (the maximum effect that this well pumping can have on river flows), the predicted impact of the proposed maximum authorized juvenile steelhead passage pumping rates on riffle area can be estimated. At a river flow of 10 cfs, a 1 cfs pumping rate would result in a <1% decrease in riffle area (Table 4). At a river flow of 3 cfs, a 0.3 cfs pumping rate would reduce riffle area by <6%.

Table 4. Estimated changes in riffle area at the D2 riffle in response to the juvenile steelhead pumping schedule (i.e. <10% of USGS gage flow).

USGS gage flow (cfs)	Riffle area at USGS gage flow (cfs)	Pumping rate (cfs)	USGS gage flow (cfs) under juvenile pumping schedule	Riffle area under pumping schedule (ft^2)	Percentage decrease in riffle area (%)
10	1,620	1	9	1,618	<1
8	1,588	0.8	7.2	1,544	<3
5	1,328	0.5	4.5	1,260	5
4	1,185	0.4	3.6	1,120	5
3	1,014	.03	2.7	957	<6

The effects of the juvenile steelhead pumping schedule on riffle depth range from 0.01 to 0.03 ft and the greatest changes in riffle area would occur at the channel margins where the water velocity is the lowest and BMI production is relatively low. The deeper areas of the riffle that produce most of the BMI would remain underwater. Therefore, it is expected that the proposed juvenile steelhead pumping schedule would have minimal impacts on riffle area and BMI production in the reach of the North Fork Gualala River that may be affected by NGWC's well pumping.

2.6 Age 2+ Steelhead Habitat

In general, the quantity and quality of age 2+ steelhead habitat diminishes with decreasing river flows. This is true in the reach influenced by NGWC's pumping of PW 4 and 5 and in upstream reaches that are not affected by this pumping. The site-specific studies did not develop enough information to develop pumping limit recommendations for age 2+ steelhead; however, the study did identify the need for additional large woody debris (LWD) in the river to help offset the loss of suitable habitat as flows diminish during the late summer and fall. Therefore, in lieu of attempting to develop such pumping limit recommendations, we instead recommend that the NGWC install LWD in the reach affected by their operations or contribute to the Gualala River Watershed Council's (GRWC) habitat restoration program that targets wood placement in the North Fork Gualala River. The locations and types of LWD placement would be determined in consultation with the GRWC and CDFW.

3 SUMMARY

- The NGWC is considering asking the SWRCB to reduce the maximum authorized pumping rate in Permit 14853 from the current rate of 2 cfs to: (a) 0.7 cfs during 15

November to 31 May, and (b) 1.0 cfs during 1 June through 14 November. These reductions will significantly reduce the potential for NGWC's pumping of PW 4 and 5 to have impacts on aquatic resources in the North Fork Gualala River.

- We recommend that daily sand bar observations be conducted beginning on the first day after 1 November when maximum daily flow at the USGS North Fork Gualala River gage exceeds 15 cfs, and that data of the condition of the sand bar (open or closed) be recorded for each day of such observations. Such observations should continue through June 15 of the following year.
- We recommend that the following schedule of pumping limits (Table 5) for NGWC's total pumping of PW 4 and 5 be in effect beginning on the day that the barrier sand bar at the mouth of the Gualala River breaches for the first time after 1 November of each year, and that this schedule then remain in effect through 15 June, except that this schedule will not be in effect beginning two weeks following any closure of the river mouth during the 1 November through 15 June period or for the remaining duration of that closure:

Table 5. Schedule of maximum authorized pumping limits for adult steelhead passage.

Flow (cfs) at USGS North Fork Gualala River gage	Maximum Authorized Pumping Rate (cfs)*
30	0.7
25	0.65
20	0.6
15	0.55
10	0.5

* For river flows between the flow steps listed in this table, the NGWC may use linear interpolation to determine the maximum authorized pumping rate. For river flows less than 10 cfs, the maximum authorized pumping rate will be 5% of the river flow measured at the USGS Gage.

- We recommend that the following juvenile migration pumping limit schedule (Table 6) go in to effect on 16 June and remain in effect until the first day after 1 November when the sand bar at the mouth of the Gualala River breaches, and that this schedule also be in effect during all other times when the adult steelhead passage pumping limit schedule is not in effect:

Table 6. Schedule of maximum authorized pumping limits for juvenile steelhead passage.

Flow (cfs) at USGS gage	Maximum Authorized Pumping Rate (cfs)*
10	1.0
9	0.9
8	0.8
7	0.7
6	0.6
5	0.5
4	0.4
3	0.3
2	0.2
1	0.1

* For river flows between the flow steps listed in this schedule, the NGWC may use linear interpolation to determine the maximum authorized pumping rate. For river flows less than 1 cfs, the maximum authorized pumping rate will be 10% of the river flow measured at the USGS gage.

- Implementation of the recommended adult steelhead passage pumping limit schedule is not expected to have any significant adverse effects on edgewater habitat for steelhead fry.
- Implementation of the juvenile steelhead pumping limit schedule is expected to have only minimal impacts on riffle area and BMI production.
- No pumping limits are recommended specifically for age 2+ steelhead habitat. Instead, we recommend that the NGWC install LWD in the reach of the North Fork Gualala River that may be affected by NGWC's pumping of PW 4 and 5, or that NGWC contribute to the GRWC restoration program that targets LWD placement in the North Fork Gualala River. The locations and types of wood structures would be determined in consultation with the GRWC and CDFW.

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