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14 Central Delta Water Agency, Lafayette Ranch,
15 Heritage Lands, Mark Bachetti Farms
16 and Rudy Mussi Investments L.P.

17 [ADDITIONAL PARTIES AND COUSNEL LISTED ON FOLLOWING PAGE]

18 **STATE OF CALIFORNIA**

19 **STATE WATER RESOURCES CONTROL BOARD**

20 Hearing in the Matter of California
21 Department of Water Resources and
22 United States Department of the Interior,
23 Bureau of Reclamation Request for a
24 Change in Point of Diversion for
25 California Water Fix

26 **SUR REBUTTAL TESTIMONY OF
27 JEFFREY MICHAEL**

28 **Joint Sur Rebuttal: Protestants South Delta
Water Agency, Central Delta Water Agency,
Lafayette Ranch, Heritage Lands, Mark
Bachetti Farms And Rudy Mussi Investments
L.P and County of San Joaquin,
San Joaquin County Flood Control and
Water Conservation District, and
Mokelumne River Water and Power
Authority**

1 *Joint Sur Rebuttal: Protestants South Delta Water Agency, Central Delta Water Agency, Lafayette Ranch, Heritage Lands, Mark Bachetti Farms And Rudy Mussi Investments L.P. and Local Agencies of the North Delta, Delta Watershed Landowner Coalition, Bogle Vineyards, Diablo Vineyards, Stillwater Orchards and Islands, Inc.*

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2 | *Joint Sur Rebuttal: Protestants South Delta Water Agency, Central Delta Water Agency, Lafayette Ranch, Heritage Lands, Mark Bachetti Farms And Rudy Mussi Investments L.P. and Local Agencies of the North Delta, Delta Watershed Landowner Coalition, Bogle Vineyards, Diablo Vineyards, Stillwater Orchards and Islands, Inc.*

1 I, Jeffrey Michael, do hereby declare:

2 **I. INTRODUCTION**

3
4 I am Executive Director of the Center for Business and Policy Research and Professor
5 of Public Policy at the University of the Pacific. Economic and policy issues in the Delta have
6 been a major focus of my research and the Center's work since I came to Pacific in 2008, both
7 because of its importance to the regional economy that is the Center's focus and its fit with my
8 own educational and research background in agricultural and resource economics and
9 economic development. I received my Ph.D. in Economics from North Carolina State
10 University in 1999, and my dissertation was one of the first empirical studies of the economic
11 effects of the Endangered Species Act. I received a National Needs Fellowship from the U.S.
12 Department of Agriculture to support my Ph.D. studies in the economics of natural resource
13 management. I completed graduate coursework in agricultural economics and regional
14 economics, received the outstanding graduate student research award from the Southern
15 Agricultural Economic Association, and have published in scholarly journals in agricultural
16 economics. My Delta research experience includes being Principal Investigator of the Delta
17 Protection Commission's Economic Sustainability Plan in 2011-12, and benefit-cost studies of
18 the Bay Delta Conservation Plan ("BDCP") tunnels in 2012, and the WaterFix in 2016, which
19 are the only economic analyses of the tunnels project consistent with the assumptions in the
20 WaterFix EIR and the subject change Petition ("Petition").

21 This sur-rebuttal testimony responds to the rebuttal testimony of Dr. Christopher
22 Thornberg (DWR 84). As made clear by Dr. Thornberg's testimony, he has no training and
23 experience in agricultural economics, and he has never studied Delta agriculture or the broader
24 Delta economy (DWR 23). Given this lack of background, one would expect that Dr.
25 Thornberg would have spent considerable time reading relevant studies of the Delta
26 agricultural economy, familiarizing himself with existing data on Delta agriculture, and
27 consulted other agricultural economists who have worked in this area, including many
28 consulting and staff economists of the agency who retained him, DWR. He did not.
(Transcript 5/10/2017, page 123, lines 7-9) Instead, Dr. Thornberg focused most of his time

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1 and testimony on producing an empirical yield model using aggregate crop reports for San
2 Joaquin County that are obviously irrelevant and flawed with respect to the Delta-specific
3 questions at hand. His critique of my testimony a) shows he has not read or does not
4 understand critical, previous studies including the data, empirical approach or findings, b) has
5 no knowledge of basic facts about Delta agriculture and how farmers make decisions, c)
6 misrepresents my testimony and makes false comments about my handling of data, and d)
7 shows poor knowledge of current and proposed state policies relevant to his economic analysis.

8 The next sections outline many of the critical inaccuracies in Dr. Thornberg's rebuttal
9 testimony on the following topics:

- 10 • Basic information and concepts about Delta farming.
- 11 • Crop Choice Model utilized by me and Dr. David Sunding in reports for the
12 Delta Protection Commission and Department of Water Resources.
- 13 • Dr. Thornberg's countywide empirical yield model.
- 14 • Delta specific theoretical yield model in my testimony.
- 15 • Delta levees and potential non-agricultural economic harm to Delta water users
16 and the regional economy.
- 17 • Non-agricultural economic impacts

18 19 **II. Basic information and concepts about Delta farming.**

20 This section reviews Dr. Thornberg's lack of basic knowledge that results in multiple
21 errors throughout his testimony.

22 *II.A. Dr. Thornberg has not read previous studies of Delta agriculture, including those
23 that are the foundation of the testimony he attempts to rebut.*

24 My testimony on Delta agriculture was brief, primarily summarizing the results of
25 previous studies of Delta agriculture. In cross-examination (Transcript 5/10/2017, page 123,
26 lines 7-9), Dr. Thornberg stated that he had not read the key studies that were the basis of my
27 testimony, the Department of Water Resource's 2013 BDCP Statewide Economic Impact
28 Report (SDWA 136) or the 2012 Delta Protection Commission Economic Sustainability Plan

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1 (SDWA 137, RTD 301, RTD 305). Dr. Thornberg's unawareness and misunderstanding about
 2 previous Delta studies' data, methods and key findings pervades multiple components of his
 3 rebuttal testimony.

4
 5 *II.B. Dr. Thornberg does not know basic, widely-reported facts concerning what crops are*
 6 *most commonly grown in the Delta, and how these crops differ from surrounding areas.*

7 Many of the arguments and empirical approach in Dr. Thornberg's rebuttal do not make
 8 any sense to anyone with basic knowledge of Delta agriculture, so Mr. Ruiz asked some easy
 9 cross-examination questions to see if Dr. Thornberg really didn't know basic facts about the
 10 Delta. (Transcript 5/10/2017, page 132, line 22 to page 133, line 6)

11 MR. RUIZ: Are you aware that corn, alfalfa and processing tomatoes are the top
 12 three crops by acreage in the Delta?

13 WITNESS THORNBERG: No, I'm not.

14 MR. RUIZ: Okay. You didn't look at that or you don't have knowledge of that
 15 particular -- those particular issues; is that fair?

16 WITNESS THORNBERG: I think it's fair to say that I was not provided with the
 17 data that would have helped me figure that.

18 Repeatedly in his cross-examination, Dr. Thornberg blames his lack of basic knowledge on
 19 others for not giving him the data. This is a surprising response for multiple reasons. First, it
 20 is simply false: he was given the data. The data on Delta crops cited by Mr. Ruiz comes
 21 directly from clear tables in the DPC Economic Sustainability Plan (RTD 301 and RTD 305)
 22 that is the focus of Dr. Thornberg's rebuttal. More importantly, these crop patterns are widely
 23 known and available to anyone with basic Google skills; it is not secret or privileged data as
 24 Dr. Thornberg claimed.¹ In addition to the Economic Sustainability Plan, the agency that
 25 retained him, DWR, has done periodic crop surveys in the Delta that are cited in reports on the
 26 Delta by the Delta Stewardship Council and groups such as the Public Policy Institute of
 27 California. Dr. Thornberg testified on a panel with Dr. Kimmelshue, whose company, LAND
 28 IQ, was hired by DWR in 2015 to complete its most recent Delta crop survey update.²

¹ (Transcript 5/10/2017, page 128, lines 1-2), In response to questions crop acreage in the Delta compared to the County, Dr. Thornberg replied "Sir, I'm going to have to rely upon your expertise on this, because you clearly have access to data that I don't have access to."

² <http://www.water.ca.gov/waterconditions/docs/DWR-Drought-Web-Contract-Listing-04-29-16.pdf>

The following table lists the top 10 crops by value in San Joaquin County (“County”) in 2009 from the County Crop Report and compares them to the Delta acreage listed in the Economic Sustainability Plan. The Delta is about 30% of San Joaquin County’s crop land, but only about 15% of the County’s total crop value. The Delta and non-Delta portions of San Joaquin County are very near each other and have common markets for both input and outputs. However, there are large differences in environmental factors, especially water quality, between the Delta and non-Delta parts of the County. The table below clearly shows that high-value salt-sensitive crops like grapes, almonds and walnuts are very abundant in the County outside the Delta, but rare in the Delta. SDWA 106 and SDWA 111 are testimony from Delta farmers that illustrate the additional cost and yield loss experienced when they have tried to grow these more lucrative crops that are most common in other areas of the County. The vast differences between agriculture in and out of the Delta are evident in the table and illustrate the problem with trying to draw any conclusions about Delta agriculture using aggregate County data.

Table 1. Crop acreages in San Joaquin County and the Delta portion of San Joaquin County in 2009 for the ten most valuable crops grown in San Joaquin County.

	San Joaquin County		San Joaquin County Delta	
	Value (\$millions)	Acres	Acres	Share of County
Total	\$1,523	702,000	214,000	30.5%
Grapes	\$285	91800	9133	9.9%
Cherries	\$213	17853	334	1.9%
Tomatoes	\$202	45500	20671	45.4%
Walnuts	\$161	48700	2576	5.3%
Almonds	\$134	47800	3273	6.8%
Corn	\$82	86900	73187	84.2%
Alfalfa	\$56	68300	47480	69.5%
Apples	\$54	2900	0	0.0%
Asparagus	\$52	7400	6479	87.6%
Blueberries	\$31	1313	1129	86.0%

II.C. Dr. Thornberg’s “logic chain” misrepresents my testimony and the way farmers make decisions about crops.

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1 Dr. Thornberg repeatedly refers to a “logic chain” that is the basis of my analysis. His
2 describes the sequence as 1) WaterFix (or something else) changes salinity, 2) Farmers suffer
3 reduced yields and revenue in some crops from salt damage, 3) Farmers shift to lower-value
4 crops in response to decreased yield, 4) this causes broader economic impacts. Dr. Thornberg
5 focuses on the yield reduction in step 2, and, when he claims to find there is no evidence of it,
6 he concludes that the crop choice model is of little relevance (DWR 84, page 27, lines 6-9).

7 Dr. Thornberg’s logic chain does not accurately describe the logic in my testimony or
8 the way farmers make decisions. Crop choice and planting decisions are primarily made far
9 before any salinity damage can be observed, not after the fact as Dr. Thornberg describes.
10 Crop choices are based on many factors, but expectations about future conditions, both in
11 markets and water quality and quantity, are essential. Farmers can make good estimates of
12 growing season salinity prior to planting based on winter precipitation, and formulate long-run
13 expectations of water quality based on their experience and expected changes to future
14 conditions – including the WaterFix proposal. Some farmers may still choose to plant a crop if
15 salinity damage is low, but they would not plant a salt-sensitive crop when salinity damage is
16 expected to be high. As discussed later, the real sequence of crop choice being made first
17 creates problems for Dr. Thornberg’s empirical model as yield is not observed for those who
18 rationally choose not to plant salt-sensitive crops when significant damage can be expected.

19 20 **III. Crop Choice Model utilized by me and Dr. David Sunding in reports for the Delta** 21 **Protection Commission and Department of Water Resources.**

22 The multinomial logit crop choice model is by far the most important of the three
23 agricultural economic models discussed in my testimony and rebuttal, as it is the only valid and
24 peer-reviewed empirical analysis. While it is the most important, the description in my
25 testimony is brief and references two previous reports using the model and then summarizes
26 the results of the more recent Department of Water Resource’s report for several reasons a) its
27 predictions are most relevant to this stage of the proceeding since it is based on salinity
28 modeling similar to that presented in this Petition, and b) it should be accepted without

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1 controversy since the results come from the Petitioners' Economic Impact report prepared by
2 their economic consultant, Dr. David Sunding. As such, I did not expect much rebuttal of this
3 model, and the two references provide all the necessary detail. However, because Petitioners
4 are using a new economic consultant who is unfamiliar with this model and data, let alone any
5 previous research on the Delta economy, it is necessary for me to provide some additional
6 background on the development of the model to correct erroneous assertions in Dr.
7 Thornberg's testimony. This lack of prior background does not excuse Dr. Thornberg's
8 ignorance about the model and its origins since the data and model has been in the possession
9 of DWR for years and was developed and utilized by their chief economic consultant on the
10 WaterFix, Dr. David Sunding. It would have been easy for Dr. Thornberg to obtain and
11 explore the model and data, and ask questions of Dr. Sunding and other DWR consultants and
12 staff who understand these issues.

13 As noted in my testimony, the modeling approach and dataset was originally
14 developed collaboratively with the Brattle Group and me while working on the DPC Economic
15 Sustainability Plan (SDWA 134, page 3). However, I did not think it was previously necessary
16 for my testimony to describe the specific roles taken in developing the data and model. Dr.
17 Thornberg's criticism now makes that necessary. The dataset was compiled by a Brattle Group
18 analyst working under Dr. Sunding's direction. The Brattle Group analyst also ran the
19 multinomial logit models, under both Dr. Sunding's and my own direction. Towards the end
20 of the analysis, in the summer of 2011, Dr. Sunding had to step away from the project due to a
21 conflict-of-interest that was created by new contracts he had received from state and federal
22 water contractors in support of the WaterFix. Shortly thereafter, Dr. Sunding also joined
23 DWR's BDCP consulting team and has led their economic analysis of the project. Thus, I took
24 over the lead for the direct oversight of the data analysts work and drafting of the final drafts of
25 the DPC Economic Sustainability Plan.

26 Subsequently, and independent of me, Dr. Sunding utilized the data and multinomial
27 logit crop choice model in a 2013 report for the Department of Water Resources (SDWA 136,
28 BDCP Statewide Economic Impact Report, chapter 3). The data and empirical model used by

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1 Dr. Sunding is the same as the DPC Economic Sustainability Plan as stated by him on page
2 3.1-1 of the 2013 BDCP report (SDWA 136):

3 “The modeling methodology is consistent with that employed in the
4 Economic Sustainability Plan for the Sacramento-San Joaquin River Delta (ESP)
5 (Delta Protection Commission 2012). The model is implemented as outlined in
6 the ESP, with the exception of the incorporation of estimated salinity data from
7 the DSM-II.”

8 While Dr. Sunding and I were working on the DPC ESP in 2011, we requested DSM-II
9 or other salinity modeling of BDCP tunnels from DWR to assist with the model predictions,
10 but DWR would not share any preliminary modeling results at that time. Thus, for the DPC
11 Economic Sustainability Plan, in the absence of salinity modeling results, we illustrated
12 potential impacts within a range of plausible percentage increases to salinity given that the
13 BDCP’s proposal in 2011 for tunnels with a 15,000 cfs capacity, not the 9,000 cfs capacity of
14 the WaterFix, combined with the proposed 41% increase in D-1641 salinity that is still under
15 active consideration of this board in Phase 2 of the Bay-Delta Plan Update. These results from
16 the ESP (RTD 301) based on the percentage changes were discussed in Mike Machado’s
17 testimony (RTD 30) that Dr. Thornberg also rebutted. These higher damage estimates from the
18 DPC Economic Sustainability Plan should still be considered since the tunnels have the
19 physical capacity to be utilized much more extensively than described in this Petition.
20 However, for my testimony in this proceeding, I chose to use the results from Dr. Sunding’s
21 2013 BDCP assessment because it closely follows this change Petition and related DSM-II
22 modeling presented by the Petitioners.

23 With this background on model development, and Dr. Thornberg’s admission that he
24 did not read the two studies that utilized the model, I will now describe some of the false and
25 misleading claims about the multinomial logit crop choice model in Dr. Thornberg’s written
26 and oral rebuttal testimony.

27 *II.A. Dr. Thornberg’s claim that I had intentionally deleted 2005 data is false and reckless.*

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1 Dr. Thornberg claims my analysis was not credible because I supposedly deleted 2005
2 data from the model to produce a desired result. This is a serious accusation of research
3 misconduct. If true, it would be sufficient grounds for termination of my academic
4 appointment and disqualification as an expert witness in this and other proceedings.
5 Fortunately, Dr. Thornberg's remarks are baseless and easily proven false with information
6 that was readily available to Dr. Thornberg and that he should have reviewed before making
7 such a serious charge. The evidence that Dr. Thornberg's reckless assertion to diminish my
8 credibility is false includes:

- 9 • The 2005 data was also excluded in DWR's 2013 BDCP Statewide Economic Impact
10 Report that was produced to promote the tunnels (SDWA 136, page 3.1-11, last
11 paragraph). If I deleted the data in the initial Economic Sustainability Plan analysis to
12 produce desired results, why would Dr. Sunding continue to leave the 2005 data out in
13 his subsequent report which was produced to support and promote the tunnels?
- 14 • As discussed above, the data was compiled by Dr. Sunding's analyst at the Brattle
15 Group working under his direction. Any decision to exclude 2005 data was made by
16 the Brattle Group and not by me. If Dr. Thornberg had read the 2013 DWR report that
17 is the primary reference in my testimony, and simply asked Dr. Sunding why he also
18 excluded the data, he would have known this.
- 19 • Finally, if the omission of 2005 data really did bias the results, the professional
20 standard to support such a serious claim would have been to obtain the model and data,
21 incorporate the data in question and show how it affects the results. Dr. Thornberg
22 failed to do this even though the data and model is in the possession of Petitioner's
23 consultants and readily available to him.

24 *II.B. Dr. Thornberg's other criticisms are invalid and show that he did not fully*
25 *understand the data and the empirical model.*

26 Dr. Thornberg incorrectly testifies that the data is "thin", and suggests that the sample
27 size is too small because we only used 8 years of data compared to the 26 years of data in his
28 time-series yield model. This is inaccurate, and my testimony clearly shows that our empirical

1 model uses over 6,000 individual observations across eight years. The dataset is very large,
2 and was assembled at significant time and expense. Dr. Thornberg seems to be improperly
3 comparing and possibly confusing this large detailed data set with the mere 26 observations in
4 his simple yield regressions discussed in the next section.

5 Dr. Thornberg criticizes the models for not including an auto-regressive, lagged
6 dependent variable as is commonly done in the type of time-series regressions he did for his
7 yield model (page 31, lines 16-20). This criticism is invalid and merely displays Dr.
8 Thornberg's lack of understanding and experience with field level crop data and his decision
9 not to obtain the data and work with it himself. The data is not a panel in the sense that Dr.
10 Thornberg is familiar as a macroeconomist and as he describes in his testimony (page 30, line
11 26 to page 31, line 1). The borders of a field dedicated to an individual crop can and do change
12 from year to year. In other words, each field is not defined identically from year to year and a
13 field is omitted from the data in a year it is left fallow. Thus, it would be impossible to include
14 an autoregressive lagged variable as Dr. Thornberg incorrectly insists is necessary.

15 Dr. Thornberg criticizes the crop groupings used in the model at length, incorrectly
16 stating that it would be better to use individual crops in the model, and inaccurately suggesting
17 that they were chosen to create desired results. Because there are so many crops grown in the
18 Delta, some on only a few fields, to make the model usable and easier to interpret, it is
19 necessary to aggregate into groups. This is common practice in the literature. It is valid to
20 question some of the decisions that were made in the final model, and I can confirm that we did
21 try some disaggregation of some crops such as alfalfa from field crops and tomatoes separate
22 from truck/vegetable crops, but it had little impact on the results and made the model more
23 complicated and harder to interpret. In reply to Dr. Thornberg's suggestion that groupings are
24 intentional to skew results, I would emphasize that Dr. Sunding used the same crop groupings
25 in his study for DWR promoting the tunnels plan and that the approach was positively peer-
26 reviewed by an independent panel.

27 28 **IV. Dr. Thornberg's Empirical Yield Model.**

1 Dr. Thornberg heavily relies on new data analysis introduced for the first time in his
2 rebuttal testimony which has not been peer-reviewed. Putting aside the question of whether it
3 is appropriate to introduce an entirely new, never reviewed empirical model in rebuttal, it is
4 rather obvious to anyone with basic familiarity with Delta agriculture that Dr. Thornberg's
5 analysis is invalid. The most obvious problem is the use of County-wide data. However, in
6 sections IV.B. to IV.F below, I will put aside my criticism of his use of the County-wide data
7 to draw conclusions about the Delta. Even if Dr. Thornberg had used Delta-specific yield data,
8 major problems with the macroeconomic-type statistical analysis he is applying to the
9 estimation of crop yields would remain.

10 *IV.A. Dr. Thornberg's use of county-wide yield data correlated to water quality in an isolated*
11 *part of the south Delta is invalid.*

12 The SWRCB has been wrestling with the question of salinity impacts on yield in the
13 South Delta for decades with numerous experts analyzing and testifying on the topic utilizing
14 theoretical approaches and the very limited available data. To my knowledge, no parties or
15 experts have ever attempted to utilize County-wide crop report data for this purpose since it is
16 so obviously invalid due to the tremendous differences between Delta farming and overall
17 County farming, as I detailed in Section II.B. In cross-examination, Dr. Thornberg himself
18 admits that it would be better to use Delta-specific yield data if it were available (Transcript
19 5/10/2017, page 127, lines 5-7) and that this is a weakness in his analysis. However, he
20 displays no knowledge of the differences between Delta and in-Delta farming such as
21 differences in the crops grown (Transcript 5/10/2017, page 127 line 8 to page 128, line 2). He
22 incorrectly states that the sources of irrigation water used in the areas he is analyzing is
23 irrelevant to his analysis as long as the Delta is a small part of it. (Transcript 5/10/2017, page
24 130, line 23 to page 131, line 7) Dr. Thornberg's lack of basic knowledge revealed in his
25 testimony and cross-examination is remarkable, as is his dismissal and disinterest in knowing
26 highly relevant facts such as the sources of irrigation water in the area his data describes. In
27 fact, these dramatic differences in cropping patterns between adjacent farming areas with
28

1 vastly different irrigation water quality is in itself strong evidence that salinity in the Delta does
2 negatively affect crop choice and revenue for Delta farmers.

3 Dr. Thornberg does make a simple comparison of changes in crop choices at the
4 County level on page 32 and 33 of his testimony where he compares a low-salinity period
5 (1997-2000) to a more recent high-salinity period at the County level. As I show in Section
6 II.B., the highly salt-sensitive crops (Almonds, walnuts, cherries, etc.) have very little acreage
7 in the Delta in recent years. Thus, the growth in acreage Dr. Thornberg is showing for salt-
8 sensitive crops is occurring in areas outside the Delta that do not irrigate with Delta water. It is
9 well-known that market forces have been creating rapid growth in lucrative nut crops
10 throughout the Valley, with the notable exception of the Delta. The most plausible explanation
11 is that water quality either creates additional costs or reduces yields for those who do irrigate
12 with Delta water. Dr. Thornberg also interprets the dramatic reduction in acres of salt-tolerant
13 asparagus during a time of increasing salinity as evidence that Delta salinity doesn't matter to
14 farmers. However, it is well-known that asparagus acres have been decreasing for decades due
15 to rising labor costs in California compared to new low-cost competition from imported
16 asparagus from Mexico that was restricted prior to the NAFTA treaty in the 1990s. As recently
17 as a few years ago, the Delta still grew the majority of asparagus that is produced in California,
18 but overall California asparagus production is on a sharp declining trend due to these market
19 forces.

20 *IV.B. Dr. Thornberg's model does not control for strong and well-known increasing trends in*
21 *crop yields over time, even as he notes a clear increasing trend in Delta salinity.*

22 Average yields for most crops, including those grown in the Delta, are on a strong
23 upward trend as overall agricultural productivity has a strong increasing trend for a variety of
24 well-known reasons (advanced seeds, better chemicals, equipment, and other techniques). Dr.
25 Thornberg also notes the increasing trend in Delta salinity, thus Delta salinity is positively
26 correlated with agricultural technological productivity although it is obviously not the cause of
27 it. Dr. Thornberg's model fails to control for this. In fact, Dr. Thornberg acknowledges this
28 potentially serious problem with his model in his testimony (page 23, lines 1-3), but does

1 nothing to address this critical problem. On page 23, lines 4-9 he states that his reaction is to
2 add more control variables to his regressions and include a seemingly unrelated regression.
3 While he adds controls for temperature, precipitation, and production costs to some of the
4 models, he does not include any additional controls to address the issue of trend productivity
5 growth. Simple approaches to account for this would include a) creating a panel or matched
6 sample with other counties with similar growing conditions with the exception of water quality
7 and the same access to technology and markets, or b) including a time trend variable in the
8 regression to account for trend growth in crop yields from technological advancements. Dr.
9 Thornberg fails to utilize either of these common and relatively easy to implement controls.
10 Thus, it is likely that his salinity variable is merely showing the effect of spurious correlation
11 with trend productivity growth that increases average yield over time.

12 *IV.C. Dr. Thornberg's model does not account for considerable additional costs that farmers*
13 *incur trying to reduce the effect of salinity on their crop yields.*

14 Farmers can and do apply costly measures to combat high-salinity water to maintain
15 crop productivity and success. These measures and their costs are described by Delta farmers
16 in SDWA 106 and SDWA 111. I believe Dr. Kimmelshue's testimony also cited costly actions
17 that are available to farmers to reduce the effects of increased salinity. Reported yields could
18 show little or no change even when increased salinity is imposing real costs on farmers. Thus,
19 it is invalid for Dr. Thornberg to conclude that salinity is not imposing costs on farmers from
20 yield data if he has no data on costs incurred by farmers to combat its effects.

21 *IV.D. Dr. Thornberg's model has a sample-selection bias problem because it does not control*
22 *for crop shifting when salinity is high.*

23 While some farmers fight the effects of salinity, others may fallow their land or shift to
24 more salt-tolerant crops when salinity is high. Dr. Thornberg's model does not account for
25 fallowing or crop-shifting, and assumes that salinity has no effect on the acres planted or what
26 acres are planted. In fact, the fields that are most likely to be fallowed, or shift crops, as
27 salinity rises are those that are already suffering some level of salt-stress before a salinity
28 increase. Thus, when salinity rises, it is likely that the lowest yielding fields are the ones that

1 fallow or shift crops. Thus, average yields as measured at the county level could decrease
2 when salinity rises because low productivity acres exit the sample under these conditions and
3 are most likely to reenter the sample when salinity is low. This is known as a sample-selection
4 bias and Dr. Thornberg's model of using county wide average yield is unable to control for this
5 issue.

6 *IV.E. The use of a 2-year annual average for salinity instead of a 1-year growing season*
7 *salinity does not make sense and contradicts Dr. Thornberg's other testimony about leaching*
8 *fractions.*

9 In Table 7 (DWR 84, page 23, lines 17-27), Dr. Thornberg defines the variables used in
10 his yield regressions. In his table, the definition of the key salinity variable describes annual
11 electroconductivity average as "the covariate of primary interest, and is the average of the
12 current and previous year to take into account the additive impact of salt." This variable
13 definition is odd, and contradicts Dr. Thornberg's earlier testimony (page 20, line 22, page 21,
14 line 2) stating that he uses an annual average, not a two-year annual average. The tables of
15 regression results show the variable as $ec + ec(-1)$ indicating that the 2-year average was
16 actually used in the regression models. Current year growing season salinity is clearly the
17 most important factor, and Dr. Thornberg provides no explanation for why he did not properly
18 include it as a separate variable in the regressions. By using a 2-year average, Dr. Thornberg's
19 regression masks the effect of current year salinity, and thus any conclusions about salinity and
20 yield are invalid. To test the effect of prior year salinity (whether from 2, 3 or more years ago),
21 these should be included as separate variables in the regression. While I would not advise
22 combining these as Dr. Thornberg does, any combination should give higher weight to current
23 year salinity rather than a simple 2-year average. Finally, the fact that Dr. Thornberg is
24 accounting for the "additive impact of salt" with this simple average contradicts other parts of
25 his testimony that claims leaching fractions are high in the Delta. The use of such a flawed and
26 deceptive definition of the key salinity variable renders his results meaningless. It is
27 perplexing that Dr. Thornberg puts such weight in a regression model where both the
28

1 dependent variable (Countywide yield) and primary independent variable (2-year average
2 salinity for a specific region of the Delta) are defined in such an obviously invalid manner.

3 *IV.F. Dr. Thornberg uses very different sets of control variables for every regression of*
4 *individual crops, and the combined seemingly unrelated regression without any explanation.*

5 Dr. Thornberg includes the regression model results as Appendix B and C, pages 48 to
6 56 of his rebuttal testimony. Each of the individual regressions uses a unique combination of
7 the control variables in Table 7, with some adding an additional control not included in Table
8 7, "hacres", which I assume is harvested acres. In the SUR regression that has a much larger
9 dataset, Dr. Thornberg should have ample data to use all of his control variables, but he
10 actually uses less. The SUR only uses 4 (salinity, max temperature, precipitation, and
11 unemployment rate) instead of all 9 control variables listed in Table 7 and included in the
12 various individual regressions. This highly unstable set of control variables between regression
13 models without any explanation raises a very large red flag about the validity and reliability of
14 the results. Unfortunately, I did not have time to obtain the models and data to test the effects
15 of including a consistent and larger set of control variables, including a control for trend
16 productivity, and thus will refrain from speculating about why Dr. Thornberg's control
17 variables were so inconsistent across his models.

18 **V. My Delta Specific Theoretical Yield Model**

19 This section of my testimony (SDWA 134-R, pages 4-6) relies on calculations of yield
20 loss functions and leaching fractions that are the subject of other experts. Because there is no
21 Delta specific data on yields, these calculations are necessarily theoretical. Dr. Thornberg
22 criticizes the use of a theoretical model, and I agree that an empirical approach is preferable if
23 the data is available. But it is not, and this theoretical approach is preferable to the invalid
24 empirical approach to yield utilized by Dr. Thornberg and discussed in Section IV above. The
25 model relies on a set of assumptions on leaching fractions and loss functions that can be
26 legitimately challenged since actual data is so scarce, but they are plausible and illustrate the
27 key point that farmers could suffer harm from the WaterFix even if operations are compliant
28

1 with the current D-1641 standard. The following comments respond to some of Dr.
2 Thornberg's rebuttal comments about this model.

3 *V.A. Dr. Thornberg invalidly characterized the crops I used as non-representative of the*
4 *Delta.*

5 As discussed earlier, Dr. Thornberg displayed that he had no knowledge of which crops
6 are actually grown in the Delta, thus his testimony that the crops I used for my analysis were
7 not at all representative were baseless and false. To Dr. Thornberg's credit, he did acknowledge
8 at cross examination that his criticism of the crops I used were an "overstatement."
9 (Transcript 5/10/2017, page 133, lines 12-15).

10 *V.B. Dr. Thornberg's criticism of my use of the median instead of the mean is irrelevant and*
11 *an inaccurate representation of the model.*

12 Dr. Thornberg dedicates a full page of criticism of this model on the fact that the mean
13 leaching fraction in Dr. Leinfelder-Miles' study is higher than the median leaching fraction,
14 and suggests that my results are biased for not using the mean. (page 17, line6 to page 18 line
15 7) The mean leaching fraction is irrelevant as the results depend on the amount of land in the
16 Delta with low leaching fractions, not the average leaching fraction of all land. In other words,
17 it is the distribution, the share of land with low leaching fractions that is important, not the
18 mean, median or any measure of central tendency. . I mention the median because it shows
19 50% of the sample points had leaching fractions below 5%. Therefore, I assumed that only
20 50% of the acreage within the Delta would have leaching fractions at 5% or below.
21 Consequently, I only used half of the Delta acreage of the affected crops in the calculations. If
22 only 30% of the sample had leaching fractions at or below 5%, I would have only utilized 30%
23 of the reported acreage. In fact, my approach can be seen as conservative because I assumed a
24 5% leaching fraction for all of the low leaching fractions sites even though some have even
25 lower values. Dr. Thornberg's entire discussion of the mean leaching fraction is thus irrelevant
26 and only shows that he didn't understand the calculations in the model.

27 Of course, the 50% assumption is based on a small sample and we don't really know
28 the full extent of low leaching fraction land in the central and south Delta. Dr. Leinfelder-

1 Miles study is not sufficient to establish the distribution of low leaching fraction lands, but it
2 does show multiple examples where such land does in fact exist. Low leaching fractions are
3 also consistent with numerous field observations of salt-stress and crop damage in the Delta.
4 While it is not possible at this time to estimate the impacts with precision, there is ample
5 evidence that there can and likely will be impacts to Delta farmers if salinity increases even
6 within the boundaries of the D-1641 standard.

7 *V.C. Dr. Thornberg's use of a corrected yield loss function to reduce the estimated loss does*
8 *not refute the main claim that losses are likely to occur even with D-1641 compliance.*

9 On pages 9-11 and 15-16 of his rebuttal testimony, Dr. Thornberg recalculates the
10 results of my yield loss model based on the assertion that the tables I received from Terry
11 Prichard included a mistake. I understand that there was a mistake and thus Dr. Thornberg is
12 correct to recalculate my model's estimated loss from \$4.8 million annually to \$2.8 million
13 annually. While this reduces the estimated loss, it does not change the conclusion that losses
14 can and are likely to occur even with D-1641 compliance. This is not unlike arguing about the
15 specific quantities of land with low leaching fractions, it can affect the point estimate of loss
16 but not the overall conclusion that there will be losses.

17 **VI. Non-agricultural economic impacts.**

18 Large sections of Dr. Thornberg's rebuttal testimony on non-agricultural economic
19 impacts was stricken because it covered Part 2 topics such as feasibility, finance, and broader
20 economic benefits that were stricken from my original testimony in Part 1. However, there are
21 still several remaining rebuttal points in Dr. Thornberg's testimony in this section that severely
22 misrepresent the content of my original testimony.

23 *IV.A. While rebutting my testimony on the wages of jobs in the Delta, Dr. Thornberg once*
24 *again invalidly uses data from San Joaquin County as a whole to rebut comments specific to*
25 *the Delta.*

26 Dr. Thornberg quotes from my oral testimony (DWR 84, page 36, lines 1-4) that
27 referred to energy and logistics jobs as the highest-paying in the Delta. He then ignores the
28 high-paying natural gas sector and only focuses on logistics by presenting irrelevant data that

1 shows that there are higher-paying sectors in San Joaquin County as a whole. My testimony
2 clearly is referring to jobs in the Delta itself where most jobs are low-paying farm work in
3 addition to low-paying recreational and hospitality jobs. Infrastructure related jobs: logistics,
4 natural gas, the ports, etc. are indeed the best paying jobs located in the Delta itself and I am in
5 no way “aggrandizing” as Dr. Thornberg claims. In fact, same is documented and verified in
6 the DPC Economic Sustainability Plan (RTD 301).

7 *VI.B. Dr. Thornberg badly misrepresents my testimony on levees and flood risk and my actual*
8 *testimony on why WaterFix increases catastrophic flood risk in the Delta and San Joaquin*
9 *County remains valid.*

10 Dr. Thornberg misrepresents the arguments I made about why the WaterFix increases
11 flood risk in the Delta. (DWR 84, page 34 lines 12-13, and page 38, lines 3-9) On page 34, Dr.
12 Thornberg states, “Dr. Michael incorrectly suggests that WaterFix expenditures would come at
13 the expense of levee upkeep expenditures” and on page 38 says “Dr. Michael maintains that
14 construction of the WaterFix will leave fewer dollars available for maintaining and improving
15 the Delta levee system.”

16 In fact, my testimony on levees is silent on how the WaterFix is paid for because this
17 has been defined as a Part 2 issue. For my arguments, it makes no difference what the
18 WaterFix costs to build or how these costs are paid. To make this clear, I will briefly
19 summarize the two arguments I made in this testimony.

20 The first argument is based on the fact that Delta levee funding is likely to shift to a
21 beneficiary pays financing model in the future. The benefits water contractors receive from the
22 levees are clearly different in a world with and without the WaterFix, and thus their payments
23 for levees under a beneficiary pays system would be different as a matter of state law unless
24 some other voluntary commitment was made. For instance, the WaterFix proposal could
25 contain a commitment to pay their assessments if the WaterFix is built at the same level they
26 would be required if it were not built. This would be similar to the commitment the WaterFix
27 has made to counties for lost property tax revenue. However, there is no such commitment in
28

1 the WaterFix proposal. For purposes of rebuttal, the important fact is that this argument is in
2 no way linked to how construction of the WaterFix is financed as Dr. Thornberg misstates.

3 The second argument is about the false and misleading information DWR has been
4 providing to the legislature and the general public about the efficacy and desirability of levee
5 investments. This has directly undermined the legislature and general public awareness of the
6 options and value of levee investments which directly results in reduced funding and policy
7 focus. As evidence, I discussed the most important report DWR has made to the legislature to
8 date, and the clear and undisputed evidence that DWR staff changed the ranking of options to
9 elevate isolated conveyance over seismic levee upgrades. These facts are clearly documented,
10 and have never been rebutted when presented in various venues. It remains unrebutted today
11 by Dr. Thornberg's testimony. While my testimony focuses on one egregious case of
12 misinformation to the legislature, the fact that Petitioners' public relations campaign for the
13 WaterFix continues to inaccurately promote it as a superior system to levees is common
14 knowledge.

15 Dr. Thornberg's only attempt to rebut my testimony in this respect is to state on page 38
16 (line 25) through page 39 (line 2) that "the levees are maintained and improved by different
17 governmental agencies – it is not the function of the WaterFix to further bolster the levees."
18 Dr. Thornberg's statement here is correct, but it actually bolsters my argument. First, I did not
19 state that it is the function of the WaterFix to bolster the levees. However, the WaterFix has
20 been put forward by DWR as the best and only option to achieve the goal of protecting the
21 state from the effects of a catastrophic, earthquake-induced flood in the Delta; even though the
22 assessments of DWR's DRMS consultants and the DPC Economic Sustainability Plan clearly
23 show that seismic levee upgrades do more to protect against this risk because they
24 simultaneously protect water exports and other critical state and public interests. Dr.
25 Thornberg is also correct that the levees are improved by multiple government agencies. These
26 agencies depend on appropriations from the legislature and other sources to fund their
27 activities, and my testimony shows that these are precisely the agencies that DWR has
28 repeatedly provided false and misleading reports about the current status and best options for

1 dealing with the risk of levee failure. Thus, my second argument that DWR's WaterFix efforts
2 are reducing public support for levee upgrades in the past, present and future is also unrebutted
3 and in fact reinforced by some aspects of Dr. Thornberg's rebuttal testimony.

4 *VI.C. Dr. Thornberg misrepresents my testimony on the potential effects of WaterFix on the*
5 *transportation of people and goods between San Joaquin County and the Bay Area.*

6 Dr. Thornberg's rebuttal testimony focuses on construction impacts on transportation
7 and ignores that the primary point was about flood risk and transportation. My testimony
8 clearly states this (SDWA 134-R, page 11, lines 18-21), "After the construction period, the
9 WaterFix may have little impact on these infrastructure related sectors such as transportation
10 and energy. However, these sectors could be indirectly impacted, potentially severely, if the
11 WaterFix affects levee investments and flood control the area."

12 This statement is supported by my previous testimony regarding the findings of the
13 DRMS study (page 8, line 27 to page 9 line 3) where I discuss that DRMS found that only 20%
14 of the economic loss from the catastrophic flood scenario in the Delta was from disrupted
15 water exports, and 80% of the economic loss is in the Delta itself. While I did not cite this
16 specifically in my testimony, further disaggregated results from DRMS found that economic
17 losses related to the 3 state highways crossing the Delta are equal to the loss from water
18 exports as assessed in 2006. As the state is becoming less dependent on Delta water exports
19 over time, the county economy is becoming more dependent on its linkages to the Bay Area
20 and efficient transportation in between. Thus, in my opinion it is clear that future assessments
21 will find that transportation losses from a catastrophic flood will actually exceed any losses
22 related to water exports. This is because thousands of people will be cut off from access to
23 their jobs for an extended period; the movement of goods will be disrupted creating severe
24 impacts on regional businesses, and the increased traffic delays on alternative routes. It is also
25 important to note that the loss of highways and transportation services would likely take much
26 longer to repair and restore than the through Delta conveyance of water. While not a direct
27 impact of WaterFix, the WaterFix as proposed will indirectly increase the risk of these
28 catastrophic flood losses to the Delta and San Joaquin County economy. Dr. Thornberg's

1 rebuttal ignores this main argument, and instead inaccurately characterizes my testimony as
2 stating that the construction impacts of WaterFix would be significant and negative for the
3 logistics industry.

5 **VII. Conclusion**

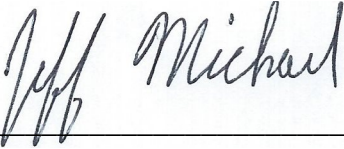
6 As discussed above, it is clear that Dr. Thornberg's rebuttal testimony is ill-informed
7 and invalid on virtually all the points he discusses. It should be disregarded entirely.

8 The evidence is clear that the WaterFix will negatively affect water users in the Delta.
9 For example, the multinomial logit model of crop choice developed by myself and Dr. Sunding
10 is the most credible and advanced study of the impacts of salinity on Delta agriculture, peer-
11 reviewed and accepted by experts working on both sides of the WaterFix debate. This and
12 direct observational data on current crop damage and new evidence that low leaching fractions
13 occur within the Delta provide clear and convincing evidence that WaterFix is likely to harm
14 agricultural water users in the Delta. Non-agricultural impacts, especially related to flood
15 control, are also important to consider and need to be directly addressed in the WaterFix
16 proposal to prevent the risk of large additional economic and public safety impacts from
17 increasing. Dr. Thornberg provides no credible evidence to contradict any of these findings.

18 While it is clear there will be negative economic effects from WaterFix, it is impossible
19 to accurately gauge the magnitude of the economic losses at this stage. If petitioners are able to
20 comply with the current D-1641 standard and add provisions to ensure no increase to flood
21 risk, the economic losses will be lower. However, given the large physical capacity of the
22 tunnels and their extreme cost, reliable assessments of the magnitude of these impacts cannot
23 be made until after the feasibility assessment in part 2 of this hearing and all of the conditions
24 placed on the approval of the project are known. The negative economic effects on Delta water
25 users could be much larger than described in my Part 1 testimony as this additional information
26 becomes known as Part 2 progresses.

1 I declare under penalty of perjury under the laws of the State of California that the
2 foregoing statements are true and correct.

3 Executed on the 9th day of June 2017, at Stockton, California.

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7 **Jeffrey Michael**
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