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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
ATOMIC SAFETY AND LICENSING BOARD

**Entergy Nuclear Operations, Inc.
(Indian Point Nuclear Generating
Units 2 and 3)**

Docket Nos.
50-247-LR
and 50-286-LR

**PREFILED REBUTTAL TESTIMONY OF DR. JORAM HOPENFELD REGARDING
RIVERKEEPER CONTENTION TC-2 – FLOW ACCELERATED CORROSION**

On behalf of Riverkeeper, Inc. ("Riverkeeper"), Dr. Joram Hopenfeld submits the following rebuttal testimony regarding Riverkeeper Contention TC-2.

Q. Please identify yourself.

A. My name is Dr. Joram Hopenfeld and I am a nuclear engineer and currently the CEO and founder of Noverflo, Inc. I prepared prefiled direct written testimony, which included my qualifications and *curriculum vitae*, that was submitted in this proceeding on December 22, 2012.¹

Q. Please state the purpose of your rebuttal testimony.

A. The purpose of this rebuttal testimony is to respond to numerous assertions, explanations, statements, positions, and claims contained in the testimony of Entergy and NRC Staff's witnesses,² and in Entergy and NRC Staff's statements of position,³ regarding Riverkeeper Contention RK-TC-2. Contention RK-TC-2 concerns Entergy Nuclear Operations, Inc.'s ("Entergy") failure to demonstrate that flow accelerated corrosion ("FAC") will be adequately

¹ See Prefiled Written Testimony of Dr. Joram Hopensfeld Regarding Riverkeeper Contention TC-2 – Flow Accelerated Corrosion (December 21, 2011) (RIV000003). I will hereinafter cite to my initial testimony as “Hopensfeld Prefiled Direct.”

² Testimony of Entergy Witnesses Ian D. Mew, Alan B. Cox, Nelson F. Azevedo, Jeffrey S. Horowitz, and Robert M. Aleksick Regarding Contention RK-TC-2 (Flow-Accelerated Corrosion), March 28, 2012 (ENT000029) (“Entergy’s Testimony”); NRC Staff Testimony of Matthew G. Yoder and Allen L. Hiser, Jr. Concerning Riverkeeper Technical Contention RK-TC-2 Flow Accelerated Corrosion, March 31, 2012 (NRC000121) (“NRC Staff’s Testimony”).

³ Entergy Statement of Position Regarding Contention RK-TC-2 (Flow-Accelerated Corrosion), March 28, 2012 (ENT000028) (“Entergy’s Statement of Position”); NRC Staff’s Statement of Position Regarding RK-TC-2 (NRC000120), March 31, 2012 (“NRC Staff’s Statement of Position”).

1 managed at Indian Point Generating Unit Nos. 2 and 3 during proposed 20-year extended
2 operating terms, as required by 10 C.F.R. § 54.21(c).

3
4 **Q. Have you reviewed the testimony of Entergy and NRC Staff's witnesses regarding**
5 **Contention RK-TC-2 and related statements of position?**

6 A. Yes.

7
8 **Q. Have you reviewed anything else in preparation of this rebuttal testimony?**

9 A. Yes. In addition to the many documents I previously reviewed as discussed in my initial
10 written testimony, I have reviewed the exhibits appended to the testimony of Entergy and NRC
11 Staff's witnesses relating to Contention RK-TC-2, pleadings related to the contention that were
12 filed after the submission of my initial testimony and expert report, including Entergy's Motion
13 *in Limine* seeking to exclude portions of my testimony and related filings, numerous documents
14 identified by Entergy as relevant to Riverkeeper's FAC contention that were identified and
15 disclosed *after* the submission of my initial testimony, including several additional
16 CHECWORKS modeling reports, and relevant scientific and industry reports. I have used these
17 documents to inform me of the relevant facts and derive my conclusions.

18
19 In addition to the documents identified in my initial testimony on Contention RK-TC-2 that were
20 provided as Exhibits RIV000002 through RIV000033 (or which were provided as exhibits by
21 other parties in the proceeding), additional documents that I reference and rely upon in this
22 testimony have been provided as Exhibits RIV000109 through RIV000113, in support of my
23 testimony. To the best of my knowledge, these are true and accurate copies of each document
24 that I referred to, used and/or relied upon in preparing this testimony. In cases where the
25 document was extremely long and only a small portion is relevant to my testimony, an excerpt of
26 the document is provided. If it is only an excerpt, that is noted on the cover of the Exhibit.

27
28 **Q. Can you summarize your overall reaction to the testimony of Entergy's witnesses**
29 **regarding Riverkeeper Contention RK-TC-2?**

30 A. My review of Entergy's witnesses testimony indicates that Entergy's FAC program at
31 Indian Point is deficient in various respects. In particular, Entergy's witnesses fail to

1 demonstrate that Entergy's use of the CHECWORKS computer code at Indian Point is
2 appropriate and in compliance with applicable regulatory guidance. Nothing in Entergy's
3 testimony disturbs my initial testimony and conclusions that the CHECWORKS code at Indian
4 Point produces unreliable, inaccurate, non-conservative results, and that, as a result, fails to
5 adequately detect FAC in susceptible components. Further, though Entergy discusses various
6 "other tools" allegedly employed at the plant, Entergy has failed to provide sufficient details to
7 show that the use of such other methods, in the absence of a quantitative predictive code, will
8 adequately manage FAC at Indian Point. Importantly, Entergy's witnesses fail to meaningfully
9 address the critical safety issues posted by Entergy's inadequate FAC management program.
10 Overall, my review of Entergy's witnesses' testimony has not changed my opinions and
11 conclusions about the adequacy of Entergy's aging management program ("AMP") for FAC at
12 Indian Point: it is inadequate and not in compliance with all relevant standards and regulatory
13 guidance.
14

15 **Q. Can you summarize your overall reaction to the testimony of NRC Staff's witnesses**
16 **regarding Riverkeeper Contention RK-TC-2?**

17 A. My review of NRC Staff's witnesses' testimony indicates that NRC Staff has essentially
18 taken Entergy at its word about the adequacy of the FAC program at Indian Point. My review of
19 NRC Staff's hearing submissions did not reveal any independent NRC Staff analysis of key FAC
20 issues at Indian Point, and NRC Staff's witnesses' testimony does not resolve the concerns raised
21 by initial testimony and expert report. Importantly, NRC Staff's approval of Entergy's FAC
22 program appears to be based on the incorrect assumption that CHECWORKS is a predominant
23 feature of the program and used to predict component degradation and to establish inspection
24 intervals, when in reality, Entergy's witnesses now make it clear that CHECWORKS plays a
25 minor role in the program as a ranking tool. NRC Staff's conclusions, thus, do not appear well-
26 founded. In addition, NRC Staff ignores the fact that Entergy's FAC program is fundamentally
27 inconsistent with applicable guidance due to Entergy's use of the CHECWORKS code even
28 though it lacks adequate calibration and produces non-conservative results. Overall, my review
29 of NRC Staff's witnesses' testimony has not changed my opinions and conclusions about the
30 adequacy of Entergy's FAC AMP at Indian Point: it is inadequate and not in compliance with all
31 relevant standards and regulatory guidance.

REBUTTAL TO ENTERGY HEARING SUBMISSIONS ON RK-TC-2**I. Dr. Hopenfeld's Qualifications to Provide Testimony on RK-TC-2**

Q. On Pages 2 and 13-15 of Entergy's Statement of Position, Entergy makes statements concerning your experience with FAC issues, including suggesting that you are "not a specialist in the management of aging due to FAC," that you have not "worked directly on FAC program issues," and that your publications are "silent on FAC-related issues." Do you have a response to these allegations about your experience and familiarity with FAC issues?

A. Entergy's various statements questioning my qualifications are completely unfounded, as my education, experience, and extensive knowledge make me well qualified to provide opinions and testimony related to the material degradation phenomenon known as flow accelerated corrosion, or FAC. In particular, evaluating metal degradation by corrosion and erosion that is commonly observed in power plants requires knowledge in electrochemistry, instrumentation, materials and mass transfer, and I have ample educational and professional experience in these fields. This is evident from the information contained in my *curriculum vitae*,⁴ which I elaborate on as follows:

The major fields of study I pursued to obtain my Doctorate degree were heat transfer and mass transfer, fluid dynamics, and electrochemistry/electrochemical engineering. My doctoral thesis related to electrochemical machining.

My professional career has involved considerable experience with material/environment interaction, including the following: in the employ of Atomics International, I conducted corrosion and fatigue tests on the effect of flowing sodium on internally heated specimens at high heat fluxes. In the Materials Branch of the Atomic Energy Commission ("AEC") (the predecessor agency of the NRC), I evaluated environmental effects on corrosion, fatigue, and fouling in connection with the development of standards for liquid metal fast breeder reactors ("LMFBRs"), and reviewed and revised standards on coolant chemistry and oxygen monitoring

⁴ *Curriculum Vitae* of Dr. Joram Hopenfeld (RIV000004).

1 for LMFBFRs. In the Component Branch of AEC, I managed tests and analytical studies on
2 flow/structure interaction and cavitation damage, a form of fatigue damage. In the
3 Magnetohydrodynamic ("MHD") Division of the Energy Research and Development
4 Administration ("ERDA"), I was responsible for the resolution of issues on erosion/corrosion
5 and instrumentation for high temperature Balance of the Plant Components in fossil fuel steam
6 generators, and I studied manufacturers' data on erosion damage from pin hole leaks in adjacent
7 tubes in Kraft Boilers in relation to pulp and paper plants. While employed at the NRC for 18
8 years, I evaluated all modes of steam generator tube degradation (including corrosion, high cycle
9 fatigue, wear, and jet erosion), and applicable instrumentation (including eddy current, fiber
10 optics, and acoustics), analyzed the safety consequence of steam generator tube ruptures and
11 other component failures following main steam line breaks (including conducting extensive
12 safety studies on the consequences of tube leaks, such as those formed by erosion in the steam
13 generator under design basis accidents), evaluated the effects of FAC on leak before break
14 scenarios, reviewed NUREG-1570, "Risk Assessment of Severe Accident-Induced Steam
15 Generator Tube Rupture," from the perspective of component aging, conducted an assessment of
16 the safety risk of significant FAC failures inside steam generators following the 1987 Surry
17 Power Station accident, and visited the Sequoyah Nuclear Generating Station to inspect J-tube
18 failures. Notably, while at NRC, I was afforded with knowledge and expertise regarding the use
19 of the CHECWORKS computer model, and CHEC, its predecessor. Lastly, as owner and CEO
20 of Noverflo, Inc., I sponsored and defined the scope of a program of experimental and analytical
21 studies relating to FAC (in, particular, to the feasibility of online remote monitoring of
22 corrosion/erosion) at the University of Virginia, and installed on-line pipe wall thinning monitors
23 at a large copper mine facility in Arizona. In sum, my 45-year career as a nuclear engineer has
24 afforded me with a vast amount of direct, hands-on experience with FAC (that is,
25 erosion/corrosion) related issues.

26
27 Entergy's statement that my publications are "silent" on FAC-related issues are simply baseless,
28 as I have published numerous peer reviewed papers that relate to corrosion, wall thinning, and
29 mass transfer modeling, that is, issues that relate to, and are relevant to understanding FAC. As
30 clearly listed in my *curriculum vitae*, these including the following: "Continuous Automatic
31 Detection of Pipe Wall Thinning," ASME Proceedings of the 9th International Conference on

1 Offshore Mechanics and Arctic Engineering (Feb. 1990); "Experience and Modeling of
2 Radioactivity Transport Following Steam Generator Tube Rupture," Nuclear Safety 26, 286-300
3 (1985); "Predictions of the One Dimensional Cutting Gap in Electrochemical Machining,"
4 ASME Transaction, J. of Engineering for Industry, p.100 (1969); and "Corrosion of Type 316
5 Stainless Steel with Surface Heat Flux in 1200 Flowing Sodium," Nuclear Engineering and
6 Design, 12; 167-169, (1970).⁵

7
8 In addition, I hold two patents related to monitoring wall thinning due to erosion/corrosion, as
9 indicated in my *curriculum vitae*: Method for Monitoring Thinning of Walls and Piping
10 Components 4,922,74 and Method for Monitoring Thinning of Pipe Walls, 4,779,453.⁶

11
12 There is simply no credence to Entergy's alleged claim that I do not have specialized knowledge
13 relating to the management of the aging effects of FAC. I clearly possess specialized knowledge
14 in relation to FAC and FAC management processes.

15
16 **Q. On page 14 of Entergy's Statement of Position, Entergy claims that you "admitted"**
17 **during the Vermont Yankee license renewal proceeding that you "lack[] expertise" on "the**
18 **corrosion process." Do you have a response to this allegation?**

19 A. Entergy has lifted a quotation from an Atomic Safety and Licensing Board ("ASLB")
20 decision out of context. In the Vermont Yankee Nuclear Power Plant license renewal
21 proceeding, where I provided expert support for a FAC-related contention, there was an
22 adjudicatory hearing during which corrosion was discussed at length. In particular, an issue
23 discussed in the *Vermont Yankee* proceeding was the degree with which mechanical abrasion
24 plays a part in wall thinning due to erosion-corrosion at high flow rates, an issue that is complex
25 and not well understood. Notably, CHECWORKS was designed in a manner that limits its wall
26 thinning predictions to chemical dissolution only, and the common term, "corrosion-erosion,"
27 was changed to FAC, which was defined to include only wall thinning by chemical dissolution;
28 wall thinning involving abrasion of a protective oxide layer either by droplet impingement,
29 bubble collapse or shear forces all affected by flow, are not considered by the computer model.

⁵ *Curriculum Vitae* of Dr. Joram Hopenfeld at 4 (RIV000004).

⁶ *Id.* at 5 (RIV000004).

1 In providing its final resolution, the licensing board in the *Vermont Yankee* proceeding
2 deliberated on the various aspects of the definition of FAC, and in this context stated, in full:
3 “Dr. Hopenfeld stated that he was not an expert on the corrosion process, but that it was difficult
4 for him to separate erosion from corrosion, and there is no acceptable theory for exactly what
5 happens during the erosion process.”⁷ What I actually stated was that “[i]t doesn't take much to
6 affect the cohesion, to affect the oxide layer. And I am not an expert on oxide layer
7 characteristics and all the details of that.”⁸ It is based upon this statement that Entergy
8 apparently concludes that I stated I am “not an expert on the corrosion process” and that I “lack[]
9 expertise on an issue central to this contention . . . the physical process associated with FAC.”⁹
10 These conclusions are clearly baseless.

11
12 As the field of corrosion engulfs numerous disciplines (including electrochemistry, material
13 science, chemistry, and mass transfer), and corrosion involves many varying scientific principles
14 and mechanisms, it is highly unlikely that a given person will be an expert in all aspects of
15 corrosion. A lack of expertise on one particular aspect of corrosion, that is, oxide layer
16 formation and destruction, does not render me unqualified to provide an opinion about FAC-
17 related issues (in particular, the issues relevant to Contention RK-TC-2) with which I have much
18 expertise. As the discussion above makes patently clear, I have a significant amount of
19 education, professional experience, and knowledge related to these issues. I, without a doubt,
20 consider myself an expert on corrosion and the issues raised in Contention RK-TC-2.

21
22 Moreover, Entergy misrepresenting my statement in the *Vermont Yankee* proceeding is
23 significant: it demonstrates that *Entergy* lacks the understanding of the underlying assumptions
24 in CHECWORKS. This is very important because Entergy relies on non-technical reasoning to
25 exclude large number of components from the FAC program. In particular, Entergy equating the
26 lack of understanding of oxide layer formation and destruction, to a lack of familiarity with FAC
27 and the corrosion process reflects ignorance of the possibility that actual observed wall thinning

⁷ *Entergy Nuclear Vt. Yankee* (Vt. Yankee Nuclear Power Station), LBP-08-25, 68 NRC 763, at 862 (2008).

⁸ Official Transcript of Proceedings, Nuclear Regulatory Commission, Entergy Nuclear Vermont Yankee, 50-271-LR; ASLBP No. 06-849-03-LR, Newfane, Vermont, pages 1451-1741 (July 24, 2008), at 1477 (RIV000109).

⁹ Entergy's Statement of Position at 14.

1 may have resulted from a combination of chemical and mechanical forces and, therefore, beyond
2 the predictive capabilities of CHECWORKS.

3
4 **Q. On page 15 of Entergy's Statement of Position, Entergy claims that a statement**
5 **made by you in a Declaration submitted in the Vermont Yankee license renewal**
6 **proceeding, in which you asserted that the issues in that case required specific expertise,**
7 **"speaks directly to the deficiencies in [your] own testimony, which reflects a lack of**
8 **specialized expertise in the field of FAC." Do you have a response to this allegation?**

9 A. As evidenced by the lengthy discussion above, as well as by the information contained in
10 my *curriculum vitae*, I undoubtedly have expertise relating to the "very specific and not broadly
11 understood materials, mechanics, energy, and plant operations phenomena beyond the depth of
12 most generalists" that I was referring to in my Declaration in the Vermont Yankee proceeding.
13 As a result, Entergy's statement that I lack specialized expertise is wrong. My previous
14 statement that Entergy refers to does not in any way render my testimony "deficient," since I
15 possess precisely the kind of specialized knowledge that allows me to competently testify about
16 FAC and managing the aging effects of FAC at Indian Point.

17
18 **II. The Qualifications and Objectivity of Entergy's Witnesses**

19
20 **Q. Pages 1-15 of Entergy's Testimony, as well as pages 15-20 of Entergy's Statement of**
21 **Position, discuss the educational and professional backgrounds of Entergy's witnesses on**
22 **Contention RK-TC-2. Do you have any comments on the qualifications of Entergy's**
23 **witnesses to testify about FAC and Contention RK-TC-2?**

24 A. I have reviewed these portions of Entergy's Testimony and Statement of Position, as well
25 as the *curricula vitae* of Entergy's witnesses (provided as Exhibits ENT000030 to ENT000033,
26 and ENT000037), and have the following observations:

27
28 Mr. Ian D. Mew's *curriculum vitae* does not reflect expertise in mass transfer, nuclear safety
29 analysis, electrochemistry, or materials, which would be demonstrated by technical publications
30 in these fields. While Mr. Alan B. Cox is the engineer responsible for managing license renewal
31 activities at Indian Point, his *curriculum vitae* also indicates that he does not have expertise in

1 mass transfer, nuclear safety analysis, electrochemistry, or materials, which, again, would be
2 demonstrated by technical publications in these areas. Similarly, though Mr. Nelson F. Azevedo
3 is responsible for implementing American Society of Mechanical Engineers (“ASME”) code
4 programs, his *curriculum vitae* does not show that he has expertise in thermal hydraulics, nuclear
5 safety analysis, or electrochemistry, as would be established by technical publications about such
6 topics. A fundamental, in-depth knowledge in all these fields is required to understand the
7 capabilities, limitations, acceptability of CHECWORKS, and to properly assess CHECWORKS’
8 predictions.

9
10 I would also like to highlight that as a co-developer of the CHECWORKS computer model and a
11 consultant to the Electric Power Research Institute (“EPRI”), it is my understanding that Dr.
12 Jeffrey S. Horowitz has a direct financial interest in the promotion and use of CHECWORKS at
13 nuclear power plants.

14
15 Finally, Mr. Robert M. Aleksick’s *curriculum vitae* does not appear to contain any technical
16 publications relating to nuclear safety risk assessment. Furthermore, Mr. Aleksick is the
17 President and founder of a company (CSI Technologies, Inc.) which markets the application of
18 CHECWORKS and is closely affiliated with EPRI and with the development and use of
19 CHECWORKS. As a result, it is my understanding that he also has a financial interest in the use
20 of the CHECWORKS computer model to manage FAC at nuclear power plants.

21
22 **III. Entergy’s Reliance on “Other Tools” Apart from CHECWORKS in the Indian Point FAC**
23 **Program**

24
25 **Q. Entergy’s witnesses testify that “predictions from CHECWORKS normally**
26 **comprise between one-quarter and one-third of FAC inspections in a given outage” and**
27 **that only 22% and 20% of susceptible lines are modeled in CHECWORKS at Indian Point**
28 **Unit 2 and 3, respectively.¹⁰ Do you have a response to these statements?**

29 **A. Entergy’s license renewal application (“LRA”) for Indian Point included an AMP**
30 **relating to FAC that focused on the use of CHECWORKS as the main predictive tool for**

¹⁰ Entergy’s Testimony at A76, A77, A94.

1 identifying specific inspection locations and scheduling inspection intervals.¹¹ In particular, in
2 its LRA, Entergy committed to control wall thinning from FAC by following the guidance of
3 NUREG-1801, *Generic Aging Lessons Learned (GALL) Report* (“*GALL Report*”), and EPRI’s
4 Recommendations for an Effective Flow-Accelerated Corrosion Program, NSAC-202L, both of
5 which discuss a FAC management program based upon using the predictive computer code
6 CHECWORKS.¹² The heart of these guidelines was the use of the predictive computer code
7 CHECWORKS to measure FAC-induced wear in susceptible locations and thereby schedule
8 timely inspection intervals at those locations and prevent leaks and ruptures in such risk
9 significant components. My understanding that CHECWORKS was the primary feature of
10 Entergy’s FAC program was also based on my review of NRC Staff’s final Safety Evaluation
11 Report (“SER”) which focused on and discussed Entergy’s use of CHECWORKS as a predictive
12 model.¹³ Further, most of the information that was disclosed by Entergy and made available for
13 my review related to Entergy’s (and predecessor owners’) use of CHECWORKS.

14
15 The testimony of Entergy’s witnesses now presents a very different picture: Entergy has for the
16 first time quantified the degree with which FAC inspections are chosen based upon
17 CHECWORKS, and indicated that CHECWORKS only accounts for a fraction of the overall
18 FAC program at Indian Point. Entergy’s witnesses’ testimony reveals that CHECWORKS plays
19 a relatively minor role in managing FAC at the plant.¹⁴ Based on my review of Entergy’s
20 testimony, it appears that the total CHECWORKS contribution to the FAC program is about
21 25%, with less than half of that amount being attributed to actual wear predictions and inspection
22 schedules, with the balance to provide relative ranking.

23
24 Despite Entergy’s apparent relegation of CHECWORKS to a secondary role in the FAC program
25 at Indian Point, the relevant guidelines in the *GALL Report* and NSAC-202L clearly emphasize
26 the use of quantitative predictions of a computer code such as CHECWORKS as the main tool to
27 predict wall thinning and manage FAC. While the guidelines contained in NSAC-202L indicate

¹¹ See LRA at Appendix B § B.1.15.

¹² EPRI, Recommendations for an Effective Flow-Accelerated Corrosion Program, NSAC-202L-R3 (RIV000012); *GALL Report*, Rev. 1 at § XI.M17 (NYS00146A-NYS00146C); *GALL Report*, Rev. 2 at § XI.M17 (NYS00147A-NYS00147D).

¹³ SER at pp.3-21 to 3-31.

¹⁴ See Entergy’s Testimony at A72, A76, A77, A84 and A113.

1 that the use of tools other than a predictive computer model can be applied to components with
2 widely varying operating conditions, the guidelines clearly prefer analytical models over any
3 such other tools. This guidance recommends that wherever possible, a Predictive Plant Model
4 together with thickness measurements be used for FAC predictions, and indicates that other
5 methods may be used only when plant operations vary widely.¹⁵ Furthermore, nowhere in this
6 guidance does EPRI recommend that “other tools” be used to the exclusion of a predictive
7 model. As such, Entergy’s clarification that CHECWORKS only accounts for about 25% of the
8 FAC program at Indian Point is inconsistent with applicable guidance specifying that the FAC
9 program must be based on a predictive tool. Of the 25% less than half is actually used to
10 predict wall thinning, the balance is for screening purposes.

11
12 In any event, assuming Entergy’s characterization of the extent to which CHECWORKS is used
13 in the FAC program at Indian Point is true, Entergy’s reliance on CHECWORKS for a quarter to
14 a third of its aging management efforts still renders Entergy’s program unacceptably flawed, as
15 this represents a significant percentage of Entergy’s program, which, for the reasons discussed at
16 length in my initial testimony, does not adequately address FAC.¹⁶

17
18 **Q. Entergy’s witnesses testify that a significant amount of FAC-inspection locations are**
19 **chosen based upon the “trending of pipe wall thickness measurements from past**
20 **outages,”¹⁷ and that Entergy’s reliance on data trending is “entirely independent” of**
21 **CHECWORKS.¹⁸ Do you agree with Entergy’s characterization that the use of trending is**
22 **independent from CHECWORKS at Indian Point?**

23 **A.** No, trending is not “entirely independent” of CHECWORKS: reinspections based on
24 actual data in relation to components that were “newly selected” for inspection based upon
25 CHECWORKS predictions, depend upon CHECWORKS in that the scope of components
26 subject to reinspections is necessarily limited by the original CHECWORKS’ predictions which
27 resulted in actual inspections. In this regard, Entergy’s statement that “[t]he reason a component

¹⁵ EPRI, Recommendations for an Effective Flow-Accelerated Corrosion Program, NSAC-202L-R3, at §§ 3.3., 4.4.1-3 (RIV000012).

¹⁶ Hopenfeld Prefiled Direct at 4-7, 9-12.

¹⁷ See Entergy’s Testimony at 49-50 (for example, explaining that during refueling outages 2R19 and 3R16, reinspections based on trending accounted for 46% of the total number of inspections at IP2, and 67% of total number of inspections at IP3, respectively).

¹⁸ Entergy’s Testimony at A72, A77, A79, A80, A95, A96, A97.

1 was originally selected for inspection is irrelevant.”¹⁹ So, while the actual trending calculation
2 may not involve the use of the CHECWORKS code (which, Entergy implies is what I meant in
3 my discussion of Entergy’s use of actual inspection data in the FAC program at Indian Point),²⁰
4 CHECWORKS’ predictive results clearly inform the future use of trending as a “tool” for
5 managing FAC. It is not clear from Entergy’s witnesses’ testimony how much modeling by
6 CHECWORKS is included in trending or component reinspections.

7
8 Moreover, the use of trending measurements *independent of CHECWORKS* at Indian Point fails
9 to comply with the acceptance criteria articulated in *GALL Report*, that “[i]nspection results are
10 input for a predictive computer code, such as CHECWORKS, to calculate the number of
11 refueling or operating cycles remaining before the component reaches the minimum allowable
12 wall thickness.”²¹ NRC Staff’s discussion of Entergy’s Indian Point FAC program in the final
13 SER also evinced the understanding that trending measurements are used at Indian Point in
14 connection with the use of CHECWORKS:

15 The staff also noted the modeling includes a feature to incorporate
16 actual inspection wall thickness results back into the computer
17 modeling, and that this feature is used to accomplish two important
18 aspects of CHECWORKSTM predictive modeling capability: (1) it
19 permits the user to compare that actual as-found wall component
20 thickness measurements of an inspected component to the wall
21 thickness for the component that was predicted by
22 CHECWORKSTM in the previous modeling results, thus providing
23 a method for confirming the degree of accuracy of the model’s
24 previous component wear rate predictions and component wall
25 thickness predictions, and (2) it permits the user to perform re-
26 baselined component wear rate predictions and component wall
27 thickness predictions based on the incorporation of the compiled
28 inspection data for components that are modeled by the computer
29 code and are inspected as part of the applicant’s Flow-Accelerated
30 Corrosion Program.²²

¹⁹ Entergy’s Testimony at A95.

²⁰ Entergy’s Testimony at A80.

²¹ *GALL Report*, Revision 2 at § XI.M17, p.XI M17-2 (NYS00147A-NYS00147D).

²² SER at p. 3-28.

1 **Q. Can you provide your opinion about the effectiveness of performing reinspections**
2 **based upon data trending for managing FAC at Indian Point?**

3 A. I disagree with Entergy's witnesses' testimony that actual pipe wall thickness
4 measurements are useful as a stand-alone tool at Indian Point,²³ and continue to offer my
5 professional opinion that such measurements are only meaningfully useful for preventing
6 unacceptable wall thinning at Indian Point when used in conjunction with a predictive tool. In
7 particular, without a predictive tool, a very large number of points would have to be monitored to
8 assure that the minimum or the critical wall thickness of components at Indian Point will not be
9 exceeded during the proposed periods of extended operation. Because FAC is a local
10 phenomena, and involves variations in local flow velocities and affects a large number of
11 components, an effective and reliable resinspection program would require many inspection
12 points. Notably, as numerous components are in difficult to access areas, it may be difficult to
13 design a reliable resinspection program that is cost-effective; in fact, if it was feasible to inspect,
14 reinspect, and trend the data for every FAC-susceptible point in the plant at frequent intervals,
15 resinspection would be the tool of choice for managing FAC-induced wall thinning. However,
16 Entergy has not put forth any evidence to suggest that a sufficient number of components are
17 monitored and inspected to establish that trending is acceptable as an "independent tool" for
18 managing FAC at Indian Point: while this "tool" consists of taking measurements at some
19 preselected locations, Entergy's witnesses fail to describe what percent of the area out of the total
20 FAC-susceptible area in the plant, is covered by resinspection and how the frequency of
21 inspections is determined, especially in difficult to access locations inside the steam generators.
22 Nor do Entergy's witnesses discuss how the inspection locations are identified, or how the
23 success of the resinspection "tool" is measured, by, for example, providing a comparison of
24 trending measurements with predictions for a statistically significant number of components.
25 Based on the available information I have reviewed, the use of trending at Indian Point appears
26 to be limited to a relatively small number of inspected components. Further, it appears that the
27 use of trending by Entergy is based on the unproven assumption that past wear rate would remain
28 the same in the future, which also limits the usefulness of trending as a tool for managing FAC at
29 Indian Point.
30

²³ See Entergy's Testimony at A94, A96.

1 Overall, despite the fact that trending is Entergy's apparent tool-of-choice establishing inspection
2 intervals, Entergy's use of component reinspections based on trending was not described in
3 sufficient detail to allow a complete and thorough assessment: Entergy does not address or
4 describe what percent of the total FAC-susceptible area in the plant is monitored by this
5 technique, how often each area is re-inspected, or the accuracy of the predictions based upon this
6 technique. For example, if direct wall thickness measurements and reinspections are used to
7 monitor the feed ring and blowdown lines, Entergy must provide the related data at all high
8 turbulence areas prior to and after the power uprate, but Entergy has not provided such data.
9 Importantly, this "tool" is based mainly on two assumptions: first that the proper location for any
10 given measurement has been identified, and that the wear rate at that location is linear with time.
11 Entergy must demonstrate that these assumptions are valid for all selected locations and the wear
12 predictions agree with actual measurements on a statistically significant number of components.
13 Entergy, and Entergy's witnesses, have not done this. Overall, it remains to be seen that the use
14 of trending will adequately address FAC at Indian Point during the proposed periods of extended
15 operation.

16
17 **Q. Entergy's witnesses dispute your description of Entergy's use of industry operating**
18 **experience for selecting FAC in section locations as not necessarily an independent tool.²⁴**

19 **Do you have a response to this?**

20 **A.** To the extent Entergy relies upon industry operating experience as an independent tool
21 for determining FAC inspection locations, Entergy has failed to provide an adequate description
22 of its meaning. EPRI's NSAC-202L dictates that if tools other than CHECWORKS are used,
23 sample selection must be justified, and Entergy did not provide the required justification.
24 Entergy must provide sufficiently detailed information about how precisely "operating
25 experience" is used to establish inspection schedules and account for changes in plant operating
26 parameters. This is necessary in order to understand the robustness of using "operating
27 experience" to estimate wear rates and predict wall thinning at Indian Point. At the very
28 minimum, Entergy should provide a description of its use of "operating experience" similar to
29 the detail provided about CHECWORKS, as memorialized in NRC Staff's SER.²⁵ Due to the

²⁴ See Entergy's Testimony at A77, A95, A98.

²⁵ SER at pp. 3-25 to 3-30.

1 lack of complete information relating to Entergy's "independent" reliance on operating
2 experience, it is not clear at all that this tool is useful apart from its use in connection with
3 CHECWORKS, or that it will adequately address FAC at Indian Point.

4
5 **Q. Entergy's witnesses indicate that Entergy relies upon "other inspection programs"**
6 **and plant activities to select FAC inspection locations, and states as an example that "if a**
7 **leaking isolation valve is discovered, it would be appropriate to inspect the piping**
8 **downstream of the leaking valve."**²⁶ **Do you have a response to this explanation?**

9 A. Once again, Entergy has not provided enough information in order to assess the
10 effectiveness of Entergy's reliance upon other plant programs and activities to monitor and
11 detect FAC. Entergy has provided nothing quantitative to evaluate, but rather only a brief
12 qualitative description of its use of "other inspection programs." Moreover, in my professional
13 opinion, a properly designed FAC management program would ensure the identification of all
14 high turbulence areas as inspection locations before a leak occurs. The whole idea of proactively
15 identifying inspection location is to prevent leaks, and not use them to identify inspection
16 locations. The fact that *many* leaks occur at Indian Point is only an indication that the FAC
17 program at the plant is ineffective.

18
19 **Q. Entergy's witnesses dispute your description of Entergy's use of engineering**
20 **judgment in its FAC program as ineffective, and opine that "the exercise of engineering**
21 **judgment . . . is a positive aspect of the program."**²⁷ **Do you have a response to these**
22 **statements?**

23 A. Entergy witnesses' discussion of Entergy's use of engineering judgment is qualitative and
24 fails to mention the uncertainties involved in using engineering judgment in selecting specific
25 inspection areas. For example, while the witnesses point out that the feedwater lines were
26 selected for inspection because of their high level of risk, they do not indicate how that risk was
27 calculated, and what models and assumptions were used. Notably, the feedwater line extends
28 into the steam generator and the risk would depend on the specific location along the feeding; in
29 contrast, Entergy's witnesses say nothing about how the frequency of inspection and inspection

²⁶ Entergy's Testimony at A95.

²⁷ Entergy's Testimony at A99, A100.

1 areas are selected.

2
3 I continue to offer my professional opinion that Entergy has failed to show that engineering
4 judgment is a sufficiently reliable tool for managing FAC at Indian Point. Notably, nuclear
5 power plant experiences with FAC, such as those that occurred at the Surry and Mihama plants,
6 demonstrated that operator judgments were not sufficiently reliable to protect plant operators
7 from catastrophic accidents. This principle is well recognized throughout the non-nuclear
8 industry where on-line monitoring coupons are commonly used to aid plant operators in
9 monitoring wall thinning. I continue to opine that Entergy has not provided enough detailed
10 information to show that engineering judgment is effectively employed at Indian Point.²⁸

11
12 **Q. Based on your review of Entergy's witnesses testimony about "other tools" (that is,**
13 **those allegedly separate from CHECWORKS) for managing FAC at Indian Point, has your**
14 **opinion about the adequacy of Entergy AMP for FAC changed?**

15 A. No. My evaluation of Entergy's "other tools," as discussed by Entergy's witnesses, leads
16 me to conclude that they were not described in sufficient details to allow a thorough assessment
17 of their effectiveness for managing FAC or to draw meaningful conclusions about the validity of
18 their performance. Though these other tools apparently account for 75% of Entergy's FAC
19 inspection program, Entergy's witnesses do not provide a quantitative description of the
20 predictive methodology employed for these techniques.

21
22 For example, Entergy's witnesses have not described how many components per outage are
23 inspected by each method, a ranking of component safety significance, the size of the inspection
24 areas relative to all FAC susceptible locations, what percentage of the total FAC susceptible area
25 in the plant is addressed with these other tools, how often the components are inspected, how the
26 frequency of inspections is established, how the validity of the measurements is verified, what
27 the accuracy of the "other tool" predictions' are in relation to actual measurements, or the
28 validity of each method to schedule inspection intervals. Notably, Entergy has failed to show a
29 single comparison of predictions with actual measurements in relation to their "other tools."
30 Further, it appears that the "other tools" identified are subjective in nature and based on personal

²⁸ See Hopenfeld Prefiled Direct at 13-16 (RIV000003).

1 judgments for selecting inspection areas and assumptions regarding local wear rates and the
2 frequency of inspections. Without detailed information about how these methods are
3 implemented, I cannot form a credible opinion about the risk of major component failures at
4 Indian Point during the proposed extended operating periods. While such information need not
5 be exhaustive, it must be thorough enough to evaluate Entergy's claims. Without the kind of
6 information I've described, it is impossible to determine whether Entergy's FAC program is
7 consistent with the *GALL Report*.
8

9 For Entergy to comply with the standard set forth in 10 C.F.R. § 54.21(a)(3), it has the burden of
10 describing its "other techniques" in sufficient detail to assure the public that the integrity of all
11 FAC susceptible components will be maintained between inspection intervals. Entergy has not
12 done this. Until Entergy does this, it cannot rely on "other tools" as a substitute for a reliable
13 predictive software package, as contemplated by applicable guidance. As such, I continue to
14 opine that Entergy does not employ any meaningful tools that, separate and apart from
15 CHECWORKS, would sufficiently manage the aging effects of FAC at Indian Point.²⁹
16

17 **IV. The Performance of CHECWORKS at Indian Point**
18

19 **Q. Entergy's witnesses testify that CHECWORKS "provides a screening and**
20 **prioritization function," "is designed to provide *best-estimate* wear rates due to FAC" and**
21 **not a bounding analysis because "CHECWORKS is primarily a ranking tool," and that the**
22 **model is performing this intended role at Indian Point.³⁰ Do you have a response to these**
23 **explanations?**

24 **A.** To begin with, this appears to be a previously undisclosed explanation of how
25 CHECWORKS functions in the FAC program at Indian Point. This understanding of how
26 CHECWORKS is used at Indian Point is not reflected in NRC Staff's assessment of Entergy's
27 FAC program in its SER.³¹ In particular, NRC Staff's discussion in the SER reflects an
28 understanding that CHECWORKS is used as a tool to predict component wall thickness.³²

²⁹ See generally Hopenfeld Prefiled Direct at 13-16 (RIV000003).

³⁰ Entergy's Testimony at A36, A102, A103 (emphasis in original).

³¹ SER at 3-21 to 3-30.

³² *Id.*

1
2 More to the point, based on my understanding of applicable regulations and guidance, Entergy's
3 use of CHECWORKS in the manner described, that is, as screening and ranking tool, is
4 unacceptable. In particular, the apparent role of CHECWORKS at Indian Point does not appear
5 to comply with the *GALL Report*, which states that CHECWORKS "is used to *predict*
6 component degradation in the systems conducive to FAC" and that CHECWORKS is acceptable
7 "*because it provides a bounding analysis for FAC.*"³³ In addition, the *GALL Report* requires that
8 CHECWORKS be employed to provide an inspection schedule,³⁴ and this integrally depends on
9 absolute wear rate predictions. The *GALL Report* elaborates that "[i]nspection results are input
10 for a predictive computer code, such as CHECWORKS, to calculate the number of refueling or
11 operating cycles remaining before the component reaches the minimum allowable wall
12 thickness."³⁵ This language is unequivocal and does not evince an understanding that the
13 usefulness of CHECWORKS in a FAC AMP is as a screening tool to establish component
14 inspection priorities.

15
16 In addition, industry guidance in EPRI's Recommendations for an Effective Flow-Accelerated
17 Corrosion Program, NSAC-202L, also do not indicate that the prime use of CHECWORKS is for
18 screening purposes and not for predicting absolute wear rates; quite the opposite, this guidance
19 states that "[t]he purpose of quantitative analysis [meaning using a predictive methodology such
20 as CHECWORKS] is to predict the FAC wear rate and to determine the remaining service life
21 for each piping component, including uninspected components."³⁶

22
23 Moreover, even if this was an appropriate role for CHECWORKS at Indian Point, since
24 CHECWORKS does not provide accurate wear predictions, as discussed at length in my initial
25 testimony,³⁷ I do not believe CHECWORKS is a reliable screening tool to establish inspection

³³ *GALL Report*, Rev. 1 at § XI.M17 ¶ 5 (NYS00146A-NYS00146C); *GALL Report*, Rev. 2 at § XI.M17 ¶ 5 (NYS00147A-NYS00147D).

³⁴ *GALL Report*, Rev. 1 at § XI.M17 ¶ 5 (NYS00146A-NYS00146C); *GALL Report*, Rev. 2 at § XI.M17 ¶ 5 (NYS00147A-NYS00147D).

³⁵ *GALL Report*, Rev. 1 at § XI.M17 ¶ 6 (NYS00146A-NYS00146C); *GALL Report*, Rev. 2 at § XI.M17 ¶ 6 (NYS00147A-NYS00147D).

³⁶ EPRI, Recommendations for an Effective Flow-Accelerated Corrosion Program, NSAC-202L-R3, at § 4.3 (RIV000012)..

³⁷ Hopenfeld Prefiled Direct at 5-10 (RIV000003).

1 priorities. For example, components that are assigned a low inspection priority may wear ten
2 times faster than other components that are assigned as higher priorities. This notion is clearly
3 supported by recently published data on the effects of chromium on FAC wear rates.³⁸
4

5 **Q. Entergy's witnesses disagree with your conclusion that CHECWORKS has very**
6 **poor predictive accuracy, which you surmised because CHECWORKS provides highly**
7 **non-conservative predictions 40%-60% of the time, and indicate that at Indian Point**
8 **"CHECWORKS is logically expected to overpredict the wear rate 50% of the time and**
9 **underpredict the wear rate 50% of the time." ³⁹ Do you have a response to this testimony?**

10 A. Entergy's witnesses' statements are completely contrary to the guidance contained in the
11 *GALL Report*, Revision 2, that the use of CHECWORKS is acceptable because it provides a
12 bounding, that is, conservative analysis, and that when measurements show the predictions to be
13 non-conservative, the model *must be re-calibrated*.⁴⁰ Instead, Entergy's witnesses readily admit,
14 and apparently agree with my assessment, that CHECWORKS produces non-conservative
15 predictions about half of the time, however, they believe that such a circumstance is acceptable.
16 This is inappropriate. Entergy's witnesses' testimony further indicates Entergy's apparent
17 concession that recalibration of the CHECWORKS model is unattainable, since Entergy expects
18 non-conservative predictions, 50% of the time, to continue. This is consistent with the reality
19 that Entergy has been trying to recalibrate the code for the last 10 years with no apparent success.
20

21 Unlike Entergy's witnesses, I believe that there is a potential safety risk from such a large
22 number of non-conservative predictions, evidenced by the fact that CHECWORKS can under
23 predict the actual wall thickness by as much as a factor of 10. A predictive code that 50% of the
24 time is not conservative by more than a factor of 1.5 (50%) and as high as a factor of 10 (900%),
25 clearly poses a safety risk in connection with improper monitoring of component wall thinning.
26

27 **Q. Entergy's witnesses also disagree with your conclusion that CHECWORKS has**
28 **very poor predictive accuracy because they believe "there is adequate correlation and since**

³⁸ Stéphane Trevin & Marie-Pierre Moutrille, *Optimization of EDF's NPPs Maintenance due to Flow Accelerated Corrosion and BRT-CICEROTM Improvement by NDT Results Analysis* (18th World Conference on Nondestructive Testing, 16-20 April 2012, Durban, South Africa) (Exhibit RIV000110).

³⁹ Entergy's Testimony at A102, A106, A109.

⁴⁰ *GALL Report*, Rev. 2 at § XI.M17 ¶ 5 (NYS00147A-NYS00147D).

1 **“good correlation will not be achieved for all Analysis Lines”⁴¹ Do you have a response to**
2 **this testimony?**

3 A. I disagree with Entergy’s witnesses’ characterization of CHECWORKS’ predictions as
4 generating “adequate correlation.” As I discussed and demonstrated in my initial testimony at
5 length, CHECWORKS over-predicts or under-predicts wall thinning by as much as a factor of
6 10.⁴² In my professional opinion, such a wide margin, demonstrated by much of the data I
7 reviewed, is not what I would consider “adequate correlation.”
8

9 **Q. Entergy’s witnesses testify that your assessment that CHECWORKS produces**
10 **highly inaccurate results does not indicate “a deficiency in the FAC program.”⁴³ Do you**
11 **agree with this conclusion?**

12 A. No, I do not. While Entergy’s witnesses do not challenge my conclusion that
13 CHECWORKS produces inaccurate results in many instances (or the fact that this inaccuracy in
14 many cases exceeds a factor of 2 and in some cases a factor of 10),⁴⁴ they do not characterize this
15 as a deficiency. I emphatically disagree, and view the highly unreliable nature of the
16 CHECWORKS model at Indian Point as problematic. Overall, my review revealed a data scatter
17 on the order of 5-10, and the inability of the code to predict wear by as much as a factor of 10,
18 which is significant from a safety perspective. This should preclude the use CHECWORKS as a
19 tool for predicting wear.
20

21 In particular, in light of the gross inaccuracy of CHECWORKS for predicting wear of
22 components at Indian Point, there is no confidence that CHECWORKS identifies the correct
23 inspection locations, and, in turn, no confidence that Energy will develop an adequate inspection
24 schedule. I previously provided examples showing that such inaccuracies could cause many
25 components to operate with wall thicknesses below their design thickness.⁴⁵ This was not the
26 intent of the *GALL Report*, which indicates that “[t]he inspection schedule developed by the
27 licensee on the basis of the results of such a [properly benchmarked] predictive code” must

⁴¹ Entergy’s Testimony at A109.

⁴² Hopenfeld Prefiled Direct at 5-10 (RIV000003); *see also* Report of Joram Hopenfeld in Support of RK-TC-2 (“Hopenfeld RK-TC-2 Report”) at 4-18 (RIV000005).

⁴³ Entergy’s Testimony at A114.

⁴⁴ *See* Hopenfeld Prefiled Direct at 6 (RIV000003); Hopenfeld RK-TC-2 Report at 7-8 (RIV000005).

⁴⁵ Hopenfeld Prefiled Direct at 10-11 (RIV000003); Hopenfeld RK-TC-2 Report at 13-15 (RIV000005).

1 “provide[] reasonable assurance that structural integrity will be maintained between
2 inspections.”⁴⁶

3
4 While some variation in code predictions would be expected when compared to experiential data,
5 since all measurements are subject to instrument errors and the chemical composition between
6 components will always vary, a properly designed predictive tool would account for
7 measurement uncertainties and variations in chemical composition. CHECWORKS, on the other
8 hand, has inherent deficiencies in its design, and results in predictive variations that cannot be
9 considered acceptable.

10
11 Moreover, the inability of CHECWORKS to predict FAC with any degree of accuracy is also a
12 deficiency because it runs afoul of applicable guidance, including the *GALL Report* for the
13 reasons discussed above. In addition, Entergy’s FAC program document, EN-DC-315 requires
14 that future inspections consider “CHECWORKS-predicted margins between nominal wall
15 thickness and minimum required wall thickness.”⁴⁷ However, because CHECWORKS
16 predictions are highly inaccurate, Entergy cannot meet these criteria.

17
18 **Q. Based on your assessment of Entergy’s CHECWORKS data, in your initial prefiled**
19 **testimony and accompanying report, you concluded that the CHECWORKS model is not**
20 **currently benchmarked and, therefore, is an ineffective tool for detecting and managing**
21 **FAC at Indian Point.⁴⁸ Entergy’s witnesses disagree that the data and “selected” graphs**
22 **you analyzed demonstrate a deficiency in CHECWORKS.⁴⁹ Do you have a response to this**
23 **explanation?**

24 **A.** My assessment of Entergy’s CHECWORKS data involved reviewing *every* graph
25 included in *every* CHECWORKS modeling report that was provided to me for review by
26 Entergy. In total, I reviewed approximately 225 plots with 6,500 data points, memorializing my
27 analysis in a table that was included in my expert report.⁵⁰ Thus, Entergy’s characterization that

⁴⁶ *GALL Report*, Rev. 1 at § XI.M17 ¶ 5 (NYS00146A-NYS00146C); *GALL Report*, Rev. 2 at § XI.M17 ¶ 5 (NYS00147A-NYS00147D).

⁴⁷ Entergy’s Testimony at A72.

⁴⁸ Hopenfeld Prefiled Direct at 5-10 (RIV000003); Hopenfeld RK-TC-2 Report at 4-13 (RIV000005).

⁴⁹ Entergy’s Testimony at A104, A105, A106.

⁵⁰ Hopenfeld RK-TC-2 Report at 9-12 (RIV000005).

1 the graphs I excerpted from Entergy's reports and included in support of my testimony as
2 Exhibits RIV00016A and RIV00016B are "partial results" and "selected graphs" is misleading
3 and wrong. I did not simply point to "examples with poor agreement between wear predictions
4 and actual measurements,"⁵¹ but rather included *all graphs from all reports*. There was nothing
5 selective about my analysis of Entergy's data, and I did not knowingly exclude any data.

6
7 In reality, all of this data, and not simply selected data, demonstrated the poor predictive
8 capability of CHECWORKS at Indian Point and the lack of correlation between predicted and
9 measured wear rates. All of the data I reviewed exhibited wide scatter, not simply "selected"
10 graphs and data. Moreover, I counted every data point that fell below the 45° line as a non-
11 conservative result, and every data point above the 45° line as a conservative result, to derive my
12 analysis as memorialized in Table 1 in my expert report.⁵² My analysis clearly demonstrated that
13 about 50% of the time, CHECWORKS produced non-conservative predictions. Thus, my review
14 of Entergy's data led me to the correct conclusion that CHECWORKS at Indian Point cannot
15 predict wall thinning to any degree of accuracy. In fact, Entergy's own witnesses even testify
16 that "CHECWORKS is logically expected to overpredict the wear rate 50% of the time and
17 underpredict the wear rate 50% of the time."⁵³ This seems inconsistent with the witnesses' other
18 statements intimating that CHECWORKS produces accurate results too.

19
20 **Q. Entergy's witnesses testify to their belief that 0.5-2.5 is an acceptable range for a line**
21 **correction factor ("LCF") because of user experience and because this range was defined**
22 **by EPRI.⁵⁴ Do you agree with this assessment?**

23 A. As I explained in my prefiled direct testimony, I am not aware of any adequate
24 justification to support a conclusion that an LCF within the range of 0.5 to 2.5 is acceptable or
25 that an LCF within this range would be an indication that CHECWORKS can be used to
26 accurately predict inspection locations.⁵⁵ Entergy's witnesses' testimony has not changed my
27 opinion. In fact, Entergy's vague and general responses indicate to me that Entergy may not
28 know what the true reason for the LCF range is.

⁵¹ Entergy's Testimony at A105.

⁵² Hopenfeld RK-TC-2 Report at 9-12 (RIV000005).

⁵³ Entergy's Testimony at A109.

⁵⁴ *Id.* at A108.

⁵⁵ Hopenfeld Prefiled Direct at 7 (RIV000003).

1
2 Notably, Entergy's witnesses' perception that CHECWORKS is an "effective tool," does not
3 constitute a technical justification for using the 0.5-2.5 criterion for either accepting or rejecting
4 CHECWORKS' predictions. As the LCF constitutes a key criterion that dictates whether
5 components should be reinspected or not, the criterion must be based strictly on safety
6 considerations. The numerous Entergy documents I reviewed failed to provide any such
7 technical explanation or justification. Not knowing the basis for the acceptance of this LCF
8 range is an indication that Entergy does not know the safety risk of using CHECWORKS. My
9 assessment of Entergy's data indicated that this acceptance criteria was exceeded by as much as
10 17%,⁵⁶ yet Entergy does not appear to know the safety consequences of exceeding the EPRI
11 criteria. Since the CHECWORKS data I reviewed represents a small fraction of all FAC
12 susceptible components in the plant, one must conclude that a large number of components are
13 operating outside the range of the EPRI criteria.

14
15 Moreover, Entergy's witnesses point to the fact that NRC Staff has endorsed the EPRI
16 documents which "defined" the LCF range Entergy uses.⁵⁷ However, my review of various
17 documents identified by Entergy and NRC Staff as relevant to Contention RK-TC-2 revealed no
18 NRC documents providing a scientific basis for the 0.5-2.5 LCF inspection criteria range. Thus,
19 simply because NRC Staff may blindly "endorse" the range, is not adequate justification for
20 using it.

21
22 **Q. Entergy's witnesses dispute your criticism of the fact that CHECWORKS fails to**
23 **provide a single measured value for every predicted data point.⁵⁸ In particular, Entergy's**
24 **witnesses attribute varying measured results to "different reasons, such as differing**
25 **amounts of trace chromium in different components, uncertainties in component initial**
26 **thickness, or uncertainties in NDE measurements."⁵⁹**

27 **A. Entergy's witnesses' response as to why there is no one-to-one correspondence between**
28 **predictions and measurements is inadequate. While some data scatter will always exist when**

⁵⁶ Hopenfeld RK-TC-2 Report at 9-12 (RIV000005).

⁵⁷ Entergy's Testimony at A108.

⁵⁸ *Id.* at A110.

⁵⁹ *Id.*

1 code predictions are compared to experiential data, since all measurements are subject to
2 instrument errors and the chemical composition between components will always vary, a
3 properly designed predictive tool should account for such variations. CHECWORKS predictions
4 for example show that for one predicted value there were 17 thickness measurements ranging
5 from 30 to 250 mils—that is, variation by a factor of 8. In reality, the reason for the lack of
6 correlation is that CHECWORKS has inherent deficiencies in its design. State-of-the-art
7 computer codes, such as the one described in Stéphane Trevin & Marie-Pierre Moutrille,
8 *Optimization of EDF's NPPs Maintenance due to Flow Accelerated Corrosion and BRT-*
9 *CICEROTM Improvement by NDT Results Analysis*,⁶⁰ show an order of magnitude better
10 accuracy of predicting wall thicknesses, and relatively little scatter in comparison to
11 CHECWORKS.

12
13 **Q. Entergy's witnesses respond to your discussion of +/-50% lines located on graphs in**
14 **Entergy CHECWORKS reports plotting measured versus predicted wear.⁶¹ In particular,**
15 **Entergy indicates that these lines "are there for the convenience of the reader of the report,**
16 **to provide consistent reference points across different graphs" and are not used by FAC**
17 **engineers to determine whether any CHECWORKS prediction is accurate or acceptable.⁶²**
18 **Do you have a response to this explanation?**

19 A. I disagree that the +/-50% lines provide convenience to the reader. In fact, I believe that
20 the opposite is true, since these lines convey misleading information in two ways:

21
22 First, they incorrectly inform the reader about the degree of non-conservatism in CHECWORKS
23 predictions. Put another way, the -50% line masks the degree of deviation of non-conservative
24 predictions from actual measurements. As an example, I have excerpted one graph from a
25 CHECWORKS modeling report which shows a typical plot of CHECWORKS wear predictions
26 versus actual wall measurements at Indian Point Unit 2, redrawn it to focus on the non-
27 conservative portion of the plot (i.e. including only the data below the LCF line), and included

⁶⁰ Stéphane Trevin & Marie-Pierre Moutrille, *Optimization of EDF's NPPs Maintenance due to Flow Accelerated Corrosion and BRT-CICEROTM Improvement by NDT Results Analysis* (18th World Conference on Nondestructive Testing, 16-20 April 2012, Durban, South Africa) (Exhibit RIV000110).

⁶¹ Entergy's Testimony at A111, A112.

⁶² *Id.* at A111.

1 these in support of my rebuttal testimony.⁶³ In this redrawn plot,⁶⁴ it is clear that most of the
2 non-conservative data, with the exception of five points, is bounded by the -50% line. Without
3 counting actual points, the reader cannot tell the degree of non-conservatism. The picture
4 becomes clearer when the measured wear is plotted on the y-axis and the predicted values are
5 plotted on the x-axis, as seen in a second redrawn plot I have included in support of my
6 testimony.⁶⁵ Now, one can easily see that fifteen data points, that is, three times as many, now
7 fall above the 50% line.⁶⁶ So, by assigning the y-axis with predictions and the x-axis with
8 measured wear, the non-conservative data appears to be bounded by the -50% line. When,
9 however, that arrangement is reversed, many of data points, can be seen as under-predicting
10 measurements by more than a factor of 1.5. In addition, the upper line (+50%) on some plots
11 was displaced by a factor 2 instead a factor of 1.5, giving the impression that a much larger set of
12 data points is being bounded. CHECWORKS performance graphs as presented are not showing
13 the real truth, that is, that a large number of data points show underpredicted measurements by
14 more than 1.5. A plot of CHECWORKS data with the y-axis as the measured wear and the x-
15 axis as the predicted wear would have provided a much more informative and objective display
16 of CHECWORKS performance. The manner in which CHECWORKS predictions are plotted
17 by Entergy's vendor hides the fact that a very large number of data points fall outside a margin
18 of 1.5 accuracy. In other words, the plots provided by Entergy mask the degree of non-
19 conservatism of CHECWORKS predictions.

20
21 Second, the line in some of the plots misrepresents how much of the data is really bounded by
22 the +50% line. I explained this in my initial testimony,⁶⁷ however, to reiterate and emphasize: in
23 some plots, the line labeled 50%, actually represents a line of points which exceed the points on
24 the 45° line by a factor of 2. To be consistent with the 50% label, the points on that line would
25 have to be larger by a factor of only 1.5 but then that line would bound a smaller number of
26 points. Thus, Entergy's presentation of the Indian Point CHECWORKS data exaggerates the
27 bounding capabilities of the model.

⁶³ Hopenfeld, Demonstration of Flawed Presentation of CHECWORKS Data (RIV000111).

⁶⁴ *Id.* at Figure 2a.

⁶⁵ *Id.* at Figure 2b.

⁶⁶ *Id.*

⁶⁷ Hopenfeld Prefiled Direct at 6 (RIV000003); Hopenfeld RK-TC-2 Report at 6-12 (RIV000005).

1 The release of and reliance on misleading and incorrect information is an indication of a poor
2 quality control of the FAC program at Indian Point.

3
4 **Q. Entergy's witnesses further testify that you reference older, allegedly outdated,**
5 **documents in support of your discussion of the +/-50% lines on CHECWORKS graphs,**
6 **and that "more valuable information about the goodness-of-fit of the program's**
7 **predictions" is available.⁶⁸ Do you have a response to this testimony?**

8 A. For the reasons discussed above, I continue to believe that Entergy's use of +/-50% lines
9 on CHECWORKS graphs is inappropriate, and misconstrues the data. The bottom line is that
10 the wide scatter in and out of the +/-50% lines demonstrates a very wide margin of conservative
11 and non-conservative predictions and complete lack of correlation. The relevant fact, which
12 Entergy's witnesses confirm in their testimony, is that CHECWORKS at Indian Point
13 underpredicts wear rates about 50% of the time. My review of thousands of data points
14 indicates that the discrepancy between predictions and actual measurements varies as much as by
15 a factor of 10. Thus, it is evident that CHECWORKS is "unfit," notwithstanding my discussion
16 of older documents.

17
18 **Q. Entergy's witnesses dispute your characterization of the highly erratic nature of**
19 **CHECWORKS predictions by indicating that certain analysis lines are not calibrated.⁶⁹**
20 **Do you have a response to this explanation?**

21 A. I assumed that the data Entergy provided was complete and ready for evaluation and
22 assessment. Notably, the CHECWORKS reports containing the graphs I reviewed did not
23 specify which graphs were calibrated and which were not. If some data was not ready for
24 evaluation, Energy should have not released that data, or provided an explanation in order to
25 fully understand the graphs.

26
27 My review of the data provided showed erratic and inaccurate predictions for a large majority of
28 the data. For example, one plot contained in an Entergy's CHECWORKS report⁷⁰ is one

⁶⁸ Entergy's Testimony at A112.

⁶⁹ *Id.* at A114.

⁷⁰ See RIV00016A at CSI Technologies, Inc., Indian Point Unit 2 CHECWORKS SFA Model, CSI Calculation No. 0705.101-01, Revision A, November 17, 2008, pageJ-5 of 36 (plot J.4: 4th Point Extrac Stm).

1 example of erratic predictions and/or unexplained behavior, as well as the lack of proper quality
2 controls in Entergy's FAC program. This plot shows no wall thinning predictions and the
3 measurements show thinning vary from 25 to 180 mils.⁷¹ It is, needless to say, difficult to
4 completely evaluate this kind of information in the absence of sufficient explanations from
5 Entergy.

6
7 **Q. Entergy's witnesses testify that "CHECWORKS is universally accepted in the**
8 **United States as the best available analytical tool for prioritizing inspections for a FAC**
9 **program . . . and has been endorsed by the NRC Staff."**⁷² **What is your response to these**
10 **statements?**

11 A. I do not believe that CHECWORKS is the best analytical tool for *predicting* wall
12 thinning, which is how the *GALL Report* contemplates its use. In particular, NRC's guidance in
13 the *GALL Report*, indicates NRC's belief that "CHECWORKS is acceptable because it provides
14 a bounding analysis for FAC. The analysis is bounding because in general the predicted wear
15 rates and component thicknesses are conservative when compared to actual field
16 measurements."⁷³ In addition, I also do not agree that CHECWORKS is the best analytical tool
17 for prioritizing inspection locations. Entergy's witnesses' statement is self-serving. EPRI
18 aggressively markets this tool.

19
20 Although I am not aware of the reasons why, the reality is that NRC endorses the use of
21 CHECWORKS. It is naïve to believe that once the NRC specifically endorses a single and a
22 specific computer code, any plant operator in the US would not use it. However, there is no
23 evidence that CHECWORKS was peer reviewed by an independent group of experts, and NRC
24 Staff has provided no scientific justification for using CHECWORKS as a predictive tool at
25 Indian Point.

⁷¹ See *id.*

⁷² Entergy's Testimony at A114.

⁷³ *GALL Report*, Rev. 1 at § XI.M17 ¶ 5 (NYS00146A-NYS00146C); *GALL Report*, Rev. 2 at § XI.M17 ¶ 5 (NYS00147A-NYS00147D).

1 Lastly, Entergy's witnesses' confidence in CHECWORKS begs the question: if CHECWORKS
2 is so reliable, why is it that its contribution is limited only to 25% of Entergy's total FAC
3 program?
4

5 **Q. Entergy's witnesses testify that Entergy has updated the CHECWORKS model to**
6 **account for the stretch power uprates ("SPUs") that occurred at Indian Point Units 2 and 3**
7 **in 2004 and 2005, respectively, and that "the overall accuracy of the CHECWORKS model**
8 **was not significantly affected by the SPUs."⁷⁴ Do you agree with this assessment?**

9 A. I agree that the grossly inaccurate predictions produced from CHECWORKS before the
10 SPUs continued after the SPUs. I discussed this at length in my initial testimony and expert
11 report, and further below.⁷⁵
12

13 **Q. Entergy's witnesses testify that CHECWORKS does not monitor or generate data in**
14 **relation to components inside the steam generators at Indian Point.⁷⁶ Do you have a**
15 **response to this explanation?**

16 A. Components inside the steam generators, as well as valves and blow down lines, are
17 important safety/risk-significant components that are highly vulnerable to FAC and fall within
18 the license renewal rule, and yet are not monitored at all by CHECWORKS. For example, the
19 steam generator feedring is subjected to very high turbulence especially at the flow stagnation
20 area, yet is not monitored by CHECWORKS to determine inspection intervals. In my
21 professional opinion, this is problematic, and fails to ensure that the steam generator will
22 maintain its integrity, in particular, during design basis accidents such as main steam-line breaks
23 and station blackouts. It remains unclear how such components are screened. Notably, EPRI's
24 guidance does not recommend the use of tools other than a quantitative predictive model such as
25 CHECWORKS.⁷⁷ Furthermore, the *GALL Report* encompasses all FAC-susceptible
26 components.
27

28 **Q. Entergy's witnesses disagree with your position that CHECWORKS does not**

⁷⁴ Entergy's Testimony at A91, A92.

⁷⁵ Hopenfeld Prefiled Direct at 5-10 (RIV000003); Hopenfeld RK-TC-2 Report at 5-13 (RIV000005).

⁷⁶ Entergy's Testimony at A64.

⁷⁷ EPRI, Recommendations for an Effective Flow-Accelerated Corrosion Program, NSAC-202L-R3 (RIV000012).

1 **ensure that all forms of FAC will be adequately managed.**⁷⁸ **Do you have a response to this**
2 **testimony?**

3 A. To begin with, I continue to respectfully disagree with Entergy's arbitrarily restrictive
4 definition of FAC, which improperly excludes wall thinning by cavitation, wet steam, galvanic
5 corrosion, and jet impingement/erosion even though all are effected by flow velocities.⁷⁹ Based
6 upon Entergy's characterization of a statement I made during the *Vermont Yankee* nuclear power
7 plant license renewal proceeding, it appears that Entergy lacks understanding of certain basic
8 principles of FAC, as well as the underlying assumptions in CHECWORKS, as I discussed
9 earlier.⁸⁰ Moreover, Entergy leaves out wall thinning by all mechanisms other than chemical
10 dissolution. Notably, the theory espoused by EPRI that FAC is strictly controlled by metal
11 dissolution is not universally accepted. Other researchers believe that fluid shear forces are
12 sufficiently large to remove the protective oxide film and thereby control wall thinning.

13
14 This is a limitation on Energy's use of the CHECWORKS computer code at Indian Point, since
15 the CHECWORKS model does not predict wall thinning by these other mechanisms, including
16 cavitation or droplet impingement. Entergy's witnesses appear to believe that just because EPRI
17 defined FAC as a process controlled by chemical dissolution only, wall thinning by cavitation
18 and wet steam do not require a predictive methodology. This is not accurate. Notably, a model
19 which combines mechanical and chemical mechanisms would predict much higher velocity
20 dependence than CHECWORKS predicts. Very high dependence of wall thinning on velocity
21 has been observed in laboratories.

22
23 However, Entergy's witnesses indicate that "inspection locations for erosive mechanisms are
24 selected based on operating experience by other IPEC programs (e.g., thermal performance has
25 identified a leaking valve), and engineering judgment."⁸¹ Entergy's witnesses' vague and
26 general description makes it impossible for me to assess whether Entergy is adequately
27 managing these other mechanisms, or whether Entergy will be able to adequately manage such
28 mechanisms during the proposed periods of extended operation. It appears that at least in some

⁷⁸ Entergy's Testimony at A51 (discussing Hopenfeld Report at 2 (RIV000005)); *see also id.* at A101.

⁷⁹ *Id.* at A51.

⁸⁰ *Supra* pp. 7-8.

⁸¹ Entergy's Testimony at A101.

1 cases the programs relies on pinhole leaks for future inspection. Pinhole leaks, through sentry
2 holes, were commonly used in refineries prior to 1950 to locate areas with excessive wall
3 thinning.
4

5 **V. The CHECWORKS Model is Not, and Will Not Become, Adequately Benchmarked at**
6 **Indian Point**
7

8 **Q. Entergy's witnesses testify that "there is no need for extended post-SPU calibration**
9 **or benchmarking over a period of multiple years or outage cycles *before* CHECWORKS**
10 **can be used as part of the FAC Program."⁸² Do you have a response to this assertion?**

11 A. For the reasons discussed at length in my initial testimony, I disagree with Entergy's
12 witnesses' statement, and continue to offer my expert opinion that because the model at Indian
13 Point clearly lacks adequate benchmarking, and cannot be used as part of the FAC program.
14 Based on my review of Entergy's witnesses' testimony, as well as a recently published study on
15 new data and a different computer code,⁸³ I believe that the design of CHECWORKS is so
16 fundamentally flawed that recalibration efforts will not be successful.
17

18 In particular, Entergy's CHECWORKS data reveals a constant lack of correlation over a period
19 of numerous years, and the data further reveals no signs that CHECWORKS' predictions are
20 improving with time, it appears unlikely that the model could be sufficiently recalibrated in the
21 future, and certainly not before Indian Point would enter the imminent extended operating terms
22 Entergy is seeking.⁸⁴ In fact, this notion is confirmed by Entergy's witnesses, who testify that
23 CHECWORKS was designed to "overpredict the wear rate 50% of the time and underpredict the
24 wear rate 50% of the time."⁸⁵ This reveals Entergy's witnesses' understanding that the
25 CHECWORKS model will not be properly calibrated in the future, and therefore, Entergy's use
26 of CHECWORKS is not consistent with Revision 2 of the *GALL Report*.
27

⁸² Entergy's Testimony at A115 (emphasis in original); see also *id.* at A116.

⁸³ Stéphane Trevin & Marie-Pierre Moutrille, *Optimization of EDF's NPPs Maintenance due to Flow Accelerated Corrosion and BRT-CICEROTM Improvement by NDT Results Analysis* (18th World Conference on Nondestructive Testing, 16-20 April 2012, Durban, South Africa) (Exhibit RIV000110).

⁸⁴ Hopenfeld Prefiled Direct at 5-10 (RIV000003); Hopenfeld RK-TC-2 Report at 4-13 (RIV000005).

⁸⁵ Entergy's Testimony at A109.

1 In addition, Entergy's witnesses have attributed the inaccuracy of CHECWORKS predictions to
2 chromium content in the components and measurement uncertainties. Recent data shows that the
3 uncertainty in chromium alone could affect FAC wear by an order of magnitude. Thus,
4 Entergy's witnesses identification of the presence of chromium is further evidence that extended
5 recalibration of the code is necessary, even if more accurate methods were used to determine
6 component chromium content.

7
8 It remains my opinion that because the CHECWORKS code is not adequately benchmarked,
9 despite years of continuous recalibration, it cannot be used reliably to schedule inspection
10 intervals, screen components for inspection, or to ensure that the structural integrity of
11 components between inspections will be maintained.

12
13 **Q. Entergy's witnesses believe that extended post-SPU benchmarking of**
14 **CHECWORKS at Indian Point is not necessary because "one of the goals of developing**
15 **CHECWORKS was to allow the user to predict the impact of changes of input**
16 **parameters."**⁸⁶ **Do you have a response to this statement?**

17 A. The fact that the code user can perform the mechanical task of changing or tweaking
18 input parameters is not a sign that the code has been recalibrated. There is only one way of
19 demonstrating that the code has been recalibrated, and therefore consistent with the guidance
20 contained in the *GALL Report*: comparing CHECWORKS predictions against actual measured
21 component thickness measurements. As my analysis, as contained in Table 1 of my expert
22 report, shows, the predictions of the recalibrated code (that is those predictions made after the
23 SPUs), are not different than the earlier results.⁸⁷ In all cases, approximately 50% of the data
24 points are non-conservative, most of the time by a factor of two (that is, by 100%), but also
25 upwards of in excess of a factor of 10 (that is, by 1000%).⁸⁸

26
27 **Q. Entergy's witnesses testify that extended post-SPU benchmarking of**
28 **CHECWORKS at Indian Point is not necessary because "CHECWORKS was designed,**
29 **and has been shown, to accommodate changes in chemistry, flow rate and other operating**

⁸⁶ Entergy's Testimony at A115.

⁸⁷ Hopenfeld RK-TC-2 Report at 9-12 (RIV000005).

⁸⁸ *Id.*

1 **conditions that may be associated with power uprates, without inspection data from**
2 **multiple outages.”⁸⁹ Do you have a response to this statement?**

3 A. My analysis of Entergy’s CHECWORKS data, as memorialized in Table 1 of my expert
4 report, does not support this claim. In particular, my analysis clearly demonstrates that following
5 each post-SPU refueling outage at Indian Point, the code has remained uncalibrated and therefore
6 not consistent with the *GALL Report*. The data shows no improvement in CHECWORKS
7 predictions; it consistently produces non-conservative predictions by a wide margin. I, therefore,
8 disagree that the CHECWORKS code at Indian Point has adequately accommodated the changes
9 in plant operating parameters following the SPUs.

10
11 Entergy’s witnesses support their statement by citing to an EPRI study where EPRI concluded
12 that CHECWORKS’ predictions in 22 reactors, notably *not* including Indian Point, were
13 reasonable following power uprates. The same document also states that the CHECWORKS
14 analysis is plant specific.⁹⁰ At Indian Point, the outcome of CHECWORKS’ predictions do not
15 agree with EPRI’s observations.

16
17 **Q. Entergy’s witnesses cite to an Entergy response to a “request for additional**
18 **information” (“RAI”) in which Entergy stated that “[d]ue to the low wear rates, the small**
19 **changes in operating parameters due to SPU, and the relatively short time since SPU,**
20 **changes to wear rates since SPU will be very small. The accuracy of the model is not**
21 **expected to change significantly due to the SPU” and that “additional data sets [following**
22 **SPU] when added to the CHECWORKS database, will result in more refined wear rate**
23 **predictions.”⁹¹ Entergy’s witnesses then testify that they agree with Entergy’s conclusion**
24 **in the RAI response, and believe that “the validity of the IPEC CHECWORKS model did**
25 **not change significantly due to the SPU.”⁹² Do you have a response to this testimony?**

26 A. To begin with, Entergy’s response to NRC Staff’s RAI is misleading, because it hides the
27 fact that CHECWORKS predictions at Indian Point are non-conservative 50% of the time, with
28 many of the actual measurements higher than predictions by a factor of two and as much as a

⁸⁹ Entergy’s Testimony at A116.

⁹⁰ EPRI, Plant Engineering: Impact of Electric Power Uprates on Flow-Accelerated Corrosion (July 2011)
ENT000081 at p.1-3.

⁹¹ Entergy’s Testimony at A117.

⁹² *Id.* at A118.

1 factor of 10. Nor does Entergy's RAI response indicate that wear to steam generator components
2 were not included in the CHECWORKS database.

3
4 Overall, for the reasons stated in this rebuttal testimony, as well as in my initial testimony, I
5 disagree that additional post-SPU data sets adequately "refined" the CHECWORKS model,
6 though do agree that the accuracy of the CHECWORKS model has not changed significantly: as
7 evidenced by more than 6,500 data points I analyzed, the model produced grossly inaccurate
8 predictions before the SPUs, and this continued after the SPUs. The scatter of the predictions is
9 so wide that no comparison is possible for any period since approximately 2000 (that is, the
10 years for which Entergy provided data).

11
12 **Q. Entergy's witnesses testify that NRC Staff concluded in its SER that**
13 **"CHECWORKS is 'a self-benchmarking' computer code."⁹³ Do you agree with this**
14 **characterization?**

15 A. No, I do not. Notably, the relevant issue is not whether CHECWORKS is manually or
16 automatically adjusted to accommodate changes in plant parameters, but rather, whether the
17 predictions of the recalibrated code are accurate and actually demonstrate that the code has been
18 sufficiently benchmarked, as required by the *GALL Report*. As discussed at length above and in
19 my initial testimony, this is not the case at Indian Point, and this is not likely to be demonstrated
20 prior to, or during, Entergy's proposed periods of extended operations.

21
22 **Q. You indicated earlier that you reviewed additional CHECWORKS reports which**
23 **Entergy disclosed and provided *after* your initial testimony was submitted in this**
24 **proceeding. Can you describe these reports?**

25 A. At the end of March, 2012, Entergy disclosed approximately 20 additional, previously-
26 undisclosed CHECWORKS modeling reports relating to Indian Point Unit 3. The dates of these
27 reports varied from 1999 to 2004 and discussed CHECWORKS data from several different
28 refueling outage FAC inspections at Unit 3. I am aware that in the context of a document
29 dispute between the parties that occurred around August of 2010, Entergy had indicated that
30 CHECWORKS data relating to Unit 2 prior to 2000 could not be located, but that Entergy had

⁹³ Entergy's Testimony at A119.

1 committed to disclose all available documentation related to CHECWORKS for Unit 3 dating
2 back to 2001. Thus, Entergy's March 2012 disclosure of these additional documents included
3 several which should have been disclosed earlier in accordance with Entergy's commitment to
4 do so, but also several other additional earlier reports.

5
6 While it is my understanding that in resolving the parties' document dispute the ASLB ruled that
7 Entergy did not have to disclose historical CHECWORKS data, I am aware that CHECWORKS
8 has been used at Indian Point since it was developed in or around the late 1980s/early 1990s.
9 Thus, the newly disclosed documents still do not constitute all of the CHECWORKS data that
10 has been generated from using the model at Indian Point.

11
12 **Q. Do you have any conclusions based upon your review of the additional**
13 **CHECWORKS modeling reports disclosed by Entergy in March 2012?**

14 A. I reviewed the data plots contained in these reports of CHECWORKS wear predictions of
15 component wall thickness relative to actual measurements. Once again, I have excerpted these
16 plots and included them in support of my rebuttal testimony.⁹⁴ My review of this additional data
17 confirms and supports my previous testimony and opinion that the CHECWORKS computer
18 code produces highly unreliable and non-conservative component wear predictions. Like the
19 previous plots I analyzed, these plots likewise exhibit wide scatter, and a high percentage of non-
20 conservative results. This data supports my conclusion that even prior to the SPU's at Indian
21 Point, the CHECWORKS code lacked adequate benchmarking, that the calibration of the code
22 has not improved with time, and that the code has never been properly benchmarked.⁹⁵

23
24 Based on my review of this additional CHECWORKS data, I continue to offer my professional
25 expert opinion that CHECWORKS is an ineffective tool for selecting and prioritizing piping and
26 piping component locations at Indian Point for inspections and wall thickness measurements, and
27 that the model will not be properly calibrated before Indian Point enters the rapidly approaching
28 proposed PEO.

⁹⁴ Graphs from CHECWORKS Reports (Excerpts) (RIV000112).

⁹⁵ Hopenfeld Prefiled Direct at 5-7 (RIV000003); Hopenfeld RK-TC-2 Report at 4-13 (RIV000005).

1 **VI. Entergy's Witnesses Inapposite Discussion of and Reliance on Findings Made in**
2 **Vermont Yankee Proceeding**
3

4 **Q. Entergy's witnesses testify at various points about findings made by a different**
5 **ASLB about FAC and CHECWORKS in the *Vermont Yankee* license renewal proceeding.⁹⁶**
6 **Do you have an overall response to such testimony?**

7 **A.** It is my understanding that a licensee must demonstrate that it has an adequate AMP for
8 FAC at *Indian Point*, which makes findings that relate specifically to Entergy's program at the
9 Vermont Yankee plant irrelevant.

10
11 In particular relation to the benchmarking of CHECWORKS, a discussion of what happened in a
12 different license renewal proceeding is irrelevant, because a CHECWORKS analysis is plant-
13 specific.⁹⁷ For example, EPRI has explained that "[a]s plant configurations, amounts of resistant
14 material and way in which the uprate is performed vary greatly, the CHECWORKSTM analysis is
15 plant specific."⁹⁸ Moreover, the Vermont Yankee adjudicatory hearings were held before the
16 *GALL Report*, Revision 2 was issued, which specifically requires recalibration of the
17 CHECWORKS code if it produces non-conservative results. Thus, Entergy's witnesses' reliance
18 on a proceeding that occurred when there was a different understanding of applicable guidance is
19 clearly inappropriate.

20
21 In general, notwithstanding Entergy's witnesses' testimony, I continue to opine that there are
22 several critical differences between the Vermont Yankee and Indian Point plants that also makes
23 the ASLB's findings in the former proceeding unreliable, including the size and type of reactors
24 at issue.

25
26 **Q. Entergy's witnesses cite the ASLB in the *Vermont Yankee* license renewal**
27 **proceeding as stating that the intervenors' experts in that case "may be misunderstanding**

⁹⁶ See Entergy's Testimony at A53, A115, A116, A121, A123-A130.

⁹⁷ Hopenfeld Prefiled Direct at 9 (RIV000003).

⁹⁸ EPRI, Plant Engineering: Impact of Electric Power Uprates on Flow-Accelerated Corrosion (July 2011)
ENT000081 at p.1-3.

1 **the purpose of CHECWORKS in the FAC program in their attempt to use continuous**
2 **benchmarking of the model to predict absolute wear.”⁹⁹ Do you have a response to this?**

3 A. While I completely understand Entergy’s stated purpose for which it uses CHECWORKS
4 at Indian Point, that is, as simply a ranking tool, I disagree with the appropriateness of doing this.
5 My understanding of the purpose of CHECWORKS is based on applicable regulations and
6 guidance, which, as I’ve discussed already, contemplate CHECWORKS as a quantitative
7 predictive tool, and which require recalibration of the model when results are non-
8 conservative.¹⁰⁰

9
10 Notably, in the *Vermont Yankee* proceeding, which I recall participating in, the emphasis
11 remained on Entergy’s use of the CHECWORKS code was for *predictive* purposes, and not
12 relative comparison purposes. It is, therefore, difficult to understand Entergy’s dependence upon
13 findings made in the Vermont proceeding when it uses the code in such a different manner at
14 Indian Point.

15
16 **Q. Entergy’s witnesses dispute your testimony distinguishing the findings in the**
17 ***Vermont Yankee* proceeding due to the small size of the Vermont Yankee plant.¹⁰¹ Do you**
18 **have a response to this?**

19 A. I continue to believe this is a valid difference that renders the findings made in the
20 *Vermont Yankee* proceeding unique to the Vermont plant, and not necessarily applicable to the
21 Indian Point proceeding. In addition, this testimony is somewhat puzzling to me, since, during
22 the *Vermont Yankee* proceeding, one of Entergy’s witnesses specifically testified that the effect
23 of the size of the plant effects FAC:

24 Q22 Are there features of the VY design that result in a reduction
25 of the amount of piping and components at a typical plant that are
26 potentially susceptible to FAC?

27 A22 (JCF) Yes. Compared to the majority of nuclear power plants
28 in operation, VY is a relatively small and simple plant. There are
29 fewer FAC-susceptible systems and piping components than at a
30 typical plant, and many of those were either originally constructed

⁹⁹ Entergy’s Testimony at A115 (citing *Entergy Nuclear Vt. Yankee* (Vt. Yankee Nuclear Power Station), LBP-08-25, 68 NRC 763, at 891 (2008)).

¹⁰⁰ See *GALL Report*, Rev. 2 at § XI.M17 ¶ 5 (NYS00147A-NYS00147D).

¹⁰¹ Entergy’s Testimony at A126.

1 of FAC-resistant materials or have been replaced with FAC-
2 resistant materials since their initial installation.¹⁰²
3

4 Dr. Horowitz testifies inconsistently in this proceeding that the size of Indian Point will not
5 affect FAC wear because velocities are about the same. I agree with Entergy's witness' own
6 opinion that the size of a plant will affect FAC, I continue to opine that this distinguishes any
7 findings made in the *Vermont* proceeding from the instant case.
8

9 **Q. Entergy's witnesses dispute your testimony that the findings of the ASLB in the**
10 ***Vermont Yankee* proceeding were inapposite because in that case post-SPU data was not**
11 **available.¹⁰³ Do you have a response?**

12 A. I continue to believe that this is a critical difference that makes the ALSB findings in the
13 *Vermont Yankee* proceeding totally inappropriate to apply in this proceeding related to Indian
14 Point. As I discussed in my initial testimony, the actual data from more than three post-SPUs
15 show that CHECWORKS produces non-conservative results more than 50% of the time, and is,
16 thus, not adequately calibrated. In contrast, there was no post-power uprate data in the *Vermont*
17 *Yankee* proceeding. Thus, the finding in the *Vermont Yankee* proceeding that CHECWORKS
18 did not require extended benchmarking following a SPU, clearly does not apply to a case where
19 concrete data supports a contrary conclusion: a look at almost any one of the hundreds of plots of
20 CHECWORKS predictions shows beyond a doubt that CHECWORKS produces a high
21 percentage of (at times grossly) non-conservative results, and thus, as required by the *GALL*
22 *Report*, must be recalibrated. A finding that was made without the benefit of actual data,
23 essentially in a vacuum, and before the clarification in the *GALL Report* about the necessity of
24 recalibrating the CHECWORKS model when it produces non-conservative results, is simply
25 irrelevant to this case.
26

27 **Q. Entergy's witnesses dispute your testimony that the findings of the ASLB in the**
28 ***Vermont Yankee* proceeding were inapposite because in that case the board found**
29 **prolonged benchmarking unnecessary since Vermont Yankee had the benefit of data**

¹⁰² In the Matter of Entergy Nuclear Vermont Yankee, LLC and Entergy Nuclear Operations, Inc. (Vermont Yankee Nuclear Power Station), Docket No. 50-271 -LR, ASLBP No. 06-849-03-LR, Testimony of Jeffrey S. Horowitz and James C. Fitzpatrick on NEC Contention 4 – Flow-Accelerated Corrosion (May 12, 2008), at 12-13(RIV000113).

¹⁰³ Entergy's Testimony at A128.

1 **dating back to 1989, whereas at Indian Point, data predating approximately the year 2000**
2 **had been lost.¹⁰⁴ In particular, Entergy's witnesses testify that even though data dating**
3 **back to the inception of the FAC program at Indian Point was not available and/or**
4 **disclosed, the data has been incorporated into and reflected in the CHECWORKS**
5 **model.¹⁰⁵ Do you have a response to this explanation?**

6 A. To begin with, it was my understanding (based on representations made by Entergy,
7 which were confirmed by the ASLB in a ruling on a document disclosure dispute about
8 CHECWORKS data), that older, historical CHECWORKS data related to Indian Point was
9 unavailable, and/or too burdensome to disclose. Notably, although Entergy provided certain
10 additional CHECWORKS reports recently in March, 2012, as I discussed above, these reports
11 dated back only to 1999, and still did not cover the time period dating back to the original use of
12 CHECWORKS at Indian Point.

13
14 I find Entergy's witnesses' reference to the incorporation of historical CHECWORKS data into
15 the model problematic to the extent Entergy's witnesses and Entergy rely upon this older data,
16 (and the fact that it has been incorporated into the CHECWORKS model), to demonstrate that
17 the code has been properly benchmarked and does not require "prolonged benchmarking." In
18 order to assess such claims, it would be necessary for me to actually review the data; I could not
19 simply rely on the fact that such data has allegedly been incorporated into the model. This is
20 consistent with the ASLB ruling that because Entergy did "not have ready access to the data
21 requested" they "cannot, rely on it to provide the track record for its AMP that Riverkeeper
22 claims is lacking" or to "demonstrate that its use of CHECWORKS is adequately
23 benchmarked."¹⁰⁶ And yet, despite the fact that no older data was required to be disclosed based
24 on Entergy's representations in this case and the fact that I have, therefore, not reviewed any
25 historical data, Entergy now appears to want to rely on it to support its reliance on
26 CHECWORKS. In my opinion, Entergy cannot point to older data in this way.

¹⁰⁴ Entergy's Testimony at A129.

¹⁰⁵ *Id.*

¹⁰⁶ In the Matter of Entergy Nuclear Operations, Inc. (Indian Point Nuclear Generating Units 2 and 3), Docket Nos. 50-0247-LR and 50-286-LR, ASLBP No. 07-858-03-LR-BD01, Order (Ruling on Riverkeeper's Motion to Compel) (November 4, 2010), at 5.

1 In any event, the CHECWORKS data that *was* disclosed overwhelmingly shows the fact that the
2 code has consistently provided highly non-conservative predictive results, and that over the time
3 span of the data I reviewed (from approximately 1999 to 2011), the code has not improved.
4 Based on the behavior of the code that I was able to analyze based upon data, I do not believe
5 that the additional historical data, which I have not had the benefit of reviewing, would
6 materially change my opinions and conclusions. Based on how the model has behaved (that is,
7 consistently poorly) since 1999, I believe that the historical data would actually in all likelihood
8 bolster and be consistent with my findings.

9
10 **VII. Leaks at Indian Point Demonstrate a Defective FAC Program**
11

12 **Q. Entergy's witnesses dispute your discussion of various leaks and wall thinning**
13 **events at Indian Point, which you testified are indicative of a deficiency in the FAC**
14 **program at Indian Point.¹⁰⁷ Do you have a response to this testimony?**

15 A. It is puzzling to me that when leaks or excessive instances of wall thinning occur,
16 Entergy can claim such instances are "program successes," and that, despite these events, the
17 FAC program nevertheless performs well.

18
19 Although Entergy's witnesses explain that various leaks I discussed did not occur under the FAC
20 program, the *GALL Report* requires that all FAC-susceptible components be properly monitored,
21 whether they fit Entergy's definition of FAC or not. In many instances it is difficult to establish
22 the exact mechanism that caused wall thinning. Moreover, the main purpose of a well-executed
23 program is to prevent failures by wall thinning regardless of whether it is managed by the FAC
24 program as defined by Entergy.

25
26 In addition, I strongly dispute Entergy's witnesses' explanation that certain leaks do not
27 demonstrate a FAC program deficiency because the leak was of "negligible safety
28 significance."¹⁰⁸ I disagree that such leaks are not a cause for concern. Small leaks, if not
29 controlled in a timely manner, can grow in size or damage adjacent equipment and quickly
30 become a safety risk. For example, the occurrence of a large rupture in a non-safety area at the

¹⁰⁷ Entergy's Testimony at A131 to A134.

¹⁰⁸ *Id.* at A132.

1 Surry plant quickly propagated to safety areas. At Surry, 20% of the wall thickness was lost in
2 less than 18 months. This was sufficient to cause a major rupture when the line pressure was
3 suddenly increased by 20% due to a valve closure. Although the rupture occurred in a non-
4 safety area, it resulted in seepage of toxic chemicals into the control room. Thus, the witnesses'
5 trivialization of small leaks is superficial.

6
7 Simply because Entergy instituted corrective action in response to the leak and thinning events I
8 cited to, does not mean that such events are acceptable and consistent with applicable guidance,
9 which requires adequate management of FAC. I, therefore, continue to opine that the operational
10 events I testified about in my initial testimony do demonstrate a deficiency in Entergy's FAC
11 program.

12
13 **VIII. The Relevance of FAC Occurrences and the Failure of CHECWORKS at Other**
14 **Nuclear Power Plants**
15

16 **Q. Entergy's witnesses dispute your discussion of FAC instances that have occurred at**
17 **other nuclear plants and the failure of CHECWORKS on a global scale.¹⁰⁹ Do you have a**
18 **response to this testimony?**

19 A. I disagree with Entergy's witnesses' testimony about the relevance and implications of
20 the various events of FAC and use of CHECWORKS at other nuclear plants, which I discussed
21 in my initial testimony and expert report.¹¹⁰ Entergy's witnesses' testimony does not change my
22 opinions regarding the significance of these events, or the unreliability of CHECWORKS.

23
24 For example, Dr. Horowitz testifies that a FAC event that occurred at San Onofre that I raised in
25 my initial hearing submissions, did not indicate a problem with the use of CHECWORKS or
26 Entergy's FAC program because "[a]t San Onofre, the cited events occurred within the plant's
27 steam generators" and "CHECWORKS was not used to analyze these components (and, even
28 today, it is not commonly used to analyze piping components located within equipment such as
29 steam generators)."¹¹¹ However, the fact that CHECWORKS was not used to predict many

¹⁰⁹ Entergy's Testimony at A135 to A140.

¹¹⁰ Hopenfeld RK-TC-2 Report at 15-18 (RIV000005); Hopenfeld Prefiled Direct at 11-12 (RIV000003).

¹¹¹ Entergy's Testimony at A.135.

1 components in steam generators is not a valid explanation of why many of FAC wall thinning
2 events have gone undetected. In addition, I continue to maintain, as I discussed above, that all
3 FAC-susceptible components must be monitored, as dictated by the guidance in the *GALL*
4 *Report*, whether CHECWORKS is used or not. Thus, this example does raise a valid deficiency
5 with Entergy's reliance on CHECWORKS, and, Entergy's FAC program overall.

6
7 By way of another example, Dr. Horowitz also disputed my conclusion that CHECWORKS was
8 not adequate to model the flow situation that was present at the Mihama plant. Dr. Horowitz
9 testified that "some of the single-phase data from the UK [United Kingdom] showed the FAC
10 rate downstream of an orifice, such as Mihama. These data were used extensively in developing
11 the algorithm used in CHECWORKS" and concluded that "CHECWORKS is capable of
12 correctly modeling the flow conditions that existed at Mihama."¹¹² However, turbulence
13 intensity and, therefore, the local corrosion/erosion rate down stream of an orifice is a well
14 known observation. It is true that CHECWORKS allows the user to take such information into
15 account, but in some cases the data is questionable, such as measurements of corrosion rates of
16 copper in flowing hydrofluoric acid. The dependence of the mass transfer on velocity as it was
17 modeled in CHECWORKS is also questionable. Therefore, Dr. Horowitz's explanation does not
18 change my opinion about the inability of CHECWORKS to adequately account for and model all
19 relevant flow situations.

20
21 **IX. Entergy's Failure to Comply with Relevant Regulatory Guidance**

22
23 **Q. Entergy's witnesses testify that "the IPEC FAC Program is consistent with the**
24 **recommendations in NUREG-1801, Revision 1 [the *GALL Report*]" and "also meets the**
25 **intent of the guidance in NUREG-1801, Revision 2."¹¹³ Do you have a response to this**
26 **position?**

¹¹² Entergy's Testimony at A136.

¹¹³ *Id.* at A141.

1 A. I disagree with this position. For the reasons discussed at length in my initial testimony
2 and expert report,¹¹⁴ and in this rebuttal testimony, Entergy's AMP for FAC does not meet the
3 guidance contained in the *GALL Report*.

4
5 To begin with, Entergy's witnesses' testimony fails to acknowledge a critical difference between
6 Revisions 1 and 2 of the *GALL Report*, in that the latter and most recent revision requires the
7 recalibration of the CHECWORKS code when the results are non-conservative.¹¹⁵ In fact, both
8 revisions of the *GALL Report* indicate that the use of the CHECWORKS code is acceptable
9 because it provides a bounding, conservative analysis.¹¹⁶ However, as discussed above,
10 Entergy's FAC program does not heed this guidance, and Entergy's witnesses instead indicate
11 their position that the code at Indian Point is *expected to and does* produce non-conservative
12 results about 50% of the time.¹¹⁷ Indeed, my extensive review of the performance of
13 CHECWORKS at Indian Point clearly demonstrates a continuous trend of highly non-
14 conservative, inaccurate results, as discussed at length in my expert report and initial
15 testimony.¹¹⁸ In this glaring respect, Entergy's FAC program does not meet the guidance of the
16 *GALL Report*. In fact, it is difficult to understand how, in light of the overwhelming evidence
17 about the non-conservative nature of CHECWORKS predictions at Indian Point, which
18 Entergy's witnesses testify to, Entergy can still claim compliance and consistency with the *GALL*
19 *Report*.

20
21 Moreover, as discussed in my initial testimony, and in my discussion above of Entergy's alleged
22 "other tools" for managing FAC, it remains my professional opinion that Entergy has yet to
23 provide sufficiently detailed information to ensure its program is otherwise consistent with the
24 *GALL Report* and other relevant standards. It is not sufficient for Entergy to just state that it
25 adopted the elements outlined in the *GALL Report*. Entergy must describe how those elements
26 will be implemented to ensure that the critical wall thickness of all susceptible components will
27 be maintained between inspections. Entergy has not done this. Thus, Entergy's witnesses have

¹¹⁴ See Hopenfeld Prefiled Direct at 16-18 (RIV000003); Hopenfeld RK-TC-2 Report at 18-19, 25 (RIV000005).

¹¹⁵ See Entergy's Testimony at A48; *GALL Report*, Rev. 2 at § XI.M17 ¶ 5 (NYS00147A-NYS00147D).

¹¹⁶ *GALL Report*, Rev. 1 at § XI.M17 ¶ 5 (NYS00146A-NYS00146C); *GALL Report*, Rev. 2 at § XI.M17 ¶ 5 (NYS00147A-NYS00147D).

¹¹⁷ Entergy's Testimony at A102, A106, A109.

¹¹⁸ See Hopenfeld Prefiled Direct at 5-10 (RIV000003); Hopenfeld Report at 4-13 (RIV000005).

1 not demonstrated that the effects of aging for FAC-susceptible components will be adequately
2 managed as outlined by 10 elements in the *GALL Report*.

3
4 **Q. Entergy's witnesses testify that NRC Staff concluded in its SER that the FAC**
5 **program at Indian Point was acceptable and consistent with the ten program elements**
6 **contained in the *GALL Report*.¹¹⁹ Do you have a response to this?**

7 A. It appears that NRC Staff's conclusions in the SER were based on materially different
8 information about Entergy's FAC program than has been presented in Entergy's testimony. In
9 particular, Entergy's testimony has revealed for the first time how relegated Entergy's use of
10 CHECWORKS is, and how Entergy largely relies upon "other tools." This was not clear by
11 Entergy's statements in its LRA that Entergy's FAC program was based on the *GALL Report* and
12 NSAC-202L, both of which focus on the use of a quantitative predictive code. NRC Staff's
13 discussion of Entergy's FAC program in its SER, as well as the testimony NRC Staff provided
14 on Contention RK-TC-2, indicate NRC Staff's apparent understanding of CHECWORKS as the
15 main tool to predict component wall thickness for scheduling inspection intervals at Indian
16 Point.¹²⁰ Thus, it does not appear appropriate for Entergy to rely on conclusions made in the
17 NRC Staff's SER.

18
19 **X. The Failure of Entergy's FAC Program to Address Critical Safety Issues**

20
21 **Q. Entergy's witnesses disagree with your position that FAC at Indian Point poses an**
22 **accident risk at Indian Point, and state that this position "presupposes a deficiency in the**
23 **FAC Program, which is not the case."¹²¹ Do you have a response to this testimony?**

24 A. As I discussed in my initial testimony and expert report, as well as in this rebuttal
25 testimony, Entergy's FAC program contains numerous deficiencies, making the risk of an
26 accident very real.¹²² My observations that Entergy is not using CHECWORKS to detect FAC
27 in the steam generators and for other risk significant components, and that Entergy has not
28 sufficiently described how the "other tools" in the FAC program at Indian Point are used (such as

¹¹⁹ Entergy's Testimony at A58.

¹²⁰ SER at pp. 3-21 to 3-31.

¹²¹ Entergy's Testimony at A142.

¹²² Hopenfeld Prefiled Direct at 10-11, 18-20 (RIV000003); Hopenfeld RK-TC-2 Report at 24-25 (RIV000005).

1 failing to provide information about uncertainties in selecting measurement points, frequency of
2 inspection, measurements accuracy, and safety consequences), lead me to the fully supported
3 conclusion that FAC may go undetected in some components during the extended period of
4 operations, posing an accident risk.

5
6 I continue to opine that after forty years of operation, some critical components may be operating
7 with wall thicknesses below the minimum allowable, unknown to Entergy, and, therefore, would
8 be vulnerable to failure when exposed to loads from design basis accidents, including Main
9 Steam Line Breaks. Entergy's witnesses ignore this foreseeable circumstance. Notably, the
10 Indian Point current licensing basis ("CLB") requires that that the plant be able to accommodate
11 such accidents.

12
13 **Q. Entergy's witnesses disagree with you position that Entergy has failed to adequately**
14 **consider how the uncertainty related to pipe wall thickness at Indian Point will affect**
15 **component integrity under transient loads, including earthquakes and station blackouts.**
16 **In particular, Entergy's witnesses testify that "[w]hen FAC Program inspections reveal**
17 **wall thinning, that data is evaluated against the appropriate design loading conditions,**
18 **including seismic loads."**¹²³ **Do you have a response to this testimony?**

19 A. To begin with, for the reasons discussed in my initial testimony and expert report, as well
20 as in this rebuttal testimony,¹²⁴ I disagree that Entergy's FAC program "provides reasonable
21 assurance that components within its scope will continue to perform their intended functions
22 throughout the PEO."¹²⁵ Entergy's witnesses' testimony about this issue presupposes that the
23 FAC program will not miss detection of excessive wall thinning. This, of course, is a highly
24 unrealistic assumption given forty years of operating experience showing otherwise. As
25 discussed above, my observations about the various deficiencies in Entergy's FAC program
26 make the concerns I raised about the ability of pipes to handle varying transient loads, very real.

¹²³ Entergy's Testimony at A143.

¹²⁴ Hopenfeld Prefiled Direct at 10-11, 18-20 (RIV000003); Hopenfeld RK-TC-2 Report at 24-25 (RIV000005).

¹²⁵ Entergy's Testimony at A143.

1 **Q. Entergy's witnesses disagree with your position that Entergy has failed to consider**
2 **how uncertainty related to pipe wall thickness at Indian Point will affect whether**
3 **components succumb to metal fatigue.¹²⁶ Do you have a response to this testimony?**

4 A. Once again, Entergy's witnesses first indicate that they disagree with my testimony
5 because it "presupposes a deficiency in the FAC Program."¹²⁷ As discussed above and in my
6 initial testimony and expert report, my testimony has, in fact, demonstrated numerous
7 deficiencies with the program.

8
9 Entergy's witnesses next essentially dismiss the concern I have articulated related to metal
10 fatigue, claiming that requirements for calculating fatigue factors do not apply to FAC-
11 susceptible components, and that "stress allowable" of components in the FAC program "are
12 maintained" and that this "adequately protect[s] components against fatigue cracking."¹²⁸

13
14 In relation to the potential for FAC to affect primary plant components that are clad with
15 stainless steel that are subject to fatigue, Entergy's witnesses cite to a statement I made in a
16 pleading filed in this proceeding that "I am well aware that stainless steel is not affected by flow
17 accelerated corrosion." However, this statement is cited out of context and the witnesses
18 misrepresent what I was saying. Entergy's witnesses are clearly not familiar with NUREG/CR-
19 6260, *Application of NUREG/CR-5999 Interim Fatigue Curves to Selected Nuclear Power Plant*
20 *Components* (1995). First, in that statement, I was not discussing balance of plant components,
21 but rather the reactor vessel nozzles, which are part of the reactor coolant system ("RCS").
22 Second, my comment about the stainless steel cladding was related to the fact that in their fatigue
23 analysis, Entergy used a model of an un-cladded nozzle. In this model, a low alloy steel ("LAS")
24 surface was exposed to high velocity flow making the nozzle susceptible to wall thinning by
25 FAC. The F_{en} equations, which were used to calculate the environmental correction factor, were
26 applicable to LAS, clearly indicating that the model recognized that the LAS was in direct
27 contact with the coolant. Because of the high flow velocities through the nozzle and the LAS
28 material, FAC must be included the fatigue analysis. While I fully discussed Entergy metal
29 fatigue model in testimony that I submitted in this proceeding in support of Riverkeeper

¹²⁶ Entergy's Testimony at A144.

¹²⁷ *Id.*

¹²⁸ *Id.*

1 Contention TC-1B,¹²⁹ I simply note here that it is common in fatigue analysis to assume that the
2 cladding has been breached and to proceed accordingly. In this regard, NUREG/CR-6260
3 specifies that the effect of the cladding must be considered not from the perspective of its
4 contribution to structural strength, but rather in relation to how it is affected by fatigue.¹³⁰ It is
5 apparent that Entergy's witnesses overlooked an important practice in the selection of models for
6 analysis: once a model has been selected, the analysis must be consistent with the underlying
7 assumptions.

8
9 It is clear based on the witnesses' response that they do not understand the possible synergy
10 between metal fatigue and FAC. I continue to opine that due to Entergy's flawed FAC program,
11 metal fatigue may become increasingly problematic, and that Entergy has not sufficiently
12 considered this issue.

13
14 **XI. Conclusion**

15
16 **Q. Please summarize your opinions and conclusions relating to the testimony proffered**
17 **by Entergy's witnesses relating to Contention RK-TC-2.**

18 A. Entergy's witnesses' testimony does not change my opinion that the effects of aging for
19 FAC-susceptible components at Indian Point will not be adequately managed throughout the
20 period of the extended operation, such that their intended functions will be maintained consistent
21 with the Indian Point current licensing basis ("CLB"), as required by 10 C.F.R. § 54.21(a)(3).
22 Entergy's witnesses' have not provide any supporting evidence that the CLB will be valid
23 throughout the extended period beyond merely stating that the CLB will be maintained. While
24 relevant guidance in the *GALL Report* envisions the use of a reliable, properly benchmarked,
25 bounding predictive code to manage FAC, Entergy employs the use of the CHECWORKS
26 computer model for only a fraction of its FAC program, and to the extent it does, uses a grossly
27 inaccurate model that consistently produces non-conservative results, as acknowledged by
28 Entergy's witnesses. This is completely inconsistent with the *GALL Report*, Revision 2.

¹²⁹ See Prefiled Direct Testimony of Dr. Joram Hopenfeld Regarding Consolidated Contention NYS-26B/RK-TC-1B – Metal Fatigue (December 20, 2011) (RIV000034); Report of Dr. Joram Hopenfeld in Support of Contention Riverkeeper TC-1B – Metal Fatigue (December 19, 2011) (RIV000035).

¹³⁰ NUREG/CR-6260, *Application of NUREG/CR-5999 Interim Fatigue Curves to Selected Nuclear Power Plant Components* (1995) (NYS000355).

Moreover, Entergy has failed to demonstrate that alleged “other tools” Entergy employs are adequate at managing FAC. Entergy has further failed to consider critical safety issues posed by the numerous deficiencies in Entergy’s FAC program. In light of the difficulties in predicting component degradation from FAC without a reliable predictive tool, Entergy has not demonstrated the CLB would be maintained during the proposed extended period of operations.

REBUTTAL TO NRC STAFF’S HEARING SUBMISSIONS ON RK-TC-2

Q. NRC Staff’s witnesses testify that the CHECWORKS computer code is used “to predict component degradation” and “to identify the most susceptible components for inspection and to calculate wear rates to predict when the components will reach the minimum allowable wall thickness.”¹³¹ Do you have any response to this testimony?

A. I agree with NRC Staff’s understanding of the appropriate use and function of CHECWORKS. However, this appears to be inconsistent with how Entergy uses the computer model at Indian Point: as “primarily a ranking tool” that “provides a screening and prioritization function.”¹³² In addition, Entergy’s witnesses’ testimony makes clear that Entergy only uses CHECWORKS to model susceptible components and predict component degradation for a small fraction of its FAC program.¹³³ Nowhere in NRC Staff’s witnesses’ testimony do they discuss an understanding and/or acceptance of using CHECWORKS as purely a ranking/screening tool. In light of this apparent misunderstanding of how Entergy actually uses the CHECWORKS model at Indian Point, I do not believe that NRC Staff’s acceptance of Entergy’s use of CHECWORKS¹³⁴ is well-founded or appropriate.

Q. NRC Staff’s witnesses testify that “[t]he future predicted wear rates and thickness values are based on the calibrated models that have been adjusted to reflect the actual wear from the inspection data. In other words, wear rates and wear rate predictions are based on calibration of CHECWORKS™ using actual physical inspection data from

¹³¹ NRC Staff’s Testimony at A20, A23, A30.

¹³² Entergy’s Testimony at A36, A102, A103.

¹³³ *Id.* at A76, A77, A94.

¹³⁴ See NRC Staff’s Testimony at A31, A52.

1 **components,” and further that “[t]his comparison showed that the CHECWORKS™**
2 **model accurately predicts FAC behavior.”¹³⁵ Do you have a response to this position?**

3 A. Once again, it is not clear whether NRC Staff’s witnesses understand that at Indian Point,
4 Entergy only models a fraction of susceptible components in CHECWORKS.¹³⁶ As a result,
5 NRC Staff’s witnesses’ acceptance of Entergy’s use of CHECWORKS appears mistaken.

6
7 In any event, as I discussed above, as well as at length in my initial testimony and expert report,
8 my analysis of data from about five successive outages between 2000 and 2010 at Indian Point
9 Units 2 and 3, clearly demonstrated that CHECWORKS under predicted the actual wear
10 approximately 50% of the time, and by as much as a factor of 10.¹³⁷ Notably, while Entergy data
11 is shown as “bounded” by +/-50% lines, above and below a 45° line, that is, 50% conservative
12 and the other 50% non-conservative, a gross split of conservative versus non-conservative
13 numbers is relatively a minor indicator of CHECWORKS performance. A more important
14 indicator, from the safety perspective, is the accuracy of the non-conservative predictions, that is,
15 the degree by which the predictions are underpredicted. At Indian Point, a great deal of the
16 CHECWORKS results underpredicted the component wear by more than a factor of 2. As I
17 discussed above, the manner in which CHECWORKS predictions are presented hides that type
18 of information.¹³⁸ By assigning the y-axis as the predicted coordinate and the x-axis as the
19 measured coordinate, the accuracy of the non-conservative data appears to be bound by the -50%
20 line.¹³⁹ However, when that arrangement is reversed, it is far clearer that many data points (3
21 times as many) represent under-predictions of more than a factor of 1.5.¹⁴⁰

22
23 The evidence plainly shows that the code is *not* adequately calibrated, and does *not* accurately
24 predict FAC behavior, at Indian Point. I, therefore, disagree with this testimony.

135 NRC Staff’s Testimony at A20, A23.

136 See Entergy’s Testimony at A76, A77, A94.

137 See Hopenfeld Prefiled Direct at 5-10 (RIV000003); Hopenfeld RK-TC-2 Report at 4-13 (RIV000005); *supra* § IV (*The Performance of CHECWORKS at Indian Point*).

138 See *supra* pp. 24-26.

139 Hopenfeld, Demonstration of Flawed Presentation of CHECWORKS Data, at Figure 2a (RIV000111).

140 *Id.* at Figure 2b.

1 **Q. NRC Staff's witnesses testify that when plant operating conditions change, a line**
2 **correction factor may be applied to adjust wear rate predictions, that is "calibrate" the**
3 **model, a process NRC Staff's witnesses call "self-benchmarking."¹⁴¹ Do you have a**
4 **response to this testimony?**

5 A. Firstly, I disagree with the witnesses' use of the term "self-benchmarking." This term is
6 not appropriate, because it conveys an erroneous message that simply tweaking computer inputs
7 will automatically adjust the model and it will become calibrated.

8
9 In any event, once again, my review of actual data from Indian Point has revealed that that
10 notwithstanding the use of line correction factors, the CHECWORKS model is not adequately
11 calibrated at the plant. Moreover, NRC Staff's witnesses, just like Entergy's, testify that there is
12 an "expectation that the model will yield conservative and non-conservative predictions about
13 50% of the time."¹⁴² As this is apparently an inherent feature of CHECWORKS, the calibration
14 of the code could ostensibly never improve. Thus, NRC Staff's testimony does not appear well-
15 founded. While I do agree with the NRC's Staff's witnesses that "it is not realistic to expect
16 physical inspection data of component thickness to fit the predicted values exactly 100 percent of
17 the time,"¹⁴³ I do not agree that it is the intent of the *GALL Report* to allow a significant number
18 of non-conservative predictions to exceed a factor of two and some a factor of ten.

19
20 **Q. NRC Staff's witnesses disagree with the concerns you articulated about LCFs in the**
21 **CHECWORKS data at Indian Point.¹⁴⁴ Do you have a response to this?**

22 A. NRC Staff's vague and general testimony does not address the concerns I raised with
23 respect to the arbitrary LCF range employed at Indian Point, or the fact that for many
24 measurements fall outside the allegedly "acceptable" range at the plant. Notably, I am not aware
25 of any NRC statement or explanation that provides an adequate scientific basis for the 0.5-2.5
26 LCF inspection criteria range.

27

¹⁴¹ NRC Staff's Testimony at A24.

¹⁴² *Id.* at A59.

¹⁴³ *Id.*

¹⁴⁴ *Id.* at A60.

1 **Q. NRC Staff's witnesses dispute your position that CHECWORKS lacks a track**
2 **record or performance at Indian Point, and point to your own report as stating that**
3 **CHECWORKS has been used at Indian Point since at least 2000 and under power uprate**
4 **conditions.¹⁴⁵ Do you have a response?**

5 A. While it is true that in my expert report I described that CHECWORKS was implemented
6 at Indian Point, I also described at length the various reason why Entergy's use of the model at
7 Indian Point since at least 2000 had been, and continues to be, a complete failure, and not in
8 compliance with relevant standards and guidance. Moreover, simply because various leaks and
9 thinning incidents I cited did not result in a "structural failure"¹⁴⁶ or accident, does not render
10 such events acceptable. As I discussed above and in my initial testimony and expert report, I
11 continue to believe that such instances demonstrate a deficiency in the FAC program at Indian
12 Point.¹⁴⁷

13
14 **Q. Overall, NRC Staff's witnesses testify about NRC Staff's approval of Entergy's use**
15 **of CHECWORKS at Indian Point.¹⁴⁸ Do you have a response to this position?**

16 A. I disagree with the witnesses' assessment that CHECWORKS is acceptable for managing
17 FAC at Indian Point. NRC Staff's witnesses provide no scientific justification for using
18 CHECWORKS as a predictive tool at Indian Point. Nor do NRC Staff's witnesses reveal any
19 indication that NRC Staff has ever commissioned an independent peer review group to evaluate
20 the applicability and efficacy of CHECWORKS at Indian Point. One of the main justifications
21 of the NRC Staff for using CHECWORKS appears to be that "[t]he NRC has long accepted the
22 use of CHECWORKS™ and its predecessor CHEC as important tools to manage FAC. The
23 acceptably of CHECWORKS™ has long existed in the NRC's guidance documents."¹⁴⁹
24 However, the actual explanation for the NRC accepting CHECWORKS, found in the *GALL*
25 *Report*, is that CHECWORKS bounds wear predictions conservatively. As I have discussed
26 above, this is not the case at Indian Point, and it should, therefore, not be acceptable to use the

¹⁴⁵ NRC Staff's Testimony at A32.

¹⁴⁶ *Id.*

¹⁴⁷ See Hopenfeld Prefiled Direct at 11-12 (RIV000003); Hopenfeld RK-TC-2 Report at 15-18 (RIV000005); *supra* § VII (*Leaks at Indian Point Demonstrate a Defective FAC Program*).

¹⁴⁸ See NRC Staff's Testimony at A31, A49-A60.

¹⁴⁹ *Id.* at A31.

1 code there. My initial testimony and expert report provide ample evidence to show that the use
2 of CHECWORKS at Indian Point is misguided and inappropriate.

3
4 **Q. NRC Staff's witnesses testify that "findings of the Board in the *Vermont Yankee***
5 **license renewal proceeding on the FAC contention are applicable to Indian Point."**¹⁵⁰ **Do**
6 **you agree?**

7 A. No I do not. For the many reasons I already discussed in my initial testimony, expert
8 report, as well as above in response to various statements made by Entergy's witnesses, I believe
9 that the findings of a different licensing board in a difference proceeding are not relevant to
10 whether or not Entergy's program for managing FAC at *Indian Point* during proposed extended
11 operating terms, are irrelevant.¹⁵¹

12
13 **Q. NRC Staff's witnesses testify that Entergy's FAC program employs multiple**
14 **"independent" tools, including not just CHECWORKS, but also Indian Point and industry**
15 **operating experience, re-inspections, the non-modeled program, and engineering**
16 **judgment.**¹⁵² **Do you have a response to this testimony?**

17 A. While this testimony mirrors Entergy's witnesses' claims that other tools are used in the
18 FAC program at Indian Point, it is not clear whether NRC Staff understands that such "other
19 tools" make up that large majority of the FAC program, that is about 75% according to Entergy's
20 witness testimony.

21
22 In any event, based on NRC Staff's witness testimony, it is apparent that the NRC Staff has not
23 performed an adequate check of Entergy's "other tools." Had it done so, it would have found
24 that, while on the surface Entergy's claim sounds impressive, key elements which are required to
25 assess such "other tools" are missing. To meet the regulatory criteria of 10 C.F.R. Part 54 and
26 the *GALL Report*, more than a hollow statement is required. Instead, the applicant must provide
27 enough information to allow the NRC and public to assess the efficacy of such other tools, since
28 scientific uncertainty is inherent in relying on tools that are obviously based in large part on

¹⁵⁰ NRC Staff's Testimony at A41.

¹⁵¹ See Hopenfeld Prefiled Direct at 8-9 (RIV000003); Hopenfeld RK-TC-2 Report at 20-21 (RIV000005); *supra* § VI (*Entergy's Witnesses Inapposite Discussion of and Reliance on Findings Made in Vermont Yankee Proceeding*).

¹⁵² NRC Staff's Testimony at A8, A70.

1 subjective judgments. The rebuttal testimony I provided above in response to Entergy's witness
2 testimony about Entergy's "other tools" fully describes how Entergy's "other tools" aside from
3 CHECWORKS in the FAC program at Indian Point were not described in sufficient details to
4 allow a thorough assessment of their effectiveness or to draw meaningful conclusions about the
5 validity of their performance.¹⁵³

6
7 **Q. NRC Staff's witnesses testify that Entergy's FAC program "is consistent with the**
8 **guidance in the NUREG-1801, Rev. 2, *Generic Aging Lessons Learned (GALL) Report*" and**
9 **the *GALL Report*, Revision 1.¹⁵⁴ Do you agree?**

10 A. No, I do not, as I have already discussed above in relation to Entergy's witnesses similar
11 conclusion, as well as in my initial testimony and expert report.¹⁵⁵ To briefly reiterate, Entergy's
12 program for managing FAC is not consistent with the guidance in Revisions 1 or 2 of the *GALL*
13 *Report* for several reasons.

14
15 First, Revision 2 of the *GALL Report* clearly states that

16 CHECWORKS is acceptable because it provides a bounding
17 analysis for FAC. The analysis is bounding because in general the
18 predicted wear rates and component thicknesses are conservative
19 when compared to actual field measurements. It is recognized that
20 CHECWORKS is not always conservative in predicting
21 component thickness; therefore, when measurements show the
22 predictions to be non-conservative, the model must be re-calibrated
23 using the latest field data.¹⁵⁶

24
25 At Indian Point, my analysis of thousands of data points showed that predicted wear rates and
26 component thicknesses *are not* conservative when compared to actual field measurements about
27 50% of the time. For numerous comparisons, wear was grossly underpredicted by as much as a
28 factor of 10, while most non-conservative measurements were underpredicted by a factor of 1.5.
29 According to the *GALL Report*, because of this circumstance, "the model must be re-calibrated,"
30 but this has not, and will not happen at Indian Point. In particular, because decades of apparent

¹⁵³ See *supra* § III (Entergy's Reliance on "Other Tools" Apart from CHECWORKS in the Indian Point FAC Program).

¹⁵⁴ NRC Staff's Testimony at A8, A30, A48.

¹⁵⁵ See Hopenfeld Prefiled Direct at 16-18 (RIV000003); Hopenfeld RK-TC-2 Report at 25 (RIV000005); *supra* § IX (*Entergy's Failure to Comply with Relevant Regulatory Guidance*).

¹⁵⁶ *GALL Report*, Rev. 2 at § XI.M17 ¶ 5 (NYS00147A-NYS00147D).

1 attempted “recalibration” have not produced a model that yields conservative results, it is
2 unlikely that the model will be able to be adequately recalibrated before, or even during, the
3 proposed periods of extended operation. However, NRC Staff’s witnesses (echoing Entergy’s
4 witnesses) testify to their *expectation* that CHECWORKS will produce non-conservative
5 predictions about 50% of the time.¹⁵⁷ As Entergy’s testimony makes plain, there is no
6 expectation or requirement that Entergy recalibrate the CHECWORKS model to generate
7 conservative results, and, thus, consistency with the *GALL Report* will not be achieved. Notably,
8 CHECWORKS at Indian Point does not produce the “bounding analysis” contemplated by in the
9 *GALL Report*, since the model produces highly inaccurate non-conservative results, as discussed
10 above.¹⁵⁸

11
12 Furthermore, while the *GALL Report* focuses on the use of CHECWORKS as a quantitative tool
13 to manage FAC: “CHECWORKS or a similar predictive code is used to predict component
14 degradation in the systems conducive to FAC.”¹⁵⁹ A FAC programs’ central focus on the use of
15 CHECWORKS is also consistent with the guidance in EPRI’s Recommendations for an
16 Effective Flow-Accelerated Corrosion Program, NSAC-202L.¹⁶⁰ The *GALL Report* explains that
17 “[i]nspection results are input for a predictive computer code, such as CHECWORKS, to
18 calculate the number of refueling or operating cycles remaining before the component reaches
19 the minimum allowable wall thickness.”¹⁶¹ In contrast, as the testimony from Entergy’s
20 witnesses makes clear and as I discussed above, CHECWORKS is only used at Indian Point for a
21 fraction of the FAC management program, and primarily to rank components and establish
22 inspection priorities, and not as contemplated in the *GALL Report*.¹⁶²

23
24 Moreover, as discussed in my initial testimony, and in my discussion above of Entergy’s alleged
25 “other tools” for managing FAC, it remains my professional opinion that Entergy has yet to

¹⁵⁷ NRC Staff’s Testimony at A59.

¹⁵⁸ See Hopenfeld, Demonstration of Flawed Presentation of CHECWORKS Data at Figures 2a, 2b (RIV000111).

¹⁵⁹ *GALL Report*, Rev. 1 at § XI.M17 (NYS00146A-NYS00146C); *GALL Report*, Rev. 2 at § XI.M17 (NYS00147A-NYS00147D).

¹⁶⁰ EPRI, Recommendations for an Effective Flow-Accelerated Corrosion Program, NSAC-202L-R3 (RIV000012).

¹⁶¹ *GALL Report*, Rev. 1 at § XI.M17 ¶ 6 (NYS00146A-NYS00146C); *GALL Report*, Rev. 2 at § XI.M17 ¶ 6 (NYS00147A-NYS00147D).

¹⁶² *Supra* at pp. 10, 11.

1 provide sufficiently detailed information to ensure its program is consistent with all elements
2 discussed in the *GALL Report*.¹⁶³

3
4 It is shocking to me that even though NRC Staff conducted several audits at Indian Point, they do
5 not comprehend how inconsistent the FAC program is with the *GALL Report*.

6
7 **Q. Please summarize your opinions and conclusions relating to the testimony proffered**
8 **by NRC Staff's witnesses relating to Contention RK-TC-2.**

9 A. I disagree with NRC Staff's witnesses' conclusions that Entergy's program for managing
10 FAC during the proposed periods of extended operation is adequate.

11
12 Importantly, it appears that NRC Staff have based their determination about the adequacy of
13 Entergy's FAC AMP on incorrect information. In particular, the testimony submitted by Entergy
14 in this proceeding on March 28, 2012, has revealed new information about Entergy's FAC
15 program that is substantially and materially different than what was described in the LRA and
16 the SER: contrary to the explanation in the LRA that Entergy's FAC program was based on the
17 *GALL Report* and NSAC-202L, both of which focus on the use of a quantitative predictive code,
18 Entergy has now revealed that CHECWORKS informs but a fraction of its FAC inspection
19 program. Since Entergy's modifications of its original FAC program go to the heart of Entergy's
20 AMP, the NRC Staff's assessment and conclusions about Entergy's FAC program in the Indian
21 Point SER, as well as in the NRC Staff's witness testimony, must be reevaluated to more
22 accurately reflect the program and its compliance with relevant guidance.

23
24 Furthermore, NRC Staff fails to recognize how Entergy's FAC program is fundamentally
25 inconsistent with Revision 2 of the *GALL Report*, which requires that CHECWORKS be
26 recalibrated if it produces non-conservative results, a circumstance that is impossible to achieve
27 at Indian Point, and that NRC Staff's witnesses actually appear to approve.

28

¹⁶³See *supra* § III (Entergy's Reliance on "Other Tools" Apart from CHECWORKS in the Indian Point FAC Program).

1 NRC Staff's witnesses appear to endorse Entergy's FAC program by essentially restating
2 previous Entergy statements about the program at Indian Point. My review of NRC Staff's
3 hearing submissions did not reveal any independent NRC Staff analysis of key FAC issues at
4 Indian Point, such as, locations for inspections, accuracy of wall thickness predictions, inspection
5 frequencies, or the efficacy of CHECWORKS at the plant. NRC has raised many arguments
6 identical to those of Entergy, which, for the reasons I discussed in my initial testimony and
7 expert report, as well as in the above rebuttal to Entergy's witness testimony, do not resolve the
8 concerns raised in Contention RK-TC-2.

9
10 Overall, NRC Staff's witnesses' testimony does not change my opinion that the effects of aging
11 on FAC-susceptible components at Indian Point will not be adequately managed throughout the
12 period of the extended operation, such that their intended functions will be maintained consistent
13 with the Indian Point CLB, as required by 10 C.F.R. § 54.21(a)(3).

14
15 **Q. Does this conclude your rebuttal testimony regarding Riverkeeper Contention RK-**
16 **TC-2?**

17 **A. Yes.**

June 20 2012