UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION I
2100 RENAISSANCE BLVD., SUITE 100
KING OF PRUSSIA, PA 19406-2713

September 1, 2015

EA-15-081

Mr. John Dent
Site Vice President
Entergy Nuclear Operations, Inc.
Pilgrim Nuclear Power Station
600 Rocky Hill Road
Plymouth, MA 02360-5508

SUBJECT: FINAL SIGNIFICANCE DETERMINATION FOR A WHITE FINDING AND NOTICE OF VIOLATION - INSPECTION REPORT NO. 05000293/2015011 – PILGRIM NUCLEAR POWER STATION

Dear Mr. Dent:

This letter provides you the final significance determination for the preliminary finding discussed in the U.S. Nuclear Regulatory Commission (NRC) letter dated May 27, 2015, which included NRC Inspection Report Number 05000293/2015007 (ML15147A412).[1] The finding involved the failure by Entergy Nuclear Operations, Inc. (Entergy) to identify, evaluate, and correct a significant condition adverse to quality associated with the Pilgrim Nuclear Power Station (Pilgrim) 'A' safety/relief valve (SRV). Specifically, Entergy did not identify, evaluate, and correct the 'A' SRV's failure to open upon manual actuation during a plant cool-down on February 9, 2013, following a loss of offsite power (LOOP) event. The failure to take actions to preclude repetition resulted in the 'C' SRV failing to open due to a similar cause following a January 27, 2015, LOOP event. The NRC also determined that the 'A' SRV had been inoperable for a period greater than the Technical Specifications allowed outage time of 14 days.

The May 27, 2015, NRC letter informed you that the NRC preliminarily determined the finding to be of low to moderate safety significance (i.e., White), and included a choice for Entergy to accept the preliminary finding as characterized in the inspection report, attend a regulatory conference, or reply in writing to provide the licensee's position on the facts and assumptions the NRC used to arrive at the finding and its safety significance. At Entergy's request, a regulatory conference was held on July 8, 2015, at the NRC Region I office in King of Prussia, Pennsylvania. The presentation provided by Entergy at the conference is included as Enclosure 1. The conference agenda and attendee list is included as Enclosure 2. As described more fully below, after considering the information presented by Entergy at the conference, the NRC maintains that the finding is appropriately characterized as White.

[1] Designation in parentheses refers to an Agency-wide Documents Access and Management System (ADAMS) accession number. Documents referenced in this letter are publicly-available using the accession number in ADAMS.

At the regulatory conference, Entergy staff did not contest the performance deficiency, the related violation, or the NRC description of the event. Entergy staff described the corrective actions that have been taken in response to the issue, which include: performing an ongoing root cause analysis, the results of which the licensee staff would share with the Entergy fleet; and continuing improvements to the site corrective action program (CAP), including establishing performance indicators to monitor CAP performance. These actions were in addition to the actions Entergy has already completed including: replacing the 'A' and 'C' SRVs in February 2015, prior to restarting from the January 27, 2015 event; and replacing all four SRVs with a different model during the Spring 2015 refueling outage.

Entergy staff also presented the results of their quantitative and qualitative assessments of the issue, which supported Entergy's view that the finding is of very low safety significance (i.e., Green). Entergy staff presented the results of the vendor's analysis of the 'A' and 'C' SRVs, which revealed wearing of internal components, resulting in the valve first stage piston rings creating grooves in the guide cylinder. As a result, the valve pistons required higher pressure in order for the rings to lift out of the grooves to allow the piston to move and open the valve. This degradation (the cause of which was not fully understood, but was likely caused by the method of vendor testing followed by operational vibration and pressure fluctuations) was less significant on the other two Pilgrim SRVs ('B' and 'D'), which had not failed to open at any pressure. Entergy also stated that, although the 'A' and 'C' SRVs had failed to open at low pressures, both valves had demonstrated functionality at high pressure, thereby reducing the range of plant scenarios for which the finding was of concern. Accordingly, Entergy stated that the NRC's risk analysis should treat the 'B' and 'D' valves separately from the 'A' and 'C' valves and also that the NRC common cause failure methodology and risk assumptions were overly conservative.

The NRC considered the information developed during the inspection and the information provided by Entergy at the regulatory conference, and concluded that the finding is appropriately characterized as White. A summary of the information provided by Entergy during this regulatory conference, and the NRC response, are provided in Enclosure 3. Because the finding has been determined to be White, we used the NRC's Action Matrix to determine the most appropriate NRC response for this finding. You were notified of that determination in the Mid-Cycle Assessment Letter issued today (ML15243A259).

The NRC also determined that the finding involved a violation of Title 10 of the *Code of Federal Regulations* (10 CFR) 50, Appendix B, Criterion XVI, "Corrective Action," as cited in the Notice included as Enclosure 4. The circumstances surrounding the violation were described in detail in the subject inspection report. In accordance with the NRC Enforcement Policy, the Notice is considered an escalated enforcement action because it is associated with a White finding.

The NRC has concluded that the information regarding: (1) the reason for the violation; (2) the interim and long term corrective actions already taken and planned to correct the violation and prevent recurrence; and, (3) the date when full compliance was achieved, is already adequately addressed on the docket in NRC Inspection Report 05000293/2015007, in your presentation at the July 8, 2015, regulatory conference, and in this letter. Therefore, you are not required to respond to this letter unless the description therein does not accurately reflect your corrective actions or your position.

You have 30 calendar days from the date of this letter to appeal the NRC staff's determination of significance for the identified White finding. Such appeals will be considered to have merit only if they meet the criteria given in the NRC Inspection Manual Chapter 0609, "Significance Determination Process," Attachment 2. An appeal must be sent in writing to the Regional Administrator, Region I, 2100 Renaissance Boulevard, King of Prussia, PA 19406.

In accordance with 10 CFR 2.390 of the NRC's "Rules of Practice," a copy of this letter, its enclosure, and your response, if you choose to provide one, will be made available electronically for public inspection in the NRC Public Document Room located at NRC Headquarters in Rockville, MD, and from the NRC's Agency-wide Documents Access and Management System (ADAMS), accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html. To the extent possible, your response, if you choose to provide one, should not include any personal privacy, proprietary, or safeguards information so that it can be made available to the Public without redaction.

Should you have any questions regarding this matter, please contact Mr. Raymond McKinley, Chief, Projects Branch 5, Division of Reactor Projects in Region I, at (610) 337-5150.

Sincerely,

/RA/

Daniel H. Dorman
Regional Administrator

Docket No. 50-293
License No. DPR-35

Enclosures:
1. Entergy Regulatory Conference Presentation (ML15208A460)
2. Regulatory Conference Agenda/List of Attendees (ML15208A458)
3. Summary of the Information Provided by Entergy and the NRC Response
4. Notice of Violation

cc w/encl: Distribution via ListServ

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Letter to John Dent from Daniel Dorman dated September 1, 2015

SUBJECT: FINAL SIGNIFICANCE DETERMINATION FOR A WHITE FINDING AND NOTICE OF VIOLATION - INSPECTION REPORT NO. 05000293/2015011 – PILGRIM NUCLEAR POWER STATION

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ENCLOSURE 3

NRC RESPONSE TO INFORMATION PROVIDED BY
ENTERGY NUCLEAR OPERATIONS, INC (ENTERGY) AT THE
JULY 8, 2015, REGULATORY CONFERENCE

SUMMARY OF INFORMATION PROVIDED BY ENTERGY

At the regulatory conference, Entergy staff presented the results of its quantitative and qualitative assessments of the issue, which supported Entergy's view that the finding is of very low safety significance (i.e., Green).

Entergy staff presented the results of the vendor's analysis of the Pilgrim Nuclear Power Station (Pilgrim) 'A' and 'C' safety/relief valves (SRVs), which revealed wearing of internal components, resulting in the valve first stage piston rings creating grooves in the guide cylinder. As a result, the valve pistons required higher pressure in order for the rings to lift out of the grooves to allow the piston to move and open the valve. This degradation (the cause of which was not fully understood, but was likely caused by the method of vendor testing followed by operational vibration and pressure fluctuations) was not as significant on the other two Pilgrim SRVs ('B' and 'D').

Based on the results of this analysis, Entergy staff stated that the NRC should factor the following considerations in its qualitative and quantitative evaluations of the finding:

- The 'B' and 'D' valves exhibited only minor degradation and remained operable at all times, and opened and closed reliably on multiple demands when called upon across the entire pressure range. Therefore, pressure control for Pilgrim was always available.

- Although the 'A' and 'C' SRVs had failed to open at low pressures, both valves demonstrated functionality at high pressure, thereby reducing the range of plant scenarios for which the finding was of concern.

- Other mitigating strategies remained available, including alternate depressurization systems (High Pressure Coolant Injection (HPCI), Reactor Core Isolation Cooling (RCIC), Main Steam Line drains, and Reactor Water Clean-Up in let-down mode) and for high pressure injection (HPCI, RCIC, Feedwater, Control Rod Drive, and Standby Liquid Control). Pilgrim Emergency Operating Procedures (EOPs) provided direction to operators to use these alternate means, if necessary.

- The value used by the NRC for an increased probability that the SRVs would fail to close was not credible. This was because, due to the design of the valves, sufficient pressure was always available to achieve closure.

- The value used by the NRC for the probability that the SRVs would fail to open was overly conservative. Independent engineering analysis obtained by Entergy indicated that the 'A' SRV would have opened at pressures above approximately 200 psig and that the ‘C’ SRV would have opened at pressures above approximately 300-400 psig. The ‘B’ and ‘D’ SRVs should have been credited for opening at any pressure based on actual in-plant observation and the minimal degradation of the valves.

- The common cause failure methodology applied by the NRC in its Standardized Plant Analysis Risk (SPAR) modeling was overly conservative and failed to consider plant-specific information.

NRC RESPONSE

The NRC’s preliminary risk determination was performed utilizing NRC Inspection Manual Chapter (IMC) 0609, Appendix M, “Significance Determination Process Using Qualitative Criteria.” This method was utilized because an existing, quantitative significance determination process is not available that can adequately assess the significance of the finding given the uncertainty in the actual pressure at which the SRVs would fail to function, as well as other uncertainties as described below. The resulting NRC preliminary analysis utilized a quantitative assessment to bound the risk and qualitative insights based on the circumstances of the finding and the licensee’s actions.

The NRC evaluated the considerations raised by Entergy. Specifically:

- Regarding Entergy’s position that pressure control for Pilgrim was always available due to the continued operability of the ‘B’ and ‘D’ SRVs, the NRC determined that, due to the as-found condition and historical observed degradation of the valves of the same design, there was an increased likelihood that the valves would fail if called upon. The as-found and historical degradation of the valves was determined to have an impact on the overall reliability of all the valves to function. Testing performed by the vendor and validated by the licensee’s engineering finite element analysis indicated that new or refurbished valves were experiencing damage during pre-installation testing at pressures as low as 60 psig. This is significantly less pressure and driving force than the valves would be exposed to during at-power transients. This degradation was expected to worsen with additional cycling of the valves during plant transients.

  The NRC determined that it was reasonable to conclude that given the performance history of the valves (including but not limited to the fretting wear, stem deformation, spring shortening, piston de-torqueing, piston wobble, thread damage, and locking device failures), there was an increased likelihood that the valves would fail if called upon during an event. This, in conjunction with the risk importance of the valves, could challenge the ability to depressurize the reactor under postulated accident conditions. Taken collectively, the NRC determined that additional information provided by Entergy regarding performance of the degraded SRVs did not establish that their failure rate should be considered equivalent to the failure rate of non-degraded SRVs. Entergy accounted for the uncertainty in the valves’ degraded condition by assuming a 2X increase in the probability of failure (above the baseline probability of failure), while the NRC’s analysis assumed a 10X increase in the SRVs’ probability of failure for events other than medium break loss of coolant accidents (MLOCAs). This difference highlighted an uncertainty associated with conducting a quantitative risk assessment for this condition. Based on Entergy's assumption that the degraded SRVs would fail at twice the rate of non-degraded valves, they determined that the core damage frequency (CDF) for internal events not associated with MLOCAs would increase by 3.6E-7. Both the NRC's and Entergy's methods conclude that the degraded SRVs would increase the CDF by some amount.

- The NRC reviewed the independent engineering analysis obtained by Entergy that provided a postulated lower pressure range at which the valves would function. The independent analysis provided an approximation of the pressures at which the 'A' and 'C' SRVs would function, but did not include any in-situ measurements or consider other relevant factors that would have correlated to or impacted the calculated lift pressure. Specifically, the calculated lift pressure was highly sensitive to the assumed value assigned to the coefficient of friction (i.e. a small increase in the coefficient of friction would result in a large increase in the expected lift pressure). The coefficient of friction assumed in the analysis was reported as conservative and derived from industry reference data. However, a review of the available NRC-published data (e.g., NUREG/CR 6807, "Results of NRC-Sponsored Stellite 6 Aging and Friction Testing) indicated that the credible range of coefficients could be higher than assumed in the analysis. In addition, the coefficient used in the evaluation apparently did not consider other factors such as the buildup of corrosion or wear products that could further increase the coefficient of friction above that assumed in the calculation. Inspectors observing the valve disassembly and pictures taken by Entergy indicated that some amount of corrosion and/or wear products were present in the main body of the valves. Further, the analysis did not consider the potential impact of multiple cycles on the degradation rate of the SRVs. Taken collectively, the NRC determined that the engineering analysis did not fully resolve the uncertainty associated with the operation of the SRVs at low pressures or make an adequate case for significantly revising downward the NRC's CDF determination.

- Regarding Entergy's position that the common cause failure methodologies and values used in the NRC's risk analysis for failure to open and close were not credible, the NRC determined that the licensee did not provide an adequate basis to demonstrate that the valves should not be coupled within the same common cause failure grouping or provide any other accepted method to quantify the risk from common cause failure. Specifically, the licensee stated that one of the degradation mechanisms (the amount of wear in the guide cylinder from interaction with the piston rings) was less significant for two of the valves, but did not provide any plant data or specific reason for the difference. In addition, the licensee did not address why the valves should be treated differently considering that they exhibited multiple degradation attributes that were common to all of the valves. The NRC determined that the valves should be treated as a common group since they had multiple, comparable degradation mechanisms and no information was presented to differentiate the design, manufacturing, testing, maintenance, or operation of any of the valves. The NRC's methodology used to determine the risk associated with common cause failure potential for these valves was peer-reviewed, published, and is considered to be state-of-the-art and the appropriate method to estimate the risk impact associated with the failure of common components.

- Entergy estimated an increase in CDF of 1.3 E-7 for internal events associated with a MLOCA. The NRC agreed with the Entergy's determination that the degraded SRVs would increase plant risk during MLOCA events but calculated a higher core damage frequency based on the difference in how the common cause failure potential was determined.

- Entergy did not present any specific risk insights with regard to external event risk; however, Entergy's risk analyst indicated that the increase in risk from external events was approximately equal to the increase in internal events. The NRC determined that the dominant external risk contributors would be from seismic and fire events, resulting in loss of offsite power and/or a complete station blackout. Core damage would result in the event of further failure of high pressure injection systems coupled with the failure to depressurize the reactor. The NRC did not conduct a more detailed analysis but agreed with the licensee's estimation that the risk from external events would be approximately equal to the internal event risk contribution. The NRC did not consider the external event contribution to be as significant for the MLOCA scenarios and did not include this risk in the summary below.

Combining the above quantitative aspects, Entergy estimated an increase in CDF of 4.9E-7 for internal events that, when considering the risk of external events (for non-MLOCA scenarios) would result in an overall estimated CDF increase of 8.5E-7. This was comparable to the NRC's computed increase in CDF of 4E-6. The differences are due to the analytical uncertainties and differences in some of the assumptions used in the quantitative analysis. Based on the above, the NRC determined that the risk estimates for this performance deficiency overlapped the green to white threshold. The NRC staff concluded that there are significant limitations in the use of existing tools to fully and accurately quantify this risk because of the uncertainties associated with: the degradation mechanism and its rate and the range of reactor pressure at which the degraded valves could be assumed to fully function; any potential benefit from an SRV lifting at rated pressure, such that the degradation would be less likely to occur and, therefore prevent a subsequent failure at low pressure in the near-term; the time-based nature of plant transient response relative to when high pressure injection sources fail and the associated impact of reduced decay heat on the SRV depressurization success criteria; and the ability to credit other high pressure sources of water. Therefore, the above numerical values were considered as an input into the final significance determination, along with the qualitative factors described in IMC 0609, Appendix M.

Entergy provided information regarding operational risk mitigating factors as discussed earlier in this section, and Enclosure 1 contains their assessment of the Appendix M qualitative factors. The NRC reviewed the factors in Appendix M starting with a conservative bounding analysis. As described in NRC Inspection Report Number 05000293/2015007, the NRC calculated a bounding increase in CDF of mid E-4. The NRC determined this value was overly-conservative since both the 'A' and 'C' SRVs passed as-found high pressure American Society of Mechanical Engineers code required testing and a subsequent lower pressure special test at 100 psig at the testing vendor. This, and the fact that the 'A' SRV successfully functioned at high pressure in the plant after the failed low pressure attempt, partially supported the theory that the valves would function at high pressure. However, as previously discussed, there is a high degree of uncertainty associated with SRV performance, which can strongly influence the specific initiating events, success criteria, and common cause factors. The first attribute described in Appendix M is to consider whether the finding impacted defense-in-depth. As noted above, Entergy stated that other mitigating strategies remained available, such as alternative pressure control and high pressure injection. Even so, the NRC considered that the SRVs and low pressure injection provide redundancy and backup to the high pressure injection sources. Specifically, the SRVs are required to perform both an overpressure protection function and to provide a means to rapidly reduce pressure to allow for low pressure sources to inject into the reactor vessel. Emergency depressurizations are directed in the emergency operating procedures when the suppression pool reaches it heat capacity temperature limit, when there is a reactor coolant leak into secondary containment, and when level reaches the minimum steam cooling water level. The NRC determined that SRVs were associated with and required to perform a defense-in-depth mitigation function and, therefore, this attribute was impacted by the performance deficiency.

The second attribute is to determine the effect of the finding on a plant's safety margin, and the fourth attribute is to consider the degree of degradation of the failed components. These two attributes were considered jointly, as they could be assessed by their impact on plant risk. While there is no existing tool to precisely model the impact of the degraded SRVs on plant risk, the NRC and Entergy performed independent risk assessments, achieved comparable results, and bounded the risk in the overlap range between the green to white significance threshold.

The third attribute in Appendix M is to consider the effect of the finding on other equipment. The NRC determined that Entergy's failure to identify and correct the condition of the 'A' SRV following the 2013 winter storm event resulted in the failure to identify a significant condition adverse to quality that led to the failure of the 'C' SRV during plant cool-down following an actual plant event in January 2015. Thus, the NRC determined that this performance deficiency affected redundant safety equipment.

The fifth attribute is to consider the period of time of the effect of the finding. While Entergy stated that the time period should be limited to twelve months, the NRC determined that it was likely that the valves were nonconforming upon installation, and that the period would then exceed one year. The NRC determined that the performance deficiency led to operation with degraded SRVs for a significant period of time.

The sixth attribute is to evaluate the likelihood that the licensee's recovery actions would successfully mitigate the finding. As described above, Entergy stated that other mitigating strategies remained available, including alternative pressure control and high pressure injection, which the operators would have utilized in accordance with EOPs. However, the NRC concluded that these strategies are highly dependent on initial plant conditions and operator response to the event. The NRC considered that the redundant mitigation strategies would have been included in the risk estimates provided above, which quantified the risk of this event in the green to white significance level.

The final attribute in Appendix M is to consider any additional qualitative circumstances associated with the finding. Accordingly, the NRC considered Pilgrim's organizational performance during the 2013 and 2015 events, as documented in NRC Inspection Report Number 05000293/2015007. Specifically, during the 2013 event, Pilgrim staff did not identify that the 'A' SRV had failed to open in spite of having sufficient information available to do so.

During the 2015 event, Pilgrim operators and staff did identify that the ‘C’ SRV failed to open. However, engineering, operations, and plant management erroneously concluded that the SRV was operable. Pilgrim did not declare the SRV inoperable until NRC inspectors on the Special Inspection Team raised concerns about the valve’s response. Additionally, during the 2015 event, operators used a high-volume injection system (Core Spray) when other, more desirable, injection systems were available to provide finer level control. As a consequence, reactor level remained high in the control band, allowing reactor pressure to rise, requiring operators to cycle the SRVs. Given that all of the SRVs were exposed to some level of degradation, it is plausible to conclude that stressors, such as excessive cycling, had the potential to increase the probability of SRV failure.

Based on the above factors, taken in conjunction with the uncertainties of the quantitative analysis, the NRC concluded that the finding is appropriately characterized as White (low to moderate safety significance).

ENCLOSURE 4
NOTICE OF VIOLATION

Entergy Nuclear Operations, Inc.
Pilgrim Nuclear Power Station

Docket No. 50-293
License No. DPR-35
EA-15-081

During an NRC special inspection conducted from February 2, 2015 through March 20, 2015, and for which an inspection exit meeting was conducted on March 20, 2015, a violation of NRC requirements was identified. In accordance with the NRC Enforcement Policy, the violation is listed below:

> 10 CFR 50, Appendix B, Criterion XVI, "Corrective Action," requires, in part, that measures shall be established to assure that conditions adverse to quality, such as failures, malfunctions, and deficiencies, are promptly identified and corrected. In the case of significant conditions adverse to quality, the measures shall assure that the cause of the condition is determined and corrective action taken to preclude repetition.
>
> Technical Specification 3.5.E requires the Automatic Depressurization System (ADS) to be operable whenever there is irradiated fuel in the reactor vessel and the reactor pressure is greater than 104 psig and prior to startup from a Cold Condition. From and after the date that one valve in the ADS is made or found to be inoperable for any reason, continued reactor operation is permissible only during the succeeding 14 days. Otherwise, an orderly shutdown of the reactor shall be initiated and the reactor shall be in the Cold Shutdown Condition within 24 hours.
>
> Contrary to the above, on February 9, 2013, Entergy Nuclear Operations, Inc. (Entergy) failed to establish measure to promptly identify and correct a significant condition adverse to quality involving a component that is essential to perform the ADS safety-related reactor vessel depressurization and overpressure protection functions, or assure that the cause of the condition was determined and corrective actions taken to preclude repetition. Specifically, Entergy failed to identify that the ADS 'A' safety/relief valve (SRV) did not open upon manual actuation during a February 9, 2013, loss of offsite power (LOOP) event. Although the valve's inoperability constituted a significant condition adverse to quality, Entergy did not identify and correct the condition, or take action to preclude repetition, which resulted in the failure of the ADS 'C' SRV to operate upon manual actuation during a subsequent LOOP event on January 27, 2015. Additionally, because the licensee was not aware of the 'A' SRV's inoperability from February 9, 2013, until January 27, 2015, a period greater than the allowed Technical Specification outage time, required actions of TS 3.5.E were not followed.

This violation is associated with a White Significance Determination Process finding.

The NRC has concluded that the information regarding: (1) the reason for the violation; (2) the corrective actions taken and planned to correct the violation and prevent recurrence; and, (3) the date when full compliance was achieved, is already adequately addressed on the docket in NRC Inspection Report 05000293/2015007, in your presentation at the July 8, 2015, regulatory conference, and in the letter transmitting this Notice of Violation (Notice). Therefore, you are not required to respond to this Notice. However, if the description therein does not accurately reflect your corrective actions or your position you are required to submit a written statement or explanation pursuant to 10 CFR 2.201. In that case, or if you choose to respond, clearly mark your response as a "Reply to a Notice of Violation – EA-15-081," and send it to the U.S. Nuclear Regulatory Commission, ATTN: Document Control Desk, Washington, DC 20555-0001 with a copy to the Regional Administrator, Region I, 2100 Renaissance Boulevard, Suite 100, King of Prussia, PA 19406, and a copy to the NRC Resident Inspector at Pilgrim Nuclear Power Station, within 30 days of the date of the letter transmitting this Notice of Violation (Notice).

If you choose to respond, your response will be made available electronically for public inspection in the NRC Public Document Room and from the NRC's Agency-wide Documents Access and Management System (ADAMS), accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html. Therefore, to the extent possible, the response should not include any personal privacy, proprietary, or safeguards information so that it can be made available to the Public without redaction. If you contest this enforcement action, you should also provide a copy of your response, with the basis for your denial, to the Director, Office of Enforcement, United States Nuclear Regulatory Commission, Washington, DC 20555-0001.

In accordance with 10 CFR 19.11, Entergy may be required to post this Notice within two working days of receipt.

Dated this 1st day of September 2015.