NMC
Committed to Nuclear Excellence

Kewaunee Nuclear Power Plant
Operated by Nuclear Management Company, LLC

February 20, 2004

NRC-04-023
10 CFR 50.90

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

KEWAUNEE NUCLEAR POWER PLANT
DOCKET 50-305
LICENSE No. DPR-43

Responses To NRC Requests For Additional Information Regarding License Amendment Request 195, Stretch Power Uprate For Kewaunee Nuclear Power Plant (TAC NO. MB9031)

References:

1) Letter NRC-03-057 from Thomas Coutu to Document Control Desk, "License Amendment Request 195, Application for Stretch Power Uprate for Kewaunee Nuclear Power Plant," dated May 22, 2003.
2) Letter from Thomas Coutu to Document Control Desk, "Responses to Requests for Additional Information and Supplemental Information Regarding License Amendment Request 195, Stretch Power Uprate For Kewaunee Nuclear Power Plant," dated November 5, 2003.
3) Letter from Thomas Coutu to Document Control Desk, "Responses To NRC Clarification Questions On Responses To Requests For Additional Information Regarding License Amendment Request 195, Stretch Power Uprate For Kewaunee Nuclear Power Plant," dated December 15, 2003.
4) Letter from John Lamb (NRC) to Thomas Coutu (NMC), "Kewaunee Nuclear Power Plant - Review Of License Amendment Request No. 195, Stretch Power Uprate (TAC NO. MB9031)," dated January 26, 2004
5) Letter from Thomas Coutu to Document Control Desk, "Responses To NRC Clarification Questions On Responses To Requests For Additional Information Regarding License Amendment Request 195, Stretch Power Uprate For Kewaunee Nuclear Power Plant (TAC NO. MB9031) dated January 30, 2004.

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6) Letter from Thomas Coutu to Document Control Desk, "Responses To NRC Clarification Questions On Responses To Requests For Additional Information Regarding License Amendment Request 195, Stretch Power Uprate For Kewaunee Nuclear Power Plant (TAC NO. MB9031), dated February 9, 2004

In accordance with the requirements of 10 CFR 50.90, Nuclear Management Company, LLC (NMC) submitted license amendment request (LAR) 195 (Reference 1) for a stretch power uprate of six percent. The stretch power uprate would change the operating license and the associated plant Technical Specifications (TS) for the Kewaunee Nuclear Power Plant (KNPP) to reflect an increase in the rated power from 1673 MWt to 1772 MWt.

On November 5, 2003, December 15, 2003, January 30, 2004, and February 9, 2004, NMC responded to requests for additional information from the Nuclear Regulatory Commission (NRC) regarding the proposed stretch power uprate (References 2, 3, 5, and 6). Subsequent to NMC's February 9$^{th}$ response, the NRC staff requested additional information regarding the use of essential service water to feed the steam generators following postulated accident conditions. This letter and enclosures contain the NMC responses to the NRC requests for additional information.

Enclosure 1 contains the questions from the NRC. These questions were derived from an email from the NRC Project Manager for the Kewaunee Nuclear Power Plant. Enclosure 2 contains NMC's response to these questions.

These responses do not change the Operating License or Technical Specifications for the KNPP, nor do they change any of the proposed changes to the Operating License or Technical Specifications in reference 1. The responses do not change the no significant hazards determination, the environmental considerations, the requested approval date, or the requested implementation period originally submitted in reference 1.

In accordance with 10 CFR 50.91, a copy of this letter, with attachments, is being provided to the designated Wisconsin Official.

<u>Summary of Commitments</u>

This letter makes no new commitments.

If there are any questions or concerns associated with this response, contact Mr. Gerald Riste at (920) 388-8424.

I declare under penalty of perjury that the foregoing is true and correct.
Executed on February 20, 2004.

[signature] for

Thomas Coutu
Site Vice-President, Kewaunee Plant
Nuclear Management Company, LLC

GOR

Enclosures: (2)

cc:- Administrator, Region III, USNRC
Project Manager, Kewaunee Nuclear Power Plant, USNRC
Senior Resident Inspector, Kewaunee Nuclear Power Plant, USNRC
Electric Division, PSCW

ENCLOSURE 1

NUCLEAR MANAGEMENT COMPANY, LLC
KEWAUNEE NUCLEAR PLANT
DOCKET 50-305

**February 20, 2004**

Letter from Thomas Coutu (NMC)

To

Document Control Desk (NRC)

Responses to NRC Requests for Additional Information Regarding LAR 195

NRC Requests for Additional Information

1 Page Follows

NRC Questions Received February 09, 2004

1. Kewaunee relies upon the essential service water system for providing an assured source of water to feed the steam generators following postulated accident conditions. The steam generators will tend to concentrate impurities that are in the water such that they will collect and plate out on the steam generator heat transfer surfaces, moisture separators, and steam dryers, potentially impacting the ability of the steam generators to remove reactor decay heat and cool down the reactor coolant system. Given the complete range of aquatic substance and impurities that can be drawn into the essential service water system from Lake Michigan (e.g., lake weed and other forms of marine life, silt, minerals, debris, pollutants, and micro-organisms), describe in detail bounding analyses that have been completed, test data that are credited, steam generator specifications and data sheets, and other applicable information that demonstrate that the Kewaunee steam generators will be able to perform their safety function over the longest mission time that is assumed in the plant design basis following stretch power uprate, when essential service water is used as the source of steam generator makeup water.

2. Describe measures that have been (or will be) taken to assure that the quality of essential service water that is assumed in No. 1 (above) will be maintained over the life of the plant.

ENCLOSURE 2

NUCLEAR MANAGEMENT COMPANY, LLC
KEWAUNEE NUCLEAR PLANT
DOCKET 50-305

**February 20, 2004**

Letter from Thomas Coutu (NMC)

To

Document Control Desk (NRC)

NRC Requests for Additional Information Regarding LAR 195

NMC Responses to NRC Questions

11 Pages Follow

**NRC Question 1:**

Kewaunee relies upon the essential service water system for providing an assured source of water to feed the steam generators following postulated accident conditions. The steam generators will tend to concentrate impurities that are in the water such that they will collect and plate out on the steam generator heat transfer surfaces, moisture separators, and steam dryers, potentially impacting the ability of the steam generators to remove reactor decay heat and cool down the reactor coolant system. Given the complete range of aquatic substance and impurities that can be drawn into the essential service water system from Lake Michigan (e.g., lake weed and other forms of marine life, silt, minerals, debris, pollutants, and micro-organisms), describe in detail bounding analyses that have been completed, test data that are credited, steam generator specifications and data sheets, and other applicable information that demonstrate that the Kewaunee steam generators will be able to perform their safety function over the longest mission time that is assumed in the plant design basis following stretch power uprate, when essential service water is used as the source of steam generator makeup water.

**NMC Response 1:**

Background

The Auxiliary Feedwater (AFW) System is designed to remove decay heat during plant startups, plant shutdowns, and under accident conditions. During plant startups and shutdowns the system is used in the transition between Residual Heat Removal (RHR) System decay heat removal and Main Feedwater System operation. NMC has reviewed the accident analyses associated with the need to provide decay heat removal from the reactor coolant system through the steam generators. As a part of this review the normal operation and lineup of the auxiliary feedwater (AFW) system was reviewed.

The Auxiliary Feedwater System is shown in Kewaunee Nuclear Power Plant (KNPP) Updated Safety Analysis Report (USAR) Figure 10.2-3. The system consists of one steam turbine-driven pump, capable of delivering feedwater to either or both steam generators. In addition, there are two motor driven pumps, one for each steam generator, which are interconnected on the discharge side by a cross-over pipe, which may be isolated by two normally-open motor operated valves and are capable of supplying feedwater to either or both steam generators. Separate safeguards buses energize the two motor-driven pumps.

Normal feedwater supply to the auxiliary feedwater pumps is from two 75,000-gallon condensate storage tanks (150,000 gallons total) shown on USAR Figure 10.2-2. KNPP technical specifications (TS) require 39,000 gallons (41,500 for Stretch Uprate) of water inventory for the supply to the AFW pumps. The specified minimum water supply in the condensate storage tanks (CST) is sufficient for four hours of decay heat removal. The four hours are based on the Kewaunee site-specific station blackout (loss of all AC power) coping duration requirement. The KNPP USAR states that the Service Water System provides a backup water supply to the pumps even though this is the safety related supply. An individual trip for each auxiliary feedwater pump is initiated on low pump discharge pressure. This trip provides automatic protection for the pumps in the event the condensate supply to the pumps is lost following a seismic event or a tornado. The pumps can be restarted following manual switchover to the Service Water System.

Although the primary source of water for the AFW system is the CST's, the TS basis for the AFW system states that the AFW System is considered OPERABLE when the components and flow paths required to provide redundant AFW flow from the AFW pumps to the steam generators are OPERABLE. This requires that the two motor-driven AFW pumps be OPERABLE, each capable of taking suction from the service water system and supplying AFW to separate steam generators. The turbine-driven AFW pump is required to be OPERABLE with redundant steam supplies from each of two main steam lines upstream of the main steam isolation valves and shall be capable of taking suction from the service water system and supplying AFW to both of the steam generators. Thus, the service water system may be relied upon to provide the water for the AFW system during the time the AFW system is relied on to remove the reactor core decay heat and the reactor coolant system sensible heat post accident.

NMC performed an analysis[1] assuming that the amount of Lake Michigan water necessary for the steam generators to remove the decay and sensible heat via the AFW system and service water system was 900,000 gallons. This assumption bounds that amount of water necessary following any design basis accident or event. Following the initial response to the accident or event, the KNPP Integrated Plant Emergency Operating Procedures (IPEOP's) direct the operators to cool the reactor coolant system using the steam generators, if necessary, to conditions where the residual heat removal (RHR) system can be placed in service. Once the RHR system is in service, reactor decay heat and sensible heat can be removed without any further need for steam generator cooling. The design basis accidents and events for KNPP were reviewed to determine the maximum mission time for the use of the steam generators to cool down the RCS to the conditions that allow placing RHR in service.

The design basis accidents were evaluated as follows: A large break loss of coolant accident does not utilize the steam generators for cooling, since the RCS break flow provides adequate cooling in conjunction with emergency core cooling. For a small break LOCA[2] NMC provided the time analysis that stated, based on a conservative analysis of operator actions and action times using KNPP emergency operating procedures and human reliability data/experience, upper plenum injection of emergency core cooling system (ECCS) low head safety injection (LHSI) water injected directly into the reactor vessel above the reactor core and RHR cooling is established at 6.6 hours. Since the time to establish LHSI to the reactor upper plenum and RHR cooling (6.6 hours) is less than the time to reach the boron precipitation limit at one atmosphere (7.8 hours), there is no potential for boron precipitation following the limiting design basis LOCA accidents.

Based on a similar scenario as SBLOCA, the SG mission time to establish RHR cooling for SG tube rupture, steam line break accident, and Non-LOCA transients would be expected to be similar to that for SBLOCA (i.e. approximately 7 hours).

For response to design basis events such as Appendix R fire, Station Blackout (SBO), tornado and seismic event, the required SG mission time could be as long as 72 hours to achieve cold shutdown conditions (Note that the RHR system would be in service well before achieving cold shutdown).

Based on the above, the longest SG mission time for response to a design basis accident or event at KNPP is 72 hours. Accident analysis shows that 200-gpm AFW flow provides enough water to remove the heat generated in the reactor core post accident at current and stretch power uprate conditions. Assuming 900,000 gallons of water is necessary to cool down the RCS to a condition whereby RHR can be placed in service allows 75 hours of operation on the AFW system (900,000 gallons ÷ 200 gpm ÷ 60 minutes per hour = 75 hours). Additionally, as the time after shutdown increases the amount of decay heat generated decreases providing additional margin between the amount of water required to cool the RCS and the amount of water available. Therefore 900,000 gallons of water from Lake Michigan pumped into the steam generators via the AFW and SW systems bounds the amount of water necessary to cool the RCS to a condition where the SGs are no longer necessary to provide cooling of the RCS.

The accident analyses assume 0% to10% tube plugging and a fouling factor of $11.0 \times 10^{-5}$ hr-ft$^2$-°F/BTU. KNPP's past steam generators (series 51 SG's) were degraded by > 20% steam generator tube plugging and we were able to provide sufficient SG heat removal capability to run the plant at 1650 MWth reactor power. As the current SG have no plugging this supports the conclusion that we can foul the SG's to a certain level over a defined mission time injecting lake water and still effectively remove reactor decay heat from a trip from 1772 MWth.

The NRC staff questioned the affect of contaminants, which may be found in Lake Michigan water including:

- lake weed and other forms of marine life,
- silt,
- minerals,
- debris,
- pollutants, and
- micro-organisms

NMC's analysis of the Lake Michigan water separates contaminants into the following categories:

- Total Dissolved Solids (TDS)
- Total Suspended Solids (TSS)
- Total Organic Carbons (TOC)
- Silt
- Debris

Included in the TDS category are cations; including Calcium, Magnesium, and Sodium and anions including; chloride, sulfate, and (Bi)carbonate. The TSS contains the "silt" that would collect in the steam generators. The TOC factor contains the lake weed, other marine life, and micro-organisms. Debris would then include any biological or inanimate solids that would be large enough to not be included in the silt. The following explanation describes the affect of each of these contaminants on the SG heat removal capability.
The total suspended solids include the debris, silt, and the "large" organic compounds such as lake weed, marine life and even micro-organisms depending on size (> 5 microns).

In general, tube deposit formation can be divided into two groups[3]: 1) chemical processes involving crystallization from solutions, and 2) physical processes that depend on adhesion of particulates (solid particles) to the surface. Tube scale formation in SGs probably involves contributions from both of these phenomena. Regardless of whether tube scale formation is a chemical or physical process (or both), it occurs in stages as follows: (1) incubation, (2) initiation, (3) growth, (4) growth-limiting stage, and (5) spalling and re-deposition. This process is time dependent. Studies have shown that deposits have no observed effect on heat transfer performance during an initial incubation or induction time, which is then followed by a period during which deposits actually augment heat transfer. Subsequently, the deposit thickness or fouling factor may: 1) increase linearly with time, 2) decrease in growth rate but continue to increase in thickness indefinitely, or 3) level off at some thickness asymptotically. Which behavior is observed in steam generators is never certain, but will likely depend on feedwater chemistry control, steam generator pH, rate of corrosion product transport, feedwater oxygen concentrations, ingress of hardness species and silicon, and chemical and physical changes in the existing deposits over time.

**Lake Michigan Contaminants**

NMC monitors the composition of minerals in the Lake Michigan water supply. The following table lists the results of this monitoring

| Lake Michigan Concentration Levels<br>Table1 | | | |
|---|---|---|---|
| Cations | Concentration (ppm) | Anions | Concentration (ppm) |
| Calcium | 38 | Chloride | 10 |
| Magnesium | 12 | Sulfate | 32 |
| Sodium | 8 | (Bi)Carbonate | 130 |
| | | | |
| Neutral | | | |
| Silica | 0.2 | | |
| TOC | 10 | | |
| TSS | 67.1* | | |

* Statistical Calculation of 2-sigma (350 ppm maximum)

**Silt**

Silt is defined as sand or earth, which is carried along by flowing water and then dropped, especially at a bend or some other low velocity area. In the service water system to the steam generators the silt will come from Lake Michigan, flow through the traveling water screens and the service water rotating strainers into the AFW system, and then feed into the steam generators.

The Auxiliary Feedwater is discharged into the steam generator secondary side through a feedwater distribution ring containing inverted J-nozzles[4]. The feed-ring contains 34 J-nozzles around the circumference of the feed-ring. The J-nozzles are 2" schedule 80 SB 167 Alloy NO6600 (Inconel 600). The inlet feedwater is combined with separate drain water and flows through the annular downcomer between the tube bundle wrapper and the shell. The shell ID is 129.37", and the wrapper OD is 124.26", resulting in an annular gap of ~2.5". Feedwater enters ~460" above the tubesheet surface. At the bottom of the downcomer annulus, the water flows underneath the wrapper radially into the tube bundle, where it is heated and rises through the tube bundle as a steam-water mixture. The wrapper ends approximately 16" above the tubesheet surface. The tube bundle consists of 3592 Inconel 690 U-tubes, with a 7/8"OD tube pitch and a 1.225" centerline to centerline. (i.e., gap of ~0.35"). The tube bundle is supported by 7 tube support plates spaced nominally 4' apart containing quatrefoil broached holes for the tube to pass though. Feedwater inlet temperature is ~437°F and flows through the downcomer at ~12 fps at uprate power. Fluid approach velocities at the tubesheet region, between the wrapper opening and the bundle periphery, are ~4 fps. The maximum gap velocities of the fluid occur between the tubes in the outer periphery, and between the tubes just inside the bundle periphery. Gap velocities are approximately 14 fps. As the secondary fluid moves radially inward, velocities decrease to ~0.5 fps near the SG centerline[5]. Thus the silt accumulates near the SG centerline on the top of the tubesheet.

To determine the impact of this silt buildup in the steam generators past sludge lancing results were reviewed. This review showed the amounts of sludge that were removed from the steam generators without a significant reduction in the steam generator thermal capability. Additionally, in determining the fouling factor for the reduction in heat transfer capability, the calculation assumed all the silt that entered the Steam Generator plated out onto the steam generator tubes. This assumption adds additional conservatism to the heat transfer capability reduction.

| Steam Generator Sludge Lance<br>Sludge Weights (lbs)<br>Table 2 | | |
|---|---|---|
| Year | SG A | SG B |
| 1985 | 438.0 | 485.0 |
| 1986 | 359.0 | 364.0 |
| 1987 | 313.0 | 246.0 |
| 1988 | 288.0 | 365.0 |
| 1989 | 234.0 | 290.0 |
| 1990 | 192.0 | 216.0 |
| 1991 | 444.0 | 486.0 |
| 1992 | 299.0 | 327.0 |
| 1993 | 212.0 | 201.0 |
| 1994 | 156.0 | 215.0 |
| 1995 | 142.0 | 126.0 |
| 1996 | 140.0 | 131.0 |
| 1998 | 185.0 | 150.0 |
| 2000 | 133.0 | 85.0 |
| | | |
| Total | 3535 | 3687 |

From the analysis of Lake Michigan water samples the total amount of sand/silt that would enter the steam generators after 900,000 gallons of water was fed would be $2.286 \times 10^5$ grams (or 503.98 lbm). From the above table the closest sludge lance results occurred in 1985 and 1991 when 485 lbm and 486 lbm was removed from "B" steam generator. Therefore, if all the silt were to deposit in the bottom of the steam generators the affect on the heat removal capability of the steam generator is insignificant.

**Debris**

Debris is prevented from entering the steam generators by physical barriers in the circulating water and service water systems. The circulating water intake system is designed to provide a reliable supply of Lake Michigan water, regardless of weather or lake conditions, to the suction of two circulating water pumps, four service water pumps and two fire pumps. The screenhouse is a Class I structure. The intake system and screenhouse are shown in KNPP USAR Figures 1.1-2 and 1.2-9. The intake structure is located approximately 1,600 feet from the shore in a water depth of ~15 feet. The intake consists of a submerged cluster of three vertical 22-foot diameter inlets with trash grilles of 2 foot by 2 foot. The trash grilles are provided with recirculated water to remove ice formations. During winter operation the inlet crib and auxiliary inlets are below the ice blanket and are at least 450 feet outboard of maximum windrow ice development.

The spacing of the three inlet cones and the auxiliary inlets is such that the largest lake barge could not directly cover all water inlets. Any four of the inlets could be blocked and still leave an inlet capacity of greater than the 24,000 gpm required cooling water. The three inlet cones are reduced to 6-foot diameter steel pipes which join at a trifurcation into one 10-foot diameter steel pipe which is buried a minimum of 3 feet below lake floor and coated inside and out with asphaltum. The velocity at the surface of the intakes at the full plant load is < 1 fps.

The plant intake is equipped with two auxiliary water intake tees 50 and 100 feet shoreward of the intake crib. Each tee has a 30-inch opening rising vertically to 1 foot above the lake bottom at Elevation ~559 feet. Special screened cover plates are suspended 12 inches above the auxiliary intake openings to exclude entrainment of debris. Each auxiliary water intake can supply water in excess of 24,000 gpm.

The 10-foot diameter steel intake pipe carries the water to a 56.5-foot by 25-foot forebay with an overflow weir whose crest is at Elevation 582.5 feet. The weir has a bottom length of 38.5 feet and side slopes of 45°. From the forebay, water passes through four 10-foot wide by 36-foot long traveling screens with a mesh size of ⅜ inch to the suction of the service water and circulating water pumps. Normal plant operation is with one or two circulating water pumps, depending on inlet water temperature, and two or three service water pumps operating.

SW System capability to provide plant required SW flow is automatically controlled. SW pumps start automatically to maintain pressure. Traveling Water Screens, mesh size ⅜ inch, and SW strainers, mesh size ⅛ inch, remove debris from the SW and automatically backwash to provide self-cleaning. The strainers are Kinney rotating, single drum, multiple basket media, automatic backwash strainers installed on the discharges of the SW pumps. Each strainer has a motor drive unit to rotate the strainer constantly whenever the associated SW pump is operating although they are powered from a non-safety related power supply.

This system design prevents debris of greater than 1/8 inch from entering the service water system. From the description of the steam generator flow path, found under the silt section above, the clearances in the steam generators are greater than 1/8 inch. Therefore, debris large enough to block the AFW flow path is prevented from entering the steam generators by the use of the traveling water screens and the service water strainers.

**Analysis**

Base on the above mineral and organic composition NMC performed a calculation using 900,000 gallons of Lake Michigan water injected into the Steam generators. This calculation had the following assumptions:

1. Uniform coating of material on the steam generator tubing in both steam generators.
2. No removal of contaminants via feed and bleed or blowdown.
3. No common ion effects on the solubility's of the chemical species. This is due to the relatively low concentration of the individual species. The combined concentration of all the chemicals in the steam generators will be about the same as the Potable water system.

4. Due to the pH of the steam generators staying in the caustic region (>~8), all the carbonate and bicarbonate is assumed to be in the carbonate form. This is conservative due to the reduced solubility of the carbonate over the bicarbonate species.
5. The amount of the calcium and magnesium that is soluble was calculated but not used in precipitate formation. This value was found to be small so it is assumed that all calcium carbonate and magnesium carbonate will precipitate. There is excess Carbonate available.
6. All organic material is attracted to the entire tube surface and is deposited. The thickness of this material with the appropriate thermal conductivity is determined and compared to a non-fouled scenario. Amorphous carbon was used for the organic layer.
7. The volume of water assumed to enter the steam generators is 900,000. This bounds the duration of 72 hours and assuming aux feed flow of 200 gpm (864,000 gallons).
8. Suspended solids are present in service water. There is a correlation that 1 ppm of suspended matter is approximately 1 nephelometric turbidity unit (NTU) of turbidity. Looking at the last 3 years of flocculator inlet turbidity, the time-weighted average for turbidity was 17.1 ppm. This was used in the form of sand to further coat the tubes. In actuality, these insoluble solids would not preferentially go to the tube material; it would just stay suspended in the bulk water. To better determine a bounding calculation, the concentration of the sand (suspended solids) was set at 67.1 ppm, which is, plus two sigma over the time weighted average of 17.1 to encompass the concentration 95 percent of the time.

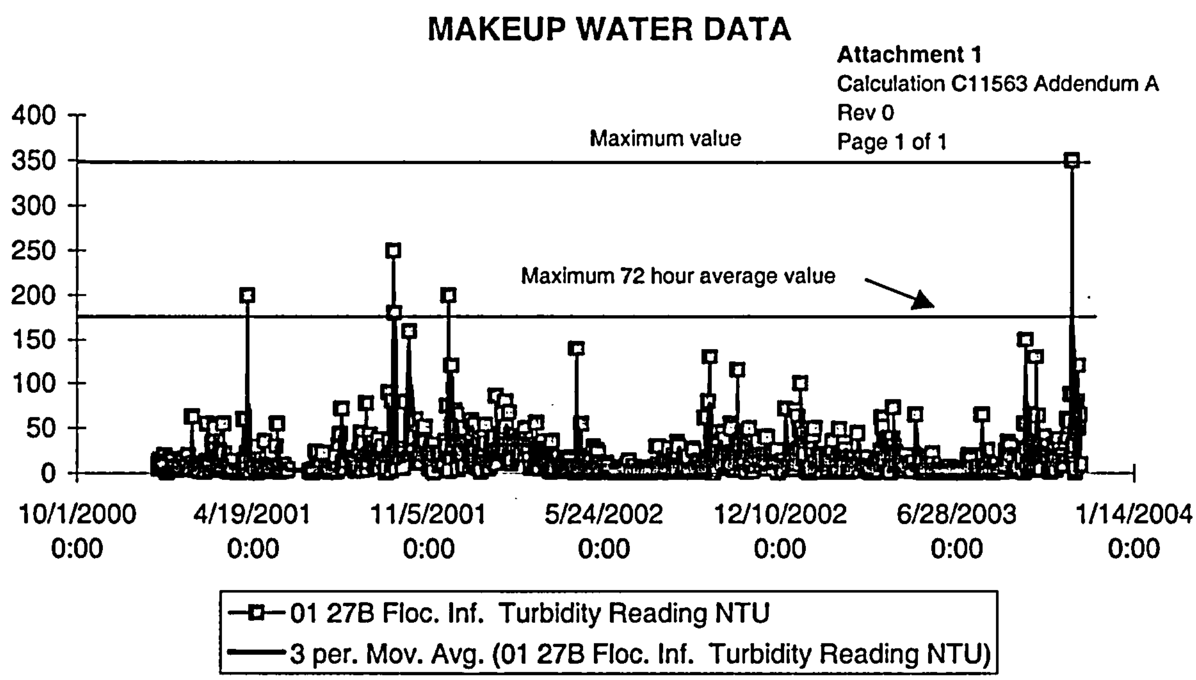
The methodology used to determine the thickness of the film from precipitation of the chemical species found in Lake Michigan is to determine how much material is present in the steam generator after 900,000 gallons of water was put into the steam generator and boiled down to the normal volume of the steam generator. After the amount was determined, a certain portion of those identified insoluble products do experience some solubility in hot water. This portion was determined but was not removed from the available contaminants.

Then, all the scale producing species were uniformly concentrated on the entire surface area of both steam generators. The resulting thickness was determined using the specific gravity of respective chemical species. Only Calcium Carbonate and Magnesium Carbonate were considered because of the increased solubility of all the other combinations. All organic material is attracted to the entire tube surface and is deposited. The thickness of this material with the appropriate thermal conductivity is determined and compared to a non-fouled scenario. To cover the affect on steam generator performance from suspended material, an amount of equivalent sand was based on time-weighted average flocculator inlet turbidity plus 2-sigma.

There is only a 14% reduction in steam generator heat transfer performance due to using 900,000 gallons of Lake Michigan water to cool down the plant. This calculation is very conservative by assuming all the insoluble material sticks to the tubing. Especially for the insoluble suspended solids, these species would not necessarily plate out on the tubes. This calculation does not address long-term corrosion of the steam generators. Also notice that the concentration of contaminants in the steam generators are more than a factor of 10,000 above the EPRI Secondary Chemistry Guidelines for Action Level 3 requirements, which require plant shutdown to cold shutdown.

Evaluations based on analysis[6] show that film thickness resulting from postulated precipitation of the chemical species found in 900,000 gallons of Lake Michigan water introduced into the steam generators is 1.0804 mils. The calculated fouling factor for this film is $15.027 \times 10^{-5}$ hr-ft$^2$-ºF/BTU. This value is comparable to the $11.0 \times 10^{-5}$ hr-ft$^2$-ºF/BTU fouling factors used for the thermal design conditions for uprated power conditions. Therefore the steam generator heat transfer efficiency with the hypothetical introduction of 900,000 gallons of Lake Michigan water is only marginally affected and the steam generators are expected to function as designed following postulated design bases accidents and events from an uprated power condition.

All the Lake Michigan turbidity data from 2001 through 2003 was analyzed and then plotted. See makeup water chart below. A trend line analysis was performed to take the average of three daily data points (72 hours). This produced a maximum average 72-hour value of 175 ppm Total Suspended Solids. This maximum 72-hour value is included on the makeup water data chart below. The 175-ppm TSS value was used to perform a sensitivity calculation using the same methods and other assumptions used in Calculation C11563, except for the TSS, and determined that the added solids would reduce the efficiency of the steam generators to 78.775%. Then NMC took the maximum value observed over the 3-year period of 350 ppm and performed a similar calculation. This reduced the efficiency to 71.504 %.




NMC performed these additional calculations[7] to show that even with the conservative assumptions included in the calculation of steam generator fouling, if the worst case turbidity results were used in the calculation the steam generators would still be able to remove greater than 2% reactor thermal power, the amount of power the reactor decay heat quickly drops to following a reactor trip. Note also that the reactor decay heat continues to drop as the nuclear fission daughter products decay away.

In conclusion, the heat transfer efficiency of steam generators, due to hypothetical introduction of contaminated Lake Michigan water, is not significantly affected. Therefore, the steam generators are expected to function as designed following design basis accidents and events.

**Moisture Separators/Dryers**

Sludge (i.e., precipitated contaminants and debris) enters the steam generators through the feed water system during normal plant operation. The vast majority of this sludge settles on the tubesheet and is removed by sludge lancing during refueling shutdowns. Significant fouling of any moisture separator components has not been identified during inspections of the Kewaunee original steam generators. This includes primary and secondary separators and associated drain piping. Kewaunee replaced steam generator lower assemblies in 2001. Upper assemblies were not replaced, although several minor modifications were made to the moisture separator equipment. The modifications enhance moisture separation during the passage between the primary and secondary stages. The primary separators consist of three axial swirl vane risers. Each riser contains four flat separate but overlapping inclined blades arranged around and welded to a central hub and to the inside surface of the swirl vane barrel. The inside diameter of the swirl vane barrel is 56 inches with a central hub diameter of 20 inches. Therefore, there is an 18-inch opening between the central hub and the swirl vane barrel for steam flow. The secondary moisture separator consists of banks of contoured vanes. The spacing between the vanes is 0.200 inches. The secondary separator drainpipes are 2 inches in diameter. The openings and flow paths on the primary and secondary separators are not constricted for the collection of small particles or dissolved contaminants in the water. Any larger debris reaching the primary separators would pass through the large openings and this debris is never expected to reach the secondary separators. Furthermore, since the surfaces of the separators are not heated, there is no boiling on the surfaces that could promote concentration of contaminants, with resulting fouling of flow passages.

Over 3500 pounds of sludge has been removed from each steam generator over the life of the plant prior to steam generator replacement (see Table 2). It was determined in calculation C11563 Addendum A for the worse case of 350 ppm Total Suspended Solids that approximately 4241 pounds of contaminants would enter the steam generators from the service water system via the auxiliary feedwater system. This is not expected to have any effect on the moisture separators since more than 7000 pounds of sludge has been removed from the tubesheets over the history of the plant. Inspections of the steam drum were performed during the steam generator replacement outage before the upper assemblies were re-attached. The inspections revealed that there was no fouling present inside of the steam drums, including the moisture separation equipment, after nearly thirty years of operation.

Based on the above, no significant performance degradation is expected in the primary and secondary steam generator separators at KNPP due to the effects of feeding up to 900,000 gallons of Lake Michigan water into them following a design-basis accident or event.

Additionally, Westinghouse, the manufacturer of the steam generators, has reviewed the information contained in this document and concurs with the methodology used and the conclusions reached.

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February 20, 2004
Enclosure 2, Page 11

**NRC Question 2:**

Describe measures that have been (or will be) taken to assure that the quality of essential service water that is assumed in No. 1 (above) will be maintained over the life of the plant.

**NMC Response 2:**

The evaluations and analysis documented in the response to Question Number 1 above were based on the results of Lake Michigan water (the safety-related source of water for the Auxiliary Feedwater System) samples measured for contaminates, which could potentially degrade the steam generator heat transfer capability over time. The contamination levels used in the above response for dissolved contaminants, including silica, magnesium, calcium, sodium, chloride, sulfate, and carbonate, were selected to bound several samples over the last 30 years. These contaminants have not significantly changed over the operating life of the plant. The organic contaminants (total organic carbon or TOC) can vary, however, based on lake and weather conditions. Therefore, roughly three years of sample data were reviewed and a TOC value was selected for the analysis that bounded all of the data points over that three-year period. Likewise, the suspended solids can also vary based on lake and weather conditions. A time-weighted average value was calculated for approximately three years of data and then a 2-sigma statistical value was selected for the above analysis, which bounds 95% of the daily readings. Additional calculations were performed for the maximum 72-hour average and the maximum observed value with the results indicating acceptable steam generator performance. In conclusion, conservative values of contaminants were utilized for the Lake Michigan water contaminants in the above analysis.

The results of the evaluation in Question 1 provided significant margin in performing the safety function of the steam generators to remove decay and sensible heat from the reactor coolant system following a design basis accident or event. Since the Lake Michigan water contamination levels utilized in the analysis of the effects of service water on the steam generator are conservative values, the results above are applicable to current and future operation at stretch uprate conditions over the remaining term of the operating license. No specific measures or actions are required to assure that the results of the above analysis will remain applicable over the remaining life of the plant.

References

[1] Kewaunee Calculation C11563, "Affects of using Service Water as Auxiliary Feed on Steam Generator Heat Exchanger Performance."
[2] Letter from Thomas Coutu to Document Control Desk, "Responses To NRC Clarification Questions On Responses To Requests For Additional Information Regarding License Amendment Request 195, Stretch Power Uprate For Kewaunee Nuclear Power Plant (TAC NO. MB9031), dated February 9, 2004
[3] EPRI TR-106048 p2-52
[4] SG Technical Manual TM 1440-C384
[5] WCAP-15941
[6] Kewaunee Calculation C11563, "Affects of using Service Water as Auxiliary Feed on Steam Generator Heat Exchanger Performance."
[7] Kewaunee Calculation C11563, "Affects of using Service Water as Auxiliary Feed on Steam Generator Heat Exchanger Performance," Addendum A.