Progress Energy

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United States Nuclear Regulatory Commission
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H. B. ROBINSON STEAM ELECTRIC PLANT, UNIT NO. 2
DOCKET NO. 50-261/LICENSE NO. DPR-23

SUPPLEMENTAL RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION PERTAINING TO NRC GENERIC LETTER 2004-02, "POTENTIAL IMPACT OF DEBRIS BLOCKAGE ON EMERGENCY RECIRCULATION DURING DESIGN BASIS ACCIDENTS AT PRESSURIZED-WATER REACTORS"

Ladies and Gentlemen:

By letter dated December 3, 2009, a request for additional information (RAI) regarding the H. B. Robinson Steam Electric Plant (HBRSEP), Unit No. 2, response to NRC Generic Letter (GL) 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation during Design Basis Accidents at Pressurized-Water Reactors," was provided by the NRC. The initial response to that RAI was provided to the NRC by letter dated March 30, 2010. In that letter, Carolina Power and Light Company, also known as Progress Energy Carolinas, Inc., committed to perform additional testing and provide the results of that testing by September 30, 2010. Extension of this due date to October 8, 2010, was documented in an electronic mail message from the NRC Project Manager for HBRSEP, Unit No. 2, dated September 29, 2010. The results of the additional testing and analysis are being provided in this letter.

Attachment I to this letter provides an Affirmation in accordance with the provisions of Section 182a of the Atomic Energy Act of 1954, as amended, and 10 CFR 50.54(f).

Attachment II to this letter provides the supplemental response to the RAI.

No commitments are being made in this letter. If you have any questions concerning this matter, please contact Mr. Curtis A. Castell, Supervisor – Licensing/Regulatory Programs, at (843) 857-1626.

A116
NRR

Progress Energy Carolinas, Inc.
Robinson Nuclear Plant
3581 West Entrance Road
Hartsville, SC 29550

Sincerely,

Benjamin C. White
Manager – Support Services – Nuclear

BCW/cac

Attachments:

I. Affirmation
II. Supplemental Response to Request for Additional Information Pertaining to NRC Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation during Design Basis Accidents at Pressurized-Water Reactors"

c: L. A. Reyes, NRC, Region II
T. J. Orf, NRC, NRR
NRC Resident Inspector

AFFIRMATION

The information contained in letter RNP-RA/10-0104 is true and correct to the best of my information, knowledge, and belief; and the sources of my information are officers, employees, contractors, and agents of Carolina Power and Light Company, also known as Progress Energy Carolinas, Inc. I declare under penalty of perjury that the foregoing is true and correct.

Executed On: 10/8/10

Benjamin C. White
Benjamin C. White
Manager – Support Services – Nuclear
HBRSEP, Unit No. 2

H. B. ROBINSON STEAM ELECTRIC PLANT, UNIT NO. 2

SUPPLEMENTAL RESPONSE TO REQUEST FOR ADDITIONAL INFORMATON PERTAINING TO NRC GENERIC LETTER 2004-02, "POTENTIAL IMPACT OF DEBRIS BLOCKAGE ON EMERGENCY RECIRCULATION DURING DESIGN BASIS ACCIDENTS AT PRESSURIZED-WATER REACTORS"

By letter dated December 3, 2009, a request for additional information (RAI) regarding the H. B. Robinson Steam Electric Plant (HBRSEP), Unit No. 2, response to NRC Generic Letter (GL) 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation during Design Basis Accidents at Pressurized-Water Reactors," was provided by the NRC. The initial response to that RAI was provided to the NRC by letter dated March 30, 2010. In that letter, Carolina Power and Light Company, also known as Progress Energy Carolinas, Inc., committed to perform additional testing and provide the results of that testing by September 30, 2010. The results of the additional testing are being provided as supplemental information to the March 30, 2010, RAI response, as follows:

Debris transport

RAI 1 & RAI 4:

Provide additional information to justify the credit taken for the retention of small fibrous fines and particulate debris in the upper containment and inactive holdup volumes or provide additional basis to demonstrate that the head loss impact of the debris is insignificant.

Response:

The debris quantity and characteristics for blowdown and washdown transport were recalculated based on the baseline methodology, as described in the Nuclear Energy Institute's (NEI) Guidance Report 04-07, "Pressurized Water Reactor Sump Performance Evaluation Methodology." Small fibrous fines and fine particulate were distributed with 25% to upper containment, 75% to lower containment, and 100% washdown of all small fines in upper containment.

The head loss testing was repeated using the revised debris quantity and methodology consistent with the guidance provided in the report, "NRC Staff Review Guidance Regarding Generic Letter 2004-02 Closure in the Area of Strainer Head Loss and Vortexing, March 2008" (ADAMS Accession No. ML080230038). A summary of the testing and results follows the itemized RAI responses.

RAI 2:

Provide additional information in light of the discussion below to justify the assumptions of zero percent erosion and zero percent transport of large pieces of fibrous debris.

Response:

Transport of large pieces was addressed by assuming erosion of the large pieces and including the erosion fines in the head loss test debris mix. Ten percent of the large pieces were assumed to erode and deposit on the screens as fines. This is considered reasonable and conservative because the fines in the debris bed are expected to add more to the head loss than large pieces.

The debris quantity and characteristics were recalculated with the above assumption and the baseline methodology as described in the NEI Guidance Report 04-07. As previously stated, the head loss testing was repeated, using the revised debris quantity and methodology consistent with the guidance provided in the report, "NRC Staff Review Guidance Regarding Generic Letter 2004-02 Closure in the Area of Strainer Head Loss and Vortexing, March 2008" (ADAMS Accession No. ML080230038). A summary of the testing and results follows the itemized RAI responses.

Head Loss and Vortexing

RAI 7:

Provide information that justifies that any agglomeration of debris did not affect head loss test results non-conservatively.

Response:

As previously stated, the head loss testing was repeated, using the revised debris quantity and methodology consistent with the guidance provided in the report, "NRC Staff Review Guidance Regarding Generic Letter 2004-02 Closure in the Area of Strainer Head Loss and Vortexing, March 2008" (ADAMS Accession No. ML080230038). The debris preparation and introduction for this testing was consistent with methods previously determined to be acceptable for this type of testing. A summary of the testing and results follows the itemized RAI responses.

RAI 8:

Provide an evaluation that shows that any settling that occurred resulted in a negligible effect on head loss test results or that the settling was prototypical or conservative compared to the expected plant conditions.

Response:

As previously stated, the head loss testing was repeated, using the revised debris quantity and methodology consistent with the guidance provided in the report, "NRC Staff Review Guidance

Regarding Generic Letter 2004-02 Closure in the Area of Strainer Head Loss and Vortexing, March 2008" (ADAMS Accession No. ML080230038). The debris preparation and introduction for this testing was consistent with methods previously determined to be acceptable for this type of testing. A summary of the testing and results follows the itemized RAI responses.

RAI 11:

Provide the size distribution of the particulate insulation surrogate used during testing.

Response:

As previously stated, the head loss testing was repeated, using the revised debris quantity and methodology consistent with the guidance provided in the report, "NRC Staff Review Guidance Regarding Generic Letter 2004-02 Closure in the Area of Strainer Head Loss and Vortexing, March 2008," (ADAMS Accession No. ML080230038). Surrogates used in the repeat tests were as follows:

Green Silicon Carbide produced by UK Abrasives was used as a surrogate for qualified and unqualified coatings. The powder has a nominal mean particle diameter of 10 microns (μm).

Silica Sand prepared by Performance Contracting, Incorporated was used as a surrogate material for latent dirt and dust debris. The size distribution of the silica sand was prepared to be consistent with the latent dirt/dust size distribution provided in the SER. The table below presents the size distribution.

PWR Mix 2	**Sand Type Distributions Based on Product Data Sheets**			**Size Classification / Consolidation**			
Sand Recipe Mix (lbs)	Coarse Sand **8**	Medium Sand **54**	Fine Sand **38**	Allocation Basis (lbs)	PWR 2 Calc	NRC Target	
< 75 microns			**98.50%**	37.4	37.4%	37%	**Fines**
> 75 microns			**1.50%**	0.6	35.3%	35%	**Medium**
< 500 microns		**63.77%**		34.4			
> 500 microns		**36.23%**		19.6	27.3%	28%	**Coarse**
< 500 microns	**3.37%**			0.3			
> 500 but < 2000 microns	**96.63%**			7.7			
				100.0	100.0%	100.0%	
			Sand Class Key	Fine	Medium	Coarse	

Note: Each type of sand has particles in two size ranges.
The above recipe will achieve the NRC Target.

Powdered Calcium Silicate was used as the surrogate for Cal-Sil insulation material.

RAI 14:

Provide justification that the debris bed head loss was not limited due to bed shifting or provide an evaluation based on the head loss that could occur should the head loss be limited as described above.

Response:

The three tests, conducted in May 2010, exhibited relatively large increases in head loss with the initial chemical precipitate addition and very minor or no effect on head loss from the following chemical precipitate additions. This pattern correlates to a saturation limit of chemicals in the debris bed and would limit the head loss effect of any increased chemical debris additions.

In order to address the potential for bed shifting, the chemical effects head loss (tested at 86°F) was not temperature corrected. The net positive suction head (NPSH) margin is determined based on chemical precipitate formation at sump fluid temperatures below 140°F based on bench top test results, as previously described in the December 17, 2008, RAI response letter. The limiting NPSH values are tabulated in the response to RAI 16 below.

Net Positive Suction Head

RAI 16:

Please address whether a single failure of a throttle valve to the open position in post-LOCA scenarios during recirculation where throttling credit is taken would result in increased flows through the residual heat removal (RHR) pump(s) that could result in a loss of net positive suction head margin or emergency core cooling system strainer structural limits being exceeded.

Response:

As explained in the March 30, 2010, RAI response, the valves are throttled only in the alignment of two RHR pumps operating and providing suction to the High Head Safety Injection (SI) pumps for simultaneous hot leg and cold leg recirculation. This is not the limiting system alignment for determination of RHR pumps NPSH because with two pumps operating, each pump operates at a lower flowrate, with a lower NPSH required (NPSHR) than the single pump operation case. The loss of throttling capability in this configuration results in a less limiting condition for determining NPSH than the limiting condition of one pump operating because the additional head loss through the screens resulting from the higher total flowrate is less than the NPSH required improvement resulting from lower individual pump flowrate. The following tables provide the baseline limiting case (Case 1) and the cases (Case 3 and 4) of two pump operations with and without throttle valve failure.

In the process of revising the emergency core cooling system NPSH calculation to include the new strainer head loss test results, it was determined that under certain conditions (i.e., simultaneous hot leg and cold leg recirculation with one throttled valve failing to the full open position and with sump temperature less than or equal to 140°F) differential pressure on the strainer could exceed the structural design limit value. This condition was entered into the corrective action program as Nuclear Condition Report 422109. It is expected that procedure revision will resolve this issue. The procedure revision is expected to provide guidance that the throttled alignment is procedurally allowed only when sump temperatures are above 140°F so chemical precipitate debris loading is not applicable to the failure. In the absence of chemical precipitates, strainer head loss will not encroach upon the structural design limit. If the throttle valve fails to the full open position, the procedure revision will require the system to be realigned for either hot leg recirculation or cold leg recirculation (similar to Case 2 in the tables below, except only one SI pump and no Containment Spray [CS] pump) before sump temperature decreases below 140°F.

During recirculation the system is initially aligned for cold leg recirculation. The results for this condition are shown as Case 1and 2 in the tables below.

After approximately 11 hours, the system is aligned in piggyback mode (SI pump suction is aligned to receive suction from the discharge of the RHR pump) for hot leg recirculation via an SI pump, which is similar to Case 2 in the tables below. Sump temperatures below 140°F are not expected to occur in that condition.

If the necessary equipment is available, the system is then aligned for simultaneous hot and cold leg recirculation (cold leg via the RHR system and hot leg via the SI system), which is Case 3 in the tables below. By the planned procedure revision, a sump temperature greater than 140°F will be added as a constraint to aligning for simultaneous hot and cold leg recirculation.

If the equipment is not available, or the sump temperature is less than 140°F, then the system is maintained in piggyback mode and aligned to alternate between hot leg and cold leg recirculation via the SI system, similar to Case 2 in the tables below, except with only one SI pump and no CS pump, every 16 hours. Piggyback mode alignment is not a limiting case for NPSH available (NPSHA) or differential pressure due to the flow being limited by the SI pump capacity.

The planned procedure revision will also address long term low sump temperatures and reduced flow, if aligned for simultaneous hot and cold leg injection, before the sump temperatures could cause excessive head loss at the screens. The expected configuration is addressed in Case 5 below.

NO CHEMICAL PRECIPITATE LOADING
(Sump Temperature > 140°F)

Case	Containment press.	Sump Temp	RHR Pump (s)	SI Pumps	CS Pumps	Screen + Plenum Head Loss	RHR Pump NPSHA	RHR Pump NPSHR	RHR Pump NPSH Margin
	psig	°F				ft	ft	ft	ft
1	-0.8	209	B	-	-	4.88	15.08	14.48	0.60
2	-0.8	209	A	A & B	A	2.80	14.50	9.80	4.70
3	-0.8	209	A & B	A & B	-	3.77	A 18.29	9.18	9.11
							B 18.34	9.18	9.16
4	-0.8	209	A & B	A & B	-	7.95	A 13.18	10.01	3.17
							B 13.20	10.23	2.97

Case 1: RHR Cold Leg Recirculation
Case 2: SI Cold Leg Recirculation (piggyback alignment)
Case 3: Simultaneous Hot and Cold Leg Recirculation
Case 4: Simultaneous Hot and Cold Leg Recirculation with Throttle Valve Failure

INCLUDES CHEMICAL PRECIPITATE LOADING
NO TEMPERATURE ADJUSTMENT TO PEAK AS-TESTED HEAD LOSS FOR SUMP TEMPERATURES ABOVE AS-TESTED TEMPERATURE OF 86°F

Case	CV press	Sump Temp	RHR Pump (s)	SI Pumps	CS Pumps	Screen + Plenum Head Loss	RHR Pump NPSHA	RHR Pump NPSHR	RHR Pump NPSH Margin
	psig	°F				ft	ft	ft	ft
1	-0.8	140	B	-	-	15.0	30.79	14.18	16.61
2	-0.8	140	A	A & B	A	9.5	33.58	9.79	23.79
3	-0.8	140	A & B	A & B	-	12.3	A 35.53	9.18	26.35
							B 35.58	9.18	26.40
5	-0.8	60	A & B	A	-	9.4	A 44.57	9.15	35.42
							B 44.63	9.14	35.48

Case 1: RHR Cold Leg Recirculation
Case 2: SI Cold Leg Recirculation (piggyback alignment)
Case 3: Simultaneous Hot and Cold Leg Recirculation
Case 5: Simultaneous Hot and Cold Leg Recirculation, Aligned for Low Sump Temperature (piggyback alignment)

Incorporating strainer head loss, NPSH margin was determined to be at least 9.11 feet of water gauge (feet) without valve failure and 2.97 feet with a valve failure.

The strainers are designed for a differential pressure of 6.5 psi (15 feet). The total head loss across the screen and plenum concurrent with throttle valve failure is 7.95 feet at 209°F and will remain less than 15 feet at the same flowrate with temperatures above 140°F. Therefore, structural limits are not challenged as a result of throttle valve failure. With chemical precipitate loading, the total head loss is predicted to be as high as 15.0 ft (Case 1).

Summary of Testing

The increase in debris load (caused by minor changes to the transport fractions) and the preparation and introduction of debris in accordance with the March 2008 NRC guidance appears to have increased the non-chemical bounding head loss by approximately 4 feet and the bounding maximum head loss by approximately 3.6 feet.

Debris Preparation:

The fibrous debris classified as "small fines" in the debris generation calculation was further refined to "fines" and "small pieces" for the test with a size distribution based on NEI-04-07 SER which states, "In the debris generation tests conducted...15 to 25 percent of the debris from a completely disintegrated TPI fiberglass blanket was classified as non-recoverable...it would be reasonable to assume that 25 percent of the baseline small fined debris is in the form of individual fibers and the other 75 percent is in the form of small-piece debris."

Based on the above guidance, 25% of the "small fines" used for testing were prepared as "fines" and 75% were prepared as "small pieces." Latent fibers were considered as "fines."

"Fines" were double-shredded through a leaf shredder and "Small Pieces" were single-shredded through a leaf shredder. The shredded fiber was boiled for 10 minutes.

Fiber "Fines" were then placed in a bucket with sufficient water to create a thin slurry using ¼ lbs of fiber per 4 gallons of water. Fiber "Small Pieces" were placed in a bucket to create a thin slurry – ½ lbs fiber per 4 gallons of water. The fiber and water mixture was stirred with a paint stirrer. Fiber "Fines" were beaten for a minimum of 4 minutes and "Small Pieces" beaten to break up clumps. The resulting slurry was sampled to visually verify that the fiber met the required size distribution.

Particulates were placed in a bucket with sufficient water to create a thin slurry. The mixture was stirred with a paint stirrer to ensure homogeneous dispersal with no clumps.

Three tests were conducted using the revised debris quantity and methodology consistent with the guidance provided in the report, "NRC Staff Review Guidance Regarding Generic Letter 2004-02 Closure in the Area of Strainer Head Loss and Vortexing, March 2008" (ADAMS Accession No. ML080230038). The debris preparation and introduction for this testing was consistent with methods previously determined to be acceptable for this type of testing. The tests consisted of a "thin bed" test to explore if the strainer design was susceptible to a "thin bed." A second test was conducted with the maximum design quantity of non-chemical and chemical debris loads. A third test was conducted to determine the head loss with the maximum design quantity of non-chemical and chemical debris load plus 5%.

Thin Bed Test:

The thin bed threshold test was conducted with the introduction of particulate debris first, followed by incremental batches of fine fibrous debris until complete screen coverage was observed. The screen was deemed to be completely covered at an equivalent fibrous debris bed thickness of approximately ¼ inch.

The maximum head loss observed prior to the introduction of chemical precipitates was 4.69 feet at approximately 81°F. The "Thin Bed" test produced a maximum head loss with chemical precipitates of 6.57 feet at approximately 82°F prior to an unexpected loss of power at the test facility which tripped the main pump of the test array. At the time of the power loss the final chemical precipitate was stabilizing at a head loss of 5.71 feet. This head loss is indicative that there was sufficient fibrous debris available to cover the strainer, but no "Thin Bed Effect" of a high head loss at this debris load was observed. The full scale array in the plant would be expected to load more non-uniformly and would also exhibit low head loss at low fiber loads.

The "Thin Bed" test produced lower head loss results than, and was thus bounded by, the Maximum Debris Quantity test.

Maximum Debris Quantity Test:

The Maximum Debris Quantity test was performed for the purpose of determining the head loss associated with the maximum debris loading on the strainer. The fibrous and particulate debris were added simultaneously to the tank. Fiber fines were added before fiber small pieces. This debris load represented the plant's maximum debris load, which would form a fibrous debris bed of approximately 0.57 inches thick, if uniformly distributed on the screen. Once a stable head loss was achieved, chemical precipitates were added in batches. The maximum head loss prior to the addition of any chemical precipitates was 9.39 feet at approximately 83°F. The maximum measured head loss after the addition of chemicals was 13.72 feet at approximately 86°F (note this value does not include plenum losses, which are included in the above tables).

Flow sweeps at the end of the test showed the flow to be laminar. The head loss was adjusted for temperature based on laminar flow and a linear relationship with viscosity. When adjusted for temperature, the maximum head loss for a maximum debris bed under design conditions is 3.26 feet for the fibrous and particulate debris (note this value does not include plenum losses, which are included in the above tables) and 4.93 feet for the fibrous and particulate debris plus chemical effects.

Additional Margin Test:

The Additional Margin test was performed for the purpose of determining the head loss associated with an additional 5% of the chemical and non-chemical debris types beyond the maximum debris loading on the strainer. The test was conducted similar to the Maximum Debris Quantity test with additional debris, and would result in a fibrous debris bed of approximately 0.60 inches thick if uniformly distributed on the screen. Once a stable head loss was achieved, chemical precipitates were added in batches. The maximum head loss prior to the addition of any chemical precipitates was 8.71 feet at approximately 91°F. The maximum measured head loss after the addition of chemicals was 11.01 feet at approximately 91°F. This test produced lower head loss results than, and was thus bounded by, the Maximum Debris Quantity Test. Based on the test results, it is apparent that a 5% increase in the debris load had a minimal effect on head loss.

Debris Introduction:

Turbulence was induced in the test tank by a sparger and mechanical mixers to suspend debris and allow the debris to drift on to the strainer so as to form a flow induced debris bed. Mechanical mixers and manual stirring were directed away from test strainer to allow a flow induced debris bed while avoiding artificial disturbances of the debris bed. Debris was allowed to accumulate on the screens based on the approach flow to strainer.

Vortexing:

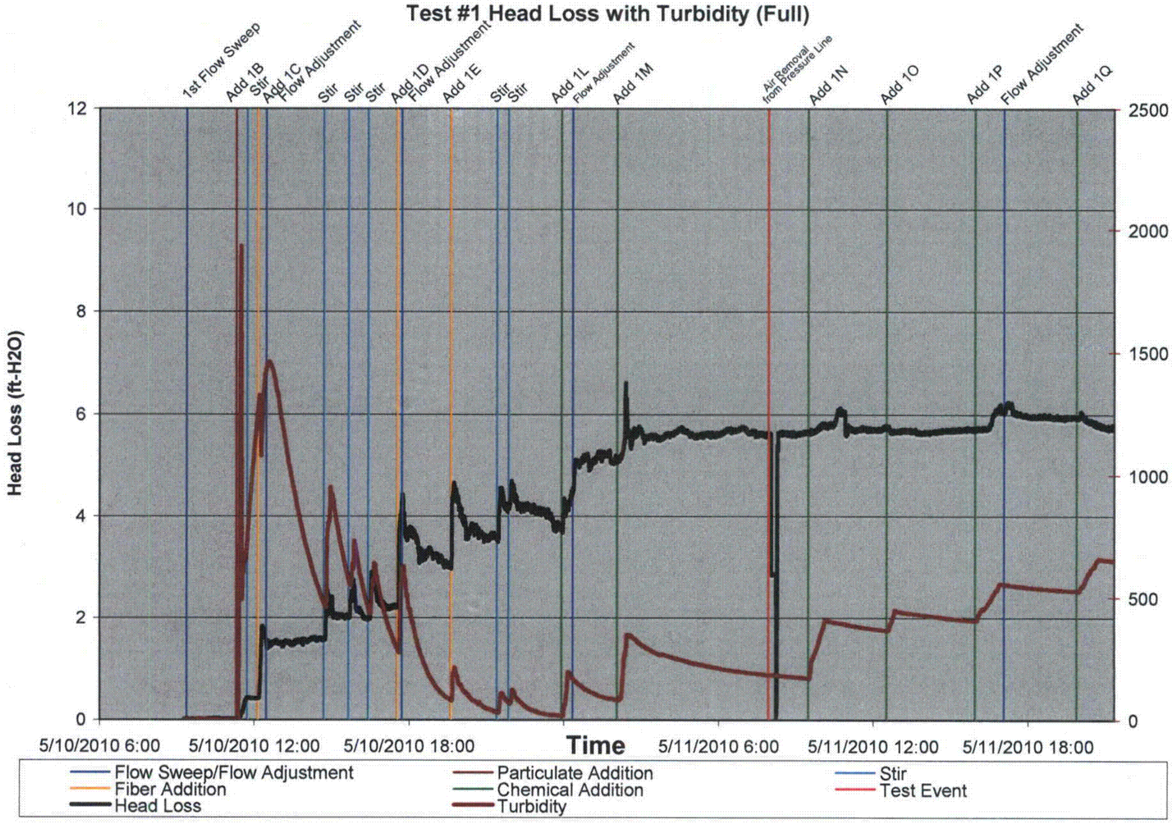
Flow sweeps were conducted with clean screens and fully loaded screens at the minimum expected water level associated with the debris load. No sustained vortices or air ingestion was observed.

Test Results:

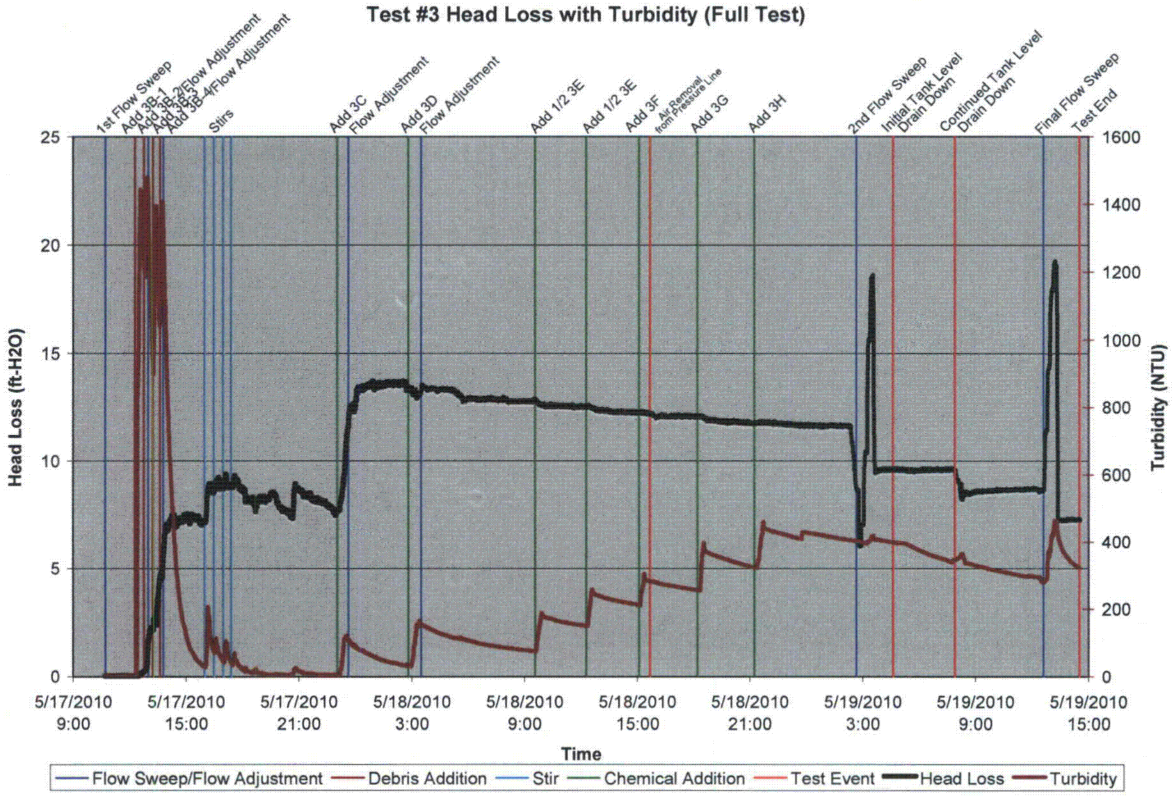
The test results are provided in graphical format in the following three figures.

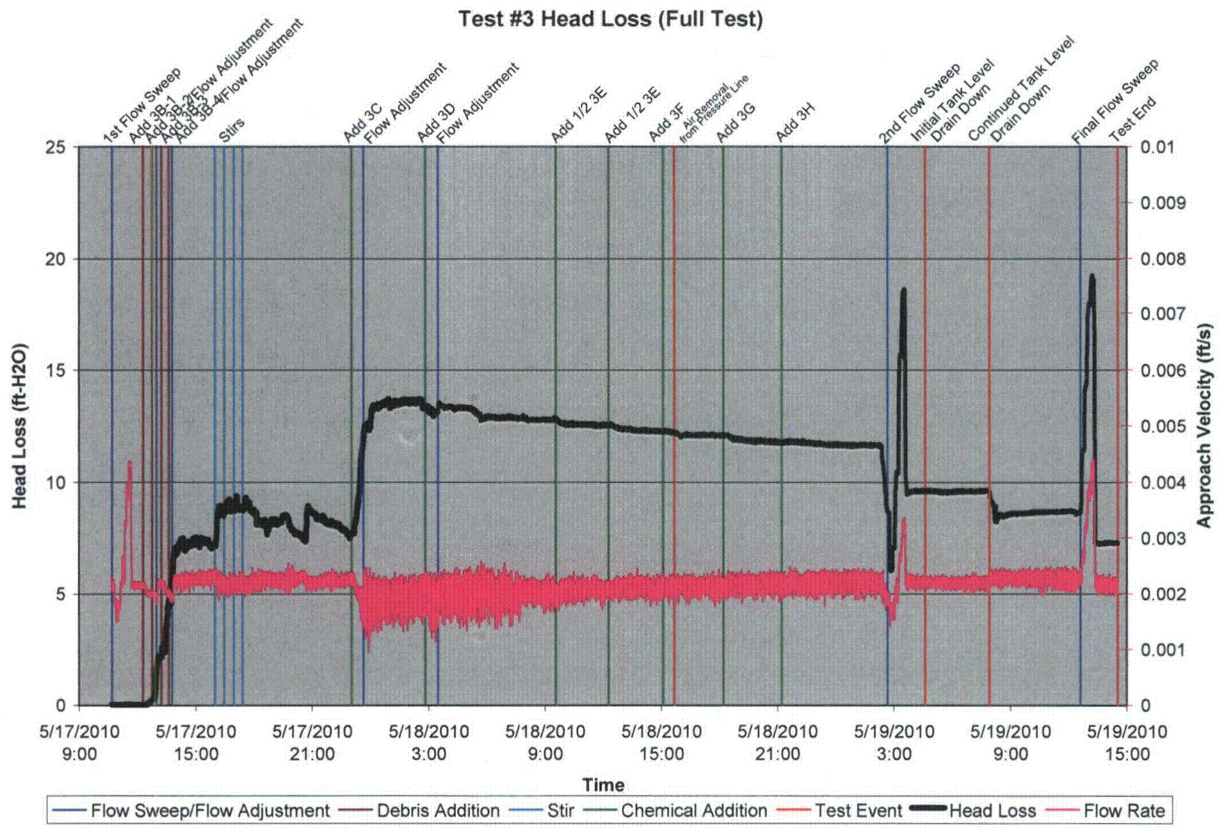
TEST RESULTS: THIN BED TEST

Test #1 Head Loss with Turbidity (Full)



TEST RESULTS: FULL LOAD HEAD TEST




Test #3 Head Loss (Full Test)
1st Flow Sweep
Stirs
Add 3C
Flow Adjustment
Add 3D
Flow Adjustment
Add 1/2 3E
Add 1/2 3E
Add 3F
Add 3G
Add 3H
2nd Flow Sweep
Initial Tank Level Drain Down
Continued Tank Level Drain Down
Final Flow Sweep
Test End
Head Loss (ft-H2O)
Approach Velocity (ft/s)
Time
5/17/2010 9:00
5/17/2010 15:00
5/17/2010 21:00
5/18/2010 3:00
5/18/2010 9:00
5/18/2010 15:00
5/18/2010 21:00
5/19/2010 3:00
5/19/2010 9:00
5/19/2010 15:00
Flow Sweep/Flow Adjustment
Debris Addition
Stir
Chemical Addition
Test Event
Head Loss
Flow Rate