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Attachment 2

FGD WASTEWATER TREATMENT SYSTEM

URS EXECUTIVE SUMMARY

of

"ANTI-DEGRADATION STUDY"

URS	MERRIMACK 1&2 CLEAN AIR PROJECT EXECUTIVE SUMMARY OF ANTI-DEGRADATION STUDY PREPARED IN SUPPORT OF STATION NPDES PERMIT RENEWAL NH0001465	Project No.: 29384-002

1.0 PURPOSE AND BACKGROUND

Operation of the Flue Gas Desulfurization (FGD) system, which is being installed as part of the Merrimack Station Clean Air Project, will result in a purge stream (scrubber blowdown). This stream will be treated by a new dedicated physical-chemical Wastewater Treatment System (WWTS), whose treated effluent will be directed to the existing Station treatment pond. At the request of PSNH, URS prepared an anti-degradation water quality study, the results of which are summarized in this Executive Summary document.

The goal of the anti-degradation study is to demonstrate that the following criteria are satisfied for each regulated chemical species (in the order shown):

1) The Merrimack River has sufficient remaining assimilative capacity so that there is not a "reasonable potential" (per EPA procedure) for the metals in the future effluent to exceed the New Hampshire Water Quality Standards. In this case, the impact of the future treated FGD wastewater stream would be deemed to be insignificant.
2) If the river is impaired or does not have sufficient assimilative capacity, there must be a demonstration of no net mass increase between present and future discharges.

As directed by the NHDES and USEPA to PSNH, the regulated chemical species to investigate are: Aluminum, Antimony, Arsenic, Beryllium, Cadmium, Chromium III, Copper, Iron, Lead, Manganese, Mercury, Nickel, Selenium, Silver, Thallium, Zinc, Chlorides, Ammonia (as N), and Nitrates (as N). This is a subset of the chemical species listed in Table 1703.1 of State of New Hampshire Surface Water Quality Regulations, Chapter 1700, dated 12/10/99. Also as directed by the agencies, Chromium +6 was analyzed in two of the treatment pond samples to show that it is not present in the discharge.

URS and PSNH met with the NHDES on September 11, 2009 to discuss the anti-degradation study, which was under development. A meeting was held with PSNH and the NHDES on January 28, 2010 to discuss the results of URS' preliminary work. URS was unable to attend that meeting because of weather-related travel restrictions. A meeting between URS, PSNH, and the NHDES was held on February 18, 2010, to review the anti-degradation methodology in detail. During this meeting, calculation methods were reviewed, compared, and refined. In addition, the NHDES provided updated requirements regarding the calculation of river concentration data, based on analyzed samples and loadings due to future upstream discharges.

On March 23, 2010, the NHDES provided their spreadsheet model for PSNH information and use.

2.0 WATER SAMPLES AND CHEMICAL ANALYSIS

To support the anti-degradation study, PSNH obtained new water samples from the Merrimack River during the months from June 2009 through September 2009, and from the Station Treatment Pond, during the months from June 2009 through January 2010. Eastern Analytical, Inc. of Concord, N.H. obtained the water samples, using "clean techniques" and also performed standard analytical techniques for some of the analytes. Low method detection limit (MDL) testing methods were performed by Frontier GeoSciences, Inc. of Seattle, WA. The analytical results are summarized in Attachment 1.

2.1 Treatment Pond Analytical Data

It should be noted that analytical data from station compliance monitoring at the treatment pond weir for previous years (2/18/97 to 9/09/09), had been used for copper and iron concentrations in the treatment pond. Following DES review on January 7, 2010, it was decided to use the copper and iron concentrations from the last eight quarterly pond weir samples. In its latest implementation of their model (March 23, 2010), the NHDES used long term averages for copper and iron concentrations. For nitrate concentration in the treatment pond, data from the period 4/26/06 to 7/24/07 was used.

It should also be noted that for measurements that were below method detection limit (MDL), the calculations used the MDL, as requested by the NHDES.

Maximum values of treatment pond data were used for the calculations, as previously discussed with the NHDES. In addition, a statistical multiplier, based on the number of pond samples, was applied to the maximum pond concentration data, for assimilative capacity calculations (not for "no net mass" increase calculations). This is consistent with the method presented in the 2/05/08 DES letter, regarding Hooksett NPDES Permit No. NH0100129. This Hooksett Permit background information was provided to PSNH as a guideline for the preparation of the Merrimack anti-degradation study.

2.2 Merrimack River Analytical Data

Merrimack River flow rates were as follows when the new river water samples were obtained:

Sample Date	River Flow Rate
7/16/09	4860 cfs
8/17/09	3530 cfs
9/17/09	1850 cfs
9/25/09	1590 cfs

Average values of river water concentrations were used for the calculations, in accordance with previous PSNH discussions with the NHDES.

Following the issue of the URS preliminary anti-degradation study, the NHDES commented that some of the river water analysis data used by URS had been reported by the laboratories as concentrations of dissolved metals, not as total metals. Subsequently, URS used correction factors, from Surface Water Quality Regulation Env-Ws 1703, to convert from dissolved to total concentrations.

During the February 18, 2010 meeting, the DES provided URS with additional river data. The new data corrects the average data from the four river samples, by accounting for the anticipated future discharges from upstream facilities. This results in higher river concentrations for all of the metals, because additional mass loadings are artificially added to current loadings. This correction procedure is required by Surface Water Quality Regulations Env-Ws 1708. The revised data is shown on Attachment 1.

3.0 FLOW DATA USED FOR CALCULATIONS

3.1 Station Flow Rates

The following flow values have been used for the Anti-Degradation Study:

Station Treatment Pond Weir Future Permit (Proposed): 5.3 MGD Average

Design FGD makeup water flow: 750 gpm (1.08 MGD)

Design WWTS treated wastewater discharge flow: 35 gpm (0.05 MGD).

The future average permit weir flow rate has been adjusted to account for the FGD withdrawal and WWTS discharge flow rates. The weir flow rate of 5.3 MGD corresponds to a pond flow rate of 6.3 MGD, upstream of the service pump house and FGD WWT treated effluent discharge location. This is due to the net effect of the withdrawal of the FGD makeup water and discharge of the treated WWTS effluent.

3.2 River Flow Rates

The following river flow rates have been used:

7Q10:	587.75 cubic feet per second (cfs)
Harmonic Mean Flow:	1,990 cubic feet per second (cfs)

In accordance with DES direction to PSNH, the Harmonic Mean Flow was used for calculations for species which use the Human Health Criteria - Carcinogen subcategory. For this evaluation, arsenic is the only species for which this criteria is applicable.

4.0 CALCULATION METHOD

4.1 Assimilative Capacity Calculation

In accordance with New Hampshire DES direction at a 9/11/09 meeting, attended by PSNH and URS, future permit pond flow rates are to be used for "assimilative capacity" calculations. The calculation method that was used by URS is summarized below.

Calculated Future River Downstream Concentration	<	Allowable Future Concentration for Assimilative Capacity
Determined by mass balance using the following flow rates and characterizations: • Treatment pond • FGD makeup from treatment pond • WWTS treated effluent discharge • River		Determined using method presented in 2/05/08 letter from DES regarding Hooksett NPDES Permit No. NH0100129. This method results in "the allowable downstream concentration considered to be 'insignificant'". (ref: Attachment 2)

Statistical treatment of the pond analysis data is based on the number of samples and in this case, six pond samples were provided. In accordance with New Hampshire DES methodology, this results in applying a statistical multiplier of 3.8 (variable "M") to the maximum pond data.

At the February 18, 2010 meeting, the NHDES and URS reviewed in detail the formulas used by the NHDES "Desktop Permit Limit Calculator Model" Excel program, which is used to calculate $K_{Assimilative-Capacity}$, which is "the allowable downstream concentration considered to be 'insignificant'" (Reference Attachment 2). The NHDES method for determining $K_{Assimilative-Capacity}$ uses a calculated value of $K_{RiverDownstream}$, which accounts for the measured upstream (of the Station) river concentration, K_{River}, AND the existing load from the Station. In addition, the backwards mass balance used by the NHDES, to determine the allowable weir concentration, uses $K_{Assimilative-Capacity}$ in conjunction with the future permitted Station flow and the river flow rate. The method originally used by URS was similar but had some minor differences.

After receiving the NHDES model for review (on March 23, 2010), URS revised its model to mimic the NHDES calculation and to arrive at the same numerical results.

During the February 18, 2010 meeting, the NHDES also clarified the details of their calculation method for "reasonable potential", which is based on EPA procedures. URS added this additional calculation step to its study. This method compares the corrected (using the statistical multiplier "M") measured maximum pond data with the calculated allowable pond weir concentration, as determined using a backwards mass balance, which includes $K_{Assimilative-Capacity}$, as one of the inputs.

The revised URS model has allowed URS to directly evaluate the NHDES recommendations regarding metals of concern and proposed limits.

- Maximum Allowable Downstream River Concentration (Assimilative Capacity) (*Previous URS Method*):

$$K_{Assimilative-Capacity} = K_{River} + (0.2 \times (0.9 \times WQC - K_{River}))$$

Calculated Future Combined River Concentration:

$$K_{River-Calc-future} = \frac{M \times K_{Max-TP} \times (Q_{TP(F)} - Q_{FGD}) + (K_{Guaranteed-WWTS} \times Q_{WWTS}) + (K_{River} \times Q_{River})}{Q_{TP(F)} - Q_{FGD} + Q_{WWTS} + Q_{River}}$$

It is required that:

$$K_{River-Calc-future} < K_{Assimilative-Capacity}$$

(The calculated combined river concentration must be less than the Maximum Allowable Downstream River Concentration (Assimilative Capacity)).

- Calculated Concentration to Determine Reasonable Potential (*NHDES Philosophy as Implemented by URS during the week of March 23, 2010*):

$$K_{RiverDown} = \frac{K_{Pond} \times Q_{TP(P)} + K_{River} \times Q_{River}}{Q_{TP(P)} + Q_{River}}$$

$$K_{Assimilative-Capacity} = K_{RiverDown} + (0.2 \times (0.9 \times WQC - K_{RiverDown}))$$

$$K_{Weir\_Assimilative-Capacity} \le \frac{K_{Assimilative-Capacity} \times (Q_{Weir(F)} + Q_{River}) - K_{River} \times Q_{River}}{(Q_{Weir(F)})}$$

where $Q_{Weir(F)} = Q_{TP(F)} - Q_{FGD} + Q_{WWTS}$

$$K_{Calc-ReasonablePotential} = M \times K_{Max-TP}$$

For "no reasonable potential" (for which no permit limit is required), it is required that:

$$K_{Calc-ReasonablePotential} < K_{Weir\_Assimilative-Capacity}$$

- Maximum WWTS Discharge Concentration to Meet Assimilative Capacity at Weir, Without Multiplier on Pond Concentration (*URS Method*):

$$K_{Max-WWTS} < \frac{K_{Assimilative-Capacity} \times (Q_{Weir(F)} + Q_{River}) - K_{River} \times Q_{River} - K_{Max-TP-Measured} \times (Q_{TP(F)} - Q_{FGD})}{Q_{WWTS}}$$

where $Q_{Weir(F)} = Q_{TP(F)} - Q_{FGD} + Q_{WWTS}$

4.2 No Net Mass Increase Calculation

In accordance with New Hampshire DES direction at the 9/11/09 meeting, future and present actual pond flow rates are to be used for the "no net mass increase" criteria. The calculation method used by URS is summarized below.

Future Mass Discharge Over Pond Weir of Each Chemical Species	<	Present Mass Discharge Over Pond Weir of Each Chemical Species
Determined by mass balance using the following flow rates and characterizations: • Treatment pond • FGD makeup from treatment pond • WWTS treated effluent discharge		Determined by mass balance using the following flow rates and characterizations: • Treatment pond

A statistical multiplier is not applied to the maximum pond data. To meet the criteria of "No Net Mass Increase" in the treatment pond discharge, the Guaranteed FGD WWTS discharge concentration has to be less than the calculated Maximum Allowable WWTS discharge concentration.

- The Max Allowable WWTS effluent level is developed from the following mass balance formula:

$$(K_{Max-WWTS} \times Q_{WWTS}) + (K_{Max-TP} \times (Q_{TP(F)} - Q_{FGD})) < (K_{Max-TP} \times Q_{TP(P)})$$

- When simplified and solved for Max Allowable WWTS effluent level, the following equation is obtained:

$$K_{Max-WWTS} < \frac{K_{Max-TP} \times (Q_{FGD} + Q_{TP(P)} - Q_{TP(F)})}{Q_{WWTS}}$$

- For no changes in future versus present Station pond flow rates (other than FGD and WWTS operations), $Q_{TP(P)} = Q_{TP(F)}$.

Therefore,

$$K_{Max-WWTS} < \frac{K_{Max-TP} \times Q_{FGD}}{Q_{WWTS}}$$

- It is required that:

$$K_{Guaranteed-WWTS} < K_{Max-WWTS}$$

An important aspect of the "no net mass increase" equation should be noted. The calculation allows for using present and future Station pond flow rates (Station pond concentrations and flow rates are considered at a location upstream of the FGD withdrawal and WWTS treated effluent discharge locations). This potentially allows for credit to be taken for the difference between present and future mass discharges, even with pond concentrations considered to be constant.

- A similar equation, expressing the allowable future maximum weir concentration, for no net mass increase, is the following (Column 8.5):

$$K_{MaxWeir(F)}\left(Q_{TP(F)} - Q_{FGD} + Q_{WWTS}\right) < \left(K_{Weir(P)} \times Q_{TP(P)}\right)$$

$$K_{MaxWeir(F)} < \frac{K_{Weir(P)} \times Q_{TP(P)}}{\left(Q_{TP(F)} - Q_{FGD} + Q_{WWTS}\right)}$$

At present time : $K_{Weir(P)} \equiv K_{Max-TP-Measured}$

4.3 Nomenclature:

$K_{Max-WWTS}$ =	maximum allowable WWTS discharge concentration for no net mass increase (mg/l)
K_{Max-TP} =	maximum treatment pond concentration for 6 reported values (mg/l)
$K_{Weir-Allowable}$ =	Allowable concentration at weir per NHDES calculation for "reasonable potential".
Q_{FGD} =	FGD withdrawal flow rate (gpm)
$Q_{TP(P)}$ =	current treatment pond discharge flow rate (gpm)
$Q_{TP(F)}$ =	future treatment pond discharge flow rate (gpm)
Q_{WWTS} =	WWTS effluent flow rate (gpm)
$K_{Guaranteed-WWTS}$ =	guaranteed FGD WWTS discharge concentration (mg/l)
$K_{River-Calc-future}$ =	calculated future combined river concentration (mg/l)
M =	3.8 multiplier for 6 data samples (non-dimensional)
K_{River} =	measured river upstream concentration (mg/l)
$K_{RiverDown}$ =	calculated river downstream concentration (mg/l)
$Q_{River7Q10}$ =	7Q10 river discharge flow rate (gpm)

$K_{Assimilative-Capacity}$ = Maximum Allowable Downstream River Concentration (mg/l)

WQC = Water Quality Criteria for Toxic Substances (Table 1703.1 from State of New Hampshire Surface Water Quality Regulations Chapter 1700, December 10, 1999) (mg/l)

5.0 RESULTS

5.1 Summary

The following chemical species satisfy the assimilative capacity criteria (no reasonable potential):

CHEMICAL SPECIES	ASSIMILATIVE CAPACITY
Antimony	√
Arsenic (Aquatic)	√
Beryllium	√
Cadmium	√
Chromium III	√
Lead	√
Manganese	√
Mercury	√
Nickel	√
Selenium	√
Silver	√
Thallium	√
Zinc	√
Chlorides	√
Ammonia (as N)	√
Nitrates (as N)	√

The following chemical species satisfy the no net mass increase criteria:

CHEMICAL SPECIES	NO NET MASS INCREASE
Aluminum	√
Arsenic (Human)	√
Arsenic (Aquatic)	√
Copper	√
Iron	√
Zinc	√

5.2 Discussion

Three chemical species warrant discussion:

5.2.1 Mercury

Even though the river assimilative capacity requirement for mercury has been demonstrated to be satisfied, PSNH plans to add additional treatment to the physical-chemical system, to further decrease the mercury concentration in the WWTS effluent, in order to achieve no net mass increase in mercury discharge. This goal has been established because of impairment with regard to reported concentrations of mercury in fish tissue. The purpose of additional treatment would be to achieve a reduction in the mercury concentration to a value significantly below the physical-chemical WWTS guaranteed value of 1.0 µg/l. Calculations show that a value less than 0.130 µg/l would meet the requirement of no net mass increase. PSNH is in the process of preparing a competitive Request for Proposal to obtain this additional treatment technology.

5.2.2 Selenium

Earlier calculations had indicated that the expected effluent of the physical-chemical system would not result in exceedance of the river assimilative capacity requirement. In fact, using the latest data, the NHDES calculation method demonstrates that there is not "reasonable potential" for selenium concentrations in the Station discharge to exceed the future allowable concentration, based on river assimilative capacity. It is anticipated that the treatment pond discharge weir selenium concentration will be below the 0.057 mg/l required to meet the assimilative capacity requirement. Therefore, as recommended earlier, discharge selenium concentrations should be subject to a "monitor and report" approach.

It should be noted that the selenium concentration in the treated physical-chemical WWTS effluent is expected to be considerably below the contracted guarantee concentration of 9 mg/l. This is because URS has usually calculated the FGD wastewater selenium concentrations conservatively, using worst case partitioning data from EPRI and using maximum selenium concentrations from all candidate coals. In addition, WWTS vendors guarantee a relatively small percent decrease in selenium concentrations, because the wastewater is not available for bench testing at the time of system design. As a result, the relative concentrations of elemental selenium (non-dissolved) and of selenite and selenate (the two major forms of dissolved selenium), are not known in advance. The concentrations in the treated FGD wastewater effluent have generally been much lower than the values estimated prior to system startup.

5.2.3 Arsenic

Two water quality criteria have been considered for arsenic: 1) Aquatic Fresh Chronic (0.15 mg/l) and 2) Human Health-Water and Fish Ingestion (0.000018 mg/l).

The assimilative capacity requirement for arsenic is met by a large margin, for the Aquatic Fresh Chronic Criteria. However, the river is impaired with regard to the Human Health criteria, which sets a very low target concentration (18 parts per trillion). If the Human Health criteria is to be met, the "no net mass increase" approach would be required. It is anticipated that the treatment pond discharge weir arsenic concentration will be below the 0.00227 mg/l value required to meet the no net mass increase requirement.

6.0 CONCLUSIONS

1) All chemical species meet one or both of the criteria, "assimilative capacity" (NHDES/EPA "reasonable potential" criteria) or "no net mass increase."
2) PSNH plans to attain additional mercury reductions, beyond the guarantees of the currently contracted physical-chemical system, in order to achieve "no net mass increase," even though the assimilative capacity criteria is satisfied.
3) Calculations using measured river and pond concentrations indicate that there is not a "reasonable potential" to exceed the allowable water quality concentrations for selenium. Also, historical data indicates that selenium concentrations are expected to be significantly below the guaranteed value of 9.0 mg.l. Therefore, it is recommended that a "monitor and report" approach be applied to selenium.
4) If the Aquatic Fresh Chronic criteria for arsenic is applied, the assimilative capacity requirement is satisfied. If the Human Health-Water and Fish Ingestion limit is imposed, the no net mass increase criteria must be used. Based on pond concentrations and anticipated WWTS performance, it is expected that this criteria will be met.