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Mr. Jeffrey Pantazes
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Environment

Subject:
Quarterly Remedial Action Progress Report, Third Quarter 2011
PSEG Nuclear, LLC, Salem Generating Station

Date:
February 23, 2012

Contact:
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Our ref:
NP000571.SW11.00004

Dear Mr. Pantazes:

ARCADIS U.S., Inc. (ARCADIS) has prepared this Quarterly Remedial Action Progress Report (RAPR) summarizing the groundwater remediation activities performed during the Third Quarter of 2011 at the PSEG Nuclear, LLC, Salem Generating Station (Station) as a component of the Site-wide Integrated Tritium Management Program (ITMP). The Site is located on Artificial Island in Hancock's Bridge, Salem County, New Jersey. Salem Unit 1 occupies the southernmost portion of this multi-reactor Site. Salem groundwater remediation activities are being conducted to address tritium detected in shallow groundwater adjacent to and south of the Salem Unit 1 Reactor Containment and Fuel Handling Building. The Site plan is depicted on **Figure 1**.

The source of the release of tritium contaminated water to the environment was remedied in February 2003 when the Salem Unit 1 telltale drains were cleared and the Spent Fuel Pool (SFP) water that had accumulated behind the liner was drained. Routine maintenance of the SFP telltale drains has prevented a reoccurrence of the standing water condition responsible for the initial release and has precluded further flow restrictions in those drains. The installed seismic gap drains continue to provide a hydraulic gradient into the building and to the waste management systems, and away from the environment. The Groundwater Recovery System (GRS) continues to control the flow of shallow groundwater outside the cofferdam in the shallow unconsolidated zone maintaining the plume to the on-site area while removing the remaining tritiated groundwater.

The monitoring program provides data to support the adaptive management program and analyze the efficiency of the program. Plant related gamma-emitting radioisotopes have not been detected and tritium concentrations have generally continued to decline in groundwater samples, indicating that current activities meet the objectives of the program as provided in the Remedial Action Work Plan (RAWP).

As of December 2010, the present estimate of tritium left in the plume, where it exists above the New Jersey Department of Environmental Protection (NJDEP) Ground Water Quality Criteria (NJGWQC), is less than 1 Curie (Ci) of tritium (approximately 0.72 Ci). Calculated annually, the estimate is based upon the concentrations in wells (past and present) modified by estimates of: the amount of tritium drawn back through the seismic gap by gap draining activities, the actual degree of variability in the tritium concentrations of the groundwater, and the amount of mass held in dead end pore space. Further complicating the estimate is the fact that the existing monitoring network was designed to monitor a much more extensive plume; therefore the great reductions in plume mass achieved to date has resulted in the present situation where only a few wells indicate concentrations above the NJGWQC.

The following sections present the background of environmental investigation and remedial action at the Site, the details and results of activities conducted since the submittal of the Second Quarter 2011 RAPR, and provide a discussion of upcoming activities projected for the next reporting period.

Project Background

The remedial is based upon the 2004, Remedial Investigation Report (RIR) submitted to the New Jersey Department of Environmental Protection Bureau of Nuclear Engineering (NJDEP-BNE). This report presented results of the groundwater investigation performed in response to the discovery of tritium in groundwater adjacent to Salem Unit 1 resulting from a release from the Spent Fuel Pool.

The remedial action strategy was developed to hydraulically control and recover tritium remaining in groundwater adjacent to Salem Unit 1. Following the implementation of a successful pilot study, a full scale system was activated in early 2005 following NJDEP-BNE approval of the RAWP in November 2004. As an additional protective measure, weekly draining of the Unit 1 seismic gap was initiated

In April 2005. A drain for the Unit 2 seismic gap was subsequently installed. This ensures control of water present in the seismic gap through continuous draining through both the Unit 1 and Unit 2 seismic gap drains.

Continued Groundwater Monitoring

Groundwater monitoring has continued in accordance with the schedule provided to NJDEP-BNE. The sampling program was developed to provide the best reasonable understanding of plume distribution and containment. The monitoring program has been supplemented with other wells outside the area of the plume to help provide an understanding of the presence of tritium in groundwater throughout the Site.

Groundwater samples are collected by Maplewood Testing Services personnel, submitted to Salem Chemistry for preliminary tritium analysis and gamma emitter screening, and then sent to an external lab for more refined evaluation yielding lower detection limits.

Analytical data indicate that plant related gamma-emitting radioisotopes have not been detected in groundwater from any monitoring well since monitoring was initiated in 2003.

Recent analytical tritium results for groundwater collected from the Station monitoring wells are presented on **Figure 2**, which includes: panel 1) the extent of tritium in groundwater at the completion of the remedial investigation (Baseline Plume); panel 2) the extent of tritium in groundwater one year prior to the reporting period (September 2010); and, panel 3) the extent of tritium in groundwater in September 2011. **Figure 2** shows that the mass of tritium in groundwater is comparable to previous submittals, and although the rate of change will decrease over time, the comparability is prompting an investigation of the effectiveness of the groundwater recovery system (GRS).

The following sections present the groundwater analytical results based on the water-bearing zone from which they are collected. The three primary water-bearing units investigated beneath the Station are: 1) the Vincentown Formation; 2) the shallow water-bearing unit within the limits of the cofferdam surrounding Salem Unit 1; and, 3) the shallow, water-bearing unit outside the limits of the cofferdam.

Tritium Analytical Results for the Vincentown Formation

Six monitoring wells are screened in the Vincentown Formation. Groundwater quality for Well K, Well L, Well P and Well Q is currently monitored on a semiannual basis, Well V is currently monitored quarterly and Well CB is typically monitored on a monthly basis.

Tritium has consistently not been detected above Station laboratory detection limits or detected at relatively low levels in groundwater at all monitoring wells screened within the Vincentown formation since the initiation of monitoring at these locations, with the recent exception of Well CB. As previously discussed, concentrations of tritium increased at Well CB following the March/April 2008 outage, during which the steam generators in Unit 2 were replaced. Well CB was damaged during these activities and was repaired in mid 2010. Tritium concentrations in Well CB continue to fluctuate and PSEG will continue to monitor the analytical results collected from Well CB on a monthly basis.

The groundwater monitoring results continue to indicate that the previous release of tritium impacted water from the SFP has not significantly migrated below the shallow water-bearing unit.

Tritium Analytical Results for Wells Installed Within the Limits of the Cofferdam

The following wells are screened in the shallow, water-bearing unit within the limits of the cofferdam: Well M, Well N, Well O, Well R, Well AC, Well AE, Well AI, Well AM, Well AN, and Well AO. Groundwater quality for these wells is currently monitored on a monthly basis, with the exception of Well AO, which has been permanently tagged out. **Figure 2** shows tritium concentrations in monitoring wells surrounding Salem Unit 1.

As previously discussed, Well M had exhibited a long term decline until the end of March 2011 when an uncharacteristic detection above the NJDEP Groundwater Quality Criterion (GWQC) for Class IIA aquifers (20,000 pCi/L) occurred. Tritium concentrations remained elevated in this well throughout the second quarter of 2011. Although remaining slightly above 20,000 pCi/L, subsequent analytical results show a significant decline in tritium concentrations in Well M during the third quarter of 2011. Nearby Well AI exhibits an overall decreasing trend since July 2010, however during this reporting period, concentrations in Well AI slightly increased in July

2011(6,910 pCi/L) when compared with the previous month, June 2011 (6,400 pCi/L). PSEG will continue to monitor Well AI in conjunction with Well M.

During the third quarter of 2011, tritium concentrations observed in Well AE and AM continued a decreasing trend, remaining below 20,000 pCi/L. Nearby Wells O and AN exhibit an overall decreasing trend since January 2011, however concentrations in Well O slightly increased in July 2011(9,460 pCi/L) when compared with the previous month, June 2011 (4,130 pCi/L). Similarly, concentrations in Well AN increased in September 2011 (11,600 pCi/L) when compared with the previous data point which was collected in May 2011 (2,440 pCi/L).

Tritium concentrations in Well R, Well N and Well AC continue to fluctuate and demonstrated a slightly increasing trend during this reporting period. September 2011 concentrations from these three wells were below 20,000 pCi/L and are comparable to historical results revealing no increasing or decreasing trend.

In general, tritium concentrations in the cofferdam wells exhibit general decreasing trends since the initiation of remediation and will continued to be monitored on a monthly basis.

Tritium Analytical Results for Wells Installed Outside the Limits of the Cofferdam

The wells installed in the shallow, water-bearing unit beyond the limits of the cofferdam include Well S, Well T, Well U, Well W, Well Y, Well Z, Well AA, Well AB, Well AD, Well AF, Well AG (Shallow and Deep), Well AH (Shallow and Deep), Well AJ, Well AL, Well AP, Well AQ, Well AR, Well AS, Well AT (**Figure 2**), and Well CA (**Figure 3**). These wells are screened either just above the clay confining unit that separates the shallow water-bearing unit from the Vincentown Formation, or in the interval indicating the highest tritium concentrations found in the shallow water-bearing unit at each boring location at the time of the Supplemental Investigation completed in August 2003. Five of these wells (Well T, Well U, Well Y, Well Z and Well AL) are monitored under the Radiological Groundwater Protection Program (RGPP). Additional data for these wells can be found in the Annual Radiological Environmental Operating Report.

Elevated tritium concentrations were observed in samples collected from certain monitoring wells in July/August 2011 due to accelerated precipitation recapture due to the number and magnitude of rain events. Well AA, Well AC, Well AG-D, Well AG-S, Well AH-D, Well AH-S, Well AL, Well AP, Well O, Well S, Well Y, and Well Z

displayed increased concentrations of tritium, some above administrative limits, which initiated an investigation (Attachment 1). Evaluation of the subsequent data points (September and October 2011) indicate that tritium concentrations are consistent with concentrations observed prior to August 31, 2011.

As presented on Figure 2, tritium concentration trends for wells screened in the shallow, water-bearing unit, beyond the limits of the cofferdam, are observed to be generally stable with the exception of the July/August 2011 event described above and Well AR, which demonstrates a decreasing trend.

Groundwater Extraction

Groundwater extraction was selected as the remedial strategy for the plume. As stated above, operation of the full scale system was initiated in 2005. The system is routinely inspected and serviced to ensure continued operation in support of the remedial action objectives.

Full-Scale System

The objectives of the full-scale GRS consist of:

- Maintaining hydraulic containment of the tritium plume; and
- Reducing tritium concentrations in groundwater.

The present operation of the GRS consists of groundwater extraction from Wells S, AB, AD, AJ, AN, AO, AS, and AT. Groundwater extracted from the wells is processed in accordance with the Station's United States Nuclear Regulatory Commission (USNRC) license and plant procedures. Details of the extracted effluent are discussed below.

The operation of the pumping wells varies from month to month based on pumping yields and pump function. The GRS system is inspected periodically to ensure appropriate system service to maximize system operation and efficiency. As discussed above, Figure 2 shows that the mass of tritium in groundwater is comparable to previous submittals, prompting an investigation of the effectiveness of the groundwater recovery system (GRS). PSEG will begin this investigation in the 4th quarter of 2011 and expects that with the continued effective operation of the GRS, tritium concentrations in groundwater will continue to decrease.

Mobile Groundwater Recovery Unit

The mobile groundwater recovery unit was designed to recover groundwater from specific areas of the plume as needs arise. The mobile unit is presently out of service. Repairs are needed prior to reactivation of the unit. Required maintenance will be performed to make the unit operable if required in the 1st quarter of 2012.

Total System Effluent Data and Evaluation

GRS operations were initiated on February 16, 2005. The GRS discharges continuously in accordance with the Station's USNRC license. As of September 2011, the GRS has recovered nearly 28 million gallons of groundwater averaging an estimate of 0.38 gallons per minute throughout the third quarter.

Water-Level Data and Evaluation

Water level measurements from the extraction and select observation wells have been monitored to confirm hydraulic containment of the tritium groundwater plume. Water levels are periodically collected by MTS and ARCADIS personnel and are evaluated to provide insight into groundwater flow patterns at the Site.

Cumulative Curies Removed

The various groundwater recovery activities conducted to date have been successful in controlling the plume and recovering tritium from groundwater at and downgradient of the Salem Unit 1 seismic gap.

Figure 4 summarizes the results of groundwater remediation activities conducted using the well field, including both the pilot study and the permanent system. As shown on **Figure 4,** approximately 3.3 curies of tritium have been recovered from the operation of the GRS through September 2011. Approximately 1 curie (0.93 curies) of tritium was removed by the pilot system. Therefore a total of 4.3 curies of tritium have been recovered from the operation of the GRS through September 2011. The effectiveness of the GRS is emphasized by the decrease and stabilization of system effluent concentrations since the activation of the full scale system in February 2005. System effluent concentrations averaged 27,825 pCi/L during the third quarter of 2011. This indicates that the GRS has been successful at decreasing tritium concentrations in groundwater as discharge concentrations are roughly 25% of the peak concentration (109,000 pCi/L) observed in March 2005. It is noted that as the

mass remaining in the plume decreases so will the rate of tritium recovery by the GRS based on the concentrations recovered.

Operation of the Seismic Gap Drain

As stated above the seismic gap drains in Salem Unit 1 and Unit 2 are being used to continuously drain the water from the gaps to provide control over water present within the gaps. This permits recovery of additional tritium concentrations over that which is recovered by the GRS system.

Water samples from the seismic gap drains are periodically collected for tritium analysis. **Figure 5** summarizes the results of periodic tritium analysis from the Unit 1 seismic gap. A comparison of **Figure 2** and **Figure 5** indicates that concentrations of tritium in water recovered in the Unit 1 seismic gap have been consistently higher than those detected in groundwater samples collected from Well AC and Well AM located to the southeast and southwest of the seismic gap, respectively. Thus, continuous operation of the Unit 1 seismic gap drain is effectively removing SFP water in the seismic gap. Tritium concentrations in water presently being removed from the gap are close to the concentrations present in the pool, indicating that the continuous draining program has been successful in establishing a more direct flow path between the seismic gap drain and any SFP water.

Continuous draining (resulting in a hydraulic head less than that which is present in the geologic materials present outside the seismic gap) provides a positive assurance that the engineering control established by the seismic gap drain is effective at capturing any SFP water that enters the gap. The gap drain creates an inward gradient such that groundwater flows into the seismic gap limiting the potential for a discharge to the environment from the gap.

Monitoring of water drained from the Unit 2 seismic gap acts as a screen for a potential release from the Unit 2 SFP. Water collected in the Unit 2 seismic gap drain indicate tritium levels several orders of magnitude below the Unit 1 seismic gap drain concentration, and consistent with the trends in the Unit 1 seismic gap drain.

Water samples will continue to be obtained from the Unit 1 and Unit 2 seismic gap drain to evaluate the potential for the release of radioisotopes to the environment.

Upcoming Activities

Activities projected for the 4th Quarter 2011 include the following:

- Continue to monitor continuous draining of seismic gap drains;
- Evaluate GRS operation to determine if well operation should be modified;
- Continue to measure groundwater levels and evaluate flow and plume containment;
- Continued groundwater sampling and analysis; and
- Continued operation and evaluation of the GRS performance.

If you have any questions or comments regarding the contents of this report, please do not hesitate to contact me at (609) 860-0590, extension 248.

Sincerely,

ARCADIS U.S., Inc.

John H. Balletto
Principal Scientist/Vice President

Attachments:
Tritium Recapture Evaluation, February 2012

Copies:
Peter Milionis - ARCADIS
Kate Kenny - ARCADIS

ARCADIS

Figures

LEGEND:

WELL R ■ MONITORING WELL SCREENED IN THE ENGINEERED FILL WITHIN THE COFFERDAM, 20 FEET DEEP (WELLS M, N, O, R)

WELL S ⊗ MONITORING WELL SCREENED IN THE SHALLOW, WATER TABLE AQUIFER OUTSIDE THE COFFERDAM, 35 FEET DEEP (WELLS S, T, U, W)

WELL L ◎ MONITORING WELL SCREENED IN THE VINCENTOWN FORMATION, 80 FEET DEEP (WELLS K, L, P, Q, V.)

WELL BD ◬ RGPP WELL

⊕ MONITORING WELL LOCATIONS

◬ PRODUCTION WELL LOCATIONS

▣ CATCH BASIN

⊗ MANHOLE (STORM SEWER)

——— PROPERTY BOUNDARY

NOTES:

1. THE MEAN TIDE LEVEL OF THE DELAWARE RIVER AT ARTIFICIAL ISLAND IS 0.11 FT (NAVD88)
2. WELL BF, WELL BG AND WELL BU LOCATED ON HOPE CREEK GENERATING STATION PROPERTY BUT ASSOCIATED WITH SALEM UNIT II INVESTIGATION.

DELAWARE RIVER

WELL BP
OW-1
WELL BL
HC-1
WELL BO
WELL BK
WELL BH
WELL BR
WELL BN
WELL BI
WELL BM
WELL BQ
WELL BG
WELL BJ
WELL L
WELL BC
WELL BE
WELL BF
WELL Y
WELL Z
WELL BD
WELL W
WELL AC-S/D
WELL AP
WELL AQ
WELL AJ
WELL AA
WELL AH-S/D
WELL AK
WELL M
WELL DB
PW-6
WELL U
WELL BB
WELL AT
WELL AD
WELL DD
OW-6
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WELL DE
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WELL AL
WELL DH
WELL CB
WELL CA
PW-2
WELL AE
WELL DI
WELL BA
WELL P
HC-2
WELL BT
WELL BU
PW-3
WELL Q

HOPE CREEK GENERATION STATION
SALEM GENERATION STATION

0 150 300 475
SCALE: 1"=150'

PSEG NUCLEAR, LLC, SALEM GENERATING STATION,
ARTIFICIAL ISLAND, HANCOCK'S BRIDGE, NEW JERSEY
REMEDIAL ACTION PROGRESS REPORT

WELL LOCATIONS

ARCADIS

FIGURE 1

CITY: Newtown, Pa DIV/GROUP: ENV DB: M. Wasilewski LD: M. Wasilewski PIC:(Opt) PM:(Reqd) TM:(Opt) LYR:(Opt)ON=*;OFF=*REF*
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ewtownCT
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ARCADIS Color Logo.JPG

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THAT CAN BE VIEWED AT THE RECORD TITLED:

"WELLS BEYOND THE PLUME AREA", FIGURE 2

WITHIN THIS PACKAGE

D-01

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THAT CAN BE VIEWED AT THE RECORD TITLED:

"WELLS BEYOND THE PLUME AREA", FIGURE 3

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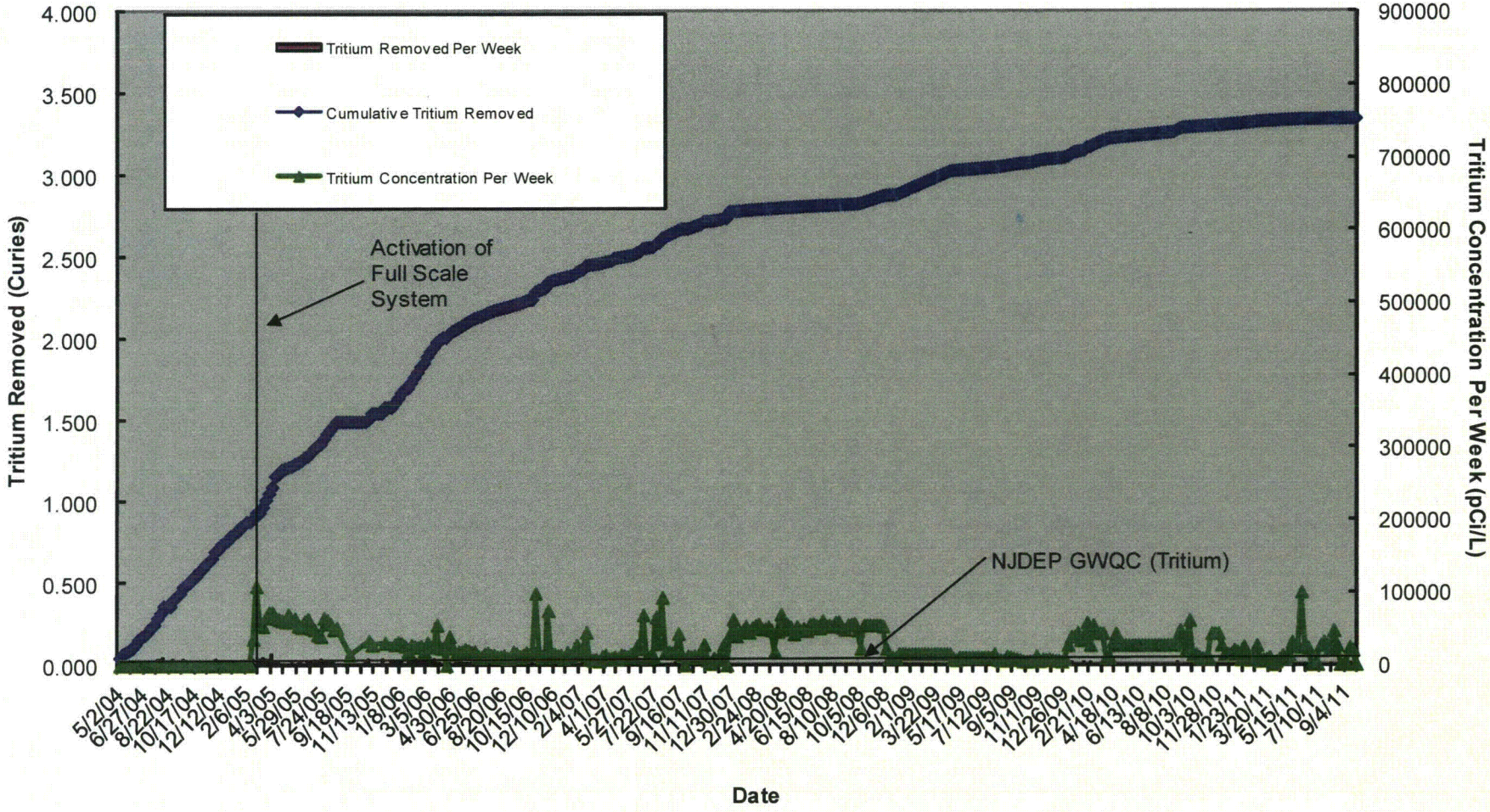
D-02

PSEG Nuclear, LLC Salem Generating Station - Unit 1
Tritium Recovered Through Well Field Operation



Path\Name: G:\ENVCAD\Newtown\ACT\NP000571\SW11\00007\DWG\Q3\FIG-04 HISTORIC TRITIUM RECOVERED THROUGH WELL FIELD OPERATION_Final.dwg
Plot Date\Time: 1/17/2012 4:54 PM Current Plotstyle: ---- Page Set Up Name: ----
Acad Version: 17.1s (LMS Tech) User Name: Wosilewski, Matt

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Project Director	P. MILIONIS
Task Manager	C. SHARPE
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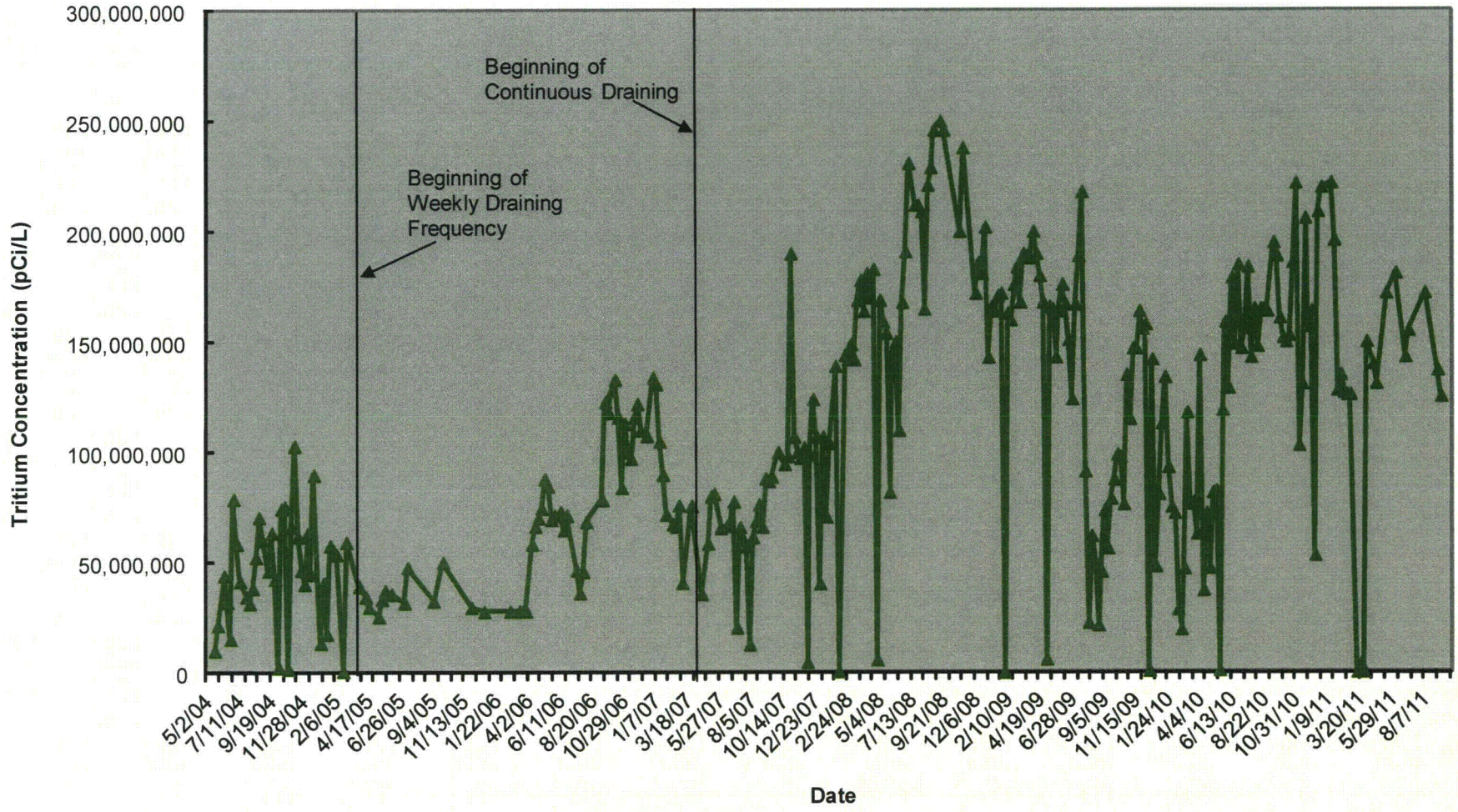
PSEG NUCLEAR, LLC
SALEM GENERATING STATION

HISTORIC TRITIUM RECOVERED THROUGH WELL FIELD OPERATION

HANCOCK'S BRIDGE, NEW JERSEY

Project Number	NP000571.SW11
Drawing Date	17 JANUARY, 2012
Figure	4

PSEG Nuclear, LLC Salem Generating Station - Unit 1
Concentrations of Tritium in Water Recovered Through Seismic Gap Drain Operation



Area Manager	R. GAN
Project Director	P. MILIONIS
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PSEG NUCLEAR, LLC
SALEM GENERATING STATION

HISTORIC TRITIUMCONCENTRATIONS OBSERVED DURING SEISMIC GAP DRAIN OPERATION

HANCOCK'S BRIDGE, NEW JERSEY

Project Number	NP000571.SW11
Drawing Date	17 JANUARY, 2012
Figure	5

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Attachments

Attachment 1
Tritium Recapture Evaluation, February 2012

From July through late August 2011, tritium was detected at a increased concentration in Wells AA, AC, AG-D, AG-S, AH-D, AH-S, AL, AP, O, S, Y, and Z. Some of these concentrations exceeded the administrative limits and initiated an investigation. A series of hypotheses were developed and investigated. After review of relevant available data and information, the hypotheses were classified. The following table describes the hypotheses considered.

Hypothesis	Mechanisms
Most Probable Sources	
Accelerated precipitation recapture due to number and magnitude of rain events	Concentration of tritium accumulating in soil pore space and being liberated through precipitation events
Historical Releases	Hydraulic control of existing plume is degrading due to either GRS system performance issues or increased recharge
Spent fuel pool plume and / or cofferdam was flushed by hurricane recharge or August/September excessive precipitation	Combination of the above
Unlikely Sources	A new, unidentified leak [the wide area of distribution of higher results indicates that a single leak is unlikely]
Lab issues [considered unlikely due to some non-detect results]	Earthquake induced groundwater movement [deemed not likely by hydrogeologists]
Equipment leakage	Areal extent required multiple simultaneous leaks

Based on the above, the most likely cause of the increased tritium concentrations was the result of the accelerated precipitation recapture due to the number and magnitude of rain events.

During July 8, 2011, over a five hour period (1300-1800 hrs) 1.78 in of rainfall was measured (Figure 1). In August 2011, approximately 14.5 inches of precipitation accumulated at Artificial Island. Normal August mean monthly precipitation (as recorded from 1895 through2011; http://climate.rutgers.edu/stateclim_v1/data/njhistprecip.html) is 4.5 inches. During a 36-hour period from August 13 to August 14, 2011, approximately 6.9-inches of rain accumulated. Also, Hurricane Irene passed over Artificial Island from August 27 to August 28, 2011 and during a 36-hour period approximately 5.3-inches of rain accumulated.

The nuclear industry has detected tritium in water vapor and rainwater around plants coincident with permitted gaseous releases of tritium. Through a number of evaluations the industry has identified that permitted gaseous releases of tritium can be recaptured from the atmosphere as water vapor and precipitation downwind (EPRI 2009). The potential pathways followed by tritium at the site are presented in Figure 2.

Based on observed tritium exchange between atmospheric water vapor and liquid water (EPRI 2009), it appears that tritium was exchanged from the atmosphere into the liquid water in the vadose zone (Figure 3). During average precipitation accumulation timeframes, this rain water with elevated tritium concentrations would flow slowly down into the groundwater. During the abnormally high precipitation accumulation during August 2011, the rain water with elevated tritium concentrations was flushed from the vadose zone and flowed rapidly through shallow groundwater and was detected in the Riverbed Deposits monitored by the RGPP wells. Subsequent sampling events detected tritium at a historical concentration range indicating tritium concentrations have equilibrated in the subsurface.

Figure 1. Daily Precipitation for August 2011

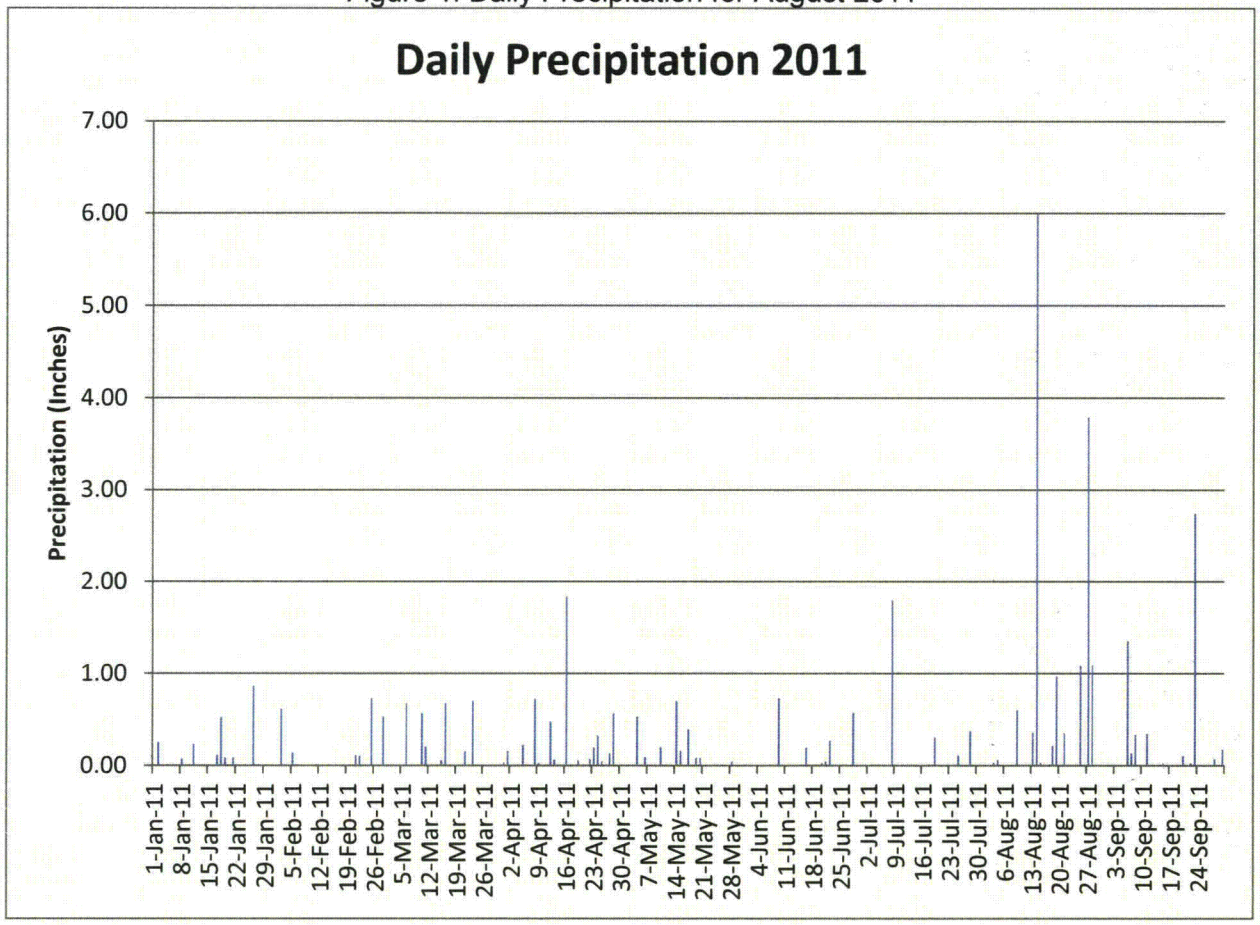


Figure 2. Conceptual Model of Tritium Pathways

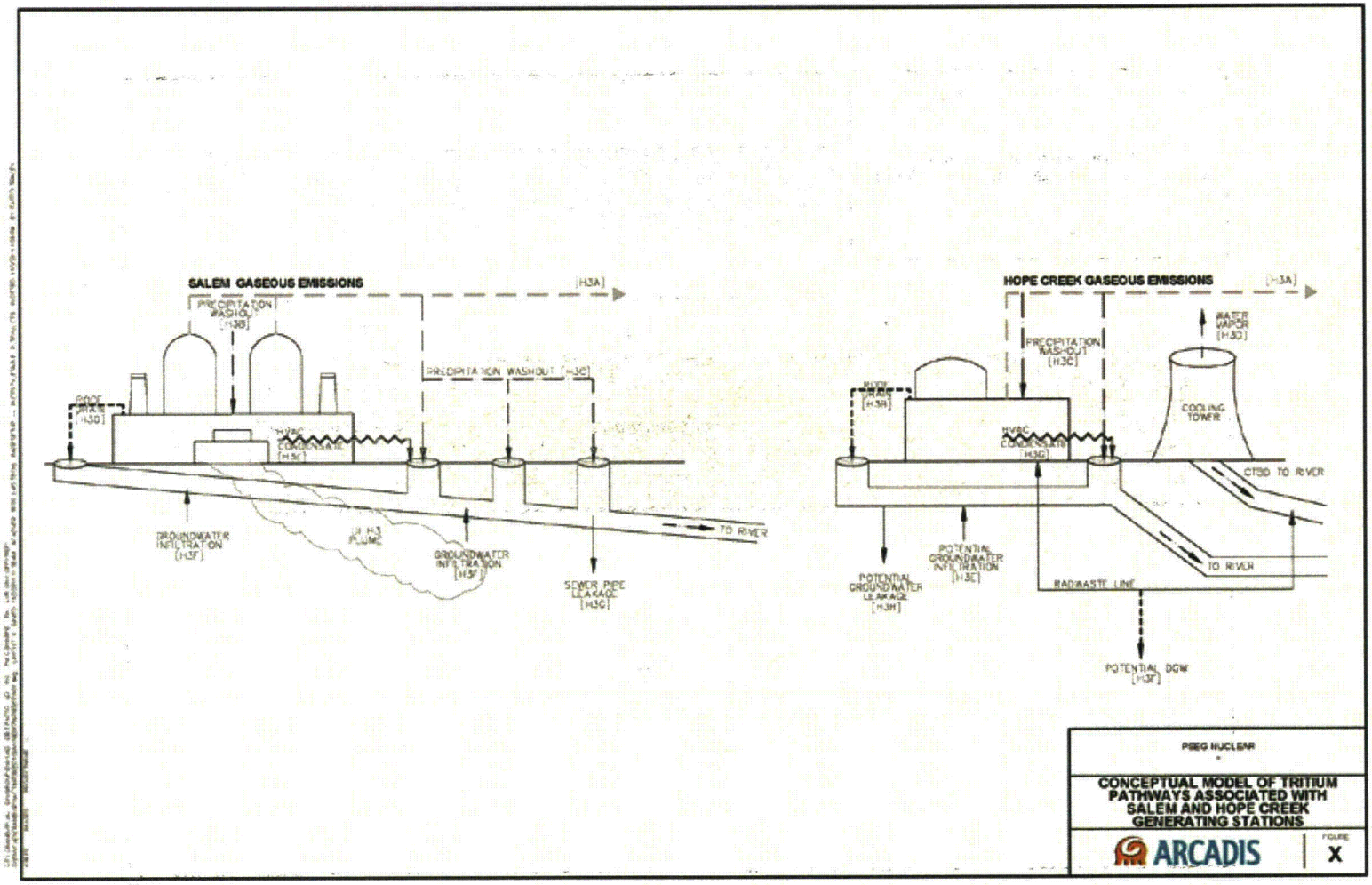
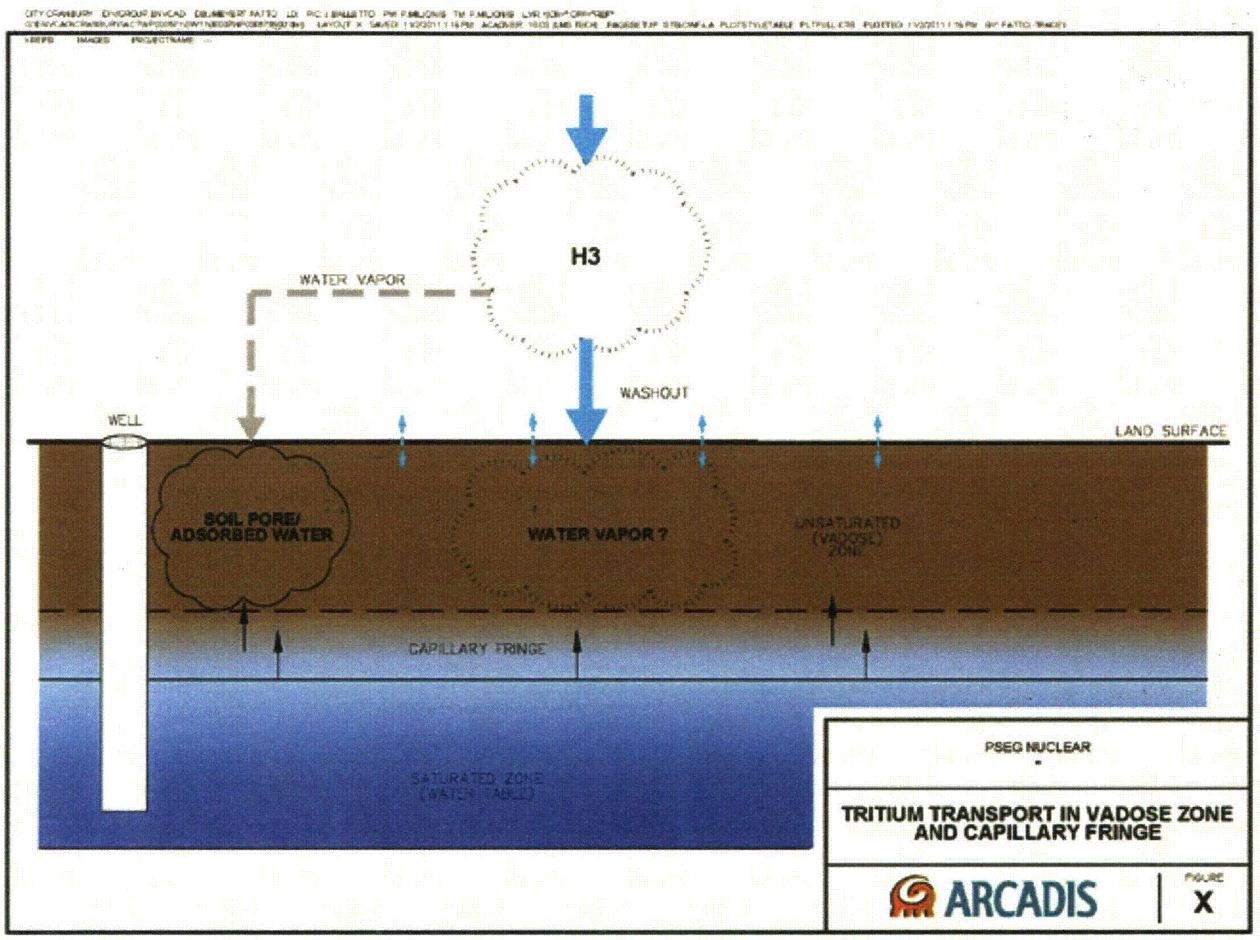


Figure 3. Tritium Transport in Vadose Zone and Capillary Fringe



REFERENCES

Electric Power Research Institute (EPRI). 2009. Review of Methods and Tools for Estimating Atmospheric Deposition of Tritium at Nuclear Power Plants. Report No. 1019226.Palo Alto, CA: 2009.