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REVIEW OF FILES CONTAINING RADIOLOGICAL INFORMATION FOR NORTHROP GRUMMAN BETHPAGE, NY OPERATIONS

September 28, 2016

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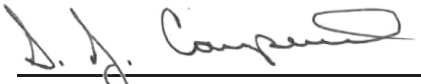

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1 INTRODUCTION

I understand that there have been assertions that radioactive materials used at the Northrop Grumman Bethpage, New York facility (Site) could be associated with detections of low levels of Radium-226 and Radium-228 in groundwater in the vicinity of the Site. I was asked to review certain Northrop Grumman Systems Corporation (NG) records dating roughly from the 1960s through 2015 and report on what radioactive materials were used at the Site; to evaluate whether the documents reflect proper use, handling and disposal of such materials; and to evaluate whether there is any possible relationship between such materials and the Radium-226 and Radium-228 detected in groundwater.

Following the Company's record search, I was provided with and reviewed nine storage boxes of documents in the Manhattan office of NG outside counsel Sive, Paget & Riesel, P.C. (SPR) during September 7th and 8th, 2016, and subsequently reviewed further documents provided to me by SPR. The documents were selected for my review because they contain information relating to the use of radiological materials at the Site in connection with the operations of NG and its predecessors, Grumman Aircraft Engineering Corporation and Grumman Aerospace Corporation (also referred to as NG herein). This report presents the findings of my review.

The records I reviewed indicate that radioactive materials were used for testing and research and development purposes, for making quality-assurance and quality-control oriented measurements of manufactured products at the Site. Radioactive materials were also contained in components that were present at the Site for installation in aircraft.[1] It is my opinion that the use, handling and disposal of radiological materials at the Site during the documented period were consistent with contemporaneous industry standards, and often performed at a level exceeding contemporaneous industry standards. The documents did not indicate that the radioactive materials used at the Site could be a source of the elevated Radium-226 and Radium-228 detected in the groundwater in the vicinity of the Site.

[1] Although NYSDEC did not specifically ask for a discussion of radioactive materials unrelated to NG's manufacturing operations, I note that, per the reviewed records, buildings onsite contained Pyr-A-Larm brand smoke detectors containing either of the radioisotopes Radium-226 and Americium-241. Smoke detectors used in homes and buildings today contain Americium-241.

2 DISCUSSION

Most of the records that I reviewed reported on-going employee monitoring and general radiological safety protocols. These documents were reviewed as to the monitoring approaches that were employed and the technical content of applicable manuals and work procedures. I found the monitoring to be consistent with contemporaneous industry-standard practices and found the radiological protection-oriented documents and manuals to be of superior quality. Critically, in my opinion, the continual emphasis on the fundamental radiological safety components of "Distance, Time, and Shielding," with the purpose of preventing adverse exposure of staff to radiation, documented that care was taken to develop a safe work environment, with work procedures and design that complied with applicable regulatory standards. Further, I found that protocols for handling radiological material exceeded the industry-standard practices of the relevant time periods. The records reviewed included inventories documenting the proper disposal of radioisotopes, including, significantly, an apparent complete accounting for uranium and thorium products (through virtually the same amounts arriving onsite and being subsequently disposed of offsite) that could theoretically decay into Radium-226 and Radium-228.

A detailed discussion of my findings is set forth below.

2.1 Evaluation as to Various Radiological Materials Used for Quality-Control and Research and Development-Related Testing

The records indicated the presence of the following radionuclides at the Site during various periods of time from the 1960s through 2015:

Fe-55, Zn-65, Sn-113, Y-88, Hg-203, Tc-99, Ni-63, Ir-192, Yb-169, Eu-152, Sr-90, Co-60, Ta-182, H-3, C-14, Am-241, Pm-147, Ba-133, Ra-226, Cr-51, Ba-140, Th-232, Ca-45, Cs-137, Po-210, Po-218, Bi-210, Kr-85, Th-230, Na-22, Mn-54, Co-57, Tl-204, Rh-106, Pb-210, Ca-252, S-35, U-238, U-235, U-234, Depleted Uranium, Enriched Uranium (apparent maximum U-235 was limited to 5%), Uranium hexafluoride [UF_6], Pu-238, Pu-239, Pu-241, Pu-244 (as a longer-lived decay product from Ca-252),Thorium nitrate, 2% Thorium Alloy Metal.

Many of these radionuclides were brought to the Site for materials testing purposes and were present at low levels of radioactivity. Specifically, many were apparently used in conjunction with non-destructive testing of plated metal thicknesses. The degree to which efforts were made to optimize both metal plating and the associated quality assurance and quality control processes to maximize the quality of aircraft and

components are consistent with the high level of attention devoted to worker safety and proper radionuclide management.

The reviewed records document disposal of radioactive materials in appropriate offsite facilities. While I did not undertake to trace full “cradle to grave” disposition for every radionuclide that arrived at the Site, the records do show that NG's use and disposal of radioactive materials were highly regulated, and that NG employed tracking protocols for the proper management and disposition of such materials. These protocols were consistent with or superior to contemporaneous industry-standard practices, and included good accounting for uranium, thorium, and other radionuclides.

The reviewed records report the presence of one Cobalt-60 [Co-60] sealed source in a gamma irradiator used at the Site. The records do not discuss the use of this instrument, but it was likely used for industrial radiography applications, possibly for quality assurance/quality control efforts for documenting weld integrity. This instrument is routinely used in radiography applications and can be safely employed by trained and monitored workers, as is done commonly across the United States and around the world. This instrument was brought to the facility on July 13, 1976 at a design activity of 7,000 Curies. Due to the 5.3-year half-life of Co-60, the instrument was returned to its vendor on October 28, 1992 for “reloading” with fresh Co-60 to reestablish the 7,000 Curie activity. The instrument was ultimately decommissioned by the vendor on October 21, 1998, with the vendor then taking possession of the Co-60 source.

Another radionuclide utilized in materials testing operations in relatively larger quantities was Tritium [H-3], a naturally-occurring and human-made radioactive form of hydrogen. This radioisotope was used in neutron generation in conjunction with metal thickness measurement testing. The records document that tens of Curies of Tritium were present and used onsite over the course of years, and that proper disposal practices were observed. I did not undertake to compare documentation of amounts used and disposed of on a record-for-record basis, but existing waste manifests document the disposal of Tritium at appropriate off-Site locations.

Records specifically state that waste Tritium was sequestered within concrete blocks that attenuated Tritium within hydrous cementitious phases, allowing safe offsite transportation, disposal, and subsequent decay. This is significant, in my opinion, in that it documents that NG was a leader in the innovative sequestration of Tritium into a non-leachable form before many in the industry understood the efficacy of this approach. I believe that this is illustrative of NG’s leadership in the handling of radioactive material in preparation for disposal.

The records note the testing and use of a radioisotope thermoelectric generator (RTG) powered by the use of Plutonium-238. Per subsequent communications with NG staff, this testing was apparently related to the use of Plutonium-238 to power the Apollo Lunar Surface Experiments Package (ALSEP). The ALSEP consisted of an array of scientific instruments that were deployed on the Moon during five different Apollo missions and which required electrical power. The Apollo missions used the RTG to supply this required power. The RTG employed the heat derived from alpha decay (a form of radiation with very low penetrating capacity) emanating from a "block" of material containing Plutonium-238 to produce the required electrical power. Plutonium-238 is now routinely used in spacecraft to electrically power instruments and on-board computers. The Plutonium-238 was in a discrete, contained form, with very limited potential for uncontrolled release.

There is no evidence that any of the radioisotopes listed above were not properly disposed of off-Site, and there is affirmative evidence that radiological material was disposed of appropriately in off-Site locations, including the following material:

Ni-63, Eu-152, Sr-90, Co-60, Y-88, Hg-203, Fe-55, Ta-182, H-3, C-14, Am-241, Pm-147, Tl-204, Rh-106, Po-218, Po-210, Bi-210, Ba-133, Ra-226, Cr-51, Ba-140, Th-232 (which also includes “Natural Thorium”), Ca-45, Cs-137, Kr-85, Tc-99, Th-230, Na-22, Mn-54, Co-57, Pb-210, Ca-252, S-35, U-238, U-235, U-234, Thorium nitrate, Thorium metal, Depleted Uranium, Enriched Uranium, and Uranium hexafluoride [UF_6], Pu-239, Pu-241, and Pu-244 (stemming from in-growth of Ca-252).

I did not identify any specific information indicating that the Pu-238 generated any waste requiring disposal; it is likely that no waste or other residuals would have been produced from operation of the RTG at the Site, and the Pu-238 power source would have been removed intact with the RTG upon completion of the power generation-related testing (for ultimate deployment on the Moon), obviating the need for disposal of any radioactive material.

Some radionuclides used at the facility were elements that decay so quickly (i.e., into non-radioactive isotopes) that the resultant material would not need to be disposed of as radioactive material. These radionuclides are as follows:

Zn-65 (half-life 245 days)

Sn-113 (half-life 115 days)

Ir-192 (half-life 73.83 days)

Yb-160 (half-life 32 days)

Importantly, NG staff undertook periodic re-calculations of the activity of many short half-life radioisotopes to estimate their then-current activity, and documented the need for "reloads," as was the case for the Co-60 irradiator as discussed above; they also documented the decay of other radioisotopes to below regulated activity levels.

2.2 Evaluation as to Radioactive Materials Used in Aircraft Components

Documents from the 1960s and 1970s show that Tritium and Promethium-147 were present at the Site within luminescent dials and switches used in aircraft. I noted, in particular, extensive documentation from the 1970's of a particular type of luminescent switch used in certain aircraft manufactured on Site, pursuant to U.S. Navy specifications requiring such luminescence. Critically, these switches were manufactured offsite by a third party (3M), with repair of any defective switches also performed offsite by a repair vendor (Microswitch). Ultimate disposal of the switches was the responsibility of the U.S. Navy once the switches were installed in the aircraft and the planes were delivered to the Navy for use. The documentation reflecting the purchasing of pre-manufactured switches is consistent with the recollections, relayed to me by SPR, of an engineer involved in quality-control testing for the aircraft in which luminescent dials and switches were installed. The engineer recalled that electronic components installed in aircraft at the Site were pre-produced by vendors and delivered to Bethpage.

I was positively impressed with the management protocols developed and implemented to track the use of Promethium-147-based luminescent switches, as reflected in the documents I reviewed. This systematic program carefully documented the receipt, initial and scheduled wipe testing, storage, and final disposition of the switches brought to the Site.

The documents reviewed indicate that Radium-226 was also present in luminescent dials for aircraft, and suggest that such use was phased out in the 1960s and 1970s, when it appears that tritium and Promethium-147 were used for the same purpose in larger quantities. These documents did not indicate that there was onsite fabrication of Radium-226 dials, for example, involving the physical process of painting radium-based luminescent paint directly onto dials. The absence of any discussion as to the radiological safety of direct handling of Radium-226 luminescent paints in dial manufacturing suggests that this fabrication was very likely conducted off-site by a vendor.

Again, based on the overall review of the records, I believe that NG had appropriate practices in place for radioactive materials management and disposal, and while I have not compared every quantity used to every quantity disposed, I have no reason to believe that any radioisotopes used in aircraft manufacturing were not responsibly removed from the Site, mostly in finished aircraft.

2.3 Evaluation of The Radiological Implications of Misplaced Alnor Dewpointers® Containing Radioisotopes

Radioisotopes were present in Alnor Dewpointer® devices (dew point detectors) used at the Site. The detectors contained a radioactive source that emitted alpha radiation that improved the measurement of the humidity of the air and calculation of the dew point. The radioisotope was contained in a foil rectangle measuring 0.5 inches by 0.625 inches within a measurement chamber of the device. Alnor manuals, obtained from their website, indicate that the metal foil consisted of layers of precious (and therefore largely chemically inert) metals including gold, silver, and platinum. The radioactive source was embedded within these precious metals layers that were then thermally sandwiched together, a process designed to eliminate release of radioactivity to the environment.

Reviewed documents reported that two Alnor detectors were reported to have been misplaced in 1974. One of these detectors was believed to have been placed into an offsite landfill or “scrapped”, and the other unaccounted for among the documents I reviewed. (In 1990, two other detectors were initially reported to have been misplaced, but they were apparently located later, as they were documented to have been sent to Alnor to be “desourced” (have the radium foil removed) in 1993 and 1994.)

The two detectors misplaced in 1974 reportedly each contained a 6.25 microCurie Radium-226 source. In the event of a hypothetical (and undocumented) onsite disposal of any of these instruments, the precious metal composition of the radium-bearing foil and the high degree of chemical inertness of the foil would greatly limit, if not preclude, the release of any radioactivity to the environment. Thus, the two misplaced detectors do not pose a human health risk as the radium would not be releasable to the groundwater as a consequence of it being encased in an insoluble precious metal foil.

2.4 Evaluation as to The Use of Uranium-Bearing Materials and Their Ultimate Disposition

The data files reported the use of approximately 109 pounds of depleted uranium at the Site prior to 1963-1964 for testing for the potential use of this very physically dense

material as ballast within aircraft. This was not an especially unusual test program; depleted uranium has been and is currently being used in the aviation industry as ballast in a variety of aircraft, including the 747 and various military cargo aircraft. Depleted uranium projectiles ("penetrators") are also used in military weapons, including fighter and attack aircraft ammunition.

My experience with depleted uranium use at other facilities is that the environmental challenge stems from the uncontrolled release of machine turnings and cuttings removed from the main depleted uranium billet or stock material. Importantly, quite unlike those facilities, documents revealed that NG developed a very thorough and comprehensive process for handling and storing depleted uranium, which addressed potential concerns as to uncontrolled release of small and more chemically active depleted uranium fragments. Further, records support the conclusion that the reported amount of uranium brought to the Site was properly disposed in an offsite licensed facility at the conclusion of the testing.

The reviewed records reflect that uranium-related work included two additional areas, other than the aforementioned use of depleted uranium for ballast-related research: (1) testing as to the enrichment of Uranium-235 for use in nuclear fuel applications and (2) testing as to the alloying of cobalt metal with depleted uranium metal in 1977. Consistent with the other records, there is evidence that these uranium materials were properly disposed offsite, no indication of inappropriate disposal or material loss, and no evidence as to the loss of any of the minor amounts of decay products that formed during the comparatively short duration that uranium was present in a controlled form onsite.

2.5 Evaluation as to Anecdotal Reports of a "Nuclear Reactor" At The Site.

Anecdotal rumors have reportedly suggested a "nuclear reactor" was present at the Bethpage facility and that it was then buried onsite.

The records were specifically searched for any information as to the presence of a nuclear reactor at the Site. No information was located that documented the presence of any nuclear reactor or information that was suggestive of its presence. The degree of detail found as to radiological protection protocols for the use of test radioactive reagents and neutron generators indicate that if a nuclear reactor were present, an extensive library of associated radiological safety documents would have been

maintained along with the records I reviewed. There is no evidence of the presence of such a reactor, much less its burial onsite.

3 CONCLUSIONS

The completed document review established the following findings:

1. In general, the use, handling and disposal of radiological materials at the Site during the documented period were consistent with contemporaneous industry standards, and often performed at a level exceeding contemporaneous industry standards.
2. The documents reviewed suggest no reason to believe that the use of certain radionuclides at the Site is connected with Radium-226 and Radium-228 detected in area groundwater.
3. Various small quantities of radionuclides were employed in test applications. Records indicate that at least some Tritium, which was used in larger quantities at the Site than the other radionuclides, was sequestered in concrete and disposed of offsite, which indicates that appropriate management and disposal protocols were in place. Cobalt-60 is documented to have been completely removed from the Site by October 1998.
4. Radium-226, Promethium-147, and Tritium were present at the Site within luminescent components of aircraft manufactured by NG. There is documentary evidence that many luminescent components arrived at the Site pre-manufactured by one or more vendors, as corroborated by the recollection of a NG employee, and there is no indication that any luminescent components were fabricated onsite.
5. Two Alnor Dewpointers containing 6.25 microCuries of Radium-226 each were reportedly misplaced, with one believed to have been “scrapped” in an offsite landfill. Regardless of the ultimate location of the remaining unaccounted-for device, embedment of the radioisotope in gold, silver, and platinum metal foil — metals that would be insoluble under natural surface conditions — precludes the adverse release of radioactivity to the environment.
6. The limited use of depleted uranium at the Site is consistent with industry-standard use of this dense metal, with extensive associated worker safety protocols and material handling developed to allow for safe use and ultimate off-site disposal.
7. No evidence of the presence (or burial) of a "nuclear reactor" on the Site was found.

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