Hunters Point Shipyard Cleanup Used Outdated and Grossly Non-Protective Cleanup Standards

source: Todd Lapin

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EXECUTIVE SUMMARY

In prior reports, we have disclosed that ~90% of sites at Hunters Point Shipyard (HPS) weren't sampled for radioactivity, and at the sites that were sampled, no measurements were made for ~90% of radionuclides used at HPS. Of the 10% of HPS that was sampled and the 10% of radionuclides that were measured, EPA and state regulators have determined that 90-97% of survey units showed evidence of falsification of data by Navy contractor Tetra Tech. In other words, a large fraction of the measurements taken by Tetra Tech, that were used to claim radioactivity levels were below the levels set for cleanup, were fabricated.

What has not been revealed until now is that the cleanup levels themselves were also erroneous. They were grossly outdated, violated the Superfund law, and are far, far less protective than promised. Therefore, both the measurements and the standards against which they were checked were wrong, in ways that seriously undercut public safety.

<u>The Navy was supposed to use EPA's Preliminary Remediation Goal (PRG) calculators to establish and evaluate cleanup standards, but has to date refused to do so. We therefore have done the evaluations using the EPA PRG calculators that the Navy has failed to perform. The results are deeply troubling.</u>

Under the Superfund Law, the Navy Is Required to Use Standards Consistent with EPA's Superfund Guidance, But Failed to Do So

It is remarkable that virtually the entire radioactive cleanup of HPS has been in violation of the elementary requirement to use up-to-date EPA standards. Instead, the Navy has been employing cleanup standards for contaminated buildings derived from *a 44-year-old document*, Regulatory Guide 1.86, by the now-defunct Atomic Energy Commission, rather than standards derived from EPA's own Building Preliminary Remediation Goal (PRG) Calculator which are far more restrictive. Additionally, the Navy used—and continues to use—long-outdated soil cleanup PRGs *from 1991* instead of the more protective modern EPA PRGs. **Thus, the public's health has been placed at risk both by Tetra Tech fabricating radiation measurements and by the use of cleanup standards that in themselves are considerably weaker than required by law.**

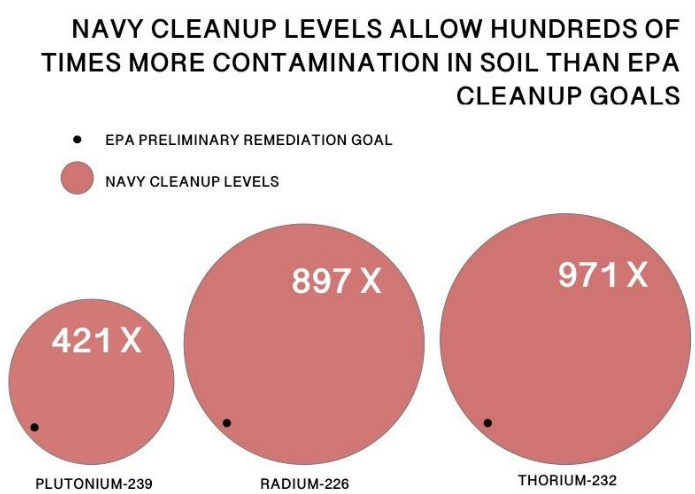
The Navy is Required to Perform 5-Year-Reviews to Determine that Cleanup Standards Are Still Protective Based on Current EPA Guidance—And Has to Date Refused to Do So, Despite Repeated Orders from EPA

Over the last year, EPA has repeatedly directed the Navy to evaluate the HPS radionuclide cleanup standards against the current EPA PRG Calculator for soil and the Building PRG Calculator in the Navy's Five-Year Review, and to use updated cleanup values based on those PRG calculations in its plans for retesting due to the Tetra Tech scandal. However, the Navy has to date refused to do so, releasing a draft Five Year Review in July 2018 and draft retesting plans in March and June that ignore the EPA directives and fail to assess the current adequacy of the ancient radionuclide cleanup values the Navy has been employing.

Despite these repeated and escalating directions from EPA, the Navy as of yet hasn't evaluated its HPS cleanup standards by **running EPA's PRG and BPRG Calculators, so we have. The results:**

The HPS Cleanup Standards the Navy and Tetra Tech Have Been Using Are Grossly Less Protective Than EPA's Preliminary Remediation Goals, and Above Even EPA's Upper Limit of Acceptable Risk

Soil cleanup levels for HPS are hundreds of times less protective than the current EPA PRGs. The Navy is allowing **421** times higher concentrations of plutonium-239, **971** times higher concentrations of thorium-232, and **897** times higher concentrations of radium-226 than the EPA PRGs.



Risk from Soil Cleanup Limits Far Exceed the Promised Risk Limits and Also Exceed the Absolute Upper Limit of Risk Deemed Acceptable by EPA

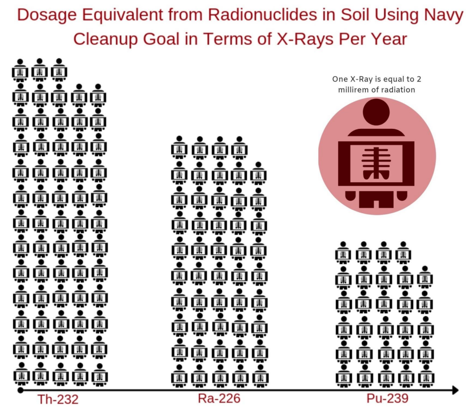
Using EPA's PRG Calculator to estimate risk at the cleanup levels employed by the Navy, associated risks are far, far greater than the promised one-in-a-million level, and for several radionuclides, well above EPA's absolute upper limit on allowable risk.

For plutonium-239 soil contamination, for example, at the levels the Navy sets as the threshold below which the contamination would not be cleaned up at HPS, the EPA PRG Calculator estimates residential cancer risk at **421 times the risk goal the Navy claimed**. (It is four times higher than even EPA's very upper limit of acceptable risk.) The cancer risk from thorium-232 is **974 times higher than the risk goal the Navy claimed** (and roughly ten times higher than the EPA upper limit of the acceptable risk range.) Once again, radium-226 far exceeds the EPA PRG, by a factor of **895** (and nine times even the upper limit of acceptable risk).

Because the risk from exposure to each radionuclide is additive, and under Superfund guidance one is supposed to add the risk from each radionuclide present (and indeed, also all chemical contaminants), these HPS standards are estimated by the BPRG Calculator to cumulatively produce a risk or **1 in every 380 people if exposed at those levels getting a cancer they wouldn't have gotten had the contamination not been present.**

Radiation Dose from Contamination at the Navy Cleanup Levels is the Equivalent of Many Unneeded Chest X-rays Per Year

EPA's dose calculator estimates doses from the Navy's soil cleanup levels for americium-241, plutonium-239, radium-226, and thorium-232 that are considerably above the levels deemed by EPA as "non-protective." The thorium dose, for example, is the equivalent of **63 chest X-rays per year**, year after year. For plutonium- 239, the dose is equivalent to **29 chest X-rays** each year. **It need not be said that this radiation exposure poses an increased health risk without any medical benefit, let alone consent of the recipient.**



The Inexplicable Radium Exception

Despite the Navy claiming that the primary radionuclide of concern and risk-driver at HPS is radium-226, it sought and obtained an exception to allow far higher levels of radium to be left unremediated than would be the case if cleanup levels were based on risk.

For radium-226, which the Navy claims represents 99% of the contamination at HPS and presents the greatest risk, it is allowing 900 times higher concentrations to remain, not cleaned up, than would be the case were the PRG to be used.

EPA's risk output function in its soil PRG calculator estimates risks from that level of radium- 226 alone at about **900 times higher than the promised one-in-a-million risk level and nine times higher than the upper limit of acceptable risk**. It is the equivalent, according to the EPA Dose Compliance Calculator, of about **a chest X-ray a week, year after year**.

It is exceedingly difficult to comprehend how the Navy could explain setting the cleanup level for the radionuclide it says is responsible for 99% of the HPS contamination at a level so vastly higher than what is deemed an acceptable risk or dose. How can the Navy tell members of the public that it has decided that an allowable radiation dose for the contamination it is choosing to not clean up would result in the public receiving the equivalent of hundreds of chest X-rays over the years of living there?

HPS Building Cleanup Standards Are Also Grossly Outdated & Non-Protective

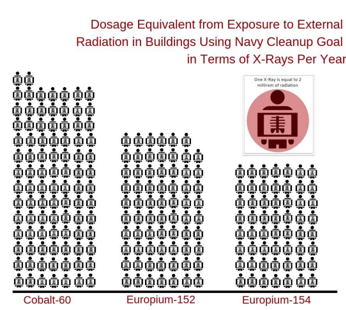
Rather than using the EPA BPRG Calculator, as required, the Navy has been using an ancient AEC guidance document that is far less protective. For external exposures, the Navy's HPS cleanup standards allow cobalt-60 in the buildings at levels about **3925 times higher** than the EPA building PRGs; europium-152 at levels **2876 times higher**; europium-154 at **2341 times higher;** and cesium-137 **446 times higher. We are not talking about differences of 10 or 20%; instead, the Navy's cleanup levels are hundreds and thousands of times weaker than the EPA BPRGs.** The standards they have been using are inconsistent with EPA's Superfund guidance, by a wide margin, despite the CERCLA requirement to be consistent.

Cancer Risks Associated with the Navy Cleanup Levels for External Radiation Inside Buildings Far Exceed Primary Risk Goals as Well as the Upper Limit of Acceptable Risk

Risks for cobalt-60, europium-152, and europium -154 in buildings at the cleanup level are all **thousands of times higher than the stated risk goal**. They are also higher than the upper limit of EPA's acceptable risk range. The EPA BPRG Calculator estimates combined risk from the radionuclides at the Navy release criteria levels at 1 in 100 – **every hundredth person exposed at those levels would get cancer from the exposure.** This is 10,000 times higher than the basic risk goal and 100 times higher than the upper limit of acceptable risk

Radiation Dose from External Exposure Inside Buildings at the Navy Cleanup Levels is the Equivalent of Many X-rays Per Year

The EPA Dose Compliance Calculator estimates doses from external exposures alone inside the building at the HPS release levels that are **the equivalent of dozens of chest X-rays annually. It is hard to conceive the public would be comfortable re-occupying these former Hunters Point Shipyard buildings if told that the standards the Navy is using to clean them up allowed residual contamination sufficient to cause occupants to receive the equivalent of a chest X-ray a week, week after week, year after year.**



The Navy's Cleanup Levels for Removable Radioactive Contamination in Buildings

The Navy is allowing roughly <u>a thousand times higher concentration</u> than the EPA BPRGs of removable contamination of each of the following: americium-241, cesium-137, cobalt- 60, europium-152, europium-154, and plutonium-239. Radium-226 is allowed a stunning 3288 times higher concentrations than the BPRG, and uranium-235 4148 times higher.

Cancer Risks Associated with the Navy Cleanup Levels for Removable Contamination Inside Buildings Far Exceed Primary Risk Goals as Well as the Upper Limit of Acceptable Risk

Most radionuclides exceed the risk goal by about a factor of a thousand. The upper limit of acceptable risk is exceeded individually by every radionuclide. The collective risk from removable contamination for the isotopes listed is such that every sixty-third person is predicted by EPA's BPRG Calculator to get a cancer from that exposure **In other words, at the levels of removable contamination permitted by the Navy's standards, <u>every sixty-third person</u> <u>exposed is predicted by EPA's BPRG Calculator to get a cancer from that exposure</u>. This risk level is absolutely extraordinary – more than ten thousand times the basic risk goal and more than a hundred times higher than the upper limit of what is considered by EPA an acceptable risk. It is hard to conceive how the Navy could explain to people that a cleanup goal based on such an astronomically high risk could possibly be OK.**

The combined risk estimated by EPA's BPRG Calculator for external *and* removable contamination inside buildings at the Navy's release levels is a remarkable <u>1 in 37</u>. Put plainly, if the radionuclides were at the levels allowed for release of the building, the estimate is <u>every 37th person so exposed would get a cancer from that exposure.</u>

No one is asserting that this is the true risk for people in re-purposed buildings at Hunters Point, or that the separate risk from exposure to soil at the Navy cleanup levels of 1 in 380 estimated by the EPA PRG Calculator is the true risk from actual soil contamination. **One simply does not know what that risk is, because Tetra Tech is accused of falsifying most of the measurements that were made, and the great majority of Hunters Point was never sampled in the first place.**

However, this is what the EPA BPRG and PRG Calculators estimate the risk would be at the contamination levels the Navy has deemed acceptable, i.e., not requiring cleanup. **The results of all these runs using EPA's PRG, BPRG, and DCC Calculators clearly indicate that the cleanup levels for HPS are woefully non-protective and need to immediately be brought into compliance with current EPA guidance.**

FOREWORD

by

Daniel Hirsch

At the beginning of 2016, the Program on Environmental and Nuclear Policy at the University of California, Santa Cruz, of which I was the Director, received a request to review the adequacy of the radioactive cleanup at Hunters Point Shipyard (HPS) and present any issues uncovered to the community at a meeting of the Bayview Hunters Point Environmental Justice Taskforce. We frankly did not expect to find much of significance. Hunters Point was, of course, in the midst of San Francisco, just a few minutes from EPA's Regional Headquarters. The Responsible Party and lead agency was not a private polluter with profit-motive incentives to cut corners but the U.S. Navy, which had since the days of Admiral Rickover, the founder of the nuclear navy, cultivated an image of by-the-books careful controls.

We assembled teams of students who worked with me in reviewing large numbers of documents. One of our first steps was to request from the Navy the cleanup standards it was employing at HPS for radioactive contamination. The information was provided to us on February 18, 2016, and within minutes we knew something was terribly wrong.

I had taught my students to always take a hard look at tables of numbers at the back of documents and, in particular, at footnotes, because life-and-death matters are often buried in them. The Navy table of "release criteria" (cleanup levels) consisted of concentrations of radioactivity; if contamination were below those levels, no cleanup would be required. The values were, however, in units that were opaque to the general public.

The first two footnotes, identifying the sources for the limits on equipment, waste, and structures, indicated that the release criteria came from a 1974 Regulatory Guide by the Atomic Energy Commission (AEC) and also a dose limit of 25 millirem/year. The AEC hasn't existed for decades, and under the Superfund law (CERCLA), cleanups are supposed to follow EPA Superfund guidance, which, for buildings, involves the far more protective Building Preliminary Remediation Goal (BPRG) Calculator. 25 millirem per year is the equivalent of about a dozen chest X-rays per year, considerably above the level EPA deems "non-protective."

Similarly, while the Navy claimed it was using EPA's Preliminary Remediation Goals (PRGs) for cleaning up contaminated soil, buried further in the document was a brief reference indicating that it was in fact using values from 1991. EPA has updated those PRGs over time, making them far more restrictive (i.e., more protective) as more is learned about the magnitude of risks from radiation, but the Navy continued to use—and uses to this day—values that are severely outdated.

I taught the students how to use the EPA PRG and BPRG Calculators and we performed the runs that the Navy and EPA should have. We quickly determined that the HPS cleanup levels being employed by the Navy and approved by EPA were not just outdated but far less protective than they should be.

We naively thought that if we brought this matter to the attention of the Navy and EPA, it would be soon remedied. After all, this was a Superfund site and EPA's Superfund guidance was supposed to be followed. We therefore pushed for a meeting or conference call with the Navy and personnel from the EPA regional office and the subject matter expert from EPA headquarters.

Rather than eagerness to learn if there were a health and safety problem that needed to be addressed, the agencies resisted and delayed having a meeting or call. It finally occurred on April 12, 2016. During the call, EPA staff begrudgingly admittedly that we were right—the Navy should not be using that ancient AEC set of release criteria for buildings instead of EPA's BPRG Calculator, should not be using 25 millirem/year, and decisions on cleaning up contaminated soil should not be based on quarter-century-old PRGs. However, they seemed caught in a bind, not knowing how to fix the problems without having to admit they had failed to catch them in the first place. It is understandably embarrassing that EPA personnel a few minute ride from HPS didn't catch these problems and a group of students did.

The community meeting for the Bayview Hunters Point Environmental Justice Taskforce was held the following week. The Navy made a presentation; EPA was there as well. My students and I presented our preliminary findings to the community. The Navy and EPA did not respond to the substance of what we had set forth. Efforts by community members at getting answers from the agencies were frustrated.

Thereafter, we pushed for a face-to-face meeting with EPA to try to resolve the issues and see what steps it was willing to take to address the problems. This meeting was put off and put off, until finally it was scheduled for late August 2016 in the Program's offices at UCSC. The night before the scheduled meeting, EPA cancelled, saying they were not willing to discuss problems that may have occurred in the past.

By this time it was becoming clear that the troubles with the Hunters Point Shipyard cleanup were far larger than we had initially contemplated. The Tetra Tech scandal involving allegations of falsified measurements was beginning to appear much more serious than revealed up to that point. Whereas neither the Navy or EPA had evaluated the HPS cleanup standards against current EPA BRPGs and PRGs, the EPA had done some cursory, brief reviews of the protectiveness of HPS cleanups based on Tetra Tech's reported measurements. Now those were useless, given that they relied on fabricated data.

As we probed further, more and more questions arose. The scope of our review expanded. Efforts to get needed documents, data, and other information from the Navy and federal and state regulators were frustrated, however. We will discuss this transparency issue in a subsequent report, but suffice it to say that the agencies were not forthcoming and we could not obtain a great many of the records we needed by the time I retired from the university in the spring of 2017. We were under some pressure to issue our reports before having obtained all the information necessary for them, but in conscience could not do that.

However, we also felt an obligation to the community to keep trying to get the missing documentation and data and complete the work. So, we have pressed on with those efforts through a non-profit organization, the Committee to Bridge the Gap, with which I have long been associated. CBG provides independent technical assistance to communities near nuclear sites. This continued Hunters Point work has been conducted with the help of teams of past and current UCSC students. The present report is based on new runs using the most current versions of the EPA BRPG and PRG Calculators.

We are now in the process of concluding work that has taken nearly three years, and reporting the results to the community, agencies, and policymakers. This is the third major report in the series; two more are to follow. We have also issued four other reports associated with specific proposals related to Hunters Point Shipyard. The reports can be found at www.committeetobridgethegap.org. It is our hope that they may be of use in efforts to repair a broken cleanup process for Hunters Point.

Hunters Point Shipyard Cleanup Used Outdated and Grossly Non-Protective Cleanup Standards

Introduction

In prior reports, we have disclosed that ~90% of sites at Hunters Point Shipyard (HPS) weren't sampled for radioactivity, and at the sites that were sampled, no measurements were made for ~90% of radionuclides used at HPS. Of the 10% of HPS that was sampled and the 10% of radionuclides that were measured, EPA and state regulators have determined that 90-97% of survey units showed evidence of falsification of data by Navy contractor Tetra Tech. In other words, a large fraction of the measurements taken by Tetra Tech, that were used to claim radioactivity levels were below the levels set for cleanup, were fabricated. The U.S. Justice Department is now suing Tetra Tech for fraud.

What has not been revealed until now is that the cleanup levels themselves, apparently also prepared by Tetra Tech, were also erroneous.[1] They were grossly outdated, violated the Superfund law, and are far, far less protective than promised. Therefore both the measurements and the standards against which they were checked were wrong, in ways that seriously undercut public safety.

Under the Superfund Law, the Navy Is Required to Use Standards Consistent with EPA's Superfund Guidance, But Failed to Do So

Under section 120(a)(2) of the Superfund law (the Comprehensive Environmental Response, Compensation, and Liability Act, or CERCLA), a Superfund site such as HPS that is owned by a federal entity, in this case the Navy, is barred from using cleanup criteria that are inconsistent with EPA's Superfund guidance:

> No department, agency, or instrumentality of the United States may adopt or utilize any such guidelines, rules, regulations, or criteria which are inconsistent with the guidelines, rules, regulations, and criteria established by the [EPA] Administrator under this chapter.

EPA's Superfund guidance for establishing cleanup goals for radioactively contaminated soil is found in its Preliminary Remediation Goal (PRG) Calculator.[2] The EPA guidance for cleaning up contaminated buildings is found in EPA's Building PRG Calculator.[3] EPA also has Dose Compliance Calculators (DCC)[4] and other key guidance documents for remediating radioactive contamination at Superfund sites.[5] As indicated above, the Superfund law bars the Navy from using any standards that are inconsistent with EPA's guidance.

It is therefore remarkable that virtually the entire radioactive cleanup of HPS has been in violation of the elementary requirement to use up-to-date EPA standards. Instead, the Navy has been employing cleanup standards for contaminated buildings derived from *a 44-year-old document,* Regulatory Guide 1.86, by the now-defunct Atomic Energy Commission (subsequently

Nuclear Regulatory Commission), rather than standards derived from EPA's own Building PRG Calculator which are far more restrictive. Additionally, the Navy used—and continues to use—long-outdated soil cleanup PRGs *from 1991* instead of the more protective current EPA PRGs.[6] Every Record of Decision (ROD) and other associated document that set remediation goals for radionuclides used ones that were in violation of the CERCLA §120(a)(2) requirement to be consistent with EPA CERCLA guidance; each used cleanup standards that were weaker than the EPA values then in effect, despite claiming to be consistent with them. This repeated failure by the Navy—which EPA and state regulators either consistently didn't catch, or caught but did nothing about—resulted in allowing far higher levels of radioactive contamination to evade cleanup than should have been the case had the Navy used the appropriate EPA guidance, as required. **Thus, the public's health has been placed at risk both by Tetra Tech fabricating radiation measurements and by the use of cleanup standards that in themselves are considerably weaker than required by law.**

Under Section 121(c) of Superfund, the Navy is Required to Perform Five-Year-Reviews to Determine that Cleanup Standards Used Are Still Protective Based on Current EPA Standards—And Has to Date Refused to Do So

As discussed above, the Navy employed standards for cleaning up contaminated HPS soil and buildings that were, even at the time, inconsistent with EPA Superfund guidance, in violation of CERCLA Section 120(a)(2). In addition, however, CERCLA Section 121(c) and the associated National Contingency Plan (NCP), 40 CFR Part 300.430(f)(4)(ii), require the Navy every five years to review the standards it has been employing to determine they are protective given current information. This review is particularly required to compare the HPS cleanup standards against the updated EPA PRGs, which have tended to tighten significantly over time as more is learned about the dangers of radiation. However, the Navy failed to perform such a review in its First, Second, and Third Five-Year Reviews.

Over the last year, EPA has repeatedly directed the Navy to evaluate the HPS radionuclide cleanup standards against the current EPA PRG Calculator for soil and the Building PRG Calculator in its latest, Fourth Five-Year Review, and to use updated cleanup values based on those PRG calculations in its plans for retesting due to the Tetra Tech scandal. However, the Navy has to date refused to do so, releasing a draft Five Year Review in July 2018 and draft retesting plans in March and June that ignore the EPA directives and fail to assess the current adequacy of the ancient radionuclide cleanup values the Navy has been employing. (While the Navy may at some point finally comply, its longstanding resistance raises questions whether such an analysis, if ever performed, would be a candid assessment or would instead try to change inputs into the PRG calculations so as to achieve more desirable outputs. We discuss this prospect in a subsequent section of this report.)

EPA on March 26, 2018, commented on the Navy's February 2018 Draft Work Plan for Radiological Survey and Sampling, regarding the section on release criteria (cleanup standards):

> As part of the fourth Five-Year Review occurring in parallel this year, the Navy is performing updated risk evaluations of these existing Remedial Goals (RG's). **EPA has previously recommended that this evaluation should use the current versions of the USEPA's Preliminary Remediation Goals (PRG) Calculator for soil and the Building PRG Calculator for buildings (BPRG). The new work performed under this Work Plan should use cleanup criteria that reflect findings of the updated risk evaluations to ensure the protectiveness of the cleanup."**
>
> (emphasis added)

The Navy ignored the directive.

In the same communication, EPA told the Navy to stop using the old and non-protective Regulatory Guide 1.86 and instead use EPA's current PRG Calculators:

> Please find and update all references to the Nuclear Regulatory Commission's **(NRC) Regulatory Guide 1.86, which has been withdrawn**. Some of the release criteria in the RODs were originally based on Regulatory Guide 1.86 limits. Please see above comment on Section 4.1.1 (Release Criteria) **regarding review of the protectiveness of these criteria using the current versions of EPA's risk models, the PRG and BPRG Calculators**.
>
> (emphasis added)

The Navy continued to ignore this directive also. When the Navy subsequently issued the draft Work Plan for Parcel G Retesting and the draft Five-Year Review, neither contained the required review using the PRG Calculators and both were based on the old, inadequate standards such as Reg. Guide 1.86 rather than updated standards based on the EPA PRGs.

Five months later, EPA renewed these orders in a letter to the Navy on August 14, 2018, commenting on the Navy's draft retesting plan for Parcel G:

> Section 3.3 and 4.3, Remediation Goals for soil and buildings, respectively: These sections list the current ROD RGs. The HPNS's Five-Year Review occurring in 2018 is evaluating whether the current selected remedies, including these ROD RGs, are still protective and whether any changes are necessary to ensure continued protectiveness. **Based on national practices directed by EPA headquarters, EPA expects this process to use the most current version of the EPA Preliminary Remediation Goal (PRG) Calculator and Building PRG Calculator to assess the ROD radiological RGs. The Work Plan should use only those cleanup goals confirmed through this analysis to be protective.**
>
> (emphasis added)

Despite these repeated directions from EPA to the Navy to use the PRG and BPRG Calculators to update cleanup goals in the Five-Year Review, the Navy failed to do so. The draft Five-Year Review had no analysis whether the cleanup standards being employed at HPS for radionuclides were protective; no running of the PRG and BPRG Calculators to determine what the standards should in fact be. Furthermore, the draft Retesting Plan for Parcel G failed to use standards based on the EPA PRG Calculators.

EPA criticized that again, for at least the fourth time, in its September 21, 2018 comments on the Navy's draft Five-Year Review, and once again directed the Navy to comply, seemingly beginning to lose patience:

> Section 6.2.2, Changes in Toxicity and Other Contaminant Characteristics: EPA Guidance calls for evaluation of the significance of changes in toxicity values and other contaminant characteristics when conducting a Five-Year Review. [fn deleted] The EPA's Preliminary Remediation Goal (PRG) Calculators for soil, the Building PRG Calculator for buildings, and the Surface PRG Calculator for surfaces, "which are used to develop risk-based PRGs for radionuclides, are recommended by EPA for Superfund remedial radiation risk assessments."[fn deleted] ... **EPA has previously commented that this fourth FYR should include updated risk evaluations for existing remediation goals (RGs) using the current versions of the EPA's PRG Calculators, but this is not addressed in the FYR. For example, risk should be calculated for soil, buildings, piers, and bollards. Please revise the FYR to include the results of updated risk evaluations for existing RGs using the current versions of the EPA's PRG calculators to ensure that existing RGs remain protective.**
>
> (emphasis added)

Despite these repeated and escalating directions from EPA, the Navy as of yet hasn't done the comparisons, so we have. The results are troubling.

The Fundamental Issue – The HPS Cleanup Standards the Navy and Tetra Tech Have Been Using Are Grossly Less Protective Than EPA's Preliminary Remediation Goals, and Above Even EPA's Upper Limit of Acceptable Risk

A. HPS Soil Cleanup Levels

1. Substantially Weaker Than Current EPA PRGs

The Navy stated that its HPS soil cleanup levels—initially put forward in 2006 and all subsequent cleanup decision documents to this day merely use the same values without updating them—were

from EPA's Preliminary Remediation Goals, which are based on a one-in-a-million cancer risk (10^{-6}).[7] However, it turns out that the Navy has been using PRGs from *1991*. Even when the first Navy standards were set, these were already outdated and the then-current PRGs for several of the radionuclides were lower (i.e., more protective) than the values used by the Navy.[8] Over subsequent years, new cleanup decisions were made by the Navy and approved by EPA and state agencies, but rather than using the then-current EPA PRGs, the remediation goals were consistently the same outdated and less protective values. (There was one exception. The Navy's cleanup value for Cobalt-60 was *weakened*, in 2012, from 0.0361 picocuries/gram to
0.252 in 2012, a factor of 7 times less protective and far below the PRG of that time, let alone the current PRG of 0.008, which is 32 times more restrictive.)

The table below compares the soil cleanup standards that have been and continue to be employed at HPS to the current EPA default residential PRGs.[9]

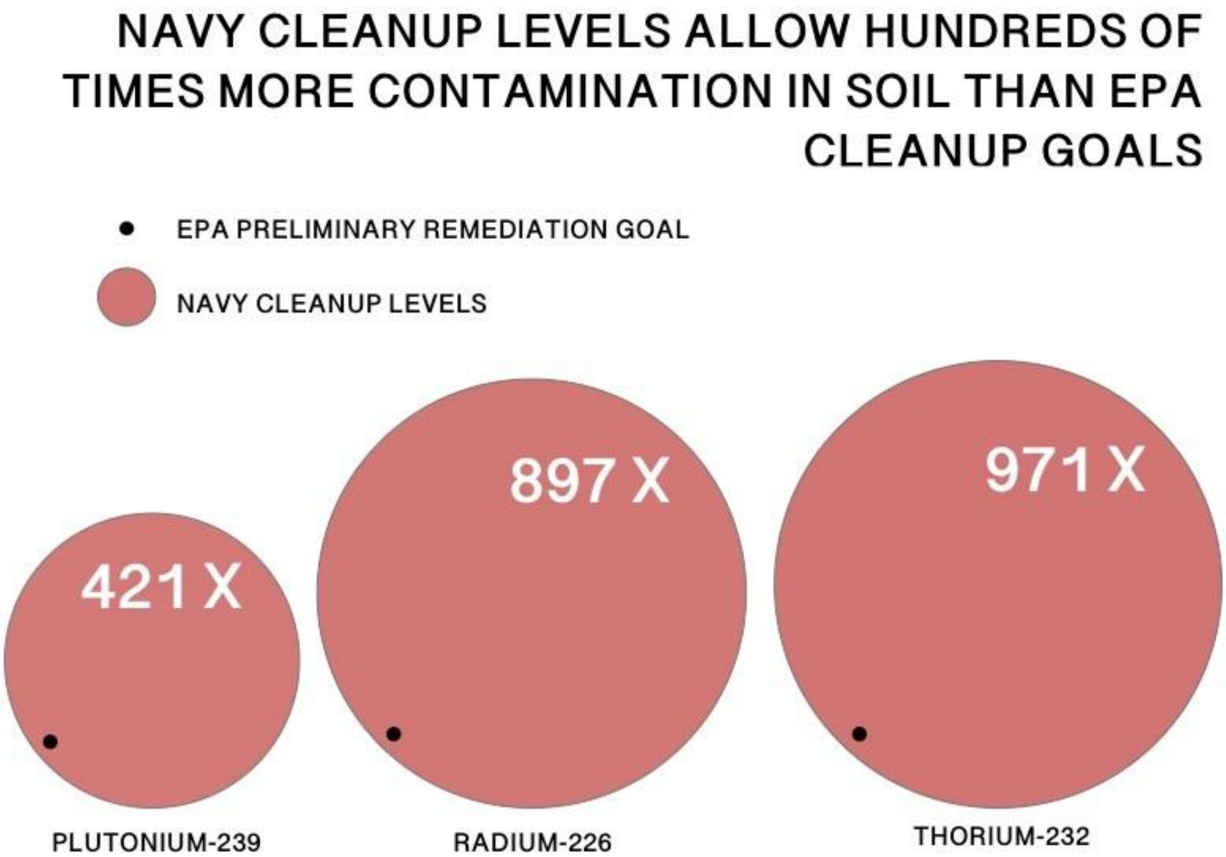
Comparison Between Navy's Hunters Point Cleanup Levels and EPA Preliminary Remediation Goals (PRG) for Radioactively Contaminated Soil

Radionuclide	Navy's Hunters Point Residential Cleanup Levels for Soil (pCi/g)	EPA Residential Preliminary Remediation Goal for Soil (pCi/g)	How Many Times Less Protective (Weaker) is the Navy's Hunters Point Removable Cleanup Levels than the EPA Preliminary Remediation Goals (PRGs)
Americium-241 (Am-241)	1.36	0.0104	**131**
Cesium-137 (Cs-137)	0.113	0.0303	**4**
Cobalt-60 (Co-60)	0.252	0.0081	**31**
Europium-152 (Eu-152)	0.13	0.0208	**6**
Europium-154 (Eu-154)	0.23	0.0195	**12**
Plutonium-239 (Pu-239)	2.59	0.0062	**421**
Radium-226 (Ra-226)	1.633	0.0018	**897**
Strontium-90 (Sr-90)	0.331	0.0036	**92**
Thorium-232 (Th-232)	1.69	0.0017	**971**
Tritium (H-3)	2.28	0.0612	**37**
Uranium-235 +D (U-235)	0.195	0.0062	**31**
pCi= picocuries			

Take the example of plutonium-239, one of the most dangerous substances on earth and, as indicated in our prior reports, one which was potentially present at HPS in large quantities. The Navy is using a cleanup level of 2.59 picocuries of plutonium per gram of soil, which it claims is the EPA PRG for residential exposure. However, the actual current EPA residential PRG is 0.0062—**421 times lower**. The Navy's outmoded standard thus allows it to leave 421 times higher concentrations of plutonium than if it were using the PRG, not from 1991, but from today. [As indicated above, EPA has tightened standards over time as radiation risks have been found to be greater than previously realized.]

For thorium-232, the Navy is now supposedly cleaning up any HPS soil that is below 1.69 pCi/g, which it claimed was based on the EPA PRG. However, the current EPA PRG is 0.0017 pCi/g, **nearly a thousand times lower (i.e., more protective.)** In other words, the Navy's standard allows it to leave behind almost a thousand times higher concentrations of thorium-232 than would be the case had they used current EPA PRGs rather than 27-year-old ones. The figure below illustrates just how astronomical of a discrepancy this is.

The Navy's radium cleanup level—at **897 times the PRG**—is a special case that we shall discuss later in this report.



2. Risk Levels Far Exceed the Promised Risk Limits and Also Exceed the Absolute Upper Limit of Risk Deemed Acceptable by EPA

EPA Superfund guidance aims for reducing contamination so as to produce an excess cancer risk of one-in-a-million (10^{-6}). The PRGs are set as the concentration that will produce that risk. (If one can't readily meet that risk goal, one can apply for permission for a higher residual risk, based on CERCLA's nine balancing and other criteria, but in no case over a risk of one-in-ten- thousand. The Navy has made no such request.) Indeed, the Navy committed in its Records of Decision to clean up HPS radionuclide contamination to PRG levels, i.e., to a risk of one-in-a- million. **However, as seen in the table below, using EPA's PRG Calculator to estimate risk at the cleanup levels actually employed by Navy, associated risks are far, far greater than the promised one-in-a-million level, and for several radionuclides, well above the absolute upper limit on allowable risk of one-in-ten-thousand.**

Cancer Risk Estimates from EPA's Preliminary Remediation Goal (PRG) Calculator for Exposure to Soil at Navy's Cleanup Levels				
Radionuclide	**Navy Hunters Point Residential Cleanup Levels for Soil (pCi/g)**	**EPA PRG Calculator Estimate of Cancer Risk from Navy's Hunters Point Residential Cleanup Levels**	**Ratio of the Cancer Risk from the Navy's HPS Soil Cleanup Level to EPA's Highest Risk Allowed (1 in 10,000)**	**How Many Times Higher Cancer Risk is the Navy's HPS Cleanup Level than EPA's Risk Goal (1 in 1,000,000)**
Americium-241 (Am-241)	1.360	1.30×10^{-4}	**1.3**	**130**
Cesium-137 (Cs-137)	0.113	3.73×10^{-6}	0.04	**4**
Cobalt-60 (Co-60)	0.252	3.13×10^{-5}	0.31	**31**
Europium-152 (Eu-152)	0.130	6.26×10^{-6}	0.06	**6**
Europium-154 (Eu-154)	0.230	1.18×10^{-5}	0.12	**12**
Plutonium-239 (Pu-239)	2.590	4.21×10^{-4}	**4.21**	**421**
Radium-226 (Ra-226)	1.633	8.95×10^{-4}	**8.95**	**895**
Strontium-90 (Sr-90)	0.331	9.17×10^{-5}	**0.92**	**92**
Thorium-232 (Th-232)	1.690	9.74×10^{-4}	**9.74**	**974**
Tritium (H-3)	2.280	3.73×10^{-5}	0.37	**37**
Uranium-235 +D (U-235)	0.195	3.13×10^{-5}	0.31	**31**
Total Risk	**2.63×10^{-3} 1 in every 380 people will get cancer**			
pCi= picocuries				

For plutonium-239 contamination, for example, at the levels the Navy sets as the threshold below which the contamination would not be cleaned up at HPS, the EPA PRG Calculator estimates residential cancer risk at **421 times the risk goal the Navy claimed**. (It is four times higher than even EPA's very upper limit of acceptable risk.) The cancer risk from thorium-232 is **974 times higher than the risk goal the Navy claimed** (and roughly ten times higher than the EPA upper limit of the acceptable risk range.) Once again, radium-226 far exceeds the EPA PRG, by a factor of **895** (and nine times even the upper limit of acceptable risk).

Because the risk from exposure to each radionuclide is additive, and under Superfund guidance one is supposed to add the risk from each radionuclide present (and indeed, also all chemical contaminants), these HPS standards would cumulatively produce a risk of 2.63×10^{-3}, or **1 in every 380 people if exposed at those levels getting a cancer they wouldn't have gotten had the contamination not been present.** (This assumes no chemical contamination also exists, which of course isn't the case. With chemical contamination, the risks deemed "allowable" by the Navy would be even higher.) Because HPS worked with mixes of large numbers of radionuclides (e.g., the full range of fission and activation products and unfissioned plutonium and uranium from nuclear weapons tests), there may be many places at HPS with a wide range of radioactive contaminants. Furthermore, because the Navy excluded from its cleanup standards the majority of the radionuclides identified in its Historical Radiological Assessment as being used at and of concern at HPS, the risks could be considerably higher, because of the decision to allow unlimited levels of the other radionuclides

Furthermore, EPA warned the Navy, in comments on the draft Five-Year Review, that in calculating risks from cleanup standards it should keep each radionuclide's risk far below 10^{-4}, the one-in-ten-thousand upper limit of allowable risk, because there may be multiple contaminants present and because standards continually tighten:

> For EPA to sign a Finding of Suitability to Transfer (FOST) for any parcel, the record must also show that the remedy is consistent with the NCP. Please note that if this review shows that the estimate risk is close to $1 \text{ X } 10^{-4}$, EPA recommends not setting a Remedial Goal too close to this upper bound 10^{-4}. First, this increases the potential for the combined risk from multiple contaminants of concern found at a single location to exceed the National Contingency Plan (NCP) risk range of 10^{-6} to 10^{-4}. Adding risks from multiple radionuclides of concern found at the same location, even if individual radionuclide concentrations do not exceed the individual thresholds of concern, is consistent with the Unity Rule in the Multi Agency Radiation Survey and Site Investigation Manual (MARSSIM). [fn deleted] Second, in general, EPA estimates of risk at a given radionuclide concentration have increased over time. It would be prudent to allow room to accommodate these likely future increases.

Thus, the Navy HPS soil cleanup standards for all radionuclides for which the Navy has set limits far exceed the risk level the Navy claimed it would meet and established in its RODs and which is the primary EPA risk goal. Americium-241, plutonium-239, radium-226, and thorium- 226, furthermore, all individually exceed even the upper limit of EPA's acceptable risk range. Strontium-90, tritium, and uranium-235 are each fairly close individually to the upper limit of the risk range, which EPA recommends avoiding because of the potential for multiple radionuclides present to thus collectively exceed that upper limit and to provide room for subsequent increases in EPA risk estimates, which has historically been the pattern. Finally, the collective risk from just the radionuclides for which the Navy has set cleanup limits—leaving out all the other radionuclides present as well as toxic chemical contamination—is 2.63×10^{-3}, or **2630 times the risk goal and**

26.3 times the upper limit of acceptable risk. One can understand why the Navy has been reluctant to do these PRG calculations.

3. Radiation Dose from Contamination at the Navy Cleanup Levels Far Exceeds What is Acceptable—It is the Equivalent of Many Unneeded Chest X-rays Per Year

EPA Superfund guidance generally requires cleanup based on risk, not radiation dose. An exception is if there is an "applicable or relevant and appropriate requirement" (ARAR) with a dose limit that EPA deems protective (i.e., within its acceptable risk range). EPA has declared that no ARAR allowing a dose of over 12 millirem/year is protective; no ARAR over 12 millirem/year can be applied.[10] [There is only one ARAR in the United States that meets this requirement, that of the State of Maine.]

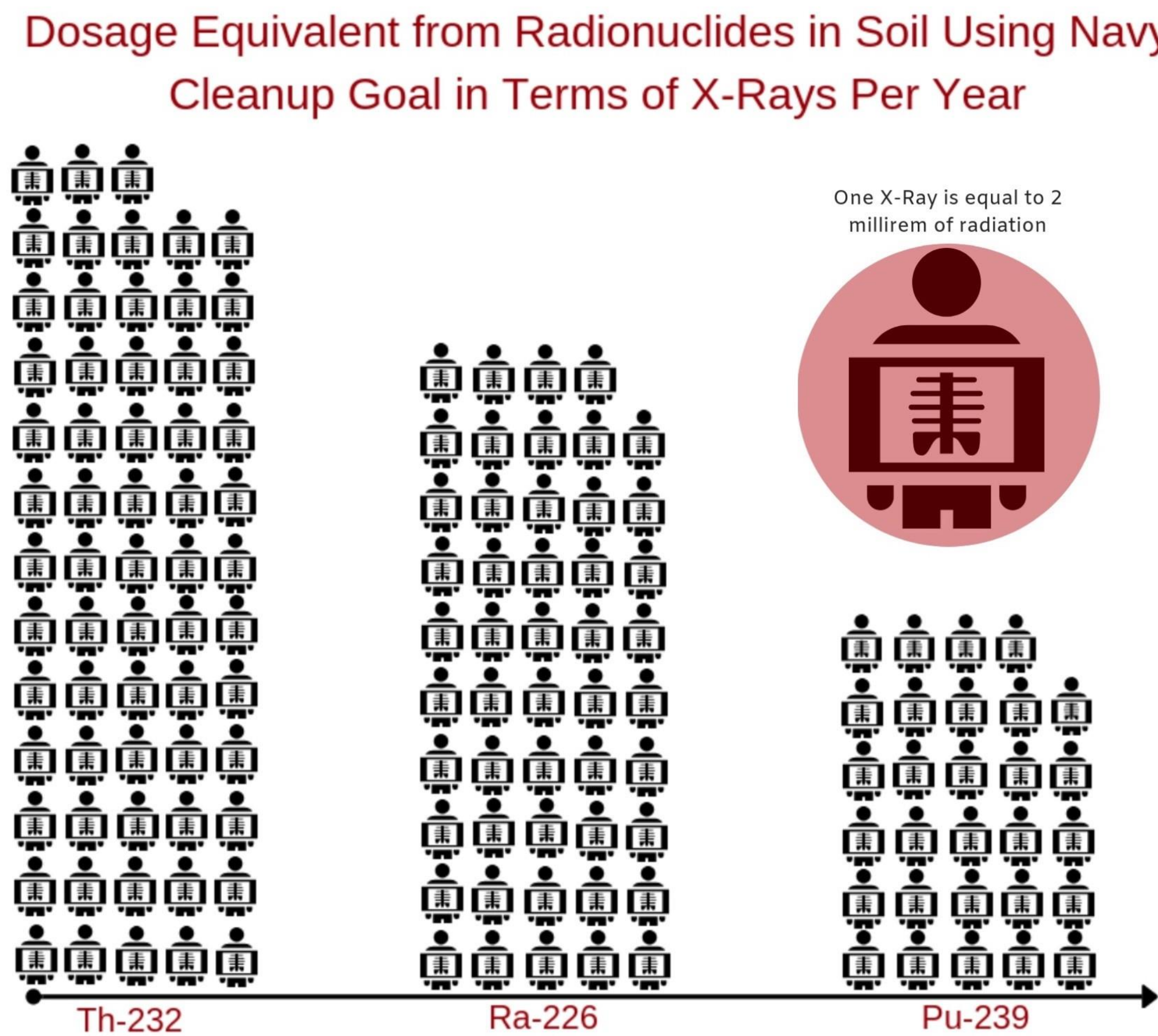
In general, EPA aims for annual doses in the range of a few hundredths of a millirem/year in order to be roughly equivalent to its goal of one-in-a-million risk.[11] If the risk goal the Navy promised after cleanup of one-in-a-million were indeed being carried out, the radiation dose from the Navy cleanup levels should be on the order of 0.03 millirem/year.[12]

However, the Navy itself has estimated the dose from the contamination levels it is allowing to remain at HPS as far, far higher than the one-in-a-million risk dose equivalent, and even higher than the 12 millirem/year level EPA deems automatically non-protective (outside even the upper limit of the acceptable risk range). For example, the Navy estimates the risk from its soil cleanup level for americium-241 as 24.84 millirem/year and 25 millirem/year for thorium-232.[13] To put that in perspective, that is the equivalent of a chest X-ray each month, year after year.[14]

EPA's CERCLA Program has a Dose Compliance Calculator (DCC), and as indicated above, under CERCLA it is EPA's guidance that is supposed to be used at Superfund sites. We have used EPA's DCC to estimate radiation dose at the Navy cleanup levels. The results are included in the table below. To put the results in more understandable terms, we have shown the equivalent number of chest X-rays associated with each radionuclide's estimated dose at the cleanup levels the Navy is employing at HPS.

Dose Estimates from EPA's Dose Compliance Calculator (DCC) for Exposure to Contamination in Soil at Navy's Hunters Point Cleanup Level				
Radionuclide	**Navy's Hunters Point Cleanup Level for Soil (pCi/g)**	**EPA DCC level (pCi/cm² that will produce 1 mrem/yr)**	**EPA DCC Dose Estimate for Navy's Hunters Point Cleanup Level (mrem/yr)**	**Equivalent Number of Chest X-Rays Per Year**
Americium-241 (Am-241)	1.360	0.064	**21.2**	**11**
Cesium-137 (Cs-137)	0.113	0.616	0.2	0
Cobalt-60 (Co-60)	0.252	0.175	1.4	1
Europium-152 (Eu-152)	0.130	0.342	0.4	0
Europium-154 (Eu-154)	0.230	0.410	0.6	0
Plutonium-239 (Pu-239)	2.590	0.044	**58.9**	**29**
Radium-226 (Ra-226)	1.633	0.017	**97.6**	**49**
Strontium-90 (Sr-90)	0.331	0.049	6.8	3
Thorium-232 (Th-232)	1.690	0.013	**126**	**63**
Tritium (H-3)	2.280	1.300	1.8	1
Uranium-235 +D (U-235)	0.195	0.045	4.3	2
mrem= millirem				
pCi= picocuries				
DCC = EPA's Dose Compliance Calculator				

As seen from the table, the EPA's dose Calculator estimates doses from the Navy's soil cleanup levels for americium-241, plutonium-239, radium-226, and thorium-232 that are considerably above the levels deemed by EPA as "non-protective." The thorium dose, for example, is the equivalent of **63 chest X-rays per year**, year after year. For plutonium-239, the dose is equivalent to **29 chest X-rays** each year. **It need not be said that this radiation exposure poses an increased health risk without any medical benefit, let alone consent of the recipient.**



4. The Inexplicable Radium Exception

The Navy claims that the primary radionuclide of concern at HPS is radium-226. Indeed, it asserts that radium "accounts for 99% of the radiological contamination found."[15] (It is not clear that this is true, since the Navy gamma scans generally can't detect any other radionuclide at the cleanup levels, and soil samples generally weren't measured for anything except radium-226 and cesium-137.) Given this Navy assertion, however, one would think that radium-226 would have the most protective cleanup standard, as it supposedly drives the risk to the public.

The actual situation is to the contrary. Rather than basing the radium-226 cleanup standard on a risk-based value, i.e., the PRGs, the Navy asked for and was granted from EPA a special exception, allowing the Navy to avoid cleaning up any radium-226 below 1 picocurie per gram (pCi/g) of soil. The exception went even further, setting the limit at 1 picocurie *above* background. (EPA Superfund guidance sets cleanup standards at the actual cleanup level, e.g., the PRG, not the increment above background.[16]) The Navy has claimed various background values, but generally used 0.633 pCi/g. (As we have discussed in other reports, the Navy skewed background measurements upward by frequently taking measurements in the midst of potentially contaminated areas.). The radium-226 cleanup level for soil was therefore generally 1.633 pCi/g.

We have repeatedly asked EPA for its justification for approving this remarkable exception. We were told by the project manager for HPS that no one now at EPA knew why this exemption had been granted. We asked repeatedly for documentation as to any risk analysis EPA performed before approving this waiver, and were promised that it would be obtained from the EPA records center, but we have never received it.

So how does 1.633 pCi/g of radium-226 compare to a normal risk-based cleanup level? As seen earlier, the current EPA residential soil PRG for radium-226 is 0.0018 pCi/g—about **900 times lower.** (This is with the radon gas pathway turned off; with it considered, the risk would be considerably greater, and a cleanup level based solely on risk considerably lower.) For all other radionuclides for which it set limits, the Navy said it was using EPA's PRGs. **For radium-226, which the Navy claims represents 99% of the contamination at HPS and presents the greatest risk, it is allowing 900 times higher concentrations to remain, not cleaned up, than would be the case were the PRG to be used.**

EPA's risk output function in its soil PRG Calculator estimates risks from that level of radium-226 alone at about **900 times higher than the promised one-in-a-million risk level and nine times higher than the upper limit of acceptable risk**. [This is without even considering the risk from the radon gas emitted.] The radium-226 dose is thus far beyond the level deemed non-protective by EPA; it is the equivalent, according to the EPA Dose Compliance Calculator, of about **a chest X-ray a week, year after year**.

It is exceedingly difficult to comprehend how the Navy could explain setting the cleanup level for the radionuclide it says is responsible for 99% of the HPS contamination at a level so vastly higher than what is deemed an acceptable risk or dose. How can the Navy tell members of the public that it has decided that an allowable radiation dose for the contamination it is choosing to not clean up would result in the public receiving the equivalent of hundreds of chest X-rays over the years of living there? (It is worth remembering that the half-life of radium-226 is 1600 years.)

HPS Building Cleanup Standards Are Grossly Outdated & Non-Protective

All HPS Records of Decision issued by the Navy that include radionuclide cleanup levels for buildings have set them based on the 1974 Atomic Energy Commission's Regulatory Guide 1.86 rather than, as required under CERCLA, EPA's Building Preliminary Remediation Goal Calculator. Reg. Guide 1.86 was never based on risk or health, but on what hand-held radiation detectors generally available in the 1960s could readily detect. Equipment, of course, has substantially improved in the subsequent half-century. As quoted earlier, EPA has recently reiterated to the Navy that it is not to use Reg. Guide 1.86 but instead to use EPA's BPRG Calculator. Yet the Navy's building cleanup standards have been and remain those Reg. Guide 1.86 values, and to date it has not issued evaluations of those standards compared to the BRPG values. We have done so here.

There are two aspects of radiation dose from being inside a contaminated building. One is external, direct radiation dose—the contaminated floors, walls and ceilings of the building give off radiation that can penetrate one's body while working or living in the structure. The second comes from removable contamination, essentially radioactively contaminated dust, that one can, for example, inhale or ingest. The Navy established two sets of cleanup levels for buildings, one for external exposure, and one for dust. The BPRG Calculator can be used to produce results for each pathway. In the discussion that follows, we use the BPRG Calculator to estimate the PRGs for external and for removable exposures, the associated risks and doses. We begin with the cleanup limits for external exposures from radiation within buildings.

B. The Navy's Limits for External Exposure Inside Buildings

1. Far, Far Weaker Than Current EPA Building PRGs

Year after year for more than a decade, the Navy has failed to use the EPA BPRG Calculator to establish cleanup levels for structures but instead used the ancient AEC Reg. Guide 1.86, which they are not supposed to employ. EPA has over and over again in the last year directed the Navy to update the values it has been using by running them against the BPRG Calculator, but the Navy has declined to do so to this point. We have thus run the BPRG Calculator, and compared its output with the cleanup values used by the Navy for external exposure inside buildings. The results are below, and are striking.

Comparison Between Navy's Hunters Point Cleanup Level and EPA Preliminary Remediation Goals (PRGs) for External Exposure from Contamination Inside Buildings			
Radionuclide	Navy's Hunters Point Cleanup Level for Buildings (dpm/100 cm²)	EPA Building Preliminary Remediation Goal (dpm/100 cm²)	How Many Times Less Protective (Weaker) is the Navy's HPS Cleanup Level Than the EPA PRG?
Americium-241 (Am-241)	100	5.88	**17**
Cesium-137 (Cs-137)	5000	11.21	**446**
Cobalt-60 (Co-60)	5000	1.27	**3925**
Europium-152 (Eu-152)	5000	1.74	**2876**
Europium-154 (Eu-154)	5000	2.14	**2341**
Plutonium-239 (Pu-239)	100	7.17	**14**
Radium-226 (Ra-226)	100	2.69	**37**
Strontium-90 (Sr-90)	1000	3,085,800	0
Thorium-232 (Th-232)	36.5	1.33	**27**
Uranium-235 +D (U-235)	488	7.17	**68**
dpm= disintegrations per minute			

As seen in the table above, the Navy's HPS cleanup standards allow cobalt-60 in the buildings at levels about **3925 times higher** than the EPA building PRGs; europium-152 at levels **2876 times higher**; europium-154 at **2341 times higher;** and cesium-137 **446 times higher. We are not talking about differences of 10 or 20%; instead, the Navy's cleanup levels are hundreds and thousands of times weaker than the EPA BPRGs. One cannot help wondering whether this is the reason the Navy has been so resistant to doing the calculations and using the EPA BPRGs.** The standards they have instead been using are inconsistent with EPA's Superfund guidance, by a wide margin, despite the CERCLA requirement to be consistent.

2. Cancer Risks Associated with the Navy Cleanup Levels for External Radiation Inside Buildings Far Exceed Primary Risk Goals as Well as the Upper Limit of Acceptable Risk

The Navy claimed its cleanup goals for radionuclides at Hunters Point were based on EPA's PRGs, which are set, as we indicated earlier, at a one-in-a-million (10^{-6}) risk level. So what is the actual risk from contamination at the levels the Navy was allowing from external radiation inside buildings? One can run the EPA BPRG Calculator in risk output mode to find out. The results are below, again extremely striking and worrisome.

Cancer Risk Estimates from EPA's Building Preliminary Remediation Goal (BPRG) Calculator for External Exposure to Radiation Inside Buildings at Navy's HPS Cleanup Levels				
Radionuclide	Navy's Hunters Point Cleanup Level for Buildings (pCi/cm^2)	Residential Cancer Risk from Navy HPS Building Cleanup Level, Using EPA BPRG Calculator	Ratio of the Cancer Risk from the Navy's HPS Building Cleanup Level to EPA's Highest Risk Allowed (1 in 10,000)	How Many Times Higher Cancer Risk is the Navy's HPS Cleanup Level than EPA's Risk Goal (1 in 1,000,000)
Americium-241 (Am-241)	0.451	1.70×10^{-5}	0.2	**17**
Cesium-137 (Cs-137)	22.523	4.46×10^{-4}	**4**	**446**
Cobalt-60 (Co-60)	22.523	3.92×10^{-3}	**39**	**3920**
Europium-152 (Eu-152)	22.523	2.88×10^{-3}	**29**	**2880**
Europium-154 (Eu-154)	22.523	2.34×10^{-3}	**23**	**2340**
Plutonium-239 (Pu-239)	0.451	1.40×10^{-5}	0.1	**14**
Radium-226 (Ra-226)	0.451	3.72×10^{-5}	0.4	**37**
Strontium-90 (Sr-90)	4.505	3.25×10^{-10}	0	0
Thorium-232 (Th-232)	0.164	2.75×10^{-5}	0.3	**28**
Uranium-235 +D (U-235)	2.198	6.81×10^{-5}	0.7	**68**
Total Risk	**9.75×10^{-3} = 1 in every 103 people will develop cancer**			
pCi= picocuries				

As one sees above, risks for cobalt-60, europium-152, and europium -154 are all **thousands of times higher than the stated risk goal.** Cesium-137 is hundreds of times higher, and other radionuclides dozens of times higher. The standards used by the Navy were inconsistent with EPA CERCLA guidance for many years, yet used in the cleanup of HPS regardless.

Even if the standards had been right when the RODs and other documents setting them were issued—and as we have seen, they were not—in the Five-Year Reviews one is supposed to demonstrate that the standards previously employed are still within the risk range, given changes to standards as EPA has found greater and greater risks from radiation. As noted before, although the primary risk goal is one-in-a-million (10^{-6}), EPA's upper limit of what is acceptable risk is one-in-ten-thousand (10^{-4}). And as EPA has reminded the Navy, as discussed earlier, risks for individual radionuclides should not approach that level, as there may be a number of other radionuclides (and chemicals) present, contributing to overall risk, and one wants to leave "room" for future increases in risk determinations as EPA continues to find increased evidence of harm from radiation.

So how do the Navy's actual building cleanup values compare to EPA's upper limit of acceptable risk? As seen in the table above, cobalt-60 is 39 times higher, europium-152 is 29 times higher, europium-154 is 23 times higher, and cesium-137 is 4 times higher than the upper limit of acceptable risk. Each alone exceeds the maximum risk allowed; together (and with risk from the removable contamination in the buildings that we shall shortly discuss), the level of risk is grossly beyond what EPA allows as acceptable at Superfund sites. Virtually all of the others individually are significant fractions of the upper risk limit (e.g., uranium-235 is 70% of the allowable risk just on its own), which EPA says is to be avoided because of the potential for multiple contaminants present and the prospect of future increases in risk coefficients.

The combined risk from external exposure inside buildings from just the radionuclides for which the Navy has established limits is on the order of 1 in 100 (10^{-2}).[17] [Other radionuclides not listed can have unlimited concentrations.] **In plain language, for every hundred people exposed at the limits the Navy allows, one would get a cancer s/he would not have gotten absent that exposure. These are extraordinary and unacceptable risk levels, one hundred times higher than the EPA deems ever acceptable at Superfund sites and ten thousand times higher than EPA aims for in such cleanups.**

Now, it can be argued that it is unlikely that all the radionuclides would be present together (although contamination was frequently from mixtures of fission and activation products and unfissioned uranium and plutonium from nuclear weapons test debris brought back to HPS). But other contaminants might also be present (e.g., radionuclides for which the Navy has set no limits, or the toxic chemicals of concern identified by the Navy) that add to the risk. Furthermore, there is additional risk, as we shall discuss shortly, from the removable contamination (radioactive dust) in those same buildings. Plus, there is the potential exposure outdoors from radioactive contamination of soil at the extremely high levels allowed by the Navy, as we discussed at the outset.

The bottom line is that the cleanup levels for external radiation exposures inside buildings exceed EPA's BPRGs and primary risk goals by factors of thousands, and far exceed even the outer limit of what EPA deems as acceptable cancer risk from Superfund sites.

3. Radiation Dose from External Exposure Inside Buildings at the Navy Cleanup Levels Far Exceeds What is Acceptable—It is the Equivalent of Many Unneeded Chest X-rays Per Year

As indicated earlier, EPA requires Superfund cleanups to be based on risk, not dose. Additionally, it has declared that doses above 12 millirem/year are automatically considered non- protective, outside the acceptable risk range, and aims for radioactivity concentrations that produce doses hundreds of times lower. Furthermore, the Navy is obligated under CERCLA to employ standards consistent with EPA's Superfund guidance.

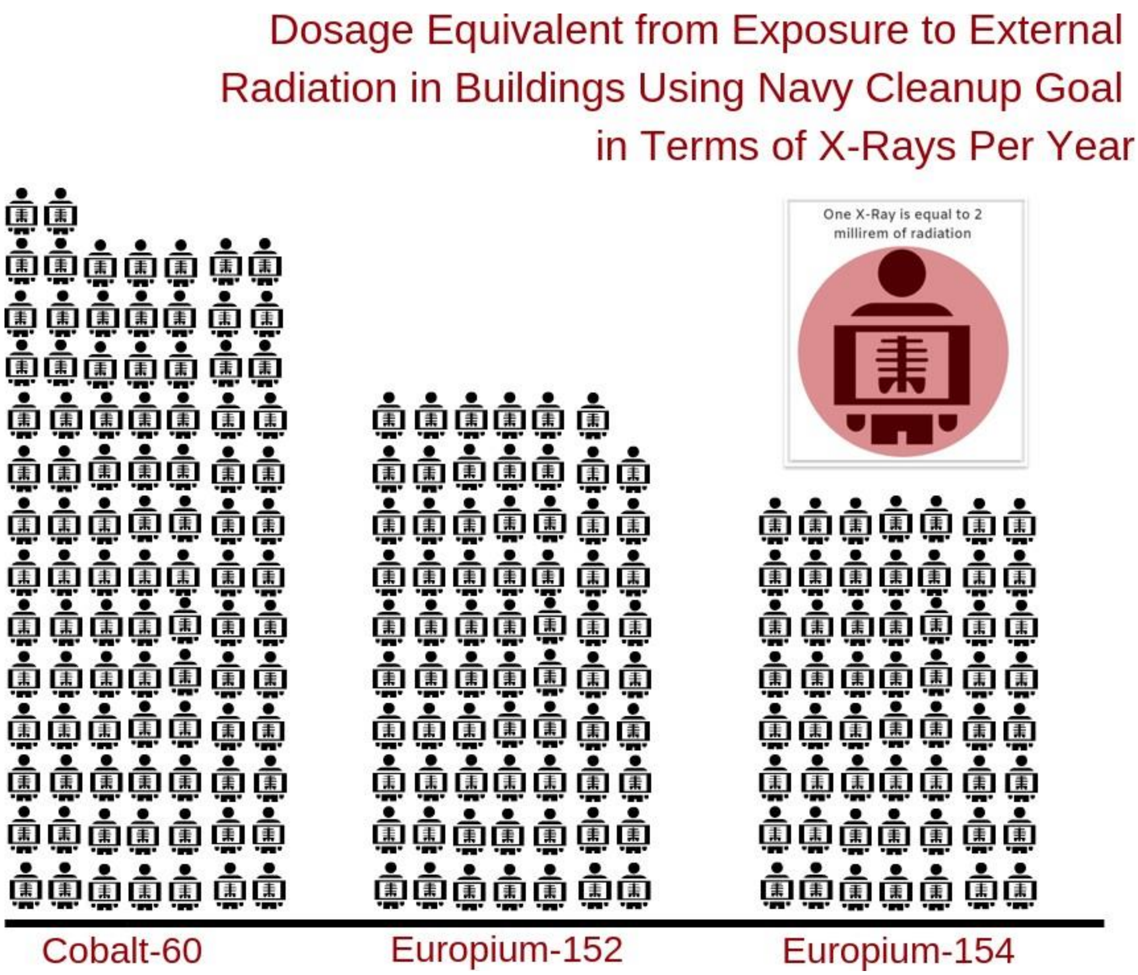
Nonetheless, for years the Navy has based its building cleanup standards in part on 25 millirem/year. Initially EPA said nothing about this, but in recent years it has made clear that it objected, saying, "EPA does not believe this...is protective of human health and the environment."[18] However, the Navy has continued to decline to change its cleanup standards for buildings.

The Navy itself estimates the risk from exposure inside buildings at its cleanup levels to be in excess of the 12 millirem/year EPA says is automatically considered non-protective for a number of radionuclides.[19] Its estimates are from a non-EPA source, RESRAD-Build, when it is supposed to use EPA's instead. We have therefore run EPA's Dose Compliance Calculator, and the results are presented below.

Dose Estimates from EPA's Building Dose Compliance Calculator (DCC) for External Exposure Inside Buildings at Navy's Hunters Point Cleanup Levels				
Radionuclide	**Navy's Hunters Point Cleanup Levels for for External Exposure Inside Buildings (pCi/cm²)**	**EPA Building DCC (pCi/cm² that will produce 1 mrem/yr)**	**EPA DCC Dose Estimate (mrem/yr) for Navy's Hunters Point Building Cleanup Levels**	**Equivalent Number of Chest X-Rays Per Year**
Americium-241 (Am-241)	0.45	0.53	0.8	0.4
Cesium-137 (Cs-137)	22.52	1.04	**21.7**	**11**
Cobalt-60 (Co-60)	22.52	0.12	**186**	**93**
Europium-152 (Eu-152)	22.52	0.16	**137**	**69**
Europium-154 (Eu-154)	22.52	0.20	**112**	**56**
Plutonium-239 (Pu-239)	0.45	0.66	0.7	0.3
Radium-226 (Ra-226)	0.45	0.24	1.8	1
Strontium-90 (Sr-90)	4.50	46,800	0.0001	0
Thorium-232 (Th-232)	0.16	0.12	1.3	0.7
Uranium-235 +D (U-235)	2.20	0.66	3.3	2
mrem= millirem				
pCi= picocuries				
DCC= dose compliance calculator				

From external exposures alone inside buildings (ignoring the risk from exposure to radioactive dust discussed in the next section), the dose estimates are **the equivalent of 11 chest X-rays per year from cesium-137 at the Navy's allowable level, 93 chest X-rays annually from cobalt-60, 69 chest X-rays annually from europium-152, and 56 chest X-rays annually from europium-154**. **It is hard to conceive the public would be comfortable re-occupying these former Hunters Point Shipyard buildings if told that the standards the Navy is using to clean them up allowed residual contamination sufficient to cause occupants to receive the equivalent of a chest X-ray a week, week after week, year after year.** If presented in a clear fashion, such as that below, rather than in the opaque terms of "5000 dpm/100cm^2" as found in the Navy's cleanup tables, the public might not find such weak cleanup standards very reassuring.

One should note that the Navy used similar standards for allowing radioactive debris from the demolition of nuclear buildings, and contaminated equipment and debris, to be sent for recycling, where it could be melted down into, for example, the consumer metal supply, and to regular landfills not licensed or designed for radioactive wastes. In addition to the grossly weak standards, of course, is the problem that even at those elevated release criteria, Tetra Tech appears to have fabricated many of the measurements, which could result in even higher levels of exposures within buildings and from materials sent out for recycle or disposal.



C. The Navy's Cleanup Levels for Removable Radioactive Contamination in Buildings

1. Vastly Weaker Than Current EPA Building PRGs for Removable Contamination

As indicated earlier, there are two primary exposure pathways inside buildings: direct external exposure from penetrating radiation on building surfaces, and exposure (e.g., inhalation or ingestion) from removable contamination inside the buildings (radioactive dust). Separate cleanup standards are established for each. We have just examined the Navy's standards for external exposure limits against those it was supposed to use from EPA's Building PRG Calculator. We now perform the same exercise for the limits for removable contamination. We have done what the Navy should have done, run EPA's Building PRG Calculator for removable contamination. As one readily sees, the standards the Navy has been using are thousands of times weaker than the

EPA BPRG values.

Comparison Between Navy's Hunters Point Cleanup Levels and EPA Preliminary Remediation Goals (PRG) for Removable Contamination in Buildings			
Radionuclide	Navy's Hunters Point Cleanup Levels for Buildings (dpm/100 cm²)	EPA Building Preliminary Remediation Goal (dpm/100 cm²)	How Many Times Less Protective (Weaker) is the Navy's HPS Cleanup Levels than the EPA Building PRG
Americium-241 (Am-241)	20	0.02	**919**
Cesium-137 (Cs-137)	1000	0.78	**1283**
Cobalt-60 (Co-60)	1000	0.74	**1345**
Europium-152 (Eu-152)	1000	0.54	**1854**
Europium-154 (Eu-154)	1000	1.17	**855**
Plutonium-239 (Pu-239)	20	0.02	**980**
Radium-226 (Ra-226)	20	0.01	**3288**
Strontium-90 (Sr-90)	200	0.26	**783**
Thorium-232 (Th-232)	7.3	0.01	**612**
Uranium-235 +D (U-235)	97.6	0.02	**4148**
dpm= disintegrations per minute			

As seen above, the Navy is allowing roughly <u>a thousand times higher concentrations</u> of removable contamination of each of the following than the EPA BPRGs: americium-241, cesium-137, cobalt-60, europium-152, europium-154, and plutonium-239. The Navy value for strontium-90 is 783 times less protective and for thorium-232 its cleanup level is 612 times weaker than the EPA BPRG. Radium-226 is allowed a stunning 3288 times higher concentrations than the BPRG, and uranium-235 4148 times higher.

Again, the Navy has been relying on a 45-year-old guidance document from the long-defunct Atomic Energy Commission that was never risk-based, instead of using EPA's BPRG Calculator as required by CERCLA and EPA guidance for Superfund sites. By having done the comparisons the Navy has to date refused to perform, one can see why – had the Navy used compliant standards, far more cleanup would be required. On the other hand, people living or working in buildings that were released under these woefully inadequate standards, or exposed to contaminated materials recycled or dumped in places not licensed or designed for radioactive waste, may be exposed at levels far in excess of what is appropriate.

2. Cancer Risks Associated with the Navy Cleanup Levels for Removable Contamination Inside Buildings Far Exceed Primary Risk Goals as Well as the Upper Limit of Acceptable Risk

Using the EPA BPRG Calculator in risk output mode generates risk estimates for removable contamination at the level the Navy has been allowing for each specified radionuclide in buildings. The goal, again, is supposed to be one-in-a-million (10^{-6}). As seen below, most radionuclides individually exceed that risk level by about a factor of a thousand, and two by several thousand.

Cancer Risk Estimates from EPA's Building Preliminary Remediation Goal (BPRG) Calculator for Exposure to Removable Contamination Inside Buildings at Navy's Hunters Point Cleanup Levels				
Radionuclide	**Navy's Hunters Point Cleanup Level for Buildings (pCi/cm²)**	**Risk to Residents Using EPA Building PRG Calculator**	**How Many Times Higher Cancer Risk is the Navy's Hunters Point Cleanup Levels than EPA's Maximum Allowable Risk Level (1 in 10,000)**	**How Many Times Higher Cancer Risk is the Navy's Hunters Point Release Criterion Than EPA's Risk Goal (1 in 1,000,000)**
Americium-241 (Am-241)	0.090	9.2×10^{-4}	9	**920**
Cesium-137 (Cs-137)	4.505	1.28×10^{-3}	13	**1280**
Cobalt-60 (Co-60)	4.505	1.34×10^{-3}	13	**1340**
Europium-152 (Eu-152)	4.505	1.86×10^{-3}	19	**1860**
Europium-154 (Eu-154)	4.505	8.55×10^{-4}	9	**855**
Plutonium-239 (Pu-239)	0.090	9.8×10^{-4}	10	**980**
Radium-226 (Ra-226)	0.090	3.29×10^{-3}	33	**3290**
Strontium-90 (Sr-90)	0.901	7.81×10^{-4}	8	**781**
Thorium-232 (Th-232)	0.033	6.13×10^{-4}	6	**613**
Uranium-235 +D (U-235)	0.440	4.14×10^{-3}	41	**4140**
Total Risk		**1.59×10^{-2} = 1 out of 63 people will get cancer**		
pCi= picocuries				

The upper limit of acceptable risk, 1 in 10,000 (10^{-4}) is exceeded individually by every radionuclide the Navy lists, by as much as a factor of forty-one. Since one can have a mix of radionuclides in the contaminated dust, the collective risk from removable contamination inside buildings at the Navy cleanup levels, not counting the external exposure risk, is an astonishing 1.59×10^{-2}. **In other words, at the levels of removable contamination permitted by the Navy's standards, <u>every sixty-third person exposed is predicted by EPA's BPRG Calculator to get a cancer from that exposure</u>. This risk level is absolutely extraordinary – more than ten thousand times the basic risk goal and more than a hundred times higher than the upper limit of what is considered by EPA an acceptable risk. It is hard to conceive how the Navy could explain to people that a cleanup goal based on such an astronomically high risk could possibly be OK.**

3. Radiation Dose from Exposure To Radioactive Dust Inside Buildings at the Navy Cleanup Levels Far Exceeds What is Acceptable—It is the Equivalent of Many Unneeded Chest X-rays Per Year

As we have seen previously, the doses from the Navy's allowable limits for contamination in buildings, in this case for radioactive dust, far exceed what EPA deems "non-protective." As shown in the table below, using EPA Building Dose Compliance Calculator to estimate doses at the Navy's cleanup levels, every radionuclide individually, and far more so when in combination, exceeds the upper limit deemed non-protective. **The doses are extraordinary; for uranium-235, for example, the equivalent of 248 chest X-rays annually. If there are several radionuclides present, as is likely, the dose at the Navy's free-release criteria levels would significantly exceed the equivalent of a chest X-ray daily, for years or decades.**

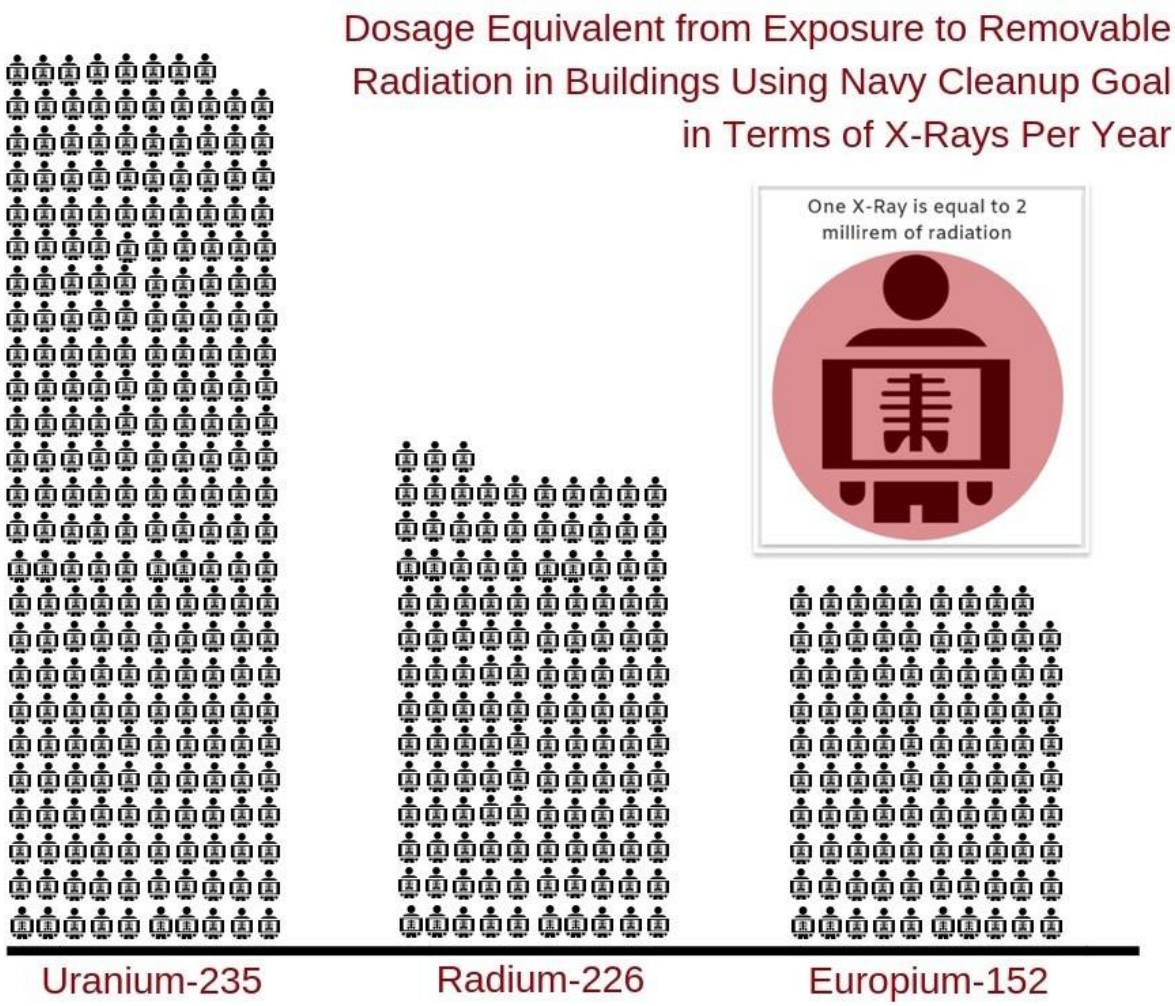
Dose Estimates from EPA's Building Dose Compliance Calculator (DCC) for Navy's Hunters Point Cleanup Levels for Exposure to Removable Contamination from Buildings

Radionuclide	Navy's Hunters Point Cleanup Levels for Buildings (pCi/cm^2)	EPA Building DCC (pCi/cm^2 that will produce 1 mrem/yr)	EPA Building DCC Dose Estimate for Navy's Hunters Point Ceanup Levels (mrem/yr)	Equivalent Number of Chest X-Rays Per Year
Americium-241 (Am-241)	0.0901	0.0008	109	**55**
Cesium-137 (Cs-137)	4.5045	0.0786	57	**29**
Cobalt-60 (Co-60)	4.5045	0.1320	34	**17**
Europium-152 (Eu-152)	4.5045	0.0229	197	**99**
Europium-154 (Eu-154)	4.5045	0.2710	17	**8**
Plutonium-239 (Pu-239)	0.0901	0.0007	125	**63**
Radium-226 (Ra-226)	0.0901	0.0003	265	**133**
Strontium-90 (Sr-90)	0.9009	0.0276	33	**16**
Thorium-232 (Th-232)	0.0329	0.0005	64	**32**
Uranium-235 +D (U-235)	0.4396	0.0009	496	**248**

mrem= millirem

pCi= picocuries

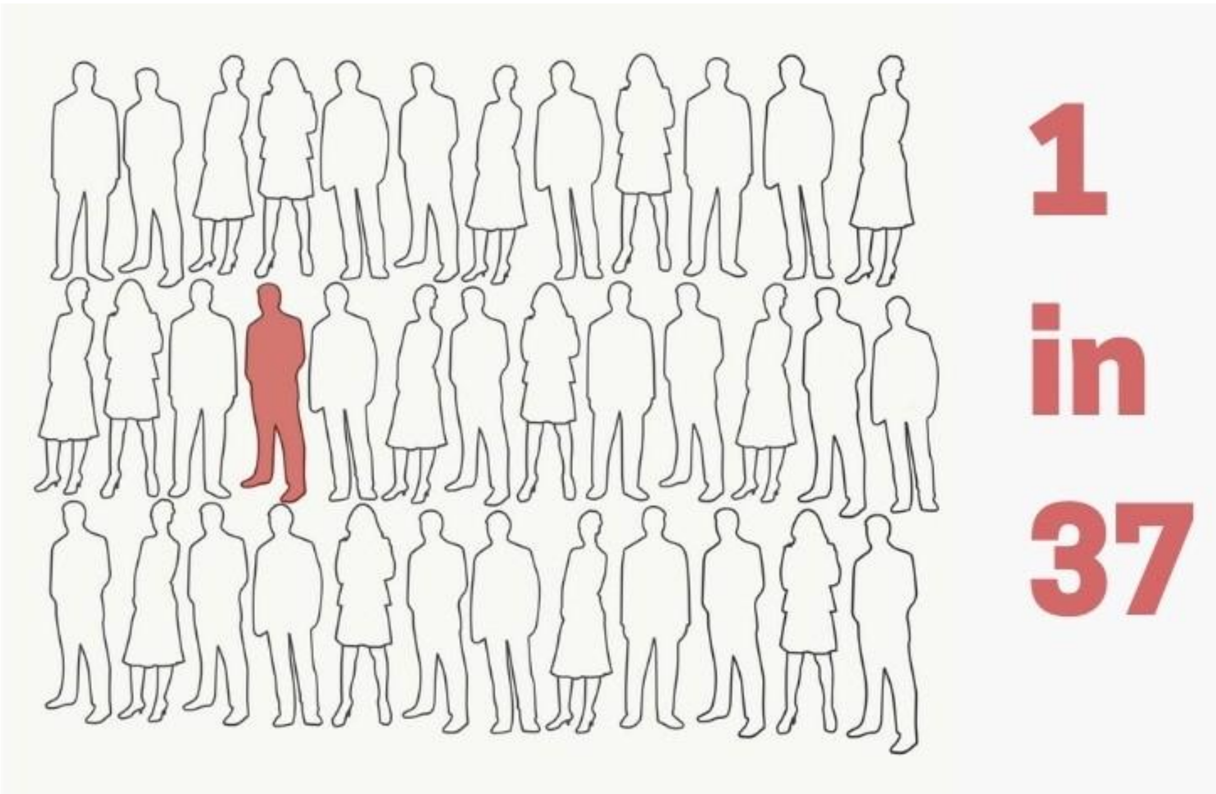
DCC = dose compliance calculator



D. Risk from Exposure to Combined External Radiation and Removable Contamination in Buildings

Under the Superfund law – and in real life – risk is associated with the combination of all contributors to it. If one is working or living in a building that is producing both external radiation from surfaces and has contaminated removable contamination (dust), one's risk is additive from both. Judging the adequacy of cleanup standards is done in part by examining the risk from what is allowed, and that is in this case both how much external exposure one is permitted plus how much exposure to radioactive dust is allowed by those standards without measures being required to be taken to clean up the contamination.

The combined risk from the external and removable contamination allowed under the Navy's building cleanup standards is an astonishing 1 in 37. If the external radiation and removable contamination inside former nuclear buildings at HPS never exceeded the Navy's level requiring cleanup, the combined risk would be about 2.7×10^{-2}, or 2.7 people getting cancer from that exposure for every 100 people exposed at that level—every 37^{th} person exposed getting a cancer from that exposure. This is astronomically higher than any risk level considered acceptable for the public. (To be clear, this is the *excess* cancer risk, the risk in addition to the existing risk one has without the exposure.)



No one is asserting that this is the true risk for people in re-purposed buildings at Hunters Point, or that the separate risk from exposure to soil at the Navy cleanup levels of 1 in 380 is the true risk from actual soil contamination. **One simply does not know what that risk is, because Tetra Tech is accused of falsifying most of the measurements that were made, and the great majority of Hunters Point was never sampled in the first place.**

But this is what the risk would be at the contamination levels the Navy deemed acceptable, i.e., not requiring cleanup. It does not include the risk from the unacceptably weak cleanup levels for soil, nor for the risk from the radionuclides for which no limits were set at all, nor from the chemical contamination, all of which should be added together. Nor does it include the risk from contamination above even these very weak cleanup levels that Tetra Tech may have failed to remediate because of measurement fabrication

What this shows, however, is the grossly non-protective nature of the cleanup levels employed at Hunters Point Shipyard.

E. If the Navy Finally Complies and Uses EPA's PRG and BPRG Calculators for Evaluating and Establishing Cleanup Criteria, It May Attempt to Alter the Default Inputs Inappropriately

EPA's PRG and BPRG Calculators are set to default to certain standard assumptions. The calculations presented in the main body of this report used those standard defaults (with one exception discussed in more detail below).

One is permitted to alter inputs to the Calculators if there are good site-specific reasons to do so. If the Navy, many years after it was supposed to, and after at least four recent directives from EPA that to date it has ignored, finally performs and releases cleanup standard evaluations using the PRG and BPRG Calculators, there is a chance, if past patterns continue, that it may attempt to alter various default inputs in an effort to produce a more desirable outcome, i.e., higher (less protective) cleanup standards that would reduce cleanup obligations. The question is whether such alterations, if made, would be technically defensible.

We are at an obvious disadvantage having to try to anticipate changes the Navy might make to the default inputs in the EPA PRG and BPRG Calculators, were it to finally use them as they were supposed to have, beginning so long ago. At minimum, such analyses are supposed to be in the Navy's Five-Year Reviews, but the Navy failed to perform them, including in the most recent draft Five-Year Review issued for public comment (the comment period for which has now closed). Since the Navy hasn't done so, in the interest of completeness we here discuss possible input changes the Navy might nonetheless attempt.

BPRG Calculator Inputs

We are aware of three changes to the default inputs for the BPRG Calculator that the Navy has already proposed, were it to at some point do the calculations. These were apparently put forward by the Navy in a conference call with EPA on September 5, 2018, and EPA's decisions are set forth in its September 21, 2018, comments on the Navy's draft Five-Year Review at pp. 4-5. Two of the three proposed alterations were rejected by EPA (although one does not know if EPA will stick to its guns on either or both if pushed further by the Navy).

The Navy asked first of all to change an assumption for dust/removable contamination in the BPRG to presume all the surfaces in the building to be hard surfaces instead of the default mix of hard and soft surfaces. EPA OK'd this change, and we have used it in the BPRG calculations presented in this report. It is the only change to the defaults we have made, and it was one proposed by the Navy and approved by EPA.

Secondly, the Navy asked to add a dissipation rate to the model for removable contamination; i.e., to assume that the level of contamination inside the building goes down dramatically over time. EPA rejected this proposal, noting in part "Not having a dissipation factor also ensures that if by chance contamination does get back into the home that recontamination is accounted within the model" and that the BPRG Calculator Users Guide "warns users about adding a dissipation rate." The Navy, however, may not give up and may still try to push for such a dissipation rate, at some point putting forward what is claims are data from Hunters Point. Given its history of, for example, choosing skewed background data (e.g., taken from potentially contaminated areas), such asserted data should be viewed with significant skepticism. Furthermore, while there may indeed be some mechanisms whereby removable contamination levels decrease over time, there are, as EPA pointed out, other mechanisms whereby outside contamination can be brought into the building, increasing rather than decreasing levels inside. For example, much of Hunters Point soil is contaminated, and with substantial excavation, construction and remediation activities, contaminated soil particles can readily be resuspended and flow into homes or otherwise be tracked in over many years. Assuming depletion or dissipation of contamination in the structures would be questionable.

Thirdly, “the Navy suggested that the transfer factor for hard surfaces of 0.5 be reduced to 0.2 since ‘20% removable’ is what has been assumed [by the Navy] at Hunters Point....” EPA rejected this request, saying, “With extensive research conducted for hard surfaces at the World Trade Center, EPA cannot deviate from the default of 0.5 for hard surfaces.” However, once again, the Navy may come back with purported data from HPS suggesting there is something special about the hard surfaces inside buildings there to argue for ignoring EPA’s CERCLA guidance and World Trade Center experience. Such claims should be viewed critically. At present, however, that proposed weakened factor has been rejected.

These three alterations to the defaults for the BPRG Calculator proposed by the Navy are the only ones known publicly, and two of the three have been rejected by EPA. We therefore used the standard EPA defaults, with the one change being that which had requested by the Navy and approved by EPA, the assumption that all interior surfaces are hard surfaces.

Soil PRG Calculator Defaults

In establishing its remedial objectives for soil contamination, the Navy said it was using EPA’s default residential PRGs. [There are two exceptions to this, the Navy says: the special case given it by EPA for radium-226, and the Navy’s subsequent seven-fold increase/weakening of the standard for cobalt-60, to reduce costs in radiation measurements.] As we have seen, in fact the Navy used PRGs from 1991 rather than contemporary ones. Nonetheless, the Navy position was that whatever PRGs it used, they were based on the defaults for residential use. It would thus be inappropriate to now, if running the current PRG Calculator, change those defaults.

The Navy might nonetheless try to do so. One approach to try to allow weaker cleanup standards and thus reduce cleanup costs might be to turn off the garden inputs in the Calculator. One residential exposure pathway is consumption of, say, lettuce or tomatoes from a backyard or community garden or apples or oranges from a fruit tree. If they are growing at a location that is contaminated and has not been fully cleaned up, radionuclides can concentrate in the fruit or vegetables and add to the residents’ exposures.

It is possible that the Navy might quietly attempt to turn off those defaults in the Calculator. That would be inappropriate.

First of all, more than one parcel, including Parcel A which has significant numbers of residents on it, was released *without restrictions.* In other words, there are no prohibitions on growing fruit or vegetables. On a recent trip to Parcel A, for example, we visited residents in a house; across the street, a block away, vegetables and fruit tree grow.

Source: Google Maps Street View

Source: Linda Parker Pennington

Source: Linda Parker Pennington

Additionally, in the neighboring Bayview-Hunters Point area, there are numerous community gardens, attempting to address the "food desert" problem. For example, note the recent KCBS report, "Community Gardeners Come Together in Bayview-Hunters Point Neighborhood."[20] See also, regarding community gardens in the neighborhood, "Transforming the Land-- One Garden at a Time" by Crystal Carter.[21] See also KQED, "Teens in San Francisco's Bayview Find Haven in Garden," and the photos therein. https://www.kqed.org/stateofhealth/135966/teens-in-san-franciscos-bayview-find-haven-in-garden. As the story says, "On a sunny day in San Francisco's southeast corner, a group of teenagers are getting ready to plant strawberries and build raised garden beds in a small plot of land **blocks away from the former Hunters Point Naval Shipyard**." (emphasis added)

The community gardens grow a wide array of crops. See, e.g., the Quesada Gardens below, http://www.quesadagardens.org/projects.php:

Source: Quesada Gardens[22]

Source: Quesada Gardens[23]

There is thus no basis for turning off the garden inputs in the PRG Calculator. If anything, with the presence of community gardens in the area, the inputs should perhaps be increased.

The Navy may claim that some parcels will eventually have institutional controls regarding gardening. We will discuss that issue in detail in a subsequent report. But suffice it to say here those controls do not prohibit gardens. They require, for example, growing them in raised beds (which are generally about 8 inches), and/or on top of a couple of feet of clean dirt. But roots for many plants extend far deeper, and evapotranspiration can draw contaminants up from deeper in the soil profile into the plants.

To check the impact of assuming reduced gardening—which does not seem justified given the actual situation in the area, described above—we have performed PRG runs in which half or more of the fruits and vegetables were eliminated, leaving the risk drivers. It produces very little change in the results. It increases the PRG for strontium-90 and radium-226 by a mere 15%, for example, and for plutonium-239 by 23%, trivial in the context of PRGs that are hundreds of times more protective than the cleanup values being employed by the Navy at HPS. We have also run the Calculator with a two foot clean soil cover; for most of the radionuclides of particular concern, it makes little difference. The assumption of a cover would in any case be inappropriate for parcels which have no restrictions; for others, it is not really realistic either, in that in order to do the development planned at HPS construction will dig through them and soil moved around significantly. We discuss these issues further in our report on institutional controls.]

We note that there are some conservatisms built into the EPA models. That is as it should be, because there are also non-conservatisms. For example, the models don't take into account risks from the significant amounts of radioactively contaminated soil being released into the air from the large amount of excavation, construction, and remediation occurring and that will continue to occur at the site. Furthermore, even the normal resuspension pathway, for example, is arbitrarily set as involving only half an acre, when the potentially contaminated area at HPS is hundreds of acres. And, as we have seen, PRGs keep tightening as the science of radiation danger demonstrates greater risks than thought before. [One should keep in mind also that the Navy has excluded most radionuclides of concern at HPS from any cleanup limits at all.] Some level of conservatism is therefore appropriate to compensate for the non-conservatisms.

In summary, with the minor exception of the hard surface assumption in buildings that the Navy asked to change and EPA OK'd, there seems no reason at present to change any of the default assumptions in the PRG and BPRG Calculators. If anything, there are non-conservatisms that might result in underestimating risks.

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[1] The cleanup standards all are taken from or refer back to a 2006 document, Final Basewide Radiological Removal Action, Action Memorandum, Hunters Point Shipyard, San Francisco, CA, as their initial source. The copy posted on the Envirostor database for HPS documents begins with a Tetra Tech transmittal memorandum.(https://www.envirostor.dtsc.ca.gov/public/deliverable_documents/1402066886/Basewide%20Rad%20Removal%20Action%20Memo_Final%204.21.06.pdf) We have twice emailed the Navy's Derek Robinson requesting confirmation that Tetra Tech prepared the document, but have received no response. All subsequent Hunters Point Records of Decision and other documents setting cleanup standards simply incorporated these earlier numbers (with one exception, a further weakening of the cobalt-60 standard), without updating them to reflect current EPA values.

[2] EPA Preliminary Remediation Goals for Radionuclides, https://epa-prgs.ornl.gov/radionuclides/

[3] EPA Preliminary Remediation Goals for Radionuclides in Buildings (BPRG), https://epa-bprg.ornl.gov/

[4] https://epa-dccs.ornl.gov/cgi-bin/dose_search

[5] See for example, *Radiation Risk Assessment at CERCLA Sites: Q&A*, OSWER 9285.6-20, June 13, 2014.

[6] The use of 1991 PRGs rather than current ones is not readily disclosed in the Navy documents, but rather is buried in the list of references to the 2006 document in which the values first appear and which are subsequently used repeatedly in decision documents long after.

[7] The 2006 document indicates the source for the cleanup values are the EPA PRGs. PRGs by definition are concentrations that will produce a one-in-a-million risk.

[8] For example, when the first standards were adopted by the Navy in 2006, supposedly based on EPA PRGs, the actual PRG at the time was twice as protective for cesium-137 as the value used by the Navy.

[9] Note that in this table and others in this report, ratios may vary slightly because of rounding of values. Note also that the Navy has continued to try to quietly weaken even its original, weak PRGs by altering the remediation objectives in footnotes to extraneous documents other than and subsequent to the Records of Decision. For example, it has recently added new footnotes to cleanup tables saying not just the radium-226 value is the increment above background, but the cleanup levels for all radionuclides is the increment above background. See, e.g., footnote 2 of Table 3 of *Final Remedial Action Completion Report: Remedial Action in Parcel D-1 Phase I* , April 2018. This violates the RODs and EPA policy, which set the PRGs as the actual measured concentration, including background, not the increment above.

[10] Radiation Risk Q&A, *supra*.

[11] EPA in its "Blue Book" gives the risk per unit dose of radiation as 1.16×10^{-3} cancers/rem or 1.16×10^{-6} cancers/millirem. Thus one millirem accumulated dose is roughly a one-in-a-million risk. 30 years of exposure at 0.03 millirem/year thus produces a one-in-a-million risk. Actually a lower dose applies, since EPA assumes exposure of children, and the child's risk per unit dose is higher than for adults.

[12] See note above.

[13] 2006 Table 1 Release Criteria.

[14] A single Posterior-Anterior (PA) chest X-ray is about 2 millirem. See, e.g., FDA: https://www.fda.gov/radiation-emittingproducts/radiationemittingproductsandprocedures/medicalimaging/medicalx-rays/ucm115329.htm

[15] NAVFAC HPNS, *More Information on Radiation*, April 2015.

[16] See, e.g., EPA, *Role of Background in the CERCLA Cleanup Program*, OSWER 9285.6-07P, April 2002 and the Users Guide to EPA's PRG Calculator, section 3.2.

[17] The BPRG Calculator in risk output mode gives the collective risk as 9.75×10^{-3}, or in round numbers, 10^{-2} (1 in 100).

[18] See e.g., Parcel B ROD, January 2009, Table 8-4.

[19] Table 1, 2006 Action Memo.

[20] https://kcbsradio.radio.com/media/audio-channel/community-gardeners-come-together-bayview-hunters-point-neighborhood, September 29, 2018.

[21] https://www.reimaginerpe.org/17-2/carter, Weaving the Threads, Fall 2010, last accessed October 28, 2018.

[22] Permission for use of the photograph was granted by Shane King, Quesada Gardens Director, by email October 29, 2018.

[23] *ibid.*

Conversions for External Radioactive Exposure from Contaminated Structures

Radionuclide	Navy's Hunters Point Cleanup Level for Structures in dpm/100 cm^2	Navy's Hunters Point Cleanup Level for Structures in pCi/cm^2	EPA Building Preliminary Remediation Goal in pCi/cm^2	EPA Building Preliminary Remediation Goal in dpm/100 cm^2
Americium-241 (Am-241)	100	0.45	0.0265	5.88
Cesium-137 (Cs-137)	5000	22.52	0.0505	11.21
Cobalt-60 (Co-60)	5000	22.52	0.0057	1.27
Europium-152 (Eu-152)	5000	22.52	0.0078	1.74
Europium-154 (Eu-154)	5000	22.52	0.0096	2.14
Plutonium-239 (Pu-239)	100	0.45	0.0323	7.17
Radium-226 (Ra-226)	100	0.45	0.0121	2.69
Strontium-90 (Sr-90)	1000	4.50	13,900.0000	3,085,800
Thorium-232 (Th-232)	36.5	0.16	0.0060	1.33
Uranium-235 +D (U-235)	488	2.20	0.0323	7.17

pCi= picocuries

dpm= disintegrations per minute

1 pCi/cm^2 = 222 dpm/100 cm^2

Conversions for Exposure to Removable Contamination (Dust) from Hard Surfaces in Buildings*

Radionuclide	Navy's Hunters Point Cleanup Levels for Removable Contamination in Buildings (dpm/100 cm²)	Navy's Hunters Point Cleanup Levels for Structures in pCi/cm²	EPA Building Preliminary Remediation Goal for Removable Contamination Inside Buildings (pCi/cm²)	EPA Building Preliminary Remediation Goal in dpm/100 cm²
Americium-241 (Am-241)	20	0.09	0.00010	0.02
Cesium-137 (Cs-137)	1000	4.50	0.00351	0.78
Cobalt-60 (Co-60)	1000	4.50	0.00335	0.74
Europium-152 (Eu-152)	1000	4.50	0.00243	0.54
Europium-154 (Eu-154)	1000	4.50	0.00527	1.17
Plutonium-239 (Pu-239)	20	0.09	0.00009	0.02
Radium-226 (Ra-226)	20	0.09	0.00003	0.01
Strontium-90 (Sr-90)	200	0.90	0.00115	0.26
Thorium-232 (Th-232)	7.3	0.03	0.00005	0.01
Uranium-235 +D (U-235)	97.6	0.44	0.00011	0.02
pCi= picocuries				
1 pCi/cm² = 222 dpm/100 cm²				
dpm= disintegrations per minute				

*Note: The EPA BPRGs for dust cited here are those using the EPA defaults with one exception: the EPA and the Navy on September 5, 2018, agreed to one change in the defaults, to assume all surfaces are hard (e.g. walls) and none are soft (e.g., carpeting),), so that 16 hours per day is exposure to hard surfaces rather than the default of 8 hours each for soft and hard surfaces. This was the only change to the defaults reported by EPA in its comments on the Draft Five-Year Review as acceptable at that time to EPA. We have incorporated that one change in the defaults here.