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Health Risks from Supposedly Remediated US Hazardous-Waste Sites: An Early-Warning Signal

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Abstract

Scientific data are almost nonexistent regarding the health-protectiveness of most hazardous-waste-site remediation. Given this data-gap, recently the World Health Organization (WHO) urged scientists to develop methods of "cost-efficient health surveillance" of toxics' cleanups, including any "illegal operations". Following WHO, this article's **importance** is to develop one such cost-efficient method. Given the **assumption** that remediators'-redevelopers' **public misrepresentations** of their cleanups' safety may warrant independently assessing the health-adequacy of their remediation, the article asks the **question:** "For US hazardous-waste sites, deemed by the courts 'Imminent and Substantial Endangerment' (ISE) health threats, are remediators' *public* representations of testing-cleanup quality consistent with what their more *private* technical documents say?" The **working hypothesis** is that for representative toxic sites, remediators'-redevelopers' public representations of cleanup often contradict their private technical documents. Using the US Environmental Protection Agency (EPA) weight-of-evidence **method**, the article (1) develops 5 transparent, reproducible criteria for discovering representative, ISE-designated, US toxic-waste sites; (2) develops 3 transparent, reproducible criteria to discover remediators'-redevelopers' *public* representations of their testing-cleanup; (3) uses these 3 criteria to discover what remediators'-redevelopers' *private* or technical documents say about the health-adequacy of their testing/cleanup; (4) investigates whether any *public* representations in (2) contradict any of (3)'s private or technical documents; and (5) discusses the degree to which such contradictions, if any, suggest waste-site threats to health or environmental justice. Our **results** show that for the representative hazardous sites assessed, many remediator-redeveloper public guarantees of testing-cleanup quality contradict their private or technical documents. The **discussion** suggests that such contradictions likely violate EPA scientific-integrity regulations, threaten public health, jeopardize environmental justice, thus may require independent investigation of the adequacy of testing-cleanup. For representative, US toxic-waste sites, posing court-determined ISE, remediators'-developers' **public** representations of testing-cleanup quality threaten health by often contradicting their **private** technical documents. The article closes by outlining two scientific strategies to promote health-protective, hazardous-waste testing/remediation.

Keywords

Waste cleanup; imminent and substantial endangerment (ISE); scientific integrity; Trammell Crow; waste remediation

1. Introduction

Throughout the world disproportionate numbers of children, minorities, and poor people---members of environmental-justice (EJ) communities---typically live near hazardous-waste sites [1]. In the US most Blacks, most Hispanics, most below-poverty-level residents, most people with less than a grade-12 education, and most nonspeakers of English live within three miles of such a site, although each group is only a small minority of the US population [2]. Because a majority of the members of such EJ communities lives near toxics facilities, they also face higher rates of cancer, birth defects, and other health problems [3], eg., [4].

Apart from EJ, hazardous-waste facilities often harm health because in the US, 45 percent of the population lives within three miles of a toxic site [2], most of which have never been remediated, many for half a century [5, 6]. Moreover, there is little/no US government oversight of cleanup [7]. Perhaps as a result, in the state of Massachusetts (one of only three US states that audits toxics remediation) roughly 70 percent of supposedly remediated facilities may threaten health and violate health-safety regulations. Partly because the contents of such limited audits are private, there is no comprehensive, systematic, scientific literature on the public-health-protectiveness of hazardous cleanups [8]. Instead, there are only audit pass-fail rates from three states plus a handful of single-site, post-cleanup empirical studies, typically conducted by government, usually only in response to public or political pressure caused by post-remediation, near-site deaths or health problems [3, 8, 9].

Obviously, however, society needs quick, proactive, inexpensive evaluations of the health-effectiveness of all toxic-waste cleanups. The current policy, waiting to check a hazardous-site cleanup until post-remediation cancers or birth defects appear, is "too little, too late" to protect health [10]. This article's **importance** is in developing and illustrating one such proactive, inexpensive evaluation of the health-effectiveness of claimed toxics' remediation.

1.1 The Waste-Remediation Data Gap

For at least three additional reasons, "little is known" about whether the mostly privatized US toxic-waste cleanups actually protect health [8, 11]. *First,* the high costs of cleanup mean both that roughly 80 percent of US hazardous-waste sites are unremediated, and that the federal government cannot fund most assessment-cleanup. Much US toxic-site remediation was formerly financed by a tax on the US chemical and petroleum industries, until the tax expired in 1995 [6]. Given current inadequate waste-remediation funding, the US government appears more concerned with incentivizing cleanup of the 80 percent of unremediated toxic sites, than with overseeing the quality of remediation supposedly completed in 20 percent of US sites [11].

Second, although US states differ in the degrees to which their toxic-waste cleanups are privatized (the degrees to which remediation functions such as permitting, testing, cleanup, oversight, and enforcement are outsourced to for-profit developers or remediators), most US remediation is privatized, typically performed by toxic-site redevelopers [12, 13]. As a result, private, for-profit interests typically control testing-cleanup results, even audit results in the three states that conduct audits; they typically do not make results available to the public, perhaps to avoid corporate liability. Yet without either site data or conducting additional expensive, independent empirical testing, it is unknown whether or not remediation protects health. The methods section of this study shows one way to overcome this data difficulty. It develops and illustrates a cost-efficient, early-warning method to detect possible "dirty cleanups".

Third, because most remediation is privatized [6, 12, 13] and US government oversight of toxic-waste cleanup is minimal, no systematic, comprehensive government-oversight documents exist for most waste-remediation sites [7].

Fourth, information on cleanups' health effectiveness also is limited because there are few data on most mechanisms and pathways of nearby-human exposure to hazardous-site contaminants, either pre- or post-remediation [14].

1.2 Four Types of Limited Remediation Studies

Given the preceding data gaps, there are only four types of limited-scope, systematic studies of remediation: (a) near-site **health-parameter tests**; (b) **government audits** of privatized clean-ups in three US states, (c) independent scientific **data-quality audits**, and (d) independent **single-site contaminant testing**. Studies (a) are the most common post-remediation assessments [10, 14-18]. They take a bodily-contaminant level as the dependent variable, and pre/post cleanup-time periods as the independent variable, without checking whether or what cleanup occurred.

Despite such obvious flaws, type-(a)-study authors claim, for instance, "to investigate the effect of soil remediation on children's blood" level of contaminants near hazardous-waste sites [10]. Yet clearly such test results could indicate not only remediation effects, but also faulty-remediation effects, null effects, or some mixture of all three, given at least 6 facts. Studies of type (a) typically involve (1) no information on exposure levels, pathways, media, or populations, (2) no empirical assessment of pre-/post-site-cleanup contaminants, (3) no controls for confounders, (4) no independent empirical measures of remediation effectiveness, (5) a focus only on blood-lead levels, attributable to many factors besides toxic sites, and (6) results that show no/mixed health-parameter improvement after supposed waste-site remediation [14, 15, 18].

Type-(b) studies (state-required toxics-cleanup audits in Connecticut, Massachusetts, and New Jersey) audit only a small percentage of annual remediations (10% in New Jersey, 20% in Massachusetts, no specified percentage in Connecticut) [7, 19]. Moreover, when states conduct audits, their contents are available only to the parties involved, and they typically include only paperwork reviews, not testing/empirical assessment/site visits [7, 19]. Yet audits in these three states show that only 13-29% of sampled cleanups meets basic health-regulatory requirements, thus passes the audit [7, 19]. Yet, though most clean-ups fail the audit, there has been no increase in percentage of sites audited. Even worse, most states mandate no such remediation-audit [20].

Type-(c) studies show that testing-cleanup documents for small, representative samples of US hazardous-waste sites often fail to meet standards of data-quality analysis [21]; empirical-data audits [22]; and data-usability analysis [23]. These studies provide quick, cost-effective insights into remediation quality, but no empirical testing. The method used in the current study is another cost-effective method.

Type (d) studies, eg, [24-29], are the rarest, most expensive, but theoretically most credible assessments of toxics remediation. They are independent (of interested parties) empirical tests of post-cleanup, hazardous-site-contaminant levels before any confirmed harm has occurred.

1.3 Purpose of This Article, Question to Be Addressed, and Hypothesis

Given neither testing-cleanup of most hazardous sites, nor confirmation of health-protective remediation, the World Health Organization (WHO) recently called for preventing toxics threats by developing methods of “cost-efficient health surveillance” of cleanups and illegal operations [8]. Although most of the world's worst toxic hot spots are in lower-income countries [30], data/economics gaps present major obstacles to reliable investigation of remediation in these nations. Even for US hazardous-waste sites, the cleanup-data gap is too large to allow health evaluation of remediation, mainly because most US states make no privatized-site-remediation documents available. As a result, this article begins by investigating only part of the remediation health-protectiveness issue, using only a cost-effective method, and only for states that make all toxic-site-testing/cleanup documents available.

Following WHO, this article’s **importance** and **purpose** is to develop and illustrate one first-step, cost-efficient, early-warning method of toxics-cleanup surveillance. Based on the **assumption** that remediator-redeveloper misrepresentations of testing/remediation quality may signal potential cleanup problems, this article asks the **question:** “For US hazardous-waste sites that courts designate ‘Imminent and Substantial Endangerment’ (ISE) health threats, are remediators’-redevelopers’ *public* representations of testing/cleanup quality consistent with what their more *private* technical documents say?” The **working hypothesis** for this meta-analysis is that for representative toxic sites, remediators’ **public** representations of cleanup adequacy often contradict their more **private** technical documents. To investigate this consistency, the article uses the US Environmental Protection Agency (EPA) weight-of-evidence method.

2. Materials and Methods

US EPA developed the classic 2016 weight-of-evidence (WoE) **method.** Except for WoE, scientists have virtually no transparent, systematic method for weighing multiple pieces of diverse, often-conflicting lab, field, statistical, epidemiological, and modelling evidence, in order to infer contaminant causality, safety, regulatory failures, or needed regulatory action. As a result, US EPA, most US hazardous-site assessors, and many risk- or environmental-impact assessors typically employ WoE to assess toxic sites, their cleanup, and their likelihood of causing health harm [31].

WoE is essential because answering the article's question cannot easily be accomplished experimentally, through long-term, expensive, randomized, controlled trials covering all environmental media at all US toxic sites. Instead, one cost-effective, initial method is to weight multiple pieces of pre-existing testing-and-cleanup evidence through meta-analysis. The best systematic way to do so is US EPA's three-part WoE method.

WoE proceeds in three main steps. *First*, it requires one to assemble a body of positive and negative evidence regarding some question, e.g., "is (or is not) this representative, toxic-waste-site remediation health protective?"; *second*, to formulate/justify evidence-scoring procedures for the preceding question; and *third,* to evaluate preceding scoring results to answer the assessment question [31] (p.1). The WoE method thus assembles, justifies, scores, and evaluates the scoring of all relevant positive and negative evidence.

The ***materials*** required for this WoE analysis will be discovered through the first part of the WoE Method, discussed in subsequent paragraphs. Next these materials (all technical documents from representative waste-cleanups assessed) will be used to conduct the evaluations that constitute the second and third parts of the WoE Method.

2.1 WoE Method, Part 1: Justifying Relevant Evidence

To discover and justify all relevant evidence regarding whether representative US hazardous-waste remediation is health-protective, we:

(1) develop 5 systematic, reproducible criteria---(a)-(e) in section 2.1.1 below, to obtain a *list of representative US toxic sites;*

(2) develop 3 systematic, reproducible criteria---(i)-(iii) in section 2.1.3 below, to obtain a *list of remediator-developer* ***public*** *representations of toxic sites' testing/cleanup-adequacy*; and

(3) use the same criteria from (2) to obtain *a list of cleanup facts-statements from remediator-developer more* ***private*** *technical documents that reveal the adequacy of testing/cleanup*.

Once we have completed (1)-(3) in WoE Part 1, we shall use WoE Parts 2-3 to determine whether representations in (2)-(3) claim testing-cleanup is complete, follows regulatory standards, or is health-acceptable---or whether they show testing-cleanup is partial, violates regulatory standards, or threatens health. If any responses to (2)-(3) are inconsistent, this inconsistency could be an "early warning sign" that the misrepresented toxic-site poses testing-cleanup or health problems and requires independent testing/cleanup. A major assumption underlying this consistency test (see section 2.4 below) is that if the remediator-developer's more **private** technical documents (3) indicate questionable testing-cleanup that remediators-developers misrepresent in their **public**/regulatory claims (2), then that testing-cleanup may threaten health.

2.1.1 Selection Criteria for US Hazardous-Waste Sites, for (1) Above

To discover and assess evidence for whether remediators' **public**/regulatory statements about waste-site testing-cleanup adequacy are consistent with facts in their more **private** technical <CEQA.net> documents, one must first choose a representative sample of US hazardous sites (numbering up to one million [32]), so as to assess their regulatory and technical documents. To find such sites, we employ 5 criteria, (a)-(e). The toxic sites must:

(a) have privatized cleanup;
(b) be in California (CA), thus have public, government-web-accessible, toxic-site documents;
(c) have testing-cleanup performed by/for Trammell Crow Corporation;
(d) have undergone testing-remediation since 2011;
(e) pose court-determined risks of "Imminent and Substantial Endangerment" to health.

We employ criterion (a) to ensure sample representativeness; most US hazardous-waste testing-cleanup is privatized, as already noted.

We also use criterion (b) to promote sample representativeness and conservativeness because, among US states, CA has: (b1) more US military-hazardous-waste sites [33]; (b2) a reputation for environmental leadership [34] that should provide conservative data regarding whether cleanups are health protective; (b3) one of the two-highest numbers of US CERCLA sites [35], the deadliest US toxic sites; and (b4) the only complete, government-run, online, public, hazardous-waste-site databases, Envirostor dtsc.ca.gov/your-envirostor/, and Geotracker waterboards.ca.gov/water_issues/programs/groundwater/sb4/geotracker/. These two databases and CA city/county websites (containing city-/county-approval documents for city/county toxics cleanups) include all public, regulatory, testing-remediation documents relevant to CA toxic sites. No other US state appears to make all waste-remediation documents available to all. Yet, for at least three reasons, document availability is a necessary condition for analyzing the health adequacy of toxics cleanup. *First*, US EPA has brought many civil/criminal lawsuits for toxic-site health/safety violations, including fraud [36], and WHO specifically requested "cost-efficient" information on hazardous-site "illegal operations" [8]. *Second*, to confirm cleanup misrepresentations, they must be written, in official documents. *Third*, such misrepresentations indicate "missing, weak, or inadequate internal controls" and thus are a classic fraud indicator, say US government overseers [37] (p.2).

We employ criterion (c) above because Trammell Crow Corporation pioneered privatized remediation and is "the industry leader" in toxic-site redevelopment [38]. It is the largest US/global commercial developer [39]; is a subsidiary of the world's largest real-estate services corporation [39]; and therefore likely has economic, scientific, and leadership resources to conduct the best testing-cleanup, without cleanup confounders like limited experience or funding.

We use criterion (d) to ensure an analysis of current waste cleanup. We chose 2011 and later testing/remediation because a key CA toxic-waste-testing-remediation regulatory document appeared in 2011 [40] and is used throughout CA eg., [41].

We use criterion (e) to include hazardous sites that are believed to pose the most serious threats to health, as determined by government regulators' protective ISE court orders [42].

2.1.2 Implementing the Preceding Selection Criteria for Hazardous-Waste Sites

To find hazardous sites that meet selection criteria (a)-(e), we begin by using two CA-government hazardous-waste databases, EnviroStor <dtsc.ca.gov/your-envirostor/> and <CEQAnet>. Envirostor is the online, searchable database of the CA Department of Toxic Substances Control (DTSC), the premier data-management system, including all documents associated with state-controlled, hazardous-site testing/remediation/enforcement, including contaminated US military sites. CEQAnet is the online, searchable database of the State Clearinghouse for CA Environmental Quality Act (CEQA) documents associated with toxic sites' having federal financial assistance/development [41]. CEQAnet is not a comprehensive database, as most CEQA toxic sites have no federal financial/development assistance; instead, most US testing-cleanup is privatized, owing to inadequate government funding [6, 12, 13].

Because the EnviroStor and CEQAnet databases have limited filters that allow no searches for our study-question's keywords, working hypothesis, and selection criteria (a)-(e) from section 2.2.1, one cannot use them for our initial-stage search for CA toxics facilities that meet criteria (a)-(e). Thus, although Envirostor and CEQAnet provide abundant database-documents for CA hazardous-waste sites, they give little help in finding sites that meet criteria (a)-(e).

To generate an initial list of toxic-waste sites, instead one needs at least 6 interdependent search strategies 1-6 that use Envirostor, CEQAnet, several online Trammell Crow lists of its remediation-redevelopment sites, and online searches. Because these transparent, reproducible, database-search strategies 1-6 are complex and very lengthy, they appear in Appendix A.

2.1.3 WoE, Part 1.1: Criteria for Evidence, Remediator-Developer Public Representations of Cleanup

After using Strategies 1-6 to discover which toxic sites meet criteria (a-e), WoE Part 1.1 uses Strategy 7, an explicit/comprehensive/reproducible/public search strategy for CA-state/county/city documents (so as to find all evidence of remediators'-developers' public representations of toxics testing/cleanup adequacy. Strategy 7 requires one to use all websites provided in preceding Strategies 1-6, then to search each document, associated with each hazardous site, discovered through these strategies. In particular, Strategy 7 requires searching for site documents containing remediators'-developers' public representations that they have:

i. identified and *tested* all site contaminants;
ii. met all *regulatory standards* for a site's assessment/cleanup;
iii. achieved a complete, safe, acceptable cleanup.

We use (i)-(iii), respectively, for Strategy 7 because US/CA EPA require testing all toxic sites, meeting all required regulations, and achieving complete/safe remediation. Such cleanups must meet the 10^{-6} US/CA EPA post-remediation, risk criterion of causing no more than one cancer per million persons exposed over a lifetime [43]. Strategy 7 results are a list of remediator-developer public statements re (i)-(iii), culled from all documents discovered (via section 2.1.2).

2.1.4 WoE, Part 1.2: Criteria for Evidence, Remediator-Developer Private Technical Documents

To find all more **private** or technical-document evidence of how each hazardous site's testing-cleanup was actually conducted, one must employ Strategy 8. It uses the same criteria (i-iii) as Strategy 7. Strategy-8 evidence comes from each technical document for each site assessed, especially each site's *Remedial Investigation and Feasibility Study* (containing testing data); *Removal Action Workplan* or *Remedial Action Plan* (containing required toxin mitigation/remediation); and the *Remedial Action Closure Report* (containing cleanup-confirmation tests).

2.2 WoE Method, Part 2: Developing and Justifying Evidence-Scoring Procedures

WoE Part 2 employs 2 procedures to formulate/justify evidence-scoring procedures to assess Strategy-7 and Strategy-8 evidence consistency, thus evaluate this study's question: Are remediators'-developers' public, regulatory representations of testing/cleanup adequacy consistent with what their more private testing-cleanup technical documents say? The first procedure identifies the characteristic used to conduct environmental scoring, namely, the ***consistency*** between remediator-developer public, versus private, representations of testing-cleanup quality. Inconsistency occurs if any public-versus-private statements mutually exclude each other; inconsistency does not occur merely if statements are different from each other. If there are no inconsistencies, the statements are consistent.

The second WoE Part-2 procedure tells how to score each consistency violation: score each violation, at each hazardous site, as 1. That is, for any hazardous site y_i, the sum of that site's consistency violations (regarding issues (i)-(iii) above) are given by ($x_i + x_{ii} +…+ x_{n-i} + x_n$). Numbers of consistency violations range from 0 to x_n; for all assessed hazardous sites y_n, total violations are the sum of each site's violations; maximum violations number (x_n)(y_n).

2.3 WoE Method, Part 3: Evaluating the Preceding Evidence-Scoring

WoE Part 3 employs 5 procedures, based on WoE Part 2, to assess the consistency between remediators'-developers' public, versus more private, representations (i)-(iii) of testing/cleanup. The **first** procedure is to electronically search for all remediator-developer representations of remediation in each site's **public**, regulatory documents (see section 2.1.3) and to list these representations. The **second** procedure is to electronically search all more **private** technical testing-cleanup documents for representations regarding (i)-(iii), then make a list of them. The **third** procedure is **examination** of lists from the first-second procedures, to follow directions given in section 2.2, and to assess any inconsistencies between statements in the two lists. The **fourth** procedure is **scoring** any inconsistency as 1. The **fifth** procedure is **addition** of all numbers of consistency violations from all electronically-searched documents for all hazardous-waste sites.

The **sixth** procedure is **comparison** of the numbers of actual violations, just obtained, to total potential violations by using the scoring system outlined in section 2.2. Thus, violations are represented by (the number of sites that violates consistency regarding issue x_i) + (the number of sites that violates consistency re issue x_{ii}) +…+ (the number of sites that violates consistency re issue x_{n-i}) + (the number of sites that violates consistency re issue issue x_n).

The **seventh** procedure is to determine, for each of the preceding scored consistency violations, whether any site/**situation-specific conditions** might justify saying no inconsistency occurred. For instance, suppose that two years ago, a site had full-grid, soil-gas testing down to groundwater, to cover its horizontal-vertical extent, thus all contaminant plumes. The developer would be consistent if he publicly affirmed that "all required site testing had been done", as his more private technical documents showed testing within the last 3 years.

Because US EPA recommends testing in the last year before site approval, but requires testing within the last 3 years [44], no inconsistency occurs here. If anyone fully explained and defended any controversial, situation-specific circumstances relevant to an alleged inconsistency, that supposed inconsistency could be deleted from the sum of total alleged contradictions. Without such defenses of site-specific circumstances, total consistency violations would be those alleged.

Thus, to answer our question (Do remediators'-developers' public or regulatory representations of their testing/cleanup adequacy contradict their more private technical documents regarding testing/cleanup quality?), one merely adds all violations (less any violations with defensible, situation-specific justifications), then compares total, to potential, consistency violations. Fewer violations make a "yes" response (to the question) more likely. Many violations make a "no" response more likely.

2.4 Five Methodological Assumptions

A central assumption (A1) of this analysis is that it is important to assess CA toxic sites that are both **more dangerous to health** (criterion (e) in 2.1.1) and **remediated by the industry toxics-cleanup leader** (criteria (b)-(c) in 2.1.1), Trammel Crow (TC), so as to obtain representative, conservative, health-protective results regarding remediation adequacy.

Assumption A2 is that if TC exhibits health-protective CA testing/cleanup, such results are achievable elsewhere. Assumption A3 is that if TC testing/cleanup exhibits health-consistency violations in wealthy, environmental-leader CA, with its superior testing-cleanup requirements, such violations may be more likely elsewhere.

A4 is the assumption that **WoE can provide no randomized, controlled testing** of this study question/hypothesis, only systematic, transparent meta-analysis [31], because WoE is a method for assessing multiple pieces of different types of evidence, most involving empirical testing.

A5 is the assumption that the three-part, WoE Method can be used to assess consistency (therefore likely health or regulatory) violations at toxics-remediation sites elsewhere, provided that: (5.1) all government regulatory-testing-cleanup documents are available online to all residents (something that only CA has done); and (5.2) one uses defensible WoE toxic-site-selection criteria and **reproducible, public, search strategies**.

No human, animal, or plant subjects were involved in the study.

3. Results

3.1 WoE Method, Part 1, Collecting Evidence

As described earlier (section 2.1), WoE Part 1 results include three data sets:

(1) a *list of toxic sites*, meeting criteria (a)-(e) in section 2.1.1, whose cleanups will be assessed;

(2) a *list of remediator-developer* ***public*** *representations about the quality of testing-remediation* that meet criteria (i)-(iii) in section 2.1.3 for sites in (1) above; and

(3) a *list of remediator-developer statements/facts from more* ***private*** *technical documents (re testing-cleanup adequacy*) that meet criteria (i)-(iii) in 2.1.3 above) for sites in (1) above.

3.1.1 WoE, Part 1.1: US Toxic Sites That Meet Criteria (a)-(e)

Results (1) above constitute a representative, conservative sample of toxic facilities, precisely because among all 1,400+ current CA hazardous sites, they meet criteria (a)-(e). Assessing these sites will help answer the question whether remediators'-developers' **public**, regulatory representations of testing-remediation quality are consistent with their more **private** or technical documents, or whether their public statements guarantee better testing/cleanup than (their more private or technical documents show) they provide. The only sites that meet these criteria are:

- the 9-acre former US Naval Ordnance Testing Station, 3202 East Foothill Boulevard, Pasadena, CA 91107 (NOTSPA), Envirostor ID 19970020 [45]; and
- the 18-acre former Santa Fe Railyards at 2425-55 E. Washington Boulevard, Los Angeles, CA 90021 (SFR), Envirostor ID 19400008 [46].

3.1.2 WoE, Part 1: Remediator-Developer **Public** Representations of Cleanup Meeting Criteria (i)-(iii)

Results (2), WoE Part 1.2, are remediator-developer **public** and regulatory representations of testing-cleanup quality for each toxic site I 3.1.1, discovered by using the public, reproducible search strategies; criteria (i-iii); and outlined in sections 2.1.1-2.1.2. The results are 6 NOTSPA and 11 SFR testing-cleanup representations. The 6 NOTSPA public, quoted representations, listed after their respective health criteria (i-iii) are:

i. Have **NOTSPA** remediators-developers guaranteed identification-**testing** of all contaminants?
   1. "All contaminants…onsite were fully Investigated" [47].
   2. There is "no evidence of radiation" [47].
   3. "A radiation survey…found no abnormal radiation levels" [47].
   4. "There is no evidence of [common military explosives/propellants] RDX or TNT" [47].

ii. Have **NOTSPA** remediators-developers guaranteed *testing-**cleanup meets regulatory standards***?
   5. The site is "cleaned up to the highest residential standards" [48], 10^{-6} cancer risk [49], which is the norm for residential sites [43].

iii. Have **NOTSPA** remediators-developers guaranteed *testing-**cleanup is complete**, health-acceptable*?
   6. They committed to "thorough and safe clean-up of the existing soil contaminants" [50], a "fully cleaned up, fully remediated" site [47].

The 10 SFR public, quoted representations (7-17) of testing/cleanup quality, listed after their respective health criteria/questions (i-iii) are:

i. Have **SFR** remediators-developers guaranteed *identification-testing of all toxic site contaminants*?
   7. The site has "been adequately evaluated for vapor-intrusion [VI] risk… Evaluation of…rebound tests…display an overall decreasing trend" [51] (pp.12, 23).
   8. "Sampling [was done]… per the DTSC 2012 Advisory for Active Soil Gas Investigations" [51, 52].

ii. Have **SFR** remediators-developers guaranteed *testing-cleanup meets all regulatory standards*?
   9. "Excavation removed impacted soil to below cleanup standards" [51].
   10. "No rebound of VOC soil vapor" occurred 2013-2015" [51].

11. "All rebound tests show no significant increases" [51], a necessary condition for site closure. Post-soil-vapor-extraction (SVE) tests show that if deeper soil-gas sources rebound, move upward, or recontaminate shallow soils, deeper sources need more cleanup [53, 54].

iii. Have **SFR** remediators-developers guaranteed *testing-cleanup is complete and health-acceptable*?

12. 2013 testing shows "no engineering controls [land-use restrictions, LUR] are needed for vapor intrusion" [51].
13. because of "ongoing SVE remediation" [that will control pollution] [51], and
14. because "ongoing SVE remediation" will "reduce… [VOC] concentrations" [51].
15. "The SVE system has been effective in treating VOCs… [as] no probes at the Site exhibit soil vapor concentrations that exceed the site-specific clean up goals" [51].
16. "Shallow soil vapor does not pose an unacceptable risk to human health, based on meeting the Site-specific cleanup goals" [51].
17. "Soil vapor contamination has been addressed and found to be below Site-specific clean up goals" [51].

3.1.3 WoE, Part 1.3: Remediator-Developer **Private**/Technical Representations Meeting Criteria (i-iii)

Results (3), WoE Part 1.3, are 17 sets of cleanup statements/facts from remediators'-developers' more private or technical toxic-site documents, discovered via criteria (a-e) in section 2.1.3. For clarity of presentation, results (3) for the NOTSPA and SFR sites are given in Table 3, Table 4, Table 5, Table 6 and Table 7. However, Table 1 and Table 2 give a quick summary of relevant testing-cleanup data/background information that later Table 3, Table 4, Table 5, Table 6 and Table 7 presuppose.

Table 1 and Table 2 show both cleanups fail to meet the mandated 10^{-6} health standard. Table 1 and Table 2 provide data relevant to remediator-developer claims of full site testing/cleanup/adherence to government standards. These data include the remediator's contaminant/risk levels for PCE and TCE at both facilities, as well as standards/regulations/other technical details about the NOTSPA and SFR hazardous-waste sites.

Although the remediator-developer's post-cleanup-contaminant levels (Table 1 and Table 2) are not likely toxin maxima at either site (see next section), they are far above hazardous-waste levels and violate regulatory standards. (Hazardous waste has one or more of the properties of ignitability, corrosivity, reactivity and toxicity [55], and poses cumulative lifetime cancer risks $>10^{-4}$.) However, the allowed US/state-government, lifetime-cancer-risk level for cleanups is $<10^{-6}$-10^{-4} [43, 56, 57]). Table 1 and Table 2 use the US-/state-mandated 10^{-6} soil-gas-contaminant levels for 2017-2018 (the time of the latest NOTSPA and SFR studies), given in remediator-developer documents [49] (App D, Table 3), to calculate risks associated with each contaminant level.

Both sites assessed here violate cleanup standards, mandated to protect against cancer/birth defects. Table 1 shows NOTSPA VOC carcinogens are roughly 300,000 > the allowed 10^{-6} cleanup level, and about 1000 times > the 0.5 μg/m^3 TCE level, thought (by regulators) to cause birth defects after brief exposure [58, 59]. Likewise, Table 2 shows SFR VOC carcinogens are roughly 280,000 > the government's allowed 10^{-6} cleanup level, and about 56,000 times > the 0.5 μg/m^3 TCE level, thought (by regulators) to cause birth defects after brief exposure [58, 59]. Both tables follow regulatory documents' mandate to use residential screening levels, 10^{-6}, for all sites, as site uses often change [60].

Table 1 and Table 2 give the developer's tested toxin levels, yet understate both sites' contaminants. At both toxic sites, the remediator's-developer's own testing data, given in Table 1 and Table 2, show that post-cleanup-contaminant levels are up to 300,000 times less protective than allowed. Yet, for at least 5 reasons, developer data likely underestimate contaminant levels/risks at both toxic sites.

- *First*, contra government-testing requirements [40], NOTSPA and SFR, respectively, had no VOC-soil-gas sampling within 80 ft [51] and 180 ft [49]) above groundwater, though VOCs migrate to/contaminate deep soil/groundwater, where their levels tend to be highest [40, 57].
- *Second,* contra government-testing requirements [40], NOTSPA and SFR had no mandated, under-building, subslab tests where soil-gas toxins tend to be higher than elsewhere [40, 57].
- *Third,* because VOC soil gas attenuates/decreases through time, as it moves through soil/air/water, Table 1 and Table 2 exclude contaminant maxima from decades-older, deeper-testing data, though these old maxima are 2 orders of magnitude > those given by the developer's recent sampling, shown in Table 1 and Table 2, eg, [51] (App A).
- *Fourth*, though soil-gas-VOC contaminants attenuate (see preceding point) as they move through soil/air/water, little/no attenuation occurs at sites with preferential toxin routes, like sewers/drains [40, 57], which both sites have, eg, [49], but of which neither site took account.
- *Fifth*, contra government-testing requirements [40, 57], neither NOTSPA nor SFR sampled indoor air [49] (App A-G). Yet in the absence of indoor-air testing, government requires calculating indoor-air-VOC levels (μg/m^3) as = (default attenuation factor, 0.03, which presupposes no preferential toxin routes) × (soil-gas-VOC level) [40, 57]). Table 1 and Table 2 use this default-attenuation factor, thus likely underestimate indoor-air toxins at both sites [40, 57].

Table 1 Post-cleanup, NOTSPA military toxic site, soil-gas risks/concentrations (μg/m^3) [49]. Post-cleanup per/tetrachloroethylene (PCE) and trichloroethylene (TCE) levels below are from the remediator-developer's tests at the former US Naval Ordnance Test Station, Pasadena, CA (NOTSPA) military toxic site, a weapons-testing facility to be redeveloped to hold 550 apartments, many for families with children. As mentioned, the regulatory target/allowed NOTSPA cancer risk is 10^{-6}, equivalent to 0.46 μg/m^3 PCE, or 0.48 μg/m^3 TCE [49]. However, Table 1, row 5 shows NOTSPA-toxin levels at least 297,826 to 538 times > this 10^{-6} government-allowed-cancer risk. Likewise, the allowed brief-indoor-air, TCE residential-exposure level is 0.5 μg/m^3 [58, 59]; however, post-cleanup TCE levels are at least 1,056 times > this TCE level associated with birth defects. Yet as the 5 reasons of the preceding paragraph reveal, Table 1 and Table 2 likely underestimate health harm from NOTSPA-contaminant levels, illustrated below.

	Soil Gas		**Indoor Air**	
	PCE[1]	**TCE[2]**	**PCE[1,3]**	**TCE[2,3]**
Current level, μg/m^3	137,000	8,590	4,110	258
Current cancer risk	3.0(10^{-1})	1(10^{-4})	1.8(10^{-2})	5.4(10^{-2})

Times >10^{-6} cancer risk	297,826	17,896	8,935	538
Times > level causing birth defects	Unknown	17,180	unknown	1,056

[1][49] (App D, Table 3, sample V9-19). [2][49] (App D, Table 3, sample NMSD3-113). [3]Calculated using required attenuation factor 0.03 [40,57].

Table 2 Post-cleanup, Santa Fe Railyards (SFR) soil-gas risks/concentrations (μg/m^3) [51]. Post-cleanup perchloroethylene (PCE) and trichloroethylene (TCE) levels below are from the remediator-developer's tests at the former SFR toxic site, which was redeveloped, pre-cleanup, into a massive, multi-building, commercial rental space in Los Angeles, CA. As noted, the regulatory target/allowed site-cancer risk is 10^{-6}, equivalent to 0.46 μg/m^3 PCE, or 0.48 μg/m^3 TCE [49]. However, Table 2, row 5 shows SFR post-cleanup-contaminant levels are at least 280,000 to 1,750 times >10^{-6} allowed cancer risk. Likewise, the allowed brief-indoor-air, TCE residential-exposure level is 0.5 μg/m^3 [58, 59]; yet row 6 shows post-cleanup TCE levels are at least 56,000 times > those associated with birth defects. Yet as the 5 reasons in the 2 preceding paragraphs reveal, Table 1 and Table 2 likely underestimate SFR toxin-level harm, as illustrated below.

	Soil Gas		**Indoor Air**	
	PCE[1]	**TCE[1]**	**PCE[1,2]**	**TCE[1,2]**
Current level, μg/m^3	130,000	28,000	3,900	840
Current cancer risk	2.8(10^{-1})	5.8(10^{-2})	8.5(10^{-3})	1.8(10^{-3})
Times >10^{-6} cancer risk	280,000	58,333	8,478	1,750
Times > level causing birth defects	unknown	56,000	unknown	1,690

[1][51] (Table 2, sample CC-SV-16-A). [2]Calculated using required attenuation factor 0.03 [40,57].

3.2 WoE Method, Parts 2-3 Results: Scoring Potential Consistency Violations

WoE Part-2 results are the **scored outcomes** from consistency-comparisons between the preceding 17 remediator-developer's **public** and more **private** representations. Giving these scored comparisons to assess the health protectiveness of toxics cleanups is faster/easier/cheaper than all-media, years-long, full-site, hazardous re-testing. The scoring results are the statement-consistency comparisons listed in Table 3, Table 4, Table 5, Table 6, and Table 7, Columns (A)-(B).

WoE Part-3 results are **evaluations** of the previous 17 consistency-comparisons. These results determine whether the columns (A)-(B) 17 potential inconsistencies are actual inconsistencies. Results show 13 inconsistencies and 4 logical fallacies, listed in column (C).

Together, the scored outcomes (A)-(B) and consistency evaluations (C) show the results of WoE Parts 2-3. They illustrate a "cost-efficient health surveillance" method for toxics clean-ups/possible "illegal operations," requested by WHO [8]. For ease of comparison, results are given mostly in tables.

3.2.1 Remediator-Developer Representations 1-4 About NOTSPA Testing Quality

Table 3 compares 4 remediator-developer **public** (column A) guarantees of full NOTSPA testing with what his more **private**/technical documents say (column B). It shows A1 and A2, respectively, contradict B1 and B2, and A3 and A4 are guilty of no inconsistency but instead commit the logical fallacy of appeal to ignorance, assuming something is true (testing is adequate) merely because it has not yet been proved false [61].

Though A1 claims the remediator-developer conducted a “full investigation” of site contaminants, his testing violates all 6 state-regulatory, VOC-sampling “requirements” [40] (p.17) and failed to conduct required groundwater and indoor-air tests. When the author’s university team conducted the first-ever NOTSPA indoor-air tests, it found contaminants 2 orders of magnitude > health/safety standards [29]. Likewise, state-regulatory scientists said site VOCs have likely harmed groundwater and city drinking water [49] (App A, p.8).

A2-A3 deny evidence of radioactive contamination that B2-B3 provide [62, 63 (p.13), 64 (pp.7, 31)], including using the wrong radiation tests [64 (pp.7, 31), 65, 66]---two clear commissions of the fallacy of appeal to ignorance: Failure to test/test correctly provides no evidence one way or the other, thus errs logically. These are serious errors, given radiation’s having no safe dose [67] and the site’s long history of nuclear-weapons development/testing/manufacturing [68].

A4 commits the same logical fallacy when it denies evidence for explosives/propellants RDX/TNT [47] (p.3), failed to test for RDX/TNT, though site documents show (1) 71% of all weapons developed/manufactured onsite contained RDX/TNT [68] (p.90), and (2) other neurotoxic site propellants/explosives (perchlorate), used only for US military weapons, have been found in downgradient City drinking-water wells and traced to NOTSPA [49 (App A, p.9), 63 (p.13), 70)]. California Institute of Technology ran the US Navy’s onsite manufacturing plant for nuclear/conventional weapons [69]. Thus Table 3 shows that of 4 NOTSPA potential remediator-developer contradictions (1-4), there are 2 contradictions and commission of 2 logical fallacies.

Table 3 NOTSPA remediator-developer misrepresentations 1-4 of site testing. For the NOTSPA US-military, weapons-manufacturing toxic site on which 550 apartments will be built, Table 3 assesses the remediator-developer’s **public** (column A) guarantees of full testing with what his **private**/technical documents say (column B); column C shows potential consistency violations between A and B. A1 and A2, respectively, contradict B1 and B2 for the reasons given in the preceding two paragraphs. A3 and A4 do not formally contradict B3 and B4, but instead commit the logical fallacy of appeal to ignorance, as “no testing” does not equal “no toxins”. Thus the developer appears to have misrepresented his testing quality to regulators and the public.

NOTSPA Remediator-Developer Health-and-Safety Statements		
(A) His Public Guarantees	**(B) Admissions in His Private or Technical Documents**	**(C) Consistent?**
1. “All contaminants… onsite were fully investigated.[1]	1. No testing was done of site indoor air, groundwater, or soil/soil gas within 180 feet above groundwater.[2] [Government mandates all 3 types of tests for vapor-intrusion (VI) sites.[3]] Though full investigations require following all regulatory requirements, assessors also violated all 6 CA soil-gas-test regulatory requirements.[3]	1. No

2. "There is no evidence of radiation."[1]	2. The site stored, used in weapons, and transported radioactive and hazardous, classified materials; it developed, tested, and manufactured Polaris nuclear missles.[4]	2. No
3. "A radiation survey… found no abnormal radiation levels."[1]	3. Despite site-adjacent city drinking-water wells, fouled by radon, radium, strontium, uranium,[5] and a radiation-warning sign, found onsite (2007),[6] site groundwater was never tested, including for radiation.[2] Only one 2001, site-radiation survey was done, using only 4 radiation swipes in 1 (#20) of 29 site buildings; it assessed only gross alpha, beta radiation," no gamma;[6, 7] with only EPA Method 900[6] [which is usable only for water,[8] not swipe, tests].	3. Yes, but (A) commits a logical fallacy, appeal to ignorance, and radiation survey was grossly inadequate in scope and method.
4. "There is no evidence of [the common military explosives-propellants] RDX or TNT."[1]	4. Besides nuclear missiles, the site developed, tested, manufactured, stored Mk 32, Mk 42, Mk 43, Mk 44, and Mk 46 torpedoes, anti-submarine rockets (ASROCs), and submarine rockets.[4] CalTech ran the US Navy's onsite weapons-manufacturing plant.[9] [71% of all known weapons, tested and manufactured onsite, contain RDX/TNT,[10] yet no site testing was done for RDX/TNT.[2, 14]]	4. Yes, but (A) commits a logical fallacy, appeal to ignorance, and there was no testing whatsoever for RDX and TNT; that is why there is no evidence.

[1][47] (see Table 1). [2][49] (App D (esp Table 3) and E). [3][40] (pp.2, 5, 6, 17). [4][62] (App B, p.4). [5][63] (p.13). [6][64] (pp.7, 31). [7][65]. [8][66]. [9][69] (p.90). [10][68] (p.90). [11][62] (App C, p.3). [12][49] (App A, p.9). [13][70]. [14]After site development was approved, the state regulator relented and required RDX/TNT tests---which have not yet been conducted [68] (p.8).

3.2.2 Remediator-Developer NOTSPA Representations 5-6 About Obeying **Regulatory Standards**

Table 4 below shows that remediator-developer **public**/regulatory guarantees (A5-A6) about following regulatory standards, contradict what his more **private**/technical documents say (B5-B6). A5-A6 guarantee site 10^{-6} risk-cleanup, the highest residential standard [71], but B5-B6 contradict this guarantee in at least 5 ways. The NOTSPA remediator-developer admits that:

(1) many disallowed contaminant-levels will be left onsite at hazardous-waste concentrations [72];

(2) toxin "cleanup" levels pose 10^{-1}-10^{-2} risks and, are 100,000x less safe than the required 10^{-6} risk [49, 72];

(3) site toxin levels could "exceed" regulatory levels [72];

(4) his partial cleanup is cheaper than full cleanup that would use soil-vapor extraction (SVE) [72];

(5) he is allowed to use land-use restrictions (LUR) [73, 74], such as under-apartment blowers to disperse carcinogenic gases. Yet LUR are used only when "hazardous waste…[is] left in place" [49] (App A (pp.4, 8); see Table 1), thus threatens health [73, 74]. In fact, CA regulatory documents explicitly say LURs are "not compatible" with NOTSPA's intended residential use [75], given "the difficulty of monitoring…and the sensitive nature of the population" [75] (p.20).

Table 4 thus shows 2 more NOTSPA remediator-developer contradictions, A5-A6. So far, WoE scoring shows 4 remediator-developer contradictions + 2 logical fallacies, of 6 possible contradictions.

Table 4 NOTSPA remediator-developer misrepresentations 5-6 re meeting regulatory standards. Regarding meeting regulatory standards at the NOTSPA US-military, weapons-manufacturing toxic site on which 550 apartments will be built, Table 4 compares remediator-developer **public** guarantees (A5-A6)---of "highest" cleanup, "full remediation"---with what his more **private** or technical documents say (B5-B6). Column C shows column A contradicts column B. The remediator-developer appears to have misrepresented to regulators and the public the degree to which he follows regulatory standards and achieves "highest" cleanup.

NOTSPA Remediator-Developer Statements		
(A) His Public Guarantees	**(B) Admissions in His Private or Technical Documents**	**(C) Consistent?**
5. The site is "cleaned up to the highest residential standards,"[1] 10^{-6} cancer risk, the norm for residential sites.[2]	5. Post-cleanup shallow-soil TCE or PCE carcin-ogens "could…exceed…regulatory" limits,[3] as shallow-soil cleanup levels are 7,050 µg/m^3 carbon tetrachloride (CT); 12,400 µg/m^3 TCE; 5,470 µg/m^3 PCE,[4] respectively posing 10^{-1}, 10^{-2}, 10^{-2} cancer risks.[4, 5] [This is not the guaranteed 10^{-6} highest" protection. Yet for risks >10^{-4}, land-use restrictions[6] (LUR) are required[4, 7, 8]], as site toxins are at hazardous-waste levels.	5. No
6. Developer guaranteed "thorough and safe cleanup of…existing soil" toxins,[9] a "fully remediated" site.[10]	6. Cleanup is partial ("alternative 2"), costs $1-2 M < full cleanup, thus requires LUR or land-use restrictions,[11] because site documents (1) have unprotective clean-up levels (above); (2) say "it is unknown" whether site VOC carcinogens "will continue to present" health threats to residents,[11] and (3) many site carcinogens have been "left in place."[12]	6. No

[1][71]. [2][49] (pp.36, 34). [3][72] (p.48). [4][72] (p.37, Table 4). [5][49] (Appendices D-E). [6]eg., [72] (pp.46, 54). [7][43]. [8][73]. [9][50]. [10][47]. [11][72] (p.31). [12][49] (App A and D, pp.4, 8).

3.2.3 Remediator-Developer Representations 7-8 About SFR Testing Quality

Regarding remediator-developer testing quality, Table 5 shows his **public**/regulatory guarantees A7-A8 contradict his more **private** or technical documents/data logs/lab reports (B7-B8). Instead of following regulatory mandates, at SFR he violated US/CA EPA requirements:

- to test indoor air;
- to follow all state-prescribed testing methods; and
- to correctly assess VOC rebounds, so as to confirm VOC cleanup [51] (App A-G).
- to test VOC-contaminant extent, all toxin sources, all sub-slab preferential pathways, and
- to capture maximum-toxin levels and dense sampling for required isoconcentration maps [52].
- to test soil down to groundwater, given: (1) US/CA EPA regulatory warnings that VOCs >100 ft subsurface can enter surface buildings [40, 56], and (2) evidence of 37 locations, deeper than 84 ft, with VOCs 10 K-400 K times > US/CA EPA-allowed levels [51] (App A, Table 4).
- to use long-term probes for multi-yr, same-spot tests, not his 15 such probes for 20 acres;
- to test only after toxins are stable, as ongoing toxin migration [51] made all his tests unreliable;
- to conduct required, two-location, subslab tests under all site buildings;
- to use test-detection limits < screening levels (ESLs), thus to detect all disallowed toxin levels; and
- to follow the state's Soil-Gas Advisory [40] (p.17).
- not to redevelop the site, pre-cleanup, yet the developer TC [39, 76] did so [51].
- not to use faulty tests, as for dichloromethane (DCM), then to deny site DCM [51 (p.14)], 77]. For all the preceding reasons, the remediator-developer's 2018 more **private** or technical data/lab reports/documents B7-B8 [51] (App A, App F) contradict his 2018 **public** guarantees of "adequate" SFR assessment/testing [51] (pp.1-28).

Perhaps most disturbing (see 7 in Table 5), while the remediator-developer's 2018 **public** representations claimed "adequate" SFR testing and rebound "evaluation," his more **private** data logs show failed SVE/cleanup because of his not removing contaminant sources. Although his final (2017) VOC-toxin-rebound tests were supposed to confirm cleanup, only one month after he ended SVE cleanup, 61% of rebound-test locations indicated dangerous/disallowed, soil-VOC increases up to 5000%, even in easy-to-remediate shallow soil, thus serious health threats to site renters [51] (Table 2 and Apps C-F). Instead of removing threats through further cleanup, the developer-remediator:

- ignored regulatory documents' warnings about rebounds [54] (p.53; App C); and
- requested/received permission to halt SVE cleanup [51], because he falsely claimed rebounds showed an "overall decrease" [51] (p.23).

Yet "overall decreases" in VOC rebounds are irrelevant because:

- Even brief exposure to one location of no-safe-dose, genotoxic TCE at levels of 0.5 $\mu g/m^3$ can cause birth defects [58, 59].
- Even 1 location with unstable/migrating/rebounding VOCs can cause cancer or neurological dysfunction [53, 54].
- His cleanup-confirmation tested soil only 20% of the distance down to groundwater [51] (App F), yet VOCs 100+ ft subsurface can cause cancer in surface residents [40, 56].
- His 2017 cleanup-confirmation tested only 10% of wells [51] (App B, Table 11; App F).

Also problematic for his "adequate" assessment claim, much site testing/cleanup was conducted by Tetra Tech. It now faces $27 billion in federal/state government and private lawsuits for testing-and-cleanup fraud [78, 79]. The remediator -developer never re-evaluated Tetra Tech work.

Thus, of possible remediator-developer contradictions 7-8, there is a score of two additional inconsistencies. So far, there are 6 remediator-developer contradictions and 2 instances of logical fallacies, out of 8 possible inconsistencies.

Table 5 Santa Fe Railyard (SFR), remediator-developer misrepresentations 7-8 of full site assessment. On Los Angeles' SFR toxic site, the largest US commercial developer [39, 76] has built the largest commercial rental space in downtown Los Angeles, begun and completed 2013-2015, years before supposedly completing subsurface-VOC cleanup. Table 5 assesses remediator-developer **public** guarantees (A7-A8)---of his "adequate" site assessment---with what his more **private**/technical documents say (B7-B8). Column C indicates potential contradictions between columns A and B. Because preceding paragraphs and column B of Table 5 show many ways in which SFR assessment violates state-federal requirements, thus understates contamination/health threats, the remediator-developer has misrepresented to regulators and the public his adherence to standards of full site assessment.

SFR Remediator-Developer Statements		
(A) His Public Guarantees	**(B) Admissions in His Private or Technical Documents**	**(C) Consistent?**
7. The site has "been adequately evaluated for vapor-intrusion (risk)….Evaluation of…rebound tests…display an overall decreasing trend."[1]	7.1 *No required indoor-air tests were conducted*,[2] yet site tenants occupy massive new toxic-site buildings atop soil-gas "cleanup" levels of 324 K $\mu g/m^3$ PCE.[2] Such VOCs, 100+ feet subsurface, can cause vapor intrusion (VI).[3] [These "site-specific cleanup" levels (10,000 > the highest PCE that US-CA EPA regulatory documents allow[4, 5]) pose a cancer certainty for all exposed.][5]	7.1 No
	7.2 No required, post-1998 soil-gas tests deeper than 84 ft were done,[6] yet soil gas 100+ ft subsurface can cause VI.[3] Below 84 ft, 1998 tests show 37 locations with PCE at levels 1 M-38 M x > US-state cleanup targets, and 10 K-400 K[7] times > allowed levels.[4] All soil-gas tests[2] violated all 6 CA EPA test "requirements."[8]	7.2 No
	7.3 Assessors misrepresented 2018 VOC-cleanup-rebound tests, claiming VOC "concentrations…were consistent with previous sampling," then requesting/receiving approval for immediate site closure.[9] Yet remediator-developer technical documents/data reports show 2018 tests of only 10% of cleanup locations, of which 61% had rebounds which (US/CAL EPA say) show unremoved sources and serious health threats,[10] thus require further cleanup.[11] Yet no additional cleanup was done.	7.3 No

	7.4 Assessors claimed "no detectable" DCM, PCE, CBZ,[12] but their data reports show disallowed detection limits, 10 K x > ESLs,[13, 14] contrary to the state Soil Gas Advisory that they claimed to use.[15]	7.4 No
	7.5 US EPA says Tetra Tech committed testing fraud on up to 97% of samples on another US Navy toxic site;[16] it did much SFR testing-cleanup---none of which the developer re-checked.	7.5 No
8. "Sampling [was done]… per the DTSC 2012 Advisory for Active Soil Gas."[17]	8. Contrary to the Advisory,[18] data reports show that remediator-developer sampling failed to: • Trace contaminant-plume extent; • Obtain maximum toxin levels; • Sample all source areas; • Assess into-building preferential pathways; • Test and show all isoconcentration contours; and • Avoid using Tedlar bags with Method TO-15.[2]	8. No

[1][51] (pp.1, 2, 23). [2][51] (App A-G, esp A, F). [3][40, 56]. [4][43, 80]. [5] See 3.1.3, paragraph 3. [6][51] (Table 2). [7][51] (App A). [8][40] (esp pp.16, 17). [9][51] (pp.20, 23). [10][51] (App B-F). [11][53, 54]. [12][51] (p.14). [13][51] (Table 31). [14][77] (DCM, PCE, and CBZ). [15][52]. [16][51] (pp.3-13). [17][51] (p.18). [18][52].

3.2.4 Remediator-Developer Claims 9-11, Santa Fe Railyards Excavation/Soil-Vapor Extraction (SVE)

Despite the developer-remediator's **public** claims that his SFR "excavation removed impacted soil to below cleanup standards" [51] (p.14) and SVE "rebound tests….show no significant increases" [51] (p.23), his more **private**/technical documents eg, [51] (Apps A, B, F) show the opposite. As Table 6 reveals, his own private documents/data reports show that not all impacted soil was removed:

(1) the excavation was on one side, only shallow, not even of most impacted soil [51] (esp Apps A, B, F);
(2) only 10% of areas with 2013 illegal toxin levels were tested at site closure (2018) [51] (Apps A, B, F);
(3) 61% of rebound-test locations show disallowed VOC levels, 1 month after VOC removal [51] (App C-E).

As already noted, any VOC rebounds violate US/CA EPA standards and show VOC sources have not been removed [54] (C-11). Yet Table 6 shows the remediator-developer instead claimed "no significant rebounds" occurred---by failing to test 90% of areas, then using a disallowed, 10-times-less-protective, rebound level (50% > the previous test). Falsely denying rebounds, he requested/received site closure without any additional cleanup [51].

In **public**, the remediator-developer also claimed he reduced VOCs to below "cleanup standards," but his more **private** lab/data reports [51] (Apps A, B, F) show his "site-specific cleanup" standards:

- fail to meet the required 10^{-4}-10^{-6} US/CA risk standard [43] and are hazardous-waste levels;
- used 2018 PCE "cleanup" levels of 324,000 µg/m^3 PCE---7,043 times higher than allowed [43]---that could give site tenants a $7(10^{-1})$ risk, a 70% lifetime certainty of cancer [51] (Table 2);
- used apparently illegal 2018 TCE "cleanup" levels of 85,000 µg/m^3 [58, 59] that are 170,000x >0.5 µg/m^3 TCE, the allowed brief exposure level, above which US EPA says (2018) birth defects occur. Yet even a 21% single-location-rebound increase (to 2900 µg/m^3) [51]

(Table 2, p.14) could raise some site TCE levels to 1000x > what could cause many birth defects [58, 59].

The developer's private/technical documents also reveal his rebound tests violated US/CA EPA requirements:

- to use 30 data points per soil-gas well to test rebound "significance" via the Central Limit Theorem [81], yet he employed only 4-6 data points [51] (App D-E), then denied any "significant" VOC rebound [51].
- to remove most source-mass and to leave toxins stable and non-migrating [53] (pp.33-38);
- to quantify source-mass using gamma, alpha input [54] (p.53; App C (pp.C-4--C-6)-E);
- to show rebound tests cover all toxin areas [53] (App C (pp.C-4--6)-E); yet they cover 10% [51] (App F);
- to assess whether/not subslab VI-pathways imperil health [53] (pp.33-38);
- to test levels of indoor-air VOCs in site rental buildings [53] (pp.33-38); and
- to show VOC-source removal is adequate [54] (p.53; App C (pp.C-11--C-15)-E).

Such contradictions, between public representations and more private/technical documents of the remediator-developer are important, given serious site health threats. Yet the developer used rebound falsehoods to "justify" building the largest contiguous commercial rental space in downtown Los Angeles [76], despite ongoing VOC-toxin rebounds that have never been remediated [51] (pp.8, 12, 23-24).

Table 6 thus shows that of possible remediator-developer contradictions 9-11, there is a score of 3 additional inconsistencies. So far, site documents reveal 9 remediator-developer contradictions and 2 instances of logical fallacies, of 11 possible inconsistencies.

Table 6 Santa Fe Railyards (SFR), claims 9-11 re excavation and soil-vapor extraction (SVE) standards. For the SFR toxic site, now housing a massive, multi-building, Los Angeles commercial-rental redevelopment, Table 6 compares remediator-developer **public** guarantees (A9-A11) with what his more **private** or technical/data-report documents say (B9-B11) about his removing "impacted soil," so "no significant" VOC-toxin rebounds occurred after his limited cleanup. Column C shows his **public** representations contradict what his **private** documents reveal. That is, contrary to remediator-developer assurances, most impacted soil has not been removed; the site has deadly toxins thousands of times above government-allowed cleanup levels; and site toxin-rebound tests violate US/CA EPA regulatory standards. The remediator-developer has misrepresented site excavation and soil-vapor extraction to regulators and the public.

	SFR Remediator-Developer Statements	
(A) His Public Guarantees	**(B) Admissions in His Private or Technical Documents**	**(C) Consistent?**
9. Site "excavation removed impacted soil to below cleanup standards."[1]	9.1 Excavation removed only east-side, 25-ft subsurface) VOCs.[2] Most site PCE/TCE/VOCs are below 25 ft,[3] but they remain onsite,[4] can easily enter surface buildings, and cause cancer.[5, 6]	9.1 No

	9.2 As noted, site-specific soil-gas "cleanup" standards are actually hazardous-waste levels, such as 324 K $\mu g/m^3$ PCE at 84 ft.[4] [The "standards" are 1000x less safe than the US/CA require[5] (ie, risks < of 10^{-4} and cleanup to 100+ ft subsurface).[6]]	9.2 No
10. "No rebound of VOC soil vapor" occurred 2013-15."[7]	10. In 2013-15,[8, 9] 14% of soil-gas wells had no rebound,[8] but 86% had rebounds of 1370%, 1100%, 820%, etc---rebounds up to 250 K $\mu g/m^3$ PCE and 25 K $\mu g/m^3$ TCE, respectively.[4, 8] These respective levels pose risks of $5.4(10^{-1})$, $5.2(10^{-2})$, > the 10^{-4} risk allowed by US/CA EPA regulatory standards.[5]	10. No
11. "Rebound tests …. show no significant increases…[an] overall decreasing trend," so site cleanup can stop.[10]	11. The remediator-developer denied rebounds by arbitrarily redefining required US/CA EPA rebound standards. He (a) assessed all rebounds using 4-6 data points[8] that violated "significance" testing;[11] and (b) understated rebound by claiming any "significant rebound" =>50% increase over earlier tests.[11] US/CA EPA's definition is > a 1-5% increase.[12] The remediator-assessor "overall decreasing trend" claim is false; tests[8] show 61% of wells had rebounds, increases (eg, 47,600%, 400%, 375%, 360%, etc); 39% did not, contra A11.[4, 8] [Rebounds show deeper source testing-cleanup is required to achieve toxin stability, prevent vapor intrusion, avoid harm.[13]	10. No

[1][51] (p.14). [2][51] (p.3). [3][51] (pp.5, 8 and Table 2). [4][51] (Appendices A-G). [5][43]. [6][40, 56]. [7][51] (p.12). [8][51] (Table 2, p.14; Apps C-E). [9][51] (pp.10-12). [10][51] (p.23). [11][51] (p.19). [12][54] (p.C-11). [13][53, 54] (Appendix C).

3.2.5 Remediator-Developer Claims 12-17 Re Santa Fe Railyards' Risks and Land-Use Restrictions

Six remediator-developer **public** represesentations (A12-A14) are that land-use restrictions (LUR) are not needed for the former SFR toxic site because his SVE has reduced toxins [51] (pp.8-11), and site soil vapor contamination "has been addressed" (A15-A17) [51] (p.24). However, Table 7 illustrates that his **private** data reports/documents contradict his claims.

Table 7 below shows A12-13 contradict B12-13. A12 (No site engineering controls, that is, land-use restrictions, LUR---such as blowers to disperse under-building carcinogenic gases---are needed onsite, given "ongoing" soil-vapor extraction, SVE) contradicts B12 because remediator-developer more private data reports reveal his "site-specific" cleanup levels pose forbidden risks up to 10^{-1} [51] (Appendices A-G)---at least 1000 times higher than the US- and state-defined, toxics-cleanup levels (10^{-4}-10^{-6}) and hazardous-waste level (>10^{-4}). Because regulators require LURS if toxins are left onsite at hazardous-waste levels (>10^{-4}), A12-B12 are inconsistent. A13 likewise contradicts B13, as A13 guarantees "ongoing" SVE, but B13 proves the remediator-developer stopped SVE after only one year, contradicting his own claims: He left onsite more than 75% of disallowed levels of unremediated contaminants/sources that now threaten site renters' health.

A14-15 err by committing the logical fallacy of false cause. That is, A14 falsely assumes that reducing VOCs is a sufficient cause-condition to stop SVE remediation. However, CA/US EPA regulatory technical guidance instead mandates that SVE site remediation can be stopped only if there are no onsite: (1) toxin migrations; (2) rebounds; (3) violations of technical-regulatory standards, such as TCE >0.5 μg/m^3, the level causing birth defects; and (4) non-negligible gaps between total, and removed, VOC mass [42-44, 53, 54, 57-60, 73-75, but especially 40, 52, 56]. Yet, the SFR toxic site meets none of these preceding 4 jointly-sufficient conditions/requirements for stopping SVE remediation. Therefore A14 is false.

A15 likewise falsely assumes that meeting “site-specific cleanup goals” [51] (p.5) is a sufficient cause-condition for “effective” SVE remediation. However, CA/US EPA regulatory technical guidance instead mandates that meeting the 4 preceding, jointly-sufficient conditions are requirements for “effective” SVE. Again, however, the toxic site fails to meet any of these 4 jointly-sufficient conditions/requirements for A15’s claim about “effective” SVE remediation. Thus A14-A15 make false claims, given false assumptions about SVE cleanup; they do not contradict remediator-developer private documents on points B14-B15.

As Table 7 indicates, Claim A16 (to regulators/the **public)** that current shallow-soil-gas levels pose an “acceptable risk to human health” [51] (p.24), contradicts B16, hundreds of pages of more **private**, technical-sampling-data reports. B16 contradicts by revealing in 2018, just before site closure, that:

- This commercial site’s shallow (15 ft) VOC levels, eg, 3,600 μg/m^3 TCE [51] (App F) are **illegal,** as they violate the 2014 US/CAL EPA “urgent” removal requirement for indoor soil-gas TCE, namely, 6 μg/m^3 or greater [58]. Because 0.5 μg/m^3 TCE can cause birth defects [58, 59], 3,600 μg/m^3 TCE is not “acceptable” for “human health” [51] (p.24), as the remediator developer claims [51] (p.24).
- The site’s current shallow (15ft) contaminant-levels, eg, 20,000 μg/m^3 PCE [51] (App F, sample CC-SV-09) violate US/CAL **hazardous-waste levels** (any toxin with >10^{-4} risk), which are 46 μg/m^3 for PCE [49] (App D, Table 3). Thus 20,000 μg/m^3 PCE represents a risk of 4(10^{-2}), so that 1 in 23 persons exposed to this level could get cancer from the exposure. Obviously this is not an “acceptable risk to human health,” [51] (p.24), as the remediator developer claims [51] (p.24).
- The site’s current-contaminant levels, eg, 42,000 μg/m^3 PCE [51] (App F, sample CC-SV-08) are within the 100+ ft-subsurface depths that (US/CA EPA warn) easily travels to surface indoor air [40, 56]. For instance, when this 59-ft-level of subsurface PCE (eg, 42,000 μg/m^3) travels indoors, it could pose a risk of 10^{-1}, a **10% chance of getting cancer** from this exposure alone [49] (App D, Table 3). Obviously such a contaminant/risk level is not an “acceptable risk to human health,” [51] (p.24), as the remediator developer claims [51] (p.24).
- The (2017-2018) site-VOC screening levels (100-1000 μg/m^3 [51] (App F)) are wrong/unprotective. US/CA EPA requires them to be at the 10^{-4} risk level or safer [40] (p.17); hazardous wastes are 10^{-4} and riskier. Because the PCE/TCE 10^{-4} risk level, respectively, is 46/48 μg/m^3 [49] (App D, Table 3), the remediator-developer’s site-screening levels are 217%-2,173 times less protective than the minimum that US/CA EPA requires (46 and 48 μg/m^3). Therefore the screening levels are not an “acceptable risk to human health,” [51] (p.24), contrary to the remediator-developer [51] (p.24).

Finally, the remediator-developer's A17 guarantees, that soil-gas contamination "has been addressed," contradict B17. Column-B entries show (1) required US/CA EPA site testing has not been done and (2) the highest/worst contaminants, those deeper than 25 feet, have not been remediated, thus could cause inside-surface-building vapor intrusion (VI), cancer, and birth defects.

Of the of 6 possible remediator-developer contradictions AB 12-17, AB 12-13 are particularly worrisome as they both guarantee later SVE cleanup but the remediator-developer stopped SVE. This stoppage caused toxic-waste levels to remain onsite, obvious public-health threats. Moreover, though the A13 remediator-developer **public** claims are that the final, 2017 toxic-contaminant rebounds were "consistent" with earlier reduced toxins, his own more **private**, technical data show this claim is false. Instead, 61% of final, 2017 toxin-rebound data show PCE or TCE increases, and only 39% of the data are consistent with previous data showing no toxin increases/rebounds. Instead toxin increases/rebounds were 4762%, 364%, 327%, 310%, 256%, 224%, etc [51] (Table 2), thus indicating failed/incomplete cleanup and serious health threats.

The remediator-developer's failure, to keep his 2013 guarantees of "ongoing" SVE cleanup, has created the preceding public-health threats, revealed in Table 7's Column B. He stopped SVE, thus violated his "ongoing SVE" guarantee, despite no remediation of 75% of prohibited shallow-soil VOCs: US/CA SVE regulatory documents allow SVE stoppage only given a "negligible" difference between removed, vs total, VOC-contamination mass [53 (p.67), 54]. Yet brief site SVE removed only 25% (3 of 12 tons of VOC toxins, leaving 9 non-negligible tons in *shallow* soil (<25 ft). Worse, 100 percent of deeper (25-330 ft subsurface) toxins remain unremediated. Hence the site violates regulatory mandates to leave only "negligible" VOC-contaminants onsite.

In summary, Table 7 shows that of 6 additional possible contradictions 12-17, there is a score of 4 additional contradictions. This means site documents reveal a to-date total of 13 remediator-developer inconsistencies and 4 instances of logical fallacies, of 17 possible inconsistencies.

Table 7 Santa Fe Railyards (SFR), representations 12-17 regarding land-use restrictions and site risks. Regarding SFR land-use restrictions (LUR) and health risks, A12-A14 give remediator-developer **public** or regulatory representations, while B12-14 provide his more **private** or technical-data-report facts. Column C shows contradictions between columns A and B. A12-A14 claim LURs are not needed at SFR, because soil-vapor extraction (SVE) is "ongoing" and "will reduce" contaminants [51] (pp.8-11). Likewise A15-A17 guarantee SFR soil-vapor contamination "has been addressed," though "effective" SVE (A15-A17) [51] (p.24). However, Table 7 shows remediator-developer more **private** information B12-B13, B16-B17 contradict his own public claims A12-A13, A16-A17. The remediator developer again has misrepresented to the public/regulators his SFR cleanup's health/safety and required LURs.

	SFR Remediator-Developer Statements	
(A) His Public Guarantees	**(B) Admissions in His Private or Technical Documents**	**(C) Consistent?**
12."No engineering controls are	12. Site soil-gas cleanup levels (eg, 85 K μg/m^3 TCE,[2] 324 K μg/m^3 PCE[3]) are toxic-waste levels.[3] [They require either removal or land-use restrictions (LUR), that is, "engineering controls."[4] Since 2014, any	12. No

needed [2013] for vapor intrusion”[1]	commercial-site, indoor-air TCE >6 μg/m^3 has been illegal, requiring “urgent” removal.[5] Yet this 2018 site-TCE-cleanup-level, 85 K μg/m^3, is >14,000x what is allowed].	
13. because of post-construction, “ongoing SVE remediation”[1]	13. Because in 2013 the remediator-developer guaranteed post-construction, “ongoing SVE remediation,”[1] he was allowed to stop SVE-remediation for 3 years, to develop the site (2013-15) as Los Angeles’ largest contiguous commercial rental space.[6, 7] Yet 1 yr-post-construction, he broke his promise, stopped SVE, and violated US/CA EPA conditions for ending SVE,[8] eg, total-less-removed site VOC mass must be “negligible.”[9] Total *shallow* (<25 ft deep) VOCs = 12 T,[10] but he ended SVE after (1) shallow-removing only 3 T of 12 T;[11] and (2) doing no cleanup below 25 ft.[12] He thus failed to remove 75% of toxins, required to be removed and violated at-least-100 ft-subsurface-cleanup mandates [thus failed to protect site renters (see 3.2.5)].[13]	13. No
14. will “reduce …[VOC] concentrations” in soil gas.[1]	14. The remediator-developer claims reduced VOCs alone will preclude LURs. Yet SFR meets none of US-CA 4 regulatory necessary conditions/causes for avoiding LURs.[3] These are: (1) no site toxin migration; (2) no rebounds; (3) no violations of regulatory-technical standards, eg, limiting TCE to <0.5 μg/m,[3] the level causing birth defects; and (4) no non-negligible gaps between total, and removed, VOC mass; together (1)-(4) are jointly sufficient to avoid LURs,[14] but SFR does not meet them.	14. Yes, but a logical fallacy, false cause
15. “SVE…has been effective in treating VOCs…no probes…[on] Site exhibit… concentrations that exceed… Site-specific clean up.”[12]	15. The remediator falsely says his short-term SVE remediation “has been effective,” given that SFR toxins are below “site-specific” cleanup levels. However, the “site-specific” cleanup levels violate both CA-US cleanup standards and all 4 requirements for “effective” SVE (see 4 items in B14),[14] as site technical documents/data reports show.[3, 15] They contradict remediator-developer claims of “effectiveness” (A15).	15. Yes, but a logical fallacy, false cause
16. “Shallow soil vapor does not pose an unacceptable risk to human health,	16. Current shallow (to 25 ft)[13] tests show PCE up to 36 K μg/m^3 (risk = 7.8(10^{-2})) and TCE up to 8,200 μg/m^3 (risk = 1.7(10^{-2}));[2] these are toxic-waste levels (>10^{-4} risk),[3] thus unacceptable, requiring LUR (see B12). Even shallow site-cleanup levels---71,000 μg/m^3	16. No

based on meeting the Site-specific clean-up goals."[12]	PCE (risk = $1.5(10^{-1})$) and 19,000 µg/m^3 TCE (risk = 1.7(10-2))[2]---also are unacceptable, toxic-waste levels that require LUR. A16 "acceptable-risk" guarantees contradict his B16 private, data-report documents showing (1) 75% of prohibited-toxin levels remain onsite,[3, 15] and (2) VOCs >100 ft subsurface can move into shallow soils/surface buildings and cause cancer, birth defects, and neurological problems.[14-17] These are unacceptable risks.	
17. "Soil vapor contamination has been addressed and found to be below site-specific clean up goals."[11, 12]	17. See all preceding B12, B15, and B16 entries, each of which contradicts A17.	17. No

[1][51] (pp.8, 10-11). [2][51] (Table 2). [3][43, 51 (App A-C), 55]. [4][73]. [5][58]. [6][76, 82]. [7][83]. [8][51] (pp.8, 15-16). [9][53] (p.67). [10][51] (pp.4-5). [11][51] (Figure 11). [12][51] (p.24). [13][40, 56]. [14][42-44, 54-60, 73-75, esp 40, 52, 53 (App C), 56]. [15][51] (App D-G). [16][53]. [17][40] (pp.13-14).

The preceding misrepresentations show that at both toxic sites, sampling and partial remediation violate US/CA health/safety requirements, yet site remediators-developers cover up these violations through misrepresentation. Remediators-developers appear to have violated testing requirements (Table 3); regulatory cleanup standards (Table 4); technical-assessment norms (Table 5); technical/regulatory excavation and SVE standards (Table 6); and technical-legal land-use-restriction and site risk standards (Table 7)---then misrepresented these violations.

3.3 WoE Method Results: Summary

In summary, WoE Part 1 results are three types of evidence. These are documents for 2 toxic sites, given in section 3.1.1; 17 remediator-developer **public** or regulatory representations about testing/cleanup at the sites assessed, given in section 3.1.2; and 17 remediator-developer **private** or technical-document/data-report statements about site testing/cleanup, given in section 3.1.3. We used this evidence to answer the question whether, "For US hazardous-waste sites that the courts say pose "Imminent and Substantial Endangerment" (ISE) threats to health, are remediators-developers' **public** or regulatory testing-and-cleanup representations consistent with their more **private** or testing-and-cleanup technical/data-report documents?"

WoE Part-2 results, given in section 3.2, are a scoring of 17 sets of *remediator-developer, public-versus-private, representations* of testing/cleanup. This initial scoring revealed a total of 17 potential contradictions (1-17) between remediator-developer public and private claims.

WoE Part-3 results, in section 3.2, evaluate the scoring of the 17 sets of *remediator-developer representations*. From a total score of 17 potential contradictions, we scored 13 inconsistencies (numbered 1, 2, 5, 6, 7, 8, 9, 10, 11, 12, 13, 16, 17) and 4 remediator-developer instances of logical fallacies, appeals to ignorance and false cause (numbered 3, 4, 14, 15). The logical fallacies include no contradictions, but 13 of 17 remediator-developer public claims contradict his private documents.

4. Discussion

In response to preceding results of remediator-developer misrepresentations/inconsistencies (re toxic-site testing/cleanup) by Trammell Crow, the world's "industry leader" in toxic-waste remediation, at least 5 questions arise. They address how/why such unexpected results have occurred; whether these misrepresentations pose public-health threats; whether they pose environmental-justice risks; whether other research supports the results of this article; and what the main limitations of this research are.

4.1 What Might Explain These Misrepresentations/Inconsistencies About Toxics Cleanup?

4.1.1 Flawed Regulatory Enforcement

One of the most obvious answers to the preceding question is that, if the toxic sites assessed here are typical, state regulators are not enforcing scientific/technical rules for privatized testing-cleanup. For instance, results showed that at especially dangerous, "Imminent and Substantial Endangerment" (ISE) sites, regulators have not enforced VOC-site requirements for indoor-air tests; yet all sites examined here have tenants who could be hurt. Likewise regulators have not enforced requirements for deep-soil-gas testing, down to groundwater, needed to protect groundwater/drinking water, to stop toxic VOC migration up into buildings, and to remove all VOC sources.

Indeed, even at ISE sites, state regulators have not forced privatized remediators-developers to adhere to US/CA EPA-cleanup standards, as Table 8 shows. Yet government mandates that remediators-developers must either adhere to these default cleanup standards [40] (p.17), or provide "adequate technical documentation" that their "alternative" methods/tests/cleanup are "technically equivalent" to the default standards, [40 (pp.1, 2), 57 (p.2)]. However no assessors provided such documentation, and none was enforced. Thus it does not appear that preceding deviations from toxic-waste standards are defensible on rational scientific grounds

Table 8 Remediator-Developer Soil-Gas-Cleanup Levels for Perchloroethylene (PCE) and Trichloroethylene (TCE) at the former US Naval Ordnance Test Station, Pasadena (NOTSPA), CA, and Santa Fe Railyards Toxic Site, Los Angeles, CA, toxic sites. The developer's post-cleanup perchloroethylene (PCE) and trichloroethylene (TCE) toxic-site-cleanup levels (for the few site areas that will be remediated; most will not be remediated), for both the former NOTSPA and SFR toxic sites, violate US/CA EPA-cleanup standards that allow a cancer-risk level of only 10^{-6}. This level is 0.46 μg/m^3 PCE, and 0.48 μg/m^3 TCE [49]. However, Table 8, column 5 shows NOTSPA and SFR post-cleanup PCE/TCE levels, respectively, are 25,833 and 147,917 times more dangerous than 10^{-6}. In fact, many onsite areas remain above 10^{-6} and have not/will not be remediated. Moreover, for at least two reasons, harm from the developer's weak-remediation levels is likely greater than shown here. *First*, both sites have preferential subsurface soil-gas-migration routes (eg, sewers/drains), allowing greater/all toxic-VOC concentrations to move from soil gas to indoor air. *Second*, because neither site conducted US/CA EPA-required, indoor-air testing, assessors relied on government's soil-gas-to-indoor-air conversion factor to determine indoor-air risks. Because this factor presupposes no such preferential routes, it yields indoor-air-toxin levels that are higher/more dangerous than those presupposed in Table 8 and earlier tables [56, 57].

VOCs[1, 2]	**US EPA,[3] DTSC,[4] 10^{-6} required cleanup level,[4, 5] μg/m^3**	**NOTSPA actual cleanup,[6] μg/m^3**	**Railyards actual cleanup,[7] μg/m^3**	**Standards are how many times safer than remediator-developer cleanup?**	
				NOTSPA	**Railyards**
TCE[8]	0.48	12,400	71,000	25,833	147,917
PCE	0.46	5,470	19,000	11,891	28,850

[1][49] (p.34). [2][51] (p.5). [3][84]. [4][85]. [5][60] says residential screening/ESL levels should be used on both residential and commercial sites as one never one never knows how a site could be used in future and, otherwise, innocent people could be hurt. [6][72] (p.37). Interestingly, US EPA says brief exposure to TCE at 0.5 μg/m3 can cause birth defects [86], yet the NOTSPA and railyards TCE cleanup levels, respectively, are 24,800 and 142,000 times above this level. [7][51] (Table 2).

4.1.2 Privatized Remediation and Remediator-Developer Financial Conflicts of Interest

Other possible reasons for remediator-developer cleanup misrepresentations/inconsistencies, some suggested in section 1.1, are (1) privatized testing [12, 13]; (2) little toxin-exposure data [14]; thus (3) little remediation-health-effectiveness data. In addition, because of (1), there is (4) little access to site testing-cleanup documents, because they are the remediator-developer's property. As a result, there is (5) little *public* waste oversight, except perhaps in CA where all site documents are available, even those of the remediator-developer. There also are (6) few systematic, comprehensive, *government*-oversight documents [7], and (7) limited examples of adequate government toxic-waste oversight---for reasons already stated earlier [7, 13].

This minimal oversight is risky, given that government induces private developers to conduct privatized toxic-site testing-cleanup by contractually guaranteeing them liability protection, eg, [87]. Yet lack of liability may incentivize flawed testing-cleanup and its misrepresentation. Given market operations and profit motives, privatized remediation thus faces a massive conflict of interest: Conducting less testing-cleanup saves $ for remediators-developers but threatens health. Conducting better testing-cleanup threatens remediator-developer $, not public health.

The preceding financial conflicts of interest, inherent in privatized cleanups, might help explain why nearly all our results show VOC undertesting and underreporting. Perhaps this undertesting/under-reporting is used to justify inexpensive, shallow-soil-contaminant mitigation (instead of using more expensive, full-site soil SVE remediation and source removal).

Because most of our results are unidirectional, showing inconsistency and misrepresentation, they suggest determinate bias. Why? 100% of the 13 VOC-testing-cleanup inconsistencies and 4 logical fallacies have unidirectional effects, namely, contaminant/risk underestimates because they rely on less-than-required testing that exhibits less-than-maximum contaminant levels, eg, by failure to test all sources, most deeper soil, and indoor air. Yet because random or accidental violations should have bidirectional effects (both over- and under-estimating site risks, thus needed cleanup), our results show apparent remediator-developer bias. This apparent bias, in turn, suggest that toxic sites might benefit from empirical reassessment of testing-cleanup. In short, the inconsistencies illustrated in this study could be red flags, “early warnings” about faulty, health-threatening hazardous-site testing-cleanup.

CA recognized similar red flags and financial conflicts of interests with private prisons and banned them in 2019. The governor said private prisons are “driven to maximize shareholder profits” and “lack proper oversight” [88]. Is the same true of privatized toxic-site testing-cleanup?

4.1.3 The Absence of a Legally Binding Scientific Integrity Code

Still another reason for the surprising remediator-developer misrepresentations of his toxic-site testing-cleanup, documented here, may be that most states do not have binding scientific-integrity clauses that are required in all state contracts with subcontractors. Nor do most have any laws or penalties, imposed on state-government subcontractors, for scientific-integrity violations.

Recently, however, US EPA passed a scientific-integrity law, binding on federal contractors who are “conducting, supervising, communicating, and utilizing [scientific testing and] results” [89]. If California’s privatized-toxic-site-cleanup contract included such a contractor-integrity clause, it might have prevented the scientific and public-health misrepresentations outlined here [21-23, 29].

4.2 Do Misrepresentations of Testing-Cleanup Pose Public-Health Threats?

At both toxic sites with testing-cleanup misrepresentations, the remediators-developers have put site tenants at health risk by giving them false assurances of site safety. At NOTSPA, Table 4 and Table 5 show the remediator-developer confirmed cleanup “to the highest residential standards," 10^{-6}, to the **public**/regulators, but his more **private** or technical documents/raw-data reports show shallow-soil, cleanup-VOC-risk levels of 10^{-1} and 10^{-2}, at least 100 times less protective than allowed. Independent university testing likewise shows NOTSPA tenants currently (2021) face indoor-air risks from PCE alone that are at least as high as $4.4(10^{-4})$ [29], 440 times greater than the developer’s guaranteed “highest residential standards,” and 4.4 times greater than the minimum risk government allows (10^{-4}). Instead of a risk of 1 cancer per million people exposed, NOTSPA tenants face at least a risk of 1 cancer for every 2273 people exposed [29]. Given the age-dependentadjustment factor, young NOTSPA-site children will face an even higher risk, 1 cancer for every 272 exposed children [90].

Similarly, as this document's SFR tables reveal, remediators-developers assured their tenants that "the soil vapor contamination has been addressed." Instead, study tables show current renters face toxic-waste "cleanup" levels. The 324 K-μg/m^3 PCE cleanup level has a cancer risk of $7(10^{-1})$, which is 7000x > 10^{-4} the maximum-allowed risk---and nearly a certainty of site-induced cancer.

At both NOTSPA and SFR, remediators-developers contradicted themselves, misrepresented their own documents, understated toxics risks. Therefore their clean-ups and public-health protection likely also have been inadequate. Developers likewise have misled tenants about indoor-air risks, so tenants may face especially serious risks. In summary, TC's misrepresentations of its hazardous-site testing-cleanup exacerbate its apparent violations of VOC-testing requirements, cleanup levels, and rebound testing.

4.3 Do These Misrepresentations of Testing-Cleanup Pose Environmental-Justice Threats?

This question is important, as mentioned earlier, because EJ communities typically host toxic-waste facilities, and both sites could worsen health/economic harm to EJ communities. For instance, the CA regulator's CalEnviroScreen, the online multiple-pollutant indicator, ranks the census tract, in which SFR is located, as among California's 4%-most-polluted [91, 92]. This community is 94% Latino, 46% foreign-born, with 42% more children than California's average [93]. In addition, TC built the largest contiguous commercial rental space in Los Angeles [76] on the not-fully-remediated railyards site, a fact that threatens onsite blue-collar workers. Misrepresentations of toxic-site risks thus could worsen health harm for all members of this already-vulnerable EJ community [92, 94].

Similarly, NOTSPA remediator-developers testing-cleanup misrepresentations also could worsen harm to near-NOTSPA EJ communities which, the Introduction noted, are disproportionately minority, uneducated, unemployed, low-birthweight, and asthmatic. Patients at Kaiser Health's hospital-size/medical/urgent-care facility, abutting east-side NOTSPA, are a second EJ group, put at further risk from site-safety misrepresentations. The same is true for the middle- and high-schoolers and college students, taking classes at Pasadena City College, abutting north-side NOTSPA [23].

Still another NOTSPA EJ population are disproportionate numbers of children who will live in the 550, toxic-site-apartment residences that abut the 10-lane Interstate 210, a major East-West, Los Angeles diesel-truck artery [95]. Only 31% of CA households include children ages 18 and younger [96], yet 40% of NOTSPA hazardous-site apartments are for families with children [62]. The children will face both subsurface-VOC, indoor-air risks, plus airborne-freeway-cancer risks 1500 times higher than California's average cancer threats [97]. Although CA recommends against building homes, medical facilities, daycare centers, schools, or playgrounds within 500 feet of freeways [98], NOTSPA's remediator-developer appears to have ignored these recommendations, as well as state testing-remediation requirements. In summary, remediator-developer misrepresentations of toxic-site risks likely worsen the medical and economic harm imposed on surrounding EJ communities.

4.4 Does Previous Research Support Our Results?

Despite the massive data gap about the medical/health protectiveness of toxic-site testing-cleanup, several types of other results are generally consistent with these results, as shown in section 1.2: (a) near-single-site **health-parameter tests**, such as blood-lead tests; (b) **state-**

government audits of privatized cleanups, (c) independent scientific **data quality audits**, and (d) independent **single-site contaminant tests**. Studies (a) provide little precise support for this analysis, as preceding section 1.2 showed these studies beg the question of whether adequate remediation was conducted.

However, preceding studies (b), conducted annually on a tiny percentage of supposedly remediated toxic sites in Connecticut, New Jersey, and Massachusetts, generally support these results. The audit studies confirm that US privatized toxic-site testing-cleanup is not adequately health protective, as section 1.2 noted, because only 13-29% of sampled cleanups meet basic health/regulatory requirements and pass the audit. Studies (c) are small in number, given lack of access to site documents; they show that scientific testing-cleanup documents for small but representative samples of hazardous-waste sites fail to meet the scientific standards of data-quality analysis [21], empirical-data audits [22], and data-usability analysis [23]. These studies provide quick, cost-effective insights into the quality of remediation because they involve no empirical testing, but they must be done on a site-by-site basis. Studies (d), eg, [29, 99] also are non-interested-party studies. They the rarest, most expensive, and theoretically the most credible of the four types of testing-remediation assessments because they involve independent empirical tests of toxic-site-contaminant levels before any site-related injuries or deaths have been reported, but after claimed testing-remediation, as preceding section 1.2 noted, studies (d) tend to support the results of this study, as do analysis of types (b) and (c).

Additional research, published by the CA legislature, but not in scientific journals, however, may be consistent with our findings about private interests' failure to follow government-mandated, toxic-site scientific requirements and the apparent failure of state regulators to enforce these requirements. This research shows that, for decades, the state legislature has been attempting to reform the CA toxic-waste-site regulator, the Department of Toxic Substances Control (DTSC) because of massive citizen complaints of failed enforcement. After more than 10 years of attempts to reform DTSC, in 2021 the CA Legislature explained that these reform efforts had largely failed:

"Over the past decade…DTSC has received complaints [that]…DTSC is not properly enforcing state and federal law….Numerous statutory changes have been made to…address outstanding programmatic failings. However, many of the underlying concerns about [DTSC] transparency…[and] accountability…remain" [100] (pp.6, 7).

4.5 What Are the Key Limitations of This Research?

This study has at least 5 limitations. *First*, instead of empirical testing, it provides one type of study, specifically requested by the WHO: a "cost-efficient health surveillance" of cleanups and possible "illegal operations" [8]. *Second,* this study limits costs, per WHO, by using as a proxy (for potentially flawed cleanups or health-threatening "illegal operations"), a simple comparison between remediator-developer official **public**, regulatory statements, versus what their most **private** or technical/data-report documents say. If the public and private or technical statements are contradictory, our assumption is that the remediator-developer may be hiding something, thus that site testing-remediation may be flawed and should be tested empirically. *Third,* this study is limited in assessing only the *two sites* that meet our 5 public, reproducible selection criteria; it was impossible to know, ahead of time, how many sites would satisfy these criteria, especially the criterion of court-mandated Imminent and Substantial Endangerment (ISE). *Fourth*, this research provides no quantitative analysis of specific medical harm caused by poor testing-cleanup. *Fifth*, given the inability to assess any sites without full public access to all available technical documents, this assessment covered only CA sites, as explained earlier.

While it would be desirable to avoid the preceding limitations, overcoming limitations 1 and 4 requires funding of remediation-misrepresentation studies. Yet such studies are applied science, thus not typically fundable by government-research agencies, and empirical testing is quite expensive. Limitation 3 could be overcome by conducting a subsequent test involving more toxic sites; this could be achieved by dropping some of the site-selection criteria; however, dropping the Trammell Crow requirement would increase confounders, misrepresentations caused by developers with less inexperience and fewer financial resources. Similarly, dropping the ISE criterion would mean assessing sites that pose fewer health threats than those assessed here. However, overcoming limitation 5 is not possible at present because, as noted, scientists do not have access to all hazardous-site-testing documents, except perhaps in CA.

In addition, a more comprehensive analysis of whether hazardous-waste testing-cleanup in different nations or state meets scientific standards is not possible because regulations and scientific-guidance documents for vapor intrusion differ among US states and different nations, eg, [101]. Moreover, vapor-intrusion field testing is not common, except in developed countries like Australia, Canada, Denmark, the UK, and US; in fact, most nations have no vapor-intrusion regulatory and scientific/technical guidance [102]. Nevertheless, this limited analysis is important; it and its 2021 companion paper [84] are the first, independent, systematic, reproducible studies of the health-protectiveness of hazardous-waste testing-remediation.

4.6 What Research Needs and Policy Solutions Does This Research Suggest?

Our results---showing that at some of the most dangerous, privatized US waste sites, remediators-redevelopers tend to misrepresent the quality of their cleanups----suggest the importance of examining non-privatized, non-CA, or non-TC waste cleanups to see whether further results are consistent with those discovered here. However, such studies will be difficult, given the data-availability problems noted earlier. Future investigations likewise might compare different hazardous-waste exposures and resulting health impacts associated with sites whose remediators-redevelopers correctly, versus incorrectly, represent the regulatory and health adequacy of their cleanups.

Another inexpensive way to improve future hazardous-waste policy, oversight of waste testing-cleanup, environmental justice, and environmental health might be to require all toxic-site testing/cleanups to have annual, routine, independent scientific-data audits (RISDA) [20, 103]. Like financial-audits, RISDA check whether reported/published testing conclusions agree with test data; they do not interfere with sampling or operation. RISDA might incentivize sound remediation and adherence to standards. To promote reliable testing-cleanup, states also could require scientific-integrity clauses in all the contracts that they sign with government contractors, as suggested earlier.

5. Conclusion

This study addresses the question whether, "For US hazardous-waste sites that the courts say pose 'Imminent and Substantial Endangerment' (ISE) threats to health, are remediators' public or regulatory testing-and-cleanup representations consistent with their private or technical technical-document statements?" To answer this question, the author followed 4 steps. These are (1) employing 5 public, reproducible, transparent criteria (a)-(e) to select toxic sites to assess; (2) using 3 public, reproducible, transparent criteria (i-iii) to discover 17 remediator-developer **public** representations of toxic-site cleanup; (3) employing 3 public, reproducible, transparent criteria (i-iii) to discover data in remediator-developer more **private** or technical documents---that address these same 17 claims; and (4) using US EPA's classic, toxic-waste-site-assessment method, the weight-of-evidence method, to assess the consistency between the preceding public regulatory representations and statements or data in private or technical documents.

The results of this study use remediator-developer public-technical consistency as a method of conducting a "cost-efficient health surveillance" of both toxics cleanups and possible "illegal operations," as the World Health Organization requested [8]. The conclusions of this research are that, given 17 possible remediator-developer contradictions between their public regulatory representations of cleanup and their more private technical cleanup documents, there were 13 remediator-developer contradictions and four instances of logical fallacies. These results support the conclusions that:

- Remediators-developers often make **public** regulatory claims (about the health-protectiveness of their cleanups) that fail to meet regulatory standards and are not always consistent with what their more **private**, data-report, or technical documents say.
- Such inconsistencies appear to be red flags, possible early warnings of allegedly remediated toxic sites that fail to adequately protect health.

Discussion of the preceding results also supports two additional conclusions:

- Remediator-developer misrepresentations of their hazardous-site testing-remediation exacerbate apparent violations of testing-cleanup requirements and cause additional threats to human and environmental health.
- Remediator-developer misrepresentations of their hazardous-site testing-remediation result in, and exacerbate, threats to the environmental-justice communities that tend to surround toxic sites throughout the world.
- Because the effects of these misrepresentations are unidirectional, showing misreports about contaminant undertesting, unrreporting, and undercleanup, they show both apparent determinate bias and that these sites might benefit from independent re-testing.

In short, the apparent bias and misrepresentation discovered here could provide red flags, cost efficient "early warnings" about health-threatening hazardous-site testing and cleanup.

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Author Contributions

KSF conceived, analyzed, and rewrote this article.

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Competing Interests

The author declares competing interests. However, the author declares no financial conflicts of interest and no actual conflicts of interest of any kind. Nevertheless, to avoid the perception of conflicts of interest, the author shares the following information. For decades Shrader-Frechette has directed and been a member of a University of Notre Dame pro-bono faculty-student group, the Center for Environmental Justice and Children's Health. It responds to worldwide requests for pro bono scientific assistance on behalf of minorities, children, and poor people who are threatened by environmental injustice. No member of the Notre Dame group has ever received payment for these requested services. In spring 2018, Pasadena, CA residents, living near the former Naval Ordnance Test Station Pasadena (NOTSPA) hazardous site, requested a pro-bono, Notre Dame, technical consultation. As a result, during August-December 2018, the Notre Dame group assessed developer Trammell Crow's NOTSPA studies. Because they discovered regulatory violations, risk underestimates, testing and cleanup errors, violations of data-quality standards and data-usability evaluation, and failure to pass a scientific-data audit, the Notre Dame scientists concluded in December 2018 that their results should be published. In December 2018, members of the Notre Dame faculty group began writing up and documenting their extensive results for various scientific publications. In January 2019, they began presenting their results to the near-NOTSPA community members who had requested the pro-bono technical consultation. Members of the near-NOTSPA community next asked the Notre Dame scientists to present their results to the state regulator, CA Department of Toxic Substances Control (DTSC). The scientists did so in May 2019. However, because members of the University group continued to perform their other University duties, including teaching and other research, they did not submit their first NOTSPA publication until October 15, 2019. In November 2019, the state regulator, DTSC, issued a final refusal to correct the many scientific errors that the Notre Dame team had discovered in site documents, errors that appear to jeopardize public safety and environmental justice. Because of Dr. Shrader-Frechette's leading the Notre Dame pro-bono, site-assessment team, members of the NOTSPA community group, a nonprofit charity, Stop Toxic Housing, elected Dr Shrader-Frechette as President of the nonprofit. The charitable nonprofit then voted to sue the state regulator for failure to enforce state and federal hazardous-waste laws. Developer Trammell Crow was not sued. This lawsuit against DTSC thus was the result of DTSC regulatory failure to correct serious site testing, cleanup, safety failures, documented by more than a year of Notre Dame scientific studies. Without DTSC's uncorrected scientific violations, discovered by Notre Dame scientists, there would be no public-interest lawsuit by the local community. Because state-required, site-indoor-air testing had not been done at NOTSPA and because some site renters requested indoor-air testing of their units, beginning in 2020 the Notre Dame group conducted onsite indoor-air testing. This testing provided empirical support for their earlier publications. In summary, the authors declare that although Dr. Shrader-Frechette's and Notre Dame's pro-bono scientific assistance to EJ communities is a potential, non-financial, conflict of interest, this volunteer work is part of Dr. Shrader-Frechette's, and university scientists', typical job description: to perform (1) research, (2) teaching, and (3) pro-bono professional service that helps to protect the public good.

Additional Material

The following additional material is uploaded at the page of this paper.

1. Appendix A: Explanatory materials with additional references.

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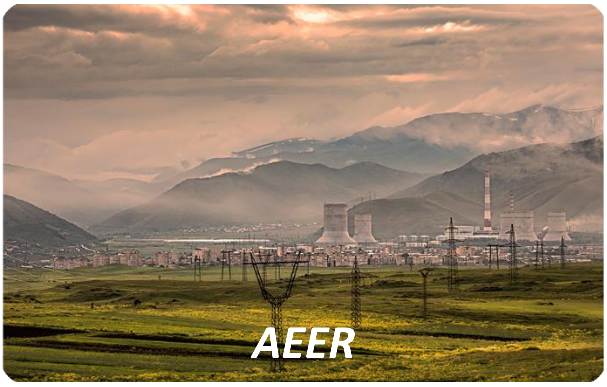
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