Supplementary Materials S2, Including All References

2.1 US CERCLA and Brownfields Sites and Why They Have Not Been Tested and Remediated

Under Superfund, the US Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), there are two main types of US hazardous-waste facilities: National Priorities (NPL)/Superfund installations and brownfields. NPL sites are federally remediated under the US Environmental Protection Agency (US EPA) and have "national priority among the known releases or threatened releases of hazardous substances" [11]. They must follow CERCLA testing/cleanup rules. Brownfields, typically remediated through state programs, are properties with "the presence or potential presence of a hazardous substance" [118]. Brownfields (that are no longer continuing their operations) usually follow Resource Conservation and Recovery Act (RCRA) testing/cleanup rules that are less demanding than CERCLA rules [119]. However, US military installations, whether owned/operated by private defense contractors or the armed services, can be either NPL or brownfields (RCRA) sites [120]. As CERCLA allows [111] (p. 12), the former Naval Ordnance Testing Station, Pasadena, California (NOTSPA) is a state-cleanup brownfield [7], but must follow CERCLA testing/remediation rules, given its serious contamination [88]. Sites like NOTSPA show there is no mutually exclusive distinction between brownfields and CERCLA/NPL sites.

US EPA estimates that US brownfields number up to 1,000,000 [14], of which only a small fraction have been remediated (which requires prior testing). Of these brownfields, EPA has remediated 2,180; state programs have remediated another 190,050; and 8,871 are "ready for reuse" but not remediated [15]. Those in the last category have not been remediated because state regulators claim either that toxins have been reduced [16], that the wastes are unlikely to cause significant effects, or that the economic benefits of immediate site reuse "outweigh… the significant and unavoidable impact" of contaminants [17] (p. 18). Given US EPA's total-brownfields estimate (up to 1,000,000), roughly 19% (192,230 of 1,000,000) have been remediated.

Of 1,714 US NPL sites, only 387 or 23% have been tested and remediated [11, 12, 13]. Most of those unremediated are military sites [122, 114 (p. 11)]: facilities of military contractors such as Boeing; armed-services bases, laboratories, or test sites, like NOTSPA; or US nuclear-weapons facilities that constitute "the largest environmental cleanup program in the world" [123]. Because NPL and military sites are the most contaminated and difficult to remediate, most unremediated NPL sites were added to the list more than 30 years ago, during the first 10 years after 1980 CERCLA passage [12].

At least 6 reasons help explain US toxic sites' incomplete testing and remediation.

First, testing and cleanup are ***expensive***, "costly and time-intensive," not "practical" [58] (pp. 47, 51), claims Trammell Crow Company (TCC) the largest US commercial developer [10]. Expensive testing/cleanup is why multiple prospective purchasers rejected NOTSPA. TCC's own tests show that NOTSPA soil concentrations of volatile organic compound (VOC) chlorinated solvents, such as trichloroethylene (TCE), perchloroethylene (PCE), carbon tetrachloride (CT), and dibromochloromethane---the four site "risk drivers" [6](p. 34)---are up to nearly one million times above allowed levels [59] (see Table S1 in Appendix 1). As a result, NOTSPA faces vapor intrusion (VI) [5], migration of subsurface gaseous carcinogens like CT, PCE, and TCE into surface buildings [128]. VI sites have reported increases in rates of cancer, low-birthweight children, restricted fetal growth, and cardiac defects, although only a few epidemiological studies have fully confirmed VI causality, given background co-exposures, eg., [5, 27, 30, 125,127,128].

Second, remediation often does not occur because responsible parties use anti-regulatory ***legal maneuvers*** to avoid teting/cleanup. For instance, given suspected VI that threatens NOTSPA renters, California Department of Toxic Substances Control (DTSC) issued a 2004 "Imminent and Substantial Endangerment" order and demanded cleanup [87, 123]. Yet despite no cleanup, DTSC was forced to drop the order, a condition demanded by the responsible parties before they would enter negotiations with DTSC. Because negotiations failed [128], NOTSPA remains contaminated.

Third, both state and federal cleanups face ***inadequate funding***. Federal/CERCLA remediation monies have fallen by half since 1995 because the tax (on the petrochemical industries) that financed Superfund expired in 1995 and was not renewed [12]. Because all US states face prohibitive toxics-cleanup costs, all have adopted privatized programs through which most remediation occurs. Privatized schemes include US EPA's so-called "voluntary agreement" program[19]. In voluntary programs, private parties (usually redevelopers) negotiate testing/cleanup levels with a state, in exchange for US EPA-funded financial and regulatory incentives [19], such as tax credits, site-liability protection, allowing land-use controls, and letting the redeveloper choose a licensed private party, not the state, to conduct testing/cleanup oversight [129].

Fourth, as the US Government Accountability Office (GAO) warns, frequently full testing/cleanup does not occur because of ***the absence of interagency agreements.*** EPA is able to enforce toxic-site remediation only if other agencies, such as the Department of Defense (DOD), agree to report hazardous facilities to it [121] (p. 22). Yet few incentives exist for agencies to report toxic sites for whose cleanup they are financially liable.

Fifth, testing/remediation often does not occur because US EPA's list of hazardous facilities includes only those with reported releases. Any ***unknown or untested toxic sites*** have no reported releases, thus are not on the list [111].

Sixth, ***outdated cleanup regulations*** have not kept pace with scientific knowledge, as illustrated by NOTSPA contaminants like VOCs and perfluoroalkyl substances (PFAS) that cause vapor intrusion (VI) [130, 131]. As a result, US EPA warns that at least one quarter (up to 250,000) of estimated US toxic sites [14], poses VI threats [20]. As a result, hundreds of thousands of facilities, once considered clean, now must be reevaluated, tested for VI [31, 32, 45, 132, 133].

2.2 Privatization and Why Many Threats at US Hazardous-Waste Sites Are Unknown

Besides incomplete testing and remediation, at least three facts suggest that many toxic-waste threats are unknown because of incomplete government data.

First, despite US EPA's 2020 estimate of up to 1,000,000 US hazardous sites [14], US GAO warned the number is "unknown, due primarily to ***incomplete and inaccurate data***" (authors' bold) and that "it will take decades to complete the inventory" [121], partly because US EPA's estimates come from other agencies that have inadequate data. For instance, the Bureau of Land Management of the Department of the Interior (DOI) lists more than 30,000 abandoned unassessed mines on its lands, but only 4,722 contaminated sites. Although GAO's latest estimate is that up to 500,000 abandoned US mines require cleanup [134], many of them must be added to US EPA's list of hazardous facilities [111].

Second, even when toxic sites have been assessed/remediated/closed, US GAO warns that ***assessments often are incomplete*** [121], partly because it cannot document safe cleanup at 40 percent of supposedly remediated military facilities [135]. DOD's Inspector General agrees, citing fraudulent cleanup contractors [136] like Tetra Tech. It took $1 billion from the US Navy to remediate Hunter's Point Naval Station in San Francisco. Yet after thousands of mostly African-Americans moved onto the redeveloped site and reported disproportionate numbers of cancers, the Navy and US EPA discovered Tetra Tech had falsified 97% of cleanup data [137, 138, 139, 140].

Third, many toxic-site problems also are unknown because, except for CERCLA facilities, most US hazardous-waste locations have ***privatized*** [18, 15], including voluntary-program cleanups, including testing [19, 129]. This remediation often occurs with minimal state oversight/knowledge. New Jersey and Massachusetts, for instance, have two of the longest established, privatized, voluntary-cleanup programs, yet their results suggest significant safety problems. For instance, every year, 20% of Massachusetts' privatized cleanups must receive state-government audits, of which only 2% undergo soil sampling [18]. Yet annually 87-71% of audited, privatized, Massachusetts toxic-site cleanups, numbering roughly 1,800 or more locations per year, fail this audit [18, 33]. If the unaudited 80% of privatized, Massachusetts cleanups undergo similar poor remediation, this means the numbers of risky, but supposedly clean, toxic sites are substantially greater than 1,800 per year. Why? Most threats are neither detected nor remediated because most sites are not audited. Such failures help explain why attorneys say private remediators "routinely" violate regulations and create public-health risks [18]. Every year as many as 21% of audited, privatized, Massachusetts cleanups (479 locations) pose such urgent health threats that the state invalidates their closures ; if these data are representative, they suggest that the remaining 80 percent of annual, unaudited, supposedly remediated toxic sites could include nearly 2,000 Massachusetts locations whose closures threaten public health and should be invalidated [33].

In New Jersey two reasons suggest privatized site remediation is more problematic than in Massachusetts. One reason is that only 10% of hazardous-facility, privatized-facility cleanups receive annual audits, not 20%, as in Massachusetts. Another reason is that New Jersey has no voluntary-program cleanups, overseen by the state; instead, to save money, the entire cleanup and regulatory process is privatized, with persons hired by the interested parties being responsible for choosing testing/cleanup options, a situation that creates a conflict of interest [18].

If the preceding data are representative of most states, where no routine scientific-data audits occur, then other privatized cleanups, as at NOTSPA, may be questionable because site assessors and remediators know that no one will officially check on them according to specific, prescribed standards. At the very least, the safety of many privatized, hazardous-waste cleanups is unknown.

Although negotiated, privatized schemes dominate remediation in every state [19, 132], the schemes differ, state to state, depending on the degree to which the state privatizes, or outsources, various testing/cleanup functions [18, 33]. Such functions include control of (1) permitting, (2) scope of testing/cleanup, (3) testing, (4) cleanup, (5) oversight, (6) certification of cleanup, and (7) enforcement [33].

In the privatized programs of Connecticut, Massachusetts, and New Jersey, the state controls functions (1) and (7), outsources (2)-(6) [18, 33], then guarantees it will not sue the assessors, remediators, and redevelopers, provided they follow required standards [141]. However, as preceding paragraphs illustrated, Massachusetts has a more robust enforcement/auditing program than New Jersey, and most states have no such post-cleanup audits [18, 33] In California, the state controls functions (1) and (5)-(7). However, in exchange for liability protection, streamlined regulatory responses, and financial incentives, private redevelopers may negotiate (2)-(4), reduced toxic-site testing and cleanup [141, 142].

Mainly because private redevelopers negotiate reduced toxic-site testing/cleanup, the success of privatized cleanups is controversial. On one hand, most states focus on economics and claim that privatized programs have saved money, reduced cleanup time, and increased brownfields redevelopment. Within several years, New Jersey's program greatly increased the pace of testing/remediation and closed 6,000 of 20,000 active hazardous sites [143]. Similarly, Massachusetts remediated "thousands more sites per year" than its earlier, non-privatized program [18]. On the other hand, public-health and legal experts say that state oversight of privatized testing/cleanup is inadequate; that "remediation is typically driven by purely financial motives"; and that private interests routinely "conduct a partial investigation or remediation without penalty" [18].

Such a privatized, partial investigation occurred at the TCE- and PCE-contaminated site in Franklin, Indiana. As a result, in the last 11 years Franklin families have reported 58 children in their small town with rare blood and brain cancers, although epidemiological studies have not been completed. During the supposed Franklin cleanup, US EPA and the state retained control of (1) permitting, (5) oversight, (6) cleanup certification, and (7) enforcement, but outsourced to private interests (2) the scope of testing/cleanup, (3) testing, and (4) cleanup. However, the private interests ignored state/federal scientific guidance to test for offsite-VOC migration and VI---testing that might have prevented the town's increase in reported child cancers. Typical of most US privatized cleanups, until children began dying, no officials investigated the quality of the supposed testing/remediation [125].

2.3 Why Hazardous-Waste Cleanup Does Not Correct Environmental Injustice

Despite the preceding, documented, limited oversight of privatized testing/cleanup, US EPA relies on little evidence when it touts brownfields remediation and redevelopment as a way to correct environmental injustice [144].

However, because hazardous facilities tend to be located in environmental-justice communities, hurt by the toxins, therefore EPA gratuitously assumes that brownfields remediation will protect these communities eg, [8, 9, 145, 146].

Contrary to US EPA's assumption, the literature shows that testing/remediation often fails to serve environmental-justice communities because toxic-site redevelopers tend to drive privatized cleanups, based on what is most profitable, not what ensures environmental justice. Given reliance on market mechanisms and the absence of federal statutory requirements to consider environmental injustice [138], privatized cleanups tend to employ less protective cleanup standards. Although privatized programs typically give redevelopers immunity from toxic-site liability, in exchange for partial testing/remediation, redevelopers frequently fail to address contamination, thus worsen environmental injustice [147, 148].

Post-cleanup gentrification also is a problem. Because supposed cleanup tends to increase percentages of white and non-poor populations living on former toxic-waste sites, it can worsen inequity and the plight of marginalized populations [149, 150, 151]. Genuine remediation and redevelopment also are less likely to occur in poorer, largely minority communities than in wealthier, non-minority communities. When partial cleanup does occur in poorer locations, it typically proceeds much more slowly than in wealthier areas [8, 147, 148].

2.4 The Weight of Evidence (WoE) Method

In part to protect environmental-justice communities and ensure defensible science, how does one evaluate the adequacy of toxic-site assessments and cleanup? Although current epidemiological methods are reliable, largely because they are very narrow, they cannot be used for such an evaluation. Because of their narrowness, they are unable to evaluate either the adequacy of multi-disciplinary, toxic-site cleanups or the degree to which they protect environmental-justice and affected communities.

Except for US EPA's systematic 2016, three-part, weight-of-evidence (WoE) method, scientists have virtually no transparent, systematic method for integrating/weighing multiple pieces of diverse, often-conflicting lab/field/statistical/epidemiological/modeling evidence, in order to infer likely causality/teratogenicity/safety/needed regulatory action [34], based on examining all available/relevant positive and negative evidence. WoE dictates (1) assembling a body of positive/negative evidence regarding some question, e.g., which of two hypotheses is superior; (2) justifying evidence-weighting/scoring procedures; and (3) evaluating this weighting/scoring to answer the relevant question [34](p. 1).

WoE is widely used, primarily by US EPA/risk/environmental-impact/hazardous-site assessors and is based on Bradford-Hill considerations [34]. Given diverse, conflicting, and incomplete evidence, US EPA recently used WoE, for instance, to weigh this evidence and infer the teratogenicity of TCE [41] and to impose TCE Interim/Early Action Mandates on Superfund sites [42].

Precisely because WoE evaluates many diverse, often conflicting, pieces of evidence, it can tentatively answer questions that are more policy relevant than those of most statistical or epidemiological methods, questions such as whether a hazardous-waste site is safe, or whether a particular chemical should be regulated, questions that cannot be answered by a single lab/field/statistical/epidemiological/ modeling method [34]. No single statistical or empirical method can assess, for instance, which of two diverse-evidence hypotheses/theories is more reliable, because there are **no specific/quantitative methods or methodological rules** for such hypothesis/theory assessment. Instead, each theory-assessment situation is partly different, requiring comparison/interpretation of different evidence from different sources. Thus one can only argue, not show quantitatively or empirically, that such comparisons/interpretations of theory-relevant methodological rules/values (such as predictive power, coherence, etc) are tentatively correct, unless one refers to other scientists' expectations, which (by definition) are not empirical [44].

Yet because WoE is not quantitative or empirical in the traditional sense, but meta-scientific/analytical, it can more easily be used badly or arbitrarily than can narrower scientific methods. To avoid such arbitrariness, we follow four US EPA-recommended, WoE strategies:

- comparing which of two same-subfield theories/hypotheses is more credible, rather than whether a single theory/hypothesis is credible [34] (pp. 16, 39). Thus, our study asks whether privatized soil-gas tests tend to follow or to violate government testing guidance.
- specifying all WOE methods, procedures, strategies, ahead of time [34] (p. 4), as we do in 2.5 below.
- using a program or field's own criteria to assign weights/scores to evidence [34] (p. 4). Thus, our study assigns weights in WoE Part 2, based on what DTSC and US EPA guidance call testing "requirements."
- being transparent and systematic in specifying strategies for each of the 3 stages of WoE [34] (pp. 4-5).

Thus, our study specifies and defends 7 WoE Part 1 selection criteria for hazardous sites to evaluate, and 6 WoE Part 2 requirements for soil-gas testing, based on what guidance calls requirements.

2.5 WoE Part 1.1: Strategies to Find Federal and State of California Guidance on VI Testing

2.5.1 The Strategy for Federal Documents

The first part of the first (or federal) document-search strategy for WoE Part 1.1 is to go to <epa.gov/vaporintrusion>, then to the website header, "Current Guidance," then to download documents listed under it. The second part of the first strategy is to go to "Vapor Intrusion at Superfund Sites," at <epa.gov/vaporintrusion/vapor-intrusion-superfund-sites#:~:text=hazard%20ranking %20system-,Trichloroethylene%20and%20Vapor%20Intrusion,non%2Dcancer%20human%20health%20hazards>, then to download all guidance documents that appear.

2.5.2 Strategy for State of California Documents

The second (or state) document-search strategy is more complex than the federal strategy because California VI-guidance documents are spread among the different CAL-EPA offices that generated each of them. Thus, one must employ at least 3 separate/mutually exclusive sub-strategies to find all documents:

- Go to <dtsc.ca.gov/vapor-intrusion/>, use the search term "guidance," then download all non-duplicate, latest-version records listed under "VI guidance documents" (Search Strategy 1, WoE Part 1.1).
- Go to <dtsc.ca.gov/vapor-intrusion/>, then to the header, "Site Mitigation and Restoration Program Links," then click on "Proven Technologies and Remedies Documents," which leads to <dtsc.ca.gov/proven-technologies-remedies-documents/>. At the previous link, click on "Remediation of Chlorinated VOCs in Vadose Zone Soil," then download all guidance documents for subsurface-VOC tests (Search Strategy 2, WoE Part 1.1).
- Go to <dtsc.ca.gov/vapor-intrusion/>, then to the header, "Site Mitigation and Restoration Program Links," then click on "Human and Ecological Risk Office (HERO)," which leads to <dtsc.ca.gov/assessing-risk/ >. At the preceding link, click on "Human Health Risk Assessment," which leads to <dtsc.ca.gov/human-health-risk-hero/>. At the preceding link, under the header "Human Health Risk Assessment Guidance," download all (but only) guidance documents for VOCs, soil-gas, or VI testing (Search Strategy 3, WoE Part 1.1).

2.6 WoE Part 1.1: Strategies to Find Hazardous-Waste Sites Whose VI-Testing Documents to Evaluate

To find California toxic sites whose documents to evaluate for conformity to testing guidance, one can begin by using two prominent California databases. EnviroStor <dtsc.ca.gov/your-envirostor/> is the DTSC's premier online data-management system. It tracks state-controlled (not federal) hazardous-facility assessment, cleanup, permitting, and enforcement, including US military sites with known/suspected contamination. CEQAnet <ceqanet.opr.ca.gov/> is the online, searchable database of the State Clearinghouse for California Environmental Quality Act (CEQA) documents that provide cumulative state/local environmental review of proposed actions/projects that involve federal financial assistance or development documents [152]. CEQAnet is not a comprehensive database, as most toxic sites (required to follow CEQA) have no federal financial/development assistance, thus have no documents in CEQAnet [146].

Unfortunately, EnviroStor and CEQAnet databases have limited filters that allow no searches for most criteria/key words in our hypothesis. As a result, one cannot use the databases to search for toxic sites that satisfy the 7 selection criteria (for WoE, Part 1.2), listed in the text:

i **California locations**, subject to state guidance;

ii **sampling performed by/for TC**, the largest US commercial developer [10], who "pioneered…privatized remediation" [40] and is "the industry leader in Brownfields development" (see Appendix 2 (2.6);

iii **recent testing/remediation**, conducted since 2011, when California's main subsurface-VOC/VI guidance appeared [21];

iv **publicly accessible documents**, on Envirostor;

v **subsurface-trichloroethylene** (TCE) contamination;

vi multiple subsurface-**VOC carcinogens**; and

vii **privatized cleanup**.

In Envirostor, one can search for only the fifth (v) of our selection criteria (TCE sites), but if one then searches by year, or by using any successive search terms (e.g., Trammell Crow, TCC, TCC, VOC, etc.), each successive search produces 0 results. Even advanced Envirostor searches allow only name, address, assessor's parcel number, census tract, school district, cleanup program (e.g., NPL, voluntary, etc.), funding, contaminant, past uses (e.g., aerospace rocket testing), and media affected <envirostor.dtsc.ca.gov/public/search>. One can search Envirostor for voluntary cleanups, but because much privatized cleanup is not voluntary (see the Introduction in the text), this search fails to capture many privatized cleanups. Moreover, Envirostor's 14,000+ toxic sites (and even its 926 sites with known TCE) are too many to search by hand, to check whether each site's roughly 20 documents meet all 7 selection criteria. <envirostor.dtsc.ca.gov/public/search?CMD=search&ocieerp=&HWMP=False&business_name=&main_street_name=&city=&zip=&county=&censustract=&case_number=&apn=&CRITICAL_POL=30027&Search=Get+Report>.

Similar problems beset CEQAnet. Like Envirostor, CEQAnet has limited filtering/search capacities. CEQAnet permits searches for only 2 of the preceding 7 criteria, the first ("Trammell Crow") and the third (by year). Yet such searches do not allow hypothesis assessment because CEQAnet contains only a small percentage of toxic sites and associated documents.

Because of CEQAnet incompleteness and the inability to search either Envirostor or CEQAnet by using most of the 7 selection criteria, Envirostor and CEQAnet cannot generate a reliable list of current TCC California cleanups that meet our 7 toxic-site, selection criteria. To generate such a list, one needs at least 4 interdependent, successive strategies, only the last of which generates the final results:

- *Strategy 1*: employ (a) CEQAnet <ceqanet.opr.ca.gov/> and the two online (b) TCC lists of California toxic sites that TCC is testing, remediating, or redeveloping [154, 155], so as to generate a **preliminary, unedited toxic-site list** of California redevelopment projects that meet the first 2 of 7 selection criteria.
- *Strategy 2*: use Strategy-1 results to conduct internet searches for addresses of each Strategy-1 site, then use these addresses to strike all differently named, same-address, duplicate sites, thus generate a **preliminary, nonduplicate toxic-site list** of locations that meet the first 2 selection criteria.
- *Strategy 3*: use each Strategy-2 address to search Envirostor <dtsc.ca.gov/your-envirostor/> and CEQAnet, then download/examine all official documents for each site. Remove any sites that are not redevelopments of installations that state or federal governments list as former/existing hazardous facilities, then use the resulting inventory to generate a **preliminary, nonduplicate, toxic-site list** of redevelopment projects, based on the first 2 of 7 selection criteria**.**
- *Strategy 4*: use all Strategy-3 downloads to find all testing-related documents for each site; assess each document, so as to determine which hazardous facilities meet the last 5 of the 7 selection criteria; and thus generate a **final toxic-site list**, based on all 7 selection criteria.

To implement preceding Strategy 1, we used the search term "Trammell Crow" in (a) CEQAnet and found 23 entries. To find (b) lists of California TCC assessment/remediation/redevelopment sites, we went to the website of

TCC Vice President (Robert Chute), in charge of all Environmental Risk Management and hazardous locations; he lists 6 toxic-site projects [155]. Because TCC is both the largest US commercial developer [4] and "the industry leader in Brownfields development" [154], next we went to the website of TCC's major unit, the brownfields unit, Brownfields Acquisition and Development (BAD), within the environmental-risk or EASI (Environmental Asset Services, Inc.) Division; it contains a list of 26 sites [154]. Strategy 1 thus provides a list of (CEQAnet+Chute+EASI) projects numbering (23+6+26), 55 in all. Strategy 1 thus generates a 55-item **preliminary, unedited, toxic-site list** of TCC California redevelopment projects that meet the first 2 of our 7 criteria.

We implemented Strategy 2 to eliminate Strategy-1 duplicates. (Duplicates occur because TCC lists its toxic sites in inconsistent ways: by pre-redevelopment, post-redevelopment, informal, or LLC names; or combinations of the preceding labels [154, 155].) Strategy 2 generates a **25-item** (9+5+11) list, respectively, of (CEQAnet+Chute+EASI) projects: a **preliminary, nonduplicate, toxic-site list** of TCC projects that meet our first 2 selection criteria.

We implemented Strategy 3 by using Strategy-2 addresses as search terms, downloading Envirostor/CEQAnet documents for the 25 sites, then examining the documents, so as to strike (from our Strategy-2 list) all projects not at current/former toxic sites. Strategy 3 thus generates 11 (CEQAnet+Chute+EASI) or (2+2+7) toxic-site redevelopments ---an **11-item**, TCC, California, **preliminary, nonduplicate toxic-site list**, based on the first 2 selection criteria**.**

To implement Strategy 4, we assessed Strategy-3 findings (documents from all TCC toxic-site redevelopments) to determine which projects meet all 7 selection criteria. The Results presents our WOE Part 1 findings: a **final toxic-site list**, based on all 7 selection criteria.

2.7 How Can Government Guidance Impose Requirements

Of course, the main purpose of generating the preceding list of toxic sites is to provide an objectively determined inventory of hazardous-waste facilities whose assessment and remediation to evaluate. In order for this evaluation to answer the main question of the paper, the evaluation must determine whether actual toxic-site testing meets government testing requirements. However, this evaluation raises the question: **How can guidance (which is not part of regulations) impose testing requirements** [21]? We ask and answer this question because, in response to our criticisms that TCC violates DTSC technical-guidance testing requirements [95], DTSC's NOTSPA project director wrote that NOTSPA testing "satisfies current regulatory requirements and enforceable cleanup standards" [95] (p. 192). That is, he appears to accept only legally enforceable requirements, but not scientific requirements mandated by government technical guidance. If he is correct, then this paper is incorrect in evaluating adherence to testing-guidance requirements, as there are no such requirements.

On the contrary, as the text's discussion of methodological assumptions suggests, we believe that US EPA/DTSC VI guidance mandates technical requirements for toxic-site testing [46]. These technical requirements [21] "clarify … implementation of the regulations" [156] but, of course, impose no "inflexible requirements" [21], because they must be flexible enough to incorporate ongoing scientific progress in testing methods. That is, scientific/technical guidance imposes ***default technical requirements*** that are binding---unless scientists explicitly demonstrate better or technically equivalent test procedures. If assessors do not follow (what DTSC calls) its testing "requirements," then DTSC technical guidance says assessors' "alternative approaches and technologies should be supported by adequate technical documentation" [45] (p. 2); see [157].

Because TCC provides no justification for any of its testing violations/alternative test methods---but instead misrepresents its testing as adhering to the highest standards, its testing violations are indefensible. Why? Contrary to DTSC technical guidance [45] (p. 2), TCC provides no "technical documentation" to justify its violations of requirements and its use of alternative tests. Moreover, TCC likely cannot justify its violations because the Results and Question-1 discussion in the text show that all TCC testing violations cause risk underestimates; yet, by definition, contaminant/risk underestimates cannot provide testing that is "technically equivalent" to what DTSC requires [45, 21].

2.8 How Trammell Crow Violates DTSC Risk Calculations for Cancer

In addition to underestimating NOTSPA-site risk as a result of testing violations, TCC also underestimates site risk as a result of technical-calculation violations. It *violates 6 cancer-calculation rules,* mandated by DTSC for toxic-site Human Health Screening Evaluations (HHSEs) [21, 49, 50]. In doing so, it undercalculates NOTSPA cancer risks by a factor of nearly 100. This undercalculation is a result of TCC's providing:

(1) no calculations of **unmitigated risk,** required by DTSC [21, 50]; instead, it gives only estimated mitigated site risk, after presumed removal of metals hotspots/drains [6], some never tested [6] (see Figure S1 in Appendix 1).

(2) no calculations for **"the maximum measured indoor-air concentration of each chemical,"** required by DTSC [21 (p. 35), 49, 50] (authors' bold). Instead, TCC uses an illegitimate assumption, rejected by DTSC [21 (pp. 21, 55), 45 (p. vii)] that at a site like NOTSPA, with subsurface preferential VI pathways, indoor-air carcinogenic gases

are only 0.001 of soil-gas levels. This faulty assumption causes an illegitimate, 50-fold underestimate of NOTSPA indoor-air VOCs [21, 45].

(3) no risk calculations for **highest-level, any-depth site toxins,** required by DTSC [21, 50], as VI can arise from from toxins 100+ feet subsurface [21, 45]; instead, it provides only highest-level toxins from 30 feet subsurface [6].

(4) no total cancer risk, based on "**all lines of evidence"** (authors' bold), as DTSC requires, from ambient air, groundwater, indoor air, soil, soil gas [21, 50]; instead, it omits groundwater, indoor-air, and ambient-air risks [59].

(5) no calculation for the **site-attenuation factor,** required by DTSC, [21]. Instead, it uses an outdated, default-factor attenuation (0.0001, not 0.05) [6] that illegitimately reduces indoor risks by a factor of 500 [45, 21]

(6) no risk for **maximum toxin concentrations,** required by DTSC [21, 50]; instead, it uses the average concentration for the 95th percentile Upper Confidence Limit (UCL) [6], that illegitimately reduces risks by roughly 100 [85].

With respect to (6), health threats from TCC's undercalculating cancer risks, **for 2 reasons DTSC mandates that HHSEs must use maximum-concentration levels of all site contaminants** [21 (p. 16), 50].

First, HHSEs rely on **limited sampling** [50] (p. 15). For instance, NOTSPA-VOC sampling avoided the three typically highest VOC-contamination areas: deep soil, under (sub-slab) buildings, and toxin sources [21, 45, 48]. It tested no soil within 180 feet above groundwater [6, 59]; conducted no sampling under 89% of NOTSPA buildings [6]; and identified only low-level, shallow-soil sources for only 2 of the 35 VOC contaminants [6]. This illustrates why DTSC thus warns that because HSSE screening sampling, by definition, has no "robust dataset" of "at least…. eight subsurface samples for a single building" [21] (p. 23), and because "a robust dataset is needed for statistical approximation" [21] (p. 23) and employing UCLs, HHSEs should use "maximum subsurface concentration data" [21] (p. 24).

Second, by definition, HHSEs employ only screening tests, thus include **no randomization** in sampling strategies [50] (p. 15) unlike epidemiological or probabilistic risk assessments. Yet any statistical interpretation of HHSE results requires such randomization [158] (p. 13). For both preceding reasons, DTSC warns that "unless the data are sufficiently robust for statistical approximation of the average concentration, the maximum measured" toxin concentrations should be used [21] (p. 35), and "the 95 percent upper confidence limit (95% UCL) on the arithmetic mean" should not be used [50] (p. 15). Yet because TCC uses NOTSPA average concentrations for the 95 percent UCL, it underestimates risks, violates DTSC cancer-calculation rules, and makes an elementary error: confusing the statistics available for full grid/random sampling with those for screening sampling. This error, apparently designed to make TCC's flawed sampling look statistically robust, instead underestimates risks.

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