2. Mitigating durable bads: trichloroethylene contamination in Silicon Valley

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> [I]t may help to call 'what to do?' a political question. The term *politics* resonates openness, indeterminacy. It helps to underline that the question 'what to do' can be closed neither by facts nor arguments. (Mol 2002: 177)

2.1 Introduction

Today's consumer electronics are sometimes classed as a type of 'fast-moving consumer goods' (FMCGs). As implied in the name, FMCGs are defined by rapid turnover and consumption (see, e.g., Hawkins et al. 2015 on bottled water). Today's consumer electronics market is valued in excess of US$ 1 trillion (Statista 2022) and brands in the sector typically rely on multiple tiers of hundreds or thousands of contract manufacturers whose facilities are unevenly distributed globally, although they are strongly concentrated in Asia. While the electronics manufacturing industry has been part of the global economy for a lengthy period of time – at least 60 years – the devices produced by it have an increasingly fraught relationship with durability. On the one hand, brands are (rightly) criticised for making devices that break easily or are forced into obsolescence by the vagaries of fashion or the end of software support. On the other hand, the chemistry of materials out of which electronics are made means that chemical pollution from the industry can remain a problem for centuries or even millennia. In the electronics manufacturing sector we find the paradoxes built into enacting 'durable economies'.

Consider the complications of trichloroethylene (TCE). TCE is a chemical product. It exists only as a consequence of industrial technoscientific manufacturing. It is produced for use as a commodity, typically as a solvent and cleaning agent. It is also the main contaminant in a plume of groundwater seeping through part of what is today called Silicon Valley. TCE has wildly variable relationships with durability. Chemists had to find ways to stabilise it if it were to be of use for industrial applications. When exposed to variable combinations of air, light, certain metals, chemicals, and heat, TCE can break down very quickly, in seconds (Doherty 2000b; Russell et al. 1992: 6). But outside laboratories and in the wild, the '[h]alf-lives' of TCE 'are on the order of days to centuries' (Russell et al. 1992: 3; Barbash and Roberts 1986: 344). Distinctions between the technical life and the useful life of TCE are mixed up. Without making it stable, TCE is not useful for industry. But, once stabilised and it escapes containment, TCE's endurance is a problem again. It lasts too long. There's more: TCE has been commercially manufactured for at least a century by now. But, prior to its synthesis by chemists and its manufacture in industrial facilities, TCE did not exist on Earth. In this sense, TCE is brand new. And so, the question that introduces the issues addressed in this chapter, is 'Are durable economies "good"?'

To help answer this question I draw on Mol's (2002) notion of a 'politics-of-what'. A politics-of-what explores the differences between various enactments of a particular version of things. By this, Mol is making the argument that a politics-of-what is not a question of different perspectives on a singular reality having to be reconciled. Instead, it is literally a question of different realities (ontologies) being at stake. A politics-of-what asks several linked questions: what 'goods' are sought? What 'bads' are fought? How are 'good' and 'bad' set up or framed as such to start with? How the good and bad are set up in the first place helps methodically approach what kinds of claims, reasons, and evidence a particular set-up permits and how this or that framing is justified in a contested – that is, political – field. How a framing of good or bad is set up means that different forms of reasons and evidence will be deemed relevant and others not. The distinction between 'goods' and 'bads' is less like a sliding scale and more like patchy, distributed, and not necessarily coherent or reconcilable archipelagos of possible ways of being, of doing the good and the bad, of enacting them. As such, some ways of being may find ways to coexist and flourish, others may clash, and still others may be extinguished (Liboiron et al. 2018). As Mol writes:

> In a political cosmology [a vision of the world as a well-ordered whole] 'what to do' is not given in the order of things, but needs to be established. Doing good does not follow on finding out about it, but is a matter of,

> indeed, doing. Of trying, tinkering, struggling, failing, and trying again. (Mol 2002: 177)

I open the chapter with a brief discussion of the complications of TCE as a durable manufacture of the industrial chemicals industry. That discussion proceeds via a synopsis of the geography and history of TCE manufacturing and use; it is a story that helps illustrate how the durability of manufactures are situated, partial, and particular rather than an intrinsic property of products-in-themselves. Initially, the durability of TCE was a problem to be solved due to TCE's chemical instability. Once solved, however, the durability of TCE became a problem again. By the 1950s in the United States, industrial conditions were in place that would generate TCE as a durable 'bad', as a toxicant that could persist and leak beyond its industrial confines to harm human life. One case where these harms became acute is the landscape now called Silicon Valley. By the 1980s, the toxic effects of TCE use in the electronics sector of Silicon Valley could be ignored no longer. Something needed to be done. The chapter then turns to an analysis of regulations that began to emerge in the 1980s to mitigate those toxic consequences of TCE use in the Silicon Valley electronics sector. Here, the question is raised anew of how the 'goods' and 'bads' of durability as they relate to TCE are framed. I pay particular attention to regulatory documents and how they define alternative solutions to managing the toxicity of TCE. These regulatory solutions rely on various criteria, including calculations of economic cost and toxic harm, as well as unstated assumptions about the permission to pollute. Through this analysis, I show that the desirability of durability is partial and situated, rather than automatic and inherent. By extension, a desire for durable economies more broadly, then, is one to be enacted with circumspection.

2.2 Enacting trichloroethylene and durability

Trichloroethylene (TCE) is a member of a class of chlorinated chemical compounds known as halocarbons. These compounds have very wide-ranging applications. By the time TCE was being applied to electronics manufacturing, it had been in economic use for half a century or more. Specifically, TCE is or was used in everything from anaesthesia and wound cleaning to printing inks and paints, and it was used in the textile industry as a solvent and cleaning agent for waterless dyeing and finishing. It came into use in electronics manufacturing as a solvent and metal degreaser. By 1975, TCE was known to be carcinogenic (Doherty 2000b, citing a National Cancer Institute report).

The economic geohistory of TCE manufacturing is intimately bound up with the emergence of the synthetic organic chemical industry in the nineteenth century and military applications in both world wars. A fuller industrial geohistory of this sector is not the point of this chapter (for those sorts of stories, see, e.g., Unattributed 1929; Hamilton 1929; Doherty 2000a; 2000b; Thornton 2000). However, a synoptic discussion of that geohistory helps us analyse TCE's relationship with durability. Mol's notion of a politics-of-what is a useful analytical concept for understanding the geohistory of TCE's production as an economic commodity and its effects as a toxicant. As I will discuss, the chemical instability of TCE meant that the question of how to stabilise it and, thus, make it more durable was an important early problem for industrial chemists. However, long after ways were found to stabilise TCE for industrial applications, durability would again emerge as a problem but now in the form of a chemical toxicant that lasts too long.

TCE can be manufactured in a number of different ways. Early methods involved the chlorination of acetylene, a hydrocarbon compound. The acetylene method was developed by Austrian chemists between 1903 and 1905 and was in use for over 70 years. In the 1960s, Pittsburgh Plate and Glass (PPG) filed patents for new methods of TCE production via oxychlorination, a process that reacts the hydrocarbon ethylene with air and other compounds (Vancamp and Deppe 1968; Schaschke 2014).[1] Eventually, these other methods came to prominence as the cost of acetylene rose. By 1978, the last plant using the acetylene process – operated by Hooker Chemicals in Niagara Falls, New York – was closed.

TCE was in use for a long time before it became a prominent chemical input in the electronics sector. By 1912 it was being used as a cleaning agent for commercial laundry and textile industries. It was also briefly used to defat soya bean-based animal feeds, particularly in Europe, but by 1916 it was identified as a toxicant that poisoned herd animals. Nevertheless, the use of TCE continued in other parts of the food-processing sector to extract fats and oils from sources such as palm, coconut, and soya beans.

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[1] 'Production of trichloroethylene and perchloroethylene', GB1144842A, filed 22 December 1966 and issued 12 March 1969. Available at https://patents.google.com/patent/GB1144842A/en?q=oxychlorination+trichloro&assignee=PPG+Industries&oq=PPG+Industries+oxychlorination+trichloro.

Prior to the First World War, the US depended largely on foreign supplies of chemicals or facilities owned by foreign business interests, especially from Germany (Doherty 2000a). When the US entered the war, it used the Trading with the Enemy Act to confiscate German-owned facilities on US soil. After the war, TCE would go on to find a wide range of uses. Although TCE would not become of strategic military significance until the Second World War, commercial applications of TCE proliferated from the 1920s onwards, much of it produced in US-based factories that had been expropriated during the First World War.

Applications for TCE were found in medicine for pain management, as well as it being a major chemical for use in dry cleaning. By the 1930s, manufacturers making metal or products with metal components found TCE to be an excellent degreasing agent, in part because of its low boiling point that made it possible for it to be almost completely recovered and reused. However, as more uses of TCE were found, so was more evidence of its toxicity.

Demand for TCE rose sharply during the Second World War and the Korean War due to its utility as a metal degreaser. It was important enough that US-based production by companies such as Dow, Du Pont, and Westvaco Chlorine was controlled to meet military requirements, with commercial applications following. By 1952, in the midst of the Korean War, over 90 per cent of TCE produced was used for vapour degreasing applications – essentially, the removal of water-insoluble oil and wax compounds from surfaces of various kinds (Doherty 2000b). By 1960, US domestic production capacity for TCE reached almost 220,000 metric tonnes annually.

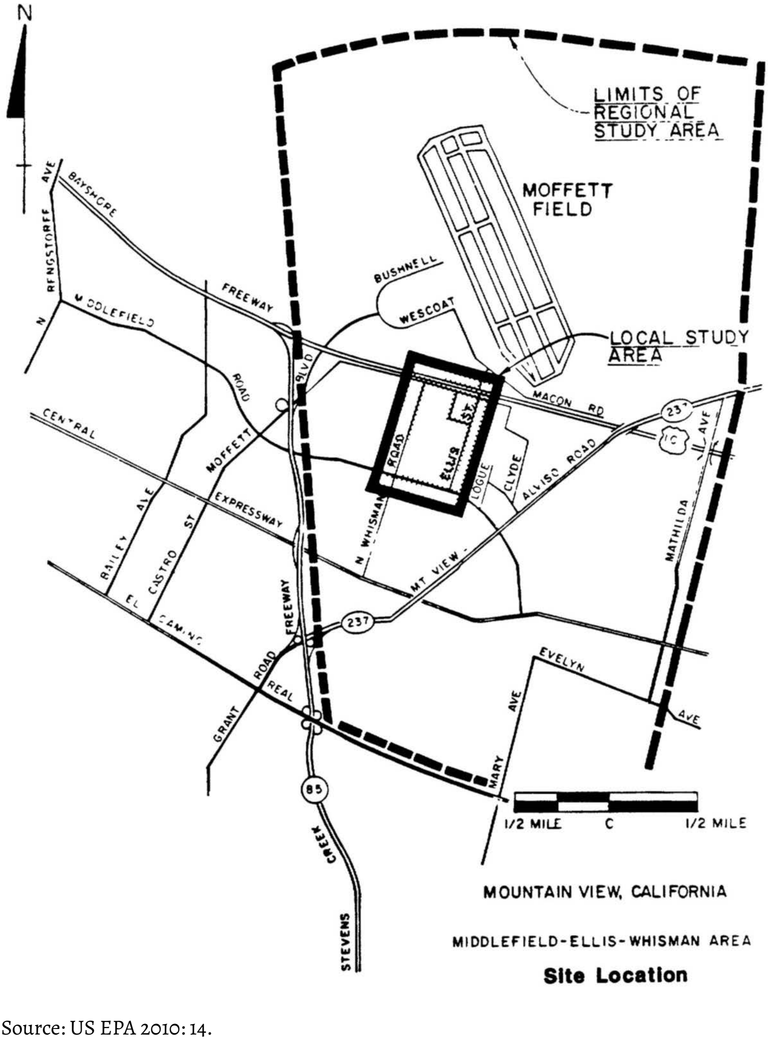
2.3 Durability: from good solution to bad problem

The Middlefield-Ellis-Whisman Superfund Study Area (MEW) is a zone comprising a regional study area of roughly 25 km^2 surrounding a smaller local study area of approximately 1.3 km^2 (US EPA 1989: 1, imperial measures converted to metric and areas mapped by the author; see Figure 2.1). The zone is some four kilometres east and north of the geographic centre of Silicon Valley (Madrigal 2013). It is a site that in many ways embodies the contradictions and paradoxes of what is now sometimes packed into terms such as 'the military-industrial complex' (see Lécuyer and Brock 2010: chapter 1) and, more recently, 'Big Tech'.

Three of what might be called the roots of Silicon Valley's 'family tree' (Siegel 1982: 15) had manufacturing sites in the MEW: Fairchild Semiconductors, Intel, and Raytheon. I focus on these 'roots' because in 1989 they became three 'Superfund' sites designated by a decision of the Environmental Protection Agency (EPA) that created the MEW. 'Superfund' is the colloquial term given to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), which was passed by the US Congress in 1980. The act empowers the EPA to extract clean-up costs from liable parties or, when such parties no longer exist (e.g. after a merger or bankruptcy), to use public funds derived from a tax on chemical and petroleum companies to cover the costs (US EPA 2017). The responsibilities of Fairchild, Intel, and Raytheon under the Superfund programme stem from the release of volatile organic compounds (VOCs), of which TCE is deemed to be of primary concern (US EPA 2010: 8), into soil and groundwater from these companies' manufacturing operations within the MEW. The specific origins of the plume of pollutants in the MEW have been traced to the entwined histories of US Navy operations in the area from the 1930s onwards and, later, to the manufacturing of semiconductors and integrated circuits in the area starting in the 1950s. The case of the MEW demonstrates durability as a political question in Mol's sense. TCE is durable in use and, in that sense, its durability is 'good'; but the case of the MEW illustrates that when TCE leaks beyond its industrial infrastructure, its durability becomes a problem again. Long after use, TCE can persist as an environmental toxicant.

Today, the MEW encompasses a landscape that is a mix of corporate office locations (including some operated by Google) and residential areas. It is a landscape that has become almost a cliché of urban design under the aegis of the 'corporate campus'. The design was a deliberate decision to which the facilities operated by Fairchild Semiconductors, Intel, and Raytheon had to conform. As environmental historian Aaron Sachs writes: 'By the time Silicon Valley got its name ... its companies had to follow strict building codes, which included "complete concealment" of things like smokestacks, generators, transformers, ducts, storage tanks, and air conditioning equipment' (Sachs 1999: 16; see also Madrigal 2013).

Figure 2.1: The MEW plume and Vapour Intrusion Study Area showing TCE concentrations.



Source: US EPA 2010: 14.

This designed occlusion of infrastructure would go on to play a constitutive role in the making of the MEW as a Superfund site. Prior to the passage of relevant environmental regulations, 'semiconductor companies routinely released acids and solvents into storm drains and sewers. The acids ate through the pipes, and the solvents leaked out and spread' (Siegel 2013: 5). The legacy of leaks, seeps, and spills led to the formation of a plume of toxicants in the subsurface geology of the zone.

The EPA designated the MEW regional study area in 1989. Initially, the problems associated with the plume of toxicants was understood solely in terms of contamination of soil and groundwater (i.e. subsurface geology). Later, however, as knowledge evolved about how toxicants can migrate from one medium (e.g. groundwater) to another (e.g. air), a third form of exposure risk was identified; this is known as the 'vapour intrusion pathway' (US EPA 2010: 9; US EPA et al. 2009: 2). The latter pathway directly impacts people who live and work in the MEW, including today's information workers at companies such as Google (Rust and Drange 2013).

2.4 Eleven versions of the good

In 1989, when the question of how to remediate the pollution problems at MEW was initially raised, several possible alternatives were identified (US EPA 1989: 9). These alternatives were evaluated against six criteria plus an additional three cost-related criteria (see Table 2.1). The assessment criteria are left without explicit definition in the original 1989 record of decision: for example, 'short-term effectiveness' is not given a definite period of time; 'implementability' is left implicit as if it speaks for itself. More explicit definitions of these criteria appear in the 2010 amendment to the record of decision; this responded to the recognition of the vapour intrusion pathway (this pathway essentially refers to the migration of VOCs, such as TCE, out of the groundwater matrix as vapour that can seep into buildings via basements, crawl spaces, and similar environments; see US EPA 2010). Tracking the definition of these criteria between the 1989 record of decision and its amendment in 2010 is an important part of understanding the evolution of the goods sought and bads fought at the MEW site.

These alternatives can be interpreted as different versions of the goods sought and the bads fought by the various interests at the site. Mol's concept of the politics-of-what offers an approach to analysing the list of alternatives and the criteria used to evaluate their desirability.

Table 2.1: Criteria used to evaluate alternatives in US EPA 1989: 39.

Criteria	**Definition**
Short-term effectiveness	'period of time needed to implement the remedy and any adverse impacts on workers, the community, or the environment during construction and operation of the remedy until clean-up levels are achieved' (US EPA 2010: 31)
Long-term effectiveness and permanence	'the expected residual risk, the ability of a remedy to maintain reliable protection of human health and the environment over time once clean-up levels have been met' (US EPA 2010: 30)
Implementability	'a remedy's technical and administrative feasibility from design through construction and operation' (US EPA 2010: 31)
Compliance with Applicable or Relevant Appropriate Requirements (ARARs)	Legal requirements under CERCLA that remedies 'at least attain legally applicable or relevant and appropriate Federal and State requirements, standards, criteria, and limitations, unless such ARARs are waived under CERCLA section 121(d)(4)' (US EPA 2010: 30)
Long-term protection of human health and the environment	'Long-term' is replaced by 'Overall' in the 2010 definition, which 'addresses whether each alternative provides adequate protection of human health and the environment and describes how risks posed through each exposure pathway are eliminated, reduced, or controlled, through treatment, engineering controls, and/or institutional controls' (US EPA 2010: 29–30)
Additional capital cost ($) / Annual operation and maintenance costs ($) / Present worth ($)	'Cost' becomes an amalgamation of the three original meanings of 'cost' in the 1989 record of decision; the latter are amalgamated into 'present worth' of 'existing and future' commercial and residential buildings and assume wide margins of uncertainty in which dollar estimates 'may be within −30 per cent to +50 per cent of the final project cost' (US EPA 2010: 32)

The EPA's 1989 record of decision for the MEW identifies and evaluates nine alternative remediation possibilities, divided into two broad classes: those relating to soil and those relating to groundwater in underlying aquifers. One category of alternative possibilities cut across both classes: the option of 'no further action' (US EPA 1989: 9). Despite the name, it was not synonymous with 'do nothing'. 'No further action' would include ongoing monitoring of the soil in various subsections of the MEW. It would entail between US$82,000 and US$310,000 in one-time capital costs and between US$187,000 and US$685,000 in ongoing annual operations and maintenance costs (ibid.: Table 12–1). The 'no further action' option would mean that considerable sums would be spent to monitor the plume under the MEW, but nothing would be done to reduce the pollution from it.

A second alternative was to install specialised wells in the soil that would pump VOCs out but leave the soil in place. Technically called in-situ vapour extraction and treatment, this alternative would use carbon-based filters to remove contaminants as they moved from water to gas in the soil matrix and pump them out via the well system. This alternative was understood to meet the criteria for effectiveness in both the short and the long term by reducing the presence of toxicants in the MEW over time (although, as I discuss below, the temporality associated with different alternatives was understood to be wildly indeterminate even in the 1989 record of decision). This alternative would have higher costs, surpassing US$1 million in capital costs and ranging between US$638,000 and US$863,000 in annual operations and maintenance costs.

A third alternative was to excavate soil in place to deliberately volatize the VOCs into ambient air inside 'controlled atmosphere enclosures' (US EPA 1989: 10), and then to return the soil to the ground. A drawback of this approach was that polluted soils under existing building footprints could not be excavated and would continue to be sources of soil and groundwater pollution in the MEW. This problem could be mitigated to a certain extent by combining soil excavation with in-situ vapour extraction at sites with building footprints where full excavation of soils was not feasible. This alternative was estimated to cost over US$6.6 million in upfront capital costs with indeterminate annual operation and maintenance costs. It was also noted that if this approach were used it would be difficult to control emissions of VOCs into the ambient air and it would leave some contaminated soils at least partially untreated.

A second class of remediation alternatives related to mitigating contaminants in groundwater. The main distinguishing feature of this class had to do with the vertical depth of the aquifers in question, whether 'shallow' or 'deep' (those approximately 50 metres below the surface; US EPA 1989: 2). The deep aquifers were already used for drinking water in the region whereas the shallow aquifers were not (although the EPA anticipated that they might be in the future).

Two different forms of groundwater extraction and treatment were contemplated, one involving hydraulic *control* and one devoted to hydraulic *remediation*. Both would entail pumping water out of the ground and treating it, but with different ends in mind. The former would pump and treat water at a rate to maintain the plume in equilibrium – that is, neither expanding nor shrinking it. In both systems, water would be extracted and treated to below a threshold of contamination. Treated water would then be discharged to storm sewers that empty into Stevens Creek on the east side of the MEW. Stevens Creek ultimately flows into San Francisco Bay. Hydraulic control was estimated to require over US$2.7 million in upfront costs and over US$1.6 million in ongoing operations and maintenance costs. In contrast to hydraulic control, hydraulic remediation would pump out water faster than the rate of groundwater recharge and thus shrink the contaminant plume over time (how much time, as we will see, is a major matter of concern). Hydraulic remediation was estimated to be almost twice as expensive as hydraulic control.

Additional alternatives relating to groundwater included installing impermeable barriers, creating and maintaining an inward and upward hydraulic pressure gradient in the plume, and flushing. Barriers would entail physical structures to impound the plume, although those barriers would reduce neither the plume's size nor its degree of contamination unless they were used in conjunction with other measures, such as hydraulic remediation. The barrier option was also almost five times more expensive in terms of upfront costs than the next most expensive option. Creating and maintaining a pressure gradient would move contaminated water out of the aquifer and across the extant slurry walls of the Fairchild, Intel, and Raytheon facilities, where the water would be pumped out and treated; this option would require over US$5.5 million in upfront costs and over US$2.5 million in annual operations and maintenance expenses. Flushing would involve a complex process of extracting water from saturated soil, treating the water and then reinjecting that water into unsaturated soil; over time, this would move contaminants out of the underlying soils and groundwater. This option was estimated to cost less than US$1 million for upfront costs and for annual operation and maintenance.

Ultimately, a combination of two alternatives was chosen for soil remediation and one option was selected for groundwater (US EPA 1989: 22). Soil was to be decontaminated via in-situ vapour extraction and by excavation and treatment with a goal of reducing contamination to below '0.5 ppm [parts per million] TCE for all soils outside slurry walls and 1 ppm TCE for soils inside the slurry walls' (ibid.: 22). Groundwater, meanwhile, would be handled by hydraulic remediation – that is, pumping it out and treating it with the goal of reducing TCE contamination of the plume to 5 parts per billion (ppb) for the shallow aquifers and 0.8 ppb for the deep aquifers (i.e. those already used for drinking water).

In 2010, the EPA amended the original 1989 record of decision relating to the MEW to include mitigation measures to reduce the chance of human exposure to VOCs present in the ambient air of homes and workplaces (US EPA 2010). The decision to do so arose from a complex combination of community activism (Smith et al. 2003; Siegel 2009) and evolving scientific understanding about how VOCs such as TCE can phase change (e.g. by shifting from solute in groundwater to airborne vapour) and move from one environmental medium to another (e.g. groundwater to ambient air). That complex situation led to the recognition of what was dubbed the 'vapour intrusion pathway'.

The recognition of another route of exposure to TCE meant that another set of alternative mitigation measures was to be considered. These alternatives included no action, active ventilation of indoor air, passive ventilation beneath building foundations (called 'passive sub-slab ventilation'), and active ventilation beneath building foundations (called 'active sub-slab ventilation'). Two categories of additional mitigation measures were mandated out of four alternatives. The alternative mitigation methods for vapour intrusion were evaluated against the same set of criteria as those for the 1989 record of decision, but with two additions: 'state acceptance' and 'community acceptance' (US EPA 2010: 33). In this case, 'state acceptance' meant that a given alternative would be approved by a California regulatory body (the San Francisco Bay Regional Water Quality Control Board); meanwhile, 'community acceptance' meant that a given alternative would be favourable to a group of people, as defined by their attendance and comments at a public meeting held by the EPA in the MEW and written comments received by the EPA.[2]

Ultimately, a combination of two of the four alternatives were selected to deal with vapour intrusion: active indoor ventilation and active sub-slab ventilation. Existing buildings in the MEW were then categorised into tiers of prioritisation for implementing the selected mitigation methods. Those buildings found to have indoor concentrations of TCE exceeding 'outdoor (background) concentrations' and beyond a threshold of 0.4 $\mu g/m^3$ would be prioritised for

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[2] Full transcripts of those verbal and written comments are available in US EPA (2010), but a fuller analysis of these comments is beyond the scope of this chapter.

mitigation (US EPA 2010: 35). Moreover, future buildings would have to include the costs for operating the same mitigation methods.

What might the selected remedies suggest about the politics-of-what as they pertain to the durability of TCE in play in the MEW? The 11 alternative approaches to remediating the toxicants illustrate 11 possible arrangements of people, places, and things that could have cohered into the making of an actual ordering of the world. A combination of five alternatives – two for soil, one for groundwater, plus two for vapour intrusion – was ultimately chosen. The goods sought include reducing (but not eliminating) human exposure to toxicants, especially TCE. The bads fought include cancer and the 'potential human health hazard for noncancer toxicity to the central nervous system, kidney, liver, immune system, male reproductive system, and the developing fetus' (US EPA 2011: xlii). These goods and bads are set up as such through both explicit criteria (see Table 2.1) and two premises that hide in plain sight: threshold theories of harm and the permission to pollute.

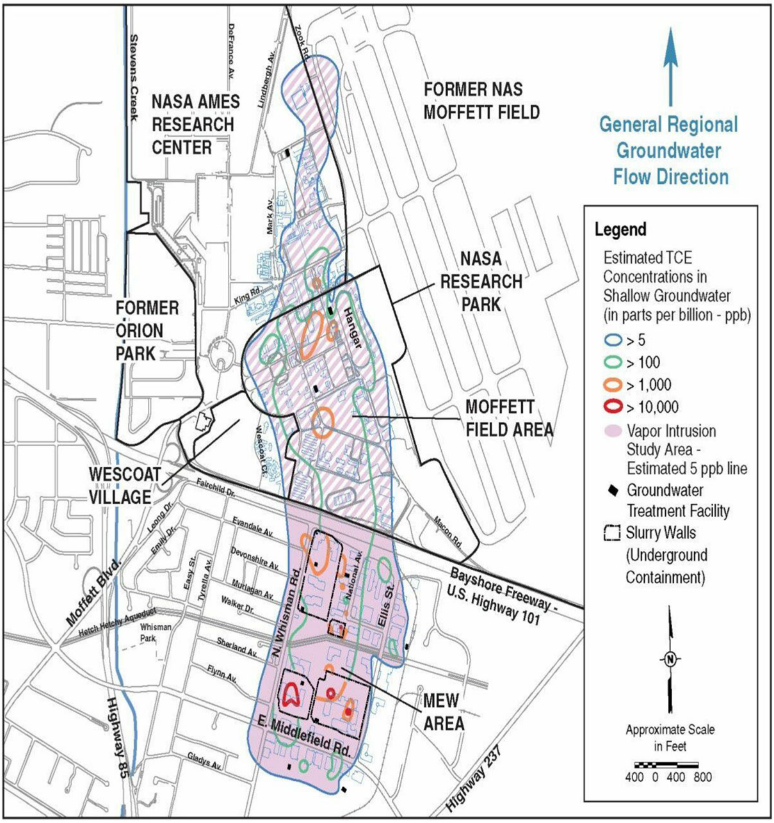
The idea that there is a definitive line separating harm from harmlessness is a particular way of setting up 'goods-as-good' and 'bads-as-bad' – that is, it is an answer to the question 'What to do?' This is a question of politics in Mol's sense of that term. As Mol claims, the question remains open and cannot be shut once and for all by either facts or arguments. Liboiron's (2021) work on pollution as colonialism demonstrates that the effects of attempts to act *as if* a threshold theory of harm *can* be definitively determined once and for all, always, and everywhere (i.e. universally) are, in contrast, provisional and contingent achievements whose presumptions of universality do not hold always and everywhere.

The EPA defined 5 ppb and 0.8 ppb as the thresholds beyond which pollution to shallow and deep aquifers respectively would be considered unacceptable in its record of decision for the MEW (US EPA 1989). Moreover, the EPA's record of decision notes that it multiplied two metrics to derive 0.8 ppb as an acceptable threshold. Those two metrics are the lifetime average daily dose (LADD) and the cancer potency factor (CPF). The LADD was determined by 'multiplying a concentration by 2 litres [of water] per day and dividing by 70 kilograms' (ibid.: 20).

Similar, but not identical, quantitative approaches were used to answer the question of 'What to do?' with respect to the vapour intrusion pathway. The answers to that question, as in the original record of decision of 1989, manage a line (i.e. a threshold) between good and bad forms of contamination by toxicants. The answers to what to do about vapour intrusion came down to two formulas: one for ‘residential settings’ and one for ‘commercial indoor workers’ (US EPA 2010: 20; see Figure 2.2).

What do the different quantitative definitions of thresholds of harm for soil, groundwater, and vapour intrusion in the MEW suggest about what goods are sought, what bads are fought, and how the good is set up as such in the first place? What might they also have to say about ‘durability’?

Figure 2.2: Formulas used to calculate thresholds of harm for the MEW vapour intrusion pathway.



Source: US EPA 2010: 20.

The thresholds for harm from toxicants defined for soil, groundwater, and vapour intrusion in the MEW tell us that some quantum of toxicants is too much (i.e. 'bad') for humans to be exposed to. At the same time, they also tell us that some amount of exposure to toxicants *is* acceptable (i.e. 'good' or at least 'not so bad'). Yet, note some of the effects of specifics in these calculations. To arrive at 5 ppb and 0.8 ppb for groundwater contamination, for example, multiplication factors are used: 70 kilograms represents a person of a particular mass, one that excludes people who are heavier (for whom risk is, by this metric, presumably lower) and also people who are lighter (for whom risk is, presumably, higher). One obvious category of persons who typically weigh less than 70 kilograms is children. The metric also excludes all sorts of other factors that might influence cancer risk: age, gender, and cumulative doses from other sources, for example. The bracketing out of risk from cumulative doses is especially noticeable in the way in which residential and commercial exposure risks are calculated. Among other specificities, the ostensibly generic 'human' imagined in those calculations is either at home or at work, but not both. There is no variable that connects the two calculations (one formula for 'residential settings' and one for 'commercial indoor workers'), so they remain separate. Notice, too, that it is risk of cancer that is being calculated to determine harm. It is not hard to accept cancer as a 'bad' one might want to avoid, but recall that exposure to TCE also entails risks of non-cancerous harms to 'the central nervous system, kidney, liver, immune system, male reproductive system, and the developing fetus' (US EPA 2011: xlii). So, while risk of human exposure to TCE is defined in the calculations of thresholds for soil, groundwater, and vapour, this is *not* some free-floating, acontextual universal 'human' whose exposure risk is being calculated. The EPA arrives at a metric (i.e. a number) of carcinogenic risk it deems 'acceptable', but these numbers are not simply out there waiting to be plucked out of context-free 'nature'. These numbers are made – not in the sense of being 'made up' but in the sense of being 'built'.

Something that is built needs a foundation. A key foundation on which the numerical exposure risks of TCE are built is the idea of a threshold theory of harm. That theory itself is derived from studies by two engineers, Earl B. Phelps and H. W. Streeter, who in the early twentieth century studied organic contamination of rivers in Ohio (Liboiron 2021). Phelps and Streeter eventually derived an equation that could mathematically describe how biological oxygen demand changed in relation to the relative concentration of biological pollutants in water (e.g. faecal matter). Yet, as Liboiron shows, the idea of a threshold theory of harm that arises from the Streeter–Phelps equation is poorly suited to managing other types of pollutants, such as carcinogens. Carcinogens, such as TCE, are part of a class of toxicants for which harm is a ‘[l]inear nonthreshold’ – that is, harm arises ‘immediately upon contact’ (ibid.: 92, 93). As Liboiron (ibid.: 92, footnote 46) writes, ‘threshold-thinking is so strong that even in the case of carcinogens and radiation, policy uses risk analysis that allows for a certain amount of population death (or acceptable loss)’. In the case of the EPA’s record of decision for the MEW, that acceptable loss associated with 0.8 ppb ‘corresponds to a cumulative estimated carcinogenic risk of $1.0(10)^{-6}$’ (US EPA 1989: 20) or, said differently, one excess cancer case per million people.[3]

The thresholds of harm calculated for the toxicants in the soil, groundwater, and vapour of the MEW are initial steps in answering the question ‘What to do with the MEW?’ These calculations are political in Mol’s sense of the term. The EPA makes explicit what *is* included in those calculations (e.g. body mass, volume of drinking water, average lifespan, time at home or at work). The explicit inclusions also suggest an indeterminate array of excluded questions that some people (e.g. people who live and work in the MEW) might argue *ought* to have been asked: for example, should the measures of cancer risk from TCE include measures of mass that would include children and the elderly who may be particularly vulnerable? Cumulative doses from more routes of exposure than drinking water alone? Exposure in utero? These sorts of questions are indeed part of the public record of community organising around environmental exposure to TCE and other VOCs in the MEW (Siegel 2009, 2020; Smith et al. 2003). All of these questions can be answered, but not definitively or once and for all. They are and will remain constantly open to contestation (i.e. political).

Threshold theories of harm are part of what sets up the good as good with respect to mitigating human exposure to TCE and other toxicants in the MEW. Yet, as Liboiron (2021) documents, threshold theories of harm are themselves grounded on another premise: the permission to pollute. Much of the regulatory authority in which the EPA is situated is premised on parcelling out the permission to pollute (Davies and Mazurek 2014; see also Liboiron 2021). This regulatory role of the EPA had been in place for almost 20 years by the time TCE and other toxicants were found to be leaking from the facilities of Fairchild, Intel, and Raytheon in the MEW. The permission to pollute is ultimately underwritten by the legal frameworks and associated infrastructure of power of

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[3] ‘Introduction to Risk Assessment’, p. 5. Available at https://ec.europa.eu/health/ph_projects/2003/action3/docs/2003_3_09_a23_en.pdf (accessed 15 February 2022).

the United States as a settler state. None of the mitigation measures recommended for the MEW eliminate TCE or other pollutants completely. Some of the remedies explicitly presume the use of nearby bodies of water to transport and receive water treated to the point of being at or below prescribed thresholds from the MEW via storm sewers that ultimately lead to San Francisco Bay. Polluting in this mode is colonialism – that is, the axiomatic assumption of settler access to Indigenous land as sinks for toxicants.[4] The presumption of access colonises both the present and the future. In the initial 1989 record of decision, the EPA bluntly states that the soil remedy 'is expected to be in operation between 1 to 6 years. The groundwater remedy for the shallow aquifers may be in operation for as long as 46 years or into the indefinite future' (US EPA 1989: iv). As scientific understanding of how TCE and VOCs behave in the wild have evolved, a more recent analysis of the groundwater remedies selected for the MEW indicate that it will require 700 years before 90 per cent or more of the current groundwater pollution plume under the MEW reaches the target threshold of 5 ppb. An 'optimised' remedy could reduce the time required to 500 years (Gallinatti et al. 2012: 27). These are temporalities and spatialities of durability that must be reckoned with by those who ask 'What to do with the MEW?'

2.5 Conclusion

In many ways, the MEW is an allegory for broader concerns relevant to durable economies. The example of TCE contamination at the site demonstrates a need to approach durability with circumspection. The example of the MEW shows that durability is not inherently good. Instead, durability is political. If, as Mol claims, the politics-of-what is a perennially open question that neither facts nor argument can close once and for all, what then to do? There are concrete interventions that could be implemented beyond the mitigation measures already in place at the MEW. Within the North American Free Trade Agreement (NAFTA) region, companies are already required to disclose what pollutants are released at their facilities that are located within the region (Lepawsky 2022). That such cross-jurisdictional requirements for disclosure already exist tells us

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[4] See Liboiron (2021) for important discussions of the meaning of Land/land in the context of pollution as colonialism.

that extending those requirements is possible. For example, electronics manufacturers could be required to disclose the same releases of chemical pollutants that they are already required to disclose in the NAFTA region throughout their entire supply chain, wherever their suppliers are located. There is some evidence that suggests that the mere requirement to disclose such pollutant releases can lead firms to find ways to reduce or even eliminate them (Ma Jun et al. 2018). Precedent for such an approach already exists. The Dodd–Frank Act of 2010, passed in the wake of the global financial crisis, also contains a requirement for US manufacturers to disclose whether conflict minerals derived from Congo occur anywhere in their supply chains, no matter what national jurisdiction those supply chains may crisscross. A similar approach could be taken with the requirement to publicly disclose releases of chemical pollutants from the electronics manufacturing sector.

Another approach is that of the EU and its Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) legislation. Unlike the EU's Reduction of Hazardous Substances (RoHS) legislation, which applies only to electronics, REACH will be much more expansive. It is intended to reduce or eliminate the manufacture and use of toxicants in any products sold in the EU. Due to the size of the European economy, REACH will have effects well beyond the EU since many manufactures sold in the region are sold in others as well.

As the EPA records examined in this chapter show, there are various measures for mitigating the harms of TCE that either could be or are being pursued. However, those same records also show that the question of what to do with TCE in the MEW is one that has yet to be fully closed. Ongoing concerns are expressed by residents (Siegel 2020) and workers (Rust and Drange 2013) in or adjacent to the MEW about the toxic consequences of TCE and other VOCs released from the legacy of electronics manufacturing in the region. Those ongoing concerns premised on lived lives and working lives are also tangled up with chemical lives of toxicants. As I have shown elsewhere, the electronics manufacturing sector is a chemically intensive one that is responsible for some 366 million kilograms of toxicant releases and transfers in the NAFTA region between 2006 and 2017 (Lepawsky 2022). Yet, as that work also demonstrates, TCE exists in a chemical galaxy comprised of well over 160 million chemical substances available for industrial use, less than 1 per cent of which have been tested for toxicity. Indeed, the number of chemicals already available for industrial use exceeds all toxic testing capacity on Earth. There is no solution to a problem like this, if by 'solution' we mean some kind of 'clean-up' (Gray-Cosgrove et al. 2015). A world of effectively permanent pollution is a world of harm reduction, rather than harm elimination.

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