Adaptive Cleanup of the "Regional Plume" in Mountain View, California

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The "Regional Plume" of volatile-organic-compound (VOC) groundwater contamination in Mountain View, California ranks as one of the nation's more serious remediation challenges. For two decades, community oversight in Mountain View has served as a national model. Now, I believe, discussions among U.S. EPA, federal and private responsible parties, and the local community may serve as a model for conducting long-term cleanup where the application of conventional technologies is diminishing in effectiveness and where existing remedies have been found to be unprotective.

Three Decades

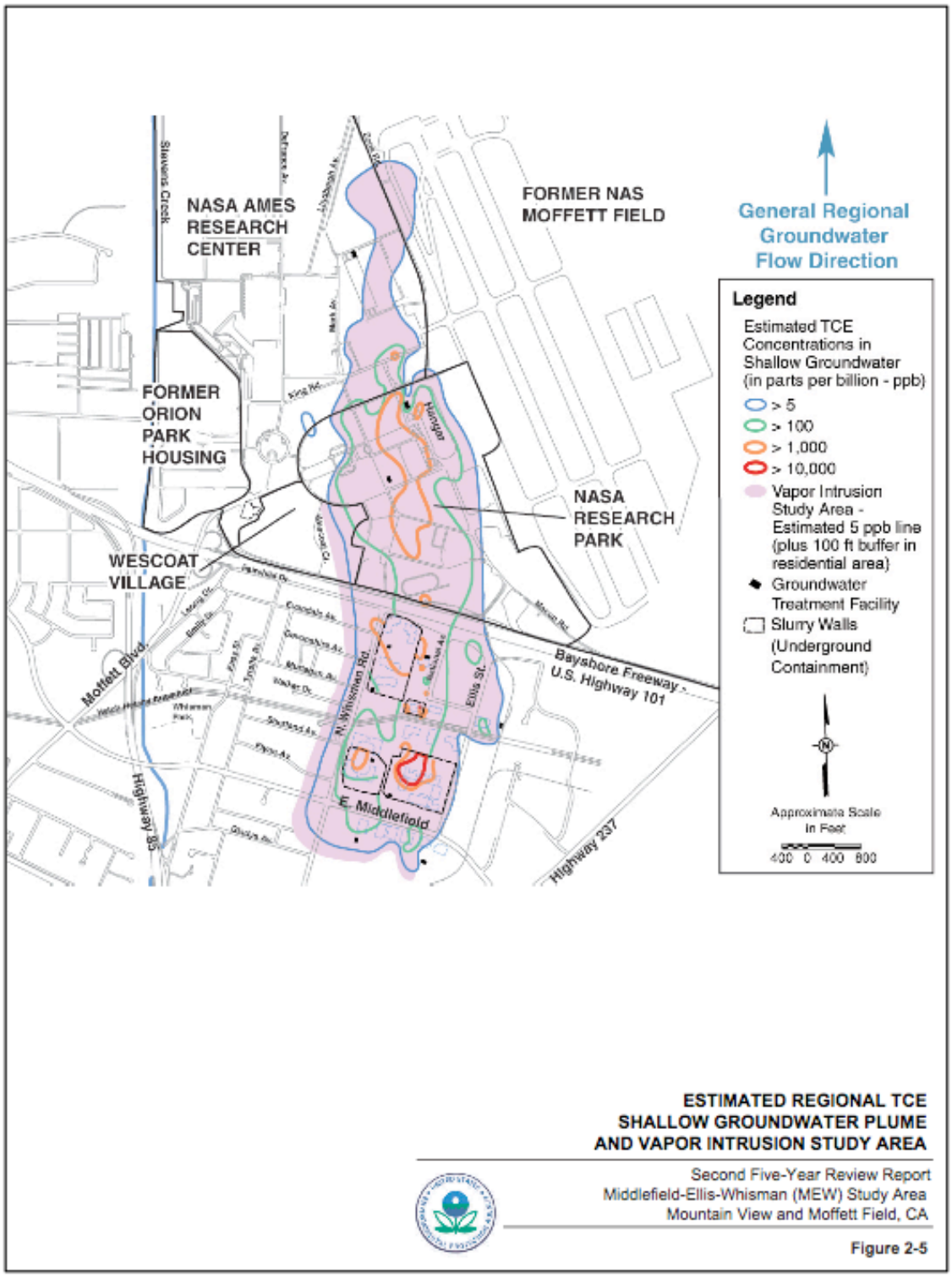
This is the place where I learned about environmental contamination and the ways we address it. At a recent meeting discussing the Regional Plume cleanup, officials described that they don't look beyond thirty-years to estimate future costs. I responded that I've been engaged at this site, less than a mile from my home, for nearly thirty years.

I first learned about the hazards of toxic substances in Silicon Valley in the mid-1970s from Amanda Hawes, a local attorney who represented electronics workers who were exposed hazardous materials in the workplace. My organization, the Pacific Studies Center, featured this issue, among others, in our 1977 conference and booklet, "Silicon Valley: Paradise or Paradox?" We also obtained a Department of Labor grant that led to the formation of what became the Santa Clara Center for Occupational Safety and Health.

In 1981 I wrote my first article about *environmental* contamination in Silicon Valley. In "The Hazards of High Tech," I retold how dead fish were found in Stevens Creek near the "birthplace of Silicon Valley" and reported that "small amounts of trichloroethylene (TCE) … have been found in area wells."[1] At that time, only a handful of us activists challenged the conventional wisdom that electronics production was a clean, safe industry.

However, in December 1981 Fairchild Semiconductor revealed that contamination from its south San Jose factory, 20 miles away, had contaminated local drinking water supplies. This lead to the disclosure and discovery of similar leaks and spills, primarily from leaking underground waste and storage tanks, throughout the watershed. Fortunately, because of our proximity to the San Francisco Bay, in Mountain View the public water supply did not come from shallow aquifers, so the fraction of our water produced locally was never impacted by industrial contamination.

[1] Lenny Siegel and John Markoff, "The Hazards of High Tech," *Environmental Action,* July/August, 1981.



EPA's 2009 map of the upper-aquifer Regional Plume in Mountain View

In response, the Fire Chiefs from all of the jurisdictions in Santa Clara County developed a model Hazardous Materials Storage Ordinance, which our communities adopted. The activists who had warned that high-tech industry was toxic gained widespread credibility, and led by attorney Ted Smith and local labor leaders, we formed the Silicon Valley Toxics Coalition. At well-attended community meetings throughout the Valley, residents demanded action. Local news outlets found that reports of toxic releases, just like crime and natural disasters, attracted viewers, listeners, and readers.

Middlefield, Ellis, and Whisman

In Mountain View, contamination was identified at several locations. The biggest problem was found in the industrial area bounded by Middlefield Road, Ellis Street, Whisman Road, and U.S. 101 (Bayshore Freeway). This is where Fairchild Semiconductor built the Valley's first successful semiconductor plant, and where spin-off firms such as Intel and Raytheon Semiconductor set up shop as well. In the early 1980s, companies engaged in finger-pointing, doing relatively little to investigate, let alone remove, groundwater contamination. In 1986-87 they built underground slurry walls to separate their plumes from those of neighbors. They removed contaminated soil, operated soil vapor extraction systems, and installed localized groundwater extraction and treatment (pump-and-treat) systems. Meanwhile, officials found that trichloroethylene, the principal contaminant, had made its way, through two abandoned but un-sealed agricultural wells, to the deep aquifer that upgradient (a mile or more away) stored and supplied drinking water. The companies found and sealed as many as 16 old deep wells.

I attended a series of public meetings at which members of my community insisted that cleanup be accelerated. We were incensed that the projected cleanup timespan was 300 years. Supported by the city of Mountain View, the Toxics Coalition successfully urged U.S. EPA to place what we called the "Mountain View Five" companies on the relatively new "Superfund" National Priorities List (NPL) of most contaminated properties in the U.S. Fairchild, Intel, and Raytheon were eventually listed, and EPA began calling the area the Middlefield-Ellis-Whisman (MEW) Superfund Study Area. In 1990 EPA issued a Unilateral Administrative Order to Fairchild, its successor Schlumberger, and seven other companies, and early the next year Intel and Raytheon signed a Consent Decree with EPA.

Also, in 1989 EPA issued a Record of Decision (ROD) designating groundwater extraction and treatment as the regional remedy for the MEW plume. Regional treatment systems were activated in 1998. Though the ROD has been modified over the years, pump-and-treat remains the principal cleanup technology.

Around the same time, EPA placed four other civilian sites in Mountain View on the NPL. Meanwhile, the Navy found groundwater contamination at the Moffett Naval Air Station, just across Highway 101 from MEW, and EPA added Moffett Field to the NPL in 1987. Eventually, EPA listed a total of 29 Superfund sites in Santa Clara County, the most for any county in the country. This attention was a function both of the ubiquity

of groundwater contamination and the political organizing of the Toxics Coalition, with support from the public at large.

Federal Facilities

In 1989, the Navy sought public comments on its Moffett Field Federal Facilities Agreement with EPA and state regulatory agencies. The base commander, Capt. Tim Quigley, not only established a Technical Review Committee (TRC), as required under the 1986 Superfund Amendments that established the Defense Environmental Restoration Program, but he invited community activists to join. I was surprised to be asked, because I was known in the community as an anti-war activist and had in fact been suspended indefinitely from Stanford University in 1969 for activities opposing the Indochina War.

At the first few meetings, I learned that the Navy was taking the Moffett Cleanup seriously. I recall a presentation in which we learned the substantial effort that it put into identifying and sealing an old agricultural well. On the other hand, community members were aghast that there was a three-year gap in the proposed Federal Facilities Agreement schedule during which there would be no deliverables. To us, this was unacceptably slow. Remarkably, the electronics industry responsible parties and the *San Jose Mercury News* backed our position.

About the same time, the National Toxics Campaign, in which the Toxic Coalition participated, sought a researcher to write a national report on Defense Department pollution. Smith recommended me, so I began establishing contact with activists at other contaminated military bases and traveled to DC to interview key officials at EPA and the Pentagon.[2] In September, 1990, as the armed forces geared up for war in the Persian Gulf, I worked with the National Toxics Campaign to organize activist participation in the military's Defense & the Environment Initiative conference. I was next to Ted Smith as he read a list of demands to Defense Secretary Cheney.

I was next invited to an October, 1991 meeting in Keystone, Colorado—facilitated by the Keystone Center—where representatives of federal agencies, states, and environmental organizations were supposed to hammer out ideas for setting priorities for addressing contamination at Defense and Energy Department facilities. On the way to the Keystone mountain resort we took bus tours of the Army's Rocky Mountain Arsenal and the Energy Department's Rocky Flats Plant, two of the most contaminated spots on the planet. On the bus, I sought out the ranking Defense participant to complain about the slow schedule planned for the Moffett cleanup.

At the meeting in Keystone we learned about mathematical models for setting priorities, but we also heard from the leadership of the Yakima Indian Nation, whose ceded lands include part of the Energy Department's egregiously polluted Hanford Reservation. The Yakima argued that other considerations, such as their treaty rights, should govern priority-setting and other decision-making. Along with other

[2] This was published as Lenny Siegel, Gary Cohen, and Ben Goldman, *The U.S. Military's Toxic Legacy,* National Toxics Campaign Fund, March, 1991.

environmentalist participants, I used this as a springboard to suggest that public participation was a key element of the cleanup process. The body asked Energy and Defense to report back at our next meeting about how they worked with the public.

Soon after the Keystone meeting, Moffett Naval Air Station and its regulators announced that they planned to divide Moffett Field into multiple Operable Units, creating a new schedule that drastically cut the time that it would take to more forward with actual cleanup. To this day, I have no idea whether activist efforts had anything to do with this new approach, but I "leaked" this positive story to the press.

When the national dialogue—later to be formalized as the Federal Facilities Environmental Restoration Dialogue Committee (FFERDC)—met in DC in December, 1991, the Defense Department chose to use Moffett as an example of how it genuinely involved the public. In the wake of recent progress, I felt obligated to agree. I remember talking during a break to a top Energy Department official who was absolutely shocked to hear that an environmental activist had instigated a positive news story about a federal polluting agency.

FFERDC kept meeting over a period of five years, issuing reports in 1993 and 1996.[3] We made a number of significant contributions to the way federal agencies address cleanup and budget shortfalls. One of our most successful recommendations was the formation of Site-Specific Advisory Boards, modeled after Moffett Field's Technical Review Committee. The military eventually established about 300 Restoration Advisory Boards (RABs), based upon the Moffett experience, and the Moffett TRC expanded to become a RAB.

Meanwhile, the Toxics Coalition received technical assistance grants from EPA to oversee cleanup at both MEW and Moffett. We asked EPA to consolidate oversight of the federal and private sites, and in late 1993 the Navy agreed "to adopt MEW Record of Decision for the Navy contamination located in the area north of Highway 101 on former NAS Moffett Field that has commingled with the MEW regional groundwater contamination plume."[4] This gave EPA clearer authority than it would have had if the Navy portion of the plume was treated as a federal-only Superfund site.

We convened a separate Community Advisory Board, involving a number of members of the official advisory group, to oversee our consultant, Peter Strauss. Over the 1990s, we helped the agencies and responsible parties establish regional groundwater treatment systems to remove TCE and other contaminants from the Regional Plume. In 1996 we supported the Navy's demonstration of the emerging permeable reactive barrier (PRB) technology—originally nicknamed the "iron curtain"—on a portion of the regional

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[3] *Interim Report of the Federal Facilities Environmental Restoration Dialogue Committee,* February 1993 and *Final Report of the Federal Facilities Environmental Restoration Dialogue Committee,* April, 1996. The latter is available on line at http://www.epa.gov/fedfac/pdf/fferdc.pdf.

[4] "Final Second Five-Year Review Report for MEW Superfund Study Area," U.S. EPA Region 9, September 2009, page 2-7. Available on line at http://yosemite.epa.gov/r9/sfund/r9sfdocw.nsf/3dc283e6c5d6056f88257426007417a2/5967b74a78ef4d118825765c0053cd9b/$FILE/Final%20Second%20Five-Year%20Review%20-%20Sept%202009.pdf.

plume. The Moffett RAB and Toxics Coalition gradually shifted our focus to other sites, such as cleanup of Moffett's 150-acre Stormwater Retention Pond.

Promoting Public Oversight

In 1993 San Francisco State University, with the support of Congresswoman Nancy Pelosi, established the California Economic Recovery and Environmental Restoration Project (CAREER/PRO). I was first hired as a consultant then as Director in 1994. While the original purpose was to train base workers and neighbors to conduct cleanup at closing Bay Area military bases—something which we did successfully—I shifted the focus to facilitating community engagement in military cleanup programs. We eventually renamed the project the Center for Public Environmental Oversight to reflect that new emphasis.

We were originally funded by a Pelosi earmark in the Defense budget, funding that I helped work through the Defense environmental offices, and then EPA's Federal Facilities Restoration and Reuse Office. This funding enabled my colleagues and me to continue to participate in national meetings and conferences and, more important, to visit and work with communities facing Defense cleanup challenges. During many of those visits, I drew upon our growing body of experience in Mountain View.

While CPEO staff continued to advocate for communities and help them organize, we established constructive working relationships with officials at all levels in the Defense Department, EPA, private industry, and environmental agencies in numerous states. We participated in the National Dialogue on Military Munitions, the original Defense Science Board task force on Unexploded Ordnance, the Committee to Demonstrate On-Site Innovative Technologies, the Interstate Technology Regulatory Council, the Bay Area Defense Conversion Action Team, and numerous other multi-stakeholder committees. We spoke at military and regulatory agency conferences and training sessions. In 1998, when the Navy sponsored a National Research Council (NRC, an arm of the National Academies of Sciences) committee to advise on ways to improve remediation, Navy officials recommended me as a community involvement expert. It was the first of several NRC committees in which I've taken part.

Adaptive Site Management

In 2003, the second NRC Committee on Navy Remediation released its report on Adaptive Site Management (ASM). I believe that I was instrumental in asking the questions that led to this application of the "observational approach." The NRC summarized, "ASM facilitates making decisions about when remedies can be changed due to ineffectiveness, when to incorporate a new technology, when remedies can be discontinued, and when site cleanup goals should be revised."[5]

While the NRC was consulting with the Navy, the Navy issued its "Guidance for

[5] *Environmental Cleanup at Navy Facilities: Adaptive Site Management,* National Research Council, 2003. See http://dels.nas.edu/Report/Environmental-Cleanup-Navy-Facilities-Adaptive/10599.

Optimizing Remedial Action Operation (RAO)," designed to help project managers evaluate and improve ongoing cleanup remedies. At Moffett, just after the release of the NRC report, it applied the lessons of the two documents to the Regional Plume. I wrote, in CPEO's Military Environmental Forum newsgroup:

> I am pleased to report that the Navy is implementing its optimization approach at my home base of Moffett Field. That is, it is working to improve the performance of a major groundwater treatment system even though that system is generally performing well.
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> In the "Final West-Side Aquifer Treatment System [WATS] Optimization Work Plan," the Navy describes a series of field activities designed to "increase efficiency and minimize operational costs for the treatment system." The work plan calls for the collection of chemical and geologic data, the installation of an additional extraction well in an area where hydraulic control of the contamination plume is incomplete, and the upgrading of the pumping system.[6]

Moffett's massive, historic Hangar One behind pump-and-treat system

[6] Lenny Siegel, "Optimization at Moffett Field," CPEO Military Environmental Forum, August 25, 2003, http://www.cpeo.org/lists/military/2003/msg00966.html. The RAO report was Radian International, "Guidance for Optimizing Remedial Action Operation (RAO)," Naval Facilities Engineering Command Special Report SR-2101-ENV, Interim Final, April 2001.

Successful Pump-and-Treat

The Moffett-MEW Regional Plume is one of the nation's larger, more complex groundwater remediation projects. The plume is about two miles long and nearly a half-mile wide. TCE, its breakdown products, and other contaminants are primarily found in the upper three aquifers, with only localized breakthrough identified in the C aquifer that serves as a drinking water supply. When measured in 1982, maximum TCE concentrations reached 1,000,000 parts per billion (ppb) south of Highway 101 and 110,00 ppb at Moffett Field.

With minor exceptions, the regional extraction system has worked well. Approximately 100 extraction wells removed over 4.5 billion gallons of groundwater through 2009. Nearly 100,000 pounds of volatile organic compounds, led by TCE, have been removed. Water levels are sampled semi-annually in nearly 1000 monitoring wells, and contaminant concentrations are measured annually in about 500 wells. By 2009, the average TCE concentration had fallen 90%, with the maximum down to 40,000 ppb south of 101 and 4,700 ppb at Moffett.

Continuing operation and maintenance of the pump-and-treat systems remains costly, however. Based on ranges that EPA provided in its 2009 Second Five-Year Review, combined annual costs exceed $3 million. Since much of this expenditure goes for electricity to run the pumps, the current remedy also represents a growing accumulation of greenhouse gas emissions. Furthermore, the current systems waste another valuable resource, groundwater, since most of the treated water is discharged to wastewater systems or the San Francisco Bay without beneficial use.

Successful Redevelopment

Meanwhile, MEW became a model for contaminated site redevelopment. The manufacturing plants closed and were replaced by high-tech offices bearing names such as Netscape, Nokia, Symantec, Veritas, Hewlett-Packard, and Verisign. In fact, U.S. EPA featured the site on the cover of its "Reusing Superfund Sites" brochure. It said, "By 1999, all the available office space had been leased and most of the remaining property was at some stage of development."[7] At Moffett Field, now owned by NASA's Ames Research Center, a consortium of colleges and universities, led by the University of California at Santa Cruz and the Foothill-De Anza Community College District, started planning a new college campus, including dormitories and family housing, and leading corporations have proposed Moffett for the 2020 World's Fair. Most recently, Google announced plans to lease 450,000 square feet of office space on one of the former Fairchild properties.

The Rise of Vapor Intrusion

But all is not well. EPA has found that the remedy is not protective against vapor intrusion, the migration of subsurface organic compound vapors into overlying buildings. In October 2002 EPA sent letters to the MEW Responsibly Parties requesting that they submit work plans "to conduct a human health risk assessment to evaluate the groundwater to indoor air exposure pathway by collecting indoor air, outdoor air, and soil gas samples at each Facility," thus initiating one of the agency's first major vapor intrusion investigations.[8] At the same time EPA's RCRA (Resource Conservation and Recovery Act) program undertook a similar investigation at the nearby former GTE property.

When local activists got wind of the new investigations, we requested a public meeting. EPA convened a meeting in January, 2003, and over 400 people attended. A majority were from the new, upscale Whisman Station housing developing located above and around GTE's small, unremediated TCE plumes. The high level of public interest drove the investigations forward, and with EPA support the community formed the Northeast Mountain View Advisory Council (NMAC) to focus on the vapor intrusion response. Years of study found a high potential for vapor intrusion but relatively few homes or offices with a completed pathway. NMAC stopped meeting when interest among Whisman Station residents declined.

Equally important, in its September 2009 Five-Year Review EPA concluded, "The remedy at the MEW Site is not protective because it does not adequately address potential health risks from long-term exposure to TCE and other VOCs through the vapor intrusion pathway."[9] It thus laid the legal basis for re-opening the groundwater remedy. EPA and leading state regulatory agencies have for years said that the long-term solution to vapor intrusion is accelerated subsurface remediation, but it is rare that anyone actually reconsiders implemented groundwater remedies for this reason.

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[7] "Reusing Superfund Sites," U.S. EPA. EPA/540/K-00/004, October 2000, page 9.
[8] Letter from Alana Lee, U.S. EPA Region 9 to Intel Corporation and Raytheon Company, October 2, 2002.
[9] "Second MEW Five-Year Review," page 9-1.

January 2003 public meeting in Mountain View

Re-Considering the Remedy

In August 2010 EPA announced a ROD Amendment requiring both engineering controls and institutional controls to mitigate current exposures and prevent future problems. It also established a new remedial objective:

> To accelerate the reduction of the source of vapor intrusion (i.e., Site contaminants in shallow groundwater and soil gas) to levels that are protective of current and future building occupants, such that the need for a vapor intrusion remedy would be minimized or no longer be necessary.[10]

Vapor intrusion was not the only argument for re-opening the MEW remedy. In the same Five-Year Review EPA found:

> At several of the facilities, the remedy's cost efficiency and potential for achieving cleanup goals are decreasing with continued operation, due to decreasing influent VOC concentrations and declining mass removal efficiency. Estimates in the 1989 ROD for the time required to reach the TCE cleanup level for the Deeper Aquifers is between 2 to 45 years. For the shallow aquifers, the cleanup time was estimated to be considerably longer—from 46 years into the indefinite future—because the shallow aquifers are low-yielding and contain soils with high clay content that attracts and retains site chemicals. Based on

[10] "Record of Decision for the Vapor Intrusion Pathway. MEW Superfund Study Area," U.S. EPA Region 9, August 16, 1910, page 21. Available on line at http://yosemite.epa.gov/r9/sfund/r9sfdocw.nsf/3dc283e6c5d6056f88257426007417a2/717b008a94310662882577820077 90bc/$FILE/MEW%20VI%20ROD%20Amendment%20and%20RS%20-%20Aug%2016%202010.pdf

remedy optimization evaluations conducted for each of the facilities by the MEW Companies, Navy, and NASA in 2008, the existing groundwater remedy as it stands is not expected to achieve Site cleanup levels for several more decades. The optimization evaluations identified several technologies that may expedite groundwater cleanup at the Site; EPA is planning on developing these technologies into alternatives and further evaluating them in the future Site-wide Feasibility Study for the MEW Site.[11]

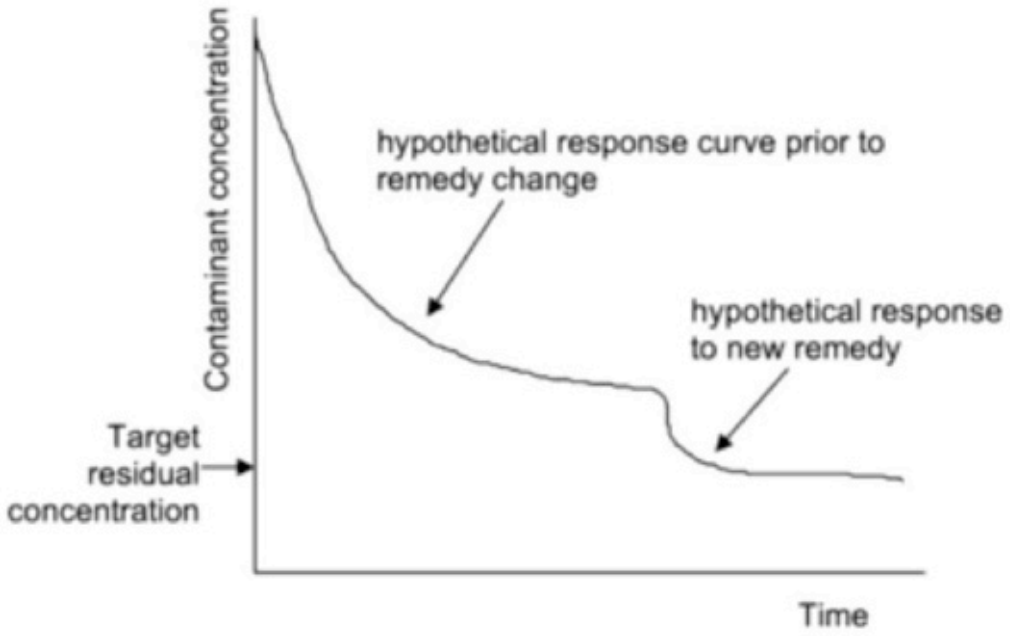

FIGURE 3-9 Hypothetical effect of changing the remedy on the concentration versus time curve.

From NRC report on Adaptive Site Management

Such diminishing returns are common and predictable. In fact, it was this phenomenon that prompted the NRC findings on Adaptive Site Management. Nevertheless, it is unlikely that EPA would have considered a major overhaul of the existing regional remedies in the absence of the vapor intrusion risk. Coincidentally, it is the vapor-generating upper aquifer where the road to complete cleanup appears most challenging.

The Community's Strategy

Our community is perhaps unusually well prepared to oversee such a transition. We have a long history of constructive criticism of groundwater cleanup programs, and we have support from our elected officials. This is Silicon Valley, so many residents are comfortable with technical language, scientific notation, large tables of numbers, and the scientific method. At a recent meeting, I compared the technical challenges of vapor

[11] "Second MEW Five-Year Review," page 7-2.

intrusion and groundwater cleanup to "rocket science." Then, looking around the room, I noticed that a large fraction of the community representatives actually were rocket scientists. Furthermore, at a number of meetings over the past decade, I have presented the classical diminishing returns curve (see above) to my neighbors and explained the opportunity for changing the curve. We recognize that matrix diffusion and other phenomena can delay or even prevent the achievement of absolute groundwater cleanup objectives.

We have also consistently supported the demonstration of innovative cleanup technologies by both the electronics industry responsible parties and the Navy. For example, Intel and Raytheon determined that one of their pump-and-treat systems was actualy spreading VOCs from an adjacent property, so they proposed an Enhanced *In-Situ* Bioremediation Pilot Test. They injected edible emulsified oil as an electron donor and for part of the test area, *dehalococcides* bacteria.

Site of *in situ* pilot

They reported, "The site-wide reductive dechlorination has been shown to rapidly and effectively reduce TCE to very low or non-detectable levels." They concluded that the *in-situ* approach was degrading TCE to non-toxic ethenes. Furthermore, "Enhanced *In-Situ* Bioremediation appears to have increased the dissolution and desorption of VOCs from the soil matrix at a more rapid rate than pump and treat." EPA concluded, "This removal rate [from the *in-situ* pilot] is approximately three times greater than the removal rate of the extraction and treatment system during its last few years of operation Furthermore, it reported, "The costs associated with the in-situ bioremediation pilot test appear to be significantly less per pound of VOCs removed compared to the groundwater

extraction and treatment system."[12] Energy use was significantly lower as well, and there were no water discharges.

The Navy's newer pilot project in the Westside Aquifer has demonstrated similar success, but both EPA and the responsible parties continue to remind us that remedies that rely on injection are difficult, if not impossible, to apply over a two-mile long plume that has spread under two hundred buildings, roadways, and other infrastructure. While EPA is confident that pump-and-treat will achieve remedial objectives in the lower aquifers in a reasonable amount of time, the responsible parties tell us that even with the application of new technologies that it will take decades, at the least, to reach the 5 ppb TCE drinking water standard throughout the upper aquifer, let alone a lower (more protective) standard that might result from the toxicity review now underway at EPA.

EPA has kept us informed on the progress of the new Groundwater Feasibility Study, at meetings of the Moffett RAB as well as special meetings of CPEO's technical assistance Community Advisory Board. In response, we have developed a strategy that EPA says it is using to help evaluate remediation technologies. In essence, we are focusing on what *can* be done instead of what *cannot* be done. We have called for better coordination among the responsible parties, additional characterization, and improved long-term monitoring. We have endorsed, where applicable, *in-situ* bioremediation and bioaugmentation, and we have suggested that some of the old, leaking slurry walls be converted into funnel-and-gate permeable reactive barriers.

Reluctantly accepting the argument that it is impractical to implement such technologies throughout the upper-aquifer plume, we have proposed that they be focused on addressing the problems that led us all to initiate the cleanup decades ago, those portions of the plume that pose the greatest risk to human health and the environment. Specifically, we have suggested that the new Feasibility Study and remedy selection focus on the following:

- Areas with high mass
- Areas that continue to act as a source
- Areas that reduce the need for long-term Vapor Intrusion mitigation
- Where the detectable plume encroaches on residential areas, schools, and other sensitive uses
- To enable reasonable future use of the property.[13]

Despite the increased use of innovative technologies, it is clear that pump-and-treat will remain a significant part of the overall response, not only in the lower aquifers but in the upper aquifer as well. We have offered the following guidance to govern the

[12] Weiss Associates, "2009 Annual Progress Report for Former Intel Mountain View Facility," April 15, 2010, pages 136, 152-3; "Second MEW Five-Year Review," pages 4-9, 4-20.
[13] Peter Strauss, "Focused Feasibility Study for the MEW-Moffett Regional Plume: Community Criteria and Suggested Strategy," Center for Public Environmental Oversight, April 2011, pages 2-3. Available on line at http://cpeo.org/pubs/MEW-MoffettStrategy.pdf.

optimization of site groundwater cleanup, including the introduction of innovative technologies as well as the continued use of conventional approaches.

- Alternatives that replace current systems must speed up remediation (increasing progress towards remediation goals), remove or destroy contaminants that are not being addressed by the current system, and/or increase mass removal rates.
- The remedy selection process should evaluate hot spot removal.
- The remedy selection process should evaluate, where appropriate, the effectiveness of existing institutional controls (e.g., restrictions on drilling wells) as well as the need to establish new institutional controls (e.g., establish requirements to restrict use).
- The remedy selection should consider energy use and natural resource use/re-evaluate treated water recycling.
- The remedy selection process should evaluate the need for additional extraction wells and/or increasing extraction rates, particularly upstream from the slurry walls.
- Long-term monitoring and a contingency plan (e.g., failure of slurry walls) should be part of the scope of the [Feasibility Study]. We note that in 2008, the Northgate efficiency evaluation found that the slurry walls were "leaky," yet we know of little that has been done to address this problem.
- Remedy selection is complicated by the fact that property owners must give consent to the Responsible Party to conduct pilot tests and implement new technologies. The [Feasibility Study] should account for this complication.[14]

It may be, even if EPA and the responsible parties accept all of the recommendations that our community has put forward, that contaminant concentrations in portions of the plume may still remain, for decades, above drinking water standards. The temporal and spatial mix of remedial technologies—the treatment train—may at some locations at some time rely upon natural degradation "to polish off" residual or re-emerging low-level contamination. But every effort should be made to get concentrations down to the point that natural degradation can finish the job in a reasonable timeframe.

We also ask that all the parties recognize that new technologies and strategies may continue to offer more effective, less expensive, and/or more sustainable—that is using less energy and wasting less water—approaches to cleanup. We have proposed:

> The Feasibility Study should require an adaptive optimization strategy that continually looks at new ways to attain clean-up standards. This should be a requirement that occurs every two years. That is, every two years the Responsible Parties should take a systematic look at the entire remediation process and determine what is working, what can be improved, and if there are new techniques and technologies that can enhance remediation performance.[15]

[14] Strauss, "Community Criteria," page 3.
[15] *ibid*.

When the cleanup going gets tough, my neighbors and I believe that it is time to optimize and adapt, not to give up. Plume-wide remedial objectives may morph from absolute short-term requirements to goals that guide our continuing efforts. But we believe that we have demonstrated that the people whose communities continue to bear the health, environmental, and economic impacts of subsurface contamination can be positive partners in the cleanup process, and that we can keep regulators and responsible parties focused on the reasons we are conducting cleanup in the first place.