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TO: Office of Information and Regulatory Affairs
FROM: Lenny Siegel, Center for Public Environmental Oversight
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SUBJECT: CHIPS Environmental Questionnaire Information Collection

Semiconductor production, particularly wafer fabrication, is a chemical intensive process. To evaluate the suitability of projects seeking federal funding and to help host communities prepare for potential problems, the NIST questionnaire should ask detailed questions about the use, storage, and release of hazardous substances in chip manufacturing.

The semiconductor industry uses a large number of chemicals and metals in both its manufacturing processes, such as photolithography, and its final products. For example, the industry explains, “Without PFAS, the ability to produce semiconductors (and the facilities and equipment related to and supporting semiconductor manufacturing) would be put at risk.”[1] It also reports, “While in the 1980s semiconductor fabs used fewer than 20 elements, today they are using over 50% of the nonradioactive elements in the periodic table.”[2]

Historically, the use of these chemicals has created significant environmental and worker safety risks. Santa Clara County, the principal birthplace of the semiconductor industry, has more federal Superfund sites than any other county in the U.S., primarily as a result of chipmaking pollution. For example, at the MEW Superfund Study Area in Mountain View and the Triple Site in Sunnyvale, groundwater cleanup will continue for decades, while people in hundreds of overlying buildings are potentially exposed to vapor intrusion from TCE, a cancer-causing solvent known to unacceptably increase the risk of cancer, Parkinson’s disease, and cardiac birth defects. The same is true at Motorola Semiconductor facilities in Phoenix.

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[1] “The Impact of a Potential PFAS Restriction on the Semiconductor Sector,” SIA PFAS Consortium, April 13, 2023, p. 3.
[2] “Background on Semiconductor Manufacturing and PFAS,” SIA PFAS Consortium, May 17, 2023, p. 54.

Most of these chemicals are unregulated. In fact, many have not been studied for either human health or environmental risks. Industry routinely introduces new chemicals and other materials without first evaluating their toxicity. In the case of PFAS, the class of highly toxic "forever chemicals" that are found today in the bloodstream of most Americans, industry reports, "Most PFAS are not regulated pollutants and therefore unless company specific provisions are in place, the wastewater from processes that use aqueous wet chemical formulations that contain PFAS would likely be discharged to the publicly owned treatment works without substantive removal of the PFAS."[3]

Furthermore, semiconductor companies and their suppliers consider their complex chemical formulations to be confidential business information. That is, they argue against public disclosure. In many cases, the chip manufacturers do not even know what is in the products that they use. The SIA PFAS Consortium reports, "semiconductor device makers did not know exactly which chemical products contained PFOS and PFOA, as safety data sheets do not regularly disclose this information…. In other instances, the use of the substances was classified as confidential business information (CBI) and shared only by generic names such as 'surfactant' or 'photoacid generator,' without a corresponding Chemical Abstracts Service registry number."[4] It also reports, "Because PFAS have not yet been regulated as a class, traceability for those compounds throughout the entire ATPS supply chain is difficult and would require a multicompany, multistep, multiyear effort to improve the level of knowledge within the supply chain."[5]

The semiconductor industry and the associated semiconductor equipment and materials industry have made some progress in managing their environmental impact, but that trails far behind their constant improvements in product and process technology. Improvements are largely the result of three factors:

- The costs of cleaning up past environmental contamination, such as the Silicon Valley Superfund sites, has been substantial.
- Some of the industry's activities have been regulated by government agencies. For example, in the 1980s the Santa Clara County Fire Chiefs Association developed a model Hazardous Materials Storage Ordinance, requiring the use of double-walled underground storage tanks.
- In the case of PFOS, the industry was forced to find a substitute when 3M phased out its production. Unfortunately, manufacturers replaced PFOS with another, comparably hazardous chemical, PFBS.

The semiconductor industry has not reached out to community, environmental, or worker organizations to learn how they expect the industry to improve its environmental and worker

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[3] "The Impact of a Potential PFAS Restriction on the Semiconductor Sector," SIA PFAS Consortium, April 13, 2023, p. 3

[4] "PFOS and PFOA Conversion to Short-Chain PFAS-Containing Materials Used in Semiconductor Manufacturing," SIA PFAS Consortium, June 5, 2023, p. 8.

[5] "PFAS-Containing Materials Used in Semiconductor Manufacturing Assembly Test Packaging and Substrate Processes," SIA PFAS Consortium, June 2, 2023, p. 5.

safety practices. In fact, the public has to look hard to find current information about the hazards of chip production.

The NIST Questionnaire, therefore, provides an opportunity to enlighten and engage the impacted public, and well as inform government agencies at all levels in their efforts to limit the human health and environment risks of semiconductor production.

The environmental and workplace threats of hazardous substances in the semiconductor industry can be broken down into several categories, each with its own questions for industry.

1. The fugitive emission of extremely toxic (even lethal) gases, such as arsine.
    A. What will be done to prevent the release of toxic gases in wafer fabrication?
    B. How will employees be educated about the risk from toxic gases?
    C. Are exposure standards based upon current toxicology? (OSHA standards are not.)
    D. How will first responders be prepared for the potential release of toxic gases?
    E. Will there be any warning systems for notifying people downwind of production facilities of the potential emission of extremely toxic gases?

2. Leaks and spills of liquid (and solid) hazardous substances.
    A. What will be done to prevent the release of hazardous substances in production, storage, and waste storage?
    B. How will employees be educated about the risk from leaks and spills?
    C. How will employees be separated/protected from potential leaks and spills
    D. What are the protocols for cleaning leaks and spills?
    E. To what degree are treatment systems in place for remediating legacy spills (such as TCE) spreading PFAS or other chemicals not removed by the treatment systems?

3. Waste water.
    A. What will be done to measure the presence of hazardous substances in waste water, not only in facility discharges, but at the various stages of production?
    B. Will waste water be analyzed for chemicals for which there is no drinking water standard (yet)?
    C. Will total fluorine (as opposed to targeted PFAS) be measured? "At present, only a small percentage of PFAS compounds within typical semiconductor wastewater are detectable and quantifiable using conventional U.S. EPA analytical methods for PFAS-containing materials."[6] Academic researchers are overcoming this challenge, finding that failure to measure total fluorine misses discharges of significant quantities of PFAS pollutants. "[B]ecause many studies of total organic fluorine have shown that total PFAS concentrations are at least 10 times higher than the sum of target PFASs.

[6] "PFOS and PFOA Conversion to Short-Chain PFAS-Containing Materials Used in Semiconductor Manufacturing," SIA PFAS Consortium, June 5, 2023, p. 11.

However, this does reinforce the idea that PFAS monitoring should incorporate complementary target and nontarget analyses or otherwise include measures of total organic fluorine to accurately assess PFAS abundance and potential environmental impacts. These data also support the recent push by policymakers to regulate total PFASs, rather than individual compounds, underscoring the importance of total PFAS concentration monitoring."[7]

D. Will initial waste water streams be treated before mixing with other waste water.

4. Disposal of hazardous solid wastes including filtration media.
   A. What is the anticipated quantity of hazardous solid waste generation?
   B. How will such waste be treated, stored, or disposed of?
   C. To what degree will wastes be incinerated off site? Industry reports, "Organic waste, including organic liquids containing PFAS, is typically segregated, collected, and containerized to be treated at an offsite licensed treatment and disposal facility, as a blended fuel by high temperature incineration or reprocessing."[8] Incineration, even when permitted by regulatory agencies, may release products of incomplete combustion into the atmosphere.
   D. To what degree will waste generators (chip manufacturers) be responsible for what happens to the wastes once they move off site?

5. Disclosure and pollution prevention.
   A. What hazardous substances are used in production? Answers should include quantitative ranges and where feasible, the hazardous substances contained in commercial chemicals. At a minimum, these should include those for which there are state or EPA drinking water standards or health advisories, those listed in U.S. EPA's Toxics Release Inventory, and those listed according to California's Prop 65. All PFAS should be listed, whether are not they are contained on the above lists.
   B. Is there a mechanism for requiring suppliers of equipment and materials to identify hazardous substances in their products?
   C. To what degree will automation and containment be used to prevent exposures —inside or outside manufacturing plants — to hazardous substances?
   D. Will new substances used in production be evaluated for their toxicity before introduction?
   E. To what degree do manufacturers hold stocks of PFAS or other hazardous substances that have been phased out of production?
   F. How are the benefits of replacing hazardous substances with more benign substances weighed against the costs?

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[7] Paige Jacob, Kristas Barzen-Hanson, and Damian Helbling, "Target and Nontarget Analysis of Per- and Polyfluoralkyl Substances in Wastewater from Electronics Fabrication Facilities," *Environmental Science & Technology,* February 16, 2021, p. 2353.

[8] "Background on Semiconductor Manufacturing and PFAS," SIA PFAS Consortium, May 17, 2023, p. 30.

G. To what degree is the manufacturer working with representatives of environmental organizations and worker safety organizations.

6. Life cycle.
    A. What hazardous substances remain in finished semiconductor products? Include packaging.
    B. At the end-of-life, are there mechanisms for preventing the environmental release of semiconductor hazardous substances? SIA PFAS Consortium reports, "At the end-of-life of the product containing the semiconductor, or any parts replaced during the manufacture of semiconductors, would enter waste disposal streams where any PFAS contained therein could enter the environment."[9]

[9] "The Impact of a Potential PFAS Restriction on the Semiconductor Sector," SIA PFAS Consortium, April 13, 2023, p. 90,