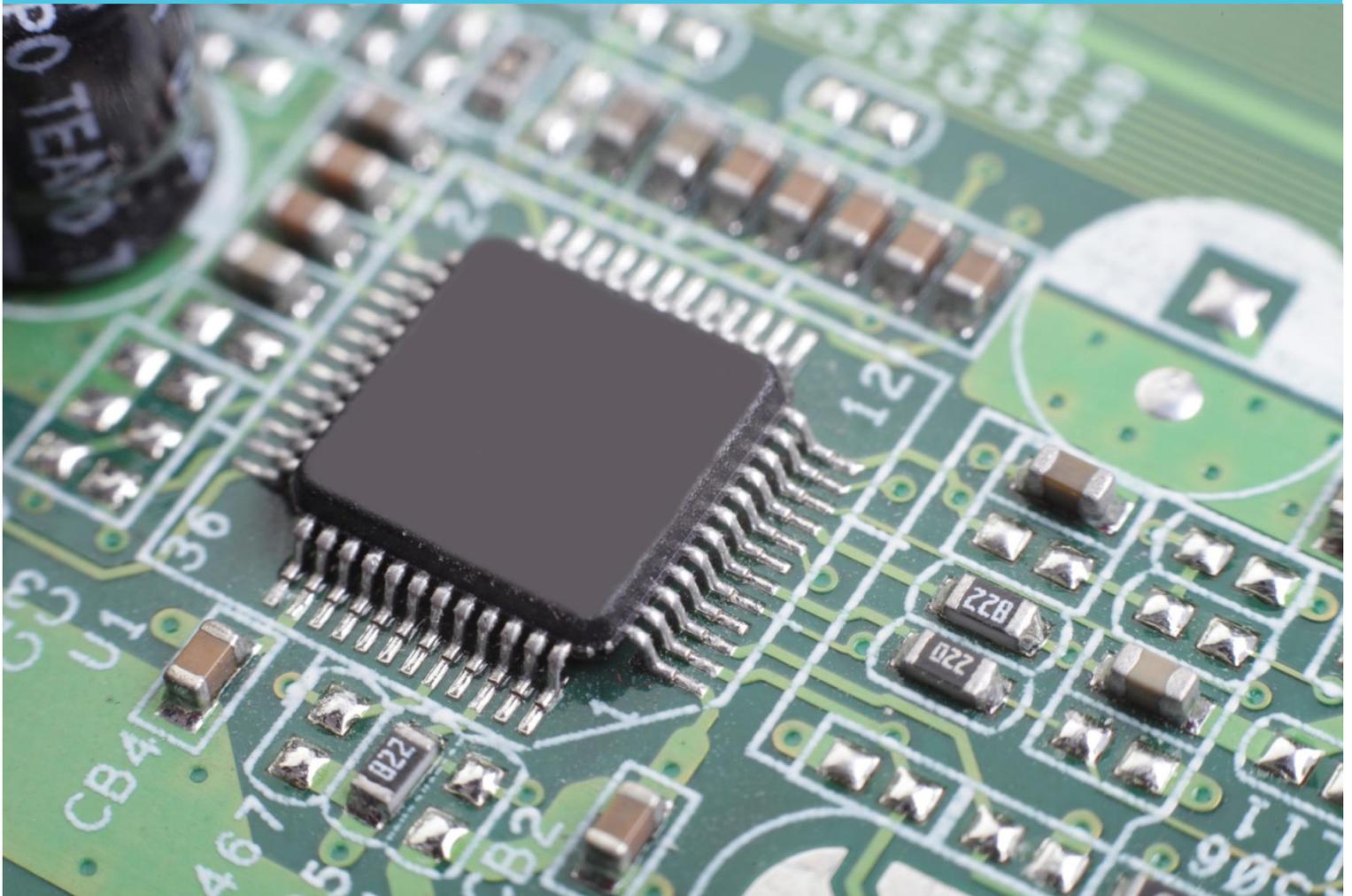




Electronics Supply Networks and Water Pollution in China

Understanding and Mitigating Potential Impacts

November 2010



About this Report

This report and related activities were developed in cooperation with the Electronic Industry Citizenship Coalition (EICC) and generously funded by the Rockefeller Brothers Fund. We wish to thank the leads of the Environmental Sustainability Working Group for their support in project design and implementation, consultation and facilitation with the EICC, and review of this report. Please direct comments or questions to Laura Ediger at lediger@bsr.org or Jesse Nishinaga at jnishinaga@bsr.org.

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Executive Summary

Electronics manufacturing has become an important economic contributor to China's success, but its rapid growth has come with environmental costs as well, including negative impacts on water quality. As governmental enforcement of wastewater standards improves, along with public awareness and civil society engagement on environmental issues, global companies have a growing need to effectively understand and mitigate potential risks.

For this study, BSR worked with the Electronic Industry Citizenship Coalition (EICC) to better understand the environmental performance of a sample of China-based suppliers to EICC members in relation to wastewater management. With the support of ten EICC members who submitted lists of their suppliers in China, BSR searched an online public database of water pollution information compiled by the Institute of Public and Environmental Affairs to identify violations linked to suppliers to the EICC members who participated in the study.

The findings of the database search included these results:

- Environmental violations were found in the database for 33 (of 640) suppliers, representing approximately five percent of the sample. The majority of these matches were located in the provinces of Jiangsu (39 percent), Guangdong (30 percent), and Shanghai (15 percent), where electronics manufacturers are concentrated.
- Approximately 30 percent of the 33 supplier matches were for supplier names submitted by more than one EICC member company, showing the interconnected nature of the electronics supply chain and the widely shared risk of poor supplier environmental performance.
- More than 20 percent of the suppliers with recorded violations had multiple matches in the database, demonstrating that these companies may have long-term systemic challenges with effective wastewater management.

The assessment findings provide helpful information for EICC members, and also demonstrate the usefulness of the IPE database as one tool in a comprehensive supplier evaluation and development program. Companies can work to improve supply chain performance by fully understanding where relatively higher risks exist in their supply networks, communicating effectively with suppliers regarding expectations for water use and wastewater treatment, and integrating supplier performance into initial and ongoing supplier selection and assessment.

Introduction

With nearly 20 percent annual growth in recent years, electronics manufacturing has become a core export industry for China, helping to fuel the country's rapid economic development.¹

Providing everything from discrete components to final product assembly, China is not only a major electronics producer – the country's burgeoning middle-class has also turned China into an important market for products that were once sold primarily to Western consumers.



Global electronics companies have played a central role in building the electronics industry into a crucial sector for China. However, the dramatic expansion of electronics manufacturing, along with other sectors that rely on intensive use of water and chemicals, has contributed to some of the challenging water issues that China faces today.

Recent media reports and campaigns by nongovernmental organizations (NGOs) have highlighted the contribution of electronics manufacturing to China's water pollution issues, sparking interest from consumers and government regulators. Corporate response has been varied, in part because many companies do not have a clear understanding of the extent to which their own supply chains are contributing to these water pollution impacts.

Some electronics companies have already established stringent programs to address supplier wastewater management issues. For those that haven't, combining a clear understanding of their supply chains and a process to evaluate potential environmental impacts will make it easier to determine how to effectively address water pollution concerns.

The goal of this report is threefold: (1) provide global electronics companies with the context needed to understand China's water challenges, (2) present the results of a supplier assessment that was conducted on behalf of Electronic Industry Citizenship Coalition (EICC) member companies, and (3) document recommendations and resources for identifying and mitigating water pollution risks in electronics supply chains.

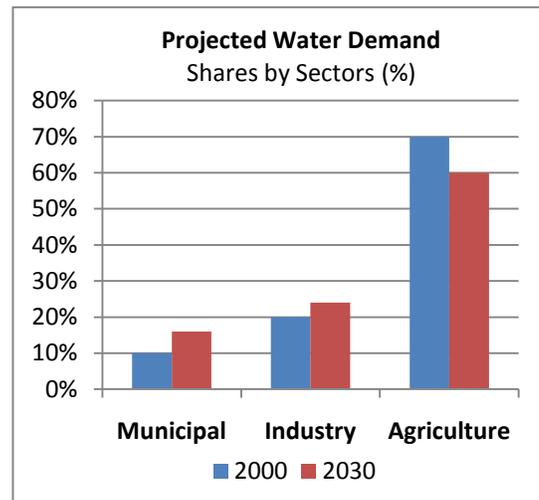
CHINA'S WATER CRISIS

China has experienced unprecedented economic growth in the last few decades, which has improved the lives of millions of Chinese citizens. Unfortunately, this growth has also come at the expense of environmental losses that threaten China's public health and long-term prosperity.

China's water resources are scarce, unevenly distributed, extensively polluted, and often poorly managed. According to the UN Food and Agriculture Organization (FAO), China's per capita availability of water resources is only one-fourth the global average and among the lowest for a major country. This scarcity is further aggravated by extensive water pollution. A 2009 World Bank report noted that of the 745 monitored river sections in China, only 40 percent met the Grades I-III surface quality standards (i.e. safe for human consumption after treatment). Additionally, only 56 percent of the total annual discharge of municipal and industrial wastewater was treated.²

With China's population expected to peak at 1.5 billion around 2033, under a "business as usual" scenario, total water demand will increase by an estimated 16 percent to 653.5 km³ in 2030, largely driven by industrial and municipal demands.³ The economic cost of China's water crisis will also rise under this scenario, putting additional strain on the country's public and environmental health. World Bank research estimated that the direct costs of water scarcity and pollution are equivalent to approximately 2.3 percent of China's GDP, with 1.3 percent attributable to scarcity and 1 percent to the direct impacts of pollution.⁴ Other studies have found significant correlation between water pollution and health impacts such as typhoid, diarrhea, anemia, birth defects, and mortality due to esophageal, stomach, bladder, lung, and liver cancer.⁵

Different regions of China experience varying challenges related to water resources. Water-scarce regions are largely concentrated in the northern and western areas of the country. For example, the Huang-Huai-Hai (3H) area, named after the region's three major rivers, is home to 34.7 percent of China's population but only 7.6 percent of naturally available water resources. The annual level of water access in the 3H area is far below the international scarcity level of 1,000 cubic meters per capita.⁶



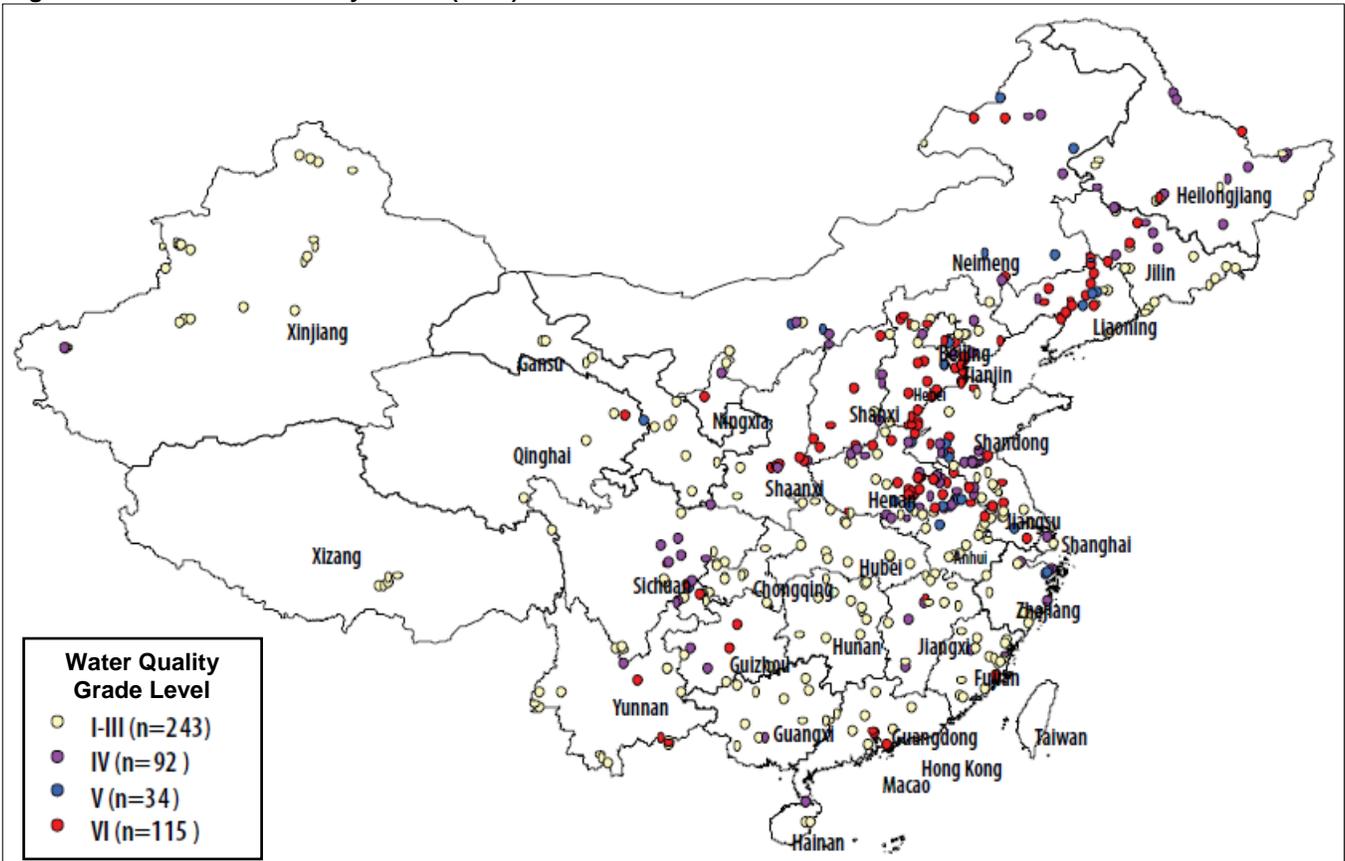
Source: Data from Xie 2009

Of the 745 river sections being monitored in China, only 40 percent met the Grades I-III surface quality standards (safe for human consumption after treatment).

Source: Xie 2009

Parts of central China and the eastern seaboard experience the most concentrated pollution. In the Shanghai area, only one percent of surface water meets drinking water standards, and Zhejiang and Guangdong Provinces also have challenges with water quality. Figure 1 illustrates the surface water quality levels in China, with the greatest concentrations of polluted water unsafe for human consumption (i.e. Grades IV and above) in the central and eastern parts of China as well as some key areas in the south.

Figure 1: Surface Water Quality Levels (2004)



Source: Nygard 2006

Note: Grades I–III refer to water that is safe for human consumption after treatment, Grades IV–V refer to water that is safe only for industrial and irrigation use, and higher than Grade V refers to water that is unsafe for any use.

REGULATORY AND CIVIL SOCIETY CONTEXT

Over the last decade, China’s leaders have increasingly recognized the severe challenges of environmental pollution and the need to address them with better laws and effective enforcement. China’s State Environmental Protection Agency was elevated to the Ministry of Environmental Protection (MEP) in early 2008, signaling the central government’s intention to strengthen the regulatory power of government agencies in regard to natural resource management.

In contrast to many developing countries, the legal aspects of environmental protection in China are relatively strict. For example, detailed guidelines have

From April to August 2010, a coalition of Chinese NGOs, led by Friends of Nature, the Institute of Public and Environmental Affairs (IPE), and Green Beagle produced a public report alleging that 29 electronics brands used suppliers in China with poor environmental practices, such as dumping heavy metals into China's water bodies.

See www.ipe.org.cn for a series of reports on this campaign.

been published for acceptable standards of industrial air and water emissions discharge. In order to operate, manufacturers must go through a complicated process of obtaining permits and approvals.

The main weakness of the regulatory system exists at the level of local implementation. Municipal branches of the MEP are effectively dependent on local government for their financial survival, so often they do not have the independence to penalize companies if that is contrary to the wishes of local officials. Close relationships between business owners and government officials, along with the importance of steady tax revenues, mean that local government often has little incentive to cite or shut down polluting businesses.

Meanwhile, the role of civil society organizations and activists in raising public awareness and drawing attention to violations of the law is increasingly important. Although NGOs in China often have limited scope regarding their activities, organizations focused on environmental issues have had an increasing amount of freedom in recent years. There is growing acceptance of the positive role that NGOs can play in educating the public about environmental issues and even aiding enforcement efforts by identifying offenders, especially if NGO activities are not directed toward criticism of government initiatives.

For global electronics companies, the implications of an improved climate for civil society activity are twofold. First, there is a higher reputational risk of having a facility in their supply chain publicly identified as a polluter or targeted in a campaign. The second and more positive perspective is that increased public awareness of corporate environmental performance can also help to support global electronics companies in their sustainability work by improving accountability of supplier environmental performance at the local level.

Risk Assessment

A typical electronics product is a complex construction of a wide range of diverse components. Some of these components, which may number in the thousands, are manufactured at facilities with highly intensive processes that use significant amounts of water and chemicals. The waste byproducts of these processes must be treated appropriately before discharge to limit impacts on human and environmental health.⁷

Because of the complexity and sheer size of electronics supply networks, a consumer brand or OEM's knowledge of supplier activities and identities is often limited. This challenge is amplified by the fact that many components used to build a typical electronics product are provided by suppliers with varying degrees of vertical integration. As suppliers and their associated manufacturing processes are identified, companies can assess specific supplier facilities to determine the locations of the most water-intensive and potentially polluting facilities.

The following assessment identifies potential supply chain risks based on evaluation of publicly available information on previous violations. BSR used a list of suppliers collected from EICC members and checked the suppliers' names against a database created by a Chinese NGO that includes official violations published by local media and government agencies.

ENVIRONMENTAL DATABASE

The Institute of Public and Environmental Affairs (IPE) is a Chinese NGO that works to increase public awareness and disclosure of environmental information, in part by publishing information about water and air pollution in China. One of IPE's project activities is maintaining an online database that contains published information related to industrial air and water emissions. As of October 2010, there were more than 50,000 individual entries in the database, which is available to the public at www.ipe.org.cn (in Chinese) and is searchable by company name, year, industry type, province, and city.

Information captured in the database includes environmental violations such as negative evaluations received during an official environmental review, violations for illegal or improper discharge, cases in which wastewater discharge did not meet water quality standards, and community complaints that led to investigations regarding pollution. There is also neutral information in the database that is not linked to any violation, such as data from environmental impact assessments or public mention of company participation in water quality improvement projects.

The database is frequently updated by IPE staff based on information published in the media and on official government websites. There are certain limitations in relying on such sources, such as the preference of some government agencies not to publish lists of offenders despite legal requirements. This means that the database cannot be considered a comprehensive measure of environmental performance. However, this information channel serves as a useful tool for companies to identify known pollution risks in their supply networks.

METHODOLOGY

Ten EICC members submitted supplier lists to be included in the database-matching assessment. From these lists, in combination with supplier names provided for the EICC's Carbon Reporting System initiative and suppliers that have participated in the EICC audit process, we were able to check 640 suppliers

in the IPE database using the supplier’s Chinese name. Additional supplier names (in English) were provided by EICC member companies, but we were not always able to identify the likely Chinese name, and thus were limited to checking the 640 suppliers with identifiable Chinese names.

Where EICC members also provided details of supplier location, we checked any database matches against that location. The results presented below distinguish “primary location,” where the location matched, from “secondary location,” where the company name matched but the location did not. Suppliers at secondary locations may or may not be linked to the supply chains of EICC members, but these findings were included because in some cases, the matching facility may be a close affiliate of the actual EICC supplier. In all instances, further investigation is required to confirm whether the facility identified in the database is in fact the supplier of an EICC member. Correct identification of suppliers can be complicated by slight variations in company or facility name and address, so while this exercise was conducted with the best information available to us at the time, there may be additional suppliers in the database that we were not able to identify.

Matches indicated below are only those related to negative information or explicit violations, and do not include database matches linked to neutral or positive information about a facility. Violations from previous years are not necessarily indicative of current performance, as corrective actions may have been taken.

RESULTS

Of the 640 suppliers checked against the IPE database, we found 33 matches (over 5 percent of the total) that indicated negative information about a supplier’s performance on wastewater.

Table 1: Suppliers and Secondary Locations with Violations

Province	Suppliers	% of Total Suppliers	Suppliers w/ Violations	Secondary Locations w/ Violations	Total Violations	% of Total Violations
Anhui	1	0%	0	2	2	6%
Beijing	2	0%	0	0	0	0%
Fujian	5	1%	0	0	0	0%
Guangdong	163	25%	4	6	10	30%
Guangxi	2	0%	0	0	0	0%
Hainan	2	0%	0	0	0	0%
Hebei	0	0%	0	1	1	3%
Henan	1	0%	0	0	0	0%
Hunan	2	0%	0	0	0	0%
Jiangsu	295	46%	10	3	13	39%
Jiangxi	1	0%	0	0	0	0%
Liaoning	3	0%	0	0	0	0%
Shaanxi	3	0%	0	0	0	0%
Shandong	4	1%	0	0	0	0%
Shanghai	75	12%	3	2	5	15%
Shanxi	1	0%	0	0	0	0%
Sichuan	2	0%	0	0	0	0%
Tianjin	15	2%	0	0	0	0%
Zhejiang	6	1%	1	1	2	6%
Unidentified	57	9%	0	0	0	0%
Total	640		18	15	33	

Results by location

The majority of these matches were located in the provinces of Jiangsu (39 percent) and Guangdong (30 percent) in southeastern China, which reflects the concentration of suppliers in those areas (68 percent total in the two provinces). Shanghai, also a significant electronics manufacturing hub, represents 11 percent of all suppliers and 15 percent of all matches.

The fact that most matches were found in these areas may also reflect that government agencies in these locations are more effective at monitoring and evaluating companies within their jurisdiction, and may be relatively more open and transparent regarding the publication of environmental information.

Results by product type

EICC members were also asked to include information about suppliers' primary products. The most common components produced by facilities that were found to have negative information in the IPE database were printed circuit boards (PCBs) (see Table 2). However, it is important to note that for more than half of the matches identified, the key product is unknown. Regardless, the high number of matches for PCB facilities supports common perceptions and expert opinion about the relative water pollution risk of PCB manufacturing.

Table 2: Number of Violations by Component

Component	Number of Violations
PCB	5
Hard drive	2
ANT receiver plate & PG9	1
BP, CG, Midplate	1
Electrical	1
Encoders	1
IO, NBK keyboard	1
Nut	1
Passives	1
Rubber	1
Systems/Thermals	1
Unidentified	17

Suppliers are linked to multiple companies

Approximately 30 percent of the 33 supplier matches were for supplier names submitted by more than one EICC member company (see Table 3), demonstrating that the risk of supplier pollution impacts is broadly shared. Since only 10 companies submitted supplier lists, it is possible that other EICC members also have business relationships with some of the suppliers identified in this assessment.

Many suppliers had multiple violations

More than 20 percent of the suppliers with violations in the IPE database had multiple matches (see Table 3). One facility even had four separate violations

captured in the database, all related to wastewater discharge. The presence of multiple violations indicates systemic problems with suppliers that are not just related to a one-time accidental discharge or temporary equipment failure.

Table 3: Violation Location, Year(s), and Number of Buyers

Location Match	City	Province	Year of Violation(s)	Number of Buyers*
Primary	Dongguan	Guangdong	2007	1
Primary	Guangzhou	Guangdong	2009	1
Primary	Guangzhou	Guangdong	2006	2 + AP
Primary	Zhongshan	Guangdong	2006	1
Primary	Kunshan	Jiangsu	2007, 2008	1
Primary	Kunshan	Jiangsu	2008	1
Primary	Kunshan	Jiangsu	2006, 2007	1 + AP
Primary	Suzhou	Jiangsu	2008, 2009	1
Primary	Suzhou	Jiangsu	2007	2
Primary	Suzhou	Jiangsu	2007	1
Primary	Suzhou	Jiangsu	2008	1
Primary	Suzhou	Jiangsu	2008	1
Primary	Wuxi	Jiangsu	2008	1
Primary	Wuxi	Jiangsu	2007	1
Primary	Shanghai	Shanghai	2009	1
Primary	Shanghai	Shanghai	2008, 2009	1
Primary	Shanghai	Shanghai	2008	1
Primary	Ningbo	Zhejiang	2006	1
Secondary	Hefei	Anhui	2007	1
Secondary	Hefei	Anhui	2005	2
Secondary	Dongguan	Guangdong	2008	AP
Secondary	Shenzhen	Guangdong	2008	1
Secondary	Shenzhen	Guangdong	2006, 2008	1
Secondary	Shenzhen	Guangdong	2008	1
Secondary	Shenzhen	Guangdong	2006, 2007, 2008, 2008	1
Secondary	Zhongshan	Guangdong	2006, 2008	1
Secondary	Langfang	Hebei	2010	3
Secondary	Nanjing	Jiangsu	2006	3 + AP
Secondary	Nanjing	Jiangsu	2009	3 + AP
Secondary	Wuxi	Jiangsu	2006	2
Secondary	Shanghai	Shanghai	2009	3 + AP
Secondary	Shanghai	Shanghai	2005	1
Secondary	Jiaying	Zhejiang	2008	2 + AP

*AP indicates that supplier names were included in lists from EICC's audit process.

Supply Chain Recommendations

Understanding risks to water resources at a local level for the electronics industry is challenging. However, companies can take action with their suppliers to mitigate risk by improving wastewater treatment processes, based on experience from best practices in supply chain management.

The following are practical steps that global electronics companies can take to understand and address key challenges in the supply chain related to water resource risks in China. These recommendations provide guidance for how companies can better invest their time and resources in improving supply chain performance.

KNOW YOUR SUPPLIERS

One important aspect of working with suppliers is to fully understand complex supply chain relationships, and to prioritize suppliers with higher potential for water risk, whether due to their processes, management, or location. Information collected should include details about which processes suppliers are using and how wastewater is being treated at the first-tier supplier level and beyond based on prioritized supplier types and characteristics. A full assessment of supply chain impacts on water quality would also trace the supply chain to early phases of the product life cycle such as mining and metallurgy, which also have the potential for negative environmental impacts.

Focus Your Efforts

A typical supply network may be too large and complex to effectively evaluate in its entirety. The scope can be narrowed by applying certain basic criteria for risk characterization, such as:

1. Suppliers that are the most “strategic” in terms of spending and importance to business. Importance to business may be higher for suppliers that produce components or products that generate the greatest revenues or profits for the company, and/or are used extensively for less tangible but equally important purposes, such as for branding;
2. Suppliers that have already been identified by the public, media, or NGO community as responsible for previous environmental offenses;
3. Suppliers known to have poor quality management or reporting systems; or
4. Suppliers that are financially unstable, maintain poor external relationships, or have a history of labor or environmental issues, ownership changes, and workforce disruptions.

Look at Process, not Product

As part of supplier prioritization, companies should work to identify which suppliers are using the most water-intensive and potentially polluting manufacturing processes in a product’s life cycle. Rather than identifying each supplier primarily based on the product it manufactures, electronics companies should understand their supply chains in terms of where specific manufacturing processes are located.

Electronics companies will ultimately have to work with technical experts on chemical and industrial processes to understand the relative risk of different

operations. Across the industry, however, some components are highlighted more often than others as relatively intensive in terms of water, energy, and chemical usage during production. These include printed circuit boards (PCBs), semiconductors, LCD screens, and batteries and power supply units.

Particular manufacturing processes may present pollution risks due to large volumes of water required, specific chemicals and treatment methods, and the need for multiple repetitions of phases such as etching and cleaning. For example, PCB manufacturing involves a number of complicated and intensive processes, including cleaning and surface preparation of the base, electroless copper plating, pattern printing and masking, electroplating, and etching.⁸

Similarly, manufacturing of semiconductors typically requires 200 to 300 steps with three basic elements: layering, doping, and patterning. Large amounts of water are needed, primarily for rinsing after the etching and cleaning stages. The rinsing process results in large volumes of wastewater, which may contain a wide range of chemicals.⁹

Consider the Geographic Context

An additional consideration is whether any suppliers are located in a particularly sensitive environmental context. Key factors related to water impacts include local water scarcity and infrastructure and enforcement limitations.

As detailed above, some regions of China experience chronic water shortages, with decreasing availability of both surface and groundwater. Not only does this mean that suppliers may experience more regulatory pressure in terms of water use and efficiency, but wastewater discharge quality is also of greater concern because lower water volumes mean that pollutants are more concentrated.

Another type of sensitive geographic context can be found in China's interior provinces or smaller cities, where local capacity to enforce wastewater standards is not as developed. With rising labor costs in the traditional manufacturing hubs in China's southern and eastern regions, many manufacturers are moving to smaller cities or townships, or to inland provinces with lower operating expenses. Water demand is expanding rapidly in such locations, which are often experiencing expansion of both industrial and residential water needs.¹⁰ However, investment in appropriate wastewater treatment infrastructure is still relatively limited in these areas compared to larger cities and coastal provinces, along with the level of local enforcement and government transparency.

ESTABLISH PERFORMANCE EXPECTATIONS FOR SUPPLIERS

Direct engagement with suppliers to communicate expectations is a critical piece of risk mitigation. Once a company has identified its high-risk suppliers, the company should work with its suppliers to identify specific challenges, develop customized approaches to improve water efficiency and wastewater treatment methodologies, set expectations for disclosure and reporting, and provide incentives for implementing best practices. Regular engagement and evaluation will help a company and its supplier to set appropriate expectations, track progress, and adjust activities when necessary.

Tangible results of supplier engagement may include recommendations or joint exploration of technical improvements, such as using the best available technologies and state-of-the-art treatment systems to reduce pollution and contaminant levels in effluent streams.

CONSIDER ALTERNATIVE SUPPLIERS

Integrating evaluation of supplier performance on water use and wastewater treatment into the overall supplier assessment process would enable companies to incorporate water-related risks into business decisions. Electronics companies may need to consider alternative suppliers and supply chain partners who will support a company's sustainability goals. This approach obviously does not eliminate the root problem of wastewater mistreatment, but can signal to new and existing suppliers that continued mismanagement of wastewater will result in loss of business opportunities.

WORK WITH PEERS TO BOOST INDUSTRY-WIDE PRACTICE

Industry-wide collaboration can be an effective means of combining company resources to maximize societal impact. One example of a collaborative approach to environmental challenges is the EICC's Carbon Reporting System initiative. Since early 2008, the EICC has used the Carbon Reporting System to standardize reporting of organizational greenhouse gas (GHG) emissions between suppliers and enterprise customers.

Water assessment can work in similar ways as GHG emissions assessment, and in fact, the Carbon Reporting System already asks a few basic water-use questions in the current version of its supplier questionnaire. Leading electronics companies can work through the EICC framework to gather basic information from suppliers and communicate the importance of water resource protection.

Another example of a joint initiative is the Global Social Compliance Program (GSCP). The GSCP provides a framework of environmental reference requirements that can be used by global electronics companies as a model for continuous improvement in environmental performance of suppliers, moving suppliers from basic compliance (Level 1) to proactive management (Level 2) to leading-edge performance (Level 3). The GSCP also provides an implementation guide to help companies meet these requirements step-by-step and gradually move from Level 1 to Level 3.

Companies may be able to work within existing initiatives like the ones offered by the EICC and GSCP to address water pollution issues in China, or adapt other tools for this purpose. The investment that companies have already made in EICC participation demonstrates a commitment to collaborative supply chain engagement. Using this type of framework to address water pollution in China and other manufacturing hubs would be a straightforward and valuable expansion of current efforts.

Conclusion

China's water challenges are long-term and complex, and the electronics industry is just one small piece of the country's overall water management. However, the global visibility of the industry, and of EICC members, provides an opportunity for addressing water-related business risks in a way that can provide broader environmental benefits.

BSR's supply chain assessment of EICC member supplier lists found that over 5 percent of suppliers were linked to negative environmental performance citations in the IPE database. More than 20 percent of these suppliers had not just one but multiple negative matches in the database, indicating that wastewater mismanagement is a systemic problem rather than just a one-time incident.

The finding that 30 percent of negative matches were suppliers that have relationships with multiple EICC members demonstrates the widely shared risk that is created by overlapping supply networks, as well as the shared benefits that can be generated by improved supplier performance.

Companies with more extensive understanding of their supply chains, including prioritization of high-risk suppliers, that communicate performance expectations clearly to their supply chains and integrate assessment of water management into business decisions, can make significant progress towards mitigating water pollution risks, both for their own business and for the local environment.

Appendix

HELPFUL REPORTS, GUIDES, AND TECHNICAL RESOURCES:

General Information on China and Water:

- 1) Aquastat, Food and Agricultural Organization of the United Nations, <http://www.fao.org/nr/water/aquastat/countries/china/index.stm>
- 2) The Asia Water Project, <http://www.asiawaterproject.org/>
- 3) Institute of Environmental and Public Affairs, <http://www.ipe.org.cn/>
- 4) World Bank 2009 Report, “Addressing China’s Water Scarcity,” http://www-wds.worldbank.org/external/default/WDSPContentServer/WDSP/IB/2009/01/14/0003333037_20090114011126/Rendered/PDF/471110PUB0CHA0101OFFICIAL0USE0ONLY1.pdf

Guides for Electronics Manufacturing:

- 5) Environmental Guidelines for Electronics Manufacturing, Multilateral Investment Guarantees Agency, <http://www.miga.org/documents/ElectronicsManufacturing.pdf>
- 6) Environmental, Health, and Safety Guidelines for Semiconductors & Other Electronics Manufacturing, [http://www.ifc.org/ifcext/enviro.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_Semiconductors/\\$FILE/Final+-+Semiconductors+and+Other+Electronic+Mnfg.pdf](http://www.ifc.org/ifcext/enviro.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_Semiconductors/$FILE/Final+-+Semiconductors+and+Other+Electronic+Mnfg.pdf)
- 7) U.S. Environmental Protection Agency, Design for Environment, <http://www.epa.gov/dfef/>

Technical Reports:

- 8) Alternative Technologies for Surface Finishing: Cleaner Technologies for Printed Wiring Board Manufacturers, http://www.epa.gov/opptintr/dfef/pubs/pwb/tech_rep/Surface_Finishing.pdf
- 9) Desktop Computer Displays: A Life Cycle Assessment, <http://www.epa.gov/dfef/pubs/comp-dic/lca/index.htm>
- 10) Implementing Cleaner Printed Wiring Board Technologies: Surface Finishes, http://www.epa.gov/dfef/pubs/pwb/pdf/sf_guide.pdf
- 11) Printed Wiring Board Pollution Prevention and Control Technology: Analysis of Updated Survey Results, <http://www.epa.gov/dfef/pubs/pwb/pdf/p2tech.pdf>
- 12) Solders in Electronics: A Life-Cycle Assessment, <http://www.epa.gov/dfef/pubs/solder/lca/lca-summ2.pdf>

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