The Institute of Public & Environmental Affairs Unilever China

Understanding the Water Footprint of a Business

Case Study of a Corporate Water Footprint

Cheng Shuijie Ruan Qingyuan Ma Jun

2012-7-4

Translated by: Matthew Collins and Karl McAlinden

This research looked at one of Unilever's factories in China and aimed to calculate the operational water footprint of the business. It explored a number of issues that exist when calculating the grey water footprint of a business under China's environmental and pollution control conditions.

Acknowledgements:

This study was carried out based on the Global Water Footprint Standard as developed by the Water Footprint Network, headquartered in the Netherlands.[1]

The EHS departments of Unilever China and its factory provided a large amount of monitoring data which allowed this research to be completed.

Many thanks to:

Professor Liu Junguo from the College of Nature Conservation, Beijing Forestry University, for his careful guidance on the methodology.

Dr. Zhang Guoping from the Water Footprint Network for his constructive comments on the methodology.

Those organizations and experts who gave their support during the research process.

[1] For the water footprint standards and assessment manual please see the Water Footprint Network website, http://www.waterfottprint.org/
Cover photo of global grey water footprint from the Water Footprint Network, http://www.waterfootprint.org/downloads/WF_grey_large.jpg

Contents

Summary 4
1. Introduction 6
2. Study Sample 9
3. Calculation Method and Results 10
3.1. Introduction to the components of the water footprint 10
3.1.1. Production Operational Water Footprint ($WF_{oper, inputs}$) 10
3.1.2. Operational Overhead Water Footprint ($WF_{oper, overhead}$) 11
3.2. Calculation Process 11
3.2.1. Green Water Footprint 12
3.2.2. Method of Calculating Blue Water Footprint 12
3.2.3. Method of Calculating Grey Water Footprint 13
3.2.4. Difficulties in Calculating the Grey Water Footprint of a Business 16
➢ Selecting Source Data for Calculating Grey Water Footprint in the Study 18
4. Results and Explanations 24
4.1. Results 24
4.2 Explanation of Results 24
4.2.1. The grey water footprint will probably occupy a large proportion of the business's operational water footprint 25
4.2.2. Improving Pollution Control Measures can substantially Reduce Grey Water Footprint..26
4.2.3. Overhead Water Footprint cannot be overlooked 28
4.2.4. Considerations on how to reduce water footprints from the point of view of a green supply chain 29
5. Findings and Recommendations for the business 31
5.2. Findings & Conclusions for the Water Footprint Calculation Method 32

Summary

Even though fresh water is a renewable resource, it is a limited natural resource. Since industrialization, and following social economic development and continuous global population growth, unprecedented pressure has been placed on already limited water resources. In order to characterize humanity’s direct and indirect use and consumption of water resources, in 2002, Arjen Y. Hoekstra from the University of Twente in the Netherlands, proposed the “water footprint” concept. In 2009, Hoekstra went on to develop “The Water Footprint Assessment Manual” to calculate and assess water footprints and establish a standard. According to this theory, a water footprint includes green water, blue water and grey water footprints.

The green water and blue water footprints are relatively easy to understand. Over the past eight years, these calculation methods have become relatively mature and have started to be used by large corporations in the global food and beverage industry, such as Coca-Cola and the world’s largest brewer SABMiller. However, grey water footprint calculation is not so straightforward. While agricultural grey water footprint methodology has been initially established, and has already been put into trial use (Coca-Cola & WWF), grey water footprint methodology for businesses needs improvement, and has seen less practical application.

Following high speed development and the progression of industrialization and urbanization in countries with large populations such as China and India, the problem of water pollution has become increasingly prominent. This not only threatens the public’s health and endangers social stability, but also further damages fresh water resources. Pollution discharge from industrial businesses is an important source of water pollution. It is for this reason that corporate grey water footprint calculations have a particular significance for developing countries that are going through the process of industrialization.

In view of this, the Institute of Public & Environmental Affairs (IPE) collaborated with Unilever China to carry out joint research on the grey water footprint of industrial businesses. For this research, one of Unilever’s plants in China was used as a sample. Corporate water footprint is defined as the following:

“The water footprint of a business – which can also be called alternatively corporate or organizational water footprint – is defined as the total volume of freshwater that is used directly and indirectly to run and support a business. The water footprint of a business consists of two components: the direct water use by the producer (for producing/manufacturing or for supporting activities) and the indirect water use (the water use in the producer’s supply chain). The ‘water footprint of a business’ is the same as the total ‘water footprint of the business output products.’”[2]

This research shows that when calculating water footprints, especially grey water footprints of industrial businesses, there are still some issues that need further deliberation. However, overall it is feasible.

From this research we can see that industrial businesses may create huge water footprints, which also means that if they can improve pollution control and practice water conservation then their potential to cut back water use is very large. For these reasons, we feel that the calculation of corporate

[2] Water Footprint Assessment Manual 2011 p. 194

grey water footprint will be valuable because it not only allows businesses in China, but also in other areas, to better understand the impact they are creating on water resources and can also extend mitigation measures to reduce this impact.

1. Introduction

Water is a prerequisite for the existence and development of human life and all ecosystems (Costanza and Daly, 2002). Today, 70% of water resources are used for agricultural irrigation (Gleick, 1993; Bruinsma, 2003; Shiklomanov and Rodda, 2003; UNESCO, 2006). Municipal Governments and urban residents are also important water users. It is not only humans that can't do without water; natural ecosystems also need water to continue to function normally. Water is also an essential factor in industrial development.

Large scale industrialization processes that are occurring in developing countries, including China, mean that industrial water use will be in competition with agricultural water use, the water used by municipal governments and urban residents, as well as water used by natural ecological systems. From looking at the current situation, industrial water use is in a dominant position in its competition with agricultural and ecological water use. Under the principle of marketization of the distribution of natural resources, industrial businesses are able to gain even more resources through paying higher prices for water.

The global population reached seven billion in 2011. Therefore, in order to safeguard global food security and ensure there is enough water for agricultural use, these issues need to be elevated to a level of global security. Industrialization and urbanization are both occurring on a large scale in developing countries, meaning that the amount of water used by urban residents is also increasing. Over the past few decades, groundwater and rivers have been overexploited to a level that is unsustainable. In order to avoid serious ecological degradation of these areas we must consider how to rebalance the deficit in water resources.

Water is also a crucial factor in the processes of industrial development. Faced with increasingly strained global water supply, some scholars believe that industry will face risks to water resources in the following four ways:

- **Physical risk**: companies may increasingly face freshwater shortage in their supply chain or own operations.
- **Reputational risk**: the corporate image of a company will be damaged when questions arise among the public about whether the company properly addresses issues of sustainable and equitable water use.
- **Regulatory risk**: governmental interference and regulation in the area of water use will undoubtedly increase.
- **Financial risk**: above risks may translate into increased costs and/or reduced revenues. (Rondinelli and Berry, 2000; WWF, 2007).[3]

Responsible companies need to formulate a water resources strategy so as to avoid those risks and achieve longevity and development. The first step in dealing with a risk is to identify what that risk is. A fundamental part in calculating that risk is to clearly determine the amount of water consumed and polluted by a business through direct or indirect operations.

In order to characterise the degree of water resources consumed by humans either directly or

[3] Rondinelli and Berry, 2000; WWF, 2007

indirectly, Professor Hoekstra from the University of Twente in Holland proposed the concept of a water footprint:

> "The water footprint is an indicator of freshwater use that looks at both direct and indirect water use of a consumer or producer. The water footprint of an individual, community or business is defined as the total volume of freshwater used to produce the goods and services consumed by the individual or community or produced by the business. Water use is measured in terms of water volumes consumed (evaporated or incorporated into a product) and/or polluted per unit of time. A water footprint can be calculated for a particular product, for any well-defined group of consumers (for example, an individual, family, village, city, province, state or nation) or producers (for example, a public organization, private enterprise or economic sector). The water footprint is a geographically explicit indicator, showing not only volumes of water use and pollution, but also the locations."[4]

The water footprint devised by Professor Hoekstra and others includes green water, blue water and grey water footprints.

- "Green water footprint - Volume of rainwater consumed during the production process."[5]
- "Blue water footprint - Volume of surface and groundwater consumed as a result of the production of a good or service."[6]
- "The grey water footprint refers to pollution and is defined as the volume of freshwater that is required to assimilate the load of pollutants given natural background concentrations and existing ambient water quality standards."[7]

Green water footprint and blue water footprints are relatively easy to understand. The calculating methodology has been refined over the past few years and many large scale international businesses have started using them. However, calculating grey water footprint is not so straightforward. The methodology for calculating agricultural grey water footprint has been initially formed and has even been used to some extent (Coca-Cola and WWF). However, the methodology for calculating the grey water footprint of industrial businesses has still not been perfected and is seldom used.

The reason for the lack of research and absence of use of the grey water footprint is that many developed countries and regions have gone through several decades of pollution control. This means that the water pollution situation is fairly stable and the total discharge from industry has been reduced. The total amount of pollutants discharged is also within the authorized standards for discharge concentrations and total amount of pollutants. At the same time, rivers, lakes and wetlands all have relatively large environmental capacity and so can effectively dilute and purify industrial discharge. Therefore, when companies calculate water footprints, more attention is paid to the blue and green water footprints that show total amount of water consumed, whereas water pollution in the form of the grey water footprint is rarely considered.

[4] Water Footprint Assessment Manual 2011, p. 194.
[5] Water Footprint Assessment Manual 2011, p. 189.
[6] Water Footprint Assessment Manual 2011, p. 187.
[7] Water Footprint Assessment Manual 2011, p. 2.

As countries with large populations, such as China and India, have entered into a period of industrialization and urbanization, water pollution problems have become increasingly prominent. “In 2007, a spokesperson from the Ministry of Environmental Protection gave a presentation to the National People’s Congress detailing the water situation currently facing China.[8]

- Rivers flowing through cities all suffer from pollution and some areas are already suffering from the phenomenon of ‘dry rivers and filthy water’.”
- “Shallow groundwater in large to medium cities nationwide is contaminated to varying degrees with approximately half of the groundwater pollution in municipal areas considered serious.”
- “Nationwide, some 300 million rural citizens have unsafe drinking water.”
- “The total discharge volume of main water pollutants is clearly in excess of environmental capacity and the number of complaints from the general public about water pollution is increasing.”

In reality, the total amount of water pollutants discharged is even greater. Taking COD, an important index for evaluating water pollution, as an example, the 2007 “Report on the State of the Environment in China,” stated that the total discharge amount was 13,818,000 tons. According to the 2010 national pollution source survey, which was the first to ever be disclosed, the total national COD discharge was 30,289,600 tons, which was more than double the previous statistic.

Natural ecosystems are capable of regulating and absorbing a certain amount of pollutants, known as environmental capacity. According to research carried out by the Chinese Academy for Environmental Planning, the environmental capacity for surface water COD nationwide is 7,400,000 tons.[9] According to previously published COD discharge amounts, if the 2007 water pollutant discharge amounts were halved then they would be under the environmental capacity. The “Survey Report” shows that the real COD discharge for 2007 was actually more than four times the environmental capacity. China’s “12th Five Year Plan” stated that COD needed to be reduced by 10% over the five years. However, to offer true payback to China’s rivers, these efforts really need to be doubled.

Under these circumstances, industrial businesses producing in China need to recognize that overall, China’s pollution discharge is already over the environmental capacity for water. Therefore, wastewater discharge from industrial businesses will have a detrimental effect on bodies of water. If this cannot be effectively controlled, then it could threaten the health of the general population, further aggravate water resource shortages and even threaten social stability.

Clearly, industrial water pollution discharge can bring even greater risks to companies that produce in and procure from developing countries such as China. Through calculating an industrial business’s grey water footprint, it is possible to gain a quantitative understanding of the risks created by water pollutant discharge. Correctly identifying hazards is an important precondition for controlling those hazards.

Based on this understanding, the Institute of Public & Environmental Affairs worked together with Unilever China by using a typical daily care products business as a blueprint to jointly research the corporate grey water footprint of the business. It was hoped that by using the water footprint methodology in a real situation, it would help to perfect the way of calculating corporate water footprints.

---

[8] Outlook 2007: “Water Pollution Prevention Still Amongst the Most Important,” Xinhua, 07-01-2007
[9] State Environmental Protection Administration (SEPA): China’s Resources and Environment Already Close to their Limit, Science & Technology Daily, November 17th, 2004.

2.Study Sample

For this research, one of Unilever's plants in China was used as a sample. There are two parts that make up the corporate water footprint: the operational (direct) water footprint and the supply chain (indirect) water footprint. On this occasion, we focused on calculating the operational water footprint.

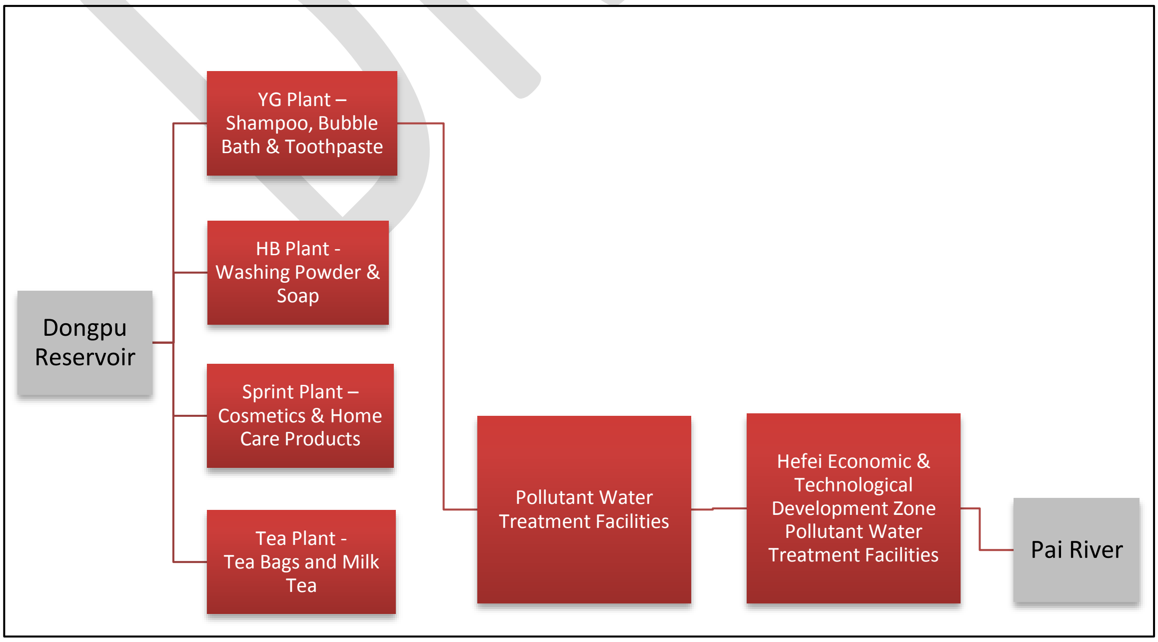
This business mainly produces daily care products. Daily care products have become a necessity for people's daily life which means that production and consumption volumes are substantial and substantial production and consumption uses up large amounts of water resources. Therefore, understanding the water resource use of daily care product businesses is extremely important.

This daily care products business is split into four independent plants according to different product lines: 1) YG Plant – produces shampoo and toothpaste. 2) HB Plant - produces washing powder and soap. 3) Sprint Plant – produces daily care and home care products. 4) Tea Plant - produces tea bags and milk tea.

All branches have independent drainage systems whereby domestic water and production water is separately discharged. There is no distribution of wastewater between the four branches. Wastewater that has been discharged from the four branches comes together afterwards and is then discharged into the combined factory wastewater treatment plant. After being treated, it is then discharged into the development zone's wastewater plant, and finally, after being treated again, it is discharged into a river in the local area.

The boundaries of the calculation were denoted as the starting point, which was the water intake from the Dongpu Reservoir, and the end point, which was where the municipal wastewater treatment plant discharged into a local river.

Figure 1. Composition of Factories within the Business



3. Calculation Method and Results

3.1. Introduction to the components of the water footprint

Corporate water footprint is made up of two parts: the operational (direct) water footprint and the supply chain (indirect) water footprint (see figure 2). On this occasion, we only calculated the operational water footprint of the business. The operational water footprint of a business consists of the operational water footprint directly associated with the production of the product and the overhead operational water footprint. The former refers to the water footprint directly related to the production of the product. For instance, water incorporated into the product and water consumed or polluted through a washing process.[10] The latter refers to the water footprint required for the business to carry out normal production. For instance, domestic water used for drinking, washing clothes, showering, flushing toilets, watering plants and for maintaining and cleaning the factory area.

Figure 2. Composition of the water footprint of a business[11]

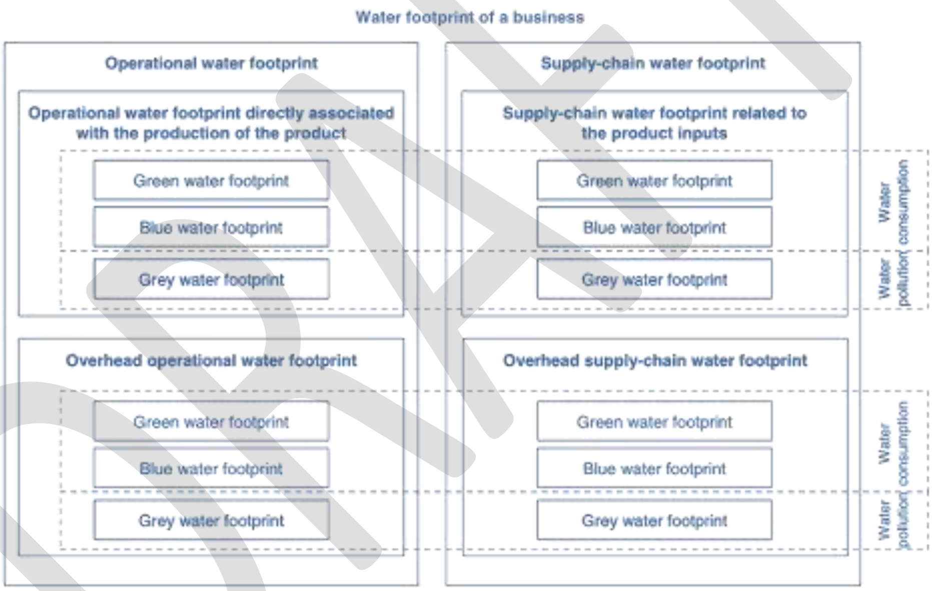


Fig. 1 Composition of the water footprint of a business

3.1.1. Production Operational Water Footprint ($WF_{oper, inputs}$)

The sources of production operational water footprint ($WF_{oper, input}$) include:

- Water incorporated into a product.
- Water consumed during the production process (for instance, water that is not returned back to the water intake source).
- Water polluted during the production process.

The first two points form the operational blue water footprint and the third makes up the

[10] Water footprint Assessment Manual 2011, p. 64.
[11] Water footprint Assessment Manual 2011, p. 64.

operational grey water footprint. The business in this study didn't have any kind of facilities for rainwater collection to be used within the factory area, and the factory did not consume any green water (rain water) during production. Therefore, we assumed it did not have a green water footprint, and so for the calculations, the green water footprint was thought to be zero. The business's production processes include: paste manufacturing, compression, mixing, labeling and packaging. The transportation of water for the aforementioned production processes occurs in sealed pipes so therefore we can assume that there is no water loss.

The wastewater from the production processes at each branch factory is integrated and discharged to the final factory area wastewater treatment plant. After it is treated there it is discharged to the municipal wastewater treatment plant. The discharge from the municipal sewage treatment plant can reach the authorized standards. However, because the pollutant discharge uses up the purification capacity of the Pai River, a grey water footprint is still produced. Therefore, the operational production water footprint of the business studied in this report is a combination of the production process blue water footprint and the grey water footprint.

3.1.2. Operational Overhead Water Footprint ($WF_{oper, overhead}$)

The water consumption or water pollution produced by the following activities all contribute to the operational overhead water footprint ($WF_{oper, overhead}$).

- Water consumed by employees (for drinking etc.);
- Water consumed or polluted by kitchens and toilets;
- Water consumed or polluted by workers washing clothes;
- Water consumed or polluted by cleaning in the factory;
- Water consumed for maintaining greenery.

It was assumed that the amount of drinking water used by all the staff in the factory and for maintaining greenery was very small compared with the total amount of water consumed or polluted by the business, so this part of the water footprint has not been calculated. The wastewater from all the branch factories of the business is managed by the combined treatment plant. Therefore, the part of the grey water footprint for the domestic wastewater of each branch factory should be calculated according to the number of workers in each branch.

3.2. Calculation Process

The summary and methodology for calculating the water footprint can be found in the water footprint assessment manual, 2011 edition. However, we were unable to find a clear method of calculating the water footprint of discharge from the water treatment plant in the assessment manual so we used our own method for the calculations.

Green water footprint refers to the amount of green water resources (rain water) that is consumed during the production of a product and service processes whilst a business is operational. The blue water footprint refers to the blue water resources (surface water and ground water) consumed during the production of a product and service processes. Grey water footprint refers to the amount of water resources polluted during the production of a product and service processes of a business.

For this report we have only calculated the operational water footprint of a business and have not touched on the water footprint of the supply chain.

The sequece to calculate the business's operational water footprint was as follows:

- Investigate the environmental conditions at the factory's water intake point and discharge point as well as the classification for water use at these points.
- Confirm how the business's different production lines are split up. Obtain the status of water use and water discharged for each branch factory and the business as a whole.
- Obtain discharge water quality for the business from 2007-2010. Assuming this part of the wastewater did not get discharged into the municipal wastewater treatmnent plant and was discharged into a natural water body, then this calculation would give the grey water footprint, which was simply be called WFgrey1.
- Obtain information for 2007-2010 on the quality of wastewater from the studied business after it has passed through the municipal wastewater treatment plant for treatment. This can then be calculated as the grey water footprint of the wastewater that is discharged into the Pai River and can simply be called WFgrey2.
- Combine these two procedures to calculate the operational grey water footprint of the business.

3.2.1. Green Water Footprint

Green water footprint refers to the amount of rainwater consumed by a business in the production of products and during service processes. The studied business basically did not use any rainwater resources therefore the green water footprint was considered to be zero.

3.2.2. Method of Calculating Blue Water Footprint

Blue water footprint (WF_{blue}) refers to the amount of ground water and surface water consumed during the business's production process.

WFblue = evaporated water + water incorporated into a product + water abstracted from surface or groundwater in a catchment and returned to another catchment or the sea

The ground water and surface water used in the production process of the business enters the business through municipal pipes in the form of mains water. It's thought that there is no evaporation and no leaking of water. Furthermore, because there is mains water that goes through the factory and is returned to where it originally came from, the figure for the annual blue water footprint is equal to the difference in amount of fresh water used by the business and the amount of wastewater discharged. For each of the branch factory units the blue water footprint is calculated by subtracting the amount of water discharged from the amount of mains water resources used. For the calculations in this study, the true blue water footprint is as follows:

WFblue = the volume of fresh water used by the business – the volume of sewage discharged by the business.

3.2.3. Method of Calculating Grey Water Footprint[12]

Calculation Formula and Relevant Preferences

The sewage from the studied business is discharged in the form of a combined discharge. Pollutant load can be calculated from the amount of sewage discharged and the pollutant concentrations. The corporate grey water footprint calculation method is in accordance with the calculation requirements for grey water from point source pollution. Therefore, the point source calculation method from the Water Footprint Assessment Manual (2011) was used[13] and the grey water footprint was calculated for 2007 – 2010. The annual grey water footprint was chosen as the grey water footprint corresponding to each of the pollutants with the highest grey water footprint values.

$$WF_{proc,grey} = \frac{L}{c_{max} - c_{nat}} = \frac{Effl \times c_{effl} - Abstr \times c_{act}}{c_{max} - c_{nat}} \quad [\text{volume/time}]$$

Effl: Volume of effluent (wastewater flow)
Ceffl: Concentration of a chemical in an effluent
Abstr: Volume of water abstraction
Cact: Actual concentration of a chemical in a water body from which water is abstracted
Cmax: Maximum acceptable concentration of a chemical in a receiving water body
Cnat: Natural concentration of a chemical in the receiving water body

The studied business gets its fresh water from the Dongpu reservoir which is then treated at the mains water treatment plant. Because there is no data on water losses during transportation and during treatment processes at the mains water treatment plant, this study does not include these in the calculations. The amount of water abstracted is equal to the amount of mains water used.

The report on the state of Anhui's ground water quality shows that the water quality where water is abstracted from the Dongpu Reservoir is good and is maintained at a level II standard. As it is not possible to obtain specific information for water quality concentrations for the Dongpu Reservoir each pollutant evaluation for Cact was considered as surface water quality level II.

[12] This research separately calculated the enterprise's theoretical operational water footprint, that is the water footprint produced by wastewater from the enterprise if it had just gone through their own wastewater treatment plant for treatment and then been discharged to the surrounding environment. The actual operational water footprint was also calculated, that is the water footprint produced by the wastewater after it had gone through the municipal water treatment plant and then been discharged into the surrounding environment.

[13] Water Footprint Assessment Manual, 2011, p. 147.

After initial treatment, the wastewater from the business enters into the development zone's sewerage system. It is then discharged into the Hefei Economic and Technological Zone Wastewater Treatment Plant. Water from the Hefei Economic and Technological Zone is discharged into the middle reaches of the Pai River and finally runs into Chaohu Lake. Dongpu Reservoir and the Pai River both belong to the Chaohu Lake drainage area. Because Dongpu Reservoir is the source of Hefei's drinking water, the water quality standard is set at Level II of the "Surface Water Environmental Quality Standard," GB3838-2002. For details of the corresponding standards please refer to table 3. Cmax values are considered to be the optimal water quality in the water intake boundary, which is Level II water.

Furthermore, it was not possible to obtain the original concentrations of pollutants in the Pai River before it was affected by human activity. Therefore, for this study the Cnat value was assumed to be zero.[14]

Figure 3: Surface Water Environmental Standard Values for Different Pollutants mg/l

Pollutant	BOD_5	COD	NH3-N	LAS	TP	Oil
II	3	15	0.5	0.2	0.025	0.05
IV	6	30	1.5	0.3	0.1	0.5

- Background on the Drainage Basin:

The abstraction point and drainage points of the studied business were both situated in the Chaohu Lake drainage basin. According to the 2009 Report on the State of the Environment in China, for 2009, the eastern half of Chaohu Lake had Level IV water quality, the western half was Level V and the lake as a whole had an average of Level V. The main pollutant indexes and water quality status can be seen below:

Figure 4. Summary of different Pollutant Values in Different Parts of Chaohu Lake

Lake Section	Permanganate Index (mg/L)	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)	Chlorophyll a (mg/L)	Trophic State Index (TSI)	Water Quality Category
Western Half	5.4	0.129	2.19	0.034	62.6	劣 V
Eastern Half	4.6	0.075	1.19	0.011	54.3	IV
Entire Lake Average	5.0	0.102	1.69	0.023	59.2	V

[14] This kind of assumption decreases the water footprint value.

Figure 5. 2000-2009 Annual Changes in Total Phosphorus and Total Nitrogen in Chaohu Lake

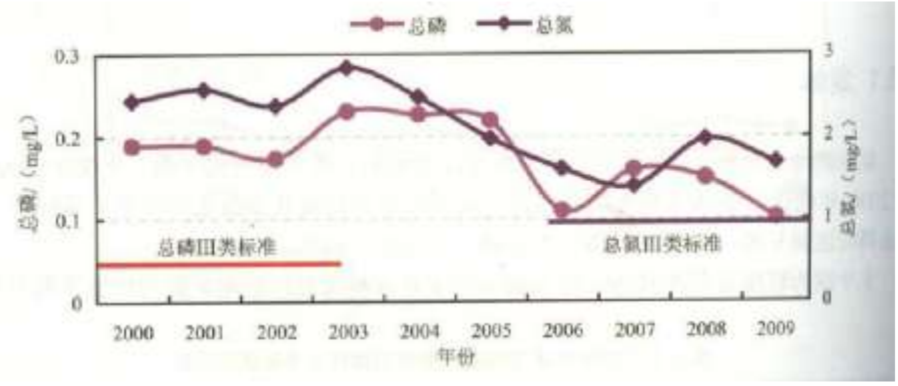
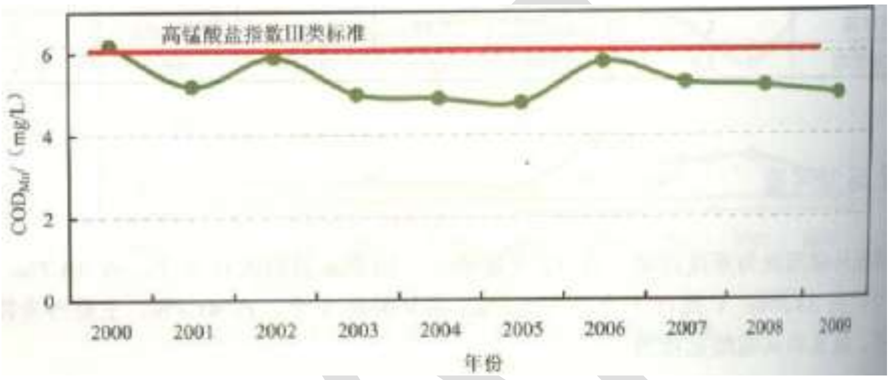


Figure 6. 2000 – 2009 Changes in Annual Manganese Sulfate Concentrations in Chaohu Lake



During the course of this water footprint study the investigation team, on May 13th, 2011, took samples at a spot 300m upstream from where the Pai River flows into Chaohu Lake and also at the point where the Pai River flows into the lake. The results showed that at the two points where the samples were taken the water quality was worse than Level V. The results of the tests were as follows:

Figure 7. Sample Monitoring Data

Sample Point	COD(mg/L)	NH3-N(mg/L)	TP
Pai River - 300m up-steam from point of entering lake	104	6.75	1.47
Pai River - point of entering lake	35.5	5.6	1.03

Conclusion: The environmental capacity of the Chaohu Lake drainage area is already seriously limited.

3.2.4. Difficulties in Calculating the Grey Water Footprint of a Business

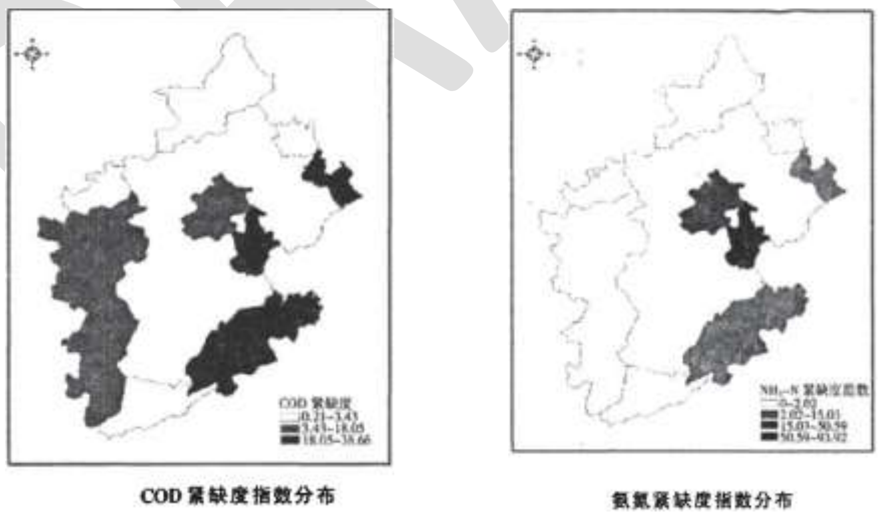
- How can Grey Water Footprint be calculated after a Business Discharges through the Sewerage System?

At present, the vast majority of industrial business's in China discharge wastewater into sewerage systems for treatment. Wastewater from businesses is channeled to municipal wastewater treatment plants, where, after being treated and reaching the authorized discharge standard, it is discharged (at a level lower than the pollutant concentration values of the local municipal wastewater discharge standards) into a surrounding water body. In theory, this will not consume the environmental capacity so this discharge does not produce any grey water footprint.

As already mentioned, the amount of water pollutants discharged in China far exceeds the environmental capacity. Some of the amounts of main pollutants that are discharged are multiple times higher than the environmental capacity.

Taking the Haihe River Basin as an example, according to the, "Analysis in Deficiencies in Water Environmental Capacity in all Regions of the Haihe River Basin," [15] the COD capacity of the surface water environmental capacity is already exhausted and is even overloaded in Tianjin, Shandong and Liaoning. The NH_3-N discharge amount in Tianjin is 9.4 times capacity and 4.7, 3.9 and 2.9 times respectively for Liaoning, Beijing and Hebei. As can be seen in figure 8, at present, China's environmental capacity is extremely deficient.

Figure 8. Diagram showing deficiency of COD and Ammonia Nitrogen Capacity[16]



At the same time, water treatment standards of China's water treatment plants are formulated based on the assumption that enough environmental capacity can carry out effective dilution and purification of pollutants. By comparing pollutant discharge concentrations and ground water standards they are still inferior to grade V classification. When environmental capacity is limited, or is even zero,

[15] Zhang Dongju, Liu Baiqiao, Tian Binghui, Analysis of Deficiency of Environmental Capacity in all areas of the Haihe Drainage Basin, Hebei Normal University Journal of Natural Sciences, 2011, 35 (1).
[16] When there is a definite lack of environmental capacity, this is known as the environmental capacity deficiency index.

then wastewater that reaches the standard but has not been thoroughly treated by the wastewater treatment plant can still have a serious effect on water environmental capacity.

What's more serious is that, at present, many town and city wastewater treatment plants cannot ensure that discharge consistently meets discharge standards. In the first quarter of 2011, 607 town and city wastewater treatment plants that had been in operation for over a year did not reach national requirements and average operational capacity did not reach 60%. A number of wastewater treatment plants' pollutant reduction efficiency is inadequate and many wastewater treatment plants have discharge in breach of the authorized standards and also halt operations without permission.[17]

China currently has a deficiency in environmental capacity. Pollutant processing capabilities of final wastewater treatment plants are also insufficient and breach authorized standards. Therefore, in river basins where there is not sufficient environmental capacity to dilute and purify wastewater discharged from wastewater treatment plants, this discharge still produces a water footprint. For these reasons it cannot be neglected when looking at the grey water footprint of a business discharging into the sewerage system and cannot be regarded as zero discharge.

- Selection of Pollution Indicators

    According to materials such as the environmental impact assessment report provided by the business, the main pollutants produced during the production process include COD, BOD_5, LAS, SS and total phosphorus. Monitoring data that was supplied by the business for 2007-2010 showed that for each successive monitoring that took place, COD, BOD_5, SS, pH, NH_3-N, LAS, total phosphorus and oils were all found to be within the authorized standards. The pollution indexes were chosen for the following reasons: groundwater environmental quality standards do not have any requirements for suspended solids; pH limit values for water quality category I through to category V are all 6-9; the main pollutant going into the Pai River water body from the wastewater was ammonia nitrogen; at the point where the Pai River flows into the Chaohu Lake the main pollution indicators, apart from ammonia nitrogen, were oils. So, for these reasons, COD, BOD5, NH3-N, LAS, total phosphorus and oils were chosen as the pollution indexes to calculate the grey water footprint for this study.

- Selecting Grey Water Footprint Values

    According to the Water Footprint Assessment Manual (2011 Edition), when there are a number of different pollutants contained in wastewater then the water footprint should be separately calculated for each pollutant produced and the one with the largest footprint should be used as the final water footprint. However, when calculating these values for real, the problem exists that businesses discharge into the sewerage system and then municipal wastewater treatment plants accept wastewater from many different sources. This makes a complex problem that wastewater, after being treated, has concentrations of some pollutants that are even higher than the concentrations in the sewage pipes corresponding to a particular business.

[17] The first quarter of 2011 report on the construction and operation of national town and cities' wastewater treatment facilities. Ministry of Housing and Urban-Rural Development of the People's Republic of China, 2011/05/09, http://smkl.net/zcfg/jswj/csjs/201107/t20110715_203781.htm

We felt that when the pollutant concentration corresponding to the water footprint of a business is less than that of the pollutant concentration of water that has been treated by and discharged by a wastewater treatment plant, then this should be regarded as the pollutants have not received further treatment by going through the municipal wastewater plant. Therefore, the discharge concentration from the wastewater treatment plant should not be used to calculate the pollutant grey water footprint value.

To sum up, we feel that for businesses that discharge to wastewater treatment plants, calculating corporate grey water footprint should be done according to the Water Footprint Manual assessment method as well as whether or not the pollutant load of wastewater discharged from a factory has been effectively reduced by going through a wastewater treatment plant.

- Selecting Source Data for Calculating Grey Water Footprint in the Study

Because the business discharges into a wastewater treatment plant, we calculated separately the grey water footprint that would be created by wastewater directly discharging into natural water bodies (WFgrey1), and also the grey water footprint value for wastewater that had gone through the municipal wastewater treatment plant and then was discharged into the Pai River (WFgrey2). All of the different pollutant concentrations that are used for each annual water footprint calculation are the average of the concentrations from the monitoring data for that year. Because there are limitations to the amount of monitoring data collected, the concentration value for each annual pollutant value comes from a different number of samplings. Therefore, the final water footprint value could differ from the actual data. In addition to this, according to the grey water footprint calculation formula,

, if the grey water footprint is zero this means that the pollutant load of a certain pollutant in sewage is less than the pollutant load for that pollutant at the extraction point and so does not add any extra pollution to the environment.

2007

In 2007, the business's own wastewater treatment facilities were capable of treating 400 tons/day and so were only capable of treating a portion of the production wastewater (in 2007 the amount of wastewater treated by their own treatment facilities was 95,045 tons). The remainder of industrial wastewater that could not be treated was sent for treatment externally to the Hefei Urban Wastewater Treatment Plant. According to their statistics, 31,845 tons of wastewater was sent for treatment externally. After going through pre-treatment in a septic tank, domestic wastewater is mixed with industrial wastewater that has been treated and is discharged through the discharge outlet for treatment at the Hefei Economic and Technological Development Zone wastewater treatment plant. In 2007, there was no concrete data for domestic wastewater discharge but it was estimated to be 90,000 tons/year. Total wastewater discharge was 216,886 tons/year.

- During the 2007 grey water footprint calculations, WFgrey1[18] was calculated according to a discharge outlet wastewater monitoring report for monitored pollutants including COD, ammonia

[18] WFgrey1 refers to the grey water footprint of the wastewater that would be created if the wastewater did not go through the municipal wastewater treatment plant for treatment and was discharged into a natural water body.

nitrogen, LAS, SS, TP and pH, as well as average on-line COD monitoring data for 2007. The 31,841 tons of wastewater sent externally and the 90,000 tons of domestic wastewater that did not get treated by the business's own wastewater treatment facilities had no specific monitoring values. For these reasons, assuming that this part of the wastewater all reaches the final discharge outlet then a combined discharge concentration calculation can be carried out. The 31,841 tons of high concentration wastewater was not treated and was sent externally for treatment. So, using the assumptions mentioned previously, their true 2007 WFgrey1 would be underestimated and the calculation results would be 1,202,580 tons, with the corresponding pollutant being total phosphorous.

Figure 9: WFgrey1 Calculation Results

Pollutant	Water Footprint (10^4tons)
Total Phosphorus	1202.580
NH3-N	639.544
LAS	211.411
COD	174.540
Oil	0
BOD_5	0

- During the process of calculating the grey water footprint it was not possible to obtain wastewater discharge concentrations for the municipal wastewater treatment plant and Hefei Economic and Technological Zone Wastewater Treatment Plant. In addition to this, Hefei Economic and Technological Development Zone Wastewater Treatment Plant was only operating in a trial capacity. For these reasons, the 2007 WFgrey2 calculation assumes that the wastewater concentrations discharged from the Urban Water Wastewater Plant and Hefei Economic and Technological Zone Wastewater Treatment Plant meet the "Urban Wastewater Treatment Plant Pollutant Discharge Standards" (GB18918-2002) Level 1 B standard corresponding to 80%[19] of pollutants. The results of the 2007 calculation showed that WFgrey2 was 9,943,690 tons for both total phosphorus and oils.

Figure 10: 2007 WFgrey2 Calculation Results

Pollutant	Water Footprint (10^4tons)
Total Phosphorus	**994.369**
Oil	994.369
NH3-N	473.843
BOD_5	68.989
LAS	40.071
COD	22.720

[19] According to the "Unilever Hefei Industrial Park Expansion Construction Project (toothpaste workshop relocation and SPRINT expansion project) EIA Report" submitted by the factory, Hefei Economic and Technological Development Zone wastewater treatment plant water discharge "Town and City Wastewater Treatment Plant Pollutant Discharge Standard" (GB18918-2002) was Level 1 A standard. However, in the 2010 monitoring data that they provided the corresponding standard was Level 1 B Standard. Therefore, during this water footprint calculation we chose the "Town and City Wastewater Treatment Plant Pollutant Discharge Standard" (GB18918-2002) Level 1 B Standard to be their wastewater discharge standard.

- Considering that in 2007, oils in the wastewater discharge from the studied factory created a grey water footprint of 0, this value was not used to produce the final grey water footprint. The main pollutant in the wastewater discharge from the studied factory in 2007 was total phosphorus. Although the amount was effectively reduced after being treated by the municipal wastewater treatment plant, it still constituted the main contributor to pollutants in WFgrey2. Therefore, total phosphorus was used for the WFgrey2 value for calculating the 2007 studied factory's 2007 operational water footprint value, which was 9,943,690 tons.

2008

From October 2007, the business stopped sending high concentration industrial wastewater to the Urban Wastewater Treatment Plant for treatment and started on the construction of the third phase of their wastewater treatment plant. They started using the facilities in May 2008. From this time on, the business sent all wastewater, including domestic wastewater, through their own wastewater treatment plant for treatment. After wastewater reached the authorized standards it was then sent to Hefei Economic and Technological Zone Wastewater Treatment Plant for treatment. There was no statistical data for domestic wastewater discharge for before May 2008, so the amount was estimated to be 30,000 tons. In 2008, the total amount of wastewater discharged was 255,379 tons.

- The 2008 WFgrey1 was calculated according to a total of 11 "Control Monitoring Unified Industrial Enterprise Wastewater Discharge Results" from January – December 2008, a commissioned monitoring report from February 2008 and COD online monitoring data for the whole of 2008, all of which were provided by the business. All this was summarized into average discharge concentrations for each pollutant and used for the calculations. The results of the calculations were as follows:

Figure 11: 2008 WFgrey1 Calculation Results

Pollutant	Water Footprint (10^4tons)
Oils	363.429
Total Phosphorus	**277.622**
LAS	239.582
COD	113.021
BOD_5	92.557
NH3-N	0

- The 2008 WFgrey2 was calculated according to a total of 12 "Control Monitoring Unified Industrial Enterprise Wastewater Discharge Results" from January – December 2008. The results of the calculations were as follows:

Figure 12: 2008 WFgrey2 Calculation Results

Pollutant	Water Footprint (10^4tons)
Total Phosphorus	699.111
Oils	102.942
COD	4.934
NH3-N	0
BOD_5	0
LAS	0

- After the main pollutant (oils) from the business had been through the municipal wastewater treatment plant it was effectively reduced. After this reduction the corresponding water footprint was 1,029,420 tons. The second most present pollutant, total phosphorus, after passing through the municipal wastewater treatment plant did not have a reduced grey water footprint and on the contrary it actually increased because of discharge from other factories. Furthermore, it was the highest WFgrey2 figure for the year. Therefore, it was decided that even though the total phosphorus discharged from the business was not reduced after passing through the municipal wastewater treatment plant, the amount the concentration went up by should not be considered the fault of the business. As a result, the 2008 total phosphorus WFgrey1 value was used as the value for the business's operational grey water footprint. The result of the calculation was 2,776,220 tons.

2009

- The 2009 WFgrey1 was calculated according to a total of nine "Control Monitoring Unified Industrial Enterprise Wastewater Discharge Results," from January – October 2009, a commissioned monitoring report from February 2009 and COD online monitoring data for the whole of 2009. All this was summarized into average discharge concentrations for each pollutant and used for the calculations. The results of the calculations were as follows:

Figure 13: 2009 WFgrey1 Calculation Results

Pollutant	Water Footprint (10^4tons)
Total Phosphorus	**212.443**
COD	70.262
LAS	0
NH3-N	0
Oils	0
BOD_5	0

- The 2009 WFgrey2 was calculated according to a total of 12 "Control Monitoring Unified Industrial Enterprise Wastewater Discharge Results" from January – December 2009, all of which were supplied by the business. The results of the calculations were as follows:

Figure 14: 2009 WFgrey2 Calculation Results

Pollutant	Water Footprint (10^4tons)
Total Phosphorus	377.801
Oils	193.660
BOD_5	75.191
NH3-N	24.564
COD	0
LAS	0

- The main pollutant for the grey water footprint of the studied factory and municipal wastewater treatment plant for 2009 was total phosphorus. With regards to the grey water footprint value, WFgrey2 was bigger than WFgrey1. The study group felt that total phosphorus, the main pollutant of the water footprint, was not effectively reduced after going through treatment at the wastewater treatment plant. However, the part of the grey water footprint from the municipal wastewater treatment plant should not be considered the responsibility of the studied factory. Therefore, the WFgrey1 corresponding to this year's operational water footprint value was calculated as 2,124,430 tons.

2010

- The 2010 WFgrey1 was calculated according to a "Control Monitoring Unified Industrial Enterprise Wastewater Discharge Result" from January 8th, 2010; two commissioned monitoring reports from 2010 and COD online monitoring data for the whole of 2010, all of which was supplied by the business. All this was summarized into average discharge concentrations for each pollutant and used for the calculations. The results of the calculations were as follows:

Figure 15: 2010 WFgrey1 Calculation Results

Pollutant	Water Footprint (10^4tons)
COD	58.811
LAS	26.208
Total Phosphorus	**1.533**
NH3-N	0
Oils	0
BOD_5	0

- The 2010 WFgrey2 was calculated according to a total of 5 "Control Monitoring Unified Industrial Enterprise Wastewater Discharge Results" from August – December 2010, all of which were supplied by the business. The results of the calculations were as follows:

Figure 16: 2010 WFgrey2 Calculation Results

Pollutant	Water Footprint (10^4tons)
Total Phosphorus	743.2047
Oils	198.4168
NH3-N	1.3978
BOD_5	1.1759
COD	0
LAS	0

- By comparing tables 15 and 16, for the three largest pollutants in the municipal wastewater treatment plant grey water footprint, COD, LAS and total phosphorus, COD and LAS were effectively reduced after being treated by the wastewater treatment plant. However, after going through the wastewater treatment plant, the grey water footprint for total phosphorus had actually increased rather than decreased. The studied factory should not be held responsible for the part of the municipal wastewater plant's grey water footprint value. Therefore, the operational water footprint value WFgrey1 corresponding to total phosphorus for 2010 was calculated as 15,330 tons.[20]

[20] According to 2009 and 2010 operational grey water footprint calculations, it can be seen that the monitoring of the business's main pollutants of BOD_5 and oils was not sufficient and so with regards to choosing the grey water footprint index values this had quite a large impact. We recommend that in future environmental management processes, the monitoring of these two indexes could be strengthened so that a more complete judgment can be made of the grey water footprint they produce.

4. Results and Explanations

4.1. Results

For this water footprint calculation, the operational grey water footprint and operational blue water footprint of the business was calculated for 2007-2010. Additionally, for 2009 and 2010, the operational water footprint, including grey water footprint and blue water footprint, was calculated for each separate plant. The results of the calculations are shown in the table below. From the table it can be seen that the corporate blue water footprint only decreased slightly from 249,950 tons in 2007 to 217,670 tons in 2010. However, the operational water footprint for the business decreased significantly from 1,019,365 tons in 2007 to 233,000 tons in 2010.

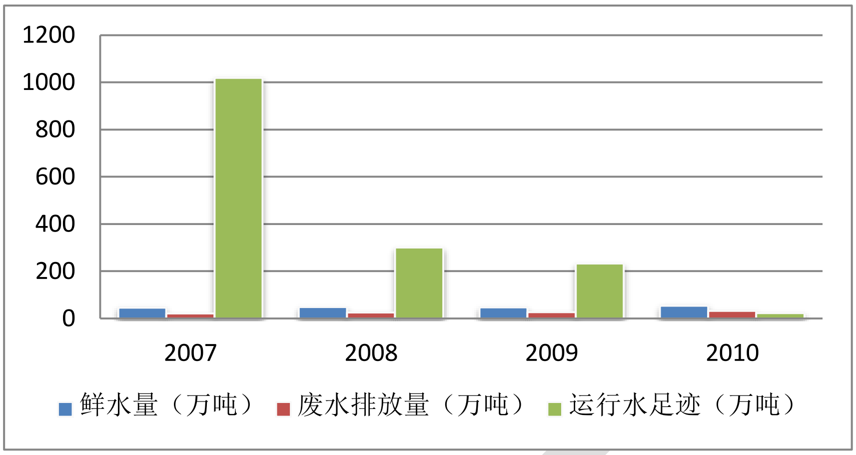
Figure 17. 2007-2010 Operational Water Footprint Results

Year	2007	2008	2009	2010
Operational Grey Water Footprint (10^4tons)	994.369	277.622	212.443	1.533
Operational Blue Water Footprint (10^4tons)	24.995	23.215	20.240	21.767
Operational Water Footprint (10^4tons)	1019.364	300.836	232.683	23.300

4.2 Explanation of Results

The overall process of calculating the water footprint was based on the method from the 2011 "Water Footprint Assessment Manual." At the same time, this methodology was combined and developed with the actual circumstances of China's water environment in mind. The findings from the calculation results can be seen in the figures below. The operational water footprint of a business is related to the amount of freshwater used by a business and amount of wastewater discharged. Even when the amount of freshwater used and amount of wastewater discharged is kept stable there are still a number of different measures a business can take to substantially reduce their water footprint. From the calculation results it can be seen that the grey water footprint makes up a relatively large proportion of the corporate water footprint and so the corporate grey water footprint has a large effect on the overall operational water footprint of a business.

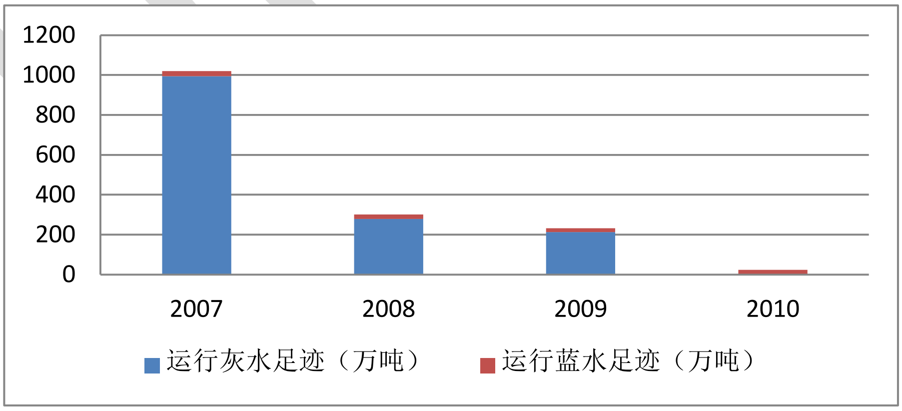
Figure 18: Comparison of Corporate Water Footprint, Water Volume and Discharge Volume



4.2.1. The grey water footprint will probably occupy a large proportion of the business's operational water footprint

By comparing the composition of the water footprint from 2007 to 2010, it is possible to see that for the first three years, the grey water footprint was much larger than the blue water footprint. This was especially so in 2007 when the operational grey water footprint was 9,943,690 tons, which made up 97.55% of the total water footprint. It can be seen that when this company does not carry out strict management of its wastewater, its grey water footprint is much larger than its blue water footprint – the true amount of water the business used.

Figure 19: Composition of the Operational Water Footprint for the Factory



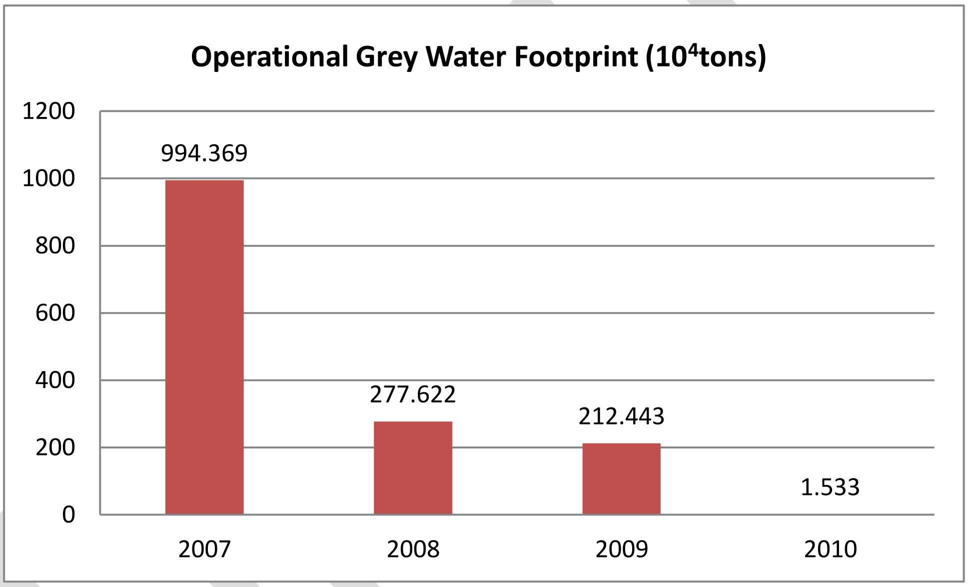
4.2.2. Improving Pollution Control Measures can substantially Reduce Grey Water Footprint

- Improvements that were to be completed by 2010

  - Pollution Control Measures Upgraded and Improved

In October 2007, the business started to carry out upgrades and improvements to its wastewater facilities and implemented phase three sewage treatment plant. After the project became operational in May 2008, there was a huge decrease in wastewater COD (COD concentration dropped from 153mg/L to 52.35mg/L). See the figure below for details.

Figure 20: Operational Water Footprint[21]



  - Discharge through the Sewerage System

Figure 21: Comparison of Operational Grey Water Footprint

Year	2007	2008	2009	2010
Grey Water Footprint of Wastewater Discharged Directly (10^4tons)	1202.580	363.429	212.443	58.811
Operational Grey Water Footprint of Wastewater that had passed through the wastewater Plant (10^4tons)	994.369	277.622	212.443	1.533

The wastewater from the business was discharged after being channeled to and treated at the municipal wastewater treatment plant. From figure 21 it is possible to see that if wastewater had just been treated by the business's own wastewater treatment facilities and then directly discharged into a natural water body, then this would mean that the 2010 production grey water footprint, corresponding

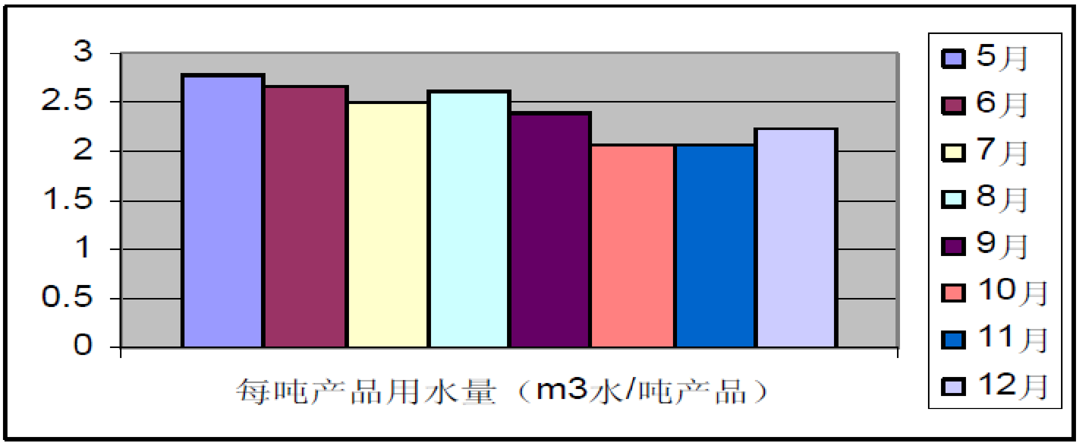
[21] According to the calculation results, the 2007-2010 operational grey water footprints were for the pollutant total phosphorus.

to the pollutant COD, would have been 588,110 tons.[22] If this wastewater was sent to the municipal wastewater treatment plant for treatment and then discharged to a natural water body the grey water footprint would be reduced to 15,330 tons, a very effective reduction. Centralized wastewater treatment not only effectively reduces the water footprint but also reduces the business's operating costs. Therefore, this study has come to the conclusion that whether or not the locality has infrastructure such as municipal wastewater treatment plants is very important and should be one of the factors considered when investments are made.

- Improvement in Industrial Processes, Reductions in Wastewater Discharge

Since late 2007, the business has managed to reduce its wastewater discharge volume through improvement programs such as the installation of a production matrix that reduces the frequency of product switches (product switches going from light to dark, for instance, white-blue-black, so as to avoid unnecessary washing), improvements in washing methods and by sending some wastewater with high concentrations of (LAS) to be used in the laundry detergent factory. According to statistics for May to December 2007, the amount of water used to produce one ton of products in May 2007 was 2.77m^3 but by November 2011 this was down to 2.06m^3 for each ton of products. For details see figure 22. Since 2007, the business has been implementing improvements to their production processes as well as integrating other emissions reduction measures. From figure 23 it can be seen that there has been a significant downward trend in the company's product value water footprint.

Figure 22: Water Consumed per Ton of Production Volume



- New Development for 2011: Recycled water to reduce wastewater discharge volumes

According to explanations from the factory, in 2011, they implemented a water recycling system.[23] After wastewater is treated in the wastewater treatment facilities, it once again gets sterilized, goes through sand filtering, fine filtering and super-fine filtering. After going through these processes it is used for municipal gardening and to flush toilets within the plant area. Through the water reuse system, the business can significantly reduce their use of water resources and wastewater discharge volumes, thus reducing their water footprint.

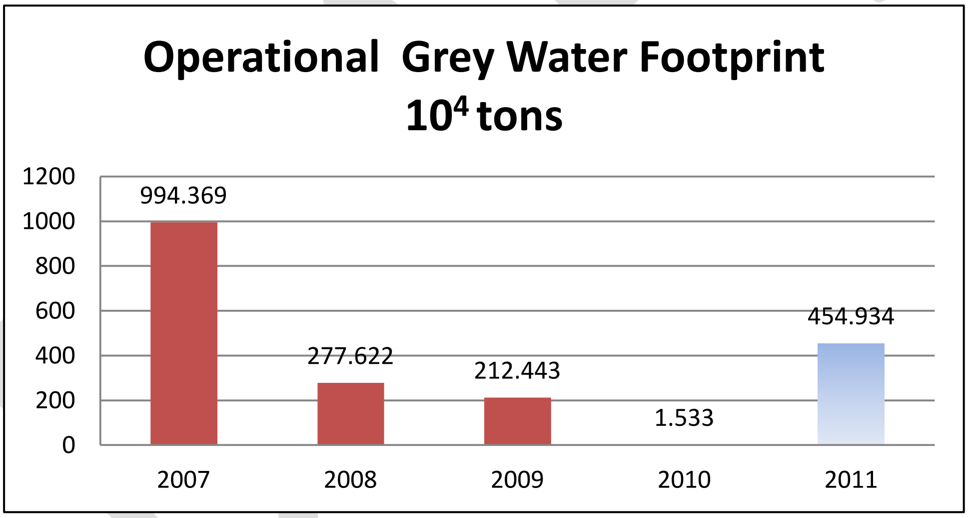
[22] According to materials submitted by the business, the average COD concentration for the plants 2010 wastewater discharge was 52.35mg/L (Integrated Wastewater Discharge Standard GB8978-1996, COD level I standards is 100mg/L).

[23] Because this water system was only launched during the study period there was a lack of adequate data and so this was not brought into the calculations.

➢ Improvement Projects

- The business carried out improvements to their wastewater treatment facilities in October 2007. However, after the improvements were put in place, the wastewater treatment plant's ability to reduce the amount of total phosphorus was limited. According to the results of the 2007-2010 grey water footprint calculations, the main pollutant to affect the grey water footprint of the business was total phosphorus. The municipal wastewater treatment facilities' ability to reduce the amount of this pollutant was extremely limited and sometimes could not reduce it at all. According to the 2007-2010 water footprint calculations for the business, there were comprehensive improvements to the business's wastewater treatment system and management was strengthened. This meant total phosphorus concentrations in discharged wastewater were reduced to some degree. However, on the whole, the business did not bring total phosphorus into the main controlled pollutants, so the monitoring of total phosphorus was not sufficient. For example, in 2011, total phosphorus was only monitored once and the concentration was 0.388mg/l. Using this concentration, and the municipal wastewater treatment plant's ability to reduce total phosphorus from the factory between 2007 and 2010, the 2011 grey water footprint created by total phosphorus would increase to 4,549,340 tons.

Figure 23: 2011 Operational Grey Water Footprint



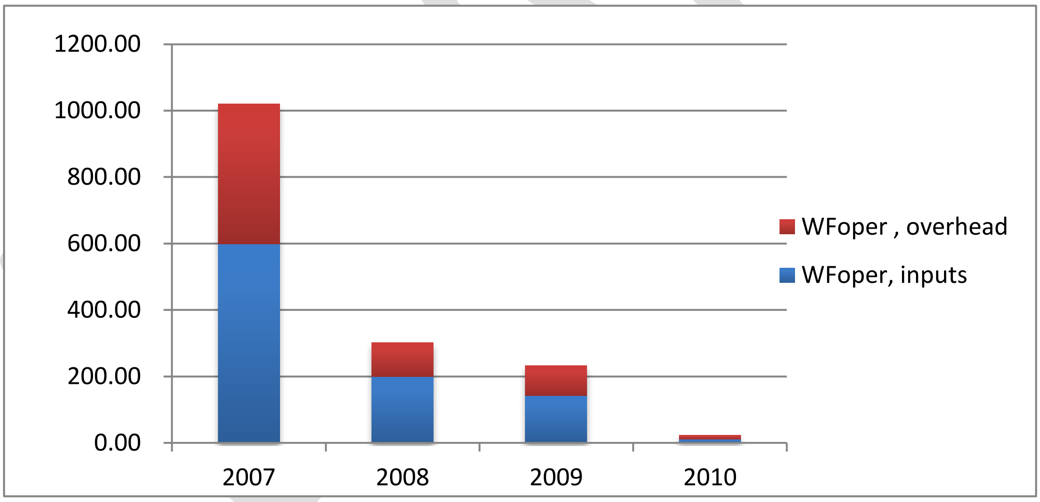
4.2.3. Overhead Water Footprint cannot be overlooked

Overhead water footprint refers to the volume of water resources consumed or the amount of fresh water polluted indirectly during operational processes and production. The overhead water footprint of the business can be seen in the figure below. Between 2007 and 2010, production capacity at the business increased from 350,100 tons to 550,000 tons, whilst the operational water footprint was reduced from 3,069,000 tons to 784,700 tons. Included in this was the annual overhead water footprint which went from occupying 26.43% to 38.12%. This shows that if a company wants to reduce its water footprint then it should not concentrate solely on the grey water footprint that comes directly from production but should also pay attention to the overhead water footprint. This means that reducing domestic wastewater can also reduce a business's operational water footprint.

Figure 24: Operational Inputs Water Footprint and Operational Overhead Water Footprint

Category	Operational Water Footprint (10^4 tons/year) / Proportion							
	2007		2008		2009		2010	
WF oper, inputs	597.74	58.64%	198.84	66.10%	142.13	61.08%	10.90	46.79%
WF oper, overhead	421.63	41.36%	102.00	33.90%	90.55	38.92%	12.40	53.21%
Total (10,000 tons/year)	1019.36		300.84		232.68		23.30	

Figure 25: Operational Inputs Water Footprint and Operational Overhead Water Footprint



4.2.4. Considerations on how to reduce water footprints from the point of view of a green supply chain

This research also calculated the 2009 and 2010 water footprints for the four separate factory units within the business. The operational water footprints and their composition for each of the factories can be seen in the figures below.

Figure 26. 2009 Water Footprint for each Branch Factory

It is not hard to see that for the studied factory, the YG, HB and Sprint branch factories' water footprints made up the largest part. For these three branch factories, the blue water footprint occupies a relatively large proportion, with most of the blue water being incorporated into the product, meaning this part of the blue water footprint cannot really be reduced. After reducing their operational water footprint by implementing improvements to pollution control facilities, industrial processes, water reuse and the sewerage system, the potential for further reducing their water footprint gradually becomes limited. However, links in the business's supply chain still contain huge potential for water footprint reduction.

5. Findings and Recommendations for the business

- The business first of all needs to strengthen the monitoring and recording of wastewater discharge. During the investigation we discovered that the business's monitoring of wastewater discharge was limited. Therefore the number of samples was relatively small and so affected how representative they were, and this then affected the accuracy of the calculation results. For example, for total phosphorus, which was the main pollutant producing the grey water footprint, there were only three monitoring values for 2010. Using these limited monitoring values to calculate the results means that it is difficult to accurately represent the business's grey water footprint.

Using the current improvements as a basis in order to help companies reduce their water footprints in the future, we recommend the following:

- **Reducing grey water footprint:** It is recommended that businesses, through thorough wastewater treatment and recycling, directly lower their wastewater discharge and reduce their grey water footprint. Furthermore, businesses can, from improvements in production processes, raise water use efficiency and basically reduce their production of grey water. From the four branch plants, the grey water footprint at the YG plant was the largest (occupying 47.6% of the corporate grey water footprint for 2009 and 42.76% for 2010). We recommend that this company really focuses its attention on adopting the appropriate measures to reduce its grey water footprint.

- **Reducing blue water footprint:** This can be carried out in two sets of ways. The first is through measures such as optimizing production matrixes, strengthening water use management, reducing the amount of water resources that go into a product and reducing the amount of fresh water usage, so reducing the blue water footprint. The second set of ways involves improving the efficiency of water treatment at the water treatment plants so that water can be treated more thoroughly and so reach a standard whereby it can be reused. At the same time, increasing the amount of water recycling also reduces the blue water footprint.

- **Focusing on the supply chain water footprint:** Out of the company's four branch plants in this research, the tea plant's operational water footprint was the smallest. However, if we were to calculate the *total* water footprint for the tea factory, it is not certain that it would be the smallest. This is due to the fact that their supply chain water footprint can be estimated to be very large. Furthermore, after a company has gone through a series of measures to reduce the operational water footprint, the potential to again reduce their water footprint is extremely limited, whereas there is room in the supply chain to make reductions. Therefore, apart from just implementing their own water footprint reduction measures, a company should also, from the perspective of a green supply chain, reduce their water footprint. Calculating the water footprint is the first step in reducing it. It is recommended that businesses select some large suppliers of raw materials and then use a step-by-step approach to develop a supply chain water footprint calculation.

5.2. Findings & Conclusions for the Water Footprint Calculation Method

- The water footprint calculation method in the "Water Footprint Assessment Manual" is suitable for use with industrial business water footprint calculations.

  In respect to agriculture, the water footprint has already been applied. However, with regards to industrial businesses, it has been rarely applied. Through the investigation of this daily care products business, we believe this same methodology can be used in the calculation of the water footprint of industrial businesses.

- Water footprint calculations for industrial businesses in China are essential

  China's pollution burden has already far exceeded its environmental capacity. Through an effective water footprint calculation formula, it will be possible to calculate the indirect water resource consumption brought about by all domestic production activities. By comparing this with the amount of surplus water resources currently available it is hoped that it will motivate or push governments and businesses to adopt measures to reduce their pollutant discharge. This then would reduce their water footprint, which as far as reducing China's current environmental burden is concerned, is extremely important.

  Furthermore, through water footprint calculations, businesses or governments can calculate and compare several years of water footprint values, thereby determining the qualitative and quantitative nature of their emissions reduction efforts. From the calculation results they could analyze potential for water footprint reduction and thereby provide better paths for reducing pollution load.

- If a business wants to fully utilize the water footprint tools they first need to strengthen the monitoring and recording of wastewater discharge. If the number of samples is very small, this can affect how representative they are and this can then affect the accuracy of the calculation results.

- The grey water footprint methodology from "The Water Footprint Assessment Manual," should be further explored.

  According to the water footprint manual, after sewage from a business has been discharged into municipal wastewater treatment plants it has already been treated to reach the discharge standards (local discharge standard). When this is then discharged into surrounding water bodies the grey water footprint is equal to zero as the discharge does not produce a grey water footprint. China's current water environment is so seriously polluted that the pollutant burden is already far beyond the sustainable capacity. Further to this, forms of malpractice that exist at municipal wastewater treatment plants whilst they are operational include them breaching authorized discharge standards, secretly discharging, and even halting operations without permission. This means that even after treatment, wastewater concentrations are often unable to reach the lowest natural concentration. As a result, natural water resources must also be consumed to dilute the pollutants that have been discharged. Therefore, we believe that in China, once wastewater from a business enters the sewerage system, it can still produce a water footprint and therefore the water footprint cannot be considered zero.

"The Water Footprint Assessment Manual" gives no detailed explanation on the selection of indexes to be calculated. In particular, there is no detailed explanation on the selection of indexes within the grey water footprint after the wastewater has entered the municipal wastewater treatment plant. We believe that when the concentration of one pollutant used for the business's water footprint calculation is lower than the pollutant concentration that is discharged after being treated at the sewage treatment plant, then the pollutant concentration and pollutant indicator from the discharge from the sewage plant should not be calculated as the business's water footprint. The reason for this is that the rise in pollutant discharge concentration in discharge from the sewage treatment plant is not created by the business. The actual water footprint calculation for the grey water footprint value should then use a different pollutant ranked at number two or lower, which is then the grey water footprint indicator.

- Having mature environmental protection infrastructure has a notable effect on a business's water footprint.

  Through this study we found that after wastewater from a business is treated by the municipal wastewater treatment plant, the pollutant concentration in the wastewater will on the whole be reduced. This directly and significantly reduces the grey water footprint produced by the business. At the same time, centralizing treatment of wastewater can also reduce the business's operating costs.

  Therefore, we believe that the availability of infrastructure such as local municipal wastewater treatment is extremely important and is one of the factors to be considered when investments are being made.

  It is recommended that businesses, municipal government departments and wastewater treatment plants maintain communications. Firstly, this is to promote the stable operation of treatment facilities so as to avoid negating efforts to reduce emissions. Secondly, this pushes for further improvements in production processes and is a step towards more thorough treatment, which assists companies to further reduce their grey water footprints.

- Reduce water footprints through thorough treatment as well as water recycling

  Following municipal wastewater treatment infrastructure being put in place and businesses improving their treatment facilities, the space for a business to reduce its grey water footprint will be greatly reduced.

  At the same time, following the expansion of business operations, the water consumed during the manufacture of products and the safeguarding of logistics will unavoidably increase, this means that the corporate blue water footprint will also increase.

  Thorough treatment and effective water resource reuse is not only beneficial for reducing a company's grey and blue water footprints but can also help a business in taking a step towards a real water balance.

- Further development of supply chain water footprint calculations

  Corporate water footprint includes the operational footprint as well as the supply chain water footprint. After adopting measures such as reusing sewage wastewater and grey water, the potential for an enterprise to further reduce its own water footprint is limited. Up-stream suppliers' environmental performance definitely affects an enterprise's own water footprint. Therefore, it is recommended that, as a foundation for the calculation of a business's water footprint, the supply chain water footprint calculation should be developed.