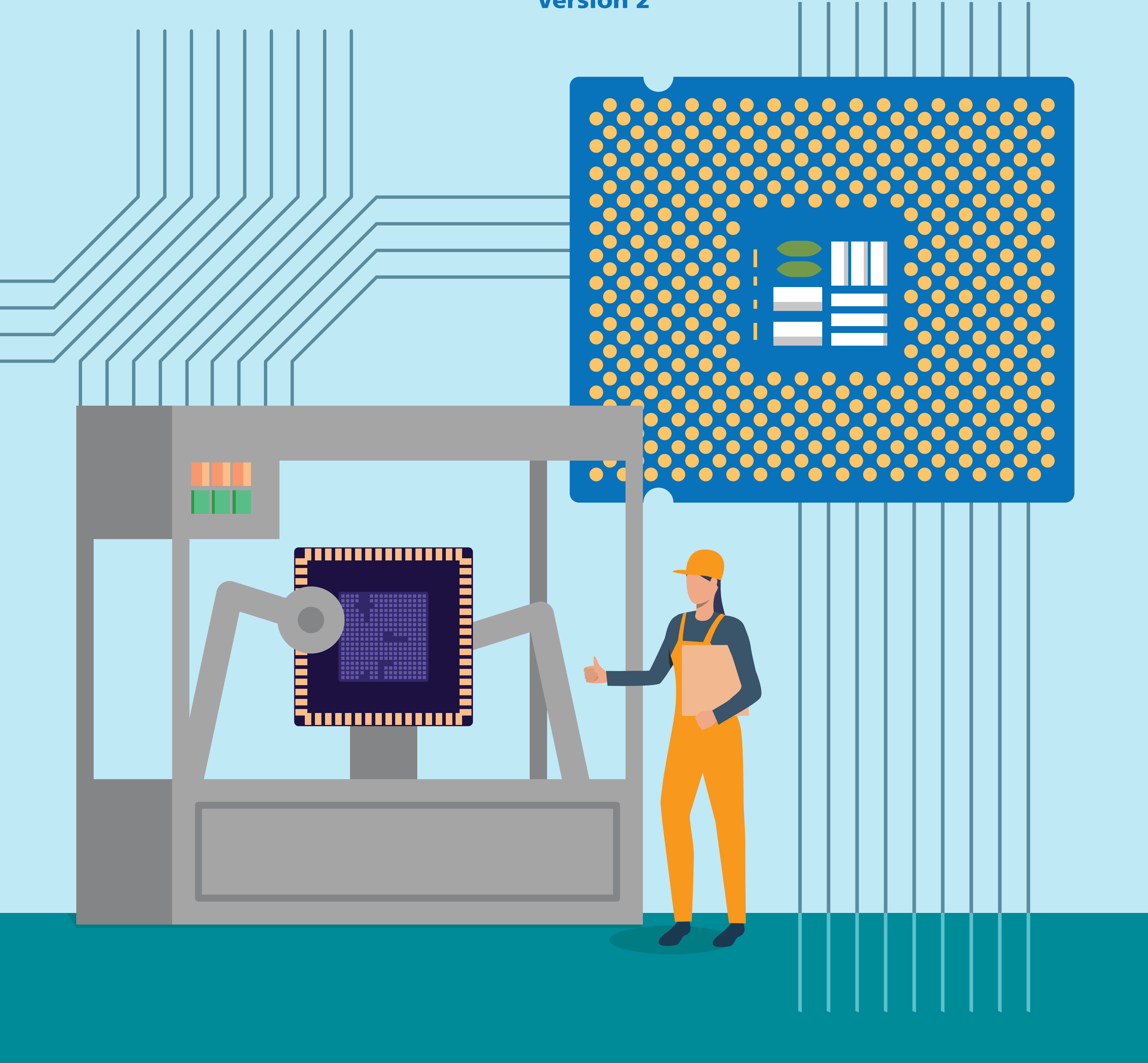
SINGAPORE'S NATIONAL WATER AGENCY

Best Practice Guide in

WATER EFFICIENCY

Wafer Fabrication and Semiconductor Sector

Version 2



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PREFACE

Singapore's water consumption stands at 430 million gallons a day, with the domestic sector accounting for 45% of total water use, while the remaining 55% comes from the non-domestic sector. By 2060, Singapore's water consumption is expected to double, with the non-domestic sector making up 70% of total water demand. Therefore, it is important that PUB's partners in the non-domestic sector join us in the move to conserve water, and reduce water demand. This will help Singapore in its water sustainability journey.

The aim of this Best Practice Guide in Water Efficiency – Wafer Fabrication and Semiconductor Sector is to provide professional engineers, developers, plant owners and facilities operators involved in water management, with the basic knowledge of designing, maintaining and operating a water-efficient plant. We have also compiled best water efficiency practices in this publication to help you in your journey towards sustainable water use.

ACKNOWLEDGEMENTS

This guide could not have been possible without the participation, assistance and invaluable insights from the following organisations. Their contributions are appreciated and gratefully acknowledged.

Singapore Semiconductor Industry Association

GLOBALFOUNDRIES Singapore Pte Ltd

Micron Semiconductor Asia Operations Pte Ltd

Siltronic Singapore Pte Ltd

Siltronic Silicon Wafer Pte Ltd

STMicroelectronics Pte Ltd

STATS ChipPAC Ltd

Systems on Silicon Manufacturing Company Pte Ltd

United Microelectronics Corporation (Singapore Branch)

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01

Introduction

The Wafer Fabrication & Semiconductor sector is one of the largest water consuming industries in Singapore. Many of these fabrication plants are water intensive users, due to the large amount of ultrapure water (UPW) required in rinsing and cleaning procedures in the production process.

Water usage for processes makes up about 76% of total water usage. Facility supporting systems such as cooling towers and scrubbers also account for sizable portions of water usage, at 9% and 11% respectively, for process cooling and to maintain tightly controlled environments within cleanrooms. Water usage breakdown of the sector is as shown in Figure 1.

To reduce water uptake, many wafer fabrication and semiconductor plants do incorporate some form of water reuse and recycling in the plant, albeit to different degrees. Based on 2018 reported data, wafer fabrication plants' recycling rates range from 23% to 65%, with an industry average of 45%.

However, the overall plant recycling rates among local wafer fabrication plants fall significantly behind international best practices such as Taiwan, where fabs in the industrial science parks are expected to meet total plant recovery rates of over 75%. For the semiconductor plants, the local recycling rates range from 2% to 80%, with an industry average of 23%.

Recycling rate is calculated as follows:

$$\frac{\textbf{Total Water Recycled}}{\left(\textbf{Total Water Recycled} + \textbf{Total Water Consumption}\right)}$$

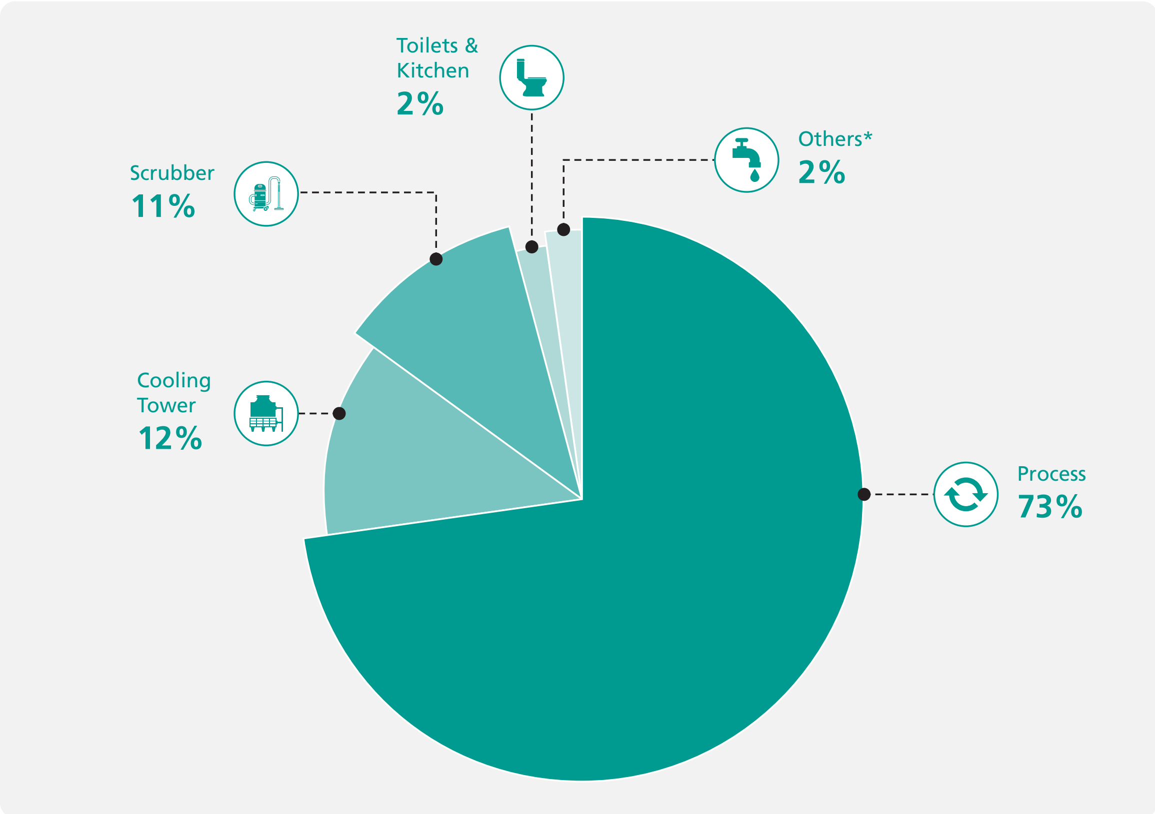


Figure 1: Water usage breakdown for Wafer Fabrication and Semiconductor sector

** Others include fire protection system, irrigation etc.*

There are many opportunities to improve water efficiency and reduce water consumption within this sector. As Singapore is a water stressed country, PUB aims to work closely with industries to harness these water saving opportunities, to support the growth and advancement of this sector in a sustainable manner.

PUB is committed to working with and supporting industries to recycle water and raise water efficiency. Interested companies can approach PUB's in-house Industrial Water Solutions Project Unit (IWSPU) team or independent consultants to review the feasibility of water efficiency improvements at process areas. Prospective companies with plans to construct new fabs or expand their existing plants are also highly encouraged to engage PUB in maximising water saving opportunities before finalising the factory's blueprint.

This guide seeks to share with companies practical and cost-effective approaches, illustrated by actual case studies, to manage water usage in the wafer fabrication and semiconductor plants efficiently. It is not intended to be prescriptive nor does it set an industry standard.

Companies may wish to read this guide in conjunction with:

> **ISO 46001:2019 Water Efficiency Management Systems and Technical Reference for Water Conservation in Cooling Towers**

02

Water Recycling Opportunities

As a lot of water is used in the wafer fabrication and assembly processes, it is paramount for all wafer fabrication and semiconductor plants to reuse and recycle as much water as possible. Wafer fabrication plants typically have significantly higher opportunities to recycle water than semiconductor plants, from the large amount of wastewater generated from rinsing and cleaning processes.

The key in harnessing water recycling opportunities lies in effective waste stream segregation, where waste streams are segregated according to water quality at the point of generation. This allows for fit-for-purpose recycling or reuse, whereby cleaner streams can be recycled with minimal treatment for reuse in UPW production or supporting systems like scrubbers and cooling towers, depending on reclaimed water quality and companies' policies on water reuse.

Figure 2 illustrates the recycling opportunities in a typical wafer fabrication plant.

Recycling opportunities are grouped into commonly recycled streams and additional recycled streams, that will be discussed in Sections 2.1 and 2.2 respectively. Waste stream segregation will be covered in greater detail in Chapter 3. Additional best practices to improve water efficiency in other parts of the plants can be found in Chapter 4.

If waste segregation can be planned during preliminary design stage and in consultation with tool vendors, wafer fabrication plant with water consumption of at least 60,000 m^3/yr can achieve at least 50% recycling rate. Incorporating recycling opportunities at the design stage is more cost-effective than retrofitting measures in a brownfield site, with an estimated investment break-even point in less than 2 years. In addition, water reuse and recycling can translate to long term cost savings as the recycling operational cost usually ranges from $0.20/$m^3$ to $1.40/$m^3$ (depending on type of recycled stream) of water for reuse. This is cheaper as compared to total price of NEWater supplied by PUB at $2.33/$m^3$ (from Jul 2018, prices are before GST).

Although it would be easier and more cost-effective to segregate waste streams at the onset to maximise water recovery, many plants have successfully raised recycling rates through retrofitting measures to recycle and reuse waste streams within existing facilities. These case studies are elaborated in Section 5.

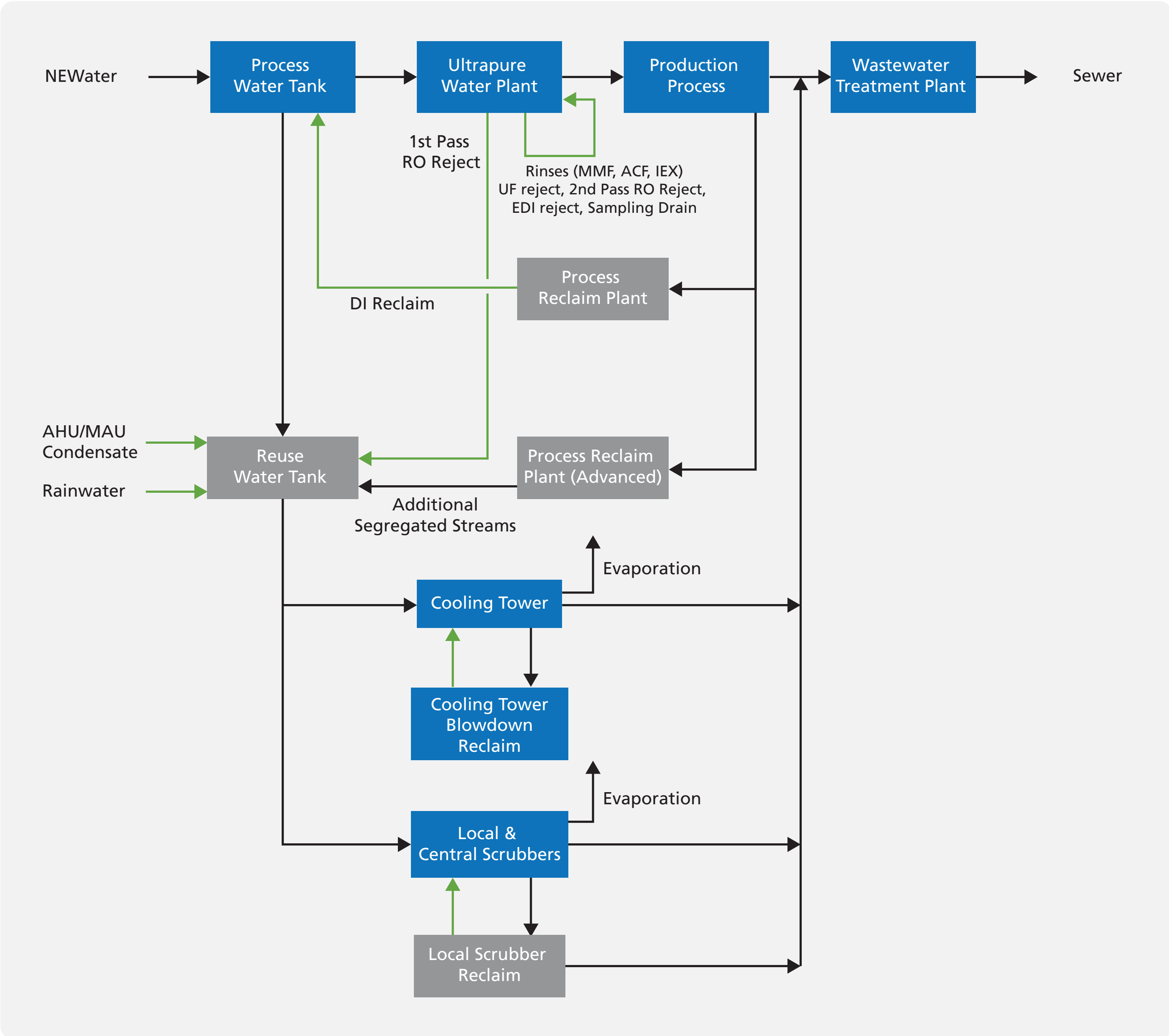
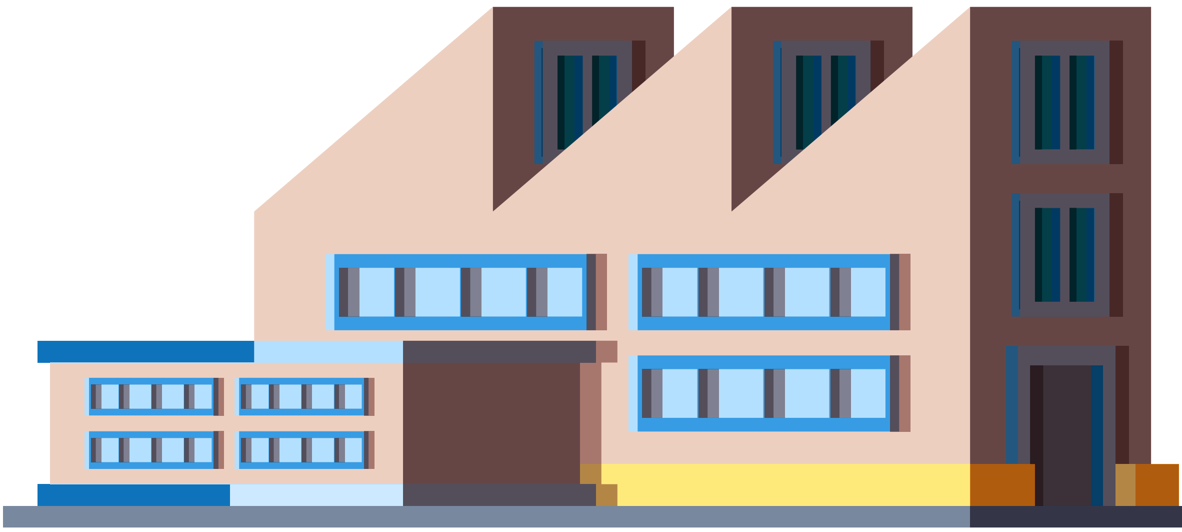


Figure 2: Water Recycling Opportunities in a Typical Wafer Fabrication and Semiconductor Plant



2.1. Commonly Recycled Streams

The waste streams listed in Table 1 can be recycled at relatively low cost, as minimal or no additional purification processes are required due to the low concentration of contaminants. Hence, these measures are commonly incorporated into the UPW plant setup to conserve the good quality wastewater.

A wafer fabrication plant could easily achieve recycling rates in excess of 30% by recycling these commonly recycled streams.

Table 1: List of Commonly Recycled Streams in the Wafer Fabrication and Semiconductor Sector

Streams	Recommendations
Reverse Osmosis (RO) Reject	Dual pass RO is a common process for Ultrapure Water (UPW) production. The first pass RO Reject can be re-used at cooling towers, scrubbers or for cleaning purposes with minimal treatment. Alternatively, it can be treated and reused in UPW production. The second pass RO Reject is typically recirculated back as first pass RO feed due to its low Total Dissolved Solids (TDS) content.
Electro-deionisation (EDI/CEDI/CDI) Reject	The electro-deionisation (EDI) system may be used as a polishing step after the RO process in UPW production to further reduce TDS and Total Organic Carbon (TOC). EDI Reject is generally of better water quality than the RO feed and can be reused with little or minimal treatment back to the RO pre-treatment stage but it is subject to final quality control of the UPW process due to concerns on high boron concentration. Alternatively, it can also be reused directly to cooling towers and/or scrubbers.
Ultrafiltration (UF) Reject	Ultrafiltration (UF) Reject is generally returned either directly or with minimal treatment to UPW plant feed due to its good water quality.
AHU/MAU Condensate	Air Handling Unit/ Make-up Air Unit (AHU/MAU) condensate is commonly combined with other recycled streams such as RO Reject and selected process recovery streams to be reused at cooling towers and/or scrubbers. Minimal treatment, if any, is required.
Sampling / Analyser Drain	Drain water from sampling lines or analyser instruments can be collected and reused directly to the UPW tank for process usage. Additional treatment is typically not required as the water does not come into contact with contaminants.
Final Rinse	Wafers undergo final rinse to remove any residual chemicals or particles that remain after the intermediate rinsing processes. Final rinse is of good quality water and can be reused directly for UPW production.

2.2. Additional Recycled Streams

In additional to the commonly recycled streams described in Section 2.1, companies should also consider other types of wastewater (listed in Table 2) for reclamation and reuse using water treatment technologies.

Table 2: List of Additional Recycled Streams in the Wafer Fabrication and Semiconductor Sector

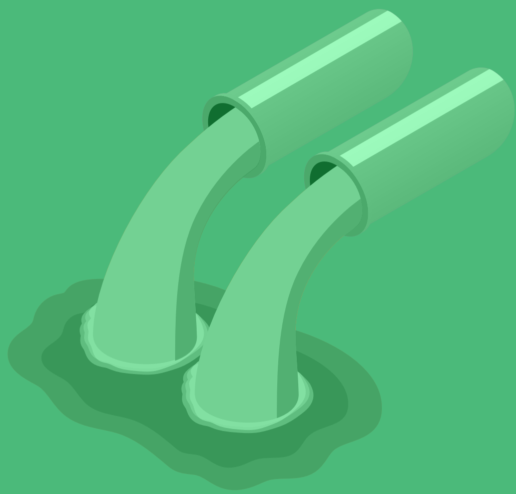
Streams	Recommendations
Local Scrubber Reject	Local scrubber reject can be reclaimed using Multimedia Filter (MMF), Activated Carbon Filter (ACF), Ion Exchange (IX) and RO. The reclaimed water is generally returned back as feed to the scrubbers and/or cooling towers.
Backwash Water	Backwash water from MMF, ACF and Mixed Bed (MB) generally contains suspended solids and a small amount of TOC. Simple sedimentation may be required and water can be reused back to the UPW tank.
Chemical Mechanical Planarisation (CMP) Waste Water	Wastewater from the CMP process is characterised by high suspended solids, high turbidity and high conductivity. However, it can be treated and reused to the cooling towers and/or scrubbers. Treatment processes include the use of ceramic filters for the removal of suspended solids followed by ACF to remove organics and IX beds for the removal of heavy metal ions.

Table 2: List of Additional Recycled Streams in the Wafer Fabrication and Semiconductor Sector (cont'd)

Streams	Recommendations
Organic Waste Water	Organic waste water can be treated and reused to cooling towers and/or scrubbers. Biological treatment such as membrane bioreactors or biological contact oxidation process is required to remove organic pollutants, Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) followed by further filtration via reverse osmosis.
Backgrinding Waste Water	Waste water generated from the wafer backgrinding process is typically high in colloidal silica suspended solids. The waste water can be treated by membrane filtration processes and/or the mixed bed process.
Deionised (DI) Rinse Water / Acid Rinse	DI Rinse water is spent UPW that has been used for wafer rinsing purposes. It contains a variety of contaminants such as acids and may contain some particulate matter as well. Typical treatment may include Activated Carbon, Bio-Filters, IX and MMF.
Rainwater	Rainwater can be harvested and reused with minimal treatment such as simple filtration. It can be recycled to areas such as cooling towers, scrubbers or for toilet flushing etc.
Cooling Tower Blow Down	Cooling tower blowdown can be recycled back to the cooling tower, via a combination of Microfiltration (MF)/ Ultrafiltration (UF) and Nanofiltration (NF) / Reverse Osmosis (RO) processes. However, as blowdown water contains high TDS levels which will subsequently be rejected from reclaim RO, care must be taken to ensure that the final effluent can still meet the trade effluent discharge requirements.

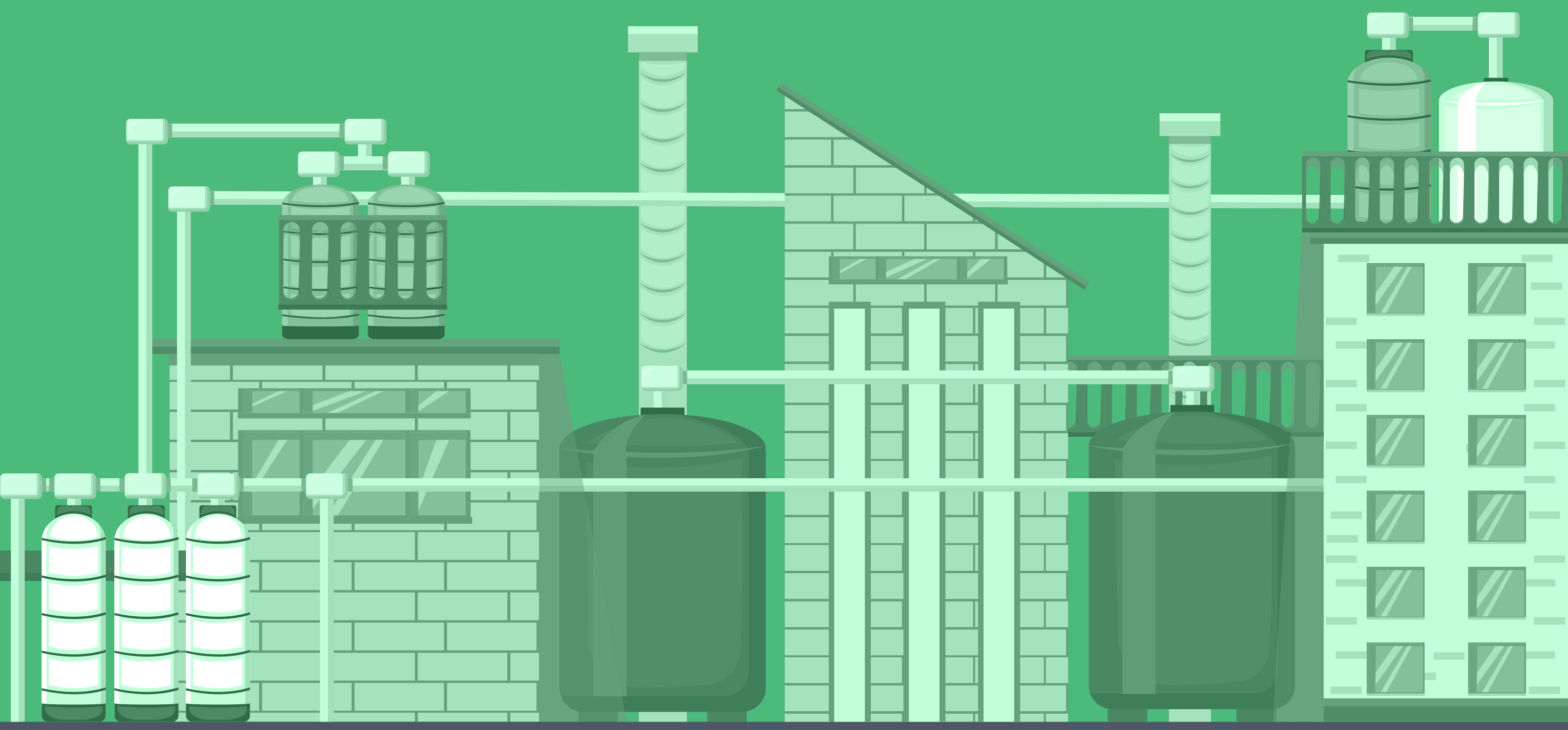
03

Waste Stream Segregation

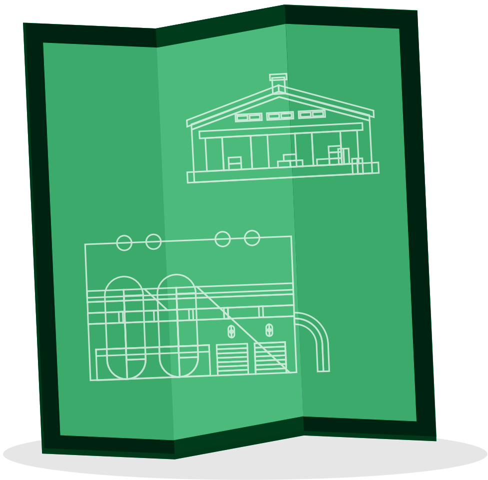


There are two general approaches to water recycling. The first approach is where waste water from different process streams in the plant are combined together and back-end reclamation of the final effluent from the waste water treatment plant is carried out. The downside to this approach is that treatment will generally be costlier due to the poor water quality of the combined final effluent. This contributes to an inflated payback period which in turn, deters recycling.

Alternatively, the second and more effective approach is to recycle water at the production and secondary (e.g. scrubbers) use levels, which necessitates a segregated drainage network design. Proper segregation of process tool drainage is especially critical to ease recycling, where the 'cleaner' streams can be captured during certain rinsing steps and reused with minimal treatment. This maximises water recovery cost-effectively. Consequently, the 'dirtier' stream will have a reduced volume for treatment and the reclaim equipment can be designed at smaller capacities with lower costs.



Planning for Waste Stream Segregation at Plant Design Stage



Waste stream segregation should be planned for during plant design stage to reduce unnecessary retrofitting works and operational downtime, and to allocate space for drainage network and reclaim facilities. This will reduce unnecessary retrofitting costs, which will enable a lower payback period on the recycling projects.

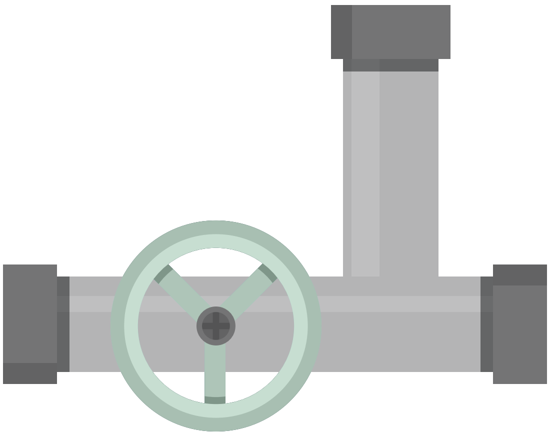
First, layout of the plant can be optimised to channel recycled streams to various points of uses as well as to accommodate drain collection systems and reclaim facilities. Second, waste stream segregation functionalities can be specified in design requirements to tool vendors before the tools are procured (e.g. dedicated drain outlets to segregate rinse water and high TOC rinse water in the same tool).

On the contrary, modifying existing drain piping can have high financial costs depending on the extension of works, as current drain piping could already be installed with little or no space for plant improvements.

Understanding Water Quality of Generated Waste Streams is Key to Maximise Recovery and Reuse

A good understanding on how water is used in wafer fabrication as well as the types of chemicals used and their by-products, is necessary to maximise recovery and reuse. Waste stream segregation starts at the rinse drains, where sampling and analysis of streams are conducted to characterise and profile waste streams based on typical and non-typical contaminant concentration levels.

This would allow for an effective design to segregate waste based on varying strengths and types of contaminants (e.g. isolation of concentrated chemicals from moderately/ lightly contaminated drains).



Treatment systems and storage capacities are then designed based on water quality and flow rates of these streams as well as the requirements of the intended uses. Segregation process can be automated through incorporation of online sensors and valves to divert waste streams to intended points based on specified water quality parameters.

Figure 3 illustrates several processing units without and with waste stream segregation. The left diagram depicts tools with unsegregated waste streams, with all the production waste sent to the WWTP. Consequently, the wastewater at the WWTP will contain a variety of contaminants and will be difficult to treat and recycle. The right diagram shows wastewater at each processing unit segregated into 2 streams of different contaminant concentrations. For example, at the etching unit, the stream with high hydrofluoric acid (HF) concentration will be sent for fluoride treatment before it goes to WWTP. Waste streams with low HF concentrations can be captured during certain rinsing steps for treatment and reclaim (R1). As the streams at R1, R2 and R3 contain specific contaminants respectively, instead of a mixture of contaminants, the reclaim pre-treatment can be targeted based on the contaminant for a higher reclaim RO recovery.

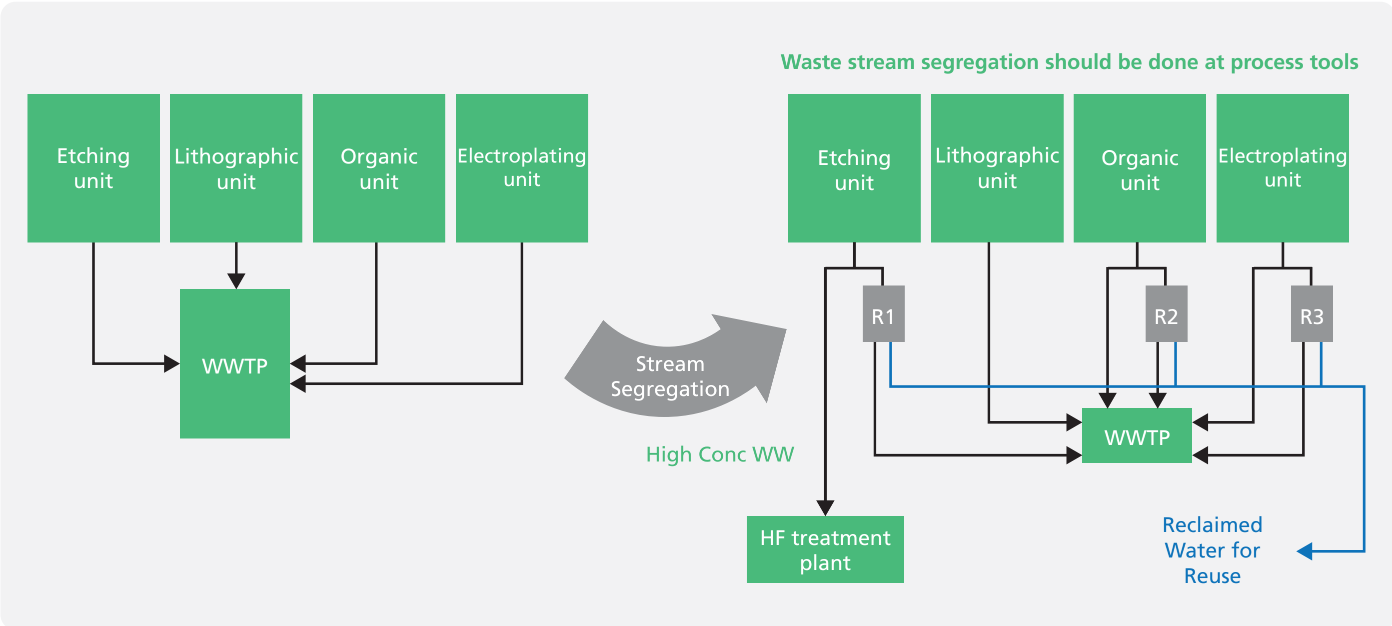


Figure 3: Processing Units with and without Waste Stream Segregation
Note: For illustration purposes only, reclaim design to depend on fabrication processes and chemicals used.

Besides the inclusion of segregated drainage network in factory design stage, it is also important to specify these segregation requirements to tool vendors before procurement to cater for such diversion capabilities.

The list of waste streams (nomenclature may vary for different facilities) that can be segregated out in wafer fabrication processes with methods and reuse areas are indicated in Table 3. Besides the below streams, fabs in Taiwan are also treating tetramethylammonium hydroxide (TMAH) and ammonia (NH_3-N and NH_4) waste streams for reuse.

Table 3: List of Possible Waste Streams that can be Segregated with Suggested Treatment Methods

No	Stream	Stream Name	Quality*	Treatment	Possible Reuse Areas
1	PWR	Pure Water Reclaim	< 10 µS/cm < 0.5 ppm TOC	MF/UF	• DI Water Tank • Cooling Tower Make-up • Scrubbers
2	CEDI Reject	CEDI reject in secondary loop	< 10 µS/cm, < 100 ppb B	Boron polisher, ACF	• Back to UPW System
3	WWR	Waste Water Reclaim	< 800 µS/cm < 1 ppm TOC	UF, RO	• DI Water Tank • Cooling Tower Make-up • Scrubbers
4	AWR	Acid Waste Water Reclaim	< 2000 µS/cm < 5 ppm TOC	ACF, MF/ UF, ion exchange/RO	• DI Water Tank • Cooling Tower Make-up • Scrubbers
5	AWL	Low Concentration Acid Waste Water	< 8000 µS/cm > 5 ppm TOC	ACF, MF/UF, RO	• Cooling Tower Make-up • Scrubbers
6	AWH	High Concentration Acid Waste Water	> 8000 µS/cm	-	Drain to WWTP
7	FWL	Low Concentration Hydrofluoric Acid Waste Water	< 2000 ppm F-	ACF, ion exchange/RO	• Back to UPW System • Scrubbers
8	FWH	High Concentration Hydrofluoric Acid Waste Water	> 2000 ppm F-	-	Drain to WWTP after treatment at fluoride treatment plant
9	CMP	CMP Waste Water	-	Ceramic Membrane Filtration, ACF, ion exchange/RO	• Cooling Tower Make-up • Scrubbers
10	IPAL	Low Concentration Isopropyl Alcohol	-	Distillation	• Cooling Tower Make-up • Scrubbers
11	IPAH	High Concentration Isopropyl Alcohol	-	-	Drain to WWTP

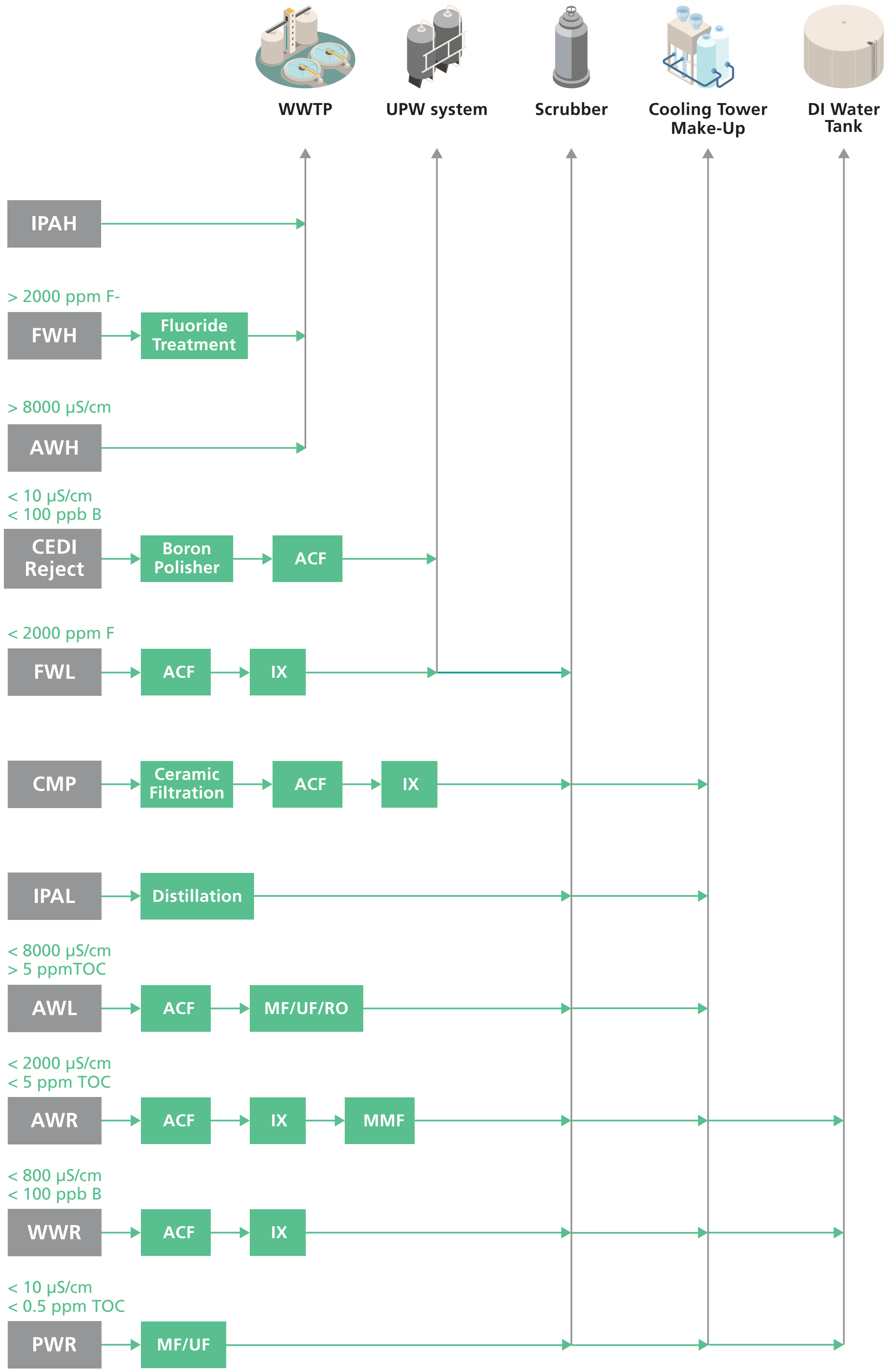


Figure 4: Illustration of Segregated Waste Streams

Note: This diagram is for illustration purpose only.

04

Recommended Water Efficiency Practices

Besides water recycling, the following best practices can be considered to raise the plant's overall water efficiency and reduce water usage.

Areas	Recommended Best Practices
Overall Water Management	A comprehensive water audit can be conducted to identify and prioritise potential areas of water efficiency, reuse and recycling.
Process	There are generally four approaches to reduce water usage in semiconductor manufacturing where two or more approaches can be implemented simultaneously. • Replace wet processes with dry processes where possible e.g. anisotropic etching with dry plasma etches instead of wet isotropic etches. • Improve in the efficiency of present processes used to produce UPW from NEWater or other sources of raw water. • Optimise the tools and procedures for utilising UPW in production processes e.g. more efficient rinse process by optimising flow distribution in the rinse tank, right timing and sequencing of these rinse steps for wafer rinsing to get more chips per drip. Using sprays to rinse wafers instead of bath minimises water usage and total rinse times without sacrificing wafer cleanliness. • Reuse spent rinse water and other wastewater streams from existing production processes but with managed risks via segregation of waste water quality e.g. using spent rinse water as feed water to UPW reduces maintenance and operating costs of UPW plant with fewer contaminants providing fewer regeneration cycles for both RO and ion exchange columns.
Toilets/ Pantries/ Domestic Use	Install water-saving devices at basin, sink/kitchen, and shower tap/mixer to meet water-efficient flow rates designated by PUB.

Cooling Towers

Method	Water Efficiency Opportunities	
	New / Existing Plants	New Plants Only
Reduce	• Improve cycles of concentration (COC) to minimum 7 and 10 for cooling towers using potable water and NEWater respectively • Install a side-stream filter • Install a makeup water or side-stream softening system when hardness is a limiting factor on COC • Reduce cooling load by minimising waste heat generated and/or using waste heat for other purposes in the facility	• Use of dry cooling instead of cooling towers • Install and interlock automated chemical feed system with blowdown controls on large cooling tower systems (more than 100 tons)
Replace	• Replace potable water or NEWater with harvested rainwater and air-conditioning condensate as cooling tower make-up	
Reuse/ Recycle	• Recycle cooling tower blowdown back to the cooling tower as make-up, via a combination of Microfiltration (MF)/ Ultrafiltration (UF) and Reverse Osmosis (RO) / Nanofiltration (NF) process • Recycle wastewater effluent (e.g MBR permeate) as makeup for cooling towers	

For water quality requirements, please refer to Technical Reference for Water Conservation in Cooling Towers: Annex C - Typical Parameters of Potable Water, NEWater and Industrial Water as Makeup Water for Cooling Tower.

05

Case Studies

Case Study 1

Systems on Silicon Manufacturing Company (SSMC)

An advanced wafer fabrication manufacturer, Systems on Silicon Manufacturing Company (SSMC) obtained the Water Efficient Building (Gold) Certification in 2013, Watermark Award in 2013 and President's Award for the Environment in 2015.

Their commitment to making a positive impact to the environment and community is supported by integrating the water conservation component as part of their ECOvision Journey, where they monitor their consumption in the areas of energy, water, generation of waste and use of substances, in the planning process and sustaining their efforts through daily operations and external outreach to all stakeholders (employees, suppliers, customers and the community).

The first wafer fabrication company in Singapore to use NEWater for wafer processing in 2003, SSMC remains fully committed to water conservation and has seen a reduction in their annual water consumption, even as their operations expand to more than double in capacity over the years. Their initiatives include reusing wet bench discharge waste, optimising wet bench flow rates and commissioning new water recycling plants to recycle different sources of wastewater such as CMP waste water, organic waste water and acid rinse waste water etc.

Figure 5: Aerial view of SSMC

In 2012, SSMC tapped onto PUB's Water Efficiency Fund to install a local scrubber reuse system to recycle the local scrubber wastewater back to their local scrubber systems, resulting in annual savings of more than 300,000 m^3. This corresponds to annual cost savings of more than \$700,000, with a simple payback period of less than a year. The key technologies include filtration and reverse osmosis with appropriate dosing and ion exchange system. This is one of such efforts that have contributed to a yearly reduction of more than 2 million m^3 of water. SSMC's latest Best Known Method is to segregate ultrapure Hydrofluoric Acid (~1%) from production tools and reclaim the water for UPW inlet, resulting in annual NEWater savings of 88,000m^3. Through various water efficiency initiatives, SSMC achieved a recycling rate of 65% in 2018, which is the highest in the wafer fabrication industry.

Figure 6: Wafer fabrication process

Case Study 2

Figure 7 and 8 from top to bottom: (i) View of UMC (Singapore branch) headquarters and (ii) Reclaim Water Collection Tank

United Microelectronics Corporation (UMC) (Singapore Branch)

United Microelectronics Corporation (UMC) (Singapore Branch) is a global semiconductor foundry that provides advanced Integrated Circuit production for applications spanning every major sector of the electronics industry. Committed to environmental protection and water consumption reduction, and as a responsible corporate citizen, UMC was awarded the Water Efficiency Awards (WEA) and Watermark Award in 2017 and has the second highest water recycling rate in the water fabrication industry at 61% in 2018.

UMC has a detailed plan on the use of water in all of their processes, which includes recovering water for reuse and managing water efficiently. In 2015, UMC set a target to reduce their water usage by 10% over 5 years. They are on track to meet their corporate target and in 2018, they had achieved an increase in the amount of recycled water by 1.5% or 50 million imperial gallons of water.

UMC's implementation of the second rinse recycle is commendable and has helped contribute to their high recycling rate. Other water saving measures implemented by UMC include recycling Air Handling Unit condensate water, recycling regeneration rinse water from the deionised water system and the use of recycled water at local scrubber systems.

Case Study 3

GlobalFoundries Singapore Private Limited

GlobalFoundries (GF) is a specialty foundry that provides design, development and fabrication of integrated circuits for semiconductor companies worldwide. GF focuses on delivering differentiated feature-rich solutions for clients to develop innovative products in high-growth markets, e.g. Communication, Automotive, Data Centres and Internet of Things (IoT).

GF is committed to eco-efficiency in its foundry operations. In early 2016, GF established new resource conservation goals and identified projects across its global manufacturing sites to reduce water consumption, amongst electricity and chemical usages, greenhouse gas emissions and waste generation.

GlobalFoundries Singapore Private Limited (GFS) owns Fabs 2, 3/5 and 7G/7 locally. Since 2012, GFS has executed a series of process optimisation and water reclamation projects to reduce water consumption and conserve Singapore's water supply. With the completion of the latest water reclamation project in 2021, GFS will have attained water recycling rates ranging from 49% to 54% across its five local wafer fabrication plants.

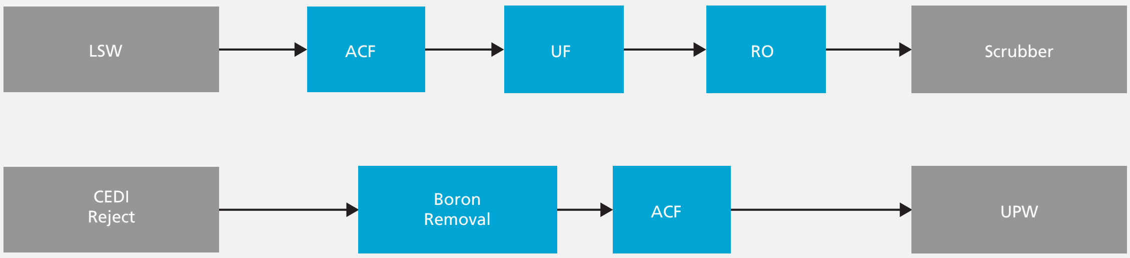


Fig. 9a: Schematic diagrams of CDO (top) and CEDI (bottom) reclaim systems in GFS Fab 7

Fig 9b: Schematic diagram of reclaim system to treat wastewater in GFS Fabs 7/7G

In 2018, GFS commissioned wastewater reclamation projects in Fab 7 which consist of 2 reclaim systems - controlled decomposition oxidation (CDO) and continuous electro-deionisation (CEDI) reject. The CDO reclaim system treats local scrubber wastewater (LSW) and comprises of activated carbon filter (ACF) to remove residual chlorine, ultrafiltration (UF) to remove total suspended solids (TSS) and reverse osmosis (RO) to remove total dissolved solids (TDS) and dissolved organic matter. The CEDI reject reclaim system treats concentrate waste from CEDI and consists of boron selective resins (BSR) and ACF, to reduce boron and organic carbon levels respectively. The total water savings from the 2 systems amount to approximately 2,000 m^3/day and resulted in a 5% increase in recycling rate.

GFS plans to implement another wastewater reclamation project in Fabs 7 and 7G which treats waste water (including DI drain and slurry waste) for reuse in cooling tower, scrubber and controlled decomposition oxidation (CDO) unit. The reclaim system employs silicon carbide filtration membrane to remove TSS and sludge, catalytic carbon filters to remove organic compounds and residual oxidising agents, and RO to remove TDS and total organic carbon (TOC). The project has a design reclaim capacity of 1,680 m^3/day and has commissioned in end 2021.

Case Study 4

Lumileds Singapore Private Limited

Lumileds Singapore Private Limited (Lumileds) is a semi-conductor company that develops, manufactures and distributes light-emitting diodes (LEDs), light bulbs and related products for automotive lighting, general lighting and specialty lighting.

In 2013, Lumileds implemented an UF-RO reclaim system, with design capacity of 916 m^3/day, to recycle used water from 3 sources - Disco tools, RO reject and sampling drain, with funding from PUB. The treated water is reused in cooling towers, scrubbers and production. With this system, the plant's recycling rate has increased by more than 30%.

As the Lumileds' facility is an old setup, their production drainage was not well segregated. The waste water is mostly mixed with different types of organic and inorganic chemicals, resulting in high TDS and COD, and making it difficult to treat to acceptable water quality for facility or production usages. One exception is the Disco tool, where a dedicated drainage was installed during tool expansion in 2011. The other 2 wastewater streams identified for recycling are RO reject and sampling drain. As both streams are good quality wastewater, they are fed after the UF system to maximise water recovery rate and Return of Investment (ROI), resulting in ROI of less than 2 years.

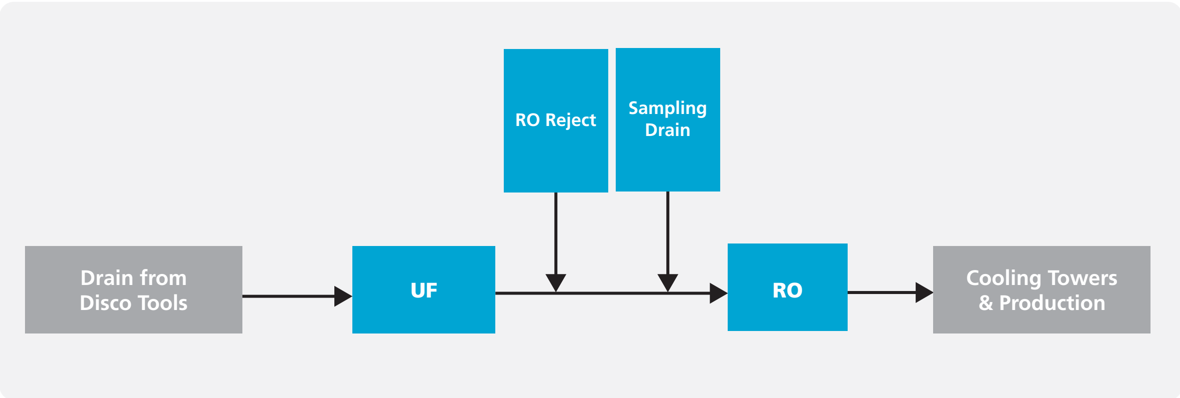


Figure 10: Schematic diagram of reclaim plant in Lumileds

Case Study 5

Hoya Electronics Singapore Private Limited

Hoya Electronics Singapore Private Limited (Hoya) develops and manufactures advanced mask blanks for the semiconductor manufacturing companies.

In 2017, a waste water reclamation system with 96 m^3/day capacity was set up in Hoya to treat its waste water treatment plant (WWTP) effluent for production reuse. Key equipment in the recycling facility include ACF and RO systems. Prior to reclamation, the WWTP effluent was sent to final inspection chamber (IC) as effluent discharge.

Besides reclaiming WWTP effluent, Hoya is also recycling a portion of their electro-deionisation (KCDI) reject for reuse as make-up water to cooling tower, MAU air washer and scrubber systems. The remaining KCDI reject, RO Reject and Pre-Case Cleaner (CC) rinse water are treated using RO Reject Recovery System and recycled back to the NEWater tank for reuse in their production. Both recycling systems are cost-effective with simple payback of less than a year.

With all the water conservation measures in place, Hoya achieved a recycling rate of 80% in 2018, which is the highest in the semiconductor industry.

Figure 11: Waste Water Reclamation System

SUPPORT AND RESOURCE

PUB provides funding and technical support as part of PUB's effort to encourage companies to explore ways to improve water efficiency.

For technical support, interested companies may contact PUB's in-house Industrial Water Solutions Project Unit team at PUB_IWSDF@pub.gov.sg.

For information on funding available from PUB including Water Efficiency Fund and Industrial Water Solutions Demonstration Fund, please refer to PUB's website at www.pub.gov.sg.

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Environment Building, Singapore 228231

MAKE EVERY DROP COUNT