Water Management

V Achieved ↑ Exceeded — Missed Target

Strategies	2030 Goals	2021 Targets	2020 Achievements
Manage Water Resource Risk Enforce climate change mitigation policies, implement water conservation and water shortage adaptation measures	▪ Reduce unit water consumption (liter/12-inch equivalent wafer mask layer) by **30%** (Base year: 2010)	▪ Reduce unit water consumption (liter/12-inch equivalent wafer mask layer) by **9%** (Base year: 2010)	▪ Reduced unit water consumption by **8.9%** (Base year: 2010) Note4 — **Target: 10%** — —
Develop Diverse Water Sources Develop water reclamation technologies; continue to practice water conservation and use reclaimed water during fabrication	▪ Increase the replacement rate of reclaimed water by more than **30%** Note1	▪ Complete the TSMC Tainan Science Park Reclaimed Water Plant and begin water supply	▪ TSMC Tainan Science Park Reclaimed Water Plant tender project completed and construction commenced — **Target:** Commence the TSMC Tainan Science Park Reclaimed Water Plant tender project and start supplying water in 2021 — V
Develop Preventive Measures Improve the efficiency of water pollution prevention and removal of water pollutants Note2	▪ Water pollution composite indicator **50%** above effluent standards Note3	▪ Water pollution composite indicator reduction rate of **44%**	▪ Water pollution composite indicator reduction rate of **42.4%** — **Target: 20%** — ↑ ▪ Discharged less than **6.3 ppm** of tetramethylammonium hydroxide(TMAH) Note5 — **Target:** Less than **6 ppm** — —

Note 1: Replace city water with reclaimed domestic or industrial wastewater.

Note 2: The scope of water pollution projects and figures include Taiwan facilities and VisEra.

Note 3: 2030 Goals raised from 30% to 50%.

Note 4: Due to test production in new fabs, unit water consumption did not meet our target. TSMC continues to commit to the development of water reclamation technologies. The TSMC Tainan Science Park Reclaimed Water Plant is expected to be operational by 2021.

Note 5: Due to increased fab production, TMAH concentration levels in discharge failed to meet the target. TSMC is evaluating expansion of the treatment system.

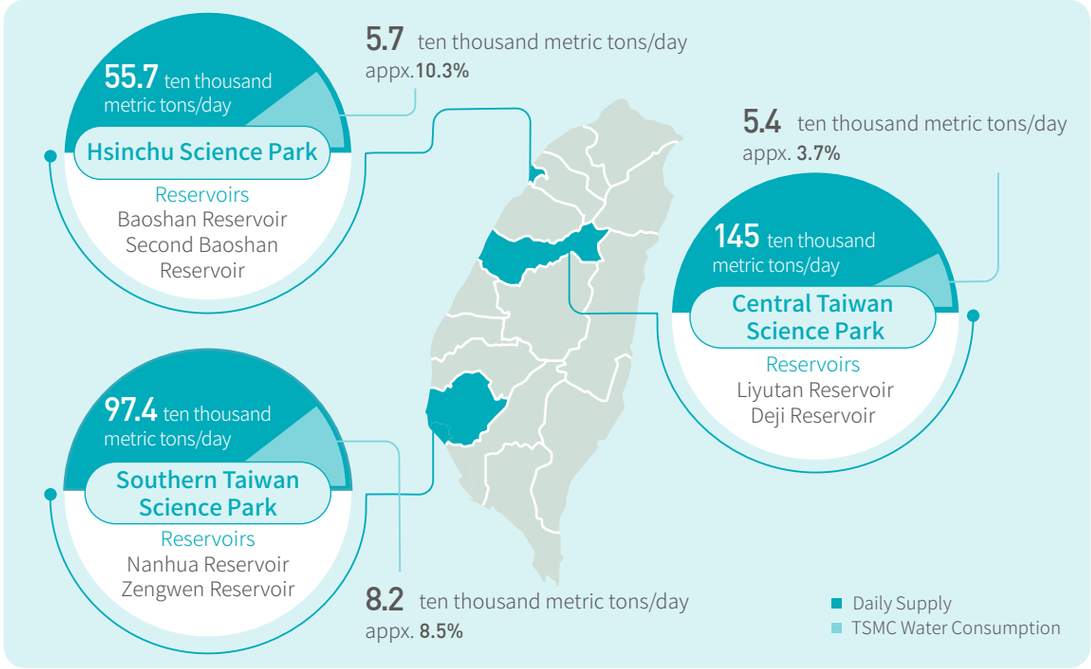
In 2020, TSMC became the first to bring 5 nanometer (5nm) process technologies to mass production. TSMC increased clean water consumption as 5nm process technology includes advanced wafer stacking and reduced wire width, meaning that the smallest dust particle could have an impact on yield. This further demonstrates the importance of effectively using water resources and flexibility in water resource management. TSMC strives for comprehensive water cycle management through the following three major strategies: managing water resource risk, developing diverse water sources, and developing preventive measures.

Manage Water Resource Risk

Assess Water Risks & Establish Water Risk Indicators

In 2020, TSMC adopted the Water Risk Atlas from the World Resources Institute (WRI) to evaluate water risk levels in areas with TSMC facilities by using key indicators of water supply, effluent water quality, and regulatory/reputation risks. TSMC facilities in Taiwan and our affiliate VisEra were both rated medium-to-low risk while Wafertech was rated low risk. TSMC (China) and TSMC (Nanjing) were rated high and medium-to-high risk as they face differences in water quality in their regions and require refined water, thereby increasing wafer unit water consumption.

TSMC Water Consumption Rate at Three Science Parks



TSMC WRI Risk Identification

1 Overall WRI Risk Index

- **Frequency**: Water risk, decreasing underground water levels, interannual variation, seasonal variation, drought, flood risks, tsunami risks
- **Quality Control**: Coastal erosion, untreated water bodies
- **Regulation & Reputation**: Drinking water quality, sanitary conditions, sustainable investment index

2 TSMC Assessment

- Flood Risk
- Water Risk
- Water Quality Risk

3 TSMC Assessment Results

Low Risk	Mid-to-low Risk	Mid-to-high Risk	High Risk
1 Facility	15 Facilities	1 Facility	1 Facility

4 TSMC Response Measures

Facility Design

- Elevate facility
- Install flood gates

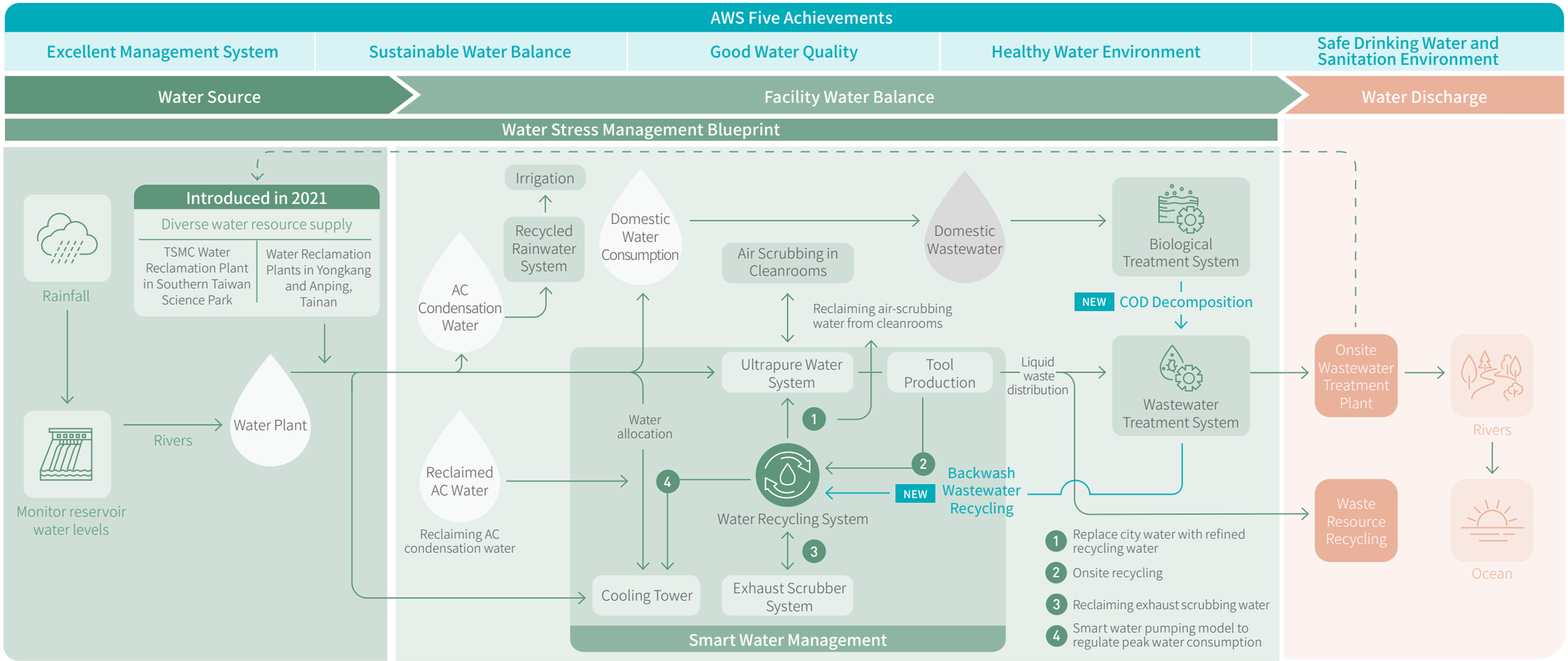
Water Management

- Establish emergency response procedures
- Develop diverse water sources
- Recycle and reuse water
- Set water pollution composite indicator

Effective Water Management with AWS

The Alliance for Water Stewardship (AWS) sets the global standard for sustainable water management. TSMC became the first semiconductor company in the world to receive Platinum Certification when Fab 6 and Fab 14B were certified. Other TSMC fabs are using the "smart copy" technique to earn AWS certifications as well. In 2020, Fab 15A and Fab 15B broke records again by obtaining Platinum Certifications from AWS. In 2021, TSMC will be focusing on certifications for Hsinchu facilities including Fab 12A, Fab 12B, Fab 5, and Advanced Backend Fab 3.

Water Balance and Supply Chain Environmental Relationship Chart



As a result of climate change, 2020 was the first year without typhoons since 1964. Without typhoons, the reservoir watershed experienced a sharp decline in rainfall collection. TSMC deployed a blueprint for water stress management to monitor water levels in various reservoirs and adopted a water balance chart to take stock of water conservation measures. In May 2020, when the drought monitoring signal changed from blue to green (indicating fairly severe drought conditions), TSMC immediately established a Drought Emergency Response Team to monitor water sources and water truck capacities and reduce water consumption by 5%. Water levels remained low until November 2020, during which TSMC decided to further reduce water consumption by 7%. Smart water recycling management mechanisms were activated to allocate reclaimed water to TSMC facilities and increase water efficiency.

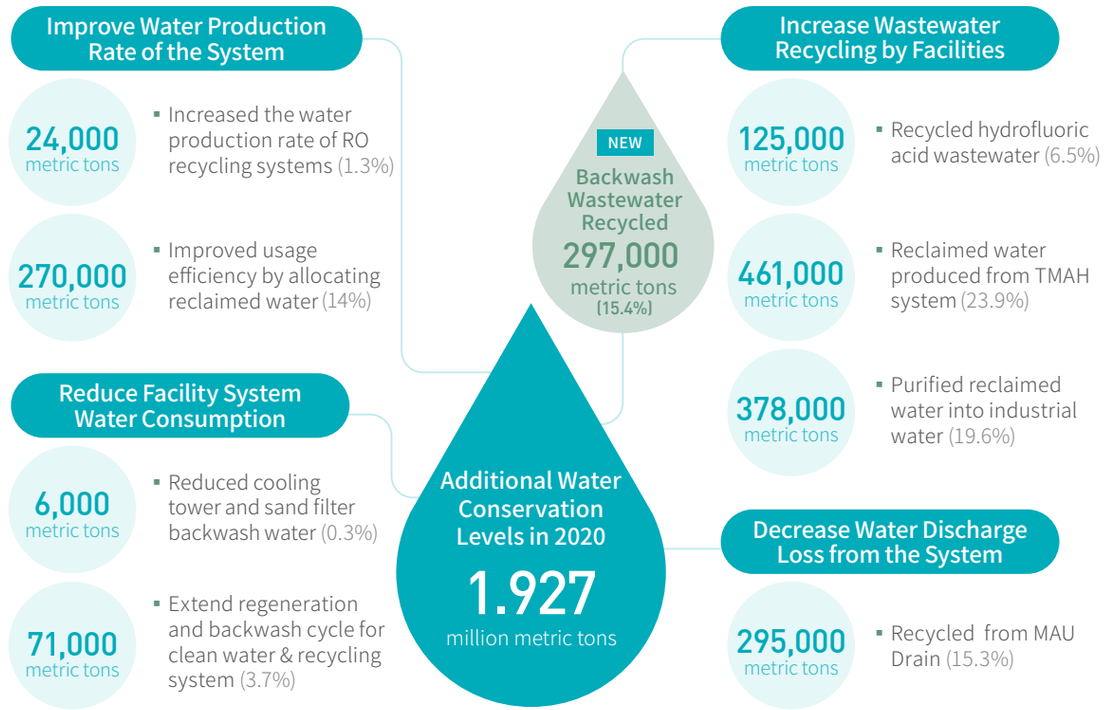
Drought Contingency Measures

Government		TSMC
Drought Monitoring Signal from the Water Resources Agency	Government Response Measures	Response Measures
Blue Normal water levels	Stabilize supply and demand	Monitor WRA reservoirs supplying water to TSMC facilities and regularly host drills
Green Fairly severe	Encourage farmers to suspend farming	Drought Emergency Response Team begins to monitor water sources/water truck capacities and reduce water consumption by 5%.
Yellow First stage	Suspend water supply for irrigation in certain areas for specific times	Perform Water truck drills Reduce water consumption by 7%
Orange Second stage	Reduce water supply to industrial users by 5-20%	Activate water trucks Reduce water supply by 5-20% Reduce water consumption by 7-20% (Not initiated in 2020)
Red Third stage	Ration water by district	

Strengthen Water Management & Increase Water Recycling

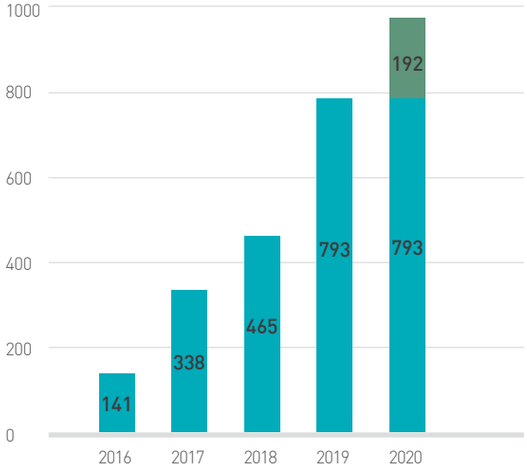
The four major water conservation measures at TSMC are to "Reduce Facility System Water Consumption, Increase Wastewater Recycling of Facilities , Improve Water Production Rate of the System, and Decrease Water Discharge Loss from the System ". These four measures are integrated with the three water management processes of "Water Supply Diversity, Water Efficiency Management, and Wastewater Resource Recycling". TSMC strives to uncover more opportunities to conserve water and has developed 38 distribution systems based on the composition and concentration of wastewater from fabrication for wastewater classification and resource management. Equipment is then used to decompose pollutants and increase water recycling. With 9 recycling systems and 13 wastewater facilities, TSMC has been able to develop 10 renewable materials as of 2020.

Water Conservation Measures & Achievements in 2020



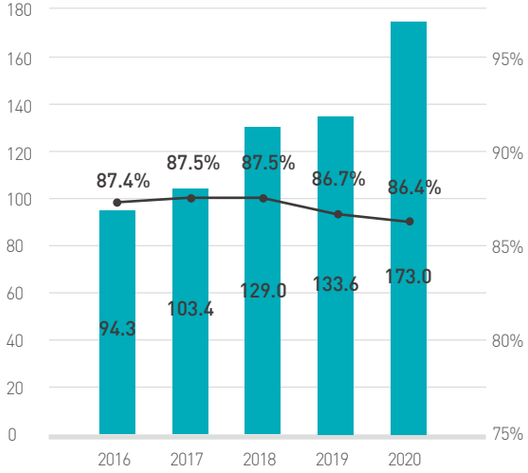
Wafer unit water consumption continues to increase due to stricter requirements for clean water from advanced processes and optimized operations. TSMC is implementing our four water conservation measures to increase water sources and reduce water consumption, but we continue to seek other opportunities to conserve water. In 2020, TSMC launched a backwash wastewater recycling system and was able to conserve 297,000 metric tons of water, further increasing water conservation levels in 2020 to 1.927 million metric tons, and reducing wafer unit water consumption to 128.4 (L/12-inch equivalent wafer mask layer). TSMC was able to achieve an 8.9% reduction from the base year but was unable to meet our annual target. In 2021, the TSMC Tainan Science Park Reclaimed Water Plant will become operational and it is expected to reduce TSMC's demand for city water. In 2020, the wafer unit wastewater discharge was 86.0 (L/12-inch equivalent wafers mask layer), which was a 3.9% reduction from last year. This indicates that our four water conservation measures are effective in reducing pollutant concentration and increasing water recycling.

Annual Water Conservation



- Annual Cumulative Water Conserved (ten thousand metric tons)
- Annual Additional Water Conserved (ten thousand metric tons)

Water Recycling and Usage Efficiency

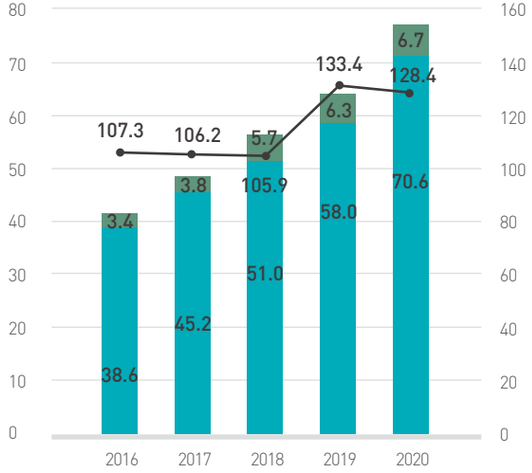


- Average process water recycling rate (%)
- Total amount of water recycling (million metric tons)

Note 1: Total amount of water recycled includes numbers from manufacturing process water treatment and recycling as well as manufacturing process water recycling in scrubber towers

Note 2: Total volume of water recycled and average recycling rate of water for manufacturing processes are calculated with data from TSMC facilities in Taiwan, WaferTech, TSMC (China), TSMC (Nanjing) and VisEra

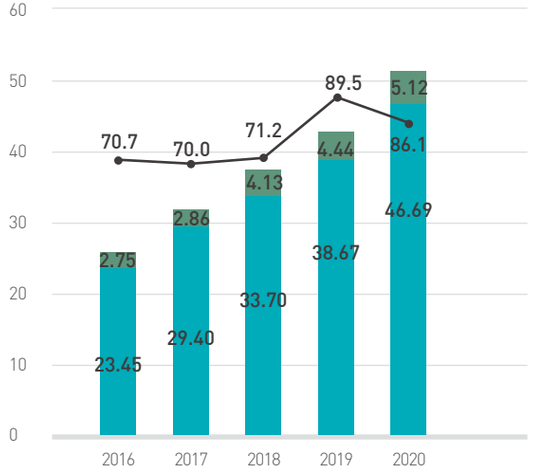
City Water Consumption and Water Consumption per Wafer-Layer



- Water consumption per wafer-layer (Liter/12-inch equivalent wafer mask layer)
- Total city water consumption of Taiwan facilities (million metric tons)
- Total city water consumption of subsidiaries (million metric tons)

Note: City water consumption and unit water consumption intensity index are calculated with data from TSMC facilities in Taiwan, WaferTech, TSMC (China), TSMC (Nanjing) and VisEra

Wastewater Discharge per Unit Product



- Wafer mask unit wastewater (Liter/12-inch equivalent wafer mask layer)
- TSMC Wastewater (million metric tons)
- Subsidary Wastewater (million metric tons)

Note: Wastewater discharge and unit wastewater intensity index are calculated with data from TSMC facilities in Taiwan, WaferTech, TSMC (China), TSMC (Nanjing) and VisEra

Develop Diverse Water Sources

Cyclical Water Resources & Developing Reclaimed water

As a leading global semiconductor company, TSMC began investing in water reclamation technologies in 2015 by coordinating with government agencies to develop domestic wastewater recycling processes that meet water quality standards and establish industrial wastewater recycling facilities. In 2019, bidding for TSMC Tainan Science Park Reclaimed Water Plant opened successfully and in 2020, construction commenced and wastewater supply network designs within the park began. In 2021, we expect the water plant to supply ten thousand metric tons of reclaimed water per day. The water plant will help reduce city water consumption, make strides toward water recirculation, and develop diverse water sources.

Fab 18A biological treatment system.

Milestones in Water Reuse

Procurement, Tenders and Project Collaboration

- Collaborate with partner firms for the establishment of water reclamation plant
- Participate in the promotion of reclaimed water in Taiwan with the Construction and Planning Agency of the Ministry of Interior, the Water Resources Agency of the Ministry of Economic Affairs, and the Water Resources Bureau of the Tainan City Government

Construct Water Reclamation Plant and Supply Water

- Construct domestic water reclamation plant and supply water
- Construct industrial water reclamation plant and supply water

2019

- Collaborated with Southern Taiwan Science Park Management Department to build the TSMC Tainan Science Park Reclaimed Water Plant
- Commenced construction of water reclamation plant in Yongkang, Tainan

2020

- Construction contract signed for TSMC Tainan Science Park Reclaimed Water Plant
- Wastewater supply network and construction of the Tainan Science Park Reclaimed Water Plant

2021

- Supply 5,000 tons/day of water from the water reclamation plant in TSMC Tainan Science Park Reclaimed Water Plant
- Supply 5,000 tons/day of water from the water reclamation plant in Yongkang, Tainan

2022

- Increase water supply from the TSMC Tainan Science Park Reclaimed Water Plant to 10,000 tons/day
- Supply TSMC with 5,000 tons/day of water from the water reclamation plant in Yongkang, Tainan
- Supply TSMC with 10,000 tons/day of water from the water reclamation plant in Anping, Tainan

2023

- Increase water supply from the TSMC Tainan Science Park Reclaimed Water Plant to 20,000 tons/day
- Increase water supply for TSMC from the water reclamation plant in Yongkang, Tainan to 9,500 tons/day
- Supply TSMC with 10,000 tons/day of water from the water reclamation plant in Anping, Tainan

2024

- Supply 20,000 tons/day of water from the water reclamation plant in TSMC Tainan Science Park Reclaimed Water Plant
- Supply TSMC with 9,500 tons/day of water from the water reclamation plant in Yongkang, Tainan
- Increase water supply for TSMC from the water reclamation plant in Anping, Tainan to 37,500 tons/day

Total Water Supply from the Tainan Science Park Reclaimed Water Plant

67,000

(metric tons/day)

TSMC Water Reclamation Plant Progress

Jun

Water Reclamation Plan Groundbreaking Ceremony

Sep

Concrete Pouring for Ground-Level Walls

Dec

Rebar Works

Note: Water supply schedule and volume for 2021 and thereafter are calculated from reclaimed water consumption contracts between TSMC and government departments agencies (Southern Taiwan Science Park Administration and Tainan City Government).

Develop Preventive Measures

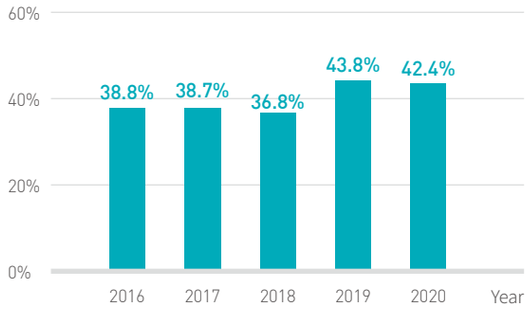
Reduce Pollutant Concentration in Effluents

As a leader in the global semiconductor industry, TSMC is working on developing a variety of measures for water pollution prevention to mitigate impact on the environment caused by TSMC operations. Suspended solids, ammonia nitrogen, and copper ion are key pollutants that were reduced to legally required effluent standards ahead of schedule in 2018 and 2019. In 2020, Tetramethylammonium hydroxide (TMAH) concentration was reduced to 6.3ppm but failed to achieve the 2020 target despite a 20% reduction from the previous year. TSMC is working to reduce TMAH concentration by developing low-concentration TMAH recycling and anion adsorption technologies. COD reduction is more difficult to achieve because evolving fabrication processes have increased demand for organic compounds. TSMC hopes to develop biological treatment systems that can help achieve 100ppm by 2025.

Water Pollution Composite Indicator

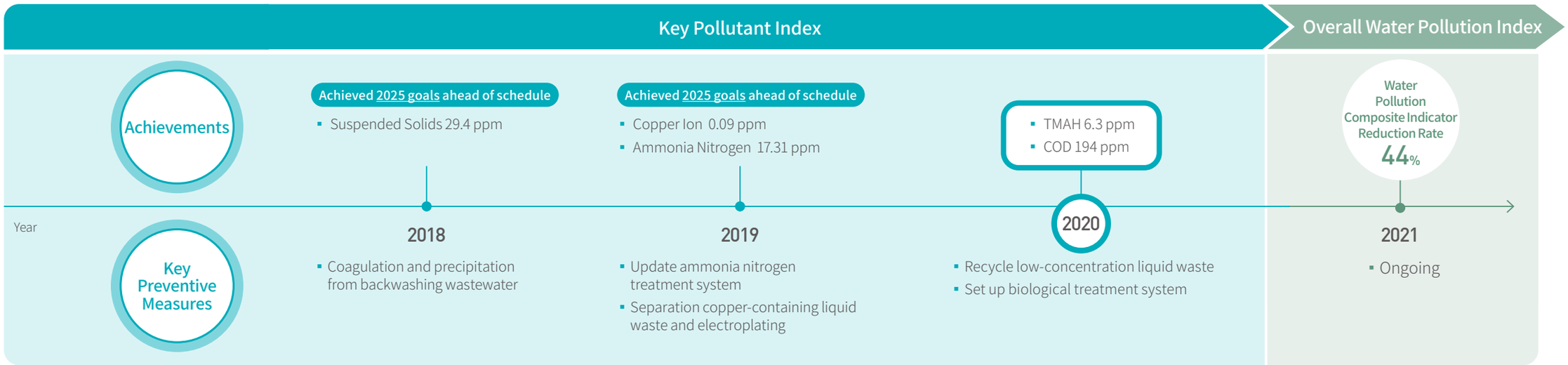
For a comprehensive insight into the environmental impact of effluent pollutants, TSMC has developed a water pollution composite indicator based on eight major pollutants. The indicator is capped by legal effluent standards and serves as a key indicator in reducing and preventing pollutant concentration in effluents. In response to evolving fabrication processes and increased demand for chemicals, TSMC will continue to develop its own membrane bioreactor system and has increased reduction goals in 2030 from 30% to 50%. In 2020, the Water Pollution Composite Indicator was reduced by 42.4%, exceeding the 20% target of the year.

Water Pollution Composite Indicator Reduction



Note: Data includes Taiwan Facilities.

Preventive Techniques on Key Pollutants of Wastewater Quality



Wastewater Classification and Resource System

	38 Different Types of Liquid Classified	9 Recycling Systems	13 Types of Wastewater Treatment	10 Products Recycled
Hydrofluoric (HF) Acid Wastewater	▪ HF acid wastewater (2 types) ▪ Ozone-containing HF acid wastewater ▪ Manufacturing process scrubbing water	▪ Hydrofluoric (HF) acid wastewater ▪ Local scrubber wastewater recycling	▪ Chemical coagulation treatment of HF acid ▪ HF (including ammonia) treatment ▪ Biological treatment of HF acid wastewater	▪ Calcium fluoride ▪ Fluorite
Acidic, Caustic, and Organic Wastewater	▪ Deionized water ▪ Ozone-containing deionized water ▪ Acidic wastewater (2 types) ▪ Ozone-containing acidic wastewater ▪ Caustic wastewater ▪ Ozone-containing Caustic wastewater ▪ TMAH wastewater ▪ Organic wastewater (2 types)	▪ Acidic wastewater recycling ▪ Ozone-containing acidic wastewater recycling ▪ Caustic wastewater recycling ▪ Caustic wastewater upcycling ▪ Organic wastewater recycling	▪ Acidic and Caustic wastewater treatment ▪ NH_4-N wastewater treatment and recycling ▪ TMAH liquid waste recycling ▪ Biological treatment system for organic wastewater	▪ Ammonium sulfate ▪ Ammonia water ▪ Gypsum ▪ TMAH
CMP Wastewater	▪ Electroplating wastewater ▪ CMP wastewater (2 types) ▪ Copper-containing CMP wastewater ▪ Cobalt-containing CMP wastewater	▪ Chemical coagulation recycling of CMP wastewater ▪ Copper-containing CMP wastewater upcycling	▪ CMP wastewater treatment ▪ Copper-containing CMP wastewater treatment ▪ Cobalt-containing CMP wastewater treatment	▪ Silicon slurry NEW
High-concentration Liquid Waste	▪ Waste sulfuric acid ▪ Waste copper sulfate ▪ Cobalt-containing liquid ▪ Other wastewater (16 types)		▪ Waste-H_2SO_4 reclamation ▪ Copper-containing electroplating wastewater recycling ▪ Cobalt-containing electroplating wastewater recycling	▪ Sulfuric acid ▪ Copper bar ▪ Cobalt bar

Note 1: TMAH stands for Tetramethylammonium hydroxide
Note 2: Among these recycled products, sulfuric acid and electronic grade coating copper are reused on TSMC sites, while the rest are reused externally by other industries
Note 3: Introduced silicon slurry recycling in 2020

Case Study

Track Distribution in High-concentration Organic Matter Processes to Reduce COD Emissions > 90%

Semiconductor manufacturing technology continues to advance, increasing the demand for organic compounds as well as increasing COD levels in effluents. To improve water quality, TSMC has designed a distribution system to collect advanced organic wastewater (AOR) and monitor equipment that emit high-concentration organic compounds. TSMC has been able to reduce COD concentration by more than 90% through adjusting organic compound emission parameters on equipment. Organic wastewater from semiconductors requires a more complex biological treatment than regular organic wastewater. TSMC invested labor and resources to sustain our environment, successfully developing a membrane bioreactor system applicable to semiconductor manufacturing to further reduce COD levels.

Developing Hydro luoric Acid Wastewater Membrane Bioreactor System to Reduce COD

The membrane bioreactor system is a key technology that resolves previous problems with organic wastewater. However, the system requires a large area and the process faces problems with clogging from biological thin films as the organic wastewater from semiconductor fabrication contains hydrofluoric acid. As such, TSMC is working to develop a membrane bioreactor system applicable to semiconductor manufacturing. High-concentration organic wastewater sources are first identified and channeled into the membrane bioreactor system to reduce the size of the system and ensure the system can be placed within fabs. Organic wastewater containing hydrofluoric acid will undergo reverse osmosis to increase fluoride ion levels, increase efficiency gain with calcium fluoride, and contain calcium carbonate levels (water hardness) below 300 ppm. An automatic thin film pickling device is also designed so that bacteria can adhere to the permeable membrane for better performance, reduced clogging, and water recycling.

In 2020, Fab 18A successfully used a distribution tracking to improve machinery emission parameters and reduce COD emission concentration to 150 ppm with the help of TSMC's unique membrane bioreactor system. Fab 18A accomplished a major milestone for new fabs and its processes will become the design standard for future fabs. We are also advancing our biological treatment of organic wastewater to drive green manufacturing, and expect to achieve <100 ppm in COD emissions by 2025.

COD Treatment Process