UWR Rainwater Offset Unit Standard

(UWR RoU Standard)

Concept & Design: Universal Water Registry

www.uwaterregistry.io

Project Concept Note & Monitoring Report

(PCNMR)

Project Name: Wastewater Treatment and Reuse for Member Textile Industries by Chinnakkarai CETP

UWR RoU Scope: 5

Monitoring Period: 01/01/2021-31/12/2024

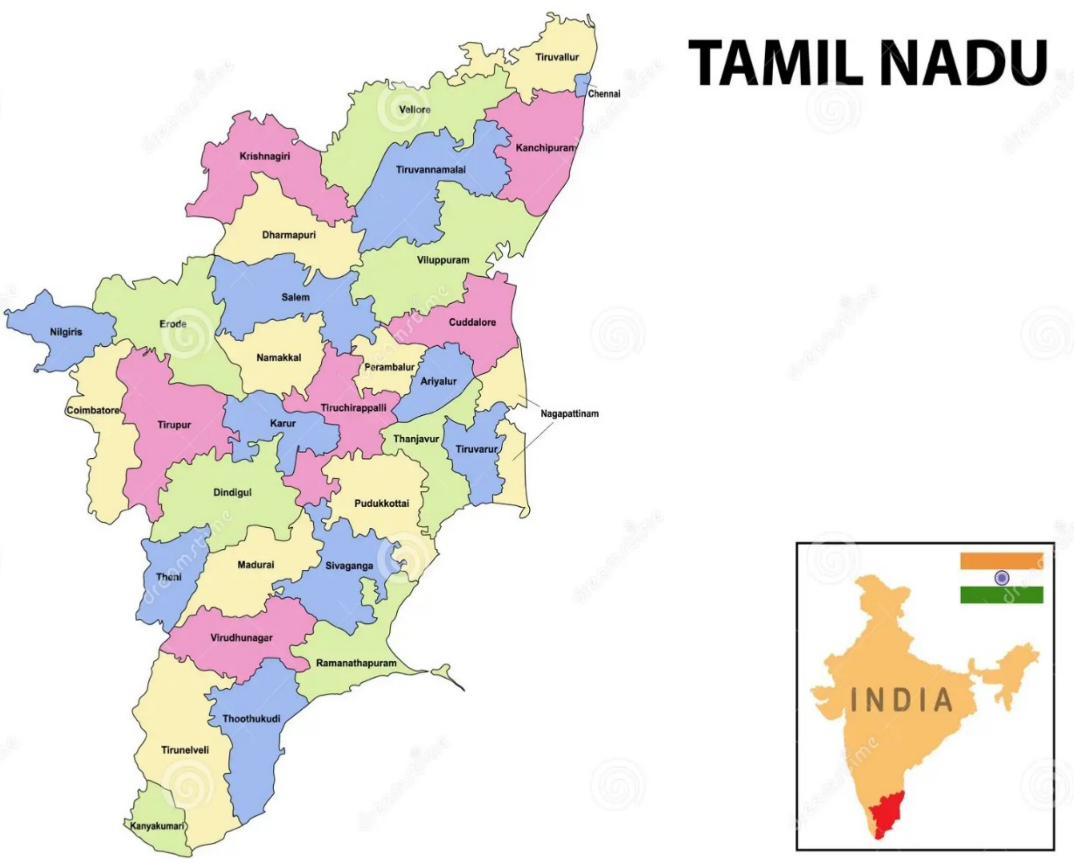
Crediting Period: 01/01/2021-31/12/2024

UNDP Human Development Indicator: 0.644 [1](India)

[1] https://www.undp.org/

A.1 Location of Project Activity

State	Tamil Nadu
District	Tirupur
Block Basin/Sub Basin/Watershed	Noyyal River Basin http://cgwb.gov.in/watershed/basinsindia.html
Lat. & Longitude	11.064413, 77.3271706
Area Extent	2.5 acres (CETP premises)
No. of Villages/Towns	Kuppandampalaym, Veerapandi



A.2. Project owner information, key roles and responsibilities

Project Proponent (PP):	**Chinnakkarai Common Effluent Treatment Plant Private Limited**
UCR Project Aggregator	Viviid Emissions Reductions Universal Private Limited
Contact Information:	lokesh.jain@viviidgreen.com

Chinnakkarai Common Effluent Treatment Plant Private Limited operates an integrated Common Effluent Treatment Plant (CETP) with a treatment capacity of 8 million litres per day (MLD). The facility was first commissioned on 13th January 1999 and serves 31 member industrial units, ensuring responsible and sustainable water management.

The project participant holds both exclusive water user rights within the defined project boundary and the legal land title for the project site, which spans 7.54 acres. These rights facilitate full control over water resource utilization and infrastructure development.

With a total capital investment of ₹55.88 Crores, the project covers all critical components, including construction, equipment procurement, permitting, and operational setup. The company has secured all required approvals from relevant regulatory bodies, demonstrating full compliance with applicable environmental and industrial regulations.

This project activity underscores a strong commitment to sustainable water reuse and treatment, aligning with national legal frameworks and environmental standards.

A.2.1 Project RoU Scope

PROJECT NAME	**Wastewater Treatment and Reuse for Member Textile Industries by Chinnakkarai CETP**
UWR Scope:	Scope 5: Conservation measures taken to recycle and/or reuse water, spent +washing wastewater etc. across or within specific industrial processes and systems, including wastewater recycled/ reused in a different process, but within the same site or location of the project activity. Recycled wastewater used in off-site landscaping, gardening or tree plantations/forests activity are also eligible under this Scope.
Date PCNMR Prepared	25-06-2025

A.3. Land use and Drainage Pattern

- **Land Use:** The CETP is constructed on industrial-use land and occupies a secured, fenced plot with no encroachment on agricultural or forest land.

- **Drainage Pattern:** The entire plant is constructed with impervious flooring to prevent leaching. Effluent flows through a closed-loop pipeline system, ensuring there is no interaction with natural drainage. The design prevents both surface runoff and groundwater percolation, adhering to TNPCB norms.

This project activity involves treating and reusing wastewater. It doesn't include any land-use practices. Also, this is an industrial process designed with technical requirements and following the specified norms of the local pollution control board. Hence, the project activity does not harm any land and Drainage system**.**

A.4. Climate

The operations of the CETP are fully mechanized and located within a covered plant infrastructure. Thus, weather conditions such as temperature and humidity do not impact the process.

All treatment units (biological, filtration, RO, evaporation) function independently of climatic variables. Hence, operational consistency is maintained year-round.

A.5. Rainfall

The Annual Average Rainfall is ~754 mm, spread unevenly over ~35 rainy days per year. The facility is designed for effluent treatment and is not dependent on rainwater. Rainwater harvesting is not integrated into this facility as water is derived from industrial operations. Proper drainage channels are installed to prevent rainwater ingress into effluent channels.

A.6. Ground Water

The CETP does not have borewells or any other means of drawing groundwater. By recycling 90% of wastewater, the CETP significantly reduces pressure on local aquifers. Prevents the common industry practice of extracting groundwater for dyeing operations.

A.7. Alternate methods

The selection of the Zero Liquid Discharge (ZLD) system for the Chinnakarai Common Effluent Treatment Plant (CETP) was the result of a comprehensive evaluation of local geographic, climatic, and hydrological conditions. The project site is located in Tirupur, a region characterized by semi-arid topography, erratic rainfall, and significant stress on both surface and groundwater resources. The terrain is largely undulating and lacks robust natural drainage systems, especially during the dry season. As a result, traditional disposal or dilution-based methods of effluent management were deemed inappropriate for the area.

Rainfall in Tirupur averages around 754 mm annually, but it is highly seasonal and concentrated within a few weeks of the year, leading to negligible natural recharge of water bodies or aquifers. Furthermore, the hydrogeological profile of the region indicates over-exploited aquifers with shallow, brackish, or saline groundwater. Most of the groundwater extracted in this area is already considered unsuitable for industrial or domestic use without treatment. Continued abstraction would only aggravate water table depletion and salinity intrusion, making it an unsustainable source for any effluent dilution or disposal system.

Surface water options were also considered. However, the Noyyal River, which flows close to the Chinnakarai industrial cluster, has historically been a recipient of untreated or partially treated effluent, leading to heavy pollution loads, ecological degradation, and civic protests. Environmental regulations now prohibit any form of surface discharge into the river or its tributaries. This context rules out surface discharge as a viable or legal option, even for treated water.

Alternative strategies such as marine discharge, where treated effluent is transported to the sea via pipeline for dispersion, were examined. However, the nearest coastline is over 250 kilometres away, and the high capital investment, energy requirements, and right-of-way challenges make this method logistically and economically unfeasible for a cluster-scale project like Chinnakarai CETP. Additionally, the environmental risks associated with large-scale marine disposal further limit its acceptability under Tamil Nadu Pollution Control Board (TNPCB) guidelines.

Historically, member dyeing units used solar evaporation pans for effluent disposal. Although simple in concept, this method has led to severe environmental damage in the past. The open pans require significant land area, often leak salts into the soil, and can overflow during rainfall events, causing localized contamination and community health risks. TNPCB has explicitly discouraged this method and issued closure notices to several non-compliant units.

Given these constraints, the ZLD method was selected as the most technically sound and environmentally sustainable solution for managing the high-TDS effluent generated by the 31 member dyeing units. ZLD integrates physical, biological, and advanced membrane technologies to ensure over 90% water recovery, with the remaining concentrate managed through evaporation and crystallization. The recovered water is reused within the member units, significantly reducing their dependency on freshwater sources, while sodium sulphate salts are recovered and reused in the dyeing process, creating a closed-loop system.

This decision aligns with Tamil Nadu's mandatory ZLD policy for textile clusters and ensures full compliance with environmental norms. The choice was supported by feasibility studies conducted by Tamil Nadu Water Investment Company Ltd. (TWIC), which demonstrated that ZLD is both technically viable and economically justifiable in the context of Tirupur's environmental and industrial challenges.

A.8. Design Specifications

The Chinnakarai CETP's Zero Liquid Discharge (ZLD) facility is a technically advanced and environmentally sustainable wastewater treatment solution that caters to the Tirupur textile cluster. It is engineered to treat up to 8.0 million litres of industrial effluent daily, sourced from 31 member dyeing units. The system integrates biological pretreatment, high-recovery membrane separation via reverse osmosis (RO), thermal evaporation through multiple-effect evaporators (MEE) and mechanical vapour recompression (MVR), and final salt recovery via crystallization and drying. The treated water is reused in industrial processes while salts, primarily sodium sulphate, are reclaimed and reused, thus fulfilling the principle of complete water loop closure. This section elaborates each technical component and its specifications in a structured format.

Effluent Conveyance:
Effluent is conveyed from all connected member units to the CETP through an underground network of high-density polyethylene (HDPE) pipelines, with a diameter of 355 mm. These pipelines are designed for chemical resistance and high durability under varying flow conditions. The effluent is received at a central inlet chamber and conveyed to a booster pump sump, which lifts the flow into an equalization tank. This arrangement ensures balanced hydraulic loading into the treatment train. Provision for a parallel 300 mm HDPE pipeline ensures operational redundancy and future scalability. The layout is equipped with isolation valves, inspection chambers, and flow distribution systems to manage dynamic industrial discharge variations.

Pretreatment Section:
Once collected, the effluent undergoes a multi-stage pretreatment process. The equalization tank performs hydraulic and pollutant load balancing. It is followed by a neutralization chamber where pH correction is achieved using lime or acid dosing to maintain the required range of 6.5 to 8.5. This is crucial for protecting downstream membrane systems. Next, the biologically activated aeration tank facilitates the breakdown of biodegradable organic content through microbial oxidation, using fine-bubble diffusers and air blowers. The resulting mixed liquor is settled in a secondary clarifier, which separates suspended solids and microbial sludge. The clarified supernatant then flows through a dual-stage tertiary treatment unit. This unit uses a pressure sand filter to remove fine suspended matter and a resin-based ion exchanger to eliminate turbidity and trace contaminants, thereby ensuring optimum feed quality for the reverse osmosis unit.

Reverse Osmosis (RO) System:
The Reverse Osmosis system is the core of the water recovery process. It comprises two blocks—Block 1 for primary separation and Block 2 for polishing of reject water. Pretreated effluent enters Block 1, where 90–95% of total dissolved solids (TDS), such as sulphates, chlorides, and calcium, are removed. The reject from Block 1 is routed to Block 2, which further reduces salinity and improves water recovery rates. The RO system operates at a design capacity of 8.0 MLD. It uses spiral-wound thin-film composite membranes under an operating pressure range of 12 to 16 bar. The recovery efficiency is 80–85% of the influent. The system is equipped with an online Cleaning-In-Place (CIP) system using acid and alkali solutions for membrane maintenance, along with continuous dosing of antiscalants to minimize fouling. All critical parameters such as pressure, conductivity, and flow rate are monitored in real time through SCADA (Supervisory Control and Data Acquisition).

Multiple Effect Evaporator (MEE):
The reject stream from the RO process, which still contains significant dissolved solids, is treated using a Multiple Effect Evaporator (MEE). The MEE system comprises seven stages of falling film evaporators that function under vacuum. Each stage reuses vapor from the preceding stage to heat the feed in the next stage, significantly improving steam economy. The feed is preheated using a plate heat exchanger to ~55°C before entering the evaporator. Dry saturated steam at 9 kg/cm^2 is used as the primary heat source. The process concentrates the RO reject to a slurry with up to 27% total solids (TDS). The entire MEE unit is constructed using stainless steel grade SS 316L for corrosion resistance and is operated with automated controls for temperature, level, and vacuum, all monitored via SCADA.

Crystallizer and Centrifuge

The concentrated effluent from the MEE is cooled to 40°C and fed into a crystallizer, which is an agitated vacuum vessel operating at a vacuum of approximately 10 Torr. In this vessel, sodium sulphate precipitates out of the solution as crystals. These crystals are separated from the remaining mother liquor in a high-speed centrifuge, yielding salt with approximately 56% moisture content. This semi-dry salt is reusable by the dyeing units, thereby closing the salt recovery loop. The crystallizer is equipped with a three-stage ejector system for vacuum generation and operates using cooling water condensers.

Secondary Evaporation – Double Effect + Forced Circulation

The mother liquor that remains after crystallization, typically containing around 15% TDS, undergoes further evaporation using a combination of a double-effect falling film evaporator and a single-effect forced circulation evaporator. This unit further concentrates the mother liquor to 50% solids. The resulting residue is directed to a solar pond for passive evaporation. Any residual semi-solid sludge from the pond is fed into a fluidized bed dryer, which uses heated air to reduce the moisture content to less than 2%. The dried product—Glauber's salt—is recovered at a rate of approximately 33 tons per day and reused directly in the textile dyeing process. This advanced recovery approach eliminates hazardous salt disposal and supports circular material reuse.

Mechanical Vapour Recompression (MVR)

In addition to the MEE system, the CETP is also equipped with a Mechanical Vapour Recompression (MVR) system as an alternative evaporation method. The MVR unit works by compressing the vapour generated during evaporation using an electrically powered centrifugal fan. This compressed vapour is then used as a heating medium, thereby reducing or eliminating the need for external steam. The MVR unit uses polymeric heat transfer surfaces that are corrosion-resistant and minimize scaling. It operates under vacuum at around 55°C and delivers energy performance equivalent to a 40-stage conventional evaporation system. The integration of MVR into the evaporation scheme significantly lowers operating costs and enhances energy efficiency by reducing steam consumption by more than 50%.

Treated Water Reuse

Treated water recovered from RO permeate and MEE/MVR condensate is stored in a treated water tank and redistributed to the dyeing units via HDPE pipelines. These pipelines are fitted with electromagnetic flow meters and manual sampling points to ensure traceability and quality assurance. The water meets reuse specifications with TDS levels below 300 ppm and a pH range of 6.5 to 7.5. Multi-stage centrifugal pumps with variable frequency drives (VFDs) are used for distribution. Over 90% of the effluent volume is effectively recycled and reused in industrial processes, significantly reducing the dependency on freshwater abstraction.

The Chinnakarai CETP stands as a model of industrial wastewater management, offering a technically integrated and operationally efficient ZLD facility. With its advanced reverse osmosis, thermal evaporation, vapour recompression, and crystallization systems, it meets Tamil Nadu Pollution Control Board's ZLD mandates and exemplifies best practices in circular water economy. It is scalable, replicable, and represents a sustainable pathway for effluent-intensive industrial clusters across India and beyond.

A.9. Implementation Benefits to Water Security

The implementation of the Zero Liquid Discharge (ZLD) system at Chinnakarai CETP brings substantial benefits to water security in the Tirupur region. The system has been designed to handle and treat up to 8.0 MLD of high-TDS effluent generated by 31 textile dyeing units. Through a closed-loop treatment process involving biological treatment, tertiary filtration, membrane separation via reverse osmosis, and thermal concentration using a multi-effect evaporator and crystallizer, more than 90% of the treated water is recovered and reused. This translates into an annual recovery of approximately 2.4 million kilolitres of water, which would otherwise have been sourced from over-exploited aquifers or surface water bodies.

In the absence of this CETP, industrial units historically relied heavily on borewell water for their operations. This pattern of unsustainable abstraction had led to rapid groundwater table depletion in the Tirupur region. By introducing a reliable and high-quality recycled water supply, the CETP has helped eliminate borewell dependency among its member units, thereby conserving local aquifers and supporting regional water security.

Additionally, the ZLD system recovers salts primarily sodium sulphate from the effluent stream. This not only reduces the environmental burden associated with chemical procurement and disposal but also creates a secondary resource stream that supports circular industrial practices. On average, 200–300 kg/day of reusable salt is recovered and returned to the dyeing process.

The facility also enhances regional resilience to climate variability. Given Tirupur's semi-arid climate and irregular rainfall, the availability of consistent recycled water throughout the year ensures that textile operations are not interrupted due to water shortages. The system operates independently of rainfall, unlike recharge wells or surface water tanks, making it a robust drought-proofing strategy.

In conventional recharge-based water security models, large-scale deployment of recharge wells, check dams, or injection bores would be required to compensate for industrial water consumption. Assuming a recharge capacity of 500 KL/year per recharge well (based on local hydrogeology), the CETP's reuse of ~2.4 million KL/year equates to the functional equivalent of constructing and maintaining nearly 4,800 such artificial recharge wells. Thus, the CETP represents an engineered substitute for thousands of traditional recharge structures, offering more efficient, controlled, and verifiable outcomes.

The water security benefits are not limited to quantity alone. By preventing untreated or semi-treated effluent from being discharged into the Noyyal River, the project safeguards downstream surface water quality. This not only protects aquatic ecosystems but also improves water availability for domestic, agricultural, and other industrial users.

Finally, from a socio-economic standpoint, the ZLD system provides employment to over 40 personnel and has led to capacity building through training in water treatment technologies. This human capital development supports the long-term sustainability of the water security initiative.

A9.1 Objectives vs Outcomes

The primary objective of the Chinnakarai CETP ZLD project was to establish an environmentally compliant, technically robust, and economically feasible model for complete effluent treatment and reuse within a cluster of small- to medium-scale textile dyeing units in Tirupur. The intention was to mitigate groundwater depletion, eliminate surface water pollution, and reduce dependency on freshwater sources by integrating a closed-loop water reuse system. The project also aimed to demonstrate the feasibility of salt recovery (particularly sodium sulphate) from industrial effluent and reintegrate it into the production process, thereby creating a circular economy for critical raw materials.

Prior to the implementation of the CETP, member dyeing units relied heavily on groundwater extraction via borewells and disposed of partially treated effluents in solar evaporation pans. These pans often overflowed during the monsoon or led to subsurface salt contamination due to prolonged exposure and percolation. The absence of a centralized, reliable treatment and recovery system led to widespread non-compliance with TNPCB discharge norms, deterioration of groundwater quality, and a negative environmental image for the region.

Post-implementation, the Chinnakarai CETP achieved over 90% water recovery using a multi-stage ZLD system. This includes biological pretreatment, reverse osmosis for membrane-based separation, and thermal concentration with crystallization. The recovered water is supplied back to the member dyeing units through a dedicated pipeline for direct reuse in dyeing and finishing operations. This has completely eliminated the need for groundwater extraction among the member industries.

Furthermore, the recovered sodium sulphate extracted in the crystallization stage is reused as a dyeing chemical by the same member units. This has reduced their reliance on commercially purchased salts and closed the material loop for one of the largest chemical inputs in the textile process.

A significant outcome of the project is the creation of an engineered, verifiable substitute for conventional recharge structures. With approximately 2.4 million kilolitres of water reused annually, the system provides the same water replenishment benefit as nearly 4,800 traditional recharge wells. Unlike such traditional methods, the CETP enables continuous, quantifiable, and quality-controlled water reuse that is independent of rainfall.

Socially, the CETP has created a replicable and inclusive water security model. Over 40 personnel are employed for its operations, including roles in process management, instrumentation, laboratory analysis, and administration. Capacity-building programs have improved technical skills and environmental awareness among plant operators and member unit staff.

The Chinnakarai CETP has now emerged as a benchmark for other clusters in Tirupur and across India, demonstrating how collective action, appropriate technology, and compliance-driven design can transform water-intensive industries from major polluters into stewards of water security.

A9.2 Interventions by Project Owner / Proponent / Seller

In order to address the growing environmental and water security challenges in the Tirupur textile cluster, the Project Proponent, in collaboration with Tamil Nadu Water Investment Company Ltd. (TWIC), implemented a series of integrated interventions leading to the successful commissioning and operation of the Chinnakarai CETP with Zero Liquid Discharge (ZLD) capability.

Initially, extensive stakeholder consultations were held among member dyeing units to understand their operational pain points, especially the unsustainable reliance on groundwater and the environmental risks posed by evaporation pans and illegal discharges. These discussions led to the formation of TIWWRCL as a collective SPV, enabling shared ownership and responsibility.

A detailed hydrogeological and environmental assessment of the Tirupur region was conducted by TWIC, which confirmed severe aquifer depletion, high TDS in groundwater, and the ineffectiveness of decentralized treatment models. This reinforced the need for a centralized, technically advanced treatment infrastructure. The findings informed the preparation of a Detailed Project Report (DPR), which included process flow designs, effluent load modelling, and financial feasibility analysis.

To ensure water conservation and reuse, a comprehensive water budget for the industrial cluster was developed. This budget considered daily effluent generation, seasonal fluctuations in production, potential for RO permeate reuse, and the quantity of recoverable salts. Based on these insights, an 8.0 MLD ZLD system was proposed and accepted by stakeholders.

For successful implementation, multiple capacity-building sessions were held for member unit operators and plant staff. These included training on source segregation of effluent, consistent pH and TDS monitoring at discharge points, and standard operating procedures for pumping, filtration, and chemical dosing. Awareness was also built around the environmental and cost-saving benefits of reusing both water and salt, which improved long-term buy-in and compliance.

Infrastructure-wise, the CETP was equipped with corrosion-resistant HDPE pipelines for both effluent inflow and treated water outflow. Flow meters and SCADA-enabled automation were installed to ensure accurate measurement and remote tracking of water volumes, supporting transparency and RoU verification. Interventions were also made in sludge handling and salt crystallization, enabling cleaner recovery and reuse of sodium sulphate.

Financially, the project was made viable through a combination of member contributions, bank financing, and operational cross-subsidies. Each member unit committed to monthly service charges linked to volume processed, ensuring sustainability of operations and maintenance.

Post commissioning, regular audits and lab tests were initiated to verify compliance with TNPCB norms. Additionally, lessons learned were documented and shared with other CETPs in the region to promote replication.

These coordinated interventions covering technical design, stakeholder engagement, operational capacity-building, and regulatory alignment have enabled the CETP to function as a fully circular, high-efficiency wastewater treatment and reuse system. The outcomes align closely with national water policy goals and provide a replicable model for industrial water sustainability in India.

A.10. Feasibility Evaluation

The feasibility of implementing the Zero Liquid Discharge (ZLD) project at Chinnakarai CETP was comprehensively evaluated by Tamil Nadu Water Investment Company Limited (TWIC) through a series of technical, financial, and environmental assessments. These evaluations formed the basis of the Detailed Project Report (DPR) and were also cross-referenced during third-party appraisals and funding decisions.

Economically, the project was found to be highly viable due to several interlinked factors. First, the consistent availability of industrial effluent from 31-member dyeing units guaranteed a continuous feed for the CETP, ensuring full utilization of installed capacity. The high volume of effluent and the potential for up to 90% water recovery significantly reduce the dependency on freshwater abstraction. This results in substantial cost savings for the member units, who otherwise relied on commercially extracted borewell water or private tanker supplies, both of which are costly and environmentally unsustainable.

Secondly, the reuse of recovered Sodium Sulphate salt within the dyeing process offers direct economic benefits. This reduces the need for procurement of fresh salts, minimizes raw material expenses, and introduces circularity into the production chain. Cost savings from internal salt reuse further strengthen the business case for the project.

From a compliance and regulatory standpoint, the feasibility study highlighted that the proposed ZLD configuration would enable the member industries to comply with Tamil Nadu Pollution Control Board (TNPCB) discharge norms. This helped mitigate the risk of environmental penalties and operational shutdowns due to non-compliance. The inclusion of a crystallizer and a multi-effect evaporator ensured that even the RO reject was processed and that the final discharge was zero, satisfying the legal ZLD mandate enforced in the region.

TWIC's technical assessment included pilot studies and vendor trials to identify appropriate membrane systems, evaporators, and automation controls. These trials confirmed the technical reliability of selected components. Risks such as membrane fouling, sludge management, and brine crystallization were accounted for in the operational and maintenance plans. The project design incorporated redundancy in pumps, instrumentation, and power systems to ensure uninterrupted operations.

Third-party evaluators and financial institutions supported the project’s feasibility, based on expected cash flows from member service charges and the quantifiable cost savings. Furthermore, the project achieved collective buy-in from member units, which ensured shared financial responsibility and risk mitigation through a cooperative model.

The feasibility evaluation determined that the Chinnakarai CETP ZLD project is economically justified, technically sound, and environmentally essential. It provides a sustainable and replicable model for industrial wastewater treatment and reuse, particularly in water-stressed regions like Tirupur. The integrated benefits cost savings, compliance assurance, salt recovery, and ecological protection strongly validate the long-term sustainability of the project. Technology risks mitigated through vendor trials; operational risks handled via trained staff deployment

A.11. Ecological Aspects & Sustainable Development Goals (SDGs):

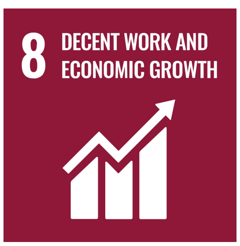
The Chinnakarai CETP ZLD project has been specifically designed to address critical ecological risks historically posed by the textile dyeing industry in Tirupur. These include land inundation due to poor wastewater handling, creation of unhygienic waterlogged areas that support vector-borne diseases, and long-term deterioration of groundwater quality caused by unregulated effluent discharge. The following sections detail how the project mitigates these issues:

- **Inundation of Habitated Land:** Before the commissioning of the CETP, many member units relied on solar evaporation pans and unregulated effluent discharge, often resulting in overflows during peak production or rainy seasons. These overflow events led to localized flooding of adjacent lands, including areas near worker colonies and peri-urban agricultural plots. The treated effluent, being high in TDS and organic matter, posed serious risks to land usability, corroded infrastructure, and limited the safe use of space around industrial zones. The CETP's infrastructure has completely mitigated this issue. All effluent is now collected through a sealed underground HDPE pipeline network and conveyed directly to the treatment plant. There are no open drains or holding lagoons on-site. Additionally, all plant operations take place on impervious concrete flooring with containment bunds, eliminating any risk of seepage or accidental runoff. The ZLD system ensures that 100% of effluent is either recovered as clean water or converted into solid salt, leaving no liquid residuals for disposal. This eliminates the possibility of inundation or flooding of adjacent lands.
- **Creation of Water Logging and Vector Disease Prevention Mitigation:** Previously, member units storing effluent in open solar pans experienced chronic waterlogging, especially during monsoons. Stagnant effluent became breeding grounds for mosquitoes, increasing the incidence of malaria, dengue, and other vector-borne diseases in surrounding worker communities and residential zones. Additionally, the decomposing organic material created foul Odors and encouraged microbial proliferation, leading to poor hygiene and health outcomes. By implementing a mechanized and fully enclosed ZLD process, the CETP prevents the accumulation of any untreated effluent in open areas. There are no collection ponds, sumps, or temporary holding zones exposed to the atmosphere. All water pathways raw effluent, treated permeate, RO reject, MEE condensate are contained within closed pipelines and storage tanks. This infrastructure design ensures there is no stagnation or accumulation of water that could serve as a breeding ground for disease vectors. This has greatly improved sanitation in the industrial zone and surrounding residential areas.
- **Deterioration of Quality of Groundwater:** One of the most pressing environmental challenges in Tirupur has been the degradation of groundwater quality due to industrial effluent seepage. Legacy practices of using solar pans or illegal underground disposal led to the infiltration of untreated high-TDS water into the shallow aquifers. Groundwater tests from the pre-project period showed elevated levels of chlorides, sulphates, TDS, and chemical oxygen demand (COD), rendering water unfit for human consumption or irrigation.

The Chinnakarai CETP directly addresses this issue by eliminating all groundwater discharge and introducing a fully contained treatment loop. The CETP itself abstracts no groundwater for operations. Additionally, the entire facility is constructed with leak-proof flooring and lined sludge beds. The RO reject is processed thermally and crystallized into reusable salts, with no liquid residue released into the subsurface or sewerage systems. Since commissioning, member units have entirely ceased groundwater abstraction, relying instead on recycled permeate and condensate supplied by the CETP. This has helped stabilize the local aquifer both in terms of quantity and quality, and over time, can lead to natural attenuation of existing groundwater pollutants.

The sustainable development attributes attached to the project activity are demonstrated below:

Sustainable Development Goals	SDG Indicator & Description	Project Relevance

Targeted		
	3.9.1: By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination	The PP showcases how recycling and reusing wastewater can prevent depletion of natural water reserves and prevent water scarcity during droughts. The hazardous impact of industrial wastewater is now avoided due to this project. The PP ensures water availability in the nearest to the project location.
	6.3.1: By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally	The PP has showcased recycling and safe reuse of 5500 million liters within the industry during this monitored period, which directly correlates to this indicator 6.3.
	8.5.1 / 8.5.2: By 2030, achieve full and productive employment and decent work for all women and men, including for young people and persons with disabilities, and equal pay for work of equal value	Number of jobs created, and the Number of people trained as part of this project activity.
	13.2.1: Integrate climate change measures into national policies, strategies and planning	Recycling and reusing wastewater is an effective solution for climate change adaptation because it helps mitigate the impacts of droughts, floods, and other extreme weather events that are becoming increasingly common due to climate change due to water scarcity. The quantity of wastewater recycled and reused by the PP is the SDG indicator.

A.12. Recharge Aspects:

NA

A.12.1 Solving for Recharge

NA

Water Budget Component	Typical Estimated Uncertainty (%)	Description
Surface Inflow	1-12%	Typical range of accuracy from meters to minimum delivery accuracy requirements of delivery and diversion measurement devices.
Precipitation	2-20%	Typical range of accuracy from field-level rain gauges to extrapolation of local weather station data
Surface Outflow	1-20%	Typical range of accuracy from meters to estimated outflow relationships
Evapotranspiration	20.00%	Clemmens and Burt, 1997; typical accuracy based on free water surface evaporation coefficient.
Change in Storage	15-25%	Estimated accuracy of change in storage calculation based on field scale water budget calibration to observed water levels.
Deep Percolation	5-30%	Typical range of calculated accuracy from field-scale water budget results (fields ranging from 56 to 125 acres)

A.13. Quantification Tools

Baseline scenario:

The baseline scenario is the situation were, in the absence of project activity, the PP would have one or all of the following options:

a. Installed multiple bore wells within the project boundary which would have depleted the local groundwater resources (aquifers); **and/or**

b. Diverted existing safe drinking water resources from the surrounding residential area; **and/or**

c. Discharged the ETP effluent without further recycling and reuse.

Hence the following baseline scenario is applicable for this project activity:

"The net quantity of treated ETP effluent / wastewater that would be discharged directly into the local drain/sewer without further being recycled and/or reused daily post treatment per year"

The net quantity of treated water used is measured via flow meters installed at the site. The primary set of data records are kept at plant level, managed by the RTECT team (as defined under the Organization Chart under the Appendix 2. Also, for conservative purposes, the working days or operational days have been assumed at 330 days in a year during the 1st monitoring period. However, the number of days is not an influential parameter on RoUs calculation as RoUs are calculated based on the total quantity of treated water being recycled & reused.

CHINNAKKARAI COMMON EFFLUENT TREATMENT PLANT PVT LTD					
Sl. No.	**Month**	**Total quantum of effluent Intake from Member Industries (In KL)**	**RO Permeate**	**Brine**	**RoUs (RO per +Brine) *0.98**
1	Jan-21	37,643	24,467.95	13,175.05	36,890.14
2	Feb-21	51,360	33,384.00	17,976.00	50,332.80
3	Mar-21	60,558	39,362.70	21,195.30	59,346.84
4	Apr-21	50,405	32,763.25	17,641.75	49,396.90
5	May-21	43,217	28,091.05	15,125.95	42,352.66
6	Jun-21	46,361	30,134.65	16,226.35	45,433.78
7	Jul-21	58,938	38,309.70	20,628.30	57,759.24
8	Aug-21	61,002	39,651.30	21,350.70	59,781.96
9	Sep-21	55,345	35,974.25	19,370.75	54,238.10
10	Oct-21	63,035	40,972.75	22,062.25	61,774.30
11	Nov-21	29,965	19,477.25	10,487.75	29,365.70
12	Dec-21	60,139	39,090.35	21,048.65	58,936.22
13	Jan-22	43,953	28,569.45	15,383.55	43,073.94
14	Feb-22	59,901	38,935.65	20,965.35	58,702.98
15	Mar-22	59,660	38,779.00	20,881.00	58,466.80

16	Apr-22	49,261	32,019.65	17,241.35	48,275.78
17	May-22	42,964	27,926.60	15,037.40	42,104.72
18	Jun-22	48,734	31,677.10	17,056.90	47,759.32
19	Jul-22	39,713	25,813.45	13,899.55	38,918.74
20	Aug-22	38,560	25,064.00	13,496.00	37,788.80
21	Sep-22	50,002	32,501.30	17,500.70	49,001.96
22	Oct-22	33,868	22,014.20	11,853.80	33,190.64
23	Nov-22	37,095	24,111.75	12,983.25	36,353.10
24	Dec-22	54,320	35,308.00	19,012.00	53,233.60
25	Jan-23	34,584	22,479.60	12,104.40	33,892.32
26	Feb-23	50,674	32,938.10	17,735.90	49,660.52
27	Mar-23	61,099	39,714.35	21,384.65	59,877.02
28	Apr-23	60,867	39,563.55	21,303.45	59,649.66
29	May-23	50,010	32,506.50	17,503.50	49,009.80
30	Jun-23	50,793	33,015.45	17,777.55	49,777.14
31	Jul-23	52,330	34,014.50	18,315.50	51,283.40
32	Aug-23	44,759	29,093.35	15,665.65	43,863.82
33	Sep-23	54,034	35,122.10	18,911.90	52,953.32
34	Oct-23	57,018	37,061.70	19,956.30	55,877.64
35	Nov-23	39,868	25,914.20	13,953.80	39,070.64
36	Dec-23	60,135	39,087.75	21,047.25	58,932.30
37	Jan-24	40,308	26,200.20	14,107.80	39,501.84
38	Feb-24	57,639	37,465.35	20,173.65	56,486.22
39	Mar-24	58,727	38,172.55	20,554.45	57,552.46
40	Apr-24	57,671	37,486.15	20,184.85	56,517.58
41	May-24	56,079	36,451.35	19,627.65	54,957.42
42	Jun-24	51,428	33,428.20	17,999.80	50,399.44
43	Jul-24	60,695	39,451.75	21,243.25	59,481.10
44	Aug-24	53,853	35,004.45	18,848.55	52,775.94
45	Sep-24	53,201	34,580.65	18,620.35	52,136.98
46	Oct-24	54,864	35,661.60	19,202.40	53,766.72
47	Nov-24	37,192	24,174.80	13,017.20	36,448.16

48	Dec-24	51,215	33,289.75	17,925.25	50,190.70
Total RoUs					**23,76,541.16**

A.14. UWR Rainwater Offset Do No Net Harm Principles

The Chinnakarai CETP project contributes significantly to water stewardship through its engineered approach to sustainable water use in an area previously affected by aquifer overdevelopment. The project enhances sustainable yield by enabling a shift from over-extraction of groundwater to the reuse of treated industrial effluent. With over million kilolitres of high-quality water recycled annually, the project relieves pressure on the Noyyal sub-basin aquifer, which was historically exploited by the cluster's textile units. This is particularly crucial in Tirupur, where aquifer recharge is poor due to semi-arid conditions and impervious subsoils.

Unlike conventional recharge systems that rely on incidental percolation, the CETP provides a controlled and measurable mechanism for offsetting groundwater extraction. The system reduces abstraction volumes from shared community aquifers, functionally increasing sustainable yield. In doing so, it acts as a substitute for thousands of recharge wells, providing equivalent replenishment impact in a more efficient and accountable manner.

Although the CETP does not directly collect rainwater, it plays a role in preventing unutilized water from entering storm drains or sewer systems. The closed-loop design eliminates the need for rain-sensitive solar pans and unlined evaporation ponds, which historically became contaminated runoff sources during rain events. Furthermore, by maintaining impermeable surfaces and drainage infrastructure, the project prevents rainwater-laden industrial sites from contributing to stormwater contamination. This indirectly supports the management of urban rainwater.

The system is designed to conserve and store all reusable water derived from effluent sources. Through RO and MEE processes, treated water is stored in dedicated tanks and redistributed to member dyeing units for process reuse. This stockpiling of recovered water ensures continuous availability even during production fluctuations or seasonal water scarcity. Such long-term water conservation and on-site reuse are critical in Tirupur's water-stressed industrial landscape.

Importantly, the Chinnakarai CETP has actively encouraged women's participation in the project's operation and professional ecosystem. The plant's laboratory, environmental monitoring, and administrative sections include trained female technicians and staff members. TWIC and the CETP's operating team have conducted capacity-building workshops specifically for women from nearby communities, promoting inclusivity in water governance. By integrating gender equity into workforce development, the project aligns with broader SDG goals and empowers local women through employment, skill-building, and leadership opportunities in the environmental services sector.

A.15. Scaling Projects-Lessons Learned-Restarting Projects

The Chinnakarai CETP ZLD project presents a replicable model of integrated industrial wastewater management that can be scaled within and beyond the Tirupur textile cluster. It is currently being studied for application in other Common Effluent Treatment Plants (CETPs) across Tirupur, Perundurai, and Karur, which face similar challenges of groundwater depletion, high-TDS effluent discharge, and regulatory non-compliance. The project's integration of biological treatment, membrane-based separation, thermal evaporation, and crystallization offers a modular and adaptive framework for managing industrial wastewater in diverse geographies.

A key lesson learned from the Chinnakarai experience is the importance of collective action and stakeholder alignment. Early efforts to implement ZLD across individual units failed due to high capital costs, inconsistent effluent quality, and lack of technical expertise. By organizing member units, the project was able to pool financial and operational resources, enabling the creation of a centralized, professionally managed treatment facility. This collaborative structure can be replicated in other clusters, where fragmented ownership and resource disparity have historically impeded sustainable water management.

Another significant insight relates to public perception and local acceptance. Prior to implementation, there was widespread scepticism about the feasibility of recycling industrial wastewater and reusing crystallized salts. However, through targeted awareness campaigns, factory visits, and training programs conducted by TWIC, member units were convinced of the operational, environmental, and economic advantages of the system. Today, the reuse of water and sodium sulphate is seen as a mark of innovation and sustainability within the Tirupur dyeing industry. This shift in mindset illustrates that, with proper communication and demonstrated success, resistance to recycling practices can be overcome.

The project also highlights that abandoned or underperforming CETPs can be revived using the revenue generated from RoUs. Several older CETPs in Tirupur had previously discontinued operations due to escalating power costs, sludge management challenges, or lack of compliance with ZLD norms. With UWR registration and verified RoUs, these CETPs now have a pathway to monetize their environmental services and reinvest in upgrades. In 2025–26, it is proposed that the learnings from Chinnakarai will support the retrofitting of at least three defunct CETPs, restoring their capacity to treat over 10 MLD of wastewater and recycle nearly 3 million KL annually.

From a policy standpoint, the Chinnakarai CETP ZLD project serves as evidence supporting Tamil Nadu's state-level mandates for ZLD in textile processing zones. It demonstrates that advanced water treatment is not only environmentally necessary but also financially and operationally viable when backed by the right institutional and market mechanisms. It further aligns with India's Jal Shakti Abhiyan and Sustainable Water Management initiatives, indicating that sector-specific, place-based innovations can complement national objectives.

The Chinnakarai CETP ZLD project has proven that decentralized wastewater challenges can be addressed through centralized infrastructure, strong governance, and outcome-based incentives like RoUs. Its lessons and structure provide a clear roadmap for scaling water reuse infrastructure in similar industrial environments across India.

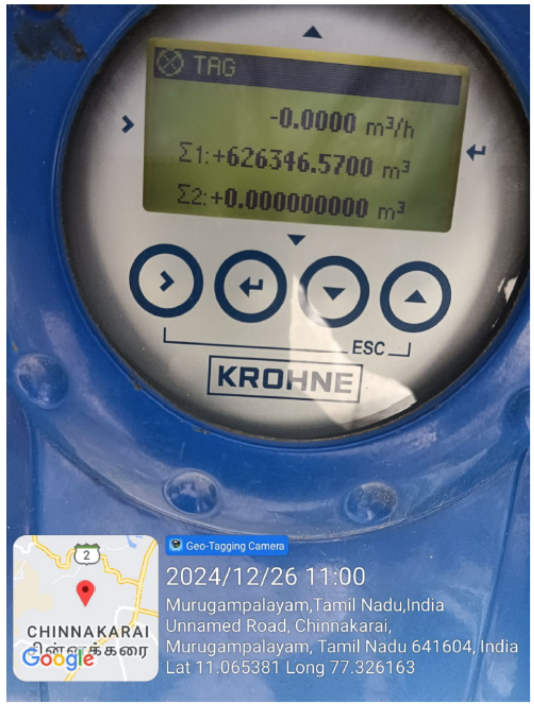
Annexure

Flow Meters:

CHINNAKKARAI CETP PVT LTD

Flow Meter - Inlet

CHINNAKKARAI CETP PVT LTD



Flow Meter – Outlet (RO Permeate to Member Unit)

CHINNAKKARAI CETP PVT LTD

Member Unit's Capacity

Sl.No.	Name of the Member Unit	DPR Capacity (In KLD)
1.	GOWTHAM PROCESSORS	556
2.	ALAYA BLEACHERS & PROCESS	221
3.	ARULJOTHI PROCESSORS	295
4.	BHARAT DYEINGS	450
5.	CARLOO TEX PVT LTD	428
6.	CASABLANCA APPARELS PVT LTD	218
7.	DHANALAKSHMI COLOUR & WASHING	232.5
8.	DYEWIN PROCESS	215
9.	ES ES KNIT PROCESS	240
10.	GOWRI PROCESS	528
11.	JAIHIND DYEING	307
12.	KRISHNAA PROCESSORS	456.5
13.	MS DYEING COMPANY	460
14.	NEW WIN PROCESORS	100
15.	NS COLOURS	199
16.	PIRAGULL DYEING MILLS	347
17.	POWER TEXTILE PROCESS	273
18.	RENUKA KNIT PROCESS	547
19.	SHREE MEENATCHI COLOURS	218
20.	SRINIVI PROCESS	196.5
21.	SRI BALAJI PROCESS	255
22.	SREE SUGANYA TEXTILE PROCESS	400
23.	SURYA PROCESSORS	273
24.	SRI KALAIMAGAL PROCESS	33
25.	AKBER EXPORTS	223.5
26.	RENAISANCE CREATION INDIA PVT LTD	328
TOTAL		**8000**

Design Specifications

Description	Quantity	Details
Pressure sand filter	3 w + 1 s	Capacity: 112.5 cum/hr (each); Design pressure: 6.0 kg/cm²; Diameter: 3.0 m; Height on standing (HOS): 2.5 m; MOC: MSEP (inside)
Cartridge filter	2 w + 1 s	MOC of housing: SS316; Elements per housing: 42 nos.; Element length: 40 inches; Element type: Polypropylene fiber honeycomb wound
RO system	No. of streams: 3	Flow rate per stream: 112.5 cum/hr; No. of stages: 4; Recovery: 85%; Array configuration: 14:7:4:2; Average flux: 17.82 LMH; Elements per PV: 6; Size of element: 40" x 8"; Type of element: Polyamide spiral wound fouling resistant; MOC of PV: FRP; Dimension of PV: 254 mm x 6598 mm; MOC of RO piping: SS316
Pressure sand filter feed pump	2 w + 1 s	Capacity: 167 cum/hr; Head: 40 m; Type: Horizontal, centrifugal; MOC of casing: Cast Iron; MOC of impeller: CF8M
Pressure sand filter	1 w + 1 s	Capacity: 200 cum/hr
Sodium hydroxide dosing pump	1 w + 1 s	Capacity: 30 ltr/hr; Head: 25 m; Type: Positive displacement, diaphragm; MOC of casing: PP; MOC of diaphragm: Teflon
RO chemical cleaning pump	1 w + 1 s	Capacity: 110 cum/hr; Head: 40 m; Type: Centrifugal; MOC of casing: ASTM A743; MOC of diaphragm: ASTM A743
Chemical cleaning cartridge filter	1 w + 1 s	MOC of housing: SS316; Elements per housing: 27 nos.; Element length: 40 inches; Element type: Polypropylene fiber honeycomb wound
RO reject transfer pump	1 w + 1 s	Capacity: 52 cum/hr; Head: 40 m; Type: Centrifugal; MOC of casing: Duplex; MOC of impeller: Duplex
Pressure sand filter backwash air blower	1 w + 1 s	Air flow rate: 300 cum/hr; Head: 0.5 kg/cm²; Type: Twin lobe
Degasser tower	1	Diameter: 2.5 m; Height: 2.75 m; MOC: MSRL
Degasser air blower	2 w + 1 s	Air flow rate: 2900 cum/hr; Head: 50 mm of water column; Type: Fan type; MOC of casing: MS; MOC of impeller: MS
Sodium bisulphite dosing pump	1 w + 1 s	Capacity: 50 ltr/hr; Head: 25 m; Type: Positive displacement, diaphragm; MOC of casing: PP; MOC of diaphragm: Teflon
Antiscalant dosing pump	1 w + 1 s	Capacity: 20 ltr/hr; Head: 25 m; Type: Positive displacement, diaphragm; MOC of casing: PP; MOC of diaphragm: Teflon
Hydrochloric acid dosing pump	1 w + 1 s	Capacity: 50 ltr/hr; Head: 25 m; Type: Positive displacement, diaphragm; MOC of casing: PP
Backwash pump		Head: 20 m; Type: Horizontal, centrifugal; MOC of casing: Cast Iron; MOC of impeller: CF8M
Cartridge filter feed pump	2 w + 1 s	Capacity: 168 cum/hr; Head: 25 m; Type: Horizontal, centrifugal; MOC of casing: Cast Iron; MOC of impeller: CF8M
High pressure RO feed pump	3 w + 1 s	Capacity: 112 cum/hr; Head: 170 m; Type: Horizontal, multistage centrifugal; MOC of casing: CF8M; MOC of impeller: CF8M
RO booster pump I	3 w + 1 s	Capacity: 68 cum/hr; Discharge head: 210 m; Type: Horizontal, multistage centrifugal; MOC of casing: CF8M; MOC of impeller:

		CF8M
RO booster pump II	3 w + 1 s	Capacity: 42 cum/hr; Discharge head: 390 m; Type: Horizontal, multistage centrifugal; MOC of casing: CF8M; MOC of impeller: CF8M
RO booster pump III	3 w + 1 s	Capacity: 25 cum/hr; Discharge head: 520 m; Type: Horizontal, multistage centrifugal; MOC of casing: CF8M; MOC of impeller: CF8M
RO permeate transfer pump	2 w + 1 s	Capacity: 145 cum/hr; Head: 60 m; Type: Centrifugal

Plant Layout: