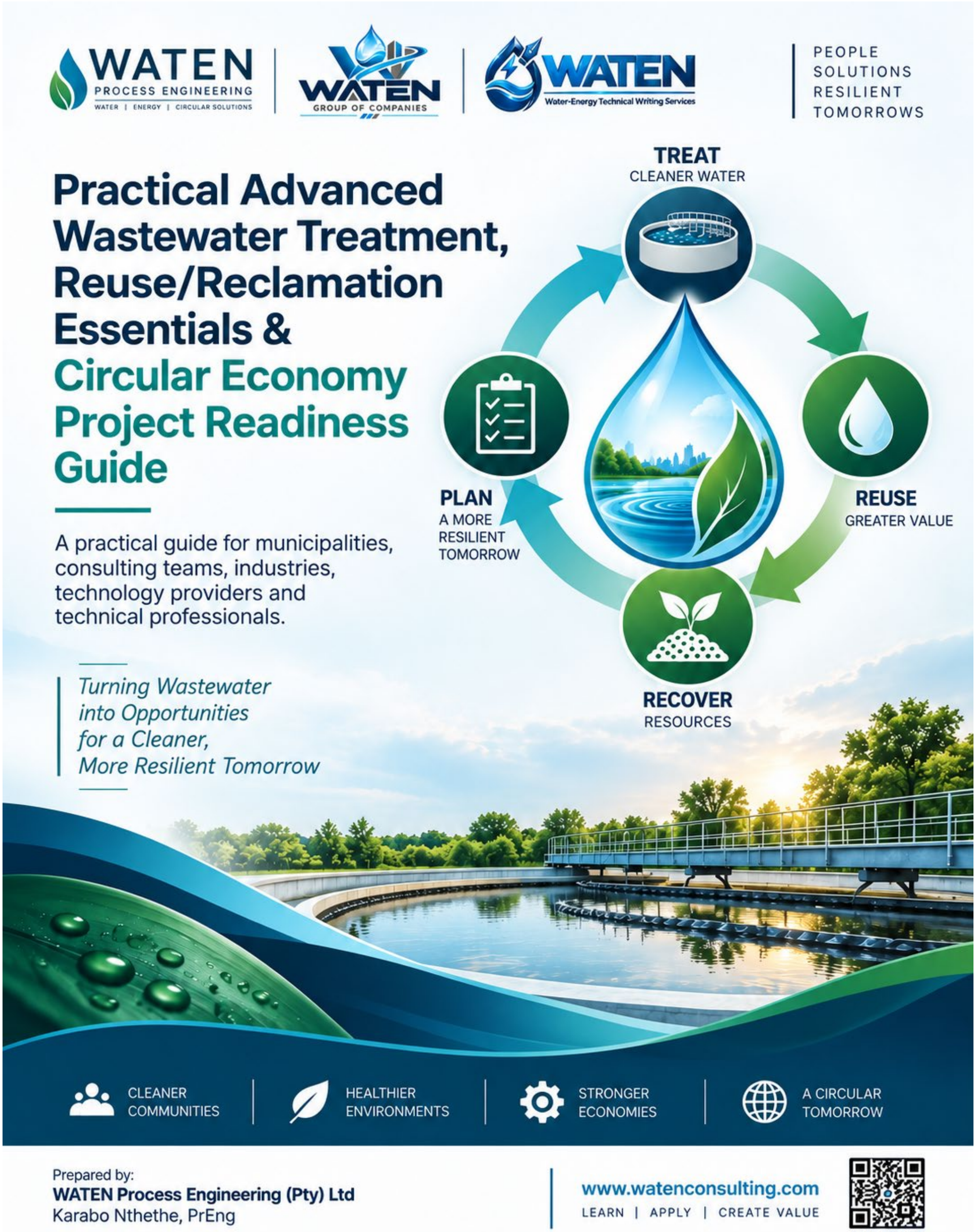
WATEN PROCESS ENGINEERING
WATER | ENERGY | CIRCULAR SOLUTIONS
WATEN GROUP OF COMPANIES
WATEN Water-Energy Technical Writing Services
PEOPLE SOLUTIONS RESILIENT TOMORROWS
Practical Advanced Wastewater Treatment, Reuse/Reclamation Essentials & Circular Economy Project Readiness Guide
A practical guide for municipalities, consulting teams, industries, technology providers and technical professionals.
Turning Wastewater into Opportunities for a Cleaner, More Resilient Tomorrow
TREAT CLEANER WATER
REUSE GREATER VALUE
RECOVER RESOURCES
PLAN A MORE RESILIENT TOMORROW
CLEANER COMMUNITIES
HEALTHIER ENVIRONMENTS
STRONGER ECONOMIES
A CIRCULAR TOMORROW
Prepared by:
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Contents

About WATEN

WATEN brings together specialist process engineering consulting, SME technical content writing, and practical training under one group, so municipalities, industries, consultants, and technology providers can move from a wastewater problem to a project-ready decision with support at every stage.

	Entity	What it does
	WATEN Process Engineering (Pty) Ltd	Specialist process engineering consulting: feasibility studies, design-basis development, treatment-train selection, reuse/reclamation feasibility and readiness diagnostics.
	WATEN Water & Energy Technical Writing Services (Pty) Ltd	Subject-matter-expert technical content: white papers, case studies, knowledge-sharing digital products, and technical marketing support for the water, wastewater and energy sectors.

Founder

Karabo Nthethe, PrEng

Founder, WATEN Group of Companies

Karabo Nthethe, PrEng, is the Founder and Managing Director of the **WATEN Group of Companies.** He is a professionally registered process/chemical engineer with more than 20 years of experience in wastewater treatment operations, process engineering, infrastructure planning, project leadership, advanced treatment, reuse/reclamation, sludge management, resource recovery and circular economy project development.

His experience includes senior process engineering and management roles in a municipal wastewater treatment entity, optimizing multiple wastewater treatment plants, BNR upgrades, sludge strategy development, process audits, modeling, water-use licensing support, and procurement-related technical input. Through WATEN, he provides specialist process engineering consulting, practical training, digital knowledge products, and subject-matter-expert technical content writing for the water, wastewater, waste management, and circular economy sectors.

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1. Purpose of this guidebook

This guidebook provides a practical starting point for understanding **advanced wastewater treatment, reuse/reclamation, circular economy opportunities, and wastewater project readiness.** It gives municipal officials, consultants, industry teams, engineers, and technology providers a shared, practical framework for moving from "we have a wastewater problem or opportunity" to "we have a defensible, scoped, fundable project." It does this by connecting three things usually treated separately: the technical logic of treatment and reuse, the readiness evidence a project needs to move forward, and the practical next step for whoever is reading it.

It covers wastewater sources and characteristics, conventional treatment foundations, biological and nutrient-removal processes, advanced treatment technologies, effluent quality and monitoring, sludge and biosolids management, water reuse, resource recovery, infrastructure planning, Green Drop and regulatory readiness, risk mitigation, future trends, and the embedded Wastewater Circular Economy Project Readiness Checklist.

The guidebook helps the reader to:

1. Understand why advanced wastewater treatment is driven by more than compliance alone.
2. Classify wastewater problems before selecting technologies.
3. Identify where conventional treatment ends and where advanced treatment becomes necessary.
4. Understand the role of biological treatment, membranes, filtration, advanced oxidation, adsorption, and disinfection in reuse and polishing.
5. Consider reuse/reclamation in terms of users, water quality, exposure risk, monitoring, storage, distribution and governance.
6. Screen circular economy opportunities such as water recovery, sludge beneficiation, biogas, nutrient recovery and biosolids use.
7. Recognize residuals, sludge, concentrate and by-products as core design issues, not afterthoughts.
8. Use the embedded **Wastewater Circular Economy Project Readiness Checklist** to identify gaps before feasibility, procurement, design or public communication.

It is deliberately not a substitute for a feasibility study, detailed design or regulatory approval process. It is the practical bridge that gets a project, a proposal or a conversation ready for that next, more rigorous stage.

This guidebook is intended for the following practical use :

Table 2: How to practically use this guidebook

Use case	How to use the guidebook	Expected output
Municipal or utility planning	Use the readiness sections to identify data, compliance, sludge, operator, and funding gaps before technology selection.	A practical gap list and clearer scope for feasibility or upgrade planning.
Consulting or project team support	Use technology, data-pack and readiness tables as a scoping aid for design-basis and options development.	A stronger technical brief and a better process-engineering input list.
Engineer/scientist learning	Use the sections as a practical bridge between theory, unit processes and project-level decisions.	A structured learning pathway into masterclasses, workshops and digital products.
Technology provider or technical marketer	Use the readiness logic to communicate product fit, benefits, risks and application boundaries more credibly.	Better case studies, white papers, product explainers and technical narratives.

PRACTICAL TAKEAWAY

Read this guide with a specific plant, project, reuse idea, technology proposal or content brief in mind. The more specific the context, the more useful the checklist becomes. Use the Wastewater Circular Economy Project Readiness Checklist near the end in section 21 to identify your strongest opportunities, key gaps, and next practical steps.

2. The practical shift from wastewater treatment and discharge to circular economy project readiness

Wastewater treatment is shifting from a narrow pollution-control model to a broader resource- and infrastructure-readiness model. Conventional treatment still matters, but modern projects are increasingly shaped by water scarcity, discharge compliance, public-health risk, reuse potential, sludge and residuals management, carbon and energy pressure, and the need to make defensible infrastructure decisions.

Table 2. Reframing wastewater questions for practical decisions

Old question	Better practical question	What WATEN helps clarify
Which advanced technology should we use?	What treatment objective, risk profile, quality target, operating capacity, and residuals route are we designing for?	Treatment-train logic, design basis, and technology-selection rationale.
Can the plant reuse water?	Which reuse application is realistic, what barriers are needed, and who owns monitoring and failure response?	Reuse/reclamation readiness and offtaker quality profiling.
Can sludge create value?	What sludge/residual streams exist, are they quantified, and is there a legal, safe, and marketable use route?	Sludge/resource recovery screening and gap closure.

Old question	Better practical question	What WATEN helps clarify
Can this be funded or approved?	Is there defensible data, a clear value case, practical phasing, lifecycle-cost logic and stakeholder communication?	Project-readiness narrative, concept notes and decision support.

PRACTICAL TAKEAWAY

Advanced wastewater treatment only earns its keep when it matches a defined problem, an end-use objective, an operating reality and a credible implementation route.

3. How to use this guide

Use this guidebook as a practical screening tool for advanced wastewater treatment, reuse/reclamation, and circular economy project opportunities. It will help you clarify the wastewater problem, treatment objective, reuse or recovery potential, technology implications, sludge and residuals issues, operational requirements, regulatory context and readiness gaps. After reading the guide, complete the embedded **Wastewater Circular Economy Project Readiness Checklist** to identify what is ready, what is uncertain, and what must be strengthened before moving to feasibility, procurement, design, or implementation

Table 3. Guide navigation by audience

Audience	Main need	Best starting point	What WATEN Companies can offer
Established consultants/project teams	Specialist process input for tender bids, feasibility studies, preliminary design, design-basis reviews and reuse projects.	Sections 4, 5, 9, 15, 16, 18, 19	Process engineering services or readiness diagnostic.
Municipalities/utilities	Practical decision support on compliance, Green Drop readiness, reuse, sludge and infrastructure priorities.	Sections 5, 11, 13, 14, 15, 19	Diagnostic review, workshop or advisory support.
Industries and business parks	Fit-for-purpose reclaimed water and practical treatment/reuse risk understanding.	Sections 10, 11, 12, 16, 19	Reuse/reclamation feasibility support.
Civil/chemical engineers and scientists	Applied learning that connects biology, chemistry, hydraulics, processes and project decisions.	Sections 6, 7, 8, 9, 11	Masterclass, workshop, eBook or online course.
Technology providers, OEMs and agencies	Clearer technical market education, white papers, case studies and content that engineers trust.	Sections 2, 9, 10, 13, 18, 21	SME technical content writing or technical-content review.

4. Define the wastewater problem before selecting technology

A treatment train that works well for one wastewater stream may fail in another. Start by understanding the source, flow pattern, contaminant profile, discharge or reuse objective, and operating constraints.

Table 4. Wastewater source profiles and treatment implications

Wastewater source	Typical issues to check	Practical implication for treatment/reuse
Municipal domestic wastewater	Organic load, suspended solids, nutrients, pathogens, wet-weather dilution, infiltration/inflow, trade-effluent inputs.	Usually starts with conventional treatment and biological nutrient removal, then adds polishing where reuse or stricter compliance requires it.
Industrial wastewater and trade effluent	Variable COD, extreme pH, oils/grease, salts, metals, solvents, toxic compounds, intermittent shock loads.	Requires source control, pretreatment, compatibility checks and sometimes segregated treatment before municipal co-treatment.
Stormwater and infiltration/inflow-affected sewage	High peak flows, grit, dilution, combined-sewer-overflow risk, hydraulic overload, sewer corrosion and septicity.	Requires hydraulic capacity review, equalization, robust preliminary treatment and wet-weather operating rules.
Mine-affected or high-salinity water	Dissolved salts, hardness, metals, sulfate, alkalinity, scaling risk and concentrate route.	Often requires chemical conditioning, membranes, RO/NF and a clear brine/concentrate management plan.
Sludge and organic residuals	Solids concentration, volatile solids, pathogens, metals, odor, stabilization potential and biogas potential.	Treat as both a constraint and a potential circular-economy stream.

PRACTICAL TAKEAWAY

Don't let vendor technology define the project. Let the wastewater problem, end-use objective and readiness evidence define the treatment train.

5. Minimum data pack before technology selection

The minimum data pack is the practical bridge between an idea and a defensible project. It doesn't need to be perfect, but it must be good enough to support the next decision.

Table 5. Minimum data pack by data area

Data area	Minimum information to collect	Why it matters	Common weakness
Flow envelope	Average, peak, seasonal and wet-weather flows; current and future loads.	Sets hydraulic sizing, equalization need, process resilience and phasing.	Using one average flow without peak-flow or storm response.
Quality envelope	BOD/COD, TSS, nutrients, pathogens, pH, alkalinity, EC/TDS, metals, oils/grease and site-specific determinands.	Sets process selection, biological stability, dosing, reuse barriers and monitoring scope.	Old grab samples become the design basis.
Existing plant condition	Unit capacity, bottlenecks, mechanical reliability, controls, operator practices and maintenance condition.	Determines whether upgrade, retrofit, polishing, or new works is appropriate.	Assuming advanced technology will fix poor basic operations.
End-use objective	Discharge compliance, non-potable reuse, industrial reuse, potable-linked reuse or resource recovery.	Defines treatment targets, monitoring and validation requirements.	Designing before the user or compliance objective is clear.
Residuals and by-products	Sludge, screenings, grit, chemical residuals, membrane concentrate, spent media and brine.	Avoids creating a new, unmanaged waste problem.	Discovering residuals issues after technology selection.
Institutional readiness	Skills, budget, maintenance support, procurement route, governance and reporting capacity.	Determines whether the treatment train can be sustained.	Selecting complex equipment without operating capacity.

PRACTICAL TAKEAWAY

Where data is weak, don't hide the assumptions. Build a data-gap table, flag which gaps affect the decision, and define the sampling or verification plan.

6. Conventional treatment as the baseline platform

Advanced treatment does not replace good conventional treatment. In most projects, advanced treatment depends on a stable upstream platform: preliminary treatment, primary solids removal where used, secondary biological treatment, clarification, disinfection, and basic nutrient control.

Figure 1. Conventional treatment as the foundation for advanced polishing, reclaimed water and recovery opportunities.

Table 6. Conventional treatment stages and readiness checks

Conventional stage	Main role	Practical check before adding advanced treatment
Preliminary treatment	Screens, grit removal and hydraulic protection of downstream equipment.	Do screens, grit systems, bypasses, and inflow controls protect pumps, membranes, and disinfection units?
Primary treatment	Settles suspended solids and reduces some BOD load; produces primary sludge.	Is solids capture reliable, and what does this mean for sludge quantity and downstream biological loading?
Secondary biological treatment	Removes biodegradable organics and some nutrients through microbial processes.	Is the biological process stable under current and peak loading, with adequate sludge age/DO/RAS/WAS control?
Secondary clarification	Separates biomass from treated water.	Is settleability acceptable, and are bulking, rising sludge, short-circuiting, or solids carry-over controlled?
Tertiary/disinfection	Reduces pathogens, turbidity and residual solids/nutrients where required.	Is water quality good enough for reliable disinfection and reuse barriers?

PRACTICAL TAKEAWAY

A polishing plant cannot compensate indefinitely for unstable upstream treatment. Confirm the baseline process before designing the advanced layer.

7. Practical science behind treatment decisions

This section is not a textbook recap. It shows how physical, chemical, and microbiological principles translate into practical design and operating questions.

Table 7. Practical science principles and design questions

Principle	Practical meaning	Design/operation question
Hydraulics and detention time	Flow pattern, mixing, short-circuiting, and residence time affect every unit process.	Is the real hydraulic behavior consistent with the assumed treatment time and contact efficiency?
Sedimentation and flotation	Particles settle or float depending on size, density, floc formation and hydraulic loading.	Are solids, fats, oils, algae and flocs being separated before they reach sensitive units?
Filtration and membrane barriers	Particles and microbes are removed by straining, depth filtration or membrane pore exclusion.	Is upstream pretreatment good enough to protect filters and membranes from fouling?
Coagulation/flocculation	Fine colloids need destabilization and floc growth before clarification or filtration.	Has dosing been validated by jar tests or site-specific trials?
pH, alkalinity and redox	Biological and chemical treatment depend strongly on buffering, pH and oxygen/anoxic/anaerobic conditions.	Will nitrification, phosphorus removal, digestion, AOP or chemical precipitation remain stable?
Microbial growth and sludge age	Activated sludge, BNR and digestion are controlled ecosystems.	Are SRT, DO, F/M ratio, biomass concentration, and toxicity risk under control?

PRACTICAL TAKEAWAY

Practical decisions improve when you translate the science into control variables: flow, solids, pH, alkalinity, DO, SRT, dose, contact time, flux, pressure, turbidity, and residuals.

8. Biological treatment and BNR control essentials

Biological treatment is the heart of many municipal wastewater systems and can also be the weakest point when inflow data, operator control, aeration, sludge wasting, industrial shocks, or carbon balance are not well managed.

Table 8. Biological treatment process areas and controls

Process area	What it does	Key controls	Common failure signal
Activated sludge	Removes biodegradable organic matter and supports nitrification where SRT is sufficient.	MLSS/MLVSS, DO, SRT, F/M ratio, RAS/WAS, aeration and settleability.	High effluent COD/BOD, ammonia breakthrough, poor settling, foaming or bulking.

Process area	What it does	Key controls	Common failure signal
Nitrification	Converts ammonia to nitrate using slow-growing autotrophic bacteria.	SRT, DO, pH, alkalinity, temperature, toxicity, and ammonia load.	Ammonia remains high despite aeration.
Denitrification	Converts nitrate to nitrogen gas in anoxic conditions using carbon.	Anoxic volume, nitrate recycle, carbon availability, ORP, and mixing.	High nitrate and poor total nitrogen removal.
Biological phosphorus removal	Uses anaerobic/aerobic selection to promote PAOs and remove phosphorus with wasted sludge.	VFA availability, anaerobic integrity, nitrate leakage, sludge wasting, and SRT.	Unstable phosphorus removal or high ortho-P in effluent.
Attached growth / MBBR / IFAS	Adds biofilm capacity for BOD removal or nitrification, often as a retrofit.	Carrier retention, oxygen transfer, mixing, media fill, backwash where applicable.	Carrier loss, clogging, poor nitrification, or solids carry-over.

PRACTICAL TAKEAWAY

BNR is not simply a process configuration. It's a controlled biological system that depends on the right carbon, nitrogen, phosphorus, oxygen, and sludge-age environment.

9. Advanced treatment toolbox

Advanced treatment is best explained as a toolbox that manages specific risks, upgraded biological performance, high-rate solids separation, media filtration, membrane barriers, activated carbon, AOPs, ion exchange, and nature-based polishing.

Table 9. Advanced treatment toolbox by process

Technology/process area	Main practical role	Useful when	Main watch-out
BNR / activated sludge optimization	Carbon, nitrogen and phosphorus control.	Nutrients drive discharge or reuse limits.	Requires sludge age, DO, RAS/WAS, carbon balance and settling control.
DAF / high-rate solids separation	Removes fine solids, algae, oils, or coagulated flocs.	Downstream filtration, disinfection, or membranes need protection.	Chemical control and sludge handling are critical.
Dual-media or tertiary filtration	Polishes turbidity and suspended solids.	Effluent must support reliable disinfection or lower turbidity.	Backwash, media condition and upstream solids control matter.
MBR / UF	Strong solids and pathogen barrier.	High-quality effluent or compact footprint is required.	Fouling, cleaning, energy, and operator discipline.
NF / RO	Reduces dissolved salts and trace contaminants.	High-grade industrial or potable-linked reuse needs low dissolved contaminants.	Pretreatment, scaling, concentrate route, and lifecycle cost.

Technology/process area	Main practical role	Useful when	Main watch-out
UV / ozone / AOP	Disinfection and/or oxidation of trace organics.	Reuse or emerging-contaminant risk needs additional barriers.	Energy, by-products, validation and water-quality dependence.
Activated carbon / BAC	Organic polishing, taste/odour and trace-organic reduction.	Residual organics, color or micropollutants need polishing.	Media life, regeneration/replacement and upstream solids.
Anaerobic digestion / co-digestion	Stabilizes sludge and can recover energy value.	Sludge and suitable organics create a viable feedstock.	Feedstock control, gas safety, digester stability and biosolids route.
Nature-based polishing	Low-energy final polishing and resilience.	Land is available, and loading is controlled.	Land requirement, seasonal performance and maintenance.

PRACTICAL TAKEAWAY

The "best" advanced process is the one that controls the actual risk with the least lifecycle burden and a realistic operating model.

10. Membranes, AOPs, adsorption and polishing: decision guidance

Membrane and polishing technologies can produce very high-quality effluent, but they shift the project into a higher discipline of pretreatment, monitoring, energy management, chemical control, membrane cleaning, residuals management, and operator competence.

Table 10. Membrane and polishing technology decision guidance

Process	What it can add	Before specifying it, check
MBR	High-quality effluent, solids retention, compact footprint and a stronger pathogen barrier.	Influent screening, grease control, membrane cleaning regime, aeration/scour energy, operator capacity and sludge handling.
UF / MF	Reliable particulate and microbial barrier after secondary or tertiary treatment.	Turbidity, algal solids, iron/manganese, fouling potential, backwash/cleaning waste and disinfection strategy.
NF / RO	Dissolved salts, hardness, nitrate, trace organics and high-grade reuse polishing.	Scaling risk, silica/hardness, antiscalant need, recovery, brine/concentrate route, product-water stability and power cost.
AOP / ozone / UV-H2O2	Oxidation of trace organics and additional disinfection/advanced barrier.	UV transmittance, bromide/bromate risk, peroxide quenching, energy demand, target contaminant and validation approach.

Process	What it can add	Before specifying it, check
GAC / BAC / PAC	Residual organic polishing, colour/taste/odour and some micropollutant reduction.	Empty-bed contact time, breakthrough monitoring, media life, regeneration/replacement and spent-media route.
Ion exchange	Targeted removal of selected ions such as nitrate, ammonium, boron or metals in specific applications.	Competing ions, resin selectivity, regeneration chemicals and brine waste.

PRACTICAL TAKEAWAY

Membranes and AOPs can solve difficult water-quality problems, but they rarely remove the need for good pretreatment, clear residuals planning and disciplined operations.

11. Reuse and reclamation essentials

Reuse and reclamation are project-readiness questions before they are technology questions. A reuse project must define the end user, water-quality target, exposure risk, treatment barriers, storage/distribution requirements, monitoring regime, failure response, and institutional owner.

Table 11. Reuse and reclamation levels and readiness questions

Reuse/reclamation level	Typical applications	Practical treatment implication	Readiness question
Non-potable reuse	Irrigation, washdown, landscape use, construction water and selected industrial uses.	Reliable secondary/tertiary treatment, solids control and validated disinfection.	Who will use the water, and what quality must be guaranteed?
Industrial reuse	Cooling water, dust suppression, washing, process water and selected industrial circuits.	Often filtration, membranes, softening, carbon or site-specific polishing.	What does the offtaker's process actually require?
Environmental or indirect potable-linked reuse	Environmental buffer, groundwater recharge or source-water augmentation.	Multi-barrier treatment, monitoring, governance and public-health validation.	What buffer, monitoring and regulatory route apply?
Direct potable reuse	Direct introduction to the potable system or a highly controlled potable pathway.	Highest-barrier validation, operational control, real-time monitoring and governance.	Is the utility technically and institutionally ready?

PRACTICAL TAKEAWAY

Fit-for-purpose reuse does not mean minimum treatment. It means enough treatment, monitoring and institutional control for the specific use and exposure pathway.

12. Reuse/offtaker profile template

A common weakness in reuse projects is designing the treatment plant before properly profiling the offtaker or reuse category. Use the following template as an early discussion tool.

Table 12. Reuse/offtaker profile template

Offtaker profile item	Question to answer	Evidence/output required
User identity and location	Who will receive or use the reclaimed water, and where will it be used?	Offtaker list, maps, service area and contact/responsibility details.
Demand profile	What is the daily, weekly and seasonal demand, and how firm is it?	Demand curve, minimum/average/peak demand and storage need.
Water-quality requirement	Which parameters matter for the intended use?	Quality specification covering microbiology, TSS/turbidity, nutrients, EC/TDS, hardness, silica, metals and process-specific parameters.
Exposure pathway	Who or what can come into contact with the water?	Risk category, user restrictions, signage/cross-connection controls and failure response.
Treatment barriers	Which combination of biological, filtration, membrane, disinfection and polishing barriers is required?	Treatment-train concept and barrier validation plan.
Commercial/value logic	What is the value of using reclaimed water instead of another source?	Tariff, avoided cost, supply-risk reduction, ESG/water-security rationale.
Institutional owner	Who operates, monitors, maintains, reports and communicates?	Roles matrix, O&M plan and monitoring/reporting responsibility.

PRACTICAL TAKEAWAY

No offtaker profile means no robust reuse business case. At minimum, build a realistic offtaker envelope before fixing treatment specifications.

13. Circular economy opportunities in wastewater systems

Circular economy opportunities turn wastewater from a disposal burden into a potential source of recovered value. Each opportunity must still be tested realistically; not every plant can recover every resource, and not every recovered output has a viable user, market, or regulatory pathway.

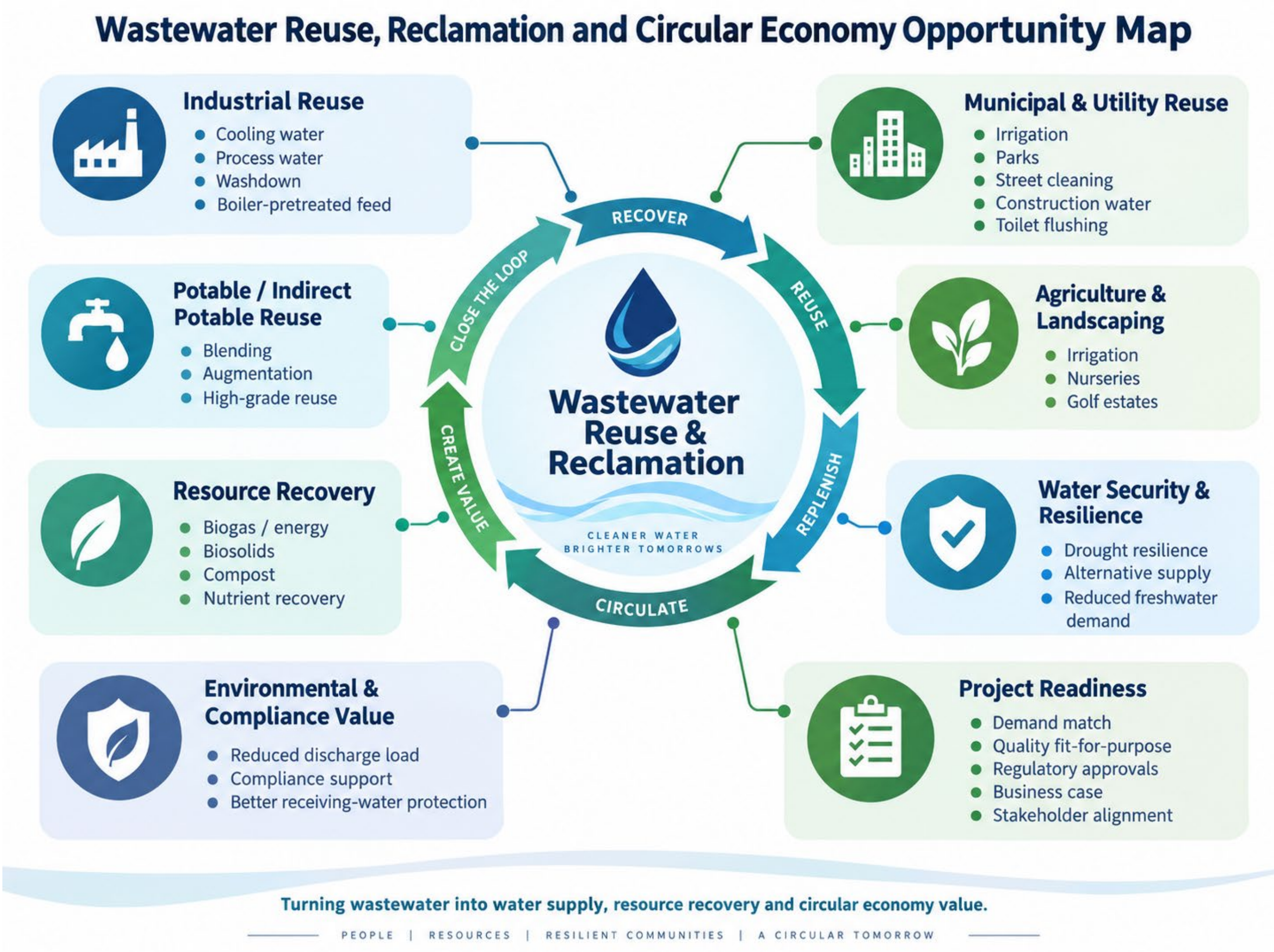

Table 13. Circular economy opportunities and readiness evidence

Opportunity	What can be recovered or improved	Where it may apply	Readiness evidence required
Water recovery	Fit-for-purpose reclaimed water.	Municipal reuse, industrial reuse, irrigation, estates and business parks.	End-user demand, quality targets, barriers, storage/distribution, monitoring and value logic.
Energy recovery	Biogas, electricity/heat offset and reduced energy intensity.	Plants with sufficient sludge or co-digestion feedstock.	Sludge/organics mass balance, digester condition, gas handling and power-use case.
Nutrient recovery	Phosphorus/struvite, ammonia control and biosolids nutrient value.	Plants with suitable nutrient loads, sidestreams or biosolids route.	Chemistry data, user route, regulatory acceptance and process control.
Biosolids/residual value	Beneficial use of stabilised sludge or residuals where compliant and marketable.	Municipal/industrial sludge systems, agriculture, composting and soil-amendment pathways.	Biosolids quality, pathogens, metals, permits, land/user route and acceptance.

Opportunity	What can be recovered or improved	Where it may apply	Readiness evidence required
Infrastructure resilience	Better phasing, reduced risk and more robust operations.	WWTP upgrades, WRPs, reuse schemes and municipal/industrial projects.	Design basis, risk register, O&M plan, capex/opex logic and procurement strategy.

PRACTICAL TAKEAWAY

A circular-economy idea becomes a project only once resource quantity, quality, user route, regulation, cost and operations have all been tested.

14. Sludge, biosolids and residuals as project constraints and opportunities

Sludge and residuals are often the hidden constraint in advanced wastewater projects. Any upgrade, reuse plant or polishing system can fail commercially or operationally if sludge, screenings, grit, chemical residuals, spent media or membrane concentrate are not managed.

Table 14. Residual streams and planning questions

Residual stream	Why it matters	Practical planning question
Primary and waste activated sludge	Contains organics, nutrients, pathogens, and sometimes industrial contaminants.	How much sludge will be produced, how will it be stabilized, and where will it go?
Anaerobic digestion / co-digestion feedstock	Can reduce solids and produce biogas, but needs feedstock control and stable operation.	Is there enough compatible organic material and a viable gas/use route?
Dewatering centrate/filtrate	Can return high ammonia, phosphorus and COD loads to the head of works.	Does the sidestream require nutrient control or struvite management?
Biosolids	Can provide soil value, but must meet quality, pathogen and acceptance requirements.	Are metals, pathogens, odour and regulatory classifications acceptable?
Membrane concentrate/brine	Concentrates salts, nutrients and trace contaminants.	What is the legal, affordable and sustainable concentrate route?
Chemical sludge and spent media	Adds disposal burden and may be classified differently from biological sludge.	What waste classification, handling and replacement strategy apply?

PRACTICAL TAKEAWAY

Don't call a project circular if its residual streams simply move the waste problem elsewhere without a safe and viable route.

15. Monitoring, compliance and Green Drop readiness

Performance is not proven by design intent only, it's proven by data, monitoring discipline, process control, credible sampling, operator response and regulatory reporting. For South African municipal systems, Green Drop-related thinking reinforces the need to link effluent performance to risk, operations, maintenance, monitoring, and management capacity.

Table 15. Monitoring, compliance and Green Drop readiness dimensions

Readiness dimension	What to check	Why it matters
Permit and standard clarity	Water-use authorization, license conditions, discharge limits, reuse requirements and monitoring obligations.	The treatment target must be legally and technically defined.
Sampling and laboratory credibility	Sampling points, frequency, method, preservation, accredited lab, QA/QC and record keeping.	Poor data leads to poor decisions and weak regulatory confidence.
Online monitoring and process data	Flow, pH, DO, ORP, turbidity, ammonia/nitrate, chlorine residual, UV intensity and alarms where appropriate.	Fast feedback allows an operating response before non-compliance becomes persistent.
Process-control records	MLSS, SVI, sludge age, WAS/RAS, aeration, chemical dose, membrane TMP/flux and backwash/cleaning logs.	Internal controls explain final effluent results.
O&M readiness	SOPs, maintenance plans, spare parts, operator training and incident response.	Technology complexity must match management capacity.
Public accountability	Reporting, incident communication, complaint management and performance-improvement plans.	Wastewater performance affects public trust and environmental health.

PRACTICAL TAKEAWAY

Readiness isn't just "can we meet the number?" It's "can we keep meeting it, prove it, respond when it fails, and improve over time?"

16. Infrastructure planning and technology selection

Treatment technology is only one part of infrastructure planning. A credible project must consider demand, catchment growth, existing assets, land, hydraulics, power, operator capacity, O&M cost, phasing, procurement, residuals, stakeholder acceptance and future regulatory tightening.

Table 16. Infrastructure and technology selection criteria

Selection criterion	Question to answer	Decision implication
Treatment performance	Will the process reliably meet discharge or reuse objectives under variable flows and loads?	Determines process train and barrier requirements.

Selection criterion	Question to answer	Decision implication
Lifecycle cost	What are capex, energy, chemicals, spares, membranes/media, sludge/residual handling and staffing costs?	Avoids choosing a low-capex option with unsustainable O&M burden.
Footprint and land	Is land available, constrained, environmentally sensitive or expensive?	Influences compact technologies, modularity or nature-based options.
Operational complexity	Can the owner operate, maintain and monitor the proposed technology?	May favor robust/simple solutions or require a training/support plan.
Expandability and flexibility	Can capacity, treatment level or reuse route be expanded later?	Supports modular planning and future-proofing.
Reliability and redundancy	Are critical units duplicated or designed with standby capacity?	Protects compliance and reuse supply continuity.
Procurement and vendor risk	Is the technology proven, supported locally, and compatible with procurement rules?	Reduces implementation and long-term support risk.
Community and environmental factors	Do you address odour, noise, land use, safety, and public acceptance?	Improves approvals and social license.

PRACTICAL TAKEAWAY

A feasibility study should compare treatment trains and implementation pathways — not isolated equipment items.

17. Operational risks, by-products and future trends

Advanced systems can reduce risk, but they also introduce new ones. A practical guide should help readers anticipate process upsets, by-products, safety issues, residuals, energy demand, monitoring dependence and emerging contaminants.

Table 17. Operational risks, by-products and future trends

Risk or trend	Practical issue	Readiness response
Toxic or shock inflows	Industrial spills, pH shocks, high COD loads or wet-weather peaks can upset biology.	Trade-effluent control, equalization, influent monitoring and emergency diversion rules.
Power and mechanical reliability	Blowers, pumps, membranes, UV systems and dosing units are critical.	Standby capacity, maintenance planning, spares and load-shedding/emergency power strategy.
Disinfection by-products	Chlorination and ozonation can produce by-products depending on water chemistry.	Optimise dosing, consider alternatives, monitor bromide/organics where relevant and validate.

Risk or trend	Practical issue	Readiness response
Greenhouse gas emissions	Aeration energy, methane and nitrous oxide affect climate footprint.	Energy efficiency, biogas capture, process optimisation and resource recovery.
Microplastics and emerging contaminants	Conventional systems do not fully address some pollutants.	Risk-based monitoring and appropriate tertiary/quaternary barriers where justified.
Digital automation	Sensors, SCADA and analytics can improve control but introduce data and cybersecurity dependence.	Calibrated instruments, governance, cybersecurity and manual fallback procedures.
Climate resilience	Floods, droughts and hotter conditions affect capacity, reliability and reuse demand.	Flood protection, hydraulic planning, reuse resilience and robust infrastructure design.

PRACTICAL TAKEAWAY

A project-readiness checklist should capture what can go wrong and not only what the proposed technology can do under ideal conditions.

18. Circular economy project readiness framework

Before taking a wastewater circular-economy project into feasibility, procurement, design, or public promotion, test it against seven readiness areas. This helps avoid presenting an attractive circular-economy idea while the data, users, residuals, approvals, skills, or business case remain weak.

Table 18. Circular economy project readiness framework (seven areas)

Readiness area	Practical question	Evidence to look for
1. Problem and objective readiness	Is the project solving a clearly defined treatment, compliance, reuse, recovery, capacity, cost, or resilience problem?	Problem statement, baseline condition, target outcome, and decision requirement.
2. Data readiness	Is there enough defensible flow, load, and quality data to support the next project decision?	Sampling plan, historical data review, data gaps and assumptions register.
3. Treatment and technology readiness	Is the treatment train selected for the real risk profile and target use — not just a preferred technology?	Options shortlist, process logic, risk review and residuals assessment.
4. Reuse/offtake readiness	Is there a defined user, quality target, demand profile and governance pathway?	Offtaker profile, product-water specification, demand pattern and monitoring plan.
5. Resource recovery readiness	Are recoverable streams quantified and linked to a credible use or market?	Sludge/energy/nutrient/water balances, value route and regulatory pathway.

Readiness area	Practical question	Evidence to look for
6. Implementation readiness	Can the project be funded, procured, operated, monitored and maintained?	Phasing plan, capex/opex assumptions, O&M requirements and institutional capacity.
7. Communication readiness	Can the project be explained clearly to decision-makers, funders, partners and technical reviewers?	Decision memo, concept note, technical narrative, diagrams and business-case story.

19. Wastewater Circular Economy Project Readiness Checklist

Use this checklist as a practical self-assessment before committing to detailed feasibility, technology procurement, funding applications, design development or public communication. Mark each item Yes, Partly, or No, attach evidence, and define the immediate next action.

Suggested scoring: Yes = 2, Partly = 1, No = 0. The score is not a final decision — it helps identify which gaps must be closed before the project is promoted as implementation-ready.

Problem and objective readiness

Table 19. Readiness checklist — Problem and objective readiness

Checkpoint	Status	Evidence to attach	Immediate next action
The main problem is clearly stated: compliance, reuse, recovery, capacity, cost, resilience, or a combination.	☐ Yes ☐ Partly ☐ No	Problem statement; permit or performance issue; business need.	Write a one-paragraph project problem statement.
Define the intended outcome in practical terms, not just as a technology choice.	☐ Yes ☐ Partly ☐ No	Target effluent/reuse quality; service objective; performance target.	Separate the outcome from the proposed technology.
The project has a clear decision to support screening, scoping, funding, design, procurement, or implementation.	☐ Yes ☐ Partly ☐ No	Decision memo; project stage; approval requirement.	State the next decision and the information needed.

Data readiness

Table 20. Readiness checklist — Data readiness

Checkpoint	Status	Evidence to attach	Immediate next action
Historical flow and load data have been reviewed and limitations recorded.	☐ Yes ☐ Partly ☐ No	Flow records; influent/effluent quality; rainfall/wet-weather notes.	Prepare a data-gap table.

Checkpoint	Status	Evidence to attach	Immediate next action
The current hydraulic and quality envelope is known with enough confidence for the next stage.	☐ Yes ☐ Partly ☐ No	Minimum/average/peak flows; BOD/COD/TSS/nutrients/pathogens/EC/TDS as relevant.	Plan additional sampling where gaps affect process selection.
Identify industrial, trade-effluent, or unusual waste contributors.	☐ Yes ☐ Partly ☐ No	Trade-effluent register; catchment/user notes; process-industry inputs.	Map high-risk contributors and likely contaminants.

Treatment and technology readiness

Table 21. Readiness checklist — Treatment and technology readiness

Checkpoint	Status	Evidence to attach	Immediate next action
Select the treatment train around the contaminant/risk profile and end-use objective.	☐ Yes ☐ Partly ☐ No	Options table; process-train sketches; performance targets.	Prepare an options shortlist rather than a single technology claim.
Basic treatment performance, equalisation, pretreatment and polishing needs are understood.	☐ Yes ☐ Partly ☐ No	Mass balance; PFD; hydraulic concept; technology notes.	Confirm what each unit process is expected to remove.
The concept includes residuals, sludge, chemical wastes, spent media, and membrane concentrate.	☐ Yes ☐ Partly ☐ No	Residuals register; sludge route; concentrate route; disposal/use options.	Add residuals handling to the process concept.

Reuse/offtake readiness

Table 22. Readiness checklist — Reuse/offtake readiness

Checkpoint	Status	Evidence to attach	Immediate next action
The reuse or reclaimed-water user is defined, or at least realistically profiled.	☐ Yes ☐ Partly ☐ No	Offtaker list; demand estimate; use category; engagement notes.	Interview or profile potential offtakers.
The product-water quality target is linked to intended use and exposure risk.	☐ Yes ☐ Partly ☐ No	Quality specification; guideline/standard reference; risk notes.	Draft a fit-for-purpose water-quality target.
Consider monitoring, storage, distribution, failure response, and user communication.	☐ Yes ☐ Partly ☐ No	Monitoring plan; storage/distribution concept; operational response plan.	Prepare a simple reuse governance note.

Resource recovery readiness

Table 23. Readiness checklist — Resource recovery readiness

Checkpoint	Status	Evidence to attach	Immediate next action
Water, energy, nutrients, biosolids and other recoverable streams have been screened.	☐ Yes ☐ Partly ☐ No	Recovery-opportunity matrix; mass-balance assumptions.	Score opportunities by technical feasibility and practical value.
Recovered outputs have a credible user, market or internal-use route.	☐ Yes ☐ Partly ☐ No	Offtake letters; internal demand; market scan; regulatory route.	Do not claim value recovery without a route to use.
Regulatory, health, environmental and acceptance risks have been identified.	☐ Yes ☐ Partly ☐ No	Applicable permits; biosolids quality data; risk register.	Prepare a regulatory and acceptance gap list.

Implementation readiness

Table 24. Readiness checklist — Implementation readiness

Checkpoint	Status	Evidence to attach	Immediate next action
The project has a realistic phasing and procurement route.	☐ Yes ☐ Partly ☐ No	Program; procurement approach; pilot needs; stakeholder approvals.	Define a stage-gate plan.
Capex, opex, energy, chemicals, skills and maintenance implications are recognised.	☐ Yes ☐ Partly ☐ No	Cost assumptions; operating philosophy; staffing and maintenance notes.	Create a lifecycle-cost assumptions sheet.
Operator capacity and management systems match the proposed technology's complexity.	☐ Yes ☐ Partly ☐ No	Skills assessment; SOPs; monitoring capacity; maintenance support.	Identify training and SOP needs.

Communication readiness

Table 25. Readiness checklist — Communication readiness

Checkpoint	Status	Evidence to attach	Immediate next action
The project can be explained in a clear decision-maker narrative.	☐ Yes ☐ Partly ☐ No	Concept note; executive summary; diagrams; one-page value case.	Prepare a one-page project story.
The project has a clear next-step CTA for funders, project teams, consultants, partners, or learners.	☐ Yes ☐ Partly ☐ No	Contact route; diagnostic offer; workshop/masterclass link; proposal pathway.	Choose one primary next action.

20. Scoring, gap closure and next-step decision rules

Scoring turns the checklist into action. Do not use it to make a final investment decision. Its role is to show where the project is strong, where assumptions are weak, and which gaps must be closed before moving to the next stage.

Table 26. Readiness score bands and recommended actions

Score band	Interpretation	Recommended action
32–40	Strong readiness for the next project stage, subject to technical verification and approvals.	Move to feasibility refinement, concept design, funding package or detailed planning.
22–31	Promising concept, but important gaps remain.	Close gaps in data, offtake, residuals, lifecycle cost, O&M, governance or communication before procurement/design.
12–21	Early concept with several weak assumptions.	Use the checklist to build a gap-closure plan before presenting the project as ready.
0–11	Not yet ready as a project; still an idea or awareness topic.	Clarify the problem, data, target user, technology logic, and business case before further investment.

Gap-closure planning template

Table 27. Gap-closure planning template

Gap	Why it matters	Owner	Due date	Closure evidence
Example: no offtaker profile	Product-water quality and demand are not confirmed.	Project sponsor/process engineer	Insert date	Offtaker interview notes, demand estimate, target specification.
Example: weak historical data	Technology selection may be based on uncertain loads.	Process engineer/operations team	Insert date	Data-gap table and sampling plan.
Example: no residuals route	Concentrate, sludge or chemical waste may undermine feasibility.	Process engineer / environmental specialist	Insert date	Residuals register and disposal/reuse route.

Need help interpreting your readiness score? Contact WATEN by email at karabon@watenconsulting, or on WhatsApp at 0810046980, to request a free consultation session for the Wastewater Circular Economy Readiness Diagnostic, or visit our website at https://www.watenconsulting.com/. Attach your completed checklist or summarise your main gaps, and WATEN will advise on the most suitable next step.

21. Take the Next Practical Step with WATEN

After completing this guidebook and the readiness checklist, decide which support or learning pathway best fits your situation. Some readers may need deeper technical understanding, while others may need help interpreting project risks, reuse opportunities, treatment options, or circular economy potential.

WATEN provides practical next-step options through specialist process engineering support, diagnostics, training, workshops, masterclasses, digital products, and subject-matter-expert technical content writing. The purpose is to help readers move from awareness to clearer decisions, stronger project preparation, and more practical implementation. Use the options below to choose the WATEN offer that best matches your current need.

Table 28. WATEN next-step pathway by reader situation

Reader situation	Best next step	WATEN offer lane
A consultant or project team needs process engineering input for a tender, feasibility study, or preliminary design.	Request specialist process engineering support or a design-basis/readiness review.	WATEN Process Engineering: process engineering services.

Reader situation	Best next step	WATEN offer lane
A professional wants deeper practical learning on advanced treatment, reuse and biological/process interfaces.	Join the 90-minute masterclass or register for a workshop.	Founder/WATEN Process Engineering-led training, workshops and masterclasses.
A learner or small team wants self-paced practical tools and references.	Download or buy the full eBook, templates, worksheets or toolkit bundle.	Expertise-based digital products.
A technology provider, agency or consultant needs technically credible content.	Request a technical-content audit, writing brief, white paper or case-study support.	WATEN Water & Energy Technical Writing Services: SME technical content writing.

Choose the WATEN offer that matches your needs: process engineering support, masterclass/workshop, full eBook or digital product, in-house training, or SME technical content writing. Visit https://www.watenconsulting.com/ or email karabon@watenconsulting.com, and let us know how WATEN can assist.

22. References and source notes

Table 30. External reference basis used to frame the guidebook

Source	Use in this guidebook
World Health Organization / SDG 6 indicator 6.3.1	Used to frame global wastewater treatment and safe-treatment monitoring.
WHO report on SDG 6.3.1 wastewater flows	Used to support the broader need for safe wastewater treatment, reuse and health-oriented monitoring.
World Bank: Wastewater — From Waste to Resource	Used to frame wastewater as a resource for water, energy, nutrients, biosolids and economic/financial value.
World Bank WICER framework	Used to connect circular economy, resilience, investment prioritisation, design and operations in the water sector.
Water Research Commission TT 882/22	Used to align reuse/reclamation framing with South African municipal engineering guidance.
South African Department of Water and Sanitation — Green Drop reporting	Used to anchor monitoring, compliance, operations and municipal wastewater performance readiness in the South African context.

Ready to move from wastewater treatment to advanced wastewater treatment and circular-economy project readiness?

Use this guidebook to clarify the problem, identify reuse and recovery opportunities, test readiness gaps, and choose the next practical step with WATEN.

Choose the WATEN services and/or digital technical products that fit your needs

PROCESS ENGINEERING SUPPORT

Request a readiness diagnostic, process-engineering input, design-basis review, feasibility support or reuse/reclamation advice.

TRAINING, WORKSHOPS & MASTERCLASSES

Build practical understanding of advanced wastewater treatment, BNR, reuse, circular economy opportunities and implementation readiness.

DIGITAL PRODUCTS

Use WATEN eBooks, guides, checklists, templates and tools to support scoping, learning, project screening and team alignment.

SME TECHNICAL CONTENT WRITING

Request technically credible articles, white papers, case studies, proposal narratives, training material, or content review.

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Focus: *water treatment, wastewater treatment and reuse/reclamation, waste management feasibility, resource recovery, and circular economy project readiness.*

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