EPIC™
TOTAL WATER SOLUTIONS



Concept rendering, EPIC Total Water Solutions — roadside capture, filtration and storage beneath the verge

RAINWATER HARVESTING · STORMWATER MANAGEMENT

SINGAPORE

YOU ALREADY BUILD THE STORAGE. KEEP THE WATER.

PUB's Code of Practice already requires every development over 0.2 hectares to detain its peak runoff — and to empty that tank within four hours. **The volume is in the budget either way.** EPIC holds it inside the landscape the project is building anyway, filters the water going in, and gives it back to the planting instead of to the drain.

500+ INSTALLATIONS · 3 US PATENTS · SINCE 1999 · 100 L/m^2 IN THE PROFILE · 50-YEAR LIFE

EPIC — ENVIRONMENTAL PASSIVE INTEGRATED CONVEYANCE

01 — THE POSITION

THE DRAINS CANNOT GET ANY BIGGER

> **"It is neither practical nor prudent in land-scarce Singapore to keep building more drains or expanding our drainage infrastructure."**
>
> Ministry of Sustainability and the Environment, oral reply on drainage improvement, February 2025

Singapore has already done the expensive part, and done it well: **S$2.5 billion** of drainage improvement since 2011 has cut flood-prone land from about **3,200 hectares in the 1970s to under 25 hectares** today. But conveyance has reached its practical limit, and the rain has not. 2025 was the seventh wettest year since 1980 — **2,984.9 mm island-wide, 18% above average** — with the wettest March on record, and annual rainfall is rising by roughly **83 mm a decade**. Meanwhile national water demand is expected to **almost double by 2065**, met at the margin by desalination that the government itself calls energy-intensive.

S$2.5bn	2,985 mm	+83 mm	S$3.24
spent on drainage improvement since 2011, plus about S$150 m in FY2025	island-wide rainfall in 2025 — 18% above the long-term average of 2,534 mm	added to Singapore's annual rainfall every decade since 1980	per m^3 of potable water, non-domestic, from 1 April 2025

THE BIND

Singapore spends heavily to move rainwater off site within hours, then buys water back — desalinated or recycled — to irrigate the landscape the rain fell on. Two-thirds of the island is water catchment; the built third is engineered to shed. What follows is about closing that gap on the plot itself, using storage the Code of Practice already obliges the developer to provide.



Rain intercepted at the kerb line and taken into a lined subsurface cell rather than to the drain. Concept rendering, EPIC Total Water Solutions.

02 — THE DUTY YOU ALREADY CARRY

THE STORAGE IS ALREADY IN YOUR BUDGET

Clause 7.1.5 of the Code of Practice requires every development of 0.2 hectares or more to control the peak runoff discharged from its site.

Where post-development peak flow exceeds the allowable discharge — $Q = (1/360) \cdot C_{0.55} \cdot i_{10} \cdot A$ — detention is mandatory. That means a tank, and the tank brings a permanent statutory tail with it. None of which criticises the Code: the volume is the right requirement.

The question is narrower. **Having been made to build the storage, why give the water away?**



The same detention volume, built as landscape: a lined cell going in between kerbs beside a new access road, Modesto, California. Backfilled with gravel, sand and planting, it is invisible.

WHAT THE TANK COMMITS YOU TO, FOR THE LIFE OF THE BUILDING

4 hours

Completely drained after every storm, to stop mosquito breeding

N + 1

Duty pumps plus a standby, with **EMA licences** filed annually

Quarterly

Pump, level-control and **desilting** records for tank and sump

Annually

A **declaration to PUB** that it remains in proper order

THE SAME DUTY, TWO WAYS

	CONVENTIONAL ON-SITE DETENTION TANK	EPIC CELL BENEATH THE LANDSCAPE
DETENTION VOLUME	Sized to the Cl 7.1.5 shortfall, as a dedicated structure below the site — additional to the landscape	About **100 L/m²** of cell — 2.5 US gal/ft² in a 13–16 in profile, roughly 100 mm of rainfall depth — held inside the landscape, in place of sub-base and topsoil
THE WATER	Discharged within four hours; bought back later at tariff	Retained, and drawn up to the root zone by capillary action; surplus decants through a set outlet
ENERGY AND UPKEEP	Pumps, level controls, a standby set; EMA licence, quarterly records, annual declaration	No energy in the passive configuration. No pump, no licence, no sump — service is raking or sweeping the top half-inch of the intake strip
QUALITY AND VECTOR RISK	Settlement only, silt removed by scheduled cleaning; open water until drained — which is why the four-hour rule exists	Gravel gravity trap, sand filtration, aerobic biological band and root uptake in series; no standing water exposed to air anywhere. It also irrigates, cools and can cap contaminated ground

Centre column and the commitments above: PUB, On-site Stormwater Detention Tank Systems — Technical Guide, and the Code of Practice 7th Ed., Addendum No. 3. Right column: EPIC drainage dynamics and chamber datasheets.

03 — THE ALTERNATIVES, MEASURED IN SINGAPORE

WHAT THE OTHER ANSWERS ACTUALLY DELIVER

Singapore has not been short of green stormwater ideas. It has been short of ones that hold their performance in a tropical downpour — and its own published monitoring says so.

METHOD	WHAT IT IS ASKED TO DO	WHAT THE MEASUREMENT SHOWS	WHAT YOU ARE LEFT WITH
ON-SITE DETENTION TANK The Code's default	Hold the peak, release slowly	It works — and is required to be **empty within four hours**. Storage without retention: nothing recovered, nothing treated beyond settlement	A structure, pumps, an EMA licence and quarterly desilting for the life of the building
ABC WATERS BIORETENTION AND RAIN GARDENS	Detain and biofilter runoff at source	At Waterway Ridges, features over about **60% of the site** gave a **33% peak-flow reduction** and an effective C of **0.60** — short of the Code's 0.55. Performance **falls as rainfall intensity, depth and duration rise**, and sits below international benchmarks (USA 24–99%, Australia 80–90%)	A large surface footprint on land Singapore does not have, working hardest in the storms that matter least
VEGETATED SWALES	Convey, filter and polish	Monitored in Singapore: TSS 69%, but **total phosphorus 9.4%** and **total nitrogen 8.2%**. Effluent TSS measured **above** the 10.0 mg/L quality objective	Nutrients pass through to the reservoir; sediment slowly reduces hydraulic conductivity
POROUS PAVING AND INFILTRATION CHAMBERS	Infiltrate at the surface, store below	Open-bottomed chambers have a deep interface, a cap that limits gas exchange and no dewatering mechanism: **"once the bottom interface becomes clogged, the units merely function as storage vessels"**	Vacuum sweeping, declining infiltration, and a device that quietly reverts to being a tank
RAINWATER TANK PLUS PUMPED IRRIGATION	Harvest roof water, spray it back	Roof area only; it cannot take carriageway runoff without treatment. Needs pumps, filters, controls and — for non-potable water in public areas — disinfection, because the water reaches the surface	Two systems, two energy bills, two maintenance regimes and a public-contact problem
SPRINKLER AND DRIP IRRIGATION	Deliver water to planting	Sprinklers lose water to evaporation and overspray and create **standing water, fungus and weeds**; salts concentrate at the surface, roots stay shallow. Drip clogs at the emitters — small perforations, poor water, and eventually roots	A pressurised network of moving parts with no stormwater function at all
EPIC	Detain, filter, store and irrigate in one profile	About **100 L/m^2** held; roughly **25 mm absorbed before drainage begins**; **25 mm/hour sustained** through mature turf. Monitored on a whole site by the engineer of record: **56% runoff volume** and **85% total phosphorus** reduction (Wildwood Commons, 2007)	The detention the Code requires, plus 50–85% off irrigation demand, with no pump and no open water

Rows 2 and 3: Water 2017, 9(8), 577 (runoff quantity, Waterway Ridges) and Water 2022, 14(3), 468 (quality evaluation of ABC Waters design features) — peer-reviewed studies of Singapore installations. Row 1: PUB technical guide and Code of Practice. Rows 4–6: EPIC comparative analysis and resource papers. The EPIC row keeps two kinds of figure deliberately apart — a design capacity and a monitored annual load reduction — rather than blending them.

04 — HOW ONE PROFILE DOES THREE JOBS

DETAIN, FILTER, IRRIGATE



Runoff crosses a gravel intake where a gravity trap holds grit and separates oil; a lined cell of arched chambers spreads it laterally at a controlled level while the sand above draws it back to the root zone by capillary action, and surplus leaves through a set overflow. The solar array and air-capture frame are optional additions shown in the same rendering. Concept rendering, EPIC Total Water Solutions.

100 L/m²

held in the profile — 2.5 US gal/ft² in a 13–16 in profile, about 100 mm of rainfall depth

25 mm

of rain absorbed before drainage even begins; porosity 33–47% above the outlet invert

25 mm/hr

sustained through mature turf. Sand drains 1 in in under 10 minutes, gravel in 15 seconds

143 mm

in 24 hours before backup shows at the surface, on a worked field through one 150 mm drain — the governing field rate

THREE THINGS WORTH KNOWING

The outlet governs, and it is a design variable

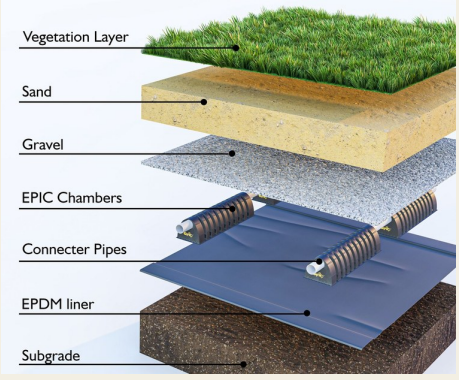
The sand–chamber interface will take far more than the field ever delivers; what sets the field rate is the discharge. One 2-inch connector passes about **`20 US gal/min`** at a foot of head. Larger transfer pipe or a direct reservoir connection raises the rate with the catchment — it is sized, not fixed.

It cannot silt shut

The chamber is a patented double wall: grit entering the low outer apertures must travel upward and turn a right angle to reach the conveyance, so gravity will not take it there. Debris stays in the gravel at the surface, where a rake or a sweeper reaches it.

The biology runs here all year

The aerobic band works between roughly 13 and 49 °C, and Singapore sits inside that range every day of the year. Over **99% of an installed system is gravel, sand and vegetation**.



The profile, layer by layer: vegetation, washed sand, gravel, the chamber network on its connector pipes, the EPDM liner and the prepared subgrade.

05 — RAINWATER HARVESTING AND STORMWATER, BUILT AND MEASURED

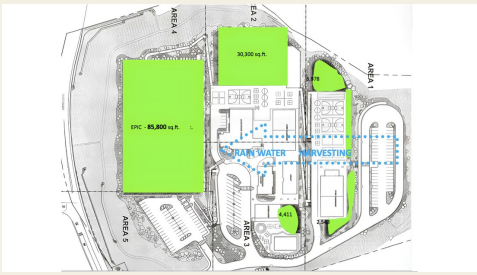
THE RECORD

Five stormwater and rainwater-harvesting installations, each with a third party of record. None is in Singapore — which is exactly the gap this document proposes to close.

PROJECT	THIRD PARTY OF RECORD	WHAT WAS BUILT, AND WHAT WAS MEASURED
CAMBRIA ELEMENTARY SCHOOL CALIFORNIA COAST, 2004–05	RRM Design Group (architect and civil engineer); Earth Systems Pacific (soil engineer); Coast Unified School District	A 12-acre campus the town could supply with neither the volume nor the pressure for conventional irrigation. **All stormwater and hardscape runoff from the whole campus is collected**, pre-filtered through the EPIC profile and stored in a reservoir under the main playfield — 40 pipes of 380 ft, about **2 million US gallons (≈7,600 m^3)** — feeding **130,000 ft^2 of turf**. On an average **17 in (432 mm) of rain a year** the harvest covers the whole campus irrigation demand, in a store that takes no extra land, does not evaporate and does not go green
WILDWOOD COMMONS MINNESOTA, MONITORED 2007	W. McCully, PE — RESI, engineer of record	Over 13.55 in of rain: site runoff fell from **32,181 to 14,172 ft^3, a 56% reduction**, and total phosphorus from **0.2 to 0.019 lb, an 85% reduction**. The first project in the seven-county Twin Cities metro to manage a whole site on a single BMP; the liner also caps officially remediated ground
WESTSIDE PARK LOS ANGELES, COMPLETED 2011	City of Los Angeles (owner); Psomas (civil engineer); Proposition O funded	Runoff from a **5,000-acre urban catchment** screened, filtered and reused. **E. coli down about 97%**, coliform about 95%, metals about 40%; **38,000 ft^2 of park irrigated entirely on captured runoff**. Because the water never reaches the surface, **no disinfection was required**
SR-28 ROAD FILTER LAKE TAHOE, NEVADA, 2016–17	Nevada Department of Transportation	457 m of filter under the road shoulder. Discharge from the EPIC section sampled **visibly clear** against both the conventional ditch and the pond, all three draining to Lake Tahoe; a 518 g snow-melt sample left **23 g of grit** in the filter bag, and **8.5 L/s of clear water** ran at the 150 mm discharge
STANFORD FARMS SANTA BARBARA, 2002–03	EPD — Bill Wilson, architect, civil engineer and contractor	A **2-acre watershed** of roof and driveway runoff taken into an EPIC-fed cistern and returned as irrigation across the estate, with passive watering between the pavers and **erosion control** on coastal bluffs above the Pacific

More than 500 installations since 1999; three US patents — 5,921,711, 7,517,172 B2 and 10,472,813 B1 — all to Jonas Z. Sipaila of Reno, Nevada.

Cambria runs on 432 mm of rain a year. Singapore had 2,985 mm in 2025. A Californian campus harvests its own hardscape runoff and covers its whole irrigation demand on a seventh of Singapore's rainfall, in a store that takes no land and does not evaporate. Singapore is not short of rain. It is short of places to put it.



Cambria site plan, RRM Design Group — the rainwater harvesting run marked.





Left to right: chambers and liner going in beside the carriageway, SR-28, Lake Tahoe · a lined cell between kerbs, Modesto, California · a rainwater-harvesting reservoir field being placed on its liner.

06 — WHERE THE RUNOFF IS, AND HOW IT LANDS WITH THE AGENCIES

SIX CATCHMENTS ON THIS ISLAND

EXPRESSWAY AND ARTERIAL VERGES

The carriageway is the catchment and the verge is the reservoir. Chambers have carried vehicle loads on parking and sports installations, so the cell can extend under hardstanding where a load case is agreed.

CAR PARKS AND HARDSTANDING

A kerbside intercept over a lined cell takes the sheet flow off the paving, drops the grit and the oil at the gravel, and stores what is left.

HDB PRECINCT GREENS

Roof and podium downpipes routed into the courtyard, which becomes the detention volume for the blocks around it and waters itself from what it caught.

INDUSTRIAL AND LOGISTICS ESTATES

Large roofs and yards generate the peak that triggers Clause 7.1.5. The perimeter landscape strip can carry the whole duty instead of a tank under the slab.

PARKS AND PARK CONNECTORS

Path, plaza and lawn runoff caught where it falls and stored under the grass — so the park is watered by its own rain rather than from the main.

RESERVOIR FEEDER CATCHMENTS

Cells inserted along drains as filtration points, taking sediment and nutrients out before the water reaches a reservoir rather than after.

REGULATORY FIT

PUB, Code of Practice. The cell provides the Clause 7.1.5 detention volume as source control — with no pump, no EMA licence, no sump and no desilting schedule.

PUB, ABC Waters. A subsurface biofiltration feature, lined by default, so it complies where infiltration to ground is not permitted — and the liner is omitted where recharge is the objective.

BCA Green Mark. Harvested rainwater as an alternative source for irrigation, and a genuinely water-efficient landscape.

NEA vector control. No open standing water anywhere in the system — nothing to drain in four hours and nothing to inspect for larvae, against 20,469 breeding habitats found in 565,730 inspections in 2025.

Water Efficiency Fund and IWSDF. PUB already funds pilot studies of novel water technologies. A monitored EPIC cell is the kind of demonstration those instruments exist for.



Finished works. Left: a car park draining to a kerbside cell, Modesto, California. Right: Cambria Elementary School, California — 130,000 ft² of playfield running on harvested campus runoff, photographed in 2011, six years after completion.

WHAT WE ARE ASKING FOR

EPIC has not yet been built in Singapore. That is stated plainly rather than dressed up: everything in this document was measured somewhere else, and the only honest way to close that gap is to measure it here.

One instrumented cell of 500–2,000 m², on a site that already carries a Clause 7.1.5 detention duty — a verge, a precinct green or an estate landscape strip. Metered for inflow, outflow, stored volume and water quality, and read for twelve months against the tank it would otherwise replace.

EPIC supplies the design, the AutoCAD details, the specification and installation supervision. Singapore contractors do the work and keep the capability. If the cell does not hold its design volume or does not cut irrigation demand, the result is publishable either way.

ISSUED BY

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PROTECTED BY

US 5,921,711
US 7,517,172 B2
US 10,472,813 B1

SOURCES. PUB, Code of Practice on Surface Water Drainage (7th Edition) and Addendum No. 3, 16 April 2025; PUB, On-site Stormwater Detention Tank Systems – Technical Guide. Ministry of Sustainability and the Environment, oral reply on drainage improvement, February 2025, and MSE water policy pages. Meteorological Service Singapore, Singapore Climate 2025: The Year in Numbers. National Climate Change Secretariat, impact of climate change in Singapore. PUB water tariff schedule effective 1 April 2025. National Environment Agency, dengue prevention campaign 2026, carrying the 2025 inspection and enforcement figures. "Effectiveness of ABC Waters Design Features for Runoff Quantity Control in Urban Singapore", Water 2017, 9(8), 577; "Evaluation of Active, Beautiful, Clean Waters Design Features in Singapore", Water 2022, 14(3), 468. EPIC figures from the EPIC Total Water Solutions technical corpus: EPIC drainage dynamics, chamber datasheets, the case-studies binder, W. McCully PE (RESI) Wildwood Commons monitoring, NDOT SR-28 performance results (2017), and US Patents 5,921,711, 7,517,172 B2 and 10,472,813 B1.