The Vetiver Latrine

Pilot learnings and research priorities from two Kenyan installations

Learning Brief 1 of 4 | August 2026

Prepared by Opero Services and Centre for Affordable Water and Sanitation Technology

Summary

- Two pilots are operational: a household installation at Busia and a workplace installation at the Kisumu treatment lagoons. Only the pour flush variant has been built and monitored in Kenya, though the drop hole configuration has been field tested in Haiti.
- Odour control emerges as the clearest and most consistent finding, directly addressing one of the concerns households mention most often.
- Treatment data came from a single sampling round. It indicates the vetiver bed is working. It does not yet establish how well.
- No pathogen indicators have been measured; therefore, no claim can yet be made about whether the treated effluent is safe for discharge into the ground.
- Managing the accumulated solids onsite remains the largest unresolved question and will determine whether the product's central claim can be supported.

About this brief

This brief presents what two pilot installations of the Vetiver Latrine have demonstrated, what remains unproven, and the research questions that follow. The pilots comprise a household installation in Busia, operating since early 2024, and a workplace installation at the Kisumu wastewater treatment lagoons. To date, only the pour-flush variant has been constructed and monitored in Kenya.

This brief was developed through a collaboration between Opero Services and the Centre for Affordable Water and Sanitation Technology (CAWST), with CAWST supporting the Kisumu pilot installation and the development of the learning brief series. The findings draw on observations and field experience from Opero's pilot installations, with methods and sample sizes presented alongside each finding. These observations are distinguished from insights drawn from published literature, while areas requiring further investigation are highlighted to guide future research and technology development.

This is the first of four learning briefs in the series. Brief 2 examines household toilet preferences, Brief 3 assesses the sanitation market across the eight counties of Western Kenya, and Brief 4 reviews the toilet options currently available in that market.

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1. The challenge

Sanitation coverage in western Kenya is already high. Across the eight counties of the project area - Bungoma, Busia, Homa Bay, Kakamega, Kisii, Kisumu, Migori and Siaya, 87 per cent of households have a functional latrine and open defecation stands at around 1 per cent, with ordinary pit latrines accounting for 81 per cent of facilities (WKSP, 2022, n = 2,328). The main constraint is therefore durability rather than access.



Figure 1. A deteriorated pit latrine of the type common in the project area

Almost half of the households surveyed in rural Busia, Kakamega and Homa Bay reported that their toilet had collapsed within five years of construction, and 67 per cent of all toilets in that sample had been built within the previous five years (WASHPaLS, 2021, n = 931).

Households attribute these failures to loose soils, high water tables, flash flooding, and the rotting of timber used to support toilet floors. Only 24 per cent had ever upgraded a toilet, largely because facilities fail before improvements are considered. As a result, households tend to rebuild rather than upgrade, often replacing the failed facility with one of a lower standard.

Where a pit fills rather than fails, access to emptying services becomes the main constraint. Such services are largely absent in rural areas because households are widely dispersed, access roads are poor, and long distances to treatment sites make journeys uneconomical. In Kisumu's low-income areas, where emptying services are available, households pay a median of KES 3,000 per emptying, and 62 per cent rely on informal manual emptiers. Vacuum operators are widely considered too expensive or unable to access the facility (WKSP, 2022). Under these conditions, covering a full pit and digging another becomes the rational response, but it returns the household to the beginning of the same cycle.

Customer discovery conducted under the same project identified flies, odour, limited privacy, and frequent maintenance as the most common sources of dissatisfaction with existing facilities. These concerns influence whether households choose a replacement toilet and continue using it. The Vetiver Latrine is designed to address the two principal causes of toilet loss: structural collapse and pit filling. The remainder of this brief examines the extent to which evidence from the pilots supports these claims.

2. The technology

The Vetiver Latrine treats toilet wastewater onsite using a gravel-filled treatment bed planted with vetiver grass. Sealed barrels retain the solids, while liquid effluent flows into the planted bed, where the gravel, plant roots and associated microorganisms help treat it before it infiltrates the ground. The system is designed to operate without external energy and with minimal water use and maintenance.

Field testing during this phase covered only the pour-flush variant. All findings on performance, cost, and user experience presented in this brief therefore relate to that configuration. The drop configuration has been tested elsewhere: a drop-type vetiver latrine was field-tested in Haiti from 2012 and documented in a practitioner guide. In that design, vetiver was planted around the pit so that its roots could stabilise the walls (Gietzen, 2019). Opero's Basic Drop design differs by using a perforated barrel for containment, an arrangement that has not yet been constructed or monitored under this project.

Basic Drop

Not piloted in Kenya

For low resource settings with limited water. A perforated plastic barrel collects all waste and leachate exits through the perforations into the surrounding soil. Vetiver is planted around the barrel.

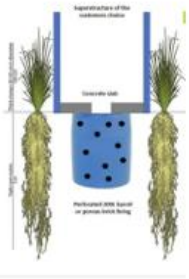


Figure 1 Basic Drop Green Latrine

Pour flush

Piloted in Kenya

For settings where water is available. A series of barrel septic tanks feeds a gravel filled vetiver bed lined with polyethylene and fitted with a perforated outlet. Flush volume is one litre.

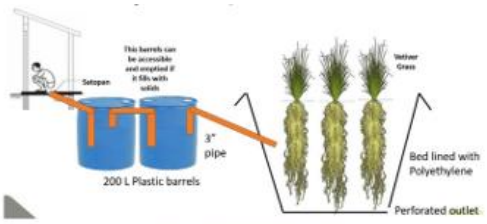


Figure 2 Pour Flush Green Latrine

Figure 2. The two design configurations. Only the pour flush variant has been built in Kenya

2.1 Properties of vetiver relevant to wastewater treatment

Vetiver (*Chrysopogon zizanioides*) is not a conventional wetland treatment plant. It has been used for decades in more than 100 countries for soil and water conservation and slope stabilization. These applications rely on its deep, dense root system, which binds the soil and forms hedges that slow surface runoff.Its roots extend two to four metres into the ground, forming a dense matrix that stabilises soil, reduces erosion, and helps retain groundwater.

Above ground, the grass can be harvested for thatch, fodder, mulch, briquettes, crafts, and essential oil, giving it value beyond soil stabilisation. Its use in sanitation, however, is a more recent application.. The properties described below come from studies conducted under different system designs and climatic conditions. They explain vetiver's potential for use in sanitation but do not establish the performance of the Vetiver Latrine itself.

Availability and cost	Vetiver grows throughout tropical and subtropical regions and propagates readily from root divisions (Grimshaw, 2003). Nurseries and suppliers are established in Bungoma, Busia, Vihiga, Kakamega, Kisumu, Siaya and wider Nyanza, at roughly KES 10 to 15 per slip.
Tolerance of harsh conditions	Once established, vetiver can tolerate acidity as low as pH 3.3, elevated concentrations of heavy metals—including arsenic, cadmium, chromium, nickel, and lead—and COD concentrations of up to 14,000 mg/L, conditions that would kill most plants (Truong, 2006). Constructed wetland trials in Tanzania found vetiver outperforming unplanted cells in removing COD, iron, lead and chromium from landfill leachate, and surviving throughout (Bwire et al., 2011). This matters in a latrine context, where influent quality varies widely.

High water uptake	Vetiver is a hydrophyte that thrives hydroponically and consumes considerably more water than common wetland species such as Typha and Phragmites (Truong et al., 2008). Roughly 1 kg of dry shoot biomass can transpire 6.86 litres per day, reducing the volume of effluent reaching the soak pit.
Nutrient absorption	Vetiver takes up nitrogen and phosphorus at higher rates than eucalyptus, ryegrass, or kikuyu grass (Truong, 2006). Australian trials using hydroponic vetiver rows to polish septic-tank effluent reported removal rates of up to 99 per cent for total nitrogen and 85 per cent for total phosphorus, alongside a 95 per cent reduction in faecal coliforms (Truong et al., 2008). Kenyan laboratory studies found that soil-based vetiver systems removed 57 per cent of total nitrogen from domestic wastewater over five days (Lishenga et al., 2015).
Flood resilience	Vetiver can survive prolonged waterlogging and full submergence, with periods of up to 90 days documented under some conditions (Bwire et al., 2011; Vimala & Kataria, 2003). This tolerance is directly relevant to the flood-prone lowlands of Western Kenya. However, the plant's survival under flooded conditions does not necessarily mean that treatment performance will be maintained.

2.2 Growing requirements

Three requirements determine whether an installation will function as intended, and each can easily be overlooked during design. Adequate sunlight and sufficient establishment time determine whether the vetiver survives, while household acceptance determines whether it remains in place.

The properties summarised describe what vetiver can do. The constraints below set out the conditions required for it to do so.

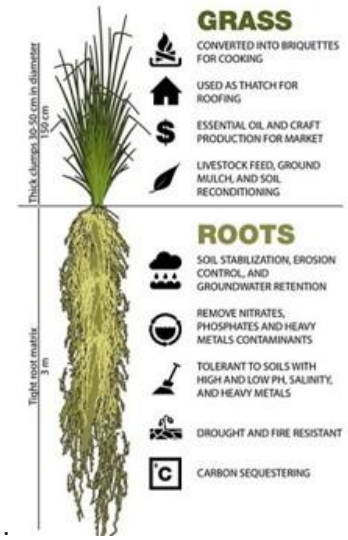


Figure 3. Uses and properties of vetiver, above and below ground

Sunlight	Vetiver is highly intolerant of shade. Prolonged shading suppresses growth and will eventually kill the plant. Beds must be sited clear of tree canopy and oriented so the superstructure does not shade them through the day.

Time to establish	Vetiver takes one to two growing seasons to reach full size. Kenyan field research in the Rift Valley highlands found that vetiver hedges took more than 18 months to close, slower than Napier grass. During the first year, treatment is therefore expected to depend largely on the gravel media and its associated microbial film rather than root activity. Treatment performance during this establishment period has not yet been measured.
Protection and understanding	Young vetiver plants must be protected from grazing animals until they are established, and households need to understand that the plants serve a function rather than merely ornamental purpose. In Haiti, some vetiver latrine installations failed after families removed or replaced the grass. In every documented case, the purpose of the vetiver had not been explained to the household.

3. The pilots

Two Vetiver Latrine installations are currently operational in Kenya, and each tests a different aspect of the system. The Busia pilot examines long-term household use under a relatively low load, while the Kisumu pilot evaluates an updated design under a higher daily load in a workplace setting. Because the Kisumu installation is located at a wastewater treatment facility, it also has access to a solids-disposal route that would not normally be available to a household. These differences are important when interpreting the findings presented below.

Pilot 1

Busia, household scale

The Busia installation has been operational since early 2024 and serves a household of four. It uses a one-litre pour-flush system, with two sealed barrels connected in series and feeding a gravel-filled vetiver bed. The interlocking-brick superstructure contains separate toilet and bathroom compartments.

The total construction cost was USD 778, comprising USD 526 for the superstructure and USD 251 for the vetiver treatment system. Because the superstructure is built to a substantially higher specification than a basic toilet shelter, USD 251 is the more appropriate figure for comparing substructure costs

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Pilot 2

Kisumu, community scale

Installed at the Kisumu wastewater treatment lagoons, the system serves approximately 10 to 15 users per day and also uses a one-litre pour flush. Its primary users are the pit latrine-emptying operators working at the site, for whom it now serves as their regular daily toilet.

This is a workplace rather than a household installation; therefore, its loading pattern and users' expectations may differ from those of the target household market. It is an evolved version of the Busia design, incorporating three changes:

- **Increased holding capacity.** The barrel system was extended from two barrels to three, giving greater sludge retention.
- **Solids and liquids separator.** Introduced in the first barrel to reduce the solids load reaching the bed.
- **Local filter media.** River gravel replaced with locally available gravel and sand, addressing a cost and sourcing constraint identified in the first pilot.



Figure 4. Busia: the vetiver bed alongside the superstructure



Figure 5. Kisumu: the established vetiver bed



Figure 6. Barrel containment at Kisumu[1]

[1] The lined concrete chamber was built for the pilot so that the barrels could be opened, sampled and inspected repeatedly without excavation. It is not part of the standard design: in a normal installation the barrels are set directly in the ground. The chamber cost should be disregarded in any construction cost comparison.

4. Pilot findings

4.1 Odour

Odour is among the most common reasons pit latrines are avoided, and one of the clearest indicators of whether a sanitation system will be continually used. Across the monitoring period at both Busia and Kisumu, no odour has been reported by users, and hydrogen sulphide readings taken by meter inside the superstructure were below the detection limit of the instrument.

The Kisumu users are pit-emptying operators whose daily work involves close contact with faecal sludge, giving them considerable experience in recognising and assessing sanitation-related odour. At the same time, this exposure may make them more accustomed to odour and less sensitive to it than typical household users. Feedback from the Busia household nevertheless supports the findings reported in Kisumu.

Probable mechanism

Two design features are likely responsible. The offset barrel arrangement physically separates the superstructure from the containment chamber, removing the direct pathway by which gases would rise into the toilet space. The SATO pan's counterweighted flap keeps the interface sealed between uses, preventing gas migration from below.

User feedback was gathered qualitatively from a small number of users at each site rather than through a structured instrument, and hydrogen sulphide was measured by handheld meter rather than continuous logging. The finding is consistent across both sites and across twelve months at Busia, though the sample is small.

4.2 Rate of containment filling

Rapid filling drives abandonment of pit latrines, particularly where emptying services are absent. In a pour flush system most of what enters the containment is liquid: flush water, cleansing water and urine. Solid faecal matter is a small share of the volume, and it is the only share that accumulates as sludge At both pilot sites, the containment units are emptied at least twice a month, with liquids making up most of the volume removed.

Because the liquid fraction drives filling rates, separating it before it reaches the containment chambers is the design response to slow filling. Left unseparated, it increases desludging frequency and raises the organic load of the effluent leaving the system.

The accumulation rate itself has not been quantified. Doing so requires metered inflow set against measured sludge volume over a defined period, and that measurement would give the design the desludging interval it currently lacks.

4.3 Containment volume and retention time

The barrel setup is cheap and quick to install, but the original two barrel configuration gave insufficient retention time for adequate primary treatment. Reduced hydraulic retention time limits how much settling and digestion occurs before effluent reaches the vetiver bed, and the constraint becomes more acute as usage rises. Monitoring at Busia indicated COD of around 1,477 mg/L leaving the second barrel, indicating the effluent still carries a significant organic load.

The Kisumu design responded by increasing the system from two barrels to three. Ongoing monitoring aims to establish sizing rules so that future installations can specify containment volume against expected daily load rather than by rule of thumb.

4.4 Solids Separation

The Kisumu pilot is fitted with a solids–liquid separation unit developed by AKYAS Sanitation and installed inside the first barrel. Liquids continue through the containment system, while solids are retained in the first chamber. The first barrel therefore functions as a solids-retention chamber rather than a conventional settling stage, an important distinction when interpreting the sampling data presented in the next section.



Figure 7. The AKYAS separator inside the first barrel

The unit is intended to slow solids accumulation in the downstream chambers and reduce the load reaching the vetiver bed, thereby extending the life of the filter media. Visual observations confirm that solids are accumulating in the first chamber as intended.

Performance has not yet been quantified. The effect on filling rates and on effluent quality remains to be measured.

4.5 Treatment performance

The results presented in this section are based on a single set of grab samples collected from four points in the Kisumu pilot on one occasion. They provide an initial snapshot of the system but are not sufficient to establish its overall treatment performance. Sampling has not yet been repeated across different times or seasons.

The first sampling point also requires careful interpretation. The first barrel receives and stores the solids captured by the AKYAS separator; it does not contain ordinary wastewater flowing through the treatment system. Its total suspended solids concentration of 134,250 mg/L—approximately 13 per cent solids by mass—therefore reflecting the intended purpose of this chamber. Calculating percentage reductions from this column would compare concentrated sludge with the treated liquid, making treatment performance appear better than the data can support. These reductions are therefore not reported.

Table 1. Wastewater parameters at four sampling points, Kisumu pilot (single grab sample)

Parameter	After 1st barrel (With the solid separator)	After 2nd barrel	After 3rd barrel	After vetiver bed
TDS (mg/L)	*3,852.9*	1,558.8	3,014.7	1,066.2
Suspended solids (mg/L)	*138,102.9*	1,787.8	3,449.7	1,203.2
TSS (mg/L)	*134,250*	229	435	137
pH	*7.42*	8.05	8.40	7.79
COD (mg/L)	*14,668*	2,126	1,456	186.5
BOD (mg/L)	*5,000*	808.7	585.3	600.5

Parameter	After 1st barrel (With the solid separator)	After 2nd barrel	After 3rd barrel	After vetiver bed
Phosphate (mg/L)	*6,075*	15.2	26.1	16.7
Nitrate (mg/L)	*142.5*	0.373	0.099	1.01
Ammonia (mg/L)	*7,350*	22.4	39.7	17.7

The first column, shown in italic, represents retained solids in the separator chamber rather than flowing effluent, and is not comparable with the other columns.

Two aspects of the dataset need clarification before the results are interpreted. Both concern the consistency of the measurements rather than the overall treatment trend, and repeat sampling is needed to investigate them. They are outlined below to help readers assess the reliability of the figures.

- BOD in the final effluent, at 600.5 mg/L, exceeds COD at 186.5 mg/L. COD is by definition the larger measure, so one of the two laboratory results is wrong. Both BOD figures across the bed should be retested before they are used. The laboratory also returned two separate suspended solids determinations, reported here as suspended solids and TSS, which differ by an order of magnitude at every sampling point; the analytical methods behind the two have not been confirmed with the laboratory and the discrepancy is unresolved.
- Several parameters rise between the second and third barrels. Solids carryover, hydraulic short circuiting, or the variability inherent to a single grab samples would each account for this. The next sampling round should establish which.

COD decreases by 91 per cent along the liquid treatment pathway, from the second barrel to the bed outlet. Comparing the third-barrel sample with the outlet sample provides an initial indication of changes across the vetiver bed, as shown below.

Table 2. Change across the vetiver bed, third barrel to outlet

Parameter	Into the bed	Out of the bed	Change
COD (mg/L)	1,456	186.5	−87%
TSS (mg/L)	435	137	−69%
Suspended solids (mg/L)	3,449.7	1,203.2	−65%
TDS (mg/L)	3,014.7	1,066.2	−65%
Ammonia (mg/L)	39.7	17.7	−55%
Phosphate (mg/L)	26.1	16.7	−36%
Nitrate (mg/L)	0.099	1.01	increase

The rise in nitrate is consistent with nitrification occurring within the bed.

Scope and limits of the finding

In this single sampling round, concentrations of organic matter, solids, and ammonia were lower at the vetiver bed outlet than at its inlet. This pattern is consistent with the treatment effects reported in published literature.

However, one sampling round cannot establish whether these reductions are sustained over time or under different loading conditions. A more significant gap is the absence of pathogen-indicator measurements: neither E. coli nor faecal coliforms have been tested. The claim that the system can safely discharge treated effluent into the ground, particularly in areas with shallow groundwater, therefore remains unverified.

The outlet COD concentration of 186.5 mg/L remains above the Kenyan EMCA standard cited for discharge to surface waters. For this application, the practical comparison is with an unlined pit latrine releasing untreated leachate, rather than a discharge into a watercourse. This distinction provides context for interpreting the result, but does not establish that ground discharge is safe or meets applicable requirements.

5. Management of accumulated solids

On the evidence so far, the barrel and vetiver bed configuration is performing as intended on the liquid fraction. It contains waste without a pit, it does not smell, and the vetiver bed is measurably reducing the strength of the effluent leaving the system. No operating cost has been incurred across twelve months at Busia, though that period is shorter than any plausible emptying interval and therefore carries no information about what emptying will eventually involve or cost.

The solid fraction remains unresolved, and its resolution determines whether the central claim made for the product holds.

The design intention is a facility that can be built once and kept, with longer interval between emptying than a conventional pit latrine. Neither pilot has yet demonstrated this, nor does Opero claim that the system eliminates the need for emptying. At Kisumu, accumulated sludge is discharged directly from the barrels into the adjacent wastewater treatment works.This arrangement is practical at the pilot site but does not resolve solids management for household installations. Because the treatment works is immediately adjacent, sludge disposal requires no transport and incurs no reported disposal cost. Such access would not normally be available to a rural household. Across much of Western Kenya, emptying services are unavailable; where they exist, costs and distances to treatment sites often lead households to cover a full pit and dig another. Until onsite solids management is demonstrated, Opero does not claim that the system removes the need for emptying.

5.1 Emptying at the two pilots

What is known at present is limited to the Kisumu arrangement described above. The operational record from both sites has not yet been compiled, and without it the brief cannot state what emptying actually involves for a household, which is the question a prospective customer will ask first.

The Kisumu pilot is emptied approximately every two weeks, reflecting its regular use by pit-emptying operators working at the wastewater treatment site. During each emptying, approximately 200 litres of liquid and accumulated sludge are removed, mainly from the first barrel, where most solids are retained.

The barrels are emptied in place using a pump that transfers the contents directly into the treatment pond beside the toilet. This arrangement avoids the emptying and transport costs that a household installation would normally incur, although the process still requires equipment and labour. The pilot's location therefore provides a convenient disposal route but does not demonstrate how households would manage accumulated solids where treatment facilities and emptying services are not readily available.

The Busia system has been operational since 2024 and is emptied approximately twice a month. The household lead opens the barrels, manually removes the accumulated material and buries it. This practice creates a risk of exposure to faecal waste and raises concerns about acceptability, as households may be unwilling to handle toilet waste themselves.

These experiences make solids management a central unresolved issue for the Vetiver Latrine. The system retains solids that require periodic removal, while the current arrangements rely on either direct household handling or access to equipment, labour and treatment facilities. The frequency, cost and potential exposure involved challenge its positioning as a low-maintenance alternative. A safe, practical and acceptable approach tto managing the solids remains necessary before that claim can be supported.

5.2 Pathways under investigation

1. **Co composting with organic waste.** Combining faecal solids with household organic waste to produce a soil conditioner, turning a waste stream into a resource with direct value for the smallholder farmers who make up a significant share of the target user group.
2. **Vermicomposting with tiger worms.** Introducing tiger worms into the containment chamber to break down solids in situ, reducing volume and potentially producing vermicompost as a byproduct.

Both are at an early stage. Neither has been trialed on these pilots, and both raise handling, safety and pathogen questions that would need answering before household deployment.

6. Research priorities

The gaps below are separated by whether they block scale up or improve an already viable product. This is a working prioritization, and several would suit student research projects.

6.1 Priorities that block scale up

1. **Onsite solids management.** Test co composting and vermicomposting pathways to establish whether accumulated solids can be safely managed at household level, at what interval and at what cost. This determines whether the product's central claim survives.
2. **The Basic Drop variant.** Build and monitor the variant designed for water scarce households, which addresses the larger share of the rural market. The Haitian experience gives useful precedent on user acceptance and on the failure modes to watch, but says nothing about the barrel containment Opero has substituted for the open pit.
3. **Pathogen indicators.** Measure E. coli or faecal coliforms in and out of the vetiver bed across repeated sampling rounds. Inexpensive, quick, and the only route to substantiating any claim about safe discharge to ground.

6.2 Priorities that improve the product

- **Long term performance.** Monitor treatment efficiency across seasons and varying user loads, with repeat sampling and corrected sampling points.
- **System sizing.** Establish the containment volume and vetiver bed area required per user.
- **Desludging frequency.** Quantify how quickly solids accumulate and when emptying becomes necessary.
- **Separator performance.** Measure the effect of the AKYAS unit on filling rates and on effluent quality.
- **Vetiver bed lifespan.** Determine how long plants and filter media remain effective, and what first year performance looks like during establishment.
- **Flood performance.** Test treatment, structural integrity, barrel buoyancy and contamination risk during prolonged inundation, directly relevant in Bunyala, the Kano plains and Nyando.
- **Replication cost.** Assess affordability at household and community scale against the KES 10,000 substructure target and the observed market price of a durable improved toilet.
- **Maintenance.** Document routine maintenance, replacement needs, required skills and costs, including vetiver management and protection from grazing.

7. Summary of findings

Liquid fraction	The barrel and vetiver bed configuration is working on the liquid fraction, on early evidence from two pilots.
Odour	Consistent across both sites and twelve months, and it addresses the pain point households cite most often.
Treatment data	The findings come from a single sampling round, with repeated sampling needed. They suggest the treatment bed is working but do not yet establish how well it performs.
Pathogen indicators	No claim about safe discharge to ground can be made until that changes.
Accumulated solids	Onsite solids management is the largest gap and determines whether the product delivers what it promises.

For more information about the Vetiver Latrine, or to discuss any of the research priorities set out above, contact **edwin@opero-services.com**.

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