

STORM WATER AWARENESS WEEK 2026

45-minute technical workshop • Sediment pretreatment

THE IMPORTANCE OF SEDIMENT PRE TREATMENT IN TREATMENT TRAINS

WHAT'S ACTUALLY KILLING YOUR BIOFILTRATION SYSTEM?

Your bioretention cell is beautiful on the day it's installed. Three years later it's ponding, growing algae, and up for media replacement. This session is about what never got stopped upstream.



AGENDA

WHAT WE'LL COVER

01 The treatment train

What each stage is actually protecting

03 How biofilters clog

Mechanics, field evidence, service life

05 The device landscape

Five categories, honestly assessed

02 Where the sediment comes from

Curb, street, construction, washoff

04 The regulatory floor

Who requires it, and where it's heading

06 Specifying pretreatment

Criteria, two case studies, Q&A

RUNNING THROUGHOUT

One bioretention cell on one arterial corridor, followed from ribbon cutting to media replacement. We come back to it five times.

HARBOR BOULEVARD • CELL 14

YEAR 0

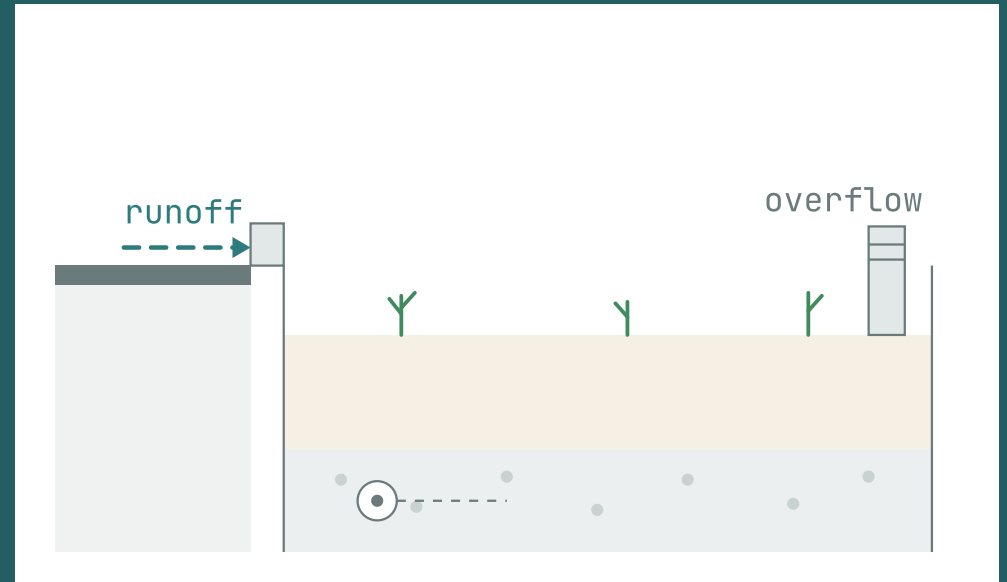
Ribbon cutting

ONE CELL, FOLLOWED FOR FIVE YEARS

A 1,400 sq ft bioretention cell on a four-lane arterial retrofit. Engineered media, underdrain, curb cut inlets, twenty-year design life.

The plan set shows no pretreatment. The permit did not require it, and the line item came out during value engineering.

Harbor Boulevard is hypothetical. Every number in its story is taken from the published field studies in this deck.

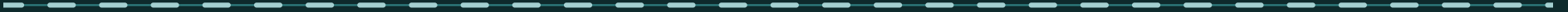


As built • runoff enters at the curb cut, infiltrates the media, leaves through the underdrain

SECTION 01

THE TREATMENT TRAIN

No single BMP removes everything. Each stage exists to protect the one behind it.



DEFINITIONS

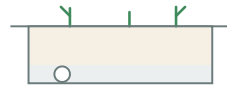
ANATOMY OF A TREATMENT TRAIN



STAGE 1

Pretreatment

Coarse sediment, trash, debris captured at the curb or inlet.



STAGE 2

Primary treatment

Biofiltration, bioretention, media filters, infiltration.



STAGE 3

Storage and conveyance

Vaults, chambers, underdrains, detention.



STAGE 4

Discharge

Receiving water, groundwater, or the storm drain network.

→ Cost per unit, excavation depth, and difficulty of replacement all increase left to right. The cheapest thing in the train is the one doing the dirtiest work.

RATIONALE

WHY TREATMENT TRAINS EXIST

A train is not redundancy. It is a division of labour: each stage removes the fraction it is good at, so the next stage receives a load it was actually designed for.

Performance

Serial stages raise total removal beyond what any single BMP achieves alone.

Protection

Coarse solids are kept out of media that cannot be cleaned, only replaced.

Maintenance economics

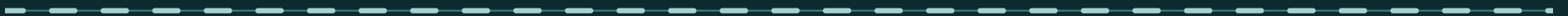
Captured material is centralized at one accessible point instead of spread across a filter bed.

Sources: Minnesota Stormwater Manual, pretreatment practices; STEP LID SWM Planning and Design Guide

SECTION 02

WHERE THE SEDIMENT COMES FROM

Almost all of it is generated upstream of the inlet, at street level.



LOAD SOURCES

SEDIMENT SOURCES AT STREET LEVEL

Upstream erosion

Bare slopes, unstabilized shoulders, and landscape beds that drain to the gutter line.

Impervious washoff

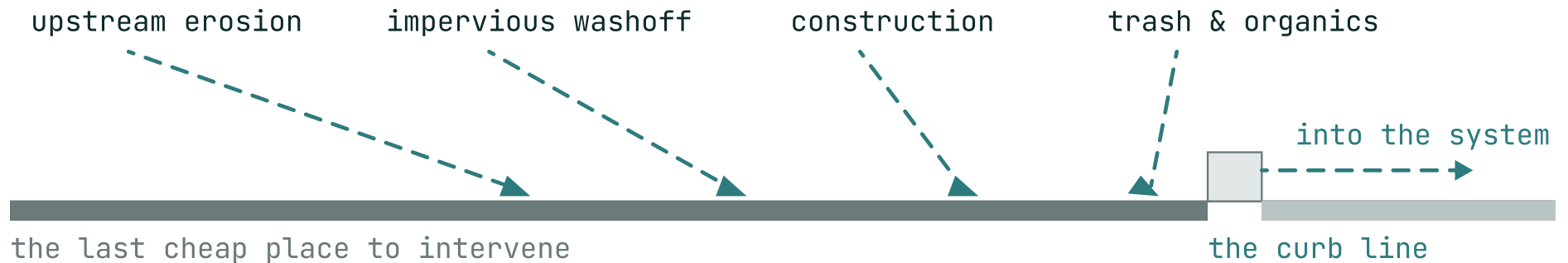
Tire and brake wear, pavement grit, roofing granules, winter sand and salt residue.

Construction activity

Track-out and disturbed soil. Episodic, but a single season can deliver years of design load.

Trash and organics

Leaf litter, packaging, and gross solids that blind the surface before fines ever reach the media.





WAILEA-MAKENA, MAUI • MARCH 2026

AN INLET UNDER SEDIMENT

Two back-to-back Kona lows produced what the University of Hawai'i described as a historic flooding event for the state. This corridor already sat directly downslope of an active rock-crushing facility and a wastewater treatment plant.

62 in

of rain on Maui, first storm

3,000%

of normal seasonal rainfall

Afterward, every storm drain on this street needed an emergency vacuum truck to clear blockages. One did not — the inlet that had a capture device in front of it.

HARBOR BOULEVARD • CELL 14

MONTH 8

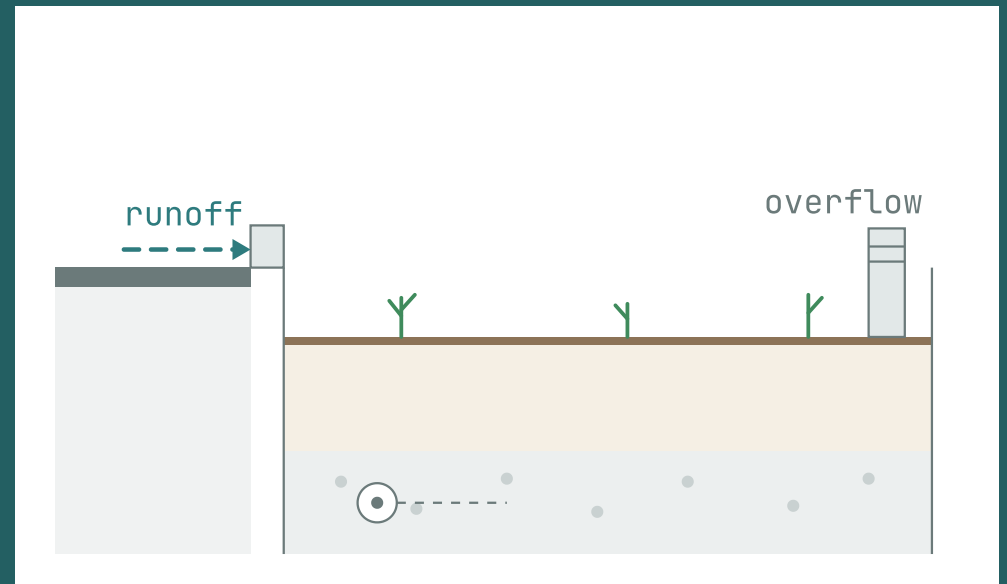
First wet season

THE SLOPE THAT NEVER ESTABLISHED

The graded embankment at the top of the catchment did not take vegetation. Every storm moves a little of it to the gutter line and onto the media surface.

Nothing about the cell looks wrong. The plants are healthy, the mulch is level, and no one measures infiltration rate.

The clock started eight months ago and the asset owner has no way to see it.



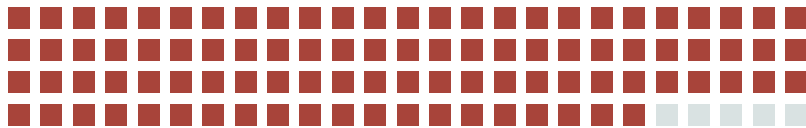
A few millimetres of fines on the surface • no measurable change in drawdown yet

OWNER SURVEY

CELL 14 IS NOT AN OUTLIER

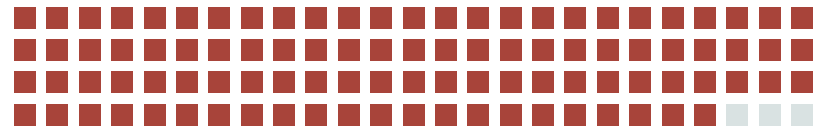
We asked more than 100 stormwater asset owners — cities, counties, ports, and private operators — how their treatment trains were actually working for them.

95%



were unsatisfied with the way their treatment trains had been built out.

97%



named cost and maintenance — not treatment performance — as their primary concern.

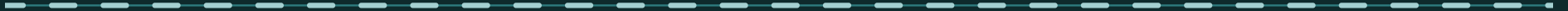
Almost nobody is worried that their media doesn't treat water. They are worried about what it costs to keep the thing alive. That is a pretreatment problem wearing a maintenance budget's clothes.

Source: Kai Pono Solutions owner survey, n > 100 stormwater asset owners

SECTION 03

HOW BIOFILTERS CLOG

Clogging is not a media defect. It is a loading problem with a predictable curve.



HARBOR BOULEVARD • CELL 14

YEAR 2

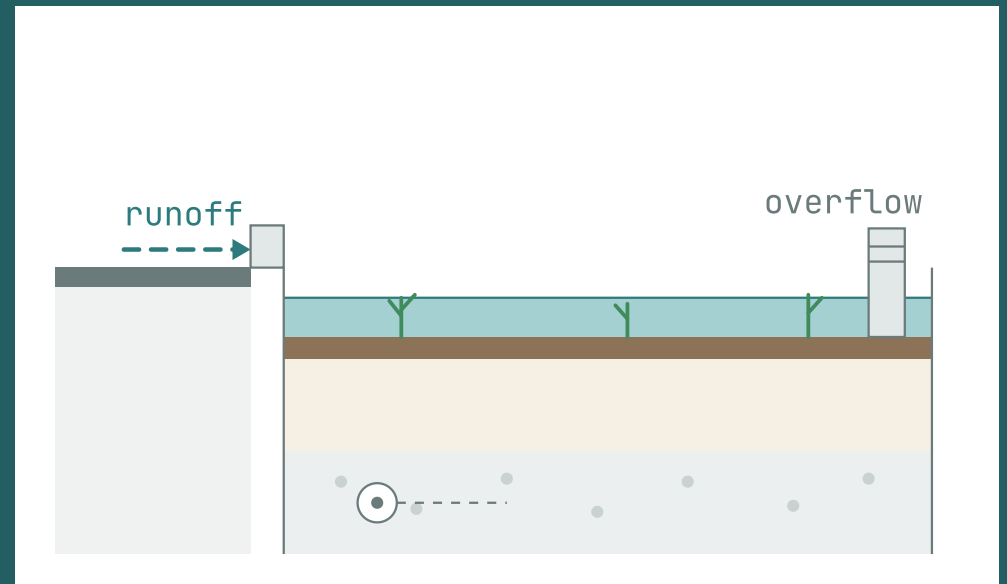
Annual inspection

PONDING OBSERVED — MONITOR

Water now stands in the cell for six hours after a half-inch storm. It used to drain in under two. Algae has appeared at the low end.

The inspection form has one line for this, and the inspector checks it correctly. The asset is reported as functioning.

Two years in, the only record that anything changed is a checkbox.



Surface crust forming • water ponding above the media, drawdown time tripled

MECHANICS

THREE CLOGGING MECHANISMS

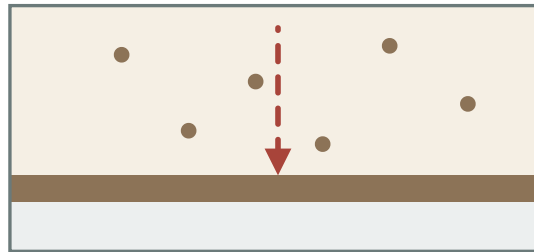
MECHANISM 01



Surface blinding

Fines and organics form a low-permeability crust in the top few inches of media. Infiltration falls fastest here, and earliest.

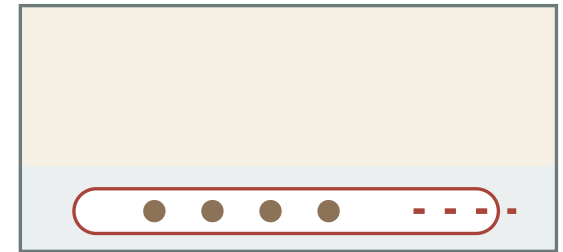
MECHANISM 02



Depth accumulation

Silt migrates through the profile and accumulates at the base of the media, where it cannot be scraped or raked out.

MECHANISM 03



Conveyance occlusion

Silt-sized particles clog perforated inflow pipes and underdrains. The media may still be sound while the system is hydraulically dead.

Source: Field-Scale Assessment of Surface Filtration Pretreatment to Reduce Sediment Accumulation in a Stormwater Infiltration Trench, ASCE Journal of Sustainable Water in the Built Environment

1

YEAR TO FAILURE

actual

20-year design life



5% of the life it was specified for



■ Phase II — small systems, thinner permits

FIELD EVIDENCE • 01

AN INFILTRATION TRENCH WITHOUT PRETREATMENT

STUDY	ASCE J. Sustainable Water in the Built Environment, 12(3) — peer reviewed
SITE	Parking-deck infiltration trench · 160:1 catchment ratio · deliberately undersized
METHOD	Forensic excavation after failure — all three clogging mechanisms found together

The rebuild specified the same media. What changed was a pretreatment system in front of it.

FIELD EVIDENCE · 02

A THIRD OF FLOW WAS BYPASSING TREATMENT

BEFORE MAINTENANCE

35%



of inflow volume bypassing the bioretention cell



AFTER 75 MM MEDIA REMOVAL

11%



restored simply by scraping the clogged surface layer

The cell was never reported as failed. It was quietly passing a third of its design flow straight through — the kind of loss that never appears in an annual inspection checkbox.

STUDY	Brown & Hunt (2012) — peer reviewed, North Carolina State University
SITE	Two monitored bioretention cells · inflow and overflow both metered
ACTION	75 mm of surface media scraped off — no media replacement, no redesign

HARBOR BOULEVARD • CELL 14

YEAR 3

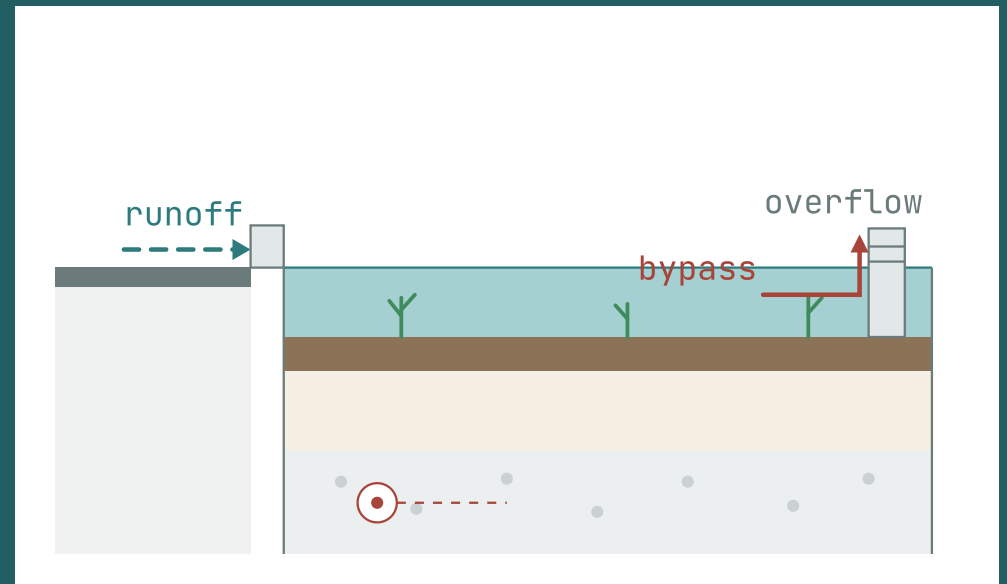
Media replacement quoted

SEVENTEEN YEARS SHORT OF DESIGN LIFE

A metered storm shows roughly a third of inflow leaving through the overflow without touching the media.

Nothing about the media specification was wrong. What failed is about three inches deep, sits on top, and is made of the corridor's own soil.

It arrived one storm at a time, past an inlet that had nothing in front of it.



Crust sealed • a third of inflow short-circuits to the overflow, underdrain running dry

SIZING

CLOGGING IS A LOADING-RATE PROBLEM

Small facilities relative to their catchment take the highest solids loading rate per unit of filter area, and clog fastest. Two published trenches, same technology, very different outcomes:

STUDIES Emerson et al. (2010) and Warnaaars et al. (1999), via ASCE JSWBE

MEASURED Impervious catchment area ÷ trench bottom area, against observed clogging

CAVEAT Only the 23:1 system was monitored — most built systems have no record at all

160 : 1



Impervious catchment to trench bottom area. Purposely undersized. Diminished performance after one year.

23 : 1



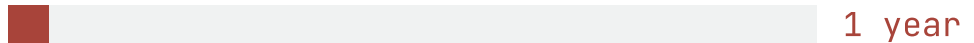
Same technology, generous ratio. Only slight clogging observed after three years of operation.

ASSET LIFE

SERVICE LIFE, WITH AND WITHOUT PRETREATMENT

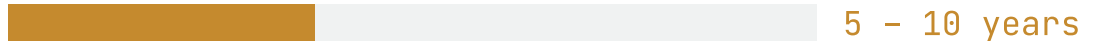
Undersized, no pretreatment

ASCE JSWBE field forensic study



Media loading capacity, typical site

Sediment loading and clogging tests



Well maintained, proper pretreatment

Stormwater Center bioretention fact sheet



Infiltration with proper pretreatment

Minnesota Stormwater Manual



Every row is the same technology. The spread is not a difference in media — it is a difference in what reached the media.

MINNESOTA STORMWATER MANUAL

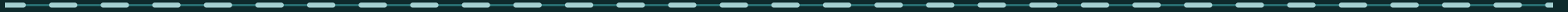
***"IF PROPER PRETREATMENT IS PRESENT, SERVICE
LIFE FOR INFILTRATION SHOULD BE UNLIMITED."***

The same manual states that a pretreatment device is REQUIRED for all bioretention facilities, and that pretreatment is required under Minnesota's Construction Stormwater General Permit for filtration and infiltration water quality BMPs.

SECTION 04

THE REGULATORY FLOOR

Who actually requires pretreatment, and which direction the requirement is moving.



HARD REQUIREMENTS

THREE JURISDICTIONS THAT REQUIRE IT

Minnesota

A pretreatment device is **required** for all bioretention facilities to settle particulates before stormwater enters the BMP. The Construction Stormwater General Permit carries the same requirement for filtration and infiltration BMPs.

MN Stormwater Manual • CSW Permit
III.D.1.d

Virginia

Filtering practices are specified with a dedicated sedimentation chamber upstream of the filter bed. The pretreatment cell is part of the design standard, not an optional add-on.

VA DEQ Stormwater Design
Specification No. 12

Philadelphia

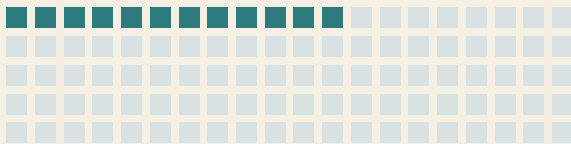
Pretreatment of runoff from **all** inlets is required. Sumps and traps or hoods are the stated minimum for every stormwater management practice in the city.

PWD Stormwater Management Guidance
Manual §4.10

Philadelphia goes further than most: area and yard drains 18 inches or smaller must carry a permanent pretreatment device, and filter bag inserts are required outright at loading docks, material storage, and waste handling sites.

7,250

PERMITTED MS4s NATIONWIDE



- Phase I – large and medium systems (~855)
- Phase II – small systems, thinner permits

THE PATCHWORK

THERE IS NO FEDERAL PRETREATMENT RULE

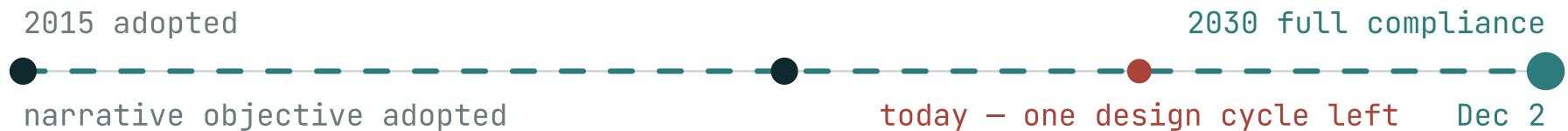
MS4 permits are issued by states and EPA regions, not from a single federal template. "Is pretreatment required?" is answered separately in roughly 7,250 permits, so no one publishes a national count.

Some states mandate it outright. Others make it mandatory in practice through biofiltration design criteria strict enough that systems cannot stay in compliance without it.

Source: U.S. EPA, MS4 Stormwater Management Program

DIRECTION OF TRAVEL

THE TREND LINE: CALIFORNIA'S TRASH AMENDMENTS



ADOPTED

2015

State Water Board adopts a narrative trash objective and a prohibition on trash discharge.

APPLIES TO

I + II

All Phase I and Phase II MS4 permittees with authority over priority land uses, plus transportation MS4s.

FULL COMPLIANCE

2030

Full capture systems installed, operated and maintained across priority land uses by December 2.

Full capture is a trash standard, but the devices that satisfy it sit in exactly the same position in the train as sediment pretreatment. Agencies are being pushed toward curb-level capture whether or not their permit uses the word pretreatment.

Source: California State Water Resources Control Board, Trash Amendments

BIOFILTRATION MANUFACTURER FAQ

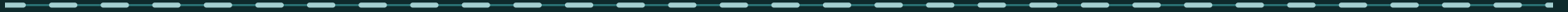
"IN MOST STATES AND LOCALITIES, UPSTREAM PRETREATMENT IS NOT REQUIRED. HOWEVER, THAT DOESN'T MEAN IT'S NOT A GOOD IDEA! GOOD PRE-TREATMENT FACILITATES FUTURE MAINTENANCE AND WILL PAY FOR ITSELF QUICKLY."

This is the vendor of the downstream asset telling you to protect it. The absence of a mandate is not an argument against pretreatment — it is an argument about who carries the cost when it is skipped.

SECTION 05

THE DEVICE LANDSCAPE

Five categories in common use. Each one is good at something and bad at something else.



OVERVIEW

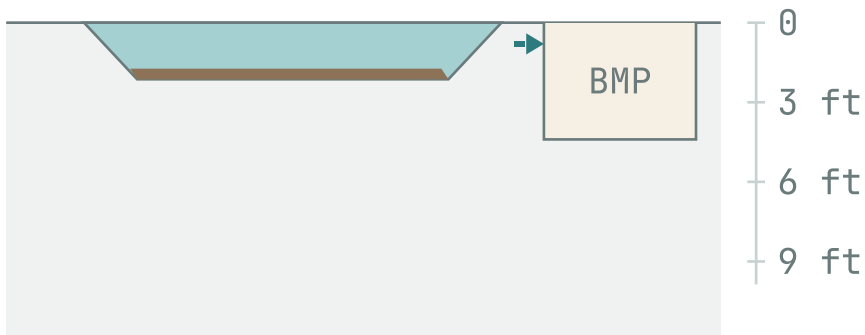
FIVE CATEGORIES OF PRETREATMENT

CATEGORY	MECHANISM	DEPTH	CAPACITY	SERVICE ACCESS
Sedimentation forebay	Gravity settling in open pool	Shallow	Moderate	Open
Catch basin / inlet insert	Screening in a basket or bag	None added	Very low	Open
Hydrodynamic separator	Vortex separation	Deep	High	Vac truck
Underground vault / sump	Settling in buried chamber	Deep	High	Confined space
Curb-level shallow media	Screening plus settling at grade	Shallow	Modular	At grade

CATEGORY 01

SEDIMENTATION FOREBAYS

A shallow pool or cell ahead of the main BMP that slows velocity and lets coarse solids drop out by gravity. The default recommendation in most state manuals.



Open pool at grade • failure is visible from the sidewalk • needs 1-3% of the catchment as surface area

TYPICAL SEDIMENT CAPTURE

15 – 35%

of incoming sediment load, reported range

STRENGTHS

Low cost, no proprietary parts, and failure is visible from the sidewalk. Maintenance is a loader and a truck, not a confined-space permit.

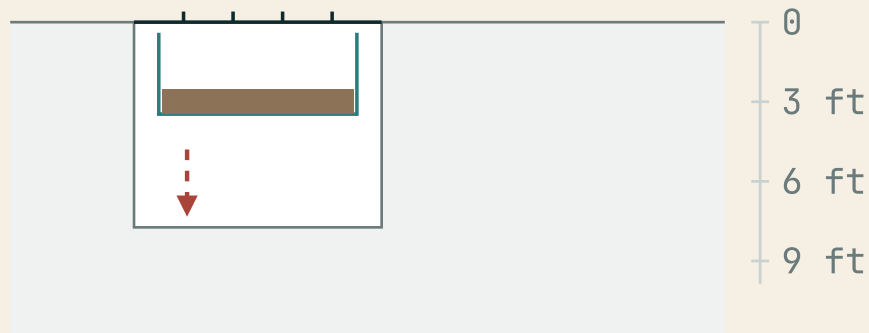
LIMITATIONS

Capture efficiency is modest and drops sharply for fines. Needs real surface footprint, which retrofit corridors and urban curb lines rarely have. Re-suspends in high-flow events if not cleaned.

CATEGORY 02

CATCH BASIN AND INLET INSERTS

A basket, bag, or media cartridge dropped into an existing catch basin. Philadelphia accepts permanent filter bags for retrofits where inlet reconstruction is not feasible, and requires them outright at pollutant-generating sites.



Basket or bag inside the existing basin • no added depth • restricts the inlet once full

PWD Stormwater Management Guidance Manual §4.11

STRENGTHS

Cheapest entry point in the category. No excavation, no utility conflicts, installable in an afternoon across an entire catchment.

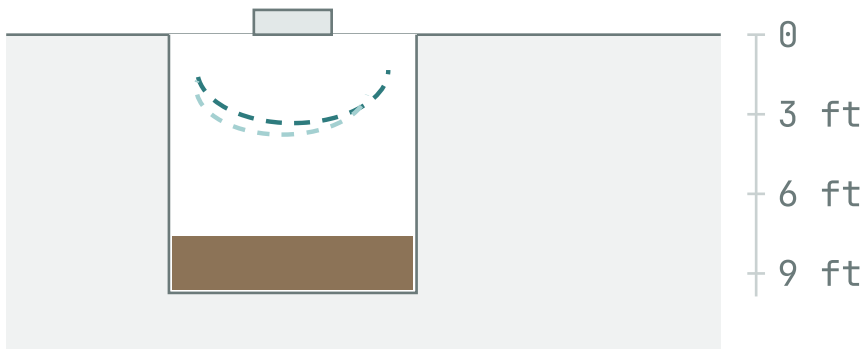
LIMITATIONS

Very small storage volume, so they overload quickly under real sediment loads. High maintenance frequency, and a neglected insert becomes a hydraulic restriction — surcharging the inlet it was meant to protect.

CATEGORY 03

HYDRODYNAMIC SEPARATORS

Underground chambers that induce a swirl, throwing solids to the chamber wall while treated flow exits the centre. Often fitted with coalescing plates for oil and grease.



Vortex separation in a deep chamber • high capacity • cleaned by vacuum truck

COARSE PARTICLE CAPTURE

60 – 98%

for 150–600 micron particles, manufacturer test ranges

STRENGTHS

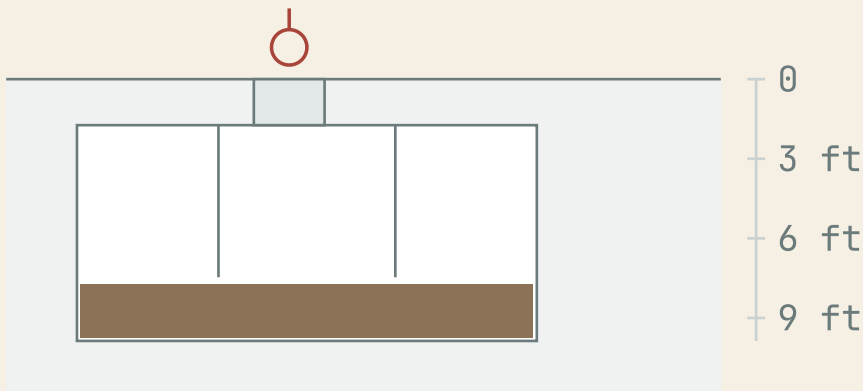
Highest coarse-sediment capacity of the passive options, handles high flow rates, and takes no surface footprint. Twenty years of field performance data behind it.

LIMITATIONS

Deep excavation that frequently conflicts with utilities, high unit and installation cost, weak on fine sediment, and captured material can wash out in the next high-flow event if the cleanout interval slips.

UNDERGROUND VAULTS AND SUMPS

Large buried chambers, sometimes baffled, that settle solids out of the flow within the footprint of existing infrastructure.



Large buried chamber • the most storage, the least access • confined-space entry to service

"DEVICES WITHOUT EASY ACCESS MAKE SEDIMENT REMOVAL MORE DIFFICULT AND EXPENSIVE."

Minnesota Stormwater Manual, O&M guidance

STRENGTHS

Out of sight, large storage volume, and fits where there is no surface real estate at all. Well understood by contractors.

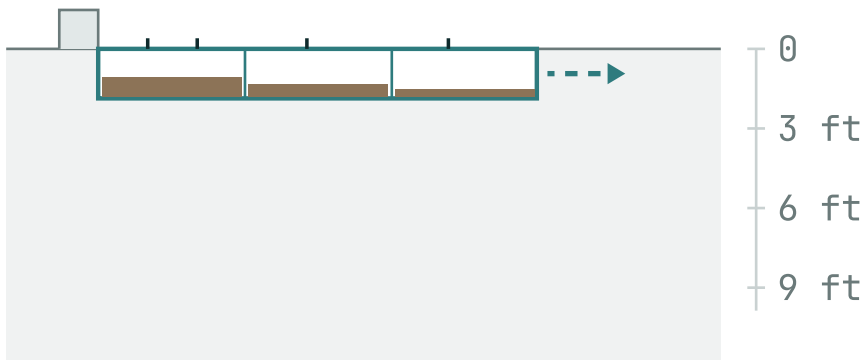
LIMITATIONS

Confined-space entry and vacuum-truck dependency turn maintenance into a scheduled operation rather than a routine one. When the truck is the bottleneck, the cleanout interval stretches — and so does the sediment depth.

CATEGORY 05

CURB-LEVEL SHALLOW MEDIA DEVICES

Modular units set at the curb or gutter line, typically within about 18 inches of excavation, combining screening and settling at the point where the load enters the system.



Three basins in the curb line, coarse to fine • ~18 in excavation • serviced at grade

This category sits between the very small and the very large: more capacity than an insert, far less depth than a vault.

STRENGTHS

Shallow excavation avoids most utility conflicts. Serviceable at grade without confined-space entry or a vacuum truck. Modular capacity can be matched to the catchment rather than to a fixed chamber size.

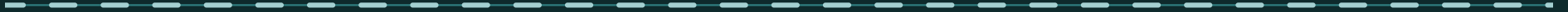
LIMITATIONS

A newer category. There is less multi-decade field performance data than for hydrodynamic separators or forebays, and unit capacity is bounded by the curb geometry it has to live in.

SECTION 06

SPECIFYING PRETREATMENT

What to write into the spec, and two projects where the site decided the answer.



CHECKLIST

SIX CRITERIA FOR A PRETREATMENT SPEC

01 Capture at the source

Intercept at the curb or inlet, not halfway down the pipe network.

03 Specify a particle size

"Pretreatment provided" is not a spec. Name the target fraction and the removal basis.

05 Check the depth envelope early

Utility conflicts kill more pretreatment line items than budget does.

02 Size to the catchment

State the contributing area ratio. Undersizing is the documented failure mode.

04 Design for the cleanout

If service needs a vac truck and a confined-space permit, the interval will slip.

06 Name who maintains it

An unassigned cleanout obligation is the same as no pretreatment.

HARBOR BOULEVARD • CELL 14 THE REWIND

PUT THE LINE ITEM BACK IN

Same corridor, same media, same storms. The only change is one pretreatment device at the curb — the item that came out during value engineering.

YEAR 0

One line item. Shallow excavation, no utility relocation.

YEAR 2

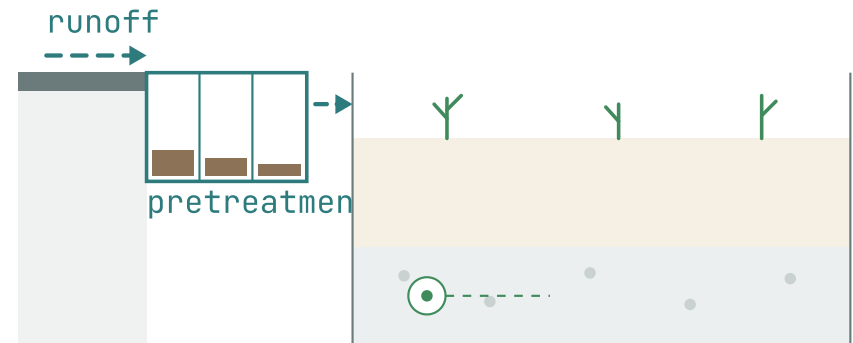
Drawdown unchanged. The inspection form has nothing to record.

MONTH 8

Slope material caught at the curb, where a crew can see it.

YEAR 3

No media replacement, no traffic control. A cleanout log instead.



■ Phase I — large and medium systems (~855)

■ Phase II — small systems, thinner permits

Coarse load intercepted at the curb • media surface stays open • underdrain keeps flowing

CASE STUDY 01 • WAILEA-MAKENA, MAUI •
MARCH 2026

ONE STREET, ONE STORM, ONE DIFFERENCE

A three-basin gravity-fed pretreatment device at the inlet, certified by the California State Water Resources Control Board for 5 mm trash capture. It becomes the primary flow path; the original storm drain becomes the bypass, so overflow always has somewhere to go.

Sediment captured	66 gal
Basins at capacity	3 × 22 gal
Downstream drain clogging	None
Street flooding from the device	None
Emergency vac truck	Not needed



Every neighbouring inlet on this street required a vacuum truck after the floods. This one did not, because the sediment never reached the drain.

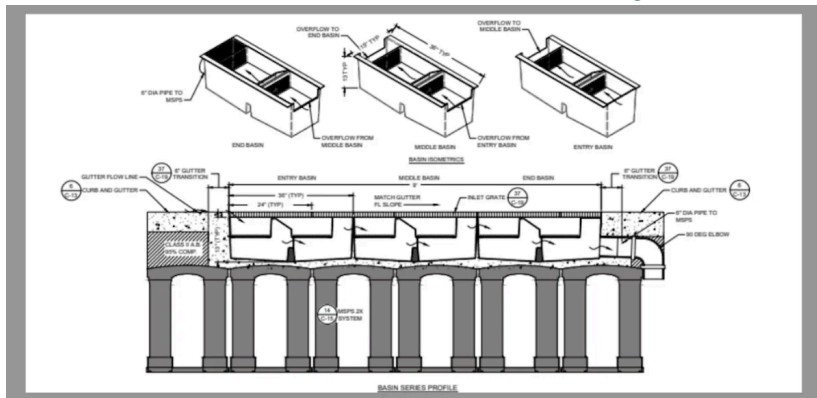
Source: Kai Pono Solutions field case study, Wailea-Makena, Maui

CASE STUDY 02 • SUISUN CITY, CALIFORNIA

WHEN PRETREATMENT WAS NOT OPTIONAL

A treewell biofiltration retrofit where pretreatment was written into the design as a requirement, not a recommendation. The site then removed most of the options:

- ✗ Shallow cover ruled out large vault and separator systems
- ✗ Basket inserts could not carry the corridor's sediment load
- ✓ A street-level device with an 8 inch discharge was the only fit



THE UPSTREAM STAGE: KAI PONO MAKENA MODEL

A three-basin modular curb-line unit that captures sediment, trash, and pollutants before runoff enters the drain. Shallow enough to sit above most utilities, and serviced at grade.

~99%

TSS removal

100+ GPM

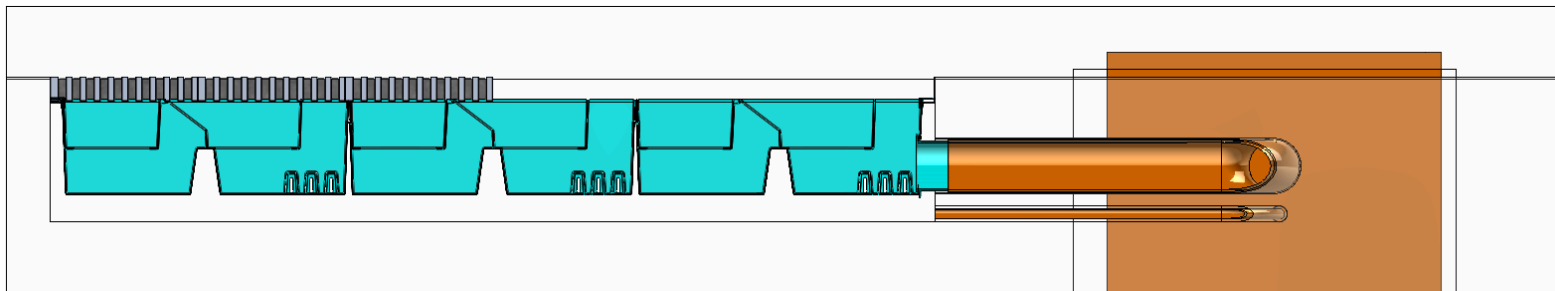
treated flow

18 in

excavation depth, ~9 ft unit

15 min

shop-vac cleanout



Section • three basins, grate at grade, 8 in
discharge to the storm drain

CA State Water Board Trash Capture Certified • ~90-95%
lower cost than deep-vault

RECAP

FIVE THINGS TO TAKE BACK

-
- 01 Premature biofiltration failure is usually a loading problem upstream, not a media problem downstream.
 - 02 The catchment-to-facility ratio predicts service life better than any product specification does.
 - 03 Failure is quiet. A cell bypassing a third of its flow still looks fine on an annual inspection.
 - 04 Every pretreatment category trades depth, capacity, and maintenance access. Pick which one your site can afford to lose.
 - 05 The regulatory floor is rising. Minnesota, Virginia, and Philadelphia already require it; California's 2030 deadline is pulling the rest along.
-

STORM WATER AWARENESS WEEK 2026

QUESTIONS

Bring me your worst maintenance story. There is usually an explanation upstream.

NAVY MCKEE

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