Designed to Fail

Why Most Commonly Used Designs Will Fail and How to Fix Them

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Overview

- Background
- Most common BMPs reviewed
- Reasons BMPs Fail in the Northeast
  - **Design and plan review failures**
  - Construction not according to design (usually lack of adequate inspection)
  - Maintenance not done
- Top 10 reasons for design failure and how to fix them
- Conclusions

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Background

- 1998-2003 intensive **field reviews** of BMPs by CEI in one watershed, 3 communities revealed most had failed
- Extensive **plan reviews**, some of approved projects, for communities in 3 states revealed many serious flaws
- CEI's experience in designing, constructing and monitoring a wide range of BMPs identified a **lack of published design criteria**

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Most Commonly Used BMPs in Private Developments

- Detention basins
- Proprietary units
- Infiltration beds
- Wet ponds
- Wetlands treatment

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Top 10 Reasons for Design Failure

1. Undersized units need excessive maintenance and won't work well
2. Lack of recognition of quantity/velocity/scour issues
3. Design does not include a pretreatment component
4. Pollutants of concern not addressed by selected BMP
5. Design basis calculations assume unrealistic level of maintenance
6. Maintenance needs/failure hidden from view; some designs include unneeded bypass features
7. Cleanouts inaccessible or difficult to reach
8. Site not segregated by quality factors; single BMP
9. Not sized for performance decline over time
10. Design not appropriate for site

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Is it a maintenance or design issue?

- Failure often blamed on inadequate maintenance, but if maintenance is unreasonable, then it's a design failure
- Many private designs focus on minimizing capital costs and size, but this results in higher O&M costs for operation
- Other issues, such as unrealistic runoff calculations, are also clearly design issues but are often not caught during review

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Approved CN Values for the NRCS Methods (TR-20, TR-55)

	Hydrologic Soil Group			
Pre-Construction Runoff Curve Number (CN Values)	**A**	**B**	**C**	**D**
Open space such as lawns, parks, and cemeteries[2]				
Poor condition (grass cover <50%)	68	79	86	89
Fair condition (grass cover 50% to 75%)	49	69	79	84
Good condition (grass cover >75%)	39	61	74	80
Woods and forest[3, 4]	30	55	70	77
Impervious areas such as paved parking lots, driveways and roofs	98	98	98	98
Gravel roads (processed, dense graded)	76	85	89	91
Dirt roads	72	82	87	89
Newly graded pervious areas (no vegetation)	77	86	91	94
Post-Construction Runoff-Curve Number (CN Value)	**A**	**B**	**C**	**D**
Open space such as lawns, parks, and cemeteries[2]	68	79	86	89
Woods and forest that is selectively cleared[3]	36	60	73	79
Impervious areas such as paved parking lots, driveways and roofs	98	98	98	98
Gravel roads (processed, dense graded)	76	85	89	91
Dirt roads	72	82	87	89
Newly graded pervious areas (no vegetation)	77	86	91	94

TR-55, 1986

Pre-submittal Clearing

"Sites wooded in the last 5 yrs must be considered undisturbed woods for all preconstruction runoff conditions, regardless of clearing or cutting activities that may have occurred on the site during that pre-application period." The purpose is to discourage pre-submittal clearing that sometimes results in undersized stormwater facilities.

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No. 1: Undersized BMPs

- Problem: undersized BMPs often means eventual failure due to:
  - Unreasonable maintenance frequency
  - Manufacturer's sizing recommendations not followed or call for unrealistic schedule of maintenance
  - Frequent maintenance is burdensome and likely to be skipped when schedules are tight

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Most important cold climate design issue:
S A N D

Typical Sand Loads

- 1,000 lbs per acre (spreading rate of common Swenson spreader)
- 5,000 lbs for 5-acre parking lot (typical small mall)
- 5 storms per winter = 25,000 lbs (12 ½ tons or 8.3 cubic yards)

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No. 1: Undersized BMPs

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- Recommendation
  - Size to accommodate 1 year sand/sediment minimum
  - Design frequency of maintenance should be no more than annual

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No. 2: Scour Velocity

- Problem: focus on “any BMP is better than nothing” may lead to unrealistic designs that:
  - Result in BMPs that can’t handle the volume of discharge
  - Wash out soon after built because they reach scour velocities without adequate armoring
  - Will resuspend and wash out collected pollutants from smaller storms

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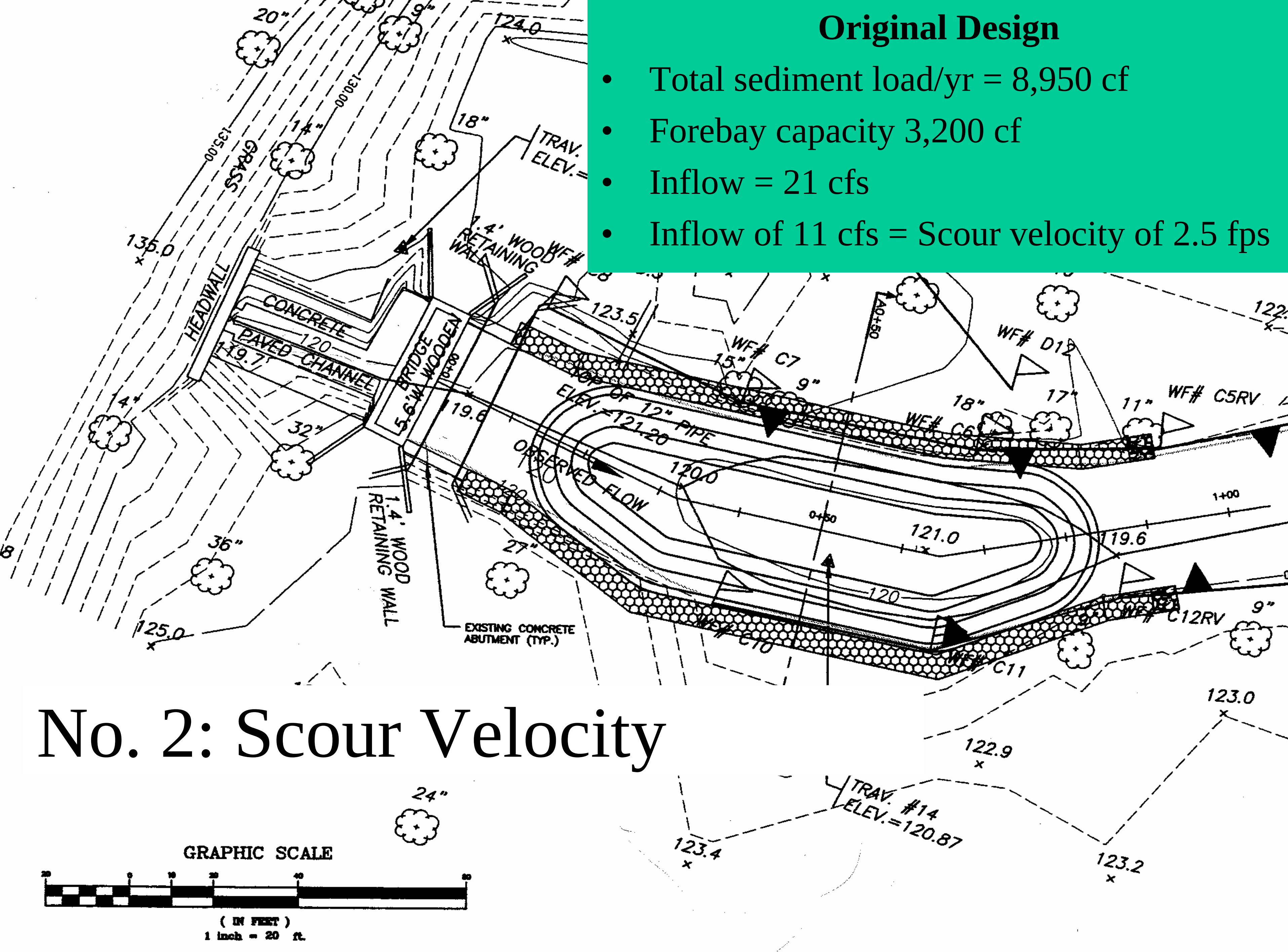
No. 2: Scour Velocity

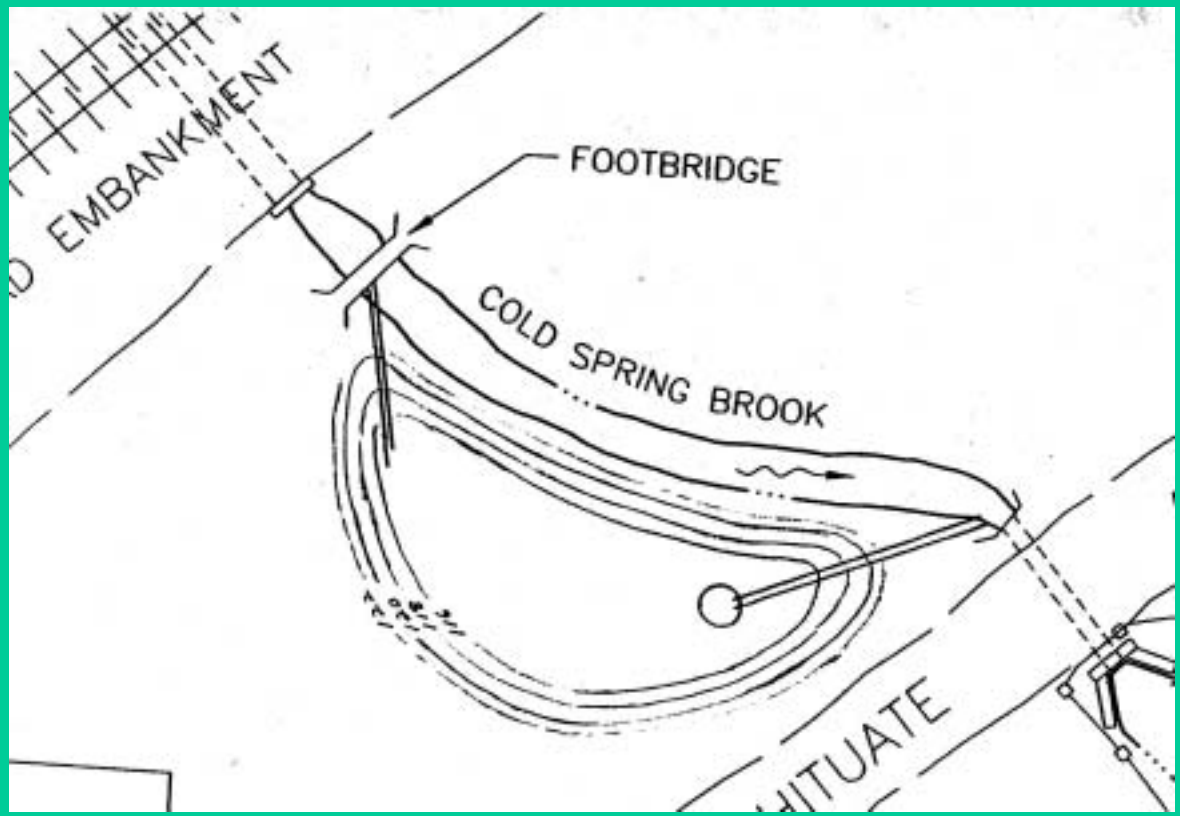
Original Design

- Total sediment load/yr = 8,950 cf
- Forebay capacity 3,200 cf
- Inflow = 21 cfs
- Inflow of 11 cfs = Scour velocity of 2.5 fps

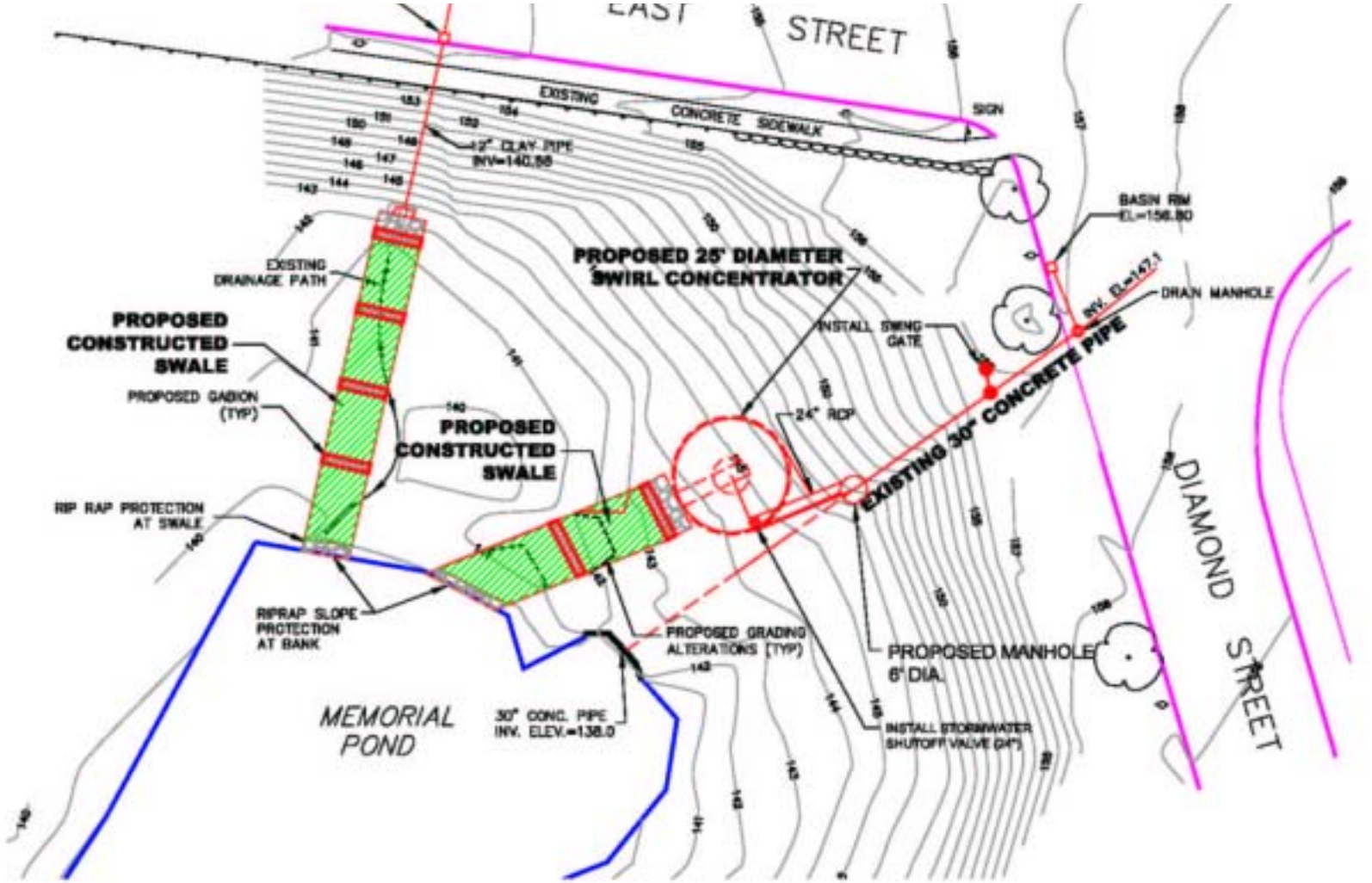


No. 2: Scour Velocity

- Recommendations:
  - Large drainage areas need a treatment train, not a single BMP
  - Offline treatment may keep size and cost down, and effectiveness up



Treatment train that includes offline diversion for a large, high velocity drainage area



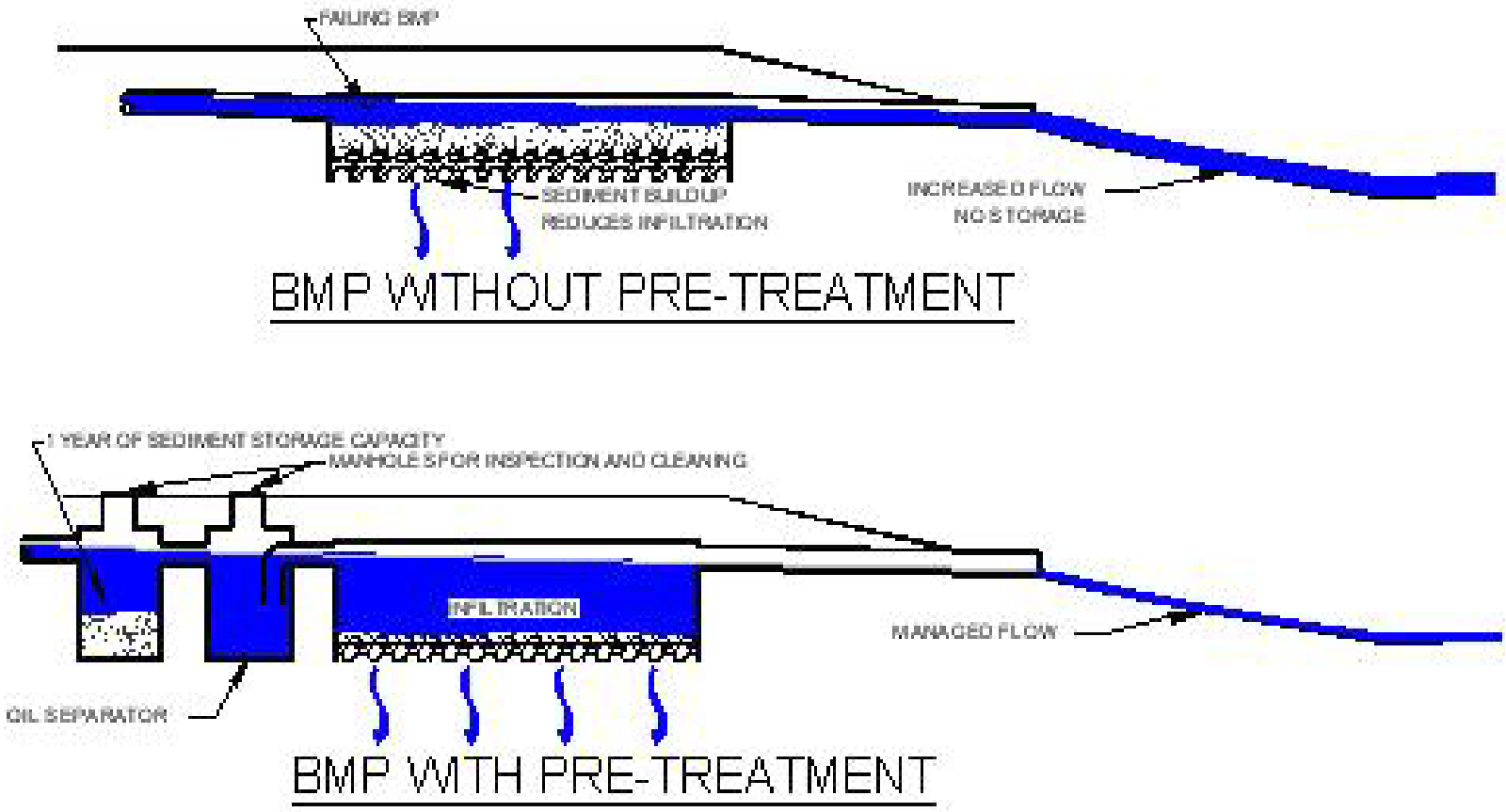
No. 3: No Pretreatment

- Problem:
  - Many BMPs are going in without adequate pretreatment
  - Most problematic:
    - Wetlands treatment
    - Underground units

No. 3: No Pretreatment

- Recommendation:
  - To trap sand, all BMPs in cold climates should have pretreatment
  - Forebays, deep sumps, baffle tanks and similar traps will work if:
    - Accessible
    - Easily cleanable
    - Adequately sized, placed in multiples if needed
  - CEI recommends using sand traps separate from hoods to avoid breakage

No. 3: No Pretreatment



No. 4: Ineffective for site pollutants

- Problem: Use of proprietary units or other designs not known for removing nutrients surprisingly common in high nutrient situations
- Recommendation: Use tailored treatment train

Post Treatment Photos

No. 5: Unrealistic Maintenance Assumptions

- Problem: estimates of loadings sometimes use unrealistic assumptions.
  Example: one design assumed that the parking lot would be swept weekly.

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No. 6: Maintenance Needs Hidden

- Problem:
  - Most underground units are “out of sight, out of mind”
  - Some have bypasses to prevent backing up and flooding if not maintained
  - Some designs make it difficult for inspectors to see if maintenance is needed

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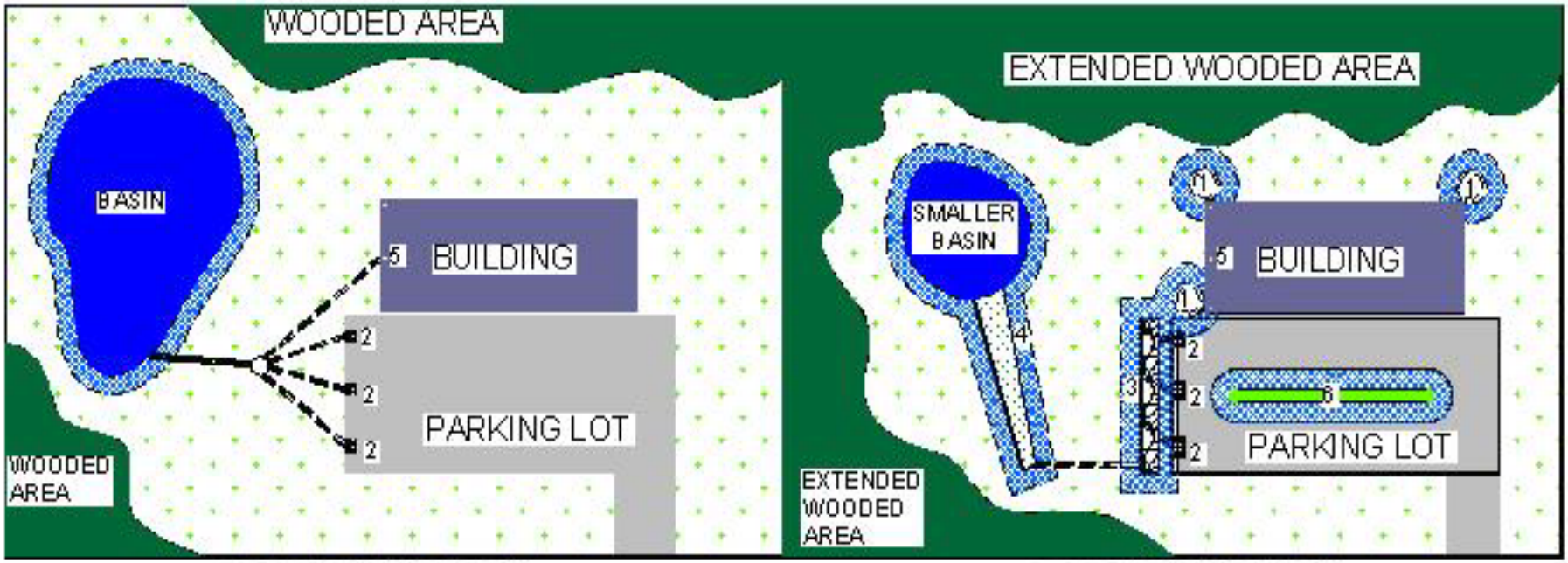
No. 7: Cleanouts Inaccessible or Non-Existent

- Problem: no way to maintain the BMP due to long reach; steep slope or other reason for inaccessibility to the equipment used by the community or site owner

No. 8: One Size Fits All Approach

- Problem: many site engineers are using the same BMPs for every situation
- Recommendation: BMPs need site specific design that matches sites pollutants, site constraints and minimizes imperviousness to begin with



No. 9: Not designed using worst case criteria

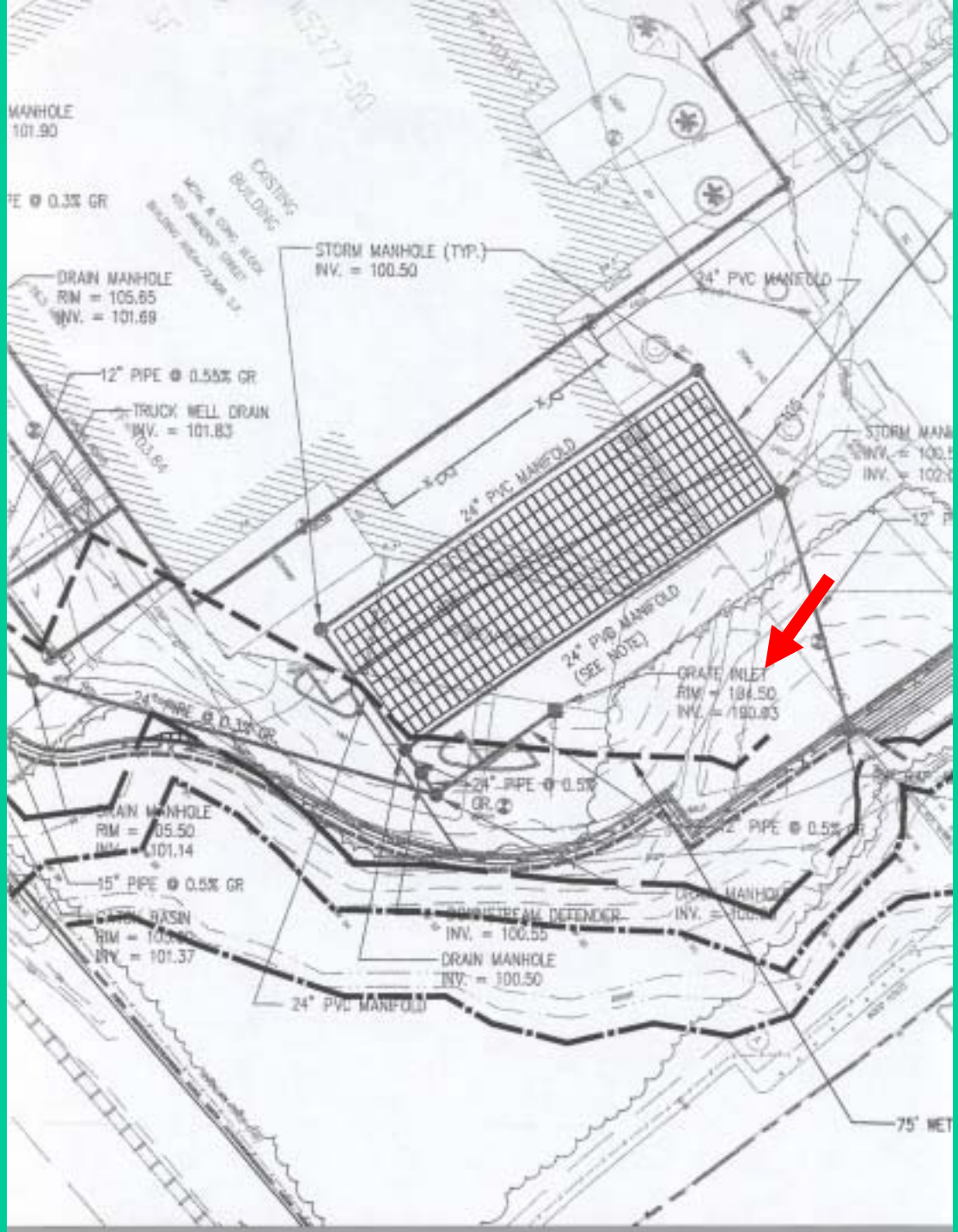
- Problem: Most BMPs designed today make optimistic assumptions:
  - Overall site use is optimal, for example, “good” or “excellent” forest; no compaction of playground soils
  - No eventual decline in performance over time
  - Rapid exfiltration at all times
- Recommendation: BMPs need to be designed for worst case instead of the most optimistic assumptions available.

Above site was designed assuming that the post condition would be “good” condition grass cover >75%

No. 10: Design doesn’t fit site

- Problem: Sites with specific constraints, such as shallow groundwater, matched with designs that won’t work under the site’s constraints

Sediment forebay in area of high groundwater near a landfill. Discharge is below surface of groundwater which appears to contain leachate.



No. 10 Design Doesn't Fit Site

Infiltration galleries proposed but invert is at 100 and groundwater shown at 98-100 feet. A minimum of 3 feet to seasonal high groundwater is needed.


Wetlands treatment (including pretreatment) usually most appropriate for sites with shallow groundwater

No. 10: Design doesn't fit site

- Recommendations:
  - Borings needed before final design
  - Most BMPs should drain within 48 hours to avoid mosquito breeding
  - Need 3 foot separation from seasonal high groundwater

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Conclusions

- Talking about maintenance is not enough; reduced maintenance needs to be built into the designs
- Boards often assume that the engineering is being reviewed, but many of the techniques used today are not “standard” engineering and may appear adequate to the reviewer
- It is unrealistic to assume that BMPs will be cleaned out more than 1/year
- Communities can
  - 1) adopt design criteria in regulations;
  - 2) create review checklists;
  - 3) specify O&M requirements; and
  - 4) have specialized plan reviews or training for municipal reviewers

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