Enhanced Aquifer Recharge Using Stormwater: State of the Science Review

Presented by: Thomas Johnson

EPA Office of Research and Development

September 29, 2021 – GWPC Annual Forum

The views expressed in this presentation are those of the authors and do not necessarily reflect the views or policies of the U.S. Environmental Protection Agency

Acknowledgements

Eastern Research Group

Julie Blue

Sam Arden

Jason Rose

Andrew Shapero

Chi Ho Sham

EPA ORD

Jim Carleton

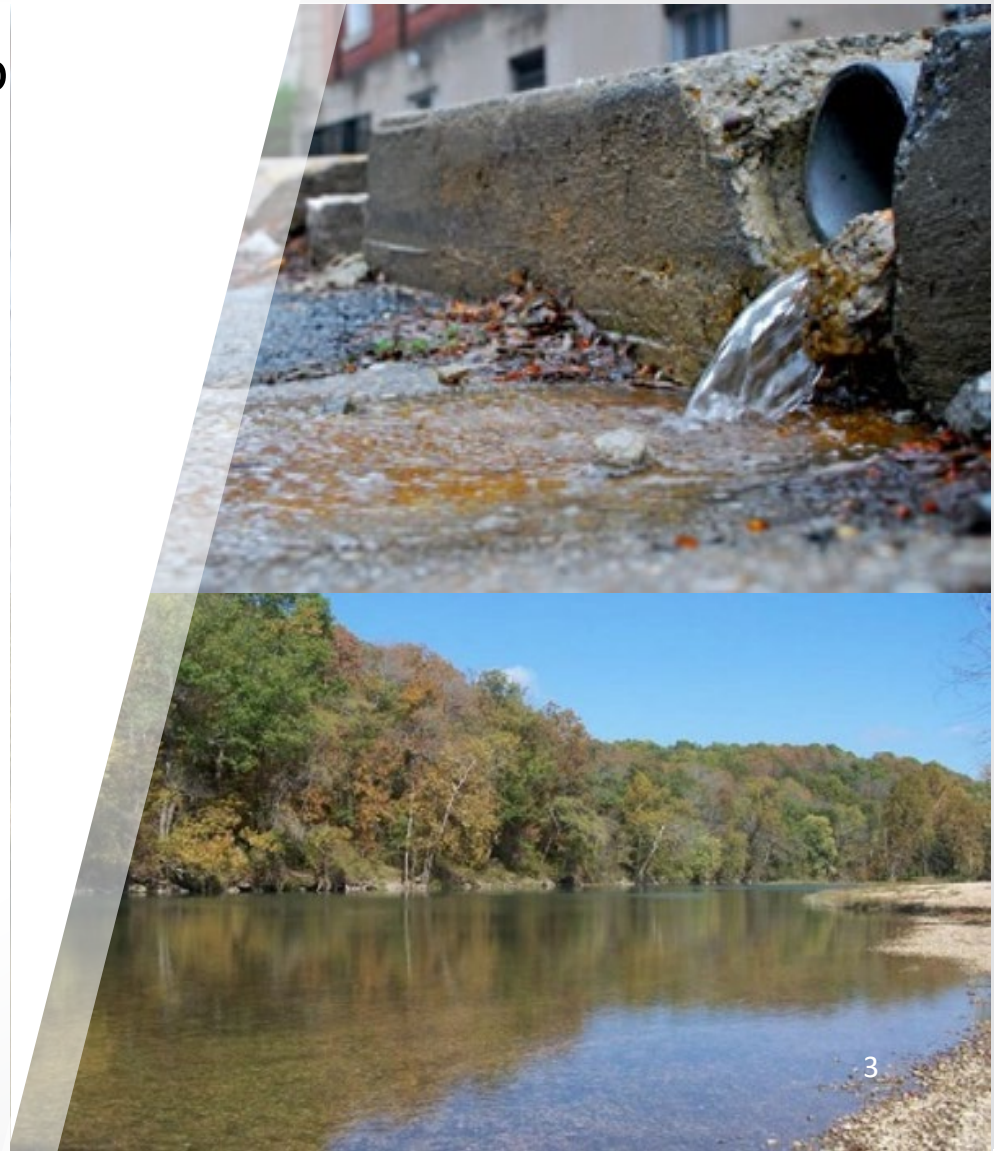
Michael Pennino

Laurie Alexander

Britta Bierwagen

Problem Statement

- Growing interest in enhanced aquifer recharge (EAR) to augment water supplies, replenish groundwater
- EAR using stormwater is increasingly attractive
  - dovetails with traditional stormwater management
  - treats stormwater as a resource
- But introducing stormwater to subsurface can also present a risk of groundwater contamination
- Need for improved understanding of best practices; fit-for-purpose uses and risk of EAR using stormwater



State of the Science Review

ORD report (July 2021):

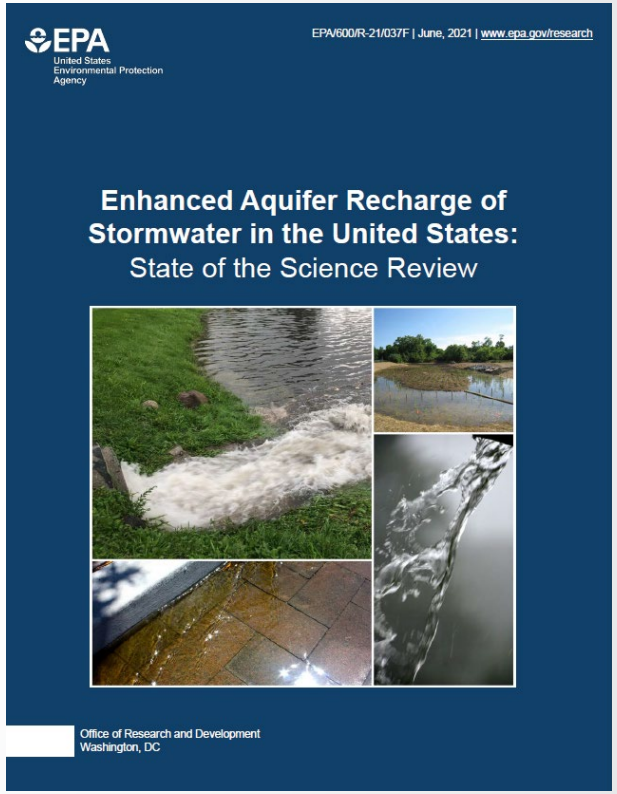
Enhanced Aquifer Recharge of Stormwater in the United States: State of the Science Review

Goal: Summarize the state of the science of information leading to best practices for EAR using stormwater

Topics addressed:

- practices used for stormwater EAR
- factors affecting recharge volumes achievable
- risks; particularly water quality degradation
- what current science suggests about best practices
- knowledge gaps to help advance stormwater EAR

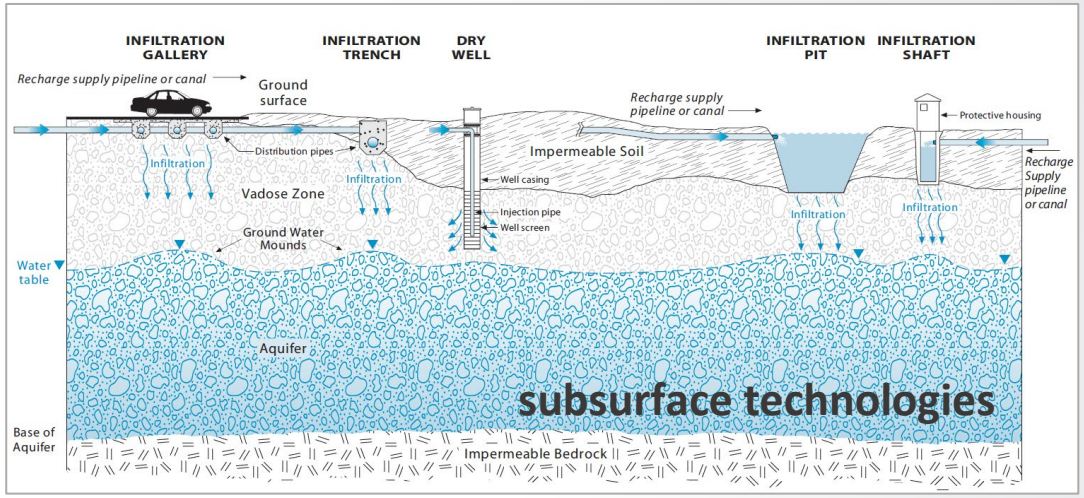
Does not address regulatory, legal, economic or policy issues

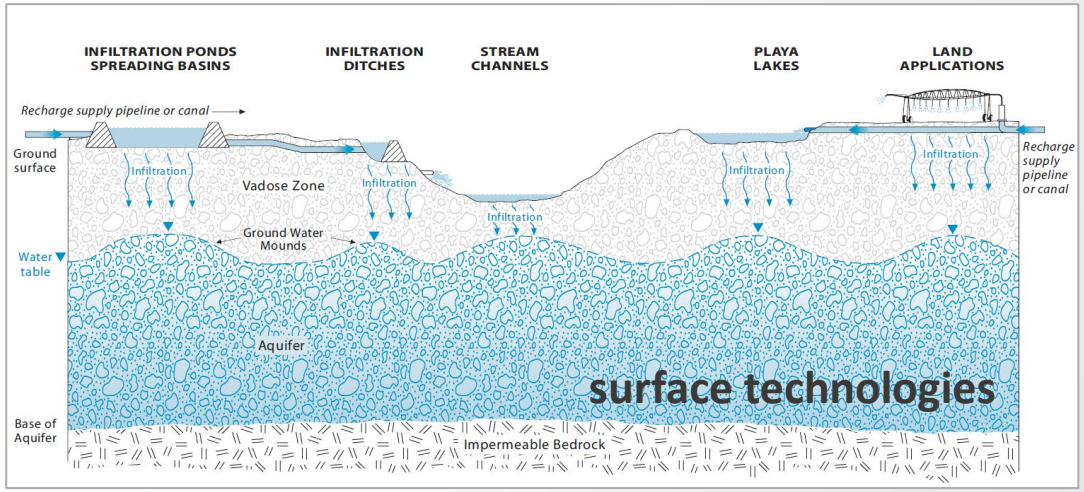


Enhanced Aquifer Recharge

EAR methods considered include:

- Infiltration basins and ponds
- Infiltration trenches/galleries; ditches
- Dry wells
- Dry riverbeds
- Injection wells (including stormwater drainage wells and ASR wells)





Literature Survey

Conducted a keyword-based literature search

- Web of Science
- ProQuest
- Science Direct

Heat maps show the distribution of literature citations identified as "relevant", by category (n=685)

Publication Date	Items
2016 - 2020	257
2011 - 2015	195
2006 - 2010	102
2001 - 2005	54
2000 or earlier	78

Region	Items
General (lab/review)	225
Northeast	21
Southeast	56
Midwest	6
Great Plains North	4
Great Plains South	26
Northwest	11
Southwest	113
Australia	100
Other International	124

Literature Survey (continued)

Study Endpoint	Items
Volume/Hydrology	144
Quality - Microbial	35
Quality - Chemical	187
Quality - General	95
General	182
Aquifer - Microbial/Biofilm	11
Economic/Policy/Decision	32

Study Focus	Items
Design/Planning/Siting	98
Maintenance/Pre-treatment	87
Performance/Risk	246
General/Case Study	108
Review Paper	147

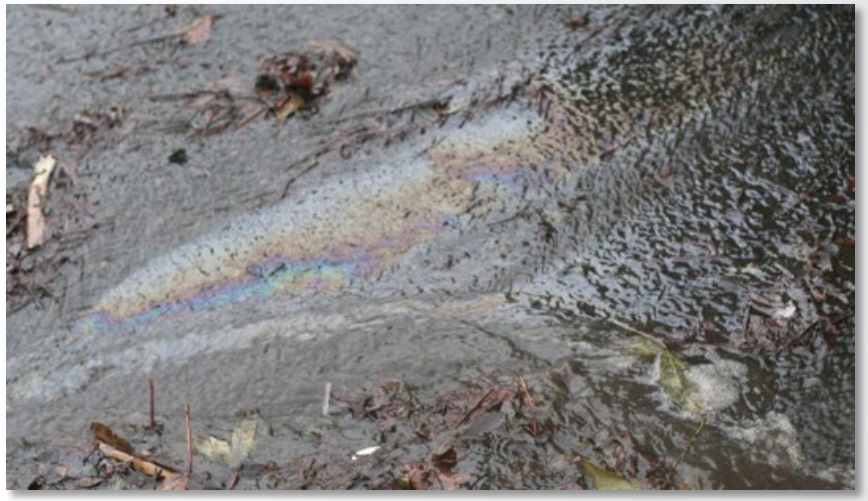
Factors Affecting Recharge Volumes

Factor	Mechanism
Precipitation	Frequency, duration, intensity, and seasonality
Land cover	Runoff generation (impervious surface), runoff reduction (pervious and vegetated surfaces), stormwater quality (developed areas)
Soils	Soil type, grain size, hydraulic conductivity
Geology	Clogging in fractured rock or fine-grained unconsolidated aquifers; dissolution of karstic substrate when exposed to mildly acidic
Depth to water table	Higher groundwater tables leading to early intersection of the water table with the infiltration practice floor
Total suspended solids in recharge water	Physical clogging
Nutrients and organic content in recharge water	Biological clogging

Risk to Groundwater Quality

Urban stormwater can contain a range of contaminants:

- pathogens
- organic contaminants
- metals
- nutrients
- road salts



Introduction of stormwater to aquifers can also mobilize subsurface contaminants

- precipitation/dissolution of minerals
- oxidation/reduction reactions (w/ introduction of DO)
- sorption and cation exchange reactions
- clay swelling and dispersion

Towards Best Practices

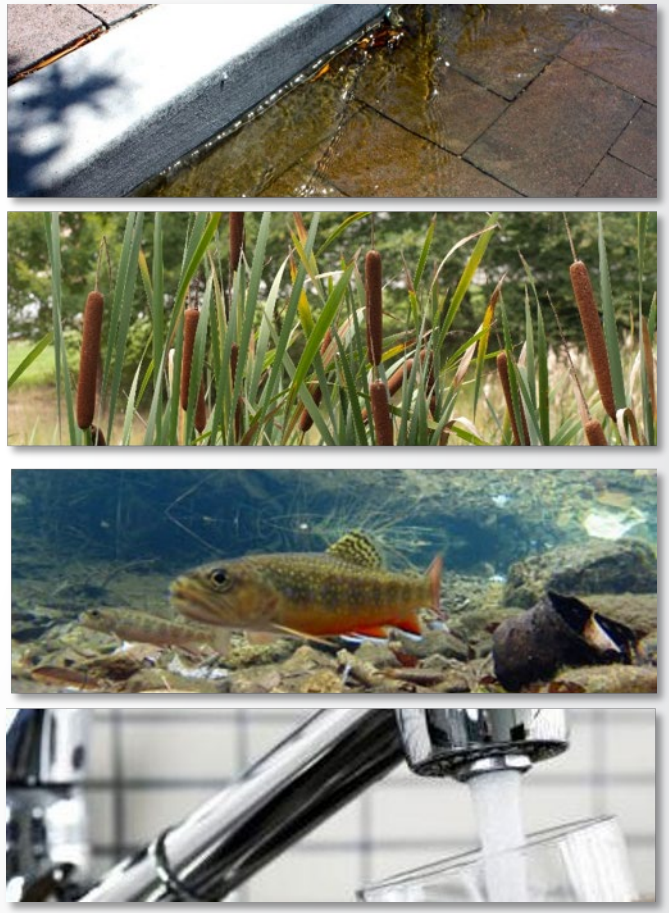
Stormwater can be a significant source of water supply

Soil/aquifer systems provide opportunities for natural filtering and inactivation or removal of contaminants from recharging stormwater

But must consider potential risk of groundwater contamination

Opportunities/constraints include (biophysical):

- influent stormwater volume and quality
- site selection (soil and hydrogeologic setting)
- project design/pretreatment needs (specific contaminants)
- maintenance and monitoring



Pre-treatment

Examples of pre-treatment methods

- Settling basins
- Constructed wetlands
- Green infrastructure
- Media filtration
- Roughing filters
- Granular media filters
- Advanced media filters
- Chemical pretreatment

Knowledge Gaps

Physical, chemical, and biological aspects of stormwater in different development/ land use settings

Variable performance and risk of EAR practices

- contaminant fate and transport in subsurface
- spatial and temporal variability

Effectiveness of pre-treatment (fit-for-purpose, specific contaminants)

- evaluation of new technologies

Long term sustainability

- changes in performance over time
- effects of changing conditions (e.g., climate, land use)

More Information

Report available online (July 2021):

Enhanced Aquifer Recharge of Stormwater in the United States: State of the Science Review (EPA/600/R-21/037F)

https://cfpub.epa.gov/si/si_public_record_Report.cfm?dirEntryId=352238&Lab=CPHEA

Thanks!

Tom Johnson
johnson.thomas@epa.gov