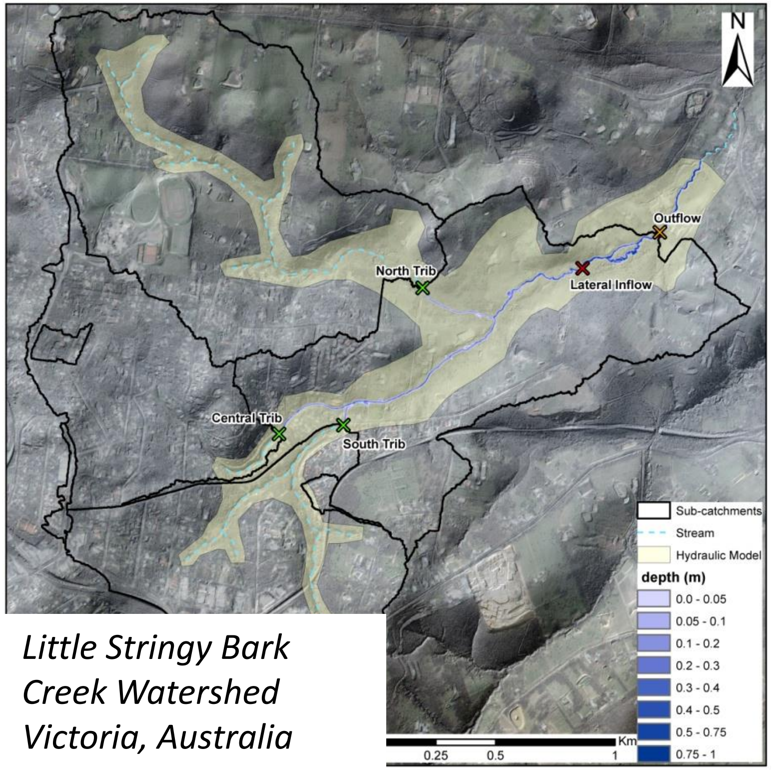
# Catchment Scale: Impact of rainbarrels and biofilters on flooding

- Can rainbarrels and biofilters substitute for conventional drainage upgrades?




*Little Stringy Bark Creek Watershed Victoria, Australia*

***Brett Sanders, UCI***

***Jochen Schubert, UCI***

***Tim Fletcher, U. Melbourne***

***Matt Burns, U. Melbourne***

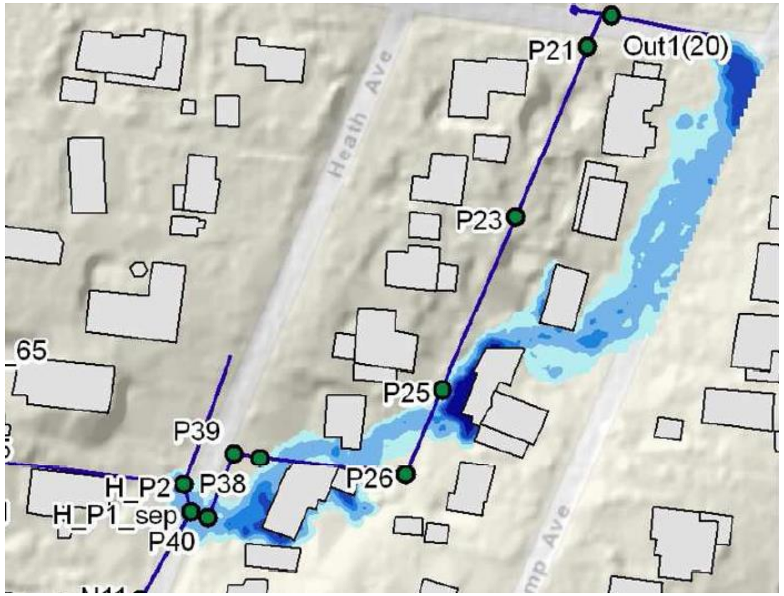
Little Stringybark Creek

POSTERA CRESCAM LAUDE
THE UNIVERSITY OF MELBOURNE

# Coupling of Network and Overland Flow Models

- US EPA Stormwater Management Model (SWMM)
  - Simulates urban stormwater drainage and accounts for distributed stormwater capture
  - Storm flows that surcharge the drainage system become input to overland flow model

- BreZo overland flow model (UCI)
  - – Predicts localized ponding and flow of surcharging storm flows
  - – “Microwatershed scale” modeling of flooding to identify and mitigate flood risk on a house by house basis



# Approach: Flood Modeling

- Testing in eastern suburbs of Melbourne, Australia (Little Stringybark Creek Watershed)
  - Focus on small 2.8 ha catchment  with 23% imperviousness
  - Storm water infrastructure in small catchments typically designed for only 10-20 year events
- Investigated two stormwater management scenarios
  - (1) Current landuse and stormwater infrastructure
  - (2) Redeveloped with:
    - Roof drainage through rain barrels
    - Other impervious surfaces drain through infiltration trenches
- SWMM Model Calibration (using obs of rainfall/runoff)
- Analyzed storm events with average recurrence intervals (ARIs) ranging from 1 to 100 years

# Results

Table 2. The effect of SCMs on flooded area.

| ARI (X years) | Scenario | | Reduction of flooded area (%) |
|---|---|---|---|
| | Developed ($m^2$) | Developed with SCMs ($m^2$) | |
| 1 | 185 | 185 | 0 |
| 1.5 | 1284 | 1284 | 0 |
| 5 | 2004 | 1729 | 14 |
| 10 | 2835 | 1795 | 37 |
| 20 | 3071 | 1850 | 40 |
| 50 | 3886 | 2973 | 23 |
| 100 | 4564 | 3211 | 30 |

- Reduction of flooded area is maximized with 10-20 year storm events
  - Substantial reductions for ARI > 50 yr

# Conclusions:

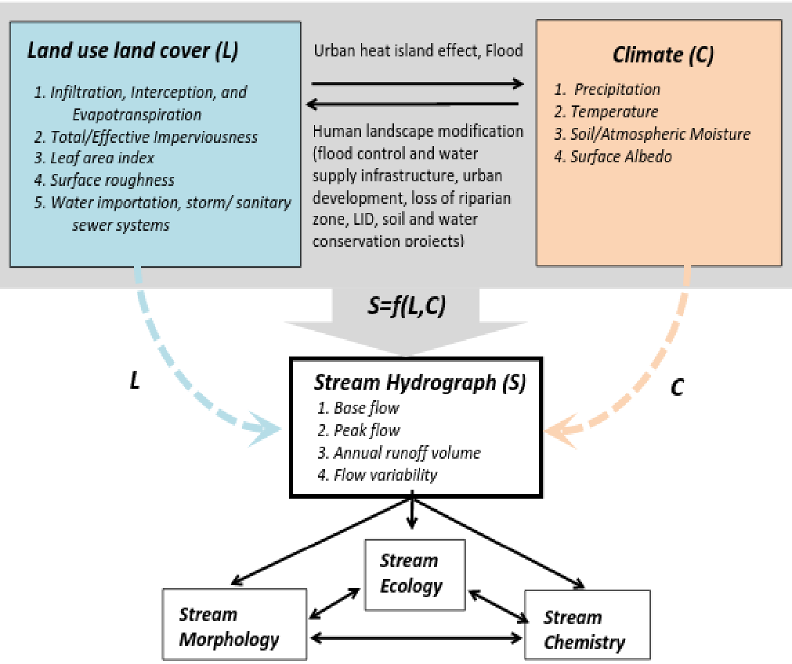
- Rainbarrels and biofilters can substitute for conventional drainage upgrades to reduce localized urban flooding
    - Also benefits receiving water bodies and provides urban amenities (green space, ET cooling,…)
- Research continues to examine impacts at larger scales and measure cost effectiveness
    - riverine flooding and geomorphic impacts

# Products:

- Burns M, J Schubert, T Fletcher, B Sanders. Testing the impact of at-source stormwater management on urban flooding through a coupling of network and overland flow models, *journal article under review*
- Research funding provided by Melbourne Water to support M Burns and T Fletcher on this project

# Catchment Scale: Impacts of NTS on Stream Hydrographs

- What is currently known about the effects of distributed stormwater capture on stream hydrographs?

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# Evaluating the Effects of Green Infrastructure at the Watershed Scale

309 studies have explored the impact of land use land cover (LULC) change on watersheds worldwide

< 15% of these document the effects of green technologies on watersheds

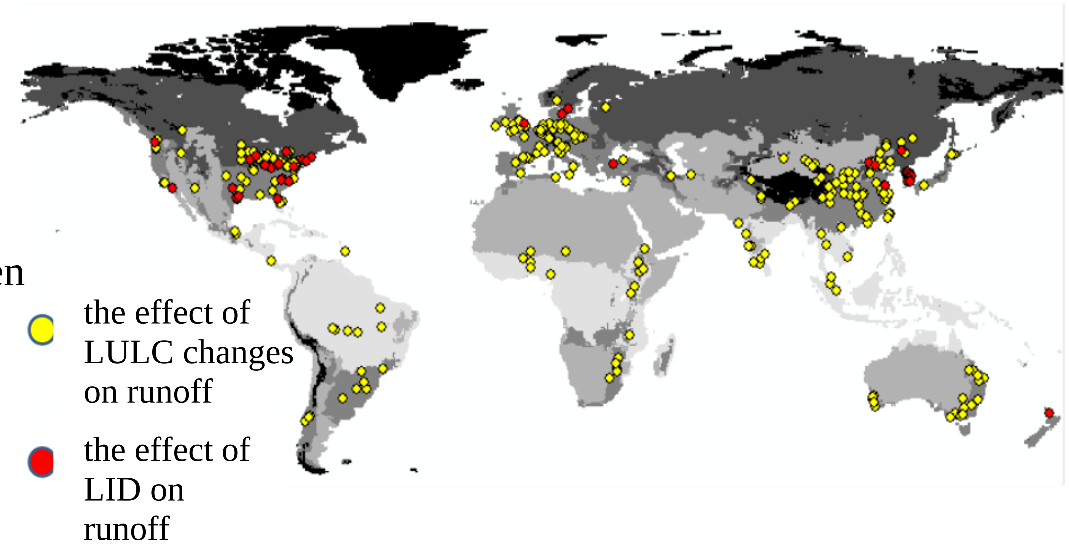
- the emphasis is on subtropical or Mediterranean climates

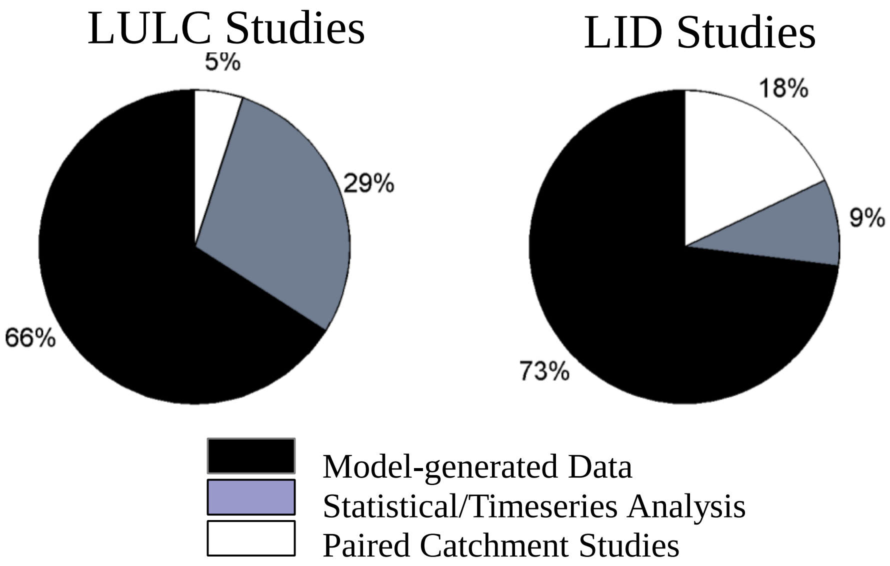
- sensitive polar and arid biomes are vastly understudied

Most LID studies use synthetic data to explore different installation scenarios

- statistical and time-series methods for change detection are underutilized

- the broader LULC literature can be used as a resource for additional analytical methods



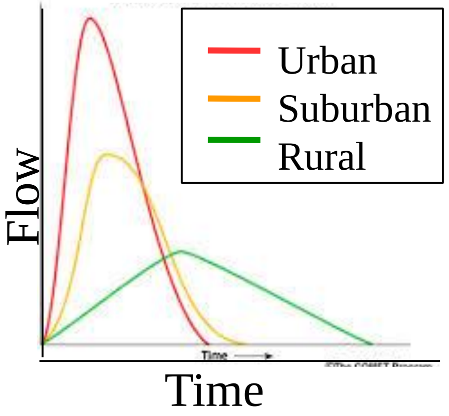



# Evaluating the Effects of Green Infrastructure at the Watershed Scale

## FUTURE DIRECTIONS:

Integrate statistical/time-series approaches and model-based approaches for evaluating LID impacts on stream hydrology in Southern California

→ case study Compton Creek
(Nash IUH model)




Utilize change detection methods to evaluate the impact of urbanization (increased imperviousness, water importation) on stream baseflow in Southern California

→ case study San Diego Creek

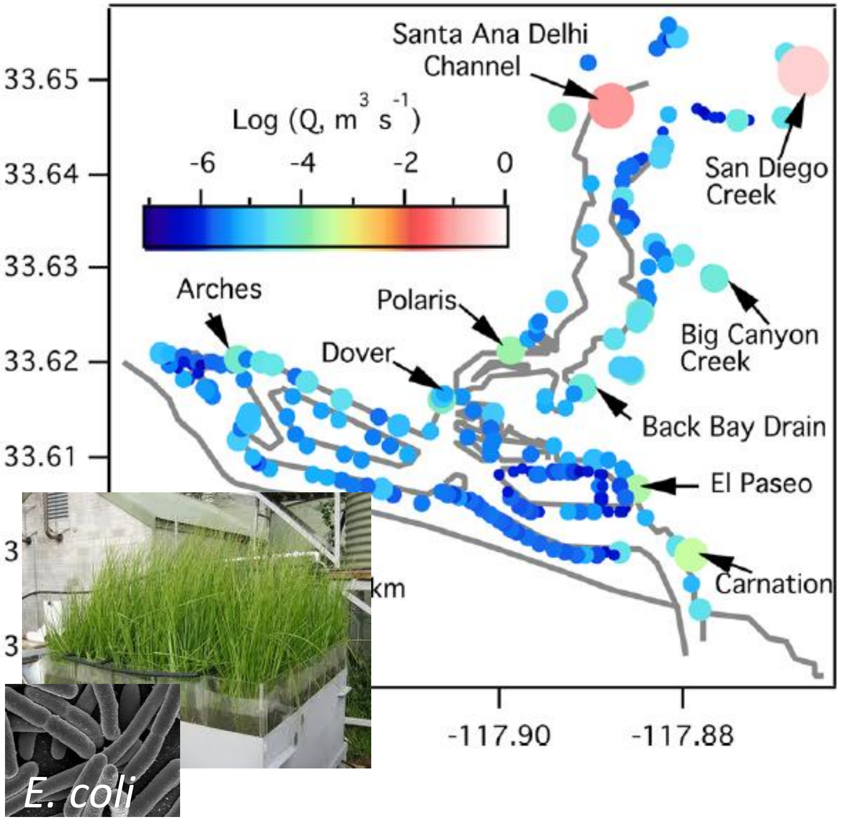
| land use | San Diego Creek watershed (km$^2$)[a] 1968 | 1993 | 2003 |
|---|---|---|---|
| 1. agricultural | 104 (34%) | 19 (6%) | 5 (2%) |
| 2. commercial | 2 (1%) | 26 (9%) | 30 (10%) |
| 3. industrial[b] | 5 (2%) | 65 (21%) | 61 (20%) |
| 4. residential | 33 (11%) | 47 (15%) | 76 (25%) |
| 5. other (public, recreational) | 34 (11%) | 2 (1%) | 13 (4%) |
| 6. undeveloped & unaccounted | 129 (42%) | 148 (48%) | 123 (40%) |

## PRODUCTS (to date):

Askarizadeh et al., From raingardens to catchments: evaluating the impact of LID on the hydrology of urban streams. *Environ. Sci. Tech.* in prep.

# Catchment Scale: How Might NTS Improve Receiving Water Quality in Southern California?

- What mechanisms dominate shoreline fecal contamination in Newport Bay, Southern California?
- How can Bay water quality be improved?

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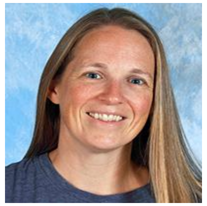
***Robert Stein, City of Newport Beach***



***Karen McClaughlin, SCCWRP***

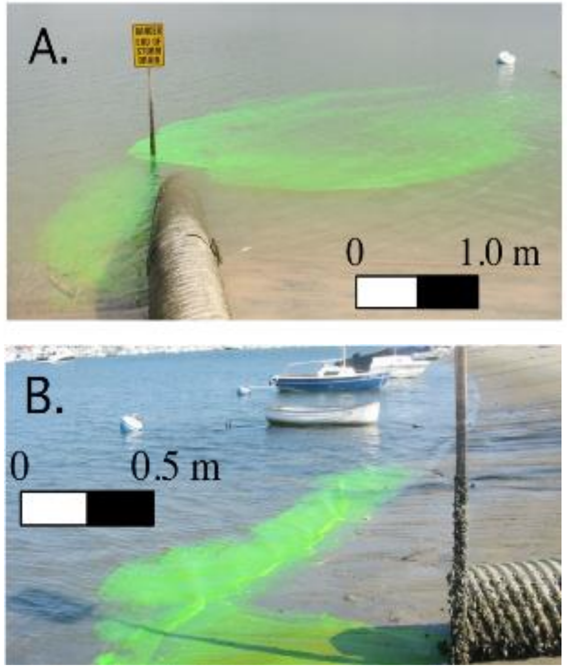
***Jack Skinner, City of Newport Beach***

# How Might Advancements in Biofilter Design Improve Water Quality in Southern California?


Newport Bay is the second largest urban estuary in Southern California
- Upper Bay is a wildlife refuge
- Lower Bay is a recreation area for beachgoers & boaters

**PROBLEM**: Dry Weather Water Quality

-storm drain discharges are a dominant source of FIB pollution to shoreline waters
- freshwater and FIB accumulate in drainpipes at high tide, and are discharged (in bulk) at low tide




**SOLUTION:** Green Infrastructure

Disconnect impervious surfaces and storm drain inlets using green technologies like SZ biofilters
- treats urban slobber at its source
- facilitates stormwater technology transfer between AU and the US

# How Might Advancements in Biofilter Design Improve Water Quality in Southern California?

## FUTURE DIRECTIONS:

Is the Newport Bay storm sewer system unique? To what extent does tidally forced trap and release of urban slobber impact other estuaries? The impact of stormwater on streams is similar globally (the urban stream syndrome)

- Is there an analogous urban estuary syndrome?
    - If so, what are its symptoms?

Emily Parker, UCI UPP Down Under 2013, participant

## PRODUCTS:

**Posters:** Rippy, M. A.; Ciglar, A.; Grant, S. B. Are fecal indicator bacteria like salt?: conservative tracer modeling and resistor theory in Newport Bay, California. Ocean Sciences, 2014, Honolulu, HI.

**Publications:** Rippy et al., Small drains, big problems: the impact of dry weather runoff on shoreline water quality at enclosed beaches. *Environ. Sci. Tech.*, 2014.

**Press:**

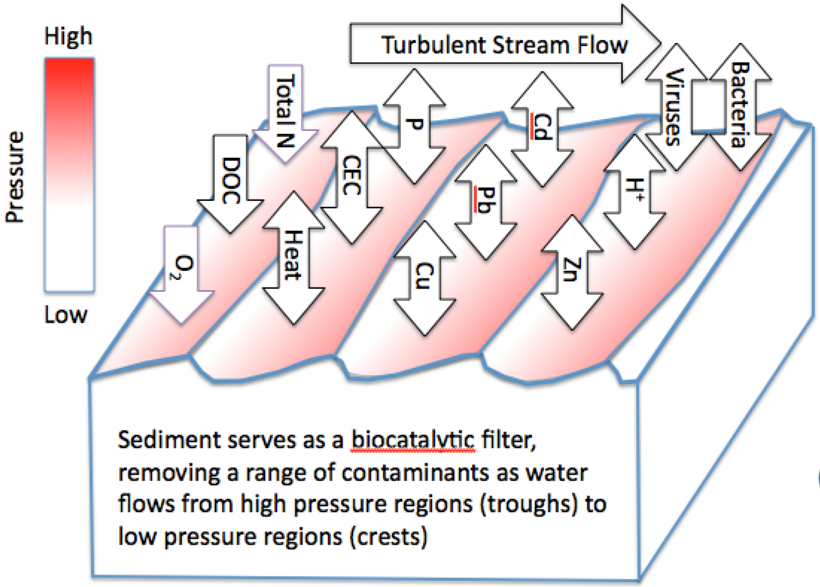
OCWEEKLY

**UC Irvine Researchers Pooh-Pooh Small Drainpipes for Stinking Up Baby Beaches**

- Mat Coker

# Catchment Scale: Modeling nitrogen removal in permeable sediments

- Can we predict the nutrient removal provided by flow over permeable sediments in coastal marine and river ecosystems?

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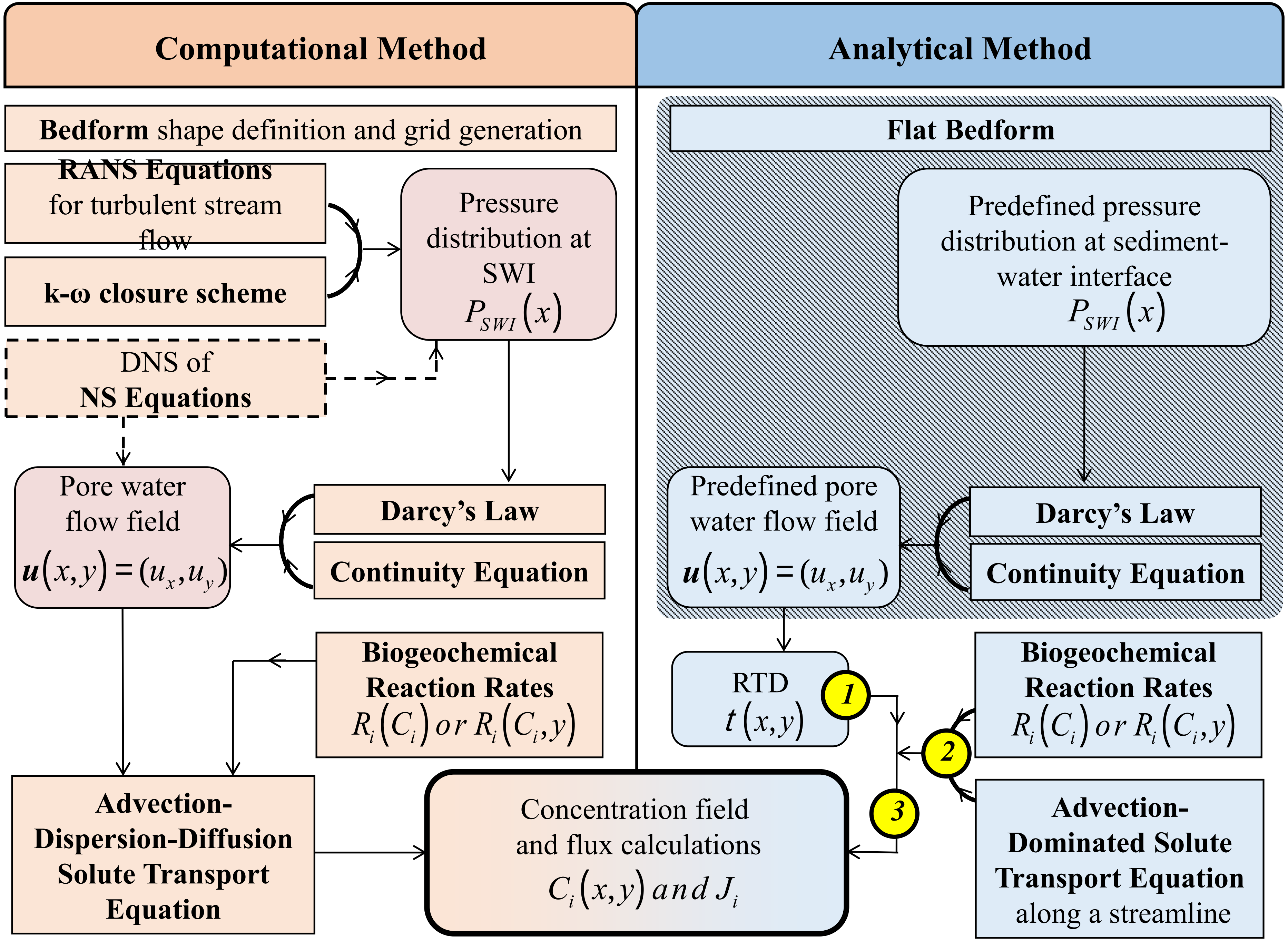
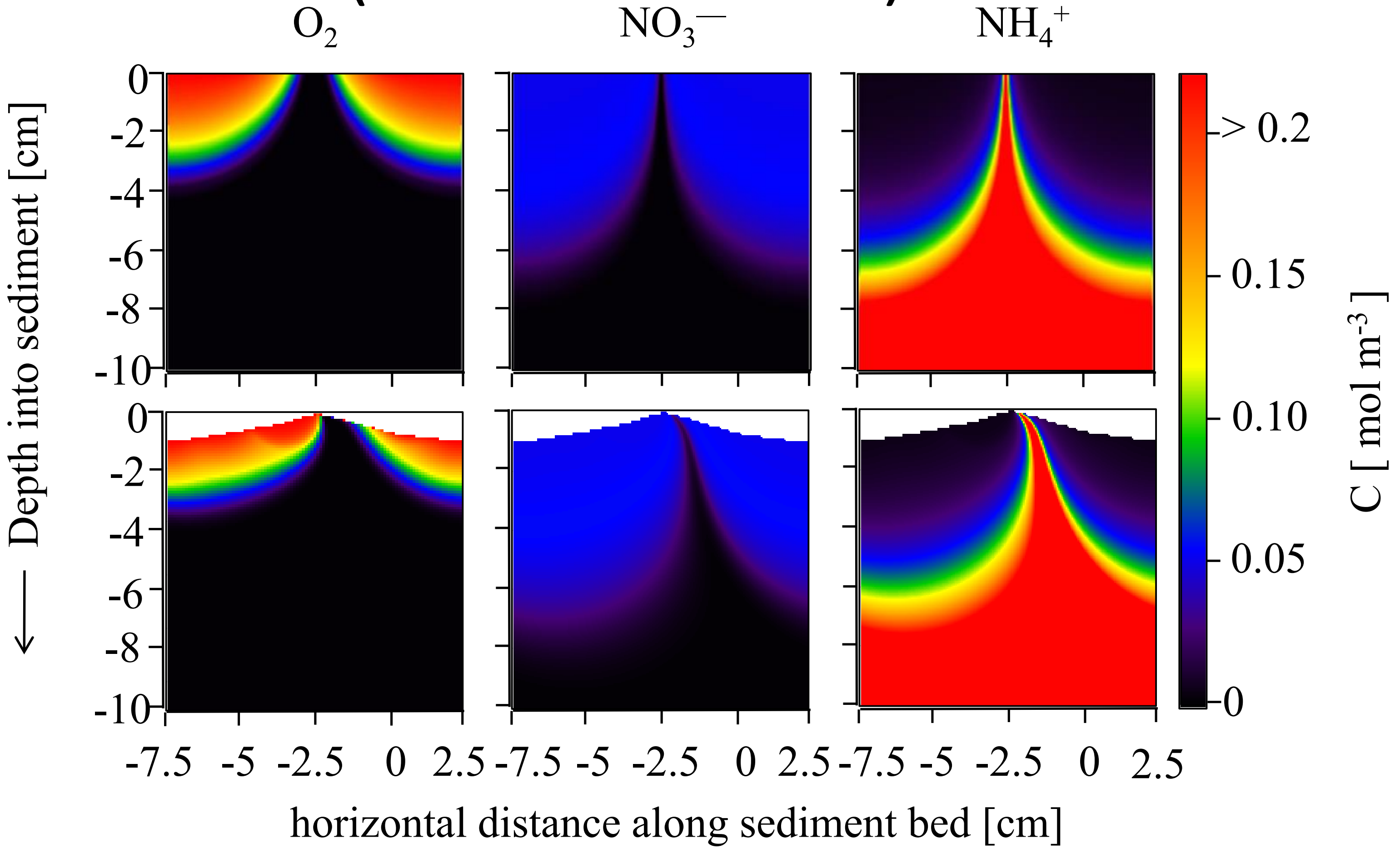


Computational Method
Analytical Method
Bedform shape definition and grid generation
RANS Equations for turbulent stream flow
k-ω closure scheme
Pressure distribution at SWI $P_{SWI}(x)$
DNS of NS Equations
Pore water flow field $\boldsymbol{u}(x,y)=(u_x,u_y)$
Darcy's Law
Continuity Equation
Biogeochemical Reaction Rates $R_i(C_i)\ or\ R_i(C_i,y)$
Advection-Dispersion-Diffusion Solute Transport Equation
Concentration field and flux calculations $C_i(x,y)\ and\ J_i$
Flat Bedform
Predefined pressure distribution at sediment-water interface $P_{SWI}(x)$
Predefined pore water flow field $\boldsymbol{u}(x,y)=(u_x,u_y)$
Darcy's Law
Continuity Equation
RTD $t(x,y)$
1
2
3
Biogeochemical Reaction Rates $R_i(C_i)\ or\ R_i(C_i,y)$
Advection-Dominated Solute Transport Equation along a streamline

# Results: Analytical (top row) vs. Computational (bottom row)



# Conclusions

- Simple (analytical) models can reasonably represent respiration and coupled nitrification-denitrification in permeable sediments
- Immediate applications for estimating nitrogen removal rates across various environments (coastal marine, rivers)
- Theory could also be used to aid the design of “hyporheic zone treatment systems” as suggested by Lawrence et al (2013)

# Products

1. Grant et al (2014) “First-order contaminant removal in the hyporheic zone of streams: physical insights from a simple analytical model” *Environmental Science and Technology* **48** (19) 11369-11378.
2. Grant et al (20XX) “A simple analytical model for coupled nitrification-denitrification in permeable sediments”, in preparation

*Lawrence et al (2013) “Hyporheic zone in urban streams: A review and opportunities for enhancing water quality and improving aquatic habitat by active management” Environmental Engineering Science, 30, 480-501.*