Newtown Creek Superfund Site – Modeling Overview
## CAG Technical Meeting
March 20, 2019

Presentation Overview

- Role of models in decision-making

- Scope of modeling study

- Overview of modeling framework

- Review of individual sub-models

- Model application for feasibility study

- Status of modeling study

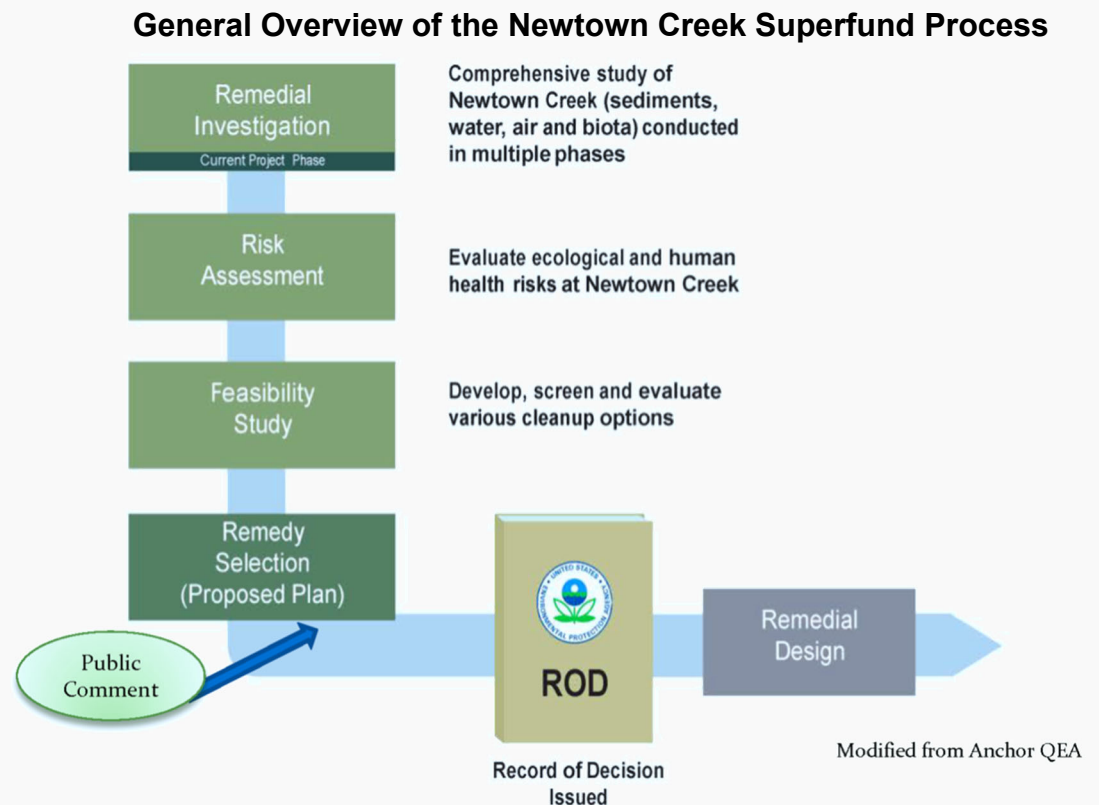# Role of Models in Decision-Making

- What are models?
  - Computational or numerical models
    - A simplification of reality...formal representation in mathematical terms (USEPA, 2009)
    - Implementation in software algorithms
    - Flexible applications
      - 0D, 1D, 2D, 3D
      - Time-variable

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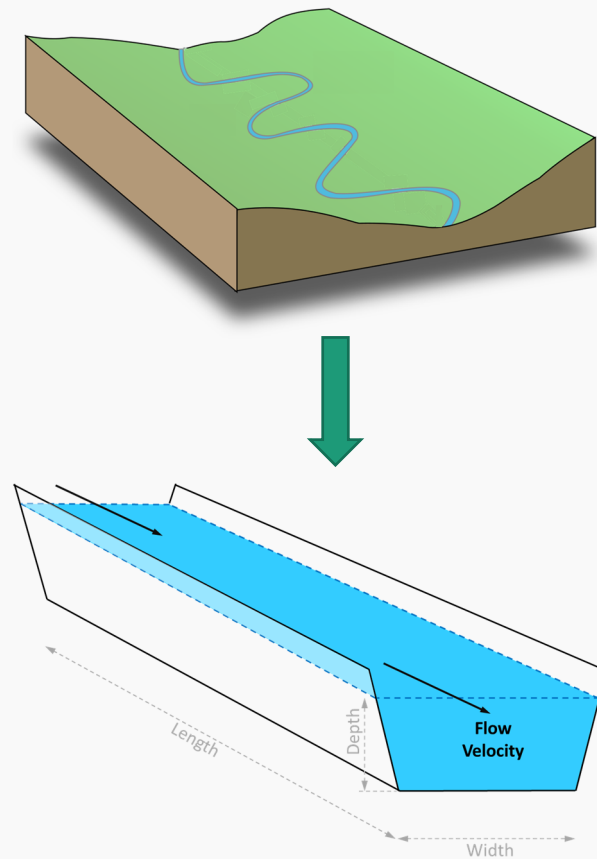
Role of Models (Contd.)

- Modeling in the Superfund process
  - Remedial investigation
  - Feasibility study
  - Remedy design

General Overview of the Newtown Creek Superfund Process

Remedial Investigation — Current Project Phase	Comprehensive study of Newtown Creek (sediments, water, air and biota) conducted in multiple phases
Risk Assessment	Evaluate ecological and human health risks at Newtown Creek
Feasibility Study	Develop, screen and evaluate various cleanup options
Remedy Selection (Proposed Plan)	

Public Comment

ROD — Record of Decision Issued

Remedial Design

Modified from Anchor QEA

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Role of Models (Contd.)

- Why use models?
  - Issues related to site characterization
    - Identify data gaps
    - Quantitative assessment of contaminant fate and transport – sources, sinks, etc.
    - Develop conceptual site model
  - Issues related to site management
    - Develop site management options
    - Predictive tool for comparison of remedial alternatives
    - Provides another line of evidence in addition to empirical observations in developing a remedy
  - Support remedy design
    - Engineering design of remedial elements, environmental and flood impacts assessments, etc.

Role of Models (Contd.)

- Interaction between modeling and data
  - Identify fate and transport processes
  - Model inputs, calibration & validation
- Model limitations and constraints (USEPA, 2002; 2005; 2009a; 2017)
  - *Simplification of reality*
  - *Constraints – computational limitations, assumptions and knowledge gaps*
  - *Tools to help inform decisions rather than machines to generate truth or make decisions*
- Consideration of model assumptions and uncertainties in site decision-making
- Use of model results as one of several lines of evidence to inform site decision-making

USEPA, 2009b

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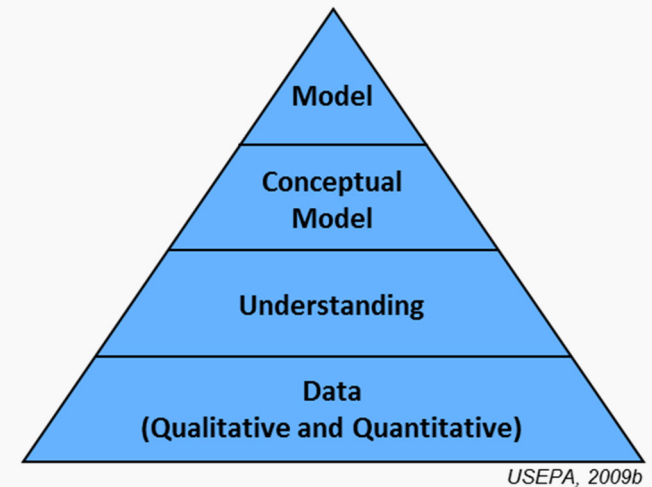
Scope of Modeling Study

- Primary objective of the Newtown Creek modeling study (Anchor QEA, 2012; 2014) is to develop a reliable management tool that can be used to

  - Inform the conceptual site model

  - Evaluate the efficacy of remedial alternatives

Scope of Modeling Study (Contd.)

- Specific questions that may be answered by the Newtown Creek modeling study

  - Site characterization

    - What effects do chemical concentrations in the sediment bed have on total chemical concentrations in the water column and in biota?

    - What is the effect of chemical loads from the East River on chemical concentrations in the sediment bed and in biota?

    - What is the annual load of chemicals from Newtown Creek to the East River under current conditions?

    - What are the effects of ongoing sources on chemical concentrations in the sediment bed and in biota?

    - What are the effects of high-flow events or storms on chemical concentrations in the sediment bed, in the water column, and in biota?

    - What is the potential for erosion, transport, and re-deposition of particle-associated chemicals in the sediment bed during high-flow events or storms at different locations within Newtown Creek?

Scope of Modeling Study (Contd.)

- Specific questions that may be answered by the Newtown Creek modeling study

  - Feasibility study

    - What is the rate of natural attenuation of chemical concentrations in the sediment bed and in biota under future conditions?

    - How would various remedial alternatives affect the rate of attenuation of chemical concentrations in the sediment bed and in biota?

    - How would various remedial alternatives affect the annual load of chemicals from Newtown Creek to the East River?

    - What is the potential for recontamination of remediated areas due to inputs from the East River and/or ongoing sources?

    - What is the potential effect of ship traffic (i.e., propwash) on the effectiveness of various remedial alternatives?

Conceptual Site Model – Physical

- Draft version

  - Food chain shown subsequently
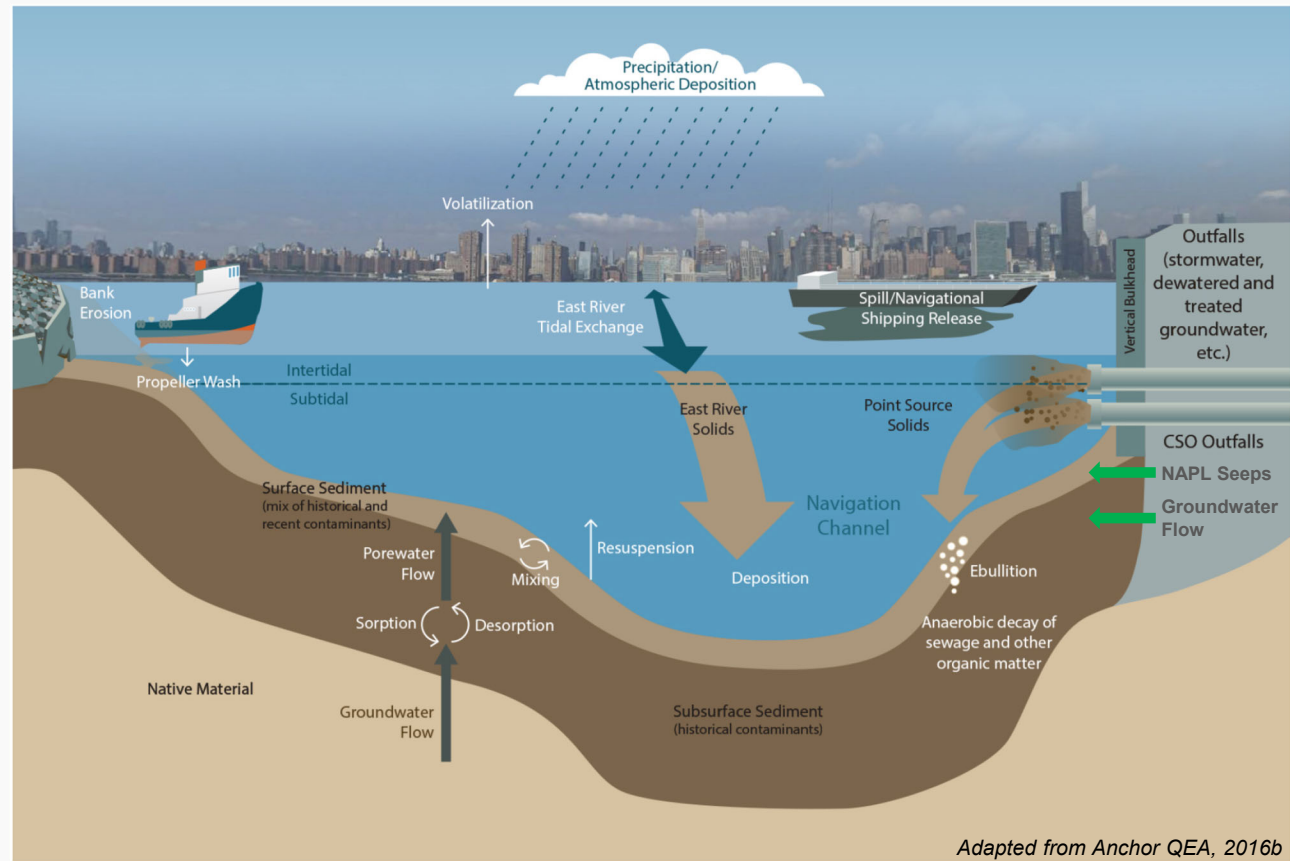

Adapted from Anchor QEA, 2016b

Modeling Framework

- Contaminant fate and transport in Newtown Creek proposed to be modeled by a suite of sub-models

  - Watershed or point-source model

  - Groundwater model

  - Surface water hydrodynamic model

  - Surface water sediment transport model

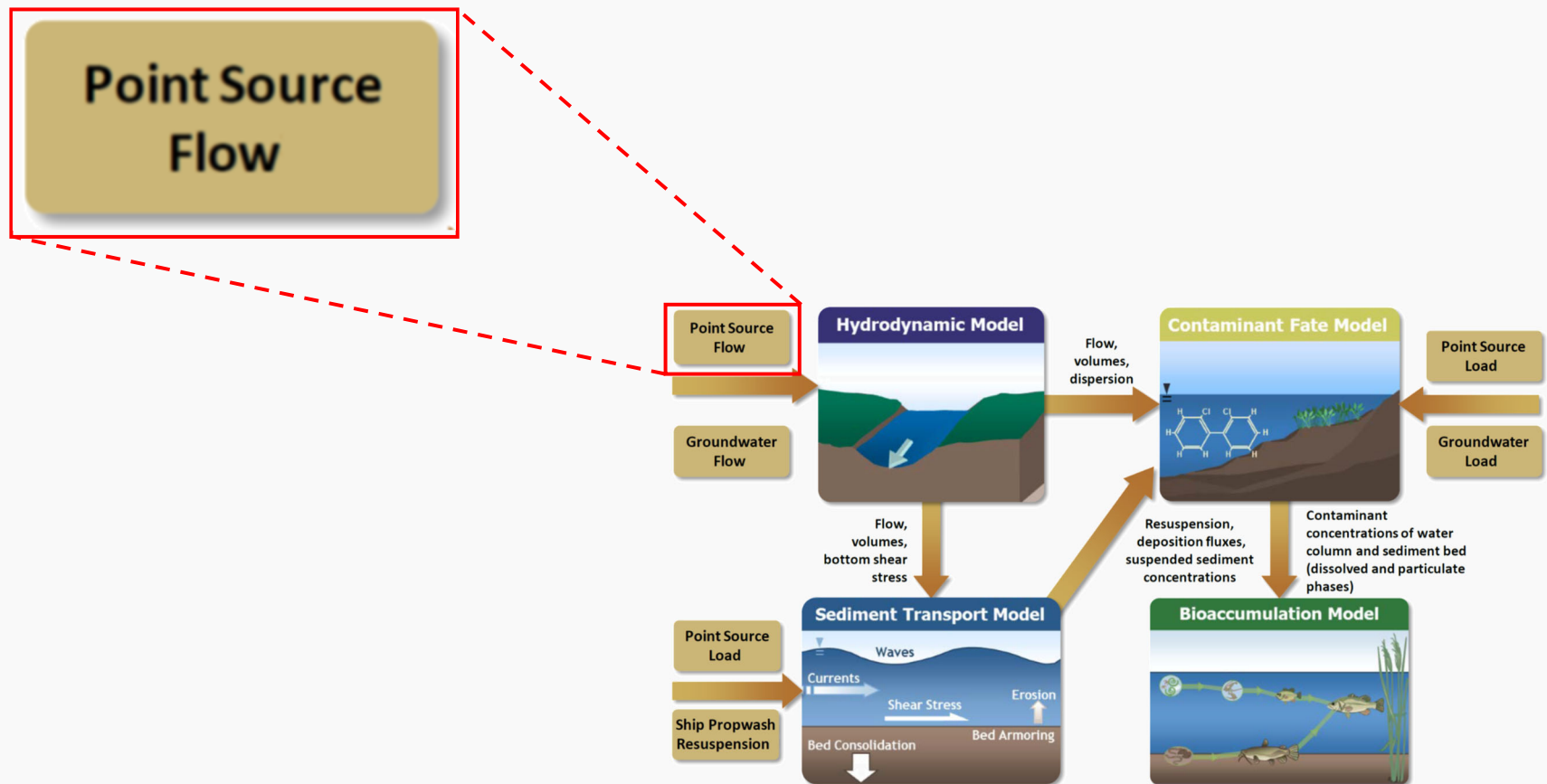 - Surface water contaminant fate and transport model

  - Foodchain or bioaccumulation model

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Modeling Framework (Contd.)

• Draft version

Anchor QEA, 2016b

Model Review – Watershed

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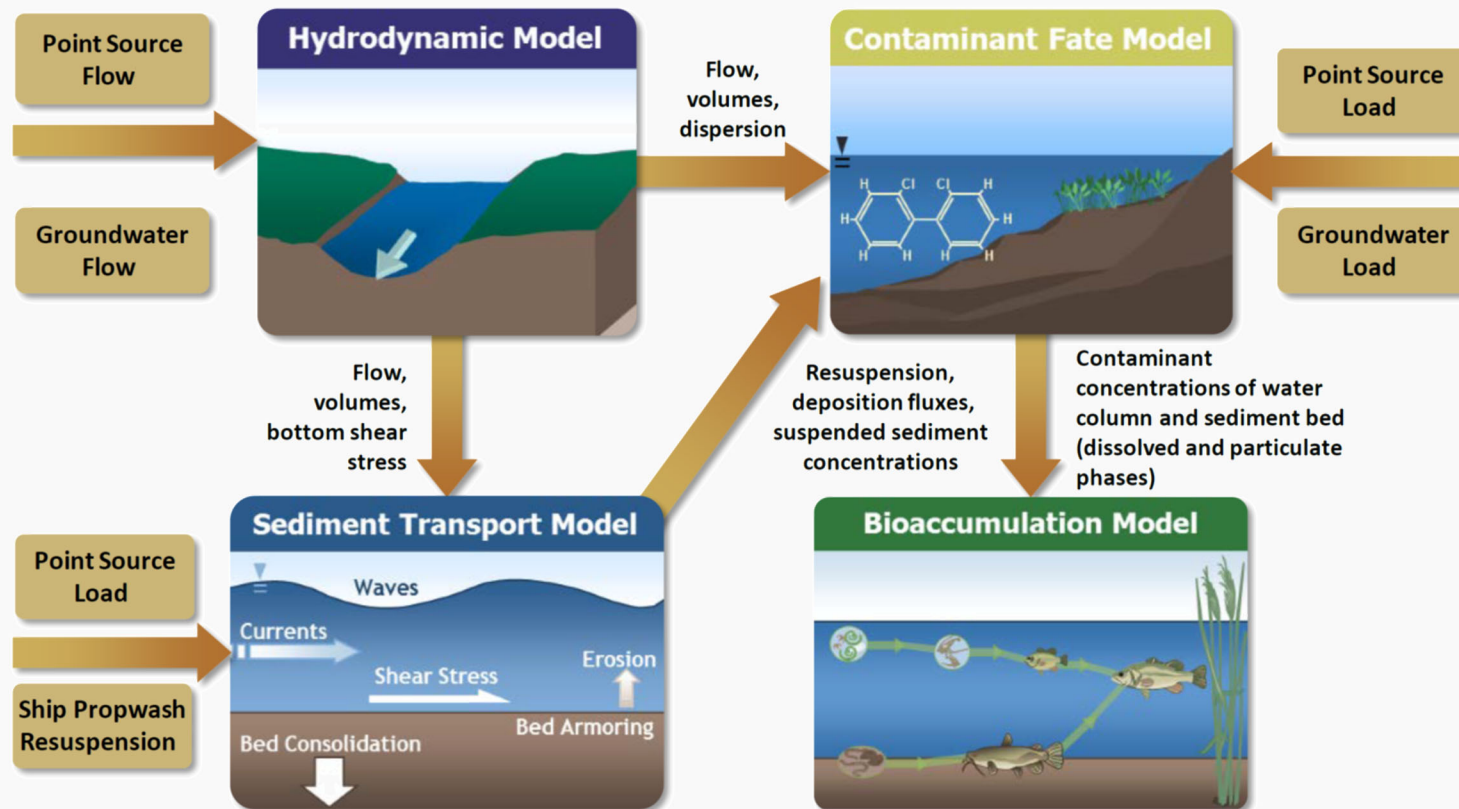
Model Review – Watershed (Contd.)

- Processes simulated

  - Rainfall runoff

  - Transport through collection system

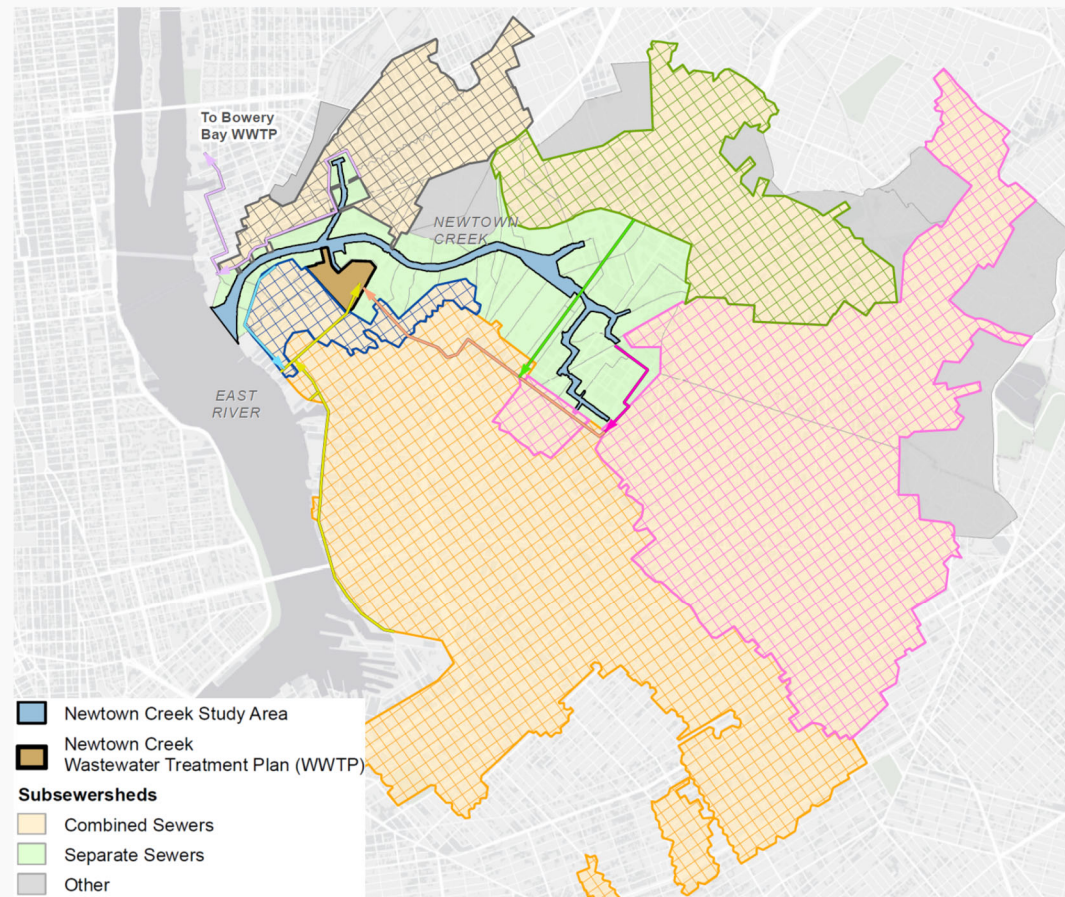 - Release to Newtown Creek via combined sewer overflow (CSO) and storm drains
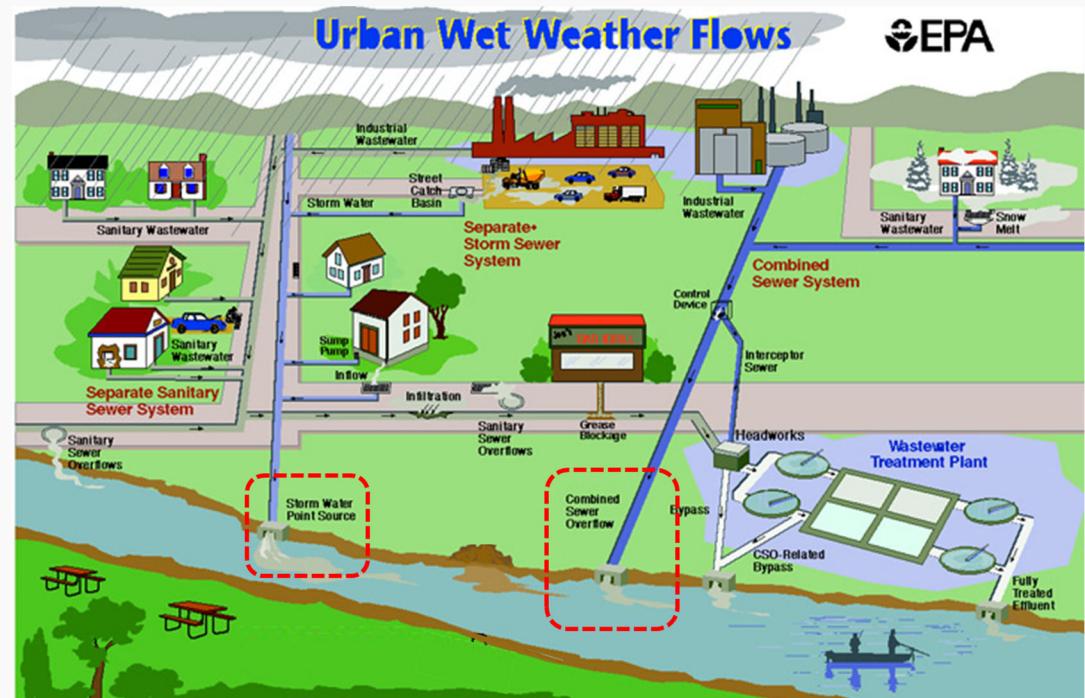
Note: General schematic of urban wet weather flows. Not intended to be a conceptual schematic of the Newtown Creek watershed

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Model Review – Watershed (Contd.)

- Model framework
  - InfoWorks hydrologic and hydraulic model
    - Developed by NYC for the LTCP
- Model domain
  - Newtown Creek and Bowery Bay WWTP sewersheds
- Model inputs
- Model calibration

To Bowery Bay WWTP

NEWTOWN CREEK

EAST RIVER

Newtown Creek Study Area

Newtown Creek Wastewater Treatment Plan (WWTP)

Subsewersheds

Combined Sewers

Separate Sewers

Other

Anchor QEA, 2016b

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Model Review – Watershed (Contd.)

- Model outputs and linkages with other models

    - Outputs

        - Flow rates

    - Model linkages

        - Hydrodynamic

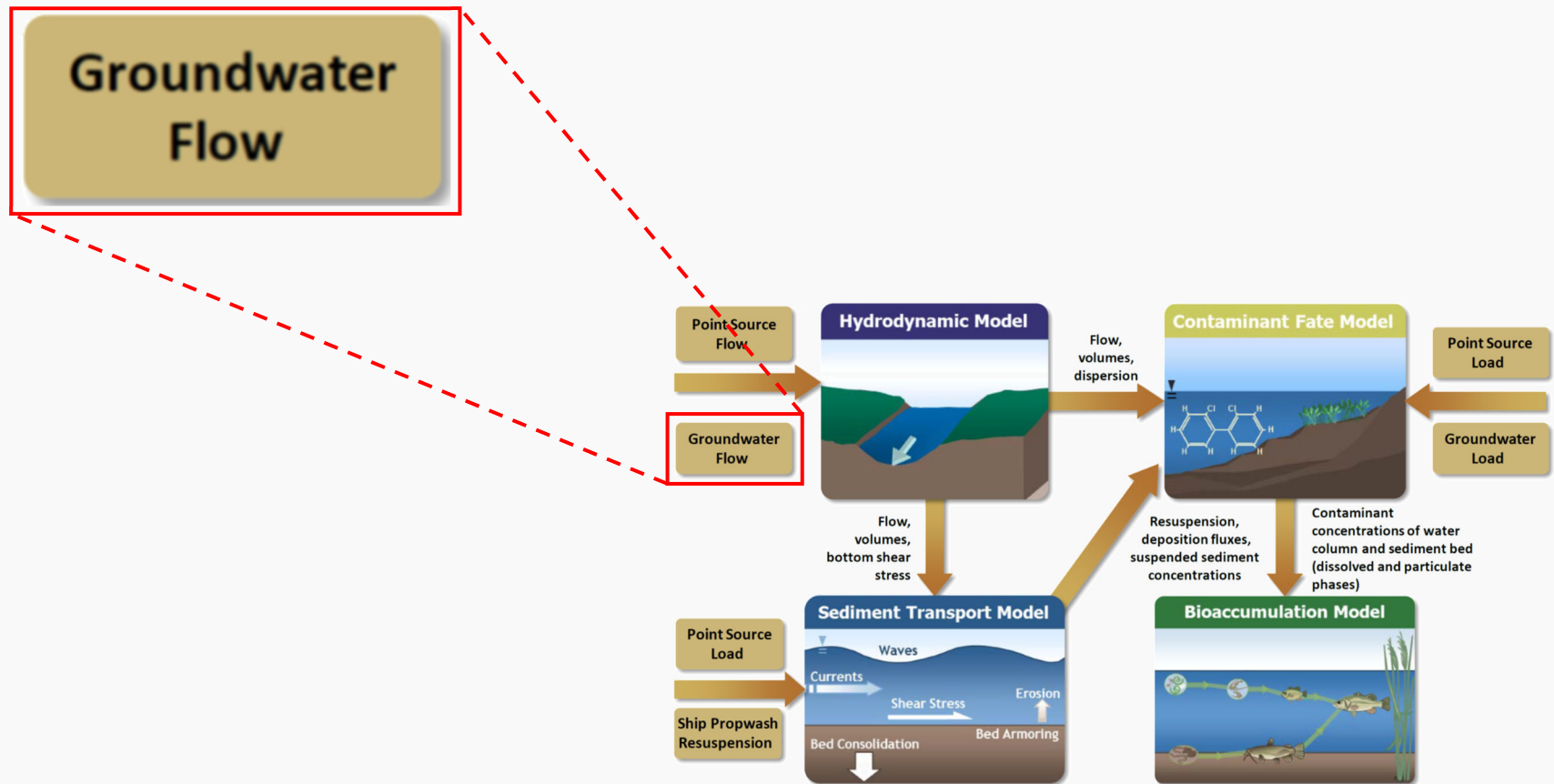   - Sediment transport

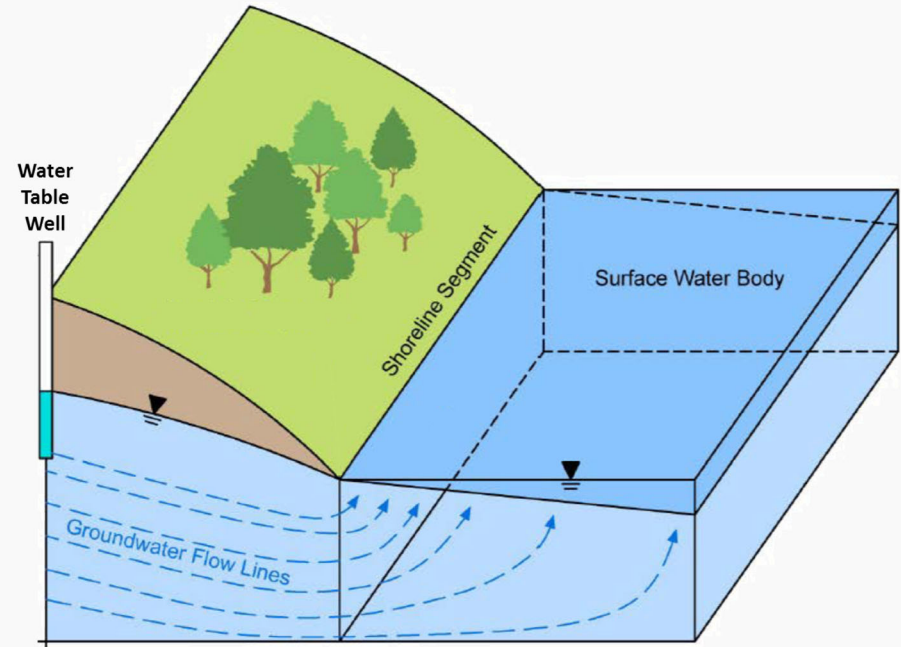   - Contaminant fate and transport

Anchor QEA, 2014

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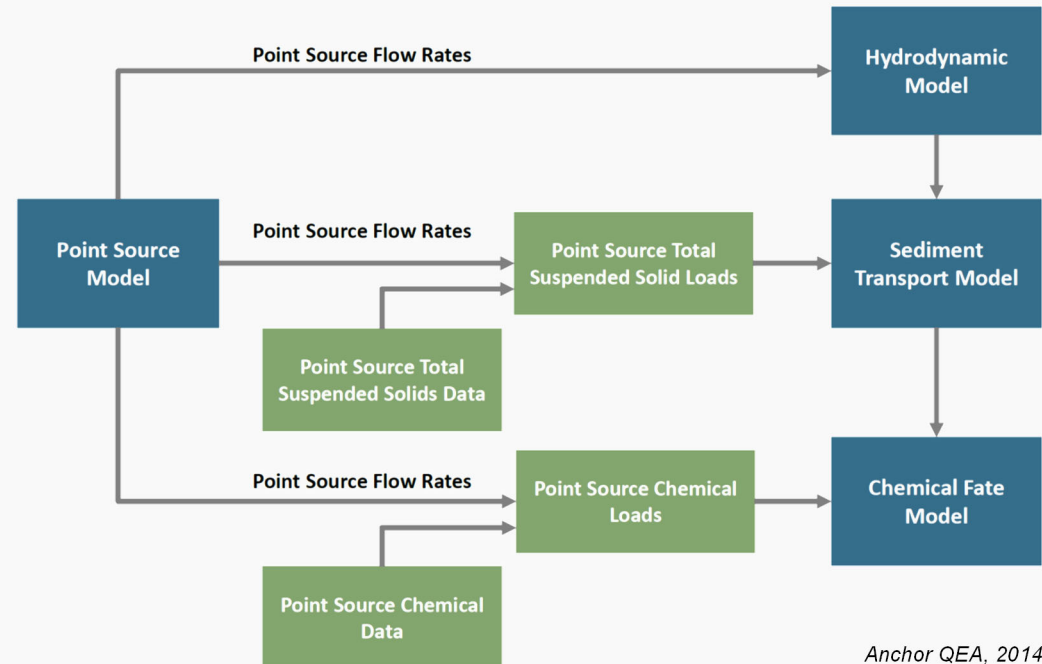
Model Review – Groundwater

Model Review – Groundwater (Contd.)

- Processes simulated
    - Rainfall infiltration and groundwater recharge
    - Subsurface groundwater flow
    - Release to Newtown Creek (exfiltration), loss to sewer and subway system, withdrawal
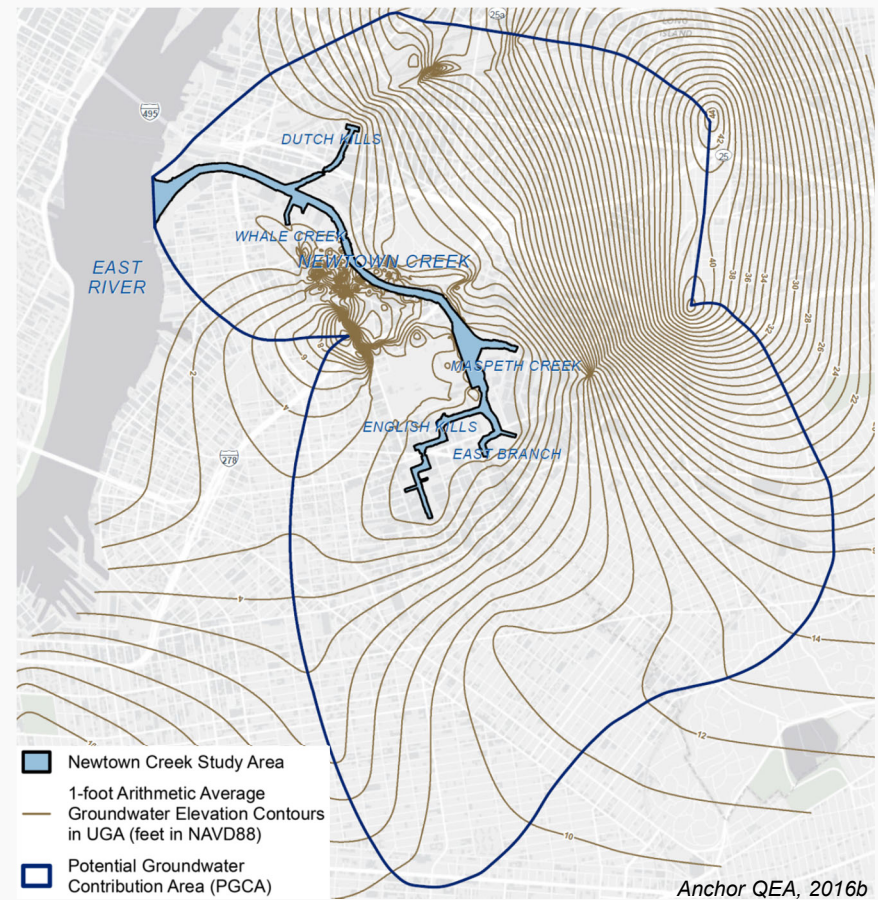

Anchor QEA, 2016b

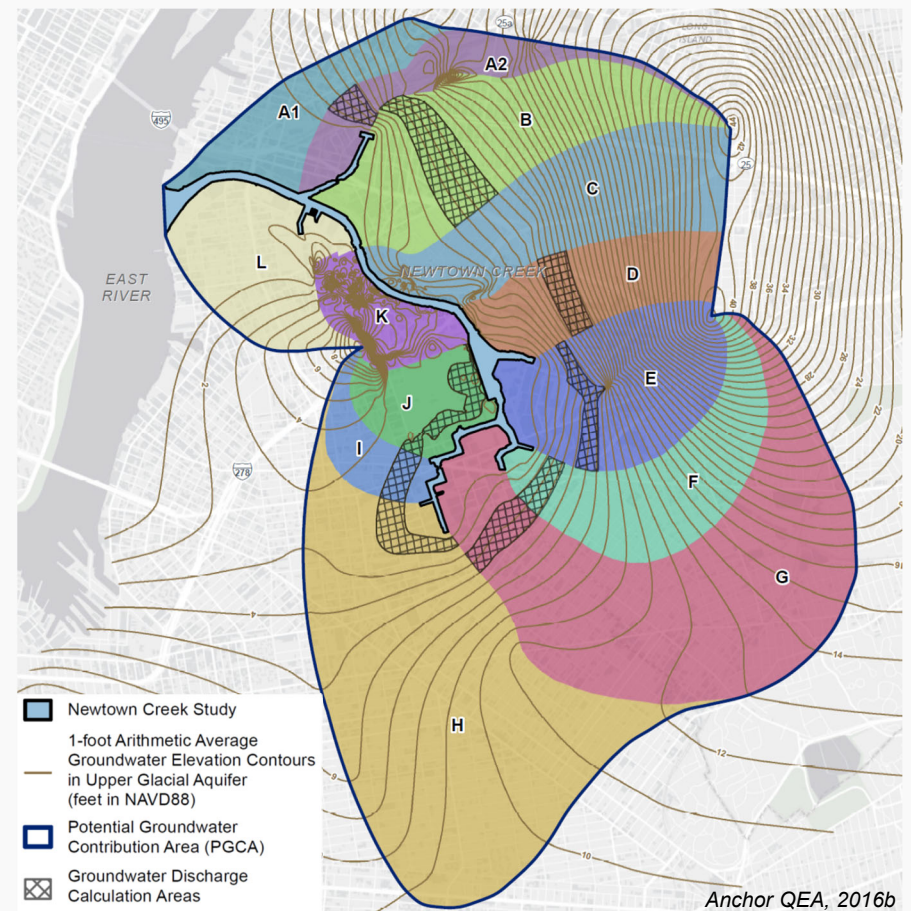# Model Review – Groundwater (Contd.)

- Steady-state model

- Model domain

  - Defined using groundwater elevation contours

- Model inputs

  - USGS data and modeling

  - RI data

  - Secondary data sources

Newtown Creek Study Area

1-foot Arithmetic Average Groundwater Elevation Contours in UGA (feet in NAVD88)

Potential Groundwater Contribution Area (PGCA)

Anchor QEA, 2016b

Model Review – Groundwater (Contd.)

- Tiered approach for modeling

  - Tier 1

    - Develop regional water balance

  - Tier 2 and Tier 3

    - Estimate flow rates for groundwater discharge into Newtown Creek

    - Calibrated to measured seepage data

Newtown Creek Study

1-foot Arithmetic Average Groundwater Elevation Contours in Upper Glacial Aquifer (feet in NAVD88)

Potential Groundwater Contribution Area (PGCA)

Groundwater Discharge Calculation Areas

Anchor QEA, 2016b

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Model Review – Groundwater (Contd.)

- Model outputs and linkages with other models

  - Outputs

    - Flow rates

  - Model linkages

    - Hydrodynamic

    - Contaminant fate and transport

      - Loadings based on RI contaminant concentrations in native sediments

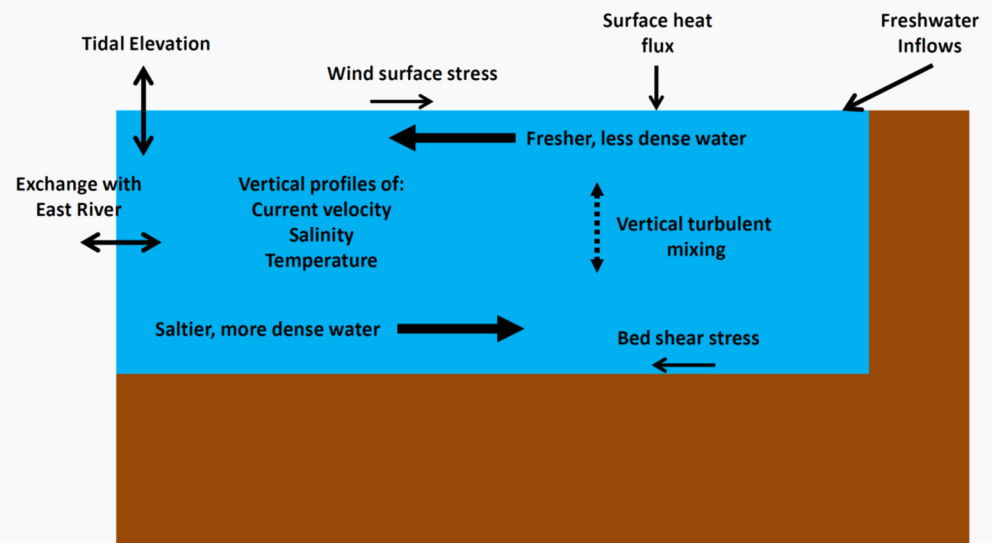Anchor QEA, 2014

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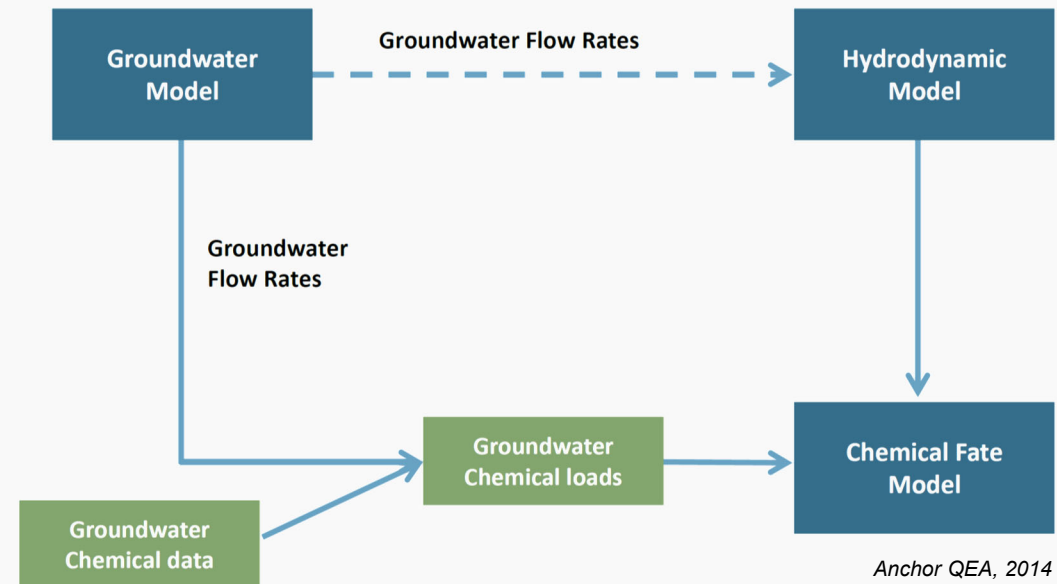
Model Review – Hydrodynamic
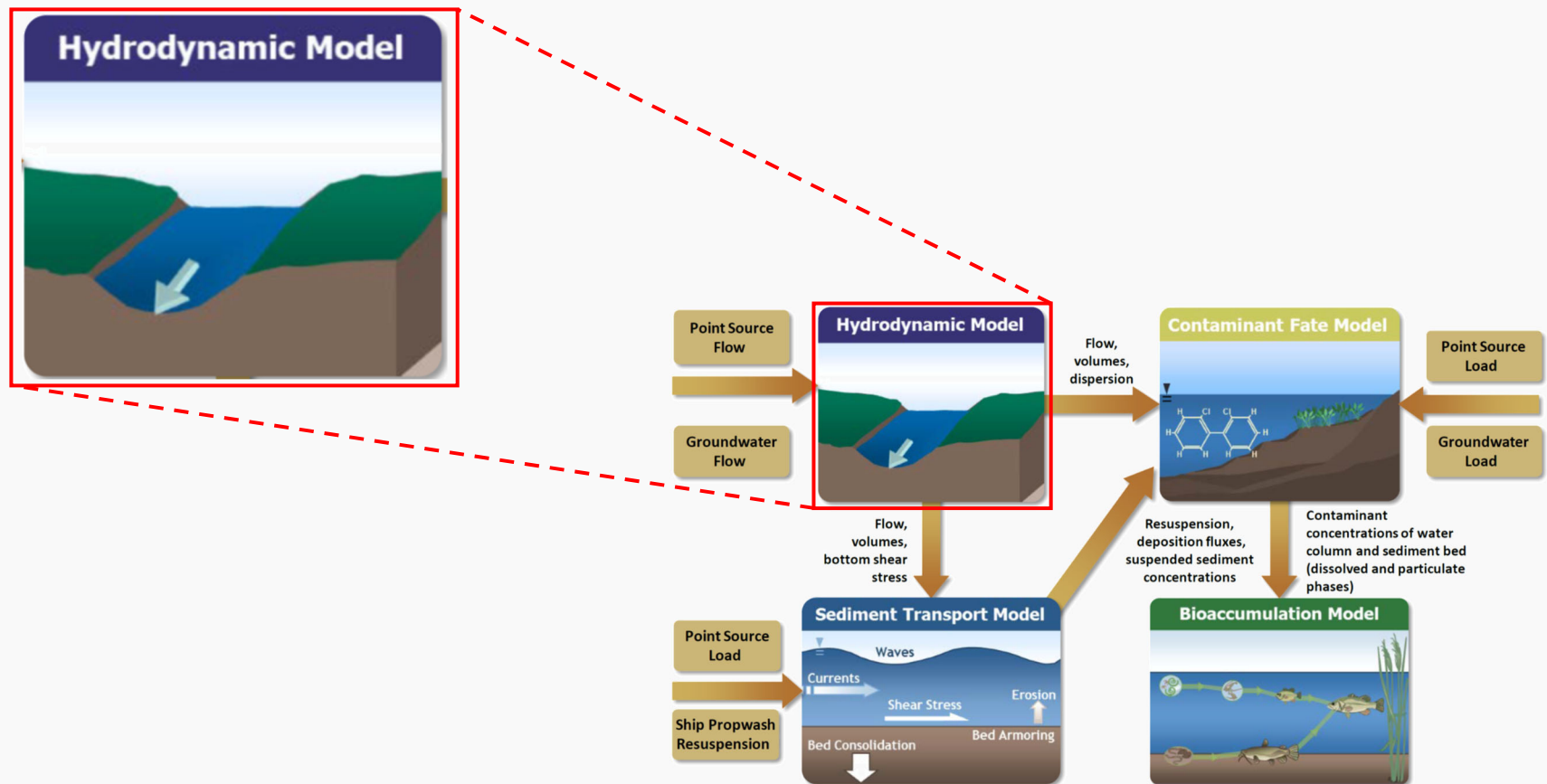
Model Review – Hydrodynamic (Contd.)

- Parameters simulated

  - Currents (advection)

  - Dispersion

  - Water depths/levels

  - Salinity

  - Temperature

- Processes simulated

  - Freshwater inflow from CSOs, SW outfalls, direct runoff, etc.

  - Tide and other water level fluctuations (eg. surge) propagating from East River, i.e., tidal transport

  - Estuarine circulation resulting from density differences between seawater and freshwater (also temperature)

Anchor QEA, 2012

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Model Review – Hydrodynamic (Contd.)

- Model framework
    - Environmental Fluid Dynamics Code (EFDC)
    - 3-dimensional
- Model domain
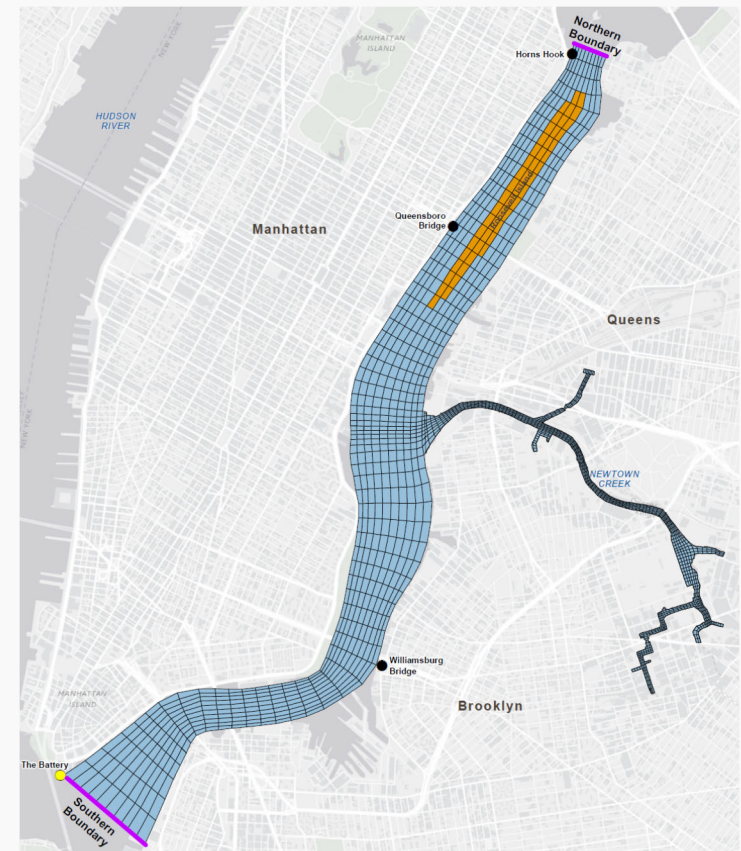   - Average grid size 140 ft x 60 ft in Newtown Creek

Anchor QEA, 2016b

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Model Review – Hydrodynamic (Contd.)

- Model inputs
  - Boundary conditions
  - Bathymetry
- Model calibration
  - Calibration metrics
  - Calibration datasets
  - Calibration period
  - Calibration parameters
- Model application

Anchor QEA, 2016b

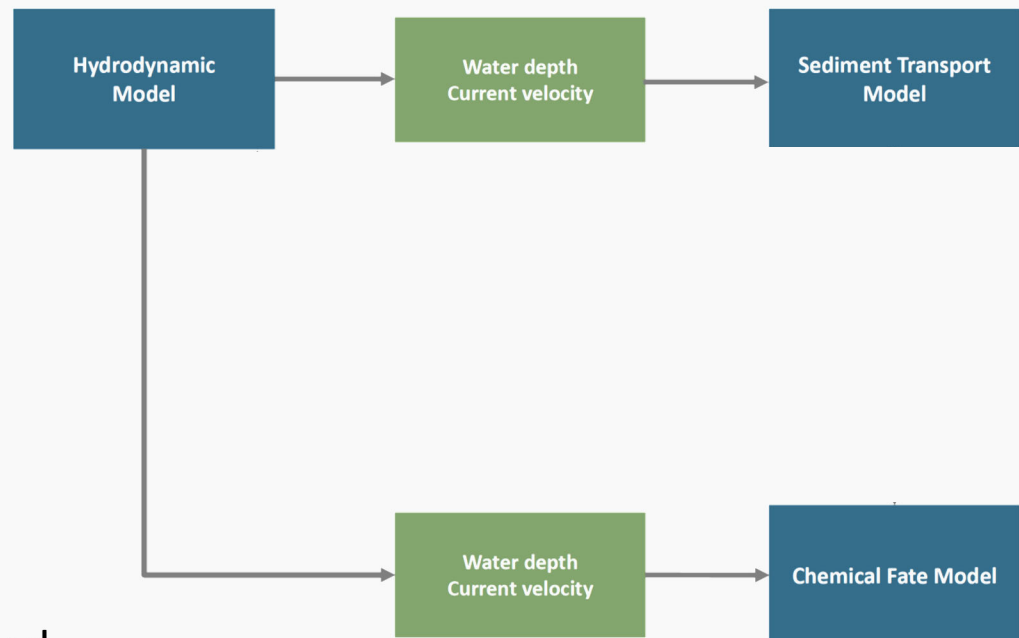# Model Review – Hydrodynamic (Contd.)

- Model outputs and linkages with other models
  - Outputs
    - Currents
    - Water depths
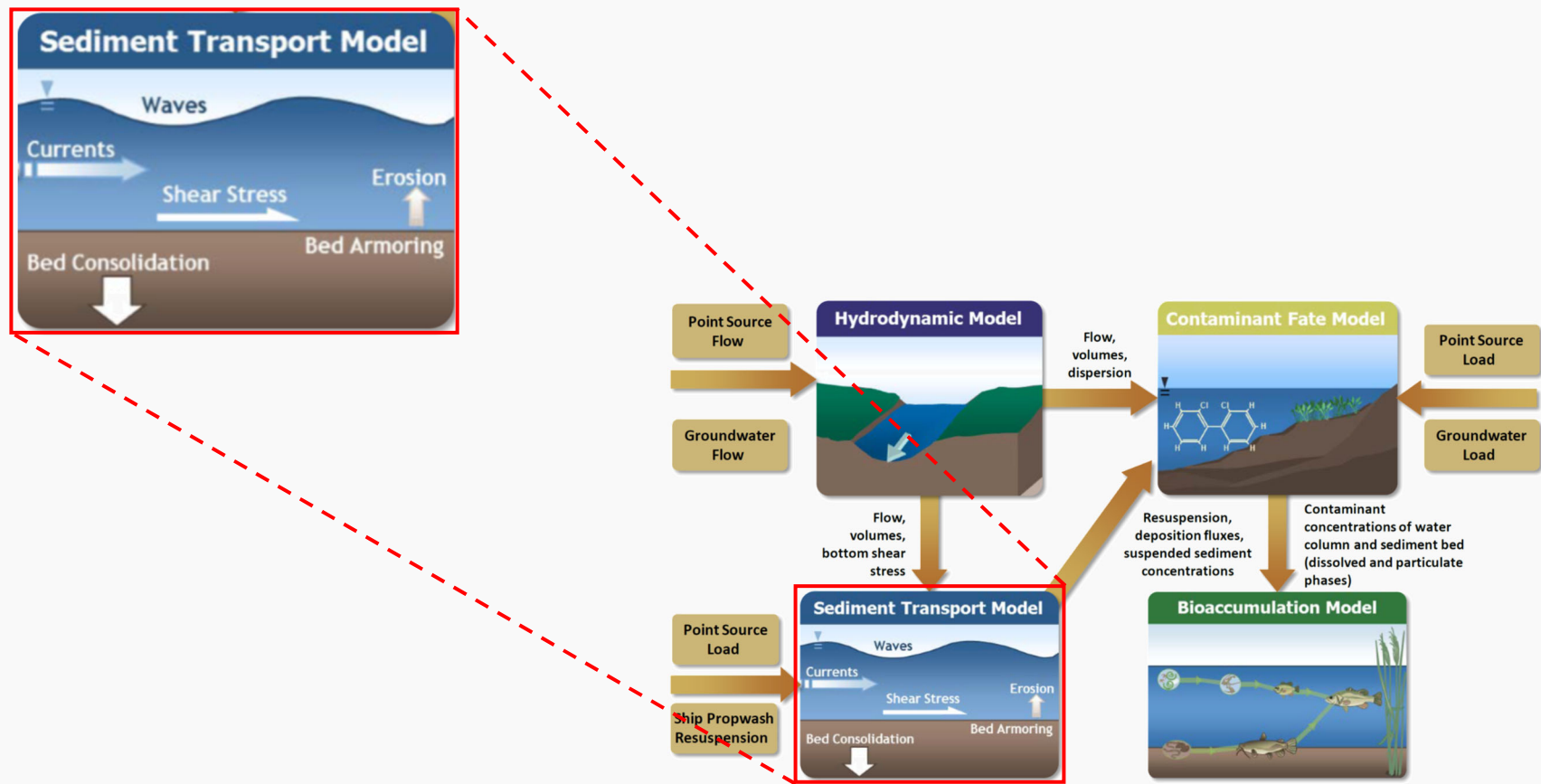   - Dispersion
  - Model linkages
    - Sediment transport
    - Contaminant fate and transport
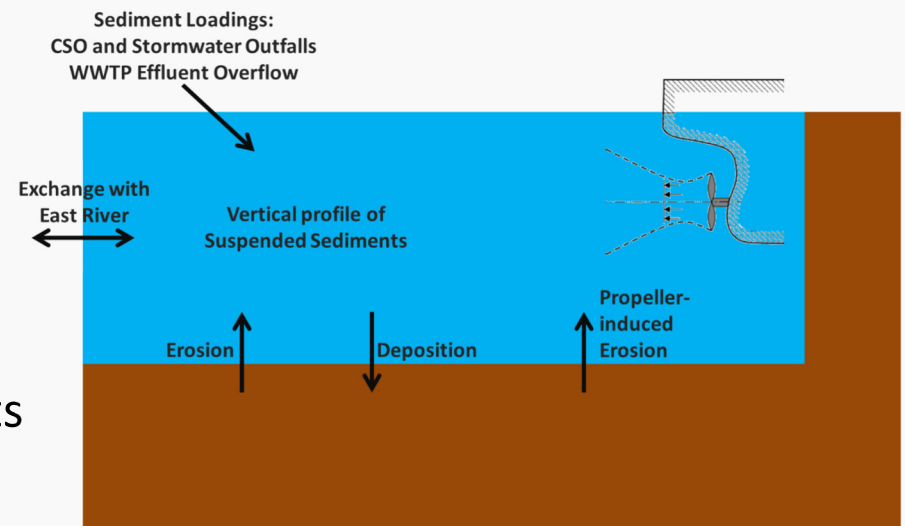

Anchor QEA, 2014

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Model Review – Sediment Transport

Model Review – Sediment Tran. (Contd.)

- Parameters simulated

  - Sediment in the water column and the bed

    - Transport – external loadings, advection, dispersion

    - Resuspension

    - Settling and deposition

- Processes simulated

  - Fate and transport of sediments from various sources

    - East River

    - Point source loadings

  - Impact of navigation

Sediment Loadings:
CSO and Stormwater Outfalls
WWTP Effluent Overflow

Exchange with
East River

Vertical profile of
Suspended Sediments

Erosion   Deposition   Propeller-
induced
Erosion

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Model Review – Sediment Tran. (Contd.)

- ## Model framework

  - ### SEDZLJ

    - Cohesive sediments (fines or clays and silts; <63 μm)

    - Non-cohesive sediments (sands; >63 μm)

  - ### 3-dimensional

- ## Model domain and grid same as hydrodynamic model
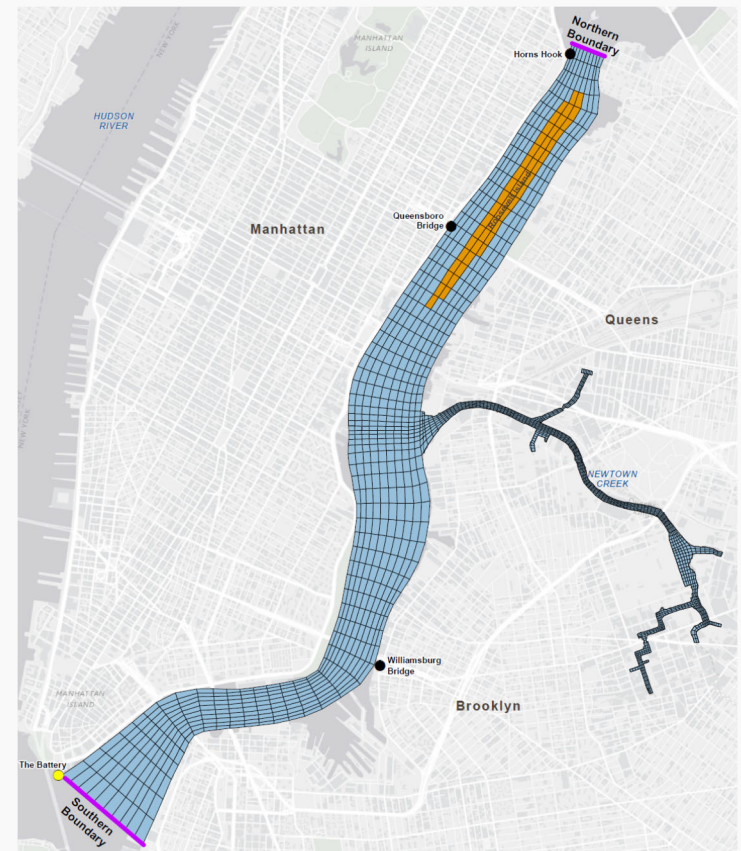
Anchor QEA, 2016b

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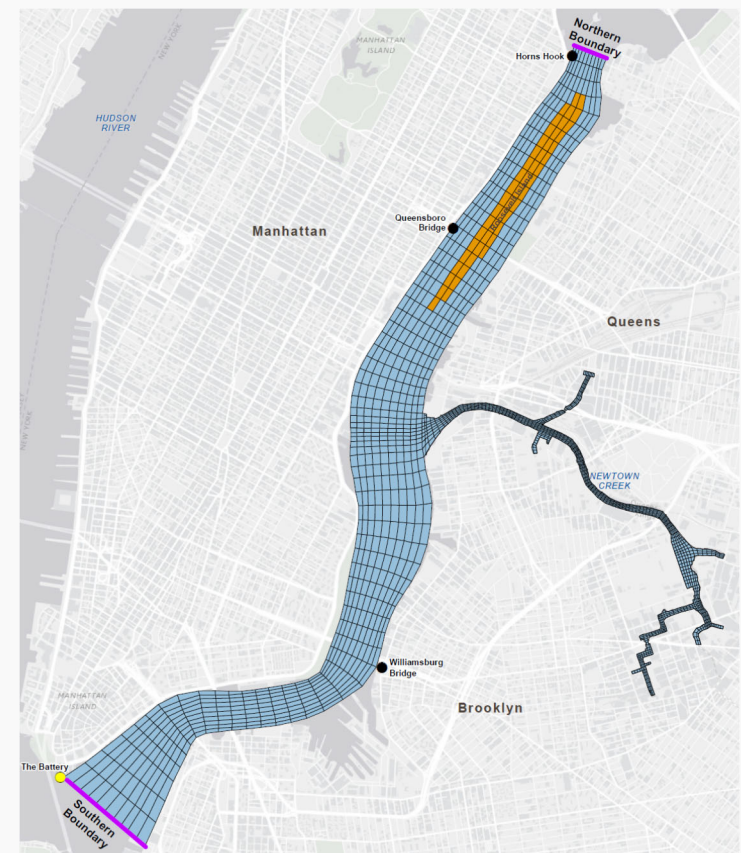
Model Review – Sediment Tran. (Contd.)

- Model inputs
  - Sediment classes
  - Boundary conditions
  - Bed initial conditions
  - Erosion properties
  - Settling velocities
  - Navigation traffic
- Model calibration
  - Calibration metrics
  - Calibration datasets
  - Calibration period
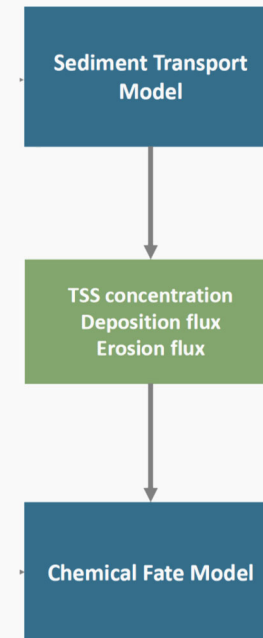 - Calibration parameters
- Model application

Anchor QEA, 2016b

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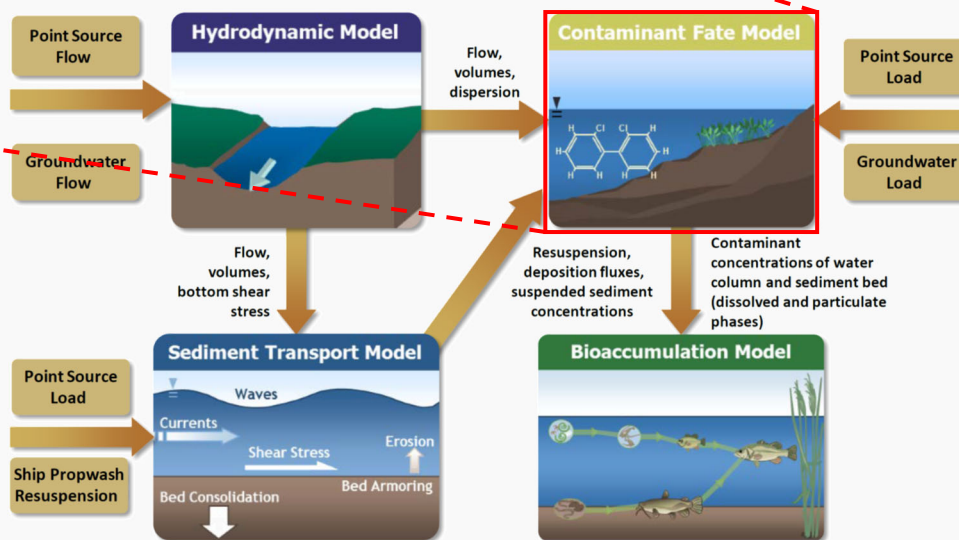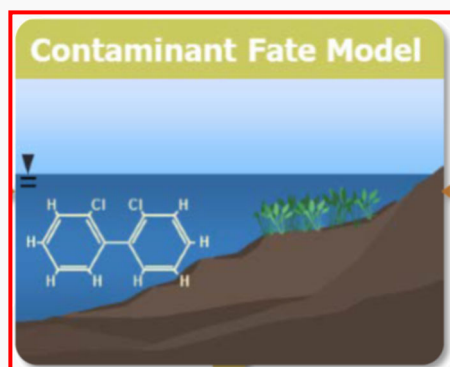# Model Review – Sediment Tran. (Contd.)

- Model outputs and linkages with other models

  - Outputs

    - Suspended sediment concentrations

    - Fluxes

      - Erosion

      - Deposition

  - Model linkage

    - Contaminant fate and transport

Sediment Transport Model

TSS concentration
Deposition flux
Erosion flux

Chemical Fate Model

Anchor QEA, 2014

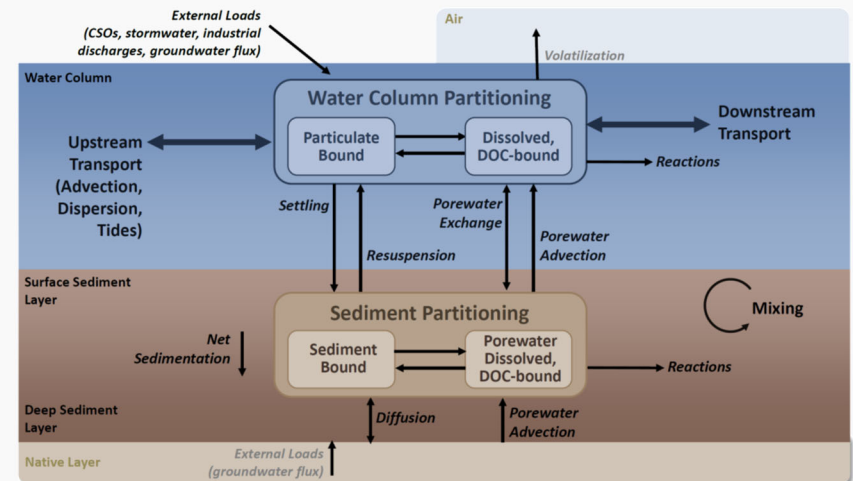# Model Review – Contaminant Fate & Transport

Model Review – Contaminant F&T (Contd.)

- Parameters/formulations simulated
  - Water column and bed contaminants
    - External loadings, advection, dispersion
    - Resuspension and deposition
    - Partitioning
    - Bed-water dissolved exchange
    - Bioturbation
    - Volatilization
    - Porewater advection
    - Ebullition and NAPL loadings*
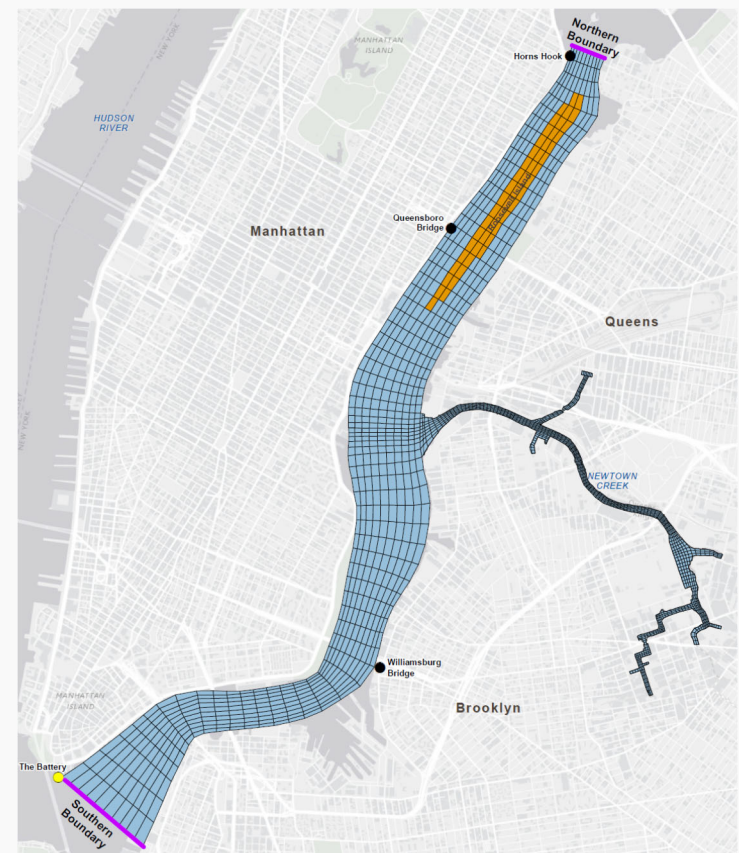

Anchor QEA, 2014

- Processes simulated
  - Fate and transport of contaminants from various sources
  - Quantitative evaluation of various contaminant fate and transport processes
  - Contaminant exposure over various temporal & spatial scales

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* Exact model setup/inputs to be determined

Model Review – Contaminant F&T (Contd.)

- Model framework

  - AQFATE

  - Contaminants – to be determined based on human and ecological risk

- Model domain and grid same as hydrodynamic, and sediment transport models

- Model inputs

  - Bed initial conditions

  - Boundary conditions and loadings

  - Partition coefficients

- Model calibration

  - Proposed calibration metrics

  - Proposed calibration parameters

  - Proposed calibration period

Anchor QEA, 2016b

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Model Review – Contaminant F&T (Contd.)

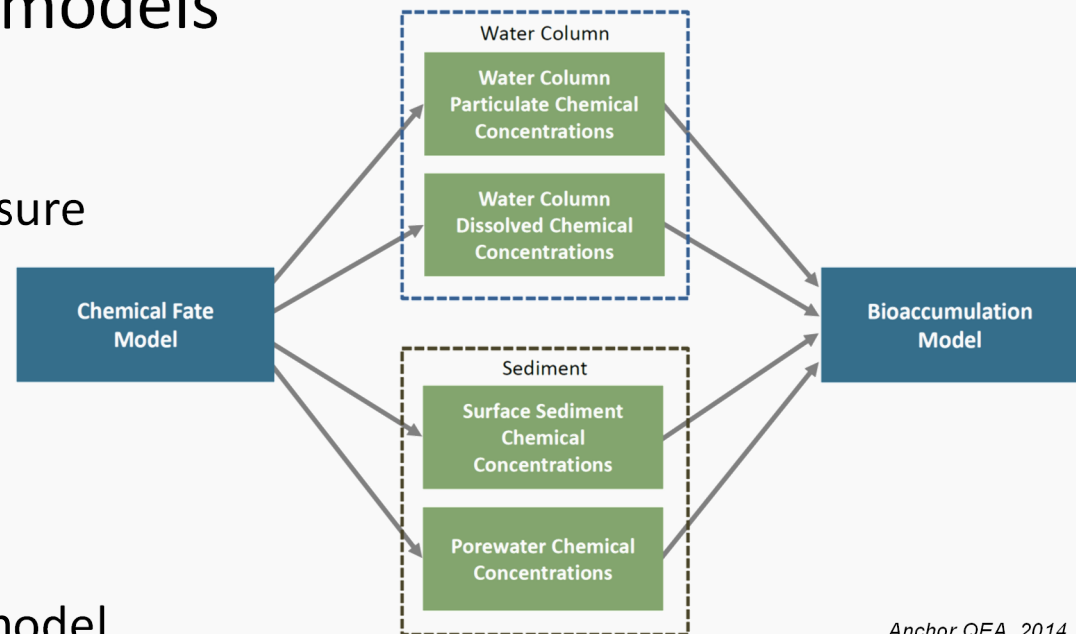- ## Model outputs and linkages with other models

  - ### Outputs

    - #### Contaminant exposure concentrations

      - ##### Water column

      - ##### Bed
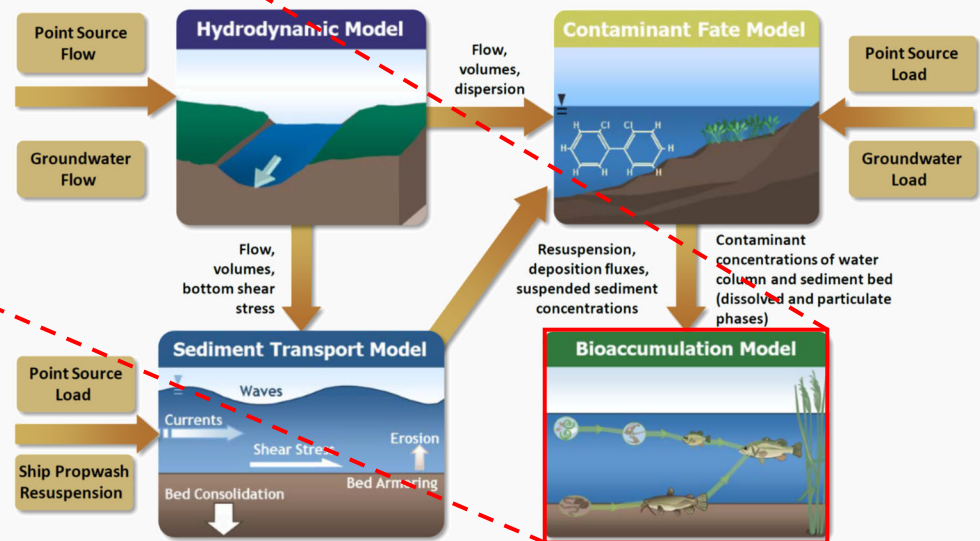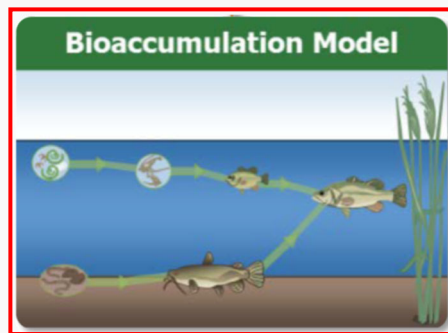
  - ### Model linkage
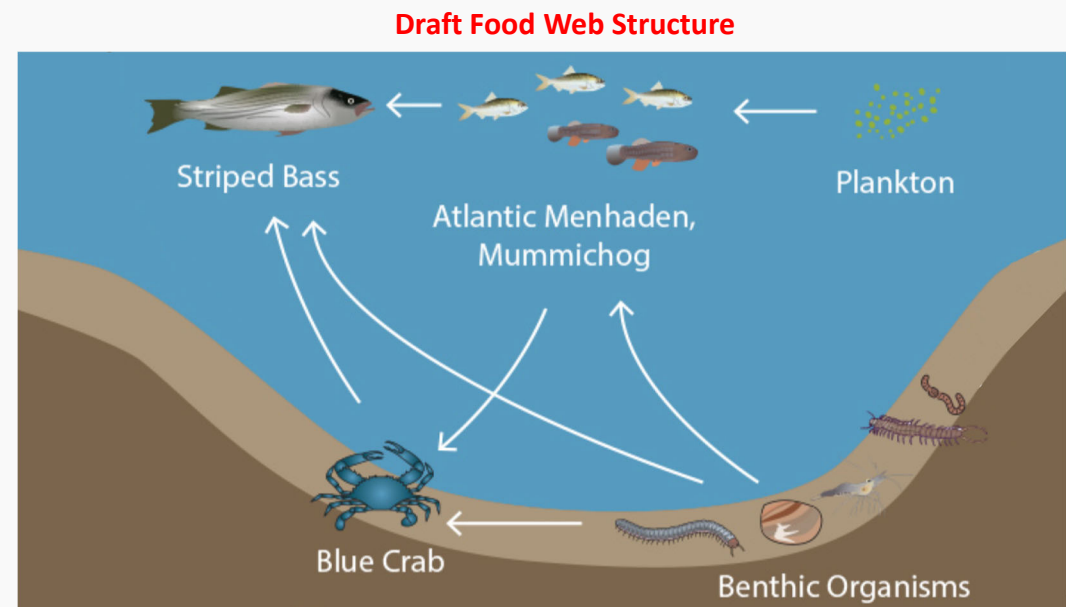
    - #### Bioaccumulation model

Anchor QEA, 2014

Model Review – Bioaccumulation

Model Review – Bioaccumulation (Contd.)

- Objective to calculate contaminant uptake and accumulation in biota

  - Calculate tissue concentrations

  - Relevant for human and ecological exposure

  - Use to assess remediation effectiveness

Draft Food Web Structure

Adapted from Anchor QEA, 2016a

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Model Review – Bioaccumulation (Contd.)

- Model framework
 - Simple approaches such as BAF and BSAF
  - Complicated mechanistic approaches that include
    - Diet and food web structure
    - Movement/migration patterns, spatial and temporal scales
    - Uptake and depuration
    - Metabolism
    - Bioenergetics
  - Exact details under development
- Phase 1 and Phase 2 data (in combination with literature data) to be used to support model development and calibration

Model Application for Feasibility Study

- Future projections
  - Typically decadal-scale
  - Comparison of several metrics for various management alternatives
    - Baseline (no remediation)
    - Various alternatives including remediation

Examples of Typical Feasibility Study Assessments

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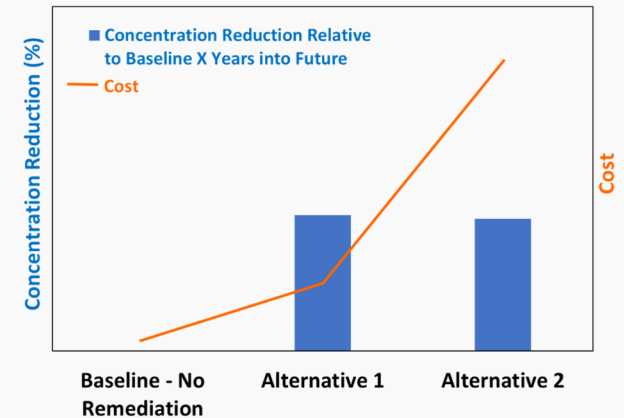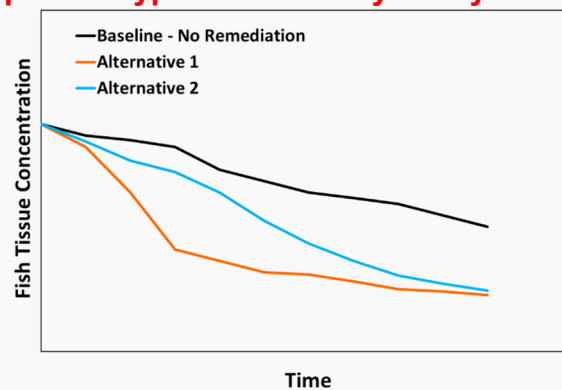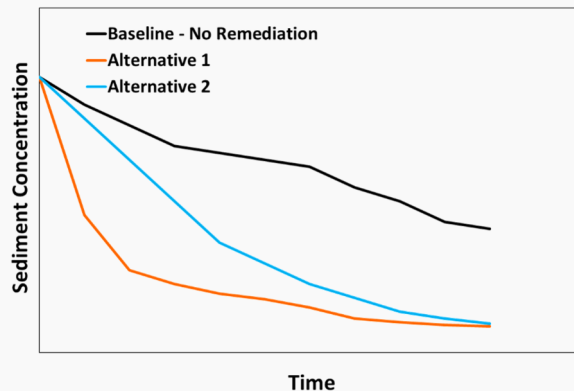
Status of Modeling Study

- Watershed (point source) model complete
  - Developed by New York City for the LTCP
- Groundwater, hydrodynamic, and sediment transport models
  - Initial versions submitted with draft RI in 2016
  - Revised versions expected in April 2019
- Contaminant fate and transport model
  - Under development
  - Initial version expected to be submitted in December 2019
- Bioaccumulation model
  - Under development
  - Initial version expected to be submitted in March 2020

References

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- Anchor QEA, 2012. Modeling Approach Memorandum (1), Remedial Investigation/Feasibility Study, Newtown Creek. Montvale, NJ

- Anchor QEA, 2014. Draft Modeling Approach Memorandum (2), Remedial Investigation/Feasibility Study, Newtown Creek. Montvale, NJ

- Anchor QEA, 2016a. Draft Modeling Approach Memorandum (3), Remedial Investigation/Feasibility Study, Newtown Creek. Montvale, NJ

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- USEPA, 2002. Principles for Managing Contaminated Sediment Risks at Hazardous Waste Sites. Office of Solid Waste and Emergency Response, OSWER 9285.6-08

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- USEPA, 2009a. Guidance on the Development, Evaluation, and Application of Environmental Models. Office of the Science Advisor, Council for Regulatory Environmental Modeling, EPA/100/K-09/003

- USEPA, 2009b. Environmental Modeling 101, Web-based Training on Best Modeling Practices and Technical Modeling Issues, Council for Regulatory Environmental Modeling.

- USEPA, 2017. Remediating Contaminated Sediment Sites - Clarification of Several Key Remedial Investigation/Feasibility Study and Risk Management Recommendations, and Updated Contaminated Sediment Technical Advisory Group Operating Procedures. Office of Land and Emergency Management, OLEM 9200.1-130