Overview of Sediment Budgets

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SBAS Training Workshop
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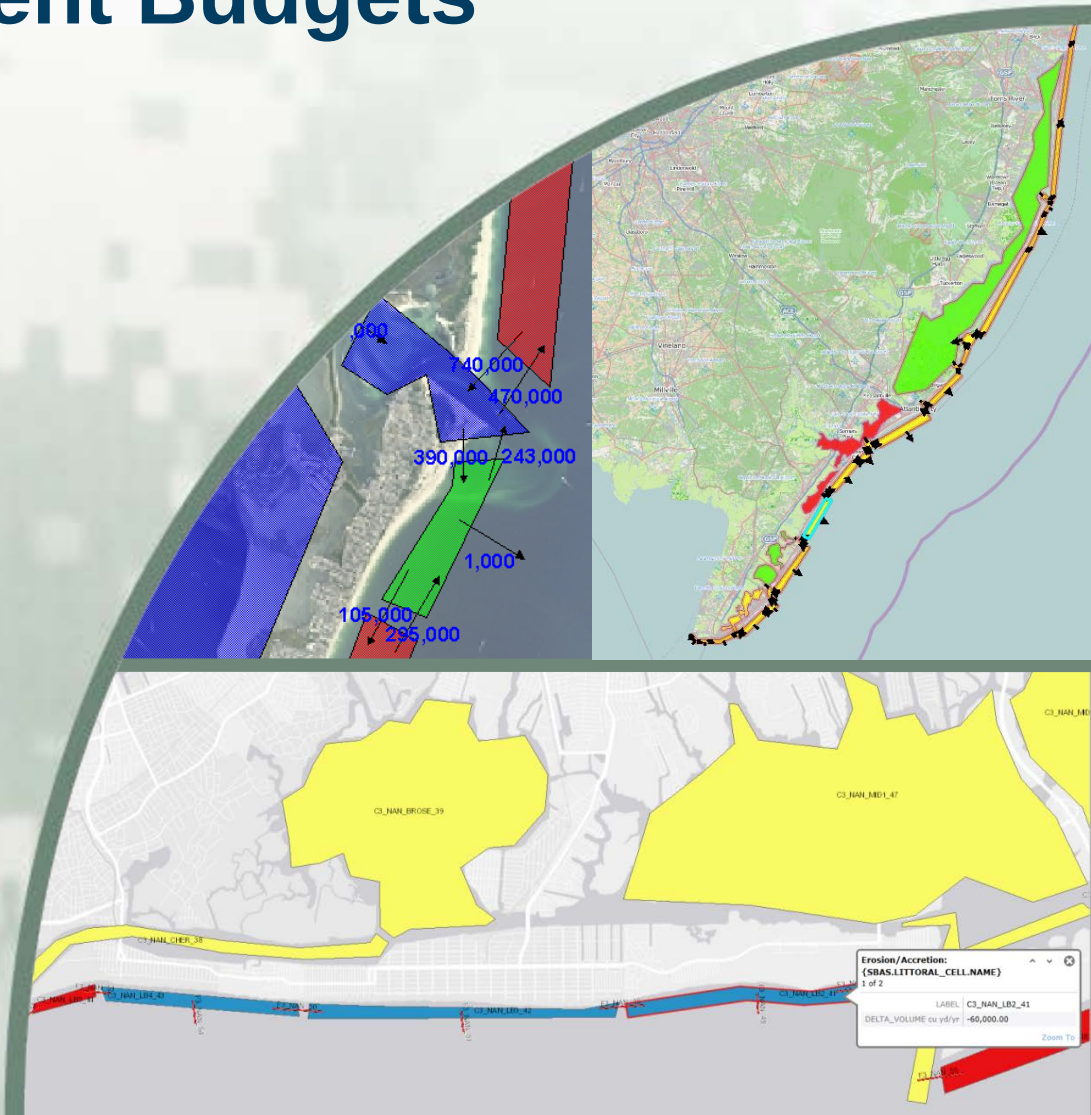


RSM Process

1. UNDERSTAND REGION
-Sediment sources, project needs, processes, gaps, engineering actions, ecological considerations
-Resources, challenges & requirements

2. EVALUATE RSM STRATEGIES (PROJECT SCALE)
-Efficient & effective use of sediments
-Project-level analysis (tools, models, technologies)
-RSM pilot projects

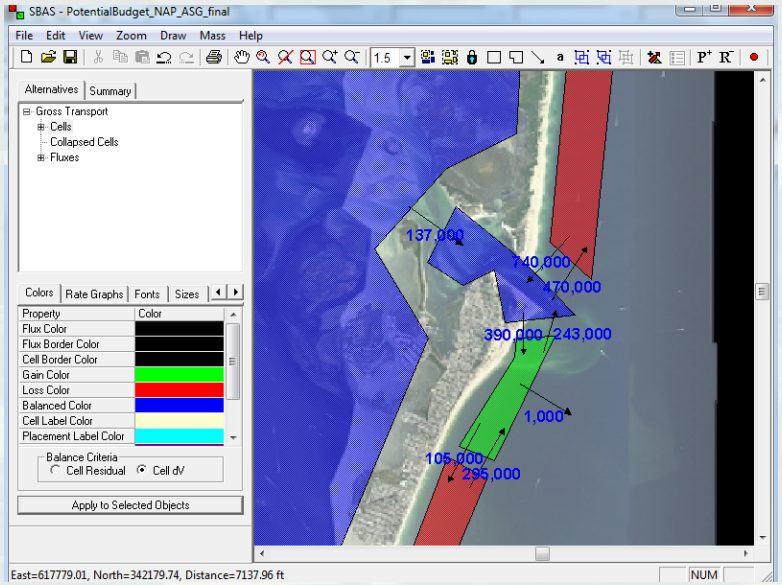
3. REGIONAL RSM STRATEGY
-Integrate projects into Regional Strategy
-ID authorities, funding, permit requirements, leveraging opportunities
-Prioritize: need, benefits, timelines

4. TAKE ACTION
-Construct, monitor & adaptively manage
-Capture benefits & lessons learned
-Incorporate into standard practice

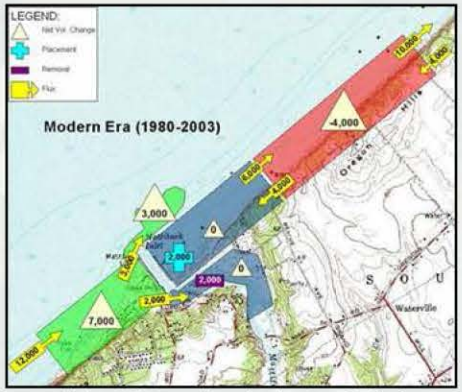
Communication, Collaboration, Innovation, Decision Making
Interagency, Stakeholders, Partners, Resource Agencies

Overview

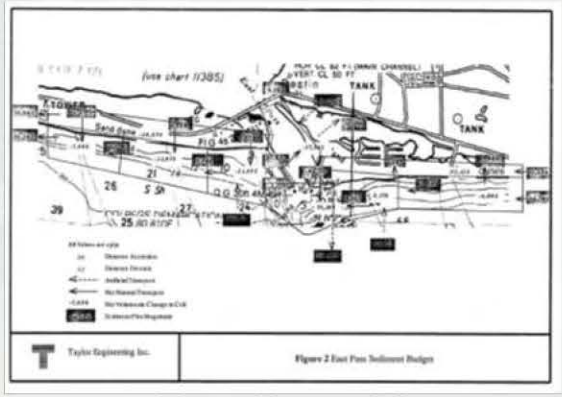
- Applications of sediment budgets
- Terminology
- Steps in formulating a sediment budget
- Simple example: Hillsboro Inlet, FL
- Brief intro to SBAS



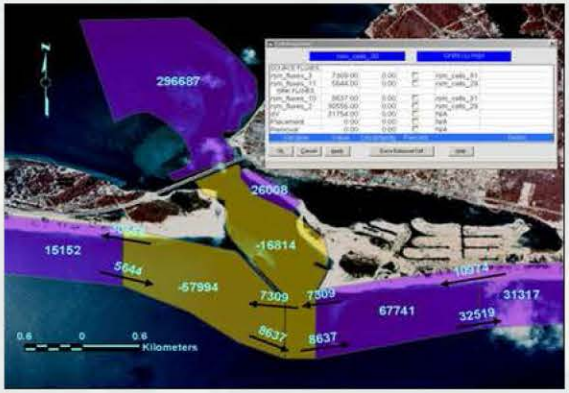
Why and When do we need Sediment Budgets?



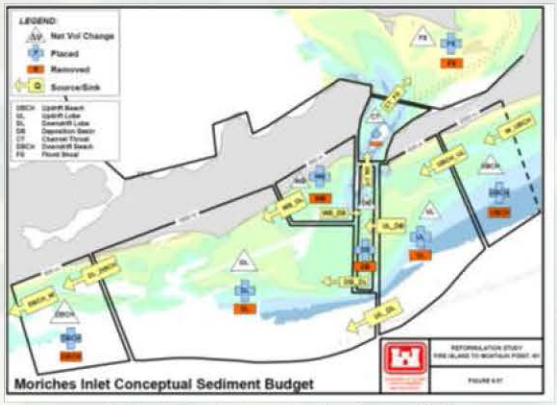
Mattituck Inlet, NY



East Pass, FL
(Taylor Engineering)
from Inlet Management Plan



East Pass, FL (USAED Mobile)



Moriches Inlet, NY
(Moffatt & Nichol)

Sabine Pass to Matagorda
Ship Channel, TX

Fire Island Inlet to Montauk Point, NY

Sediment Budgets…

- Define regional and local patterns and magnitudes of sediment transport
  - For different time periods (e.g., “historic” and “present-day”)
  - For different projects (e.g., beach nourishment versus groin field)
  - For different conditions (e.g., “typical” and “storm”)
- Provide ground-truthing for more detailed modeling
- Tool for communication with clients, sponsors, and partners
- May be applied to determine design criteria and mitigation
  - e.g., sand bypassing quantity, adjacent beach nourishment

Definitions of Sediment Budget Types

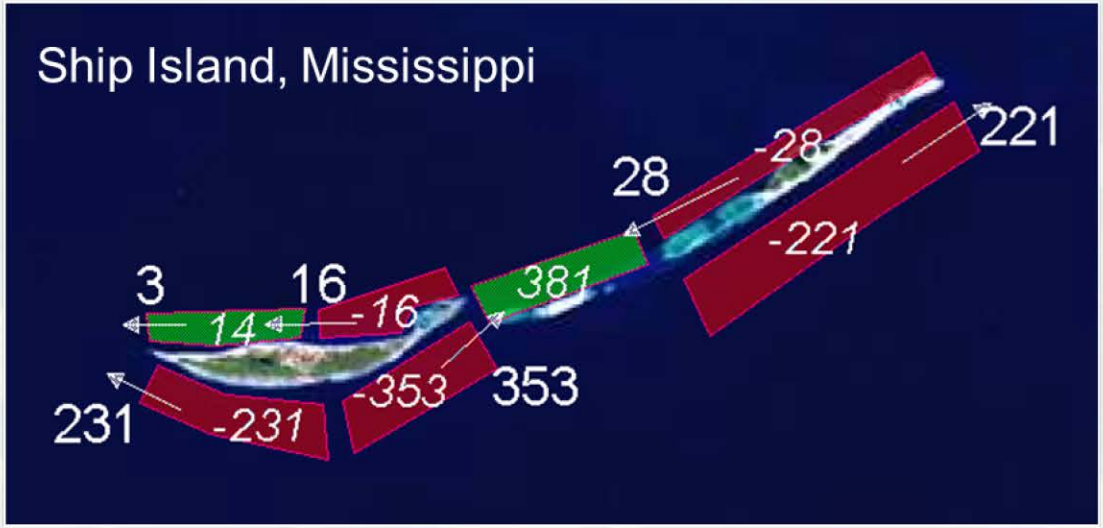
Conceptual

- Developed relatively quickly (~days to weeks)
- Reconnaissance level
- Based on literature review, existing knowledge, observable morphologic change, available databases
- Could be as simple as cells and direction of transport rates
- Used to develop a framework for more detailed budgets and identify gaps in knowledge
- Estimate confidence level

Definitions of Sediment Budget Types

Interim

- "Working budget" based on initial analyses
- Data analyzed may include historical data, dredging records, shoreline change, numerical model calculations
- Interim budget has time period and event = epoch
- May be revised several times in developing operational budget
- Feasibility-level
- Time ~ months



Definitions of Sediment Budget Types

Operational

- A final budget that is used in regional planning and initial design of site-specific projects
- May be a series of budgets representing typical and storm years
- Represents regional as well as project sources and sinks
- Developed with most available data sets, with some redundancy to develop confidence in estimates
- Can be updated with new knowledge and engineering activities
- Typically associated with programmatic efforts used in adaptive management, *e.g., Inlet Management Plans*
- Time ~ months to years

Conceptual

Literature Review/Available Data

ID Gaps in Knowledge

Develop Plan to Improve Knowledge

Interim

Models

Data Management
GIS

Field Data

Understanding of Existing Regional System
and Coastal Processes

Operational

- Maintained/Up-To-Date
- Evaluate Alternatives
- Evaluate Impacts of Actions
- Decision Tool (Engineering and Management)

Terminology:
Sediment Budget Equation

$$\Sigma Q_{source} - \Sigma Q_{sink} - \Delta V + P - R = Residual$$

Q_{source} , Q_{sink} = input or export to cell

ΔV = Volume change within cell

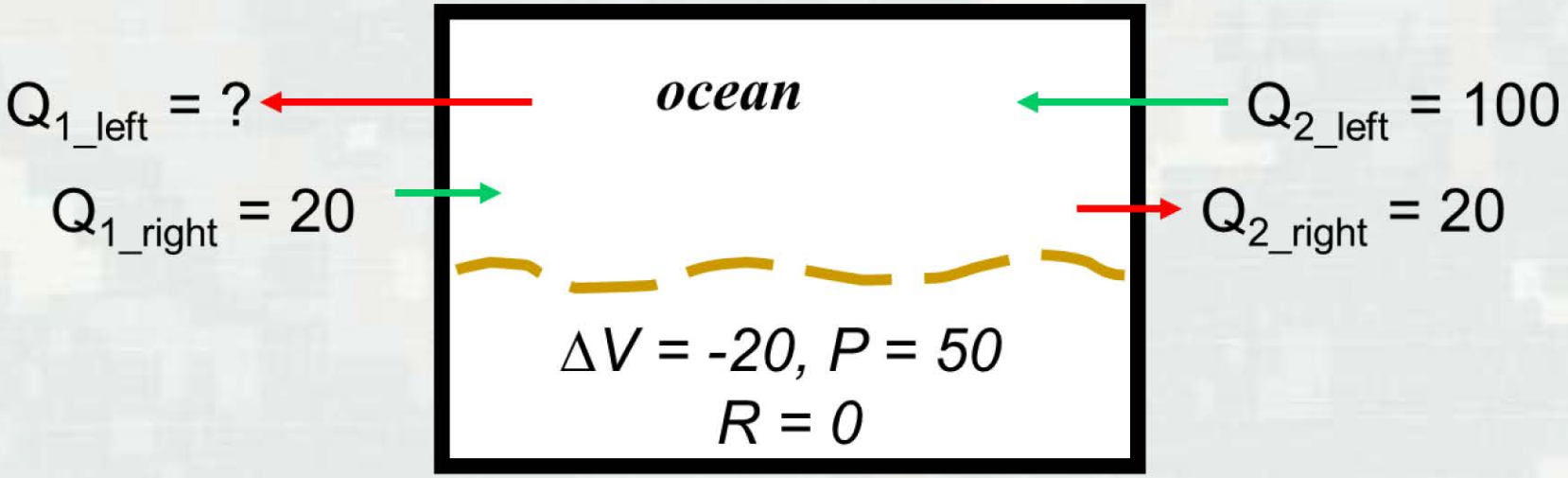
P = Placement into cell

R = Removal from cell

Residual = cell surplus or deficit

(= 0 for balanced cell)

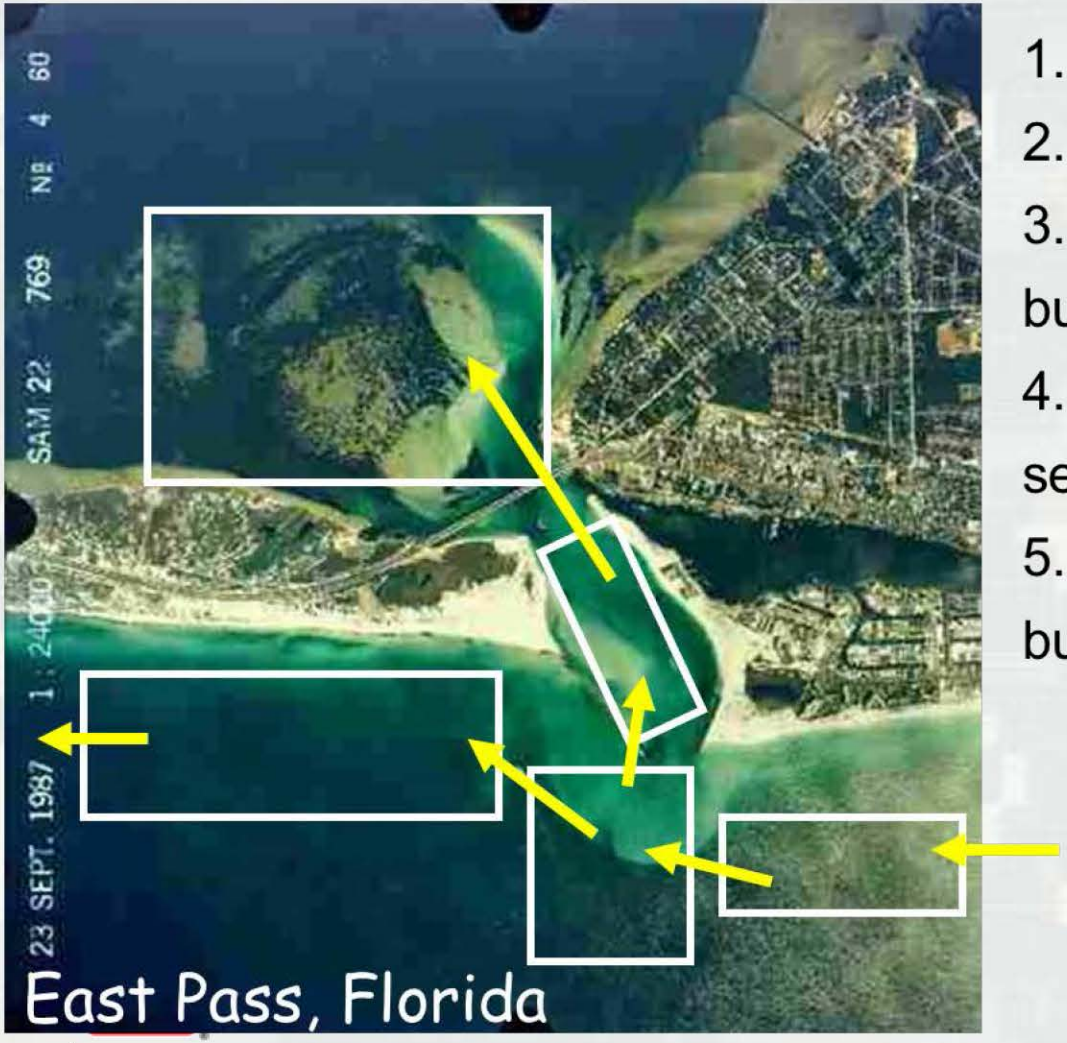
Illustration of Concept



ΣQ_{source}	$-\Sigma Q_{sink}$	$-\Delta V$	$+P$	$-R$	$=0$
100+20	$-(20+Q_{1_left})$	$-(-20)$	$+50$	-0	$=0$

$$Q_{1_left} = 170$$

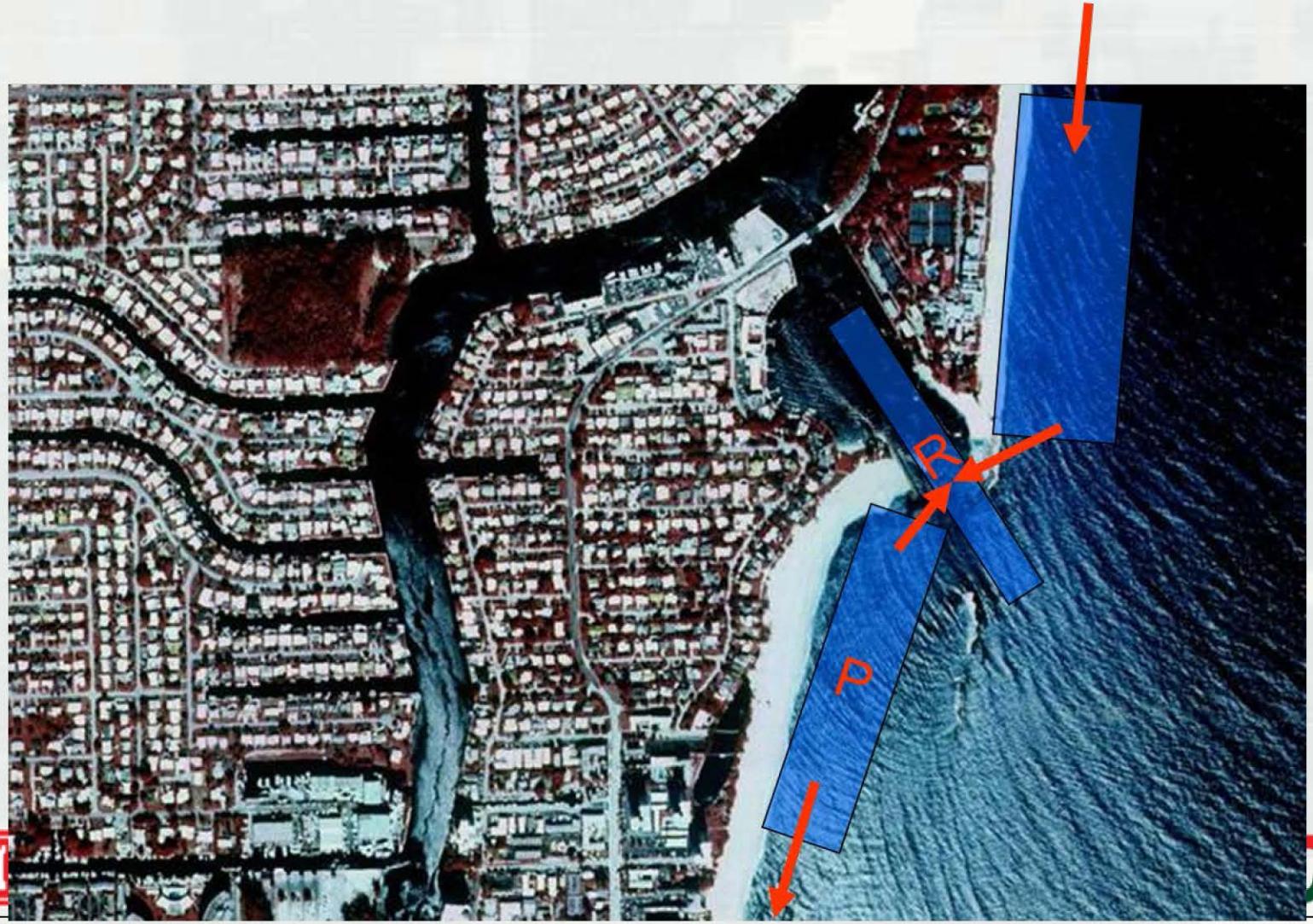
Creating a Sediment Budget



1. Develop a conceptual budget
2. Analyze data
3. Develop an interim (working) budget
4. Refine based on uncertainty and sensitivity testing
5. Develop operational (final) budget(s)

Hillsboro Inlet, Florida
Location & Setting

Hillsboro Inlet, Florida
1. Conceptual Sediment Budget



Hillsboro Inlet, Florida
Information from Jacksonville District

120,000 cy/yr is the net longshore sand transport rate updrift of the inlet

54,000 cy/yr is transported over the north jetty weir section into the sediment basin

60,000 cy/yr is deposited into the entrance channel

30,000 cy/yr moves into the inlet from the south

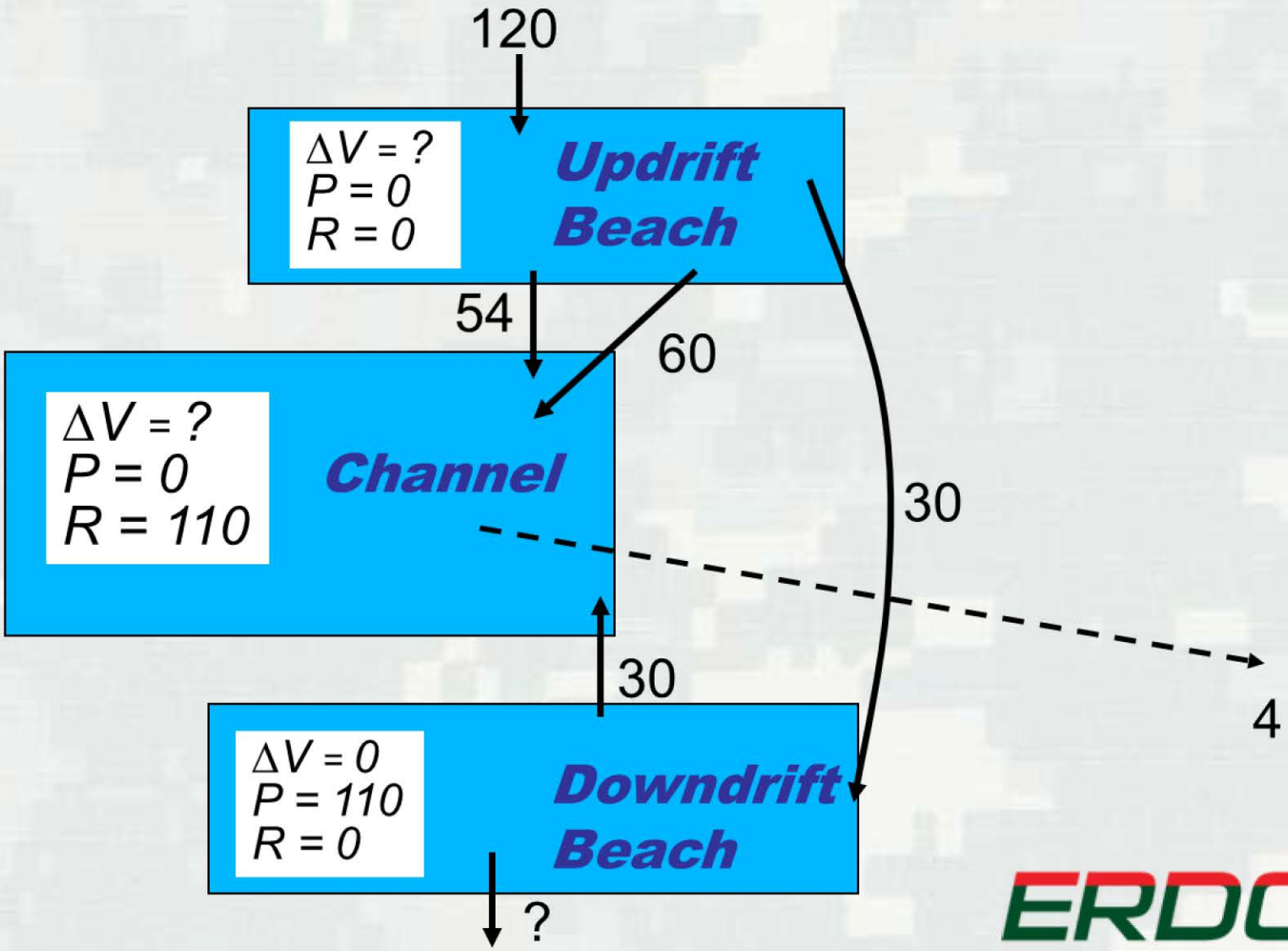
30,000 cy/yr bypasses the inlet naturally (north to south)

4,000 cy/yr lost to deep water on ebb flow

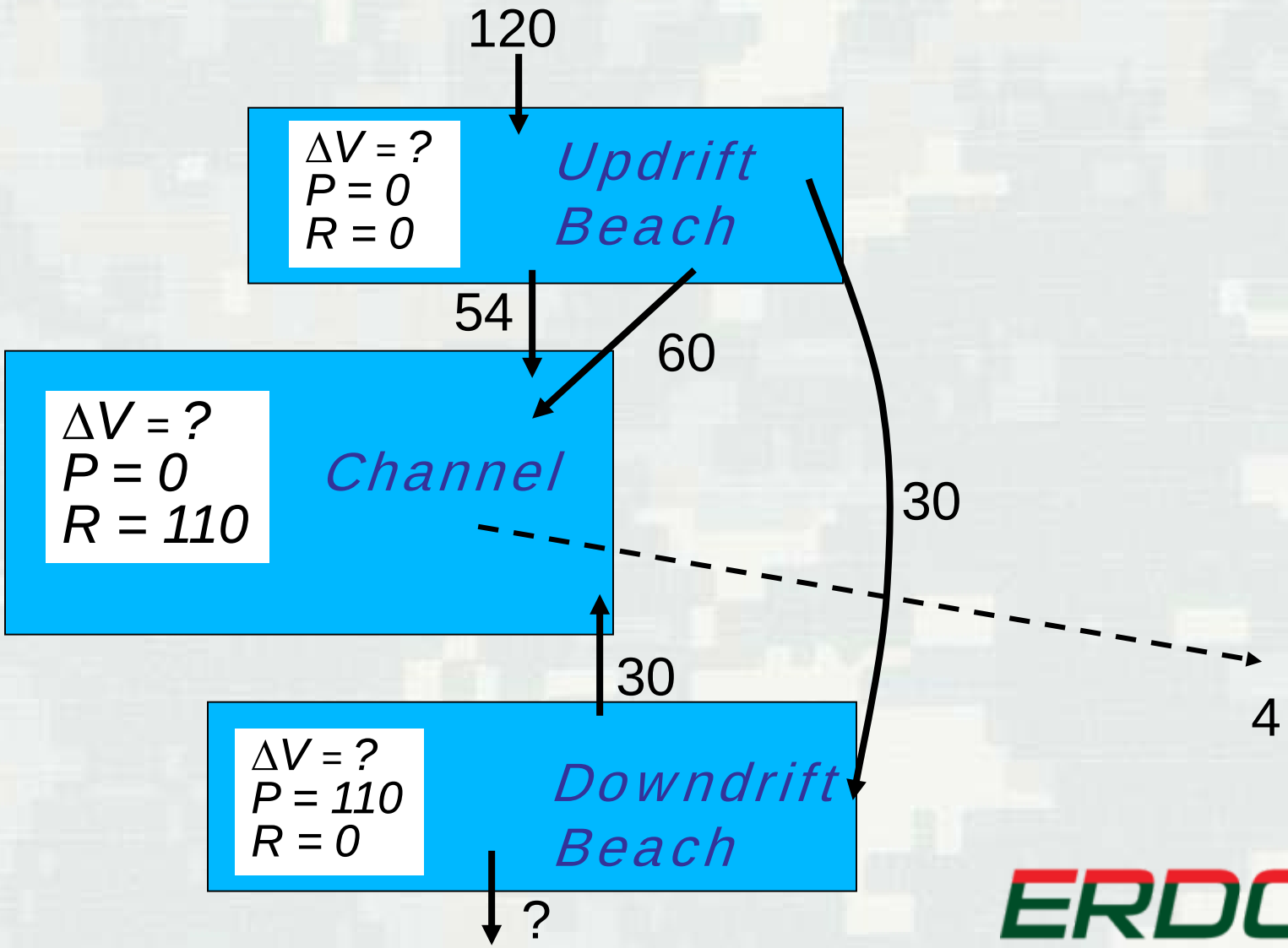
110,000 cy/yr is dredged from the channel and bypassed to the downdrift beach

Hillsboro Inlet, Florida
Sediment Budget

Hillsboro Inlet Sediment Budget

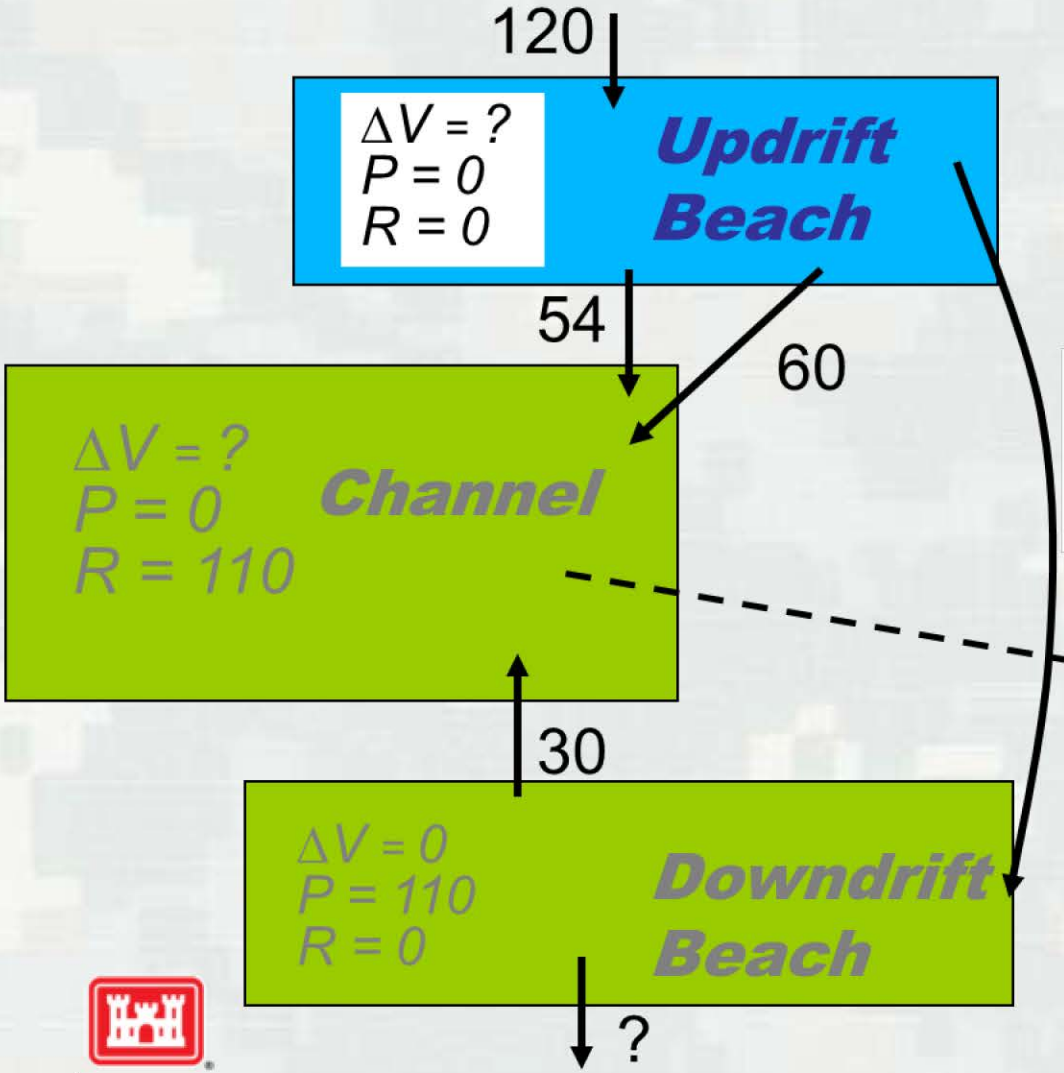


Hillsboro Inlet Sediment Budget



Hillsboro Inlet Sediment Budget:

Updrift Cell



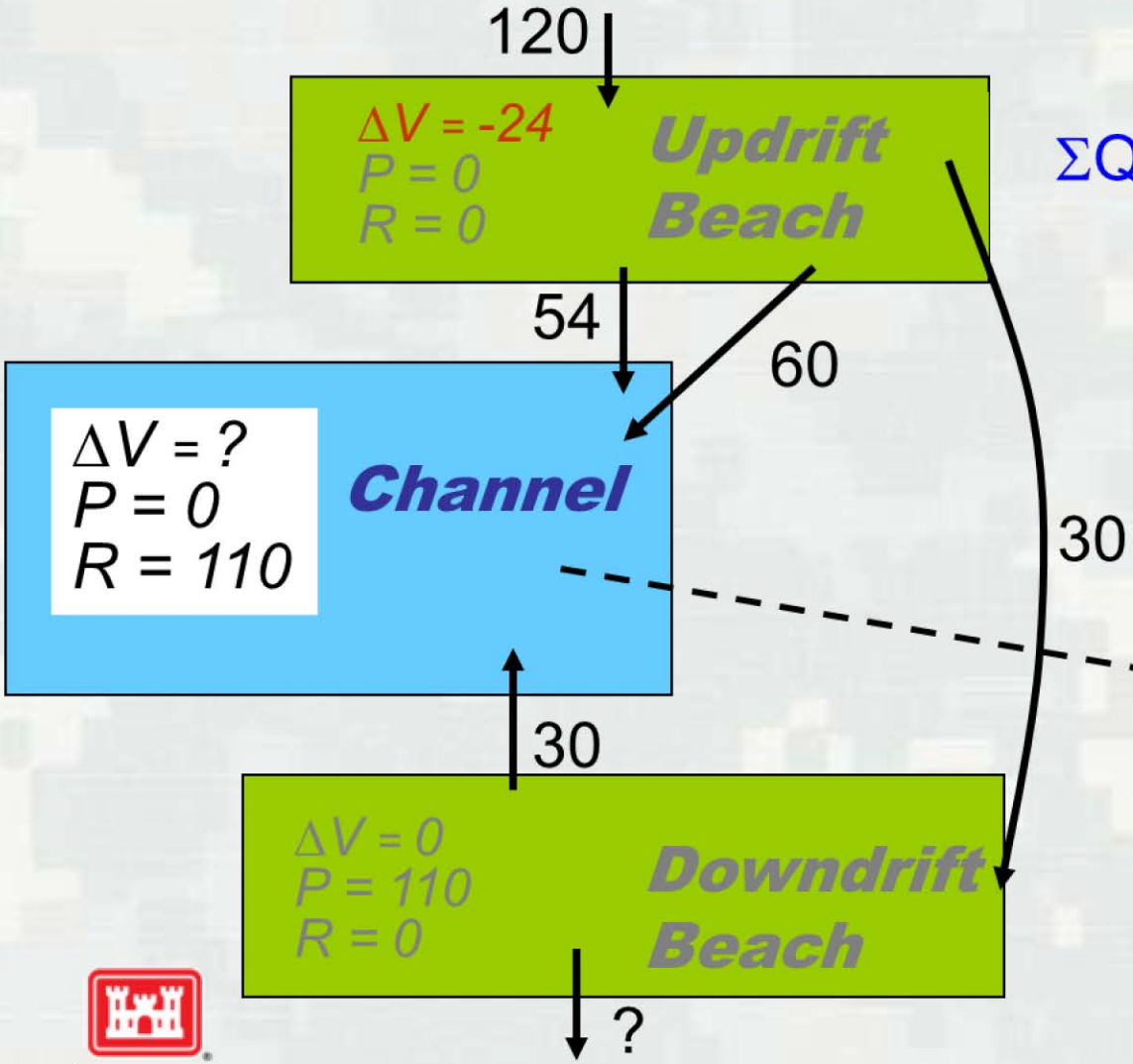
$$\Sigma Q_{source} - \Sigma Q_{sink} - \Delta V + P - R = 0$$

$$120-(54+60+30)-\Delta V+0-0=0$$

$$\rightarrow \Delta V = -24$$

Hillsboro Inlet Sediment Budget:

Channel Cell



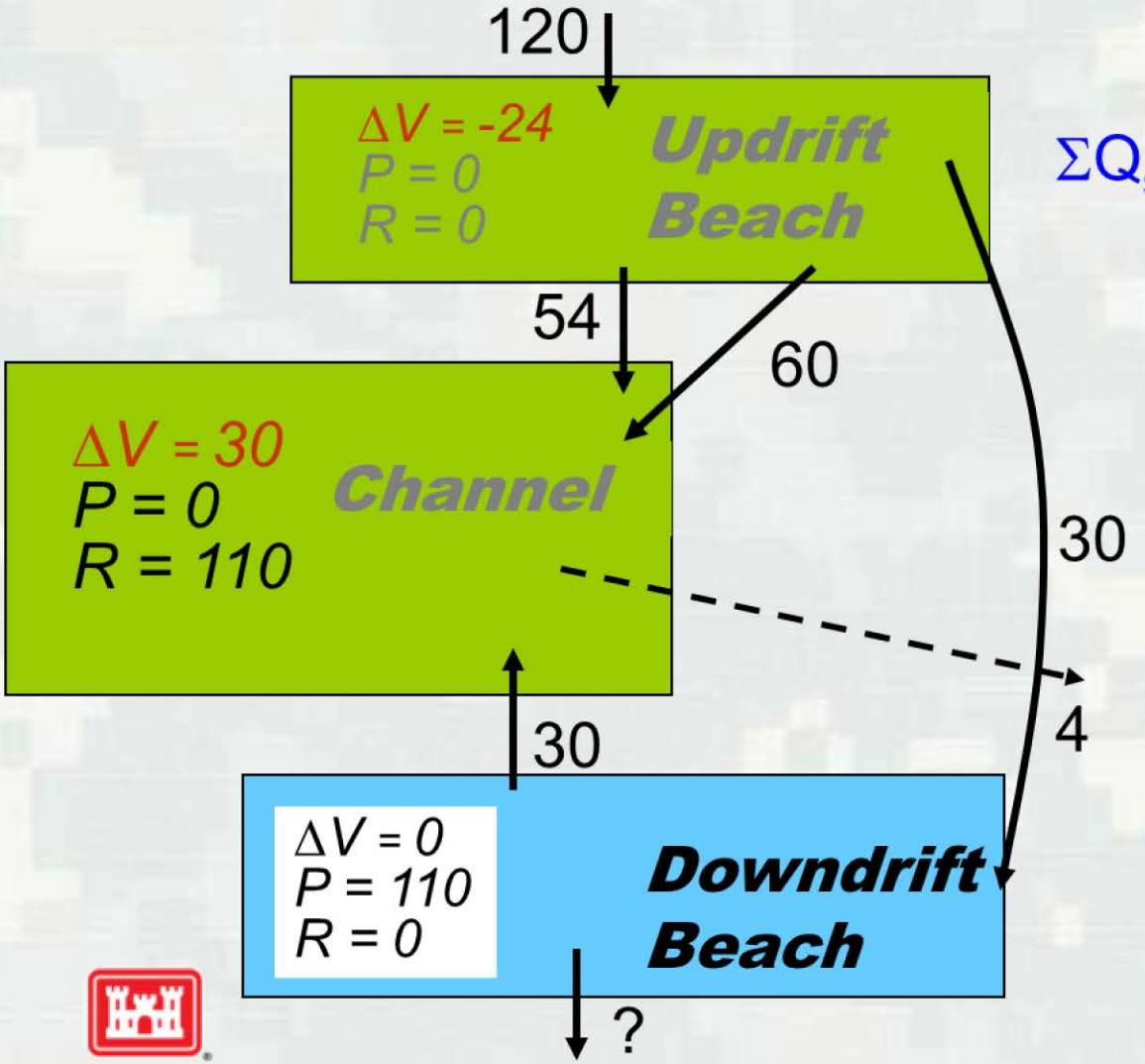
$$\Sigma Q_{source} - \Sigma Q_{sink} - \Delta V + P - R = 0$$

$$(54+60+30)-(4)-\Delta V+0-110=0$$

$$\rightarrow \Delta V = 30$$

Hillsboro Inlet Sediment Budget:

Downdrift Cell



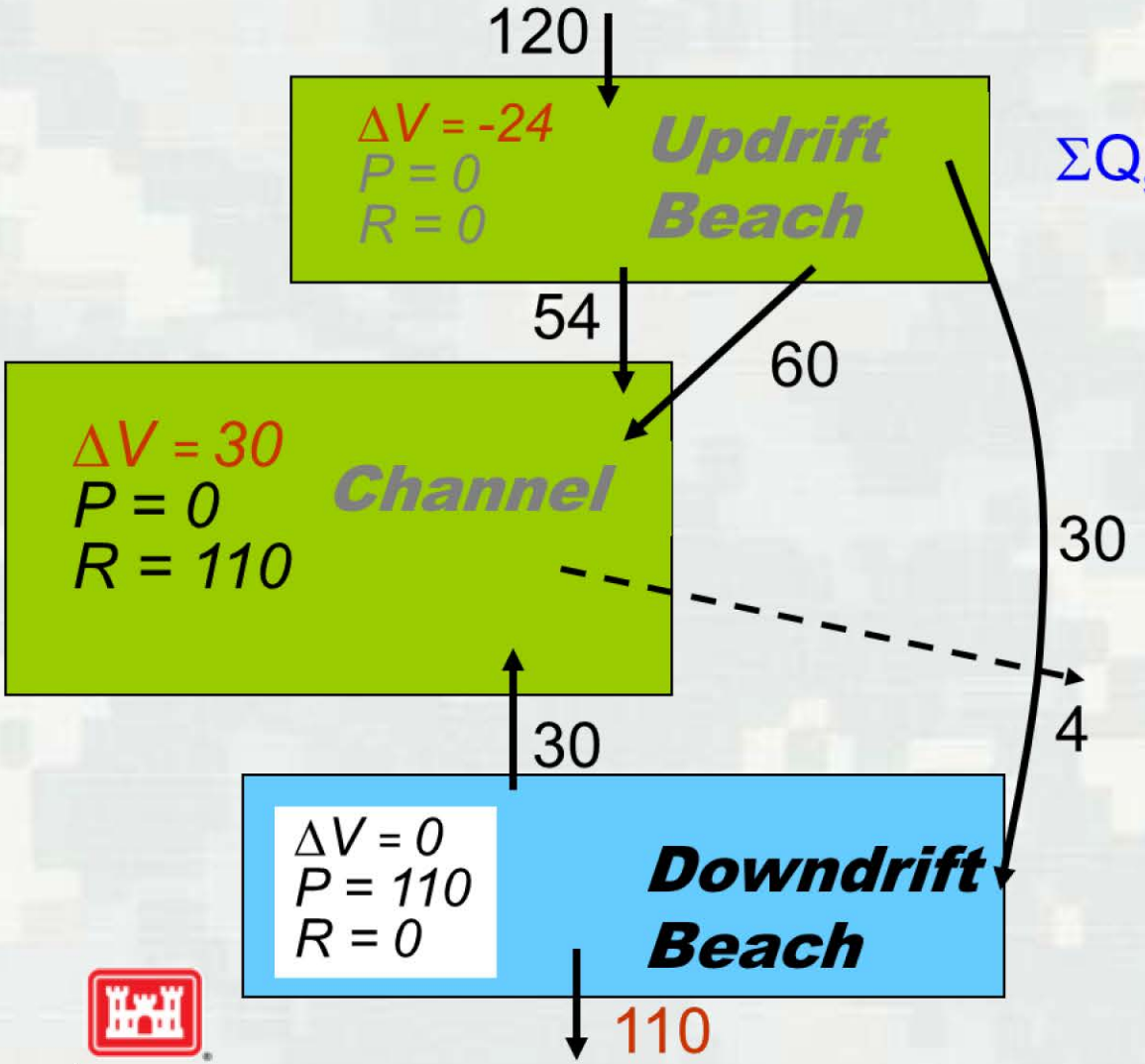
$\Sigma Q_{source} - \Sigma Q_{sink} - \Delta V + P - R = 0$

$(30)-(30+Q_{out})-0+110-0=0$

$\rightarrow Q_{out} = 110$

Hillsboro Inlet Sediment Budget:

Downdrift Cell

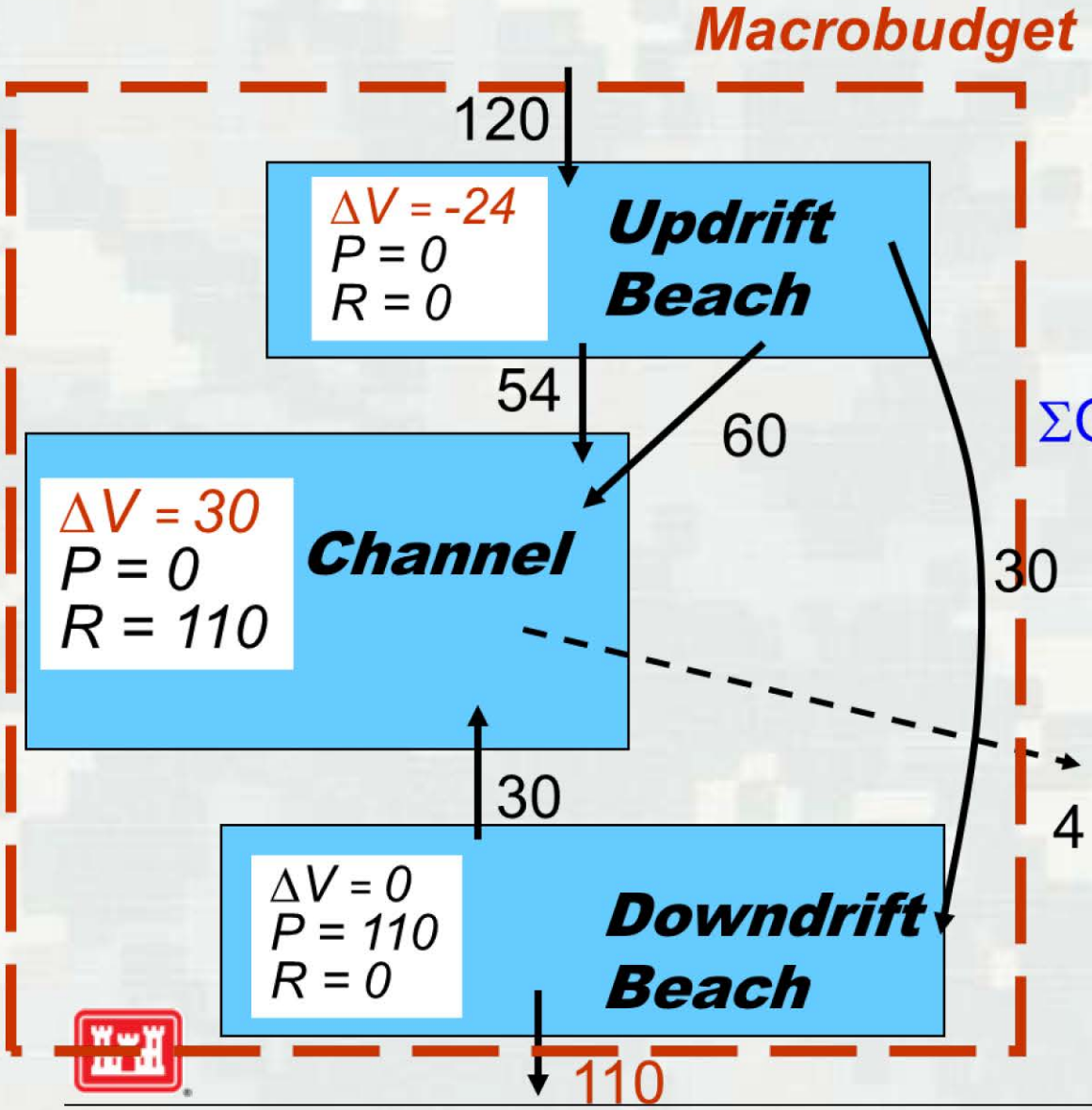


$\Sigma Q_{source} - \Sigma Q_{sink} - \Delta V + P - R = 0$

$(30)-(30+Q_{out})-0+110-0=0$

$\rightarrow Q_{out} = 110$

Hillsboro Inlet Sediment Budget:



Macrobudget:
Budget of all cells

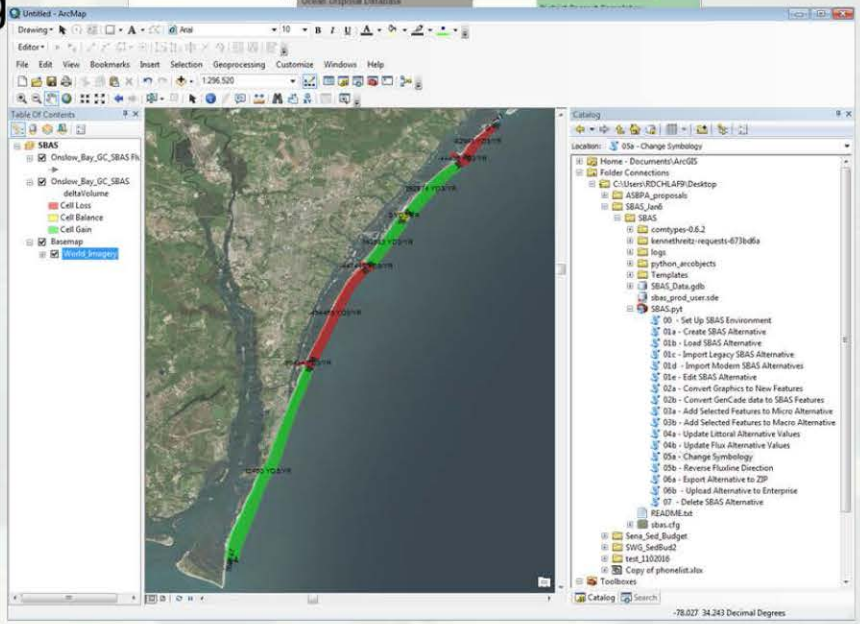
$\Sigma Q_{source} - \Sigma Q_{sink} - \Delta V + P - R = 0$

(120)-(110+4)-(-24+30+0)+(110)-(110)=0

Checks correctly!

SBAS

Sediment **B**udget **A**nalysis **S**ystem (SBAS) – provides a framework for formulating, documenting, and calculating sediment budgets, including estimation of uncertainty



ArcGIS version and documentation: http://rsm.usace.army.mil/

Summary

- We use sediment budgets for a range of applications
  - Simple: communication/illustration tool
  - Detailed: determine design elements
  - May be many budgets to characterize a particular coastal setting
- Steps in formulating a sediment budget:
  1. Conceptual budget (quickly formulated, use available information)
  2. Interim (Working) budget (analyze data, new modeling, sensitivity testing)
  3. Operational (Final) budget(s)
- Important concepts:
  - Macro-budget – provides a check on calculations
  - Residuals – should be zero for balanced budget, but can carry residuals to illustrate problems with data or lack of available information
- SBAS – tool useful for:
  - Communications – free to all partners, easily share files
  - Check on algebra
  - Keeping track of various budgets and data