ERDC
Engineer Research and
Development Center

Introduction to GenCade

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US Army Corps of Engineers®

Outline

- What is GenCade?
- Background, overview, and conceptual coverage
- GenCade capabilities
- GenCade limitations and assumptions
- Workflow
- Model theory and formulation
- I/O Files and Cards

GENESIS + Cascade → GenCade

Cascade (top to bottom)

- **Planning tool (RSM Support)**
- **Time scales: months to centuries**
- **Multiple inlets, shoals, and barrier islands; cumulative impacts; retains curvature of regional geomorphology**
- **Fast**
- **Typical grid resolution ~ 500 m**

GENESIS (bottom to top)

- **Engineering design tool**
- **Can represent all engineering details – structures, etc.**
- **Mature technology – big payback by updating**
- **Typical grid resolution ~ 25 m**

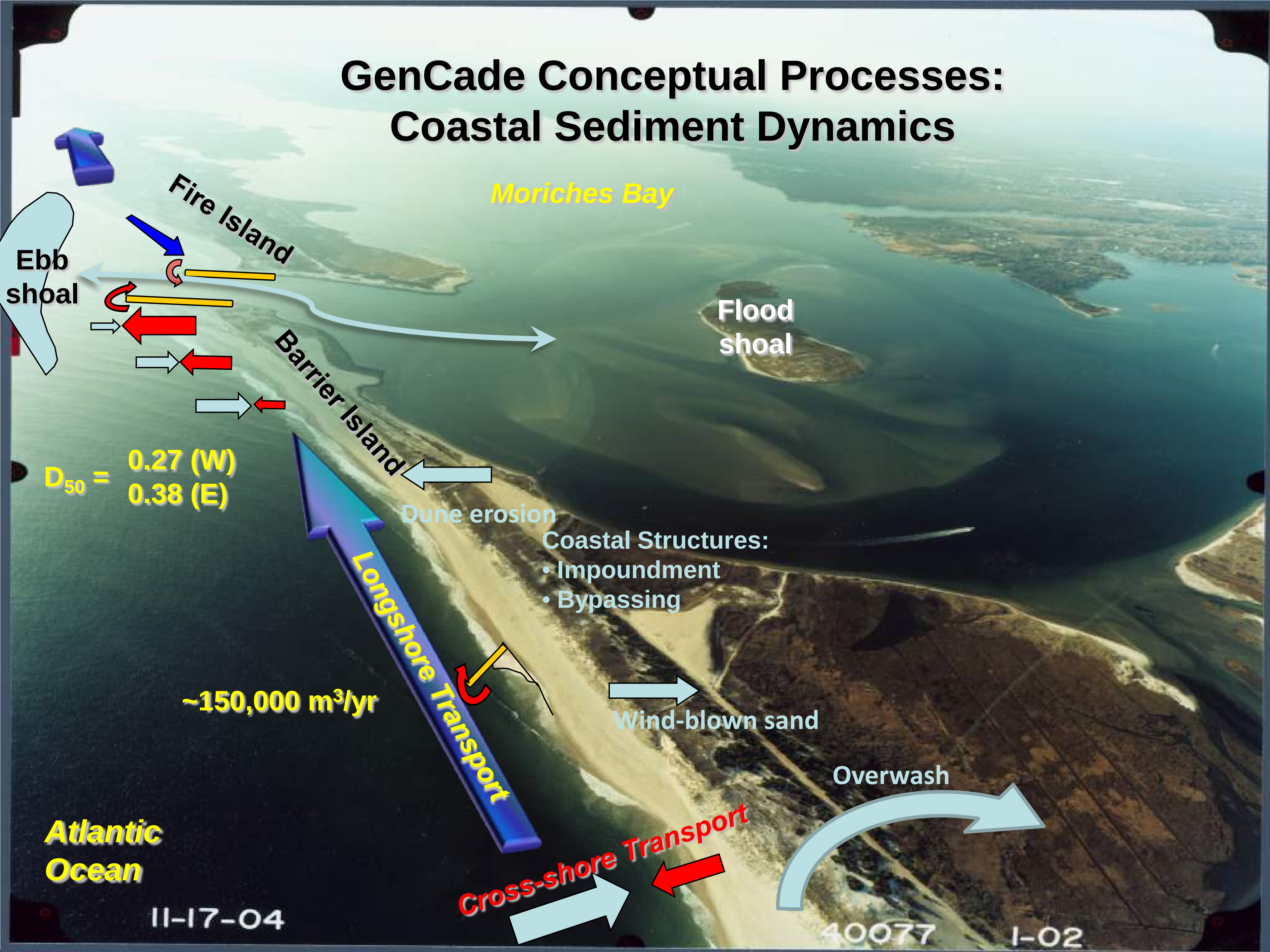
Strategy: Add Cascade capabilities to GENESIS to automatically include all GENESIS features

GENESIS + Cascade → GenCade

- Integrate from planning through engineering design
- Cover time scales from one year to centuries
- Preserve regional trends
- Furnish regionally consistent boundary conditions to local projects
- Represent cumulative local projects interacting regionally
- Represent inlet bypassing and tidal delta evolution
- Resolve engineered elements
- Include variable grid resolution for accuracy and efficiency
- Improve computational efficiency (over GENESIS)

Strategy: Add Cascade capabilities to GENESIS to automatically include all GENESIS features

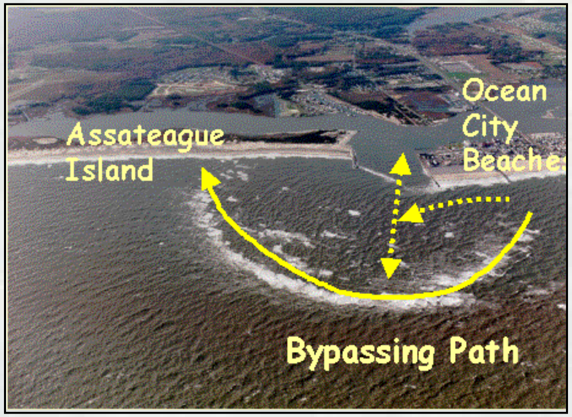
GenCade Conceptual Processes: Coastal Sediment Dynamics



GenCade Applicability

Regional processes, Long-term morphology change

Project Planning & Design

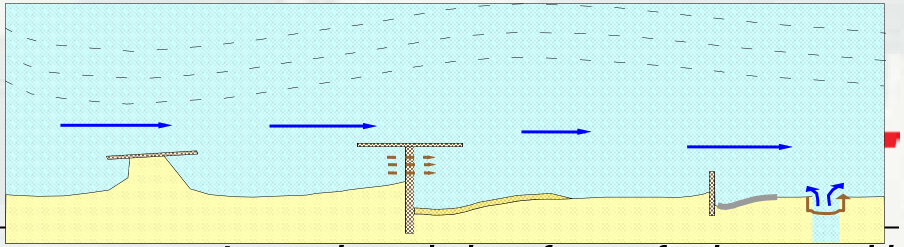


Habitat Change

- Regional Sediment Management
  - Beach fills
  - Inlet bypassing
  - Channel maintenance
- <u>Unifying technology</u> for multiple projects
- Intuitive interface (SMS)

Model Functionality and Capabilities

- Variable resolution grids
- Inlet bypassing
- Inlet Reservoir Model for calculation of shoal and inlet feature sediment balance
- Representation of regional morphologic trends
- Multiple wave input forcing locations
- Representation of coastal structures: groins, jetties, seawalls, t-head groins, breakwaters, etc.
- Calculation of salients and tombolos behind breakwaters
- Time-dependent detached breakwater transmission
- Efficient calculation of breaking wave properties in internal wave model



GenCade Assumptions

- Beach profile maintains a constant average shape
- Longshore transport occurs only between top of berm and depth of closure (or active transport)
- Sand transported alongshore by breaking waves is not affected by nearshore current patterns
- There is a long-term trend in shoreline evolution
- The detailed structure of the nearshore circulation is ignored

General Workflow

- Coastal Problem
  - Formulate question
  - Identify constraints
  - Develop criteria to review and evaluate the solutions
- Assemble and analyze relevant input data
- Develop engineering solutions and alternatives
- Develop and execute GenCade to optimize project solutions and alternatives
- Calibrate, Validate, Evaluate Alternatives
- Evaluate results

GenCade Workflow

- Compile project data
- Assimilate data as GenCade forcing or BC input
- Develop conceptual model from input data
- Develop GenCade project grid and alternatives

Pre-Process

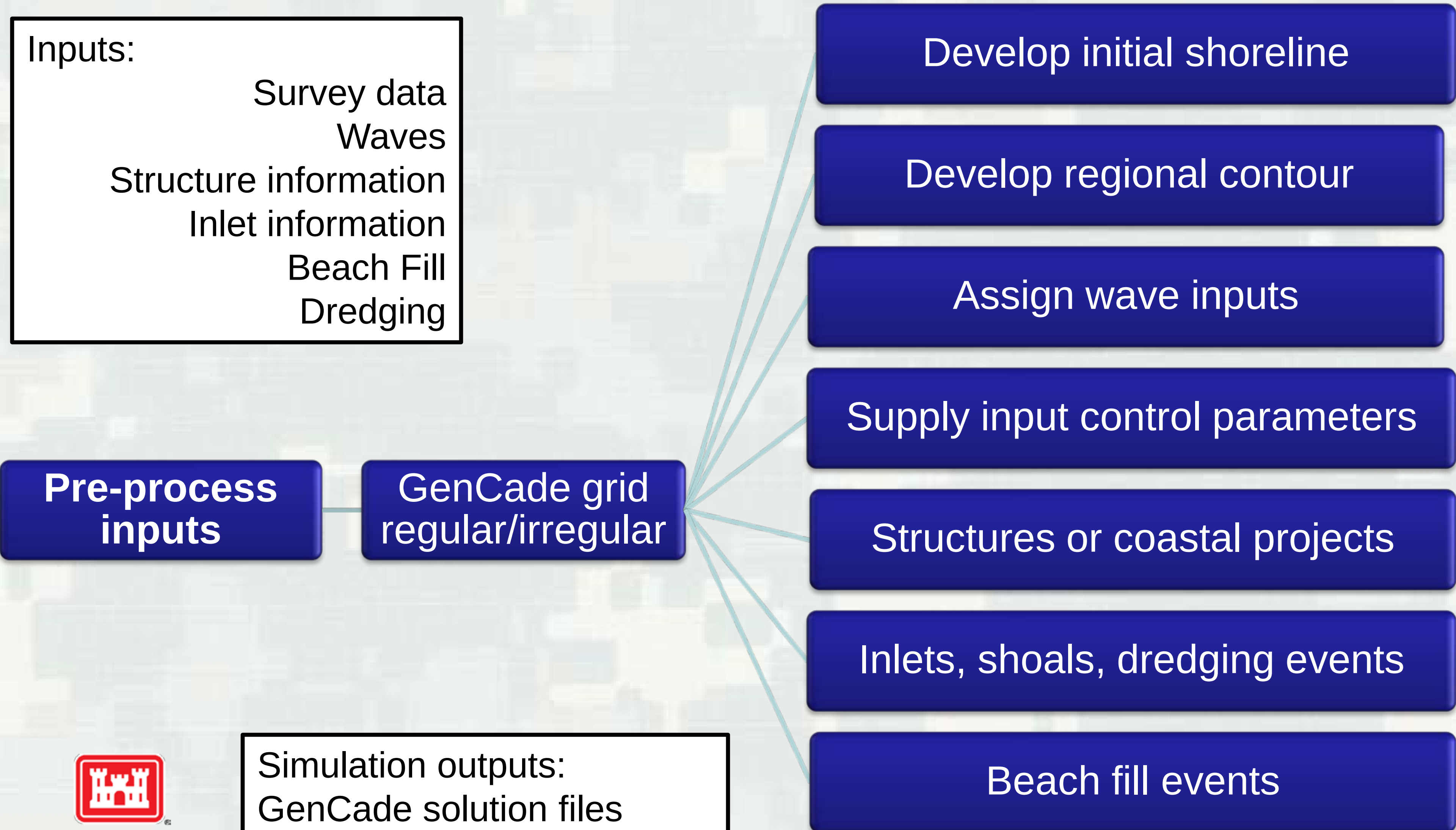
- Execute calibration simulations/sensitivity tests
- Review and analyze calibration results
- Refine setups
- Execute production simulations

Simulate

- Review results
- Analyze and post-process results

Post-Process

GenCade Workflow



GenCade Workflow

Inputs:

GenCade Solution files;
Measured Data

Post-process

- Transport rates
- Sediment budgets
- Shoreline Change
- Inlet bypass/shoal evolution
- Compare measured
- Compare alternatives

Post-process outputs:
Calculations, figures,
images, exported data

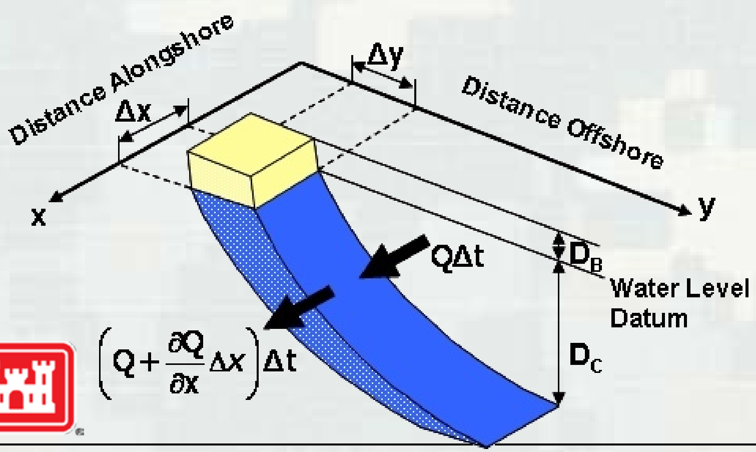
Model Formulation

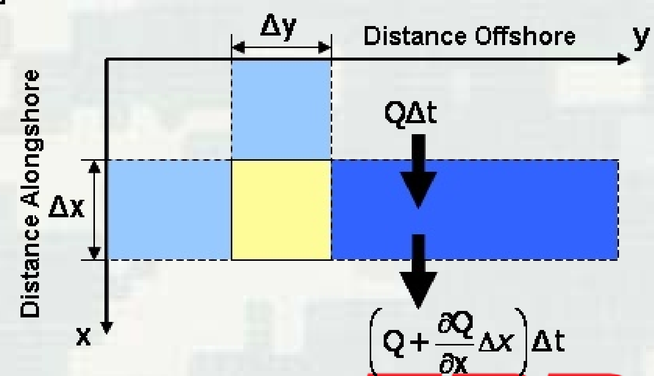
Longshore Net Volume Change: $$\frac{dQ}{dt} = \left(\frac{\partial Q}{\partial x}\right) dxdt$$

Cross-shore Net Volume Change: $$dqdt$$

Total Volume Change: $$dV = dxdy\left(D_B + D_C\right) = \left(\frac{\partial Q}{\partial x}\right) dxdt + qdxdt$$

$$\therefore \text{ as } dt \rightarrow 0: \quad \frac{\partial y}{\partial t} + \frac{1}{D_B + D_C} \bullet \left[\frac{\partial Q}{\partial x} - q\right] = 0$$



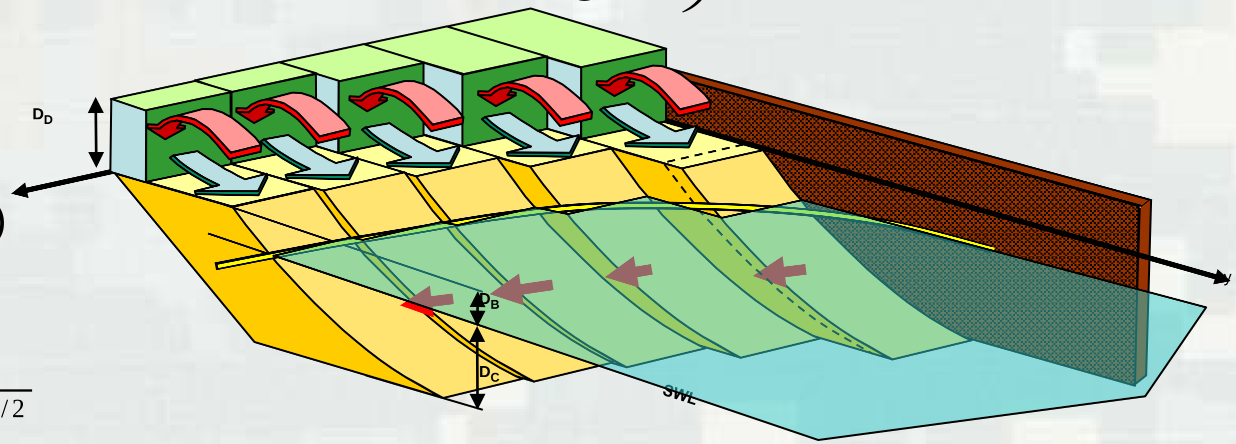


Model Formulation

Sediment transport rate Q (m^3/s):

$$Q = \left(H^2 C_g\right)_b \left(a_1 \sin 2\alpha_{bs} - a_2 \cos \alpha_{bs} \frac{\partial H_b}{\partial x} \right)$$

Where,
H = wave height (m)
C_g =wave group speed (m/s)
α_{bs} = angle of the breaking



$$a_1 = \frac{K_1}{16(\rho_s/\rho - 1)(1-p)1.416^{5/2}}$$

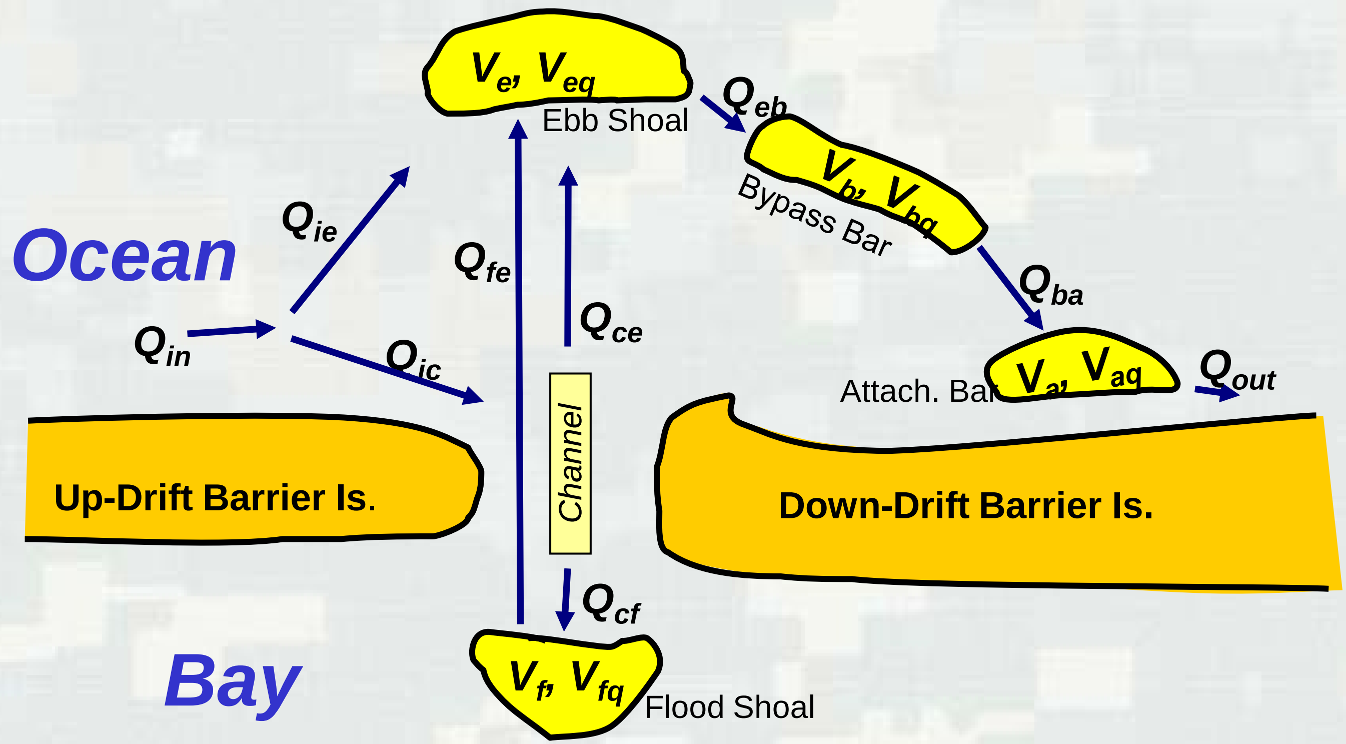
$$a_2 = \frac{K_2}{8(\rho_s/\rho - 1)(1-p)\tan\beta \; 1.416^{5/2}}$$

Typically, value of K_2 is:
$0.5K_1 < K_2 < 1.5K_1$

Where,
K_1 = Primary empirical transport coefficient (controls magnitude of longshore transport rate)
K_2 = Secondary empirical transport coefficient (controls distribution of sand within an area; esp. where large wave height gradients, e.g. salients)
tanβ = average bottom slope

Inlet Reservoir Model

Inlet bypassing and evolution of inlet deltas



$$Q_{ie} = \delta Q_{in}$$
$$Q_{ic} = (1-\delta) Q_{in}$$
$$Q_{ce} = \beta Q_{ic} = \beta (1-\delta) Q_{in}$$
$$Q_{cf} = (1-\beta) Q_{ic} = (1-\beta)(1-\delta) Q_{in}$$
$$Q_{fe} = (V_f - V_{fq}) / dt, \; V_f > V_{fq}$$

$$Q_{eb} = \frac{V_e}{V_{eq}} (Q_{ie} + Q_{fe} + Q_{ce})$$
$$Q_{ba} = \frac{V_b}{V_{bq}} Q_{eb}$$
$$Q_{out} = \frac{V_a}{V_{aq}} Q_{ba}$$
$$\delta = (V_e + V_f) / (V_{eq} + V_{fq})$$

$$dV_e = (Q_{ie} + Q_{fe} + Q_{ce} - Q_{eb}) dt$$
$$dV_f = (Q_{cf} - Q_{fe}) dt$$
$$dV_b = (Q_{eb} - Q_{ba}) dt$$
$$dV_a = (Q_{ba} - Q_{out}) dt$$
$$\beta = (1 - V_e / V_{eq}) / (2 - V_e / V_{eq} - V_f / V_{fq})$$

Output File Format for GenCade

Instantaneous Net Transport at Output Time (*.*qtr*) File	
Column 1	**Column 2 through Column NX**
Date (yyyymmdd)	Net sediment transport (length^3/year) for each grid cell

Mean Net Transport Over Simulation or Specified Time (*.*mqn*) File	
Column 1	**Column 2 through Column NX**
Date (yyyymmdd)	Net sediment transport (length^3/year) for each grid cell averaged over entire simulation (and optionally from start to specified times)

Mean Left Transport Over Simulation or Specified Time (*.*mql*) File	
Column 1	**Column 2 through Column NX**
Date (yyyymmdd)	sediment transport (length^3/year) to left for each grid cell averaged over entire simulation (and optionally from start to specified times)

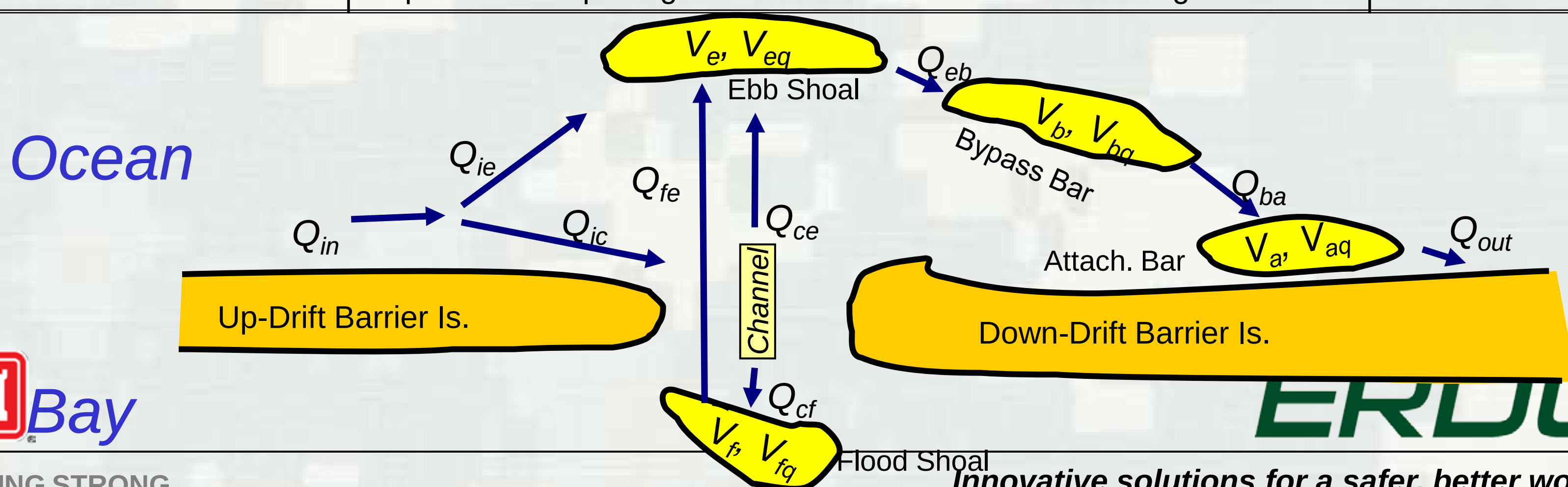
Mean Right Transport Over Simulation or Specified Time (*.*mqr*) File	
Column 1	**Column 2 through Column NX**
Date (yyyymmdd)	sediment transport (length^3/year) to right for each grid cell averaged over entire simulation (and optionally from start to specified times)

Output File Format for GenCade

Shoreline Position at Output Time (*.*slo*) File	
Column 1	**Column 2 through Column NX**
Date (yyyymmdd)	Y-position of shoreline (length unit) for each grid cell

Calculated Offshore Contour at Output Time (*.*off*) File	
Column 1	**Column 2 through Column NX**
Date (yyyymmdd)	Y-position of offshore contour applied to wave transformation (length unit) for each grid cell

Inlet Shoal Volume Output (*.*irv*) File (one file for each inlet)		
Column 1	**Column 2 Through Column 16**	**Column 17**
Time-step at which shoal volumes are printed as output	Shoal volume (length^3) or in /.out volume at each shoal output time-step for the morphological shoal features identified in the figure below	Date (yyyymmdd)



GenCade Input Cards

- TITLE Title of simulation run
- INIFILE Path and name of initial shoreline file
- REGFILE Path and name of regional shoreline file
- NUMWAVES Number of wave input locations/files
- WAVEID Cell ID; Depth; number of wave events; and file path/name of wave input data (1 WAVEID line/file)
- PRFILE Path and name of printed output file
- GENUNITS (ft) or (m) System of units for model I/O
- X0 X-origin
- Y0 Y-origin
- AZIMUTH Angle (deg) of grid rotation about origin
- NX Number of alongshore cells
- DX Cell resolution or -1 indicates variable resolution
- SIMDATS YYYYMMDD Start date of simulation
- SIMDATE YYYYMMDD Ending date of simulation
- DT 1.0 Time step in hours
- DTSAVE 10.0 Data (shoreline/transport) output times
- K1 0.5 Longshore sediment transport coefficient 1
- K2 0.25 Longshore sediment transport coefficient 2
- PRTOUT Output to PRFILE yes (t), no (f)
- PRWARN Print warnings yes (t), no(f)
- PRDATE Dates to save simulated shoreline
- ISMOOTH 11 #cells in offshore contour smoothing
- IREG Include regional contour (1 = yes; 0 = no)

- HAMP 1.0 Height amplification factor
- THETAAMP 1.0 Angle amplification factor
- THETADEL 0.0 Angle offset
- LMOVY 0.0 Leftward shoreline displacement velocity
- D50 0.33 Grain size diameter in millimeters
- BERMHT 2 Average berm height
- DCLOS 8 Depth of closure
- LBCTYPE 0 Left boundary condition type
- LMOVY 0.0 Leftward shoreline displacement velocity
- LMOVPER 1 Simulation period (0), day(1), time step (2) period for LMOVY
- LGROINY 0.0 Length of left groin from shoreline to seaward tip
- RBCTYPE 0 Right boundary condition type
- RMOVY 0.0 Rightward shoreline displacement velocity
- RMOVPER 1 Simulation period (0), day(1), time step (2) period for RMOVY
- RGROINY 0.0 Length of right groin from shoreline to seaward tip

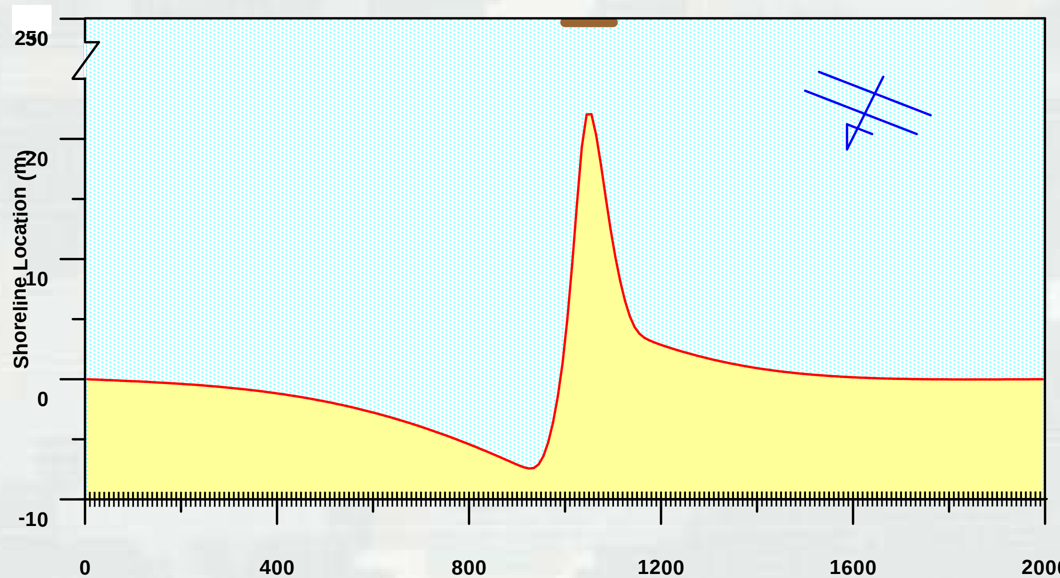
GenCade – Variable Grid Alongshore

Detached Breakwater
3-month simulation

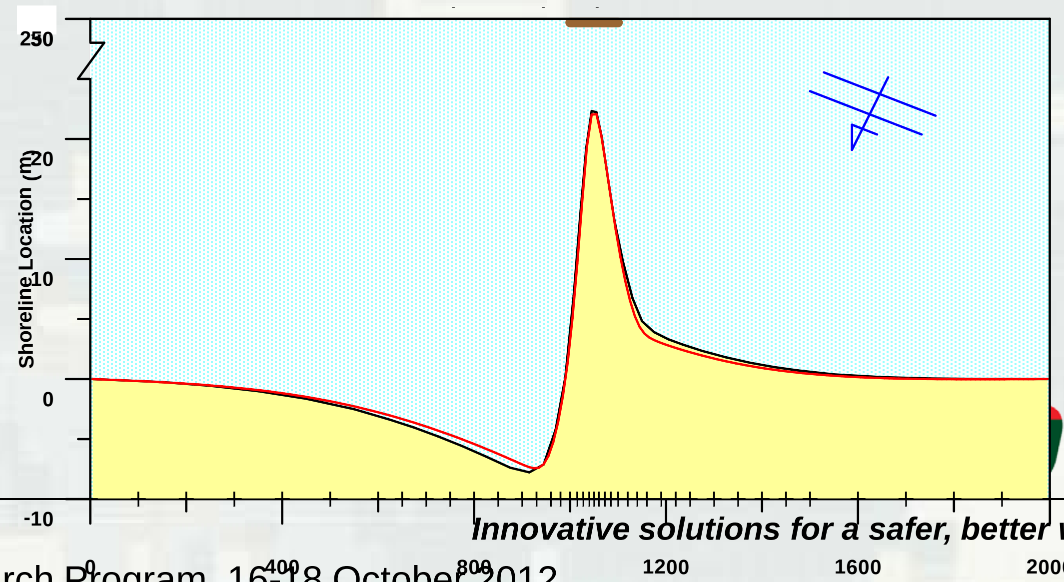
250 m offshore
100 m long

H = 1 m, T = 5 sec, θ = -5 deg.

N = 200
DX = 10 m



N = 40
DX_{max} = 100 m
DX_{min} = 10 m



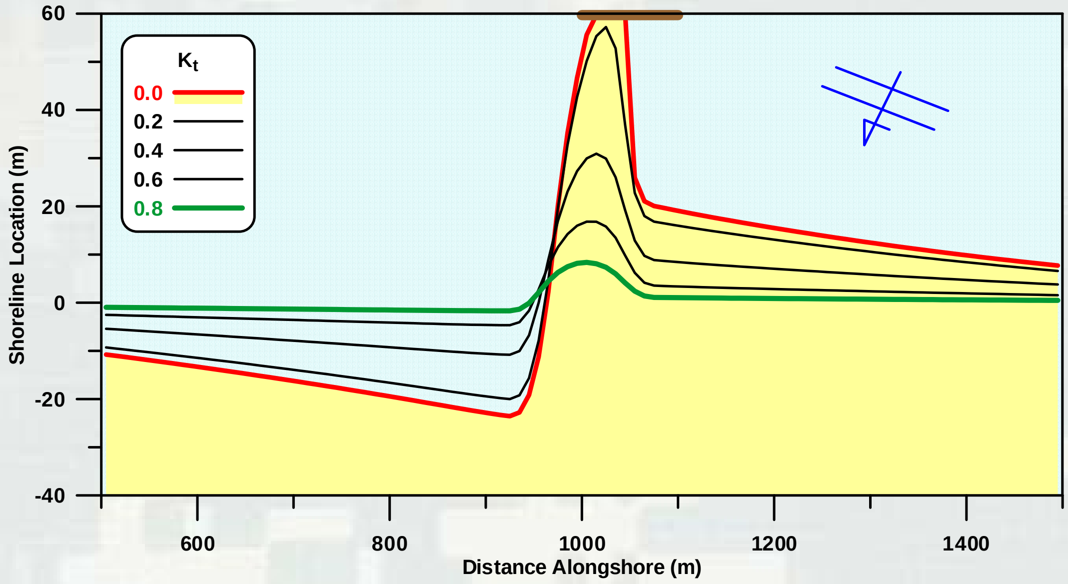
GenCade – Transmissive Breakwater

Detached Breakwater
12-month simulation

60 m offshore
100 m long

H = 1 m, T = 5 sec, θ = -5 deg.

N = 200
DX = 10 m



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http://cirpwiki.info/wiki/GenCade
http://cirp.usace.army.mil/products