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DATE: August 19, 2009

SUBJECT: Guidelines for Documenting Numerical Model Studies in Submittals to the FDEP Bureau of Beaches and Coastal Systems (BBCS)

Purpose and Authority

The purpose of this document is to introduce permit applicants to guidelines for documenting numerical model studies in submittals to the FDEP Bureau of Beaches and Coastal Systems (BBCS). When a permit application is required for the construction of a proposed beach erosion control or inlet management project, according to Florida Statues (FS) 161.041, the department may authorize an excavation or erection of a structure at any coastal location upon consideration of facts and circumstances, including: (a) Adequate engineering data concerning inlet and shoreline stability and storm tides related to shoreline topography; (b) Design features of the proposed structures or activities; and (c) Potential impacts of the location of such structures or activities, including potential cumulative effects of any proposed structures or activities upon such beach-dune system or coastal inlet, which, in the opinion of the department, clearly justify such a permit.

Pursuant to Florida Administrative Code (F.A.C) 62B-41, the application for permit includes submittal of an analysis of the expected physical effect of the proposed activity on the existing coastal conditions and natural shore and inlet processes. The analysis should include a quantitative description of the existing coastal system, the performance objectives of the proposed activity, the design parameters and assumptions, relevant computations, calibration procedures, validation of the results and the data used in the analysis. In addition, an analysis of available alternatives to the proposed coastal construction that would minimize adverse impacts to the coastal system should be investigated.

Scope

These guidelines are intended to assist applicants with documenting numerical model studies that are submitted to BBCS. These guidelines are NOT a statement of acceptable standards and practice in the engineering and design of beach erosion control and inlet management projects. The professional engineer and geologist are solely responsible for applying, with due diligence, the generally acceptable standards and practice of coastal engineering and geology in the conduct of their work.

Furthermore, the BBCS does not endorse the exclusive use of the numerical model software for which guidelines are provided in the appendices. These are not the only software that may be applied in the development of the proposed beach erosion control and inlet management projects. These software are recognized by the engineering community nationally and internationally, and have been frequently submitted to BBCS. It is expected appropriate numerical model(s) will be used for the proposed project study. Model results of these software will be accepted by BBCS provided proper input parameters for the project area have been used and the models have been thoroughly calibrated and validated and the results are certified by a Florida Professional Engineer. BBCS is not liable for the use of any of these software in anyway.

Procedures

Adequate engineering data should typically include an analytic solution based upon empirically-derived formulas and theories of physical coastal processes, and when necessary, additional analysis should be conducted using computer-based numerical modeling applications. Recent and historical physical monitoring data of coastal conditions and processes may be sufficient for quantitative assessments or qualitative inferences, and should always be used to supplement and validate the analytical solution and the numerical model solution. When a numerical model study has been deemed necessary for engineering and design of a project, the BBCS engineering staff generally recommends that all three approaches be applied: numerical modeling and analytic solutions supplemented with assessment of coastal monitoring data.

All relevant and reliable coastal monitoring data including, but not limited to, historical photos, surveys, monitoring reports, and regional studies, together with the numerical model results, should be used by the design professional in understanding the coastal processes and quantifying the potential effects of the proposed project on the coastal system.

Currently, guidelines for documenting a numerical model study to be submitted to BBCS are provided for DELF3D, MIKE21 and SBEACH in the Appendices to this memorandum. Guidelines for documenting other numerical models under consideration will be included in the Appendices as they are completed.

When preparing a scope of work for consideration by the project sponsors, the consultant may reference the guidelines in the specifications. If it becomes necessary to deviate or omit the submittal of information as specified in the guidelines, then a detailed explanation should be provided in the design report as to why this is appropriate.

APPENDIX

DELFT3D

Guidelines for Documenting DELFT3D Model Applications in Submittals to the FDEP Bureau of Beaches and Coastal Systems

This is a listing of information recommended to be provided for studies using the **DELFT3D model**, including the **sediment transport module**. If the DELFT3D implementation includes wave modeling, either independently of the flow model or for providing inputs to the flow and sediment transport simulations, those wave modeling efforts should be documented according to the wave model guidance. The design professional may chose to omit or deviate from recommendations in these guidelines based upon site or project specific circumstances that affect the scope of the model study effort. The model study report shall identify which of these recommendations are not applicable to the study and the circumstances specific to the study.

1. Modeling Objectives

State the purpose of the modeling analysis and the intended use of the modeling outputs. Identify the versions of DELFT3D model and the modules used in the study. This statement should include a discussion of the coastal system at the project site, the potential effects of the design alternatives on the coastal system and the ability of the DELFT3D model to accurately predict these potential effects that justifies the use of DELFT3D model rather than another numerical model. The discussion of the coastal system should include a brief description of the site, including critical structures and any other features. Discuss the choice of using the depth-averaged (2D) model option or the 3D model option for the analysis. The discussion should include role of vertical velocity profiles, vertical density stratification, wind shear, water depth and other features of the system that could create significant 3D flow response.

If the sediment transport or morphology module is being used, characterize the sediments, geomorphic features, erosion and deposition patterns and discuss the role of current and wave forcing. If relevant, describe how wave forcing will be included in the analysis.

2. Model Data

The data used in the analysis should be described and organized into configuration data, forcing data and calibration/validation data.

<u>Configuration data include:</u>

- Bathymetry
- Shoreline
- Bottom friction characteristics
- Structures
- Sediment characteristics

For these configuration data, state the sources of the data, the original projection and vertical datum, the units and all transformations and merging of the data. Describe the quality assurance review of the data and include a qualifying statement regarding the degree of

accuracy of the data. Discuss the effects of structures in the project area. Discuss the bottom conditions and sediment characteristics and how they establish the bottom friction characteristics. The submitted data should include the raw and the final bathymetric maps of the modeled system that include pre- and post-project conditions with structures and shorelines.
The input and output files shall be submitted in their electronic format suitable to adequately convey the requested information.

Forcing data include:

- Wave radiation stress data
- Wind data
- Offshore tide (surge) data

For these forcing data, state the sources of the data, the station location and the time zone, the recording instruments, the time period covered by the data, and the recording frequency and units of the data. Describe all transformations, merging and filtering of the data. Describe the quality assurance review of the data and include a statement regarding the degree of accuracy of the data. The submittal should also provide justification for the forcing data that confirms that the data used in the modeling is representative of typical and/or extreme conditions. The submitted data should include comprehensive summaries and statistical analyses of the forcing data used in the modeling. The data may be submitted in electronic or paper format suitable to adequately convey the requested information.

Calibration data include:

- Flow or velocity
- Water surface elevation data
- Suspended sediment and sediment transport data
- Morphological change data

For these calibration data, state the sources of the data, the station location and the time zone; state the recording instruments, the time period covered by the data and recording frequency and the data units. Describe the quality assurance review of the data and include a statement regarding the degree of accuracy of the data. Describe all transformations, merging and filtering of the data. The submitted data may include either summaries, statistical analyses or the actual calibration raw data used in the modeling.

The need to have sufficient, representative and reliable measurements from a minimum number of stations to calibrate and validate the numerical models cannot be over emphasized. It will be necessary to show such data have been used in the model calibration and validation process.

3. Model Configuration and Parameter Selection

1. Discuss the selection of all modeling parameters and justify the values specified.
2. Provide the results of sensitivity analyses of all modeling parameters.

3. Discuss the selection of calibration/validation periods and application of forcing conditions.
4. Discuss how well the full range of forcing conditions is represented by the calibration/validation periods.
5. Discuss other models considered for this study and why DELFT3D was selected.
6. Discuss the selection of the grid coordinate system, either Cartesian or spherical and the choice of a sigma-grid or Z-grid.
7. Describe and discuss the selection of grid resolution. Demonstrate that the grid resolution sufficiently represents critical features in the domain.
8. Discuss the time step and the choice of the advection solution scheme (WAQUA, Cyclic method, Flooding-scheme, Multi-directional). If morphology is simulated, then discuss the selection of the morphology time scale factor with special attention to simulation of historical storm events.
9. Describe the application of initial conditions for un-steady flow simulations and the designation of any spin-up periods.
10. Describe in detail the application of all forcing and boundary conditions applied.
11. Discuss the choice of sediment size/type classes.
12. Describe the DELFT3D modeling options used and the selection of associated parameter values. These may include:

    - Flooding and drying
    - Application of slip or no-slip boundary conditions
    - Eddy viscosity and turbulence closure scheme used
    - Bed friction
    - Tide potential
    - Wind friction
    - Structures

13. If sediment transport or morphology is simulated then describe the DELFT3D modeling options used and the selection of associated parameter values. These may include:

    - Choice of bed load, suspended load and cohesive and non-cohesive representations
    - Erosion, deposition and settling properties
    - Bed-load formulation and parameters
    - Multi-size class hiding and exposure factors
    - Specification of hard bottom (fixed layers)

4. Model Calibration/Validation

- Describe the approach for model calibration – which parameters or forcing data were modified to obtain the calibration.
- Describe which parameters or forcing data (from Section 2) were modified or used to obtain the calibration.

- Describe any adjustments to the grid domain, grid resolution and parameter values and model options made during the calibration process. Clearly state the reasons for the adjustments.
- Show graphically or in a table the calibration results and discuss the accuracy of the calibration. Describe the metrics used to evaluate the calibration and validation.
- Discuss any implication of the calibration/validation on the model applications.
- Revisit and reconfirm the model calibration following any revisions to the model.

5. Model Applications

Describe the selection of the time periods, wave and wind ranges for the application scenarios. For instance, if they are intended to represent worst case or typical conditions, what is the quantitative basis for defining ‘worst case’ or ‘typical’? If the DELFT3D flow module outputs are being used as input to other modules, for example, for sediment transport, then demonstrate that periods and conditions used represent the proper range of forcing conditions.

Describe any changes to the model configuration to represent future conditions, alternative designs. Include a discussion of any changes to model parameter values obtained in the model validation and the rational for making the changes.

6. Results

The DELFT3D modeling information should be included in a design report and bear the seal and certification of the design engineer registered pursuant to Chapter 471, Florida Statutes. Provide a written report of the modeling effort and its results, and include all items that were requested to be described or discussed in these guidelines. This report should include figures, maps, or tables capable of presenting the results of the existing and post-project conditions. All figures, maps and tables should be produced in a scale sufficient to allow for clear view and accurate review of the results.
Include a comparative table of all model parameters, the default parameter values and the final values used in the model study. Compute correlation coefficients for all measured data versus computed and comment on the confidence levels for the model calibration.
Include in the appendix, the printout of all the parameter settings including the contents of the files *.SED and *.MOR.

The results of the modeling should also provide a full discussion of the modeling output and its accuracy. This discussion should include comments on the model stability, parameter sensitivity, the time step used in the modeling, simulation period used and active grid elements. Any anomalies produced during the modeling should be identified and discussed.

All final input data files used to run the model and the output files used to produce the report should be submitted in CDs or DVDs.

7. Conclusions

Review all assumptions made in the modeling analysis and any limitation they may induce on the results. Provide an overall assessment of the model effectiveness and its suitability for the project area.

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APPENDIX

MIKE21 FLOW MODEL

Guidelines for Documenting MIKE21 Model Applications in Submittals to the FDEP Bureau of Beaches and Coastal Systems

This is a listing of information recommended to be provided for studies using the **MIKE21 Flow model** and its **sediment transport module**. If the MIKE21 implementation includes wave modeling, the wave modeling effort should be documented according to the selected wave model's guidelines. The design professional may chose to omit or deviate from recommendations in these guidelines based upon site or project specific circumstances that affect the scope of the model study effort The model study report should identify which of these recommendations are not applicable to the study and the circumstances specific to the study.

1. Modeling Objectives

State the purpose of the modeling analysis and the intended use of the modeling outputs. Identify the versions of MIKE21 model and the modules used in the study. This statement should include a discussion of the coastal system at the project site, the potential effects of the design alternatives on the coastal system, and the ability of the MIKE21 model to accurately predict these potential effects that justifies the use of MIKE21 rather than another numerical model. The discussion of the coastal system should include a brief description of the site, including bathymetry, shorelines, inlets, critical structures and any other features. Also, discuss the suitability of using a depth averaged model for the analysis (as opposed to 3D modeling). The discussion should include the role of vertical velocity profiles, vertical density stratification, wind shear and water depth and other features of the system that could create significant 3D flow response.

If a sediment transport module is being used, characterize the sediments, and discuss the role of current and wave forcing. If wave analyses were used, describe how wave forcing was incorporated in the analysis.

If wave module is used, describe the advantages and the capability of the model to simulate and predict the prevailing wave climate. Describe the general wave climate, wind, and waves and storm surges during storm conditions for the area.

If storm profile and shoreline change models are used describe the rationale for their selection. Describe the general feature of the beach profiles and shoreline change trends.

2. Model Data

Describe the model area – the selection of land and open boundaries. Discuss the regional geographic setting that indicates the boundaries of the model domain are far enough from the area of interest to have negligible effects on the model results.

The data used in the analysis should be described, and organized into configuration data, forcing data, and calibration/validation data. For each category of data describe the quality assurance review of the data and state your opinion on its degree of accuracy and completeness. The input and output files shall be submitted in their electronic format suitable to adequately convey the requested information.

Configuration data include

- Bathymetry
- Shoreline
- Bottom friction characteristics
- Structures
- Sediment characteristics

For these configuration data, state the sources of the data, the original projection and vertical datum, the units and all transformations, and merging of the data. Discuss the effects of existing structures in the project area on the coastal littoral system. Discuss the bottom conditions and sediment characteristics and how they establish the bottom friction characteristics. The submitted data should include bathymetric maps of the modeled system that include pre- and post-project conditions with structures and shorelines. The submitted data should also include geotechnical characterization of the sediments from the project area. If the grain sizes are determined from sand samples, identify the locations of the sand samples and the methodology used to determine the grain size distribution. If the grain sizes are derived from empirical formula, then give the details including published references. In either case, plot grain size values on bathymetric contours for representative areas of interest.

Describe the sources of data – their coverage in space and time and how they have been adapted, interpolated or smoothed, if any, for model applications. Often such pre-processing tasks are integral parts of modeling. Indicate the implications of pre-processing on model calibration and predictions. Present any pre-processing results that would enhance the characterization and understanding of the system.

Forcing data include:

- Wave radiation stress data
- Wind data
- Current or flow data
- Offshore Tide (surge) data
- Offshore wave data

For these forcing data, state the sources of the data, the station location, time zone, the recording instruments, the time period covered by the data, and recording frequency, and the units of the data. Describe all transformations, merging and filtering of the data. The submittal should also provide justification for the forcing data that confirms that the data used in the modeling is representative of typical and/or extreme conditions. The submitted data should include comprehensive summaries and statistical analyses of the forcing data used in the modeling.

Calibration data include:

- Flow or velocity
- Water surface elevation data

- Wave data
- Suspended sediment and sediment transport data
- Morphological change data
- Shoreline and beach profile data

For these calibration data, state the sources of the data, the station location, time zone, the recording instruments, the time period covered by the data, and recording frequency, and the units of the data. Describe all transformations, merging and filtering of the data. The submitted data may include either summaries, statistical analyses, or the actual calibration raw data used in the modeling.

Describe any practical constraints that are related to applying the calibration data. The need to have sufficient, representative and reliable measurements from a minimum number of stations to calibrate and validate the numerical models cannot be over emphasized. It will be necessary to show such data have been used in the model calibration and validation process.

3. Model Configuration and Parameter Selection

1. Discuss the selection of all modeling parameters and identify the value(s) chosen.
2. Provide the results of sensitivity analyses of all modeling parameters.
3. Discuss the selection of calibration/validation periods, and application of forcing conditions.
4. Discuss how well the full range of forcing conditions is represented by the calibration/validation periods
5. Describe and discuss the selection of grid resolution. Demonstrate that the grid resolution sufficiently represents critical features in the domain.
6. Discuss the time integration scheme used (first order or higher) and the choice of the maximum and minimum time steps for each module.
7. Describe the application of initial conditions for un-steady flow simulations and the designation of any spin-up periods
8. Describe the application of all forcing and boundary conditions applied
9. Describe the MIKE21 modeling modules used and the selection of associated parameter values. These may include:

    - Flooding and drying
    - Eddy viscosity
    - Bed Friction
    - Wind friction
    - Structure parameterization
    - Grain size formulation (constant or variable)
    - Sediment transport formulation and parameters
    - Sediment porosity
    - Morphological filtering scheme and coefficients
    - Morphological bed slope coefficients
    - Wave energy transfer

- Wave breaking
- Diffraction
- White capping

4. Model Calibration/Validation

- Describe the approach for model calibration – which parameters or forcing data were modified to obtain the calibration
- Describe any adjustments to the grid domain, grid resolution and parameter values and model options made during the calibration process. Clearly state the reasons for the adjustments
- Show graphically or in a table the calibration results and discuss the accuracy of the calibration. Describe the metrics used to evaluate the calibration and validation
- Discuss any implication of the calibration/validation on the model applications
- Revisit and reconfirm the model calibration following any revisions to the model
- Discuss any statistical parameter used in calibrating the model to a level of acceptable comfort margin. Describe the uncertainty of such parameters and its implication in the model performance.

5. Model Applications

<u>Scenario Development</u>
Describe the selection of the time periods, wave and wind ranges. for the application scenarios. For instance, if they are intended to represent worst case or typical conditions, what is the quantitative basis for defining 'worst case' or 'typical'? Discuss how the selected scenarios are relevant for design or environmental effects assessments. Two minimum application cases are often necessary, the first is the 'as is' case – the absence of any engineering intervention; and the second is with the presence of engineering interventions. These cases can be combined with forcing conditions to generate scenarios of interest. If the MIKE21 flow module outputs are being used as input to other modules, for example, for sediment transport, then demonstrate that periods and conditions used represent the proper range of forcing conditions.

Describe any changes to the model configuration to represent future conditions, alternative designs. Include a discussion of any changes to model parameter values obtained in the model validation and the rational for making the changes.

6. Results

The MIKE21 modeling information should be included in a design report and bear the seal and certification of the design engineer registered pursuant to Chapter 471, Florida Statutes.
Provide a written report of the modeling effort and its results, and include all items that were requested to be described or discussed in these guidelines. This report should include figures, maps, or tables capable of presenting the results of the post-project conditions. All

figures, maps and tables should be produced in a scale sufficient to allow an accurate review of the results or submitted in electronic format with sufficient resolution to allow zoom to a suitable scale for detailed examination.
Include a comparative table of all model parameters, the default parameter values and the final values used in the model study. Compute correlation coefficients for all measured data versus computed and comment on the confidence levels for the model calibration.

The results of the modeling should also provide a full discussion of the modeling output and its accuracy. This discussion should include comment on the model stability, the time step used in the modeling, simulation period used, and active grid elements. Any anomalies produced during the modeling should be identified and discussed.

Discuss and interpret the results to show that the model results make hydraulic sense. Describe the uncertainties involved and the implications on model predictions.

All final input data files used to run the model and the output files used to produce the report should be submitted in CDs or DVDs.

7. **Conclusions**

Discuss all assumptions made in the modeling analysis and any limitations they may induce on the results. Provide an overall assessment of the effect of the post-project system and its suitability for the project area.

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APPENDIX

MIKE21 NSW WAVE MODEL

Guidelines for Documenting MIKE21 NSW Model Applications in Submittals to the FDEP Bureau of Beaches and Coastal Systems

This is a listing of information recommended to be provided for studies using the **MIKE21 wave model NSW**. The design professional may chose to omit or deviate from recommendations in these guidelines based upon site or project specific circumstances that affect the scope of the model study effort. The model study report shall identify which of these recommendations are not applicable to the study and the circumstances specific to the study.

1. Modeling Objectives

State the purpose of the modeling analysis and the intended use of the modeling outputs. Identify the version of the wave module NSW used in the study. This statement should include a brief description of the site, including bathymetry, critical structures and any other features. Discuss the suitability of the selected MIKE21 wave model to the project including the role of: wave propagation from offshore, wind generated waves, changing water depths due to tides and surges, wave-current interactions, reflection, diffraction and shoaling. Discuss the suitability of using a steady-state simulation. Describe the suitability of the model version to the application.

2. Model Data

The data used in the analysis should be described, and organized into configuration data, forcing data, and calibration/validation data.

<u>Configuration data includes</u>

- Bathymetry
- Shoreline
- Structures

For these configuration data, state the sources of the data, the original projection and vertical datum, the units and all transformations and merging of the data. Discuss all relevant structures in the project area.
The input and output files shall be submitted in their electronic format suitable to adequately convey the requested information.

<u>Forcing data include</u>:

- Offshore wave data
- Wind data
- Current data
- Tide (surge) data

For these forcing data, state the sources of the data, the station location, time zone, the recording instruments, the time period covered by the data, and the recording frequency and the units of the data. Describe all transformations, merging and filtering of the data.

<u>Calibration data include</u>:

- Wave data

For these calibration data, state the sources of the data, the station location, time zone, the recording instruments, the time period covered by the data, and the recording frequency and the units of the data. Describe all transformations, merging and filtering of the data. The need to have sufficient, representative and reliable measured data from a minimum number of stations to calibrate and validate the numerical models cannot be over-emphasized. It will be necessary to show such data have been used in the model calibration and validation process.

3. Model Configuration and Parameter Selection

1. Discuss the selection of calibration/validation periods, and application of forcing conditions.
2. Discuss how well the full range of forcing conditions is represented by the calibration/validation periods
3. State the model version, any graphical user interface used in applying the model (and its version) and the vendor from which the model was obtained.
4. Describe the model grid domain
5. Describe and discuss the selection of grid resolution. Demonstrate that the grid resolution sufficiently represents critical features in the domain.
6. Describe the location and application of boundary conditions along the entire grid boundary
7. Describe and discuss the selection of MIKE21 implementation and/or parameter values for each of the physics options. These may include:

    - Wind growth option
    - Bottom friction
    - Wave breaking (steepness and depth limited)
    - Wave-Current field interaction

8. Describe the MIKE21 numeric options and associated parameter values, if used. These may include

    - Directional resolution

4. Model Calibration/Validation

- Describe the approach for model calibration – which parameters or forcing data were modified to obtain the calibration
- Describe any adjustments to the grid domain, grid resolution and parameter values and model options made during the calibration process.
- Show graphically or in a table the calibration results and discuss the accuracy of the calibration. Describe the metrics used to evaluate the calibration and validation
- Discuss any implication of the calibration/validation on the model applications

5. Model Applications

Scenario Development

Describe the selection of the time periods, wave and wind ranges. for the application scenarios. For instance, if they are intended to represent worst case conditions, what is the quantitative basis for defining 'worst case'? If the MIKE21 outputs are being used as input to other models, for example, for radiation stress gradient forcing or sediment transport modeling, then demonstrate that periods and conditions used represent the proper range of forcing conditions.

Describe any changes to the model configuration to represent future conditions, alternative designs. Include a discussion of any changes to model parameter values obtained in the model validation and the rational for making the changes.

Results

The MIKE21 NSW modeling information should be included in a design report and bear the seal and certification of the design engineer registered pursuant to Chapter 471, Florida Statutes.

Provide an example of the model results, showing forcing inputs and wave outputs. These examples should demonstrate that the model is functioning as intended and providing reasonable results. Any anomalies should be identified and discussed.

Include in the MIKE21 Flow model results, a comparative table of all MIKE21 NSW wave model parameters, the default parameter values and the final values used in the model study. Compute correlation coefficients for all measured data versus computed and comment on the confidence levels for the model calibration associated with the MIKE21 NSW wave model.

6. Conclusions

Review all assumptions made in the modeling analysis and any limitation they may induce on the results.

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APPENDIX

MIKE21 PMS WAVE MODEL

Guidelines for Documenting MIKE21 PMS Model Applications in Submittals to the FDEP Bureau of Beaches and Coastal Systems

This is a listing of information recommended to be provided for studies using the **MIKE21 wave model PMS**. The design professional may chose to omit or deviate from recommendations in these guidelines based upon site or project specific circumstances that affect the scope of the model study effort. The model study report shall identify which of these recommendations are not applicable to the study and the circumstances specific to the study.

1. Modeling Objectives

State the purpose of the modeling analysis and the intended use of the modeling outputs. Identify the version of the wave module P used in the study. This statement should include a brief description of the site, including bathymetry, critical structures and any other features. Discuss the suitability of the selected MIKE21 wave model to the project including the role of: wave propagation from offshore, wind generated waves, changing water depths due to tides and surges, wave-current interactions, reflection, diffraction and shoaling. Discuss the suitability of using a steady model simulation. Describe the suitability of the model version to the application.

2. Model Data

The data used in the analysis should be described, and organized into configuration data, forcing data, and calibration/validation data.

<u>Configuration data includes</u>

- Bathymetry
- Shoreline
- Structures

For these configuration data, state the sources of the data, the original projection and vertical datum, the units and all transformations and merging of the data. Discuss all relevant structures in the project area.
The input and output files shall be submitted in their electronic format suitable to adequately convey the requested information.

<u>Forcing data include</u>:

- Offshore wave data
- Wind data
- Current data
- Tide (surge) data

For these forcing data, state the sources of the data, the station location, time zone, the recording instruments, the time period covered by the data, and the recording frequency and the units of the data. Describe all transformations, merging and filtering of the data.

<u>Calibration data include</u>:

- Wave data

For these calibration data, state the sources of the data, the station location, time zone, the recording instruments, the time period covered by the data, and the recording frequency and the units of the data. Describe all transformations, merging and filtering of the data. The need to have sufficient, representative and reliable measured data from a minimum number of stations to calibrate and validate the numerical models cannot be over-emphasized. It will be necessary to show such data have been used in the model calibration and validation process.

3. Model Configuration and Parameter Selection

1. Discuss the selection of calibration/validation periods, and application of forcing conditions.
2. Discuss how well the full range of forcing conditions is represented by the calibration/validation periods
3. State the model version, any graphical user interface used in applying the model (and its version) and the vendor from which the model was obtained.
4. Describe the model grid domains, and whether Cartesian or Polar coordinates are used.
5. Describe and discuss the selection of grid resolution. Demonstrate that the grid resolution sufficiently represents critical features in the domain.
6. Describe the location and application of boundary conditions along the entire grid boundary
7. Describe and discuss the selection of MIKE21 implementation and/or parameter values for each of the physics options. These may include:

    - Bottom friction
    - Wave breaking (steepness and depth limited)

8. Describe the MIKE21 numeric options and associated parameter values, if used. These may include

    - Choice of parabolic approximation
    - Filtering coefficient for dissipative interface

4. Model Calibration/Validation

- Describe the approach for model calibration – which parameters or forcing data were modified to obtain the calibration
- Describe any adjustments to the grid domain, grid resolution and parameter values and model options made during the calibration process.
- Show graphically or in a table the calibration results and discuss the accuracy of the calibration. Describe the metrics used to evaluate the calibration and validation
- Discuss any implication of the calibration/validation on the model applications

5. Model Applications

Scenario Development

Describe the selection of the time periods, wave and wind ranges. for the application scenarios. For instance, if they are intended to represent worst case conditions, what is the quantitative basis for defining 'worst case'? If the MIKE21 outputs are being used as input to other models, for example, for radiation stress gradient forcing or sediment transport modeling, then demonstrate that periods and conditions used represent the proper range of forcing conditions.

Describe any changes to the model configuration to represent future conditions, alternative designs. Include a discussion of any changes to model parameter values obtained in the model validation and the rational for making the changes.

Results

The MIKE21 PMS wave modeling information should be included in a design report and bear the seal and certification of the design engineer registered pursuant to Chapter 471, Florida Statutes.

Include in the MIKE21 Flow model results, a comparative table of all MIKE21 PMS wave model parameters, the default parameter values and the final values used in the model study. Compute correlation coefficients for all measured data versus computed and comment on the confidence levels for the model calibration associated with the MIKE21 PMS wave model. Provide an example of the model results, showing forcing inputs and wave outputs. These examples should demonstrate that the model is functioning as intended and providing reasonable results. Any anomalies should be identified and discussed.

6. Conclusions

Review all assumptions made in the modeling analysis and any limitation they may induce on the results.

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APPENDIX

MIKE21 SW WAVE MODEL

Guidelines for Documenting MIKE21 SW Model Applications in Submittals to the FDEP Bureau of Beaches and Coastal Systems

This is a listing of information recommended to be provided for studies using the **MIKE21 wave model SW**. The design professional may chose to omit or deviate from recommendations in these guidelines based upon site or project specific circumstances that affect the scope of the model study effort. The model study report shall identify which of these recommendations are not applicable to the study and the circumstances specific to the study.

1. Modeling Objectives

State the purpose of the modeling analysis and the intended use of the modeling outputs. Identify the version of the wave module SW used in the study. This statement should include a brief description of the site, including bathymetry, critical structures and any other features. Discuss the suitability of the selected MIKE21 wave model to the project including the role of: wave propagation from offshore, wind generated waves, changing water depths due to tides and surges, wave-current interactions, reflection, diffraction and shoaling. Discuss the suitability of using an unsteady model simulation. Describe the suitability of the model version to the application.

2. Model Data

The data used in the analysis should be described, and organized into configuration data, forcing data, and calibration/validation data.

<u>Configuration data includes</u>

- Bathymetry
- Shoreline
- Structures

For these configuration data, state the sources of the data, the original projection and vertical datum, the units and all transformations and merging of the data. Discuss all relevant structures in the project area.
The input and output files shall be submitted in their electronic format suitable to adequately convey the requested information.

<u>Forcing data include</u>:

- Offshore wave data
- Wind data
- Current data
- Tide (surge) data

For these forcing data, state the sources of the data, the station location, time zone, the recording instruments, the time period covered by the data, and the recording frequency and the units of the data. Describe all transformations, merging and filtering of the data.

<u>Calibration data include</u>:

- Wave data

For these calibration data, state the sources of the data, the station location, time zone, the recording instruments, the time period covered by the data, and the recording frequency and the units of the data. Describe all transformations, merging and filtering of the data. The need to have sufficient, representative and reliable measured data from a minimum number of stations to calibrate and validate the numerical models cannot be over-emphasized. It will be necessary to show such data have been used in the model calibration and validation process.

3. Model Configuration and Parameter Selection

1. Discuss the selection of calibration/validation periods, and application of forcing conditions.
2. Discuss how well the full range of forcing conditions is represented by the calibration/validation periods
3. State the model version, any graphical user interface used in applying the model (and its version) and the vendor from which the model was obtained.
4. Describe the model grid domains, and whether Cartesian or Polar coordinates are used.
5. Describe and discuss the selection of grid resolution. Demonstrate that the grid resolution sufficiently represents critical features in the domain.
6. Describe the location and application of boundary conditions along the entire grid boundary
7. Describe the application of initial conditions
8. Describe and discuss the selection of MIKE21 implementation and/or parameter values for each of the physics options. These may include:

    - Wind growth option
    - Bottom friction
    - White capping
    - Wave breaking
    - Wave-wave interactions
    - Structures
    - Wave-Current field interaction

9. Describe the MIKE21 numeric options and associated parameter values, if used. These may include

    - Maximum and Minimum time step if applied
    - Choice of Spectral method or Directionally Decoupled representation
    - Directional and frequency resolution

4. Model Calibration/Validation

- Describe the approach for model calibration – which parameters or forcing data were modified to obtain the calibration
- Describe any adjustments to the grid domain, grid resolution and parameter values and model options made during the calibration process.
- Show graphically or in a table the calibration results and discuss the accuracy of the calibration. Describe the metrics used to evaluate the calibration and validation
- Discuss any implication of the calibration/validation on the model applications

5. Model Applications

<u>Scenario Development</u>
Describe the selection of the time periods, wave and wind ranges. for the application scenarios. For instance, if they are intended to represent worst case conditions, what is the quantitative basis for defining 'worst case'? If the MIKE21 outputs are being used as input to other models, for example, for radiation stress gradient forcing or sediment transport modeling, then demonstrate that periods and conditions used represent the proper range of forcing conditions.

Describe any changes to the model configuration to represent future conditions, alternative designs. Include a discussion of any changes to model parameter values obtained in the model validation and the rational for making the changes.

<u>Results</u>
The MIKE21 SW modeling information should be included in a design report and bear the seal and certification of the design engineer registered pursuant to Chapter 471, Florida Statutes.

Include in the MIKE21 Flow model results, a comparative table of all MIKE21 SW wave model parameters, the default parameter values and the final values used in the model study. Compute correlation coefficients for all measured data versus computed and comment on the confidence levels for the model calibration associated with the MIKE21 SW wave model. Provide an example of the model results, showing forcing inputs and wave outputs. These examples should demonstrate that the model is functioning as intended and providing reasonable results. Any anomalies should be identified and discussed.

6. Conclusions

Review all assumptions made in the modeling analysis and any limitation they may induce on the results.

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APPENDIX
SBEACH

Guidelines for Documenting SBEACH Model Applications in Submittals to the FDEP Bureau of Beaches and Coastal Systems

This is a listing of information recommended to be provided for engineering and design studies using the SBEACH model. The design professional may chose to omit or deviate from recommendations in these guidelines based upon site or project specific circumstances that affect the scope of the model study effort. The model study report should identify which of these recommendations are not applicable to the study and the circumstances specific to the study.

1. Modeling Objectives

State the purpose of the modeling analysis and the intended use of the model outputs. Identify the version of SBEACH model used in the study, including the built-in wave model and describe their major features. Discuss the suitability of SBEACH model compared to other models for the intended use. Discuss any SBEACH model limitations for the intended application.

2. Model Data

The modeling data should include map(s) of the shoreline and bathymetry in the project area with sufficient detail to validate the hypothesis that alongshore sediment transport can be ignored for these SBEACH analyses and still fulfill the purpose of the study. The maps should also identify and locate any existing and proposed structures affecting the project area.

The SBEACH input and output files shall be submitted in their electronic format. Identify and organize data files by their typical file types (extensions) into groups of required files to run the SBEACH model. Also, identify the calibration/validation data files used to calibrate the model for application to the project area. The following is a list of information used to run the SBEACH model.

1. Initial beach profile data
2. Median grain size representative of the surf zone and the beach
3. Time series of storm tide–(storm surge + tide)
4. Time series of wave height & period
5. Values of model parameters, which include grid size, time-step, and transport rate coefficient.
6. Final measured profile data after storm, used for calibration
7. Optional wave direction time series
8. Optional wind speed & direction time series
9. Optional shoreward boundary conditions, such as, seawall location and failure mode.

Describe in detail how the storm surge hydrograph data used to run SBEACH model was determined for the storm severity under consideration (for example, for the high frequency storm return interval of 25 years) for the project area. Also, describe in detail how the representative wave data used was determined for the high frequency storm return period.

For all data above, state the sources of the data, the station location and the time zone, the recording instruments, the time period covered by the data and the recording frequency and the units of the data, as each is applicable. Describe all transformations, merging and filtering of the data. Describe the quality assurance review of the data and include a statement regarding the degree of accuracy of the data.

The need to have sufficient, representative and reliable measured data from a minimum number of stations to calibrate and validate the numerical models cannot be over-emphasized. It will be necessary to show such data have been used in the model calibration and validation process.

3. Model Configuration and Parameter Selection

1. Discuss the selection of calibration/validation parameters and their significance in sediment transport computations across the 4 zones, from the dune to the surf zone and offshore, due to high frequency storm tides and waves.
2. Describe and discuss the selection of profile grid resolution. Demonstrate that the grid resolution sufficiently represents critical features in the beach & offshore profile. Also note the transformation of the original profile coordinate system used in the model.
3. Describe and discuss the selection of the time step and the duration of the simulation time period required for the initial beach profile to reach the state of equilibrium beach profile.

4. Model Calibration/Validation

For the calibration process and the statistical analysis of the accuracy of the calibration of the computed post-storm profile to the measured post- storm profile, the differences in elevations between these two profiles should be weighted by the distances from about the surf zone or the swash zone locations to the locations of the elevations on the profiles. Distances away from the surf zone or the swash zone should be given less weight.

- Describe the approach for model calibration – which parameters or forcing data were modified to obtain the calibration.
- Describe any adjustments to the beach & offshore profile, grid resolution and parameter values and model options made during the calibration process.

- Identify parameters that are significant to sediment transport in the 4 zones and perform sensitivity analysis of these parameters to the changes in the initial beach profile. Provide the results of the sensitivity analysis.
- Show graphically or in a table the calibration results and discuss the accuracy of the calibration. Describe the metrics used to evaluate the calibration and validation.
- Discuss any implication of the calibration/validation on the model applications.
- Revisit and reconfirm the model calibration following any revisions to the model.

5. Model Applications

Describe the forcing conditions (storms, waves, winds, tides) used to compute eroded beach profiles or equilibrium beach profiles for designing beach fill projects or for analysis of alternative shore protection measures. For instance, if they are intended to represent worst case or typical conditions, what is the quantitative basis for defining 'worst case' or 'typical'?

Describe any changes to the model configuration to represent future conditions, alternative designs. Include a discussion of any changes to model parameter values obtained in the model validation and the rational for making the changes.

6. Results

The SBEACH modeling information should be included in a design report and bear the seal and certification of the design engineer registered pursuant to Chapter 471, Florida Statutes.

Provide a written report of the modeling effort and its results, and include all items that were requested to be described or discussed in these guidelines. This report should include figures, maps, or tables capable of presenting the results of the post-project conditions. All figures, maps and tables should be produced in a scale sufficient to allow for clear view and an accurate review of the results.

Include a comparative table of all model parameters, the default parameter values and the final values used in the model study. Compute correlation coefficients for all measured data versus computed and comment on the confidence levels for the model calibration. Include comparative plots of hydrographs used for the calibration versus SBEACH output hydrographs, before and after adjustments, if any. Provide similar plots for the high frequency storm hydrographs.

Provide all other calibration data in tables and graphs where applicable as an appendix in the report. For application data, provide an example of the model results, showing forcing inputs and model outputs in the report. These examples should demonstrate that the model is functioning as intended and providing reasonable results. Any anomalies should be identified and discussed.

The results of the modeling should also provide a full discussion of the modeling output and its accuracy. This discussion should include comment on the model stability, the time step used in the modeling, simulation period used, and active grid elements. Any anomalies produced during the modeling should be identified and discussed.

Provide all calibration input and output data files in ASCII files and/or in CEDAS format in CDs or DVDs, including a file with detailed description of the calibration files.

7. **Conclusions**

Provide a review of all the assumptions made in the modeling analysis and any limitation they may induce on the results. Provide an overall assessment of the model's effectiveness and suitability for the project area.

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