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Memorandum

August 16, 2005

Baird

To: Wendy Leger

From:

Pete Zuzek
W.F. Baird & Associates Coastal Engineers Ltd.

Re: Task 4 – Shore Protection Costs
IJC Contract Number: IJC-5-0003

Task 4 of the above referenced contract between Baird and the IJC requests a review of the shore protection costs utilized in the Flood and Erosion Prediction System (FEPS) for the economic calculations. These costs are utilized for two of the Performance Indicators (PIs): 1) Erosion, and 2) Existing Shore Protection. The two PIs and costs utilized in the FEPS are discussed further below.

Erosion Performance Indicator

In the FEPS, the Erosion PI simulates shoreline recession for the individual 1 km reaches. The cumulative erosion estimate is then used to predict when new shoreline protection structures will be built for the individual developed parcels within that reach (parcels with a home, commercial or industrial building). The variable 'Distance to Protection' is used to determine how much shore erosion will occur in the computer simulation before the riparian constructs shore protection. A standard value of 10.0 m is presently being utilized for this variable.

In the Quarter Month when the distance between the top of bank/shoreline and the lake facing side of the home/building is equal to or less 10.0 m, the algorithm predicts

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the construction of 'new' shore protection. The unit costs per meter are summarized in the County table of the FEPS relational database (Ontario19.mdb). For example, in Monroe County the unit cost for the construction of new protection, at a parcel that has never been armored, is $1,933 per meter. In Jefferson County, where the exposure to storm surges is greater and the crest elevations of the structures must be higher, the unit cost is $2,488 per meter.

Table 1 summarizes the unit cost to construct new shoreline protection for all the Counties and Regional Municipality on Lake Ontario and the Upper St. Lawrence River. Since this is a first time installation (no previous shoreline protected existed), the structure toe is assumed to have an elevation of 74.2 m IGLD'85 (243.3 ft).

Table 1 Unit Costs for the Construction of New Shoreline Protection (Erosion PI)

ShoreUnit	Shore Protection Cost ($/m)	Shore Protection Cost ($/ft)
CayugaCo	2,168	661
DurhamRM	2,012	613
Frontenac	2,432	741
HaltonRM	2,432	741
HamiltonRM	2,432	741
Hastings	2,012	613
JeffersonCo	2,488	759
Leeds	2,134	651
Lennox	2,432	741
MonroeCo	1,933	589
NiagaraCo	1,889	576
NiagaraRM	2,070	631
NorthumberlandRM	2,012	613
OrleansCo	1,889	576
OswegoCo	2,168	661
PeelRM	2,048	624
PrinceEdward	2,012	613
StLawrenceCo	2,134	651
Stormont	2,134	651
Toronto	2,048	624
WayneCo	1,933	589

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Shore Protection Performance Indicator

Parcels that have been protected in the past with a seawall or revetment, fall under the 'Existing Shore Protection' Performance Indicator. The type and quality of each structure on Lake Ontario has been classified for each individual property parcel and is stored in the Parcel table of the relational database. The impacts of water levels for this PI are quantified in terms of future shore protection failures or maintenance requirements. In other words, the economic costs are measured in the amount of capital required to maintain the shoreline in the present position.

Reach 1024 – 778 m of Level 2 Concrete Seawall

Figure 1 summarizes the predicted failure history for all Level 2 seawalls in Reach 1026, which is just west of Cranberry Pond, Edgemere Drive, for the historical net basin supplies and 1958DD. The first failure is an age or degradation failure (~5,000 days on the X-axis). The second failure is due to overtopping (~19,000 days). The third structure failure is also due to wave overtopping, around 28,000 days. Even though the structure never fails due to downcutting, about 0.6 m of downcutting is calculated during the 101 year simulation.

Every time an existing seawall in Reach 1026 fails, the FEPS evaluates the critical site conditions for the redesign, such as lake bed depth and design water level, to design the replacement structure. For example, after the third failure around day 19,000, the lake bed is predicted to be 0.6 m deeper than at the beginning of the simulation. The deeper conditions increase the freeboard water level or design water depth computed by the FEPS, which in turn raises the required crest height for the structure. For an eroding shoreline, the cumulative impact of building multiple structures on the same footprint is an ever increasing cost to provide the same level of protection from erosion and flooding, due to downcutting.

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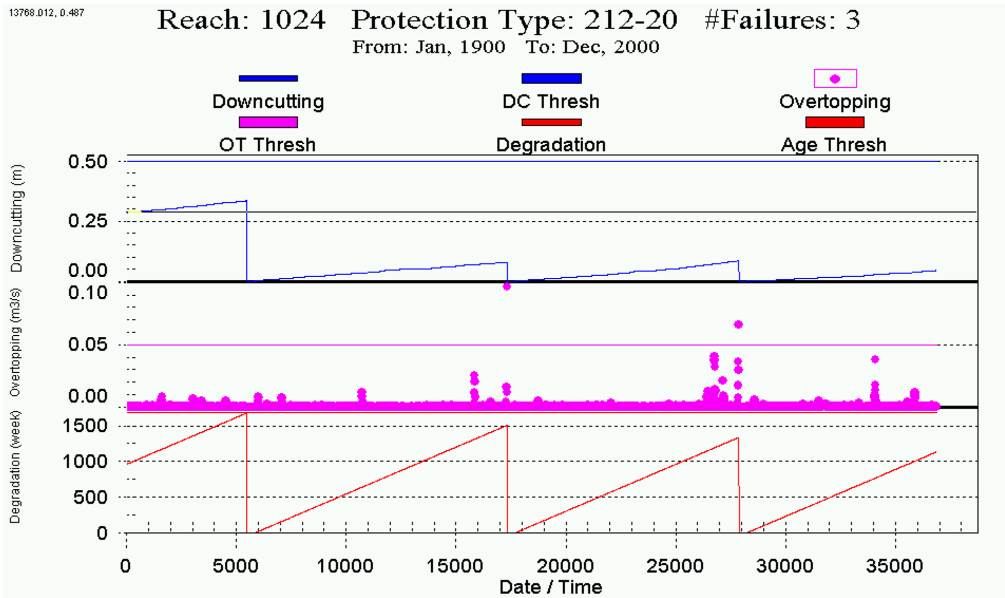

Figure 1 Failure History for Level 2 Seawalls in Reach 1024, Edgemere Drive

Since the unit cost for each new structure built in the FEPS is a separate calculation, there is no summary table in the FEPS relational database. The calculations are done internally in the FEPS. Figure 2 below summarizes the resulting damage

Lake Ontario - St. Lawrence River Economic Calculations

Impact to Existing Shore Protection
Regulation Plan: 1958D with Deviations

Reaches from 1026 to 1026 Start Date: 1900 Jan 01 End Date: 2000 Dec 22
Replacement Buffer: 1 Crest Coefficient: 1.05 Average Age: 20

Region Details				Shore Protection Calculations							
				Failures				Maintenance Cost in $			
Reach Number	Shore Protection Type	Protection Length (m)	Estimated Existing Value($)	Down cutting	Over topping	Age	Sum	Down cutting	Over topping	Age	Total
1026	202-20	190.46	193,513	0	1	2	3	0	296,029	478,242	774,271
1026	212-20	326.02	630,279	0	2	1	3	0	1,767,485	704,692	2,472,176
1026	302-20	31.16	22,240	0	1	2	3	0	34,525	55,375	89,900
Total:		548	846,032	0	4	5	9	0	2,098,039	1,238,308	3,336,347

Figure 2 Summary Table of Damage Calculations for Reach 1026

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calculations. The reach features 190 m of Level 2 Revetment (type 202-20). The '–20' refers to the assumed average age of all existing shoreline protection structures in Lake Ontario at the beginning of the simulation. There are 326 m of Level 2 Vertical Concrete Seawalls (212) and 31 m of Level 2 Ad Hoc protection (302). The Level 2 Vertical Concrete Seawalls are predicted to fail a total of three times during the 101 year simulation with historical supplies and Plan 1958DD. The total cost to repair/rebuild the shore protection three times is $2,472,176, or an average of $824,059 per event. When converted to a value per linear measurement, the average shore protection cost is $2,528 per meter or $771 per foot. It is important to note that these unit costs are for the construction of Level 2 protection to replace existing Level 2 protection.

Reach 1043 – 36.76 m of Level 2 Seawall

A second example of failure history and unit cost for shore protection is provided for a Level 2 seawall in Reach 1043, which is located at Payne Beach, west of Edgemere Drive. This reach features a higher Average Annual Recession Rates (AARR) than the previous example (0.79 m/yr versus 0.37 m/yr). The higher AARR results in more lake bed downcutting during simulation time and consequently higher unit costs to rebuild since the toe gets deeper and the freeboard is greater for every re-build.

The simulation predicts the Level 2 Concrete Seawall will failure three times for the historical net basin supplies and 1958DD. The types and sequence of failures are identical to Reach 1026 (one age failure followed by two overtopping failures). Refer to Figure 3 below.

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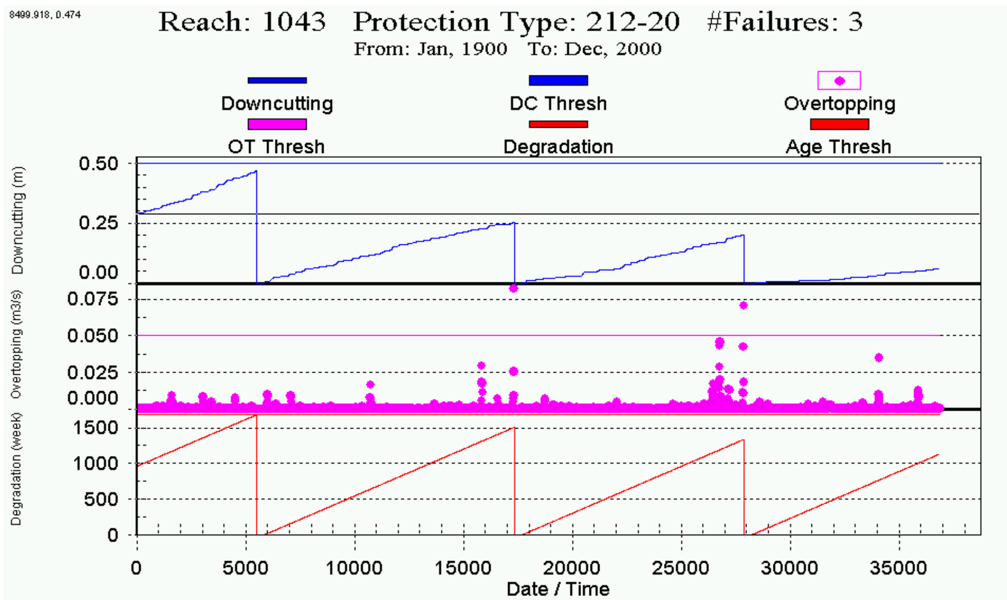

Figure 3 Failure History for Level 2 Seawalls in Reach 1043, Payne Beach

There are 36.76 m of Level 2 seawall in Reach 1043. Refer to Figure 4. The estimated existing value is $71,066, although this information is not used in the

Lake Ontario - St. Lawrence River Economic Calculations

Impact to Existing Shore Protection
Regulation Plan: 1958D with Deviations

Reaches from 1043 to 1043 — Start Date: 1900 Jan 01 — End Date: 2000 Dec 22
Replacement Buffer: 1 — Crest Coefficient: 1.05 — Average Age: 20

Region Details				Shore Protection Calculations							
				Failures				Maintenance Cost in $			
Reach Number	Shore Protection Type	Protection Length (m)	Estimated Existing Value($)	Down cutting	Over topping	Age	Sum	Down cutting	Over topping	Age	Total
1043	201-20	756.65	1,054,489	0	0	1	1	0	0	1,829,321	1,829,321
1043	202-20	92.72	94,206	0	1	2	3	0	197,973	287,709	485,682
1043	212-20	36.76	71,066	0	2	1	3	0	263,154	90,490	353,644
1043	302-20	22.49	16,052	2	1	1	4	44,953	34,608	33,579	113,140
1043	202+74	26.60	27,026	0	1	0	1	0	28,688	0	28,688
1043	202+97	51.04	51,858	0	0	0	0	0	0	0	0
Total:		986	1,314,699	2	5	5	12	44,953	524,423	2,241,099	2,810,475

Figure 4 Summary Table of Damage Calculations for Reach 1026

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calculation. The predicted maintenance cost by the algorithm is $353,644. This converts to an average of $117,881 per repair, or $3,207 per meter. Translated to feet, the unit cost for the maintenance is $977 per foot. It is worth noting that this cost is considerably higher than the $1,933 per meter utilized by the Erosion PI for Monroe County (for first time structures).

Calculating Unit Costs for Shoreline Protection Maintenance/Replacement

The following section of the memorandum provides specific details on the methodology for estimating the cost of replacement shore protection for the Existing Shore Protection PI. As discussed earlier, there is no summary table in the FEPS relational database since each calculation is dynamic and based on the local site conditions. For a complete description, refer to the report entitled "Shore Protection Performance Indicator: Methodology and Shared Vision Model Application, February 2004", which can be found on the study FTP site at:

**ftp>ijcstudy/coastal/reports/FEPS PI Methods Reports/
ShoreProtectionPI MethodsReport.pdf**

It should be recognized that downcutting of the lakebed is the primary mechanism for increasing the design wave height, and thus increasing the structure size and cost based on standard coastal engineering design procedures. For this reason, the unit cost for the shore protection is calculated based upon the cumulative downcutting that has occurred up to the date of the simulation time step. The following formula is used in the FEPS to calculate unit costs:

$$UnitCost = CM \times DWD^{CE}$$

Where:

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UnitCost represents the cost of replacing a structure in $/m.

CM represents a cost multiplier, sourced from the Shore Protection database.

CE represents a cost exponent, sourced from the Shore Protection database. This exponent reflects the sensitivity of the design to increases in water depth.

DWD represents the design water depth; $DWD = DWL + \sum DC$

Where:

DWL represents the design water level in meters, above chart datum, for the Level 1 and 2 structures, as sourced from the Counties database.

$\sum DC$ represents the sum of the downcutting in meters, since the start of the simulation (calculated by the FEPS for each 1 km shoreline reach).

The County and Shore Protection databases are provided in Appendix A for reference. The above mentioned columns are highlighted in yellow for reference.

A series of manual calculations have been completed for Monroe County to estimate replacement costs for three structures types: Level 1 and 2 Steel Sheet Pile Wall, Level 1 and 2 Concrete Wall, and Level 1 and 2 Revetment. The calculations were completed for 0.0, 0.3, 0.6 and 0.9 m of lake bed downcutting to demonstrate the influence of increasing design water depth for each successive reconstruction. Refer to the Table on Cost Calculations in Appendix A for additional details. For example, the current costs for a Level 1 Steel Sheet Pile Wall, assuming a lake bed depth of 74.2 m at the base of the structure, is $2,452 per meter ($748 per foot). If the structure is reconstructed in the future following 0.3 m of lake bed downcutting, the unit cost increases to $2,999 per meter ($914 per foot).

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Figure 5 provides a visual summary of the unit costs for the reconstruction of a Level 1 and 2 Steel Sheet Pile Wall in Monroe County for different estimates of future lake bed downcutting.

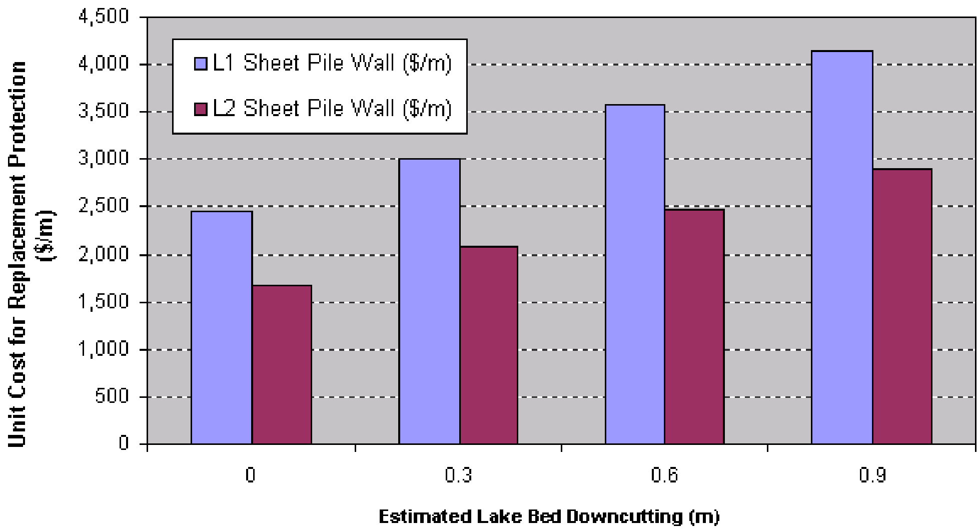

Figure 5 Replacement Costs for a Steel Sheet Pile Wall in Monroe County for Different Future Lake Bed Downcutting Estimates

Summary

The following bullet points summarize the unit costs applied in the FEPS for the construction of new shore protection (Erosion PI) and the maintenance of existing shoreline protection (Shore Protection PI):

- The County table in the FEPS relational database provides unit costs ($/m) for the construction of new shoreline protection on previously unprotected parcels for the Erosion PI. Also summarized in Table 1;

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- The unit costs for the Existing Shoreline Protection PI are not fixed and therefore not stored in the FEPS relational database. Rather, the calculations are completed for each type of shore protection in every reach around the perimeter of Lake Ontario throughout the simulation. The unit costs will increase for each subsequent replacement/maintenance event at the parcel due to the influence of lake bed downcutting;
- In the two examples presented above for Monroe County, the average replacement costs for a Level 2 Vertical Seawall ranged from $2,528 to $3,207 per meter or $771 to $977 per foot. These values compare relatively well to a recently constructed vertical seawall along Edgemere Drive, reported to be of high quality (it may be a Level 1, but the author has no pictures or data on engineering), which had a unit cost of $979 per foot;
- The construction costs to replace the existing Vertical Seawall in Reach 1206 were 31% higher than the unit cost in the County table ($1,933 per meter). In Reach 1243, where downcutting plays a larger role in the future maintenance expenses, the average replacement cost per meter is 66% greater than the values in the County table for the Erosion PI (for new shore protection);
- When a structure failure or maintenance event is predicted with the FEPS algorithm, no credit is given to the previous construction materials. For example, if a rubble mound structure such as a revetment fails, the displaced armor stones can often be re-used in the newly constructed replacement structure. However, in the present FEPS algorithm, there is no value assigned to the existing armor stone in the calculation and consequently no reduction in the replacement costs. This likely over-estimates the true replacement costs for structures when material can be salvaged; and
- A systematic defensible methodology was developed to calculate the cost of replacement shore protection in the FEPS to account for individual structure

types (seawalls versus revetments), quality (Level 1 versus Level 2), and geographic variables, such as County level storm surge data and the associated design water levels.

If you have any questions or comments, please don't hesitate to contact me personally by phone or e-mail.

enc: n/a

File No. 10389.10

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APPENDIX A

FEPS RELATIONAL DATABASE TABLES AND COST CALCULATION DETAILS FOR REPLACEMENT SHORE PROTECTION

COUNTY DATABASE TABLE

ShoreUnit	TruckedSand	FrontYard	BuildingEnvelop	ShoreProtectionCost	DWLmCD_Class1	DWLmCD_Class2	TwoYr_Surge_m	Hs_Max_Surge
CayugaCo	33.26	5	10	2168	1.79	1.67	0.22	3.00
DurhamRM	15.68	5	10	2012	1.73	1.61	0.15	2.30
Frontenac	13.64	5	10	2432	1.89	1.77	0.29	2.90
HaltonRM	26.57	5	10	2432	1.89	1.77	0.31	1.60
HamiltonRM	42.45	5	10	2432	1.89	1.77	0.21	1.60
Hastings	23.63	5	10	2012	1.73	1.61	0.00	-9975.00
JeffersonCo	52.95	5	10	2488	1.91	1.79	0.30	3.70
Leeds	20.00	5	10	2134	-999.90	-999.90	0.00	-9975.00
Lennox	25.59	5	10	2432	1.89	1.77	0.29	2.90
MonroeCo	45.12	5	10	1933	1.70	1.58	0.13	2.60
NiagaraCo	41.71	5	10	1889	1.68	1.56	0.12	2.00
NiagaraRM	33.48	5	10	2070	1.75	1.63	0.16	2.00
NorthumberlandRM	28.87	5	10	2012	1.73	1.61	0.15	2.30
OrleansCo	36.27	5	10	1889	1.68	1.56	0.12	2.00
OswegoCo	48.50	5	10	2168	1.79	1.67	0.22	3.00
PeelRM	35.08	5	10	2048	1.74	1.62	0.18	2.40
PrinceEdward	26.55	5	10	2012	1.73	1.61	0.15	2.30
StLawrenceCo	20.00	5	10	2134	-999.90	-999.90	0.00	-9975.00
Stormont	20.00	5	10	2134	-999.90	-999.90	0.00	-9975.00
Toronto	24.09	5	10	2048	1.74	1.62	0.18	2.40
WayneCo	29.65	5	10	1933	1.70	1.58	0.13	2.60

SHORE PROTECTION DATABASE TABLE

ProtectionType	Description	IsUsed	ClassType	UndemineFail_M	CostMultiplierCAD	CostExponentWLmCD	AgeThreshYrs	OT_thresh_m3ps	IsVertivalWall
0	Second row parcel has no protection	0	0	-999.90	-999.90	-999.90	0	0	0
201	Revetment Class 1 (well engineered well maintained - will last over 50 year window)	1	1	0.75	454.71	2.12	75	0.200000003	0
202	Revetment Class 2 (moderately engineered)	1	2	0.50	388.77	2.11	35	0.050000001	0
203	Revetment Class 3 (poorly constructed poorly maintained)	0	3	-999.90	-999.90	-999.90	-999	-999.9000244	0
211	Seawalls\Bulkheads concrete	1	1	0.75	1030.30	2.00	75	0.200000003	1
212	Seawalls\Bulkheads concrete	1	2	0.50	776.38	2.00	35	0.050000001	1
213	Seawalls\Bulkheads concrete	0	3	-999.90	-999.90	-999.90	-999	-999.9000244	0
221	Groins	0	1	-999.90	-999.90	-999.90	75	-999.9000244	0
222	Groins	0	2	-999.90	-999.90	-999.90	35	-999.9000244	0
223	Groins	0	3	-999.90	-999.90	-999.90	-999	-999.9000244	0
231	Jetties	0	1	-999.90	-999.90	-999.90	75	-999.9000244	0
232	Jetties	0	2	-999.90	-999.90	-999.90	35	-999.9000244	0
233	Jetties	0	3	-999.90	-999.90	-999.90	-999	-999.9000244	0
241	Offshore\Marina Breakwaters	0	1	-999.90	-999.90	-999.90	75	-999.9000244	0
242	Offshore\Marina Breakwaters	0	2	-999.90	-999.90	-999.90	35	-999.9000244	0
243	Offshore\Marina Breakwaters	0	3	-999.90	-999.90	-999.90	-999	-999.9000244	0
251	Artificial\Constructed\Perched Beaches	0	1	-999.90	-999.90	-999.90	75	-999.9000244	0
252	Artificial\Constructed\Perched Beaches	0	2	-999.90	-999.90	-999.90	35	-999.9000244	0
253	Artificial\Constructed\Perched Beaches	0	3	-999.90	-999.90	-999.90	-999	-999.9000244	0
261	Beach Nourishment	0	1	-999.90	-999.90	-999.90	75	-999.9000244	0
262	Beach Nourishment	0	2	-999.90	-999.90	-999.90	35	-999.9000244	0
263	Beach Nourishment	0	3	-999.90	-999.90	-999.90	-999	-999.9000244	0
271	Vegetation Planting\Bioengineering	0	1	-999.90	-999.90	-999.90	75	-999.9000244	0
272	Vegetation Planting\Bioengineering	0	2	-999.90	-999.90	-999.90	35	-999.9000244	0
273	Vegetation Planting\Bioengineering	0	3	-999.90	-999.90	-999.90	-999	-999.9000244	0
281	Slope Grading\Bluff Stabilization	0	1	-999.90	-999.90	-999.90	75	-999.9000244	0
282	Slope Grading\Bluff Stabilization	0	2	-999.90	-999.90	-999.90	35	-999.9000244	0
283	Slope Grading\Bluff Stabilization	0	3	-999.90	-999.90	-999.90	-999	-999.9000244	0
291	Protected Wetlands	0	1	-999.90	-999.90	-999.90	75	-999.9000244	0
292	Protected Wetlands	0	2	-999.90	-999.90	-999.90	35	-999.9000244	0
293	Protected Wetlands	0	3	-999.90	-999.90	-999.90	-999	-999.9000244	0
301	Ad Hoc Concrete Rubble\Rip Rap similar to Level 2 revetment but without engineering. Will	1	1	0.50	338.34	2.18	75	0.200000003	0
302	Ad Hoc Concrete Rubble\Rip Rap	1	2	0.25	264.21	2.18	35	0.050000001	0
303	Ad Hoc Concrete Rubble\Rip Rap	0	3	-999.90	-999.90	-999.90	-999	-999.9000244	0
311	Ad Hoc Other Materials likely will not occur	0	1	-999.90	-999.90	-999.90	75	-999.9000244	0
312	Ad Hoc Other Materials	1	2	0.25	264.21	2.18	35	0.050000001	0
313	Ad Hoc Other Materials	0	3	-999.90	-999.90	-999.90	-999	-999.9000244	0
321	Boat Docks Private	0	1	-999.90	-999.90	-999.90	75	-999.9000244	0
322	Boat Docks Private	0	2	-999.90	-999.90	-999.90	35	-999.9000244	0
323	Boat Docks Private	0	3	-999.90	-999.90	-999.90	-999	-999.9000244	0
331	Boat Docks Marina	0	1	-999.90	-999.90	-999.90	75	-999.9000244	0
332	Boat Docks Marina	0	2	-999.90	-999.90	-999.90	35	-999.9000244	0
333	Boat Docks Marina	0	3	-999.90	-999.90	-999.90	-999	-999.9000244	0
341	Commercial\Industrial Docks/Piers/Wharves	0	1	-999.90	-999.90	-999.90	75	-999.9000244	0
342	Commercial\Industrial Docks/Piers/Wharves	0	2	-999.90	-999.90	-999.90	35	-999.9000244	0
343	Commercial\Industrial Docks/Piers/Wharves	0	3	-999.90	-999.90	-999.90	-999	-999.9000244	0
351	Boat Launch Ramp Docks Private/Public	0	1	-999.90	-999.90	-999.90	75	-999.9000244	0
352	Boat Launch Ramp Docks Private/Public	0	2	-999.90	-999.90	-999.90	35	-999.9000244	0
353	Boat Launch Ramp Docks Private/Public	0	3	-999.90	-999.90	-999.90	-999	-999.9000244	0
361	Boat Launch Ramps	0	1	-999.90	-999.90	-999.90	75	-999.9000244	0
362	Boat Launch Ramps	0	2	-999.90	-999.90	-999.90	35	-999.9000244	0
363	Boat Launch Ramps	0	3	-999.90	-999.90	-999.90	-999	-999.9000244	0
371	Seawalls\Bulkheads steel sheet pile	1	1	0.75	1269.90	1.24	75	0.200000003	1
372	Seawalls\Bulkheads steel sheet pile	1	2	0.50	966.07	1.21	35	0.050000001	1
373	Seawalls\Bulkheads steel sheet pile	0	3	-999.90	-999.90	-999.90	-999	-999.9000244	0
381	Seawalls\Bulkheads stacked armor stone/concrete blocks	1	1	0.75	815.78	2.02	75	0.200000003	1
382	Seawalls\Bulkheads stacked armor stone/concrete blocks	1	2	0.50	657.03	2.02	35	0.050000001	1
383	Seawalls\Bulkheads stacked armor stone/concrete blocks	0	3	-999.90	-999.90	-999.90	-999	-999.9000244	0
400	No Shore Protection	0	0	-999.90	-999.90	-999.90	-999	-999.9000244	0

FEPS Shore Protection PI - Cost Calculations

County	Level 1 DWL	Level 2 DWL
Monroe	1.7	1.58

Quality of Protection	Level 1	Level 2	Level 1	Level 2	Level 1	Level 2
Type of Protection	Sheet Pile Wall	Sheet Pile Wall	Concrete Wall	Concrete Wall	Revetment	Revetment
Cost Multiplier (CM)	1269.90	966.07	1030.30	776.38	454.71	388.77
Cost Exponent (CE)	1.24	1.21	2.00	2.00	2.12	2.11

Cost Equation for Shore Protection
Unit Cost = CM * DWD^{CE}
DWD = Design Water Depth (DWL + DC)
DWL = Design Water Level (from County Database)
DC = cumulative downcutting during simulation

Description of Shore Protection Quality
Level 1 (L1) - Well engineered and maintained, design life of 75 years
Level 2 (L2) - Moderately engineered and not maintained, design life will not exceeding 35 years

Comments on Structure Crest and Toe Elevations
1. At start of simulation, toe depth assumed to be 74.2 m (243.3 ft)
2. In Monroe County, Level 1 Crest Height is 77.2 m (253.2 ft)
3. In Monroe County, Level 2 Structure Crest Height is 76.1 m (250.6 ft)
4. As downcutting increases through the simulation, Design Water Depth increases, which in turn increases the replacement cost for shore protection structures. See table below:

Monroe County Unit Costs for Shore Protection Maintenance (during simulation time)

Type, Quality and Estimated Cost for Shore Protection Based on Downcutting				
Type and Quality of Shore Protection	**Modeled Downcutting (m) with FEPS**			
	0	**0.3**	**0.6**	**0.9**
L1 Sheet Pile Wall ($/m)	$2,452	$2,999	$3,567	$4,153
L1 Sheet Pile Wall ($/ft)	$748	$914	$1,088	$1,266
L2 Sheet Pile Wall ($/m)	$1,680	$2,074	$2,481	$2,899
L2 Sheet Pile Wall ($/ft)	$512	$632	$756	$884
L1 Concrete Wall ($/m)	$2,978	$4,121	$5,450	$6,965
L1 Concrete Wall ($/ft)	$908	$1,256	$1,662	$2,123
L2 Concrete Wall ($/m)	$1,938	$2,744	$3,690	$4,775
L2 Concrete Wall ($/ft)	$591	$837	$1,125	$1,456
L1 Revetment ($/m)	$1,401	$1,977	$2,658	$3,447
L1 Revetment ($/ft)	$427	$603	$810	$1,051
L2 Revetment ($/m)	$1,021	$1,473	$2,013	$2,642
L2 Revetment ($/ft)	$311	$449	$614	$806