APPENDIX H – HABITAT EQUIVALENCY ANALYSIS OCTOBER 2002

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HEA APPROACH FOR CALCULATING BROWARD COUNTY NEARSHORE MITIGATION AMOUNT

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With many contributions by others for parameter formulation

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ABSTRACT

The proposed Broward County shore protection project will cover 10.1 areas of relatively low surface relief nearshore hardground. Mitigation in the form of boulders has been proposed by Broward County. An HEA analysis is conducted here to determine the area of mitigation that is needed as compensation. Corals larger than approximately 15 cm diameter are to be transplanted to the mitigation in order to speed recovery of ecological services. The HEA analysis indicates that 11.81 acres of mitigation are needed when corals 15 cm in diameter or greater are transplanted from the ETOF to the mitigation.

1 Introduction

The current plan for the shore protection project of Broward County involves the covering of a gross amount of up to 13.6 acres of sand and nearshore hardground by renourished sand. The actual net amount of hardbottom to be covered is 10.1 acres. Chris Creed of Olsen Associates Inc. provides the areas of gross and net injury impact below.

Estimated Nearshore Hardbottom Impacts (acres)
Broward County Shore Protection Project

	Plan-View Acres	Plan-View Acres
	Gross	**Net**
Segment II	6	2.5
John U. Lloyd	5	5
Hollywood/Hallandale	1.5	1.5
Segment III (Worm Rock)	1.1	1.1
Total Impacts	**13.6**	**10.1**

Broward County has proposed to provide acres of mitigation in the form of limestone boulders in order to compensate for the loss of the net 10.1 nearshore acres. NMFS in its consultation review has questioned if this mitigation amount adequately compensates for the time factor of loss of the services of the nearshore hardbottom. NMFS has suggested using habitat equivalency analysis (HEA) in order to better determine the amount of mitigation required.

This white paper presents the HEA approach to determine what should be provided as a compensatory area of mitigation for the loss of 10.1 net acres of nearshore hardground. A number of conservative assumptions have been made concerning natural recovery of the nearshore hardground, and recovery of the mitigation boulders (assisted by transplanted corals).

2 Methods

2.1 HEA General

The HEA approach is particularly well suited for analysis of compensatory restoration because it can be used to quantify the time factor of loss and recovery of resources. An injury to natural resources involves a time component during which the ecological services that the resources provide are lost. The injury therefore must be quantified not only by the area of the injury but also by the amount of time over which the services are unavailable. The HEA allows calculation of a compensatory restoration amount which can provide back those lost services over time. The HEA approach requires as input the amount of injured area, the recovery time for the injury, and the time over which the mitigation area will reach full ecological services. It also requires a discount rate. With these inputs, the HEA provides the amount of compensatory mitigation area that is required to match the lost services of the injury.

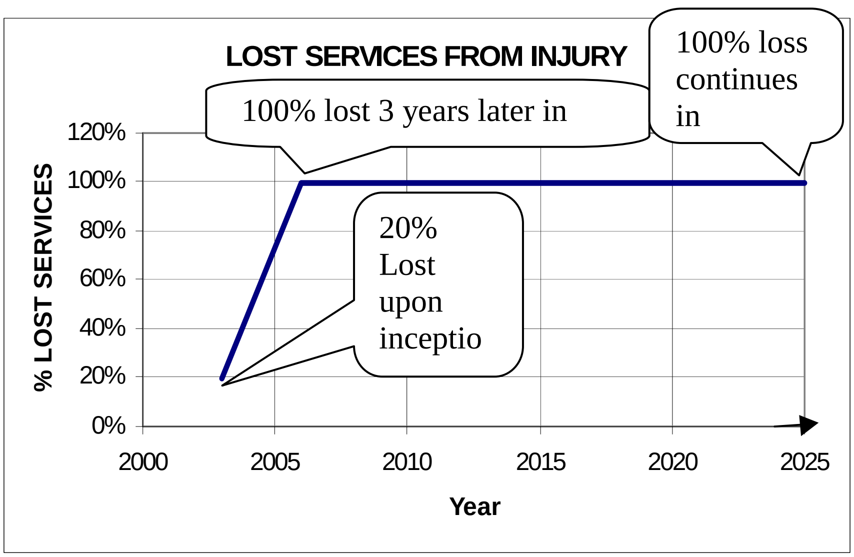
"Natural resources can be viewed as natural assets that provide services throughout their lifetime. A fundamental principle of asset valuation is that the total value of an asset is equal to the present discounted value of the future stream of all service flows from the natural resource. … It follows that the value of a natural resources is the present discounted value of the future stream of all the service flows from the natural resource." (NOAA 1997). This concept of discounting is explained by an individual's time preference for goods and services. Discounting takes into account that the further into the future that a service is provided, the less it is valued today. For example, given a choice between receiving $1,000 today or receiving it one year from now, most would prefer to have the money immediately. This is because one can invest $952.38 at 5% in a savings account for a year and receive $1,000. Hence, with discounting, the choice between $1,000 today and $1,000 a year from now can be reinterpreted as a choice between $1,000 today and the equivalent of $952.38. NOAA recommends the use of a 3% discount rate which is the long-term historical average (NOAA, 1997). Use of discounting allows formulaic calculation of compensatory areas given specified recovery times.

2.2 Assumptions

In order to complete the HEA, reasonable assumptions have been made about the relative recovery rates of the 10.1 nearshore hardground acres and the mitigation boulders, the discount rate of 3%, and the start times and amounts of lost and full services of the injury and mitigation.

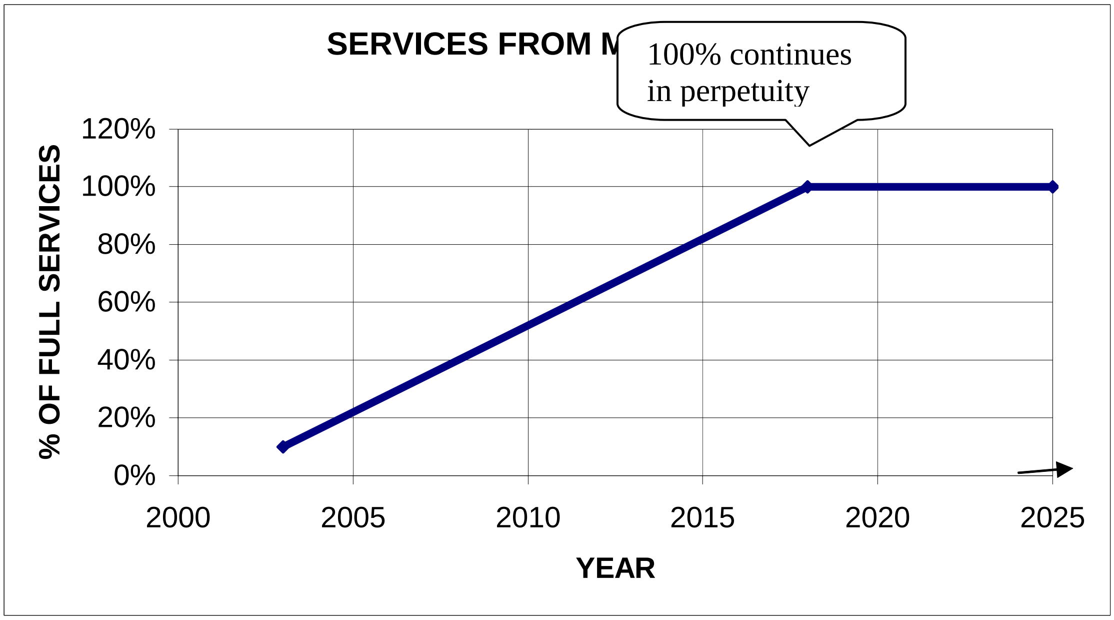
The nearshore injury is assumed to begin in 2003 and the mitigation to also begin at the same time in 2003. The discount rate is assumed to be the long-term historical average of 3%.

It is assumed that the 10.1 acres of nearshore hardbottom, once covered by the renourished sand, are never uncovered.



Therefore, the injury will be permanent. It is also assumed that the injury will not occur to the 10.1 acres instantly, but over a three-year period. It is assumed that 20% of the 10.1 acres will initially be lost with the remaining 80% lost in a linear fashion over 3 years which will continue into perpetuity. The chart above illustrates the injury assumptions.

It is also assumed that while the mitigation boulders will recover to 100% full services in 50 years naturally, they will recover to those 100% full services in less time, 15 years, for by transplanting corals onto them. By way of explanation: while most flora and fauna will recovery quickly, probably within less than 8 to 10 years, the reef building coral fauna is the slowest growing component and will take a longer time. In order to speed recovery, reef-building corals of an estimated 15 years in age or greater will be transplanted to the mitigation boulders. The corals will come from the potentially impacted hardground prior to construction. This effectively will make the recovery rate of the mitigation boulders to be 15 years with transplantation instead of 50 years without. By way of further explanation, the mitigation boulders upon inception can be assumed to take 50 years to recover based on the fact that the oldest element of the most important part of the ecosystem is about 50 years old. The non-coral component comes back in much less time, probably about 8-10 years. So it is the coral component that is driving the long recovery time of 50 years. Transplantation kickstarts the mitigation recovery by transplanting corals 15 years of age and greater. Hence, the mitigation will only take 15 years to recover.



By transplanting corals, the mitigation boulders will begin recovery not at 0% of full services, but at some higher value. Hence, by transplanting corals 15 years old and greater, we might consider that we have kickstarted the recovery by 70% (35 years divided by 50 years). However, others feel that the stony coral component is small in terms of coverage and that this should be taken into account. We approximate that the mitigation boulders, upon receiving the transplanted corals, will therefore have 10% of full services. This is a negotiated figure. It is agreed that it will take 15 years to reach 100% full services. A linear increase from 10% to 100% over the 15 years is assumed. The mitigation will continue at 100% full services in perpetuity. The chart above illustrates this.

2.2.1 Number of corals to be transplanted

The following provides information on number of corals that will be required to be transplanted.

Cheryl Miller of CPE has data on coral density (number of corals per square meter) within the 10.1 acres in the ETOF using a sample size of 260 m2. Using her total coral density times the net area of impact gives the number of corals potentially affected.

This is listed by coral species and by total coral below.

Stony coral species	Ave # corals / m2 inside ETOF 10.1 acres	Total # corals to be killed in 10.1 acres
Siderastrea radians	0.4650	19,007
Porites porites	0.0662	2,706
Diploria clivosa	0.0190	777
Solenastrea bournoni	0.0146	597
Colpophyllia natans	0.0071	290
Favia fragum	0.0063	258
Dichocoenia stokesii	0.0063	258
Montastrea cavernosa	0.0060	245
Porites astreoides	0.0048	196
Meadrina meandrites	0.0032	131
Cladocora arbuscula	0.0032	131
Solenastrea hyades	0.0032	131
Total Corals	**0.6049**	**24,725**

In order to find out number of corals that would be impacted at various size categories, we used coral diameter size-frequency data (Gilliam et al., 2001) we obtained from a sample size of 210 m2 from 7 of our nearby First Reef monitoring stations.

The size frequency distribution is:

Coral Diameter (cm)	% number of corals > Indicated Diameter
8	12.30%
10	10.88%
12	7.73%
15	4.73%
25	2.52%
35	1.10%
50	0.16%
65	0.00%

Given a total of 24,725 corals and multiplying the total times the various percentages gives the number of corals in each size class.

Diameter (cm)	# corals > Diameter
8	3,042
10	2,691
12	1,911
15	**1,170**
25	624
35	273
50	39
65	0

Thus, there are approximately 2,691 corals that are greater than 10 cm diameter, **1,170 corals greater than 15 cm diameter**, and 624 corals greater than 25 cm diameter within the 10.1 net acres of impact.

An alternative estimation method can be obtained from data from Cheryl Miller of CPE who found 12 corals of diameter greater than 15 cm within a sample of 260 m2 of nearshore hardground. Scaling this number up to 10.1 acres (40,875 m2) gives an estimate of **1,887 corals of 15 cm diameter or greater**.

2.2.2 Approximate Age of a 15 cm diameter coral

Species	RADIAL Growth rate (cm)	15 year theoretical RADIUS size (cm)	DIAMETER	Life history pattern
Siderastrea radians	0.43	6.45	12.9	A
Porites porites	1.79	26.85	53.7	A
Porites astreoides	1.76	26.4	52.8	A
*Cladocora arbuscula**	5.35	80.25	160.5	A
Favia fragum	0.4	6	12	A
Diploria clivosa	1.73	25.95	51.9	B
Montastraea cavernosa	0.44	6.6	13.2	B
Colpophyllia natans	ND			
Solenastrea hyades	ND			B
Solenastrea bournoni	0.89	13.3	26.6	B
Meandrina meandrites	ND			B
Dichocoenia stokesii	0.67	10.05	20.1	B

(Walt Jaap kindly provided the base information for the above table)

The table above shows massive corals including those species commonly expected to be found and transplanted in this area (e.g., *P. astreoides, D. clivosa, M. cavernosa, S. bournoni, D. stokesii*) have a radial or vertical growth rate of between .4 to .79 cm/yr. While lateral growth is typically faster, an approximation to the plan-view diameter growth rate is double the radial growth rate which equals 0.8 cm to 1.6 cm/yr. Taking a conservative average of 1 cm/yr diameter growth rate, this means a 15 cm diameter coral is approximately 15 years old.

2.2.3 HEA Requirements Summary

In summary, in order to complete the HEA analysis, several variables must be assigned values. These values are based on assumptions regarding ecological processes and habitat functionality at both impact and mitigation sites and include:

- The interval of recovery of each habitat, and form of the recovery function (e.g., linear, exponential, hyperbolic, etc.), must be assigned.
- The relative loss and full services amount of each habitat must be known.
- The interval between impact and restoration/mitigation must be known.

For the nearshore relief hardgrounds, the following assumptions and corresponding values were used:

(1) Renourishment would leave the nearshore habitat with 20% of lost services immediately upon the start of the project and 100% after three years value with a linear gradation between.
(2) Placement of mitigation substrate in the mitigation area will begin at the inception of the injury with 10% of full habitat function,
(3) Habitat value in the impact area will not recover,
(4) Habitat value in the mitigation areas would increase in a linear fashion until 100% complete recovery in 15 years assuming transplantation of corals 15 years,
(5) The mitigation areas will reach full (i.e., 100%) functionality which will continue in perpetuity,
(6) Project impacts and implementation of mitigation occur simultaneously.

3 HEA Calculation Results

Calculating the HEA with an input of 10.1 injured acres and that it is mitigated by appropriate habitat with coral transplants of 15 years old and greater gives a mitigation requirement for 11.81 acres. The table in Appendix A details the results of the HEA.

4 Appendix A Habitat Equivalency Analysis Assuming Transplantation

Habitat Equivalency Analysis

Date: 10-04-2002
File: rug24.txt

Area unit: ACRE
Time period: Year
Service unit: ACRE-Year

Affected area units: 10.1
Discount rate per time period: .03
Present time period: 2003

Lost Services

Time		-------(Service Units)--------	
Period	(Percent)	Current Value	Present Value
2003	20.00	2.02	2.02
2004	46.67	4.71	4.58
2005	73.33	7.41	6.98
2006	100.00	10.10	9.24
Beyond			308.10
Total			330.92

Relative Productivity

Time Period	----------(Percent)----------- Current Value	Present Value
2003	10.00	10.00
2004	16.00	15.53
2005	22.00	20.74
2006	28.00	25.62
2007	34.00	30.21
2008	40.00	34.50
2009	46.00	38.52
2010	52.00	42.28
2011	58.00	45.79
2012	64.00	49.05
2013	70.00	52.09
2014	76.00	54.90
2015	82.00	57.51
2016	88.00	59.92
2017	94.00	62.15
2018	100.00	64.19
Beyond		2139.54
Total		2802.55

Compensatory restoration area units: 11.81

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