Grand Cayman CBF
Addendum to the Outline Business Case: Environmental Economic Appraisal

September 2015

DRAFT FOR DISCUSSION PURPOSES ONLY

Contents

Important notice

Basis of preparation

This addendum to the Outline Business Case ("OBC") for the Grand Cayman cruise berthing project ("CBF") has been prepared solely for the Cayman Islands Government ("CIG" or "Government"), as required under the contract for consultancy services dated 2 July, 2013, between PwC Corporate Finance & Recovery (Cayman) Limited ("PwC") and the CIG. PwC Corporate Finance & Recovery (Cayman) Limited is a member firm of PricewaterhouseCoopers International Limited, each member firm of which is a separate legal entity.

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In preparing this addendum PwC must stress that it has relied upon information provided by, amongst others, W.F. Baird & Associates and its sub-consultants, the CIG, the Port Authority of the Cayman Islands, the Department of Tourism, the Department of Environment, the National Roads Authority, Caribbean Marine Services, Mott MacDonald Ltd. and BCQS International. PwC has not performed an audit examination on this information. Except where specifically stated, PwC has not sought to establish the reliability of the sources of information presented to them by reference to independent evidence. The economic analysis presented in this report is based on estimates and assumptions, and projections of uncertain future events. Accordingly, actual results will vary from the information provided in this report, even if some or all of the assumptions materialize such variances may be significant as a result of unknown variables.

Introduction

On 18 June 2015, PwC was asked by the CIG to prepare this addendum to the Outline Business Case for a proposed CBF (the "OBC") so as to incorporate the findings of the Environmental Impact Assessment ("EIA") conducted by W.F. Baird & Associates and its sub-consultants ("Baird") with respect to economic appraisal of the CBF.

In particular, the EIA process identified a significant level of damage to coral reefs in George Town Harbour (GTH)[1], which must be considered when assessing the overall cost-benefit of the CBF.

As requested by CIG, the analysis in this addendum is based solely on the information collated by Baird in its EIA, together with the economic and financial information analysed during the original OBC development.

Since preparing this analysis, in September 2015, the CIG received a report from Business Research & Economic Advisors (BREA) which analyses the potential impact of the development of the proposed CBF in George Town harbour on the pattern of cruise passenger onshore visits and spending. Accordingly, as requested by the CIG, we have included a supplement to this addendum to update the analysis in the main part of the Addendum to illustrate the implications of the evidence contained in the BREA report for the OBC.

Scope of work

The EIA undertaken as part of the appraisal of the proposed CBF identified four potential groups of ecosystem services which would be adversely affected by damage to the coral reefs in GTH:

- Cultural services which reflect the recreational and cultural value of the reefs, notably the opportunities provided for diving and snorkelling;
- Provisioning services which value the food and materials derived from the reefs;
- Regulating services which reflect the value of the coastal protection and climate regulation arising from the reefs; and
- Supporting services which reflect the value of maintaining the ecological integrity of the reefs.

The EIA sought to estimate the economic value of each of these ecosystem services, focusing on how they would be affected by the development of the CBF. The approach to valuing the services recognised that some services have obvious, marketable use values whilst others generate value indirectly, and still others provide value which is intangible, such as the existence value of the resource to be passed onto future generations.

The purpose of this document is to explain how the findings of the EIA can and should be integrated into the OBC.

Background

The EIA drew on several existing studies to value each element of the ecosystem services:

- A study of Bonaire (which was chosen because it is a small island state like the Cayman Islands and depends heavily on tourism from both air and cruise ship visitors in part driven by its reputation for diving) estimates that the total economic value of each hectare of coral reef is US$40,000 per year[2].
- Various studies of the Montego Bay Marine Park in Jamaica which assess the economic value of the Marine Park which estimated that the total economic value of each hectare of coral reef is over US$250,000 per year.
- A recent meta-analysis by de Groot et al. (2012) based on 94 data sources specific to coral reefs[3].

[1] W. F. Baird & Associates, Environmental Impact Assessment Cruise Berthing Terminal for Cayman Islands: Appendix J2: Preliminary Economic Valuation of Ecosystem Goods and Services Provided by GTH Reefs, June 2015.

[2] van Beukering P, Muresan L, IVM Institute for Environmental Studies, The total economic value of nature on Bonaire, 2013.

Table 1 summarises the value of ecosystem services from the studies of Bonaire and Montego Bay Marine Park as well as the meta-analysis by de Groot et al.

Table 1

Economic value of ecosystem services in Bonaire, Montego Bay and based on a meta-analysis of multiple reef sites (US$/ha/yr)[4]

Ecosystem goods and services	Bonaire	Montego Bay	Meta-analysis - De Groot et al. (2012)[5]
1.Cultural services			
Tourism and recreation	$14,615	$210,000	$108,837*
History, culture, traditions, art	$808		
Science, research, knowledge, education	$423		
Non-use (stakeholder perception)	$23,077	n/a	n/a
2.Provisioning services			
Fisheries (food)	$846	$867	$55,724
Raw materials			
Medicinal resources, pharmaceutical			
Genetic resources			
3.Regulating services			
Coastal protection /storm/erosion regulation	$38	$43,333	$171,478
Climate regulation/carbon sequestration	$808		
4.Supporting services			
Primary production	n/a	n/a	$16,210
Nutrient cycling			
Habitat/species/ecosystem protection			
Total valuation per hectare per year	**$40,615**	**$254,200**	**$352,249**

Source: Environmental Impact Assessment Cruise Berthing Terminal for Cayman Islands: Appendix J2

The EIA also drew on data collected and analysed specifically for the EIA, notably through various stakeholder surveys:

To consider the impact on the conclusions of the OBC, we have reviewed the approach taken in the EIA. We have then developed and extended this analysis so that it can be integrated into our economic impact assessment on a consistent basis. We have made the following main modifications:

1. We have adjusted for the potential diversion or displacement of economic activity associated with the GTH reefs (i.e. water-based activities such as diving and snorkelling) either to other locations in the Cayman Islands (as visitors opt to undertake water-based activities elsewhere in Cayman) and/or to other activities (including attractions in George Town and around Grand Cayman Island): the EIA only considers the impact in George Town;
2. We have adjusted the estimated economic losses from changes in spending to reflect the impact on Gross Value Added (GVA) in the Cayman Islands, not the level of spending: GVA is the measure of the contribution to national economic output used in economic appraisal;
3. We have included an adjustment to incorporate the multiplier effects arising from the impacts in the Cayman supply chains which meet the needs of visitors' spending and their employees; and

[3] The EIA also referenced an earlier meta-analysis by TEEB of the economics of ecosystems which reviewed more than 80 studies of the value of the ecosystem services that coral reefs provide: it revealed that "..., a single hectare of coral reef, for example, provides annual services to humans valued at US$130,000 on average, rising to as much as US$1.2 million." This value breaks down as follows: cultural services average US88,700 (ranging up to US$1.1 million), provisioning services average US$1,100 (up to US$6,000), regulating services average US$26,000 (up to US$35,000) and supporting services average US$13,500 (up to US$57,000).

[4] For ease of comparison, the resulting ecosystem component values were standardized to *per hectare* values.

[5] We note that these estimates use 2007 prices and should, therefore, be revalued to reflect expected price levels when the CBF is developed (i.e. 2016 and beyond).

4. We have avoided potential double counting of impacts already included in the economic impact assessment (e.g. the adverse impact on tendering services).

Estimated economic value of George Town Harbour reefs

We start by reviewing the approach taken in the EIA to estimating the economic value of the GTH reefs. This is the initial step in estimating the economic value of the environmental impacts associated with development of the CBF. The EIA considers the value provided by each of the ecosystem services in turn.

Cultural services

The cultural services provided by the GTH reefs have both a use value and a non-use value. The EIA focuses on the former.

Use value

The GTH reefs bring use value to Cayman because they provide a "product" which is attractive to visitors. Due to their proximity to the shoreline, the sites are attractive locations for diving and snorkelling as well as other water-based activities. Unlike other reefs in the Cayman Islands (e.g. those along 7 Mile Beach and Armchair Reef) which require boat transportation for diving and snorkelling, the reefs in GTH are accessible from the shore and, hence, they are popular among cruise passengers and overnight (air) visitors. In addition, boat and submersible tours are also available in GTH.

The use value of the GTH reefs can be estimated by assessing the (economic) value added in the Cayman Islands as a result of the spending by cruise passengers and overnight (air) visitors on activities directly linked to the reef (i.e. water-based activities such as diving and snorkelling). Each group needs to be considered separately – as the EIA does – using official statistics and the results of a survey of GTH dive shops. Below, we summarise and review the two approaches used in the EIA for each passenger group. We comment on their potential limitations and their implications for the resulting estimates of the use value of the GTH reefs.

Cruise passengers

The first approach starts from the number of cruise passengers arriving in the Cayman Islands in 2013 (the latest year for which data are available). According to the Economics and Statistics Office (ESO) *Public Tourism Arrivals Report*, 1,375,872 tourists arrived by cruise ship and disembarked. The subsequent calculations rest on some critical assumptions:

- 5.6%[6] of (disembarking) cruise passengers are assumed to "dive"[7] in GTH – this is based on the proportion of overnight air visitors who cited "to dive" as the main reason for their visit to the Cayman Islands. It means that the estimated number of passengers arriving by cruise ship that "dived" in GTH in 2013 is 77,049.
- Each passenger who "dives" is assumed to spend US$125 on "diving": this is stated to be the median value of the range of prices for various water based activities advertised in GTH.
- In addition, each passenger is assumed to spend a further US$86 per person on "non-diving" activities.

[6] http://www.eso.ky/UserFiles/right_page_docums/files/uploads/cayman_islands_compendium_of_statistics_.pdf pp.126-130.

[7] This is used in the remainder of this report as shorthand to describe all water based activities undertaken in GTH which are at risk from the development of the CBF.

On this basis, the value of the cultural services arising from cruise visitors is estimated to be $16.3 million (see Table 2).

Table 2

EIA - economic value of cultural services arising from cruise passengers based on ESO Tourism Statistics

	EIA estimate	Comments
Number of cruise ship passenger arrivals (2013)	1,375,872	
Number of cruise ship passengers "diving"	77,049	Limited evidence on propensity of cruise passengers to "dive"
Spending on diving, snorkelling, boat, submersible tours (US$m)	$9.6	Based on median advertised price for various water based activities in GTH
Other (associated) spending (US$m)	$6.6	Basis on assumed spend of US$86 per person on "non-diving" activities
Total spending (US$m)	**$16.3**	Expenditure not value added

Source: Environmental Impact Assessment Cruise Berthing Terminal for Cayman Islands: Appendix J2

This estimate, however, suffers from several material methodological and data weaknesses which we summarise below:

- We are not aware of any reliable data on the proportion of cruise passengers who "dive" in GTH – using the proportion of overnight air visitors who cited "to dive" as the main reason for their visit to the Cayman Islands may be misleading because:
  - The characteristics of cruise passengers and overnight air visitors may be quite different and so may their behaviour
  - Only including those who see the opportunity to dive as the main reason for their visit will overlook those who still take advantage of the opportunity to "dive" even if it is not the main reason for their visit. It will also ignore those who undertake other water-based activities such as snorkelling and tours by boat and submersible.

  These factors mean that the number of tourists arriving by cruise ship that "dived" in GTH in 2013 could be significantly different from the 77,049 estimated.
- Whilst the assumption that the average spend per passenger on "diving" activities is $125 per person may reflect the cost of lengthy dives, it is hard to reconcile this figure with the cost of other water-based activities, such as snorkelling and boat tours, which appear more typically to be undertaken by cruise passengers. The cost of these activities is substantially less which means that, depending on the actual mix between diving and other forms of water-based activities which are less expensive, the actual spending on water sports could be significantly overstated in the EIA.
- The assumption that each passenger will spend a further US$86 per person on "non-diving" activities is also hard to reconcile with the available evidence on total spending by cruise passengers. As noted in the OBC, the evidence from the BREA report[8] suggests that average total spending is US$94, much less than that assumed in the EIA. The ESO's estimate of CI$84 is broadly consistent with the BREA report.
- The EIA expresses the value of the GTH reefs in terms of their impact on spending rather than their contribution to economic value added. If we assume that spending on "diving" has similar economic effects to other visitor spending, this would imply the contribution to value added of each US$1 spent is US$0.65. This includes the multiplier effects.

The second approach starts from the estimated number of customers of GTH dive shops who are cruise passengers (39,523). This is based on a survey of GTH dive shops (albeit the methodology is not explained). The subsequent calculations rest on some critical assumptions:

- Each passenger who "dives" is assumed to spend US$78 on "diving": it is not clear why this is less than the assumption made in the first approach[9].

[8] BREA, Economic Contribution of Cruise Tourism to the Destination Economies (Volume II Destination Reports), September 2012.

[9] It is arguable that "diving" outside GTH could be more costly for cruise passengers if they need to pay for land and sea transport to reach the dive site although this may be at the expense of other spending.

- In addition, each passenger is assumed to spend a further US$86 on "non-diving" activities.

On this basis, the value of the cultural services accruing from cruise visitors is estimated to be US$6.5 million (see Table 3).

Table 3

EIA - estimated economic value of cultural services arising from cruise passengers based on survey of GTH dive shops

	EIA estimate	Comments
Number of cruise passengers reported by GTH dive shops	**39,523**	Based on survey of GTH dive shops
Spending on diving, snorkelling, boat, submersible tours (US$)	$3.1	Based on spend per person on water based activities in GTH of $78
Other (associated) spending (US$m)	$3.4	Basis on assumed spend of US$86 per person on "non-diving" activities
Total spending (US$m)	**$6.5**	Expenditure not value added

Source: Environmental Impact Assessment Cruise Berthing Terminal for Cayman Islands: Appendix J2

This estimate, however, suffers from some of the same weaknesses as the first approach as well as new ones:

- It is unclear why cruise passengers are assumed to spend less on "diving" in this approach than in the first one (US$78 compared to US$125).
- The assumption that each passenger spends a further US$86 per person on "non-diving activities" is hard to reconcile with the available evidence on total spending by cruise passengers.
- The value of the GTH reefs needs to be expressed in terms of value added not spending: the OBC assumes that the contribution to value added of each US$1 spent is US$0.65 (including the multiplier effects).

Given the inherent data limitations which affect the estimates of the value of the cultural services, we have examined the sensitivity of the results to changes in the key assumptions. Our results are summarized in Table 4. The key points to note are:

- The value of the cultural services provided to cruise passengers by the GTH reefs is highly uncertain ranging from $2.9 million to $18.4 million depending on the key assumptions.
- Understanding the number of cruise passengers who spend money on "diving" is a crucial influence on the value of cultural services. If the assumption in the EIA about the proportion of passengers who "dive" (5.6%) is on the low side, then the number of "divers" could be significantly underestimated. On the other hand, it would mean that the estimate based on the survey of GTH dive shops would be considerably smaller.
- The different amounts assumed to be spent on "diving" ($78 and $125) also have a significant bearing on the economic value of the cultural services of the GTH reefs.
- We believe that the EIA's estimate of the amount of "other spending" by cruise passengers is too high and is inconsistent with the overall pattern of spending by cruise passengers: we estimate that the "other spend" is more likely to be in the range $36-$81 per person[10]. Incorporating this into the analysis, reduces the overall value of the cultural services provided by the GTH reefs.
- We assume that the impact on value added is 65% of the impact on visitor spending.

Table 4

Revised estimates of economic value of cultural services arising from cruise passengers

	Based on ESO Tourism Statistics		Based on GTH dive shop survey	
	Low	High	Low	High
Number of cruise passenger arrivals (2013)	**1,375,872**	**1,375,872**		
% of tourists "diving"	3%	10%		
Number of cruise passengers "diving"	**41,276**	**137,587**	**39,523**	**39,523**
Average spend on diving, snorkelling, boat submersible tours (US$m per person)	$78	$125	$78	$125

[10] Our analysis holds overall spending by cruise passengers constant and allows spend by "divers" and "non-divers" to vary.

	Based on ESO Tourism Statistics		Based on GTH dive shop survey	
	Low	High	Low	High
Spending on diving, snorkelling, boat, submersible tours (US$m)	$3.2	$17.2	$3.1	$4.9
Average other spending (US$m per person)	$36	$81	$36	$81
Other (associated) spending (US$m)	$1.5	$11.2	$1.4	$3.2
Total spending (US$m)	**$4.7**	**$28.4**	**$4.5**	**$8.2**
Total value added (US$m)	**$3.1**	**$18.4**	**$2.9**	**$5.3**

Source: PwC analysis

Overnight air visitors

The approach to assessing the value of the GTH reefs to overnight air visitors is similar to that adopted for cruise passengers.

The first approach starts from the number of overnight air visitors to the Cayman Islands in 2013 (the latest year for which data were available). According to the ESO's *Public Tourism Arrivals Report*, 345,385 tourists arrived by air. The subsequent calculations rest on some critical assumptions:

- 5.6%[11] of overnight air visitors are assumed to "dive" somewhere in the Cayman Islands – this is based on the proportion of air passengers who cited "to dive" as the main reason for their visit to the Cayman Islands.
- (At least) 47% of these visitors (9,091 or 2.6% of the total) "dive" at the GTH reefs (rather than other reefs in the Cayman Islands).
- Each visitor spends US$125 on "diving" which, by implication, also assumes that each visitor "dives" only once per trip.
- Each visitor spends an average of US$246 on other activities whilst in the Cayman Islands which, by implication, also assumes that they spend one extra day in the Cayman Islands as a direct result of the reefs.

On this basis, the value of the cultural services accruing from overnight air visitors is estimated to be US$3.4 million (see Table 7).

Table 5

EIA - estimated economic value of cultural services arising from overnight visitors by air based on ESO Tourism Statistics

	EIA estimate	Comments
Number of overnight air visitor arrivals (2013)	**345,385**	
Number of overnight air visitors "diving"	19,342	Limited evidence on propensity of overnight air visitors to "dive"
Number of overnight air visitors diving in GTH	9,091	Limited evidence on proportion of overnight air visitors who "dive" in GTH
Spending on diving, snorkelling, boat, submersible tours (US$m)	$1.1	Based on median advertised price for various water based activities in GTH
Other spending - air (US$m)	$2.2	Basis on assumed spend of US$86 per person on "non-diving" activities
Total spending (US$m)	**$3.4**	Expenditure not value added

Source: Environmental Impact Assessment Cruise Berthing Terminal for Cayman Islands: Appendix J2

This estimate, however, suffers from some of the same weaknesses as the approach to estimating the value to cruise passengers as well as new ones:

- We are not aware of any reliable data on the proportion of overnight air visitors who "dive" in the Cayman Islands – using the proportion of air passengers who cite "to dive" as the main reason for their visit to the Cayman Islands will probably provide a lower limit on the number but will not take account of the other 94.4% of visitors some of whom may take advantage of the opportunity to "dive" in the Cayman Islands.

[11] http://www.eso.ky/UserFiles/right_page_docums/files/uploads/cayman_islands_compendium_of_statistics_.pdf pp.126-130.

- On the other hand, limited data exist on where in the Cayman Islands visitors participate in "diving". The EIA assumes that 47% of "diving" occurs in GTH - for no obvious reason – yet, of approximately 80 popular Cayman dive sites listed in promotional material[12], only seven are located in GTH.
- These two factors suggest that the annual number of overnight air visitors who "dive" in GTH may be quite different from the 9,091 which is assumed.
- No consideration is given to how many times a visitor may "dive" while staying in the Cayman Islands: the approach implicitly assumes it is once (on one day), but in practice some visitors may participate in water-based activities more times than this since their average stay is nearly 4½ days.
- On the other hand, the assumption that each visitor will spend a further US$246 (which is the average total spend per person per day) ignores the fact that this average will already include spending on "diving".
- The value of the GTH reefs needs to be expressed in terms of value added not spending: the OBC assumes that the contribution to value added of each US$1 spent is US$ 0.65 (including the multiplier effects).

The second approach starts from the estimated number of customers at GTH dive shops who are overnight air visitors (38,700). This is based on a survey of GTH dive shops. The subsequent calculations rest on two critical assumptions:

- Each visitor who "dives" is assumed to spend US$78 on "diving": it is not clear why this is less than the assumption made in the first approach.
- In addition, each visitor is assumed to spend a further US$246 on "non-diving" activities.

On this basis, the value of the cultural services accruing from overnight air passengers is estimated to be US$12.5 million (see Table 6).

Table 6

EIA - estimated economic value of cultural services arising from overnight visitors by air based on survey of GTH dive shops

	EIA estimate	Comments
Number of overnight air visitors reported by GTH dive shops	**38,700**	Based on survey of GTH dive shops
Spending on diving, snorkelling, boat, submersible tours (US$)	$3.0	Based on spend per person on water based activities in GTH of $78
Other spending - air (US$m)	$9.5	Basis on assumed spend of US$86 per person on "non-diving" activities
Total spending (US$m)	**$12.5**	Expenditure not value added

Source: Environmental Impact Assessment Cruise Berthing Terminal for Cayman Islands: Appendix J2

This estimate, however, suffers from some of the same weaknesses as the first approach as well as new ones:

- It is unclear why overnight air visitors are assumed to spend less on "diving" in this approach than in the first approach (US$78 compared to US$125).
- No consideration is given to the number of times that a visitor may "dive": the approach implicitly assumes it is once (on one day), but in practice some visitors are likely to "dive" more times than this during their stay in the Cayman Islands.
- The assumption that each passenger will spend a further US$246 (which is the average spend per person per day) ignores the fact that this average already includes spending on "diving".
- The value of the GTH reefs needs to be expressed in terms of value added not spending: the OBC assumes that the contribution to value added of each US$1 spent is US$ 0.65 (including the multiplier effects).

Given the inherent data limitations which affect the estimates of the value of the cultural services, we have examined the sensitivity of the results to changes in the key assumptions. Our results are summarized in Table 7. The key points to note are:

[12] http://www.caymanactivityguide.com/DiveSites.htm

- The value of the cultural services provided to overnight air visitors by the GTH reefs is highly uncertain ranging from $2.6 million to $35.1 million depending on the key assumptions.
- Understanding the number of overnight air visitors who spend money to "dive" in the Cayman Islands is a crucial influence on the value of cultural services. We view the assumption in the EIA about the proportion of passengers who "dive" (5.6%) as an absolute minimum since it includes only those visitors who cite "to dive" as the main reason for their visit. This means that the number of "divers" could be significantly underestimated. As sensitivities, therefore, we test the implications if we assume that 5% and 25% of other overnight air visitors to the Cayman Islands for recreational purposes also "dive" during their stay.
- Linked to this is the question of what proportion of water-based activities such as diving is undertaken in GTH. The EIA assumes this could be as much as 47.0%. We think this is the upper limit. At the other end of the spectrum, if we assume the share is proportionate to the number of dive sites in the Cayman Islands which are in GTH, the proportion would be 8.8%. These two assumptions lead to estimates of the number of "divers" in GTH which are either side of the estimate based on the survey of GTH dive shops.
- The different amounts assumed to be spent on "diving" ($78 and $125) have a significant bearing on the economic value of the cultural services of the GTH reefs but do not seem to recognise the length of the trips made by overnight air visitors which opens up the possibility of multiple "dives".
- We believe that the EIA's estimate of the amount of other spending by overnight air visitors is too low and is inconsistent with the overall pattern of spending by overnight air visitors: we estimate that the other spend is more likely to be in the range $910-$1,332 per person[13]. Incorporating this into the analysis, increases the overall value of the cultural services provided by the GTH reefs.
- We assume that the impact on value added is 65% of the impact on visitor spending.

Table 7

Revised estimate of economic value of cultural services arising from overnight visitors by air based on ESO Tourism Statistics

	Based on ESO Tourism Statistics		Based on GTH dive shop survey	
	Low	High	Low	High
Number of overnight air visitors (2013)	**345,385**	**345,385**		
% of overnight air visitors "diving" in Cayman Islands	9.2	23.6		
Number of overnight air visitors "diving"	31,775	51,511		
% of overnight air visitors "diving" in GTH	8.8	47.0		
Number of overnight air visitors "diving" in GTH	**2,796**	**38,311**	**38,700**	**38,700**
Average spend on diving, snorkelling, boat submersible tours (US$m per person)	78	500	78	500
Spending on diving, snorkelling, boat, submersible tours (US$m)	0.2	19.2	3.0	19.4
Average other spending (US$m per person)	1,332	910	1,332	910
Other spending - air (US$m)	3.7	34.9	51.6	35.2
Total spending (US$m)	**3.9**	**54.0**	**54.6**	**54.6**
Total value added (US$m)	**2.6**	**35.1**	**35.5**	**35.5**

Source: PwC analysis

Non-use value

Besides the use value, the GTH reefs also have the potential to provide three types of non-use value:

- Option value includes the opportunity to preserve a resource for future use instead of using it at the present time: for example, coral reefs may have yet-to-be-discovered important pharmaceutical compounds and ecological functions;
- Existence value is derived from the knowledge that a particular natural resource or endangered animal is preserved, for example, protection of coral species that have been identified as threatened or endangered may have a perceived value in the present and a tangible value in the future; and

[13] Our analysis holds overall spending by cruise passengers constant and allows spend by "divers" and "non-divers" to vary.

- Bequest value is derived from the desire to pass on a value to future generations.

The EIA makes no allowance for this non-use value of the GTH reefs.

Provisioning services

The value of the provisioning services provided by the coral reefs in GTH reflects their ability to provide fisheries and other valuable materials and resources[14]. The value of these services in Bonaire and Montego Bay has been estimated at US$846[15] and US$867 per hectare per year respectively (see Table 8). In both cases, the limited value reflects a strategy of limiting fishing and resource extraction. The meta-analysis, however, suggests a much larger average value. The average is boosted by a small number of locations where raw materials and genetic materials are important.

Historically, however, fishing in the Cayman Islands has been on a small scale, primarily for subsistence and recreational purposes. This suggests that the estimated value of the provisioning services in Bonaire and Montego Bay may be a more reasonable basis from which to estimate the value of the provisioning services provided by the GTH reefs.

Table 8

Estimated economic value of provisioning services in Bonaire, Montego Bay and based on a meta-analysis of multiple reef sites (US$/ha/year)

Provisioning services	
Bonaire	$846
Montego Bay Marine Park	$867
Meta-analysis - de Groot et al (2012)	$57,742

Source: Environmental Impact Assessment Cruise Berthing Terminal for Cayman Islands: Appendix J2

Regulating services

The reefs at GTH provide two main forms of regulating service: shoreline protection and climate regulation (and carbon sequestration).

Shoreline protection

The shoreline protection services provided by the GTH coral reefs can be quantified in terms of the wave energy attenuation attributable to their presence or the increase in wave energy attributable to a reduction in the reef's size[16]. The economic value of these services reflects the value of the property, lives and well-being preserved by the attenuation of the wave energy or the value lost due to the increase in wave energy.

As part of the EIA, the shoreline protection services offered by the reefs in GTH were modelled. The results suggest that the reefs play a significant role in wave attenuation in GTH and, as such, any damage to them would reduce the value of their regulating services along the shoreline (including nearby shops and restaurants which are already subject to wave inundation during storm events).

Climate regulation (and carbon sequestration)

The GTH reefs also deliver value indirectly by providing benefits such as climate regulation and carbon sequestration. These ecosystem services are much harder to value based on conventional methods. The EIA uses the results of the meta-analysis which suggests that the average value of climate regulation and carbon sequestration is US$1,188/ha/year.

The value of these regulating services afforded by the GTH reefs is estimated on two bases:

[14] van Beukering P, Sarkis S, McKenzie E, Hess S, Brander L, Roelfsema M, Putten1 L der, L, Bervoets T (2010) Total economic value of Bermuda's coral reefs: Valuation of ecosystem services. 197.

[15] TEEB_NL (2012) What's Bonaire's Nature Worth ?

[16] Principe BP, Yee PS, Fisher W, Johnson W, Allen P, Campbell D (2012) Quantifying Coral Reef Ecosystem Services.

- The "avoided damages" method considers the likely economic losses (in lost property value) from a storm event with and without the reefs: the meta-analysis by de Groot et al estimated the average value of all the regulating services at US$171,478/ha/year; and
- The "replacement value" method considers the (estimated) cost to replace the lost reefs with artificial reef structures or the cost of beach and shoreline restoration in GTH over the 1,000-1,300ft (300-400m) of shoreline that could be affected by the damage to the reefs: this is approximately US$2.5 million or ~$89,693/ha/year[17].

The two estimates are used to provide a range of estimated values for the regulating services provided by the GTH reefs (see Table 9).

Table 9

Estimated economic value of regulating services based on meta-analysis and estimated cost of coastal protection works (replacement value) (US$/ha/year)

Regulating services	*Avoided damages – based on meta-analysis - de Groot et al (2012)*	Replacement value
Coastal protection/erosion prevention	$153,214	$71,429
Disturbance	$16,991	$16,991
Climate regulation	$1,188	$1,188
Waste treatment	$85	$85
Total	$171,478	$89,693

Source: Environmental Impact Assessment Cruise Berthing Terminal for Cayman Islands: Appendix J2

Supporting services

Finally, supporting services are "those that are needed for the production of all other ecosystem services"[18]. In the case of coral reefs, this includes photosynthesis and nutrient cycling which represent ecosystem functions that underpin ecosystem resilience and are essential for the persistence of the ecosystem and the associated goods and services. According to the meta-analysis by de Groot et al[19], the average value of supporting services of reefs is estimated at US$16,210/ha/year. This is the value used in the EIA.

Summary

The EIA's estimate of the value of the ecosystem services provided by all 35 ha of reef in GTH (not just those affected by the CBF) is summarized in Table 10:

- For cultural services, which encompass tourism, the estimated (annual) economic value is between US$12 million and US$13 million: note that this estimate is the value added arising from all the reefs' ecosystem services, not the spending as used by the EIA.
- For provisioning services, the value is based on Bonaire (US$846/ha/year) which gives an estimated value of US$29,610 per annum.
- The value of regulating services based on the avoided damages method is US$171,478/ha/year and US$89,593/ha/year based on "replacement value". This gives an annual value of between US$6 million and US$3.1 million.
- The value of the supporting services is estimated at US$16,210/ha/year (or US$567,350 per annum for all the GTH reefs).

The value of the ecosystem services of each hectare of the GTH reefs ranges between US$459,700 and US$553,100. This gives an overall annual value of in a range from US$16.1 million to US$19.4 million.

[17] The estimated value is specific to GTH in that it reflects its physical requirements to provide compensating protection rather than being based on a benefits transfer approach used in other areas.

[18] MEA (2005) Millennium Ecosystem Assessment. In: Hassan R., Ash N. (eds) Ecosystems and human well-being : Current State and Trends: Findings of the Condition and Trends Working Group. UNEP, Washington, DC.

[19] De Groot R, Brander L, van der Ploeg S, Costanza R, Bernard F, Braat L, Christie M, Crossman N, Ghermandi A, Hein L, Hussain S, Kumar P, McVittie A, Portela R, Rodriguez LC, ten Brink P, van Beukering P (2012) Global estimates of the value of ecosystems and their services in monetary units. Ecosyst. Serv. 1:50–61.

Table 10

Estimated total economic value of ecosystem services from GTH reefs

Ecosystem services	Average economic value per hectare (US$'000 per year)	Total economic value of GTH reefs (35 hectares) (US$ million per year)
Cultural services	$353.2 - $364.6	$12.36 - $12.76
Provisioning services	$0.8	$0.03
Regulating services	$89.7 - $171.5	$3.14 - $6.00
Supporting services	$16.2	$0.57
All ecosystem services	**$459.9 - $553.1**	**$16.10 - $19.36**

Source: PwC analysis

As we have noted, however, the estimated value of the cultural services of the GTH reefs, the most significant element of value, depends critically on the underlying assumptions. As we have discussed earlier, the range of possible values of the cultural services is very wide in the absence of reliable evidence. The value of each hectare of reef ranges from $157,100 to $1.54million. In Table 11, we summarise our revised estimates of the economic value of the ecosystem services provided by the GTH reefs. The value ranges from US$9.2 million to US$60.5 million.

Table 11

Revised estimates of total economic value of ecosystem services from GTH reefs

Ecosystem services	Average economic value per hectare (US$'000 per year)	Total economic value of GTH reefs (35 hectares) (US$ million per year)
Cultural services	$157.1 - $1,540.4	$5.50 – $53.91
Provisioning services	$0.8	$0.03
Regulating services	$89.7 - $171.5	$3.13 - $6.00
Supporting services	$16.2	$0.57
All ecosystem services	**$263.8 – $1,728.9**	**$9.23 - $60.51**

Source: PwC analysis

Estimated impact of the CBF

Based on its assessment of the economic value of the ecosystem services provided by the GTH reefs, the EIA considers the potential impacts of three options for the design of the CBF (compared to a counterfactual scenario where the CBF is not developed):

- Option A is intended to optimise functional performance and capital costs of the CBF, albeit it would also have significant environmental impacts as the dredge footprint would be 15.3 ha of which 7.3 ha would be coral reef spurs and patch reefs. Given the magnitude of the dredge footprint, it is estimated that an additional 6-8 ha of coral reef (within a 100-200m buffer zone footprint) would be negatively affected by increased turbidity and sedimentation during the dredging/construction and operational phases.
- Option B delivers the "least" environmental impact as it would have the smallest dredge footprint (1.5 ha). It is estimated that reefs within 300ft (100m) of the project footprint (~2 ha) would be degraded by cruise ship traffic.
- Option C is a "middle ground" option in terms of functional performance and environmental impact. The dredging footprint would be 13 ha, including ~6 ha of coral reef that would be destroyed by dredging and an additional 6-8 ha of reefs located within approximately 660ft (~200 m) which would be subject to extended periods of lethal/sub-lethal sedimentation and turbidity during the dredging operations and to chronic sediment re-suspension during the operational phase. These areas are designated as high-impact zones where coral mortality is likely.

All these options are expected to result in ecological losses, including loss of habitat and habitat complexity, loss of ecological functionality and connectivity and loss of biodiversity. The associated loss of ecosystem services in GTH on the Cayman Islands can be expressed in economic terms by estimating the expected change in the value of each service provided by the GTH reefs as a result of the CBF. The key impact is on the cultural services which result from any changes in spending by cruise passengers and overnight (air) visitors on activities directly affected by the CBF.

The EIA focuses on estimating the impact on an area around GTH, rather than across the Cayman Islands as a whole. As such, it makes no allowance for the possibility that activity and spending will be displaced from GTH to other parts of the Cayman Islands.

The approach to estimating the economic loss of ecosystem services is summarized in Table 12.

Table 12

Approach to estimating the economic impact of loss of ecosystem services in GTH arising from development of CBF in EIA

Ecosystem services	Vale of economic loss of ecosystem services per hectare of reef affected	Scale of reef affected by development of the CBF
Cultural services	For cultural services, which encompass tourism, the estimated (annual) economic value is US$353,200 - $364,600/ha/year[20]	The area of reef affected by development of the CBF is the reef area destroyed, which is defined as the reef areas within the project footprint, and the wider reef impact zone, which includes the adjacent reef areas indirectly affected by construction and operation of the CBF.
Provisioning services	The value of the loss of provisioning services is based on evidence from Bonaire which estimates the damage at US$846/ha/year.	
Regulating services	The value of the loss of regulating services depends on the method used: the avoided damages method values the loss at US$171,478/ha/year and the replacement value method values it at US$89,693/ha/year.	
Supporting services	The value of the loss of supporting services is based on the evidence from the meta-analysis and is valued at US$16,210/ha/year.	

Source: PwC analysis

[20] This is based on the estimated impact on value added (see Table 10).

The EIA estimated economic losses associated with the impact on ecosystem services are summarized in Table 13 for each of the three Options. The losses range from US$1.6-1.9 million per annum in Option B to US$6.3-8.5 million per annum in Option A.

Table 13

EIA - estimated economic loss due to loss of reefs in GTH under Options A, B and C[21] (US$'000/yr)

Estimated value of ecosystem services	Area (ha)	Cultural services $353.2 - $364.6	Provisioning services $0.8	Regulating services $89.7 - $171.5	Supporting services $16.2	All ecosystem services
Option A						
Dredged area	15.3					
Reef area destroyed	7.3	2,578.6 – 2,661.3	5.8	654.8 – 1,252.0	118.3	3,357.5 – 4,037.3
Reef impact zone	~ 6-8	2,119.4 – 2,916.5	6.4	538.2 – 1,372.0	129.6	2,793.6 – 4,424.5
Total economic loss	**13.3-15.3**	**4,698.1 – 5,577.7**	**12.2**	**1,192.9 – 2,624.0**	**247.9**	**6,151.1 – 8,461.8**
Option B						
Dredged area	1.5					
Reef area destroyed	1.5	529.9 – 546.8	1.2	134.5 – 257.3	24.3	689.9 – 829.6
Reef impact zone	~ 2	706.5 – 729.1	1.6	179.4 – 343.0	32.4	919.9 – 1,106.1
Total economic loss	**3.5**	**1,236.3 – 1,275.6**	**2.8**	**313.9 – 600.3**	**56.7**	**1,609.8 – 1,935.7**
Option C						
Dredged area	13					
Reef area destroyed	6	2,119.4 – 2,187.4	4.8	538.2 – 1,029.0	97.2	2,759.6 – 3,318.4
Reef impact zone	~ 6-8	2,119.4 – 2,916.5	6.4	538.2 – 1,372.0	129.6	2,793.6 – 4,424.5
Total economic loss	**12-14**	**4,238.9 – 5,103.8**	**11.2**	**1,076.3 – 2,401.0**	**226.8**	**5,553.2 – 7,742.8**

Source: PwC analysis

If we use the revised estimates of the economic value of ecosystem services in Table 11 as the basis for estimating the losses associated with the impact on ecosystem services, the range of the potential impact increases markedly (see Table 14). The losses range from US$0.9-6.1 million in Option B to US$3.5-26.5 million in Option A. This reflects the scale of the uncertainties that exist around the cultural value of the reefs in GTH.

Table 14

EIA – revised estimates of economic loss due to loss of reefs in GTH under Options A, B and C[22] (US$'000/yr)

Estimated value of ecosystem services	Area (ha)	Cultural services $128.4 - $1,640.4	Provisioning services $0.8	Regulating services $89.7 - $171.5	Supporting services $16.2	All ecosystem services
Option A	13.3-15.3	2,069.1 – 23,568.2	10.6 – 12.2	1,192.9 - 2,624.0	215.5 – 247.9	3,508.1 – 26,452.2
Option B	3.5	549.8 - 5,391.4	2.8	313.3 - 600.3	56.7	923.2 - 6,051.2
Option C	12-14	1,884.9 - 21,565.7	9.6 - 11.2	1,076.3 - 2,401.0	194.4 – 226.8	3,165.2 - 24,204.7

Source: PwC analysis

But these estimates are subject to some important limitations which have significant implications for the results. In particular, as we have noted, the estimates do not make any allowance for the potential diversion or displacement of economic activity associated with the GTH reefs (i.e. water-based activities such as diving) either to other locations in the Cayman Islands (as visitors opt to "dive" elsewhere in Cayman) and/or to other

[21] The reef area destroyed is defined as the reef areas within the project footprint and the wider reef impact zone includes the adjacent reef areas indirectly affected by construction and operation of the CBF.

[22] The reef area destroyed is defined as the reef areas within the project footprint and the wider reef impact zone includes the adjacent reef areas indirectly affected by construction and operation of the CBF.

activities (including attractions in George Town and elsewhere around Grand Cayman Island). This is partly because the EIA only considers the impact of the CBF in George Town.

Below, we illustrate the potential implications of this weakness for the results by considering how the estimated impact of the CBF is influenced by assumptions about the likely reaction of cruise passengers and overnight air visitors its development. We consider each group in turn.

Cruise passengers

Figure 1 illustrates a framework for considering how cruise passengers might react to potential damage to parts of the GTH reefs as a result of development of the CBF. There are three key steps.

First, it is important to distinguish between cruise passengers who "dive" in GTH (i.e. undertake water-based activities), those who "dive" in other parts of Cayman and those who do not "dive" at all. The latter two groups can be assumed to be largely unaffected by the CBF although it is possible that if a large number of passengers who would otherwise "dive" in GTH were prompted to undertake other activities this could contribute to overcrowding and reduce enjoyment of these alternative activities. The focus needs to be on those who "dive" in GTH.

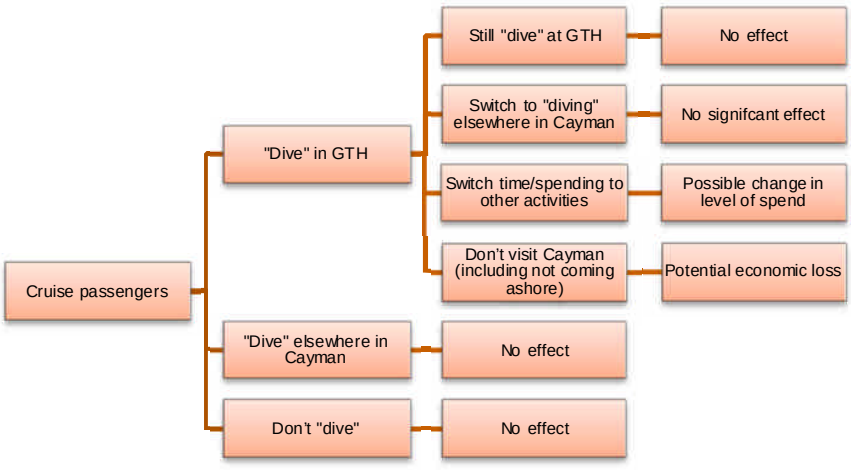
For this group, the second step is to consider how if at all these cruise passengers would alter their behaviour in response to any damage to the CBF. There are four possible effects:

- Cruise passengers continue to "dive" in GTH;
- Cruise passengers switch to "diving" elsewhere in Cayman – where this is the case the net impact on spending is likely to be insignificant;
- Cruise passengers choose other activities which are not water-based activities as an alternative to "diving" – where this is the case the net impact depends primarily on the extent to which tourist spending in the Cayman Islands is reduced as a result of the different activities; and
- Cruise passengers choose not to join cruises which visit the Cayman Islands or they opt not to disembark from their ship in Grand Cayman – the former proportion seems likely to be very small given that cruises typically stop at multiple destinations but the latter may be bigger thus adding to the uncertainty about the magnitude of the potential loss of cultural services provided by the reefs in GTH.

The final step is to consider the spending implications of each response and what this means for the value added in the Cayman Islands.

Figure 1

Elements of potential impact of development of CBF on cultural services – cruise passengers



Source: PwC analysis

Three groups of parameters shape the scale of the potential impact of the CBF:

- The number of cruise passengers who "dive";
- How the cruise passengers would respond to potential damage to the GTH reefs; and
- What change in the level (and type) of spending would be associated with each response.

In practice, we have only very limited evidence that can be used to inform the key assumptions needed to establish each parameter and, thus, estimate the potential impact. Thus, to illustrate the possible implications, we have considered three different scenarios (see Table 15):

- Scenario 1 is based on the smallest proportion of "divers" who are least sensitive to the development of the CBF;
- Scenario 2 assumes more "divers" than Scenario 1 who are less sensitive to the CBF than Scenario 3; and
- Scenario 3 is based on the largest proportion of "divers" who are most sensitive to the development of the CBF.

Given the lack of existing evidence, we think all of the scenarios are plausible.

Table 15

Assumptions underpinning the scenario based analysis of potential impact of CBF on cultural services arising from cruise passengers

	Scenario 1	Scenario 2	Scenario 3
% of cruise passengers "diving" in GTH	3% of arrivals	5% of arrivals	10% of arrivals
% passengers continuing to "dive" at GTH	5%	0%	0%
% passengers "diving" at GTH switching to "diving" elsewhere in the Cayman Islands	20%	20%	5%
% passengers "diving" at GTH switching to other activities in the Cayman Islands	60%	55%	55%
% passengers "diving" at GTH not visiting the Cayman Islands	15%	25%	40%
Change in spending resulting from overnight air visitors "diving" at GTH changing behaviour			
Switching to "diving" elsewhere in the Cayman Islands ($ per passenger)	$0	$0	$0
Switching to other activities in the Cayman Islands ($ per passenger)	$45	$45	$80
Not visiting the Cayman Islands ($ per passenger)	$114	$183	$183

Source: PwC analysis

We show the implications of each scenario for the net impact estimates (see Table 16):

- Scenario 1 leads to the smallest impact on spending ($1.82 million per annum);
- Scenario 2 leads to an impact on spending of ($4.85 million per annum); and
- Scenario 3 leads to the largest impact on spending ($16.13 million per annum), nine times the impact in Scenario 1.

Table 16

Scenario based analysis of potential impact of CBF on cultural services arising from cruise passengers

	Scenario 1	Scenario 2	Scenario 3
Number of passengers "diving" at GTH ('000)	41.3	68.8	137.6
Number of passengers continuing to "dive" at GTH	2.1	-	-
Number of passengers diving at GTH switching to "diving" elsewhere in the Cayman Islands	8.3	13.8	6.9
Number of passengers "diving" at GTH switching to other activities in the Cayman Islands	24.8	37.8	75.7
Number of passengers "diving" at GTH not visiting the Cayman Islands	6.2	17.2	55.0
Change in spending resulting from passengers "diving" at GTH changing behaviour			

	Scenario 1	Scenario 2	Scenario 3
Switching to "diving" elsewhere in the Cayman Islands ($m)	$0	$0	$0
Switching to other activities in the Cayman Islands ($m)	$1.11	$1.70	$6.05
Not visiting the Cayman Islands ($m)	$0.71	$3.15	$10.07
Total change in spending resulting from passengers changing behaviour ($m)	$1.82	$4.85	$16.13

Source: PwC analysis

Overnight air visitors

Figure 2 illustrates an equivalent framework for thinking about how overnight air visitors might react to potential damage to parts of the GTH reefs as a result of development of the CBF. As with cruise passengers, there is a series of steps in the analysis.

First, it is important to distinguish between overnight air visitors for whom the opportunity "to dive" was the "main reason" for choosing for visit the Cayman Islands, those who took advantage of the diving opportunities (but where "diving" was not the main reason) and those who did not "dive".

Second, for each of the two groups who "dive", a distinction is needed between those who "dive" in GTH and those who "dive" in other parts of Cayman. The latter group can be assumed to be largely unaffected by the CBF. The focus, therefore, needs to be on the likely behaviours of the former group who "dive" in GTH. The former group (i.e. the one citing "diving" as the main reason for visiting the Cayman Islands) might be expected to be most sensitive to damage to the GTH reefs.

For this group, the third step is to consider how these visitors would alter their behaviour in response to any damage to the CBF. As with the cruise passengers, there are four possible responses:

- They continue to "dive" in GTH;
- They switch to "diving" elsewhere in Cayman – where this is the case the net impact on spending is likely to be insignificant;
- They choose other activities as an alternative to "diving" – where this is the case the net impact depends primarily on the extent to which tourist spending in the Cayman Islands is reduced as a result of the different activities; and
- They choose not to visit the Cayman Islands – this proportion seems likely to depend on the importance of diving to the decision to visit the Cayman Islands and the attractiveness of the GTH reefs as a dive site (compared to others in the Cayman Islands).

The final step is to consider the spending implications of each response and what this means for impact on value added in the Cayman Islands.

Three groups of parameters shape the scale of the potential impact of the CBF:

- The number of cruise passengers who "dive";
- How the cruise passengers would respond to the potential damage to the GTH reefs; and
- What change in the level (and type) of spending would be associated with each response.

In practice, we have only very limited evidence that can be used to inform the key assumptions needed to establish each parameter and, thus, estimate the potential impact. Statistics from the ESO indicate the proportion of overnight air visitors who indicate that the main reason for their visit to the Cayman Islands is "to dive" but there is less evidence on the proportion of other visitors who "dive". Thus, to illustrate the possible implications, we have considered three different scenarios as we have done with cruise passengers (see Table 17):

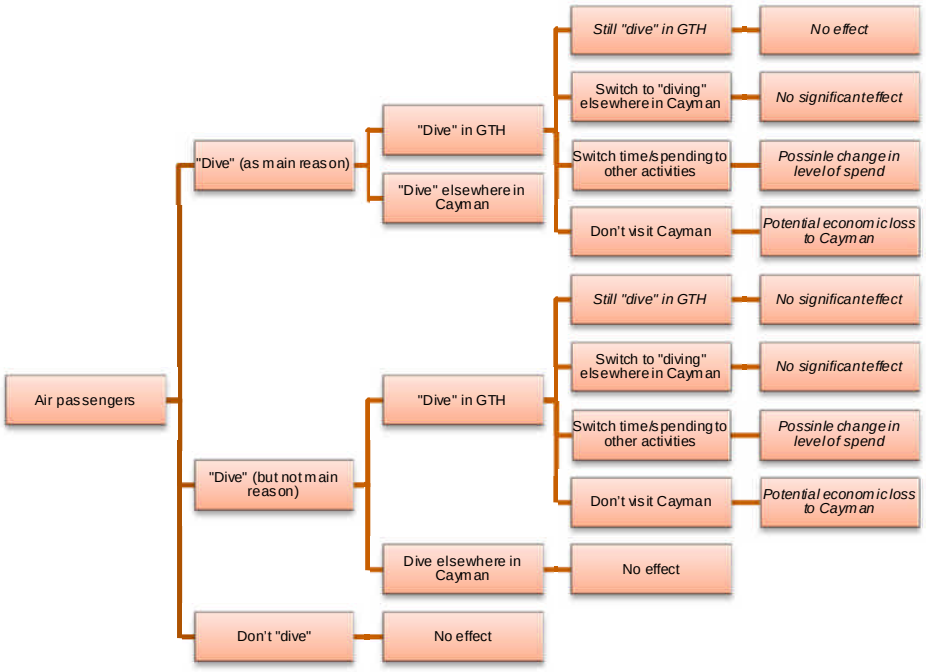
- Scenario 1 is based on the smallest proportion of "divers" who are least sensitive to the development of the CBF;
- Scenario 2 assumes more "divers" than Scenario 1 who are less sensitive to the CBF than Scenario 3; and

- Scenario 3 is based on the largest proportion of "divers" who are most sensitive to the development of the CBF.

Given the lack of existing evidence, we think all of the scenarios are plausible.

Figure 2

Elements of potential impact of development of CBF on cultural services – overnight air visitors



Source: PwC analysis

Table 17

Assumptions which underpin scenario based analysis of potential impact of CBF on cultural services arising from overnight air visitors

	Scenario 1	Scenario 2	Scenario 3
% overnight air visitors stating "diving" main reason for visit[23]	5.6%	5.6%	5.6%
% overnight air visitors "diving" but not stating main reason for visit[24]	5%	15%	25%
% overnight air visitors not "diving"	89%	79%	69%
% overnight air visitors "diving" in the Cayman Islands who "dive" at GTH	9%	30%	50%
"To dive" main reason for visit			
% overnight air visitors continuing to "dive" at GTH	5%	0%	0%
% overnight air visitors diving at GTH switching to "diving" elsewhere in the Cayman Islands	70%	70%	55%
% overnight air visitors "diving" at GTH switching to other activities in the Cayman Islands	10%	5%	5%
% overnight air visitors "diving" at GTH not visiting the Cayman Islands	15%	25%	40%
"To dive" - not main reason for visit (but may be factor)			
% overnight air visitors continuing to "dive" at GTH	5%	0%	0%
% overnight air visitors "diving" at GTH switching to "diving" elsewhere in the Cayman Islands	20%	35%	45%

[23] This reflects the evidence available from the ESO's latest tourism statistics.

[24] This is estimated as a percentage of recreational visitors to the Cayman Islands.

	Scenario 1	Scenario 2	Scenario 3
% overnight air visitors "diving" at GTH switching to other activities in the Cayman Islands	70%	55%	45%
% overnight air visitors "diving" at GTH not visiting the Cayman Islands	5%	10%	10%
Change in spending resulting from overnight air visitors "diving" at GTH changing behaviour			
Switching to "diving" elsewhere in the Cayman Islands ($ per passenger)	$0	$0	$0
Switching to other activities in the Cayman Islands ($ per passenger)	$45	$100	$250
Not visiting the Cayman Islands ($ per passenger)	$1,250	$1,250	$1,250

Source: PwC analysis

In practice, as with cruise passengers, there is only very limited evidence that can be used to inform the key assumptions needed to estimate the potential impacts of the CBF. Nonetheless, as an illustration of their effects on the net impact, we show the implications of the key assumptions on the net impact estimates (see Table 18):

- Scenario 1 leads to the smallest impact on spending ($0.33 million per annum);
- Scenario 2 leads to an impact on spending of ($3.44 million per annum); and
- Scenario 3 leads to the largest impact on spending ($10.95 million per annum), over thirty times the impact in Scenario 1.

Table 18

Scenario based analysis of potential impact of CBF on cultural services arising from overnight air visitors (based on 2013 arrivals)

	Scenario 1	Scenario 2	Scenario 3
Number of overnight air visitors stating "diving" main reason for visit	19,342	19, 342	19,342
Number of overnight air visitors "diving" but not main reason for visit	12,434	37,303	62,172
Number of overnight air visitors "diving" at GTH - main reason for visit	1,692	5,803	9.671
Number of overnight air visitors "diving" at GTH – "diving" but not main reason for visit	1,088	11,191	31,086
Number of overnight air visitors "diving" at GTH – total	2,780	16,994	40,757
"To dive" - main reason for visit			
Number of overnight air visitors			
Continuing to "dive" at GTH	85	-	-
Switching to "diving" elsewhere in the Cayman Islands	1,185	4,062	5,319
Switching to other activities in the Cayman Islands	169	290	484
Not visiting the Cayman Islands	254	1,451	3,868
Change in spending resulting from overnight air visitors changing behaviour			
Switching to "diving" elsewhere in the Cayman Islands ($m)	$0	$0	$0
Switching to other activities in the Cayman Islands ($m)	$0.01	$0.03	$0.12
Not visiting the Cayman Islands ($m)	$0.32	$1.81	$4.84
Total ($m)	$0.32	$1.84	$4.96
"To dive" - not main reason for visit (but may be factor)			
Number of overnight air visitors			
Continuing to "dive" at GTH	54	-	-
Switching to "diving" elsewhere in the Cayman Islands	218	3,917	13,989
Switching to other activities in the Cayman Islands	762	6,155	13,989
Not visiting the Cayman Islands	54	1,119	3,109
Change in spending resulting from overnight air visitors changing behaviour			
Switching to "diving" elsewhere in the Cayman Islands ($m)			
Switching to other activities in the Cayman Islands ($m)	$0.03	$0.62	$3.50
Not visiting the Cayman Islands ($m)	$0.07	$1.40	$3.89

	Scenario 1	Scenario 2	Scenario 3
Total ($m)	$0.10	$2.01	$7.38

Source: PwC analysis

Summary

The final part of this section draws together the evidence from the previous parts of the section to assess the potential implications for the overall impact of the CBF.

Table 19 summarises the expected annual change in spending and value added arising from the changes in behaviour assumed in each of the three scenarios. Value added is assumed to be 65% of the change in spending[25]. The change in value added, which ranges from $1.5 million to $18.5 million, is a measure of the impact of the CBF on the cultural services provided each year by the GTH reefs.

Table 19

Expected change in spending and value added in the Cayman Islands from effect of CBF ($m)

	Scenario 1	Scenario 2	Scenario 3
Total change in spending of cruise passengers resulting from changing behaviour	$1.82	$4.85	$16.13
Total change in spending of air passengers resulting from changing behaviour			
"Diving" main reason	$0.32	$1.84	$4.96
"Diving" reason (but not main reason)	$0.10	$2.01	$7.38
Total change in visitor spending	$2.25	$8.71	$28.46
Cruise passengers	$1.18	$3.15	$10.48
Overnight air visitors	$0.28	$2.51	$8.02
Total change in value added	$1.46	$5.66	$18.50

Source: PwC analysis

As with other parts of the OBC, the annual impact needs to be converted into a NPV over the expected lifetime of the project (20 years) using a discount rate of 3½%. For simplicity, we assume that the impact increases in line with the projected growth of cruise passengers (i.e. 1% per annum). The resulting estimates are shown in Table 20.

Table 20

Estimated change in GVA arising from visitor spending ($m, NPV @1% growth over 20 years with 3½% discount rate)

	Scenario 1	Scenario 2	Scenario 3
Cruise passengers	$18.31	$48.77	$162.16
Overnight air visitors	$4.30	$38.78	$124.09
Total	$22.60	$87.56	$286.25

Source: PwC analysis

Just as Table 20 provides estimates of the potential impact of the CBF on cultural services over the project lifetime, it is also necessary to express the impacts on other ecosystem services on the same basis. Table 21 summarises the resulting estimates based on the economic losses in Table 14.

Table 21

Estimated economic costs of loss of reefs in GTH under Options A, B and C ($m, NPV @1% growth over 20 years, 3½% discount rate)

	Provisioning services	Regulating services	Supporting services
Option A	$0.16 – $0.19	$18.46 – $40.60	$3.33 – $3.83
Option B	$0.04	$4.86 – $9.29	$0.88

[25] This is the same assumption as the one used elsewhere in the OBC.

	Provisioning services	Regulating services	Supporting services
Option C	$0.15 – $0.17	$16.65 – $37.15	$3.01 – $3.51

Source: PwC analysis

Implications for OBC – net impact of the CBF

The final step in the analysis is to integrate the estimated environmental impact into the analysis of the economic impact of the CBF in the OBC. The OBC, it will be recalled, assesses the economic impact of the CBF by comparing the impact on value added estimated with the CBF and the corresponding impact without the CBF.

The results are presented in Table 22 which compares the two scenarios. The incremental economic benefit of the CBF is estimated to be an increase in value added of $245 million when expressed in NPV terms over the lifetime of the investment (20 years post construction). The environmental costs are estimated to range from £42 million to $327 million. This means the net impact of the CBF ranges from a benefit of $203 million to a cost of $72 million.

Table 22

Net economic and environmental impact of CBF ($m, NPV)

	With CBF	Without CBF	Net impact	
Economic				
Direct	18	85	-67	
Indirect & induced	14	2	11	
Wider	2,148	1,905	242	
Tax revenue	347	288	59	
Total economic	2,526	2,281	245	
Environmental - ecosystem services			**Low Impact**	**High Impact**
Cultural services			-23 (Scenario 1)	-286 (Scenario 3)
Provisioning services			-0 (Option C)	-0 (Option A)
Regulating services			- 17 (Option C)	-37 (Option A)
Supporting services			-3 (Option C)	-4 (Option A)
Total environmental			-42	-327
Total economic and environmental			**213**	**-72**

Source: PwC analysis

Sensitivity analysis

The OBC also tested the sensitivity of the estimated economic impact to the key assumptions that underpin them. Table 23 summarizes the four key sensitivities that were tested. It shows the assumptions made in the base case, the sensitivities that were tested and the reasons why the sensitivities were felt to be appropriate.

Table 23

Summary of key sensitivities

Sensitivity	Base case assumption	Sensitivity tested	Reason for sensitivity analysis
Level of cruise passenger number growth	1%, with CBF/-1% without CBF	3%, with CBF/-3% without CBF	The base case with the CBF assumes that cruise passenger numbers in the Cayman Islands grow at 1% per annum and fall at 1% per annum without the CBF. The sensitivity considers the impact if the rate of change is 3% and -3% respectively.
Disembarkation rates – cruise passengers	92% with CBF/90% without CBF	90% with and without CBF	The base case assumes that the rate of disembarkation of cruise passengers at the Cayman Islands increases by 2% following the development of the CBF, principally reflecting the reduced disembarkation and embarkation times. The sensitivity considers the impact if there is no change in the rate of disembarkation.

Sensitivity	Base case assumption	Sensitivity tested	Reason for sensitivity analysis
Disembarkation rates – crew	44% with CBF/37% without CBF	37% with and without CBF	The base case assumes that the rate of disembarkation of crew at the Cayman Islands would increase by 7% following the development of the CBF. The sensitivity considers the impact if there is no increase in disembarkation.
Cruise passengers taking tours	65% with CBF/54% without CBF	54% with and without CBF	The base case assumes that 65% of cruise passengers take tours with the development of the CBF compared to 54% if it is not developed. This is assumed to increase average spending per head. The sensitivity considers the impact if there is no change in the take up of tours.

Source: PwC analysis

Table 24 summarizes the results of the sensitivity analysis. The second column describes the base case and the subsequent columns to the right show the results of each sensitivity considered. The results shown are the change in the expected NPV of the economic impact as a result of the sensitivity. The rows below show the economic value of the potential loss of ecosystem services under each of the three design options considered in the EIA.

The key points to note are that:

- Variation in cruise passenger growth rates will have the most significant impact: if passenger volumes grow at 3% per annum with a CBF whereas they fall at 3% without the facility, the benefits increase compared to $1,196m.
- The results are less sensitive to the proportion of cruise passengers who disembark from cruise ships arriving in the Cayman Islands. Without any change in the disembarkation rate, the benefits are $34 million lower at $211 million.
- Similarly, if the proportion of crew members coming ashore remains unchanged, the expected benefits are $26 million lower.
- Finally, if the longer time passengers can spend ashore does not affect the take up of tours (and per capita visitor spending as a whole), the benefits are reduced to $176 million, a fall of $69 million.

Table 24

Impact of key sensitivities on expected GVA ($m, NPV)

Sensitivity	Base case	Level of cruise passenger number growth	Disembarkation rates – cruise passengers	Disembarkation rates – crew	Cruise passengers taking tours
Net economic impact	245	1,196	211	219	176
Potential loss of ecosystem services					
Option A	45-331	45-331	45-331	45-331	45-331
Option B	28-296	28-296	28-296	28-296	28-296
Option C	42-327	42-327	42-327	42-327	42-327
Overall net impact					
Option A	-86 - 200	865 - 1,151	-120 - 166	-112 - 174	-155 - 131
Option B	-51 - 217	900 - 1,168	-85 - 183	-87 - 189	-120 - 148
Option C	-72 - 203	869 - 1,154	-116 - 169	-108 - 177	-151 - 134

Source: PwC analysis

Conclusions

This addendum to the OBC, has been prepared in order to incorporate the findings of the EIA conducted by Baird into the economic appraisal of the project undertaken as part of the OBC. In particular, the EIA identified a significant level of potential damage to the reefs in GTH, which must be considered when assessing the overall cost-benefit of the project.

As requested by CIG, the analysis in this addendum is based solely on the information collated by Baird in its EIA, together with the economic and financial information analysed during the original OBC development. The focus has been on expressing the estimated impacts in economic terms using measures of economic output, as measured by GVA, and economic welfare. As such, the approach is consistent with guidance on economic appraisal as outlined in the Green Book.

In order to make Baird's work comparable with the OBC, it has been necessary to extend the analysis, principally through the following modifications:

1. We have adjusted for the potential diversion or displacement of economic activity associated with the GTH reefs (i.e. water-based activities such as diving) either to other locations in the Cayman Islands (as visitors opt to "dive" elsewhere in Cayman) and/or to other activities (including attractions in George Town and around Grand Cayman Island): the EIA only considers the impact in George Town;
2. We have adjusted the estimated economic losses from changes in spending to reflect the impact on Gross Value Added (GVA) in the Cayman Islands, not the level of spending: GVA is the measure of the contribution to national economic output used in economic appraisal;
3. We have included an adjustment to incorporate the multiplier effects arising from the impacts in the Cayman supply chains which meet the needs of visitors' spending and their employees; and
4. We have avoided potential double counting of impacts already included in the economic impact assessment (e.g. the adverse impact on tendering services).

As illustrated in Table 20, the estimated economic costs associated with the damage to the reef vary significantly depending on which of the three scenarios examined is being considered. Essentially, the level of impact is driven by the number of visitors to the Cayman Islands who participate in "diving" and their behaviour in response to any damage to the reefs in GTH. The most important variables are:

1. How many visitors to GTH participate in "diving"?
2. Will they choose to "dive" elsewhere in Grand Cayman? Or,
3. Will they engage in other activities, such as shopping, which will partly compensate for lost spend on "diving"? Or,
4. Will they choose not to come to the Cayman Islands (in the case of overnight air visitors) or choose not to disembark from the cruise ship (in the case of cruise passengers)?

These questions are fundamental to the economic rationale of the CBF.

As illustrated by Table 22, under the lowest impact scenario for ecosystem services (Scenario 1), the economic impact of the damage to the reefs has only a minimal impact on the overall net economic benefit, which is estimated at $204 million after taking into account the expected losses associated with damage to the reefs. However, under the highest impact scenario for ecosystem services (Scenario 3), the economic impact of the damage to the reefs more than outweighs the economic benefits of the CBF in the base case.

Accordingly, in Scenario 3, if "divers" are on the scale envisaged and respond in the ways outlined to the loss of parts of the reef, then the costs of the CBF would exceed its economic benefits.

We note, however, that the assumptions about the rate of growth of cruise passenger volumes which underpin the base case in the OBC are relatively conservative. As outlined in the sensitivity analysis summarised above in Table 24, if the rate of growth of cruise passengers increases to 3% per annum with the CBF, then the economic benefits would more than outweigh the economic impact of the loss of the reef. However, the poor quality of the data currently available means that this upside scenario should not be relied upon for the overall assessment of the costs and benefits of the CBF.

As such, the current data which underpin the economic and environmental impacts, including the marine resource valuation, are inconclusive and do not provide the basis for drawing a definitive conclusion about whether or not to proceed with the CBF.

Prior to continuing with the CBF project it would, therefore, be valuable to develop a more detailed understanding of the scale of the impacts put at risk by the CBF and the anticipated behaviour of "divers" in

response to loss of parts of the GTH reefs. This could be conducted through a detailed survey of tourists, combined with questionnaires / interviews with dive, water sports and other leisure industry operators. It will also be important to consider the ways in which the potential adverse impacts can be mitigated.

Supplement

Introduction

Since the original draft of the Addendum was prepared, the Ministry of District Administration, Tourism and Transport commissioned BREA to analyse the potential impact of the development of the proposed CBF in George Town harbour on the pattern of cruise passenger onshore visits and spending[26].

BREA's report in September 2015 contains data and analysis which are more up to date than those available at the time of the preparation of the OBC in October 2015 and the Addendum to the OBC which assessed the economic implications of the environmental impacts in June - July 2015, building on the earlier EIA.

The purpose of this part of the Addendum is to summarise the key conclusions of the BREA analysis and explain their implications for the findings of the OBC and the Addendum.

Implications of BREA analysis for OBC

The BREA report provides:

- Updated data on the volumes of cruise passengers and their spending in Grand Cayman – the data relate to 2014, whereas the OBC and the Addendum draw on earlier data from 2012;
- A comparison of trends in cruise passenger arrivals in Grand Cayman with four other cruise destinations in the Caribbean (the Bahamas, Cozumel, the US Virgin Islands and St Maarten); and
- A set of three scenarios which project the potential future pattern of cruise passenger spending in Grand Cayman.

The report's findings show that:

- The baseline level of cruise passengers in Grand Cayman in 2014 was 1.61 million with nearly 90% of passengers coming ashore on visits: this is lower than assumed in the baseline for the OBC (1.82 million in 2014) but more than in the EIA (1.38 million in 2013).
- The average spend per passenger coming ashore in 2014/2015 – the date of the BREA's latest survey – is $115.60, which is 23% more than was assumed in the OBC (which used $93.70, as reported for 2012).

Together, these findings mean that the total cruise passenger spend is now estimated to be:

- Around 10% higher than in the baseline for the OBC ($167.5 million in 2014/2015 – assuming 90% of passengers come ashore - compared to $153.5 million in 2014).
- Nearly 30% higher than in the baseline for the EIA ($167.5 million in 2014/2015 compared to $129.3 million in 2012/2013).

For the purposes of our analysis, we focus on incorporating only the difference in the average spend per passenger since the estimate in the BREA report is a direct update of the data originally used in the economic impact assessment as part of the OBC and the Addendum. The position with respect to passenger volumes is more complex.

The BREA report also provides some analysis of the key differences in the pattern of cruise passengers (and their behaviour) in Grand Cayman compared to the four other smaller cruise destinations in the Caribbean. It shows that over the last 5-10 years, the growth in cruise passenger arrivals in Grand Cayman has significantly lagged the growth in the three destinations with berthing piers (i.e. excluding the Bahamas). In addition, cruise passengers spend less time ashore in Grand Cayman than in any of the three destinations with berthing piers. Linked to this, cruise passengers visiting Grand Cayman spend less on average per passenger and per hour while ashore than in any of the three destinations with piers.

[26] 'Grand Cayman Cruise Berthing Facility: Potential Impact of Cruise Passenger Onshore Visitation and Spending', BREA, September 2015.

On this basis, BREA conclude that it is reasonable to assume that, following the development of the CBF, cruise passengers will be able to spend more time ashore since the need to tender will be eliminated. As a result, average and total spend during the visit will increase and be more in line with spending rates in the other three destinations with berthing piers.

The research also provides stronger evidence to support an assumption that the CBF would boost cruise passenger volumes in the Cayman Islands as it regains lost market share. Overall, the analysis points to the Cayman Islands being able to grow the volume of cruise passengers it receives faster than the conservative assumption made in the OBC (1% growth with the CBF compared with 1% decline without the CBF).

Reflecting these findings, the BREA report develops and assesses the implications of six different scenarios for cruise passenger spending in the Cayman with the CBF. One set of three options assumes different uplifts in passenger spending. The other three also allow for a 5% uplift in cruise passenger volumes. The impact on total spending is summarised in Table 25. It shows that the BREA report anticipates that cruise passenger spending could rise by 15-74% over the higher baseline level of spending.

Table 25

Potential impact of CBF on cruise passenger spending (% increase from baseline)

	No change in volume of passengers	5% increase in passenger volumes
Low impact – based on more time ashore	15%	21%
Medium impact – based on more time ashore and higher spending per hour	30%	36%
High impact – based on spending in Cayman reaching level of St Maarten	65%	74%

Source: BREA

It is also important to note the limitations of the scope of the BREA analysis since it does not:

- Consider how cruise passengers would change their spending in response to the CBF's impact on the reef;
- Examine how cruise passenger volumes and spending would change in the absence of the CBF - there is an assumption that it would remain unchanged (like our analysis), but the analysis of the benefits that other locations enjoy suggest this may be optimistic; and
- Assess the potential effects on non-cruise visitors to the Cayman Islands.

All of these also have a bearing on the anticipated impacts of the CBF but none is addressed by the BREA report.

Effect of additional data on key results

The final part of this note analyses the implications of incorporating the BREA data and analysis into both the economic and environmental impact assessments to gauge the net economic impact of the CBF.

The results of the original economic analysis are presented in Table 26 which compares the two scenarios with and without the CBF. The incremental economic benefit of the CBF was originally estimated to be an increase in value added of $245 million when expressed in NPV terms over the lifetime of the investment (20 years post construction). Table 26 also shows the updated results which draw on the new evidence in the BREA report.

Specifically, we show the impact of adjusting the estimated economic impact for the higher average passenger spend shown in the BREA report (but keeping the estimated passenger volumes the same as in the OBC). This change increases the wider economic impact with and without the CBF. Given the BREA report provides no assumptions for long term volume of passengers, no adjustment in this respect has been possible and the baseline OBC assumptions have been retained.

The net impact is now estimated to be higher: $487 million following the spend change. The majority of the change is attributable to the effect on the wider economic impact.

Table 26

Net economic impact of CBF ($m, NPV)

	Original OBC			Updated to include latest BREA spend data		
	With CBF	Without CBF	Net impact	With CBF	Without CBF	Net impact
Direct	18	85	-67	16	75	-60
Indirect & induced	14	2	11	14	2	12
Wider	2,148	1,905	242	2,559	2,082	477
Tax revenue	347	288	59	347	288	59
Total economic impact	2,526	2,281	245	2,936	2,449	**487**

Source: PwC analysis

The results in Table 26 are also sensitive to the expected change in spend per passenger that could result from the development of the CBF. The BREA considers various scenarios for the potential impact (see Table 25). If these are factored into the analysis, the estimated economic benefits of the CBF increase sharply: for example, a 15% increase in passenger spend would increase the total economic impact to about $749 million whilst a 74% increase would push the total economic impact to around $2,105 million. This analysis assumes that baseline passenger volumes are those used in the OBC.

Table 27

Estimated economic impact of CBF under each of BREA scenarios ($m, NPV)

	No change in volume of passengers	5% increase in passenger volumes
Low impact – based on more time ashore	749	889
Medium impact – based on more time ashore and higher spending per hour	1,094	1,332
High impact – based on spending in Cayman reaching level of St Maarten	1,899	2,105

Source: BREA

The results of the economic analysis of the environmental impacts first presented in the Addendum are shown in Table 28 which assesses two scenarios with and without the CBF. The environmental costs were originally estimated to range from $28 million ('low' environmental impact) to $331 million ('high' environmental impact). After revisions to take account of the higher average passenger spending in the BREA report, the costs increase to $34 million to $378 million respectively. The changes are attributable to the effects on the value of cultural services, which derive from the value of diving and other water based activities affected by the impacts on the reef.

As a result, the net benefit of the CBF now ranges from $109 million to $453 million, before taking into account the additional benefits from BREA's assumed increases in spend per passenger, which are illustrated in Table 27 above. This compares with the original range of a benefit of $213 million to a cost of $72 million.

Table 28

Net environmental impact of CBF ($m, NPV)

	Addendum		Updated to include latest BREA spend data	
	Net impact		Net impact	
Environmental - ecosystem services	**Low Impact**	**High Impact**	**Low Impact**	**High Impact**
Cultural services	-23 (Scenario 1)	-286 (Scenario 3)	-28	-334
Provisioning services	-0 (Option C)	-0 (Option A)	-0 (Option C)	-0 (Option A)
Regulating services	-17 (Option C)	-37 (Option A)	-17 (Option C)	-37 (Option A)
Supporting services	-3 (Option C)	-4 (Option A)	-3 (Option C)	-4 (Option A)
Total environmental	-42	-327	-48	-375
Total economic and environmental	**213**	**-72**	**439**	**112**

Source: PwC analysis

Conclusions

This supplement to the Addendum to the OBC has been prepared in order to incorporate the findings of the BREA report into the economic appraisal of the project undertaken as part of the OBC (including the environmental impacts identified through the EIA).

As requested by CIG, the analysis is based solely on the information provided in the BREA report together with the economic and financial information analysed during the original OBC development and the information from the EIA used in the Addendum. As before, the focus is on expressing the estimated impacts in economic terms using measures of economic output, as measured by GVA, and economic welfare. This approach is consistent with guidance on economic appraisal as outlined in the Green Book.

Table 28 shows that the estimated economic benefits of the CBF now exceed the environmental costs associated with the damage to the reef under the 'low' and 'high' environmental impact scenarios. Further, if BREA's scenarios for increased spend per passenger with the CBF are taken into account, the net benefits increase substantially.

The impact of the CBF is still driven by the number of visitors to the Cayman Islands who participate in "diving" and their behaviour in response to any damage to the reefs in GTH. These questions are fundamental to the economic rationale of the CBF.