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NEW ZEALAND INSTITUTE OF ECONOMIC RESEARCH

Effects of the Parnell sinkhole on Hauraki Gulf ecosystem services

NZIER report to Hauraki Gulf Forum

December 2023

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Key points

The report was commissioned to assess the impact of the Parnell sinkhole on the Hauraki Gulf's ecosystem services.

- The Hauraki Gulf Forum commissioned NZIER to assess the effects of a major sewage infrastructure failure in Parnell, Auckland, on access to and the value of ecosystem services derived from the Hauraki Gulf.
- This research aims to estimate the costs of the effects of the sewage system failure in terms of human access to the ecosystem services of the Hauraki Gulf.

This report builds on and implements the findings of the valuation of the ecosystem services associated with the Hauraki Gulf (NZIER 2023)

- This report builds on and implements the findings of NZIER's previous analysis, *Valuing the Hauraki Gulf: An ecosystem services and natural capital approach*.
- Ecosystem services associated with the Hauraki Gulf have an estimated total economic value of $5.14 billion per year.
- $1.75 billion is explicitly measured in GDP, and $3.39 billion is a value not measured in GDP, such as avoided costs and expressions of public preference for activities like recreation in water of suitable quality.
- The estimates of some potential value sources are incomplete, given data limitations, so the overall estimate is likely to understate the total economic value of the Gulf's ecosystem services.
- Our approach has been to identify, quantify and monetise the effects on ecosystem services in accordance with Treasury's general guidelines for assessment.

The total estimated cost of the sinkhole valued based on estimated lost access to ecosystem services ranges from between $50.9 million and $166.6 million over up to 50 days

- Table 1 summarises the results by category of ecosystem service.
- The estimates are based on a range of scenarios for the extent and duration of the effects.
- The implicit assumption is the effects are temporary and, in all cases, the environment will be able to recover.
- This window of consideration includes the 50 days from the sinkhole collapsing and the rāhui being lifted.
- The largest effect was on cultural services, which included recreation benefits.
- The average cost per day was between $1.02 million and $3.33 million.

Table 1 Summary results

Millions, based on a duration of impacts of up to 50 days

Ecosystem services	Lower estimate	Upper estimate	Proportion of the upper estimate
Provisioning services	$5.2	$12.9	7.7%
Cultural service costs	$44.0	$148.0	88.8%
Regulation and supporting services costs	$1.7	$5.7	3.4%
Total loss in ecosystem services	$50.9	$166.6	100.0%

Source: NZIER

The loss of provisioning services was estimated to be from $5.2 million to $12.9 million

- The estimated loss of value from recreational fishing ranges from $5.2 million to $12.9 million.
- Residents were advised by the Ministry of Primary Industries not to fish in the affected areas for the period of the overflow and for up to 28 days after.
- Other provisioning services were not affected by the waste from the sinkhole.

The loss in access to cultural services reflected in recreational activities was estimated to be from $44 million to $148 million

- Recreation services were the only quantified cultural service to be identified as affected by the sinkhole.
- The loss of recreation services for people in Auckland was found to have a non-market value of $44 million to $148 million.
- Many water-based community events, such as boating events and cliff diving competitions, were cancelled as a result. This estimate does not include the costs of rescheduling these activities and the flow-on effects of related consumption spending, as this spending may have been diverted to other forms of recreation and entertainment.

The loss in regulation and supporting services costs services was estimated to be between $1.7 million and $5.7 million

- The experience of a decline in water quality will vary across the community and in terms of duration.
- The experience of a decline in water quality will vary across the community and in terms of duration. If the Auckland community experiences a loss in water quality for between 30 and 50 days, then the cost attributed to a loss of water quality services is between $1.7 million and $5.7 million.

Comparison to public investment in waste management infrastructure

We suggest viewing the Central Interceptor costs approach as a basic value measure, which may account for wider public values and non-market effects to an indeterminate degree. This value should be viewed alongside the compilation of other sources of value from the *Value of the Hauraki Gulf* report, estimated as proportional to the wastewater leakage's scale, spread and duration of detriment in the harbour's availability for ecosystem services. If the estimates of the spill's impacts made with other values exceed the Interceptor-based value, that suggests a portion of public value is over and above that implied by the Interceptor investment decision.

Table 2 The value of daily leaks in terms of the value of reducing pollution

	Units	Low estimate	Medium estimate	High Estimate
Value of reducing sewage leaks	$/m^3	$28.36	$32.97	$38.37
The leak from the sinkhole damage	Litres/day	8,000,000	8,000,000	8,000,000
Value of reducing sewage leaks	$/ day	$ 226,893	263,780	$306,960

Source: NZIER

Conclusion

- This assessment of the cost of the sinkhole on the access to services provided by the Hauraki Gulf, and to estimate the value of the service provided by the Gulf in assimilating the waste, is the first test case of the natural capital valuation work done earlier in 2023.
- It is conservative in nature and limited in scope but demonstrates that such incidents have costs far beyond their immediate repair.
- This, in turn, provides further rationale for investment in resilient infrastructure to reduce the likelihood of further adverse effects and costs in future.

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1 About the report

On 27 September 2023, a sinkhole ruptured and blocked a sewage pipe in Parnell, allowing wastewater to spill into stormwater pipes and the harbour. On 29 September, the New Zealand Herald reported that more than 8 million litres of sewage were entering Waitemata Harbour due to the Parnell sinkhole and a sewer pipe failure (Franks, 2023).

The Hauraki Gulf Forum commissioned NZIER to assess the effects of a major sewage infrastructure failure in Parnell Auckland on access to and the value of ecosystem services derived from the Hauraki Gulf. Understanding this is important because infrastructure failures can have wide-ranging effects that are not always factored into investment decisions.

This report builds on and implements the findings of NZIER's previous analysis, *Valuing the Hauraki Gulf: An ecosystem services and natural capital approach* (NZIER 2023).

1.1 Research aim

This research aims to estimate the costs of the effects of the sewage system failure in terms of human access to the ecosystem services of the Hauraki Gulf.

1.2 Scope of the research

The scope was limited to desktop research to estimate the impact using existing information.

The following tasks were in scope: using data and contacts from the previous study, information gathered from Auckland Council, media, and other organisations involved in dealing with the situation.

The following tasks were out of scope: primary data gathering, surveys or interviews, and any assessment of the risk and likely effects of future infrastructure failures.

1.3 Funding statement

This research was funded by the Hauraki Gulf Forum and independently completed by NZIER.

1.4 Structure of the report

The structure of the report is as follows:

- about the report
- research methodology
- previous findings
- inputs and assumptions
- results and discussion.

2 Research methodology

The assessment of the costs imposed on the access to and provision of the ecosystem services from the Hauraki Gulf draws on the valuation of those ecosystem services by NZIER (2023).

The costs of the sinkhole are defined as the lost access to or the presence of the benefits of the ecosystem services. Our approach has been to identify, quantify and monetise the effects on ecosystem services in accordance with Treasury's general guidelines for assessments (Treasury NZ 2015).

2.1 A summary of the prior research on the value of ecosystem services

NZIER's prior research brief was to estimate the economic value provided by the Hauraki Gulf's functioning natural ecosystems, which is informative for a range of assessments about how to consume, manage, conserve and protect the natural environment. It was intended to ensure that marine ecosystems are correctly valued in decisions simply because their environmental damage has been inadequately recorded and actual value has not been sufficiently quantified.

The ecosystem services approach adopts a natural capital perspective on the services provided by the Hauraki Gulf environment. From this perspective, natural capital is a monetary expression of the value streams obtainable over time from healthy functioning ecosystems. This is a 'hidden value' that needs to be made explicit, using both the ecosystem services approach to identify and quantify value streams and the total economic value on the approach to monetary valuation, covering both market and non-market values. Market values are based on the goods and services traded in the market. In contrast, non-market values reflect the value of the natural environment to society beyond transactions for goods and services.

The ecosystem services approach categorises the benefits people obtain from the natural environment into provisioning, cultural, regulating, and supporting services.

- Provisioning services include the supply of wild food, timber, sources of energy and water.
- Regulating services include flood mitigation, erosion control, and water quality.
- Supporting services include basic processes like nutrient cycling or pollination, on which all other services depend. However, supporting services are rarely subject to separate estimation because of their interconnection with other services and the risk of double counting.
- Cultural services include providing settings for recreation and non-use or passive nature appreciation – simply knowing that species like Maui's dolphin exist or that sites with heritage associations will remain for future generations.

Of these categories of services from the environment, only the provisioning services are currently counted as contributing to gross domestic product (GDP).

The key findings were:

- Ecosystem services associated with the Hauraki Gulf have an estimated total economic value of $5.14 billion per year.
- $1.75 billion is explicitly measured in GDP, and $3.39 billion is a value not measured in GDP, such as avoided costs and expressions of public preference for activities like recreation in water of suitable quality.
- The estimates of some potential value sources are incomplete, given data limitations, so the overall estimate is likely to understate the total economic value of the Gulf's ecosystem services.

Table 3 shows the previous estimates of the value of the ecosystem services from the Hauraki Gulf using the categories of the ecosystem services approach discussed above and the subcategories of services that were valued. The regulatory and supporting services have been combined into a joint category. This is a common response due to the practical risk of double counting and the difficulty separating the two services.

Table 3 Central estimates of ecosystem services from the Hauraki Gulf

Per year in 2023 dollars

Ecosystem service category	Central estimate ($m)
Provisioning services	
Ports and shipping	$1,340.0
Cruise tourism	$292.0
Aquaculture	$83.3
Commercial fishing	$29.8
Recreational fishing	$187.8
Sand extraction	$5.0
Total provisioning services	**$1,937.9**
Cultural services	
Recreation	$2,493.0
Property value uplift	$526.1
Total cultural services	***$3,019.1***
Regulating and supporting services	
Water quality	$96.0
Biodiversity health	$89.8
Carbon sequestration	$2.5
Total regulating and supporting services	***$188.3***
Total economic value of the Hauraki Gulf ecosystem	***$5,145.3***

Source: NZIER

2.2 Our approach to assessing the cost of the sinkhole on access to Gulf ecosystem services

As indicated earlier, the assessment of the cost of the sinkhole draws on the previous assessment of the value of the Hauraki Gulf ecosystem services. The approach to assessing the costs of the sinkhole is outlined in Table 4. This approach provides a systematic and consistent evaluation of the costs.

Table 4 Research approach

Step	Description
1.	Identify which services are affected by the sinkhole
2.	Calculate the daily values of ecosystem services from our previous report
3.	Determine the degree of effect in percentage terms 0%–100%
4.	Estimate the duration of the effect in terms of the number of days
5.	Calculate total effect (services effected x degree of effect x duration)
6.	Discuss other observations or considerations pertinent to this assessment based on what is known at the time of the assessment.

Source: NZIER

Steps 1 to 5 are a quantitation assessment based on the previous work, and then the last step is relevant and contextual for the assessment of the cost.

This approach to the assessment aims to capture the extent of the impact of the sinkhole and the duration aspect of the effects. The implicit assumption is the ultimate environmental effects are not lasting, and the environment will recover. This window of consideration includes the 50 days from the sinkhole collapsing and the rāhui being lifted.

Arriving at a precise estimate is impossible due to the inability to gather the full information set required for that level of precision. Therefore, the assessment is based on the available evidence and credible evidence for making assumptions where they are necessary to overcome information gaps.

The discussion of these steps is grouped according to the ecosystem service categories used in the assessment and presentation of the value of the Hauraki Gulf benefits in NZIER (2023):

- provisioning services
- cultural services
- regulation and supporting services.

3 The effect on provisioning services

Provisioning services linked to the Hauraki Gulf include shipping, cruise ship tourism, aquaculture, commercial fishing, recreational fishing, and sand extraction.

3.1 Identifying the affected provisioning services

The logic for determining which provisioning services were affected or unaffected by the sinkhole effects is discussed in Table 5.

The only provisioning service that was affected by the sinkhole was recreational fishing. Much of the provisioning services happen far away from the outlets of untreated waste. In effect, distance and the scale of the Hauraki Gulf were protective factors because waste monitoring showed that the solid waste was not travelling far from the outlet.

Table 5 Effected and unaffected provisioning services

Service	Status	
Ports and shipping	**Unaffected**	Ports and shipping continued without deviation from normal business.
Cruise tourism	**Unaffected**	Cruise ships did not alter schedules because of the sinkhole.
Aquaculture	**Unaffected**	Aquaculture activities in the Hauraki Gulf are undertaken far from the waste outlet, and that distance was protective.
Commercial fishing	**Unaffected**	Like aquaculture, commercial fishing activities in the Hauraki Gulf are undertaken far from the waste outlet, and that distance was protective.
Recreational fishing	**Affected**	Recreational fishing was affected by both perceptions of the adverse effects of untreated waste and the risk of health consequences.
Sand extraction	**Unaffected**	Sand extraction was unaffected because it happens far from the untreated waste outlet.

Source: NZIER

3.2 The cost of limiting access to recreational fishing in the Hauraki Gulf

The value of recreational fishing as a provisioning service of the Hauraki Gulf was estimated to be $187.8 million per year. That is equivalent to an average value of $515,000 per day. Recreational fishing activity is strongly linked to the provision of seafood, and the effects of the sinkhole, water quality impacts and health safety risks are likely to have had a material impact on the level of recreational fishing, even if anglers can potentially go further out into the Hauraki Gulf.

There were 50 days from the collapse of the sinkhole occurrence on 27 September 2023 to when the Rāhui was lifted on 17 November 2023 (Radio New Zealand 2023b). Table 6 shows estimates of the costs of the sinkhole based on scenarios depending on the following factors:

- The number of days that recreational fishing was affected by the sinkhole
- Residents were advised by the Ministry of Primary Industries not to fish in the affected areas for the period of the overflow and for up to 28 days after.
- Percentage of recreational fishing affected.
- The average value of recreational fishing per day.
- The effect was mainly limited to between the Waitematā out to the inner islands.

The estimated loss of value from recreational fishing ranges from $5.2 million to $12.9 million.

Table 6 Recreational fishing cost scenarios

Millions

Days	Percentage of fishing affected	Costs of loss fishing benefits
40	25%	$5.2
50	50%	$12.9

Source: NZIER

4 The effect on cultural services

In the previous report, the assessment of cultural ecosystems services was able to quantify the value of two subcategories of services:

- recreation services
- property amenity services

4.1 Identifying the affected cultural services

The consequences of the sinkhole included the closure of many beaches for several weeks, foul odours near the water, sewage on the beaches and visible sewage in the water. The effect was the loss of the benefits of in-water activities in some areas and disincentives to engage in land-based activities besides the water.

Property amenity services were not affected because the adverse conditions were short-term and temporary.

4.2 The cost of limiting access to recreation around the Hauraki Gulf

In 2023, the value of recreation services linked to the Hauraki Gulf was estimated to be $2.5 billion. That is equivalent to an average daily service value of $6.8 million per day. Residents were advised by Safeswim not to swim in the affected areas.

A key consideration is also the affected population. Around 750,000 people in Auckland access water-based recreation in the Gulf annually. Based on use surveys and population estimates (Horizon Research 2021; Statistics NZ 2022; Sport New Zealand 2019), this represents 87 percent of active users from the wider Hauraki Gulf area. This means the average daily value of recreation exposed to a loss of service is $5.92 million.

To estimate the loss of access to recreation services, some scenarios were developed based on varying assumptions on the following factors:

- The duration of limitations to access recreation services
- The recreation affected by barriers to access to recreation services
- Cost of no access to recreation services per day.

An evaluation of swimming in Auckland showed that poor water quality was a factor in the decision not to swim for 53 percent to 59 percent of respondents (Rangsivek, Katja et al. 2019).

To be conservative, it has been assumed that there was a 25 percent to 50 percent loss in all[1] Hauraki Gulf-based recreation services in Auckland for between 30 and 50 days.

Table 7 shows the estimated loss in recreation services in Auckland depending on the duration and extent of the effects. The estimated cost of the sinkhole for recreation services in Auckland is from $44 million to $148 million.

Table 7 Cost estimates due to lost access to recreation services

Millions

Duration (Days)	Proportion of access to services lost	
	25%	**50%**
30	$44	$89
40	$59	$118
50	$74	$148

Source: NZIER

Many water-based community events, such as boating events and cliff diving competitions, were cancelled as a result (Radio New Zealand 2023a). This estimate does not include the costs of rescheduling these activities and the flow-on effects to related consumption spending, as this spending may have been diverted to other forms of recreation and entertainment.

5 The effect on regulation and supporting services

Regulation and supporting services linked to the Hauraki Gulf include:

- Marine water quality
- biodiversity health
- carbon sequestration.

Marine water quality is the only service that is likely to be adversely affected. The value of water quality annually was estimated to be $96 million. This is equivalent to $263,000 per

[1] By all, we mean more than only swimming.

day over the Gulf area. As discussed above, those in Auckland are the most likely to be affected, representing 87 percent of the active users. The Auckland share of the daily value of water quality represents $229,000.

The experience of a decline in water quality will vary across the community and in terms of duration. If the Auckland community experiences a loss in water quality for between 30 and 50 days, then the cost attributed to a loss of water quality services is between $1.7 million and $5.7 million (see Table 8).

Table 8 Cost estimates due to lost access to water quality services

Millions

Duration (Days)	Proportion of access to services lost	
	25%	50%
30	$1.7	$3.4
40	$2.3	$4.6
50	$2.9	$5.7

Source: NZIER

Figure 1 Footage of the sewerage overflow

Source: Watercare

6 Other observations

Ecosystem services of the Hauraki Gulf include the assimilation of wastewater spills being performed by the Gulf that ought to have been done in wastewater treatment plants. There are different ways to approach the valuation of this:

- Avoided cost of alternative treatment – this approach values waste treatment in the sea as at least as much as the next best alternative waste treatment – if we didn't use the sea for this purpose, what would it cost? This requires looking at the cost of land-based treatment on a volumetric basis and then applying that to the volumes leaking into the harbour. This is an incomplete valuation approach as it treats the sea as a waste treatment facility, not the more multifunctional natural asset it is. But this approach provides a lower bound value.
- Public willingness to pay for cleaner water – this approach values (potentially) all the attributes that people seek from water quality – safe contact, safe to take fish for food, etc. This can be addressed by examining the households' willingness to pay for water quality improvements. That is based on a marginal willingness to pay for water quality improvement, which is usually inferred through surveys, to derive a value per incremental tonne of waste removed from the spill.
- Another approach to willingness to pay is to look at Watercare's Central Interceptor project, which is costing close to $1.5 billion to build and is expected to remove most of the wastewater-contaminated stormwater entering the harbour.

6.1 Context

In older parts of central Auckland, wastewater and stormwater flow into a combined network of pipes, which can be overwhelmed by heavy rain. This results in wastewater mixed with stormwater overflowing into creeks, streams and the sea.

To counter this risk, Watercare is building the Central Interceptor, a 13km long, 4.5-metre diameter pipe up to 65 metres beneath the central city to carry wastewater flows to the Mangere Wastewater Treatment Plant. The new Interceptor is expected to reduce the volume of contaminated overflows by at least 80 percent and reduce the number of days each year when contaminated stormwater spills into the harbour from 52 to 10 days or fewer.[2]

The cost of the new "Interceptor" pipes and feeder sewers was put at $1.7 billion to build in 2017. It was expected to reduce wet-weather overflows from the area from St Mary's Bay to Blockhouse Bay by 91 percent, from 2.2 million to 190,000cu m a year,[3] by 2035 (Collins 2023). More recently, Watercare has stated the Interceptor should collect more than 80 percent of contaminated spills and has enough capacity to relieve the pressure from new residential buildings on already heavily used old pipes. But the Herald (op. cit.) reports it could cost $1.5 billion on top of the $1.7 billion to build new interceptors, feeder sewers and separated stormwater pipes to accommodate an expected 16,000 new homes that

[2] Note that reducing wastewater affected days in the sea around Auckland from 52 to 10 days or fewer equates to an 80 percent reduction in the number of wastewater affected days. Other reports on the volume of wastewater-affected discharges suggest a higher percentage reduction in volumetric discharges into the sea, enabled by the Central Interceptor, at 90 percent or higher.

[3] Reduction in volumetric discharges from 2.2 million to 190,000 cubic metres per year equates to a 91 percent reduction in discharge volumes.

could otherwise overload the old, combined pipeline network and increase the frequency of leakage.

More recent information from the Council is that the total cost of the Central Interceptor is around $1.5 billion. Estimated costs for the sinkhole response – repairs, pumps, overland bypass and new pipe lining – are around $20 million. The effective lifetime of the Interceptor is expected to be 100 years.

6.2 The value of reducing harbour contamination implied by the Interceptor

We use the information from the previous section to estimate the value Watercare and its regional ratepayers and customers place on cleaning up the harbour of wastewater-contaminated stormwater. As numerous variable factors in such a calculation may change with improved data, these estimates are of necessity illustrative rather than definitive.

Table 9 summarises estimates of the economic value of leakages of wastewater-contaminated stormwater into the sea. These are based on the following assumptions:

- Contamination of the Auckland Harbours from this source is annually around 2.2 million m^3 of sewage-contaminated stormwater.
- The effectiveness of interceptors is about 91 percent (we also use 80 percent for comparison)
- The cost of the Interceptor is annualised, assuming a discount rate based on the Reserve Bank's 20-year average of its 60-day bank bills.

The results show that the longer the operating life of the new Interceptor, the lower the cost of the pipe system. A 100-year life has an annualised cost of $57 million. Dividing that cost by the expected annual tonnage of contaminated water removed from overspilling into the harbour yields a cost of $28.36 per cubic metre. Applying that value to the 8,000 cubic metres of contaminated stormwater entering the harbour daily implies a value of $226,893 for each day's spill. Assuming a shorter 50-year operating life for the Interceptor would have an annualised cost of $66.3 million, equating to a cost of $32.97 per cubic metre, which implies a value of $263,780 for each day's 8,000 cubic metres spill. An even shorter 35-year operating Interceptor life increases the cost of the spill to nearly $306,960 per day and $38.37 per cubic metre.

By comparison, the daily spill value of $226,893 (with a 100-year pipe life) is roughly the same as the $20 million response cost averaged over 90 days ($222,222). In other words, daily spills of 8,000 cubic metres would accumulate to $20 million in 90 days. Spending $20 million to stop the leak would result in a combined cost of $20 million + $X, where X is the number of days of spillage avoided by rapid response implementation.

Table 9 The value of daily leaks in terms of the value of reducing pollution

	Units	Low estimate	Medium estimate	High Estimate
Sewage-contaminated water leakage	m^3/yr	2,200,000	2,200,000	2,200,000
Effectiveness of Interceptor		91.36%	91.36%	91.36%
Removed by Interceptor	m^3/yr	2,010,000	2,010,000	2,010,000
Residual after Interceptor	m^3/yr	190,000	190,000	190,000
Cost of Interceptor	$m	1,500	1,500	1,500
Term	Years	100	50	35
Rate	Rate	3.70%	3.70%	3.70%
Annualised cost	$m/yr	-57.0	-66.3	-77.1
Value of reducing sewage leaks	$/$m^3$	$28.36	$32.97	$38.37
The current leak from sinkhole damage	Litres/day	8,000,000	8,000,000	8,000,000
Value of reducing sewage leaks	$/ day	$ 226,893	263,780	$306,960

Source: NZIER

The longer the expected lifespan of infrastructure, the lower the present value cost of it and the wastewater it is designed to remove. The higher the discount rate, the larger the cost. The less effective the Interceptor, the higher the cost per volume of wastewater removed. Alternative results with 80 percent and 91 percent effectiveness are summarised in Table 10.

Table 10 Variations in value with changes in effectiveness

	Units	Low estimate	Medium estimate	High Estimate
80% effective wastewater leak reduction	$/cu m	$32.39	$37.66	$43.82
Sinkhole leak (on 29 September 2023)	$/ day	$259,122	$301,249	$350,563
91% effective wastewater leak reduction	$/cu m	$28.36	$32.97	$38.37
Sinkhole leak (on 29 September 2023)	$/ day	$226,893	$263,780	$306,960

Source: NZIER

These estimates reveal something about public preferences: they reflect public authorities' willingness to commit public funds to reduce the wastewater spilling into the Auckland harbours and could be taken as an indicator of public willingness to pay for cleaner waters.

The sinkhole spillage is the complete opposite, negating part of the removal of wastewater by the Interceptor at the cost of at least equal unit value to the benefit of removing it.

This approach equates the value of cleaner water to avoiding the additional cost of cleaning it up. 'Avoided cost' valuation is at the lower end of the spectrum of economic valuation techniques: a reasonably firm basis for a lower bound value of what society loses by not reducing wastewater, but usually, it lacks the full scope of use values affected by a spill (days of water recreation forgone, kilogrammes of seafood not fit for human consumption, health costs for human and animal contact with contaminated water, etc.) and does not cover the nobler sentiments of altruism towards other people, other generations, other species, etc., that underpin non-use value and could be articulated in a more customised stated preference survey to yield total economic value.

However, apportioning the cost of the Central Interceptor to variation in the costs of harbour contamination is not a conventional avoided cost measure. The cost committed to installing the Central Interceptor expresses public agencies' willingness to pay to achieve cleaner water in the harbour. Decisions on that spending may be motivated by any number of considerations, spanning use values for recreation, provisioning ecosystem services such as food gathering, public health and safety concerns, as well as non-use values such as existence and bequest values held towards the state of the natural environment, and cultural concerns of mana whenua about restoring the mana of the harbour and its tributary waterways. But how much such considerations affected the decision to invest in the Interceptor, alongside other considerations such as affordability for the community, is difficult to disentangle.

These estimates are illustrative and only part of the answer to the economic value of water quality in the Hauraki Gulf. They can be explored more thoroughly, with alternative assumptions around effectiveness, discount rate and so on, to build a fuller picture of what's gained and what's lost with changes in water quality. They can be supplemented with other values of both market and non-market attributes of the Gulf and its water quality, given explicit estimates of the value of those attributes.

6.3 Summarising the Interceptor

In summary:

- Auckland's public agencies have revealed a willingness to pay for cleaner harbour waters in their decision to invest in the Central Interceptor, so the addition of more contaminated water from the Parnell Sinkhole and sewage spill can be valued as the antithesis of removing contamination at the cost of doing so with the Central Interceptor
- There may be wider public value in the protection of ecosystem services that are not explicitly accounted for in the public agency decisions, such as benefits to widespread members of the public from the use and appreciation of a cleaner harbour environment, in ways that are not necessarily captured the public agencies' approach to valuation.

We suggest viewing the Central Interceptor costs approach as a basic value measure, which may account for wider public values and non-market effects to an indeterminate degree. This value should be viewed alongside the compilation of other sources of value from the *Value of the Hauraki Gulf* report, estimated as proportional to the wastewater leakage's

scale, spread and duration of detriment in the harbour's availability for ecosystem services. If the estimates of the spill's impacts made with other values exceed the Interceptor-based value, that suggests a portion of public value is over and above that implied by the Interceptor investment decision. If the interceptor value is larger than the combined values of other ecosystem services, that would suggest the public agency's willingness to pay adequately reflects value relating to non-market effects.

7 Conclusion

This assessment of the cost of the sinkhole on the access to services provided by the Hauraki Gulf, and to estimate the value of the service provided by the Gulf in assimilating the waste, is the first test case of the natural capital valuation work done earlier in 2023.

It is conservative in nature and limited in scope but demonstrates that such incidents have costs far beyond their immediate repair. This, in turn, provides further rationale for investment in resilient infrastructure to reduce the likelihood of further adverse effects and costs in future.

8 References

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