Honiara Flood Risk Management Study and Plan

Overview

What is the Honiara Flood Risk Management Study and Plan?

The Honiara Flood Risk Management Study and Plan is an investigation of flooding and the possible problems caused by flooding (i.e., flood risks), and an assessment of a range of measures to manage and reduce these problems in Greater Honiara.

The project's focus is on flooding from rivers and creeks rather than the sea. The primary output of the work is a Master Plan of recommended measures to manage the flood risk. Measures include greater advance warning and preparedness for floods, planning controls to guide development away from areas affected by the most dangerous floodwaters, and structural works to reduce flooding in certain areas.

The project's study area encompasses the Greater Honiara area, from the White River floodplain in the west to the Lungga River floodplain in the east, including the Mataniko River and Burns Creek (figure 1). It also includes the various small catchments that drain directly to the ocean, located between the main creeks and rivers.

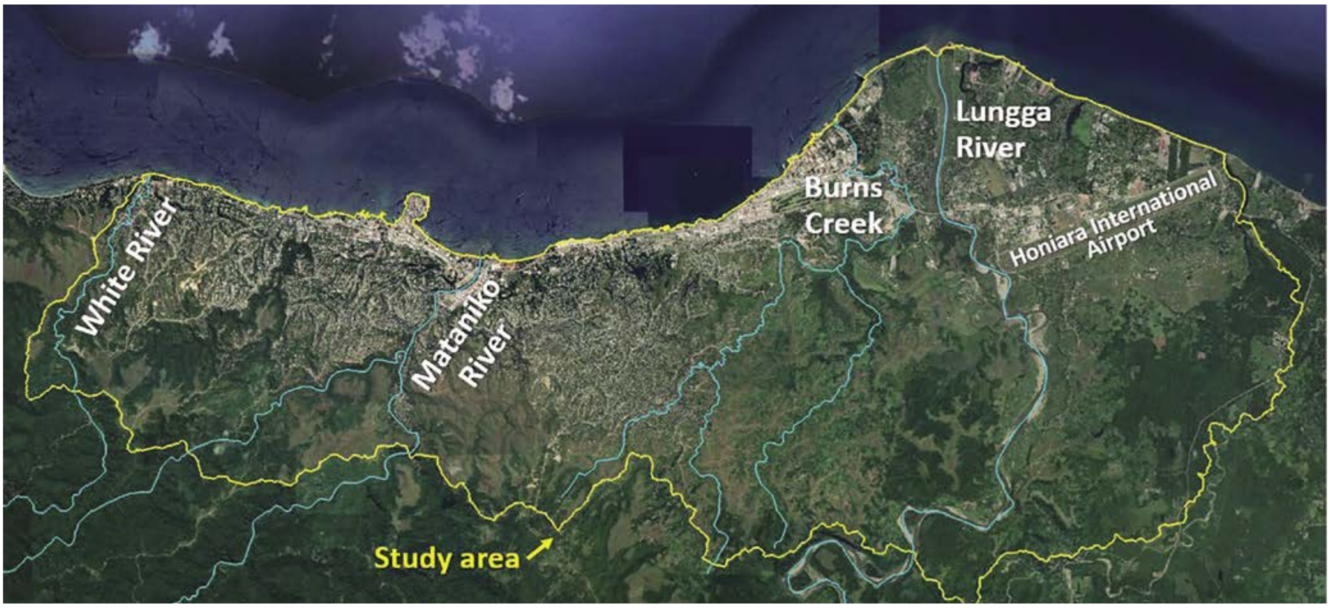
This document provides an overview of the Study and Plan.

WHAT IS A FLOODPLAIN?

A floodplain is land that is occasionally flooded. It is often defined by the extent of the biggest flood that could possibly occur, called the probable maximum flood.

Floodplains such as the Lungga River floodplain are formed by deposition of silt during floods over thousands of years. Rivers can cut new channels through floodplains.

Figure 1: Study area for the Honiara Flood Risk Management Study and Plan (source: Google Earth and World Bank Group).



Why was this study developed?

Severe flooding in April 2014 caused significant damage and loss of life in the Greater Honiara area (see below). Nationwide, an assessment identified a total economic impact of SI$787 million (US$108 million), equivalent to 9.2 percent of gross domestic product at the time.[1]

The history of floods in Honiara shows that the 2014 flood is not a one-off event. Many damaging floods are known to have happened, including those associated with tropical cyclones in 1966, 1967, 1972, and 1986. The Koa Hill floodplain was also flooded in 2009 and 2012. Flooding has happened in the past, and will happen again in the future.

Figure 2: Floodplain before (top) and after (bottom) the April 2014 flood at Koa Hill, Honiara (source: Google Earth).

THE APRIL 2014 FLOOD

A slow-moving low pressure system—later named Tropical Cyclone Ita—caused very heavy rain to fall on Guadalcanal from April 2 to April 4, 2014. Severe flooding was experienced in and around Honiara on the afternoon of Thursday April 3 and in the days following. Based on modeling presented in this study, the flooding in Greater Honiara's river systems was between a 1 in 50 and 1 in 70 chance per year flood event.

In the center of the city, the Mataniko River flooded to its highest level in living memory. This was confirmed by conversations with residents from Tandai Ward who had survived World War II. The extreme depths (~5m over the floodplain at Koa Hill), the rapid speed of the floodwater, and the large volume of debris combined to destroy some 239 houses on the Mataniko River floodplain within the city boundary (figure 2). The Old Mataniko Bridge collapsed. The riverbank at Chinatown suffered about 10m of erosion, with some buildings falling into the river channel. The rapid rise of the floodwater and the dangerous location of many houses on low-lying land—especially in informal settlements—contributed to 21 fatalities in the Mataniko River Valley. This death toll would have been much worse had the flood come at night.

At the eastern end of the city, Burns Creek flooded and the large Lungga River inundated Honiara International Airport, the primary gateway to the Solomon Islands.

1. Government of Solomon Islands and Global Facility for Disaster Reduction and Recovery, "Rapid Assessment of the Macro and Sectoral Impacts of Flash Floods in the Solomon Islands, April 2014," World Bank, Washington DC, 2014, https://openknowledge.worldbank.org/handle/10986/21818

Floods are expected to become more frequent and floodwaters to rise higher with climate change. Flood modeling presented in this report indicates that floods in Honiara that currently happen once every 10 years on average could in the future happen once every 5 years on average.

HOW FLOOD SIZE RELATES TO FLOOD CHANCE

- Smaller floods happen frequently.
- Bigger floods happen rarely.
- But with climate change, bigger floods are expected to happen more often.

Figure 3: New house on the floodplain, one month after the April 2014 flood, Marble Street, Honiara (source: World Bank Group).

Honiara also experienced rapid urban growth of 5.8 percent, equal to 5,700 people per year, between 2009 and 2019. Greater Honiara is now home to more than 159,000 people.[2] This growth increases pressure to develop floodplains and other marginal sites. Some areas devastated by the April 2014 flood were quickly resettled, pointing to a high demand for land even when it is known to be impacted by deep floods (see figure 3). Increasing exposure to floods is a major driver of increased disaster risk.

Previously, only limited information was available to understand the problem of flooding. But a new expert study, carried out using the most up-to-date techniques, has generated new and reliable information. This provides confidence that the measures recommended to manage and reduce the problem are well founded.

The 2014 flood disaster, and the growing exposure to flooding, highlight the need to better understand, manage, and reduce flood problems in the Greater Honiara area. The Honiara Flood Risk Management Study and Plan was developed to meet these needs.

WHY INVESTING IN DISASTER RISK REDUCTION MAKES SENSE

Governments often spend much more on post-disaster recovery and reconstruction than on actions that would limit the impacts of disasters in the first place. Studies show that expenditure before floods happen reduces their impacts and saves expenditure afterward.

The Honiara Flood Risk Management Study and Plan aims to equip decision-makers with knowledge to reduce disaster impacts.

2. Census Office / National Statistics Office, “Provisional Count, 2019 National Population and Housing Census,” 2020, https://www.solomonchamber.com.sb/media/1997/provisional_count-2019_census_result.pdf.

What is the purpose of this study?

The key purpose of the Honiara Flood Risk Management Study and Plan is to develop a strategic plan to guide investments to better manage flood risks in the Greater Honiara area, in turn building and strengthening Honiara's resilience to weather extremes.

The Study and Plan assesses options and provides recommendations for several specific purposes:

1. Better response to flood emergencies, including through enhanced warning systems
2. Better management of land use planning on floodplains
3. Implementation of works to reduce flooding

How was this study developed and what are its findings?

COLLABORATION

A task force was set up to contribute to and oversee the development of the Honiara Flood Risk Management Study and Plan. Because flooding problems relate to many different sectors, the task force included representatives from several ministries of the Solomon Islands Government:

- Ministry of Environment, Climate Change, Disaster Management and Meteorology
- Ministry of Lands, Housing and Survey
- Ministry of Infrastructure Development
- Water Resources Division of the Ministry of Mines, Energy and Rural Electrification.
- Ministry of Health and Medical Services

Representatives from the Honiara City Council (HCC) and Guadalcanal Provincial Government (GPG) were also on the task force.

Regular meetings of the task force were vital for confirming flood mapping and selecting options to manage the flood risk (figure 4).

Figure 4: Community meeting, October 2019 (source: World Bank Group).

The plan was developed in three key stages, as illustrated in figure 5 and described below.

STAGE 1
UNDERSTAND FLOODING

The first stage in developing the plan was to better understand the flooding using flood models. A model is a mathematical representation of how a system works. In the case of flooding, the system relates to rainfall, runoff, river flows, and the movement of water across a floodplain.

A first step in the process was to *collect data* for the models. The World Bank with the Solomon Islands Government had collected a large amount of data from the 2014 flood, including rainfall data from the Solomon Islands Meteorological Service and surveyed peak flood levels along the rivers (figure 6). The Ministry of Health and Medical Services provided aerial imagery and topographic data for the study area. River channels were also surveyed.

The second step was development of a *hydrologic model*. Hydrology is the study of how rainfall is converted into runoff. A hydrologic model (HEC-HMS) was developed to calculate river flows resulting from rainfall across the study area.

The third step was development of a *hydraulic model*. Hydraulics is the study of the physical movement of water along rivers and over floodplains. A hydraulic model (TUFLOW) was developed to calculate flood levels, depths, velocities (speeds), and hazard that result from the flood flows inputted from the hydrologic model.

Figure 6: Community meeting, October 2019 (source: World Bank Group).

A key step in developing models is *calibrating* them to real floods to ensure the models are representing floods realistically. Only limited data were available for this purpose, but a good match was achieved between most modeled and surveyed 2014 flood peak levels. Also, a good match was achieved between modeled and observed flood extents based on photographs (figure 7). Input from the task force helped to improve the model's representation of the 2014 flood.

Tests were carried out to assess the sensitivity of the models. It was found that flooding in the rivers is generally insensitive to the level of the sea owing to the rivers' steep gradient and the small tidal range. On the other hand, how wet catchments are at the start of a storm makes a big difference to the size of flooding.

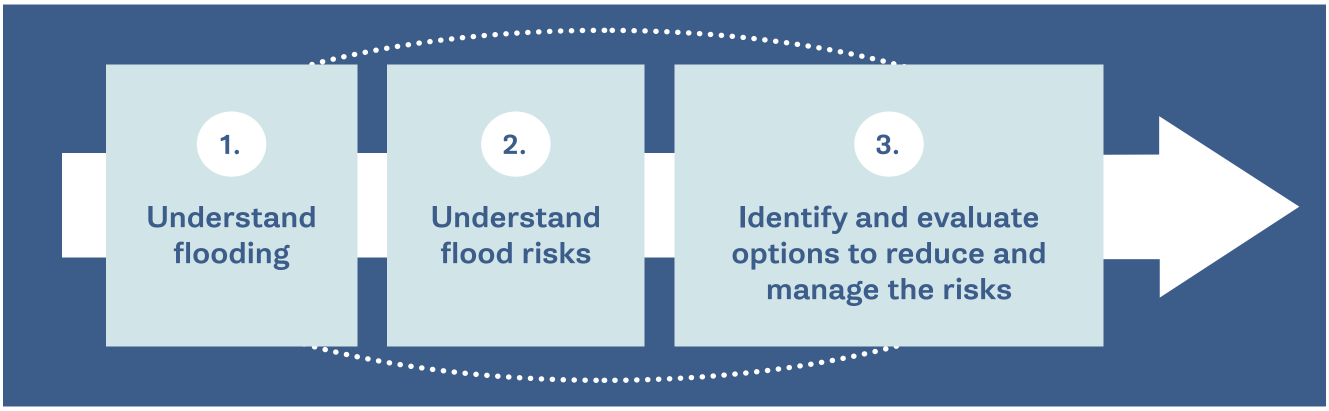


Figure 5: Three stages for development of the flood plan (source: World Bank Group).

Figure 7: Comparison of observed (above) to modeled (below) flooding at Honiara International Airport at 1600 hours on April 4, 2014 (sources: RAMSI for photograph; T+TI for modeled output.)

DESCRIBING FLOODS

Floods are described in terms of the chance that a flood of a certain size could happen.

This study uses the scientific term "annual exceedance probability" or AEP to describe the chance of floods. A "1 in 100 AEP flood" refers to a flood that has a 1 in 100 (or 1%) chance of happening or being exceeded in any given year. Expressed another way, it means that a person living to the age of 70 has about a 50 percent chance of experiencing a flood this size or larger during his or her lifetime (see table 1).

It's important to understand that a 1 in 100 chance per year flood can happen several times within a few years. The 1 in 100 AEP label doesn't mean that such a flood happens only once every 100 years. This is why the traditional term "100-year return period" flood is no longer used.

The calibrated flood models were then used to assess a range of *potential flood scenarios*. Four scenarios were selected:

- 1 in 5 (20%) chance per year
- 1 in 20 (5%) chance per year
- 1 in 100 (1%) chance per year
- 1 in 500 (0.2%) chance per year[3]

The rainfall corresponding to each flood frequency was calculated from an assessment of Honiara rainfalls from 1955 to 2018. Adjustments were made for elevated inland areas and for storm durations of less than one day.

A selection of flood maps for the 1 in 100 chance per year event—as generated by the flood model—is presented in figures 8, 9, and 10.

3. It is important to know that even rarer, bigger floods can happen. The Townsville (Australia) flood in February 2019 was near a 1 in 1,000 (0.1%) chance per year event. The probable maximum flood was not modeled for the current study.

TABLE 1: Chance of floods in one person's 70-year lifetime

LIKELIHOOD	CHANCE OF HAPPENING IN ANY YEAR		CHANCE OF HAPPENING AT LEAST ONCE IN A 70-YEAR LIFETIME
Very high	1 in 5	20%	100%
High	1 in 20	5%	97%
Medium	1 in 100	1%	51%
Low	1 in 500	0.2%	13%

Flood maps

Flood maps at a scale of 1:10,000 were produced for the entire study area. This effort included flood depth maps (examples are in figures 8–10) and flood hazard maps.

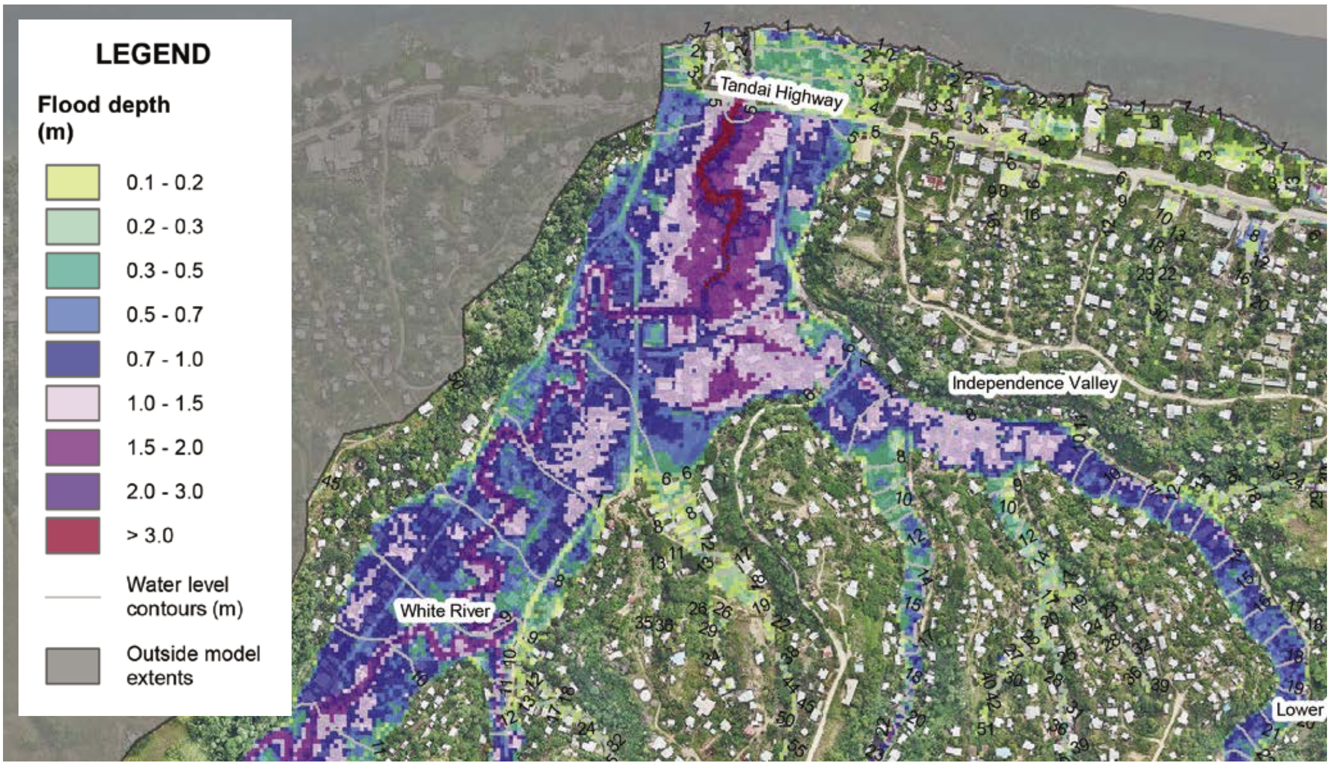


Figure 8: Peak flood depths for 1 in 100 chance per year flood over part of White River floodplain (source: T+TI).

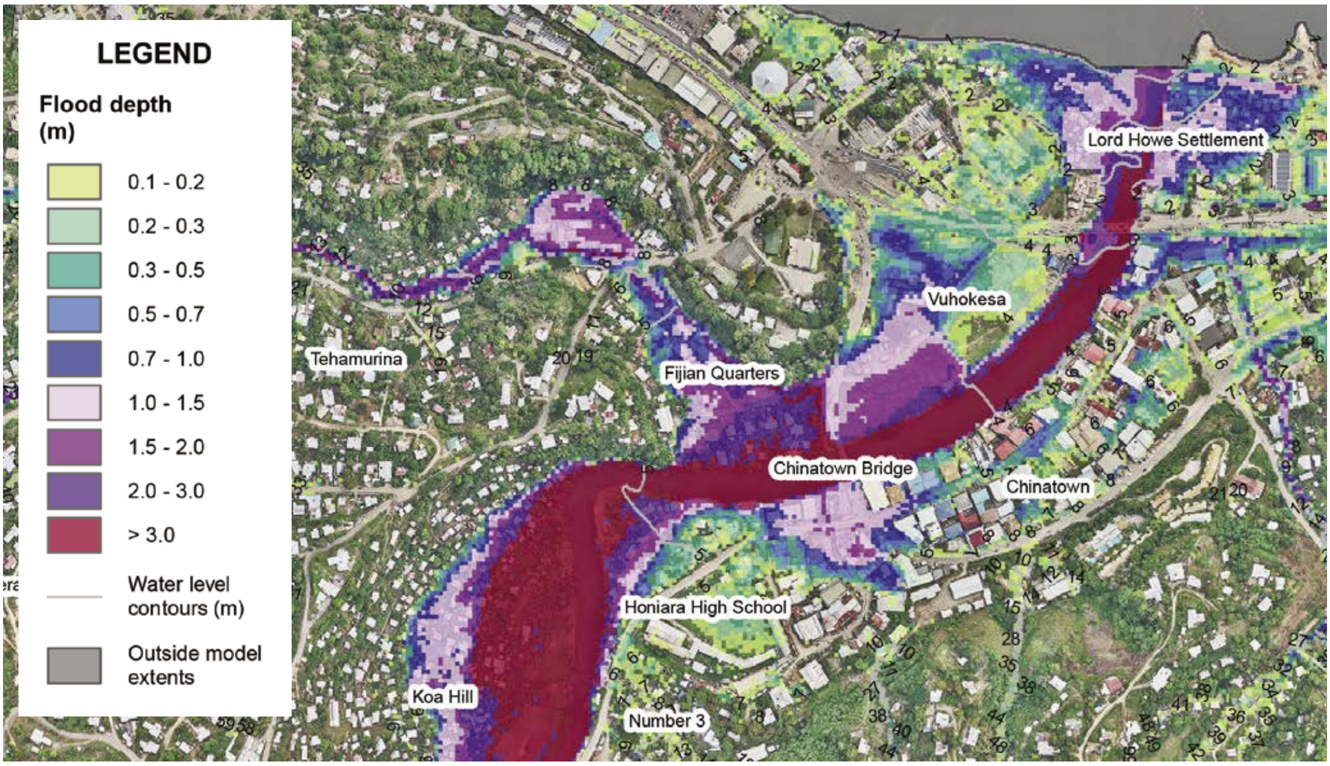


Figure 9: Peak flood depths for 1 in 100 chance per year flood over part of Mataniko River floodplain (source: T+TI).

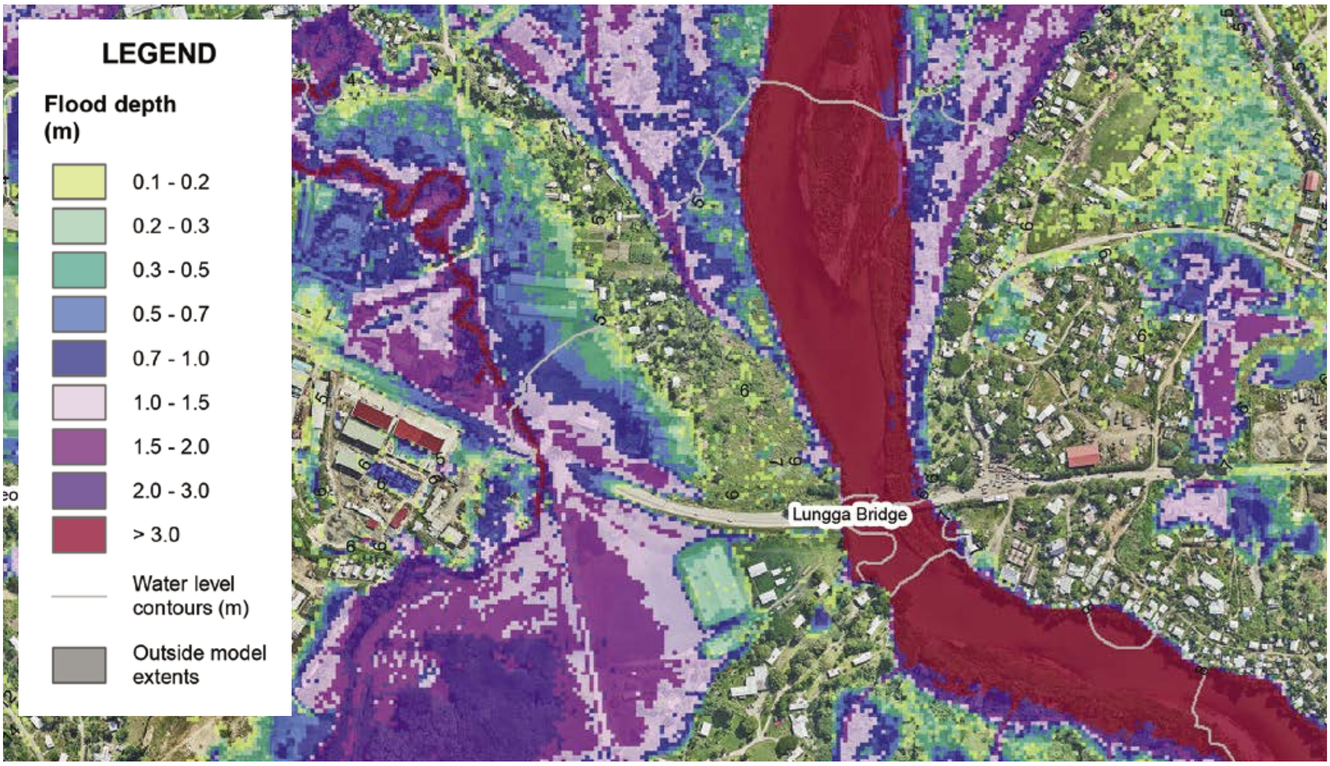


Figure 10: Peak flood depths for 1 in 100 chance per year flood over part of Burns Creek and Lungga River floodplains (source: T+TI).

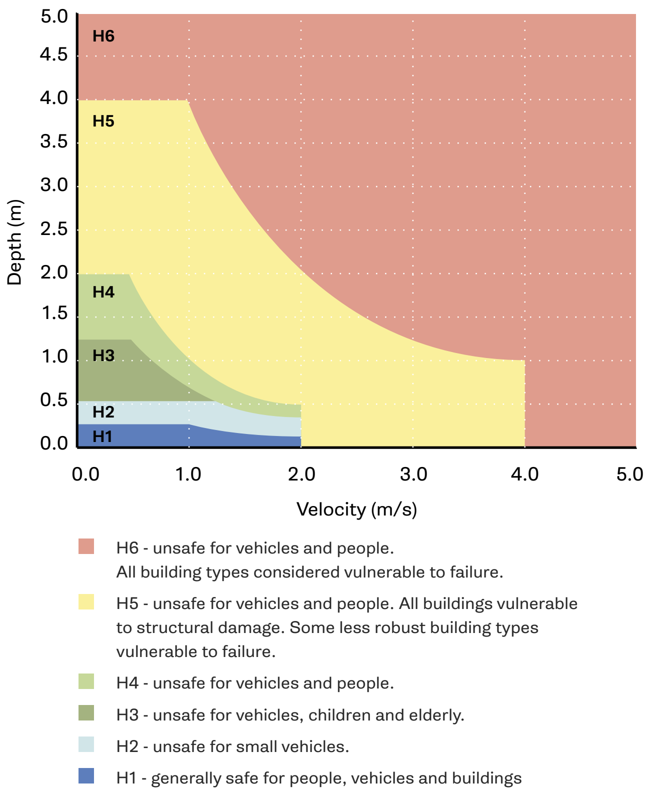


Figure 11: Flood hazard vulnerability curves developed for Australia (source: Australian Institute for Disaster Resilience, "Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia," Australian Disaster Resilience Handbook 7, 2017).
Note: m/s = meters per second.

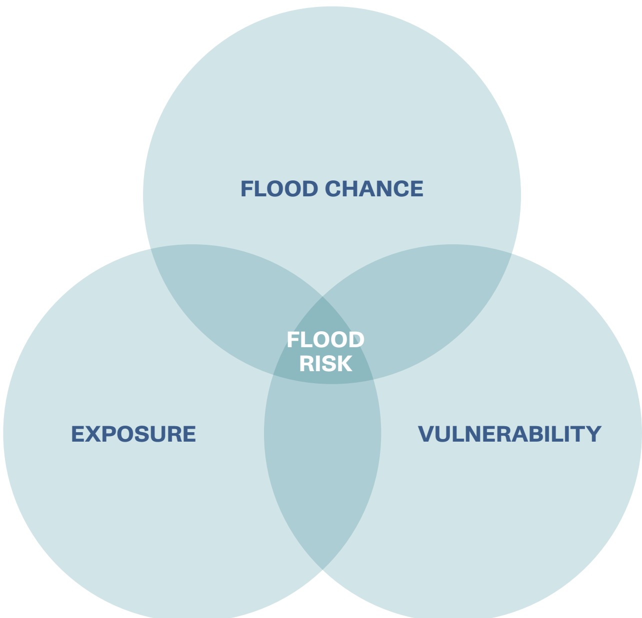


Figure 12: Components of flood risk

Flood hazard maps are particularly useful because they show combinations of flood depths and velocities that are unsafe for buildings, motor vehicles, and people. Floodwaters in the H5 or H6 hazard categories—the two highest Australian Institute for Disaster Resilience categories—are so deep and/or fast that many housing structures in Greater Honiara would not survive them (figure 11).

Climate change

A warmer atmosphere is able to hold more moisture. Under a very high emissions scenario (RCP 8.5), by 2090, a temperature increase of 2.8°C is projected, potentially increasing rainfall intensity by about 19 percent.

Modeling indicates that such increased rainfall would increase peak flows by 30–40 percent, leading to more frequent and severe flooding. What is currently a 1 in 10 chance per year flood would become a 1 in 5 chance per year flood, and what is currently a 1 in 250–350 chance per year flood would become a 1 in 100 chance per year flood.

Sea level could rise by about 0.6m in the Solomon Islands, but due to steep flood gradients, this would have limited impact on riverine flood extents.

STAGE 2 UNDERSTAND FLOOD RISKS

The second stage to developing the plan was to better understand flood *risks*—that is, the assets floods could damage or destroy, including buildings, critical infrastructure, and roads, and the location of those assets. A key component of flood risk is the risk to human life.

Flood risk depends on the chance of flooding, exposure to flooding (i.e., where assets/people are located), and vulnerability to flooding (i.e., how sensitive or adaptive buildings, etc. are to floods). See figure 12.

The study focused on understanding flood risks on Greater Honiara's main river floodplains: Lungga River/Burns Creek, Mataniko River, and White River.

A brief description of methods used to assess risk and a selection of results are presented below.

Figure 13: Damaged traditional house, Koa Hill floodplain, after April 2014 flood (source: World Bank Group)

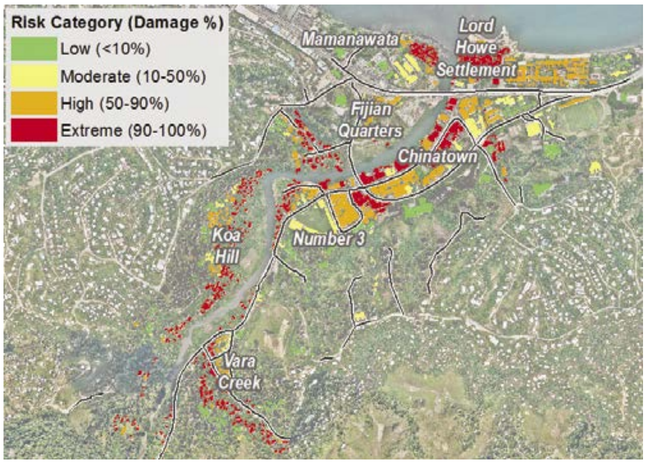


Figure 15: Risk to buildings in a 1 in 100 chance per year flood, lower Mataniko catchment (Source: T+TI)

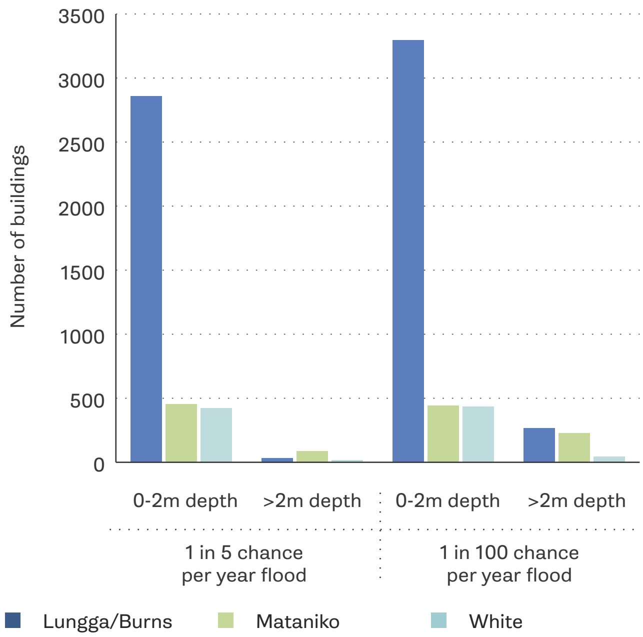


Figure 14: Number of buildings exposed to various depths of flooding

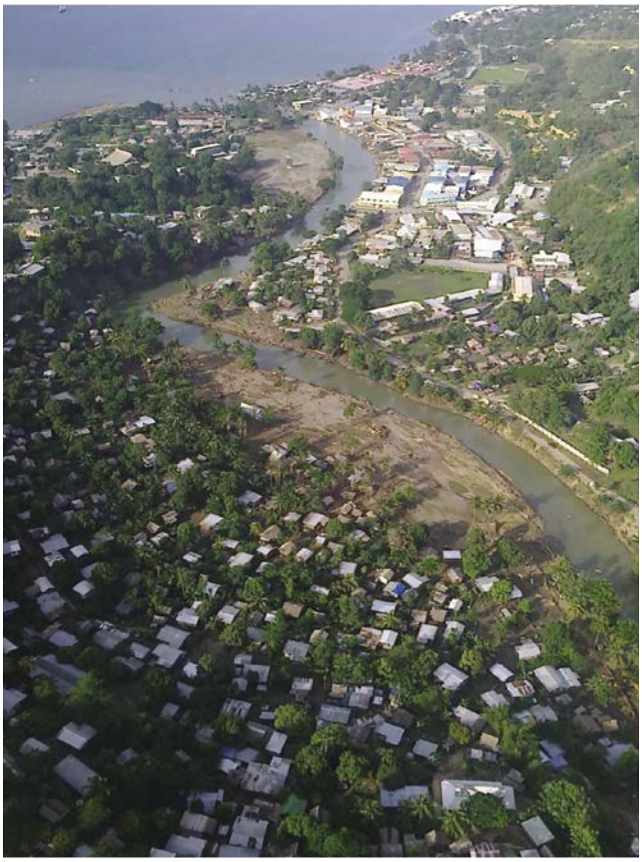
Buildings

Information about the built environment was derived from the Pacific Catastrophe Risk Assessment and Financing Initiative (PCRAFI) assets database, together with recent aerial photography. Depth-stability functions developed for Pacific island building structures were validated and adopted for Honiara. Traditional leaf homes are more susceptible to flood damage than well-built concrete homes (see figure 13).

The assessment found as follows:

- More than 5,000 residential and commercial buildings are exposed to flood risks.
- The number of buildings exposed to flooding doesn't increase much for rarer, higher floods, though the depth of flooding does increase, posing greater risks (figure 14).

Maps showing the distribution of buildings likely to be destroyed in different flood sizes were prepared. An example is provided for the Mataniko catchment (figure 15).



Images of damage from the April 2014 flood (clockwise from top left): Aerial view of lower Mataniko River showing Koa Hill floodplain swept clear of houses (source: unknown); Debris on coast near mouth of Mataniko River (source: Solomon Star); floor detached from house posts (source: Water Resources Division of the of the Ministry of Mines, Energy and Rural Electrification); debris building up against old Chinatown bridge before its collapse (source: Solomon Star); silt deposits and flood mark inside St. John the Baptist church, Koa Hill floodplain (source: World Bank Group).

Figure 16: Flooding of the Honiara International Airport in April 2014 (source: Solomon Islands Meteorological Service).

Figure 17: Flooding of Tuvaruhu School in April 2014 (source: Tuvaruhu School).

Figure 18: Flooding of Kukum Highway at Burns Creek in April 2014 (source: RAMSI).

Critical infrastructure

Floods affect important elements of critical infrastructure in the study area. For example:

- ***Honiara International Airport.*** This vital gateway is affected by breakouts from the Lungga River. The airport was closed for three days in April 2014 after the domestic terminal and runways were flooded (see figure 16).
- ***Health facilities.*** The National Referral Hospital sits on the coast at a low elevation, and is affected by poor drainage. The Mataniko and White River clinics are at high risk in a 1 in 100 chance per year flood.
- ***Education facilities.*** Tuvaruhu School is modeled to be at extreme risk even in a 1 in 20 chance per year flood (see figure 17). Betikama Adventist College and King George VI National High School are at high risk in all floods. Honiara High School is mostly at moderate risk.
- ***Police stations.*** Mataniko Police Station is subject to the highest flood risk (extreme for some floods), whereas the White River station is subject to high risk and the Henderson station mostly to moderate risk.
- ***Evacuation centers.*** Many evacuation centers are subject to flooding; those at high risk are unsuitable to serve as evacuation centers. For example, modeling shows the Burns Creek Riverside, Christchurch, and SIFF Academy centers to be at high risk in all floods.

Roads

Floods affect many roads in the study area, causing significant disruption. The following important roads are cut off for many hours even in very frequent floods:

- Tuvaruhu Road at Vara Creek
- Kukum Highway at the eastern end of the airport
- Kukum Highway at Burns Creek (see figure 18)

Risk to human life

A large number of people in Greater Honiara are directly exposed to flooding. Based on the distribution of dwellings, National Census population data, and flood mapping, more than 33,000 people live within the extent of the 1 in 100 chance per year flood (main floodplains only).

Early evacuation to high ground—before flooding makes evacuation impossible—is a vital response for saving lives. Locations where low-lying evacuation routes are cut off early, and where rising floodwater subsequently floods homes, are particularly dangerous. Known as “flooded-isolated-submerged” or FIS areas, these locations were mapped as part of the study. Many areas in the Lungga River delta and Burns Creek are classified this way (see figure 19).

For evacuation to work, the time available to evacuate needs to be greater than the time required to evacuate. To better understand this, a model of pedestrian evacuation was developed. Although a number of assumptions were required, the model was able to identify areas with a time deficit where evacuation could readily fail:

- Burns Creek and White River in particular can rise faster than people can evacuate to designated evacuation centers.
- Several communities in the Lungga area could be stranded, though additional evacuation centers could lessen the risk in some areas.
- The area southeast of the airport runway is prone to being cut off by flooding.

Economic impact

The economic impact of flooding of the main rivers in Greater Honiara was assessed, based on the flood modeling, the risk assessment, and the rapid impact assessment after the April 2014 flood. The assessment included *direct damages* to buildings and contents, critical infrastructure, and roads, as well as allowances for emergency accommodation and food.

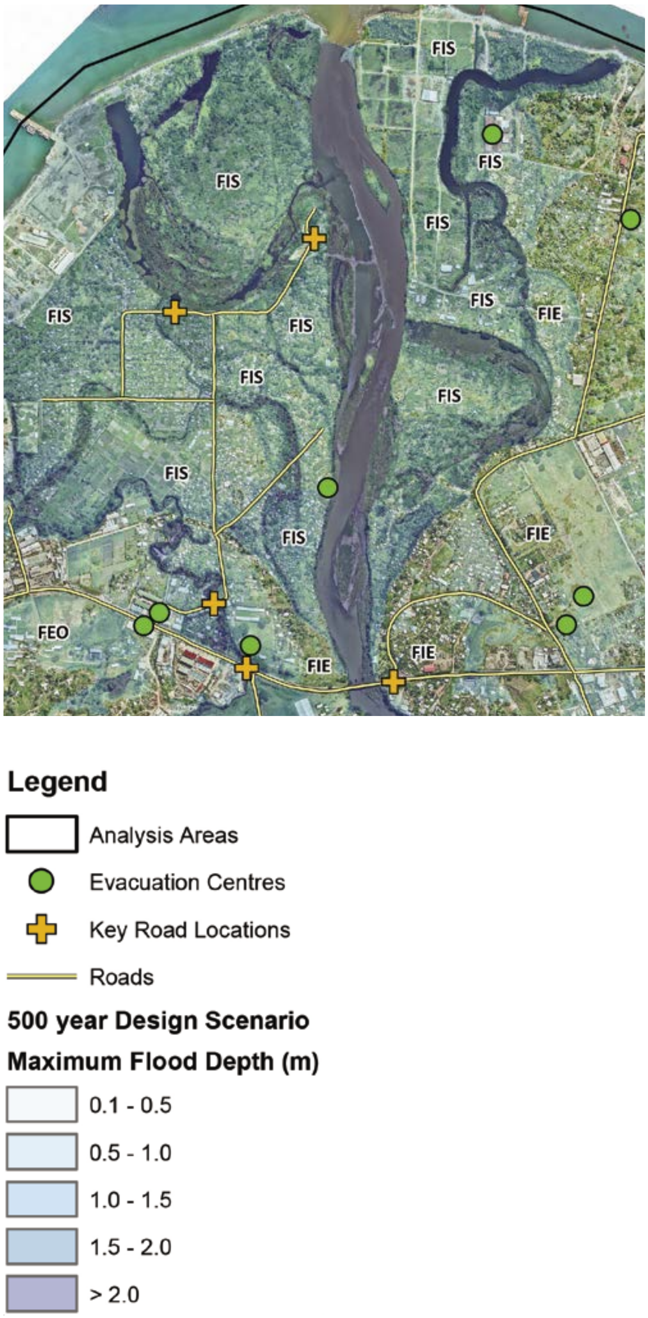


Figure 19: Flood emergency response classifications for the lower Lungga Catchment (source: T+TI). Note: FIS = flooded-isolated-submerged; FIE = flooded-isolated-elevated; FEO = flooded-exit route-overland.

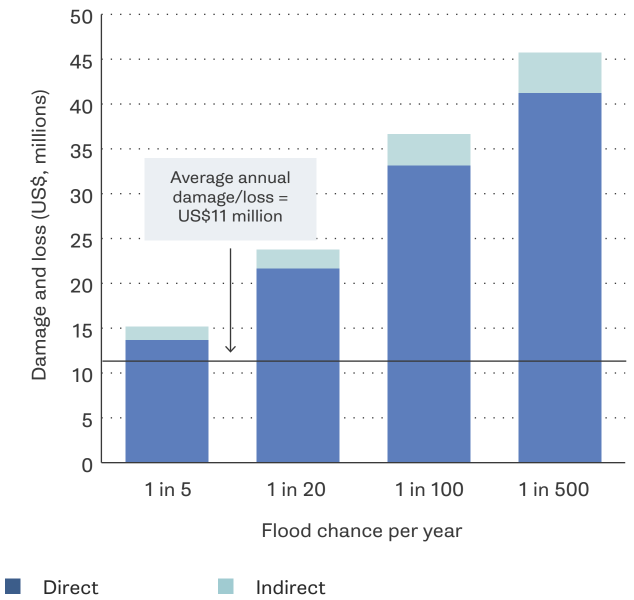


Figure 20: Estimated economic impact of flooding from main rivers in Greater Honiara (source: T+TI).

It also included *indirect losses* such as loss of livelihoods, increased transport and travel costs, and additional health care costs. *Intangible losses*—including loss of life, injury, and lifetime mental health impacts—were not monetized.

THE TRUE COST OF "INTANGIBLES"

A study of the costs of the 2019 North Queensland floods found that "intangible" social impacts on people's health and well-being contributed 40 percent of total costs.

The estimated cost of flooding for the four scenarios is shown in figure 20. The average annual damage/loss from flooding was then calculated mathematically.

The average annual damage/loss from flooding is estimated at US$11 million.

Assuming a discount rate of 5 percent, the net present value of flood impacts over a 50-year period is US$201 million. This provides a fiscal reference point for justifying expenditure on flood risk reduction measures. However, if intangible losses are included, the figure is considerably higher.

STAGE 3

IDENTIFY AND EVALUATE OPTIONS

The plan's third stage was to develop a plan for identifying and evaluating options to reduce and manage flood risks and build resilience to flooding. The Honiara Flood Risk Management Study investigated a range of options. These were identified in consultation with the task force.

Options generally fell into three categories:

- Measures that modify how and where flooding occurs, known as flood modification options. These change the way floods behave, and include flood detention dams, river channel works, diversion channels, levees, and watershed management (e.g., afforestation).
- Measures that reduce exposure and vulnerability to the hazard, known as property modification options. These include formal land use and development control policies, actions that increase resilience of housing stock, measures to influence the informal housing sector, and relocation of at-risk communities.
- Measures to modify short-term human response to flooding, known as response modification options. These include flood early warning systems, flood emergency planning, and community flood education.

Flood modification options were evaluated using the flood model to see how much each option would reduce the depth of flooding and the number of buildings impacted by flooding. Short-listed options, together with the property and response modification options, were assessed by the task force in a multicriteria analysis workshop.

Each option was scored against 10 criteria:

1. Impact on flood behavior
2. Number of houses/businesses benefiting
3. Economic merit (e.g., benefit-cost ratio)
4. Risk-to-life benefit
5. Environmental and social impact
6. Technical feasibility
7. Political/legislative acceptance
8. Community acceptance
9. Performance in rare floods
10. Long-term performance (design life, climate change, long-term maintenance requirements)

The following section describes the outcomes of the options assessment.

Options to modify flooding

Flood detention dams work by temporarily capturing floodwaters to reduce downstream flood peaks. These were considered for all four catchments covered by the study (see Figure 1). Flood detention dams would achieve substantial benefits for the Mataniko River and Burns Creek, and are considered economically feasible there. Further investigation is required relating to site selection, dam safety, optimization of detention performance, land due diligence, and environmental and social impact assessment. Stakeholder consultation is essential to ascertain whether land tenure could be secured, both at the dam site and within the footprint of temporary inundation upstream of the dam.

MATANIKO RIVER FLOOD DETENTION DAM

A 19m-high dam upstream of Tanakio would benefit approximately 320 buildings downstream, with approximately 210 buildings experiencing a decrease of 0.75m or more in a 1 in 100 chance per year event.

BURNS CREEK FLOOD DETENTION DAM

A 6.5m dam on Burns Creek would provide a large flood storage capacity, benefiting approximately 470 buildings downstream, with approximately 120 buildings experiencing a decrease of 0.75m or more in a 1 in 100 chance per year event.

Channel works can reduce flooding by improving flows in rivers. One option for a "monsoon drain" in the lower White River is recommended for further investigation.

WHITE RIVER "MONSOON DRAIN"

This option considers a constructed open channel, about 15m wide and 580m long, to replace the existing river channel. While the adjacent areas will still experience flooding, a channel would reduce flood hazard for approximately 120 buildings. However, several properties would be adversely impacted, requiring either dwelling relocation or compensation to owners.

Levees are typically earthen embankments designed to protect areas from a certain level of flooding. One disadvantage of levees is that they can make flooding worse in areas outside the levee, because less space is available for the free movement of floodwaters (see figure 21). A levee on the southern side of the airport runway is being constructed to safeguard this critical national asset from Lungga River overflows. Further investigation is recommended to mitigate flood impacts south of the runway, potentially by increasing the drainage capacity of Alligator Creek.

Afforestation could theoretically reduce flooding, but apart from the Vara Creek subcatchment, most of the study area catchments are forested, so there is little opportunity. Sustainable watershed management is recommended to ensure forestry operations do not increase erosion or flooding.

No flood modification options are recommended for implementation at this time. Rather, four options are recommended for further technical investigation and stakeholder engagement (see Table 2).

LEVEE ON THE SOUTH SIDE OF HONIARA INTERNATIONAL AIRPORT RUNWAY

A levee is currently being built to reduce the frequency of flooding at this critically important national asset, with its design pre-dating this study. This study confirmed the levee will reduce flooding at the airport but also showed areas of increased flooding elsewhere. Further investigation is required to mitigate the impacts of the levee south of the runway.

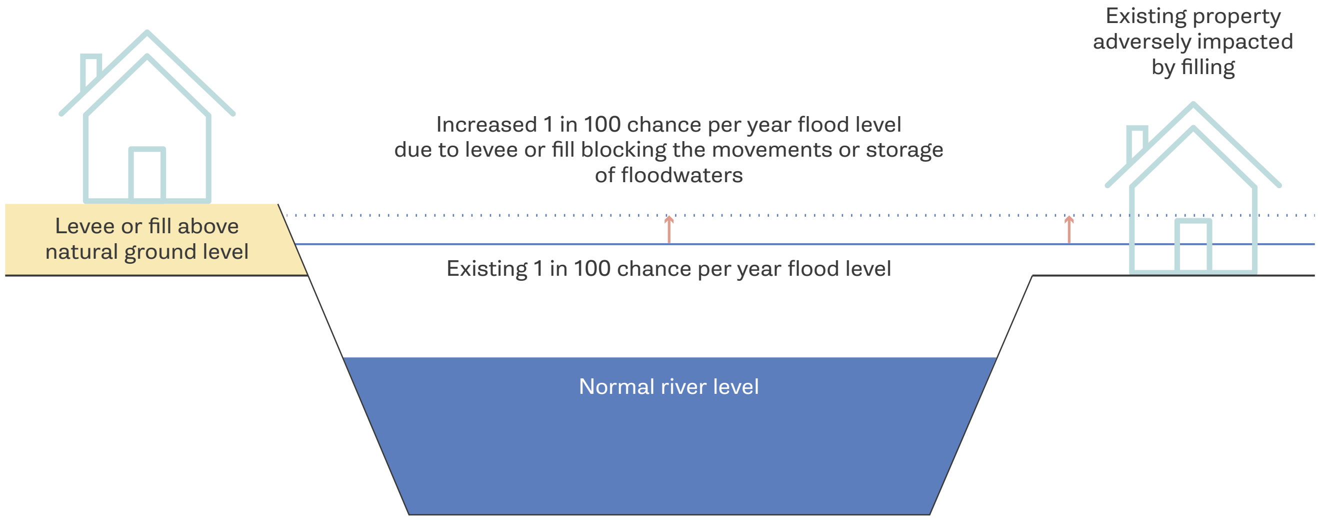


Figure 21: How constructing a levee or filling the floodplain can worsen flooding upstream and opposite (source: World Bank Group).

Options to modify exposure and vulnerability

Measures to modify exposure and vulnerability to floods are a key flood risk management tool. However, there are many challenges to their implementation in Greater Honiara:

- A large number of dwellings already exist on floodplains.
- A high proportion of these dwellings are informal.
- Population growth is placing pressure on marginal land.
- HCC and GPG have limited capacity in land use planning and enforcement.

This is the challenging context for assessing property modification options in this study. It means that both regulatory and nonregulatory measures are required to manage exposure.

The study thoroughly reviewed the flood risk management provisions of the existing legislative and policy framework. The following changes are recommended:

- Amend the flood overlay within the Honiara Local Planning Scheme (LPS) and draft Henderson LPS. Currently the overlays are based on anecdotal April 2014 flood extents. The flood hazard categories (figure 11) for the 1 in 100 chance per year flood could be used to apply risk-based land use and development controls (see figure 22). New development on land subject to the most dangerous flooding (H6 hazard category – see figure 22) would be prohibited. A comprehensive risk assessment would be required for new development on land subject to H5 flood hazard conditions. New requirements for risk assessments are proposed, including an assessment of the impact of development on the movement of flood flows. Any works to fill floodplains can increase flooding in surrounding areas (figure 21), and should be avoided.
- Provide capacity building to support enforcement of development controls.
- Amend the Planning and Development Act 2017 to provide LPSs with more weight.
- Amend the Environment Act 1998 to better address natural hazards.
- Replace building ordinances with a national building code that enhances flood resilience.
- Review land uses for future urban growth identified in the Greater Honiara Urban Development Strategy and Action Plan, taking into account the modeled flood hazard.

The following initiatives are recommended to reduce and manage flood risk in Greater Honiara's informal settlements:

- Coordinate a program of community-led flood resilience initiatives. Flood information could be shared with Community Development Committees to help them develop spatial plans to keep land subject to high flood hazard (H5 and H6) clear of inappropriate development. Illustrated guidelines tailored to Honiara's informal settlements could be developed, and training provided, to inform more resilient construction of houses.[4] This need was identified by observing structural flaws after the April 2014 flood.
- Explore opportunities for resettlement. In theory, resettlement of people living in dwellings subject to high flood hazard (H5 and H6) is a desirable long-term solution. However, resettlement has significant challenges. Establishment of a working group is recommended to explore options for relocating communities to areas outside the highest flood hazard areas.

4. See Iftekhar Ahmed, "Housing and Flood Resilience in Honiara," in *Honiara Flood Risk Management Study and Plan, Working Paper 4: Options Analysis,* Tonkin & Taylor International 2020.

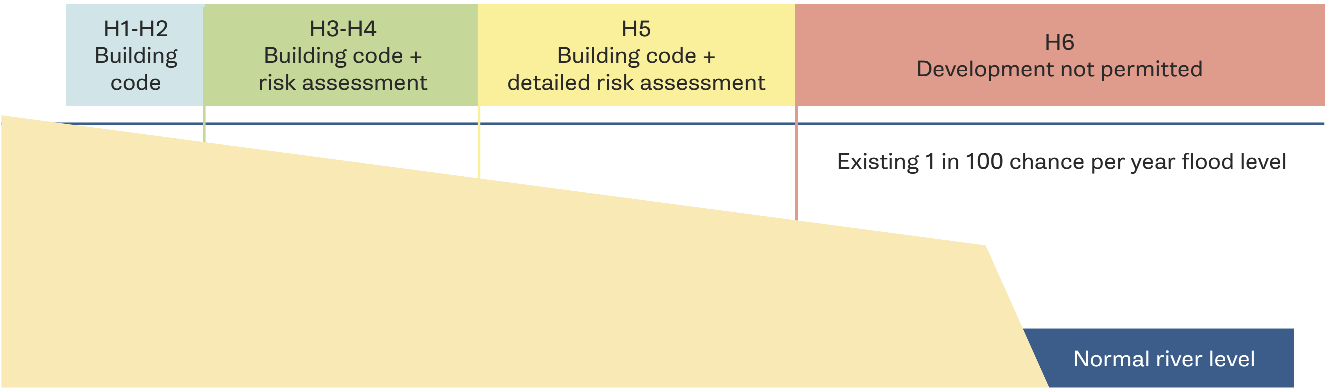


Figure 22: Proposed alignment of land use and development controls to flood hazard categories (source: World Bank Group)

Options to improve emergency response

Given the challenges of reducing flood risk in Greater Honiara by either modifying floods or reducing exposure/vulnerability to floods, it is vital that measures be in place to enable people's safety during flood emergencies. A strong response relies on sufficient warning time, well-informed emergency plans, and good awareness in the community and in government of how and where flooding occurs.

The following measures are recommended:

- Improve and upgrade the flood early warning system, as follows:
  - Improve national-level heavy rainfall alert and warning system.
  - Install and operate real-time rainfall and river gauges in Greater Honiara, including design features to mitigate the risk of vandalism.
  - Develop flash flood guidance system or similar for Greater Honiara.
  - Develop flood forecasting system for Mataniko and Lungga rivers.
  - Strengthen flood warning dissemination and risk communication.
  - Provide capacity building to support hydrological monitoring.
  - Facilitate development of community-based flood warning systems using robust processes to maintain systems.
- Undertake flood emergency planning, as follows:
  - Upgrade evacuation centers and routes (and develop new shelters as needed) based on the risk assessment in this study; 14 new sites are identified for evacuation shelters, and two existing centers are recommended for expansion.
  - Update HCC and GPG Disaster Operating Procedures for floods.
  - Disseminate flood hazard and flood risk information.
- Conduct flood education activities, as follows:
  - Raise awareness of flood risk at ward and village levels, and at schools.
  - Promote participatory planning at ward and village levels.

Figure 23: White River flooding, April 2014 (source: Solomon Star). Note: Development of a flash flood guidance system could provide an early warning for flooding in such catchments.

Improving flood risk management governance

In addition to the three categories of measures described above, there is the need for holistic, integrated, and sustainable arrangements for flood risk management governance. This is vital so that responsibilities for managing flood risk are assigned, understood, and supported at a national level.

An assessment of existing institutional arrangements relating to flood risk management was completed as part of the study. It identified a lack of clarity about roles and responsibilities within HCC and GPG, between national and local government agencies, and at ward and village levels.

Several actions are recommended for strengthening institutions and enhancing coordination to achieve flood risk management outcomes:

- Convene working groups and committees in accordance with the National Disaster Management Plan (2018).
- Establish a committee for managing cross-boundary flood risk between HCC and GPG.
- Increase capacity for relevant institutions, especially those implementing LPSs and the Water Resources Division.
- Regularly review progress on implementing the Honiara Flood Risk Management Plan.

RECOMMENDED PLAN

Various options aimed at reducing and managing flood risk in Greater Honiara were evaluated. The evaluation considered the benefits of each option, using the flood model where possible, while also considering the option's feasibility, cost, and potential social and environmental impacts. A range of government stakeholders contributed to this plan through meetings of the task force, including a multicriteria analysis workshop. Some options were also discussed with community representatives. It should be noted that many of the options will require significant further design and investigation before they can be implemented.

> Comparing all available options, an integrated flood risk management plan for Greater Honiara was developed. It includes further investigation of flood modification options, implementation of options to reduce exposure and vulnerability to floods, and options to improve emergency response.

The recommended Honiara Flood Risk Management Plan is presented in table 2; it includes indicative costing (where possible), priority, and responsibility.

Successful implementation of the plan and sustained gains in reducing and managing flood risks requires improved flood risk management governance. This in turn depends on clear definition of roles and responsibilities and effective coordination to avoid gaps and/or overlapping mandates. Furthermore, the implementation of recommended options requires that the capacity of relevant institutions be strengthened. This need is implicit but is noted specifically for implementing the land use planning/ development control options and hydrological monitoring.

STUDY OUTPUTS

The Honiara Flood Risk Management Study and Plan is the largest project of its kind ever carried out in the Solomon Islands (possibly in any of the Pacific Small Island Developing States). It has produced a number of important deliverables:

1. **Honiara Flood Risk Management Plan.**
   The plan is a prioritized program of actions to better manage flood risks in Greater Honiara and increase the city's resilience to weather extremes.

2. **Online information management system.**
   This tool, called the Honiara Flood Map Viewer, allows users to look up flood depths, flood levels (height above sea level), and flood hazard classification (see figure 11) for seven modeled flood scenarios: the 1 in 5, 1 in 20, 1 in 100, and 1 in 500 chance per year floods, plus two climate change scenarios, plus the modeled April 2014 flood. The link is http://honiarafloodmap.mecdm.gov.sb.

3. **Training of key stakeholders.**
   In addition to regular meetings of the task force throughout the project, a series of workshops was held at the study's conclusion to transfer the knowledge, lessons learned, and next steps to relevant sectors within the Solomon Islands Government. Training was provided to GIS (geographic information system) operators in the use of the information management system app.

4. **Resources for future flood studies.**
   Design of stormwater infrastructure requires design rainfalls, which describe the intensity of rain that can be experienced over different time durations for different storm chances. The current study has interrogated historical rainfall data for Honiara to develop new design rainfalls.

TABLE 2: Recommended Honiara Flood Risk Management Plan

OPTION	ESTIMATED COST (US$)	PRIORITY	RESPONSIBILITY
OPTIONS TO MODIFY FLOODS			
Investigate options to mitigate flood impacts from Honiara International Airport levee	$200,000	High	MCA, NDC, MID
Undertake sustainable watershed management	-	High	MoFR
Further investigate White River monsoon drain	$140,000	Medium	NDC, NDMO, MID
Further investigate Mataniko River flood detention dam	$480,000	Medium	NDC, MID
Further investigate Burns Creek flood detention dam	$350,000	Medium	NDC, MID
OPTIONS TO MODIFY EXPOSURE AND VULNERABILITY			
Coordinate program of community-led flood resilience initiatives	-	High	MLHS, MID, NDMO, development partners
Provide capacity building to support development controls	$230,000 for first year	High	HCC, GPG, MLHS
Amend flooding overlays in Honiara LPS and draft Henderson LPS	-	High	HCC, GPG, MLHS
Review land uses for future urban growth identified in the Greater Honiara Urban Development Strategy and Action Plan	-	High	MLHS
Replace building ordinances with a national building code that enhances flood resilience	-	Medium	HCC, GPG, MLHS
Amend the Planning Development Act	-	Medium	HCC, GPG, MLHS
Amend the Environment Act	-	Medium	HCC, GPG, MLHS
Explore opportunities for resettlement	-	Low	HCC, GPG, MLHS

OPTION	ESTIMATED COST (US$)	PRIORITY	RESPONSIBILITY
OPTIONS TO IMPROVE EMERGENCY RESPONSE			
Improve national-level heavy rainfall alert and warning system	-	High	SIMS
Develop flash flood guidance system or similar for study area	$150,000	High	SIMS
Develop flood forecasting system for Mataniko and Lungga Rivers	$175,000	High	SIMS
Strengthen flood warning dissemination and risk communication	-	High	SIMS, NDMO
Install and operate real-time river and rainfall gauges in study area	Included in cost below	High	WRD
Provide capacity building to support hydrological monitoring	$330,000 plus $70,000 a year	High	WRD
Facilitate development of community-based flood warning system	$250,000	High	NDMO, HCC, GPG, SIMS
Upgrade evacuation centers and routes (and develop new shelters)	-	High	HCC, GPG, NDMO
Update HCC and GPG Disaster Operating Procedures for floods	-	High	HCC, GPG, NDMO
Disseminate flood hazard and flood risk information	-	High	HCC, GPG, NDMO
Raise flood awareness at ward and village levels, and at schools	-	High	NDMO, MoE
Conduct participatory planning at ward and village level	-	High	NDMO, MoE

Note: GPG = Guadalcanal Provincial Government; HCC = Honiara City Council; LPS = Local Planning Scheme; MCA = Ministry of Communication and Aviation; MID = Ministry of Infrastructure Development; MLHS = Ministry of Lands, Housing and Survey; MoE = Ministry of Education; MoFR = Ministry of Forestry and Research; NDC = National Disaster Council; NDMO = National Disaster Management Office; SIMS = Solomon Islands Meteorological Service; WRD = Water Resources Division of Ministry of Mines, Energy and Rural Electrification; - = Not estimated.

Front cover photo: Riverbank erosion, Mataniko River, after April 2014 flood (source: World Bank Group).
Rear cover photo: (source: Solomon Star)

ABBREVIATIONS

AEP	Annual exceedance probability
GPG	Guadalcanal Provincial Government
HCC	Honiara City Council
LPS	Local Planning Scheme
RCP	Representative Concentration Pathway
T+TI	Tonkin & Taylor International

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A task force was established to enable key stakeholders from the Solomon Islands Government, Honiara City Council, and Guadalcanal Provincial Government to influence the scope of the project, oversee its progress, and shape its outcomes. The contribution of the task force is gratefully acknowledged. Flood modeling utilized (adjusted) topographic data acquired by the Ministry of Health and Medical Services.

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