Preserving Resilience of Historic Properties Through Rapid Interdisciplinary Collaboration

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More than 680 million people live in low-lying coastal areas susceptible to climate change and flooding (IPCC 2019). The Jean and Zohmah Charlot House is a historic residence in Honolulu, located in a flood-prone neighborhood, that provides a powerful case study on preservation, planning, hazard mitigation, retrofitting and adaptive design of historic structures. The research, learning and engagement among diverse stakeholders supports resilient placemaking and preservation of treasured community assets. The home is listed on National and State registries of historic properties. The Historic Hawai'i Foundation partnered with the University of Hawai'i (UH) to identify research methods for addressing climate resilience and develop and test engagement strategies, which included virtual workshops to develop a hazard mitigation plan for the property. An interdisciplinary team of faculty members, professionals, and students: i) identified hazards; ii) documented site vulnerabilities; iii) mapped and analyzed hazards and mitigation strategies; iv) reviewed literature and evaluated mitigations; v) engaged subject matter experts to support assessment of strategies; vi) developed and shared alternatives that were compiled and disseminated among stakeholders. The research team forged new relationships by including subject matter experts from landscape architecture, planning, emergency management, engineering, insurance, law and environmental sciences.

Participants joined in three 1.5 hour virtual workshops to identify hazards, mitigation strategies, and review plans. Technologies including 360 degree imagery and ArcGIS StoryMap enhanced the virtual workshop. Based on feedback from the workshops, the Disaster Mitigation Plan illustrates, annotates, and ranks strategies for risk reduction and future policy and research needs.

This university-led collaboration is a model for engaging planners, architects, landscape architects, preservationists, engineers, lawyers, and insurance agents on the challenges of preservation and hazard risk reduction. The rapid, three-part planning process using all-virtual, all-volunteer participants provides a low cost approach for subject matter expert engagement and focused knowledge-sharing on resilience strategies that can be applied and implemented for other endangered properties and scaled up to address broader neighborhood, watershed, and regional impacts from climate change and extreme events.

INTRODUCTION AND OVERVIEW

This research demonstrates a replicable process to rapidly create a Natural Disaster Mitigation Plan for a historic building through an interdisciplinary, university-led collaboration. The topic of disaster mitigation and resilience is globally relevant and requires consideration of climate change, including increasingly powerful storms and rising sea levels (HCCC 2018). In 2020, the Historic Hawai'i Foundation partnered with the UH Community Design Center to develop a Natural Disaster Preparation and Mitigation Plan for the Charlot House: a historic residence that was gifted to the University of Hawai'i. An interdisciplinary team of faculty and students from the UH Mānoa School of Architecture, Department of Urban and Regional Planning, Sea Grant College Program, Community Design Center, National Disaster Training and Preparedness Center, and Environmental Research and Design Laboratory conducted the research and hosted volunteer professionals who participated in three virtual workshop sessions.

Recognizing that natural hazard mitigation saves $6 on average for every $1 spent (NIBS 2018), this research proposes potential adaptation treatments to withstand and recover from a natural disaster while maintaining the property's historic character. Resilience is "the ability [for the built environment] to resist, absorb, accommodate, and recover from the effects of a hazard in a timely and efficient manner, including through preservation and restoration of its essential basic structures and functions" (UNISDR 2009). "For historic buildings, future proofing means preparing for [threats and] changes in a way that protects a building's historic character while extending its lifespan and conserving resources. So far, however, there has been no widely accepted rubric for applying concepts of future proofing or resilience to historic preservation and heritage conservation" (O'Connell 2014). "Cultural heritage-specific

Figure 1. Charlot House and Waialae Stream. Image credit. © Darren Bradley

Figure 2. Charlot House interior with mural by Jean Charlot. Image credit. © Darren Bradley

research is scarce within the climate change literature … challenging climate adaptation efforts to minimize adverse impacts on cultural heritage" (Seekamp 2020). A study in Colorado found that most municipalities value their historic resources but very few proactively plan for their protection from hazards (Rumbach 2020).

Practicing architects and scholars need to address climate change, as the American Institute of Architects (AIA) Code of Ethics and Professional Conduct references the important role of the architect in addressing climate change and adaptation (AIA 2020). This is reinforced by the AIA Framework for Excellence "Design for Change." This project offers one way that architects can act as conveners of people and curators of knowledge that communities need to address climate change.

BACKGROUND ON CHARLOT HOUSE

Situated on the island of O'ahu, the Charlot House is located in the Kahala neighborhood, less than 500 feet from the ocean, sited next to a drainage canal. Built in 1958, the home expresses a globally significant cross cultural interpretation of mid-century modern idiom and a careful integration of art and architecture. The home is a product of the collaboration between the artist Jean Charlot, architect Pete Wimberly, and landscape architect James Hubbard (Fig. 1 and 2). The house is on the U.S. National Register of Historic Places (NPS n.d.). After the passing of Jean Charlot, the family gifted the house to the university.

APPROACH AND METHODS

When approaching the Charlot House as a case study for hazard mitigation, the research team collectively developed and utilized the following methods to plan for future resilience: i) identify hazards; ii) document existing site vulnerabilities; iii) map and visualize hazards; iv) review literature and compile strategies; v) engage subject matter experts; vi) develop and share the plan (Fig. 3). The methods build upon the AIA Resilient Project Process Guide, which includes: i) hazard and climate projections; ii) vulnerabilities, cascading consequences, and adverse effects; and iii) design solutions (AIA 2022).

Planning and design which benefits diverse communities should include better hazard data, improved guidance on risk identification for historic resources, and engagement tools for improved collaboration to mitigate natural hazard risk (Rumbach 2020). This research documents a case study on the gathering and sharing of hazard data, risks, mitigation strategies, and virtual engagement between disciplines.

The team identified the natural disaster hazards and climate projections for Honolulu. The team mapped the site-specific flood hazards, including sea level rise and groundwater inundation, tsunami, storm surge, and FEMA flood zones.

Second, the team identified the vulnerabilities and ways in which the people and built environment are susceptible to adverse effects (AIA 2022). The team sought to identify hazards that threaten the building, sculptures, surrounding site, and occupants. After the team had identified several risks to the home and property, fire, wind, and flooding were selected as the three primary hazards for the study.

The team documented hazards, quantified risks, and primary points of vulnerability such as low openings in the facade where flood waters might enter, dry brush that could fuel a fire, and the lack of hurricane ties at the roof. A 360 degree camera was used to provide visual access to the house, virtually, which was

Figure 3. Research process. Image credit. research team

critical to subject matter expert engagement during a period in which the pandemic limited in-person meetings.

The team surveyed mitigation and adaptation strategies in existing guides, and compiled those applicable to the Charlot House into documents for discussion. The National Park Service (NPS) Guidelines on Flood Adaptation for Rehabilitating Historic Buildings (NPS 2021) included relevant flood adaptation strategies and examples. The Homeowner's Handbook to Prepare for Natural Hazards offered practical measures for retrofitting residences (Hwang, Okimoto 2019). The Charlot House provides a case study for surveying adaptation strategies and selectively considering and assessing their site-specific relevance.

The research team forged new interdisciplinary relationships by inviting subject matter experts from diverse disciplines including architecture, preservation, landscape architecture, emergency management, engineering, insurance, law, and environmental sciences. Preservationists and natural hazards planners largely work independently from one another, which is a dynamic that needs to evolve (Rumbach 2020). Interdisciplinarity integrates information, data, methods, tools, concepts, and/or theories from two or more disciplines focused on a complex question, problem, topic, or theme. The key defining concept of interdisciplinarity is integration, a blending of diverse inputs that differs from and is more than the sum of the parts" (National Research Council 2014; Peek and Guikema 2021).The subject matter experts volunteered their time in three, two-hour virtual workshops. All of the workshop material (such as photos, maps, and strategies) were posted to the storymap.arcgis.com website for the current and future teams working on the Charlot House. The first workshop introduced participants to the objectives, the house, and the material compiled on the project website. In the second meeting, participants assessed and proposed strategies in terms of urgency, feasibility, historic impacts, structural impacts, and cost. The findings were synthesized and presented at the third meeting and informed the Disaster Preparation and Mitigation Plan.

RESULTS: HAZARDS, RISKS, AND VULNERABILITY ASSESSMENT

Consistent with the AIA Resilient Project Process Guide (AIA 2022), the team first determined the hazard and climate projections for the Charlot House site. In Honolulu, HI, sea level rise will likely inundate coastal areas in the long-term and in the short-term cause high tide flooding with increasing frequency (CCH 2018). Researchers in Hawai'i estimate a $19 billion dollar loss of land and structures due to sea level rise impacts (Hawai'i Climate Change Mitigation and Adaptation Commission 2017). Heavy rainfall events and droughts have become more common (HCCC 2018) and modeling estimates tropical cyclones will track further northward toward Hawai'i (Murakami 2013). In the subtropical climate of Honolulu, HI, the trend of warming air temperatures is expected to continue (HCCC 2018).

The research team and volunteer experts identified the three highest priority hazards as flooding, hurricane, and fire because they threaten the house's historic features. Fires may be ignited by electrical wiring, appliances, or wildfire and fueled by dry vegetation or the house's wood structure. The Waialae-Kahala area is rated a low risk for wildfires (HI-EMA 2017). There is a 25% chance of a hurricane or tropical storm (and associated high wind event) and a 3% chance of a hurricane leading to a FEMA-declared disaster (HI-EMA 2018).

Figure 4. Waialae stream adjacent to property nears overtopping. Image credit. Keola Annino

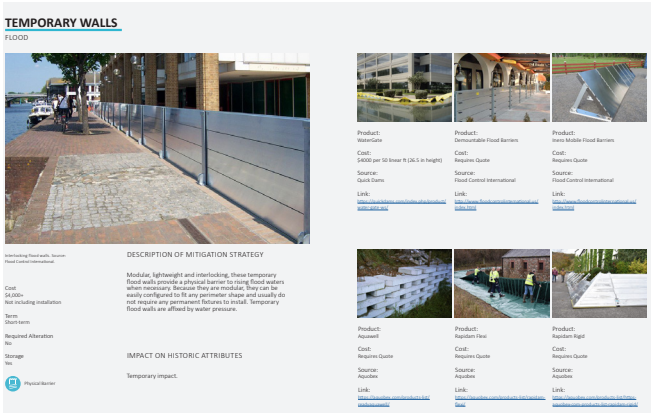

Figure 5. Thumbnail view of a hazard mitigation strategy cut sheet. Image credit: research team.

Based on research and input from subject matter experts, flooding was identified as the most significant threat. The Charlot House is located less than 1,000 feet from the shoreline bounded by a canal, Waialae Stream, on the east. The property is approximately 5–6 feet above mean sea level located in the 100-year floodplain (1% annual flooding probability) in FEMA flood zone AE with a base flood elevation of 9 feet above mean sea level. Another way to describe the flood probability is that there is a 26% chance that there will be a 100-year flood over a 30 year time period. Thirty years is selected for this example because it is the duration of a typical mortgage.

Annually, there is a 100% chance of the state experiencing a flood event due to storm surge or heavy rainfall and a 26% chance one will be a FEMA-declared disaster (HI-EMA 2018). Regarding tsunamis, there is a 17% chance annually of a coastal evacuation and a 34% chance of an advisory with no required evacuation (HI-EMA 2018).

The team mapped the flood hazards from short term shocks such as rainfall, storm surge, high tides, hurricane, or tsunami, as well as long term stressors such as sea level rise, and noted the base flood elevation. The concrete canal adjacent to the house is downstream from the larger, urban watershed and water levels approach the edge of the canal during present-day heavy rain events (Fig. 4). This raises concern about canal overtopping as more intense rainfall and sea level rise increase the volume of water in the canal.

To visualize the flood hazards and risks to the property, the team created building elevation drawings to illustrate potential flood water depths for various types of flooding. For a Category 4 Hurricane, flood depths are estimated at 5.9 to 10.8 feet above mean sea level, resulting in approximately 1–6 feet of flooding above grade the Charlot House (Fig. 6). These drawings also estimate the height of the interior floor if the building were to be significantly renovated now or in the future with sea level rise.

The research team and volunteer experts described the risk, quantifying each of the threats (AIA 2016). The lifespan of the building is indefinite; the caretakers are responsible for the building in perpetuity. The team documented and discussed the risk of damage to the elements that define the historic character of the house such as the paintings, sculpture, reliefs, and tiles by Jean Charlot, and the hapu'u fern wall. Historically significant sculptures, flooring, walls, furniture are located outside and inside at grade, vulnerable to flooding, and would be difficult or impossible to repair. The roof and awnings, single-pane glazing, and trees appear vulnerable to hurricane force winds and projectiles. Dry brush, wood structure, and lack of a fire suppression system make fire a risk to the entire building and site. The house serves as a primary residence for the caretaker, who would be vulnerable in the case of a natural disaster. After a hazard strikes, focus should be on restoring critical functional requirements as soon as possible such as electricity, water, and a secure enclosure. When preparing for a natural disaster such as a hurricane, mitigation strategies should be suitable for the one caretaker to deploy.

RESULTS: MITIGATION AND ADAPTATION

Drawing on existing guides and best practices, the research team identified potential mitigation and adaptation strategies to address fire, flooding, and hurricane hazards and ranked the risks and refined assessment of effectiveness based on input of experts in engineering and design. Prior to the workshops, the project team created cut sheets to describe mitigation strategies using photos, product information, manufacturers, suppliers, costs, and factors relevant to installation and use (Fig. 5). During the workshop, each cut sheet was displayed as experts provided feedback on the mitigation strategies for the Charlot House. Strategies were evaluated for ease of implementation, cost, urgency, and impact on the long term historic character of the house and site. These interactions with subject matter experts provided the research team with new perspectives and were incorporated into the strategies. The feedback

FEEDBACK: FLOOD RISK MITIGATION STRATEGIES

FLOOD INSURANCE

PRIORITY: HIGH

DISCUSSION POINTS:

- Flood insurance is required for this house as it is located in a flood zone.
- Consider that flooding can occur both from above and from below, such as through groundwater inundation.

TAKEAWAY:

Flood insurance should be purchased for this property.

FLOOD WALL- PREVENTING CANAL OVERTOPPING

PRIORITY: HIGH

DISCUSSION POINTS:

- It is a high priority to implement protection around the entire site.
- If this involves raising the existing wall along the canal, it may become complicated. There must be an assessment of the existing wall to understand its engineered resistance and construction
- It would prevent high velocity flooding from the canal, but would not prevent groundwater inundation.
- There would need to be a structural post every three feet or so apart. This would have a significant impact on the historical property.

TAKEAWAY:

The installation of a flood wall can be effective and may be a worthwhile investment. Consider installing the flood wall along the sides of the house and using a temporary wall along the canal and driveway to minimize visual impacts.

RELOCATE/ELEVATE UTITILIES TO A HIGHER ELEVATION

PRIORITY: MEDIUM

DISCUSSION POINTS:

- The water heater could be placed on a structure to raise it higher.
- It is not feasible to relocate all utility conduits.
- Additional structural members may be required to support equipment.

TAKEAWAY:

It is possible to elevate all utilities, but it will be expensive and challenging.

FLOOD GATES

PRIORITY: HIGH

DISCUSSION POINTS:

- Flood gates may be a useful strategy.
- Will these be temporarily deployed? If not, they will detract significantly from the aesthetics of the house.
- Consider the hydrostatic forces on the framing. WIll the structure hold up to the forces?

TAKEAWAY:

Installing flood gates could be a very effective strategy.

Table 1. Sample page from research report documenting feedback from workshop participants on strategies . Image credit. research team

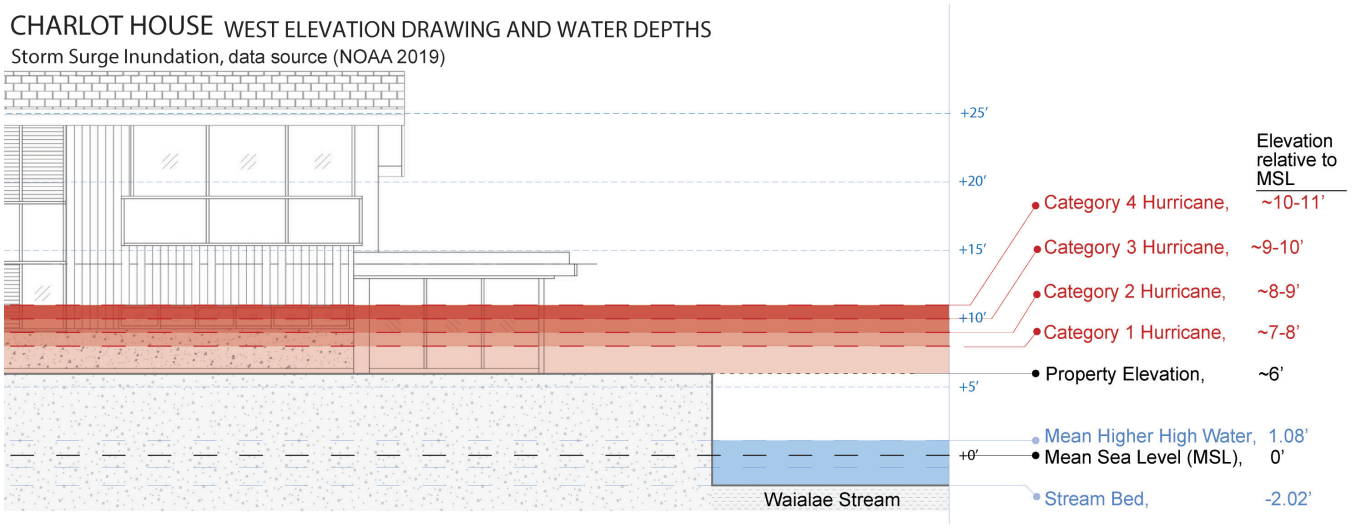

Figure 6. Elevation drawing overlaid with estimated water levels from hurricanes. Image credit: research team.

was summarized, categorized and documented into discussion points and key takeaways in a report and website (Table 1).

From the long list of recommendations, high-priority actions and longer term planning needs were identified. Short term, high priority action items identified included purchasing flood and hurricane insurance, acquiring sandbags, installing window film, conducting a structural assessment, and using structural screws to discreetly secure the roof from wind uplift. Further investigation is needed to assess if other temporary protective measures could be installed without altering the historic character, including flood barriers at doors or fabric over windows. Some strategies were discarded because they altered the historic character, such as elevating the entire slab on grade house or moving the house to a different location. The team recognized the need for both site-scale and regional scale mitigation measures to infiltrate, slow, and store stormwater runoff.

The following outline of disaster plan strategies is a glimpse of the more detailed information available on the project website.

Short Term/On-Site Strategies

Assess the Property and Transfer Risk

- [High] Conduct house assessment(s) with an insurance agent and fire department to assess fire and flood risks.
- [High] Conduct structural assessment(s) of house and retaining wall.
- [High] Purchase recommended insurance (flood, hurricane).
- [Moderate] Assess for flood gate/Quick Dam feasibility.

Acquire and Install Protection Measures:

- [High] Purchase and store sandbags and train caretakers for deployment.
- [High] Purchase and install window film.
- [High] Purchase polycarbonate sheets and assess the house for pre-determined installation points.
- [High] Purchase fire extinguishers and place them at appropriate intervals.
- [Moderate] Consult with hurricane experts on feasibility of hurricane fabric and associated hardware.
- [Moderate] Purchase and store Quick Dam and train for deployment.

Establish Maintenance Plans:

- [High] Design emergency deployment plan, focusing on caretaker's responsibilities and training for emergency situations and equipment maintenance.
- [High] Design landscape maintenance plan including regular pruning, removing dead vegetation, and cleaning gutters.
- [High] Outline a regular home maintenance plan to minimize clutter, storage of hazardous materials, and maintenance of vents.

Mid-term On-Site

Construct Protective Barriers and Increase Wind Resistance Mechanisms:

- [High] Build a new wall around the perimeter of the property, building off the preexisting canal retaining wall.
- [High] Attain a structural assessment for an installation plan for hurricane screws and install the hurricane screws to brace the roof.
- [Moderate] Conduct an electrical assessment.

Long term/Off-Site

Collaborate With the Waialae Golf Club and Neighbors to Integrate Retention Basin to Protect Houses and Greens:

- [Low] Collaborate with the adjacent golf course on diverting stream water into the golf course retention basin.
- [Low] Work with policymakers on canal dredging policy.

DISCUSSION

The research findings inform practical applications, lessons learned, and future research. This research serves as a case study on resilience-related planning and retrofits for historical residences and non-historical coastal buildings, as well as a format for expert and student engagement. The low-cost, rapid process represents a volunteership model that could be used to provide underserved communities with resilience assistance. This process could be used by other university centers, AIA Design for Risk and Resilience committees, or communities seeking resilience expertise.

Reflecting on the process, the team compiled the following lessons learned.

1. Interdisciplinarity supports design and planning. This is consistent with findings from a study of historic preservation in Colorado where communication and collaboration across departments and organizations seemed key (Rumbach 2020).

2. The design process can help to clarify values as there are conflicts between preservation and protective actions, and different willingness to pay for risk reduction and protection of assets.

3. Preservation is not just about the past, it also must address future problems including climate change.

4. We need to expand our view beyond the structure and site to address problems and generate solutions at the scale of the neighborhood, watershed and broader community. There is a need to address the needs of low-income and under-represented communities. Expansion will require new relationship-building and partnerships.

5. Mitigation and adaptation are forms of insurance and provide alternatives to both doing nothing and merely reacting to harm-causing hazards.

6. Uncertainty provides new opportunities for research and learning. Efforts to clarify areas of uncertainty and new research and data needs are needed to support both site-specific design and broader lessons on climate risk management.

The next steps for continuing research on the Charlot House and this type of work include the following actions. Prepare for a natural disaster by implementing immediately actionable steps: initiating funding for assessments; integrating the plan with the management of the house; and initiating conversations on policies for regional flood mitigation. The team also recommended enhancing university programming by developing disaster planning curricula utilizing the house as a living lab, potentially partnered with industry. As a historic residence and living lab, the house presented a unique tool to disseminate disaster preparedness information with homeowners and neighborhoods.

Future research may seek to improve researchers' interactional expertise or the ability to understand other disciplinary foundations and communicate effectively with contributory experts and practitioners in those disciplines (Gilligan 2021). Interactional expertise requires trust and practice in effective group communication, with attention to dialects, metaphors, and articulation (Gilligan 2021). In the Charlot House workshops, trust was established by inviting familiar, respected volunteer experts. Discussion of mitigation strategy cut sheets in small break-out groups gave each participant time to contribute thoughts, which were written down on a shared screen. Participants listened and incorporated each other's comments into the evolving assessment of each strategy's suitability. In the future, more interaction between participants would likely enhance interactional expertise. The tradeoff between a short-duration volunteer model versus a longer-duration model in which experts are compensated may be considered.

CONCLUSIONS

This research showcases methods and a case study to address resilience at the building scale while acknowledging issues best addressed at a regional scale through policy. A university-led research team compiled natural hazards, risks, vulnerabilities, and potential mitigation strategies for the historically significant Charlot House in Honolulu, HI. Adaptation requires much more than the "control of nature" (McPhee 1989) and must include interdisciplinary approaches (Peek and Gukema 2021). An interdisciplinary group of volunteer experts supported the research team in assessing, suggesting, and prioritizing mitigation strategies to inform planning and design to reduce hazard risks. The short-duration, three-workshop format efficiently gathered expertise from volunteers resulting in a low-cost yet informed plan. The project storymap website was useful in the virtual workshop delivery. The website continues to provide a repository of information on the Charlot House and a process framework that can be replicated in other locations. This framework would be especially critical for vulnerable communities that are often less insured and situated in at-risk areas. The discussions also revealed needs for regional scale policy. Given more time and funding, the team considered another round of workshop sessions that would have broadened the

conversation to include adjacent property owners, the neighborhood board, and City Council members. More directly, the project highlighted opportunities for ongoing university curricula and research, and practical next steps for the Charlot House stewards.

WEBSITE

https://storymaps.arcgis.com/stories/9636b578430d4c7bacaf5e4988f2bed6

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