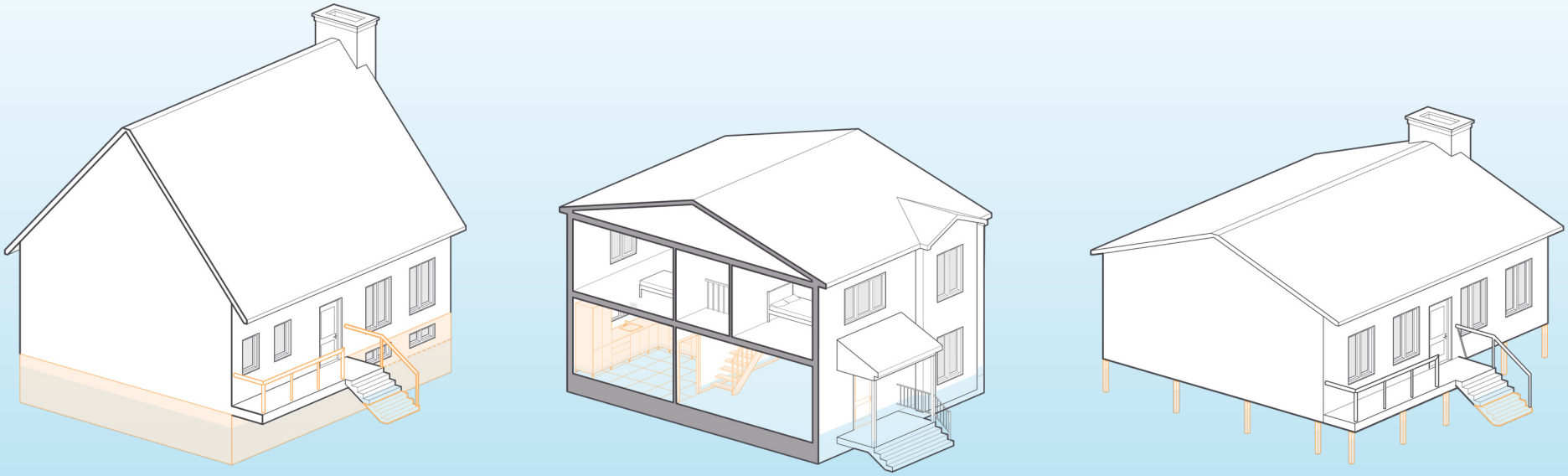

DWELLINGS + FLOODING

MEASURES FOR RESIDENTIAL ADAPTATION

Fact sheets, 2024.03

ARCHITECTURE SANS FRONTIÈRES
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QUÉBEC

ARIACTION

About

ARCHITECTURE WITHOUT BORDERS QUEBEC

Architecture Without Borders Quebec (AWBQ) is an organization assisting populations suffering from crises, natural disasters or social inequalities. It works with communities to build local capacity through the involvement of different actors in the architectural field. AWBQ works overseas with other Canadian international development organizations, and locally within Quebec's urban areas and indigenous communities.

Founded in 2008 by the Quebec Order of Architects, AWBQ represents the official humanitarian arm of the architectural profession. The organization's mandate is to promote volunteerism and social responsibility amongst all 4,500 licensed architects in the province. Given this unique partnership with the Quebec Order of Architects, AWBQ also benefits from the commitment of several trades and many other partners in the implementation of its programs.

For more information
https://www.asf-quebec.org/

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ARIACTION

ARIAction (Adaptation – Resilience – Innovation – Action) is a research team from the University of Montreal's School of Urban Planning, dedicated to studying questions associated with the vulnerability, adaptation, and resilience in living environments.

The research team works to identify both challenges and opportunities associated with climate resilience. Their goal is to promote the implementation of recommendations, solutions, and tools that contribute to greater territorial resilience. Additionally, they aim to enhance the adaptability of societal actors when faced with various risks.

For more information
https://www.ariaction.com/

ARIACTION

RESEARCH TEAM

The fact sheets were developed as part of an extensive project titled "Flood-Resilient Architecture: Expertise Development and Knowledge Transfer," which began in January 2021 in partnership with the ARIAction group from the University of Montreal's School of Urban Planning, and with the support of Concordia University, the Montreal Metropolitan Community (CMM), the Société québécoise des infrastructures (SQI), and the Société d'habitation du Québec (SHQ). This project was made possible through the Fonds de recherche du Québec (FRQ) contribution via the Réseau Inondations InterSectoriel du Québec (RIISQ) and the Mitacs Acceleration program.

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Société québécoise des infrastructures Québec
Société d'habitation Québec

About

TARGET AUDIENCE

The ***Dwellings + Flooding : Measures for Residential Adaptation*** fact sheets are designed to assist homeowners, building professionals, and other stakeholders in preparing for preventive work or reconstruction following water-related damage. They also serve as a resource for local governments looking to promote complementary strategies or alternatives to existing flood risk reduction initiatives or the relocation of buildings at risk of urban flooding, ice-jam, or open-water flooding.

WHEN AND HOW TO CONSULT THIS GUIDE?

The fact sheets present a variety of measures that can reduce the vulnerabilities faced by both homes and homeowners when properly implemented in the appropriate context. These measures can be adopted either as preventive actions or during recovery.

To determine the most suitable measures for a specific situation, one must :

1- Understand hazard characteristics :
Unofficial flood maps can be reviewed for reference on the Géo-Inondations website at geoinondations.gouv.qc.ca.
Additionally, details about the areas affected by the 2017 and 2019 floods are also available at www.cehq.gouv.qc.ca/zones-inond/zone-intervention-speciale.htm.
It is also possible to obtain further information from municipalities, regional county municipalities (MRCs), and watershed organizations.

2- Get familiar with the current normative and regulatory frameworks regarding public safety, zoning, and construction.

3- Conduct a property assessment (soil, foundation, structure, etc.) with a qualified professional.

CLASSIFICATION

The fact sheets are divided into three categories to better support the prioritization of measures to implement.

Sheets C : Key measures
Measures intended for short-term implementation as preventive actions for any residence exposed to water-related damage, whether located in a flood-prone area or not. Their objective is to improve personal safety and/or minimize damage to belongings and equipment during hazardous events. Typically, these measures come at relatively low costs*.

Sheets A : Adaptation measures
Measures intended for medium-term implementation, either as preventive actions or during recovery. Their objective is to improve the resilience (or reduce vulnerability) to flood risk of various elements within a property. The effectiveness of these measures relies on execution quality and they are typically associated with moderate costs*.

Sheets E : Avoidance Mesures
Measures intended for long-term implementation, either as preventive actions or during recovery. Their objective is to minimize the exposure of a residence or living spaces to floods to the greatest extent possible. These measures involve structural and/or foundation work and are typically the most expensive*.

*The implementation costs for these measures are not clearly established, given the uniqueness of each situation. However, in general, the key measures tend to be more economical in terms of materials and labor, while avoidance measures are generally considered the most costly. The latter often require the expertise of engineers and/or architects due to their involvement with structural aspects of the building.

WARNING

The fact sheets present adaptation options that help increase the resilience capacity (or decrease vulnerability) of homes and homeowners to floods. In no way do they offer definitive solutions guaranteeing complete protection against floods, as such solutions do not exist. Therefore, regardless of people's level of preparedness and a building's level of adaptation, it is essential to follow government recommendations for safety in the event of a flood. More specifically, any evacuation orders issued by authorities during a flood or in anticipation of one must be followed.

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The research team thanks all the professionals who contributed to the development and evaluation of this tool :

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Glossary

Adaptation measure : Specific intervention on or within a building aimed at enhancing its flood resilience and reducing the vulnerability of both the building and its occupants.

Adaptation strategy : A broader action plan consisting of a set of measures aimed at better managing flood-related risks.

Assembly : The combination of elements (structural components, cladding, membranes, etc.) that form a structure (or part of a structure) when combined using various attachment techniques (gluing, nailing, screwing, welding, etc.).

Coastal inundation : Flooding of coastal areas caused by marine phenomena such as tides, storm surges, winds, low-pressure zones, etc. (CEHQ, adapted).

Degree of exposure : An indicator related to the risk exposure of an element to a climatic hazard and its effects. It is determined based on the characteristics of the hazard and the position of an element.

Flood risk zone : An area susceptible to flooding, either because it has been flooded in the past, is identified as a flood-prone area, or is exposed to water accumulation (e.g., low-lying areas in urban environments).

Flood Zone : Land that becomes submerged by a watercourse when it overflows its banks (CEHQ).

Fluvial flooding : Flooding caused by a significant increase in the quantity and/or flow of water in a watercourse (CEHQ, adapted).

Hazard : An uncertain and unpredictable event.

Ice jam flooding : Flooding caused by the accumulation of ice, sand, debris, or other materials that obstruct the flow of water and lead to upstream overflow.

MEP systems : Mechanical, electrical, or plumbing systems or components of such systems.

Potential flood level : The height at which water is likely to rise. This height can be assessed based on established reference levels, considering the highest level reached in the past or based on projected climate scenarios anticipating water level increase.

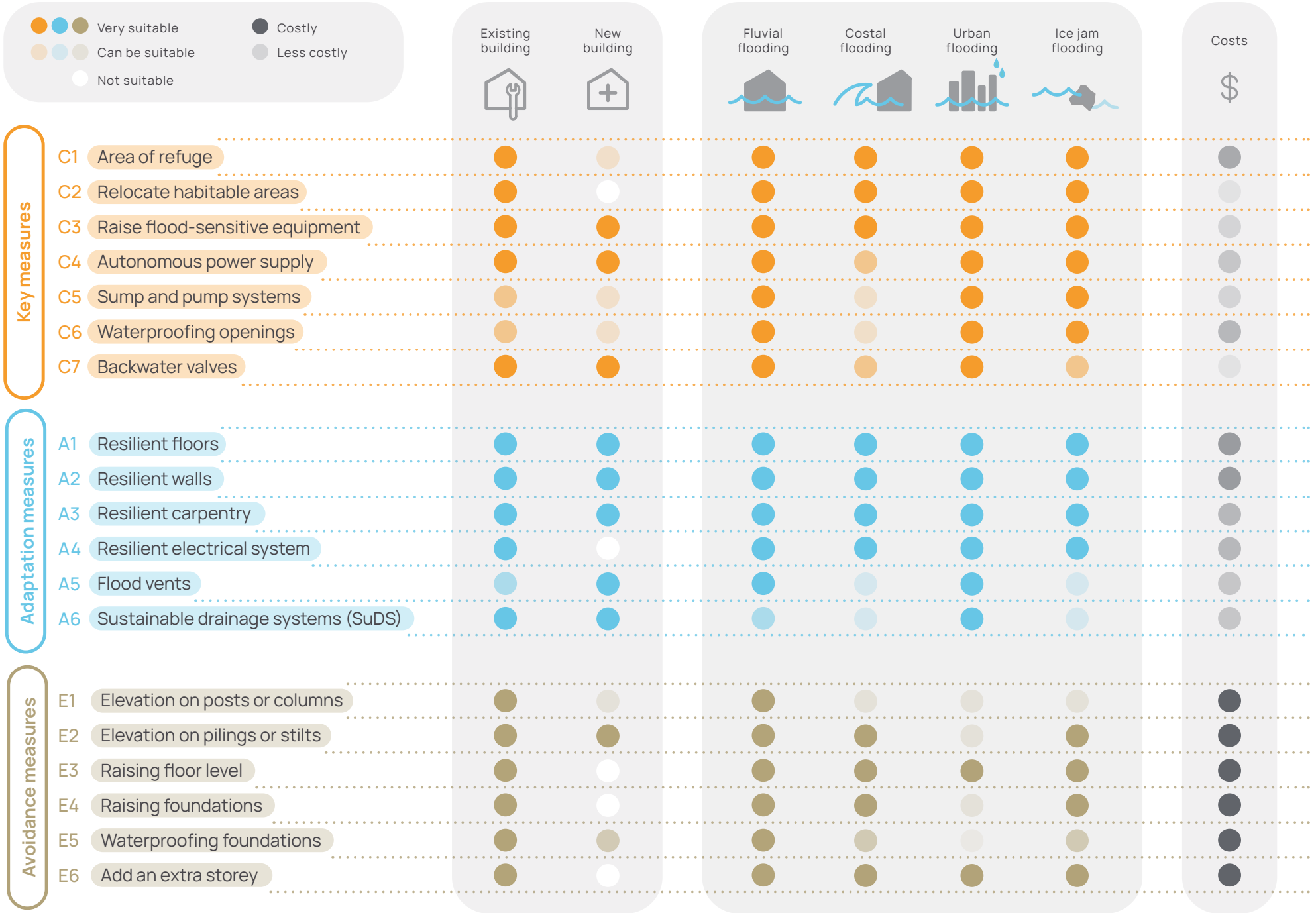
Resilience : The ability to maintain or rapidly regain desired functions following a disruption; to adapt to change; and to promptly transform systems that limit current or future adaptive capacity.

Secondary occupancy space : Space used for purposes other than the primary residence (parking, storage, workshop, etc.).

Urban flooding : Flooding caused by heavy rainfall events over a short period of time, resulting in runoff due to soil saturation or sewer system overload.

Vulnerability : The predisposition of something or someone to suffer damage. It is a factor that combines the degree of exposure and the nature of the exposed element (modified CMM).

Summary table



Fact sheets reading guide

Aspects targeted by the measure

Measure's temporality

Required expertise

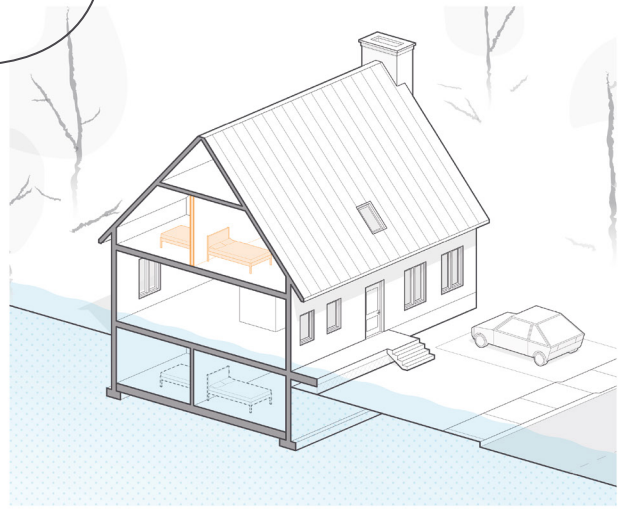
Complementary measures

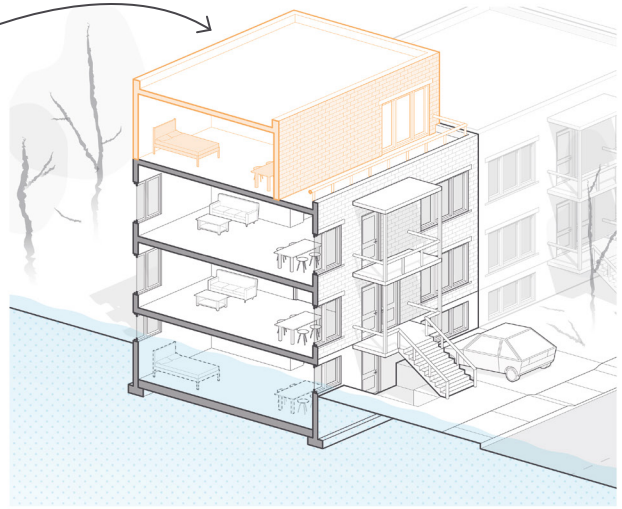
Measure's title and classification

Brief description of the measure

Implementation represented in orange

XX Explanatory sheet





envelope + structure + space | *permanent* | *reversible* | *temporary* | engeneering construction (*expertise*) | C3, C4, C7 A6 (*combinations*)

This section provides a brief description of the measure. It includes, among other things, the building components involved in its application and whether the building remains exposed to floods.

OBJECTIVES

- ☐ Increase occupant safety
- ☑ **Minimize structural damage**
- ☐ Minimize damage to belongings and materials
- ☐ Reduce recovery and reoccupation time

BENEFITS

- Benefits provided by the implementation of the measure. For example, reduction in the building's exposure to risks, decrease in construction costs, preservation of the building's appearance, etc.

IMPLEMENTATION

- This section explains the **implementation** of the measure, focusing on essential information to facilitate communication with professionals. These guidelines should be adjusted according to the contexts.
- Implementation is sometimes accompanied by a **specification** section that describes the various options available.

WARNING

Highlighting of dangers or issues related to the safety or proper functioning of the measure.

CONSIDERATIONS

- Factors to consider before, during, or after the implementation of the measure. For example, compliance with regulatory frameworks, redesigning living spaces, necessary inspection or maintenance, etc.

ADVICE

Additional tips and ideas to facilitate maintenance or increase the benefits associated with the measure.

The **implementations** of some measures are detailed in a second page.

Verso

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ADDITIONAL INFORMATION https://www.asf-quebec.org/en/dwellings-flooding/

Pictogram descriptions

ASPECTS TARGETED BY THE MEASURE

The site is targeted when implementation involves land redevelopment or excavation.

The envelope is targeted when implementation involves altering the composition of exterior walls, the roof, or openings.

The structure is targeted when implementation involves modification of the foundations and/or any essential component to the structural integrity of the building.

Systems are targeted when implementation involves modifications to mechanical, electrical, or plumbing systems, as well as any equipment connected to these networks.

Space is targeted when implementation involves the reorganization of rooms and considers modifications to interior components.

Belongings are targeted when implementation involves their protection in place or relocation.

Individuals are targeted when implementation involves human intervention before, during, or after the hazard.

MEASURE'S TEMPORALITY

A permanent measure involves a permanent modification of the building and provides continuous flood resilience.

A reversible measure is designed to be sustainable over time but can be removed or adapted if the needs of occupants or the risk level change.

A temporary measure involves an intervention during each hazard event to ensure protection of the building and/or occupants.

C1-7

Key measures

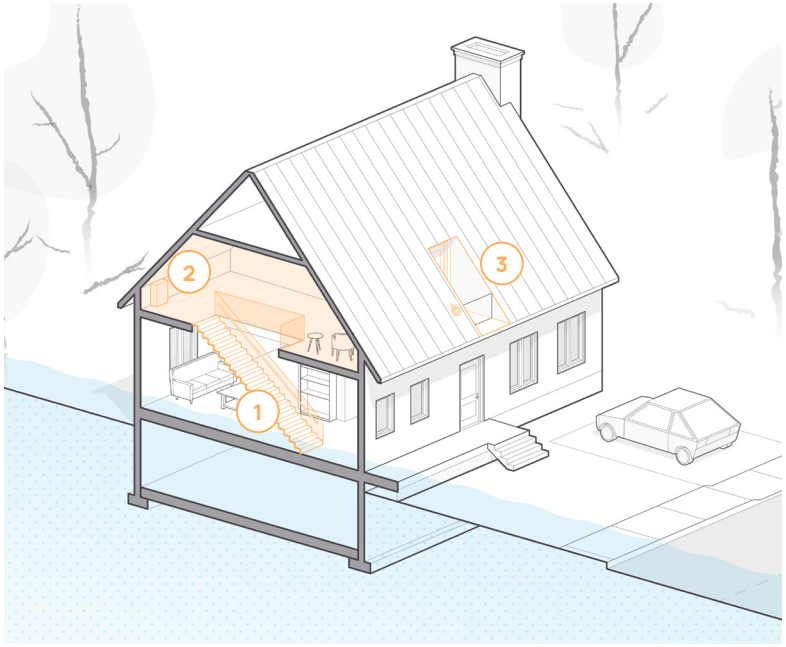
- **C1** Area of refuge
- **C2** Relocate habitable areas
- **C3** Raise flood-sensitive equipment
- **C4** Autonomous power supply
- **C5** Sump and pump systems
- **C6** Waterproofing openings
- **C7** Backwater valves

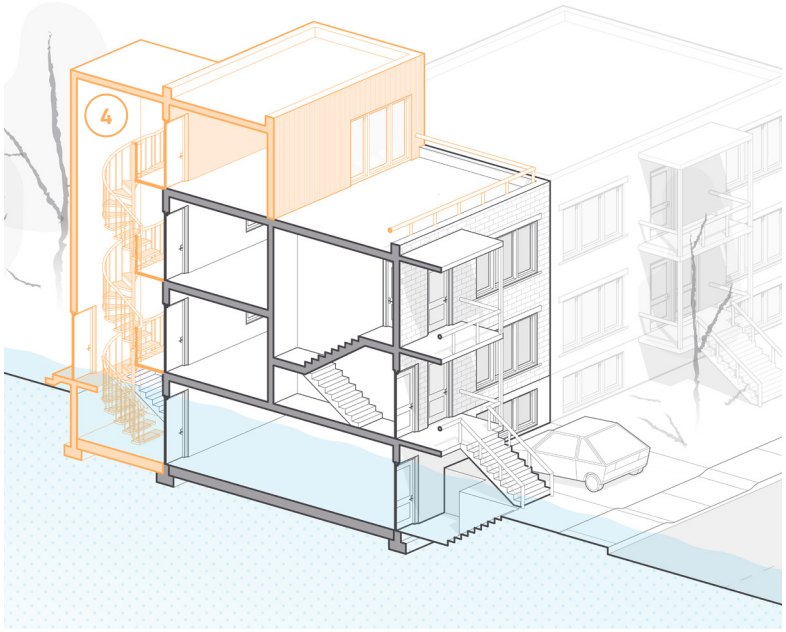
Measures intended for **short-term** implementation as preventive actions for any residence exposed to water-related damage, whether located in a flood-prone area or not. Their objective is to improve personal safety and/or minimize damage to belongings and equipment during hazardous events. Typically, these measures come at relatively low costs.

C1 Area of refuge

space + belongings + individuals | permanent | reversible | temporary | architecture engineering | C4 A4

expertise | combinations





Creating an area of refuge above flood levels is a **reversible safety measure** for individuals, reducing their vulnerability in the event of a flood. It is essential to have one in any building exposed to flooding. The building remains exposed to the hazard, and the levels below the flood level should implement adaptation measures to cope with it.

A refuge area is a space that must have **an access point from inside the building for shelter and a second one leading outside for evacuation.** It can be created as a result of the adaptation of an existing indoor space or through an extension.

OBJECTIVES

- [x] **Increase occupant safety**
- [ ] Minimize structural damage
- [ ] Minimize damage to belongings and materials
- [ ] Reduce recovery and reoccupation time

BENEFITS

- Preservation or minor alteration of the **building's exterior appearance**
- Potential usage of the **additional space created**

IMPLEMENTATION

General

- Provide interior access via a fixed staircase with a handrail, a ladder, or a retractable staircase. (1)
- Provide a 72-hour emergency kit. (2)
- Ensure an emergency exit (door or window) with a minimum dimension of 1m x 1m. (3)
- Allocate a minimum area of 1m² per person.
- Ensure a ceiling height of 2.20 m.
- Ensure the load-bearing capacity of the structure and floor is at least 125 kg/m².
- Use non-slip flooring materials to ensure safer evacuation.
- Install a docking ring on the exterior wall to facilitate access for rescue via waterway.

Building without a floor above the flood level

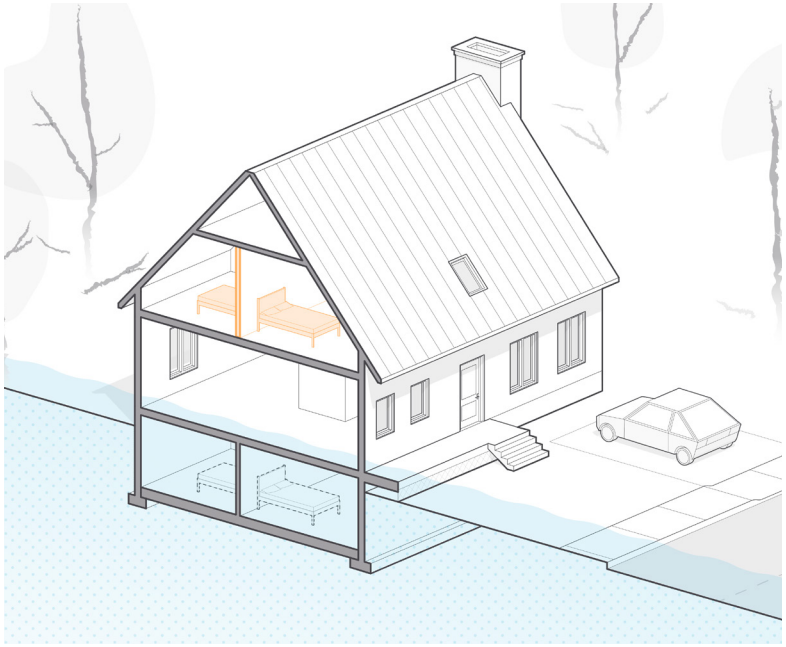
- Create a space on the roof, ideally covered, or on the roof of an adequately anchored annex building.
- Provide access from inside the residence.
- Adopt a short-term avoidance strategy and adaptation measures.

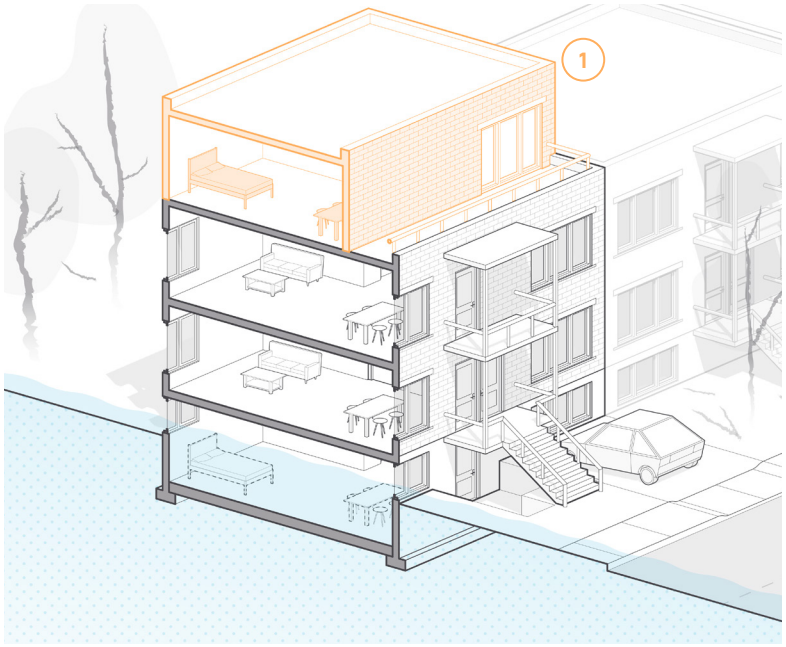
Multi-family dwelling

- No dwelling should be located below the established flood level. Ideally, dwellings should be relocated through strategies such as adding an extra storey **(see the Add an extra storey fact sheet).**
- In the extraordinary case where a dwelling is located below the flood level, provide interior access to a properly designed refuge area. (4)

C2 Relocate habitable areas

space + belongings | permanent | reversible | temporary | expertise | C3, C4 A4 combinations





Relocate habitable areas above the potential water level is a **reversible safety measure** that reduces the vulnerability of individuals and the exposure of belongings to floodwaters. The building remains exposed to the hazard, and the levels below the flood level should implement adaptation measures to cope with it.

This measure involves **relocating the building's habitable areas, originally located below the flood level, to higher levels.** This involves either abandoning the original spaces or using them for low-risk purposes such as parking, access, or storage in flood-prone areas.

OBJECTIVES

- ☑ **Increase occupant safety**
- ☐ Minimize structural damage
- ☑ **Minimize damage to belongings and materials**
- ☑ **Reduce recovery and reoccupation time**

BENEFITS

- **Does not require the services of building professionals**

IMPLEMENTATION

General

- Prioritize relocating bedrooms, kitchen, and bathroom to a level above the flood level.
- Adapt areas located below the flood level **(see the Adaptation fact sheets).**
- Maintain access to basement spaces in buildings exposed to tornadoes and severe wind risks.

Building without a floor above the flood level

- Not applicable : adopt short-term avoidance and/or adaptation measures.

Multi-family dwelling

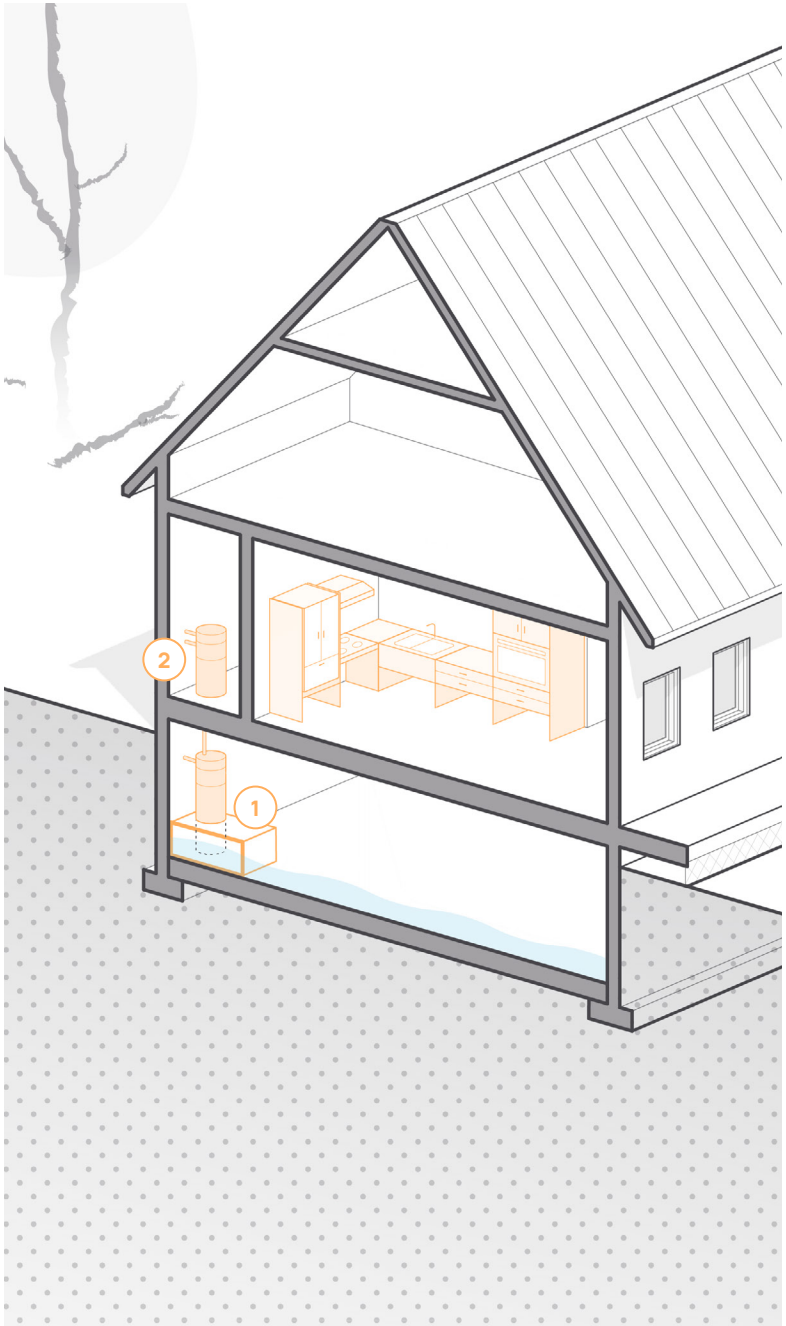
- No dwelling should be located below the reference mark. Dwellings below this mark can be relocated by adding an extra storey if municipal regulations allow it **(see the Add an extra storey fact sheet).** (1)

CONSIDERATIONS

- **Loss of basement living spaces**

C3 Raise flood-sensitive equipment

systems + belongings | permanent | reversible | temporary | mechanical, electrical, plumbing (expertise) | C2, C4, C7, A3, A4 (combinations)



Raising equipment above flood levels is a **reversible adaptation measure** that reduces flood exposure. The building remains exposed to the hazard, and the levels below the flood level should implement adaptation measures to cope with it.

Protecting flood-sensitive equipment includes **MEP systems and their appliances (water heater, air conditioner, heat pump, etc.), as well as household appliances.** It involves raising them above the reference mark (1), relocating them to a higher floor (2) or protecting them in place.

OBJECTIVES

- ☐ Increase occupant safety
- ☐ Minimize structural damage
- ☑ **Minimize damage to belongings and materials**
- ☑ **Reduce recovery and reoccupation time**

BENEFITS

- **Reduced repair costs**
- Ability to **keep equipment running** during the flood
- Accelerated **recovery of equipment** after the flood

WARNINGS

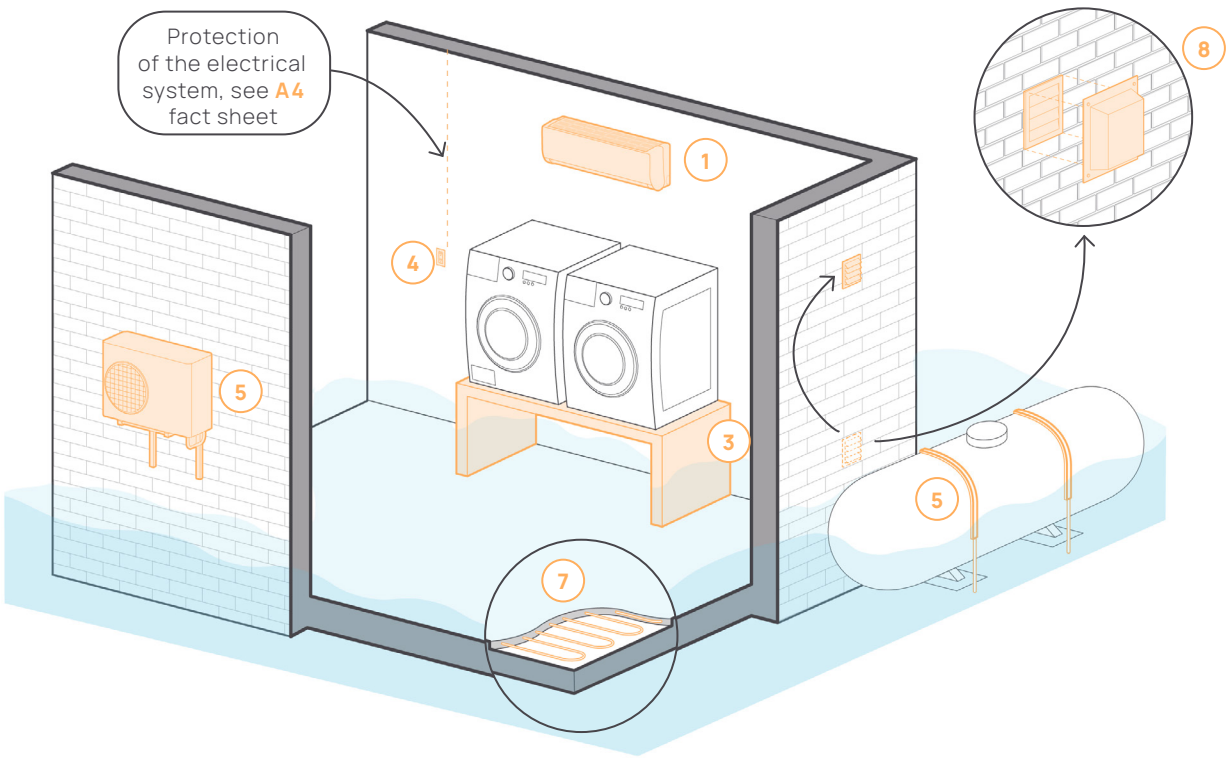
It is not advised to use any device or system that has come into contact with water. **These should be replaced or cleaned and inspected by a professional.**

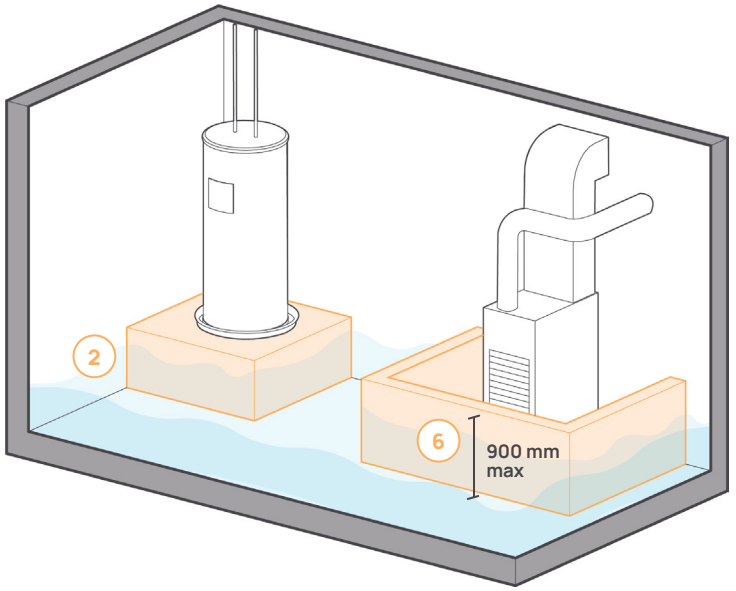
On-site protection of equipment carries a risk of infiltration. For equipment sensitive to water or humidity, **prioritize elevation or relocation strategies.**

Power outages are common during floods. To ensure the continuous operation of essential equipment, it is recommended to combine the measure of waterproofing equipment with the addition of an **autonomous power supply**.

CONSIDERATIONS

- **Redesign of certain spaces**
- Greater proximity to **potentially noisy equipment**





IMPLEMENTATION

Elevation and relocation

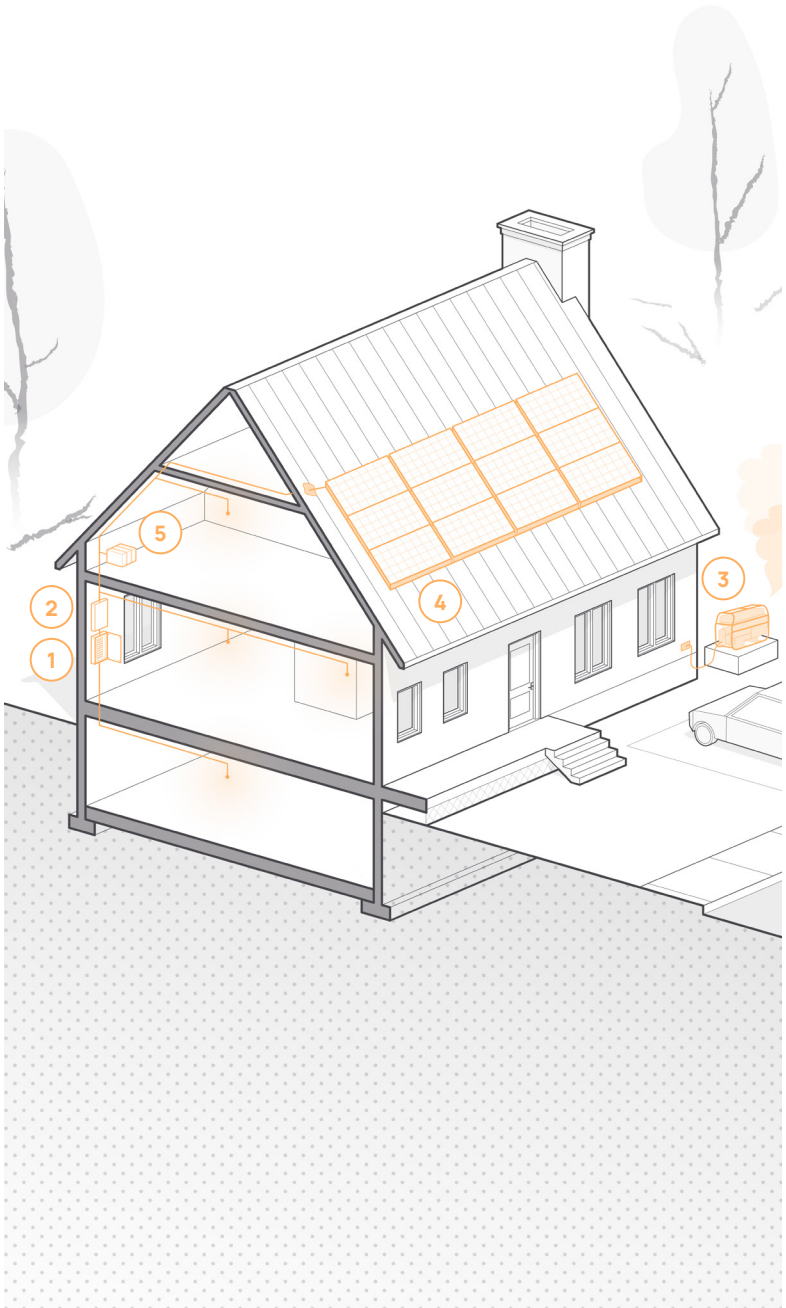
- Remove heating and air conditioning equipment located below the flood level (baseboards, convector heaters, radiators, ventilation ducts). (1)
- Raise the equipment on a platform above the flood level or move them to an upper floor. (2)
- Elevate or install at a higher level all appliances that cannot be moved to a higher floor using furniture with good flood resilience capacity **(see the Resilient carpentry fact sheet).** (3)
- Raise electrical outlets and all wall penetrations above the flood level. (4)
- Relocate the HVAC ventilation hatches to a higher position.

On-site Protection

- Secure appliances (water heaters, air conditioners, heat pumps, etc.) in place using anchors. (5)
- Protect appliances with flood barriers or walls. (6) Pair this measure with a **water evacuation system** (submersible pump) to prevent infiltration. This strategy applies to low water levels. A water height above **900 mm** (3 feet) exerts greater hydrostatic pressure, requiring stronger and more complex flood walls.
- Protect radiant floor heating systems with a waterproof assembly, such as a concrete slab or ceramic coating. (7)
- Protect small equipment that cannot be elevated with covers. These covers should be removed after the flood. (8)

C4 Autonomous power supply

systems | permanent | reversible | temporary | electrical installation expertise | C1, C3 C5 combinations



The installation of an autonomous power supply is a **temporary or reversible support measure** that reduces the vulnerability of components, systems, equipment, and assets exposed to floodwaters. The building remains exposed to the hazard, and the levels below the flood level should implement adaptation measures to cope with it.

If the main electrical grid is shut down or affected by flooding, an autonomous power supply such as batteries, solar panels, or a generator **can provide power to a building or certain elements of a building**, including the equipment necessary for the safety of occupants or water evacuation.

OBJECTIVES

- ☑ **Increase occupant safety**
- ☐ Minimize structural damage
- ☐ Minimize damage to belongings and materials
- ☑ **Reduce recovery and reoccupation time**

BENEFITS

- Ability to **keep equipment running** during the flood
- Accelerated **recovery of equipment** after the flood
- Accelerated **water drainage**
- Use for **other types of power outages**

IMPLEMENTATION

General

- Ensure that essential operational elements, such as the electrical panel and connections to independent power sources, are positioned above the potential water level. (1)
- Calculate the electrical power (watts) required to provide power to essential appliances, including sump pump systems and both the lighting and heating system associated with the shelter area. A safety margin of 25% should be provided to accommodate the startup loads of certain appliances.
- Include a transfer switch (2) connecting the power source to the main distribution panel.

Generator (3)

- Position the generator **outside the residence,** away from openings and air intakes, in a location protected from floodwater.
- Ensure an adequate supply of gasoline, propane, and/or natural gas to operate the appliances (approximate operating time varies from 5 to 11 hours).
- Plan for a voltage regulator to reduce the risk of damaging certain appliances.

Solar panels (4)

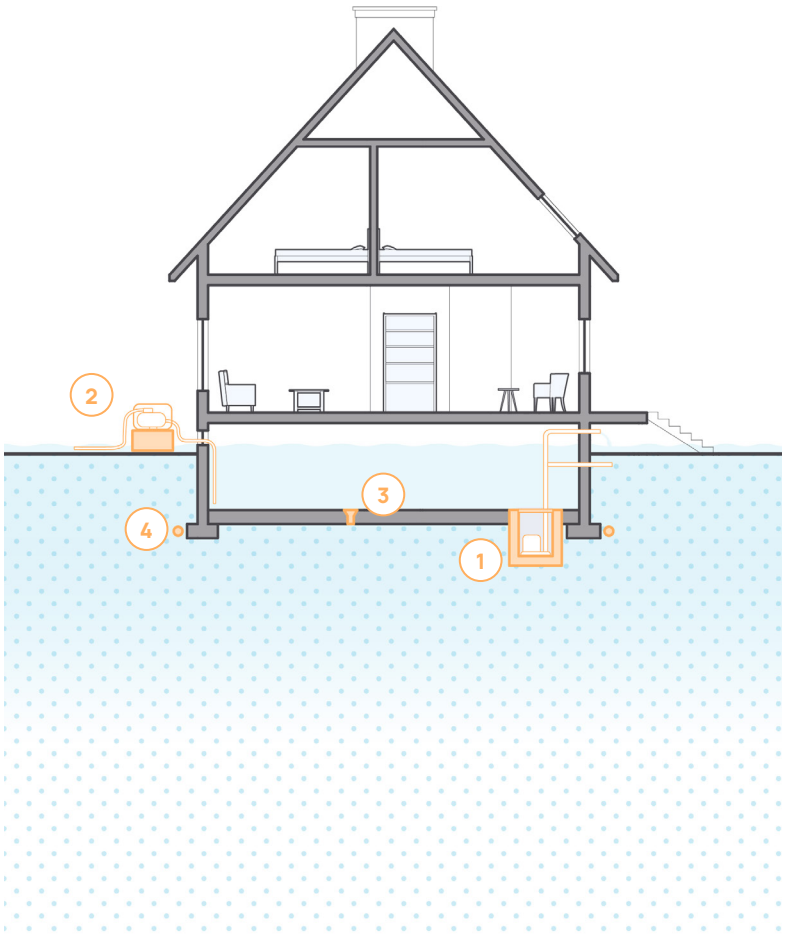
- Based on the supplier's recommendations, choose the type of system suitable for your needs. (Grid-tied or off-grid system, inverter type, number of batteries, etc.)
- Ensure you have a system that allows electricity storage in batteries to be self-sufficient in case of a power outage.

Batteries (5)

- Select the type and quantity of batteries that best fit your needs. There are several types of batteries that can provide uninterrupted power to residences. Batteries can be rechargeable from the electrical grid or through solar panels.

C5 Sump and pump systems

systems | permanent | reversible | temporary | plumbing (expertise) | C3, C4, C7 A6 (combinations)



The installation of water drainage devices, such as a submersible pump, portable pump, or gasoline-powered pump, as well as drainage systems, is a **permanent, reversible, or temporary support measure** to reduce the vulnerability of a building's components to flooding. The building remains exposed to the hazard, and the levels below the flood level should implement adaptation measures to cope with it.

The selection of the type of pump and drainage system is **based on the characteristics of the predicted flooding event.** It helps **prevent basement flooding** during a low water entry into the building or **pump water out after a significant flood event.**

OBJECTIVES

- ☐ Increase occupant safety
- ☐ Minimize structural damage
- ☐ Minimize damage to belongings and materials
- ☑ **Reduce recovery and reoccupation time**

BENEFITS

- Accelerated **water drainage**
- **Automatic** operation

SPECIFICATIONS

There are different types of pumps designed for various needs. It may be relevant to combine more than one type of pump.

The submersible pump (1) is installed at the lowest point of the basement, in a sump pit or pit. It activates automatically when water accumulates and remains functional even when submerged.

The gasoline-powered pump (2) is for temporary use and is installed at an elevated position outside the building. It remains operational even during a power outage and can evacuate large quantities of water at a high flow rate.

The portable pump is for temporary use. It has a lower flow rate but can evacuate water to a very low level (1mm).

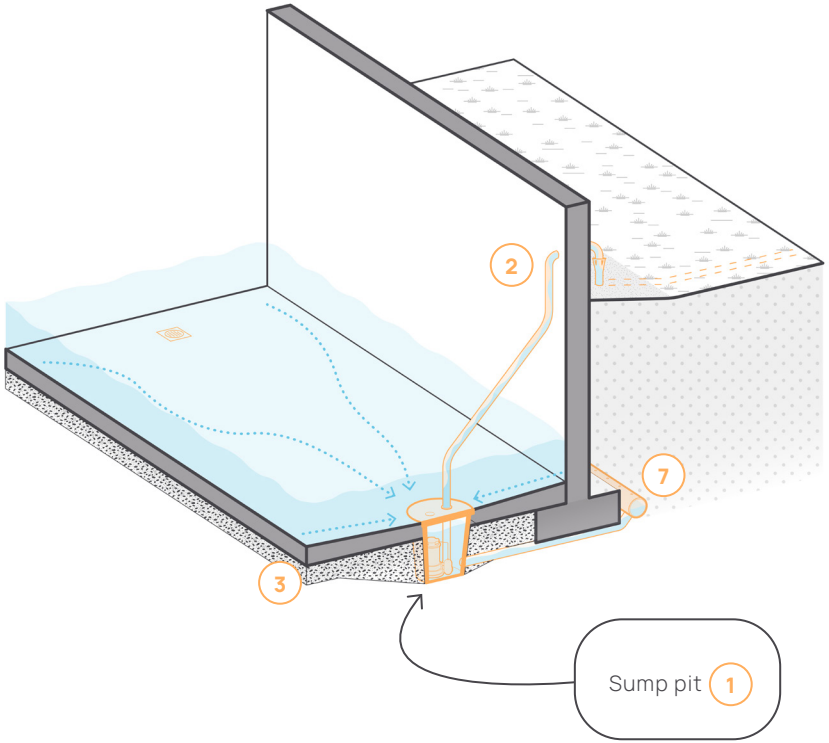
Drainage systems are essential for managing outdoor water and evacuating the water accumulated inside buildings. They include **floor drains** (3) and **drains.** (4)

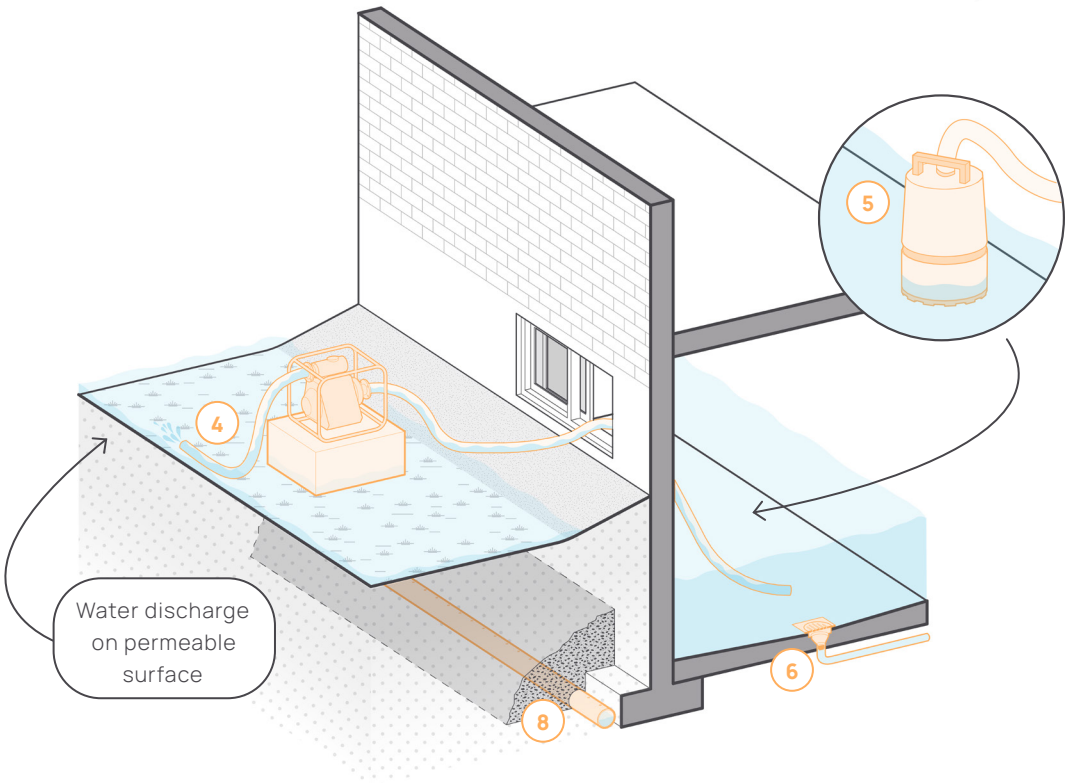
WARNINGS

A weakened foundation can collapse if the difference in water levels between the interior and exterior is too great. To prevent overloading the structure, **pump out 2 feet of water at a time** while monitoring to see if water continues to accumulate. If so, wait for 12 hours before pumping again.

CONSIDERATIONS

- **Mandatory annual inspection and maintenance** of permanent devices
- Requires an **independent power supply**





IMPLEMENTATION

The submersible pump

- Sump pump installed in the sump pit. (1)
- Connect the pump to a discharge pipe directing water to the sewer, a pit, or a soakaway. (2)
- Granular drainage layer beneath the slab, (3) sloping towards the sump pit.

The gasoline-powered pump

- Pump positioned outside the building, at an elevated point (it cannot be submerged).
- Water discharge hose (4) installed on the property, in a location far from the foundations.

The portable pump

- Pump positioned inside the building. (5)

Floor Drain

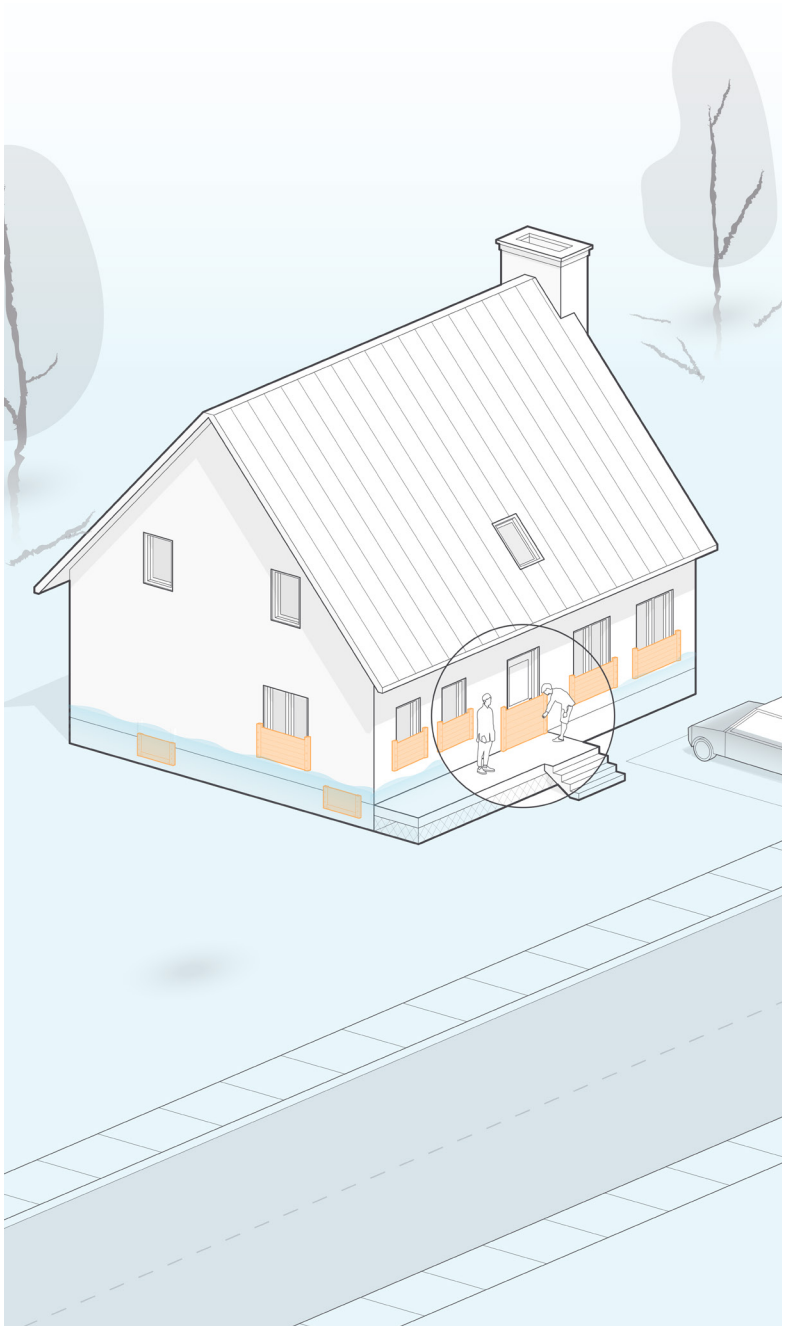
- Floor surface sloped towards the floor drain. (6)
- Connected to a pump or by gravity to the sewer system, a ditch, or a soakaway.
- Check valve insert **(see Backwater valves fact sheet).**

Foundation Drains

- Perforated drainage pipes around the foundation footing (minimum 100mm or 4 inches in diameter). (7) The top of the pipes should be located below the underside of the slab.
- Connected to a pump or by gravity to the sewer system, a ditch, or a soakaway.
- Filter cloth and 150mm (6 inches) of crushed stone or other coarse granular material. (8)
- Moisture barrier.
- Proper lot grading **(see Sustainable drainage systems fact sheet).**

C6 Waterproofing openings

envelope + individuals | permanent | reversible | temporary | engineering installation | expertise



Waterproofing openings is a **temporary or permanent resistance measure**, depending on the chosen devices, that reduce the exposure of living spaces and belongings to floodwaters. The building remains exposed to the hazard, and the levels below the flood level should implement adaptation measures to cope with it.

There are various types of devices, both temporary and permanent, for the sealing of building openings. **They are suitable for new constructions and existing ones when the existing structure is designed to withstand flood loads.**

OBJECTIVES

- ☐ Increase occupant safety
- ☐ Minimize structural damage
- ☑ **Minimize damage to belongings and materials**
- ☑ **Reduce recovery and reoccupation time**

BENEFITS

- **Reduced repair costs**
- Reduced **drying and cleaning time** after the flood
- Reduced **amount of materials discarded** after the flood

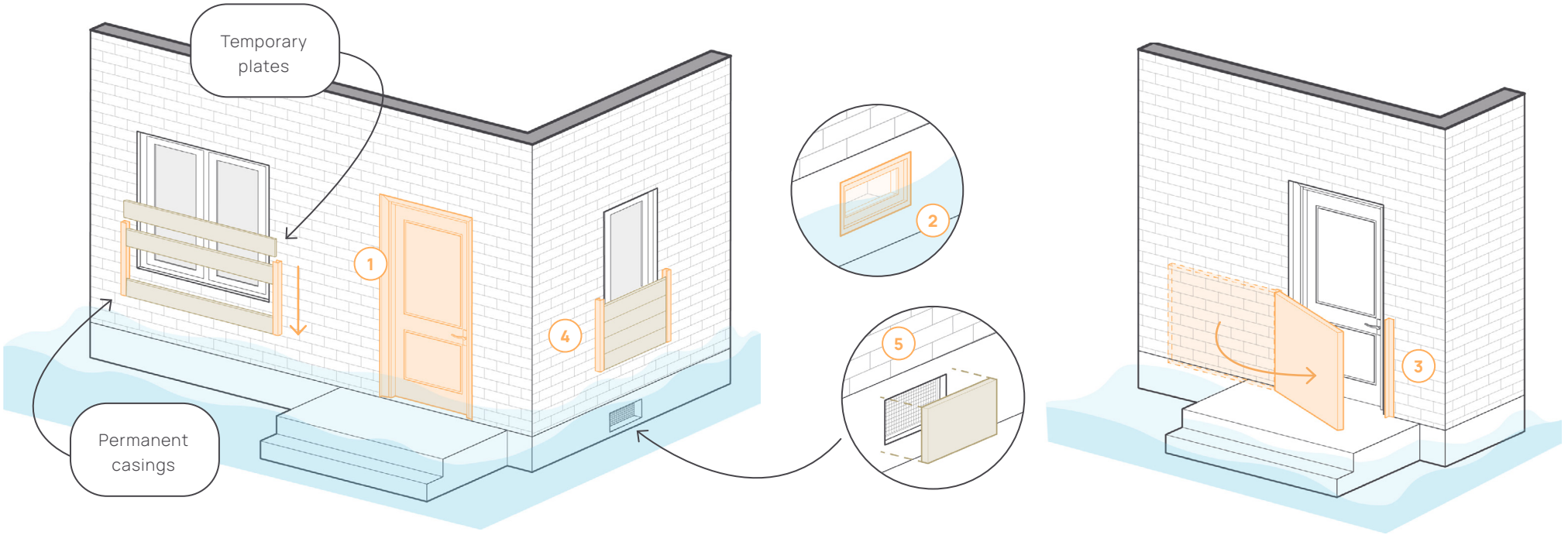
WARNINGS

Choosing to use sealing devices **without knowing the condition of a building's structure** jeopardizes its integrity.

Forgetting to remove temporary sealing devices can **make the building susceptible to damage related to inadequate ventilation, such as mold.**

CONSIDERATIONS

- **Physical intervention** for the installation of temporary devices
- Compliance with **regulatory frameworks**
- **Stability of structural components and foundations** exposed to flood loads
- Suitable only in **low-recurrence flood areas**



IMPLEMENTATION

Permanents devices

Flood-resistant doors (1) and windows (2) designed to withstand floods.
Permanent barrier systems with manual or automatic deployment to seal doors and windows. (3)

- Preventively install flood-resistant doors and windows as well as permanent barrier systems installed by a professional.
- Annually maintain and check door and window seals to ensure their performance.
- Annually maintain automatic systems and clear them to ensure reliability when needed.
- Connect automatic systems to an autonomous power supply.

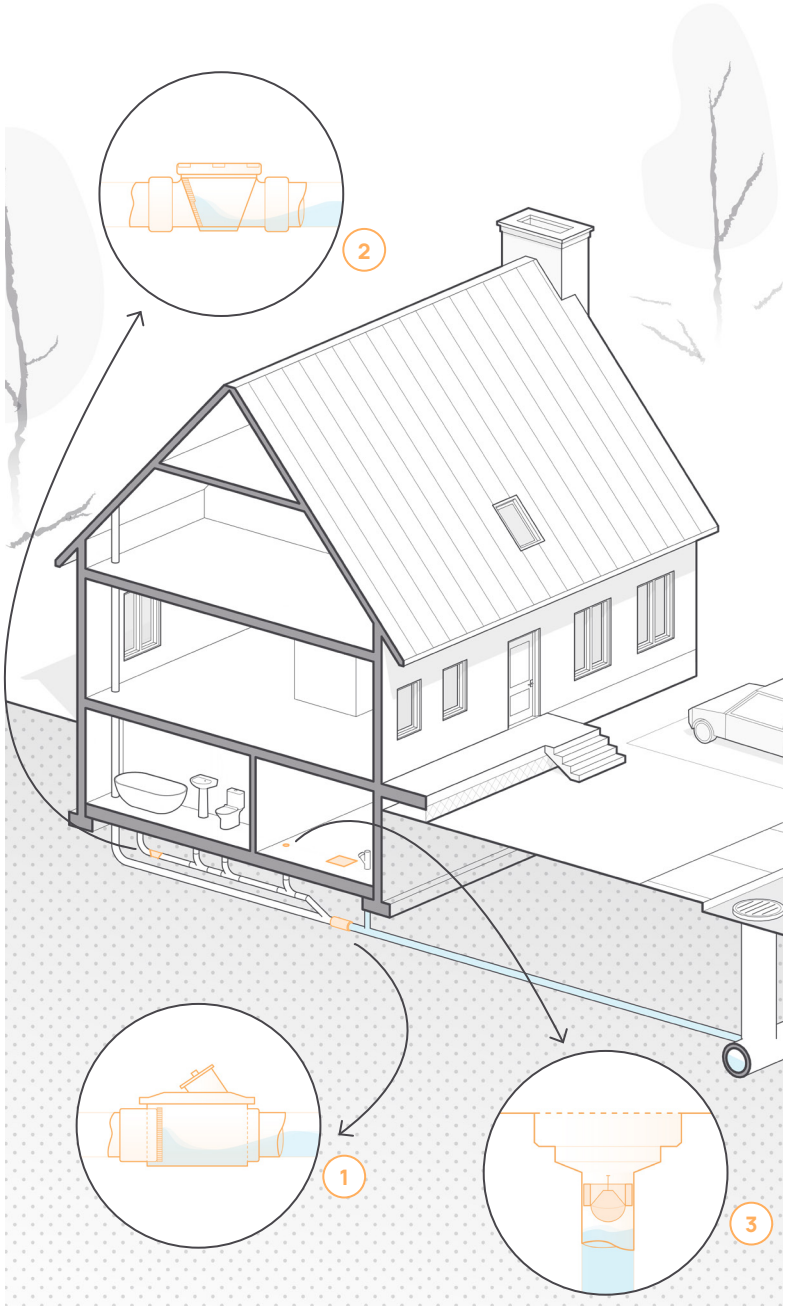
Temporaires devices

Flood barriers (system of temporary plates and permanent casings) for doors and windows. (4)
Covers for small openings (e.g., basement air vents, weep holes in masonry). (5)

- As a preventive measure, have a professional install the permanent side casings for door and window frames.
- As a preventive measure, store the covers and temporary boards or plates in an easily accessible location.
- Before the flood, install the covers and temporary boards or plates in the casings.
- After the flood, remove the covers and temporary boards or plates to allow for building ventilation and store them in an accessible location.

C7 Backwater valves

systems | permanent | reversible | temporary | plumbing | expertise



The installation of backwater valves is a **permanent resistance measure** that prevents sewage water from flowing backwards into a property. The building remains exposed to the hazard, and the levels below the flood level should implement adaptation measures to cope with it.

The backwater valve, or backflow prevention device, **prevents the rise of wastewater inside the building** by allowing the flow of water in only one direction.

OBJECTIVES

- ☐ Increase occupant safety
- ☐ Minimize structural damage
- ☑ **Minimize damage to belongings and materials**
- ☑ **Reduce recovery and reoccupation time**

BENEFITS

- Reduced risks of **contamination and sewage infiltration**
- **Automatic** operation

SPECIFICATIONS

There are three types of backwater valves. Depending on the needs, it may be necessary to install more than one type of backwater valve to have a fully effective backflow prevention system.

The normally open backwater valve (1) can be installed on the building's main sewer line and only closes in the event of backflow.

The normally closed backwater valve (2) is installed on equipment discharges or equipment connections to the sewer line. It cannot be installed on the building's main sewer line because it does not allow air to circulate in the system.

The floor drain check valve (3) is installed in floor drain pipes and allows water to flow under pressure using a spring.

CONSIDERATIONS

- **Annual inspection and maintenance**
- Compliance with **regulatory frameworks**

ADVICE

Install an **accessible floor hatch** to provide access to the backwater valve for maintenance. It is recommended to perform maintenance on them **at least twice a year.**

A1-6

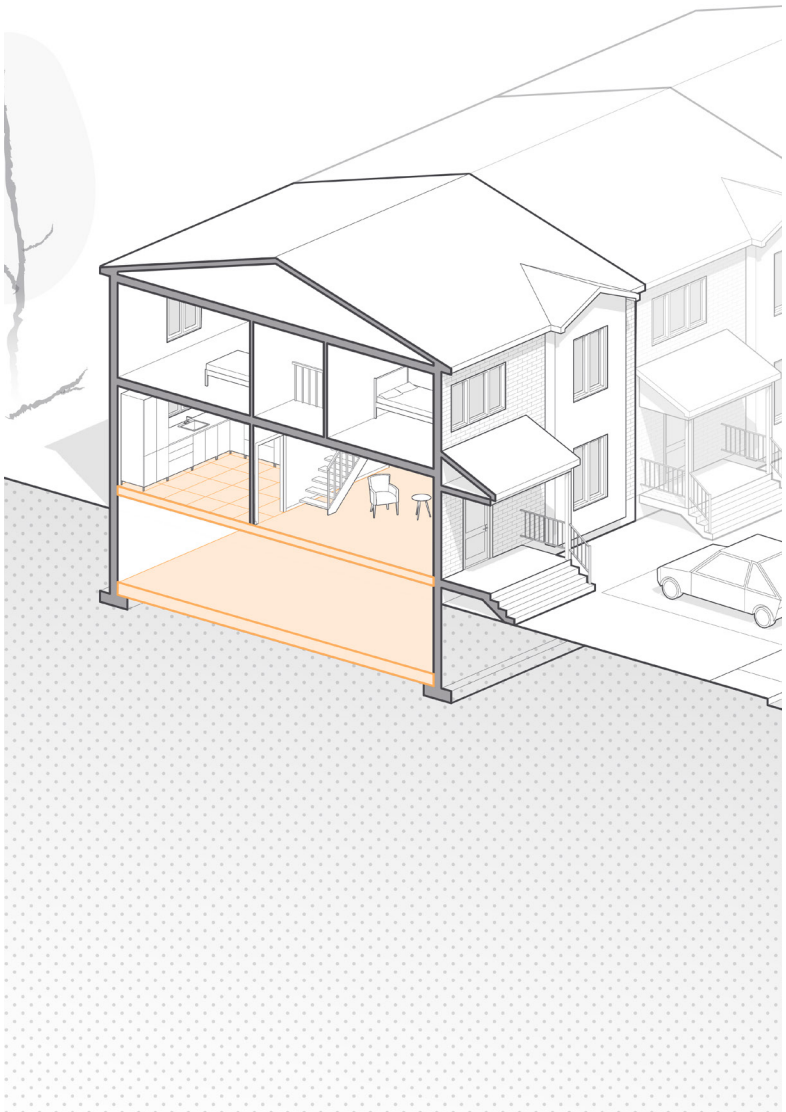
Adaptation measures

- **A1** Resilient floors
- **A2** Resilient walls
- **A3** Resilient carpentry
- **A4** Resilient electrical system
- **A5** Flood vents
- **A6** Sustainable drainage systems (SuDS)

Measures intended for **medium-term** implementation, either as preventive actions or during recovery. Their objective is to improve the resilience (or reduce vulnerability) to flood risk of various elements within a property. The effectiveness of these measures relies on execution quality and they are typically associated with moderate costs.

A1 Resilient floors

structure + space | permanent | reversible | temporary | architecture, engineering, construction | C5, A2



The construction of resilient floors is a **permanent adaptation measure** that reduces the building's vulnerability to floodwaters.

Resilient floors are built with **flood-resilient materials and assemblies** that absorb little to no water (impermeability), dry easily, and maintain their original dimensions and structural integrity (stability) when exposed to floodwaters.

In cases where resilient assemblies or materials can't be used, **easily replaceable materials** should be strategically used.

OBJECTIVES

- ☐ Increase occupant safety
- ☐ Minimize structural damage
- ☑ **Minimize damage to belongings and materials**
- ☑ **Reduce recovery and reoccupation time**

BENEFITS

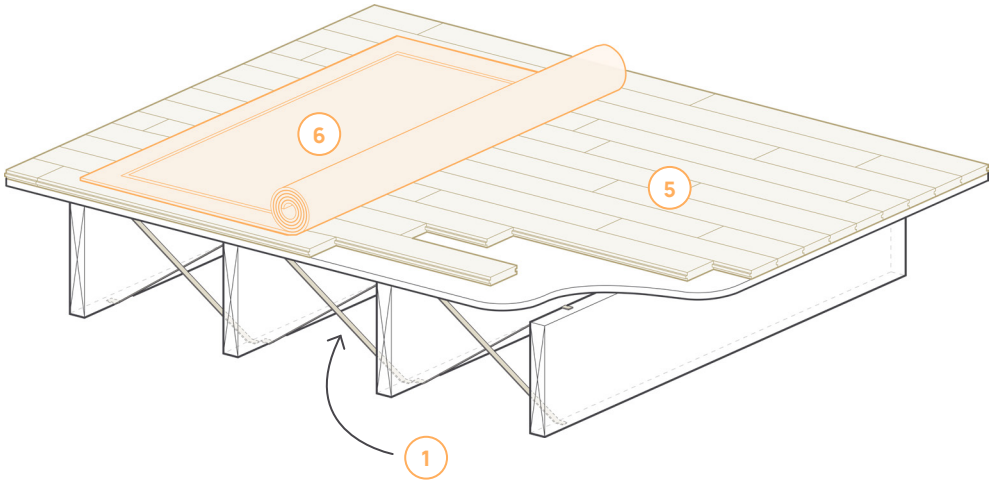
- **Reduced repair costs**
- Reduced **drying and cleaning time** after the flood
- Reduced **amount of materials discarded** after the flood

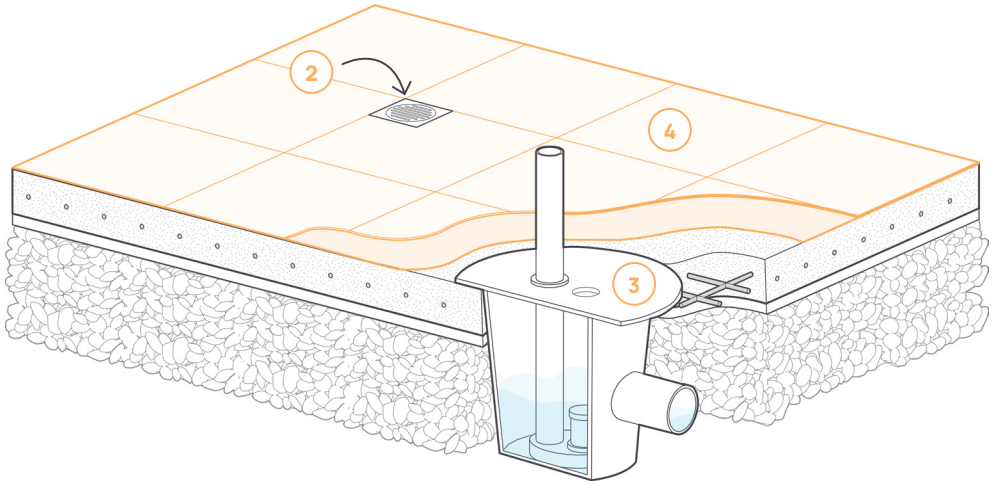
WARNINGS

The design of resilient floors does not guarantee complete protection of the components. After the flood, it is essential to **thoroughly clean and dry the floors, ensure that the components have not deformed, and monitor the formation of mold.**

CONSIDERATIONS

- **Ventilation and disinfection of exposed components** to prevent mold formation after flooding
- Measure's effectiveness relies on the **quality of execution**





IMPLEMENTATION

Before altering the composition of a floor, a structural assessment must be carried out to evaluate the impact of the proposed changes on the capacities of the building and its structural elements. However, this assessment is not necessary for the replacement of finishing materials with more resilient materials.

Wooden structure

- Treat the wooden structural elements with a protective varnish.
- Add galvanized steel bracing between the wooden beams to limit their deformation when in contact with water. (1)

Concrete slab

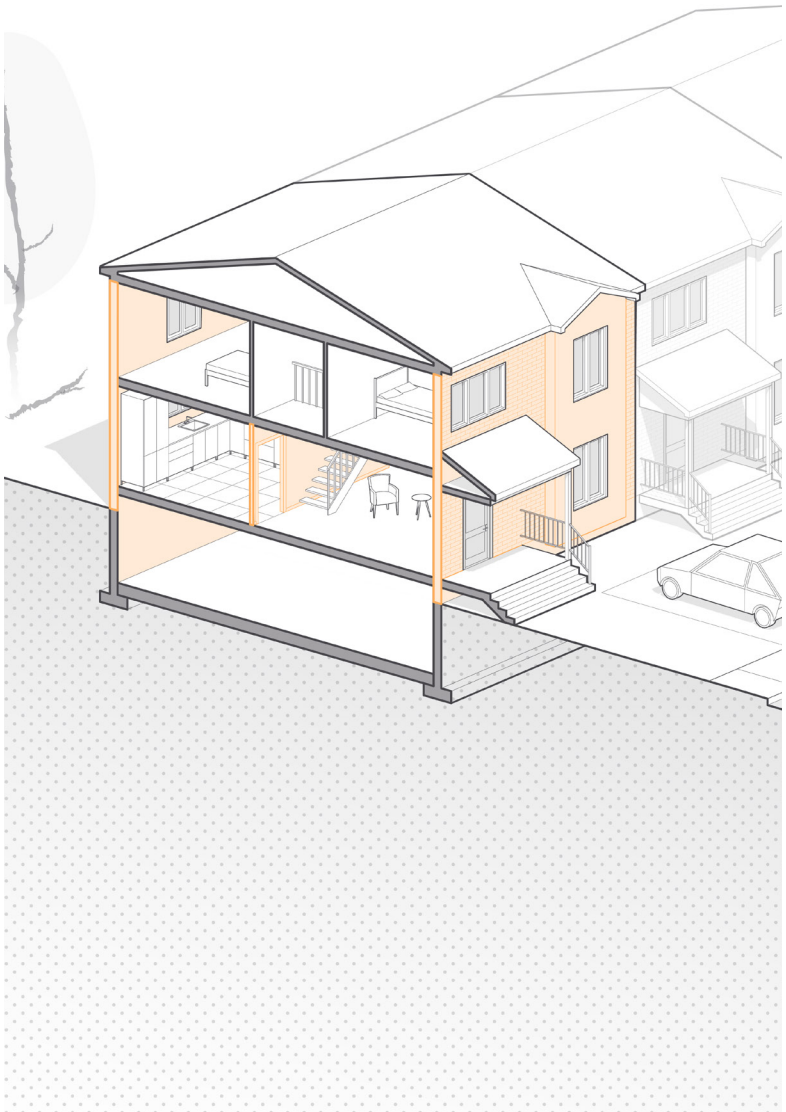
- Incorporate a drainage (2) and pumping system, such as a submersible sump pump (3), to facilitate water evacuation **(see the Sump and pump systems fact sheet).**
- For floors requiring insulation, opt for water-resistant insulation, such as rigid, sprayed, or compressed rockwool insulation.

Coating

- Choose a waterproof finishing material that reduces water penetration risks, such as ceramic, vinyl, or epoxy. (4)
- For a wooden floor, prioritize hardwood that can regain its original shape after drying. Ensure flooring is installed with expansion joints that accommodate the swelling of the floorboards following water penetration. (5)
- Avoid materials known to be vulnerable to water, such as laminate flooring or carpet. Choose a decorative rug instead that can easily be removed when needed. (6)

A2 Resilient walls

envelope + structure + space | permanent | reversible | temporary | architecture construction | expertise | C3, C6 A1, A3 | combinations



The construction of resilient walls is a **permanent adaptation measure** that reduces the building's vulnerability to floodwaters.

Resilient walls are composed of **assemblies and materials with a good capacity for resilience when exposed to water** : they absorb little to no water (impermeability), dry easily, and maintain their original dimensions and structural integrity (stability).

In cases where it is impossible to use resilient assemblies or materials, **sacrificial finishing materials** (easily replaceable) should be used strategically.

OBJECTIVES

- ☐ Increase occupant safety
- ☐ Minimize structural damage
- ☑ **Minimize damage to belongings and materials**
- ☑ **Reduce recovery and reoccupation time**

BENEFITS

- **Reduced repair costs**
- Reduced **drying and cleaning time** after the flood
- Reduced **amount of materials discarded** after the flood

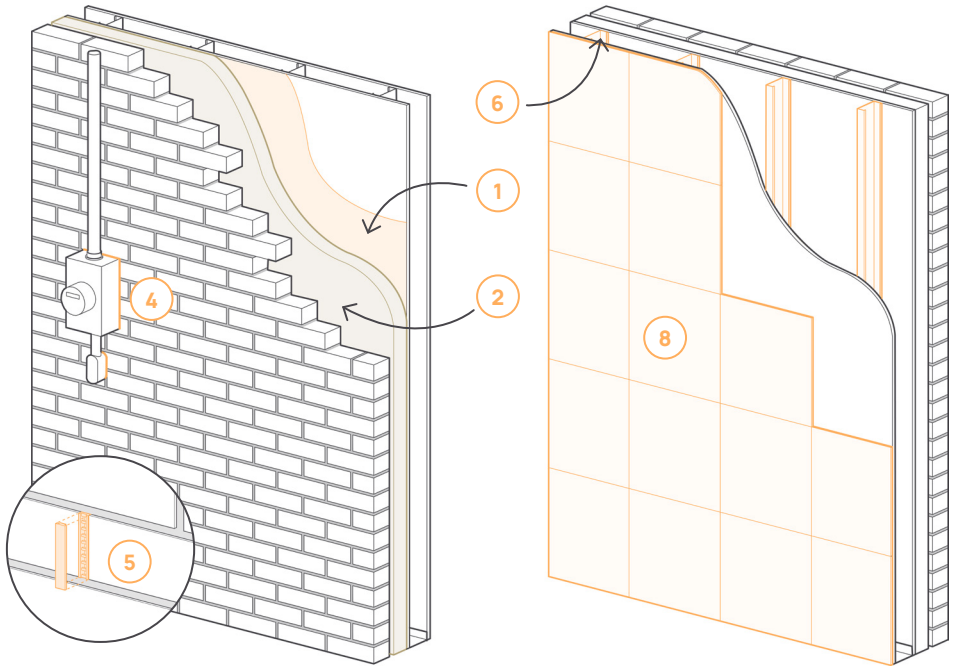
WARNINGS

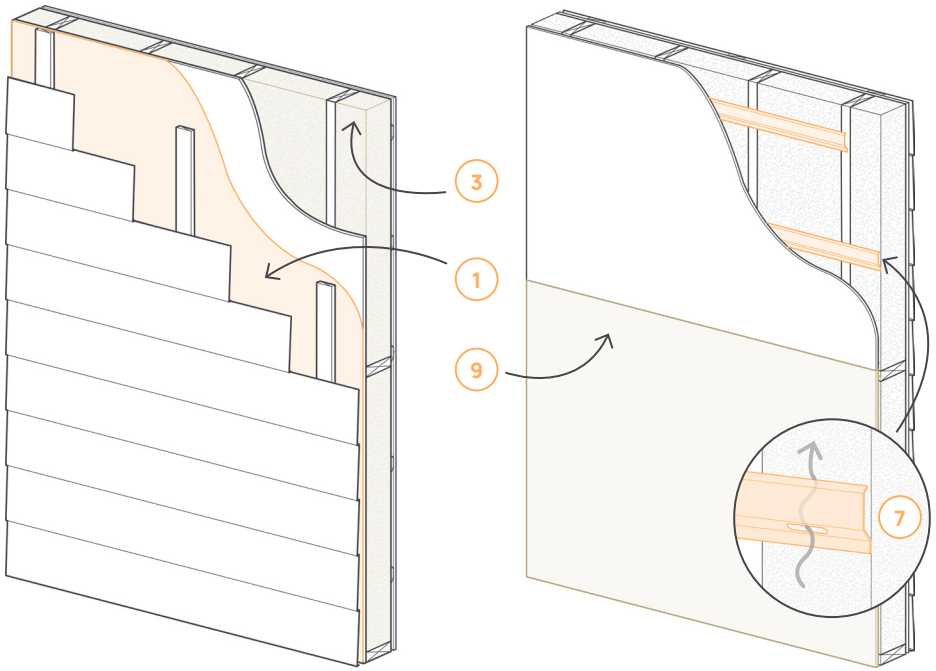
The design of resilient walls does not guarantee the total protection of the components. After flooding, it is essential to **thoroughly clean and dry the walls, ensure that the components have not deformed, and monitor the formation of mold.**

It is not advisable to waterproof masonry walls without the recommendation of a professional. The application of paint, water repellent sealant, or lime plaster can compromise the structural capacity of the wall to resist water forces and cause moisture accumulation that will deteriorate the facing over time.

CONSIDERATIONS

- **Ventilation and disinfection of exposed components** to prevent mold formation after flooding
- Measure's effectiveness relies on the **quality of execution**





IMPLEMENTATION

Before altering the composition of a floor, a structural assessment must be carried out to evaluate the impact of the changes on the building's capacities and other structural elements. However, this assessment is not necessary for the replacement of finishing materials with more resilient materials.

Exterior wall and insulated wall

- Install a waterproof or drainage membrane behind the exterior finishing material to reduce the risk of water entering the wall. (1)
- Opt for water-resistant insulation, such as rigid, (2) sprayed, or compressed rock wool insulation. (3)
- Seal the joints of service entries and, when possible, position them above the flood level **(see the Raise flood-sensitive equipment fact sheet).** (4)
- During rising waters, securely cover weep holes and ventilation openings positioned below the flood level with caps **(see the Waterproofing openings fact sheet).** (5)

Structure

- Protect softwood studs with a water-resistant sealant or replace them with steel (6) or hardwood studs.
- Install resilient bars or other devices that allow for ventilation within the assembly and reduce drying time. (7)

Interior finishing

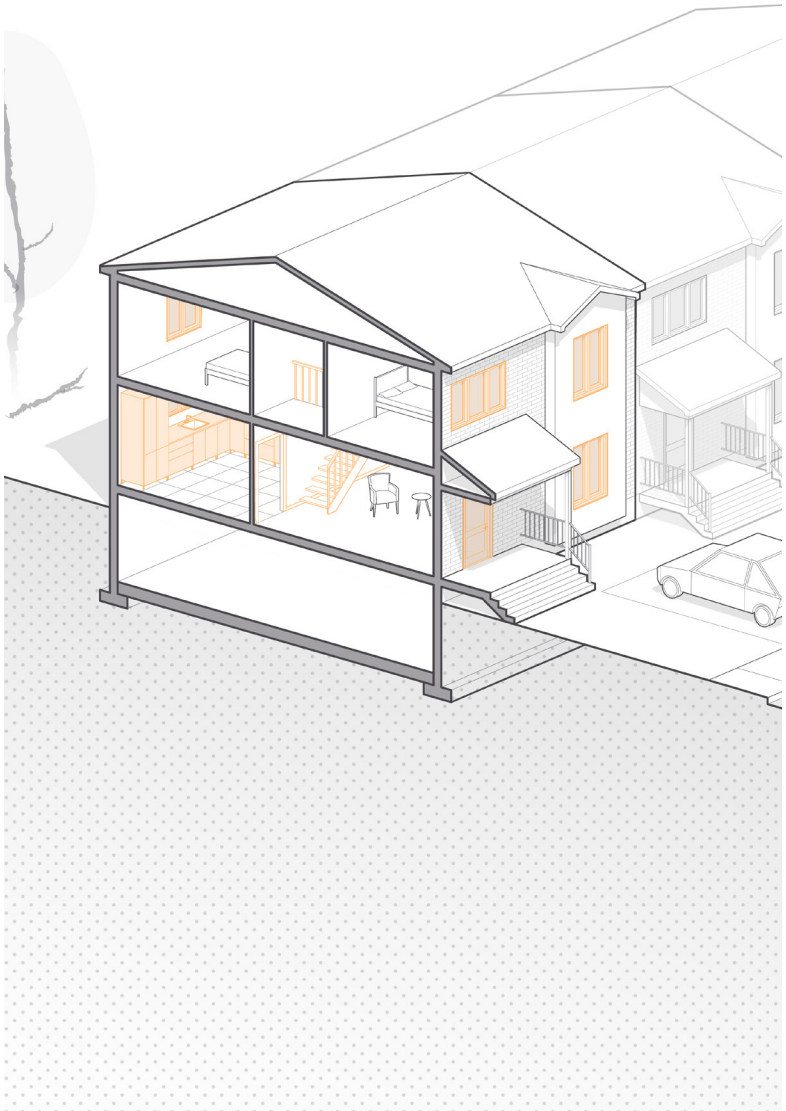
- Prefer waterproof or water-compatible finishing materials for the entire wall or only below the flood level, such as ceramic, lime-based plaster, or fiber cement panels. (8)
- In cases where it is impossible to use resilient assemblies or materials, use sacrificial finishing materials that are easily replaceable. For example, horizontally installed gypsum panels allow for the replacement of only the wall portion that has been exposed to water. (9)

A3 Resilient carpentry

space + belongings + individuals | *permanent* | *reversible* | *temporary* | architecture construction carpentry *expertise* | C3 A1, A2 *combinations*

Using resilient carpentry is a **permanent adaptation measure** that reduces the building's vulnerability to floodwaters.

In this context, carpentry refers to cabinets, cupboards, stairs, doors and windows, and ornamental components. Resilient carpentry is composed of flood-resilient **assemblies and materials that present the following characteristics** : they absorb little to no water (impermeability), dry easily, and maintain their original dimensions and structural integrity (stability).



OBJECTIVES

- ☐ Increase occupant safety
- ☐ Minimize structural damage
- ☑ **Minimize damage to belongings and materials**
- ☑ **Reduce recovery and reoccupation time**

BENEFITS

- **Reduced repair costs**
- Reduced **drying and cleaning time** after the flood
- Reduced **amount of materials discarded** after the flood

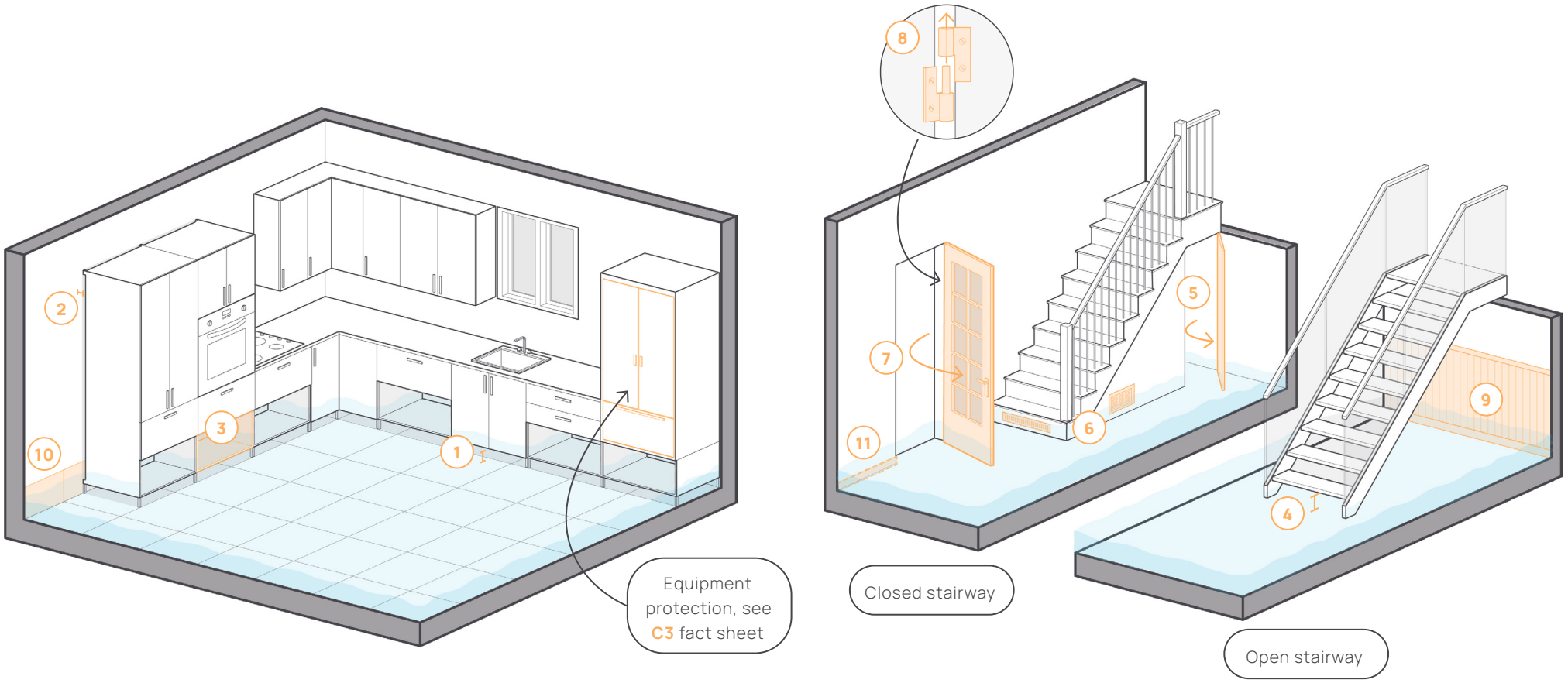
WARNINGS

The implementation of resilient carpentry does not **guarantee full protection of components.**

After the flood, it is essential to clean and dry components thoroughly, **ensure that they have not deformed, and monitor mold formation.**

CONSIDERATIONS

- **Ventilation and disinfection of exposed components** to prevent mold formation after flooding



IMPLEMENTATION

Cabinets and cupboards

- Position cabinets on legs and use removable baseboards to facilitate cleaning and drying following a flooding event. (1)
- Provide space behind cabinets to allow for ventilation. (2)
- Opt for cabinets with removable drawers and relocate them when anticipating a flood. (3)
- When it is impossible to use resilient assemblies or materials, install cabinets above the flood level.

Stairs and Handrails

- Prioritize an open configuration staircase without risers (4) to prevent water accumulation in the cavities under the stairs. Otherwise, provide access beneath the stairs (5) or install ventilation traps to facilitate material drying. (6)

Doors and windows

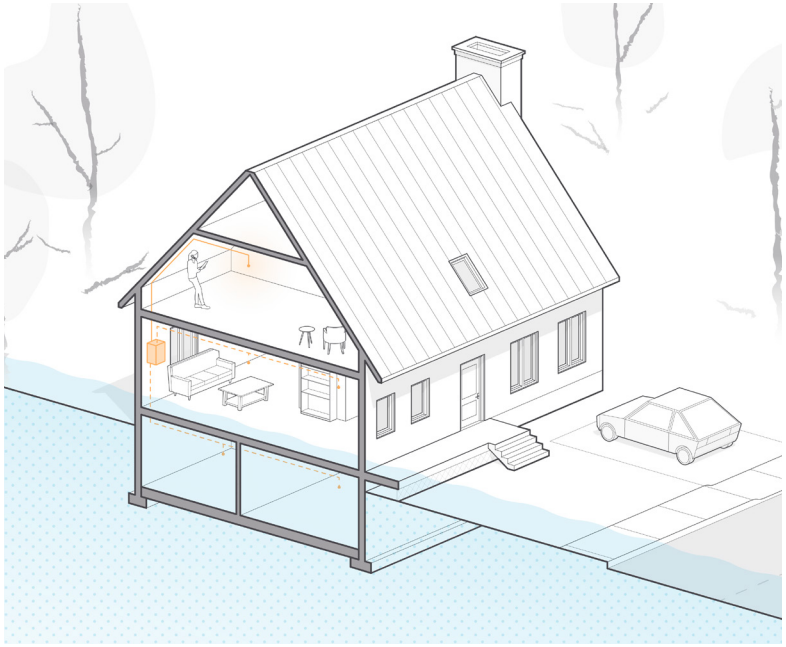
- Prioritize solid core doors, made of aluminum or with glazing, to minimize damage.
- Avoid using hollow core doors that are prone to mold formation.
- Choose hinged doors over sliding doors to limit the impacts of water pressure or mechanism distortion. (7)
- Install doors on quick-release hinges for easy relocation during a flood. (8)

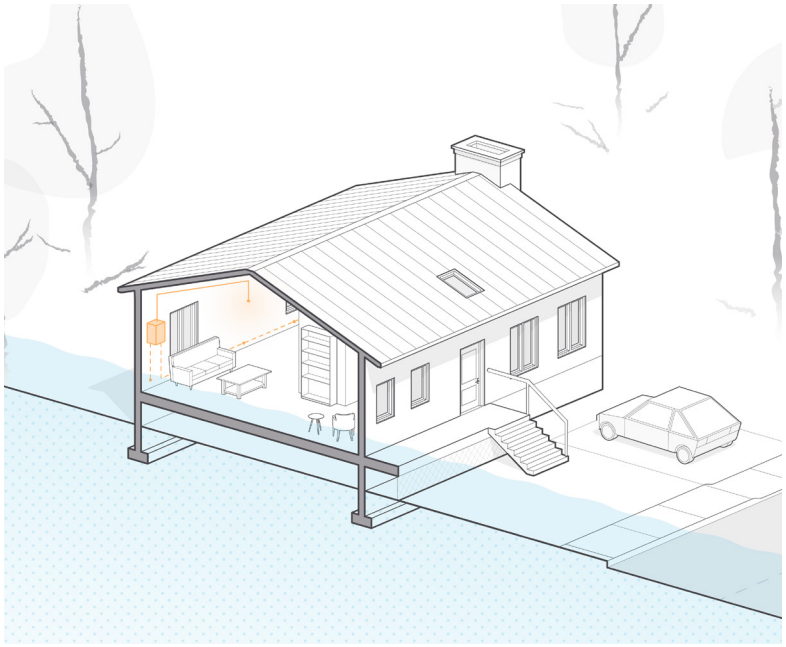
Moldings and ornaments

- Choose hardwood (9) (such as maple, oak, ash, cherry, etc.) or ceramic.
- Use removable baseboards. (10)
- Avoid softwood (such as spruce, fir, pine, cedar, etc.) as it tends to warp and rot when in contact with water. (11)

A4 Resilient electrical system

systems | permanent | reversible | temporary | electrical expertise | C3, C4 combinations





Implementing a resilient electrical system is a **permanent adaptation measure** that reduces the exposure of systems and equipment to floods. The building remains vulnerable to the hazard, and adaptation measures should be implemented for the levels below the flood level to cope with it.

Opting for a resilient electrical system involves two main actions : **the protection of electrical components** and **the creation of a separate electrical network** in the flood-exposed parts. This allows for the establishment of an electricity-served area above the flood level and the disconnection of flooded areas.

OBJECTIVES

- ☑ **Increase occupant safety**
- ☐ Minimize structural damage
- ☑ **Minimize damage to belongings and materials**
- ☑ **Reduce recovery and reoccupation time**

BENEFITS

- **Reduced repair costs**
- Ability to **keep equipment running** during the flood
- Accelerated **recovery of equipment** after the flood

IMPLEMENTATION

Protection of electrical components

- Install the electrical panel and circuit breaker at least 0.5 meters above the flood level, and ideally on a floor not exposed to flooding.
- Electrical equipment, such as the meter and service connections (telephone line, internet, etc.), should also be elevated **(see the Raise flood-sensitive equipment fact sheet)**
- Place electrical outlets and switches above the flood level. Use specialized outlets and waterproof boxes in flood-exposed spaces.
- Plan a downward distribution. Where possible, install wiring at the ceiling level and along the walls rather than at floor level. Wiring located below potential water levels should be equipped with a waterproof sleeve.

Separate electrical network for flood-exposed areas

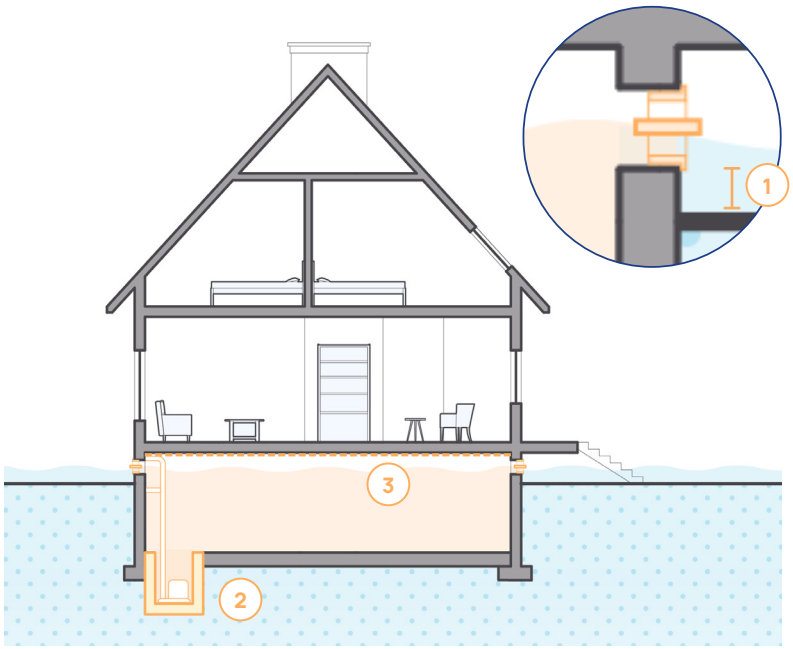
- Separate electrical circuits that are at-risk of flooding from other circuits on higher floors.
- Clearly indicate instructions for cutting off power on the lower circuit with appropriate signage.
- Cut off the power from floors below the flood level before the flood.
- In support of the above mentioned measures, install a highly sensitive differential circuit breaker that automatically shuts off the circuits affected by a flood.
- If needed, plan an independent power source **(see the Autonomous power supply fact sheet)** as well as suitable connection to the main network.

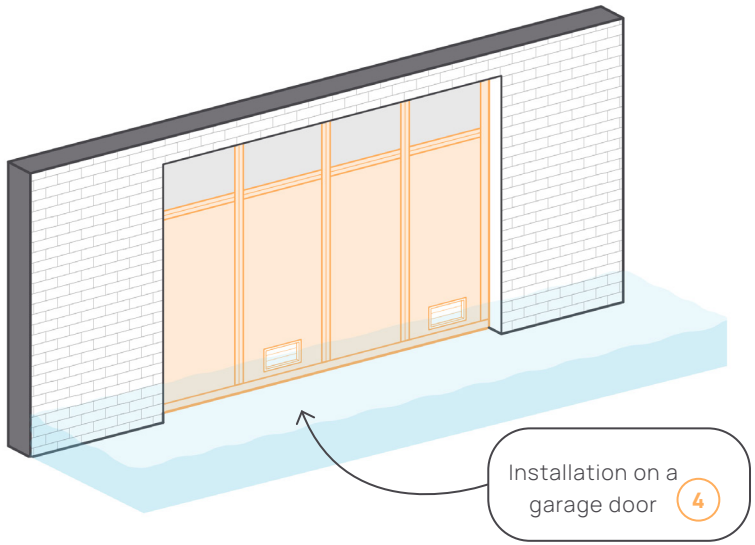
CONSIDERATIONS

- **Risk of power outage** at the sector level

A5 Flood vents

envelope + structure | permanent | reversible | temporary | engineering installation | expertise | C5 A1, A2, A3, A4 | combinations





The creation of openings in a foundation or the installation of flood vents is a **permanent adaptation measure** that reduces the vulnerability of building components exposed to flooding.

Including openings in a foundation or installing flood vents allows for the controlled passage of floodwater into a building made of water-resistant materials or materials that can quickly recover from water exposition. **This measure helps reduce hydrostatic pressure on a building** (equalization of interior and exterior pressure), thereby preserving its structural integrity.

OBJECTIVES

- ☐ Increase occupant safety
- ☑ **Minimize structural damage**
- ☑ **Minimize damage to belongings and materials**
- ☐ Reduce recovery and reoccupation time

BENEFITS

- Improved **natural ventilation** (during recovery and under normal circumstances)
- **Reduced pressure** on foundation walls

IMPLEMENTATION

- Plan at least 2 vents on 2 different walls for each enclosed room below the flood level to allow water flow. Depending on the room layout, openings may be necessary in certain interior walls.
- Ensure that the bottom of the openings for each vent is no more than 0.3 meters above the highest exterior ground level. (1)
- Create a rough opening, based on the dimensions specified by the manufacturer, between two studs or in the foundation (consult with a professional).
- Secure the vent frame in this opening according to the manufacturer's recommendations.
- Install the movable part (a pivoting device) of the vent into the frame.
- Provide a pump and drain to evacuate water after the flood **(see the Sump and pump systems fact sheet).** (2)
- Remove materials that are not compatible with water in flood-prone areas and plan for easily cleanable finishes **(see the Resilient floors, walls, and carpentry fact sheets).**
- If the flood-prone area is located in the basement, provide water repellant protection for the ceiling to protect the ground floor. (3)

CONSIDERATIONS

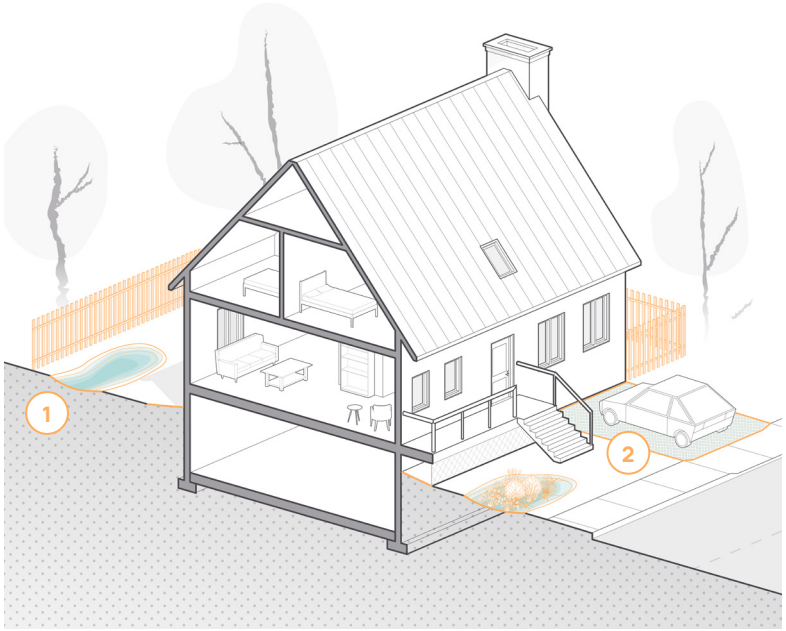
- **Loss of basement living spaces**
- Exposure of the building to **debris or wave impacts**
- **Basement exposure** to flooding
- Requires a **water evacuation device**

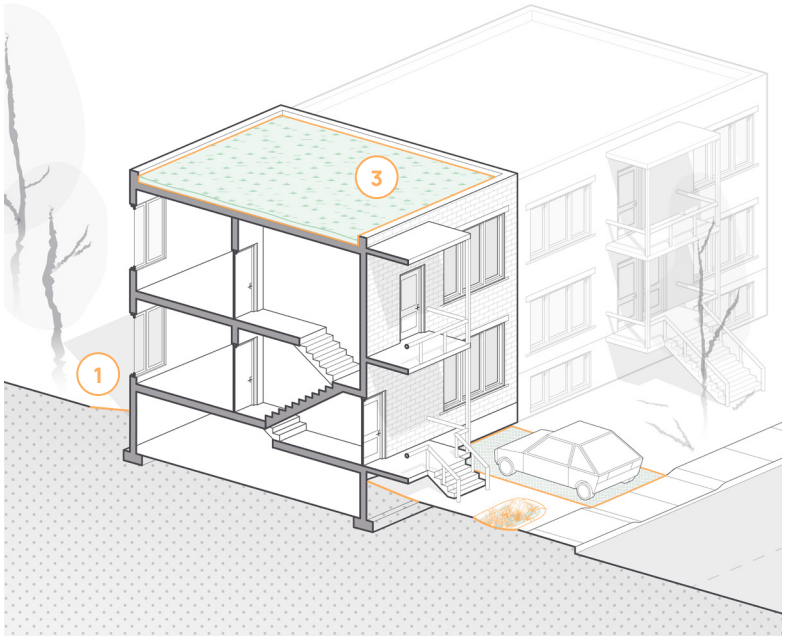
ADVICE

It is possible to install flood vents within existing openings. For instance, vents could be installed on a garage door that is not entirely below the potential water level. (4) Openings in doors should be used **only when wall areas suitable for vents are insufficient.** The garage doors cannot be considered as vents since their opening requires human intervention during flooding.

A6 Sustainable drainage systems (SuDS)

site | permanent | reversible | temporary | landscaping (expertise) | C3, C5, A3 (combinations)





The creation of sustainable drainage systems is a **permanent support measure** that reduces the impacts of flooding or heavy rainfall.

During a minor flood or heavy rainfall event, sustainable drainage systems help **divert water away from the building** and **prevent overloading of the sewer system** by slowing down the water flow and reducing runoff. Creating these landscapes involves three actions :
directing water through the slopes of the terrain (1), promoting soil infiltration with permeable surfaces (2), and slowing water down through vegetated surfaces. (3)

OBJECTIVES

- ☐ Increase occupant safety
- ☐ Minimize structural damage
- ☑ **Minimize damage to belongings and materials**
- ☑ **Reduce recovery and reoccupation time**

BENEFITS

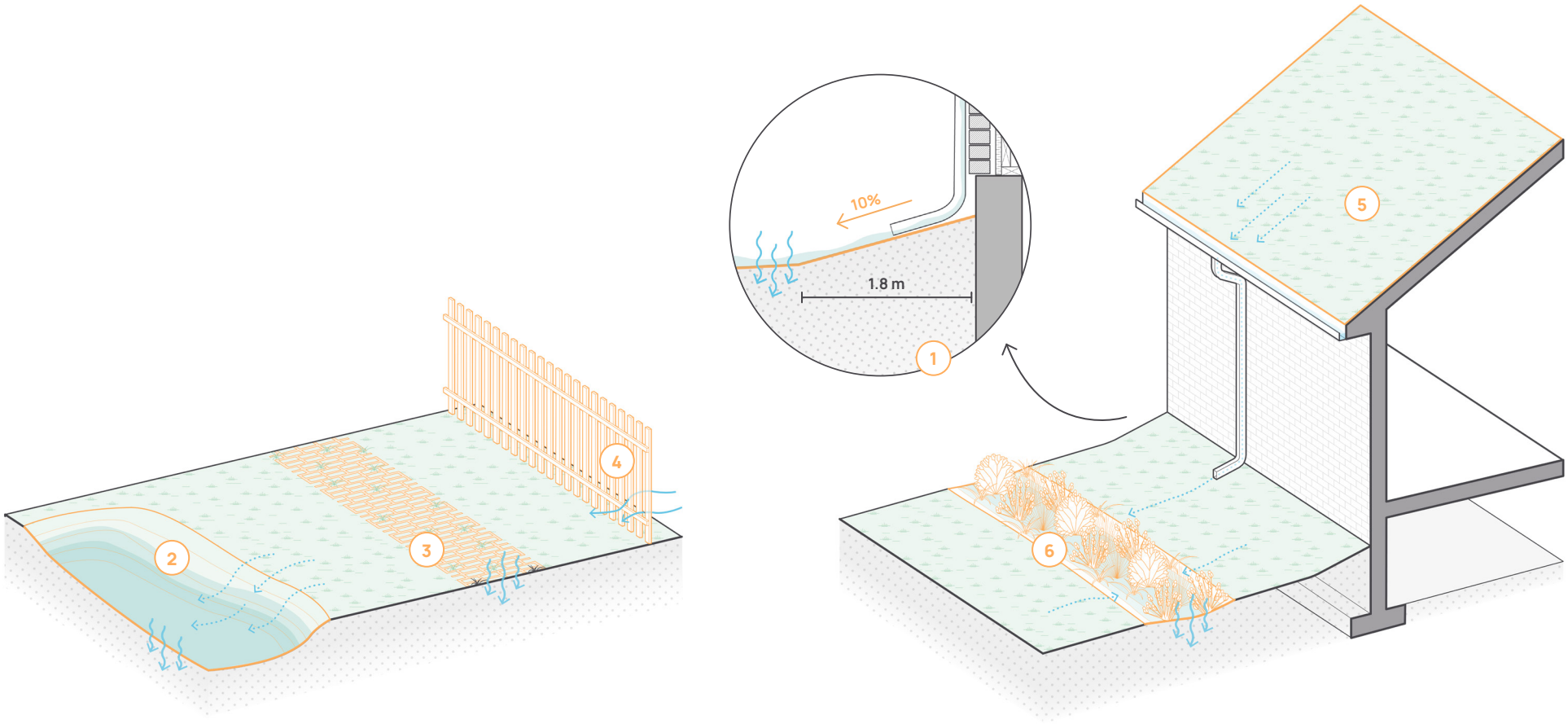
- **Reduced risk of water infiltration** in the basement
- Accelerated **water drainage**
- Reduction in **heat islands**
- Improved **soil absorption capacity**
- Reduces the risk of **water accumulation on the ground** during heavy rainfall

WARNINGS

The creation of sustainable drainage systems **does not eliminate the risk of flooding.** Therefore, these interventions should be combined with other **building resilience measures.**

CONSIDERATIONS

- **Potential maintenance** of new landscaping and vegetation
- Compliance with **regulatory frameworks**



IMPLEMENTATION

Lot grading

Slopes are used to direct the flow of water on the site and should be strategically positioned to move it away from the building.

- Plan for a negative slope around the foundations to reduce the risk of water infiltration in the basement. The slope should be at least 2%, but a slope of 10% is recommended. (1)
- Naturally occurring land depressions can also be adapted to form a catch basin that collects water runoffs during heavy rainfall events. (2)

Permeable Landscaping

- Optimize vegetated surfaces and the use of materials that promote water infiltration into the soil. Permeable pavers and gravel are examples of coverings that promote water infiltration into the ground. (3)
- Avoid fences and walls that block the flow of water. Instead, opt for a fence with an openwork design made of resilient materials (4) **(see the Resilient carpentry fact sheet).**

Vegetated surfaces

Vegetated surfaces allow for a slower water flow while absorbing some of it.

- Adding a green roof is an example of an intervention that can produce co-benefits such as reducing the heat island effect and improving building insulation. However, a green roof adds extra load to the structure, requiring a consultation with an engineer. (5)
- A second option is to create a rain garden that can retain water during heavy precipitations. These gardens consist of plants and shrubs collecting water that slowly infiltrates in the soil. (6)

The goal is to limit the amount of water near the building's perimeter and as such, it is not recommended to plant vegetation near the foundations. Instead, prioritize a compact and sloping soil that pushes water away from the foundations.

E1-6

Avoidance Mesures

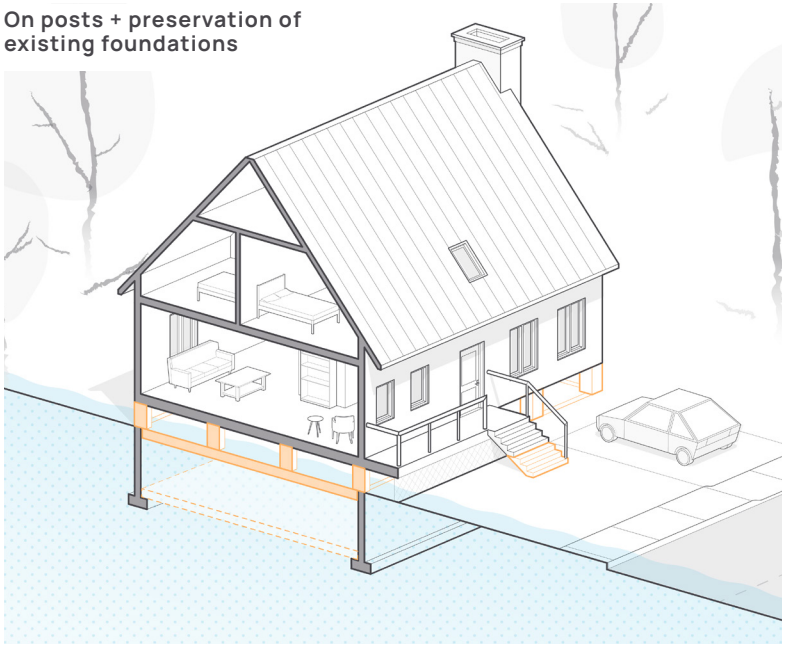
- **E1** Elevation on posts or columns
- **E2** Elevation on pilings or stilts
- **E3** Raising floor level
- **E4** Raising foundations
- **E5** Waterproofing foundations
- **E6** Add an extra storey

Measures intended for **long-term** implementation, either as preventive actions or during recovery. Their objective is to minimize the exposure of a residence or living spaces to floods to the greatest extent possible. These measures involve structural and/or foundation work and are typically the most expensive.

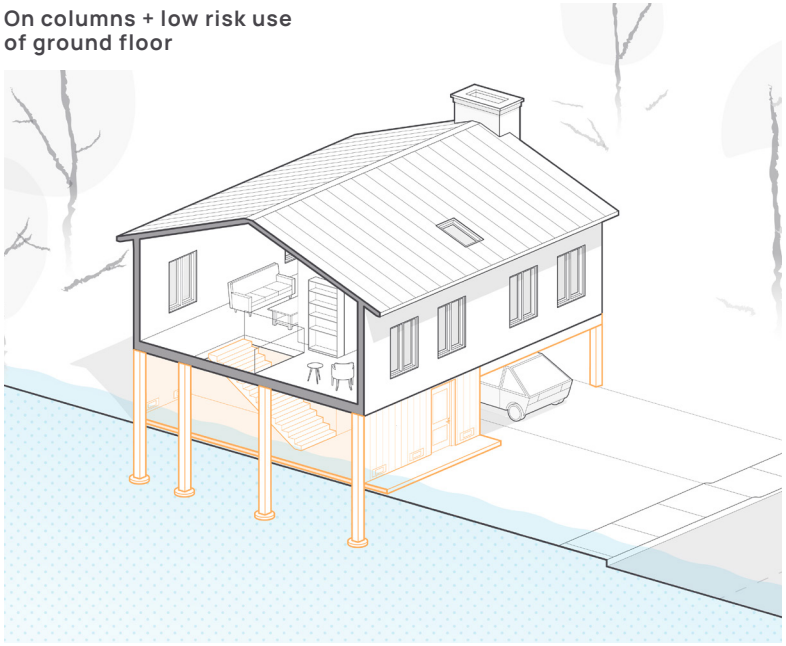
E1 Elevation on posts or columns

site + structure | permanent | reversible | temporary | architecture engineering construction expertise

On posts + preservation of existing foundations



On columns + low risk use of ground floor



Raising the building on posts or columns above the potential water level is a **permanent avoidance measure** that reduces the building's exposure to floods.

A foundation on posts (concrete or masonry) or columns (wood or steel) consists **of punctual vertical supports placed and anchored on a footing.** It is suitable for new constructions and existing ones, whether or not they have a continuous foundation, with or without a basement. It allows the building to be raised without removing the existing foundations.

OBJECTIVES

- ☑ **Increase occupant safety**
- ☑ **Minimize structural damage**
- ☑ **Minimize damage to belongings and materials**
- ☑ **Reduce recovery and reoccupation time**

BENEFITS

- Creation of an **area of refuge** above the defined flood level
- **Preservation of some foundation elements** (material and resource savings)
- Allows for **unobstructed water movement**
- **Additional natural light and improved views** in living spaces

CONSIDERATIONS

- **Redesign of building access and addition of steps** (universal accessibility concern)
- Compliance with **regulatory frameworks**
- **Loss of basement living spaces**
- Not suitable for **rowhouses**
- **More challenging insulation** of pipes and flooring on the main floor
- **Temporary lifting** of the building (during implementation)
- Not suitable for **areas at risk of high waves, strong currents, or ice jams**
- Not suitable for **unstable soils**
- Not suitable for areas at **moderate and high risk of tornadoes**

ADVICE

Depending on the height of the elevation, it is possible to **design the space below the building for low-risk use** (parking, access, storage). However, the design of this space should be done with flood-resilient materials and assemblies **(see the Resilient floors, Resilient walls et Resilient carpentry fact sheets).**

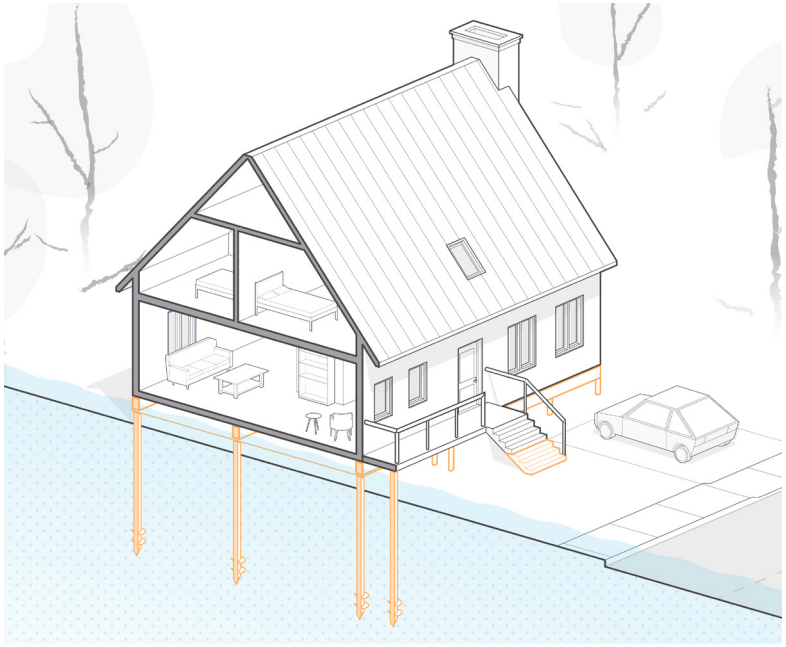
E2 Elevation on pilings or stilts

site + structure

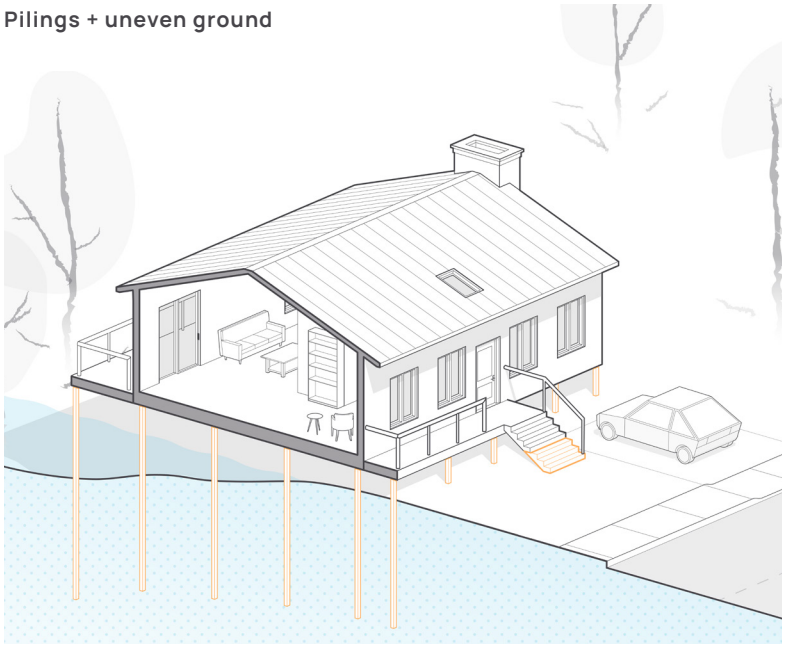
permanent reversible temporary

architecture
engineering
construction

expertise



Pilings + uneven ground



The elevation of the building on pilings or stilts above the potential water level is a **permanent avoidance measure** that reduces the building's exposure to flooding.

A foundation on screw piles or pilings consists of **a series of vertical posts deeply driven into the ground without prior excavation** (except for prefabricated concrete piles). They are placed below the frost line and do not require a footing. This approach is suitable for new constructions and existing ones that can be temporarily moved to allow the vertical posts to be driven in.

Several types of piles or pilings exist : **screw piles, wooden pilings, steel, and concrete pilings.** The appropriate choice should be made based on the characteristics of the building and the soil.

OBJECTIVES

- ☑ **Increase occupant safety**
- ☑ **Minimize structural damage**
- ☑ **Minimize damage to belongings and materials**
- ☑ **Reduce recovery and reoccupation time**

BENEFITS

- Creation of an **area of refuge** above the defined flood level
- Good **resistance to lateral forces** (waves, ice jams, winds, earthquakes)
- Improved **soil absorption capacity**
- Allows for **unobstructed water movement**
- Suitable for **various soil types, unstable soils, and uneven terrains**
- Suitable for areas exposed to **rhigh waves, strong currents, or ice jams**
- **Additional natural light and improved views** in living spaces

CONSIDERATIONS

- **Redesign of building access and addition of steps** (universal accessibility concern)
- Compliance with **regulatory frameworks**
- **Temporary relocation** of the building (requires space)
- Not suitable for **rowhouses**
- **More challenging insulation** of pipes and flooring on the main floor
- Not suitable for areas at **moderate and high risk of tornadoes**

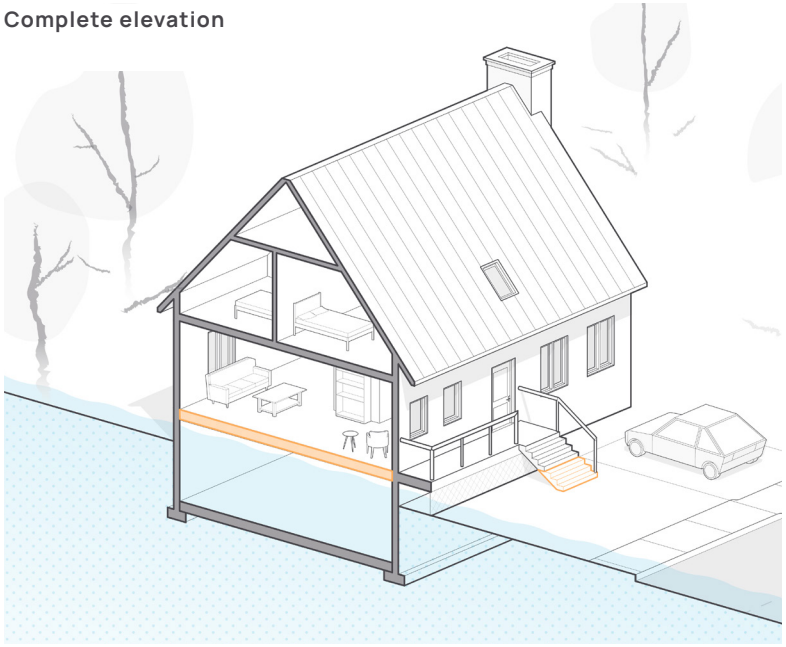
ADVICE

Depending on the height of the elevation, it is possible to **design the space below the building for low-risk use** (parking, access, storage). However, the design of this space should be done with flood-resilient materials and assemblies **(see the Resilient floors, Resilient walls et Resilient carpentry fact sheets).**

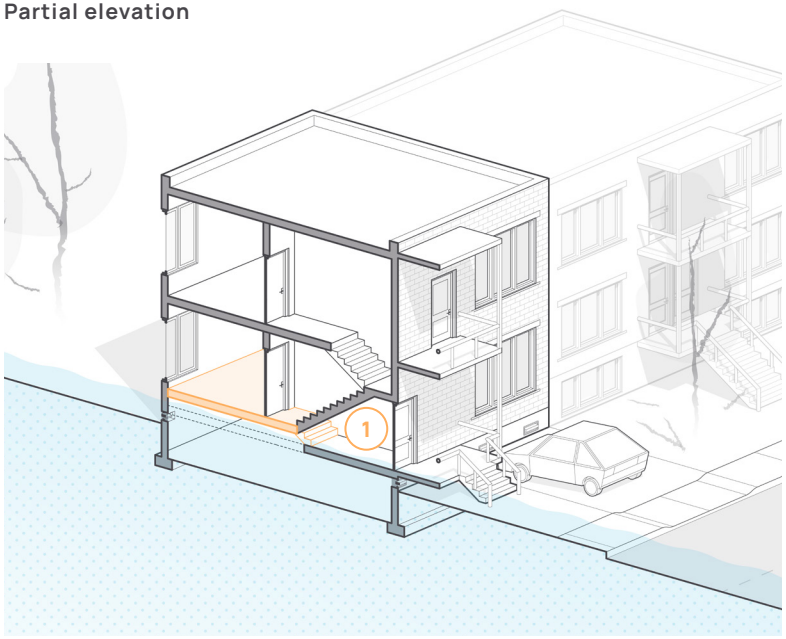
E3 Raising floor level

envelope + structure + space | *permanent* | *reversible* | *temporary* | architecture engineering construction *expertise*

Complete elevation



Partial elevation



Raising the ground floor level above the potential water height is a **permanent avoidance measure** that reduces the exposure of the property and its living spaces to floodwaters. The building remains vulnerable to the hazard, and adaptation measures must be implemented in the basement to cope with it.

Raising the floor involves **elevating the inhabited first floor above the flood level**. This measure is suitable for existing buildings with sufficient ceiling height on the ground floor to allow for the floor to be raised, and buildings with a structure that can withstand flood loads.

It is possible to **raise most of the floor while leaving the entrance space at the original height.** (1) This approach eliminates the need to reconfigure the building's access point but leaves the entrance space exposed to flood risk.

OBJECTIVES

- ☑ **Increase occupant safety**
- ☐ Minimize structural damage
- ☑ **Minimize damage to belongings and materials**
- ☑ **Reduce recovery and reoccupation time**

BENEFITS

- Creation of an **area of refuge** above the defined flood level
- Preservation or minor alteration of the **building's exterior appearance**
- Preservation of the basement as a **secondary living space**
- Potential preservation of the **existing foundation** (material and resource savings)

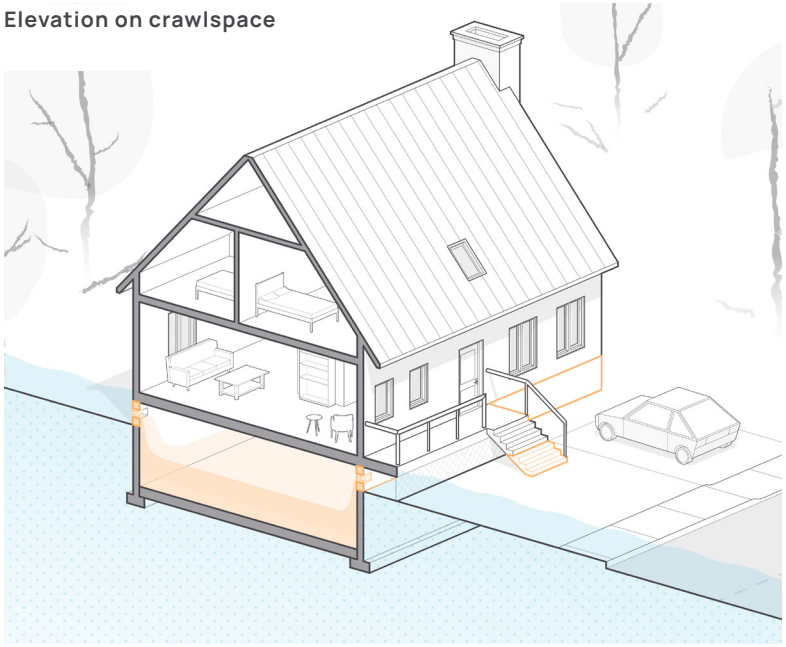
CONSIDERATIONS

- **Redesign of building access and addition of steps** (universal accessibility concern)
- **Lower ceilings**
- Temporary relocation of **furniture, belongings, and equipment from the ground floor** (during implementation)
- Exposure of the building to **flood loads as well as debris or waves impacts**
- **Basement exposure** to flooding

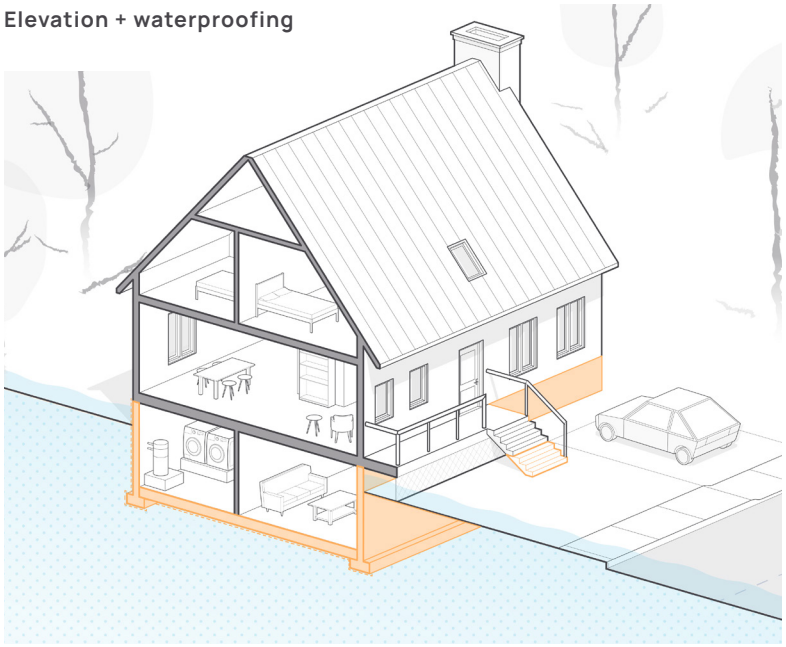
E4 Raising foundations

structure | permanent | reversible | temporary | architecture engineering construction expertise | A5 combination

Elevation on crawlspace



Elevation + waterproofing



Elevating the foundation walls above the potential water level is a **permanent avoidance measure** that reduces the exposure of living spaces and belongings to floodwaters. The building remains vulnerable to the hazard, and adaptation measures must be implemented in the basement to cope with it.

Raising the foundations involves **extending the existing concrete foundation walls to elevate the ground floor** (first inhabited floor) above the reference level. This measure is suitable for existing buildings with a continuous foundation, with or without a basement, and whose structure can withstand flood loads. This method allows to raise the building without removing its existing foundations or filling the existing basement.

OBJECTIVES

- ☑ **Increase occupant safety**
- ☐ Minimize structural damage
- ☑ **Minimize damage to belongings and materials**
- ☑ **Reduce recovery and reoccupation time**

BENEFITS

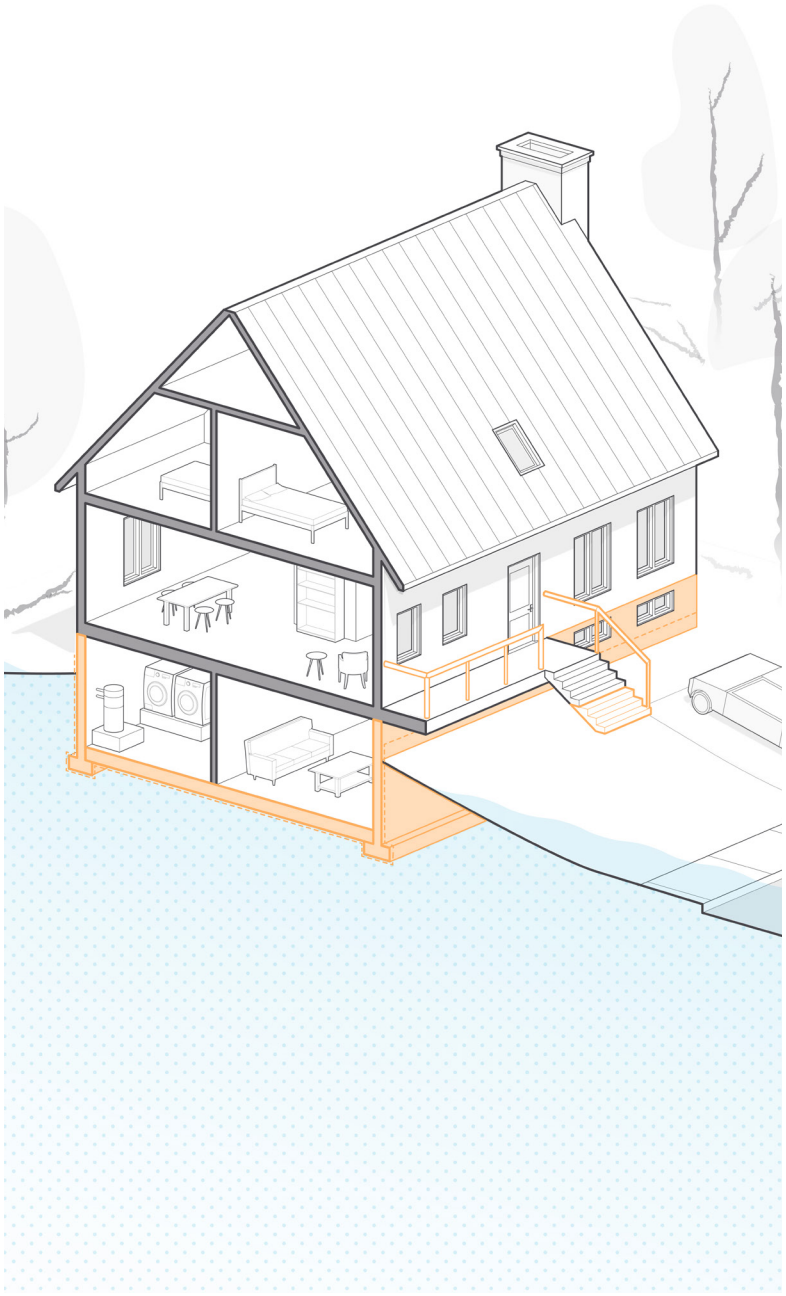
- Creation of an **area of refuge** above the defined flood level
- Preservation of the basement as a **secondary living space**
- Potential preservation of the **existing foundation** (material and resource savings)
- **Additional natural light and improved views** in living spaces

CONSIDERATIONS

- **Redesign of building access and addition of steps** (universal accessibility concern)
- Compliance with **regulatory frameworks**
- **Temporary lifting** of the building (during implementation)
- Not suitable for **unstable soils**
- Exposure of the building to **flood loads as well as debris or waves impacts**
- **Basement exposure** to flooding

E5 Waterproofing foundations

site + structure + space | permanent | reversible | temporary | architecture engineering construction expertise



Waterproofing foundations is a **permanent resistance measure** that reduces the exposure of basements and living spaces to floodwaters. The building remains vulnerable to the hazard, and adaptation measures must be implemented in the basement to cope with it.

Waterproofing foundations involves **completely waterproofing all foundations**. This includes the installation of a **membrane or rubberized waterproofing coating** on the slab located below the potential flood level. Depending on the context, backfilling of the terrain may be necessary.

OBJECTIVES

- ☑ **Increase occupant safety**
- ☐ Minimize structural damage
- ☑ **Minimize damage to belongings and materials**
- ☑ **Reduce recovery and reoccupation time**

BENEFITS

- **Reduced risk of water infiltration** in the basement
- Creation of an **area of refuge** above the defined flood level
- Preservation of the basement as a **secondary living space**

WARNINGS

The **risk of water infiltration in the basement** is never completely eliminated. Plan a flood adaptation strategy for basement spaces.

Waterproofing foundations poses a risk of imbalanced forces against the building if the calculation of water pressure is incorrect, resulting in lifting the building. During the 2019 floods in Beauce, many residents had decided to solely dry-proof their foundations to protect themselves from flooding. However, the floodwaters reached unprecedented levels during the event and some buildings ended up **lifted from the water pressure.**

CONSIDERATIONS

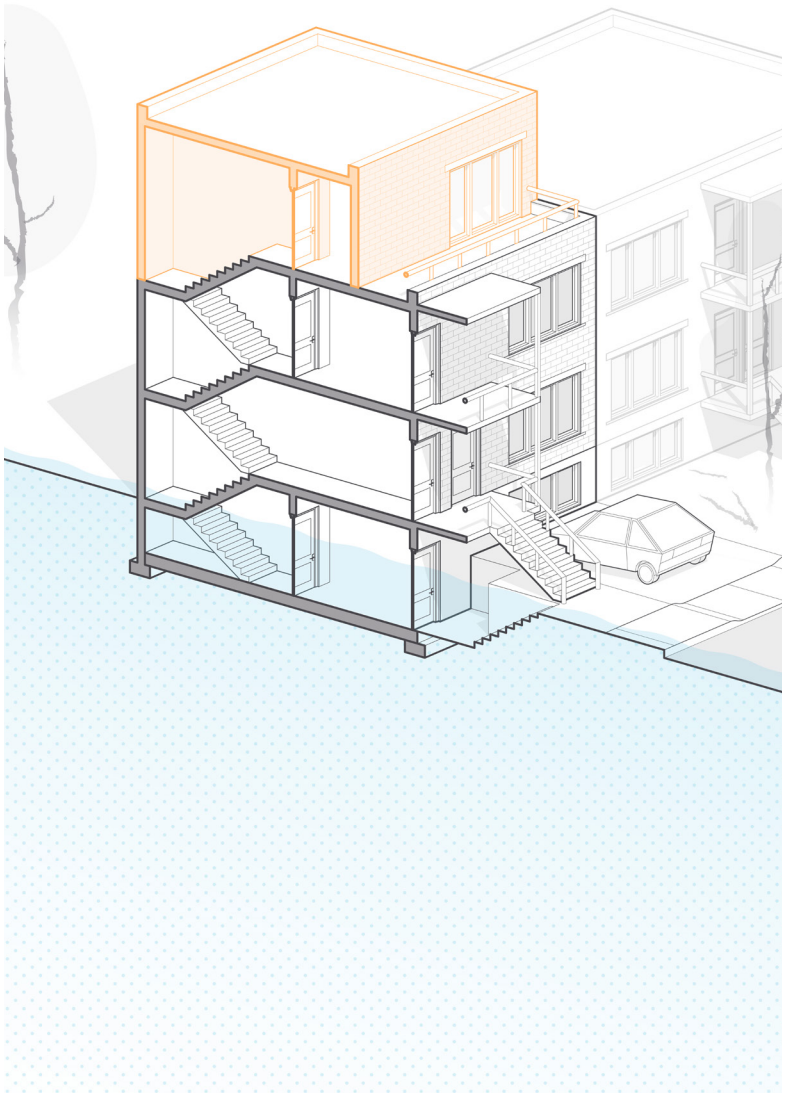
- Not suitable for **rowhouses**
- **Temporary lifting** of the building (during implementation)
- **Stability of structural components and foundations** exposed to flood loads
- **Risk of building uplift** if not properly anchored
- Suitable only in **low-recurrence flood areas**
- Measure's effectiveness relies on the **quality of execution**

E6 Add an extra storey

envelope + structure + space | permanent | reversible | temporary | architecture engineering construction expertise

Adding a floor to a building located in a flood-prone area is a **permanent avoidance measure** that reduces the exposure of living spaces and property to floodwaters. The building remains vulnerable to the hazard, and adaptation measures must be implemented in the lower levels to cope with it.

Adding a floor allows for **the relocation of vulnerable rooms** (such as bedrooms) initially located below the flood level and the **creation of an area of refuge** in a building that cannot be elevated.
This measure is suitable for existing buildings where the structure can support additional loads and withstand flood forces.



OBJECTIVES

- ☑ **Increase occupant safety**
- ☐ Minimize structural damage
- ☑ **Minimize damage to belongings and materials**
- ☑ **Reduce recovery and reoccupation time**

BENEFITS

- Creation of an **area of refuge** above the defined flood level
- Preservation of the basement as a **secondary living space**
- Potential preservation of the **existing foundation** (material and resource savings)
- **Additional natural light and improved views** in living spaces

CONSIDERATIONS

- **Redesign of building access**
- Increased **number of steps to climb daily** (universal accessibility concern)
- Compliance with **regulatory frameworks**
- **Stability of structural components and foundations** exposed to flood loads
- Exposure of the building to **flood loads as well as debris or waves impacts**
- **Basement exposure** to flooding