Useful Links

- EGBC Guidelines & Advisories (https://www.egbc.ca/app/Practice-Resources/Individual-Practice/Guidelines-Advisories)
  - Building Enclosure Engineering Services V2.0
- Geotechnical Engineering Resources - RAM Consulting (https://ramconsulting.com/geotechnical-engineering-resources/)
  - Builder Guide to Site and Foundation Drainage
  - Building Design Philosophy Statement
  - Residential Design Philosophy Statement
  - Building Resiliency Recommendations Matrix
  - Parkade Vent Shaft Model
  - Housing Foundations and Geotechnical Challenges - Best Practices B.C.
- iMapBC (https://www2.gov.bc.ca/gov/content/data/geographic-data-services/web-based-mapping/imapbc)
- Coastal Floodplain Maps (https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/drought-flooding-dikes-dams/integrated-flood-hazard-management/flood-hazard-land-use-management/floodplain-mapping/coastal)
- BRE Flood Resilient Repair House - BRE Group (www.bre.co.uk/floodhouse)
- UK Homeowner's Guide (https://www.floodguidance.co.uk/knowyourfloodrisk-co-uk-homeowners-guide/)

2022 BCBEC CONFERENCE & AGM

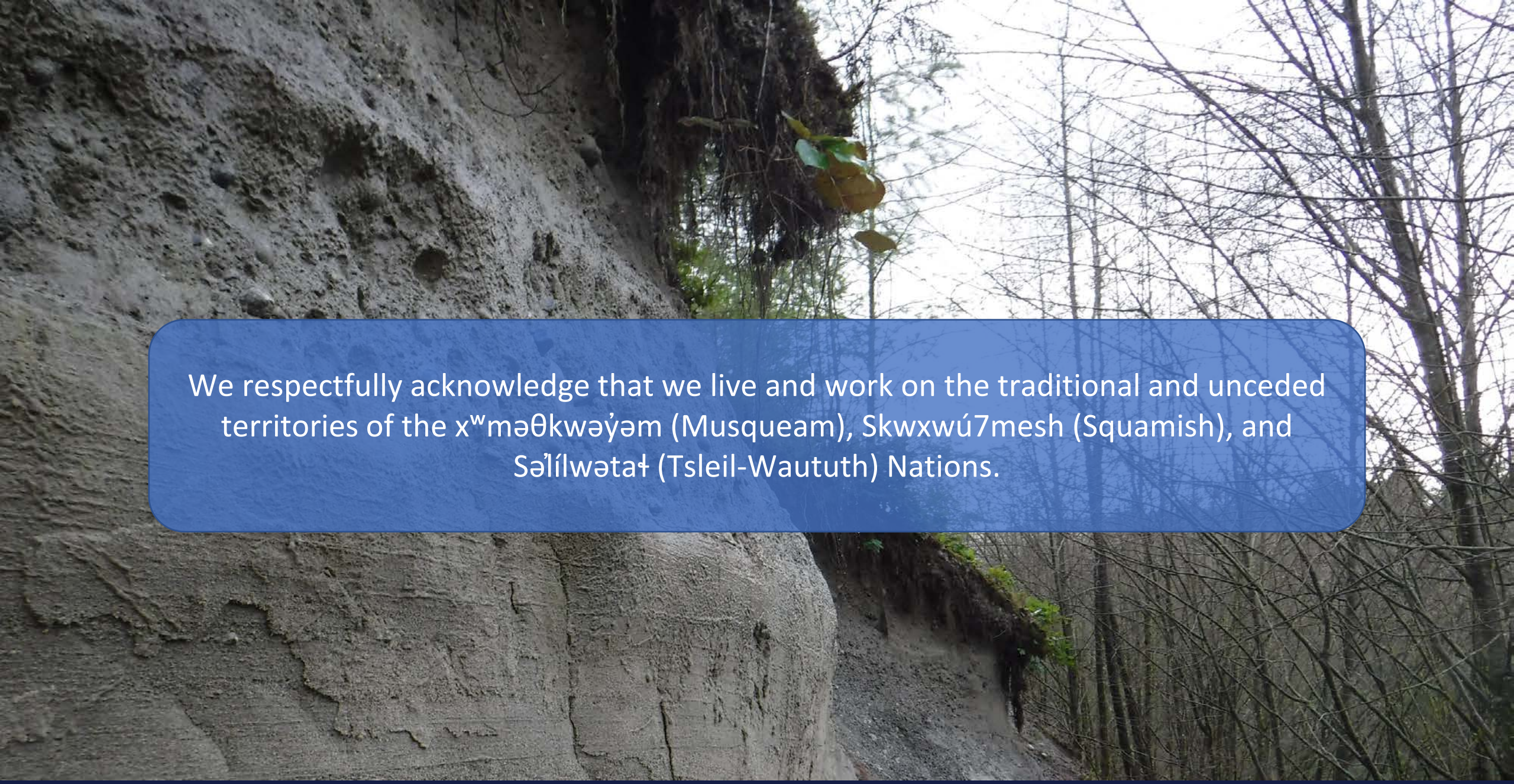
BUILDING RESILIENCE FOR A CHANGING CLIMATE

November 4, 2022

Impacts of Overland Flooding on Below-Grade Structures

Karen Savage, P.Eng., FEC
Diane Meehan, P.Eng.

HORIZON ENGINEERING INC



We respectfully acknowledge that we live and work on the traditional and unceded territories of the xʷməθkwəy̓əm (Musqueam), Skwxwú7mesh (Squamish), and Sə̓lílwətaɬ (Tsleil-Waututh) Nations.

HORIZON ENGINEERING INC

Overland Flooding and Below-Grade Structures

Outline

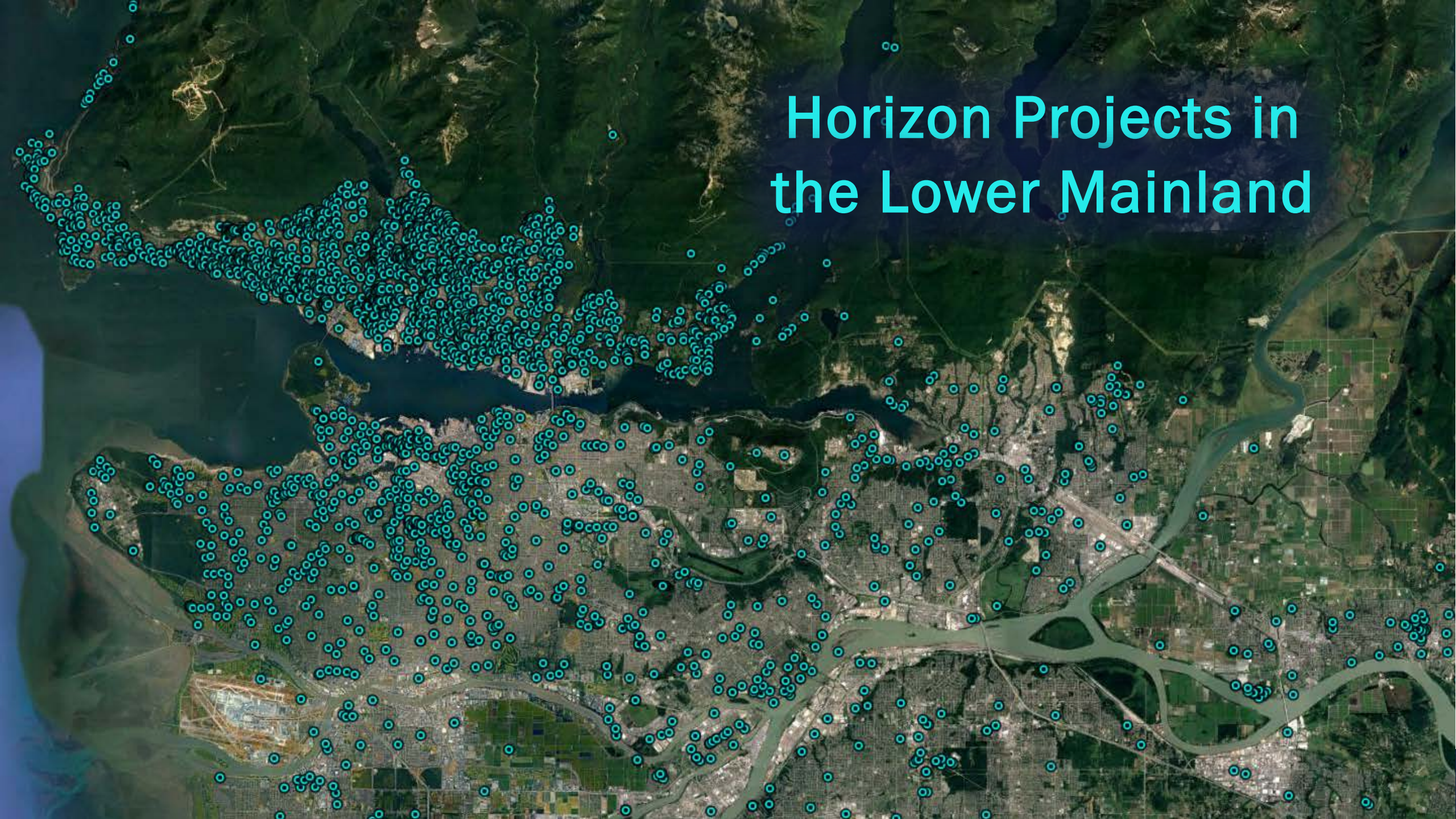
HORIZON ENGINEERING INC

HORIZON ENGINEERING INC

Meet the Team

- Established in 1997
- Acquired by RAM in 2021
- 5000+ projects
- Team of 20+
- 11 Professional Engineers

RAM
YOUR PROJECT. OUR PASSION.


Horizon Projects in
the Lower Mainland

6 R’s of Engineering

- Right
- Reasonable
- Rigorous
- Reviewed
- Responsive
- Respectful

HORIZON ENGINEERING INC

Our Background

"The drop of water and the grain of sand"

What do geotechnical engineers do?

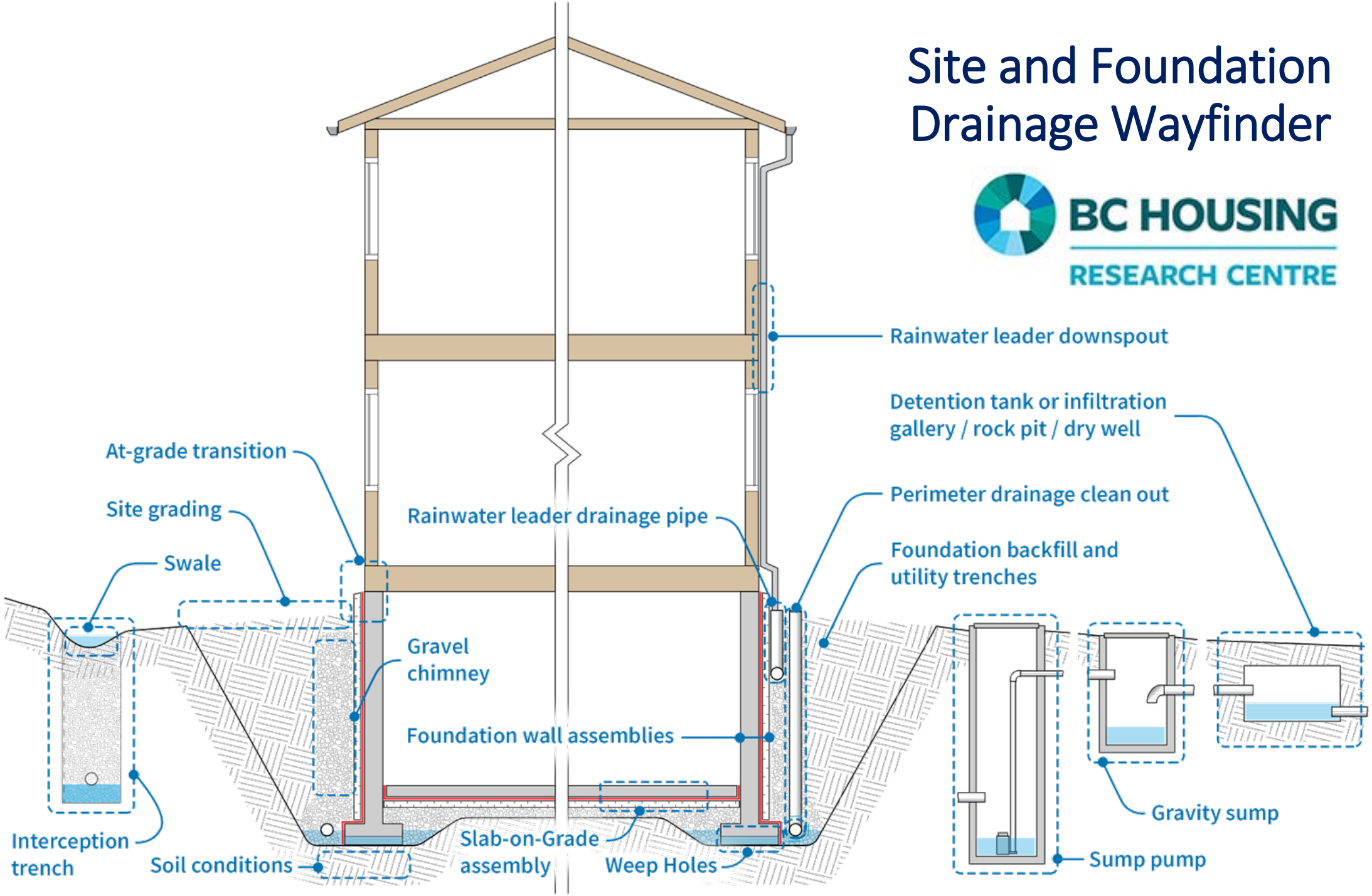
- Apply an understanding of geology and natural processes to the built environment
- Examine the relationship between earth materials and how they interface with the built environment during and following construction
- Work with Building Code and Practice Guidelines

Guidelines

HORIZON ENGINEERING INC

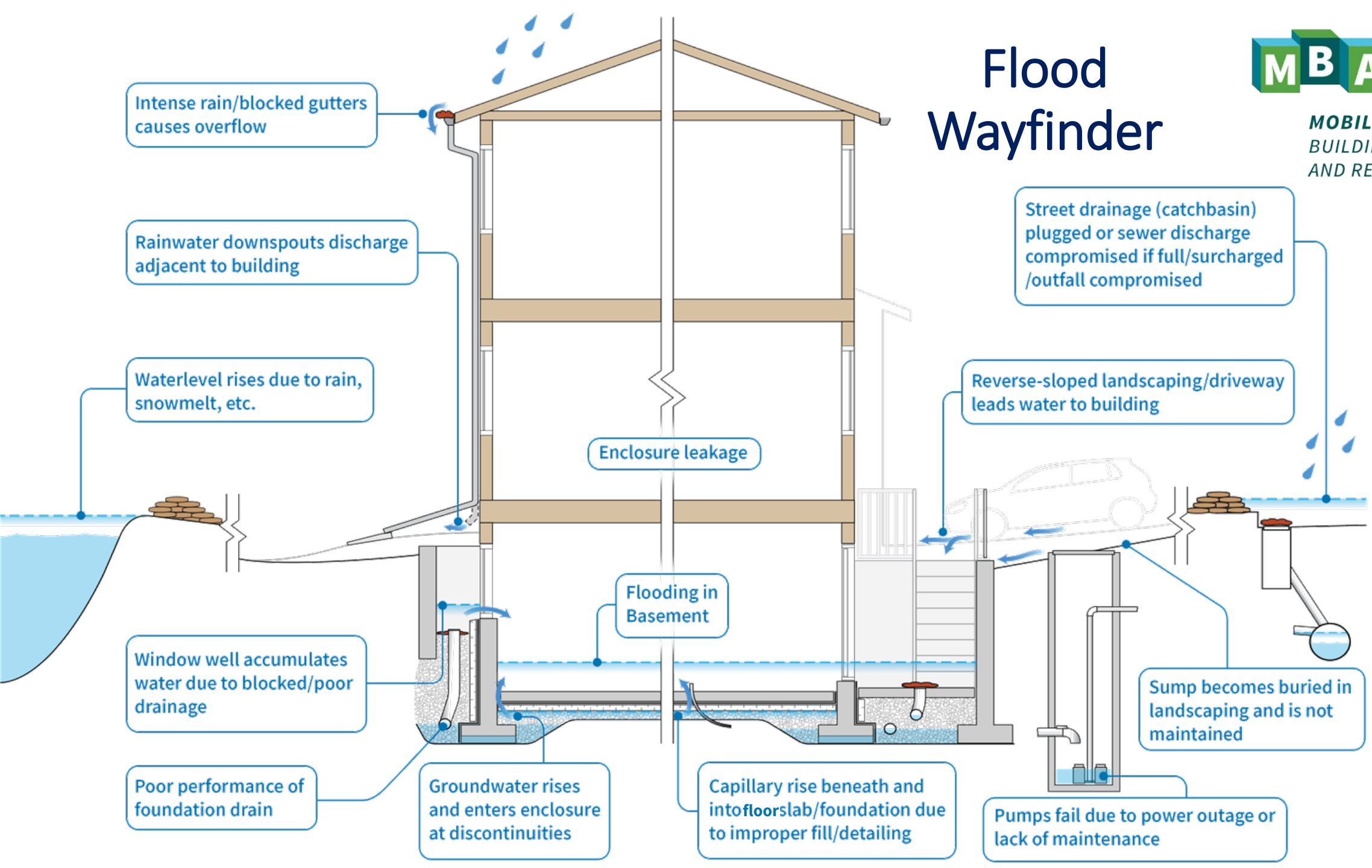
Site and Foundation Drainage Wayfinder

BC HOUSING
RESEARCH CENTRE



Flood Wayfinder

MOBILIZING BUILDING ADAPTATION AND RESILIENCE



EGBC PP Guidelines: Building Enclosure Engineering Services (v2.0, Table 2)

	PROJECT TYPE				
ROLES	NEW BUILDING CONSTRUCTION OR RENOVATIONS	BUILDING ENCLOSURE REHABILITATION OR RENEWAL – SCENARIO 1	BUILDING ENCLOSURE REHABILITATION OR RENEWAL – SCENARIO 2	BUILDING ENCLOSURE REPAIRS	OTHER SERVICES[a]
COORDINATING REGISTERED PROFESSIONAL (CRP)	• Either an Architect or an Engineering Professional may fulfill the CRP role.	• Where required, the Architect usually fulfills the CRP role with the same responsibilities as for a new construction project.	• Where required, the BEE usually fulfills the CRP role.	• Letters of Assurance and a CRP are not required for projects that do not require a building permit. • The BEE must confirm that a building permit is not required for each project before proceeding on that basis. • If a permit is required, then the roles for a Rehabilitation project apply.	• Letters of Assurance and a CRP are not required for projects that do not require a building permit.
REGISTERED PROFESSIONAL OF RECORD (RPR)	• An Architect must act as the RPR for the Building Enclosure and submit Schedules B and C-B. • The BEE must not submit Schedules B or C-B for the Building Enclosure.	• An Architect must act as the RPR for the Building Enclosure and submit Schedules B and C-B. • The BEE must not submit Schedules B or C-B for the Building Enclosure. • Other RPRs may be required, depending on the scope of services.	• When a BEE is the RPR for the Building Enclosure, the BEE submits Schedules B and C-B. • Other RPRs may be required, depending on the scope of services.	• Not required. See above.	• Not required. See above.
SUPPORTING REGISTERED PROFESSIONAL (SRP)[b]	• If required by the RPR, the BEE may submit Schedules S-B and S-C to the Architect RPR, customized for the scope of services provided and in support of the RPR's Schedules B and C-B.	• The BEE may submit Schedules S-B and S-C to the Architect RPR, customized for the scope of services provided and in support of the Architect's Schedules B and C-B. • Other SRPs may be required, depending on the scope of services.	• An Architect or Engineering Professional must review the project scope to identify any need for the involvement of an Architect or other RPs. • SRPs may be required, depending on the scope of services and the expertise of the BEE.	• Other SRPs may be required, depending on the scope of services and the expertise of the BEE.	• SRPs may be required, depending on the scope of services and the expertise of the BEE. • Schedules S-B and S-C could be used if desired but are not required.
CONSTRUCTION DOCUMENTS	• The Architect RPR must prepare and take responsibility for the Construction Documents associated with the Building Enclosure.	• The Architect RPR must prepare and take responsibility for the Construction Documents associated with the Building Enclosure.	• The BEE acts as RPR for the Building Enclosure and must prepare and take responsibility for the Construction Documents associated with the Building Enclosure.	• At minimum, sketches will be required to describe the scope of services, provide necessary details, and specify the materials to be used.	• Not typically required.

Building Enclosure Engineering Services

- BEE may act as CRP on building renewal / rehabilitation projects
- Includes for older buildings which may be more vulnerable to the impacts of climate change
- Water and drainage are considerations of these projects
- Rehabilitation projects may present an opportunity for Owners to implement resiliency strategies

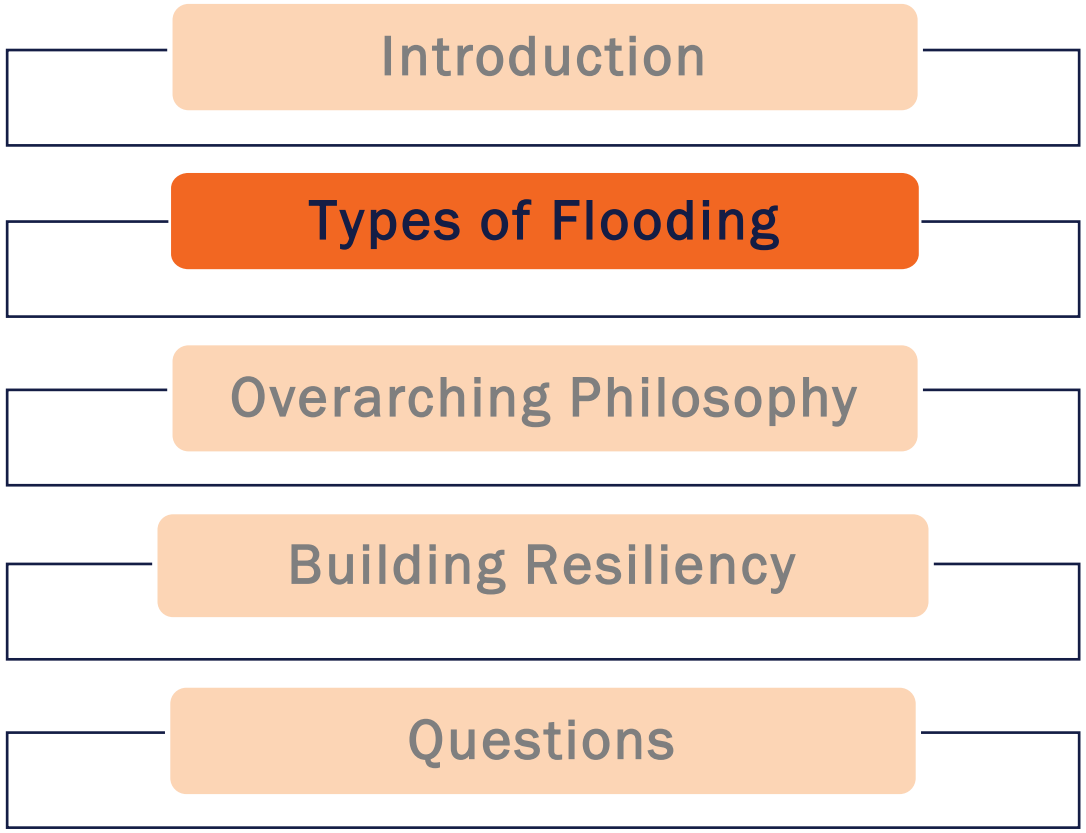
3.4.9 VULNERABILITY TO CLIMATE CHANGE

Engineering Professionals are expected to keep informed about the changing climate and consider potential impacts of climate change on their professional activities.

BEEs are encouraged to inform Clients about the implications of climate change. If the Client elects to consider climate change impact on the building, a climate change vulnerability study proportionate to the size and complexity of the project should be carried out to inform the design of the Building Enclosure.

The Association has undertaken several initiatives to explore the impact of climate change on professional engineering and geoscience practice and maintains relevant literature in the “Climate” section of the Association’s website, under Practice Resources (Engineers and Geoscientists BC 2019).

Overland Flooding and Below-Grade Structures



Outline

HORIZON ENGINEERING INC

Common Types of Flooding

- In a Floodplain:
  - Inland / Fluvial / Riverine flooding
  - Coastal flooding
  - Other

- Urban Flooding:
  - Rainfall / “Pluvial” flooding
  - Civil infrastructure failure causing back-up in street

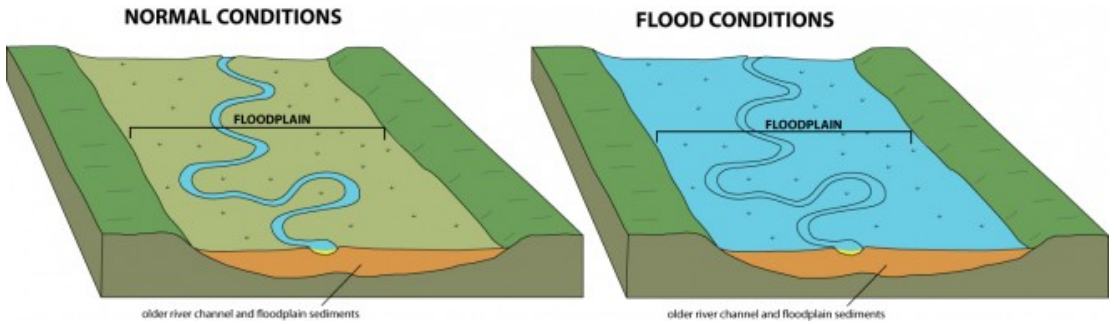
- Below-grade:
  - Groundwater flooding / ingress
  - Civil infrastructure failure causing back-up into building

Refer to Builder Guide to Site and Foundation Drainage

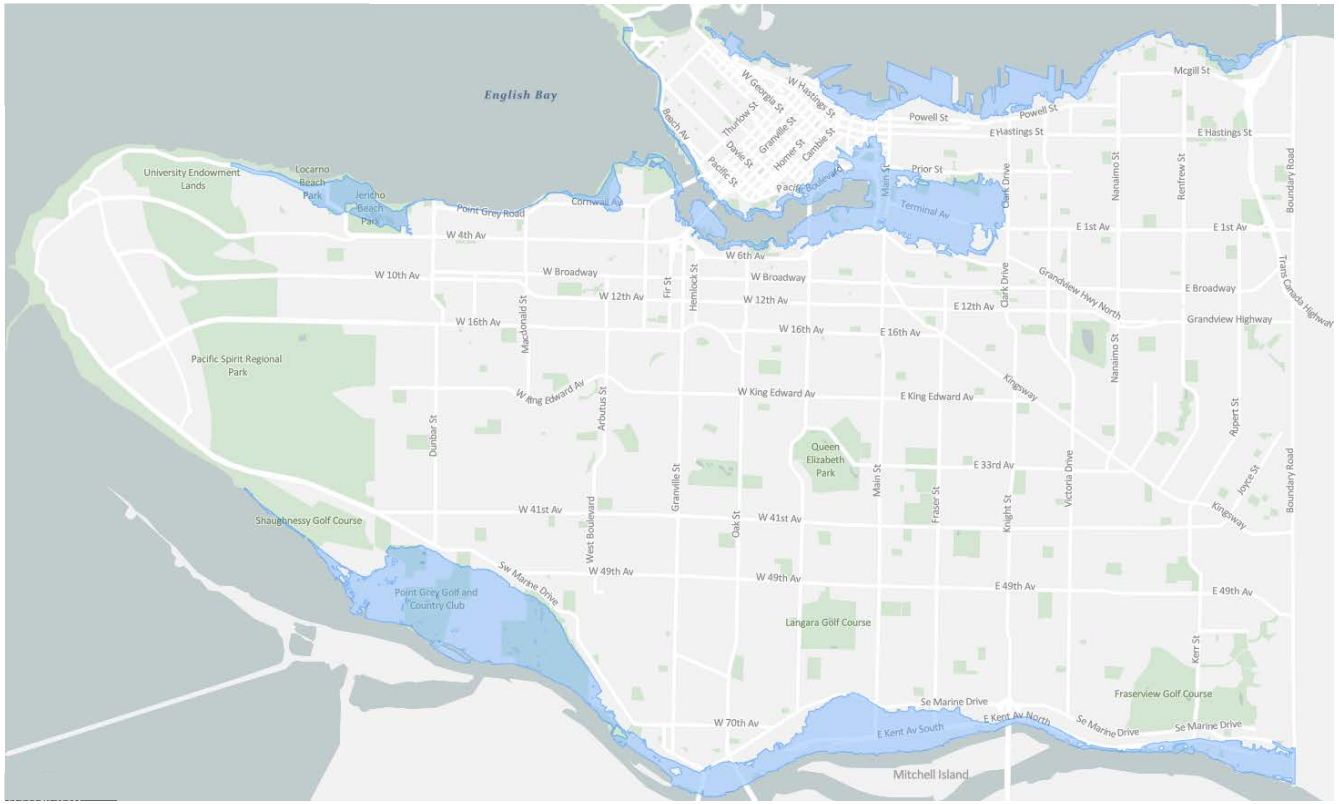
- Reservoir / pond / dam failure (including due to seismic)

Floodplains: Known Flood Risk

- Defined by design event(s) which are changing
- The reach of a flood for a particular water body varies



https://www.wired.com/2011/05/flooding-creates-floodplains/

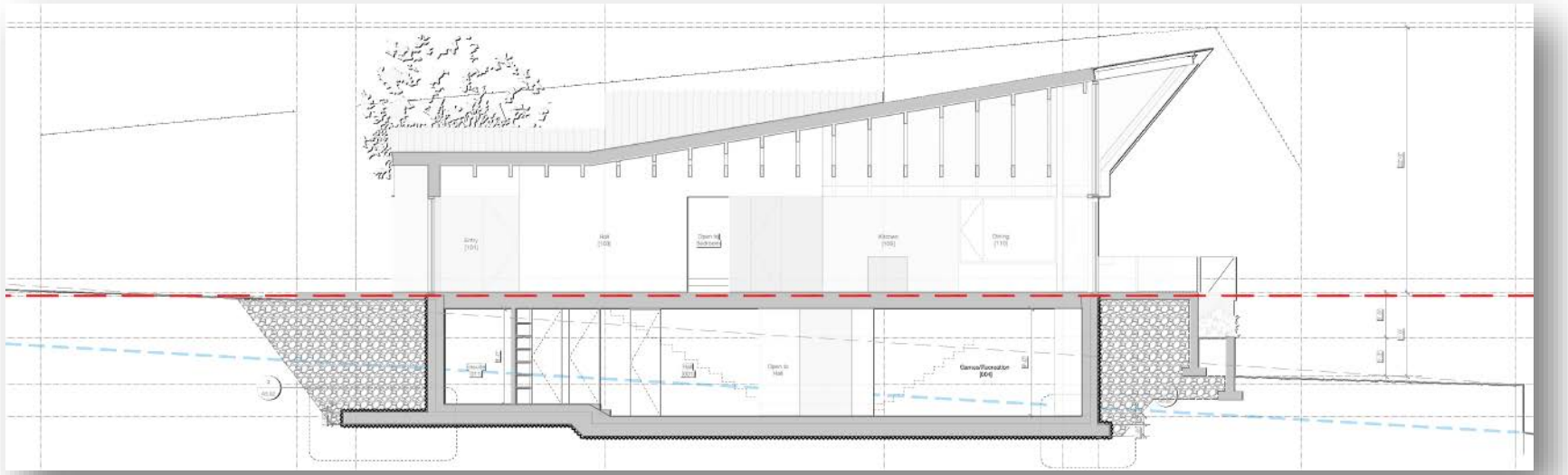


City of Vancouver designated floodplain
(Map: “City of Vancouver Groundwater Areas of Concern”)

Ministry of Environment: Flood Hazard Area Land Use Management Guidelines (FHALUMG)

Flood Construction Level (FCL)

- Elevation of the underside of a wooden floor system or top of concrete slab for habitable buildings
- Used to keep living spaces and areas used for the storage of goods which are damageable by floodwaters above flood levels
- Parking is often allowed beneath the FCL
- Basements are typically not allowed beneath the FCL (unless the building is “tanked”, for example)



Ministry of Environment: Flood Hazard Area Land Use Management Guidelines (FHALUMG)

Flood Construction Level (FCL)

- In some locations FCLs have been established, otherwise they are typically referenced as an elevation above the natural boundary
- Is NOT the “maximum possible” flood
- Although conservative, should be expected to be exceeded and to increase in the future
- Limited consideration of ‘geologic scale’ trends
- Not tied to BCBC or VBBL but if it were, current language pertaining to required building performance generally requires “no collapse / safe to exit from”

Note: Flood mapping older than ~2010 may be out of date

Ministry of Environment: Flood Hazard Area Land Use Management Guidelines (FHALUMG)

Terminology

Q200:

- The designated flood level associated with a 200-year return period
- Most accurately determined by a hydraulic engineer
- NOT the ‘high water level’ or ‘natural boundary’ at the nearest water body

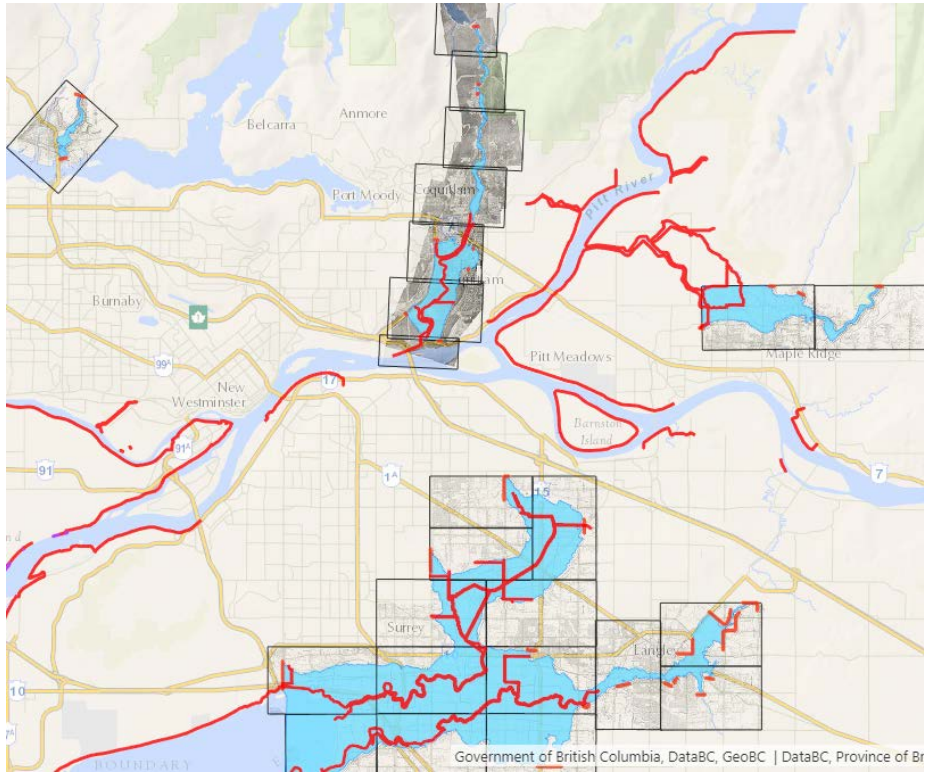
Natural Boundary:

- Determined by Land Surveyors and defined in the Land Act of BC as:

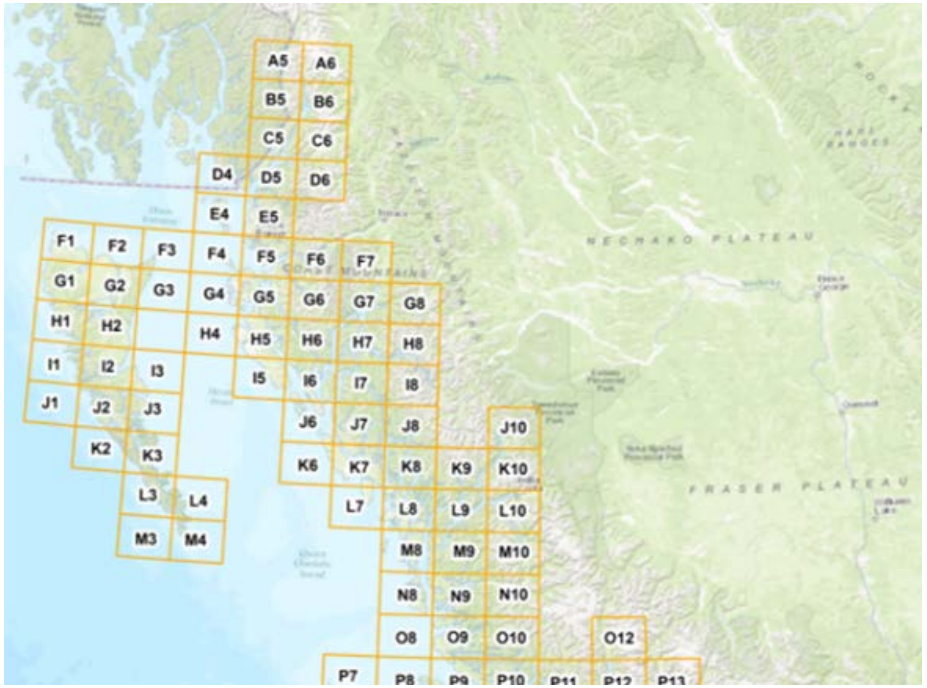
  “the visible high water mark of any lake, river, stream or other body of water where the presence and action of the water are so common and usual, and so long continued in all ordinary years, as to mark on the soil of the bed of the body of water a character distinct from that of its banks, in vegetation, as well as in the nature of the soil itself”

Flood Maps

- **Inland:** iMap BC → Launch → Data Sources → Add Provincial Layers → search “flood” and add to map



- Coastal (potential to 2100)



Note: Flood mapping older than ~2010 may be out of date

Other Overland Flooding / Urban Flooding

- **FCL is not applicable**
- Pluvial / Rainfall / “Flash” flooding
  - Microtopography / grading
  - Hydrology (e.g. wildfire zones experience increased runoff specifically if soil has become hydrophobic/repels water)
- Snowmelt contribution
  - Especially rain on snow
- ‘Cloudbursts’ / Atmospheric Rivers
  - Extreme amount of precipitation in a short period of time
- Lack of maintenance
- Increase in extreme rainfall events due to climate change

Civil Infrastructure Failure

- Often a major factor in basement flooding
- **Increasingly becoming a major concern for municipalities**
  - Increased development leads to more impermeable surfaces and therefore more runoff
  - Climate change / more intense rainfall events
  - Adding cost to development
- Can cause back-up
  - Into building (i.e., through basement fixtures)
  - Into street (i.e., causing flooding over surface)

A lawsuit over three stormwater floods of a building over the past year has been launched against Langley City. (Langley Advance Times file)

Flooded apartment building sparks lawsuit against Langley City

A downtown landlord claims a lack of storm sewer upgrades is negligence

MATTHEW CLAXTON / Jan. 20, 2021 2:00 p.m. / LOCAL NEWS / NEWS

https://www.langleyadvancetimes.com/news/flooded-apartment-building-sparks-lawsuit-against-langley-city/?fbclid=IwAR1Zi2QTL3t4WksqK8a6Qq6OuU6kVFpeP9z8lwQHlmj1VQqSaicahlpbgrE -

Civil Infrastructure Failure

- **‘Minor drainage system’** to manage ‘10-year rainfall’ (i.e., sewers)
- **‘Major drainage system’** to manage ‘100-year rainfall’ (can include over roadways / drainage channels)

- No allowance for any groundwater
- “10-year” events are happening more frequently now due to climate change
- Historic data likely used to design these until recently

Civil Infrastructure Failure

- Where ditches and open channels convey stormwater:
  - Ice damming in the winter
  - Habitat develops at downstream outlet that can not be cleared and capacity of the natural habitat (which acts as a ‘sponge’) is reduced

Overland Flooding and Below-Grade Structures

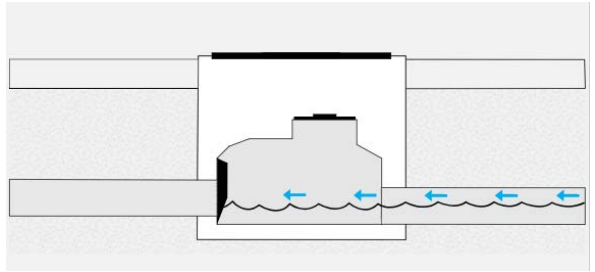
- Introduction
- Types of Flooding
- **Overarching Philosophy**
- Building Resiliency
- Questions

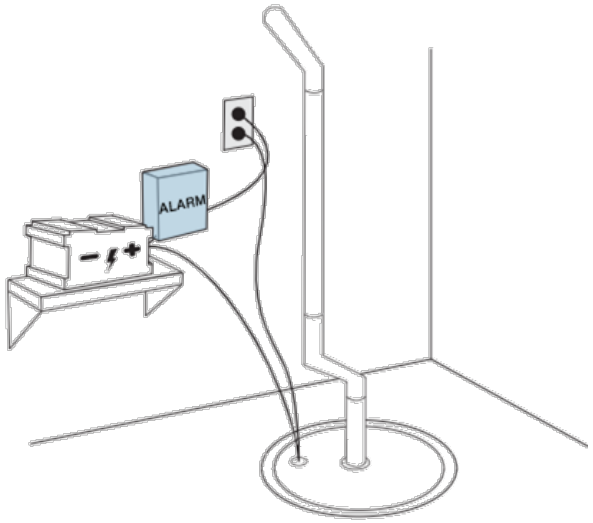
Outline

HORIZON ENGINEERING INC

Overarching Philosophy

- **Plan for failure.**
- What happens if:
  - The power goes out?
  - The pumps burn out / fail?
  - The sewers are full?
  - Backflow valves seize



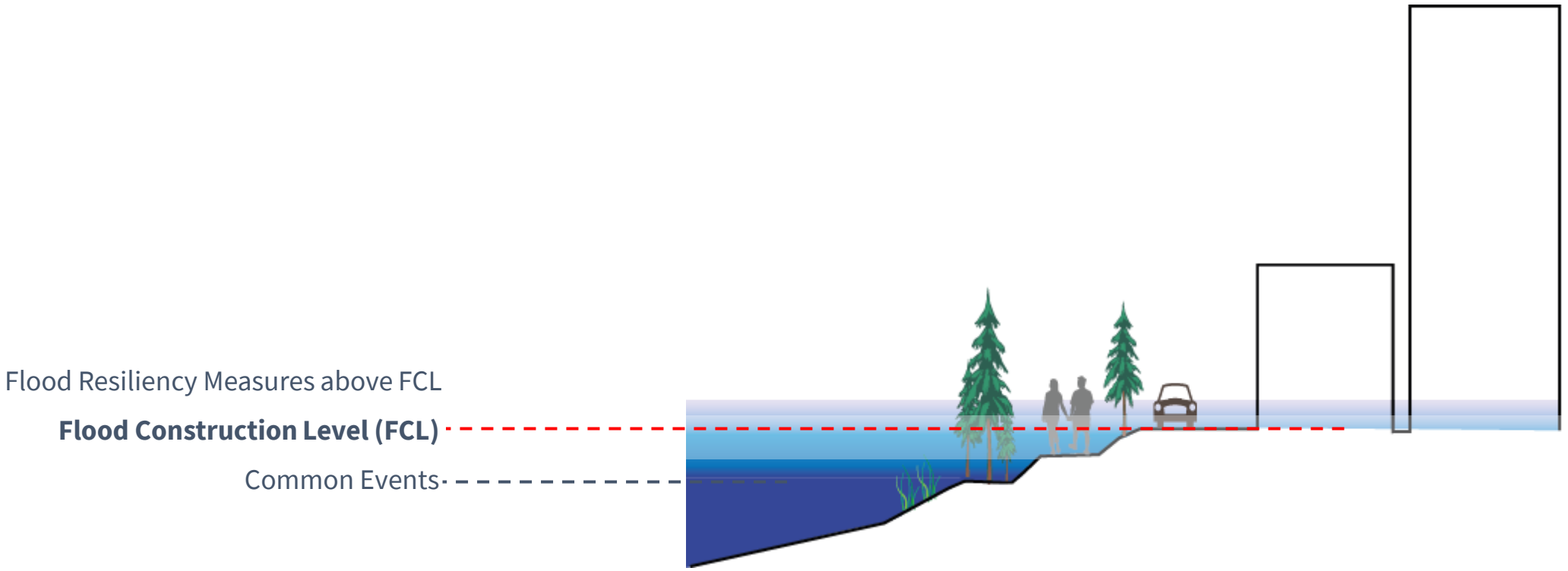


- Expect that water will enter the basement or parkade at some time during the building design life – how can you reduce the impact
- Adopt ‘low hanging fruit’ measures (low cost – high impact)
- Future owners/occupants should understand design philosophy of building; they will have new materials and technologies at time of renovation (“build back better”)

Home Flood Protection Check-Up (Intact Centre on Climate Adaptation)

Overarching Philosophy

- **Manual back-up for passive systems**
- Recognize FCL is not static / enshrined
- Plan for an event in excess of FCL of sufficiently extended duration such that:
  - building and underground below FCL is flooded, and
  - all regular mechanical and electrical systems fail.
- Consider cascade events
- Identify value propositions for developers and clients
- Adopt ‘low hanging fruit’ measures (low cost – high impact)
- Future owners/occupants should understand design philosophy of project team; they will have new flood resistive materials and technologies at time of renovation (“build back better”)
- Consider sewers, manholes, sumps, catch basins, and floor drains as sources of water



Adapted from Compass Resource Management

Understand Hazard and Assess Risk: Overland Flooding

- Am I in a floodplain? If so, what protections are in place?
- Is there a nearby water body or creek (including ephemeral)?
- Is there a community flood monitoring / alert system?
- Am I at the bottom of a slope that could direct water towards my property?
- Is my site graded to conduct water toward my home?
- Am I in a flat / low-lying area?
- Has flooding occurred in the past? What was the cause?
- What level of maintenance has been carried out?
- Is the storm or sanitary sewer connection vulnerable to backing up?

Design Philosophy Statement

- Summarizes key design considerations and construction methodologies in one document
  - Intended design life
  - Building Code at time of permitting
  - FCL at time of construction
  - Conventional waterproofing vs ‘tanked’ structure
- Targeted at Part 3/4 buildings
- Good list of things to consider for a new building or significant renovation
- Future owner to be involved in these decisions
- Consider putting on title

Sample may be downloaded online at https://ramconsulting.com/geotechnical-engineering-resources/

Design Philosophy Statement: _____

_____

_____

- ❑ Address: _____
- ❑ Development Description: _____
- ❑ Applicable Building Code: _____
- ❑ Number of Storeys: _____
- ❑ No. of underground levels: _____
- ❑ Types of construction: _____
- ❑ Closest water body: _____
- ❑ Geology: _____
- ❑ Primary type of flooding: _____
- ❑ FCL: El. _____
- ❑ FARE: El. _____
- ❑ Existing grades: El. _____ m to El. _____ m
- ❑ Main Floor: El. _____ m to El. _____ m

- ❑ Parkade Ramp Entry: El. _____
- ❑ Slab-on-grade: El. _____ m to El. _____ m
- ❑ Sewer connections: El. _____ m to El. _____ m
- ❑ Vent shafts / Rims: El. _____ m to El. _____ m
- ❑ Other penetrations: El. _____ m to El. _____ m
- ❑ Any other connections to sewer/ground?
  (ie sewage heat recovery, geothermal, …)
- ❑ "Max Design" groundwater table: El. _____
- ❑ Waterproofing/tanking system: _____
- ❑ Electrical room above FCL/FARE? _____
- ❑ Backup generator above FCL/FARE? _____
- ❑ Elevator Water Sensor? _____
- ❑ Pull Pit Sensor? _____
- ❑ On-site power generation? _____

Intent of Design Team for future upgrades: _____

_____

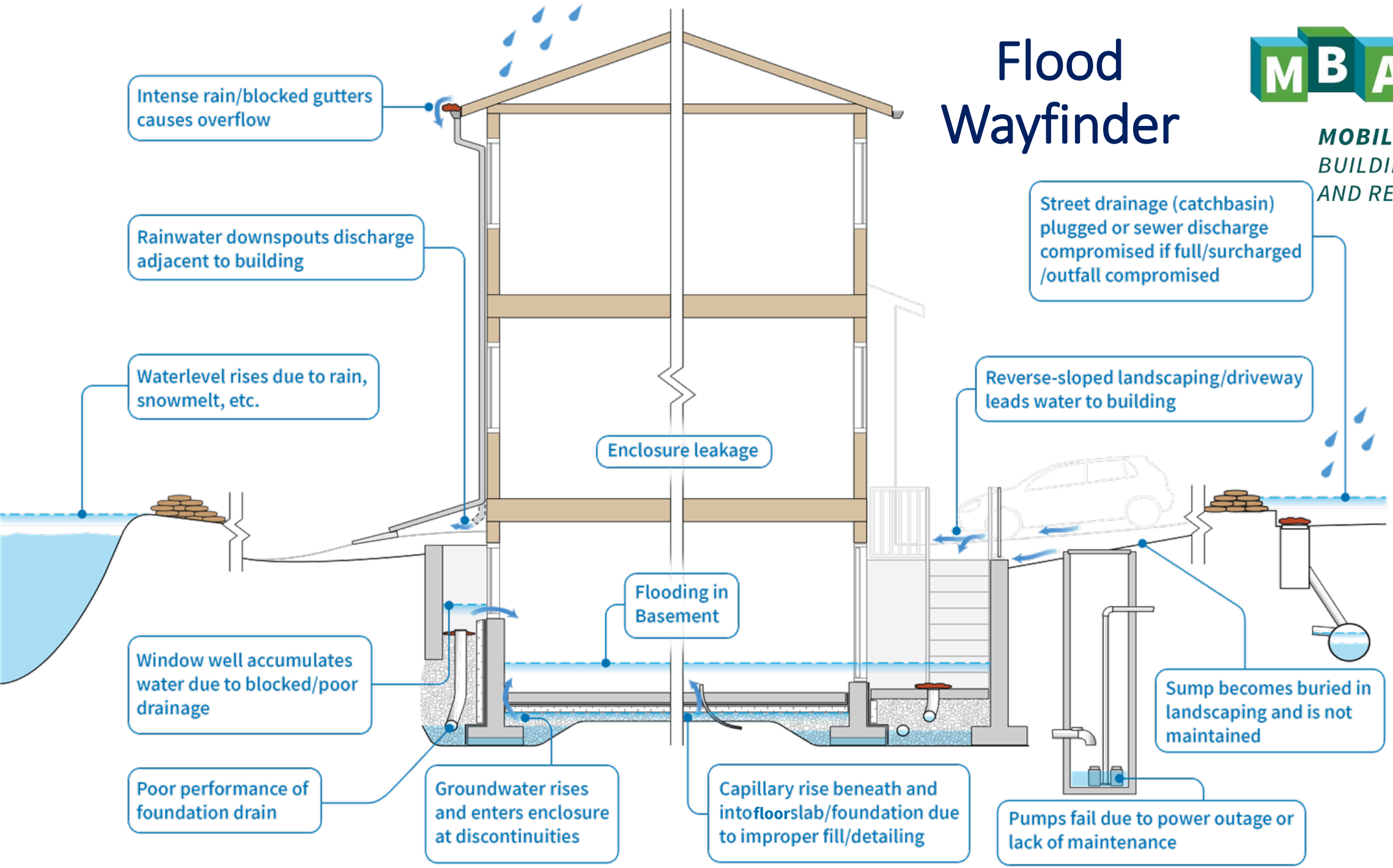
_____

Overland Flooding and Below-Grade Structures

Outline

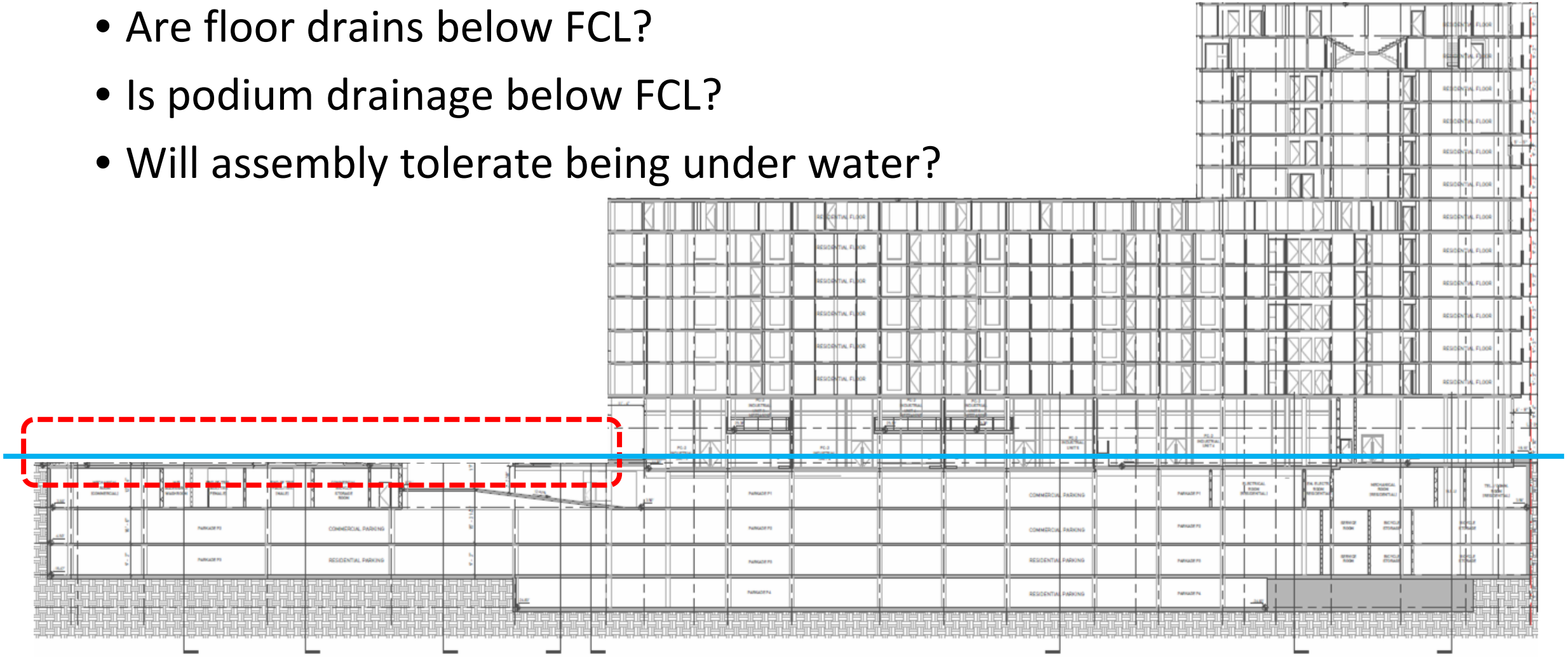
Flood Wayfinder

MOBILIZING
BUILDING ADAPTATION
AND RESILIENCE



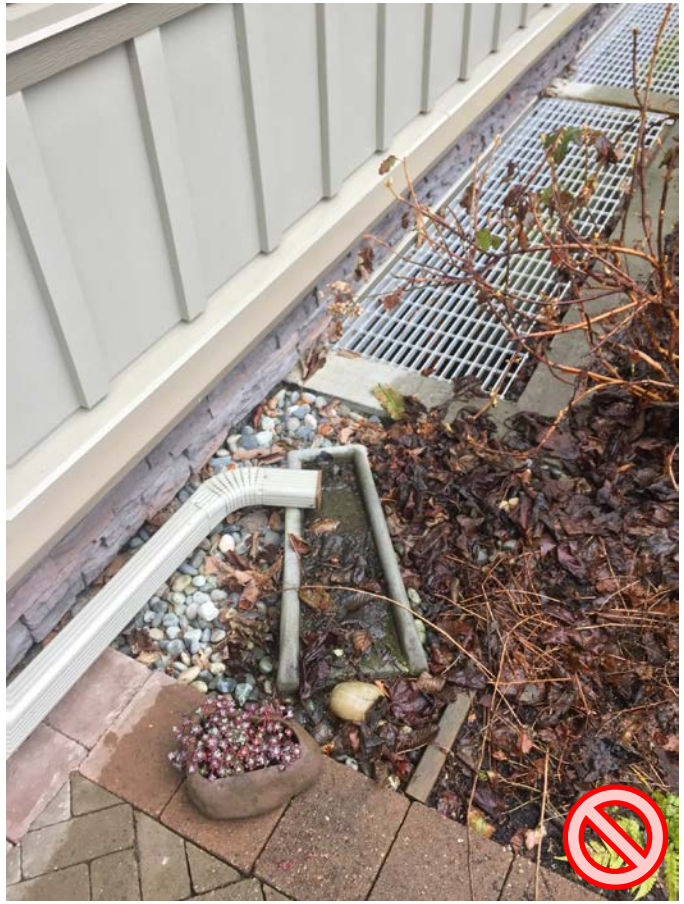
Building Envelope	B1	Consider top termination of waterproofing/drainage membranes applied to exterior building walls up and to lap to slab membranes below FCL[3] elevation; consider utilizing a concrete curb with waterproofing up to FCL
	B2	Consider performance and discharge of area drains in landscaped plazas below FCL
	B3	Consider material durability with respect to potential deterioration due to wetting (consider salinity or contamination of water)
	B4	Consider integrity of dampproofing / waterproofing seals under a few feet of water head
	B5	Utilize concrete curbs to elevate sill plates of framing and other moisture-sensitive materials (potentially including architectural cladding of clad columns)
	B6	Consider adding drains to architectural cladding of columns

- What if the podium floods?
- Are floor drains below FCL?
- Is podium drainage below FCL?
- Will assembly tolerate being under water?



Keep Water Out

- Door and window sills
- Reverse-sloping driveways
- Window wells
- Downspouts
- Grading
- Other vulnerabilities at building perimeter



Keep Water Out

Door Sills

- Raise in vulnerable areas if possible
  - Consider accessibility (i.e., for wheelchairs)
- Prepare for installation of flood barriers
  - C-channel to allow installation of barrier
  - Sandbags on hand
  - Store near to where they will be used
- Maintain proximate floor drains
- Have submersible pump on hand

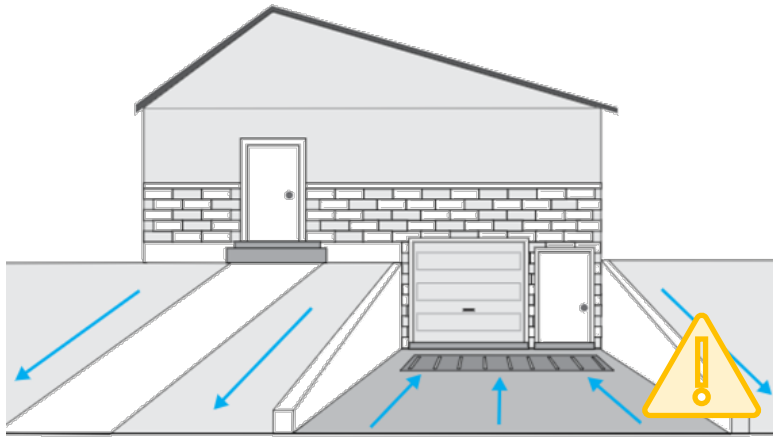
Figure 1 Demountable barrier for external door 1 donated by www.floodtec.co.uk

Figure 2 Demountable type barrier on external door 2 donated by www.lakesidefloodsolutions.co.uk

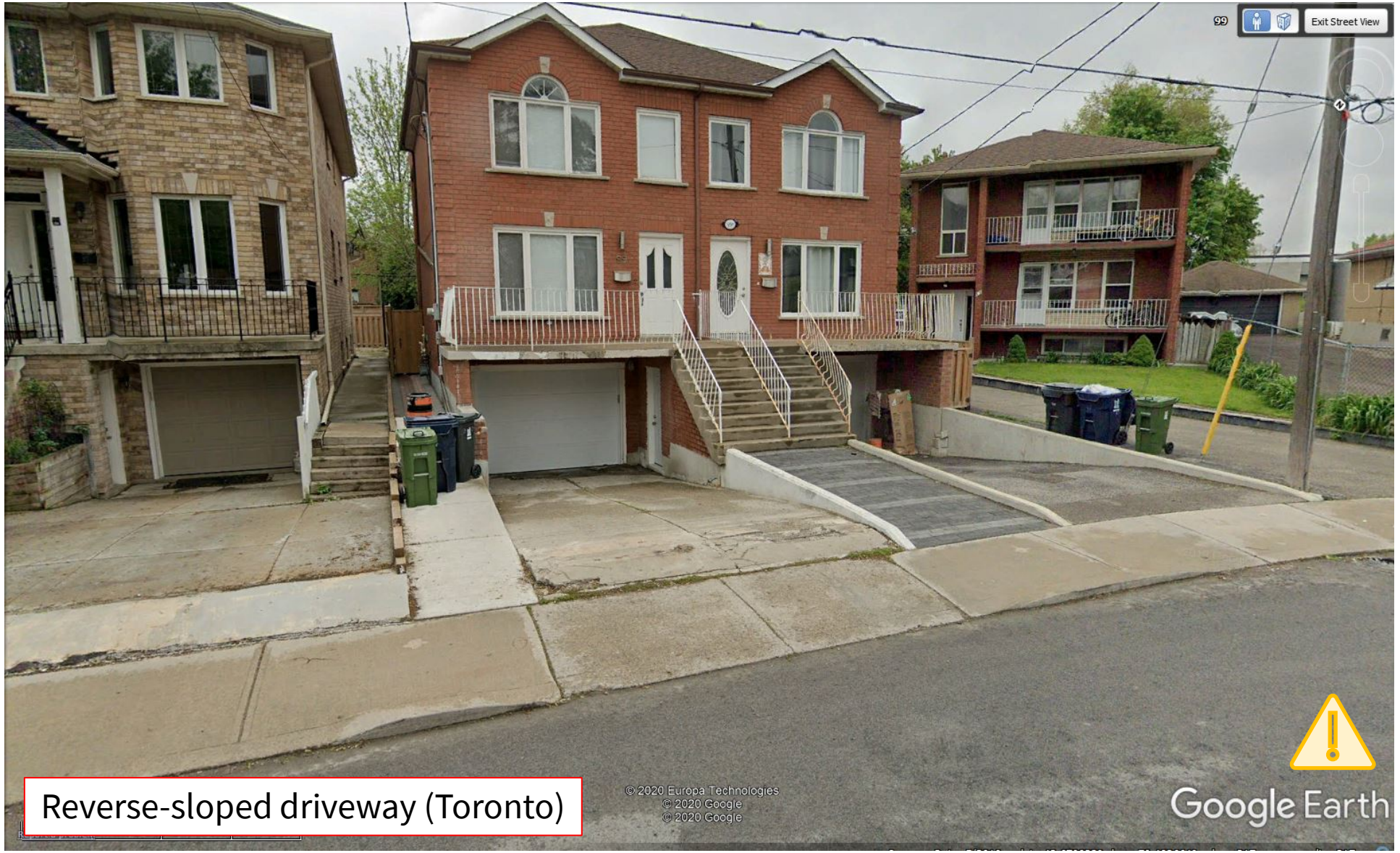
Keep Water Out

Reverse-sloped Driveway

- Where possible, grade down and away from the building
- Raise ‘crown’ of ramp
  (at least above road grade)
- Maintain trench drains
- Prepare for installation of flood barriers
  - Sandbags on hand; store near to where they will be used
  - Consider vulnerability if neighbour does not have a flood barrier



Home Flood Protection Check-Up (Intact Centre on Climate Adaptation)

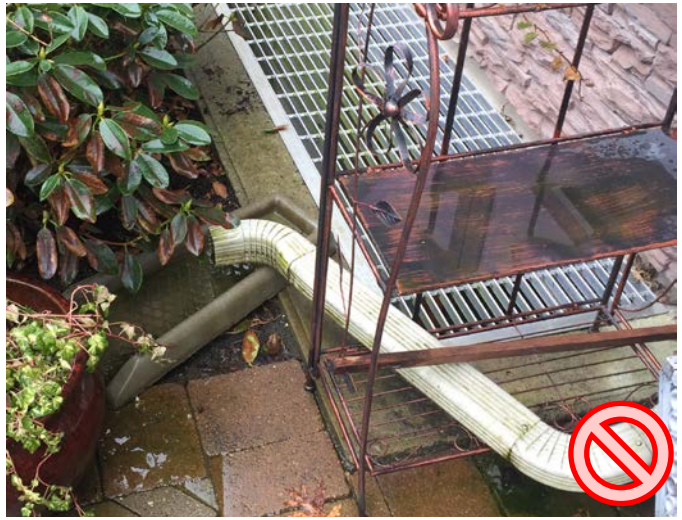


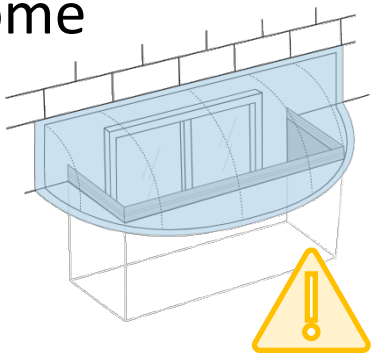
Reverse-sloped driveway (Toronto)

Keep Water Out

Window Wells

- Raise curb around window well
  - Can be implemented after construction
- Ensure grade at bottom of well is below level of window sill
- Ensure bottom of well has a drain with a solid connection to perimeter drainage
- Consider covers (must allow for emergency egress in some wells)
- Maintain drains and rainwater leaders / gutters
- Prepare for installation of flood barriers
  - Sandbags on hand; store near to where they will be used





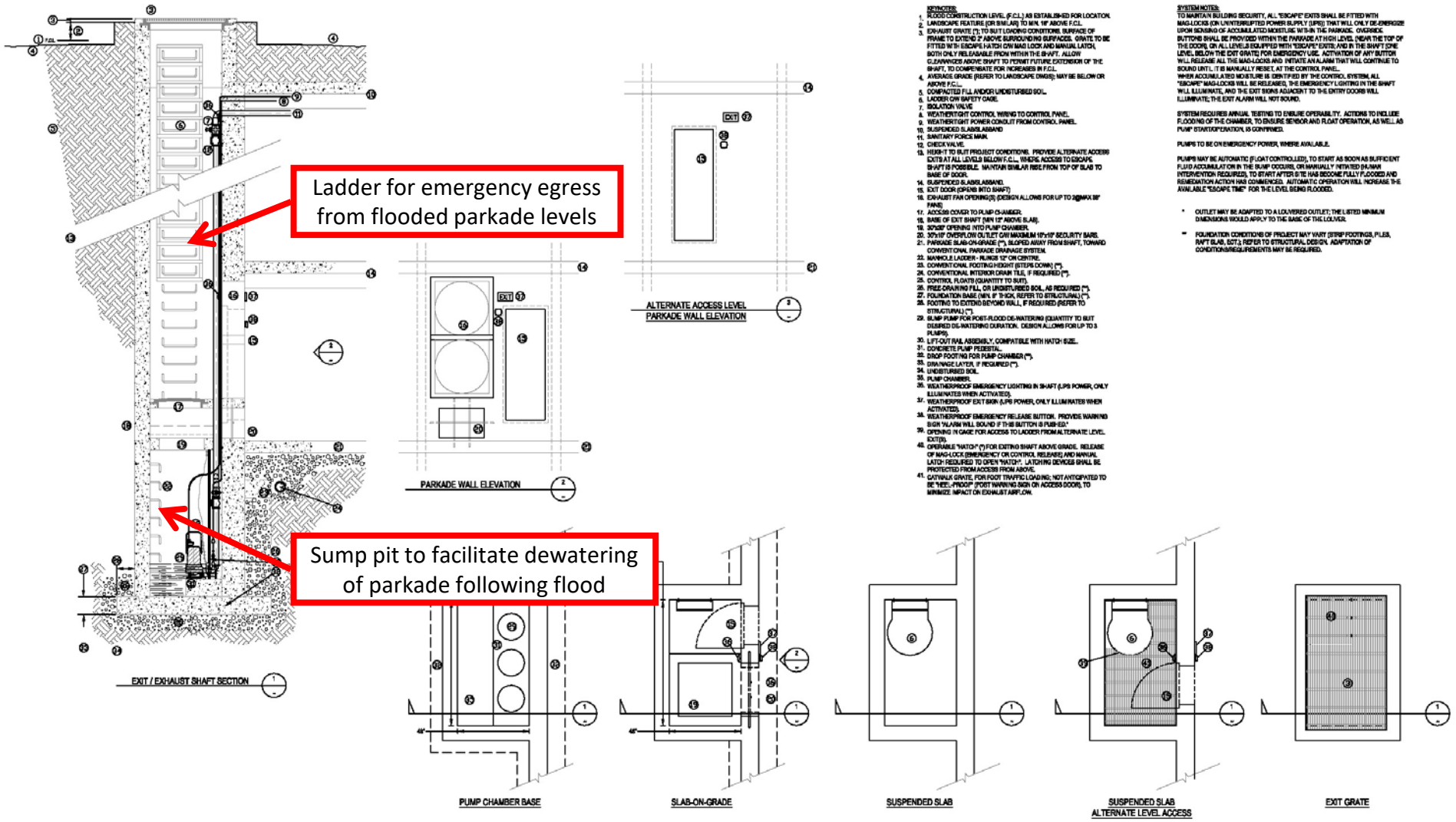
Home Flood Protection Check-Up (Intact Centre on Climate Adaptation)

Window well failure; cascade failure

Parkade vent shaft (similar concept)

Vent shaft detail

Schematic detail may be downloaded online at
https://ramconsulting.com/geotechnical-engineering-resources/



HORIZON ENGINEERING INC

Limit Damage When Water Gets In

Programming and Construction Materials

- Locate vulnerable components of the building in higher levels during original design
- Use water/mold/decay resistant materials for interior walls and finishes
  - Cement board instead of drywall
  - Flooring: Concrete/tile with rug instead of carpet
  - Studs: Steel or ‘blue wood’ rather than timber
  - Insulation: ‘Rigid’ types typically better than non-rigid (ie fibreglass, cellulose)
- Use well-graded materials to limit potential erosion
  - Including of backfill, underslab fills, landscaping base course, etc
  - ‘River sand’ is highly erodible and should be used with caution

Limit Damage When Water Gets In

Electrical Design for Resiliency

- Raise electrical outlets and fixtures above potential flood level
- Separate electrical panels for levels above and below FCL
- Allow for safe shut-off of systems below FCL in case of a flood
- Seal annuli between conduit and cables in below-grade utilities
- Consider safety of elevators
  - Moisture sensor and alarm in elevator pit
  - Equipment and systems above flood level
  - Safe shut-off above flood level

Raised electrics/meters

Figure 1 Sump pump controls are on separate circuit, fixed high above water level

UK Homeowners Guide to Flood Resilience

Limit Damage When Water Gets In

Structural Design for Resiliency

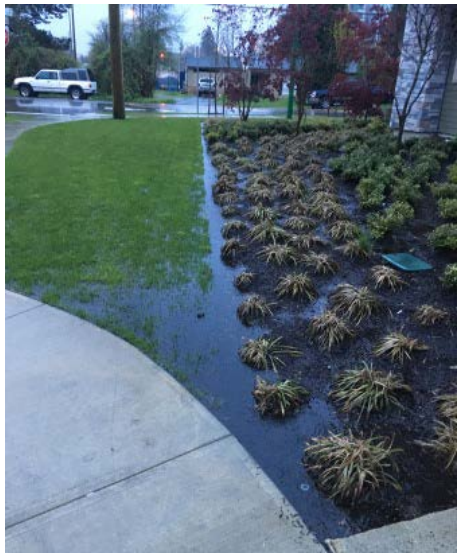
- Selective ‘sealing’ of specific rooms that cannot get wet (i.e., electrical and mechanical)
- Design for hydrostatic forces on internal walls, if applicable
  - Allow for weep holes at maximum allowable water depth
- Design for hydrodynamic forces and scour, if applicable
  - Impact of large objects and waves
  - Requires assessment by a suitable hydrotechnical engineer

Limit Damage When Water Gets In

Mechanical Design for Resiliency

- Note that the design life of regular pumps will expire during a flood event
- Do not design with cross-connection between sanitary and storm (i.e. wastewater heat recovery) unless suitably detailed
- Backflow valves
- Allow for pumping of plumbing fixtures

Limit Damage When Water Gets In



Landscape Design for Resiliency

- Grade property so water drains away from the building
- Use flood-tolerant plant species
- Include perimeter flood walls / barriers (parapet walls)

Maintenance Manual

- Builder to enable maintenance to be carried out by owner
- Drawings / locations of drainage and flood protection features
- Maintenance schedule
- Specifications and **design life** for building components / materials

Facilitate Clean-up

- How will the building be restored after a flood event?

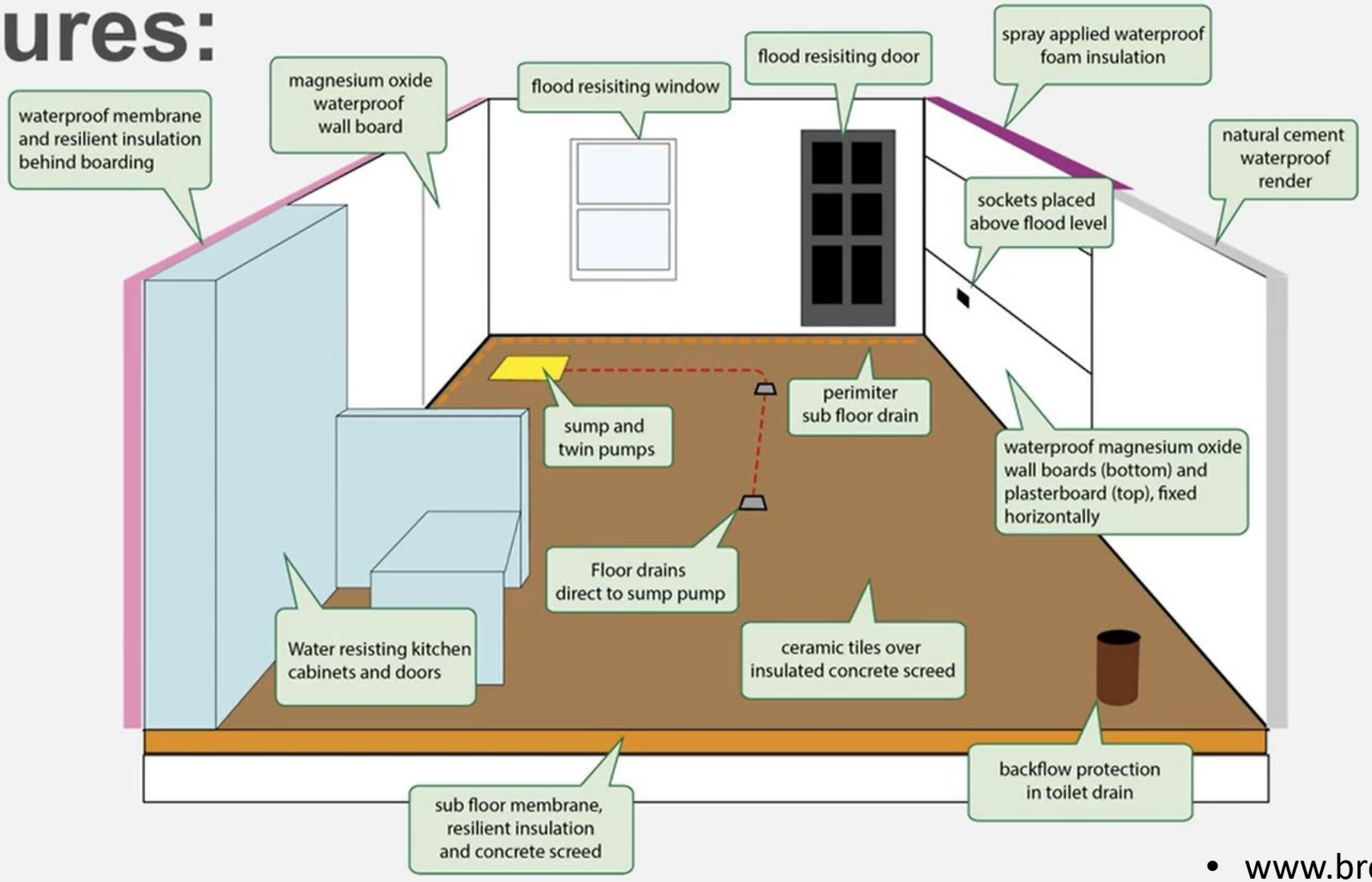
- How will the water be drained from the building?
  - Grade slab to drain to a designated location to allow for installation of a pump for clean-up
  - Reveals in concrete slab below subfloor to collect / convey water

Flood Resilience

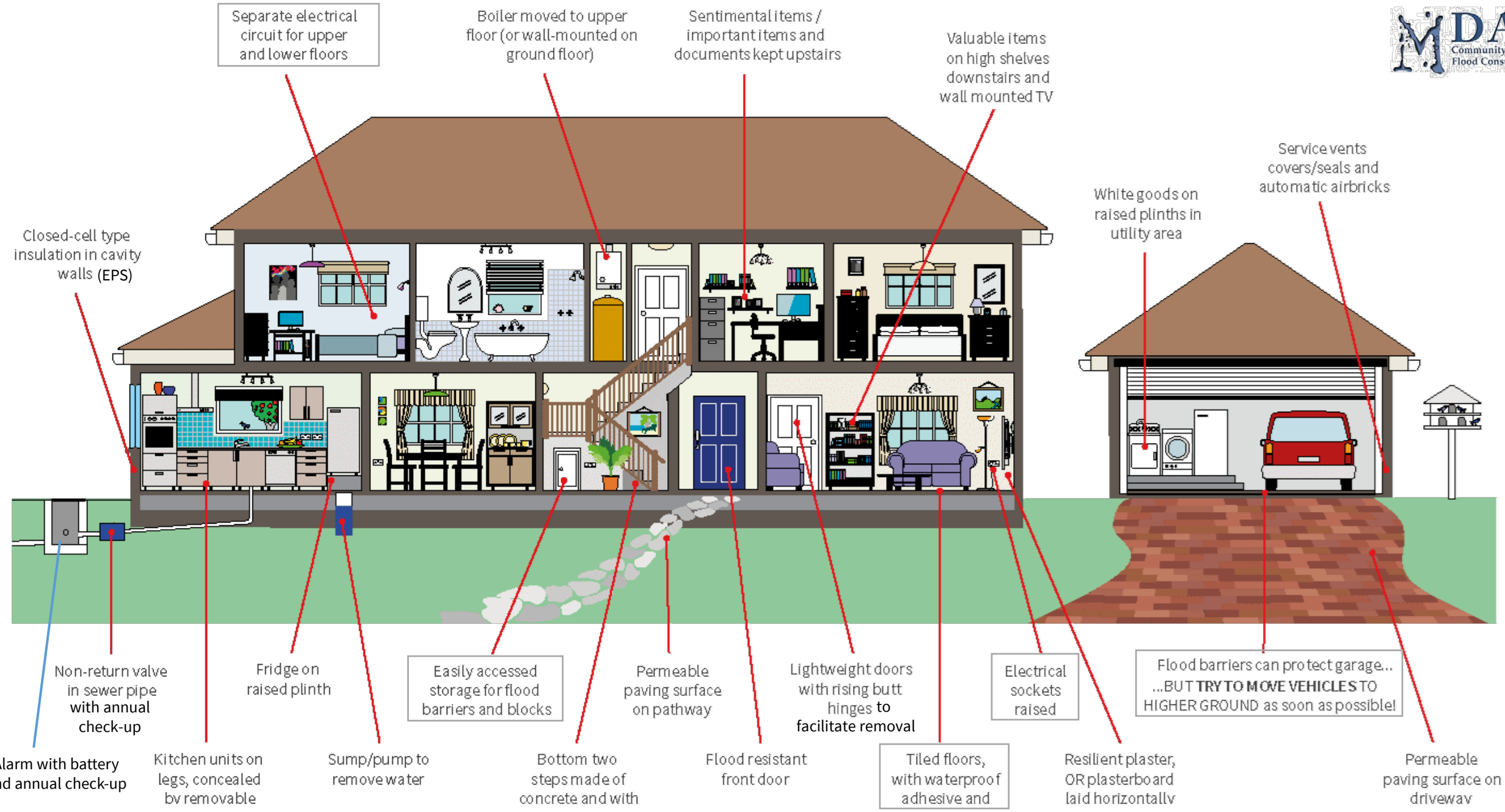
- UK: BRE Centre
- www.bre.co.uk/floodhouse
- BRE Innovation Park at Watford
- Demonstration home adapted to be:
  - resistant to flooding from water up to 600mm
  - resilient to the effects of being flooded beyond
- Designed to dry out quickly and be suitable very short time after a flood incident

bre INNOVATION PARK WATFORD

Features:



- www.bre.co.uk/floodhouse



Combined resistance and resilience measures

Keeping water out for as long as possible buys valuable time to raise / move your belongings

Adapted from UK Homeowners Guide to Flood Resilience

Overland Flooding and Below-Grade Structures

Outline

HORIZON ENGINEERING INC

Thank you!

RAM

YOUR PROJECT. OUR PASSION.

HORIZON ENGINEERING INC