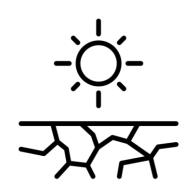


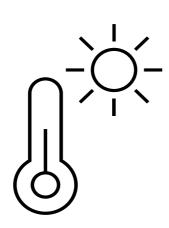
ASSOCIATION OF UNIVERSITY DIRECTORS OF ESTATES

Climate Change Adaptation and Resilience: Catalogue of Adaptation Measures





Adaptation measures for drought and dry weather



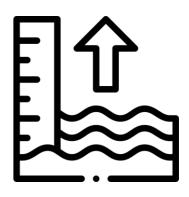
Adaptation measures for heat/high temperatures



Adaptation measures for flood



Adaptation measures for heavy rainfall



Adaptation measures for sea level rise



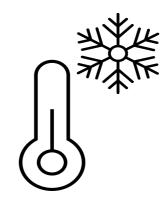
Adaptation measures for storm



Adaptation measures for wildfire



Adaptation measures for ground movement



Adaptation measures for low temperatures / frost and ice



Adaptation measures for multiple hazards



Taking Action

Catalogue of Adaptation Measures

AUDE have developed the Climate Change Adaptation and Resilience Guide to provide its members with a set of recommendations they can take away and apply to their estate. When addressing climate risks, Estates Teams will need to physically adapt to climate change. Identifying the most suitable climate adaptation measures as well as timeframes for implementation will be important for climate resilience of the estates.

This following pages have been developed to inform users of measures that can be used to address physical climate change adaptation, relevant to university estates. They should be considered alongside your Strategy and Plan as outlined in the Guide and, it is recommended that the key messages from these sub-sections are considered when reviewing adaptation options, whether from this catalogue or elsewhere.

The catalogue presents a number of adaptation options, but it is not a complete list, there will be other options available and more will be developed as adaptation, and mitigation, become more commonplace.

Adaptation measures for drought and dry weather

What are the options for drought and dry weather?

For university campuses, drought adaptation measures need to support large populations and diverse facilities. First course of action is to lower overall water consumption. After this the main areas of adaptation focus on rainwater harvesting and the capture and infiltration of rainwater to recharge groundwater via rainwater gardens, swales and permeable surfaces.

Greywater collection

The collection of greywater from sinks, baths, showers and washing machines can be treated and used for irrigation and toilet flushing.



For universities, greywater systems are most effective when used for irrigation, where treatment requirements are lower and deployment is simpler. To ensure safety and performance, systems must use biodegradable, low-sodium detergents and include treatment processes to minimise pollutants and prevent pathogen growth. While greywater reuse offers environmental benefits, it can be complex and may not always be cost-effective—especially when factoring in storage, piping, pumping, and treatment costs.

Rainwater harvesting Rainwater

Rainwater harvesting is the process of collecting, storing and using rainwater as an alternative to mains water. A water butt is a simple rainwater harvesting system, capturing and storing rainwater ready to be used in a university green space, garden, planters and for washing of some surfaces or vehicles.



For universities, these systems are easy to install, and particularly effective in outdoor maintenance and landscaping. While rainwater can also be used internally—for example, in toilet flushing or cleaning—this is most viable in new developments or larger buildings with extensive roof areas and high non-potable water demand.

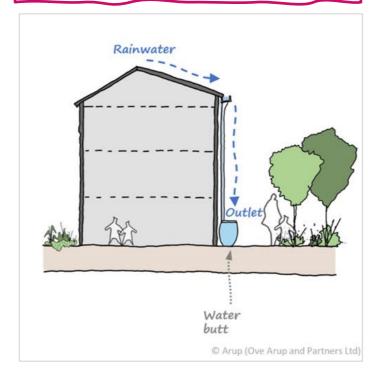


Figure A: Rainwater harvesting: water butt

Internal water efficiency measures

Water-efficient fixtures and appliances are a practical way to reduce water consumption across university facilities, including toilets, laboratories, kitchens, and halls of residence. Installing low-flow taps, dual-flush toilets, and low-flush urinals can significantly cut usage without compromising functionality. Taps fitted with aerators, for example, can reduce water flow by up to 50%, offering immediate savings.



For universities, these upgrades are cost-effective and easy to implement during routine maintenance or refurbishment. Complementing these measures with water-efficient dishwashers and washing machines further reduces overall demand. Educational signage and engagement campaigns with students and staff also play a key role—promoting drought-resilient practices also educate and promote water conservation behaviour.

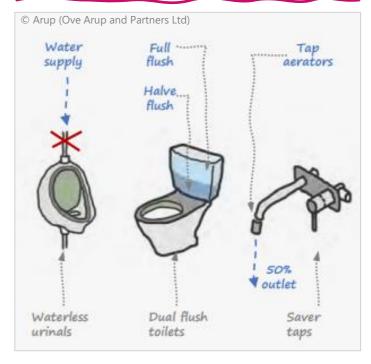


Figure B: Internal water efficiency measures

Adaptation measures for heat/high temperatures

What options are there for dealing with heatwaves and high temperatures?

For university campuses, adapting to extreme heat means protecting the health and wellbeing of students, staff, and visitors while maintaining the performance of buildings and infrastructure. The first priority is to reduce indoor overheating through passive cooling strategies. Following this, key adaptation measures focus on increasing external shading, improving building insulation, and enhancing green infrastructure to lower surrounding temperatures and provide thermal comfort.

Ventilation

Natural stack ventilation (also known as buoyancy-driven stack ventilation, where cooler air enters the building at low level, is heated by occupants, equipment, heating systems and so on, becomes less dense and so more buoyant and rises through the building to be ventilated to the outside at the top), windcatchers, small vents, skylights, louvres, manually opening windows, fans and ceiling fans improve airflow and thermal comfort for people and thermal load for equipment inside buildings, rail and energy assets.



These systems offer a low to moderate-cost solution to enhance thermal comfort in lecture halls, libraries, and accommodation blocks. They also help manage thermal loads on sensitive equipment in labs and IT rooms. However, it's important to consider building orientation, window placement, and seasonal performance to ensure effectiveness.

However, it's important to consider potential safety concerns related to glare and visibility—particularly in areas near universities where transport systems such as buses and trains operate, as high reflectivity could pose risks for drivers.

Green screens, walls and Roofs

Green screens, walls, and roofs consist of systems supporting climbing vegetation like ivy, and multi-layered structures with vegetation and drainage. They reduce urban heat island effects and overheating risks by absorbing heat, providing shade and reducing temperatures in- and outdoors. They can also reduce local air pollution. Any external greening must consider the fire safety strategy of the building and combustion risk from dry and / or dead vegetation.



For universities, these support resilience while enhancing the visual appeal of campus buildings. However, it's important to consider structural load capacity, maintenance needs, and plant selection, especially for retrofitting older buildings. When well-designed, green infrastructure can improve thermal comfort, reduce energy use, and create healthier learning environments for students and staff.

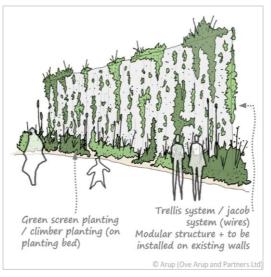


Figure C: Green Wall

Insulation



Insulating walls and roofs involves adding materials that act as a barrier to heat transfer, helping to maintain cooler indoor temperatures during hot weather and retain warmth in colder months. This contributes to thermal comfort, reduces reliance on mechanical cooling and heating, and supports long-term energy efficiency. Any retrofitting of insulation must consider the fire safety strategy of the building.



For universities, insulation is a cost-effective, high-impact measure that can be applied across a range of building types—particularly in older or poorly performing structures. It's important to ensure that insulation materials are appropriate for the building fabric and installed to a high standard, especially in areas exposed to extreme weather or where retrofitting may be complex.

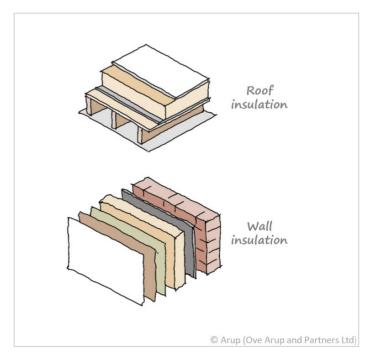


Figure D: Insulation: walls and roofs

Adaptation measures for heat/high temperatures

Planting trees



Planting trees involves introducing vegetation into urban environments to provide shade, reduce wind speeds, and enhance ground infiltration. Strategically placed trees can help lower local temperatures, improve air quality, and reduce surface water runoff—particularly when integrated with Sustainable Drainage Systems (SuDS) such as tree pits.



For universities, tree planting is a visible, nature-based solution that can be implemented across campuses to support climate resilience—especially in open spaces or along pedestrian routes. It's important to select appropriate species, favouring drought-tolerant and native varieties, and to avoid planting near critical infrastructure or building foundations where root systems could pose risks

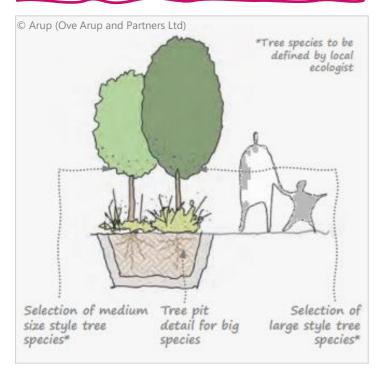


Figure E: Trees

Cool surfaces

Cool surfaces are made of reflective or light-coloured materials that reduce heat absorption by reflecting solar radiation. By reflecting more sunlight and absorbing less heat, these surfaces stay cooler than darker materials. This can lower ambient temperatures.



These surfaces typically involve low capital expenditure due to the affordability of the materials used. However, it's important to consider potential safety concerns related to glare and visibility—particularly in areas near universities where transport systems such as buses and trains operate, as high reflectivity could pose risks for drivers.

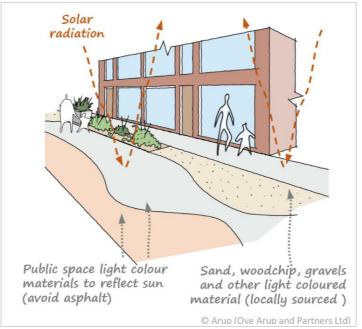


Figure F: Cool Surfaces

Shading

Plastic awnings, brise-soleil, louvres, canopies and shaded walkways around and between buildings provide effective building and pavement shading, reducing heat gain. These external measures when paired with internal shading measures will further improve thermal comfort.



Awnings or canopies are relatively easy to-install shade structures for university buildings. They are best placed on facades above ground floor windows or on single story buildings. They need to be well ventilated to avoid overheating.

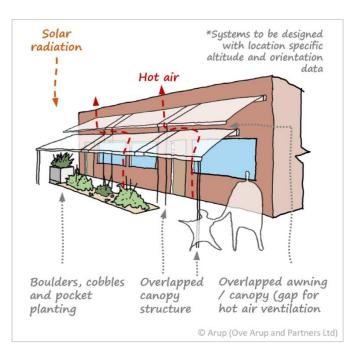


Figure G: Awning or canopy

Adaptation measures for heat/high temperatures

Raising height of power lines

Raising the height of power line poles prevents sagging during high temperatures, reducing risks of electrocution, fires, and accidents during heatwaves. For example, increasing the design height of wooden poles by 0.5 metres.



For universities, especially those with campuses in rural or semi-rural areas, this measure can help protect outdoor learning spaces, sports fields, and access roads. While the capital expenditure is moderate, implementation often requires coordination with utility providers or local authorities, as universities are unlikely to manage high-voltage infrastructure independently.

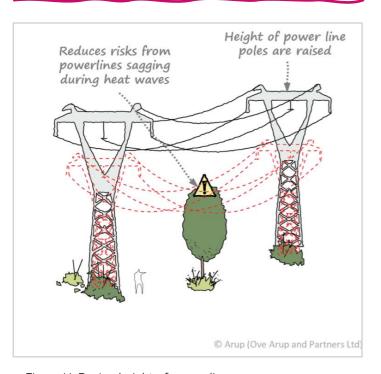


Figure H: Rasing height of power lines

Adjusting Occupancy times

Adjusting occupancy times involves scheduling building use or activities outside of the hottest parts of the day to reduce exposure to extreme heat. This approach helps maintain thermal comfort, lowers cooling demand, and supports the wellbeing of building users during periods of high temperature.



For universities, adjusting occupancy times is a low-cost, operational measure that can be applied flexibly across teaching spaces, libraries, and communal areas—particularly during summer months or heatwave alerts. It's important to coordinate changes with timetabling systems and ensure that any adjustments consider accessibility, transport schedules, and student routines.

Cool rooms, zones or spaces

Cool rooms, zones or spaces involve designating indoor areas that are actively cooled and accessible during periods of extreme heat. These spaces provide thermal relief and are particularly important for protecting the health of vulnerable individuals, such as those with medical conditions or limited mobility.



For universities, cool zones can be set up in libraries, student centres, or other communal buildings— especially during heatwaves or high-temperature alerts. It's important to ensure these spaces are well-signposted, accessible to all, and equipped with adequate ventilation or air conditioning, particularly in older buildings or densely populated areas of campus.

Extreme heat guidance

Extreme heat student guidance involves providing students with clear, accessible information on how to stay safe and healthy during periods of high temperature. This typically includes advice on hydration, recognising heat-related symptoms, and adopting safe behaviours during heatwaves.



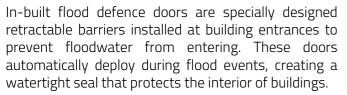
For universities, online guidance is a low-cost, high-impact measure that can be promoted through student portals, email bulletins, and social media—particularly during summer months or when heat alerts are issued. It's important to ensure that messaging is inclusive, easy to understand, and reaches both domestic and international students, especially those unfamiliar with local climate risks.

Adaptation measures for flood

What options are there for dealing with Flooding?

For university campuses, flood adaptation measures need to protect buildings, infrastructure, and open spaces while ensuring continuity of operations. The priority is to manage surface water through sustainable drainage and permeable design. Following this, key adaptation strategies focus on slowing and storing runoff using features such as rain gardens, swales, green roofs, and tree pits, alongside measures to raise awareness and improve emergency response planning.

Floor defence doors





For universities located in flood-prone areas, these doors can be particularly valuable. They offer robust protection for critical infrastructure such as laboratories, where water ingress could result in significant financial loss and disruption to research. While the associated risks are minimal.

Flood embankments



Flood embankments are earth-filled structures designed to contain river flows and coastal flooding. Enhancing these embankments by fortifying existing levees and dykes, reinforcing slopes, and integrating multi-use features improves their effectiveness against extreme weather events and sea level rise.



For universities situated near rivers or coastal areas, flood embankments can serve as a vital first line of defence. They help protect large campus areas, including sports fields, student housing, and research facilities, from inundation.

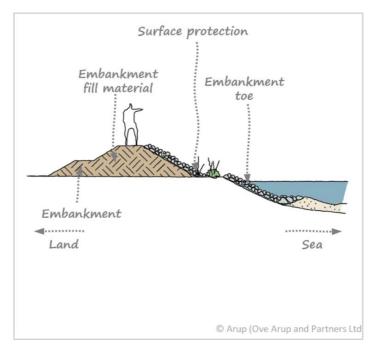


Figure I: Flood Embankment

Flood Storage Areas



Flood Storage Areas (FSA) temporarily store excess water during heavy rainfall, reducing peak river flood flows downstream by attenuating and releasing water at a controlled rate. There are two types of FSAs: online, storing water within the river channel and floodplain, and offline, diverting water to a separate area.



Universities with large campuses or green spaces can incorporate FSAs into their landscape design. These areas not only mitigate flood risk but can also support biodiversity, improve water quality through sedimentation and filtration, and help recharge groundwater.

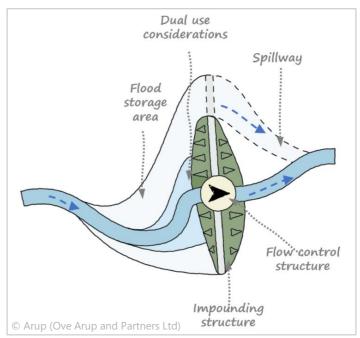


Figure J: Flood Storage Areas

Adaptation measures for flood

Debris Screen |



Debris screens are installed at culvert (tunnels carrying waste water under roads or railways etc.) inlets to prevent debris from entering and causing blockages. By capturing debris before it can enter the culvert, these screens ensure efficient water flow during heavy rainfall. This helps to prevent flooding and maintain the integrity of drainage systems, reducing the risk of water damage to surrounding areas.

Automated debris screens can be effectively deployed across campus drainage systems to reduce the burden on maintenance teams and enhance operational safety.

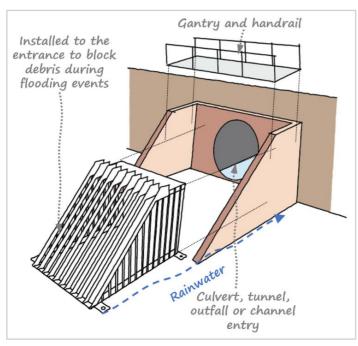


Figure K: Debris screen

Water Management Channels



Water management channels, including flood relief channels and rills (open surface water channels), divert water away from flood-prone areas. These channels can feature reed beds for wildlife habitats and act as pre-treatment to remove silt before water enters main drainage system.



Water management channels are a visible and effective flood mitigation measure that can be integrated into landscaped areas or alongside footpaths. It's important to ensure they are safely designed, regularly maintained, and connected to wider SuDs to maximise their performance and protect campus infrastructure from flood damage.

Elevated Infrastructure



Elevated roads, walkways, and floors are designed to keep essential infrastructure above expected flood levels, allowing safe access and continued use during flood events. These raised structures act as physical barriers, preventing floodwaters from entering buildings and disrupting daily operations.



For universities, elevating key assets—such as access routes, building entrances, and plant rooms—is a practical way to reduce flood risk, particularly in lowlying or flood-prone areas of campus. It's important to consider additional measures such as raising troughing and service lines off the ground to protect water systems from damage and contamination, especially in floodplain zones.

Critical equipment flood protection



Protecting critical equipment against flooding involves elevating or relocating transformers, switchgear, and other standalone equipment above projected flood levels and using water-resistant materials. This ensures the continuous operation of essential services.



While elevating or relocating critical electrical equipment is an effective way to ensure operational continuity during floods, it often requires substantial construction work, including additional concrete foundations and structural modifications. In contrast, improving site drainage may offer a less disruptive and more cost-effective solution.

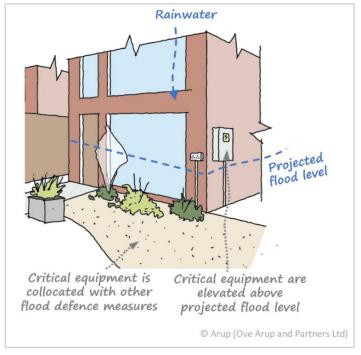


Figure L: Critical equipment flood protection

Adaptation measures for flood

Water resistant dry floodproofing



Water-resistant dry floodproofing of buildings are flood resilience strategies designed to protect buildings from water damage. Dry proofing involves sealing a structure to prevent water infiltration.



This measure is particularly relevant for universities, where many buildings are older and often have inadequate drainage systems. It can be implemented as part of a retrofit by sealing walls, doors, and windows with waterproof coatings. This helps prevent rainwater runoff and surface flooding from entering buildings—especially important in urban campuses where drainage infrastructure may be limited.

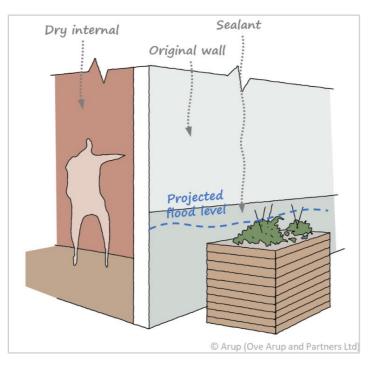


Figure M: Water resistant dry floodproofing

Academic input on flood resilience

Academic input on flood resilience involves leveraging local expertise through participation in flood partnerships and contributing to research on flood prevention and response. This supports evidence-based decision-making and helps align campus strategies with wider community resilience efforts.



For universities, engaging academic staff in local flood initiatives is a valuable, low-cost measure that enhances collaboration and knowledge exchange—particularly in departments focused on environmental science, engineering, or urban planning. It's important to ensure that research findings are shared with estates teams and local authorities, and that opportunities for student involvement are explored where appropriate.

Flood Gates

Flood gates are operable barriers that can be closed during flood events to prevent inundation and opened at other times to maintain access. They are effective in areas prone to river or coastal flooding, allowing normal water flow while blocking floodwaters when needed.



In a university context, flood gates can be installed at key access points such as service roads, underground car parks, or pedestrian routes. This ensures that critical infrastructure remains accessible and protected during flood events, while maintaining normal campus operations the rest of the time.

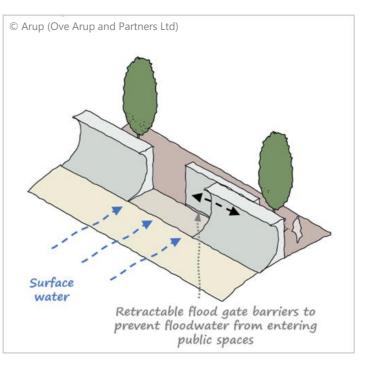


Figure N: Flood gates

Adaptation measures for flood

Flood walls

Flood walls are permanent vertical structures, such as sheet pile or poured concrete walls, constructed in river and coastal settings to mitigate flood risks. They protect people, properties, and infrastructure by holding back floodwaters and preventing erosion. Some examples include bund walls and bulkheads.



In a university context, flood walls can play a crucial role in protecting campuses located near rivers or coastlines. They act as strong vertical defences against high tides, storm surges, and rising sea levels, as well as river flooding caused by heavy rainfall or snowmelt. While universities may not directly construct these walls, they can collaborate with local authorities or environmental agencies to support their development and ensure that campus infrastructure benefits from the protection they provide.

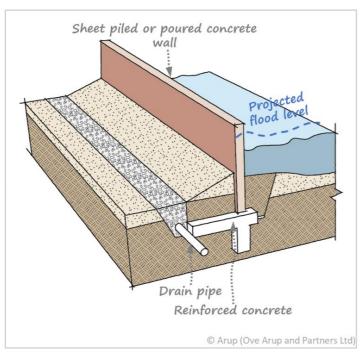


Figure O: Flood walls

Berms for flooding



A berm for flood control is an engineered mound of soil, stone, or debris designed effectively to slow the movement of water and soil. It divides embankments into several horizontal subareas, reducing earth pressure on the embankment foot. By creating berms through topographic modifications, elevated earth structures are constructed to redirect and slow water flow, often directing it into a swale.



Berms help universities reduce long-term costs by preventing floodwaters from reaching critical infrastructure such as libraries, laboratories, student accommodation, and IT systems. This proactive protection minimises the need for costly emergency responses, repairs, and insurance claims.

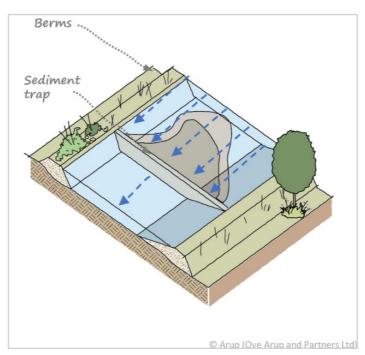
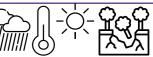


Figure P: Berms for flooding

Smart infrastructure



Smart infrastructure involves embedding digital technologies—such as temperature sensors, infrared cameras, and remote sensing tools—into assets to monitor conditions and detect changes in real time. These systems support more efficient inspections and enable proactive responses before and after extreme weather events.



For universities, smart infrastructure offers a forward-looking solution that can be integrated during new construction or major refurbishments—particularly in areas prone to flooding, subsidence, or heat stress. It's important to ensure that installations allow for clear access and visibility, especially where drones, satellites, or radar systems are used for monitoring, such as by incorporating corner reflectors for improved viewing angles.

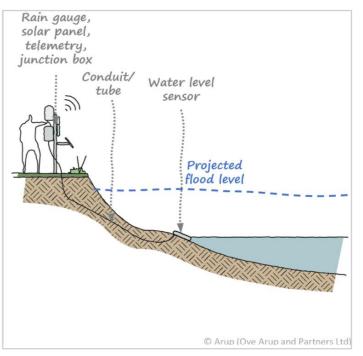


Figure Q: Smart Infrastructure

Adaptation measures for heavy rainfall

What options are there for dealing with heavy rainfall?

For university campuses, flood adaptation measures need to protect buildings, infrastructure, and open spaces while ensuring continuity of operations. The priority is to manage surface water through sustainable drainage and permeable design. Following this, key adaptation strategies focus on slowing and storing runoff using features such as attenuation tanks. Temporary measures like sandbags can also provide short-term protection in high-risk areas. These interventions should be supported by awareness-raising and emergency response planning to ensure preparedness across campus.

Sand Bags

Sandbags are used as a temporary barrier to absorb and block floodwater, helping to protect buildings and infrastructure during heavy rainfall or rising water levels. Traditional sandbags are made from hessian and filled with sand, while modern alternatives use woven polypropylene and absorbent gel to achieve similar results.



For universities, sandbags are a low-cost, flexible measure that can be deployed quickly in flood-prone areas—particularly around entrances, basements, and service access points. It's important to store them in accessible locations and ensure they are dried and reused where possible, especially in areas with recurring surface water issues or limited drainage capacity.

Drains and improved drainage



Channel drains and filter drains capture, collect, and direct runoff from hard surfaces into drainage systems or the ground, reducing flood risk and easing drainage burdens. Channel drains are typically made of concrete, metal, and plastic components, while filter drains are stone-filled trenches with perforated pipes that also help drain groundwater. Existing drainage can also be improved upon. This involves renovating gullies and pumping stations or installing new permanent pumps, increasing drainage capacity to meet future standards, and maintaining culverts (tunnels carrying waste water under roads or railways etc.)



Efficient drainage reduces surface water on roads and walkways, lowering the risk of accidents, slips, and vehicle skidding during storms, and improving public safety on campus for public, students and staff.

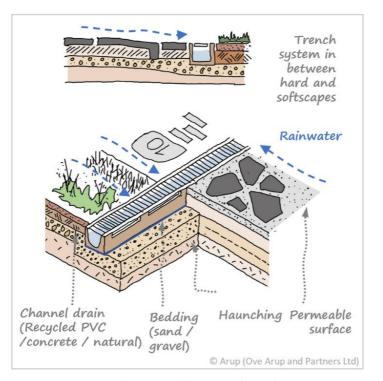


Figure R: Drains and improved drainage channel

Attenuation tanks



Attenuation tanks are underground storage systems designed to temporarily hold excess rainwater during heavy rainfall, reducing the risk of surface water flooding. They slowly release stored water into the drainage network, helping to manage runoff and prevent overwhelming local infrastructure.



For universities, attenuation tanks are a reliable, longterm solution that can be integrated into new developments or retrofitted beneath car parks, courtyards, or sports fields. It's important to ensure they are connected to wider Sustainable Drainage Systems (SuDS) where possible, and that access is maintained for inspection and maintenance to ensure continued performance.

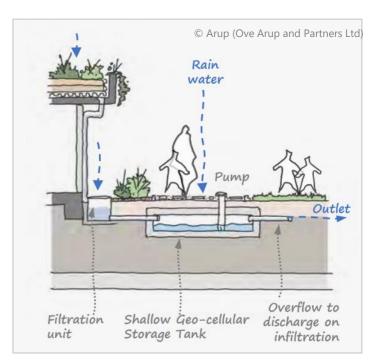


Figure S: Attenuation tank

Adaptation measures for heavy rainfall

Detention Basins (SuDs)

Detention basins are shallow, grass-covered depressions designed to temporarily hold surface water runoff during heavy rainfall. They slow the flow of water and allow it to soak into the ground where possible, helping to reduce the risk of flooding and downstream pressure on drainage systems.



For universities, detention basins are a practical and multifunctional solution that can be integrated into green spaces, sports fields, or landscaped areasparticularly in parts of campus with limited drainage. It's important to ensure they are safely designed with gentle slopes and are connected to other SuDS features such as swales to maximise their effectiveness.

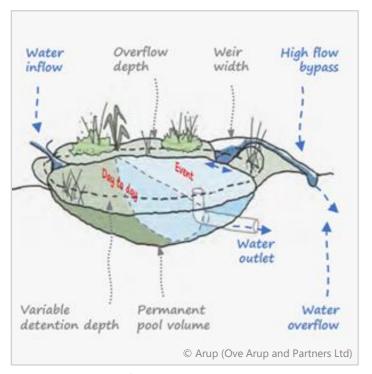


Figure T: Detention basins

Wetlands (SuDs)



Wetlands are natural or constructed areas made up of shallow ponds and marshy ground, densely covered with aquatic vegetation. They hold water during heavy rainfall, allow sediments to settle, and provide effective flood protection by slowing and storing runoff.



For universities, wetlands are a multifunctional adaptation measure that can enhance biodiversity, support environmental education, and regulate local temperatures—particularly in larger green spaces or near watercourses. It's important to ensure they are designed to suit the local landscape and maintained to prevent overgrowth or blockages, especially where they form part of a wider Sustainable Drainage System (SuDS) network.

Filter Drains (SuDs)



Filter drains are stone-filled trenches containing perforated pipes that collect runoff from impermeable surfaces such as playgrounds, pavements, or car parks. They direct water into the ground, helping to manage surface runoff and reduce localised flooding. Filter drains can also assist in draining shallow groundwater, allowing excess water to soak away gradually.



For universities, filter drains are a discreet and effective measure that can be integrated into outdoor spaces—particularly in areas with high footfall or limited green cover. It's important to ensure they are properly designed to suit local soil conditions and regularly maintained to prevent blockages from debris or sediment build-up.

Ponds (SuDs)



Ponds are permanent water features designed to store and attenuate surface runoff, helping to manage flood risk and reduce pressure on drainage systems. In addition to their drainage function, ponds can help regulate local temperatures and contribute to reducing the urban heat island effect.



For universities, ponds are a multifunctional adaptation measure that can enhance biodiversity and provide educational or recreational value—particularly in landscaped or open areas of campus. It's important that runoff is treated through other SuDS features before entering the pond to improve water quality, and that ponds are safely designed and regularly maintained.

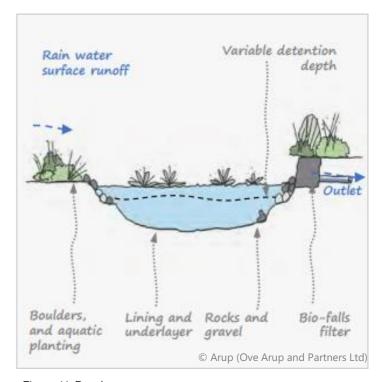


Figure U: Ponds

Adaptation measures for heavy rainfall

Permeable surfaces



Permeable surfaces are ground coverings designed to allow water to infiltrate through them, helping to manage surface runoff and reduce the risk of localised flooding. Unlike traditional impermeable materials, these surfaces support natural groundwater recharge and contribute to urban cooling—particularly valuable in densely built environments.



For universities, replacing or upgrading hard landscaping with permeable alternatives is a practical, low-cost intervention. Where possible, consider planting over these areas with hardy grasses to maximise environmental benefits. Materials like wood chip offer a biodegradable, affordable, and easy-tomaintain solution, especially suitable for informal paths and landscaped zones.

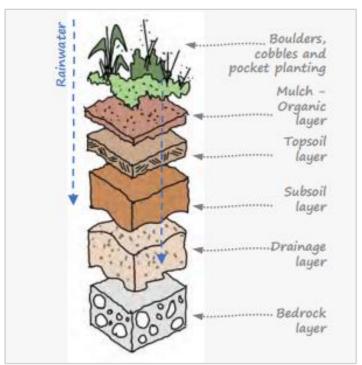


Figure V: Permeable surfaces

Rain Gardens and Swales - Y->

Rain gardens and swales are shallow, landscaped features designed to manage rainwater runoff from roofs and hard surfaces. These systems help reduce surface flooding, recharge groundwater, and support biodiversity by allowing water to slowly infiltrate the



For universities, they offer a low-maintenance, visually appealing way to enhance campus resilience—particularly in areas prone to heavy rainfall or with limited drainage infrastructure. Rain gardens can be planted with low-maintenance species that tolerate both dry spells and storm events. Similarly, swales—shallow ditches with flat bases and gently sloping sides—can store, transport, and absorb runoff, and are best suited to underused or open areas of campus.

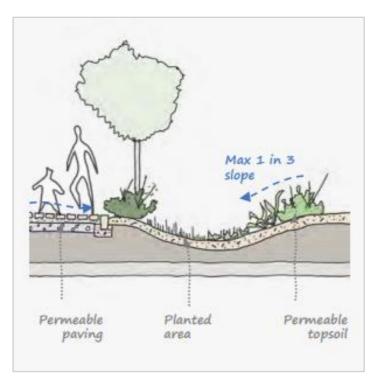
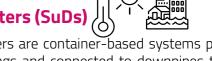


Figure W: Rain Gardens and Swales

Planters (SuDs)



Planters are container-based systems placed next to buildings and connected to downpipes to collect and store rainwater. The water is absorbed by layers of gravel and soil and used by the plants, helping to manage runoff and reduce pressure on drainage systems.



For universities, planters are a space-efficient and visually appealing measure that can be installed in courtyards, along walkways, or near entrances particularly in areas with limited green space. It's important to select plant species suited to the location's sunlight and shade levels, and to maintain the planters regularly to ensure healthy growth and effective water absorption.

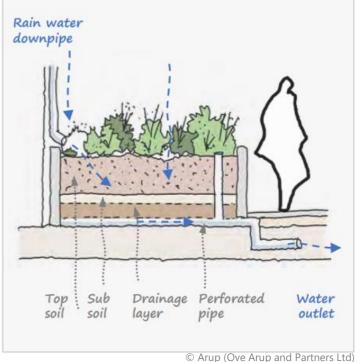


Figure X: Planters

Adaptation measures for sea level rise

What options are there for dealing with sea level rise?

Key adaptation strategies for managing sea level rise include the use of seawalls and bioactive seawalls to absorb wave energy and protect shorelines, as well as coastal revetments to stabilise vulnerable edges. These measures are typically large-scale and capitalintensive, meaning universities are likely to implement them in partnership with local authorities, infrastructure providers, or coastal management agencies. Collaborative planning and long-term investment are essential to ensure resilience in the face of rising sea levels.

Seawalls and bioactive seawalls



Sea walls and tidal barriers protect coastal infrastructure by reducing the risk of storm surges and flooding and safeguard structures. Bioactive seawalls are designed to protect coastlines while supporting marine life. By mimicking natural ecosystems with textured surfaces, grooves, and notches, they create micro-habitats for marine organisms like barnacles, mussels, and oysters.



While the cost of constructing seawalls is moderate when applied on a smaller or localised scale, they offer long-term savings by reducing the need for emergency repairs, disaster response, and recovery efforts. Although a university is unlikely be solely responsible for funding such infrastructure, it is likely to partner with local authorities, environmental agencies, or research bodies to co-fund and support these projects—especially when they protect valuable university asset

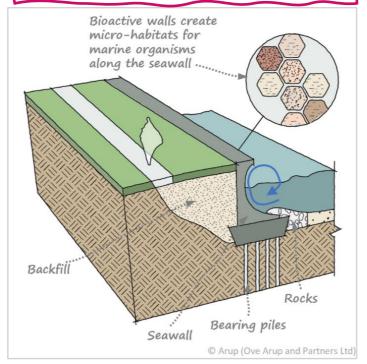


Figure Y: Seawalls and bioactive seawalls

Coastal Revetments



A coastal revetment is a sloped structure designed to dissipate wave energy and protect shorelines from erosion and flooding. Typically constructed from solid materials such as concrete, these structures often feature stepped or sloped designs and are built parallel to the sea, adjacent to levees, embankments, or flood walls. In addition to their primary protective function, coastal revetments can also be repurposed to house high-voltage cables from offshore sources. However, where these cables transition to the seabed, they must be adequately buried to ensure protection from physical damage caused by currents, anchors, or seabed movement.



As with seawalls, the responsibility for implementing these measures typically does not rest solely with universities. Instead, they are often developed through partnerships with regulatory bodies, local authorities, or environmental agencies.

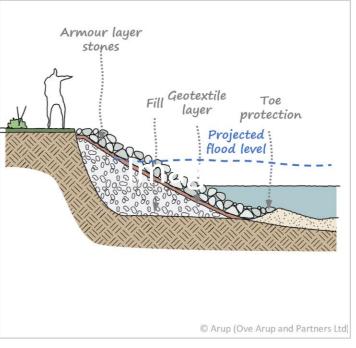


Figure Z: Coastal revetments

Adaptation measures for storm

What options are there for dealing with storms?

For universities, the priority is to reduce vulnerability to high winds, lightning, and hail through resilient design and protective features. Following this, key adaptation strategies focus on reinforcing structures with windproof roofing and canopies, installing lightning protection systems, and incorporating hailresistant materials where appropriate. These measures should be supported by regular maintenance, risk assessments, and awarenessraising to ensure campus safety during severe weather events.

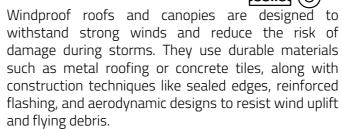
Lightning protection

Enhanced lightning protection involves safeguarding critical energy and communications equipment from voltage spikes caused by lightning strikes. This includes installing surge protection devices on power, data, and communication lines to prevent damage and service disruption.



For universities, these systems are essential for protecting sensitive research equipment and maintaining operational continuity—particularly in laboratories, data centres, and control rooms. It's important to consider advanced measures such as isolated grounding systems and to ensure that protection is regularly tested and maintained, especially in buildings with high-tech infrastructure or located in storm-prone areas.

Windproof roof and Canopies





For universities, windproofing is a critical measure for protecting buildings and outdoor structures particularly in exposed areas or campuses with older facilities. It's important to carry out regular inspections and maintenance, and to consider design features such as hip roofs and minimal overhangs to reduce vulnerability to wind tunnel effects and extreme weather.

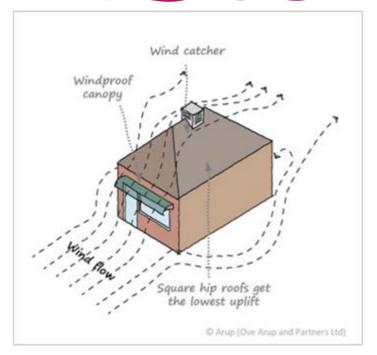


Figure AA: Windproof roof and canopy

Hail Protection

Hail protection measures involve using materials and design features that can withstand the impact of hailstones, helping to prevent damage to buildings, equipment, and outdoor areas. This includes installing impact-resistant roofing, laminated or tempered glass, storm shutters, and protective mesh over vulnerable assets like HVAC units, solar panels, and skylights.



For universities, these measures are particularly useful in exposed or high-value areas—such as research facilities, walkways, and car parks. It's important to consider reinforced canopies or awnings to shield entrances and gathering spaces, and to ensure that protective materials are regularly inspected and maintained to remain effective during severe weather.

Adaptation measures for wildfire

What options are there for dealing with wildfires?

While wildfires were once largely confined to rural areas within the remit of specific fire and rescue services, they are now increasingly occurring across the UK.

The priority is to reduce fire risk through landscape design and material choices. Key adaptation strategies include fire-resistant planting, the use of fire-resistant materials in construction, and the creation of defensible space around buildings. These should be supported by a wildfire monitoring and management plan to ensure early detection, coordinated response, and long-term resilience.

Fire-Resistant planting

Fire-resistant planting involves selecting vegetation with high moisture content—such as succulents and certain hardwood species—and plants that can selfregenerate after fire exposure. These species are less likely to ignite and can help slow the spread of fire, making them a valuable component of landscape design in areas at risk of wildfires.



For universities, this approach typically requires moderate investment, as many fire-resistant plants are low-maintenance and well-suited to long-term planting schemes. However, it's important to consider site-specific factors, such as proximity to buildings, wind exposure, and maintenance capacity. On campuses located near woodland or heathland, fireresistant planting can form part of a broader wildfire mitigation strategy.

Wildfire monitoring and management plan

Wildfire management plans involve the development of systems to detect, monitor, and alert authorities and communities about potential wildfires before they escalate. A key component is the implementation of Fire Early Warning Systems, which use sensors, satellite data, and communication networks to provide timely alerts and support rapid response.



These systems can be integrated into broader emergency planning frameworks at universities. While the initial investment may be moderate to high, depending on the technology used, the long-term benefits include enhanced safety, reduced disruption to academic operations, and protection of critical infrastructure. Universities are unlikely to implement such systems independently, but they can play a vital role in collaborative efforts with local authorities, emergency services, and research institutions to codevelop and maintain these systems.

Fires-Resistant Materials

Fire-resistant materials are non-combustible or fireretardant substances used in the construction of surfaces and infrastructure to reduce the risk of ignition and slow the spread of fire. Common examples include treated timber, fire-rated cladding, and concrete or metal components that meet specific fire safety standards.



For universities, incorporating these materials into new buildings or retrofits can significantly enhance campus fire resilience—particularly in areas near woodland or where student accommodation is densely clustered. While the initial capital costs may be higher than standard materials, the long-term benefits include reduced fire risk, lower insurance premiums, and compliance with safety regulations.

Defensible Space design

Defensible space design involves creating strategic buffer zones around buildings by maintaining clear areas, firebreaks, and reduced vegetation. These zones act as barriers that slow or stop the spread of wildfires, helping to protect structures and provide safer access for emergency services.



For universities—particularly those with campuses near woodland, heathland, or other fire-prone areas—this approach can be integrated into landscape planning and estate management.

Adaptation measures for ground movement

What options are there for dealing with heatwaves and high temperatures?

For university campuses, ground movement adaptation measures need to protect buildings, infrastructure, and buried services while ensuring continuity of operations. Climate-related hazards like drought and heavy rainfall are increasing soil moisture variability, especially in clay-rich areas, leading to more frequent ground movement. This can damage foundations, pipes, and cables. The priority is to stabilise soil conditions and monitor vulnerable areas.

Revegetation and afforestation



Planting of deep-rooted trees in areas where vegetation has been lost due to construction or other disturbances, as well as areas that were not previously forested, helps mitigate the risks of ground movement by binding soil particles together which stabilises the soil and reduces erosion.



This is specifically relevant for universities located on or near slopes, hillsides, or areas with loose soil. Vegetation protects infrastructure by stabilising slopes near buildings, roads, or walkways and minimising erosion related damage to facilities and drainage systems.

Ground movement sensors





Ground movement sensors are monitoring devices used to detect and measure shifts in the earth's surface. These sensors are part of an early warning system that helps identify potential landslides, subsidence, or soil instability before they cause any damage.



This includes the use of inclinometers, extensometers, tiltmeters, GPS and remote sensing to alert facilities teams to ground instability before it affects buildings, roads, or utilities, and ensures the safety of students, staff, and visitors.







Moving trees involves relocating trees that are too close to building foundations to prevent structural damage and manage soil moisture levels. Tree roots can draw moisture from surrounding soil, increasing the risk of ground movement and subsidenceparticularly during dry periods.



For universities, relocating trees is a preventative measure that supports long-term building stability especially around older structures or those with shallow foundations. It's important to assess each site carefully and ensure that relocated trees are replanted in suitable areas, ideally contributing to wider campus greening and biodiversity goals.

Slope stabilisation and -\(\hat{\phi}\)-







terracing

Slope stabilisation and terracing involves modifying sloped terrain to reduce the risk of ground movement, particularly during periods of heavy rainfall or drought. Techniques such as installing retaining walls, gabions, and terraced steps help to reduce slope angles, improve stability, and manage surface water runoff.



For universities, these measures are especially relevant for campuses with uneven topography or buildings located near embankments. It's important to ensure that designs are tailored to local soil conditions and that installations are regularly inspected particularly in areas with high footfall or near critical infrastructure like access roads and retaining structures.

Rewetting soil around -\hat{\psi}foundations







Rewetting soil around foundations involves using controlled watering or irrigation to maintain stable soil moisture levels near buildings. This helps prevent shrinkage or expansion of clay soils, which can lead to ground movement and structural damage particularly during prolonged dry periods.



For universities, this is a simple, preventative measure that can be applied to vulnerable buildings—especially older structures or those with shallow foundations. It's important to monitor moisture levels regularly and ensure irrigation is targeted and efficient, particularly in landscaped areas or where tree roots may be contributing to soil drying.

Adaptation measures for low temperatures / frost and ice

What options are there for dealing with Low temperatures

For university campuses, low temperatures, frost, and freeze-thaw cycles can damage surfaces, disrupt services, and create safety risks.

The priority is to maintain safe access and prevent cold-related damage. Key strategies include using freeze-thaw resistant materials, gritting and salting key routes, and insulating exposed pipes. Additional measures such as the provision of warm zones or rooms can help protect people and maintain comfort during extreme cold events.

Freeze-thaw resistant materials

Freeze-thaw resistant materials are designed to withstand repeated cycles of freezing and thawing without cracking, spalling, or degrading. These materials—commonly used in roads, pavements, and building exteriors—are particularly important in climates where winter temperatures fluctuate around freezing point, causing moisture within materials to expand and contract.



For universities, especially those in colder parts of the country, using freeze–thaw resistant materials can significantly extend the lifespan of campus infrastructure and reduce maintenance needs.

Gritting and salting

Gritting and salting strategies involve the application of de-icing materials—such as rock salt or alternative non-toxic compounds—to roads, cycle lanes, and pedestrian paths to prevent ice formation and improve safety during freezing conditions. These measures are essential for maintaining safe access across university campuses during winter months.



For universities, this typically involves low to moderate expenditure, depending on the size of the estate and the frequency of application. However, it's important to consider the environmental impact of traditional salts, which can harm nearby vegetation and soil. Using non-toxic de-icers offers a better alternative, helping to protect green spaces and biodiversity on campus.

Pipe lagging

Pipe lagging involves wrapping outdoor or exposed water pipes with insulating material to protect them from freezing during cold weather. This insulation helps maintain water flow, prevents pipe bursts, and reduces the risk of costly water damage to buildings and infrastructure.



For universities, pipe lagging is a low-cost, highimpact measure that can be easily implemented across campus facilities—particularly in older buildings or areas with external plumbing. It's important to ensure that materials used are weatherresistant and properly installed, especially in hightraffic or exposed locations.

Snow Fences

Snow fences—also known as windbreaks—are barriers installed to reduce wind speed and control the drifting of snow. By encouraging snow to accumulate in designated areas, they help keep roads, footpaths, and access routes clear and safer during winter conditions.



For universities, snow fences can be particularly effective in open or exposed parts of campus, such as sports fields, car parks, or rural access roads. Its t's important to consider strategic placement and seasonal maintenance, as poorly positioned fences may lead to unintended snow build-up. When used effectively, snow fences can reduce the need for frequent snow clearance, improve winter safety, and minimise disruption to campus operations.

Adaptation measures for low temperatures/ frost and ice

Vegetation shelter δ L δ



Vegetation shelter involves using natural or built elements—such as walls, hedges, rocks, or raised beds—to create sheltered microclimates that protect plants from wind and cold. Positioning sensitive or less hardy species near south-facing walls can maximise sun exposure and warmth, helping them thrive in cooler conditions.



For universities, this approach is a low-cost and lowmaintenance strategy that can be integrated into campus landscaping and biodiversity plans. It's particularly useful in courtyards, garden spaces, or exposed areas where wind chill and frost pose risks to planting schemes. By creating sheltered zones, universities can extend growing seasons, support diverse planting, and enhance the resilience of green spaces.

Warm rooms, zones or spaces

Warm rooms, zones, or spaces are designated heated areas on campus that provide a safe and comfortable environment during cold weather—particularly for students and staff who may be more vulnerable to the health impacts of low temperatures. These spaces can include libraries, common rooms, or specific study areas equipped with reliable heating and insulation.



For universities, establishing warm zones typically involves low to moderate expenditure, especially when using existing buildings or underutilised spaces. However, it's important to consider accessibility, opening hours, and communication, ensuring that those who need these spaces are aware of them and can use them safely. Providing warm spaces supports student wellbeing, reduces the risk of cold-related illnesses.

Adaptation measures for multiple hazards



Evacuation routes

Evacuation routes are clearly designated pathways that guide people away from danger zones during emergencies such as flooding, fire, or extreme weather events. These routes can be horizontal, leading individuals to safer areas outside the hazard zone, or vertical, directing them to higher floors or elevated shelters when ground-level evacuation is not possible.



For universities, establishing and maintaining evacuation routes plays a critical role in campus safety planning. This includes not only buildings but also transport infrastructure—such as ensuring safe evacuation procedures for people stranded on university-linked trains or buses. It's important to ensure that routes are well-signposted, accessible to all users, and regularly tested through drills. Effective evacuation planning helps protect students, staff, and visitors, and supports compliance with health and safety regulations.



Figure AB: Evacuation routes

Cable sealing

Cable sealing involves sealing conduits and cable ends (already typically sealed for high voltage cables) to prevent water and contaminants from infiltrating. This process ensures that cables remain dry which can cause damage or reduce their efficiency. By effectively sealing these entry points, cable sealing helps maintain the integrity and longevity of electrical and communication systems, preventing potential malfunctions and ensuring reliable performance.



For universities, cable sealing is a low-cost, preventative measure that can be applied during installation or as part of routine maintenance—particularly in areas with underground cabling, external power supplies, or exposed service ducts. It's important to use durable, weather-resistant materials and ensure proper sealing techniques to maintain system integrity. By protecting critical infrastructure, cable sealing helps ensure reliable performance, reduces the risk of outages, and extends the lifespan of campus-wide electrical and IT systems.

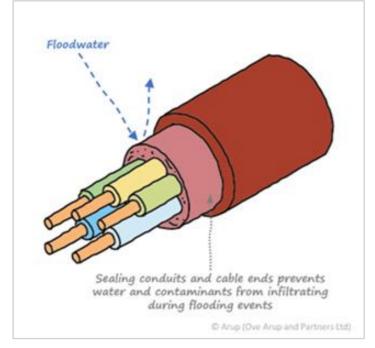
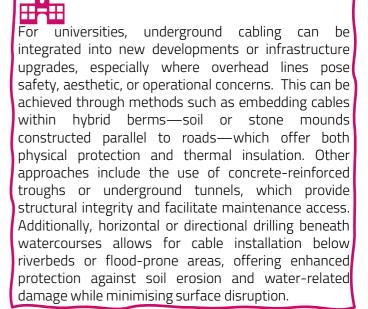


Figure AC: Cable sealing

Underground cabling

Burying protected cabling underground, including overhead high-voltage cables, enhances resilience by shielding infrastructure from adverse weather, physical damage, and environmental degradation.



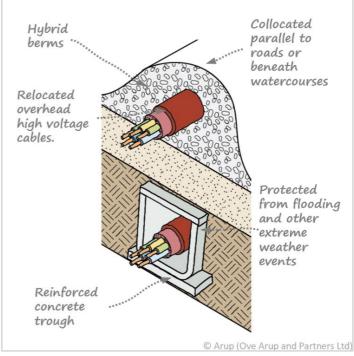


Figure AD: Underground cabling

Adaptation measures for multiple hazards



Power Supply Resilience

Power supply resilience involves using systems such as Uninterruptible Power Supplies (UPS), batteries, flywheels, and backup generators to ensure continuous electricity during outages or extreme events. These systems help maintain critical operations and protect sensitive equipment from power disruptions.



For universities, this is particularly important for research labs, data centres, and teaching facilities that rely on uninterrupted power. Universities may also consider partnering with local energy providers or integrating renewable sources to further strengthen energy resilience and support sustainability goals.

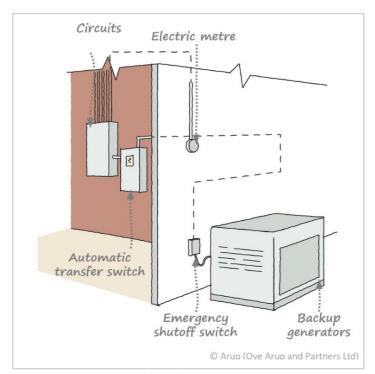


Figure AE: Power Supply Resilience

Updated incident or adverse weather plan

Updated incident or adverse weather plans provide a structured framework for how a university will respond to extreme weather events and other climate-related disruptions. These plans outline procedures for maintaining operations, protecting people and assets, and coordinating with emergency services during events such as flooding, heatwaves, snowstorms, or high winds.



Maintaining up-to-date plans is a low-cost but highimpact measure that supports both safety and business continuity. It's important that these plans are inclusive of all climate hazards, regularly reviewed, and clearly communicated to staff and students. By doing so, universities can ensure a coordinated and effective response to emergencies.

Early Warning Plan

Early Warning Plans (EWPs) involve monitoring environmental and climate indicators to forecast potential hazards such as heatwaves, floods, or wildfires. These systems use data and modelling to issue alerts that help inform timely planning and response actions, reducing the risk of harm to people and infrastructure.



EWPs are a practical and cost-effective measure that can be integrated into campus operations—particularly in areas with high footfall or vulnerable populations such as student housing. It's important to ensure that alerts are accessible, clearly communicated, and tailored to local risks, especially in locations with complex transport networks or large international student communities.

AUDE

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