BLUE MOUNTAINS PLANETARY HEALTH INITIATIVE

blue mountains City Council

Bushfire water spray systems

Design guide V1.0 2024

The City of the Blue Mountains is located within the Ngurra (Country) of the Dharug and Gundungurra peoples. Blue Mountains City Council recognises that Dharug and Gundungurra Traditional Owners have a continuous and deep connection to their Country and that this is of great cultural significance to Aboriginal people, both locally and in the region.

These guidelines have been developed by the Blue Mountains Planetary Health Initiative with support from the Disaster Risk Reduction Fund, which is jointly funded by the Australian and New South Wales Governments. They are based, in part, on Australian Standard 5414-2012. They have also been informed by collaboration with the University of Wollongong Sustainable Buildings Research Centre and Sustainability Workshop Pty Ltd.

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Bushfire Water Spray Systems General Guidance

How to use this document and what it is intended to achieve

This document is a design guide intended to help planners, engineers, architects, builders, homeowners and plumbers to design and install more effective bushfire water spray systems.

Bushfire sprinklers are widely used, however there is limited scientific evidence which supports the design of an effective system. There is an Australian Standard (AS5414-2012) which supports the design of bushfire water spray systems and which is currently under review. The standard has some critical limitations. For example, to apply AS5414-2012 requires an understanding of which parts of a house need to be protected from bushfire. Designers need to answer questions such as “does a corrugated roof typically need protection?”

The standard leaves it up to the user to determine what needs to be protected and therefore which parts of the dwelling should be covered by a water spray system. Advice is that users should focus efforts on more combustible parts of the dwelling such as decks, and windows which are subject to thermal shocks and breaking etc.

To protect a whole dwelling is possible, however would require very large volumes of water – well in excess of 100,000 litres. The costs of these systems are high and designers and homeowners are placed in extremely difficult risk management positions.

This document, limited by the current state of knowledge, is intended to distill key learnings from several sources and to compile them into one document which is easily accessible for those who want to design and install a bushfire water spray system. It is hoped this document will help users better understand the risks which we know about, especially the impact of wind and water spray droplet size on effectiveness.

The University of Wollongong was commissioned to model the effectiveness of various sprinkler locations and configurations on a typical Blue Mountains house to see how they are impacted by wind. We hope the images produced will make system designers think about how effective their systems are going to be under high wind and extreme temperatures.

What are the risks associated with a bushfire sprinkler system?

Evidence from previous bushfires has demonstrated that in the same fire, houses with and without sprinkler systems, as well as houses which were hardened against heat and ember attack, were significantly damaged or destroyed during the bushfire.

Therefore, at the current time, it is not possible to form a definitive conclusion as to the effectiveness of sprinkler systems. There are many factors which significantly influence the risk of a house being damaged or destroyed by a bushfire as well as many factors which impact on the effectiveness of sprinkler systems. In the past, it is known that crude or ineffective systems have been installed and in light of the work by the University of Wollongong (refer to Sheets 7 and 8 in this guideline), the effectiveness of these systems is questionable.

Owners should not rely on bushfire sprinkler systems instead of evacuating early.

Homeowners MUST NOT wait until the last possible minute to evacuate so they can be present to turn on their bushfire sprinkler system. This has occurred in the past and the message no-one wants to hear is that it is too late to evacuate and you must “shelter in place”. The lives of homeowners, RFS and Emergency Services should not be put at risk.

There is a risk that homeowners may incorrectly think that a bushfire sprinkler system (which is described as an active system) is better than hardening a house to bushfire and using passive measures such as sealing all gaps where embers can enter the fabric of the building. In fact, there is currently little evidence that bushfire sprinkler systems are effective against ember attack while passive measures to stop ember attack are understood to be more effective.

Limited and precious funds should be spent on passive management measures first. The Australian Standard for construction in bushfire prone areas AS3959 requires new buildings to be built with no openings or gaps greater than 2mm. Homeowners of older homes are urged to close the underfloor area, seal all gaps, such as under doors, at windows, eaves lines and ridgelines of steel roofs where wind born embers could enter the building and start a fire inside. Also consider installing ember screens or shutters. Replacing more combustible cladding with less combustible materials such as cement fibre sheet, Hebel Panel, brick or cement blocks, replacing glass so that it complies with AS3959 means it should be at least 4mm thick safety glass. Higher BAL situations are more complex and would require different responses and the advice of an Architect or Bushfire Consultant should be sought when deciding what passive measures to put in place.

More information on passive bushfire protection measures can be found here:
https://www.yourhome.gov.au/live-adapt/bushfire-protection

More information on windows and doors can be found here:
https://awa.associationonline.com.au/documents/item/236

Attention to maintenance of an asset protection zone and removal of combustible vegetation from around a building are considered low hanging fruit that should be undertaken first.

Only after all passive measures are undertaken should homeowners consider spending money on installing a bushfire sprinkler system.

How do houses burn?

Users are directed to the following website for further information and which is the source of the information below: https://bushfireresilience.org.au/article_groups/how-houses-are-destroyed/

The following causes of house loss during bush fires are listed in order of severity or risk:

1) Ember Attack (most common cause).

2) Debris Accumulation – embers which build up against a wall or part of the building and then cause the building to catch on fire – often this will happen where leaves build up in winter.

3) Surface Fire – embers igniting grass or vegetation close to the building.

4) Consequential Fire – having something flammable, like a shed or fence to close to the building and which then sets the building on fire. Consequential fire risk should be carefully considered in terms of having enough water to fight a consequential fire.

5) Radiant Heat – this can cause the building to ignite due to it becoming too hot. Sprinkler spray systems can help to reduce the impact of radiant heat by spraying water onto the house which is then evaporated and cools the house.

6) Flame Front contact – flames being fanned by strong winds which physically touch the building and cause it to ignite.

7) Wind – powerful winds can cause severe damage to the building fabric or cause enough damage to allow embers to enter the building.

8) Tree Strike - branches fallen from burning or wind blown trees.

Bushfire Sprinkler Basics

Bushfire Sprinkler systems have four main components:

1) An independent source of water.

2) An independent means of pressurising the system with a pump that has its own motor or source of power, or a gravity-fed system where the water source is more than 20 m higher than the sprinkler system.
3) Pipes to transport the water to the sprinklers from the water source.

4) The sprinklers and nozzles.

A general arrangement of a system is shown on Sheet 4.

Remote Activation

It is recommended that new bushfire sprinkler systems be installed with a capacity for remote activation. There is currently no specific guidance on this however systems that rely on the mobile network may be prone to reliability issues during an emergency when the network may not be functional.

Other types of remote operation include having heat sensors on the boundary of a property, or radio controlled systems. These all have reliability limitations.

It is recommended homeowners talk to their local RFS to inform them of their system with the hope that RFS may be able to turn on the systems if RFS are present.

Signage and RFS Coordination

It is critical to display signage identifying the property has a bushfire water supply system. Refer to sheet 3 for signage details.

Inform your local RFS brigade that you have a bushfire sprinkler system and show them how to activate the system so that if you need to evacuate they might activate the system on your behalf. Ensure your pump has clear signage indicating how to operate the pump. This will be useful in an emergency to someone who may not be familiar with your pump. Test your signage on someone who is unfamiliar with pumps.

Sources of Water

Refer to Sheet 5 for details. A standalone water source is recommended by AS5414-2012 as mains water supplies are unreliable during bushfires. The volume of water required will depend on the size of the bushfire sprinkler system that is designed. Typically, large volumes of water are required, often exceeding 100 kL. In addition, homeowners may wish to keep some water in reserve for household use after a bushfire.

An elevated tank is an option for those with access to elevated ground. Refer to Sheet 4 for details.

Pumps and Pump Systems

Refer to Sheet 6 for details. The most reliable pump systems would be submersible pumps powered by a diesel generator which can be placed in a protected position away from or protected from the primary fire risk. Submer sible pumps are less likely to overheat given they are immersed in water.

Electrical cabling is an extra cost and can be buried at least 600mm below the ground to achieve cover requirements for buried electrical cables. This depth can be reduced if using strong conduits. Discuss these requirements with your licensed electrician.

All generators and pumps with engines need to be in well ventilated spaces. Their exhaust can be dangerous to breathe in. Ensure the pumps and generators can function as intended.

As an alternative to a generator and submersible pump, a diesel pump (preferably as they are considered more reliable and less prone to overheating) or a petrol pump in a protective enclosure provide pressure to the system. Note that during a fire emergency reliance on the local water supply network is not recommended.

Designers should also consider adopting a fail safe approach and having say an electrical pump which can rely on electricity if present, with back-up generator or with back up pump, i.e. a system which allows for some failure.
Houses with batteries can use these batteries to supply the electricity however the batteries will need to be protected from ember attack, radiant heat and fire and located where they will not be the cause of a consequential fire.

Pipes and Plumbing

Information on pipes and plumbing requirements are included on Sheets 5 and 6.

Generally, all exposed pipes should be metal and buried pipes should have at least 300mm cover. Pipe sizes should be designed to limit friction losses on systems, especially where a gravity main is being relied upon.

Nozzles and Sprinklers

A range of nozzles are available however at the time of writing very few of them had been tested for compliance with Appendix A of AS4514-2012 which details the testing requirements. Refer to sheet 7 for details.

Designers are faced with the reality of having very limited water storage volumes available to supply the water for sprinkler systems. The design cha llenge is therefore to:

1) Limit the surfaces (area and volume of water required) of a building which are to be protected to those which really need to be protected. For example – carefully consider if a metal roof needs protection and in the case of a system limited by a homeowner's funds, focus on higher risk elements such as windows and doors, flammable decks, ensuring gutters are kept wet to stop embers causing a fire under the eaves and of course ensuring that all passive measures that can be practically implemented are done so prior to designing a bushfire sprinkler system.

2) Complement the sprinkler system with passive measures to reduce the quantity of water required; for example, by installing metal flyscreens over windows.

3) Source the best sprinklers and nozzles size them appropriately – selecting an oversized sprinkler that delivers much more water than is needed will rapidly and unnecessarily deplete the volume of water available, whereas selecting an undersized sprinkler could fail to deliver enough water to protect the building.

Readers are directed to Sheets 8 and 9 which show the effect of wind on spray patterns - called spray drift. From Sheet 8 and 9, it is clear that the effectiveness of sprinklers will be reduced due to the significant effects of wind causing spray drift. All target surface areas are unlikely to be covered under windy fire conditions. Aided by Sheets 8 and 9, designers need to carefully consider the likely direction of the fire threat and then consider the location and orientation of sprinklers to maximise wetting of target surfaces under windy conditions and to minimise spray drift.

Sprinkler spacings

With reference to Sheet 6: To achieve the right water application rate, a designer would normally decrease the spacing between nozzles until you achieve the target value in L per min per m^2. Note that the water will also run down a surface (e.g. roof or wall) from where it is applied. So the area covered is not necessarily confined to the circle that is sprayed directly – the nominal sprinkler coverage is useful only in indicating roughly the maximum spacing between nozzles to avoid dry regions between adjacent sprinklers.

To estimate the water application rate one could use the following procedure:

1. Select sprinklers and determine the maximum spacing that would still wet the entirety of the target surfaces, remembering that water will flow down from where it is applied.

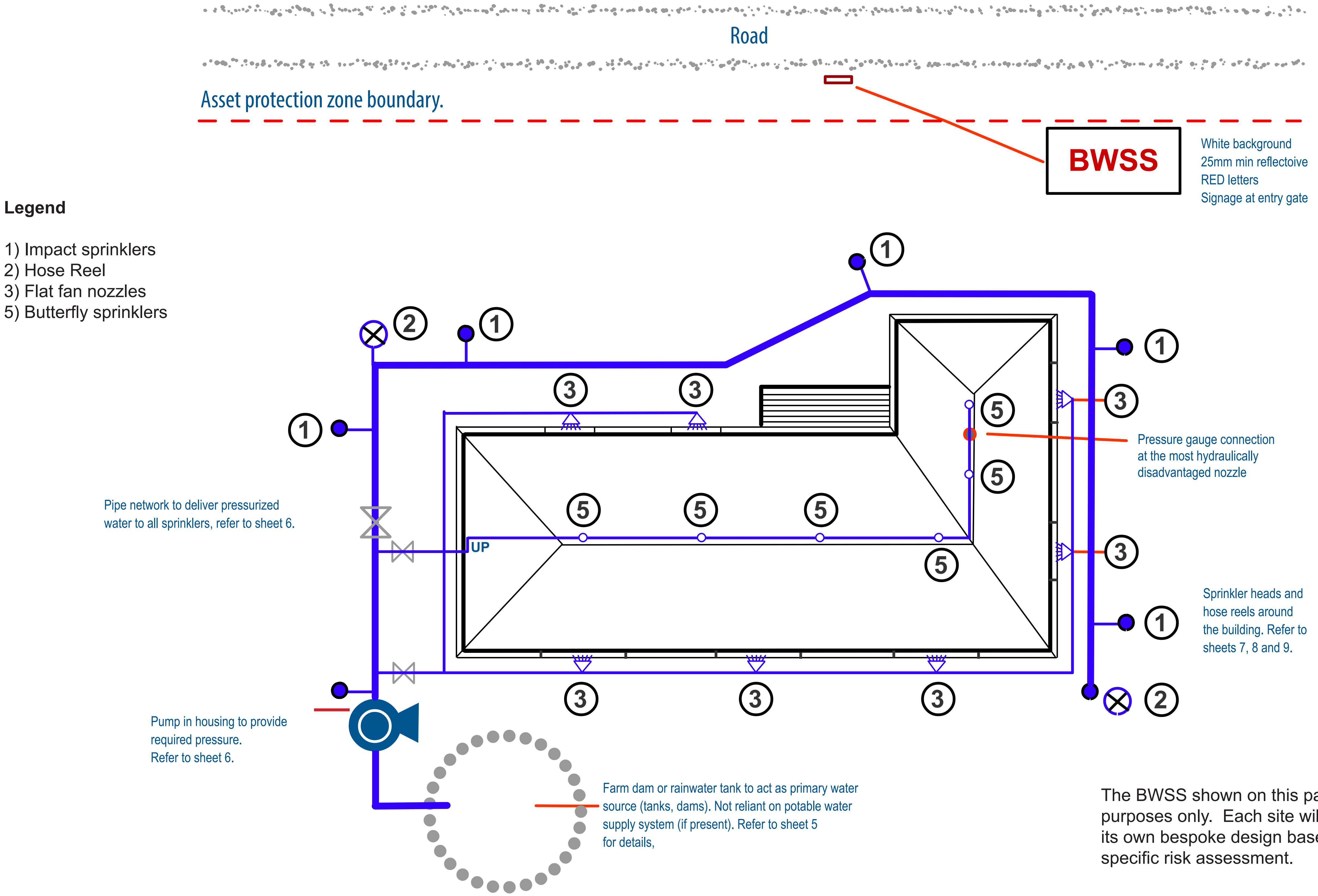
2. Calculate F = (W x A)/E, where:

   F is the total water flow rate through all sprinklers if you used that maximum spacing (L/min)
   W is the required water application density (L per min m^2) (Refer to Sheet 6 for more information on this rate). Refer to Sheets 6 and 7.
   A is the total area of the surface being protected (m^2)
   E is a 'delivery efficiency' which accounts for the loss of water from wind, evaporation, splashing, etc – refer to Sheets 7, 8 and 9 for more information. For example, for a gutter-mounted butterfly sprinkler University of Wollongong simulation predicted roughly half the water sprayed will land on the roof so one could adopt a delivery efficiency factor of 0.5 for that configuration.

3. Adjust the design so that the equation above gives the desired water application density. Adjustments you can make include:

   a. Change nozzles
   b. Changing the supply pressure
   c. Reduce spacing between sprinklers (noting that spray patterns can, and probably should, overlap). Also consider how spray patterns interact.

Bushfire water spray systems
General Arrangement Plan



The BWSS shown on this page is for illustrative purposes only. Each site will need to have its own bespoke design based on the a site specific risk assessment.

Figure 1. Bushfire water spray systems General Arrangement

Water Sources

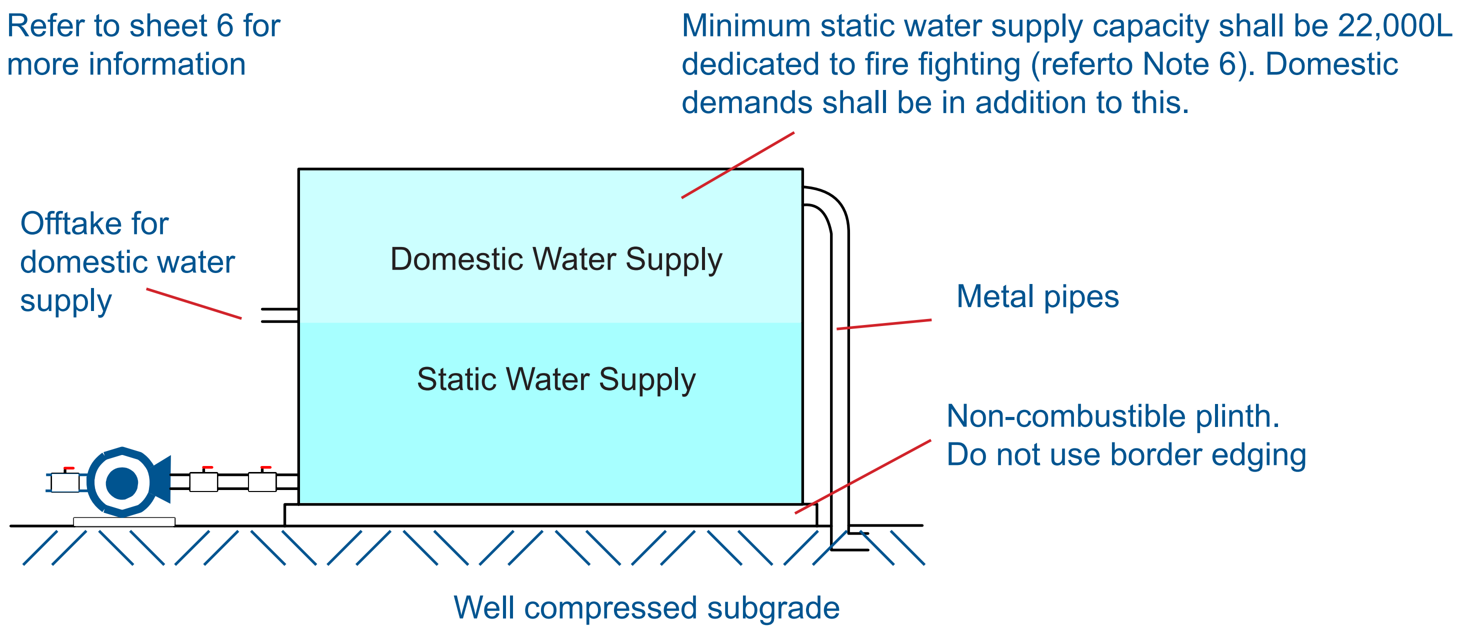


Figure 2. Above ground tank

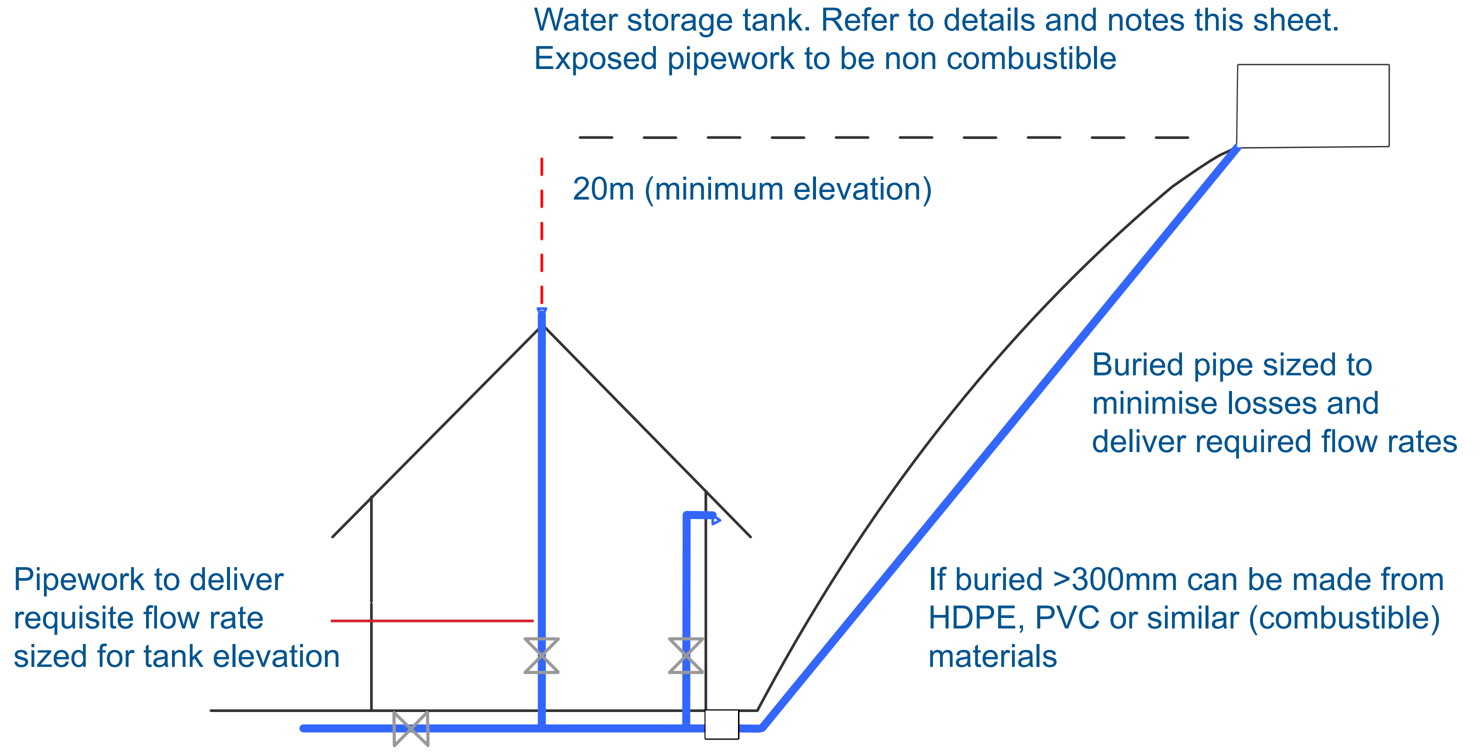


Figure 4. Gravity fed water source

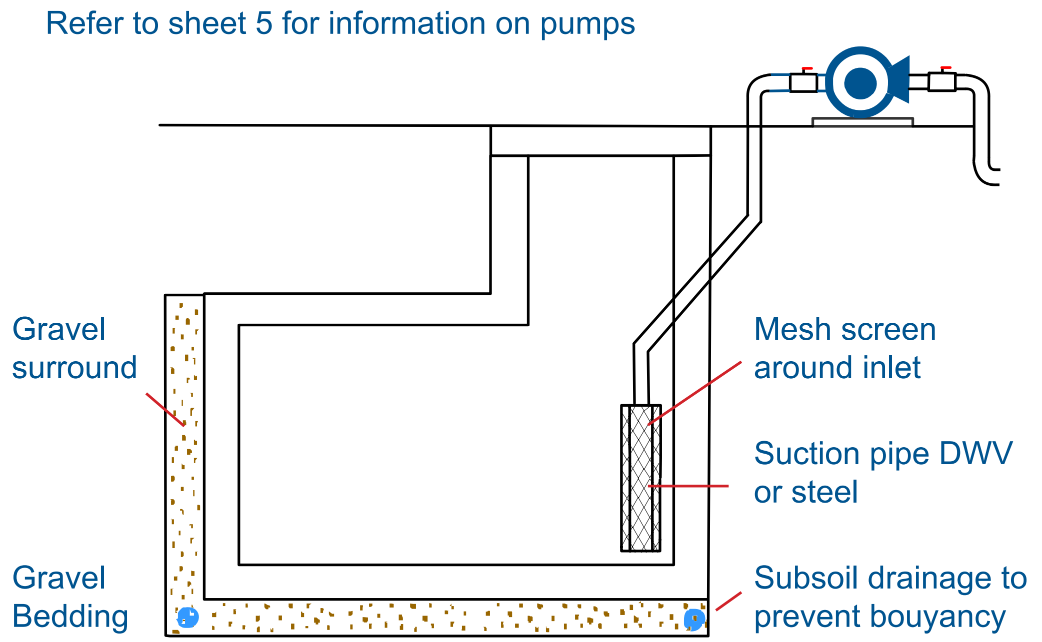


Figure 3. Below ground tank

Above ground tank notes

1. Above ground tanks can be from non combustible materials such as Colorbond (ZincAlum), stainless or concrete.
2. Colorbond tanks may come with a food grade polymer lining, which may be impacted by radiant heat and render the tank unfit for supply of potable water after a fire.
3. Stainless steel and concrete typically do not have a polymer lining.
4. Ensure tanks are located far enough away from buildings such that in the event of tank rupture, the building will not be damaged.
5. Tank stands, if used, shall be constructed from steel and have no combustible elements.

Tanks General Notes:

1. The volume of the tank shall be sized to meet the demand of the sprinkler system for at least a 30 minute fire (AS 5414-2012), in addition to pre exposure, wetting, exposure protection and post exposure dampening.
2. Tanks buried more than 300 millimeters are unlikely to be impacted by radiant heat.
3. Consider concrete (precast or cast in situ), fiberglass, geocellular structures such as AcoStormbrixx, which can be lined in a welded HDPE membrane (>1.0 mm).
4. Some tanks are fitted with a concrete collar or thickened base to counteract buoyant uplift forces. Alternative and where possible, provide subsoil drainage around the tank.
5. If a buried tank is used, understand its load rating and if it can be driven over or needs to be located and protected from vehicles and farm equipment.

Pumps and Pipework

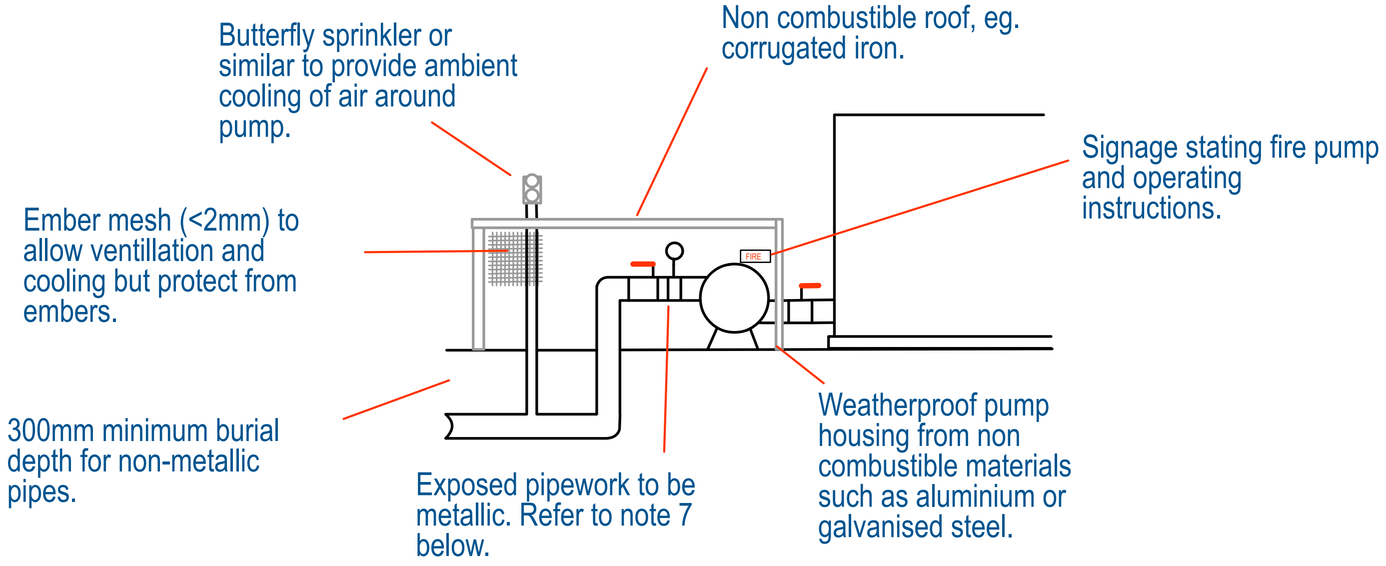


Figure 5. Above ground pump arrangement

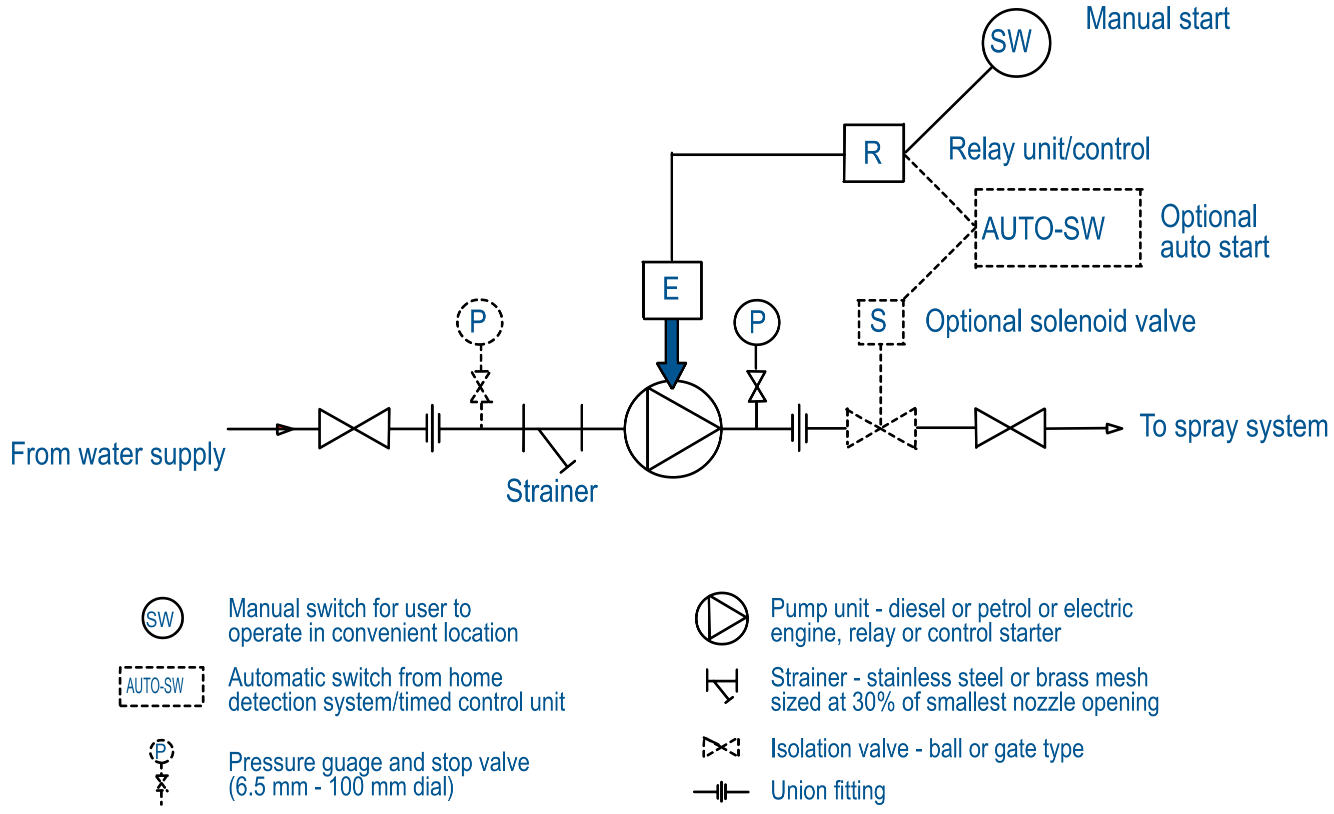


Figure 6. Pump configuration as per AS514-2012

Notes

1. Pumps are to be petrol or diesel to provide pressure to the sprinkler system which is not reliant on town's water supply.
2. All pumps need to be regularly checked and maintained in accordance with manufacturer's guidelines.
3. Pump should have a fuel tank capacity of not less than 2 hours.
4. Pump housing should be easily accessible under emergency operational conditions.
5. Starting should be automatic supplemented with a pull cord.
6. Where available, generators may be used to provide electrical power for electrical pumps complying with AS3000.
7. External piping should be galvanised steel, copper or stainless steel complying with AS4118.2.1
8. A pressure gauge connection should be provided at the most hydraulically disadvantaged nozzle.

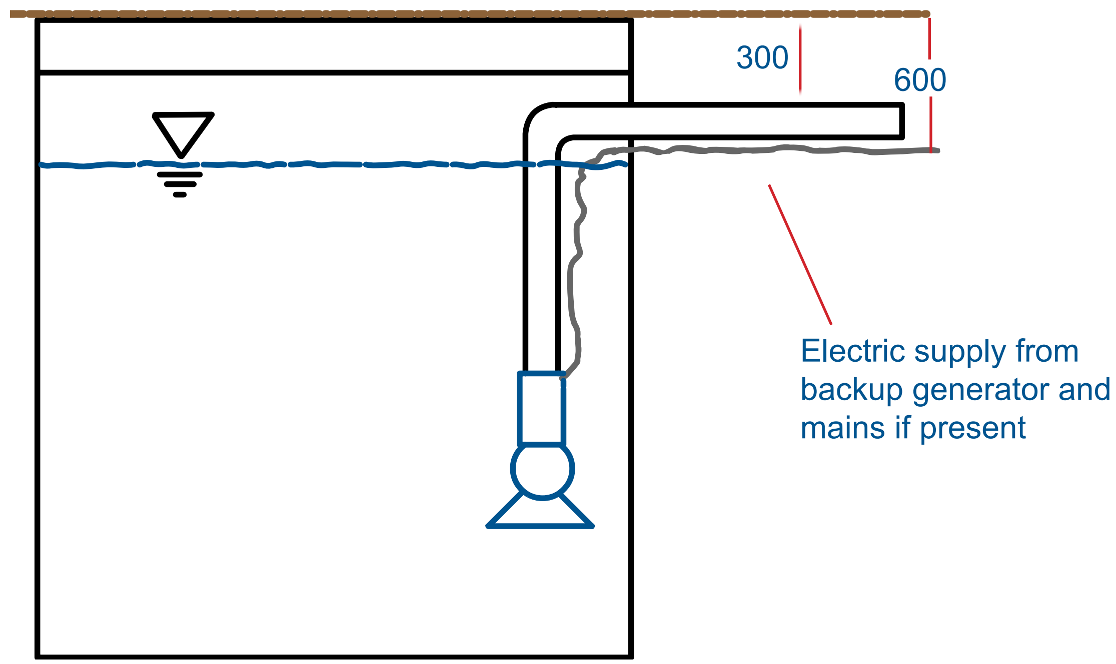


Figure 7. Submersible electric pump arrangement

Spray Nozzles

Table 1. Different types of nozzles and sprinklers

Type	Manufacturer	Model #	Application	Rate*	Image
Flat fan window sprinkler	Viking	VK790	Windows and doors	28.6LPM @ 1.75 bar	
Flat fan window sprinkler	Spray Nozzle Engineering	FF250	Windows and doors	33.8 LPM @ 2 bar	
Full cone or hollow cone	Spray Nozzle Engineering	MaxiPoss MP187n	Decking areas	17.6 LPM @ 2 bar	
Deflector plate or pendant sprinkler	Lechler	525.809	Mount under eaves to wet wall, decking and vegetation	10LPM @ 2 bar	
Impact sprinkler	Vyrsa	VYR80 with 3mm nozzle	Mount at ground level or on riser near building to wet deck and surrounding ground	8 LPM @ 2 bar	
Butterfly sprinkler	Holman	Brass butterfly sprinkler	Rooftop ridge line or under eaves or above gutter	12.5 LPM @ 1.5 bar (4m coverage)	

Designers will need to adjust stated application rates to allow for wind dispersion and evaporation. A reduction in the application rate of between 50% to 80% is recommended and will depend on the location of the nozzle. Refer to sheets 8 and 9 for guidance.

Rooftop sprinklers and higher nozzles will be affected more than nozzles on the ground. Sheets seven and eight demonstrate the effectiveness of different types of sprinkler systems on different parts of the house exposed to a bushfire, and will help designers appreciate the effect of wind, and also the effect of droplet size and provide guidance on where to place a sprinkler to suit a specific design scenario.

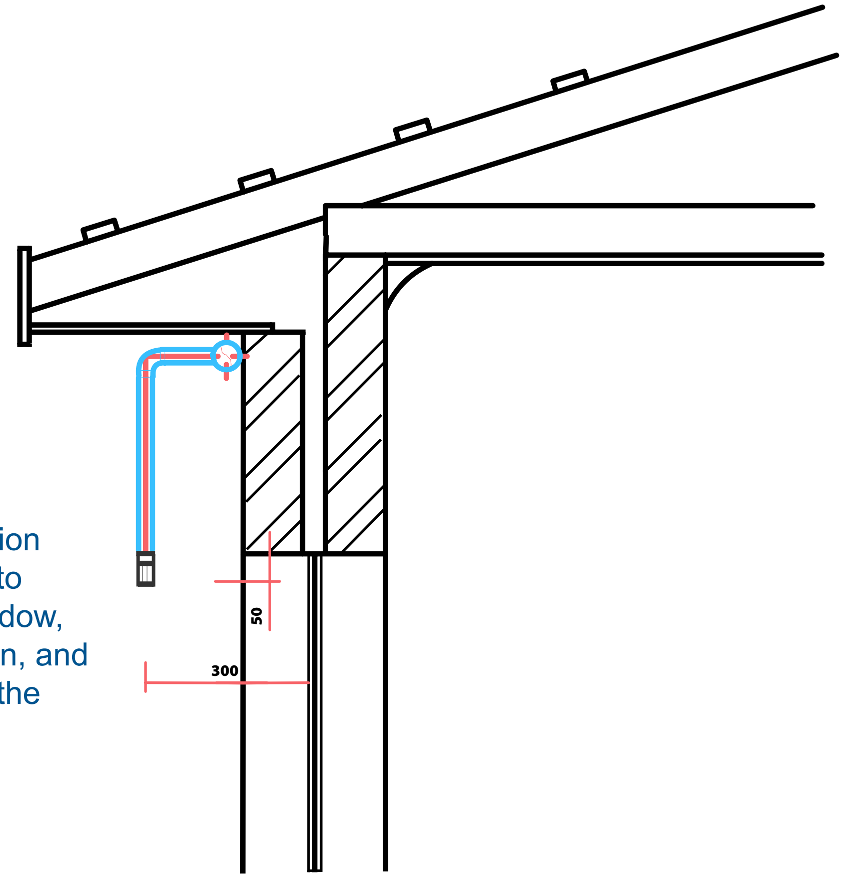
Example calculation to comply with AS5414-2012 for windows.

Required application rate = 10L/min/m2 of window.

For a window which is 0.7m wide and 2.0m high, and from Sheet 9, we need to apply:

$$(W \times A) / E = (10 \times 1.4)/(0.4) = 35 \text{ l/min.}$$

We could use a Viking VK790 nozzle as this will provide 28.6 LPM at 175 kPa, and



Typical flat fan sprinkler Installation Detail. The nozzle is positioned to spray water at the top of the window, door or wall that needs protection, and gravity spreads the water down the surface.

Figure 8

comply with the standard. A smaller nozzle may be more practical and reduce water consumption.

Notes

1. Bushfire water spray systems shall be designed by experienced hydraulic designers, accounting for gravity and friction and all losses in accordance with AS3500.

2. Systems shall deliver the following application rate over surfaces requiring protection per AS 5414:
   a) 10L/m²/minute on unscreened glazing
   b) 5L/m²/minute on screened glazing, roofs, decks and other surfaces.
   c) 1L/m²/minute on perimeter ground surfaces

3. Minimum operating pressure of most challenged nozzle shall be at least 160kpa

4. Sprinklers are to be located as needed to wet any building surfaces identified as needing protection, with consideration of potentially very strong winds and the direction the bushfire is likely to come from.

5. Note that sprinklers may also be needed on the side of the building not facing the bush, as embers often accumulate on the leeward side of buildings.

Computer modelling of calm and windy conditions with various sprinkler and nozzle configurations on a typical house.

These figures are extracted from University of Wollongong SBRC Blue Mountains Planetary Health Centre bushfire sprinkler modelling Final Report (2024).

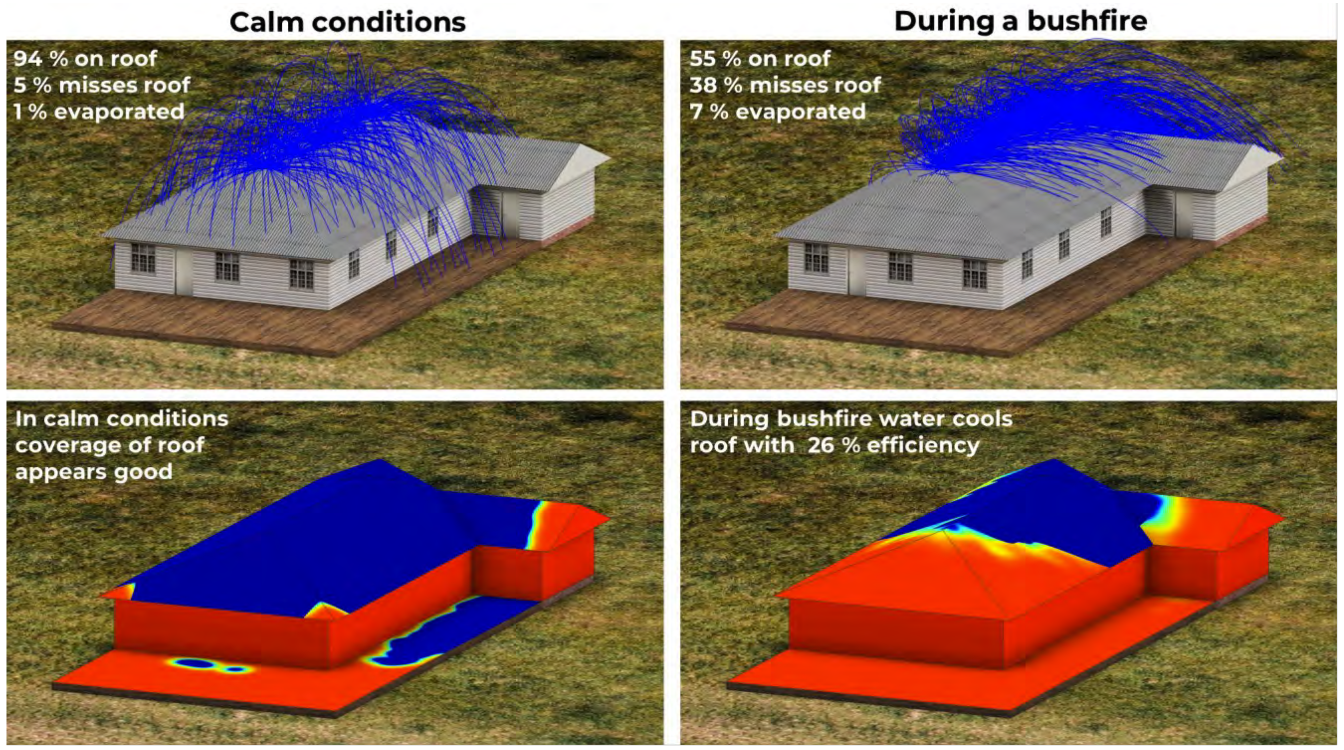


Figure 9. Comparison of droplet trajectories (top) and wetting of building surfaces (bottom) predicted for a system of 5 butterfly sprinklers mounted above the roof ridge, from simulations of calm conditions (left) and bushfire conditions (right).

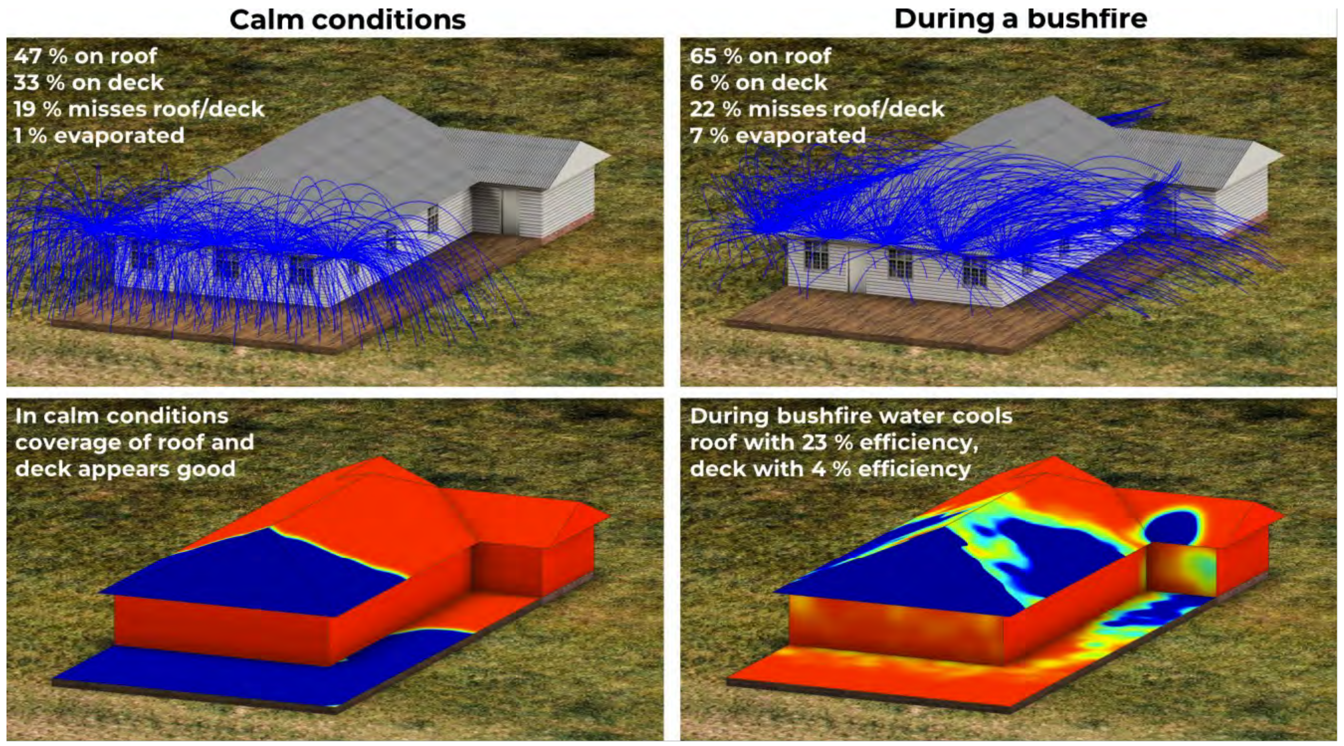


Figure 10. Comparison of droplet trajectories (top) and wetting of building surfaces (bottom) predicted for a system of 5 butterfly sprinklers mounted above the house's gutters, from simulations of calm conditions (left) and bushfire conditions (right).

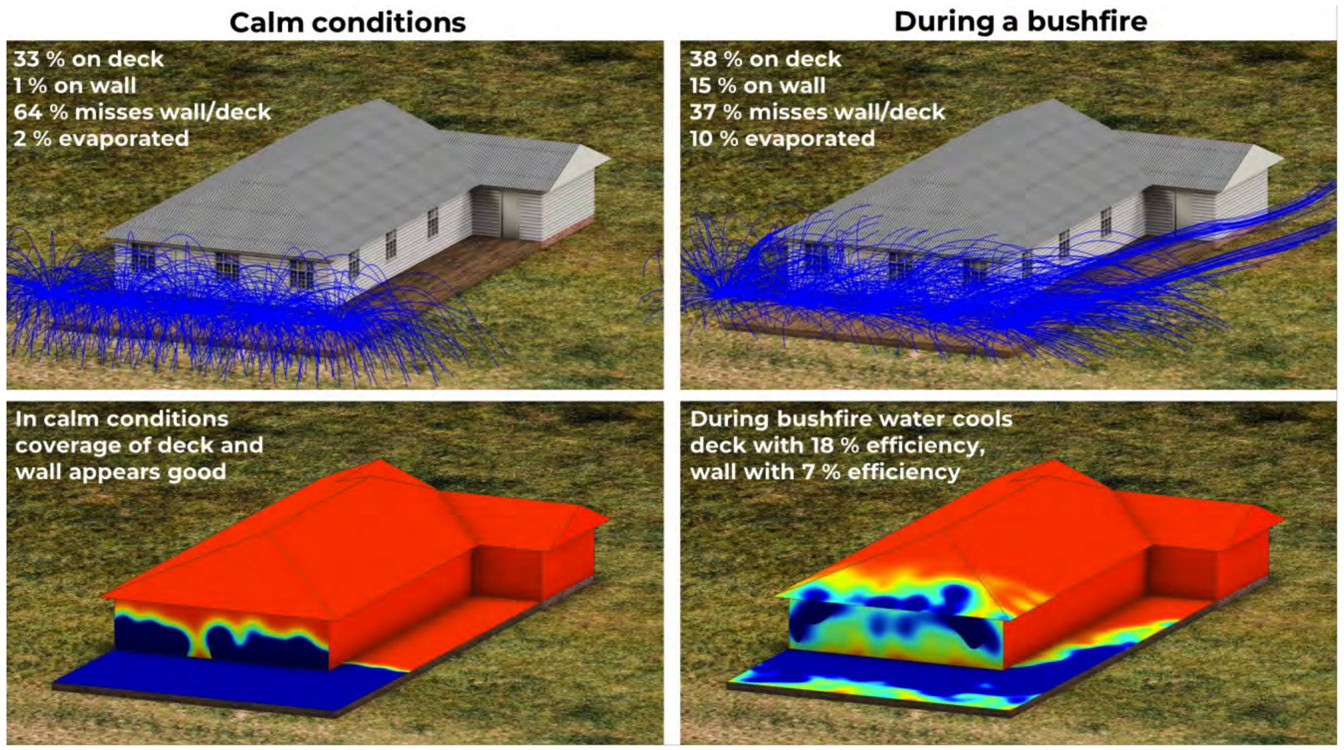


Figure 11. Comparison of droplet trajectories (top) and wetting of building surfaces (bottom) predicted for a system of 5 butterfly sprinklers mounted 1 metre above the edge of the deck, from simulations of calm conditions (left) and bushfire conditions (right).

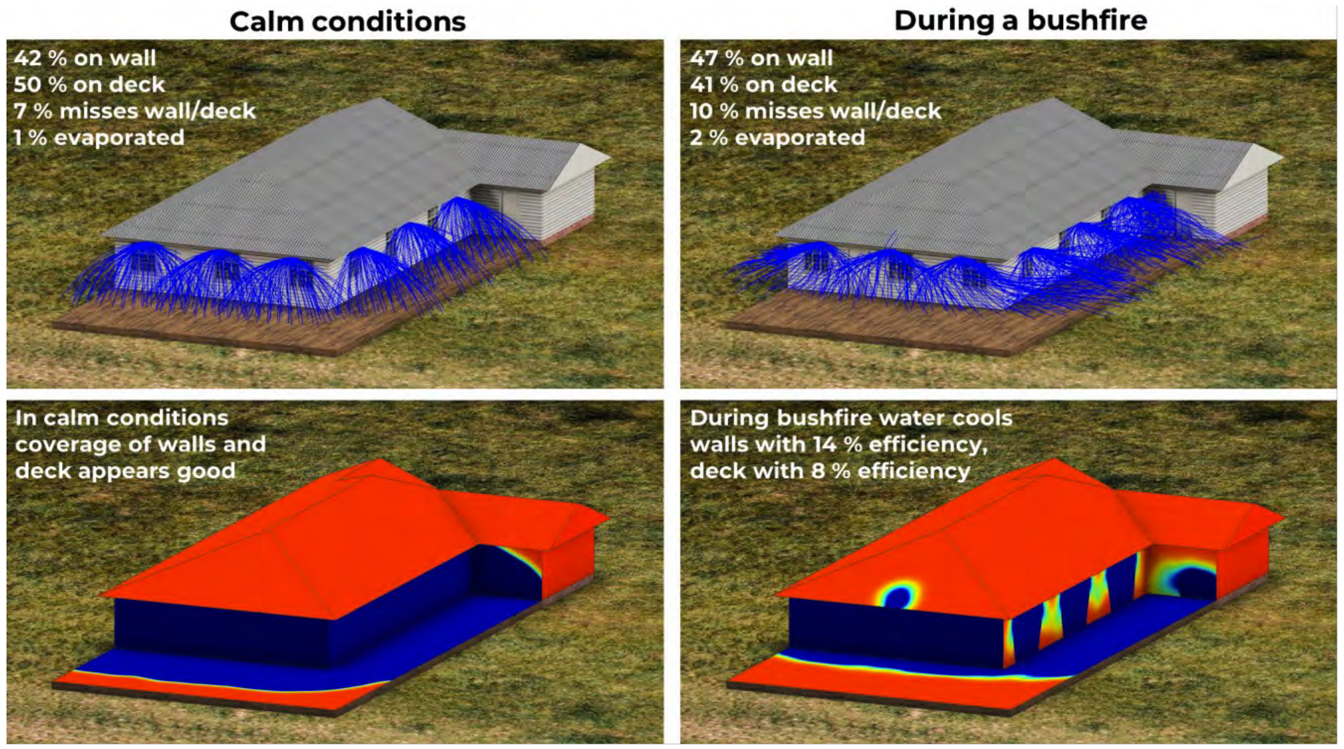


Figure 12. Comparison of droplet trajectories (top) and wetting of building surfaces (bottom) predicted for a system of 5 butterfly sprinklers mounted under the house's eaves, from simulations of calm conditions (left) and bushfire conditions (right).

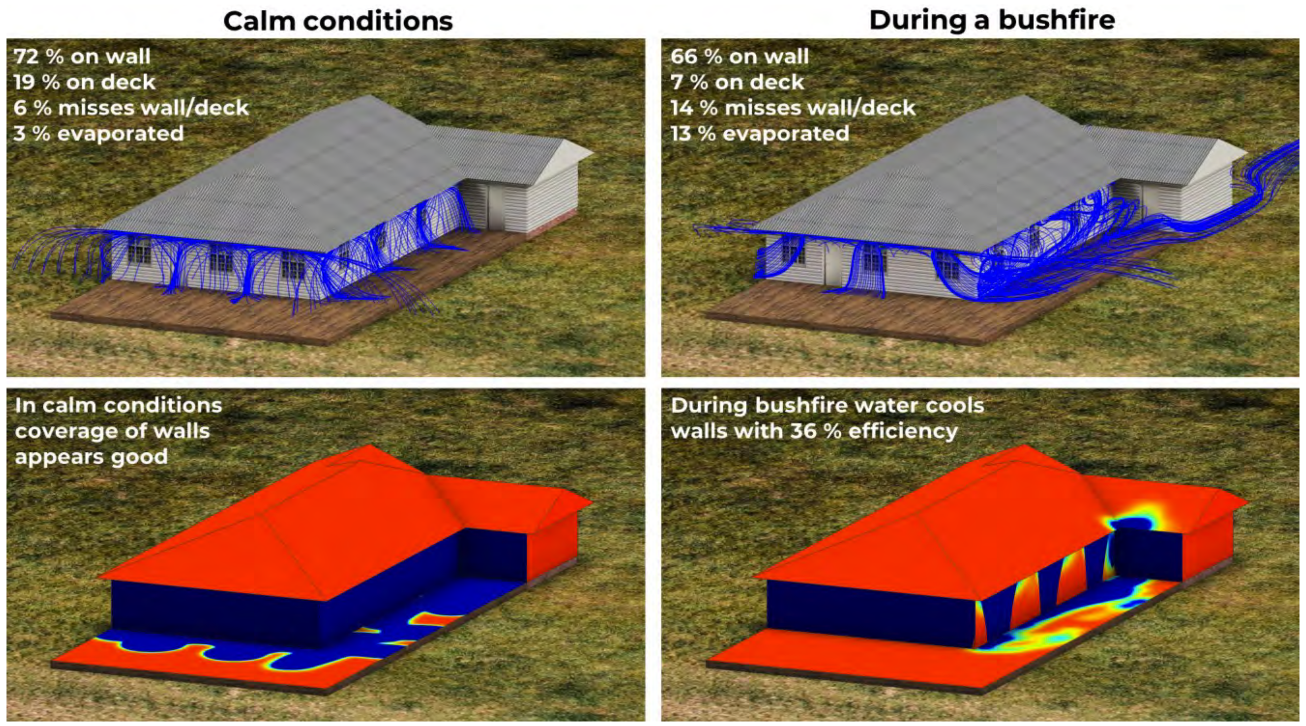


Figure 13. Comparison of droplet trajectories (top) and wetting of building surfaces (bottom) predicted for a system of 6 flat fan sprinklers mounted under the house's eaves, aimed at the top of its walls,, from simulations of calm conditions (left) and bushfire conditions (right).

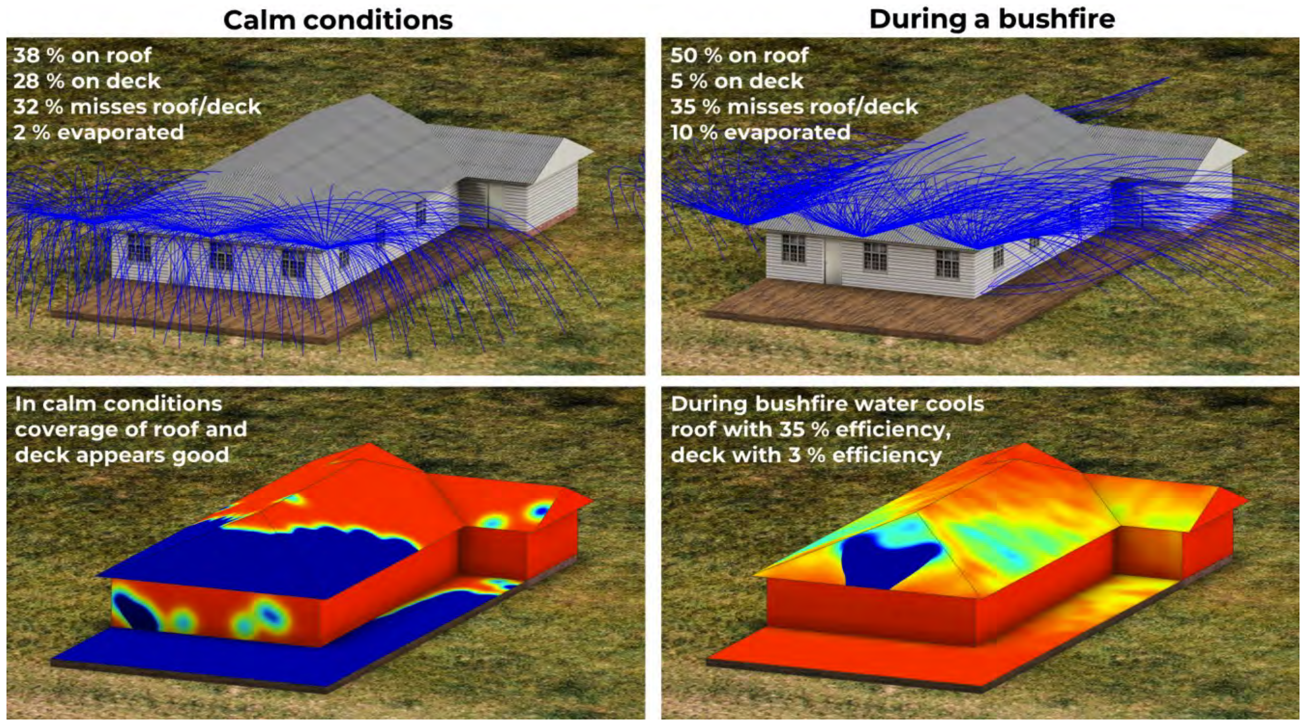


Figure 14. Comparison of droplet trajectories (top) and wetting of building surfaces (bottom) predicted for a system of 3 impact sprinklers mounted above the house's gutters, from simulations of calm conditions (left) and bushfire conditions (right).

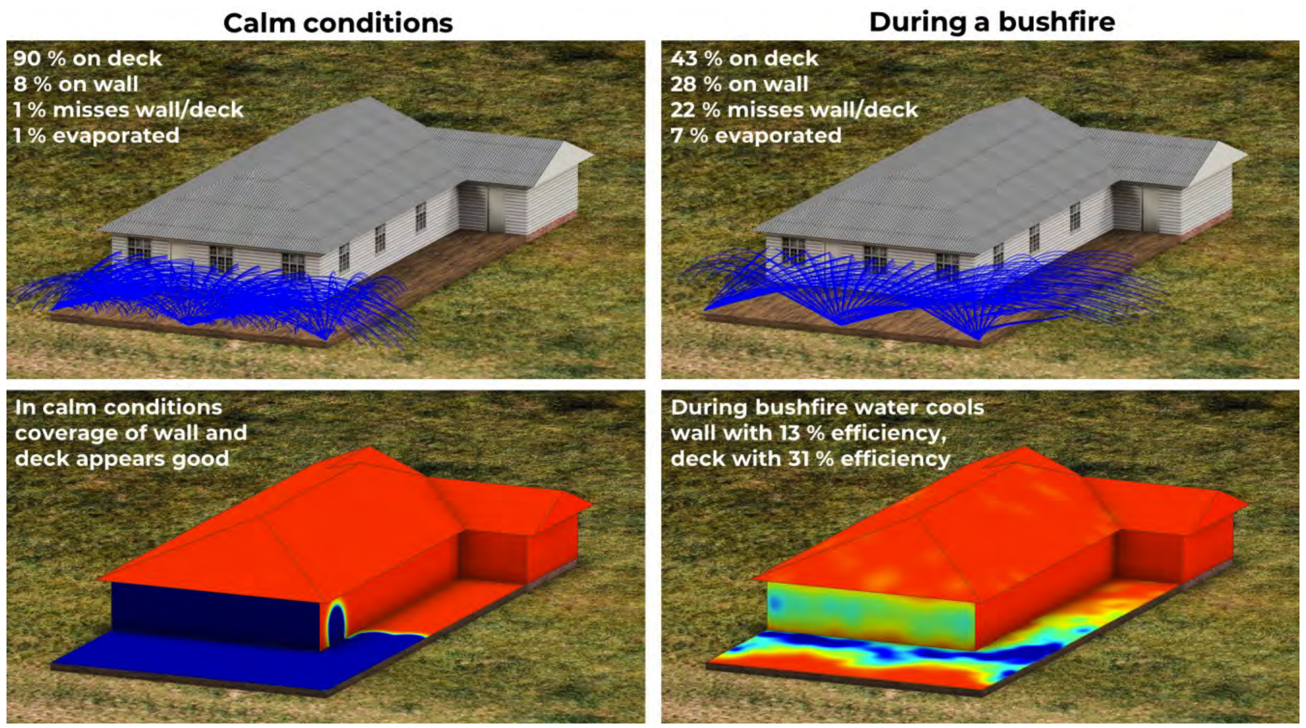
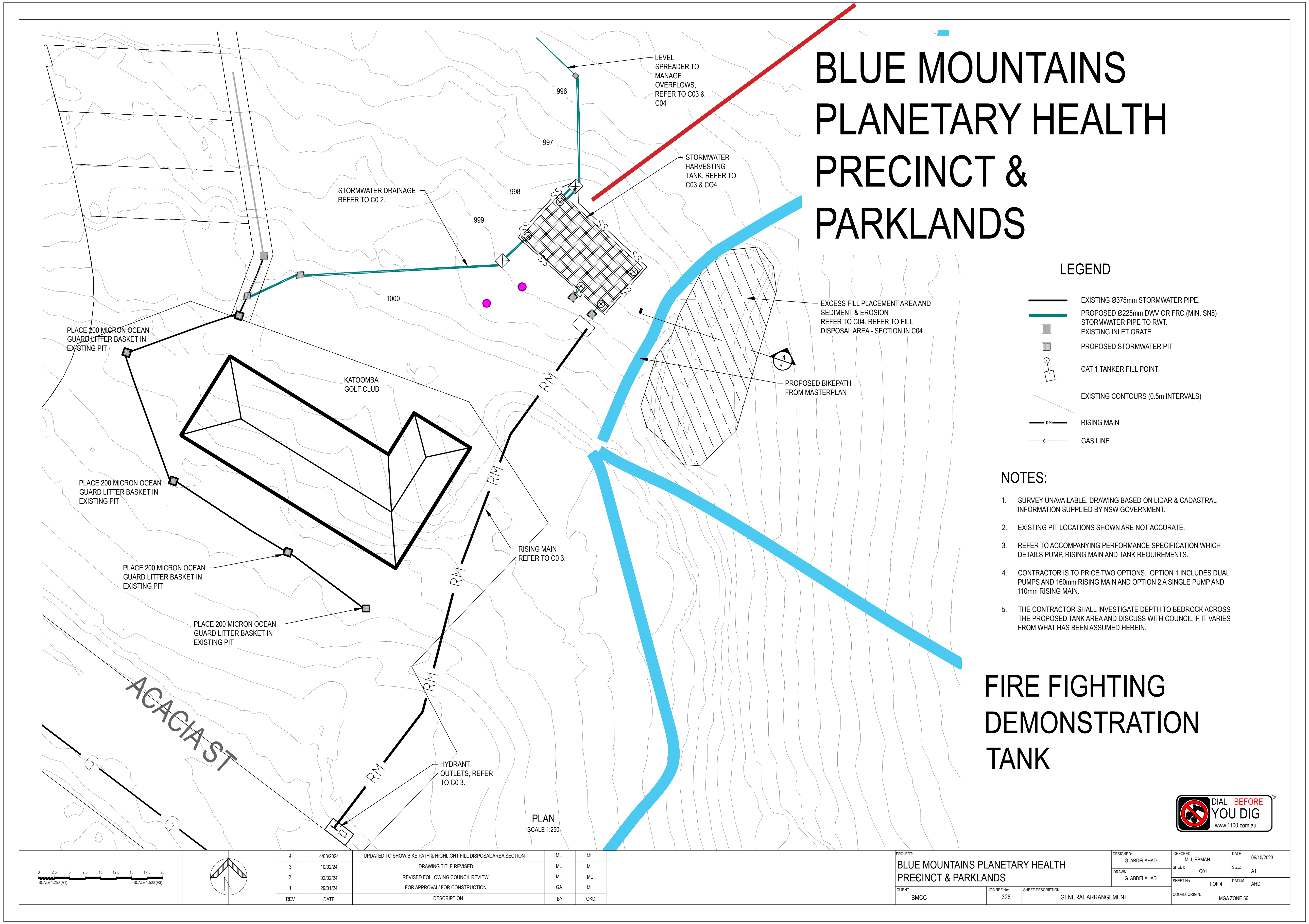


Figure 15. Comparison of droplet trajectories (top) and wetting of building surfaces (bottom) predicted for a system of 3 impact sprinklers mounted at the edge of the deck, from simulations of calm conditions (left) and bushfire conditions (right).

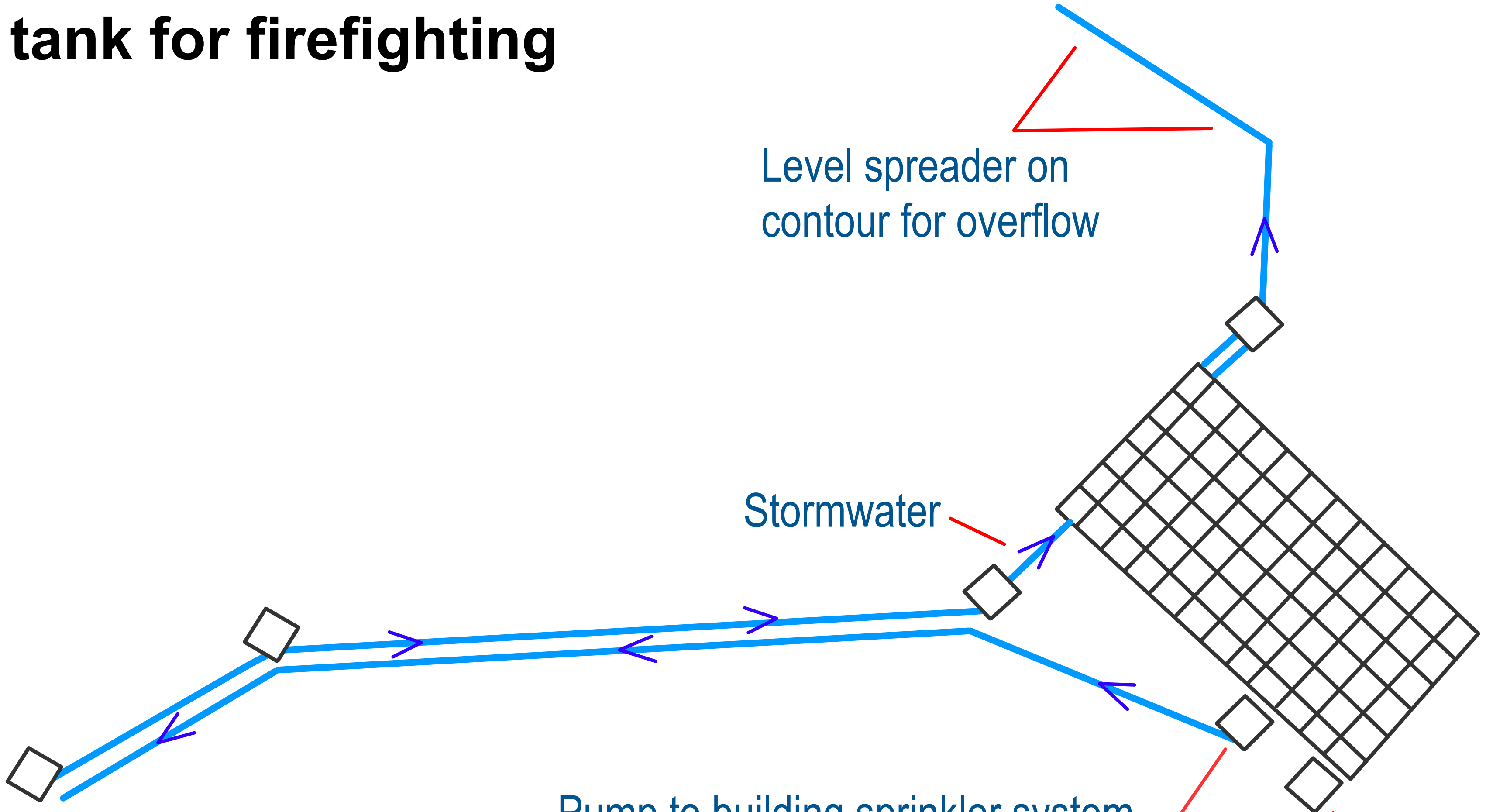
Refer to sheet 11 for details

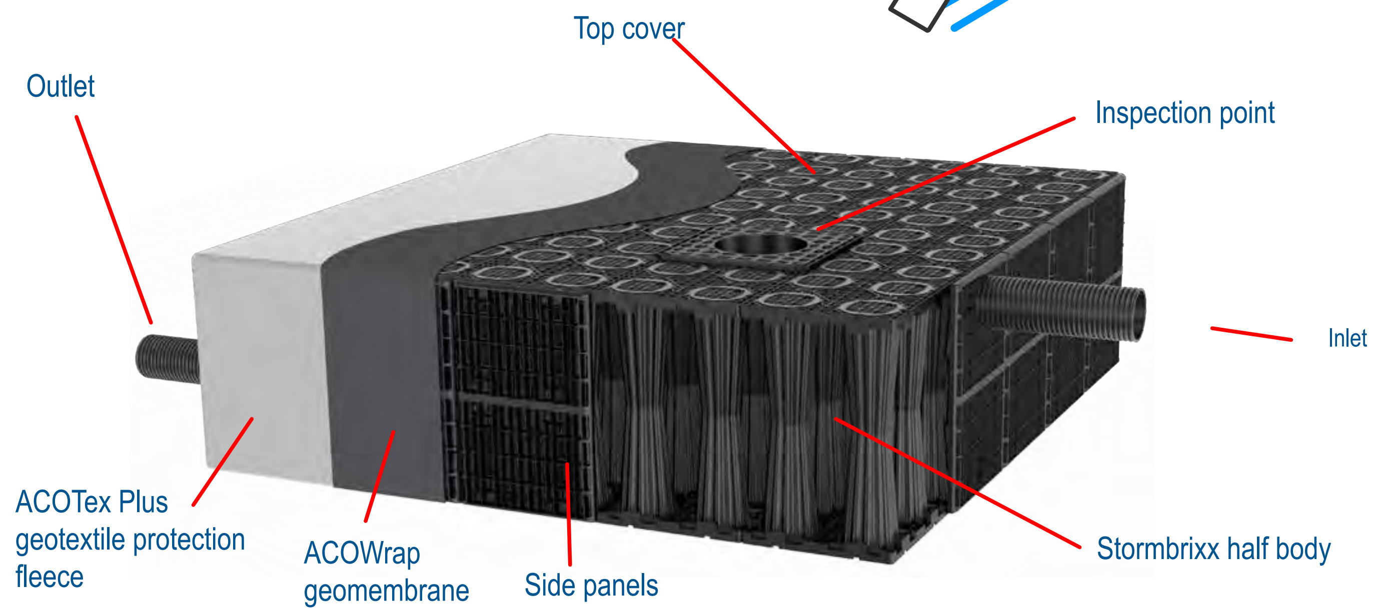


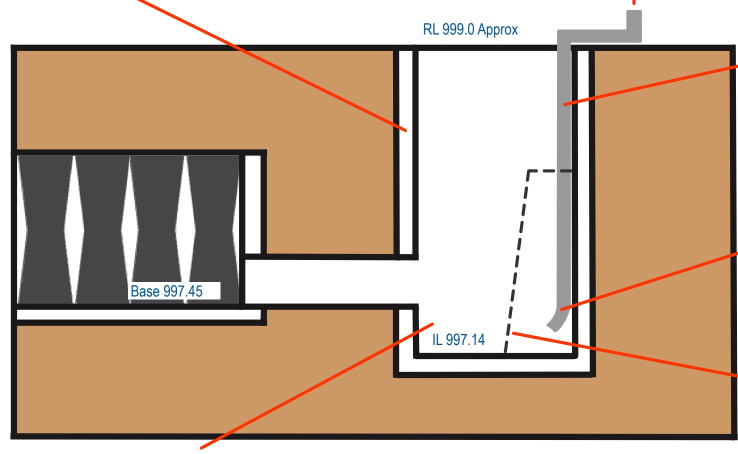
Example of a community bushfire water tank at the Planetary Health Precint.

150,000 litre underground tank for firefighting

This underground tank has been built with Stormbrixx: ideal for shallow soil profiles. The tank is fed by stormwater and is a model for potential tanks around the perimeter of the City to slow stormwater surges and provide a Static Water Supply for firefighting. It also supplies water to the building sprinkler system.







BLUE MOUNTAINS PLANETARY HEALTH INITIATIVE

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This underground tank was built with the support of the Disaster Risk Reduction Fund, which is jointly funded by the Australian and New South Wales governments.

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