**Session 3 - climate change coastal and non-coastal catchments**

In the flood management strategy we have focus area five that focuses all about the challenges of climate change.

And here at Melbourne Water we know that climate change adaptation requires a shift in thinking and needs to be considered in flood policy,

planning and operations. It's such a vast area and so we're mindful that we want to be covering quite a few different parts of the climate change journey,

but that we are very much wanting to incorporate as varying information as we can to make this nice and relevant to councils. You can see on our slide here,

this is one that we've used before, but I just wanted to highlight the recent Victorian Marine and coastal council findings there. We have some pretty phenomenal stats regarding the impacts of sea level rise and also storm surge.

Just one I wanted to highlight to you to keep at the forefront of your mind is there's a projection that by 2100 the Victorian Marine and coastal council have indicated that the impacts of sea level rise and storm surge are predicted to result in a $442 billion economic loss with almost every community along Victoria's coastline affected.

So, staggering figures there and you can see some of the implications that's going to have on our communities and our population growth that we have there with a projection of more than 100 ,000 people a year.

We have a growing Victoria's population. Sometimes I feel like the challenges is really overwhelming. But running today's session,

for those that have joined us previously, we have the brilliant rain consulting with us again today, both Luke and Rianda who are helping facilitate this, as well as our Melbourne Water sea level rise guru in Tara Wilson,

Wilson, our senior land use planner. So a bit of a quick intro into both of these people and then I will hand it over. So rain consulting was founded in 2019 to pursue creative and original approaches for managing water in Australia.

Both Rianda and Luke, they're founders and directors of rain consulting and they have a team of environmental engineers and scientists across both Melbourne and Perth,

focusing on all things stormwater management from integrated water management to large strategic projects through to flood studies and even designing and facilitating courses like the one you're about to see today.

Rianda and Luke both draw upon their decades of experience to help translate really complex ideas for a range of audiences. And they're passionate about knowledge sharing and enjoy learning and incorporating new ideas and concepts through their work.

And Tara, who will be presenting later on is a senior land use planner at Melbourne Water focusing on coastal hazards, particularly sea level rise.

Tara has 17 years in state and local government in coastal planning, flood management, waterway and stormwater management and emergency and disaster event response.

So I'll hand over to Rianda and Luke first and then we'll work through to Tara. - Thank you so much, Lucy, for the introduction.

I'm Rianda from rain consulting. I just wanted to start off as well by respectfully acknowledging the traditional custodians of the land,

the Wajak Nungar people in which I work and live today, having relocated back to my hometown of Perth after a very long time over in Victoria. I'd also like to acknowledge the traditional owners and custodians of the land and water on which Melbourne water rely on operate and many of you are located on today.

We pay our deepest respects to their elders past, present and emerging. I lived in Melbourne for 14 years, so a lot of my professional career on Wurundjeri land.

Here's the Wurundjeri calendar prepared by the Mary Creek Management Committee. During our last presentation, Luke described to us the poor neat tadpole season. Now we've moved across into the Boathgaru grass flowering season.

The weather in Melbourne is warm and rainy. The bats are catching insects in flights and the male common brown butterflies are flying. I love this.

The Victorian Christmas bush is coming into flower. I wanted to then talk about the Nungar season calendar. The Nungar are the traditional custodians which cover a large swathe of southwest Western Australia.

Today I live on the traditional lands of the Wajak Nungar people near Perth and as a kid I lived over 300 kilometres north of Perth on the lands of the U Ed Nungar people in a diversity hotspot in terms of its flowering plants and trees.

The region is home to over 900 species of plants. Some of you might have heard of Lissue National Park. People come from all over the world to see the wildflowers at this time of year. The rest of the year it just looks like a lot of scrub but wildflower season is amazing.

So in the Nungar calendar we're in Canberra which is wildflower season or the season of birth. We have the Mulja which is the West Australian Christmas tree.

That's in flower at this time of year the Nootsia Flora Bunda. It's in full bloom and it's pretty amazing to see across the vast vast landscape. This season is particularly special to me and every day I like to go for walks and see all the beautiful flowers,

wear a hat to protect myself as well from the swooping which are the magpies who are currently protecting their nests. We move into this final presentation in this training series with very much I suppose gratitude and thanks to Melbourne Water for having us involved on a personal note as well.

This is quite an important topic for Luke and I and as I know it is for a lot of people. I just wanted to acknowledge a little bit off script as well that it is it is a very challenging time to be in this industry and you know there is a bit of burnout amongst consultants and authorities alike.

Councils, Melbourne Water , we're all doing our best and I think we continue to learn together and just do everything we can for betterment in this space and for the ongoing protection of the community.

So introducing I guess the quick facts on climate change. It's so wonderful to see such a variety of people here today as well from different professions amongst council so some of you will be quite familiar with a lot of this content.

Others won't but I hope that there's something in here for everyone. We've really put together I think a pretty good little package of relevant information so hoping you can all take something home.

So what is the cause of climate change? So while they use interchangeably at times global warming. So we've got global warming and we've got climate change. Global warming refers to the gradual increase of the earth's surface temperature.

Climate change includes this but also covers the long -term change in global weather patterns. It's generally agreed by scientists that humans cause climate change. Sometimes you may hear people refer to it as human -induced climate change.

We know that the gases in the earth's atmosphere like carbon dioxide and methane work like a greenhouse. They can trap heat from escaping back into space. Greater levels of these gases increase the strength of the greenhouse effect.

Carbon dioxide levels fluctuate and have significantly fluctuated in the past. Things like volcanic activity can also influence this. The rises in temperature and carbon dioxide levels that we've seen in the past century are unprecedented and the rate of carbon emissions is the highest they've been in 66 million years.

I just wanted to talk about the IPCC as well, which we've probably all heard of by this point, so it stands for the Internet Governmental Panel on Climate Change. They're responsible for providing policymakers with regular scientific assessments on climate change,

its implications and potential future risks, as well as adaptation and mitigation options. So how does the IPCC communicate their research? They've recently released the Six Assessment Report.

You might have heard of it as the 6AR. The previous version was in 2014. This one was released, the 6AR was released in March 2023, so fairly recently.

It's nearly 8 ,000 pages long and authorities, I suppose, in governments throughout the place are still, I guess, digesting and working out what this means for them and how their guidelines.

So what are the key findings from this Six Assessment Report that we feel that are relevant to councils? So number one, there is evidence of global warming already underway.

The finding was that there was already 1 .1 degrees Celsius of global temperature rise attributed to human impact. And the last decade was the warmest decade for the last 125 ,000 years.

The summer Arctic ice coverage is the lowest it has been in any time in the last 1 ,000 years. Just on that topic actually,

there's some really interesting data sets that you can look at that show the summer Arctic ice coverage each year and how that has, I guess, declined particularly in recent years.

The ocean is warming faster than any time since the end of the last ice age and sea levels are rising faster than any century in the past 3 ,000 years. There's more evidence that there are tipping points in the climate system that once crossed can trigger self -amplifying feedbacks such as thawing permafrost.

And I think that this is really critical to sort of try and understand and get our heads around as well. If we have heard the word tipping points, you know, thrown about,

it's really good to try and understand a little bit more about what that means and it helps build that picture. Second relevant finding is that future risk will escalate rapidly with every fraction of a degree of warming.

So we've just got a table here from which explains the RPCC's working group to report the AR6 comparing risks from rising temperatures.

So across the top we've got the different temperature categories so what if we have one and a half degree of increase versus two, three and so on.

On the y -axis we've got what happens in terms of droughts, floods and coral reef impact. So we can see at one and a half degree of temperature increase 0 .95 billion people will be exposed to heat stress and desertification of areas.

So the dry land population exposed to these issues are reaching a billion people. At two degrees of warming it exceeds that with estimated 1 .15 billion people being affected.

In terms of floods, a lot of us are here today, at one and a half degree increase there's an increase in global population exposed to flooding of 24 % and at two degrees of increase this increases to 30 % of the population being exposed across the globe so in some areas it's more and in others it's less.

In terms of coral reef decline 70 -90 % of the decline of coral reef is expected under one and a half degrees of warming versus 99 % at two degrees of warming.

AR6 also provides global mean sea level rises projections. In Victoria the current 2100 planning level rise is for 0 .8 meters of sea level rise.

Sea level rise will be incremental over that period and that's an important note as well so it's not going to jump suddenly to 0 .8 meters at 2100 it'll be incremental and it's also expected to continue rising past 2100 as well.

Those seem like obvious statements but I think it's really important just to have a think about that as well when we're considering our planning. Adaptation can build resilience but is expensive to scale solutions.

So now we have around 170 countries that have climate policies considering adaptation. So by now you'd be quite familiar with what adaptation measures might be and in many cases these policies are yet to progress from planning to implementation.

In terms of some financials the 127 billion per year by 2030 and 295 billion per year by 2050 is required by developing countries alone to adapt to climate change.

So yearly budgets. In 2018 the funding was 46 billion. A bit of an interesting slide on ecosystem -based adaptation.

Probably nice to have a bit of a look at it. It breaks it down from all the way from the mountains for us and watersheds through the rivers and wetlands, farmland cities and coasts.

In terms of ecosystem -based adaptation a lot of these measures hinge around restoration of natural areas. For example if we're looking at rivers and wetlands a hazard might be asset loss yield reduction and contamination due to flooding with the solution being to restore wetlands to absorb and filter floodwaters.

We see some of these sorts of measures starting to come in as well even in terms of protecting our current waterways strategy.

Another hazard being to reduce or intermittent river flow due to drought. So the opposite end with the solution being to protect and restore forests and watersheds to regulate flow.

In some areas the damage has been done while adaptation is required to combat impacts or to you know be able to live with some of the impacts.

Some regions and ecosystems are approaching the points of no return. The 1 .1 degree of warming has shown in some areas that the damage is so frequent and severe that no existing adaptation strategies can fully avoid losses and damages.

So what needs to occur to limit the intensifying risks by 2025? The peak greenhouse gas emissions need to have been reached and those peak greenhouse gas emissions need to have been halved by 2030 with net zero greenhouse gas emissions worldwide by 2050.

Let's hand over to Luke. Thanks Rhianna. So a bit of a sobering start there so let's keep moving through it and then we're going to so I want to talk about what's expected to change so what sort of changes we're going to see on the ground here in Melbourne and in Australia where did the projections come from and then we're going to go through some brief technical work to sort of work out what this might mean for

you at council. So to the next slide here we've got the relative representative concentration pathway so you might have heard of RCPs before and these RCP numbers so the standard that we've got sort of three ranges we work within.

But the first one being 4 .5. Now just thinking back to Rianda's last slide of the needle on the graph there, we were saying that 2025 the peak greenhouse gas emissions need to be reached.

So we need to peak 2025 and half by 2030 and that's to limit the intensifying risks. So at the bottom of the scale here at RCP 4 .5.

And this is what the IPCC called the intermediate scenario. So in this one the emissions peak around 2040. So we were talking about 2025 to limit any of the irreversible risks.

So this one's peaking at 2040 and this is our bottom of the range one and then begin to decline from 2040 onwards. So, emissions should be well into decline at 2045 and around half the levels by 2050.

And by 2100. Sorry, I said that wrong there so half the levels of 2050 by the year 2100 so we need to half again by then.

So many of our plant species and animal species will be unable to adapt to RCP 4 .5. And we'll see a loss of ecosystem in Florida there. So what does that look like in terms of what we'll see on the ground that's a temperature increase of approximately one and a half degrees Celsius.

And this is based on Melbourne I should say the rainfall increase intensity increase at the 2100 would be around 7 .8 % increase. So,

if you get, you know, 20 millimetres an hour of rainfall today that'll be 7 .8 % more in 2100 and sea level rise impacts are still there and extreme weather changes,

you know, there'd be a moderate increase there. there. Remove to RCP6, that's the next one, that one's called the high scenario by the IPCC. So in this one the peak emissions,

we're hitting those around 2080 and then we start the decline from there so that's a sort of a slower reaction I guess there. The temperature increase we're talking about there is 2 .1 in Melbourne,

10 .5 % increase in rainfall intensity, sea level rise a bit more again and a moderate increase in extreme weather. Then finally let's have a look at 8 .5,

so this is the worst case, they title it. So this one emissions will continue to rise all the way through the 21st century. So a lot of people out there say that this scenario is very unlikely whilst also saying that those feedback loops that we were talking about earlier are really well not well understood and so hence 8 .5 is often taken as our worst case.

Sometimes it's called business as usual as well and that's a really sobering one there so if we continue the way we're going that's where we'll end up. Now with all the,

I'll go through the numbers on that one, so that's a three and a half degree increase in temperature, 18 .5 % increase in rainfall. The level we're planning to at the moment for Melbourne is 0 .8 of a meter sea level rise and we're going to see a large increase in extreme weather.

So across these RCPs here we could also almost have another column here of cost of adaptation and the theory generally is here that the highest cost to that too is RCP 4 .5 now,

so if we want to do something about it now that's obviously going to be where we're going to need to do the most work is to stay there and but at the other end of the scale RCP 8 .5 at 2100 the cost of adaptation,

if at all possible, is going to be much, much more expensive than what it will cost to try and stick to 4 .5. So that could also be another column there of little dollar signs of now and into the future there and with the big asterisks there of adaptation at RCP 8 .5 where possible.

So as the note says to the side there that the VPPs now or the Victoria planning provisions require land use and development plan for sea level rise of not less than 0 .8 of meter by 2100 and allow for the combined effects of tides and storm surges and other coastal processes and local conditions such as topography and geology when assessing any other risks with coastal impacts with climate change.

I think Tara's going to have a little bit more of a chat about this sort of stuff after our presentation. Okay, so how does this translate into your council?

So when we, on that previous table, we had RCP 4 .5 through to 8 .5, a strain rainfall and runoff, which is the book that a lot of drainage engineers stick to,

it dictates how we do things in our industry with regards to estimating rainfall and the impacts suggest that we do look at climate change and we plan for between 4 .5 and 8 .5.

So we're meant to look at both ends of the scale and make a decision at that point and it's widely accepted across Melbourne that we work with RCP 8 .5 for now. So if you click through this one read,

this is what we call, this is a page of the Australian rainfall and runoff data hub and this I'm going to show you how you can get your council's climate change factors.

So what you do, and we'll go through a worked example in a second, but we get your popular address in where we're at and this example on the screen, it just says Melbourne. We click the interim climate change factor button,

and then press submit. There you go, and you can circle it. And then what will pop up is you'll get this table here. So this tells us our interim climate change factors.

What you've got is in the first number under each level there is the temperature increase. So the very first box, RCP 4 .5 in the year 2030.

We're planned for a 0 .648 degree increase in temperature and a 3 .2 % increase in rainfall intensity. Those two are linked there. And then if we go to the very opposite end of the scale,

RCP 8 .5 at 2090, it's saying just over three degrees of temperature rise and 16 .3 % increase in rainfall intensity.

So what we might quickly do is just do that live. And I'll touch around and throw it here. She does it on screen. So what we'd start with,

you can do this for your council, of course, as well, start with an address. So you can either enter a longitude latitude over to the left or much easier way is just to write a suburb in the top window there and search.

It's not so defined that you'll get a different answer from number one on your street through to number 44 on your street. It's quite broad. So just go by suburb to suburb and you'll get close,

or you'll get the right at the same answer. So now that we've located ourselves, there's all these different options down the side which do all sorts of things for flood modellers and hydrologists.

The ones we want to click today is the interim climate change factors. And just for the next part of the presentation, I'll ask Brenda to do the bomb IFD depths as well. And we submit and you get this print out here.

And you can see here that we've got the same table I showed on the previous page. And you can download that down the bottom as a text file or a PDF or whatever you need. So one thing that worth noting here is this goes to 2090 down the bottom.

So and we often plan to 20 on 100. So it'd be lovely if this could be updated in AR &R, but I can see Ruwan on screen.

Hi, Ruwan. Good to see you. I've got your spreadsheet on the next slide. So let's jump into the next slide. So this one might look familiar,

Ruwan. So this is a spreadsheet Ruwan showed me when he was at Melbourne Water. And this is how Melbourne Water extrapolate out from the 2 ,090 value that was on the AR &R website there,

that last website we're looking at. And to work out where we'll be at 2 ,100. And it does it for temperature and increase in rainfall intensity. It shows a bit of a method there to just extrapolate out.

It's really just a bit of an extrapolation out from based on the data behind it. This is where in Melbourne, it'll take you to an 18 .5 % increase at the year 2 ,100 as the total,

so bit of a linear interpolation out, more or less. In some of the previous presentations, we've talked about the IFD curves or intensity frequency duration curves.

Just as a recap, what that does is we've got all the different colors shown through the rainbow there. And they correspond in the legend on the right to different what we call AEP events,

annual exceedance probability. There's a translation from the old way we used to say things where we used to say the 1 in 100 year or the 1 in 50 or the 1 in 20 year, we now turn those into probabilities which just help us a little bit with communicating with the community and others.

But essentially 1 % AP is similar to what we used to call the 1 in 100 year event. Along the bottom of the screen on the x -axis we've got the different storm durations,

that's more or less how long is it going to rainfall, how rainfall and on the y -axis on the left it's the rainfall intensity. So really simply we can look at that and go across and say if we got 10 millimetres in 10 minutes in this particular area what sort of event would that result in?

On this point here and maybe we'll skip back to the Bureau website, just sorry to the AR &I website here and you can see when we ticked the Bomber IFD button previously we also get that little section there it says Bomber IFDs and says click here to obtain the IFDs for your catcher.

So we'll do that. Now this is based on where you put your data in previously so we'd be right Melbourne if you put Lilydale, it'd be Lilydale or anywhere in between.

On the left hand side we've got the design rainfall section, very frequent so there are more common events, smaller ones frequent and end frequent so that's taking us up to the 100 year or 1 % AP and the rare that's going to take us up to the 1 in 2000 year event so we can pick which one we want there we'll leave it on that one for now.

On the right hand side in the green we've got the table which shows it you know in the number way but if we click the chart tab there to the right you can it's a similar graph to what we had on the previous slide.

What was on the similar on the previous slide? So what a really cool thing to do with this is, though, is that you could set this up for your council and have it ready to go.

And then over to the left of the screen, it says observed rainfalls. Yeah, and we can drop that down there. So what often comes up,

obviously we say we had a big rainfall event last night. But you've arrived at work this morning and people said that was a big rainfall event or you've got complaints coming in from the community and you want to understand what that event was.

So you've got a rainfall gauge somewhere in the municipality. Let's have a look at that and go, okay, it was about rain for 45 minutes and we had 20 millimetres of rain.

So we can just put in 20 there and if ground oppresses the update button. And it clicks us back to the table view and it tells us it was between a 50 % and a 20 % AP.

And if we click on the chart, it also plots a little black dot, which is a little bit hard to see, but just below the orange there, it's around us pointing to. So it plots it there. And say it again,

if we put that up to, say, 50 millilitres, so it's a bigger event or 505 would be huge. We can see here that it's coming up as a less than 1 % AP event,

which don't get confused there like I do sometimes that it's actually higher than a 1%. So less rare, but when we're talking about probabilities, it's less than 1%.

- More rare. - More rare, yes, sorry. So it's above, it's greater than a 1 in 100 year event or a lower probability of occurring than a 1 % AP event.

So that's a really useful tool for you when you're at council and you have a big rainfall event, you've got people wondering what happened. We can use this sort of style thing to help us through that and help communicate with the community.

Back to the preso. Okay, so what does this mean when we're talking about for this particular example with an 18 .5 % increase in rainfall intensity?

On this one, I've just replicated the plot twice just for the one percent AAP from the 1 in 100. And if you don't mind clicking here around in the current climate,

if we were to imagine a one hour duration event, so it's rain for an hour in Melbourne, that would equate to 41 point, let's call it 42 millimetres of rainfall would have fallen.

And if we plotted that on the previous website, it would have shown up right on 100 year. In 2100 with an RCP of 8 .5, 18 and a half percent increase in intensity brings us up to just under 50 millimetres.

So we're going to see a greater volume of rainfall in that period fall across our catchments, increasing that intensity. What does it mean for plant management? So how is this going to apply?

This slide gets a little bit technical. I'm going to take it nice and slow. But yeah, we'll see how we go here. So this is our catchment. That's very typical catchment. We've got some trees,

houses, cars, and up on down the bottom or a waterway or a lake. The rain comes in, starts to rain across this catchment. What we get here is as soon as that rainfall hits the ground,

we'll lose some of that rainfall through vapour transpiration or land in the trees. We'll also lose some to infiltration into the ground where we've got heavy surfaces. What doesn't run into the ground?

We'll run off and head down towards the houses and the cars and end up down in our water body or a waterway or a receiving outlet. And of course,

there's some evaporation that occurs then once it sits for long enough. And once the sun's come back out again, and there might be some flooding along the way, you can see that little flood down the bottom of the catchment there.

So generally speaking, when we're talking in hydrology and when we're working at what happens in catchments and thinking about the volume of rainfalls, how much water fell from the sky, how much of it did we lose to what infiltrated into the ground and other losses like evapotranspiration,

things like that and what was lost through evaporation and often that evaporation when we're talking about flood management and things like that doesn't come into it because it's not that quick a process to really make a difference to us.

So we're going to do a quick example thinking about what the impacts of climate change would be. So we're going to imagine that we've got a catchment draining to an area that's about to be impacted by the border and that's called that pond down the bottom.

We'll say that catchment's 45 hectares so that's a pretty big council size catchment that's pretend it's a critical storm of nine hours so what that means is when we look at all our different storm durations the worst case scenario for this particular catchment is the rain that goes for about nine hours there and then peters off after that.

In the current climate so in today's climate the thinking 92 millimetres of rainfall will land across that nine hour period and that will increase to 109 with the 18 .5 % increase in intensity there so a bit of an increase so what that would look like in a graph format to the left there this is what we call a haitograph but it's essentially rainfall falling over those periods so you've got nine hours across the x -axis

there and the how much rain falls in the y -axis and we can just say very simply it's just backed it up a little bit each time so more rain is going to fall.

So let's assume that the catchment is pretty developed so that's 70 % impervious so there's a lot of hard surface out there and that limits the amount of infiltration that can occur when it hits the ground.

We're going to take some of, say, AR &R, Australian rainfall and runoff, does give us some guidance on losses and how much is going to soak into those annual areas. There's lots of things we need to consider around applying those losses,

but we're just going to crudely, for this example, grab them and use them. So when we talk about losses, there's an initial loss. So as soon as the rain falls, how much rain needs to fall before stuff will start to runoff?

That's 12 millimetres. So we're going to throw the first 12 millimetres that lands on these permeable areas away. And then for every hour after that, we're going to throw away 1 .9 millimetres.

So that's just some losses. We're just taking some of that rainfall away and discounting that. So just as a quick recap,

we've got 45 hectares. We've got 92 or 109 millimetres of rain, depending on which scenario. And we've just thrown away some of that rainfall as well due to losses. So now we're just thinking about what's left on the ground and what's running towards that puddle.

So in the background, a little spreadsheet's doing some work. The model is working away there. And it results around 31 ,000 cubic meters of water reaching the flooded area in the current conditions and 39 ,000 in 2100 conditions.

The takeaway here is that in this particular example, and this is not linear by any means, that will change depending on your catchment and conditions. That's a 25 .8 percent increase in volume from an 18 .5 percent increase in rainfall intensity.

So when we talk about an 18 .5 percent increase in rainfall intensity, that's not an 18 .5 percent worsening of impacts as a variable.

So when we then translate that, though, that 25 .8 percent increase or the extra 8 ,000 cubic meters of water in that puddle down the bottom,

that could mean all sorts of different things too, depending on the shape of that puddle. The difference in depth that creates will mean one thing, depending on the shape of that, the extent of it,

the volumes, the velocities, all these different things will change, but the important takeaway here is that's not a linear translation of the 18 .5 % change in rainfall intensity. So this is what I'd call a calculation here,

looking at the impacts based on a storage type solution. So we have two types of flooding really, ones that where the water comes to a point and stops and stores. On the next example we'll go through is a conveyance example.

This is where water's moving through a catchment and so where the water's traveling at the moment. So we're going to adopt exactly the same conditions again, 92 mils or 109,

70 % impervious and crude losses. So what have we got left? There's a formula that hydrologists love to use called the rational method estimate.

It takes in some of these catchment characteristics and tells us what the flow rates are going to be. So how much water is going to be passing a point across all the different AP events.

In this one you can see that when I plugged all the numbers in to the rational method estimate, we've got in the hundred year in the green, that's today's conditions 7 .35 meters cubic per second.

That's the flow rate and then with the additional 18 .5 % intensity it would go up to just under 9 cubic meters per second. What will that mean though is in the real world in design.

So what we're going to do here is pretend we need to design a pipe for a road. So you've got a new development area, you're trying to to replace an existing pipe within your council area. And let's pretend that we want to keep the 10 % AP or the one in 10 year event underground and the rest will go down the road.

So council's level of service here will be sort of a one in 10 year pipe capacity. So in the green again, I'll just run through some quick numbers here. We've got in the current climate,

a 1200 millimetre pipe will do the job. But when we go up, we need to upsize the pipe one size to a 1350. So that's the realities there of that one that we've gone up a pipe size.

The next click for me. So that results in a 22 % increase in required capacity from an 18 and a half percent increase in rainfall intensity. So not quite as large an increase as the previous slide,

there's still an increase in this example. So we've had to upsize a part there and work with that. So that's not too bad. Then one more here is the remainder.

So that was talking about the pipe and how much room we need for the pipe and what size pipe we needed. How would this translate to what was running down the road though instead? So we've just assumed a normal road,

a 1 % sloping roads, just a nice gentle slope with normal curb height, you know, 150, 200 mils or something like that and 20 meters wide. And you can see here the top rows,

the current climate, the one below is the future climate. The velocities go up slightly. So the water's going to move a little bit quicker in the 2100,

just to pass that same volume through. In this one, the depth has gone up two centimetres. So a little bit deeper and the flood hazard has gone up slightly as well,

but all still remain within water safety limits in this example. So again, just sort of demonstrating that we've got some impacts here due to this increase in rainfall intensity.

- I'll just add in there Luke as well for anyone that isn't familiar with what we're talking about here. The gap flow is referring to whatever can't fit in the pipes underground.

So in this case council says for the 10 % AP all that flow to be piped underground. So if you get a 1 % rainfall or a 100 year rainfall event occurring you can assume that anything up to that capacity will flow underground and anything above that up to the total volume for the 1%.

We call that the gap flow that'll flow down the road down the road reserve and generally we kind of design around that. So Luke demonstrating here the difference then between even that gap flow what flows overland in the 2100 climate change 1 % AP event.

Thanks Rhonda. There's a lot of detail on these last two slides. I know that but I wanted to give a practical example with the key takeaway. I don't want you to feel like we're trying to show you half size pipe or anything here.

It's around looking at what sort of impacts this will mean on the ground for your day -to -day operations and Ruwan I've seen you've just said can we share the recording. These will all go up on the your say website after the presentations absolutely and all the previous ones are there too.

Okay so we're going to look at a little bit more specifics of how this will impact both coastal and non -coaster regions.

So what creates a downstream tail water level for our part designs in this little picture. We've got a part you know going through a dune at a beach to an outlet on the in the bay there.

It's a Bayside City Council or a Kingston City Council or Frankston or the Mornington Peninsula or any of the Bayside ones there. We've got different tides.

They've got spring tides and neap tides and you can have a look at the diagram in there that need to sort of explain it word for word but essentially the moon drives our tides. Hopefully that's not a surprise to anyone and we get different levels of those tides as well.

So there's obviously much higher tides and much lower tides and that's something we would be considering in drainage design if we were doing an outlet to the bay or any coastal area.

Yeah, we calculate that. Next slide. Okay, so like I said there, we're looking at the outfall of this part. So with the impacts of climate change,

we're going to adopt a 0 .8 metre of sea level rise by 2100. I'm devastated because that water's meant to be moving up and down and I put a lot of effort into that animation and it's meant to be shifting.

Oh, here it goes. Thank you. So what I want to talk about here is inlet conditions and outlet conditions and this is really, really critical in when we're designing drainage.

So when we work at how big a part needs to be, how it's going to interact with the surface and how much flooding it's going to create, we need to understand whether the part that we're looking at or the asset we're looking at is going to be inlet or outlet controlled.

So the first example, inlet control and that's most common in drainage design. So it's where the capacity of the pipe or what happens within the pipe is controlled by the upstream conditions.

So what's happening at the top of the pipe? Generally, water moving through these pipes flows faster and that can be called supercritical flow sometimes. And the roughness of the pipe,

the length of the pipe, and outlet conditions do not play a part in determining the capacity of that pipe. So it's all about what happens at the top end of the pipe. But in the scenario here of the water going up and down,

if the water's below the bottom of the pipe, it's going to be in that controlled. Then outlet controlled. So when we've got the water level moving up and down,

we've got some climate change impacts. We might see some of our outlets become drowned. That's going to mean that they fit to outlet -conditioned controls. So the flow capacity is heavily controlled by what's going on in the bay or in your downstream condition.

The flow through the pipe moves a lot slower. So you can think about, you've got a drowned pipe and the water's got to push its way through to get out again. Roughness of the pipe does play a big part of it.

But most of the difference is between what we call the head water and the tail water depth. So where is it deeper? Is it deeper at the upstream end or the downstream end? That creates an energy grade which pushes the water through.

And that's what's dictating the capacity there. So if we've got pipes out there at the moment, which are sitting above the tide level and are acting under inlet controls and climate change and sea level rise of 0 .8 is going to drown those,

we don't see a difference in the performance of those assets and a difference in the way we design replacements. About waterway outlets.

Another amazing animation here. Next job is going to be a Pixar, I think. So same again, inlet and outlet controlled.

So you can just probably do the second click on this one, if you like. So very similar. So in this example here, though, this is say a waterway at the downstream end, not necessarily the bay going up and down or the tides.

This could be a waterway. And the reason the water might be going, being higher in 2100 is because we've got that more intense rainfall intensity from other catchments draining to this waterway,

more volume moving through our catchments, this could be a retarding basin that could be anything like that. And yeah, so if when they're sort of coming in below those levels,

it's going to again impact the way we do things. Okay, so this is a snippet from the two -flowing user manual,

a lot of you might have heard of two -flow before, that's the main flood modelling program out there and it's got a nice little diagram here which we refer to a lot in terms of how water moves through pipes and they've sort of identified all these different ways which water can move through a pipe here.

And there's two that we're going to focus on being B and F, B is an inlet control one and F is an outlet control one. Okay,

some more amazing animations if you'd like to click to get them started. Okay, cool. So on the left we've got the inlet controlled, so this is the one where we've got the low -tail water,

what you'd expect to see there is a high, so the inlet or the the head water level which is the left of the screen. We've got the water levels higher there than it is on the downstream end and the water pulls down through the pipe,

so where those are as ours within the pipe or a culvert and starts moving a lot faster through that pipe and is controlled by what's going on upstream, so very much inlet controlled. And when it gets out to the tail water it's maybe a little bit of what we call a hydraulic jump there just to help balance itself back out again and move downstream,

so very much inlet controlled. The second example being the outlet control where the tail water level is high, so we've drowned our pipe. The upstream level is the same at the moment and we can see that that's water's moving a little bit slower by the arrow and sort of waiting to get out and what that's going to do is create that that animation is not as great.

Sorry about that one, but that's a flood coming up. The water level on the upstream side is rising because of that change in conditions there downstream. So we've fit from inlet control to outlet control.

And so in what I'm trying to demonstrate here is in reality, this is going to create some deeper head water levels that might be an area that we're interested in upstream.

That might be a residential area. It might be about to overtop the road there, just an important road. It's just something to know that now it's going to start constraining our drainage network if we flipped out that controlled conditions.

And then that can, of course, propagate all the way back up our catchment and create all sorts of issues. So sort of the real world scenario of what a change in tail water level can do to us here.

Back to you now, Heather. Thanks, Luke. At the other end of the spectrum, everybody, I got frustrated trying to animate this flow chart. So we can all just settle into a static few flow charts coming up.

And you just have to follow along at home. I thought the animations were great, Luke. So we're going to go through the R &R guidelines for consideration of climate change.

I think these ones from the interim guidelines are correct, Luke. So they kind of give some, you'll find these flow charts pretty well in their current form within those guidelines.

And it sort of steps you through some key questions to ask when determining how or whether to consider climate change.

So step one is to understand the service life. life. So what is the expected timeline of the asset or the planning horizon? So we determine the service life with the asset or the planning horizon,

and this underpins the design philosophy and may fundamentally control the selection of material methods and expertise. A broad perspective on service life may be required incorporating engineering,

client and community perspectives. Potential climate change considerations may influence these decisions, particularly as the risks from climate change are likely to increase over time.

So if the service life or planning horizon is relatively short, anthropogenic climate change may have a negligible impact potentially,

and so currently the guidance is to just simply use AR &R Book 2 for those sorts of things. So that's saying that the exposure risk is low and that we should base that design process on Book 2.

So for that we'd use approaches such as at -site frequency, regional frequency or catchment simulation techniques. Otherwise,

if there is a longer planning horizon, then we proceed to step two where we have to set a flood design standard around it. In step three,

we need to consider the purpose and the nature of the facility. I think in the previous step as well, sometimes we might consider that two. But anyway,

step three, what is the purpose of the asset? What is the flood risk and the consequence of failure? So what sort of asset do we have? What's the purpose of the facility?

Is it an asset, process or management strategy? May include flow conveyance, improved safety or reduced frequency of exposure and damage. Flood -related design requirements,

for example, minimum fill levels and floor levels need to be considered as well as the consequences of failure. So what are the risks to life, property and the environment?

And we might consider things like what is the vulnerability of the assets that may be impacted or the community that may be impacted in the area? What is the cost of retrofitting assets as the rainfall,

IFD characteristics change in future? The impact of possible failure of the facility will have direct and indirect consequences and should be assessed in terms of primary risk outcomes as issues of cost,

safety, social acceptability and environmental impact. Some categorization of facilities may be useful when determining the consequences of failure.

For example, projects or decisions involving assets involved in the delivery of essential services can have very damaging consequences if performance is significantly impaired or if failure occurs.

So if we determine that it's low risk, again it points to using AR &R Book 2 for design. However, if it's determined as being high risk,

we then move on to the next step which is to carry out a screening analysis. So this responds to the question, is climate change a significant issue for the facility of interest?

And here the risks of climate change to assess with regard to their capacity to impair the facility's ability to perform its intended function. The outputs from this step include an improved understanding of the extent to which the risks of climate change may exceed the coping capacity of the facility to perform its intended function.

If the incremental impact and consequence are low, we jump back down here. However,

if otherwise we need to proceed to another step, step five, so we'll do that. Step five, we need to consider climate change projections and their consequences.

At this point, the exposure to climate change and consequences of impact on performance has been judged to be medium or high risk. Hence, consideration needs to be given to whether the original design specifications of the project or decision need to be reviewed and adjusted.

This will necessitate the use of climate change projections. So we might find here that we have a trivial impact or it might be anywhere from there up to a large impact,

at which point statutory requirements also need to be considered. And back over to Luke.

- Thanks, Rhianna. So final couple of slides here about climate emergencies. You've probably heard about councils declaring council emergencies.

And just wanted to talk about what that means. So let's jump to the next slide here. So usually councils are declaring climate emergencies.

It's something that happens at council level. And it's generally recognizing that climate change is causing significant damage to our economy, society and environment.

And that urgent emergency action is required to reverse current trends and secure our plan. So there's a nice website, climatecommendacydeclarations .org, demo in the bottom corner there,

which looks across the world at how this is going in terms of councils or the areas of management in other countries declaring an emergency.

You can see on the left got the little graph there of how many councils have declared a climate emergency across each state and territory in Australia with Victoria sitting up at 41 of the councils.

And then as you go to the right, it shows the population covered by those. So, South Australia and the ACT are doing a great job there, 100 % of the population now living in areas where a climate emergency has been declared and we're not too far behind on 62 % of the population are now living in areas where the council has declared a climate emergency and a little bit of catch up to do in Queensland and WA there.

So, there's a list here which was, it may have changed if there's any new commas in the last month or so. These are the ones we had about a month ago.

So, check to see if yours is in there and a special shout out to Darebin City Council who were the first in the world.

So, I think that's pretty awesome to have a Victorian council in there who was the first in the world to declare. So, yeah, have a look through there. What we'd like to think about those,

what does this actually mean? So, we've got a, your council's now declared a climate emergency. Does that change the way we do our jobs on a day -to -day basis?

So, what do you think that means for stormwater management? I've just in the chat window posted a link to a little poll. If you've been to any of the previous ones,

you'll be familiar with these. It'll ask you to go to your previous one there, right handed down the bottom. If you just pop that in,

I'd ask you for your name and then when you come in, it'll say for a council that has declared a climate emergency, what do you think this means for stormwater management? What do you think it means for you in your role at councils?

You can write a response and submit. Other people's responses will start popping up below and you can thumbs up or thumbs down them depending on what you think as well if you really want to,

democratic here. Let's see, let's let a few of them pop through. So needing to assess the capacity and resilience of our stormwater assets,

obviously, what we've been talking about today, that's brilliant. We've got no change there as well,

thinking that means a few things it might mean that we're not expecting to see much change for climate change in that opinion or perhaps the climate emergency there is not,

doesn't have the teeth to actually do anything. Maybe that's the comment there. Feel free to shout out if you're that person. I want to talk to that one, taking climate change into consideration when making decisions.

There's another one there and that's that sort of flowchart that we're going to talk through there as well of understanding when it's important. It doesn't necessarily need to be every decision has to incorporate climate change factors,

but it's important to keep it at that starting point and to understand the life of your asset and community of risk and those sorts of things to understand. understand. But try to just click that yellow box there,

and then we'll see the other responses that are coming through. So good ones. Ready use of WSUD principles, lovely, reduced level of service for existing infrastructure, absolutely.

Yeah, priority of climate change may go up compared to other types of investments. And maybe your projects that I'm working towards addressing this might get a little bit more attention than they may have in the past.

Responsibility to build and plan according to flood risk and rainfall intensity. Absolutely, build and plan is a big one there and help the community do the same. Excellent,

feel free to keep writing those in. We might skip back to the presentation. Is there too bad for time, I don't think. This last slide,

just a lovely little montage of some of the front covers of all your climate emergency response plans. So usually a lot of the councils that have declared a climate emergency then produce a climate response plan.

And you can see that they've generally got dates on them. I can see the Brimbank ones is 2020 to 2025. The Knox one, 21 to 31, 21 to 25 for Glen Eira and so on.

So plenty of those out there, if your council's got one, you haven't read it. They're generally very easy to find on the websites. So we might now throw over to Tara.

I don't know if I'm through with a bigger presentation for us. So thank you, Tara. Thanks, Luke. And thank you so much, Rianda and Lucy as well. Great presentation so far.

And I just wanted to run you through some of the changes that are coming from the Melbourne Water perspective in terms of sea level rise and how we're responding to recent changes.

So if we jump in, thanks. Okay, so you may have used Melbourne Water's sea level rise guidelines. So the latest version is from 2017.

but there has been a few things that have changed since then at a global scale and at a Victorian state policy scale. So firstly we had the IPCC special report on oceans and cryosphere in 2019 and that actually re -looked at the melting of Antarctica and the impact on sea ice and it led to a revision of the change of sea level rise for the Australian context and there was a response by the state government to

actually re -look at the sea level rise benchmarks that are in our policy. So we've had to respond to this as well in terms of updating our guidelines and I'm just going to talk you through the three reasons why we need to do that and what's possible in terms of opportunities going forward.

So the first reason obviously is the change to the marine and coastal policy led by that change in the global predictions and what's happened there is they've actually removed the 2040 infill sea level rise level.

So previously we've had a level of 0 .2 metres for 2040 basically for infill development and that was removed in 2020 as part of the marine and coastal policy and the year before that we actually had the release of the what was DELP guidelines for development in flood affected areas.

Now this included coastal flooding within the context of flooding and also included safety criteria for maximum depths on roads of 0 .3 meters for residential and 0 .5 meters for industrial.

Now this has been a bit of a policy shift and it means that we're considering sea level rise within this new context so we need to update our 2017 guidelines to firstly make those changes and then a few of you today may have realised too that the Marine and Coastal Strategy 2022 also from DECA included an action to update the sea level rise benchmark over time.

Now this is in recognition that as Luke and Rianda have mentioned earlier that sea level rise is not static it won't simply jump to a 0 .8 meter for 2100 level it will incrementally increase and it also is not predicted to stop at 2100 it's also predicted to continue on in an exponential manner past 2100 so it's expected now that the range of sea level rise will see within Victoria is likely to continue rising so

there's a lot of work going on behind the scenes to consider what that could mean and where that will go so in terms of Melbourne waters planning for sea level rise guidelines we need to consider wording around the longer term so our policy is still 0 .8 for 2100 but there's an expectation that over time things may increase so we need to update that in our guidelines as well.

And then the third thing is related to adopting a risk -based approach. We're considering how we can adopt risk -based planning. Now, we did have an action within the Port Phillip Bay and Westernport Flood Strategy action plan, action 1 .4, that specifies the need to consider a risk -based approach in terms of how we do our land use planning.

A good example of this is when you look at the vulnerability of land use, you wouldn't necessarily want a hospital in a high risk location or even a medium risk location.

Whereas if we were considering a shed or something that could be temporary or have a lower asset life or less of a consequence,

then that might be more suitable within a high risk location. But there's a lot of testing and analysis that is actually required before we can apply that use.

And a lot of consideration about the current Victoria's planning provisions and where the state direction is heading. So, this was just an update to let you know that we are considering these issues very seriously.

We're responding to the state policy changes and we're trying to update and amend our approach to consider risk over time as well.

But our current approach, if we flip to the next slide, thanks. So, currently, to meet the transition, we've developed an interim development assessment principles for sea level rise.

Now, this incorporates the changes from the Victoria's planning provisions, so that removal of the 0 .2 metres for 2040 for infill development and just remaining with the 0 .8 for 2100 as per the state planning policy.

And it also includes the, as I mentioned earlier, the guidelines for flood affected area for development in flood affected areas that has those considerations for depth on road flooding.

And how that interacts with evacuation and emergency egress during a coastal flooding event. And so consideration of that is within Melbourne waters process now.

So we've had to respond to those guidelines. And so there has been a change. Yeah, I've got someone off mute.

So did we, so I just wanted to give you an update on that following on from the fantastic presentation that we've had.

And that these, this process is in the works due to the ongoing nature of changes occurring within the policy context.

It's likely that that we will update our guidelines fully mid next year, but there'll be ongoing communications on this. Great.

And thanks, Lucy. Great. Thank you so much Tara for your update there and also to Luke and Rianda for the presentation.

We have a few minutes here for questions that we would like to address. And then we'll run through our feedback survey there.

We'll pop the link in the chat as well. So please implore you all to provide any feedback you have on this session and also the series of sessions that we've run as we're looking to roll out the capacity building next year as well.

And we welcome any feedback or particular topics that you'd like us to cover. So I'm just going to run through the chat here and I'll see whether we've got some questions that we can talk to now and let me just scroll up.

Okay so Roger I can see here you have a question on whether we can comment on whether the projected 2100 18 .5 % increase in rainfall intensity addresses urban heat island effects and if not what the impact of urban heat island effects could be.

Luke I can see you're off mute. Yeah I can I can do it. G’day Roger. So um as far as I understand uh so we'll go back a step to urban heat island effect for those who aren't aware is in sort of heavily let's just say concreted areas we can get an exacerbation of temperatures in those areas where you sort of get the refractive effect of you know the heat coming off the roads and the buildings and all those

sorts of things and particularly in very urbanized areas we can that have sort of been um stripped of trees and green vegetation and things like that we can get seemingly hotter conditions in these areas and lots of science behind there.

So when we're talking about the 18 .5 % increase in rainfall intensity it is very much linked to the projected temperature increases from what I understand though they are separate to any urban heat island effects so you wouldn't expect to see a greater rainfall intensity over a very urbanized area compared to a rural area um I think it's more sort of a weather thing there.

But absolutely, if we were to be seeing an increase of temperature, let's say it's three degrees by 2100 or something like that, the impact in areas that are currently seeing urban heat island effects would also be exacerbated there too.

So it's extra temperature and extra warming again on top of that. So it is, you know, probably why a lot of our councils and governments have got urban forest programmes and things like that now to try and limit the impacts of those urban heat island effects at the moment and trying to keep water in these catchments to help all these areas nice and green and wetting things like that.

So I can see your second question here, Bradshaw, absolutely. We'll send her a link to that part of the area now or the decision tree sort of section there. Great.

Thank you, Luke. And I can see here there is a question from Justine. And the question is, how would you approach risk -based land use planning with only some of the data sets,

including climate change? Tara, are you happy to talk to that one? Yes. If Justine's there, did you want to just clarify? So in terms of climate change,

so we're looking at risk -based planning from the perspective of sea level rise. So we're looking at just sea level rise. We're not looking at broader other climate change.

Were you thinking, was your question regarding broader climate change data sets or just sea level rise information? Justine's there.

Probably more broader flooding data sets.

so Ruwan who's also on the call, I know we've called you out a Extrapolation of the AR &R data in terms of assessing the 18 .5 percent rainfall For the Melbourne region and then there's been considerable work looking at what the impacts of climate change would mean For flooding and that's an ongoing and assessment through our flood modelling program so The increase in rainfall is being considered And it's

an ongoing modelling Process and program but as you can probably appreciate it's a Cost the exercise to remodel areas and the Melbourne water region covers from Western Port Bay through to All of Port Phillip Bay and the upper catchments.

So There's a lot of catchments to cover but If you're interested I can put you in touch with someone from the flood information team who works more in that area And Lucy we had another question further down regarding the Port Phillip Bay Coastal Hazard Assessment that DEECA is managing So and sorry,

who was that from Alan? Yes, so Alan myself and the flood information team are working through that transition. So I think my details are available or I can get in contact with you about that as well I think I've got your email through the invite list Yep,

so again, that's um, we're aware there will be implications In terms of flood levels Mapping extents etc. And we're eagerly awaiting the release of the data as well Great.

Thank you. Thank you, Tara. And I think there's time for one more question, and it might be another one for you too, Tara, from Lalitha. And the question is,

how Melbourne Waters Update dovetail with incoming planning and building considerations, acknowledging that it's all a bit of a moving beast.

But any update from you, Tara? Yep. So Melbourne Water is determining a referral under the LSIO and the Flood Overlay. And the specific provisions of the Victorian Planning provisions relate to the LSIO requirements,

which haven't changed. So our consideration, currently, we still use the same requirements and criteria from that LSIO,

but yes, there will be further considerations needed as provisions change. But currently, our determination is based upon the LSIO requirements and our Planning for Sea Level Rise interim development principles at the moment.

Great. Thank you very much, Tara. I might wrap up our Q &A session there just so we have time to finish up. Again,

I'd like to give a really big thank you to Tara for your update and questions today. It's very much appreciated. And also a huge shout out to Luke and Rianda from Rain Consulting,

who have been with us on our capacity building journey through this year and have expertly delivered, helped us deliver and facilitate these sessions.

So it's very much appreciated. I wanted to give a quick update that on our Your Say page, we'll be releasing one more session that will be uploaded later on this month.

And the session is designed at being a bit more of a tutorial resource at working through some of the flood data systems and applications.

So if you're a subscriber on the your say page, if you've followed the page, you will receive an update when that one is released. But I'll also be sending through an email to say that that final session is uploaded.

And please feel free to share that internally with your colleagues and anyone in the flood management space that you think it's beneficial to. I'm going to give one more plug for our feedback poll there.

We would really appreciate any suggestions for any content or upgrades that you have for these sessions. As I mentioned,

we're looking at running them again next year as part of the flood management strategy. We're really keen to incorporate any feedback and ideas you have. And on that note,

I would like to thank everybody for their attendance today and throughout the capacity building presentation series. It's really nice to see some familiar faces and names joining across the series.

And we look forward to working with you more closely in the future. So thanks to everybody for coming and have a great rest of your afternoon.