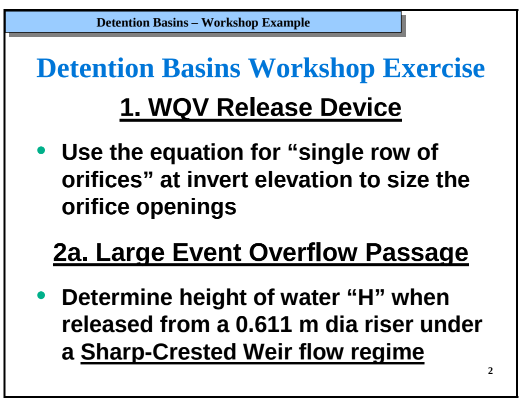
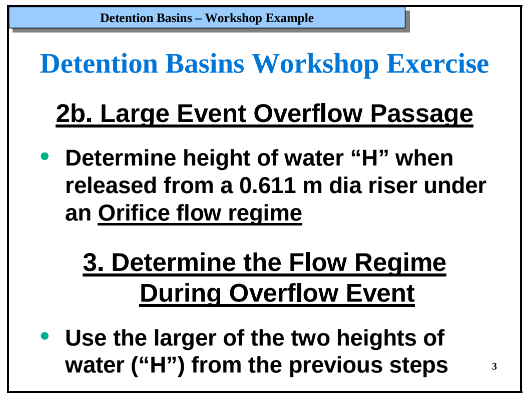
Slide 1: We will perform several engineering calculations needed in the design of a Detention Basin; refer to the Workshop Handout for a description of the problem, and to find the equations that will be used. The steps and calculations to determine the tributary area, the runoff coefficient, the Water Quantity Volume event depth, all related to calculating the WQV to be treated, are assumed to have already been done.



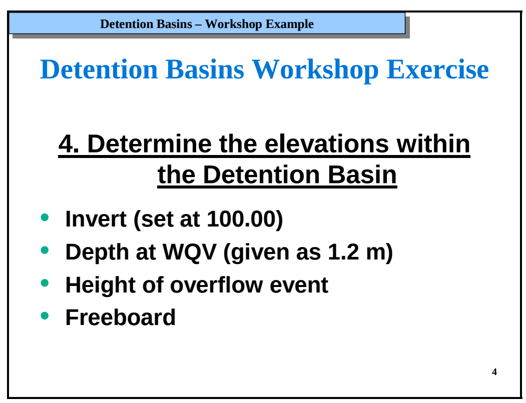
Slide 2: This slide and the following give an overview of what we will solve today.

For Part 1 we will use the Orifice equation for "single row of orifices" at invert elevation to size the orifice openings. For Part 2 is a two-step problem: for Part 2a we will solve release from an open riser assuming flow over the riser acts as a Sharp Crested Weir. We will then analyze as Part 2b release for the condition of the flow over the riser when the flow regime if orifice flow. The formulas for both flow regimes are in your Workshop Handout in under Detention Basins. Remember that the largest event that can enter the basin (up to or equal to the 100-year intensity event) must be accommodated for the safety of the basin.



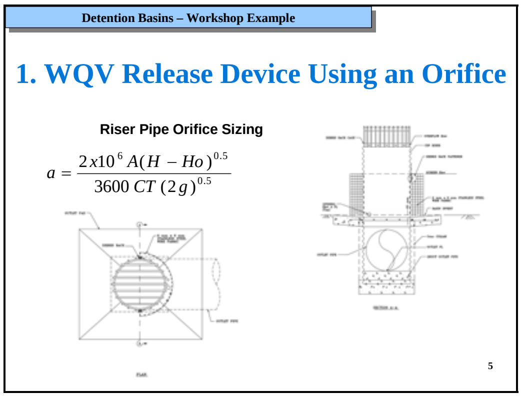
Slide 3: We will then analyze as Part 2b release for the condition of the flow over the riser when the flow regime if orifice flow.

In Part 3 we will take the higher H over the open top of the riser, as this will define the flow regime for this overflow event.



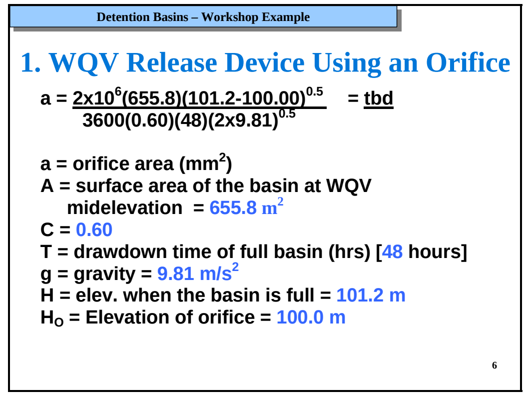
Slide 4: Once we have calculated the flow height, in Part 4 we can set the elevations of the WQV under static conditions; beginning with the invert elevation (taken as a given), we would add the elevation of water under a

statically-held WQV (also a given for today's exercise); then we would add the height of water during the overflow event (which we will calculate today); then to that elevation we would add freeboard to the top of the confinement (freeboard of 1.0 ft (0.3 m).

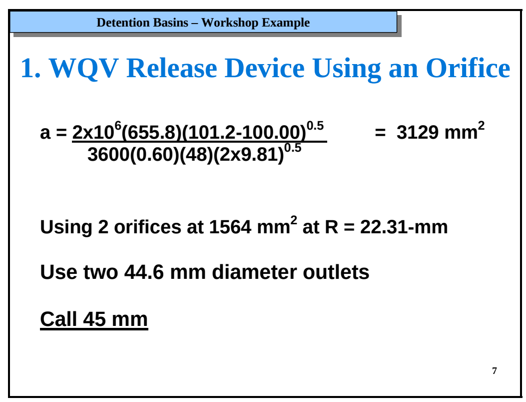


Slide 5: We will release the WQV from our Detention Basin using orifices at the lowest elevation in the basin, the invert or floor of the basin. This formula is for orifice opening at the invert of the basin. This equation is in your Workshop Handout, and refer to the handout for more discussion.

The formula will provide the total open area needed; several orifice openings may be used, summing to the required open area. The orifice(s) should be at least 13 mm (1/2 inch) in diameter. The use of at least two orifice opening should be considered. Please note: the orifices could also be placed in columns, along the riser, and there are some benefits to that placement. However, considering the classroom setting, for ease of discussion we will use this formula.



Slide 6: All the givens in the problem statement are shown in blue on this slide. Note the location where A, surface area of the basin at WQV, is measured. This will also have to be calculated, but we gave it today. Also, when complete, consider if need to round up or down to achieve an orifice having a diameter in a reasonable US Customary dimension (as Contract's equipment may not be metric).



Slide 7: With all the values shown, this should be the result of the calculation. We have divided the calculated area into to orifices, and have rounded up for the convenience of construction. This is a small change, and the drawdown time should be little changed from the design time of 48 hours.

Detention Basins – Workshop Example

2a. Riser as Sharp Crested Weir

$Q = (C_{SCW}) \times L \times (H^{1.5})$ rearranging terms:
$L = (Q)/[(C_{SCW} \times H^{1.5})]$ if solving for L or
$H = [(Q)/(C_{SCW} \times L)]^{2/3}$ if solving for H

Q = Design Storm
C_{SCW} = SC Weir coefficient (See handout)
L = Length of weir (perpendicular to flow)
Note: Minimum 'L' is 1.92 meter

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Slide 8: This equation is in your Workshop Handout, and refer to the handout for more discussion.

Detention Basins – Workshop Example

2a. Riser as Sharp Crested Weir

$Q = (C_{SCW}) \times L \times (H^{1.5})$
For today: take C_{SCW} = 1.84, L = 1.92, and
Q = 0.26 m3/sec

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Slide 9: The terms in blue were given in the problem statement.

Detention Basins – Workshop Example

2a. Riser as Sharp Crested Weir

$Q = (C_{SCW}) \times L \times (H^{1.5})$
For today: take C_{SCW} = 1.84, L = 1.0, and
Q = 0.26 m^3/sec

Then, re-arranging terms,
$H = [Q / [C_{SCW} \times L]^{2/3}$
solving $[0.26/(1.84 \times 1.92)]^{2/3}$ = 0.18 m

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Slide 10: Re-arranging terms, inserting the givens, and solving.

Detention Basins – Workshop Example

2b. Riser as Orifice

$Q_{orifice\ flow} = K_{OR} \times D^2 \times H^{0.5}$
For today: take K_{OR} = 2.09, L = ???, and
Q = 0.26 m^3/sec

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Slide 11: This equation is in your Workshop Handout, and refer to the handout for more discussion.

Detention Basins – Workshop Example

2b. Riser as Orifice

$Q_{orifice\ flow} = K_{OR} \times D^2 \times H^{0.5}$
For today: take K_{OR} = 2.09, L = 0.611, and
Q = 0.26 m^3/sec

Then, re-arranging terms,
$H = [Q_{orifice\ flow} / (K_{OR} \times D^2)]^2$
solving $[0.26/(2.09 \times 0.611\ ^2)]^2$ = 0.11 m

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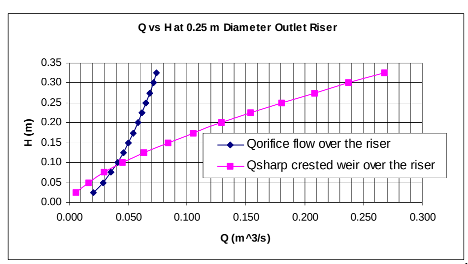
Slide 12: The numbers in lighter blue were given or provided in the formula. Then we can solve for the H height of water over the open-topped riser for an orifice flow regime.

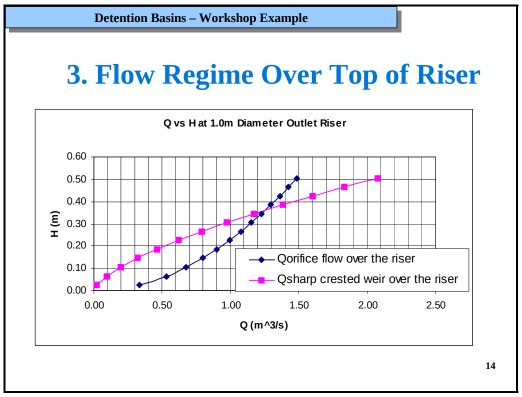
Detention Basins – Workshop Example

3. Flow Regime Over Top of Riser

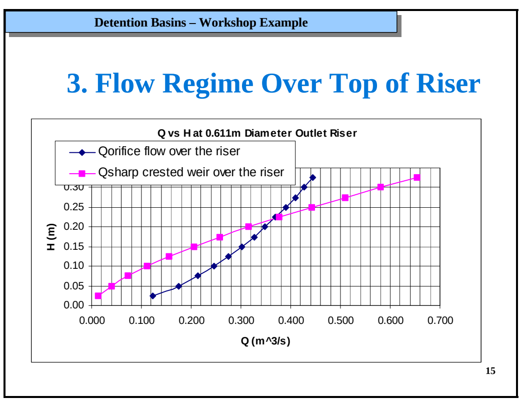


13

Slide 13: We will show three slides with various diameter openings; note how one flow regime controls, but which one will depend on the Q, and the diameter of the riser. This is for 0.26 m diameter riser opening. Not that the H increases dramatically for orifice flow, and in fact orifice flow controls for all flows when Q is greater than 0.04 m^3/sec – a fairly low flow. This would not be a good design for an open riser to handle large flows.

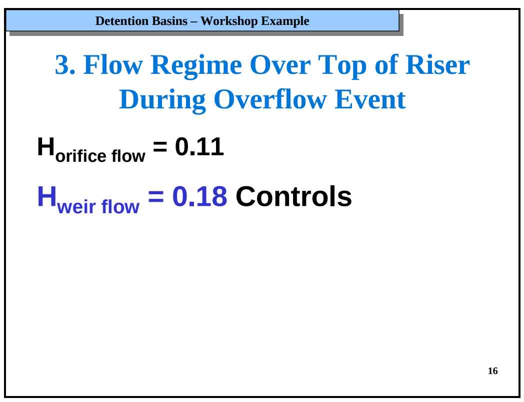


Slide 14: This is for 1.0 m diameter riser opening. The flow regime as a sharp crested weir controls until the Q is greater than about 1.25 m^3/sec.

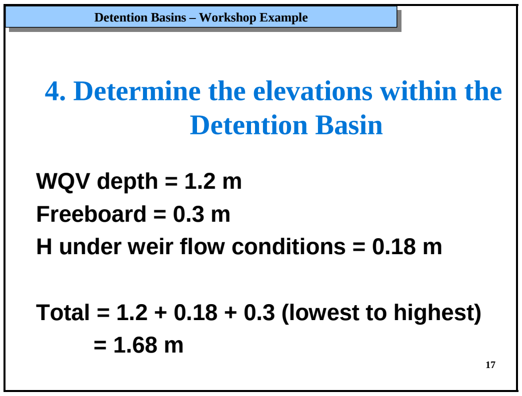


Slide 15: This is the plot of relevant to our workshop problem, with the diameter equal to 0.611 m. Solving the equation and then plotting the results for our site-specific problem. Note that the flow regime changes as the flow changes, and that the higher H value controls the flow regime. At the Q of .026m^3/sec, the H for the sharp crested weir of 0.18 m +/- controls.

For a good design you would want to be sure that there was a fairly large margin for the same flow regime to control; for example if our design flow placed us near the cross-over point on this figure, the flow regime might fluctuate with little effect between the two flow regimes, but if our design flow was slightly in error, and too low, there would be a large change in the H height of flow as under orifice flow conditions. Our design flow of 0.26 m^3/sec could be increased nearly 50% before the flow regime changes and overflow height would begin to rise dramatically, so this seems like a ‘stable’ design.



Slide 16: The higher H controls the flow regime, and for our problem flow acts as weir flow over the open-topped riser.



Slide 17: Since we have calculated the flow height for the overflow event, we now can set all the elevations in the Detention Basin; beginning with the invert elevation (taken as 100.0 m), we would add the elevation of water under a statically-held WQV (given in the problem statement as 1.2 m, to elevation 101.2 m); then we would add the height of water during the overflow event (calculated as 0.18 m, giving 1.38 m); then to that elevation we would add freeboard to the top of the confinement (freeboard of 1.0 ft (0.3 m), giving 1.68 m.

Slide 18: End of the presentation.