ENVR 755 Assignment 3

Sarah Wright

1. First, I used inputs of inflow I(t), an initial storage for the first month S(t-1), and the constant demand q(t) to calculate S(t), the amount of water in the system for that month before any usage or spillage. S(t) = I(t) + S(t-1) – q(t). The amount of water in storage at the end of each month is S(t), except when S(t) is greater than the working capacity, in which case the amount of the working capacity is stored and any excess is let off as spillage, resulting in a total release of spillage added to actual usage, which in this case is equal to demand.  
   Final storage code: =IF(S(t)>(working capacity),(working capacity),IF(S(t)<0,0,S(t)))

Spillage code: =IF(S(t)>(working capacity),S(t)-(working capacity))

Total release code: =(actual usage) + (spillage)  
  
With these equations in place, I was able to adjust the working capacity until there were no failures during the 72 years of data. A failure is defined here as a month when demand cannot be met. I accomplish this calculation by assigning any negative value of S(t) to be zero and counting the number of zeros as failures.

S(t) code: =IF((initial storage + inflow - demand)>0,(initial storage + inflow - demand),0)

Identify failures code: =IF(S(t)=0,1,0)

Count failures code: =COUNTIF(top cell of column : last cell of column, "failure")

(note – this code is used to count non-critical and critical failures throughout the assignment. I’m only writing it here once for the sake of space. For critical failures, the key word “failure” is changed to “critical failure”)

With a working capacity of at least 8348 million gallons, this reservoir experiences no failures.

1. Using the same formulas as problem one, I determined the working capacity necessary for safe yields of 900 MGM and 1500 MGM to be 5,641 million gallons and 12,583 million gallons, respectively.
2. To vary the demand, I made a column of the proportions for each month and multiplied this by the demand column. Under these conditions, the working capacity must be 8,821 million gallons. This is a larger quantity than found in section 1 with constant demand, but is still in the same range. The difference is that the winter months need more storage from the summer and fall to prevent failures. The non-stored excess in summer is let off as spillage.
3. Allowing a monthly failure rate of 2% and keeping with the varied demand from section three, the minimum working capacity for the reservoir 5,970 million gallons.  
     
   The main difference in calculation here is making actual usage, formerly equal to demand, equal to inflow + initial storage each time there is a failure – so as not to allow the reservoir storage to be negative. Again, we define failure as a month where demand cannot be met.  
   Actual usage code: =IF(demand>(initial storage + inflow), initial storage + inflow, demand)

At a cost of $3000/MG increased capacity, the marginal cost if increasing reliability dramatically increases as reliability increases. As seen on the plot above, the more vertical slope farther left on the graph signifies the most gain in reliability per increase in unit capacity. As the curve nears 100% reliability, the curve is almost flat, signifying almost no gain in reliability with each added unit of capacity.

Using slopes from the first two and last two points:

Marginal cost (from 92% to 93%): $925k

Marginal cost (getting to 100%): $6.47 million

1. For this section, we were tasked with finding the minimum working capacity that yielded no critical failures and less than or equal to 2% monthly failures (98% reliability).

Critical failures are defined as when (initial storage + inflow)/demand is equal to or greater than the set critical failure threshold. A non-critical failure happens when (initial storage + inflow)/demand falls in between the critical failure threshold and 1.

Critical/failure code: =IF((initial storage + inflow)/demand)<=critical fail threshold, "critical failure", IF((initial storage + inflow)/demand)<1, "failure",""))

With critical failure thresholds of 0.7 and 0.5, the minimum working capacities are 8,533 million gallons and 8,341 million gallons respectively. These numbers make sense – there is more room needed in a reservoir with a higher critical failure threshold. This way, more water can be stored to prevent getting to a critically low level.

1. With environmental regulations of 120 MGM for downstream flow, a portion of our previously storable water now must be released as spillage to protect ecosystems.

Water available for storage code: = inflow + initial storage – 120MGM

Storage S(t) code: = water available for storage – demand

Actual usage code: =IF(demand>water available, water available, demand)

Basically, we have less water available to hold back as storage. The code for failure and critical failure is the same – we just have a higher likelihood of reaching those levels at the previously used capacity because there is less of a buffer in place.

To ensure no critical failures over the 72 year period, the working capacity must be at least 9,613 million gallons.

1. With the constraint that the reservoir must be at least 80% full for recreation purposes, the total capacity needs to be 49,113 million gallons to stay at this level enough of the time.

Code: =IF(actual storage0.8\*working capacity,1,0)

=COUNTIF(start column : end column, 1)

Percentage = counted number above / number of rows

For all of the varied critical failure thresholds, I got a minimum working capacity of 49503. The graph would be a horizontal line. I know this is wrong, but this assignment is due in five minutes so I will figure it out tomorrow.

Cost: capacity \* $3000/unit = $148,509,000