# Powell Operational Rules Outline for Midterm Probabilistic Model

Revisions:

* Rev. 1, 23 July 2010 *Cameron Bracken*
* Rev. 2, 26 July 2010 *Cameron Bracken*

## Data

### Data Object

PowellData

* Equalization Elevation Table
* Tear Limits
* Steady Flow Experiment October Minimum Release = 492 kaf
* Non Steady Flow Experiment October Minimum Release = 600 kaf
* November Minimum Release = 700 kaf
* December Minimum Release = 800 kaf

Table 1: Lake Powell Equalization Elevation Table

|  |  |
| --- | --- |
| **Water Year** | **Elevation (feet)** |
| 2008 | 3,636 |
| 2009 | 3,639 |
| 2010 | 3,642 |
| 2011 | 3,643 |
| 2012 | 3,645 |
| 2013 | 3,646 |
| 2014 | 3,648 |
| 2015 | 3,649 |
| 2016 | 3,651 |
| 2017 | 3,652 |
| 2018 | 3,654 |
| 2019 | 3,655 |
| 2020 | 3,657 |
| 2021 | 3,659 |
| 2022 | 3,660 |
| 2023 | 3,662 |
| 2024 | 3,663 |
| 2025 | 3,664 |
| 2026 | 3,666 |

Table 2: Powell Monthly Disaggregations of Annual Release Volumes

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Annual Volume** | **7.0 MAF** | **7.48 MAF** | **7.8 MAF** | **8.23 MAF** | **9.0 MAF** | **9.5 MAF** | **10 MAF\*** | **10.5 MAF\*** |
|
| **OCT** | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 |
| **NOV** | 600 | 500 | 600 | 600 | 600 | 600 | 600 | 600 |
| **DEC** | 800 | 600 | 600 | 800 | 800 | 800 | 800 | 800 |
| **JAN** | 662 | 800 | 800 | 800 | 800 | 850 | 900 | 950 |
| **FEB** | 540 | 600 | 600 | 600 | 650 | 650 | 650 | 650 |
| **MAR** | 450 | 600 | 600 | 600 | 650 | 650 | 650 | 650 |
| **APR** | 450 | 450 | 600 | 600 | 600 | 650 | 700 | 750 |
| **MAY** | 450 | 530 | 600 | 600 | 650 | 800 | 950 | 1100 |
| **JUN** | 540 | 600 | 600 | 650 | 800 | 900 | 1000 | 1100 |
| **JUL** | 720 | 800 | 800 | 850 | 1000 | 1050 | 1100 | 1150 |
| **AUG** | 720 | 800 | 800 | 900 | 1050 | 1100 | 1150 | 1200 |
| **SEP** | 468 | 600 | 600 | 630 | 800 | 850 | 900 | 950 |

\*All Disaggregation Patterns for 7.0 MAF to 9.5 MAF taken from FEIS. 10 MAF and 10.5 MAF patterns are extrapolated from the difference between 9.0 MAF and 9.5 MAF

Table **3**: Powell Release Tiers

|  |  |
| --- | --- |
| **Projected Powell Jan1 Elevation** | **Tier** |
| >= Eq. Level for WY | Equalization |
| < Eq. Level and >= 3575 ft. | Upper Elevation Balancing |
| < 3575 ft. and >= 3525 | Mid-Elevation Release |
| < 3525 ft. | Lower Elevation Balancing |

Table 4: Releases for steady flow experiment

|  |  |
| --- | --- |
| Annual Volume (MAF) | Oct/Nov Steady flow (cfs) |
| ≤ 9 | 8000 |
| 10 | 10000 |
| 11 | 12000 |
| 12 | 16000 |
| 13 | 18000 |
| 14 | 22000 |
| 15 | 25000 |

### Required User Data Input

Steady Flow experiment year?

## Rules

In order of priority

### 1. Steady Flow Experiment

*Execution Constraint*: Current year is a steady flow experiment year (user input) and Month is May - September.

*Description*: The release in September and October must be steady and equal according to Table 3. This may require reductions to meet the annual volume requirement. Reductions are made in the following order:

1. Reduce July to 800 kaf
2. Reduce August to 800 kaf
3. Reduce June to 800
4. Reduce June to 600
5. Reduce April to 500
6. Reduce May to 500

*Slots Set*: Powell.Outflow

### 2. Set Lower Elevation Balancing Release

*Execution Constraint*: Tier is Lower Balancing

*Description*: Ensure release is between 7 and 9.5 MAF. Release according to the set release patterns (interpolate in between limits if release is between 7 and 9.5 MAF).

*Slots Set*: Powell.Outflow

### 3. Set Mid-Elevation Release

*Execution Constraint*: Tier is Mid Release

*Description*: If the Mead Jan1 projected elevation is greater than or equal to 1025 ft then release 7.48 MAF/yr, otherwise release 8.23 MAF/yr.

IF Mead.Elevation[Jan 1] >= 1025

Powell.Outflow = 7.48 MAF/yr

ELSE

Powell.Outflow = 8.23 MAF/yr

*Slots Set*: Powell.Outflow

### 4. Set Upper Balancing Release

*Execution Constraint*: Tier is Upper Balancing

*Description*: If the Mead EDWY elevation is less than 1075 ft. then release to equalize Mead and Powell storage by the end of the water year. Ensure that the release is between 7 and 9 MAF. If this release is greater than 8.23 then check that Oct, Nov, Dec volume is greater than 2 MAF.

If the Mead EDWY elevation is greater than or equal to 1075 ft then release 8.23. In April readjustment is allowed, though this rule will not need to check because the Tier will have already been reset to equalization if necessary. If the Mead end of water year elevation projected on April 1 is less than or equal to 1075 ft. and the Powell end of water year projected elevation is greater than or equal to 3575 ft. then release to equalize Mead and Powell storage by the end of the water year. Ensure that the release is between 8.23 and 9 MAF.

IF Mead.Elevation[Jan 1] >= 1075

IF (Month is April or later) and

(Mead.ProjectedElevation[Jan 1] >= 1075) and

(Powell.ProjectedElevation[Jan 1] >= 3575)

EnsureReleaseLimits(EqualizationRelease(),8.23,9)

ELSE

Powell.Outflow = 8.23 MAF/yr

ELSE IF Required Powell Release > 9.0 MAF

Powell.Outflow = 9 MAF/yr

ELSE IF Required Powell Release < 7.0 MAF

Powell.Outflow = 7 MAF/yr

ELSE IF Required Powell Release > 8.23 MAF

Check OND total Release

ELSE

Powell.Outlfow = Required Powell Release

*Slots Set*: Powell.Outflow

### 5. Set Equalization Release

*Execution Constraint*: Tier is Equalization

*Description*: Release steady to meet the Equalization level at end of water year or such that Powell and Mead storage are equal by the end of the water year. Release above this amount if necessary to avoid spills. If this release causes Mead elevation to be less than 1105 ft then increase release until the first of the following is met:

1. Powell Storage equals Mead storage at the end of the water year
2. Mead elevation is 1105 ft. at the end of the water year
3. Powell Elevation at the end of the water year is 20 feet below the equalization level.

*Slots Set*: Powell.Outflow

### 6. Reset Upper Tier to Equalization

*Execution Constraint*: April and Currently in Upper Balancing Tier

*Description*: If the current tier is upper and the projected Powell elevation on April 1 is greater than equalization level then change to Equalization tier.

*Slots Set*: Powell.Outflow

### 6. Set Release Tier

*Execution Constraint*: August

*Description*: Sets the Powell Release Tier for the next water year. First determine the Jan1 elevation then look up tier from Table **3**.

Jan1Elevation = SumFlowsToVolume(August to December Inflow) - Aug and Sep outflow from current tier – Fixed Oct to Dec Release.

*Slots Set*: Powell.Outflow

### 7. Project Elevations

*Execution Constraint*: August

*Description*: Projects Powell and Mead Elevation/Storage assuming an 8.23 release pattern.

## Functions

### EqualizationRelease()

Release to equalize Powell and mead storage at the end of the WY

(Powell.Storage – Mead.Storage + LossesBetween-GainsBetween)/MonthsUntilEndWY

### ProjectPowellElevation()

Assume an 8.23 release pattern.

StorageToElevation(ElevationToStorage(Powell)+SumFlowsToVolume(Powell.Inflow)-Sum(Powell.ReleaseVolume))

### ProjectMeadElevation()

TBD

### EnsureReleaseLimits(Release, ul, ll)

Ensure that a number is between ul and ll, if not set it to the respective limit.

## Midterm Model Questions

1. How to deal with “projected” Mead elevation/storage (calculate or input)? If calculated, should mead and demands below be modeled explicitly from the beginning (i.e. start with the expanded 24 month study)?

Rick: My guess is that the expanded 24-month study model should be the source for the demands for the mid-term model and that these demands would be static for all traces. If the mid-term model runs out beyond the 24-month study then averages should be used and LC would provide those inputs.

1. Will the 24-Month study results be input into the Midterm model?