VWP CIA Summary (TEMPLATE)

JK

08/03/2021

This is an R Markdown document. This will serve as the template for VWP Project Model Summaries moving forward. For related GitHub issue see <https://github.com/HARPgroup/vahydro/issues/317>.

# VAHydro Model Boilerplate:

## VAHydro

The comprehensive VAHydro hydrologic model is used to evaluate instream and off-stream beneficial uses for surface water withdrawals throughout Virginia. The VAHydro model simulates streamflow with inputs such as precipitation, climate, land use, and topography, as well as local data collected through DEQ water supply planning and reporting programs including all known withdrawals and discharges, as well as operational rules of VWP permits and major hydrologic features such as reservoirs.

The VAHydro model is built on rainfall-evaporation-runoff (RER) time-series from the Chesapeake Bay Model Phase 6 which runs from 1984-2014 in the Chesapeake Bay watershed drainage, and 1984-2005 in the rivers flowing outside of the Chesapeake Bay watershed, aka the “southern rivers.” The VAHydro model features high-resolution hydrologic subsections called “river segments” (over 600 river segments in total), roughly the size of HUC 10 hydrologic units, with additional high-resolution segments added for VWP modeling projects as needed.

## CIA

DEQ assesses water supply sustainability through Cumulative Impact Analysis (CIA) modeling. CIA is a modeling and analysis approach that takes into account the varied hydrologic process occurring throughout a river network (including meteorology and human water use). By simulating a daily water balance for every individual river segment within a watershed, DEQ is able to evaluate the potential “cumulative impact” of all streamflow changes occurring upstream of any location within the river network, as well as the downstream impact of individual permitted withdrawal operations.

The goal of the folloing analysis was to estimate the cumulative impacts of all existing water users in addition to the requested water withdrawal upon existing beneficial uses, including both in-stream and off-stream uses.

# Project Introduction (To be provided by permit writer)

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## Location Map

*No location map available for this facility model*

# Model Overview and Scenario Descriptions

**River Model Description** Crooked Run is a tributary that joins the Shenandoah River just south of Front Royal VA. The area of Crooked Run above it’s confluence with the Shenandoah River in this model is 47.0 square miles.

**Facility & Intake Model Description** The Blue Ridge Shadows golf course is modeled as a pump-store facility with a local impoundment having no direct drainage area, and an intake on Crooked Run to refill when water is available. The impoundment is estimated to have a maximum storage of 21.84 acre-feet. The previous permit featured a static MIF below which no pumping was possible. Model scenarios were selected in order to explore “percent of flow” type withdrawal limits in order to mimic natural flows, and also provide operational flexibility. Flow at the Crooked Run intake is simulated through the use of a rainfall-runoff model, with explicit simulation of the land-use above the intake. This differs from some historical models that would have used a USGS gage flow record from a nearby gage to simulate flows at the intake. By using the rainfall-runoff simulation at a point very close to the actual intake, modeled low-flows can be improved due to consideration of specific catchment area, land use, and other upstream withdrawals. As a result, this permit-max simulation may have lower available water because it reflects current demands with historical meteorology in a smaller watershed. Because of practical considerations of permit operation, a surrogate gage may still be employed, and that gage may have higher base flows than Crooked Creek at this intake, therefore, permit rules should attempt to account for that possibility.

The following model scenarios were simulated in order to determine the most effective means of meeting the project need and all other in-stream beneficial uses:

* **Existing permit conditions** (Current Permit) - The existing permit scenario has a static minimum instream flow of 4.13 cfs, which means that all withdrawal must cease from Crooked Run when flow drops below 4.13 cfs. This MIF is based on flows in Opequon Creek near Berryville, since the alternative gage, Opequon Creek at Stephens City is no longer in service. Flowby value at the intake is area-weighted as 4.13 cfs = 9.4 \* 25.6 / 58.2, since 9.4 cfs is flowby at Berryville gage, with Drainage area 58.2 square miles, and the Crooked Creek model intake is 25.6 square miles.
* **Proposed permit conditions with 90% flowby** (90% Flow-by) - The 90% flow-by scenario limits the daily withdrawal from Crooked Run to no more than 10% of the flow in the stream, based on the previous days simulated flow.

# Intake Site Description & Current Estimated Stream Flows

**Table 1:** Modeled monthly current flow statistics for Blue Ridge Shadows at Crooked Run in cubic feet per second (cfs). Columns show the minimum (Min) and average (Mean) modeled flow, and a range of non-exceedence flow percentiles, that is, the column header indicates the percent of flows that do *not* exceed the given value. For example, the “10%” states that only 10% of flows in the given month are expected to be less than the indicated value, and therefore, 90% of the flows in that month are expected to be greater than the given value. For example, in the table below the 10% column states that 10% of flows within the month of January would be less than 4.7cfs.

| **Month** | **Min** | **5%** | **10%** | **25%** | **30%** | **50%** | **Mean** |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Jan | 0.3 | 2.7 | 4.7 | 8.9 | 9.9 | 14.8 | 23.7 |
| Feb | 0.3 | 3.2 | 5.8 | 12.2 | 13.1 | 17.5 | 28.1 |
| Mar | 0.2 | 4.9 | 7.5 | 13.3 | 15.8 | 24.9 | 43.1 |
| Apr | 1.1 | 4.9 | 6.4 | 11.4 | 12.6 | 18.3 | 31.4 |
| May | 1.3 | 3.9 | 5.3 | 8.6 | 9.5 | 13.3 | 21.9 |
| Jun | 0.3 | 1.3 | 1.9 | 3.9 | 4.6 | 7.8 | 12.3 |
| Jul | 0.0 | 0.2 | 0.5 | 1.5 | 1.8 | 3.1 | 5.5 |
| Aug | 0.0 | 0.0 | 0.1 | 0.6 | 0.8 | 1.8 | 4.7 |
| Sep | 0.0 | 0.0 | 0.0 | 0.3 | 0.4 | 1.4 | 10.1 |
| Oct | 0.0 | 0.1 | 0.3 | 1.1 | 1.3 | 3.4 | 8.9 |
| Nov | 0.0 | 0.0 | 0.7 | 2.9 | 3.5 | 6.6 | 15.6 |
| Dec | 0.0 | 1.2 | 2.7 | 6.6 | 7.9 | 13.5 | 22.3 |

# Model Summary Results - Conclusion/Recommendation

* **Existing permit conditions** - The static minimum instream flow in this scenario results in reduced water availability during 5 out of 30 years of the long-term simulation. During 4 years out of the 30 years simulated, pond storage is totally depleted and pumping from Crooked run is reduced below the modeled need for periods in excess of 1 month. For example, during summer 1986, average flow in Crooked Run drops below 4 cfs for over 2 months, coinciding with the period of greatest demand for this facility. Modeled pond storage dropped below 50% in 18 out of 30 years simulated.
* **Proposed permit conditions with 90% flowby** - The 90% flow-by scenario results in more flexibility to pump under extremely dry conditions, as compared to the current static MIF permit condition. As a result, the operation is able to meet off-stream need during all simulated periods, with pond drawdown below 50% occuring 5 times in the 30 year simulation.

## CIA

This table summarizes the cumulative impacts to flows, aquatic life, and off-stream demand for the project. The section entitled “River Segment Model Statistics” contains mean flows (Flow Out), and drought flows (30 and 90 Day Low Flow), as well as an estimated percent total consumptive use as a resutl of all withdrawals (Cumulative Withdrawal) and discharges (Cumulative Point Source) in the watershed. The section entitled “Facility Model Statistics” shows the withdrawals, return flows (Point Source), and the model estimate for potential unmet demand due to demands exceeding the allowable withdrawal at the intake based on the cumulative conditions in the watershed and the flow-by rules in effect. There will be one or more columns in this table representing each scenario considered for this analysis.

# Stats Comparison Table:

| **Description** | **Current Permit** | **90% Flow-by** |
| --- | --- | --- |
| runid | 400 | 600 |
| River Segment Model Statistics: |  |  |
| Flow Out (cfs) | 34.58 | 34.57 |
| Flow Baseline (cfs) | 34.72 | 34.72 |
| Minimum Days of Storage Remaining |  |  |
| 30 Day Low Flow (cfs) | 0.10 | 0.09 |
| 90 Day Low Flow (cfs) | 0.75 | 0.73 |
| Consumptive Use Fraction | 0 | 0 |
| Cumulative Withdrawal (mgd) | 0.09 | 0.10 |
| Cumulative Point Source (mgd) | 0 | 0 |
| Richness Change (abs) | No elfgen Available | No elfgen Available |
| Richness Change (%) | No elfgen Available | No elfgen Available |
| Facility Model Statistics: |  |  |
| Withdrawal (mgd) | 0.04 | 0.04 |
| Point Source (mgd) | 0 | 0 |
| Maximum 30 day potential unmet demand (mgd) | 0.08 | 0.00 |

# Reservoir Storage Plots:

## This property does not exist

[1] “No riverseg impoundment for run id 400”

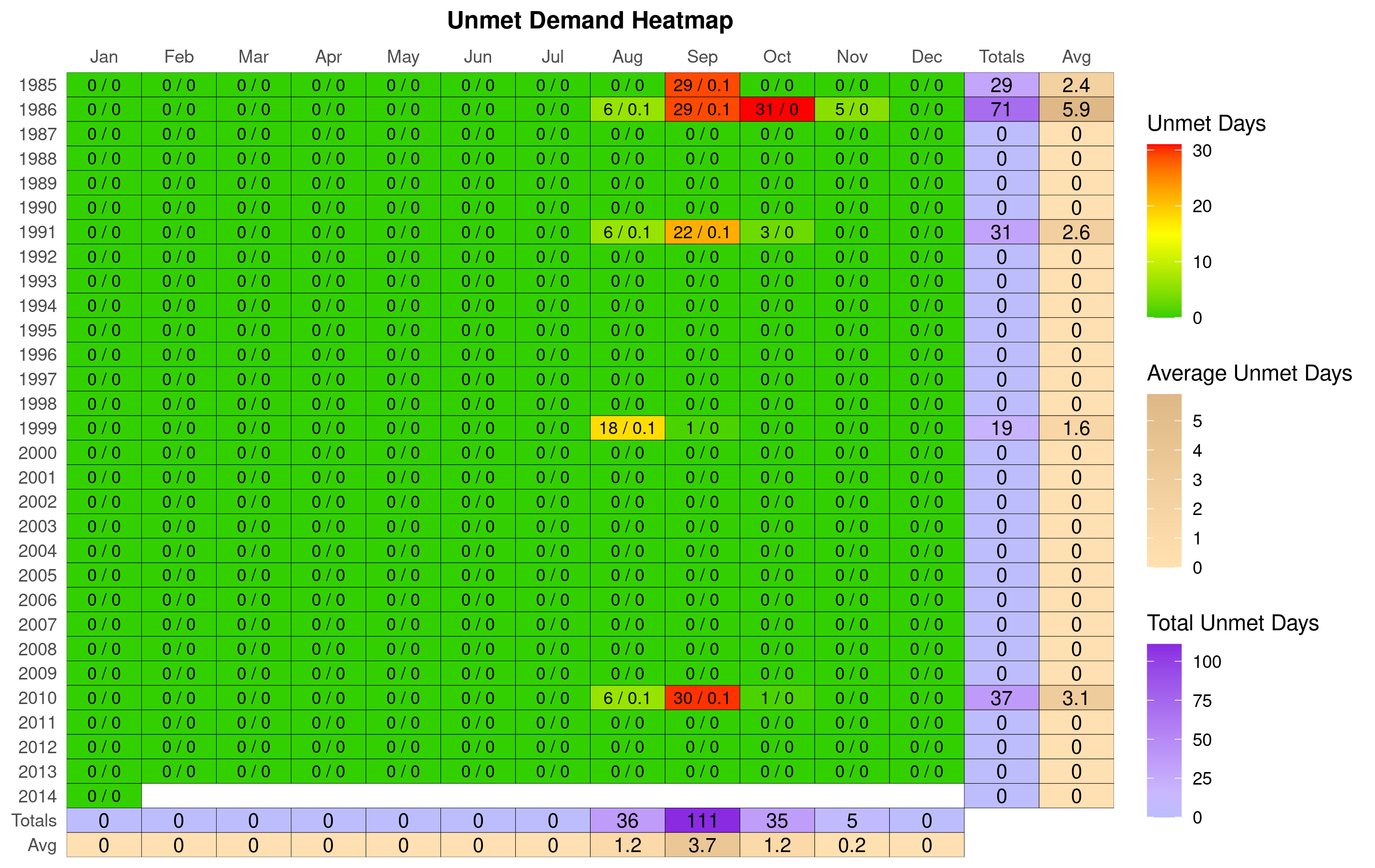
## This property does not exist

[1] “No riverseg impoundment for run id 600”

# Unmet Demand Heatmaps:

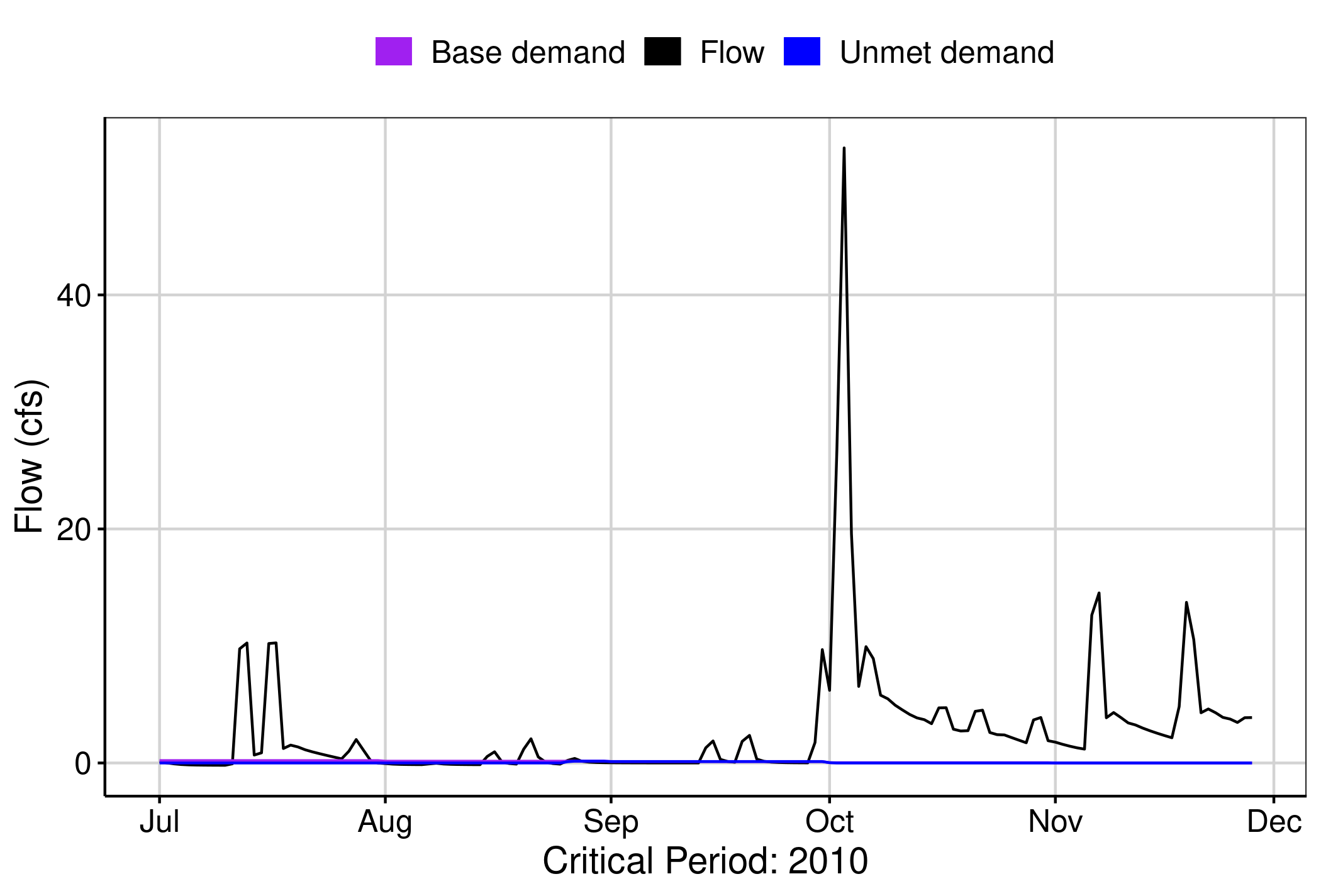
## Number of properties found: 1

## Reservoir Storage: Current Permit



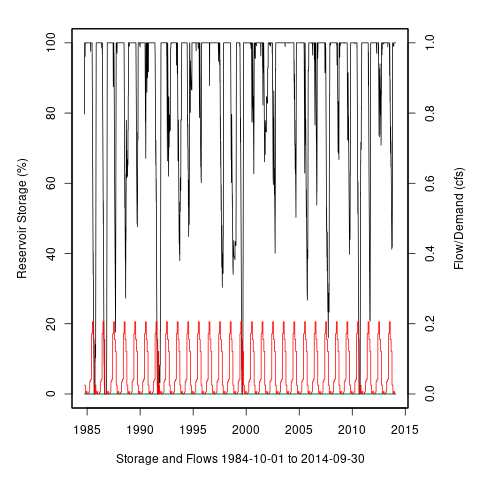
## Number of properties found: 1

## Unmet Demand: Current Permit



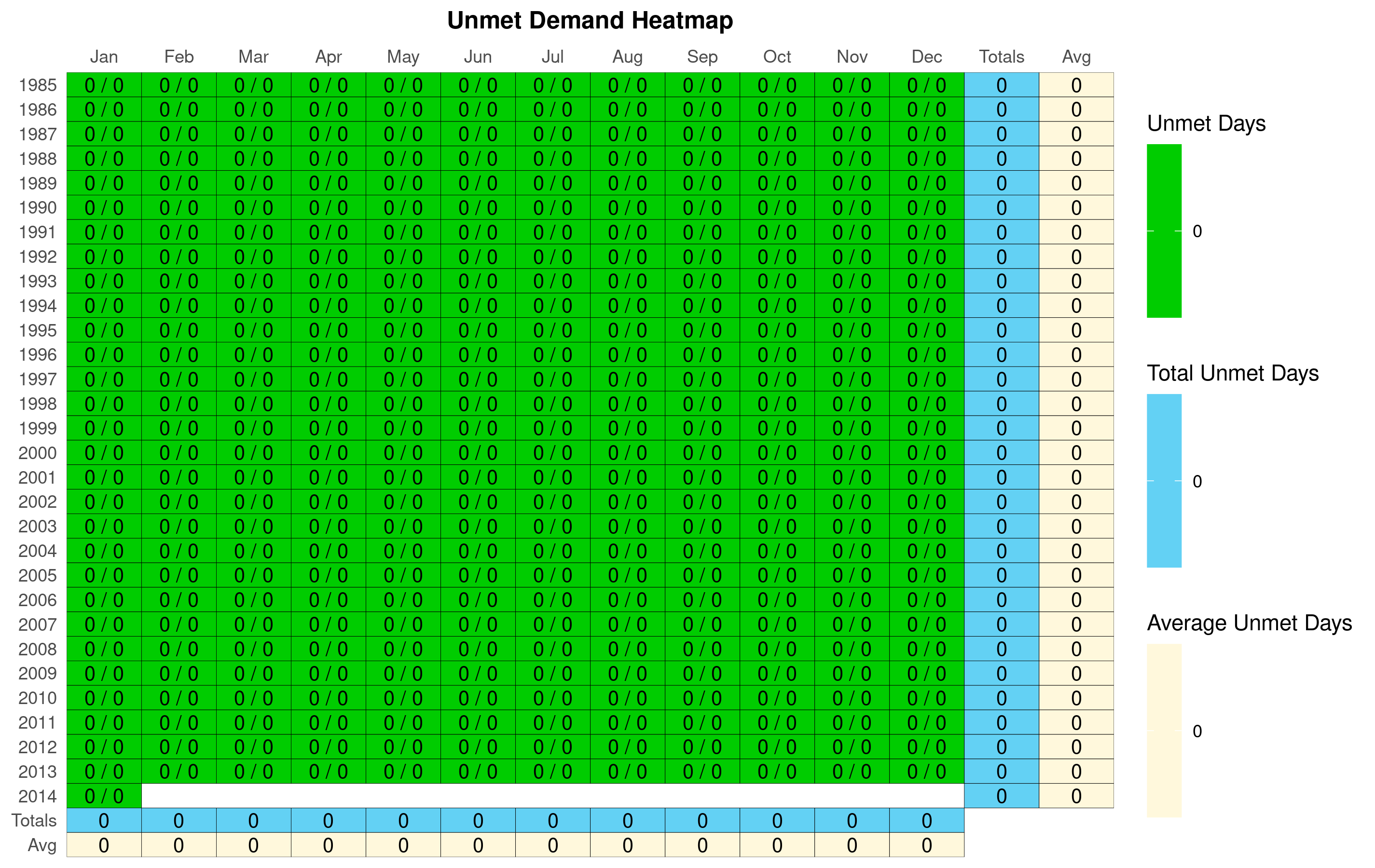
## Number of properties found: 1

## Reservoir Storage: Current Permit



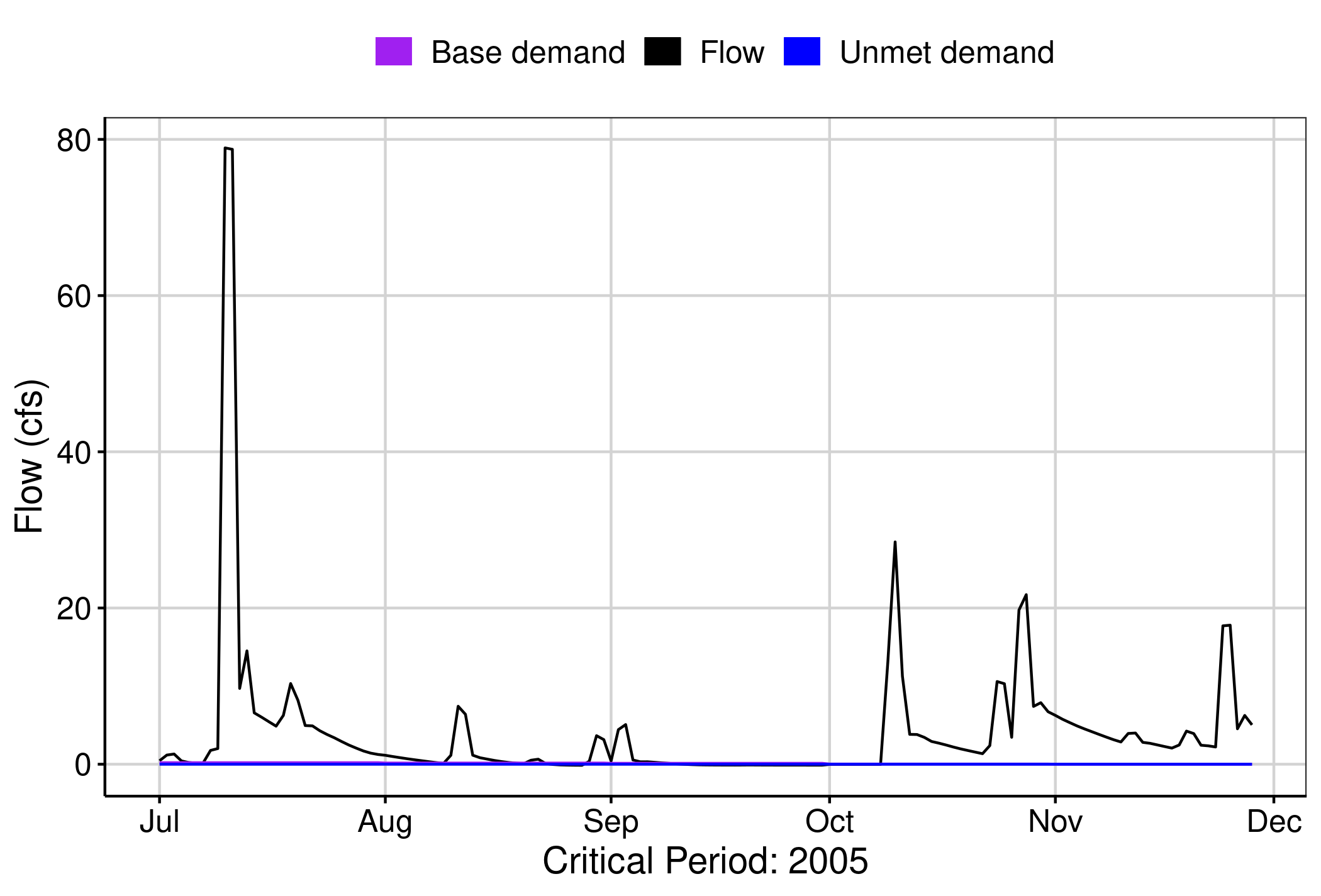
## Number of properties found: 1

## Reservoir Storage: 90% Flow-by



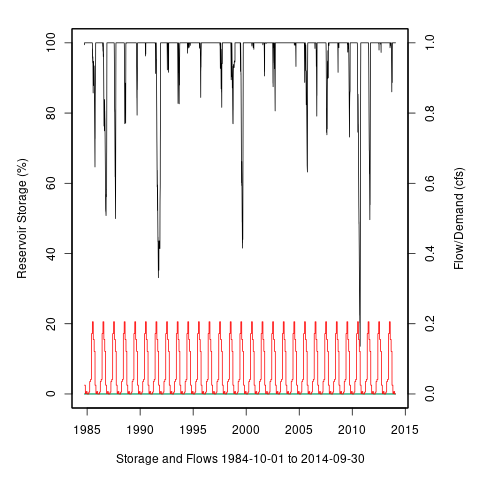
## Number of properties found: 1

## Unmet Demand: 90% Flow-by



## Number of properties found: 1

## Reservoir Storage: 90% Flow-by



# Ecological Impacts Assessment:

## Elfgen:

*No elfgen plot available for this model*

## Habitat (If Applicable):

# Additional Sections

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