

# ALP in San Juan Basin Hydrology Model

## Second Generation Implementation

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### Operating Criteria

Animas La Plata Project (ALP) has following primary operating criteria:

1. Provide Durango M&I direct flow water right before any pumping to Ridges Basin can occur. Pumping capacity is 12.0 cfs.
2. Provide New Mexico ALP users a direct flow water right before any pumping can occur.
3. Provide a fish bypass at Durango of monthly cfs values before any pumping can occur.
4. Do not injure historic and unused senior water rights.
5. Pumping amount is limited by pump capacity (currently 280 cfs every month)
6. If pumping, minimum pumping amount is 15 cfs.
7. Release from Ridges Basin Reservoir to meet all demands not met by direct flow supply. Limit by outlet works capacity of 150 cfs.

To support the SJRIP, the following mitigation options were tested:

1. Minimum flow season (January through April, August through December):

If minimum estimated daily flow of San Juan reference gages (Farmington, Shiprock, Stateline, and Bluff) is greater than threshold flow (ie, 500 cfs) and Navajo Reservoir elevation is greater than a monthly reference elevation, then limit pumping to estimated San Juan minimum flow less reference flow. Otherwise, no pumping is allowed.

2. Runoff season (May through July), higher flow limitations as Option A or Option B where:

Option A - If estimated daily flow of San Juan at Farmington is within a set of flow ranges, pumping is 0.0. The suggested flow ranges are 4500 - 5500, 7500-8500, and 9500-10500 cfs.

Option B - If estimated daily flow of San Juan at Farmington is within one range (4500-10500 cfs), pumping is 0.0.

3. Lookback Criteria – This criterion looks at the number of years since the last flushing release. If this has been greater than a specified number of years, the month is June, and no release or the minimum release is scheduled for current year, pumping is stopped for the entire month.

If none of the above options invoke, low flows are tested as per minimum flow season. The additional pumping restrictions can only be implemented when both direct flow ALP users have been provided a full supply.

Capability was also provided such that Ridges Basin Reservoir can make supplemental (enhanced) releases basin upon following criteria:

If Navajo release is less than or equal to monthly minimum release (typically, 250 cfs) and minimum flow of San Juan reference gages is less than threshold minimum flow, then release additional water as:

fish enhancement release = ALP demand release + San Juan threshold flow  
- minimum San Juan flow - pumping reduction

In practice, the second generation model only used option 3 of the mitigation criteria. Note that the mitigation criteria introduce an interaction with Navajo Reservoir. Navajo's second pass release setting estimates the impact of the ALP mitigation operation and adjusts the second pass release accordingly.

## Actual Implementation

Actual implementation of above criteria in SJRIP RiverWare model was complicated by three factors:

1. Most operating criteria are daily while model uses a monthly timestep.
2. Respect of historic and unused senior water rights requires multiple iterations.
3. Adjustment of ALP operation for RIP criteria requires additional iterations which occur after Navajo operates.

The first factor was addressed by using historic flows of Animas at Durango and Animas at Farmington. Daily percent of monthly flows were computed for periods of record. Daily flows at each gage are estimated as:

historic daily percentage \* modeled monthly flow

Animas at Farmington gage is adjusted for ALP influences when historic percentage is 0.0.

Estimated flows of San Juan reference gages are computed as:

daily flow = San Juan Archuleta daily flow (from Navajo operation)  
+ Animas at Farmington daily flow (from estimated value)  
+ average monthly gains between same gages

The second factor was addressed by computing the net nonshorted diversion requirement of historic, unused senior water rights, and New Mexico ALP direct flow rights. This value is computed by RiverWare rules function NetSubBasinDiversionRequirement for a user specified subbasin (consisting of all reaches downstream of Durango and upstream of desired reach). NetSubBasinDiversionRequirement accounts for all intervening hydrology and depletions. Bypassing of this value insures that no historic nor unused depletions are injured. In addition, pumping is reduced to 0.0 any time step that monthly downstream demand is greater than Animas At Durango monthly flow.

If sufficient water is available, New Mexico ALP direct flow requirements are met. To compute the value of the New Mexico ALP direct flow water supply, ALP is first operated with a traditional pumping limit and a 0.0 release (first pass). When water arrives at New Mexico ALP diversion object, river inflow is the direct flow supply. Daily river inflow is estimated daily Animas At Farmington flow as described above adjusted for Farmers Mutual Ditch. The daily direct flow supply is integrated to a monthly value.

The next iteration is to reoperate ALP with a reservoir release set to meet project demands (second pass). The second pass also adjusts pumping limits. First, if any ALP direct flow user (downstream historic water user) is limited, pumping is limited to Durango's first pass direct flow supply. Second pass was not reduced below Durango direct flow supply to avoid maximum iterations in RiverWare. Second, pumping is proportionately reduced to respect mass balance at Durango when historic diversion shortages occur. First pass of Navajo is made only after ALP's second pass.

As indicated above, the third factor was addressed by structure of the rules which forces two passes of ALP to fire and Navajo to fire before any mitigation adjustments are made. In addition, Navajo has an adjustment pass to compensate for inability to exactly estimate demands and to properly respond to ALP mitigation adjustments. This is to prevent both reservoirs from trying to meet flow criteria on same time step.

Note that the majority of ALP rules compute daily values which are integrated to monthly values. Navajo adjustment pass is computed using monthly values only. Because Navajo adjustment pass is a monthly test and ALP adjustment pass is a daily test, ALP adjustments for a month can create an average daily flow greater than threshold flow.

The criteria that the rules use are controllable to a large extent by data stored in data objects ALPData and

NavajoData. The following RiverWare slots are used:

NavajoData.MinFishElevation is 12 monthly elevation values used by both Navajo adjustment pass and ALP adjustment pass to trigger when not to use Navajo for supplemental releases, when to restrict Ridges Basin reservoir pumping, and when to use Ridges Basin reservoir releases to enhance flows for fisheries.

FlushingFlow.minimumSanJuanFlow is a time series of minimum flows that downstream San Juan gages need to meet on an average monthly basis. This table is only used by Navajo rules.

ALPData.NonRunoffSeasonFlowConstraints is a table with 2 lines, each representing 12 monthly flow thresholds. The first line is labeled "Pumping" and the values are used as flows to which to compare estimated San Juan flows when making fish pass of ALP operation. The second line is labeled "Releasing" and the values are used as flows to which to compare estimated San Juan flows when determining supplemental fish release from Ridges Basin reservoir. These values affect daily operation of Ridges Basin reservoir.

A number of other output slots exists in ALPData object. Of particular interest is slot ALPData.SanJuanConstrainingFlow which is the estimated minimum San Juan flow (of the 4 reference gages) when ALP adjustment pass is making its computations.

The above data correspond to various items in the ALP and Navajo rules. Main ALP rules and Navajo Monthly Release rule are computed as shown in pseudo code below. Note that if fish mitigation rules are being used, Navajo adjustment pass backs out anticipated adjustments to Ridges Basin to avoid over releasing. To keep downstream water users from taking ALP water, the reaches that divert water to these water users use the Minimum Diversion Bypass category. The ALP reservoir operation rules set the Minimum Diversion Bypass slot values.

Animas La Plata can be operated in four combinations: 1. No ALP, 2. No Ridges Basin ALP, 3. ALP Only, and 4. ALP With Mitigation. The sequence of rules for the respective scenarios are:

No ALP:

1. Operate ALP with 0 demands, 0 pumping, and 0 release
2. Operate Navajo with flow recommendations procedures.
3. Operate Navajo adjustment pass.

No Ridges Basin ALP:

1. Operate ALP with ALP direct flow demands, Durango MI pumping, 0 pumping, and 0 release
2. Operate Navajo with flow recommendations procedures.
3. Operate Navajo adjustment pass.

ALP Only:

1. Operate ALP with ALP demands, ALP pumping, and 0 release
2. Operate ALP with project releases and pumping adjustments.
3. Operate Navajo with flow recommendations procedures.
4. Operate Navajo adjustment pass.

ALP With Mitigation:

1. Operate ALP with ALP demands, ALP pumping, and 0 release
2. Operate ALP with project and mitigation releases and pumping adjustments.
3. Operate Navajo with flow recommendations procedures.
4. Operate Navajo adjustment pass.

To set up the desired scenario, do the following steps for the given scenario:

No ALP:

1. turn ALP Fish adjustment group off
2. turn ALP normal operation group off
3. turn No Ridges Basin ALP group off
4. turn No Alp group on

No Ridges Basin ALP:

1. turn ALP Fish adjustment group off
2. turn ALP normal operation group off
3. turn No Ridges Basin ALP group on
4. turn No Alp group off

ALP Only:

1. turn ALP Fish adjustment group off
2. turn ALP normal operation group on
3. turn No Ridges Basin ALP group off
4. turn No Alp group off

ALP With Mitigation:

1. turn ALP Fish adjustment group on
2. turn ALP normal operation group on
3. turn No Ridges Basin ALP group off
4. turn No Alp group off

## Rules Pseudo Code - ALP Normal Operations

First pass available to divert =

    If monthly flow at Durango < monthly downstream demand

        0

    Else

        If estimated daily flow at Durango > greater of downstream demands and aquatic bypass

            estimated daily flow at Durango - greater of downstream demands and aquatic bypass

        Else

            0

First pass pumping limit =

    If available to divert < minimum daily diversion

        0

    Else

        If available to divert > maximum daily diversion

            maximum daily diversion

        Else

            available to divert

First pass pumping =

    If pumping limit < space in reservoir

        pumping limit

    Else

        space in reservoir

First pass release = 0

Second pass available to divert =

    If any direct flow user did not receive a full supply

        daily Durango direct flow supply

    Else

```

    If first pass monthly available to divert > Durango monthly flow - (monthly downstream demand + diversion shortage)
      If proportioned value > daily Durango direct flow supply
        proportioned value
      Else
        daily Durango direct flow supply
    Else
      previous available to divert

```

Proportioned value =  $\frac{\text{previous daily value} * (\text{Durango monthly flow} - (\text{monthly downstream demand} + \text{diversion shortage}))}{\text{previous monthly value}}$

```

Second pass pumping = If pumping limit < space in reservoir adjusted for anticipated release
                      pumping limit
                      Else
                        space in reservoir adjusted for anticipated release

```

Second pass release = project demands

## Rules Pseudo Code - ALP Mitigation Operations

First pass computations are identical.

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Second pass available to divert =
  If any direct flow user did not receive a full supply
    daily Durango direct flow supply
  Else
    If first pass monthly available to divert > Durango monthly flow - (monthly downstream demand + diversion shortage)
      If proportioned value < mitigation pumping limit
        If proportioned value > daily Durango direct flow supply
          proportioned value
        Else
          daily Durango direct flow supply
    Else
      previous available to divert

```

```

Else
    If mitigation pumping limit > daily Durango direct flow supply
        If mitigation pumping limit > previous available to divert
            previous available to divert
        Else
            mitigation pumping limit
    Else
        daily Durango direct flow supply
Else
    If mitigation pumping limit > daily Durango direct flow supply
        If mitigation pumping limit > previous available to divert
            previous available to divert
        Else
            mitigation pumping limit
    Else
        daily Durango direct flow supply
Mitigation pumping limit =
    If month = 6 And no fish release occurred in past n years
        And this year=s fish release > minimum release
        daily Durango direct flow supply
    Else
        If month is greater than 4 and less than 8
            If estimated minimum San Juan daily flow is within specified range of flows
                Estimated daily Durango - daily Durango direct flow supply
            Else
                daily Durango direct flow supply
        Else
            If estimated minimum San Juan daily flow > minimum allowable daily flow
                And Navajo Pool Elevation > minimum fish elevation
                estimated minimum San Juan daily flow - minimum allowable daily flow
            Else
                daily Durango direct flow supply

```

Note that this version of the mitigation pumping limit is for the one fish release period flow range. Also note that if the flow range criteria are not invoked, function reverts to non flow range criteria.

Second pass release = project demands + mitigation release

Mitigation release = If any pumping is occurring  
0

```
If Navajo Outflow <= minimum monthly release
    And estimated minimum San Juan daily flow < minimum allowable daily flow
        minimum allowable daily flow - estimated minimum San Juan daily flow - pumping reduction
Else
    0
```

