THE STATE OF WYOMING

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September 9, 1988

Mr. Gary Fritz
Administrator, Water Resources Division
Department of Natural Resources and Conservation
1520 East Sixth Avenue
Helena, Montana 59620-2301

Dear Gary:

This letter accompanies a report completed in 1986 by Louis Allen, former Water Resources Engineer, before his retirement concerning the Administration of water under the Yellowstone River Compact, using the Tongue River as an example. Lou is also completing a revision with additional information to more accurately estimate flows of the Tongue and how that may effect compact allocations. I will forward the revised report to you after my staff has had an opportunity to review it.

The enclosed report is arranged into two main sections. The first reviews Article V, C, of the Yellowstone River Compact and how, in general, allocation should take place. The second portion of the report focuses on an example computation using the Tongue River and how allocation would proceed based on Article V, C. The Tongue River example contains fairly complex calculations based on mean monthly flow data to arrive at compact allocation, located behind the final tab in the report.

I apologize for the length of time that elapsed in getting you a copy of this report. I was awaiting the additional work being done by Lou, but felt it would be best to forward on this original report and then send you the additional details after we have reviewed the information contained in the latest report.

Corrected
Exhibit W

As you and your staff are reviewing this report, please do not hesitate to contact me if its contents seem vague or unclear. We look forward to discussing this proposed alternative of how Article V, C, specifies the allocations between the states should proceed.

With best regards,

Jeff

GORDON W. FASSETT
State Engineer

GWF/kmc

Enclosures

cc: Grady Moore, Chairman
Yellowstone River Compact Commission

YELLOWSTONE
COMPACT DISCUSSION

YELLOWSTONE RIVER COMPACT
DISCUSSION and TONGUE RIVER EXAMPLE
August, 1986

Introduction The Yellowstone River Compact of 1950 was prepared to apportion the waters of the Yellowstone River drainage between the States of Montana, North Dakota, and Wyoming. Of interest here is the apportionment of the Clarks Fork River, Big Horn River, Tongue River, and Powder River, all tributaries of the Yellowstone River, between the States of Montana and Wyoming. The following is of general applicability to these four tributaries, but with particular attention to the Tongue River situation.

The apportionment question has been addressed in various levels of detail almost since the ratification of the Compact. More recently, the State of Montana has presented several schemes for accomplishing the apportionment. The most recent presentation was based on a very simplified approximation of the Tongue River system. While this scheme is acceptable as a sincere attempt to develop procedures for water accounting and allocation under the Compact, the State of Wyoming remains unconvinced that it is a valid approach. Wyoming has commented on the difficulties in acceptance of the Montana scheme at length, and in detail, previously. Wyoming believes that the Montana approach deviates significantly from the allocation procedure described in Article V, Paragraph C, of the Compact, and that Article V, C, should be followed literally.

The Montana Tongue River Example, offered in September of 1984, has been revised by Wyoming to more nearly reflect the actual situation, so far as could be determined. This 1986 Wyoming version still contains approximations and numerous assumptions. It reflects the Wyoming portion of the Tongue River with an increased degree of reality. The Montana portion has been refined within the limits of information available. Wyoming's 1986 Tongue River Example will be addressed in detail below, following some basic discussion.

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Rationale The basic conclusion to be drawn from Article V, C, of the Compact is that the intent was to eventually have sufficient water use and storage within each State, and within each State's allocation of water, so that essentially no water passes the point of measurement. The point of measurement for the Tongue River is currently the USGS gaging station 06308500, Tongue River at Miles City, Montana.

Until the limits of post Compact (post-1950) water uses and storage under the Montana and Wyoming allocations are approached, the water apportioned to each State would be expected to significantly exceed the actual cumulative diversions and storage in each State. Water that could have been claimed under the Compact in either State, but due to lack of post-1950 uses and storage facilities was not utilized, will continue to flow past the point of measurement into the Yellowstone River. This water is allocated to each State, but is no longer physically available for use. It becomes an indicator of the quantity of water that could be developed in the future by the two States.

One point sometimes overlooked in river and reservoir operation studies is that water must be physically available at a diversion or storage facility, and legally available to the priority date of the facility, before it can be utilized for the purposes of that facility. Further, in operation studies water uses can be adjusted in retrospect to show better utilization or to adjust usage under compact allocations. In reality, adjustments to the operation of a system can only be a future action.

The frequency of Article V, C, calculations required becomes a function of the demands on the allocations and of the "fineness" of operational adjustments believed to be necessary to meet the demands, and of the level of the water supply in the river system. This is discussed further under the Article V, Paragraph C heading.

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no, - not true

Article V is structured to provide total depletion of the four Yellowstone River tributaries common to Montana and Wyoming. With future developments this might be achieved, or nearly so, in "normal" years and those years of shortage in the water supply. Some years would carry flows of such a magnitude that water would pass the point of measurement.

Article V is specific in reference to cumulative diversions entering into the allocation calculations. The only reference to depletion in the entire Compact is in Article II, H. defining beneficial use as "...that use by which the water supply of a drainage basin is depleted when usefully employed by the activities of man". Article V, A, refers to the enjoyment of appropriative rights to the beneficial uses of water existing as of January 1, 1950, which is water not allocated under the Compact. Article V, B, gives the percentages by tributary river for allocations "...to each State for storage or direct diversions for beneficial use...", clearly an expression that diversions and not depletions are intended. Article V, D, contains two references to beneficial use in connection with allocation of water between Montana and North Dakota, and neither carries an implication that depletion is to be the allocation measure, nor do they involve the tributaries entering from Wyoming.

The measurement of diversions is simple, straight forward, and definite, whereas depletions can at best only be estimated, especially for irrigation. In those few cases where all of the return flow can be measured, it is still necessary to measure the diversion to calculate the depletion by difference. Use of diversions in the allocation determination accounts for beneficial use depletions and for losses, and should result in the same final water use value as if all depletions could be accurately measured. Diversion of a given quantity of water results in some quantity of return flow which is again subject to

yes

no.

diversion, and so on until the return flow is insignificant. Return flows, from irrigation diversions in particular, are normally distributed along a stream and distributed over succeeding time periods, and are often intermingled with return flows from other diversions. A diversion for a totally consumptive use (no return flow) or to an out-of-basin use is analogous to a total depletion, but the measure is of the diversion, according to Article V.

The "change in storage" term in the allocation has not been controversial. The change in storage for a particular reservoir is the algebraic difference of reservoir content at one time minus the reservoir content at an earlier time.

Article V While the major concern here is with Paragraph C of Article V of the Yellowstone River Compact, it is appropriate to consider Article V in total.

Paragraph A has the effect of excluding appropriative rights for water uses that existed as of January 1, 1950, (pre-Compact, or pre-1950) from allocation under the Compact. Uses of water under these rights does not enter into the Compact allocation calculations. However, Montana and Wyoming would be expected to measure the storage and diversions exercised under these pre-1950 rights, and to maintain records, to the extent necessary for water administration within each State.

Paragraph B allocates that portion of the "unused and unappropriated waters of the Interstate tributaries" to each State necessary to supply supplemental water to the rights desscribed in Paragraph A. This quantity of water is to "make whole" the pre-1950 water rights; and the intent to exclude it from the allocation calculations is obvious. The paragraph continues with the percentages for allocation to each State of "...the remainder of the unused and unappropriated water..." in each of the four compacted tributary rivers. This water is "...allocated to each State for storage or direct diversions for beneficial use on new lands or for other purposes...". The percentage allocations for the Tongue River are 40 percent to Wyoming and 60 percent to Montana.

Paragraph C describes how "The quantity of water subject to percentage allocations...shall be determined...". Certain points were discussed above. The paragraph is addressed in detail in the following section.

Paragraph D addresses the allocation of water between Montana and North Dakota. The four tributary rivers listed in Paragraph B are not involved, and the State of Wyoming is not involved.

Paragraph E excludes from the Compact provisions domestic and stock water uses, and stock water reservoirs of 20 acre-feet or less capacity. Also exluded are "Devices and facilities for the control and regulation of surface waters". These would include spreader dams, diversion dams, and measuring devices.

Paragraph F allows modification of the allocations upon the unanimous agreement of the Commissioners. Since this refers to the allocations, and considering the balance of the paragraph, the intent appears to be modification of the allocation percentages, and not the Paragraph C procedure.

Article V, Paragraph C Wyoming's position is that Paragraph C of Article V of the Yellowstone River Compact is an adequate, complete, and simple procedure for allocating water between Montana and Wyoming for the four tributary rivers named in the Compact. Paragraph C says:

C. The quantity of water subject to the percentage allocations, in Paragraph B 1, 2, 3, and 4 of this Article V, shall be determined on an annual water year basis measured from October 1st of any year through September 30th of the succeeding year. The quantity to which the percentage factors shall be applied through a given date in any water year shall be, in acre-feet, equal to the algebraic sum of:

1. The total diversions, in acre-feet above the point of of measurement, for irrigation, municipal, and industrial uses in Wyoming and Montana developed after January 1, 1950, during the period from October 1st to that given date;
2. The net change in storage, in acre-feet, in all reservoirs in Wyoming and Montana above the point of measurement completed subsequent to January 1, 1950, during the period from October 1st to that given date;
3. The net change in storage, in acre-feet, in existing reservoirs in Wyoming and Montana above the point of measurement, which is used for irrigation, municipal, and industrial purposes developed after January 1, 1950, during the period October 1st to that given date;
4. The quantity of water, in acre-feet, that passed the point of measurement in the stream during the period from October 1st to that given date.

The first sentence of the paragraph is clear. The water year of October 1st through the succeeding September 30th is the commonly used water year. There is no provision for carryover of any uses or allocations from one water year to the next. All values for allocations, diversions, changes in storage, and flow passing the point of measurement would be zero on October 1st, so far as the allocation calculation is concerned.

The second sentence contains four clauses describing how the quantity to which the percentages are to be applied will be determined. It also refers to the determination of this quantity from October 1st "through a given date". This given date is not restricted, except that it cannot extend beyond the water year for which allocations are being determined. The quantity may, therefore, be determined at any time, or times, during the water year. It may be determined at the end of the water year, daily, weekly, monthly, or at some other frequency as a periodic event. It may be done on an "as needed" basis, such as certain dates or when either State calls for the determination.

The frequency of calculating the allocations should be a function of the quantity of the allocated water used, and the corresponding need for close monitoring. Too long a period between determinations would not allow the system to be kept in balance between allocations and uses. Determinations made more often than needed would be wasteful of both States' resources. As the quantities of use and storage increase in the future, the water passing the point of measurement under present conditions will become less, and this water will appear in the diversion and storage measurements upstream in each State.

The diversion and change in storage quantities are to be measured in acre-feet. This is an accepted measure for water volumes.

The quantity of water to be allocated is specified as an "algebraic sum" of the items set forth in the subsequent four clasues. This is a sum obtained by observing the algebraic signs of the separate values. Values with plus signs, or positive values, are added, and those with minus, or negative, signs are subtracted to arrive at the algebraic sum, or the net value of all the separate items.

Clauses 1 through 4 of the second sentence spell out quite specifically the calculation procedure for determining the quantity of water to be allocated to each State by the percentages. The numerical values necessary to the calculation would be expected to be measured values that were a matter of record in each State, particularly as the uses of Compact water approached the Compact allocations. The algebraic signing conventions as used herein are necessary to Article V, C, and vary in some situations from the signing conventions used for an operation study of a river system.

Clause 1 refers to the total diversions in acre-feet for post-1950 irrigation, municipal, and industrial uses in both States from October 1st to the "given date", the date of the allocation calculation. The diversions must be considered positive in sign, and the total of the diversions will be the sum of a series of positive numbers. In practice, for simplification in comparing uses with allocations, the total diversions in each State should be recorded separately for later combining. Diversions can be measured directly.

Clause 2 addresses the "net change in storage" in all post-1950 reservoirs. Each individual post-1950 reservoir will have a change in storage for the period in question. Water placed into storage in a reservoir would result in a positive change in storage, and water released from storage would result in a negative change in storage. The change for the period would be positive or negative in sign, depending upon whether the quantity of water stored was greater than or less than the quantity of water released during the period. The net change in storage for the purpose of Clause 2 is the algebraic sum of all of the individual changes in storage in the system since October 1st, considering the algebraic sign of each. Again, the net change in storage for each State should be noted separately for later combining.

The change in storage in a reservoir is normally determined from the change in water surface elevation, with the contents at each time obtained from an elevation - content table for the reservoir. The storage content at the end of the period minus the storage content at the beginning of the period gives the changes in storage during the period. The change will then be positive or negative depending on whether the storage increased or decreased during the period. Water surface elevations can be measured directly, referenced to the datum used for the elevation - content table. This method would suffice for the purpose of Clause 2.

The change in storage up to the "given date" can be obtained in two ways. The reservoir content on October 1st can be subtracted from the content of the reservoir on the given date. The result is the change in storage since October 1st. Alternatively, if periodic allocation calculations are made, the cumulative change in storage up to the previous "given date" will be a matter of record. The current period change in storage can be added to the previous value, with regard to the algebraic signs, to obtain the current date cumulative change in storage. Both methods give equivalent results with little difference in effort. The second approach may be preferable, as it lends itself to tabulation with the cumulative diversions and cumulative flows past the point of measurement.

Clause 3 is concerned with storage in pre-1950 reservoirs used for post-1950 irrigation, municipal, and industrial purposes. Instate water administration would necessitate accounting the quantity of storage and the portion of the releases assigned to pre-1950 purposes separately from those assigned to post-1950 uses. The result is, in effect, the same as if there were two separate reservoirs. The net change in storage consideration in the portion used for the post-1950 purposes would be the same as described above under Clause 2. The pre-1950 portion of the storage and releases would not enter into the Compact calculation. If a pre-1950 reservoir is used entirely to serve post-1950 purposes, it would then effectively be a post-1950 reservoir for the purposes of the Compact allocations.

Clause 4 includes the quantity of water "...that passed the point of measurement in the stream during the period from October 1st to that given date" in the allocation determination. This volume, in acre-feet, is readily measured at the USGS gaging station designated by the Compact Commission for each of the four rivers, and is a matter of record. It will always carry a positive sign.

Any water passing the point of measurement is water that could have been utilized but was not, although its use is allocated to the two States.

So far as the tributary water use is concerned, it is wasted water. It has "escaped" the tributary river system, and can no longer be brought into the cumulative uses of the particular river. Adjustments may be possible to the uses for the succeeding allocation period to reduce the quantity passing the point of measurement in that period, but that quantity that has previously "escaped" will still be allocated.

The only way to eliminate this wasted water from the allocations is to increase the uses of water in each State. When the cumulative water uses in each State approach the quantities allocated to each State, the flow passing the point of measurement will approach zero in most years.

It does not seem proper to eliminate this quantity of water passing the point of measurement from the allocation determination, as has been suggested in the past. The intent of Article V, C, 4 is clear that this be included in the allocation. Its inclusion provides an indicator of the quantity of water available to future uses.

The Allocation Calculation Article V, C, sets out a clear and simple procedure for allocating the water in the four tributary rivers between Montana and Wyoming. The appended 1986 Tongue River Example illustrates in simplified form how this might be done in the "Article V, C, Compact Calculations - Tongue River Example" section.

At the beginning of the water year, on October 1st, all items described in Clauses 1 through 4 of Paragraph C would be zero. As noted above, the individual diversions and changes in storage affected by the Compact, and the flow past the point of measurement are readily measured and made a matter of record. Assuming that periodic allocations of the water are made, either daily, weekly, monthly, or at some other interval, reference here will be to the period in a generic sense.

The recorded volumes of diversions and changes in storage for post-1950 uses should be maintained separately for each State, and this would be expected under each State's needs for good water administration. The individual values for the diversions and changes in storage can be accumulated over the current period, with regard to algebraic signs. These values can then be algebraically added to the corresponding cumulative values at the end of the preceeding period to obtain the new cumulative values for each item.

The cumulative values for diversions and changes in storage in each State represent the algebraic sum of the uses in that State. Separate records for each State for these use accumulations facilitate comparison with each State's allocation of water. This in turn facilitates decision making for adjustments to increase or decrease uses according to whether the cumulative uses are less than or greater than the allocation for each State.

The quantity of water that passed the point of measurement during the period can be added to the cumulative quantity at the end of the previous period.

The quantity of water to be allocated to each State is then the algebraic sum of the cumulative uses in both States plus the cumulative quantity of water that passed the measuring point. This sum is to be allocated by multiplying it by the percentages set forth in Paragraph B of Article V. For the Tongue River, the percentages are Wyoming, 40%, and Montana, 60%, or multipliers of 0.40 and 0.60, respectively.

Subtracting the cumulative uses for a State from that State's allocation of water indicates whether that State must decrease (negative difference), or may increase (positive difference), its use of water. The entire calculation procedure is readily adapted to tabulation, with the calculations performed on the tabulation sheet. It is also readily adaptable to a computer format for calculation and record keeping.

Reservoir and Diversion Considerations Certain reservoir situations could cause double counting of water under the Compact. Also, the discussion and the Tongue River Example are based on Wyoming laws governing reservoir storage. Montana's law may differ, but the end result on the changes in storage over a water year should be quite similar. In any reservoir there is a finite amount of space in which water may be stored. The change in storage over a water year would be expected to be small in most years, as the quantity of water released is normally nearly the same as the amount stored. Exceptions occur when carryover storage is being accrued or depleted.

Wyoming law allows only one filling of a reservoir during the water year. The space that can be filled (the quantity of water that can be stored) is the difference between the reservoir capacity and the reservoir content at the beginning of the water year. Counted toward this filling are: Water that is stored and retained in storage for release after the filling; Water that is stored and released prior to the filling; and Water that could have been stored but was passed through the reservoir. The accounted storage, or "paper storage", is used to determine when the reservoir has filled. This accounted storage on paper may, or may not correspond to actual, or physical, water storage in the reservoir.

These principles were used in the Tongue River Example, although they might not be true in Montana. Their use in the Example avoids a false picture of stored water availability for the river operation, when in actuality it may not be available. For instance, a reservoir supplying an all-year release for an industrial use will never physically fill, as some of the water is released concurrently as it is counted into storage.

Some combinations of stream, reservoir, and storage release situations merit attention for compact allocations. The usual situation, Case 1, is a reservoir in the stream channel releasing water to the same channel, and is straightforward. The only concerns under the Compact are the change in storage and the downstream diversions of released water.

In Case 2, a reservoir in the stream channel but releasing water directly to its place of use through a ditch or pipeline without using the stream channel for conveyance of the release, the released water must be counted as a diversion, with a positive sign. If water is also released to the stream channel for conveyance, its subsequent diversion would be counted as a diversion under Article V, C. 1. The change in storage of the reservoir would also be accounted.

Case 3 would apply to an off-stream reservoir with releases directly to a totally consumptive use (or to an export out of the drainage). In this case, it is necessary to count the diversion to the reservoir, since the water is removed from the opportunity for downstream use and it is a diversion. It is also necessary to consider the change in storage in the reservoir. The release to the use (or export) should not be counted. Counting the initial diversion and the release also as a diversion would result in double counting. The change in storage of the reservoir includes the accounting for the released water.

Case 4 pertains to diversion to an off-stream reservoir with water released back to the stream for conveyance to a downstream diversion point. The change in storage of the reservoir must be accounted. It appears the diversion to the reservoir should be the diversion entered into the cumulative diversions, and the subsequent diversion of released water ignored. To count both diversions would result in double counting, and the released water is reflected in the change in storage of the reservoir.

The subsequent diversion of the released water is somewhat similar to the diversion of imported water, except that its "source" is the initial diversion to the reservoir. Article X of the Compact addresses imported water, allowing credit for it to the State entitled to its use.

Case 5 is a not infrequently occurring situation. A pre-1950 reservoir, with its storage dedicated to pre-1950 purposes, may have a post-1950 enlargement with the storage dedicated to post-1950 uses. Instate water accounting for administrative purposes would normally keep the two reservoir pools separate in the records. A form of storage and release accounting would be necessary to determine the change in storage of the post-1950 reservoir pool. In effect, Case 5 could be considered as two separate reservoirs, with only the change in storage of the post-1950 portion of concern under the Compact. Diversion accounting would depend on the circumstances outlined under the other four cases, and would be treated accordingly.

Other Considerations The change in storage in a reservoir determined as a difference in storage content at two different times includes the integrated effect on the change due to evaporation, seepage, and other losses, or to precipitation, springs, ungaged surface inflows, and other gains. A computation based on measured inflows to, and outflows from the reservoir may also be used, with a similar integrating effect for losses and gains. Change in storage determined by the inflow-outflow approach requires more computation, but water administration needs may necessitate measurement of inflow and/or outflow, and possibly storage content as well. Evaporation, normally the major loss, need not be determined as a separate item to comply with the Compact provisions.

Water in a stream whether natural flow or release from a reservoir, will experience some degree of depletion due to evaporation, seepage, consumption by riparian vegetation, etc. There will also be gains to the stream from unmeasured tributaries, springs, overland runoff from snowmelt or rainfall or direct precipitation on the water surface. A stream reach is considered a losing reach or a gaining reach, depending upon whether the losses are greater than or less than the gains. Their net effect determines whether a reach is considered a losing reach or a gaining reach, and a losing reach at one time may be a gaining reach at another time.

Since stream losses do occur, a reservoir release that is to be conveyed in the stream channel may have a loss factor assigned to it. The magnitude of the loss factor is, at present, normally based largely upon experience, the distance the water is to be conveyed, the nature of the channel and its valley, and other considerations.

For the Tongue River Example, considering the distances water would be conveyed from the reservoirs, an arbitrary loss factor of 30 percent was assigned. This means that only 70 percent of the released quantity could be diverted at its assigned point of diversion. The actual magnitude of the loss factor is not critical in the example, so long as it is approximately reasonable. The important consideration is that a conveyance loss is included.

1996 Tongue River
Example - Narrative

1986 Tongue River Example

Introduction The schematic diagram for the Tongue River in the example offered by Montana in 1984 was taken as the starting point for Wyoming's 1986 Tongue River Example. It was, however, felt necessary to correct certain features and to bring certain assumptions closer to the real situation, and at the same time to increase the level of detail in the example. The example "model" is still a simplified one and still contains numerous assumptions and approximations, particularly for the Montana portion of the river system.

Montana's 1984 example injected an allocation calculation scheme that in part appears to circumvent Article V, Paragraph C, of the Yellowstone River Compact. Wyoming is not convinced this is a proper approach, and believes the Article V, C, procedure is simple and sufficient. This 1986 example is based on the allocation procedure set out in Article V, C. Montana may wish to test its scheme against this example to see if the same results are obtained, and with similar ease.

In actual practice, allocations under the Compact would be made with measured diversions, changes in storage, and flow passing the point of measurement. These would all be a matter of record and readily available. The example includes hypothetical future reservoirs and diversions for which there are no measurements or records. Simplifying assumptions are also necessary, such as "lumping" the diversions in a given reach into a single diversion in the reach. An operation calculation of the approximated system to include appropriative rights existing or assumed both before and after the Compact date is necessary to derive the values for the allocation simulation. The example uses monthly calculations.

The example is described below, with figures, tabulations, and calculations included following the description. Some of the narrative may seem overly elementary, but this is done to give all readers a common base for evaluating the example, and to provide answers to those questions that can be anticipated. Copies of the calculation forms are provided so that they can be copied and used in calculations with other assumed flows and/or diversion variables, should this be desired.

Operation Schematic Figure 1 illustrates the "model" of the system in schematic form. The headwater inflows, reservoirs, diversions, river reaches, tributaries, and reach gains are shown in their spatial sequences, although not to any scale. The irrigated acreages are shown for the lumped irrigation diversions, along with the estimated return flow percentages. Industrial diversions show the assumed constant diversion for each month. Reservoirs show the actual or assumed capacity for each. Relative priority dates for each reservoir and diversion are shown as pre-'50 or post-'50 for those in existence, and as post-1986 for the hypothetical future ones.

USGS gaging stations are shown in their relative positions, along with their USGS identifying number and a node number for the operation calculations. These stations did not necessarily have the same period of record, but nearly all had some overlap in their periods of record. There are now, or have been in the past, several other USGS stations in the basin, but these had too short a period of record to be meaningful and were ignored.

Those tributaries with USGS gaging station records were considered as measured inflows. Where irrigation was indicated below the gage, the tributary gage was adjusted for the irrigation use to obtain the "measured" inflow to the main stem. Unmeasured tributaries were assumed to be part of the unmeasured reach gain.

The letter prefixes and the symbols used are indicated in the legend on Figure 1. The identifiers are further defined and explained in the 5-sheet "Dictionary".

Dictionary A "Dictionary of Notations Used - 1986 Tongue River Example" is provided to define the notations used in Figure 1 and the operation calculations, and in the allocation determinations. Arrangement is alphabetical, except the terms used in the Compact accounting and allocation are together on Sheet 5.

Flows Used Flows at the USGS gaging stations deemed to have a suitable period of record were used as the base for the operation model flows. Each gaging station record was examined, and the median flow for each of the twelve months was determined for the station. These are shown in Table 1.

Each USGS station carries an 8-digit identifying number. Since all in the Missouri River drainage carry the basin prefix "06", this was dropped. The final two digits are generally "00", but may contain numbers other than zeroes. If these were zeroes, they were dropped. If other than zeroes, they were carried as the decimal numbers in the older USGS method. A number such as 06307740 was, for brevity, carried as 3077.4 in most of the tabulations and calculations.

The USGS stations used, and their periods of record utilized in the example, are:

North Fork Tongue River near Dayton, 2965:	Sept. 1945 - Dec. 1958
South Fork Tongue River near Dayton, 2970:	Sept. 1945 - Sept. 1972
Highline Ditch near Dayton, 2975 (diversion):	Oct. 1920 - Sept. 1982
Tongue River near Dayton, 2980:	Oct. 1919 - Sept. 1982
Little Tongue River near Dayton, 2985:	Jan. 1951 - Sept. 1974
Wolf Creek at Wolf, 2995:	Jan. 1945 - Sept. 1982
Goose Creek below Sheridan, 3055:	Oct. 1942 - Sept. 1982
Squirrel Creek near Decker, MT. 3061:	Sept. 1975 - Sept. 1982
Prairie Dog Creek near Acme, WY, 3062.5:	June 1965 - Oct. 1980
Tongue River at State Line, near Decker, 3063:	Sept. 1960 - Sept. 1982

Tongue River at Tongue River Dam, 3075:	June 1939 – Sept. 1982
Hanging Woman Creek near Birney, 3076:	Sept. 1973 – Sept. 1982
Otter Creek at Ashland, 3077.4:	Oct. 1973 – Sept. 1983
Pumpkin Creek near Miles City, 3084:	Oct. 1973 – Sept. 1983
Tongue River at Miles City, 3085:	Apr. 1938 – Sept. 1983

Some of these stations have one or more years of missing winter records. The data available at the station was utilized. Strict analysis would require using only corresponding periods of record for all stations. For an example containing approximations and assumptions, median flows based on the available records were considered to be sufficiently accurate.

It should be noted that the Tongue River flows north into Montana where it is joined by Squirrel creek, returns to Wyoming where Prairie Dog Creek enters, and then flows into Montana on its course to the Yellowstone River.

All of the tributary inflows to the Tongue River in Wyoming and Montana with sufficient USGS records were included in the example. Some are small contributors of water to the Tongue River, particularly in Montana, but may be locally important in the water supply picture.

The flow values, and all other numerical values except decimal fractions, were rounded to hundreds for all tabulations and calculations in the example. The errors inherent in the various assumptions would make any greater precision questionable.

Calculation points, or nodes, along the Tongue River are designated by N, followed by a number. These are sequential downstream. They coincide with the USGS gaging stations where a gaging station is located, but are primarily located to facilitate operation calculations. Nodes at the mouths of tributaries are designated by the immediately upstream node number, with the suffix A attached. A second tributary above the next downsteam node on the mainstem carries the suffix B.

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The only node of concern for the Compact allocation is N18, USGS gaging station 06308500, designated as the point of measurement. For the example river operation the flow at N18 will be a calculated value rather than the median flow value.

Diversions The quantity of the irrigation diversions each month is a function of the acres to be irrigated, the water supply, and other factors. Irrigated acres for Wyoming were obtained from "Tabulation of Adjudicated Water Rights of the State of Wyoming, Water Division Number Two", April 1984. The water right acres were compiled into totals by river reach, and for each tributary below the USGS gage. They were also examined for pre-1950 and post-1950 priority dates. The post-1950 water rights were found to be so minor that they could be ignored for this example. Future (post-1986) irrigated acres were estimated to be compatible with the assumption in the Montana 1984 example, and assumed supplied by direct flow only.

Irrigated acres for Montana are estimations based on several sources. Copies of tabulations from county reports (20 or more years old), examination of maps for terrain and "possible" areas, and the assumptions used by Montana in its 1984 example were used to guide the estimations for pre-1950 irrigated acres. Future (post-1986) Montana irrigation estimations were guided by the 1984 Montana example. The post-1986 irrigation was assumed supplied by a combination of direct flow and releases from the post-1950 enlargement of Tongue River Reservoir.

Industrial diversions were assumed only in Wyoming, consistent with Montana's 1984 example. A pre-1950 industrial right was estimated to have a constant 1500 acre-feet per month diversion rate. Based on some personal knowledge of the situation, a 20 percent return flow was estimated. A future (post-1986) industrial demand for 1000 acre-feet per month was assumed, again consistent with the 1984 Montana example. It was further assumed that there was a direct flow right for this that would allow diversion of up to 600 acre-feet per month. The balance of the 1000 acre-feet per month would be supplied from the hypothetical post-1986 reservoir on the South Fork of the Tongue River. This post-1986 industrial use was assumed to have no return flow.

Each example diversion point is identified by D, followed by a number in downstream order, with some exceptions. D1 was initially intended for the diversion of water to the post-1986 industrial use, but after further consideration it was discarded without renumbering the other diversions. D15 and D16 were dropped for similar reasons, and the numbers retained for the two Tongue River Reservoir pools.

Table 2 lists the diversion points by identifier number, and shows the source stream, the acres, and the maximum monthly diversion volumes at 2 cfs per 70 acres and at 1 cfs per 70 acres for each. Notations are included where appropriate. The acres and the maximum monthly diversion volumes are rounded to hundreds.

Preliminary work seemed to suggest that the Highline Ditch diversions, USGS gage 06297500, would serve as a guide to the percentages of the 1 cfs/70 acre irrigation diversion rate that might be applied each month. Estimations of the percentage of the maximum diversion volume for each month were made, considering the different conditions encountered from the Highline Ditch diversion to the mouth of the river. The results are irrigation diversion fractions for each month for Wyoming (fW) and for Montana (fM).

Subsequent work and thought suggests that these fractions may be low in some months, and possibly should approach a value of 2.00. Available time has not allowed pursuit of this. Wyoming law allows a diversion rate of 2 cfs/70 acres under certain conditions. The 1984 Montana example used the 2 cfs/70 acres for all irrigation diversions in both States.

Diversions for post-1950 purposes must enter the allocation calculation. All diversions must be considered in the example operation.

Return Flows Return flows are associated with the diversion of water for purposes where the water is not totally consumed. Flood irrigation is generally assumed to have a return flow to the stream equal to 50 percent of the diversion. This percentage was assumed in the example for all irrigation with a pre-1950 priority. The future (post-1986) irrigation was assumed to return only 40 percent of the diverted water, as future irrigation should be more efficient. Both percentages may be high. Some of the pre-1950 irrigation has been converted to some form of sprinkler application. Most future irrigation application would be expected to be by sprinkler or some other efficient method. For simplicity in the example, return flows are assumed to occur in the same reach and in the same month as the diversion. The exception is the Highline Ditch, D2, which has a node (N5) between the diversion and the uses.

As noted under "Diversions", the pre-1950 industrial diversion is assumed to have a 20 percent return flow. A part of this water has been used for "once-through" cooling at a powerplant, and may be so used again. The 20 percent figure may be low. All future industrial diversions would be expected to have no return flow, due to cost and water quality considerations.

Return flows do not enter into the Compact allocations, except as subsequent diversions of the returned water. They must, however, be considered in the example operation of the system, as they become a part of the water available to downstream diversions.

Reservoirs Two reservoirs are considered in this example. One in Wyoming is hypothetical, and the pre-1950 Tongue River Reservoir in Montana has a post-1950 enlargement. The result is, effectively, three reservoirs, two of which enter the Compact allocation. All must be considered for operation of the system "model".

The future hypothetical reservoir in Wyoming, designated by number 1, assumes a capacity of 25,000 acre-feet, with the yield dedicated to supplementing the direct flow right for the post-1986 industrial diversion, D6. An initial content, considered carryover storage, of 11,000 acre-feet was assumed for the operation study.

The capacity and the location on the South Fork of the Tongue River were assumed in the Montana 1984 Example, and carried into this example. However, the water supply situation to the reservoir was corrected. The USGS gage on the South Fork was located downstream of the presumed site (node 2, or N2). Inflow to the reservoir, N1, was estimated as 80 percent of the N2 flow, based on terrain, tributaries above and below the site, and relative drainage areas.

Conveyance loss for reservoir releases conveyed in the river to the D6 diversion point was assumed to be 30 percent for this example. The quantity of stored water needed at the D6 diversion, divided by 0.70 equals the amount of water that must be released from the reservoir. For simplicity, the reservoir release is deducted from the storage, but only the amount needed at D6 is counted through the intervening node calculations. This procedure precludes the diversion of the water needed at D6 at some upstream diversion point, and eliminates the need to continually track a diminishing quantity of water through several nodes.

The change in storage in the reservoir, $\Delta S1$, is obtained for the system operation calculation by the difference, water stored minus water released. The sign of $\Delta S1$ may be positive or negative, depending upon the relative magnitudes of the quantities stored and released. The change in storage quantity of this reservoir is necessary to the allocation calculation.

The Tongue River Reservoir in Montana can be treated in the example as a pre-1950 reservoir with 66,000 acre-feet of capacity, and a post-1950 reservoir with 4,000 acre-feet of capacity, as in the 1984 Montana Example. System calculations for the current example and actual water administration accounting would both require the two reservoir concept. In this example, the pre-1950 reservoir is designated number 15, and the post-1950 enlargement reservoir is designated number 16.

The change in storage, conveyance loss, and quantity of release determinations for each reservoir priority date would be handled in the same manner as described above for the Wyoming reservoir. The change in storage for the post-1950 portion would be required for Compact allocation determination. The change in storage for the pre-1950 reservoir is necessary to the operation calculations, but would not enter into the allocation.

The pre-1950 reservoir storage is used for supplemental supply for pre-1950 irrigation diversions D17 and D20, as needed. The post-1950 reservoir storage supplements the post-1950 irrigation diversion D18.

This 1986 example uses Wyoming laws applicable to reservoirs to govern the reservoir operations, although Montana laws may differ. Information on Montana's statutes for reservoirs was not available. In either case, the change in storage over a typical water year should approach zero.

Wyoming allows only one filling per year. The storage space that can be filled is the vacant space at the beginning of the water year, or the reservoir capacity minus the storage content on October 1st. The reservoir fill is determined by accounting the water actually stored, the water that could have been stored but was not, and water "stored" but immediately released to its specified use. This is often referred to as "paper storage", where the numbers add up to the reservoir capacity but the actual or physical storage content may be a lesser quantity. The above strict "rule" was applied in the 1986 example, with both paper storage and physical storage considered for the operations.

Montana Stockwater A court decree, apparently predating the Tongue River Reservoir, requires a stock water flow to be passed through the reservoir. Available details on the decree were limited, but apparently a flow of 167 cfs or the reservoir inflow, whichever is less, is required below the Tongue River Dam. This water is not available for storage, and is not to be counted into the paper storage of the reservoir.

The flow of 167 cfs equates to approxiamtely 9900 acre-feet per month. It was assumed that this water would be available, along with other natural flow and/or reservoir releases, to meet downstream diversion needs. Since this quantity, designated as "Stock" in the example model, is natural flow, any losses would appear in the reach gain estimations.

Reach Gains Water flowing in a stream channel is subject to a variety of natural phenomena that work together to produce an increase or a decrease in the water quantity that entered a given stream reach. The net effect of these phenomena may be a net gain or a net loss in flow through a particular stream reach, depending upon whether the total gains or the total losses are greater. For the purpose of the operation calculations in this example, a loss is treated as a negative gain.

Using the main stem USGS gaging stations available, the flow of the stream at an upstream station can be subtracted from the flow at a downstream station to obtain the stream gain (or loss) between the stations. In the example calculations for estimation of reach gains, this gain between USGS stations is referred to as the Net Gain, or N.G. The median flows used in the example represent approximately the mid-level flow regimen with pre-1950 water uses included.

Those tributaries with gaging stations, adjusted for irrigation below the station, represent measured inflows or Measured Gains, M.G. in the example. Diversions from the reach for pre-1950 water rights must have been supplied from available water and should be considered, as they represent depletions.

An Unmeasured Gain (U.G.) for a reach is estimated by the Net Gain minus the Measured Gain plus the estimated diversions reduced by the estimated return flow. U.G. may be positive or negative in sign. If a reach between main stem gaging stations is subdivided into shorter reaches between calculation nodes, U.G. is prorated by percentages among the shorter reaches. The percentages are rather arbitrary for this example, guided by knowledge of the area and map inspections.

The Unmeasured Gains are influenced by similar factors to those for conveyance losses, and the two are related. It should be noted that some irrigation return flows are included in the Unmeasured Gains. In actuality the 50 percent estimate for return flow from irrigation is a blend of return flows from diversions in previous months and likely also from diversions from an upstream reach. A diversion from a given reach may actually have all or part of its return flow reentering the river in one or more downstream reaches. The Unmeasured Gains calculation would include those return flows not already used to reduce a diversion, or that might have been under or over estimated for the diversion.

Table 3 collects values needed for the operation calculations, except for the diversion quantities other than the D2 median diversion. The maximum diversion quantities for each diversion are shown in Table 2.

Table 3 lists the values by month for the diversion fractions, the median flows at inflow nodes N1 and N3, reach gains, the Highline Ditch median diversions, and gaged tributary inflows adjusted when necessary for irrigation downstream of the gage.

Calculation Forms Blank calculation forms are included following Table 3, and the completed calculation forms for this example are appended.

Form 1 Form 1 is designed to facilitate the calculation of the estimated reach gains. At the top of the form there is provision for entering the month, the level of water supply (medians, in this example), and the diversion fractions for each State for that month. Other notes outline basic information for ready reference. A basic assumption, which is probably very nearly correct, is that the median flows and other parameters represent pre-Compact conditions.

The reach gains are not needed for allocation of water under the Compact. They are necessary to the operation of the system in the example "model" whereby the estimates of the values used in Article V, C, are derived.

A cautionary note is in order. The reach gains are directly and strongly influenced by the diversion fractions, fW and fM, that are used for each month. Preliminary work indicates these fractions might be increased or decreased in at least some months. For example, the month of May as shown in the example calculations, has negative reach gains for G5 and G6. Positive values would result if fM were assumed to be 1.60 or greater. Time has not allowed further investigation of this, or for correction of the subsequent calculations if it was found necessary. The Net Gain between USGS gages at nodes N14 and N18 is negative in October, May, July, August, and September, but the calculated Unmeasured Gain for the present example is only negative in May. Since the Unmeasured Gains are derived from the USGS gage median flows, the median flows can always be checked (within rounding errors) through the system operation with the pre-1950 conditions, a "chicken and egg" situation. Sufficient diversion records need to be obtained to more reliably estimate the monthly fW and fM diversion fractions.

Form 2 Form 2 provides a systematic procedure for calculation of the example, with post-1950 water uses imposed. Notes are added on pertinent lines as reminders of limits. Provisions are made at the top for entering basic data for the applicable month. These include the month and the interation number if it is necessary. The first calculation for the month would be iteration number 0, since it is not an iteration. The water supply level, median in this example is noted, as are the diversion fractions fW and fM for that month.

Reservoir data should be recorded for each reservoir. The paper content, for accounting toward reservoir filling, is entered as a Beginning of Month content for each — BOM1, BOM15, and BOM16. The physical, or actual, content of each reservoir is entered for BOM1 Phys, BOM15 Phys, and BOM16 Phys. These values are assumed, as initiating values, for October, and would be equal in a given reservoir. For subsequent months, they are the End of Month, or EOM, corresponding reservoir contents from the previous month.

The example calculation uses numerical data from Table 3, except for the maximum diversion values from Table 2. The first calculation is to determine the space available for storage in Reservoir 1, and to limit the water stored, Store 1, to the inflow N1 or to the amount needed to complete the filling. The required release from Reservoir 1 is estimated, assuming the first 600 acre-feet of the D6 diversion will be met from direct flow and if so, then 400 acre-feet (D6 Short) will be needed at the diversion point. This would require 600 acre-feet be released (Rel 1) to allow for the conveyance loss. The change in storage for the month, ΔS1, is then the difference, Store 1 - Rel 1. This should be noted at the bottom of the sheet for later allocation use.

The EOM1 and EOM 1 Phys. calculations merely add the "paper" storage and the actual change in storage (+ or -) to the BOM1 and BOM1 Phys. quantities. EOM1 cannot exceed the 25,000 acre-feet of reservoir capacity.

Determinaton of N4 involves subtracting the quantity stored from the reservoir inflow, adding the quantity released for D6 with the conveyance loss removed from the release, and adding the North Fork flow, N3, and the reach gain, Gain. Values for N3 and Gain are in Table 3.

Flow at N5 is the N4 flow less D2, the Highline Ditch diversion. D2 is diverted a short distance above the gage at N5, and all return flows occur downstream of N5, assumed above the D3 diversion. The flows at N5 and N6 must equal or exceed the delivery to D6 (D6 Short), as this is "ownership" water.

N6 is obtained by deducting the D3 depletion from the N5 flow, adding R2 (the return from D2) and the reach gain, G1. The D3 depletion is determined from the D3 quantity (Table 2) multiplied by the diversion fraction fW and the return flow fraction of 0.50 in this case.

The N7 calculation adds the tributary inflow from Little Tongue River (N6A) to the N6 flow. The value for N6A was estimated on the corresponding month's Gains Derivation sheet (Form 1) and recorded in Table 3.

After calculating N7, the situation for D6 is checked. One-third of the G2 reach gain is assumed to have accrued upstream of the D5 diversion. The direct flow available to D6 (D6 Direct) is then N7 plus one-third of G2, which is water available at the D5 diversion, minus the D5 diversion. The D5 return flow is disregarded because it may not be available at the D6 diversion. D6 Direct cannot exceed 600 acre-feet per month, its assumed direct flow water right. If the D6 direct value is negative, all of the D6 demand must be supplied from the reservoir release and D5 will be short by the D6 Direct negative amount.

The shortage to the D6 demand, D6 Short, is the total demand of 1000 acre-feet per month minus D6 Direct. It will be at least 400 acre-feet per month, but no greater than 1000 acre-feet per month. D6 Short divided by 0.7 gives the quantity to be released from the reservoir, Rel 1. If D6 Short differs from that estimated for the reservoir calculations, an iteration is necessary to adjust the system. (The adjusted release can be assumed present, and the operation continued to see if other adjustments might be needed, before starting the iteration.) Note the D6 total quantity at the bottom of the sheet for later allocation calculations.

The N8 through N13 calculations are similar to those described above. In calculating N12, should a shortage occur (negative N12 value), post-1950 diversion D12 must bear the shortage necessary to meet the pre-1950 diversion D11. Note the D12 diversion quantity at the bottom of the sheet for later use in the allocation.

N13 represents the simulated flow entering Montana. Diversion D14 is assumed to occur between N13 and Tongue River Reservoir. In view of the stock water decree, the lesser of 9900 acre-feet per month or the inflow to the reservoir will be passed through as unavailable for storage, but is assumed available downstream for diversions.

Water available for storage in Tongue River Reservoir, Avail, is estimated from the N13 flow minus the D14 depletion minus 9900. If the result is negative, the stock water bypass, Stock, will be N13 reduced by the D14 depletion, and no water will be stored.

Calculations for the pre-1950 and the post-1950 portions of the reservoir are made as though they were two separate reservoirs. The post-1950 reservoir of 4000 acre-feet capacity is not allowed to store water until the pre-1950 reservoir has filled on paper, or EOM15 equals 66,000 acre-feet. The two sets of reservoir calculations are carried along together, but kept distinct.

Releases for D17 Short and D20 Short from the pre-1950 portion, and for D18 Short from the post-1950 portion, of the reservoir can only be estimated at this stage. The initial estimates would normally be zero.

The change in storage for the post-1950 storage, in reservoir 16, ΔS16, is noted at the bottom of the sheet for the allocation determination. The change in storage in reservoir 15 (pre-1950) is of interest only for the operation calculations.

Operation downstream of Tongue River Dam begins with calculation of the flow at N14, immediately below the dam. The inflow to the reservoir, less Stock, was determined above as Avail. Releases from the reservoir are treated as for reservoir 1, with the 30 percent conveyance loss removed, and just the downstream needs counted in the N14 flow. Avail is reduced by the water stored as Store 15 and Store 16, and increased by any water released to provide supplemental supplies, D17 Short, D18 Short, and D20 Short, and is further increased by addition of the stock water bypass, Stock.

The flow at N15 is obtained by adding the tributary inflows from Hanging Woman Creek (N14A) and Otter Creek (N14B) and the reach gain G5 to the N14 flow. There may be some irrigation between N14 and N15, but it was not apparent from the available information examined.

Any shortage to the D17 pre-1950 irrigation diversion is estimated from the diversion requirement minus the N15 flow minus one-third of the G6 reach gain. A zero or negative value for D17 Short indicates there is no shortage to the diversion. If there is a shortage (D17 Short greater than zero), an iteration is necessary to provide supplemental water from reservoir 15. However, the calculation should be continued under the assumption that D17 is satisfied, in order to estimate any shortages to D18 and D20.

The D18 post-1950 irrigation diversion is next checked for a shortage estimation. The total diversion requirements for D17 plus D18 minus the N15 flow minus one-third of the G6 reach gain estimates any shortage for

D18, D18 Short. Again, there is no shortage if D18 Short is zero or negative. If D18 Short is greater than zero, an iteration is necessary to provide supplemental water from reservoir 16. As with D17 Short, assume both D17 and D18 are just satisfied and continue the calculation to estimate any shortage to D20 before starting the iteration.

The operation continues with calculation of the flow at N16 by depleting the N15 flow for D17 and D18 and increasing it by the reach gain, G6. If N16 is negative, there is obviously a supply shortage for D17 and/or D18, and an iteration may be necessary to try to meet the shortages. D18 is a post-1950, or junior, diversion and can only be supplemented from reservoir 16 storage. The D17 diversion can "call" water from D18 before drawing on reservoir 15 storage. Enter the D18 diversion quantity at the bottom of the sheet for use in the allocation.

Calculation for N17 adds the Pumpkin Creek tributary inflow, N16A, to the flow at N16. This is the supply to D20.

N18 is obtained by depleting the N17 flow for the D20 pre-1950 diversion. Return flow from D20 is assumed to enter the system downstream of the point of measurement, N18, and therefore is not considered. This is consistent with the 1984 Montana Example system. If the calculation for N18 results in a negative value, D20 Short is equal to this quantity, and an iteration is needed to either "call" water from the post-1950 D18 diversion or to supplement D20 from reservoir 15.

In the actual situation, a zero flow at N18 would probably not be obtainable, and a small flow at N18 in the example would be acceptable. If the N18 flow is significantly greater than zero, an iteration may be possible to decrease Rel 15 and/or Rel 16, or to increase storage, provided water is available at the reservoirs for additional storage. It may also be possible to increase all or part of the irrigation diversions, up to the limit of 2 cfs per 70 acres. Unused flow at N18 is also an indicator that more water could be "appropriated" in the example, provided the reaches were selected for the diversions so that water was available at the proper times to the diversions.

The value of N18 is to be noted at the bottom of the sheet as the water passing the point of measurement, N18 or the "compact gage", for the allocation.

Form 3 Form 3 provides an allocation calculation procedure for this Tongue River example. The quantities needed for the allocation were derived on the Monthly Operation Calculation sheets (Form 2) and recorded at the bottom of each sheet. In actual real-time river operation under the Compact provisions these values would be measured and a matter of record. The operational exercises as on Forms 1 and 2 would not be necessary to the allocation "in real life".

The brevity of each allocation determination for the example allows three month and/or iteration allocations per sheet. When operations on Form 2 require iteration, only the final results for the allocation need be brought to Form 3.

Each monthly block on Form 3 provides for entry of the month and the iteration number, corresponding here to the Form 2 sheet where the allocation values were derived. The procedure involves keeping the values for each State and the N18 compact gage separate, and then combining them in the "allocable" column for allocation. Having the values for each State separate, the total use for each State can be compared with that State's allocation. There is provision for a "yes" or "no" iteration decision, and space for notes to outline "why", or for any other brief pertinent notes. A "Comments" space is provided at the bottom of each sheet for use as needed.

Within a block, there are headings for each State (WY and MT), the point of measurement (Gage N18), and the algebraic sum of the water to be allocated (Allocable). Each State heading has subheadings for the values to be entered for the post-1950 uses in that State. The "Accum" subheadings are used only to record the sum of the State's individual item cumulative values.

There are three line items in the tabulation. "Previous Accum" refers to the cumulative values for the previous month under the subheadings (except "Accum") and for the "Gage N18" heading. For the month of October these entries would all be zero. The second line, "Current Period", is for entry under the subheadings of the values generated on Form 2 for that month that were recorded at the bottom of the Form 2 sheet. The third line is "Current Accum", and is the algebraic sum of each column in the first two lines. These values are then algebraically summed across for each State and entered into the "Accum" column for that State. Finally, the two "Accum" values and the "Current Accum" for Gage N18 are algebraically summed across into the "Allocable" column.

Below the tabulation, the allocations are determined for Wyoming and Montana by multiplying the "Allocable" quantity by 0.40 and 0.60, respectively. The resulting quantities are the amounts of water that each State was entitled to utilize since October 1st. In the "Compare" lines, each State's "Accum" quantity (since October 1st) is subtracted from the State's allocation. A negative result indicates the State's utilization of water exceeded the State's allocation, and an iteration to make appropriate adjustments is called for. Adjustments to increase water utilization may be possible, and would also require iteration.

The Form 3 allocation procedure conforms to Article V, C, of the Compact. In use, it is simple and straightforward, and can be accomplished for a given month much more rapidly than the above description can be read.

A more complex example, or the actual river allocation, would require modifications to the tabular format, but the same type of procedure could be used.

Suggestions Several areas for further work for this, or future, examples became apparent during the work described above. Some Suggestions offered are:

1. Pursue the relationship between unmeasured gains and quantities of water diverted, specifically the diversion fractions. It may be necessary to obtain diversion records from both State's to determine the fractions needed.

2. Obtain better detailed information from Montana on water uses, locations of use, diversion limitations, and reservoir operation.

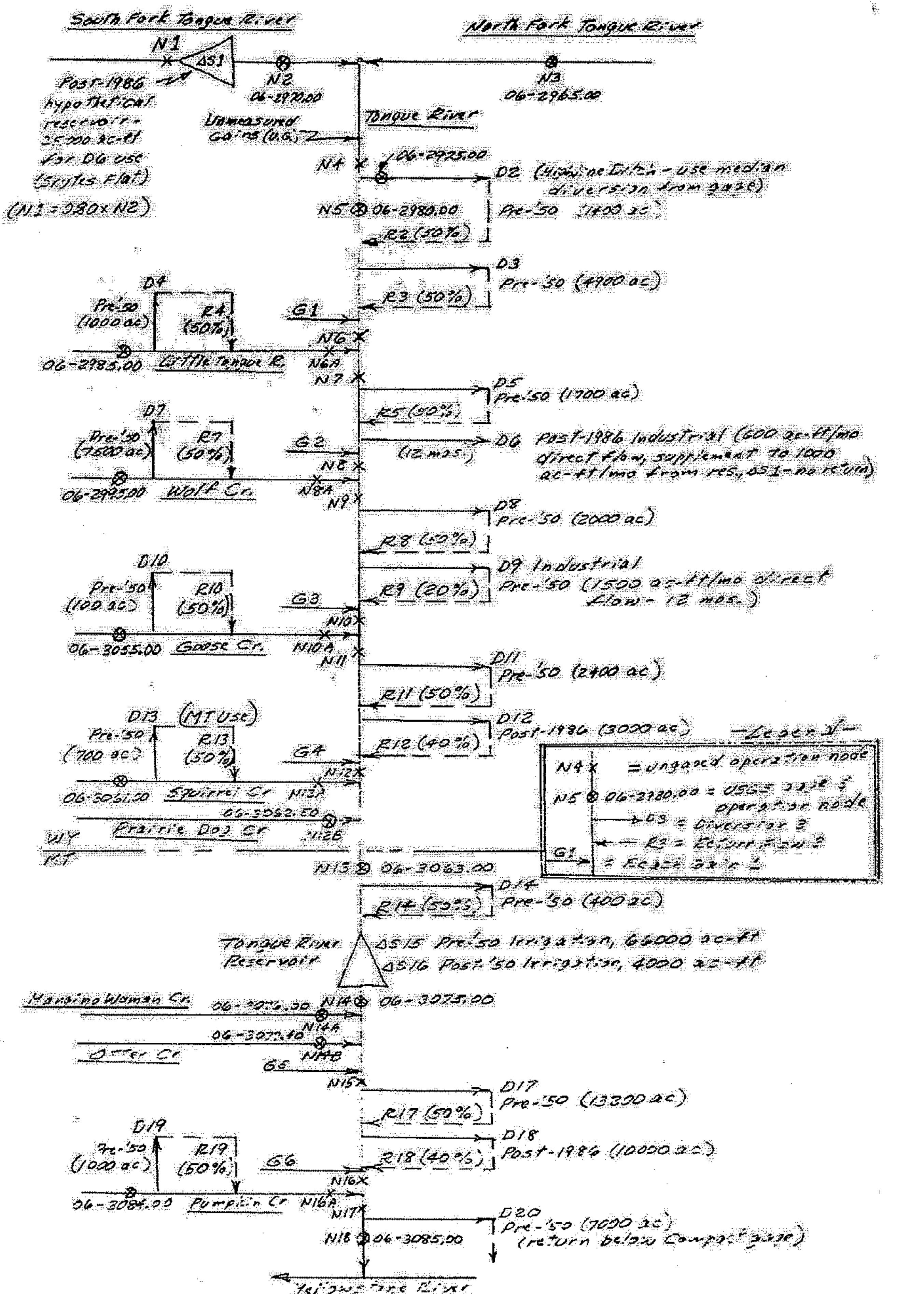
3. Include tributary operations to the extent possible from flow and diversion records and water rights. The Goose Creek tributary is a complex system in itself, and probably includes most of the post-1950 storage and diversions in the system.

4. Expand the detail on diversions from the Tongue River main stem, including any post-1950 diversions.

5. Explore possibilities for increasing storage in the system.

Torque R. Example
Schematics, Tables

Tongue River-1986 Operation Schematic Figure 1



MT-00970

Dictionary of Notations Used – 1986 Tongue River Example (sheet 1)

Avail – Water available for storage in Tongue River Reservoir in MT, flow at N13, less irrigation depletion above res., less required stock water below res. (lesser of 9900 ac-ft/mo or inflow).

BOM1, BOM15, BOM16 – Accounted Beginning of Month content in storage spaces 1 (Post-1950), 15 (Pre-1950), & 16 (Post-1950) respectively ("paper" storage). (EOM contents, previous month).

BOM1 Phys, BOM15 Phys, BOM16 Phys – Actual (Physical) storage content in spaces as above. (EOM physical contents, previous month).

D2 – Highline Ditch diversion, Pre-1950, WY (USGS gage 06299500).

D3 – Lumped diversion between N5 & N6, 4900 ac, Pre-1950, WY.

D4 – Lumped diversion, Little Tongue River below USGS gage [illegible], 1000 ac, Pre-1950, WY.

D5 – Lumped diversion between N7 & N8, 1700 ac, Pre-1950, WY.

D6 – Assumed industrial diversion between N7 & N8, 1000 ac-ft/mo, 600 ac-ft/mo maximum direct flow, balance from assumed res. on S. Fork Tongue R., Post-1950, WY, no return.

D6 Direct – Direct flow amount diverted at D6, to 600 ac-ft/mo.

D6 Short – Quantity needed from storage at D6, to 1000 ac-ft/mo.

D7 – Lumped diversion Wolf Creek below USGS gage [illegible], 7500 ac, Pre-1950, WY.

D8 – Lumped diversion between N9 & N10, 2000 ac, Pre-1950, WY.

D9 – Industrial diversion between N9 & N10, 1500 ac-ft/mo direct flow, Pre-1950, WY (assumed 20% return flow based on nature of use).

D10 – Lumped diversion, Goose Creek below USGS gage [illegible], 100 ac, Pre-1950, WY.

D11 – Lumped diversion between N11 & N12, 2400 ac, Pre-1950, WY.

D12 – Assumed new diversion between N11 & N12, 3000 ac, Post-1950, WY, assumed 40% return.

D13 – Lumped diversion, Squirrel Creek below USGS gage 06306100, Pre-1950, MT.

(continued)

(Dictionary - continued) (Sheet 2)

D14 — Lumped diversion between N13 & Tongue River Reservoir, 400 ac, Pre-1950, MT.

D17 — Lumped diversion between N15 & N16, 13200 ac, Pre-1950, MT

D18 — Assumed new diversion between N15 & N16, 10 000 ac, Post-1950, MT, assumed 40% return.

D19 — Lumped diversion, Pumpkin Creek below USGS gage 06 308400, 1000 ac, Pre-1950, MT.

D20 — Lumped diversion between N17 & N18, 7000 ac, pre-1950, MT, return flow is below compact gage 06308500 (N18) and not considered.

EOM1, EOM15, EOM16 — Accounted End of Month content in storage spaces 1 (Post-1950), 15 (Pre-1950), & 16 (Post-1950), respectively ("paper" storage). Becomes BOM contents for following month.

EOM1 Phys., EOM15 Phys., EOM16 Phys. — Actual (Physical) storage content in spaces as above. (BOM physical contents for following month).

FW — Fraction of 1cfs/70 ac irrigation diversion for current month for Wyoming irrigation.

FM — Fraction of 1cfs/70 ac irrigation diversion for current month for Montana irrigation.

Gage No. — USGS gages carry an 8-digit no. for identification. All used in the example are in drainage 06, and these first two digits are generally dropped. Also for brevity, the last two digits are dropped when zero, leaving a 4 or 5 digit identifier in the example — e.g., N13 is at gage no. 06306300, used as 3063, and N12B is at gage no. 06305350, used as 3053.5.

Gain — The unmeasured gains above N5, N5-N2-N3+D2 on Gains Calculation sheets. (A negative gain is a loss.)

G1 — The unmeasured gain calculated for the reach N5 to N6.

G2 — The unmeasured gain calculated for the reach N7 to N8.

G3 — The unmeasured gain calculated for the reach N9 to N10.

G4 — The unmeasured gain calculated for the reach N11 to N12.

(continued)

(Dictionary - continued) (Sheet 3)

G5 - The unmeasured gain calculated for the reach N14 to N15.

G6 - The unmeasured gain calculated for the reach N15 to N16.

M.G. - Measured Gain for a given reach, primarily tributary inflows.

N1 - Calculated inflow node for assumed reservoir on S. Fork Tongue River, N1=0.80N2.

N2 - USGS gage 06297000, S. Fork Tongue River, or calculated.

N3 - USGS gage 06296500, N. Fork Tongue River.

N4 - Calculated node just above Highline Ditch diversion.

N5 - USGS gage 06298000, Tongue River near Dayton, or calculated.

N6 - Calculated node just above mouth of Little Tongue River

N6A - Calculated node, Little Tongue River at mouth (trib. inflow).

N7 - Calculated node below mouth of Little Tongue River

N8 - Calculated node above mouth of Wolf Creek.

N8A - Calculated node, Wolf Creek at mouth (trib. inflow).

N9 - Calculated node below mouth of Wolf Creek.

N10 - Calculated node above mouth of Goose Creek.

N10A - Calculated node, Goose Creek at mouth (trib. inflow).

N11 - Calculated node below mouth of Goose Creek.

N12 - Calculated node above mouths of Squirrel Creek (N12A) and Prairie Dog Creek (N12B).

N12A - Calculated node, Squirrel Creek at mouth (trib. inflow).

N12B - USGS gage 06306250, Prairie Dog Creek near Acme (trib. inflow).

N13 - USGS gage 06306300, Tongue River at State Line or calculated.

N14 - USGS gage 06307500, Tongue River below Tongue River Dam, or calculated

(continued)

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(Dictionary – continued) (Sheet 4)

N14A – USGS gage 06307600, Hanging Woman Creek near Birney (Trib. inflow).

N14B – USGS gage 06307740, Otter Creek near Ashland (Trib. inflow).

N15 – Calculated node below mouth of Otter Creek.

N16 – Calculated node above mouth of Pumpkin Creek.

N16A – Calculated node, Pumpkin Creek at mouth (Trib. inflow).

N17 – Calculated node below mouth of Pumpkin Creek.

N18 – USGS gage 063085, Tongue River at Miles City, or calculated – compact measurement point.

N.G. – Net Gain through reach. Difference, downstream gage minus upstream gage.

R- – Return flow, R-numbers correspond to D-numbers – e.g., R2 is the return flow for D2. Calculated.

Rel1, Rel15, Rel16 – Releases from respective storages to satisfy diversion needs for D6, D17 and/or D20, and D18, respectively.

Short – (see also D6Short) Shortage at diversion for D17 and/or D20 to be met by Rel15, or at D18 to be met by Rel16. Rel15 = (D17Short + D20Short) ÷ 0.7, and Rel16 = D18Short ÷ 0.7. A 30% conveyance loss is assumed for all releases including Rel1, hence the shortage is divided by 0.7. The released amount is entered at the first downstream node as the Short amount, which removes the loss from the calculations.

Stock – Maximum stock water required to pass Tongue River Dam, decreed as 167 cfs (approx. 9900 ac-ft/mo), or the inflow to the reservoir, whichever is less. This amount is assumed available for diversion downstream of N15. Losses thereof are reflected in the net gain from N14 to N18, and are not considered separately.

Store 1, Store 15, Store 16 – Amount of water stored toward "paper" fill in the respective reservoir space, reservoir capacity minus BOM content ("paper" content), and limited to inflow to the reservoir.

(continued)

(Dictionary - continued) (Sheet 5)

U.G. — Unmeasured Gains in a reach, calculated from Net Gain, Measured Gains and calculated depletions through the reach. The reach N5 to N13 is prorated as G1, G2, G3, and G4. The reach N14 to N18 is prorated as G5 and G6. For reaches N12 to N13, N13 to N14 (reservoir), and N16 to N18, U.G. is assumed negligible due to the short distances and other considerations. The reach above N5 is calculated as a single U.G. value, Gain, and not prorated.

ΔS1, ΔS15, ΔS16 — Changes (+ or −) in storage in the respective storage spaces. Calculated as the Store amount minus the Rel amount for the respective storage spaces.

For accounting under Article V, C, of the compact, the following definitions are used. For this example, only the Post-1950 water storages and uses are of concern, and these would be expected to be measured values. (Refer to the "Article V, C, Compact Calculation - Tongue River Example" sheets.)

Previous Accum — the accumulated values for ΔS1, D6, and D12 for WY, and ΔS16 and D18 for MT, and the N18 compact gage value from the previous month (or, if October, zero for each).

Current Period — The values for ΔS1, D6, D12, ΔS16, D18 and Gage N18 calculated for the month under consideration.

Current Accum — the algebraic sums of the respective Previous Accum and Current Period values.

Accum (WY heading) — The algebraic sum of ΔS1, D6, and D12 for the Current Accum sums. (WY use since Oct 1)

Accum (MT heading) — The algebraic sum of ΔS16 and D18 for the Current Accum sums. (MT use since Oct 1.)

Allocable — The algebraic sum of WY Accum, MT Accum, and Gage N18 Current Accum sums.

Allocations — To WY, 40% of Allocable; to MT, 60% of Allocable, the allocated water for each state.

Compare — Subtract Accum from Allocation for each state, adjust uses as appropriate to eliminate negatives or increase uses

MT-00975

Tongue River Drainage - Median Flows from Gage Records, (acre-feet rounded to hundreds)

USGS Gage Name, Location	Node & USGS Gage No. (all 06-)	Month: Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Sum of Medians	Notes
N. Fk Tongue nr Dayton	N3 2965	1300	1200	1100	900	800	800	900	4500	6200	3200	1800	1500	24200	(WY)
S. Fk Tongue nr Dayton	N2 2970	1400	1300	1000	900	700	700	1100	15300	23100	6700	2600	1700	56400	(WY)
Highline Ditch nr Dayton	2975	400	0	0	0	0	0	0	100	900	1200	1200	1000	4800	Diversion (WY)
Tongue R. nr Dayton	N5 2980	4800	4000	3700	3500	2900	3200	4600	32400	39400	14200	6700	5000	124400	(WY)
Little Tongue nr Dayton	2985	200	100	100	100	100	100	300	2800	3100	800	200	100	8000	Trib. (WY)
Wolf Cr. at Wolf	2995	500	400	300	300	300	300	700	5800	7600	3400	900	600	20100	Trib. (WY)
Goose Cr. bel Sheridan	3055	6200	5600	5100	4300	4100	5800	7800	25400	40000	9000	2800	4500	120600	Trib. (WY)
Squirrel Cr nr Decker	3061	100	100	100	0	100	200	400	500	300	100	0	0	1900	Trib. (MT)
Prairie Dog Cr nr Acme	N12B 3062.5	2500	2000	1500	1300	1700	4800	3600	3100	2200	1100	1500	2400	27600	Trib. (WY)
Tongue R. at St. Line, Decker	N13 3063	16300	13400	12100	11100	12400	17600	23400	70500	95300	28100	10700	12200	323100	(MT)
Tongue R. at Tongue R. Dam	N14 3075	17700	14500	11700	10600	9400	12800	22100	55600	73400	29400	20000	17800	295000	Res. Outflow (MT)
Hanging Woman Cr. nr Birney	N14A 3076	100	100	100	100	100	300	200	200	200	300	0	0	1600	Trib. (MT)
Otter Cr nr Ashland	N14B 3077.4	100	200	200	300	600	500	400	300	300	100	0	0	3000	Trib. (MT)
Pumpkin Cr nr Miles City	3084	0	0	0	0	700	300	800	700	300	0	0	0	2800	Trib. (MT)
Tongue R. at Miles City	N18 3085	15200	15200	12300	11100	12400	24400	23700	38900	74700	24000	9100	11900	272800	Compact Gage (MT)

Table 1

Table 2

Water Use Demands Based on Adjudicated Acres (WY) and Limited Available Information on MT Uses, Values Rounded to 100 acres and 100 acre-feet/month, for Pre-1950 Median Operation

Diversion Number	Source Stream	Acres	Maximum Diversion ac-ft/mo*	
			at 2 cfs/70 ac	at 1 cfs/70 ac
WY				
D2	Tongue River (Highline Ditch, 06-2975.00)	1400	2400	1200
D3	Tongue River	4900	8300	4200
D4	Little Tongue R. (trib.)	1000	1700	800
D5	Tongue River	1700	2900	1400
D6	Tongue River Industrial (Post-1986, no return)	(assumed to 600 ac-ft/mo direct flow, supplemented from res. to 1000 ac-ft/mo)		
D7	Wolf Creek (trib)	7500	12700	6400
D8	Tongue River	2000	3400	1700
D9	Tongue River Industrial Pre-1950 (assumed 20% return)	—	(1500 ac-ft/mo direct flow)	
D10	Goose Creek (trib.)	100	200	100
D11	Tongue River	2400	4100	2050
D12	Tongue River (Post-1986)	(3000)	—	(2500)
MT				
D13	Squirrel Creek (Use in MT, mostly from Squirrel Cr.)	700	1200	600
D14	Tongue River (assumed above Tongue R. Res.)	400	700	400
D17	Tongue River	13200	22400	11200
D18	Tongue River (Post-1986)	(10000)	—	(8500)
D19	Pumpkin Creek (trib.)	1000	1700	900
D20	Tongue River (no return)	7000	12000	6000

No. 2 is assigned to potential "new" (Post-1986) reservoir on South Fork Tongue River.
No. 15 is assigned to Tongue River Reservoir, ΔS for 66,000 af pre-1950 irrigation space.
No. 16 is assigned to Tongue R. Res. "new" Post-1950 space for ΔS, 4000 ac-ft for post-'50 irr.

* $\frac{\text{acres}}{\text{cfs}/70\text{ acres}}$ × 1.98 × 30 da/mo, rounded to 100 ac-ft/mo.

Values for Operation Calculations, Median Water Supply – Tongue River Example
(Values from USGS Record Medians, from Gain Calculations, and Assumptions) (Rounded to 100 acre-feet)

Identification	Monthly Values											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Fraction of max. diversion–WY = fW*	0.30	0	0	0	0	0	0	0.30	0.80	1.00	1.00	0.80
" " " " –MT = fM*	0.40	0	0	0	0	0	0.60	1.00	1.00	1.00	1.00	0.90
N1 = 0.80 × N2 (S. Fork Tongue)	1100	1000	800	700	600	600	900	12200	18500	5400	2100	1400
N3 = Gage 2965 (N. Fork Tongue)	1300	1200	1100	900	800	800	900	4500	6200	3200	1800	1500
Gain (to N5)	2500	1600	1600	1700	1400	1700	2600	12700	11000	5500	3500	2800
D2 = Gage 2975 (Highline Ditch)	400	0	0	0	0	0	0	100	900	1200	1200	1000
R2 = 0.5 × D2 (Highline return)	200	0	0	0	0	0	0	0	400	600	600	500
G1 = N5–N6 gain	1000	500	500	600	900	900	1500	900	2100	1500	900	900
N6A = Little Tongue, operated for diversions below 2985 gage	100	100	100	100	100	100	300	2700	2800	400	100	0
G2 = N7–N8 gain	1200	600	600	700	1100	1100	1800	1100	2500	1800	1100	1100
N8A = Wolf Cr, operated for diversions below 2995 gage	200	400	300	300	300	300	700	4800	5000	1200	400	300
G3 = N9–N10 gain	1200	600	600	700	1100	1100	1900	1100	2600	1900	1100	1100
N10A = Goose Cr, operated for diversions below 3055 gage	6100	5600	5100	4300	4100	5800	7800	25400	40000	9000	2800	4400
G4 = N11–N12 gain	1500	700	800	900	1300	1300	2200	1400	3100	2200	1300	1400
N12A = Squirrel Cr, operated for diversions below 3061 gage	0	100	100	0	100	200	200	200	100	0	0	0
N12B = 3062.5 gage, Prairie Dog Cr.	2500	2000	1500	1200	1700	4800	3600	3100	2200	1100	1500	2400
N14A = 3076 gage, Hanging Woman Cr.	100	100	100	100	100	300	200	200	200	200	0	0
N14B = 3077.4 gage, Otter Cr.	100	200	200	300	600	500	400	300	300	100	0	0
G5 = N14–N15 gain	1100	200	100	100	1000	6300	4500	(–)3600	7400	3500	400	2700
G6 = N15–N16 gain	800	300	100	0	600	4200	3000	(–)2400	4900	2400	300	1800
N16A = Pumpkin Cr, operated for diversions below 3084 gage	0	0	0	0	700	300	700	400	100	0	0	0

* Based on 1 cfs/70 ac., and assumes the necessary water is available at the diversion.

Table 3

Gains Derivations - Tongue River Example
(Values rounded to 100 acre-feet)

Month ______; ______ Water Supply; Pre-1950 Condition.
Irrigation Diversions: WY: fW = ______; MT: fM = ______; 50% Return
Industrial Diversion, WY only, at 1.00 with 0.20 Return Flow (0.80 Depletion)
Irrigation Diversions based on 1 cfs/70 ac.
(U.G. = Unmeasured Gain; M.G. = Measured Gain; N.G. = Net Gain through reach)

WY Gain (to N4) = N5 − N2 − N3 + D2 =

N.G. = N13 − N5 =

R2 = 0.50 (D2) = =
N6A = Gage 2985 − D4 + R4 = =
N8A = Gage 2995 − D7 + R7 = =
N10A = Gage 3055 − D10 + R10 = =
N12A = Gage 3061 − D13 + R13 = =
N12B = Gage 3063.5 = = ______
M.G. =

U.G. = N.G. − M.G. + fW (0.50)(Σ Irrig. Diversions) + (1.00−0.20)(Indust. Diversion)
= N.G. − M.G. + fW (0.50)(9200) + 0.80(1500)
= N.G. − M.G. + fW (4600) + 1200 =

G1 = 0.20 × U.G. = 0.20 × =
G2 = 0.25 × U.G. = 0.25 × =
G3 = 0.25 × U.G. = 0.25 × =
G4 = 0.30 × U.G. = 0.30 × = ______
(Check U.G. − adjust G2 or G3 if needed, due to rounding)

MT N.G. = N18 − N14 =

N14A = Gage 3076 = =
N14B = Gage 3077.4 = =
N16A = Gage 3084 − D19 + R19 = = ______
M.G. =

U.G. = N.G. − M.G. + fM (0.50)(Σ Irrig. Diversions with return) +
fM (Σ Irrig. Diversions without return)
= N.G. − M.G. + fM (0.50)(11200) + fM (6000) = N.G. − M.G. + fM (5600 + 6000)
= N.G. − M.G. + fM (11600) =

G5 = 0.60 × U.G. = 0.60 × =
G6 = 0.40 × U.G. = 0.40 × = ______
(Check U.G. − adjust if needed, due to rounding)

(Assumes that gage record medians reflect essentially pre-1950 uses. Post-1950 uses included appear to be small compared to pre-1950 uses, and can be ignored for present purposes.)

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Monthly Operation Calculation - Tongue River Example

Form 2

Month _____; Iteration No. _____; _____________ Water Supply

Fraction for Irrigation Diversions; WY, fW= _____; MT, fM= _____

Paper Content: BOM1= __________ a-f; BOM15= __________ a-f; BOM16= __________ a-f

Physical Content: BOM1 Phys. _________; BOM15 Phys. _________; BOM16 Phys. _________

WY N1 = 0.80 N2 =

N3 =

Store 1 = 25000 - BOM1 = 25000 - (≤ N1)

Rel 1 = D6 Short / 0.7 = (600 ≤ Rel 1 ≤ 1400)

ΔS1 = Store 1 - Rel 1 =

EOM1 = BOM1 + Store 1 = (EOM1 ≤ 25000)

EOM1 Phys. = BOM1 Phys. + ΔS1 =

N4 = N1 - Store 1 + D6 Short + N3 + Gain =

N5 = N4 - D2 = (N5 ≥ D6 Short)

N6 = N5 - fW(.5)(D3) + R2 + G1 = (N6 ≥ D6 Short)

N7 = N6 + N6A =

D6 Direct = N7 + G2/3 - fW(D5) = (if <0, D6 Short, D6 Direct = 0)

D6 Short = 1000 - D6 Direct = 1000 - (400 ≤ D6 Short ≤ 1000)

N8 = N7 - fW(.5)(D5) - D6 Direct - D6 Short + G2 =

N9 = N8 + N8A =

N10 = N9 - fW(.5)(D8) - .8(D9) + G3 =

N11 = N10 + N10A =

N12 = N11 - fW(.5)(D11) - fW(.6)(D12) + G4 = (Meet D11 first)

N13 = N12 + N12A + N12B =

MT Avail = N13 - fM(.5)(D14) - 7900 = (if <0, Stack = N13 - fM(.5)(D14))

Store 15 = 66000 - BOM15 = 66000 - (≤ Avail)

Store 16 = 4000 - BOM16 = 4000 - (≤ Avail - Store 15)

Rel 15 = (D17 Short + D20 Short)/0.7 =

Rel 16 = (D18 Short)/0.7 =

ΔS15 = Store 15 - Rel 15 =

ΔS16 = Store 16 - Rel 16 =

EOM15 = BOM15 + Store 15 = (EOM15 ≤ 66000)

EOM15 Phys. = BOM15 Phys + ΔS15 =

EOM 16 = BOM16 + Store 16 = (EOM16 ≤ 4000)

EOM16 Phys. = BOM16 Phys. + ΔS16 =

N14 = Avail - Store 15 + D17 Short + D20 Short - Store 16 + D18 Short + Stack =

N15 = N14 + N14A + N14B + G5 =

D17 Short = fM(D17) - N15 - G6/3 = (if ≤0, D17 Short = 0)

D18 Short = fM(D18) + fM(D17) - N15 - G6/3 = (if ≤0, D18 Short = 0)

N16 = N15 - fM(.5)(D17) - fM(.6)(D18) + G6 =

N17 = N16 + N16A =

N18 = N17 - fM(D20) =

D20 Short = fM(D20) - N17 = (if ≤0, D20 Short = 0)

For Compact Article V, C, Accounting and Calculation, Note (for this example) and use Compact Calculation sheet:

WY: ΔS1 =
D6 =
D12 =

MT: ΔS16 =
D18 =

N18 (Compact Gage)
=

Form 3

Article V.C. Compact Calculation – Tongue River Example

(Data from Monthly Operation Calculation — In actual practice these types of data would be measured, and the Monthly Operation Calculations would not be necessary for compact purposes.)

Month ______ Iteration No. ______

Item	WY				MT			Gage N18 (6-308500)	Allocable WY+MT+N18
	ΔS1	D6	D12	Accum	ΔS16	D18	Accum.		
Previous Accum.									
Current Period									
Current Accum.									

Allocations: WY: 0.40 × Allocable =
MT: 0.60 × Allocable =

Compare: WY Allocation – WY Accum. = (<0, Adjust)
MT Allocation – MT Accum. = (<0, Adjust)

Iterate to adjust storage or diversions?
Notes:

Month ______ Iteration No. ______

Item	WY				MT			Gage N18 (6-308500)	Allocable WY+MT+N18
	ΔS1	D6	D12	Accum.	ΔS16	D18	Accum.		
Previous Accum.									
Current Period									
Current Accum.									

Allocations: WY: 0.40 × Allocable =
MT: 0.60 × Allocable =

Compare: WY Allocation – WY Accum. = (<0, Adjust)
MT Allocation – MT Accum. = (<0, Adjust)

Iterate to adjust storage or diversions?
Notes:

Month ______ Iteration No. ______

Item	WY				MT			Gage N18 (6-308500)	Allocable WY+MT+N18
	ΔS1	D6	D12	Accum.	ΔS16	D18	Accum.		
Previous Accum.									
Current Period									
Current Accum.									

Allocations: WY: 0.40 × Allocable =
MT: 0.60 × Allocable =

Compare: WY Allocation – WY Accum. = (<0, Adjust)
MT Allocation – MT Accum. = (<0, Adjust)

Iterate to adjust storage or diversions?
Notes:

Comments:

Form #1 Calculations

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Gains Derivations – Tongue River Example

(Values rounded to 100 acre-feet)

Month Oct ; Median Water Supply ; Pre-1950 Condition.

Irrigation Diversions: WY: fW = 0.30 ; MT: fM = 0.40 ; 50% Return

Industrial Diversion, WY only, at 1.00 with 0.20 Return Flow (0.80 Depletion)

Irrigation Diversions based on 1cfs/70 ac.

(U.G. = Unmeasured Gain; M.G. = Measured Gain; N.G. = Net Gain through reach)

WY Gain (to N4) = N5 − N2 − N3 + D2 = 4800 − 1400 − 1300 + 400 = 2500

N.G. = N13 − N5 = 16300 − 4800 = 11500

R2 = 0.50 (D2) = 0.5(400)	=	200
N6A = Gage 2985 − D4 + R4 = 200 − 200 + .5(200)	=	100
N8A = Gage 2995 − D7 + R7 = 500 − 500 + .5(500)	=	200
N10A = Gage 3055 − D10 + R10 = 6200 − 100 + .5(100)	=	6200
N12A = Gage 3061 − D13 + R13 = 100 − 100 + .5(100)	=	0
N12B = Gage 3062.5 =	=	2500
	M.G. =	9200

U.G. = N.G. − M.G. + fW(0.50)(Σ Irrig. Diversions) + (1.00 − 0.20)(Indust. Diversion)

= N.G. − M.G. + fW(0.50)(9200) + 0.80(1500)

= N.G. − M.G. + fW(4600) + 1200 = 11500 − 9200 + .3(4600) + 1200 = 4900

G1 = 0.20 × U.G. = 0.20 × 4900	=	1000
G2 = 0.25 × U.G. = 0.25 × 4900	=	1200
G3 = 0.25 × U.G. = 0.25 × 4900	=	1200
G4 = 0.30 × U.G. = 0.30 × 4900	=	1500
		4900 ✓

(Check U.G. – adjust G2 or G3 if needed, due to rounding)

MT N.G. = N18 − N14 = 15200 − 17700 = −2500

N14A = Gage 3076 =	=	100
N14B = Gage 3077.4 =	=	100
N16A = Gage 3084 − D19 + R19 = 0 − 0 + 0	=	0
	M.G. =	200

U.G. = N.G. − M.G. + fM(0.50)(Σ Irrig. Diversions with return) + fM(Σ Irrig. Diversions without return)

= N.G. − M.G. + fM(0.50)(11200) + fM(6000) = N.G. − M.G. + fM(5600 + 6000)

= N.G. − M.G. + fM(11600) = −2500 − 200 + .4(11600) = 1900

G5 = 0.60 × U.G. = 0.60 × 1900	=	1100
G6 = 0.40 × U.G. = 0.40 × 1900	=	800
		1900 ✓

(Check U.G. – adjust if needed, due to rounding)

(Assumes that gage record medians reflect essentially pre-1950 uses. Post-1950 uses included appear to be small compared to pre-1950 uses, and can be ignored for present purposes)

Gains Derivations – Tongue River Example
(Values rounded to 100 acre-feet)

Month Nov.; Median Water Supply; Pre-1950 Condition.
Irrigation Diversions: WY: fW = 0; MT: fM = 0; 50% Return
Industrial Diversion, WY only, at 1.00 with 0.20 Return Flow (0.80 Depletion)
Irrigation Diversions based on 1cfs/70 ac.
(U.G. = Unmeasured Gain; M.G. = Measured Gain; N.G. = Net Gain through reach)

WY Gain (to N4) = N5 − N2 − N3 + D2 = 4000 − 1200 − 1200 + 0 = 1600

N.G. = N13 − N5 = 13400 − 4000 = 9400

R2 = 0.50 (D2) = .5(0) = 0
N6A = Gage 2985 − D4 + R4 = 100 − 0 + 0 = 100
N8A = Gage 2995 − D7 + R7 = 400 − 0 + 0 = 400
N10A = Gage 3055 − D10 + R10 = 5600 − 0 + 0 = 5600
N12A = Gage 3061 − D13 + R13 = 100 − 0 + 0 = 100
N12B = Gage 3062.5 = 2000

M.G. = 8200

U.G. = N.G. − M.G. + fW (0.50)(Σ Irrig. Diversions) + (1.00−0.20)(Indust. Diversion)
= N.G. − M.G. + fW (0.50)(9200) + 0.80(1500)
= N.G. − M.G. + fW(4600) + 1200 = 9400 − 8200 + 0(4600) + 1200 = 2400

G1 = 0.20 × U.G. = 0.20 × 2400 = 500
G2 = 0.25 × U.G. = 0.25 × 2400 = 600
G3 = 0.25 × U.G. = 0.25 × 2400 = 600
G4 = 0.30 × U.G. = 0.30 × 2400 = 700

2400 ✓ (Check U.G. – adjust G2 or G3 if needed, due to rounding)

MT N.G. = N18 − N14 = 15500 − 14800 = 700

N14A = Gage 3076 = 100
N14B = Gage 3077.4 = 200
N16A = Gage 3084 − D19 + R19 = 0 − 0 + 0 = 0

M.G. = 300

U.G. = N.G. − M.G. + fM (0.50)(Σ Irrig. Diversions with return) +
fM (Σ Irrig Diversions without return)
= N.G. − MG. + fM (0.50)(11200) + fM (6000) = N.G. − M.G. + fM (5600 + 6000)
= N.G. − M.G. + fM (11600) = 700 − 300 + 0(11600) = 400

G5 = 0.60 × U.G. = 0.60 × 400 = 200
G6 = 0.40 × U.G. = 0.40 × 400 = 200

400 ✓ (Check U.G. – adjust if needed, due to rounding)

(Assumes that gage record medians reflect essentially pre-1950 uses. Post-1950 uses included appear to be small compared to pre-1950 uses, and can be ignored for present purposes.)

Gains Derivations – Tongue River Example
(Values rounded to 100 acre-feet)

Month Dec ; Median Water Supply; Pre-1950 Condition.
Irrigation Diversions: WY: fW = 0 ; MT: fM = 0 ; 50% Return
Industrial Diversion, WY only, at 1.00 with 0.20 Return Flow (0.80 Depletion)
Irrigation Diversions based on 1cfs/70 ac.
(U.G. = Unmeasured Gain; M.G. = Measured Gain; N.G. = Net Gain through reach)

WY Gain (to N4) = N5 − N2 − N3 + D2 = 3700 − 1000 − 1100 + 0 = 1600

N.G. = N13 − N5 = 12100 − 3700 = 8400

R2 = 0.50 (D2) = .5(0) = 0
N6A = Gage 2985 − D4 + R4 = 100 − 0 + 0 = 100
N8A = Gage 2995 − D7 + R7 = 300 − 0 + 0 = 300
N10A = Gage 3055 − D10 + R10 = 5100 − 0 + 0 = 5100
N12A = Gage 3061 − D13 + R13 = 100 − 0 + 0 = 100
N12B = Gage 3062.5 = = 1500
M.G. = 7100

U.G. = N.G. − M.G. + fW (0.50)(Σ Irrig. Diversions) + (1.00 − 0.20)(Indust. Diversion)
= N.G. − M.G. + fW (0.50)(9200) + 0.80 (1500)
= N.G. − M.G. + fW (4600) + 1200 = 8400 − 7100 + 0(4600) + 1200 = 2500

G1 = 0.20 × U.G. = 0.20 × 2500 = 500
G2 = 0.25 × U.G. = 0.25 × 2500 = 600
G3 = 0.25 × U.G. = 0.25 × 2500 = 600
G4 = 0.30 × U.G. = 0.30 × 2500 = 800
2500 ✓ (Check U.G. – adjust G2 or G3 if needed, due to rounding)

MT N.G. = N18 − N14 = 12300 − 11700 = 500

N14A = Gage 3076 = = 100
N14B = Gage 3077.4 = = 200
N16A = Gage 3084 − D19 + R19 = 0 − 0 + 0 = 0
M.G. = 300

U.G. = N.G. − M.G. + fM (0.50)(Σ Irrig. Diversions with return) +
fM (Σ Irrig Diversions without return)
= N.G. − M.G. + fM (0.50)(11200) + fM (6000) = N.G. − M.G. + fM (5600 + 6000)
= N.G. − M.G. + fM (11600) = 500 − 300 + 0(11600) = 200

G5 = 0.60 × U.G. = 0.60 × 200 = 100
G6 = 0.40 × U.G. = 0.40 × 200 = 100
200 ✓ (Check U.G. – adjust if needed, due to rounding)

(Assumes that gage record medians reflect essentially pre-1950 uses. Post-1950 uses included appear to be small compared to pre-1950 uses, and can be ignored for present purposes.)

Form 1

Gains Derivations – Tongue River Example
(Values rounded to 100 acre-feet)

Month Jan ; Median Water Supply; Pre-1950 Condition.
Irrigation Diversions: WY: fW = 0 ; MT: fM = 0 ; 50% Return
Industrial Diversion, WY only, at 1.00 with 0.20 Return Flow (0.80 Depletion)
Irrigation Diversions based on 1cfs/70 ac.
(U.G. = Unmeasured Gain; M.G. = Measured Gain; N.G. = Net Gain through reach)

WY Gain (to N4) = N5 − N2 − N3 + D2 = 3500 − 900 − 900 + 0 = 1700

N.G. = N13 − N5 = 11100 − 3500 = 7600

R2 = 0.50 (D2) = .5(0) = 0
N6A = Gage 2985 − D4 + R4 = 100 − 0 + 0 = 100
N8A = Gage 2995 − D7 + R7 = 300 − 0 + 0 = 300
N10A = Gage 3055 − D10 + R10 = 4300 − 0 + 0 = 4300
N12A = Gage 3061 − D13 + R13 = 0 − 0 + 0 = 0
N12B = Gage 3062.5 = 1200
M.G. = 5900

U.G. = N.G. − M.G. + fW(0.50)(Σ Irrig. Diversions) + (1.00−0.20)(Indust. Diversion)
= N.G. − M.G. + fW(0.50)(9200) + 0.80(1500)
= N.G. − M.G. + fW(4600) + 1200 = 7600 − 5900 + 0(4600) + 1200 = 2900

G1 = 0.20 × U.G. = 0.20 × 2900 = 600
G2 = 0.25 × U.G. = 0.25 × 2900 = 700
G3 = 0.25 × U.G. = 0.25 × 2900 = 700
G4 = 0.30 × U.G. = 0.30 × 2900 = 900
2900 ✓ (Check U.G. – adjust G2 or G3 if needed, due to rounding)

MT N.G. = N18 − N14 = 11100 − 10600 = 500

N14A = Gage 3076 = 100
N14B = Gage 3077.4 = 300
N16A = Gage 3084 − D19 + R19 = 0 − 0 + 0 = 0
M.G. = 400

U.G. = N.G. − M.G. + fM(0.50)(Σ Irrig. Diversions with return) + fM(Σ Irrig Diversions without return)
= N.G. − M.G. + fM(0.50)(11200) + fM(6000) = N.G. − M.G. + fM(5600 + 6000)
= N.G. − M.G. + fM(11600) = 500 − 400 + 0(11600) = 100

G5 = 0.60 × U.G. = 0.60 × 100 = 100
G6 = 0.40 × U.G. = 0.40 × 100 = 0
100 ✓ (Check U.G. – adjust if needed, due to rounding)

(Assumes that gage record medians reflect essentially pre-1950 uses. Post-1950 uses included appear to be small compared to pre-1950 uses, and can be ignored for present purposes.)

Gains Derivations – Tongue River Example
(Values rounded to 100 acre-feet)

Month Feb ; Median Water Supply; Pre-1950 Condition.
Irrigation Diversions: WY: fW = 0 ; MT: fM = 0 ; 50% Return
Industrial Diversion, WY only, at 400 with 0.20 Return Flow (0.80 Depleted)
Irrigation Diversions based on 1cfs/70 ac.
(U.G. = Unmeasured Gain; M.G. = Measured Gain; N.G. = Net Gain through reach)

WY Gain (to N4) = N5 − N2 − N3 + D2 = 2900 − 700 − 800 + 0 = 1400

N.G. = N13 − N5 = 12400 − 2900 = 9500

R2 = 0.50 (D2) =	.5(0)	=	0
N6A = Gage 2985 − D4 + R4 =	100 − 0 + 0	=	100
N8A = Gage 2995 − D7 + R7 =	300 − 0 + 0	=	300
N10A = Gage 3055 − D10 + R10 =	4100 − 0 + 0	=	4100
N12A = Gage 3061 − D13 + R13 =	100 − 0 + 0	=	100
N12B = Gage 3062.5 =		=	1700
		M.G. =	6300

U.G. = N.G. − M.G. + fW (0.50)(Σ Irrig. Diversions) + (1.00 − 0.20)(Indust. Diversion)
= N.G. − M.G. + fW (0.50)(9200) + 0.80 (1500)
= N.G. − M.G. + fW (4600) + 1200 = 9500 − 6300 + 0(4600) + 1200 = 4400

G1 = 0.20 × U.G. = 0.20 ×	4400	=	900
G2 = 0.25 × U.G. = 0.25 ×	4400	=	1100
G3 = 0.25 × U.G. = 0.25 ×	4400	=	1100
G4 = 0.30 × U.G. = 0.30 ×	4400	=	1300
			4400 ✓

(Check U.G. – adjust G2 or G3 if needed, due to rounding)

MT N.G. = N18 − N14 = 12400 − 9400 = 3000

N14A = Gage 3076 =	=	100
N14B = Gage 3077.4 =	=	600
N16A = Gage 3084 − D19 + R19 = 700 − 0 + 0	=	700
	M.G. =	1400

U.G. = N.G. − M.G. + fM (0.50)(Σ Irrig. Diversions with return) + fM (Σ Irrig Diversions without return)
= N.G. − M.G. + fM (0.50)(11200) + fM (6000) = N.G. − M.G. + fM (5600 + 6000)
= N.G. − M.G. + fM (11600) = 3000 − 1400 + 0(11600) = 1600

G5 = 0.60 × U.G. = 0.60 ×	1600	=	1000
G6 = 0.40 × U.G. = 0.40 ×	1600	=	600
			1600 ✓

(Check U.G. – adjust if needed, due to rounding)

(Assumes that gage record medians reflect essentially pre-1950 uses. Post-1950 uses included appear to be small compared to pre-1950 uses, and can be ignored for present purposes.)

Gains Derivations – Tongue River Example
(Values rounded to 100 acre-feet)

Month Mar ; Median Water Supply ; Pre-1950 Condition.
Irrigation Diversions: WY: fW = 0 ; MT: fM = 0 ; 50% Return
Industrial Diversion, WY only, at 1.00 with 0.20 Return Flow (0.80 Depletion)
Irrigation Diversions based on 1cfs/70 ac.
(U.G. = Unmeasured Gain; M.G. = Measured Gain; N.G. = Net Gain through reach)

WY Gain (to N4) = N5 − N2 − N3 + D2 = 3200 − 700 − 800 + 0 = 1700

N.G. = N13 − N5 = 17600 − 3200 = 14400

R2 = 0.50 (D2) = .5(0)	=	0
N6A = Gage 2985 − D4 + R4 = 100 − 0 + 0	=	100
N8A = Gage 2995 − D7 + R7 = 300 − 0 + 0	=	300
N10A = Gage 3055 − D10 + R10 = 5800 − 0 + 0	=	5800
N12A = Gage 3061 − D13 + R13 = 200 − 0 + 0	=	200
N12B = Gage 3062.5 =	=	4800
	M.G. =	11200

U.G. = N.G. − M.G. + fW (0.50)(Σ Irrig. Diversions) + (1.00−0.20)(Indust. Diversion)
= N.G. − M.G. + fW (0.50)(9200) + 0.80 (1500)
= N.G. − M.G. + fW (4600) + 1200 = 14400 − 11200 + 0 (4600) + 1200 = 4400

G1 = 0.20 × U.G. = 0.20 × 4400	=	900
G2 = 0.25 × U.G. = 0.25 × 4400	=	1100
G3 = 0.25 × U.G. = 0.25 × 4400	=	1100
G4 = 0.30 × U.G. = 0.30 × 4400	=	1300
		4400 ✓

(Check U.G. – adjust G2 or G3 if needed, due to rounding)

MT N.G. = N18 − N14 = 24400 − 12800 = 11600

N14A = Gage 3076 =	=	300
N14B = Gage 3077.4 =	=	500
N16A = Gage 3084 − D19 + R19 = 300 − 0 + 0	=	300
	M.G. =	1100

U.G. = N.G. − M.G. + fM (0.50)(Σ Irrig. Diversions with return) +
fM (Σ Irrig Diversions without return)
= N.G. − M.G. + fM (0.50)(11200) + fM (6000) = N.G. − M.G. + fM (5600 + 6000)
= N.G. − M.G. + fM (11600) = 11600 − 1100 + 0 (11600) = 10500

G5 = 0.60 × U.G. = 0.60 × 10500	=	6300
G6 = 0.40 × U.G. = 0.40 × 10500	=	4200
		10500 ✓

(Check U.G. – adjust if needed, due to rounding)

(Assumes that gage record medians reflect essentially pre-1950 uses. Post-1950 uses included appear to be small compared to pre-1950 uses, and can be ignored for present purposes)

Gains Derivations – Tongue River Example
(Values rounded to 100 acre-feet)

Month Apr ; Median Water Supply; Pre-1950 Condition.
Irrigation Diversions: WY: fW = 0 , MT: fM = .60 , 50% Return
Industrial Diversion, WY only, at 1.00 with 0.20 Return Flow (0.80 Depletion)
Irrigation Diversions based on 1 cfs/70 ac.
(U.G. = Unmeasured Gain; M.G. = Measured Gain; N.G. = Net Gain through reach)

WY Gain (to N4) = N5 − N2 − N3 + D2 = 4600 − 1100 − 900 + 0 = 2600

N.G. = N13 − N5 = 23400 − 4600 = 18800

R2 = 0.50 (D2) = .5(0)	=	0
N6A = Gage 2985 − D4 + R4 = 300 − 0 + 0	=	300
N8A = Gage 2995 − D7 + R7 = 700 − 0 + 0	=	700
N10A = Gage 3055 − D10 + R10 = 7800 − 0 + 0	=	7800
N12A = Gage 3061 − D13 + R13 = 400 − .6(600) + .3(600)	=	200
N12B = Gage 3062.5 =	=	3600
	M.G. =	12600

U.G. = N.G. − M.G. + fW(0.50)(Σ Irrig. Diversions) + (1.00 − 0.20)(Indust. Diversion)
= N.G. − M.G. + fW(0.50)(9200) + 0.80(1500)
= N.G. − M.G. + fW(4600) + 1200 = 18800 − 12600 + 0(4600) + 1200 = 7400

G1 = 0.20 × U.G. = 0.20 × 7400	=	1500
G2 = 0.25 × U.G. = 0.25 × 7400	=	1800
G3 = 0.25 × U.G. = 0.25 × 7400	=	1800 (adjusted)
G4 = 0.30 × U.G. = 0.30 × 7400	=	2200
		7400 ✓

(Check U.G. – adjust G2 or G3 if needed, due to rounding)

MT N.G. = N18 − N14 = 23700 − 22100 = 1600

N14A = Gage 3076 =	=	200
N14B = Gage 3077.4 =	=	400
N16A = Gage 3084 − D19 + R19 = 800 − .6(900) + .3(900)	=	500
	M.G. =	1100

U.G. = N.G. − M.G. + fM(0.50)(Σ Irrig. Diversions with return) + fM(Σ Irrig. Diversions without return)
= N.G. − M.G. + fM(0.50)(11200) + fM(6000) = N.G. − M.G. + fM(5600 + 6000)
= N.G. − M.G. + fM(11600) = 1600 − 1100 + .6(11600) = 7500

G5 = 0.60 × U.G. = 0.60 × 7500	=	4500
G6 = 0.40 × U.G. = 0.40 × 7500	=	3000
		7500 ✓

(Check U.G. – adjust if needed, due to rounding)

(Assumes that gage record medians reflect essentially pre-1950 uses. Post-1950 uses included appear to be small compared to pre-1950 uses, and can be ignored for present purposes.)

Gains Derivations – Tongue River Example

(Values rounded to 100 acre-feet)

Month May ; Median Water Supply; Pre-1950 Condition.

Irrigation Diversions: WY: fW = 0.30 , MT: fM = 1.00 ; 50% Return

Industrial Diversion, WY only, at 1,500 with 0.20 Return Flow (0.80 Depletion)

Irrigation Diversions based on 1cfs/70 ac.

(U.G. = Unmeasured Gain; M.G. = Measured Gain; N.G. = Net Gain through reach)

WY Gain (to N4) = N5 – N2 – N3 + D2 = 32400 – 15300 – 4500 + 100 = 12700

N.G. = N13 – N5 = 70500 – 32400 = 38100

R2 = 0.50 (D2) = .5(100) = 0

N6A = Gage 2985 – D4 + R4 = 2800 – .3(800) + .15(800) = 2700

N8A = Gage 2995 – D7 + R7 = 5800 – .3(6400) + .15(6400) = 4800

N10A = Gage 3055 – D10 + R10 = 25400 – .3(100) + .15(100) = 25400

N12A = Gage 3061 – D13 + R13 = 500 – 500 + .5(500) = 200

N12B = Gage 3062.5 = 3100

M.G. = 36200

U.G. = N.G. – M.G. + fW (0.50)(Σ Irrig. Diversions) + (1.00 – 0.20)(Indust. Diversion)

= N.G. – M.G. + fW (0.50)(9200) + 0.80(1500)

= N.G. – M.G. + fW(4600) + 1200 = 38100 – 36200 + .3(4600) + 1200 = 4500

G1 = 0.20 × U.G. = 0.20 × 4500 = 900

G2 = 0.25 × U.G. = 0.25 × 4500 = 1100

G3 = 0.25 × U.G. = 0.25 × 4500 = 1100

G4 = 0.30 × U.G. = 0.30 × 4500 = 1400

4500 ✓ (Check U.G. – adjust G2 or G3 if needed, due to rounding)

MT N.G. = N18 – N14 = 38700 – 55400 = –16700

N14A = Gage 3076 = 200

N14B = Gage 3077.4 = 300

N16A = Gage 3084 – D19 + R19 = 700 – 700 + .5(700) = 400

M.G. = 900

U.G. = N.G. – M.G. + fM (0.50)(Σ Irrig. Diversions with return) + fM (Σ Irrig. Diversions without return)

= N.G. – M.G. + fM (0.50)(11200) + fM (6000) = N.G. – M.G. + fM (5600 + 6000)

= N.G. – M.G. + fM (11600) = –16700 – 900 + 1.0(11600) = –6000

G5 = 0.60 × U.G. = 0.60 × (–6000) = –3600

G6 = 0.40 × U.G. = 0.40 × (–6000) = –2400

–6000 ✓ (Check U.G. – adjust if needed, due to rounding)

(Assumes that gage record medians reflect essentially pre-1950 uses. Post-1950 uses included appear to be small compared to pre-1950 uses, and can be ignored for present purposes.)

Form 1

Gains Derivations – Tongue River Example
(Values rounded to 100 acre-feet)

Month Jun ; Median Water Supply; Pre-1950 Condition.
Irrigation Diversions: WY: fW = 0.80 ; MT: fM = 1.00 ; 50% Return
Industrial Diversion, WY only, at 1.00 with 0.20 Return Flow (0.80 Depletion)
Irrigation Diversions based on 1 cfs/70 ac.
(U.G. = Unmeasured Gain; M.G. = Measured Gain; N.G. = Net Gain through reach)

WY Gain (to N4) = N5 − N2 − N3 + D2 = 39400 − 23100 − 6200 + 900 = 11000

N.G. = N13 − N5 = 95300 − 39400 = 55900

R2 = 0.50 (D2) = .5(900)	= 400
N6A = Gage 2985 − D4 + R4 = 3100 − .8(800) + .4(800)	= 2800
N8A = Gage 2995 − D7 + R7 = 7600 − .8(6400) + .4(6400)	= 5000
N10A = Gage 3055 − D10 + R10 = 40000 − .8(100) + .4(100)	= 40000
N12A = Gage 3061 − D13 + R13 = 300 − 300 + .5(300)	= 100
N12B = Gage 3062.5 =	= 2200
M.G. =	50500

U.G. = N.G. − M.G. + fW(0.50)(Σ Irrig. Diversions) + (1.00−0.20)(Indust. Diversion)
= N.G. − M.G. + fW(0.50)(9200) + 0.80(1500)
= N.G. − M.G. + fW(4600) + 1200 = 55900 − 50500 + .8(4600) + 1200 = 10300

G1 = 0.20 × U.G. = 0.20 × 10300	= 2100	
G2 = 0.25 × U.G. = 0.25 × 10300	= 2500	(adjusted)
G3 = 0.25 × U.G. = 0.25 × 10300	= 2600	
G4 = 0.30 × U.G. = 0.30 × 10300	= 3100	
	10300 ✓	(Check U.G. − adjust G2 or G3 if needed, due to rounding)

MT N.G. = N18 − N14 = 74700 − 73400 = 1300

N14A = Gage 3076 =	= 200
N14B = Gage 3077.4 =	= 300
N16A = Gage 3084 − D19 + R19 = 300 − 300 + .5(300)	= 100
M.G. =	600

U.G. = N.G. − M.G. + fM(0.50)(Σ Irrig. Diversions with return) + fM(Σ Irrig Diversions without return)
= N.G. − M.G. + fM(0.50)(11200) + fM(6000) = N.G. − M.G. + fM(5600 + 6000)
= N.G. − M.G. + fM(11600) = 1300 − 600 + 1.0(11600) = 12300

G5 = 0.60 × U.G. = 0.60 × 12300	= 7400	
G6 = 0.40 × U.G. = 0.40 × 12300	= 4900	
	12300 ✓	(Check U.G. − adjust if needed, due to rounding)

(Assumes that gage record medians reflect essentially pre-1950 uses. Post-1950 uses included appear to be small compared to pre-1950 uses, and can be ignored for present purposes.)

Form 1

Gains Derivations - Tongue River Example
(Values rounded to 100 acre-feet)

Month July ; Median Water Supply ; Pre-1950 Condition.
Irrigation Diversions: WY: fW = 1.00 , MT: fM = 1.00 ; 50% Return
Industrial Diversion, WY only, at 1.00 with 0.20 Return Flow (0.80 Depletion)
Irrigation Diversions based on 1 cfs/70 ac.
(U.G. = Unmeasured Gain; M.G. = Measured Gain; N.G. = Net Gain through reach)

WY Gain (to N4) = N5 - N2 - N3 + D2 = 14200 - 6700 - 3200 + 1200 = 5500

N.G. = N13 - N5 = 28100 - 14200 = 13900

R2 = 0.50 (D2) =	.5(1200)	=	600
N6A = Gage 2985 - D4 + R4 =	800 - 1.0(800) + .5(800)	=	400
N8A = Gage 2995 - D7 + R7 =	2400 - 2400 + .5(2400)	=	1200
N10A = Gage 3055 - D10 + R10 =	9000 - 1.0(100) + .5(100)	=	9000
N12A = Gage 3061 - D13 + R13 =	100 - 100 + .5(100)	=	0
N12B = Gage 3062.5 =		=	1100
		M.G. =	12300

U.G. = N.G. - M.G. + fW (0.50)(Σ Irrig. Diversions) + (1.00-0.20)(Indust. Diversion)
= N.G. - M.G. + fW (0.50)(9200) + 0.80 (1500)
= N.G. - M.G. + fW (4600) + 1200 = 13900 - 12300 + 1.0(4600) + 1200 = 7400

G1 = 0.20 × U.G. = 0.20 ×	7400	=	1500
G2 = 0.25 × U.G. = 0.25 ×	7400	=	1800
G3 = 0.25 × U.G. = 0.25 ×	7400	=	1900 (adjusted)
G4 = 0.30 × U.G. = 0.30 ×	7400	=	2200
			7400 ✓

(Check U.G. - adjust G2 or G3 if needed, due to rounding)

MT N.G. = N18 - N14 = 34000 - 39400 = - 5400

N14A = Gage 3076 =		=	200
N14B = Gage 3077.4 =		=	100
N16A = Gage 3084 - D19 + R19 =	0 - 0 - 0	=	0
		M.G. =	300

U.G. = N.G. - M.G. + fM (0.50)(Σ Irrig. Diversions with return) +
fM (Σ Irrig. Diversions without return)
= N.G. - M.G. + fM (0.50)(11200) + fM (6000) = N.G. - M.G. + fM (5600 + 6000)
= N.G. - M.G. + fM (11600) = - 5400 - 300 + 1.0 (11600) = 5900

G5 = 0.60 × U.G. = 0.60 ×	5900	=	3500
G6 = 0.40 × U.G. = 0.40 ×	5900	=	2400
			5900 ✓

(Check U.G. - adjust if needed, due to rounding)

(Assumes that gage record medians reflect essentially pre-1950 uses. Post-1950 uses included appear to be small compared to pre-1950 uses, and can be ignored for present purposes.)

MT-00992

Gains Derivations - Tongue River Example
(Values rounded to 100 acre-feet)

Month Aug ; Median Water Supply; Pre-1950 Condition.
Irrigation Diversions: WY: fW = 1.00 ; MT: fM = 1.00 ; 50% Return
Industrial Diversion, WY only, at 1.00 with 0.20 Return Flow (0.80 Depletion)
Irrigation Diversions based on 1cfs/70 ac.
(U.G. = Unmeasured Gain; M.G. = Measured Gain; N.G. = Net Gain through reach)

WY Gain (to N4) = N5 - N2 - N3 + D2 = 6700 - 2600 - 1800 + 1200 = 3500

N.G. = N13 - N5 = 10700 - 6700 = 4000

R2 = 0.50 (D2) = .5(1200) = 600
N6A = Gage 2985 - D4 + R4 = 200 - 200 + .5(200) = 100
N8A = Gage 2995 - D7 + R7 = 400 - 700 + .5(700) = 400
N10A = Gage 3055 - D10 + R10 = 2800 - 1.0(100) + .5(100) = 2800
N12A = Gage 3061 - D13 + R13 = 0 - 0 + 0 = 0
N12B = Gage 3062.5 = 1500
M.G. = 5400

U.G. = N.G. - M.G. + fW(0.50)(ΣIrrig. Diversions) + (1.00-0.20)(Indust. Diversion)
= N.G. - M.G. + fW(0.50)(9200) + 0.80(1500)
= N.G. - M.G. + fW(4600) + 1200 = 4000 - 5400 + 1.0(4600) + 1200 = 4400

G1 = 0.20 × U.G. = 0.20 × 4400 = 900
G2 = 0.25 × U.G. = 0.25 × 4400 = 1100
G3 = 0.25 × U.G. = 0.25 × 4400 = 1100
G4 = 0.30 × U.G. = 0.30 × 4400 = 1300
4400 ✓ (Check U.G. - adjust G2 or G3 if needed, due to rounding)

MT N.G. = N18 - N14 = 9100 - 20000 = -10900

N14A = Gage 3076 = 0
N14B = Gage 3077.4 = 0
N16A = Gage 3084 - D19 + R19 = 0 - 0 + 0 = 0
M.G. = 0

U.G. = N.G. - M.G. + fM(0.50)(ΣIrrig. Diversions with return) +
fM(ΣIrrig Diversions without return)
= N.G. - M.G. + fM(0.50)(11200) + fM(6000) = N.G. - M.G. + fM(5600 + 6000)
= N.G. - M.G. + fM(11600) = -10900 - 0 + 1.0(11600) = 700

G5 = 0.60 × U.G. = 0.60 × 700 = 400
G6 = 0.40 × U.G. = 0.40 × 700 = 300
700 ✓ (Check U.G. - adjust if needed, due to rounding)

(Assumes that gage record medians reflect essentially pre-1950 uses. Post-1950 uses included appear to be small compared to pre-1950 uses, and can be ignored for present purposes.)

Gains Derivations – Tongue River Example
(Values rounded to 100 acre-feet)

Month Sept.; Median Water Supply; Pre-1950 Condition.
Irrigation Diversions: WY: fW = 0.80; MT: fM = 0.90; 50% Return
Industrial Diversion, WY only, at 1.00 with 0.20 Return Flow (0.80 Depletion)
Irrigation Diversions based on 1 cfs/70 ac.
(U.G. = Unmeasured Gain; M.G. = Measured Gain; N.G. = Net Gain through reach)

WY Gain (to N4) = N5 − N2 − N3 + D2 = 5000 − 1700 − 1500 + 1000 = 2800

N.G. = N13 − N5 = 12200 − 5000 = 7200

R2 = 0.50 (D2) = .5(1000) = 500
N6A = Gage 2985 − D4 + R4 = 100 − 100 + .5(100) = 0
N8A = Gage 2995 − D7 + R7 = 600 − 600 + .5(600) = 300
N10A = Gage 3055 − D10 + R10 = 4500 − .9(100) + .4(100) = 4400
N12A = Gage 3061 − D13 + R13 = 0 − 0 + 0 = 0
N12B = Gage 3062.5 = = 2400
M.G. = 7600

U.G. = N.G. − M.G. + fW(0.50)(Σ Irrig. Diversions) + (1.00 − 0.20)(Indust. Diversion)
= N.G. − M.G. + fW(0.50)(9200) + 0.80(1500)
= N.G. − M.G. + fW(4600) + 1200 = 7200 − 7600 + .8(4600) + 1200 = 4500

G1 = 0.20 × U.G. = 0.20 × 4500 = 900
G2 = 0.25 × U.G. = 0.25 × 4500 = 1100
G3 = 0.25 × U.G. = 0.25 × 4500 = 1100
G4 = 0.30 × U.G. = 0.30 × 4500 = 1400
4500 ✓ (Check U.G. – adjust G2 or G3 if needed, due to rounding)

MT N.G. = N18 − N14 = 11900 − 17800 = −5900

N14A = Gage 3076 = = 0
N14B = Gage 3077.4 = = 0
N16A = Gage 3084 − D19 + R19 = 0 − 0 + 0 = 0
M.G. = 0

U.G. = N.G. − M.G. + fM(0.50)(Σ Irrig. Diversions with return) + fM(Σ Irrig. Diversions without return)
= N.G. − M.G. + fM(0.50)(11200) + fM(6000) = N.G. − M.G. + fM(5600 + 6000)
= N.G. − M.G. + fM(11600) = −5900 − 0 + .9(11600) = 4500

G5 = 0.60 × U.G. = 0.60 × 4500 = 2700
G6 = 0.40 × U.G. = 0.40 × 4500 = 1800
4500 ✓ (Check U.G. – adjust if needed, due to rounding)

(Assumes that gage record medians reflect essentially pre-1950 uses. Post-1950 uses included appear to be small compared to pre-1950 uses, and can be ignored for present purposes.)

Item #2- Monthly
Operations

Form 2

Monthly Operation Calculation - Tongue River Example

Month Oct ; Iteration No. 0 ; Median Water Supply

Fraction for Irrigation Diversions: WY, fW = .30 ; MT, fM = .40

Paper Content: BOM1 = 11000 a-f; BOM15 = 30000 a-f; BOM16 = 1000 a-f

Physical Content: BOM1 Phys. 11000 ; BOM15 Phys 30000 ; BOM16 Phys. 1000

WY N1 = 0.80N2 = 1100

N3 = 1500

Store1 = 25000 - BOM1 = 25000 - 11000 = 14000 (1100) (≤ N1)

Rel1 = D6 Short / 0.7 = 400/0.7 = 600 (600 ≤ Rel1 ≤ 1400)

ΔS1 = Store1 - Rel1 = 1100 - 600 = 500

EOM1 = BOM1 + Store1 = 11000 + 1100 = 12100 (EOM1 ≤ 25000)

EOM1 Phys. = BOM1 Phys. + ΔS1 = 11000 + 500 = 11500

N4 = N1 - Store1 + D6 Short + N3 + Gain = 1100 - 1100 + 400 + 1300 + 2500 = 4200

N5 = N4 - D2 = 4200 - 400 = 3800 (N5 ≥ D6 Short)

N6 = N5 - fW(.5)(D3) + R2 + G1 = 3800 - .3(.5)(4200) + 200 + 1000 = 4400 (N6 ≥ D6 Short)

N7 = N6 + N6A = 4400 + 100 = 4500

D6 Direct = N7 + G2/3 - fW(D5) = 4500 + 1200/3 - .3(1400) = 4500 (600) (if < 0, D5 Short, D6 Direct = 0)

D6 Short = 1000 - D6 Direct = 1000 - 600 = 400 (400 ≤ D6 Short ≤ 1000)

N8 = N7 - fW(.5)(D5) - D6 Direct - D6 Short + G2 = 4500 - .3(.5)(1400) - 600 - 400 + 1200 = 4500

N9 = N8 + N8A = 4500 + 200 = 4700

N10 = N9 - fW(.5)(D8) - .8(D9) + G3 = 4700 - .3(.5)(700) - .8(1500) + 1200 = 4400

N11 = N10 + N10A = 4400 + 6200 = 10600

N12 = N11 - fW(.5)(D11) - fW(.6)(D12) + G4 = 10600 - .3(.5)(2500) - .3(.6)(2500) + 1500 = 11400 (Meet D11 first)

N13 = N12 + N12A + N12B = 11400 + 0 + 2500 = 13900

MT Avail = N13 - fM(.5)(D14) - 9900 = 13700 - .4(.5)(400) - 9900 = 3900 (Stock = 9900) (if < 0, Stock = N13 - fM(.5)(D14))

Store15 = 66000 - BOM15 = 66000 - 30000 = 36000 (3900) (≤ Avail)

Store16 = 4000 - BOM16 = 4000 - 1000 = 3000 (0) (≤ Avail - Store15)

Rel15 = (D17 Short + D20 Short)/0.7 = (0+0)/0.7 = 0

Rel16 = (D18 Short)/0.7 = 0/0.7 = 0

ΔS15 = Store15 - Rel15 = 3900 - 0 = 3900

ΔS16 = Store16 - Rel16 = 0 - 0 = 0

EOM15 = BOM15 + Store15 = 30000 + 3900 = 33900 (EOM15 ≤ 66000)

EOM15 Phys. = BOM15 Phys + ΔS15 = 30000 + 3900 = 33900

EOM16 = BOM16 + Store16 = 1000 + 0 = 1000 (EOM16 ≤ 4000)

EOM16 Phys. = BOM16 Phys. + ΔS16 = 1000 + 0 = 1000

N14 = Avail - Store15 + D17 Short + D20 Short - Store16 + D18 Short + Stock

= 3900 - 3900 + 0 + 0 - 0 + 0 + 9900 = 9900

N15 = N14 + N14A + N14B + G5 = 9900 + 100 + 100 + 1100 = 11200

D17 Short = fM(D17) - N15 - G6/3 = .4(11200) - 11200 - 800/3 = -7000 (0) (if ≤ 0, D17 Short = 0)

D18 Short = fM(D18) + fM(D17) - N15 - G6/3 = .4(8500) + .4(11200) - 11200 - 800/3 = -3600 (0) (if ≤ 0, D18 Short = 0)

N16 = N15 - fM(.5)(D17) - fM(.6)(D18) + G6 = 11200 - .4(.5)(11200) - .4(.6)(8500) + 800 = 7700

N17 = N16 + N16A = 7700 + 0 = 7700

N18 = N17 - fM(D20) = 7700 - .4(6000) = 5300

D20 Short = fM(D20) - N17 = -5300 (0) (if ≤ 0, D20 Short = 0)

For Compact Article V, C, Accounting and Calculation, Note (for this example) and use Compact Calculation sheet:

WY: ΔS1 = 500 MT: ΔS16 = 0 N18 (Compact Gage)

D6 = 1000 D18 = 3400 = 5300

D12 = 800

MT-00996

Form 2

Monthly Operation Calculation - Tongue River Example

Month Nov ; Iteration No. 0 ; Median Water Supply

Fraction for Irrigation Diversions: WY, fW = 0 ; MT, fM = 0

Paper Content: BOM1 = 12100 a-f; BOM15 = 33900 a-f; BOM16 = 1000 a-f

Physical Content: BOM1 Phys. 11500 ; BOM15 Phys 33900 ; BOM16 Phys. 1000

WY N1 = 0.80N2 = 1000

N3 = 1200

Store1 = 25000 - BOM1 = 25000 - 12100 = 12900 (1000) (≤ N1)

Rel1 = D6 Short / 0.7 = 400/0.7 = 600 (600 ≤ Rel1 ≤ 1400)

ΔS1 = Store1 - Rel1 = 1000 - 600 = 400

EOM1 = BOM1 + Store1 = 12100 + 1000 = 13100 (EOM1 ≤ 25000)

EOM1 Phys. = BOM1 Phys. + ΔS1 = 11500 + 400 = 11900

N4 = N1 - Store1 + D6 Short + N3 + Gain = 1000 - 1000 + 400 + 1200 + 1600 = 3200

N5 = N4 - D2 = 3200 - 0 = 3200 (N5 ≥ D6 Short)

N6 = N5 - fW(.5)(D3) + R2 + G1 = 3200 - 0 + 0 + 500 = 3700 (N6 ≥ D6 Short)

N7 = N6 + N6A = 3700 + 100 = 3800

D6 Direct = N7 + G2/3 - fW(D5) = 3800 + 600/3 - 0 = 4000 (600) (if < 0, D5 Short, D6 Direct = 0)

D6 Short = 1000 - D6 Direct = 1000 - 600 = 400 (400 ≤ D6 Short ≤ 1000)

N8 = N7 - fW(.5)(D5) - D6 Direct - D6 Short + G2 = 3800 - 0 - 600 - 400 + 600 = 3400

N9 = N8 + N8A = 3400 + 400 = 3800

N10 = N9 - fW(.5)(D8) - .8(D9) + G3 = 3800 - 0 - .8(1500) + 600 = 3200

N11 = N10 + N10A = 3200 + 5600 = 8800

N12 = N11 - fW(.5)(D11) - fW(.6)(D12) + G4 = 8800 - 0 - 0 + 700 = 9500 (Meet D11 first)

N13 = N12 + N12A + N12B = 9500 + 100 + 2000 = 11600

MT Avail = N13 - fM(.5)(D14) - 9900 = 11600 - 0 - 9900 = 1700 (Stock = 9900) (if < 0, Stock = N13 - fM(.5)(D14))

Store15 = 66000 - BOM15 = 66000 - 33900 = 32100 (1700) (≤ Avail)

Store16 = 4000 - BOM16 = 4000 - 1000 = 3000 (0) (≤ Avail - Store15)

Rel15 = (D17 Short + D20 Short)/0.7 = (0 + 0)/0.7 = 0

Rel16 = (D18 Short)/0.7 = 0/0.7 = 0

ΔS15 = Store15 - Rel15 = 1700 - 0 = 1700

ΔS16 = Store16 - Rel16 = 0 - 0 = 0

EOM15 = BOM15 + Store15 = 33900 + 1700 = 35600 (EOM15 ≤ 66000)

EOM15 Phys. = BOM15 Phys + ΔS15 = 33900 + 1700 = 35600

EOM16 = BOM16 + Store16 = 1000 + 0 = 1000 (EOM16 ≤ 4000)

EOM16 Phys. = BOM16 Phys. + ΔS16 = 1000 + 0 = 1000

N14 = Avail - Store15 + D17 Short + D20 Short - Store16 + D18 Short + Stock

= 1700 - 1700 + 0 + 0 - 0 + 0 + 9900 = 9900

N15 = N14 + N14A + N14B + G5 = 9900 + 100 + 200 + 200 = 10400

D17 Short = fM(D17) - N15 - G6/3 = 0 - 10400 - 200/3 = -10500 (0) (if ≤ 0, D17 Short = 0)

D18 Short = fM(D18) + fM(D17) - N15 - G6/3 = 0 + 0 - 10400 - 200/3 = -10500 (0) (if ≤ 0, D18 Short = 0)

N16 = N15 - fM(.5)(D17) - fM(.6)(D18) + G6 = 10400 - 0 - 0 + 200 = 10600

N17 = N16 + N16A = 10600 + 0 = 10600

N18 = N17 - fM(D20) = 10600 - 0 = 10600

D20 Short = fM(D20) - N17 = -10600 (0) (if ≤ 0, D20 Short = 0)

For Compact Article V, C, Accounting and Calculation, Note (for this example) and use Compact Calculation sheet:

WY: ΔS1 = 400 , MT: ΔS16 = 0 , N18 (Compact Gage)

D6 = 1000 D18 = 0 = 10600

D12 = 0

Form 2

Monthly Operation Calculation - Tongue River Example

Month Dec ; Iteration No. 0 ; Median Water Supply

Fraction for Irrigation Diversions: WY, fW = 0 ; MT, fM = 0

Paper Content: BOM1 = 13100 a-f; BOM15 = 35600 a-f; BOM16 = 1000 a-f

Physical Content: BOM1 Phys. 11900 ; BOM15 Phys 35600 ; BOM16 Phys. 1000

WY N1 = 0.8 N2 = 800

N3 = 1100

Store1 = 25000 - BOM1 = 25000 - 13100 = 11900 (800) (≤ N1)

Rel1: D6 Short / 0.7 = 400/0.7 = 600 (600 ≤ Rel1 ≤ 1400)

ΔS1 = Store1 - Rel1 = 800 - 600 = 200

EOM1 = BOM1 + Store1 = 13100 + 800 = 13900 (EOM1 ≤ 25000)

EOM1 Phys. = BOM1 Phys. + ΔS1 = 11900 + 200 = 12100

N4 = N1 - Store1 + D6 Short + N3 + Gain = 800 - 800 + 400 + 1100 + 1600 = 3100

N5 = N4 - D2 = 3100 - 0 = 3100 (N5 ≥ D6 Short)

N6 = N5 - fW(.5)(D3) + R2 + G1 = 3100 - 0 + 0 + 500 = 3600 (N6 ≥ D6 Short)

N7 = N6 + N6A = 3600 + 100 = 3700

D6 Direct = N7 + G2/3 - fW(D5) = 3700 + 600/3 - 0 = 3900 (600) (if < 0, D5 Short, D6 Direct = 0)

D6 Short = 1000 - D6 Direct = 1000 - 600 = 400 (400 ≤ D6 Short ≤ 1000)

N8 = N7 - fW(.5)(D5) - D6 Direct - D6 Short + G2 = 3700 - 0 - 600 - 400 + 600 = 3300

N9 = N8 + N8A = 3300 + 300 = 3600

N10 = N9 - fW(.5)(D8) - .8(D9) + G3 = 3600 - 0 - .8(1500) + 600 = 3000

N11 = N10 + N10A = 3000 + 5100 = 8100

N12 = N11 - fW(.5)(D11) - fW(.6)(D12) + G4 = 8100 - 0 - 0 + 800 = 8900 (Meet D11 first)

N13 = N12 + N12A + N12B = 8900 + 100 + 1500 = 10500

MT Avail = N13 - fM(.5)(D14) - 9900 = 10500 - 0 - 9900 = 600 (Stock = 9900) (if < 0, Stock = N13 - fM(.5)(D14))

Store15 = 66000 - BOM15 = 66000 - 35600 = 30400 (600) (≤ Avail)

Store16 = 4000 - BOM16 = 4000 - 1000 = 3000 (0) (≤ Avail - Store15)

Rel15 = (D17 Short + D20 Short)/0.7 = (0 + 0)/0.7 = 0

Rel16 = (D18 Short)/0.7 = 0/0.7 = 0

ΔS15 = Store15 - Rel15 = 600 - 0 = 600

ΔS16 = Store16 - Rel16 = 0 - 0 = 0

EOM15 = BOM15 + Store15 = 35600 + 600 = 36200 (EOM15 ≤ 66000)

EOM15 Phys. = BOM15 Phys + ΔS15 = 35600 + 600 = 36200

EOM16 = BOM16 + Store16 = 1000 + 0 = 1000 (EOM16 ≤ 4000)

EOM16 Phys. = BOM16 Phys. + ΔS16 = 1000 + 0 = 1000

N14 = Avail - Store15 + D17 Short + D20 Short - Store16 + D18 Short + Stock
= 600 - 600 + 0 + 0 - 0 + 0 + 9900 = 9900

N15 = N14 + N14A + N14B + G5 = 9900 + 100 + 200 + 100 = 10300

D17 Short = fM(D17) - N15 - G6/3 = 0 - 10300 - 100/3 = -10300 (0) (if ≤ 0, D17 Short = 0)

D18 Short = fM(D18) + fM(D17) - N15 - G6/3 = 0 + (-10300) = -10300 (0) (if ≤ 0, D18 Short = 0)

N16 = N15 - fM(.5)(D17) - fM(.6)(D18) + G6 = 10300 - 0 - 0 + 100 = 10400

N17 = N16 + N16A = 10400 + 0 = 10400

N18 = N17 - fM(D20) = 10400 - 0 = 10400

D20 Short = fM(D20) - N17 = -10400 (0) (if ≤ 0, D20 Short = 0)

For Compact Article V, C, Accounting and Calculation, Note (for this example) and use Compact Calculation sheet:

WY: ΔS1 = 200 ; MT: ΔS16 = 0 ; N18 (Compact Gage)

D6 = 1000 ; D18 = 0 ; = 10400

D12 = 0

Form 2

Monthly Operation Calculation - Tongue River Example

Month Jan; Iteration No. 0; Median Water Supply

Fraction for Irrigation Diversions: WY, fW = 0; MT, fM = 0

Paper Content: BOM1 = 13900 a-f; BOM15 = 36200 a-f; BOM16: 1000 a-f

Physical Content: BOM1 Phys. 12100; BOM15 Phys 36200; BOM16 Phys. 1000

WY N1 = 0.80N2 = 700

N3 = 900

Store1 = 25000 - BOM1 = 25000 - 13900 = 11100 (700) (≤ N1)

Rel1 = D6Short/0.7 = 420/0.7 = 600 (600 ≤ Rel1 ≤ 1400)

ΔS1 = Store1 - Rel1 = 700 - 600 = 100

EOM1 = BOM1 + Store1 = 13900 + 700 = 14600 (EOM1 ≤ 25000)

EOM1 Phys. = BOM1 Phys. + ΔS1 = 12100 + 100 = 12200

N4 = N1 - Store1 + D6Short + N3 + Gain = 700 - 700 + 400 + 900 + 1700 = 3000

N5 = N4 - D2 = 3000 - 0 = 3000 (N5 ≥ D6Short)

N6 = N5 - fW(.5)(D3) + R2 + G1 = 3000 - 0 + 0 + 600 = 3600 (N6 ≥ D6Short)

N7 = N6 + N6A = 3600 + 100 = 3700

D6 Direct = N7 + G2/3 - fW(D5) = 3700 + $\frac{700}{3}$ - 0 = 3900 (600) (if < 0, D5 Short, D6 Direct = 0)

D6 Short = 1000 - D6Direct = 1000 - 600 = 400 (400 ≤ D6Short ≤ 1000)

N8 = N7 - fW(.5)(D5) - D6Direct - D6Short + G2 = 3700 - 0 - 600 - 400 + 700 = 3400

N9 = N8 + N8A = 3400 + 300 = 3700

N10 = N9 - fW(.5)(D8) - .8(D9) + G3 = 3700 - 0 - .8(1500) + 700 = 3200

N11 = N10 + N10A = 3200 + 4300 = 7500

N12 = N11 - fW(.5)(D11) - fW(.6)(D12) + G4 = 7500 - 0 - 0 + 900 = 8400 (Meet D11 first)

N13 = N12 + N12A + N12B = 8400 + 0 + 1200 = 9600

MT Avail = N13 - fM(.5)(D14) - 9900 = 9600 - 0 - 9900 = -300 (0) (Stock = 9600) (if < 0, Stock = N13 - fM(.5)(D14))

Store15 = 66000 - BOM15 = 66000 - 36200 = 29800 (0) (≤ Avail)

Store16 = 4000 - BOM16 = 4000 - 1000 = 3000 (0) (≤ Avail - Store15)

Rel15 = (D17Short + D20Short)/0.7 = (0 + 0)/0.7 = 0

Rel16 = (D18Short)/0.7 = 0/0.7 = 0

ΔS15 = Store15 - Rel15 = 0 - 0 = 0

ΔS16 = Store16 - Rel16 = 0 - 0 = 0

EOM15 = BOM15 + Store15 = 36200 + 0 = 36200 (EOM15 ≤ 66000)

EOM15 Phys. = BOM15 Phys + ΔS15 = 36200 + 0 = 36200

EOM16 = BOM16 + Store16 = 1000 + 0 = 1000 (EOM16 ≤ 4000)

EOM16 Phys. = BOM16 Phys. + ΔS16 = 1000 + 0 = 1000

N14 = Avail - Store15 + D17Short + D20Short - Store16 + D18Short + Stock

= 0 - 0 + 0 + 0 - 0 + 0 + 9600 = 9600

N15 = N14 + N14A + N14B + G5 = 9600 + 100 + 300 + 100 = 10100

D17Short = fM(D17) - N15 - G6/3 = 0 - 10100 - 0/3 = -10100 (0) (if ≤ 0, D17Short = 0)

D18Short = fM(D18) + fM(D17) - N15 - G6/3 = 0 + (-10100) = -10100 (0) (if ≤ 0, D18Short = 0)

N16 = N15 - fM(.5)(D17) - fM(.6)(D18) + G6 = 10100 - 0 - 0 + 0 = 10100

N17 = N16 + N16A = 10100 + 0 = 10100

N18 = N17 - fM(D20) = 10100 - 0 = 10100

D20 Short = fM(D20) - N17 = (-10100) (0) (if ≤ 0, D20Short = 0)

For Compact Article V, C, Accounting and Calculation, Note (for this example) and use Compact Calculation sheet:

WY: ΔS1 = 100; D6 = 1000; D12 = 0

MT: ΔS16 = 0; D18 = 0

N18 (Compact Gage) = 10100

Form 2

Monthly Operation Calculation - Tongue River Example

Month Feb; Iteration No. 0; Median Water Supply

Fraction for Irrigation Diversions: WY, fW = 0; MT, fM = 0

Paper Content: BOM1 = 14600 a-f; BOM 15 = 36200 a-f; BOM16 = 1000 a-f

Physical Content: BOM1 Phys. 12200; BOM15 Phys 36200; BOM16 Phys. 1000

WY N1 = 0.80N2 = 600

N3 = 800

Store 1 = 25000 - BOM1 = 25000 - 14600 = 10400 (600) (≤ N1)

Rel1 = D6Short/0.7 = 400/0.7 = 600 (600 ≤ Rel1 ≤ 1400)

ΔS1 = Store 1 - Rel1 = 600 - 600 = 0

EOM1 = BOM1 + Store 1 = 14600 + 600 = 15200 (EOM1 ≤ 25000)

EOM1 Phys. = BOM1 Phys. + ΔS1 = 12200 + 0 = 12200

N4 = N1 - Store1 + D6 Short + N3 + Gain = 600 - 600 + 400 + 800 + 1400 = 2600

N5 = N4 - D2 = 2600 - 0 = 2600 (N5 ≥ D6 Short)

N6 = N5 - fW(.5)(D3) + R2 + G1 = 2600 - 0 + 0 + 900 = 3500 (N6 ≥ D6 Short)

N7 = N6 + N6A = 3500 + 100 = 3600

D6 Direct = N7 + G2/3 - fW(D5) = 3600 + 1100/3 - 0 = 4000 (600) (if < 0, D5 Short, D6 Direct = 0)

D6 Short = 1000 - D6Direct = 1000 - 600 = 400 (400 ≤ D6Short ≤ 1000)

N8 = N7 - fW(.5)(D5) - D6 Direct - D6 Short + G2 = 3600 - 0 - 600 - 400 + 1100 = 3700

N9 = N8 + N8A = 3700 + 300 = 4000

N10 = N9 - fW(.5)(D8) - .8(D9) + G3 = 4000 - 0 - .8(1500) + 1100 = 3900

N11 = N10 + N10A = 3900 + 4100 = 8000

N12 = N11 - fW(.5)(D11) - fW(.6)(D12) + G4 = 8000 - 0 - 0 + 1300 = 9300 (Meet D11 first)

N13 = N12 + N12A + N12B = 9300 + 100 + 1700 = 11100

MT Avail = N13 - fM(.5)(D14) - 9900 = 11100 - 0 - 9900 = 1200 (Stock = 9900) (if < 0, Stock = N13 - fM(.5)(D14))

Store 15 = 66000 - BOM15 = 66000 - 36200 = 29800 (1200) (≤ Avail)

Store16 = 4000 - BOM16 = 4000 - 1000 = 3000 (0) (≤ Avail - Store 15)

Rel15 = (D17Short + D20Short)/0.7 = (0 + 0)/0.7 = 0

Rel 16 = (D18 Short)/0.7 = 0/0.7 = 0

ΔS15 = Store 15 - Rel 15 = 1200 - 0 = 1200

ΔS16 = Store 16 - Rel 16 = 0 - 0 = 0

EOM15 = BOM15 + Store 15 = 36200 + 1200 = 37400 (EOM15 ≤ 66000)

EOM15 Phys. = BOM 15 Phys + ΔS15 = 36200 + 1200 = 37400

EOM 16 = BOM16 + Store 16 = 1000 + 0 = 1000 (EOM16 ≤ 4000)

EOM16 Phys. = BOM16 Phys. + ΔS16 = 1000 + 0 = 1000

N14 = Avail - Store 15 + D17 Short + D20 Short - Store16 + D18 Short + Stock

= 1200 - 1200 + 0 + 0 - 0 + 0 + 9900 = 9900

N15 = N14 + N14A + N14B + G5 = 9900 + 100 + 600 + 1000 = 11600

D17Short = fM(D17) - N15 - G6/3 = 0 - 11600 - 600/3 = -11800 (0) (if ≤ 0, D17Short = 0)

D18 Short = fM(D18) + fM(D17) - N15 - G6/3 = 0 + (-11800) = -11800 (0) (if ≤ 0, D18 Short = 0)

N16 = N15 - fM(.5)(D17) - fM(.6)(D18) + G6 = 11600 - 0 - 0 + 600 = 12200

N17 = N16 + N16A = 12200 + 700 = 12900

N18 = N17 - fM(D20) = 12900 - 0 = 12900

D20 Short = fM(D20) - N17 = (-12900) (0) (if ≤ 0, D20 Short = 0)

For Compact Article V, C, Accounting and Calculation, Note (for this example) and use Compact Calculation sheet:

WY: ΔS1 = 0, MT: ΔS16 = 0, N18 (Compact Gage)

D6 = 1000 D18 = 0 = 12900

D12 = 0

MT-01000

Form 2

Monthly Operation Calculation - Tongue River Example

Month March ; Iteration No. 0 ; Median Water Supply

Fraction for Irrigation Diversions: WY, fW = 0 ; MT, fM = 0

Paper Content: BOM1 = 15200 a-f; BOM15 = 37400 a-f; BOM16: 1000 a-f

Physical Content: BOM1 Phys. 12200 ; BOM15 Phys 37400 ; BOM16 Phys. 1000

WY N1 = 0.80N2 = 600

N3 = 800

Store1 = 25000 - BOM1 = 25000 - 15200 = 9800 (600) (≤ N1)

Rel1 = D6Short/0.7 = 400/0.7 = 600 (600 ≤ Rel1 ≤ 1400)

ΔS1 = Store1 - Rel1 = 600 - 600 = 0

EOM1 = BOM1 + Store1 = 15200 + 600 = 15800 (EOM1 ≤ 25000)

EOM1 Phys. = BOM1 Phys. + ΔS1 = 12200 + 0 = 12200

N4 = N1 - Store1 + D6 Short + N3 + Gain = 600 - 600 + 400 + 800 + 1700 = 2900

N5 = N4 - D2 = 2900 - 0 = 2900 (N5 ≥ D6Short)

N6 = N5 - fW(.5)(D3) + R2 + G1 = 2900 - 0 + 0 + 900 = 3800 (N6 ≥ D6 Short)

N7 = N6 + N6A = 3800 + 100 = 3900

D6 Direct = N7 + G2/3 - fW(D5) = 3900 + $\frac{1100}{3}$ - 0 = 4300 (600) (if ≤0, D5Short, D6 Direct = 0)

D6 Short = 1000 - D6Direct = 1000 - 600 = 400 (400 ≤ D6Short ≤ 1000)

N8 = N7 - fW(.5)(D5) - D6Direct - D6Short + G2 = 3900 - 0 - 600 - 400 + 1100 = 4000

N9 = N8 + N8A = 4000 + 300 = 4300

N10 = N9 - fW(.5)(D8) - .8(D9) + G3 = 4300 - 0 - .8(1500) + 1100 = 4200

N11 = N10 + N10A = 4200 + 5800 = 10000

N12 = N11 - fW(.5)(D11) - fW(.6)(D12) + G4 = 10000 - 0 - 0 + 1300 = 11300 (Meet D11 first)

N13 = N12 + N12A + N12B = 11300 + 200 + 4800 = 16300

MT Avail = N13 - fM(.5)(D14) - 9900 = 16300 - 0 - 9900 = 6400 (Stock = 9900) (if < 0, Stock = N13 - fM(.5)(D14))

Store15 = 66000 - BOM15 = 66000 - 37400 = 28600 (6400) (≤ Avail)

Store16 = 4000 - BOM16 = 4000 - 1000 = 3000 (0) (≤ Avail - Store15)

Rel15 = (D17Short + D20Short)/0.7 = (0+0)/.7 = 0

Rel16 = (D18 Short)/0.7 = 0/.7 = 0

ΔS15 = Store15 - Rel15 = 6400 - 0 = 6400

ΔS16 = Store16 - Rel16 = 0 - 0 = 0

EOM15 = BOM15 + Store15 = 37400 + 6400 = 43800 (EOM15 ≤ 66000)

EOM15 Phys. = BOM15 Phys + ΔS15 = 37400 + 6400 = 43800

EOM16 = BOM16 + Store16 = 1000 + 0 = 1000 (EOM16 ≤ 4000)

EOM16 Phys. = BOM16 Phys. + ΔS16 = 1000 + 0 = 1000

N14 = Avail - Store15 + D17Short + D20Short - Store16 + D18Short + Stock
= 6400 - 6400 + 0 + 0 - 0 + 0 + 9900 = 9900

N15 = N14 + N14A + N14B + G5 = 9900 + 300 + 500 + 6300 = 17000

D17Short = fM(D17) - N15 - G6/3 = 0 - 17000 - $\frac{4200}{3}$ = -18400 (0) (if ≤0, D17Short = 0)

D18 Short = fM(D18) + fM(D17) - N15 - G6/3 = 0 + (-18400) = -18400 (0) (if ≤0, D18Short = 0)

N16 = N15 - fM(.5)(D17) - fM(.6)(D18) + G6 = 17000 - 0 - 0 + 4200 = 21200

N17 = N16 + N16A = 21200 + 300 = 21500

N18 = N17 - fM(D20) = 21500 - 0 = 21500

D20 Short = fM(D20) - N17 = (-21500) (if ≤0, D20Short = 0)

For Compact Article V, C, Accounting and Calculation, Note (for this example) and use Compact Calculation sheet:

WY: ΔS1 = 0
D6 = 1000
D12 = 0

MT: ΔS16 = 0
D18 = 0

N18 (Compact Gage) = 21500

Form 2

Monthly Operation Calculation - Tongue River Example

Month Apr ; Iteration No. 0 ; Median Water Supply

Fraction for Irrigation Diversions: WY, fW = 0 ; MT, fM = .60

Paper Content: BOM1 = 15800 a-f; BOM 15 = 43800 a-f; BOM16: 1000 a-f

Physical Content: BOM1 Phys. 12200 ; BOM15 Phys 43800 ; BOM 16 Phys. 1000

WY N1 = 0.80N2 = 900

N3 = 900

Store 1 = 25000 - BOM1 = 25000 - 15800 = 9200 (900) (≤ N1)

Rel 1 = D6 Short /0.7 = 400/.7 = 600 (600 ≤ Rel1 ≤ 1400)

ΔS1 = Store 1 - Rel 1 = 900 - 600 = 300

EOM1 = BOM1 + Store 1 = 15800 + 900 = 16700 (EOM1 ≤ 25000)

EOM1 Phys. = BOM1 Phys. + ΔS1 = 12200 + 300 = 12500

N4 = N1 - Store 1 + D6 Short + N3 + Gain = 900 - 900 + 400 + 900 + 2600 = 3900

N5 = N4 - D2 = 3900 - 0 = 3900 (N5 ≥ D6 Short)

N6 = N5 - fW(.5)(D3) + R2 + G1 = 3900 - 0 + 0 + 1500 = 5400 (N6 ≥ D6 Short)

N7 = N6 + N6A = 5400 + 300 = 5700

D6 Direct = N7 + G2/3 - fW(D5) = 5700 + 1800/3 - 0 = 6300 (600) (if < 0, D5 Short, D6 Direct = 0)

D6 Short = 1000 - D6 Direct = 1000 - 600 = 400 (400 ≤ D6 Short ≤ 1000)

N8 = N7 - fW(.5)(D5) - D6 Direct - D6 Short + G2 = 5700 - 0 - 600 - 400 + 1800 = 6500

N9 = N8 + N8A = 6500 + 700 = 7200

N10 = N9 - fW(.5)(D8) - .8(D9) + G3 = 7200 - 0 - .8(1500) + 1900 = 7900

N11 = N10 + N10A = 7900 + 7800 = 15700

N12 = N11 - fW(.5)(D11) - fW(.6)(D12) + G4 = 15700 - 0 - 0 + 2200 = 17900 (Meet D11 first)

N13 = N12 + N12A + N12B = 17900 + 200 + 3600 = 21700

MT Avail = N13 - fM(.5)(D14) - 9900 = 21700 - .6(.5)(400) - 9900 = 11800 (Stock = 9900) (if < 0, Stock = N13 - fM(.5)(D14))

Store 15 = 66000 - BOM15 = 66000 - 43800 = 22200 (11800) (≤ Avail)

Store 16 = 4000 - BOM16 = 4000 - 1000 = 3000 (0) (≤ Avail - Store 15)

Rel 15 = (D17 Short + D20 Short)/0.7 = (0 + 0)/.7 = 0

Rel 16 = (D18 Short)/0.7 = 0/0.7 = 0

ΔS15 = Store 15 - Rel 15 = 11700 - 0 = 11700

ΔS16 = Store 16 - Rel 16 = 0 - 0 = 0

EOM15 = BOM15 + Store 15 = 43800 + 11700 = 55500 (EOM15 ≤ 66000)

EOM15 Phys. = BOM 15 Phys + ΔS15 = 43800 + 11700 = 55500

EOM 16 = BOM16 + Store 16 = 1000 + 0 = 1000 (EOM16 ≤ 4000)

EOM 16 Phys. = BOM16 Phys. + ΔS16 = 1000 + 0 = 1000

N14 = Avail - Store 15 + D17 Short + D20 Short - Store 16 + D18 Short + Stock

= 11700 - 11700 + 0 + 0 - 0 + 0 + 9900 = 9900

N15 = N14 + N14A + N14B + G5 = 9900 + 200 + 400 + 4500 = 15000

D17 Short = fM(D17) - N15 - G6/3 = .6(11200) - 15000 - 3000/3 = -9300 (0) (if ≤ 0, D17 Short = 0)

D18 Short = fM(D18) + fM(D17) - N15 - G6/3 = .6(8500) + (-9300) = -4200 (0) (if ≤ 0, D18 Short = 0)

N16 = N15 - fM(.5)(D17) - fM(.6)(D18) + G6 = 15000 - .6(.5)(11200) - .6(.6)(8500) + 3000 = 11600

N17 = N16 + N16A = 11600 + 700 = 12300

N18 = N17 - fM(D20) = 12300 - .6(6000) = 8700

D20 Short = fM(D20) - N17 = .6(6000) - 12300 = -8700 (0) (if ≤ 0, D20 Short = 0)

For Compact Article V, C, Accounting and Calculation, Note (for this example) and use Compact Calculation sheet:

WY:	ΔS1 = 300	MT:	ΔS16 = 0	N18 (Compact Gage)
	D6 = 1000		D18 = 5100	= 8700
	D12 = 0			

Monthly Operation Calculation - Tongue River Example — Form 2

Month May; Iteration No. 0; Median Water Supply
Fraction for Irrigation Diversions: WY, fW = .30; MT, fM = 1.00
Paper Content: BOM1 = 16700 a-f; BOM15 = 55500 a-f; BOM16: 1000 a-f
Physical Content: BOM1 Phys. 12500; BOM15 Phys 55500; BOM16 Phys. 1000

WY N1 = 0.80N2 = 12200
N3 = 4500
Store1 = 25000 - BOM1 = 25000 - 16700 = 8300 (≤ N1)
Rel1 = D6Short/0.7 = 400/.7 = 600 (600 ≤ Rel1 ≤ 1400)
ΔS1 = Store1 - Rel1 = 8300 - 600 = 7700
EOM1 = BOM1 + Store1 = 16700 + 8300 = 25000 (filled) (EOM1 ≤ 25000)
EOM1 Phys. = BOM1 Phys. + ΔS1 = 12500 + 7700 = 20200
N4 = N1 - Store1 + D6 Short + N3 + Gain = 12200 - 8300 + 400 + 4500 + 12700 = 21500
N5 = N4 - D2 = 21500 - 100 = 21400 (N5 ≥ D6 Short)
N6 = N5 - fW(.5)(D3) + R2 + G1 = 21400 - .3(.5)(4200) + 0 + 900 = 21700 (N6 ≥ D6 Short)
N7 = N6 + N6A = 21700 + 2700 = 24400
D6 Direct = N7 + G2/3 - fW(D5) = 24400 + 1100/3 - .3(1400) = 24300 (600) (if < 0, D5 Short, D6 Direct = 0)
D6 Short = 1000 - D6 Direct = 1000 - 600 = 400 (400 ≤ D6 Short ≤ 1000)
N8 = N7 - fW(.5)(D5) - D6 Direct - D6 Short + G2 = 24400 - .3(.5)(1400) - 600 - 400 + 1100 = 24300
N9 = N8 + N8A = 24300 + 4800 = 29100
N10 = N9 - fW(.5)(D8) - .8(D9) + G3 = 29100 - .3(.5)(1700) - .8(1500) + 1100 = 28700
N11 = N10 + N10A = 28700 + 25400 = 54100
N12 = N11 - fW(.5)(D11) - fW(.6)(D12) + G4 = 54100 - .3(.5)(2000) - .3(.6)(2500) + 1400 = 54800 (Meet D11 first)
N13 = N12 + N12A + N12B = 54800 + 200 + 3100 = 58100

MT Avail = N13 - fM(.5)(D14) - 9900 = 58100 - 1.(.5)(400) - 9900 = 48000 (stock = 9900) (if < 0, Stock = N13 - fM(.5)(D14))
Store15 = 66000 - BOM15 = 66000 - 55500 = 10500 (≤ Avail)
Store16 = 4000 - BOM16 = 4000 - 1000 = 3000 (≤ Avail - Store15)
Rel15 = (D17Short + D20Short)/0.7 = (0 + 0)/.7 = 0
Rel16 = (D18Short)/0.7 = 0/.7 = 0
ΔS15 = Store15 - Rel15 = 10500 - 0 = 10500
ΔS16 = Store16 - Rel16 = 3000 - 0 = 3000
EOM15 = BOM15 + Store15 = 55500 + 10500 = 66000 (filled) (EOM15 ≤ 66000)
EOM15 Phys. = BOM15 Phys + ΔS15 = 55500 + 10500 = 66000
EOM16 = BOM16 + Store16 = 1000 + 3000 = 4000 (filled) (EOM16 ≤ 4000)
EOM16 Phys. = BOM16 Phys. + ΔS16 = 1000 + 3000 = 4000
N14 = Avail - Store15 + D17Short + D20Short - Store16 + D18Short + Stock
= 48000 - 10500 + 0 + 0 - 3000 + 0 + 9900 = 44400
N15 = N14 + N14A + N14B + G5 = 44400 + 200 + 300 + (-3600) = 41300
D17Short = fM(D17) - N15 - G6/3 = 1.0(11200) - 41300 - (-2400/3) = -29300 (0) (if ≤ 0, D17Short = 0)
D18 Short = fM(D18) + fM(D17) - N15 - G6/3 = 1.(8500) + (-29300) = -20800 (0) (if ≤ 0, D18 Short = 0)
N16 = N15 - fM(.5)(D17) - fM(.6)(D18) + G6 = 41300 - 1.(.5)(11200) - 1.(.6)(8500) + (-2400) = 28200
N17 = N16 + N16A = 28200 + 400 = 28600
N18 = N17 - fM(D20) = 28600 - 1.(6000) = 22600
D20 Short = fM(D20) - N17 = (-22600) (0) (if ≤ 0, D20Short = 0)

For Compact Article V, C, Accounting and Calculation, Note (for this example) and use Compact Calculation sheet:

WY: ΔS1 = 7700; D6 = 1000; D12 = 800
MT: ΔS16 = 3000; D18 = 8500
N18 (Compact Gage) = 22600

Form 2

Monthly Operation Calculation - Tongue River Example

Month June; Iteration No. 0; Median Water Supply

Fraction for Irrigation Diversions: WY, fW = .80; MT, fM = 1.00

Paper Content: BOM1 = 25000 a-f; BOM 15 = 66000 a-f; BOM16 = 4000 a-f

Physical Content: BOM1 Phys. 20200; BOM15 Phys 66000; BOM16 Phys. 4000

WY N1 = 0.80N2 = 18500

N3 = 6200

Store1 = 25000 - BOM1 = 25000 - 25000 = 0 (≤ N1)

Rel1 = D6Short/0.7 = 400/.7 = 600 (600 ≤ Rel1 ≤ 1400)

ΔS1 = Store1 - Rel1 = 0 - 600 = -600

EOM1 = BOM1 + Store1 = 25000 + 0 = 25000 (EOM1 ≤ 25000)

EOM1 Phys. = BOM1 Phys. + ΔS1 = 20200 + (-600) = 19600

N4 = N1 - Store1 + D6Short + N3 + Gain = 18500 - 0 + 400 + 6200 + 11000 = 36100

N5 = N4 - D2 = 36100 - 900 = 35200 (N5 ≥ D6Short)

N6 = N5 - fW(.5)(D3) + R2 + G1 = 35200 - .8(.5)(4200) + 400 + 2100 = 36000 (N6 ≥ D6Short)

N7 = N6 + N6A = 36000 + 2800 = 38800

D6Direct = N7 + G2/3 - fW(D5) = 38800 + 2500/3 - .8(1400) = 38500 (600) (if < 0, D5Short, D6Direct = 0)

D6Short = 1000 - D6Direct = 1000 - 600 = 400 (400 ≤ D6Short ≤ 1000)

N8 = N7 - fW(.5)(D5) - D6Direct - D6Short + G2 = 38800 - .8(.5)(1400) - 600 - 400 + 2500 = 39700

N9 = N8 + N8A = 39700 + 5000 = 44700

N10 = N9 - fW(.5)(D8) - .8(D9) + G3 = 44700 - .8(.5)(1700) - .8(1500) + 2600 = 45400

N11 = N10 + N10A = 45400 + 40000 = 85400

N12 = N11 - fW(.5)(D11) - fW(.6)(D12) + G4 = 85400 - .8(.5)(2000) - .8(.6)(2500) + 3100 = 86500 (Meet D11 first)

N13 = N12 + N12A + N12B = 86500 + 100 + 2200 = 88800

MT Avail = N13 - fM(.5)(D14) - 9900 = 88800 - 1.(.5)(400) - 9900 = 78700 (Stock = 9900) (if < 0, Stock = N13 - fM(.5)(D14))

Store15 = 66000 - BOM15 = 66000 - 66000 = 0 (≤ Avail)

Store16 = 4000 - BOM16 = 4000 - 4000 = 0 (≤ Avail - Store15)

Rel15 = (D17Short + D20Short)/0.7 = (0+0)/.7 = 0

Rel16 = (D18Short)/0.7 = 0/.7 = 0

ΔS15 = Store15 - Rel15 = 0 - 0 = 0

ΔS16 = Store16 - Rel16 = 0 - 0 = 0

EOM15 = BOM15 + Store15 = 66000 + 0 = 66000 (EOM15 ≤ 66000)

EOM15 Phys. = BOM15 Phys + ΔS15 = 66000 + 0 = 66000

EOM16 = BOM16 + Store16 = 4000 + 0 = 4000 (EOM16 ≤ 4000)

EOM16 Phys. = BOM16 Phys. + ΔS16 = 4000 + 0 = 4000

N14 = Avail - Store15 + D17Short + D20Short - Store16 + D18Short + Stock
= 78700 - 0 + 0 + 0 - 0 + 0 + 9900 = 88600

N15 = N14 + N14A + N14B + G5 = 88600 + 200 + 300 + 7400 = 96500

D17Short = fM(D17) - N15 - G6/3 = 1.(11200) - 96500 - 4900/3 = -86900 (0) (if ≤ 0, D17Short = 0)

D18Short = fM(D18) + fM(D17) - N15 - G6/3 = 1.(8500) + (-86900) = -78400 (0) (if ≤ 0, D18Short = 0)

N16 = N15 - fM(.5)(D17) - fM(.6)(D18) + G6 = 96500 - 1.(.5)(11200) - 1.(.6)(8500) + 4900 = 90700

N17 = N16 + N16A = 90700 + 100 = 90800

N18 = N17 - fM(D20) = 90800 - 1.(6000) = 84800

D20Short = fM(D20) - N17 = (-84800) (0) (if ≤ 0, D20Short = 0)

For Compact Article V, C, Accounting and Calculation, Note (for this example) and use Compact Calculation sheet:

WY: ΔS1 = -600; D6 = 1000; D12 = 2000

MT: ΔS16 = 0; D18 = 8500

N18 (Compact Gage) = 84800

MT-01004

Form 2

Monthly Operation Calculation - Tongue River Example

Month July ; Iteration No. 0 ; Median Water Supply

Fraction for Irrigation Diversions: WY, fW = 1.00 ; MT, fM = 1.00

Paper Content: BOM1 = 25000 a-f; BOM15 = 66000 a-f; BOM16: 4000 a-f

Physical Content: BOM1 Phys. 19600 ; BOM15 Phys 66000 ; BOM16 Phys. 4000

WY N1 = 0.80N2 = 5400

N3 = 3200

Store 1 = 25000 - BOM1 = 25000 - 25000 = 0 (≤ N1)

Rel 1 = D6 Short /0.7 = 400/.7 = 600 (600 ≤ Rel 1 ≤ 1400)

ΔS1 = Store 1 - Rel 1 = 0 - 600 = -600

EOM1 = BOM1 + Store 1 = 25000 + 0 = 25000 (EOM1 ≤ 25000)

EOM1 Phys. = BOM1 Phys. + ΔS1 = 19600 + (-600) = 19000

N4 = N1 - Store 1 + D6 Short + N3 + Gain = 5400 - 0 + 400 + 3200 + 5500 = 14500

N5 = N4 - D2 = 14500 - 1200 = 13300 (N5 ≥ D6 Short)

N6 = N5 - fW(.5)(D3) + R2 + G1 = 13300 - 1.(.5)(4200) + 600 + 1500 = 13300 (N6 ≥ D6 Short)

N7 = N6 + N6A = 13300 + 400 = 13700

D6 Direct = N7 + G2/3 - fW(D5) = 13700 + $\frac{1800}{3}$ - 1.(1400) = 12900 (600) (if < 0, D5 Short, D6 Direct = 0)

D6 Short = 1000 - D6 Direct = 1000 - 600 = 400 (400 ≤ D6 Short ≤ 1000)

N8 = N7 - fW(.5)(D5) - D6 Direct - D6 Short + G2 = 13700 - 1.(.5)(1400) - 600 - 400 + 1800 = 13800

N9 = N8 + N8A = 13800 + 1200 = 15000

N10 = N9 - fW(.5)(D8) - .8(D9) + G3 = 15000 - 1.(.5)(1700) - .8(1500) + 1900 = 14800

N11 = N10 + N10A = 14800 + 9000 = 23800

N12 = N11 - fW(.5)(D11) - fW(.6)(D12) + G4 = 23800 - 1.(.5)(2000) - 1.(.6)(2500) + 2200 = 23500 (Meet D11 first)

N13 = N12 + N12A + N12B = 23500 + 0 + 1100 = 24600

MT Avail = N13 - fM(.5)(D14) - 9900 = 24600 - 1.(.5)(400) - 9900 = 14500 (Stock = 9900) (if < 0, Stock = N13 - fM(.5)(D14))

Store 15 = 66000 - BOM15 = 66000 - 66000 = 0 (≤ Avail)

Store 16 = 4000 - BOM16 = 4000 - 4000 = 0 (≤ Avail - Store 15)

Rel 15 = (D17 Short + D20 Short)/0.7 = (0+0)/.7 = 0

Rel 16 = (D18 Short)/0.7 = 0/.7 = 0

ΔS15 = Store 15 - Rel 15 = 0 - 0 = 0

ΔS16 = Store 16 - Rel 16 = 0 - 0 = 0

EOM15 = BOM15 + Store 15 = 66000 + 0 = 66000 (EOM15 ≤ 66000)

EOM15 Phys. = BOM15 Phys + ΔS15 = 66000 + 0 = 66000

EOM16 = BOM16 + Store 16 = 4000 + 0 = 4000 (EOM16 ≤ 4000)

EOM16 Phys. = BOM16 Phys. + ΔS16 = 4000 + 0 = 4000

N14 = Avail - Store 15 + D17 Short + D20 Short - Store 16 + D18 Short + Stock

= 14500 - 0 + 0 + 0 - 0 + 0 + 9900 = 24400

N15 = N14 + N14A + N14B + G5 = 24400 + 200 + 100 + 3500 = 28200

D17 Short = fM(D17) - N15 - G6/3 = 1.(11200) - 28200 - $\frac{2400}{3}$ = -17800 (0) (if ≤ 0, D17 Short = 0)

D18 Short = fM(D18) + fM(D17) - N15 - G6/3 = 1.(2500) + (-17800) = -9300 (0) (if ≤ 0, D18 Short = 0)

N16 = N15 - fM(.5)(D17) - fM(.6)(D18) + G6 = 28200 - 1.(.5)(11200) - 1.(.6)(8500) + 2400 = 19900

N17 = N16 + N16A = 19900 + 0 = 19900

N18 = N17 - fM(D20) = 19900 - 1.(6000) = 13900

D20 Short = fM(D20) - N17 = (-13900) (0) (if ≤ 0, D20 Short = 0)

For Compact Article V, C, Accounting and Calculation, Note (for this example) and use Compact Calculation sheet:

WY: ΔS1 = -600	MT: ΔS16 = 0	N18 (Compact Gage)	
D6 = 1000	D18 = 8500	= 13900	
D12 = 2500			

MT-01005

Monthly Operation Calculation - Tongue River Example — Form 2

Month Aug ; Iteration No. 0 ; Median Water Supply

Fraction for Irrigation Diversions: WY, fW = 1.00 ; MT, fM = 1.00

Paper Content: BOM1 = 25000 a-f; BOM15 = 66000 a-f; BOM16 = 4000 a-f

Physical Content: BOM1 Phys. 19000 ; BOM15 Phys 66000 ; BOM16 Phys. 4000

WY N1 = 0.80 N2 = 2100

N3 = 1800

Store 1 = 25000 - BOM1 = 25000 - 25000 = 0 (≤ N1)

Rel 1 = D6 Short /0.7 = 400/.7 = 600 (600 ≤ Rel1 ≤ 1400)

ΔS1 = Store 1 - Rel 1 = 0 - 600 = -600

EOM1 = BOM1 + Store 1 = 25000 + 0 = 25000 (EOM1 ≤ 25000)

EOM1 Phys. = BOM1 Phys. + ΔS1 = 19000 - 600 = 18400

N4 = N1 - Store 1 + D6 Short + N3 + Gain = 2100 - 0 + 400 + 1800 + 3500 = 7800

N5 = N4 - D2 = 7800 - 1200 = 6600 (N5 ≥ D6 Short)

N6 = N5 - fW(.5)(D3) + R2 + G1 = 6600 - 1.(.5)(4200) + 600 + 900 = 6000 (N6 ≥ D6 Short)

N7 = N6 + N6A = 6000 + 100 = 6100

D6 Direct = N7 + G2/3 - fW(D5) = 6100 + 1100/3 - 1.(1400) = 5100 (600) (if < 0, D5 Short, D6 Direct = 0)

D6 Short = 1000 - D6 Direct = 1000 - 600 = 400 (400 ≤ D6 Short ≤ 1000)

N8 = N7 - fW(.5)(D5) - D6 Direct - D6 Short + G2 = 6100 - 1.(.5)(1400) - 600 - 400 + 1100 = 5500

N9 = N8 + N8A = 5500 + 400 = 5900

N10 = N9 - fW(.5)(D8) - .8(D9) + G3 = 5900 - 1.(.5)(1700) - .8(1500) + 1100 = 5000

N11 = N10 + N10A = 5000 + 2800 = 7800

N12 = N11 - fW(.5)(D11) - fW(.6)(D12) + G4 = 7800 - 1.(.5)(2000) - 1.(.6)(2500) + 1300 = 6600 (Meet D11 first)

N13 = N12 + N12A + N12B = 6600 + 0 + 1500 = 8100

MT Avail = N13 - fM(.5)(D14) - 9900 = 8100 - 1.(.5)(400) - 9900 = -2000 (0) (stock = 7900) (if < 0, stock = N13 - fM(.5)(D14))

Store 15 = 66000 - BOM15 = 66000 - 66000 = 0 (≤ Avail)

Store 16 = 4000 - BOM16 = 4000 - 4000 = 0 (≤ Avail - Store 15)

Rel 15 = (D17 Short + D20 Short)/0.7 = (0+0)/.7 = 0

Rel 16 = (D18 Short)/0.7 = 0/.7 = 0

ΔS15 = Store 15 - Rel 15 = 0 - 0 = 0

ΔS16 = Store 16 - Rel 16 = 0 - 0 = 0

EOM15 = BOM15 + Store 15 = 66000 + 0 = 66000 (EOM15 ≤ 66000)

EOM15 Phys. = BOM15 Phys + ΔS15 = 66000 + 0 = 66000

EOM16 = BOM16 + Store 16 = 4000 + 0 = 4000 (EOM16 ≤ 4000)

EOM16 Phys. = BOM16 Phys. + ΔS16 = 4000 + 0 = 4000

N14 = Avail - Store 15 + D17 Short + D20 Short - Store 16 + D18 Short + Stock

= 0 - 0 + 0 + 0 - 0 + 0 + 7900 = 7900

N15 = N14 + N14A + N14B + G5 = 7900 + 0 + 0 + 400 = 8300

D17 Short = fM(D17) - N15 - G6/3 = 1.(11200) - 8300 - 300/3 = 2800 (Short) (if ≤ 0, D17 Short = 0)

D18 Short = fM(D18) + fM(D17) - N15 - G6/3 = 1.(8500) + 2800 = 11300 (Short) (if ≤ 0, D18 Short = 0)

N16 = N15 - fM(.5)(D17) - fM(.6)(D18) + G6 = 8300 - 1.(.5)(11200 - 2800) - 1.(.6)(8500) + 300 = -700

N17 = N16 + N16A = 0

N18 = N17 - fM(D20) = 0 - 1.(6000) = -6000

D20 Short = fM(D20) - N17 = 6000 Short (Iterate for MT) (if ≤ 0, D20 Short = 0)

For Compact Article V, C, Accounting and Calculation, Note (for this example) and use Compact Calculation sheet:

WY: ΔS1 = -600 MT: ΔS16 = 0 N18 (Compact Gage)

D6 = 1000 D18 = =

D12 = 2500

Form 2

Monthly Operation Calculation - Tongue River Example

Month AUG; Iteration No. 1 (MT) Median Water Supply

Fraction for Irrigation Diversions: WY, fW = 1.00; MT, fM = 1.00

Paper Content: BOM1 = 25000 a-f; BOM15 = 66000 a-f; BOM16 = 4000 a-f

Physical Content: BOM1 Phys. 19000; BOM15 Phys 66000; BOM16 Phys. 4000

WY N1 = 0.80 N2 = 2100

N3 = 1800

Store1 = 25000 - BOM1 = 25000 - 25000 = 0 (≤ N1)

Rel1: D6 Short / 0.7 = 400/.7 = 600 (600 ≤ Rel1 ≤ 1400)

ΔS1 = Store1 - Rel1 = 0 - 600 = -600

EOM1 = BOM1 + Store1 = 25000 + 0 = 25000 (EOM1 ≤ 25000)

EOM1 Phys. = BOM1 Phys. + ΔS1 = 19000 + (-600) = 18400

N4 = N1 - Store1 + D6 Short + N3 + Gain = 2100 - 0 + 400 + 1800 + 3500 = 7800

N5 = N4 - D2 = 7800 - 1200 = 6600 (N5 ≥ D6 Short)

N6 = N5 - fW(.5)(D3) + R2 + G1 = 6600 - 1.(.5)(4200) + 600 + 900 = 6000 (N6 ≥ D6 Short)

N7 = N6 + N6A = 6000 + 100 = 6100

D6 Direct = N7 + G2/3 - fW(D5) = 6100 + 1100/3 - 1.(1400) = 5100 (600) (if < 0, D5 Short, D6 Direct = 0)

D6 Short = 1000 - D6 Direct = 1000 - 600 = 400 (400 ≤ D6 Short ≤ 1000)

N8 = N7 - fW(.5)(D5) - D6 Direct - D6 Short + G2 = 6100 - 1.(.5)(1400) - 600 - 400 + 1100 = 5500

N9 = N8 + N8A = 5500 + 400 = 5900

N10 = N9 - fW(.5)(D8) - .8(D9) + G3 = 5900 - 1.(.5)(1700) - .8(1500) + 1100 = 5000

N11 = N10 + N10A = 5000 + 2800 = 7800

N12 = N11 - fW(.5)(D11) - fW(.6)(D12) + G4 = 7800 - 1.(.5)(2000) - 1.(.6)(3500) + 1300 = 6600 (Meet D11 first)

N13 = N12 + N12A + N12B = 6600 + 0 + 1500 = 8100

MT Avail = N13 - fM(.5)(D14) - 9900 = 8100 - 1.(.5)(400) - 9900 = -2000 (0) (Stock = 7900) (if < 0, Stock = N13 - fM(.5)(D14))

Store15 = 66000 - BOM15 = 66000 - 66000 = 0 (≤ Avail)

Store16 = 4000 - BOM16 = 4000 - 4000 = 0 (≤ Avail - Store15)

Rel15 = (D17 Short + D20 Short)/0.7 = (2800 + 6000)/.7 = 11400

Rel16 = (D18 Short)/0.7 = 8500/.7 = 12100 (4000) D18 Short = .7(4000) = 2800 (≤ BOM16 Phys.)

ΔS15 = Store15 - Rel15 = 0 - 11400 = -11400

ΔS16 = Store16 - Rel16 = 0 - 4000 = -4000

EOM15 = BOM15 + Store15 = 66000 + 0 = 66000 (EOM15 ≤ 66000)

EOM15 Phys. = BOM15 Phys + ΔS15 = 66000 + (-11400) = 54600

EOM16 = BOM16 + Store16 = 4000 + 0 = 4000 (EOM16 ≤ 4000)

EOM16 Phys. = BOM16 Phys. + ΔS16 = 4000 - 4000 = 0

N14 = Avail - Store15 + D17 Short + D20 Short - Store16 + D18 Short + Stock
= 0 - 0 + 2800 + 6000 - 0 + 2800 + 7900 = 19500

N15 = N14 + N14A + N14B + G5 = 19500 + 0 + 0 + 400 = 19900

D17 Short = fM(D17) - N15 - G6/3 = 1.(11200) - 19900 - 300/3 = -8800 (0) (if ≤ 0, D17 Short = 0)

D18 Short = fM(D18) + fM(D17) - N15 - G6/3 = 1.(8500) + (-8800) = -300 (0) (if ≤ 0, D18 Short = 0)

N16 = N15 - fM(.5)(D17) - fM(.6)(D18) + G6 = 19900 - 1.(.5)(11200) - 1.(.6)(8500) + 300 = 9500

N17 = N16 + N16A = 9500 + 0 = 9500

N18 = N17 - fM(D20) = 9500 - 1.(6000) = 3500

D20 Short = fM(D20) - N17 = 1.(6000) - 9500 = -3500 (0) (if ≤ 0, D20 Short = 0)

(Iterate MT - reduce ΔS15 by 3500)

For Compact Article V, C, Accounting and Calculation, Note (for this example) and use Compact Calculation sheet:

WY: ΔS1 =
D6 =
D12 =

MT: ΔS16 =
D18 =

N18 (Compact Gage)
=

Form 2

Monthly Operation Calculation - Tongue River Example

Month Aug ; Iteration No. 2 (MT) ; Median Water Supply

Fraction for Irrigation Diversions: WY, fW = 1.00 ; MT, fM = 1.00

Paper Content: BOM1 = 25000 a-f; BOM15 = 66000 a-f; BOM16 = 4000 a-f

Physical Content: BOM1 Phys. 19000 ; BOM15 Phys 66000 ; BOM16 Phys. 4000

WY N1 = 0.80N2 =

N3 =

Store1 = 25000 - BOM1 = 25000 - (≤ N1)

Rel1 = D6 Short /0.7 = (600 ≤ Rel1 ≤ 1400)

ΔS1 = Store1 - Rel1 = (-600)

EOM1 = BOM1 + Store1 = (EOM1 ≤ 25000)

EOM1 Phys. = BOM1 Phys. + ΔS1 = (18400)

N4 = N1 - Store1 + D6 Short + N3 + Gain =

N5 = N4 - D2 = (N5 ≥ D6 Short)

N6 = N5 - fW(.5)(D3) + R2 + G1 = (N6 ≥ D6 Short)

N7 = N6 + N6A =

D6 Direct = N7 + G2/3 - fW(D5) = (if < 0, D5 Short, D6 Direct = 0)

D6 Short = 1000 - D6 Direct = 1000 - (400 ≤ D6 Short ≤ 1000)

N8 = N7 - fW(.5)(D5) - D6 Direct - D6 Short + G2 = D6 = 1000

N9 = N8 + N8A =

N10 = N9 - fW(.5)(D8) - .8(D9) + G3 =

N11 = N10 + N10A =

N12 = N11 - fW(.5)(D11) - fW(.6)(D12) + G4 = (D12 = 2500) (Meet D11 first)

N13 = N12 + N12A + N12B = 8100

... WY from initial calc's Iteration 1

MT Avail = N13 - fM(.5)(D14) - 9900 = 0   Stock = 7700 (if < 0, Stock = N13 - fM(.5)(D14))

Store15 = 66000 - BOM15 = 0 (≤ Avail)

Store16 = 4000 - BOM16 = 0 (≤ Avail - Store15)

Rel15 = (D17 Short + D20 Short)/0.7 = 11400 - 3500 = 7900 (D17 Short + D20 Short = [illegible])

Rel16 = (D18 Short) /0.7 = 4000

ΔS15 = Store15 - Rel15 = 0 - 7900 = -7900

ΔS16 = Store16 - Rel16 = 0 - 4000 = -4000

EOM15 = BOM15 + Store15 = 66000 + 0 = 66000 (EOM15 ≤ 66000)

EOM15 Phys. = BOM15 Phys + ΔS15 = 66000 + (-7900) = 58100

EOM16 = BOM16 + Store16 = 4000 + 0 = 4000 (EOM16 ≤ 4000)

EOM16 Phys. = BOM16 Phys. + ΔS16 = 4000 + (-4000) = 0

N14 = Avail - Store15 + D17 Short + D20 Short - Store16 + D18 Short + Stock

= 0 - 0 + (5530) - 0 + [illegible] = 16200

N15 = N14 + N14A + N14B + G5 = 16200 + 0 + 0 + [illegible] = 16[illegible]

D17 Short = fM(D17) - N15 - G6/3 = 1.(11000 - [illegible]) = -5500 (0) (if ≤ 0, D17 Short = 0)

D18 Short = fM(D18) + fM(D17) - N15 - G6/3 = 1.([illegible]) - 5500 = 3000 short (if ≤ 0, D18 Short = 0)

N16 = N15 - fM(.5)(D17) - fM(.6)(D18) + G6 = 16600 - [illegible] = 6200

N17 = N16 + N16A = 6200 + 0 = 6200

N18 = N17 - fM(D20) = 6200 - 1.(6000) = 200 OK

D20 Short = fM(D20) - N17 = (-200) (0) (if ≤ 0, D20 Short = 0)

For Compact Article V, C, Accounting and Calculation, Note (for this example) and use Compact Calculation sheet:

WY: ΔS1 = -600		MT: ΔS16 = -4000		N18 (Compact Gage)
D6 = 1000		D18 = 3500		= 200
D12 = 2500				

Form 2

Monthly Operation Calculation - Tongue River Example

Month Sept. ; Iteration No. 0 , Median Water Supply

Fraction for Irrigation Diversions: WY, fW = .80 ; MT, fM = .90

Paper Content: BOM1 = 25000 a-f; BOM 15 = 66000 a-f; BOM16 = 4000 a-f

Physical Content: BOM1 Phys. 18400 ; BOM15 Phys 58100 ; BOM16 Phys 0

WY N1 = 0.80N2 = 1400

N3 = 1500

Store 1 = 25000 − BOM1 = 25000 − 25000 = 0 (≤ N1)

Rel 1 = D6 Short /0.7 = 400/.7 = 600 (600 ≤ Rel 1 ≤ 1400)

ΔS1 = Store 1 − Rel 1 = 0 − 600 = −600

EOM1 = BOM1 + Store 1 = 25000 + 0 = 25000 (EOM1 ≤ 25000)

EOM1 Phys. = BOM1 Phys. + ΔS1 = 18400 + (−600) = 17800

N4 = N1 − Store 1 + D6 Short + N3 + Gain = 1400 − 0 + 400 + 1500 + 2800 = 6100

N5 = N4 − D2 = 6100 − 1000 = 5100 (N5 ≥ D6 Short)

N6 = N5 − fW(.5)(D3) + R2 + G1 = 5100 − .8(.5)(4000) + 500 + 800 = 4800 (N6 ≥ D6 Short)

N7 = N6 + N6A = 4800 + 0 = 4800

D6 Direct = N7 + G2/3 − fW(D5) = 4800 + 1100/3 − .8(1400) = 4000 600 (if < 0, D5 Short, D6 Direct = 0)

D6 Short = 1000 − D6 Direct = 1000 − 600 = 400 (400 ≤ D6 Short ≤ 1000)

N8 = N7 − fW(.5)(D5) − D6 Direct − D6 Short + G2 = 4800 − .8(.5)(1400) − 600 − 400 + 1100 = 4300

N9 = N8 + N8A = 4300 + 300 = 4600

N10 = N9 − fW(.5)(D8) − .8(D9) + G3 = 4600 − .8(.5)(1700) − .8(1500) + 1100 = 3800

N11 = N10 + N10A = 3800 + 4400 = 8200

N12 = N11 − fW(.5)(D11) − fW(.6)(D12) + G4 = 8200 − .8(.5)(6000) − .8(.6)(3000) + 1400 = 7600 (Meet D11 first)

N13 = N12 + N12A + N12B = 7600 + 0 + 2400 = 10000

MT Avail = N13 − fM(.5)(D14) − 9900 = 10000 − .9(.5)(400) − 9900 = −80 (Stock = 9900) (if < 0, Stock = N13 − fM(.5)(D14))

Store 15 = 66000 − BOM15 = 66000 − 66000 = 0 (≤ Avail)

Store 16 = 4000 − BOM16 = 4000 − 4000 = 0 (≤ Avail − Store 15)

Rel 15 = (D17 Short + D20 Short)/0.7 = (0 + 0)/.7 = 0

Rel 16 = (D18 Short)/0.7 = 0/.7 = 0

ΔS15 = Store 15 − Rel 15 = 0 − 0 = 0

ΔS16 = Store 16 − Rel 16 = 0 − 0 = 0

EOM15 = BOM15 + Store 15 = 66000 + 0 = 66000 (EOM15 ≤ 66000)

EOM15 Phys. = BOM 15 Phys + ΔS15 = 58100 + 0 = 58100

EOM 16 = BOM16 + Store 16 = 4000 + 0 = 4000 (EOM16 ≤ 4000)

EOM16 Phys. = BOM16 Phys. + ΔS16 = 0 + 0 = 0

N14 = Avail − Store 15 + D17 Short + D20 Short − Store 16 + D18 Short + Stock

= 0 − 0 + 0 + 0 − 0 + 0 + 9900

N15 = N14 + N14A + N14B + G5 = 9800 + 0 + 0 + 2700 = 12500

D17 Short = fM(D17) − N15 − G6/3 = .9(11000) − 12500 − 1200/3 = −3000 0 (if ≤ 0, D17 Short = 0)

D18 Short = fM(D18) + fM(D17) − N15 − G6/3 = .9(8500) + (−3000) = 4400 [illegible] (if ≤ 0, D18 Short = 0)

N16 = N15 − fM(.5)(D17) − fM(.6)(D18) + G6 = 12500 − .9(.5)(11000) − .9(.6)(8500) − 1200 = 4700

N17 = N16 + N16A = 4700 + 0 = 4700

N18 = N17 − fM(D20) = 4700 − .9(6000) = −700

D20 Short = fM(D20) − N17 = .9(6000) − 4700 = 700 short (Iter 1 — MT Rel 15 = 700/.7 = 1000) (if ≤ 0, D20 Short = 0)

For Compact Article V, C, Accounting and Calculation, Note (for this example) and use Compact Calculation sheet:

WY:	ΔS1 = −600	MT:	ΔS16 = 0	N18 (Compact Gage)
	D6 = 1000		D18 =	=
	D12 = 3000			

Monthly Operation Calculation - Tongue River Example

Month Sept.; Iteration No. 1 (MT) Median Water Supply

Fraction for Irrigation Diversions: WY, fW = .80; MT, fM = .90

Paper Content: BOM1 = 25000 a-f; BOM15 = 66000 a-f; BOM16 = 4000 a-f

Physical Content: BOM1 Phys. 13400; BOM15 Phys. 58100; BOM16 Phys. 0

WY N1 = 0.80N2 =

N3 =

Store1 = 25000 − BOM1 = 25000 − (≤ N1)

Rel1 = D6Short/0.7 = (600 ≤ Rel1 ≤ 1400)

ΔS1 = Store1 − Rel1 = −600

EOM1 = BOM1 + Store1 = (EOM1 ≤ 25000)

EOM1 Phys. = BOM1 Phys. + ΔS1 = 12800

N4 = N1 − Store1 + D6Short + N3 + Gain =

N5 = N4 − D2 = (N5 ≥ D6 Short)

N6 = N5 − fW(.5)(D3) + R2 + G1 = (N6 ≥ D6 Short)

N7 = N6 + N6A =

D6 Direct = N7 + G2/3 − fW(D5) = (if < 0, D5 Short, D6 Direct = 0)

D6 Short = 1000 − D6 Direct = 1000 − (400 ≤ D6 Short ≤ 1000)

N8 = N7 − fW(.5)(D5) − D6 Direct − D6 Short + G2 = D6 = 1000

N9 = N8 + N8A =

N10 = N9 − fW(.5)(D8) − .8(D9) + G3 =

N11 = N10 + N10A =

N12 = N11 − fW(.5)(D11) − fW(.6)(D12) + G4 = D12 = 2000 (Meet D11 first)

N13 = N12 + N12A + N12B =

MT Avail = N13 − fM(.5)(D14) − 9900 = 0 Stock = 9800 (if < 0, Stock = N13 − fM(.5)(D14))

Store15 = 66000 − BOM15 = 0 (≤ Avail)

Store16 = 4000 − BOM16 = 0 (≤ Avail − Store15)

Rel15 = (D17Short + D20Short)/0.7 = (0 + 700)/.7 = 1000

Rel16 = (D18Short)/0.7 = 0/.7 = 0

ΔS15 = Store15 − Rel15 = 0 − 1000 = −1000

ΔS16 = Store16 − Rel16 = 0 − 0 = 0

EOM15 = BOM15 + Store15 = 66000 + 0 = 66000 (EOM15 ≤ 66000)

EOM15 Phys. = BOM15 Phys + ΔS15 = 58100 + (−1000) = 57100

EOM16 = BOM16 + Store16 = 4000 + 0 = 4000 (EOM16 ≤ 4000)

EOM16 Phys. = BOM16 Phys. + ΔS16 = 0 + 0 = 0

N14 = Avail − Store15 + D17Short + D20Short − Store16 + D18Short + Stock
= 0 − 0 − 0 + 700 − 0 + 0 + 9800 = 10500

N15 = N14 + N14A + N14B + G5 = 10500 + 0 + 0 + 2700 = 13300

D17Short = fM(D17) − N15 − G6/3 = .9(11200) − 13300 − 1200/3 = −3700 (0) (if ≤ 0, D17Short = 0)

D18Short = fM(D18) + fM(D17) − N15 − G6/3 = .9(8500) + (−3700) = 4000 7600 (if ≤ 0, D18Short = 0)

N16 = N15 − fM(.5)(D17) − fM(.6)(D18) + G6 = 13300 − .9(.5)(11200) − .9(.6)(8500) + 1200 = 5400

N17 = N16 + N16A = 5400 + 0 = 5400

N18 = N17 − fM(D20) = 5400 − .9(6000) = 0

D20 Short = fM(D20) − N17 = .9(6000) − 5400 = 0 (if ≤ 0, D20Short = 0)

For Compact Article V, C, Accounting and Calculation, Note (for this example) and use Compact Calculation sheet:

WY: ΔS1 = −600; D6 = 1000; D12 = 2000

MT: ΔS16 = 0; D18 = 7600

N18 (Compact Gage) = 0

Form #3- Compact
CALCULATIONS

Article V.C, Compact Calculation - Tongue River Example

(Data from Monthly Operation Calculation — In actual practice these types of data would be measured, and the Monthly Operation Calculations would not be necessary for compact purposes.)

Month Oct Iteration No. 0

Item	WY				MT			Gage N18 (6-308500)	Allocable WY+MT+N18
	ΔS1	D6	D12	Accum.	ΔS16	D18	Accum.		
Previous Accum.	0	0	0		0	0		0	
Current Period	500	1000	800		0	3400		5300	
Current Accum.	500	1000	800	2300	0	3400	3400	5300	11000

Allocations: WY: 0.40 × Allocable = 4400
MT: 0.60 × Allocable = 6600

Compare: WY Allocation – WY Accum. = 4400-2300 = 2100 (<0, Adjust)
MT Allocation – MT Accum. = 6600-3400 = 3200 (<0, Adjust)

Iterate to adjust storage or diversions? No

Notes: Water available to storages is stored, all demands are met.

Month Nov Iteration No. 0

Item	WY				MT			Gage N18 (6-308500)	Allocable WY+MT+N18
	ΔS1	D6	D12	Accum.	ΔS16	D18	Accum.		
Previous Accum.	500	1000	800		0	3400		5300	
Current Period	400	1000	0		0	0		10600	
Current Accum.	900	2000	800	3700	0	3400	3400	15900	23000

Allocations: WY: 0.40 × Allocable = 9200
MT: 0.60 × Allocable = 13800

Compare: WY Allocation – WY Accum. = 9200-3700 = 5500 (<0, Adjust)
MT Allocation – MT Accum. = 13800-3400 = 10400 (<0, Adjust)

Iterate to adjust storage or diversions? No

Notes: water available to storages is stored, all demands are met.

Month Dec Iteration No. 0

Item	WY				MT			Gage N18 (6-308500)	Allocable WY+MT+N18
	ΔS1	D6	D12	Accum.	ΔS16	D18	Accum.		
Previous Accum.	900	2000	800		0	3400		15900	
Current Period	200	1000	0		0	0		10400	
Current Accum.	1100	3000	800	4900	0	3400	3400	26300	34600

Allocations: WY: 0.40 × Allocable = 13800
MT: 0.60 × Allocable = 20800

Compare: WY Allocation – WY Accum. = 13800-4900 = 8900 (<0, Adjust)
MT Allocation – MT Accum. = 20800-3400 = 17400 (<0, Adjust)

Iterate to adjust storage or diversions? No

Notes: water available to storage is stored, all demands are met.

Comments:

Form 3

Article V.C, Compact Calculation - Tongue River Example

(Data from Monthly Operation Calculation — In actual practice these types of data would be measured, and the Monthly Operation Calculations would not be necessary for compact purposes.)

Month Jan Iteration No. 0

Item	WY				MT			Gage N18	Allocable
	ΔS1	D6	D12	Accum.	ΔS16	D18	Accum.	(6-308500)	WY+MT+N18
Previous Accum.	1100	3000	800		0	3400		26300	
Current Period	100	1000	0		0	0		10100	
Current Accum.	1200	4000	800	6000	0	3400	3400	36400	45900

Allocations: WY: 0.40 × Allocable = 18300

MT: 0.60 × Allocable = 27500

Compare: WY Allocation – WY Accum. = 18300 - 6000 = 12300 (<0, Adjust)

MT Allocation - MT Accum. = 25500 - 3400 = 22100 (<0, Adjust)

Iterate to adjust storage or diversions? No

Notes: Water available to storage is stored, all demands are met.

Month Feb Iteration No. 0

Item	WY				MT			Gage N18	Allocable
	ΔS1	D6	D12	Accum.	ΔS16	D18	Accum.	(6-308500)	WY+MT+N18
Previous Accum.	1200	4000	800		0	3400		36400	
Current Period	0	1000	0		0	0		12900	
Current Accum.	1200	5000	800	7000	0	3400	3400	49300	59700

Allocations: WY: 0.40 × Allocable = 23900

MT: 0.60 × Allocable = 35800

Compare: WY Allocation - WY Accum. = 23900 - 7000 = 16900 (<0, Adjust)

MT Allocation - MT Accum. = 35800 - 3400 = 32400 (<0, Adjust)

Iterate to adjust storage or diversions? No

Notes: water available to storage is stored, all demands are met.

Month March Iteration No. 0

Item	WY				MT			Gage N18	Allocable
	ΔS1	D6	D12	Accum.	ΔS16	D18	Accum.	(6-308500)	WY+MT+N18
Previous Accum.	1300	5000	800		0	3400		49300	
Current Period	0	1000	0		0	0		21500	
Current Accum.	1300	6000	800	8000	0	3400	3400	70800	82200

Allocations: WY: 0.40 × Allocable = 32900

MT: 0.60 × Allocable = 49300

Compare: WY Allocation - WY Accum. = 32900 - 8000 = 24900 (<0, Adjust)

MT Allocation - MT Accum. = 49300 - 3400 = 45900 (<0, Adjust)

Iterate to adjust storage or diversions? No

Notes: water available to storage is stored, all demands are met.

Comments:

MT-01013

Form 3

Article V.C, Compact Calculation – Tongue River Example

(Data from Monthly Operation Calculation — In actual practice these types of data would be measured, and the Monthly Operation Calculations would not be necessary for compact purposes.)

Month Apr Iteration No. 0

Item	WY ΔS1	WY D6	WY D12	WY Accum.	MT ΔS16	MT D18	MT Accum.	Gage N18 (6-308500)	Allocable WY+MT+N18
Previous Accum.	1200	6000	800		0	3400		70800	
Current Period	300	1000	0		0	5100		8700	
Current Accum.	1500	7000	800	9300	0	8500	8500	79500	97300

Allocations: WY: 0.40 × Allocable = 38900
MT: 0.60 × Allocable = 58400

Compare: WY Allocation – WY Accum. = 38900 – 9300 = 29600 (<0, Adjust)
MT Allocation – MT Accum. = 58400 – 8500 = 49900 (<0, Adjust)

Iterate to adjust storage or diversions? No

Notes: water available to storage is stored, all demands are met.

Month May Iteration No. 0

Item	WY ΔS1	WY D6	WY D12	WY Accum.	MT ΔS16	MT D18	MT Accum.	Gage N18 (6-308500)	Allocable WY+MT+N18
Previous Accum.	1500	7000	800		0	8500		79500	
Current Period	7700	1000	800		3000	8500		22600	
Current Accum.	9200	8000	1600	18800	3000	17000	20000	102100	140900

Allocations: WY: 0.40 × Allocable = 56400
MT: 0.60 × Allocable = 84500

Compare: WY Allocation – WY Accum. = 56400 – 18800 = 37600 (<0, Adjust)
MT Allocation – MT Accum. = 84500 – 20000 = 64500 (<0, Adjust)

Iterate to adjust storage or diversions? No

Notes: storage filled, all demands met.

Month June Iteration No. 0

Item	WY ΔS1	WY D6	WY D12	WY Accum.	MT ΔS16	MT D18	MT Accum.	Gage N18 (6-308500)	Allocable WY+MT+N18
Previous Accum.	9200	8000	1600		3000	17000		102100	
Current Period	–600	1000	2000		0	8500		84800	
Current Accum.	8600	9000	3600	21200	3000	25500	28500	186900	236600

Allocations: WY: 0.40 × Allocable = 94600
MT: 0.60 × Allocable = 142000

Compare: WY Allocation – WY Accum. = 94600 – 21200 = 73400 (<0, Adjust)
MT Allocation – MT Accum. = 142000 – 28500 = 113500 (<0, Adjust)

Iterate to adjust storage or diversions? No

Notes: storage filled, all demands met

Comments:

Article V.C, Compact Calculation - Tongue River Example

Form 3

(Data from Monthly Operation Calculation — In actual practice these types of data would be measured, and the Monthly Operation Calculations would not be necessary for compact purposes.)

Month July Iteration No. 0

Item	WY ΔS1	WY D6	WY D12	WY Accum.	MT ΔS16	MT D18	MT Accum.	Gage N18 (6-308500)	Allocable WY+MT+N18
Previous Accum.	8600	9000	3600		3000	25500		186900	
Current Period	-600	1000	2500		0	8500		13900	
Current Accum.	8000	10000	6100	24100	3000	34000	37000	200800	261900

Allocations: WY: 0.40 × Allocable = 104800

MT: 0.60 × Allocable = 157100

Compare: WY Allocation - WY Accum. = 104800 - 24100 = 80700 (<0, Adjust)

MT Allocation - MT Accum. = 157100 - 37000 = 120100 (<0, Adjust)

Iterate to adjust storage or diversions? No

Notes: Storage filled, all demands are met.

Month Aug. Iteration No. 2

Item	WY ΔS1	WY D6	WY D12	WY Accum.	MT ΔS16	MT D18	MT Accum.	Gage N18 (6-308500)	Allocable WY+MT+N18
Previous Accum.	8000	10000	6100		3000	34000		200800	
Current Period	-600	1000	2500		-4000	8500		200	
Current Accum.	7400	11000	8600	27000	-1000	42500	41500	201000	269500

Allocations: WY: 0.40 × Allocable = 107800

MT: 0.60 × Allocable = 161700

Compare: WY Allocation - WY Accum. = 107800 - 27000 = 80800 (<0, Adjust)

MT Allocation - MT Accum. = 161700 - 41500 = 120200 (<0, Adjust)

Iterate to adjust storage or diversions? No

Notes: Storage filled, all demands met, with storage releases.

Month Sept. Iteration No. 1

Item	WY ΔS1	WY D6	WY D12	WY Accum.	MT ΔS16	MT D18	MT Accum.	Gage N18 (6-308500)	Allocable WY+MT+N18
Previous Accum.	7400	11000	8600		-1000	42500		201000	
Current Period	-600	1000	2000		0	7600		0	
Current Accum.	6800	12000	10600	29400	-1000	50100	49100	201000	279500

Allocations: WY: 0.40 × Allocable = 111800

MT: 0.60 × Allocable = 167700

Compare: WY Allocation - WY Accum. = 111800 - 29400 = 82400 (<0, Adjust)

MT Allocation - MT Accum. = 167700 - 49100 = 118600 (<0, Adjust)

Iterate to adjust storage or diversions? No

Notes: Storage filled, all demands met, with storage releases.

Comments: