Outline


Parallel flow to drains. (Figure)
(a) Differential equation - solution. Table 10 (h_0/H).

River valley idealization. Page 137 of text.
(b) The part remaining function ( \( \int \frac{dx}{HL} \) ) = p. (Table 11. p 300.)

Computation of return flow.
(a) Need for a set of factors giving the part of the return flow occurring in the nth month of the amount reaching the water table in the first month. (Text p 158)
(b) Advantage for digital computer operation. (Factors can be stored in new row)
(c) Computation using the p function if the drainable volume reaches the water table at the middle of the month.
(d) Table showing this computation. A computation based upon application at the end of the first and third weeks and for uniform application rate during the first month. DelManzo. (Text p 158) (See pages 158 & 159)

Second hour.

Existence of a set of factors if the valley width is not constant and the river is not in the middle of the valley.
(a) Method of computation. (Blackboard)
(b) Comparison of results for the Kersey, Julesburg reach.
(c) Stream depletion due to pumping. 1942-1949. 1948-1950.
(d) Estimate of stream depletion due to pumping in the South Platte Valley. (Chart showing rise of pumping)

(1) CSU records.
(2) Count of wells from Code’s map. (CSU Bull 483 - Sept 1943)
(3) Factors from USGS-WSP 1978.
(4) Estimate of water lifted and stream depletion in the main valley of the South Platte.

(e) Estimate of the monthly pattern of stream depletion.
(1) The USBR pattern. (From The U.S.B.R. Narrows studies)
(2) Reduction of the 60 factor set to a 12 factor set.
(3) Factors must be in reverse order.
(4) Results of the computation. (Check against performance of river)
(5) Estimate of restoration flows.
(a) Effective depletion.
(b) Surface diverters with pumps.
(c) Effect of stream-flow pattern.
(d) Final estimate and results of first years experience. (Also: Available water must be reserved for qualifying priorities.

Third hour.

Test against the historic performance of the river.
(a) Precedents. Newton 1666. (Reason for adopting “rule of procedure - Test of delineated")
(b) Details of computations for the 10 year period ending 1958. (Figure 1957)
(1) Flow at Kersey-by months.
(2) Diversions, Pumping, precipitation.
(3) Computed and observed flow at Julesburg.
(4) Flows with return flows omitted - Surface waters and Ground waters are one water supply.
(5) Reason for the lack of large experienced difficulties due to pumping. (Surface diverters were using pumps)
Third hour, (continued)

(a) Comparison of estimated and computed Kersey flows on the basis that the yield of the watershed has not changed with time. (Table).

(b) Investigation of the validity of the postulate that if a pump is shut down anywhere in the valley the flow which the well was delivering will immediately appear back in the river.

(c) The Maasland idealization.
   (1) Bureau of Reclamation employee—For papers see reference list.
   (2) Developments based upon the concept of a continuous infiltration.
   (3) His results can be related to the formula 8-1. The integration procedure is explained beginning on pages 117 to 119 inclusive. The flow of water to the drains is treated on pages 125 and 126. The final result is:

\[
\frac{Q^2}{L} = 1 - 8 \sum_{n=3, 5, \ldots} \frac{e^{-\frac{n^2\pi^2}{L^2}}}{n^2} \approx 1 - p
\]

(4) As an example, estimate the restoration of river flow which would result from shutting down of 100(ft³/sec) of pumping distributed over the valley width. (Table).

(5) Conclusions.
   (a) A method of estimating return flows and pumping depletions has been worked out, based upon the law of Darcy and the condition of continuity.
   (b) The validity of the method has been confirmed by tests against the historic performance of the South Platte river.
   (c) The formula can be a source of information for effective management of the water resources of the South Platte and Arkansas river valleys.
The parallel flow case will be the object of our discussion in the next 3 hours.

Applications - Design of dams. (Table 10, Chapter 11) p. 287

Computation of return flow in an irrigated river valley.

Pump operation in a river valley.

Examples: Design problems in the Buffalo Platte Valley.

Laws: Eq. 148-21-17, 148-21-34, Conservation law.

Detached viewpoint.

Technical approach (Figure)

\[ \frac{\partial^2 h}{\partial x^2} = -\frac{H}{T} \left( 1 + \frac{\alpha n^2 \pi^2}{L^2} \sum_{n=1,3,5} \frac{\epsilon}{\lambda} \sin \left( \frac{\pi n x}{L} \right) \right) \]

\[ \frac{\partial h}{\partial t} = -\frac{H}{T} \left( 1 + \frac{\alpha n^2 \pi^2}{L^2} \sum_{n=1,3,5} \frac{\epsilon}{\lambda} \sin \left( \frac{\pi n x}{L} \right) \right) \]

Needed:

- Surface models
- A.W.A. paper
- State Constitution
- Colorado Water Law
- Bulletin 100
- Text
Port Remaining Function (Table 11-6 300)
Parallel flow.

Ground surface.

\[ h \]

Drain

\[ K \]

Permeability.

\[ V \]

Voids.

Barrier.

Flow to drains.

River

Ground surface.

River valley.

Darcy's law is:

\[ F = KD \frac{\partial h}{\partial x} \]

The continuity condition is:

\[ V \frac{\partial h}{\partial t} \ dx = \frac{\partial F}{\partial x} \ dx \quad \text{or} \quad \frac{\partial F}{\partial x} = V \frac{\partial h}{\partial t} \]

By differentiation and substitution:

with:

\[ \alpha = \frac{KD}{V} \quad \text{(The aquifer constant.)} \]

\[ \alpha \frac{\partial^2 h}{\partial x^2} = \frac{\partial h}{\partial t} \]

If \( h = H \) for \( 0 < x < L \) when \( t = 0 \). (Flow to drains)

\[ h = 0 \] for \( t > 0 \) when \( x = 0 \).

\[ \frac{\partial h}{\partial x} = 0 \] for \( t > 0 \) when \( x = \frac{L}{2} \).

A solution is:

\[
 h = H \sum_{n=1}^{\infty} \frac{4}{n \pi} e^{-\frac{\alpha n^2 \pi^2 t}{L^2}} \sin\left(\frac{n \pi x}{L}\right)
\]
Need for a set of factors
Water applied at middle of first month
Significance of differences
\[ h = \frac{H4}{\pi} \sum_{n=1,3,5,\ldots}^{n=\infty} \frac{e^{-n^2 \pi^2 \left( \frac{\alpha t}{L^2} \right)}}{n} \sin \left( \frac{n \pi x}{L} \right). \]

Since:

\[ \int_0^L \sin \left( \frac{n \pi x}{L} \right) \, dx = -\frac{L}{n \pi} \cos \left( \frac{n \pi x}{L} \right) \bigg|_0^L = \frac{2L}{n \pi}. \]

Then; the part remaining is:

\[ p = \frac{\int_0^L h \, dx}{HL} = \frac{8}{\pi^2} \sum_{n=1,3,5,\ldots}^{n=\infty} \frac{e^{-n^2 \pi^2 \left( \frac{\alpha t}{L^2} \right)}}{n^2}. \]
Factors for estimating return flows or pump depletions based upon

\[ \Delta = 1.50 \text{ ft}^2/\text{sec} \quad L = 21120 \text{ ft}(4 \text{ miles}) \]

Months of 2628000 seconds

These are appropriate for South Platte Valley conditions.

Factors obtained by use of the part remaining table.

One half of the monthly quota is applied at the end of the first week and the other half at the end of the third week (Weeks of 657 000 seconds). Factor applied to the monthly quota, applied in month 1, gives the effect on the stream for a specified succeeding month. Factors for the fifth year are adjusted so that the total of the factors is 1.00000.

Factors obtained by use of the Maasland-DelManzo procedure.

The monthly quota is applied by a steady infiltration \( i \) (if return flow is being computed). The infiltration is maintained for the first month and then ceases. Factors give the return flow to the river during a specified succeeding month. (Pump depletion can be treated as a negative infiltration). The water applied during the first month is \( iLt \) where \( t \) represents the time equivalent to the first month. After the fifth year there still remains a residue of \( 1.00000 - 0.99548 = 0.00452 \). To account, approximately, for the contributions of years prior to the fifth add the product of this factor and the average monthly quota for the prior years.

The factors are arranged with the factor for the month of application (Month 1) at the bottom so that they can be applied to quantities listed to run forward in time. The total return flow during the specified month is the sum of the products of these factors and the monthly quotas.
Computation of return flow factors when the drainable volume reaches the water table at the middle of the month.

One month is 2628000 seconds. For South Platte conditions.

\[
\left( \frac{Kt_1}{L^2} \right) = \frac{(1.50)(2628000)}{21120^2} = 0.008,837,487 \quad \frac{1}{2} \left( \frac{Kt_1}{L^2} \right) = 0.004,418,7435
\]

<table>
<thead>
<tr>
<th>Month</th>
<th>( \frac{Kt_1}{L^2} )</th>
<th>( p )</th>
<th>( \Delta p )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>1.0000000000</td>
<td>0.150014927</td>
</tr>
<tr>
<td>1</td>
<td>0.004418744</td>
<td>0.849985073</td>
<td>0.109818779</td>
</tr>
<tr>
<td>2</td>
<td>0.013256230</td>
<td>0.740166294</td>
<td>0.075609532</td>
</tr>
<tr>
<td>3</td>
<td>0.022093718</td>
<td>0.664556762</td>
<td>0.061445957</td>
</tr>
<tr>
<td>4</td>
<td>0.030931205</td>
<td>0.603110805</td>
<td>0.053045700</td>
</tr>
<tr>
<td>5</td>
<td>0.039768692</td>
<td>0.550065105</td>
<td>0.047158732</td>
</tr>
<tr>
<td>6</td>
<td>0.048606179</td>
<td>0.502906373</td>
<td>0.042559015</td>
</tr>
<tr>
<td>7</td>
<td>0.057443666</td>
<td>0.460347358</td>
<td>0.038703522</td>
</tr>
<tr>
<td>8</td>
<td>0.066281153</td>
<td>0.421643836</td>
<td>0.035333584</td>
</tr>
<tr>
<td>9</td>
<td>0.075118640</td>
<td>0.386310249</td>
<td>0.032319732</td>
</tr>
<tr>
<td>10</td>
<td>0.083956127</td>
<td>0.353990516</td>
<td>0.029591636</td>
</tr>
<tr>
<td>11</td>
<td>0.092793614</td>
<td>0.324398880</td>
<td>0.027106928</td>
</tr>
<tr>
<td>12</td>
<td>0.101631101</td>
<td>0.297291952</td>
<td>0.027106928</td>
</tr>
</tbody>
</table>

\[
\pi^2 = 9.869,604,401 \quad \frac{8}{\pi^2} = 0.810,569,4691
\]

Ref. G. Mar 28 1975
Factors based upon identifications.
(a) The half is applied at the end of the first and third weeks.
(b) Application is in the form of a continuous inflation rate i.

There is a development of the R function in the text, see pages 153 and 155. The preceding is an independent development.

\[
dW = \frac{8}{\pi^2} \sum_{n=1}^{\infty} e^{-\pi^2 n^2} \int \frac{x(x-5)}{L^2} \, dx = \frac{4}{\pi} \int \frac{dx}{x}
\]

By integration,

\[
W = \frac{8}{\pi^2} \left[ \frac{L^2}{\alpha \pi^2} \right] = \frac{8}{\pi^2} \left[ 2 \frac{L^2}{\alpha \pi^2} \right] = 2 \frac{L}{\alpha \pi}
\]

But since

\[
\frac{1}{1+3^4+5^4+\ldots} = \frac{\pi^4}{90}
\]

This is one of the Bernoulli numbers.

\[
\frac{W}{2Lt} = \left( \frac{L^2}{\alpha t} \right) \frac{1}{12} - \left( \frac{L^2}{\alpha t} \right) \frac{8}{\pi^4} \sum_{n=1}^{\infty} e^{-\pi^2 n^2 (\frac{L^2}{t})}
\]

This represents the total drawdown volume remaining. The total lost is

\[
\left( \frac{W}{2Lt} \right) = R = 1 - \left( \frac{L^2}{\alpha t} \right) \frac{1}{12} + \left( \frac{L^2}{\alpha t} \right) \frac{8}{\pi^4} \sum_{n=1}^{\infty} e^{-\pi^2 n^2 (\frac{L^2}{t})}
\]

This is tabulated in Table 13, page 304.

Its use in deriving a set of factors is shown on page 158.
Comparison of sets of factors:
(a) Application is made as shown on page 160 of text.
(b) Show case of text.
(c) Reason for the reverse order. Reside.
(d) Summary page 161 of text.
Factors obtained by use of the part-remaining table.

Factors obtained by the Maasland-Delmanzo procedure.
Return flow factors

\[ \alpha = 1.50 \text{ ft}^2/\text{sec} \quad L = 21120 \text{ ft (4 miles)} \]

One month is 2628000 seconds (1/12 year)

\[ \frac{\alpha t^2}{L^2} = \frac{(1.50)(2628000)}{(21120)^2} = \frac{(3.942)(10)^6}{(446.054)(10)^6} = 0.008837 \]

<table>
<thead>
<tr>
<th>Time (months)</th>
<th>( \frac{\alpha t}{L^2} )</th>
<th>( \beta )</th>
<th>( \Delta \beta ) (1. application per mo.)</th>
<th>( \Delta \beta ) (2. application per mo.)</th>
<th>Maasland Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.004418</td>
<td>.849595</td>
<td>.150405</td>
<td>.14491</td>
<td>.14140</td>
</tr>
<tr>
<td>2</td>
<td>.013255</td>
<td>.740213</td>
<td>.109382</td>
<td>.11402</td>
<td>.11721</td>
</tr>
<tr>
<td>3</td>
<td>.022092</td>
<td>.664576</td>
<td>.075637</td>
<td>.07609</td>
<td>.07627</td>
</tr>
<tr>
<td>4</td>
<td>.030929</td>
<td>.603128</td>
<td>.061448</td>
<td>.06162</td>
<td>.06168</td>
</tr>
<tr>
<td>5</td>
<td>.039766</td>
<td>.550086</td>
<td>.053042</td>
<td>.05312</td>
<td>.05313</td>
</tr>
<tr>
<td>6</td>
<td>.048603</td>
<td>.502929</td>
<td>.047157</td>
<td>.04720</td>
<td>.04724</td>
</tr>
<tr>
<td>7</td>
<td>.057440</td>
<td>.460369</td>
<td>.042560</td>
<td>.04258</td>
<td>.04254</td>
</tr>
<tr>
<td>8</td>
<td>.066277</td>
<td>.421664</td>
<td>.038705</td>
<td>.03870</td>
<td>.03875</td>
</tr>
<tr>
<td>9</td>
<td>.075114</td>
<td>.386329</td>
<td>.035335</td>
<td>.03536</td>
<td>.03535</td>
</tr>
<tr>
<td>10</td>
<td>.083951</td>
<td>.354008</td>
<td>.032321</td>
<td>.03232</td>
<td>.03236</td>
</tr>
<tr>
<td>11</td>
<td>.092788</td>
<td>.324418</td>
<td>.029590</td>
<td>.02960</td>
<td>.02958</td>
</tr>
<tr>
<td>12</td>
<td>.101625</td>
<td>.297312</td>
<td>.027106</td>
<td>.02712</td>
<td>.02715</td>
</tr>
</tbody>
</table>

One application per month.

Month of application

Two applications in the month.

Maasland's concept is of a continuous application during the month.

1. 2. 3. 4.

Ends of months.
Stream depletion by pumping:
(a) Electrical power used for pumping in the South Platte Valley.
Electric Power used for Pumping in the South Platte Valley in Colorado.

Drainage
South Platte - direct.
Bear Creek.
Cherry Creek.
Clear Creek.
St Vrain Creek.
Thompson River.
Box Elder Creek (Dist 3).
Cache la Poudre River - direct.
Lone Tree Creek.
Crow Creek.
Box Elder Creek (Dist 1).
Prospect Valley.
Kiowa Creek.
Bijou Creek.
Beaver Creek.

Code: Bulletins 483 & 500s - C.S.U. Data
Computation of stream depletion
(a) necessary for administrative purposes

End of first hour

Questions
South Platte

Electrical power used for pumping in the South Platte Valley. Source: U.S. Geological Survey. Units are Kilowatt-Hours (KWH).

<table>
<thead>
<tr>
<th>Month</th>
<th>KWH</th>
</tr>
</thead>
<tbody>
<tr>
<td>1961</td>
<td>57,674,351.0</td>
</tr>
<tr>
<td>1965</td>
<td>10,820,482.4</td>
</tr>
<tr>
<td>1970</td>
<td>11,586,453.8</td>
</tr>
<tr>
<td>Total</td>
<td>94,464,929.9</td>
</tr>
</tbody>
</table>

(Acre feet lifted by months)

<table>
<thead>
<tr>
<th>Month</th>
<th>Acre Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>266,098.8</td>
</tr>
<tr>
<td>February</td>
<td>266,098.8</td>
</tr>
<tr>
<td>March</td>
<td>266,098.8</td>
</tr>
<tr>
<td>April</td>
<td>266,098.8</td>
</tr>
<tr>
<td>May</td>
<td>21,287.7</td>
</tr>
<tr>
<td>June</td>
<td>266,098.8</td>
</tr>
<tr>
<td>July</td>
<td>266,098.8</td>
</tr>
<tr>
<td>August</td>
<td>79,829.9</td>
</tr>
<tr>
<td>September</td>
<td>266,098.8</td>
</tr>
<tr>
<td>October</td>
<td>18,626.5</td>
</tr>
<tr>
<td>November</td>
<td>266,098.8</td>
</tr>
<tr>
<td>December</td>
<td>266,094.4</td>
</tr>
</tbody>
</table>

Total (A.F.) 266,094.4

Reg. May 28, 1975
Second Month

First Month

Yearly depletion: 26,560,941

South Platte: Summary of water supplied by pumps, in the main valley. June, January, December.

South Platte of residue. Unit is acre-feet. Residue factor. 1,900,000 + I

Monthly depletion: 26,560,941

Residue (AFmd) 10,395.579

Check total depletion should be identical years of pump operation.

12,183,971 + I

12,183,971 + I

4,579 + I

12,183,971 + I
Note. Restore to compulsion of Aug 15 1969.

Robert E. Clover
1936 So. Lincoln
Denver, Colorado 80210
South Platte
Estimated stream depletion
by pumps. Units are acre feet
for the month.

January.
0.000 + T
0.000 + T
0.000 + T
0.000 + T
21.288 + T
0.000 + T
0.000 + T
0.000 + T
0.000 + T
21.288 + T
31.932 + T
61.203 + T
79.830 + T
53.220 + T
18.627 + T
0.000 + T
0.000 + T
0.000 + T
0.000 + T
0.000 + T
18.627 + T
54.067 =
1007.106 T

June.
31.932 + T
61.203 + T
79.830 + T
53.220 + T
18.627 + T
0.000 + T
0.000 + T
0.000 + T
0.000 + T
0.000 + T
0.000 + T

December.

December.
532200 + T
532200 =
2.000 =
TR

Check (O.K.)
266100 T

South Platte
Computation of depletion due
to pumping for the month of
June.

0.000 + T
3.193 2 x
179.084 =
5718.510 T
5718.510 + T
21.288 x
151.717 =
3229.751 T

0.000 + T
3229.751 + T
0.000 + T
0.000 + T
0.000 + T
0.000 + T
0.000 + T
0.000 + T
18.627 x
54.067 =
1007.106 T

0.000 + T
1007.106 + T
532200 x
49536 =
2636305 T

0.000 + T
2636305 + T
79.830 x
45376 =
3622366 T

0.000 + T
3622366 + T
61.203 x
41574 =
2544453 T

Sub total.
18758491 T

0.000 + T
41574 + T
45376 + T
49536 + T
54067 + T
59152 + T
64903 + T
71595 + T
79758 + T
98706 + T
107953 + T
151717 + T
179084 + T

South Platte
Sums of factors for a 5 year
period when the years are
identical.

0.000 + T
41574 + T
45376 + T
49536 + T
54067 + T
59152 + T
64903 + T
71595 + T
79758 + T
98706 + T
107953 + T
151717 + T
179084 + T

Check (O.K.)
.995421 T

Subtotal.
18758491 T

Residue (A/F)
101539 + T

Depletion (A/F)
18860030 T

A<F for 1sec for 1 month: 60,330 =
27380 T

Depletion (A/F) 312614 T

R.O.S. Nov 28 1975
Check of the estimated depletion rate due to pumping in the South Platte valley against the performance of the river.

<table>
<thead>
<tr>
<th>Description</th>
<th>Period 1926-1930</th>
<th>Period 1961-1965</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average flow at Julesburg for the years</td>
<td>326200</td>
<td>354074</td>
</tr>
<tr>
<td>Transmountain and transbasin diversions</td>
<td>540001</td>
<td>540001</td>
</tr>
<tr>
<td>Estimated depletion of the South Platte by pumps</td>
<td>266080</td>
<td>360193</td>
</tr>
<tr>
<td>Estimated average flow of the South Platte at Julesburg for the period</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average observed flow of the South Platte at Julesburg for the period</td>
<td>333120</td>
<td></td>
</tr>
</tbody>
</table>

Quantities are in Acre Foot per Year units. Subtracted quantities are shown in red. Dates shown are inclusive. The periods 1926-1930 and 1961-1965 are five year periods.
South Platte.
Restoration flow estimate
for July: 0.000 T I
A.F. for July: 10,200.4
(A/F/mo) for 1 (ft³/see): 60.330 = 4230 TR
(ft³/see) for July: 169.7

Will suffice for priorities to 1881 if first call
date is 1880.
South Platte river at Kersey - 1970.
SOUTH PLATTE SURFACE PRIORITIES.
STREAM DEPLETION AND RESTORATION FLOW PATTERNS.

Diversions to irrigation pattern.

Stream depletion.

Gross Restoration.

Net Restoration. 60250.

July, Aug, Sept. 28270.

Acres feet per month.

JANUARY JUNE DECEMBER
STREAM DEPLETION AND RESTORATION FLOW PATTERNS.

Diversions to irrigation pattern.

Stream depletion.

2,661,000 (AF/yr)

Gross Restoration.

112,000 (AF/yr)

Net Restoration. 60,250.

Diversions to irrigation pattern.

Jul 3, 1974

Acres feet per month.
Test against the historic performance of the river.
(a) River is the final arbiter.
(b) Precedents, Newton 1666.
(c) Reason for adopting the procedure of computing first and testing afterward. Test difficulties.

(d) Kessey to Julesburg reach
   (1) Flow at Kessey
   (2) Diversion
   (3) Precipitation
   (4) Consumptive use
   (5) Area
   (6) Pumping
   (7) Return flows.

(e) Computed and observed flow at Julesburg 1957.

<table>
<thead>
<tr>
<th>Time</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>2:56</td>
<td></td>
</tr>
<tr>
<td>3:00</td>
<td></td>
</tr>
</tbody>
</table>
Attempted correlation of the Kersey—Judsonburg flows on the basis of surface flows only.
(a) Proof that the surface and ground waters of the South Platte Valley are one water supply.
ESTIMATED FLOW AT JULESBURG.

OBSERVED FLOW AT JULESBURG.

1957.
Observed flow at Julesburg

Flow at Kersey - diversions for irrigation - diversions to storage.
Effect of width variations on return flows.

Idealization (1).

4 Miles. (Valley width.)

River 1

140 Miles.

For \( \alpha = 1.50 \) ft\(^2\)/sec. \( L = 21120 \) ft (4 Miles). \( T = 31536000 \) seconds (1 year).

\[
\sqrt{\frac{4\alpha T}{L}} = \sqrt{\frac{(4)(1.5)(31536000)}{21120}} = \frac{1375.5}{21120} = 0.651
\]

From Fig 4 of "The Pumped Well" bulletin \( \frac{a}{A} = 0.260 \)

Idealization (2).

2 Miles.

6 Miles. River 1

70 Miles.

For the 2 Mile width. \( L = 10560 \) feet.

\[
\sqrt{\frac{4\alpha T}{L}} = \sqrt{\frac{(4)(1.5)(31536000)}{10560}} = \frac{1375.5}{10560} = 1.302
\]

From Fig 4: \( \frac{a}{A} = 0.580 \)

For the 6 Mile width: \( L = 31680 \) feet.

\[
\sqrt{\frac{4\alpha T}{L}} = \sqrt{\frac{(4)(1.5)(31536000)}{31680}} = 0.434
\]

From Fig 4: \( \frac{a}{A} = 0.175 \)

For the whole area:

\[
\frac{a}{A} = \frac{(0.580)(2)(70) + (0.175)(6)(70)}{(2)(70) + (6)(70)} = 0.276
\]

Return flow.

Infiltration.

Mean.

0.260 or 0.276

1 year.

REC 9/22/70
River valley 4 miles wide.

\( \alpha = 1.50 \ \text{ft}^3/\text{sec} \)

Effect of the position of the river in the valley on the amplitude of the seasonal variation of return flow or depletion.

Distance of the river from the middle of the valley - miles

Average rate of return flow or depletion.

Amplitude of seasonal fluctuation
Computation of a set of factors of the river is not in the middle of the valley and the valley is not of uniform width.

(a) Method of computation:

1. Divide valley into two widths at the river.
2. Compute both sides and compute a p-function for each.
3. From the p-function compute a set of factors for each part.
4. Do this for as many reaches as needed.
5. Make up a composite set of factors.

(b) Example of such a computation for the South Platte

1. Computation of stream depletion for one part and two-part aquifers.
Evaluation of the effectiveness of the provisions of section 148-21-17

Faulty case provision 148-21-3f

formula \[ \frac{Q^2}{2L} = (1 - f) \]
on page 126 Formula 8-35

choices:
(a) Shut down all pumps and adjusting surface diverted
(b) Shut down enough pumps to ultimately meet the required amount of water back in the river ( Corps de
(c) Involve the "faulty case provision" - No relief for same

South Platte
River restoration due to shutting down all wells in the main valley.

\[ Q = 0.000 \times 1 \]

Afl. lifted in 1 year 798294.1
Entr. for August 0300 =
Afl. lifted in August 239488.4

\[ \frac{798294.1}{239488.4} \]

\( \frac{798294.1}{239488.4} \) = \( \frac{60330}{38230} \)

\( \frac{60330}{38230} \) = \( \frac{3969.9}{13.23} \)

Fraction returned at 7 da 0.34
\( \frac{0.34}{13.23} \) restored to the river 13.4

Question 2

9.95

(End)
Estimate of river flow restoration due to shutting down 100\( (\text{ft}^3/\text{sec}) \) of pumpage distributed uniformly over the South Platte Valley, here considered to be 4 miles wide, with the river in the middle. \( \Delta C = 1.50 (\text{ft}^2/\text{sec}) \). The shutdown is assumed to be made August first.

For 1 day \( \left( \frac{\Delta C t}{L^2} \right) = \frac{(1.50) (86400)}{21120^2} = 0.000290 \)

The river depletion is given by Maasland's idealization as:

\[
\frac{a_2}{iL} = (1 - p) \quad \left( \frac{100}{3} \right) = 33.333 \quad \text{Amount consumed.}
\]

<table>
<thead>
<tr>
<th>Days</th>
<th>( \left( \frac{\Delta C t}{L^2} \right) )</th>
<th>( p )</th>
<th>Restoration flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>1.000</td>
<td>0 (\text{ft}^3/\text{sec})</td>
</tr>
<tr>
<td>1</td>
<td>0.000290</td>
<td>0.961</td>
<td>1.3</td>
</tr>
<tr>
<td>2</td>
<td>0.000580</td>
<td>0.945</td>
<td>1.8</td>
</tr>
<tr>
<td>3</td>
<td>0.000870</td>
<td>0.932</td>
<td>2.3</td>
</tr>
<tr>
<td>4</td>
<td>0.001160</td>
<td>0.922</td>
<td>2.6</td>
</tr>
<tr>
<td>5</td>
<td>0.001450</td>
<td>0.916</td>
<td>2.8</td>
</tr>
<tr>
<td>6</td>
<td>0.001740</td>
<td>0.907</td>
<td>3.1</td>
</tr>
<tr>
<td>7</td>
<td>0.002030</td>
<td>0.899</td>
<td>3.4</td>
</tr>
<tr>
<td>8</td>
<td>0.002320</td>
<td>0.892</td>
<td>3.6</td>
</tr>
<tr>
<td>9</td>
<td>0.002610</td>
<td>0.885</td>
<td>3.8</td>
</tr>
<tr>
<td>10</td>
<td>0.002900</td>
<td>0.878</td>
<td>4.1</td>
</tr>
<tr>
<td>11</td>
<td>0.003190</td>
<td>0.872</td>
<td>4.3</td>
</tr>
<tr>
<td>12</td>
<td>0.003480</td>
<td>0.866</td>
<td>4.5</td>
</tr>
<tr>
<td>13</td>
<td>0.003770</td>
<td>0.861</td>
<td>4.6</td>
</tr>
<tr>
<td>14</td>
<td>0.004060</td>
<td>0.855</td>
<td>4.8</td>
</tr>
<tr>
<td>15</td>
<td>0.004350</td>
<td>0.850</td>
<td>5.0</td>
</tr>
<tr>
<td>20</td>
<td>0.005800</td>
<td>0.8281</td>
<td>5.7</td>
</tr>
<tr>
<td>30</td>
<td>0.008700</td>
<td>0.7895</td>
<td>7.017</td>
</tr>
</tbody>
</table>

Note: Checked by an independent computation.
Consumptive use pattern.
Adapted from Munson.

Total 2.0 ft.
South Platte Valley.
Kersey to Julesburg.
Pumping pattern.

Courtesy of Region-7.
U.S. Bureau of Reclamation.

Total: 100.
Precipitation at Ft Morgan, Colorado.
Precipitation at Fort Morgan - Colorado

Total. 1.072 Feet.
Performance of the river below Kersey.

\[ J = K \left[ 1 + \frac{2}{3} + \frac{4}{9} + \cdots \right] \]

\[ K = \frac{500000}{AF/yr} \]

\[ K \left[ \frac{12}{3} \right] = 830000 \text{ A.F.Yr} \]

\[ K \left[ \frac{47}{1} \right] = \frac{222000}{1052000} \text{ A.F.Yr} \]

Consumptive use of irrigation water

Kersey flow: 500000 AF/yr
Vallesburg flow: 200000 AF/yr
Difference (considered): 200000 AF/yr

Consumption of irrigation water:

\[ \frac{200000}{235000} = 0.8 \text{ A.F/Year} \]

Digital computer computation of stream depletion.
SOUTH PLATTE

Depletion due to pumping

Two part aquifer

266100. (AF/Yr)

Depletion due to restoration of flow by pumping into canals.

88700. (AF/Yr)

Aug 7, 1972
Sent to Sunada. Apr 3 1975

1) Parallel flow mathematics - original
2) Part remaining derivation - original
3) Computation of return flow factors. When the drainable volume reaches the water table at the middle of the month, original
4) Factors for determining return flows or pump depletion - page of explanation - page of factors.
5) Comparison for 12 months. Water applied at the middle of the month, at the end of the first and third weeks and continuously.
6) Three pages of computations of stream depletion for the South Platte. Yearly total and monthly values along.
7) Graph - Electric power used for pumping in the South Platte Valley - original
8) South Platte River at Kersey -1970 - original
9) Graph - Stream Depletion and Restoration Flow Patterns.
10) Graph - Comparison of estimated and observed Yuleeburg flows - 1957 - original
11) Estimate of river flow restoration due to shutting down 100 (ft³/s) of pumpage distributed uniformly over the South Platte Valley. - original.

NEG Apr 3, 1975