# SHEYENNE RIVER, NORTH DAKOTA

# BALDHILL CREEK

# BHC-15

# DAMSITE ANALYSIS

14 JUNE 1986

**Sheyenne River, North Dakota**

**Baldhill Creek: BHC-15**

**Damsite Analysis**

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## INTRODUCTION

The North Dakota State Water Commission (NDSWC) requested that the flood control effects of a dam proposed for construction on Baldhill Creek be studied. This site has been identified as BHC-15. Figure 1 shows its location.

Baldhill Creek is a tributary of the Sheyenne River, entering the Sheyenne in Lake Ashtabula, the reservoir impounded by Baldhill Dam. Baldhill Dam was constructed in 1950 and is operated for the dual purposes of water supply and flood control. The flood control storage is obtained by drawing down the water supply pool during the winter months in anticipation of spring snowmelt runoff refilling the water supply storage. In 1984 the St. Paul District recommended that the flood control pool at Baldhill Dam be raised by 5 feet to provide more storage that would be available exclusively for flood control. The raise of the flood control pool would require the acquisition of additional property and flowage easements around and upstream of Lake Ashtabula. Concern of potentially affected property owners has prompted the evaluation of other flood control measures as alternatives to the proposed raise of the flood control pool.

This present report addresses the effectiveness that a dam on Baldhill Creek would have on reducing flooding downstream of Baldhill Dam in comparison to raises of the flood control pool at Baldhill Dam.

Also requested and included in this report is a review of the Baldhill Creek Watershed Report done by Moore Engineering for the Upper Sheyenne Joint Water Resource Board, dated January 1985.

DAMSITE LOCATION MAP

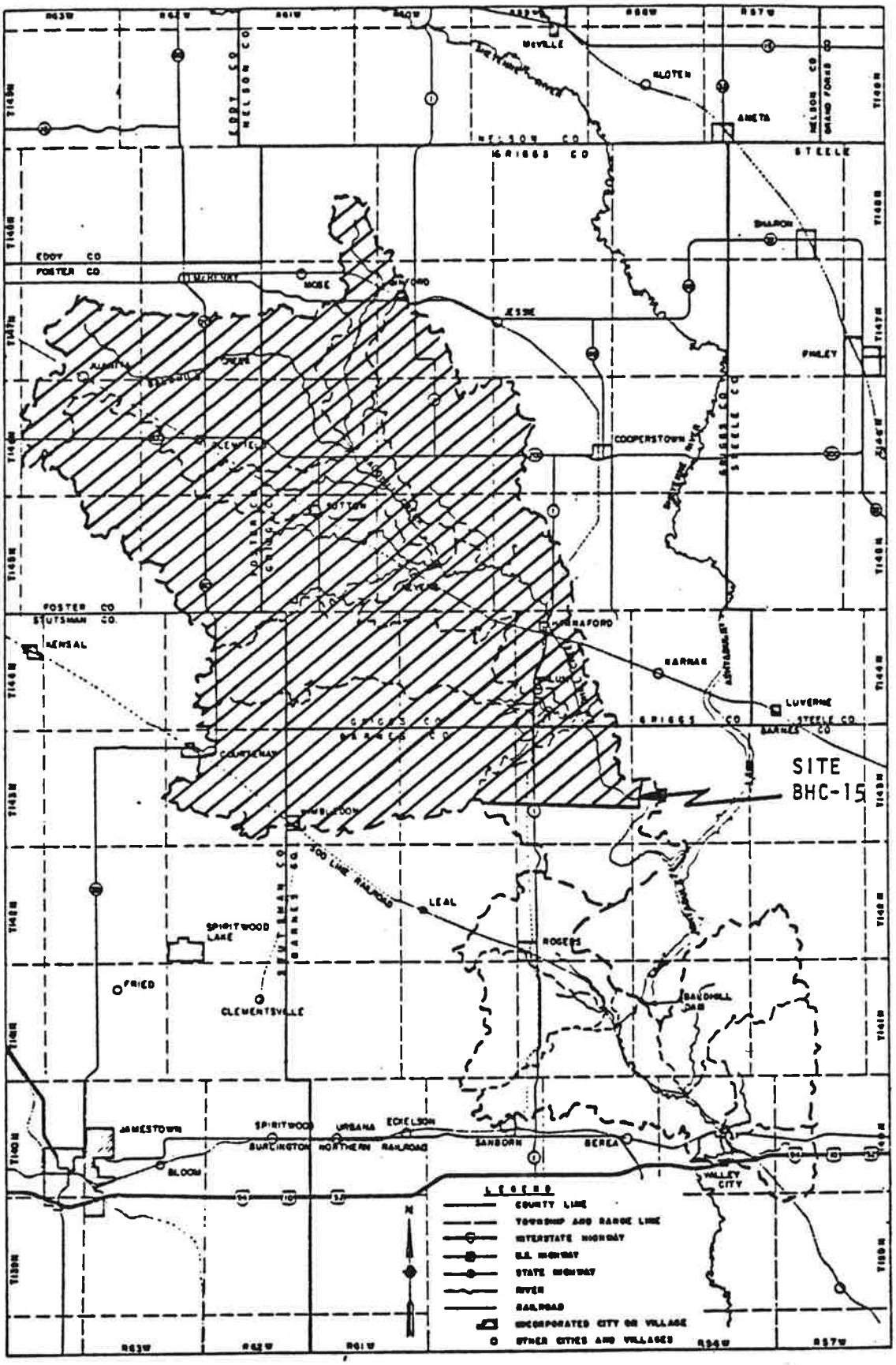


FIGURE 1

(After Moore Engineering Report)

Various combinations of flood control pool raises at Baldhill Dam with the proposed Baldhill Creek Dam were evaluated for flood control effectiveness.

## FLOOD REDUCTION PLANS

Plan 1 - Existing Baldhill Dam with Existing Baldhill Creek
Plan 2 - Existing Baldhill Dam with Baldhill Creek Dam
Plan 3 - Baldhill Dam Flood Control Pool Raised 2.3 feet with Existing Baldhill Creek
Plan 4 - Baldhill Dam Flood Control Pool Raised 2.3 feet with Baldhill Creek Dam
Plan 5 - Baldhill Dam Flood Control Pool Raised 5.0 feet with Existing Baldhill Creek
Plan 6 - Baldhill Dam Flood Control Pool Raised 5.0 feet with Baldhill Creek Dam

Plan 1 was developed so that it is possible to compare an existing conditions model with the various modified conditions models. Since it is not possible to match the gaged flows exactly when developing a computer model, an expected discrepancy is inherently present in all models. Creation of this first model, therefore, allows a better basis for comparison because this same modeling discrepancy is then consistently present throughout.

A number of pool raises of Baldhill Dam, alone and in combination with the proposed Baldhill Creek Dam, have been included in this analysis to give a wider range of alternatives to compare with Plan 2.

## METHODOLOGY

It was requested that the 1969, the 1979, and the 1-percent exceedence frequency flood events be analyzed to assess the benefits of a dam on Baldhill Creek. The HEC-5 computer model was selected for this evaluation because of its capability to model several independent reservoir operations based on the given flood control storage available. This is required since the peak flow from Baldhill Creek tends to occur before the peak on the main stem of the Sheyenne River above Cooperstown.

The capability to modify flows as conditions change downstream requires that the proposed Baldhill Creek Dam have a gated outlet structure. This will increase the cost of the dam, but should also increase economic benefits received from the proposed dam through greater flood damage reduction capabilities.

The reduction of flows for each plan was assessed at three locations below Baldhill Dam - Valley City, Lisbon, and Kindred. Since Valley City is the major damage center below the dam, the greatest benefits from any plan would occur in this area. The other two cities were included in this analysis to ensure that there would be no increase in damages farther downstream as a result of the proposed changes associated with each plan.

Existing Baldhill Dam - Dam Safety: The existing spillway capacity of Baldhill Dam is not large enough to pass the spillway design flood as determined by current criteria. The current spillway capacity is about 43,100 cubic feet per second (cfs); the current spillway design criteria require a capacity of about 126,000 cfs. Modifications to the spillway to increase the capacity and prevent overtopping of the dam are being considered and undertaken through the Corps dam safety program. These dam safety modifications would not change the flood control storage or operation of the Baldhill Dam. However, the dam safety modifications would be accomplished so as not to preclude subsequent changes in the operation or flood control pool.

## EXISTING FREQUENCY DATA

For this study, the frequency data for existing conditions from the "General Reevaluation and Environmental Impact Statement for Flood Control and Related Purposes, Sheyenne River, North Dakota," dated August 1982 were used. This allowed easier comparison of this present analysis with past work done on B-ldhill Dam. Table 1 provides the frequency data for existing conditions at various points of interest for this study.

Volume data has also been developed to match that data given in the 1982 report. Data from the 1982 report was unavailable for the gaging stations at Cooperstown and Dazey, North Dakota. Therefore, volume data from WATSTORE with the peak and 1-day frequency curve data from the 1982 report in the Regional Frequency Computer Program was used to develop this information. The volume frequency statistics were adjusted at Dazey (shorter record station) based on the two station comparison method.

TABLE 1, EXISTING FREQUENCY DATA, DISCHARGE IN CFS

COOPERSTOWN

| EXCEEDENCE FREQUENCY IN PERCENT | PEAK | 1-DAY | 3-DAY | 7-DAY | 15-DAY | 30-DAY |
|---|---|---|---|---|---|---|
| 0.2 | 20000 | 18000 | 17000 | 14800 | 11500 | 7480 |
| 0.5 | 14500 | 13200 | 12600 | 11000 | 8600 | 5670 |
| 1.0 | 11100 | 10300 | 9790 | 8620 | 6770 | 4510 |
| 2.0 | 8300 | 7800 | 7460 | 6590 | 5210 | 3510 |
| 5.0 | 6950 | 5140 | 4940 | 4390 | 3500 | 2390 |
| 10.0 | 3690 | 3550 | 3410 | 3040 | 2450 | 1700 |

BALDHILL CREEK AT DAZEY

| EVENT | PEAK | 1-DAY | 3-DAY | 7-DAY | 15-DAY | 30-DAY |
|---|---|---|---|---|---|---|
| 0.2% | 23500 | 15800 | 10500 | 7310 | 4450 | 2430 |
| 0.5% | 14500 | 10200 | 6980 | 4940 | 3070 | 1710 |
| 1.0% | 9790 | 7160 | 4980 | 3570 | 2250 | 1280 |
| 2.0% | 6440 | 4840 | 3440 | 2500 | 1600 | 931 |
| 5.0% | 3440 | 2700 | 1970 | 1450 | 955 | 572 |
| 10.0% | 2020 | 1590 | 1190 | 892 | 599 | 368 |
| 1969 | ---- | 2260 | 1943 | 1340 | --- | --- |
| x1.6 | ---- | 3616 | 3109 | 2149 | --- | --- |
| x2.0 | ---- | 4520 | 3886 | 2680 | --- | --- |
| 1979 | ---- | 4500 | 3483 | 2324 | --- | --- |
| x1.6 | ---- | 7200 | 5573 | 3718 | --- | --- |
| x2.0 | ---- | 9000 | 6966 | 4648 | --- | --- |

BALDHILL DAM INFLOW

| EVENT | 1-DAY | 3-DAY | 10-DAY | 30-DAY |
|---|---|---|---|---|
| 0.2% | 16800 | 16200 | 13500 | 8900 |
| 0.5% | 13000 | 12800 | 10400 | 6800 |
| 1.0% | 10400 | 10200 | 8380 | 5480 |
| 2.0% | 8180 | 7920 | 6490 | 4270 |
| 5.0% | 5700 | 5380 | 4430 | 2930 |
| 10.0% | 4080 | 3810 | 3140 | 2090 |
| 1969 | 5275 | ---- | 4645 | 2682 |
| x1.6 | 8440 | ---- | 7432 | 4291 |
| x2.0 | 10550 | ---- | 9289 | 5364 |
| 1979 | 9284 | ---- | 5686 | 3274 |
| x1.6 | 14854 | ---- | 9098 | 5238 |
| x2.0 | 18568 | ---- | 11372 | 6548 |

VALLEY CITY

| EXCEEDENCE FREQUENCY IN PERCENT | FIS | Pn existing PEAK | Pn existing M.D. | Pn natural PEAK | Pn natural M.D. |
|---|---|---|---|---|---|
| 0.2 | 18000 | 18100 | 16800 | 18100 | 16800 |
| 1.0 | 9400 | 9400 | 9000 | 10900 | 10400 |
| 2.0 | 5400 | 5400 | 5200 | 8520 | 8180 |
| 10.0 | 3200 | 3220 | 3200 | 4170 | 4080 |

## 1-PERCENT FLOOD EVENT

To determine the 1-percent event for the inflow to Baldhill Dam, it would be necessary to do a period of record routing or a coincidental frequency analysis of the flows from Baldhill Creek, the area above Cooperstown, and the local area at Baldhill Dam. Since this was beyond the level of detail of the present study, the 1-percent flood event was estimated by using a ratio of historic events. Ratios of 1.6 and 2.0 were applied to both the 1969 and the 1979 flood events.

To obtain the 1-percent reduction in flow for Plans 2 through 6, the peak flows from each of these plans were plotted against the peak flows obtained from Plan 1 at Valley City. Curves were plotted which represent the effects of each plan as compared to Plan 1. These curves, when used with the existing frequency curve at Valley City, can estimate the modified frequency curve at Valley City for each plan.

## OPERATING PLAN

In order to evaluate the effectiveness of the various flood control alternatives using the HEC-5 computer model, operating plans were assumed for Baldhill Dam and the proposed dam on Baldhill Creek. A description of these plans follows.

### BALDHILL DAM

The operating plan for the existing Baldhill Dam was used for Plan 1 and Plan 2. Plans 3 through 6 were modeled with the operating plan for the Baldhill Dam that was proposed as part of the 5-foot pool raise for the dam. In general, this plan would function in the following manner.

1. For smaller flood events, outflows from the dam would be limited so that the first peak downstream would not exceed 2,400 cfs at Valley City. This would allow time for levees to be constructed at Valley City if required.

2. For larger flood events, flows would be released early to allow the first peak downstream to be at or below the peak which would have occurred under existing conditions. The expected runoff from the area above Baldhill Dam would be used to determine the discharge required to pass this flow while maintaining the maximum pool within the Baldhill Dam reservoir (Lake Ashtabula).

## PROPOSED BALDHILL CREEK DAM

For each plan, the proposed Baldhill Creek Dam was operated to maximize the operation of Baldhill Dam by reducing t. Baldhill Creek flows with the available storage in the proposed Baldhill Creek Dam.

## MODEL RESULTS

Using HEC-5, Plans 1 through 6 were run with the 1969 and the 1979 flood events. The two ratios were also applied to each flood event for the six plans. Table 2 contains the peak flows from each of the plans at the three selected locations downstream of Baldhill Dam.

From the tables it can be seen that the results from Plan 2 are similar to the results that would be obtained by implementing Plan 3. The flows from Plans 4 and 5 were also close to each other. Based on this information, the following general statements can be made.

1. Baldhill Creek Dam is equivalent to about a 2.3-foot raise of the flood control pool at Baldhill Dam.

2. Baldhill Creek Dam plus a 2.3-foot raise of the flood control pool at Baldhill Dam is equivalent to about a 5.0-foot raise of the flood pool elevation at Baldhill Dam.

TABLE 2. PEAK FLOWS FROM HEC-5 MODELS

PLAN 1: BALDHILL DAM / BALDHILL CREEK

| EVENT | COOP. | BHC | BHDIN | BHDOU | VALLEY CITY 1st | VALLEY CITY 2nd | LISBON 1st | LISBON 2nd | KINDRED 1st | KINDRED 2nd |
|---|---|---|---|---|---|---|---|---|---|---|
| 1969 | 4890 | 2260 | 5275 | 4765 | 1415 | 4696 | 3925 | 4565 | 4553 | 4493 |
| 69x1.6 | 7824 | 3616 | 8440 | 7932 | 2144 | 7754 | 7074 | 7534 | 8004 | 7379 |
| 69x2.0 | 9780 | 4520 | 10550 | 10126 | ---- | 9986 | 9267 | 9642 | 10323 | 9468 |
| 1979 | 4350 | 4500 | 9284 | 4552 | 2085 | 4500 | 2467 | 4454 | 3926 | 4422 |
| 79x1.6 | 6960 | 7200 | 14855 | 11075 | 2856 | 10045 | 3567 | 8800 | 5801 | 8410 |
| 79x2.0 | 8700 | 9000 | 18570 | 15440 | 3602 | 13910 | 4465 | 11843 | 7251 | 11125 |

PLAN 2: EXISTING BALDHILL DAM FLOOD CONTROL POOL
WITH PROPOSED BALDHILL CREEK DAM

| EVENT | COOP. | BHC | BHDIN | BHDOU | VALLEY CITY 1st | VALLEY CITY 2nd | LISBON 1st | LISBON 2nd | KINDRED 1st | KINDRED 2nd |
|---|---|---|---|---|---|---|---|---|---|---|
| 1969 | 4890 | 230 | 4884 | 4247 | 1415 | 4183 | 3912 | 4066 | 4505 | 4006 |
| 69x1.6 | 7824 | 2000 | 7914 | 7202 | 2144 | 7008 | 6858 | 6733 | 7804 | 6591 |
| 69x2.0 | 9780 | 3000 | 10356 | 9803 | 2680 | 9491 | 9018 | 9066 | 10081 | 8895 |
| 1979 | 4350 | 1008 | 6421 | 3687 | 2085 | 4070 | 2458 | 4074 | 3926 | 4047 |
| 79x1.6 | 6960 | 4000 | 11831 | 7852 | 3033 | 7511 | 3636 | 7040 | 5801 | 6826 |
| 79x2.0 | 8700 | 5000 | 15089 | 11741 | 4023 | 10769 | 4648 | 9760 | 7252 | 9307 |

TABLE 2 (cont.), PEAK FLOWS FROM HEC-5 MODELS

PLAN 3: BALDHILL DAM FLOOD CONTROL POOL RAISED 2.3 FEET

| | | | | | VALLEY CITY | | LISBON | | KINDRED | |
|---|---|---|---|---|---|---|---|---|---|---|
| EVENT | COOP. | BHC | BHDIN | BHDOU | 1st | 2nd | 1st | 2nd | 1st | 2nd |
| 1969 | 4890 | 2260 | 5275 | 4213 | 1340 | 4134 | 4006 | 4003 | 4606 | 3934 |
| 69x1.6 | 7824 | 3616 | 8440 | 7225 | 2158 | 7100 | 6846 | 6909 | 7813 | 6802 |
| 69x2.0 | 9780 | 4520 | 10550 | 8211 | 2708 | 8253 | 9142 | 8263 | 10281 | 8292 |
| 1979 | 4350 | 4500 | 9284 | 3962 | 1936 | 4260 | 2320 | 4215 | 3905 | 4192 |
| 79x1.6 | 6960 | 7200 | 14855 | 6738 | ---- | 6934 | 4198 | 6866 | 5843 | 6834 |
| 79x2.0 | 8700 | 9000 | 18570 | 11196 | 3707 | 10934 | 4575 | 10451 | 7259 | 10283 |

PLAN 4: BALDHILL DAM FLOOD CONTROL POOL RAISED 2.3 FEET
WITH PROPOSED BALDHILL CREEK DAM

| | | | | | VALLEY CITY | | LISBON | | KINDRED | |
|---|---|---|---|---|---|---|---|---|---|---|
| EVENT | COOP. | BHC | BHDIN | BHDOU | 1st | 2nd | 1st | 2nd | 1st | 2nd |
| 1969 | 4890 | 660 | 5292 | 2858 | 1344 | 2794 | 3885 | 2745 | 4513 | 2864 |
| 69x1.6 | 7824 | 1621 | 8600 | 5680 | 2213 | 5688 | 6614 | 5682 | 7605 | 5793 |
| 69x2.0 | 9780 | 2000 | 10248 | 8444 | 2794 | 8329 | 8424 | 8163 | 9613 | 8114 |
| 1979 | 4350 | 1009 | 6421 | 3002 | 1999 | 3521 | 2355 | 3474 | 3871 | 3450 |
| 79x1.6 | 6960 | 4700 | 12758 | 6318 | 3046 | 6624 | 3615 | 6610 | 5824 | 6548 |
| 79x2.0 | 8700 | 6000 | 16239 | 7794 | ---- | 8234 | 5360 | 8239 | 7286 | 8155 |

TABLE 2 (cont.), PEAK FLOWS FROM HEC-5 MODELS

PLAN 5: BALDHILL DAM FLOOD CONTROL POOL RAISED 5.0 FEET

| EVENT | COOP. | BHC | BHDIN | BHDOU | VALLEY CITY 1st | VALLEY CITY 2nd | LISBON 1st | LISBON 2nd | KINDRED 1st | KINDRED 2nd |
|---|---|---|---|---|---|---|---|---|---|---|
| 1969 | 4890 | 2260 | 5275 | 2500 | 1354 | 2553 | 3943 | 2566 | 4576 | 2700 |
| 69x1.6 | 7824 | 3616 | 8440 | 5400 | 2202 | 5491 | 7037 | 5513 | 7962 | 5652 |
| 69x2.0 | 9780 | 4520 | 10550 | 8517 | 2852 | 8433 | 8630 | 8304 | 9827 | 8269 |
| 1979 | 4350 | 4500 | 9284 | 3000 | ---- | 3520 | 2427 | 3485 | 3871 | 3469 |
| 79x1.6 | 6960 | 7200 | 14855 | 6500 | 3553 | 6536 | 3994 | 6766 | 5830 | 6717 |
| 79x2.0 | 8700 | 9000 | 18570 | 8488 | ---- | 8356 | 5490 | 8404 | 7296 | 8354 |

PLAN 6: BALDHILL DAM FLOOD CONTROL POOL RAISED 5.0 FEET
WITH PROPOSED BALDHILL CREEK DAM

| EVENT | COOP. | BHC | BHDIN | BHDOU | VALLEY CITY 1st | VALLEY CITY 2nd | LISBON 1st | LISBON 2nd | KINDRED 1st | KINDRED 2nd |
|---|---|---|---|---|---|---|---|---|---|---|
| 1969 | 4890 | 679 | 5431 | 2323 | 1354 | 2341 | 3851 | 2358 | 4459 | 2515 |
| 69x1.6 | 7824 | 2000 | 7815 | 4928 | 2144 | 4935 | 6639 | 4939 | 7612 | 5131 |
| 69x2.0 | 9780 | 2000 | 11100 | 6748 | 2993 | 6715 | 9040 | 6688 | 10150 | 6782 |
| 1979 | 4350 | 1009 | 6421 | 2600 | 1847 | 3120 | 2229 | 3110 | 3871 | 3079 |
| 79x1.6 | 6960 | 4000 | 12231 | 5451 | 2906 | 5962 | 3573 | 5929 | 5801 | 5893 |
| 79x2.0 | 8700 | 6000 | 16239 | 7885 | ---- | 8257 | 5367 | 8144 | 7280 | 8000 |

Using the discharge-discharge plots for the 1-percent flood event, the following results were obtained at Valley City:

| | | |
|---|---|---|
| 1. | Plan 1 (existing conditions) | 9,400 cfs |
| 2. | Plan 2/Plan 3 | 8,100 cfs |
| 3. | Plan 4/Plan 5 | 7,100 cfs |
| 4. | Plan 6 | 6,100 cfs |

## REVIEW OF MOORE ENGINEERING REPORT

The following is a review of the work done by Moore Engineering Inc., West Fargo, North Dakota as contained in the "Baldhill Creek Watershed, Hydrologic Analysis and Floodwater Retention Study for the Upper Sheyenne Joint Water Resource Board," dated January 1985. Only the data contained in the report and the resulting analysis presented therein which was based on this data were reviewed. Reviewed items which are given below have not been arranged into any particular order.

Computer Model Development.

1. Given the characteristics of Baldhill Creek subbasin, hypothetical storms having durations greater than 24 hours should also have been analyzed.

2. The Soil Conservation Service (SCS) Type I Rainfall Distribution was used in the Moore study. With the exception of Minnesota and North Dakota, the remaining States use a Type II Rainfall Distribution. This latter approach would have produced a more critical event than the Type I distribution. The Corps determines synthetic storms using methods that produce results similar to those produced by the Type II SCS distribution method. It is our opinion that the Type II Rainfall Distribution would have been the method of choice for this analysis.

3. There is a gaging station on Baldhill Creek at Dazey, North Dakota. Data from this station should have been used to calibrate subbasin characteristics. (Table 3 lists the peak flows from the HEC-1 model for a 24-hour rainfall event at location BHC-021 which is just upstream of the Dazey gaging station.)

Table 3, Peak Discharge from 24-hour Rainfall Upstream of the Dazey Gaging Station for Selected Frequencies

| Gaging Station | Frequency of Discharge - Years | | | |
|---|---|---|---|---|
| | 10 | 25 | 50 | 100 |
| Baldhill Creek | 5,426 | 7,707 | 10,297 | 13,476 |

Existing Gaging Station Data.

A Log Pearson Type III frequency analysis was done for 4 gaging stations in the study area. The gages are: Baldhill Creek near Dazey, and the Sheyenne River near Cooperstown, below Baldhill Dam, and at Valley City.

Table 4 shows the results obtained in the Moore Engineering Report from the Log-Pearson Type III Frequency Analysis. For comparison, table 5 contains the Corps frequency data for peak flows at the same locations. There are differences between the values presented at Dazey and Cooperstown which can be accounted for by the different level of detail and the different period of record used.

Table 4, Log-Pearson Flow Frequency Analysis, Discharge in cfs

| Gaging Station | Years of Record | Frequency of Discharge - years | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 5 | 10 | 25 | 50 | 100 | 500 |
| Baldhill Creek near Dazey | 28 | 7 | 280 | 980 | 1,865 | 3,650 | 5,595 | 8,175 | 17,360 |
| Sheyenne River nr Cooperstown | 38 | 83 | 1,095 | 2,475 | 3,695 | 5,560 | 7,175 | 8,960 | 13,790 |
| Sheyenne River at Valley City | 43 | 111 | 1,075 | 2,160 | 3,040 | 4,290 | 5,310 | 6,390 | 9,120 |

Table 5, Corps Frequency Data for Peak Flows in cfs

| Gaging Station | Years of Record | Frequency of Discharge - years | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 5 | 10 | 25 | 50 | 100 | 500 |
| Baldhill Creek near Dazey | 42* | | | | 2,020 | 3,440 | 6,440 | 9,790 | 23,500 |
| Sheyenne River nr Cooperstown | 42* | | | | 3,690 | 6,950 | 8,300 | 11,100 | 20,000 |
| Sheyenne River at Valley City | 42* FIS | | | | 3,200 | | 5,400 | 9,400 | 18,000 |
| | 42* Pn existing | | | | 3,220 | | 5,400 | 9,400 | 18,100 |
| | 42* Pn natural | | | | 4,170 | | 8,520 | 10,900 | 18,100 |

* Equivalent length of record based on two-station comparison

1. While the Log-Pearson III frequency analysis can be used at Dazey and Cooperstown, it is not applicable for the gaging stations at Baldhill Dam and Valley City according to the "Guidelines For Determining Flood Flow Frequency, Bulletin #17B, revised September 1981, editorial corrections March 1982," pages 2 and 3.

2. The 1979 peak flows at Dazey should have been adjusted according to Bulletin #17B guidelines, since the peak for this year was caused in part by a road failure.

3. During a Flood Insurance Study conducted by the Corps, consideration was given to the method used by Moore Engineering to obtain the 6,390 cfs value at Valley City. This value was rejected in a joint meeting held with the NDSWC on October 16, 1980 in Bismarck, North Dakota.

4. The data for Dazey computed by Moore Engineering using rainfall data and the Log-Pearson method do not agree. Currently in the report, there are two frequency curves at Dazey for the same condition. Given the

available data, the gaged data should have been used to calibrate the HEC-1 model using rainfall.

5. The purpose of the Moore Engineering study was to determine the effects of a dam on Baldhill Creek. Since the volume of flood events should be an important aspect of this analysis, volume-frequency curves should be computed. These were not included in the report.