WATER CONTROL MANUAL

BALDHILL DAM AND LAKE ASHTABULA
RED RIVER OF THE NORTH DRAINAGE BASIN

WATER SUPPLY AND FLOOD CONTROL
SHEYENNE RIVER
VALLEY CITY, NORTH DAKOTA

U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA

SEPTEMBER 2013

Revised from
Baldhill Dam and Lake Ashtabula Reservoir Regulation Manual, March 2007
Baldhill Dam and Lake Ashtabula Reservoir Regulation Manual, March 1981
Baldhill Dam and Lake Ashtabula Reservoir Regulation Manual, September 1975
Baldhill Dam and Lake Ashtabula Reservoir Regulation Manual, October 1952

BALDHILL DAM AND LAKE ASHTABULA

NOTICE TO USERS OF THIS MANUAL

This Water Control Manual complies with the latest US Army Corps of Engineers guidelines regarding management of water control systems and preparation of water control manuals. The manual is published in loose-leaf form to facilitate modifications. In the future, only those sections, or parts thereof, requiring changes will be revised and replaced.

EMERGENCY REGULATION ASSISTANCE PROCEDURES

In the event that unusual conditions arise during normal business hours, contact can be made to Water Control by telephone at 651-290-5619 or fax at 651-290-5841. During non-duty hours, assistance can be obtained by contacting one of the following persons, in the order listed below.

Water Control Regulation Assistance			
Elizabeth A. Nelsen	Hydraulic Engineer elizabeth.a.nelsen@usace.army.mil	Duty: [redacted]	651-290-5306 [redacted]
Brian KE Johnson	Hydraulic Engineer brian.ke.johnson@usace.army.mil	Duty: [redacted]	651-290-5652 [redacted]
Farley R. Haase	Civil Engineering Technician farley.r.haase@usace.army.mil	Duty: [redacted]	651-290-5633 [redacted]
Ferris W. Chamberlin	Chief, Water Control Section ferris.w.chamberlin@usace.army.mil	Duty: [redacted]	651-290-5619 [redacted]
Michael R. Knoff	Chief, Hydraulics & Hydrology Br. michael.r.knoff@usace.army.mil	Duty:	651-290-5602
Michael J. Bart	Chief, Engineering Division michael.j.bart@usace.army.mil	Duty:	651-290-5303

Baldhill Dam and Reservoir
U.S. Army Corps of Engineers
St. Paul District

TABLE OF CONTENTS

TABLES

TABLES – Cont.

FIGURES

EXHIBITS

PLATES

PERTINENT DATA

Location: The impoundment created by Baldhill Dam is located on the Sheyenne River, 271 river miles upstream from the confluence of the Sheyenne River and Red River of the North. The dam site is about 16 river miles upstream of Valley City, North Dakota and about 75 highway miles west of Fargo, North Dakota. **Datum:** 1929 NGVD

Initial Project Purpose:

Municipal Water Supply	38 %
Rural Water Supply	31 %
Pollution Abatement	23 %
Flood Control	8 %

Drainage Area:

Primary	1,690 sq mi
Secondary	1,660 sq mi
Noncontributing	462 sq mi
Devils Lake Basin	3,573 sq mi

Dam:

Type	Compacted Impervious Earth Fill
Total Length	1,650 feet
Crest: Top of Earth Dam	Elevation 1278.5 feet
Top of Tee-Wall	Elevation 1283.5 feet
Top Width of Earth Dam	20 feet
Max Height of Earth Dam	61 feet
Freeboard	5.0 feet above PMF
Emergency Spillway	
Type	Uncontrolled Broad Crest Weir
Length	880 feet
Crest	Elevation 1271.0 feet

Control Structure:

Service Spillway	
Type	Gravity Ogee
Length	140 feet total with two 10-foot piers
Gates	Tainter, 3 @ 40-ft wide, 20-ft high
Crest	Elevation 1252.0 feet
Low Flow Outlet	
Type	Two, 36-inch reinforced concrete conduits
Intake Invert	Elevation 1238.0 feet
Discharge Invert	Elevation 1234.5 feet

Reservoir:	Elevation	Storage	Area
Probable Maximum Flood	1278.5 ft	157,500 ac-ft	8,500 ac
Top of Flood Control	1271.0 ft	101,300 ac-ft	6,750 ac
Conservation Pool	1266.0 ft	70,600 ac-ft	5,500 ac
Normal Drawdown	1262.5 ft	52,250 ac-ft	4,375 ac
Maximum Drawdown	1255.0 ft	25,100 ac-ft	2,620 ac

Pool at Conservation Level

Length: 27 miles Width: 0.6 mile Shoreline Length: 78 miles

I – INTRODUCTION

1-01. Authorization for Preparation of this Manual. The first "Regulation Manual" for the Baldhill Project was prepared in 1952 in compliance with instructions contained within a letter from the Division Engineer, dated 30 August 1928, subject: *Manual of Regulation for Flood Control and Multiple Purpose Reservoir.* In 1958, Engineering Regulation (ER) 1110-2-240, *Reservoir Regulation,* granted the Corps of Engineers the authority to prepare "Reservoir Regulation Manuals" for flood control structures regulated by the Corps of Engineers. While the ER has been updated and amended many times since the date of issuance, the document continues to give the Corps of Engineers authority to prepare "Reservoir Regulation Manuals". "Reg Manuals", as they were called, became known as "Water Control Manuals" by ER 1110-2-240, *Water Control Management*, 1982. This water control manual is an update to the *Reservoir Regulation Manual, Baldhill Dam and Lake Ashtabula,* dated March 1981. As part of the Corps of Engineers' environmental awareness, full consideration was given to ER 200-1-5, *Policy for Implementation and Integrated Application of the US Army Corps of Engineers Environmental Operating Principals* (EOP) *and Doctrine*, dated 30 October 2003. This manual was prepared in compliance with the guidelines presented in:

a. Engineering Regulation ER 1110-2-240, *Water Control Management*, 8 October 1982, amended 30 April 1987 and 1 March 1994.
b. Engineering Manual EM 1110-2-3600, *Management of Water Control System*, 30 November 1987.
c. Division Regulation, DIVR 1110-2-204, *Water Control Management, Reporting Current Conditions*, 5 August 1992.
d. Engineering Regulation ER 1110-2-8156, *Preparation of Water Control Manuals*, 31 August 1995.

1-02. Purpose and Scope. The purpose of this manual is to provide guidance and instruction for project personnel and to serve as a reference source for others who may be involved with the regulation of this project. The manual is for daily use by Water Control and Hydrology Section for most foreseeable conditions and occurrences. The manual covers all water control management activities as they relate to the hydraulic and hydrologic aspects of the project.

1-03. Related Manuals and Reports. Construction of the Baldhill Project began in July 1947. The project was completed in September of 1952. A Reservoir Regulation Manual" was prepared in October 1952. In 1967, the *Master Plan for Resource Management, Baldhill and Lake Ashtabula* was developed. The following is a list of related reports and manuals in chronological order.

a. *Flood Control, Definite Project Report on Baldhill Reservoir*, *Sheyenne River, North Dakota*, US Army Corps of Engineers, St. Paul District, 28 March 1947.
b. *Baldhill Dam and Lake Ashtabula Reservoir Regulation Manual,* US Army Corps of Engineers, St. Paul District, October 1952.
c. *Master Plan for Resource Management, Baldhill Dam and Lake Ashtabula Reservoir*, US Army Corps of Engineers, St. Paul District, March 1967.
d. *Interim Survey Report, Sheyenne River*, *North Dakota, Red River of the North Basin for Flood Control and Related Purposes,* US Army Corps of Engineers, St. Paul District, October 1968.
e. *Environmental Impact Assessment of Baldhill Dam and Lake Ashtabula, North Dakota*, US Army Corps of Engineers, St. Paul District, 1974.
f. *Red River of the North Drainage Basin, Flood Control and Low Flow Augmentation, Baldhill Dam and Lake Ashtabula, Sheyenne River, Reservoir Regulation Manual,* US Army Corps of Engineers, St. Paul District, September 1975.
g. *Negative Declaration and Finding of Fact Concerning the Environmental Aspects of Operation and Maintenance Activities at Baldhill Dam – Lake Ashtabula, North Dakota,* US Army Corps of Engineers, St. Paul District, 1975.
h. *Preliminary Report on Lake Ashtabula, Barnes and Griggs Counties, North Dakota*, Eutrophication Survey for Lake Ashtabula, Environmental Protection Agency Region VIII, 26 May 1976.
i. *Reconnaissance Report for the Dam Safety Assurance Program, Baldhill Dam and Reservoir, Lake Ashtabula, Sheyenne River ND*, US Army Corps of Engineers, St. Paul District. Revised December 1982.
j. *General Design Memorandum, Baldhill Dam and Reservoir, Lake Ashtabula, Sheyenne River ND,* US Army Corps of Engineers, St. Paul District. Revised December 1982.
k. *Alternative Analysis Report,* US Army Corps of Engineers, St. Paul District. February 1986.

l. *Risk Assessment Report and Recommendation Plan for Modifications, Baldhill Dam and Reservoir, Lake Ashtabula, Sheyenne River ND*, US Army Corps of Engineers, St. Paul District. June 1986.
m. *General Design Memorandum and Final Environmental Impact Statement, Dam Safety Assurance Program, Baldhill Dam and Reservoir, Lake Ashtabula, Sheyenne River North Dakota*, US Army Corps of Engineers, St. Paul District. January 1987.
n. *General Design Memorandum and Environmental Assessment, Flood Control, Sheyenne River, North Dakota,* US Army Corps of Engineers, St. Paul District, March 1987.
o. *Value Engineering Report, General Design Memorandum and Final Environmental Impact Statement, Dam Safety Assurance Program, Baldhill Dam and Reservoir, Lake Ashtabula, Sheyenne River ND*, US Army Corps of Engineers, St. Paul District. December 1988.
p. *Supplement 1 to the General Design Memorandum and Environmental Assessment, Dam Safety Assurance Program, Baldhill Dam and Reservoir, Lake Ashtabula, Sheyenne River ND*, US Army Corps of Engineers, St. Paul District. December 1988.
q. *Design Memorandum No. 1, Embankment and Spillway, Rehabilitation of Baldhill Dam and Reservoir, Lake Ashtabula, Sheyenne River, ND,* US Army Corps of Engineers, St. Paul District, October 1990.
r. *Design Memorandum No. 2, Construction Materials, Rehabilitation of Baldhill Dam and Reservoir, Lake Ashtabula, Sheyenne River, ND*, US Army Corps of Engineers, St. Paul District, May 1992.
s. *Value Engineering Study Report, Baldhill Dam Rehabilitation, Sheyenne River ND,* US Army Corps of Engineers, St. Paul District, August 1993.
t. *Plans and Specifications, Stage 1 – Existing Gated Spillway, Rehabilitation of Baldhill Dam, Sheyenne River ND,* US Army Corps of Engineers, St. Paul District, May 1994.
u. *Plans and Specifications, Stage 2 – Ungated Spillway, Rehabilitation of Baldhill Dam, Sheyenne River ND,* US Army Corps of Engineers, St. Paul District, November 1994.
v. *Lake Ashtabula Reservoir, Water Quality Data Report*, US Army Corps of Engineers, St. Paul District, October 1997.
w. *Environmental Assessment, Modifications in Developed Areas, Pool Raise for Flood Control, Lake Ashtabula, Baldhill Dam, North Dakota*, US Army Corps of Engineers, St. Paul District, 1998.
x. *Environmental Assessment, Rock Jetty Construction – Mel Rieman Recreation Area Boat Ramp, Lake Ashtabula/Baldhill Dam,* US Army Corps of Engineers, St. Paul District, 1998.
y. *Estimation of Monthly Evaporation from Lake Ashtabula in North Dakota, Orwell Lake in Minnesota, and Lake Traverse in Minnesota and South Dakota, 1931-2001*, Water-Resources Investigations Report 03-0482, Department of the Interior, US Geological Survey in cooperation with Bureau of Reclamation, Bismarck, North Dakota, Kevin C. Vining, 2003

z. *Policy for Implementation and Integrated Application of the US Army Corps of Engineers (USACE) Environmental Operating Principles (EOP) and Doctrine*, Engineering Regulation (ER) 200-1-5, US Army Corps of Engineers, 30 October 2003.

1-04. Project Owner. The United States Government is the owner of Baldhill Dam. The US Army Corps of Engineers, St. Paul District is responsible for the regulation, operation, and maintenance of the Baldhill Dam and Lake Ashtabula Project.

1-05. Operating Agency. Baldhill Dam and appurtenant structures are operated and maintained by the St. Paul District, Corps of Engineers. Operation and maintenance of the project is the responsibility of Operations Division, Western Flood Control Project Office. The Project Resource Manager and staff are located at the Baldhill Dam and Lake Ashtabula Project Office which is located at the damsite. The Area Resource Manager's office is in Fargo, North Dakota. **Table 1-1** provides the names, addresses and telephone numbers for personnel associated with the Baldhill Dam and Lake Ashtabula Project.

Table 1-1
Baldhill Dam/Lake Ashtabula Project
Project Office Points of Contact

Names and Addresses	Telephone Numbers
Rich Schueneman, Project Resource Manager Baldhill Dam/Lake Ashtabula Project 2630 114th Avenue SE Valley City, ND 59072	Duty: 701-845-2970 Non Duty: 701-845-4934 Cellular: 701-840-2076
Project Fax Number, Baldhill Dam	701-845-0712
Tim Bertschi, Operations Project Manager Western Flood Control Project Office 15 South 21st Street, Room 102 Fargo, North Dakota 58103-1435	Duty: 701-232-1894 Non Duty: 701-232-5967 Cellular: 701-238-1680 Fax 701-232-1789

1-06. Regulating Agency. Regulation of Baldhill Dam and Lake Ashtabula is under the supervision of the Water Control and Hydrology Section, within the Hydraulics and Hydrology Branch, Engineering and Construction Division of the St. Paul District, Corps of Engineers.

II – DESCRIPTION OF PROJECT

2-01. Location. Baldhill Dam, which creates the impoundment of Lake Ashtabula, is located on the Sheyenne River approximately 271 river miles upstream of the confluence with the Red River of the North, and about 16 river miles upstream of the community of Valley City. The project is located within Barnes, Griggs and Steele Counties in east central North Dakota about 75 miles west of Fargo. Lake Ashtabula is about half a mile wide and is 24 miles long as measured from the dam to the Burlington Northern/Santa Fe Railroad crossing near Karnak. **Plate 2-1** is a *St. Paul Project Map,* dated 30 September 1977, showing the general vicinity map and the reservoir project limits.

2-02. Purpose. Baldhill Dam and Lake Ashtabula are part of a multi-purpose reservoir project to provide water supply, flood reduction, and augmentation of flows on the Sheyenne River as authorized by the Flood Control Act of 22 December 1944. The authorized project purposes were quantified as follows:

38 %	Municipal Water Supply
31 %	Rural Water Supply
23 %	Municipal Pollution Abatement
8 %	Flood Control

Additional purposes include enhancing fish and wildlife resources and providing recreational opportunities.

Note that flood control only comprised eight percent of the authorized purpose for the project. With the “five-foot pool raise for flood control” completed in 2004, flood control took on a more important role as to project purpose. The added flood storage resulted in a revision to the water control manual but actually had very little impact on the operating plan (**Chapter VII**). The authorized purposes and those derived from general Congressional acts along with the relevant public laws are provided in **Table 2-1**.

Table 2-1 Authorized Purposes Assigned by Congress		
Authorized Purpose	**Public Law**	**Name**
Flood Control	PL 74-738	Flood Control Act of 1936
Surplus Water, Recreation	PL 89-72	Flood Control Act of 1944
Fish and Wildlife	PL 85-624	Fish and Wildlife Coordination Act of 1958
Water Supply	PL 92-500	Water Supply Act of 1958
Recreation	PL 78-534	Federal Water Project Recreation Act of 1965
Water Quality	PL 92-500	Federal Water Pollution Control Act of 1972
Fish and Wildlife	PL 93-205	Conservation, Protection and Propagation of Endangered Species Law of 1973
Flood Control	PL 99-662	Water Resources Development Act of 1986

2-03. Physical Components. **Plate 2-2** is a project *Site Map* taken from the 2003 as-built drawing for the five-foot raise in flood control. This plate shows the general project plan including the office building, shop and warehouse, and the storage building. The project consists of an earthen embankment with an emergency spillway notched into the center and a service spillway on the right bank. Three tainter gates, as well as two low flow culverts, control flow through the service spillway. There is a "separation dike" that divides the outlet channel of the service spillway from the emergency spillway. With the exception of the project buildings, all physical components can be seen in **Figure 2-1**. The US Fish and Wildlife Service leases land from the Corps downstream of the dam for their fishpond operations. The following gives a brief description of each component including the reservoir itself.

Figure 2-1. Baldhill Dam – Reservoir and Fish Ponds

a. Embankment. Baldhill Dam is a compacted earth fill structure that consists of a homogeneous material with symmetrical upstream and downstream slopes. The embankment is approximately 1,650 feet long and has a top width of about 20 feet. The crest elevation is 1278.5 feet (NGVD 1929). It has a maximum height of 61 feet. An 880-foot long emergency spillway is notched into the center of the embankment with a crest elevation of 1271.0 feet. Each end of the embankment has a tee-type parapet wall extending 5.0 feet above the embankment to elevation 1283.5 feet. A sheet pile cutoff wall extends the length of the parapet wall. On the right descending side of the emergency spillway, the tee-wall extends to the service spillway. On the left descending side of the emergency spillway, the tee-wall ties into the earthen embankment at elevation 1283.5 feet. The slopes of the embankment are 1V:2H from the crest of the dam to elevation 1270.0 feet; 1V:2.5H from elevation 1270.0 feet to 1253.0 feet; and 1V:3H from elevation 1253.0 feet to the stripping line. A disposal berm was placed against the upstream slope from the natural ground surface to a minimum elevation of 1245.0 feet. The entire upstream face of the dam is protected from erosion by a layer of 12-inch riprap placed over a 6-inch gravel filter blanket. Similar protection is placed at the toe of the dam on the downstream face to elevation 1253.0 feet. The top of the embankment and top of the parapet walls provide 5.2 feet of freeboard above the probable maximum flood pool elevation of 1278.3 feet.

b. Separation Dike. The separation dike separates the outlet channel from the emergency spillway. It begins at the crest of the embankment (elevation 1278.5 feet) and slopes downward at a rate of 1V:10H. The crest is 26 feet wide with a 20-foot wide, 3-inch thick, bituminous surface. The slope stops at elevation 1243.0 feet (a distance of 355 feet). From there the dike continues at this elevation for about 120 feet where it slopes down to meet existing ground. The surface of this portion is 6-inch aggregate surface course. All side slopes are basically 1V:3H. A 2-foot thick layer of riprap protects the “emergency spillway side” to elevation 1259.0 feet. A 1-foot thick layer of riprap protects the “service spillway side” to elevation 1259.0 feet.

c. Emergency Spillway. The emergency spillway is 880-feet long and has a crest elevation of 1271.0 feet. The spillway is broad crested with a smooth chute terminating in a short stilling basin with baffle blocks and an end sill. A sheet pile cutoff wall extends the length of the upstream edge of the crest. Spillway approach walls are provided to connect the chute walls with the left abutment and existing spillway at elevation 1283.5 feet. The chute has vertical walls with a top elevation of 1283.5 feet that slope down to elevation 1259.0 feet where they intercept the top of stilling basin walls. The chute walls and the stilling basin walls are designed to contain the Probable Maximum Flood (PMF) overflow. The sidewalls at the toe are at the level of the expected PMF tailwater elevation of 1259.0 feet to prevent eddying return flow that could lead to erosion or interfere with the hydraulic jump on the spillway slope or apron. The peak discharge over the emergency spillway during the PMF is 58,000 cfs at a pool elevation of 1278.5 feet and a peak tailwater elevation of 1259.0 feet.

The crest of the emergency spillway is capped in concrete and is 49-feet 10-inches wide. There is a slight slope to the cap. It has a crest elevation on the lake ward side of 1271.0 feet and an elevation of 1270.0 feet on the landward side. The descending side slope is 1V:3.5H. It is concrete lined and ends at elevation 1242.0 feet. At this point, the slope changes to three percent and the stilling basin is formed. It is 35 feet wide with one row of baffle blocks (top elevation 1244.67 feet). The stilling basin is terminated with an end sill (top elevation 1243.45 feet). A sheet pile cutoff wall follows the stilling basin. The cutoff is extended to elevation 1225.0 feet approximately 15 feet below the bottom of the apron slab and approximately 5 feet below the lowest elevation of the discharge channel. The three percent slope continues down the slope for a distance of 35 feet to the toe. A 2-foot thick layer of riprap protects this area.

d. Entrance Channel. The upstream and downstream wing walls and the walls of the chute and stilling basin are cantilever walls with a sloping base on a shale foundation. The right upstream wing wall has a top elevation of 1283.5 feet, whereas the left wing wall has a top elevation of 1279.0 feet. The approach channel, 80 feet in width, is excavated to elevation 1237.0 feet and is protected from scour by a 12-inch layer of riprap. It extends upstream a distance of 44 feet.

e. Service Spillway. Flows are discharged through three tainter gates located in a 140-foot spillway section on the right bank of the project. The gate bays are 40-feet wide with two 10-foot wide piers (**Plates 2-3, 2-4**). The spillway is a gravity type ogee weir with a crest elevation of 1252.0 feet and is constructed of reinforced concrete. The tainter gates have a radius of 20 feet and a vertical height of 20 feet. The trunion is located at elevation 1262.5 feet. The gate seal is located upstream of the ogee crest at elevation 1251.0 feet. Heaters are provided for the side seals and the sill. The top elevation of the gate when in the sealed position is 1271.0 feet. Individual electrically operated hoists are installed for each tainter gate. Each gate can be raised such that, with drawdown of the flow at the spillway, the Probable Maximum Flood will pass beneath the gate. The bottom lip of the gate, when fully open, is at about elevation 1276.5 feet. Should a gate be in need of repair, there are four bulkheads on site. Each one is 48 inches high, 28 inches wide, and 42 feet 9 inches in length. The bulkhead sill elevation is 1252.0 feet. Therefore, with all four bulkheads in place, the bay would be sealed to an elevation of 1268.0 feet, thereby providing two feet of freeboard for wave runup.

A structural steel service bridge spans the spillway section of the dam and is supported by the tainter gate piers and the abutments of the dam. The bridge provides a walkway for pedestrian travel and rails for the operation of the electrically driven gantry crane that is used for the installation and removal of the emergency bulkheads. The base of the rail is at elevation 1278.92 feet and the rails extend 99 feet beyond the face of the left abutment and 41 feet beyond the face of the right abutment.

f. Outlet Channel. Discharge from the service spillway is released into a concrete-lined chute that drops on a 15 percent grade from elevation 1236.92 feet at the end of the spillway weir to a stilling basin at elevation 1222.0 feet. The channel is rectangular in shape and is 140.0 feet wide. It remains at this width for a distance of 90.0 feet, at which point it begins to expand while on the downward slope. At a distance of 15.0 more feet down the slope, the stilling basin floor begins. The stilling basin is 70 feet long and is 160 feet wide at the end sill. There are two staggered rows of six feet high baffle blocks within the stilling basin. The end sill rises to elevation 1225.0 feet in 18-inch steps. There are four plugs at the bottom of the top step. Each plug is 6.0 inches in diameter. The training walls, at elevation 1259.0 feet, terminate 35 feet downstream of the end sill. Downstream of the end sill, the discharge channel is trapezoidal in shape with an invert elevation of 1224.0 feet. The invert slopes to elevation 1225.5 feet at the tailwater control structure, which is located 425 feet downstream of the stilling basin end sill. There is a set of stop logs located on the left descending side with a crest elevation of 1227.5 feet. The tailwater control structure slopes in increasing incremental steps towards the center of the structure. The invert of the V-notch is elevation 1225.0 feet. Therefore, a minimum pool of water one-foot deep is maintained. The outlet channel continues for another 300 feet where it terminates into natural ground. The side slopes vary but are fairly consistent at 1V:3H with the top portion being somewhat flatter. **Table 2-2** shows the extent of the riprap protection for the outlet channel. All riprap was placed over the appropriate granular filter blanket.

Table 2-2
Outlet Channel Riprap Design

From Station	To Station	Channel Bottom		Channel Side Slopes			
				Left Bank		Right Bank	
		Elevation	Thickness	Elevation	Thickness	Elevation	Thickness
2 + 00 ft[1]	6 + 25 ft[2]	1224.0 ft 1223.5 ft	4 feet	Top of Bank	4 feet	1240.0 ft 1259.0 ft	4 feet 2 feet
6 + 25 ft	7 + 25 ft	1223.5 ft 9% slope	2 feet	Top of Bank	2 feet	1259.0 ft	2 feet
7 + 25 ft	9 + 35 ft[3]	9% slope	1 feet	Top of Bank	1 feet	Top of Bank	1 feet

1. Stilling Basin End Sill 2. Tailwater Control Structure 3. Existing Ground

g. Low Flow Outlet Works. To provide low flow reservoir releases, there are two 3.0-foot diameter culverts located in the tainter gate piers. The intake invert is at elevation 1238.0 feet and the outlet invert is at elevation 1234.5 feet. At the inlet, each culvert has a 4.0-foot square opening that is protected by a trash rack. This opening leads to the intake chamber where outflow is regulated by a 3.0-foot square sluice gate. In the event that one of the sluice gates becomes inoperable while in the open position, the discharge through the culvert can be regulated by the use of the other sluice gate.

h. Reservoir. Congress officially named the reservoir Lake Ashtabula in 1952. It was named after Ashtabula Township. The Native American translation is "Fish River". The drainage area above the dam is 7,470 square miles of which about 5,560 square miles is noncontributing, including 3,800 square miles in closed basins (e.g. Devils Lake). For a more complete description of the drainage area, see **Chapter 4**. Lake Ashtabula is 27 miles long and, within its length, has submerged 42 river miles of the old, winding Sheyenne River streambed. At the conservation pool elevation of 1266.0 feet, the lake has a maximum width of 0.6 mile, a water surface area of 5,650 acres, a shoreline length of approximately 78 miles, and an average depth of 30 feet.

2-04. Related Control Facilities.

a. US Fish and Wildlife Service. On 1 June 1950, land downstream of the dam was leased to the US Fish and Wildlife Service (USFWS). The USFWS constructed 16 one-acre and 4 one-half acre fish rearing ponds (**Figure 2-2**). They also constructed a 30-foot by 60-foot concrete block building used to house a fish-holding tank, hatchery equipment, and food used in pond culture. Water supply required for operation of these ponds is obtained by siphon from Lake Ashtabula. The water demand varies but is typically fairly constant at 4,200 gallons per minute, or around 9.0 cfs. The flow is metered and can be observed by site staff although access to the site requires some effort. Flow from the fishponds is routed back to the Sheyenne River by the "return channel".

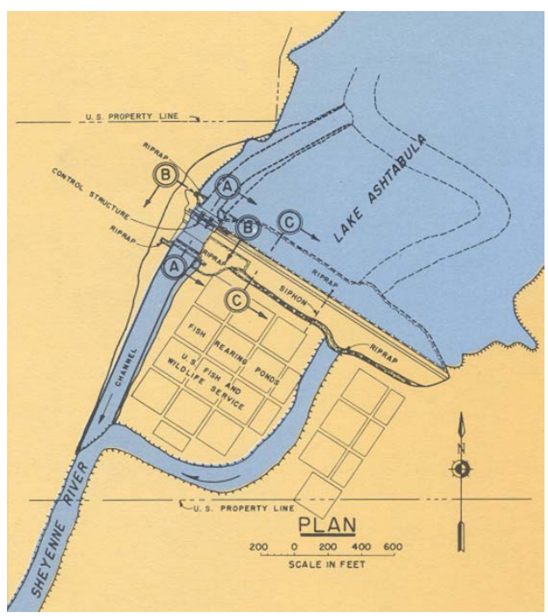


Figure 2-2. USFWS Fishponds

b. Fargo Diversion Dam and Ditch. As part of the local interest requirements of the Baldhill Dam project, the Fargo Diversion Dam was constructed by the city of Fargo, North Dakota. The purpose of the project was to alleviate the effects of low flows on the Red River of the North at Fargo. It was completed in July 1972. The diversion dam is located about 35 river miles upstream of the mouth of the Sheyenne River and three miles downstream of Horace, North Dakota. It connects the Sheyenne River with the Red River of the North via the Stanley Drainage Ditch (**Figure 2-3**).

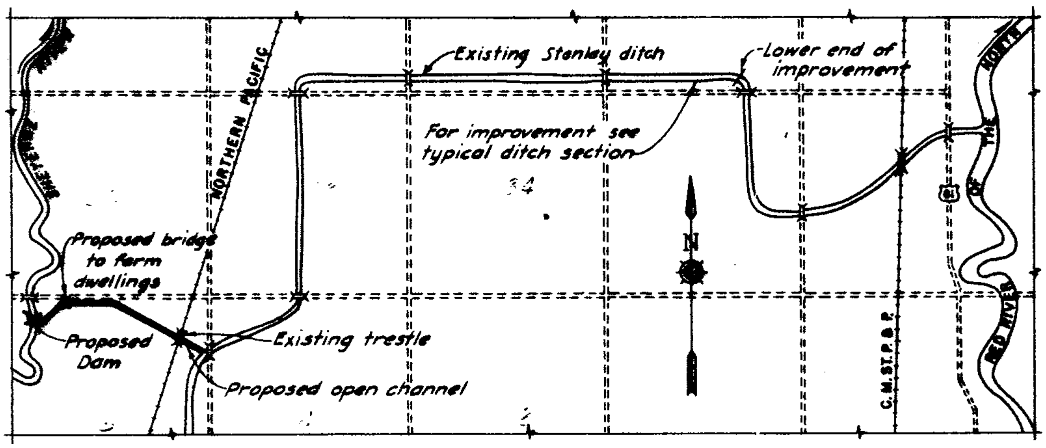


Figure 2-3. Fargo Diversion Ditch

The dam across the Sheyenne River consists of two electronically operated four-foot high slide gates that, when lowered to the supporting sill, form a weir with the crest at elevation 898.0 feet and a pool eight feet in depth. Two 12,000-gpm pumps (total outflow ~50 cfs), with intakes at elevation at 893.5 feet, are provided above the dam to discharge water from the river into a side channel and then into the Red River of the North at mile 461 (above Fargo) by way of the Stanley Drain. The diversion dam also provides a bridge with a 31-foot roadway across the Sheyenne River.

2-05. Real Estate Acquisition. Between the years of 1947 and 1951, the United States Government obtained a total of 7,816.51 acres of land in fee with perpetual flowage easements on an additional 666.15 acres. The taking line in the reservoir was at elevation 1270.0 feet, and the property line was cleared of trees, brush and debris below elevation 1268.0 feet. Most of the fee land (approximately 5,527 acres) was below the normal pool elevation of 1266.0 feet. The remaining 2,290 acres of land held in fee are above elevation 1266.0 feet, and are used for project operation, recreation, and wildlife management. The Corps of Engineers originally leased 113 acres of this land to the following:

US Bureau of Sport Fisheries and Wildlife	37 acres
Local groups and organizations	7 acres
North Dakota National Guard	69 acres

The flowage easements were located at the extreme upstream portion of the pool along the Sheyenne River and along Baldhill Creek where it joins the pool. These easements were to accommodate fluctuations of the pool above the normal level. The five-foot pool rise for flood control caused some modifications to the land acquisition.

The five-foot pool rise in the authorized flood pool level did not change the conservation pool level. However, the real estate requirements to properly operate and maintain the flood control pool required acquisition of real estate interests to elevation 1271.0 feet or one foot above the current fee ownership. Eight cabins were acquired in fee. One farmstead was acquired in part. The reason for these acquisitions was based on the fact that the ground elevation was below 1271.0 feet or the scope of modification was too high. Other locations required buildings to be moved or raised. Total land purchased in fee was 303 acres and easement acquisition was 1,503 acres. Of the land purchased in fee, 300 acres was for mitigation. The remaining 3 acres were for the eight cabin sites, platted lands that are not being protected, small portions of land for levee construction, and portions of one farmstead that was acquired in part.

2-06. Public Facilities. Not counting the Corps of Engineers recreational facility at the dam, there are seven developed recreational areas on Lake Ashtabula. The Corps facility at the dam site functions as an informal interpretive and general sightseeing area. The Mel Rieman Recreation Area is by far the largest recreational facility. It is readily accessible by paved roads from Valley City and acts as the "front door" to the entrance to Lake Ashtabula. Upon entering the site the first major activity area is the large day-use facility. It includes a Visitor Center, which provides a small self-guided interpretive program giving basic information about the lake and its facilities and serves as a comfort station for the beach and campground. A concessionaire offers various small items as well as boat rental. **Table 2-3** gives a brief description of each facility. A map with more in depth information can be found in **Exhibit B**.

Table 2-3
Recreational Facilities Within the Reservoir

Facility	Location	Area	Boat Launch	Swim-ming	Pic-nicking	Camping
Mel Rieman Rec Area	East Bank next To the Dam	70 acres	Yes	Yes	Yes	Yes
Sundstrums Landing	East Bank 2.6 mi Above the Dam	9 acres	Yes	No	Yes	No
Eggert's Landing	East Bank 5.3 mi Above the Dam	28 acres	Yes	Yes	Yes	Yes
Katie Olson's Landing	West Bank 5.3 mi Above the Dam	11 acres	Yes	No	Yes	No
East Ashtabula Crossing	East Bank 10.4 mi Above the Dam	11 acres	Yes	Yes	Yes	Yes
West Ashtabula Crossing	West Bank 10.4 mi Above the Dam	23 acres	Yes	No	Yes	Yes
Sibley Crossing	West Bank 14.9 mi Above the Dam	4 acres	Yes	No	No	No

III – HISTORY OF PROJECT

3-01. Authorization. Senate Document No. 193, 78th Congress, 2nd Session, contained a survey report, dated 24 February 1942, recommending construction of a dual purpose reservoir for flood control and alleviation of low water conditions on the Sheyenne River and on the Red River of the North, at and below Fargo, North Dakota. The project, named after Baldhill Creek which flows into the Sheyenne River 14 miles upstream of the dam, was authorized by the Flood Control Act of 22 December 1944. As included in the report of the Chief of Engineers in the project document, local interests were required to make a cash contribution of $208,000 toward the first cost of the reservoir; bear the expenses of all necessary alterations of utilities, roads, highways, and bridges; construct, operate, and maintain the Fargo Diversion Dam and Ditch; maintain the channel below the reservoir; and prevent the pollution of the waters of the Sheyenne River.

The 1986 Water Resources Development Act, Section 401(a), Public Law 99-662, approved 17 November 1986, authorized four components of additional flood control. They were;

a. Levees and a flood diversion channel at West Fargo.
b. Levees and a flood diversion channel from Horace to West Fargo.
c. Modifications to Baldhill Dam to provide capability for a five-foot pool rise for additional flood control storage.
d. A dam and reservoir to store approximately 35,000 acre-feet for flood protection on the Maple River.

The first three items were constructed with the five-foot rise for flood control being completed in 2003. Studies subsequent to the authorization found that a dam and reservoir on the Maple River did not have economic feasibility and was not eligible for Federal participation.

3-02. Planning and Design. A public hearing was held at Fargo, North Dakota on 25 January 1939, to discuss the nature and merits of the flood control improvements desired and the allied benefits which might be expected as a result of such improvements. Past floods were discussed, but the greater part of the discussion and testimony dealt with the water supply problem. The participants at the hearing were agreed that regulation of the Sheyenne River was necessary to provide a dependable all-season flow from the available runoff to supplement failing and unsatisfactory sources of water supply. By *Letter from the Secretary of War* to the Chairman of the Committee on Commerce, United States Senate, recommended the "construction of Baldhill Reservoir on Sheyenne River for flood control and water conservation." The letter also stated "improved low-water flows in Sheyenne River and Red River of the North are badly needed for pollution abatement, stock watering, and water supplies in municipal areas. Best use of Baldhill Dam site requires that the reservoir be constructed with sufficient capacity to conserve water for these purposes as well as provide flood control. The major part of the benefits would accrue in connection with water supplies and pollution abatement." The three major water supply issues were 1) Municipal water supply for Valley City, Lisbon, and Fargo, 2) Rural water supply to permit an increase in stock raising, and 3) Stream-pollution benefits (e.g. dilution of sewage waste and packing plant effluent). Therefore, Baldhill Dam was constructed with its primary intent being water supply. Benefits of the dam were estimated in by the following distribution:

Municipal Water Supply:	38 %
Rural Water Supply:	31 %
Municipal Pollution Abatement:	23 %
Flood Control:	8 %

a. Water Supply. Lake Ashtabula was a Federal project with local project sponsors. The local contribution to construction of the dam was $208,000. This money was donated by downstream cities and private industries that would benefit from the water supply. As a contributor to the construction fund, the American Sugar Company was curious about the operation of the dam and made an inquiry to the St. Paul District. The St. Paul District Commander explained the Corps of Engineers' stance on water releases from Baldhill Dam by letter dated 15 April 1947:

"The Baldhill Reservoir will be controlled, maintained, and operated solely by the War Department, but inasmuch as the major portion of the benefits resulting from its operation is the furnishing of water for water supply and pollution abatement, this office will be glad to give consideration to any suggestions by the water users, particularly those supporting the project at this time, i.e., those furnishing necessary assurances and contributing to the required contribution."

On 5 September 1950, a Special Meeting was held by the State Water Commission in the Chamber of Commerce Rooms in Fargo to discuss the allocation of stored waters in Lake Ashtabula. George Lyon of the Corps of Engineers was present and read a prepared statement representing the views of the St. Paul District:

"Greater flows will be released as required by greater demands during periods of drought and/or periods of high transmission losses. The plan of reservoir operation is not assumed to be inflexible and consideration will be given to increasing the amount of discharge from the reservoir when downstream interests believe conditions warrant. Although the reservoir will be operated by the Corps of Engineers, the assigning of water-rights and determination of priorities of water use, consistent with the intent of Congress, should be handled by the State Water Commission."

In the last sentence the Corps gave the State Water Commission the authority to distribute the stored water within the reservoir; however, releases from the dam would be the responsibility of the Corps of Engineers.

". . . the operation of Baldhill Reservoir and determination of the release therefrom will be the function of the Corps of Engineers."

This did not set well with some members at the meeting. Mr. Fred Fredrickson stated:

"I believe in the integrity of the state water laws. I am in disagreement that the government has any claim to stored waters of the Baldhill reservoir." "The fact that the government has built the dam does not give them claim to the water."

No agreement was reached as to whom has final authority on releases from the dam during low flow periods; however, a plan for distribution of the stored water was achieved. I.A. Acker, Counsel for the State Water Commission and Sivert

W. Thompson, Vice Chairman of the State Water Commission, developed a plan based on cash contributions and municipality population. The plan became known as the Thompson-Acker plan. The concept was that 25 percent of the water would be proportioned out on the basis of total cash contributions and 75 percent of the water would be proportioned to the municipalities on the basis of the population in 1950. Note that the initial normal pool elevation to provide water supply was established at 1264.0 feet; however, through a restudy done as part of the Missouri River diversion project, an elevation of 1266.0 feet was deemed necessary for the scheme of operation. At this pool elevation, the plan assumed the dam would impound 69,000 acre-feet of water. **Table 3-1** shows the original distribution of the Thompson-Acker Plan.

Table 3-1
Thompson /Acker Plan – Original Distribution of Storage

City / Organization	% Cash Con-tributed	25 % Share	% of Popula-Tion	75 % Share	Total Share	Acre-Feet
Fargo	55.69	13.92	50.77	38.08	52.00	35,880
Grand Forks	8.24	2.06	35.94	26.96	29.02	20,023
Valley City	11.11	2.78	9.21	6.91	9.69	6,686
West Fargo	1.52	0.38	1.35	1.01	1.39	959
Lisbon	2.17	0.54	2.73	2.04	2.58	1,780
Sugar Company	15.84	3.96			3.96	2,732
Union Stock Yards	0.90	0.23			0.23	159
Rail Road Companies	3.17	0.79			0.79	546
Northern States Power	1.36	0.34			0.34	235
Totals	100.00	25.00	100.00	75.00	100.00	69,000

Over time the sugar mill, stock yard, railroad, and power company relinquished their claims to the stored water. The State Water Commission altered the distribution list shown in the Thompson-Acker Plan by a letter to the Corps of Engineers dated 18 July 1988. **Table 3-2** shows a summary of the latest permitted water rights for Lake Ashtabula. All water appropriated is at the point of release.

Table 3-2
Apportionment of Storage of Lake Ashtabula
North Dakota State Water Commission

Fargo	35,880 acre-feet
Grand Forks	20,023 acre-feet
Valley City	6,686 acre-feet
West Fargo	954 acre-feet
Lisbon	373 acre-feet

While the apportionment of storage by the State Water Commission is within the power of the state, the project authorizing document made no provision for specific allocations of storage to local project sponsors. There are no known contracts between the US Government and any local project sponsor to reserve and/or provide reservoir storage at Baldhill Dam. The Baldhill Dam and Lake Ashtabula project is unique in that the Federal government through the Secretary of the Army and the Corps of Engineers is authorized by Congress to regulate the project in accordance with project purposes without being permitted by the State of North Dakota to store water. At the same time, all other uses of Lake Ashtabula storage are required, under the State's appropriative water law, to be permitted. In this unusual situation, the Corps of Engineers controls all aspects of project regulation while the State controls the right of permitting the storage.

"Inasmuch as we are a Federal agency we cannot make any commitments regarding allocation of water from the Baldhill Reservoir."

The stance that the Corps would have final say on low flow releases has not been well received by the State Water Commission. The State of North Dakota had reasoned that the $208,000 contributed to construction of the Baldhill Dam in effect gave the State the right to the water stored in Lake Ashtabula. The State Water Commission attempted to resolve this issue at a meeting with the Corps of Engineers on 5 January 1992. An executive summary of the meeting is included in **Exhibit B**. When the State Water Commission asked the Corps to acknowledge their authority in the decision process regarding low flow releases from Lake Ashtabula, the Corps responded;

"While municipal water supply needs would in all likelihood have the highest priority during drought periods, the Corps must still give consideration to adverse impacts on all authorized project purposes."

The issues brought forth by the State Water Commission were presented to St. Paul District's Division Office and were reviewed by the Assistant Division Counsel. Upon review, the Office of Council responded by memorandum dated 25 February 1993;

"This office has reviewed the subject issues, and has concluded that the subject dam and its impounded waters are a federal project, constructed by and to be managed as provided by the authorized purposes of the project. This does not mean in any way that cooperation with the State of North Dakota is not to be accomplished whenever it can be accomplished consistent with these federal purposes. However, the dam is unquestionably federal, and federal supremacy over state laws and concerns is controlling."

In past practice, cooperation between the St. Paul District Corps of Engineers and the State Water Commission has resulted in no major difficulties. In fact, when the State Water Commission has asked for an increase in outflow, it has always been delivered. The following is a history of requested releases:

Table 3-3
History of Requested Releases

Date of Request	Initial Request	Discharge (cfs) Initial	Discharge (cfs) Final
20 Aug 1976	City of Fargo	8	42
07 Aug 1984	City of Fargo	18	50
16 Jul 1985	NDSWC	13	40
14 Jul 1988	NDSWC	7	28
18 Nov 1988	City of Fargo	10	35
12 Jul 1989	NDSWC	19	30
*09 Jul 1990	NDSWC	14	30
19 Jun 1991	NDSWC	11	35
14 Aug 1992	City of Fargo	18	23
**24 Sep 2003	Valley City PW	40	40

*Not acted upon until 1 August 1990. **Request was for a release of 2.7 cfs.

It should be noted that none of the requests presented in **Table 3-3** resulted in lowering the pool level below elevation 1264.0 feet. Since construction of the dam, a severe drought such as that of the 1930's has not been experienced. The *Drought Contingency Plan* dated September 1992, discusses the Drought Management Plan. As stated "the management plan will have to be tailored to each drought situation." The Drought Contingency Plan provides a definition of the process to be followed, not a set table of releases, because the eventual response will be dependent upon the unique circumstances that prevail at the time.

b. Flood Control. It was estimated that it would take a couple of years for the reservoir to fill to conservation pool level (elevation 1266.0 feet). This was not the case. While the project was not quite complete, it was placed into emergency operation on 16 April 1950. The flood was of such magnitude that the flow of record was recorded at Cooperstown. To prevent the flooding of Valley City, one-foot of water was allowed to flow over the top of the gates thus surcharging the pool. The pool crested at elevation 1269.46 feet. While this technique greatly reduced outflow, it was not allowed to occur again until 1979 when boards were actually attached to the top of the gates to surcharge the pool. Flow over the gates was once again allowed in 1993 but only for a brief period.

In 1986, evaluations were done to determine compliance of the project with Dam Safety Assurance Program criteria. The report was published in January 1987 (**Chapter 1**). The study revealed that the dam had inadequate spillway capacity. The spillway was designed to pass 43,100 cfs, but current criteria require that the dam must have hydraulic capacity to pass the Probable Maximum Flood (PMF) flow of 126,000 cfs without overtopping the dam. Subsequent evaluations identified additional problems with stability of the right abutment and the spillway itself, as well as other less notable deficiencies. Consequently a five-year Major Rehabilitation and Dam Safety construction program was started to correct these deficiencies. In **Stage 1** the existing chute slab was replaced with a new thicker, anchored slab. In addition, the spillway retaining walls were raised and the left approach wall was extended. Construction was completed between July 1994 and June 1995. **Stage 2** consisted of notching out an 880-foot long section of the dam and installing a concrete emergency spillway. The spillway crest elevation is 1271.0 feet. The PMF water surface elevation is 1278.5 feet (elevation of the original dam crest). The dam was raised to elevation 1283.5 feet to provide the necessary five feet of freeboard. The five-foot rise was accomplished through construction of a tee-type reinforced concrete parapet wall on the right side of the new spillway and placing earth fill on the left side. Other work included construction of a separation dike between the service and emergency spillways. Work was competed between January 1995 and November 1997.

Compliance with the Dam Safety Assurance Program led to design modifications to provide capability for a five-foot pool rise for additional flood control storage. The Design Memorandum was published in May 1998. Land acquisition and flood easements had been adequately obtained to put the project into operation in the spring of 2004. As originally constructed, the top of the spillway gates, when in the closed position, was at elevation 1267.0 feet. That was just one-foot above the normal pool level. The existing 16-foot high gates were replaced with 20-foot high gates. The new gates were fitted with new trunnion beams and anchorages. The trunnion was raised from elevation 1257.0 feet to elevation 1262.5 feet. Side seal heaters were relocated. With the new gates and dam improvements, the top of flood control is now elevation 1271.0 feet (crest elevation of the emergency spillway).

Acquisition of a permanent easement to occasionally overflow the additional lands between the present Federal ownership and the freeboard guide acquisition line was found to be sufficient for project operations. The temporary inundation of any of the lands above the present Federal fee ownership is projected to be very infrequent. Total acreage needed for the project was 1,806 acres (1,500 acres in flowage easement, 303 acres in fee, and 3 acres drainage easement).

The five-foot rise required two levees to be constructed to protect existing cabins. At Sibley Crossing the levee is approximately 2,500 feet long and about 2.5 feet high. It has a top width of 10 feet and 1V:4H side slopes. Several culverts were provided for interior drainage. At Sadek's cabins there is a 2,000-foot long levee varying in height from 5 feet to less than 1-foot. Several culverts are provided for interior drainage. At other cabin sites modifications included the placing of fill, construction of modular block walls, installation of drainage facilities, and structural adjustments. Other cabins were purchased outright. There are two existing roadways that cross Lake Ashtabula. They are the Sibley Crossing and the East Ashtabula Crossing. Existing riprap along the side slopes was extended to elevation 1275.0 feet.

To show the impact the new operating plan would have on past floods, the inflow hydrographs for the foods of 1969, 1979, 1996, and 1997 were routed through the reservoir utilizing the new operating plan. Drawdown elevation remained unchanged from the actual. Gates were regulated in what was perceived as a normal operating procedure. **Plates 3-1** through **3-4** show the inflow and outflow hydrograph at the dam, and the stage hydrographs at Lake Ashtabula and cities downstream. **Table 3-4** shows a comparison of the old plan vs. the new plan in regards to peak discharge. Note that the volume of the 1997 flood was such that the new operating plan had little impact on lowering the peak discharge.

Table 3-4
Impact of the New Operating Plan on Past Flood Events - cfs

Flood Of	Baldhill Dam		Valley City		Lisbon		Kindred	
	Old	New	Old	New	Old	New	Old	New
1969	4,560	3,000	4,520	3,000	4,380	4,100	4,690	4,650
1979	4,740	4,000	Na	4,000	4,880	4,400	4,160	4,100
1996	5,460	4,500	5,250	4,500	5,060	4,500	5,100	na
1997	4,510	4,400	4,810	4,700	5,670	5,500	5,970	5,700

3-03. Construction. Construction of Baldhill Dam was started in July 1947 under direction of the St. Paul District Engineer, and although not entirely completed, the project was placed into emergency operation on 16 April 1950. Permanent operations began in the spring of 1951 and the project was formally dedicated on 21 September 1952. Construction began in July 1994 to replace the existing chute slab with a new thicker, anchored slab. The spillway retaining walls were raised and the left approach wall was extended. Construction was completed in 1995. In January 1995 the dam was notched out to provide an emergency spillway. The dam was raised five feet and a separation dike was constructed between the service and emergency spillways. Work was competed in November 1997. In 2001, construction to increase the flood storage capacity began. New gates were installed, levees were constructed, and land was purchased in fee and flowage easements. Construction was completed in 2002; however, land acquisition was not completed until 2005.

3-04. Related Projects. The US Fish and Wildlife Service operate fish rearing ponds directly below the dam. Water to operate these is siphoned directly from Lake Ashtabula. In addition, the Fargo Diversion Dam and Ditch was constructed as part of the local interest requirements of the Baldhill Dam project. More information on this and the fishponds can be obtained from paragraph **2-04. Related Control Facilities**.

Other related projects on the Sheyenne River downstream of the dam include the **West Fargo Diversion** and the **Horace to West Fargo Diversion**. While it may seem that these are two separate projects, they are actually interconnected. The West Fargo Diversion diverts flow from the Sheyenne River around West Fargo. The Horace to West Fargo Diversion diverts water from the Sheyenne River around Horace to the West Fargo Diversion. The West Fargo Diversion is shown in blue and the Horace to West Fargo Diversion is shown in yellow on **Plate 3-5**.

The primary project features of the West Fargo Diversion are two gated closure structures in the Sheyenne River, the diversion channel, a levee system with interior drainage facilities, the replacement of one railroad bridge and four roadway bridges, and two pump stations. The total length of the West Fargo Diversion channel is 6.8 miles. The diversion channel has 1V:7H side slopes that extend to the top of a protection levee on the right bank and to the top of a containment levee on the left bank. The channel has a bottom width of 106 feet and incorporates a low flow channel along the inside toe of the left bank. The low flow channel has a bottom width of 10 feet and is about 2 feet deep (capacity of 50 cfs or less). Short segments of the main channel, at the upstream and downstream ends, are 30 feet wide. The average depth of the channel is 12 feet.

At the upstream end of the diversion channel is an inlet weir with a crest elevation of 895.0 feet. It prevents water from entering the diversion channel during low flow periods. In the Sheyenne River, at the upstream and downstream ends of the diversion channel, are gated control structures. The gates are typically open; however, during flood events they are closed. When the gates are closed, all flow is diverted into the diversion channel. Therefore, the only inflow to the Sheyenne River between the two points of the diversion channel is the local inflow and interior drainage. This portion of the river acts as a ponding area. There are two pump stations to evacuate the water. One is in conjunction with the downstream closure structure and pumps interior runoff into the downstream Sheyenne River. The other pump station, which was completed in 2004, pumps interior runoff into the diversion channel.

At a point about 1.5 miles downstream of the start of the West Fargo Diversion, the Horace to West Fargo Diversion enters the channel. The Horace to West Fargo Diversion extends from about 1.5 miles upstream of Horace, north to the West Fargo Diversion. It is generally located adjacent to a section line road and is about 7.4 miles long. At about midpoint, it intercepts Drain 21 and follows it to the West Fargo Diversion. The major project features of the Horace to West

Fargo flood control project are the Sheyenne River control structure, the diversion channel with an inlet weir, a levee system with side drainage inlets along the diversion channel, and the replacement of seven roadway bridges. The diversion channel has a 15-foot base width and averages 8 to 12 feet deep. The side slopes are 1V:7H and extend to the top of the levee on both sides. The diversion inlet structure consists of a concrete weir and stilling basin. The Sheyenne River control structure consists of an earthen plug with a tie back levee and two 10-foot by 10-foot box culverts. The control structure limits flow down the natural channel to prevent flooding.

The entire channel system was designed for the one-percent flood on the Sheyenne River. The 100-year discharge on the Sheyenne River just upstream of the Horace to West Fargo Diversion is 4,000 cfs. At this point, the Sheyenne River control structure and the diversion inlet structure divide the flow such that about 2,000 cfs will flow down the Sheyenne River and 2,000 cfs will be diverted into the diversion channel. At Drain No. 21, the Horace Diversion picks up 600 cfs for a total flow of 2,600 cfs. The West Fargo Diversion diverts the total flow of 2,000 cfs from the Sheyenne River into the West Fargo Diversion. At the intersection of the West Fargo Diversion and the Horace to West Fargo Diversion, the total discharge becomes 4,600 cfs. This discharge is maintained to the outlet of Drain No. 21, where 1,800 cfs continues on down Drain No. 21 and 2,800 cfs remains in the West Fargo Diversion and is routed around the city.

3-05. Modifications to Regulation.

a. 1992 Modification. The State Water Commission and the St. Paul District met on 5 September 1989 to discuss low flow releases from Baldhill Dam. One of the issues was the need to increase the minimum flow requirements. Minimum flow at the time was 3 cfs. The State Water Commission requested that minimum outflow be increased to 20 cfs, thereby reducing the number of future requests for water supply. The Corps of Engineers agreed to study the matter and report back. On 5 January 1992, St. Paul District met with the State Water Commission and established a minimum out flow of 13 cfs. During drought phases, releases may be altered from the minimum release. Discharges are to be determined through the interagency coordination defined in the Drought Contingency Plan.

b. 1994 Modification. The tailwater gage for Baldhill Dam was originally located on the right bank 600 feet downstream of the dam. On 30 December 1994, the gage was relocated to left bank at the Barnes County Road #19 crossing. This site is 0.7 miles downstream of the dam.

c. 1997 Modification. The original dam was approximately 1,650 feet in length with a top elevation of 1278.5 feet. Dam safety modifications resulted in the construction of an emergency spillway within the earthen embankment. It is 880.0 feet long with a crest elevation of 1271.0 feet. The remainder of the dam was raised five feet to elevation 1283.5 feet to provide freeboard above the probable maximum pool elevation (1278.5 feet).

d. 2000 Modification. In the spring of 2000, the rock weir that provided the pool for discharge measurements at the tailwater gage was flanked and eroded the left bank (**Figure 3-1**).

Figure 3-1. Scour of the Tailwater Gaging Location

The weir was located on private property and gaining access through the property owner became difficult. Therefore, it was decided that the tailwater gage would be relocated to the downstream vicinity of the dam. On 19 September 2000 the tailwater gage was relocated to a site approximately 500 feet downstream of the dam (**Chapter 5**). Low flow discharge measurements are taken at the site; however, high flow discharge measurements are taken at the old gage location at the Barnes County Road #19 bridge crossing 0.7 miles downstream of the dam.

e. 2004 Modification. Real estate acquisition to allow for a five-foot rise in pool elevation was sufficiently complete to allow for the use of the added flood storage volume in spring of 2004. A heavy rainfall caused a rapid snowmelt resulting in a large volume of runoff. With wind influence, the pool crested at 1270.5 feet. Prior to this, there was little provision for flood control during summer events. Water can now be stored to the top of flood control, i.e. elevation 1271.0 feet. When it appears the pool will be exceeding elevation 1267.0 feet, public notification will be made to alert dock owners.

f. 2006 Modification. During spring periods when there was limited snow cover and little rain, drawdown would make it difficult to bring the pool back to conservation level. Minimum outflow could last for months. In an effort to preserve the pool, a change to operating plan was presented at a public meeting in Valley City on 8 March 2006. The idea was to target a drawdown elevation one-foot above the normal drawdown. At this time an assessment of the snow-water-equivalent (SWE) conditions would be made. If SWE was low, drawdown would cease. In addition to this change, the advance drawdown schedule was modified such that to achieve maximum drawdown would require over 4-inches of SWE over the basin. The proposed changes met with opposition from the Red River Joint Water Resource Board, Upper Sheyenne River Joint Water Resource Board, Sheyenne River Joint Water Resource District, Southeast Cass Water Resource District, and Moore Engineering, representing the local sponsors of the five-foot rise. The letters of concern are presented in **Exhibit F**.

On 24 May 2006, a meeting was held in Fargo, North Dakota to discuss water supply issues. Representatives of the St. Paul District, North Dakota State Water Commission, and the City of Fargo were present. Legal representation for the City of Fargo produced a questionnaire regarding releases from the Baldhill Dam. Included in **Exhibit B** is list of the questions and the responses provided by Water Control. This is included as part of the water control manual for future reference when water supply issues present themselves.

g. 2013 Modification. Both 2009 and 2011 had high snow water equivalents (SWE). In 2011, the District's Commander requested that the pool be lowered two feet below maximum drawdown elevation to 1255.0 feet due to the high potential for major flooding. Due to a quick warm-up the pool was only able to reach elevation 1256.5 feet. The district decided to complete an Environmental Assessment (EA) to determine if we can lower the pool below maximum drawdown elevation of 1257.0 feet and if so how much further. The EA found there was no significant impact with lowering the pool an additional two feet as long as water quality was monitored and the process halted if the water quality became unsustainable for fish. Therefore the new maximum drawdown elevation is 1255.0 feet if the SWE is greater than 3.0 inches.

3-06. Principal Regulation Problems.

a. Ice Jams – Winter Drawdown. Reservoir releases in late winter can cause ice jams downstream of the dam. Discharge is set to prescribed levels starting on the 1st of October to achieve minimum drawdown by 1 March. Discharges may be ramped up and down in an effort to reduce channel ice conditions.

b. Snow Depth. The snow board is located in a clearing in the woods near the lower storage building (**Figure 3-2**). While this location tends to read high due to the protective nature of its location, if it were located on the plains, the wind would tend to blow it clear. A better location has never been found. Therefore, snow measurements taken at the site are tempered with the visual conditions in the area.

Figure 3-2. Snow Board

c. Low Flow Gate Operation. Operation of the west low flow gate is difficult. Often the outer gate must be sealed to take pressure off the sluice gate to permit operation. This takes additional time and restricts flow for a brief period of time. There are currently no plans to remedy the situation. Also, accuracy of gate opening becomes critical when computing flow area. Flow is controlled by a square sluice gate in front of a round opening. A 10 percent plus or minus swing in gate opening can have a 25 percent swing in flow area. Therefore, the discharge-rating for gate operation is only an approximation.

d. Tainter Gate Openings. The tainter gates are equipped with an analog gage to indicate how far a tainter is opened. Because of the changing "slop" in the operating cable, it is often necessary to close the gate, mentally register the gate reading, and proceed from there to the desired gate opening. This operation still does not ensure a precise gate opening. In 2003 inclinometers were installed on all three tainter gates. Instrumentation is provided within the control house. The inclinometers were calibrated in April 2005. Therefore, it is recommended that the inclinometers be used to verify gate openings.

e. Inflow Hydrograph. Water Control has a basic HEC-1 model of the upper Sheyenne River basin; however, it does not possess snowmelt capabilities. The National Weather Service's (NWS) model of the upper basin includes snowmelt. The NWS provides Water Control with the inflow hydrograph around the time of spring runoff. When there is a significant change in basin conditions, a new inflow hydrograph is developed and is emailed to Water Control. Because of the unpredictability of snowmelt, there is no good source for an inflow hydrograph in the spring. Therefore, regulation is tied to using the NWS forecasted inflow hydrograph and the reported flow on the Sheyenne River at Cooperstown and Baldhill Creek at Dazey (see **Chapter V**). The total flow for these two sites is assumed to be the two-day out forecasted inflow. Water Control uses this and the NWS hydrograph to develop their own hydrograph. It is updated daily during spring runoff.

IV – WATERSHED CHARACTERISTICS

4-01. General Characteristics. The Sheyenne River basin covers parts of 16 counties in the southeastern portion of North Dakota (see **Plate 5-1**). At its extremes, the basin extends approximately 160 miles north to south and about 175 miles east to west. The river rises near Kruger Lake and flows generally eastward about 150 miles to McVille, where it turns to the south for about 200 miles to the vicinity of Lisbon. There the river forms a loop as it swings northeasterly for about 150 miles to its junction with the Red River of the North at a point about 10 miles north of Fargo. The total length of the meandering Sheyenne River is approximately 542 miles. The source of the river is at elevation 1,700 feet (NGVD 1929) and the mouth is at elevation 854 feet, indicating a fall of 846 feet in 542 miles, which is an average slope 1.6 feet per mile.

As determined by the US Geological Survey (USGS), the total basin drainage area of the Sheyenne River is 10,700 square miles. The Sheyenne River flows into the Red River of the North, which flows northward into Lake Winnipeg in Manitoba, Canada. This drainage area includes 3,800 square miles of closed basins. Of this area, 3,573 square miles is in the Devils Lake basin. The remaining 227 square miles is upstream of the Warwick gage. The remaining 6,900 square miles is divided by the USGS into a contributing drainage area of 4,850 square miles and a noncontributing drainage area of 2,050 square miles. In 1976, The Corps of Engineers made additional studies of the drainage area above Kindred. The purpose was to revise the drainage areas of the sub basins and the total basin using more detailed maps. Drainage areas were broken down into primary, secondary, and noncontributing. Primary contributing areas have a direct watercourse to the main stem of the river. Secondary contributing drainage areas start to contribute when a flood of about the 50-year frequency occurs. The noncontributing drainage areas do not contribute flow and is very close to being a "closed area". The following table gives a break down of drainage areas at key points along the Sheyenne River.

Table 4-1 Drainage Areas for the Sheyenne River at Mainstem Gaging Stations					
Gaging Station	**River Mile**	**Primary Total (sq mi)**	**Secondary Total (sq mi)**	**Non-Contributing (sq mi)**	**Total (sq mi)**
Harvey	542.5	150	263	16	429
Warwick	407.5	709	1,060	288	2,057
Cooperstown	317.0	1,149	1,332	310	2,791
Baldhill Dam	**270.5**	**1,690**	**1,660**	**462**	**3,812**
Valley City	253.0	1,824	1,737	602	4,163
Lisbon	161.1	2,213	1,737	602	4,557
Kindred	68.1	2,630	1,769	612	5,061

In addition to determining the drainage area at the principal stream gaging stations on the Sheyenne River, a study of the tributaries was done as well. The largest tributary is Baldhill Creek, which enters Lake Ashtabula about 12 miles upstream of the dam at river mile 282.0. The drainage areas for Baldhill Creek are presented in **Table 4-2**.

Table 4-2 Drainage Areas for Baldhill Creek					
Location	**River Mile**	**Primary (sq mi)**	**Secondary (sq mi)**	**Non-Contributing**	**Total (sq mi)**
Dazey	14	305	256	152	713

4-02. Topography. The Sheyenne River basin lies in two distinct topographic areas; the rolling drift prairie, which includes all of the basin upstream from the escarpment of the Sheyenne delta near Kindred and the flat Red River Valley plain through which the lower 70 miles of river passes. The Red River of the North valley floor ranges in elevation from 890 feet near the mouth of the Sheyenne River to 950 feet at the margin of the delta near Kindred. The top of the escarpment varies between elevations 1000 and 1020 feet. From the fringe of the delta westward, the elevations of the upland areas range from 1020 to 1700 feet. The Sheyenne River valley above Kindred varies in depth from 100 to 200 feet and ranges in width from ¼ to 2 miles. Of the total basin area, about 92 percent is in farms and about 83 percent of the farmland is improved. Timber is limited to the fringe along the Sheyenne River; however, portions of the river valley floor above Kindred are heavily wooded.

4-03. Geology and Soils. The Sheyenne River basin is underlain by Dakota sandstone, varying in thickness from 100 to 300 feet and lying at depths of 125 feet below ground surface in the eastern part of the basin to 1,500 feet in the western part. Above the sandstone and cretaceous formations is a glacial drift reaching a thickness of 400 feet in the drift prairie region and thinning to less than 100 feet in the lower plains region.

The flood plain of the Red River of the North is the site of glacial Lake Agassiz (**Figure 4-1**), which was formed during the final melting and recession of the ice sheet. The upper shoreline of the lake is indicated by deposits of beach gravel and sand as far westward as a line between Sheldon and Erie. The Sheyenne River brought much sediment into Lake Agassiz and formed a delta that covered the eastern part of Ransom County and a large part of western Richland County.

At the dam site, the top 20 to 50 feet of the valley floor is predominantly a well-consolidated, lean clay, which also contains some sand, silt, and gravel. A sand and gravel lens within this layer extends under a large part of the valley floor, varying in thickness from 1 to 13 feet, with the top of the lens 33 to 34 feet below the ground surface. The sand and gravel lens is water bearing but since it is likely blanketed by impervious material, no appreciable seepage loss from the reservoir is anticipated. Under the clay lies a well-consolidated shale that provides the foundation for the gated spillway structure of Baldhill Dam. The right abutment consists of sandy clay till underlain by shale. The till/shale contact daylights in the abutment area at approximately elevation 1260 feet with a gentle dip of three to four degrees towards the valley. Failures of the overlying till slope have occurred along the till/shale contact where it is exposed along the existing spillway approach and discharge channel. These failures (sloughs) can be observed throughout the Sheyenne River basin along the escarpment. A shear wall founded in shale was constructed in 1972 in an attempt to stabilize the right abutment slope in the area immediately downstream of the embankment. During the dam safety work of the mid-1990's, caissons were installed in the abutment as a further attempt to stabilize the large potential slide area. Ongoing monitoring evaluates the performance of these measures and the impact on the spillway structure.

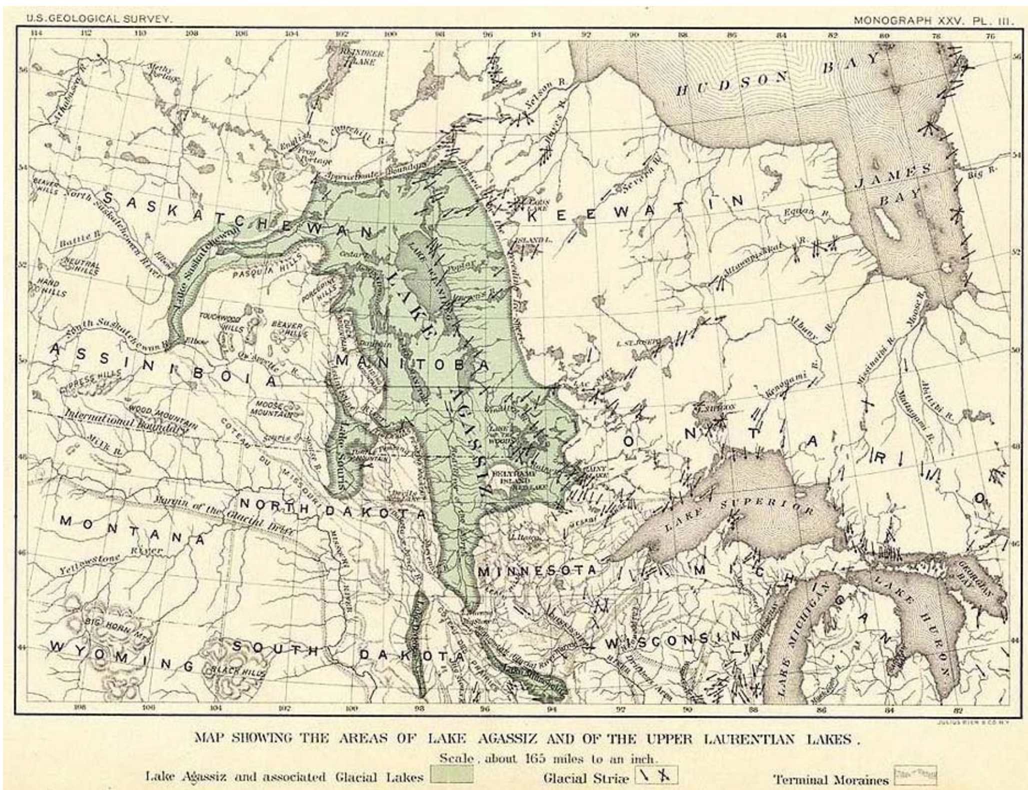


Figure 4-1. Lake Agassiz

4-04. Sediment. Thirty sediment ranges were established at time of construction of the Baldhill Dam (**Plate 4-1**). Sediment surveys were taken in 1952, 1958, 1964, 1971, and 1978. A memorandum dated 31 March 1981 indicated that the "1978 siltation survey of Baldhill shows many errors." The memorandum suggested that because of the errors, another survey should be performed as soon as possible. The next, and latest survey to be performed, was in 1984. To investigate how "bad" the 1978 data set was, **Table 4-3** was developed showing the variation in pool volume over the years. With the exception of 1978, the US Geological Survey (USGS) computed the pool volumes.

Table 4-3
Pool Volume in Acre-Feet

Elevation Feet	Date of Survey					
	1952	1958	1964	1971	1978	1984
1230.0	360	230	252	169	0	243
1240.0	2,977	2,464	2,590	2,295	1,780	2,320
1250.0	16,468	15,320	15,373	14,624	12,680	14,211
1260.0	44,946	43,418	43,201	41,917	39,270	41,238
1270.0	94,083	92,292	92,188	91,167	92,980	90,243

The above table indicates that there were sufficient errors with the 1978 survey to simply ignore the results and base sedimentation rates on the remaining years. **Table 4-4** shows the sedimentation rates as computed by the USGS.

Table 4-4
Sedimentation Rates for Lake Ashtabula

Date of Survey	Period Capacity Loss (ac-ft)		Total Sediment Deposits to Date (ac-ft)		
	Period Total	Average Annual	Total to Date	Average Annual	Per sq mi/year
Dec – 1952	0	0	0	0	0
Jan - 1958	1570	307.8	1570	307.8	0.156
Feb – 1964	194	31.8	1764	157.5	0.080
Jan - 1971	1039	150.6	2803	154.9	0.078
Feb – 1984	929	70.9	3732	119.6	0.060

The USGS computed pool volumes based on elevation and cross-sectional area in five-foot intervals. For the 1984 survey, elevation zones started at elevation 1222.0 feet and went by five-foot intervals to elevation 1280.0 feet with the last interval being three feet. In 1989 Water Control reanalyzed the cross-sectional data based on two-foot intervals and a new table was developed. The change in results was minor. The elevation-capacity and elevation-area curves are presented in **Plate 7-1**. The elevation-capacity table is presented in **Exhibit C**.

4-05. Climate.

a. Precipitation and Temperature. The National Oceanic and Atmospheric Administration (NOAA) complies a *Climatological Data Annual Summary* for North Dakota each year. The annual summary includes the monthly average precipitation and temperature and its departure from the 30-year norm. The nearest data collection sites to the dam are Valley City downstream, and Cooperstown upstream. **Tables 4-5** and **4-6** show the 30-year normal precipitation and temperature for the time period 1970 to 2000.

Table 4-5
30-Year Normal Precipitation in inches – (1970 to 2000)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Cooperstown												
0.57	0.41	0.96	1.65	2.37	3.40	3.13	2.58	2.33	1.21	0.70	0.54	19.85
Valley City												
0.56	0.42	0.96	1.75	2.42	3.25	2.53	2.49	2.08	1.06	0.56	0.52	18.39

The greatest annual precipitation observed in the basin was 32.33 inches at Enderlin in 1975. The second greatest annual precipitation was 30.42 inches at Lisbon in 1941. The lowest annual precipitation in the basin was 7.55 inches at McHenry in 1910. Snowfall averages about 36 inches per year throughout the basin.

Table 4-6
30-Year Normal Temperature in ^{o}F – (1970 to 2000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Cooperstown	5.9	12.3	26.0	42.4	55.7	65.2	70.0	68.4	57.4	45.7	27.3	11.3	40.7
Valley City	4.7	10.9	24.2	40.4	54.1	63.3	68.7	66.2	55.2	43.6	26.3	10.5	39.0

The basin experiences extreme variations in temperature. National Weather Service records show temperature extremes of 118 ^{o}F at Cooperstown on 6 July 1936 and -50 ^{o}F at Maddock Agricultural School on 7 February 1936. The average growing season between the last frost in the spring and the first frost in the fall ranges from about 110 days in the northwestern portion of the basin to about 125 days in the southeastern portion.

b. Lake Evaporation. Evaporation from the reservoir can be substantial. The *Climatic Atlas of the United States* (June, 1968) indicates that the mean annual lake evaporation for Lake Ashtabula is around 30 inches. The National Weather Service Station in Fargo, North Dakota did average monthly pan evaporation measurements for the open water months from 1963 to 1980 (**Table 4-7**). Evaporation from lakes is less than pan evaporation due to the cooler lake water. Assuming a pan coefficient of 0.7 provides a convenient means of estimating reservoir evaporation (*Hydrology for Engineers*, McGraw-Hill, 1958).

Table 4-7
Monthly Average Pan Evaporation at Fargo, ND and
Estimated Monthly Lake Evaporation for Lake Ashtabula – in inches

Location	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
Fargo, ND	3.64	7.15	7.41	8.43	7.31	4.95	3.29	42.2
Lake Ashtabula	2.55	5.01	5.19	5.90	5.12	3.47	2.30	29.5

The US Geological Survey did a study of lake evaporation for Lake Ashtabula and published a report in 2003. **Table 4-8** is a summary of the results.

Table 4-8
Estimated Lake Evaporation for Lake Ashtabula in inches - USGS

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
0.23	0.29	0.71	1.88	3.38	4.58	5.30	5.08	3.66	2.64	0.93	0.32	29.01

c. Wind Speed and Direction. Wind speed and direction are recorded everyday at the dam site. While this is very useful in the daily regulation of the pool, it is not of much use for determining monthly high wind speeds. The aforementioned *Climatic Atlas* contains monthly Fastest Mile information for Devils Lake, North Dakota. Fastest Mile wind speeds are defined as the fastest speed at which wind travels one mile measured over one month. Fastest Mile wind speeds are obtained from measurements taken over a short period of time, usually less than two minutes. The Fastest Mile winds speeds presented in the Atlas were modified to time-dependant (1-hour) average wind speeds using the procedure presented in the US Army Corps of Engineers' *Shore Protection Manual* (1984). The results are presented in **Table 4-9**.

Table 4-9
Highest Monthly Wind Speed and Direction in MPH for Devils Lake, ND

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Direction	NW	N	N	N	NW	W	NW	NW	NW	N	N	NW
Fastest Mile	41	54	54	47	52	50	56	47	46	47	57	42
1-Hour	34	45	45	39	43	42	47	39	38	39	48	35

As part of the five-foot pool rise, a wave analysis for cabins impacted by the new pool elevation was performed (**Exhibit D**). As part of this analysis it was determined that the average maximum April wind speed was 38.125 miles per hour. This is in agreement with the **Table 4-9**.

d. Wind Setup. The wind blowing across the lake surface exerts a horizontal force on the water surface and induces a surface current in the general direction of the wind. The horizontal currents induced by the wind essentially cause water to "pile up" on the downwind side resulting in a water level rise downwind and a water level drop upwind. The lowering of the water surface is called "wind set down" and the rise in water level is called "wind setup". Engineering Manual (EM) 1110-2-1414 suggests that the rise in water can be estimated by the following equation:

$$S = (U^2 F) / (1400 D)$$

S = Wind Setup (ft)
U = Wind Speed (mph)
F = Fetch Length (miles)
D = Average Depth over Fetch (ft)

This equation appears to under predict wind setup. For example, consider a 20 mph wind blowing over a three mile fetch with an average depth of 30 feet. Wind setup would only be 0.03 feet when in actuality we know it is much closer to 0.2 feet. While it is recognized the relationship between wind speed and wind setup is not linear, a rule of thumb has been developed that seems to work out quit well. For every ten miles per hour of wind speed, assume the pool level change to 0.1 feet. Therefore a north wind at 20 mph would cause a 0.2-foot rise in the pool surface at the dam. Conversely, a south wind of 10 mph would result in a lowering of the water surface at the dam by 0.1 feet.

4-06. Storms and Floods. Flooding of the Sheyenne River usually occurs during March or April and occasionally continues into May. The primary source of the flood flows is the winter's accumulation of snowfall, as the high temperatures and rainfall of spring combine to cause the rapid melting of the snow cover. The depth of frost in the ground at break-up time and the condition of the river channel affect the magnitude of the spring floods. Frozen earth contributes to larger runoff by preventing infiltration. A channel blocked by ice or drifts of packed snow forces river stages to be higher. There were several major floods on the Sheyenne River before construction of Baldhill Dam, the largest of which was 1882. The *Valley City Times* indicated that rain, warm weather, melting snow and ice, and the formation of ice gorges contributed to the high flood stages. The estimated peak flow at the present location of Baldhill Dam was 5,500 cfs. In recorded history, the largest discharge prior to construction of the dam was on 27 or 28 April 1948 when the discharge reached 4,600 cfs. Many floods have occurred since construction of the dam, with the first flood occurring before the dam was completed. **Table 4-10** gives a summary of peak discharges and elevations.

Table 4-10
Historic Peak Discharges and Pool Elevation

Month/ Year	**Inflow to Reservoir (cfs)**			**Outflow (cfs)**	**Elevation/Stage (ft)**	
	Cooperstown Peak[1]	Dazey Peak[1]	24 hr Peak Inflow[2]	Instantaneous Peak Outflow[1]	Peak Pool Elevation[2]	Peak Stage Valley City[1]
May 1950	7,830	na	na	3,150	1269.46	14.60
Mar 1966	3,040	1,880	3,800	3,250	1267.90	14.27
Apr 1969	5,050	2,510	5,170	4,580	1267.50	17.62
Apr 1979	4,680	~ 9,000[3]	8,810	4,740[4]	1268.55	na
Jul 1993	2,780	1,450	6,100	3,720[5]	1268.57	17.30
Apr 1996	6,760	1,900	8,100	5,460	1267.41	18.78
Apr 1997	5,280	2,780	6,557	4,510	1267.51	18.01
Apr 2004	3,610	2,550	5,450	3,740	1270.50	14.70

1. Taken from *USGS Water Resources Data*, North Dakota.
2. Taken from Water Control's web site for Baldhill reservoir data.
3. Estimated by USGS from floodmark.
4. Reported by USGS. Water Control records indicate 4,990 cfs and have not been updated.
5. Reported by USGS. Water Control records indicate 4,375 cfs and have not been updated.

a. May 1950. The snow survey taken in early March indicated that the average snow-water content for the Sheyenne River basin was 3.0 inches. By mid-April additional precipitation had increased the water content to 5.0 inches. The threat of serious flooding forced the Baldhill Dam project into emergency operation on 16 April. Storage of the reservoir began on 30 July 1949 and the dam was completed in September 1949. By 31 March 1950 the pool was at elevation

1243.90 feet with 5,300 acre-feet of storage. By 16 April the pool elevation had risen to 1255.39 feet. It was very fortunate the pool was this low (maximum drawdown elevation is 1257.0 ft). The inflow at Cooperstown hit a record high discharge of 7,830 cfs on 17 April (stage 32.62 ft). On 24 April the pool crested at 1267.72 feet with a maximum discharge of 2,680 cfs. That meant the tainter gates were open about 1.5 feet each putting the top of gate at elevation 1268.5 feet, thus containing the pool. By the 6th of May the pool had fallen to elevation 1265.90 feet; however, an additional 3.0 inches of rainfall fell causing a second crest to occur. Cooperstown, which had fallen to a discharge of 1,300 cfs, crested at 3,390 cfs. On 14 May the pool crested at elevation 1269.46 feet with a maximum discharge of 3,150 cfs. It was estimated that the operation of Baldhill Dam reduced the flood crest in Valley City by about six feet.

Because the project was pressed into emergency service, there is little documentation of the event; however, gate positions can be estimated based on discharge. If the top of gates were at elevation 1269.5 feet, the gate opening would be 2.5 feet per gate and discharge would be in excess of 5,500 cfs. Therefore, the gates were probably opened 1.5 feet each, passing a total discharge of around 2,750 cfs. With the gates at this position, there was approximately one-foot of water passing over the top of the gates with a discharge of approximately 400 cfs. It is interesting to note that water was allowed to pass over the top of the gates. It would not happen again until 1993.

b. March 1966. Before winter freeze-up, the ground was well saturated in the fall of 1965. Snow-water equivalents on the 1st of March varied from 0.5 to 1.5 inches. On 2-5 March a widespread blizzard occurred. By the 5th of March, snow on the ground varied from 15 to 30 inches. Snow-water equivalent measurements taken on the 8th of March averaged around 2.75 inches. Frost varied from one to two feet. The pool had been drawn down to elevation 1261.5 feet by 11 March. The rapid snowmelt had begun and runoff began to occur on the 12th of March.

The pool crested at 1267.90 feet on the 26th of March. Peak outflow was 3,250 on 28 March.

c. April 1969. Precipitation over the Sheyenne River basin from October 1968 through February 1969 ranged from 1.5 to 2.5 times normal. The unusual rains left the ground saturated. The cold air masses from Canada resulted in temperatures 4 ^{o}F to 6 ^{o}F degrees below normal during December and January. Frost depths of three to four feet were reached in the basin by 10 March. By mid-March the basin was covered with 21 to 34 inches of snow. The snow cover began to melt in late March but cold weather halted the melting for about a week. By the 5th of April the pool had been drawn down to elevation 1257.8 feet. Melting resumed when 0.5 to 1.5 inches of rain fell during the period of 7 to 10 April. By 17 April, Cooperstown had a peak discharge of 5,050 cfs. Despite the large drawdown on the reservoir, peak outflow from the dam was 4,580 cfs with a peak pool elevation of 1267.50 feet.

d. April 1979. On 5 February, the snow pack had a water equivalent of 2 to 3 inches. By 12 March this had increased to 4 to 5 inches. Temperatures in late March early April were below normal and very little melting of the snow pack had taken place. Therefore, much of the 4 to 5 inches of the snow-water was still on the ground when on the 12th and 13th of April a rainstorm produced 1 to 2 inches of rain over the basin. The combination of rainfall on a primed snow pack and temperatures above freezing throughout the melt resulted in very rapid runoff. It was fortunate that soil moisture condition from the previous fall was below normal. It was hoped that this would reduce the runoff. The peak discharge at Cooperstown was 4,680 cfs, but it was Baldhill Creek that really got hit. The peak discharge of about 9,000 cfs occurred when an upstream roadway embankment failed. The 30-day volume of the 1979 flood was nearly four times the available flood control storage in Lake Ashtabula with over half of its volume coming in less than 10 days. To save the City of Valley City, the placement of flashboards atop the gates at Baldhill Dam was authorized. This successfully reduced outflow to a peak discharge of 4,740 cfs with a peak pool elevation of 1268.55 feet on 23 April.

e. July 1993. The flood of 1993 occurred during a season of unusually high precipitation throughout the upper Midwest. Precipitation ranged between two to three times normal throughout most of the region leaving the ground saturated. Intense storms would form in the weather front convergence zone, which persisted due to the unusual jet stream pattern. On 16 July, an early morning thunderstorm dropped between 5.5 to 6.5 inches of rain between Baldhill and Valley City. Releases from the dam were held back to benefit Valley City. The pool crested at elevation 1267.4 feet on 18 July. By 24 July, the pool had only fallen one foot (1266.4 feet). On 25 July, a storm dropped six plus inches of rain in the vicinity of Cooperstown. While inflow at Cooperstown and Dazey were moderate, the impact of the local rainfall resulted in a 24-hour peak inflow of 6,100 cfs on 26 July. To benefit Valley City, flow over the top of the gates was authorized thus allowing the pool to surcharge. While the overtopping was not very high and the duration was quite short, the reduced discharge was of great benefit to Valley City. The pool crested at elevation 1268.57 feet with a peak discharge of 3,720 cfs on 28 July.

f. April 1996. The summer and fall months of 1995 experienced above average precipitation over the Sheyenne River basin. The excessive precipitation throughout the fall held base stream flow at record highs and left the soil moisture extremely high well into winter freeze-up. By mid-March heavy snowfall throughout the winter had accumulated such that the entire basin had average snow-water content of four to five inches. The pool drawdown target was elevation 1257.0 feet (maximum drawdown). This was achieved on 25 March. Although the snow cover began to melt in late March, cold weather halted the melting for about a week. The combination of the late melt, extreme antecedent conditions conducive to excess runoff, and high snow-water content provided conditions for a large flood above the flood control project. Runoff started up again on the 5th of April with inflow rising from 500 cfs to over 4,000 cfs on the 11th.

On 15 April the US Geological Survey (USGS) measured 4,090 cfs at Cooperstown. At this time Baldhill Dam releases were at 3,650 cfs. Another measurement was made on 17 April and was reported to Water Control as 5,390 cfs. Baldhill Dam releases at this time were 4,400 cfs. On the 18th another measurement was taken at Cooperstown and reported as 8,090 cfs along with a record stage of 19.07 feet. Water Control prepared a new inflow hydrograph and projected the peak inflow to be approximately 9,000 cfs. Based on this, a plan was devised to raise outflows from the present 4,700 cfs to 6,000 cfs. Downstream communities were notified and discharge from the dam was increased to 5,000 cfs at 0230-hours on the 19th. At 1230-hours outflow was increased to 5,400 cfs. At 1615-hours on 19 April, Water Control received a call from the USGS indicating that discharge measurements taken on the 17th and 18th were about 20 percent high. The measurement on the 17th was 4,740 cfs, not 5,930 cfs and the measurement on the 18th was 6,760 cfs, not 8,090 cfs. Water Control asked for an additional confirmation of the measurements and cut outflows to 5,250 cfs. With the rising pool, outflows crept up to 5,400 cfs on the morning of the 20th. The USGS reported a discharge of 5,740 cfs at Cooperstown. Inflows remained high but Water Control was able to ratchet down outflow to 3,500 cfs by 25 April. The 30-day runoff volume was over four times the available flood control storage. The release of 5,400 cfs on 20 April was a new record. The pool crested on 26 April at elevation 1267.41 feet.

g. April 1997. By early January snow depth over the Sheyenne River basin was over 26 inches. By the end of January it had reached 34 inches with a snow-water equivalent of 6.4 inches. By mid-March water content had reached 6 to 8 inches over the entire basin. On 14 March, the National Weather Service issued their Spring Snowmelt Flood Potential, which indicated a "severe" potential for the Sheyenne River. By the end of March the pool had been drawn down to elevation

1257.0 feet (maximum drawdown). Snowmelt began in late March. On 4-6 April, the blizzard ‘Hannah’ hits the basin dropping 10 to 14 inches of wet snow. The storm was followed by several days of abnormally low temperatures. Inflow to the reservoir dropped off from 5,000 cfs to 1,100 cfs. The cool period was followed by warm weather. Inflow to reservoir increased daily until it crested on 19 April with a 24-hour peak of 6,660 cfs. Outflow crested the same day at 4,510 cfs. The pool crested on 30 April at 1267.51 feet. The regulation of Lake Ashtabula reduced peak river stages at Valley City by 4.4 feet. This resulted in $42.1 million in flood damages prevented in Valley City and along the lower reaches of the Sheyenne River.

h. April 2004. The fall of 2003 had been so dry that the National weather Service’s Drought Monitor had listed basin as being abnormally dry. Winter snowfall was moderate. Water Control began to become concerned about the ability to fill the reservoir from drawdown. By mid February there was 14 inches of snow on the ground with a snow-water equivalent of 2.0 inches. Water Control decided to truncate the drawdown at elevation 1263.2 feet and sought an approval for a deviation from the Division Office. On 13 February, Public Affairs made a news release stating the new drawdown target had been achieved.

By early March, additional snowfall increased the snow-water equivalent over the basin to over three inches. While this was a significant amount of water, the fall drought conditions coupled with the shallow frost depth indicated that the current drawdown was sufficient.

Runoff to the reservoir began on 25 March. On 27-28 March, two to three inches of rain fell over the entire basin above the dam. This rainfall on top of the ripe snow pack resulted in a large volume of runoff. A peak inflow of 5,450 cfs occurred on the 2nd of April. Maximum outflow was limited to 3,700 cfs while the new flood storage made available by the five-foot pool rise for flood control was put into use. Outflow remained at or near 3,700 cfs for a week. The pool crested at 1270.50 feet on 7 April. This established a new record pool elevation. North winds were sustained at 30 to 35 mph. This resulted in 0.35 feet of wind setup at the dam. Combined with wave action, water overtopped the emergency spillway (crest elevation 1271.0 feet). See **Figure 4-2**.

Figure 4-2. Baldhill Dam Flood Crest Spring 2004

An After Action Report was prepared by Water Control following this event. Its recommendation was that all future drawdowns follow more closely the guidelines presented in **Chapter 7**.

4-07. Runoff Characteristics. The basin above the dam is "L" shaped (see **Plate 5-1**). Runoff is tracked at the Warwick gage in the upper basin to Cooperstown in the lower basin. There is 91 miles of stream between the two gage sites. Travel time from Warwick to Cooperstown is about five days. Cooperstown is 47 miles from the dam. Travel time into the reservoir is about two days. Baldhill Creek enters the reservoir about 12 miles upstream of the dam. The Baldhill Creek stream gage is at Dazey, 14 miles upstream of the mouth. Travel time from Dazey to the reservoir is less than one day. Stage and discharge are monitored at all three sites (i.e. Warwick, Cooperstown, and Dazey) by the US Geological Survey. The timing of the peak at Dazey can be critical to the peak inflow to the reservoir. Baldhill Creek typically crests before Cooperstown. The timing difference in peak discharges can be as short as one day (1979, 1993) to as long as 20 days (1997). The most likely time frame is about one week (1969, 1996, 1999, 2004).

Spring runoff is dependant upon antecedent moisture conditions, snow-water content, frost depth, speed of snowmelt, and amount of rainfall. Water Control has an HEC-1 model of the upper basin but it does not include snowmelt. While there is no reliable method for forecasting an inflow hydrograph to the reservoir during spring runoff, the National Weather Service (NWS) has had some success in modeling the snowmelt. Water Control uses US Geological Survey's (USGS) published discharges for Cooperstown and Dazey, along with input from the NWS, to develop an inflow hydrograph. The inflow hydrograph is input to the program "Flood Routing" which forecasts pool elevation based on the gate operation schedule. The gate operation schedule is developed through iterative use until the desired peak pool elevation and minimum reservoir outflow has been achieved. The gate operation schedule is updated as changes in the inflow hydrograph are observed. Coordination with the NWS during a flood event is part of the standard operating procedure.

Inflow to the reservoir can be anywhere from close to zero up to over 9,000 cfs. Inflow is computed based on the 24-hour change in pool elevation and the known outflow. Every morning at 0800-hours site personnel input to "Secure CRT" the pool elevation, from the Corps pool gage, and the outflow, as published by the USGS. The reservoir program then calculates the 24-hour average inflow to the reservoir using the 1984 stage-storage table. The accuracy of the computed inflow is dependant upon the stage-storage table, the published USGS discharge, and the pool elevation. Pool evaporation is not accounted for. Wind influence on the pool elevation is the most critical factor in the computation. When the wind is out of the north, the pool is blown up and the calculated inflow will be high and visa versa for a southern wind. **Table 4-11** shows the average monthly and annual 24-hour computed inflow rate to the reservoir.

Table 4-11
Monthly Average Reservoir Inflow – cfs (1951 through 2003)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
23	27	290	825	287	173	142	69	35	46	53	30	168

Note that evaporation my exceed inflow such that the monthly average can be a negative inflow. The lowest recorded monthly average inflow was a –95 cfs for September 1955. This equates to about one-foot of evaporation for the month or about double the normal amount. The highest recorded monthly inflow was the month of April 1997 with an inflow of 4,266 cfs. Annual inflow volume can vary greatly from year to year. **Figure 4-3** shows annual inflow volume to Lake Ashtabula from 1967 through 2000.

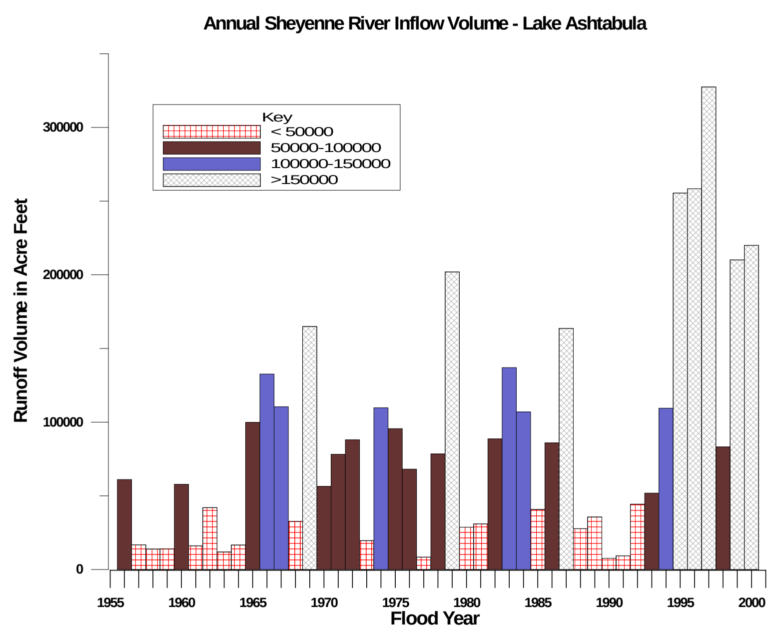


Figure 4-3. Annual Inflow Volume to Lake Ashtabula

An inflow duration table was developed based on the computer generated 24-hour inflow values for the time period 1 January 1951 through the 31 December 2003. **Table 4-12** indicates there is less than a one percent chance that inflow will be over 6,000 at any given time in the month of April.

Table 4-12
Inflow Duration
Percent of Time at or above Indicated Discharge

Flow	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
6000				0.9								
5500				1.7								
5000				2.3								
4500				3.5								
4000			0.4	4.4	0.2		0.4					
3500			1.0	5.7	0.4		0.5					
3000			1.4	7.1	0.5		0.6					
2500			1.8	9.2	0.9	0.3	0.6					
2000			2.9	12.4	1.5	0.7	0.7	1.6				
1500			6.2	17.7	2.7	1.5	0.8	1.8	0.1	0.3		
1000		0.3	9.4	28.8	7.0	3.1	2.3	2.6	0.5	1.7	0.5	
750		0.4	12.5	37.3	13.7	5.8	5.5	3.9	2.1	3.7	1.4	
500		0.6	19.2	48.8	28.2	13.3	12.2	8.6	4.4	6.3	3.6	
400		0.7	22.7	56.6	35.7	21.9	17.5	11.9	8.0	9.1	6.1	0.2
300	0.2	1.0	27.7	63.4	47.3	32.9	26.7	18.7	13.8	15.1	9.5	1.1
200	0.3	1.8	37.3	73.4	60.6	48.6	41.5	31.2	25.7	25.0	15.8	2.6
100	6.8	9.7	51.6	86.6	77.8	70.6	63.0	52.8	47.6	48.0	35.2	11.5

The change in the operating plan in 2004 significantly impacted the pool-duration curve. To present a pool-duration curve based on the old operating plan would be of limited value. It is therefore not presented in this manual.

4-08. Water Quality. The construction of Baldhill Dam changed a free-flowing river into a lake system and resulted in changes to the aquatic ecosystem. During runoff periods, the agricultural upland sources contribute minerals and nutrients, such as nitrogen and phosphorus to the Sheyenne River. These minerals and nutrients accumulate in Lake Ashtabula and cause what is known as eutrophication. Lake eutrophication leads to algae blooms, the potential for oxygen depletion, and changes in the aquatic community, usually with an increase in undesirable species.

On 26 May 1976, the Environmental Protection Agency, Region VIII released a preliminary report on the eutrophication of Lake Ashtabula. This report established that Lake Ashtabula was eutrophic. The lake was sampled three times during the open-water season of 1974. Samples were collected from four stations on the lake. Survey limnologists noted heavy algal blooms and extensive beds of submerged macrophytes during sampling visits. The Department of Health stated that the lake had a history of excessive aquatic vegetation and algal blooms, periodic depletion of dissolved oxygen, and fish kills. Sampling revealed that phosphorous loading at this time was 1.46 g/m^2/year. This was over three times what was proposed as a eutrophic loading. It was estimated that non-point sources contributed 93.7 percent of the total phosphorous loading during the sample year.

In April 1997, the US Geological Survey (USGS) installed water quality sensors downstream of Baldhill Dam at the tailwater gage site. The sensors monitor water temperature and specific conductance. The period of record is 1997 to present. Extremes for the period of record through 2001 are:

Max Water Temperature:	28.3 ^oC	20 Jul 1998
Min Water Temperature:	0.3 ^oC	16 Apr 1997
Max Specific Conductance:	1,640 microsiemens	18-27 Feb 2001
Min Specific Conductance:	401 microsiemens	14 Apr 1999

Other measurements are taken in April, May, June, July, and August. These measurements include: Oxygen (% saturation, mg/l), PH (field, lab), Hardness (mg/l $CaCO_3$), Calcium (mg/l Ca), Magnesium (mg/l Mg), Potassium (mg/l K), Sodium (absorption ratio, mg/l Na, %), Chloride (mg/l Cl), Fluoride (mg/l F), Sulfate (mg/l SO_4), Solids (tons/day), Turbidy (NTU), Arsenic (ug/l As), Iron (ug/l Fe), Lead (ug/l Pb), Lithium (ug/l Li), Manganese (ug/l Mn), Molybdenum (ug/l as Mo), Selenium (ug/l Se), Strontium (ug/l Sr), and Suspended Sediment (mg/l). Water quality records are also kept for Warwick, Cooperstown, and Valley City. The period of records are; Warwick: 1958 to present, Cooperstown: 1960 to present, Valley City: 1972 to present. All water quality data can be obtained from the USGS *Water Resources Data, North Dakota* book for the year in question.

4-09. Channel and Floodway Characteristics. The Corps of Engineers property line crosses the channel in an east–west direction about 2,000 feet downstream of the centerline of the dam. Channel improvements extend 735 feet downstream of the stilling basin. The channel capacity downstream of the dam is around 2,800 cfs at a stage of 31.0 feet. Rural flooding begins at a stage of 32.0 feet (~3,250 cfs). See **Exhibit E** for the rating table.

The project is operated for flood control at Valley City. Cities downstream of Valley City also benefit, but to a lesser degree. It is 17 miles from the dam to Valley City. A rating table for Valley City is shown in **Exhibit E**. At a discharge of 1,700 cfs the golf course in town has to close sluice gates, which adds to their interior drainage issues. At 2,000 cfs, the golf course bridge begins to become impassable. At 2,400 cfs, water begins to come out of the channel at Valley City. When the Valley City gage reaches 12.7 feet (~2,800 cfs), the city begins to close storm sewers. **Exhibit B** includes a list of the Valley City culverts and drains with a priority of closure taken from the *Valley City Emergency Flood Plan*. The list goes up to a stage of 23.0 feet. The top of the emergency levees is at 18.0 feet (~4,800 cfs). The record stage was 18.78 feet in 1996 at a discharge of around 5,500 cfs.

Channel capacities for the Sheyenne River as well as travel times from city to city are shown in **Table 4-13**. On Baldhill Creek, the travel time from Dazey to the dam is less than one day.

Table 4-13
Sheyenne River Channel Characteristics

Location	River Mile	Channel Capacity	Travel Time
West Fargo	25	2,250 cfs	> 2 days
Kindred	68	2,800 cfs	> 4 days
Lisbon	162	2,250 cfs	> 3 days
Valley City	253	2,400 cfs	> 1 day
Baldhill Dam	270	2,000 cfs	> 2 days
Cooperstown	317		> 5 days
Warwick	408		

4-10. Upstream Structures. The only hydraulic structures upstream of Baldhill Dam are the channel controls for the following gage sites; Baldhill Creek near Dazey, Ueland Dam on the Sheyenne River at Cooperstown, and the Sheyenne River at Warwick. See **Chapter V**.

4-11. Downstream Structures. Just below the Baldhill Dam, the US Fish and Wildlife Service operates 20 fishponds. Water supply for the ponds is siphoned off the reservoir at a rate of about 9.0 cfs. For more information see paragraph **2-04. Related Control Facilities.**

Approximately 17.5 miles downstream of the dam is Valley City. There are small dams in town that provide aesthetics for the riverfront. Between Valley City and Horace there are no structures in the Sheyenne River. The Horace to West Fargo Diversion begins just upstream of Horace. This joins the West Fargo Diversion downstream. For more information see paragraph **3-04. Related Projects**. Just downstream of Horace, on the Sheyenne River, is the Fargo Diversion Dam and Ditch. Its purpose was to provide water to Fargo during low flow conditions via the Stanley Ditch and the Red River of the North. For more information see paragraph **2-04. Related Control Facilities**.

The Maple River enters the Sheyenne River a few river miles upstream of the mouth. A dam on the Maple River is scheduled to be completed around 2007. It is presently under construction. It is located in Cass County some distance upstream of the mouth (**Figure 4-4**). It will control an area of 902 square miles and have a storage capacity of 60,000 acre-feet. The outlet will consist of a 66-inch reinforced concrete pipe and an emergency spillway 1,200 feet in width. The dam will have a maximum height of 70 feet and a top width of 25 feet.

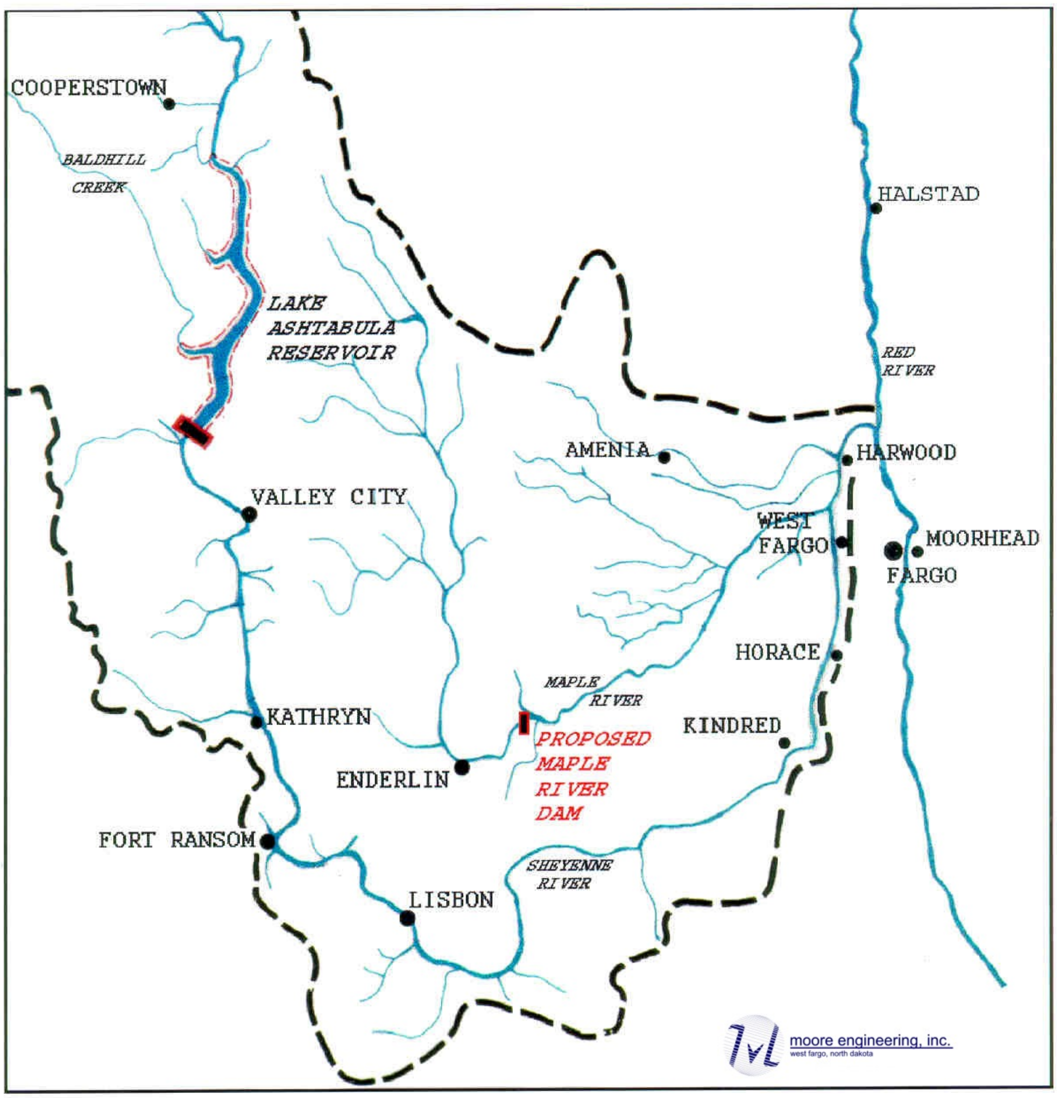


Figure 4-4. Proposed Maple River Dam

4-12. Economic Data.

a. Population. Barnes and Griggs Counties border Lake Ashtabula. The upper basin is in Nelson, Eddy, and Benson Counties. Below Baldhill Dam and Barnes County, the Sheyenne River runs through Ransom and Cass Counties. The following table shows population changes for these counties.

Table 4-14
Sheyenne River Basin - Population by County

County	Population Estimate 2003	Population 2000	Percent Change	
			1 Apr 2000/ 1 Jul 2003	1990/ 2000
Benson	6,881	6,964	-1.2 %	-3.3 %
Eddy	2,598	2,757	-5.8 %	-6.6 %
Nelson	3,454	3,715	-7.0 %	-15.8 %
Griggs	2,578	2,754	-6.4 %	-16.6 %
Barnes	11,083	11,775	-5.9 %	-6.1 %
Ransom	5,838	5,890	-0.9 %	-0.5 %
Cass	127,138	123,138	3.2 %	19.7 %

While **Table 4-14** shows the population changes for the counties in the Sheyenne River basin, **Table 4-15** shows the population changes for the major metropolitan areas in each county.

Table 4-15
City/Town Population Change in the Sheyenne River Basin

County	City/Town	1990	2000	Change
Benson	Maddock	559	498	-10.9 %
Eddy	New Rockford	1,604	1,463	-8.8 %
Nelson	McVille	559	470	-15.9 %
Griggs	Cooperstown	1,247	1,053	-15.6 %
Barnes	Valley City	7,163	6,826	-4.7 %
Ransom	Lisbon	2,117	2,292	7.6 %
Cass	Kindred	569	614	7.3 %
	West Fargo	12,287	14,940	17.8 %

b. Industry. There is little industry within the basin. What does exist is related directly to agricultural products produced. **Table 4-16** shows the number of paid employees within each job service listed.

Table 4-16
Economic Statistics for Counties within the Sheyenne River Basin
1997 Economic Census, NAICS Basis

Job Description	Number of Paid Employees by County						
	Benson	Eddy	Nelson	Griggs	Barnes	Ransom	Cass
Manufacturing							6,757
Wholesale Trade	36	42	188	83	281	154	5,945
Retail Trade	76	59	114	133	602	275	9,697
Real Estate	60	10	11	10	2	8	1,067
Professional	2	10	14	10	58	15	2,378
Administrative	10		10	60	56	10	3,977
Education					10		117
Health Care	10	10	118	10	106	60	5,939
Entertainment	375	10	10	10	23	19	769
Accommodations	60	55	68	71	318	176	7,184
Other Services	10	15	12	15	99	24	2,507

c. Agriculture. Forests only comprise 1.2 percent (43,700 acres) of the total Sheyenne River basin (~3,650,000 acres). Cropland, range and pasture, and urban land uses constitute the major portion (94.1 percent) of the basin's area. The main crops are grain, soybeans, sugar beets, and sunflowers.

d. Flood Damages. While the reservoir is drawn down in the winter to provide flood benefits during spring runoff, there are also agricultural flood benefits during the summer months. One foot of storage above the normal pool level is used to contain the peak runoff from summer thunderstorm events. Benefits during spring runoff are mainly felt in Valley City and to a lesser extent at Lisbon, Kindred, and Fargo. Every year Water Control sends a *Water Control Management Activities* report to the Division Office. As part of this report, flood damages prevented for that year are summarized. Peak inflow discharge is routed downstream and the peak stage at damage centers is recorded. The without-project stages as well as with-project stages are sent to Economics Section who in turn compute flood damages prevented. The 1997 report indicates that the Baldhill Project had prevented $179,262,500 in damages through 1996. Following the flood of 1997, the cumulative total reached $221,362,500, an increase of over $42 million. The cumulative total as of FY 2000 was $254,981,600.

V – DATA COLLECTION AND COMMUNICATION NETWORKS

5-01. Hydrometeorological Stations.

a. Facilities. The regulation and operation of Baldhill Dam requires a system of stream gages. Inflow to the pool is monitored at Warwick, Cooperstown, and Dazey. Warwick and Cooperstown are on the Sheyenne River while Dazey is on Baldhill Creek. The pool elevation is recorded at the pool gage located at the west end of the dam. Tailwater elevations are recorded on the right bank, one tenth of a mile downstream of the dam. The project is operated for flood control at Valley City and therefore, stages are monitored in town. Gage locations are shown on **Plate 5-1**. The following is description of each gaging facility.

(1) Warwick Gage. This gage is located on the left bank of the Sheyenne River, 138 miles upstream of the dam and 3.3 miles south of Warwick. The gage was established in October 1949. Gage zero is elevation 1370.0 feet NGVD 1929.

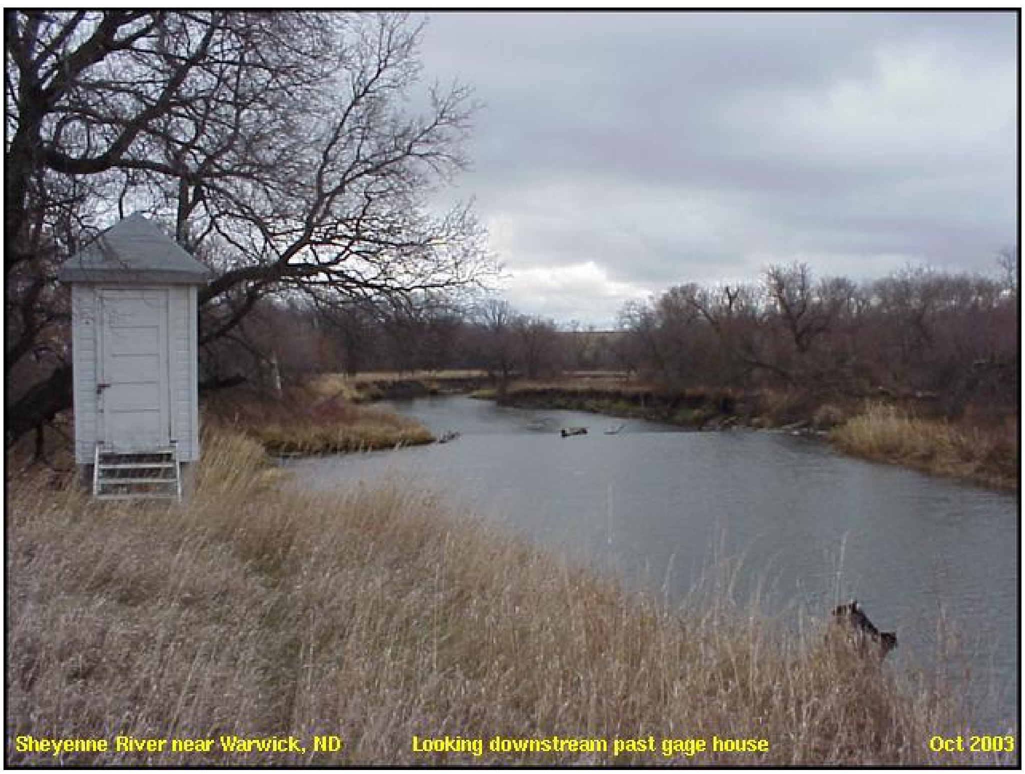


Figure 5-1. Warwick Gage on the Sheyenne River

There is a concrete weir just downstream of the gage that maintains a pool for discharge measurements during low flow. High flow measurements are made at the County Highway #20 bridge just upstream. There is a wire weight on the bridge. The site has a Data Collection Platform (DCP). The US Geological Survey (USGS) posts the hourly stage and discharge on their web site. Equipment at the site consists of a Sutron 8210 data logger with voice modem. AC power is available at the site. The gage is a stilling well with a tape indicator and a Sutron encoder. There is a staff gage in the well used to verify the tape. Because of the close proximity of a tree (**Figure 5-1**), the tipping bucket was mounted to the tree itself. A branch was sawn out of the tree thus opening the area to the sky. The bucket was attached to the stump of the branch. All the equipment is owed by the Corps of Engineers; however, it is maintained by the USGS through a cooperative agreement.

(2) Cooperstown Gage. The Cooperstown gage is located on the right bank, upstream of Ueland Dam, 0.7 miles downstream from State Highway 200, 5.0 miles east of Cooperstown, and 47 miles upstream of the dam (see **Figure 5-2**). The gage was established in October 1944. While the gage location is remote, AC power is available. The isolated gage location makes the gage house an ideal target for vandalism. Note the light brown spots on the door. These are bullet holes. There are also numerous holes on the side of the house as well. The tipping bucket located on the roof has over 20 bullet holes in it. The antenna has also been shot up.

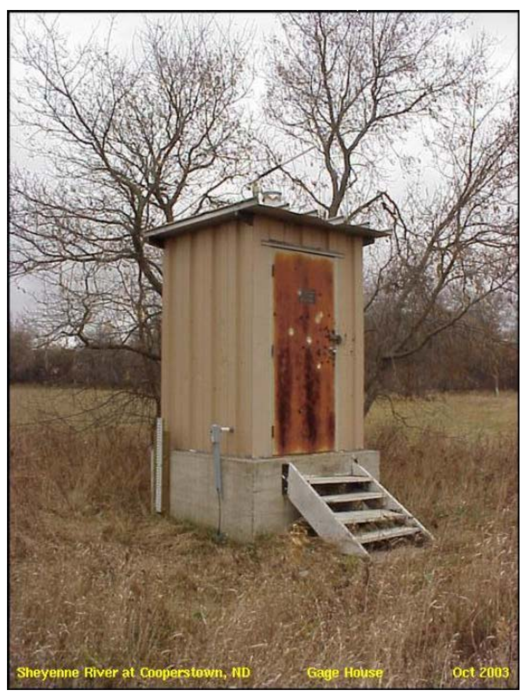


Figure 5-2. Cooperstown Gage.

To lower gage replacement costs, a layer of Kevlar was installed to protect the equipment inside the gage house. Equipment consists of a Sutron 8210 data logger with voice modem. A Design Analysis H-350/355 self-purge pressure sensor determines stage. Gage zero is elevation 1271.76 feet NGVD 1929. There is also a Campbell CR-10 Water Quality Sensor that is the property of the US Geological Survey (USGS). The Ueland Dam (**Figure 5-3**) provides a pool for low flow discharge measurements. During high flows, water passes over the wing walls and the structure is no longer visible. High flow measurements were taken at the bridge just downstream of the gage until the left abutment began to fail. High flow measurements are now taken at the County Highway 200 bridge about three quarters of a mile upstream of the gage. At Ueland Dam, there is a staff gage on the right bank wing wall. There is also a staff gage attached to the corner of the gage house platform (**Figure 5-2**). All the equipment at the site is the property of the Corps of Engineers; however, the USGS maintains the gage and places the hourly stage and discharge on their web site.

Figure 5-3. Ueland Dam at the Cooperstown Gage.

(3) Dazey Gage. The gage is located on the left bank of Baldhill Creek 14 miles upstream of the mouth and 4.5 miles northeast of Dazey (**Figure 5-4**). Baldhill Creek enters the reservoir about 12 miles upstream of the dam.

Figure 5-4. Dazey Gage on Baldhill Creek.

The gage was established in March 1956. The site has a Data Collection Platform (DCP). The US Geological Survey posts the hourly stage and discharge on their web site. Gage zero is elevation 1330.0 feet NGVD 1929. The gage site is a well with a Sutron encoder and a tape indicator. There is a staff gage inside the well to verify the tape. Equipment consists of a Sutron 8210 data logger with voice modem and a tipping bucket. There is a sheet pile weir downstream of the gage that provides a pool for discharge measurements during low flows. High flow discharge measurements are taken at the county highway bridge 500 feet downstream. The staff gage located on the left bank just upstream of the weir was removed by ice in the spring of 2004. All of the equipment is owned by the Corps of Engineers but is maintained by the USGS.

(4) Pool Gage. The pool gage house is a "concrete bunker" installed with the dam in July 1949. It is located on the right bank of the dam next to the maintenance shed (**Figure 5-5**). Drainage area above the gage is 7,470 square miles with 5,560 square miles not contributing. The gage is a well with a tape indicator and a Sutron encoder. There is a staff gage in the well used to verify the treading on the tape. Equipment consists of a Sutron 8210 data logger with voice modem but no telephone line. There is a Sutron 8200 that backs up the 8210 and is strictly used to maintain a record of the pool elevation. AC power is available. All of the equipment is owned by the Corps of Engineers. It is maintained by the Water Control gage crew. A telephone line was run into the gage house in the fall of 2005.

Figure 5-5. Pool Gage House.

(5) Tailwater Gage. The tailwater gage is located on the right bank of the Sheyenne River at river mile 270.5 (**Figure 5-6**). It is one tenth of a mile downstream of the dam and is 8.0 miles northwest of Valley City. In October 1949, the gage was established 600 feet downstream of Baldhill Dam. On 29 December 1994 it was moved 0.7 mile downstream to the county road crossing. A rock weir was constructed in the channel providing a pool for low flow discharge measurements. In the spring of 2000, the rock weir became flanked and needed repair. The repair work would require access through private land, which proved to be difficult. Therefore, on 18 September 2000 the gage was relocated back to government owned land at the tailwater of the dam. The gage site has a Data Collection Platform (DCP). It is equipped with a Sutron 8210 data logger with voice modem, however because of the gage's close proximity to the control house, no telephone line is needed. Water levels are determined by a Design Analysis H-350/355 self purge pressure sensor. There is no AC power at the site, therefore a solar panel is provided to maintain a charge on the battery. There is a staff gage at the site to verify the gage reading. Low flow discharge measurements are taken near the gage site a short distance downstream of the fishpond return. All of the equipment is owned by the Corps; however, it is maintained by the US Geological Survey through a co-op agreement.

Figure 5-6. Tailwater Gage.

(6) Valley City Gage. The Valley City gage is on the Sheyenne River at river mile 253.0, which is 17.5 river miles downstream of the Baldhill Dam tailwater gage. It is located on the left bank 100 feet downstream of Little Dam. The gage record began in March 1919 but ended in August of that year. The gage was reinstated in March 1938. Since October 1979 stage height and annual maximum discharge has been recorded. Gage datum is elevation 1,199.27 feet NGVD 1929. The site is equipped with a Sutron 8210 with voice modem; however, no telephone line is available. The site is a stilling well with a Sutron encoder and tape indicator. There is a staff gage in the well. All of the equipment is owned by the Corps of Engineers but is maintained by the US Geological Survey.

(7) Other Stream Gages. Additional downstream gages on the Sheyenne River include Lisbon, Kindred, Horace, and Harvey. Because these gages are not project related, they are not funded by the Corps of Engineers (COE). Therefore, the St. Paul District is not responsible for quality control at these sites; however, during flood events these sites are of interest to Water Control as we monitor our releases from Baldhill Dam. COE interest at Lisbon and Kindred is sufficient that the Data Collection Platform (DCP) equipment at these sites is the property of St. Paul District. All of these sites are DCP's, and as such, their hourly stages can be obtained from the Water Control web site at www.mvp-wc.usace.army.mil.

Following the 1997 flood, four wire weight gages were installed between Warwick and Cooperstown. Starting at Warwick and heading towards Cooperstown, the first wire weight is the Pekin gage. It is located on State Highway #1, approximately two miles southeast of Pekin, and about 25 miles downstream of the Warwick gage. The next wire weight is on the Nelson County Road #20 bridge, which is located one mile north of the Nelson/Griggs County line. It is approximately midway between the Warwick and Cooperstown gages. The third wire weight is on the State Highway #45 bridge crossing about 12 miles upstream of the Cooperstown gage. The fourth wire weight is on the State Highway 200 bridge crossing just three quarters of a mile upstream of the Cooperstown gage. During a significant flood event, gage readers will take two readings a day at these sites. The data set is forwarded to the Baldhill Project Office where it is formatted onto an Excel spreadsheet and emailed to Water Control. In this way the flood crest can be tracked from upstream right into the reservoir.

(8) Baldhill Office. In addition to all the stream gages, the Baldhill Office is equipped with hydrometeorological equipment as well. On the rooftop of the control building at the dam is an anemometer with a weather vane. This equipment reports directly into the Baldhill Office (**Figure 5-7**).

Figure 5-7. Baldhill Dam Project Office

Down by the dam is a National Weather Service precipitation gage and a Corps of Engineers standard eight-inch precipitation gage (**Figure 5-8**).   Site personnel mail the NWS punch tape to the NWS office in Bismarck monthly. Also near by is the maximum-minimum temperature gage.

Figure 5-8. NWS and Corps of Engineers Precipitation Gages

All the winter measuring equipment is at or near the lower storage building. An ice auger is used to drill a hole in the pool for measuring ice thickness. Located in a clearing of the woods near the lower storage building is the snow board where snow depth measurements are taken (**Figure 3-2**). A snow tube and scale are used to determine the snow-water content. Near the snowboard is the frost tube. **Figure 5-9** shows a frost tube pulled from the ground. Note that the fluid level indicates it is in need of repair.

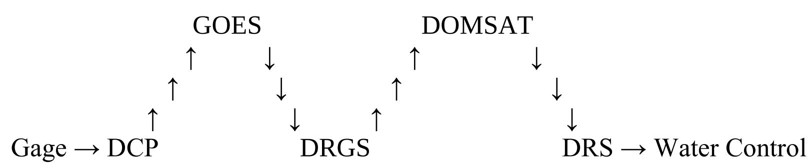
Figure 5-9. "Goose" with Frost Tube in Need of Repair.

Table 5-1
Hydrometeorological Stations

Location	Data Type	Equipment	Notes
Warwick Gage Sheyenne River 138 mi U/S of Dam	Stage Discharge Precipitation	Sutron 8210 Stilling Well Sutron Encoder Staff in Well Tipping Bucket Wire Weight	Gage Zero: 1370.0 ft NGVD 1929 AC Power U/S of Concrete Weir USGS Co-op
Cooperstown Gage Sheyenne River 47 mi U/S of Dam	Stage Discharge Precipitation Water Quality	Sutron 8210 DA H-350/355 Staff Gage Voice Modem Tipping Bucket Campbell CR-10	Gage Zero: 1271.76 ft NGVD 1929 AC Power U/S of Ueland Dam USGS Co-op
Dazey Gage Baldhill Creek 14 mi from Mouth 28 mi U/S of Dam	Stage Discharge Precipitation	Sutron 8210 Stilling Well Sutron Encoder Staff in Well Voice Modem Staff in Creek Tipping Bucket	Gage Zero: 1330.0 ft NGVD AC Power U/S of Sheetpile Weir USGS Co-op
Pool Gage Lake Ashtabula Right Bank of Dam	Pool Elevation Precipitation	Sutron 8210 Stilling Well Sutron Encoder Staff in Well Tipping Bucket Sutron 8200	Gage Zero: 1200.0 ft NGVD 1929 AC Power WC Gage Crew
Baldhill Dam Office Site	Precipitation Air Temperature Wind Speed and Direction Ice Depth Frost Depth Snow Depth Snow Water	8-inch Rain Gage Thermometer Anemometer and Wind Vane Ice Auger Frost Tube Measuring Rod Scale	All equipment maintained by site personnel. Water Control will replace all equipment except the ice auger.
Tailwater Gage Sheyenne River 0.1 mi D/S of Dam	Stage Discharge Conductivity Water Temperature	Sutron 8210 DA H-350/355 Water Sensor	Gage Zero: 1200.0 ft NGVD 1929 Solar Power Hardened Channel USGS Co-op
Valley City Gage Sheyenne River 13 mi D/S of Dam	Stage Seasonal Discharge	Sutron 8210 Stilling Well Sutron Encoder Staff in Well	Gage Zero: 1199.27 ft NGVD 1929 AC Power D/S of College Dam USGS Co-op

b. Reporting. All of the gages listed in **Table 5-1** are Data Collection Platforms (DCP). Being designated as a DCP indicates that the site transmits data on an hourly basis via a satellite system. Stage data is collected at the DCP. It is then transmitted to the US Geostationary Operational Environment Satellite (GOES). The GOES satellite transmits the data to the Direct Readout Ground Station (DRGS) at Wallops Island, Virginia. The information is reformatted and sent to the Domestic Communications Satellite (DOMSAT), which transmits the data to the DOMSAT Receive Station (DRS) located at the St. Paul District Office. Data is transmitted hourly to Water Control where it is then posted on the Water Control web site.

Transmission Path of DCP Data



During a flood event, local gage readers report the river stages at the wire weight gages between Warwick and Cooperstown to the Baldhill Dam office, which in turn reports them to Water Control.

c. Maintenance. The US Geological Survey maintains all of the gages listed in **Table 5-1**, with the exception of the Lake Ashtabula pool gage. Water Control's gage crew maintains the pool gage. All of the equipment at the Baldhill Office is maintained by site personnel; however, should the rain gage, snow measuring equipment, or frost tube become damaged, site personnel are to contact Water Control for replacement or repairs.

5-02. Water Quality Stations. The St. Paul District conducts water quality monitoring at its flood control reservoirs in support of Water Control Management as required by Engineering Regulation No. 1130-2-234, *Reporting of Water Quality Management Activities at Corps Civil Works* Projects, 30 April 1986. A monitoring program was established in 1990 and continues today. The Corps sampling program involves in situ measurement of secchi transparency, water temperature, dissolved oxygen, pH, and specific conductance. In addition, chemical analysis of water samples is conducted for total phosphorus (TP), dissolved ortho phosphorus, total kjeldahl nitrogen (TKN), nitrate+nitrite nitrogen (NO_2NO_3), ammonia nitrogen (NH_3), and chlorophyll a (CHLA). Other parameters are measured occasionally to further characterize the water and identify water quality relationships. The Corps of Engineers established five lake monitoring stations in 1990 (see **Figure 5-10**).

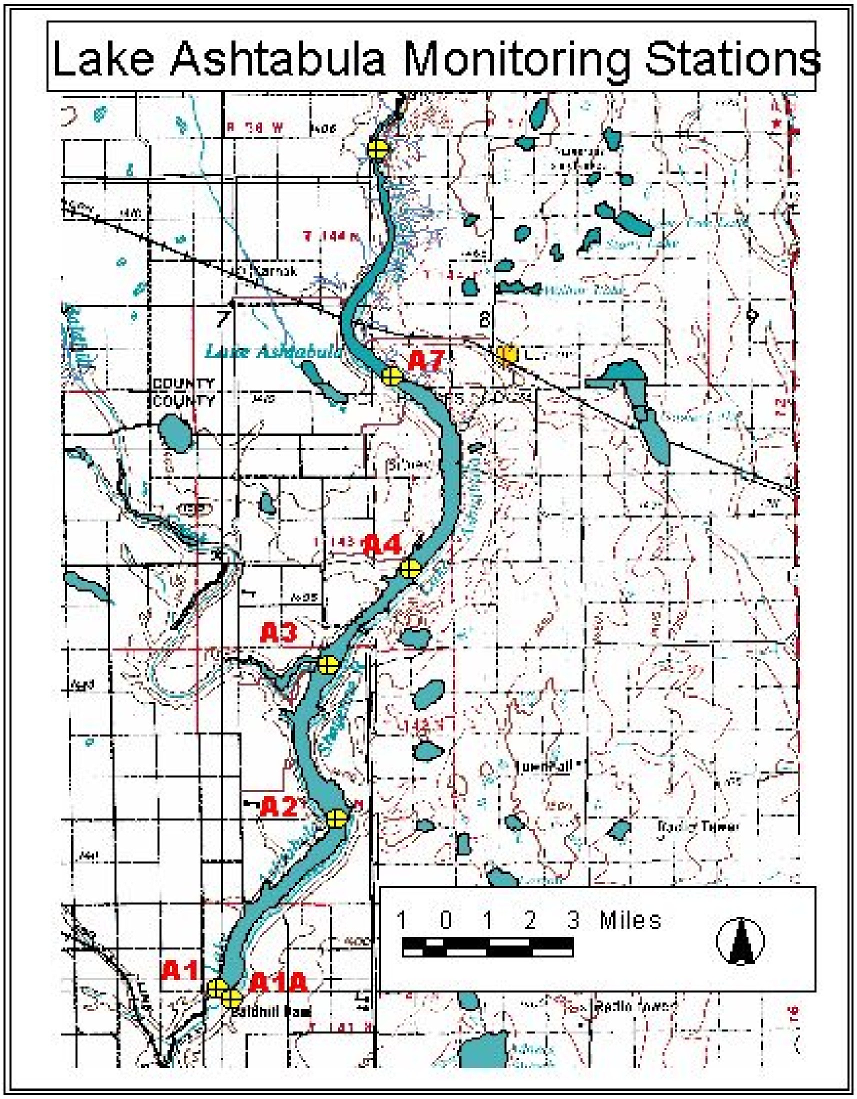


Figure 5-10. Lake Ashtabula Water Quality Stations.

In 1995 the Corps of Engineers entered into a cooperative agreement with North Dakota Department of Health establishing an intensive, routine monitoring program on the reservoir. The data record is fairly consistent with some years having no samples taken due to budget constraints. The data can be viewed from Water Control's web site at www.mvp-wc.usace.army.mil (select *Water Quality*).

The US Geological Survey (USGS) established water quality stations at Cooperstown, Dazey, and the tailwater gage. Instrumentation was installed in June 1997 at Cooperstown and in April 1997 at Dazey and the tailwater gage. The instruments monitored water temperature and specific conductance. Other data were collected intermittently. The Dazey instrumentation was removed on 30 September 2001. A discussion of the tailwater data is given in paragraph **4-08. Water Quality**. For more compete information, see the USGS publication *Water Resources Data, North Dakota*.

5-03. Sediment Stations. There are no sediment monitoring stations in Lake Ashtabula other than the 30 sediment range lines established for monitoring sedimentation into the lake. A complete discussion of this is presented paragraph **4-04. Sediment**.

5-04. Recording Hydrologic Data. There are four forms of recording hydrologic data related the Baldhill Dam project; (1) weekly log sheets, (2) Sutron data logger, (3) micro film, and (4) Hydrologic Engineering Center's Data Storage System (HEC-DSS).

a. Weekly Log Sheets. Log sheets (Form CEMVP 416) are filled out at the site and mailed to Water Control where they are achieved (**Exhibit B**). Data include 0800-hours pool and tailwater elevations, US Geological Survey discharges at Cooperstown, Warwick, and Dazey, all gate settings, air temperature, precipitation, wind speed and direction, and the 24-hour max-min air temperature.

b. Sutron Data Logger. This data logger is located in the pool gage house and replaces the old Stevens roll charts. The purpose of the roll charts was to maintain a permanent record of the pool elevations. The Sutron 8200 acts as a back up to the Sutron 8210 that transmits hourly pool elevations to water Control. Data recorded on the 8200 is downloaded a minimum of once a year. It is then stored electronically at Water Control.

c. Microfilm. Log sheets are stored at Water Control and are periodically microfilmed. The log sheets are then mailed to an offsite storage facility.

d. HEC-DSS. All data sent to Water Control via the satellite system is stored electronically using Hydraulic Engineering Center's Data Storage System (HEC-DSS). All data is hourly with the exception of gage malfunctions and is available from the Water Control web site at www.mvp-wc.usace.army.mil, (*Real Time*). The following shows the start dates for the project gage sites.

Table 5-2
Electronically Stored Gage Data – *Real Time*

Gage	Data	Start Date
Warwick	Stage	01 Jan 1996
	Precipitation	18 Jun 2002
Cooperstown	Stage	01 Jan 1996
	Precipitation	18 Jun 2002
	Conductivity	02 Jan 2000
	Water Temp	06 Apr 2000
Pool Gage	Elevation	01 Jan 1996
	Precipitation	18 Jun 2002
Tailwater Gage	Stage	01 Jan 1996
	Water Temp	02 Jan 2000
	Conductivity	02 Jan 2000
Valley City	Stage	01 Jan 1996

Site personnel also enter daily data into "Secure CRT" each morning. These data are electronically stored by Water Control and are available from the Water Control web site (*Reservoirs, Baldhill*). The following shows the daily data that can be obtained. Winter data are collected once a week on Mondays.

Table 5-3
Electronically Stored Reservoir Data – *Reservoirs, Baldhill*

Data Type	Start Date	Data Type	Start Date
Pool Elevation	06 May 1951	Precipitation	01 May 1951
Tailwater Elevation	06 May 1951	Max-Min Temp	09 Sep 2000
Outflow (USGS)	01 Jan 1951	Frost Depth	24 Nov 1985
Computed Inflow	01 Jan 1951	Ice Thickness	24 Nov 1985
Wind Speed	01 Jul 1984	Snow Depth	24 Nov 1985
Wind Direction	01 Jul 1984	Snow-Water	24 Nov 1985

5-05. Communication Network. Communications between Water Control and Baldhill Dam is typically by telephone or email. Facsimile can be used when necessary. Baldhill Dam project is under the direct supervision of the Western Area Office. Communication between the Area Office and the project office is by telephone or VHF radio.

Table 5-4
Communication Network

Site	Manager	Telephone	Facsimile
Baldhill Office	Rich Schueneman	701-845-2970	701-845-0712
Western Area Office	Tim Bertschi	701-232-1894	701-232-1789
Water Control	Ferris Chamberlin	651-290-5619	651-290-5841
Backup Regulator	Jodi Kormanik	651-290-5646	651-290-5841

5-06. Communication with Project.

a. Regulating Office with Project Office. Emergency communication between Water Control personnel and the Baldhill Dam Resource Manager is by telephone. Normal daily contact is by email.

b. Between Project Office and Others. The Resource Manager routinely provides information upon request to interested agencies and private parties. However, any public announcements of importance will be handled through Water Control and the Public Affairs Office.

5-07. Project Reporting Instructions. Every normal workday, Baldhill personnel input via remote computer the information required for daily regulation. Should more information be required, Water Control will contact the site by telephone. Log sheets are to be mailed to Water Control on a weekly basis.

5-08. Warnings. Any emergency situation should be reported to Operations Division and Water Control as soon as possible. If site personnel on a weekend witness a rainfall event in excess of three inches in a 24-hour period, they should contact Water Control at home:

Baldhill Dam Regulator:	Ferris Chamberlin	651-653-7981
Secondary Regulator:	Jodi Kormanik	763-913-4922
Secondary Regulator:	Farley Haase	715-235-1928

VI – HYDROLOGIC FORECASTS

6-01. General.

a. Role of Corps. During flood events, Water Control is in daily contact with the National Weather Service (NWS). Water Control provides forecasted outflows to the NWS to aid in their forecasts for Lisbon and Kindred. When discharges exceed 1,700 cfs, the bridge on the Valley City golf course begins to become impacted. Therefore, when forecasted flows are this high or higher, site personnel notify the golf course as well as Valley City.

b. Role of the National Weather Service. Water Control does not have a reliable reservoir inflow model for forecasting the peak inflow to the reservoir. During a flood event, the National Weather Service will provide Water Control the latest inflow hydrograph from the model results.

6-02. Flood Condition Forecasts. The St. Paul District has an HEC-1 hydrologic model of the Upper Sheyenne River basin for computation of inflow to Lake Ashtabula. While the model may be acceptable for forecasting summer rainfall runoff events it does not have a snowmelt function. Therefore, Water Control relies on input from the National Weather Service and the US Geological Survey's published discharge for inflow at Cooperstown and Dazey to formulate an inflow hydrograph. The forecasted inflow hydrograph is input to the Excel program "Flood Routing" (**Exhibit F**) and a gate operation scenario is developed. The inflow hydrograph is updated daily with consideration to the new discharges at Cooperstown and Dazey as well as any measurements taken by USGS.

6-03. Conservation Purpose Forecasts. The US Fish and Wildlife Service (USFWS) draws water from the reservoir to supply a flow of water through their numerous fishponds. The draw is fairly steady at 9.0 cfs. This only becomes a factor during low flows and does not require a forecast. Minimum release is 13.0 cfs. When discharges at the dam start nearing 13.0 cfs, the flow meter for the USFWS pond flow is monitored to insure low flow minimum standards are being met.

6-04. Long Rang Forecasts. There are no long range forecasts for the Baldhill Dam project.

6-05. Drought Forecasts. During dry periods Water Control monitors the National Weather Service's (NWS) *US Drought Monitor* on their web site (Water Control web site, *Agency Links*, Federal Agencies, National Weather Service, *River Forecast Center*, For our Partners, *Drought Monitor*).

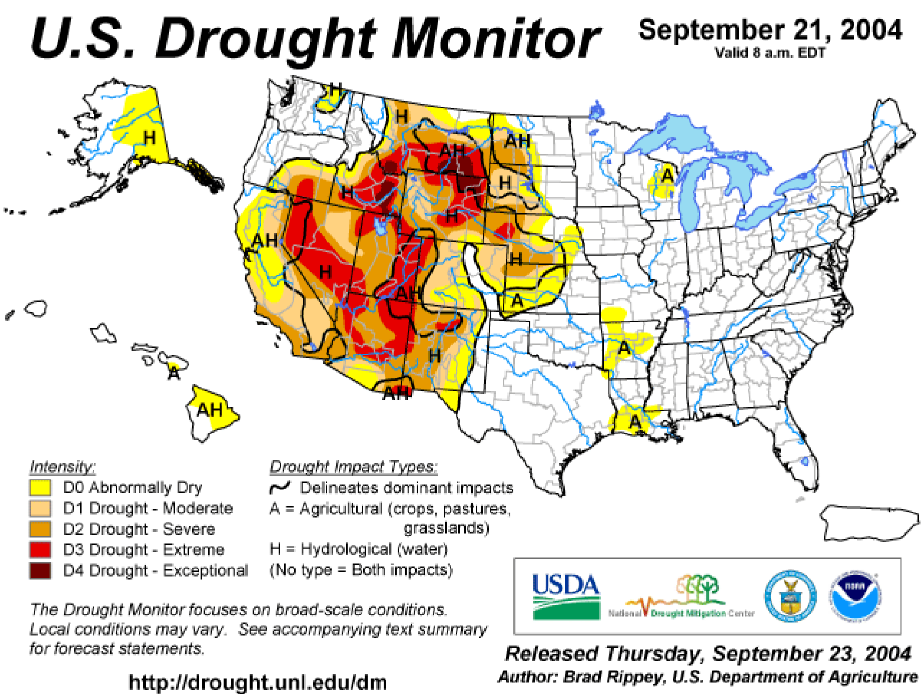


Figure 6-1. National Weather Service Drought Monitor.

The drought monitor gives an indication of ground conditions before freeze up. However, this only acts as an indicator of how severe the ground conditions are at present. Also available on the NWS web site is the *US Seasonal Drought Outlook*. This is the only drought forecast tool available for inflow to Lake Ashtabula. An example is shown in **Figure 6-2**.

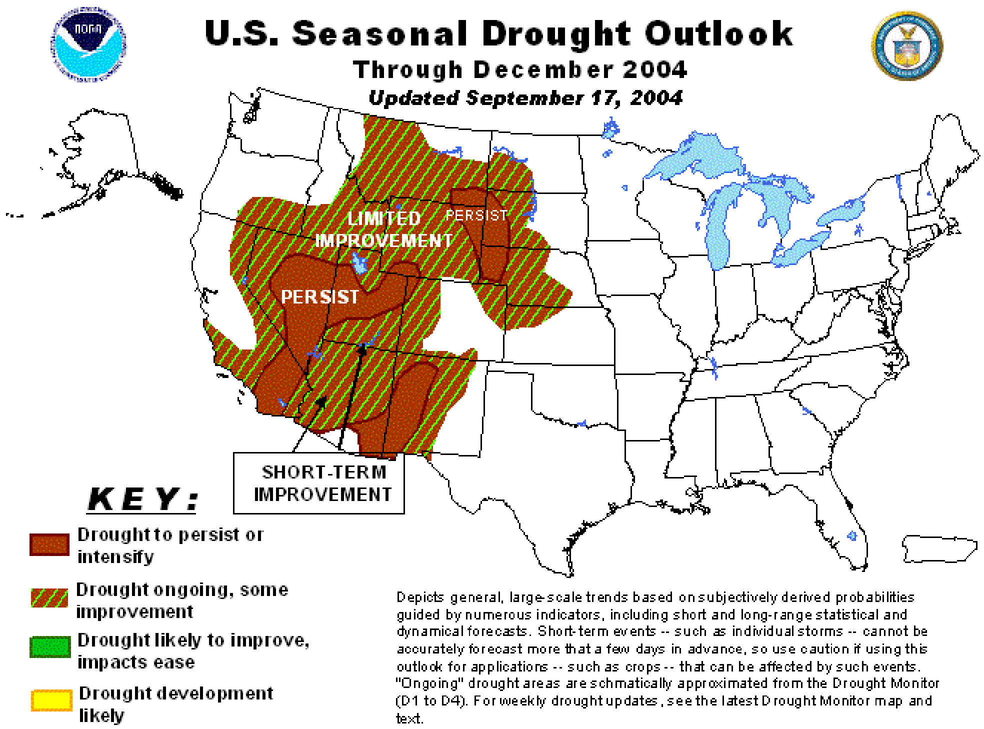


Figure 6-2. National weather Service US Seasonal Drought Outlook.

Should drought conditions become severe, the *Drought Contingency Plan*, which was developed in September 1992, would be consulted. See paragraph **7-12. Drought Contingency Plan** for more information.

VII – WATER CONTROL PLAN

7-01. General Objectives. There are two general objectives for the operating plan; (1) Flood Control and (2) Water Supply. During the winter months, Lake Ashtabula is drawn down to provide flood storage volume for spring runoff. The conservation pool level is maintained throughout the summer for water supply and recreational benefits. Should a summer flood event occur, storage to the top of flood control is allowed to prevent damages downstream.

7-02. Constraints.

a. Pool Elevation. The pool is constrained between the elevations of 1238.0 feet and 1278.5 feet. The invert elevation of the low flow conduits is 1238.0 feet making this the dead storage limit. Elevation 1278.5 feet is the top of pool for the Probable Maximum Flood (PMF). Flood control extends to elevation 1271.0 feet (top of emergency spillway). During summer months, the pool is held at the conservation pool level of 1266.0 ± 0.2 feet. Winter drawdown is constrained between elevations 1262.5 feet and 1255.0 feet. The following table shows the storage volumes and pool area for each of these constraints.

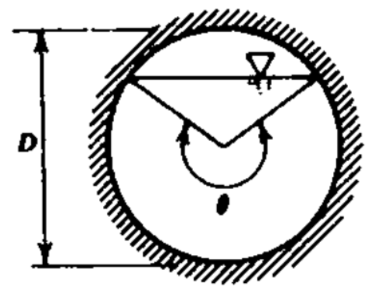
Table 7-1
Pool Elevation Constraints

Pool Condition	Elevation (feet)	Volume (acre-feet)	Area (acres)
PMF Top of Pool	1278.5	157,500	8,500
Top of Flood Control	1271.0	101,300	6,750
Conservation Pool	1266.0	70,600	5,500
Normal Drawdown	1262.5	52,250	4,375
Maximum Drawdown	1255.0	25,100	2,620
Dead Storage	1238.0	< 2,500	~350

Plate 7-1 shows the elevation-storage and elevation-area curves. **Exhibit C** contains the elevation-storage table based on the latest survey (1984).

b. Low Flow Gates. There are two low flow gated culverts. The culverts are 3.0 feet in diameter. The sluice gates that control flow are square; therefore, flow area is not linear with gate opening. Flow area can be computed from,

$$\text{Area} = 0.125\ (\theta - \text{Sin}\ \theta)\ D^2$$



The angle θ is in radians and can be calculated from the known radius and the gate setting. For example, consider a gate opening of 0.5 feet.

$$\text{Cos}\ ½\ \theta = \text{adj/hyp} = 1.0/1.5 = 0.667$$
$$½\ \theta = \text{Arc Cos} = 0.841\ \text{(radians)}$$
$$\theta = 0.841(2) = 1.68\ \text{(radians)}$$
$$\text{Area} = 0.125\ (1.68 - \text{Sin}\ 1.68)\ 3^2 = 0.772\ \text{sq ft}$$

Outflow can be calculated from $Q = CA(2gH)^{1/2}$, where '*C*' is the inlet coefficient (assume 0.98), '*A*' is the flow area, and '*H*' is the head measured from the top of pool to the centroid of the gate opening. To simplify calculations, the centroid was assumed to be located at one half the gate opening. The conduit inlet invert is elevation 1238.0 feet. **Table 7-2** shows the discharge-rating for the low flow gates at conservation pool level. Any error in the gate openings can have a significant impact on the actual flow area; therefore, this table should only be used as a guide.

Table 7-2
Low Flow Gate Discharge (cfs) – Pool Elevation 1266.0 feet

Gates Open	Gate Opening (ft) / Flow Area (sq ft)										
	0.2 0.20	0.3 0.37	0.4 0.56	0.5 0.77	0.75 1.38	1.0 1.83	1.25 2.79	1.5 3.53	2.0 5.00	2.5 6.29	3.0 7.07
1	8	15	23	32	57	75	115	145	205	255	285
2	17	30	46	64	114	150	230	290	410	510	570

The results presented in **Table 7-2** are theoretical. When compared with historical values, the theoretical values tend to be low at the smaller gate openings and high at the larger gate openings, pivoting off a gate opening of 0.75 feet. **Plate 7-2** shows the discharge-rating curves for a range of gate openings and pool elevations based historical gate settings and published discharges. Either the curves presented in **Plate 7-2** or the values shown in **Table 7-2** can be used in estimating discharges for a given gate setting. Errors in the actual gate setting and the tailwater-rating curve offset the minor differences in the two sources.

c. US Fish and Wildlife Service. The US Fish and Wildlife Service (USFWS), with the consent of the St. Paul District, draws up to 4,200 gallons per minute (9.36 cfs) off the reservoir to supply water flow through their fishponds located downstream of the dam (see **Paragraph 7-08**). A flow meter is located within the siphon well just downstream of the emergency spillway. This flow can be monitored by site personnel and is included with the total dam discharge.

d. Service Spillway Tainter Gates. A tainter gate opening can range from zero (gate sealed) to 24.5 feet (maximum gate opening). The gate seal elevation is 1251.0 feet with the top of gate at elevation 1271.0 feet. At maximum opening, the bottom of the gate is at elevation 1276.5 feet.

There are two problems with determining the actual gate opening. First, the gate seal is located upstream of the ogee weir crest such that the gate seal is at elevation 1251.0 feet and the top of the ogee weir is at elevation 1252.0 feet (see **Plate 2-3**). Therefore, the actual gate opening must be measured normal to the ogee slope. The second problem is associated with the gate hoisting cable. It follows the radius of the tainter gate to the point of attachment at the gate bottom. Therefore, one foot of travel on the gate hoist does not translate to one foot of gate opening. To solve this problem, the gate orientation and the ogee weir crest were graphically drawn out and the actual gate openings were measured normal to the ogee weir. **Table 7-3** shows the relationship of radial opening to the actual gate opening "G_o". The table indicates that if you wanted a 2.0-foot gate opening, you would read 3.0-feet on the gate dial. These points were plotted and a curve drawn as shown in **Plate 7-4**.

Table 7-3
Radial Travel Distance vs. Actual Gate Opening "G_o"

Radial Travel Distance (ft)	1.0	2.0	3.0	4.0	5.0	8.0
Actual Gate Opening (ft)	0.65	1.30	2.05	2.90	3.70	6.45
Top of Gate Elevation (ft)	1271.9	1272.8	1273.6	1274.4	1275.3	1277.5

Orders for gate openings and the recorded gate openings have always been based on the radial travel distance. All orders for "gate openings" reflect the desired dial reading and not the actual gate opening. Gate openings may be verified by reading the inclinometer indicators located next to the control panel.

Discharge through a tainter gate is dependant upon gate opening and pool elevation, providing there is no tailwater influence. The theoretical discharge through the opening can be computed by $Q = CA(2gH)^{1/2}$, where '*C*' is the inlet coefficient, '*A*' is the inlet flow area based on the actual gate opening G_o and a gate width of 40.0 feet , and '*H*' is the head measured from the top of pool to the center of the gate opening. The inlet "*C*" coefficient was reduced from 0.98 to 0.92 to account for the upward sloping outlet. Gate discharges were calculated for a range of gate openings for pool elevations ranging from maximum drawdown (1257.0 feet) to top of flood control (1271.0 feet). See **Table 7-4**.

Plate 7-3 graphically presents the tainter gate discharge rating-curve for a range of pool elevations and gate openings (G_o gate openings). These values are based on recorded gate settings and published discharges at the tailwater, therefore the results differ slightly from **Table 7-4**.

Table 7-4 Tainter Gate Rating Table for a Single Gate – cfs												
Pool Elev. in Feet	**Dial Reading in Feet**											
	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.5	2.0
	Gate Opening "G_o" in Feet											
	0.13	0.19	0.25	0.31	0.37	0.43	0.50	0.58	0.65	0.78	0.98	1.30
1257.0	95	135	180	220	265	305	355	410	455	545	680	890
1262.5	130	190	250	310	370	425	495	575	640	765	960	1,265
1266.0	150	215	285	355	420	505	565	665	735	880	1,100	1,455
1268.0	160	230	305	375	450	520	605	700	785	940	1,175	1,550
1271.0	170	250	330	410	485	565	655	760	850	1,020	1,280	1,690

e. Emergency Spillway. The crest of the emergency spillway is elevation 1271.0 feet. The pool elevation for the Probable Maximum Flood (PMF) is elevation 1278.5 feet. This constrains the operating limits of the emergency spillway. The spillway is 880.0 feet long and has only had water over its crest once since its construction in 1997. Because this was wind blown water, there are no historic records for discharge over the spillway. A rating table was developed based on $Q = CLH^{3/2}$, where '*C*' is the weir coefficient (3.2), '*L*' is length of weir (880.0 feet), and '*H*' is the head over the weir crest (1271.0 feet). **Table 7-5** shows the discharge over the spillway in one-foot pool increments from the spillway crest to the PMF pool elevation. **Plate 7-5** shows the discharge rating-curve for pool elevations up to elevation 1280.0 feet.

Table 7-5 Emergency Spillway Rating Table – cfs									
Pool Elev.	1271.0	1272.0	1273.0	1274.0	1275.0	1276.0	1277.0	1278.0	1278.5
Discharge	0	2,800	8,000	14,600	22,500	31,500	41,400	52,200	57,800

7-03. Overall Plan for Water Control. The overall plan calls for maintaining a pool for water supply and providing flood storage in the spring. During the summer months, the pool is maintained at the conservation pool level of 1266.0 ± 0.2 feet. This provides a storage volume of approximately 70,600 acre-feet for water supply. The cities of Fargo, Grand Forks, Valley City, West Fargo, and Lisbon are permitted water through the State of North Dakota to receive water upon request to meet their city needs. See paragraph **7-09. Water Supply** for more complete information. The reservoir also provides flood control benefits. Before spring runoff, a drawdown of the pool is made in preparation. The amount of drawdown is dependant upon the basin average snow-water-equivalent. As spring runoff begins outflows are adjusted upward while maximizing storage use and minimizing flow releases. During summer rainfall events, storage to the top of flood control is allowed to minimize downstream damages. For in depth detail, see paragraph **7-05. Flood Control**.

7-04. Standing Instructions to Resource Manager. The Resource Manager, or one of the staff, is to input data to "Secure CRT" every normal work day between 0800 and 0830 hours. These data include the 0800-hour readings shown in **Table 7-6**. Note that the winter data is only collected once a week on Mondays. Site personnel are also to maintain a weekly log sheet (Form CEMVP 416) that contains all the data input to Secure CRT as well as 0800-hour readings for: (1) discharge at Warwick and Dazey, (2) stage at Valley City, and (3) gate settings for radial gates and/or low flow gates. Discharges at Warwick and Dazey are to be obtained from the US Geological Survey's web site. Stage at Valley City is obtained from the DCP. Tainter gate settings are obtained from the dial indicator or from the inclinometer readings. The data set also includes the 0800-hour US Fish and Wildlife Service fishpond demand (cfs) and the air temperature (^{o}F). The log sheet is to be mailed to Water Control on a weekly basis.

Table 7-6 Data (0800-hours) Input to "Secure CRT"		
Location	**Data Type**	**Taken From:**
Cooperstown	Stage Discharge	DCP at Cooperstown Gage USGS Web Site
Pool	Elevation Ice Thickness	DCP at Pool Gage Ice Auger Hole
Central Control Station (CCS)	Precipitation Wind Speed/Direction Max-Min Temperature	Standard 8-inch Precip Gage Anemometer on Roof of CCS Max-Min Thermometer
Tailwater	Elevation Discharge	DCP at Tailwater Gage USGS Web Site
Lower Storage Shed	Frost Depth Snow Depth Snow Water Content	Frost Tube Snow Depth Measuring Rod Snow Tube and Scale

Orders for the day may be communicated to the site by email or telephone. Typically a "no change" order will be by email and a "gate change" will be by telephone. Gate changes should be made as promptly as possible unless otherwise noted. During a flood event, it is the Resource Manager's duty to inform the downstream interests when releases from the dam will have a major impact. Downstream interests include Valley City, the local golf course, and possibly the town of Lisbon or the local farmers along the Sheyenne River.

If on a weekend or holiday, it becomes necessary to make a gate change to maintain the pool band (i.e. 1266.0 ± 0.2 feet), site personnel may make a gate opening or closure but must notify Water Control on the morning of the first normal work day. If on a weekend or holiday, spring runoff begins unexpectedly, site personnel are authorized to open no more than 800 cfs without consulting with Water Control. For example, if the current release is 150 cfs and site personnel are aware of impending high inflows to the reservoir, they may immediately open to 950 cfs and then notify Water Control of their actions during normal work hours. If an additional gate opening is deemed necessary, site personnel should attempt to contact Water Control at home. The contact list shown in **Table 7-7** is to be followed in succession.

Table 7-7 **Emergency Telephone Numbers for Water Control Staff**		
Name	**Position**	**Work Cell**
Elizabeth Nelsen	Western Area Reservoir Regulator	651-724-3392
Farley Haase	Backup Regulator for all Projects	651-724-3395
Brian Johnson	Mississippi Headwaters Regulator	651-724-3394
Ferris Chamberlin	Chief, Water Control Section	651-788-0008

Should site personnel be unable to contact Water Control, they are authorized to open to an outflow not to exceed 2,400 cfs. Gate changes are not to produce a change in outflow greater than 800 cfs and the time interval between gate changes is to be a minimum of four hours.

Snow surveys are to be taken the last week of February/ first week of March. Site personnel will collect the data for the Sheyenne River basin as well as the South Fork of the Park River. Snow survey sites for the Sheyenne River basin are as follows: Upstream of Baldhill Dam; Dazey, Cooperstown, McVille, Warwick, Minnewaukan, Maddock, Hamborg, New Rockford, McHenry, Sheyenne, Aneta, Hannaford, Fort Totten. Downstream of Baldhill Dam; Fort Ransom, Lisbon, Enderlin, Kindred, Amenia, Tower City, Fingal. The Park River basin sites are as follows: Upstream of Homme Dam; Endinburg and Adams. Downstream of Homme Dam; Park River. Snow survey results are to be faxed to Water Control as soon as possible. In addition, snow data for the Sheyenne River basin are to be entered into "Secure CRT". This data set includes snow depth and snow-water content. The Resource Manager is to coordinate with the gage crew regarding the replacement of any snow measuring equipment.

7-05. Flood Control.

a. Summer Operation. During the summer months the pool is maintained at the conservation pool level of 1266.0 ± 0.2 feet. Operation basically consists of "inflow equals outflow"; however, in the event of a significant rain, outflows will be reduced to prevent damages downstream and water may be stored to the top of flood control if necessary. The Valley City golf course becomes impacted at 1,700 cfs; however, the city itself is not impacted until a discharge of 2,250 cfs. When discharge is anticipated to reach 1,700 cfs or higher, the Resource Manager is to coordinate with Valley City and other interested parties. **Table 7-8** shows the impacts on Valley City for a given stage and an approximate discharge. **Exhibit B** contains a detailed list of gate closures in Valley City.

Table 7-8
Discharge Impacts at Valley City

Stage at Valley City (feet)	Approx. Discharge (cfs)	Impact to Valley City
9.5	1,700	Interior drainage problems start at golf course.
10.3	2,000	Bridge at the golf course is closed.
11.0	2,250	Close 2 sluice gates: Two 15-inch.
11.5	2,400	Bank-full discharge.
12.7	2,800	Close 4 sluices: Two 15-inch and Two 36-inch.
12.8 - 13.0	2,900	Close 3 sluices: Two 18-inch and One 24-inch.
13.1 – 14.0	3,100	Close 3 sluices: One 12-, One 18-, One 15-inch.
14.1 – 15.0	3,500	Close 9 sluices: One 12-, One 15-, Five 18-, One 24-, One 36-inch and One 8-inch gate valve.
15.1 – 16.0	3,850	Close 11 sluices: One 12-, One 15-, Three 18-, Two 30-, One 36-, Two 48-, One 54-inch.
16.1 – 17.0	4,200	Close 10 sluices: Two 12-, Four 15-, Three 18-, One 21-, and One 8-inch gate valve.
17.0	4,400	Fill low spots and monitor emergency levees.
17.1 – 18.0	4,600	Close 4 sluices: Three 12-, One 15- inch Cover 3 inlets: One 4-, One 12-, One 18-inch.
18.0	4,800	Major Flood Stage. Top of levees threatened.

Typically outflows will be limited to a discharge of 1,500 cfs while storing the excess. For major events, the Excel program “Flood Routing” can be used to determine maximum outflow for an approximated inflow hydrograph and a targeted maximum pool elevation.

b. Fall / Winter Operation. Drawdown of the pool begins on 1 October. The pool must be drawn down to elevation 1262.5 feet by 1 March. **Table 7-9** shows the monthly target pool elevations. If conditions in the basin indicate there is more than 1.0 inch of snow-water-equivalent (SWE) additional drawdown may be required.

Table 7-9
Normal Pool Drawdown Schedule

Month	Storage Volume (acre-feet)	Pool Elevation (feet)	Discharge Above Inflow
1 October	70,600	1266.0	> 65 cfs
1 November	66,680	1265.3	> 65 cfs
1 December	62,800	1264.6	> 65 cfs
1 January	59,000	1263.9	> 60 cfs
1 February	55,500	1263.2	> 55 cfs
1 March	52,250	1262.5	

If at some time before 1 March the snow-water-equivalent as measured at the dam site exceeds 1.0 inch, a new target value of elevation 1262.0 feet will be established. New target values are assigned as the snow-water equivalent increases. **Table 7-10** shows the new target values.

Table 7-10 Target Drawdown Elevations based on SWE			
Snow-Water Content	**Pool Storage (acre-feet)**	**Flood Storage Available (acre-feet)**	**Target Pool Elevation (feet)**
< 1.0 inch	52,250	49,000	1262.5
> 1.0 but < 1.5	50,000	51,300	1262.0
> 1.5 but < 2.0	37,600	63,700	1259.0
> 2.0 but < 3.0	31,000	70,300	1257.0
> 3.0	25,100	76,200	1255.0[1]

1. Water quality must remain sufficient to support fish. See paragraph **7.07 Water Quality.**

History has shown that spring runoff typical begins in late March or early April (e.g. 1966: 22 March, 1969: 13 April, 1979: 20 April, 1996: 9 April, 1997: 2 April, 2004: 28 March). The official basin snow survey is conducted the last week of February or the first week of March. Should this survey indicate the basin-average snow-water content is higher than that measured at the dam site, a new target drawdown elevation may be established and the date to accomplish this drawdown may be extended to 1 April.

c. Operation for Spring Runoff. If runoff begins before completion of the drawdown, drawdown is to stop and spring runoff operations begin. Runoff varies from year to year. Basin average snow-water content can be less than ½ an inch (2002) or it can be over half a foot (1997). Total rainfall during runoff can be close to zero (1988) or it can be over two inches in one heavy shot (2004). Because of this variability, decisions on dam operations will be a measured response to the possibility of an extreme event occurring.

Prior to spring runoff, Water Control is in frequent contact with the National Weather Service (NWS) appraising the runoff conditions in the upper basin. When runoff begins the NWS will run their Sheyenne River Basin model and provide the inflow hydrograph to Water Control. The model results include the

24-hour quantitative precipitation forecast (QPF). With the unpredictability of snowmelt and the QPF, an accurate inflow hydrograph is not possible. As a check, Water Control monitors inflow to the reservoir at Cooperstown (2-days travel time) and Dazey (½ day travel time). Adding yesterday's Cooperstown discharge with today's Dazey discharge, gives an indication of reservoir inflow one day out. This is compared to the inflow hydrograph and adjustments are made if deemed necessary. The inflow hydrograph is then input to the "Flood Routing" program. A gate operation schedule is developed based on this hydrograph and a desired peak pool elevation. Different scenarios of gate operation are evaluated until a final plan is selected. **Table 7-4** and **Plate 7-3** are to be used to determine the gate settings.

If runoff begins on a weekend or holiday, site personnel are permitted to increase outflow by up to 800 cfs without contacting Water Control. If an additional gate opening is deemed necessary, the Resource Manager is to call the Water Control regulator at home. If Water Control can not be contacted, site personnel may increase flow to no more than a total of 2,400 cfs. Releases are to be coordinated with downstream concerns and Water Control is to be notified as soon as practical. All discharges are to be ramped up in steps not to exceed 800 cfs in 4-hour intervals. For example, if runoff was very rapid, outflow may be ramped up to channel full capacity of 2,400 cfs in three gate movements spaced at 4-hour intervals. Since the low flow gates max-out at less than 500 cfs, it is necessary to plan the switch to tainter gate operation. To avoid undue stress and vibration on any of the tainter gates, a minimum gate setting of 0.3 feet (dial reading or inclinometer) should be observed. For example, rather than have two gates set at 0.2 feet, set one gate at 0.4 feet. A single gate should be used to pass flow until a the gate is open 0.6 feet, at which time the gate opening may be split between two gates at an opening of 0.3 feet each.

When the peak of the flood has past, the pool is to be returned to its conservation level as soon as possible. For a significant event, this typically involves cutting flows back gradually from the peak discharge and then maintaining a discharge of 2,400 cfs or less until the pool nears conservation level. It should be noted that the Horace Diversion operates for a discharge of 900 cfs. The city of West Fargo views the operation of the diversion as an increase in maintenance costs and therefore would prefer outflows in the range of 700 to 800 cfs thus delaying the return to conservation pool. While this may be possible and some effort may be put forth to accommodate them, the operating plan will not be changed from "returning to conservation pool as soon as possible." The pool however is not to fall faster than 0.5 feet per day to minimize bank sloughing. Decreases in outflow should be stepped down such that no decrease is more than 800 cfs over a four-hour span. Also, no decrease shall be more than half the present outflow.

d. Operations for Lisbon. The flood control interest for the project is Valley City; however, should a significant rainfall event occur between Baldhill Dam and the city of Lisbon, as it did in 1975, outflows from the dam may be cut in an effort to reduce discharges at Lisbon. The reduction in outflow will be dependant upon available storage in the reservoir at the time.

7-06. Recreation. There are no releases made for recreation. All recreational features pertain to the pool.

7-07. Water Quality. Water quality must be monitored when drawing the pool down from elevation 1257.0 feet to elevation 1255.0 feet. In addition, through at least April of 2017 sampling must be collected two times a month from November to April. See **Exhibit B6** for detailed information on the required monitoring.

Part of the justification for construction of the Baldhill Dam was municipal pollution abatement. The purpose was to dilute sewage waste and packing plant effluent. While mandated improvements to effluents have improved water quality, river discharges are still used to dilute the effluent from the sewage lagoons located just south of Valley City. The lagoons discharge into the river through a 16-inch pipe three times a year; 1-15 June, 15-31 August, and 1-15 November. The discharge rate is based on water quality and the rate of flow in the Sheyenne River. Water quality is monitored upstream and downstream of the outlet and the discharge is set accordingly. Outflow can be as high as 4.5 million gallons per day (7 cfs) and last for five days.

The established minimum release from the reservoir is 13.0 cfs. This includes the flow through the US Fish and Wildlife Service fishponds. When outflows go to minimum, Water Control will contact the US Geological Survey to take a discharge measurement to ensure we are meeting our minimum release requirements. When there is little snow-water in the basin and spring rain fall is slight, minimum discharges must be maintained for long periods of time while the pool fills to conservation level. This makes for poor water quality in Valley City. A proposal to reduce drawdown at these times was opposed by the Red River Joint Water Resource Board, Upper Sheyenne River Joint Water Resource Board, Southeast Cass Water Resource District, Moore Engineering, representing downstream interests, and the North Dakota State Water Commission (NDSWS). All but the NDSWC provided written opposition (**Exhibit F**).

7-08. Fish and Wildlife. The US Fish and Wildlife Service (USFWS) has approval to draw 4,200 gallons per minute directly from the reservoir to provide a flow of water through their fishponds immediately downstream of the dam. The siphon enters a well just downstream of the emergency spillway (**Figure 7-1**). In the past, the Corps was never sure how much water the USFWS was drawing from the reservoir at any given time. Therefore, at the expense of the Corps of Engineers, a flow meter was installed in the line to verify the flow demand (**Figure 7-2**). The flow rate is typically very constant at 4,200 gallons per minute (9.36 cfs) but can be less. Prior to Baldhill reservoir, the Sheyenne River would frequently dry up. With the completion of the reservoir, a minimum of 13 cfs is maintained at all times. This includes the outflow from the USFWS.

Figure 7-1. USFWS Siphon Well and Water Meter

Figure 7-2. COE Water Meter to Monitor USFWS Demand

The fall/winter drawdown ranges from elevation 1262.5 feet down to elevation 1255.0 feet. The storage volume at elevation 1257.0 feet is less than half that of the conservation pool level. While this may cause some stress on fish habitat, this volume has been deemed adequate. For drawdown to occur to elevation 1257.0 feet, the basin average snow-water content must be greater than 2.0 inches. Therefore, the drawdown does not occur often. For maximum drawdown to elevation 1255.0 feet to occur water quality must be monitored to ensure sufficient support to fish. See **Exhibit B6** for detailed information.

7-09. Water Supply. The main purpose for the construction of Baldhill Dam was water supply. The Corps of Engineers controls all aspects of project regulation; however, the State of North Dakota controls the permitting of the water stored there. The North Dakota State Water Commission (NDSWC) has permitted water storage rights in Lake Ashtabula to cities downstream of the reservoir. These cities may make an application for the release of water through the NDSWC which in turn will coordinate the release with the Corps of Engineers. The following table shows each city's allotment.

Permit No.	**City**	**Volume Acre-Feet**
1091	Fargo	35,880
835	Grand Forks	20,023
1096	Valley City	6,686
921	West Fargo	954
3588	Lisbon	373
		63,916

The latest pool survey (1984) indicated there was 70,600 acre-feet of storage at a pool elevation of 1266.0 feet. From the reservoir surveys of 1971 and 1984 (**Table 4-4**), it was estimated that the annual sedimentation rate was 70.9 acre-feet per year. Assuming a steady inflow rate of sediment, around 1,560 acre-feet of storage has been lost. Dead storage begins/ends at elevation 1238.0 feet with an estimated 500 acre-feet of water left in the "pool". While it may be thought that sediment would first fill the dead storage, it is very likely not the case. The long length of the pool suggests that sediment will drop out long before it gets to the lower reaches of the pool. Therefore, there is presently around 70,600 – 1,560 = 69,040 acre-feet available for water supply. Unallocated water is 69,040 – 63,916 = 5,124 acre-feet and is falling at a rate of 71 acre-feet per year.

Since completion of the project in 1952 there have been ten requests for a release based on water supply (**Table 3-3**). The lowest resulting pool elevation due to a request was 1264.07 feet on 1 October 1976.

The Corps of Engineers gives consideration to adverse impacts on all authorized project purposes as mandated by Congress and therefore, it is the Corps of Engineers that makes the final decision on releases from the dam. However, it should be noted that no request has ever been denied.

7-10. Hydroelectric Power. There is no hydroelectric power at Baldhill Reservoir.

7-11. Navigation. There is no commercial navigation on the Sheyenne River at Baldhill Reservoir. The only navigation is recreational traffic on the pool. The conservation pool level of 1266.0 ± 0.2 feet provides a fairly constant pool level from the end of spring runoff to the 1st of October.

7-12. Drought Contingency Plan. The purpose of the *Drought Contingency Plan* is to present a broad outline of actions necessary to effectively manage the District's water resources for the Sheyenne River during drought conditions. A plan was developed in September 1992 as an appendix to the 1981 *Baldhill Dam and Lake Ashtabula Reservoir Regulation Manual*. The draft was submitted to the Division Office and comments were received in October 1992. The comments were never addressed and the document has remained unchanged. In addition, many changes have occurred since 1992. The contingency plan references National Weather Service (NWS) products that have been replaced or simply no longer exist. An update to the *Drought Contingency Plan* was put underway in 2006.

The American Meteorological Society defines a drought as a prolonged period of abnormal moisture deficiency and/or unusually hot weather. As stated in the *Drought Contingency Plan,* this is not considered to be an inconvenience or mild hardship, but rather a shortage of water so unusual that it threatens lives and/or property. It is expected that at least two to three months of extremely dry weather would be required to initiate a drought. The "Alert Phase" (Level I) begins at the onset of apparent drought conditions. While operations are still normal, awareness to the situation is disseminated to other agencies, e.g. North Dakota State Water Commission. The "trigger" that takes us to Level II was established in the summer of 2006 as "when discharge from the dam is at the minimum release of 13 cfs and the pool is consistently out of the band on the low side, i.e. below elevation 1265.80 feet". This indicates that outflow plus evaporation is in excess of inflow and that the pool is in a steady decline. At this point the Corps Drought Management Committee (CDMC) will begin to form. Water Control will contact the Corps' Environmental Branch and the North Dakota State Water Commission for input to operations.

The cities of Fargo, Moorhead, and Grand Forks rely heavily upon water from the Red River of the North for its municipal water supply. Therefore, operation of Baldhill Dam must be coordinated with operations at Orwell Reservoir in regards to water supply on the Red River of the North.

7-13. Flood Emergency Action Plans. An *Emergency Action Plan* was developed in March 1990 as a stand-alone document. At the time of this report, the emergency spillway had not been constructed. The Probable Maximum Flood (PMF) crest at this time was determined to be elevation 1282.9 feet with a peak reservoir inflow of 126,000 cfs and a peak outflow, without dam failure, of 124,000 cfs. With dam failure, outflow was determined to be 270,000 cfs. The new PMF elevation is now 1278.5 feet; however, the peak outflow remains unchanged at 124,000 cfs. With the new PMF elevation, the dam would not be overtopped and a dam failure would be highly unlikely. Therefore, only the tables in the Emergency Action Plan showing the "without dam failure" results should be used.

7-14. Periodic Inspection. Every five years there is an inspection of the stilling basin. Basically the pool is drawn down, the gates are closed, the inspection is performed, and we return to normal operations. The following is a list of individual steps involved to accomplish the inspection.

1. Draw the pool down.
2. Close all gates at the dam.
3. Pull the stop logs from the tailwater control structure.
4. Pull the drain plugs from the stilling basin end sill.
5. Replace the drain plugs.
6. Start the stilling basin pumps.
7. Perform inspection.
8. Resume normal operations

Prior to stepping down outflows, the pool is lowered to provide room for inflow during the inspection. Typically the pool is lowered to the bottom end of the band allowing 0.4 feet for the pool to rise during the inspection. If additional drawdown is required, a minor deviation request is made to the Division Office. Outflows are cut in half every four hours until down to 40 cfs or less. The final gate change is to go to zero discharge. Before zero outflow is achieved, the stop logs at the tailwater control structure and the drain plugs at the stilling basin end sill must be pulled. When the stilling basin has drained down to a depth of about two feet, the drain plugs are to be reinstalled at the end sill and the pumps started. Assuming a depth of two feet, the stilling basin volume is approximately 22,400 cubic feet or about 170,000 gallons. To ensure the Corps is meeting minimum outflow requirements, Water Control may coordinate with the US Geological Survey in advance to have a discharge measurement taken just downstream of the fish return. Site personnel should coordinate with the US Fish and Wildlife Service to ensure that they will be passing 4,200 gpm down the fish return channel. With 9.36 cfs coming from the fish return, pumps in the stilling basin will only have to provide an additional 3.64 cfs (1,635 gpm) to meet the minimum requirement of 13.0 cfs. Water stored in the stilling basin, along with inflow from gate leakage, provides to water necessary to meet the minimum requirement. Outflows are to return to normal following completion of the inspection.

7-15. Deviation from Normal Regulation. At times it is necessary to deviate from normal regulation. There are three forms of deviations; (1) a deviation because of an emergency situation, (2) an unplanned minor deviation due to an unplanned event, and (3) a planned deviation, typically to accomplish some task. Except for an emergency, to deviate from the operating plan requires permission from the Division Office (MVD). All planned deviations are to be coordinated with the District's Environmental Branch.

a. Emergency. Under an emergency deviation, the District Engineer or District Commander may authorize a deviation in an attempt to abate the problem. The Division Office is to be notified as soon as practical. Written confirmation of the deviation is to be sent to the Division Water Control Manager.

b. Unplanned Minor Deviation. Should an unplanned instance create the need for a temporary minor deviation, permission to do so is to be obtained from the Division Office. Consideration must be given to upstream and downstream watershed conditions, potential flood threat, and alternative measures that can be taken. An email explaining the deviation and its cause must be furnished to the Division Water Control Manager. Approval for an unplanned minor deviation is typically obtained by email.

c. Planned Deviations. Requests for planned minor deviations may be submitted to the Division Water Control Manager by email. Major deviations must be presented formally to the Division Water Control Manager by a memorandum from the Chief, Engineering Division. The request should include sufficient data on flood potential, lake and watershed conditions, and benefits to be expected. Approval for minor deviations is made by the Division Water Control Manager and typically is sent by email. Approval for major deviations is made by the Division Commander and is sent by memorandum.

An example of a planned minor deviation would be drawing the pool down below conservation level to provide storage room for inflows while outflows are reduced to perform a stilling basin inspection or to facilitate downstream channel work (e.g. bridge construction). An example of a planned major deviation would involve holding the pool high or low for an extended period of time. The Division Office ultimately makes the determination if the deviation request is minor or major.

7-16. Rate-of-Release Change. Before this manual, there were no rate-of-release change regulations. The following rules were developed by Water Control and have been reviewed by the District's Environmental Branch. The purpose of this guidance is to prevent the sloughing of the reservoir banks as well as the downstream channel side slopes due to a rapid change in water surface elevation. There are basically two guidelines regarding rate-of-release change. When reducing outflows, the rate of release change is limited to one half of the outflow, not to exceed 800 cfs, in four-hour increments. For example, a flow of 2,800 cfs can be cut to 2,000 cfs and then four hours later cut to 1,200 cfs. The next maximum cut would be 600 cfs, followed by 300 cfs, followed by 150 cfs, and so on. When stepping up flows, the rate of release change is limited to 800 cfs in four-hour intervals.

VIII – EFFECT OF WATER CONTROL PLAN

8-01. General. The effects of construction and continued operation and maintenance of the Baldhill Dam and Lake Ashtabula Water Supply and Flood Control Project have been previously described (Chapter I, references *e*, *g*, *m*, *p*, and *x*) and are summarized below. No changes are being proposed that have been previously assessed in those documents.

Construction of Baldhill Dam and Lake Ashtabula resulted in the inundation of timber, brush, prairie and wetland habitats as well as agricultural land. The loss of these, especially the timber and brush habitats, would have a major impact on the existing wildlife community.

The riverine aquatic habitat was converted to a lacustrine environmental and the fish community changed accordingly. The dam is now a barrier to upstream fish movement and the lake may pose a deterrent to downstream movement. Prior to construction of the project, it was reported that the Sheyenne River frequently dried up; however, releases from the dam are maintained at 13 cfs or greater to augment flows during dry periods.

High levels of inflowing nutrients and sediment contribute to the rapid eutrophication of Lake Ashtabula resulting in frequent algal blooms and poor water quality. Bank erosion occurs in some areas. Variable water levels negatively impact furbearers such as beaver and muskrat, and limit the establishment of aquatic vegetation in shallow areas.

As with most reservoirs, the operating plan causes an increase in the winter discharge (drawdown for flood storage) and reduced peak spring outflow (flood protection). In addition, the gates allow for flow manipulation to accommodate downstream channel work (e.g. bridge abutment work).

On the positive side, Lake Ashtabula has a surface area of 5,450 acres at the conservation pool level. This provides a huge source of recreational benefits. With the added five-feet of storage that became available in 2004, Baldhill Dam has greatly increased its flood control benefits. During summer rainfall events, outflows can be minimized by storing water up to one-foot above the conservation pool.

8-02. Spillway Design Flood. The design spillway flood was based on the storm of 18 to 23 July 1909. Rainfall from this storm was increased by 15 percent to obtain maximum probable rainfall for spillway design. The peak rate of inflow into the reservoir was 58,000 cfs. After routing the spillway design flood through surcharge storage, the maximum discharge capacity required was 43,000 cfs with a peak pool elevation of 1273.1 feet. Baldhill Dam is a “Standard 1” category of the security standards for spillways and dams, as described in paragraph five of Circular No. 1110-2-27, dated 1 August 1966. A “Standard 1” category of design requires that a dam be large enough to assure that it will not be overtopped by floods up to the Probable Maximum (PMF). Flood routings performed in 1988 indicated that the PMF would have an inflow of 126,000 cfs and the pool would crest at elevation 1283.0 feet, with an overtopping depth of 4.5 feet. The duration of overtopping would be nearly 10 days. It would be reasonable to expect that the dam would be breached under such conditions. A dam failure scenario indicated that the peak pool would be elevation 1279.0 feet with a maximum outflow of 270,000 cfs. This problem was rectified in 1995 when an emergency spillway was installed in the dam embankment. With this addition, the old spillway design flood will crest at an elevation of 1272.4 feet with a peak outflow of 47,000 cfs. The duration of overflow on the emergency spillway is about two days with a maximum head of 1.4 feet and a maximum discharge of 6,000 cfs. Routing of the PMF indicated that pool would crest at elevation 1278.5 feet. Outflow through the emergency spillway would be 57,800 cfs (**Table 7-5**). The tainter gates would be fully open and the discharge would be $Q = CLH^{3/2} = 4.0(120)(26.5)^{3/2} = 66,200$ cfs. The total PMF discharge would be 124,000 cfs.

8-03. Recreation. Lake Ashtabula is well used. It provides recreational opportunities for over a half a million visitors each year. Lake Ashtabula has something to offer every season of the year. Winter brings ice fishing, and snowmobiling. Spring and fall offer excellent opportunities to view migrating waterfowl. Summer means boating, camping, fishing, picnicking, and swimming. The Corps of Engineers operates seven recreation areas at Lake Ashtabula providing a variety of facilities and services. All Corps wildlife management areas are open to public hunting.

8-04. Water Quality. Prior to the construction of Baldhill Dam, the Sheyenne River would occasionally dry up. A minimum releases of 13.0 cfs helps ensure improved water quality downstream of the dam.

8-05. Fish and Wildlife. The project area is located in a predominantly agricultural/ pastureland area. The general land use characteristics within five miles of Lake Ashtabula are as follows:

cultivated	62 %	water	5 %	forested	2 %
pasture	29 %	wetland	2 %	residential	1 %

Prior to European settlement, areas that are now cultivated or pastured would have been prairie and wetlands. Woodland was not likely common in the natural prairie environment; however, it was likely very important as nesting, breeding, and over-wintering habitat for many birds and mammals. The existing wooden riparian areas are an important resource and are only wooded areas remaining. The major wetland habitat in the area is at the upstream end of the lake and scattered in the upland areas.

The wildlife value of the area is influenced by land use and human activity. The developed areas have limited wildlife value because of this. The Corps of Engineers actively manage 14 separate wildlife areas at Lake Ashtabula totaling 2,800 acres. The land, which is a combination of grassland, woodland, and shrubland, provides food and habitat for a wide variety of wildlife. Wildlife species that use the projects areas include white-tailed deer, raccoon, skunk, squirrel, rabbit, and a variety of rodents. A number of resident and migratory bird species can be found in the project area, including hawks, killdeer, shorebirds, doves, swallows, meadowlarks, sparrows, and pelicans. Two species that may occur in the project area are on the Federal threatened and endangered species list. The bald eagle, listed as threatened, may use the area for breeding habitat and may also be found there during migration. The whooping crane, listed as endangered, may be found in the project area during migration.

Some active management programs at the project consist of annual waterfowl nesting surveys, maintenance of waterfowl nesting structures, renovation and maintenance of wooded areas and shelterbelts, noxious weed control, construction of a waterfowl brood rearing pond, and winter-feeding of white tailed deer. Lake Ashtabula is located in the heart of the “prairie pothole” region and is a prime nesting area for many species of waterfowl. A unique seasonal visitor to Lake Ashtabula is the white pelican. Flocks of pelicans can be seen in the summer months in many areas around the lake.

The conservation pool level provides 5,450 acres of water with a volume 70,600 acre-feet to support fish habitat. The fishery of Lake Ashtabula is typical of eutrophic lakes. Some of the species present include white sucker, bullhead, shiners, white bass, crappie, yellow perch, walleye, northern pike, and black bullhead. The fishery has been declining over the years and is supported by stocking.

8-06. Water Supply. The water control plan provides 70,600 acre-feet of water for downstream needs. The North Dakota State Water Commission (NDSWC) permitted water to the towns of Fargo, Grand Forks, Valley City, West Fargo, and Lisbon. Any request for water supply should be coordinated with the NDSWC and the Corps of Engineers.

8-07. Hydroelectric Power. There is no hydroelectric power at Lake Ashtabula.

8-08. Navigation. There is no commercial navigation on Lake Ashtabula.

8-09. Drought Contingency Plans. The drought contingency plan calls for a minimum release of 13.0 cfs. Any reduction in this would require coordination with the North Dakota State Water Commission as it did in 1988 when releases were reduced to 6 to 8 cfs from 15 July through 21 July.

8-10. Flood Emergency Action Plan. The E*mergency Action Plan* is a stand-alone document dated March 1990. The plan provides a discussion on dam break with the Probable Maximum Flood; however, since construction of the emergency spillway in 1995, overtopping of he dam will not occur and hence dam break is highly unlikely. All other emergency operations and repairs presented in the report still apply.

8-11. Frequencies.

a. Pool Elevation History. Figure 8-1 shows a history of the pool elevation from 1952 through the spring of 2004. Electronically stored pool elevation data does not begin until 6 May 1951. Previous to the five-foot-raise, the record high pool elevation was 1269.46 feet. It occurred in May 1950 while the project was still under construction. The five-foot-raise was sufficiently complete in 2004 to allow the storage of flood waters in the upper pool limits. For the first time in the history of the project, the pool crested above elevation 1270.0 feet. Other notable flood events occurred in the spring of 1979 (1268.55 feet) and the summer of 1993 (1268.57 feet).

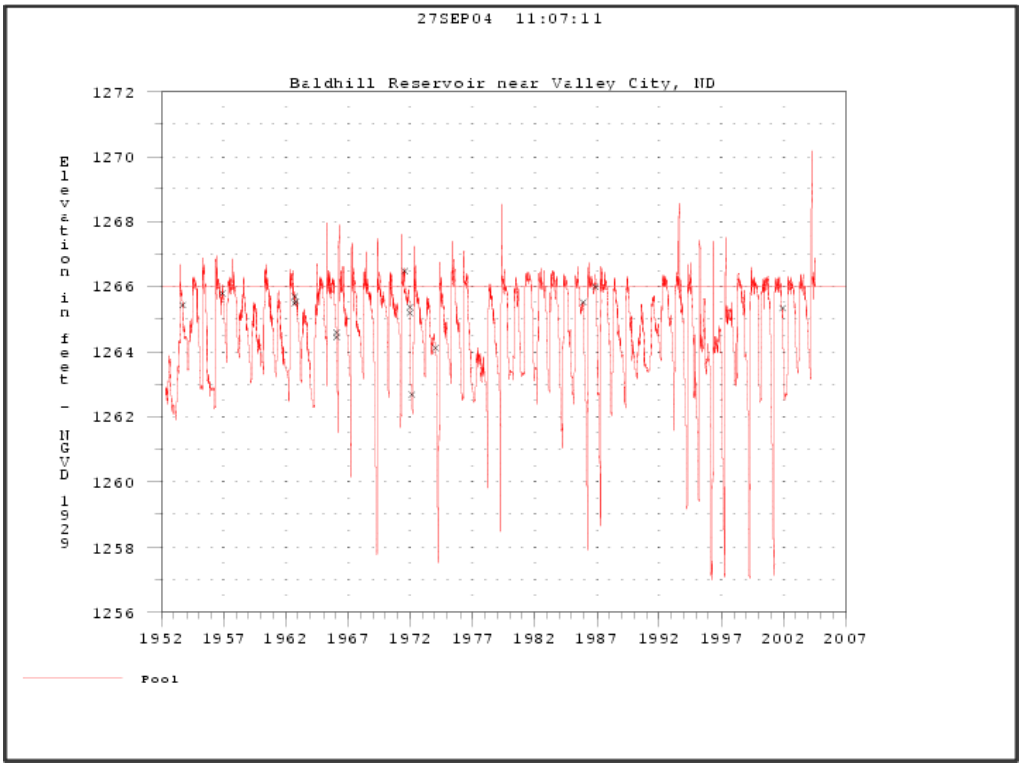


Figure 8-1. Pool Elevation History

b. Pool Elevation-Duration. The elevation-duration curve represents the percentage of time Lake Ashtabula is at or above a given elevation (**Figure 8-2**). This distribution is based on daily reservoir elevations. The period of record inflows were routed through the reservoir using the new operating plan (i.e. five-foot pool rise). The period of record used was from January 1953 to September 2004. The duration curve reflects all daily reservoir elevations for normal operation, drawdown periods, and periods of flooding. Therefore, while conservation pool elevation is 1266.0 feet, the pool elevation is only near this elevation about 10 percent of the time due to flood control operations (e.g. winter drawdown).

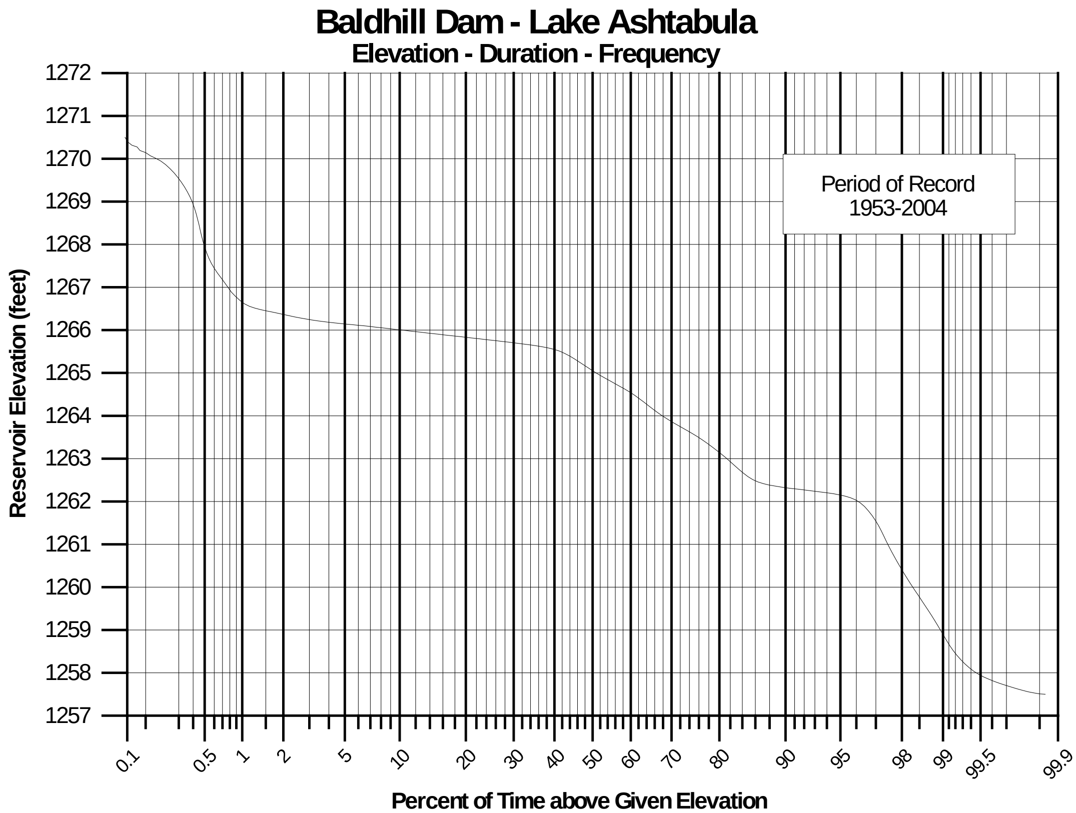


Figure 8-2. Pool Elevation-Duration

c. Pool Elevation-Frequency. The elevation-frequency curve was computed using the annual maximum reservoir elevations for the period of record from 1953 through the spring of 2004. The maximum reservoir elevations were derived from a period of record analysis of reservoir inflows with the "new operating plan" developed for the five-foot pool raise. The median plotting positions were used to plot each annual maximum elevation against its corresponding plotting position. A graphical best-fit line was drawn through these points to arrive at the annual elevation-frequency curve for this modified condition. The revised operating plan was assumed to have no impact on floods between 50,000 and 100,000 acre-feet of volume. The upper end of the frequency curve above the 10 percent recurrence interval is a graphical "best-fit" of period of record plotting positions and the larger synthetic event reservoir elevations (**Figure 8-3**).

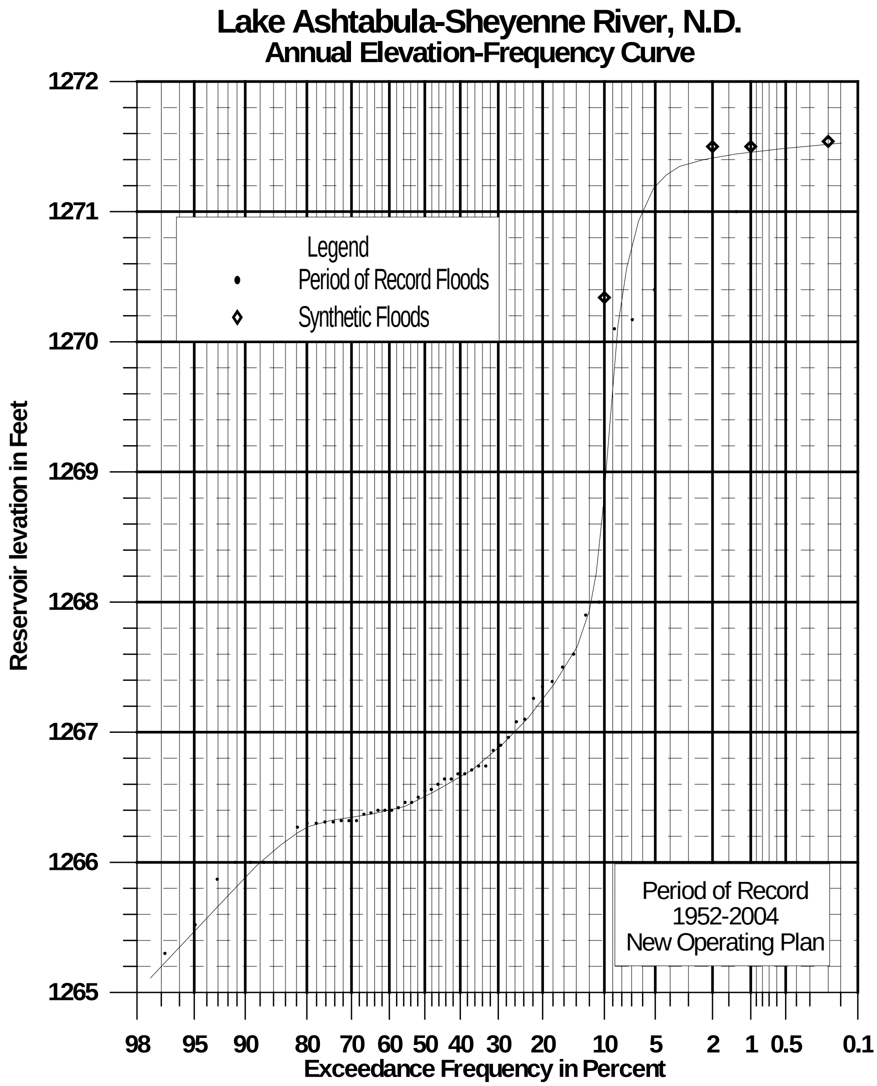


Figure 8-3. Lake Ashtabula Elevation-Frequency

d. Inflow Volume Frequency. An analysis of inflow-volume frequency was performed in 1998. Volume frequency curves were derived for inflows to Lake Ashtabula using the elevation outflow relationship at Baldhill Dam for the period of record after 1950 when the dam went into operation. In addition to this record, the daily discharges for period from 1939 to 1950 were estimated from the flow records at Valley City since the local intervening area between the dam and Valley City contributes very little volume. This provided 63 years of record (1939-2001) for use in the volume frequency analysis at the dam.

The average daily discharges were also used to compute the average discharges for durations of 3, 7, 10, 30 and 90 days. Frequency curves for the series of annual maximums for these durations were then derived using Bulletin 17B guidelines. The statistics for the standard deviation and skew coefficients were plotted against the mean logarithms and smoothed to provide a consistent relationship between the family of curves (**Figure 8-4**).

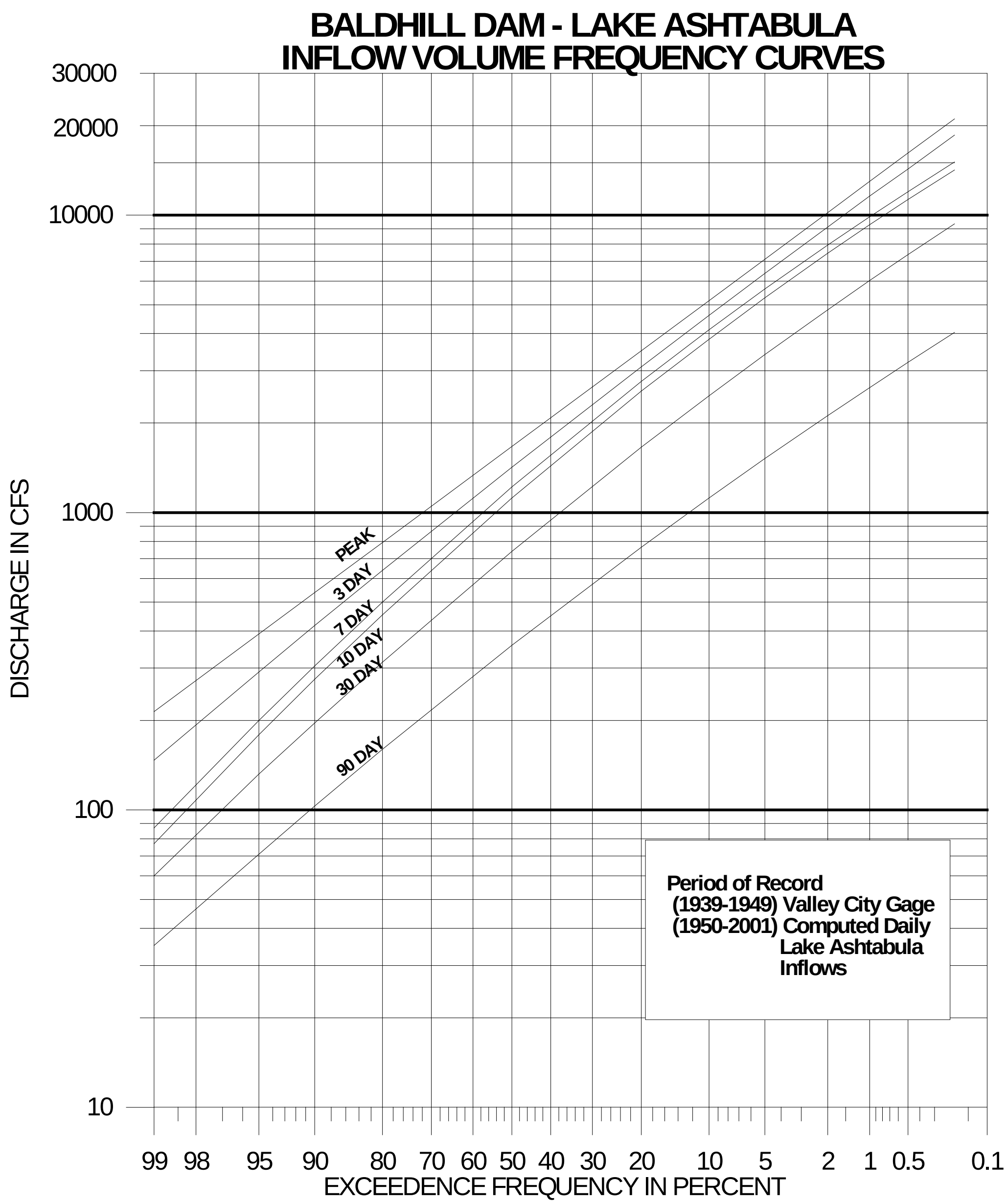


Figure 8-4. Baldhill Dam Inflow Volume Frequency Curves

e. Key Streamflow Locations.

(1) General. The flood frequency curves presented here have been computed in accordance with the guidelines outlined in Bulletin 17B, *Guidelines for Determining Flood Flow Frequency*, and Engineering Manual (EM) 1110-2-1415. The flow data were taken from US Geological Survey (USGS) daily records.

(2) Cooperstown. Cooperstown is a key point for inflow to the reservoir. It is located on the Sheyenne River 47 miles upstream of the dam. The USGS records from 1945 to 2003 were used to develop a frequency curve for the annual instantaneous peak. The station mean and standard deviation are based on computed statistics for the instantaneous peaks. The skew coefficient was weighted with the regional skew of -0.2. The skew weighting resulted in an adopted skew of –0.3290, which provides a better fit for the frequency curve and the Weibull plotting positions for the recorded floods. The annual instantaneous peak discharge frequency curve is presented in **Figure 8-5**.

FINAL RESULTS

-FREQUENCY CURVE- COOPERSTOWN - USGS STATION 05057000

COMPUTED CURVE FLOW IN CFS	EXPECTED PROBABILITY FLOW IN CFS	PERCENT CHANCE EXCEEDANCE	CONFIDENCE LIMITS .05 FLOW IN CFS	CONFIDENCE LIMITS .95 FLOW IN CFS
15900.	17700.	.2	27100.	10600.
12700.	13800.	.5	20800.	8640.
10400.	11100.	1.0	16600.	7260.
8350.	8800.	2.0	12900.	5960.
5910.	6130.	5.0	8660.	4370.
4290.	4390.	10.0	6010.	3250.
2850.	2880.	20.0	3810.	2220.
1230.	1230.	50.0	1540.	976.
486.	479.	80.0	621.	365.
290.	281.	90.0	384.	205.
186.	177.	95.0	257.	123.
77.	69.	99.0	117.	45.

SYSTEMATIC STATISTICS

LOG TRANSFORM: FLOW, CFS		NUMBER OF EVENTS	
MEAN	3.0634	HISTORIC EVENTS	0
STANDARD DEV	.4583	HIGH OUTLIERS	0
COMPUTED SKEW	-.4508	LOW OUTLIERS	0
REGIONAL SKEW	-.2000	ZERO OR MISSING	0
ADOPTED SKEW	-.3290	SYSTEMATIC EVENTS	59

Table 8-1. Cooperstown Station Statistics

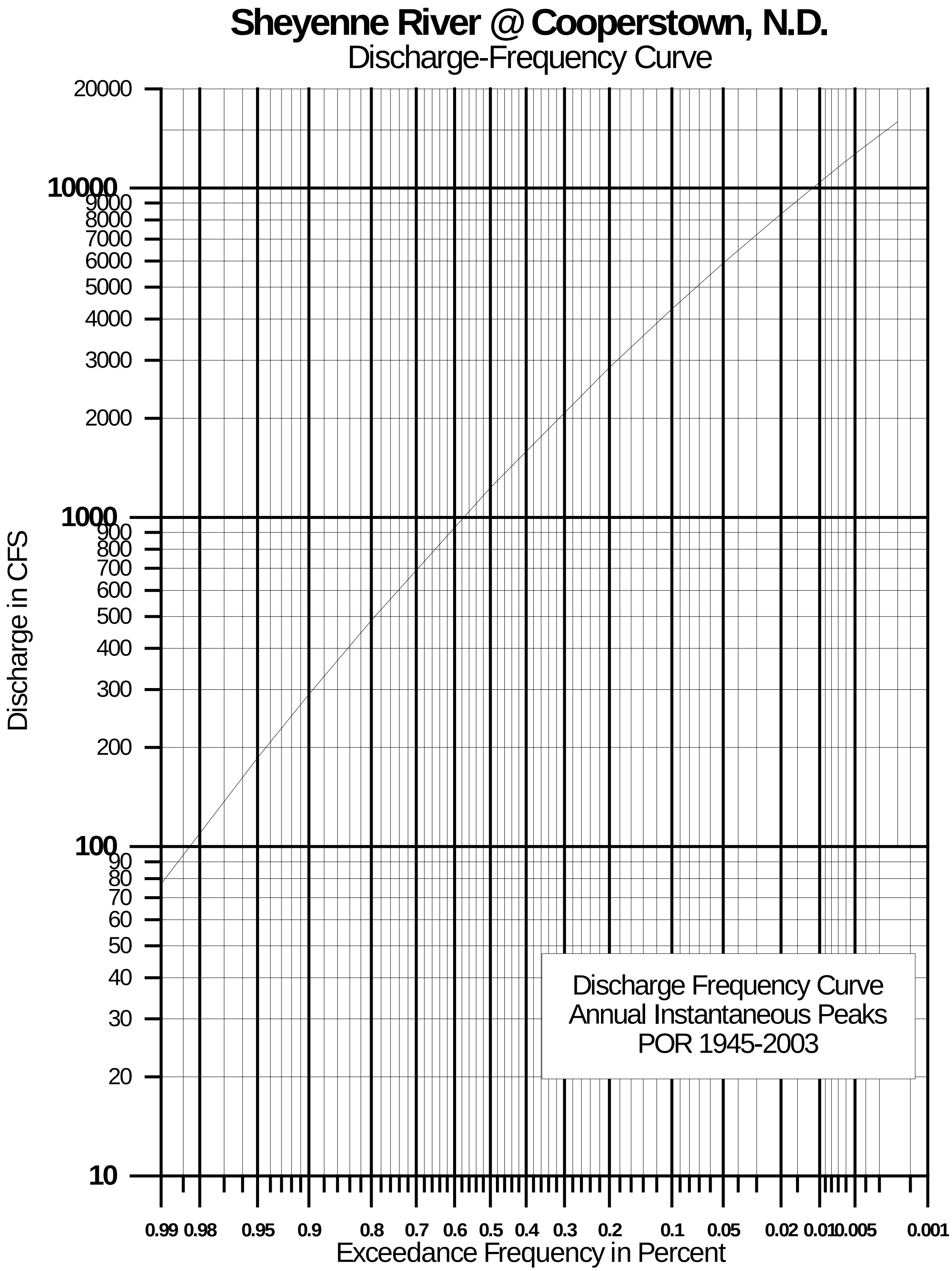


Figure 8-5. Cooperstown Discharge-Frequency

(3) Dazey. The Dazey gage is located on Baldhill Creek about 14 miles upstream of the mouth. Baldhill Creek is tributary to Lake Ashtabula and enters the reservoir about 12 miles upstream of the dam. The gage has a continuous record from 1956 to present. Water years 1956 through 2003 were used to develop the discharge frequency curve shown in **Figure 8-6**. This 48 year record was used to compute the station statistics for the mean, standard deviation, and skew of the logarithms of the annual flows (**Table 8-2**). The station skew of –0.1906 is weighted with the regional skew coefficient of –0.2 to arrive at an adopted skew of –0.1933.

FINAL RESULTS

-FREQUENCY CURVE- BALDHILL CREEK @ DAISEY - USGS STATION 05057200

COMPUTED CURVE FLOW IN CFS	EXPECTED PROBABILITY FLOW IN CFS	PERCENT CHANCE EXCEEDANCE	CONFIDENCE LIMITS .05 FLOW IN CFS	CONFIDENCE LIMITS .95 FLOW IN CFS
13200.	16300.	.2	30900.	7050.
9260.	10900.	.5	20300.	5160.
6870.	7810.	1.0	14300.	3970.
4920.	5430.	2.0	9650.	2960.
2950.	3140.	5.0	5310.	1870.
1850.	1930.	10.0	3100.	1230.
1030.	1060.	20.0	1600.	717.
324.	324.	50.0	457.	231.
95.	93.	80.0	137.	62.
49.	47.	90.0	74.	29.
28.	26.	95.0	45.	15.
9.	8.	99.0	17.	4.

SYSTEMATIC STATISTICS

LOG TRANSFORM: FLOW, CFS		NUMBER OF EVENTS	
MEAN	2.4910	HISTORIC EVENTS	0
STANDARD DEV	.6164	HIGH OUTLIERS	0
COMPUTED SKEW	-.1906	LOW OUTLIERS	0
REGIONAL SKEW	-.2000	ZERO OR MISSING	0
ADOPTED SKEW	-.1933	SYSTEMATIC EVENTS	48

Table 8-2. Baldhill Creek Station Statistics

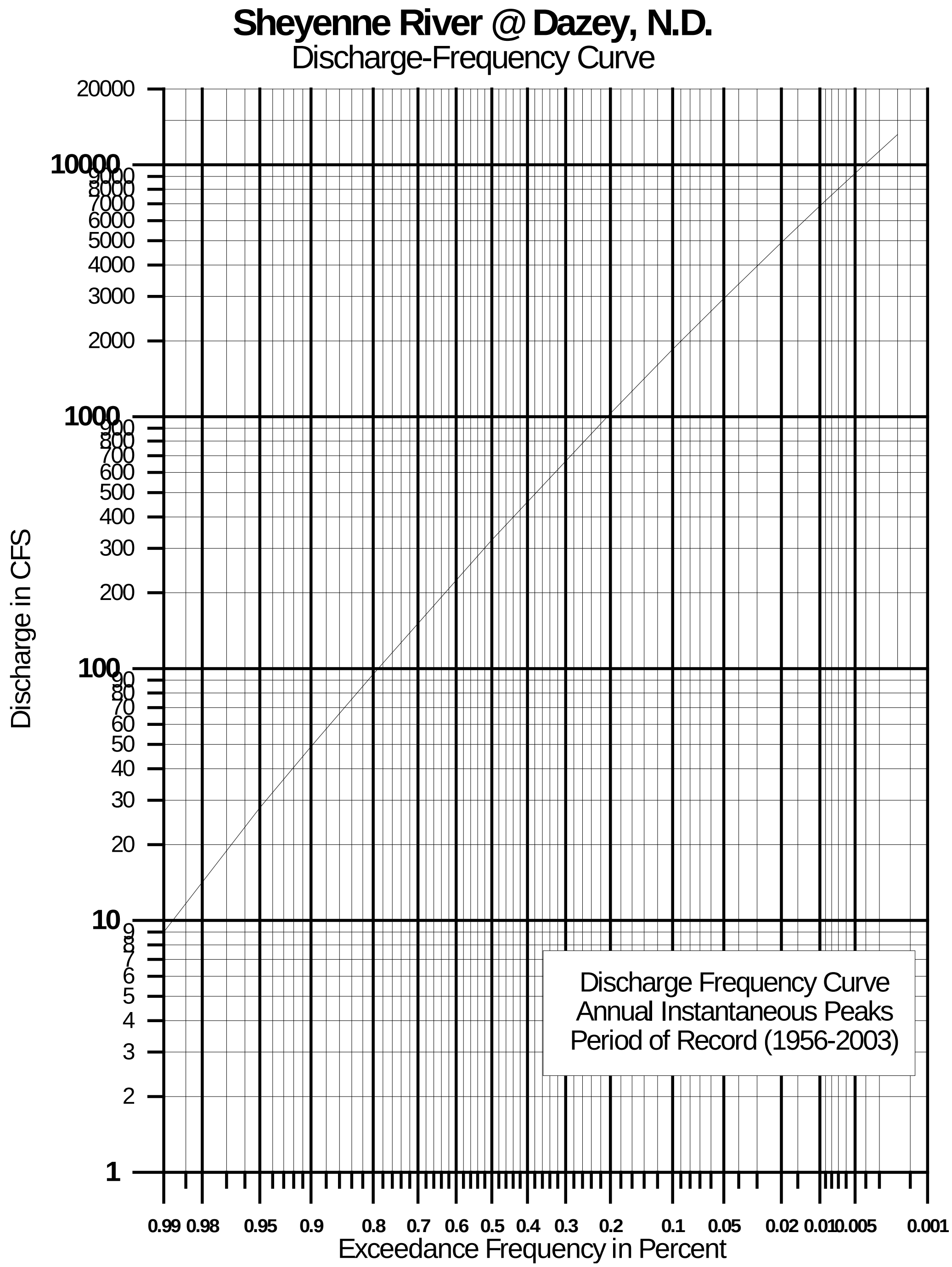


Figure 8-6. Dazey Discharge Frequency

(4) Valley City. Valley City is located about 17.5 river miles downstream of the dam. The gage at Valley City provides the longest continuous period of discharge records on the Sheyenne River. Annual instantaneous peak discharges have been recorded at Valley City since 1919. The record provides continuous daily discharges from 1939 to 1975 and daily stages and annual instantaneous peak discharges from 1979 to present. The period from 1950 to present is affected by regulation of Baldhill Dam. Therefore, the concept for the development of a discharge-frequency curve was to first develop the annual instantaneous peak discharges at Valley City for without project conditions over the period of record. Then route these flows through the reservoir with the new operating plan (i.e. five-foot pool raise).

The Corps of Engineers has a continuous daily record of reservoir elevation and outflow from Baldhill Dam from 1950 to present. An inflow record can be reconstituted based on this daily elevation/outflow relationship through reverse reservoir routing. Elevation and discharge are recorded daily at 0800-hours. Therefore, 24-hour periods are used to determine the change in storage. In addition, the daily recorded discharge does not reflect any additional gate changes made throughout the day. The computed inflow is considered to be a daily average value and does not reflect the instantaneous peak. This is assumed to be a reasonable estimation of the daily average inflow to Lake Ashtabula. The instantaneous peak inflow to the reservoir was estimated by correlating the Cooperstown mean daily peaks with the Baldhill Dam mean daily peaks. The ratio of the Cooperstown instantaneous peak to the mean daily peak was 1.09. Therefore, instantaneous inflow to Lake Ashtabula was computed by multiplying the daily inflow peak by 1.09.

The local contributing area between Baldhill Dam and Valley City is small. This area runs off several days before the upper Sheyenne River flow reaches Baldhill Dam. Also the distance between Baldhill Dam and Valley City is short such that flood attenuation is minor. It was assumed that this attenuation would be offset by the minor local flow contribution.

The “regulated” frequency curve at Valley City is based on the period of record from 1950 through 2003 with annual peaks adjusted for the new operating plan.

Synthetic hydrographs were developed with the volume frequency relationships above Baldhill Dam and routed through the reservoir and downstream to Valley City to determine regulated peak discharges for floods larger than the observed period. **Figure 8-7** shows the resulting discharge-frequency curve.

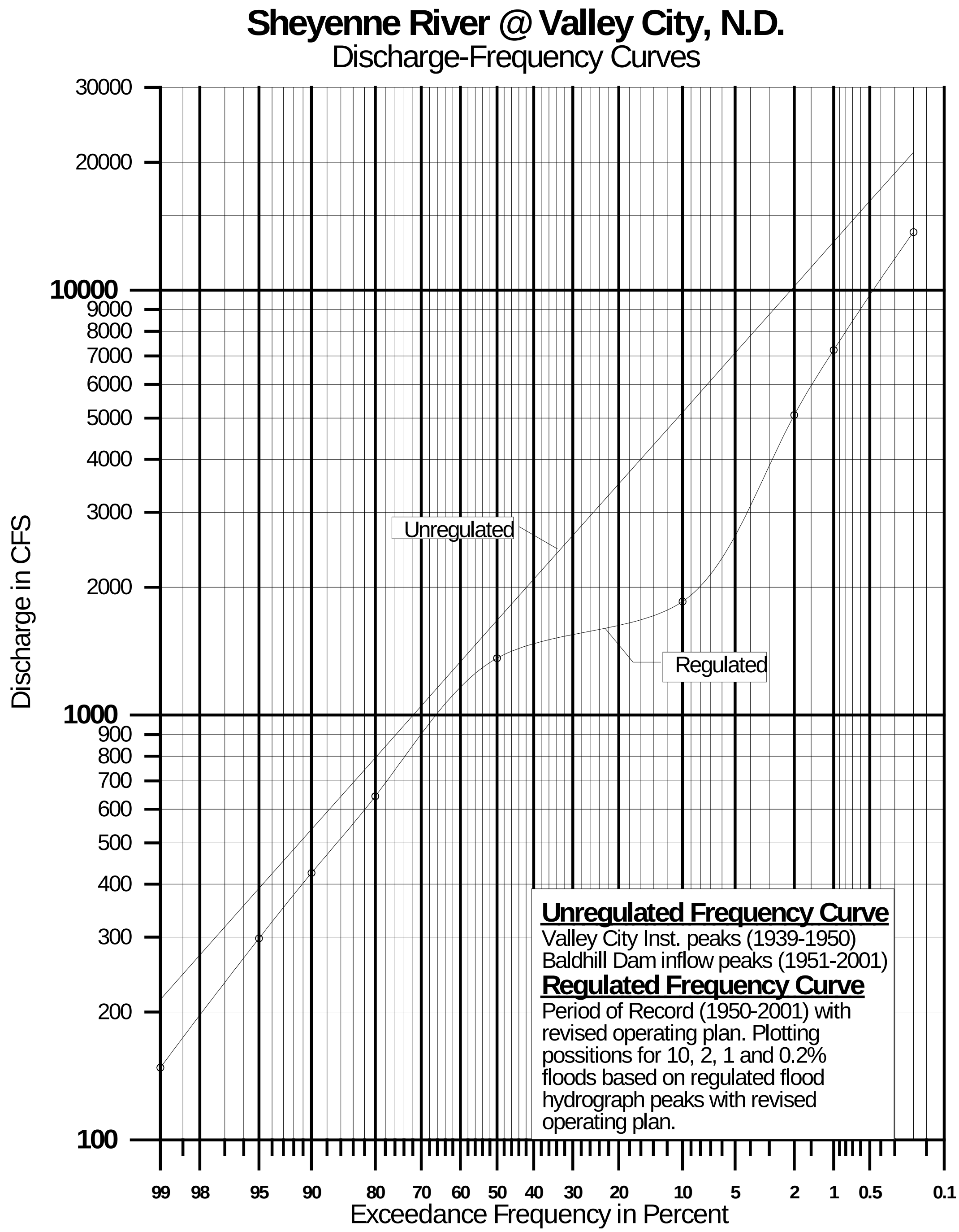


Figure 8-7. Valley City Discharge Frequency

(5) Lisbon. The Lisbon gage is located on the left bank of the Sheyenne River, 150 feet downstream from the State Fish Hatchery dam at the north edge of the city of Lisbon. The gage is at river mile 162.1, which puts it about 91 miles downstream of Valley City and a little over 108 miles downstream of Baldhill Dam. While this is a significant distance downstream, operations at the dam impact the discharge frequency curve. The Lisbon hydrograph exhibits a characteristic double peak, with the first peak from local runoff and the second peak from coming from releases at Baldhill Dam. Most of the large flood peaks at Lisbon are directly related to Baldhill Dam discharges. An exception was the flood 1975. In July intense thunderstorms dropped up to 10 inches of rain between Lisbon and Baldhill Dam. This flood resulted in the highest instantaneous peak discharge of record for the Lisbon gage at 5,270 cfs.

The existing condition annual instantaneous peak frequency curve at Lisbon was based on the USGS's published discharges for the Lisbon gage for the 47-year period from 1957 to 2003. The results of this frequency curve were used to anchor the lower portion of the frequency curve displayed in **Figure 8-8**. The upper end of the curve was adjusted for floods with a return period of 10-years or greater to account for the modified operating plan at Baldhill (i.e. five-foot raise in flood control). It was assumed that lesser floods would not be impacted by reservoir releases. The 500, 100, 50, and 10-year flood routing used to determine modified conditions at Valley City were routed from Valley City to Lisbon using HEC-1 and the Muskingum routing method. The 500, 100, 50, and 10-year local flood peaks at Lisbon were estimated by transferring the local frequency curve relationship at Kindred up to Lisbon by drainage area relationships. The 500, 100, 50, and 10-year routed hydrographs from Valley City were combined with the local flood hydrographs to derive the respective hydrographs at Lisbon. These discharges were plotted with their respective plotting positions and a curve was fitted through these points (**Figure 8-8**).

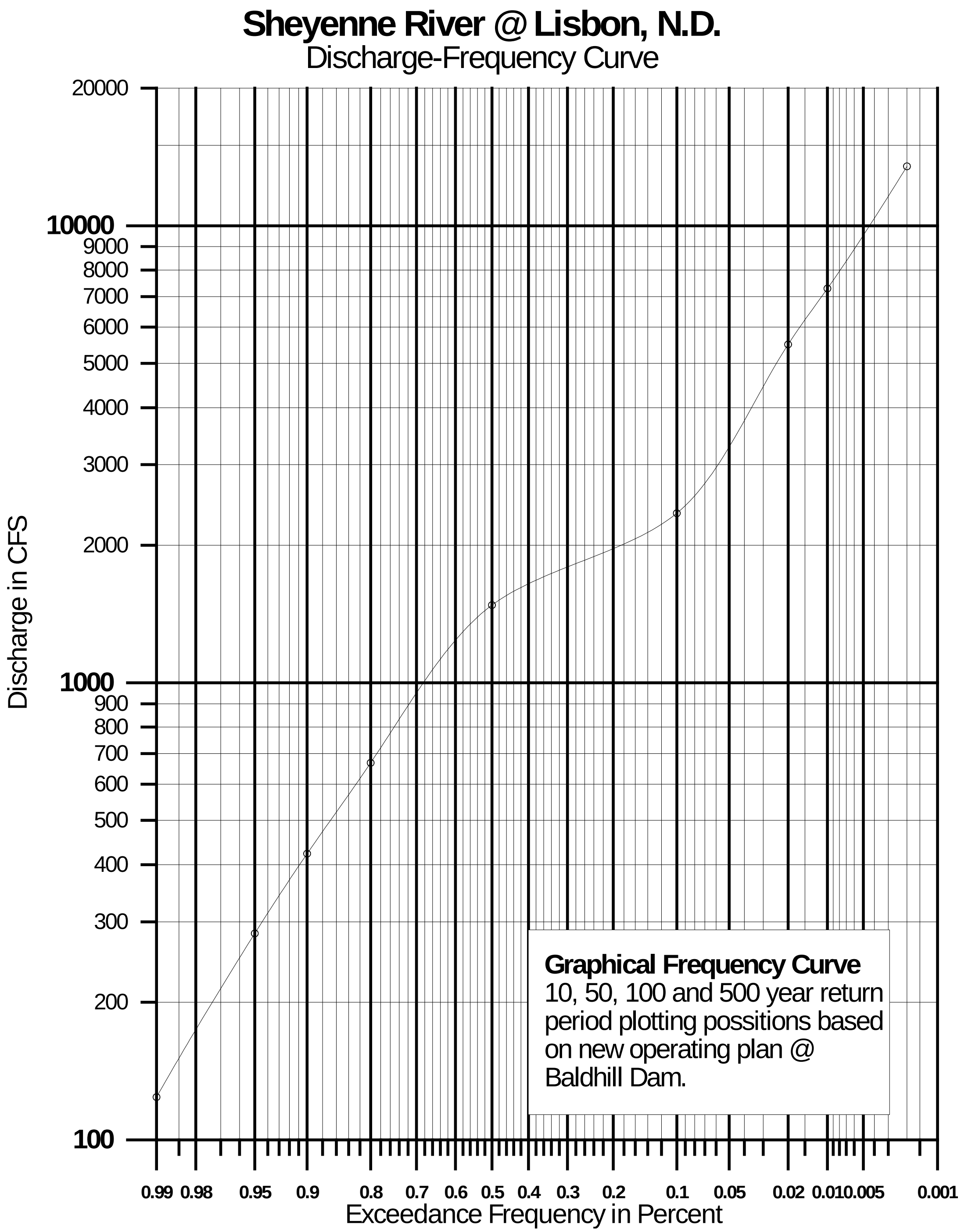


Figure 8-8. Lisbon Discharge Frequency Curve

IX – WATER CONTROL MANAGEMENT

9-01. Responsibilities and Organization.

a. Corps of Engineers. The Corps of Engineers is the owner, operator, and regulator of Baldhill Dam. Operations Division is responsible for the operation and maintenance of the project. Water Control and Hydrology Section is responsible for the regulation of the project. The following chart shows the chain of command from the District Commander to the Project Resource Manager.

← ← ← ← **District Commander** → → → →
↓ ↓
Engineering & Construction Division | Operations Division
↓ ↓
Hydraulics & Hydrology Branch | Western Area Office
↓ ↓
Water Control & Hydrology Section | Project Resource Manager
↓ ↑
Project Regulator → → → → → → → → → → →

Every normal workday, the Water Control Regulator is in contact with the Project Resource Manager or one of the staff. During runoff events contact is more frequent and may include weekends and holidays.

In the case of an emergency situation involving hazardous, toxic, or radiological waste (HTRW), Water Control would include Geotechnical Section and the Environmental Branch in the decision loop. When regulating procedures are outside normal operating parameters, Environmental Branch is included all gate change operations.

b. Other Federal Agencies. The US Geological Survey (USGS) is responsible for maintaining the Corps' gages at Warwick, Cooperstown, Dazey, Baldhill Dam tailwater, and Valley City. Stage and discharge information for these locations are published on the USGS web site for North Dakota (Valley City stage only). Maintaining the rating curve requires periodic discharge measurements to ensure the proper shift. The USGS lead office for this area is located in Bismarck North

Dakota with a satellite office located in Grand Forks. When there is a problem with a gage, Water Control contacts the USGS. The following gives the names and telephone numbers for contact.

Name	Telephone Number	Location
Steve Robinson	701-250-7404	Bismarck
Steve Norbeck	701-250-7428	Grand Forks
Jason Lambert	701-775-7221	Grand Forks

c. State Agencies. The North Dakota State Water Commission is responsible for permitting the storage in Lake Ashtabula to the cities of Fargo, Grand Forks, Valley City, West Fargo, and Lisbon. The allotted volumes are presented in **Table 3-2**. The Corps of Engineers regulates the Baldhill Dam Project; therefore, any releases made because of a request by a community for water supply will require coordination with Water Control.

9-02. Interagency Coordination.

a. Local Press and Corps Bulletins. The St. Paul District's Public Affairs Office (PAO) provides "news releases" to the local media of an advisory nature regarding the important aspects of project regulation (e.g. forecasted pool crest, forecasted peak discharge). PAO coordinates the news release with Water Control and project personnel.

b. National Weather Service. The National Weather Service (NWS) provides Water Control with their forecasted inflow hydrograph for Lake Ashtabula when spring runoff begins. This information includes the forecasted peak inflow on the Sheyenne River at Cooperstown and Baldhill Creek at Dazey. Contact between Water Control and the NWS is often on a daily bassis during a major event. In turn, Water Control provides the NWS with the proposed operating plan including forecasted discharge changes. This allows the NWS to forecast downstream of the reservoir.

c. US Geological Survey. Every year Water Control enters into a cooperative agreement with the US Geological Survey (USGS) to maintain the Corps' gages at Warwick, Cooperstown, Dazey, Valley City, and the dam tailwater. When there is a problem with a gage, Water Control contacts the USGS representative and the gage is scheduled for repair. The Water Control gage crew acts as a backup to the USGS. When a discharge measurement is needed by Water Control (e.g. tailwater discharge), Water Control coordinates with the USGS.

EXHIBIT A
SUPPLEMENTARY PERTINENT DATA

General Information

Other Names of Project:	Baldhill Dam, Lake Ashtabula Lake Named After Ashtabula Township Native American Translation: Fish River
Location:	Sheyenne River, River Mile 271 16 river miles upstream of Valley City, North Dakota 75 highway miles west of Fargo, North Dakota Lat: 47°02'00" Long: 98°05'00"
Type of Project:	Dam and Reservoir
Objectives of Regulation:	Multi Purpose: Water Supply and Flood Control
Project Owner:	US Army Corps of Engineers
Operating Agency:	St. Paul District, Operations Division
Regulating Agency:	St. Paul District, Water Control & Hydrology Section
Water Supply:	Permitted by North Dakota State Water Commission Fargo 35,880 ac-ft Grand Forks 20,023 ac-ft Valley City 6,686 ac-ft West Fargo 954 ac-ft Lisbon 373 ac-ft
Construction:	Started July 1947 Placed into Emergency Service 16 April 1950 Permanent Operations Began Spring 1951 Dedicated on 21 September 1952 Emergency Spillway completed November 1997 Five-Foot Pool Rise for Flood Control, Spring 2004
Special Project Features:	West Fargo Diversion and Horace to West Fargo Diversion US Fish and Wildlife Service Fishponds

Reservoir Pool

Pertinent Pool Data:

Pool Condition	Pool Elevation	Pool Storage	Pool Area
Probable Maximum Flood	1278.5 feet	157,500 ac-ft	8,500 acres
Top of Flood Control	1271.0 feet	101,300 ac-ft	6,750 acres
Conservation Pool Level	1266.0 feet	70,600 ac-ft	5,500 acres
Normal Drawdown	1262.5 feet	52,250 ac-ft	4,375 acres
Maximum Drawdown	1255.0 feet	25,100 ac-ft	2,620 acres
Dead Storage	1238.0 feet	500 ac-ft	250 acres

Real Estate Taking Line:

1947 to 1951

Taking Line: 1270.0 feet
- Land in Fee below 1266.0 feet: ~ 5,527 acres
- Land in Fee above 1266.0 feet: ~ 2,290 acres
- Total Land in Fee: 7,816.51 acres
- Total in Flowage Easements: 666.15 acres

Clearing Line: 1268.0 feet

2000 to 2004

Taking Line: 1271.0 feet
- Land Purchased in Fee: 303 acres
  - For Mitigation: 300 acres
- Land in Flowage Easements: 1,503 acres

Lake Ashtabula: At Conservation Pool;
- Shoreline Length: 78 miles
- Width of Lake: 0.6 miles
- Length of Lake: 27 miles
- Area: 5,500 acres
- Volume: 70,600 acre-feet

Peak Pool Elevation:
- Pre-Five-Foot Rise: May 1950 Elevation 1269.46 feet
- Post Five-Foot Rise: April 2004 Elevation 1270.50 feet

Outflow:

Probable Maximum Flood:	
Service Spillway:	66,200 cfs
Emergency Spillway:	57,800 cfs
Total Discharge:	124,000 cfs
Channel Full Discharge:	2,400 cfs
Non-Damaging Discharge:	3,000 cfs
Minimum Discharge:	13 cfs

Hydrology

Drainage Area:	Sheyenne River Basin Total;	10,700 square miles	
	Closed Basins;		
	Devils Lake Basin:	3,573 square miles	
	U/S Warwick Gage:	227 square miles	
	Contributing Drainage Area:	4,850 square miles	
	Non-Contributing Area:	2,050 square miles	
	Baldhill Dam;		
	Primary Drainage Area:	1,690 square miles	
	Secondary Drainage Area:	1,660 square miles	
	Non-Contributing Area:	462 square miles	
	Total Drainage Area:	3,812 square miles	
Minimum Daily Outflow:	Pre-Dam Construction:	0.0 cfs	
	Post-Dam Construction:	1.0 cfs	9 Sep–5 Oct 1955
		6.0 cfs	15 July 1988

Minimum Monthly Outflow: September 1955: 1.3 cfs

Minimum Annual Outflow: 1988: 46.7 cfs

Max Instantaneous Outflow: April 1996, 5,460 cfs

Minimum Monthly Inflow: Based on 24-hour average daily inflow;
(does not include pool evaporation)
September 1955: -95 cfs

Maximum Monthly Inflow: April 1997: 4,266 cfs

24-Hour Peak Inflow: April 1979: 8,810 cfs

Peak Source Inflow: Cooperstown: May 1950, 7,830 cfs
Dazey: April 1979, ~ 9,000 cfs

Key Stream Locations:
- Upstream Sheyenne River:
  - Warwick, Cooperstown
- Upstream Baldhill Creek:
  - Dazey
- Downstream Sheyenne River:
  - Valley City, Lisbon

Control Point Flood Control: Valley City

Data Input to "Secure CRT":	Cooperstown:	Stage & Discharge
	Pool:	Elevation & Ice Thickness
	Control Station:	24-hr Precipitation, Wind Speed & Direction, Max-Min Temperature
	Tailwater:	Elevation & Discharge
	Storage Shed:	Frost Depth, Snow Depth, Snow-Water Content
Additional Data to Log Sheets:	Warwick:	Discharge
	Dazey:	Discharge
	USFWS:	Fishpond Demand
	Control Station:	Current Temperature
Precipitation Gages:	Tipping Buckets:	Warwick Cooperstown Dazey Pool
	Precipitation Gage:	Central Control Station

Snow Survey Sites: Baldhill, Cooperstown, Warwick, Maddock, New Rockford, Lisbon, Colgate, Dazey, Aneta, Fort Trotten, Hamberg, McHenry, Enderlin, Kindred, Fingal, Hannaford, McVille, Minnewakan, Sheyenne, Tower City, Fort Ransom, Amenia

Sediment Ranges: 30 Ranges (Note: Disregard the 1978 survey.)
Survey Dates: 1952, 1958, 1964, 1971, 1978, 1984
.

Baldhill Dam

Type:	Compacted Impervious Earth Fill
Total Length:	1,650 feet
Crest; Top of Earth Dam:	Elevation 1278.5 feet
Top of Tee-Wall:	Elevation 1283.5 feet
Top Width of Earth Dam:	20 feet
Max Height of Earth Dam:	61 feet
Freeboard:	5.0 feet above PMF

Emergency Spillway

Type:	Uncontrolled Broad Crest Weir
Length:	880 feet
Crest:	Elevation 1271.0 feet

Service Spillway

Type:	Gravity Ogee
Length:	3 Bays; 140 feet total
Gates:	Tainter, 3 @ 40-ft wide, 20-ft high
Crest:	Elevation 1252.0 feet

Low Flow Outlet

Type:	Two, 36-inch reinforced concrete conduits
Intake Invert:	Elevation 1238.0 feet
Discharge invert:	Elevation 1234.5 feet

EXHIBIT B

MISCELLANEOUS EXHIBITS

B1. MAP OF PUBLIC RECREATIONAL FACILITIES

B2. EXECUTIVE SUMMARY - LOW FLOW RELEASE
North Dakota State water Commission and Corps of Engineers
5 January 1992

B3. RESPONSE TO QUESTIONS GENERATED BY CITY OF FARGO
24 May 2006

B4. VALLEY CITY PUBLIC WORKS EMERGENCY FLOOD PLAN

B5. WEEKLY LOG SHEET

B6. WATER QUALITY MONITORING

Lake Ashtabula
Baldhill Dam

Important Phone Numbers

Emergency	911
Lake Ashtabula Project Office	701-845-2970
National Recreation Reservation Service	877-444-6777
Park Ranger Cell Phone	701-840-0400

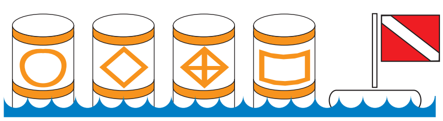
Further information may be obtained from:

U.S. Army Corps of Engineers
Lake Ashtabula Project Office
2630 114th Ave SE
Valley City, ND 58072-9795
701-845-2970

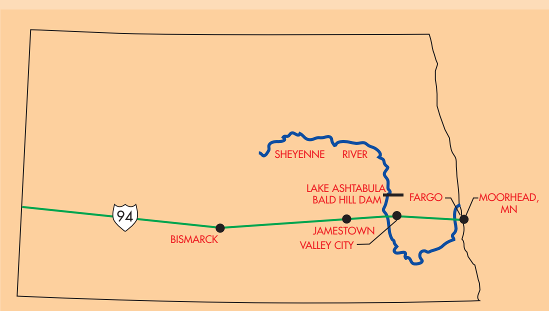
How to Get There:
The main route to Lake Ashtabula recreation sites and project office is via Interstate 94, to Valley City exit #292. Then follow the signs for approximately 12 miles, heading in a Northwesterly direction. It is also accessible from other directions by state, county, and township roads.

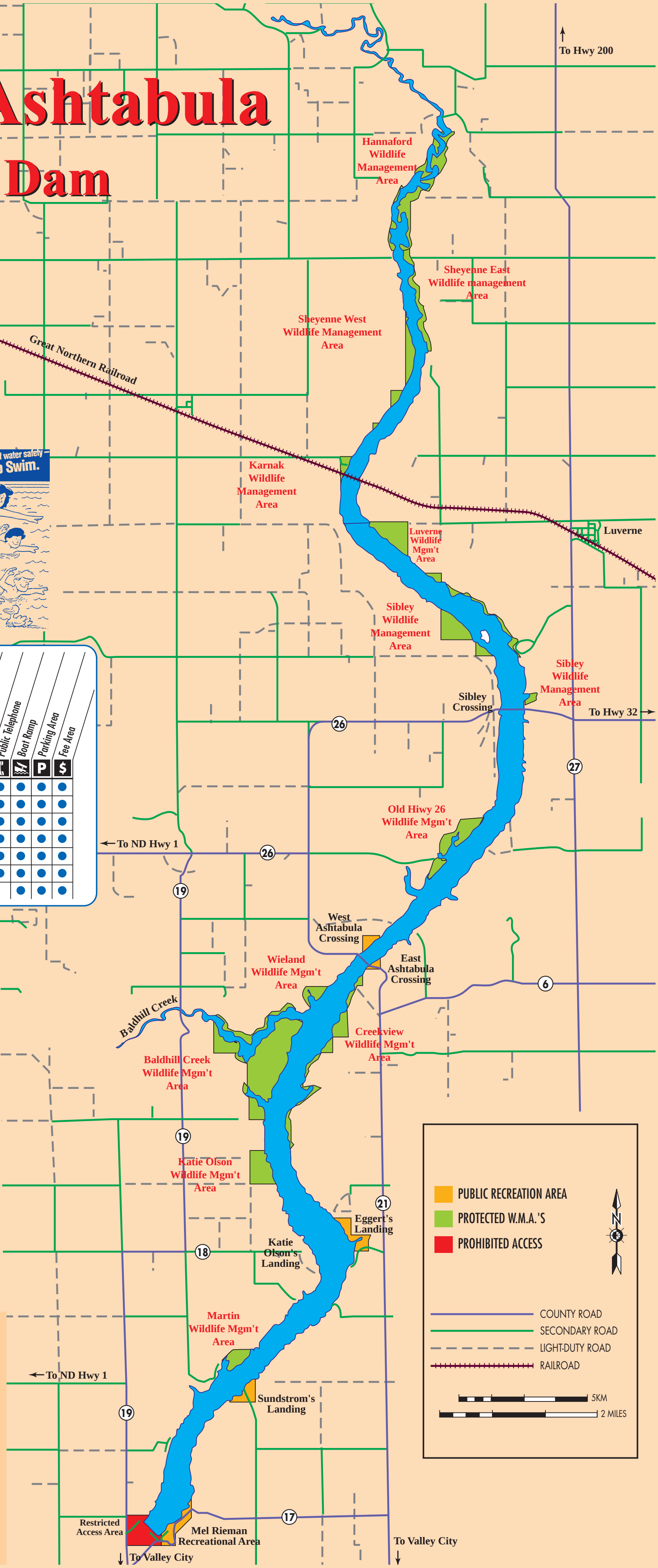
Public Recreation Areas

	Campground Trailer Sites	Campground Tent Sites	Picnic Area	Restrooms	Swimming Area	Playground Area	Picnic Shelter	Showers	Drinking Water	Sanitary Dump Station	Marina	Fish Cleaning Station / Table	Campsite – Electric Hookups	Wheelchair Access – Campsite	Wheelchair Access – Fish Platform	Concessionaires	Public Telephone	Boat Ramp	Parking Area	Fee Area
Mel Reiman	●	●	●	●	●	●	●	●	●		●	●	●			●	●	●	●	●
Sundstrom's Landing			●	●		●	●		●								●	●	●	●
Eggert's Landing	●	●	●	●	●	●			●	●	●	●	●	●	●	●	●	●	●	●
East Ashtabula Crossing	●	●	●	●	●	●	●	●	●		●		●			●	●	●	●	●
West Ashtabula Crossing	●	●	●	●			●		●	●	●	●	●		●	●	●	●	●	●
Sibley Crossing			●	●												●	●	●	●	●
Katie Olson's Landing			●	●		●			●									●	●	●



Controlled Area | Danger | Boats Keep Out | Information | Diver Below





EXECUTIVE SUMMARY

Background Information On Water Management Issues Raised By The State of North Dakota Low Flow Releases From Baldhill Dam And Lake Ashtabula January 5, 1992

PRIMARY ISSUES:

* **Issue:** North Dakota State Water Commission (NDSWC) desires for the Corps to acknowledge, by formal agreement or understanding, NDSWC authority in the decision process regarding low flow releases from Lake Ashtabula to meet permitted water needs on the lower Sheyenne River below Baldhill Dam. **(Reference 9/19/90 letter from Craig Odenbach, NDSWC, to Edward Eaton CENCS-ED-GH; 2/11/91 and 5/15/91 letters from ND State Engineer to CENCS-DE)**

* **Response:** Provisions of the Corp's reservoir regulation manual for Lake Ashtabula requires approval of the NDSWC and the Corps for low flow releases to meet permitted requests. The NDSWC is primarily concerned with municipal water supply and other permitted uses. While municipal water supply needs would in all likelihood have the highest priority during drought periods, the Corps must still give consideration to adverse impacts on all authorized project purposes. **(Reference 3/28/91 letter from CENCS-DE to ND State Engineer)**

* **Issue:** NDSWC is concerned that the Corps may not recognize, honor and give priority in all instances to permitted water rights during low flow periods, but might give weight to impacts on other project authorities that have been added since the original project authorization. **(Reference 9/19/90 letter from Craig Odenbach, NDSWC, to Edward Eaton CENCS-ED-GH and 5/15/91 letter from ND State Engineer to CENCS-DE; 12/24/92 letter from Fargo, ND Mayor Lindgren to CENCS-DE)**

* **Response:** The Corps recognizes the authority of the State Engineer, under North Dakota law, to permit water use in the state. The Corps also recognizes the need for cooperative management of low flows with the state as required in the project reservoir regulation manual. However, the Corps must still give consideration to adverse impacts on all authorized project purposes as mandated by Congress. **(Reference 3/28/91 letter from CENCS-DE to ND State Engineer)**

* **Issue:** NDSWC desires formal assurance that permitted water rights will be available when needed, as many municipalities have developed water supply plans that are dependent upon the availability of the permitted storage in Lake Ashtabula. If the State does not have the authority to guarantee the viability of the municipal permits they issue, then the dependent water supply plans are not certain. **(Reference 9/19/90 letter from Craig Odenbach, NDSWC, to Edward Eaton CENCS-ED-GH and 2/11/91 letter from ND State Engineer to CENCS-DE)**

* **Response:** The Corps recognizes the authority of the State Engineer, under North Dakota law, to permit water use in the state. The need for cooperative management of low flows with the state is also recognized. Municipal water supply needs would in all likelihood have the highest priority during drought periods; however, the Corps must still give consideration to adverse impacts on all authorized project purposes. **(Reference 3/28/91 letter from CENCS-DE to ND State Engineer)**

SECONDARY ISSUES:

* **Issue:** The NDSWC believes non-flood inflows to Lake Ashtabula following spring refill of the reservoir should be released to meet the needs of permitted users (includes irrigation) on the lower Sheyenne River below Baldhill dam. **(Reference 5/30/89 letter from ND State Engineer to CENCS-DE)**

* **Response:** Releases from Baldhill Dam during low inflow periods following spring refill must be balanced against the need to retain water for water supply purposes in the event of extended drought and to sustain recreational use and the reservoir fishery. **(Reference 7/20/89 letter from CENCS-DE to State Engineer)**

* **Issue:** The NDSWC believes that Lake Ashtabula storage, not currently permitted by the state, is available to the state to provide low flow augmentation for irrigation on the lower Sheyenne River below Baldhill Dam. The NDSWC believes that irrigation is a water supply purpose under the project authorization for the Baldhill reservoir. **(Reference 7/14/88, 7/9/90 and 5/15/91 letters from ND State Engineer to CENCS-DE; 7/18/88 letter from Craig Odenbach, NDSWC, to Edward Eaton CENCS-ED-GH; 7/12/89 letter from Milton Lindvig, NDSWC, to CENCS-DE; 9/19/90 letter from Craig Odenbach, NDSWC, to Edward Eaton CENCS-ED-GH; 12/24/92 letter from Fargo, ND Mayor Lindgren to CENCS-DE)**

* **Response:** The Corps recognizes the authority of the State Engineer, under North Dakota law, to permit water use in the state. The question of whether irrigation is or is not a project purpose is arguable based upon the general nature of the project authorizing document, according to preliminary comments by CENCS Counsel. Any arguments would need to look at the intent of Congress in this legislation. To date, NCS has acted favorably to all NDSWC requests for supplemental releases for permitted irrigators from the unpermitted storage in Lake Ashtabula. These releases were made after assessment that no adverse impacts would accrue to authorized project purposes. **(Reference 7/31/90 CENCS-ED-GH Memorandum for Record, Subject: NDSWC request of 7/9/90 for release of unallocated water for irrigation; 8/3/90 and 3/28/91 letters from CENCS-DE to State Engineer).**

DISCUSSION:

* The aforementioned primary and secondary issues had not been problematic until the NDSWC letter of 9 July 1990 requesting low flow releases for downstream irrigation. To respond to this request, significant inhouse coordination took place to assess in a preliminary way the possible adverse impacts of responding affirmatively to the NDSWC request. Concerns regarding irrigation releases were expressed to the NDSWC by Water Control. It appears that these expressed concerns and the length of time it took the Corps to respond (1 August 1990) have caused the NDSWC to become concerned that the Corps might deny some future request of a similar nature. **(Reference 7/9/90 and 2/11/91 letters from ND State Engineer to CENCS-DE; 7/31/90 CENCS-ED-GH Memorandum for Record, Subject: NDSWC request of 7/9/90 for release of unallocated water for irrigation)**

* The Lake Ashtabula project is unique in that North Dakota law requires a permit from the State Engineer for all impoundments capable of storing 12.5 acre-feet of water. The Corps has no such permit, nor does it seem the State has the power to require one of the Corps. **(Reference 5/15/91 letter from ND State Engineer to CENCS-DE).**

* There are no existing water supply contracts for Lake Ashtabula storage between the Corps and any other entity, nor have there ever been any contracts of this nature. **(Reference 9/19/90 letter form Craig Odenbach, NDSWC, to Edward Eaton CENCS-ED-GH; 7/31/90 CENCS-ED-GH Memorandum for Record, Subject: NDSWC request of 7/9/90 for release of unallocated water for irrigation).**

* Under Federal law (Stat. 890, 33 USC 709), the Secretary of the Army has all authority with regard to prescribing rules and regulations for all projects having navigation or flood control capabilities that are constructed wholly or in part with Federal funds. The Baldhill Reservoir Project was authorized for flood control and water conservation by PL 78-534, substantially in accordance with the recommendations contained in Senate Document 193, 78th Congress, 2nd Session. This authorization included provisions for local project sponsorship, but contained no provisions for water apportionment or water supply contracts. The State of North Dakota under its appropriative water law has all authority for permitting the use of waters within the state, while the Corps has no permit to impound water as required by state law. This creates a very unusual situation for regulation and usage of Lake Ashtabula storage

* The NDSWC believes that they were intended to play a major role in the allocation of stored water and the regulation of low flow releases from Lake Ashtabula. They cite several examples of correspondence between past NCS District Engineers and the NDSWC and a past Governor of North Dakota. Current project regulation

manual procedures require the concurrence of the NDSWC and CENCS for making permitted releases from Lake Ashtabula storage. **(Reference 9/19/90 letter form Craig Odenbach, NDSWC, to Edward Eaton CENCS-ED-GH)**

Reference: Meeting at Fargo, North Dakota, 24 May 2006, between the Corps of Engineers, North Dakota State Water Commission, and representatives for the city of Fargo.

Attached: Response to issues presented by representatives for the city of Fargo.

1. Who is the ultimate authority to dictate releases of water from Baldhill Dam for municipal water supply purposes? How do we coordinate the Corps' authority to operate Baldhill Dam with the State's authority and responsibility to distribute the water stored behind the dam?

Essentially the State has the responsibility to allocate the stored water while the Corps of Engineers has the authority to regulate the gates. Releases for water supply are a coordinated effort by the Corps of Engineers and the North Dakota State Water Commission.

2. What process should Fargo follow to obtain its water from Lake Ashtabula?

All requests for water supply needs are to be coordinated through the North Dakota State Water Commission (NDSWC). The NDSWC will coordinate with the Corps of Engineers.

3. How is Baldhill managed between the Corps and the State? What do the Corps and the State feel are the main issues in dispute?

Baldhill is managed in accordance with the water control plan established by the latest approved water control manual. There is no State involvement until water supply becomes an issue. When a request comes into Water Control for a release for water supply, the request is coordinated through the Corps' Environmental Branch. The Corps then decides on the ultimate release. This is the main issue of dispute between the Corps and the State Water Commission.

4. Is an Operational Agreement between the parties possible?

No. Operation of the gates is at the discretion of the Corps of Engineers.

5. The Corps states that it must consider the impacts to all project purposes when making releases.

   a. Are there additional project purposes other than those specified in SD 193 that the Corps considers when releasing water?

The project was constructed for the duel purpose of water supply and flood control. As a federal project, it is tied to numerous public laws related to these two purposes. The following is a list the authorized purposes for Baldhill Dam as presented in Chapter II of the draft Water Control Manual for Baldhill Dam.

Table 2-1
Authorized Purposes Assigned by Congress

Authorized Purpose	Public Law	Name
Flood Control	PL 74-738	Flood Control Act of 1936
Surplus Water, Recreation	PL 89-72	Flood Control Act of 1944
Fish and Wildlife	PL 85-624	Fish and Wildlife Coordination Act of 1958
Water Supply	PL 92-500	Water Supply Act of 1958
Recreation	PL 78-534	Federal Water Project Recreation Act of 1965
Water Quality	PL 92-500	Federal Water Pollution Control Act of 1972
Fish and Wildlife	PL 93-205	Conservation, Protection and Propagation of Endangered Species Law of 1973
Flood Control	PL 99-662	Water Resources Development Act of 1986

b. How does the Corps coordinate operation of the dam between all of these project benefits? In the event of a conflict, who at the Corps decides which project benefits is to receive water? How is this decided?

Operation of the dam to meet project purposes requires that the Corps follow the operating plan as presented in the Water Control Manual for Baldhill Dam. The manual offers guidance for flood control and water supply. Any deviation from this plan would require coordination with the Corps of Engineer's Division Office. During very low flow conditions, the Drought Contingency Plan would be enacted. Releases are then determined through a coordinated effort by the Corps of Engineers and the North Dakota State Water Commission.

6. Flow Operations.
   a. What steps would the Corps take in the event of a drought?

Essentially, the Drought Contingency Plan is enacted when releases are 13 cfs and the pool falls below elevation 1265.8 feet. Consult the Drought Contingency Plan for Corps action.

Basically the Corps of Engineers works with the State Water Commission in regards to releases for what purpose. Water releases for municipal water supply will take precedence over all other releases. When it comes down to "people or fish", the people will always win. Should a drought with the severity of the 1930's occur, in all likely hood, water supply needs and evaporation will deplete the pool down to the dead storage level of elevation 1238.0 feet (~1,600 acre feet).

   b. How does the State's priority system come into play when making releases during times of low flow?

The "State's priority system" is simply that. It is a priority system developed by the State Water Commission to guide the State Engineer in making requests to the Corps of

Engineers for releases. While the Corps constructed the project with water supply being a main feature, it chose not to get bogged down in water allocation. This was left to the State of North Dakota to permit. The State in turn is to bring the request to the Corps.

c. What is minimum pool elevation?

Table 7-1 of the draft Water Control Manual for Baldhill Dam shows a list of different design pool elevations.

Table 7-1
Pool Elevation Constraints

Pool Condition	**Elevation (feet)**	**Volume (acre-feet)**	**Area (acres)**
PMF Top of Pool	1278.5	155,900	8,400
Top of Flood Control	1271.0	101,300	6,750
Conservation Pool	1266.0	70,600	5,450
Normal Drawdown	1262.5	52,250	4,375
Maximum Drawdown	1257.0	31,000	3,000
Dead Storage	1238.0	< 2,500	350

Under normal conditions, the maximum drawdown elevation for fish and wildlife is 1257.0 feet. During a severe drought, the pool may go as low as dead storage, at which point there is no control at the dam.

7. Normal and Above Average Flow Operations:
   a. Is there a priority of types of use in times of average flow?

Typically at normal flow conditions, normal releases are sufficient to meet downstream needs; however, should multiple requests come in, requests for municipal water supply needs would take precedence.

b. Is it the Corps' position that water may be released for municipal water supplies only during times of low flow or drought conditions or will the Corps release water whenever a permitted water right holder (such as Fargo) requests water for daily consumption?

The question assumes that current release is not adequate to meet municipal water supply needs downstream. While at normal flow conditions this is rarely true, releases would be made to meet downstream municipal water supply needs. A release of this type, as with all release requests, are to be coordinated through the North Dakota State Water Commission.

c. Would the Corps recognize a request by Fargo or Grand Forks for a release of water during times when the water quality in the Red River is poor?

Poor water quality is not listed under the purposes of water supply. A release of this type would have to come under a form of pollution abatement to meet project purpose.

d. If the Corps will release water to municipalities only during times of emergency, what situation would constitute an emergency?

The Corps will make releases to municipalities based on *need* whether it is an emergency or not. The municipality must first convince the State Water Commission of its need and the Water Commission will in turn coordinate the release with the Corps of Engineers.

8. Would it be helpful to have a report available on line showing the current volume of water stored behind the dam?

This is available right now. Go to the Water Control web site at www.mvp-wc.usace.army.mil and select "reservoirs" and then "Baldhill". From this site the daily pool elevation can be found. In addition, a stage storage table is available. By simply entering the pool elevation on the table, the present pool volume can be found.

9. Does the Corps have a protocol for the storage of water? When the reservoir refills, is it necessary for a permit holder to notify the Corps/State that they are exercising a refill right or is the reservoir filled and the water divided pro-rata among each water right?

The Corps does not have a protocol for the storage of water. Assuming the reservoir is filled following spring runoff, the pool is at full water supply level for the allocation of water for the calendar year.

The pool is drawdown every year to elevation 1262.5 feet by 1 March. If there is inadequate snow cover or the lack of rainfall necessary to bring the pool back up to conservation level, the missing water supply must be accounted for through unallocated water or an overall reduction in permitted water. The Corps proposed a remedy to this problem at a meeting in Valley City in March 2006. The remedy called for a reduced drawdown when there was little snow cover in the basin. The proposed plan was rejected by several downstream agencies as well as the State Water Commission.

10. Does the Corps have a protocol for the spill of water?
    a. If the Corps is required to spill water from the reservoir during a period of high flow, which pool is spilled first or is the spilled water accounted for on a pro-rata basis from all pools.

The Corps does not view each of the allotted water supply volumes as separate “pools”. As far as the Corps is concerned, there is but one pool to spill from. During the summer months, the pool is maintained at elevation 1266.0 feet and inflow equals outflow. This changes when inflow is less than 13 cfs or when inflow is above the downstream channel capacity. In low flow situations we typically continue to release 13 cfs and let the pool fall. When a summer flood event occurs, water is stored to prevent downstream flooding.

b. Each spring a drawdown of water occurs to ensure sufficient space for storage of the spring runoff. Who bears the loss of the water spilled from the reservoir? Is a spill shared on a pro-rata basis by all pools?

Typicallly the pool is returned to conservation level following spring runoff. Should there be insufficient runoff for this happen, accounting for the loss of stored water would be the responsibility of the State Water Commission. It is likely that it would be accounted towards the unallocated portion of water.

11. How are evaporative losses accounted for? Are/should the losses be shared pro-rata among all water pools stored in the reservoir?

Again this is a water supply allotment issue that will be addressed by the State Water Commission. It is assumed that evaporation losses will be accounted in unallocated portion of the water supply.

12. Does the rewrite of the Baldhill Dam Operating Manual contain the previous manual's provision that the NDSWC and the Corps must both authorize a change in low flow releases?

Yes. The Corps will maintain a minimal outflow of 13 cfs even while the pool is falling. Any reduction or increases will be a coordinated effort by both agencies.

13. The current Operating Manual states in Appendix B, paragraph 6: "The reservoir will be operated during low flow periods so as to provide required flows downstream from the dam." Is this provision included in the rewrite?

Not in those exact words. "Required flows downstream" does not have a clear intent. A discharge is decided upon and that is the discharge we maintain.

14. What is the Corps' position regarding the Thompson/Acker Plan?

The Corps does not have an official position. The State Water Commission was given the authority to allot the stored water behind Baldhill Dam. The Thompson/Acker Plan was their response.

15. Who has the right to unallocated water stored in Lake Ashtabula (5,184 acre-feet)?

Allocation of water is the responsibility of the State Water Commission.

16. Recent improvements to Baldhill Dam included a five-foot rise in floodgates that control the water leaving the reservoir.

a. Were these improvements made solely for flood control purposes?

Yes.

b. Did these improvements result in increased storage capacity? If so how is this water allocated.

All of the water stored above conservation pool is passed on as soon as practical. There is no allocation to this water.

c. Why was Fargo asked to contribute funds if the improvements were solely for flood control purposes.

Benefits extend to Fargo.

17. How should additional storage space be allocated in the future?

There is no additional storage space.

18. In the past the State has requested releases of unallocated water for irrigation purposes during August and September. Research by Fargo has revealed that these

releases potentially impacted the amount of water available to the permitted municipalities.

a. Have the State's requests for water for irrigation purposes placed downstream municipal water rights holders at risk?

Yes and No. Releases made for irrigation are made from the unallocated water supply which should technically have no impact on Fargo's water supply. However, evaporation is accounted for through the unallocated water, the same water that is used for irrigation.

b. How should requests for unallocated water for irrigation purposes be handled in the future?

Allocation of water is a function of the State Water Commission. Requests are made of Corps of Engineers through the State Water Commission.

19. Is it correct that Lake Ashtabula is losing 100 acre-feet of storage per year due to sedimentation? How does the State/Corps plan to deal with this loss of storage now and in the future?

Yes, we are losing around 100 acre-feet of storage per year. Based on this loss rate, it is estimated that there is presently about 68,000 acre-feet available for water supply. The Thompson/Acker Plan assumed 69,000 acre-feet for water supply; therefore, 1,000 acre-feet must be removed from the unallocated storage.

CITY OF VALLEY CITY CULVERTS AND DRAINS
GATE # ORDER

AREA DESIGNATION	GATE #	PRIORITY	TYPE	SIZE	ELEVATION CLOSED	DATE CLOSED	COMMENTS
Golf Course	10	B	Sluice	18"	14.50		
Chautauqua Park	20	A	Sluice	15"	12.70		
Chautauqua Blvd	30	D	Ungated		18.75		COVER INLET
Chautauqua Blvd	40	D	Ungated		18.60		COVER INLET
Chautauqua Blvd	50	D	Ungated	8"	18.60		COVER INLET
DR MACHAYYA	60	C	Sluice	18"	15.50		921 9th AVE NE
	70	D	Ungated		18.50		COVER INLET
	80	D	Ungated		18.50		COVER INLET
Hospital Bridge	90	B	Sluice	36"	14.65		W SIDE BRIDGE
	100	D	Sluice	15"	17.50		
LEO LUTZ	110	A	Sluice	36"	12.70		916 6th ST NE
SCHILLING	120	C	Sluice	24"	15.00		950 5th ST NE
Storm Lift	130	B	Sluice	12"	14.00		
East Main Bridge (N Side)	140	C	Sluice	30"	16.00		
FEARING	150	A	Sluice	18"	12.80		890 E Main
9th AVE+2nd ST SE	160	B	Sluice	18"	14.65		
TOUGAS	170	B	Sluice	15"	14.80		227 10 AVE SE
SKARLOKEN	180	B	Sluice	18"	14.80		503 3rd ST SE
5th Ave SE Bridge	190	B	Gate Valve	8"	14.80		
Service Center	200	C	Sluice	21"	16.60		136 4th AVE SE
	210	D	Sluice	15"	17.00		
	220	D	Gate Valve	8"	17.00		
COLE APT BLDG.	230	A	Sluice	15"	11.00		464 3rd ST SE
LEGLER	240	A	Sluice	15"	11.00		338 6th AVE SE
	250	D	Sluice	18"	17.00		
	260	D	Ungated	8"	18.60		COVER INLET
Mill Dam	270	D	Ungated	12"	18.00		COVER INLET
	272	D?	Sluice	15"	17.00		ESTIMATED
3rd Ave SE Bridge	280	D	Flap Gate	18"	18.00		COVER INLET
	290	C	Sluice	18"	16.00		
	300	C	Sluice	30"	15.30		
VCSU Science Blg	310	E	Ungated	18"	20.10		COVER INLET
VCSU Foot Bridge	320	D	Flap Gate	15"	17.00		ESTIMATED
Music Building	330	C	Sluice	12"	16.00		
VAGLE	360	C	Sluice	15"	16.50		153 4th ST SW
	370	B	Sluice	18"	13.50		
RIVERSIDE APTS	380	B	Sluice	15"	12.70		
LANCE APTS	390	C	Sluice	15"	16.50		
	400	D	Sluice	12"	17.30		
East City Park Bridge	410	D	Sluice	8"	18.50		

CITY OF VALLEY CITY CULVERTS AND DRAINS
GATE # ORDER

AREA DESIGNATION	GATE #	PRIORITY	TYPE	SIZE	ELEVATION CLOSED	DATE CLOSED	COMMENTS
East City Park Bridge	420	D	Sluice	12"	17.30		
	430	B	Sluice	12"	14.65		
2nd + 2nd SW	440	B	Sluice	18"	14.65		
City Park Foot Bridge	450	C	Sluice	18"	16.65		
	460	C	Sluice	54"	16.00		
	470	F	Ungated	54"			
	474	E	Ungated	30"			
	480	C	Sluice	18"	16.65		
	490	E	Ungated	36"			
	500	F	Ungated	24"	22.00		COVER INLET
BETTIN'S NURSERY	510	E	Ungated	48"	20.00		COVER INLET
3rd ST+ 5th AVE SW	515	D?	Sluice	12"	18.00		ESTIMATED
West City Park Bridge	520	C?	Sluice	15"	16.50		ESTIMATED
	530	E	Sluice	15"	19.10		
	540	C?	Sluice	18"	14.60		ESTIMATED
6th + 6th SW	550	C	Sluice	48"	16.00		
	560	C	Sluice	15"	13.50		608 5TH AVE SW
	570	D	Sluice	12"	17.00		
Viking Drive Bridge	580	D	Ungated	4"	17.20		COVER INLET
	590	A	Sluice	36"	12.70		
	600	A	Sluice	24"	12.90		
Little Dam	610	C?	Sluice	15"	16.00		ESTIMATED
Master Lift	620	C?	Sluice	18"	16.00		ESTIMATED
	630	F	Ungated	24"	22.00		COVER INLET
8th Ave SW Bridge	640	C	Sluice	48"	16.00		
	650	F	Ungated	24"	23.00		COVER INLET
College Softball Complex	657	D?	Sluice	12"	17.00		ESTIMATED
1016 Riverview Drive	660	E	Ungated	24"	19.80		COVER INLET
WAGAR NURSERY	670	B	Sluice	18"	13.00		
15th AVE SW & I-94	680	C	Sluice	36"	16.00		

Priority

A	Gates between 1211.00 and 1212.99
B	Gates between 1213.00 and 1214.99
C	Gates between 1215.00 and 1216.99
D	Gates between 1217.00 and 1218.99
E	Gates between 1219.00 and 1220.99
F	Gates between 1221.00 and Higher

ST. PAUL, MN
CORPS OF ENGINEERS – US ARMY

SHEYENNE RIVER
BALDHILL DAM

DATE: 02 July 2004

LOCATION: BALDHILL DAM VALLEY CITY, N.D.	SAT	SUN	MON	TUE	WED	THUR	FRI
	26	27	28	29	30	1	2
Pool and tailwater readings begin at 1200.00 elevation as noted in ( ) for Baldhill Dam, 1929 NGVD							
POOL ELEV. (12__.__) (FT)	66.05W	66.06W	66.04W	66.07W	66.07W	66.06W	65.98W
T.W. ELEV. (12__.__) (FT)	25.38	25.38	25.38	25.14	25.22	25.34	25.34
TAINTER GATE NO. 1 (FT)	0.40	0.40	0.40	0.30	-	-	-
TAINTER GATE NO. 2 (FT)	0.40	0.40	0.40	0.40	-	-	-
TAINTER GATE NO. 3 (FT)	0.40	0.40	0.40	0.30	-	-	-
LOWFLOW GATE NO.1 (FT)	-	-	-	-	2.9	2.9	2.9
LOWFLOW GATE NO.2 (FT)	-	-	-	-	2.9	2.9	2.9
HATCHERY DISCHARGE (CFS)	9	9	9	9	9	9	9
TOTAL DISCHARGE (CFS)	580	580	580	437	483	554	554
COOPERSTOWN, ND (CFS)	555	499	444	395	348	316	292
WARWICK, ND (CFS)	240	211	197	177	m	m	129
DAZEY, ND (CFS)	64	65	60	55	52	47	43
Valley City, ND							
Pool and tailwater readings begin at 1000.00 elevation as noted in ( ) for Homme Dam, 1929 NGVD							
HOMME POOL (10__.__) (FT)	79.89D	79.89D	79.87W	79.74D	79.65D	79.56D	79.45W
HOMME T.W. ELEV. (FT)							
HOMME PREC. (INCHES)	0	0	0	0	0	0	.60
HOMME DISCHARGE CFS	0	0	0	20	20	20	20
Data collected by one of the following: W = Wire Weight, M = Voice Modem, D = DCP (Data Collection Platform), V = Tape/staff visual							
Below weather readings taken at Baldhill Dam Project Site.							
MAX. TEMP. FARH.	71	73	71	80	84	91	78
MIN. TEMP. FARH.	49	50	49	56	55	57	58
0800 TEMP. FARH.	59	59	55	60	65	58	68
PRECIP 24 HRS 0800	0	.13	0	0	0	0	0
WIND DIRECTION	NW	SE	SW	SW	-	NE	E
VELOCITY	5	8	7	4	0	9	2

ICE: 0" SNOW: 0" M.C: 0" FROST: 0"

NOTES:

.

28 Jun HOM Open low flow sluice gate to 2.5-inches for discharge of 20 cfs @ 1000 hrs per Ferris.
28 Jun BHD Close tainter gates #1 & #3 to 0.30 feet each for discharge of 500 cfs @ 0900 hrs per Ferris.
29 Jun BHD Close tainter gates #1, #2, & #3 to 0 feet each and open sluice gates #1 & #2 to 2.9 feet each for discharge of 450 cfs @ 0800 hrs per Ferris.
02 Jul HOM Close low flow sluice gate to 1.5-inches for discharge of 12 cfs @ 0800 hrs per Ferris.
02 Jul BHD Close sluice gate #1 to 1.5 feet @ 0900 hrs and then close sluice gate #2 to 1.5 feet @ 1200 hrs for discharge of 280 cfs per Ferris.
02 Jul BHD Close sluice gates #1 & #2 to 1.0 feet each for a total discharge of 230 cfs @ 1500 hrs per Ferris.

.

Rich Schueneman, Resource Manager

FORM CEMVP 416 (REVISED APRIL 1999)

EXHIBIT B6
WATER QUALITY MONITORING

Equipment

Dissolved Oxygen Meter- Using the district's YSI ProODO meter or its YSI multiparameter sonde, a vertical profile of DO (mg/l) and water temperature (Deg C) will be measured and logged. If the multiparameter sonde is used, pH and specific conductivity (uS/cm) will also be recorded.

Measuring Stick- Both snow depth and ice depth will be measured in feet at each site.

Ice auger- Either a hand or motorized ice auger can be used for drilling through the ice.

Site Selection

The three Lake Ashtabula sampling sites for this plan are in front of the dam (A1A), Sundstrom's Landing, and East Ashtabula crossing (see map below). At each site, it is important to be within the channel to capture the site's maximum depth. Once a suitable location for each site is identified, the site's coordinates will be recorded and it should be the primary site monitored to maintain sampling consistency and to enhance comparisons between monitoring sites.

Collection Schedule

Sampling will occur two times a month at the three sites between November and April, 2012-2017, depending on safe ice conditions. During high snowmelt years, such as 2011, where there was a maximum drawdown, twice a day monitoring will begin once it is decided that it is needed. This continuous type of monitoring will be done to insure that a predetermined criterion of minimum DO needed to preserve the fishery is maintained. All three sites should be sampled during daylight hours on the same day when possible.

Methods

For each sampling event the following steps are required.

Before sample round:

1. Calibrate water quality sensors indoors according to manufacturer's specifications prior to every sampling round.

At each site, drill hole at specified site location and:

2. Record weather conditions (air temperature, cloud conditions, wind, precipitation, etc.)
3. Measure snow depth.
4. Measure ice depth.
5. Assemble multiparamer sounde or Pro ODO sensor to cable and handheld display.
6. Turn on unit and lower sensor(s) to the bottom of the channel.
7. Wait 30-60 seconds for readings on handheld display to equilibrate.
8. Record parameter readings manually or digitally using the handheld display.
9. Raise sensor(s) 1 meter and repeat steps 6 and 7.
10. Repeat step 8 until sensor(s) reach the bottom of the ice.

Notes:

Make sure the sensor guard is used during sampling and that the sensors are kept moist using the calibration cup between sampling sites.

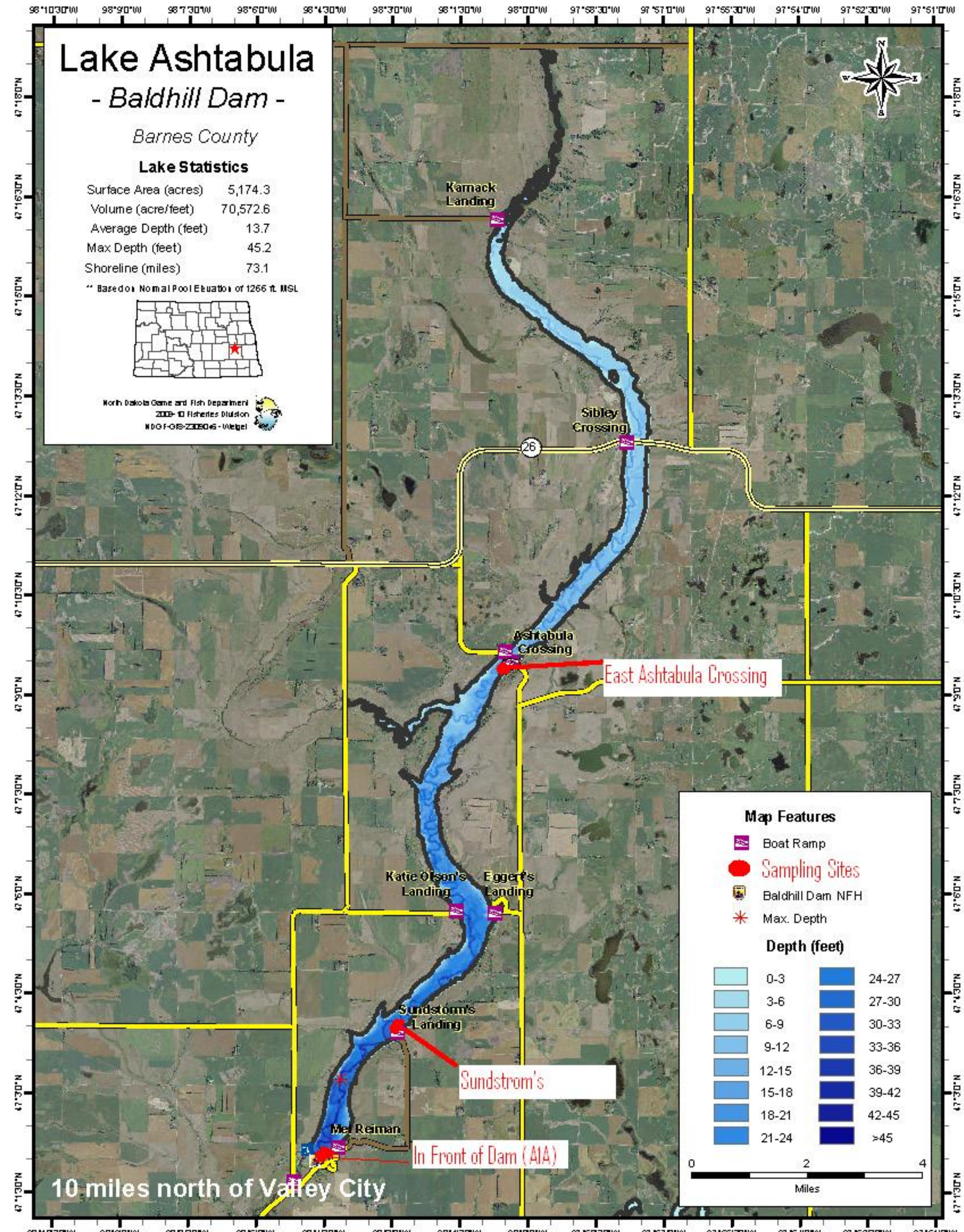
Cleaning

Rinse equipment with tap water after use and keep sensors moist with tap water using the calibration cup. Store the equipment indoors and at room temperature between sampling rounds.

Reporting

Within a few days after each sample round, email or fax vertical profile results, ice and snow measurements and weather conditions to:

Jim Noren
Hydrologist
US Army Corps of Engineers
St. Paul District
Email: James.b.noren@usace.army.mil
Phone: 651-290-5626
Fax: 651-290-5841


Lake Ashtabula
- Baldhill Dam -
Barnes County
Lake Statistics
Surface Area (acres) 5,174.3
Volume (acre/feet) 70,572.6
Average Depth (feet) 13.7
Max Depth (feet) 45.2
Shoreline (miles) 73.1
Karnack Landing
Sibley Crossing
26
Ashtabula Crossing
East Ashtabula Crossing
Katie Olson's Landing
Eggert's Landing
Sundstrom's Landing
Sundstrom's
Mel Reiman
In Front of Dam (AIA)
10 miles north of Valley City
Map Features
Boat Ramp
Sampling Sites
Baldhill Dam NFH
Max. Depth
Depth (feet)
0-3
3-6
6-9
9-12
12-15
15-18
18-21
21-24
24-27
27-30
30-33
33-36
36-39
39-42
42-45
>45
0 2 4
Miles

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
180 FIFTH STREET EAST, SUITE 700
ST. PAUL, MN 55101-1678

Regional Planning and Environment Division North

FINDING OF NO SIGNIFICANT IMPACT

In accordance with the National Environmental Policy Act of 1969, Corps of Engineers, the St. Paul District, has assessed the environmental impacts for the following proposed project:

LAKE ASHTABULA WINTER DRAWDOWN
BARNES COUNTY, NORTH DAKOTA

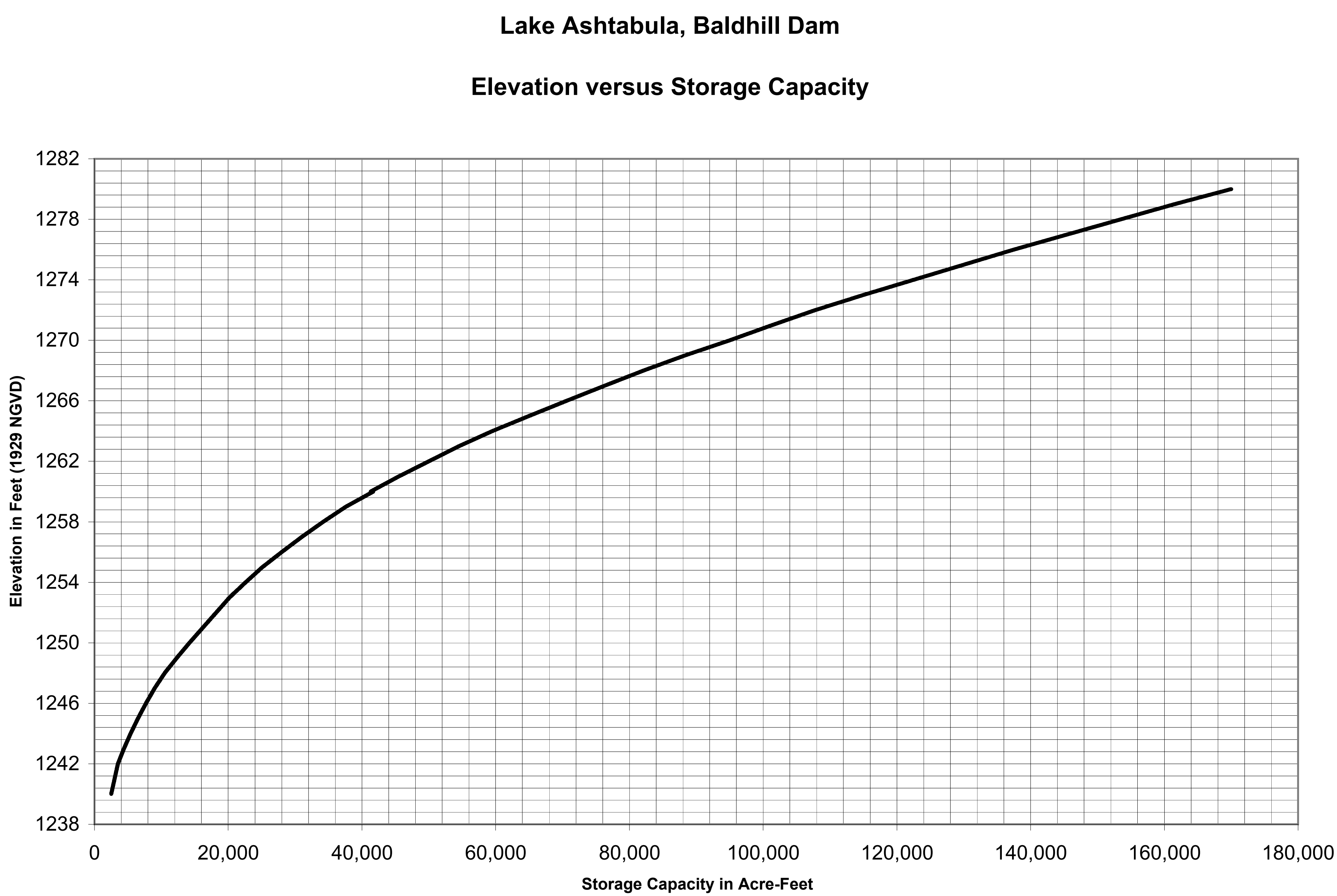
The purpose of the proposed action is to amend the Baldhill Dam Water Control Manual to allow a maximum winter drawdown to elevation 1255.0 feet (Datum NGVD 1929). The current maximum drawdown elevation is 1257.0 feet. The additional drawdown will be used to provide more flood storage in Lake Ashtabula to reduce the effects of spring flooding. The lake would only be drawn down to the lower elevation when snow cover in the basin ensures that the lake can be refilled to the normal summer pool elevation. The July 2013 Environmental Assessment describes the proposed action and includes an evaluation of the associated impacts.

This Finding of No Significant Impact is based on the following factors as discussed in the Environmental Assessment: the increased drawdown would produce minor positive effects on flooding and public health and safety in Valley City; the increased drawdown would have minor negative effects on aquatic habitat, biological productivity, surface water quality, and cultural resources; the increased drawdown would have no effect on endangered and threatened species. The increased drawdown moderately heightens the risk of a fish kill in Lake Ashtabula. The Corps of Engineers will mitigate the increased risk by monitoring the lake during drawdowns to ensure water quality remains sufficient to support fish. If water quality levels drop below a predetermined threshold, the drawdown will be halted.

For the reasons above, the proposed action does not constitute a major federal action significantly affecting the quality of the environment. Therefore, an environmental impact statement will not be prepared.

Date 9 AUG 13

Daniel C. Koprowski
Colonel, Corps of Engineers
District Engineer


Lake Ashtabula, Baldhill Dam
Elevation versus Storage Capacity
Elevation in Feet (1929 NGVD)
1282
1278
1274
1270
1266
1262
1258
1254
1250
1246
1242
1238
0
20,000
40,000
60,000
80,000
100,000
120,000
140,000
160,000
180,000
Storage Capacity in Acre-Feet

Lake Ashtabula
Elevation Storage – Acre Feet

	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
1240.0	2500	2505	2510	2515	2520	2525	2530	2535	2540	2545
1240.1	2550	2555	2560	2565	2570	2575	2580	2585	2590	2595
1240.2	2600	2605	2610	2615	2620	2625	2630	2635	2640	2645
1240.3	2650	2655	2660	2665	2670	2675	2680	2685	2690	2695
1240.4	2700	2705	2710	2715	2720	2725	2730	2735	2740	2745
1240.5	2750	2755	2760	2765	2770	2775	2780	2785	2790	2795
1240.6	2800	2805	2810	2815	2820	2825	2830	2835	2840	2845
1240.7	2850	2855	2860	2865	2870	2875	2880	2885	2890	2895
1240.8	2900	2905	2910	2915	2920	2925	2930	2935	2940	2945
1240.9	2950	2955	2960	2965	2970	2975	2980	2985	2990	2995
1241.0	3000	3005	3010	3015	3020	3025	3030	3035	3040	3045
1241.1	3050	3055	3060	3065	3070	3075	3080	3085	3090	3095
1241.2	3100	3105	3110	3115	3120	3125	3130	3135	3140	3145
1241.3	3150	3155	3160	3165	3170	3175	3180	3185	3190	3195
1241.4	3200	3205	3210	3215	3220	3225	3230	3235	3240	3245
1241.5	3250	3255	3260	3265	3270	3275	3280	3285	3290	3295
1241.6	3300	3305	3310	3315	3320	3325	3330	3335	3340	3345
1241.7	3350	3355	3360	3365	3370	3375	3380	3385	3390	3395
1241.8	3400	3405	3410	3415	3420	3425	3430	3435	3440	3445
1241.9	3450	3455	3460	3465	3470	3475	3480	3485	3490	3495
1242.0	3500	3509	3518	3527	3536	3545	3554	3563	3572	3581
1242.1	3590	3599	3608	3617	3626	3635	3644	3653	3662	3671

1242.2	3680	3689	3698	3707	3716	3725	3734	3743	3752	3761
1242.3	3770	3779	3788	3797	3806	3815	3824	3833	3842	3851
1242.4	3860	3869	3878	3887	3896	3905	3914	3923	3932	3941
1242.5	3950	3959	3968	3977	3986	3995	4004	4013	4022	4031
1242.6	4040	4049	4058	4067	4076	4085	4094	4103	4112	4121
1242.7	4130	4139	4148	4157	4166	4175	4184	4193	4202	4211
1242.8	4220	4229	4238	4247	4256	4265	4274	4283	4292	4301
1242.9	4310	4319	4328	4337	4346	4355	4364	4373	4382	4391
1243.0	4400	4410	4420	4430	4440	4450	4460	4470	4480	4490
1243.1	4500	4510	4520	4530	4540	4550	4560	4570	4580	4590
1243.2	4600	4610	4620	4630	4640	4650	4660	4670	4680	4690
1243.3	4700	4710	4720	4730	4740	4750	4760	4770	4780	4790
1243.4	4800	4810	4820	4830	4840	4850	4860	4870	4880	4890
1243.5	4900	4910	4920	4930	4940	4950	4960	4970	4980	4990
1243.6	5000	5010	5020	5030	5040	5050	5060	5070	5080	5090
1243.7	5100	5110	5120	5130	5140	5150	5160	5170	5180	5190
1243.8	5200	5210	5220	5230	5240	5250	5260	5270	5280	5290
1243.9	5300	5310	5320	5330	5340	5350	5360	5370	5380	5390
1244.0	5400	5411	5422	5433	5444	5455	5466	5477	5488	5499
1244.1	5510	5521	5532	5543	5554	5565	5576	5587	5598	5609
1244.2	5620	5631	5642	5653	5664	5675	5686	5697	5708	5719
1244.3	5730	5741	5752	5763	5774	5785	5796	5807	5818	5829
1244.4	5840	5851	5862	5873	5884	5895	5906	5917	5928	5939
1244.5	5950	5961	5972	5983	5994	6005	6016	6027	6038	6049
1244.6	6060	6071	6082	6093	6104	6115	6126	6137	6148	6159
1244.7	6170	6181	6192	6203	6214	6225	6236	6247	6258	6269

1244.8	6280	6291	6302	6313	6324	6335	6346	6357	6368	6379
1244.9	6390	6401	6412	6423	6434	6445	6456	6467	6478	6489
1245.0	6500	6512	6524	6536	6548	6560	6572	6584	6596	6608
1245.1	6620	6632	6644	6656	6668	6680	6692	6704	6716	6728
1245.2	6740	6752	6764	6776	6788	6800	6812	6824	6836	6848
1245.3	6860	6872	6884	6896	6908	6920	6932	6944	6956	6968
1245.4	6980	6992	7004	7016	7028	7040	7052	7064	7076	7088
1245.5	7100	7112	7124	7136	7148	7160	7172	7184	7196	7208
1245.6	7220	7232	7244	7256	7268	7280	7292	7304	7316	7328
1245.7	7340	7352	7364	7376	7388	7400	7412	7424	7436	7448
1245.8	7460	7472	7484	7496	7508	7520	7532	7544	7556	7568
1245.9	7580	7592	7604	7616	7628	7640	7652	7664	7676	7688
1246.0	7700	7713	7726	7739	7752	7765	7778	7791	7804	7817
1246.1	7830	7843	7856	7869	7882	7895	7908	7921	7934	7947
1246.2	7960	7973	7986	7999	8012	8025	8038	8051	8064	8077
1246.3	8090	8103	8116	8129	8142	8155	8168	8181	8194	8207
1246.4	8220	8233	8246	8259	8272	8285	8298	8311	8324	8337
1246.5	8350	8363	8376	8389	8402	8415	8428	8441	8454	8467
1246.6	8480	8493	8506	8519	8532	8545	8558	8571	8584	8597
1246.7	8610	8623	8636	8649	8662	8675	8688	8701	8714	8727
1246.8	8740	8753	8766	8779	8792	8805	8818	8831	8844	8857
1246.9	8870	8883	8896	8909	8922	8935	8948	8961	8974	8987
1247.0	9000	9015	9030	9045	9060	9075	9090	9105	9120	9135
1247.1	9150	9165	9180	9195	9210	9225	9240	9255	9270	9285
1247.2	9300	9315	9330	9345	9360	9375	9390	9405	9420	9435
1247.3	9450	9465	9480	9495	9510	9525	9540	9555	9570	9585

1247.4	9600	9615	9630	9645	9660	9675	9690	9705	9720	9735
1247.5	9750	9765	9780	9795	9810	9825	9840	9855	9870	9885
1247.6	9900	9915	9930	9945	9960	9975	9990	10005	10020	10035
1247.7	10050	10065	10080	10095	10110	10125	10140	10155	10170	10185
1247.8	10200	10215	10230	10245	10260	10275	10290	10305	10320	10335
1247.9	10350	10365	10380	10395	10410	10425	10440	10455	10470	10485
1248.0	10500	10518	10536	10554	10572	10590	10608	10626	10644	10662
1248.1	10680	10698	10716	10734	10752	10770	10788	10806	10824	10842
1248.2	10860	10878	10896	10914	10932	10950	10968	10986	11004	11022
1248.3	11040	11058	11076	11094	11112	11130	11148	11166	11184	11202
1248.4	11220	11238	11256	11274	11292	11310	11328	11346	11364	11382
1248.5	11400	11418	11436	11454	11472	11490	11508	11526	11544	11562
1248.6	11580	11598	11616	11634	11652	11670	11688	11706	11724	11742
1248.7	11760	11778	11796	11814	11832	11850	11868	11886	11904	11922
1248.8	11940	11958	11976	11994	12012	12030	12048	12066	12084	12102
1248.9	12120	12138	12156	12174	12192	12210	12228	12246	12264	12282
1249.0	12300	12319	12338	12357	12376	12395	12414	12433	12452	12471
1249.1	12490	12509	12528	12547	12566	12585	12604	12623	12642	12661
1249.2	12680	12699	12718	12737	12756	12775	12794	12813	12832	12851
1249.3	12870	12889	12908	12927	12946	12965	12984	13003	13022	13041
1249.4	13060	13079	13098	13117	13136	13155	13174	13193	13212	13231
1249.5	13250	13269	13288	13307	13326	13345	13364	13383	13402	13421
1249.6	13440	13459	13478	13497	13516	13535	13554	13573	13592	13611
1249.7	13630	13649	13668	13687	13706	13725	13744	13763	13782	13801
1249.8	13820	13839	13858	13877	13896	13915	13934	13953	13972	13991
1249.9	14010	14029	14048	14067	14086	14105	14124	14143	14162	14181

1250.0	14200	14220	14240	14260	14280	14300	14320	14340	14360	14380
1250.1	14400	14420	14440	14460	14480	14500	14520	14540	14560	14580
1250.2	14600	14620	14640	14660	14680	14700	14720	14740	14760	14780
1250.3	14800	14820	14840	14860	14880	14900	14920	14940	14960	14980
1250.4	15000	15020	15040	15060	15080	15100	15120	15140	15160	15180
1250.5	15200	15220	15240	15260	15280	15300	15320	15340	15360	15380
1250.6	15400	15420	15440	15460	15480	15500	15520	15540	15560	15580
1250.7	15600	15620	15640	15660	15680	15700	15720	15740	15760	15780
1250.8	15800	15820	15840	15860	15880	15900	15920	15940	15960	15980
1250.9	16000	16020	16040	16060	16080	16100	16120	16140	16160	16180
1251.0	16200	16220	16240	16260	16280	16300	16320	16340	16360	16380
1251.1	16400	16420	16440	16460	16480	16500	16520	16540	16560	16580
1251.2	16600	16620	16640	16660	16680	16700	16720	16740	16760	16780
1251.3	16800	16820	16840	16860	16880	16900	16920	16940	16960	16980
1251.4	17000	17020	17040	17060	17080	17100	17120	17140	17160	17180
1251.5	17200	17220	17240	17260	17280	17300	17320	17340	17360	17380
1251.6	17400	17420	17440	17460	17480	17500	17520	17540	17560	17580
1251.7	17600	17620	17640	17660	17680	17700	17720	17740	17760	17780
1251.8	17800	17820	17840	17860	17880	17900	17920	17940	17960	17980
1251.9	18000	18020	18040	18060	18080	18100	18120	18140	18160	18180
1252.0	18200	18220	18240	18260	18280	18300	18320	18340	18360	18380
1252.1	18400	18420	18440	18460	18480	18500	18520	18540	18560	18580
1252.2	18600	18620	18640	18660	18680	18700	18720	18740	18760	18780
1252.3	18800	18820	18840	18860	18880	18900	18920	18940	18960	18980
1252.4	19000	19020	19040	19060	19080	19100	19120	19140	19160	19180
1252.5	19200	19220	19240	19260	19280	19300	19320	19340	19360	19380

1252.6	19400	19420	19440	19460	19480	19500	19520	19540	19560	19580
1252.7	19600	19620	19640	19660	19680	19700	19720	19740	19760	19780
1252.8	19800	19820	19840	19860	19880	19900	19920	19940	19960	19980
1252.9	20000	20020	20040	20060	20080	20100	20120	20140	20160	20180
1253.0	20200	20224	20248	20272	20296	20320	20344	20368	20392	20416
1253.1	20440	20464	20488	20512	20536	20560	20584	20608	20632	20656
1253.2	20680	20704	20728	20752	20776	20800	20824	20848	20872	20896
1253.3	20920	20944	20968	20992	21016	21040	21064	21088	21112	21136
1253.4	21160	21184	21208	21232	21256	21280	21304	21328	21352	21376
1253.5	21400	21424	21448	21472	21496	21520	21544	21568	21592	21616
1253.6	21640	21664	21688	21712	21736	21760	21784	21808	21832	21856
1253.7	21880	21904	21928	21952	21976	22000	22024	22048	22072	22096
1253.8	22120	22144	22168	22192	22216	22240	22264	22288	22312	22336
1253.9	22360	22384	22408	22432	22456	22480	22504	22528	22552	22576
1254.0	22600	22625	22650	22675	22700	22725	22750	22775	22800	22825
1254.1	22850	22875	22900	22925	22950	22975	23000	23025	23050	23075
1254.2	23100	23125	23150	23175	23200	23225	23250	23275	23300	23325
1254.3	23350	23375	23400	23425	23450	23475	23500	23525	23550	23575
1254.4	23600	23625	23650	23675	23700	23725	23750	23775	23800	23825
1254.5	23850	23875	23900	23925	23950	23975	24000	24025	24050	24075
1254.6	24100	24125	24150	24175	24200	24225	24250	24275	24300	24325
1254.7	24350	24375	24400	24425	24450	24475	24500	24525	24550	24575
1254.8	24600	24625	24650	24675	24700	24725	24750	24775	24800	24825
1254.9	24850	24875	24900	24925	24950	24975	25000	25025	25050	25075
1255.0	25100	25129	25158	25187	25216	25245	25274	25303	25332	25361
1255.1	25390	25419	25448	25477	25506	25535	25564	25593	25622	25651

1255.2	25680	25709	25738	25767	25796	25825	25854	25883	25912	25941
1255.3	25970	25999	26028	26057	26086	26115	26144	26173	26202	26231
1255.4	26260	26289	26318	26347	26376	26405	26434	26463	26492	26521
1255.5	26550	26579	26608	26637	26666	26695	26724	26753	26782	26811
1255.6	26840	26869	26898	26927	26956	26985	27014	27043	27072	27101
1255.7	27130	27159	27188	27217	27246	27275	27304	27333	27362	27391
1255.8	27420	27449	27478	27507	27536	27565	27594	27623	27652	27681
1255.9	27710	27739	27768	27797	27826	27855	27884	27913	27942	27971
1256.0	28000	28030	28060	28090	28120	28150	28180	28210	28240	28270
1256.1	28300	28330	28360	28390	28420	28450	28480	28510	28540	28570
1256.2	28600	28630	28660	28690	28720	28750	28780	28810	28840	28870
1256.3	28900	28930	28960	28990	29020	29050	29080	29110	29140	29170
1256.4	29200	29230	29260	29290	29320	29350	29380	29410	29440	29470
1256.5	29500	29530	29560	29590	29620	29650	29680	29710	29740	29770
1256.6	29800	29830	29860	29890	29920	29950	29980	30010	30040	30070
1256.7	30100	30130	30160	30190	30220	30250	30280	30310	30340	30370
1256.8	30400	30430	30460	30490	30520	30550	30580	30610	30640	30670
1256.9	30700	30730	30760	30790	30820	30850	30880	30910	30940	30970
1257.0	31000	31032	31064	31096	31128	31160	31192	31224	31256	31288
1257.1	31320	31352	31384	31416	31448	31480	31512	31544	31576	31608
1257.2	31640	31672	31704	31736	31768	31800	31832	31864	31896	31928
1257.3	31960	31992	32024	32056	32088	32120	32152	32184	32216	32248
1257.4	32280	32312	32344	32376	32408	32440	32472	32504	32536	32568
1257.5	32600	32632	32664	32696	32728	32760	32792	32824	32856	32888
1257.6	32920	32952	32984	33016	33048	33080	33112	33144	33176	33208
1257.7	33240	33272	33304	33336	33368	33400	33432	33464	33496	33528

1257.8	33560	33592	33624	33656	33688	33720	33752	33784	33816	33848
1257.9	33880	33912	33944	33976	34008	34040	34072	34104	34136	34168
1258.0	34200	34234	34268	34302	34336	34370	34404	34438	34472	34506
1258.1	34540	34574	34608	34642	34676	34710	34744	34778	34812	34846
1258.2	34880	34914	34948	34982	35016	35050	35084	35118	35152	35186
1258.3	35220	35254	35288	35322	35356	35390	35424	35458	35492	35526
1258.4	35560	35594	35628	35662	35696	35730	35764	35798	35832	35866
1258.5	35900	35934	35968	36002	36036	36070	36104	36138	36172	36206
1258.6	36240	36274	36308	36342	36376	36410	36444	36478	36512	36546
1258.7	36580	36614	36648	36682	36716	36750	36784	36818	36852	36886
1258.8	36920	36954	36988	37022	37056	37090	37124	37158	37192	37226
1258.9	37260	37294	37328	37362	37396	37430	37464	37498	37532	37566
1259.0	37600	37641	37682	37723	37764	37805	37846	37887	37928	37969
1259.1	38010	38051	38092	38133	38174	38215	38256	38297	38338	38379
1259.2	38420	38461	38502	38543	38584	38625	38666	38707	38748	38789
1259.3	38830	38871	38912	38953	38994	39035	39076	39117	39158	39199
1259.4	39240	39281	39322	39363	39404	39445	39486	39527	39568	39609
1259.5	39650	39691	39732	39773	39814	39855	39896	39937	39978	40019
1259.6	40060	40101	40142	40183	40224	40265	40306	40347	40388	40429
1259.7	40470	40511	40552	40593	40634	40675	40716	40757	40798	40839
1259.8	40880	40921	40962	41003	41044	41085	41126	41167	41208	41249
1259.9	41290	41331	41372	41413	41454	41495	41536	41577	41618	41659
1260.0	41300	41342	41384	41426	41468	41510	41552	41594	41636	41678
1260.1	41720	41762	41804	41846	41888	41930	41972	42014	42056	42098
1260.2	42140	42182	42224	42266	42308	42350	42392	42434	42476	42518
1260.3	42560	42602	42644	42686	42728	42770	42812	42854	42896	42938

1260.4	42980	43022	43064	43106	43148	43190	43232	43274	43316	43358
1260.5	43400	43442	43484	43526	43568	43610	43652	43694	43736	43778
1260.6	43820	43862	43904	43946	43988	44030	44072	44114	44156	44198
1260.7	44240	44282	44324	44366	44408	44450	44492	44534	44576	44618
1260.8	44660	44702	44744	44786	44828	44870	44912	44954	44996	45038
1260.9	45080	45122	45164	45206	45248	45290	45332	45374	45416	45458
1261.0	45500	45545	45590	45635	45680	45725	45770	45815	45860	45905
1261.1	45950	45995	46040	46085	46130	46175	46220	46265	46310	46355
1261.2	46400	46445	46490	46535	46580	46625	46670	46715	46760	46805
1261.3	46850	46895	46940	46985	47030	47075	47120	47165	47210	47255
1261.4	47300	47345	47390	47435	47480	47525	47570	47615	47660	47705
1261.5	47750	47795	47840	47885	47930	47975	48020	48065	48110	48155
1261.6	48200	48245	48290	48335	48380	48425	48470	48515	48560	48605
1261.7	48650	48695	48740	48785	48830	48875	48920	48965	49010	49055
1261.8	49100	49145	49190	49235	49280	49325	49370	49415	49460	49505
1261.9	49550	49595	49640	49685	49730	49775	49820	49865	49910	49955
1262.0	50000	50045	50090	50135	50180	50225	50270	50315	50360	50405
1262.1	50450	50495	50540	50585	50630	50675	50720	50765	50810	50855
1262.2	50900	50945	50990	51035	51080	51125	51170	51215	51260	51305
1262.3	51350	51395	51440	51485	51530	51575	51620	51665	51710	51755
1262.4	51800	51845	51890	51935	51980	52025	52070	52115	52160	52205
1262.5	52250	52295	52340	52385	52430	52475	52520	52565	52610	52655
1262.6	52700	52745	52790	52835	52880	52925	52970	53015	53060	53105
1262.7	53150	53195	53240	53285	53330	53375	53420	53465	53510	53555
1262.8	53600	53645	53690	53735	53780	53825	53870	53915	53960	54005
1262.9	54050	54095	54140	54185	54230	54275	54320	54365	54410	54455

1263.0	54500	54550	54600	54650	54700	54750	54800	54850	54900	54950
1263.1	55000	55050	55100	55150	55200	55250	55300	55350	55400	55450
1263.2	55500	55550	55600	55650	55700	55750	55800	55850	55900	55950
1263.3	56000	56050	56100	56150	56200	56250	56300	56350	56400	56450
1263.4	56500	56550	56600	56650	56700	56750	56800	56850	56900	56950
1263.5	57000	57050	57100	57150	57200	57250	57300	57350	57400	57450
1263.6	57500	57550	57600	57650	57700	57750	57800	57850	57900	57950
1263.7	58000	58050	58100	58150	58200	58250	58300	58350	58400	58450
1263.8	58500	58550	58600	58650	58700	58750	58800	58850	58900	58950
1263.9	59000	59050	59100	59150	59200	59250	59300	59350	59400	59450
1264.0	59500	59555	59610	59665	59720	59775	59830	59885	59940	59995
1264.1	60050	60105	60160	60215	60270	60325	60380	60435	60490	60545
1264.2	60600	60655	60710	60765	60820	60875	60930	60985	61040	61095
1264.3	61150	61205	61260	61315	61370	61425	61480	61535	61590	61645
1264.4	61700	61755	61810	61865	61920	61975	62030	62085	62140	62195
1264.5	62250	62305	62360	62415	62470	62525	62580	62635	62690	62745
1264.6	62800	62855	62910	62965	63020	63075	63130	63185	63240	63295
1264.7	63350	63405	63460	63515	63570	63625	63680	63735	63790	63845
1264.8	63900	63955	64010	64065	64120	64175	64230	64285	64340	64395
1264.9	64450	64505	64560	64615	64670	64725	64780	64835	64890	64945
1265.0	65000	65056	65112	65168	65224	65280	65336	65392	65448	65504
1265.1	65560	65616	65672	65728	65784	65840	65896	65952	66008	66064
1265.2	66120	66176	66232	66288	66344	66400	66456	66512	66568	66624
1265.3	66680	66736	66792	66848	66904	66960	67016	67072	67128	67184
1265.4	67240	67296	67352	67408	67464	67520	67576	67632	67688	67744
1265.5	67800	67856	67912	67968	68024	68080	68136	68192	68248	68304

1265.6	68360	68416	68472	68528	68584	68640	68696	68752	68808	68864
1265.7	68920	68976	69032	69088	69144	69200	69256	69312	69368	69424
1265.8	69480	69536	69592	69648	69704	69760	69816	69872	69928	69984
1265.9	70040	70096	70152	70208	70264	70320	70376	70432	70488	70544
1266.0	70600	70657	70714	70771	70828	70885	70942	70999	71056	71113
1266.1	71170	71227	71284	71341	71398	71455	71512	71569	71626	71683
1266.2	71740	71797	71854	71911	71968	72025	72082	72139	72196	72253
1266.3	72310	72367	72424	72481	72538	72595	72652	72709	72766	72823
1266.4	72880	72937	72994	73051	73108	73165	73222	73279	73336	73393
1266.5	73450	73507	73564	73621	73678	73735	73792	73849	73906	73963
1266.6	74020	74077	74134	74191	74248	74305	74362	74419	74476	74533
1266.7	74590	74647	74704	74761	74818	74875	74932	74989	75046	75103
1266.8	75160	75217	75274	75331	75388	75445	75502	75559	75616	75673
1266.9	75730	75787	75844	75901	75958	76015	76072	76129	76186	76243
1267.0	76300	76358	76416	76474	76532	76590	76648	76706	76764	76822
1267.1	76880	76938	76996	77054	77112	77170	77228	77286	77344	77402
1267.2	77460	77518	77576	77634	77692	77750	77808	77866	77924	77982
1267.3	78040	78098	78156	78214	78272	78330	78388	78446	78504	78562
1267.4	78620	78678	78736	78794	78852	78910	78968	79026	79084	79142
1267.5	79200	79258	79316	79374	79432	79490	79548	79606	79664	79722
1267.6	79780	79838	79896	79954	80012	80070	80128	80186	80244	80302
1267.7	80360	80418	80476	80534	80592	80650	80708	80766	80824	80882
1267.8	80940	80998	81056	81114	81172	81230	81288	81346	81404	81462
1267.9	81520	81578	81636	81694	81752	81810	81868	81926	81984	82042
1268.0	82100	82162	82224	82286	82348	82410	82472	82534	82596	82658
1268.1	82720	82782	82844	82906	82968	83030	83092	83154	83216	83278

1268.2	83340	83402	83464	83526	83588	83650	83712	83774	83836	83898
1268.3	83960	84022	84084	84146	84208	84270	84332	84394	84456	84518
1268.4	84580	84642	84704	84766	84828	84890	84952	85014	85076	85138
1268.5	85200	85262	85324	85386	85448	85510	85572	85634	85696	85758
1268.6	85820	85882	85944	86006	86068	86130	86192	86254	86316	86378
1268.7	86440	86502	86564	86626	86688	86750	86812	86874	86936	86998
1268.8	87060	87122	87184	87246	87308	87370	87432	87494	87556	87618
1268.9	87680	87742	87804	87866	87928	87990	88052	88114	88176	88238
1269.0	88300	88367	88434	88501	88568	88635	88702	88769	88836	88903
1269.1	88970	89037	89104	89171	89238	89305	89372	89439	89506	89573
1269.2	89640	89707	89774	89841	89908	89975	90042	90109	90176	90243
1269.3	90310	90377	90444	90511	90578	90645	90712	90779	90846	90913
1269.4	90980	91047	91114	91181	91248	91315	91382	91449	91516	91583
1269.5	91650	91717	91784	91851	91918	91985	92052	92119	92186	92253
1269.6	92320	92387	92454	92521	92588	92655	92722	92789	92856	92923
1269.7	92990	93057	93124	93191	93258	93325	93392	93459	93526	93593
1269.8	93660	93727	93794	93861	93928	93995	94062	94129	94196	94263
1269.9	94330	94397	94464	94531	94598	94665	94732	94799	94866	94933
1270.0	95000	95063	95126	95189	95252	95315	95378	95441	95504	95567
1270.1	95630	95693	95756	95819	95882	95945	96008	96071	96134	96197
1270.2	96260	96323	96386	96449	96512	96575	96638	96701	96764	96827
1270.3	96890	96953	97016	97079	97142	97205	97268	97331	97394	97457
1270.4	97520	97583	97646	97709	97772	97835	97898	97961	98024	98087
1270.5	98150	98213	98276	98339	98402	98465	98528	98591	98654	98717
1270.6	98780	98843	98906	98969	99032	99095	99158	99221	99284	99347
1270.7	99410	99473	99536	99599	99662	99725	99788	99851	99914	99977

1270.8	100040	100103	100166	100229	100292	100355	100418	100481	100544	100607
1270.9	100670	100733	100796	100859	100922	100985	101048	101111	101174	101237
1271.0	101300	101365	101430	101495	101560	101625	101690	101755	101820	101885
1271.1	101950	102015	102080	102145	102210	102275	102340	102405	102470	102535
1271.2	102600	102665	102730	102795	102860	102925	102990	103055	103120	103185
1271.3	103250	103315	103380	103445	103510	103575	103640	103705	103770	103835
1271.4	103900	103965	104030	104095	104160	104225	104290	104355	104420	104485
1271.5	104550	104615	104680	104745	104810	104875	104940	105005	105070	105135
1271.6	105200	105265	105330	105395	105460	105525	105590	105655	105720	105785
1271.7	105850	105915	105980	106045	106110	106175	106240	106305	106370	106435
1271.8	106500	106565	106630	106695	106760	106825	106890	106955	107020	107085
1271.9	107150	107215	107280	107345	107410	107475	107540	107605	107670	107735
1272.0	107800	107872	107944	108016	108088	108160	108232	108304	108376	108448
1272.1	108520	108592	108664	108736	108808	108880	108952	109024	109096	109168
1272.2	109240	109312	109384	109456	109528	109600	109672	109744	109816	109888
1272.3	109960	110032	110104	110176	110248	110320	110392	110464	110536	110608
1272.4	110680	110752	110824	110896	110968	111040	111112	111184	111256	111328
1272.5	111400	111472	111544	111616	111688	111760	111832	111904	111976	112048
1272.6	112120	112192	112264	112336	112408	112480	112552	112624	112696	112768
1272.7	112840	112912	112984	113056	113128	113200	113272	113344	113416	113488
1272.8	113560	113632	113704	113776	113848	113920	113992	114064	114136	114208
1272.9	114280	114352	114424	114496	114568	114640	114712	114784	114856	114928
1273.0	115000	115075	115150	115225	115300	115375	115450	115525	115600	115675
1273.1	115750	115825	115900	115975	116050	116125	116200	116275	116350	116425
1273.2	116500	116575	116650	116725	116800	116875	116950	117025	117100	117175
1273.3	117250	117325	117400	117475	117550	117625	117700	117775	117850	117925

1273.4	118000	118075	118150	118225	118300	118375	118450	118525	118600	118675
1273.5	118750	118825	118900	118975	119050	119125	119200	119275	119350	119425
1273.6	119500	119575	119650	119725	119800	119875	119950	120025	120100	120175
1273.7	120250	120325	120400	120475	120550	120625	120700	120775	120850	120925
1273.8	121000	121075	121150	121225	121300	121375	121450	121525	121600	121675
1273.9	121750	121825	121900	121975	122050	122125	122200	122275	122350	122425
1274.0	122500	122575	122650	122725	122800	122875	122950	123025	123100	123175
1274.1	123250	123325	123400	123475	123550	123625	123700	123775	123850	123925
1274.2	124000	124075	124150	124225	124300	124375	124450	124525	124600	124675
1274.3	124750	124825	124900	124975	125050	125125	125200	125275	125350	125425
1274.4	125500	125575	125650	125725	125800	125875	125950	126025	126100	126175
1274.5	126250	126325	126400	126475	126550	126625	126700	126775	126850	126925
1274.6	127000	127075	127150	127225	127300	127375	127450	127525	127600	127675
1274.7	127750	127825	127900	127975	128050	128125	128200	128275	128350	128425
1274.8	128500	128575	128650	128725	128800	128875	128950	129025	129100	129175
1274.9	129250	129325	129400	129475	129550	129625	129700	129775	129850	129925
1275.0	130000	130075	130150	130225	130300	130375	130450	130525	130600	130675
1275.1	130750	130825	130900	130975	131050	131125	131200	131275	131350	131425
1275.2	131500	131575	131650	131725	131800	131875	131950	132025	132100	132175
1275.3	132250	132325	132400	132475	132550	132625	132700	132775	132850	132925
1275.4	133000	133075	133150	133225	133300	133375	133450	133525	133600	133675
1275.5	133750	133825	133900	133975	134050	134125	134200	134275	134350	134425
1275.6	134500	134575	134650	134725	134800	134875	134950	135025	135100	135175
1275.7	135250	135325	135400	135475	135550	135625	135700	135775	135850	135925
1275.8	136000	136075	136150	136225	136300	136375	136450	136525	136600	136675
1275.9	136750	136825	136900	136975	137050	137125	137200	137275	137350	137425

1276.0	137500	137580	137660	137740	137820	137900	137980	138060	138140	138220
1276.1	138300	138380	138460	138540	138620	138700	138780	138860	138940	139020
1276.2	139100	139180	139260	139340	139420	139500	139580	139660	139740	139820
1276.3	139900	139980	140060	140140	140220	140300	140380	140460	140540	140620
1276.4	140700	140780	140860	140940	141020	141100	141180	141260	141340	141420
1276.5	141500	141580	141660	141740	141820	141900	141980	142060	142140	142220
1276.6	142300	142380	142460	142540	142620	142700	142780	142860	142940	143020
1276.7	143100	143180	143260	143340	143420	143500	143580	143660	143740	143820
1276.8	143900	143980	144060	144140	144220	144300	144380	144460	144540	144620
1276.9	144700	144780	144860	144940	145020	145100	145180	145260	145340	145420
1277.0	145500	145580	145660	145740	145820	145900	145980	146060	146140	146220
1277.1	146300	146380	146460	146540	146620	146700	146780	146860	146940	147020
1277.2	147100	147180	147260	147340	147420	147500	147580	147660	147740	147820
1277.3	147900	147980	148060	148140	148220	148300	148380	148460	148540	148620
1277.4	148700	148780	148860	148940	149020	149100	149180	149260	149340	149420
1277.5	149500	149580	149660	149740	149820	149900	149980	150060	150140	150220
1277.6	150300	150380	150460	150540	150620	150700	150780	150860	150940	151020
1277.7	151100	151180	151260	151340	151420	151500	151580	151660	151740	151820
1277.8	151900	151980	152060	152140	152220	152300	152380	152460	152540	152620
1277.9	152700	152780	152860	152940	153020	153100	153180	153260	153340	153420
1278.0	153500	153580	153660	153740	153820	153900	153980	154060	154140	154220
1278.1	154300	154380	154460	154540	154620	154700	154780	154860	154940	155020
1278.2	155100	155180	155260	155340	155420	155500	155580	155660	155740	155820
1278.3	155900	155980	156060	156140	156220	156300	156380	156460	156540	156620
1278.4	156700	156780	156860	156940	157020	157100	157180	157260	157340	157420
1278.5	157500	157580	157660	157740	157820	157900	157980	158060	158140	158220

1278.6	158300	158380	158460	158540	158620	158700	158780	158860	158940	159020
1278.7	159100	159180	159260	159340	159420	159500	159580	159660	159740	159820
1278.8	159900	159980	160060	160140	160220	160300	160380	160460	160540	160620
1278.9	160700	160780	160860	160940	161020	161100	161180	161260	161340	161420
1279.0	161500	161585	161670	161755	161840	161925	162010	162095	162180	162265
1279.1	162350	162435	162520	162605	162690	162775	162860	162945	163030	163115
1279.2	163200	163285	163370	163455	163540	163625	163710	163795	163880	163965
1279.3	164050	164135	164220	164305	164390	164475	164560	164645	164730	164815
1279.4	164900	164985	165070	165155	165240	165325	165410	165495	165580	165665
1279.5	165750	165835	165920	166005	166090	166175	166260	166345	166430	166515
1279.6	166600	166685	166770	166855	166940	167025	167110	167195	167280	167365
1279.7	167450	167535	167620	167705	167790	167875	167960	168045	168130	168215
1279.8	168300	168385	168470	168555	168640	168725	168810	168895	168980	169065
1279.9	169150	169235	169320	169405	169490	169575	169660	169745	169830	169915
1280.0	170000									

BALDHILL DAM FLOOD POOL RAISE

Freeboard analysis

Wind Speeds

1. Wind speed data was determined from the weather station nearest to Baldhill Dam, that station being the Hector Airport station in Fargo, North Dakota. Fastest mile windspeeds recorded at this station in April for the period of 24 years (1967-1992) is 52 mph. The Month of April is the critical month for flooding on the Sheyenne River and it is windspeeds recorded during April that are most significant for wave analysis during high flood pool conditions. The following data was determined from April wind speed records for the Fargo station.

April Wind Data

Max. Windspeed - 52 mph (1 minute duration)
Average Max. April windspeed (V_{avg}) - 38.125 mph
Std. Deviation (s) - 6.22 mph
Gage height - 18 feet

2. The above statistics are used to determine the design windspeed with a return period of 25 Yrs (ANSI STANDARD A58.1-1972) which is used in non-life threatening situations. The 25yr windspeed is estimated from the following relationship: (where T_R = 25)

$$V_{25} = V_{avg} + 0.78(\ln T_R - 0.577)s$$

therefore: $V_{25} = 38.125 + 0.78(\ln 25 - 0.577)6.22 =$ 51 mph

3. The windspeed must be adjusted to the 33 foot level. The following equation from ETL 1110-2-305 is used where: Z is gage height.

$$U_{33} = (33/Z)^{1/7} U_Z$$

For Z = 18ft: $U_{33} = (33/18)^{1/7}(51) =$ 55.6 mph

4. The 25yr windspeed must also be adjusted for temperature difference between the water and air and for stability due to frictional characteristics over water. It was assumed the air and water temperatures were equal, therefore no temperature adjustment was applied. The stability adjustment for wind over land (U_L) to wind over water (U_w) for fetches less than 10 miles is $U_w = 1.1\ U_L$. For Lake Ashtabula:

$U_w = 1.1\ (55.6) =$ 61.2 mph

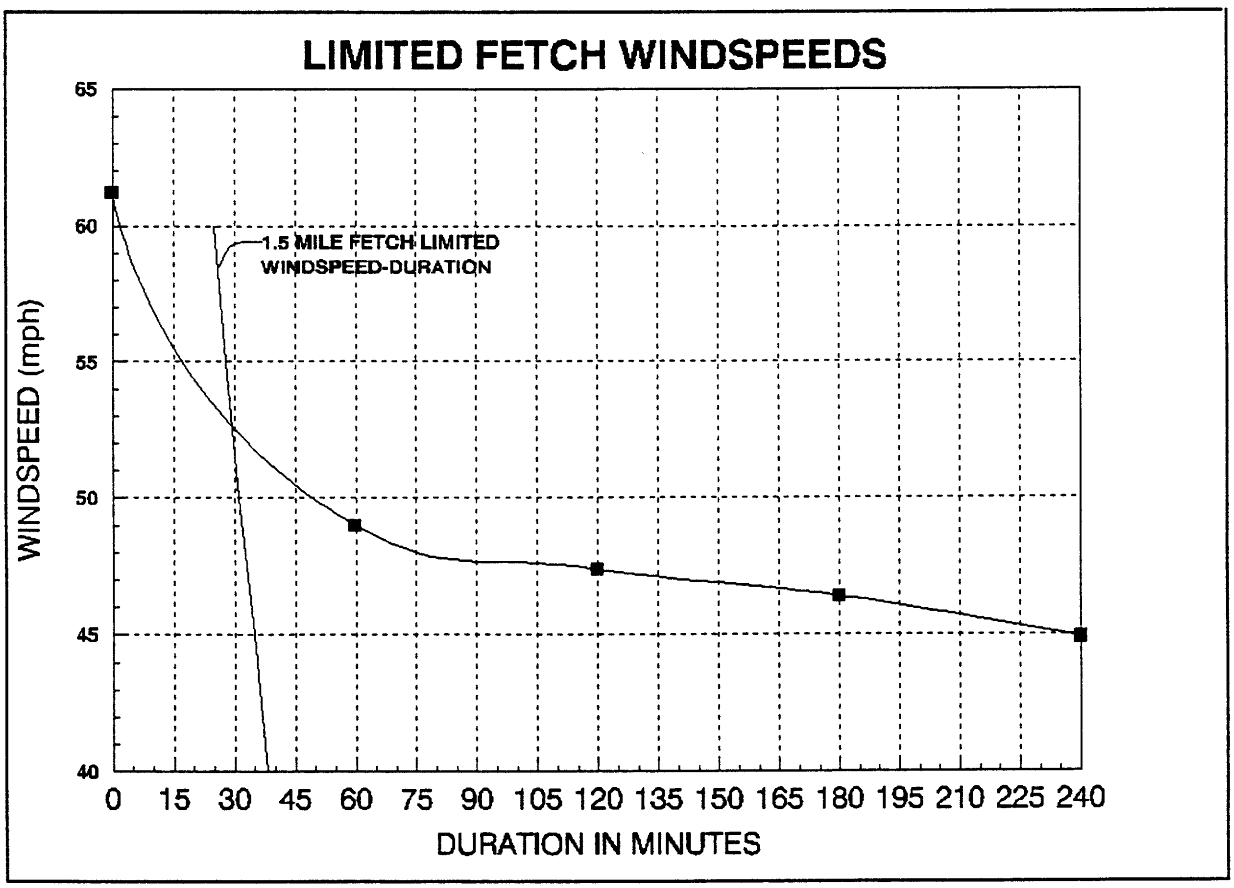
5. The next step is to determine a windspeed duration curve for limited fetches. Use Fig. 3-12 and 3-13 of the Shore Protection Manual (Vol. 1) to convert the 1 minute duration to a 1 hour duration. From Figure 3-13:

$$U_{1hr} = U_w/1.2 = 61.2/1.2 = \underline{51\ mph}$$

and from ETL 1110-2-305 the wind duration curve may be developed.

Wind Duration (hr)	Conversion Factor	Windspeed (mph)
1	1.0	51
2	0.96	49
3	0.93	47.4
4	0.91	46.4
6	0.88	44.9

6. The fetch limited windspeeds and durations are determined by plotting the fetch limited windspeeds and durations from Figure 4 of ETL 1110-2-305 against the wind duration curve. The example below shows a sample for a 1.5 mile fetch. The intersection of the two curves is the fetch limited windspeed-duration used to determine wave heights for this particular fetch length.



Wave Height and Period Analysis

1. Fetch lengths were determined for each location on Lake Ashtabula where private property such as lake homes could possibly be affected by wind driven waves during higher pool elevations proposed for flood control operations. It was assumed for this analysis that the maximum controlled pool elevation will be 1271.0 feet. This elevation is used to determine the depth at each location for shallow or deep water wave determinations, the effective near shore slopes used in wave runup determinations and the ultimate elevation that wave runup will reach.

2. The 25yr adjusted windspeeds and durations for each respective location listed in Table 1 are determined by plotting for the given fetch length, the fetch limited windspeed-duration curve against the location windspeed-duration curve as displayed in the example in Figure 1. The intersection of these two curves is the fetch limited windspeed-duration for that particular fetch length. The deepwater significant wave height (H_S) and period (T_S) can be determined from the windspeed-duration data.

3. The wave type (deep/shallow) is determined based the relationship where if one half the wavelength L_o (L_o= $5.12T^2$) is less than the depth of water above the bottom, the wave is considered a deep water wave. The deepwater wave characteristics are determined from Figure 4 of ETL 1110-2-305 which is transformed into tabular form in the attached Exhibits 1 and 2 for ease of interpolation. Where shallow water conditions apply, the windspeed and fetch length are used to determine the wave characteristics from Figures E-3 to E-5 of the ETL by interpolation between the nomographs for the depths at the various locations. The significant wave heights and periods were determined for each location based on the shallow or deep water conditions and are tabulated in Table 1.

Wave Runup

1. Wave runup is the elevation above the Still Water Line (SWL) to which a developed wave will runup onto the shore before all wave energy is dissipated. The runup computation is a function of the wave height and period and the slope of the beach/shore upon which the wave impacts. The Automated Coastal Engineering System (ACES) computer program developed by the Waterways Experiment Station (WES) Coastal Engineering Research Center was used to perform the wave runup analysis. Data required for this analysis are H_S, T_S and the nearshore slope.

2. The wave runup computation is sensitive to the nearshore slope. The typical shoreline around Lake Ashtabula has a well developed fairly steep slope near the conservation pool level of 1266 feet. This slope typically has a break in the 1268 to 1269 foot range in elevation where wave action with existing project operation has cut

Table 1

LAKE ASHTABULA WIND/WAVE ANALYSIS								
		FETCH		25 YEAR ADJUSTED			SIGNIFICANT WAVE	
LOCATION	CABIN NO's	LENGTH (feet)	DIRECTION	WINDSPEED (mph)	DURATION (min)	WAVE TYPE	HEIGHT (feet)	PERIOD (sec)
1. HEIMES	1-8	9450	NE	52.8	36	DEEP	3.12	2.88
2. H. MARTIN's	9-32	7880	S-SW	53.5	30	DEEP	2.90	2.74
3. SADEK's	33-41	4370	NE	55	19	DEEP	2.23	2.27
	42-45	4300	S-SW	55	19	DEEP	2.23	2.27
4. EGGERT's(sth)	200-209	7700	N	53.8	28.5	DEEP	2.82	2.67
5. K.OLSON's	46-50	4300	N-NE	52.6	39	DEEP	2.23	2.27
6. EGGERT's	177-199	9800	SW	52.8	36	DEEP	3.12	2.88
7. K.OLSON's	51-56	8200	N-NW	53.5	30	DEEP	2.90	2.74
8. EGGERT's(nth)	151-176	5400	S-SE	54.6	21	DEEP	2.42	2.4
9. E. ASHTABULA CROSSING D/S	145-150	6330	SW	54.2	25	DEEP	2.54	2.63
10. E.ASHTABULA CROSSING U/S	140-144	7800	NE	(53.8) 79.2[1]		SHALLOW	2.65	2.60
11. G. MEYER	128-138	6870	N-NE	(54) 79.6[1]		SHALLOW	2.5	2.5
11A. EMERY	120-127	8300	N	(53.6) 78.9[1]		SHALLOW	2.65	2.65
12. OLD 26	115-119	7670	SW	(53.8) 79.2[1]		SHALLOW	2.6	2.6
13. GRIGGS	57-70	5160	S-SE	(54.7) 80.9[1]		SHALLOW	2.20	2.30
14. SIBLEY	71-113A	4460	N	(55) 81.4[1]		SHALLOW	2.0	2.2
15. FARM	114	8150	W-NW	(53.5) 78.7[1]		SHALLOW	2.45	2.55

1. WIND STRESS FACTOR (MPH): U_a=0.589$(U_w)^{1.23}$; Where (U_w) is 25yr Adjusted Windspeed

away the banks. The slopes between this break at elevation 1268-1269 feet and the ground elevations at the cabins/trailers is much flatter than the nearshore slopes. This flatter slope comprises the lakeshore owners lawns which typically have gradual slopes in the 2-10 percent range.

3. Table 2 displays the slopes used for the wave runup analysis. These slopes were estimated from field surveys and photographs of each property on the lake. The field surveys included a ground elevation and 1st floor elevation for each property as well as a distance from the nearest corner of the structure to the waterline. These surveys were conducted when the lake was froze over for ease of access. Therefore, the distances measured are from a lake level in the 1264-1265 foot range. Where applicable, additional field data was obtained to better define the location and elevation of the break in slope near the shoreline to facilitate more accurate slope determinations on the flatter lawn areas.

4. The wave runup for each location in Table 2 was computed by the ACES computer program using the wave height and periods listed in Table 1 and the cotangent of the slope. The wave runups listed are the actual computed values, which are then rounded off to arrive at the required freeboard for each location. The freeboard is rounded off to the next highest 1/2 foot except where site specific conditions warranted less conservatism. The guidetake elevations were derived by adding the required freeboard to the assumed maximum flood induced surcharge elevation of 1271.5 feet.

5. The other components of wave freeboard analysis are wind and wave setup. Wave setup is the result of water "piling up" on the beach where the slope is flat and the water does not have time to retreat before the next wave approaches. Computation of wave setup requires detailed geometry to support a theoretical approach to this analysis. The lakeshore geometry available for Lake Ashtabula is not detailed enough for such an analysis. However, the "Handbook of Coastal and Ocean Engineering, Vol 1", pg 640, suggests that a reasonable range for wave setup is 14-21% of the significant wave height (H_S). Location 14 (Sibley) has slopes flat enough and conditions conducive for wave setup. The significant wave height H_S at this location is 2.0 feet. Asssuming a setup of about 17% of this value suggests that wave setup will be about 0.34 feet for Sibley. Wave setup at other locations should not be a factor.

6. Wind setup is a function of the windspeed and fetch length as described by the following equation:

$$S = U^2F/1400h$$

where, S=setup relative to SWL (ft), U=wind speed(mph), F=fetch lenght(miles), h=average water depth over fetch (ft)

Wind setup for the fetch lenghts estimated for Lake Ashtabula results in wind setup in the range of 0.04-0.06 feet.

7. In addition to freeboard for waves, it is necessary to consider the effects of wind driven ice in the freeboard analysis. Numerous reports of significant ice piles being formed on the shores of Lake Ashtabula have doccumented. The higher flood control pool levels being considered required an analysis of the effects of this ice concern on lake shore properties. The ice analysis is based on an extensive literature search and formulation of a methodology to estimate the effects of ice pileup and ice runup on shore with varied slopes and water depths. The analysis is outlined in Attachment 2. The results of this analysis and its effect on the ultimate freeboard determinations are summarized in Table 2. The higher of either the wave or ice freeboard is added to the maximum surcharge pool elevation of 1271.5 feet to determine a guidetake elevation.

8. The guidetake elevations developed from data in Table 2 were compared against the surveyed information for each property. Table 3 summarizes the impacts for each location or group of properties. The column titled RISKS quantifies the impacts and where the guidetake elevation affects the property, the property number and critical elevations are highlighted. The highlighted elevations are below the guidetake elevation.

TABLE 2

LAKE ASHTABULA FREEBOARD ANALYSIS						
LOCATION	CABIN\TRAILER NUMBER	NEARSHORE SLOPE (COTAN)	WAVE RUNUP (feet)	ICE PILE-UP[2] (feet)	REQUIRED FREEBOARD[1] (feet)	GUIDETAKE ELEVATION
1. HEIMES	1-8	8	4.0	3.6	4.0	1275[3]
2. H. MARTIN's	9-32	13	2.53	2.5	2.5	1274
3. SADEK's	33-41	35	0.87	1.2	1.0	1272.5
SADEK's	42-45	35	0.87	1.2	1.0	1272.5
4. EGGERT's(STH)	200-209	10	3-4	3.0	4.0	1275[3]
5. K.OLSON's	46-50	35	0.87	1.2	1.0	1272.5
6. EGGERT's	177-199	12	2.92	2.5	3.0	1274.5
7. K.OLSON's	51-56	10	3-4	3.0	4.0	1275[3]
8. EGGERT's(NTH)	151-176	24	1.27	1.5	1.5	1273
9. E. ASHTABULA CROSSING D/S	145-150	15	2.0	2.0	2.0	1273.5
10. E.ASHTABULA CROSSING U/S	140-144	10	2.81	3.0	3.0	1274.5
11. G. MEYER	128-138	20	1.54	1.7	1.5	1273
11A. EMERY	120-127	10	2.85	3.0	3.0	1274.5
12. OLD 26	115-119	15	2.03	2.0	2.0	1273.5
13. GRIGGS	57-70	20	1.34	1.7	1.5	1273
14. SIBLEY	71-113A	40	0.7	1.1	1.0	1272.5
15. FARM	114	20+	1.55	1.5	2.0	1273.5

1. Includes wave and wind setup allowances where applicable.
2. Ice pile-up assumes that ice will pile up a distance of 25 feet landward of the 1271.5 still water line (SWL) at maximum induced surcharge pool. The vertical distance above 1271.5 feet is determined by dividing this 25 ft. by the cotangent of the slope for each site. An additional 0.5 feet vertical is added to this elevation as a factor of safety to account for unknown effects of waves which may occur during ice break-up.
3. Elevation 1275 is maximum guidetake. All cabins at these locations are above 1275 el.

TABLE 3

LAKE ASHTABULA WAVE FREEBOARD ANALYSIS
(1271.5 Maximum Surcharge Pool)

	GUIDETAKE ELEVATION	NOTES	RISK
1. HEIMES	1275	Freeboard required for increased shorlline erosion potential with higher floodpool elevations.	NONE. Cabins on high ground, lowest ground elev. 1276.2 ft.
2. H. MARTIN's	1274	Shoreline is susceptible to wave action from winds out of South and East. Strong South winds are less frequent than North winds. The wave analysis uses a very conservative fetch length which is at nearly right angle to the shoreline.	NONE. One cabin affected. CABIN # / GROUND ELEV. / 1st.FLR ELEV. 24 / 1273.7 / 1277.6
3. SADEK's	1272.5	Cabins 36-37 are protected from effective fetch. Cabins/Trailers 38-41 sit relatively close to shoreline. Shoreline is susceptible to wave action from winds out of South. Strong South winds are less frequent than North winds. ICE is not expected to be a problem, as prevailing winds are in opposite direction.	MODERATE. Several cabins are impacted. CABIN # / GROUND ELEV. / 1st.FLR ELEV. 38 / 1272.1 / 1273.4 39(T) / 1271.7 / 1273.7 40 / 1271.7 / 1273.0 41(T) / 1270.7 / 1273.9 42(T) / 1271.8 / 1274.6 43(T) / 1271.8 / 1274.5 44(T) / 1271.4 / 1273.6 44C(T) / 1271.9 / 1274.4 42B / 1272.3 / 1275.2 43A / 1272 / 1274.9 43B / 1272 / 1275.2 44B / 1272.3 / 1275.4 (T)-TRAILER HOUSE
4. EGGERT's(STH)	1275	Shoreline is steep. Guidetake line should be conservative to encompass reasonable range for potential erosion on these steeper slopes with the higher flood pool elevations.	NONE. All cabins above elevation 1282 feet.
5. K.OLSON's	1272.5	Shoreline is susceptible to winds out of the Northeast, East and SE. Prevailing winds during Spring flood season are out of North-NW direction. Cabins are on West shore, where waves driven by North winds approach the shore at right angle, thereby reducing potential wave runup during Spring flood season.	MODERATE. CABIN # / GROUND ELEV. / 1st.FLR ELEV. 46,48,49 / 1272.9-1273.1 / 1275+ 47(T) / 1271.9 / 1275.3 50 / 1275.4 / 1275.6 (T)-TRAILER HOUSE

6. EGGERT's	1274.5	Shoreline is susceptible to winds out of the Northwest, the predominant direction during Spring flooding. Additional consideration for ICE being driven ashore by strong winds during high pool conditions should be factored into the required freeboard.	MODERATE-HIGH. Several cabins are impacted. CABIN # / GROUND ELEV. / 1st.FLR ELEV. 177 / 1271.8 / 1272 180 / 1273.3 / 1275.8 182 / 1273.8 / 1276 183 / 1273.2 / 1273.7 184 / 1273.5 / 1276.3 186 / 1272.9 / 1274.7 187 / 1272.2 / 1275.1 190 / 1273.4 / 1275.4 195 / 1273.7 / 1277.3 185 / 1274 / 1274.2
7. K.OLSON's	1275	Guidetake line should be conservative to encompass reasonable range for shoreline erosion with the higher flood pool elevation and erosion potential above normal pool levels.	NONE. Shoreline is steep with all cabins above elevation 1282 feet.
8. EGGERT's(NTH)	1273	Shoreline is susceptible to winds out of the South and West. Strong South winds are less frequent than North winds.	MODERATE-HIGH. Several cabins are impacted. CABIN # / GROUND ELEV. / 1st.FLR ELEV. 152 / 1272.5 / 1275.1 162 / 1272.0 / 1276.8 163 / 1272.2 / 1275.6 168 / 1271.0 / 1274.4 172 / 1272.2 / 1273.5 173 / 1270.8 / 1272.2 174 / 1271.8 / 1272.1 175 / 1272.0 / 1273.5
9. E. ASHTABULA CROSSING D/S	1273.5	Shoreline is susceptible to West and Southwest winds. The highway embankment protects the shore from the North.	NONE. Cabin # 145 ground elev. is 1273.5, 1st flr. elev. is 1274.4 feet.
10. E.ASHTABULA CROSSING U/S	1274.5	Slopes are 1:10 or steeper. 3 foot freeboard does not affect cabins.	NONE. Cabins are all above elevation 1276 feet.
11. G. MEYER	1273	Low ground elevation for this group of cabins in 1274 feet. None are threatened by wave action.	NONE.
11A. EMERY	1274.5	Shoreline is steep. Guidetake line should be conservative to encompass reasonable range for shoreline erosion with the higher flood pool elevation and erosion potential above normal pool levels.	NONE. All cabins above elevation 1280 feet.
12. OLD 26	1273.5	Shoreline are susceptible to winds out of the North, the predominant direction during Spring floods. Cabins close to shoreline (30-50 ft).	MODERATE. CABIN # / GROUND ELEV. / 1st.FLR ELEV. 115 / 1272.7 / 1275.3
13. GRIGGS	1273	The cabins are situated on the west shore, with predominant wind exposure from East and SE. Strong South winds are less frequent than North winds.	LOW. Cabin sits back from shoreline 90 feet. CABIN # / GROUND ELEV. / 1st.FLR ELEV. 57 / 1272.0 / 1273.7

14. SIBLEY	1272.5	Ground elevations at many of these cabins are in the 1271-1272 foot range. The North fetch length used for wave determination is parallel to shoreline. The NE to SE Fetch normal to shoreline would result in less runup than 0.7 feet as it is much shorter. The cabins sit back from the shoreline 100-300 feet which offers significant beach length for energy dissipation. MUST CHECK water surface for slope during flood operation, which could increase take line elevation.	LOW-MODERATE. CABIN # / GROUND ELEV. / 1st.FLR ELEV. 76 / 1271.6 / 1274.1 77 / 1271.6 / 1272.4 81 / 1271.7 / 1271.7 82 / 1271.5 / 1272.1 83 / 1271.5 / 1273.9 85 / 1271.6 / 1272.2 87 / 1271.6 / 1273.3 88 / 1271.7 / 1273.2 89 / 1271.1 / 1272.9 90 / 1270.7 / 1272.3 91 / 1271.4 / 1274.2 92 / 1271.4 / 1275.2 95 / 1271.7 / 1273.5
15. FARM	1273.5	Farmhouse is above elevation 1275 and sits back over 500 feet.	NONE.

FETCH LIMITED WAVE HEIGHTS

U_A WINDSPEED (MPH)	FETCH LENGTH F (MILES) 0.80	0.90	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00
	SIGNIFICANT WAVE HEIGHT H_s (FEET)												
50.00	1.95	2.07	2.18	2.28	2.38	2.48	2.58	2.67	2.75	2.84	2.92	3.00	3.08
50.50	1.97	2.09	2.20	2.31	2.41	2.74	2.61	2.70	2.79	2.87	2.96	3.04	3.12
51.00	2.00	2.12	2.23	2.34	2.44	2.78	2.64	2.73	2.82	2.91	2.99	3.07	3.15
51.50	2.02	2.14	2.26	2.37	2.47	2.81	2.67	2.76	2.86	2.94	3.03	3.11	3.19
52.00	2.04	2.17	2.28	2.40	2.50	2.84	2.70	2.80	2.89	2.98	3.07	3.15	3.23
52.50	2.07	2.19	2.31	2.42	2.53	2.88	2.74	2.83	2.92	3.01	3.10	3.19	3.27
53.00	2.09	2.22	2.34	2.45	2.56	2.91	2.77	2.86	2.96	3.05	3.14	3.22	3.31
53.50	2.12	2.24	2.37	2.48	2.59	2.95	2.80	2.90	2.99	3.08	3.17	3.26	3.35
54.00	2.14	2.27	2.39	2.51	2.62	2.98	2.83	2.93	3.03	3.12	3.21	3.30	3.38
54.50	2.16	2.30	2.42	2.54	2.65	3.01	2.86	2.96	3.06	3.16	3.25	3.34	3.42
55.00	2.19	2.32	2.45	2.57	2.68	3.05	2.90	3.00	3.10	3.19	3.28	3.37	3.46
55.50	2.21	2.35	2.48	2.60	2.71	3.08	2.93	3.03	3.13	3.23	3.32	3.41	3.50
56.00	2.24	2.37	2.50	2.62	2.74	3.12	2.96	3.06	3.17	3.26	3.36	3.45	3.54
56.50	2.26	2.40	2.53	2.65	2.77	3.15	2.99	3.10	3.20	3.30	3.39	3.49	3.58
57.00	2.29	2.43	2.56	2.68	2.80	3.18	3.03	3.13	3.24	3.33	3.43	3.53	3.62
57.50	2.31	2.45	2.59	2.71	2.83	3.22	3.06	3.17	3.27	3.37	3.47	3.56	3.66
58.00	2.34	2.48	2.61	2.74	2.86	3.25	3.09	3.20	3.31	3.41	3.51	3.60	3.70
58.50	2.36	2.51	2.64	2.77	2.89	3.29	3.12	3.23	3.34	3.44	3.54	3.64	3.73
59.00	2.39	2.53	2.67	2.80	2.92	3.32	3.16	3.27	3.38	3.48	3.58	3.68	3.77
59.50	2.41	2.56	2.70	2.83	2.95	3.36	3.19	3.30	3.41	3.52	3.62	3.72	3.81
60.00	2.44	2.58	2.72	2.86	2.98	3.39	3.22	3.34	3.45	3.55	3.65	3.76	3.85
60.50	2.46	2.61	2.75	2.89	3.01	3.43	3.26	3.37	3.48	3.59	3.69	3.79	3.89
61.00	2.49	2.64	2.78	2.92	3.05	3.46	3.29	3.40	3.52	3.62	3.73	3.83	3.93
62.00	2.54	2.69	2.84	2.97	3.11	3.53	3.36	3.47	3.59	3.70	3.81	3.91	4.01
63.00	2.59	2.74	2.89	3.03	3.17	3.60	3.42	3.54	3.66	3.77	3.88	3.99	4.09
64.00	2.64	2.80	2.95	3.09	3.23	3.67	3.49	3.61	3.73	3.85	3.96	4.07	4.17
65.00	2.69	2.85	3.01	3.15	3.29	3.74	3.56	3.68	3.80	3.92	4.03	4.14	4.25
66.00	2.74	2.91	3.06	3.21	3.36	3.81	3.62	3.75	3.87	3.99	4.11	4.22	4.33
67.00	2.79	2.96	3.12	3.27	3.42	3.89	3.69	3.82	3.95	4.07	4.19	4.30	4.41
68.00	2.84	3.01	3.18	3.33	3.48	3.96	3.76	3.89	4.02	4.14	4.26	4.38	4.49
69.00	2.89	3.07	3.24	3.39	3.54	4.03	3.83	3.96	4.09	4.22	4.34	4.46	4.58
70.00	2.95	3.12	3.29	3.45	3.61	4.10	3.90	4.03	4.17	4.29	4.42	4.54	4.66

SEE TABLE 3-2. SHORE PROTECTION MANUAL (VOL 1): $H_s = 2.82 \times 10^{-4} U_A F^{1/2}$ WHERE: U_A (ft/sec), F (ft)

Exhibit 1

FETCH LIMITED WAVE PERIOD

U_A WINDSPEED (MPH)	FETCH LENGTH F (MILES)												
	0.80	0.90	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00
	SIGNIFICANT WAVE PERIOD T_s (seconds)												
50.00	2.15	2.24	2.32	2.39	2.46	2.53	2.59	2.65	2.71	2.77	2.82	2.87	2.92
50.50	2.16	2.25	2.33	2.40	2.47	2.54	2.61	2.67	2.72	2.78	2.83	2.88	2.93
51.00	2.17	2.26	2.34	2.41	2.48	2.55	2.62	2.68	2.73	2.79	2.84	2.90	2.95
51.50	2.18	2.27	2.35	2.42	2.49	2.56	2.63	2.69	2.75	2.80	2.86	2.91	2.96
52.00	2.19	2.28	2.36	2.43	2.50	2.57	2.64	2.70	2.76	2.81	2.87	2.92	2.97
52.50	2.20	2.28	2.37	2.44	2.51	2.58	2.65	2.71	2.77	2.82	2.88	2.93	2.98
53.00	2.21	2.29	2.38	2.45	2.52	2.59	2.66	2.72	2.78	2.83	2.89	2.94	2.99
53.50	2.21	2.30	2.38	2.46	2.53	2.60	2.67	2.73	2.79	2.85	2.90	2.95	3.00
54.00	2.22	2.31	2.39	2.47	2.54	2.61	2.68	2.74	2.80	2.86	2.91	2.96	3.02
54.50	2.23	2.32	2.40	2.48	2.55	2.62	2.69	2.75	2.81	2.87	2.92	2.98	3.03
55.00	2.24	2.33	2.41	2.49	2.56	2.63	2.70	2.76	2.82	2.88	2.93	2.99	3.04
55.50	2.25	2.34	2.42	2.50	2.57	2.64	2.71	2.77	2.83	2.89	2.94	3.00	3.05
56.00	2.26	2.35	2.43	2.51	2.58	2.65	2.72	2.78	2.84	2.90	2.96	3.01	3.06
56.50	2.26	2.35	2.44	2.52	2.59	2.66	2.73	2.79	2.85	2.91	2.97	3.02	3.07
57.00	2.27	2.36	2.45	2.53	2.60	2.67	2.74	2.80	2.86	2.92	2.98	3.03	3.08
57.50	2.28	2.37	2.46	2.54	2.61	2.68	2.75	2.81	2.87	2.93	2.99	3.04	3.09
58.00	2.29	2.38	2.46	2.54	2.62	2.69	2.76	2.82	2.88	2.94	3.00	3.05	3.10
58.50	2.30	2.39	2.47	2.55	2.63	2.70	2.77	2.83	2.89	2.95	3.01	3.06	3.12
59.00	2.30	2.40	2.48	2.56	2.64	2.71	2.78	2.84	2.90	2.96	3.02	3.07	3.13
59.50	2.31	2.40	2.49	2.57	2.65	2.72	2.79	2.85	2.91	2.97	3.03	3.08	3.14
60.00	2.32	2.41	2.50	2.58	2.66	2.73	2.80	2.86	2.92	2.98	3.04	3.10	3.15
60.50	2.33	2.42	2.51	2.59	2.66	2.74	2.81	2.87	2.93	2.99	3.05	3.11	3.16
61.00	2.34	2.43	2.52	2.60	2.67	2.75	2.81	2.88	2.94	3.00	3.06	3.12	3.17
62.00	2.35	2.45	2.53	2.61	2.69	2.76	2.83	2.90	2.96	3.02	3.08	3.14	3.19
63.00	2.37	2.46	2.55	2.63	2.71	2.78	2.85	2.92	2.98	3.04	3.10	3.16	3.21
64.00	2.38	2.48	2.57	2.65	2.73	2.80	2.87	2.94	3.00	3.06	3.12	3.18	3.23
65.00	2.40	2.49	2.58	2.67	2.74	2.82	2.89	2.96	3.02	3.08	3.14	3.20	3.25
66.00	2.41	2.51	2.60	2.68	2.76	2.84	2.91	2.97	3.04	3.10	3.16	3.22	3.27
67.00	2.43	2.52	2.61	2.70	2.78	2.85	2.93	2.99	3.06	3.12	3.18	3.24	3.29
68.00	2.44	2.54	2.63	2.72	2.80	2.87	2.94	3.01	3.08	3.14	3.20	3.26	3.31
69.00	2.46	2.56	2.65	2.73	2.81	2.89	2.96	3.03	3.10	3.16	3.22	3.28	3.33
70.00	2.47	2.57	2.66	2.75	2.83	2.91	2.98	3.05	3.11	3.18	3.24	3.30	3.35

SEE TABLE 3-2. SHORE PROTECTION MANUAL (VOL 1): $T_s = 2.825 \times 10^{2}(U_A F)^{1/3}$ WHERE: U_A (ft/sec), F (ft)

Exhibit 2

U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION NUMBER 05058000 SHEYENNE RIVER BELOW BALDHILL DAM, ND   SOURCE AGENCY USGS
LATITUDE 470202 LONGITUDE 0980500 NAD27 DRAINAGE AREA 7470   CONTRIBUTING DRAINAGE AREA 1910
DATUM 1200.00 NGVD29   Date Processed: 2004-10-04 15:54 By smrobins RATING ID: 20.0
Created by jmlambre on 05-06-2004,   Updated by jmlambre on 05-06-2004, OFFSET: 22.00

EXPANDED RATING TABLE

Gage Height, feet	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
22.50	11.60*	11.76	11.93	12.09	12.25	12.41	12.57	12.73	12.89	13.04
22.60	13.20*	13.36	13.53	13.69	13.85	14.01	14.17	14.33	14.49	14.64
22.70	14.80*	14.99	15.18	15.37	15.56	15.75	15.94	16.13	16.32	16.51
22.80	16.70*	16.93	17.16	17.39	17.62	17.85	18.08	18.31	18.54	18.77
22.90	19.00*	19.25	19.50	19.75	19.99	20.24	20.49	20.75	21.00	21.25
23.00	21.50*	21.80	22.09	22.39	22.69	22.99	23.29	23.59	23.89	24.20
23.10	24.50*	24.83	25.17	25.50	25.84	26.18	26.52	26.86	27.21	27.55
23.20	27.90*	28.29	28.68	29.08	29.47	29.87	30.27	30.68	31.08	31.49
23.30	31.90*	32.34	32.78	33.22	33.67	34.12	34.57	35.02	35.48	35.94
23.40	36.40*	36.96	37.52	38.09	38.67	39.24	39.83	40.41	41.00	41.60
23.50	42.20*	42.85	43.51	44.18	44.85	45.53	46.21	46.90	47.59	48.29
23.60	49.00*	49.95	50.92	51.90	52.89	53.89	54.91	55.94	56.98	58.03
23.70	59.10*	60.13	61.17	62.22	63.28	64.35	65.44	66.54	67.64	68.77
23.80	69.90*	71.17	72.45	73.75	75.06	76.39	77.73	79.10	80.47	81.87
23.90	83.28	84.71	86.15	87.62	89.09	90.59	92.10	93.63	95.18	96.75
24.00	98.33	99.93	101.6	103.2	104.8	106.5	108.2	109.9	111.7	113.4
24.10	115.2	117.0	118.8	120.6	122.4	124.3	126.2	128.1	130.0	131.9
24.20	133.9	135.9	137.9	139.9	141.9	144.0	146.1	148.2	150.3	152.5
24.30	154.6	156.8	159.0	161.3	163.5	165.8	168.1	170.4	172.7	175.1
24.40	177.5	179.9	182.3	184.8	187.3	189.7	192.3	194.8	197.4	200.0
24.50	202.6	205.2	207.9	210.6	213.3	216.0	218.8	221.5	224.3	227.2
24.60	230.0	232.9	235.8	238.7	241.7	244.7	247.7	250.7	253.7	256.8
24.70	259.9	263.1	266.2	269.4	272.6	275.8	279.1	282.4	285.7	289.1
24.80	292.4	295.8	299.2	302.7	306.2	309.7	313.2	316.8	320.4	324.0
24.90	327.6	331.3	335.0	338.7	342.5	346.3	350.1	353.9	357.8	361.7

Gage Height, feet	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
25.00	365.7	369.6	373.6	377.6	381.7	385.8	389.9	394.0	398.2	402.4
25.10	406.6	410.9	415.2	419.5	423.9	428.3	432.7	437.1	441.6	446.1
25.20	450.7	455.2	459.9	464.5	469.2	473.9	478.6	483.4	488.2	493.0
25.30	497.9	502.8	507.7	512.7	517.7	522.8	527.8	532.9	538.1	543.2
25.40	548.5	553.7	559.0	564.3	569.6	575.0	580.4	585.9	591.4	596.9
25.50	602.4	608.0	613.7	619.3	625.0	630.8	636.5	642.4	648.2	654.1
25.60	660.0*	664.9	669.8	674.8	679.7	684.7	689.7	694.8	699.8	704.9
25.70	710.0*	714.9	719.8	724.8	729.8	734.7	739.8	744.8	749.8	754.9
25.80	760.0*	764.9	769.9	774.8	779.8	784.8	789.8	794.8	799.9	804.9
25.90	810.0*	814.4	818.9	823.4	827.8	832.3	836.8	841.4	845.9	850.4
26.00	855.0*	859.4	863.9	868.4	872.9	877.4	881.9	886.4	890.9	895.4
26.10	900.0*	904.5	908.9	913.4	917.9	922.4	926.9	931.4	935.9	940.5
26.20	945.0*	949.5	953.9	958.4	962.9	967.4	971.9	976.4	980.9	985.0
26.30	990.0*	994.5	998.9	1003	1008	1012	1017	1021	1026	1030
26.40	1035*	1039	1044	1048	1053	1057	1062	1066	1071	1075
26.50	1080*	1084	1089	1093	1098	1102	1107	1111	1116	1120
26.60	1125*	1129	1134	1138	1143	1147	1152	1156	1161	1165
26.70	1170*	1174	1178	1182	1186	1190	1194	1198	1202	1206
26.80	1210*	1214	1218	1222	1226	1230	1234	1238	1242	1246
26.90	1250*	1253	1257	1260	1264	1267	1271	1274	1278	1281
27.00	1285*	1288	1292	1295	1299	1302	1306	1309	1313	1316
27.10	1319	1323	1326	1330	1333	1337	1340	1344	1347	1351
27.20	1354	1358	1361	1364	1368	1371	1375	1378	1382	1385
27.30	1389	1392	1396	1399	1403	1406	1410	1413	1417	1420
27.40	1424	1428	1431	1435	1438	1442	1445	1449	1452	1456
27.50	1459	1463	1466	1470	1474	1477	1481	1484	1488	1491
27.60	1495	1498	1502	1506	1509	1513	1516	1520	1523	1527
27.70	1531	1534	1538	1541	1545	1549	1552	1556	1559	1563
27.80	1567	1570	1574	1577	1581	1585	1588	1592	1595	1599
27.90	1603	1606	1610	1614	1617	1621	1624	1628	1632	1635

Gage Height, feet	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
28.00	1639	1643	1646	1650	1654	1657	1661	1665	1668	1672
28.10	1676	1679	1683	1687	1690	1694	1698	1701	1705	1709
28.20	1712	1716	1720	1723	1727	1731	1734	1738	1742	1746
28.30	1749	1753	1757	1760	1764	1768	1772	1775	1779	1783
28.40	1786	1790	1794	1798	1801	1805	1809	1813	1816	1820
28.50	1824	1828	1831	1835	1839	1843	1846	1850	1854	1858
28.60	1861	1865	1869	1873	1876	1880	1884	1888	1892	1895
28.70	1899	1903	1907	1910	1914	1918	1922	1926	1929	1933
28.80	1937	1941	1945	1948	1952	1956	1960	1964	1967	1971
28.90	1975	1979	1983	1987	1990	1994	1998	2002	2006	2010
29.00	2013	2017	2021	2025	2029	2033	2036	2040	2044	2048
29.10	2052	2056	2060	2063	2067	2071	2075	2079	2083	2087
29.20	2091	2094	2098	2102	2106	2110	2114	2118	2122	2126
29.30	2129	2133	2137	2141	2145	2149	2153	2157	2161	2165
29.40	2168	2172	2176	2180	2184	2188	2192	2196	2200	2204
29.50	2208	2212	2216	2219	2223	2227	2231	2235	2239	2243
29.60	2247	2251	2255	2259	2263	2267	2271	2275	2279	2283
29.70	2287	2291	2294	2298	2302	2306	2310	2314	2318	2322
29.80	2326	2330	2334	2338	2342	2346	2350	2354	2358	2362
29.90	2366	2370	2374	2378	2382	2386	2390	2394	2398	2402
30.00	2406	2410	2414	2418	2422	2426	2430	2434	2438	2442
30.10	2446	2450	2455	2459	2463	2467	2471	2475	2479	2483
30.20	2487	2491	2495	2499	2503	2507	2511	2515	2519	2523
30.30	2527	2531	2536	2540	2544	2548	2552	2556	2560	2564
30.40	2568	2572	2576	2580	2584	2589	2593	2597	2601	2605
30.50	2609	2613	2617	2621	2625	2630	2634	2638	2642	2646
30.60	2650	2654	2658	2662	2667	2671	2675	2679	2683	2687
30.70	2691	2695	2700	2704	2708	2712	2716	2720	2724	2729
30.80	2733	2737	2741	2745	2749	2753	2758	2762	2766	2770
30.90	2774	2778	2782	2787	2791	2795	2799	2803	2808	2812

Gage Height, feet	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
31.00	2816	2820	2824	2828	2833	2837	2841	2845	2849	2853
31.10	2858	2862	2866	2870	2874	2879	2883	2887	2891	2895
31.20	2900	2904	2908	2912	2917	2921	2925	2929	2933	2938
31.30	2942	2946	2950	2954	2959	2963	2967	2971	2976	2980
31.40	2984	2988	2993	2997	3001	3005	3010	3014	3018	3022
31.50	3027	3031	3035	3039	3044	3048	3052	3056	3061	3065
31.60	3069	3073	3078	3082	3086	3091	3095	3099	3103	3108
31.70	3112	3116	3120	3125	3129	3133	3138	3142	3146	3150
31.80	3155	3159	3163	3168	3172	3176	3181	3185	3189	3194
31.90	3198	3202	3206	3211	3215	3219	3224	3228	3232	3237
32.00	3241	3245	3250	3254	3258	3263	3267	3271	3276	3280
32.10	3284	3289	3293	3297	3302	3306	3310	3315	3319	3323
32.20	3328	3332	3337	3341	3345	3350	3354	3358	3363	3367
32.30	3371	3376	3380	3385	3389	3393	3398	3402	3406	3411
32.40	3415	3420	3424	3428	3433	3437	3442	3446	3450	3455
32.50	3459	3463	3468	3472	3477	3481	3485	3490	3494	3499
32.60	3503	3508	3512	3516	3521	3525	3530	3534	3538	3543
32.70	3547	3552	3556	3561	3565	3569	3574	3578	3583	3587
32.80	3592	3596	3601	3605	3609	3614	3618	3623	3627	3632
32.90	3636	3641	3645	3649	3654	3658	3663	3667	3672	3676
33.00	3681	3685	3690	3694	3699	3703	3707	3712	3716	3721
33.10	3725	3730	3734	3739	3743	3748	3752	3757	3761	3766
33.20	3770	3775	3779	3784	3788	3793	3797	3802	3806	3811
33.30	3815	3820	3824	3829	3833	3838	3842	3847	3851	3856
33.40	3860	3865	3869	3874	3878	3883	3888	3892	3897	3901
33.50	3906	3910	3915	3919	3924	3928	3933	3937	3942	3946
33.60	3951	3956	3960	3965	3969	3974	3978	3983	3987	3992
33.70	3997	4001	4006	4010	4015	4019	4024	4029	4033	4038
33.80	4042	4047	4051	4056	4061	4065	407	4074	4079	4083
33.90	4088	4093	4097	4102	4106	4111	4116	4120	4125	4129

Gage Height, feet	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
34.00	4134	4139	4143	4148	4152	4157	4162	4166	4171	4175
34.10	4180	4185	4189	4194	4198	4203	4208	4212	4217	4222
34.20	4226	4231	4235	4240	4245	4249	4254	4259	4263	4268
34.30	4272	4277	4282	4286	4291	4296	4300	4305	4310	4314
34.40	4319	4324	4328	4333	4337	4342	4347	4351	4356	4361
34.50	4365	4370	4375	4379	4384	4389	4393	4398	4403	4407
34.60	4412	4417	4421	4426	4431	4435	4440	4445	4450	4454
34.70	4459	4464	4468	4473	4478	4482	4487	4492	4496	4501
34.80	4506	4510	4515	4520	4525	4529	4534	4539	4543	4548
34.90	4553	4558	4562	4567	4572	4576	4581	4586	4591	4595
35.00	4600*									

U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES
SHEYENNE RIVER AT VALLEY CITY # 05058500

Lat 465450 Long 0980030 NAD27 Drainage Area 7810 Contibuting Drainage Area 2110 Datum 1199.27 NGVD29
Date Processed: 2004-08-23 07:36 By smrobins Rating ID: 13
Created by klboespf on 02-01-2000 Updated on 02-01-2000 OFFSET: 3.00

Gage height, feet	Discharge IN cfs									
	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
2.90	0	1	2	4	5	6	7	8	10	11
3.00	12	14	15	17	18	20	22	23	25	26
3.10	28	30	33	35	37	40	42	44	47	49
3.20	51	53	56	58	61	63	65	68	70	72
3.30	75	78	80	82	85	87	90	92	95	97
3.40	99	102	104	107	109	112	114	116	119	121
3.50	124	126	129	131	133	136	138	141	143	145
3.60	148	150	153	155	157	160	162	165	167	170
3.70	172	174	177	179	182	184	186	189	191	194
3.80	196	198	201	203	205	208	210	213	215	217
3.90	220	222	225	227	229	232	234	237	239	241
4.00	244	246	248	251	253	256	258	260	263	265
4.10	268	270	272	275	277	279	282	284	287	289
4.20	291	295	296	298	301	303	306	308	310	313
4.30	315	317	320	322	325	327	329	332	334	337
4.40	339	342	344	346	349	351	354	356	358	361
4.50	363	366	368	370	373	375	378	380	382	385
4.60	387	390	392	394	397	399	402	404	406	409
4.70	411	414	416	418	421	423	426	428	430	433
4.80	435	437	440	442	445	447	450	452	454	457
4.90	459	462	464	466	469	471	474	476	478	481
5.00	483	486	488	490	493	495	498	500	502	505
5.10	507	510	512	514	517	519	522	524	526	529
5.20	531	533	536	538	541	543	545	548	550	553
5.30	555	557	560	562	565	567	569	572	574	577
5.40	579	581	583	586	589	591	593	596	598	600

Gage height feet	Discharge IN cfs .00	.01	.02	.03	.04	.05	.06	.07	.08	.09
5.50	603	605	608	610	613	615	617	620	622	625
5.60	627	629	632	634	637	639	641	644	646	649
5.70	651	654	656	658	661	663	666	668	670	673
5.80	675	678	680	682	685	687	690	692	694	697
5.90	699	701	704	706	709	711	713	716	718	721
6.00	723	725	728	730	733	735	737	740	742	745
6.10	747	749	752	754	757	759	761	764	766	769
6.20	771	773	776	778	781	783	785	788	790	793
6.30	795	798	800	803	805	808	811	813	816	818
6.40	821	824	826	829	831	834	837	839	842	844
6.50	847	849	852	855	857	860	862	865	868	870
6.60	873	875	878	881	883	886	889	891	894	896
6.70	899	902	904	907	909	912	915	917	920	922
6.80	925	928	930	933	936	938	941	944	947	949
6.90	952	955	957	960	963	965	968	971	973	976
7.00	979	982	984	987	990	992	995	998	1000	1003
7.10	1006	1009	1011	1014	1017	1019	1022	1025	1027	1030
7.20	1033	1036	1038	1041	1044	1046	1049	1052	1055	1057
7.30	1060	1063	1066	1069	1072	1075	1078	1081	1084	1086
7.40	1089	1092	1095	1098	1101	1104	1107	1110	1113	1116
7.50	1119	1122	1125	1128	1131	1134	1137	1140	1143	1146
7.60	1149	1152	1155	1157	1160	1163	1166	1169	1172	1175
7.70	1178	1181	1184	1187	1190	1193	1196	1199	1202	1205
7.80	1208	1211	1214	1217	1220	1223	1226	1229	1232	1235
7.90	1238	1241	1244	1247	1250	1253	1256	1259	1262	1265
8.00	1268	1271	1274	1277	1280	1283	1286	1290	1293	1296
8.10	1299	1302	1305	1308	1311	1314	1317	1320	1323	1326
8.20	1329	1332	1335	1338	1341	1344	1347	1350	1353	1356
8.30	1359	1362	1366	1369	1372	1375	1378	1381	1384	1387
8.40	1390	1393	1396	1399	1403	1406	1409	1412	1415	1418

Gage height feet	Discharge IN cfs .00	.01	.02	.03	.04	.05	.06	.07	.08	.09
8.50	1421	1424	1428	1431	1434	1437	1440	1443	1446	1450
8.60	1453	1456	1459	1462	1465	1469	1472	1475	1478	1481
8.70	1484	1488	1491	1494	1497	1500	1503	1507	1510	1513
8.80	1516	1519	1522	1526	1529	1532	1535	1538	1541	1545
8.90	1548	1551	1554	1557	1561	1564	1567	1570	1573	1577
9.00	1580	1583	1586	1589	1593	1596	1599	1602	1605	1609
9.10	1612	1615	1618	1621	1625	1628	1631	1634	1638	1641
9.20	1644	1647	1650	1654	1657	1660	1663	1667	1670	1673
9.30	1676	1679	1683	1686	1689	1692	1696	1699	1702	1705
9.40	1709	1712	1715	1718	1722	1725	1728	1731	1735	1738
9.50	1741	1744	1748	1751	1754	1757	1761	1764	1767	1770
9.60	1774	1777	1780	1783	1787	1790	1793	1797	1800	1803
9.70	1806	1810	1813	1816	1819	1823	1826	1829	1833	1836
9.80	1839	1842	1846	1849	1852	1856	1859	1862	1865	1869
9.90	1872	1875	1879	1882	1885	1889	1892	1895	1898	1902
10.00	1905	1908	1912	1915	1918	1922	1925	1928	1932	1935
10.10	1938	1942	1945	1948	1951	1955	1958	1961	1965	1968
10.20	1971	1975	1978	1981	1985	1988	1991	1995	1998	2001
10.30	2005	2008	2011	2015	2018	2021	2025	2028	2031	2035
10.40	2038	2041	2045	2048	2051	2055	2058	2062	2065	2068
10.50	2072	2075	2078	2082	2085	2088	2092	2095	2098	2102
10.60	2105	2109	2112	2115	2119	2122	2125	2129	2132	2136
10.70	2139	2142	2146	2149	2152	2156	2159	2163	2166	2169
10.80	2173	2176	2179	2183	2186	2190	2193	2196	2200	2203
10.90	2207	2210	2213	2217	2220	2224	2227	2230	2234	2237
11.00	2241	2244	2247	2251	2254	2258	2261	2264	2268	2271
11.10	2275	2278	2281	2285	2288	2292	2295	2299	2302	2305
11.20	2309	2312	2316	2319	2322	2326	2329	2333	2336	2340
11.30	2343	2346	2350	2353	2357	2360	2364	2367	2370	2374
11.40	2377	2381	2384	2388	2391	2395	2398	2401	2405	2408

Gage height feet	Discharge IN cfs .00	.01	.02	.03	.04	.05	.06	.07	.08	.09
11.50	2412	2415	2419	2422	2426	2429	2432	2436	2439	2443
11.60	2446	2450	2453	2457	2460	2464	2467	2470	2474	2477
11.70	2481	2484	2488	2491	2495	2498	2502	2505	2509	2512
11.80	2516	2519	2522	2526	2529	2533	2536	2540	2543	2547
11.90	2550	2554	2557	2561	2564	2568	2571	2575	2578	2582
12.00	2585	2589	2592	2596	2599	2603	2606	2610	2613	2617
12.10	2620	2624	2627	2631	2634	2638	2641	2645	2648	2652
12.20	2655	2659	2662	2666	2669	2673	2676	2680	2683	2687
12.30	2690	2694	2697	2701	2704	2708	2711	2715	2718	2722
12.40	2725	2729	2732	2736	2739	2743	2747	2750	2754	2757
12.50	2761	2764	2768	2771	2775	2778	2782	2785	2789	2792
12.60	2796	2800	2803	2807	2810	2814	2817	2821	2824	2828
12.70	2831	2835	2838	2842	2846	2849	2853	2856	2860	2863
12.80	2867	2870	2874	2878	2881	2885	2888	2892	2895	2899
12.90	2902	2906	2910	2913	2917	2920	2924	2927	2931	2935
13.00	2938	2942	2945	2949	2952	2956	2960	2963	2967	2970
13.10	2974	2977	2981	2985	2988	2992	2995	2999	3002	3006
13.20	3010	3013	3017	3020	3024	3028	3031	3035	3038	3042
13.30	3046	3049	3053	3056	3060	3063	3067	3071	3074	3078
13.40	3081	3085	3089	3092	3096	3099	3103	3107	3110	3114
13.50	3117	3121	3125	3128	3132	3136	3139	3143	3146	3150
13.60	3154	3157	3161	3164	3168	3172	3175	3179	3183	3186
13.70	3190	3193	3197	3201	3204	3208	3212	3215	3219	3222
13.80	3226	3230	3233	3237	3241	3244	3248	3251	3255	3259
13.90	3262	3266	3270	3273	3277	3281	3284	3288	3291	3295
14.00	3299	3302	3306	3310	3313	3317	3321	3324	3328	3332
14.10	3335	3339	3342	3346	3350	3353	3357	3361	3364	3368
14.20	3372	3375	3379	3383	3386	3390	3394	3397	3401	3405
14.30	3408	3412	3416	3419	3423	3427	3430	3434	3438	3441
14.40	3445	3449	3452	3456	3460	3463	3467	3471	3474	3478

Gage height feet	Discharge IN cfs .00	.01	.02	.03	.04	.05	.06	.07	.08	.09
14.50	3482	3485	3489	3493	3496	3500	3504	3507	3511	3515
14.60	3519	3522	3526	3530	3533	3537	3541	3544	3548	3552
14.70	3555	3559	3563	3566	3570	3574	3578	3581	3585	3589
14.80	3592	3596	3600	3603	3607	3611	3615	3618	3622	3626
14.90	3629	3633	3637	3640	3644	3648	3652	3655	3659	3663
15.00	3666	3670	3674	3678	3681	3685	3689	3692	3696	3700
15.10	3704	3707	3711	3715	3718	3722	3726	3730	3733	3737
15.20	3741	3745	3748	3752	3756	3759	3763	3767	3771	3774
15.30	3778	3782	3786	3789	3793	3797	3800	3804	3808	3812
15.40	3815	3819	3823	3827	3830	3834	3838	3842	3845	3849
15.50	3853	3857	3860	3864	3868	3872	3875	3879	3883	3887
15.60	3890	3894	3898	3902	3905	3909	3913	3917	3920	3924
15.70	3928	3932	3935	3939	3943	3947	3950	3954	3958	3962
15.80	3965	3969	3973	3977	3980	3984	3988	3992	3996	3999
15.90	4003	4007	4011	4014	4018	4022	4026	4029	4033	4037
16.00	4041	4045	4048	4052	4056	4060	4063	4067	4071	4075
16.10	4079	4082	4086	4090	4094	4098	4101	4105	4109	4113
16.20	4116	4120	4124	4128	4132	4135	4139	4143	4147	4151
16.30	4154	4158	4162	4166	4170	4173	4177	4181	4185	4189
16.40	4192	4196	4200	4204	4208	4211	4215	4219	4223	4227
16.50	4230	4234	4238	4242	4246	4249	4253	4257	4261	4265
16.60	4268	4272	4276	4280	4284	4288	4291	4295	4299	4303
16.70	4307	4310	4314	4318	4322	4326	4330	4333	4337	4341
16.80	4345	4349	4352	4356	4360	4364	4368	4372	4375	4379
16.90	4383	4387	4391	4395	4398	4402	4406	4410	4414	4418
17.00	4421	4425	4429	4433	4437	4441	4444	4448	4452	4456
17.10	4460	4464	4468	4471	4475	4479	4483	4487	4491	4494
17.20	4498	4502	4506	4510	4514	4518	4521	4525	4529	4533
17.30	4537	4541	4544	4548	4552	4556	4560	4564	4568	4571
17.40	4575	4579	4583	4587	4591	4595	4599	4602	4606	4610

Gage height feet	Discharge IN cfs .00	.01	.02	.03	.04	.05	.06	.07	.08	.09
17.50	4614	4618	4622	4626	4629	4633	4637	4641	4645	4649
17.60	4653	4657	4660	4664	4668	4672	4676	4680	4684	4688
17.70	4691	4695	4699	4703	4707	4711	4715	4719	4722	4726
17.80	4730	4734	4738	4742	4746	4750	4753	4757	4761	4765
17.90	4769	4773	4777	4781	4785	4788	4792	4796	4800	4804
18.00	4808	4812	4816	4820	4824	4827	4831	4835	4839	4843
18.10	4847	4851	4855	4859	4862	4866	4870	4874	4878	4882
18.20	4886	4890	4894	4898	4902	4905	4909	4913	4917	4921
18.30	4925	4929	4933	4937	4941	4945	4948	4952	4956	4960
18.40	4964	4968	4972	4976	4980	4984	4988	4992	4995	4999
18.50	5003	5007	5011	5015	5019	5023	5027	5031	5035	5039
18.60	5043	5046	5050	5054	5058	5062	5066	5070	5074	5078
18.70	5082	5086	5090	5094	5098	5101	5105	5109	5113	5117
18.80	5121	5125	5129	5133	5137	5141	5145	5149	5153	5157
18.90	5161	5164	5168	5172	5176	5180	5184	5188	5192	5196
19.00	5200	5205	5210	5215	5219	5224	5229	5234	5239	5244
19.10	5249	5253	5258	5263	5268	5273	5278	5283	5288	5292
19.20	5297	5302	5307	5312	5317	5322	5327	5332	5336	5341
19.30	5346	5351	5356	5361	5366	5371	5376	5381	5386	5390
19.40	5395	5400	5405	5410	5415	5420	5425	5430	5435	5440
19.50	5445	5449	5454	5459	5464	5469	5474	5479	5484	5489
19.60	5494	5499	5504	5509	5514	5519	5524	5529	5533	5538
19.70	5543	5548	5553	5558	5563	5568	5573	5578	5583	5588
19.80	5593	5598	5603	5608	5613	5618	5623	5628	5633	5638
19.90	5643	5648	5653	5658	5663	5668	5673	5678	5683	5688
20.00	5693	5698	5703	5708	5713	5718	5723	5728	5733	5738
20.10	5743	5748	5753	5758	5763	5768	5773	5778	5783	5788
20.20	5793	5798	5803	5808	5813	5818	5823	5828	5833	5838
20.30	5843	5848	5854	5859	5864	5869	5874	5879	5884	5889
20.40	5894	5899	5904	5909	5914	5919	5924	5929	5934	5940

Gage height feet	Discharge IN cfs .00	.01	.02	.03	.04	.05	.06	.07	.08	.09
20.50	5945	5950	5955	5960	5965	5970	5975	5980	5985	5990
20.60	5995	6000	6006	6011	6016	6021	6026	6031	6036	6041
20.70	6046	6051	6057	6062	6067	6072	6077	6082	6087	6092
20.80	6097	6103	6108	6113	6118	6123	6128	6133	6138	6144
20.90	6149	6154	6159	6164	6169	6174	6179	6185	6190	6195
21.00	6200*									

U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION NUMBER 05057200 BALDHILL CREEK NR DAZEY, ND SOURCE AGENCY USGS
LATITUDE 471345 LONGITUDE 0980728 NAD27 DRAINAGE AREA 691 CONTRIBUTING DRAINAGE AREA 351
Date Processed: 2004-10-04 15:40 By smrobins Created by snorbeck on 03-29-2004 Updated by snorbeck on 03-29-2004
RATING ID: 14.1 OFFSET: 5.50 DATUM 1330 NGVD29

Gage height, feet	Discharge IN cfs 0.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
5.60	0.000*	0.010	0.020	0.030	0.040	0.050	0.060	0.070	0.080	0.090
5.70	0.100*	0.113	0.127	0.143	0.159	0.176	0.195	0.214	0.235	0.257
5.80	0.280*	0.304	0.330	0.356	0.384	0.414	0.444	0.476	0.509	0.544
5.90	0.580*	0.624	0.670	0.718	0.768	0.821	0.876	0.933	0.993	1.06
6.00	1.12*	1.22	1.33	1.44	1.56	1.69	1.82	1.96	2.12	2.28
6.10	2.45	2.63	2.82	3.02	3.23	3.45	3.68	3.93	4.19	4.46
6.20	4.74	5.04	5.35	5.67	6.01	6.37	6.74	7.13	7.54	7.96
6.30	8.40*	8.85	9.32	9.81	10.32	10.85	11.39	11.96	12.55	13.17
6.40	13.80*	14.45	15.12	15.82	16.54	17.29	18.06	18.85	19.67	20.52
6.50	21.40*	22.17	22.96	23.76	24.59	25.44	26.31	27.20	28.11	29.05
6.60	30.00*	30.88	31.78	32.69	33.62	34.57	35.54	36.53	37.53	38.56
6.70	39.60*	40.57	41.55	42.55	43.57	44.60	45.65	46.71	47.79	48.89
6.80	50.00*	51.04	52.09	53.16	54.24	55.33	56.44	57.56	58.69	59.84
6.90	61.00*	62.30	63.61	64.95	66.30	67.67	69.06	70.47	71.89	73.34
7.00	74.80*	76.18	77.58	79.00	80.43	81.88	83.34	84.82	86.32	87.83
7.10	89.37	90.91	92.48	94.06	95.66	97.28	98.91	100.6	102.2	103.9
7.20	105.6	107.3	109.1	110.8	112.6	114.4	116.2	118.0	119.9	121.8
7.30	123.6	125.5	127.5	129.4	131.4	133.3	135.3	137.4	139.4	141.4
7.40	143.5	145.6	147.7	149.9	152.0	154.2	156.4	158.6	160.8	163.0
7.50	165.3	167.6	169.9	172.2	174.6	177.0	179.3	181.8	184.2	186.6
7.60	189.1	191.6	194.1	196.7	199.2	201.8	204.4	207.0	209.6	212.3
7.70	215.0	217.7	220.4	223.2	225.9	228.7	231.5	234.4	237.2	240.1
7.80	243.0	245.9	248.9	251.9	254.8	257.9	260.9	264.0	267.0	270.1
7.90	273.3	276.4	279.6	282.8	286.0	289.2	292.5	295.8	299.1	302.5

Gage height, feet	Discharge IN cfs 0.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
8.00	305.8	309.2	312.6	316.0	319.5	323.0	326.5	330.0	333.6	337.1
8.10	340.7	344.4	348.0	351.7	355.4	359.1	362.8	366.6	370.4	374.2
8.20	378.1	382.0	385.9	389.8	393.7	397.7	401.7	405.7	409.8	413.9
8.30	418.0	422.1	426.2	430.4	434.6	438.9	443.1	447.4	451.7	456.0
8.40	460.4*	464.9	469.5	474.1	478.7	483.3	488.0	492.7	497.5	502.2
8.50	507.0*	511.8	516.6	521.4	526.3	531.1	536.1	541.0	546.0	551.0
8.60	556.0*	560.9	565.8	570.7	575.7	580.7	585.7	590.7	595.8	600.9
8.70	606.0*	610.9	615.8	620.8	625.7	630.7	635.7	640.7	645.8	650.9
8.80	656.0*	660.8	665.6	670.4	675.2	680.1	684.9	689.8	694.7	699.7
8.90	704.6*	709.9	715.3	720.7	726.1	731.5	737.0	742.5	748.0	753.5
9.00	759.1	764.7	770.3	775.9	781.6	787.3	793.0	798.7	804.5	810.3
9.10	816.1	821.9	827.8	833.7	839.6	845.6	851.5	857.5	863.5	869.6
9.20	875.6	881.7	887.9	894.0	900.2	906.4	912.6	918.9	925.1	931.4
9.30	937.8	944.1	950.5	956.9	963.3	969.8	976.3	982.8	989.3	995.9
9.40	1003	1009	1016	1022	1029	1036	1043	1049	1056	1063
9.50	1070	1077	1084	1091	1098	1105	1112	1119	1126	1133
9.60	1140	1147	1154	1162	1169	1176	1183	1191	1198	1205
9.70	1213	1220	1228	1235	1243	1250	1258	1265	1273	1281
9.80	1288	1296	1304	1312	1319	1327	1335	1343	1351	1359
9.90	1367	1375	1383	1391	1399	1407	1415	1423	1432	1440
10.00	1448	1456	1465	1473	1481	1490	1498	1507	1515	1524
10.10	1532	1541	1549	1558	1567	1575	1584	1593	1602	1611
10.20	1619	1628	1637	1646	1655	1664	1673	1682	1691	1700
10.30	1709	1719	1728	1737	1746	1756	1765	1774	1784	1793
10.40	1802	1812	1821	1831	1841	1850	1860	1869	1879	1889
10.50	1899	1908	1918	1928	1938	1948	1958	1968	1978	1988
10.60	1998	2008	2018	2028	2038	2048	2059	2069	2079	2089
10.70	2100	2110	2121	2131	2142	2152	2163	2173	2184	2195
10.80	2205	2216	2227	2237	2248	2259	2270	2281	2292	2303
10.90	2314	2325	2336	2347	2358	2369	2380	2392	2403	2414

Gage height, feet	Discharge IN cfs 0.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
11.00	2425	2437	2448	2460	2471	2483	2494	2506	2517	2529
11.10	2540	2552	2564	2576	2587	2599	2611	2623	2635	2647
11.20	2659	2671	2683	2695	2707	2719	2731	2743	2756	2768
11.30	2780	2793	2805	2817	2830	2842	2855	2867	2880	2892
11.40	2905	2918	2930	2943	2956	2969	2982	2994	3007	3020
11.50	3033	3046	3059	3072	3086	3099	3112	3125	3138	3152
11.60	3165	3178	3192	3205	3219	3232	3246	3259	3273	3286
11.70	3300*	3314	3328	3342	3356	3370	3384	3398	3412	3426
11.80	3440	3454	3469	3483	3497	3512	3526	3540	3555	3569
11.90	3584	3598	3613	3628	3642	3657	3672	3687	3701	3716
12.00	3731	3746	3761	3776	3791	3806	3821	3836	3852	3867
12.10	3882	3897	3913	3928	3944	3959	3975	3990	4006	4021
12.20	4037	4053	4068	4084	4100	4116	4132	4147	4163	4179
12.30	4195	4211	4227	4244	4260	4276	4292	4308	4325	4341
12.40	4358	4374	4390	4407	4423	4440	4457	4473	4490	4507
12.50	4524	4540	4557	4574	4591	4608	4625	4642	4659	4676
12.60	4693	4711	4728	4745	4762	4780	4797	4815	4832	4850
12.70	4867	4885	4902	4920	4938	4955	4973	4991	5009	5027
12.80	5045	5063	5081	5099	5117	5135	5153	5171	5190	5208
12.90	5226	5245	5263	5282	5300	5319	5337	5356	5374	5393
13.00	5412	5431	5449	5468	5487	5506	5525	5544	5563	5582
13.10	5601	5621	5640	5659	5678	5698	5717	5736	5756	5775
13.20	5795	5814	5834	5854	5873	5893	5913	5933	5953	5973
13.30	5993	6012	6033	6053	6073	6093	6113	6133	6154	6174
13.40	6194	6215	6235	6256	6276	6297	6317	6338	6359	6379
13.50	6400*									

"*" indicates a rating descriptor point

U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION NUMBER 05056000 SHEYENNE RIVER NR WARWICK, ND SOURCE AGENCY USGS STATE 38 COUNTY 027
LATITUDE 474820 LONGITUDE 0984257 NAD27 DRAINAGE AREA 2070 CONTRIBUTING DRAINAGE AREA 760 DATUM 1376.34 NGVD29
Date Processed: 2004-10-07 14:33 By smrobins RATING ID: 10.0 TYPE: stage-discharge EXPANSION: logarithmic STATUS: approved
Created by smrobins on 02-25-2002 , Updated by smrobins on 02-25-2002 , Remarks: SAME AS RT 9.1 ABOVE 4.40 ft, OFFSET: 2.00

Gage height, feet	Discharge IN cfs .00	.01	.02	.03	.04	.05	.06	.07	.08	.09
2.00					0.000*	0.701	1.40	2.10	2.80	3.50
2.10	4.20*	4.91	5.65	6.44	7.27	8.13	9.04	9.98	10.95	11.96
2.20	13.00*	14.13	15.29	16.49	17.73	19.00	20.31	21.66	23.04	24.46
2.30	25.91	27.40	28.92	30.47	32.06	33.68	35.33	37.01	38.73	40.48
2.40	42.26	44.07	45.92	47.79	49.70	51.63	53.60	55.60	57.63	59.68
2.50	61.77	63.88	66.03	68.20	70.41	72.64	74.90	77.19	79.50	81.85
2.60	84.22	86.62	89.05	91.51	93.99	96.51	99.04	101.6	104.2	106.8
2.70	109.5	112.1	114.8	117.6	120.3	123.1	125.9	128.7	131.6	134.5
2.80	137.4	140.3	143.3	146.3	149.3	152.3	155.4	158.4	161.6	164.7
2.90	167.8	171.0	174.2	177.5	180.7	184.0	187.3	190.7	194.0	197.4
3.00	200.8	204.2	207.7	211.1	214.6	218.2	221.7	225.3	228.9	232.5
3.10	236.1	239.8	243.5	247.2	250.9	254.7	258.4	262.2	266.1	269.9
3.20	273.8	277.7	281.6	285.5	289.5	293.5	297.5	301.5	305.5	309.6
3.30	313.7	317.8	322.0	326.1	330.3	334.5	338.7	343.0	347.3	351.5
3.40	355.9	360.2	364.5	368.9	373.3	377.7	382.2	386.6	391.1	395.6
3.50	400.2	404.7	409.3	413.9	418.5	423.1	427.8	432.4	437.1	441.8
3.60	446.6	451.3	456.1	460.9	465.7	470.6	475.4	480.3	485.2	490.1
3.70	495.1	500.1	505.0	510.0	515.1	520.1	525.2	530.3	535.4	540.5
3.80	545.6	550.8	556.0	561.2	566.4	571.7	576.9	582.2	587.5	592.8
3.90	598.2	603.6	608.9	614.3	619.8	625.2	630.7	636.2	641.7	647.2
4.00	652.7	658.3	663.9	669.5	675.1	680.7	686.4	692.0	697.7	703.5
4.10	709.2	714.9	720.7	726.5	732.3	738.1	744.0	749.9	755.7	761.7
4.20	767.6	773.5	779.5	785.5	791.5	797.5	803.5	809.6	815.7	821.7
4.30	827.9	834.0	840.1	846.3	852.5	858.7	864.9	871.2	877.4	883.7
4.40	890.0*	896.7	903.4	910.2	916.9	923.7	930.5	937.4	944.2	951.1

Gage height, feet	Discharge IN cfs .00	.01	.02	.03	.04	.05	.06	.07	.08	.09
4.50	958.0*	964.8	971.6	978.5	985.3	992.2	999.1	1006	1013	1020
4.60	1027	1034	1041	1048	1055	1062	1069	1076	1084	1091
4.70	1098*	1105	1112	1119	1126	1134	1141	1148	1155	1162
4.80	1170	1177	1184	1191	1199	1206	1213	1221	1228	1236
4.90	1243	1250	1258	1265	1273	1280	1288	1296	1303	1311
5.00	1318	1326	1334	1341	1349	1357	1364	1372	1380	1388
5.10	1396	1403	1411	1419	1427	1435	1443	1451	1459	1467
5.20	1475	1483	1491	1499	1507	1515	1523	1531	1539	1547
5.30	1556	1564	1572	1580	1588	1597	1605	1613	1622	1630
5.40	1638	1647	1655	1663	1672	1680	1689	1697	1706	1714
5.50	1723	1731	1740	1749	1757	1766	1774	1783	1792	1800
5.60	1809	1818	1827	1835	1844	1853	1862	1871	1880	1888
5.70	1897	1906	1915	1924	1933	1942	1951	1960	1969	1978
5.80	1987	1996	2005	2015	2024	2033	2042	2051	2060	2070
5.90	2079	2088	2097	2107	2116	2125	2135	2144	2153	2163
6.00	2172	2182	2191	2201	2210	2220	2229	2239	2248	2258
6.10	2267	2277	2287	2296	2306	2316	2325	2335	2345	2355
6.20	2364	2374	2384	2394	2404	2413	2423	2433	2443	2453
6.30	2463	2473	2483	2493	2503	2513	2523	2533	2543	2553
6.40	2563	2573	2583	2594	2604	2614	2624	2634	2645	2655
6.50	2665	2675	2686	2696	2706	2717	2727	2738	2748	2758
6.60	2769	2779	2790	2800	2811	2821	2832	2842	2853	2864
6.70	2874	2885	2895	2906	2917	2927	2938	2949	2960	2970
6.80	2981	2992	3003	3014	3024	3035	3046	3057	3068	3079
6.90	3090	3101	3112	3123	3134	3145	3156	3167	3178	3189
7.00	3200*	3211	3221	3232	3243	3253	3264	3275	3286	3297
7.10	3307	3318	3329	3340	3351	3361	3372	3383	3394	3405
7.20	3416	3427	3438	3449	3460	3471	3482	3493	3504	3515
7.30	3526	3537	3548	3559	3571	3582	3593	3604	3615	3626
7.40	3638	3649	3660	3671	3683	3694	3705	3716	3728	3739

Gage height, feet	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
	Discharge IN cfs									
7.50	3750	3762	3773	3785	3796	3807	3819	3830	3842	3853
7.60	3865	3876	3888	3899	3911	3922	3934	3946	3957	3969
7.70	3980	3992	4004	4015	4027	4039	4050	4062	4074	4086
7.80	4097	4109	4121	4133	4145	4156	4168	4180	4192	4204
7.90	4216	4228	4239	4251	4263	4275	4287	4299	4311	4323
8.00	4335	4347	4359	4371	4384	4396	4408	4420	4432	4444
8.10	4456	4469	4481	4493	4505	4517	4530	4542	4554	4566
8.20	4579	4591	4603	4616	4628	4640	4653	4665	4677	4690
8.30	4702	4715	4727	4740	4752	4765	4777	4790	4802	4815
8.40	4827	4840	4852	4865	4878	4890	4903	4916	4928	4941
8.50	4954	4966	4979	4992	5004	5017	5030	5043	5055	5068
8.60	5081	5094	5107	5120	5133	5145	5158	5171	5184	5197
8.70	5210	5223	5236	5249	5262	5275	5288	5301	5314	5327
8.80	5340	5353	5366	5379	5393	5406	5419	5432	5445	5458
8.90	5472	5485	5498	5511	5524	5538	5551	5564	5578	5591
9.00	5604	5618	5631	5644	5658	5671	5684	5698	5711	5725
9.10	5738	5752	5765	5779	5792	5806	5819	5833	5846	5860
9.20	5873	5887	5901	5914	5928	5942	5955	5969	5983	5996
9.30	6010	6024	6037	6051	6065	6079	6092	6106	6120	6134
9.40	6148	6162	6175	6189	6203	6217	6231	6245	6259	6273
9.50	6287	6301	6315	6329	6343	6357	6371	6385	6399	6413
9.60	6427	6441	6455	6469	6483	6497	6512	6526	6540	6554
9.70	6568	6583	6597	6611	6625	6640	6654	6668	6682	6697
9.80	6711	6725	6740	6754	6768	6783	6797	6812	6826	6840
9.90	6855	6869	6884	6898	6913	6927	6942	6956	6971	6985
10.00	7000*									

"*" indicates a rating descriptor point

U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION NUMBER 05057000 SHEYENNE RIVER NR COOPERSTOWN, ND SOURCE AGENCY USGS STATE 38 COUNTY 039
LAT 472558 LONG 0980138 NAD27 DRAINAGE AREA 6470 CONTRIBUTING DRAINAGE AREA 1270 DATUM 1271.76 NGVD29
Date Processed: 2004-10-07 By smrobins RATING ID: 14.1 Created by jmlambre on 01-14-2003, Updated by jmlambre on 01-23-2003
Remarks: HIGHWATER EXTENSION OF RT 13 OFFSET: 9.50 EXPANDED RATING TABLE

Gage height, feet	Discharge IN cfs .00	.01	.02	.03	.04	.05	.06	.07	.08	.09
9.50	0.000*	0.801	1.60	2.40	3.20	4.00	4.80	5.60	6.40	7.20
9.60	8.00*	9.31	10.68	12.13	13.64	15.21	16.85	18.55	20.31	22.13
9.70	24.00*	25.69	27.42	29.17	30.95	32.77	34.61	36.48	38.38	40.31
9.80	42.26	44.24	46.24	48.27	50.32	52.40	54.50	56.62	58.77	60.94
9.90	63.13	65.34	67.58	69.83	72.11	74.41	76.72	79.06	81.42	83.79
10.00	86.19	88.60	91.04	93.49	95.96	98.45	101.0	103.5	106.0	108.6
10.10	111.2	113.7	116.4	119.0	121.6	124.3	127.0	129.7	132.4	135.1
10.20	137.8	140.6	143.4	146.1	148.9	151.8	154.6	157.4	160.3	163.2
10.30	166.1	169.0	171.9	174.8	177.8	180.7	183.7	186.7	189.7	192.7
10.40	195.7	198.8	201.8	204.9	208.0	211.0	214.2	217.3	220.4	223.5
10.50	226.7	229.9	233.1	236.2	239.5	242.7	245.9	249.1	252.4	255.7
10.60	258.9	262.2	265.5	268.9	272.2	275.5	278.9	282.2	285.6	289.0
10.70	292.4	295.8	299.2	302.6	306.1	309.5	313.0	316.4	319.9	323.4
10.80	326.9	330.4	334.0	337.5	341.0	344.6	348.2	351.7	355.3	358.9
10.90	362.5	366.1	369.8	373.4	377.1	380.7	384.4	388.1	391.8	395.5
11.00	399.2	402.9	406.6	410.3	414.1	417.8	421.6	425.4	429.2	433.0
11.10	436.8	440.6	444.4	448.2	452.1	455.9	459.8	463.7	467.5	471.4
11.20	475.3	479.2	483.1	487.1	491.0	494.9	498.9	502.9	506.8	510.8
11.30	514.8	518.8	522.8	526.8	530.8	534.8	538.9	542.9	547.0	551.1
11.40	555.1	559.2	563.3	567.4	571.5	575.6	579.7	583.9	588.0	592.2
11.50	596.3	600.5	604.6	608.8	613.0	617.2	621.4	625.6	629.9	634.1
11.60	638.3	642.6	646.8	651.1	655.3	659.6	663.9	668.2	672.5	676.8
11.70	681.1	685.4	689.8	694.1	698.5	702.8	707.2	711.5	715.9	720.3
11.80	724.7*	729.1	733.5	737.9	742.3	746.8	751.2	755.6	760.1	764.5
11.90	769.0*	773.5	777.9	782.4	786.9	791.4	795.9	800.4	804.9	809.5

Gage height, feet	Discharge IN cfs .00	.01	.02	.03	.04	.05	.06	.07	.08	.09
12.00	814.0*	818.5	823.0	827.4	831.9	836.4	840.9	845.4	850.0	854.5
12.10	859.0*	863.5	868.0	872.4	876.9	881.4	885.9	890.4	895.0	899.5
12.20	904.0*	908.5	913.0	917.4	921.9	926.4	930.9	935.4	940.0	944.5
12.30	949.0*	953.5	958.0	962.5	966.9	971.4	975.9	980.5	985.0	989.5
12.40	994.0*	998.5	1003	1007	1012	1016	1021	1025	1030	1034
12.50	1039*	1043	1048	1052	1057	1061	1066	1070	1075	1079
12.60	1084*	1088	1093	1097	1101	1106	1110	1115	1119	1123
12.70	1128	1132	1137	1141	1145	1150	1154	1159	1163	1168
12.80	1172	1176	1181	1185	1190	1194	1199	1203	1208	1212
12.90	1216	1221	1225	1230	1234	1239	1243	1248	1252	1257
13.00	1261	1266	1270	1275	1279	1284	1288	1293	1297	1302
13.10	1306	1311	1315	1320	1325	1329	1334	1338	1343	1347
13.20	1352	1356	1361	1366	1370	1375	1379	1384	1388	1393
13.30	1398	1402	1407	1411	1416	1421	1425	1430	1434	1439
13.40	1444	1448	1453	1458	1462	1467	1471	1476	1481	1485
13.50	1490*	1494	1499	1503	1508	1512	1516	1521	1525	1530
13.60	1534	1539	1543	1547	1552	1556	1561	1565	1570	1574
13.70	1579	1583	1587	1592	1596	1601	1605	1610	1614	1619
13.80	1623	1628	1632	1636	1641	1645	1650	1654	1659	1663
13.90	1668	1672	1677	1681	1686	1690	1695	1699	1704	1708
14.00	1713	1717	1722	1726	1731	1735	1740	1744	1749	1753
14.10	1758	1762	1767	1771	1776	1780	1785	1790	1794	1799
14.20	1803	1808	1812	1817	1821	1826	1830	1835	1839	1844
14.30	1849	1853	1858	1862	1867	1871	1876	1880	1885	1890
14.40	1894	1899	1903	1908	1913	1917	1922	1926	1931	1935
14.50	1940*	1944	1949	1953	1958	1962	1967	1971	1976	1980
14.60	1985	1989	1993	1998	2002	2007	2011	2016	2020	2025
14.70	2029	2034	2038	2043	2047	2052	2056	2061	2065	2070
14.80	2074	2079	2083	2087	2092	2096	2101	2105	2110	2114
14.90	2119	2123	2128	2132	2137	2141	2146	2150	2155	2159

Gage height, feet	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
	Discharge IN cfs									
15.00	2164*	2168	2173	2177	2182	2186	2191	2195	2200	2204
15.10	2209	2213	2218	2222	2227	2232	2236	2241	2245	2250
15.20	2254	2259	2263	2268	2272	2277	2281	2286	2290	2295
15.30	2299	2304	2308	2313	2317	2322	2326	2331	2336	2340
15.40	2345	2349	2354	2358	2363	2367	2372	2376	2381	2385
15.50	2390*	2395	2399	2404	2408	2413	2417	2422	2427	2431
15.60	2436	2440	2445	2450	2454	2459	2463	2468	2472	2477
15.70	2482	2486	2491	2495	2500	2505	2509	2514	2518	2523
15.80	2528	2532	2537	2542	2546	2551	2555	2560	2565	2569
15.90	2574	2578	2583	2588	2592	2597	2602	2606	2611	2615
16.00	2620*	2625	2629	2634	2638	2643	2648	2652	2657	2661
16.10	2666*	2671	2675	2680	2684	2689	2694	2698	2703	2707
16.20	2712*	2717	2721	2726	2730	2735	2740	2744	2749	2753
16.30	2758*	2763	2767	2772	2776	2781	2786	2790	2795	2799
16.40	2804*	2809	2813	2818	2822	2827	2832	2836	2841	2845
16.50	2850*	2856	2861	2867	2872	2878	2883	2889	2894	2900
16.60	2905	2911	2917	2922	2928	2933	2939	2944	2950	2956
16.70	2961	2967	2972	2978	2984	2989	2995	3000	3006	3012
16.80	3017	3023	3028	3034	3040	3045	3051	3057	3062	3068
16.90	3073	3079	3085	3090	3096	3102	3107	3113	3119	3124
17.00	3130*	3137	3144	3152	3159	3166	3174	3181	3188	3195
17.10	3203	3210	3217	3225	3232	3239	3247	3254	3261	3269
17.20	3276	3283	3291	3298	3306	3313	3320	3328	3335	3343
17.30	3350*	3360	3370	3380	3389	3399	3409	3419	3429	3439
17.40	3449	3459	3469	3479	3489	3499	3509	3520	3530	3540
17.50	3550*	3560	3570	3579	3589	3599	3609	3619	3629	3639
17.60	3649	3658	3668	3678	3688	3698	3708	3718	3728	3738
17.70	3749	3759	3769	3779	3789	3799	3809	3819	3830	3840
17.80	3850*	3860	3870	3880	3890	3900	3909	3919	3929	3939
17.90	3949	3959	3969	3979	3989	4000	4010	4020	4030	4040

Gage height, feet	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
	Discharge IN cfs									
18.00	4050*	4060	4070	4080	4090	4100	4109	4119	4129	4139
18.10	4149	4159	4169	4179	4189	4200	4210	4220	4230	4240
18.20	4250*	4262	4275	4287	4299	4312	4324	4337	4349	4361
18.30	4374	4386	4399	4412	4424	4437	4449	4462	4475	4487
18.40	4500*	4515	4529	4544	4559	4574	4589	4604	4618	4633
18.50	4648	4663	4678	4694	4709	4724	4739	4754	4769	4785
18.60	4800*	4831	4862	4893	4925	4956	4988	5020	5052	5084
18.70	5116	5149	5182	5215	5248	5281	5315	5348	5382	5416
18.80	5450*	5486	5521	5557	5594	5630	5667	5703	5740	5778
18.90	5815	5853	5890	5928	5967	6005	6044	6082	6121	6161
19.00	6200*	6239	6278	6318	6358	6397	6438	6478	6518	6559
19.10	6600*	6649	6698	6747	6796	6846	6896	6947	6998	7049
19.20	7100*									

"*" indicates a rating descriptor point

Red River Joint Water Resource Board

Providing a coordinated and cooperative approach to planning and implementing a comprehensive water management program in the Red River Valley

Traill County Courthouse
Box 10
Hillsboro ND 58045

Phone 701-430-0269
or 701-636-5257

March 20, 2006

Ferris Chamberlin
St. Paul District
US Army Corps of Engineers
Sibley Square at Mears Park
190 5th Street East, Suite 401
St. Paul, MN 55101-1638

RE: Baldhill Dam and Lake Ashtabula Draft Water Control Manual.

Dear Mr. Chamberlin:

Representatives of the Red River Joint Water Resource District (RRJWRD) attended the March 8, 2006 meeting in Valley City, ND where proposed changes to the operation manual for the above mentioned project were discussed. Table 3-5 was presented that showed proposed changes to the drawdown, based on basin average snow-water content. The proposal reduced the extent of the reservoir drawdown during the spring, for snow-water equivalents extending as high as 4 inches.

The executive board of the RRJWRD approved a motion on March 20, stating that they are opposed to any change of the operation plan for Baldhill Dam that would reduce the amount of available flood storage for spring runoff. The reservoir still does not have adequate capacity to completely control a large flood. Spring rains, or a quick melt, can quickly change the amount of runoff. (This occurred in the spring of 2005.) This could cause the reservoir to be filled to the top of the flood pool, causing larger discharges from the reservoir and additional downstream flooding.

The RRJWRB is comprised of 14 water resource districts within 11 counties that are located downstream of Baldhill Dam. They provided a large amount of the local cost sharing for the additional flood storage provided by the 5-foot raise of the flood pool. They recognized that the area extending downstream of the reservoir was in need of additional flood protection. The proposed change in the drawdown plan would reduce the amount of available storage for spring floods, causing a reduction in flood damage reduction benefits from the project. The RRJWRD is opposed to any change of the drawdown plan from that stated in the original operation manual.

Thank you.

Sincerely,

Donald Elston jk

Donald Elston, Chairman
Red River Joint Water Resource District

Upper Sheyenne River Joint
Water Resource Board
P.O. Box 446
Lakota, North Dakota 58344-0446

Phone: 701 247-2682
Fax: 701 247-2692
E-Mail: ncwrd@polarcomm.com

Providing a coordinated and cooperative approach to planning and implementing a comprehensive water management program in the Upper Sheyenne Watershed

March 20, 2006

Ferris Chamberlain
District Office Address
US Army Corps of Engineers
Sibley Square at Mears Park
190 5th Street East, Suite 401
St. Paul, MN 55101-1638

RE: Baldhill Dam and Lake Ashtabula Draft Operation Control Manual

Dear Mr. Chamberlain:

As a representative of the Upper Sheyenne River Joint Water Resource Board, I attended the March 8, 2006, hearing on the report and suggested changes to the operation of Baldhill Dam. I spoke of having the opportunity to make formal comments for the record as required. On March 15, 2006, the Upper Sheyenne River Joint WRB met and discussed the suggested changes with much concern. Some of the concern had to do with the ranges of draw down for relative snow-water equivalents shown in Table 3-5 of the draft manual. This could result in as much as 3 feet less draw down than listed in the original manual.

The Upper Sheyenne River Joint Water Resource Board opposes any changes to the original operation plan for Baldhill Dam. The proposed change would reduce the extent that the reservoir would be drawn down prior to spring runoff. This would reduce the amount of available flood storage. Spring rains, or a quick melt, could fill the reservoir to the top of the flood pool. This would force larger discharges from the reservoir, causing additional downstream flooding.

Many local entities have invested in the project that provides an additional 5-foot raise of the flood pool. A change in the operation of the draw down plan that would reduce the amount of storage for spring floods would be counter-productive to that project and is not acceptable.

The Upper Sheyenne River Joint WRB is represented by 10 counties above the Baldhill Dam in the watershed. A motion was made and carried by those present that the Operation Manual for Baldhill Dam not be changed but remain the same as it was prior to the draft proposal of July 2005.

Sincerely,

Ben Varnson

Ben Varnson
Upper Sheyenne River Joint WRD
Representative and Chairman

CASS COUNTY GOVERNMENT

Southeast Cass Water Resource District

Thomas L. Fischer
Chairman
Fargo, North Dakota

Mark Thelen
Manager
Fargo, North Dakota

Mark Brodshaug
Manager
Fargo, North Dakota

Carol Harbeke Lewis
Secretary-Treasurer

1201 Main Avenue West
West Fargo, ND 58078-1301

701-298-2381
FAX 701-298-2397
wrd@co.cass.nd.us
www.casscountygov.com

March 15, 2006

Ferris Chamberlin
U.S. Army Corps of Engineers
Sibley Square at Mears Park
190 5th Street East, Suite 401
St. Paul, MN 55101-1638

Dear Mr. Chamberlin:

RE: Baldhill Dam and Lake Ashtabula Draft Water Control Manual

The Southeast Cass Water Resource District (WRD) has obtained a copy of the Draft Baldhill Dam and Lake Ashtabula Water Control Manual (Revised July 2005). This letter is written to inform the U.S. Army Corps of Engineers (COE) of the WRD's opposition to the proposed drawdown schedule described in Table 3-5 of said Draft Manual.

Please be aware that the five foot raise in the Baldhill Dam was funded and constructed for the sole purpose of downstream flood protection. The local sponsor and cooperating local agencies were assured by the COE during project development that the future drawdown would remain as presented in Table 7-1 of the original operation manual, "Baldhill Dam & Lake Ashtabula Sheyenne River Reservoir Regulation Manual". Table 7-1 lists a suggested drawdown as follows:

Avg. Snow Cover (H_2O equiv.)	Suggested Drawdown
1.0 inch	1262.5
1.5 inches	1262.0
2.0 inches	1259.0
3.0 inches	1257.0

In addition, the WRD does not agree with the Draft Manual (Revised July 2005) interpretation of Table 7-1 from the Original Manual. It is our view that the ranges used in Table 3-5 of the Draft Manual underestimate the intended drawdown for relative snow-water equivalents. In some cases, the interpretation of Table 3-5 results in up to a three foot drawdown difference from that listed in the Original Manual.

At the March 8, 2006, hearing in Valley City, you advised those in attendance that the drawdown schedule in the Original Manual will be used for future operations of the Baldhill Dam. It is vitally important to us that the available flood protection benefits of Baldhill Dam are fully utilized.

Sincerely,

SOUTHEAST CASS WATER RESOURCE DISTRICT

Thomas L. Fischer
Chairman

moore engineering, inc.

Consulting Engineering • Land Surveying

1042 14th Avenue East • West Fargo, North Dakota 58078
Phone: 701-282-4692 • Fax: 701-282-4530

March 21, 2006

Ferris Chamberlin
US Army Corps of Engineers
Sibley Square at Mears Park
190 5th Street East, Suite 401
St. Paul, MN 55101-1638

RE: Baldhill Dam and Lake Ashtabula Draft Water Control Manual.

Dear Mr. Chamberlin:

I have received a copy of the Draft Baldhill Dam and Lake Ashtabula Water Control Manual (Revised July 2005) and was in attendance at the March 8, 2006 hearing in Valley City, ND. Based on this information, there are lingering concerns that have been expressed to me by the local sponsors of this project.

I would like to say up-front that we are pleased the Corps will honor the drawdown schedule of the Original Manual in its new operations manual.

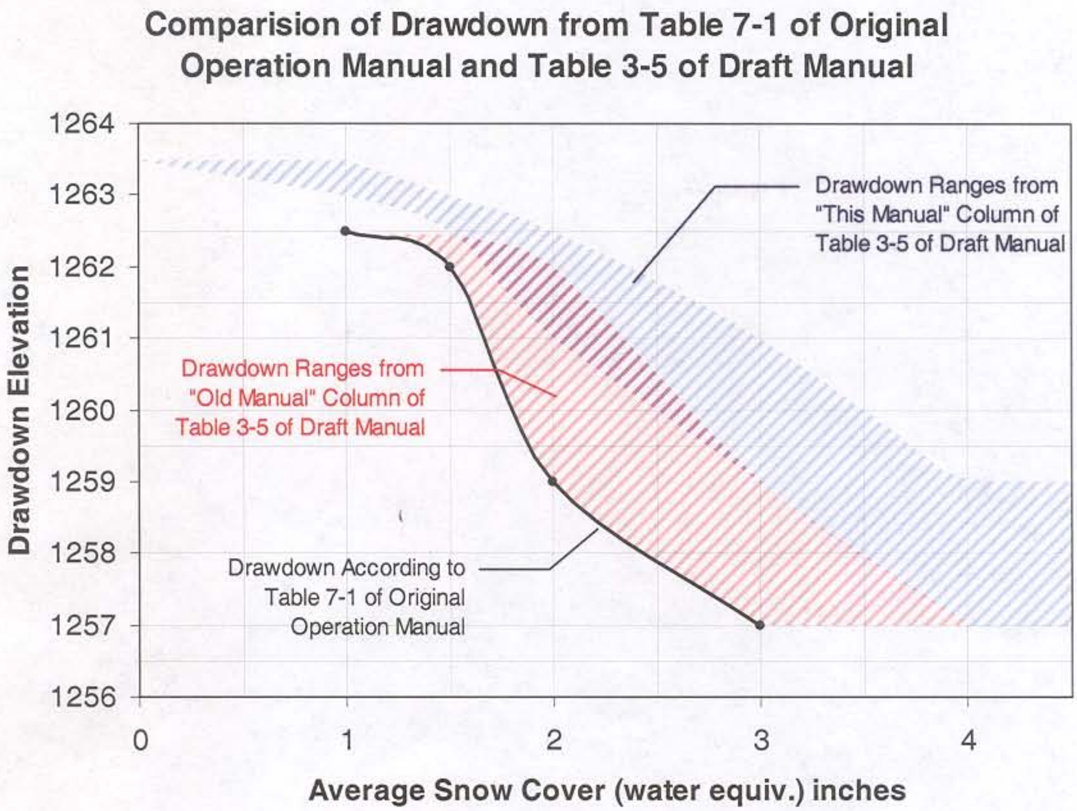
However, upon a review of Table 3-5 of the Draft Manual, which provides the drawdown schedule for Lake Ashtabula, I am concerned that the new Draft Manual does not follow the drawdown table in the Original Manual. Table 7-1 of the Original Manual describes a suggested drawdown as follows:

Table 7-1 of the Original Manual

Average Snow Cover (water equiv.)	Suggested Drawdown
1.0 inch	1262.5
1.5 inches	1262.0
2.0 inches	1259.0
3 inches	1257.0

As can be seen, the Original Manual utilizes a direct approach for determining drawdown; meaning that a specific snow-water equivalent corresponds to a specific drawdown elevation. These points have been plotted with a "black line" on the following page.

Unlike the Original Manual, the Draft Manual uses a range of snow cover values for each drawdown elevation. These ranges can be found in Table 3-5 of the Draft Manual. These ranges have also been plotted in the figure below in color.



Based on this graphical analysis, it is clear that Table 3-5 of the Draft Manual interprets the original drawdown schedule differently than the intent of the Original Manual. Because Table 3-5 of the Draft Manual utilizes a system of ranges for snow-water equivalent, an error of interpretation can occur. For example, a snow-water equivalent of 2 inches could be interpreted by Table 3-5 of the Draft Manual to correspond to a drawdown of up to 3 feet differently than the Original Manual. Should the user of the manual choose elevation 1262.00 for 2 inches of snow-water, rather than elevation 1259.00, approximately 12,400 acre-feet of available flood storage will have been lost. The five foot raise to Baldhill Dam purchased 30,700 acre-feet of storage. Under this scenario, approximately 40% of the storage purchased will have been erased due to the Draft Manual's interpretation of Table 7-1. Clearly, this is unacceptable.

In addition, the Draft Manual states the minimum drawdown is to elevation 1263.5. The Original Manual sets the minimum drawdown at elevation 1262.5. A difference of 4,750 acre-feet. The 5 foot raise purchased 30,700 additional acre-feet of storage. Changing the minimum drawdown 1 foot will result in a direct storage reduction of 15%.

The following table further shows how misinterpretation of the Original Manual reduces the available storage provided by Baldhill Dam:

Basin Average Snow-Water	Recommended Drawdown Table 7-1 Original Manual	Available Flood Storage (acre-feet)	Draft Manual's Interpretation of Original Manual	Available Flood Storage (acre-feet)	Storage Lost due to Misinterpretation (acre-feet)	Percent Loss of New Storage Purchased
1.0 inch	1262.5	49,050	1262.5	49,050	0	0
1.5 inches	1262.0	51,300	1262.5	49,050	2,250	7%
2.0 inches	1259.0	63,700	1262.0	51,300	12,400	40%
3.0 inches	1257.0	70,300	1259.0	63,700	6,600	21%

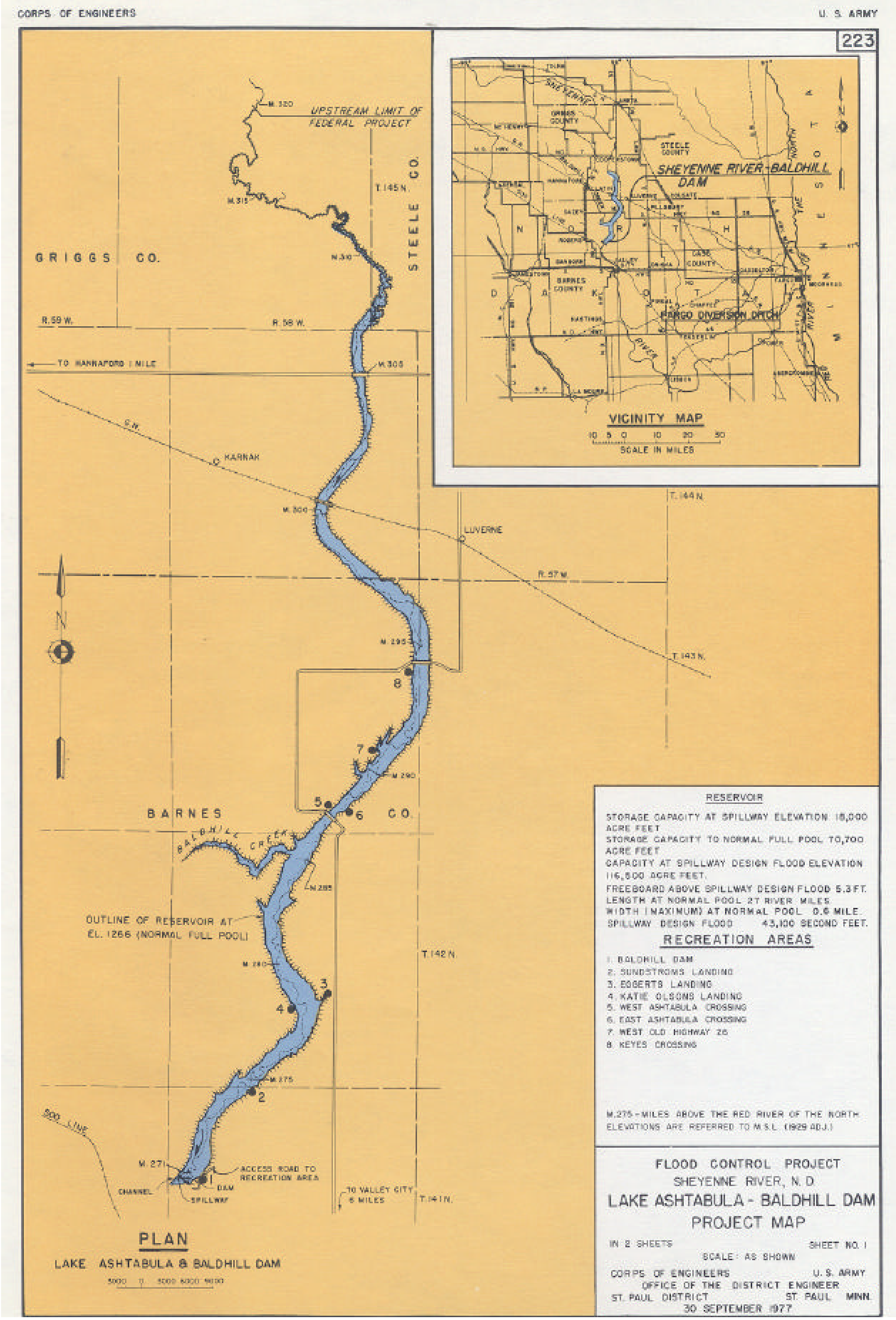
At the March 8th, 2006 Hearing in Valley City, the Corps advised those in attendance that the drawdown schedule in the Original Manual will be used for future operations of Baldhill Dam. Thus the final version of the new operations manual should strictly follow the intent of the drawdown schedule of the Original Manual.

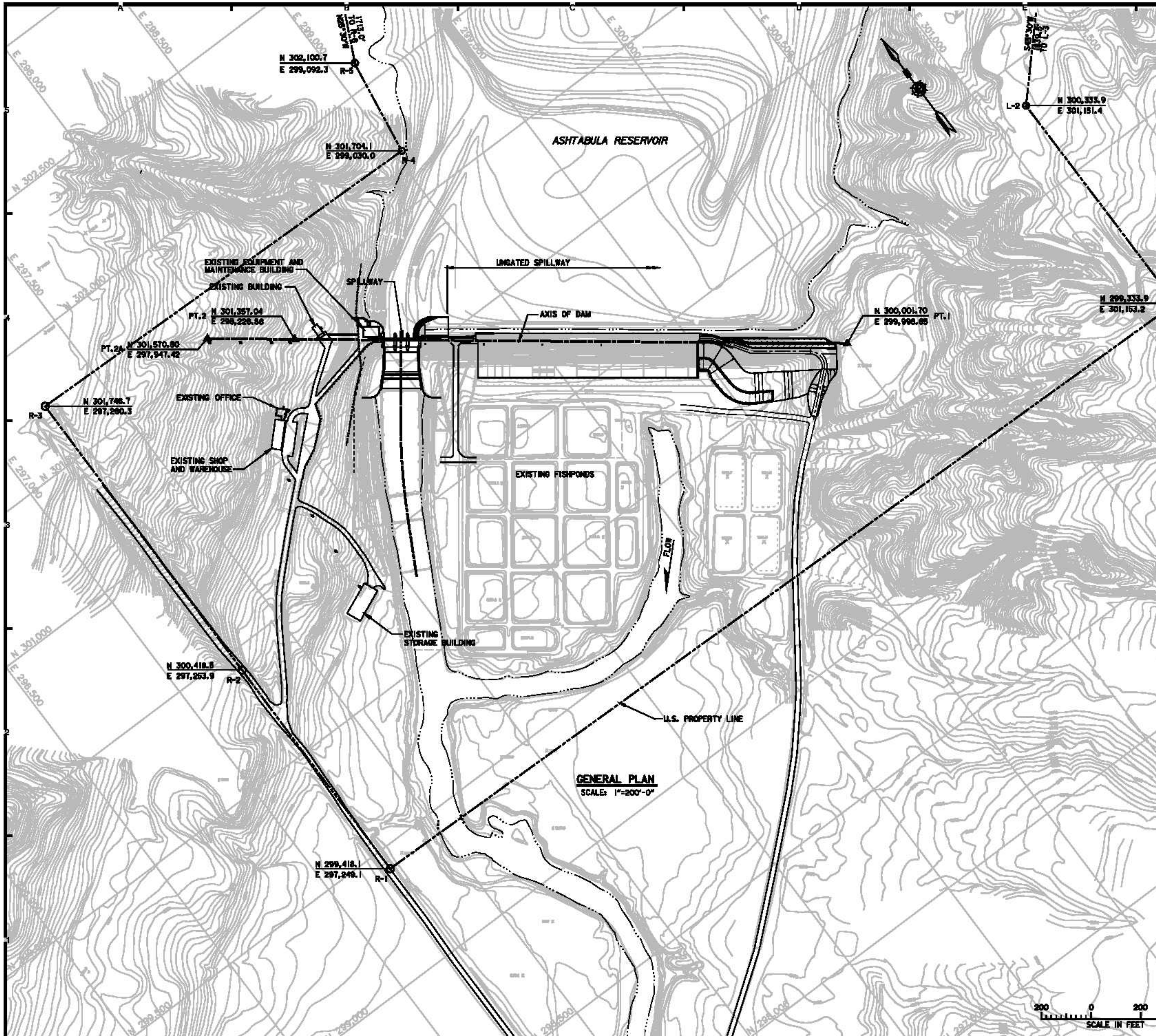
Please feel free to call Jeff Volk or myself at 701-282-4692 to discuss this matter further. It is vitally important to downstream interests that the recommended drawdown schedule of the Original Manual be strictly followed and incorporated into the new operations manual.

Sincerely,

MOORE ENGINEERING, INC.

Chad L. Engels, E.I.T.
Water Resources Engineer


CORPS OF ENGINEERS
U. S. ARMY
223
UPSTREAM LIMIT OF FEDERAL PROJECT
GRIGGS CO.
STEELE CO.
BARNES CO.
BALDHILL CREEK
KARNAK
LUVERNE
TO HANNAFORD 1 MILE
OUTLINE OF RESERVOIR AT EL. 1266 (NORMAL FULL POOL)
ACCESS ROAD TO RECREATION AREA
DAM
SPILLWAY
CHANNEL
TO VALLEY CITY 6 MILES
SHEYENNE RIVER-BALDHILL DAM
FARGO DIVERSION DITCH
VICINITY MAP
SCALE IN MILES
RESERVOIR
STORAGE CAPACITY AT SPILLWAY ELEVATION 18,000 ACRE FEET
STORAGE CAPACITY TO NORMAL FULL POOL 70,700 ACRE FEET
CAPACITY AT SPILLWAY DESIGN FLOOD ELEVATION 116,500 ACRE FEET.
FREEBOARD ABOVE SPILLWAY DESIGN FLOOD 5.3 FT.
LENGTH AT NORMAL POOL 27 RIVER MILES
WIDTH (MAXIMUM) AT NORMAL POOL 0.6 MILE.
SPILLWAY DESIGN FLOOD 43,100 SECOND FEET.
RECREATION AREAS
1. BALDHILL DAM
2. SUNDSTROMS LANDING
3. EGGERTS LANDING
4. KATIE OLSONS LANDING
5. WEST ASHTABULA CROSSING
6. EAST ASHTABULA CROSSING
7. WEST OLD HIGHWAY 26
8. KEYES CROSSING
M.275 - MILES ABOVE THE RED RIVER OF THE NORTH
ELEVATIONS ARE REFERRED TO M.S.L. (1929 ADJ.)
FLOOD CONTROL PROJECT
SHEYENNE RIVER, N. D.
LAKE ASHTABULA - BALDHILL DAM
PROJECT MAP
IN 2 SHEETS
SHEET NO. 1
SCALE: AS SHOWN
CORPS OF ENGINEERS
U. S. ARMY
OFFICE OF THE DISTRICT ENGINEER
ST. PAUL DISTRICT
ST. PAUL MINN.
30 SEPTEMBER 1977
PLAN
LAKE ASHTABULA & BALDHILL DAM



Baldhill Dam and Lake Ashtabula

Water Control Manual

SITE MAP

U.S. Army Corps of Engineers

St. Paul District - St. Paul, MN

GENERAL NOTES:

1. VERTICAL DATUM IS REFERENCED TO N.G.V.D., 1929. CONTOURS ARE SHOWN AT 2 FOOT INTERVALS.
2. TOPOGRAPHY BY PHOTOGRAMMETRIC METHODS FROM AERIAL PHOTOGRAPHS TAKEN IN NOVEMBER, 1985.
3. EXISTING TOPOGRAPHIC GROUND LINES MAY VARY FROM THAT SHOWN ON THE PLANS.
4. REFERENCE POINTS, PT. 1 AND PT. 2, REPRESENT AXIS OF DAM. DATA OBTAINED FROM ST. PAUL DISTRICT CORPS OF ENGINEERS. FIELD NOTES ARE AVAILABLE AT THE ST. PAUL DISTRICT OFFICE.
5. U.S. PROPERTY LINE DATUM FROM REAL ESTATE SHEYENNE RIVER, NORTH DAKOTA BALDHILL RESERVOIR FLOWAGE.
6. WHEN THE TERMS "RIGHT" OR "LEFT" ARE USED, THE VIEWPOINT IS FROM THE UPSTREAM TO DOWNSTREAM DIRECTION.

SYMBOL	DESCRIPTION	DATE	APPROVAL
	AS-BUILT AS OF MAY 2003		

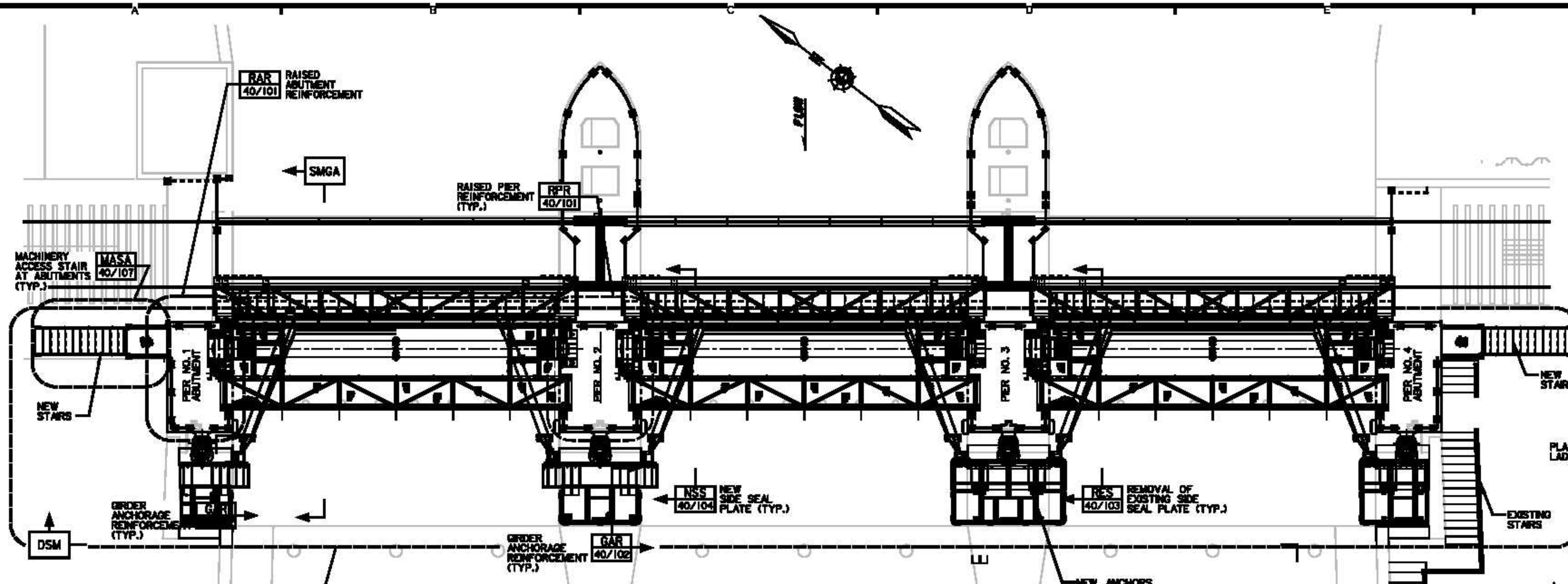
US Army Corps of Engineers
St. Paul District

AE APPROVING OFFICIAL:

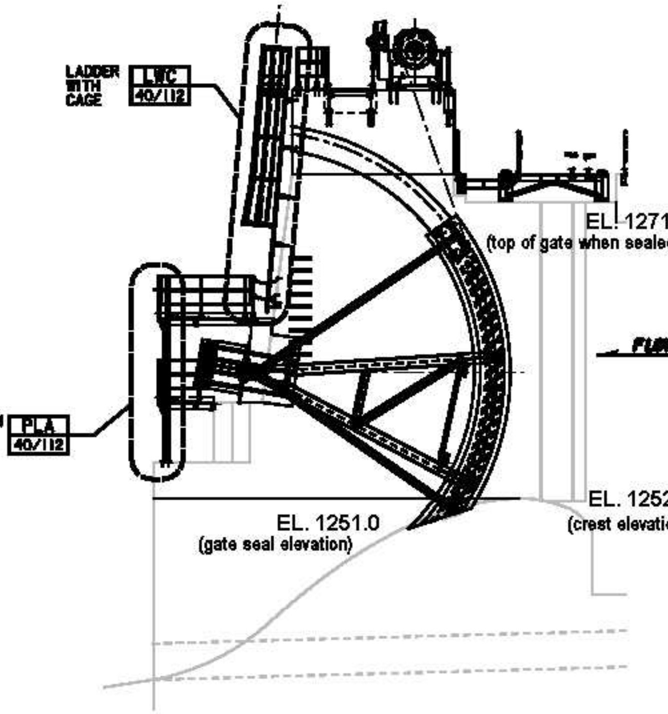
AS-BUILT
BALDHILL DAM POOL RAISE - STAGE 1
FLOOD CONTROL - SHEYENNE RIVER
LAKE ASHTABULA VALLEY CITY, NORTH DAKOTA
GENERAL MAPS
SITE MAP

DESIGNED:	PWS
CHECKED:	RGB
DRAWN:	DGS
DESIGNED:	
CHECKED:	
DATE:	08-31-00

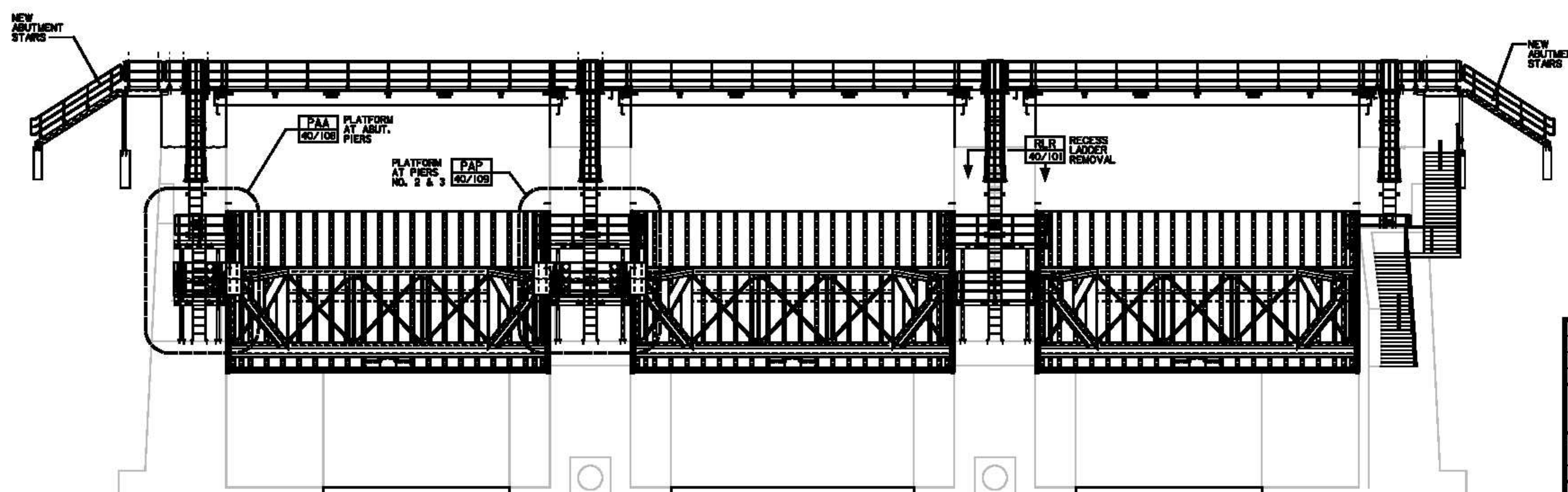
CAD FILE NAME: GA110042.DGN
SOL NO: DACW37-00-B-0005
DRAWING NUMBER: R23-L-BH-10/042
SHT 3 OF 43



PLAN MGA
MASONRY - GEN. ARRANGEMENT 10/043
SCALE: 1/8" = 1'-0"



SECTION SMGA
MASONRY - GEN. ARRANGEMENT
SCALE: 1/8" = 1'-0"



DOWNSTREAM ELEVATION DSM
MASONRY - GEN. ARRANGEMENT
SCALE: 1/8" = 1'-0"

Baldhill Dam and Lake Ashtabula

Water Control Manual

Tainter Gates

U.S. Army Corps of Engineers

St. Paul District - St. Paul, MN

SYMBOL	DESCRIPTION	DATE	APPROVAL
	AS-BUILT AS OF MAY 2003		

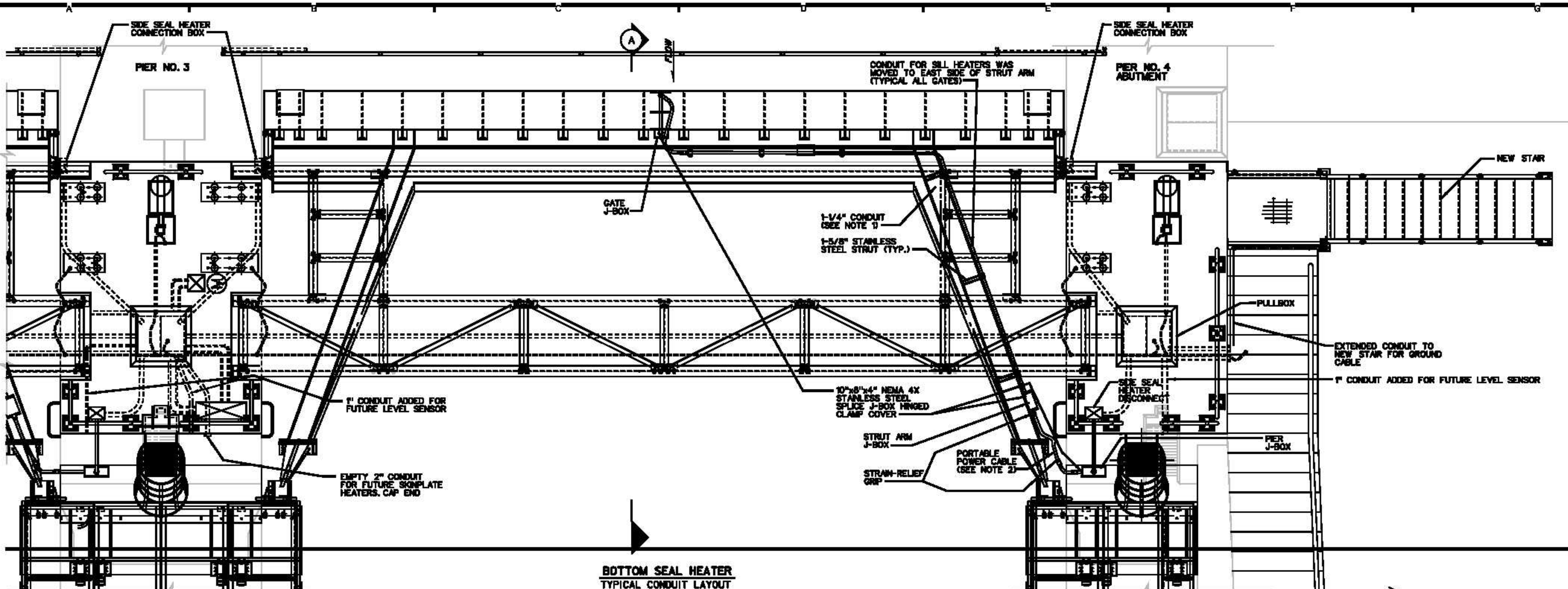
US Army Corps of Engineers
St. Paul District

AE APPROVING OFFICIAL:

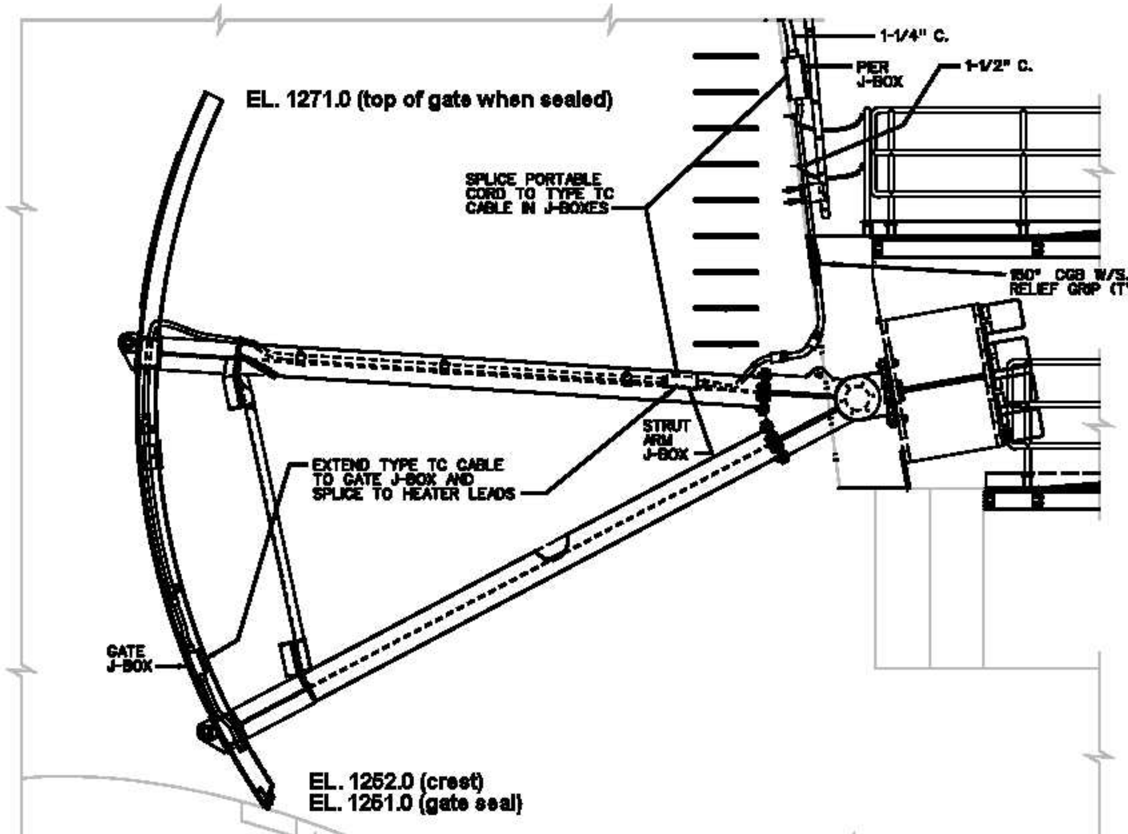
AS-BUILT
BALDHILL DAM POOL RAISE - STAGE 1
FLOOD CONTROL - SHEYENNE RIVER
LAKE ASHTABULA VALLEY CITY, NORTH DAKOTA
DAM MASONRY
GENERAL ARRANGEMENT
PLAN AND DOWNSTREAM ELEVATION

DESIGNED: PWS
CHECKED: TSF
DRAWN: DGS
DESIGNED:
CHECKED:
DATE: 08-31-00

CAD FILE NAME: SA440100.DGN
SOL NO: DACW37-00-B-0005
DRAWING NUMBER: R23-L-BH-40/100
SHT 6 OF 43



BOTTOM SEAL HEATER
TYPICAL CONDUIT LAYOUT
SCALE: 3/8" = 1'-0"



SECTION (A)

NOTES:

1. PROVIDE NEW SIDE AND BOTTOM SEAL HEATER CIRCUITS. EXTEND MCC1-1C (PIER 2), MCC1-2C (PIER3) AND MCC1-3C (PIER4) IN CONDUIT FROM LOAD SIDE OF SIDE SEAL HEATER DISCONNECT TO GATE J-BOX. SEE DRAWINGS 56/024, 56/025 AND 56/026 FOR BOTTOM AND SIDE SEAL HEATER INSTALLATION.
2. PROVIDE 1-4/C-#6 SIEMENS "CORDAFLEX (SM)" PORTABLE POWER CABLE FOR EACH GATE AS SHOWN. PROVIDE CGB FITTINGS WITH STRAIN-RELIEF GRIPS BOTH ENDS. PROVIDE SUFFICIENT SLACK CABLE TO PERMIT GATE TO FREELY OPEN AND CLOSE.

SIEMENS ENERGY & AUTOMATION INC.
POWER CABLES
3333 OLD MILTON PARKWAY
ALPHARETTA, GA. 30202
(770) 751-2417

Baldhill Dam and Lake Ashtabula

Water Control Manual

Tainter Gate

U.S. Army Corps of Engineers

St. Paul District - St. Paul, MN

SCALE: 3/8" = 1'-0"

SYMBOL	DESCRIPTION	DATE	APPROVAL
	AS-BUILT AS OF MAY 2003		

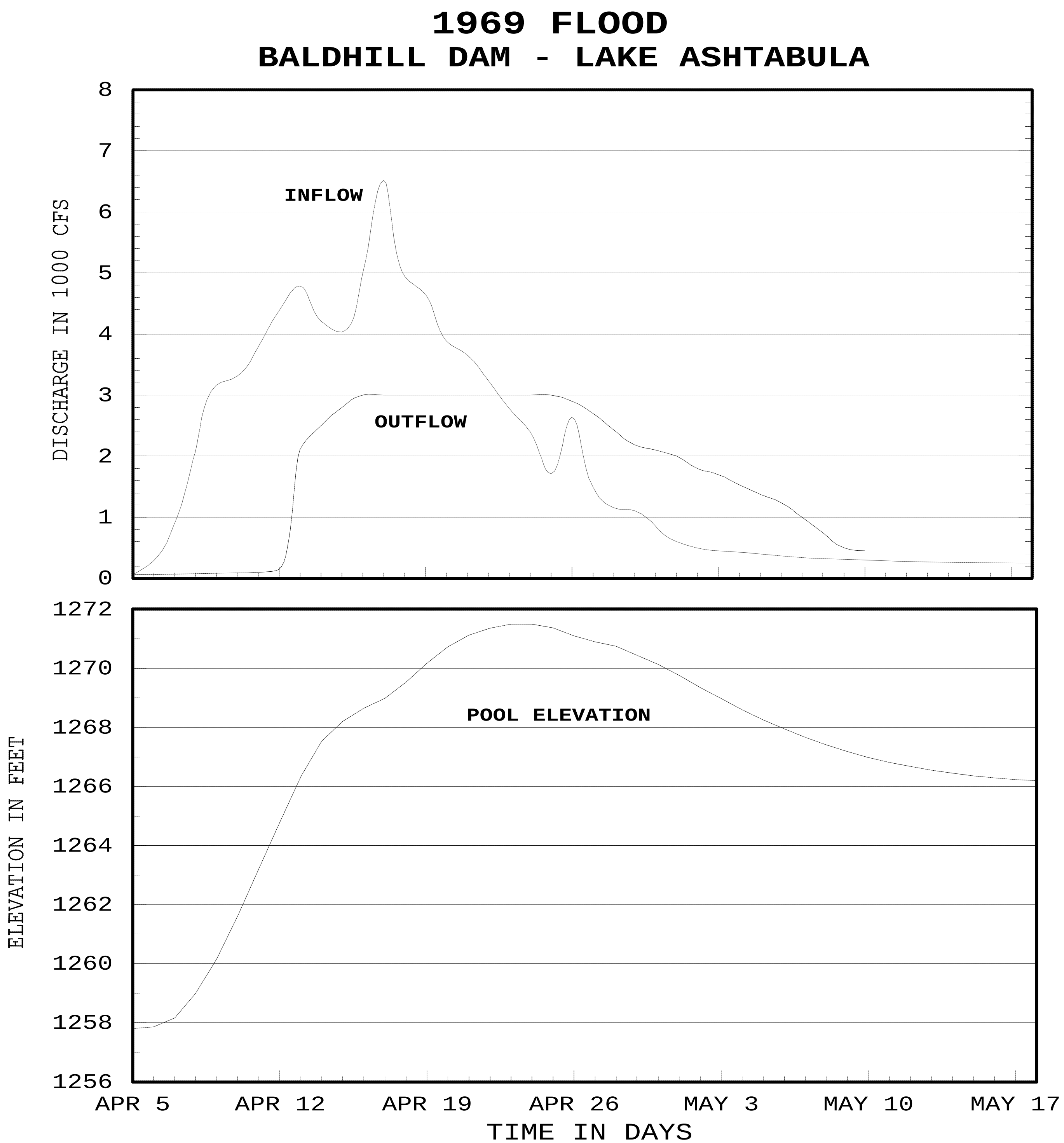
US Army Corps of Engineers
St. Paul District

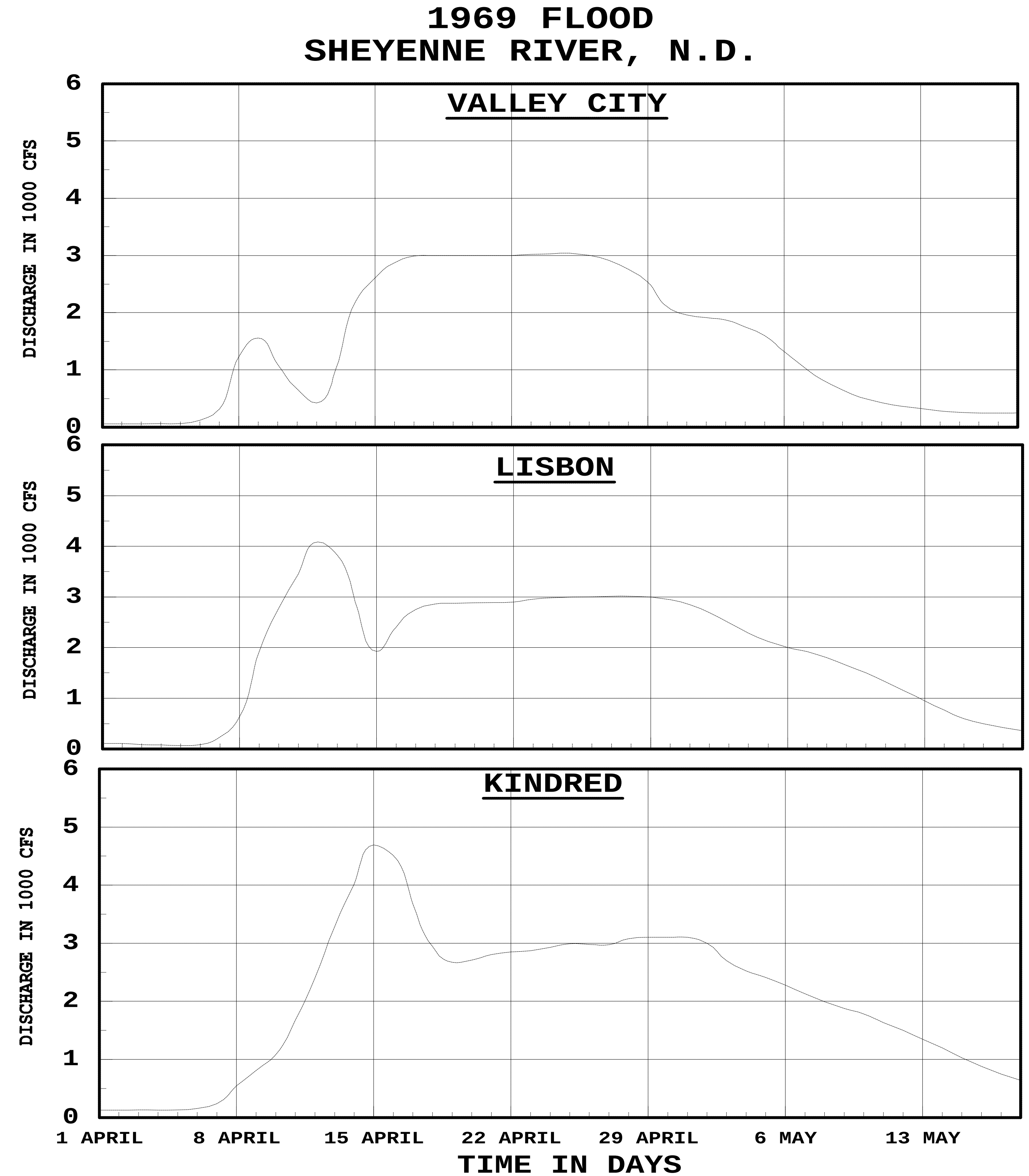
AE APPROVING OFFICIAL:

DESIGNED: BGN
CHECKED: DAV
DRAWN: DGS/FJB
DESIGNED:
CHECKED:
DATE: 08-31-00

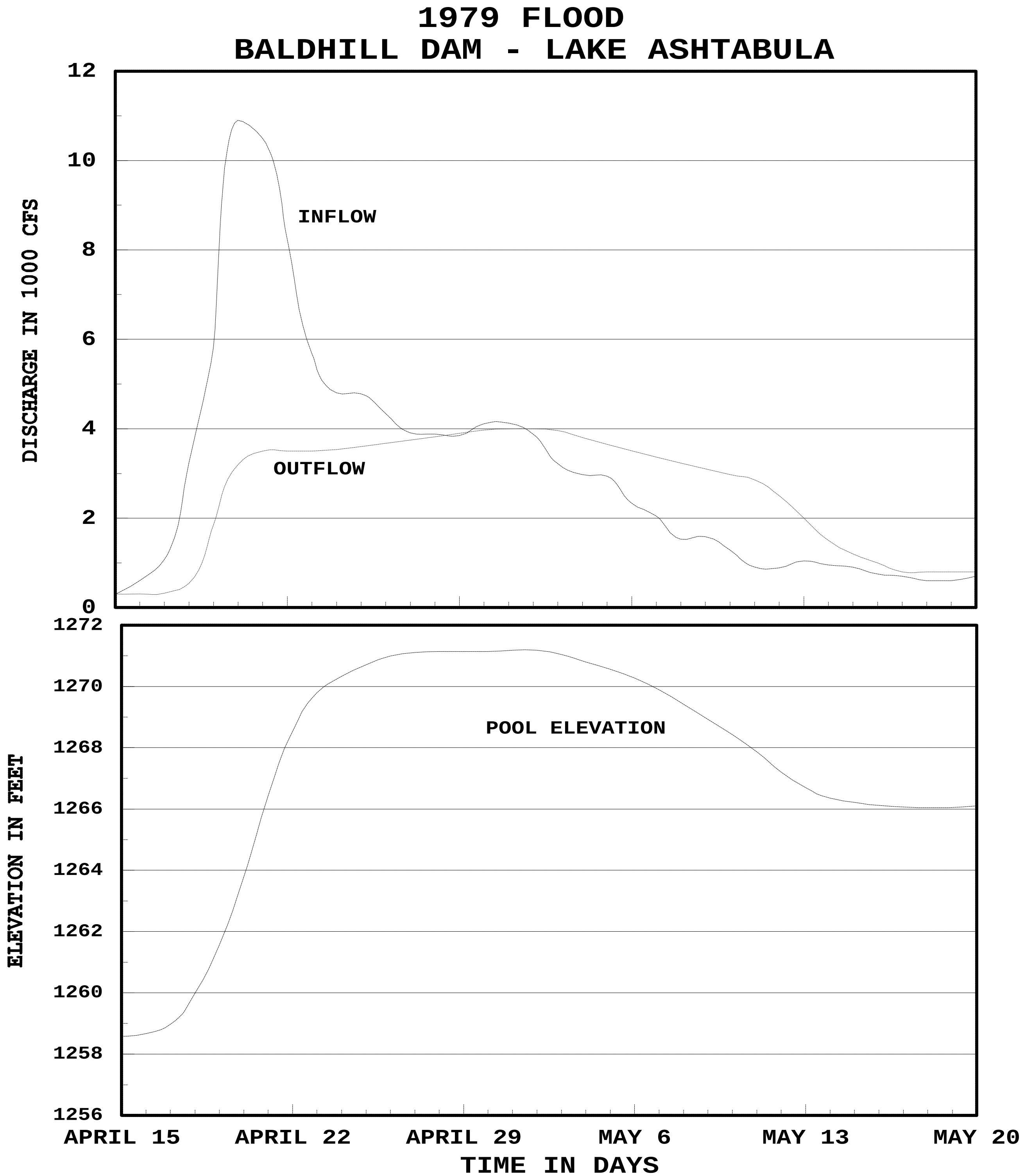
AS-BUILT
BALDHILL DAM POOL RAISE - STAGE 1
FLOOD CONTROL - SHEYENNE RIVER
LAKE ASHTABULA VALLEY CITY, NORTH DAKOTA
DAM ELECTRICAL SYSTEM
BOTTOM SEAL HEATER
CONDUIT LAYOUT

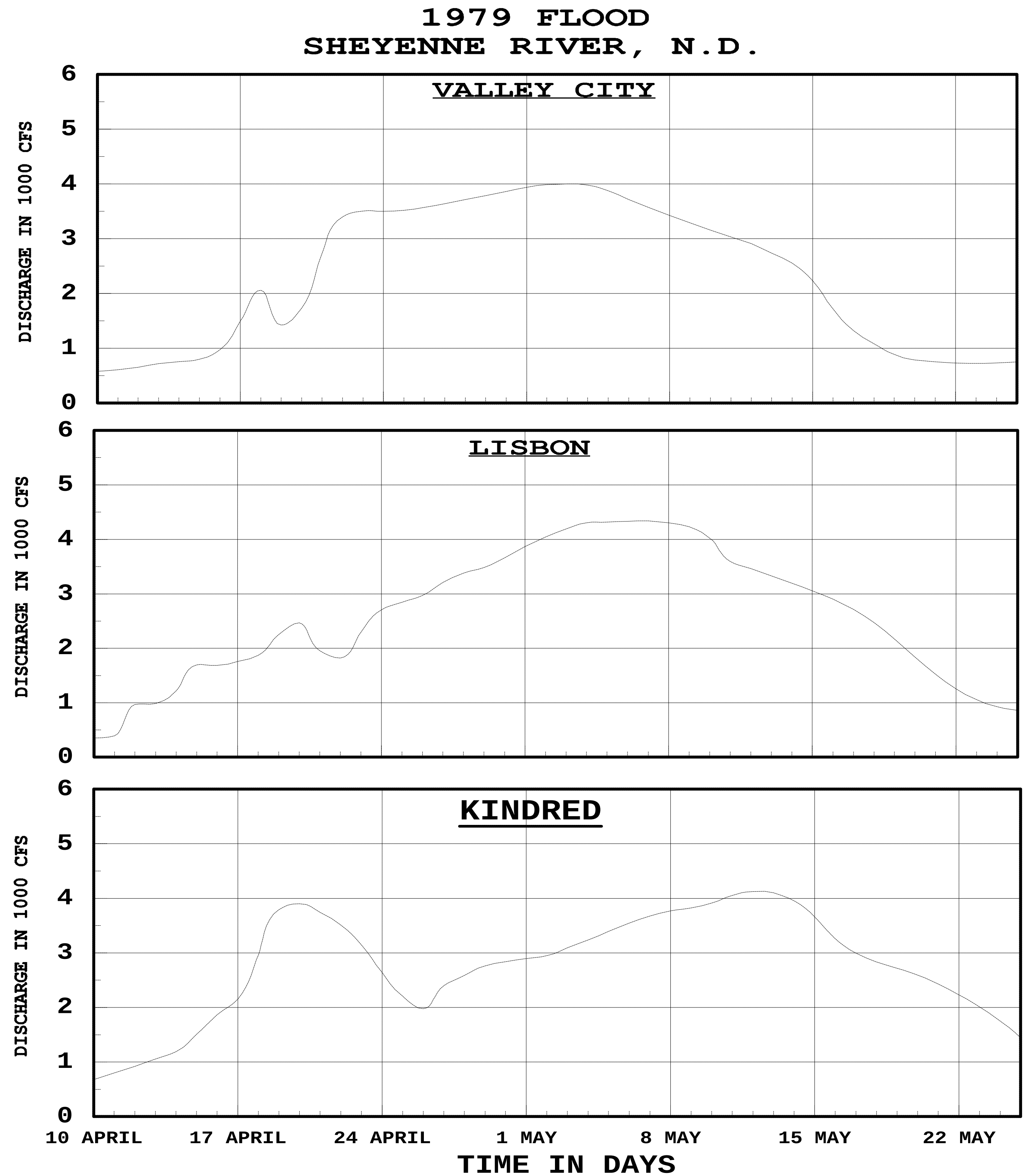
CAD FILE NAME: SA56030.DGN
SOL NO: DACW37-00-B-0005
DRAWING NUMBER: R23-L-BH-56/030
SHT 43 OF 43



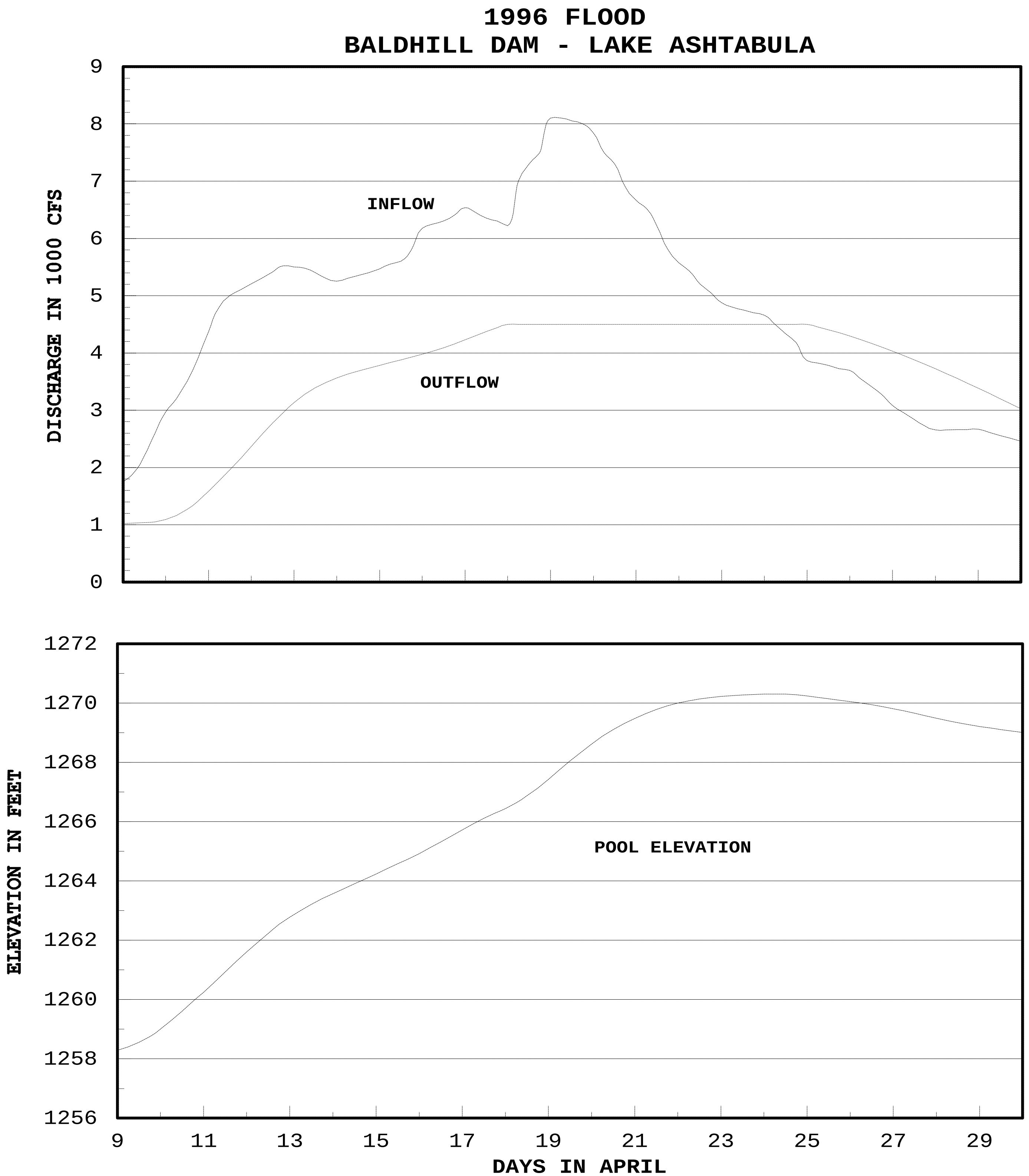


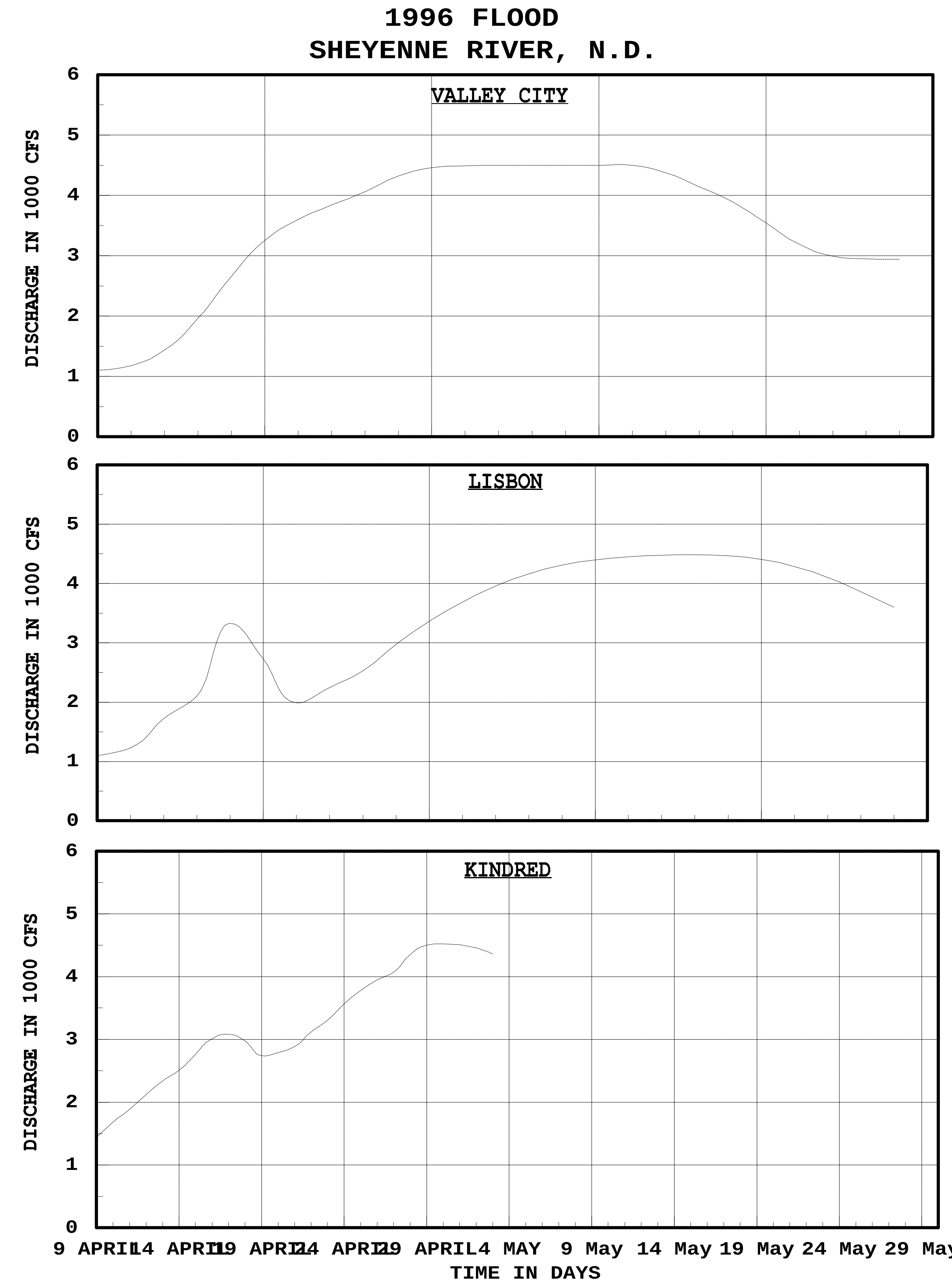
1969 Flood Routed With New Operating Plan



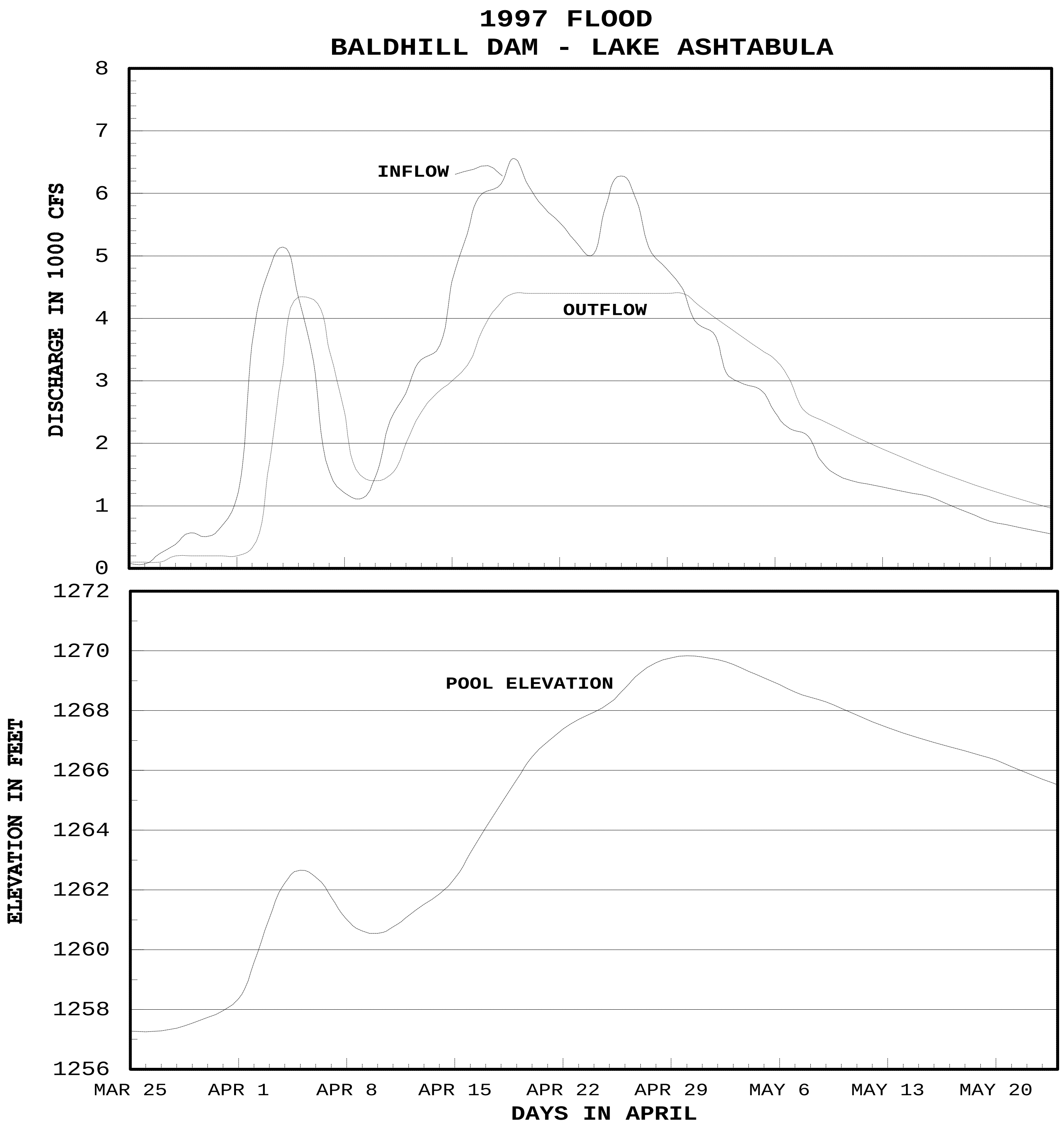


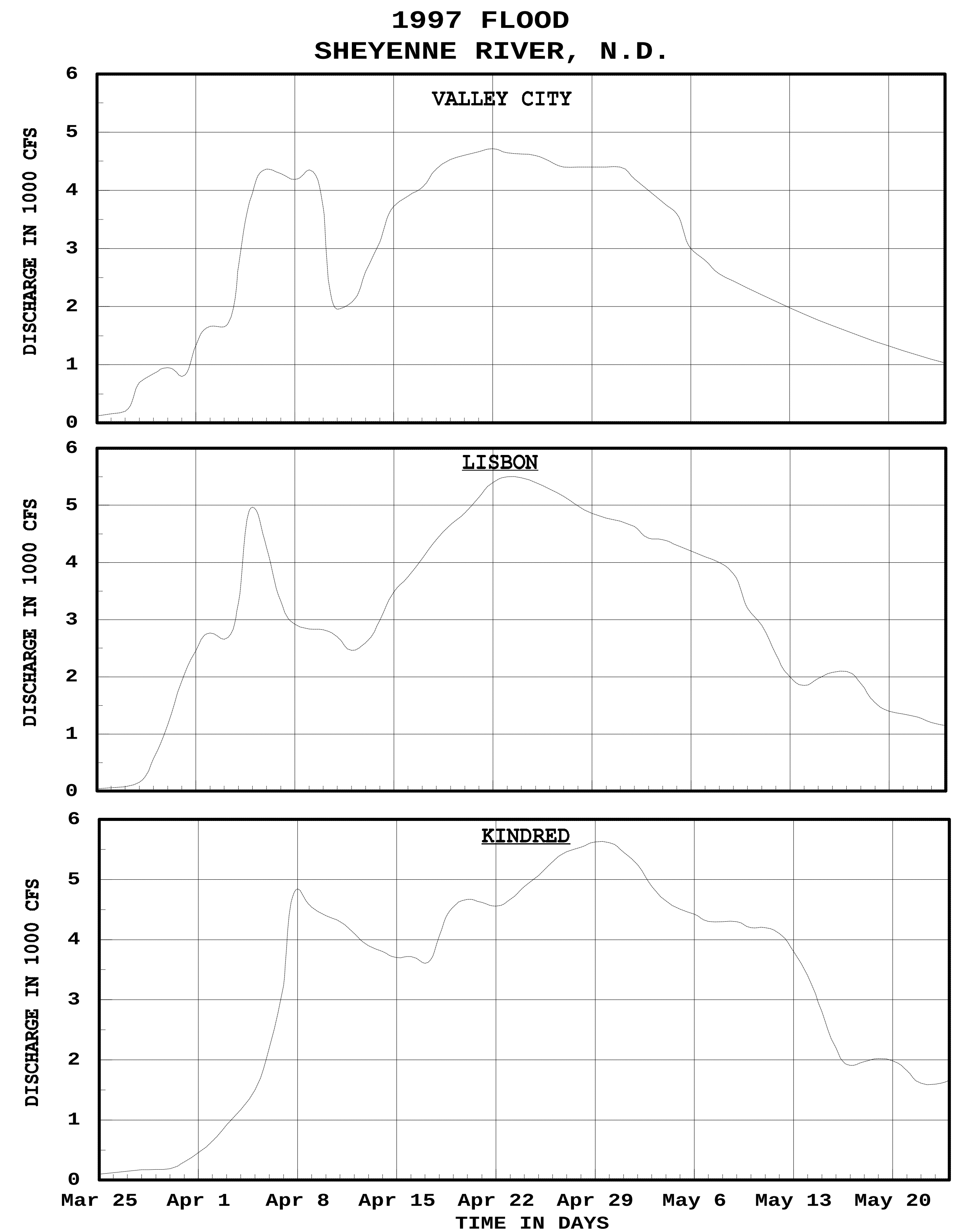
1979 Flood Routed With New Operating Plan



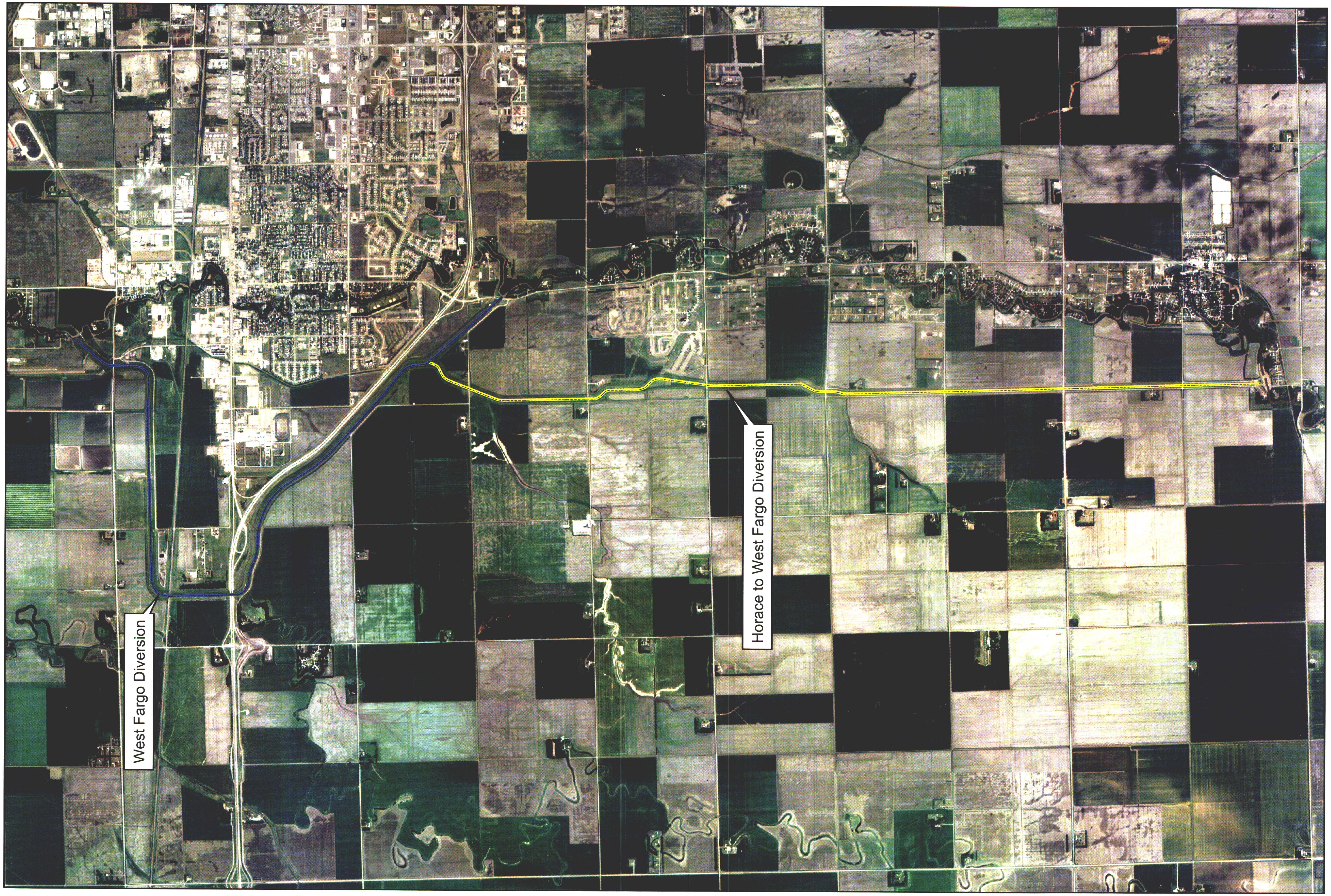


1996 Flood Routed With New Operating Plan





1997 Flood Routed With New Operating Plan

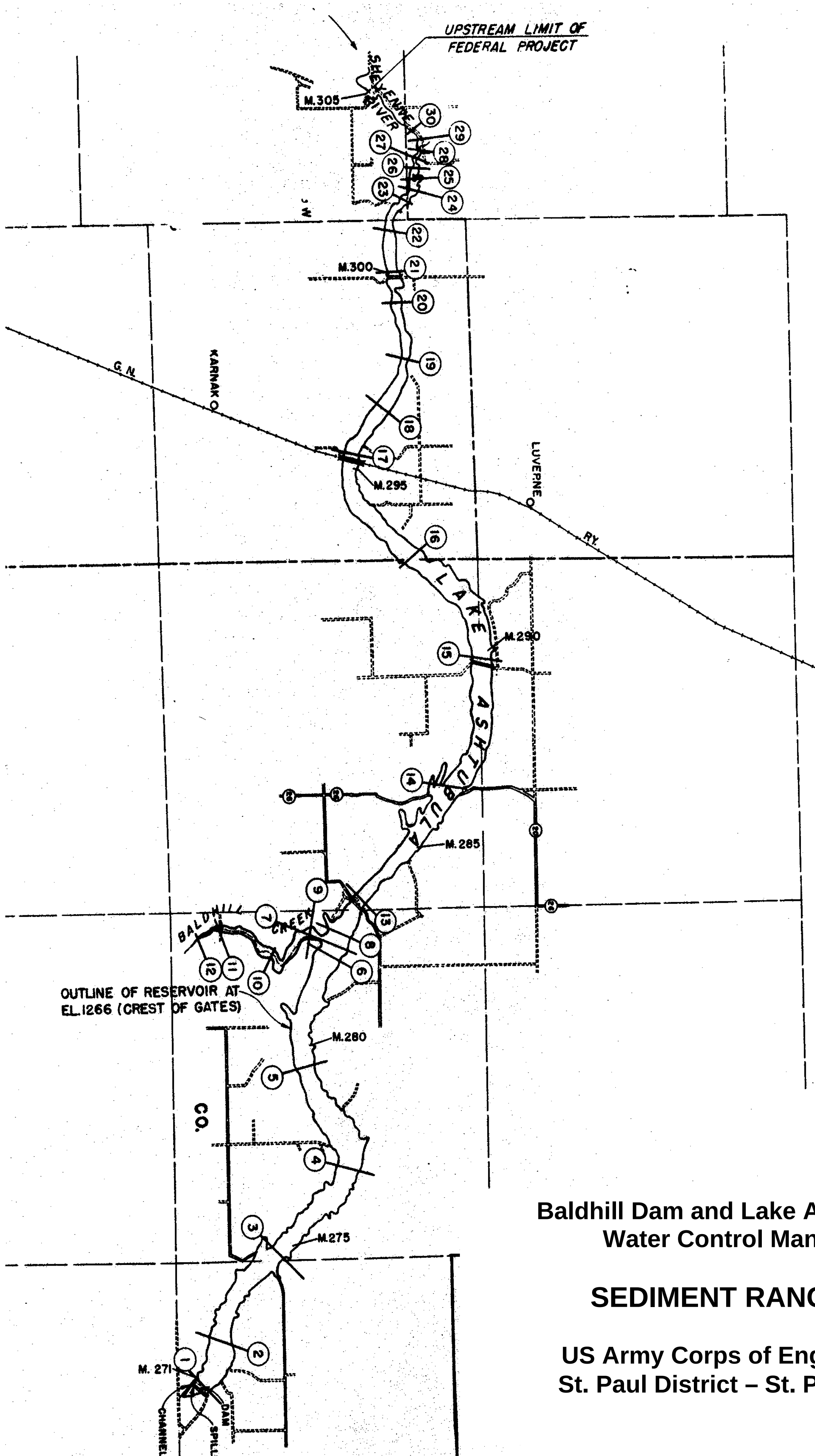


West Fargo Diversion
&
Horace to West Fargo Diversion

Feet
0 4,000 8,000 16,000

St. Paul District
HYDRAULICS
HYDROLOGY
US Army Corps
of Engineers®

PLATE 3-5

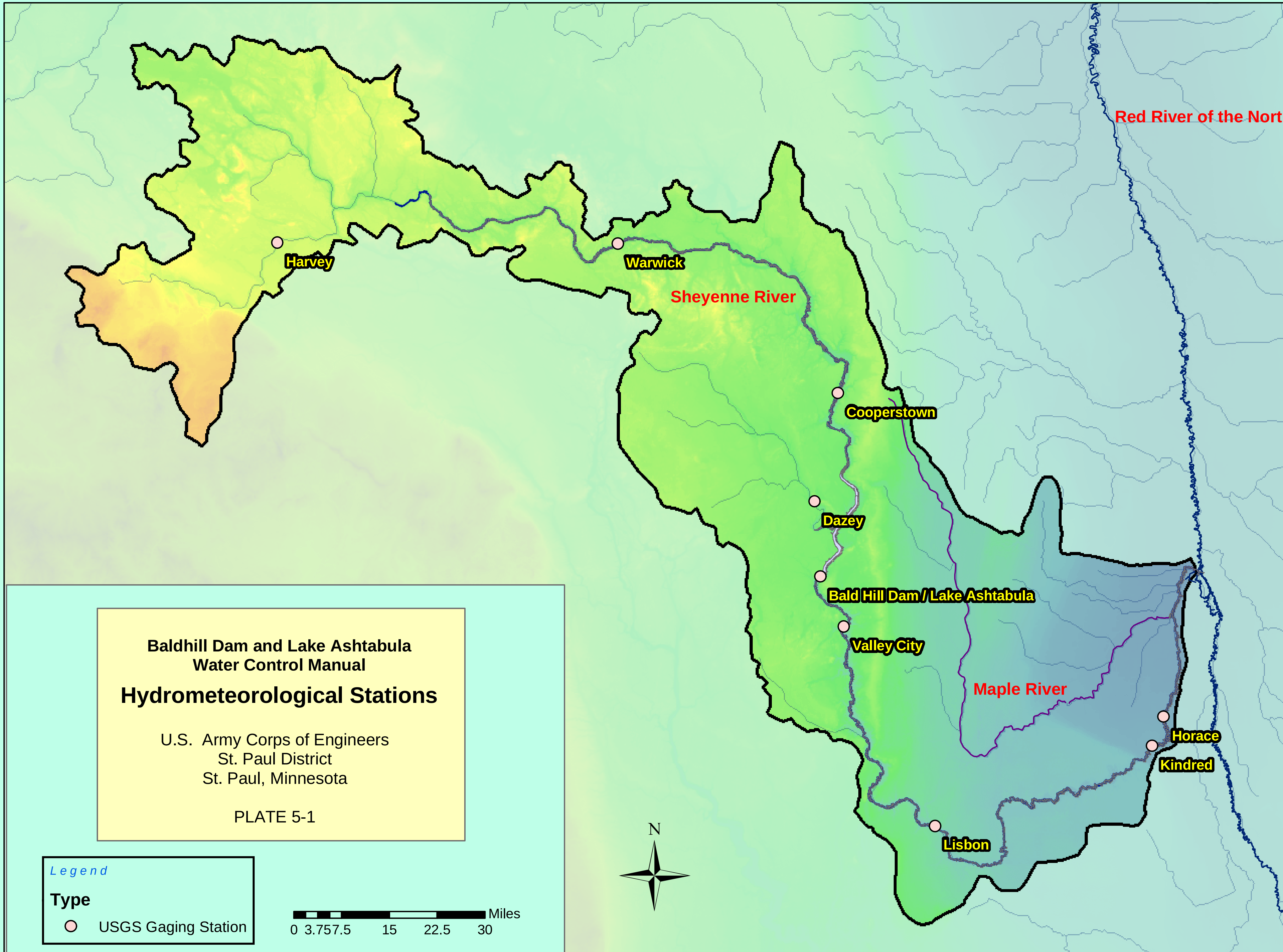


Baldhill Dam and Lake Ashtabula
Water Control Manual

SEDIMENT RANGES

US Army Corps of Engineers
St. Paul District – St. Paul MN

PLATE 4-1



Baldhill Dam and Lake Ashtabula
Water Control Manual

Hydrometeorological Stations

U.S. Army Corps of Engineers
St. Paul District
St. Paul, Minnesota

PLATE 5-1

Baldhill Dam - Lake Ashtabula
Area - Storage Curves

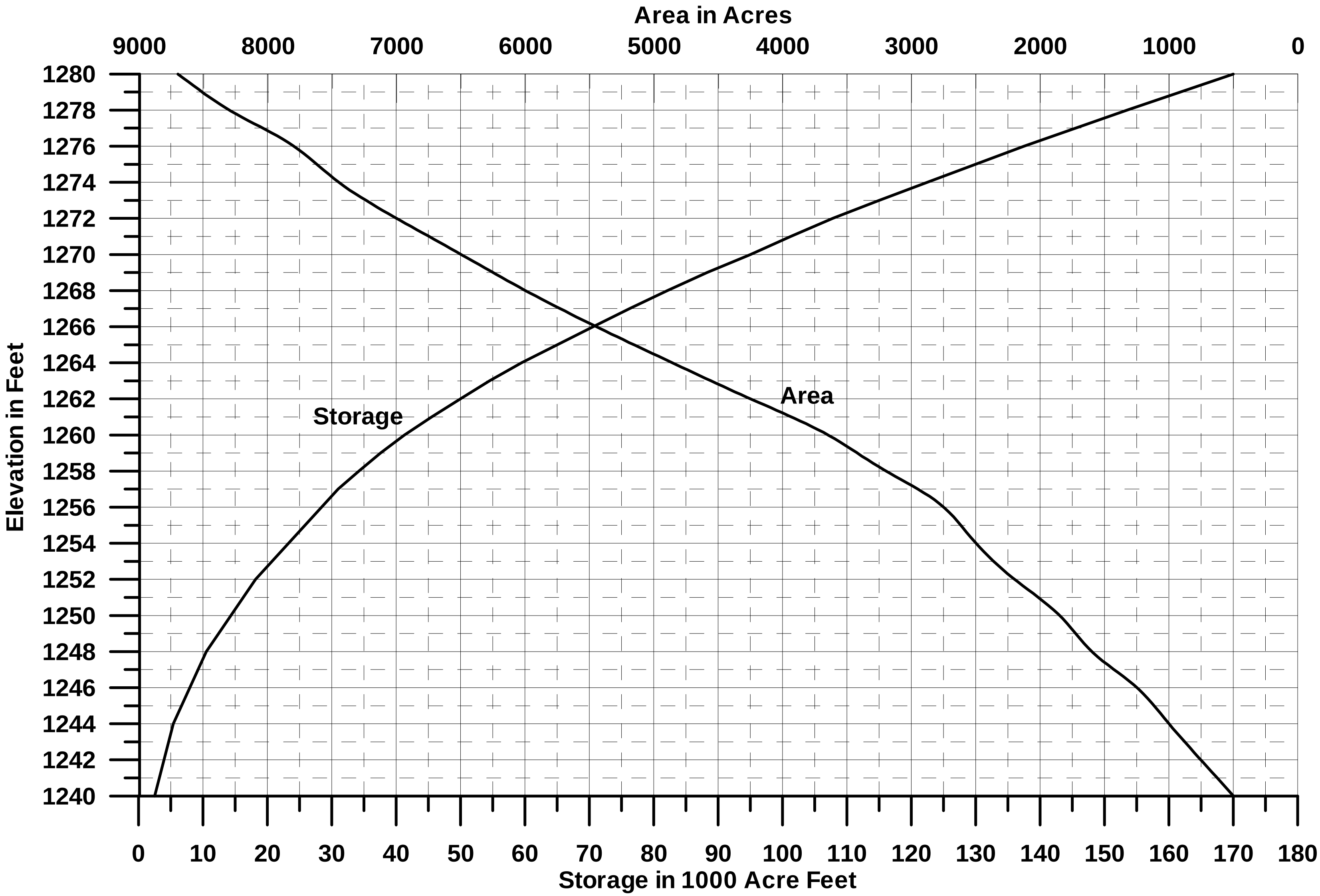
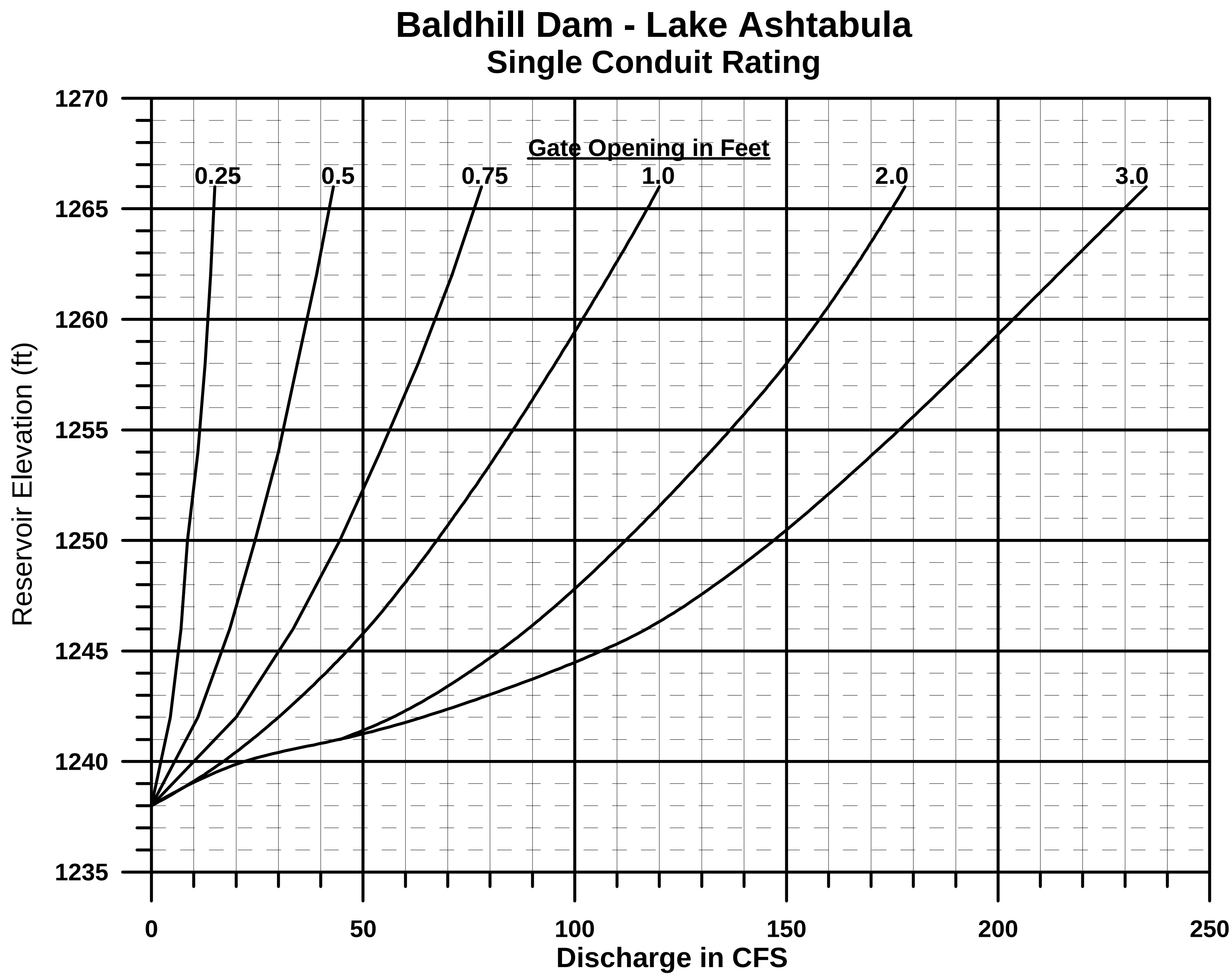


PLATE 7-1



Baldhill Dam - Lake Ashtabula
Single Conduit Rating
Gate Opening in Feet
0.25
0.5
0.75
1.0
2.0
3.0
1270
1265
1260
1255
1250
1245
1240
1235
Reservoir Elevation (ft)
0
50
100
150
200
250
Discharge in CFS

PLATE 7-2

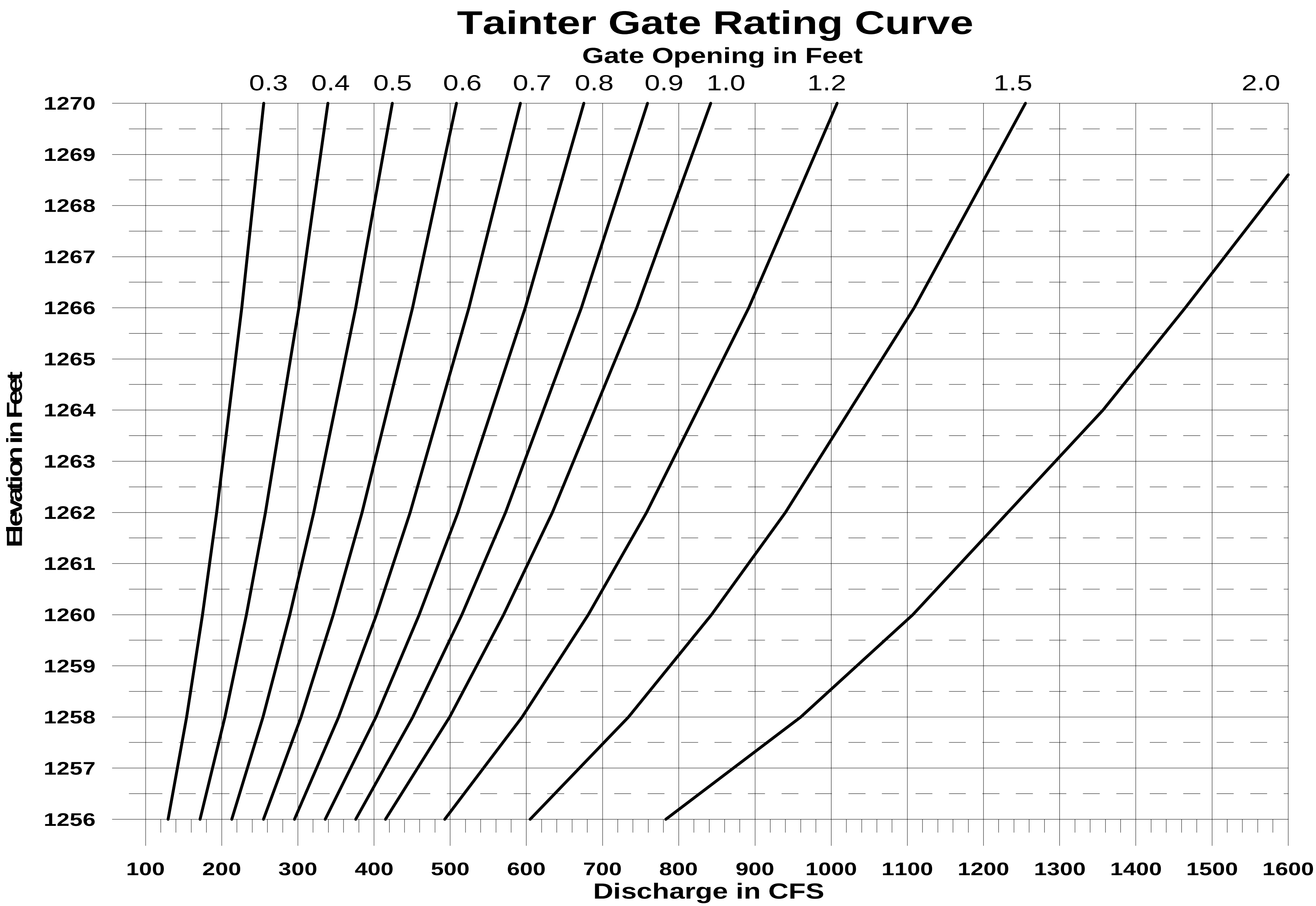

Tainter Gate Rating Curve
Gate Opening in Feet
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.2
1.5
2.0
Elevation in Feet
1270
1269
1268
1267
1266
1265
1264
1263
1262
1261
1260
1259
1258
1257
1256
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
Discharge in CFS

PLATE 7-3

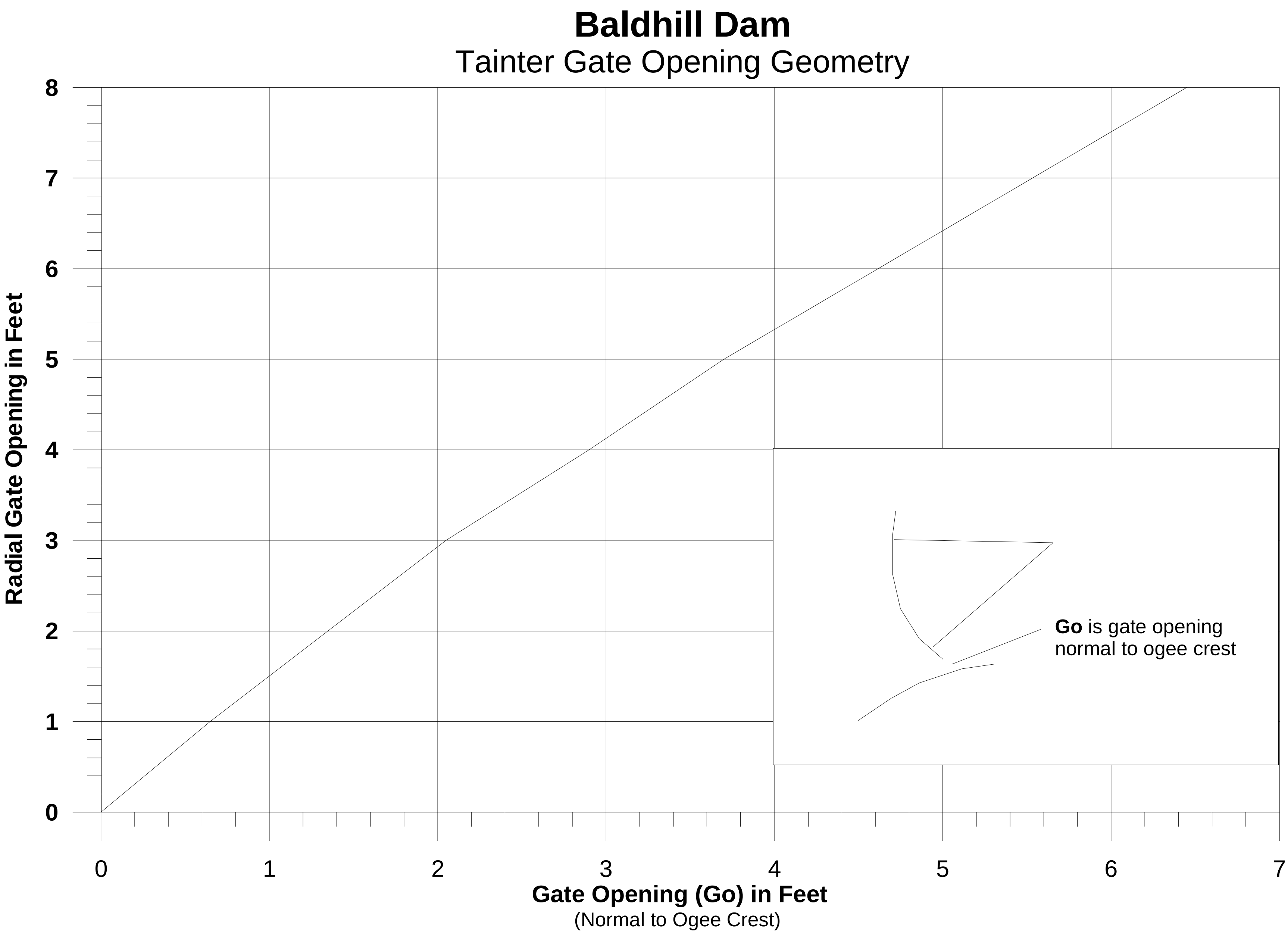

Baldhill Dam
Tainter Gate Opening Geometry
Radial Gate Opening in Feet
0
1
2
3
4
5
6
7
8
0
1
2
3
4
5
6
7
Gate Opening (Go) in Feet
(Normal to Ogee Crest)
Go is gate opening
normal to ogee crest

PLATE 7-4

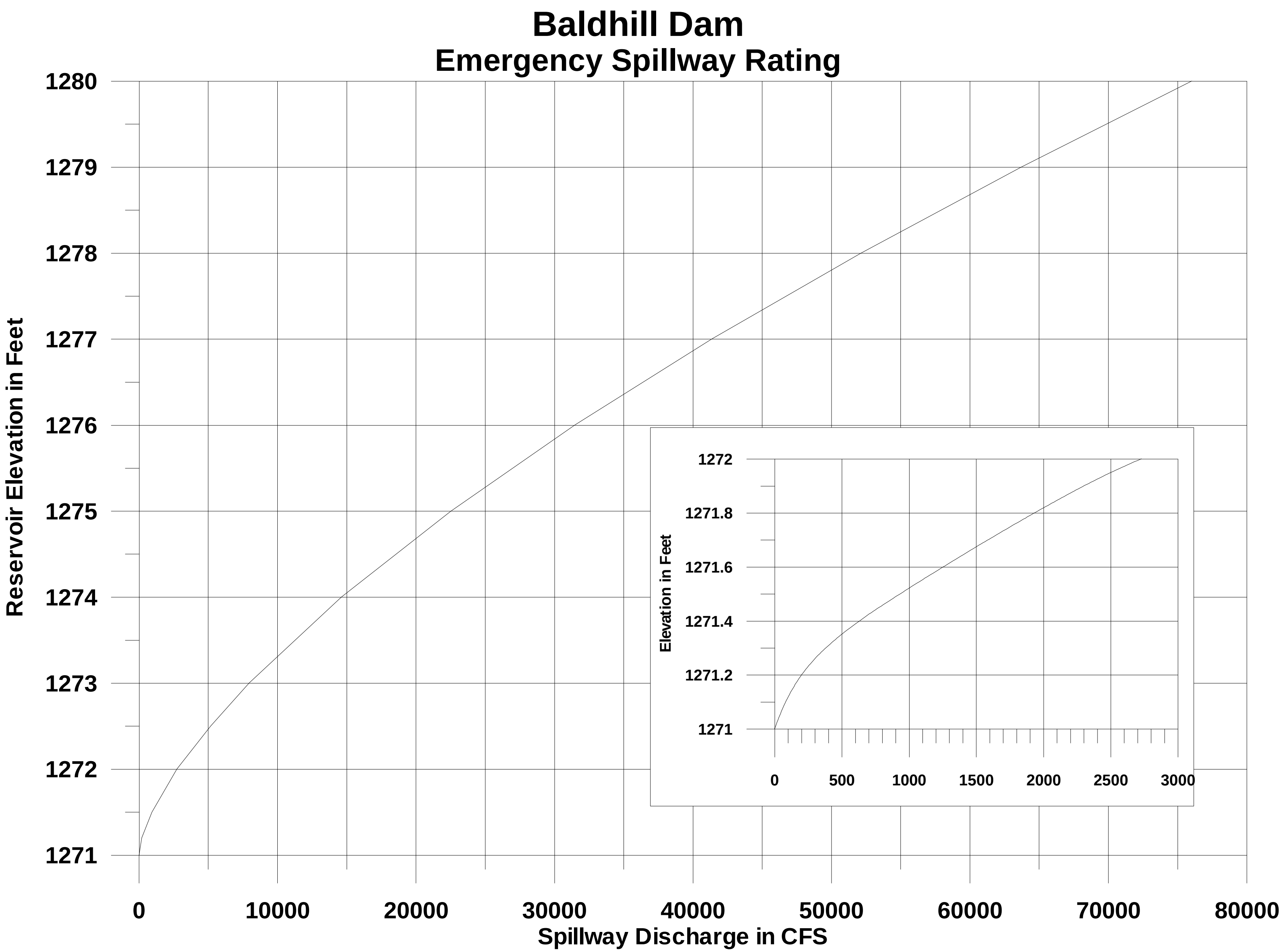

Baldhill Dam
Emergency Spillway Rating
Reservoir Elevation in Feet
1280
1279
1278
1277
1276
1275
1274
1273
1272
1271
0
10000
20000
30000
40000
50000
60000
70000
80000
Spillway Discharge in CFS
Elevation in Feet
1272
1271.8
1271.6
1271.4
1271.2
1271
0
500
1000
1500
2000
2500
3000

PLATE 7-5