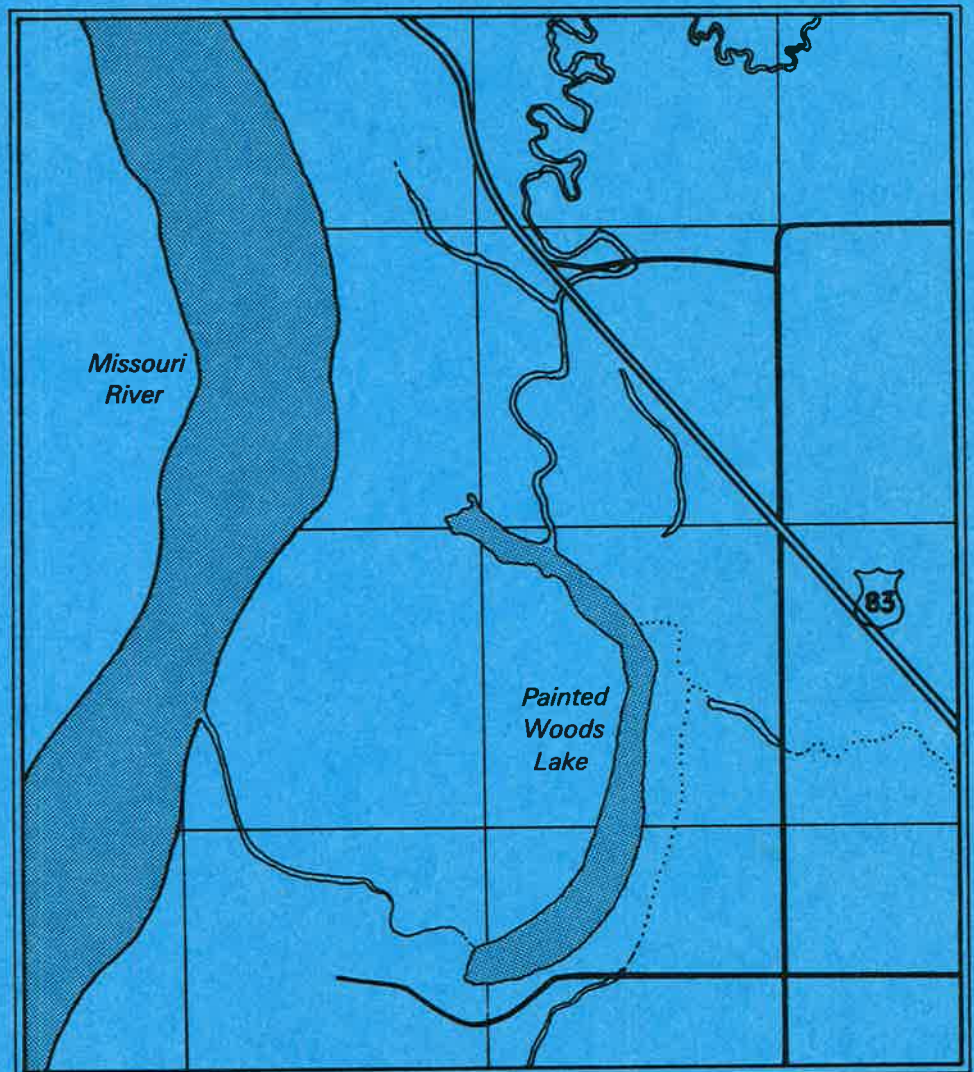


PRELIMINARY ENGINEERING REPORT

PAINTED WOODS LAKE FLOOD CONTROL PROJECT

MC LEAN COUNTY, NORTH DAKOTA

SWC PROJECT NO. 160



NORTH DAKOTA
STATE WATER COMMISSION
MARCH, 1983

PRELIMINARY ENGINEERING REPORT
PAINTED WOODS LAKE FLOOD CONTROL
SWC PROJECT #160

MARCH, 1983

NORTH DAKOTA STATE WATER COMMISSION
900 EAST BOULEVARD
BISMARCK, NORTH DAKOTA 58505

Prepared By:



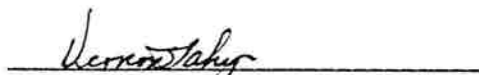
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INDEX TO SUBJECTS

	Page
I. Introduction.....	1
II. Scope of Study.....	3
III. Existing Conditions.....	3-10
IV. Phase One - Merry's Creek Improvements.....	10-11
V. Phase Two and Three - Highwater Outlets.....	11-23
V(a) Phase Two - Fahlgren Overflow.....	14-20
V(b) Phase Three - Carvell Overflow.....	20-23
VI. Summary and Conclusions.....	24-25

INDEX TO FIGURES AND TABLES

	Page
Dike Locations (Figure One).....	2
Flooded Cropland (Figure Two).....	4
Erosion Area (Figure Three).....	5
Painted Woods Lake Hydrology (Table One).....	6
Outlet and Overflow Outlets (Figure Four).....	9
Phase One - Merry's Creek Improvements (Figure Five).....	12
Phase One - Preliminary Cost Estimate (Table Two).....	13
Phase Two - Fahlgren Overflow (Figure Six).....	16
Phase Two - Preliminary Cost Estimates	
Alternative One (Table Three).....	18
Alternative Two (Table Four).....	19
Phase Three - Carvell Overflow (Figure Seven).....	21
Phase Three - Preliminary Cost Estimate (Table Five).....	23

PRELIMINARY INVESTIGATION AND
COST ESTIMATES
PAINTED WOODS LAKE OUTLET IMPROVEMENTS
AND EMERGENCY OVERFLOW

I. INTRODUCTION

In recent years a situation regarding dikes and flooding has developed in the Painted Woods Lake Area. This report will attempt to verify some of the causes and effects of the flooding. From the investigation, alternative solutions have been developed that would limit the extent of flooding and damage which occur during a range of hydrological events.

One reason flooding has increased over the past few years is due to a gradual change in climatic conditions, such as increased precipitation and more rapid snowmelts which have resulted in extremely large flows on Painted Woods Creek. Some of the increased flooding on smaller events can be attributed to man-made conditions but the larger floods have resulted directly from natural events.

To put certain items into perspective, the dikes along the west side of Painted Woods Lake were first permitted and constructed in 1957, to an elevation of 1660 m.s.l. as part of an irrigation project. Due to needed repairs, they were reconstructed in 1975 and limited by court stipulation to elevation 1660 m.s.l. The location of these dikes are as shown on Figure One. A roadway which acts as a dike was constructed near the area where the lake outlets into Merry's Creek and the land west of the roadway was leveled (SCS Project) for farming. Another dike has also been constructed west of this area. The roadway forces overflow from the lake into Merry's Creek at one location instead of allowing the water to spread out and enter the creek in a number of locations. However, because the roadway and dike west of the roadway were overtopped in 1979 and 1982, they appear to have had very little effect on those floods.

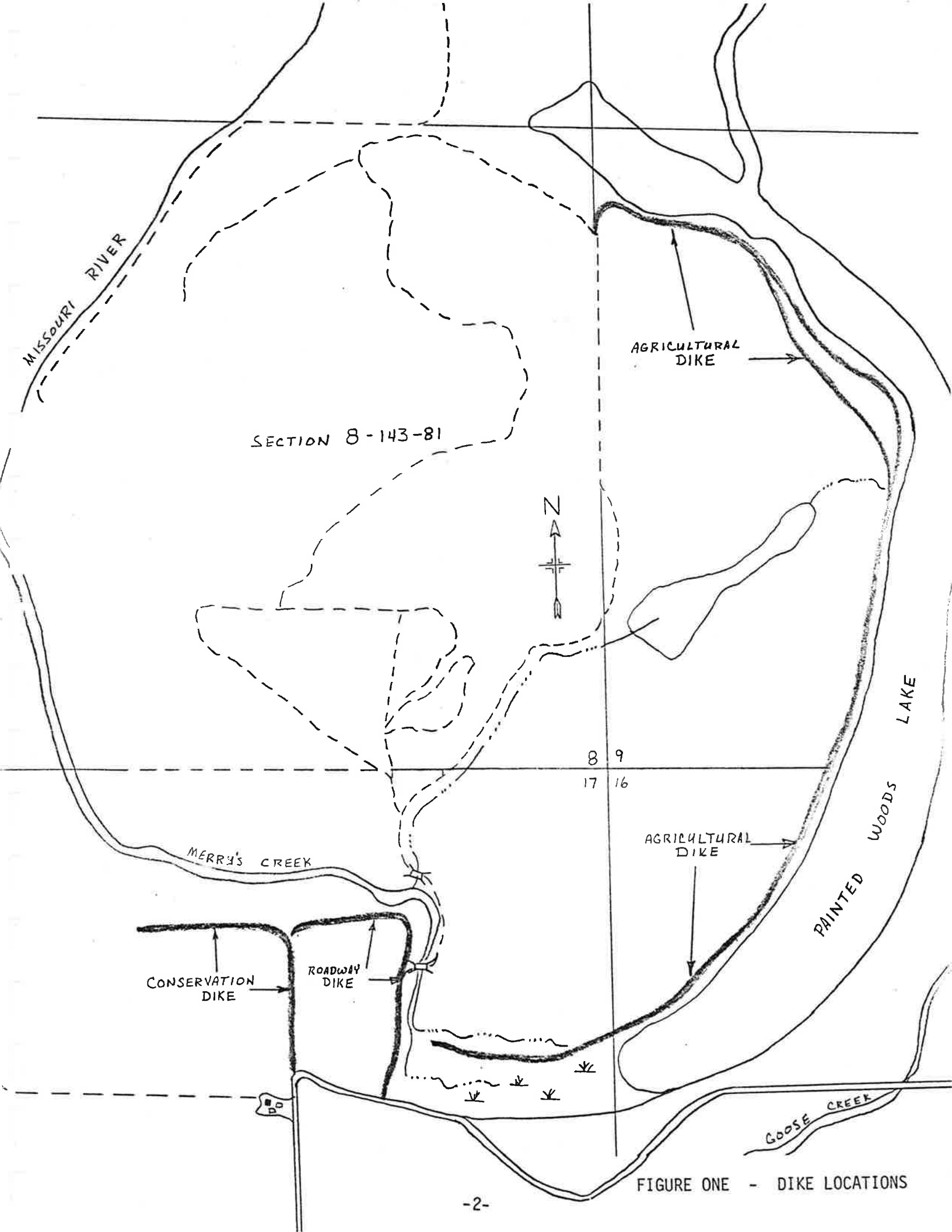


FIGURE ONE - DIKE LOCATIONS

II. SCOPE OF STUDY

This investigation includes a review of the information in the State Water Commission files on Painted Woods Creek and Painted Woods Lake. From this information, proposals have been developed that, if implemented, will alleviate flooding in the Painted Woods Lake area. This report will evaluate existing conditions and develop preliminary cost estimates for the proposals as outlined.

The most commonly provided protection for agricultural land in North Dakota is based on a 10-year frequency event. In view of the amount of flooding and damages which have occurred, however, the proposed flood control measures are designed for a 25-year event with limited flooding. The amount of protection and provisions for local access should be evaluated with further studies and development of a flood control plan.



III. EXISTING CONDITIONS

The conditions which have existed in the Painted Woods Lake area are the result of a wide range of events. The past decade has been one of above normal precipitation and delays in spring snowmelt temperatures have caused an increase in spring runoff and subsequent flooding. In addition, releases by the Bureau of Reclamation from the McClusky Canal have increased the flows to the lake. The resulting floods have caused damages to both cropland and developed real estate within the Painted Woods Lake area. The primary locations of flood damages are shown on Figures Two and Three.

Concerns have been expressed about the dikes along the west side of the lake and near the outlet. This investigation has concluded that these dikes are not the primary cause of flooding during such large hydrologic events as



FIGURE TWO - FLOODED CROPLAND

-  MAJOR FLOOD
-  MINOR FLOOD

EROSION DAMAGE

TYPICAL SECTION

(No Scale)

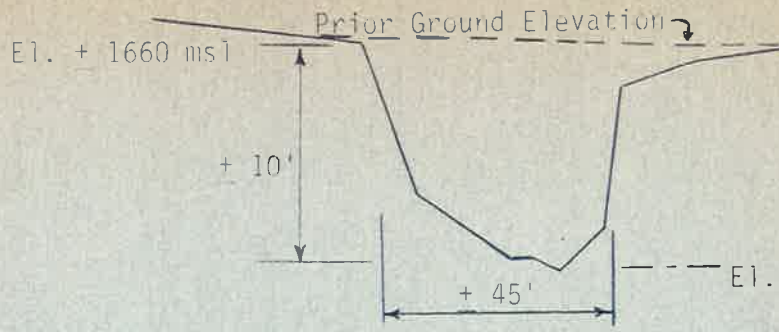


FIGURE THREE

EROSION

those which occurred in 1979 and 1982. These dikes do, however, have an effect during smaller hydrologic events. The areas to the northwest and west of the lake, as shown on Figure Two (Minor Floods), are lower in elevation than the top of the dikes. This combined with the limited storage and outlet capacity cause backwaters to flood these areas on small hydrological events. Once the dikes are overtopped, however, they have very little effect on flooding in these areas. The limited capacity and flat gradient of Painted Woods Creek just upstream of the lake is also a cause of flooding.

Painted Woods Creek, which feeds into the Painted Woods Lake, has a total contributing watershed of approximately 285 square miles. The resulting flows into the lake for specific hydrological events are given in Table One. These flows were developed from a TR-20 Hydrologic Model Study completed by this office in 1979 and updated for this report.

TABLE - ONE

PAINTED WOODS CREEK FLOWS

Location	Drainage Area	10 Year cfs	25 Year cfs	50 Year cfs	100 Year cfs
Stream Gage	170	1400	2870	3970	4900
Lost Lake Area	235	1550	3200	4450	5180
Highway 83	270	1770	3550	5000	6300
Painted Woods Lake	283	1800	3600	5080	6360

The primary outlet for Painted Woods Lake, Merry's Creek, has a present capacity, as determined from this study, of approximately 800 c.f.s. flowing

full. When compared with inflows, it can be seen that the limited capacity of Merry's Creek is a major cause of flooding. Even the inflows for the 10-year event far exceed the maximum outflow capacity.

It should be noted that the roadway and dikes located near the beginning of Merry's Creek (at the lake outlet) have had an effect on the capacity of this outlet; however, their effects during large events have been minimal since the dikes are overtopped and floodwaters reach Merry's Creek in several different areas.

To illustrate the resulting problem, an evaluation of the 10-year flood inflow of approximately 1800 cfs can be made. During this event, water is flowing into the lake at a rate faster than it can be discharged. Using a controlled lake elevation of 1657 m.s.l., the lake has a storage capacity of 500 acre-feet to the top of the dikes at elevation 1660 m.s.l. During the period of inflow before the peak, the total volume of water reaching the lake exceeds 5000 acre-feet. Thus the volume of storage fills rapidly, and the dikes are overtopped.

Including the available storage behind the dikes in the inner lake area, the total storage is increased to about 1500 acre-feet. The area to the northwest of Painted Woods Lake which floods from backwater from Painted Woods Creek prior to elevation 1660 m.s.l. would, therefore, be flooded during major events even without the dikes. Flooding can occur, however, during small events because of the dikes and the limited capacity and flat gradient of Painted Woods Creek. The removal of the dikes would increase the available storage of the lake, and will increase the lake outlet capacity. Even with the increased storage however, Merry's Creek is still not capable of removing the water from the lake fast enough to prevent flooding during major events.

The result of large flows into the lake is an increase in the water level in the lake and the backwater flooding of lands to the north and west of Painted Woods Lake. As the lake level continues to rise, the water eventually finds a path to the Missouri River through one or more highwater outlets. In reviewing the topography of the area from maps and photos dating back to the 1930's, two highwater outlets appear to exist from Painted Woods Lake as shown on Figure Four. These areas were considered for the location of possible floodways since they provide the most economical path for the removal of flood waters.

Information available shows that prior to recent flooding and erosion of the northwestern outlet, that both the west and northwest outlets had approximately the same overflow elevation of around 1661.4 m.s.l. Because of the recent flooding, the northwest outlet has been extensively eroded, lowering the overflow elevation to 1659.8 m.s.l. This will cause an increased use on smaller events and the potential for further erosion damages.

One problem which may have caused the increase in flows to the north was an ice jam which occurred during the spring of 1979, in Painted Woods Creek, just south of Highway 83. This would have caused the incoming flows to backup to the northwest via the old Turtle Creek riverbed, then through a field drain to a culvert under a roadway adjacent the Missouri River. The road was washed out and the resulting erosion created a washout approximately 1500 feet in length averaging 12 feet deep (Figure Three). The highwater overflow located just west of the lake, and downstream from the ice jam, was not affected.

Considering the existing situation and the probable cost of a complete flood control system, the project was broken into three phases, each of which is capable of providing a certain degree of flood protection. Phase One would



FIGURE FOUR

CARVELL OVERFLOW
 FAHLGREN OVERFLOW
 MERRYS CREEK OUTLET

be improvements to the existing outlet known as Merry's Creek and will provide for increased control and removal of low flows. Phase Two is the construction of a floodway from the north end of the lake west to the Missouri River known as the Fahlgren overflow and will provide for increased flood protection for the 10 to 25 year events. Third Phase is the construction of a second floodway through the northwest or Carvell overflow. Phase Three could also be used instead of the Phase Two floodway in combination with Phase One to provide protection between the 10 and 25 year events. Though the overall benefits would be less. Phase Three could also be combined with both Phase One and Phase Two for protection greater than the 25-year event.

IV. PHASE ONE - MERRY'S CREEK IMPROVEMENTS

The first and primary location for flood control improvements is the Merry's Creek outlet. These improvements include increasing the capacity of the outlet by deepening and widening the middle portions of the natural channel, between the lake and the Missouri River, construction of a sheet pile weir control structure, and a control channel from the proposed weir to an open water portion of the lake to provide unrestricted flows to the weir. An illustration and location of such improvements are shown on Figure Five. Along with these improvements, modifications to the existing dike systems could also be made to allow for better control during times of high water.

Under present conditions, erosion from Merry's Creek back into the lake will eventually result in the complete draining and loss of Painted Woods Lake. The Bureau of Reclamation's releases appear to have increased the erosion problem. The primary reason for the weir, is to regulate the flows into Merry's Creek at a given lake elevation and prevent the complete loss of the lake.

The present condition of Merry's Creek is very poor. The side slopes are very steep and highly susceptible to erosion, which has become very serious in

some areas. The velocities in the channel are in excess of 3 feet per second causing an increased probability of continued erosion on the open soils. The capacity of the bridge which crosses the creek was also of some concern; however, the placement of the weir downstream from the bridge, and the proposed control channel, provide the most effective location for these improvements. Other locations were considered but were found to be less adequate for controlling releases from the lake.

Potential improvements to Merry's Creek are limited due to the inaccessibility to certain areas along the creek, and because of ice jams which prevent flows from reaching the Missouri River.

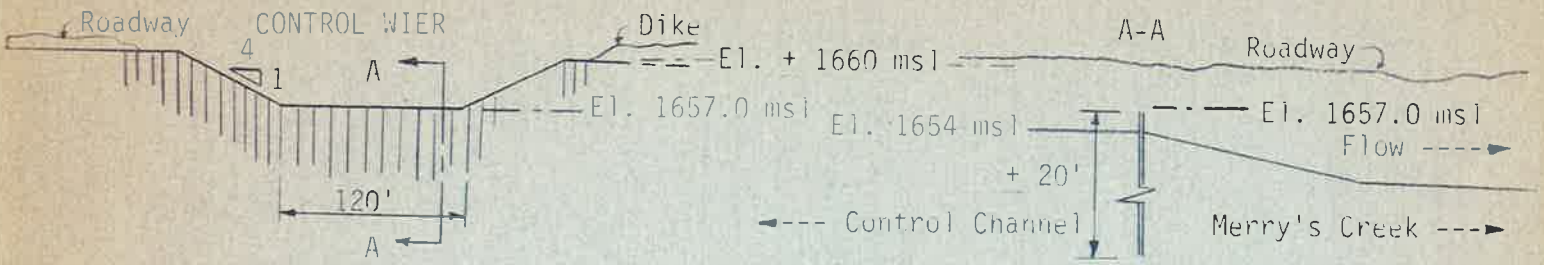
The proposed widening and clearing of Merry's Creek will increase the capacity by approximately 60% to 1400 from the present 800 cfs. The improvements would widen the channel along about 2100 feet of its length to a bottom width of 20 feet and side slopes varying from a minimum of 3:1, to 4:1. This increasing of the channel capacity would maximize the capacity of the Merry's Creek outlet at the least cost.

The preliminary cost estimate for these improvements is given in Table Two, and is considered Phase One in an overall flood control project. In conjunction with this phase, some channelization to Painted Woods Creek, between Highway 83 and Painted Woods Lake, may be required. A preliminary cost estimate for this area can not be developed until further information is obtained.

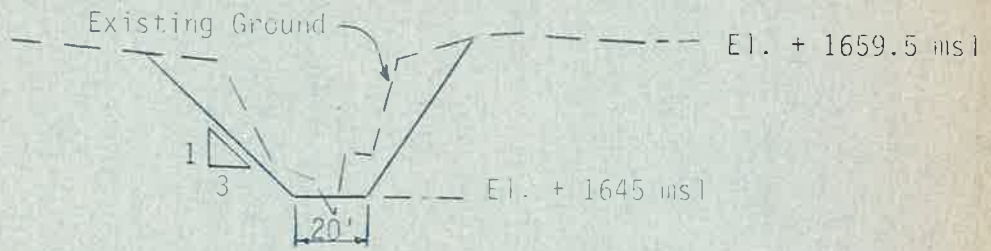
V. PHASE TWO & THREE - HIGHWATER OUTLETS

In the event of high water on Painted Woods Lake, the water would flow to the Missouri River through one or both of the known highwater outlets. These

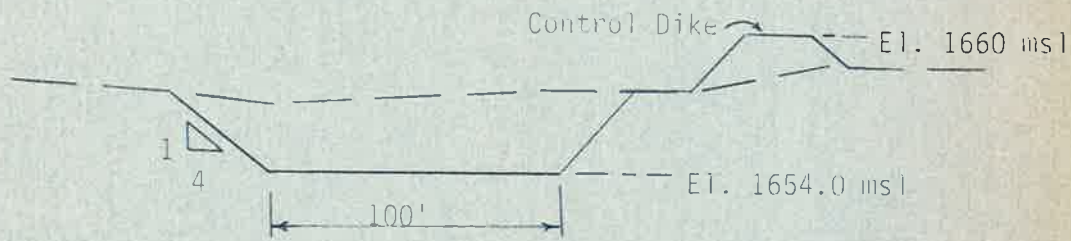
PHASE ONE IMPROVEMENTS



MERRY'S CREEK IMPROVEMENTS



CONTROL CHANNEL FROM LAKE



(No Scale)



FIGURE FIVE - PHASE ONE

MERRY'S CREEK IMPROVEMENTS

TABLE TWO

PHASE ONE

* PRELIMINARY COST ESTIMATE

MERRY'S CREEK IMPROVEMENTS

DESIGN CAPACITY 1400 CFS CONTROL ELEVATION 1657 M.S.L.

Improvements to Merry's Creek

Excavation	27,600 CY at \$1.20/CY	\$ 33,120
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Weir Construction

Excavation	2,000 CY at \$1.10/CY	2,200
Sheet Piling	2,300 L.F. at \$20.00/LF	46,000
Rock Riprap	580 CY at \$20.00/CY	11,600
Filter Blanket	300 CY at \$5.00/CY	1,500

Control Channel

Excavation	26,000 CY at \$0.85/CY	22,100
Compaction	26,000 CY at \$0.25/CY	6,500

Seeding 15 acres at \$100/Acre

	Subtotal	<u>1,500</u>
		<u>\$124,520</u>

Contingencies, Engineering and Contract Administration	<u>\$ 37,380</u>
-----------------------------------------------------------	------------------

TOTAL PROJECT COST	<u>\$161,900</u>
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* Note Does not include land costs or channel improvements to Painted Woods Creek

highwater outlets are located north and west of the lake (Carvell overflow), and directly west of the lake (Fahlgren overflow).

The highwater outlet to the west (Fahlgren overflow) appears to be the most suitable location for a flood channel, which would be located just south of the north section line of Section 8, Township 143 North, Range 81 West, (Figure Four). The distance between the lake and the Missouri River is approximately 2600 feet. The existing overflow elevation is approximately 1661.4 m.s.l.

The northwestern highwater outlet (Carvell overflow) follows the old Turtle Creek riverbed to the northwest into Section 32, Township 143 North, Range 82 West, where it outlets into the Missouri River (Figure Four). The distance from Painted Woods Creek to the Missouri is in excess of 5900 feet. This greater distance and the requirement for structures makes improvements to this outlet very costly and therefore undesirable as a single flood control outlet. During the past few years, high lake elevations have caused water to flow through this outlet resulting in extensive erosion which has caused substantial damages to both cropland and real estate. Because of the extensive erosion, the existing overflow elevation has been lowered 1.6 feet to elevation 1659.8 m.s.l. (Figure Three). Presently, flood waters outlet through this area prior to the overtopping the dikes at Painted Woods Lake.

V(a). PHASE TWO - FAHLGREN OVERFLOW

In view of its location, the western highwater outlet known as the Fahlgren overflow was selected as the primary location for a secondary outlet from the Painted Woods Lake area. There were many items considered in the selection process, the primary items being economics and the ease of construction.

In reviewing the hydraulics of this location, several proposals were developed for various design alternatives and control elevations. These proposals take into account the limited storage capacity within the lake.

During the preliminary investigation, several restrictions were placed on the design in order to protect the outlet channel and to minimize the effects of its construction on the surrounding landscape. Maximum channel velocity was limited to 2.5 feet per second for a 10 year event with higher velocities allowable on larger events. Maximum depth of flow was set at 2.0 to 2.5 feet for a 10-year event with greater depths allowable during larger events.

This criteria result in wide channels with flat slopes. Six to one side slopes were used to provide easy access across the channel when dry, which would be most of the year. Two alternative designs are included in this report.

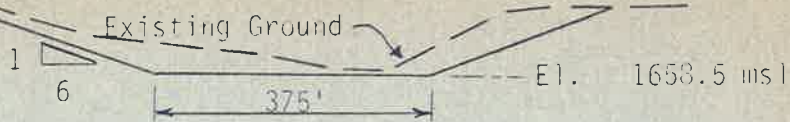
Alternative I (Phase Two Improvement) was designed to pass a 10-year frequency flood event, with the lake attaining an elevation of 1659.5 m.s.l. The design allows for a flow of approximately 1400 cfs through Merry's Creek with 400 cfs flowing through the Fahlgren overflow. The width of the channel being 375 feet for 1500 feet, then narrowing to 250 feet for the remainder. Typical sections are shown in Figure Six. The overflow elevation would be placed at elevation 1658.5 m.s.l. This elevation is currently the point at which flooding begins to occur in this area; however, actual flow to the Missouri does not occur until elevation 1661.4 m.s.l.

This alternative would also provide for the capability of passing a 25 year event with the lake at elevation 1661 m.s.l. At this elevation, major flooding would occur in a number of areas. The increased flows in the proposed overflow would cause an increase in the velocities which may create minor problems depending on the prevailing channel conditions.

PHASE TWO IMPROVEMENTS

ALTERNATIVE ONE

Inlet Section

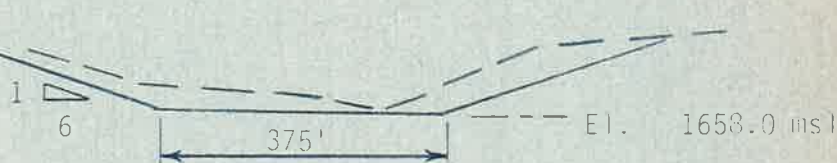


Outlet section



ALTERNATIVE TWO

Inlet Section



(No Scale)



FIGURE SIX - PHASE TWO
FAHLGREN OVERFLOW

The northwestern or Carvell overflow could also be used for the 25 year flow if constructed as proposed later in this report, thus reducing the velocity problems and providing increased protection.

The preliminary cost estimate for this alternative is given in Table Three. The cost estimate includes provisions for a Texas crossing near the Missouri River, to maintain access to the land south of the proposed floodway, and a drop structure at the Missouri River.

Alternative II (Phase Two Improvement) will provide for 10-year event flows with the lake elevation at 1659.0 m.s.l. The channel is designed with a 375 foot width for its entire length with the control elevation at 1658.0 m.s.l. (Figure Six). The flow would be split with 1150 cfs through Merry's Creek and 650 cfs through the Fahlgren overflow. The results of the lower control elevation would be a more frequent use of this outlet, and the possible need for more than a Texas Crossing to provide adequate access.

Alternative II was designed to provide for 25 year flood flows under the previously set restrictions. The 25 year flows would be passed with the lake at elevation 1660.5 and channel velocities limited to 2.5 feet per second. The amount of flooding would not be substantially decreased by this alternative as compared to Alternative One; however, it would be more effective in removing larger flows because of the increased outlet capacity.

The preliminary cost estimate for this alternative is given in Table Four and provides the same provisions for access as in Alternative I.

It should be noted that there are no provisions in either of these alternatives to pass the very large events, and major flooding will occur during these larger floods. The effect these improved outlets will have, will be to lessen the duration of the flood by the more rapid release of water to the Missouri River.

TABLE THREE

PHASE II ALTERNATIVE ONE

* PRELIMINARY COST ESTIMATE

FAHLGREN OVERFLOW OUTLET

CONTROL ELEVATION 1658.5 M.S.L.

DESIGN CAPACITY 1200 CFS AT LAKE ELEVATION 1660.5 M.S.L.

Overflow channel from Painted Woods Lake
to Missouri River

Excavation	46,000 CY at \$0.90/CY	\$41,400.00
Tree Removal	Lump Sum (200 trees)	20,000.00
Seeding	30 acres at \$150/acre	4,500.00

Channel inlet protection

Riprap	310 CY at \$25/CY	7,750.00
Filter Material	160 CY at \$10/CY	1,600.00

Drop Structure to Missouri

Excavation	3100 CY at \$1.10/CY	3,410.00
Riprap	1650 CY at \$25/CY	41,250.00
Filter Material	650 at \$10/CY	6,500.00

Provision for one Texas Crossing (Primary) 17,500.00

Second crossing over Grass Channel
Agricultural Crossing

SUBTOTAL 143,910.00

Contingencies, Engineering,
and Contract
Administration 44,090.00

TOTAL PROJECT COST \$188,000.00

* Note Does not include land costs. Costs may also vary with soil conditions.

TABLE FOUR

PHASE II ALTERNATIVE TWO

* PRELIMINARY COST ESTIMATE

FAHLGREN OVERFLOW OUTLET

CONTROL ELEVATION 1658.0

DESIGN CAPACITY 2400 CFS AT LAKE ELEVATION 1660.5 M.S.L.

Overflow channel from Painted Woods Lake
to Missouri River

Excavation	101,000 CY at \$0.90/CY	\$ 90,900.00
Tree removal	Lump sum	30,000.00
Seeding	35 acres at \$150/ACRE	5,250.00

Channel inlet protection

Riprap	310 CY at \$25/CY	7,750.00
Filter material	160 CY at \$10/CY	1,600.00

Drop structure to Missouri

Excavation	4400 CY at \$1.10/CY	4,840.00
Riprap	2500 CY at \$25/CY	62,500.00
Filter material	1000 CY at \$10/CY	10,000.00

Provision for one Texas Crossing (Primary)

Second crossing over Grass Channel Agricultural Channel		<u>22,000.00</u>
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SUBTOTAL	\$234,840.00
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Contingencies, Engineering, and Contract Administration	<u>71,160.00</u>
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<u>TOTAL PROJECT COST</u>	<u>\$306,000.00</u>
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* Note Does not include land costs. Costs may also vary with soil conditions.

There is one major problem which may exist with providing flows to the Merry's Creek and Fahlgren outlet. The problem relates to the capacity of Painted Woods Creek from Highway 83 south to the lake. There are some indications from recent surveys that natural constrictions exists which may limit flows to the lake causing backwater problems and flow through the northwestern outlet. The extent to which these constrictions affects this backwater should be investigated.

The lack of natural channel capacity comes from the limited channel size and the lack of channel slope. The runoff from the steep hills north of Highway 83 outlet into the flats on the south side of the highway. Flows then overflow the creek banks flooding a large area.

V (b). PHASE THREE - CARVELL OVERFLOW

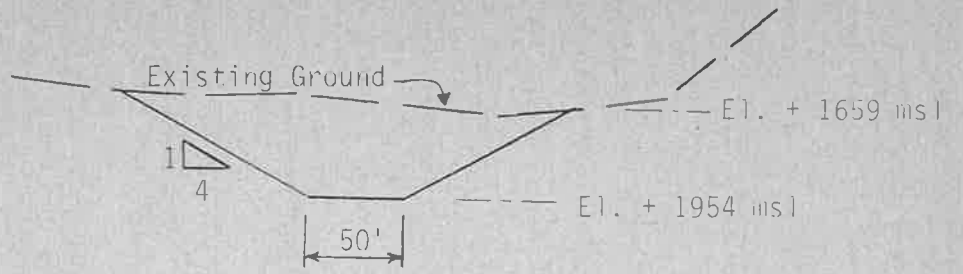
The primary deterrent to the development of the northwest or Carvell outlet, as the single or only highwater overflow from this area is its high costs. There would be a need for several bridges, a large capacity channel, and other improvements which further increase its cost. Some improvements are required to prevent further damages in this area, even if Phase Three is not constructed.

Existing conditions indicate that the outlet elevation of this highwater overflow has been lowered from 1661.4 m.s.l. to 1659.8 m.s.l. due to erosion and frequent flooding. The lowering of the outlet has increased its frequency of use, therefore, drastically increasing the probability of further damages. Any amount of backwater from Painted Woods Creek could have serious complications.

The proposed alternative for the improvements to this outlet is considered as Phase Three, and would involve the construction of a drainage channel approximately 4200 feet in length with 4 to 1 side slopes and a bottom width of 50 feet. Typical sections are shown in Figure Seven. The channel

PHASE THREE IMPROVEMENTS

TYPICAL SECTION



(No Scale)



FIGURE SEVEN - PHASE THREE

CARVELL OVERFLOW

would be constructed along and adjacent to the high bank east of the natural channel, then directly west to the Missouri River through the present washout. This alignment was selected to avoid the use of agricultural land and to obtain material to fill the existing washout area. Any excess material could be used to construct spoil piles that would protect adjacent lands from continued flooding.

The proposed channel design would provide for a capacity of approximately 900 cfs. The outlet would also be used on a permanent basis to intercept local flows which now drain south to Painted Woods Creek.

A control structure would be placed at the location of the existing bridge location near Painted Woods Creek. This proposal also provides for the installation of a 40 foot bridge near the Missouri River to restore the private river road that was washed out. The preliminary cost estimate for this proposal is given in Table Five.

TABLE FIVE
 PHASE THREE
 * PRELIMINARY COST ESTIMATE
 CARVELL OVERFLOW OUTLET
 CONTROL ELEVATION 1660 m.s.l.
DESIGN CAPACITY 900 c.f.s.

Channel Construction

Channel excavation (4200 feet)	125,000 CY at \$0.95/CY	\$118,750
Fill material required (compacted)	50,000 CY at \$0.35/CY	17,500
Riprap	600 CY at \$25.00/CY	15,000
Filter Blanket	300 CY at \$10.00/CY	3,000
Seeding	12 Acres at \$150/acre	1,800

Bridge near Missouri

40 foot x 24 foot concrete bridge	960 ft. ² at \$62/ft. ²	59,520
Excavation	2,000 CY at \$1.00/CY	2,000
Riprap	200 CY at \$25.00/CY	5,000

Control Structure

Raise existing bridge	L.S.	10,000
Concrete box culverts and drop	L.S.	<u>75,000</u>
	Subtotal	\$307,570
	Contingencies, Engineering, and Contract Administration	<u>92,430</u>
	<u>TOTAL PROJECT COST</u>	<u>\$400,000</u>

* Does not include land costs. Costs may also vary with soil conditions.

VI. SUMMARY AND CONCLUSIONS

After a complete review of the conditions that presently exist in the Painted Woods Lake area, it is apparent that a number of improvements will have to be made if further damages are to be reduced. This report outlined a three-phase project. Phase I would be improvements to the Merry's Creek outlet at the south end of Painted Woods Lake. Phase I Improvements would increase the present outlet capacity of 800 cubic feet per second to 1,400 cubic feet per second. Although, this represents less than 10-year protection, it would be a considerable improvement over existing conditions and would cost approximately \$161,900 not including any improvements to Painted Woods Creek below Highway 83.

Phase II of an overall flood control project for the Painted Woods Lake area would be the development of the Fahlgren overflow which is one of the two areas where high water has overflowed into the Missouri River. Two alternative plans were reviewed in this report. Both would provide, in conjunction with Phase I Improvements, adequate 10-year protection. The cost for this phase ranged from \$188,000 to \$306,000 depending on the selection of alternatives. Phase III Improvement or Carvell overflow has a cost of approximately \$400,000 and would provide for an additional overflow capacity of 900 cubic feet per second.

This report concludes that flood control for the study area is feasible, however, construction costs are high. An appropriate and equitable financing plan will have to be devised before these proposed improvements proceed. For this reason, the proposals were developed in three phases and each phase can stand alone, and will provide flood protection to the area. It is recommended that Phase I, Merry's Creek outlet, be developed and completed immediately, including a complete study of Painted Woods Creek below Highway 83 to evaluate

any natural constrictions which exist. Along with completion of Phase I, the roadway and washout area northwest of the lake at the Carvell overflow should be repaired or modified to prevent further damages from occurring in this area. After completion of these items, if local interests feel additional flood protection is necessary, the McLean County Water Resource Board should then proceed with Phase II and again if necessary with Phase III.

